# Appendix E-4

# United States Environmental Protection Agency
# Diamond XX Road Study

# EVALUATION OF RISKS POSED TO RESIDENTS AND VISITORS OF DIAMOND XX WHO ARE EXPOSED TO AIRBORNE ASBESTOS DERIVED FROM SERPENTINE COVERED ROADWAYS

**FINAL**

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**Prepared for:**
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**Region 9**
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**May 24, 1994**

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ICF TECHNOLOGY INCORPORATED

May 25, 1994

Kira Lynch
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United States Environmental Protection Agency
75 Hawthorne St.
San Francisco, CA 94104

RE: Work Assignment No. 59-06-D800 of Contract No. 68-W9-0059.

Dear Kira:

Please find enclosed seven bound copies and one unbound copy of our final report, "Evaluation of Risks Posed to Residents and Visitors of Diamond XX Who Are Exposed to Airborne Asbestos Derived from Serpentine Covered Roadways." Let me know if this is a sufficient number to circulate among the interested parties of EPA or if you would like additional copies for any other reason.

Note that one of the principle goals of this assessment was to reduce (or at least identify and evaluate) sources of bias to the estimated risks. If there is interest in reducing potential bias further, this can be accomplished by:

(1) performing a small number of additional paired analyses on archived samples (to improve the comparison between direct and indirect preparation);

(2) collecting a small number of additional road samples (dispersed throughout the community) and analyzing the samples to determine the distribution of asbestos in road material throughout Diamond XX;

(3) obtaining and evaluating historical wind data for the site to quantify the distribution of wind speed and direction prevalent at the site; and

(4) completing a site reconnaissance to determine the location of houses relative to the location of roads and the direction of prevailing winds.

Please call me if you have any questions or comments concerning this document.

Sincerely,

D. Wayne Berman, Ph.D.
Chief Scientist

cc Polly Quick (ICF Program Manager for ARCs)
Maria De La Cruz (ICF ARCs Contract Coordinator)

# EVALUATIONOF RISKS POSED TO RESIDENTS AND VISITORS OF DIAMOND XX WHO ARE EXPOSED TO AIRBORNE ASBESTOS DERIVED FROM SERPENTINE COVERED ROADWAYS

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In September, 1993 the U.S. Environmental Protection Agency (EPA) conducted a series of experiments designed to provide measurements of the concentrations of asbestos in air generated downwind of serpentine-surfaced roadways during controlled traffic flow. The primary purpose of this study was to provide the data required to estimate risks experienced by residents living adjacent to such roads or who use such roads for transportation. The level of risk potentially experienced by children riding bicycles along these roads was a particular concern. This report presents a risk assessment performed using the data from the EPA experiments.

## EXPERIMENTAL DESIGN

The September, 1993 study was conducted in a residential development known as Diamond XX, which is located off of Route 4 near Copperopolis, California. The experimental design of the study is described briefly below. A more detailed description of the design and procedures can be found in the Diamond XX Sampling and Analysis Plan (EPA 1993).

Based on a review of weather patterns and topography, two roads were selected, which:

- run reasonably straight for a required 300 ft;
- are clear of obstructions for several hundred feet lateral to the road in the vicinity of the selected study area; and
- run approximately perpendicular to the direction of prevailing winds.

At each roadway, sampling stations were set up on a line representing the perpendicular bisector to the 300 ft section of road that defines each study area. Stations were set at:

- 150 ft upwind;
- 25 ft downwind;
- 75 ft downwind; and
- 150 ft downwind.

Each station included a high-volume sampler to collect samples of total respirable dust and a low-volume sampler to collect samples suitable for asbestos analysis. Typically, additional sampling equipment was also set up at one station to collect duplicate samples. The station at which duplicate samples were collected was varied from experiment to experiment.

In addition to those set up in the study area, a sampling station was also typically established at a location remote from the study area and samples were collected at this remote station over the same time interval as specific experiments being conducted on the road. Measurements from these locations are intended to provide estimates of asbestos concentrations representative of remote background.

Sampling was generally conducted over a three-hour period during which a control vehicle was driven at constant speed (30 mph) back and forth at a fixed frequency (0, 5, or 15 vehicles per hour or vph) over the selected road. Experiments were conducted over the course of three consecutive days at each of the two roadway locations. Two separate runs were typically completed on each day.

A small number of sampling stations at various locations were also left to run overnight on specific evenings. Results from these measurements were designed to provide an estimate of the average concentrations of asbestos prevailing over the 12 hour period not evaluated during the main part of the study.

Wind speed and direction were monitored during each experiment to assure that conditions remained constant to within the defined tolerances of the study. The study was conducted during meteorological conditions that are believed associated with the greatest potential for asbestos release from the roads (i.e. dry and warm with steady winds blowing perpendicular to the road).

Samples of respirable particulate matter (PM10) were collected using a high volume sampler coupled to a size selective inlet per the requirements of EPA Reference Method RFPS-1287-063. The PM10 was collected during each run on 8-inch by 10-inch quartz filters and analyzed by gravimetry (i.e. the filters were weighed before and after sample collection and the difference in weights computed to provide a measure of the mass of respirable dust collected).

The airborne concentration of respirable dust at each station was determined by dividing the mass of dust captured by the volume of air passed through the quartz filter during each run. Additional details concerning the requirements for sampling respirable dust can be found in 40 CFR Part 50, Appendixes J (the reference method), and K -- "Interpretation of a National Ambient Air Quality Standard for Particulate Matter in the Atmosphere."

Due to the anticipated filter loading and a desire to improve the precision of the measurements, sample collection filters analyzed for asbestos were prepared using an indirect preparation technique (Chatfield and Berman 1990). However, because analytical results derived from directly prepared samples are believed by some researchers to relate better to available slope factors for asbestos, concentrations derived from the indirectly prepared samples of this study were converted to estimates of the equivalent concentrations to be expected from directly prepared samples using a conversion factor derived from measurements collected during the study.

To derive an appropriate conversion factor between indirectly and directly prepared samples, approximately half a dozen paired samples were collected with one filter of each pair prepared by the indirect technique and the other filter by a direct technique. Results of these paired analyses were then subjected to a regression analysis to determine the relationship between samples prepared by the different techniques. For a description and comparison of preparation techniques, see Berman and Chatfield (1990).

Filters were analyzed for the determination of asbestos using the counting and identification rules defined in the ISO method (Chatfield 1993). The stopping rules were modified so that sufficient asbestos structures would be counted to allow detection (with high probability) of the anticipated differences between upwind and downwind samples.

Asbestos concentrations are reported for each sample by each of four indices:

- a phase contrast microscopy equivalent (PCME) count defined to be consistent with the EPA "Asbestos Health Effects Assessment Update" (1986). This index is referred to as *PCME (EPA 1986)*;
- a PCME count defined to be consistent with the California Proposition '65 definition of asbestos (California ARB 1986). This index is referred to as *PCME (Ca: Prop '65)*;
- an index recommended in a pending publication (Berman et al. 1994) that is currently being evaluated by the EPA. This index is referred to as the *B & C index* in the text; and
- a count of all structures longer than 5 μm (*total long structures*), which is an index recommended in an internal review document (Berman and Crump 1989) that is also undergoing review by the EPA. This index is designed to serve as a surrogate for the B & C index, which is much more difficult to measure.

The precise definition of each index and the manner in which each index is generated is presented in Appendix A.

The purpose for presenting asbestos concentrations expressed in each of four indices is to allow multiple interpretation of asbestos risk based on various published and soon to be published procedures. The procedures employed for evaluating the risks attendant to asbestos exposure remain controversial.

The resulting measurements from the set of experiments conducted at Diamond XX were subjected to analysis of variance (ANOVA) to determine what factors potentially affect the level of airborne asbestos generated by vehicular traffic on serpentine-covered roads. Estimated average exposure concentrations appropriate for a specific set of exposure scenarios were also derived from the data and combined with corresponding slope factors to provide an estimate of risk potentially experienced by the following specific populations:

- residents in houses immediately adjacent to the roads;
- children who bicycle regularly along the roads; and
- individuals exposed continuously to concentrations typical of background.

## RESULTS

A total of 65 sample filters were prepared by the indirect technique and analyzed to derive estimated airborne asbestos concentrations at specific sampling stations during specific runs. These include 12 pairs of duplicate samples (with paired filters collected immediately adjacent to the each other). Four filters representing laboratory blanks and seven filters representing field blanks were also prepared and analyzed. Five additional sample filters (each paired with one of

the other sample filters described above) were also collected, prepared by a direct technique, and analyzed.

Because the concentrations measured on field blanks and lot blanks are small relative to the smallest field concentrations measured, it is assumed that contamination is not a problem and the blanks are not considered further except to document the concentrations measured.

Concentrations calculated for each asbestos filter sample collected during the study are provided in Appendix B. A key is also provided in this appendix that indicates the location and the conditions of the run during which each sample was collected.

The data were validated. A summary report of the results of data validation is presented in Appendix C.

ANOVA Results

Analysis of variance (ANOVA) is a formal statistical procedure that evaluates the degree to which the variability of particular dependent variables can be attributed to the effects of one or more independent variables. As applied here, the utility of the ANOVA is two-fold. First, it is a sensitive procedure for testing whether two or more sets of measurements are significantly different (i.e. for determining whether two or more measurable quantities are distinguishable). Second, it provides strong evidence for causal relationships between dependent and independent variables (i.e. for determining whether specific parameters affect the processes being studied). Thus, for example, ANOVA can be used to determine whether changes in wind speed or vehicle frequency (independent variables) affect the rate at which asbestos is released and transported from a serpentine-covered road (the dependent variable).
The ANOVA conducted on the asbestos concentrations measured in this study were performed similarly for each of the first three indices of concentration defined in the last section. The fourth index, total long structures, was added later to facilitate risk estimation by serving as a surrogate for the B & C index, but was not included in the ANOVA.

The ANOVA was conducted to determine the effect of the following parameters on measured airborne asbestos concentrations:

- sections of *roadway* (two were studied);
- *gross proximity* (i.e. remote background versus all other stations near the road);
- *station* (i.e. the specific sampling location upwind or downwind with respect to the road);
- *vehicle frequency* (i.e. the number of passes per hour conducted by the control vehicle);
- *day* (i.e. the specific day on which the experiment was run);

- *sample number* (i.e. the specific filter number; used to distinguish among pairs of filters analyzed as duplicates); and

- *test number* (i.e. the numerical identifier of specific analyses; used to distinguish among pairs of analyses for each laboratory QC re-count).

The parameters, *sample number* and *test number*, were included to provide an indication of the irreducible variability inherent in the sampling and analysis of asbestos for this study; these represent the variability introduced by sample handling, laboratory handling, and analysis of filters. All of the other parameters were included to examine their effect on airborne asbestos concentrations.

Note that the parameter, *day*, was included to serve as a surrogate for general meteorological conditions; although weather patterns were reasonably stable over the entire 10 days of the study, the relationship between airborne concentration and *day* was examined to highlight any effects due to the small changes in meteorology that did occur during the course of the study.

When an ANOVA is performed, it is also generally possible to examine the potential "interaction" between the variables being evaluated. For example, in the ANOVA conducted for the Diamond XX study, the following interactions were also evaluated:

- roadway and gross proximity;

- station within roadway and gross proximity;

- vehicle frequency within roadway and gross proximity;

- station and vehicle frequency;

- sample number within all of the other parameters (except test number); and

- test number within all of the other parameters.

The degree of interaction between two (independent) variables indicates the extent to which the effects of two the variables on a third (dependent) variable are dependent on one another. For example, testing for the interaction between *roadway* and *gross proximity* provides an indication of whether the differences noted in concentrations between stations close to the road and those remote from the road are different for the two roadways studied.

When a specific parameter is examined "within" other parameters, what is being evaluated is the effect that the specific parameter has on a particular variable while "removing" (i.e. accounting for) the effects of the other parameters. For example, evaluating *test number* within all of the other parameters studied in this ANOVA provides an indication of the variability in measured asbestos concentrations that is attributable solely to the variability inherent to sample analysis (i.e. it is a measure of the average variability expected of duplicate analyses of the same filter).

A more detailed discussion of the ANOVA conducted for Diamond XX is provided in Appendix D. The implications of the ANOVA that are relevant to risk estimation for Diamond XX are discussed below.

As expected, the effect of both *station* (i.e. location relative to the road) and *vehicle frequency* (i.e. the rate of traffic flow) on measured asbestos concentrations are highly significant. Interestingly, there also appears to be a significant interaction between *station* and *vehicle frequency*. This means that the differences between downwind concentrations that can be attributed to changes in the rate of traffic flow are a function of the specific location (downwind) at which the asbestos concentrations are measured. It is not immediately clear why this is so.

When the control vehicle is traversing the road, a strong trend is noted in which asbestos concentrations decrease as a function of distance from the road and there are significant differences between the asbestos concentrations measured at specific downwind stations (i.e. at locations that are different distances downwind from the road). However, possibly because some of the downwind stations were located too close to each other, not all of the differences between stations are significant; while concentrations measured at 25 ft downwind of the road are always significantly different and higher than concentrations measured at 75 ft or 150 ft, concentrations measured, respectively, at 75 and 150 ft are not significantly different. Still, the concentrations measured at both the 75 and 150 ft downwind stations are always significantly higher than concentrations measured upwind.

Somewhat surprisingly, upwind concentrations measured 150 ft from the road are significantly different (and lower) than concentrations measured at remote background locations. This may be due, however, to what appears to be a single, high outlier among the concentrations measured at one of the remote locations[1].

Concentrations measured downwind of the road when the control vehicle is traversing at 15 vph are significantly higher than concentrations measured when the control vehicle traversed the study area at only 5 vph. However, concentrations measured when the traverse rate was 5 vph are only significantly higher than when no vehicles traversed the roadway for measurements expressed using either the PCME (Ca: Prop '65) or the PCME (EPA 1986) indices. For the measurements expressed in terms of the B & C index, concentrations measured when the control vehicle traversed the study area at 5 vph are *in*distinguishable from concentrations measured when there was no traffic on the road. When no vehicles were traversing the road, upwind and downwind concentrations are indistinguishable.

Interestingly, variation in measured asbestos concentrations as a function of *day* is not significant. Therefore, it should be valid to extrapolate the results of this study from the time period over

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[1] Measurement of elevated asbestos concentrations at a remote location can potentially be attributed to any of several possibilities including, for example, chance selection of a location that is proximal to an unidentified asbestos source or, more simply, contamination of one of the sample filters during handling or transport. Interestingly, when the single high value is removed from the set of measurements from remote locations, they become indistinguishable from the set of upwind measurements.

which the study occurred to other days, at least for days exhibiting meteorological conditions similar to those that prevailed over the interval during which the study was conducted.

Differences between asbestos concentrations measured during similar runs at each of the two road segments studied are not significant. Therefore, because the two road segments also appear to exhibit comparable asbestos concentrations[2], the data from this study cannot be used to assess the relationship between the concentration of asbestos in road material and the rate of asbestos release from such material. At the same time, this conclusion suggests that it should be valid to extrapolate the results of this study to other roadways exhibiting similar asbestos concentrations, provided that the other characteristics of the roadway that potentially control asbestos release (e.g. asbestos concentration, size distribution, moisture content, etc.) are also similar.

In summary, it is clear that individuals who live adjacent to the downwind edge of serpentine-covered roadways may be at elevated risk (compared to general background) due to increased asbestos exposure. Similarly, individuals who use such roadways for transportation (or recreation) may also be at increased risk. Both sets of risk may increase as a direct function of the frequency of traffic on such roadways. Note, although not tested formally in this study, it is also expected that risk will increase with increasing average speed of the vehicles traversing the roadway.

## Risk Analysis Results

Risks potentially experienced by individuals visiting or residing at Diamond XX were estimated by evaluating mean airborne asbestos concentrations prevalent in the area. This was accomplished by converting such estimates to account for differences between direct and indirect preparation, combining the concentration estimates with estimates of the duration and frequency of exposure appropriate to specific receptors, and multiplying the resulting dose estimate by an appropriate slope factor.

### Estimating Exposure Concentrations

The raw concentrations derived from the asbestos measurements collected during the Diamond XX study, which are presented in Appendix B, were combined to provide estimates of the mean concentrations relevant to specific station locations. Based on the ANOVA results presented in the previous section, it is valid to average the measurements collected at each station over day and road for each combination of station and vehicle frequency over which the study was conducted.

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[2] The concentrations of asbestos in road material were measured in this study using a new, soon to be published method (Berman and Kolk 1994), which is designed to provide high precision measurements that can be related to risk. Using this method, asbestos concentrations measured in road material for both roadways are on the order of $5 \times 10^7$ s/g when expressed as PCME (EPA 1986), $5 \times 10^7$ s/g when expressed as PCME (Ca: Prop '65), and $5 \times 10^5$ s/g when expressed in terms of the B & C index.

Table 1 is a summary of the mean concentrations of asbestos measured under specific conditions during the Diamond XX study. Values are presented, respectively, for a location that is 150 ft upwind of the road and for locations that are 25, 75, and 150 ft downwind of the road for runs conducted at either a vehicle frequency of 15 or 5 vph. Mean concentrations are also presented for runs in which the vehicle frequency was zero (i.e. no vehicles traversed the road), although all downwind distances are pooled for this case (i.e. concentrations are *not* presented as a function of distance downwind). Mean concentrations are also presented that are representative of remote background and of all-night samples. Note that concentrations are expressed using each of the four concentration indices defined as described in previous sections and Appendix A.

Concentration estimates derived from field blanks are also presented in Table 1 for comparison. Note that, to provide estimated concentrations for field blanks that would be comparable to the actual measurements, it was assumed that the average volume of air passed through the sample filters during the Diamond XX study also passed through the field blanks; this is simply a hypothetical construct designed to normalize the blank concentrations.

In general, the trends that are apparent among the concentrations presented in Table 1 have been shown to be significant, as discussed in the last section. Thus, among other things concentrations downwind of a roadway being traversed by traffic are significantly higher than upwind concentrations (see last section).

Concentrations measured upwind while traffic is traversing the road are comparable to the pooled concentrations measured when no vehicles are traversing the road. These concentrations are also comparable to the upwind concentrations measured at night. However, downwind concentrations measured at night appear to be greater than any of the upwind (or no vehicle) concentrations. This is not surprising because observations indicate that local residents use the road at night to get to or from their respective residences (Ecology and Environment 1993). Thus, there is some frequency of traffic that occurred during the time that the all night samples were collected and this contributed to airborne asbestos concentrations measured downwind of the road[3].

Due to the similarity of measured concentrations for all upwind samples and the no vehicle samples, it is likely that such concentrations are representative of local background. As indicated previously, although the mean concentrations estimated for remote background are *significantly* higher than this (based on the ANOVA described above), this mean appears to be skewed by a single high outlier (Appendix B). If this single outlier is removed, the mean concentrations measured for remote background become comparable to the "upwind" concentrations and the concentrations measured downwind during the no vehicle runs.

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[3] Wind patterns at night in the area of Diamond XX tend to be unsteady, unlike the stable patterns that tend to occur during the day. Therefore, the locations defined as "upwind" and "downwind" in the daytime may not be as clearly distinguished at night. Nonetheless, the pattern of asbestos concentrations measured at these locations during the night do suggest consistency with the patterns observed during the day.

Interestingly, the mean concentrations representative of the upwind and no vehicle samples that appear to be representative of local background are nonetheless higher than those measured for field blanks. This suggests that measurable asbestos concentrations exist in the air at Diamond XX whether or not traffic is generating asbestos releases from the roads. Such asbestos may derive from any of a variety of sources including, for example, remote sources of asbestos or wind-entrained releases from the local road.

Before the concentrations presented in Table 1 can be employed to derive estimates of risk, two additional issues need to be resolved. First, as indicated previously, because concentrations presented in Table 1 are derived from samples prepared by an indirect technique and the available slope factors for asbestos have been derived from samples prepared by a direct technique, it is necessary to convert the "indirect" concentrations to "direct" concentrations. Second, the duration and frequency of exposure to the specific receptors of interest must be defined and addressed.

### Considering the Effects of Direct and Indirect Preparation

Table 2 presents the small set of paired samples from this study that were prepared, respectively, by a direct and an indirect technique (for a comparison of such techniques, see Berman and Chatfield 1990). The ratios of the direct and indirect pairs are provided at the bottom of the table. Unfortunately, careful analysis of these ratios revealed no significant correlation. Therefore, all that might be said about the conversion factor based on this table is that it likely lies somewhere between 2 and 25 (for all indices of exposure other than the B & C index).

It is possible (though unlikely) that the true conversion factor between direct and indirectly prepared samples lies outside the range indicated in Table 2. Unfortunately, the sample size employed to test the relationship between direct and indirect preparation in this study is apparently too small to provide the definitive result. However, the uncertainty attributable to the error potentially associated with this conversion factor is expected to be small relative to other sources of error typical of a risk assessment.

All of the risk calculations described below incorporate the extremes of the range of conversion factors presented in Table 2 (i.e. 2 and 25) and a middle value of 8.

### Exposure Scenarios

The second issue that must to be resolved before risks can be estimated from this study is the need to define the characteristics of exposure that are appropriate for specific populations of interest. The first page of Table 3 presents a summary of several exposure scenarios believed relevant to the Diamond XX site.

The first case involves children bicycling on the serpentine-covered roads at the site. For this scenario, it is assumed that the mean concentrations from the closest downwind location (25 ft) are representative of the levels of exposure to which such children would be exposed. It is further assumed that such children may ride along the roads for an average of 7.3 hours per day (shorter during the school day and longer on weekends) and that they may continue such activities for 9 years. It is also assumed that such exposure would continue for 310 days of the year.

The value 310 is derived by subtracting from 365 the 15 days typically assumed for a family vacation (EPA 1991) and 40 days during which at least 0.01 inches of precipitation fall in the Diamond XX area during which exposure is expected to be nil (Army Corp of Engineers 1993).

A second scenario involves residents who may live by the road and are assumed to occupy their houses during the day. It is assumed that asbestos concentrations at such a house might be represented by the mean concentrations estimated for the location 150 ft downwind of the road. It is further assumed that such exposure continues for 12 hours per day, 310 days per year, for 30 years. A similar scenario is also presented for which exposure is assumed to continue for only 9 years.

A third scenario involves residents who may live by the road and are assumed to occupy their houses only during the night. The only difference between this scenario and the previous one is that the representative concentration for this case is now assumed to be the mean downwind concentration measured from the all night samples. Both a 9-year and a 30-year case are included for this scenario as well.

In the next set of rows in Table 3, the all-day resident and the all-night resident scenarios are summed to provide a 24-hour resident scenario.

Finally, the risk to individuals exposed continuously to mean background concentrations in the Diamond XX area are also evaluated both for a 9-year and a 30-year case.

**Risk Estimates**

On Pages 2 through 4 of Table 3, estimates of risk are provided for each of the various receptor populations defined on the first page of the table. Estimates are provided based on published slope factors appropriate to each of the three exposure indices carried through the analysis. Risk estimates were not derived for the B & C index because it was decided that the measurements of this index are too variable when measured via published methods and, therefore, such risk estimates would be too uncertain. Risk estimates are included, however, for an index representing total long structures, which serves as a surrogate for the B & C index. Note that a range of three estimates are provided for each exposure index and each case, which reflects the range of factors estimated as described previously for converting between indirectly and directly prepared samples. The three estimates incorporate, respectively, conversion factors of 2, 8, and 25.

Risk estimates are provided separately for two carcinogenic end points: lung cancer (Page 2 of the Table 3) and mesothelioma (Page 3 of the Table 3). Risks to smokers and non-smokers are presented separately. Note there are no risk estimates for smoking children since it is assumed that children generally do not smoke. Total carcinogenic risks (based on the sum of lung cancer risk and mesothelioma risk) are presented on Page 4 of Table 3. Sources of slope factors employed in Table 3 and a detailed description of other assumptions employed in the risk estimates are provided on Page 5 of Table 3.

Lung Cancer Risks. Comparing across rows on Page 2 of Table 3, it is apparent that, despite the very different estimates of concentrations derived using each of the various exposure indices

(Table 1) and the very different slope factors (Page 5 of Table 3), risks for lung cancer estimated across exposure indices are quite close.

With the exception of the low estimate for PCME (Ca: Prop '65), the estimates of risk for lung cancer across exposure indices appear to vary by no more than a factor of 3 with the long structures providing the highest estimates of risk (based on the model presented in Berman and Chatfield 1989) and the PCME (EPA 1986) index providing the lowest estimated risks. However, this excludes the "low" estimates of risk associated with the PCME (Ca: Prop '65) index, which are approximately an order of magnitude lower than risk estimates assigned to either of the other exposure indices. These relationships hold across all rows in the table (i.e. across all specific exposure scenarios).

From Pages 1 and 2 of Table 3 it can also be determined that selection of the appropriate factor for converting between directly and indirectly prepared samples may alter estimates of risk by more than an order of magnitude (i.e. this factor potentially contributes as much as a factor of 10 to the uncertainty of the risk estimates). However, the range of uncertainty introduced by this factor is fully captured in the table by incorporating three estimates of risk for each combination of exposure scenario and exposure index that are derived using each of three conversion factors: 2, 8, or 25.

Among non-smokers, risks of lung cancer to children who bicycle along the roadways in Diamond XX for 9 years are comparable to the risks for full time, 30-year residents and represent the highest set of risks estimated among non-smokers. Lung cancer risks to 30-year residents who smoke are estimated to be approximately an order of magnitude greater than the risks to non-smokers.

Risks for lung cancer estimated among non-smoking full-time, 30-year residents living downwind of a serpentine-covered road are approximately 40 times greater than what might be expected due to exposure to local background concentrations of asbestos. A similar elevation in risk is found among resident smokers who live downwind from a road in comparison to the risk they might expect from exposure to background. For 9-year bicyclists, this risk is approximately 100 times what might be expected due to background.

Mesothelioma Risks. Trends in the risks of mesothelioma estimated for the various receptor populations and presented on Page 3 of Table 3 are similar to those discussed for lung cancer above and the incremental increase in the risk of contracting mesothelioma appears approximately comparable to the estimated increase in the risk of contracting lung cancer among smokers.

For any particular exposure scenario (i.e. across any row of Page 3 of Table 3), it appears that the relative estimates of mesothelioma risk assigned to each exposure index vary by no more than a factor of 3, if the "high" estimates for PCME (Ca: Prop '65) are ignored. The "high" estimates for the PCME (Ca: Prop '65) index are approximately a factor of 5 greater than the estimates of mesothelioma risk assigned to the other exposure indices. The risk of contracting mesothelioma due to asbestos exposure is believed to be independent of smoking habits.

Interestingly, in contrast to estimates for lung cancer, the Total Long Structure exposure index is associated with the lowest relative risks for contracting mesothelioma among the three exposure indices presented in the table. This is because the model from which the slope factors are derived

for this exposure index (Berman and Crump 1989) incorporates consideration of fiber type and the chrysotile structures common at the Diamond XX site are believed to be less potent toward the induction of mesothelioma relative to the induction of lung cancer than other mineral types of asbestos.

In parallel with the trends noted for lung cancer, the relative mesothelioma risks estimated for bicyclists exposed to road dust are approximately 100 times greater than those estimated in association with exposure to background asbestos concentrations. Full-time, 30-year residents living immediately downwind of a road potentially experience an approximately 40-fold increase in mesothelioma risk over what might be attributed to background.

Overall Cancer Risks. When risks for the induction of lung cancer and mesothelioma are combined (to generate overall cancer risks), trends among the various scenarios are similar to those observed when lung cancer risks and mesothelioma risks are considered separately. Thus, for example, full-time, 30-year residents living downwind of an asbestos-containing road potentially experience an increase in risk of a factor of 40 over what might be attributed to background exposure. Similarly, the estimated combined cancer risks to 9-year bicyclists exposed to road dust are about 100 fold greater than what might be expected due to exposure only to background asbestos concentrations.

When lung cancer and mesothelioma risks are combined (to generate an overall cancer risk), differences between risks to smokers and to non-smokers become much smaller than the order of magnitude difference in risks to these two groups when lung cancer is considered separately. This is because contributions to the overall risk from mesothelioma are the same to non-smokers as to smokers and because mesothelioma risks contribute at least half of the combined total risk in most cases. For smokers, mesothelioma risks contribute approximately half of total cancer risks. Among non-smokers, most of the total cancer risks can be attributed to contributions from mesothelioma while their risks for lung cancer are relatively small. For the same exposure scenario, the combined, total cancer risk to smokers and non-smokers differ by no more than a factor of four.

If all of the assumptions listed in Table 3 are valid, then the highest risks potentially attributable to exposure to asbestos from road dust are on the order of $10^{-2}$. Continuous exposure to background asbestos concentrations in the Diamond XX area yields maximum risks on the order of $10^{-4}$.

## UNCERTAINTY

The estimates of risk provided in this document must all be interpreted carefully. Although an attempt was made to incorporate consideration of most of the many factors contributing to uncertainty in these estimates, it is difficult to quantify the degree of bias that may or may not be associated with such estimates.

It is likely that the risk estimates presented in this document are conservative. This is largely because: the frequency and duration of exposure estimated for each scenario are likely on the

conservative side of the range of reasonable values[4], the estimates of slope factors are typically designed to be conservative, and the exposure indices employed in this document are designed to be conservative. Regarding exposure indices, for example, the use of total long structures (longer than 5 μm) as a surrogate for the even longer structures likely to contribute most to asbestos risk provide an overestimate of the number of such structures in a particular sample. However, because the slope factor employed with the Total Long Structure exposure index to estimate risks in this document partially addresses this over-counting (see Berman and Crump 1989 and Berman et al. 1994), the bias introduced by this last factor is probably limited.

Other factors that potentially contribute to the degree that the risk estimates in this document are conservative include distance from asbestos-containing roads and the concentration of asbestos in road material. The exposure estimates for residents provided in Table 3 assume that the resident spends their time within 150 ft downwind of an asbestos-containing road. However, very few houses in the Diamond XX area lie entirely (or even partially) within 150 ft of a road. It is likely, though not entirely assured, that the concentration of asbestos in the material of the road segments studied are among the highest concentrations to be found in the Diamond XX area. To the extent that such concentrations are higher than average, the risk estimates will be conservative.

Several factors relating to meteorology may contribute to the overall uncertainty of the estimates provided. For example, the concentrations estimated from the field study are causally associated with only a very narrow set of conditions that may represent only a very small fraction of the range of conditions that can occur throughout the year. Thus, if winds blow in different directions than that which prevailed during the study, if wind speeds are significantly higher or lower, if the relative humidity is vastly different, or even if temperature differs, exposure concentrations may be significantly higher or lower than what was in fact measured. Although precipitation was at least partially accounted for by assuming zero exposure on days with at least 0.01 inch of precipitation, there was no attempt to adjust for variation in wind speed or direction and these factors may be equally important in determining airborne asbestos concentrations.

Despite the above, the positive bias introduced into this risk assessment is likely *smaller* than those of other risk assessments typically conducted under Superfund for two reasons:

1. the estimates of airborne asbestos concentrations employed in this risk assessment were selected to be representative rather than conservative; and

2. the slope factors defined for asbestos (although controversial) are derived primarily from human epidemiology data rather than animal studies (see Berman and Crump 1989) so that they have not been subjected to the kinds of conservative treatments typically performed when animal studies are used to derive slope factors for humans.

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[4] Although the duration and frequency estimates employed in this risk assessment are likely to be conservative, it should be noted that they represent direct estimates provided by residents living in Diamond XX.

Note also that most of the contributions to uncertainty listed above are greatly mitigated when comparing among relative risks instead of estimating absolute risks. All of these factors should be considered if risk management decisions are to be developed based on the conclusions of this study.

Importantly, most of the sources of positive bias discussed above (other than those relating to the cancer slope factors for asbestos) can be eliminated, if a field reconnaissance is conducted during which historical wind data are collected and evaluated, houses are located relative to prevailing winds and roads, and additional road samples are collected and analyzed for asbestos.

## CONCLUSIONS

The highest risks attributable to exposure to asbestos that is released from Diamond XX roads by vehicular traffic that were estimated in this study are to two different populations:

- full-time, 30-year residents who are smokers and who live downwind of an asbestos-containing road; and
- children who live in the area for at least 9-years and who bicycle along asbestos-containing roads.

Based on this study, the best estimate of the level of risk experienced by such individuals are on the order of $1 \times 10^{-3}$ for both groups, with the estimates of risk ranging between $10^{-4}$ and $10^{-2}$. Such absolute risk estimates are uncertain, although it is more likely than not that they are somewhat conservative.

Less uncertain are the relative risks estimated in this document. Full-time, 30-year residents who reside within 150 ft downwind of a roadway (whether they are smokers or non-smokers) likely experience an incremental increase in risk due to exposure to asbestos in road dusts that is approximately 40 times what they would experience if they were exposed only to background asbestos concentrations.

Similarly, children who reside in the area for 9 years and who bicycle frequently along asbestos containing roadways may experience risks that are elevated by 100 fold over what might be attributable to exposure to background concentrations of asbestos.

**TABLES**

TABLE 1
AVERAGES OF CONCENTRATIONS MEASURED FOR SPECIFIC LOCATIONS
DURING THE DIAMOND XX STUDY

| | Mean Concentrations (s/cc)(a): | | | |
|---|---|---|---|---|
| | PCME (EPA 1986) | PCME (Ca: PROP '65) | B&C INDEX | TOTAL LONG STRUCTURES |
| 15 Vehicles per Hour | | | | |
| Location A: | 2.26E-03 | 6.82E-04 | 4.45E-06 | 4.66E-03 |
| Location D: | 3.04E-01 | 6.66E-02 | 7.88E-03 | 4.89E-01 |
| Location C: | 3.96E-01 | 8.09E-02 | 4.97E-03 | 6.63E-01 |
| Location B: | 1.40E+00 | 3.96E-01 | 3.10E-02 | 2.44E+00 |
| 5 Vehicles per Hour | | | | |
| Location A: | 3.25E-03 | 8.62E-04 | 1.03E-05 | 5.17E-03 |
| Location D: | 4.79E-02 | 2.31E-02 | 3.86E-04 | 1.02E-01 |
| Location C: | 6.53E-02 | 1.41E-02 | 1.40E-04 | 1.06E-01 |
| Location B: | 1.91E-01 | 5.99E-02 | 4.19E-03 | 3.33E-01 |
| All Night Samples | | | | |
| Upwind | 3.70E-03 | 1.88E-03 | 1.05E-05 | 5.68E-03 |
| Downwind | 1.54E-01 | 4.82E-02 | 5.38E-03 | 2.79E-01 |
| No Vehicles per Hour | 8.41E-03 | 3.80E-03 | 9.08E-05 | 1.81E-02 |
| Distant Background | 6.29E-02 | 1.50E-02 | 1.53E-04 | 1.02E-01 |
| Field Blanks | 4.85E-04 | 6.06E-05 | 6.41E-07 | Not Estimated |

KEY:
Concentrations presented in this table represent arithmetic averages for groups of measurements representing each case.

Location A: 150 feet upwind of road
Location B: 25 feet immediately downwind of road
Location C: 75 feet downwind of road
Location D: 150 feet downwind of road

On different nights, all night, downwind samples were collected at different downwind stations that were different distances from the road.

The no vehicle per hour run concentrations are averaged over multiple distances downwind of the road.

(a) Concentrations were derived from samples prepared by an indirect technique.

TABLE 2
AVAILABLE ANALYSIS OF PAIRED DIRECTLY AND
INDIRECTLY PREPARED SAMPLES (a)
(Units are in s/cc)

| Sample Number | Sample Type | PCME (EPA 1986) | PCME (Ca: PROP '65) | B&C INDEX | TOTAL LONG STRUCTURES |
|---|---|---|---|---|---|
| From directly prepared samples: | | | | | |
| SY8564 | R1-5DP-1B | 1.85E-02 | 1.87E-03 | 3.18E-03 | 3.30E-02 |
| SY8577 | R1-5DP-2C | 1.87E-02 | 2.34E-03 | 5.10E-04 | 3.12E-02 |
| SY8610 | R2-15DP-1D | 6.16E-02 | 3.92E-03 | 1.98E-03 | 6.48E-02 |
| SY8617 | R2-5DP-1C | 3.41E-02 | 3.23E-03 | 2.12E-03 | 4.30E-02 |
| ST8619 | R2-15DP-2A | 4.88E-04 | 2.59E-05 | 1.38E-07 | 5.69E-04 |
| From indirectly prepared samples: | | | | | |
| SY8563 | R1-5-1B | 2.99E-01 | 5.00E-02 | 9.52E-03 | 3.79E-01 |
| SY8578 | R1-5-2C | 1.04E-01 | 1.53E-02 | 1.76E-04 | 1.66E-01 |
| SY8611 | R2-15-1D | 1.66E-01 | 8.92E-02 | 4.15E-04 | 2.97E-01 |
| SY8616 | R2-5-1C | 1.51E-01 | 3.87E-02 | 3.69E-04 | 2.45E-01 |
| | R2-15-2A No indirect analysis available | | | | |
| RATIOS (b): | | 16.16 | 26.74 | 2.99 | 11.48 |
| | | 5.56 | 6.54 | 0.35 | 5.32 |
| | | 2.69 | 22.76 | 0.21 | 4.58 |
| | | 4.43 | 11.98 | 0.17 | 5.70 |
| RANGE: | | 3-16 | 7-27 | 0.2-3 | 4-11 |

Conclusion: the conversion factor (between indirectly and directly prepared samples) is likely between 2 and 25 for all indices except the B & C Index, based on the range of ratios presented in the lower part of this table for the two PCME indices and the total long structure index.

(a) Filters to be analyzed by asbestos may be prepared either by a direct or an indirect technique (for discussion, see Berman and Chatfield, 1990). However, because the direct technique is traditionally assumed to relate best to available slope factors, measurements derived from indirectly prepared samples need to be converted.

(b) These represent the ratios (quotients) of concentrations derived from the indirectly prepared specimens and the directly prepared specimens of each sample.

TABLE 3
EXPOSURE SCENARIOS AND ATTENDANT RISK ESTIMATES FOR THE DIAMOND XX SITE

| Scenario Number | Exposure Scenario | Appropriate Asbestos Station | Estimated Vehicles per Hour | Mean Estimated Asbestos Concentration (s/cc)(a) PCME (EPA 1986) | PCME (Ca: Prop '65) | B & C Index | Total Long Structures | Ind/Dir(b) Conversion Factor | Exposure Parameters Days per Year | Hours per Day | Years | Fraction Contributed by Scenario | Fraction of Lifetime |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Children Bicycling (9 yrs exposure) | 25 ft dwnwnd | 15 | 1.40E+00 | 3.96E-01 | 3.10E-02 | 2.44E+00 | 2<br>8<br>25 | 310 | 7.3 | 9 | 1 | 0.033 |
| 2. | Day Residents in Houses by Road (30 yrs exposure) | 150 ft dwnwnd | 15 | 3.04E-01 | 6.66E-02 | 7.88E-03 | 4.89E-01 | 2<br>8<br>25 | 310 | 12 | 30 | 0.5 | 0.091 |
| 3. | Night Residents in Houses by Road (30 yrs exposure) | 150 ft dwnwnd(c) | 15 | 1.54E-01 | 4.82E-02 | 5.38E-03 | 2.79E-01 | 2<br>8<br>25 | 310 | 12 | 30 | 0.5 | 0.091 |
| 4. | Full Time Residents in Houses (30 yrs exposure) | 150 ft dwnwnd | 15 | Combination of scenarios 2 & 3 | | | | 2<br>8<br>25 | 310 | 24(d) | 30 | 1(d) | 0.18 |
| 5. | Day Residents in Houses by Road (9 yrs exposure) | 150 ft dwnwnd | 15 | 3.04E-01 | 6.66E-02 | 7.88E-03 | 4.89E-01 | 2<br>8<br>25 | 310 | 12 | 9 | 0.5 | 0.027 |
| 6. | Night Residents in Houses by Road (9 yrs exposure) | 150 ft dwnwnd(c) | 15 | 1.54E-01 | 4.82E-02 | 5.38E-03 | 2.79E-01 | 2<br>8<br>25 | 310 | 12 | 9 | 0.5 | 0.027 |
| 7. | Full Time Residents in Houses (9 yrs exposure) | 150 ft dwnwnd | 15 | Combination of scenarios 5 & 6 | | | | 2<br>8<br>25 | 310 | 24(d) | 9 | 1(d) | 0.054 |
| 8. | Continuous Exposure to Background (30 yrs exposure) | Upwind | NV | 3.25E-03 | 8.62E-04 | 1.03E-05 | 5.17E-03 | 2<br>8<br>25 | 310 | 24 | 30 | 1 | 0.364 |
| 9. | Continuous Exposure to Background (9 yrs exposure) | Upwind | NV | 3.25E-03 | 8.62E-04 | 1.03E-05 | 5.17E-03 | 2<br>8<br>25 | 310 | 24 | 9 | 1 | 0.109 |

(a) These concentrations are derived from samples prepared by an indirect technique.

(b) This is the conversion factor estimated for converting measurements from indirectly prepared samples to what would be equivalent for directly prepared samples. Note: C(ind)/F = C(dir), where "F" is the conversion factor listed in the table.

(c) These concentration estimates are based on the all night samples collected from the 150 ft downwind station.

(d) For the combination scenarios, the day concentrations are assumed for 12 hours per day and the night concentrations for the remaining 12 hours.

TABLE 3 (Page 2)
ESTIMATED RISKS FOR LUNG CANCER TO SMOKERS AND
NON-SMOKERS POTENTIALLY EXPOSED TO DIAMOND XX (a)

| Scenario Number | Exposure Scenario | Non-smokers | | | | Smokers | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | PCME (EPA 1986) | PCME (Ca: Prop '65)(b) low estimate | PCME (Ca: Prop '65)(b) high estimate | Long Structures (B & C Model) | PCME (EPA 1986) | PCME (Ca: Prop '65)(b) low estimate | PCME (Ca: Prop '65)(b) high estimate | Long Structures (B & C Model) |
| 1. | Children Bicycling | 3E-04 | 1E-04 | 7E-04 | 1E-03 | | | | |
| | (9 yrs exposure) | 9E-05 | 2E-05 | 2E-04 | 2E-04 | | | | |
| | | 3E-05 | 8E-06 | 6E-05 | 8E-05 | | | | |
| 2. | Day Residents in Houses by Road | 2E-04 | 5E-05 | 3E-04 | 5E-04 | 2E-03 | 2E-04 | 2E-03 | 5E-03 |
| | (30 yrs exposure) | 5E-05 | 1E-05 | 8E-05 | 1E-04 | 6E-04 | 6E-05 | 6E-04 | 1E-03 |
| | | 2E-05 | 4E-06 | 3E-05 | 4E-05 | 2E-04 | 2E-05 | 2E-04 | 4E-04 |
| 3. | Night Residents in Houses by Road | 1E-04 | 3E-05 | 2E-04 | 3E-04 | 1E-03 | 2E-04 | 2E-03 | 3E-03 |
| | (30 yrs exposure) | 3E-05 | 8E-06 | 6E-05 | 8E-05 | 3E-04 | 4E-05 | 4E-04 | 7E-04 |
| | | 8E-06 | 3E-06 | 2E-05 | 2E-05 | 9E-05 | 1E-05 | 1E-04 | 2E-04 |
| 4. | Full Time Residents in Houses | 3E-04 | 8E-05 | 6E-04 | 8E-04 | 3E-03 | 4E-04 | 4E-03 | 7E-03 |
| | (30 yrs exposure) | 8E-05 | 2E-05 | 1E-04 | 2E-04 | 8E-04 | 1E-04 | 1E-03 | 2E-03 |
| | | 3E-05 | 6E-06 | 5E-05 | 7E-05 | 3E-04 | 3E-05 | 3E-04 | 6E-04 |
| 5. | Day Residents in Houses by Road | 6E-05 | 1E-05 | 1E-04 | 2E-04 | 7E-04 | 7E-05 | 7E-04 | 1E-03 |
| | (9 yrs exposure) | 2E-05 | 3E-06 | 2E-05 | 4E-05 | 2E-04 | 2E-05 | 2E-04 | 4E-04 |
| | | 5E-06 | 1E-06 | 8E-06 | 1E-05 | 5E-05 | 6E-06 | 6E-05 | 1E-04 |
| 6. | Night Residents in Houses by Road | 3E-05 | 1E-05 | 7E-05 | 9E-05 | 3E-04 | 5E-05 | 5E-04 | 8E-04 |
| | (9 yrs exposure) | 8E-06 | 2E-06 | 2E-05 | 2E-05 | 8E-05 | 1E-05 | 1E-04 | 2E-04 |
| | | 3E-06 | 8E-07 | 6E-06 | 7E-06 | 3E-05 | 4E-06 | 4E-05 | 6E-05 |
| 7. | Full Time Residents in Houses | 9E-05 | 2E-05 | 2E-04 | 3E-04 | 1E-03 | 1E-04 | 1E-03 | 2E-03 |
| | (9 yrs exposure) | 2E-05 | 6E-06 | 4E-05 | 6E-05 | 3E-04 | 3E-05 | 3E-04 | 6E-04 |
| | | 8E-06 | 2E-06 | 1E-05 | 2E-05 | 8E-05 | 1E-05 | 1E-04 | 2E-04 |
| 8. | Continuous Exposure to Background | 9E-06 | 2E-06 | 2E-05 | 2E-05 | 9E-05 | 1E-05 | 1E-04 | 2E-04 |
| | (30 yrs exposure) | 2E-06 | 6E-07 | 4E-06 | 6E-06 | 2E-05 | 3E-06 | 3E-05 | 5E-05 |
| | | 7E-07 | 2E-07 | 1E-06 | 2E-06 | 8E-06 | 1E-06 | 1E-05 | 2E-05 |
| 9. | Continuous Exposure to Background | 3E-06 | 7E-07 | 5E-06 | 7E-06 | 3E-05 | 4E-06 | 4E-05 | 6E-05 |
| | (9 yrs exposure) | 7E-07 | 2E-07 | 1E-06 | 2E-06 | 7E-06 | 9E-07 | 9E-06 | 1E-05 |
| | | 2E-07 | 6E-08 | 4E-07 | 5E-07 | 2E-06 | 3E-07 | 3E-06 | 5E-06 |

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2,8 or 25 listed on Page 1) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor. Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 3)
ESTIMATED RISKS FOR MESOTHELIOMA
TO INDIVIDUALS EXPOSED AT DIAMOND XX (a)

| Scenario Number | Exposure Scenario | PCME (EPA 1986) | PCME (Ca: Prop '65)(b) low estimate | PCME (Ca: Prop '65)(b) high estimate | Long Structures (B & C Model) |
|---|---|---|---|---|---|
| 1. | Children Bicycling (9 yrs exposure) | 3E-03<br>8E-04<br>2E-04 | 2E-03<br>5E-04<br>2E-04 | 1E-02<br>3E-03<br>8E-04 | 1E-03<br>3E-04<br>1E-04 |
| 2. | Day Residents in Houses by Road (30 yrs exposure) | 2E-03<br>4E-04<br>1E-04 | 1E-03<br>2E-04<br>8E-05 | 5E-03<br>1E-03<br>4E-04 | 7E-04<br>2E-04<br>5E-05 |
| 3. | Night Residents in Houses by Road (30 yrs exposure) | 9E-04<br>2E-04<br>7E-05 | 7E-04<br>2E-04<br>6E-05 | 4E-03<br>9E-04<br>3E-04 | 4E-04<br>1E-04<br>3E-05 |
| 4. | Full Time Residents in Houses (30 yrs exposure) | 3E-03<br>7E-04<br>2E-04 | 2E-03<br>4E-04<br>1E-04 | 8E-03<br>2E-03<br>7E-04 | 1E-03<br>3E-04<br>8E-05 |
| 5. | Day Residents in Houses by Road (9 yrs exposure) | 5E-04<br>1E-04<br>4E-05 | 3E-04<br>7E-05<br>2E-05 | 1E-03<br>4E-04<br>1E-04 | 2E-04<br>5E-05<br>2E-05 |
| 6. | Night Residents in Houses by Road (9 yrs exposure) | 3E-04<br>7E-05<br>2E-05 | 2E-04<br>5E-05<br>2E-05 | 1E-03<br>3E-04<br>8E-05 | 1E-04<br>3E-05<br>9E-06 |
| 7. | Full Time Residents in Houses (9 yrs exposure) | 8E-04<br>2E-04<br>7E-05 | 5E-04<br>1E-04<br>4E-05 | 3E-03<br>9E-04<br>2E-04 | 3E-04<br>8E-05<br>3E-05 |
| 8. | Continuous Exposure to Background (30 yrs exposure) | 8E-05<br>2E-05<br>6E-06 | 5E-05<br>1E-05<br>4E-06 | 3E-04<br>6E-05<br>2E-05 | 3E-05<br>7E-06<br>2E-06 |
| 9. | Continuous Exposure to Background (9 yrs exposure) | 2E-05<br>6E-06<br>2E-06 | 2E-05<br>4E-06<br>1E-06 | 8E-05<br>2E-05<br>6E-06 | 8E-06<br>2E-06<br>7E-07 |

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2,8 or 25) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor.
Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 4)
ESTIMATED COMBINED RISKS FOR LUNG CANCER AND MESOTHELIOMA
TO SMOKERS AND NON-SMOKERS POTENTIALLY EXPOSED AT DIAMOND XX (a)

| Scenario Number | Exposure Scenario | Non-smokers | | | | Smokers | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | PCME (EPA 1986) | PCME (Ca: Prop '65)(b) low estimate | PCME (Ca: Prop '65)(b) high estimate | Long Structures (B & C Model) | PCME (EPA 1986) | PCME (Ca: Prop '65)(b) low estimate | PCME (Ca: Prop '65)(b) high estimate | Long Structures (B & C Model) |
| 1. | Children Bicycling (9 yrs exposure) | 3E-03 | 2E-03 | 1E-02 | 2E-03 | | | | |
| | | 8E-04 | 6E-04 | 3E-03 | 6E-04 | | | | |
| | | 3E-04 | 2E-04 | 9E-04 | 2E-04 | | | | |
| 2. | Day Residents in Houses by Road (30 yrs exposure) | 2E-03 | 1E-03 | 5E-03 | 1E-03 | 4E-03 | 1E-03 | 7E-03 | 5E-03 |
| | | 5E-04 | 3E-04 | 1E-03 | 3E-04 | 1E-03 | 3E-04 | 2E-03 | 1E-03 |
| | | 2E-04 | 8E-05 | 4E-04 | 1E-04 | 3E-04 | 1E-04 | 6E-04 | 4E-04 |
| 3. | Night Residents in Houses by Road (30 yrs exposure) | 1E-03 | 7E-04 | 4E-03 | 7E-04 | 2E-03 | 9E-04 | 5E-03 | 3E-03 |
| | | 3E-04 | 2E-04 | 9E-04 | 2E-04 | 5E-04 | 2E-04 | 1E-03 | 8E-04 |
| | | 8E-05 | 6E-05 | 3E-04 | 5E-05 | 2E-04 | 7E-05 | 4E-04 | 2E-04 |
| 4. | Full Time Residents in Houses (30 yrs exposure) | 3E-03 | 2E-03 | 9E-03 | 2E-03 | 6E-03 | 2E-03 | 1E-02 | 8E-03 |
| | | 8E-04 | 4E-04 | 2E-03 | 5E-04 | 2E-03 | 5E-04 | 3E-03 | 2E-03 |
| | | 2E-04 | 1E-04 | 7E-04 | 2E-04 | 5E-04 | 2E-04 | 1E-03 | 7E-04 |
| 5. | Day Residents in Houses by Road (9 yrs exposure) | 6E-04 | 3E-04 | 2E-03 | 4E-04 | 1E-03 | 4E-04 | 2E-03 | 2E-03 |
| | | 2E-04 | 8E-05 | 4E-04 | 9E-05 | 3E-04 | 9E-05 | 5E-04 | 4E-04 |
| | | 6E-05 | 2E-05 | 1E-04 | 3E-05 | 1E-04 | 3E-05 | 2E-04 | 1E-04 |
| 6. | Night Residents in Houses by Road (9 yrs exposure) | 3E-04 | 2E-04 | 1E-03 | 2E-04 | 6E-04 | 3E-04 | 2E-03 | 9E-04 |
| | | 8E-05 | 6E-05 | 3E-04 | 5E-05 | 2E-04 | 7E-05 | 4E-04 | 2E-04 |
| | | 2E-05 | 2E-05 | 9E-05 | 2E-05 | 5E-05 | 2E-05 | 1E-04 | 7E-05 |
| 7. | Full Time Residents in Houses (9 yrs exposure) | 9E-04 | 5E-04 | 3E-03 | 6E-04 | 2E-03 | 8E-04 | 4E-03 | 3E-03 |
| | | 2E-04 | 1E-04 | 7E-04 | 1E-04 | 5E-04 | 2E-04 | 9E-04 | 6E-04 |
| | | 7E-05 | 4E-05 | 2E-04 | 6E-05 | 1E-04 | 5E-05 | 3E-04 | 2E-04 |
| 8. | Continuous Exposure to Background (30 yrs exposure) | 9E-05 | 5E-05 | 3E-04 | 5E-05 | 2E-04 | 6E-05 | 4E-04 | 2E-04 |
| | | 2E-05 | 1E-05 | 7E-05 | 1E-05 | 4E-05 | 2E-05 | 9E-05 | 6E-05 |
| | | 7E-06 | 4E-06 | 2E-05 | 4E-06 | 1E-05 | 5E-06 | 3E-05 | 2E-05 |
| 9. | Continuous Exposure to Background (9 yrs exposure) | 3E-05 | 2E-05 | 8E-05 | 2E-05 | 5E-05 | 2E-05 | 1E-04 | 7E-05 |
| | | 6E-06 | 4E-06 | 2E-05 | 4E-06 | 1E-05 | 5E-06 | 3E-05 | 2E-05 |
| | | 2E-06 | 1E-06 | 6E-06 | 1E-06 | 4E-06 | 2E-06 | 9E-06 | 6E-06 |

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2.8 or 25) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor. Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 5)

| UNIT RISK FACTORS | for lung cancer (s/cc)^-1 | for mesothelioma (s/cc)^-1 | |
|---|---|---|---|
| for PCME (EPA 1986) | 0.16 | 0.13 | for smokers (EPA, 1986) |
| | 0.015 | 0.13 | for non-smokers (EPA, 1986) |
| for PCME (Ca: Prop '65) | 0.8 | 1.6 | high estimate for smokers (California ARB, 1986) |
| | 0.08 | 0.32 | low estimate for smokers (California ARB, 1986) |
| | 0.11 | 1.6 | high estimate for non-smokers (California ARB, 1986) |
| | 0.02 | 0.32 | low estimate for non-smokers (California ARB, 1986) |
| for long structures | 0.21 | 0.03 | for smokers exposed to chryostile (Berman and Crump, 1989) |
| | 0.024 | 0.03 | for non-smokers exposed to chrysotile (Berman and Crump, 1989) |

NOTES:

This table is intended as a single, long table; the pages line up so that each row can be read across from Page 1 to Page 4.

Background concentrations employed in determining the risk estimates presented in this table (Scenarios No. 8 & 9) are based on the average of concentrations measured upwind of each road. Concentrations measured at remote background locations were not included in this estimate because a single high value among the remote measurements skews the average of these measurements high. It is likely that this single high measurement is the result of a poor choice of location at which contamination might exist. Interestingly, removing this single high value reduces the estimate of the average concentration for remote background so that it is indistinguishable from the upwind measurements.

The total number of days per year during which exposure may occur for any scenario is estimated as 365 minus 15 days for vacation and 40 days during which precipitation exceeds 0.01 inches. This leaves a net of 310 days.

The number of hours per day during which exposure may occur for any particular scenario is estimated based on the information provided from a survey of individuals living in the Diamond XX area. In some cases it is averaged over varying estimates provided for differing seasons of the year.

The number of years over which exposure is assumed to occur for each scenario is estimated as 9 years for children and either 9 or 30 years for adults, representing an average and conservative case.

The various "discount" factors presented for converting indirect asbestos measurements to direct asbestos measurements are based on the results of the analysis of direct/indirect filter pairs analyzed during this study. Although a clear regression could not be found, the data suggests that the factor lies between 2 and 25 with 8 as a reasonable median estimate. The risk estimates in each row of the table are derived by dividing the indicated concentration (Page 1) by the indicated ind/dir conversion factor (2, 8 or 25) and by multiplying this quotient by the appropriate fraction of lifetime (Page 1) and unit risk factor (listed above).

The estimates of the potency of long asbestos structures come from the 1989 draft hazard assessment document by Berman and Crump. The separate estimates for males and females provided in the document are averaged. The data employed are for exposure to chrysotile specifically. The potency for long structures was extrapolated from the tables to a dust assumed composed of 100% structures longer than 5 um. Separate estimates are provided, respectively, for smokers & non-smokers.

The estimates of the potency of PCME structures (EPA 1986) are derived from the Asbestos Health Effects Assessment Update (EPA, 1986). Potency estimates for males and females are averaged and separate estimates are provided, respectively, for smokers and non-smokers. Potency estimates obtained from the document are derived assuming onset of exposure at the age of 10.

The estimates of potency for PCME structures derived as recommended by California Proposition 65 are derived from California ARB (1986). Independent estimates for males and females are averaged but the separate estimates for smokers and non-smokers are each provided separately. Values from both the low estimates and high estimates provided in the document are presented in the table.

It is assumed that children are non-smokers but that adults may be either smokers or non-smokers.

## REFERENCES


Army Corp of Engineers (1993). Daily Precipitation Reports for the Army Corp of Engineers. Copperopolis Station: 1954 to 1993. Copperopolis, California.

Berman, DW and Chatfield, EJ (1990). Interim Superfund Method for the Determination of Asbestos in Ambient Air. Part 2: Technical Background Document. Office of Emergency and Remedial Response, EPA, Washington, D.C. EPA-540/2-90/005b. May.

Berman, DW and Crump, KS (1989). Proposed Interim Methodology for Conducting Risk Assessments at Asbestos Superfund Sites. Part 2: Technical Background Document. Prepared for the Environmental Services Branch of EPA, Region 9, San Francisco, California. Undergoing EPA review.

Berman, DW; Crump, KS; Chatfield, EJ; Davis, JMG; and Jones, AD (1994). The Sizes, Shapes, and Mineralogy of Asbestos Structures That Induce Lung Tumors or Mesothelioma in AF/HAN Rats Following Inhalation. Risk Analysis. Accepted for publication.

Berman, DW and Kolk, A (1994). Proposed Interim Superfund Method for the Determination of Asbestos in Soils and Bulk Materials. Part 1: Method. In preparation.

California Air Resources Board -- ARB (1986). Public Hearing to Consider the Adoption of a Regulatory Amendment Identifying Asbestos as a Toxic Air Contaminant. Staff Report: Initial Statement of Reasons for Proposed Rulemaking. February 10.

Chatfield, EJ, convener (1993). The Ambient Air Determination of Asbestos Fibres by an Indirect-transfer Transmission Electron Microscopy Procedure. ISO/TC 146/SC 3. June 14.

Chatfield, EJ and Berman, DW (1990). Interim Superfund Method for the Determination of Asbestos in Ambient Air. Part 1: Method. Office of Emergency and Remedial Response, EPA, Washington, D.C. EPA-540/2-90/005a. May.

Ecology and Environment (1993). Diamond 20 Asbestos, Phase II Site Assessment, Copperopolis, California. Prepared for the EPA. December 15.

EPA (1993). Diamond XX Sampling and Analysis Plan. September 7.

EPA (1991). Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." Office of Emergency and Remedial Response, EPA. OSWER Directive No. 9285.6-03.

EPA (1986). Airborne Health Assessment Update. Office of Health and Environmental Assessment, EPA, Washington, D.C. EPA/600/8-84/003F. June.

**APPENDIX A:**
**DEFINITIONS FOR ASBESTOS EXPOSURE INDICES**

DEFINITIONS FOR ASBESTOS CONCENTRATIONS TO BE ANALYZED AT DIAMOND XX

D. Wayne Berman

February 16, 1994

**EPA 1986 Definition of PCM Equivalent Asbestos (OHEA):**

1. $S_i$ = count all parent structures with length > 5 μm and width > 0.3 μm and components of non-eligible structures with length > 5 μm and width > 0.3 μm (repeat for both i = A and B). Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

2. Calculate the concentration using the equation for $C_{>5}$ (as defined below).

**PCM Equivalent Definition of Asbestos for proposition 65:**

1. $S_i$ = count all parent TEM structures (repeat for both i = A and B)

2. Calculate a concentration for short structures, "$C_{<5}$" and a concentration of long structures "$C_{>5}$" in the manner defined below.

3. Sum $C_{<5}$ and $C_{>5}$ and divide the sum by 100.

**Berman and Crump Definition of Potent Asbestos:**

1. $S_i$ = count all eligible component structures and eligible parent structures that contain no eligible components within the following three size categories:

   - (5 μm < length < 40 μm and width < 0.3 μm) (1);
   - (40 μm < length and width > 5 μm) (2);
   - (40 μm < length and width < 0.3 μm) (3);

   Repeat for both i = A and B and label them $S1_i$, $S2_i$, and $S3_i$, respectively (i.e. six values).

2. Calculate concentrations for each of the three size categories (each using both an $Sj_A$ and an $Sj_B$, respectively) using the equation defined for $C_{>5}$ below. Label the concentrations C1, C2, and C3, respectively.

3. Determine the following weighted sum:

$$C_{tot} = 0.0017*C1 + 0.0145*C2 + 0.853*C3.$$

EQUATIONS FOR ESTIMATING AIR CONCENTRATIONS

For categories of structures shorter than 5 μm, the equation for estimating concentration from the counts, "$S_A$" of eligible structures in the proper category is:

$$C_{<5,air} = (10^{-3})*S_A*(V_{disp})*(A_{anal})/[(V_{air})*(f_{ashed})*(V_{filt})*(\#_{g.o.})*(A_{g.o.})]$$

where:

$C_{<5,\,air}$ = the number of eligible structures per $cm^3$ air (derived as described above);
$S_A$ = the count of eligible structures;
$V_{air}$ = the volume of air filtered (liters);
$f_{ashed}$ = the fraction of the sample filter ashed;
$V_{filt}$ = the volume of the suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening ($mm^2$);
$V_{disp}$ = the volume of the initial suspension (ml); and
$A_{anal}$ = the effective area of the analytical filter ($mm^2$).

For structures longer than 5 $\mu$m, contributions from both the A and B scans must be summed:

$$C_{>5,\,air} = (10^{-3})*(S_A + S_B)*(V_{disp})*(A_{anal})/[(V_{air})*(f_{ashed})*(Q_A + Q_B)]$$

where:

$Q_i = (V_{filt})_i*(\#_{g.o.})_i*(A_{g.o.})_i$ for scans i = A and B, respectively;
$C_{>5,\,air}$ = the number of eligible structures per $cm^3$ air (derived as described above);
$S_A$ = the count of eligible structures from scan A;
$S_B$ = the count of eligible structures from scan B;
$V_{air}$ = the volume of air filtered (liters);
$f_{ashed}$ = the fraction of the sample filter ashed;
$V_{filt}$ = the volume of the suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening ($mm^2$);
$V_{disp}$ = the volume of the initial suspension (ml); and
$A_{anal}$ = the effective area of the analytical filter ($mm^2$).

EQUATIONS FOR ESTIMATING SOIL CONCENTRATIONS

For categories of structures shorter than 5 $\mu$m, the equation for estimating concentration from the counts, "$S_A$" of eligible structures in the proper category is:

$$C_{<5,soil} = (2)*S_A*(V_{scrb})*(A_{anal})*(M_{est})/[(M_{smpl})*(M_{rel})*(V_{filt})*(\#_{g.o.})*(A_{g.o.})]$$

where:

$C_{<5,\,soil}$ = the number of eligible structures per g soil (derived as described above);
$S_A$ = the count of eligible structures;
$M_{est}$ = the estimated total mass of respirable dust in the sample (g);
$M_{smpl}$ = the measured mass of the initial soil sample (g);
$M_{rel}$ = the measured mass of respirable dust released from the sample (g);
$V_{filt}$ = the volume of the scrubber suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening ($mm^2$);
$V_{scrb}$ = the volume of the liquid in the scrubber (ml); and
$A_{anal}$ = the effective area of the analytical filter ($mm^2$).

Note that the factor "2" derives from the fact that only half of the asbestos that is released from the sample is actually captured by the scrubber.

For structures longer than 5 $\mu$m, contributions from both the A and B scans must be summed:

$$C_{>5,\,soil} = (2)*(S_A + S_B)*(V_{scrb})*(A_{anal})*(M_{est})/[(M_{smpl})*(M_{rel})*(Q_A + Q_B)]$$

where:

$Q_i = (V_{filt})_i*(\#_{g.o.})_i*(A_{g.o.})_i$ for scans i = A and B, respectively;
$C_{>5,\,soil}$ = the number of eligible structures per g soil (derived as described above);
$S_A$ = the count of eligible structures from scan A;
$S_B$ = the count of eligible structures from scan B;
$M_{est}$ = the estimated total mass of respirable dust in the sample (g);
$M_{smpl}$ = the measured mass of the initial soil sample (g);
$M_{rel}$ = the measured mass of respirable dust released from the sample (g);
$V_{filt}$ = the volume of the scrubber suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening ($mm^2$);
$V_{scrb}$ = the volume of the liquid in the scrubber (ml); and
$A_{anal}$ = the effective area of the analytical filter ($mm^2$).

## APPENDIX B:
## RAW CONCENTRATION DATA AND SAMPLE KEY

TABLE
ESTIMATED CONCENTRATIONS FROM THE DIAMOND XX SITE[1]

| Sample Number | Sample Type | Prep Tech | Concentrations (s/cc) PCME (EPA 1986) | PCME (prop '65) | B & C Index | Total Long Structures |
|---|---|---|---|---|---|---|
| SY8556 | R1-NV-1A | I | 4.00E-03 | 3.22E-03 | 8.49E-06 | 8.66E-03 |
| SY8557 | R1-NV-1B | I | 3.73E-03 | 1.03E-03 | 4.59E-05 | 7.20E-03 |
| SY8558 | R1-NV-1BD | I | 2.32E-02 | 1.45E-02 | 3.88E-04 | 5.49E-02 |
| SY8559 | R1-NV-1C | I | 2.08E-03 | 2.43E-03 | 3.07E-05 | 6.07E-03 |
| SY8560 | R1-NV-1D | I | 8.87E-03 | 3.62E-03 | 2.54E-05 | 1.94E-02 |
| SY8562 | R1-5-1A | I | 7.86E-04 | 2.16E-04 | 2.36E-05 | 7.86E-04 |
| SY8563 | R1-5-1B | I | 2.99E-01 | 5.00E-02 | 9.52E-03 | 3.79E-01 |
| SY8565 | R1-5-1C | I | 5.78E-03 | 1.94E-03 | 1.25E-05 | 1.21E-02 |
| SY8566 | R1-5-1D | I | 3.12E-02 | 1.92E-02 | 1.10E-04 | 7.01E-02 |
| SY8567 | R1-15-1A | I | 1.07E-03 | 3.93E-04 | 4.68E-06 | 3.82E-03 |
| SY8568 | R1-15-1BD | I | 6.01E-01 | 2.33E-01 | 1.70E-03 | 9.01E-01 |
| SY8569 | R1-15-1B | I | 7.05E+00 | 1.55E+00 | 2.19E-02 | 1.10E+01 |
| SY8570 | R1-15-1C | I | 3.98E-01 | 1.03E-01 | 3.56E-02 | 4.67E-01 |
| SY8572 | R1-15-1D | I | 2.35E-01 | 4.12E-02 | 3.25E-04 | 3.24E-01 |
| SY8574 | R1-5-2A | I | 7.21E-03 | 1.35E-03 | 7.88E-06 | 9.79E-03 |
| SY8575 | R1-5-2B | I | 1.93E-01 | 9.38E-02 | 4.16E-03 | 2.96E-01 |
| SY8578 | R1-5-2C | I | 1.04E-01 | 1.53E-02 | 1.76E-04 | 1.66E-01 |
| SY8579 | R1-5-2D | I | 5.71E-02 | 5.07E-02 | 1.62E-04 | 1.14E-01 |
| SY8580 | R1-15-2A | I | 1.92E-03 | 4.46E-04 | 1.90E-06 | 2.56E-03 |
| SY8581 | R1-15-2BD | I | 2.01E+00 | 1.30E+00 | 1.99E-01 | 4.92E+00 |
| SY8582 | R1-15-2B | I | 1.10E+00 | 2.69E-01 | 2.08E-03 | 1.47E+00 |
| SY8583 | R1-15-2C | I | 2.81E-01 | 6.76E-02 | 3.98E-04 | 3.98E-01 |
| SY8584 | R1-DB-1 | I | 2.04E-03 | 1.58E-04 | 1.73E-06 | 3.05E-03 |
| SY8585 | R1-15-2D | I | 3.99E-02 | 2.06E-02 | 7.92E-05 | 5.99E-02 |
| SY8587 | R1-5-3A | I | 4.51E-03 | 1.75E-03 | 9.07E-06 | 9.44E-03 |
| SY8589 | R1-5-3B | I | 1.39E-01 | 2.27E-02 | 2.38E-03 | 2.09E-01 |
| ~~SY8590~~ | R1-5-3C | I | 3.38E-04 | 4.59E-04 | 3.74E-06 | 2.20E-03 |
| SY8591 | R1-DB-2 | I | 2.42E-01 | 5.69E-02 | 5.83E-04 | 3.83E-01 |
| SY8592 | R1-5-3D | I | 2.50E-02 | 1.11E-02 | 1.09E-03 | 6.25E-02 |
| SY8593 | R1-15-3A | I | 2.76E-03 | 5.96E-04 | 1.56E-06 | 3.45E-03 |
| SY8594 | R1-15-3BD | I | 4.68E-01 | 1.18E-01 | 1.08E-03 | 7.36E-01 |
| SY8595 | R1-15-3B | I | 5.52E-01 | 1.61E-01 | 1.53E-03 | 9.66E-01 |
| SY8596 | R1-15-3C | I | 7.88E-01 | 1.27E-01 | 2.92E-03 | 1.43E+00 |
| SY8597 | R1-15-3CD | I | 4.75E-01 | 5.81E-02 | 1.14E-03 | 7.12E-01 |
| SY8598 | R1-15-3D | I | 7.66E-01 | 9.14E-02 | 5.26E-02 | 1.23E+00 |
| SY8600 | R2-NV-1A | I | 1.06E-03 | 7.11E-04 | 0.00E+00 | 1.06E-03 |
| SY8601 | R2-NV-1B | I | 4.03E-03 | 2.07E-03 | 1.16E-05 | 1.05E-02 |
| SY8602 | R2-NV-1BD | I | 1.47E-02 | 2.43E-03 | 2.08E-04 | 2.94E-02 |
| SY8604 | R2-NV-1C | I | 3.07E-03 | 6.94E-04 | 9.47E-06 | 6.41E-03 |
| SY8605 | R2-NV-1D | I | 2.24E-03 | 2.68E-04 | 2.13E-04 | 7.34E-03 |
| SY8606 | R2-15-1A | I | 6.68E-04 | 1.04E-04 | 1.70E-06 | 1.67E-03 |
| SY8607 | R2-15-1B | I | 8.69E-01 | 2.53E-01 | 9.75E-02 | 1.16E+00 |
| SY8608 | R2-15-1CD | I | 1.29E-01 | 3.24E-02 | 1.34E-03 | 2.08E-01 |
| SY8609 | R2-15-1C | I | 2.46E-01 | 6.19E-02 | 4.19E-04 | 3.85E-01 |
| SY8611 | R2-15-1D | I | 1.66E-01 | 8.92E-02 | 4.15E-04 | 2.97E-01 |

TABLE (cont.)

| Sample Number | Sample Type | Prep Tech | Concentrations (s/cc) PCME (EPA 1986) | PCME (prop '65) | B & C Index | Total Long Structures |
|---|---|---|---|---|---|---|
| SY8613 | R2-5-1A | I | 4.89E-04 | 1.34E-04 | 5.54E-07 | 6.52E-04 |
| SY8614 | R2-5-1B | I | 1.34E-01 | 7.30E-02 | 6.84E-04 | 4.47E-01 |
| SY8616 | R2-5-1C | I | 1.51E-01 | 3.87E-02 | 3.69E-04 | 2.45E-01 |
| SY8618 | R2-5-1D | I | 7.83E-02 | 1.12E-02 | 1.82E-04 | 1.61E-01 |
| SY8620 | R2-15-2B | I | 1.33E+00 | 1.32E-01 | 2.47E-03 | 1.82E+00 |
| SY8621 | R2-15-2CD | I | 8.10E-01 | 1.03E-01 | 1.29E-03 | 1.24E+00 |
| SY8622 | R2-15-2C | I | 6.63E-01 | 1.36E-01 | 1.29E-03 | 1.28E+00 |
| SY8623 | R2-15-2DD | I | 4.56E-01 | 1.16E-01 | 8.31E-04 | 7.49E-01 |
| SY8624 | R2-15-2D | I | 4.52E-01 | 1.01E-01 | 9.08E-04 | 7.39E-01 |
| SY8626 | R2-150DW-AN | I | 1.33E-01 | 4.40E-02 | 1.04E-02 | 2.55E-01 |
| SY8627 | R2-250W-AN | I | 1.75E-01 | 5.24E-02 | 3.58E-04 | 3.04E-01 |
| SY8628 | R2-150UW-AN | I | 4.91E-03 | 2.91E-03 | 1.34E-05 | 4.91E-03 |
| SY8629 | R2-DB-AN | I | 2.48E-03 | 8.55E-04 | 7.58E-06 | 6.44E-03 |
| SY8630 | R2-15-3A | I | 4.86E-03 | 1.87E-03 | 1.24E-05 | 1.18E-02 |
| SY8631 | R2-15-3B | I | 3.95E-01 | 1.60E-01 | 2.98E-02 | 1.32E+00 |
| SY8632 | R2-15-3CD | I | 6.92E-02 | 4.11E-02 | 4.75E-03 | 1.60E-01 |
| SY8633 | R2-15-3C | I | 1.02E-01 | 7.91E-02 | 5.49E-04 | 3.51E-01 |
| SY8634 | R2-15-3D | I | 1.10E-02 | 6.91E-03 | 2.23E-05 | 2.14E-02 |
| SY8635 | R2-DB-1 | I | 6.80E-03 | 2.17E-03 | 2.48E-05 | 1.84E-02 |
| SY8636 | R2-DB-2 | I | 6.60E-04 | 8.31E-04 | 2.53E-06 | 2.15E-03 |
| SY8561 | R1-FB-1 | I | 7.57E-04 | 4.54E-06 | 0.00E+00 | 7.57E-04 |
| SY8573 | R1-FB-2 | I | 1.64E-04 | 8.89E-05 | 8.38E-07 | 6.57E-04 |
| SY8586 | R1-FB-3 | I | 3.46E-04 | 3.46E-06 | 5.88E-07 | 6.92E-04 |
| SY8599 | R1-FB-4 | I | 0.00E+00 | 4.37E-05 | 0.00E+00 | 0.00E+00 |
| SY8612 | R2-FB-1 | I | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| SY8625 | R2-FB-2 | I | 1.80E-03 | 2.37E-04 | 2.78E-06 | 3.44E-03 |
| SY8637 | R2-FB-3 | I | 3.30E-04 | 4.68E-05 | 2.80E-07 | 4.95E-04 |
| SY8638 | Lab blank | I | | | | |
| SY8639 | Lab blank | I | | | | |
| SY8640 | Lab blank | I | | | | |
| SY8641 | Lab blank | I | | | | |
| SY8564 | R1-5DP-1B | D | 1.85E-02 | 1.87E-03 | 3.18E-03 | 3.30E-02 |
| SY8577 | R1-5DP-2C | D | 1.87E-02 | 2.34E-03 | 5.10E-04 | 3.12E-02 |
| SY8610 | R2-15DP-1D | D | 6.16E-02 | 3.92E-03 | 1.98E-03 | 6.48E-02 |
| SY8617 | R2-5DP-1C | D | 3.41E-02 | 3.23E-03 | 2.12E-03 | 4.30E-02 |
| SY8619 | R2-15DP-2A | D | 4.88E-04 | 2.59E-05 | 1.38E-07 | 5.69E-04 |

TABLE (cont.)

| Sample Number | Sample Type | Prep Tech | Concentrations (s/cc) PCME (EPA 1986) | PCME (prop '65) | B & C Index | Total Long Structures |
|---|---|---|---|---|---|---|
| SY8834 | Soil | I | 9.54E+07 | 5.14E+07 | 2.96E+05 | 2.02E+08 |
| SY8835 | Soil | I | 4.08E+07 | 4.74E+07 | 1.62E+05 | 1.12E+08 |
| SY8836 | Soil | I | 1.35E+07 | 1.20E+07 | 4.59E+04 | 2.53E+07 |
| SY8837 | Soil | I | 5.65E+07 | 3.17E+07 | 1.19E+05 | 8.98E+07 |
| SY8838 | Soil | I | 9.87E+07 | 1.79E+08 | 1.12E+06 | 6.58E+08 |
| SY8839 | Soil | I | 3.87E+07 | 3.98E+07 | 8.44E+06 | 1.58E+08 |
| SY8840 | Soil | I | 8.84E+06 | 2.93E+07 | 1.63E+06 | 8.49E+07 |
| SY8841 | Soil | I | 7.51E+07 | 3.43E+07 | 3.60E+06 | 1.82E+08 |
| SY8842 | Soil | I | 1.54E+08 | 4.79E+07 | 3.75E+05 | 2.54E+08 |
| QC | Soil | I | 7.20E+07 | 6.62E+07 | 2.75E+05 | 1.35E+08 |
| QC#4 | R1-15-3B | I | 7.27E-01 | 1.49E-01 | 9.53E-03 | 1.01E+00 |
| QC#5 | R2-15-3B | I | 5.26E-01 | 1.85E-01 | 2.61E-03 | 1.90E+00 |
| QC1 | R1-NV-1BD | I | 2.55E-02 | 1.08E-02 | 5.79E-05 | 4.82E-02 |
| QC2 | R1-15-1BD | I | 1.18E+00 | 2.36E-01 | 3.35E-03 | 2.10E+00 |
| QC3 | R2-5DP-1C | D | 4.27E-02 | 2.40E-03 | 5.97E-05 | 5.52E-02 |

[1] All concentrations indices are defined as attached.

## DEFINITIONS FOR ASBESTOS CONCENTRATIONS TO BE ANALYZED AT DIAMOND XX

**EPA 1986 Definition of PCM Equivalent Asbestos (OHEA):**

A count of all parent structures with length > 5 μm and width > 0.3 μm and components of non-eligible structures with length > 5 μm and width > 0.3 μm. Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

**PCM Equivalent Definition of Asbestos for proposition 65:**

A count of all parent TEM structures divided by 100. Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

**Berman and Crump Definition of Potent Asbestos:**

A weighted sum of three size categories:

- (5 μm < length < 40 μm and width < 0.3 μm) (1);
- (40 μm < length and width > 5 μm) (2); and
- (40 μm < length and width < 0.3 μm) (3).

Call them $C_1$, $C_2$, and $C_3$, respectively.

$C_{total}$ is calculated for this exposure index by the weighted sum:

$$C_{tot} = 0.0017*C1 + 0.0145*C2 + 0.853*C3.$$

**Total Long Asbestos Structures**

A count of all parent structures with length > 5 μm and aspect (length to width) ratio > 3 and components of non-eligible structures with length > 5 μm and aspect (length to width) ratio > 3.

# SAMPLE MANAGEMENT OFFICE

Operated by Vlar & Company
a subsidiary of DynCorp
under contract #68-D9-0135
to the U.S. Environmental Protection Agency

## FAX COMMUNICATION

Date: 10/14/95

To: Fax Number: _____

Name: Kira Lynch

Company: U.S. EPA Region IX

From:

Brad Schorer, Advocate
DynCorp Vlar
Regional Operations Section
Direct Dial (703) 519-1439 FAX (703) 683-0378

Subject: EMSCA's problems

Number of Pages, Including This Page: 5

Comments or Special Instructions: Kira, Here is what EMSCA has sent me. They are a list of all of the samples and their condition, then look at their question about the QC at the bottom of the first page. They are also asking for an extension since they did not receive a response from Vlar on Oct. 7 about the three samples. Anyway, look these over and I'll call you at 8:30 a.m. PST.

thanks,
Brad

P.O. Box 818, Alexandria, Virginia 22313. Phone: (703) 684-3678

DATE: October 13, 1993

TO: VIAR & CO., SAMPLE MANAGEMENT OFFICE

ATTENTION: BRAD SCHORER

FAX: 703-683-0378

SUBJECT: SAS 8113-Y-03

EMS Laboratories, Inc., is in receipt of the following samples:

70 Air filters for ISO indirect preparation and analysis
4 Blanks for ISO indirect preparation and analysis
8 Air filters for ISO direct preparation and analysis
9 Soil samples for preparation using a dust generator and
9 of these samples for ISO indirect preparation and analysis

We bid for

75 ISO indirect preparation and analysis
4 Air filters for ISO direct preparation and analysis
7 Soil samples for preparation using a dust generator and
7 of theses samples for ISO indirect preparation and analysis

Enclosed are the list of samples we received and their condition. As mentioned in our conversation of October 6, three of the samples for direct preparation cannot be analyzed by the method. The condition of the filters is as follows:

SY 8751 - Filter was blown
SY 8597 - Uneven loading of particles on the filter
SY 8623 - Very heavy, uneven loading on the filter and not possible to prepare by the direct method

Please tell us how to treat these samples.

Also, should we be using the latest version of the ISO method, or the 1990 Berman-Chatfield procedure.

On the QC, are we to run 5% of the samples as blind duplicates. There was no provision in the bid for QC samples. We inquired about the QC samples in our Letter-FAX of September 23, 1993.

Also, we would like a one week extension since we never received a response to our initial call on October 6.

*SAMPLES/METHOD OF ANALYSIS*
*LN 29086*
*SAS 8213-Y-93*

**INDIRECT PREPARATIONS**

| | | | CONDITION |
|---|---|---|---|
| SY8638 | FILTER BLANK LOT # R3EM49415 | 9-28-93 | Very light |
| SY8639 | FILTER BLANK LOT # R3EM49415 | 9-28-93 | Very light |
| SY8640 | FILTER BLANK LOT # R3JM50685 | 9-30-93 | Very light |
| SY8641 | FILTER BLANK LOT # R3JM50685 | 9-30-93 | Very light |

**DIRECT PREPARATIONS**

| | VOLUME | STATION | COLLECTION | CONDITION |
|---|---|---|---|---|
| SY8564 | 2670.36 | R1-5DP-1B | 9-21 | Moderate-heavy |
| SY8571 | 2200.38 | R1-15DP-1C | 9-22 | Blown filter |
| (Not suitable for preparation) | | | | |
| SY8577 | 2206.80 | R1-5DP-2C | 9-22 | Heavy |
| SY8597 | 2229.16 | R1-15DP-3C | 9-24 | Uneven loading |
| (Not suitable for direct preparation) | | | | |
| SY8610 | 2120.97 | R2-15DP-1D | 9-27 | Moderate-heavy |
| SY8617 | 2191.3 | R2-5DP-1C | 9-28 | Moderate |
| SY8619 | 2293.38 | R2-15-2A | 9-28 | Light-moderate |
| SY8621 | 2212.60 | R2-15DP-2D | 9-28 | Very heavy |
| (Not possible to prepare by direct method) | | | | |

**INDIRECT PREPARATIONS**

| | VOLUME | STATION | COLLECTION | CONDITION |
|---|---|---|---|---|
| SY8556 | 2178.7 | R1-NV-1A | 9-20 | Light |
| SY8557 | 2333.36 | R1-NV-1B | 9-20 | Light-moderate |
| SY8558 | 2229.4 | R1-NV-1BD | 9-20 | Light |
| SY8559 | 2280 | R1-NV-1C | 9-20 | Light |
| SY8560 | 2294.4 | R1-NV-1D | 9-20 | Light |
| SY8561 | 2300.0 | R1-FB-1 | 9-21 | Light |
| SY8562 | 2285.01 | R1-5-1A | 9-21 | Light |
| SY8563 | 2285.14 | R1-5-1B | 9-21 | Moderate |
| SY8565 | 2203.96 | R1-5-1C | 9-21 | Light-moderate |
| SY8566 | 2194.10 | R1-5-1D | 9-21 | Light-moderate |
| SY8567 | 2372.80 | R1-15-1A | 9-22 | Light |
| SY8568 | 2180.70 | R1-FB-1B | 9-22 | Very heavy |
| SY8569 | 2297.79 | R1-15-1B | 9-22 | Very heavy |
| SY8570 | 2364.48 | R1-15-1C | 9-22 | Moderate-heavy |
| SY8572 | 2323.70 | R1-15-1D | 9-22 | Moderate-heavy |
| SY8573 | 2200.00 | R1-FB-2 | 9-22 | Light |
| SY8574 | 2202.86 | R1-5-2A | 9-22 | Light |
| SY8575 | 2295.24 | R1-5-2B | 9-22 | Light-moderate |
| SY8576 | NO SAMPLE | | | |

| | | | | |
|---|---|---|---|---|
| SY8578 | 2212.20 | R1-5-2C | 9-22 | Light-moderate |
| SY8579 | 2123.94 | R1-5-2D | 9-22 | Light |
| SY8580 | 2250.32 | R1-15-2A | 9-23 | Light |
| SY8581 | 2163.98 | R1-FD-2B | 9-23 | Heavy |
| SY8582 | 2019.96 | R1-15-2B | 9-23 | Heavy |
| SY8583 | 2109.99 | R1-15-2C | 9-23 | Light-moderate |
| SY8584 | 2144.76 | R1-DB-1 | 9-23 | Light-moderate |
| SY8585 | 2396.85 | R1-15-2D | 9-23 | Moderate |
| SY8586 | 2100.00 | R1-FB-3 | 9-23 | Very light |
| SY8587 | 2217.96 | R1-5-3A | 9-23 | Light |
| SY8588 | NO SAMPLE | | | |
| SY8589 | 2222.68 | R1-5-3B | 9-23 | Moderate |
| SY8590 | 2143.60 | R1-5-3C | 9-23 | Light-moderate |
| SY8591 | 2156.48 | R1-DB-2 | 9-22 | Light |
| SY8592 | 2278.35 | R1-5-3D | 9-23 | Light-moderate |
| SY8593 | 2185.00 | R1-15-3A | 9-24 | Clean |
| SY8594 | 2211.68 | R1-FD-3B | 9-24 | Moderate-heavy |
| SY8595 | 2216.13 | R1-15-3B | 9-24 | Very heavy |
| SY8596 | 2231.8 | R1-15-3C | 9-24 | Moderate |
| SY8598 | 2275.5 | R1-15-3D | 9-24 | Light-moderate |
| SY8599 | 2196.00 | R1-FB-4 | 9-24 | Light |
| SY8600 | 2200.38 | R2-NV-1A | 9-26 | Light |
| SY8601 | 2247.24 | R2-NV-1B | 9-26 | Light |
| SY8602 | 2094.82 | R2-NV-1BD | 9-26 | Light |
| SY8603 | NO SAMPLE | | | |
| SY8604 | 2029.47 | R2-NV-1C | 9-26 | Light |
| SY8605 | 2266.88 | R2-NV-1D | 9-26 | Light |
| SY8606 | 2163.98 | R2-15-1A | 9-27 | Light |
| SY8607 | 2153.90 | R2-15-1B | 9-27 | Moderate-heavy |
| SY8608 | 2252.73 | R2-FD-1C | 9-27 | Light-moderate |
| SY8609 | 2219.79 | R2-15-1C | 9-27 | Moderate |
| SY8611 | 2252.73 | R2-15-1D | 9-27 | Moderate |
| SY8612 | 2197.83 | R2-FB-1 | 9-27 | Light |
| SY8613 | 2223.5 | R2-5-1A | 9-28 | Light |
| SY8614 | 2230.8 | R2-5-1B | 9-28 | Moderate |
| SY8615 | NO SAMPLE | | | |
| SY8616 | 2182.2 | R2-5-1C | 9-28 | Light |
| SY8618 | 2229.8 | R2-5-1D | 9-28 | Light |
| SY8620 | 2332.44 | R2-15-2B | 9-28 | Very heavy |
| SY8621 | 2281.60 | R2-FD-2C | 9-28 | Heavy |
| SY8622 | 2282.90 | R2-15-2C | 9-28 | Moderate-heavy |
| SY8624 | 2325.45 | R2-15-2D | 9-28 | Moderate-heavy |
| SY8625 | 2223.70 | R2-FB-2 | 9-28 | Light |
| SY8626 | 5350.18 | R2-150DW-AN | 9-28 | Heavy |
| SY8627 | 5370.30 | R2-25DW-AN | 9-28 | Heavy |
| SY8628 | 5402.23 | R2-150UW-AN | 9-28 | Moderate-heavy |
| SY8629 | 5524.20 | R2-DB-AN | 9-28 | Moderate-heavy |

2.

| | | | | |
|---|---|---|---|---|
| SY8630 | 2292.62 | R2-15-3A | 9-29 | Light |
| SY8631 | 2248.74 | R2-15-3B | 9-29 | Moderate-heavy |
| SY8632 | 2316.93 | R2-FO-3C | 9-29 | Light-moderate |
| SY8633 | 2281.40 | R2-15-3C | 9-29 | Light-moderate |
| SY8634 | 2321.28 | R2-15-3D | 9-29 | Light |
| SY8635 | 2280.54 | R2-DB-1 | 9-29 | Light-moderate |
| SY8636 | 2196.60 | R2-DB-2 | 9-29 | Light |
| SY8637 | 2176.20 | R2-FB-3 | 9-29 | Light |

Bulk samples for dust generator sample preparation and ISO indirect sample preparation and analysis:

SY8834
SY8835
SY8836
SY8837
SY8838
SY8839
SY8840
SY8841
SY8842

# APPENDIX C:
# DATA VALIDATION REPORT

ICF KAISER
ENVIRONMENT & ENERGY GROUP

ICF Kaiser Engineers, Inc.
160 Spear Street, Suite 1380
San Francisco, CA 94105-1535
415/882-3000 Fax 415/882-3199

MEMORANDUM

TO: Dan Shane
On Scene Coordinator
Emergency Response Section, H-8-3

THROUGH: Richard Bauer
Environmental Scientist
Quality Assurance Management Section (QAMS), P-3-2

FROM: Margie D. Weiner MDW
Senior Data Review Oversight Chemist
Environmental Services Assistance Team (ESAT)

DATE: March 15, 1994

SUBJECT: Review of Analytical Data

Attached are comments resulting from ESAT Region 9 review of the following analytical data:

| | |
|---|---|
| SITE: | Diamond XX |
| EPA SSI NO.: | N3 |
| CERCLIS I.D. NO.: | Not Applicable |
| CASE/SAS NO.: | SAS 8113Y-03 Memo #02 |
| SDG NO.: | 1, 2, 3, 5, and 6 |
| LABORATORY: | EMS Laboratories, Inc. (EMSCA) |
| ANALYSIS: | SAS Asbestos |
| SAMPLE NO.: | 86 Air Samples (See Case Summary) |
| COLLECTION DATE: | September 22 through 30, 1993 |
| REVIEWER: | Dina D. David, ESAT/ICF Kaiser |

The comments presented in this report have been reviewed and approved by the EPA Task Monitor for the ESAT Contract, whose signature appears above.

If there are any questions, please contact Margie D. Weiner (ESAT/ICF) at (415) 882-3061, or Richard Bauer (QAMS/EPA) at (415) 744-1499.

Attachment

cc: Kira Pyatt Lynch, QAMS, P-3-2
D. Wayne Berman, ICF Kaiser - Oakland

Data Validation Report

Case No.: SAS 8113Y-03 Memo #02
Site: Diamond XX
Laboratory: EMS Laboratories, Inc. (EMSCA)
Reviewer: Dina D. David, ESAT/ICF Kaiser
Date: March 15, 1994

I. Case Summary

SAMPLE INFORMATION: SAMPLE #:

SDG-1: SY8556 through SY8564, SY8566, SY8567, SY8569, SY8577, SY8610, SY8617, SY8619, and SY8638 through SY8641

SDG-2: SY8565, SY8568, SY8570, SY8572 through SY8575, SY8578, SY8579, SY8581, SY8582, SY8583, SY8585, SY8589, SY8590, SY8591, SY8594, SY8598, SY8602, and SY8609

SDG-3: SY8568-QC, SY8584, SY8587, SY8592, SY8593, SY8595, SY8596, SY8597, SY8601, SY8604, SY8607, SY8608, SY8611, SY8614, SY8616, SY8618, SY8620, SY8624, SY8626, and SY8627

SDG-5: SY8595-QC, SY8631-QC, SY8580, SY8599, SY8600, SY8605, SY8606, SY8612, SY8613, SY8621, SY8622, SY8623, and SY8628 through SY8635

SDG-6: SY8558-QC, SY8617-QC, SY8586, SY8625, SY8636, and SY8637

COLLECTION DATE: September 20 through 30, 1993
SAMPLE RECEIPT DATE: October 5, 1993

MATRIX: 86 Air Samples

FIELD QC:
Field Blanks (FB): SY8561, SY8573, SY8586, SY8599, SY8612, SY8625, and SY8637
Filter Blanks: SY8638, SY8639, SY8640, and SY8641
Background Samples: SY8584, SY8591, SY8636, SY8637, and SY8629
Duplicates (D1): SY8558 and SY8558 (Duplicate)
(D2): SY8568 and SY8569
(D3): SY8581 and SY8582
(D4): SY8594 and SY8595
(D5): SY8601 and SY8602
(D6): SY8608 and SY8609
(D7): SY8621 and SY8622
(D8): SY8632 and SY8633

LABORATORY QC: Duplicates: SY8568, SY8595, SY8631, SY8558, and SY8617

ANALYSIS: Asbestos

| Analyte | Sample Preparation Date | Analysis Date |
|---|---|---|
| Asbestos | October 6 through December 11, 1993 | October 22 through December 21, 1993 |

**GENERAL COMMENTS:**

Samples SY8564, SY8571, SY8577, SY8597, SY8610, SY8617, SY8619, and SY8623 were submitted to the laboratory for direct preparation and analysis. The laboratory noted in the case narrative that sample SY8571 had a blown filter, and samples SY8597 and SY8623 had very heavy and uneven loadings. The laboratory contacted the Region for resolutions for the above deficiencies. The Region informed the laboratory to cancel the analysis of sample SY8571 and to prepare samples SY8597 and SY8623 using an indirect preparation technique.

The "A" and "B" designation on each sample refer to the analysis for all size fibers and for ≥5 μm length fibers, respectively.

All of the samples were analyzed according to method ISO/CD 13794 as stated in the case narrative submitted by the laboratory for all of the sample delivery groups (SDGs). However, the proposed validation procedures submitted by D. Wayne Berman noted that the method employed for analysis of the asbestos samples is ISO/TC 146/SC 3/WG1 N39: Ambient Air: Determination of asbestos fibers by an indirect-transfer transmission electron microscopy procedure.

Corrections made in the data packages, including the use of liquid correction fluid, were not appropriately documented by the laboratory.

There were no data confirming the measurements and calculations of the average grid opening size for each lot of grid specimens used in the analysis of the samples in any of the SDGs. In addition, no diffraction pattern data were included in any of the SDGs.

This report was prepared in accordance with the "Proposed Validation Procedures For Diamond XX," Revised February 18, 1994 by D. Wayne Berman.

II. Validation Summary

A. Calibrations:

Camera Constant

- Precision of the estimates for the camera constant are within the acceptable range of ±1 for all of the SDGs.
- All indicated multiplications are correct. Note that for camera constant (3*) on page 753, the laboratory reported a value of 303.5 instead of 30.35. However, the laboratory used the correct value (30.35) in the calculation for the camera constant average.
- All of the camera constants were correctly transcribed to the corresponding data summary sheets.

Magnification

- Precision of the estimates for the 19300X and 25000X magnifications are within the acceptable range of ± 2% for all of the SDGs.

  For ≥5 μm size range, the laboratory used 9200X/9300X as the screen magnification in the analysis of all of the samples in all of the SDGs. However, the calibration data at the above screen magnification was not provided by the laboratory.

- All of the appropriate magnifications were correctly transcribed to the corresponding data summary sheets.

Grid Opening Size

- There were no data confirming the measurements and calculations of the average grid opening size for each lot of grid specimens used in the analysis of the samples in all of the SDGs.

B. Discrepancies/transcription errors noted in the validation of the data for all of the SDGs:

SDG-1

1. On the data summary sheet for sample SY8557B (pg. 15), the structure type and identification for structure #26 on grid opening B1/D3-2 were switched.

2. On the data summary sheet for sample SY8558A (pgs. 19-20), the width for structure #49 on grid opening C1/E3-2 was calculated and reported as 0.05 μm instead of 0.10 μm. After structure #49, the size dimensions are offset by 1 place. The dimensions for structure #49 are entered for structure #50, the dimensions for structure #51/MD10 are entered for structure #51/MF, and so on. The error in offset continued all the way to structure #69. The raw data for structure #69 on page 224 was not used in the calculation.

3. On the data summary sheet for sample SY8561A (pg. 36), the laboratory used 9200X instead of 19400X and 19200X in the calculations for the size dimensions reported for structure #1 on grid opening B1/F3-3 and for structure #2 on grid opening C1/C2-3.

4. On the data summary sheet for sample SY8563A (pg. 50), the identification for structure #53 on grid oppening B1/E3-2 was incorrectly reported as CD instead of CM.

5. On the data summary sheet for sample SY8564B (pg. 57), the length for structure #57 on grid opening B1/C3-2 was incorrectly reported as 1.52 μm instead of 15.22 μm.

6. On the data summary sheet for sample SY8566B (pg. 64), the width for structure #62/CD on grid opening C1/F4-4 was incorrectly reported as 11.96 μm instead of 10.87 μm. In addition (pg. 62), the structure type for structure #7 on grid opening A1/G2-4 was incorrectly reported as CF instead of CM.

7. On the data summary sheet for sample SY8569A (pg. 72), the level of analysis reported for chrysotile and amphibole was ISO for both, instead of CM-CDQ and ADQ, respectively. In addition, the total number of grid openings was not reported.

8. On the data summary sheet for sample SY8610A (pg. 85), dimensions for structure #74 on grid opening B1/D3-1 were incorrectly calculated and reported.

9. On the data summary sheet for sample SY8617A (pg. 90), the length for structure #51 on grid opening B1/D3-4 was incorrectly reported as 8.33 μm instead of 5.21 μm.

10. On the data summary sheet (pg. 110), sample SY8640A was reported as SY8640.

11. The type of microscope used was not checked/marked on the worksheet for the following samples:

| Sample number | Page(s) |
|---|---|
| SY8557A | 188 |
| SY8559A | 247 |

12. On the worksheet for sample SY8556B (pg. 138), screen magnification was listed as 19400X instead of 9300X.

13. Analysis information for screen magnification and camera constant for sample SY8559A was not provided on the worksheet (page 253). In addition (pgs. 285-286), screen magnification of 9200X was used in the calculation for structures #44-50 instead of 9300X.

14. In the calculation of the dimensions for structures #56-64 on grid openings C1/C2-3 and C1/C2-4 for sample SY8557A, a screen magnification of 19400X was used, instead of 19300X as reported on the worksheet (pg. 188).

15. On the worksheets for sample SY8556B (pgs. 149-153 and 156-159), sample SY8558B (pgs. 227 and 238), sample SY8559B (pgs. 267-272), sample SY8560B (pgs. 305-306), sample SY8562B (pgs. 371-375), sample SY8563B (pgs. 416 and 428), sample SY8564B (pg. 449), sample SY8566B (pg. 487), sample SY8610B (pg. 629), and sample SY8617B (pg. 663), the screen magnification was listed as 9000X instead of 9200X.

16. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

| Sample Number | Page(s) |
|---|---|
| SY8556A | 120, 131 |
| SY8556B | 136-138, 157-158, 164, 167 |
| SY8559A | 240 |
| SY8559B | 255-258 |
| SY8562A | 363 |
| SY8562B | 380-382 |
| SY8564A | 430-432 |
| SY8577A | 563-564, 577 |
| SY8577B | 585, 594 |
| SY8610A | 599-600 |
| SY8610B | 622, 633 |
| SY8617A | 639-643 |
| SY8617B | 667, 673 |
| SY8619A | 676, 684 |
| SY8619B | 688-690, 699-700, 712-713, 719 |

SDG-2

1. No Inventory Sheet was provided for this SDG.

2. On the data summary sheet for sample SY8570B (pg. 19), the dimensions for structure types CD/MB and CD/MF for structure #61 on grid opening C1/C5-2 were switched.

3. On the data summary sheet (pg. 27), sample SY8573B was entered as SY573B. For structure #7 on grid opening D1/F4-4, no calculated dimensions were entered on the data summary sheet.

4. On the data summary sheet for sample SY8579A (pgs. 43-44), the dimensions for structures #24-42 on grid opening B1/D4-2 were incorrectly calculated and reported.

5. On the data summary sheet for sample SY8579B (pg. 45), the width for structure #22 on grid opening B1/G4-2 was incorrectly reported as 3.23 $\mu$m instead of 3.76 $\mu$m.

6. On the data summary sheet for sample SY8582B (pg. 57), the grid opening for structures #22-24 should be B1/E3-2 as listed on the worksheet (pg. 456) instead of B1/E3-3.

7. On the data summary sheets (pgs. 51 and 59), samples SY8581A and SY8583A were reported as SY8581 and SY8583, respectively.

8. On the data summary sheet for sample SY8590B (pg. 76), the length for structure #24 on grid opening D1/G5-3 was incorrectly reported as 6.45 μm instead of 7.10 μm.

9. On the data summary sheet for sample SY8594A (pg. 84), the structure type and identification for structure #42 on grid opening C1/D2-4 were switched.

10. On the data summary sheet for sample SY8609B (pg. 101), the identification and structure type for structure #40 on grid opening C1/D4-4 were switched.

11. On the worksheets for samples SY8565B and SY8575B (pgs. 135-138 and 334), screen magnification was listed as 9000X instead of 9200X. On the worksheet for sample SY8579B (pgs. 378 and 403), screen magnification was listed as 9300 instead of 19300.

12. On the worksheet for sample SY8568A (pg. 146), type of microscope used was not marked/checked.

13. For sample SY8598B, no elemental analysis was performed for structure #11/CDQ on grid opening A1/C2-4.

14. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

| Sample Number | Page(s) |
|---|---|
| SY8574B | 310-311 |
| SY8579B | 391 |
| SY8582A | 434 |
| SY8582B | 448 |
| SY8589A | 522 |
| SY8589B | 537 |
| SY8590A | 551 |
| SY8590B | 566 |
| SY8598B | 673 |

15. The level of analysis transcribed on the data summary sheets was CM-CDQ (for chrysotile) instead of CD-CDQ as listed on the worksheets for the following samples: SY8565, SY8570, SY8572, SY8573, SY8575, SY8579, SY8582, SY8585, SY8590, SY8594, and SY8602.

SDG-3

1. On the data summary sheet for sample SY8584B (pg. 13), the width for structure #23 on grid opening F1/C4-1 was incorrectly reported as 8.15 μm instead of 8.47 μm.

2. On the data summary sheet for sample SY8587A (pg. 15), the length for structure #9 on grid opening A1/E2-2 was incorrectly reported as 0.05 μm instead of 0.57 μm.

3. On the data summary sheet for sample SY8587B (pg. 19), the width for structure #50 on grid opening C1/B3-4 was incorrectly reported as 1.72 μm instead of 17.20 μm.

4. On the data summary sheet for sample SY8593B (pg. 26), grid opening A1/F4-2 was not reported. In addition (pg. 27), the length for structure #14 on grid opening A1/B3-4 was incorrectly reported as 8.60 μm instead of 9.14 μm.

5. On the data summary sheet for sample SY8596A (pg. 35), the width for structure #16 on grid opening B1/C4-4 was incorrectly reported as 3.37 μm instead of 3.41 μm.

6. On the data summary sheet for sample SY8597A (pg. 41), the width for structure #59 on grid opening B1/D2-4 was incorrectly reported as 1.24 μm instead of 1.76 μm.

7. On the data summary sheet for sample SY8604B (pg. 52), the width for structure #1 on grid opening A1/D2-2 were incorrectly reported as 0.22 μm and 4.35 μm instead of 2.39 μm and 0.43 μm, respectively.

8. On the data summary sheet for sample SY8611A (pg. 66), the width for structure #68 on grid opening B1/D3-3 was incorrectly reported as 0.16 μm instead of 1.55 μm.

9. On the data summary sheet for sample SY8611B (pg. 69), the width for structure #25 on grid opening A1/E3-2 was incorrectly reported as 0.54 μm instead of 5.91 μm.

10. On the data summary sheet for sample SY8618A (pg. 78), the total number of grid openings was reported as 8 instead of 9. In addition (pg. 79), the width for structure #37 on grid opening C1/C4-1 was reported as 5.73 μm instead of 5.99 μm, and the structure type for structure #57 on grid opening C1/D3-1 was incorrectly reported as MF instead of F.

11. On the data summary sheet for sample SY8626B (pg. 94), the dimensions for structures #26-28 on grid opening B1/D3-2 were incorrectly reported as 0.32 μm & 0.00 μm, 10.75 μm & 0.32 μm, and 77.42 μm & 0.11 μm, instead of 10.75 μm & 0.32 μm, 77.42 μm & 0.11 μm, and 8.06 μm & 0.32 μm, respectively.

12. On the data summary sheet for sample SY8627A (pg. 96), the length for structure #21/CD-MF on grid opening B1/F3-3 was reported as 0.10 μm instead of 1.15 μm.

13. Analysis information listed on page 467 differs from the initial information listed on page 466 for sample SY8608A. Type of instrument used, screen magnification, and camera constant changed even though the same grid opening was being observed.

14. On the worksheet for sample SY8614A (pgs. 536-537), the structure numbers were incorrectly numbered. The structure numbers should have been #42-56 instead of #34-48. Note that the data summary sheet for the above sample listed the correct structure numbers.

15. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

| Sample Number | Page(s) |
|---|---|
| SY8568-QC | 99 |
| SY8584A | 128 |
| SY8584B | 138 |
| SY8587A | 170 |
| SY8587B | 185-186 |
| SY8592A | 204,205 |
| SY8592B | 221 |
| SY8595A | 270 |
| SY8595B | 293 |
| SY8596B | 321 |
| SY8601A | 363 |
| SY8607A | 437-438 |
| SY8608A | 466 |
| SY8608B | 482 |
| SY8614A | 524 |
| SY8618A | 581-582 |
| SY8618B | 596 |
| SY8620B | 625 |
| SY8627B | 714 |

SDG-5

1. On the data summary sheet for sample SY8605B (pg. 30), the dimensions for structure #52 on grid opening C1/D5-4 were incorrectly reported as 6.99 μm and 4.30 μm instead of 7.07 μm and 4.34 μm, respectively.

2. On the data summary sheet for sample SY8613B (pg. 48), the grid opening was incorrectly reported as B1/C4-4 instead of B1/B4-4 for structure #8.

3. On the data summary sheet for sample SY8628A (pg. 64), the length for structure #14 on grid opening A1/D5-2 was incorrectly reported as 13.28 μm instead of 8.07 μm.

4. On the data summary sheet for sample SY8630B (pg. 74), structure #11 on grid opening A1/F3-1 was not reported.

5. On the data summary sheet (pg. 81), sample SY8632A was reported as SY8632. In addition, all of the dimensions for structures #1-14 on grid opening A1/D3-3 were incorrectly calculated and reported.

6. On the data summary sheet for sample SY8633A (pg. 87), a screen magnification of 19300X was used instead of 19200X in the calculation of the dimensions for structures #25-52 on grid openings B1/D2-4 through F3-1 and C1/E4-4 through G4-2.

7. On the data summary sheet for sample SY8633B (pgs. 88-89), a screen magnification of 9300X was used instead of 9200X in the calculation of the dimensions for structures #18-36 on grid openings B1/D4-4 through G3-2.

8. On the worksheet for samples SY8580A (pg. 108), no results for the EDS analyses were reported for structure #12 on grid opening A1/F5-4.

9. On the worksheet for sample SY8580B (pg. 125), no results for the EDS analyses were reported for structure #11 on grid opening A1/E6-1.

10. On the worksheet (pg. 269), sample SY8606B was reported as sample SY8602.

11. On the worksheet for sample SY8630B (pg. 527), screen magnification was listed as 19300X instead of 9300X.

12. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

| Sample Number | Page(s) |
|---|---|
| SY8580A | 107-108 |
| SY8580B | 122-127 |
| SY8595-QC | 700 |
| SY8606B | 286-289 |
| SY8613B | 341, 358 |
| SY8621A | 369-370 |
| SY8623A | 426-427 |
| SY8630B | 530-531 |
| SY8631A | 545 |
| SY8632B | 590 |

SDG-6

1. On the data summary sheet for sample SY8636A (pg. 25), the structure number for the second structure CM/F on grid opening A1/F2-1 was not reported. The structure number should have been #13.

2. On the data summary sheet for sample SY8636B (pg. 27), the grid opening was incorrectly reported as A1/F4-1 instead of A1/D4-1 for structure #3.

3. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

| Sample Number | Page(s) |
|---|---|
| SY8617-QC | 67 |
| SY8636A | 171 |
| SY8636B | 184-186 |

ICF KAISER
ENVIRONMENT & ENERGY GROUP

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MEMORANDUM

TO: Dan Shane
On Scene Coordinator
Emergency Response Section, H-8-3

THROUGH: Richard Bauer
Environmental Scientist
Quality Assurance Management Section (QAMS), P-3-2

FROM: Margie D. Weiner
Senior Data Review Oversight Chemist
Environmental Services Assistance Team (ESAT)

DATE: March 7, 1994

SUBJECT: Review of Analytical Data

Attached are comments resulting from ESAT Region 9 review of the following analytical data:

| | |
|---|---|
| SITE: | Diamond XX |
| EPA SSI NO.: | N3 |
| CERCLIS I.D. NO.: | Not Applicable |
| CASE/SAS NO.: | SAS 8113Y-03 Memo #01 |
| SDG NO.: | 4 |
| LABORATORY: | EMS Laboratories, Inc. (EMSCA) |
| ANALYSIS: | SAS Asbestos |
| SAMPLE NO.: | 9 Soil Samples (See Case Summary) |
| COLLECTION DATE: | September 24 and 25, 1993 |
| REVIEWER: | Karen Pettit, ESAT/ICF KAISER |

The comments presented in this report have been reviewed and approved by the EPA Task Monitor for the ESAT Contract, whose signature appears above.

If there are any questions, please contact Margie D. Weiner (ESAT/ICF) at (415) 882-3061, or Richard Bauer (QAMS/EPA) at (415) 744-1499.

Attachment

cc: Kira Pyatt Lynch, QAMS, P-3-2
D. Wayne Berman, ICF Kaiser-Oakland

ICF KAISER

Data Validation Report

Case No.: SAS 8113Y-03 Memo #01
Site: Diamond XX
Laboratory: EMS Laboratories, Inc. (EMSCA)
Reviewer: Karen Pettit, ESAT/ICF KAISER
Date: March 7, 1994

## I. Case Summary

SAMPLE INFORMATION: SAMPLE #: SY8834 through SY8842

COLLECTION DATE: September 24 and 25, 1993
SAMPLE RECEIPT DATE: October 5, 1993

MATRIX: 9 Soil Samples

FIELD QC: Field Blanks (FB): None
Equipment Blanks (EB): None
Background Samples (BG): None
Duplicates (D1): SY8841 and SY8842

LABORATORY QC: Duplicates : SY8842

ANALYSIS: Asbestos

Dust Generation Date: October 25 through November 9, 1993
Slide Preparation Date: December 2, 1993 through December 8, 1993
Analysis Date: December 3 through 9, 1993

GENERAL COMMENTS:

The "A" and "B" designation on each sample refer to the analysis for all size fibers and for ≥5 μm length fibers, respectively.

This report was prepared in accordance with "Proposed Validation Procedures For Diamond XX" submitted by D. Wayne Berman on February 18, 1994.

## II. Validation Summary

### A. Calibrations:

Camera Constant

- The precision for the camera constant estimates all fell within the acceptable range of ±1.
- The multiplications were all checked and found to be correct.
- All of the camera constants were correctly transcribed except for an entry on page 142, where the camera constant for the

instrument used should have been 30.4 instead of 28.2, as entered.

Magnifications

- There were calibrations performed for magnifications at 19300X and 25000X. The precision for these magnification estimates is within the acceptable range of ±2%.

  In addition to the analyses performed at magnifications of 19300/19200X, there were analyses performed at 9200/9300X that have no calibration data.

- All of the appropriate magnifications were correctly transcribed from the analysis sheet to the data report summary sheets.

Grid Opening Size

- There was no data confirming the measurements and calculations of the average grid opening size for the lot of grid specimens used in the analysis of the samples for this SDG.

B. Discrepancies/transcription errors noted in the validation of the data for this SDG:

1. The calculations for the net weight of the actual mass of total respirable dust were checked for each sample and were correct except for the following calculation discrepancies in the sample data.

| Sample Number | Raw Data | Data Entry | Reported on Table 1 | Recalculated for Table 1 |
|---|---|---|---|---|
| SY8836 | 1.2662 | 1.2870 | 1.2870 | 1.2704 |
| SY8837 | 1.2228 | 1.2228 | 1.2228 | 1.4228 |

The raw data was reviewed for completeness and to ensure that the results were correctly calculated. The raw data masses entered here are correct. The data entry sheet amounts and the amounts reported on Table 1 (Summary of Air Elutriator Results) were checked against the raw data amounts. The Table 1 data recalculations for the actual total mass of respirable dust released are the sums of the three columns containing masses released at various RPMs for each sample.

For sample SY8836, both the amounts reported on the data entry sheets and the amounts reported on Table 1 disagree with the raw data amounts. The recalculated total amount for Table 1 disagrees with both the total reported on Table 1 and the raw data total.

When the total respirable mass was recalculated on Table 1 for sample SY8837, it did not agree with the amount reported.

2. When the raw data was checked against the data entry sheets several transcription errors were found on the data entry sheets. The number of grid openings were miscounted, the entry on the data summary sheet was 42 instead of 43 as counted on the analysis sheet for sample SY8835B. The structure numbers for sample SY8840B on the data summary sheet, from number 18 to number 52, disagree with the numbers on the analysis sheets for the same sample.

   The width of structure #6 in sample SY8837B was entered as 0.76 μm. It should have been 7.61 μm.

3. Table 1 was resubmitted on February 18, 1994 with different entries for the estimated total mass of respirable dust and different entries for the percent of dust in the sample. The data entry sheets were not changed, so all of the data sheets for samples SY8834 through SY8842 do not agree with Table 1.

4. An EDS elemental analysis was performed for all parent structures bearing a "Q" designation on the analysis sheets. Although the data was correctly transcribed, samples SY8836A (page 97-98), SY8842A (page 266), and SY8842B (page 281) were not labelled in the analysis sheet comment section.

5. Both high and low magnification scans were performed for all samples and the scans at lower magnification reported only structures greater than or equal to 5 μm.

6. Some of the raw analysis sheets were incomplete.

   a. The instrument identification was omitted from ten of the analysis sheets for the following samples.

| Sample Number | Grid Address | Page Number |
|---|---|---|
| SY8836B | 1C | 124 |
| SY8839B | 1C | 208 |
| SY8840B | 1C | 233 |
| SY8841A | 1C | 249 |
| SY8841B | 1C | 263 |
| SY8842A | 1C | 277 |
| EMS Blank-B | 1C | 324 |
| QC Blank-A | 1B | 330 |
| QC Blank-A | 1C | 351 |
| QC Blank-B | 1C | 359 |

   b. There were seven analysis sheets for QC Blanks with inadequate sample identification. Since the blanks were prepared on several different dates, there should be a distinction between QC blanks. The analysis sheets are pages 330, 333, 339, 343, 351, and 359.

**APPENDIX D:**
**ANOVA RESULTS**

# ANALYSIS OF ASBESTOS CONCENTRATIONS MEASURED DURING THE SEPTEMBER, 1993 EPA STUDY CONDUCTED AT DIAMOND XX

This analysis consisted of three major tasks:

1) comparison of direct and indirect measurements of asbestos concentrations;

2) analysis to determine important factors affecting asbestos and PM10 concentrations; and

3) analysis of the relationship between respirable dust (PM10) concentrations and asbestos concentrations.

These analyses were conducted separately for three methods of calculating asbestos concentration: *PCME (EPA 1986)*, EPA's method for calculating PCM equivalent concentrations (EPA 1986); *PCME (Ca: Prop '65)*, a California Proposition 65 method for calculating PCM equivalent concentrations (California ARB 1986); and *the B & C Index*, a method proposed by Berman and Crump (1994). The three asbestos concentrations so calculated were labeled $C_1$, $C_2$, and $C_3$, respectively.

## THE DATA SET

The data that were available were obtained from samplers that were set up at defined distances up and downwind from two roadways located within the Diamond XX residential area in California. A more detailed discussion of the experimental design under which the asbestos and PM10 samples were collected is provided in the Experimental Design Section of the main text of this report.

Briefly, asbestos and PM10 concentrations were measured under controlled conditions at both roadways at four sampler locations (stations) close to each roadway (1 station 150 feet upwind and 3 downwind stations that were 25, 75, and 150 feet from the road). One station was also set up at a location distant from each roadway to collect measurements representative of remote background.

During the study, a control vehicle traversed the road at a constant speed of 30 mph and at three different frequencies (representing the number of passes per hour): 0, 5, and 15 vehicles per hour (vph). The concentrations measured at the distant background stations were not considered to be associated with any particular vehicle frequency. A graphic representation of the experimental design is presented in Figure D-1.

A total of 65 sample filters were prepared by the indirect technique and analyzed to derive estimated airborne asbestos concentrations at specific sampling stations during specific runs. These include 12 pairs of duplicate samples (with paired filters collected immediately adjacent to the each other). Four filters representing laboratory blanks and seven filters representing field

blanks were also prepared and analyzed. Five additional sample filters (each paired with one of the other sample filters described above) were also collected, prepared by a direct technique, and analyzed.

## ANALYSIS OF DATA

### Comparison Between Measurements Derived from Directly and Indirectly Prepared Samples

Of the five measurements derived from samples prepared by a direct technique, only four could be paired with a duplicate measurement derived from an indirectly prepared sample. The sample to be prepared indirectly from the fifth pair was lost.

Each of the remaining 4 measurements from directly paired samples was paired with the corresponding measurement from the indirectly prepared sample. A linear regression analysis was then conducted among these four pairs of measurements with the exposure concentrations expressed as each of three exposure indices defined as described in the first section above:

- PCME (EPA 1986);
- PCME (Ca Prop '65); and
- the B & C index.

The results of the linear regression were then examined to determine the relationship between direct and indirect concentrations.

The results of the regression analysis suggest that there is little or no relationship between measurements derived, respectively, from directly and indirectly prepared samples for the four sets of observations available from this study; measurements on indirectly prepared samples do not appear to be significantly related to measurements derived from directly prepared samples. None of the slopes of the best fit lines (for each of the three exposure indices) are significantly different from zero. Even when the log-transformed concentrations were regressed on one another, no significant relationships were detected.

### Important factors affecting asbestos concentrations

An analysis of variance was conducted to examine the effects of roadway, proximity to the road, vehicle frequency, and day-to-day variations on the concentrations of asbestos that were observed. Given the design of the experiment (see Figure D-1) the following terms were included in the model:

Roadway (R);

Gross Proximity (a parameter to distinguish remote background measurements from measurements collected at other stations: NF);

R and NF interaction (R*NF);

Station, within R and NF (S(R*NF));

Vehicle Frequency, within R and NF (V(R*NF));

S and V interaction (S*V(R*NF));

Day, within R, NF, S and V (D(R*NF*S*V));

Sample Number, within D, R, NF, S, and V (SN(R*NF*S*V*D)); and

Test Number, within SN, D, R, NF, S, and V (TN(R*NF*S*V*D*SN)).

The variable *NF* was introduced because the remote background samples could not be associated with a particular vehicle frequency. It was not appropriate to classify the remote background samples according to vehicle frequency, so the NF variable differentiates the remote background from the other stations. Sample number, *SN*, is a variable that differentiates field duplicates, when such duplicates exist, from their collocated samples. Test number, *TN*, was used to identify the laboratory QC samples that were available for four filters. The variation of TN, within SN and the other variables, can be associated with error introduced by laboratory handling and analysis of filters. Having the QC samples allows estimation of that component of the overall variance. The variation associated with SN includes the variation introduced within the laboratory, but it also includes other, unidentified factors contributing to differences in collocated samples. The variation associated with SN is a measure of pure error with respect to the model; it represents variation in the results that is not accounted for by other terms of the model (such as roadway, station, etc.).

Preliminary applications of the model specified above, ignoring the Day, SN, and TN terms, were applied to all three sets of asbestos concentrations, where the concentrations were expressed either on the natural scale or on the log-scale (i.e., with and without log-transformation). The residuals from those model fits were examined and tested for normality, to determine if the data expressed in either scale satisfy the normality assumptions of analysis of variance. For the log-scale data, but not for the natural-scale data, the residuals appeared to be satisfactorily described by a normal distribution (based on the Shapiro-Wilk test). Thus, application of the full model and inferences about the significance of the terms of the model were based on applications to the log-transformed data.

The results of the analysis of variance using the full model are summarized in Table D-1. Note that, by design, all the degrees of freedom were accounted for in the model, i.e., there was no error term. For each case, the appropriate term to use as a measure of error depends on the effect being tested.

The significance of SN was assessed by comparing the mean square associated with SN to that associated with TN, i.e., we wished to determine if the variation associated with SN, which

includes the TN component, was significantly greater than that associated with TN alone. For the $C_1$ and $C_2$ exposure indices, the sample-to-sample variation is significantly greater than the test-to-test variation alone (p-value on the SN line of Table D-1 less than 0.01) whereas for $C_3$ there does not appear to be significantly more variation from collocated samples than that introduced by laboratory handling.

The significance of day-to-day variation, within station, vehicle number and roadway, was assessed in comparison to the variation associated with SN, within day, station, vehicle number and roadway. As seen in Table D-1, the variation from day to day (the mean square for D(NF*R*S*V)) was little or no greater than that for SN, for all three exposure indices, and the p-values reflect that lack of significance. From this we concluded that the variation from day-to-day could be considered a component of the error term, so that the mean squares for D(NF*R*S*V), which include day-to-day, sample-to-sample within day, and test-to-test within sample contributions, can be used as the error term for the remaining tests of significance.

For all three asbestos exposure indices, the following results were revealed. Statistical significance, or lack thereof, for all of the comparisons is clear-cut, the tests of the effects are either highly significant ($p < 0.01$) or not significant ($p > 0.10$) with no border-line cases. Results indicate that:

- differences between the measurements at remote background and the other stations (considered as a whole) are statistically significant;

- differences between measurements collected at the two roadways are not significant; the two roadways did not appear to differ with respect to overall rate of asbestos release. The interaction between roadway and NF is also insignificant;

- the effects of station location within roadway and NF do differ significantly from one another; this implies that variation between the stations in close proximity to the roadways (A, B, C, and D, as opposed to the remote background station) is significant; and

- the effect of vehicle frequency is also highly significant. The interaction between station and vehicle frequency is not significant for the exposure indices, $C_1$ and $C_3$, but is significant for $C_2$. Thus, for $C_2$ but not for $C_1$ or $C_3$, the additive effect of vehicle frequency on ln(C) over and above the effect due to station depends on which station is being considered.

To compare the various stations or vehicle frequencies to one another, we reduced the model in accordance with the above results. Roadway was no longer considered in the model. Moreover, the distant background samples were associated with a dummy station identifier ("E") and a dummy vehicle frequency ("-1") so that NF could also be dropped from the model. The resulting model had the terms S, V, S*V, D(S*V), SN(S*V*D), and TN(S*V*D*SN). As before, the SN and TN terms identify specific components of the error contributed by unidentified differences in collocated samples and laboratory handling, respectively, whereas the day term, D(S*V), includes those components as well as day-to-day variation. The D(S*V) term is the appropriate error term for assessing the differences between station and vehicle frequency. The degrees of freedom in the full model associated with roadway, NF, and the nesting of the other terms within roadway

and NF now contribute to the mean square for D(S*V), which has 36 degrees of freedom for the reduced model.[1]

When the reduced model was run, the station and vehicle frequency effects remain highly significant. The interaction between station and vehicle frequency appear to be significant, at least at the 0.05 level, for all three asbestos exposure indices. Figure D-2 summarizes the station and vehicle frequency comparisons, obtained using a least significant difference (LSD) approach for multiple comparisons.

Stations A (upwind) and E (remote background) exhibit consistently the lowest asbestos concentrations. Somewhat surprisingly, the concentration at station A is significantly less than that for station E when concentrations are measured using the two exposure indices $C_1$ and $C_2$. The downwind stations always exhibit significantly greater concentrations than stations A or E and it appears that there is a trend of decreasing asbestos concentration with downwind distance from the road. The station closest to the road (B) shows significantly greater asbestos concentrations (using the $C_2$ and $C_3$ exposure indices) than do stations C and D and significantly greater concentrations (using the $C_3$ exposure index) than does station D; stations C and D do not differ significantly with respect to any asbestos concentration.

When no vehicles were run over the roads (0 vehicles per hour), the asbestos concentrations are indistinguishable from remote background concentrations. In all cases, a frequency of 15 vehicles per hour is associated with significantly greater asbestos concentrations than the other frequencies. A frequency of 5 vehicles per hour is intermediate. When concentrations are expressed using the $C_1$ index, runs at 5 vph yield no significantly greater concentrations than the remote background concentrations, although they do yield significantly greater concentrations than 0 vph. Using the $C_2$ exposure index, concentrations associated with runs at 5 vph are significantly different from those associated with runs at 0 vph and from concentrations measured at remote background locations. Using the $C_3$ exposure index, asbestos concentrations during runs at 5 vph are essentially the same as concentrations measured in association with 0 vph but are significantly greater than concentrations measured at remote background locations.

When mean concentrations for the distinct combinations of station and vehicle frequency are listed (Figure D-2), the patterns confirm the analyses of station and vehicle frequency alone. The highest concentrations are found in association with 15 vph at downwind stations and also for 5 vph at the closest station (B). The next highest concentrations were observed further downwind, stations C and D, during runs of 5 vehicles per hour. The lowest concentrations were observed when no vehicles were using the roadway, for remote background, and for the upwind station.

Because the downwind stations are located at specified distances from the road, an analysis of variance that considered vehicle frequency as a categorical variable and distance as a continuous variable was used to explain variations in $\ln(C_i)$ at stations B, C, and D. That analysis had effects due to vehicle frequency, a common slope factor for relating asbestos concentration to distance, and separate slope factors for the different vehicle frequencies. The significance of the separate slope factors was tested and found to be not significant. However, the common slope is

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[1] Because of a missing $\ln(C_3)$ value due to one $C_3$ value of 0, D(S*V) has only 35 degrees of freedom for $C_3$.

significantly different from zero and the intercept terms do apparently differ from one vehicle frequency to another. Consequently, a model with separate intercepts but a common slope was fit to the $\ln(C_i)$ data. That model was found to significantly describe the results; the model accounts for 67%, 70%, and 47% of the variation in $\ln(C_1)$, $\ln(C_2)$, and $\ln(C_3)$, respectively. A weighted average of the vehicle frequency-specific slope factors yields an estimate of the common slope with the smallest variance (Hyde, 1980). The results of the estimation, converted back to the natural scale, are as follows:

$C_1 = \exp(-4.55 - 0.012*\text{distance})$ for 0 vph;
$C_1 = \exp(-2.28 - 0.012*\text{distance})$ for 5 vph;
$C_1 = \exp(0.153 - 0.012*\text{distance})$ for 15 vph;

$C_2 = \exp(-5.38 - 0.011*\text{distance})$ for 0 vph;
$C_2 = \exp(-3.57 - 0.011*\text{distance})$ for 5 vph;
$C_2 = \exp(-1.20 - 0.011*\text{distance})$ for 15 vph;

$C_3 = \exp(-9.72 - 0.016*\text{distance})$ for 0 vph;
$C_3 = \exp(-6.74 - 0.016*\text{distance})$ for 5 vph;
$C_3 = \exp(-4.57 - 0.016*\text{distance})$ for 15 vph.

Factors affecting PM10 concentrations

The 42 PM10 concentrations were subjected to analysis of variance techniques in the same manner as described above for asbestos concentrations. In the case of PM10, however, the observations were limited to stations A, B, C, and D (i.e., remote background measurements were not collected) and two vehicle frequencies (5 and 15 vph). The reduced data base allowed a slight streamlining of the modeling (see Table D-2).

Unlike the asbestos data, there were no QC samples for PM10 to allow estimation of the laboratory handling component of error variance. There were only three collocated samples from which to estimate the component of error variance associated with the unidentified differences between collocated samplers.

The results of the analysis of variance are shown in Table 2. In the case of PM10, the day-to-day variation is significantly greater than the variation associated with collocated samples. The roadway, station, and vehicle frequency effects are significant contributors to differences in PM10 concentrations. The D(R*S*V) term was used as the error term for assessing the effects of roadway, station, and vehicle frequency. A comparison of the means for those effects is also included in Table D-2.

Relationship between PM10 and asbestos concentrations

The 42 PM10 concentrations were matched with their corresponding indirect asbestos concentrations (three asbestos concentrations for each PM10 concentration, because of the three methods of calculating asbestos concentration). The analytical approach employed is a variation of an analysis of variance known as a homogeneity of slopes model.

The approach adopted included effects due to roadway and station, and their interaction, a common slope factor for relating asbestos concentration to PM10 concentrations, and separate slope factors for the different roadway/station combinations. The significance of the separate slope factors can be tested for significance; if there is no significant difference among the slope factors, then a weighted average of the roadway/station-specific slope factors yields an estimate of the common slope with the smallest variance (Hyde, 1980).

Because of the results cited above indicating that log-transformed concentrations are better described by normal distributions than the untransformed data, the PM10 analyses were performed using log-transformed concentrations. The error term is contributed by day-to-day variation, consistent with the determination from the previous analysis that such variation is an appropriate measure of error, which includes sample-to-sample and test-to-test contributions.

For the regressions relating PM10 to each of the three exposure indices by which asbestos concentrations were reported, the roadway effect is not significant but the station effect is significant (Table D-3). Moreover, it appears that the slopes for the relationship between $\ln(C_i)$ and ln(PM10) do not differ from one station to another but that the common slope is significantly different from zero. The model with a single slope factor, but differing intercepts depending on station, describes the data very well (the significance of the model exceeds 0.0001) and accounts for a large proportion of the variation in $\ln(C_i)$ values (75% for $\ln(C_1)$, 79% for $\ln(C_2)$, and 71% for $\ln(C_3)$).

Since roadway is not significant, the estimation of the common slope, $\beta$, was been based on station alone (pooling the observations from the two roadways within station). The least squares estimator of $\beta$ is given by the weighted average of the station-specific slopes:

$$\beta = \Sigma b_i * SSX_i / \Sigma SSX_i,$$

where $b_i$ is the estimated slope at station i and $SSX_i$ is the corrected sum of squares for ln(PM10) at that station. This weighted average was computed for the three asbestos concentrations to yield these equations:

$$\ln(C_1) = \alpha_j + 1.392*\ln(PM10),$$
$$\ln(C_2) = \alpha_j + 1.077*\ln(PM10),$$
$$\ln(C_3) = \alpha_j + 1.422*\ln(PM10),$$

where j = A, B, C, or D. Transforming back from the log-scale and specifying values of the $\alpha_j$'s, the relationships between asbestos concentrations and PM10 concentrations are:

$$C_{1A} = 22.2*(PM10)^{1.392},$$
$$C_{1B} = 1.65*(PM10)^{1.392},$$
$$C_{1C} = 1.38*(PM10)^{1.392},$$
$$C_{1D} = .393*(PM10)^{1.392},$$

$$C_{2A} = 18.3*(PM10)^{1.077},$$
$$C_{2B} = .387*(PM10)^{1.077},$$
$$C_{2C} = .188*(PM10)^{1.077},$$
$$C_{2D} = .094*(PM10)^{1.077},$$

$$C_{3A} = .0029*(PM10)^{1.422},$$
$$C_{3B} = .0056*(PM10)^{1.422},$$
$$C_{3C} = .0091*(PM10)^{1.422},$$
$$C_{3D} = .0101*(PM10)^{1.422}.$$

The results shown above suggest that the relationship between PM10 and asbestos concentrations is not linear. Moreover, the relationships are not similar for the three methods of calculating asbestos concentrations. Although the power on PM10 concentration does not differ greatly from method to method, the coefficients differ, especially for the third method (Berman and Crump). The concentration of asbestos relative to PM10 concentration clearly depends on distance from the roadway (cf. the significant p-values for station in Table 3; the station terms are significant also in the models that ignored roadway). For the exposure indices $C_1$ and $C_2$, there is more asbestos for a fixed concentration of PM10 at station A, upwind from the road, than at the downwind stations. Moreover, the concentration of asbestos for a fixed PM10 concentration decreases with distance downwind. For the exposure index $C_3$, on the other hand, less asbestos is present per PM10 concentration upwind from the road and asbestos concentration per PM10 Aconcentration increases, although only slightly, as distance downwind increased.

**FIGURES**

FIGURE D-1
GRAPHIC DEPICTION OF DIAMOND XX ASBESTOS CONCENTRATION EXPERIMENT

| | ROADWAY 1 | | | | | ROADWAY 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STATION(a) | A | B | C | D | E | A | B | C | D | E |
| DAY 1 | 0(b) | 0 | 0 | 0 | | | | | | |
| 2 | 5 | 5 | 5 | 5 | | | | | | |
| 3 | 5/15 | 5/15 | 5/15 | 5/15 | | | | | | |
| 4 | 5/15 | 5/15 | 5/15 | 5/15 | X | | | | | |
| 5 | 15 | 15 | 15 | 15 | | | | | | |
| 6 | | | | | | 0 | 0 | 0 | 0 | |
| 7 | | | | | | 15 | 15 | 15 | 15 | |
| 8 | | | | | | 5 | 5/15 | 5/15 | 5/15 | |
| 9 | | | | | | 15 | 15 | 15 | 15 | X |

(a) Stations A are 150 feet upwind from roadways, B - 25 feet downwind, C - 75 feet downwind, D - 150 feet downwind, and E - distant background.

(b) An entry (0, 5, or 15) indicates vehicle frequency for samples collected that day. Note that on days 3, 4, and 8 two experiments were conducted. For Station E, samples were collected on days 4 and 9; the X's indicate that those samples are not associated with any particular vehicle frequency.

FIGURE D-2
COMPARISON OF ASBESTOS MEASUREMENTS ASSOCIATED WITH SPECIFIC COMBINATIONS OF STATION AND VEHICLE FREQUENCY FROM THE DIAMOND XX STUDY

Exposure Index (a)

| | | | | | | |
|---|---|---|---|---|---|---|
| C1 | Station (s): | B | C | D | E | A |
| | Mean(a): | -1.4 | -2.6 | -2.8 | -5.0 | -6.3 |
| | Vehicle Frequency (V): | | 15 | 5 | -1 | 0 |
| | Mean: | | -1.7 | -3.9 | -5.0 | -5.3 |

| S * V: | B15 | C15 | B5 | D15 | D5 | C5 | BO | E | DO | CO | AO | A5 | A15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean: | -0.06 | -1.2 | -1.7 | -1.8 | -3.1 | -4.3 | -4.6 | -5.0 | -5.4 | -6.0 | -6.2 | -6.3 | -6.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| C2 | Station (s): | B | C | D | E | A |
| | Mean: | -2.7 | -3.8 | -3.9 | -6.2 | -7.4 |
| | Vehicle Frequency (V): | | 15 | 5 | 0 | -1 |
| | Mean: | | -3.0 | -5.0 | -6.2 | -6.2 |

| S * V: | B15 | C15 | B5 | D15 | D5 | C5 | BO | E | AO | CO | DO | A5 | A15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean: | -1.4 | -2.6 | -2.9 | -3.0 | -4.0 | -5.3 | -5.6 | -6.2 | -6.5 | -6.6 | -6.9 | -7.6 | -7.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| C3 | Station (s): | B | C | D | E | A |
| | Mean: | -6.2 | -7.9 | -8.1 | -11.1 | -12.3 |
| | Vehicle Frequency (V): | | 15 | 5 | 0 | -1 |
| | Mean: | | -7.1 | -9.1 | -10.0 | -11.1 |

| S * V: | B15 | B5 | C15 | D15 | D5 | C5 | BO | DO | C5 | CO | E | AO | A5 | A15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean: | -5.0 | -5.9 | -6.4 | -7.6 | -8.3 | -9.5 | -9.5 | -9.5 | -10.1 | -11.0 | -11.0 | -11.7 | -12.1 | -12.7 |

(a) The exposure indices examined in this study are:
- C1 = PCME (EPA, 1986)
- C2 = PCME (California Prop. 65)
- C3 = B and C Index (Berman and Crump, 1994)

Note that underlines indicate cases in which differences in groups are not significant. For example, the difference in the mean concentrations measured for Station B (using index C1) is significantly greater than the mean for Station D. However, the mean concentrations measured at Station C (using exposure index C1) is NOT significantly different than the mean for Station D.

**TABLES**

TABLE D-1
ANALYSIS OF VARIANCE FOR LOG TRANSFORMED ASBESTOS CONCENTRATIONS
GROUPED BY SPECIFIED PARAMETERS

| EFFECT (a) | DEGREES OF REEDOM | Mean Square C1(b) | Mean Square C2(b) | Mean Square C3(b) | F-Test p-Value C1(b) | F-Test p-Value C2(b) | F-Test p-Value C3(b) |
|---|---|---|---|---|---|---|---|
| NF | 1 | 16.2 | 16.9 | 32.8 | < 0.01 | < 0.01 | < 0.01 |
| R | 1 | 0.69 | 0.66 | 0.03 | > 0.10 | > 0.10 | > 0.10 |
| NF * R | 1 | 4.89 | 0.38 | 1.94 | > 0.10 | > 0.10 | > 0.10 |
| S(NF * R) | 6 | 30.0 | 29.0 | 43.6 | < 0.01 | < 0.01 | < 0.01 |
| V(NF * R) | 4 | 28.3 | 22.7 | 24.5 | < 0.01 | < 0.01 | < 0.01 |
| S * V(NF * R) | 12(c) | 3.37 | 3.89 | 5.77 | > 0.10 | < 0.01 | > 0.10 |
| D(NF * R * S * V) | 23 | 1.91 | 1.14 | 3.10 | > 0.10 | > 0.10 | > 0.10 |
| SN(NF * R * S * V * D) | 12 | 1.75 | 2.2 | 3.57 | < 0.01 | < 0.01 | > 0.10 |
| TN(NF * R * S * V * D * SN) | 4 | 0.08 | 0.01 | 1.67 | | | |
| Converted Total | 64(c) | | | | | | |

(a) Key:
NF = Gross Proximity
R = Roadway
S = Station
V = Vehicle
D = Day
SN = Station Number
TN = Test Number

(b) The exposure indices examined in this study are:
C1 = PCME (EPA, 1986)
C2 = PCME (California Prop. 65)
C3 = B and C Index (Berman and Crump, 1994)

(c) Due to a C3 concentration value of 0 (from Roadway 2, Station A, 0 vehicles per hour, collected 9/26/93), only 64 log-transformed C3 values were available for analysis. Thus, for C3, the degree of freedom for corrected total and S * V(NF * R) sums of squares are 1 less than shown, i.e., 63 and 11, respectively.

TABLE D-2
ANALYSIS OF VARIANCE FOR LOG-TRANSFORMED PM10 CONCENTRATIONS
MEASURED DURING THE DIAMOND XX STUDY

| EFFECT | DEGREES OF FREEDOM | MEAN SQUARE | F-TEST p-VALUE |
|---|---|---|---|
| R | 1 | 1.04 | 0.05 |
| S | 3 | 10.8 | < 0.01 |
| v | 1 | 2.89 | < 0.01 |
| R * S | 3 | 0.24 | > 0.10 |
| R * V | 1 | 0.04 | > 0.10 |
| S * V | 3 | 0.33 | > 0.10 |
| R * S * V | 3 | 0.16 | > 0.10 |
| D(R * S * V) | 23 | 0.24 | < 0.01 |
| SN(R * S * V * D) | 3 | 0.007 | |

Comparison of Means:

| | | | | |
|---|---|---|---|---|
| Roadway: | 1 | 2 | | |
| Mean: | -1.5 | -1.8 | | |
| Station: | B | C | D | A |
| Mean: | -0.7 | -1.3 | -1.7 | -3.2 |
| Vehicle Frequency: | 15 | 5 | | |
| Mean: | -1.4 | -2.0 | | |

Note: means connected by underlines are not significantly different from one another.

TABLE D-3
ANALYSIS OF VARIANCE FOR RELATIONSHIPS BETWEEN ln (PM10) and ln (Ci)
MEASURED DURING THE DIAMOND XX STUDY

| EFFECT | DEGREES OF REEDOM | Mean Square | | | F-Test p-Value | | |
|---|---|---|---|---|---|---|---|
| | | C1(a) | C2(a) | C3(a) | C1(a) | C2(a) | C3(a) |
| Roadway | 1 | 0.17 | 0.12 | 0.32 | 0.75 | 0.74 | 0.75 |
| Station | 3 | 60 | 62 | 95 | < 0.01 | < 0.01 | < 0.01 |
| Roadway * Station | 3 | 2.0 | 2.3 | 2.0 | 0.31 | 0.12 | 0.58 |
| PM10 (Common Slope) | 1 | 31 | 19 | 25 | < 0.01 | < 0.01 | < 0.01 |
| PM10 * Roadway * Station (separate slope) | 7 | 1.8 | 20 | 5.8 | 0.39 | 0.11 | 0.11 |
| Error | 26 | 1.6 | 1.1 | 3.0 | | | |
| Collected Total | 41 | | | | | | |

(a) The exposure indices examined in this study are:

C1 = PCME (EPA, 1986)

C2 = PCME (California Prop. 65)

C3 = B and C Index (Berman and Crump, 1994)

## REFERENCES

Berman, DW; Crump, KS; Chatfield, EJ; Davis, JMG; and Jones, AD (1994). The Sizes, Shapes, and Mineralogy of Asbestos Structures That Induce Lung Tumors or Mesothelioma in AF/HAN Rats Following Inhalation. Risk Analysis. Accepted for publication.

California Air Resources Board -- ARB (1986). Public Hearing to Consider the Adoption of a Regulatory Amendment Identifying Asbestos as a Toxic Air Contaminant. Staff Report: Initial Statement of Reasons for Proposed Rulemaking. February 10.

EPA (1986). Airborne Health Assessment Update. Office of Health and Environmental Assessment, EPA, Washington, D.C. EPA/600/8-84/003F. June.

Hyde, J (1980). Determining an Average Slope. in Biostatistics Case Book. Miller, RG; Efron, B; Brown, BW; and Moses, LE (eds). John Wiley and Sons. New York, NY.