UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

MEMORANDUM

DATE: December 19, 2001

SUBJECT:
- **Wipe sampling for asbestos in Lower Manhattan**
- **Projection of airborne levels from settled WTC dusts**
- **Estimation of increased cancer risks based on various WTC dust exposure scenarios**

FROM: Cate Jenkins, Ph.D.
Waste Identification Branch (Mail Code 5304 W)
Hazardous Waste Identification Division

C Jenkins

TO: Affected Parties and Responsible Officials

The following memorandum provides information on taking wipe samples of settled dusts inside buildings in Lower Manhattan that resulted from the collapse of the World Trade Center (WTC). Studies are discussed which correlate the amount of asbestos that will become airborne (resuspended) because of activities such as sweeping, athletic activities, etc. Information is provided on the cumulative exposures (total doses) found by the Agency for Toxic Substances and Disease Registry (ATSDR) to be associated with asbestos-related health effects, and examples are given how to use this information to calculate doses of asbestos from the WTC disaster. Finally, a brief section explains the different methods for analyzing and reporting asbestos levels.

The analyses, projections, and opinions in this memorandum represent my own professional judgement and are not intended to be construed as any official position or recommendation by the U.S. Environmental Protection Agency. This memorandum is not intended as any final risk assessment risks from continued and past exposures to asbestos, and has not been reviewed by EPA. The data is too incomplete at this time for any complete projection of risks, and there are too many methods available for performing such projections. My attempt was intended only as a point of discussion prior to more rigorous assessments.

CONTRADICTORY ASBESTOS TESTING GUIDANCE

Impossible instructions from NYC DEP

The NYC Department of Environmental Protection (NYC DEP) gave impossible and unsafe instructions to owners of buildings. Furthermore, the instructions violated the standards set by the federal EPA. The NYC DEP advised building owners[1] to test dusts inside buildings to see if they were over 1%. They said that if the dusts were over 1%, a professional asbestos abatement contractor should be used for the cleanup:

> EPA is using the 1% definition in evaluating exterior dust samples in the Lower Manhattan area near the World Trade Center. All affected landlords have been instructed to test dust samples within their buildings utilizing this standard. Landlords were notified that they should not reopen any building until a competent professional had properly inspected their premise. If more than 1% asbestos was found and testing and cleaning was necessary, it had to be performed by certified personnel.

Unless the windows were blown out by the blast, interior dusts are in too thin a layer to enable them to be scooped up into a jar or bag. Only dusts that are in "bulk" form, which can be put into a bag or jar, can be tested for the percentage of asbestos.

If there is only a thin, visible surface dusting, or even an invisible layer of dust, you are forced to use what are called "wipe" samples or "microvacuum" samples. Wipe samples can only be tested for the number of asbestos fibers per area, not a percentage of asbestos in the total dust. Microvacuum samples are also typically only analyzed for number of structures per area, although there is a rarely used, very expensive ASTM method for microvacuum samples that can sometimes be employed to give mass concentration - percent values.

Laboratory results for settled dust layers are reported as "asbestos structures/square centimeter (structures/cm^2)." This cannot be converted into a percentage of asbestos. Thus, it is almost impossible for building owners to even test for the 1% level in the first place. See the last section of this memorandum for more information on asbestos sampling and analysis techniques.

NYC DEP instructions also contrary to stated EPA standard for the cleanup

The NYC DEP instructions also reversed the decision by the federal EPA that asbestos levels should be non-detectable. After the disaster, the federal EPA declared that it was applying the most stringent standard, namely the 70 asbestos structures per millimeter of air in the Asbestos Hazard Emergency Response Act (AHERA).[2] This "70" level is the lowest level that can be detected in air using the AHERA test method, because of the background level of asbestos in the filter through which the air is drawn. In other words, the level EPA stated that it required was NO detectable asbestos, not 1% or lower.

EPA regulations apply the 1% level to the asbestos containing materials themselves, such as insulation or asbestos floor tiles, not to the dusts that would result from the presence somewhere in the building of asbestos containing materials (ACM). EPA assumed that the dusts resulting from the presence of these ACM somewhere in the building would have much lower levels of

asbestos than 1%. And it is these dusts themselves that are considered to be the ultimate hazard by EPA, even though they have levels lower than 1%. The U.S. EPA has clearly stated that levels lower than 1% could present hazards:[3]

> Levels of 1% or less could present a risk where there is enough activity to stir up soil and cause asbestos fibers to become airborne.

The NYC DEP also exercised no oversight over building owners to insure that they did test their premises, or used a professional asbestos abatement firm for remediation.

TAKING WIPE SAMPLES OF INTERIOR SURFACES

Practicality of taking wipe samples

Taking a wipe or microvacuum sample may be the only practical way to quickly see if a building is contaminated inside, or if cleanup is complete. Air sampling is highly variable depending on the time, the exact location, the amount of activity stirring up dusts, etc. Furthermore, a large amount of specialized equipment is required. Even if air sampling shows no detectable asbestos, there could still be a substantial reservoir in settled dusts somewhere waiting to become airborne under the right conditions. Air sampling cannot be used in lieu of a complete removal of the asbestos-contaminated dusts.

Because there will probably be a continued demand over for at least the next year, if not more, to test areas in Lower Manhattan, it might be a good time for certain individuals to learn wipe sampling techniques. Probably an individual should not take this on her/himself for only a one-time sampling event. Even for wipe sampling, there is a fairly rigorous standardized procedure to follow with wiping methods and placing of the wipe in containers for transport, etc.

This might be an option for staff at environmental and occupational safety and health groups. Chemists, pharmacists, other scientists and health professionals might want to learn this type of sampling. The laboratory which will do the actual analysis will usually work with the person to get her/him the right materials. There appear to be no insurmountable hurdles to setting up to provide these types of services. Workshops and training sessions could be held by various groups.

An alternative to wipe sampling is using a microvacuum to sample settled dusts. This would involve purchasing a pump designed for personal monitoring of workers under OSHA, calibrating it, and adapting it to the sampling technique. These pumps cost from $1500 to $3000. This is a less practical option, and also does not transfer as much asbestos from surface into the sample to be tested. The detection limit also appears to be better than the microvacuum method.

Description of ASTM method D-6480-99

EPA does not have any wipe, or even microvacuum methods for asbestos. However, the American Society of Testing and Materials (ASTM) has developed method D-6480-99.[4] The required materials include particle-free wipe material (commonly made available for clean room supplies, called a "clean room wiper," available from major laboratory safety supply

vendors), specially filtered particle-free water, dust free disposable gloves, and a high purity alcohol. The laboratory that will perform the actual test typically will work with you to get you these supplies.

Finding a Laboratory

First, choose a laboratory which is accredited by the EPA to perform TEM (transmission electron microscopy) asbestos analyses. These labs are posted on the web at: http://ts.nist.gov/ts/htdocs/210/214/scopes/temtm.htm. Or, contact the National Institute for Standards and Technology (NIST) Laboratory Accreditation Administration, Gaithersburg, MD 20899 (telephone 301-975-4016). There are about 60 accredited labs. Since wipe samples cannot be used for regulatory purposes, it is irrelevant whether the lab also has an accreditation in New York State. You can use any out-of-state lab that is convenient.

Using TEM instead PCM analyses is important in terms of comparison of the wipe sample with the TEM air level testing required under the asbestos AHERA standard. It is particularly important to use TEM for the WTC dusts because the asbestos in them is very fine. A PCM analysis will only detect larger particles.

Contact the lab to see what type of wipe samples they are capable or willing to perform. Ask whether they will perform TEM analyses on samples that were collected by American Society of Testing and Materials (ASTM) wipe Method D 6480 (wipe). Ask advice on sample preparation, handling, etc.

Interpreting the results of settled dust levels, wipe samples or microvacuum samples

Industrial hygienists and other health professionals recommend professional asbestos abatement procedures when a wipe sample is over the detection limit, or background, of 260 s/cm^2 for wipe samples, or over 1000 s/cm^2 for a microvacuum sample.

If there are any elevated levels of asbestos on surfaces, then landlords should be contacted and asbestos abatement by trained, certified professionals should be instituted. Also, contact health and environmental agencies and elected officials so that they are aware of the problem and can provide assistance and intervene to provide assistance to others in the area who are probably contaminated as well. Contact local non-profit environmental and occupational safety and health organizations as well for assistance and advice.

PREDICTING AIR CONCENTRATIONS FROM SETTLED DUST LEVELS

To predict the amount of asbestos which will be in the air from a given settled dust level is not an exact science. Until such time as adequate air monitoring is available, the following may be the only viable method. Settled asbestos dusts get resuspended into the air inside buildings as the result of activities such as sweeping, walking around, moving heavy equipment, etc.

What is needed are factors, or numbers, to multiply the settled dust levels by to estimate the airborne levels. The following presents such a methodology. First, the conversion factors for an

experimental study are given. Then, the conversion factors are estimated for WTC asbestos dusts.

Settled dust level conversion factors found from controlled study

A study was performed by Millette and Hays to provide a correlation between the level of asbestos in settled dusts and the amount which will become airborne (resuspended) as the result of certain activities. This study used real world situations of asbestos contamination, primarily after the San Francisco earthquake. Table 1 shows the experimental results, along with the calculated "K-factor", the factor for multiplying the settled dust level by to find the air level. As can be seen, the air concentrations increase as the activity level increases.

Table 1. Resuspension K-Factors for settled asbestos dusts determined from controlled asbestos studies by Millette and Hays. [5]

ACTIVITY	SETTLED DUST LEVEL structures/square centimeter (s/cm^2)	AIR LEVEL structures/milliliter (s/mL)	K-FACTORS multiply the settled dust level by this number to get the air level
Carpet cleaning (ordinary vacuum)	23,000	0.09	3.9×10^{-6} (0.0000039)
Broom Sweeping	760,000	53.6	7.1×10^{-5} (0.000071)
Cleaning Storage Area	870,000	2.7	3.1×10^{-6} (0.0000031)
Gym-Athletic Activities	9,700	0.23	2.4×10^{-5} (0.000024)
Cable Pull	2,000,000	28.9	1.4×10^{-5} (0.000014)

Resuspension factors for settled dusts from World Trade Center

The Millette and Hays study can be used to predict airborne levels of the WTC dusts. Data is available from the Ground Zero Task Force study for two apartment buildings.[6] Settled asbestos levels along with airborne asbestos levels were measured under passive conditions. Estimations are then made of the fraction of the settled dust which will become resuspended.

The WTC dusts are unusual in that the particles of asbestos are smaller than usually, having a greater likelihood of becoming resuspended.[7] This appears to be the case. The actual measured fraction of asbestos that was suspended in air over settled dusts under passive conditions (no activities taking place to stir them up) were HIGHER than measured in the Millette and Hays study when a carpet was being vacuumed. It is reasonable and prudent to predict that if the WTC dusts were being vacuumed, the resuspension factor would be higher than actually measured under passive conditions, which means they would be higher than found in the Millette and Hays study. The resuspension factor for the WTC dusts have been predicted to be 10 times higher under vacuuming conditions than under passive conditions, which is 10 times higher than found

in the Millette and Hays study. All of the other Millette and Hays resuspension factors have also been increased by 10 for the WTC asbestos dusts. Table 2 provides the actual resuspension factor found by testing for WTC dusts under passive conditions, along with the predicted air levels under a variety of activities with the modified resuspension factors, called the WTC-Factors:

Table 2. Resuspension WTC-Factors for settled dusts from World Trade Center using actual measurements for passive conditions and modifications to K-Factors found in Millette and Hays study

	SETTLED DUST LEVEL (s/cm^2)	AIR LEVEL (s/mL)	WTC-FACTORS Multiply the settled dust level by this number to predict air levels
HIGH EXPOSURE BUILDING, 250 South End Ave. Heavy visible dust layer, could still read addresses on envelopes on table and see the lines on a yellow legal pad on the table. Windows had been blown out some places. Dust level from living room high boy side table, living room air level measured under passive conditions			
Passive conditions, found by testing	640,000	2.56	4×10^{-6} (0.000004) (measured)
Carpet cleaning (ordinary vacuum)	640,000	24.96	3.9×10^{-5} (0.000039) (estimated)
Broom Sweeping	640,000	454.40	7.1×10^{-4} (0.00071) (estimated)
Cleaning storage area	640,000	19.84	3.1×10^{-5} (0.000031) (estimated)
Gym-Athletic Activities	640,000	153.60	2.4×10^{-4} (0.00024) (estimated)
Cable Pull	640,000	89.60	1.4×10^{-4} (0.00014) (estimated)
LOW EXPOSURE BUILDING, 45 Warren St., dust layer visible on dark table, grain of wood still visible. 5 blocks from Ground Zero, building faced north. Dust level from living room table, living room air level measured under passive conditions			
Passive conditions, found by testing	29,000	0.12	4×10^{-6} (0.000004) (measured)
Carpet cleaning (ordinary vacuum)	29,000	1.13	3.9×10^{-5} (0.000039) (estimated)
Broom Sweeping	29,000	20.59	7.1×10^{-4} (0.00071) (estimated)
Cleaning storage area	29,000	0.90	3.1×10^{-5} (0.000031) (estimated)
Gym-Athletic Activities	29,000	6.96	2.4×10^{-4} (0.00024) (estimated)
Cable Pull	29,000	4.06	1.4×10^{-4} (0.00014) (estimated)

Predicting air levels if cleanup is inadequate

Air levels might also be predicted if the cleanup is inadequate. As discussed in my December 6 memorandum, the EPA determined that neither conventional nor HEPA vacuums were capable of removing significant amounts of asbestos from carpet. Only the wet-extraction HEPA vacuums removed the asbestos particles which adhere to the carpeting.[8] Even the wet-extraction HEPA vacuums did not remove all of the asbestos, only about 60%.

Thus, the same or similar levels of asbestos could remain in the carpets as their were before the cleanup. After cleanup, the air levels could remain as high as projected in Table 2. The dust in both of the apartments in the Ground Zero Task Force study (Table 2) was not that thick, only a fine dusting where you could still read the writing on papers on a table even in the high exposure building.. This small amount of dust could easily work its way into the carpet and remain.

(I have been informed that typically, in asbestos abatement, carpeting is removed and discarded because of the inability to remove all the asbestos. More documentation on recommendations and this practice is requested. Information on actually testing or test methods for asbestos contaminated carpeting is also solicited. jenkins.cate@epa.gov)

CALCULATING TOTAL DOSE FROM ATSDR's CUMULATIVE EXPOSURE INDEX

Cumulative, or total dose, found by ATSDR to be related to health effects

The Agency for Toxic Substances and Disease Registry (ATSDR) is part of the Centers for Disease Control. It develops toxicological profiles in response to the Comprehensives Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund). These profiles are subjected to extensive review by the most prestigious scientists as well as being reviewed and commented upon by affected industries and the public. The ATSDR found that the "cumulative exposure," or total dose, was valid for predicting the probability of suffering health effects from asbestos. There was no "threshold" or safe level.[9]

> A number of researchers have found that the occurrence of asbestosis and lung cancer correlates with cumulative exposure (that is, the product of concentration [PCM fibers/mL] multiplied by years of exposure). Therefore, human exposures are expressed below as PCM f-yr/mL.
> ...
> [A] number of other studies indicate that lung cancer risk is linearly related to cumulative dose without any obvious threshold

In other words, it does not matter whether or not you got the same total dose over a short period of time at higher levels, or a long period of time at lower levels. The health effects will be the same. The ATSDR does explain that there is no absolute correlation of the total dose with health effects, but uses it as a valid method to evaluate health risks.

Table 3 lists some of the "cumulative doses" found by the ATSDR to be associated with asbestos health effects. The table also gives examples of what the air asbestos levels are required for different time periods to achieve this dose.

Table 3. CUMULATIVE EXPOSURES OF ASBESTOS ASSOCIATED WITH HEALTH EFFECTS
From the ATSDR Toxicological Profile for Asbestos,[10] including examples of air levels and the amount of time needed to accumulate the dose

HEALTH EFFECT	CUMULATIVE EXPOSURE OR DOSE asbestos inhalation (f-yr/mL)	RISK LEVEL	EQUIVALENT AIR LEVEL (in fibers per milliliter - f/mL) and NUMBER OF YEARS EXPOSURE THAT WOULD LEAD TO THIS TOTAL CUMULATIVE EXPOSURE OR DOSE					
Cumulative Exposure is given in the number of fibers per milliliter times the years of exposure (f-yr/mL), measured by PCM Risk Level is the number of excess cancer cases or cases of other health effects for a given population			1 week	3 months	6 months	1 year	2 years	50 years
lung cancer, smokers, EPA risk levels	0.00035	1 cancer per million	0.018	0.0014	0.0007	0.00035	0.000175	0.000007
	0.0035	1 cancer per 100,000	0.183	0.014	0.007	0.0035	0.00175	0.00007
	0.035	1 cancer per 10,000	1.825	0.14	0.07	0.035	0.0175	0.0007
lung cancer, non-smokers, EPA risk levels	0.0035	1 cancer per million	0.183	0.014	0.007	0.0035	0.00175	0.00007
	0.035	1 cancer per 100,000	1.825	0.14	0.07	0.035	0.0175	0.0007
	0.35	1 cancer per 10,000	18.250	1.4	0.7	0.35	0.175	0.007
mesothelioma, EPA risk levels	0.00031	1 cancer per million	0.016	0.00124	0.00062	0.00031	0.000155	0.0000062
	0.0031	1 cancer per 100,000	0.162	0.0124	0.0062	0.0031	0.00155	0.000062
	0.031	1 cancer per 10,000	1.616	0.124	0.062	0.031	0.0155	0.00062
asbestosis	2.6	no effect level	135.571	10.4	5.2	2.6	1.3	0.052
	4.5	1 case per 1000	234.643	18	9	4.5	2.25	0.09
abnormal radiological findings	0.12	3.7 per 100	6.257	0.48	0.24	0.12	0.06	0.0024

How to use Table 3

First, look for the health effect that will occur at the lowest levels of asbestos. This would be mesothelioma, a type of cancer that affects the cavity of the thorax, and also lung cancer if you are also a smoker. If a person inhales the equivalent of 0.00031 fibers of asbestos/milliliter of air for one year, then their increased risk of getting mesothelioma is 1 in a million. If they breathe 10 times that much for one year (0.0031 f-yr/mL), then the chance is increased to 1 in 100,000. Then, go over to the right hand columns which give a range of different time periods. Say you are interested in those exposures which will increase mesothelioma cancer risks by 1 in 10,000. A person would need to breath the following concentrations of asbestos for the following time periods to increase the risk by 1 in 10,000:

Total dose required to increase risk of mesothelioma by 1 in 10,000	
fibers/milliliter	time period
1.616	1 week
0.124	3 months
0.062	6 months
0.031	1 year
0.0155	2 years
0.00062	50 years

If a different time period is needed than shown in the table, multiply the one-year cumulative exposure index by the time period. For 2 weeks, multiply by 14/365, etc.

Precautions when using Table 3

Confusion over the way asbestos is reported.

The first and foremost precaution in using Table 3 is this:

> DO NOT CONFUSE ASBESTOS LEVELS REPORTED AS:
> "structures per square millimeter" (s/mm^3) WITH "structures per milliliter" (s/mL)

These are very different things, although to the unwary, they appear to be the same. However, "structures per square milliliter" (s/mL) are the same thing as "structures per cubic centimeter" (s/cc^3). See the last section of this memo for more information on the way asbestos levels are reported.

At its web site, EPA only reported concentrations as "structures/square millimeter."[11] They could have given the asbestos concentration as "structures/milliliter" but did not. Thus, it is not easy to compare the EPA data unless you look at the actual lab sheets, which are posted on the internet at the NYELJP web site.[12]

Conversion of TEM measurements of WTC dusts to the PCM measurements used for the health studies.

A problem, or perhaps more an uncertainty, in using Table 3 arises from the fact that the human health studies are correlated to asbestos that was measured by the PCM method, which does not detect smaller fibers. The WTC dusts were measured by EPA using the more sensitive TEM method, which does detect these smaller fibers.

Since TEM analyses of WTC dusts give higher reading of fibers/structures asbestos than a PCM reading, some would argue that all of the WTC asbestos levels should be divided by some number (made smaller) to make them comparable to the ATSDR studies which used PCM. For the WTC dusts, the ratio of TEM fibers/structures to PCM-equivalent fibers/structures was high, around 80 to 90.[13]

I have chosen not to attempt any conversion of TEM measurements to PCM-equivalent measurements for several reasons. First, the older PCM measures used in studies cited by the ATSDR may not, in fact, be smaller than a TEM measurement of the actual asbestos to which the humans were exposed. This is because PCM cannot distinguish between asbestos and other fibrous minerals. Thus, the studies of humans using PCM measurements may actually have *overestimated* true asbestos exposures because they included non-asbestos fibers. Also, the asbestos fibers to which persons were exposed in these older studies may not have included a substantial fraction of the smaller fibers like the WTC dusts.

Second, as a matter of policy, the federal EPA has issued no guidelines or standards recommending the use of such a conversion in asbestos risk assessments. If such a recommendation were to be issued, it would first undergo extensive internal and external peer review, and be subjected to due process through a notice and comment period. As an individual staff scientist, I would not take it upon myself to lower a risk assessment until such final guidance is issued. As prudent public policy, however, it is always valid for anyone to upgrade a risk assessment based on new, even if untested, data indicating a greater hazard.

Claim that fine asbestos particles are not hazardous

Some may argue that the smaller WTC fibers are less hazardous than the larger fibers. To my knowledge, the federal EPA has not addressed this scientific theory and issued any guidance to discount any cancerous effects of fine asbestos fibers. If such a recommendation were to be issued, it would first undergo extensive internal and external peer review, and be subjected to due process through a notice and comment period. Until such time as this occurs, as a matter of prudent public health policy, it would be inappropriate to downgrade a risk assessment based on this theory. I have also been informed that EPA has no intention of downgrading the risk based on this theory.

ESTIMATING INCREASED HEALTH RISKS FROM VARIOUS WTC EXPOSURE SCENARIOS

The following represents my efforts as a staff scientist to characterize any elevated health risks from exposures to WTC asbestos-contaminated dusts. As stated at the beginning of this memorandum, this risk assessment does not represent any official EPA analysis or position and does not necessarily reflect EPA policy. It has not been reviewed by EPA. There are many alternate ways to perform a risk assessment other than the one presented below. This risk assessment has a wide range of uncertainty both because of the limited data and the many assumptions that were utilized.

The EPA does not consider any exposure to a man-made carcinogen to be acceptable, but does base its actions in existing exposure situations according to the degree of elevated risk. The EPA chooses a degree of protection, or risk level, as a criteria for abating exposures.

The EPA generally considers an upper-bound lifetime cancer risk to an individual of between 10^{-4} and10^{-6} as a safe range. A risk of 10^{-4} represents a probability that there may be one extra cancer case in a population of 10,000 (1 per 10,000). A 10^{-6} risk is the probability that there may be one extra cancer case in a population of one million people over a lifetime of exposure (1 per 1,000,000. The National Contingency Plan (NCP) (Superfund) requires that the 10^{-6} risk level should be the point of departure; the goal in any response by the EPA to ameliorate exposures to carcinogens from man-made sources. A response action is generally warranted if the cumulative excess carcinogenic risk for any single individual affected by a site exposing humans to carcinogens exceeds 1 in 10,000 (the 10^{-4} risk level) using reasonable maximum exposure assumptions for either the current or reasonably anticipated future exposures. [14]

Scenario 1 - Volunteer at Ground Zero for two weeks

A person volunteered to provide refreshments to the rescue workers on the perimeter of Ground Zero for two weeks. The volunteer spent 12-hour days, going home to Brooklyn at night. S/he stayed outdoors for the majority of the time, but came inside to one of the adjacent evacuated hotels for shelter from the elements, to rest, and to eat. Approximately 3 hours per day were spent inside this building.

This person also lived/may live in an urban environment for a life of 85 years, with and exposure level of 6 x 10^{-6} (0.000006) s/mL.[15]

From Table 2, the asbestos level inside the contaminated building near Ground Zero is estimated to be 10 s/mL, midway between the "passive" conditions tested in the high-exposure building near Ground Zero, and the level estimated for cleaning out a storage room.

The level at the refreshment stand on the perimeter of Ground Zero is estimated to be 0.16 s/mL, towards the high side of EPA's air readings outdoors near Ground Zero in the month of October, but low for the month of September..

s/mL	x	time period (years)	=	total dose (s-year/mL)
0.16		(14/365)x(9/24)		0.0023
10		(14/365)x(3/24)		0.0479
0.000006		85		0.0005
total dose (cumulative exposure)				0.0507

From Table 3, the increased risk of getting mesothelioma will be almost 2 per 100,000 for the one week volunteer service in New York City. The whole life in an urban setting contributed very little to this risk. Going indoors to the contaminated building for 3 hours a day, rather than staying outside, represents essentially all of this risk.

If the volunteer had stayed outside for the whole time, the risks would be as follows:

s/mL	x	time period (years)	=	total dose (s-year/mL)
0.16		(14/365)x(12/24)		0.0031
0.000006		85		0.0005
total dose (cumulative exposure)				0.0036

The increased risk of mesothelioma would be around 1 in 100,000, due almost entirely to the 2 weeks service in NYC.

Scenario 2 - Resident of Lower Manhattan in contaminated building

A resident works in lower Manhattan and was present nearby during the collapse of the World Trade Center, but not in a building whose windows were blown out. The resident was engulfed by the dust cloud while walking up to Warren Street to her/his apartment. The resident stayed one night with no electricity and water because of 3 cats before leaving for two days, returning September 14 after restoration of services. There was no forced evacuation of the apartment building, many residents remained even when there was no electricity or water.

The landlord was in the process of cleaning common areas, which were primarily carpeted, by common cleaning techniques, vacuuming and dusting, starting September 14, for 4 days. The resident perfomed her/his own apartment cleaning and has remained in place. The resident only wore a dust mask, as recommended by the New York City Department of Health (NYC DOH) while cleaning the apartment,[16] which provided no protection against the asbestos.

The apartment building interiors only had a minimal, small amounts of dust from the WTC. Walter Mugdan, Counsel for EPA's Region 2, stated that the NYC DOH Recommendations should be followed in situations with minimal, small amounts of WTC dust.[17] An apartment with just such minimal, small amount of WTC dusts was the subject of the Ground Zero Task Force study, and the asbestos concentrations, and may be found in Table 2. A color photograph of a dark table is included in this study, showing what would be considered "small amounts" and "minimal" dusts by most people.[18]

The office in Lower Manhattan where the resident works had similar cleaning measures

implemented by the landlord, although in this case individual offices were cleaned by the landlord. Here also the dusting from the WTC was minimal and fine. No windows were broken in either the apartment building or the office building.

The resident was in a very high-contamination situation for 2 days. Upon returning to her/his apartment, the citizen was in another 4 day high contamination exposure while cleaning the apartment and being present while cleaning was going on of other apartments and common areas. The resident has remained in contaminated circumstances while at home and in the office for approximately 3 months after inadequate cleaning procedures.

The levels of asbestos exposure during the first two days exposure is estimated to be 500 s/mL. This level is 100 times the highest level found by the HP Environmental study in passive conditions in two buildings damaged but still standing near the World Trade Center.[19] EPA did not appear to have monitoring equipment in place at this time. If it had, the portals could have been occluded with heavy dusts and no readings would have been possible.

The level of asbestos during the 4 days cleaning and living in the apartment is estimated to be 10 s/mL, a point midway between vacuum cleaning and broom cleaning from Table 2 for the low exposure building.

The level of asbestos for the balance of the time, a 3 month period at home and at an equally contaminated office, is estimated to be 0.10 s/mL. This is the same as the air level actually found in an apartment on Warren Street before the cleanup, but under passive conditions. This level is assumed to apply to the apartment now under active conditions after some minimal cleanup, where the carpets retain most of the original asbestos. The cumulative exposure is as follows:

s/mL	x	time period (years)	=	total dose (s-year/mL)
500		2/365		2.74
10		4/365		0.11
1.0		1/4 yr		0.25
total dose (cumulative exposure)				3.1

The increased risk for mesothelioma is 1 in 100. The increased risk for lung cancer is 1 in 1000. The person has a risk of nearly 1/1000 for developing asbestosis, and would probably have abnormal radiological findings of the chest.

To continue this scenario, the resident continues to live in the apartment for another 15 years before moving to Arizona because of decreased lung function. The additional exposure to asbestos, added onto the exposures to date, are as follows:

s/mL	x	time period (years)	=	total dose (s-year/mL)
cumulative dose from above		=		3.1
1.0		15		15
total dose (cumulative exposure)				18.1

This resident has almost a 1 in 10 risk of mesothelioma. The person has a risk of nearly 4/1000 for developing asbestosis, and would probably have abnormal radiological findings of the chest.

Scenario 3 - New resident moves into partially cleaned up apartment near Ground Zero

A new resident moves into an apartment near Ground Zero that had been heavily contaminated because windows had been broken out. The former tenant had died in the collapse of the World Trade Center. The apartment had wall-to-wall carpeting, which was incompletely cleaned by using only an average suction capacity dry type HEPA vacuum. The carpeting had been new, so was not replaced for another 30 years. Other carpeting in common areas of the building also was not replaced on average of 30 years after the event. There was no special duct cleaning or other abatement measures. The resident was inside the apartment an average of 3/4 of her/his life. This included extra time on weekends, but some occasional times away in the evenings and on vacations. The resident was a smoker.

The asbestos air level is estimated to be 1 s/mL over the 30 year period. This assumes that the level was probably higher initially, near 2.56, the same as the level under passive conditions in the high exposure building in Table 2 before cleanup. After time, the level decreased somewhat, but never to background.

s/mL	x	time period (years)	=	total dose (s-year/mL)
1		30 x (3/4)		22.5

The increased risk of both mesothelioma and lung cancer both is nearly 1 in 10. The person has a risk of 5/1000 for developing asbestosis, and would probably have abnormal radiological findings of the chest.

Scenario 4 - Laborer works as janitor cleaning buildings in Lower Manhattan for 3 months

A laborer works as a janitor for 3 months cleaning up buildings and apartments in Lower Manhattan for 3 months. He sometimes wore a dust mask, but never a HEPA respirator. He also sleeps in buildings which have not been cleaned up during this period to save money. He is also a heavy smoker. His average exposure is 229 s/mL, which is midway between the passive conditions and the broom sweeping for the high exposure building in Table 2.

s/mL	x	time period (years)	=	total dose (s-year/mL)
229		1/4		57

His increased risk of mesothelioma and lung cancer both is about 1 in 5. The person has a risk of over 50/1000 for developing asbestosis, and would probably have abnormal radiological findings of the chest.

Scenario 5 - Firefighter works rescue operation from September 11 until October 11

A firefighter is engaged in the rescue and recovery operation for one month, starting on September 11. He works 12 hours a day, sleeping in an adjacent hotel for 9 hours a night and

also taking breaks at this adjacent hotel for another 3 hours a day. He is a smoker.

The levels of outdoor asbestos exposure during the first 2.5 weeks exposure is estimated to be 500 s/mL. He is both in the open air and in confined spaces. This level is 100 times the highest level found by the HP Environmental study in passive conditions in two buildings damaged but still standing near the World Trade Center.[20] EPA did not have monitoring equipment in confined spaces, although it did eventually on the perimeter of Ground Zero. OSHA does not appear to have had personal monitoring equipment on firefighters, only stationary monitoring in open areas around Ground Zero.

The level of outdoor asbestos exposure is estimated to be 0.50 s/mL during the second 2.5 weeks, al level consistent with many EPA readings at Ground Zero during the first month. Actually, there would have been a gradual decline of the initial 500 to 0.50 s/mL levels over the month, but the 2-time period per exposure level is convenient for calculations.

From Table 2, the asbestos level inside the contaminated building near Ground Zero is estimated to be 10 s/mL, midway between the "passive" conditions tested in the high-exposure building near Ground Zero, and the level estimated for cleaning out a storage room.

s/mL	x	time period (years)	=	total dose (s-year/mL)
500		(15/365)x(12/24)		10.2740
0.50		(15/365)x(12/24)		0.0103
10		(30/365)x(12/24)		0.4110
total dose (cumulative exposure)				10.6952

His increased risk is 1 in 30 for both mesothelioma and lung cancer. The firefighter has a risk of over 2/1000 for developing asbestosis, and would probably have abnormal radiological findings of the chest.

LAB METHODS FOR ASBESTOS, WAYS OF REPORTING RESULTS

This section may be helpful for interpreting the many different ways that asbestos levels are measured analytically, and also the many different ways these levels are reported.

PCM methods for air and bulk samples

The older method for measuring asbestos in air was by phase contrast microscopy (PCM). PCM measurements are reported as either structures/milliliter (s/mL) or fibers/milliliter (f/mL). PCM cannot detect fibers and structures with diameters smaller than 0.5 micrometers (0.5 μm or 0.5 um). PCM cannot distinguish asbestos fibers from non-asbestos fibers.

Thus, TEM measurements will give higher readings of asbestos fibers than PCM measurements if most of the fibers are actually asbestos, and if the asbestos fibers themselves have a significant fraction that are smaller than 0.5 μm. In WTC dusts, all the data I have seen indicates that TEM measurements are higher than PCM measurements of the same sample.

PCM is still used to determine whether workers are under the permissible exposure limit (PEL) by OSHA. The OSHA method requires reporting only of single fibers, not structures of asbestos (bundles and clumps of asbestos). The OSHA method also only alloys the counting of fibers 5.0 μm in length or longer. The OSHA method uses TEM in conjunction with PCM, but only to rule out those fibers found by PCM which were not asbestos. The TEM part of the OSHA method *is not* used to detect the smaller fibers that were not found by PCM.

PLM measurements for percent asbestos in bulk dust only

Polarized light microscopy (PLM) is used for bulk building materials, dust and debris samples to determine the percentage of asbestos.

Wipe and micro-vacuum samples for settled dusts

For thin settled dust layers, there is not enough to scoop up or place in a jar or bag. Thus, the PLM method above cannot be used. The settled dust must be sampled by either wiping or with a microvacuum. A microvacuum is a modified personal air sampling pump.

There are no EPA methods for either wipe samples or micro-vacuum samples. ASTM methods D-6480 (wipe sampling) and D-5755 (microvacuum) will most commonly give the results in units of structures/square centimeter. This is not a mass concentration - percentage.

Generally speaking, there is no readily available method to determine a mass percentage of asbestos in these settled dust layers, as you can using the PLM method above. There is one method, ASTM D-5756, a microvacuum method, which is designed to give results as mass concentration - percentage, but this method is rarely used, and very tedious and expensive in terms of laboratory time and effort.

TEM method for air samples and settled dust samples detects smaller fibers and structures

The best method of measuring asbestos in air is by transmission electron microscopy (TEM). TEM is a newer, more costly technique that can detect fibers smaller than 0.5 micrometers (0.5 μm or 0.5 um), which are missed by PCM. Thus, TEM measurements will give higher readings of asbestos fibers than PCM measurements if most of the fibers are actually asbestos, and if the asbestos fibers themselves have a significant fraction that are smaller than 0.5 μm. In WTC dusts, all the data I have seen indicates that TEM measurements are higher than PCM measurements of the same sample.

Difference between "fibers" of asbestos and "structures" of asbestos

Asbestos levels are given as "structures" or "fibers" or "structures + fibers." Asbestos structures include both individual fibers as well as bundles of fibers, clumps of fibers, and things like particles of plaster with fibers sticking out. Since around the mid 1980's, methods have included counting all structures, since in the environment and/or body, these can easily break down into individual fibers.

REFERENCES

1. Miele, J. A., Commissioner, Department of Environmental Protection, City of New York (October 25, 2001) letter to Residents of Lower Manhattan. Posted on the internet at www.nyeljp.org.

2. "In evaluating data from the World Trade Center and the surrounding areas, EPA is using a protective standard under AHERA, the Asbestos Hazard Emergency Response Act ... The measurements must be 70 or fewer structures per square millimeter before children are allowed inside." www.epa.gov/epahome/wtc/activities.htm

3. www.epa.gov/region8/superfund/libby/qsafe.html

4. ASTM Designation: D 6480-99. Standard Test Method for Wipe Sampling of Surfaces, Indirect Preparation, and Analysis for Asbestos Structure Number Concentration by Transmission Electron Microscopy. ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Available for $35.00 from the internet at www.astm.org.

5. Millette, J. R., and Hays, S. M. (1994), Chapter 8, Resuspension of Settled Dust, in: *Settled Dust Sampling and Analysis*, page 63, Table 2, Lewis Publishers, ISBN 0-87371-948-4

6. Chatfield, E. J., and Kominsky, J. R. (October 12, 2001) Summary Report: Characterization of particulate found in apartments after destruction of the World Trade Center. Requested by: "ground Zero" Elected Officials Task Force. Chatfield Technical Consulting, Mississauga, Ontario, Canada and Environmental Quality Management, Inc., Cincinnati, OH.

7. Granger, R. H., McKee, T. R., Millette, J. R., Chmielinski, P., and Pineda, G. (October 2, 2001) Preliminary Health Hazard Assessment: World Trade Center, HP Environmental, Inc., 104 Elden St., Herndon, VA 20170. Paper submitted to the American Industrial Hygiene Association.

8. Evaluation of Two Cleaning Methods for Removal of Asbestos Fibers from Carpet, US EPA Risk Reduction Engineering Laboratory, Cincinnati, OH 45268, Publication No. EPA/600/S2-90/053, April, 1991. Posted at www.epa.gov/ncepihom/nepishom. Also available from the National Technical Information Service.

Evaluation of Three Cleaning Methods for Removing Asbestos from Carpet: Determination of Airborne Asbestos Concentrations Associated with Each Method, US EPA Risk Reduction Engineering Laboratory, Cincinnati, OH 45268, EPA/600/SR-93/155, September 1993. Posted at at www.epa.gov/ncepihom/nepishom/

9. ATSDR (2000) TOXICOLOGICAL PROFILE FOR ASBESTOS, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES Public Health Service Agency for Toxic Substances and Disease Registry. Available by calling 1-888-42-ATSDR. At this time, only the final draft version is posted on the internet at www.atsdr.cdc.gov/toxprofiles/tp61.html.

10. ATSDR (2000) TOXICOLOGICAL PROFILE FOR ASBESTOS. *op. cit.*

11. See any of the air monitoring locations linked to the map at: www.epa.gov/enviro/nyc/asbestos/

12. EPA response to a Freedom of Information Act Request by the New York Environmental Law and Justice Project and Arts, Crafts, and Theater Safety. Posted at www.nyeljp.org.

13. Chatfield, E. J., and Kominsky, J. R., *op. cit.*

Granger, R. H., McKee, T. R., Millette, J. R., Chmielinski, P., and Pineda, G. *op. cit.*

14. EPA (1997) Rules of thumb for superfund remedy selection. Publication No. EPA 540-R-97-013, NTIS PB97-963301. Posted at www.epa.gov/superfund/resources/rules/

EPA (2000) Presenter's manual for: "Superfund Risk Assessment and How you Can Help". Publication No. EPA/540/R-99/013. Posted at www.epa.gov/superfund/programs/risk/vdmanual.pdf

15. ATSDR (2000) TOXICOLOGICAL PROFILE FOR ASBESTOS, *op cit.*, Section 54.1 states living in an urban area results in exposures of 0.000006 f/mL.

16. New York City Department of Health (2001) Responds to the World Trade Center Disaster, Recommendations for People Re-Occupying Commercial Buildings and Residents Re-Entering Their Homes. Posted at www.ci.nyc.ny.us/html/doh/html/alerts/wtc3.html

17. Mugdan, Walter (December 19, 2001) Regional Asbestos Coordinators and National Asbestos Coordinators Meeting for December, Conference call.

18. Chatfield, E. J., and Kominsky, J. R., op. cit.

19. Granger, R. H., McKee, T. R., Millette, J. R., Chmielinski, P., and Pineda, G. *op. cit.*

20. Granger, R. H., McKee, T. R., Millette, J. R., Chmielinski, P., and Pineda, G. *op. cit.*

21. See any of the air monitoring locations linked to the map at: www.epa.gov/enviro/nyc/asbestos/

22. www.nyeljp.org

regulations for other solid toxics indoors, based on the amount of the toxic substance per surface area.[49]

This is why tests for settled asbestos dust inside building are based on the number of asbestos structures per square centimeter (s/cm^2). This is true for either EPA's ultrasonication test for carpet, as well as for the ASTM 5755 microvacuum method for dusts on hard surfaces.

At least Region 1 was correct in deriving its interior dust standard for asbestos based on a surface concentration level (asbestos structures per square centimeter, or s/cm^2).

Region 2 reverses 1% standard for settled asbestos dust

EPA Region 2 has recently reversed their position that 1% asbestos in dusts is the benchmark for the WTC cleanup. In a March 21, 2002 statement to the press, EPA stated that the 1% level was only a "guideline," but not a health standard.[50]

> In the days after Sept. 11, federal officials repeatedly referred to two "standards," one for asbestos in dust and debris and another for asbestos fibers in air. For dust and debris, the agency standard was 1% asbestos content. . . . But as Jenkins explains in her memo, federal regulations never meant the 1% figure to be considered a health standard or even to be applied to measure dust.
> ...
> "We have never said it was a health standard," said the EPA's Mears about the 1%. "We're only using it as a guideline. We say clean up the dust and get rid of the dust regardless of whether it's 1% or below 1% — it doesn't matter."

In a January 25, 2002 speech, Counsel for Region 2, Walter Mugdan also stated that the 1% level was not a health standard, but only the detection limit of an older test method for asbestos:[51]

> Note that the 1% standard is not necessarily health- or risk-based, but rather keyed to the detection limits of the specified analytical method [PLM].

Even though Region 2 has backed off its 1% standard in the statements quoted above, it has yet to change its official statements on the EPA website which advise citizens of NYC on the hazards of WTC fallout.[52]

Will NYC DEP change its position on 1% asbestos dust inside buildings?

It remains to be seen whether or not the NYC DEP will reverse it position on 1% asbestos in dusts inside buildings. This is particularly important since the NYC DEP will be in charge of the decontamination of the most heavily impacted buildings near Ground Zero, those not even

occupied at the present time.

NYC DEP's imposition of the unsafe 1% standard is compounded by their insistence on using the insensitive PLM method to detect asbestos. As documented by analyses of the exact same dust samples by both Region 2 and NYC DEP, PLM tests will find no detectable asbestos whatsoever, while the use of the more sensitive EPA transmission electron microscopy (TEM) method can show up to 5%.[53] A news story in the Wall Street Journal documents the hazard posed by the NYC DEP's use of their 1% dust standard and the PLM method.[54]

APPENDIX A

CHART FOR ESTIMATING AIR ASBESTOS LEVELS FROM DUST

Table A provides conversions from settled dusts to air levels using "K-factors." This method is widely recognized, and used by EPA Region 1 in asbestos risk assessments.[55] It is used not only in the field of asbestos, but also for dusts containing other toxic substances such as lead, beryllium, uranium particles, alpha emitters, radioactive iodine, zinc sulfur powder, and microorganisms.[56] It involves using experimentally determined ratios of levels in surface dusts to air levels, depending on the amount of human activity that would stir up the dusts.

The air test used by EPA, the AHERA TEM clearance test, is not sensitive enough to measure asbestos at the very low concentrations that can cause asbestos-related diseases such as lung cancer, mesothelioma, and asbestosis. As discussed earlier, the test is also not reproducible, giving highly erratic results, even in situations of high asbestos contamination on surfaces.

If there is settled asbestos dust, there is a potential for it to become airborne at hazardous levels, no matter what was measured in a one-time snapshot air test. Both carpets, upholstered furniture, drapes, and hard surfaces such as floors can be tested for settled asbestos dust levels, as described in the preceding memorandum.

Table A allows the user to choose from several different K-factors, depending on the amount of activity that would resuspend dusts. These K-factors were experimentally determined from real world situations. The situations involved actual buildings and rooms contaminated with asbestos, such as after the San Francisco earthquake. Researchers measured the levels of asbestos on the surfaces. Then, people outfitted with proper protective gear entered the areas to simulate different human activities. Air asbestos levels were then measured. Then, the ratio between the dust level and the air level was calculated, which is the "K-factor".

The K-factors may be higher for WTC dust, because the asbestos is much more finely divided, and thus more likely to become airborne.

Table A – ESTIMATING AIR LEVELS FROM ASBESTOS DUST LEVELS

Uses asbestos risk assessment methodology of EPA Region 1 to calculate air levels from dust using the K-factors found by Millette, J. R., and Hays, S. M. (1994) Chapter 8. Resuspension of Settled Dust. In: *Settled Dust Sampling and Analysis*, Lewis Publishers, CRC Press.

DUST LEVEL x K-factor = AIR LEVEL , where the K-factor increases with increasing human activities that stir up dusts (resuspension)

MEASURED DUST LEVEL structures per square centimeter (s/cm^2)	**K-factor = 10^{-6}** activities where K-factor measured included vacuum cleaning carpet, cleaning storage area	**K-factor = 10^{-5}** activities where K-factor measured included gym-athletic activities, broom sweeping, installing cable above ceiling tiles	**K-factor = 10^{-4}** no activities studied resulting in this K-factor	**K-factor = 10^{-3}** activities where K-factor measured included warehouse with a fork lift
	multiply dust level by 0.000001 to get **AIR LEVEL (s/mL)**	multiply dust level by 0.00001 to get **AIR LEVEL (s/mL)**	multiply dust level by 0.0001 to get **AIR LEVEL (s/mL)**	multiply dust level by 0.001 to get **AIR LEVEL (s/mL)**
100	0.0001	0.001	0.01	0.1
500	0.0005	0.005	0.05	0.5
1,000	0.001	0.01	0.1	1
2,000	0.002	0.02	0.2	2
3,000	0.003	0.03	0.3	3
4,000	0.004	0.04	0.4	4
5,000	0.005	0.05	0.5	5
6,000	0.006	0.06	0.6	6
7,000	0.007	0.07	0.7	7
8,000	0.008	0.08	0.8	8
9,000	0.009	0.09	0.9	9
10,000	0.01	0.1	1	10
20,000	0.02	0.2	2	20
30,000	0.03	0.3	3	30
40,000	0.04	0.4	4	40
50,000	0.05	0.5	5	50
60,000	0.06	0.6	6	60
70,000	0.07	0.7	7	70
80,000	0.08	0.8	8	80
90,000	0.09	0.9	9	90
100,000	0.1	1	10	100
200,000	0.2	2	20	200
300,000	0.3	3	30	300
400,000	0.4	4	40	400
500,000	0.5	5	50	500
600,000	0.6	6	60	600
700,000	0.7	7	70	700
800,000	0.8	8	80	800
900,000	0.9	9	90	900
1,000,000	1	10	100	1000
2,000,000	2	20	200	2000
3,000,000	3	30	300	3000
4,000,000	4	40	400	4000
5,000,000	5	50	500	5000
6,000,000	6	60	600	6000
7,000,000	7	70	700	7000
8,000,000	8	80	800	8000
9,000,000	9	90	900	9000
10,000,000	10	100	1000	10000
50,000,000	50	500	5000	50000
100,000,000	100	1000	10000	100000