November, 2005

To: Dave Guinnup, Group Leader, Risk and Exposure Assessment Group, OAQPS

From: Neal Fann, Risk and Exposure Assessment Group, OAQPS

Re: Perchloroethylene Dry Cleaners Refined Human Health Risk Characterization

Overview

This memo and attached documents describe the methods by which EPA conducted its refined risk assessment of the Major Source and Area Source facilities within the perchloroethylene (perc) Dry Cleaners source category; EPA performed this assessment to inform a potential residual risk rule for these sources. EPA collected site-specific information for the 7 Major Source facilities that best represented the source category of 15 facilities; EPA created several "model facilities" to represent the dispersion and risk from all Area Source facilities; finally, EPA used indoor air monitoring data to characterize the inhalation risk to residents living in the close proximity to the smaller subset of area source dry cleaners co-located with residences. The assessment evaluated chronic cancer, chronic non-cancer and acute inhalation risk for a single hazardous air pollutant (HAP), perchloroethylene (perc). EPA used the Industrial Source Complex-Short Term (ISCST3) dispersion model with default regulatory options to estimate both pre and post-control inhalation exposure. To estimate risk, the assessment used dose-response values found on the EPA Air Toxics Website.[1] Finally, EPA used the TRIM.Expo$_{Inhalation}$ model to account for population exposure variability in the Major Source assessment.

Data Gathering

Major Sources

The Perchloroethylene Dry Cleaners National Emission Standards for Hazardous Air Pollutants (NESHAP) defines a Major Source as a facility that consumes over 2100 gallons of perc solvent per year; in the NESHAP, EPA estimates that these facilities will emit at least 50% of this solvent as a gas, amounting to at least 10 tons of HAP, meeting the definition of a Major Source. The perc dry cleaners Major Source MACT rule applies to 15 facilities. These facilities may be subdivided into three cleaning specializations–commercial, industrial and leather.[2] EPA collected site-specific information from 10 of the 15 facilities (9 surveys and 1 site visit) to develop a cross-section of the 3 specializations within the source category.[3] Facilities within each specialization tend to be homogenous with respect to factors that affect the emissions, pollutant dispersion, and population size in the modeling radius, allowing EPA to extrapolate risks from the facilities it modeled to those it did not.

[1] http://www.epa.gov/ttn/atw/toxsource/summary.html

[2] See Appendix I for a description of the 15 facilities in the source category and the three dry cleaning specializations (commercial, industrial, and specialty). Any survey that EPA sends to 10 or more entities is subject to OMB review. To avoid an adverse impact on the rulemaking schedule, EPA sent the survey to nine entities.

[3] Since receiving site-specific data for 10 facilities, EPA learned that 3 facilities were incorrectly identified as Major Source facilities and subsequently omitted these facilities from additional analysis.

The information EPA collected includes:[4]

- Source locations and emission points
- Building dimensions
- Annual purchases of perchloroethylene solvent
- Annual disposal of perchloroethylene in sludge or residual waste (still bottoms)
- Annual facility operating hours
- Locations of sensitive receptors, including neighboring houses[5]

Based on these survey and site-visit data, EPA estimated annual and hourly emissions by performing a mass balance calculation on perc concentrations.[6] Using this mass balance data, EPA then estimated annual average emission rates.[7] Finally, EPA estimated maximum one-hour emissions by dividing the total emissions level by the total number of operational hours at that facility and then accounting for hourly variation in these emissions. See the section on uncertainty and variability below for a description of how EPA accounted for variability in hourly emissions. Table one below provides a summary of emissions data by specialization.

Table 1: Summary Facility Characteristics of Major Source Perc Drycleaners

			Emissions (tons/year)		Throughput (tons/year)	
Specialization	*Total Facilities*	*Facilities Surveyed*	*Average*	*2 Standard Deviations*	*Average*	*2 Standard Deviations*
Commercial	5	1	8	11	255	173
Industrial	8	5	29	57	499	831
Leather	2	1	11	5	117	50

EPA also estimated post-control emissions for each control option; these include:

1. Enhanced Leak Detection and Repair (LDAR)
2. A refrigerated condenser and a carbon adsorber
3. A perchloroethylene vapor analyzer and drum lockout

[4] See Appendix II for a description of survey questions and data gathered. EPA gathered source data from the ALAC facility during a site visit on December 4, 2002. This information included building dimensions, stack height and velocity and emission estimates. Subsequent to this visit, EPA contacted the facility to gather additional information about ALAC's stills; EPA used this latter information to develop an emissions estimate that was consistent with the methodology it used for the other facilities.

[5] Sensitive receptors include the locations of humans with increased toxicant susceptibility. See Appendix III for a summarized input file for the ALAC facility.

[6] EPA calculated a mass balance emissions estimate by assuming that perc emissions were equal to total perc purchases (in gallons) minus waste (still bottoms, waste oil, and cartridge filters). For a full description of the mass-balance technique, see Appendix IV.

[7] Two facilities possessed stacks. To derive the stack emissions at these facilities, EPA consulted the design flow rate of the carbon adsorber.

While LDAR reduces leaks, the latter options reduce process emissions. Option one, Enhanced LDAR, requires facilities to locate and repair equipment leaks, which reduces the amount of perc that they will consume. Options two and three require facilities to install additional emissions control technology. Currently about half of the major source dry cleaning facilities use either a refrigerated condenser or a carbon adsorber, but not both; option two would require these facilities to install these "secondary controls." Finally, in option three, facilities would use the perchloroethylene vapor analyzer in conjunction with option two. The analyzer and lockout mechanism ensures the performance of the secondary controls by prolonging the carbon adsorption cycle until the perc concentration in the drum falls to a predetermined point; the lockout prevents users from opening the door prior to cycle completion, therefore preventing high concentrations of perc from exiting the drum.

EPA estimates emissions reductions for each control option as the pounds of perc lost as a proportion of tons of clothing cleaned. By consulting a study by the South Coast Air Quality Management District (SCAQMD), EPA derived emission factors to calculate total perc emissions as a proportion of tons of clothing cleaned. See Appendix IV for a complete description of the estimates.

Area Sources

The NESHAP defines an Area Source as a facility that consumes less than 2100 gallons of perc solvent per year, which amounts to less than 10 tons of HAP per year. EPA estimates that there are approximately 27,000 area source perc dry cleaners. Because large-scale data collection is impractical, EPA employed a "model facility" approach, using available data on solvent use, emissions, and facility dispersion parameters to create several example facilities that represent the population of area sources. EPA attempted to ensure that the model facilities would adequately represent worst-case perc emissions and dispersion; specifically, that the model facility assessment would be health protective. Note that area source dry cleaners co-located with residences are addressed separately throughout this document.

EPA used solvent use data from the state environmental agencies of Delaware and Tennessee, multiplied by a range of equipment-specific emissions factors, to develop a distribution of emissions as a basis for dispersion modeling.[8] This solvent use and emissions data are in the table below.

Table 2: Distribution of Perchloroethylene Solvent Purchased for Area Source Perc Dry Cleaners

	Average	*99th percentile*	*Maximum*	*Standard Deviation*
Purchase/Usage (gal per year per facility)	120	930	1,700	170

[8] EPA used SCAQMD, Final Staff Report Proposed Amendment Rule 1421, Control of Perchloroethylene Emissions from Dry Cleaning Systems, October 18, 2002 for emission factors for secondary controls and engineering judgment to develop the remainder. The factors are as follows: transfer machines emit 93% of perc used; vented machines emit 85% of perc used; machines with primary controls emit 71% of perc used; machines with secondary controls emit 50% of perc used.

Table 3: Distribution of Solvent Purchase and Emissions for Area Source Perc Dry Cleaners

	Facility Emissions (lbs/year)			
Equipment Type	*Average*	*99th percentile*	*Maximum*	*Standard Deviation*
Transfer (First generation equipment)	1,497	11,631	21,406	2,087
Vented (Second generation equipment)	1,369	10,630	19,565	1,908
Refrigerated Condensor Only (Third generation equipment)	1,143	8,880	16,342	1,594
Refrigerated Condensor and Carbon Adsorber (Fourth generation equipment)	805	6,253	11,509	1,122

EPA created five facilities that shared common facility parameters. To ensure that it was making health-protective assumptions regarding pollutant dispersion, EPA varied the location of each of these five facilities to account for changes in meteorology. These summary characteristics are in table 4 below.[9]

Table 4: Summary Characteristics for Five Model Area Source Dry Cleaning Facilities

City/Region	*Urban/Rural Dispersion Modeling Option*	*Pollutant Emissions*	*Nearest Receptor*	*Emissions (tons/year)*
Ray County, Kansas	Rural	50%fugitive/50% stack	20 meters	8
Northern Florida	Rural	50%fugitive/50% stack	20 meters	8
Washington, DC	Urban	50%fugitive/50% stack	20 meters	8
Detroit, MI	Urban	50%fugitive/50% stack	20 meters	8
Northern California	Urban	50%fugitive/50% stack	20 meters	8

Co-residential Area Sources

Residents living in the same building as an area source dry cleaner may receive significantly higher exposure than other non-collocated receptors due to their close proximity to the source.[10] Because of this higher potential for exposure, EPA considered these sources as a subset of the area sources. Since the source and the receptor are located in such close proximity, air dispersion modeling is not practical. EPA used indoor air monitoring data for these sources. EPA collaborated with the New York Department of Health (NYDOH) and the New York Department of Environmental Conservation (NYDEC) to use two sources of indoor air monitoring data. The first source of data comes from the NYDEC compliance efforts, in which the agency has monitored indoor air concentrations in apartments across the state in response to complaints. The

[9] For an example of model plant release parameters, see Appendix V.

[10] See: Schreiber, Judith S. et. al., "Apartment Residents' and Day Care Workers' Exposures to Tetrachloroethylene and Deficits in Visual Contrast Sensitivity. *Environmental Health Perspectives* 110:655-664 (2002); New York Department of Health Bureau of Toxic Substance Assessment, "Investigation of Indoor Air Contamination in Residences Above Dry Cleaners." October 1991.

second source of data comes from a NYDOH epidemiological study in New York City from 2001-2003; EPA funded this study through a Science to Achieve Results (STAR) grant.[11]

The monitoring duration for the 2001-2003 data was generally 24 hours, and the apartments (or receptors) in which NYDOH placed the monitors were in the same building as the facility. Tables 5 and 6 below summarize the chronology of regulatory development in New York, as well as the number of samples and the geometric mean of the monitored concentrations in each regulatory time period for these data:[12]

Table 5: NY Regulatory Requirements for Co-Located Perc Dry Cleaners Over Time

Time Period		*Key New York Regulatory Requirements*
1	Pre-NESHAP: Prior to September 23, 1993	Before NESHAP took effect
2	NESHAP: September 23, 1993 to May 14, 1997	After NESHAP was established but before NYS Part 232 took effect; control requirements based on Perc purchases
3	Part 232: May 15, 1997 to November 14, 1997	Only new equipment allowed to be used in dry cleaning shops; transfer machines prohibited
4	Part 232: November 15, 1997 to May 14, 1999	First and second generation equipment required to achieve compliance; new shops required to install third or fourth generation units[13]
5	Part 232: May 15, 1999 to December 24, 1999	Last date to comply with vapor barrier/room enclosure requirement; training certification required for all new facilities
6	Part 232: December 25, 1999 to December 31, 2000	Mandatory yearly facility inspections
7	Part 232: January 1, 2001 to August 5, 2003	Upgrade second generation machines to fourth generation; retrofit or upgrade third generation machines to fourth generation machines; only fourth generation machines sold, leased or installed.

[11] Contract number R827446, "Improving Human Health Risk Assessment for Tetrachloroethylene by Using Biomarkers and Neurobehavioral Testing in Diverse Residential Populations." The principal investigator in this study is using these data to publish several papers. As of April, 2005, the paper titled "Tetrachloroethylene Levels in Residential Dry Cleaning Buildings in Diverse Communities in New York City," was accepted for publication in *Environmental Health Perspectives* in June of 2005.

[12] A summary of the NYDEC and NYDOH data are in Appendix VI below.

[13] See table three above for association between machine generation and level of control.

Table 6: Average Monitored Exposures of Perc for Seven Regulatory Time Periods in New York State

	Time Period	*Number of Samples*	*Geometric Mean Concentration Among Sampled Apartments (µg/m^3)*	*Standard Deviation (µg/m^3)*
1	Pre-NESHAP: before 1993	52	610	11
2	NESHAP: 1993 to 1997	705	507	8
3	Part 232: May to Nov. 1997	142	150	6
4	Part 232: Nov. 1997 to May 1999	407	155	8
5	Part 232: May 1999 to Dec. 1999	181	251	5
6	Part 232: Dec. 1999 to Dec. 2000	115	236	6
7	Part 232: Jan. 2001 to Aug. 2003	556	98	7

The NYDOH epidemiological study is a subset of the monitoring data from the period between 2001 and 2003 (time period 7 in Table 6 above). These data have two advantages compared to earlier data: (1) investigators did not select apartments to monitor entirely on the basis of complaint (previous data sets were entirely complaint-based); (2) the monitoring period occurred during the final phase of the implementation of the rigorous Part 232 regulations, allowing EPA to assess the effectiveness of these controls for the purposes of rulemaking.[14] For these reasons, EPA decided to use this set of monitoring data to assess risks from co-residential sources.

In the 2001-2003 dataset, monitors (3M organic vapor monitors) were placed in apartment living areas. Approximately 25% of all samples were collected in duplicate in addition to field and laboratory blanks which were below detection. NYDOH took care to place monitors approximately six feet away from direct sources of ventilation; these include windows, air conditioners and fans. All NYDOH sampling occurred during week days, beginning between 3 and 9pm. Monitoring generally lasted for either approximately 24 hours or 1 to 2 hours.

[14] The articles notes on page 9 that "Early analytical results indicated that indoor air perc levels in most apartments in dry cleaner buildings sampled were below, or only slightly above, the NYSDOH residential air guideline of 100 µg/m3. Higher levels were found in dry cleaner buildings located in low-income, minority neighborhoods and in buildings elsewhere that had been the subject of a residential complaint. Since successful completion of the NYC Perc Project required that as many apartments as possible with elevated perc levels be identified, the strategy for identifying buildings for inclusion was modified so that buildings located in minority or low-income ZIP code areas and those that had been the subject of complaint were prioritized." The article goes on to state on page 17 that the sample "obtained is not truly a random sample of all dry cleaners in the study area. However, socioeconomic characteristics of the census block groups where sampled buildings are located reflect socioeconomic characteristics of their larger ZIP Code area, are equivalent to census block groups where buildings that were not sampled are located, and are correlated with sampled household self-reported socioeconomic characteristics. Thus, conclusions drawn with respect to sampled building neighborhood characteristics and indoor air perc level are likely to be applicable to other residential buildings matching NYC Perc Project building inclusion criteria (e.g. dry cleaner using perc on-site; no other sources of VOC)."

Dispersion Modeling and Monitoring Data

EPA used a dispersion model to estimate inhalation exposure concentrations for the Major area sources, while it used indoor air monitoring data to estimate inhalation exposure for residents in co-residential settings.

Major Source Dispersion Modeling

EPA selected the ISCST3 steady-state Gaussian plume dispersion model for the refined assessment because it can estimate ambient air concentrations at multiple receptor locations, originating from multiple emission points. The two principal limitations of the ISC model are that it is less accurate in complex terrain and is generally only accurate up to 50 kilometers. For this assessment, neither limitation was significant; none of the modeled dry cleaners were located in complex terrain, and the relatively high volatility of perc did not make a larger modeling radius necessary.

To estimate pollutant dispersion, ISC requires three main inputs:

1. *Source Data*. This includes facility location, emission rate, physical stack location, inside stack diameter and stack gas temperature. Emissions of perc typically originate from exhaust fans, windows, and doors (fugitive emissions); in some dry cleaning facilities, emissions also originate from vents that exhaust from a carbon adsorber (stack emissions). EPA modeled all fugitive emissions as volume sources and all stack emissions as point sources, providing the model with emission point locations, release heights and emission rates. For those facilities that emitted perc from stacks, EPA calculated building downwash using the Building Profile Input Program (BPIP).
2. *Meteorological Data*. This includes the 5 consecutive years of hourly surface and upper-air data from the nearest, or most representative, meteorological station. For a complete listing of meteorological station locations EPA used in the modeling, see Appendix I.
3. *Receptor Location*. EPA selected receptor locations based on the Census block centroids within a 10-kilometer radius surrounding the facility.[15] EPA used facility survey responses to select receptor locations representing existing homes in close proximity to the facilities.

In creating the input file for the model runs, EPA combined the source parameters, meteorological data and model receptor locations above with the default regulatory modeling options below to create a single input file. EPA made the health-protective assumption that perc does not undergo any chemical reactions and that no other removal processes, such as wet and dry deposition, act on the plume during its transport from the source to the receptor. To

[15] While the ISCST3 model is generally accurate up to a radius of 50 kilometers, we performed a sensitivity analysis which showed that for these sources, we could reduce the model domain to a radius of 10 kilometers with a negligible effect on cancer incidence, saving considerable computational time. And, because of the dispersion characteristics of dry cleaning facilities (with fugitive emissions having a much larger influence on MIR than stack emissions), MIR should be unaffected by a smaller modeling radius. See Appendix XI for a full description.

determine whether to select the urban or rural dispersion option, EPA used the Auer land classification method.[16]

Finally, EPA performed a model run for each unique combination of five years of annual meteorological data, emission rate type (i.e. maximum, annual average) and level of emission control. These model runs estimated exposures and associated risks of developing cancer or adverse noncancer effects, for both pre- and post-control scenarios.[17] EPA was not aware of any perc monitors within the modeling domain of any of the facilities, and so was unable to compare modeled to monitored concentrations.

Area Source Dispersion Modeling

Before conducting new dispersion modeling for area sources, EPA first analyzed existing data, including the 1999 National Air Toxics Assessment (NATA). NATA provides census tract level estimates of exposure and risk for a subset of the 188 HAPs, including PCE through the use of the Assessment System for Population Exposure Nationwide (ASPEN). The ASPEN model simulates the impacts of atmospheric processes (winds, temperature, atmospheric stability, etc.) on pollutants after they are emitted. The output of this air dispersion model is an estimate of the annual average ambient concentration of each air toxic pollutant at the centroid of each census tract within the geographic scope of the assessment.[18]

After using NATA to perform a course-scale screening-level assessment, EPA then performed site-specific dispersion modeling. For these area sources (excluding co-residential sources), EPA chose the ISCST-3 steady-state Gaussian plume dispersion model to estimate ambient air concentrations of perc. EPA provided the model with source data, meteorological data and receptor locations (described above). However, to ensure that the assessment was modeling worst-case emissions and dispersion, EPA made several health-protective assumptions in each input. First, in providing source data for the model, the Agency assumed that each facility was emitting the maximum quantity of HAP (8 tons); EPA also assumed that emissions originated equally from both stack and fugitive sources. Second, to ensure that it was accounting for worst-case meteorology, EPA modeled facilities in both rural and urban environments. Finally, because receptors tend to be located in close proximity to area source dry cleaners, EPA assumed that the nearest receptor was 20 meters from each facility.

As with the Major Source assessment, in creating the input file for the model runs, EPA combined the source parameters, meteorological data and model receptor locations above with the default regulatory modeling options below to create a single input file. EPA made the health-protective assumption that perc does not undergo any chemical reactions and that no other removal processes act on the plume during its transport from the source to the receptor. Finally, EPA performed a model run for each unique combination of five years of annual meteorological data, emission rate type (i.e. maximum, annual average) and level of emission control.

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[16] See: Auer, Jr., A.H., 1978. "Correlation of Land Use and Cover with Meteorological Anomalies." *Journal of Applied Meteorology*, 17(5): 636-643. This method involves accounting for the land use/land cover in the area surrounding a facility to infer whether this area is "urban" or "rural" for the purposes of dispersion modeling.

[17] When modeling dispersion to reflect post-control emissions, there are two changes to the site parameters—the emissions for each control option (which decrease incrementally) and the stack exit temperature, which decreases with the addition of a refrigerated condenser.

[18] For more information regarding the NATA assessment, see: http://www.epa.gov/ttn/atw/nata/.

Co-Residential Area Source Indoor Air Monitoring

To estimate cancer and non-cancer risks for co-residential area sources, EPA derived annual average concentrations for each sample in the 2001-2003 data set by extrapolating each of the 24-hour average monitored concentrations. To calculate this one-year extrapolation, EPA used its knowledge about facility characteristics to make the following assumptions:

1. *Monitoring occurred during a day of normal facility operation*. All of the 24-hour monitoring periods took place during a week day, when the facility was assumed to be open.
2. *The monitor received perc from the facility only*. The study controlled for other sources of perc, including dry cleaned clothing within the apartment, and other facilities that might use perc.
3. *The average facility operates 6 days a week*. Facilities generally operate from 8 to 7 on week days and 4 hours on Saturday.[19]
4. *Most facilities were in compliance with Part 232 regulations*. The NYDOH provided information regarding the compliance status for each sampled facility. To calculate risks, we used sample data for facilities that were in compliance with the Part 232 regulations (i.e. vapor barriers and four generation dry cleaning equipment); see appendix VI for a additional analysis that summarizes risk estimates stratified by compliance status.
5. *Perc remains present in apartments during non-operating hours*. Some studies have shown perc to remain in building materials and subsequently re-emit.[20]

The factors listed above suggest that the 24-hour samples represent a reasonable annual average in these apartments. Table 7 below summarizes these extrapolated 1-year annual averages by providing a distribution of monitored concentrations.

Table 7: Summary of Monitored Perc Concentrations in Apartments Co-Located with Area Source Dry Cleaners

Summary Statistic	*Monitored Value ($\mu g/m^3$)*
Lower 5th Percentile	5
50th Percentile	15
Geometric Mean	30
Upper 95th Percentile	700
Maximum Value	5,000

[19] Engineering judgment, informed by site visits to area source dry cleaners.

[20] See: Holger Gulyas and Lutz Hemmerling, "Tetrachloroethene Air Pollution Originating from Coin-Operated Dry Cleaning Establishments," *Environmental Research* 53, 90-99 (1990). Scrheiber et. al., "Apartment Residents' and Day Care Workers' Exposures to Tetrachloroethylene and Deficits in Visual Contrast Sensitivity. *Environmental Health Perspectives* 110, 661 (2002).

The distribution of exposures among apartment residents is heavily skewed. Exposures for most residents are below 30 μg/m^3. However, exposures at the upper-end of the distribution are over 700 μg/m^3, indicating that the distribution is skewed right. The skewed shape of the distribution may be attributable to:[21]

- *Variable attention to work practices*. Even facilities with no history of Part 232 rule violations may occasionally fail to follow proper work practices. Such failure could include leaving the vapor barrier door open during cleaner operation, allowing perc to escape the enclosure and transport into adjacent apartments.
- *Poor ventilation*. Older buildings tend to have poorly sealed pipe chases and more cracks in walls and ceilings, which can allow perc to transport to adjacent residences. Apartments with poor ventilation can cause high levels of perc to remain resident in the apartment for longer periods of time.

Routes of Exposure

Perc exhibits a relatively high volatility and low reactivity, and is neither persistent nor bioaccumulative in the environment. For these reasons, the assessment focused on the inhalation exposure pathway only. Further, perc is not among those HAPs for which EPA typically considers a multiple pathway risk assessment.[22] As Appendix VII notes, perc is not among those substances that either the Toxics Release Inventory, Great Waters program or the Pollution Prevention program list as being persistent, bioaccumulative and toxic; further analysis, using the EPA Persistent, Bioaccumulative and Toxic (PBT) profiler, did not identify perc as a PBT.

To estimate inhalation risk, EPA used the ambient outdoor concentrations at the receptor locations (generally census block centroids) as surrogates for estimated human inhalation exposure. This is a reasonable first approximation since most people spend the majority of their time at home; therefore, the average long-term concentration at a home location is a good approximation of a persons' exposure concentration, particularly for those homes in close proximity to the facility. Also, for some pollutants, long-term average indoor and outdoor concentrations are similar. Therefore, although these estimated exposures are possible, and may even be higher, EPA expects that most people will receive lower exposures.[23]

Potential Ecological Effects

The chemical properties of perchloroethylene suggest that once it is emitted into the atmosphere as a vapor, it is not likely to partition significantly into soil, water, or sediment. Based on fugacity modeling, we estimate that 99.8% of ambient perchloroethylene remains in the

[21] The discussion that follows is drawn from McDermott MJ, Mazor KA, Shost SJ, Narang RS, Aldous KM, Storm JE. Tetrachloroethylene (PCE, Perc) levels in residential dry cleaner buildings in diverse communities in New York City. Environ Health Perspect. 2005 Oct;113(10):1336-43.

[22] See: "Selection of Persistent and Bioaccumulative HAPs for Multipathway Risk Assessments," Memo from Roy Smith to Dave Guinnup, August 20, 2003, Appendix VII. The memo describes what HAPs should trigger a multiple pathway risk assessment.

[23] EPA also considered both short-term behaviors (e.g., movement among Census blocks or microenvironments) and long-term behaviors (e.g., relocation out of the assessment area) for the Major Source assessment as part of the TRIM.Expo analysis in the section on variability and uncertainty below.

atmosphere, with the remainder partitioning into water (0.17%), and soil (0.05%).[24] Thus, perchloroethylene emitted from major stationary sources is not likely to pose a significant ecological risk due to any exposure pathway other than inhalation.

Further, to assess the potential inhalation risk to mammals from PCE inhalation, we compared the minimum Lowest Observable Adverse Effect Level (LOAEL) for rats with the highest level of modeled ambient concentration from PCE cleaners; the rat LOAEL for PCE can be found in the ATSDR toxicological profile that documents the development of the MRL (http://www.atsdr.cdc.gov/toxprofiles/tp18.html). The lowest rat LOAEL (9 ppm, or 60 mg/m3) is about 2,000 times higher than the highest modeled post-control ambient concentrations from major stationary sources. This large margin of exposure leads us to conclude that risks to mammals from PCE inhalation are insignificant, obviating the need to further quantify ecological risks to any degree.

In the atmosphere, perchloroethylene is known to degrade into many compounds, including trichloroacetic acid. Trichloroacetic acid is a persistent, known phytotoxin, which has been discontinued as a herbicide. Atmospheric transformation of perchloroethylene to trichloroacetic acid is the subject of great debate, with potential conversion efficiencies estimated to be on the order of 5-15%.[25] However, there are very few data quantifying trichloroacetic acid concentrations in the air, precipitation, water, soil, or sediment in the United States. This scarcity of data makes it difficult to determine whether there is any potential for adverse ecological impacts to plant life from perchloroethylene emissions from dry cleaners due to this conversion to trichloroacetic acid.

Dose-Response Values for Health Risk Assessment

The main effects of PCE in humans are neurological, liver, and kidney damage following acute (short-term) and chronic (long-term) inhalation exposure. The results of epidemiological studies evaluating the relative risk of cancer associated with perc exposure have been mixed; some studies reported an increased incidence of a variety of tumors, while other studies did not report any carcinogenic effects. Animal studies have reported an increased incidence of liver cancer in mice, via inhalation and gavage (experimentally placing the chemical in the stomach), and kidney and mononuclear cell leukemia in rats.

Although PCE has not yet been reassessed under the Agency's recently revised Guidelines for Cancer Risk assessment[26], it was considered in one review by the EPA Science Advisory Board to be intermediate between a "probable" and "possible" human carcinogen (Group B/C)[27] when assessed under the previous 1986 Guidelines. Since that time, the U.S. Department of Health and Human Services has concluded that PCE is "reasonably anticipated to be a human

[24] Mackay, D. "Multimedia Environmental Models: The Fugacity Approach" Lewis Publishers, Inc., Chelsea, MI, 1991.
[25] Lewis, T.E. Wolfinger, T.F., and Barta, M.L. (2004) The ecological effects of trichloroacetic acid in the environment. Atm. Environ. 30 (2004) 1119-1150
[26] USEPA. 2005. Guidelines for Carcinogen Risk Assessment. EPA/650/P-03/001B. Risk Assessment Forum, Washington, DC
[27] March 9, 1988 letter to Lee Thomas, Administrator, U.S. Environmental Protection Agency, from Norton Nelson, Chair, Executive Committee of EPA Science Advisory Board.

carcinogen[28]," and the International Agency for Research on Cancer has concluded that PCE is "probably carcinogenic to humans[29]."

Effects other than cancer associated with long-term inhalation of PCE in worker or animal studies include neurotoxicity, liver and kidney damage, and, at higher levels, developmental effects. To characterize noncancer hazard in lieu of the completed IRIS assessment, we used the Agency for Toxic Substances and Disease Registry's Minimum Risk Level (Table 8).[30] This value is based on a study of neurological effects in workers in dry cleaning shops, and is derived in a manner similar to EPA's method for derivation of reference concentrations, and with scientific and public review.

The IRIS chemical assessment for perc is currently being revised. This revision may affect the present assessment's estimates of cancer and non-cancer risk; the current schedule indicates that the IRIS assessment may not be available for this rulemaking. Because EPA has not yet issued a final IRIS document for perchloroethylene, to estimate cancer risk, EPA used the California EPA (Cal EPA) URE and the Office of Prevention, Pesticides and Toxics (OPPTS) URE. Among the available Acute Reference Levels (ARL), the one-hour California REL is the most appropriate to use in the assessment because it may be used to characterize acute risk for exposure an exposure duration of one hour. In contrast, the ATSDR acute MRL is appropriate to characterize acute risk for up to 14-days of exposure. The dose-response values are as follows:

[28] USDHHS. 1989. Report on Carcinogens, Fifth Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.
[29] IARC. 1995. Monographs on the evaluation of carcinogenic risks to humans. Volume 63. Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals. ISBN 9283212630. Geneva, Switzerland.
[30] ASTDR. 1997. Toxicological Profile for Tetrachloroethylene. Department of Health and Human Services, Public Health Services, Agnecy for Toxic Substances and Disease Registry, Atlanta, Georgia.

Table 8: Perchloroethylene Dose-Response Values

Endpoint	*Source*	*Value*
Cancer	Cal EPA[31][32]	5.9E-06 cancer risk per ug/m^3 continuous lifetime exposure
Cancer	OPPTS[33]	7.1E-07 cancer risk per ug/m^3 continuous lifetime exposure
Chronic Non-Cancer	ATSDR[34]	0.27 mg/m^3 continuous chronic exposure
Acute non-cancer	Cal EPA[35]	20 (1-hour) mg/m^3 continuous acute exposure
Acute non-cancer	ATSDR[36]	1.2 (14-days) mg/m^3 continuous acute exposure

[31] Cal EPA based its assessment on a 2-species animal study conducted by the National Toxicology Program (NTP) in 1986. Animals were exposed via inhalation for 6 h/d, 5 d/wk. The exposure caused an increased incidence of mononuclear cell leukemia in male and female rats, and of liver tumors in male and female mice. (National Toxicology Program (NTP) 1986. NTP Technical Report on the Toxicology and Carcinogenesis Studies of Tetrachloroethylene (Perchloroethylene) (CAS Number 127-18-4) in F344/N Rats and B6C3F1 Mice (Inhalation Studies). NTP TR 311, NIH Pub. No. 86-2567. Research Triangle Park, NC.)

[32] In the 2005 paper in *Critical Reviews in Toxicology* by Clewell et al states "In the OEHHA PHG derivation, body surface area scaling (to the 3/4 power) is also applied to the amount metabolized per unit body weight estimated by PBPK modeling. However the recent U.S. EPA [2003 draft] cancer guidelines indicate that when pharmacokinetic tissue dosimetry is used in a risk assessment, **no body surface area scaling should be performed**." [emphasis added]

However, EPA believes that the statement in bold is incorrect and is not what the 2003 nor final 2005 cancer guidelines state or imply. The 2005 cancer guidelines state "When toxicokinetic modeing is used without toxicodynamic modeling, the dose-response assessment develops and supports an approach for addressing toxicodynamic equivalence, perhaps by retaining some of the cross-species scaling factor (e.g., using the square root of the cross-species scaling factor or using a factor of 3 to cover toxicodynamic differences between animals and humans, as is currently done in deriving inhalation reference concentrations USEPA 1994])." This same language is in the 2003 draft cancer guidelines. So, the implication that the OEHHA assessment is in error is not correct.

[33] The EPA Office of Pollution Prevention and Toxics (EPA, 1998) based its URE on an earlier EPA analysis (USEPA, 1986) supplemented by calculations consistent with the 1996 draft of EPA's guidelines for carcinogen risk assessment (EPA, 1996). EPA (1986) and consequently EPA (1998) used the same NTP study that Cal EPA used to develop its URE. The EPA (1998) analysis updated the EPA (1986) interspecies conversion calculations and regrouped the animal data to avoid double-counting tumors. EPA (1998) then extrapolated linearly from the 95% lower confidence limit of the "effective dose" that produced tumors in 10% of the test animals (ED_{10}) to arrive at a unit risk estimate of 7.1 x 10^{-7} per µg/m^3 of tetrachloroethylene in air.

[34] ATSDR based its assessment on a study of 60 women exposed for 10 years in dry cleaning shops. The exposed subjects showed significant increases in reaction times in a battery of neurobehavioral tests http://www.atsdr.cdc.gov/toxprofiles/tp18-a.pdf .

[35] OEHHA (1999) based its assessment on a study by Stewart et al. (1970), who exposed human subjects to 100 ppm (700 mg/m³) tetrachloroethylene for 7 hours. Subjects exhibited effects to the central nervous system, as indicated by abnormal Romberg tests (which test balance and position sense) and other symptoms including headache and light-headedness, all noted after 3 hours of exposure. The exposure concentration was considered a lowest observed adverse effect level (LOAEL); the study did not report a no observed adverse effect level (NOAEL). OEHHA (1999) extrapolated this 3-hour LOAEL to a 1-hour LOAEL concentration of 1200 mg/m³, and applied an uncertainty factor of 6 to extrapolate to a NOAEL and an uncertainty factor of 10 to account for sensitive human subpopulations. The resulting acute REL for 1-hour exposures was 20 mg/m³.
http://www.oehha.ca.gov/risk/ChemicalDB/cancerpotency.asp?name=Tetrachloroethylene&number=127184

[36] ATSDR based its assessment on a study of 28 male volunteers exposed for parts of four days in a chamber. They were subjected to an extensive battery of cognitive and psychomotor tests, plus mood ratings, before and after exposure. Significant performance deficits were observed at the LOAEL.
http://www.atsdr.cdc.gov/toxprofiles/tp18-a.pdf

Risk Estimates

EPA estimated the maximum individual risk (MIR) for chronic cancer risk and chronic non-cancer hazard from inhalation exposure. The MIR combines the highest estimated exposures with health-protective dose-response values to characterize the highest estimated cancer risk and non-cancer hazard to an exposed individual in areas where people live.[37] For Major sources, EPA estimated cancer risk at each facility by multiplying the average of the five annual average concentrations for each receptor by the perc inhalation Unit Risk Estimate (URE):[38]

$$\text{Cancer Risk} = \text{Exposure Concentration } (\mu g/m^3) * \text{URE } (\mu g/m^3)^{-1}$$

To arrive at an estimated facility-specific annual cancer incidence, EPA multiplied the upper-bound cancer risk at each census block centroid by the population of that census block, summing across all census blocks within the modeling radius and dividing by 70 years.[39]

To estimate chronic non-cancer hazard, EPA calculated a chronic noncancer hazard quotient (HQ) by dividing the maximum annual average concentration across all five years by an appropriate noncancer benchmark for perc:[40]

$$HQ = \text{Exposure Concentration } (mg/m^3) / \text{MRL } (mg/m^3)$$

The HQ represents a simple ratio between the estimated maximum individual exposure likely to be without appreciable risk of deleterious effects. To estimate risk from acute (1-hour) exposure, EPA compared the maximum one-hour concentration modeled off-site to the Reference Exposure Level (REL) for perc.[41] To summarize the results, EPA compared maximum one-hour

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[37] According to the Benzene NESHAP, MIR is "…an estimate of the upper bound of risk based on conservative assumptions, such as continuous exposure for 24 hours per day for 70 years. As such, it does not necessarily reflect true risk, but displays a conservative risk level which is an upper bound that is unlikely to be exceeded."

[38] The inhalation URE is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air. EPA applies the term "upper-bound" to UREs because they incorporate protective assumptions in their extrapolation from high to low doses, and (in many cases) from animal data to projected effects on humans. Actual carcinogenic potency is likely to be less, although there remains a possibility it could be greater.

The interpretation of unit risk is as follows: if unit risk = 1.5×10^{-6}, on average 1.5 people out of 1,000,000 people are expected to develop cancer as a result of daily exposure over their lifetime to perc concentrations of 1 µg of the chemical in $1m^3$ of air. Moreover, EPA uses the average of five annual average years of dispersion modeling because the Agency considers cancer risk to be proportional to a person's total exposure over an entire lifetime, and EPA extrapolates these five years of modeling data over the course of a 70 year assumed lifetime.

[39] The EPA Cancer Guidelines (EPA, 2005) states that slope "factors generally represent an upper bound on the average risk in a population or the risk for a randomly selected individual but not the risk for a highly susceptible individual or group. Some individuals face a higher risk and some face a lower risk. The use of upper bounds generally is considered to be a health-protective approach for covering the risk to susceptible individuals, although the calculation of upper bounds is not based on susceptibility data."

[40] EPA uses health benchmarks from multiple sources for risk assessment. For perc, we used a minimum risk level (MRL) developed by the US Agency for Toxic Substances and Disease Registry. A chronic MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a period of exposure greater than one year. And, because non-cancer effects can occur after exposures shorter than a lifetime, EPA assumes that adverse non-cancer effects can occur after exposure as short as a year.

[41] The California EPA Office of Environmental Health Hazard Assessment has developed dose-response assessments for many substances, based both on carcinogenicity and health effects other than cancer. The process for developing these assessments is similar to that used by EPA to develop IRIS values and incorporates significant

concentrations against the acute (1-hr) REL only, because it represents the most health-protective acute threshold.

EPA modeled emissions after MACT-level controls as well as emissions for various control options beyond MACT. The subsections that follow characterize the risk for both of these modeling results.

Major Source Assessment: MACT-Level Risk

Table 9 below describes the results of the chronic assessment for MACT-level plant emissions. The analysis suggests that all seven facilities pose MIR at or greater than one in one million using Cal EPA and the OPPTS URE. Using the ATSDR MRL, one facility poses a Hazard Quotient above 1, while the remainder of the facilities are less than one.

Table 9: Maximum Estimated Incremental Lifetime Individual Cancer Risk and Non-Cancer Hazard by Major Source Dry Cleaning Facility—MACT-Level Emissions

	Maximum Individual Cancer Risk (per Million)		*Hazard Quotient*
Facility	Cal EPA URE	OPPTS URE	ATSDR MRL
ALAC	2,400	300	1.60
Libra Industries (IL)	400	50	0.3
Bergmann's	200	30	0.2
Midwest Industrial	150	20	0.1
LeatherRich	140	20	0.1
White Tower	60	8	0.05
Libra Industries (MI)	6	1	0.002

Appendix VIII depicts the spatial distribution of cancer risk and non-cancer hazard at the ALAC facility. Table 10 below shows the ratio of the maximum one-hour concentration at each facility to the Cal EPA Reference Exposure Level (REL) for MACT-level emissions. The risks of one facility exceed the REL by over a factor of 3, while the remainder of the facilities pose risks well below this threshold. Generally, if maximum one-hour concentrations fall below the REL, acute risk is not a concern. Appendix IX describes EPA methodology for estimating maximum one-hour emissions, and the conditions that might create worst-case emissions.

external scientific peer review. The non-cancer information includes available inhalation health risk guidance values expressed as acute inhalation and oral reference exposure levels (RELs). Cal EPA defines the REL as a concentration level at (or below) which no health effects are anticipated, a concept that is similar to EPA's non-cancer dose-response assessment perspective.

Table 10: Acute Thresholds by Major Source Facilities

Facility	*Percentage of REL*	*Percentage of REL, Accounting for Worst-Case Hourly Emissions Variability*
ALAC	337%	2,022%
Libra Industries (IL)	43%	86%
Bergmanns	19%	76%
Midwest Industrial	20%	40%
LeatherRich	16%	32%
White Tower (Mass)	4%	24%
Libra Industries (MI)	0.5%	1%

Major Source Assessment: Post-Control Risk

The post-control risk assessment evaluated the incremental risk reduction that each control option produces. Table 11 describes the change in MIR and population risk for each control option, assuming that these options work sequentially and in unison. The table below displays population risk for the full source category. To extrapolate the population risk from 7 to 15 facilities, EPA assumed that these 7 facilities represented 46% (that is, 7/15) of the population risk of the total source category and multiplied the total population at each level of risk by the inverse of this proportion. As the table indicates, the application of the most health protective control technology reduces the MIR from about 2,400 to about 300 in one million using the Cal EPA URE. Using the OPPTS URE, risks are approximately 10-fold lower. Post-control Hazard Quotients decrease to about 0.2.

Table 11: Summary of Maximum Individual and Population Risk by Dry Cleaning Emissions Control Option: Cal EPA URE & ATSDR MRL

	Risk to Individual Most Exposed[42]		*Population at Cancer Risk (in a million)*			*Population Affected by Hazard Quotient Level*
	Cancer (per Million)	Non-Cancer Hazard Quotient	≥100	≥10	≥1	≥1
MACT-Level	2400	2	1,200	30,000	400,000	500
LDAR	500	0.4	20	6,000	200,000	20
Refrigerated Condenser and Carbon Adsorber	300	0.2	10	2,000	60,000	6
Drum Lockout	200	0.1	6	900	30,000	0

[42] Cancer risk computed using the Cal EPA URE, which is more health protective than the OPPTS URE by about an order of magnitude. Non-cancer hazard calculated using the ATSDR MRL.

Table 11: Summary of Maximum Individual and Population Risk by Dry Cleaning Emissions Control Option: OPPTS URE & ATSDR MRL

	Risk to Individual Most Exposed[43]		*Population at Cancer Risk (in a million)*			*Population Affected by Hazard Quotient Level*
	Cancer (per Million)	Non-Cancer Hazard Quotient	≥100	≥10	≥1	≥1
MACT-Level	300	2	10	2,000	40,000	500
LDAR	60	0.4	0	100	8,000	20
Refrigerated Condenser and Carbon Adsorber	30	0.2	0	20	2,000	6
Drum Lockout	20	0.1	0	6	1,000	0

[43] Cancer risk computed using the Cal EPA URE, which is more health protective than the OPPTS URE by about an order of magnitude. Non-cancer hazard calculated using the ATSDR MRL.

Table 12: Summary of Cancer Incidence by Control Option[44]

Control Option	*Estimated Cancer Incidence (per year)*	*Estimated Cancer Incidence Reduction from Baseline*	*Estimated Incremental Incidence Reduction*
MACT-Level	0.03161	----	----
LDAR	0.01298	-0.02	-0.02
Refrigerated Condenser and Carbon Adsorber	0.00539	-0.03	-0.008
Drum Lockout	0.00323	-0.03	-0.002

Table 12 describes annual cancer incidence for all facilities. Column one lists the estimated cancer incidence per year; column two shows the reduction in cancer incidence from baseline, while column three describes the marginal reduction in incidence from one control technology to the next. The far-right column of table 13 below indicates that all facilities pose acute risk below the REL threshold for the most health-protective option:

Table 13: Perchloroethylene Acute Thresholds Post-Control for Major Source Dry Cleaning Facilities

Facility	*Percentage of REL*	*Percentage of REL, Accounting for Worst-Case Hourly Emissions Variability*
ALAC	20%	120%
Libra Industries (Illinois)	6%	12%
Bergmanns	3%	12%
Midwest Industrial	2%	4%
LeatherRich	7%	14%
White Tower	1%	6%
Libra Industries (Michigan)	<1%	<1%

Area Sources: GACT-Level Risk

The results of the chronic assessment for GACT-level plant emissions for area sources (excluding co-residential sources) are shown in Tables 14 and 15. Table 14 provides the estimated number of individuals exposed at each level of risk, as derived from the NATA

[44] Estimated lifetime incremental cancer incidence associated with exposure to perc emissions from all 15 facilities in the source category, extrapolated as described on page 14, using upper-end of draft IRIS range.

screening-level assessment. To estimate these population risks, EPA multiplied the proportion of total PCE emissions from area source dry cleaners (approximately 60%) by total PCE exposure at each census tract and then summed the number of individuals at each level of risk.

Table 14: NATA-Derived Population Risk for Free-Standing Area Source PCE Dry Cleaners

	Maximum Individual Cancer Risk (per million)		
Dose-Response Value	100 in a million	10 in a million	1 in a million
OPPTS	0	0	970,000
Cal EPA	0	400,000	56,000,000

The screening analysis above suggests that a large number of people are at one in a million or greater cancer risk using the Cal EPA URE. Table 15 below summarizes the maximum individual risk at each of the model facilities. The analysis suggests that, assuming worst-case emissions, all five model facilities pose maximum individual cancer risk greater than one in one million. Assuming worst-case emissions, none of the five facilities pose a Hazard Quotient greater than one using the ATSDR MRL.[45] EPA derived the estimates of cancer risk and non-cancer hazard below by modeling dispersion from a facility with primary controls (i.e. a refrigerated condenser), because these facilities compose the largest proportion of total area source facilities.

Table 15: Maximum Estimated Incremental Lifetime Individual Cancer Risk and Non-Cancer Hazard by Area Source Dry Cleaning Facility—Maximum GACT-Level Emissions

	Maximum Individual Cancer Risk (per million)		*Hazard Quotient*
City/Region	Cal EPA URE	OPPTS URE	ATSDR MRL
Ray County, Kansas	220	30	0.1
Northern Florida	200	20	0.1
Washington, DC	200	20	0.1
Detroit, MI	200	20	0.1
Northern California	100	20	0.08

[45] All risk and hazard numbers rounded to one significant figure.

EPA used the NATA-derived results to provide a screening-level estimate of cancer incidence. Table 16 below displays annual incidence using both the Cal EPA and the OPPTS dose-response values.

Table 16: NATA-Derived Estimate of Annual Cancer Incidence for Free-Standing PCE Dry Cleaners

Dose-Response Value	*Annual Incidence*
OPPTS	0.4
Cal EPA	4

Table 17 below describes the ratio of the maximum one hour off-site concentration at each facility to the Cal EPA Reference Exposure Level (REL) for GACT-level emissions. The Cal EPA REL is the most health-protective one-hour acute threshold available. Even when EPA assumed that one-hour emissions could vary by a factor of six to account for worst-case one-hour concentrations, no facility generated emissions that exceeded the acute REL.

Table 17: Perchloroethylene Acute Thresholds for GACT-level Emissions for Model Area Source Facilities

City/Region	*Percentage of REL*	*Percentage of REL, Accounting for Worst-Case Hourly Emissions Variability*
Ray County, Kansas	8%	47%
Northern Florida	9%	54%
Washington, DC	5%	32%
Detroit, MI	3%	17%
Northern California	2%	10%

Area Sources: Post-Control Risk

For area sources (excluding co-residential sources), EPA evaluated the cancer and non-cancer risk reduction from two control technologies. These include enhanced Leak Detection and Repair (LDAR) and Secondary Controls (refrigerated condenser and carbon adsorber). Table 18 below notes the estimated number of facilities that use each machine type as well as the estimated emission reduction produced by each control technology.

Table 18: Estimated Emissions Reductions for Area Sources by Machine Type

Machine Type	*Estimated Number of Facilities*	*Estimated GACT-level Emissions (tons/year)*	*Control Option and Cumulative Emissions Reduction*			
			Leak Detection and Repair (tons/year)	Cumulative Percentage from Baseline	LDAR+ Secondary Controls (tons/year)	Cumulative Percentage from Baseline
Transfer	200	800	170	20%	725	88%
Vented	200	400	80	20%	300	75%
Refrigerated Condenser	7,500	7,600	1,500	20%	3,800	50%
Refrigerated Condenser and Carbon Adsorber	12,500	7,200	900	13%	900	13%

Table 19 below describes how the estimated post-control risk varies by machine type, assuming the maximum level (8 tons) of perc emitted.[46] EPA calculated these risk estimates by using the worst-case model facility from the GACT-level assessment above and simply scaling its emission rate in proportion to the machine type emission control efficiency from Table 18.

Table 19: Estimated Maximum Individual Cancer Risk for Area Sources by Machine Type and Control Option using the Cal EPA URE[47]

Machine Type	*Control Option and Maximum Individual Cancer Risk (per million)*		
	GACT-level	Leak Detection and Repair	LDAR+Secondary Controls
Transfer	340	280	160
Vented	310	250	160
Refrigerated Condenser	220	170	160
Refrigerated Condenser and Carbon Adsorber	190	160	--

[46] EPA calculated this maximum emission estimate by using solvent use data from the states of Tennessee and Delaware. See page 3 above.

[47] Risk estimates calculated using the OPPTS, rather than Cal EPA, URE would be approximately one order of magnitude lower.

Because no facility posed significant acute risk under GACT-level emissions, EPA inferred that acute risk would remain low after the application of either control technology, i.e. neither control technology should increase acute risk. Finally, EPA could not estimate cancer incidence using model facilities.

Co-Residential Area Source Risk

Table 20 below summarizes the inhalation individual cancer risk posed by area source dry cleaners co-located with residences, when presuming lifetime exposure at 5th percentile, median, geometric mean, 95th percentile and maximum measured indoor concentrations.

Table 20: Summary of Co-Residential Area Source Inhalation Cancer Risk[48]

	Estimated Lifetime Cancer Risk (per million)	
Distribution of Exposure	Cal EPA URE	OPPTS URE
Lower 5th Percentile[49]	30	4
Median	100	10
Geometric Mean	200	20
Upper 95th Percentile	4,100	500
Maximum	30,000	4,000

Using the Cal EPA URE, estimated lifetime cancer risks estimated in this way are well above one-hundred in a million for most residents; this is above the Benzene-NESHAP generally defined acceptable level for maximum individual risk of 100 in 1 million.

Data limitations make it difficult to estimate cancer incidence for all co-located facilities accurately. Specifically, EPA lacks data regarding: (1) the number of exposed apartments co-located with PCE area source dry cleaners; (2) the number of residents in each of these apartments; (3) the PCE exposure at each un-monitored apartment.

Nonetheless, to develop a screening-level estimate of incidence, EPA first calculated annual incidence for the residents in the monitored apartments. We assumed that four residents lived in each of the 65 monitored apartments in the 24 buildings. We then simply multiplied the monitored exposure concentration by the cancer unit risk estimates and the assumed number of individuals in the apartment, summed the total incidence and then divided by 70 to derive an annual estimate. Using this method we estimated a lifetime incidence of between 0.06 and 0.5 for

[48] Risk estimates calculated using indoor air monitoring from apartments in compliance with Part 232 regulations.
[49] The lowest 5th percentile of exposure is equal to the non-detect limit of the monitors, which is 5 $\mu g/m^3$.

the monitored apartments using the OPPTS and Cal EPA URE, respectively. Annual incidence is between 0.008 and 0.07, respectively.

To estimate total annual incidence for all buildings, we linearly extrapolated the estimate above to the remaining apartments in the monitored buildings and then to the remaining estimated 1276 facilities. First, we extrapolated incidence to the remaining apartments in each monitored building by assuming that a total of 10 apartments received exposure, and that the un-monitored apartments in each building received exposure equal to the average of the monitored exposures in that building. Then, we summed the incidence for all the monitored buildings, and since the 24 monitored buildings represent slightly less than 2 percent of the all co-located buildings, we scaled our building-wide estimate by multiplying it by the inverse of this percent. Table 21 below provides a summary of the resulting cancer incidence estimates and the major assumptions.

Table 21: Lifetime and Annual Cancer Incidence Estimates for Residents of Apartments Co-Located with Area Source Dry Cleaners

	Annual Incidence Estimate		*Lifetime Incidence Estimate*	
Exposed Population	Cal EPA URE	OPPTS URE	Cal EPA URE	OPPTS URE
Monitored Buildings[i]	0.07	0.008	0.5	0.06
All Buildings[ii]	2.2	0.3	153	19

[i]Assumptions for monitored buildings: 4 people per apartment; 70-year continuous exposure

[ii]Assumptions for all buildings: Unmonitored apartments receive average of all monitored exposures; 4 residents per apartment; 70-year continuous exposure

Note that the estimates above are very sensitive to assumptions regarding: (1) the extent to which the monitored buildings are representative of all apartment buildings in which an area source dry cleaner is located; (2) the number of individuals exposed; and, (3) the level and duration of their exposure, limiting their utility. Nonetheless, they suggest that a screening-level approximation of the cancer incidence due to PCE exposures in residential buildings with dry cleaners lies between 0.3 and 2.2 cases per year.

Table 22 below summarizes the inhalation chronic non-cancer hazard posed by area source dry cleaners co-located with residences, when presuming chronic exposure at the 5th percentile, median, geometric mean, 95th percentile and maximum measured indoor concentrations. Table 20 below summarizes this chronic risk.

Table 22: Summary of Co-Residential Area Source Chronic Noncancer Hazard

Distribution of Exposure	*Estimated Hazard Quotient*
Lower 5th Percentile[50]	0.02
Median	0.1
Geometric Mean	0.1
Upper 95th Percentile	3
Maximum	20

EPA also performed an acute analysis using the 24-hour monitored concentrations. The ATSDR MRL is most appropriate for comparison because it is derived as a screening tool for 1 day to 14 day exposures. Table 23 below summarizes acute hazard quotients using this value:[51]

Table 23: Ratio of 24 Hour Monitored Concentrations to ATSDR MRL Acute Perchloroethylene Thresholds

Distribution of Exposure	*Monitored Value (µg/m^3)*	*Percentage of MRL*	*Percentage of REL*
Lower 5th Percentile	5	3%	0.03%
50th Percentile	15	1%	0.1%
Geometric Mean	30	3%	0.2%
Upper 95th Percentile	695	60%	3%
Maximum Value	5,000	400%	30%

As mentioned above, NY requires the most rigorous controls available, which were the highest levels of control in place at that time. However, as Table 18 shows, EPA estimates that most monitored apartments are receiving cancer risk well above 100 in 1 million using the Cal EPA URE and above 10 in a million using the OPPTS URE. In the absence of control technologies or work practices more stringent than those NY requires, EPA considered two options to reduce risk:

1. *Phase-out new facilities co-located with residences*. EPA would prohibit new facilities from using perc if they are located in residential buildings

[50] The lowest 5th percentile of exposure is equal to the non-detect limit of the monitors, which is 5 µg/m^3.
[51] These acute calculations represent *all* 1-2 hour monitored concentrations from the NYDOH epidemiological study dataset, rather than just the subset of facilities that demonstrated compliance; the compliance-only dataset contained very few 1-2 hour measurements.

2. *Phase-out existing and new facilities co-located with residences*. EPA would require existing facilities to relocate to a non-residential building, and prohibit new facilities from locating in residential buildings.

Cancer and non-cancer risks attributable to co-located area source dry cleaners would eventually fall to zero under both of these options.

Uncertainty and Variability

The assessment above uses site-specific facility representations and emissions data, reasonable dispersion modeling assumptions and health-protective exposure assumptions. This approach generates risk estimates which are likely to be higher, and are unlikely to be lower, than the actual risks that these facilities are currently posing to the exposed population. Estimates of emissions, air dispersion, exposure and dose-response contribute to uncertainty in the analysis.

Major Source Assessment Exposure Uncertainty

There is some uncertainty in EPA estimates of acute and chronic emissions. Because EPA used modeled short- and long-term concentrations as surrogates for exposure concentration, uncertainties are associated with these emission estimates. EPA derived the emissions estimates from site specific data using a mass-balance approach.[52] To perform a mass-balance calculation, facilities must sample their still-bottoms to measure the amount of perc solvent; this is a procedure they typically perform as part of waste characterization. However, this process suffers from two sources of uncertainty: First, the tests used to analyze these samples posses a small amount of measurement error (which is unbiased). Second, and more significantly, waste characterization does not require facilities to estimate the level of perc in their waste with a high degree of accuracy, and facilities may tend to under-report this number. Both of these uncertainties suggest that facilities will underreport the amount of perc in their waste, leading EPA to overestimate air emissions because of the mass balance approach.

Another source of uncertainty is facility ventilation parameters, which can increase both MACT-level, and to a lesser extent post-control level, maximum one-hour emissions to a level of between 2 to 6 times the one-hour value EPA used to calculate acute risk in the risk characterization section above.[53] For all facilities, acute concentrations emitted should be higher for the first load of the day, as perc has accumulated in the drum overnight; facilities with better ventilation will see higher acute concentrations because they exhaust this air to the outside at a higher rate. For some facilities, peak emissions will increase due to the failure of that facility to adequately maintain their carbon adsorber; control options that include a refrigerated condenser greatly reduce the probability of such an event. Appendix IX describes how these maximum one-hour emissions might change for each facility. Note that such a unique combination of worst-case meteorology (which the assessment has generally accounted for by using 5 years of site-specific meteorology) and worst-case variation in maximum one-hour emissions—producing a very high estimate of acute risk—would be a low-probability event.

[52] See the section on TRIM.Expo below for a discussion of how EPA attempted to minimize this source of uncertainty

[53] See Appendix IX for a discussion of how EPA estimated acute emissions.

Finally, due to the lack of a readily available source of data describing the quantitative emissions reductions for each control option, EPA derived post-control emissions estimates by developing a solvent mileage for each option; this process likely introduced additional uncertainties.[54]

The dispersion model was less uncertain than the parameters above: EPA used site-specific release parameters; the ISCST3 dispersion model has shown itself to be reasonably accurate for estimating annual average and maximum one-hour concentrations. The lack of site-specific meteorological data is unlikely to have a significant effect on the model's estimates of ambient concentration. However, it is possible for perc to penetrate the exterior of buildings surrounding these facilities and re-emit from interior surfaces; this assessment cannot consider the potential for this exposure.

Major Source Dose-Response Uncertainty

Among the variables in Table 22, uncertainty with respect to the dose-response values is probably the most significant. Both the cancer and non-cancer benchmarks were developed from a limited number of animal and human studies, and therefore incorporate important health-protective assumptions regarding extrapolation between species and potential effects on sensitive human subpopulations. Furthermore, EPA is developing a new IRIS dose-response assessment for both cancer and non-cancer effects. This assessment has the potential to alter inhalation risk estimates for PCE.

Table 24 below summarizes this uncertainty:

[54] See Appendix IV for a description of the emissions reductions associated with each control option and the methodology EPA used to make these emissions reductions estimates. Solvent mileage is the amount of solvent required to clean a given amount of clothing; lower solvent mileage indicates larger air emissions of perc.

Table 24: Qualitative Evaluation of Assessment Uncertainty in Major Source Dry Cleaners Human Health Risk Assessment for Perc Dry Cleaners

Variable	*Level of Uncertainty*	*Likely Direction of Bias Due to Uncertainty*
Exposure Uncertainty		
Emissions Estimates	Medium	High
Release Parameters	Low	Unbiased
Dispersion Model	Low	Unbiased
Meteorology	Low	Unbiased
Exposure	Medium	High
Dose-Response Uncertainty		
Cal EPA, OPPTS and ATSDR Toxicity Values	Medium	High

Finally, the individual cancer risks presented here assume that individuals living within the modeling radius will receive continuous exposure to the projected ambient concentrations for 70 years. However, individuals may move through areas (microenvironments) of differing concentrations during their daily activities. In consideration of this, EPA conducted an exposure variability analyses in which it used the Total Risk Integrated Methodology Exposure model (TRIM.Expo, also known as the Air Pollutant Exposure Model 3, or APEX3). TRIM.Expo uses a personal profile approach in which it stochastically simulates exposures for individuals of differing demographic characteristics and associated daily activity patterns. The model output provides a distribution of exposure estimates which are intended to be representative of the study population with respect to their demographically based behavior, in terms of the microenvironments through which they move during a day and throughout a year.[55] The model randomly samples the associated databases to create hypothetical individuals representative of the Census described population and simulates each individual's movements through time and space, including movement among census blocks as pertinent to an individual's commuting activity.[56] In this analysis, the annual exposure concentration estimates for each individual modeled are used as surrogates for lifetime exposure estimates for the study population.

Tables 25 and 26 below contrast the ISCST-3 and TRIM estimates of population risk for the worst-case facility:[57]

[55] For more information on the TRIM.Expo model, see: http://www.epa.gov/ttn/fera/.
[56] See Appendix X for a complete description of the creation of the TRIM.Expo input file and processing steps.
[57] Note that the ISCST-3 risk estimates do not match those for the worst-case Major Source facility. This discrepancy is due to the fact that EPA modeled this facility multiple times, and the estimates below reflect earlier modeling data.

Table 25: Comparison of ISCST-3 Exposure Estimates with Activity-patterned/day, lifetime exposure (ISC+TRIM.Expo)--Cancer Risk[58]

Model	*Total Population at Cancer Risk*			*Maximum Value*
	>1E-4	>1E-5	>1E-6	
ISCST-3	900	14,000	75,000	3.3E-4 (MIR)
TRIM.Expo	400	9,000	80,000	3.24E-4

Table 26: Comparison of ISCST-3 Exposure Estimates with Activity-patterned/day, lifetime exposure (ISC+TRIM.Expo)--Non-Cancer Hazard

Model	*Total Population at Non- Cancer Hazard*		*Maximum Value*
	>10	>1	
ISCST-3	0	200	8.6 (MIR)
TRIM.Expo	0	0	0.8

The TRIM results suggest that by accounting for variability in exposure, there are a smaller number of total individuals exposed at almost every level of cancer risk and non-cancer hazard; however, TRIM does estimate that a slightly larger number of individuals are exposed at a cancer risk of at least one in one million.

There are some limitations to this analysis. First, TRIM.Expo creates simulated individuals; for this assessment the model generated the same number of simulated individuals as actual individuals. These simulated individuals are distributed across the study area, and so some census blocks may be over-represented, while others may be under-represented. In this case, the assessment omitted 14 census blocks; these omitted blocks contained between 1 and 2 people. TRIM.Expo also omitted any blocks for which the US census counted 0 people, which amounted to 311 blocks. Thus, out of the 2,079 blocks, EPA omitted a total of 325. Second, because TRIM.Expo uses demographic characteristics to model behavior, and because EPA ran TRIM.Expo for a single year, calculating 70-year cancer risks likely introduced some error. Each simulated individual will be of a different age, and hence will have varying lifespans. The TRIM.Risk module, available since Fall of 2004, accounts for the specific demographics of the study population in calculating 70 year cancer risk. The estimates of risk above, however, make

[58] EPA derived these risk estimates using the CalEPA URE only

the health-protective assumption that individuals receive the TRIM.Expo derived exposure for 70 years.

Area Source Exposure and Dose-Response Uncertainty

There is some exposure uncertainty in the area source assessment that is unique from the major source assessment because it used a "model facility" approach. In this process, it used available data on solvent use, emissions, and facility dispersion parameters to create several example facilities that represent the population of area sources. EPA estimates that there are approximately 27,000 area source perc dry cleaners, making large-scale data collection impractical. In estimating emissions, EPA used a distribution of solvent use and emission factors. To estimate emissions from each type of dry cleaning machine, it used a different emission factor (see source characterization section above for a discussion of the emissions estimate methodology). These estimates are likely to be biased toward being more health protective.

In developing model facility dispersion parameters, EPA attempted to ensure that the model facilities would adequately represent typical area-source facilities under worst-case perc emissions and dispersion. This process likely biased the assessment toward being more health protective. By modeling five facilities, EPA attempted to account for some of the variability in meteorology across all 27,000 dry cleaning facilities. It is possible that EPA did not fully capture this variability in its selection of model facility sites. EPA employed a model facility approach using fence line receptors to account for individuals living in close proximity to the facility. This method, as well as the assumption that individuals receive continuous exposure for 70 years, may have biased exposure estimates upward.

Finally, the non-co-located Area source assessment shares the dose-response uncertainties of the Major Source assessment.

Table 27: Qualitative Evaluation of Assessment Uncertainty in Area Source Dry Cleaners Human Health Risk Assessment for Perc Dry Cleaners

Variable	*Level of Uncertainty*	*Likely Direction of Bias Due to Uncertainty*
Exposure Uncertainty		
Emissions Estimates	Medium	High
Release Parameters	Medium	High
Dispersion Model	Low	Unbiased
Meteorology	Low	High
Exposure	Medium	High
Dose-Response Uncertainty		
Cal EPA, OPPTS and ATSDR Toxicity Values	Medium	High

Co-Residential Area Source Exposure and Dose-Response Assessment Uncertainty

There is some uncertainty in EPA estimates of the exposures received by residents in apartments located above dry cleaners. NYDOH collected monitoring samples for the purposes of informing an epidemiology study examining visual acuity among residents living in close proximity to perc dry cleaners. To estimate lifetime cancer risk, EPA typically uses five consecutive years of annual average concentrations. In this case, EPA extrapolated 24-hour samples into annual averages. While EPA believes this extrapolation is reasonable (for the reasons described in the risk characterization section above), this process likely introduces some uncertainties. For example, it is possible that the period during which NYDOH collected the sample was unrepresentative of the remainder of the year because the facility had a particularly large volume of cleaning, which increased emissions. However, the fact that NYDOH collected monitors from multiple facilities is likely to have reduced this chance. Moreover, while the NY study sought to minimize the chance that its monitors would capture perc from sources other than dry cleaners, such an event is possible.[59]

The data may contain a selection bias as well due to the fact that the authors were principally undertaking an epidemiological study, rather than a human health risk assessment to support rulemaking efforts. McDermott (2005) notes on page 9 that "[e]arly analytical results indicated that indoor air perc levels in most apartments in dry cleaner buildings sampled were below, or only slightly above, the NYSDOH residential air guideline of 100 µg/m3. Higher levels were found in dry cleaner buildings located in low-income, minority neighborhoods and in buildings

[59] For example, perc may come from nail shops, freshly dry-cleaned clothing, or from off-gassing in the apartment.

elsewhere that had been the subject of a residential complaint. Since successful completion of the NYC Perc Project required that as many apartments as possible with elevated perc levels be identified, the strategy for identifying buildings for inclusion was modified so that buildings located in minority or low-income ZIP code areas and those that had been the subject of complaint were prioritized." Thus, exposures may be biased high. The article goes on to state on page 17 that the sample "obtained is not truly a random sample of all dry cleaners in the study area. However, socioeconomic characteristics of the census block groups where sampled buildings are located reflect socioeconomic characteristics of their larger ZIP Code area, are equivalent to census block groups where buildings that were not sampled are located, and are correlated with sampled household self-reported socioeconomic characteristics. Thus, conclusions drawn with respect to sampled building neighborhood characteristics and indoor air perc level are likely to be applicable to other residential buildings matching NYC Perc Project building inclusion criteria (e.g. dry cleaner using perc on-site; no other sources of VOC)."

Further, the exposure assessment assumes that residents will receive continuous exposure for 70 years. For most apartment residents, exposure duration will be shorter. Table 28 below provides a sensitivity analysis that varies this exposure duration using the 95th percentile exposure duration.

Table 28: Estimated High-End Cancer Risk and Non-Cancer Hazard for Residents of Co-Located Apartments: Exposure Duration Sensitivity Analysis

	Assumed Exposure Duration				
	70 Years	*50 Years*	*30 Years*	*20 Years*	*10 Years*
Risk per million (Cal EPA)	4,000	3,000	2,000	1,000	600
Risk per million (OPPTS)	500	400	200	100	80
Hazard Quotient (ATSDR)	7	5	3	2	1

Risk calculated assuming: (1) apartment residents receive exposure at 95th percentile of monitored concentrations from area source cleaners for duration noted; and (2) exposure falls to New York urban background (11 ug/m3) for PCE during years in which residents move away from area source cleaner

Finally, the co-located Area source assessment shares the same dose-response uncertainties as the Major Source assessment.

Table 29: Qualitative Evaluation of Assessment Uncertainty in Co-Residential Area Source Dry Cleaners Human Health Risk Assessment for Perc Dry Cleaners

Variable	*Level of Uncertainty*	*Likely Direction of Bias Due to Uncertainty*
Exposure Uncertainty		
Monitoring data	Low	Unbiased
Exposures	Medium	High
Dose-Response Uncertainty		
Cal EPA, OPPTS and ATSDR Toxicity Values	Medium	High

Key Findings

The assessment above helps characterize the cancer risk and non-cancer hazard that major and area sources pose. In summary:

- At MACT-level emissions, all major sources pose a cancer risk of greater than one in a million, one facility poses an HQ over one, and one facility poses significant acute hazard
- After the application of the most health protective control technology, cancer risk among major sources drops below one hundred in a million for all but one facility; non-cancer hazard drops below one
- Using available emissions data, area sources emitting below the 99th percentile of all facilities pose estimated cancer risk well below one hundred in a million and an estimated non-cancer hazard below one; no area sources appear to pose acute hazard
- Some residents of sampled apartments co-located with area source dry cleaners in this study receive very high exposures and, in association, have a high estimated risk of cancer.

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List of Appendices

I. Characteristics of dry cleaners affected by Major Source NESHAP, source of meteorological data for dispersion modeling
II. Copy of survey EPA sent to dry cleaning facilities
III. Sample summary ISC dispersion model input file
IV. Description of emissions estimates methodology and flow diagram of mass-balance calculation for ALAC facility
V. Sample model facility parameters for Area Source assessment
VI. Further analysis of indoor air monitoring data
VII. Memo from Roy Smith to Dave Guinnup noting what Hazardous Air Pollutants should trigger a multiple pathway risk assessment
VIII. Map of spatial distribution of MACT-level and post-control inhalation cancer risk around ALAC facility
IX. Memo from Mike Heaney, ERG consulting to Rhea Jones, engineering lead for perc dry cleaners project, describing methodology for estimating acute emissions
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XI. Memo from Neal Fann to Dave Guinnup describing reasons for using 10-kilometer dispersion modeling radius in Major Source assessment

Table 1 - Dry Cleaners Affected by Major Source Requirements

In order of decreasing usage	City	State	2002 Purchases	PCE Controls[1]	PCE Machines	Surveyed	Mileage (lb/gal)
Industrial							
ALAC Garment Services	Anderson	IN	18,144	vented	3	visited	119
White Tower Industrial Laundry	Detroit	MI	9,514	vented	8	yes	264
Libra Industries, Inc.	Chicago	IL	6,875	RC	10	yes	244
Circle Environmental	Columbia	SC	4,032	RC+CA	2	yes	--
Complete Laundering Services	Oregon	OH	3,211	RC+CA	6	no	--
Midwest Industrial Laundry	St. Joseph	MI	1,500	RC+CA	2	yes	233
Libra Industries of Michigan	Jackson	MI	1,004	RC+CA	2	yes	335
Spic and Span, Inc.	Milwaukee	WI	0	RC+CA	1	no	
Leather							
Leather Rich	Oconomowoc	WI	2,067	RC+CA	8	yes	137
Acme Sponge & Chamois Co.	Tarpon Springs	FL	1,346	RC+CA	2	no	--
Commercial							
Bergmann's Inc.	Arlington	VA	4,376	RC	5	yes	203
Jim Massey's (Formal Wear)	Montgomery	AL	3,200	RC	4	no	--
Sam Meyer Formal Wear	Louisville	KY	1,101	RC	3	no	--
Quality Chinese Laundry	Brooklyn	NY	884	RC+CA	4	visited	--
Peerless Cleaners	Fort Wayne	IN	700	RC	4	no	--
		Total	57,954				

Facility Information

Facility	Location	Population within 10 km	Met Data Information	
			Surface Air Data	Upper Air Data
ALAC	Anderson, IN	81,913	Indianapolis, IN	Dayton, OH
Bergmann's Inc.	Arlington, VA	875,959	Washington, DC	Sterling, VA
Leather Rich	Oconomowoc, WI	43,542	Milwaukee, WI	Green Bay, WI
Libra Industries (IL)	Chicago, IL	1,615,969	Chicago, IL	Green Bay, WI
Libra Industries (MI)	Jackson, MI	95,332	Lansing, MI	Flint, MI
Midwest Industrial Laundry	Saint Joseph, MI	59,952	South Bend, IN	Flint, MI
White Tower Industrial Laundry	Detroit, MI	633,862	Detroit, MI	Flint, MI

PERCHLOROETHYLENE DRY CLEANING FACILITY SURVEY

1. COMPANY INFORMATION

Company Name _____

Contact Person & Title _____

Phone Number _____

Fax Number _____

E-mail Address (Home or Business) _____

Facility Address _____

City, State, Zip _____

Mailing Address _____

City, State, Zip _____

Dun and Bradstreet Number of Facility (if applicable) _____

Dun and Bradstreet Number of Parent Company (if applicable) _____

2. BUSINESS INFORMATION

Business Type: Retail [ ] Industrial [ ] Wholesale [ ] Other (Please Describe) _____

For this section, please explain whether the data reported in this survey are from all of 2002 or other time frame

Less than $25,000…[ ] $25,000 - $49,999…[ ] $50,000 - $99,999...[ ]
$100,000 - $174,999...[ ] $175,000 - $249,999...[ ] $250,000 - $499,999…[ ]
$500,000 - $1.9 million...[ ] $2 million - $4.9 million...[ ] $5 million - $9.9 million...[ ]
Greater than $10 million...[ ]

Annual Receipts of Parent Company (if applicable):

Less than $25,000…[ ] $25,000 - $49,999…[ ] $50,000 - $99,999...[ ]
$100,000 - $174,999...[ ] $175,000 - $249,999...[ ] $250,000 - $499,999…[ ]
$500,000 - $1.9 million...[ ] $2 million - $4.9 million...[ ] $5 million - $9.9 million...[ ]
Greater than $10 million...[ ]

Percent Facility Annual Receipts from Dry Cleaning (excluding laundry, wet cleaning, other services)
Less than 10%...[ ] 10-25%...[ ] 25-50%...[ ] 50-75%...[ ] 75-100%...[ ]

Percent Parent Company Annual Receipts from Dry Cleaning (if applicable):
Less than 10%...[ ] 10-25%...[ ] 25-50%...[ ] 50-75%...[ ] 75-100%...[ ]

Business Status: Independently Owned Yes [ ] No [ ]

If no, what is the parent company contact information? Name _____
Phone _____

Employees:

Total employees: Full Time _____ Part Time _____ Avg. Part Time Hours/week _____

Total employees in parent company (if applicable): _____

3. OPERATING INFORMATION

Business Hours:

Mon - Fri ____ AM to ____ PM
Sat ____ AM to ____ PM
Sun ____ AM to ____ PM

Do these hours vary seasonal during the year? Please describe_____

4. SOLVENT/FILTER INFORMATION

Still Bottoms Disposed (Number of drums and size of drums):
2001 _____
2002 _____

Separator Water Produced (gals):
2001 _____
2002 _____

What do you do with separator water?
(Check all that apply)

Hazardous waste disposal	[ ]
Evaporator	[ ]
Carbon filter	[ ]
Discharged to sewer	[ ]
Used in a cooling tower	[ ]
Used to generate steam	[ ]

Other (Please Describe) _____

What is the perc concentration of the still bottoms and separator water disposed of as hazardous waste? _____
(The perc concentration of the still bottoms and separator water can often be obtained from your hazardous waste disposal company.)

Solvent Type:		**Amount Purchased (gallons):** 2000	2001	2002
Perc	[ ]	_____	_____	_____
DF-2000	[ ]	_____	_____	_____
Rynex	[ ]	_____	_____	_____
Stoddard	[ ]	_____	_____	_____
Green Earth	[ ]	_____	_____	_____
Liquid CO_2	[ ]	_____	_____	_____
Other (Please Describe)_____		_____	_____	_____

Filter Used:

Cartridge [ ]
Standard: (Puritan) number of filters purchased in 2000 _____ 2001 _____ 2002 _____
Split: number of filters purchased in 2000 _____ 2001 _____ 2002 _____
Jumbo: number of filter purchased in 2000 _____ 2001 _____ 2002 _____

Spin-Disk Powder [ ]
Size of filter _____
Amount of muck powder (pounds) disposed 2001 _____ 2002 _____

Spin-Disk Non-Powder [ ]

Other (Please Describe) _____

5. FACILITY INFORMATION

Facility Location:
Does your facility stand alone? Yes [ ] No [ ]

If your facility is a part of a larger building (e.g., shopping center, mall), then
- How wide is the building _____ feet building length _____ feet building height _____ feet

Identify from the list below which is closest to your facility.
- Business _____ feet; Residence _____ feet; Park _____ feet
- School (K-12) _____ feet; Day Care _____ feet; Hospital _____ feet; Senior Community _____ feet

Are you located in a shopping center? Yes [ ] No [ ] Residential area? Yes [ ] No [ ]

Do people live in the building where the facility is located? Yes [ ] No [ ]
If yes, then

- Do people live on floors above the facility? Yes [ ] No [ ]

- Do people live next to the building (share facility wall)? Yes [ ] No [ ]

Facility size _____ square feet

What is the approximate height of the building where the PCE machine is located?_____

6. EMISSIONS DATA

Has there been indoor air sampling for perc (e.g., OSHA personal exposure badges, area sampling, Drager Tubes, etc.) at your facility? Yes [ ] No [ ]

If yes, please provide the most recent concentration data, and the name of the organization/individual who did the testing, the location of the sampling, test method and date.
(For example, personal exposure badge on dry cleaning operator, ProTek T&M Inc. 10ppm average for 8 hours - time weighted average 4-22-02.) _____
_____

Were the measurements taken during typical operation? Yes [ ] No [ ]

Has there been stack emission testing for your facility? Yes [ ] No [ ]
If yes, please provide the most recent data and include the concentration, test method and date. _____
_____

7. MACHINE INFORMATION

What is the percent of total garments that are cleaned in each type of machine?
Perc_____% Alternative solvent _____% Wetcleaning _____%

Total clothes cleaned by all perc machines (pounds): 2000 _____ 2001 _____ 2002 _____

What type of garments does your facility clean? Give percent of each. What solvent is used to clean each garment?
[ ] Clothes_____% What solvent? _____ [ ] Uniforms_____% What solvent? _____
[ ] Leather gloves _____ % What solvent? _____ [ ] Shop rags_____ % What solvent? _____
[ ] Other (Please Describe) _____ What solvent? _____

8. MAINTENANCE INFORMATION

How often is the machine inspected?

Daily [ ] Weekly [ ] Monthly [ ] Bi-monthly [ ] Quarterly [ ] Twice a year [ ] Yearly [ ] Never [ ]
What type of inspection do you conduct? _____
What type of leak detector (instruments) is used during inspection? _____

How many state or industry association certified operators do you have? _____

Does the machine have a refrigerated condenser and a secondary control (carbon adsorber)? Yes [ ] No [ ]
If yes, then how often do you regenerate carbon? _____

PERC SOLVENT MACHINES? (Make extra copies of this page, as needed.)

Machine Information	Machine #1	Machine #2	Machine #3
Machine Brand			
Model (i.e., B-23, transfer or dry-to-dry)			
Capacity (pounds)			
Machine Age			
Machine Type (check row):			
Dry-to-dry (refrigerated condenser)			
Dry-to-dry (refrigerated condenser and carbon adsorber)			
Converted (vent to no-vent)			
Other (describe)			

ALTERNATIVE SOLVENT MACHINES?

Machine Information	Machine #1	Machine #2	Machine #3
Machine Brand			
Model (i.e., B-23, transfer or dry-to-dry)			
Capacity (pounds)			
Machine Age			
Type of Solvent (check row):			
DF-2000			
Rynex			
Stoddard			
Green Earth			
Liquid CO_2			
Other (describe)			

WETCLEANING OPERATIONS?

Machine Information	Machine #1	Machine #2	Machine #3
Machine Brand			
Model			
Capacity (pounds)			
Machine Age			

Future Purchase/Replacement of Machine:

If you plan to purchase or replace a machine, please document below the planned changes and indicate when they will be completed.

Perc Dry-to-dry (secondary control) [ ] and drum lock-out [ ] Wet Cleaning [ ] Alternative Solvent [ ]

Other: _____ Date _____

Type of solvent?
Perc [ ] DF-2000 [ ] Rynex [ ] Stoddard [ ] Green Earth [ ] Liquid CO2 [ ]
Other (Please Describe)_____

Other planned changes? _____

9. VENTILATION SYSTEMS

Provide a sketch of the building identifying: (See the example diagram)
(1) the building dimensions
(2) location and dimensions of the vents and exhaust stacks
(3) location of the operable windows and doors
(4) property boundaries
(5) nearby buildings
(6) name of streets
(7) location of window, wall and ceiling ventilation fans
Note: a pencil sketch of your building with the above information identified is acceptable, no need to create a computer graphic.

How many months during the year are the windows and doors open? [ ]1-3 [ ]4-6 [ ]7-9 [ ]10-12
Which months? _____

If the vents are powered (powered wall vent-PWV and powered ceiling vent-PCV), what is the horsepower of each vent?
PWV-1_____ PWV-2 _____ PWV-3 _____ PWV-4 _____
PCV-1 _____ PCV-2 _____ PCV-3 _____ PCV-4 _____

Is there an:
Exhaust hood over machine? [ ] Over pressing station? [ ] Over spotting station? [ ]

Do you have perc emission stacks on your building? Yes [ ] No [ ] If yes, how many? _____

Stack diameter _____ inches Stack height _____ feet Exit velocity _____ ft/sec

Do you have a room enclosure around the dry cleaning machine? Yes [ ] No [ ] If yes, is it: Total [ ] Partial [ ]

10. QUESTIONS AND ASSISTANCE

If you have any questions on this dry cleaning facility survey form or need further assistance in completing the survey, please feel free to contact any of the following:

Rhea Jones
Phone: (919) 541-2940
Rhea.Jones@epa.gov

Eric Goehl
Phone: (919) 468-7891
Eric.Goehl@erg.com

Please return the completed survey by _____ and mail to:
Rhea Jones
U.S. Environmental Protection Agency
OAQPS, ESD-CCPG (C539-03)
Research Triangle Park, NC 27711

ALAC Base and Control Emissions Scenarios

		Base-run			Control Options								
					LDAR			Option 1 -RC			Option 3		
EMISSION POINT ID		**VIC (stack)**	**BV (area)**	**Total**	**VIC**	**BV**	**Total**	**VIC**	**BV**	**Total**	**VIC**	**BV**	**Total**
LOCATION[1]	**UTMx (m)**	610804.40	610796.10		610804.40	610796.10		610804.40	610796.10		610804.40	610796.10	
	UTMy (m)	4441124.25	4441111.00		4441124.25	4441111.00		4441124.25	4441111.00		4441124.25	4441111.00	
SOURCE TYPE (point, area, or volume)[2]		Point	Area		Point	Area		Point	Area		Point	Area	
POINT SOURCES	**Max Hourly Emission Rate (g/s)**	1.02E+00			1.02E+00			7.95E-01			3.97E-01		
	Annual Ave Emission Rate (g/s)	4.70E-01			4.70E-01			3.67E-01			1.83E-01		
	Release Height (m)	7.92			7.92			7.92			7.92		
	Exit Gas Temp (K)	305			305			294.26			294.26		
	Exit Gas Velocity (m/s)	1.01E+01			1.01E+01			1.01E+01			1.01E+01		
	Exit Gas Flow Rate (m3/s)	1.65E+00			1.65E+00			1.65E+00			1.65E+00		
	Inside Stack Diameter (m)	0.457			0.457			0.457			0.457		
AREA SOURCES	**Max Hourly Emission Rate (g/s)**		5.01E+00			3.42E+00			2.32E+00			1.16E+00	
	Max Hourly Emission Rate (g/s/m2)		4.21E-01			2.88E-01			1.95E-01			9.76E-02	
	Annual Ave Emission Rate (g/s)		2.31E+00			1.58E+00			1.07E+00			5.35E-01	
	Annual Ave Emission Rate (g/s/m2)		1.94E-01			1.33E-01			9.00E-02			4.50E-02	
	Release Height (m)		0.91			0.91			0.91			0.91	
	Flow Rate (m3/s)		15.65			15.65			15.65			15.65	
	X Initial (m)		2.4384			2.4384			2.4384			2.4384	
	Y Initial (m)		4.8768			4.8768			4.8768			4.8768	
Total Annual Emissions (g)				8.76E+07			6.46E+07			4.53E+07			2.27E+07
Total Annual Emissions (ton)				9.66E+01			7.12E+01			5.00E+01			2.50E+01

[1] The location, in UTM coordinates, can be calculated from latitude and longitude data provided in the survey.

[2] After selecting a source type, the user should fill in the required data for that source type. Only one of the source type sections (i.e., "Point Sources," "Area Sources," or "Volume Sources") should be completed per emission point.

Appendix IV

BASELINE EMISSION ESTIMATES

Base-line Emissions

- For seven facilities that were surveyed or visited, baseline emissions were estimated by mass balance using information provided in the ICR surveys. These facilities emit 77% of the PCE from major sources. Baseline emissions equal the amount of PCE purchased minus the amount of PCE in all solid wastes.
  - The types of waste subtracted from purchases to estimate emissions were still bottoms, waste oil, and cartridge filters.
  - For two facilities, Libra of Michigan and Midwest Industrial, ERG used the emission estimate calculated by the Michigan Department of Natural Resources. MDNR also estimates emissions by subtracting solid waste from PCE purchases.
- For seven facilities that were not surveyed, baseline emissions were estimated based on the average fraction of the PCE purchased that was emitted at similar survey facilities. For example, emissions from Peerless Cleaners were estimated to be the amount of PCE purchased by Peerless multiplied by 61%, the fraction of PCE emitted by Bergmann's, the only similar facility that was surveyed. Similar means the same type of facility (industrial or commercial) and the same degree of controls (a refrigerated condenser only or refrigerated condenser and carbon adsorber).
- Baseline emissions for Quality Chinese laundry, the only commercial facility with secondary controls, were assumed to be 50% of their PCE purchases. This estimate is based on the study conducted by SCAQMD included in the Final Staff Report for the Amendment to Rule 1421.

Waste

- The still bottoms and waste oil was typically reported in as the number of 55-gallon drums. Only industrial cleaners generate waste oil.

- Cartridge filters were reported as the number disposed and the size used. None of the industrial facilities, with the exception of ALAC, used carbon filters.

- For still bottoms and waste oil, the PCE content, expressed as volume %, was based on a laboratory analysis, except for:
  - the still bottoms at Bergmann's, which was assumed to be 40% PCE, the same as a typical commercial dry cleaner that injects steam in the still bottoms
  - the still bottoms at ALAC, which was assumed to be 5% PCE, approximately the same as the other industrial cleaners using muck cookers
  - the waste oil at Libra Chicago, which they believe contains about 3% PCE. This value is not based on a lab analysis and is lower than most other facilities.

- For cartridge filters, the waste was based on a fixed volume per filter provided by filter suppliers.

Dispersion Modeling

- For dispersion modeling, the baseline emissions were partioned into one or two of the following release points: the room ventilation system, the outside control system stack, or fugitive emissions. However, the baseline emissions were used to calculate the emissions from these three types of locations, not the other way around.

Appendix IV

Example calculation attached (example emission calc2.xls steps 1 and 2)

POST CONTROL EMISSION ESTIMATES

- The control options evaluated were:
  - Leak Detection and Repair (LDAR)
  - a refrigerated condenser,
  - a carbon adsorbers, and
  - a PCE vapor analyzer and lockout.

- Post-control emissions are directly related to the facility's throughput

- The emissions of each control option and LDAR were calculated relative to the benchmark emissions of a machine with a refrigerated condenser and a carbon adsorber (i.e. secondary controls). The benchmark emissions of are calculated using:
  - a mileage of 800 pounds cleaned per gallon and
  - air emissions of 50% of the PCE consumed. The remaining 50% is disposed of with the waste (still bottoms, filters, and waste oil). The fraction emitted changes based on the emission controls. The amount of waste is constant. The fraction emitted is based on a study conducted by SCAQMD of 19 area source dry cleaners with secondary controls.

- Emission reductions were estimated based on industry-accepted mileage values. To attain the mileage target, a machine would need to be essentially free of leaks. These mileage values are:
  - 300 pounds per gallon PCE for a machine with a water-cooled condenser vented through a carbon adsorber
  - 500 pounds per gallon PCE for a machine with a refrigerated condenser
  - 800 pounds per gallon PCE for a machine with secondary controls
  - 1000 pounds per gallon PCE for a machine secondary controls optimized with a PCE analyzer and lockout.

  These mileages correspond to emission factors (in units of pound PCE per ton clothes) of:
  - 0.037 pounds per ton for a machine with a water-cooled condenser vented through a carbon adsorber
  - 0.019 pounds per ton for a machine with a refrigerated condenser
  - 0.0085 pounds per ton for a machine with secondary controls
  - 0.0051 pounds per ton for a machine with secondary controls optimized with a PCE analyzer and lockout.

Example calculation attached (example emission calc2.xls steps 3 to 5)

ALAC

Mass Balance Emission Calculation

	PCE purch. gal					
		15,049	gal/yr	PCE purchased (2001-2003 average)		
		4700	gal/yr	bottoms	235	gal/yr
2001	12,164	5%	PCE in bottoms			
2002	18,144	4810	gal/yr oil		3.41	gal/yr
2003	14,840	708	PCE in oil	(mg/kg)		
3-yr avg	**15,049**	1.00E-06	kg/mg			
		360	jumbo filters/yr		540	gal/yr
13.54	lb/gal	1.5	gal ea			
0.0005	ton/lb	**96.61**	**tons/yr**	**total**		
101.88	ton/yr					
		94.8%	= % emitted			

Model Facility Dispersion Parameters

		Base-run		
Emission Point ID		**VIC (stack)**	**BV (volume)**	**Total**
Location	**UTMx (m)**	464209.16	464198.25	
	UTMy (m)	4224440.73	4224431.00	
Source Type (point, area, or volume)[2]		Point	Volume	
Point Sources	**Max Hourly Emission Rate (g/s)**	6.46E-01		
	Annual Ave Emission Rate (g/s)	1.08E-01		
	Release Height (m)	11		
	Exit Gas Temp (K)	273		
	Exit Gas Velocity (m/s)	1.50E+00		
	Inside Stack Diameter (m)	0.15		
Volume Sources	**Max Hourly Emission Rate (g/s)**		6.46E-01	
	Annual Ave Emission Rate (g/s)		1.08E-01	
	Release Height (m)		3	
	Length of Side		20	
	X Initial (m)		4.65	
	Y Initial (m)		2.33	
Total Annual Emissions (g)				6.79E+06
Total Annual Emissions (ton)				7.48E+00

Appendix VI: Further Analysis of Indoor Air Monitoring Data

This appendix and the tables and figures below summarize the indoor air monitoring data that the state of New York has collected both for compliance purposes and to conduct an epidemiological study. This discussion is an extension of the analysis found in the main body of the risk characterization memo above. The first half of this appendix summarizes the compliance-based monitoring data set while the latter half describes the epidemiological monitoring data.

Table 1 below summarizes the significant milestones in the NY Part 232 regulations. This rule instituted more rigorous controls and inspections than the 1993 NESHAP, requiring facilities by August of 2003 to install fourth generation dry cleaning equipment enclosed in a vapor barrier and to ensure their facility received an annual third party inspection.

Table 1. Description and Date Ranges for Seven Key Regulatory Time Periods

Time Period	Key Regulatory Requirements
1. Pre-NESHAP: Prior to September 23, 1993	Before NESHAP took effect
2. NESHAP: September 23, 1993 to May 14, 1997	After NESHAP was established but before NYS Part 232 took effect; control requirements based on Perc purchases
3. Part 232: May 15, 1997 to November 14, 1997	Only new equipment allowed to be used in dry cleaning shops and transfer machines prohibited
4. Part 232: November 15, 1997 to May 14, 1999	First and second generation equipment required to achieve compliance, new shops required to install only third or fourth generation units
5. Part 232: May 15, 1999 to December 24, 1999	Last date to comply with vapor barrier/room enclosure requirement and training certification required for all new facilities
6. Part 232: December 25, 1999 to December 31, 2000	Mandatory yearly facility inspections
7. Part 232: January 1, 2001 to August 5, 2003 (last date of data)	Upgrade second generation machines to fourth generation, and retrofit or upgrade third generation machines to fourth generation machines; only fourth generation machines can be sold, leased or installed.

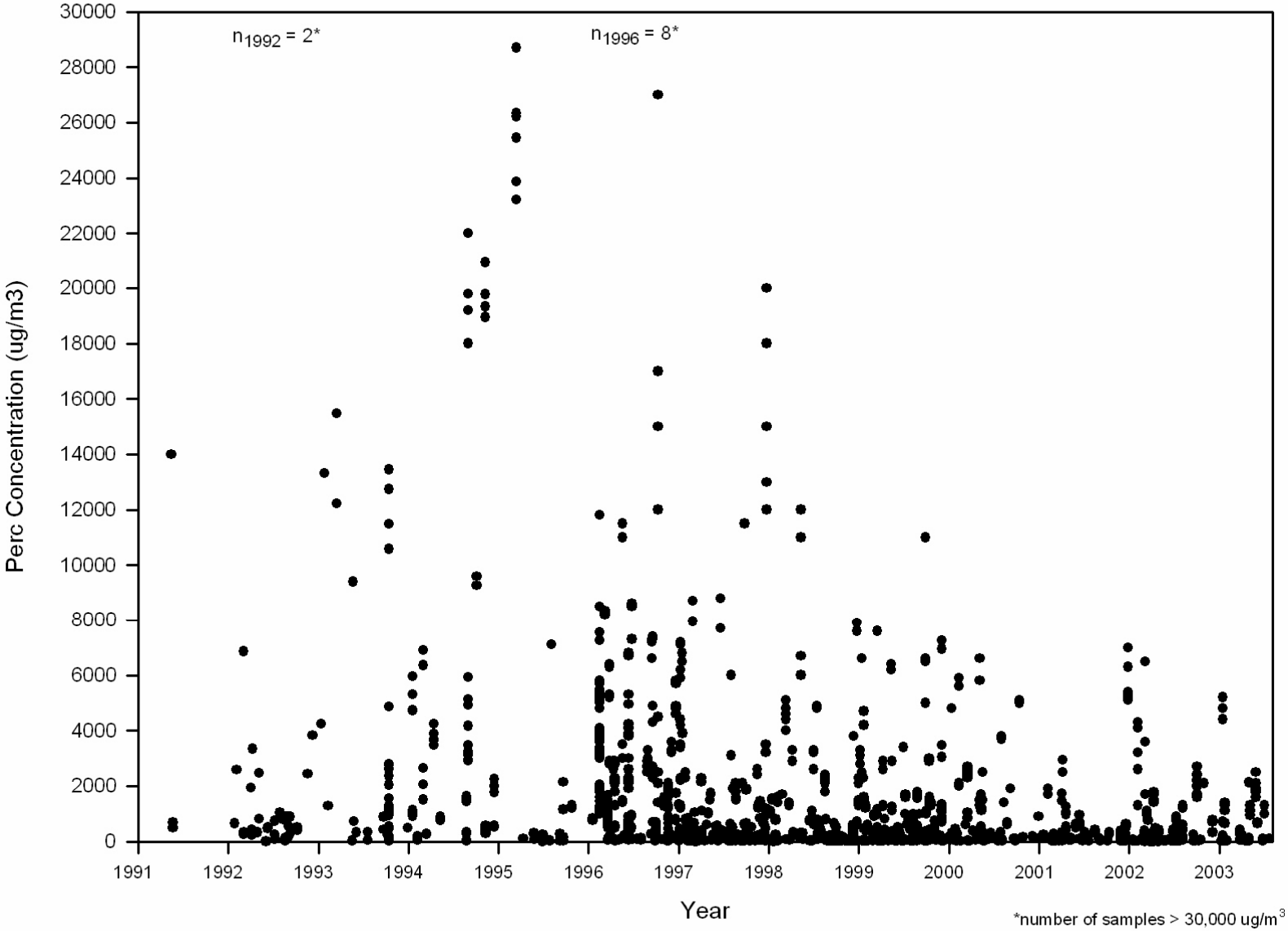
Table 2 below provides summary statistics of the compliance-based indoor air monitoring data from prior to the promulgation to the NESHAP, through the inception of the Part 232 rules, and up until the final implementation period for Part 232. As both Table 2 and Figure 1 below suggest, the Part 232 requirements appear to have significantly decreased the average and high-end indoor air concentrations of PCE in residences and other locations co-located with area source dry cleaners.

Table 2. Summary Statistics for Seven Regulatory Time Periods.

Time Period	Number of Facilities	Number of Samples	% of Samples > Background* (2.9 μg/m^3)	% of Samples > 100 μg/m^3	% of Samples > 1,000 μg/m^3	Range (μg/m^3)	Geometric Mean (μg/m^3) (Standard Deviation)	25th Percentile (μg/m^3)	50th Percentile (μg/m^3)	75th Percentile (μg/m^3)
1. **Pre-NESHAP:** prior to September 23, 1993	30	52	98.1	82.7	32.7	1.5 – 752,380	609.7 (10.7)	252.5	602.5	2,458.5
2. **NESHAP:** September 23, 1993 – May 14, 1997	64	705	98.9	78.6	39.4	0.7 – 170,000	507.2 (7.6)	130	530	2,300
3. **Part 232:** May 15, 1997 – November 14, 1997	37	142	100	62.0	14.1	5 – 11,500	150.5 (5.7)	40	160	450
4. **Part 232:** November 15, 1997 – May 14, 1999	54	407	99.5	52.3	21.9	1 – 20,000	155.4 (7.6)	26	140	790
5. **Part 232:** May 15, 1999 – December 24, 1999	36	181	100	68.5	21.0	5 – 11,000	251.6 (5.4)	70	290	900
6. **Part 232:** December 25, 1999 – December 31, 2000	30	115	100	60.0	26.1	5 – 6,600	235.6 (5.9)	65	180	1,100
7. **Part 232:** January 1, 2001 – August 5, 2003	57	556	99.3	47.7	12.2	1.8 – 7,000	98.1 (6.6)	20	91.5	390

Background value (2.9 μg/m^3) is upper range (90th percentile) of indoor perc concentrations (DOH, 2004)

FIGURE 1. Scatter Plot of Perc Concentrations Statewide



To estimate health risks to apartment residents co-located with area source PCE dry cleaners, EPA used indoor air monitoring data collected as part of a New York Department of Health (NYDOH) epidemiological study. These data are a subset of those summarized in row seven of table two above. NYDOH did not collect these samples to ensure compliance, and so they avoid some of the biases of previously-collected data. Researchers from the NYDOH recently used these data to publish a paper in *Environmental Health Perspectives* exploring the disparity in exposure to PCE among minority and low-income residents.[1] Although these data were not collected specifically for the purposes of evaluating health risks, we believe that they provide a sound basis for examining the possible health risks associated with these particular facilities.[2]

When NYDOH provided EPA with these data, they worked with the NY Department of Environmental Conservation (NYDEC) to associate each monitor with the characteristics of the building within which NYDOH captured the sample and the dry cleaning equipment with which it was co-located. These characteristics include: (1) the complaint history of the facility; (2) the status of compliance with the NY Part 232 rules; (3) whether the building was low-income or minority.[3]

The tables below stratify the indoor air data set by each of these three criteria to illustrate the extent to which resident exposures varied according to these factors.[4] Note that for clarity, the risk estimates maintain two significant figures throughout the following tables.

[1] McDermott MJ, Mazor KA, Shost SJ, Narang RS, Aldous KM, Storm JE. Tetrachloroethylene (PCE, Perc) levels in residential dry cleaner buildings in diverse communities in New York City. Environ Health Perspect. 2005 Oct;113(10):1336-43.

[2] The articles notes on page 9 that "Early analytical results indicated that indoor air perc levels in most apartments in dry cleaner buildings sampled were below, or only slightly above, the NYSDOH residential air guideline of 100 µg/m3. Higher levels were found in dry cleaner buildings located in low-income, minority neighborhoods and in buildings elsewhere that had been the subject of a residential complaint. Since successful completion of the NYC Perc Project required that as many apartments as possible with elevated perc levels be identified, the strategy for identifying buildings for inclusion was modified so that buildings located in minority or low-income ZIP code areas and those that had been the subject of complaint were prioritized." The article goes on to state on page 17 that the sample "obtained is not truly a random sample of all dry cleaners in the study area. However, socioeconomic characteristics of the census block groups where sampled buildings are located reflect socioeconomic characteristics of their larger ZIP Code area, are equivalent to census block groups where buildings that were not sampled are located, and are correlated with sampled household self-reported socioeconomic characteristics. Thus, conclusions drawn with respect to sampled building neighborhood characteristics and indoor air perc level are likely to be applicable to other residential buildings matching NYC Perc Project building inclusion criteria (e.g. dry cleaner using perc on-site; no other sources of VOC)."

[3] Probably need to include citation from McDermott's paper defining these terms.

[4] Monitored concentrations and risk estimates below rounded to two significant figures.

Table 3: Exposure and Risk Estimates for Residents in All Sampled Apartments

		Percentile					
	Maximum	*95%*	*75%*	*50%*	*25%*	*5%*	*Geometric Mean*
Monitored concentration	5,000	2,100	130	28	8	5	40
Risk per million (CalEPA Unit Risk Estimate)	30,000	12,000	770	170	50	30	240
Risk per million (OPPTS unit Risk Estimate)	3,600	1,500	92	20	6	4	28
Hazard Quotient (ATSDR MRL)	19	7.8	0.5	0.1	0.03	0.02	0.1
Number of Samples:	130						
Number of Facilities:	24						

Table 4: Exposure and Risk Estimates for Residents Co-Located with Facilities Having No Prior History of Complaint

		Percentile					
	Maximum	*95%*	*75%*	*50%*	*25%*	*5%*	*Geometric Mean*
Monitored concentration	5,000	2,135	215	27	8	5	45
Risk per million (CalEPA Unit Risk Estimate)	29,500	13,000	1,300	160	47	30	270
Risk per million (OPPTS Unit Risk Estimate)	3,600	1,500	150	20	6	4	32
Hazard Quotient (ATSDR MRL)	19	8	0.8	0.1	0.03	0.02	0.2
Number of Samples:	44 of 65						
Number of Facilities:	15 of 24						

Table 5: Exposure and Risk Estimates for Residents Co-Located with Facilities Having a Prior History of Complaint

		Percentile					
	Maximum	*95%*	*75%*	*50%*	*25%*	*5%*	*Geometric Mean*
Monitored concentration	372	352	84	28	8	5	31
Risk per million (CalEPA Unit Risk Estimate)	2,200	2,000	500	170	50	30	180
Risk per million (OPPTS Unit Risk Estimate)	260	250	60	20	6	4	22
Hazard Quotient (ATSDR MRL)	1.4	1.3	0.3	0.1	0.03	0.02	0.1
Number of Samples:	21 of 65						
Number of Facilities:	9 of 24						

Table 6: Exposure and Risk Estimates for Residents Co-Located with Facilities Not Yet in Compliance with NY Part 232 Rules[5]

		Percentile					
	Maximum	*0.95*	*0.75*	*0.50*	*0.25*	*0.05*	*Geometric Mean*
Monitored concentration	4,600	2,100	215	48	13	5	63
Risk (CalEPA Unit Risk Estimate)	27,000	13,000	1,300	290	77	30	370
Risk (OPPTS Unit Risk Estimate)	3,300	1,500	160	35	9	3.6	45
Hazard (ATSDR MRL)	17	7.8	0.8	0.2	0.5	0.2	0.2
Number of Samples:	25 of 65						
Number of Facilities:	9 of 24						

[5] While McDermott et. al. (2005) did not provide the compliance status of the facility in which they monitored in their article, the NYDEC provided these data to EPA. NYDEC accessed its AFS permitting database to obtain information on controls, including equipment generation. NYDEC compiled this data from inspection reports and EPA NESHAP initial notification forms. To ensure consistency with the summary of PCE indoor air exposure found in table two of the McDermott et. al. article, EPA averaged duplicate monitors at each apartment.

Table 7: Exposure and Risk Estimates for Residents Co-Located with Facilities in Compliance with NY Part 232 Rules

		Percentile					
	Maximum	*0.95*	*0.75*	*0.50*	*0.25*	*0.05*	*Geometric Mean*
Monitored Concentration	5,000	695	84	15	8	5	33
Risk (CalEPA Unit Risk Estimate)	30,000	4,100	500	90	50	30	190
Risk (OPPTS Unit Risk Estimate)	3,600	500	60	11	6	4	24
Hazard (ATSDR MRL)	19	2.6	0.3	0.06	0.03	0.02	0.1
Number of Samples:	40 of 65						
Number of Facilities	15 of 24						

Table 8: Exposures and Risk Estimates for Residents in Low Income and/or Minority Buildings[6]

		Percentile					
	Maximum	*95%*	*75%*	*50%*	*25%*	*5%*	*Geometric Mean*
Monitored Concentration	5,000	4,600	335	78	10	5	110
Risk per million (CalEPA Unit Risk Estimate)	30,000	27,000	2,000	460	60	30	480
Risk per million (OPPTS Unit Risk Estimate)	3,600	3,300	240	60	7	4	60
Hazard Quotient (ATSDR MRL)	20	13	1.2	0.3	0.04	0.02	0.3
Number of Samples:	26 of 55						
Number of Facilities:	10 of 24						

[6] According to the article, to determine whether the building was "low-income" or minority, during screening "participants were asked to categorize their household race/ethnicity into one or more (up to four) of the following categories: white, African American, American Indian, Chinese, Japanese, Korean, Native Hawaiian, Samoan, Hispanic, or other. Adult participants were also asked to categorize their annual household income into one of the following ranges: < $15,000, $15,000–30,000, $30,000–45,000, $45,000–60,000, or > $60,000." (pp 1337).

Table 9: Exposures and Risk Estimates for Residents Not in Low Income and/or Minority Buildings

		Percentile					
	Maximum	*95%*	*75%*	*50%*	*25%*	*5%*	*Geometric Mean*
Monitored Concentration	400	352	61	13	5	5	22
Risk per million (CalEPA Unit Risk Estimate)	2,400	2,100	370	80	30	30	130
Risk per million (OPPTS Unit Risk Estimate)	280	250	50	10	4	4	20
Hazard Quotient (ATSDR MRL)	2	1.3	0.2	0.1	0.02	0.02	0.1
Number of Samples:	29 of 55						
Number of Facilities:	14 of 24						

The summary tables above demonstrate how estimates of inhalation cancer risks and non-cancer hazards derived from the McDermott et. al. (2005) monitoring data can vary according to several factors. Specifically, these tables suggest that:

- For all apartments, even under the most stringent level of control and using the low end of the cancer potency range, the estimated 95th percentile level of cancer risks (i.e., the high-end risk) is above 1,000 in a million, while the average risk is between about 30 and 240 in a million.

- The “no prior history of complaint” apartments were subject to similar levels of estimated average risks but significantly greater high-end risks than those with a prior history of complaint. The “prior complaint” buildings were subject to significantly lower high-end cancer risks and non-cancer hazards than those without a prior history of complaint.

- Sampled apartments co-located with facilities in compliance with the Part 232 rules are exposed to approximately the same maximum estimated cancer risks as those not yet in compliance with these rules. However, risks at the lower-end of the distribution appear to be lower among the buildings with facilities in compliance with Part 232.

- People living in low income and/or minority buildings appear to be exposed at higher estimated cancer risks and non-cancer hazards than non-low income and minority buildings. However, the people living in non-low income/minority buildings are still estimated to be subject to inhalation cancer risks between 250 and 2100 in a million at the upper end of the distribution, while average risks are lower, between 20 and 130 in a million.

While the estimated cancer risks and non-cancer hazards vary according to the variable by which the dataset is stratified, the data still indicate that high-end estimated cancer risks remain well

above 100 in a million among the sampled apartments in each of the stratified subsets, while average risk is between about 100 and 500 in a million using the Cal EPA URE and between about 20 and 60 in a million using the OPPTS URE.

Correspondence between NYDOH and EPA Regarding Indoor Air Data

E-mail dated October 7, 2005

Neal & Rhea:

As you requested, we have modified a portion of the dry cleaner information that we originally sent to you in an e-mail dated September 15, 2004 (Subject: NYS DOH & NYS DEC dry cleaner data). In this email, New York State Departments of Health (NYS DOH) and Environmental Conservation (NYS DEC) provided information on indoor perc levels measured in residences and businesses co-located with perchoroethylene (perc) dry cleaners (from 1991 to 2003) and dry cleaner facility characteristics. You have asked that we narrow these data to only include the indoor air concentrations reported by McDermott et al. (2005) in "Tetrachloroethylene (PCE, Perc) Levels in Residential Dry Cleaner Buildings in Diverse Communities in New York City," published in the October 2005 journal Environmental Health Perspectives (available online June 2005). In considering this table, it should be recognized that the data described in McDermott et al. (2005) resulted from an epidemiological study, and dry cleaner building and apartment inclusion and exclusion criteria influenced buildings that were ultimately sampled. Also, buildings designated as having a prior complaint in McDermott et al. (2005) were identified in order to potentially increase the likelihood of finding apartments with elevated perc levels. Please see the table and supporting data reported in McDermott et al. (2005) provided in the attached spreadsheet, "summary_lists_ehp_confidential.xls."

I have also attached McDermott et al. (2005) for reference and another peer-reviewed journal article by Garentano et al. (2000) reporting indoor perc levels in co-located dry cleaner buildings carried out in New Jersey.

Please call me if you have any questions.

Judy Abbott, Chief
Exposure Assessment Section
Bureau of Toxic Substance Assessment
NYS Department of Health
547 River Street, Rm 330
Troy, NY 12180
E-MAIL: jaa06@health.state.ny.us

PHONE: (518) 402-7815
FAX: (518) 402-7819

Appendix VII

Subject: Selection of Persistent and Bioaccumulative HAPs for Multipathway Risk Assessments

To: Dave Guinnup

From: Roy Smith

Date: August 20, 2003

This memo provides and justifies a list of hazardous air pollutants that have sufficient persistence and bioaccumulation potential to make them candidates for multipathway risk assessments. The list was selected in two stages.

The first stage was to determine which HAPs are already listed as persistent, bioaccumulative, and toxic (PBT) substances by the following EPA programs:

1. Priority PBT Profiles (Pollution Prevention program): http://www.epa.gov/pbt/cheminfo.htm

2. Great Waters Pollutants of Concern: http://www.epa.gov/oar/oaqps/gr8water/3rdrpt/execsum.html

3. Toxics Release Inventory: http://www.epa.gov/tri/chemical/pbt_chem_list.htm

All substances that are both HAPs under the CAA and listed by at least one of these programs are shown in the table below.

The second stage was to determine if, based on their toxicity and bioaccumulation potential, any additional substances should be assessed for multipathway risk by the air toxics program. This determination was made by calculating two indexes for all HAPs for which input data were obtained. One index (intended to estimate relative carcinogenic potential by oral exposure) was the product of the oral carcinogenic potency slope and the bioconcentration factor (obtained from the EPA PBT Profiler, http://www.pbtprofiler.net/). The other index (intended to estimate relative noncarcinogenic hazard by oral exposure) was the ratio of the same bioconcentration factor to the oral reference dose. The cancer and noncancer indexes were normalized to a scale of 1 and combined by averaging (with blanks not averaged, rather than averaged as zero).

The HAPs were then ranked in descending order of the combined index, and the substances that comprised 99.9995% of the total of all substances were selected as potential candidates for multipathway risk assessment. Results of the ranking exercise are shown in the table below.

HAP/PB	OAQPS rank	2P Priority PBTs	Great Waters POCs	TRI PBTs
Cadmium compounds	NA[1]		X	
Chlordane	7	X	X	X
Chlorinated dibenzodioxins & furans	1	X[2]	X	X[3]
DDE	8	X	X	
Heptachlor	4			X
Hexachlorobenzene	6	X	X	X
Hexachlorocyclohexane (all isomers)	NA[4]		X	
Lead compounds	NA[1]	X[5]	X	X
Mercury compounds	NA[1]	X	X	X
Methoxychlor	NA[4]			X
Polychlorinated biphenyls	3	X	X	X
Polycyclic organic matter	2[6]	X[7]	X	X[8]
Toxaphene	5	X	X	X
Trifluralin	NA[4]			X

Of the 26 substances that comprised 99.9995% of the aggregate index for all HAPs, 19 are classified as polycyclic organic matter under the Clean Air Act. These were combined into a single category in the table. Metals could not be ranked because the PBT Profiler does not contain data for inorganic pollutants, but were included in the table because of their presence on the other lists. Three other substances shown as "NA" fell outside the 99.9999% aggregate limit.

In summary, no substance not already one at least one existing list emerged in this analysis as a significant potential PBT substance. Therefore, based on our current estimates of toxicity and bioaccumulation potential, the following 13 substances[9] from the table represent a conservative list for multipathway risk assessments in the air toxics program:

Cadmium compounds

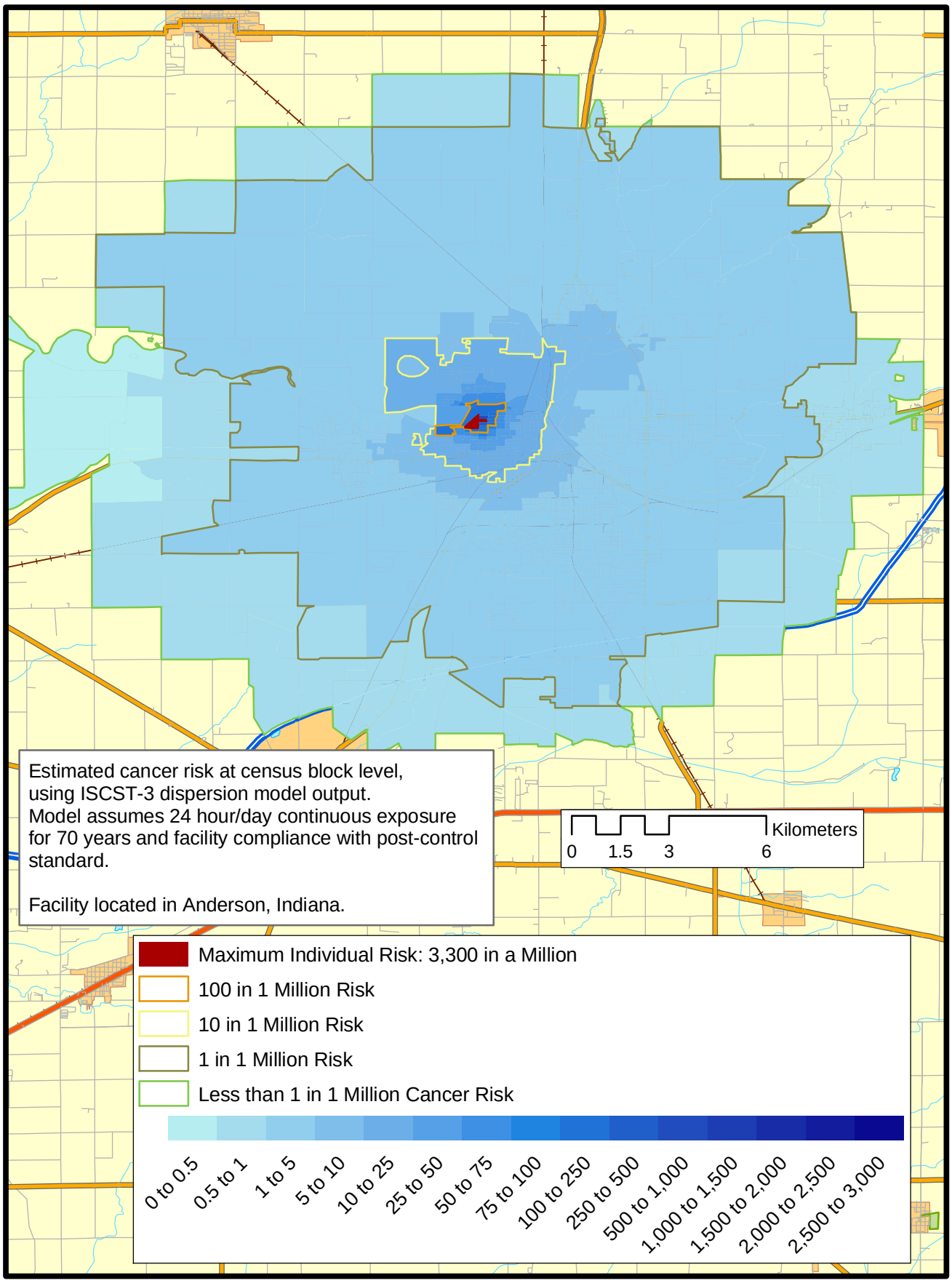
[1] Not ranked because the PBT Profiler lacks data for inorganic compounds.
[2] "Dioxins and furans"
[3] "Dioxin and dioxin-like compounds"
[4] Did not fall within 99.9999% of cumulative index.
[5] Alkyl lead
[6] 19 POM compounds that fell within the top 26 substances were assigned the rank of 7,12-dimethylbenz(a)anthracene, the highest-ranked compound.
[7] Benzo[a]pyrene
[8] "Polycyclic aromatic compounds" and benzo[g,h,i]perylene
[9] One additional substance shown in the table, lead, was omitted from this list because EPA uses its NAAQS as an RfC-equivalent benchmark for inhalation hazard estimates. Because the NAAQS development process explicitly considered multipathway exposures associated with deposition, its use in the inhalation assessment will also protect against oral exposures.

Chlordane
Chlorinated dibenzodioxins & furans
DDE
Heptachlor
Hexachlorobenzene
Hexachlorocyclohexane (all isomers)
Mercury compounds
Methoxychlor
Polychlorinated biphenyls
Polycyclic organic matter
Toxaphene
Trifluralin

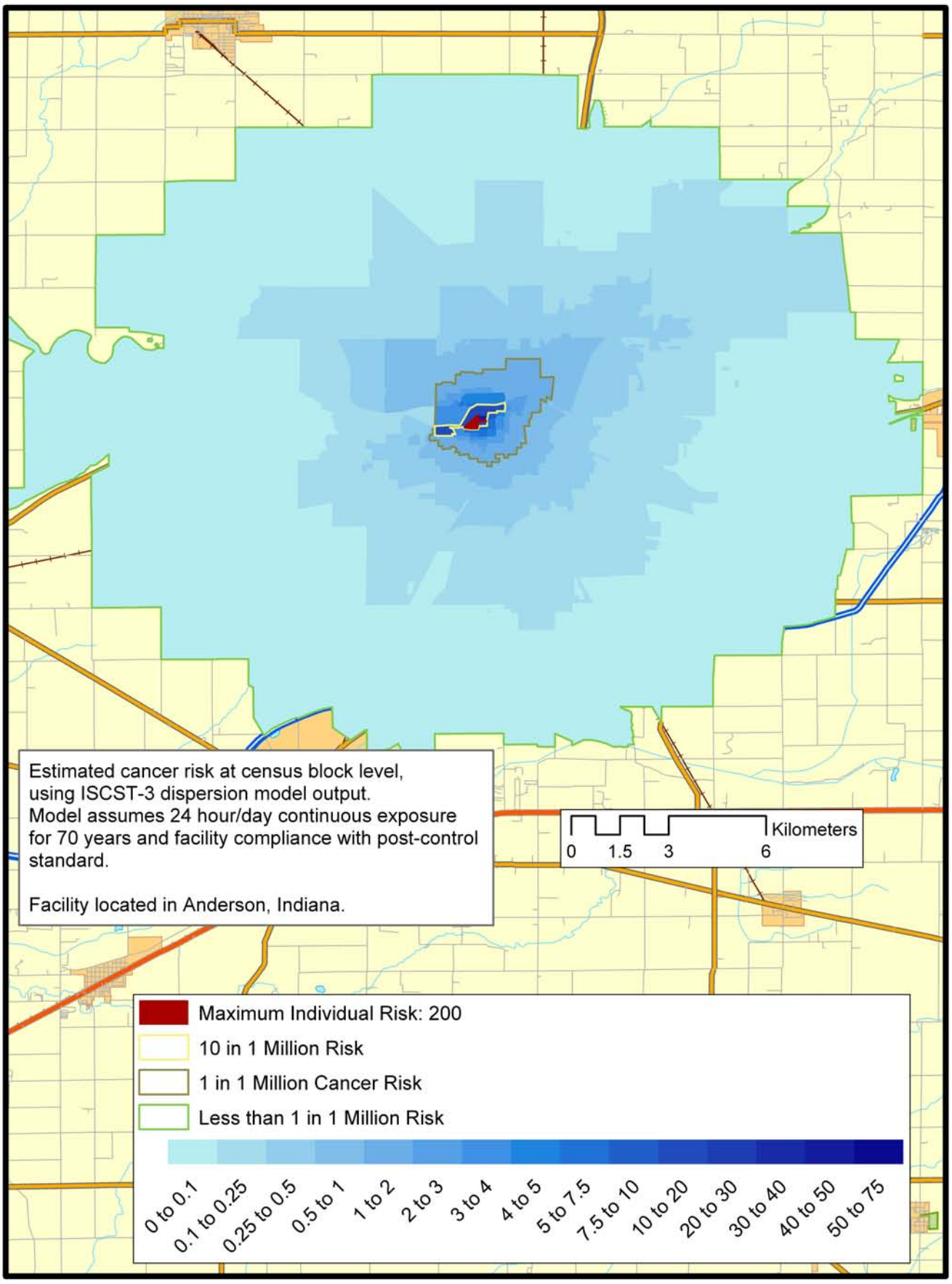
Facility- or community-level assessments based on inventories that include emissions of any of these 13 HAPs, in any amount, should include the following non-inhalation exposure pathways:

Incidental ingestion of soil and sediment
Incidental ingestion of surface water during swimming
Ingestion of drinking water (where surface water is used as a potable water source)
Dermal uptake from soil
Dermal uptake from swimming
Dermal uptake from showering (where surface water is used as a potable water source)
Ingestion of fish
Ingestion of produce
Ingestion of meat, eggs, and dairy products

Residual Risk Assessment for Perc Dry Cleaners: Cancer Risk at ALAC Facility--MACT Emissions



Residual Risk Assessment for Perc Dry Cleaners: Cancer Risk at ALAC Facility--Post-Control Emissions



May 25, 2004

To: Rhea Jones, Dry Cleaning Engineering Lead; and, Neal Fann, Dry Cleaning Residual Risk Lead

From: Mike Heaney, ERG Consulting

Re: Estimated Acute Emissions Variability

Baseline emissions were estimated based on a mass balance over a one year period so the variability of 1-hour peak emissions cannot be estimated precisely. These quantitative estimates of the variability are based on engineering judgment and data from other studies.

Average acute emissions equal the total emissions divided by the operating hours. A good way to address variability from this average is to divide emissions into the following components:

- leaks during the first load
- leaks during operation
- emissions from machine doors between loads
- breakthough emissions from vented carbon adsorber

PCE emissions from small commercial facilities during the first load of the day is much higher than later in the work day because leaks accumulate in the drum of the machine overnight. During the first hour of operation, the PCE concentration near the machine is roughly four times the average for the remainder of the work day. Major sources
probably follow a similar pattern.

Emissions from machine doors between loads and from leaks are a function of the number of loads cleaned. Major sources typically run at a steady rate throughout the work day, so these emissions would not vary much.

Emissions from machine doors between loads and from leaks are emitted via building ventilation. Poor ventilation reduces the variability of emissions to the environment from inside buildings because PCE is removed from the building more slowly. Most of the survey facilities were well-ventilated in that their machines were near exhaust vents.
For facilities with poor ventilation (Midwest and Libra, Chicago), peak emissions would be closer to the average during the work day. Peak emissions variability at these two facilities was estimated to be about half that of the well-ventilated facilities (i.e. a factor of two versus a factor of four).

Carbon adsorber breakthrough episodes are a large potential source of acute emissions variability at the two facilities with vented carbon adsorbers, ALAC and White Tower. Although it would be difficult to estimate the frequency of such episodes, during the site visit, operators at ALAC acknowledged that on occasion PCE partially broke through the carbon adsorber due to insufficient reactivation or a valve failure. During breakthough episodes, PCE is emitted from

the stack directly to the environment without the dampening effect of building ventilation. Carbon adsorbers remove about 95% of the PCE in the vent stream according to the preamble of the original NESHAP. Both facilities using vented carbon adsorbers run two beds in parallel with a third bed
off-line. If PCE completely broke through one of the two adsorbers in use, roughly half of the PCE in the vent stream would be uncontrolled. This would cause the fraction of PCE uncontrolled in the vent stream to jump from 5% to as much as 50%, a factor of ten. Because PCE emissions from leaks would be unaffected the increase in the overall emissions from the facility would be less than a factor of ten. Based on engineering judgment, the net effect of such an episode would increase 1-hour peak emissions by a factor of six or less.

Because carbon adsorber breakthough emissions occur only at facilities with vented carbon adsorbers, this source of variability occurs only in the baseline emissions scenario. Control options that include a refrigerated condenser greatly reduce the magnitude and likelihood of carbon adsorber breakthough emissions.

Table 1 below describes how peak acute emissions are estimated to exceed average emissions during operating hours by roughly the following factors:

Table 1: Variability in Maximum 1-Hour MACT-Level Emissions by Dry Cleaning Facility

Facilities	*Maximum Multiple by which Acute Emissions Could Increase*
ALAC and White Tower	6 times
Midwest Industrial; Libra Industries (IL)	2 times
All Others	4 times

Appendix X

Description of Total Risk Integration Method (TRIM) Assessment

To generate an APEX commuting file at the census block level for the selected study area, a processor was developed that used the following inputs to calculate the commuting patterns between census blocks in the study area:

- APEX census tract-level commuting file
- Census block-level population data for the study area (e.g., total people in each census block, total working people in each census block)
- Multi-Resolution Land Characteristics (MRLC) land use data for each census block in the study area

This processor uses the following algorithm to calculate the commuting flow between each pair of census blocks in the study area:

Flow[HB1,WB2] = Flow[HTa,WTa] * Frac[pop] * Frac[land]

where:

Flow[HB1,WB2] = The flow of working population from home census block 1 to work census block 2;
Flow[HTa,WTa] = The flow of working population from home census tract a to work census tract b;
Frac[pop] = The fraction of people in census tract a that work and live in census block 1; and
Frac[land] = The fraction of land area in census tract b that is in census block b and is assigned "industrial/commercial/transportation" land use in the MRLC data set.

The processor uses this commuting flow data to calculate cumulative commuting flow fractions between each pair of census blocks in the study area. The census block-level commuting file is then created using these data; however, cumulative commuting flow fractions between census block pairs meeting any of the following criteria are not included in the resulting commuting file:

(1) The distance between the blocks is larger than 100km; or
(2) The cumulative commuting flow fraction between the blocks is less than 1.0E-06.

Once EPA created the commuting file input, it followed the model steps below:

1. *Adjust the study area* based on sectors (in this case, census blocks) and the availability of air quality and weather data.
2. *Generate simulated individuals* in the study area using census-derived probability distributions of demographic and other variables (age, gender, home location, work location) to randomly select and develop a personal profile for each individual.

3. *Construct a sequence of activity events* for each profile, taking into consideration the demographic variables (age, gender) and day type (weekday or weekend, temperature) being modeled.
4. *Calculate hourly concentrations in the microenvironments* by determining pollutant concentration each hour (or less) of the profile diary, using ISCST-3 ambient concentration estimates.
5. *Estimate pollutant exposure* for each activity in the diary and then average the concentrations by hour

EPA provided TRIM with the hourly ambient concentrations from the ISCST-3 model run for the ALAC facility. For computational efficiency, EPA provided TRIM with hourly data from the single highest of five model years.[1]

[1] For the purposes of comparing ISC estimated risk with TRIM.Expo$_{Inhalation}$ risk, EPA re-calculated ISC-estimated cancer risk using a single year of ambient concentrations (the average of five is otherwise used for cancer risk calculations); this recalculation provides for a consistent point of comparison between ISC and TRIM.Expo$_{Inhalation}$ risk estimates. For this reason, the reduction in maximum cancer and non-cancer risk between TRIM.Expo and ISC will not be proportional—EPA calculated non-cancer hazard in ISC using the single highest year, rather than just a single year, of ambient concentrations.

Overview

Using a 10-kilometer, rather than 50-kilometer, air dispersion modeling radius for perchloroethylene should have negligible influence over EPA regulatory decisions for perc dry cleaners because 90% of the cancer incidence lies within the first 10-kilometers. Note that EPA intended the example below to be a very health-protective screening-level exercise, using readily available data.

Methodology

The two tables below illustrate how the estimated cancer incidence changes over distance depending on my method of extrapolation:

1. *Table one* shows the analysis from the simple health-protective extrapolation method. First, I identified the final receptor at which ISCST-3 modeled the concentration of Perchloroethylene from the Bergmann's Dry Cleaning facility; among the receptors located at the furthest periphery of the 10-kilometer radius around the facility, this one exhibited the highest average concentration. Next, for computational simplicity, I made the very health protective assumption that this concentration would remain constant across the remainder of the un-modeled census blocks beyond the 10-kilometer, and up to a 50-kilometer, radius. Finally, I calculated cancer risk by multiplying this concentration by the CalEPA Unit Risk Estimate (5.9E-06); I then calculated cancer incidence by multiplying this risk by population for each census block between 10-kilometers and 50-kilometers. The summary results are as follows:

Method One: Simple Extrapolation

Estimated 50 Kilometer Lifetime Cancer Incidence

40-Kilometer Incidence	.000617
10-Kilometer Incidence	.00234
Total Incidence	.00296
Proportion of Incidence in 10-Kilometer Buffer	79%

2. *Table two* shows the analysis from the SCREEN3 method. I used the ISCST-3 facility inputs (emissions, stack height, etc.) as inputs for SCREEN3, while selecting two discrete distances from the facility: 10 kilometers and 50 kilometers. SCREEN3 estimated that the pollutant concentration dropped by an order of 5 between 10 kilometers and 50 kilometers. Assuming that this proportional decrease would apply to the ISCST-3 results,

I divided the value that ISCST-3 estimated at 10-kilometers by 5 to arrive at a SCREEN3 estimated value at 50-kilometers; I then took the average of these 10 and 50 kilometer values. Finally, I calculated cancer incidence among the census blocks between 10 and 50 kilometers using the same method as above.[1] The summary results are as follows:

Method Two: SCREEN3 Extrapolation

Estimated 50 Kilometer Lifetime Cancer Incidence	
40-Kilometer Incidence	.00037
10-Kilometer Incidence	.00234
Total Incidence	.00271
Proportion of Incidence in 10-Kilometer Buffer	86%

[1] This analysis assumes that the worst-case meteorology in SCREEN3 will generate more health-protective estimates of ambient concentrations at each census block than ISCST-3, and so that calculating cancer incidence proportionally is generating a very health-protective result.