Analyses Performed for the Risk-Screening Environmental Indicators

Introduction

This documents presents the results of several analyses that were done for the Risk-Screening Environmental Indicators project. The analyses are grouped into three sections, the first and third of which have already been released as separate documents, but are here grouped together for convenience.

Part A presents the Ground-Truthing of the RSEI Air Pathway Component. This document was originally released in December 1998. In this analysis, the air modeling component of the RSEI model was evaluated by comparing RSEI's modeled air pollutant concentrations to concentrations obtained from Air Guide-1 (AG-1), an air dispersion model used by the New York State Department of Environmental Conservation, which relies on more facility- and stack-specific data. The results, as presented in Part A, support the use of RSEI for screening purposes.

Part B presents three analyses performed to examine options for air modeling. The first section looks at the optimal modeling distance, i.e., how far out from the facility should air concentrations be modeled before they fall relatively close to zero. The second section examines the optimum spacing and size for the cells used. The third section looks at different ways to model the center cell, where the facility is located.

Part C presents an analysis of stack height and velocity data used in the RSEI model for the first year that such specific data was used (previously one default value for each parameter was used to represent all stacks). This document was originally released in December 1998. The full results are presented here, but are accurate only for historical purposes; these data are pulled and loaded into the RSEI every year for all reporting years. An abbreviated version of this document is also presented in Technical Appendix E.

Please note that the terminology used in the RSEI project has evolved over the years. The language used in this document will vary, but is attributable solely to the relative age of the analyses.

Part A.

Ground-Truthing of the RSEI Air Pathway Component

ACKNOWLEDGMENTS

This report evaluates the air pathway component of the Office of Pollution Prevention and Toxics' (OPPT's) Risk-Screening Environmental Indicators Model. This report is one of many products of the OPPT's Risk-Screening Environmental Indicators Model Project. The project, initiated in 1991, has resulted in the Risk-Screening Environmental Indicators Model, a unique and powerful analytical tool for risk communication. The Indicators Model has the potential to make a significant contribution to environmental improvement. We wish to thank our contractor, Abt Associates Inc., for their support and creativity throughout the development of this project.

We also want to thank several persons at State agencies who were very helpful in providing data and information for the analyses described in this report. These include Mr. Eric Wade and Mr. Tom Gentile of the New York State Department of Environmental Conservation; Mr. Christopher Nguyen of the California Environmental Protection Agency's Air Resources Board; Mr. Orlando Cabrera of the Wisconsin Department of Natural Resources; and, Mr. Greg Stella of EPA's Office of Air Quality Planning and Standards.

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EXECUTIVE SUMMARY

EPA's Science Advisory Board (SAB) advised the Office of Pollution Prevention and Toxics (OPPT) to conduct a "ground-truthing" analysis of the exposure model components of OPPT's Risk-Screening Environmental Indicators Model. The objective of the Indicators Model is the analysis of Toxics Release Inventory (TRI) releases and their relative risk-related impacts, which can be used for relative ranking purposes.

In this ground-truthing analysis, the air model component of the Indicators Model was evaluated. Air pollutant concentrations estimated by the Indicators Model were compared to concentrations obtained from Air Guide-1 (AG-1), an air dispersion model used by the New York State Department of Environmental Conservation for regulatory purposes. The air pollutant concentrations calculated by the Indicators Model are based on a combination of median data (e.g., stack height and exit gas velocity) and generic assumptions, whereas the AG-1 model relies on a greater variety of facility- and stack-specific data. The differences in pollutant concentrations predicted by both models were analyzed for 24 test cases in New York. This representative sample was designed to capture the variability observed in three input variables. Four metropolitan areas were selected to sample different meteorological conditions, and two types of pollutants, with and without decay rates, were modeled in each metropolitan area. The distribution of stack heights was represented by three discrete bins, each containing about a third of the stack heights reported by all TRI facilities in New York. Two test cases (one for a pollutant with a decay rate and one for a pollutant without a decay rate) were selected from each stack height bin for each metropolitan area.

The Indicators Model estimates air pollutant concentrations for each 1 km^2 cell in a 21-km by 21-km grid surrounding a TRI facility. Each TRI facility is represented with a single stack located at the center of the central cell in the grid. Cell by cell concentrations predicted by the Indicators Model and AG-1 were compared by calculating a concentration ratio for each cell (a ratio of one indicates perfect agreement between the models). Two sets of tests were conducted: in the first, the Indicators Model used facility-specific median stack heights and exit gas velocities; in the second, the Indicators Model used stack heights and exit gas velocities corresponding to the median values for the facility's 3-digit Standard Industrial Classification (SIC) code. These SIC code-based values were nationally derived, based on available data.

Concentration ratios for individual cells ranged from 0.23 to 3.1 when using facility-specific parameters, and from 0.25 to 3.4 when using SIC code-based parameters. Average concentration ratios computed over all 440 cells surrounding a single facility differed by 48 percent or less when using facility-specific parameters, and by 35 percent or less when using SIC code-based parameters. Average ratios computed over the 24 test cases were within two percent of unity (with a standard deviation of 13 percent) when using facility-specific parameters, and within six percent of unity (with a standard deviation of 13 percent) when using SIC code-based parameters. Thus, the Indicators Model does not seem to consistently overpredict or underpredict pollutant concentrations.

Average concentration ratios were also computed over concentric square rings around the central cell. These averages show a pattern consistent across most facilities: concentration ratios converge to within a narrow band around one as distance from the stack increases. Average concentration ratios in the innermost ring, where air pollutant concentrations are highest, ranged from 0.6 to 1.7 when using facility-specific parameters, and from 0.5 to 1.8 when using SIC code-based parameters. Average ratios at the outermost ring ranged from 0.8 to 1.5 when using facility-specific parameters, and from 0.6 to 1.2 when using SIC code-based parameters. Overall, the results obtained demonstrate that predictions of pollutant concentrations are not only comparable, but are extremely close, even though key input data to the two models are not the same. Although the Indicators Model is not designed as a substitute for more comprehensive, site-specific risk assessments, the results of this ground-truthing analysis indicate that the air exposure pathway of the Indicators Model provides very good estimates of air pollutant concentrations at the facility-specific level.

Pollutant concentration is one component in the calculation of an Indicator Element, which can be used to rank facilities. An Indicator Element is the product of three components: the surrogate dose, which is based on pollutant concentration and exposure assumptions; the toxicity weight for the chemical of interest; and, the exposed population. Besides pollutant concentration, for a given chemical with one toxicity weight and one set of exposure assumptions, it is only the variation in population which influences the value of the Indicator Element. To ascertain the possible impact of population on the Indicator Element, the relative contribution of each ring to the Indicator Element was examined. Results indicate that population around a TRI facility can have a significant impact on Indicator Element values, depending on the population size and distribution relative to the predicted pollutant concentrations. The accuracy of the Indicator Elements, however, is directly dependent on the accuracy of the pollutant concentration estimates.

As done in the Indicators Model, Indicator Elements were used to rank facilities. Facilities corresponding to the 24 test cases were ranked using each set of available concentration estimates: AG-1, ISCLT3 with facility-specific median stack heights and exit gas velocities, and ISCLT3 with SIC code-based median stack heights and exit gas velocities. Separate rankings were obtained for facilities emitting chemicals that decay and those emitting chemicals which do not decay. With only one exception, the rankings corresponding to different input parameters were identical for both categories of chemicals, for all three sets of input parameters. This result lends further support to the use of the Indicators Model to develop relative rankings of TRI facilities.

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1. INTRODUCTION

The Science Advisory Board (SAB) of the U.S. Environmental Protection Agency (EPA) advised the Office of Pollution Prevention and Toxics (OPPT) to conduct a "ground-truthing" analysis of the exposure model components of OPPT's Risk-Screening Environmental Indicators Model (the Indicators Model). The Indicators Model is intended for analysis of trends in Toxics Release Inventory (TRI) releases and their relative risk-related impacts. The Indicators Model is not the equivalent of site-specific risk assessment, in part because a number of simplifying assumptions have been made to limit the data requirements of the model. These assumptions do not inhibit the use of the Indicators Model at the national level, but may have the potential to restrict the usefulness of the model at a site-specific level. To explore the use of the model for more site-specific analyses, OPPT requested a ground-truthing analysis of the air model component of the Indicators Model. The purpose of this ground-truthing analysis was to compare air pollutant concentrations predicted using a combination of median data (e.g., stack height and exit gas velocity) and generic assumptions in the Indicators Model to pollutant concentrations predicted using facility- and stack-specific data in a model used for regulatory purposes.

For this analysis, pollutant concentrations estimated by the Indicators Model were compared to concentrations obtained from an air dispersion model used by the New York State Department of Environmental Conservation. Section 2 of this memo describes the design of the ground-truthing analysis. Section 3 presents preliminary model comparisons which were conducted to assess the default assumptions built into each model. Sections 4 and 5 then present the results of the ground-truthing analysis and discuss them, respectively.

2. DESIGN OF GROUND-TRUTHING ANALYSIS FOR NEW YORK

Personnel from the New York State Department of Environmental Conservation (NY DEC) indicated an interest in providing assistance to EPA in this ground-truthing exercise. The NY DEC provided EPA with a copy of the model Air Guide 1 (AG-1), and assisted in making the model operational. AG-1 contains facility-specific data, such as stack heights, for New York facilities, including TRI reporting facilities. AG-1 is used by NY DEC to verify facility compliance with air quality standards (NY DEC, 1991; 1995). AG-1 is composed of two models: a simple model for screening analyses, and a more complex model for refined analyses. The screening analysis produces a single worst-case concentration for the facility, while the refined analysis can predict concentrations at multiple locations chosen by the user. The refined analysis is far more comparable to the air model component of the Indicators Model, and therefore was chosen for the ground-truthing analysis.

Both the Indicators Model and the more complex model in AG-1 use the same analytical algorithm to predict air concentrations of pollutants emitted from industrial point sources. Both models implement the long-term Gaussian plume algorithm included in EPA's Industrial Source Complex (ISC) models (U.S. EPA, 1992a; 1995a, b). Because the two models were developed at different times, they use different versions of ISCLT (AG-1 uses ISCLT2, while the Indicators Model uses ISCLT3). However, the same algorithm is used to model dispersion from point sources in both versions of ISCLT. Thus, identical results should be obtained when both models are used with the same input data set. The major difference between ISCLT2 and ISCLT3 lies in the treatment of area sources, for fugitive emissions. The algorithm for area sources was significantly improved in ISC3.

In this ground-truthing exercise, the results obtained from the Indicators Model are compared to results obtained from a model which uses more facility-specific data. The results from the Indicators Model are *not* being compared to air monitoring data because the ISC series of models (versions 1, 2, and 3) have already been validated. The EPA and others (e.g., Bowers and Anderson, 1981; Bowers et al., 1982; Heron et al. 1984; Moore et al., 1982) have repeatedly tested separate components and features of the ISC models. Tests have included comparisons with experimental (wind tunnel) and site-specific (air quality monitoring) data. These studies have validated improvements in model algorithms and confirmed that the ISC models can adequately reproduce field observations of pollutant concentrations. Currently, ISC3 is one of nine models recommended by EPA for refined air quality analyses (U.S. EPA, 1995c). Recently, ISC3 was used as a benchmark to which the performances of other models were compared (U.S. EPA, 1995d).

2.1 SCOPE OF THE ANALYSIS

The overall objective of the ground-truthing exercise was to assess the degree to which results from the Indicators Model differ from those of another state-of-the-art air model currently used for regulatory purposes. Given that the Indicators Model uses a combination of facility-specific median data, where available, and generic assumptions, while the AG-1 model uses almost all facility-specific data, different air pollutant concentrations are predicted for emissions from the same facility. By analyzing the differences in pollutant concentrations for a number of facilities, the degree to which predictions differ between the two models was quantified.

Because many input variables affect model predictions, the tests conducted for this ground-truthing analysis assessed the combined impact of those variables used in the air exposure pathway of the Indicators Model. Uncertainty and sensitivity analyses would be needed to obtain a complete perspective on the range of variability in model concentrations that occurs for alternative combinations of input parameters. Such analyses were not included in this ground-truthing comparison. Instead, results from a preliminary sensitivity analysis conducted using ISCLT3 were reviewed to identify the relative impact of different input variables. In that analysis, a single input variable was varied over a range of values while holding all other variables constant; the process was repeated for all stack-specific variables (stack height, stack diameter, exit gas velocity, and exit gas temperature). Relative impacts were measured in terms of the average air concentration over a grid identical to that used by the Indicators Model. The results indicated that the pollutant concentrations predicted by ISCLT3 are most sensitive to the stack height value used; exit gas velocity also has a measurable, although smaller, impact on predicted concentrations. Both stack height and exit gas velocity are negatively correlated with the average air concentration; that is, larger values of these parameters will yield smaller concentrations, and vice-versa. More extensive tests conducted by the NY DEC have reached similar conclusions (NY DEC, 1991).[1]

2.2 SAMPLING FRAMEWORK

This ground-truthing analysis compares air pollutant concentrations estimated by using a combination of facility-specific (e.g., median stack height and median exit gas velocity) and generic (e.g., stack diameter and exit gas temperature) air modeling parameters in the Indicators Model to concentrations estimated using facility-specific data. Specifically, 24 test cases were constructed to evaluate the impact of Indicators Model parameters for facilities with different stack heights, geographic location, and chemical characteristics of emissions (see Table 1).

Test cases were designed to capture the variability in stack heights, because this input variable has the largest impact on predicted air concentrations. The Indicators Model uses either the median stack height of all stacks (regardless of the chemical emitted) for TRI facilities with this information or an SIC code-based median stack height for facilities without stack data (Bouwes and Hassur, 1998). The latter is based on the median of stack heights for facilities in a particular 3-digit SIC code (or in the 2-digit SIC code if the 3-digit SIC code is invalid. If no valid 2-digit SIC code is available, the median of all stack heights in SIC codes 20 through 39 is used). Stack height data were obtained from the AIRS Facility Subsystem (AFS) within the Aerometric Information Retrieval System (AIRS), the National

[1] NY DEC quantified the impact of stack height on pollutant concentrations under different conditions, including a range of downwind distances, varying building dimensions, and differing numbers of stacks (NY DEC, 1991).

Emission Trends Database, and databases from three individual states (California, New York, and Wisconsin). In the calculation of median stack height for facilities with a particular SIC code, statistical analyses were conducted to determine whether heights for stacks not emitting any TRI chemicals should be included. For some SIC codes, significant height differences did not exist between stacks emitting TRI chemicals and stacks not emitting TRI chemicals. Thus, in those test cases, all stack heights for all facilities in that SIC code were used to estimate the median stack height for that SIC code. For other SIC codes, a significant height difference between the two groups of stacks did exist, and only those stacks emitting TRI chemicals were used in the calculation of a median stack height for that SIC code.

When running AG-1, NY DEC uses actual stack height data for those individual stacks emitting chemicals of concern at a selected facility. The sampling framework for the ground-truthing analysis was designed to evaluate in part the impact of using a facility-specific median stack height in the Indicators Model versus using multiple stack-specific heights in the AG-1 model. Three categories of facilities were represented: (1) TRI facilities with median stack heights less than seven meters, (2) TRI facilities with median stack heights between seven meters and ten meters, and (3) TRI facilities with median stack heights greater than ten meters. These categories reflect the distribution of facility-specific median stack heights for TRI facilities in New York: approximately one-third of these facilities are found in each of the stack height bins. Once the test cases were chosen for analysis, the facility-specific median stack height was used in the Indicators Model runs and the actual stack-specific heights were used in the AG-1 model runs. To evaluate the impact of using stack heights based on SIC codes, a further comparison was made, using the stack heights based on each facility's SIC code in the Indicators Model.

As previously indicated, the preliminary sensitivity analysis showed that exit gas velocity also has a measurable impact on predicted concentrations. The Indicators Model uses either the median exit gas velocity of all stacks (regardless of the chemical emitted) for TRI facilities with this information or an SIC code-based median exit gas velocity for facilities without exit gas velocity data (Bouwes and Hassur, 1998). The latter is based on the median of exit gas velocities for facilities in a particular 3-digit SIC code (or in the 2-digit SIC code if the 3-digit SIC code is invalid. If no valid 2-digit SIC code is available, the median of all exit gas velocities in SIC codes 20 through 39 is used). Exit gas velocity data were obtained from AFS within AIRS, the National Emission Trends Database, and databases from two individual states, New York and Wisconsin. The same statistical analyses as described above for stack heights were conducted before a median exit gas velocity was calculated for each SIC code. Again, the facility-specific median exit gas velocity was used in the Indicators Model runs and the actual stack-specific exit gas velocities were used in the AG-1 model runs for one comparison; a second comparison was made using exit gas velocities based on SIC codes.

Specific TRI facilities were selected from urban and rural areas covered by meteorological stations in Albany, Buffalo, Rochester, and Syracuse.[2] These four metropolitan areas were chosen to determine if particular air modeling parameters have greater impacts in certain areas due to possible interactive effects with different meteorological conditions. For each metropolitan area and stack height bin, two facilities were selected: one to represent stacks emitting chemicals with decay rates and the other to represent stacks emitting chemicals without decay rates. The distinction was intended to reflect another difference between the Indicators Model and AG-1: the Indicators Model incorporates chemical decay rates (based on photo-oxidation), while AG-1 does not. These decay rates reduce the resultant air concentrations predicted by the Indicators Model.

An attempt was made to construct the sample of test cases by selecting one chemical with a decay rate and one without a decay rate, as well as facilities that emitted both chemicals, to minimize the variability across sites. However, these restrictions yielded an insufficient number of facilities for analysis. The final set of 24 test cases reflects a compromise: a single chemical (toluene) with a decay rate and four of the most commonly released chemicals without decay rates (mercury, aluminum, lead, and nickel) for New York TRI facilities in the four locations. Four of the facilities represented in the sample discharge both types of chemicals: Facility A (Albany), Facility G (Syracuse), Facility Q (Rochester), and Facility S (Rochester). Although the information on these facilities was used for the analysis of both chemicals with decay rates and those without decay rates, each facility is considered to be two separate test cases because different sets of stacks are evaluated by AG-1 and, therefore, results do not represent the effect of changing *only* chemical characteristics.

2.3 TESTING STRATEGY

To conduct this ground-truthing analysis, the ISCLT3 model (U.S. EPA, 1995a, b) was used directly, rather than as implemented in the Indicators Model. Because of this choice, a three-way model comparison was necessary. First, the Indicators Model and ISCLT3 were compared to verify that the ISCLT3 algorithm was successfully incorporated into the Indicators Model. Second, AG-1 and ISCLT3 were compared to verify that they yielded the same results with identical inputs for point sources. Although both models implement the same ISCLT point-source algorithm, this comparison was necessary to test whether other assumptions were built into AG-1. Third, AG-1 and ISCLT3 were compared, with AG-1 using all available facility-specific data and ISCLT3 using the combination of facility-specific data and generic assumptions used in the Indicators Model. This third test evaluated how model predictions of pollutant air concentrations from point sources differ when facility-specific data (e.g., building parameters, such as height and area dimensions, and stack parameters, such as height, exit gas velocity, and temperature) are used as compared to median stack height and exit gas velocity data and generic assumptions.

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[2] "Urban" areas are defined in the Indicators Model as having populations greater than 119,070 people. In this ground-truthing analysis, fifteen facilities are located in urban areas and five are in rural areas.

3. PRELIMINARY TESTS

This section describes the first two model comparisons conducted prior to the actual comparison of results from the Indicators Model and AG-1 model. First, EPA already conducted several tests in the past that verified that the Indicators Model yielded results identical to those of the ISCLT3 model when predicting air concentrations from point sources.

Second, tests were conducted to compare results from AG-1 and ISCLT3. These tests were conducted with Facility A in Albany, for which all facility-specific data were available in the AG-1 database. A single chemical (mercury) was selected from all the TRI compounds emitted by this facility. All input data from AG-1 were used as input to ISCLT3, and two tests were run, one for the urban mode and one for the rural mode. In both tests perfect agreement was obtained between the two models' predictions for all nodes in a 21-km by 21-km grid. In the Indicators Model, each node is centered in a 1-km by 1-km cell, and the concentration at the node is assigned to that cell. The facility is located in the center cell of the 441 cells, and no concentration is attributed to that cell. The grid size is not finer because the Indicators Model assesses general population exposures, not risk to a Most Exposed Individual (MEI).

Although one facility was used to test both the urban and rural modes, only one mode is used for a given facility in the Indicators Model. If the total population in a 21-km by 21-km grid centered at the facility is larger than 119,070, the urban mode is used. Different dispersion algorithms are used for the rural and urban modes (U.S. EPA, 1995a, b), but for a given mode, the same algorithms are used in both AG-1 and ISCLT3. The two models, however, make different assumptions about building dimensions. When site-specific data are available, AG-1 calculates individual stack heights as the sum of two variables: building height and stack height above structure. When site-specific data are not available, AG-1 assumes that all building dimensions (height, width, and length) are equal to the stack height; this assumption is intended to make the model more conservative. ISCLT3 makes no specific dimension assumptions, and adopts zero building dimensions. By forcing ISCLT3 to make the same assumptions about building dimensions as AG-1, perfect agreement was obtained under both rural and urban modes. However, in the actual ground-truthing tests reported in the next section, no such correction was made. Therefore, this difference in assumptions accounts for a fraction of the total difference in air concentrations observed at each facility. Different concentrations are predicted because the presence of a building produces higher concentrations near the source due to building downwash. After downwash, there is less pollutant mass to be distributed further away from the building, because the total pollutant mass being emitted into the air is the same regardless of building dimensions. Thus, when all other inputs are the same, the Indicators Model will produce slightly higher air pollutant concentrations further away from the source than AG-1 and lower concentrations nearer the source. However, the differences in predicted concentrations are small for the range of distances sampled by the computational grid used in the Indicators Model (1 to 14.8 km, where 14.8 km is the diagonal distance from the source to the corner of the 21-km by 21-km grid). Typical maximum differences are on the order of one to two percent, and decrease to insignificant levels with increasing distance from the source.

4. MODEL COMPARISON: AG-1 VERSUS ISCLT3

As indicated in Section 2, ISCLT3 was used directly for this ground-truthing exercise. All facility-specific median data and generic assumptions used in the Indicators Model were also used in ISCLT3, to obtain the same model predictions that would be produced by the Indicators Model. In the remainder of this section these results are referred to as the "Indicators Model results" for convenience.

4.1 INPUT DATA

AG-1 and ISCLT3 share the same input parameters, but assign different values to them, as summarized in Table 2. For stack diameter, exit temperature, and building dimensions, the Indicators Model uses constant, generic values, whereas AG-1 uses facility-specific data (if available). In addition, AG-1 computes concentrations from all individual stacks that emit a particular chemical, while the Indicators Model treats all such emissions as emanating from a single stack at a central location, with stack height equal to the median height of all stacks at the facility and exit gas velocity equal to the median exit gas velocity from all stacks at the facility. For chemicals which may decay through photodegradation, the Indicators Model uses a decay rate, whereas AG-1 assumes no chemical decay occurs. Both models use comparable meteorological data, i.e., STability ARray (STAR) data from local meteorological stations.[3] For a given meteorological station, the Indicators Model uses average conditions computed over many years (typically 25 years or more), while AG-1 uses one year's worth of data corresponding to the most recent year with valid STAR data. For purposes of this ground-truthing exercise, both models used STAR data from AG-1.

The stack coordinates of the TRI facilities selected for the model comparison are listed in Table 3. All coordinates are in meters, with values corresponding to the Universal Transverse Mercator (UTM) coordinate system. Two sets of coordinates are listed, corresponding to the NY DEC and national TRI databases. The national TRI database contains a single pair of coordinates for each facility, while the NY DEC database contains stack-specific coordinates. The values listed for the latter in Table 3 are the coordinates of the point located in the middle of all stacks that emit the particular chemical selected for the model comparison. AG-1 centers the computational grid at this middle point. Note that some of the TRI database and NY DEC coordinates included in Table 3 differ by hundreds or thousands of meters, which would cause the contaminant plumes to be mapped in non-overlapping locations. Therefore, the single stack for the ISCLT3 runs was placed at the same middle point that AG-1 uses to center the grid.[4]

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[3] ISCLT uses as input meteorological data that have been summarized into joint frequencies of occurrence for particular wind speed classes, wind direction sectors, and atmospheric stability categories. These STAR summaries may include frequency distributions over a monthly, seasonal, or annual basis.

[4] In the Indicators Model, the facility stack is centered in the model cell that contains the facility coordinates from the national TRI database.

Tables 4 to 8 display the input data used by each model for the following parameters: stack height, exit gas velocity, stack diameter, exit temperature, and chemical emission rate. For stack diameter and exit temperature, the Indicators Model has single default values (Table 2), while AG-1 uses stack-specific values. Because the AG-1 emissions data are from different years for different stacks, reported releases from the TRI database could not be used. Instead, as indicated in Table 2, for a given facility the sum of the emission rates of a particular chemical from all relevant stacks in AG-1 was used as the chemical emission rate for that facility in the Indicators Model (ISCLT3). Although AG-1 uses unique chemical emission-stack combinations, the mean and median stack heights and exit gas velocities are presented in Tables 4 and 5 for purposes of comparison to ISCLT3 inputs. As shown in Tables 4 and 5, the number of stacks used in the calculation differ, as AG-1 mean and median values are based only on those stacks which emit the chemical being analyzed, whereas mean and median values in ISCLT3 are based upon all stacks at the facility.

4.2 RESULTS

Three sets of Indicators Model runs were conducted to explore the impact of having facility-specific median data or relying on assumptions when such data are not available. The first set uses facility-specific median stacks heights and exit gas velocities, representing the case with most stack-specific data. The second set uses facility-specific median stacks heights and a constant exit gas velocity of 0.01 m/sec. The third set uses median stacks heights and exit gas velocities corresponding to the 3-digit or 2-digit SIC code of the facility, representing the case with the least stack-specific data. Results from the three sets of tests are described below.

Both the Indicators Model and AG-1 report pollutant concentrations on a discrete grid. The Indicators Model uses a 21-cell by 21-cell grid composed of 1 km^2 cells, with a total of 441 cells. The same grid dimensions were chosen for the AG-1 model runs to compare results at the same locations. Figure 1A displays the pollutant concentrations in each cell predicted by AG-1 for an example facility, while Figure 1B displays the concentrations predicted by the Indicators Model. Figure 1C displays the ratio of concentrations predicted by each model for each cell (i.e., ISCLT3 concentration/AG-1 concentration); a ratio of one indicates perfect agreement between the Indicators Model and AG-1. The arrays of results shown in these figures provide a wealth of information, but they are not the most convenient means to analyze spatial patterns. Instead, concentrations can be displayed as a pollutant concentration plume with the aid of a contour plot. Figures 2A and 2B display contour plots of the pollutant plumes predicted by each model for the example facility. Figure 2C displays a contour plot of the concentration ratios shown in Figure 1C. Figure 2C reveals that concentration ratios in about 20 cells around the stack range in value from 0.6 to 0.9; concentration ratios in all other cells located further away from the stack are between 0.9 and 1.0.

Without reference to the location of individual cells, a histogram of all cell ratios provides a more compact way of comparing plumes and illustrates the variability within and among test cases. Figures 3 to 6 display such histograms for all 24 test cases, individually and averaged by metropolitan area. While some of the histograms (e.g., test case 3 in Albany) are narrowly clustered around a single value (usually one), others display more dispersion (e.g., test case 1 in Rochester), with the maximum value for any single cell ratio being 3.1 (for test case 4 in Rochester). The histograms in Figures 3 to 6 show that the average concentrations calculated by the Indicators Model for an individual facility may differ from those calculated by AG-1 by up to 48 percent, with the largest deviation corresponding to test case 4 in Albany (average concentrations are calculated over the 440 cells surrounding each facility).

In addition to the contour plots and histograms, another type of plot was developed to examine the variability of model results with distance from the source. Because the computational grid used by the Indicators Model is made up of square cells surrounding the source, a surrogate measure was used to approximate the radial distance from the source. The grid can be visualized as being made up of concentric square rings located around the central cell containing the source; in a 21-km by 21-km grid, there are ten such rings, with ring one being closest to the source and ring ten being the outermost ring. The ring number serves as a surrogate measure of distance in kilometers from the source. For each of the ten concentric square rings, an average concentration ratio was calculated; because of averaging effects, these concentration ratios display a narrower range of values than the variations depicted by the histograms in Figures 3 to 6. Figures 7 to 10 display the average concentration ratios over concentric square rings for individual test cases, grouped by metropolitan area. The shapes of the plots for test cases in the same metropolitan area are somewhat similar, but not enough to define distinct patterns for each metropolitan area. Instead, two patterns are apparent for individual test cases: concentration ratios decrease with distance when there is a maximum at ring one, or increase with distance when there is a minimum at ring one. For the second ring and further, ratios for individual test cases are within ten percent of unity for Albany, and within about 20 percent of unity for Buffalo, Rochester, and Syracuse, except for two test cases discussed below. Within the first ring, ratios for individual test cases are within 35 percent of unity, except for the two test cases discussed below.

In two of the cities there is a single curve that displays consistently higher concentrations for all rings: test case 4 in Albany (mercury) and test case 4 in Rochester (nickel). These same test cases can be identified using the histograms in Figures 3 and 5. Inspection of Table 4 reveals that test case 4 in Albany and test case 4 in Rochester share a common characteristic: the facility-specific median stack height used in the Indicators Model is significantly shorter than the corresponding median height of the stacks that actually emit the given chemical (although AG-1 uses individual stack heights, their median was computed to allow a simple comparison; other measures, such as the emission-weighted mean or median, could be used as well). The differences are 26 meters (m) and 6 m for the Albany and Rochester test cases, respectively. Calculations using the shorter stack height from the Indicators Model result in higher concentrations predicted by the Indicators Model, and therefore, higher concentration ratios. Test case 4 in Albany, which has the largest discrepancy between median stack heights, produces the largest ratios over the entire grid in the 24 test cases. These results are consistent with previous sensitivity analyses of the influence of stack heights on pollutant concentrations. However, the tests conducted for this ground-truthing analysis were not designed to isolate the influence of a single variable. Hence, the range of variability in calculated pollutant concentrations reflects the combined effect of all input variables that take different values in each model (this includes not only all stack parameter data, but also building dimensions and treatment of chemical decay).

In interpreting the average concentration ratios over concentric rings, it is important to note that the inner rings have fewer cells (e.g., 8 cells for ring 1 of an individual test case), as compared to outer rings (e.g., 80 cells for ring 10 of an individual test case). Therefore, the statistics for the inner rings are more sensitive to single high values. In contrast, the ratio statistics for the outer rings are more stable and seem to approach a constant value, typically very close to unity. In subsequent figures similar "ring" curves are used to examine the variability of concentration ratios by stack height bin, chemical, and metropolitan area.

Figure 11 displays the average concentration ratio computed for each ring for the three stack height bins. Agreement between the Indicators Model and AG-1 seems to be independent of stack height bin, because most ratios are within five percent of unity; even within the two innermost rings, ratios are within fifteen percent of unity.

Figure 12 compares the ring statistics grouped by chemical type (each group has twelve test cases). The ratios for the chemical with a decay rate are consistently lower than those for chemicals without a decay rate, which is expected, given that the Indicators Model accounts for decay rates, while AG-1 does not. Figure 12 indicates that ratios for the chemical with a decay rate are about five percent lower than unity on average, while those for the chemical without a decay rate are about two percent higher than unity. However, this figure should be taken as indicative only. Evaluating the effect of this individual variable would require running each test case with both chemical types, holding all other parameters constant.

Figure 13 shows the average ring statistics for each metropolitan area (six test cases each, averaged over both chemical types). Except for Syracuse, the ratios for all rings in the four curves shown in Figure 13 are within ten percent of unity. The concentration ratios in the first ring of Syracuse are within 17 percent of unity.

Table 9 contains similar information, but also provides the standard deviations, minimum values, and maximum values of the concentration ratio for each metropolitan area, by chemical characteristic and by stack height bin. The mean concentration ratio for the entire sample is 0.984, indicating that on average, the predictions of the Indicators Model are virtually the same as those of AG-1. Subsample average ratios (e.g., by metropolitan area, chemical characteristic, and stack height bin), shown in Table 9, vary between 0.935 and 1.05, again representing very good agreement. Table 10 contains the statistics corresponding to the concentration ratios by ring for all locations together and by metropolitan area. A complementary view is provided by the histograms in Figures 3 to 6. These figures show that the average histograms of concentration ratios for each metropolitan area have most cells clustered around one, with the highest frequency corresponding to ratios between 0.95 and 1.05.

4.2.1 Impact of Exit Gas Velocity Assumptions

When this ground-truthing exercise was initiated, the corresponding version of the Indicators Model assumed a constant exit gas velocity (0.01 m/s) for all stacks. Given that the preliminary sensitivity analysis indicated that exit gas velocity had a measurable impact on predicted concentrations, and that the default value of 0.01 m/s was three orders-of-magnitude smaller than most available data on exit gas velocities, the way in which exit gas velocities are treated in the Indicators Model was changed (Bouwes and Hassur, 1998). Tables 11 and 12 contain a summary of results for the constant exit gas velocity case, in the same format as Tables 9 and 10. Although each single statistic in Tables 11 and 12 can be compared to its counterpart in Tables 9 and 10, only the mean concentration ratio calculated over the whole sample (all rings, all metropolitan areas) is analyzed here. The mean ratio in Tables 11 and 12 equals 0.980, approximately equivalent to the mean ratio (0.984) shown in Tables 9 and 10; the corresponding standard deviations are virtually the same (0.136 and 0.134, respectively). Although these statistics are very similar, EPA believes that it is more defensible to use available data on exit gas velocities and to treat the data in the same manner that stack height data are treated than to use a default value that is three orders-of-magnitude smaller than most available data.

4.2.2 Impact of SIC Code-based Stack Height and Exit Gas Velocity Assumptions

The results presented so far correspond to the case in which facility-specific data are available to calculate median stack heights and exit gas velocities. However, only a small fraction of facilities nationwide (about ten percent) have such data in the Indicators Model database. For the vast majority of the facilities, the Indicators Model uses the median stack height and exit gas velocity corresponding to the 3-digit SIC code of the facility. Table 13 contains the median stack heights and exit gas velocities corresponding to the 3-digit SIC codes of the 24 facilities in the sample, along with the facility-specific median values (used in the previous comparison) and the chemical-specific median values (which summarize the stack by stack emissions calculated by AG-1). A brief inspection of Table 14 reveals that stack heights for individual facilities may differ by as much as a factor of seven.

To test the performance of the Indicators Model when data based on SIC codes are used, the 3-digit SIC code median values in Table 13 were used in ISCLT3 and the results were compared to AG-1. Results are displayed in Figures 14 through 24 and Tables 14 and 15. Because the figures and tables contain results parallel to those previously discussed, a side-by-side comparison is possible. For example, the histograms in Figures 14 to 17 show a summary of cell-by-cell concentration ratios similar to those in Figures 3 to 6. Overall, the histograms in Figures 14 to 17 show more scatter than those in Figures 3 to 6. This scatter is consistent with the larger differences in input parameters (stack heights) for some facilities, as shown in Table 13. An inspection of the histograms in Figures 14 to 17 shows that the average concentrations calculated by the Indicators Model for an individual facility may differ from those calculated by AG-1 by less than 35 percent (the largest average deviations correspond to test case 1 in Albany and test case 4 in Rochester). The maximum value for any single cell ratio is 3.4 (for test case 4 in Rochester).

The summary statistics in Tables 14 and 15 can be readily compared to those in Tables 11 and 12 (and Tables 9 and 10). The mean concentration ratio calculated over the entire sample (all rings, all facilities) equals 0.936 (Tables 14 and 15), somewhat lower than the mean ratio (0.984) obtained when using facility-specific median stack heights and exit gas velocities (Tables 9 and 10). This result is consistent with the inputs shown in Table 13: given that a majority of 3-digit SIC median stack heights are larger than the corresponding facility-specific median values, the Indicators Model predicts smaller concentrations and therefore the concentration ratios are lower on average. (This result in turn is consistent with the findings from sensitivity analyses already discussed.) The standard deviation of the concentration ratio (0.131) is approximately equivalent to the previous one (0.134).

A majority of the 24 test cases have 3-digit SIC code median values significantly higher than the corresponding facility-specific median values. On a nationwide basis, the Indicators Model could be expected to sometimes overpredict and sometimes underpredict, depending on the discrepancies between actual and assumed parameter values. To assess the range of discrepancies on a larger sample, parameter values for all facilities with site-specific data were compared to SIC code based values. The comparison was performed by subtracting facility-specific median values from SIC code based median values, for stack heights (1504 facilities) and exit gas velocities (1063 facilities). The results are displayed in Figures 25 and 26 for stack heights and exit gas velocities, respectively. SIC code based median stack heights range from 69 m less to 29 m more than the facility-specific median stack heights. The 95th and 5th percentiles are 18 m less and 7.0 m more, respectively. SIC code based median exit gas velocities range from 295 m/s less to 17 m/s more than the facility-specific median exit gas velocities. The 95th and 5th percentiles are 49 m/s less and 7.1 m/s more, respectively. Ground-truthing analyses were not repeated for these additional facilities, although previous results show that using median values based on SIC codes yields a wider range of concentration ratios (subsample statistics in Table 14 vary between 0.871 and 1.00, a range only slightly wider than the corresponding ranges in Tables 9 and 11). Because the concentration ratio statistics (overall average and standard deviation) are reasonably close to the values obtained when using facility-specific median values, it is concluded that the Indicators Model performs very well when using 3-digit SIC code median values for stack heights and exit gas velocities.

4.3 FUGITIVE EMISSIONS ANALYSIS

Fugitive releases, which are modeled as area sources, are a significant fraction of the total reported air emissions of TRI chemicals. The ISCLT model used by AG-1 and the Indicators Model can predict fugitive emissions from area sources as well as stack emissions from point sources. Thus, it is theoretically possible to conduct a ground-truthing exercise for fugitive emissions to test the area source component of the Indicators Model.

A ground-truthing exercise for fugitive emissions using AG-1, however, would not be very useful. Recall that AG-1 uses ISCLT2, and the Indicators Model uses ISCLT3; the area source algorithm in ISCLT3 has been improved over that used in ISCLT2 to calculate pollutant concentrations from fugitive emissions (U.S. EPA, 1992a, 1995b). Therefore, predictions made by the two models will differ even when identical input data are used. In addition, AG-1 and the Indicators Model use different data to characterize the dimensions of area sources. While AG-1 uses site-specific data for the surface area and height of an area source, the Indicators Model uses default values. Hence, comparing the fugitive emission component of AG-1 and the Indicators Model would require separate evaluations of the differences due to model algorithms and due to input data.

The essential difference in the area source algorithms used in ISC2 and ISC3 can be summarized as follows. Both algorithms are based on integrations of the Gaussian plume formula used for point sources, but the integration is carried out over different area geometries to describe the shape of an actual area source. In ISC2 the integration is carried out over a crosswind line, and calculations assume square area sources. Actual area sources may have irregular shapes; they can be represented with many small squares that approximately overlay the actual area. In ISC3 the integration is carried out over a rectangular area, and calculations allow arbitrary dimensions for each rectangle. By using rectangles of variable dimensions (aspect ratios can be as high as ten to one), area sources of irregular shape can be represented more accurately than in ISC2. (Note that these integrations cover the area source itself and therefore are independent of the computational grid used in the Indicators Model to estimate pollutant concentrations in square cells.) The revised area source algorithm included in ISC3 has been thoroughly evaluated and its predictions compared to wind tunnel data (U.S. EPA, 1992b, c, d). Because the computational algorithms are different, ISC2 and ISC3 will predict different concentrations for an identical area source, square or otherwise. However, the differences between predictions of ISC2 and ISC3 are more significant close to the source. ISC2 (and therefore AG-1) can underestimate concentrations close to the source by as much as a factor of three (NY DEC, 1995).

If the area source algorithms were identical in ISCLT2 and ISCLT3, as the point source algorithms are, a ground-truthing analysis would compare the results obtained from site-specific data on area source sizes with results obtained using default assumptions. The Indicators Model uses default values for the dimensions of all area sources: a surface area of 10 m^2 and a height of 3 m. The AG-1 Guidelines (NY DEC, 1991) recommend using a surface area of 84 m^2 in the absence of site-specific data; no default value is recommended for the height of the area source.

Sensitivity analyses conducted on ISCLT2 demonstrate that for an arbitrary area source size, there is a distance from the source at which the concentrations approach those of a point source (NY DEC, 1991). As would be intuitively expected, this distance decreases for smaller area sources. For an area source of the size used in the Indicators Model (10 m^2), this distance is about 50 m; for an area source of the size recommended in the AG-1 Guidelines (84 m^2), this distance is about 400 m (NY DEC, 1991). Therefore, at the distances sampled by the Indicators Model grid (one kilometer and larger), both models yield practically identical results (NY DEC, 1991). These results from ISCLT2 only reflect the impact due to different area sizes, not the impact of different area source heights. A similar sensitivity analysis was conducted using the ISCLT3 model to evaluate the impact of both area source size (10 m^2 and 84 m^2) and height (3 m and 0 m). From this analysis it was determined that the distances from the source at which the concentrations approach those of a point source are also less than one kilometer. Thus, a separate ground-truthing exercise for area sources would be redundant with the analysis of point sources already conducted.

5. PERSPECTIVE ON FINDINGS

This ground-truthing analysis shows that pollutant concentrations predicted by the Indicators Model are in excellent agreement with those predicted by AG-1, even though the models use different input data (median and generic values versus stack-specific data) and assumptions (e.g., building dimensions and treatment of chemical decay). Although the range of concentration ratios for individual cells is 0.23 to 3.4, the vast majority of individual cells in all 24 test cases have concentration ratios that are close to unity (within five percent of unity when facility-specific median parameters are used, and within ten percent of unity when SIC code based parameters are used). Because any one individual cell contributes very little to the impact of the facility as a whole, average concentration ratios over concentric rings around the stack were analyzed. For the majority of the test cases in the sample, average concentrations within each ring predicted by the two models are within 20 percent of each other. In the rings closest to the source, in which the largest discrepancies occur, average concentrations within each ring predicted by the two models are within a factor of 0.5 to two of each other, even when SIC code based parameters are used. Thus, although the Indicators Model is not designed as a substitute for more comprehensive, site-specific risk assessments, the results of this ground-truthing analysis indicate that the air exposure pathway of the Indicators Model provides very good estimates of air pollutant concentrations at the facility-specific level.

Not surprisingly, this ground-truthing analysis showed that the Indicators Model performs best when facility-specific median stack heights and exit gas velocities are available, rather than when median stack heights and exit gas velocities based on SIC codes are used. When facility-specific median values were used, results indicated a very close agreement between the Indicators Model and AG-1: average concentrations calculated over the approximately 10,560 cell concentrations estimated by each model for all 24 test cases differ by less than two percent, with a standard deviation of approximately 13 percent. Even when parameters based on SIC codes are used, the results of the Indicators Model compare very well to those of AG-1: average concentrations computed by both models for the 24 test cases differ by approximately six percent, with a standard deviation of approximately 13 percent.

Average ring concentrations predicted by the two models are within a factor of 0.5 to two of each other near the facility; these concentration ratios become smaller and often converge within a narrow band around unity with increasing distance from the source. Only two of the 24 test cases departed from this general pattern when using facility-specific median parameter values. As previously mentioned, such disagreements are probably due to the markedly different stack heights used by each model in these two test cases. Similar discrepancies are expected to occur in a fraction of the cases nationwide, because the facility-specific stack statistics (e.g., median) may not always accurately approximate the corresponding statistics for the subset of stacks that emit a particular chemical. This may happen regardless of whether facility-specific or SIC code based parameters are used. The sample is too small to allow precise inferences of how often this may occur, but the fact that such discrepancies occurred only twice in the 24-case sample gives some indication that this situation may occur in only a small fraction of cases on a nationwide basis as well.

5.1 CALCULATION OF INDICATOR ELEMENTS

Although the ground-truthing exercise has affirmed the accuracy of the pollutant concentrations predicted by the Indicators Model, pollutant concentration is only part of the calculation of an Indicator Element, which can be used to rank facilities. Therefore, it is imperative to ascertain the contribution of pollutant concentration, as well as other components, to the estimation of Indicator Elements. An Indicator Element is the product of three components: the surrogate dose, which is based on pollutant concentration and exposure assumptions; the toxicity weight for the chemical of interest; and, the exposed population. For each of the 440 cells surrounding a TRI facility, cell-level products, called Indicator Sub-Elements, are calculated and then added to yield the Indicator Element. Consideration of these other Indicator Element components while taking into account the increased predictive accuracy of the ISCLT3 model at greater distances from a facility will aid the analyst when interpreting Indicators Model results at the facility-level.

5.1.1 Toxicity

Toxicity weights are chemical and pathway-specific; each facility emitting a given chemical will receive that same pathway-specific weighting factor for that chemical release. Weights range from 0.1 to 1,000,000 for carcinogens and from 0.001 to 100,000 for non-carcinogens. The impact of toxicity weights on Indicator Elements will be irrelevant only when comparing facilities emitting the same chemical. In all other cases they may account for a significant fraction of the total Indicator Elements value calculated for a facility.

5.1.2 Surrogate Dose

The air pollutant concentration estimated by the Indicators Model is converted to a surrogate dose using standard assumptions for body weight and inhalation rate. These exposure assumptions are the same from facility to facility and will not influence the ranking of facilities. Thus, the surrogate dose can be viewed as the ISCLT3 concentration multiplied by a constant. As discussed above, the results of this ground-truthing exercise demonstrated that the methods employed by the Indicators Model to estimate facility stack heights and exit gas velocities result in pollutant concentrations that compare very favorably to those of the AG-1 model, which uses much more facility-specific data. Generally, the results of the two models converged at approximately 2 kilometers from the facility, resulting in only a small percentage of the 1-km by 1-km cells being prone to over or underestimation of pollutant concentrations by an appreciable amount. These cells with an appreciable amount of over or underestimation are usually located in the immediate vicinity of the source. While pollutant concentrations are also highest near the source, one cannot conclude that these cells have the greatest impact on Indicator Elements without considering the impact of population distribution.

5.1.3 Population

In addition to pollutant concentration, population is the other component of the Indicator Element that is of interest for this ground-truthing exercise. Unlike exposure assumptions and toxicity weight, which are applied consistently across all cells surrounding a facility, population is not distributed evenly around a facility. Generally speaking, it would be ideal if population was distributed at distances from the facility where the correspondence between ISCLT3 and AG-1 concentration estimates was nearly identical. Then the resulting facility rankings would be a fair representation of facilities' relative risk. If the population was concentrated primarily within 2 km of a facility, the resultant relative-risk rankings would be subject to greater error because the potential for discrepancies in estimated pollutant concentrations is higher nearer to the facility.

To consider this issue, revisit Figures 18 through 21, which show the concentration ratios using SIC code based parameters for the 24 test cases for the four metropolitan areas in New York State. Generally, concentration ratios become relatively constant at approximately 2 km. Within 1 km the ring-average estimates of the concentration ratios for the 24 test cases range from 50 percent below unity to almost 80 percent above unity. As seen in Table 15, the largest concentration ratio for a single cell of the 192 cells composing the 1 km rings of these 24 test cases (8 cells x 24 sites) was 3.4; the average of these 192 concentration ratios was 0.89.

To calculate an Indicator Element, it is necessary to multiply pollutant concentration in each cell by the number of people living in each cell. Therefore, population distribution in concentric rings around each facility was examined to see whether higher pollutant concentrations closer to the facility were counterbalanced by lower populations closer to the facility. The number of people living in each of the 440 cells surrounding the 24 facilities was obtained from the Indicators Model (AG-1 does not have a population database); these numbers were then added over all cells in a given ring for a given facility. The resulting population distributions do not display a consistent pattern, but rather vary significantly from facility to facility. While some facilities have the majority of the population living in rings 1 to 3, many facilities have increasing numbers of people living at greater distances. There is also significant variability among metropolitan areas: in Albany, most people live relatively far away from TRI facilities, while in Buffalo a high percentage of people live close to TRI facilities. In an attempt to obtain a national perspective of this, a nationwide distribution of exposure events, i.e., persons impacted by multiple TRI facilities with non-zero air releases, was also analyzed. Table 16 presents the exposure events within specific "distance rings" of TRI facilities reporting air releases. The values shown in this table are derived by assigning each person in the U.S. to each TRI facility located within a specified distance; this procedure allows a person to be counted multiple times, as is done in the Indicators Model, depending on how many TRI facilities potentially impact them. Thus, the total exceeds the U.S. population, because of individuals experiencing multiple exposures. Although approximately 28 percent of the U.S. population resides within 2 km of TRI reporting facilities, Table 16 shows that only five percent of all exposure events occur within 2 km.

When a large percentage of the population lives close to a TRI facility and when significant discrepancies exist between the AG-1 and ISCLT3 predictions of pollutant concentrations near that facility, the generated Indicator Elements could conceivably influence relative rankings of facilities. In those instances where significant discrepancies exist between the AG-1 and ISCLT3 concentration predictions close to the facility but only a small percentage of the population live close to the facility, the impacts on the Indicator Elements and the associated facility rankings will be negligible.

5.2 COMPARISON OF INDICATOR SUB-ELEMENTS' CONTRIBUTIONS BY RING

As described above, Indicator Elements are the sum of Indicator Sub-Elements calculated for each of the 440 cells surrounding a TRI facility. To investigate the relative contribution of cell rings to the total Indicator Element value, Indicator Sub-Elements were calculated for each ring around each facility by multiplying just the population and the pollutant concentration in each cell, and adding the products over all cells in a ring. (These results were not multiplied by toxicity because the focus was only on analyzing a single pollutant in a given case.) The percent contributions of each ring to a facility's Indicator Element are displayed in Figures 27 to 30 (one figure per metropolitan area), along with the corresponding concentration ratio (ISCLT3/AG1) distributions by ring (these distributions are identical to those shown in Figures 7 to 10).

Inspection of Figures 27 to 30 reveals the absence of a typical profile. In fact, the distribution of the percent contribution by ring varies widely, as a consequence of the cell-by-cell combination of population and pollutant concentrations. While there are test cases where the largest contribution to a facility's Indicator Element comes from the first few rings (e.g., test case 1 in Syracuse), the converse is true in other test cases (e.g., test case 1 in Rochester). These two test cases illustrate the correlation between the distributions of population and Indicator Sub-Elements, and help visualize the impact that discrepancies in concentration estimates (measured by concentration ratios) may have on Indicator Elements. When there is a high population density near the facility, discrepancies in concentration estimates can translate into discrepancies of similar magnitude in Indicator Elements. In the worst case, the same factor of 0.5 to two that bounds discrepancies in pollutant concentrations will apply to Indicator Elements as well. This case is exemplified by case 4 in Albany, where concentration discrepancies in excess of 40 percent occur for all rings, and therefore the Indicator Element value is also 40 percent overestimated. This case was previously identified as unique, because of significant differences in median stack height input parameters. When a small percentage of the population lives near the facility, discrepancies in concentration estimates in the first few rings will have a much smaller impact on the total Indicator Element value. An extreme case is exemplified by case 4 in Rochester (Figure 29); although the concentration ratio indicates discrepancies between 30 and 60 percent for the first two rings, these discrepancies do not impact the Indicator Element because there is no population living in the first two rings. Correspondingly, in those instances where concentrations are correctly estimated, so will be the Indicator Elements, regardless of population distribution.

As with pollutant concentration analyses, these conclusions cannot necessarily be extrapolated to the U.S. as a whole. This sample reveals the wide variability in the distributions of Indicator Sub-Elements and the significant impact on Indicator Sub-Elements that results from the particular population distribution around a facility (although higher concentrations occur close to the source, their impact on the Indicator Sub-Elements is greatly dependent on the size of the population living in that area). Because of the wide variability observed from test case to test case, the Indicators Model needs to be employed to capture the unique population distribution around each modeled facility to ensure proper treatment of population and exposure.

5.3 FACILITY RANKINGS BASED ON INDICATOR ELEMENTS

The objective of the Indicators Model is to perform relative rankings of risk-related impacts. To evaluate the use of different assumptions concerning stack heights and exit gas velocities, a ranking exercise was performed on the 24 New York test cases. Facilities were ranked by each set of available concentration estimates, generated by AG-1, by ISCLT3 with facility-specific median stack heights and exit gas velocities, and by ISCLT3 with SIC code-based median stack heights and exit gas velocities. Using the Indicator Elements calculated above, facilities were ranked in two groups, those emitting chemicals that decay (toluene) and those emitting chemicals which do not decay (aluminum, mercury, nickel, or lead). Note that because toxicity weights for individual chemicals are not included in the above Indicator Elements, it is possible to group and rank all facilities emitting chemicals which do not have decay rates, because the dispersion of inorganic chemicals is modeled without any chemical-specific data (i.e., for a given facility, a pound of lead released to the air is predicted to undergo the exact same dispersion as a pound of aluminum). The two sets of rankings are listed in Tables 17 and 18, one for the chemical with decay and one for the chemicals without, respectively.

Inspection of Tables 17 and 18 reveals that the rankings corresponding to different input parameters are virtually identical for both categories of chemicals. The only exception is the rankings of facilities F and Q. Facilities F and Q were assigned the same rankings (3 and 2, respectively) when using ISCLT3 with both sets of input parameters, but were assigned slightly different rankings (2 and 3, respectively) when using AG-1. Indicator Element values for facility F are 2633 when facility-specific parameters are used, 2729 when SIC code-based parameters are used, and 3226 when using AG-1. Indicator Element values for facility Q are 2736 when facility-specific parameters are used, 2919 when SIC code-based parameters are used, and 3097 when using AG-1. In all three cases, Indicator Elements values for facility Q are very close (within four percent, seven percent, and four percent, respectively) of the values corresponding to facility F. This suggests that relative rankings depend not only on the Indicator Element values of a given facility, but also upon the corresponding values of facilities with similar Indicator Element values. Differences in rankings may not be meaningful when the corresponding Indicator Elements are very close in magnitude.

6. CONCLUSION

This comparison of the Indicators Model to the AG-1 model was designed to measure whether the Indicators Model yields air pollutant concentrations comparable to an air dispersion model (AG-1) currently in use by a state agency, and to give an indication of the discrepancies in predictions. The air pollutant concentrations calculated by the Indicators Model are based on a combination of median and generic data and assumptions, whereas the AG-1 model relies on a greater variety of facility- and stack-specific data. The differences in pollutant concentrations predicted by both models were analyzed for 24 test cases in New York. The results obtained demonstrate that predictions of pollutant concentrations are not only comparable, but are extremely close, even though key input data to the two models are not the same. Average ratios computed over the 24 test cases were within two percent of unity (with a standard deviation of 13 percent) when using facility-specific parameters, and within six percent of unity (with a standard deviation of 13 percent) when using SIC code-based parameters. The accuracy of concentration estimates close to a facility is usually less than the accuracy observed further away from the facility, but the Indicators Model does not seem to consistently overpredict or underpredict pollutant concentrations.

The impact of population distributions around TRI facilities on the Indicator Element was also examined. Population around a TRI facility can have a significant impact on Indicator Element values, depending on the population size and distribution relative to the predicted pollutant concentrations and on the accuracy of the pollutant concentration estimates. The impact of population on the accuracy of the Indicator Element depends on the cell-by-cell combination of population and pollutant concentrations. Indicator Element values of lesser accuracy result from a combination of less accurate concentration estimates near the facility and a majority of the population living near the facility. When the concentration estimates are accurate, so are the Indicator Elements, regardless of population distribution. When a small percentage of the population lives near the facility, discrepancies in concentration estimates near the facility will have only a small impact on the Indicator Element value. Thus, the Indicators Model needs to be employed to capture the unique population distribution around each modeled facility to ensure proper treatment of population and exposure.

Indicator Elements were used to rank the facilities that correspond to the 24 test cases in New York. Facilities were ranked using each set of available concentration estimates: AG-1, ISCLT3 with facility-specific median stack heights and exit gas velocities, and ISCLT3 with SIC code-based median stack heights and exit gas velocities. Separate rankings were obtained for facilities emitting chemicals that decay and those emitting chemicals which do not decay. With the exception of one facility, the rankings corresponding to different input parameters were identical for both categories of chemicals, for all three sets of input parameters. This finding supports the use of the Indicators Model to develop relative rankings of TRI facilities based on their risk-related impacts.

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TABLES

TABLE 1
Ground-Truthing Test Cases

Urban Area	Case	Facility	Indicators Model Median Stack Height (m)	Chemical With Decay Rate	Chemical Without Decay Rate	Land Use Mode
Albany	1	A	10.06	Toluene		Urban
	2	B	9.45	Toluene		Urban
	3	C	1.22	Toluene		Urban
	4	A	10.06		Mercury	Urban
	5	D	8.08		Aluminum	Urban
	6	E	4.88		Mercury	Urban
Syracuse	1	F	11.43	Toluene		Rural
	2	G	9.14	Toluene		Rural
	3	H	3.96	Toluene		Urban
	4	I	28.35		Lead	Rural
	5	G	9.14		Lead	Rural
	6	J	5.49		Lead	Urban
Buffalo	1	K	14.63	Toluene		Urban
	2	L	9.14	Toluene		Urban
	3	M	6.10	Toluene		Urban
	4	N	11.73		Nickel	Urban
	5	O	8.53		Nickel	Rural
	6	P	3.66		Nickel	Urban
Rochester	1	Q	15.24	Toluene		Urban
	2	R	7.92	Toluene		Urban
	3	S	6.10	Toluene		Urban
	4	Q	15.24		Nickel	Urban
	5	T	7.92		Nickel	Rural
	6	S	6.10		Nickel	Urban

TABLE 2

Parameter Values Used by Each Model in the Ground-Truthing Exercise [1]

Parameter	Indicators Model (ISCLT3)	AG-1
stack height (SH)	single value; median stack height for each facility; calculation based on all stacks at the facility	single or multiple values; actual height for each stack-chemical combination
stack diameter	1 m (d)	actual stack-specific value
exit gas velocity	single value; median exit gas velocity for each facility; calculation based on all stacks at the facility	actual stack-specific value
exit temperature	293 K (d)	actual stack-specific value
decay rate	chemical-specific	no decay (d)
emission rate	total of all stack emissions for the selected chemical, from AG-1 database	actual stack-specific value
wind speed and direction	same as AG-1 (both models use the same type of meteorological data)	AG-1 STAR database
building height (BH)	assume BH=0 (d)	actual stack-specific value; in the absence of stack-specific data, assume BH=SH (d)
building width (BW)	assume BW=0 (d)	actual stack-specific value; in the absence of stack-specific data, assume BW=SH (d)
building length (BL)	assume BL=0 (d)	actual stack-specific value; in the absence of stack-specific data, assume BL=SH (d)
location coordinates (latitude, longitude)	single value for each facility (TRI database)	single or multiple; stack-specific, as reported in AG-1 database

[1] Default values are indicated with (d).

TABLE 3

Location and Stack Coordinates of TRI Facilities in New York Selected for the Model Comparison Exercise [1]

Urban Area	Case	Facility	UTME from TRI[2,3]	UTMN from TRI[2,3]	Central UTME from AG-1[2,4]	Central UTMN from AG-1[2,4]
Albany	1	A	606266	734199	606300	734200
	2	B	605871	732227	605800	732200
	3	C	605972	729363	606100	730200
	4	A	606266	734199	606200	734050
	5	D	604574	729742	604600	729400
	6	E	597218	726925	597100	727000
Syracuse	1	F	419367	761384	419400	761500
	2	G	407979	770435	403500	767200
	3	H	409308	767507	409400	767500
	4	I	371672	756557	371600	756500
	5	G	407979	770435	403500	767200
	6	J	602462	773533	402500	773700
Buffalo	1	K	188265	759084	188300	758750
	2	L	192038	755007	192100	755300
	3	M	179187	766125	179800	766300
	4	N	187367	753204	187400	753300
	5	O	171697	782845	171600	785000
	6	P	182600	765699	182500	765600
Rochester	1	Q	286491	781069	285250	786200
	2	R	284606	784275	284600	784200
	3	S	290572	783821	291000	784100
	4	Q	286491	781069	285250	786200
	5	T	269772	764903	291000	784100
	6	S	290572	783821	291000	784100

[1] Note that certain facilities are used for the evaluation of chemicals both with and without decay rates. However, these two types of chemicals may be emitted from different stacks within the facility.

[2] All coordinates are in meters, with values corresponding to the Universal Transverse Mercator (UTM) coordinate system.

[3] TRI coordinates are a single pair for each facility, contained in the TRI database.

[4] Although each stack is provided with its own coordinates in AG-1, for the purposes of comparison to the single pair of coordinates used in the Indicators Model, a single pair of coordinates was calculated for AG-1. Coordinates listed for AG-1 are the arithmetic average of the individual coordinates of the set of stacks that emit the particular chemical elected for the model comparison.

TABLE 4

Facility-Specific Stack Heights (m)

					AG-1 Parameters[1]				Indicators Model Parameters		
Urban Area	**Case**	**Facility**	**Chemical**	**# Stacks Emitting Selected Chemical**	**Mean Stack Height**	**Median Stack Height**	**Minimum**	**Maximum**	**Stack # (Total)**	**Median Stack Height**	**Mean Stack Height**
Albany	1	A	Toluene	2	5.49	5.49	3.66	7.32	19	10.06	12.48
	2	B	Toluene	3	9.45	9.45	9.45	9.45	3	9.45	9.04
	3	C	Toluene	1	1.83	1.83	1.83	1.83	3	1.22	5.28
	4	A	Mercury	2	36.58	36.58	36.58	36.58	19	10.06	12.48
	5	D	Aluminum	6	7.37	9.14	3.05	9.14	24	8.08	11.96
	6	E	Mercury	2	4.88	4.88	3.05	6.71	2	4.88	4.88
Syracuse	1	F	Toluene	7	12.63	12.80	11.58	12.80	12	11.43	10.19
	2	G	Toluene	7	6.57	7.01	3.96	8.84	17	9.14	8.53
	3	H	Toluene	1	2.44	2.44	2.44	2.44	5	3.96	3.35
	4	I	Lead	1	28.35	28.35	28.35	28.35	3	28.35	24.38
	5	G	Lead	3	7.47	8.23	7.92	9.75	17	9.14	8.53
	6	J	Lead	1	5.49	5.49	5.49	5.49	3	5.49	5.49
Buffalo	1	K	Toluene	2	10.97	10.97	10.36	11.58	40	14.63	14.67
	2	L	Toluene	1	14.94	14.94	14.94	14.94	7	9.14	10.32
	3	M	Toluene	12	4.75	3.35	1.83	9.14	21	6.10	11.57
	4	N	Nickel	1	8.23	8.23	8.23	8.23	24	11.73	15.19
	5	O	Nickel	1	3.66	3.66	3.66	3.66	99	8.53	8.57
	6	P	Nickel	8	3.39	2.44	2.44	7.62	14	3.66	4.68
Rochester	1	Q	Toluene	121	12.51	12.19	1.83	35.05	859	15.24	17.97
	2	R	Toluene	1	7.92	7.92	7.92	7.92	11	7.92	8.40
	3	S	Toluene	4	8.31	8.84	3.96	11.58	47	6.10	6.94
	4	Q	Nickel	3	20.93	21.34	17.68	23.77	859	15.24	17.97
	5	T	Nickel	1	9.14	9.14	9.14	9.14	31	7.92	9.48
	6	S	Nickel	1	6.10	6.10	6.10	6.10	47	6.10	6.94

[1]Although AG-1 uses unique chemical emission-stack combinations, the mean and median heights are presented for model input comparison purposes. The number of stack heights used in the calculation differ, as AG-1 averages are based only on those stacks which emit chemicals being analyzed, whereas average stack heights in ISCLT are based upon all stacks at the test case site.

TABLE 5
Facility-Specific Exit Gas Velocities (m/s)

					AG-1 Parameters[1]				Indicators Model Parameters		
Urban Area	**Case**	**Facility**	**Chemical**	**# Stacks Emitting Selected Chemical**	**Mean Exit Gas Velocity**	**Median Exit Gas Velocity**	**Minimum**	**Maximum**	**Stack # (Total)**	**Median Exit Gas Velocity**	**Mean Exit Gas Velocity**
Albany	1	A	Toluene	2	12.21	12.21	4.36	20.06	19	4.36	8.64
	2	B	Toluene	3	15.79	15.79	15.79	15.79	4	15.79	12.44
	3	C	Toluene	1	23.32	23.32	23.32	23.32	1	23.16	23.16
	4	A	Mercury	2	24.54	24.54	11.89	37.19	19	4.36	8.64
	5	D	Aluminum	6	20.26	19.51	17.01	26.52	25	14.72	13.56
	6	E	Mercury	2	20.13	20.13	20.13	20.13	2	20.13	20.13
Syracuse	1	F	Toluene	7	8.26	8.63	6.10	8.63	13	8.63	11.66
	2	G	Toluene	7	19.19	10.88	1.19	80.77	32	5.82	7.85
	3	H	Toluene	1	9.14	9.14	9.14	9.14	5	20.42	15.95
	4	I	Lead	1	2.77	2.77	2.77	2.77	3	7.50	95.37
	5	G	Lead	3	6.28	8.05	0.70	10.09	32	5.82	7.85
	6	J	Lead	1	4.57	4.57	4.57	4.57	3	3.57	3.90
Buffalo	1	K	Toluene	2	15.03	15.03	13.11	16.95	40	15.76	15.21
	2	L	Toluene	1	10.79	10.79	10.79	10.79	7	10.79	11.12
	3	M	Toluene	12	0.17	0.07	0.00	0.61	21	0.076	1.07
	4	N	Nickel	1	8.23	8.23	8.23	8.23	27	8.23	10.68
	5	O	Nickel	1	10.51	10.51	10.51	10.51	99	12.80	14.42
	6	P	Nickel	8	15.57	16.73	7.44	16.73	14	16.73	15.18
Rochester	1	Q	Toluene	121	11.01	10.67	0.00	39.32	873	11.67	14.69
	2	R	Toluene	1	3.96	3.96	3.96	3.96	11	10.06	12.91
	3	S	Toluene	4	14.32	16.57	2.59	21.55	48	8.18	8.20
	4	Q	Nickel	3	13.72	18.90	2.44	19.81	873	11.67	14.69
	5	T	Nickel	1	30.48	30.48	30.48	30.48	32	12.12	27.01
	6	S	Nickel	1	11.58	11.58	11.58	11.58	48	8.18	8.20

[1]Although AG-1 uses unique chemical emission-stack combinations, the mean and median exit gas velocities are presented for model input comparison purposes. The number of exit gas velocities used in the calculation differ, as AG-1 averages are based only on those stacks which emit chemicals being analyzed, whereas average exit gas velocities in ISCLT are based upon all stacks at the test case site.

TABLE 6
Facility-Specific Stack Diameters (m)

Urban Area	Case	Facility	Chemical	# Stacks Emitting Selected Chemical	Mean Stack Diameter	Median Stack Diameter	Minimum	Maximum
Albany	1	A	Toluene	2	0.18	0.18	0.10	0.25
	2	B	Toluene	3	0.91	0.91	0.91	0.91
	3	C	Toluene	1	0.05	0.05	0.05	0.05
	4	A	Mercury	2	1.30	1.30	1.07	1.52
	5	D	Aluminum	6	0.49	0.61	0.20	0.61
	6	E	Mercury	2	0.15	0.15	0.15	0.15
Syracuse	1	F	Toluene	7	1.05	1.07	0.97	1.07
	2	G	Toluene	7	0.26	0.36	0.10	0.36
	3	H	Toluene	1	0.10	0.10	0.10	0.10
	4	I	Lead	1	0.10	0.10	0.10	0.10
	5	G	Lead	3	0.66	0.61	0.51	0.86
	6	J	Lead	1	0.15	0.15	0.15	0.15
Buffalo	1	K	Toluene	2	0.43	0.43	0.25	0.61
	2	L	Toluene	1	0.91	0.91	0.91	0.91
	3	M	Toluene	12	0.21	0.15	0.10	0.48
	4	N	Nickel	1	0.61	0.61	0.61	0.61
	5	O	Nickel	1	0.33	0.33	0.33	0.33
	6	P	Nickel	8	0.22	0.20	0.20	0.30
Rochester	1	Q	Toluene	121	0.43	0.23	0.03	2.69
	2	R	Toluene	1	0.10	0.10	0.10	0.10
	3	S	Toluene	4	0.86	0.91	0.20	1.42
	4	Q	Nickel	3	0.59	0.36	0.10	1.32
	5	T	Nickel	1	0.10	0.10	0.10	0.10
	6	S	Nickel	1	0.20	0.20	0.20	0.20

Note: The default value for stack diameter in the Indicators Model is 1 m.

TABLE 7
Facility-Specific Stack Exit Temperatures (K)

Urban Area	Case	Facility	Chemical	# Stacks Emitting Selected Chemical	Mean Stack Exit Temperature	Median Stack Exit Temperature	Minimum	Maximum
Albany	1	A	Toluene	2	302	302	294	311
	2	B	Toluene	3	311	311	311	311
	3	C	Toluene	1	294	294	294	294
	4	A	Mercury	2	333	333	333	333
	5	D	Aluminum	6	293	293	293	294
	6	E	Mercury	2	294	294	294	294
Syracuse	1	F	Toluene	7	294	294	294	294
	2	G	Toluene	7	303	297	293	315
	3	H	Toluene	1	294	294	294	294
	4	I	Lead	1	408	408	408	408
	5	G	Lead	3	371	326	297	489
	6	J	Lead	1	366	366	366	366
Buffalo	1	K	Toluene	2	296	296	294	297
	2	L	Toluene	1	294	294	294	294
	3	M	Toluene	12	325	311	284	363
	4	N	Nickel	1	294	294	294	294
	5	O	Nickel	1	294	294	294	294
	6	P	Nickel	8	293	293	293	293
Rochester	1	Q	Toluene	121	299	294	284	394
	2	R	Toluene	1	450	450	450	450
	3	S	Toluene	4	296	295	295	300
	4	Q	Nickel	3	383	295	294	561
	5	T	Nickel	1	366	366	366	366
	6	S	Nickel	1	300	300	300	300

Note: The default value for stack exit temperature in the Indicators Model is 293 K.

TABLE 8
Facility-Specific Chemical Emission Rates (g/sec)

Urban Area	Case	Facility	Chemical	# Stacks Emitting Selected Chemical	Mean Chemical Emission Rate	Median Chemical Emission Rate	Minimum	Maximum
Albany	1	A	Toluene	2	2.20E-05	2.20E-05	1.41E-05	3.00E-05
	2	B	Toluene	3	1.97E+00	1.97E+00	1.97E+00	1.97E+00
	3	C	Toluene	1	3.79E-04	3.79E-04	3.79E-04	3.79E-04
	4	A	Mercury	2	1.19E-04	1.19E-04	1.19E-04	1.19E-04
	5	D	Aluminum	6	3.44E-04	4.73E-04	4.32E-05	4.73E-04
	6	E	Mercury	2	7.03E-06	7.03E-06	7.03E-06	7.03E-06
Syracuse	1	F	Toluene	7	5.22E-02	4.44E-02	7.20E-03	8.88E-02
	2	G	Toluene	7	1.76E-02	1.18E-02	1.02E-03	4.43E-02
	3	H	Toluene	1	1.08E-06	1.08E-06	1.08E-06	1.08E-06
	4	I	Lead	1	3.39E-02	3.39E-02	3.39E-02	3.39E-02
	5	G	Lead	3	7.85E-03	4.60E-03	6.10E-04	1.83E-02
	6	J	Lead	1	5.76E-05	5.76E-05	5.76E-05	5.76E-05
Buffalo	1	K	Toluene	2	3.31E-02	3.31E-02	9.50E-03	5.67E-02
	2	L	Toluene	1	9.07E-04	9.07E-04	9.07E-04	9.07E-04
	3	M	Toluene	12	1.39E-03	1.86E-04	5.26E-06	1.36E-02
	4	N	Nickel	1	1.15E-06	1.15E-06	1.15E-06	1.15E-06
	5	O	Nickel	1	7.20E-07	7.20E-07	7.20E-07	7.20E-07
	6	P	Nickel	8	1.44E-05	1.44E-05	1.44E-05	1.44E-05
Rochester	1	Q	Toluene	121	2.04E-02	1.27E-03	4.32E-08	5.88E-01
	2	R	Toluene	1	1.16E-01	1.16E-01	1.16E-01	1.16E-01
	3	S	Toluene	4	8.15E-05	1.90E-05	1.44E-08	2.88E-04
	4	Q	Nickel	3	2.16E-05	1.15E-07	1.44E-08	6.48E-05
	5	T	Nickel	1	1.18E-04	1.18E-04	1.18E-04	1.18E-04
	6	S	Nickel	1	1.44E-08	1.44E-08	1.44E-08	1.44E-08

Note: These values were used in both AG-1 and ISCLT3 for this analysis. The Indicators Model uses annual emissions reported to TRI.

TABLE 9

Summary Statistics for (ISCLT3/AG1) Ratio by Metropolitan Area, Chemical Characteristic, and Stack Height

Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

	Average	Standard Deviation	Minimum	Maximum	Number of Cells
All Cases	0.984	0.134	0.231	3.101	10539
By Metropolitan Area:					
Albany	1.049	0.196	0.810	1.731	2640
Syracuse	0.935	0.067	0.527	1.097	2640
Buffalo	0.962	0.071	0.518	1.097	2640
Rochester	0.989	0.135	0.231	3.101	2619
By Chemical Characteristic:					
Chemical with Decay Rate	0.948	0.066	0.231	1.417	5259
Chemical without Decay Rate	1.020	0.171	0.347	3.101	5280
By Stack Height:					
0m<x<=7m	0.972	0.023	0.841	1.008	3520
7m<x<=10m	0.958	0.076	0.518	1.097	3520
>10m	1.021	0.214	0.231	3.101	3499

TABLE 10

Summary Statistics for (ISCLT3/AG1) Ratio by Ring for All Locations and by Metropolitan Area

Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

OVERALL Summary	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.955	0.258	0.347	3.101	192
2nd	0.973	0.180	0.231	2.182	384
3rd	0.981	0.142	0.472	1.879	576
4th	0.984	0.125	0.348	1.672	768
5th	0.986	0.113	0.590	1.546	960
6th	0.986	0.106	0.701	1.497	1152
7th	0.986	0.101	0.754	1.491	1344
8th	0.985	0.098	0.790	1.485	1536
9th	0.984	0.095	0.810	1.482	1728
10th	0.984	0.094	0.845	1.478	1899
Overall	0.984	0.134	0.231	3.101	10539

Rochester Summary	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	1.053	0.450	0.347	3.101	48
2nd	1.007	0.280	0.231	2.182	96
3rd	0.996	0.189	0.472	1.879	144
4th	0.991	0.153	0.348	1.672	192
5th	0.989	0.124	0.590	1.546	240
6th	0.988	0.106	0.701	1.462	288
7th	0.987	0.095	0.754	1.402	336
8th	0.985	0.086	0.790	1.356	384
9th	0.983	0.081	0.810	1.322	432
10th	0.986	0.075	0.887	1.295	459
Overall	0.989	0.135	0.231	3.101	2619

Albany Summary	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	1.041	0.281	0.810	1.731	48
2nd	1.056	0.227	0.904	1.595	96
3rd	1.057	0.207	0.928	1.547	144
4th	1.057	0.199	0.936	1.521	192
5th	1.055	0.194	0.935	1.505	240
6th	1.053	0.192	0.931	1.497	288
7th	1.050	0.190	0.925	1.491	336
8th	1.048	0.190	0.919	1.485	384
9th	1.045	0.190	0.912	1.482	432
10th	1.042	0.190	0.906	1.478	480
Overall	1.049	0.196	0.810	1.731	2640

Buffalo Summary	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.899	0.137	0.518	1.091	48
2nd	0.940	0.101	0.680	1.097	96
3rd	0.954	0.084	0.759	1.097	144
4th	0.960	0.076	0.805	1.096	192
5th	0.963	0.071	0.833	1.094	240
6th	0.965	0.067	0.855	1.092	288
7th	0.965	0.065	0.859	1.089	336
8th	0.966	0.063	0.862	1.087	384
9th	0.965	0.061	0.860	1.084	432
10th	0.965	0.060	0.857	1.081	480
Overall	0.962	0.071	0.518	1.097	2640

Syracuse Summary	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.828	0.162	0.527	1.097	48
2nd	0.891	0.113	0.603	1.076	96
3rd	0.915	0.087	0.709	1.056	144
4th	0.928	0.073	0.754	1.045	192
5th	0.936	0.064	0.787	1.039	240
6th	0.940	0.057	0.819	1.033	288
7th	0.942	0.054	0.833	1.030	336
8th	0.943	0.051	0.840	1.027	384
9th	0.944	0.050	0.843	1.024	432
10th	0.943	0.050	0.845	1.023	480
Overall	0.935	0.067	0.527	1.097	2640

TABLE 11
Summary Statistics for (ISCLT3/AG1) Ratio by Metropolitan Area, Chemical Characteristic, and Stack Height
Scenario: Facility-Specific Median Stack Height and Exit Gas Velocity of 0.01 m/sec

	Average	Standard Deviation	Minimum	Maximum	Number of Cells
All Cases	0.980	0.136	0.232	3.032	10539
By Metropolitan Area:					
Albany	1.047	0.191	0.829	1.658	2640
Syracuse	0.935	0.069	0.459	1.001	2640
Buffalo	0.964	0.069	0.549	1.097	2640
Rochester	0.976	0.147	0.232	3.032	2619
By Chemical Characteristic:					
Chemical with Decay Rate	0.946	0.072	0.232	1.434	5259
Chemical without Decay Rate	1.015	0.170	0.336	3.032	5280
By Stack Height:					
0m<x<=7m	0.973	0.022	0.840	1.008	3520
7m<x<=10m	0.942	0.093	0.406	1.097	3520
>10m	1.027	0.206	0.232	3.032	3499

TABLE 12					
Summary Statistics for (ISCLT3/AG1) Ratio by Ring for All Locations and by Metropolitan Area					
Scenario: Facility-Specific Median Stack Height and Exit Gas Velocity of 0.01 m/sec					
OVERALL Summary					
	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.944	0.252	0.336	3.032	192
2nd	0.966	0.181	0.232	2.160	384
3rd	0.975	0.144	0.473	1.866	576
4th	0.979	0.128	0.348	1.663	768
5th	0.982	0.116	0.591	1.540	960
6th	0.983	0.109	0.702	1.487	1152
7th	0.983	0.104	0.755	1.482	1344
8th	0.983	0.100	0.790	1.478	1536
9th	0.982	0.098	0.800	1.475	1728
10th	0.982	0.096	0.805	1.472	1899
Overall	0.980	0.136	0.232	3.032	10539
Rochester Summary					
	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	1.017	0.467	0.336	3.032	48
2nd	0.982	0.299	0.232	2.160	96
3rd	0.975	0.208	0.473	1.866	144
4th	0.974	0.169	0.348	1.663	192
5th	0.974	0.139	0.591	1.540	240
6th	0.975	0.120	0.702	1.457	288
7th	0.975	0.107	0.755	1.398	336
8th	0.974	0.097	0.790	1.353	384
9th	0.973	0.091	0.811	1.319	432
10th	0.976	0.084	0.838	1.292	459
Overall	0.976	0.147	0.232	3.032	2619
Albany Summary					
	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	1.028	0.254	0.829	1.658	48
2nd	1.050	0.215	0.913	1.555	96
3rd	1.054	0.200	0.934	1.521	144
4th	1.054	0.193	0.941	1.504	192
5th	1.053	0.190	0.938	1.492	240
6th	1.051	0.188	0.933	1.487	288
7th	1.049	0.187	0.927	1.482	336
8th	1.046	0.187	0.920	1.478	384
9th	1.044	0.187	0.914	1.475	432
10th	1.041	0.188	0.907	1.472	480
Overall	1.047	0.191	0.829	1.658	2640
Buffalo Summary					
	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.907	0.131	0.549	1.090	48
2nd	0.945	0.096	0.706	1.097	96
3rd	0.957	0.081	0.780	1.097	144
4th	0.963	0.074	0.823	1.096	192
5th	0.965	0.069	0.848	1.094	240
6th	0.967	0.066	0.860	1.092	288
7th	0.967	0.063	0.859	1.089	336
8th	0.967	0.062	0.862	1.087	384
9th	0.967	0.061	0.860	1.084	432
10th	0.966	0.059	0.857	1.081	480
Overall	0.964	0.069	0.549	1.097	2640
Syracuse Summary					
	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.822	0.157	0.459	0.994	48
2nd	0.888	0.112	0.570	1.001	96
3rd	0.914	0.088	0.665	1.001	144
4th	0.927	0.074	0.715	1.001	192
5th	0.935	0.066	0.744	1.001	240
6th	0.940	0.060	0.771	1.001	288
7th	0.942	0.057	0.782	1.001	336
8th	0.943	0.055	0.795	1.001	384
9th	0.944	0.054	0.800	1.001	432
10th	0.943	0.053	0.805	1.001	480
Overall	0.935	0.069	0.459	1.001	2640

TABLE 13
Comparison of AG-1, Indicators Model, and 3-digit SIC Code Parameters

Urban Area	Case	Facility	SIC Code	Chemical	AG-1 Median Stack Height[1]	Indicators Median Stack Height[1]	3-Digit SIC Median Stack Height[1]	Ratio of 3-Digit SIC to Indicators Stack Height	AG-1 Median Exit Gas Velocity[2]	Indicators Median Exit Gas Velocity[2]	3-Digit SIC Median Exit Gas Velocity[2]	Ratio of 3-Digit SIC to Indicators Exit Gas Velocity
Albany	1	A	324	Toluene	5.49	10.06	32.00	3.18	12.21	4.36	12.19	2.80
	2	B	329	Toluene	9.45	9.45	12.19	1.29	15.79	15.79	12.10	0.77
	3	C	295	Toluene	1.83	1.22	9.14	7.49	23.32	23.16	14.01	0.60
	4	A	324	Mercury	36.58	10.06	32.00	3.18	24.54	4.36	12.19	2.80
	5	D	331	Aluminum	9.14	8.08	24.38	3.02	19.51	14.72	8.96	0.61
	6	E	281	Mercury	4.88	4.88	13.11	2.69	20.13	20.13	9.08	0.45
Syracuse	1	F	251	Toluene	12.80	11.43	9.14	0.80	8.63	8.63	10.72	1.24
	2	G	326	Toluene	7.01	9.14	9.45	1.03	10.88	5.82	9.28	1.59
	3	H	356	Toluene	2.44	3.96	9.14	2.31	9.14	20.42	8.37	0.41
	4	I	331	Lead	28.35	28.35	24.38	0.86	2.77	7.50	8.96	1.19
	5	G	326	Lead	8.23	9.14	9.45	1.03	8.05	5.82	9.28	1.59
	6	J	367	Lead	5.49	5.49	9.14	1.66	4.57	3.57	8.10	2.27
Buffalo	1	K	371	Toluene	10.97	14.63	12.19	0.83	15.03	15.76	10.76	0.68
	2	L	344	Toluene	14.94	9.14	9.14	1.00	10.79	10.79	8.63	0.80
	3	M	331	Toluene	3.35	6.10	24.38	4.00	0.07	0.076	8.96	117.89
	4	N	326	Nickel	8.23	11.73	9.45	0.81	8.23	8.23	9.28	1.13
	5	O	329	Nickel	3.66	8.53	12.19	1.43	10.51	12.80	12.10	0.95
	6	P	344	Nickel	2.44	3.66	9.14	2.50	16.73	16.73	8.63	0.52
Rochester	1	Q	386	Toluene	12.19	15.24	12.19	0.80	10.67	11.67	9.71	0.83
	2	R	267	Toluene	7.92	7.92	9.14	1.15	3.96	10.06	10.79	1.07
	3	S	383 [3]	Toluene	8.84	6.10	9.14	1.50	16.57	8.18	8.00	0.98
	4	Q	386	Nickel	21.34	15.24	12.19	0.80	18.90	11.67	9.71	0.83
	5	T	334	Nickel	9.14	7.92	12.19	1.54	30.48	12.12	9.30	0.77
	6	S	383 [3]	Nickel	6.10	6.10	9.14	1.50	11.58	8.18	8.00	0.98

[1]Stack height in meters.
[2]Exit gas velocity in meters per second.
[3]Facility S reported an incorrect SIC code (there is no code 383). The median stack height and exit gas velocity used are those of SIC code 38.

TABLE 14

Summary Statistics for (ISCLT3/AG1) Ratio by Metropolitan Area, Chemical Characteristic, and Stack Height

Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity

	Average	Standard Deviation	Minimum	Maximum	Number of Cells
All Cases	0.936	0.131	0.248	3.385	10539
By Metropolitan Area:					
Albany	0.871	0.125	0.479	1.079	2640
Syracuse	0.940	0.065	0.484	1.002	2640
Buffalo	0.930	0.113	0.439	1.099	2640
Rochester	1.001	0.169	0.248	3.385	2619
By Chemical Characteristic:					
Chemical with Decay Rate	0.912	0.119	0.248	1.565	5259
Chemical without Decay Rate	0.959	0.138	0.383	3.385	5280
By Stack Height:					
0m<x<=7m	0.934	0.076	0.639	1.008	3520
7m<x<=10m	0.898	0.105	0.439	1.099	3520
>10m	0.974	0.178	0.248	3.385	3499

TABLE 15

Summary Statistics for (ISCLT3/AG1) Ratio by Ring for All Locations and by Metropolitan Area

Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity

OVERALL Summary

	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.889	0.252	0.383	3.385	192
2nd	0.917	0.177	0.248	2.354	384
3rd	0.928	0.141	0.505	2.016	576
4th	0.933	0.125	0.371	1.790	768
5th	0.937	0.114	0.630	1.653	960
6th	0.938	0.107	0.662	1.561	1152
7th	0.939	0.103	0.663	1.496	1344
8th	0.939	0.100	0.664	1.447	1536
9th	0.938	0.097	0.662	1.409	1728
10th	0.938	0.096	0.660	1.380	1899
Overall	0.936	0.131	0.248	3.385	10539

Rochester Summary

	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	1.081	0.520	0.383	3.385	48
2nd	1.025	0.324	0.248	2.354	96
3rd	1.011	0.227	0.505	2.016	144
4th	1.005	0.187	0.371	1.790	192
5th	1.003	0.158	0.630	1.653	240
6th	1.001	0.140	0.748	1.561	288
7th	0.999	0.129	0.803	1.496	336
8th	0.997	0.120	0.822	1.447	384
9th	0.995	0.114	0.830	1.409	432
10th	0.995	0.111	0.836	1.380	459
Overall	1.001	0.169	0.248	3.385	2619

Albany Summary

	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.816	0.170	0.479	1.079	48
2nd	0.857	0.144	0.596	1.061	96
3rd	0.869	0.133	0.633	1.054	144
4th	0.873	0.128	0.649	1.050	192
5th	0.874	0.125	0.656	1.048	240
6th	0.875	0.123	0.662	1.046	288
7th	0.874	0.122	0.663	1.045	336
8th	0.873	0.121	0.664	1.044	384
9th	0.872	0.120	0.662	1.043	432
10th	0.871	0.119	0.660	1.043	480
Overall	0.871	0.125	0.479	1.079	2640

Buffalo Summary

	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.858	0.179	0.439	1.095	48
2nd	0.904	0.142	0.601	1.099	96
3rd	0.919	0.126	0.676	1.099	144
4th	0.927	0.119	0.722	1.097	192
5th	0.930	0.114	0.736	1.095	240
6th	0.933	0.111	0.736	1.093	288
7th	0.934	0.108	0.736	1.090	336
8th	0.934	0.107	0.735	1.087	384
9th	0.934	0.105	0.733	1.084	432
10th	0.934	0.104	0.732	1.082	480
Overall	0.930	0.113	0.439	1.099	2640

Syracuse Summary

	Average	Average Standard Deviation	Minimum	Maximum	Number of Cells
1st ring:	0.801	0.141	0.484	0.948	48
2nd	0.880	0.100	0.590	0.976	96
3rd	0.912	0.077	0.681	0.984	144
4th	0.929	0.066	0.730	0.988	192
5th	0.939	0.058	0.757	0.992	240
6th	0.945	0.054	0.783	0.998	288
7th	0.949	0.052	0.793	0.999	336
8th	0.951	0.051	0.804	1.001	384
9th	0.952	0.050	0.809	1.002	432
10th	0.952	0.050	0.814	1.001	480
Overall	0.940	0.065	0.484	1.002	2640

TABLE 16
Exposure Event Counts Surrounding TRI Facilities

		Distance to Facility (+/- 500m)										Total
		<1 km	**1-2 km**	**2-3 km**	**3-4 km**	**4-5 km**	**5-6 km**	**6-7 km**	**7-8 km**	**8-9 km**	**9-10 km**	**(0-10 km)**
All persons	*count*	36,359	116,782	187,508	246,084	297,454	339,672	377,853	413,268	449,694	470,159	2,934,834
	%	1.2%	4.0%	6.4%	8.4%	10.1%	11.6%	12.9%	14.1%	15.3%	16.0%	100.0%
Race sub-populations												
White	*count*	25,598	81,439	128,781	168,139	202,677	231,605	258,394	282,899	308,878	323,517	2,011,927
	%	1.3%	4.0%	6.4%	8.4%	10.1%	11.5%	12.8%	14.1%	15.4%	16.1%	100.0%
Black	*count*	6,632	21,605	35,750	47,300	57,411	65,952	72,971	79,173	84,926	87,440	559,159
	%	1.2%	3.9%	6.4%	8.5%	10.3%	11.8%	13.1%	14.2%	15.2%	15.6%	100.0%
Native American	*count*	197	611	948	1,212	1,424	1,595	1,735	1,850	1,971	2,029	13,571
	%	1.5%	4.5%	7.0%	8.9%	10.5%	11.8%	12.8%	13.6%	14.5%	14.9%	100.0%
Asian/Pacific Islander	*count*	1,027	3,700	6,579	9,260	11,787	13,611	15,291	17,153	19,454	20,903	118,765
	%	0.9%	3.1%	5.5%	7.8%	9.9%	11.5%	12.9%	14.4%	16.4%	17.6%	100.0%
Hispanic	*count*	5,472	18,134	29,737	38,909	46,750	52,553	57,933	63,641	68,652	72,224	454,006
	%	1.2%	4.0%	6.5%	8.6%	10.3%	11.6%	12.8%	14.0%	15.1%	15.9%	100.0%
Age sub-populations												
Age <18	*count*	9,492	30,177	48,086	62,773	75,553	86,163	95,519	104,133	112,815	117,843	742,554
	%	1.3%	4.1%	6.5%	8.5%	10.2%	11.6%	12.9%	14.0%	15.2%	15.9%	100.0%
Age >65	*count*	4,668	14,779	23,360	30,321	36,533	41,603	46,172	50,354	54,669	56,949	359,409
	%	1.3%	4.1%	6.5%	8.4%	10.2%	11.6%	12.8%	14.0%	15.2%	15.8%	100.0%

Notes:
1. Data are from facilities reporting air releases in 1996.
2. Counts are in thousands. Percentages are of subpopulation totals.
3. Each person in the U.S. is assigned to each TRI facility within a specified distance ring of them, but is not removed from the Census database.
Therefore, due to multiple impacts on one person of facilities located at varying distances, the total number of exposure events exceeds the U.S. population.

TABLE 17
Facility Rankings Based on Indicator Elements for Chemical with Decay Rate (Toluene)

AG-1				ISCLT 3-Facility-Specific Median Values				ISCLT 3- SIC-Code Based Median Values			
Facility	Indicator Element[1]	Percent of Total	Rank	Facility	Indicator Element[1]	Percent of Total	Rank	Facility	Indicator Element[1]	Percent of Total	Rank
B	16671	69.45%	1	B	16642	72.75%	1	B	15767	70.87%	1
F	3226	13.44%	2	Q	2736	11.96%	2	Q	2919	13.12%	2
Q	3097	12.90%	3	F	2633	11.51%	3	F	2729	12.27%	3
G	801	3.34%	4	G	670	2.93%	4	G	638	2.87%	4
R	144	0.60%	5	R	138	0.60%	5	R	137	0.62%	5
K	47	0.20%	6	K	41	0.18%	6	K	44	0.20%	6
M	14	0.06%	7	M	14	0.06%	7	M	10	0.05%	7
L	1.4	0.01%	8	L	1.5	0.01%	8	L	1.5	0.01%	8
C	0.78	0.003%	9	C	0.74	0.003%	9	C	0.74	0.003%	9
S	0.49	0.002%	10	S	0.48	0.002%	10	S	0.48	0.002%	10
A	0.13	0.001%	11	A	0.12	0.001%	11	A	0.08	0.0004%	11
H	0.0019	0.00001%	12	H	0.0018	0.00001%	12	H	0.0018	0.00001%	12
Total	24003	100.00%		**Total**	22876	100.00%		**Total**	22248	100.00%	

[1]Indicator Elements are the product of pollutant concentration and population in each cell, summed over all 440 cells surrounding a TRI facility.

TABLE 18
Facility Rankings Based on Indicator Elements for Chemicals without Decay Rates

AG-1				ISCLT 3-Facility-Specific Median Values				ISCLT 3- SIC-Code Based Median Values			
Facility	Indicator Element[1]	Percent of Total	Rank	Facility	Indicator Element[1]	Percent of Total	Rank	Facility	Indicator Element[1]	Percent of Total	Rank
G	130	54.45%	1	G	133	61.47%	1	G	127	58.91%	1
L	101	42.45%	2	L	76	35.11%	2	L	83	38.47%	2
D	6.3	2.66%	3	D	6.1	2.84%	3	D	4.6	2.15%	3
A	0.42	0.18%	4	A	0.66	0.30%	4	A	0.44	0.20%	4
J	0.28	0.12%	5	J	0.27	0.12%	5	J	0.26	0.12%	5
T	0.15	0.06%	6	T	0.13	0.06%	6	T	0.12	0.05%	6
P	0.09	0.04%	7	P	0.08	0.04%	7	P	0.08	0.04%	7
Q	0.06	0.03%	8	Q	0.07	0.03%	8	Q	0.08	0.04%	8
E	0.05	0.02%	9	E	0.04	0.02%	9	E	0.04	0.02%	9
O	0.003	0.001%	10	O	0.002	0.00%	10	O	0.002	0.001%	10
N	0.0015	0.001%	11	N	0.0014	0.001%	11	N	0.0014	0.001%	11
S	0.000022	0.00001%	12	S	0.000021	0.00001%	12	S	0.000021	0.00001%	12
Total	238	100.00%		**Total**	216	100.00%		**Total**	215	100.00%	

[1]Indicator Elements are the product of pollutant concentration and population in each cell, summed over all 440 cells surrounding a TRI facility.

FIGURES

FIGURE 1A
Example Concentrations (ug/m3) Predicted by AG1
Scenario: Facility-Specific Median Stack Height and Constant Exit Gas Velocity of 0.01 m/sec

	409400	410400	411400	412400	413400	414400	415400	416400	417400	418400	419400	420400	421400	422400	423400	424400	425400	426400	427400	428400	429400
751500	3.6E-03	3.8E-03	4.0E-03	4.3E-03	4.5E-03	4.7E-03	5.0E-03	6.7E-03	8.6E-03	1.0E-02	1.2E-02	1.4E-02	1.5E-02	1.6E-02	1.6E-02	1.5E-02	1.4E-02	1.3E-02	1.2E-02	1.0E-02	9.5E-03
752500	4.4E-03	4.2E-03	4.5E-03	4.8E-03	5.0E-03	5.3E-03	5.5E-03	7.2E-03	9.5E-03	1.2E-02	1.4E-02	1.6E-02	1.7E-02	1.8E-02	1.8E-02	1.7E-02	1.5E-02	1.4E-02	1.2E-02	1.1E-02	1.0E-02
753500	5.4E-03	5.2E-03	4.9E-03	5.3E-03	5.7E-03	6.1E-03	6.4E-03	7.5E-03	1.1E-02	1.4E-02	1.7E-02	1.9E-02	2.1E-02	2.2E-02	2.1E-02	1.9E-02	1.7E-02	1.5E-02	1.3E-02	1.2E-02	1.2E-02
754500	6.5E-03	6.5E-03	6.4E-03	5.9E-03	6.5E-03	7.1E-03	7.6E-03	7.9E-03	1.2E-02	1.6E-02	2.0E-02	2.4E-02	2.6E-02	2.7E-02	2.4E-02	2.1E-02	1.8E-02	1.6E-02	1.5E-02	1.4E-02	1.3E-02
755500	7.9E-03	8.1E-03	8.2E-03	8.0E-03	7.4E-03	8.2E-03	9.0E-03	9.7E-03	1.3E-02	1.9E-02	2.5E-02	3.0E-02	3.3E-02	3.2E-02	2.8E-02	2.4E-02	2.0E-02	1.9E-02	1.7E-02	1.5E-02	1.4E-02
756500	9.4E-03	9.9E-03	1.0E-02	1.1E-02	1.1E-02	9.6E-03	1.1E-02	1.2E-02	1.4E-02	2.3E-02	3.3E-02	4.0E-02	4.4E-02	3.8E-02	3.2E-02	2.7E-02	2.4E-02	2.1E-02	1.9E-02	1.7E-02	1.5E-02
757500	1.2E-02	1.2E-02	1.3E-02	1.4E-02	1.5E-02	1.5E-02	1.3E-02	1.5E-02	1.7E-02	2.8E-02	4.5E-02	5.7E-02	5.7E-02	4.7E-02	3.7E-02	3.2E-02	2.8E-02	2.4E-02	2.1E-02	1.9E-02	1.7E-02
758500	1.8E-02	1.8E-02	1.8E-02	1.8E-02	2.0E-02	2.2E-02	2.2E-02	2.0E-02	2.4E-02	3.4E-02	6.8E-02	8.9E-02	7.6E-02	5.7E-02	4.7E-02	3.9E-02	3.2E-02	2.7E-02	2.4E-02	2.2E-02	2.0E-02
759500	2.4E-02	2.6E-02	2.9E-02	3.1E-02	3.3E-02	3.2E-02	3.6E-02	4.0E-02	3.5E-02	4.6E-02	1.2E-01	1.5E-01	1.0E-01	7.8E-02	5.9E-02	4.7E-02	4.0E-02	3.5E-02	3.0E-02	2.7E-02	2.4E-02
760500	3.1E-02	3.5E-02	4.0E-02	4.6E-02	5.5E-02	6.5E-02	7.8E-02	8.8E-02	9.6E-02	9.0E-02	2.9E-01	2.8E-01	1.6E-01	1.1E-01	8.3E-02	6.5E-02	5.2E-02	4.3E-02	3.6E-02	3.1E-02	2.7E-02
761500	3.7E-02	4.3E-02	5.1E-02	6.2E-02	7.7E-02	1.0E-01	1.4E-01	2.0E-01	3.5E-01	8.3E-01		7.2E-01	2.9E-01	1.7E-01	1.1E-01	8.1E-02	6.2E-02	5.0E-02	4.1E-02	3.5E-02	3.0E-02
762500	3.5E-02	4.1E-02	4.8E-02	5.7E-02	6.9E-02	8.7E-02	1.1E-01	1.5E-01	2.1E-01	2.5E-01	2.5E-01	2.0E-01	1.8E-01	1.3E-01	9.4E-02	7.1E-02	5.6E-02	4.6E-02	3.8E-02	3.3E-02	2.8E-02
763500	3.3E-02	3.7E-02	4.3E-02	5.0E-02	5.9E-02	7.1E-02	8.4E-02	9.9E-02	1.1E-01	8.8E-02	9.9E-02	8.2E-02	7.9E-02	8.0E-02	7.0E-02	5.9E-02	4.9E-02	4.1E-02	3.5E-02	3.0E-02	2.6E-02
764500	3.0E-02	3.4E-02	3.8E-02	4.3E-02	4.9E-02	5.4E-02	6.0E-02	6.2E-02	5.9E-02	4.8E-02	5.5E-02	4.8E-02	4.8E-02	4.5E-02	4.6E-02	4.3E-02	3.9E-02	3.5E-02	3.1E-02	2.7E-02	2.4E-02
765500	2.7E-02	3.0E-02	3.3E-02	3.6E-02	3.9E-02	4.1E-02	4.2E-02	4.1E-02	3.5E-02	3.4E-02	3.7E-02	3.3E-02	3.1E-02	3.2E-02	3.0E-02	3.1E-02	3.0E-02	2.8E-02	2.6E-02	2.4E-02	2.2E-02
766500	2.4E-02	2.6E-02	2.8E-02	2.9E-02	3.0E-02	3.1E-02	3.0E-02	2.8E-02	2.3E-02	2.5E-02	2.6E-02	2.5E-02	2.2E-02	2.3E-02	2.3E-02	2.1E-02	2.2E-02	2.2E-02	2.1E-02	2.0E-02	1.9E-02
767500	2.1E-02	2.2E-02	2.3E-02	2.4E-02	2.4E-02	2.4E-02	2.3E-02	2.0E-02	1.8E-02	2.0E-02	2.0E-02	1.9E-02	1.8E-02	1.7E-02	1.8E-02	1.7E-02	1.6E-02	1.7E-02	1.7E-02	1.7E-02	1.6E-02
768500	1.8E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.9E-02	1.7E-02	1.5E-02	1.5E-02	1.6E-02	1.6E-02	1.6E-02	1.5E-02	1.3E-02	1.4E-02	1.4E-02	1.4E-02	1.3E-02	1.4E-02	1.4E-02	1.4E-02
769500	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.6E-02	1.5E-02	1.3E-02	1.2E-02	1.3E-02	1.3E-02	1.3E-02	1.3E-02	1.2E-02	1.1E-02	1.1E-02	1.2E-02	1.2E-02	1.1E-02	1.1E-02	1.1E-02	1.1E-02
770500	1.4E-02	1.4E-02	1.4E-02	1.3E-02	1.3E-02	1.2E-02	1.0E-02	1.0E-02	1.1E-02	1.1E-02	1.1E-02	1.1E-02	1.0E-02	9.8E-03	9.4E-03	9.8E-03	9.8E-03	9.7E-03	9.5E-03	9.2E-03	9.5E-03
771500	1.2E-02	1.2E-02	1.2E-02	1.1E-02	1.1E-02	9.7E-03	8.7E-03	9.1E-03	9.4E-03	9.5E-03	9.5E-03	9.4E-03	9.0E-03	8.6E-03	8.0E-03	8.3E-03	8.4E-03	8.5E-03	8.3E-03	8.1E-03	7.9E-03

NOTE: Row and column headings represent Universal Transverse Mercator (UTM) coordinates in meters.

FIGURE 1B
Example Concentrations (ug/m3) Predicted by ISCLT3
Scenario: Facility-Specific Median Stack Height and Constant Exit Gas Velocity of 0.01 m/sec

	409400	410400	411400	412400	413400	414400	415400	416400	417400	418400	419400	420400	421400	422400	423400	424400	425400	426400	427400	428400	429400
751500	3.27E-03	3.48E-03	3.70E-03	3.92E-03	4.11E-03	4.28E-03	4.60E-03	6.21E-03	7.91E-03	9.62E-03	1.13E-02	1.26E-02	1.37E-02	1.44E-02	1.48E-02	1.40E-02	1.29E-02	1.18E-02	1.08E-02	9.80E-03	8.90E-03
752500	4.04E-03	3.81E-03	4.08E-03	4.37E-03	4.63E-03	4.87E-03	5.06E-03	6.59E-03	8.76E-03	1.10E-02	1.31E-02	1.49E-02	1.62E-02	1.70E-02	1.70E-02	1.56E-02	1.42E-02	1.29E-02	1.16E-02	1.04E-02	9.85E-03
753500	4.96E-03	4.82E-03	4.51E-03	4.88E-03	5.25E-03	5.60E-03	5.89E-03	6.88E-03	9.71E-03	1.27E-02	1.55E-02	1.78E-02	1.95E-02	2.04E-02	1.93E-02	1.75E-02	1.57E-02	1.40E-02	1.24E-02	1.17E-02	1.09E-02
754500	6.03E-03	6.04E-03	5.88E-03	5.45E-03	5.97E-03	6.47E-03	6.93E-03	7.28E-03	1.07E-02	1.48E-02	1.87E-02	2.19E-02	2.40E-02	2.47E-02	2.22E-02	1.97E-02	1.73E-02	1.52E-02	1.41E-02	1.30E-02	1.20E-02
755500	7.27E-03	7.49E-03	7.57E-03	7.40E-03	6.79E-03	7.53E-03	8.25E-03	8.86E-03	1.17E-02	1.75E-02	2.32E-02	2.78E-02	3.05E-02	2.94E-02	2.58E-02	2.23E-02	1.91E-02	1.75E-02	1.59E-02	1.45E-02	1.32E-02
756500	8.68E-03	9.18E-03	9.62E-03	9.86E-03	9.70E-03	8.79E-03	9.93E-03	1.10E-02	1.23E-02	2.10E-02	2.98E-02	3.67E-02	4.01E-02	3.54E-02	3.00E-02	2.50E-02	2.25E-02	2.01E-02	1.79E-02	1.60E-02	1.44E-02
757500	1.08E-02	1.11E-02	1.20E-02	1.29E-02	1.35E-02	1.35E-02	1.20E-02	1.39E-02	1.55E-02	2.54E-02	4.03E-02	5.15E-02	5.21E-02	4.32E-02	3.48E-02	3.04E-02	2.64E-02	2.29E-02	2.00E-02	1.75E-02	1.58E-02
758500	1.63E-02	1.68E-02	1.67E-02	1.65E-02	1.83E-02	1.99E-02	2.04E-02	1.78E-02	2.13E-02	2.99E-02	5.88E-02	7.91E-02	6.91E-02	5.28E-02	4.42E-02	3.66E-02	3.05E-02	2.57E-02	2.30E-02	2.08E-02	1.89E-02
759500	2.22E-02	2.43E-02	2.65E-02	2.86E-02	3.00E-02	2.94E-02	3.25E-02	3.56E-02	3.03E-02	3.83E-02	9.75E-02	1.33E-01	9.40E-02	7.18E-02	5.49E-02	4.36E-02	3.76E-02	3.25E-02	2.83E-02	2.48E-02	2.20E-02
760500	2.82E-02	3.21E-02	3.68E-02	4.26E-02	4.99E-02	5.88E-02	6.92E-02	7.74E-02	8.30E-02	6.95E-02	2.10E-01	2.41E-01	1.44E-01	9.96E-02	7.56E-02	5.93E-02	4.79E-02	3.96E-02	3.34E-02	2.87E-02	2.50E-02
761500	3.42E-02	3.97E-02	4.69E-02	5.65E-02	6.99E-02	8.96E-02	1.20E-01	1.74E-01	2.83E-01	5.73E-01		5.33E-01	2.43E-01	1.45E-01	9.94E-02	7.34E-02	5.71E-02	4.59E-02	3.80E-02	3.21E-02	2.76E-02
762500	3.23E-02	3.72E-02	4.34E-02	5.14E-02	6.22E-02	7.68E-02	9.71E-02	1.25E-01	1.57E-01	1.71E-01	2.00E-01	1.58E-01	1.53E-01	1.13E-01	8.40E-02	6.48E-02	5.17E-02	4.24E-02	3.55E-02	3.03E-02	2.63E-02
763500	3.00E-02	3.41E-02	3.92E-02	4.53E-02	5.29E-02	6.20E-02	7.23E-02	8.27E-02	8.64E-02	7.05E-02	8.54E-02	6.96E-02	6.87E-02	7.10E-02	6.30E-02	5.37E-02	4.47E-02	3.77E-02	3.23E-02	2.80E-02	2.45E-02
764500	2.75E-02	3.07E-02	3.45E-02	3.87E-02	4.33E-02	4.81E-02	5.22E-02	5.32E-02	4.99E-02	4.18E-02	4.96E-02	4.22E-02	4.25E-02	4.01E-02	4.21E-02	3.97E-02	3.61E-02	3.24E-02	2.86E-02	2.53E-02	2.25E-02
765500	2.48E-02	2.71E-02	2.96E-02	3.22E-02	3.47E-02	3.66E-02	3.69E-02	3.60E-02	3.06E-02	3.04E-02	3.34E-02	3.02E-02	2.81E-02	2.87E-02	2.70E-02	2.84E-02	2.76E-02	2.60E-02	2.41E-02	2.22E-02	2.03E-02
766500	2.19E-02	2.34E-02	2.50E-02	2.64E-02	2.74E-02	2.75E-02	2.72E-02	2.50E-02	2.06E-02	2.31E-02	2.44E-02	2.28E-02	2.01E-02	2.11E-02	2.09E-02	1.97E-02	2.07E-02	2.05E-02	1.97E-02	1.87E-02	1.75E-02
767500	1.91E-02	2.01E-02	2.09E-02	2.15E-02	2.15E-02	2.15E-02	2.04E-02	1.80E-02	1.68E-02	1.81E-02	1.88E-02	1.79E-02	1.63E-02	1.60E-02	1.63E-02	1.60E-02	1.52E-02	1.59E-02	1.59E-02	1.55E-02	1.49E-02
768500	1.66E-02	1.71E-02	1.75E-02	1.74E-02	1.74E-02	1.69E-02	1.56E-02	1.32E-02	1.39E-02	1.47E-02	1.50E-02	1.45E-02	1.35E-02	1.24E-02	1.30E-02	1.31E-02	1.28E-02	1.22E-02	1.27E-02	1.28E-02	1.26E-02
769500	1.43E-02	1.45E-02	1.45E-02	1.45E-02	1.42E-02	1.35E-02	1.21E-02	1.10E-02	1.17E-02	1.22E-02	1.24E-02	1.20E-02	1.14E-02	1.05E-02	1.06E-02	1.08E-02	1.07E-02	1.05E-02	1.01E-02	1.05E-02	1.06E-02
770500	1.23E-02	1.23E-02	1.23E-02	1.22E-02	1.17E-02	1.09E-02	9.57E-03	9.55E-03	1.00E-02	1.03E-02	1.04E-02	1.02E-02	9.73E-03	9.12E-03	8.74E-03	9.06E-03	9.14E-03	9.04E-03	8.80E-03	8.49E-03	8.80E-03
771500	1.06E-02	1.06E-02	1.06E-02	1.03E-02	9.73E-03	8.88E-03	7.94E-03	8.36E-03	8.68E-03	8.88E-03	8.92E-03	8.75E-03	8.43E-03	8.00E-03	7.47E-03	7.68E-03	7.84E-03	7.84E-03	7.72E-03	7.53E-03	7.28E-03

NOTE: Row and column headings represent Universal Transverse Mercator (UTM) coordinates in meters.

FIGURE 1C
Example Concentration Ratios (ISCLT3/AG1)
Scenario: Facility-Specific Median Stack Height and Constant Exit Gas Velocity of 0.01 m/sec

	409400	**410400**	**411400**	**412400**	**413400**	**414400**	**415400**	**416400**	**417400**	**418400**	**419400**	**420400**	**421400**	**422400**	**423400**	**424400**	**425400**	**426400**	**427400**	**428400**	**429400**
751500	0.956	0.958	0.959	0.960	0.961	0.961	0.962	0.964	0.965	0.965	0.966	0.967	0.968	0.968	0.968	0.970	0.972	0.973	0.974	0.975	0.975
752500	0.959	0.959	0.960	0.961	0.962	0.962	0.962	0.963	0.964	0.965	0.966	0.967	0.968	0.969	0.970	0.972	0.974	0.976	0.977	0.978	0.976
753500	0.961	0.962	0.961	0.962	0.962	0.962	0.962	0.962	0.963	0.963	0.964	0.965	0.967	0.968	0.971	0.974	0.977	0.978	0.980	0.978	0.977
754500	0.963	0.964	0.964	0.962	0.962	0.961	0.960	0.959	0.960	0.960	0.961	0.963	0.965	0.967	0.972	0.976	0.979	0.982	0.980	0.979	0.978
755500	0.965	0.965	0.965	0.964	0.961	0.959	0.957	0.956	0.955	0.954	0.955	0.958	0.962	0.967	0.972	0.977	0.982	0.981	0.981	0.979	0.978
756500	0.966	0.967	0.967	0.965	0.962	0.957	0.953	0.949	0.946	0.944	0.945	0.949	0.956	0.965	0.973	0.980	0.980	0.980	0.980	0.979	0.978
757500	0.967	0.968	0.968	0.966	0.963	0.958	0.948	0.940	0.933	0.929	0.930	0.937	0.948	0.962	0.975	0.977	0.978	0.979	0.979	0.979	0.978
758500	0.966	0.966	0.967	0.967	0.964	0.957	0.947	0.929	0.915	0.906	0.905	0.918	0.942	0.963	0.968	0.973	0.976	0.978	0.978	0.978	0.977
759500	0.965	0.965	0.964	0.961	0.959	0.956	0.946	0.927	0.894	0.866	0.858	0.893	0.943	0.951	0.961	0.968	0.971	0.973	0.975	0.976	0.976
760500	0.964	0.964	0.962	0.959	0.953	0.944	0.930	0.912	0.888	0.795	0.752	0.880	0.916	0.934	0.947	0.958	0.966	0.970	0.973	0.975	0.975
761500	0.964	0.963	0.961	0.957	0.951	0.940	0.922	0.894	0.839	0.704		0.766	0.869	0.914	0.937	0.953	0.963	0.968	0.972	0.974	0.974
762500	0.962	0.961	0.958	0.954	0.946	0.932	0.909	0.872	0.807	0.717	0.806	0.802	0.871	0.911	0.935	0.951	0.962	0.967	0.971	0.973	0.974
763500	0.961	0.960	0.956	0.951	0.943	0.928	0.909	0.885	0.863	0.840	0.892	0.878	0.904	0.922	0.940	0.954	0.963	0.967	0.971	0.973	0.974
764500	0.960	0.959	0.955	0.950	0.945	0.935	0.922	0.912	0.897	0.901	0.928	0.920	0.926	0.938	0.948	0.957	0.965	0.969	0.971	0.973	0.974
765500	0.959	0.958	0.956	0.953	0.948	0.944	0.938	0.929	0.923	0.931	0.947	0.942	0.943	0.949	0.957	0.962	0.966	0.969	0.972	0.973	0.973
766500	0.960	0.959	0.958	0.956	0.953	0.951	0.947	0.942	0.943	0.948	0.959	0.956	0.957	0.959	0.963	0.965	0.968	0.970	0.972	0.973	0.973
767500	0.960	0.960	0.960	0.959	0.958	0.956	0.953	0.953	0.955	0.959	0.967	0.965	0.965	0.966	0.966	0.968	0.969	0.971	0.972	0.972	0.973
768500	0.960	0.961	0.961	0.962	0.960	0.959	0.958	0.959	0.961	0.965	0.971	0.969	0.969	0.969	0.969	0.970	0.971	0.971	0.971	0.972	0.972
769500	0.961	0.962	0.962	0.962	0.962	0.962	0.962	0.963	0.965	0.969	0.973	0.972	0.972	0.972	0.972	0.972	0.971	0.971	0.970	0.970	0.970
770500	0.960	0.962	0.962	0.963	0.963	0.963	0.964	0.966	0.968	0.970	0.974	0.973	0.973	0.973	0.973	0.972	0.971	0.971	0.970	0.968	0.968
771500	0.960	0.961	0.962	0.963	0.963	0.964	0.965	0.967	0.968	0.971	0.973	0.973	0.973	0.973	0.973	0.972	0.971	0.970	0.969	0.968	0.966

NOTE: Row and column headings represent Universal Transverse Mercator (UTM) coordinates in meters.

FIGURE 2
Example Contour Plots of Concentrations Predicted By Each Model and Example Contour Plot of the Concentration Ratios
Scenario: Facility-Specific Median Stack Height and Constant Exit Gas Velocity of 0.01 m/sec

FIGURE 2A
ISCLT-3 Concentration (ug/m^3)

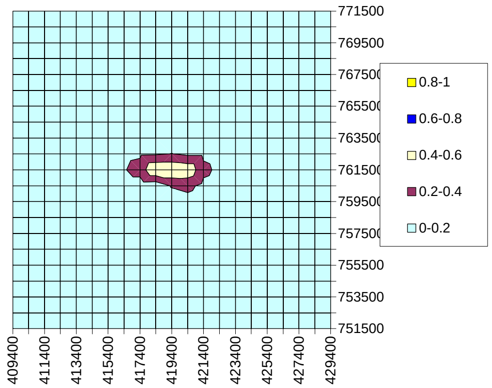


FIGURE 2B
AG-1 Concentration (ug/m^3)

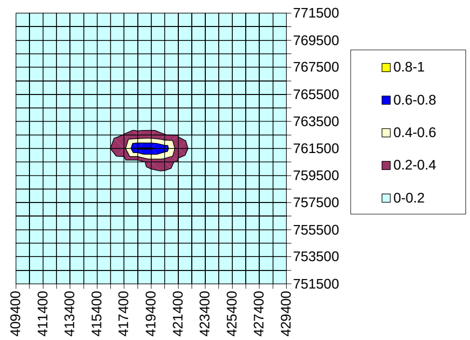
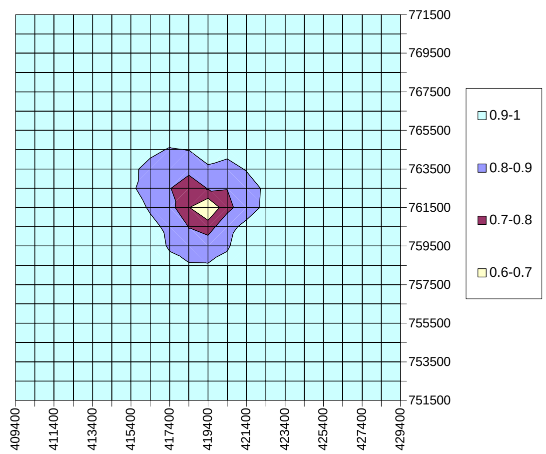


FIGURE 2C
(ISCLT3/AG1) Ratio



NOTE: All axes represent Universal Transverse Mercator (UTM) coordinates in meters.

FIGURE 3
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Albany
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

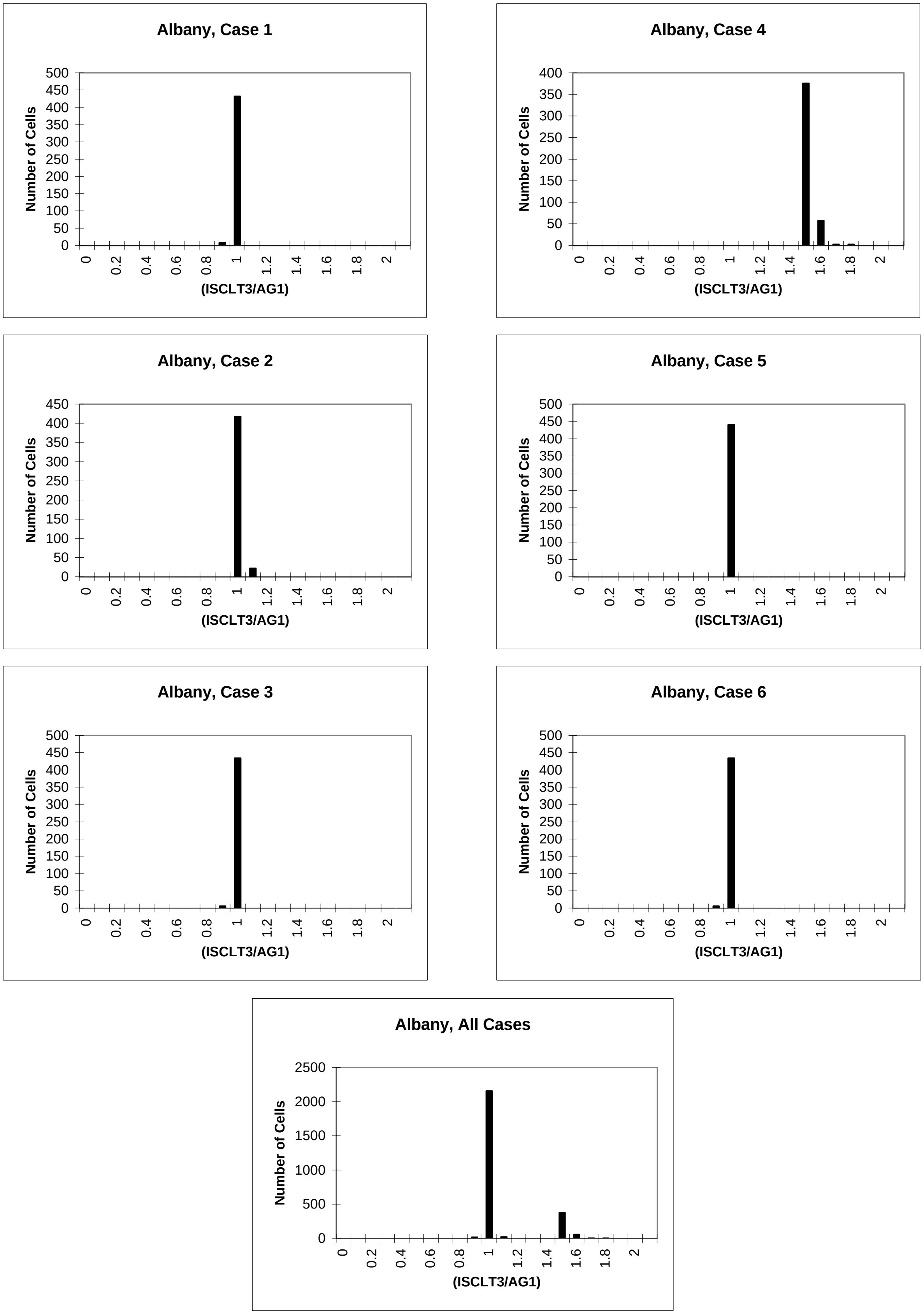


FIGURE 4
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Buffalo Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

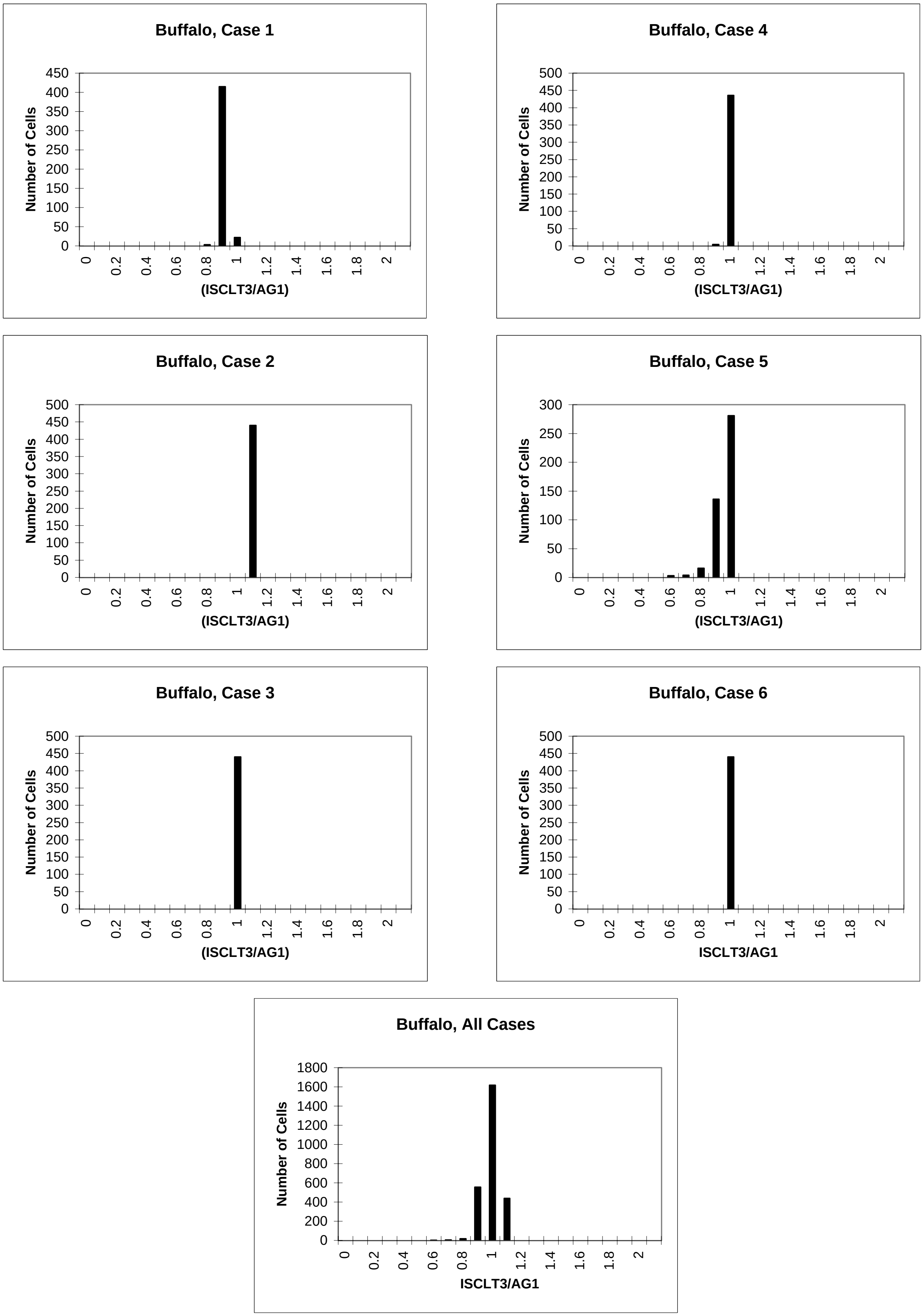
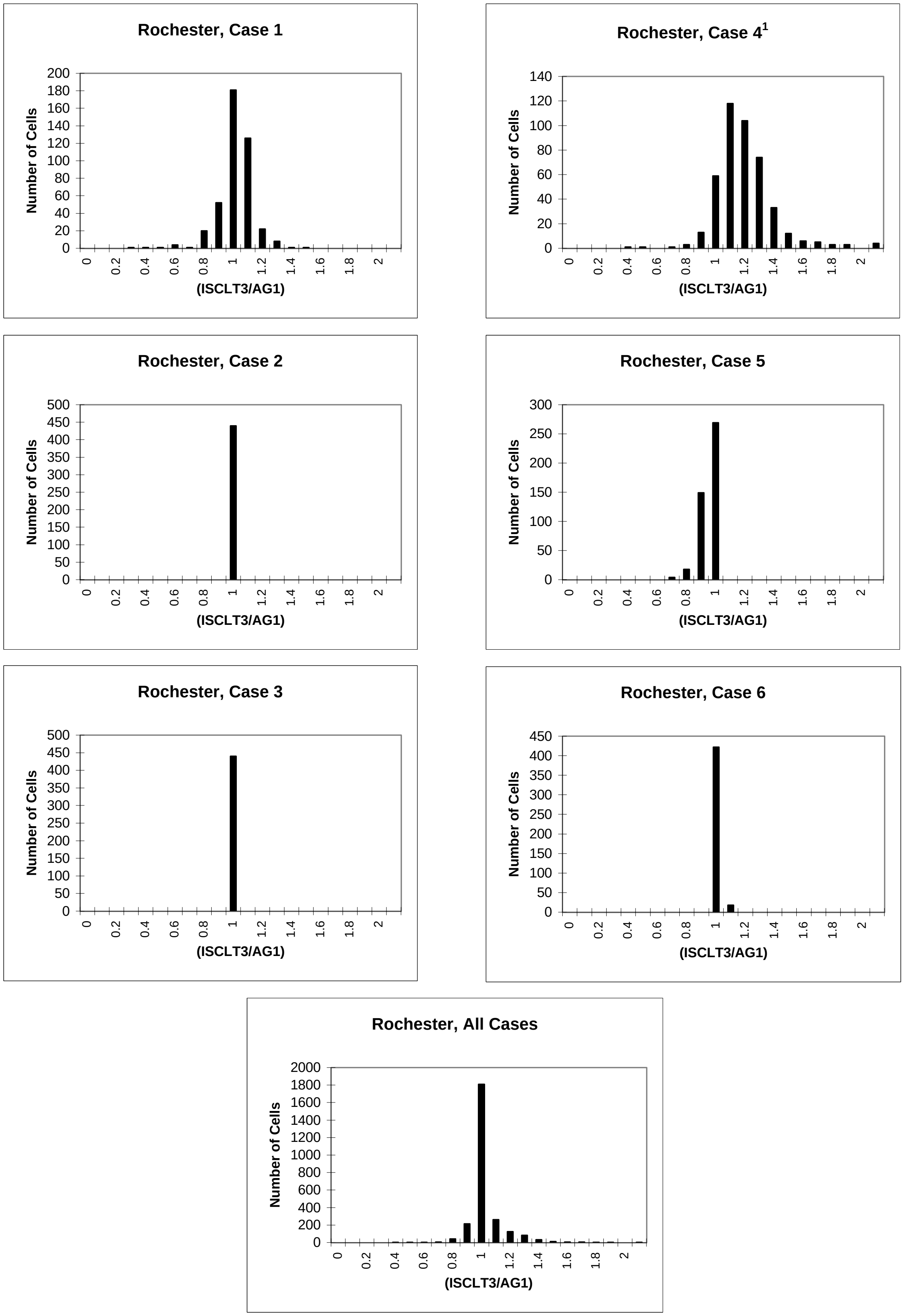


FIGURE 5
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Rochester Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity



[1]All ratios greater than 2.1 are grouped in the last bar.

FIGURE 6
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Syracuse Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

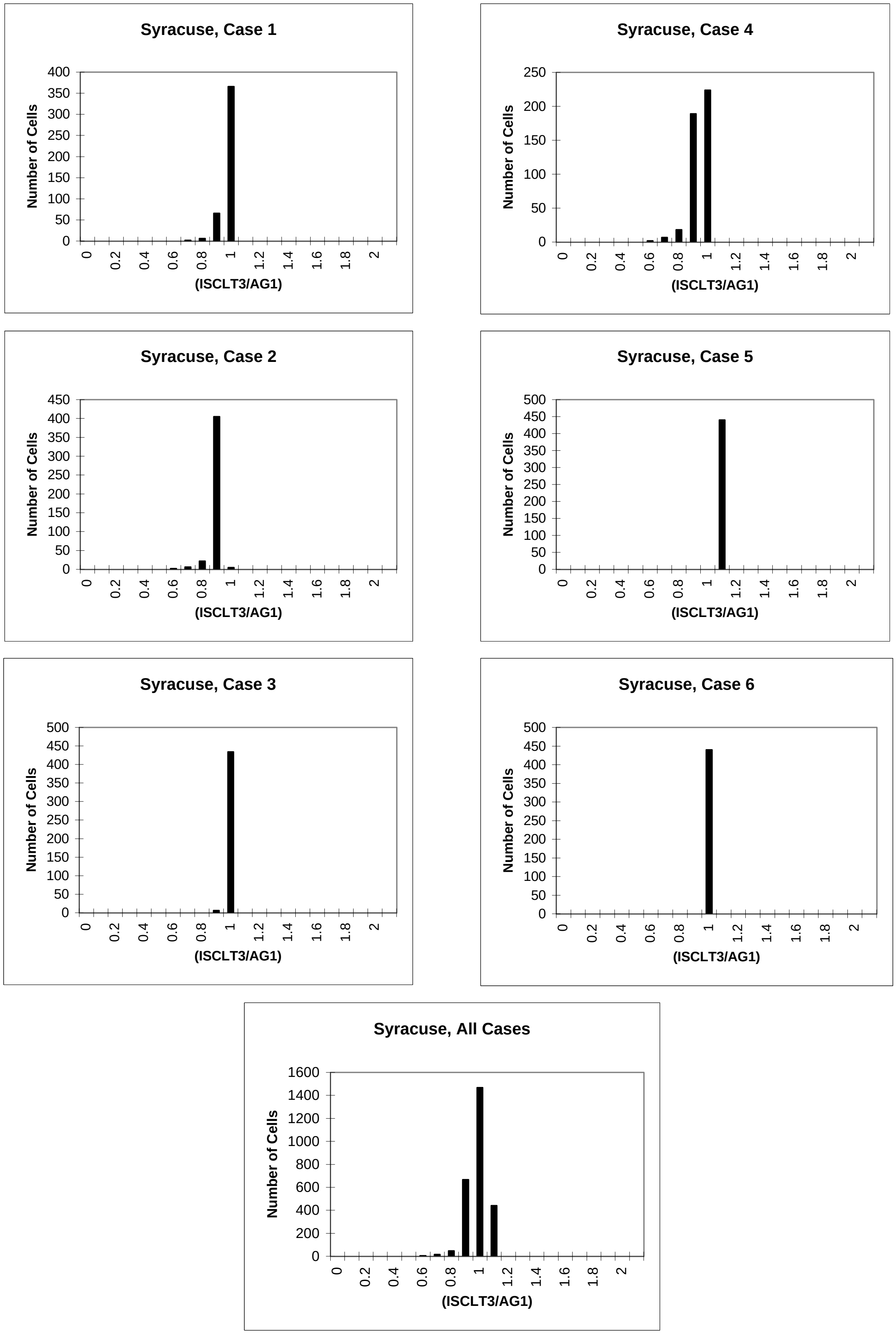
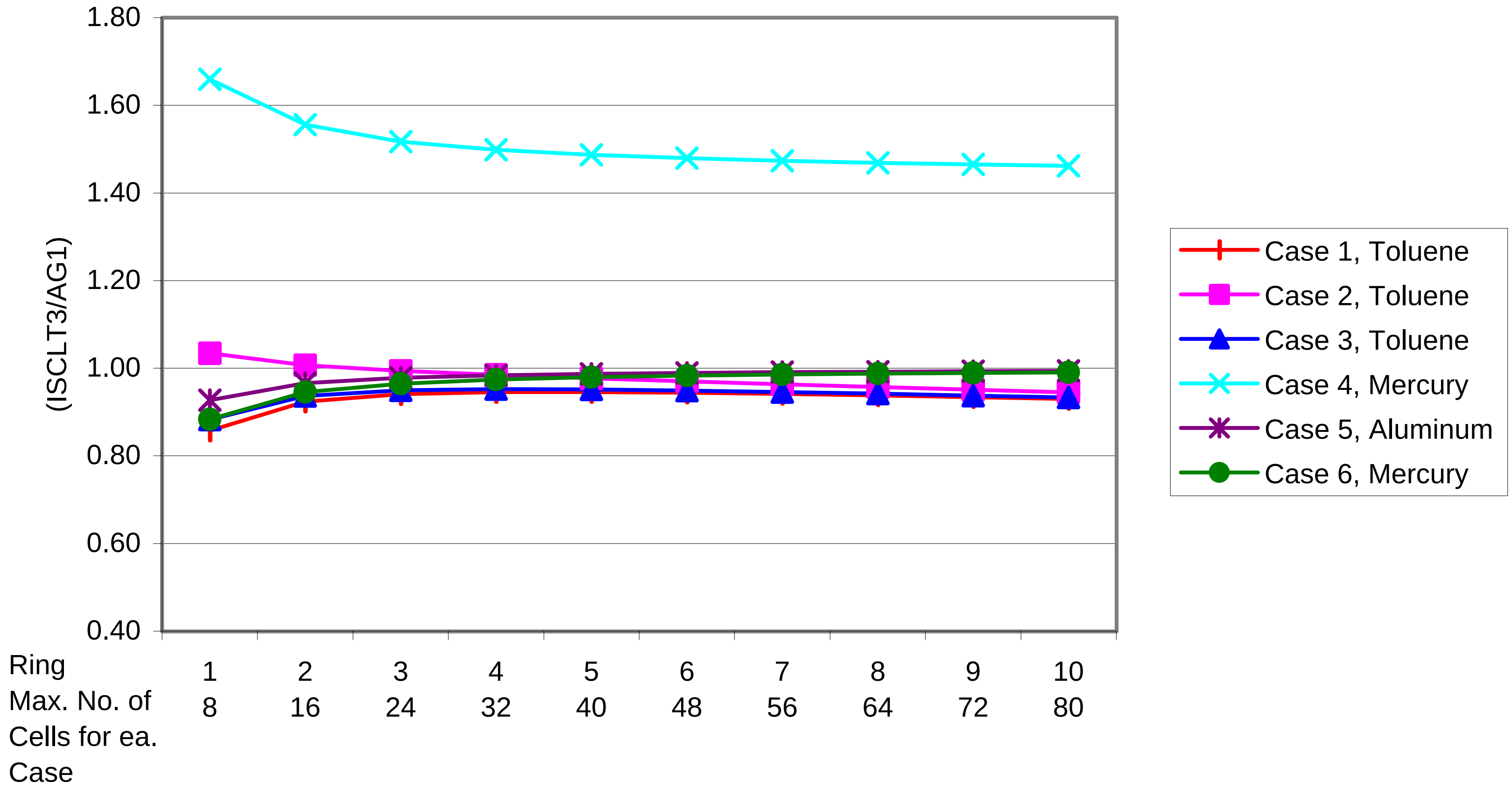


FIGURE 7
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Albany
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity



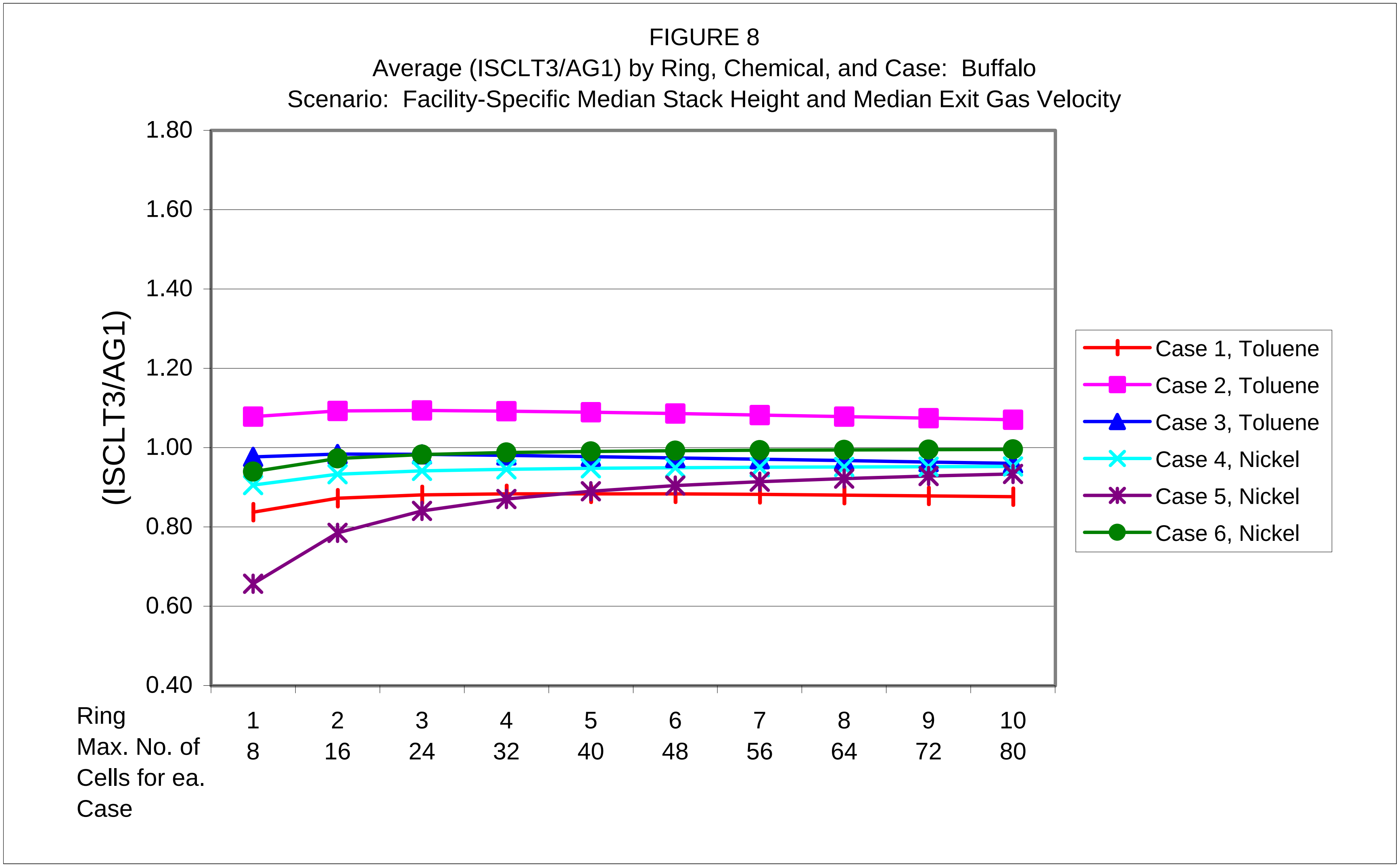


FIGURE 8
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Buffalo
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells for ea. Case
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Nickel
Case 5, Nickel
Case 6, Nickel

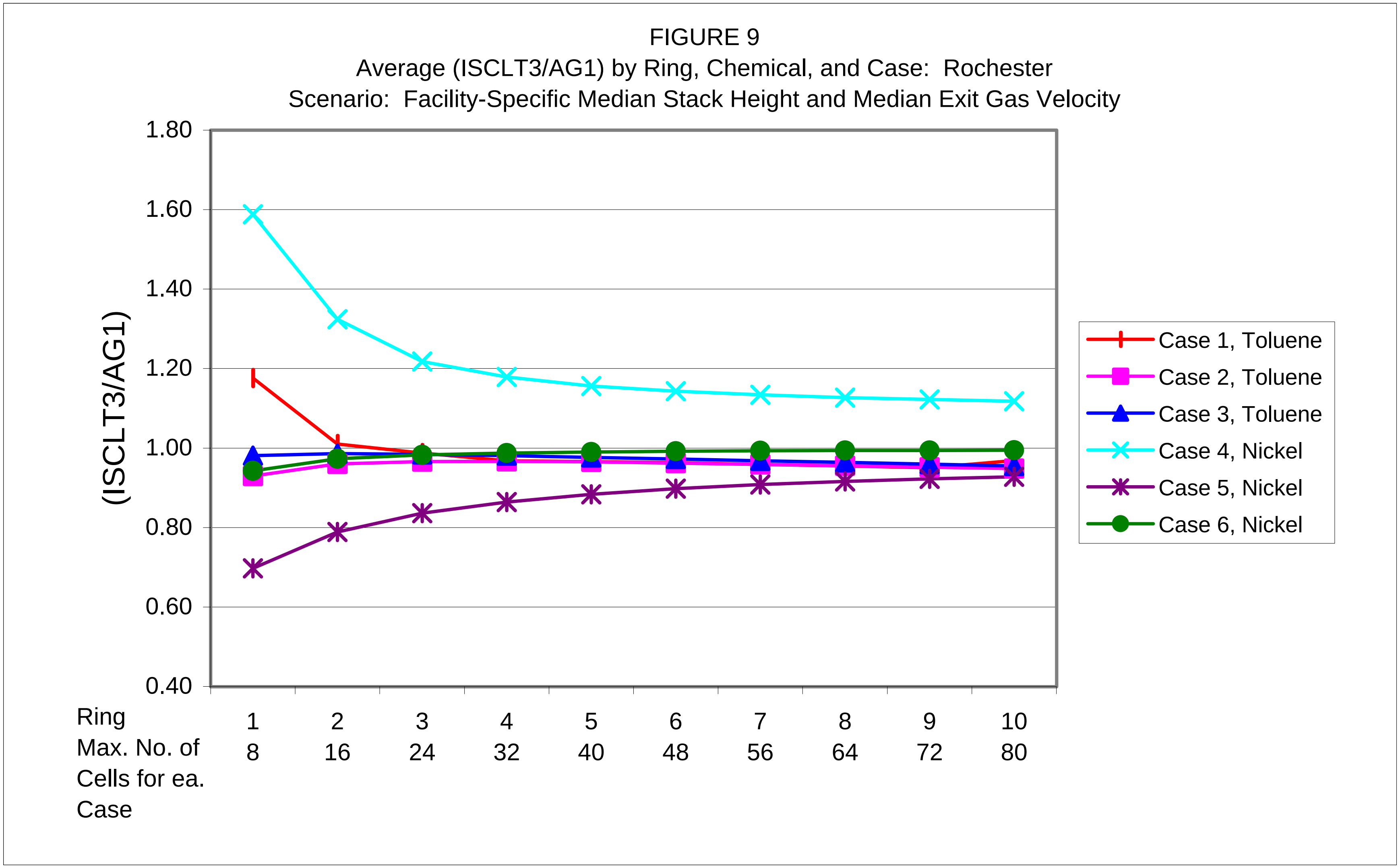


FIGURE 9
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Rochester
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells for ea. Case
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Nickel
Case 5, Nickel
Case 6, Nickel

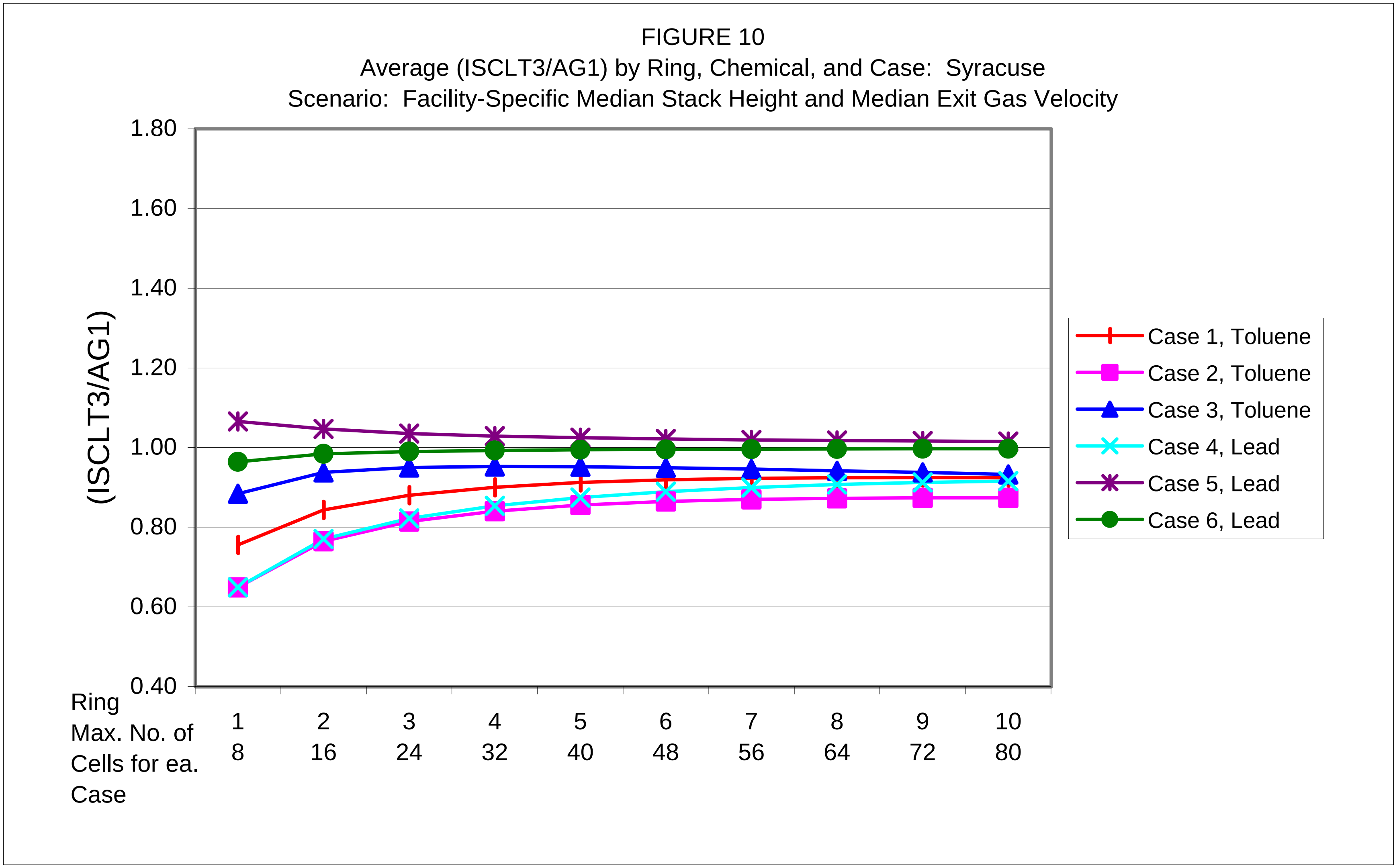


FIGURE 10
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Syracuse
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells for ea. Case
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Lead
Case 5, Lead
Case 6, Lead

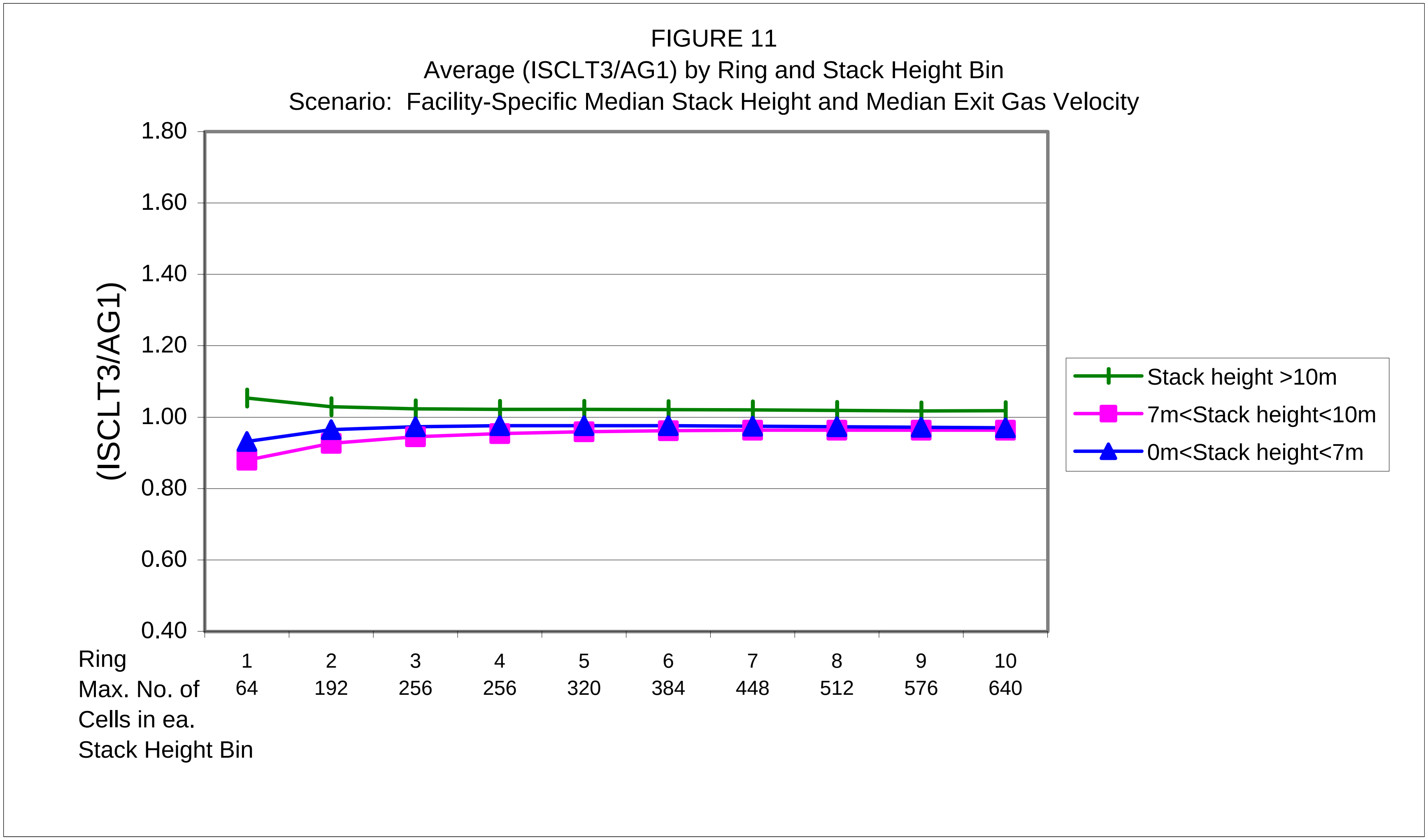


FIGURE 11
Average (ISCLT3/AG1) by Ring and Stack Height Bin
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
1 2 3 4 5 6 7 8 9 10
Max. No. of Cells in ea. Stack Height Bin
64 192 256 256 320 384 448 512 576 640
Stack height >10m
7m<Stack height<10m
0m<Stack height<7m

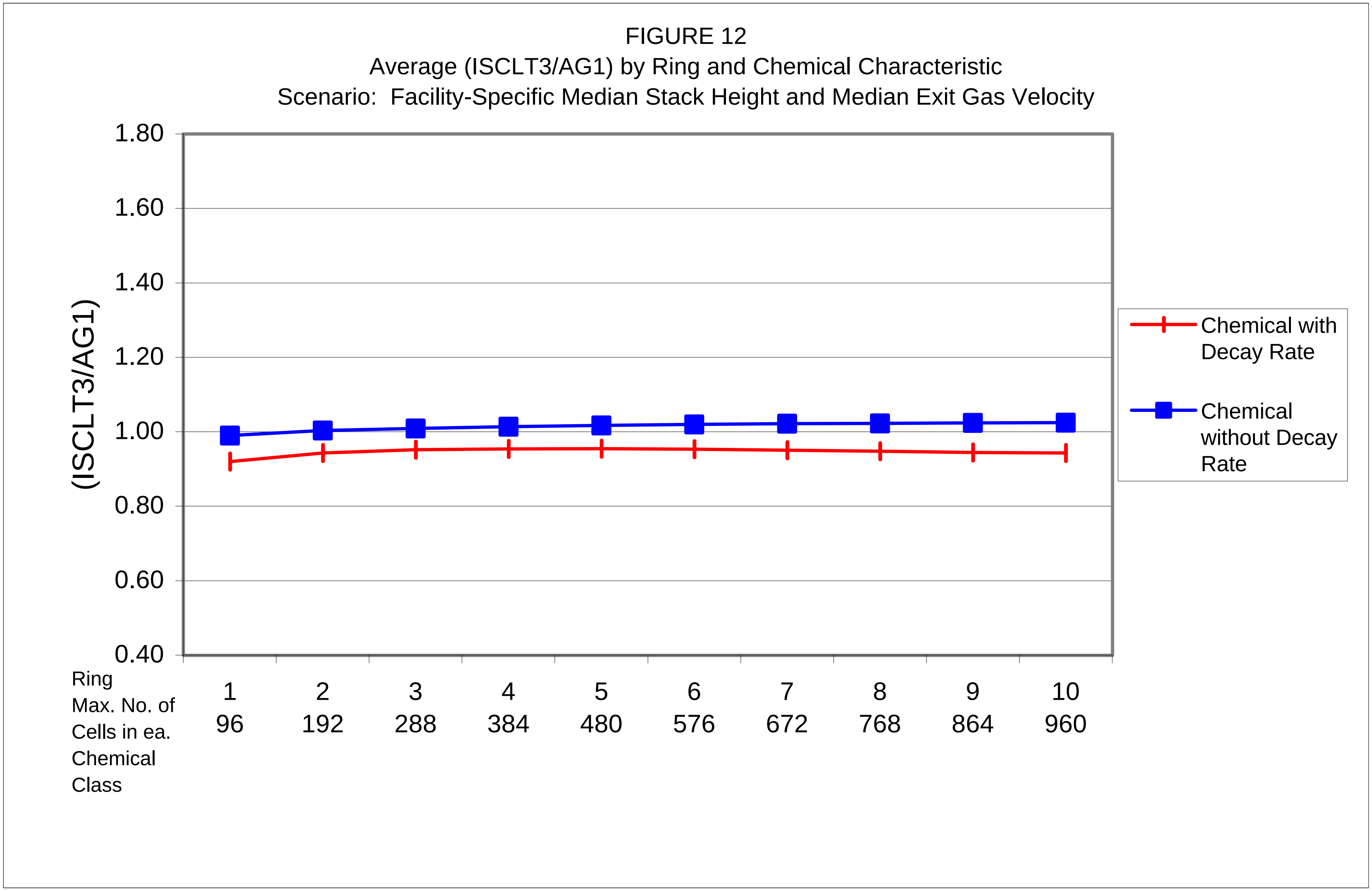
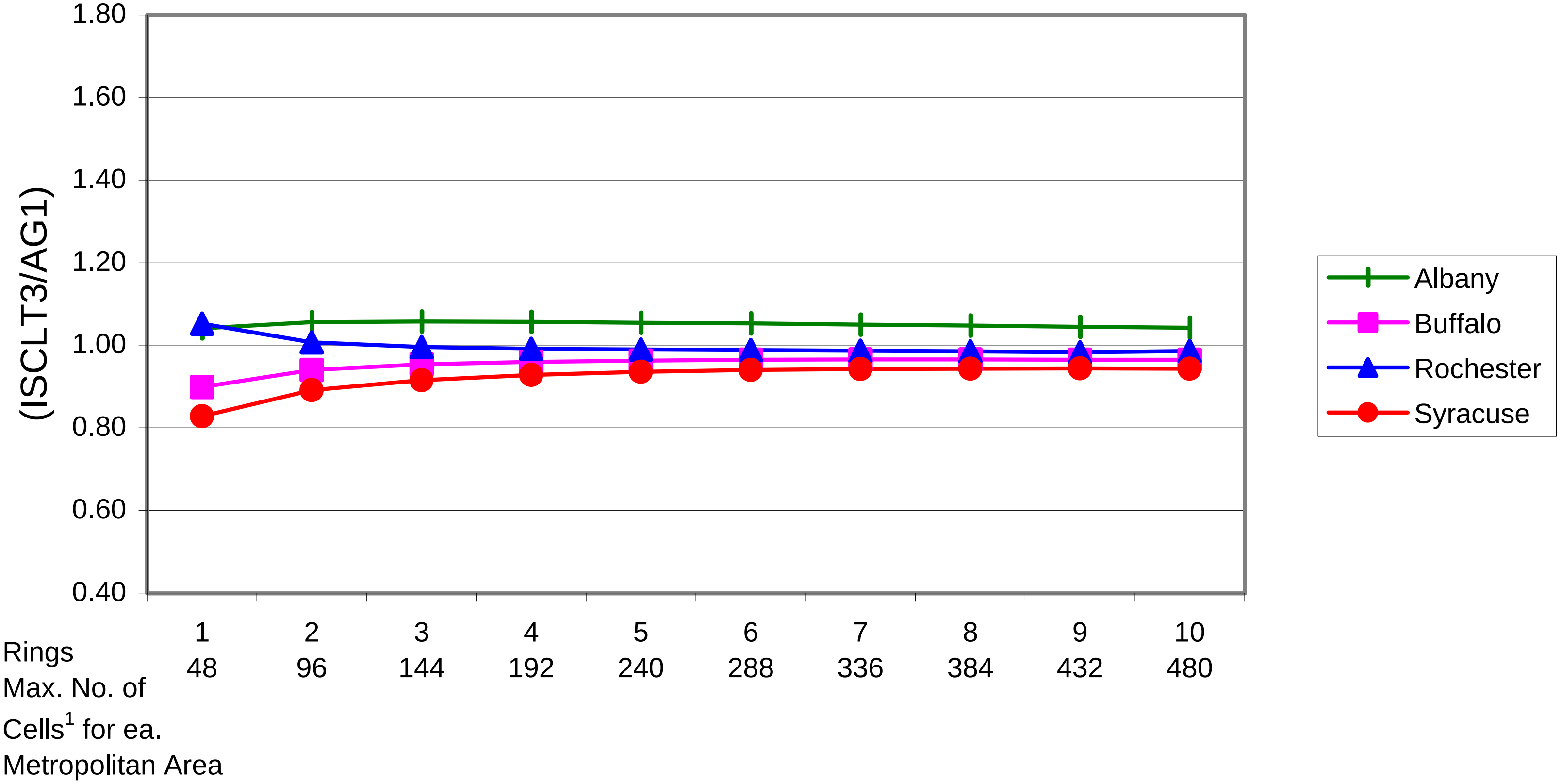


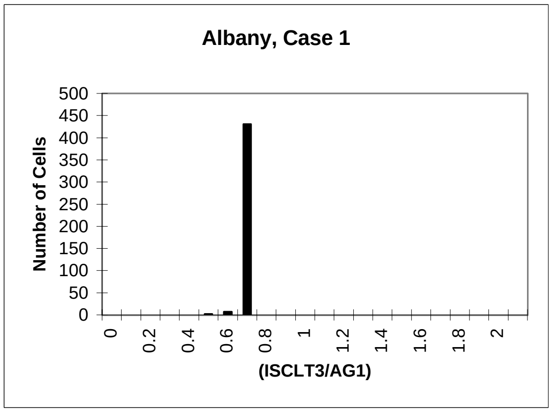
FIGURE 12
Average (ISCLT3/AG1) by Ring and Chemical Characteristic
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells in ea. Chemical Class
1 2 3 4 5 6 7 8 9 10
96 192 288 384 480 576 672 768 864 960
Chemical with Decay Rate
Chemical without Decay Rate

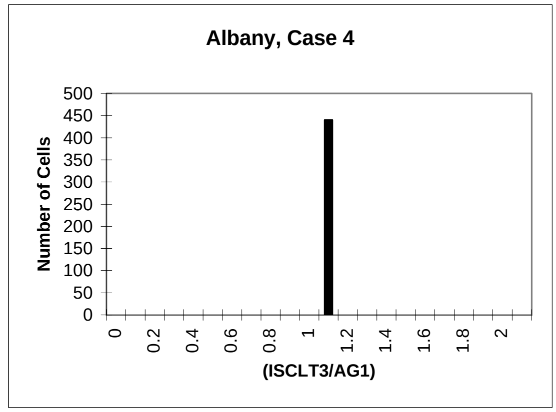
FIGURE 13
Average (ISCLT3/AG1) by Ring and Metropolitan Area
Scenario: Facility-Specific Median Stack Height and Median Exit Gas Velocity

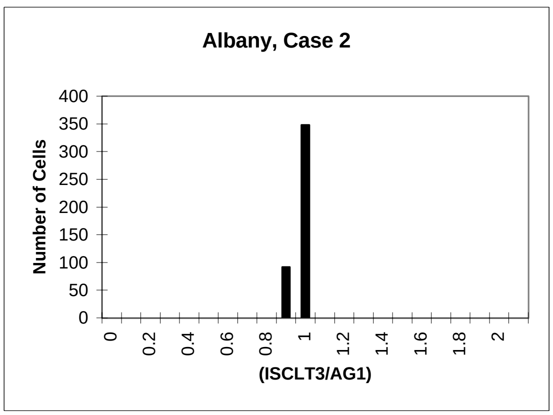


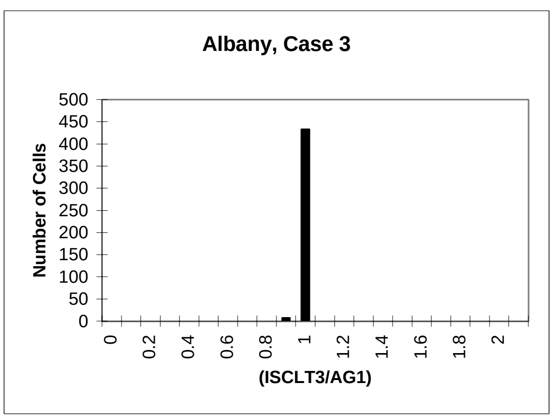
[1] See Table 10 for actual number of cells per ring in each metropolitan area

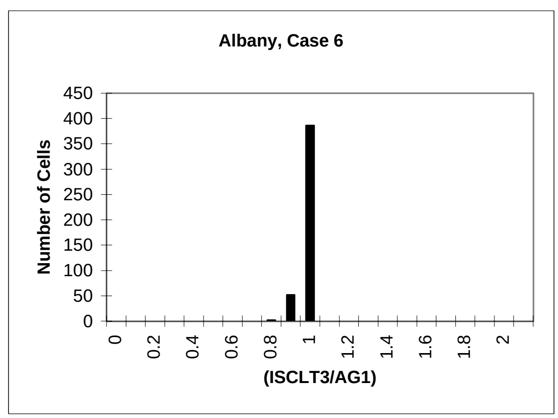
FIGURE 14
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Albany
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity











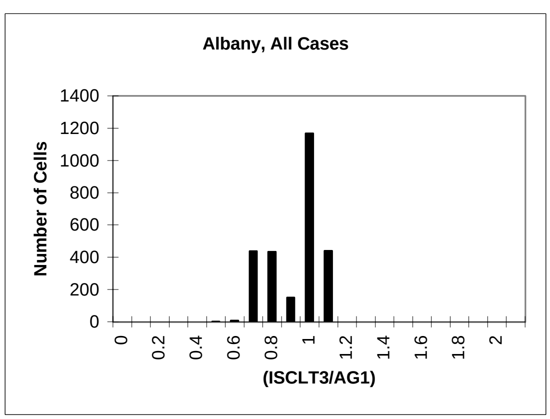


FIGURE 15
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Buffalo
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity

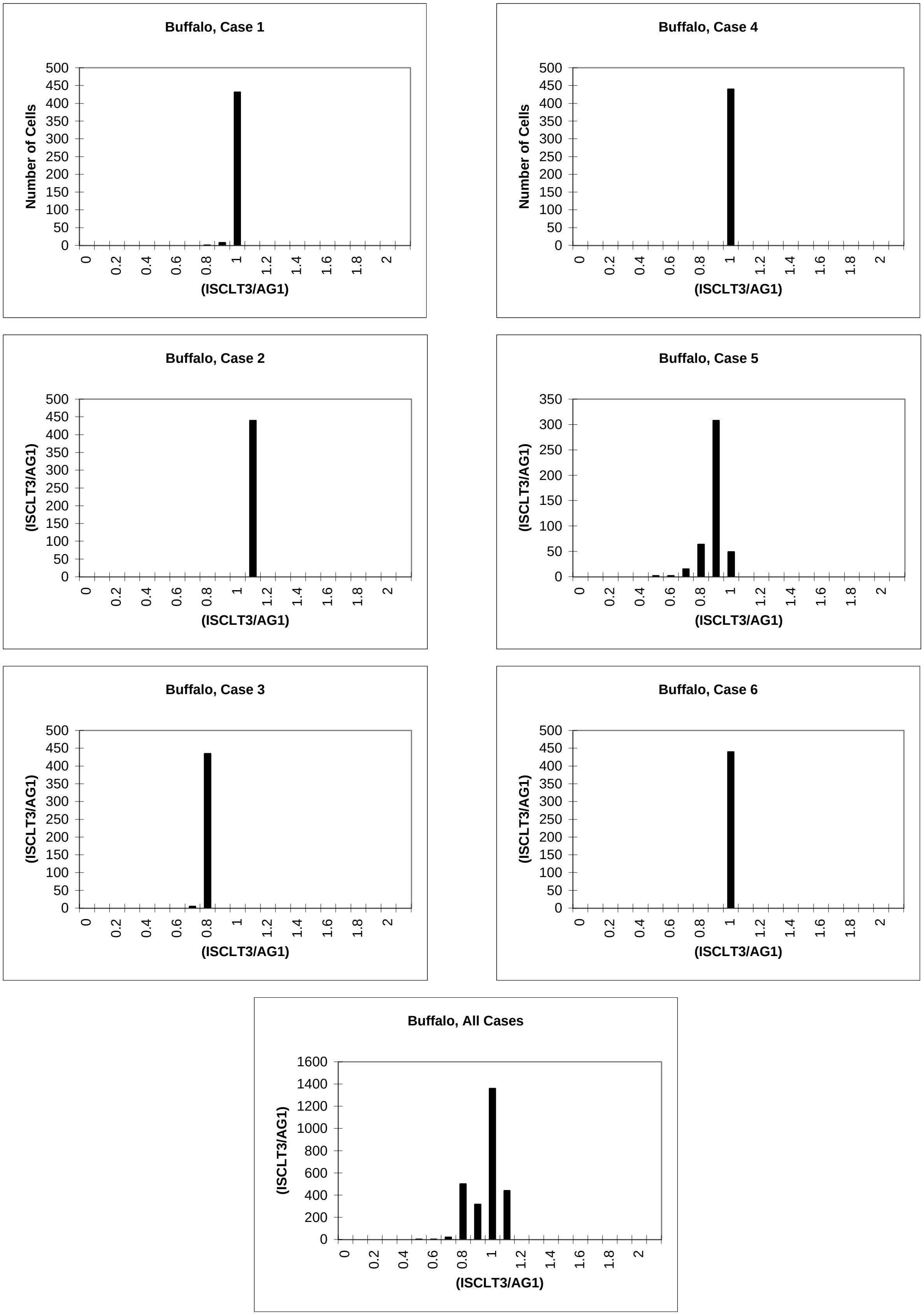
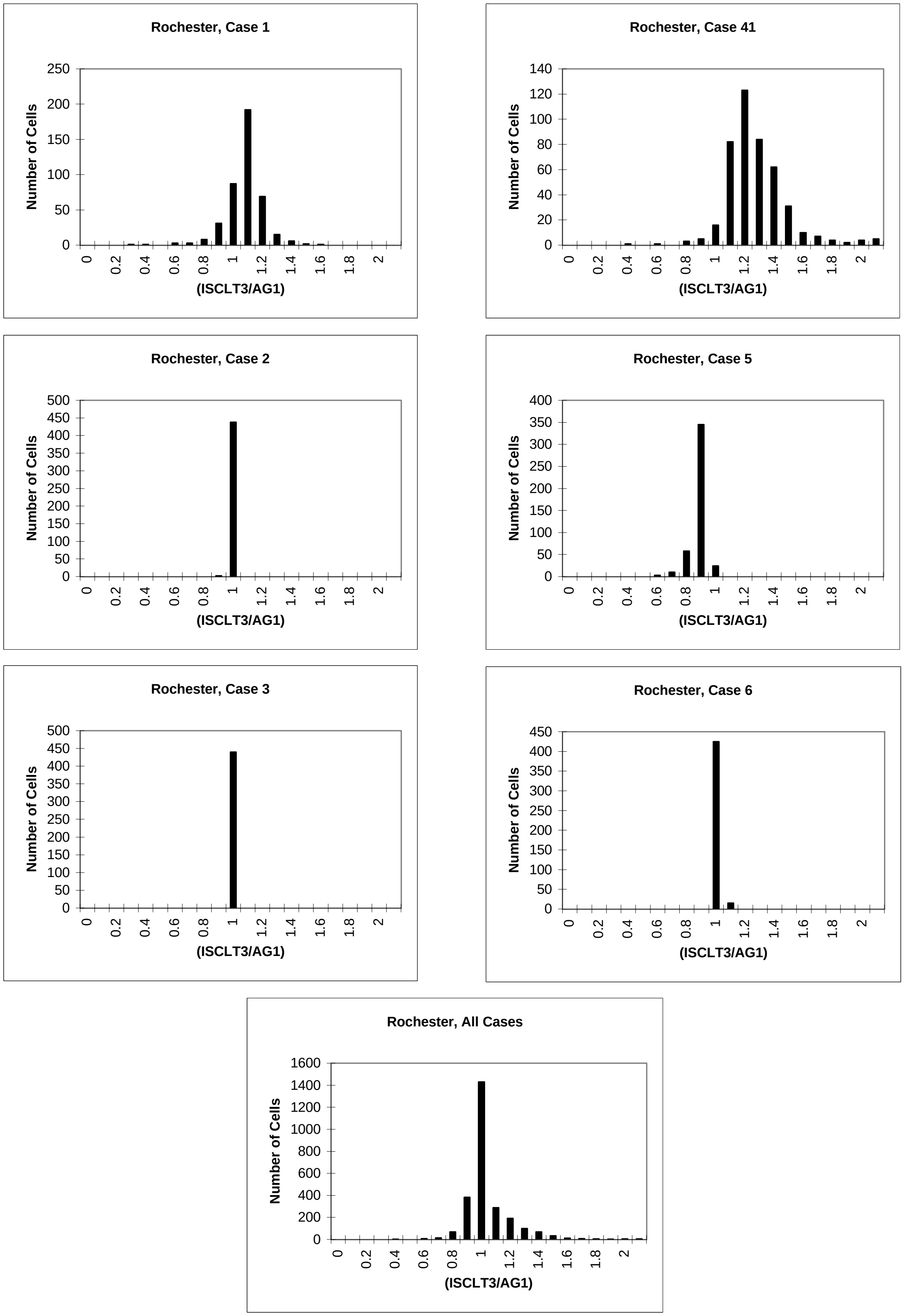
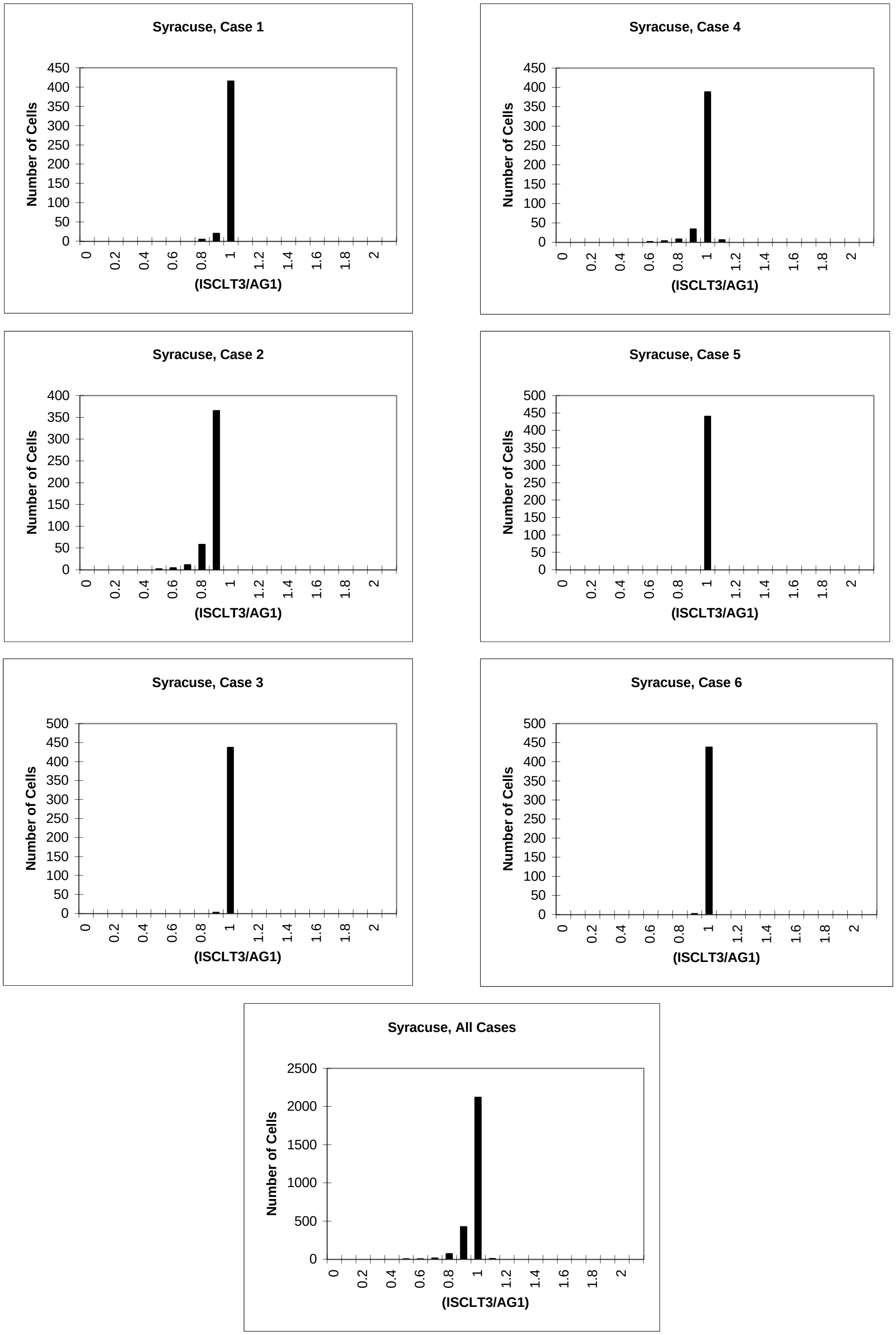


FIGURE 16
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Rochester Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity



[1]All ratios greater than 2.1 are grouped in last bar.

FIGURE 17
Frequency Distributions of Concentration Ratios (ISCLT3/AG1) by Case and For All Cases: Syracuse Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity



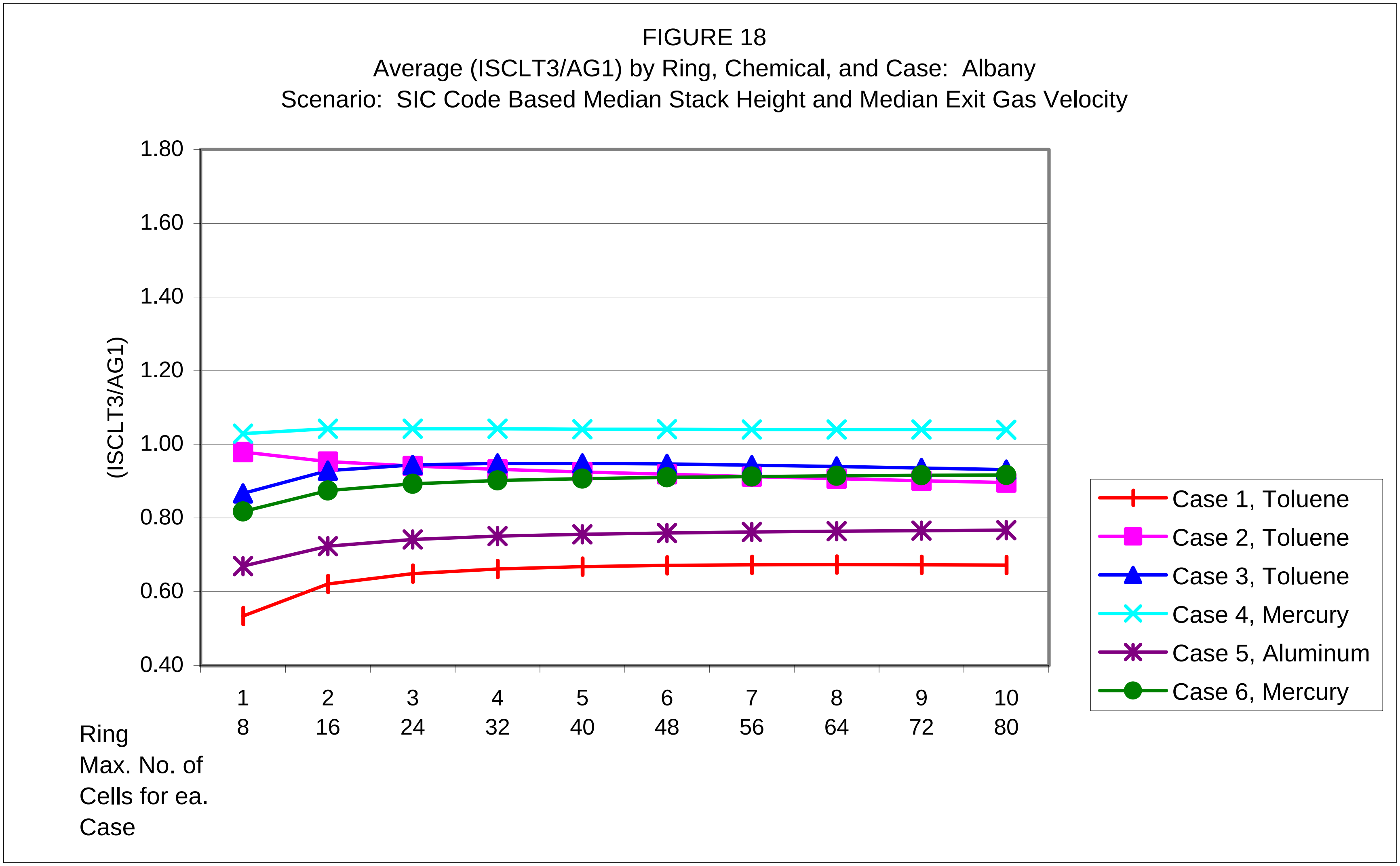


FIGURE 18
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Albany
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Ring
Max. No. of Cells for ea. Case
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Mercury
Case 5, Aluminum
Case 6, Mercury

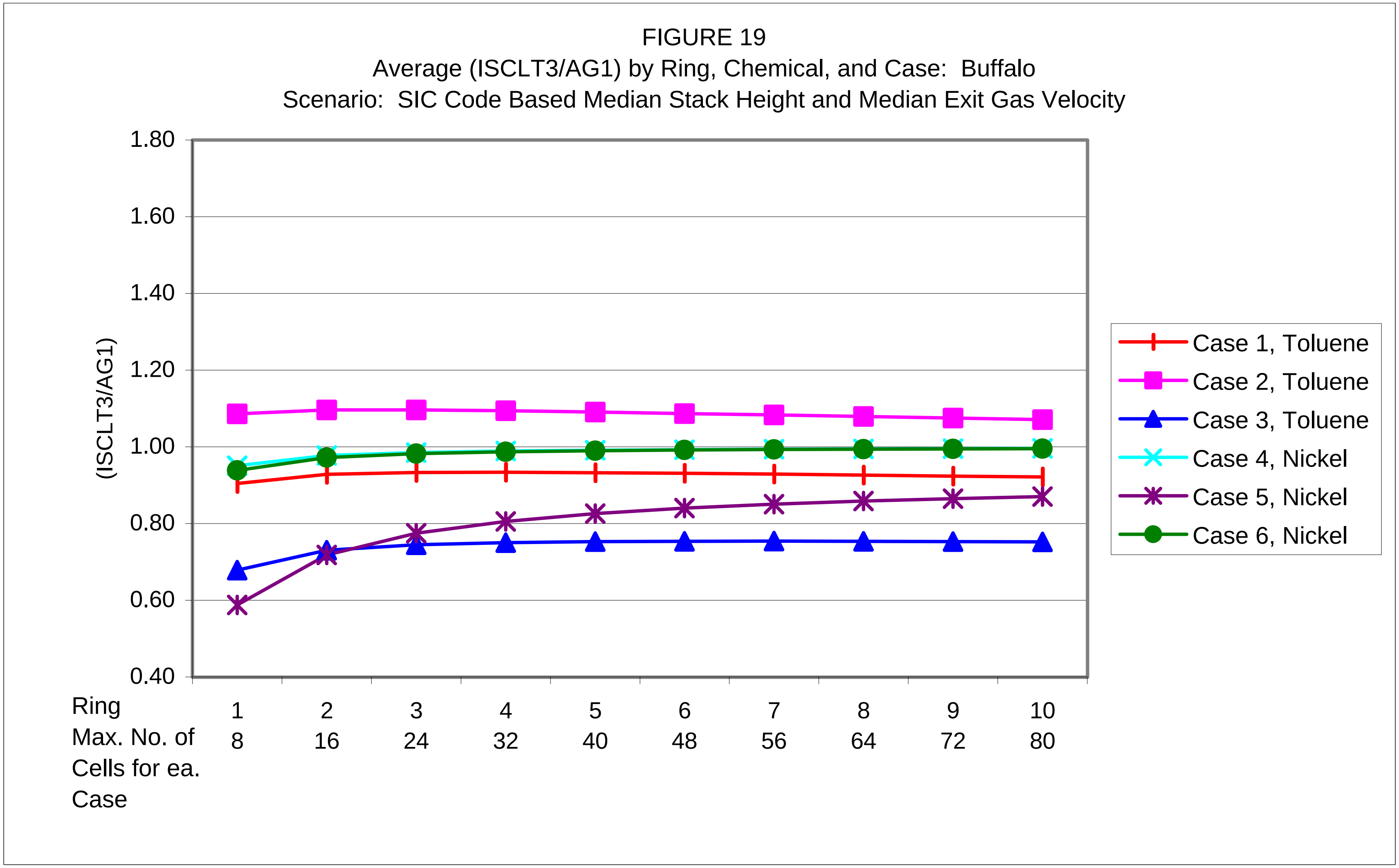
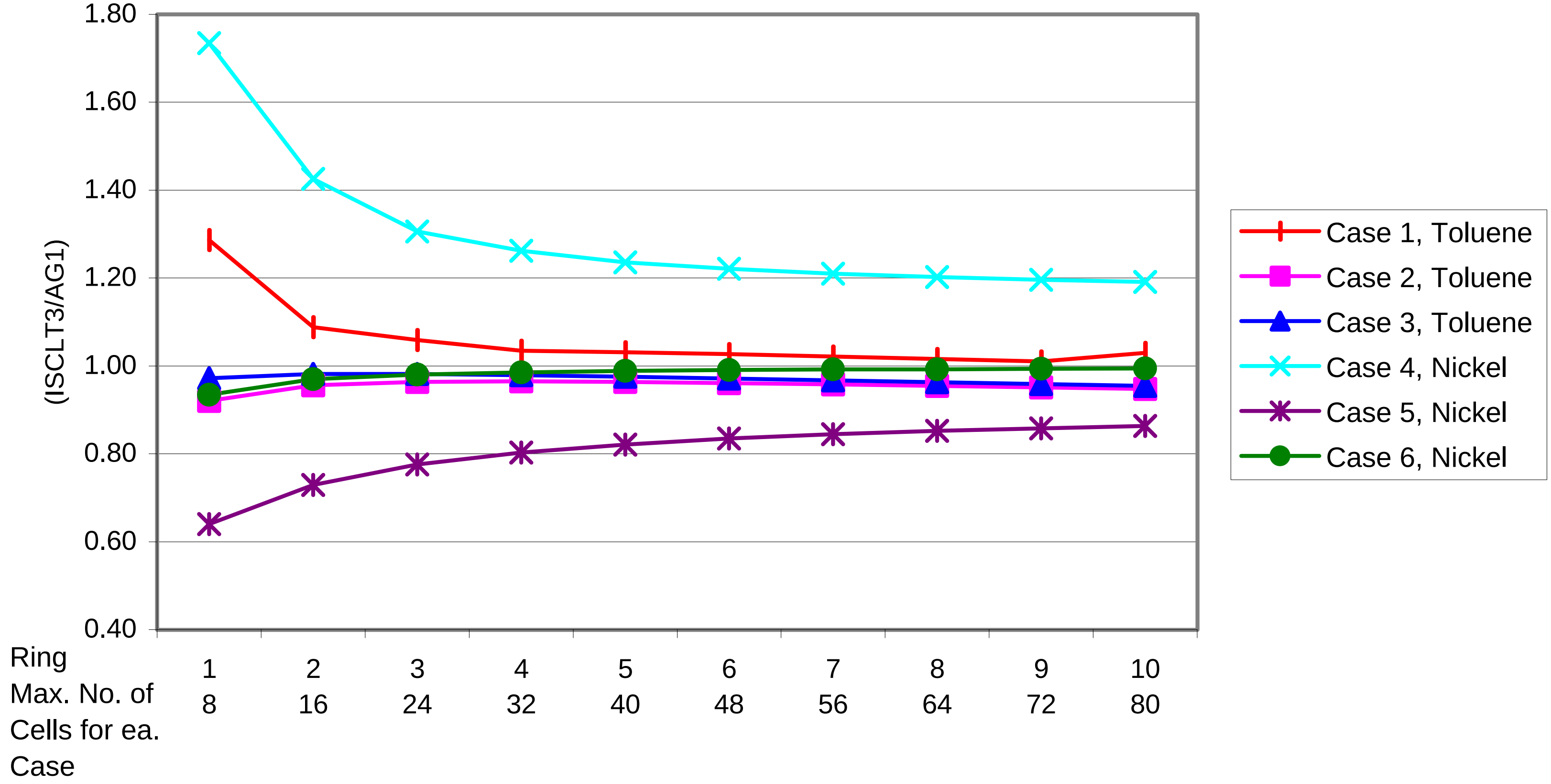


FIGURE 19
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Buffalo
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells for ea. Case
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Nickel
Case 5, Nickel
Case 6, Nickel

FIGURE 20
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Rochester
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity



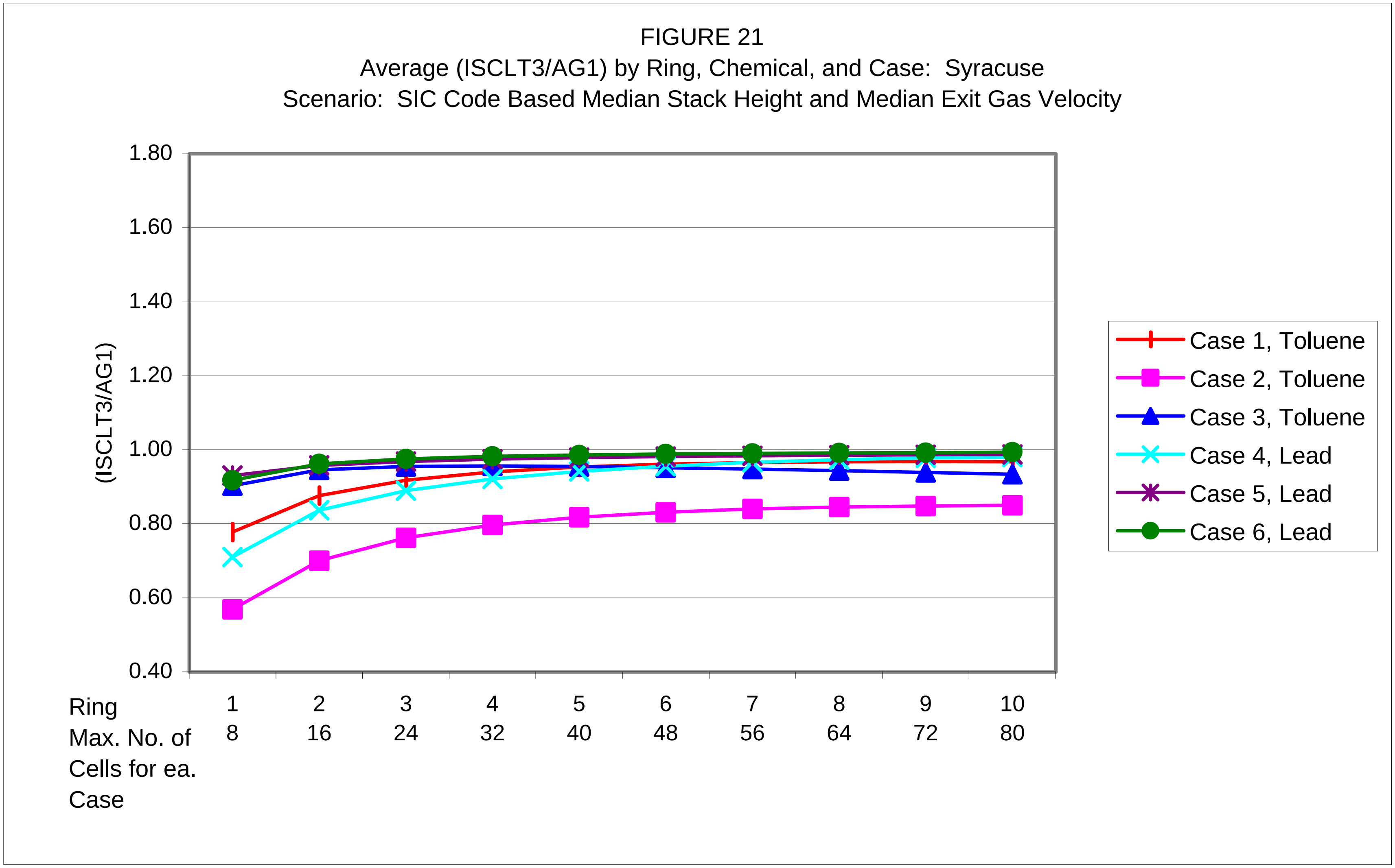
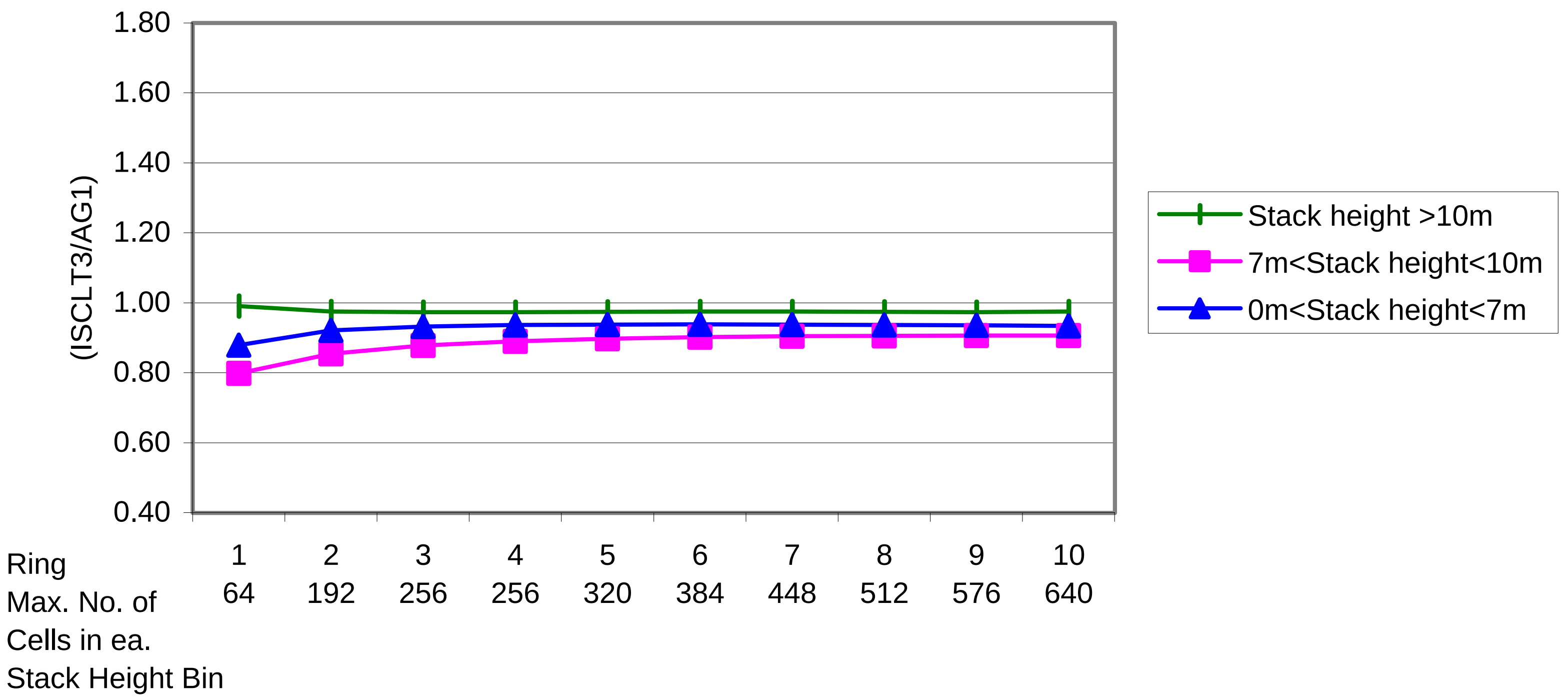


FIGURE 21
Average (ISCLT3/AG1) by Ring, Chemical, and Case: Syracuse
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells for ea. Case
1 2 3 4 5 6 7 8 9 10
8 16 24 32 40 48 56 64 72 80
Case 1, Toluene
Case 2, Toluene
Case 3, Toluene
Case 4, Lead
Case 5, Lead
Case 6, Lead

FIGURE 22
Average (ISCLT3/AG1) by Ring and Stack Height Bin
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity



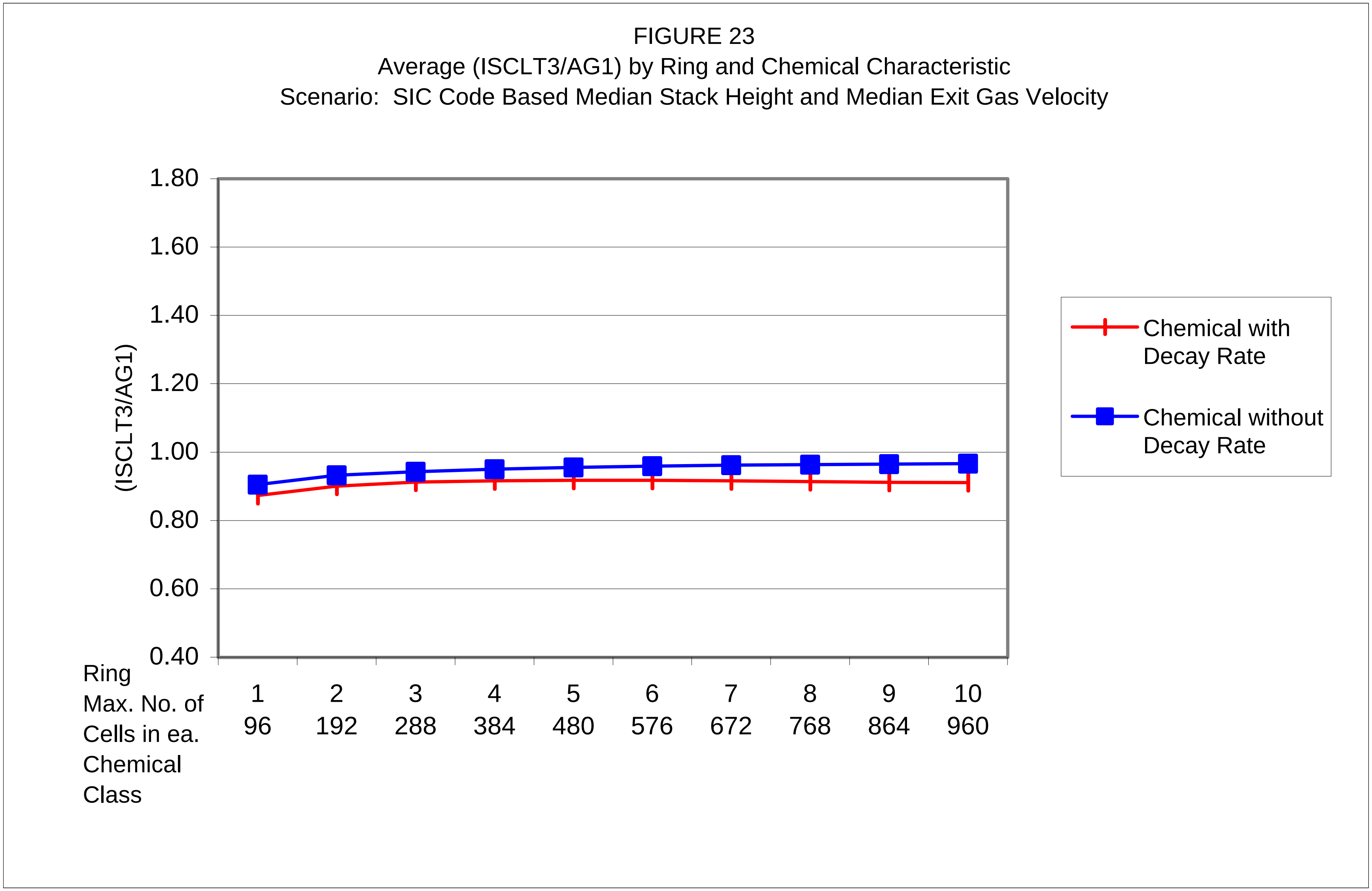
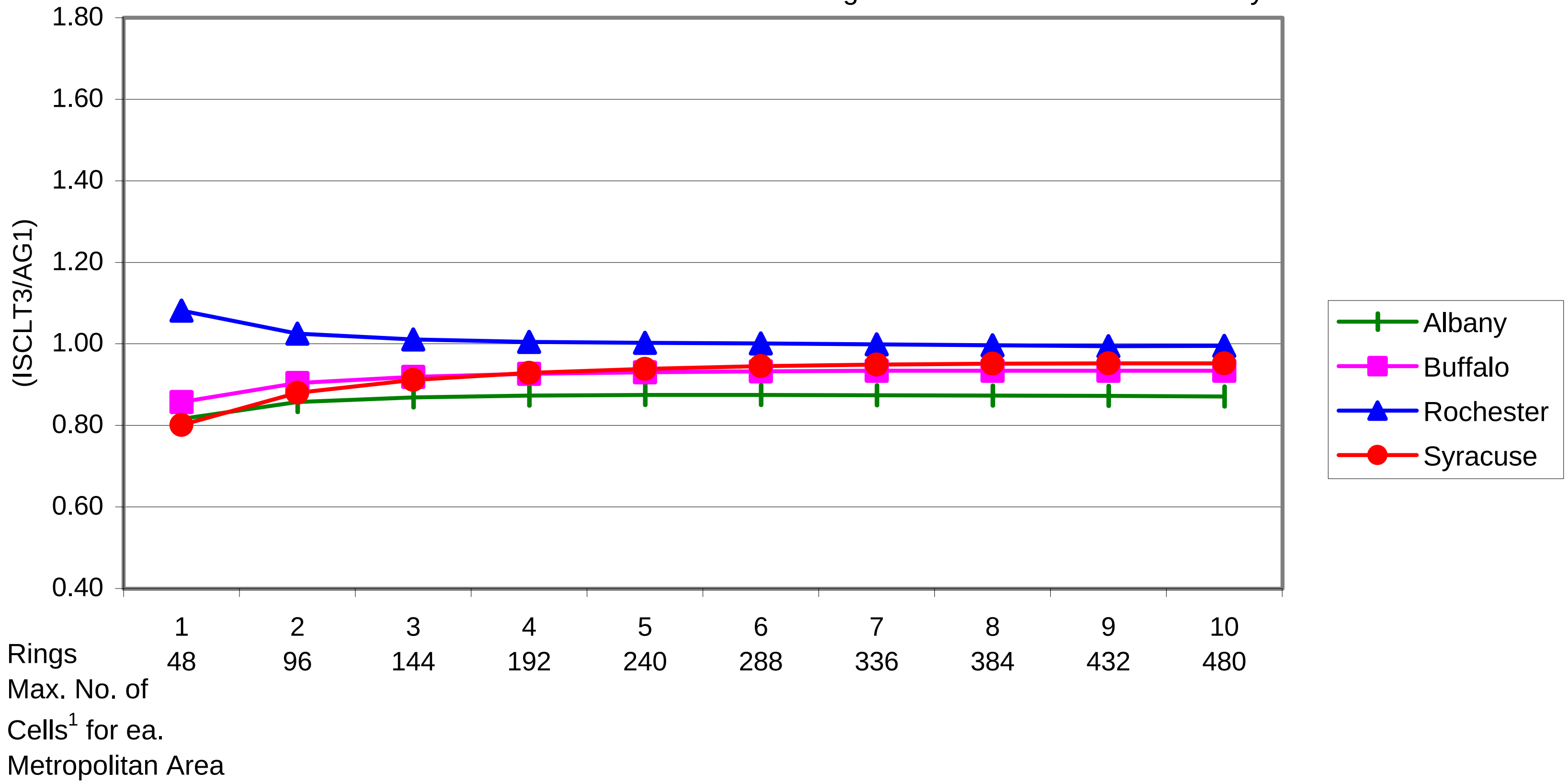


FIGURE 23
Average (ISCLT3/AG1) by Ring and Chemical Characteristic
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity
(ISCLT3/AG1)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
Ring
Max. No. of Cells in ea. Chemical Class
1 2 3 4 5 6 7 8 9 10
96 192 288 384 480 576 672 768 864 960
Chemical with Decay Rate
Chemical without Decay Rate

FIGURE 24
Average (ISCLT3/AG1) by Ring and Metropolitan Area
Scenario: SIC Code Based Median Stack Height and Median Exit Gas Velocity



[1] See Table 15 for actual number of cells per ring in each metropolitan area

FIGURE 25
Difference in Median Stack Height
(SIC Code Based Stack Height Minus Facility-Specific Stack Height)

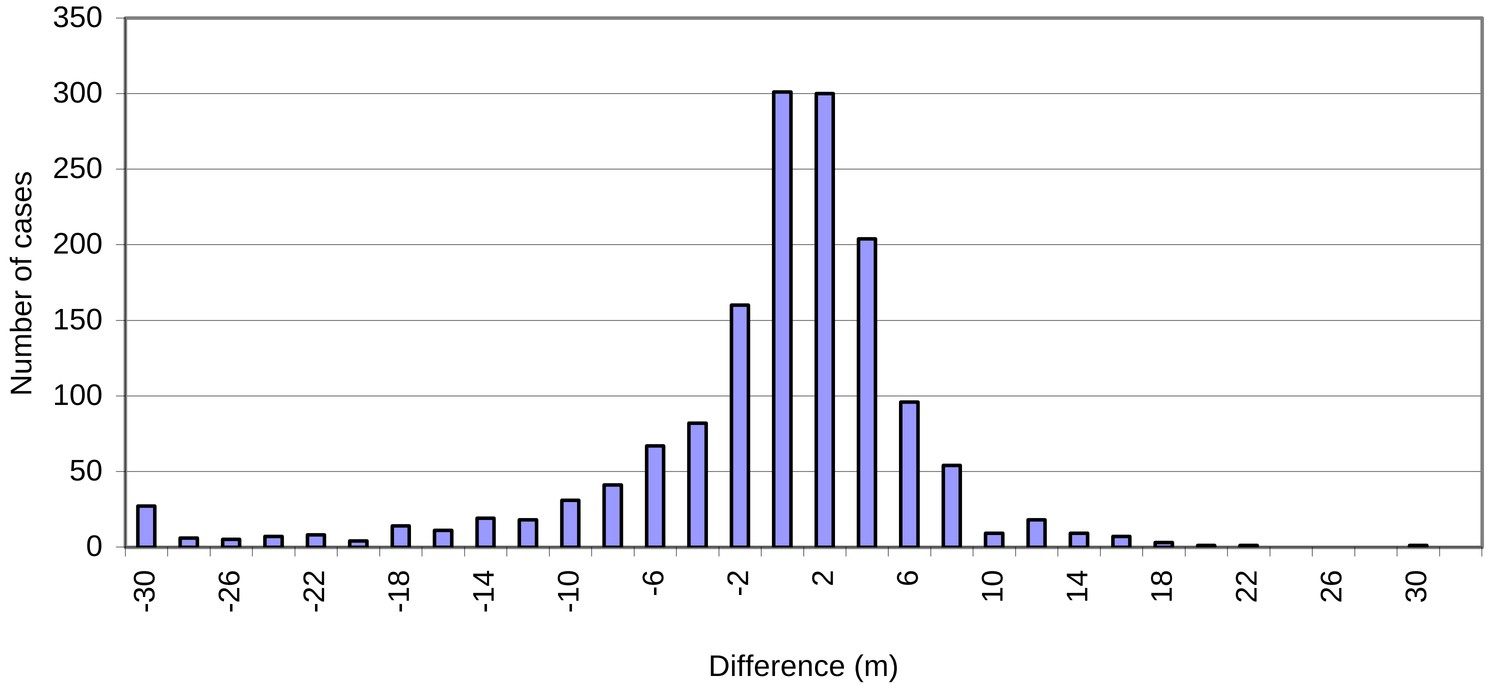


FIGURE 26
Difference in Median Exit Gas Velocity
(SIC Code Based Exit Gas Velocity Minus Facility-Specific Exit Gas Velocity)

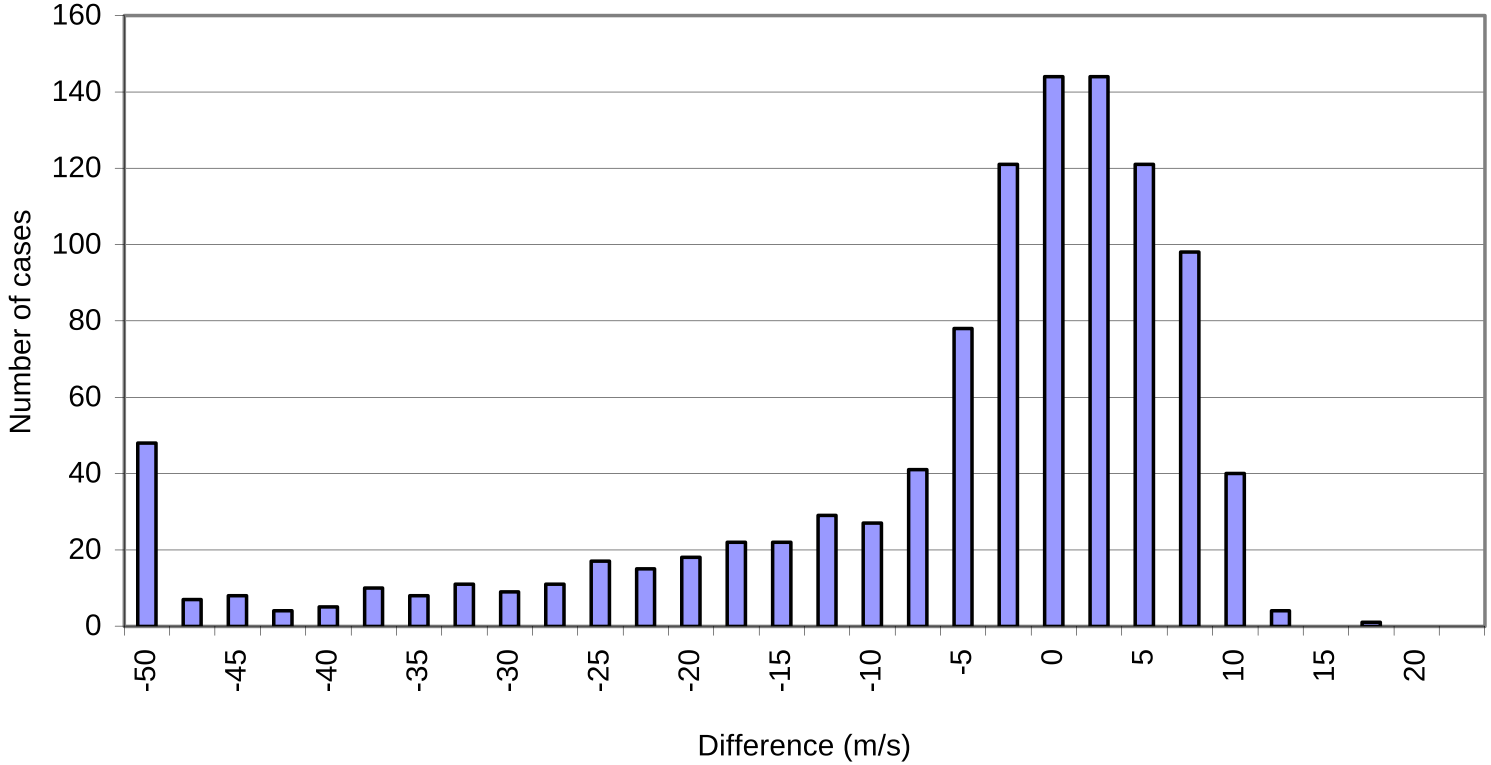
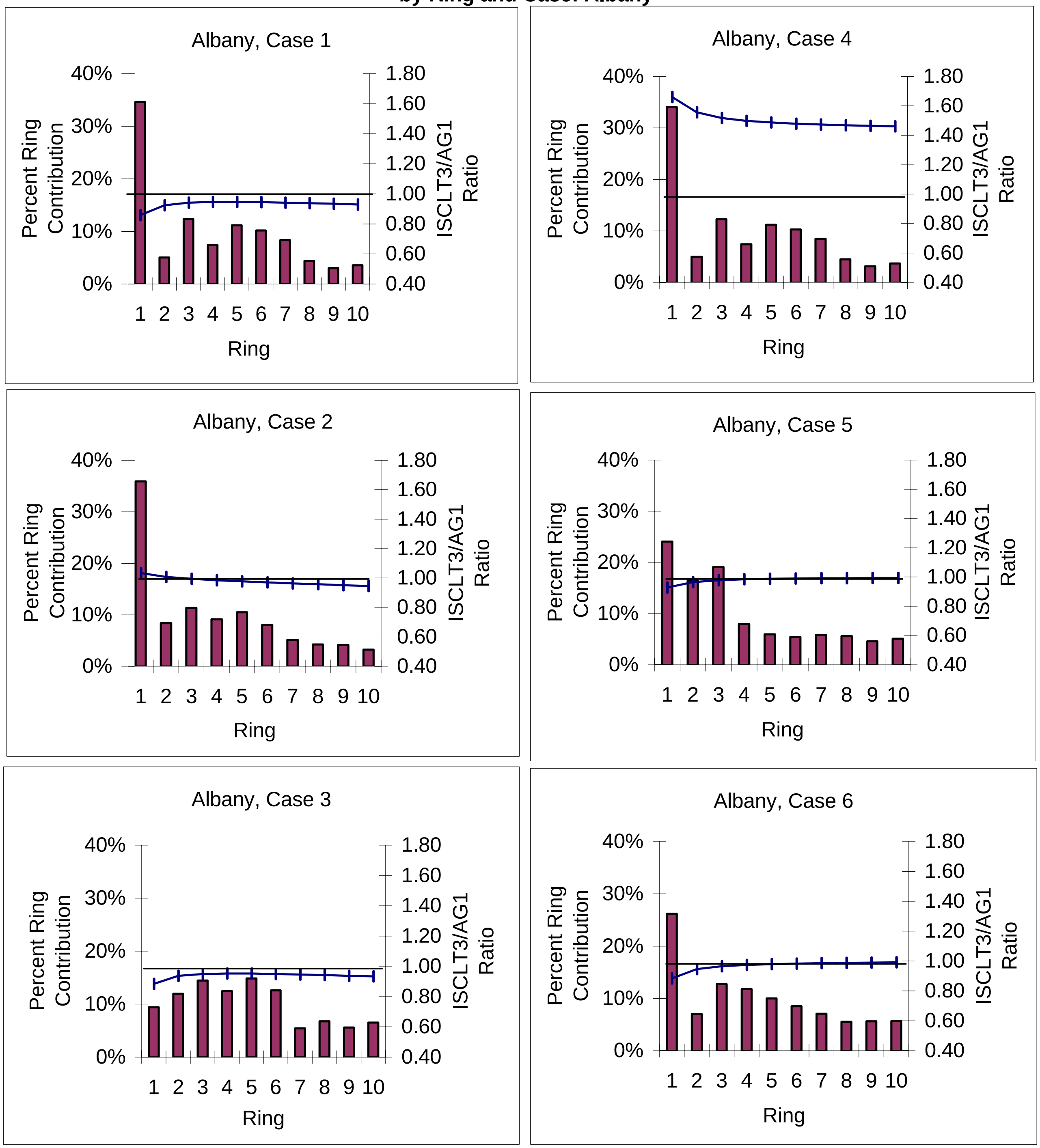


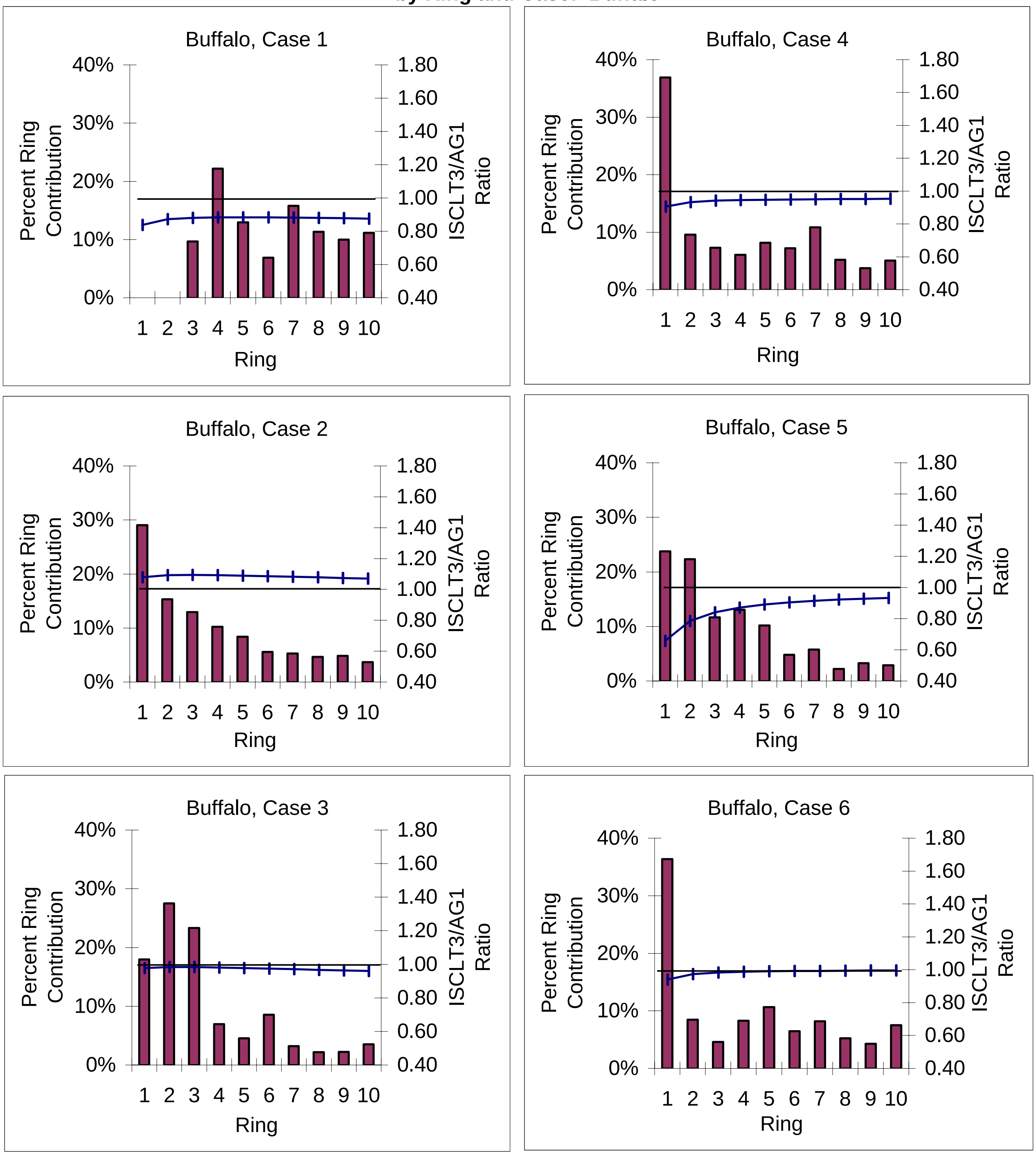
FIGURE 27
Indicator Sub-element[1] Contributions and Concentration Ratios (ISCLT3/AG1)[2] by Ring and Case: Albany



[1]Indicator Sub-elements (percent) shown as histogram and can be read on the left vertical axis. Indicator Sub-elements are the product of pollutant concentration and population in each cell, summed over all cells in a ring. They reflect percent contribution to Indicator Elements by ring (e.g., for case 1, ring 1 contributes 35% to the Indicator Element and ring 10 contributes 4%).
[2]Concentration ratios (ISCLT3/AG1) are shown as a line and can be read on the right vertical axis (e.g., for case 1, ring 1, the ratio is 0.86 and for ring 10, the ratio is 0.93).

FIGURE 28

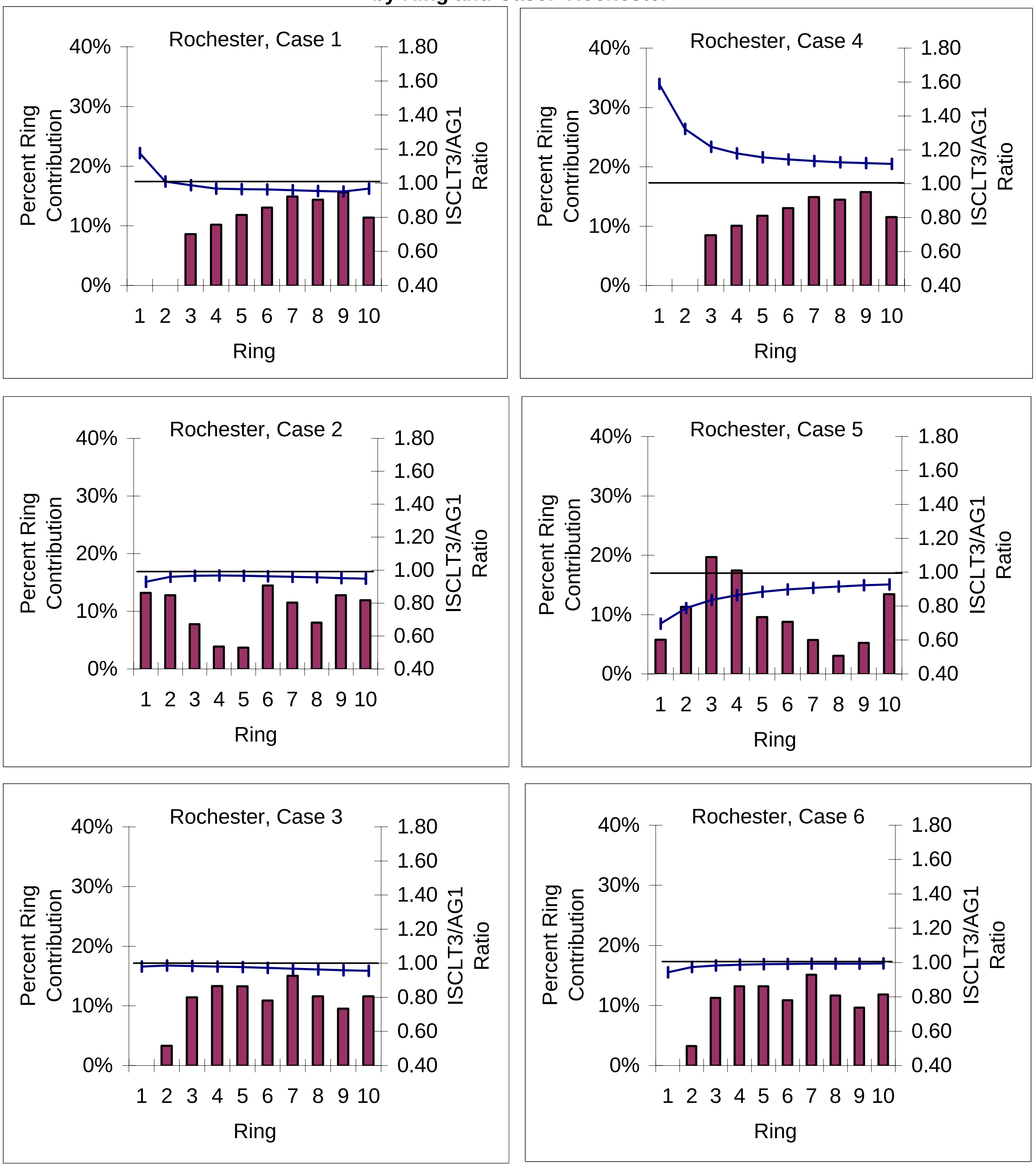
Indicator Sub-element[1] Contributions and Concentration Ratios (ISCLT3/AG1)[2] by Ring and Case: Buffalo



[1]Indicator Sub-elements (percent) shown as histogram and can be read on the left vertical axis. Indicator Sub-elements are the product of pollutant concentration and population in each cell, summed over all cells in a ring. They reflect percent contribution to Indicator Elements by ring (e.g., for case 1, ring 1 contributes 35% to the Indicator Element and ring 10 contributes 4%).

[2]Concentration ratios (ISCLT3/AG1) are shown as a line and can be read on the right vertical axis (e.g., for case 1, ring 1, the ratio is 0.84, and for ring 10, the ratio is 0.88).

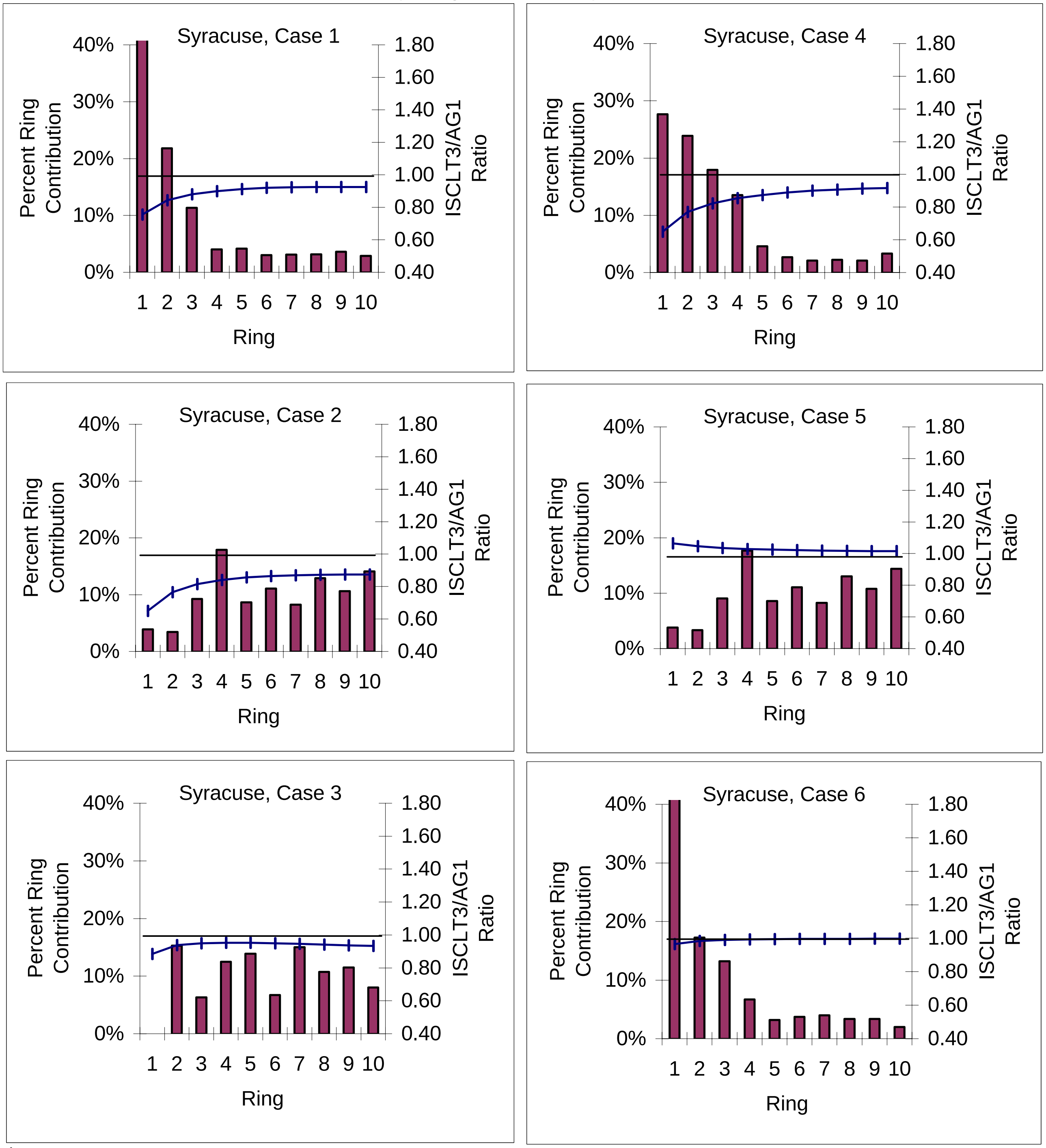
FIGURE 29
Indicator Sub-element[1] Contributions and Concentration Ratios (ISCLT3/AG1)[2] by Ring and Case: Rochester



[1]Indicator Sub-elements (percent) shown as histogram and can be read on the left vertical axis. Indicator Sub-elements are the product of pollutant concentration and population in each cell, summed over all cells in a ring. They reflect percent contribution to Indicator Elements by ring (e.g., for case 1, ring 1 contributes 35% to the Indicator Element and ring 10 contributes 4%).

[2]Concentration ratios (ISCLT3/AG1) are shown as a line and can be read on the right vertical axis (e.g., for case 1, ring 1, the ratio is 1.18, and for ring 10, the ratio is 0.97).

FIGURE 30
Indicator Sub-element[1] Contributions and Concentration Ratios (ISCLT3/AG1)[2] by Ring and Case: Syracuse



[1]Indicator Sub-elements (percent) shown as histogram and can be read on the left vertical axis. Indicator Sub-elements are the product of pollutant concentration and population in each cell, summed over all cells in a ring. They reflect percent contribution to Indicator Elements by ring (e.g., for case 1, ring 1 contributes 35% to the Indicator Element and ring 10 contributes 4%).

[2]Concentration ratios (ISCLT3/AG1) are shown as a line and can be read on the right vertical axis (e.g., for case 1, ring 1, the ration is 0.76, and for ring 10, the ratio is 0.92).

Part B.

Other Supporting Air Modeling Analyses

Table of Contents

1. Introduction

During the development of Version 2.0 of the Risk-Screening Environmental Indicators model, several analyses were performed to determine the most important modifications to be made to the air modeling methodology. The analyses were designed to address several fundamental questions:

- How large an area around the facility should be modeled? RSEI Version 1.x calculated concentrations for a 21 kilometer by 21 kilometer square surrounding each facility. The new analyses focus on determining if extending the maximum distance at which concentrations are calculated is warranted. The analyses varied model inputs such as meteorology, stack parameters, chemical toxicity, and chemical decay rates.

- How fine must the resolution of the grid cells be to adequately model concentrations near the facility? In RSEI Version 1.x, the calculated concentration nearest the facility was at 500 meters, and then additional concentration were calculated every 1000 meters. The new analyses examined the calculated concentrations beginning at 50 meters from the facility and at 50 meter increments. The analyses varied model inputs such as stack height and meteorology.

- How should concentration in the center cell where the facility is located be determined? RSEI Version 1.x assigned the highest concentration of the eight surrounding cells to the center cell. The new analyses examined whether this method was underestimating chemical concentrations close to the facility. The analyses varied model inputs such as stack height and meteorology.

The RSEI model utilizes algorithms from the Industrial Source Complex Long Term (ISCLT3) model developed by the Office of Air Quality Planning and Standards(OAQPS). ISCLT3 is a steady-state Gaussian plume model used to estimate long-term pollutant concentrations downwind of a stack or area source. The concentration in air is a function of facility-specific parameters, meteorology, and chemical specific first-order decay rates.

All of the analyses used the stand-alone version of ISCLT3. Meteorological inputs to ISCLT3 consist of Stability Array (STAR) data and average mixing height data. STAR data are normalized frequency distributions of wind speed and direction by Pasquill-Gifford stability category. To simplify analysis of model results, synthetic STAR data sets were created for each Pasquill-Gifford stability category, in which wind direction is held constant and wind speeds are evenly distributed across all wind speed categories. A synthetic mixing height file was created based on values recommended in the ISCLT3 user guide. Stack tip downwash and building downwash were not considered, nor were terrain effects, and wet or dry deposition. The model uses default wind speed profile exponents and default vertical temperature gradients.

Other assumptions are listed in the following discussion for each analysis.

2. Determination of Optimal Modeling Distance

These three analyses focus on determining if extending the maximum distance at which concentrations are calculated is warranted. RSEI Version 1.x calculates concentrations at the center of 1km by 1km cells in an area of 21 kilometers by 21 kilometers surrounding the facility. Results from the new analyses suggests that using a larger grid (51 kilometers by 51 kilometers) is advisable. The sections below describe each analysis performed, beginning with a summary of results and followed by a description the methodology for the analysis and any assumptions made. Supporting graphs and tables can be found at the end of each section.

2.1 Effect of Stack Parameters

For this analysis, stack heights ranged from 10 to 200 meters and exit gas velocities ranged from four to 200 meters per second. According to 1997 TRI data, TRI reporting facilities had exit gas velocities ranging from 0.01 to 300 meters per second, and stack heights ranging from 0.3 to 206 meters. These values include facilities from the new SIC codes required to report to TRI in 1998[5], most notably electric utilities which have substantially taller stacks on average than manufacturing facilities.

Results of the ISCLT3 model using these ranges of values for exit gas velocity and stack height suggest that:

- an **increase in stack height** lowered the maximum value for chemical concentration in air;
- the maximum concentration for **short stacks** (10 meters) occurred within two kilometers from the stack source for both stable and unstable atmospheric conditions; and
- distance to the maximum concentration for **tall stacks** ($\geq$ 50 meters) depends strongly on atmospheric stability. Distances ranged from less than 2 kilometers for unstable atmospheric conditions and greater than 10 kilometers under highly stable conditions. The greatest distance to maximum concentration observed for stack heights modeled was 49 kilometers. This occurred for a 200 meter stack under the most stable atmospheric conditions tested.

These and other more detailed observations are described below.

[5] EPA added the new industries through a rule promulgated in May 1997, effective for the 1998 reporting year.

2.1.1 General Model Assumptions

The equilibrium concentration of a non-decaying chemical released from a point source was modeled at radial distances varying from 0 to 50 kilometers at 1 kilometer intervals, assuming a stack located in a rural area.

The analyses assume an emission rate of 100 grams per second (g/s). Concentrations for other emission rates can be easily calculated from these results. For example, concentrations associated with 500 g/s emission rate are obtained by multiplying concentrations associated with the 100 g/s emission rate by 5.

Receptor locations (at which air concentrations are modeled) are assumed to be at ground level for these analyses.

2.1.2 Stack Height Analysis

Both stack height and atmospheric stability were varied for this analysis. Pasquill-Gifford stability category A corresponds to highly unstable atmospheric conditions. Category D refers to neutral conditions and categories E and F reflect increasing atmospheric stability (i.e. inversion conditions).

The maximum value for chemical concentration (among all stacks) occured for short (10 meter) stacks under highly stable atmospheric conditions. The taller the stack, the lower the maximum value for chemical concentration.

The distance to maximum concentration at ground level was approximately 1 kilometer for a 10 meter stack (using a receptor spacing of one kilometer). For 10 meter stacks, the distance to the maximum concentration did not vary with atmospheric stability. For taller stacks (>10 meters), the distance to the maximum concentration increased with increasing atmospheric stability. The greatest distance to maximum concentration, 14 kilometers, occurred for a 100 meter stack under Pasqill-Gifford category F, the most stable atmospheric conditions modeled in this analysis.

2.1.3 Exit Gas Velocity

The results of this analysis indicated that an increase in exit velocity causes a corresponding decrease in the maximum ground-level concentration under neutral and stable atmospheric conditions (Pasqill-Gifford categories D, E and F). Under unstable atmospheric conditions (Pasqill-Gifford categories A, B and C), changing the exit gas velocity caused little or no change to the maximum ground-level concentration.

The distance from the source at which the maximum concentration occurs for a 10 meter stack is nearly constant across atmospheric all stability categories. This distance is approximately 1 km using our current receptor spacing of 1 kilometer.[6]

2.2 Effect of Chemical Level of Concern

This analysis examined air releases of the top twenty carcinogenic and non-carcinogenic chemicals, based on toxicity. For carcinogenic chemicals, the basis for selection was unit risk; and for non-carcinogenic chemicals it was the reference concentration. However, only 15 of the 20 carcinogens were reported to TRI in 1997, and only 19 of the twenty non-carcinogens were reported to TRI in 1997. Thus the air modeling was conducted for the 34 chemicals for which unit risk values and reference concentrations were available For each of these 34 pollutants, we used the maximum reported volume of release from any one facility reported to the 1997 TRI to estimate an emission rate for that chemical. Tables 1 and 2 display the selected chemicals, the maximum reported 1997 TRI air release for each chemical by any facility, the estimated emission rate, and either the reference concentration (RfC) or unit risk value.

2.2.1 Modeling Air Concentration

ISCLT3 was used to determine steady state ground-level air concentrations for each of these chemicals at distances ranging from 1,000 to 50,000 meters (at 1,000 meter increments). For each chemical, maximum estimated emission rates in grams per second were used[7].

Three different stack heights were modeled (10, 50, and 100 meters). These values are within the range of stack heights reported by facilities to TRI in 1997 (0.3 to 206 meters). To simplify analysis of results, a single stack diameter (1 meter) was used; this corresponds to the default value used by RSEI Version 1.x.[8] Furthermore, this analysis also used a single exit gas velocity of 4 meters per second (m/s). The 1997 TRI facilities have exit gas velocities ranging from 0.01 to 300 m/s. Lower exit gas velocities typically result in higher concentrations near the stack (see Figure 1). The analysis assumed neutral atmospheric stability conditions (category D of the Pasquill-Gifford stability classification), a reasonable assumption for average meteorological conditions over the course of a year. Terrain effects were not considered, and all chemicals were considered non-decaying for this analysis.

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[6]Note that the maximum concentration may actually occur at a location other than 1kilometer. Finer resolution (decreasing the spacing in the receptor network will provide more accuracy in determining the location of the ground-level maximum concentration).

[7]Based on the maximum reported 1997 annual air emissions assuming constant and uniform emissions.

[8]The range of diameters is 0.003 to 23 meters, with a median of 0.6 meters; note that the 95th percentile is 1.7 meters.

2.2.2 Calculating the Level of Concern

For carcinogenic chemicals, values for unit risk were used. These unit risks are expressed as risk per unit exposure in milligrams per cubic meter (mg/m^3). From each unit risk value, a concentration associated with a particular risk level was calculated. For example, for beryllium, with a unit risk of 2.4 per mg/m^3, for a risk level of 10^{-4} (that is, 1 cancer case per 10,000 persons exposed over a lifetime), the corresponding concentration of concern is equal to ($10^{-4}/2.4$) or 4.2×10^{-5} mg/m^3. Obviously the concentration resulting from TRI emissions does not need to be very high to exceed this level of concern.

This analysis considered the concentrations associated with two levels of risk: 10^{-4} and 10^{-6} (1 cancer case per 1,000,000 persons exposed over a lifetime). ISCLT3 modeled concentrations for a chemical were then compared to the concentrations associated with these two levels of risk. The distances at which modeled concentrations fell below the concentrations associated with the two levels of risk were noted.

For non-carcinogenic chemicals, the chronic reference concentration was used for comparison to ISCLT3 modeled concentrations. We then noted the distance at which modeled concentrations fell below the RfC.

2.2.4 Results

The results of the analysis are summarized in Tables 1 and 2 for the selected carcinogenic and non-carcinogenic chemicals.

Carcinogenic Chemicals

- Fifteen of the top twenty TRI-reportable carcinogenic chemicals (by unit risk) reported air emissions in 1997.
- Of these fifteen, only four reached concentrations below the 10^{-6} level of risk within 50 kilometers from the release height for all stack heights modeled.
- Nine of the fifteen chemicals reached concentrations below the 10^{-4} level of risk within the 50 kilometers; while the remaining 6 chemicals exceeded the 10^{-4} level of risk over the entire modeled distance.

Non-Carcinogenic Chemicals

- Nineteen of the top twenty TRI-reportable non-carcinogenic chemicals (by unit risk) reported air emissions in 1997.
- Of these nineteen, only the concentration of chromium remained above the RfC for that chemical for the entire range of distances modeled. All other chemicals fell below their RfC's within fifty kilometers.

These results suggest that there are circumstances were the most toxic TRI chemicals will not fall below levels of concern even within the 50 kilometers. Of course there are also many circumstances (chemicals with lower toxicity, lower emissions rates, etc.) where the levels will fall below the level of concern before 50 kilometers. The circumstances will be very specific; that is, the distance will depend on the combination of toxicity, release volume, and stack conditions. In principle the computer algorithm could be programmed to identify these conditions and to apply a variable distance to each chemical for each facility. However, this is likely to add significant computing issues. It will also require science policy decisions regarding the selection of "levels of concern," especially for those TRI chemicals with "derived" or extrapolated toxicity weights. Finally, given that this analysis found concentrations of concern even at 50 kilometers, for a number of carcinogens under a range of stack height conditions, it may be prudent simply to model all chemicals to the 50 kilometer distance for all facilities.

Exhibit 1.
Top 20 Carcinogenic TRI-Reportable Chemicals by Unit Risk

						Atmospheric Stability Category "D" (average conditions)					
						10m stack		50m stack		100m stack	
Chemical Name	CAS Number	1997 TRI Reported Release (lbs/yr)	Average Equivalent Release (g/s)	Year Released	Unit Risk Inhale (mg/m^3)	Distance (m) at which risk $<10^{-4}$	Distance (m) at which risk $<10^{-6}$	Distance (m) at which risk $<10^{-4}$	Distance (m) at which risk $<10^{-6}$	Distance (m) at which risk $<10^{-4}$	Distance (m) at which risk $<10^{-6}$
Benzidine	92875	250	0.003595	1994	67	10000	>50000	9000	>50000	6000	>50000
Chloromethyl methyl ether	107302	2076	0.02985288	1997	63	38000	>50000	32000	>50000	28000	>50000
Bis(chloromethyl) ether	542881	3	0.00004	1997	62	0	9000	0	8,000	0	7000
N-Nitrosodiethylamine	55185	0	0	1997	43	-	-	-	-	-	-
N-Nitrosodimethylamine	62759	0	0	1997	14	-	-	-	-	-	-
Chromium compounds	N090	60000	0.8628	1997	12	>50000	>50000	>50000	>50000	>50000	>50000
Chromium	7440473	272450	3.917831	1997	12	>50000	>50000	>50000	>50000	>50000	>50000
Hydrazine	302012	1466	0.02108108	1997	4.9		>50000	5000	>50000	0	>50000
Aldrin	30.9002	0	0	1997	4.9	-	-	-	-	-	-
Hydrazine sulfate	10034932	0	0	1997	4.9	-	-	-	-	-	-
Cobalt compounds	N096	5485	0.0788743	1997	4.8	14000	>50000	11000	>50000	9000	>50000
Cobalt	7440484	2800	0.040264	1997	4.8	9000	>50000	7000	>50000	5000	>50000
Arsenic compounds	N020	65900	0.947642	1997	4.3	>50000	>50000	>50000	>50000	>50000	>50000
Arsenic	7440382	37767	0.54308946	1997	4.3	43000	>50000	37000	>50000	33000	>50000
1,4-Dichloro-2-butene	764410	2400	0.034512	1997	2.6	6000	>50000	4000	>50000	0	>50000
Beryllium compounds	N050	250	0.003595	1997	2.4	0	23000	0	19000	0	17000
Beryllium	7440417	720	0.0103536	1997	2.4	3000	45000	0	38000	0	34000
alpha-Hexachlorocyclohexane	31.9846	0	0	1997	1.8	-	-	-	-	-	-
Cadmium	7440439	468	0.0067298	1997	1.8	2000	28000	0	24000	0	21000
Cadmium compounds	N078	16434	0.23632092	1997	1.8		>50000	12000	>50000	10000	>50000

Units: mg/m^3 = milligrams per cubic meter
g/s = grams per second
lbs/yr = pounds per year
m = meter

Exhibit 2.
Top 20 Non-Carcinogenic TRI-Reportable Chemicals by Reference Concentration

						Atmospheric Stability Category "D" (average conditions)		
						10m stack	50m stack	100m stack
Chemical Name	CAS Number	1997 TRI Reported Release (lbs/yr)	Average Equivalent Release (g/s)	Year Released	RfC Inhale (mg/m^3)	Distance (m) when Concentration falls below RfC	Distance (m) when Concentration falls below RfC	Distance (m) when Concentration falls below RfC
Titanium tetrachloride	7550450	3000	0.04314	1997	0.000018	10,000	9,000	6,000
Cobalt	7440484	2800	0.040264	1997	0.00002	9,000	8,000	5,000
Acrolein	107028	36000	0.51768	1997	0.00002	7,000	6,000	6,000
Cobalt compounds	96	5485	0.0788743	1997	0.00002	14,000	12,000	9,000
2-Chloroacetophenone	532274	250	0.003595	1987	0.00003	2,000	>0	>0
Manganese compounds	450	121000	1.73998	1997	0.00005	21,000	19,000	18,000
Manganese	7439965	66522	0.95658636	1997	0.00005	38,000	32,000	29,000
Toluene diisocyanate (mixed isomers)	26471625	10419	0.14982522	1997	0.00007	10,000	8,000	5,000
Toluene-2,4-diisocyanate	584849	292	0.004199	1997	0.00007	>0	>0	>0
Toluene-2,6-diisocyanate	91087	314	0.004515	1997	0.00007	2,000	>0	>0
Chromium	7440473	272450	3.917831	1997	0.0001	>50,000	>50,000	47,000
Chromium compounds	90	60000	0.8628	1997	0.0001	23,000	19,000	17,000
Diethanolamine	111422	18300	0.263154	1997	0.0001	11,000	9,000	7,000
o-Anisidine	90040	63	0.00091	1997	0.0002	0	0	0
Chlorine dioxide	10049044	154570	2.2227166	1997	0.0002	27,000	23,000	20,000
Dicyclopentadiene	77736	71000	1.02098	1997	0.0002	17,000	14,000	11,000
Methyl isocyanate	624839	327	0.004702	1997	0.0002	0	0	0
1,2-Dibromo-3-chloropropane (DBCP)	96128	0	0	1991	0.0002	-	-	-
Molybdenum trioxide	1313275	8622	0.12398436	1997	0.00024	4,000	3,000	>0
Mercury	7439976	1204	0.0173135	1997	0.0003	>0	>0	>0

Units: mg/m^3 = milligrams per cubic meter
g/s = grams per second
lbs/yr = pounds per year
m = meter

2.3 Effect of Chemical Decay Rates

This analysis examined the effect of chemical decay rates on modeled air concentrations.

2.3.1 Modeling Air Concentrations

For this analysis, ISCLT3 was used to determine steady state air concentrations for a unit emission (1gram/second) of a generic decaying chemical at 1,000 meter intervals from 0 to 49,000 meters from the stack. The decay rates used in this analysis (see Exhibit 4) encompass the range of decay rates currently used in the RSEI model (Exhibit 3). For this analysis decay rates ranged from 0 (non-decaying) to 100,000 hr^{-1} (a half- life of 6.9×10^{-6} hours).

The analysis used a stack height of 10 meters. This value approximates the median value of stack heights reported by facilities to TRI in 1997. To further simplify analysis of results, a single stack diameter (1 meter) was used; this corresponds to the default value used by RSEI Version 1.x.[9]

This analysis also used a single exit gas velocity of 4 meters per second (m/sec). The 1997 TRI facilities have exit gas velocities ranging from 0.01 to 300 m/s; it should be noted that lower exit gas velocities result in higher concentrations near the stack. Three atmospheric stability conditions (categories B, D, and F of the Pasquill-Gifford atmospheric stability classification) were considered, corresponding to unstable, neutral, and stable atmospheric conditions. For each of these stability categories, wind speed was assumed to be evenly distributed across all wind speed categories and uniform in direction.

2.3.2 Results

The results of the analysis are summarized in Exhibits 5 through 7. These figures suggest that:

- Modeled concentration for half-lives greater than 50 hours (corresponding to a decay rates less than or equal to 1.39×10^{-2} per hour (hr^{-1}), show no appreciable difference when compared to concentrations for the non-decaying chemical.
- An decrease in half-life (increase in decay rate) results in decreased modeled concentration of the chemical for the same distance.
- Differences between modeled concentrations for the various decay rates were not appreciable at distances greater than 5 kilometers from the source for unstable atmospheres, and 15 kilometers from the source for stable atmospheres.
- The maximum modeled concentrations for half-lives less than 0.01 hours were less than 3 percent of the maximum for the non-decaying chemical.

[9]The range of diameters is 0.003 to 23 meters, with a median of 0.6 m; note that the 95^{th} percentile is 1.7 meters.

Exhibit 3.
Distribution of Chemical Decay Rates for 1997 TRI Facilities

Percentile Rank for Decay Rate	Decay Rate -Air (hr^{-1})	Half-life (hr)
Maximum	1.64	$4.23x10^{-1}$
75 %	$1.25x10^{-1}$	5.6
50 % (Median)	$3.81x10^{-2}$	$1.8x10^{1}$
2 5 %	$4.83x10^{-3}$	$1.43x10^{2}$
Minimum	$3.24x10^{-7}$	$2.14x10^{6}$

Note: hr^{-1} = per hour
hr = hour

Exhibit 4.
Range of Chemical Decay Rates Analyzed

Decay Rate -Air (hr^{-1})	Half-life (hr)
100,000	$6.93x10^{-6}$
10,000	$6.93x10^{-5}$
1,000	$6.93x10^{-4}$
100	$6.93x10^{-3}$
50	$1.39x10^{-2}$
10	$6.93x10^{-2}$
5	$1.39x10^{-1}$
1	$.6.93x10^{-1}$
0.5	1.39
0.1	6.93
0.01	$6.93x10^{1}$
0.001	$6.93x10^{2}$

Note: hr^{-1} = per hour
hr = hour

Exhibit 5.

~~Analysis of Chemical Decay Rate~~

Pasquill Stability Category=B (unstable)

Stack Height = 10 m

Exit Gas Velocity=4m/sec

Stack Diameter=1 m

Emission Rate=1 g/sec

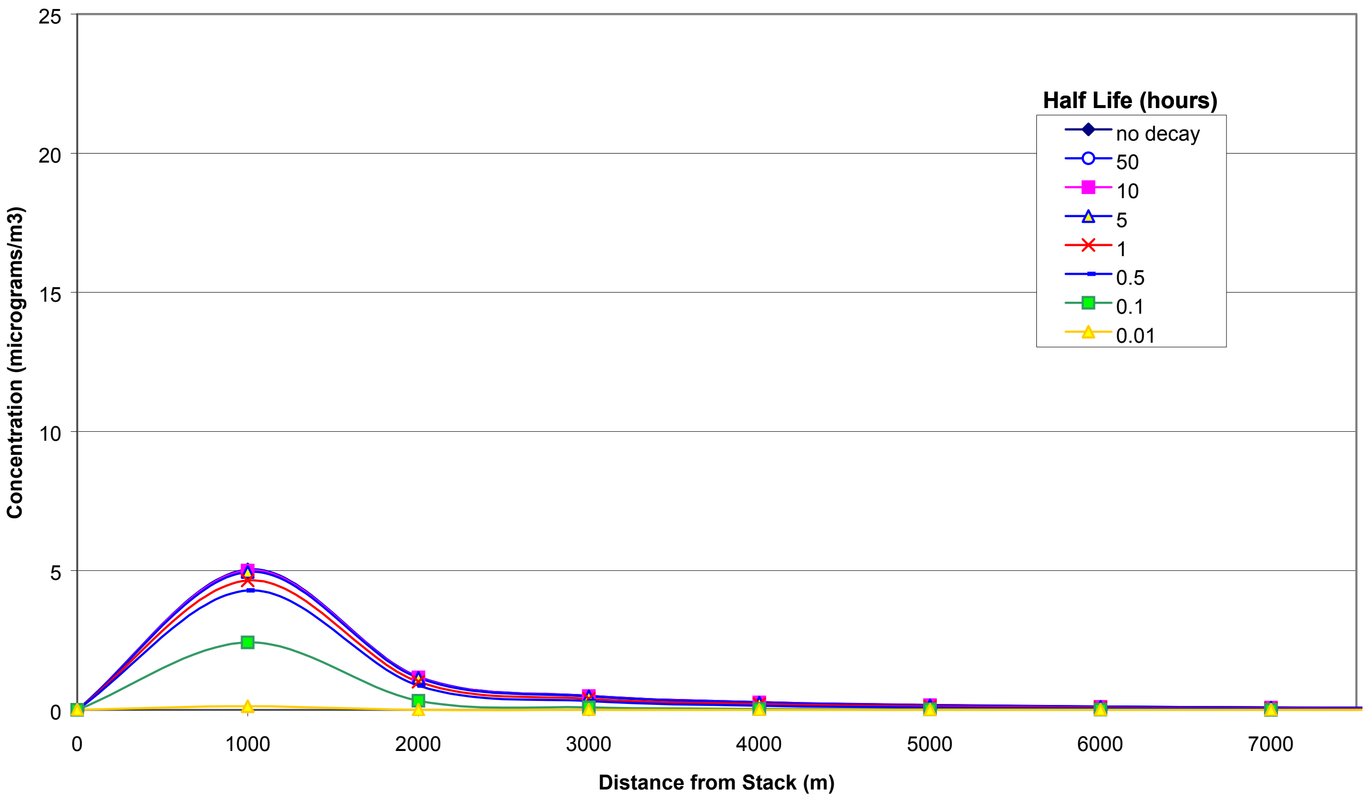


Exhibit 6.
Figure 2

Analysis of Chemical Decay Rate

Pasquill Stability Category=D (Neutral)

Stack Height = 10 m

Exit Gas Velocity=4m/sec

Stack Diameter=1 m

Emission Rate=1 g/sec

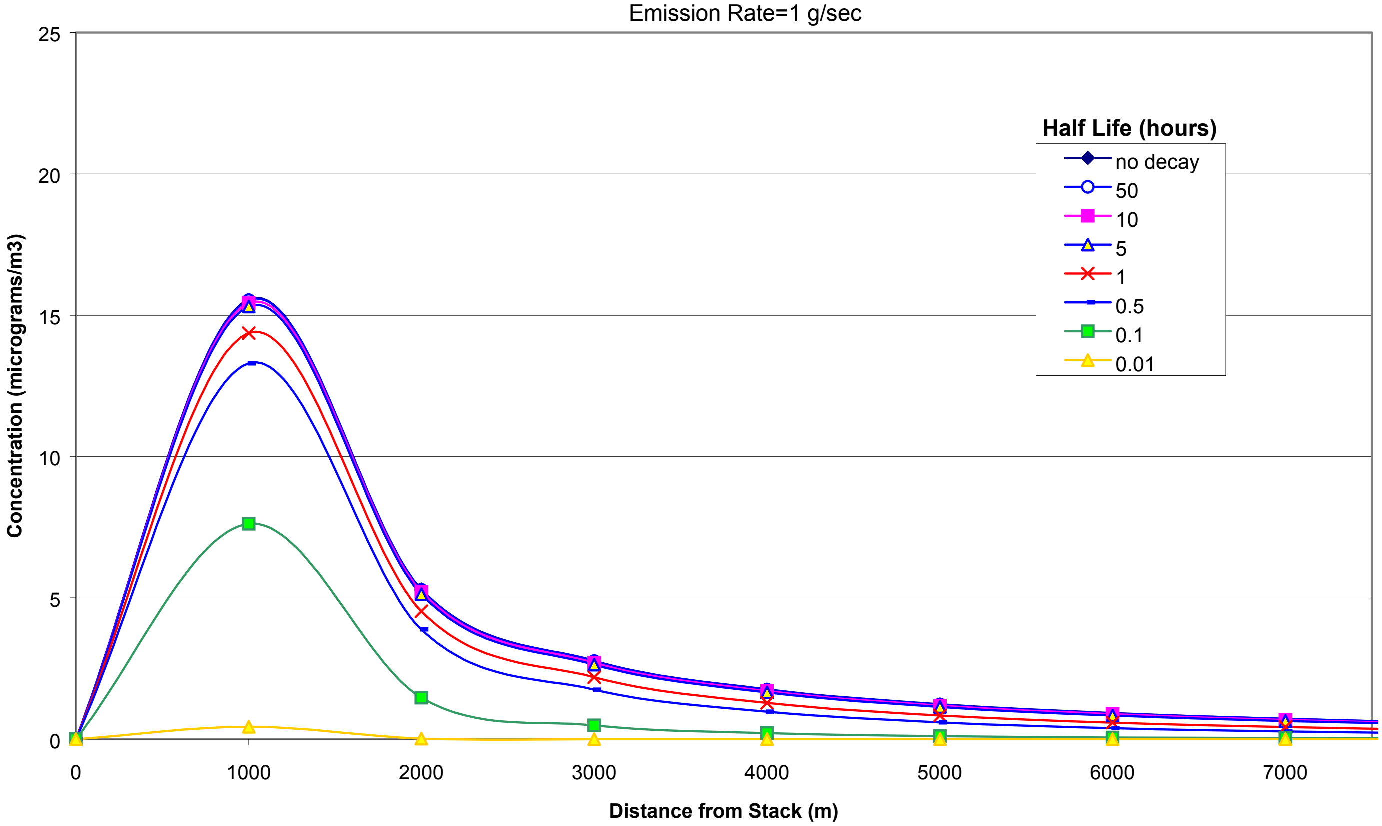
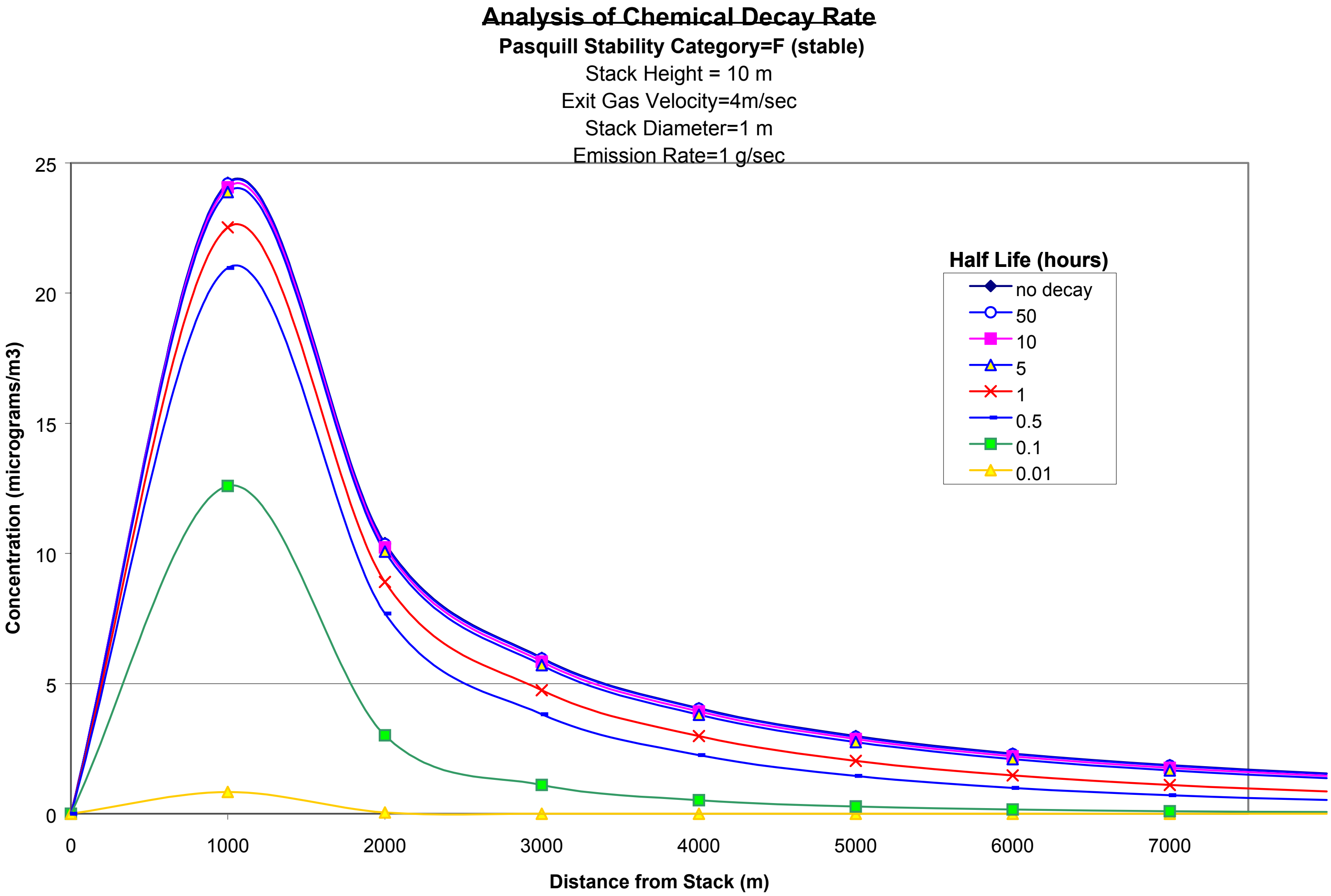


Exhibit 7.



Analysis of Chemical Decay Rate
Pasquill Stability Category=F (stable)
Stack Height = 10 m
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec
Half Life (hours)
no decay
50
10
5
1
0.5
0.1
0.01
Concentration (micrograms/m3)
25
20
15
10
5
0
0
1000
2000
3000
4000
5000
6000
7000
Distance from Stack (m)

3. Determination of Optimal Cell Size and Spacing

The purpose of this analysis is to help determine if the current grid cell size and spacing used in the RSEI model is sufficiently small for accurately modeling concentrations near the pollutant source.

3.1 Background

In the RSEI model, the U.S. is composed of a grid of 1 kilometer by 1 kilometer cells. Each facility is located in a cell of this grid based on its latitude and longitude coordinates (as reported to TRI). Regardless of the actual location of the facility within a particular grid cell, for the purposes of RSEI modeling its location is considered to be the center of that cell. As a result, the facility's reported location may differ from it's designated location in the RSEI model by up to 707 meters (707 meters is calculated as the hypotenuse of an isosceles triangle with both sides of length 500 m).

The ISCLT3 algorithms within the RSEI model are used to estimate the air concentrations in a 21 kilometer by 21 kilometer grid surrounding the cell containing the facility. For each of the 440 cells in this grid, the air concentration for a given chemical is estimated. This estimation is based on the radial distance between the stack[10] and each cell's edge located nearest the stack. For the center cell in which the facility is located, the RSEI model currently assigns the highest air concentration from the eight cells surrounding that cell. As with the other cells in the grid, air concentrations for a given chemical in the eight cells surrounding the center cell are calculated based on the modeled concentration at the edge which is closest to the source. With this methodology, the shortest distance at which chemical concentration is estimated is 500 meters from center of the cell containing the facility.

The analysis described in subsequent sections considers whether this distance is sufficiently small to adequately model instances in which the maximum concentration may occur within this 500 meter distance.

3.2 Methodology

For this analysis, ISCLT3 was used to determine steady state air concentrations for a generic non-decaying chemical at 50 meter intervals from 50 to 1500 meters from the stack. The analysis considered stack heights ranging from 10 to 200 meters. These values approximate the range of stack heights reported by facilities to TRI in 1997 (0.3 to 206 meters). To simplify analysis of

[10]Note: For RSEI modeling, the stack is considered to be at the center of the grid cell where it is located based on its reported latitude and longitude.

results, a single stack diameter (1 meter) was used; this corresponds to the default value used by RSEI version 1.x.[11]

This analysis also used a single exit gas velocity of 4 m/sec. The 1997 TRI facilities have exit gas velocities ranging from 0.01 to 300 meters per second; it should be noted that lower exit gas velocities result in higher concentrations near the stack, thus the 4 m/sec value should be considered a reasonable 'worse case scenario'. A full range of atmospheric stability conditions (categories A through E of the Pasquill-Gifford atmospheric stability classification) were considered. To simplify analysis of results, wind speed was assumed to be evenly distributed across all wind speed categories and uniform in direction.

3.3 Results

The results of the analysis are summarized in Exhibits 9 through 13. These figures indicate that:

- The distance to the modeled maximum concentration increased with increased stack height and atmospheric stability.
- For short stacks (10 meters or less), the distance to maximum concentration was less than or equal to 500 meters regardless of atmospheric stability. For taller stacks (greater than 20 meters), the distance to maximum concentration exceeded 500 meters under neutral and stable conditions.

Exhibit 8 contains some general descriptive statistics for the distribution of stack heights for the 1997 TRI facilities. From this table, it is clear that the 10 meter stack height closely represents the median stack height (9.8 meters) for 1997 facilities. The ISCLT3 modeling results shown in Exhibits 9 through 13 suggest that for all stack heights up to and including the median stack height, the current RSEI grid cell configuration under-represents the maximum concentration in the cell containing the facility.

To illustrate this point, consider the 10 meter stack under neutral conditions of atmospheric stability (Pasquill-Gifford category D). For this stack, the maximum concentration of 88.7 micrograms/cubic meter ($\mu g/m^3$) occurs at a distance of 200 meters from the stack. The closest distance to the stack at which the RSEI model would calculate concentration would be 500 m. At 500 meters, the modeled concentration for the 10 meter stack would be 44 $\mu g/m^3$. The RSEI model would assign a concentration of 44 $\mu g/m^3$ to the cell which contained the facility, under-representing the maximum concentration by half. For highly unstable atmospheres (category A), the effect is more extreme. For the same 10 meter stack height, the RSEI model would assign a concentration of 9.85 $\mu g/m^3$ to the grid cell containing the facility, based on the concentration at 500 meters. However, at a distance of 50 meters, the maximum modeled concentration was roughly 25 times greater (280 $\mu g/m^3$).

[11]The range of diameters is 0.003 to 23 meters, with a median of 0.6 meters; note that the 95th percentile is 1.7 meters.

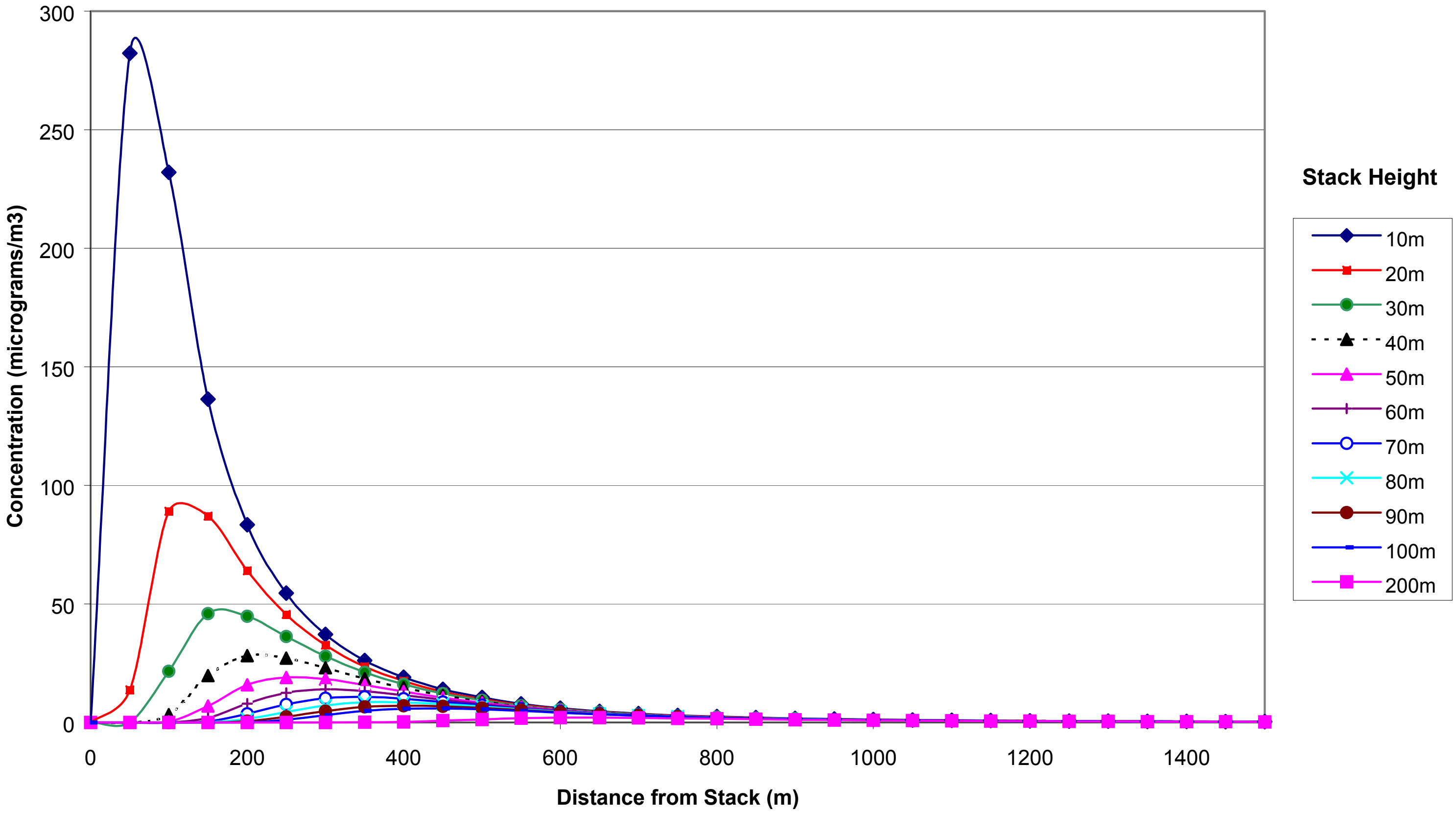
In principle the RSEI model algorithms could be modified to identify circumstances when a smaller grid cell size near those facilities is warranted (i.e. shorter stack heights), and in other cases retain the regular grid cell size. However, our results suggest that it may be prudent to consider utilizing a smaller grid cell size for all facilities for distances up to 1 kilometer and then return to a 1 kilometer by 1 kilometer grid cell size for distances further from the stack.

Exhibit 8.
Distribution of Stack Heights for 1997 TRI Facilities

Percentile Rank	Stack Height (meters)
Maximum	206.7
99 %	36.9
95 %	29.8
75 %	11.9
50 % (Median)	9.8
5 %	7.6
1 %	5.6
Minimum	0.3

Exhibit 9.

Stability Category=A
(highly unstable atmosphere)
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec



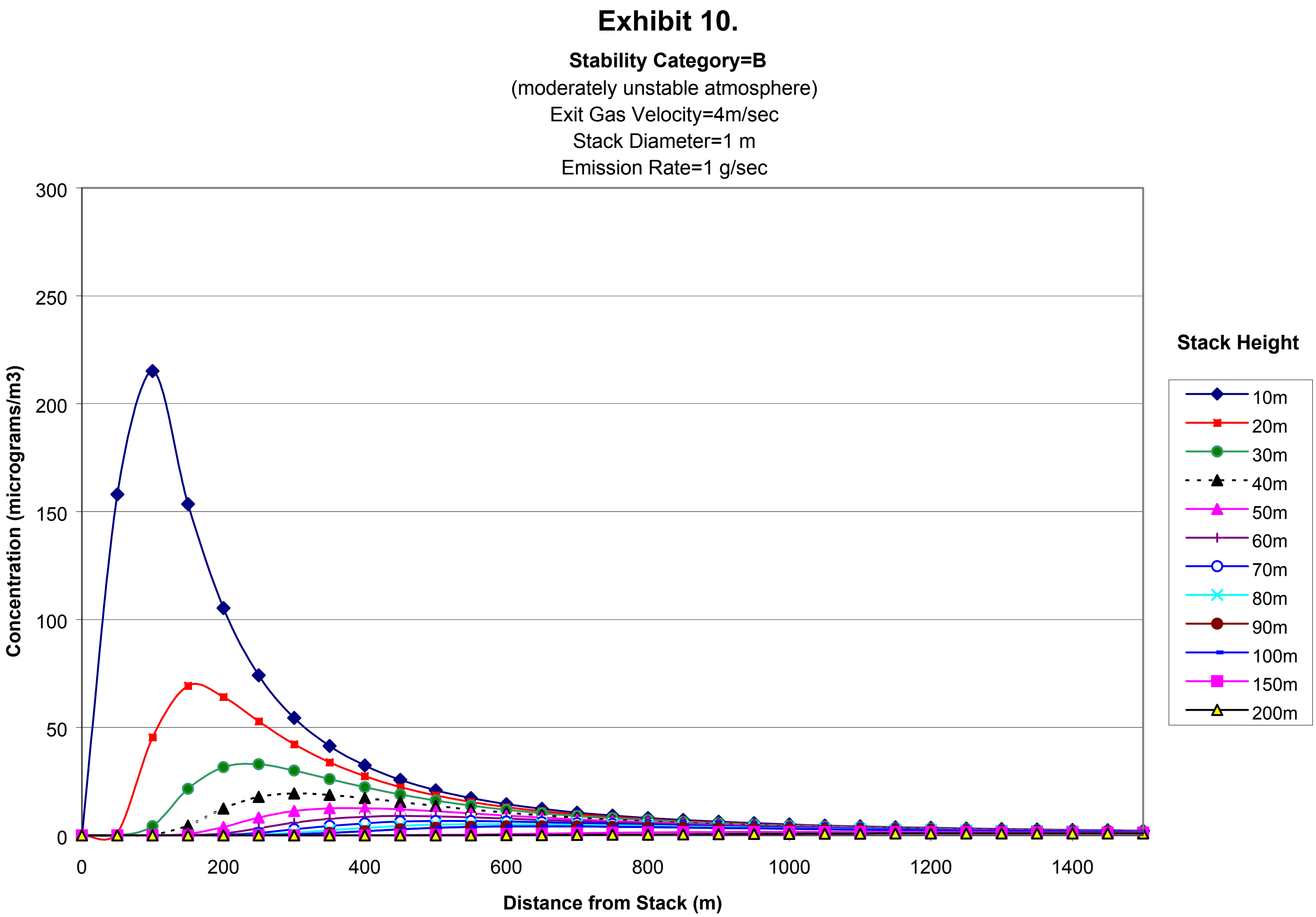
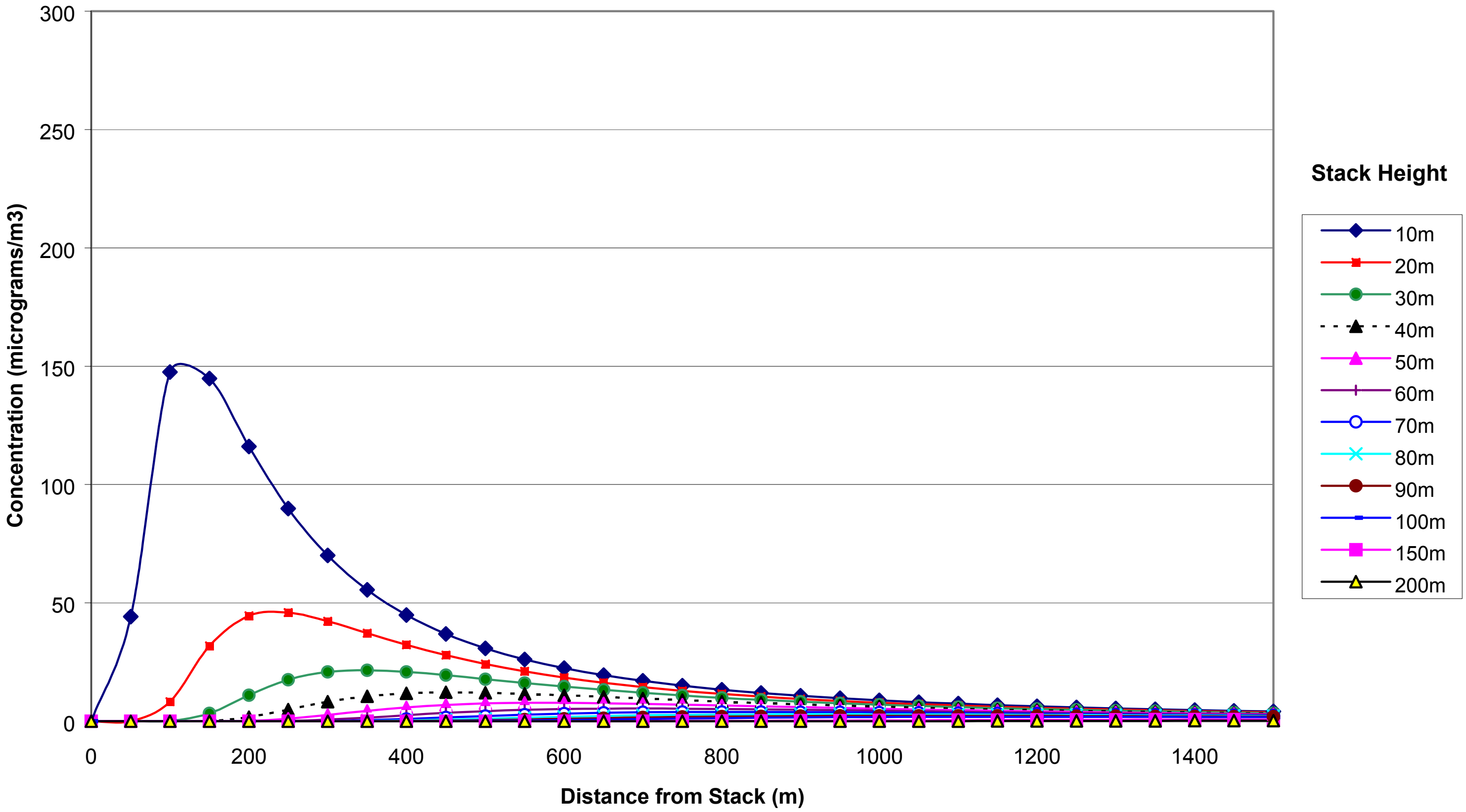


Exhibit 10.
Stability Category=B
(moderately unstable atmosphere)
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec
Concentration (micrograms/m3)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Distance from Stack (m)
Stack Height
10m
20m
30m
40m
50m
60m
70m
80m
90m
100m
150m
200m

Exhibit 11.

Stability Category=C
(slightly unstable atmosphere)
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec



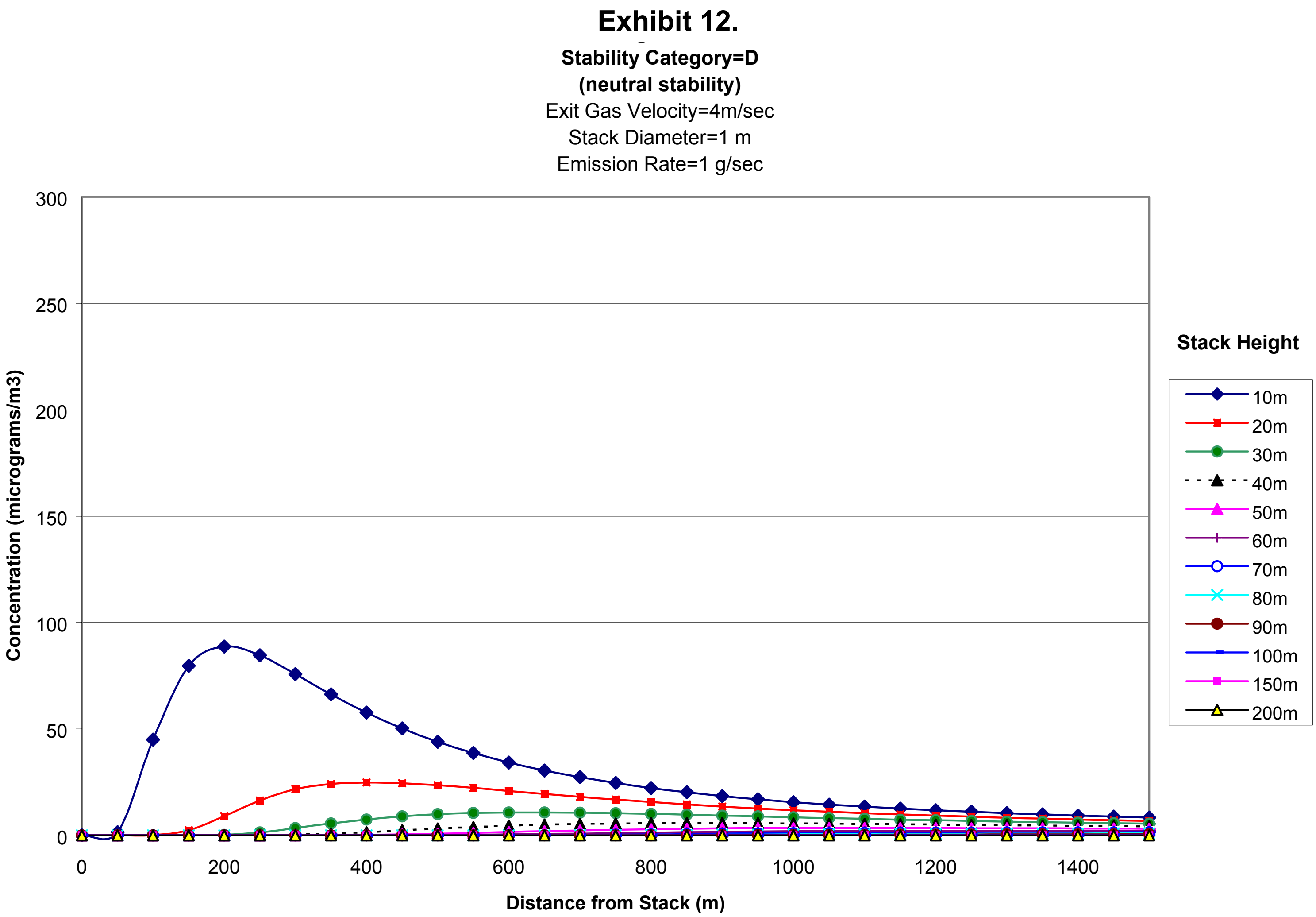
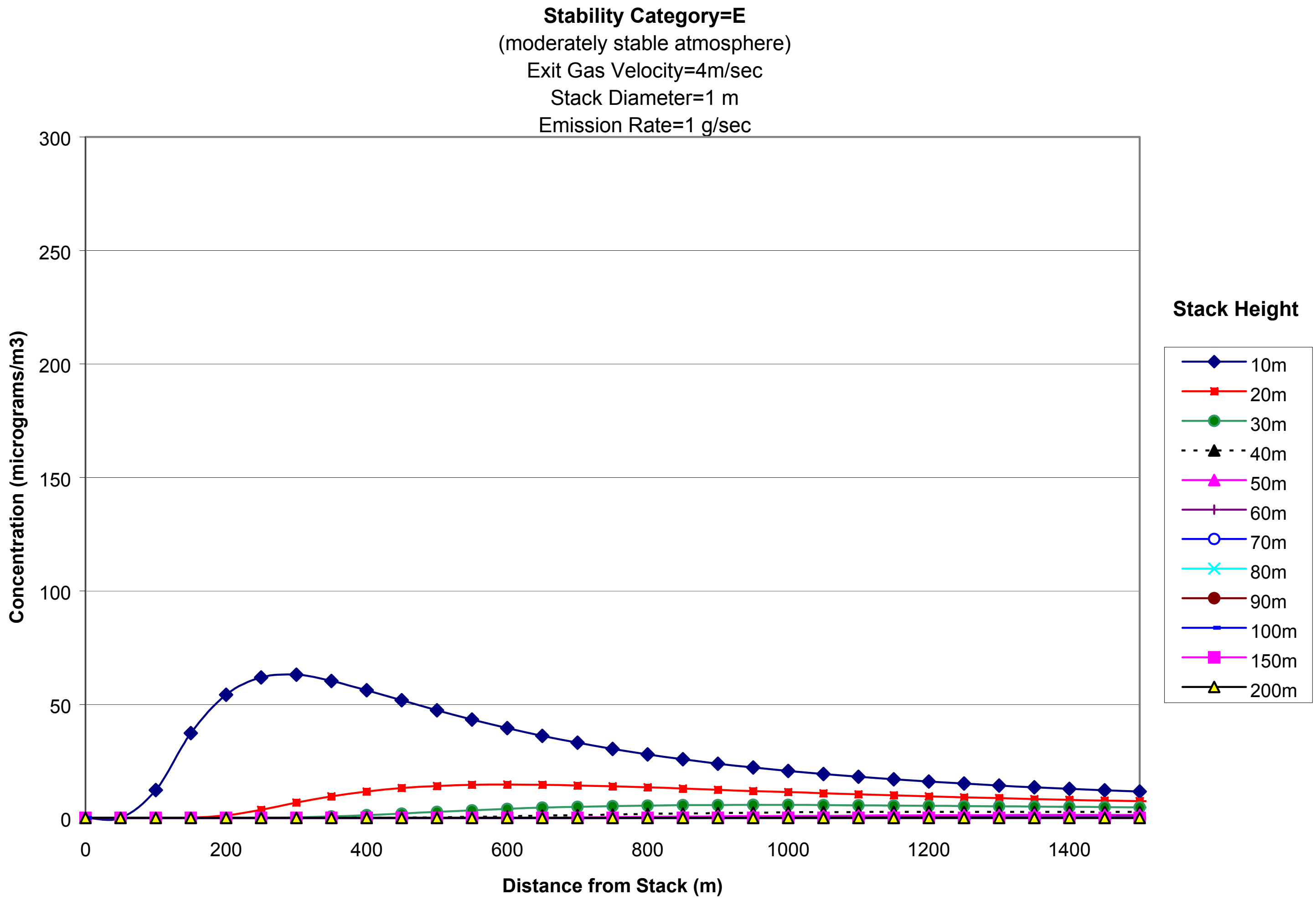


Exhibit 12.
Stability Category=D
(neutral stability)
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec
Concentration (micrograms/m3)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Distance from Stack (m)
Stack Height
10m
20m
30m
40m
50m
60m
70m
80m
90m
100m
150m
200m

Exhibit 13.



Stability Category=E
(moderately stable atmosphere)
Exit Gas Velocity=4m/sec
Stack Diameter=1 m
Emission Rate=1 g/sec
Concentration (micrograms/m3)
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400
Distance from Stack (m)
Stack Height
10m
20m
30m
40m
50m
60m
70m
80m
90m
100m
150m
200m

4. Modeling the Center Cell

These analyses present results from the ISCLT3 model, examining the effect of using a smaller grid cell size for estimating the chemical concentration at the location of the stack. The first analysis looks at median to tall stack heights (10, 20, and 50 meters). The second analysis looks at short stacks of 3 meters.

4.1 Median to Tall Stacks

In this analysis, we compare several methods for estimating chemical concentration for the center grid cell containing the facility. The first three methods involve calculating chemical concentration every 50 meters within the first 500 meters of the stack. We then determine the maximum, median, and average concentrations for distances between 50 and 500 meters (inclusive). Finally we compare the concentration curves that result when assigning either the maximum, median or average value to the center cell containing the stack. Concentrations beyond 500 meters for all methods are calculated at 1,000 meter intervals.

4.1.1 ISCLT3 Model Inputs

ISCLT3 was used to determine steady state air concentrations for a generic non-decaying chemical for receptors with varying spacing. Between 0 and 500 meters, receptors are located at 50 meter intervals. From 500 meters to 50,000 meters, the receptors have a 1,000 meters spacing. A unit emission of 1gram per second (g/s) of a non-decaying chemical was modeled using an exit gas velocity of 4 m/sec. The 1997 TRI facilities have exit gas velocities ranging from 0.01 to 300 m/s; it should be noted that lower exit gas velocities result in higher concentrations near the stack, thus the 4 m/sec value should be considered a reasonable 'worse case scenario'.
The analysis considered stack heights of 10, 20 and 50 meters. The median value for stack heights for 1997 TRI facilities was 9.75 meters and the 95th percentile was 19.1 meters. Other model inputs include a stack diameter of 1 meter, which corresponds to the default value used by RSEI Version 1.x.[12]

Three atmospheric stability conditions (categories B, D, F of the Pasquill-Gifford atmospheric stability classification) were considered. To simplify analysis of results, wind speed was assumed to be evenly distributed across all wind speed categories and uniform in direction.

4.1.2 Results

The results of the analysis are summarized in Exhibit 14 and Exhibits 15(a-f) through 17(a-f) for the three stack heights (10, 20 and 50 meters). The values for median and average concentration in the center cell may be lower when all wind directions are considered.

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[12]The range of diameters is 0.003 to 23 meters, with a median of 0.6 meters; note that the 95th percentile is 1.7 meters.

These results suggest that:

- The current RSEI model methodology may overestimate or underestimate the median or average modeled chemical concentration in the cell containing the stack depending on atmospheric conditions and stack height. These factors greatly influence the distance from the stack at which the maximum concentration occurs.

- For 10 meter stacks in *unstable* and *neutral* atmospheric conditions, the maximum modeled concentration occurred within 500 meters of the stack. Therefore, the center cell concentration using the RSEI methodology is less than the maximum, median and average of concentrations within the center cell.

- For 10 meter stacks under *stable* conditions (an atmospheric inversion), the maximum modeled concentration occurred close to the 500 meter distance. In this case, median and average concentrations within the center cell were less than the value for that cell calculated using the RSEI methodology.

- For taller stacks (≥20 meters), the maximum modeled concentration occurred at or beyond 500 meters for *stable* and *neutral* atmospheric conditions. In these cases, the value assigned to the center cell exceeded the median and average concentration within the center cell. Under *unstable* atmospheric conditions, the maximum concentration occurred within the center cell, and the RSEI value was less than the median or average concentrations within the center cell.

It is very important to remember that in the current analysis, the maximum, median and average statistics are calculated from concentrations modeled downwind of the stack in the principle wind direction. Calculating these statistics using a Cartesian grid of receptors in all directions (as in the RSEI model) would result in the same value for the maximum statistic. In this simplified analysis, median and average statistics for the central cell may be underestimated in comparison to the values calculated using receptors located in all wind directions.

Exhibit 14.
Estimated Concentration in the Center Grid Cell Containing the Stack
(Median to Tall Stacks)

Distance from Stack		Concentration (μg/m³)		
		unstable (P-G category B)	**neutral** (P-G category D)	**stable** (P-G category F)
Stack Height of 10 meters				
Value for Center Cell (x=0)	Using Maximum	215.09	88.71	37.36
	Using Median	74.18	61.97	25.17
	Using Average	95.55	59.35	21.20
	Current RSEI Default	20.85	43.97	37.36
Value for Adjacent Cell (x=500)		20.85	43.97	37.36
Stack Height of 20 meters				
Value for Center Cell (x=0)	Using Maximum	69.27	24.85	3.39
	Using Median	42.24	19.07	.17
	Using Average	39.87	14.66	.84
	Current RSEI Default	18.49	23.53	3.39
Value for Adjacent Cell (x=500)		18.49	23.53	3.39
Stack Height of 50 meters				
Value for Center Cell (x=0)	Using Maximum	12.56	.77	$2x10^{-6}$
	Using Median	8.27	.01	0.0
	Using Average	6.79	.15	$2x10^{-7}$
	Current RSEI Default	11.15	.77	$2x10^{-6}$
Value for Adjacent Cell (x=500)		11.15	.77	$2x10^{-6}$

Units: μg/m³ = micrograms per cubic meter

Exhibit 15a.

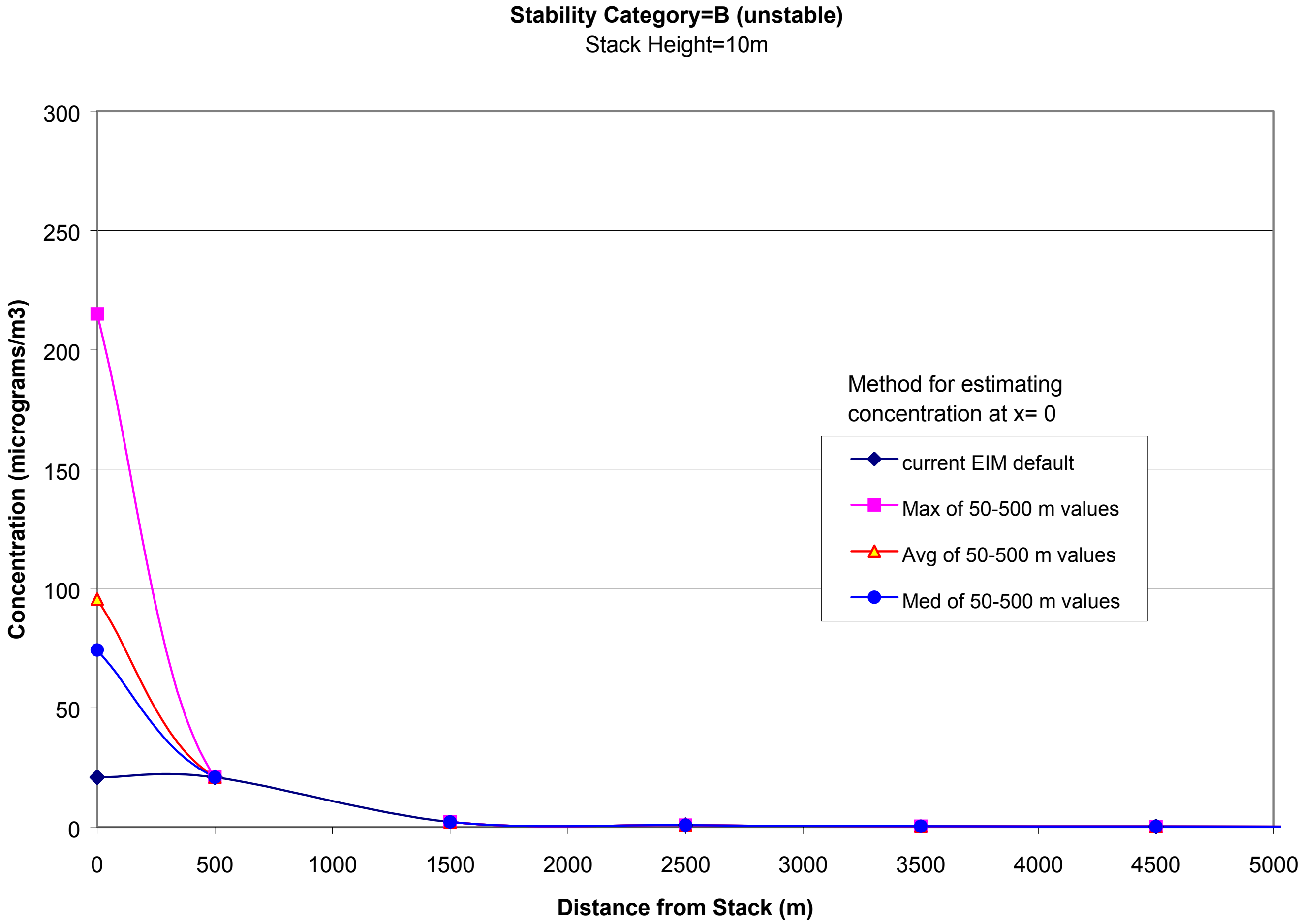

Stability Category=B (unstable)
Stack Height=10m
Concentration (micrograms/m3)
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance from Stack (m)
Method for estimating
concentration at x= 0
current EIM default
Max of 50-500 m values
Avg of 50-500 m values
Med of 50-500 m values

Exhibit 15b.

Stability Category=D (neutral)

Stack Height = 10m

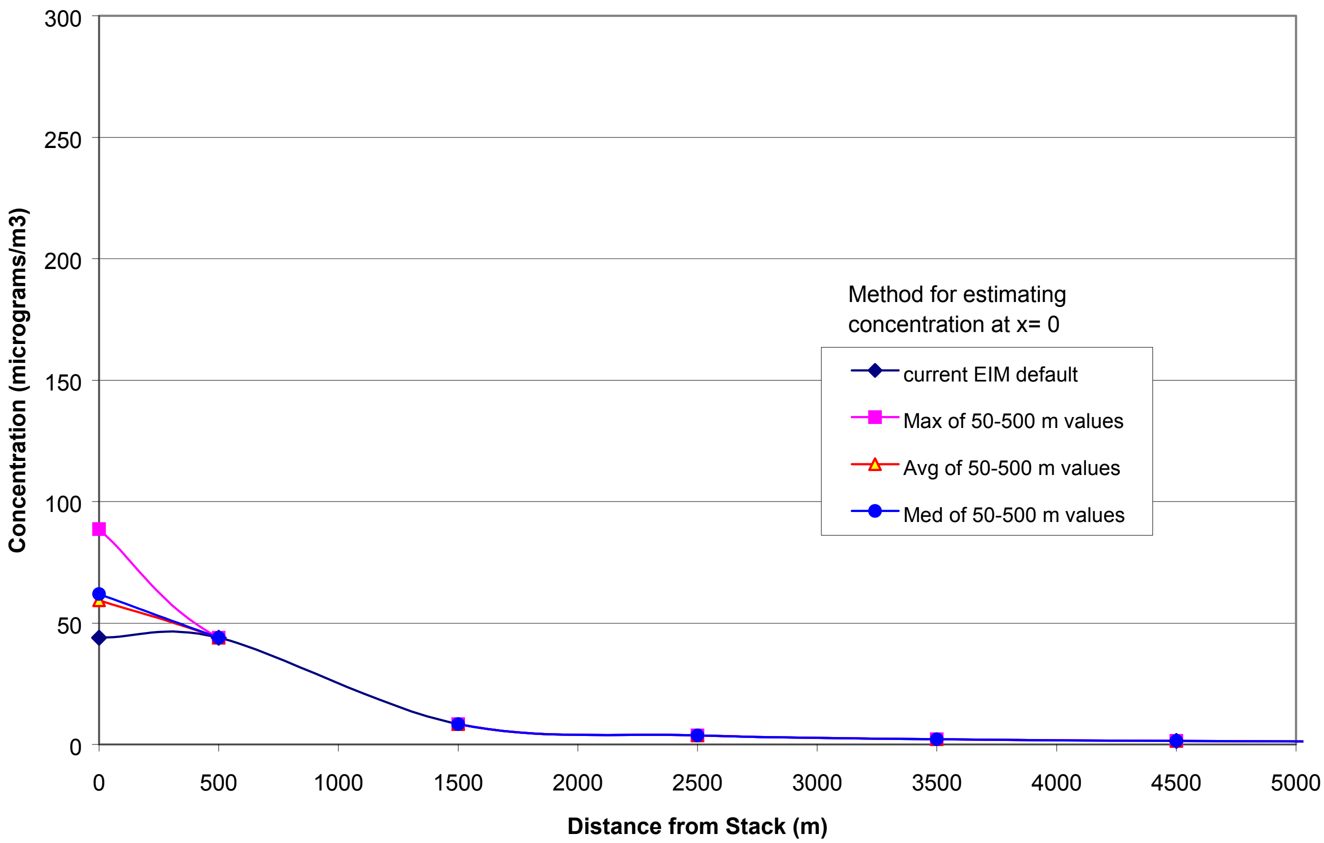


Exhibit 15c.

Stability Category=F (stable)
Stack Height = 10m

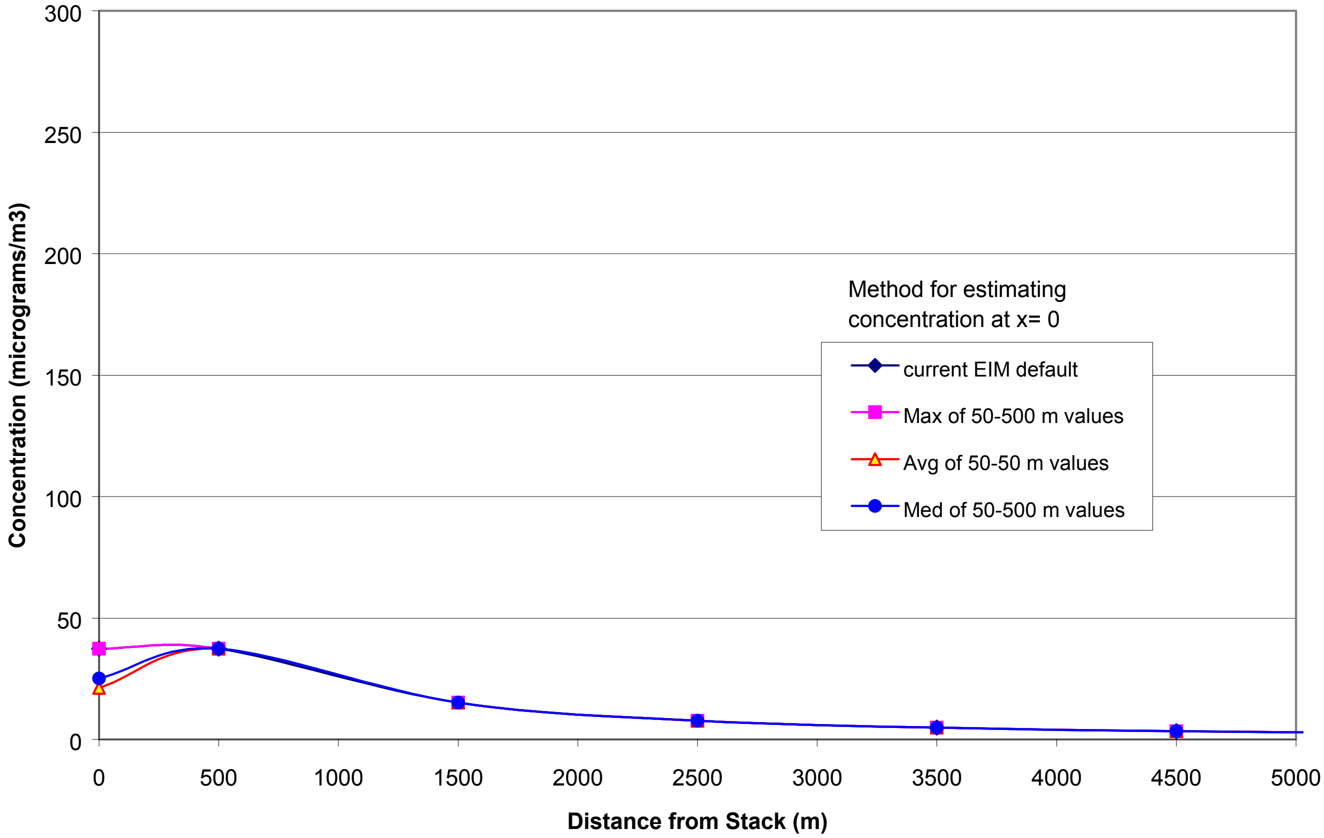


Exhibit 16a.

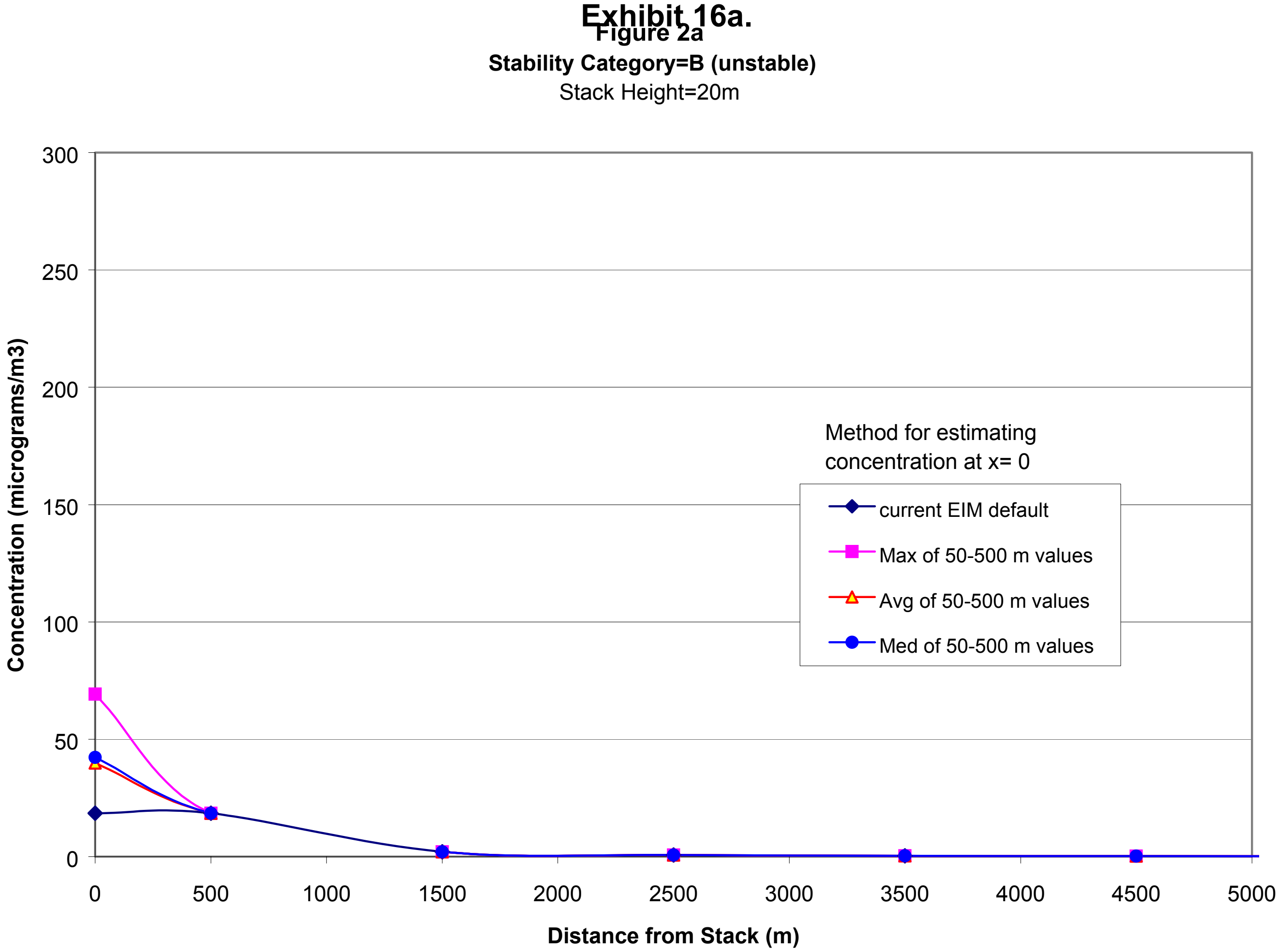
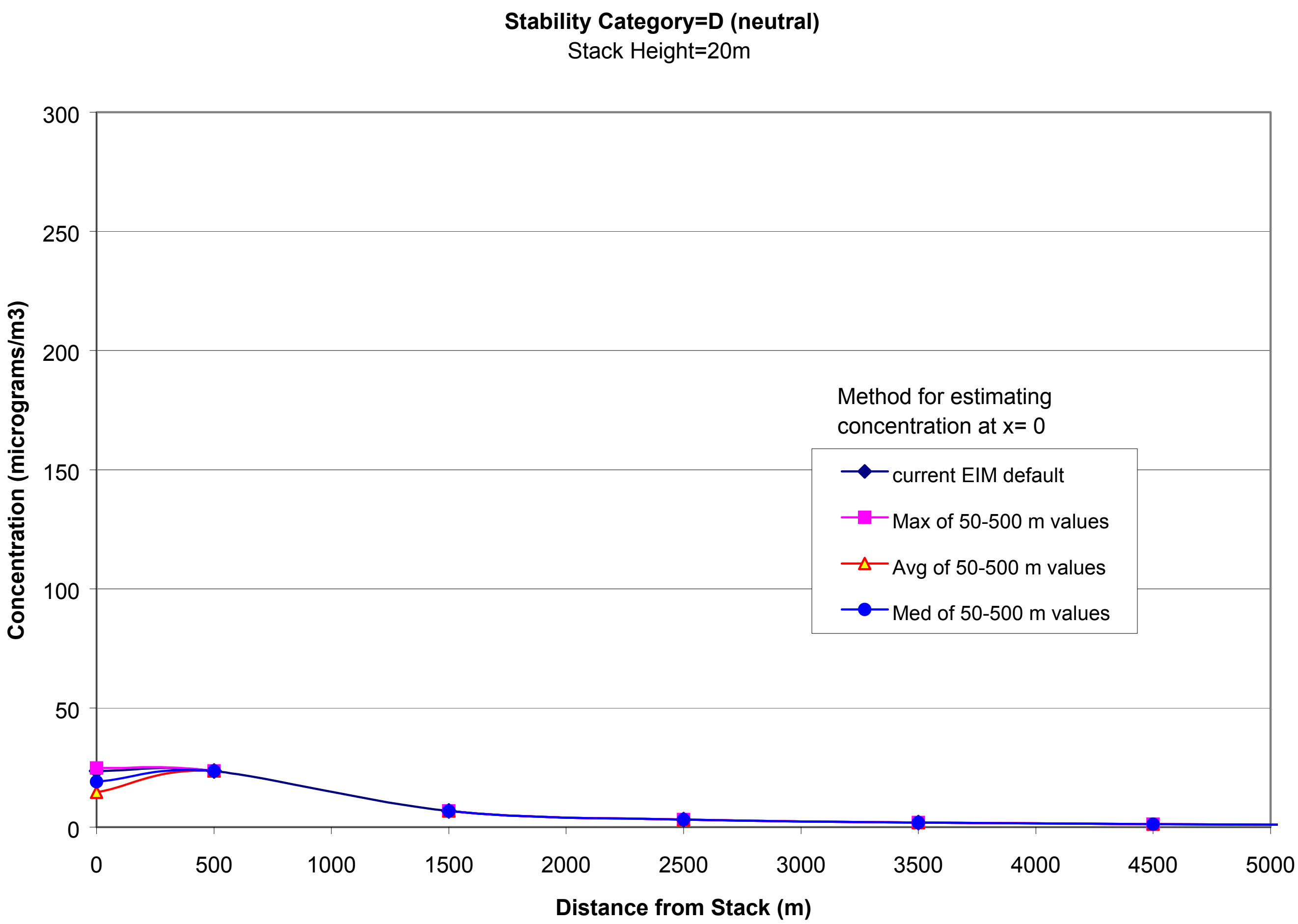


Figure 2a
Stability Category=B (unstable)
Stack Height=20m
Concentration (micrograms/m3)
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance from Stack (m)
Method for estimating concentration at x= 0
current EIM default
Max of 50-500 m values
Avg of 50-500 m values
Med of 50-500 m values

Exhibit 16b.



Stability Category=D (neutral)
Stack Height=20m
300
250
200
150
100
50
0
Concentration (micrograms/m3)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance from Stack (m)
Method for estimating
concentration at x= 0
current EIM default
Max of 50-500 m values
Avg of 50-500 m values
Med of 50-500 m values

Exhibit 16c.

Stability Category=F (stable)

Stack Height=20m

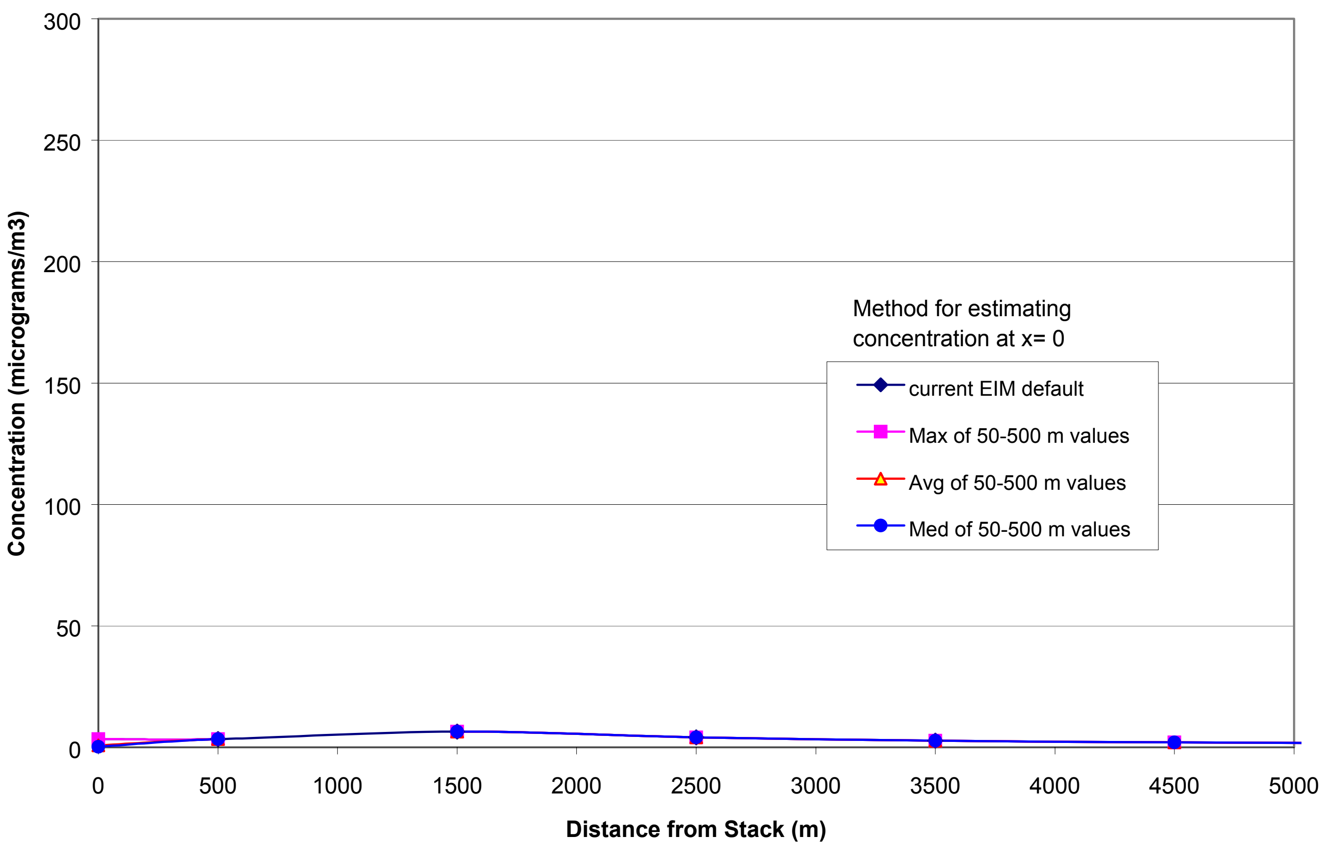


Exhibit 17a.

Stability Category=B (unstable)

Stack Height=50m

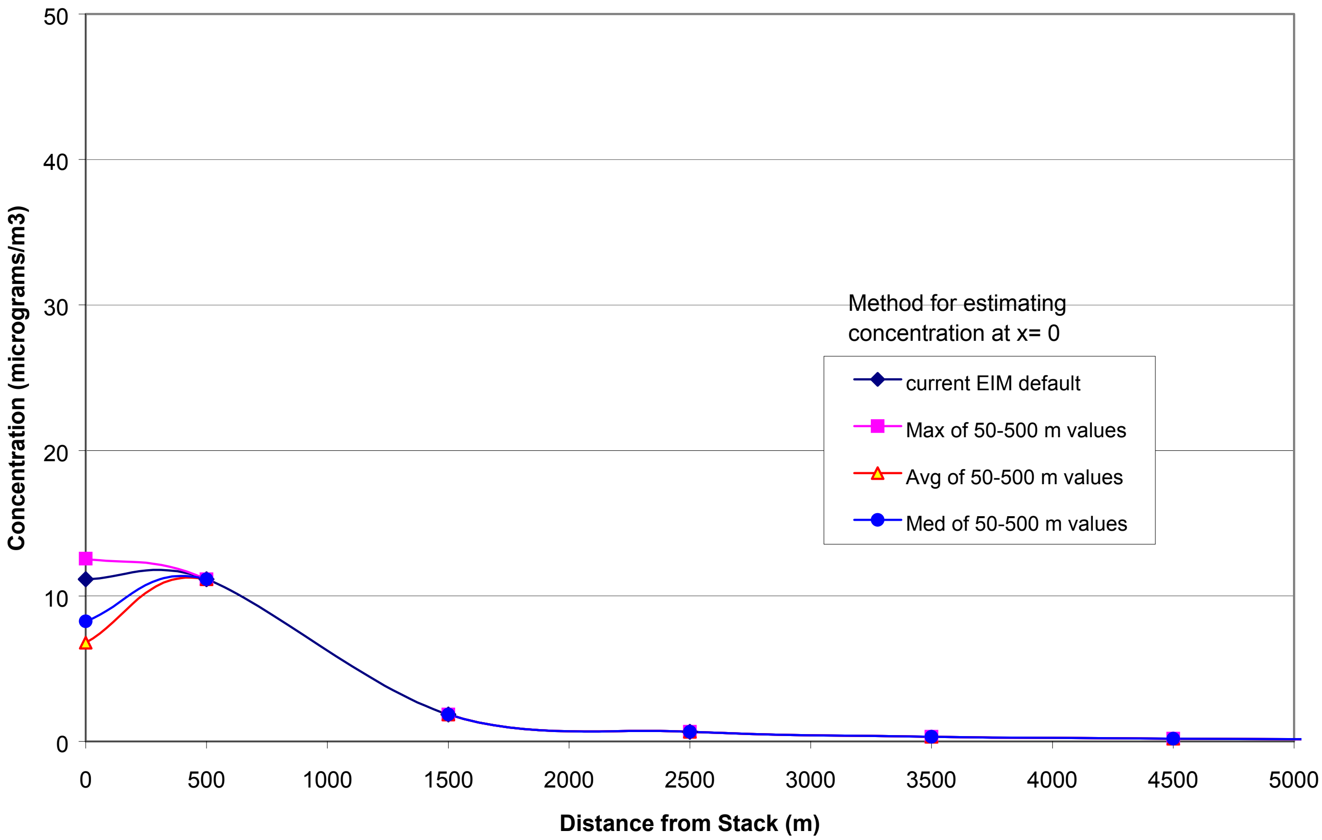


Exhibit 17b.

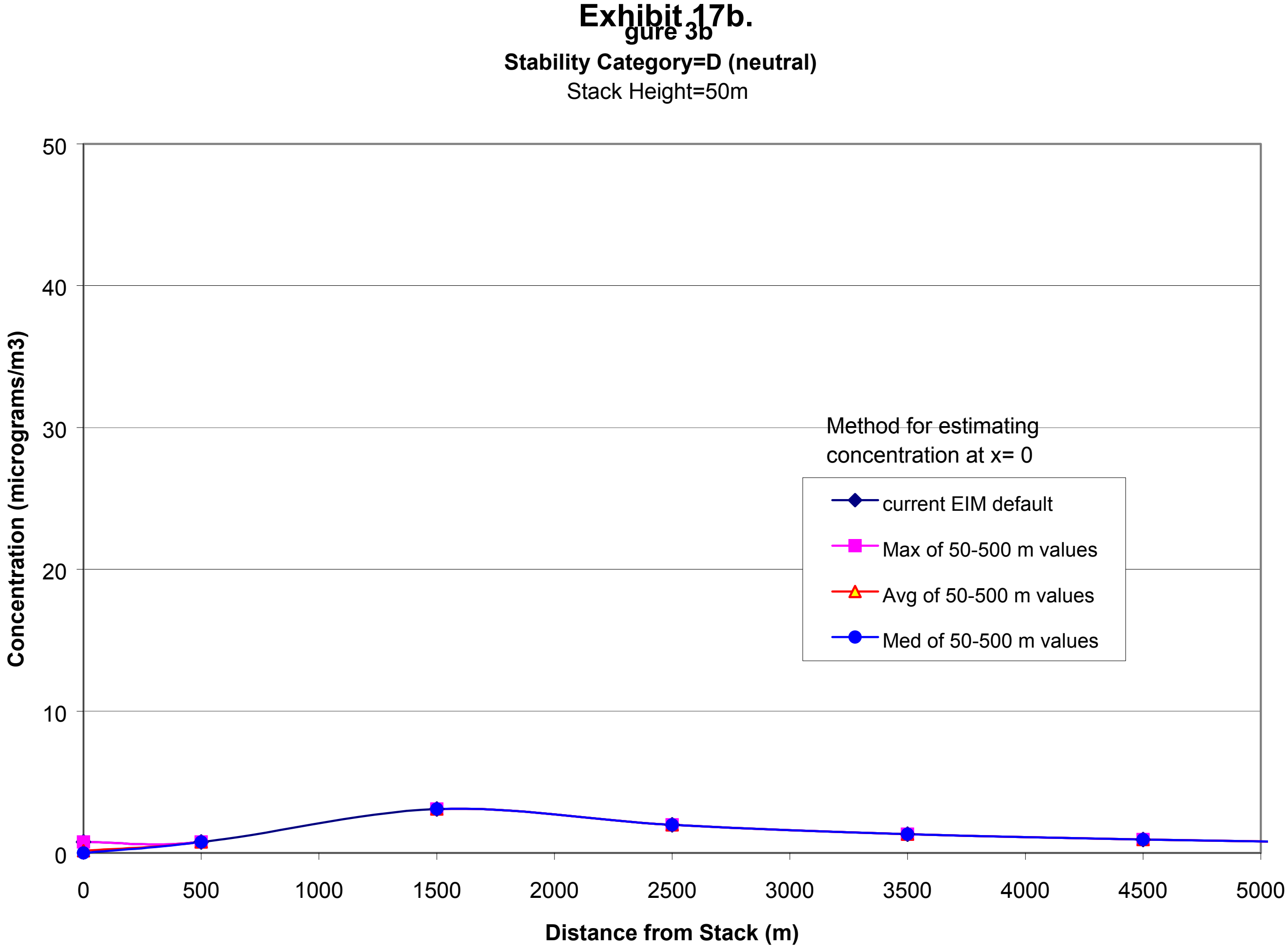
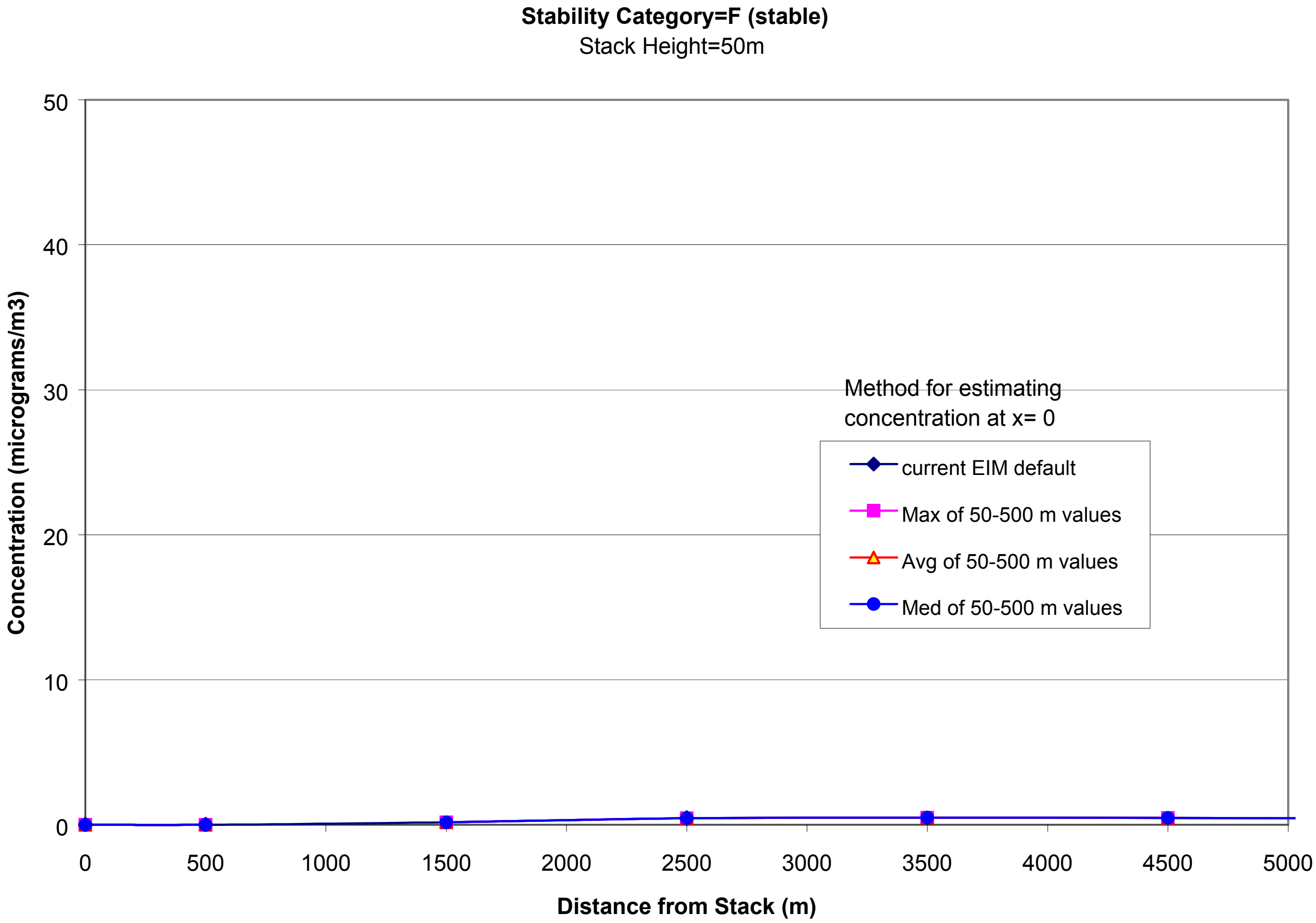

gure 3b
Stability Category=D (neutral)
Stack Height=50m
Concentration (micrograms/m3)
0
10
20
30
40
50
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance from Stack (m)
Method for estimating concentration at x= 0
current EIM default
Max of 50-500 m values
Avg of 50-500 m values
Med of 50-500 m values

Exhibit 17c.



Stability Category=F (stable)
Stack Height=50m
50
40
30
20
10
0
Concentration (micrograms/m3)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance from Stack (m)
Method for estimating concentration at x= 0
current EIM default
Max of 50-500 m values
Avg of 50-500 m values
Med of 50-500 m values

4.2 Short Stacks

In this analysis, we compare several methods for estimating chemical concentration for the center grid cell that contains the facility. The first three methods involve calculating chemical concentration every 50 meters within the first 500 meters of the stack. We then determine the maximum, median, and average concentrations for distances between 50 and 500 meters (inclusive). Finally we compare the concentration curves that result when assigning either the maximum, median or average value to the center cell containing the stack. Concentrations beyond 500 meters for all methods are calculated at 1,000 meter intervals.

4.2.1 ISCLT3 Model Inputs

ISCLT3 was used to determine steady state air concentrations for a generic non-decaying chemical for receptors with varying spacing. Between 0 and 500 meters, receptors are located at 50 meter intervals. From 500 meters to 50,000 meters, the receptors have a 1000 meter spacing. A unit emission of 1gram per second (g/s) of a non-decaying chemical was modeled using an exit gas velocity of 4 m/sec. The 1997 TRI facilities have exit gas velocities ranging from 0.01 to 300 m/s; it should be noted that lower exit gas velocities result in higher concentrations near the stack, thus the 4 m/sec value should be considered a reasonable 'worse case scenario'.

The analysis considered a stack heights of 3 meters. The median value for stack heights for 1997 TRI facilities was 9.75 meters and the 95th percentile was 19.1 meters. Other model inputs include a stack diameter of 1 meter, which corresponds to the default value used by RSEI Version 1.x.[13]

A full range of atmospheric stability conditions (categories A through F of the Pasquill-Gifford atmospheric stability classification) were considered. To simplify analysis of results, wind speed was assumed to be evenly distributed across all wind speed categories and uniform in direction.

4.2.2 Results

The results of the analysis are summarized in Exhibit 18 and Exhibits 19(a-f). Note, that the median and average concentration in the center cell would be lower if calculated using a 2-dimensional grid surrounding the stack, rather than from receptors located only in a the maximum wind direction (as in the current analysis) .

These results suggest that:

- The RSEI methodology underestimates the maximum, median and average modeled chemical concentration in the cell containing a 3 meter stack.

- For 3 meter stacks in *all* atmospheric conditions, the maximum modeled concentration occurred within 500 meters of the stack. Therefore, the center cell concentration

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[13]The range of diameters is 0.003 to 23 meters, with a median of 0.6 m; note that the 95th percentile is 1.7 meters.

estimated using the RSEI methodology is less than the maximum, median and average of concentrations within the center cell.

- The estimated concentration in the center cell decreases with increasing atmospheric stability.

It is very important to remember that in the current analysis, the maximum, median and average statistics are calculated from concentrations modeled downwind of the stack in the principle wind direction. Calculating these statistics using a Cartesian grid of receptors in all directions (as in the RSEI model) would result in the same value for the maximum statistic. In this simplified analysis, median and average statistics for the central cell may be underestimated in comparison to the values calculated using receptors located in all wind directions.

Exhibit 18.
Estimated Concentration in the Center Grid Cell Containing the Stack
(Short Stacks)

Distance from Stack		Concentration ($\mu g/m^3$)					
		very unstable (P-G category A)	unstable (P-G category B)	slightly unstable (P-G category C)	neutral (P-G category D)	stable (P-G category E)	very stable (P-G category F)
Stack Height of 3 meters							
Value for Center Cell (x=0 meters)	Using Maximum	894.23	900.90	846.54	737.95	650.83	442.27
	Using Average	89.55	189.89	207.29	221.72	232.75	211.33
	Using Median	48.03	71.36	99.54	141.27	166.64	176.30
	Current RSEI Default	10.59	21.48	33.17	54.87	72.57	92.12
Value for Cell Adjacent to Center Cell		10.59	21.48	33.17	54.87	72.57	92.12

Note: $\mu g/m^3$ = micrograms per cubic meter
P-G = Pasquill-Gifford Stability Category

Exhibit 19a.

Stability Category=A (very unstable)

Stack Height=3 m

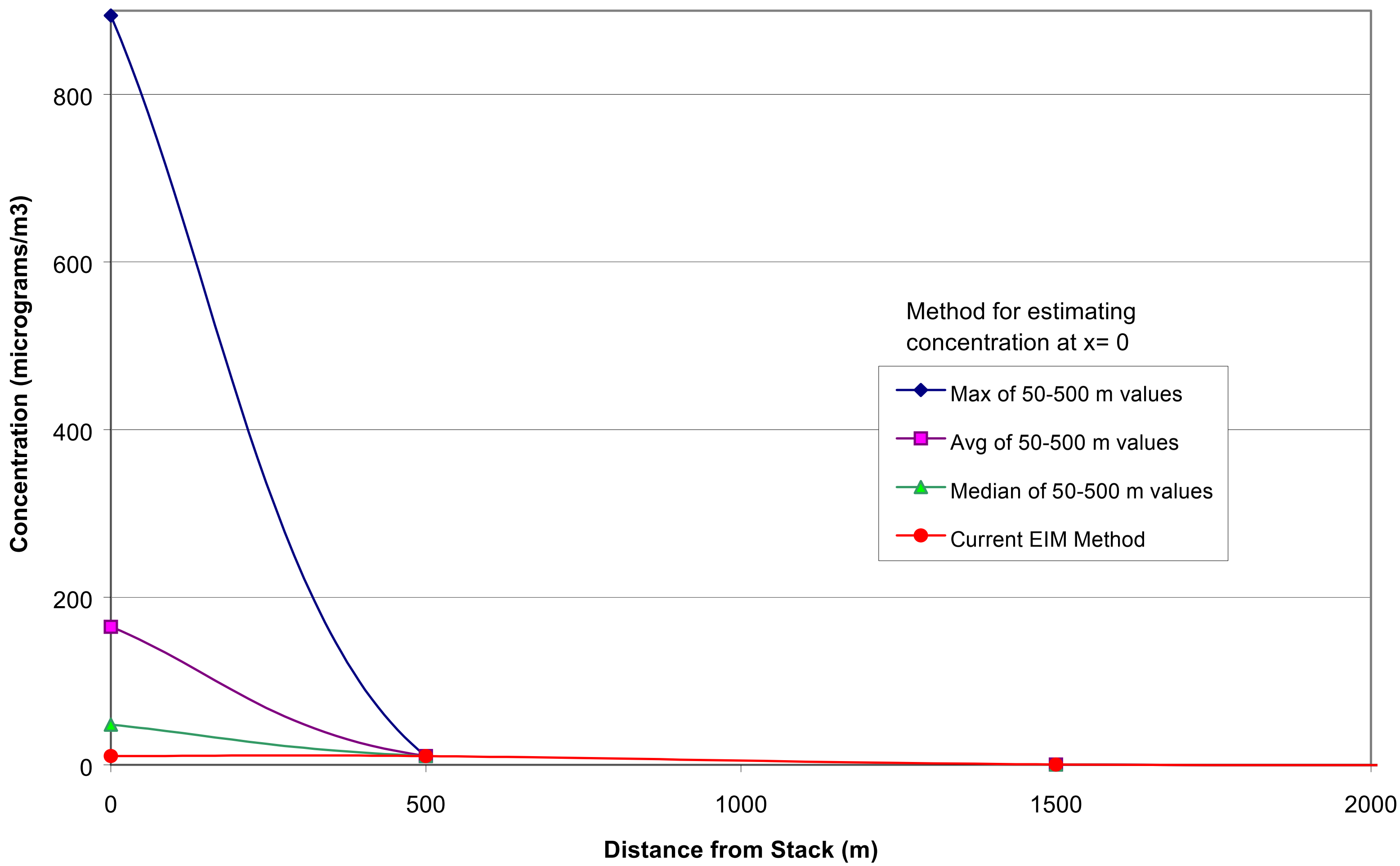


Exhibit 19b.

Stability Category=B (unstable)
Stack Height=3 m

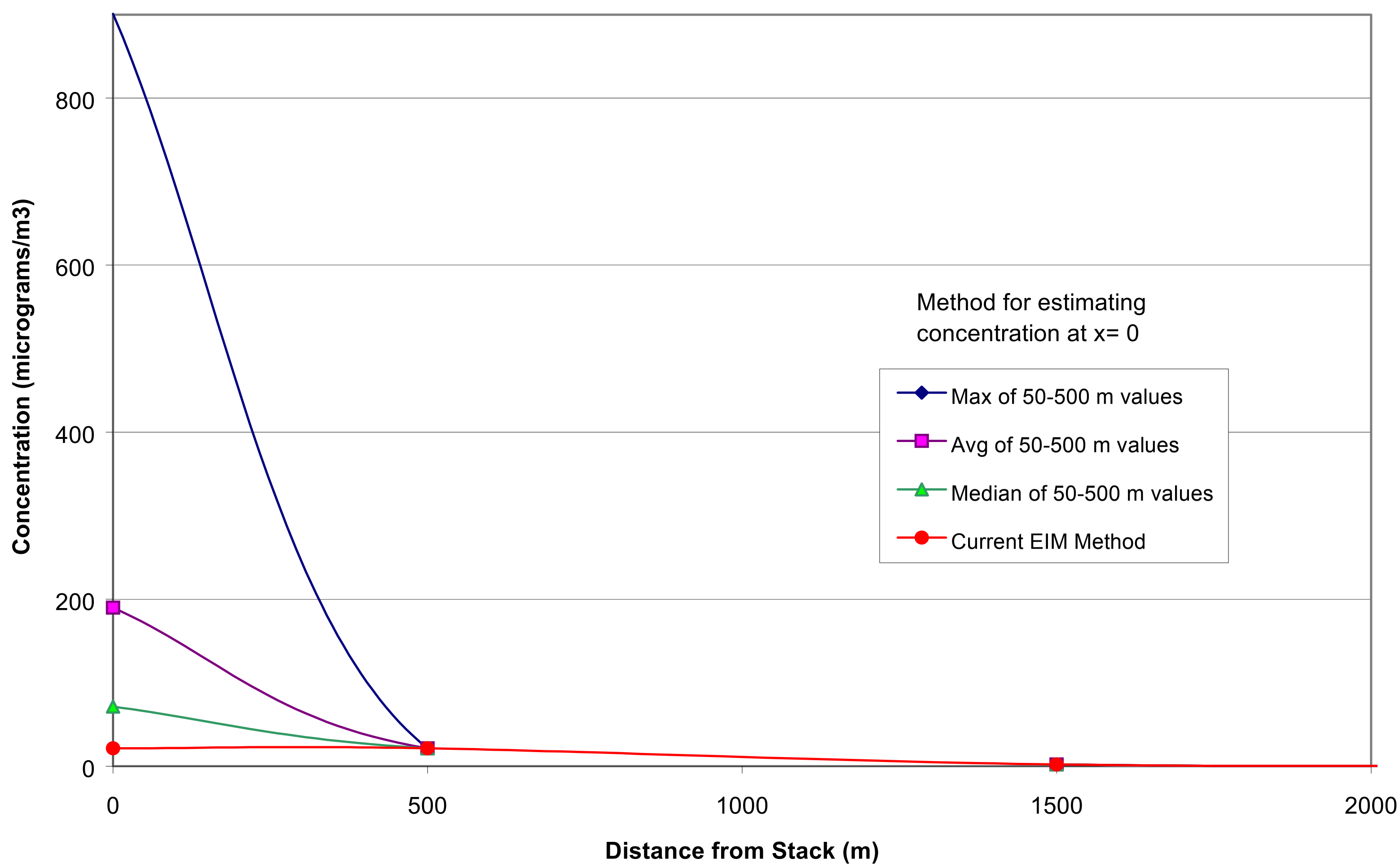


Exhibit 19c.

Stability Category=C (slightly unstable)

Stack Height=3 m

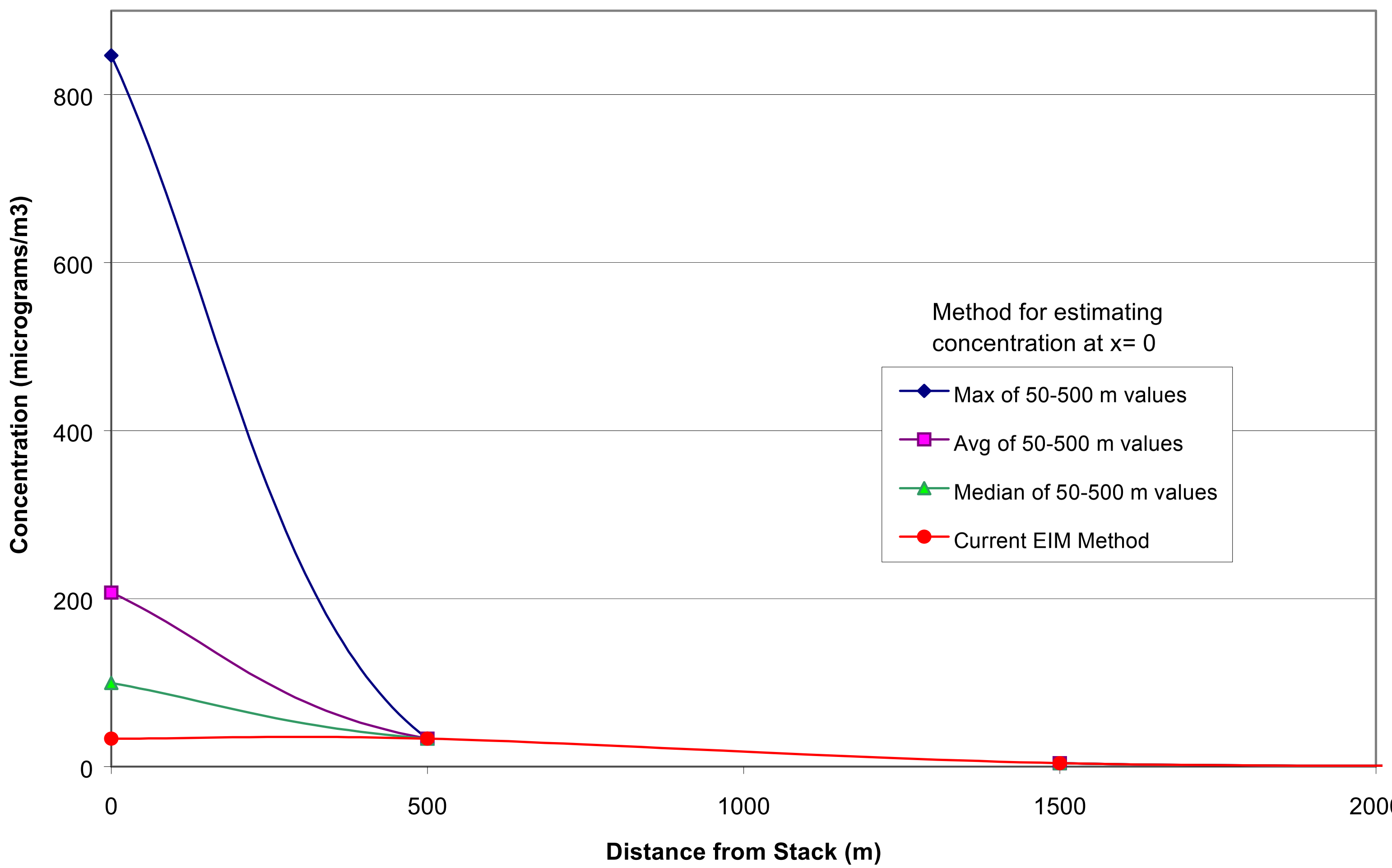


Exhibit 19d.

Stability Category=D (neutral)
Stack Height=3 m

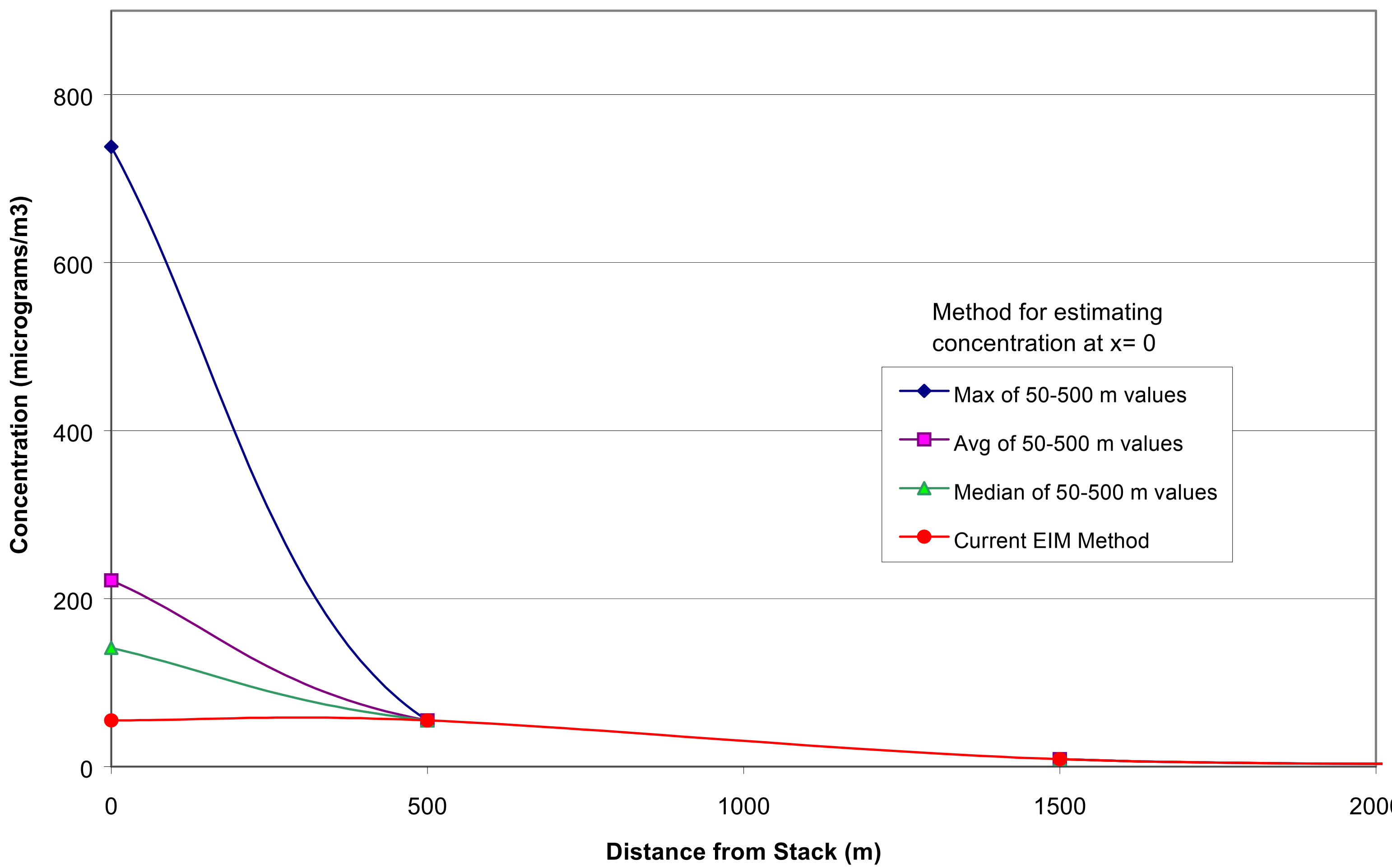


Exhibit 19e.

Stability Category=E (stable)
Stack Height=3 m

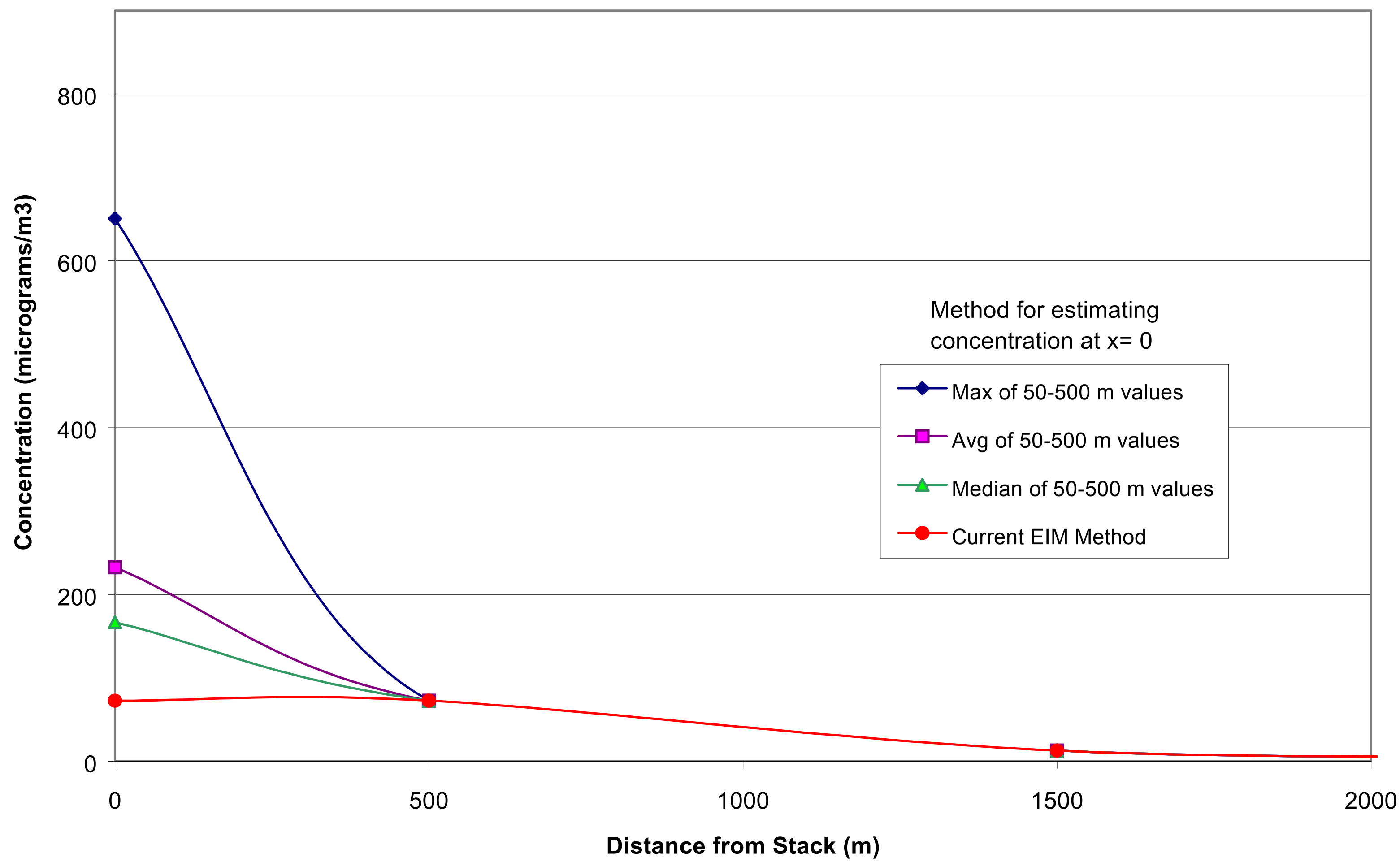
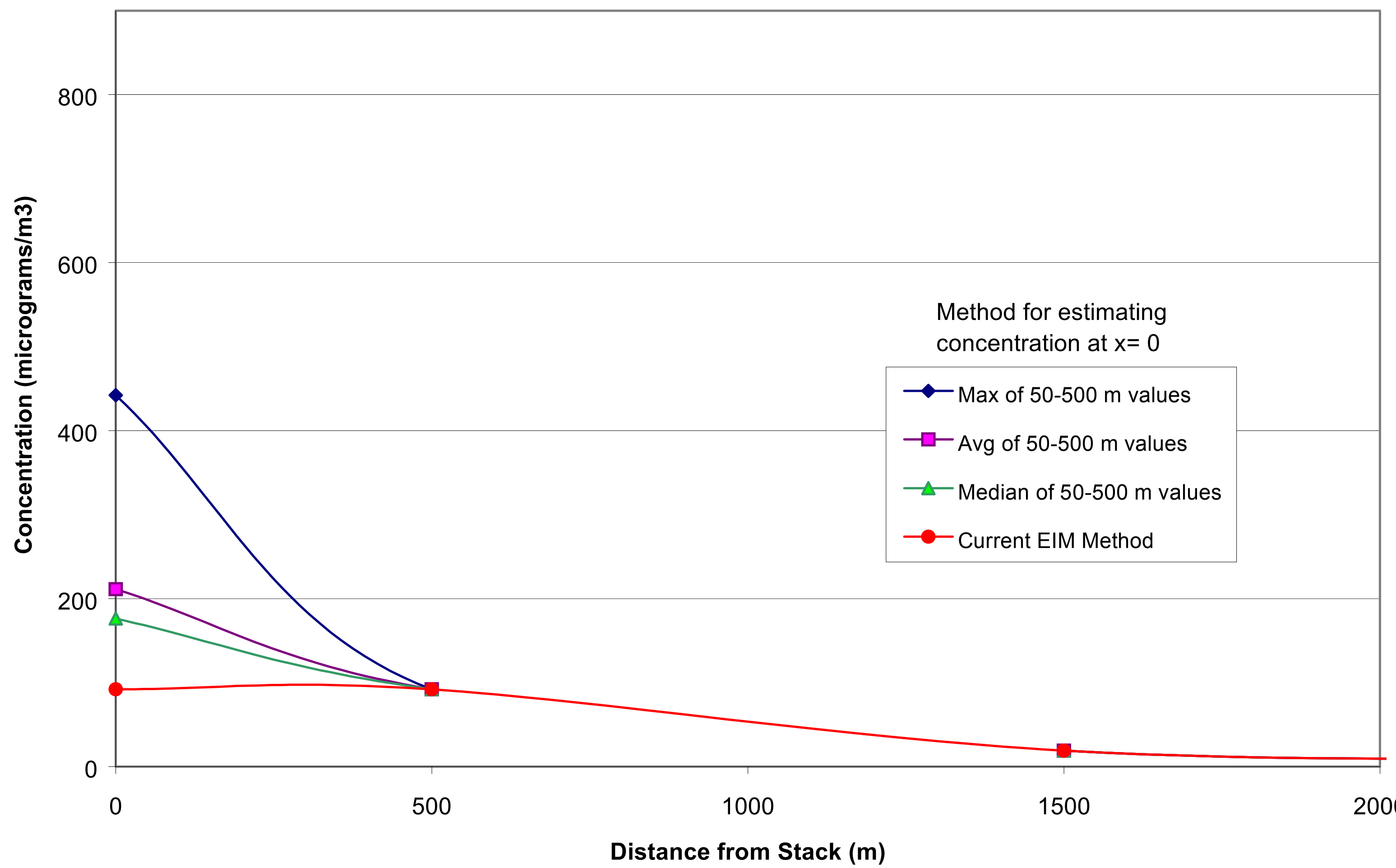


Exhibit 19f.

Stability Category=F (very stable)
Stack Height=3 m



Part C.

Estimates of Stack Heights and Exit Gas Velocities For TRI Reporting Facilities

ACKNOWLEDGMENTS

This report, which describes the methods used to estimate stack heights and exit gas velocities for TRI facilities, is one of many products of the Office of Pollution Prevention and Toxics' (OPPT's) Risk-Screening Environmental Indicators Model Project. This project, initiated in 1991, has resulted in the Risk-Screening Environmental Indicators Model, a unique and powerful analytical tool for risk-related analysis and communication. The Indicators Model has the potential to make a significant contribution to environmental improvement. We wish to thank our contractor, Abt Associates Inc., for their support and creativity throughout the development of this project.

We also want to thank several persons at State agencies who were very helpful in providing data and information for the analyses described in this report. These include Mr. Tom Gentile and Mr. Eric Wade of the New York State Department of Environmental Conservation; Mr. Christopher Nguyen of the California Environmental Protection Agency's Air Resources Board; Mr. Orlando Cabrera of the Wisconsin Department of Natural Resources; and, Mr. Greg Stella of EPA's Office of Air Quality Planning and Standards.

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EXECUTIVE SUMMARY

In July 1997, EPA's Science Advisory Board (SAB) reviewed and commented on the methodology used in the Risk-Screening Environmental Indicators Model developed by EPA's Office of Pollution Prevention and Toxics (OPPT). In response to one of SAB's comments, EPA sought to improve the estimate of facility stack height used in modeling air emissions of Toxics Release Inventory (TRI) chemicals. The sensitivity analysis of the air emission modeling used in the Indicators Model demonstrated that stack height has the greatest impact on predicted concentrations of air pollutants. At the time of SAB's review, all stacks in the Indicators Model were assumed to be 10 meters high. Also at that time, all exit gas velocities, which represent the second most important variable impacting air emissions modeling, were assumed to be 0.01 m/sec. As EPA began improving the accuracy of stack height estimates, it determined that it could also readily improve the estimation of exit gas velocities. This report describes the Agency's improvements to the accuracy of the Indicators Model through two types of changes: 1) the incorporation of facility-specific median stack heights and median exit gas velocities where available; and, 2) the estimation of median values for stack heights and exit gas velocities by Standard Industrial Classification (SIC) codes. These estimates are then assigned to facilities without facility-specific data.

To obtain facility-specific stack heights and exit gas velocities as well as estimates of stack heights and exit gas velocities by SIC code, the Agency relied on the AIRS Facility Subsystem (AFS) database within the Aerometric Information Retrieval System (AIRS); the National Emission Trends Database (NET); and databases from three states (California, New York, and Wisconsin).

From AFS and the three State databases, EPA was able to obtain stack height data specific to facilities which report to TRI. For the 421 California, New York, and Wisconsin facilities which report to TRI and the 1,209 facilities in common to the TRI and AFS databases, a representative stack height for each facility was estimated by calculating the median height for all of a facility's stacks with non-zero height. After identifying facilities in common between TRI and these data sources, EPA began investigating ways of estimating stack heights for TRI facilities *not* in AFS or in the three State databases. In the course of analysis of available data, the Agency noticed substantial variability in stack height across primary SIC codes of facilities, and chose to calculate and analyze a median stack height for each 2-digit, 3-digit, and 4-digit SIC code applicable to TRI reporters, i.e., in the 2-digit SIC code range of 20 to 39. To use the data in AFS and NET, however, EPA had to investigate the possibility that stack height may vary on the basis of whether the stack emitted possible TRI chemicals or not. For the TRI facilities with non-zero stack releases for which facility-specific data were not available, stack heights were estimated from AFS and NET based on facility 3-digit SIC codes and statistical analyses of height differences between stacks emitting TRI chemicals and stacks not emitting TRI chemicals.

For stack height, the estimation approaches used for the 13,204 TRI facilities with non-zero stack air releases reported in 1995 included: 1,209 facilities estimated directly from AFS; 69 facilities estimated from California State data; 192 facilities estimated from New York State data; 37 facilities estimated from Wisconsin State data; and 11,514 estimated based on the facilities' 3-digit SIC code. The remaining 183 facilities (13,204 facilities minus 13,021 facilities) reported 3-digit SIC codes outside the range of 201 to 399, or reported no SIC code. For these 183 facilities, a stack height was assigned based on either the 2-digit SIC code (if a valid one was available) or on the median stack height for all 108,590 unique stacks in AFS and NET. The median stack height for all 108,590 stacks from AFS and NET is 10.67 m (35.0 ft), virtually the same as the previously used default value of 10 m for TRI facilities.

At the same time that EPA obtained stack height data, it also obtained exit gas velocity data. EPA was able to obtain exit gas velocity data specific to TRI facilities from AFS and two of the three State databases. For a given facility, the exit gas velocity was estimated as the median for all the stacks. This facility-specific analysis could be conducted for 850 facilities from AFS; 192 facilities from New York State data; and 24 facilities from Wisconsin State data. Of the 13,204 TRI facilities with non-zero stack air releases reported in 1995, exit gas velocities were estimated for 11,950 facilities based on the facilities' 3-digit SIC code. The remaining 188 facilities (13,204 facilities minus 13,016 facilities) reported 3-digit SIC codes outside the range of 201 to 399, or reported no SIC code. For these facilities, an exit gas velocity was assigned based on either the 2-digit SIC code (if a valid one was available) or on the median exit gas velocity for all 108,590 unique stacks in AFS and NET. The median exit gas velocity for all 108,590 stacks from AFS and NET is 8.80 m/sec (28.9 ft/sec), considerably larger than the previously used default value of 0.01 m/sec for TRI facilities.

TABLE OF CONTENTS

1. INTRODUCTION

In July 1997, the EPA Science Advisory Board (SAB) reviewed and commented on the methodology used in the Risk-Screening Environmental Indicators Model developed by EPA's Office of Pollution Prevention and Toxics (OPPT). In response to one of SAB's comments, EPA sought to improve the estimate of facility stack height used in modeling air emissions of Toxics Release Inventory (TRI) chemicals. At the time of SAB's review, all stacks in the Indicators Model were assumed to be ten meters (32.8 feet) high. This report describes the Agency's efforts to improve the accuracy of the Indicators Model by incorporating facility-specific stack heights where available, or by estimating stack height by facility characteristics, such as the Standard Industrial Classification (SIC) code.

In response to another SAB comment, the Agency conducted a "ground-truthing" analysis of the air pathway component of the Indicators Model (Bouwes and Hassur, 1998). In the course of this analysis, the Agency determined that the accuracy of the model could be further improved by also incorporating facility-specific exit gas velocities where available, or by estimating exit gas velocity by facility characteristics, such as the SIC code.

There are a number of possible data sources to use for both facility-specific stack heights and exit gas velocities and estimates of stack heights and exit gas velocities by facility characteristics. These data sources include EPA's AIRS Facility Subsystem (AFS) database within the Aerometric Information Retrieval System (AIRS); EPA's National Emission Trends Database (NET); and databases from individual States, such as California, New York, and Wisconsin. This report documents the Agency's effort to analyze the appropriateness of the AFS and NET stack height and exit gas velocity data for use in the Indicators Model and presents the way in which the AFS and NET data and additional data from individual States are used in the model.

In Section 2 of this memo, AFS and the data elements it can provide to estimate stack heights are described. In Section 3, overviews of NET and State data are provided, including a description of how stack height data for facilities present in both NET and AFS are treated to prevent double-counting. Sections 4 and 5 present statistical analyses of the stack height data in AFS and NET, respectively. Section 6 describes the way in which facility-specific data, obtained from both AFS and States, and the results of the statistical analyses of stack heights are implemented in the Indicators Model. Finally, Section 7 presents the analyses of exit gas velocity data and describes the way these results are implemented in the Indicators Model.

2. AFS OVERVIEW

2.1 INTRODUCTION TO AFS

AFS is a component of AIRS, which is administered by EPA's Office of Air Quality Planning and Standards (OAQPS). AIRS, which is a computerized database management system for airborne pollution in the United States, consists of four subsystems. Each subsystem addresses a different (but in many cases related) aspect of the regulatory requirements of the Clean Air Act. AFS contains emissions, compliance, and enforcement data on stationary sources of air pollution. Included sources cover the spectrum from large industrial facilities to relatively small operations such as dry cleaners, although facilities must meet certain threshold requirements to be included in AFS. These threshold requirements vary by pollutant and are discussed below.

In general, facilities collect emissions data in compliance with their permits and send the data to their State environmental agencies. Some emissions data are based on actual measurements; others are based on estimation methods. Sometimes inspectors collect emissions data. Most facilities prepare emissions inventories once every five years. Each year, States consolidate the data received from facilities reporting in that year and send the data to the EPA Regional Offices, which enter the data into AFS. At the time of this analysis, the most recent data for a given facility could be from any year between 1993 to 1997.

2.2 POLLUTANTS INCLUDED IN AFS

AFS includes data on a total of 52 specific pollutants or pollutant classes (not counting fugitive emissions, visible emissions, coke oven emissions, fugitive dust, odors, and other). These data include release estimates for the following five air pollutants:

- particulate matter smaller than ten microns (PM10);
- sulfur oxides, with sulfur dioxide (SO_2) as a marker for all SO_x;
- nitrogen oxides, with nitrogen dioxide (NO_2) as a marker for all NO_x;
- carbon monoxide (CO); and
- lead (Pb).

These are the "criteria" pollutants for which EPA's OAQPS has set National Ambient Air Quality Standards. (Although PM10 is the current particulate criterion pollutant, total particulate mass (PT) was the previous criterion for particulates. Depending upon the vintage of a given facility's data, PT may be listed in place of PM10.)

The thresholds for including emissions data in AFS are 1,000 tons per year of CO; five tons per year of Pb; and 100 tons per year for each of the other pollutants, including PM10, SO_2, and NO_2. Even when a facility exceeds threshold emissions of one pollutant, it might not exceed the threshold and hence not report for another pollutant. For example, if a facility estimates annual releases of 150 tons of SO_2 and 500 tons of CO, AFS will list the facility's estimated SO_2 emissions but not its CO emissions.

The 39 pollutant and pollutant classes in AFS that are either TRI chemicals or likely to contain TRI chemicals are presented in Table 1.

Table 1 Pollutant and Pollutant Classes in AFS which are TRI Chemicals or Assumed to Include TRI Chemicals		
acetylenes	cadmium compounds *	lead compounds *
aldehydes	chlorofluorocarbons	manganese compounds *
ammonia	chlorophenols	mercury
antimony compounds *	chromium compounds *	mercury compounds *
aromatics	cobalt compounds *	nickel compounds *
arsenic	copper compounds	olefins
arsenic compounds *	cyanide compounds *	organic acids
asbestos *	fluorides	polybrominated biphenyls
barium compounds	glycol ethers *	polynuclear aromatics
benzene *	hydrochloric acid *	selenium compounds *
beryllium	hydrofluoric acid *	vinyl chloride *
beryllium compounds *	ketones	VOCs
cadmium	lead	zinc

* indicates that chemical or chemical class is classified as a Hazardous Air Pollutant (HAP).

2.3 EMISSION AND STACK HEIGHT DATA IN AFS

AFS tracks data in a hierarchy with four levels: (1) facilities; (2) stacks, the locations at which emissions are introduced into the atmosphere; (3) points, the processes that produce pollutant emissions; and (4) segments, which are components of the processes. For the criteria pollutants, estimated emissions are available in pounds per year at the facility level. For the HAPs, emissions may be estimated using "emissions factors" for specific production processes at the segment level. These processes are categorized by Source Classification Codes (SCCs), six-character identifications of the specific production processes.

Each facility in AFS has a primary SIC code, recorded at the four-digit level. The primary SIC code reflects the principal product or service generated by the facility. Within a facility, each stack is assigned a stack identification number. For each stack, the rate of emission in mass per time of each stack pollutant (identified by CAS number or other chemical identification number) is provided, along with the non-zero height of the stack measured in feet.

3. OVERVIEW OF STACK HEIGHT DATA IN NET AND STATE DATABASES

3.1 NATIONAL EMISSION TRENDS DATABASE

EPA's National Emission Trends (NET) database became available to OPPT early in 1998, well after relevant data for the project were obtained from AFS. EPA decided to use stack height data from NET to augment the AFS data because some States not included in AFS were included in NET. The NET database provides information on stack height measured in feet, and the annual emission rates of five criteria pollutants: VOCs, NO_x, CO, SO_2, and PM10. To prevent double-counting of stacks from facilities in both AFS and NET, facilities present in both databases were identified based on the AFS ID. (From NET, EPA took the State Federal Information Processing Standard (FIPS) code, county FIPS code, and plant ID and concatenated them to form an identification number equivalent to an AFS ID.) If stack height data for a given AFS ID were present in both databases, the data in AFS were kept for further analyses, and the data in NET were removed from further consideration. The NET database does not include an EPA ID for facilities, and thus specific facilities in common to TRI and NET cannot be identified, nor can the number of facilities in common be estimated.

3.2 STATE DATA

For three States not included in AFS (California, New York, and Wisconsin), EPA was able to obtain facility-specific data on stack heights. For California, 98 facilities matched TRI facilities; for New York, 279 facilities matched TRI facilities; and for Wisconsin, 44 facilities matched TRI facilities. Not all of these facilities contributed stack height data to the analysis, however, as not all facilities reported non-zero stack air releases for 1995. Again, note that although these facilities may also be present in the NET database, they cannot be identified as TRI facilities in NET because NET does not include an EPA ID for facilities.

4. ANALYSES OF STACK HEIGHT DATA IN AFS

4.1 IDENTIFICATION OF FACILITIES IN COMMON TO BOTH TRI AND AFS

To use facility-specific stack height data in the Indicators Model wherever possible, the Agency attempted to identify TRI facilities in AFS for those States that reported to AFS. The match was performed as follows. For the reporting facilities, the AFS database includes an EPA ID, the only facility identifier common to both the TRI and AFS databases. On a TRI Form R, a facility is asked to report up to four EPA IDs associated with the facility. EPA identified TRI forms with non-zero stack releases, obtained all EPA IDs reported by those facilities on their forms, and matched the TRI facilities with the AFS facilities by EPA ID. For the 1995 TRI reporting year, which, at the onset of this analysis, was the most recent year with TRI data available, there are 41,528 Forms R with non-zero stack releases, submitted by 13,204 facilities. These 13,204 facilities map to 12,106 EPA IDs. (Some TRI facilities do not have or do not report an EPA ID; others have more than one EPA ID. It is also possible for one EPA ID to match to more than one TRI ID.)

EPA identified 4,813 facilities in AFS that have primary 4-digit SIC codes in the range 2011 through 3999, not including Federal facilities, and that have stacks with non-zero stack height. EPA was able to link the 12,106 TRI EPA IDs to 1,231 AFS EPA IDs, albeit with some overlap, due to some TRI facilities having more than one EPA ID, and other TRI facilities sharing EPA IDs. After completing this analysis, EPA found 1,212 EPA IDs which represent 1,209 unique TRI facilities with non-zero stack heights in common to both AFS and TRI. In other words, about a quarter of the AFS facilities in the SIC code range required to report to TRI and with non-zero stack height can be found in TRI. Only about nine percent of TRI facilities with non-zero stack releases (1,209 of 13,204) are found in AFS with non-zero stack height. The low percent of matches can be explained by the following reasons:

- AFS data are not fully representative of all States;
- AFS reporting thresholds may exceed the threshold for reporting to TRI; and,
- AFS only covers 39 pollutant and pollutant classes that are either TRI chemicals or likely to contain TRI chemicals.

4.2 ANALYSIS OF STACK HEIGHT DATA BY CHEMICALS EMITTED AND SIC CODE

After identifying facilities in common to both AFS and TRI, EPA began investigating ways of estimating stack heights for TRI facilities *not* in AFS or in the three State databases. First, EPA identified 37,390 unique stacks in AFS associated with the 4,813 facilities listing their primary facility SIC code in the range 2011 through 3999, not including Federal facilities. The mean height of these stacks is 46.7 feet (14.2 meters). Based on the pollutants recorded in AFS as being emitted from these stacks, the Agency classified each of the 37,390 stacks as either "emitting a possible TRI chemical" or "not emitting a possible TRI chemical." The set of AFS pollutants that are classified as possible TRI chemicals for the purpose of this analysis are shown in Table 1. (It is important to note that the VOCs and other chemical classes may contain more than just TRI chemicals.) If at least one pollutant emitted from a stack was considered a possible TRI chemical, then the stack was designated as "emitting a possible TRI chemical". If none of the emitted pollutants were considered possible TRI chemicals, then the stack was designated as "not emitting a possible TRI chemical".

EPA then investigated the possibility that stack height varied by whether the stack emitted possible TRI chemicals or not. If stacks that do not emit possible TRI chemicals have different heights than stacks emitting possible TRI chemicals, then to include stacks that do not emit possible TRI chemicals in further analyses could bias the stack height results. Of the 37,390 stacks present, 16,889 (45.2%) emit pollutants considered as possible TRI chemicals. The remaining 20,501 emit only chemicals that are not considered as possible TRI chemicals from the AFS database. The mean height of those stacks emitting possible TRI chemicals is 46.9 feet (14.3 meters), with a standard deviation of 41.4 feet (12.6 meters). The mean height of the remaining stacks is 46.5 feet (14.2 meters), with a standard deviation of 35.4 feet (10.8 meters). The difference in the mean heights of these two groups of stacks is not statistically significant, as determined by using a Student's t-test to compare the means. (The Agency compared means, rather than medians, because the test of means is a more powerful statistical test than the test of medians. The more powerful test is better able to differentiate dissimilar groups.)

In the course of the above analysis, the Agency noticed substantial variability in stack height across primary SIC codes of facilities in AFS. Thus consideration was given to estimating stack height as a function of the SIC code of the facility. For 2-digit, 3-digit, and 4-digit SIC codes, EPA evaluated the mean stack heights for the two groups of stacks -- those emitting possible TRI chemicals and those that do not -- by testing the equality of the means by using a Student's t-test at the five percent level of significance. (The significance level refers to the probability of rejecting the null hypothesis that the means are equal when actually it should not be rejected; this is the probability of committing a Type I error.) For each SIC group, EPA used an F-test to check whether the variances of the two stack groups were different. If the variances were equal, EPA assumed the two groups were drawn from the same population, and a Student's t-test was used to compare the means. If the variances were not equal, EPA assumed the two groups were from two different populations, and therefore used a modified Student's t-test, accounting for the unequal variances, to compare the means. At the two-digit SIC code level, 14 SIC code groups indicated significant height differences between the two groups of stacks and six did not. At the 3-digit level, 55 SIC code groups indicated significant height differences between the two groups of stacks and 74 did not. At the four-digit level, 109 SIC groups indicated significant height differences between the two groups of stacks and 303 did not.

4.3 ANALYSIS OF OTHER FACILITY CHARACTERISTICS IN TRI USING AFS DATA

The Agency also tried to determine if certain facility characteristics tracked in TRI affect stack height. If stack heights vary in systematic ways with information available in TRI, that information could be used to refine estimates of stack height in the Indicators Model. Specifically, EPA examined the potential impact on stack height of TRI stack air release volumes and number of stacks present at the facility. The key hypothesis being tested was that facilities with larger TRI stack air releases or greater numbers of stacks would have taller stacks.

Eighteen ordinary least squares regressions were run, one for each two-digit SIC code in the range of 20 to 39. Eighteen regressions were estimated, instead of twenty, because there are no facilities with non-zero TRI stack air releases present in both TRI and AFS in SIC codes 21 and 23. The dependent variable was facility stack height, estimated as the median height of all stacks present at AFS facilities that could be linked to TRI facilities. Coefficients for two independent variables (and an intercept term) were estimated. The independent variables were: (a) stack air release volumes summed over all TRI chemicals at the facility; and (b) number of stacks indicated for the facility in AFS. Of the eighteen regressions estimated, only two (SIC codes 30 and 37) had stack air release coefficients statistically different from zero at the five percent level of significance. Based on the fact that most regressions resulted in no significant differences, the Agency concluded that the volume of TRI stack air releases and the total number of stacks at a facility are not significant determinants of stack height.

5. ANALYSES OF STACK HEIGHT DATA IN NET

As with AFS, EPA evaluated the possibility that stack heights within NET varied by whether the stack emitted possible TRI chemicals. Unlike AFS, NET does not record specific pollutants emitted from each stack. NET does, however, record annual VOC emissions from each stack. EPA identified 90,167 unique stacks in NET associated with 16,682 facilities listing their primary facility SIC code in the range 2011 through 3999, not including Federal facilities. The mean height of these stacks is 49.9 feet (15.2 meters). For the purposes of this analysis, the Agency labeled any stack with non-zero VOC emissions as a stack emitting possible TRI chemicals. Based on this definition, of the 90,167 stacks used in the analysis, 62,245 (69.0%) are classified as emitting possible TRI chemicals. The mean stack height of those stacks emitting possible TRI chemicals is 46.7 feet (14.2 meters), with a standard deviation of 47.8 feet (14.6 meters). The mean height of the remaining stacks is 57.0 feet (17.4 meters), with a standard deviation of 51.0 feet (15.6 meters). The difference in the mean heights of these two groups of stacks is statistically significant, as determined by using a Student's t-test to compare the means. (Recall that for AFS data, the comparable analysis found that the difference in the mean heights of the two groups of stacks was not statistically significant.)

6. IMPLEMENTATION OF RESULTS OF STATISTICAL ANALYSES IN THE INDICATORS MODEL

6.1 FACILITY-SPECIFIC STACK HEIGHTS

For the 421 California, New York, and Wisconsin facilities and the 1,209 facilities in common to the TRI and AFS databases, a representative stack height for each facility was estimated by calculating the *median* height for all of a facility's stacks with non-zero height. The median stack height was chosen rather than the mean because stack heights may not be normally distributed. No matter how the stack heights are distributed, the median is the appropriate measure of central tendency. For a facility with symmetrically-distributed stack heights, the median equals the mean. Therefore, for a given facility, the median of its stack heights was used as that facility's stack height in the Indicators Model.

6.2 ESTIMATED STACK HEIGHTS

For the remaining TRI facilities with non-zero stack releases for which facility-specific data were not available, stack heights were estimated from AFS and NET based on facility SIC codes. EPA decided that the 3-digit SIC code was the appropriate level at which to analyze and use stack height data. At the 2-digit level, differences between stacks emitting TRI chemicals and stacks not emitting TRI chemicals are often masked because the variance in each population is so large. From a practical standpoint, 2-digit SIC codes represent too gross a level of aggregation for purposes of estimating stack height. At the other extreme, 4-digit SIC codes offer too fine a level of disaggregation; not only might one not expect much difference in stack height between, say, a facility manufacturing creamery butter and a facility manufacturing natural, processed, and imitation cheese, but the number of observations at the 4-digit level are often too few to make a meaningful comparison of the two stack groups. Thus, the remaining TRI facilities were classified into 3-digit SIC code groups by the assigned primary SIC code in the TRI database (i.e., the leading three digits of the first 4-digit SIC code listed). Of the 13,204 TRI facilities reporting non-zero air releases in 1995, 84% reported only one unique 3-digit SIC code; 12% reported two unique 3-digit SIC codes; 3% reported three, 0.8% reported four, and 0.2% reported five.

EPA determined that of the 37,390 stacks being analyzed from AFS and the 90,167 stacks being analyzed from NET, there were 18,967 stacks in common to the two databases. To avoid double-counting these stacks in the analysis, the Agency used the stack height data from AFS for these stacks, and removed the corresponding NET data from further consideration. Augmenting the stacks from AFS with the non-duplicative stacks from NET resulted in a total of 108,590 stacks (37,390 from AFS and 71,200 from NET).

Each TRI facility within a 3-digit SIC code group was assigned the *median* stack height of the AFS and NET stacks within that 3-digit SIC group according to the following hierarchy:

1. If the combined AFS and NET stack height data for that 3-digit SIC code group indicated no statistically significant difference between the mean height of stacks emitting possible TRI chemicals and the mean height of stacks emitting non-TRI chemicals, then the median was estimated

over all stacks in that group, regardless of whether the stack emitted possible TRI chemicals. This median height was then used as the estimated stack height for all TRI facilities in the 3-digit SIC code group that did not have facility-specific data in AFS or in the three State databases.

2. If the AFS and NET stack height data for that 3-digit SIC code group *did* indicate a statistically significant difference between the mean height of stacks emitting possible TRI chemicals and the mean height of stacks emitting non-TRI chemicals, then the median for *only* those stacks emitting possible TRI chemicals was used as the estimated stack height for all TRI facilities in that 3-digit SIC code group.

In both approaches, the stack heights of facilities that occur in both TRI and AFS (i.e., facility-specific data) are included in the calculation of the median height of their 3-digit SIC code groups. State data are not included in these analyses because of the potential of double-counting with NET data, which includes data from California, New York, and Wisconsin. (Recall that NET facilities cannot be matched to TRI facilities because there is no facility identifier in common.) Table 2 presents the number of 3-digit SIC codes with median stack heights falling in particular stack height ranges for 139 of the 140 unique 3-digit SIC codes in the range 201 to 399. (No estimates of stack heights were available for facilities in SIC code 316, luggage manufacturing.) Note that the majority of SIC codes have median stack heights between 9.0 and 11.9 m; only one SIC code falls into each of the two highest ranges of stack heights.

Table A-1 in Appendix A indicates each 3-digit SIC code group in the range 201 to 399, the median stack height as estimated from the AFS and NET data, the estimation technique used (whether the median was calculated over all stacks or only those emitting possible TRI chemicals), and the number of 1995 TRI facilities using that value. Table A-1 also presents the median stack heights and the estimation technique used for 2-digit and 4-digit SIC codes within the ranges of 20 to 39 and 2011 to 3999, respectively.

Table 2 Median Stack Heights by SIC Code	
Range of Stack Heights (meters)	**Number of 3-Digit SIC Codes with Median Stack Height in Range**
6.0 to 6.9 m	7
7.0 to 7.9 m	13
8.0 to 8.9 m	13
9.0 to 9.9 m	37
10.0 to 10.9 m	25
11.0 to 11.9 m	11
12.0 to 12.9 m	14
13.0 to 13.9 m	2
14.0 to 14.9 m	2
15.0 to 15.9 m	3
16.0 to 16.9 m	2
17.0 to 17.9 m	0
18.0 to 18.9 m	2
19.0 to 19.9 m	2
20.0 to 24.9 m	4
25.0 to 29.9 m	1
30.0 to 39.9 m	1
TOTAL: 6.0 to 39.9 m	139

6.3 COMPARISON TO PRIOR ASSUMPTION OF 10 m STACK HEIGHT

In contrast to the previously assumed value of ten meters (32.8 feet), this modified approach using AFS, NET, and State data concludes that 6,173 facilities are estimated to have stack heights above ten meters, and 7,031 facilities are estimated to have stack heights below ten meters. The mean stack height for all TRI facilities reporting non-zero stack air releases is estimated to be 11.1 meters (36.5 feet), with a standard deviation of 5.00 meters (16.4 feet), and a median height of 9.14 meters (30.0) feet. Note that these stack heights are not very different than the previously assumed value of ten meters.

6.4 ESTIMATION OF STACK HEIGHTS FOR TRI FACILITIES WITH MISSING OR INVALID 3-DIGIT SIC CODES

Of the 13,204 TRI facilities with non-zero stack air releases reported in 1995, stack heights were estimated as described above for 13,021 facilities. The estimation approaches used included: 1,209 facilities estimated directly from AFS; 69 facilities estimated from California State data; 192 facilities estimated from New York State data; 37 facilities estimated from Wisconsin State data; and 11,514 estimated based on the facilities' 3-digit SIC code. The remaining 183 facilities (13,204 facilities minus 13,021 facilities) reported SIC codes outside the range of 201 to 399, at the 3-digit level, or reported no SIC code. (As noted previously, not all data provided by California, New York and Wisconsin were useable, because not all facilities reported non-zero stack air releases in 1995.) For these 183 facilities, a stack height was assigned based on either the 2-digit SIC code (if a valid one was available) or on the median stack height for all 108,590 stacks from AFS and NET. The median stack height for all 108,590 stacks from AFS and NET is 10.67 m (35.0 ft). This median stack height of 10.67 m for *stacks* should not be confused with the median height of 9.14 m for all TRI *facilities*, which is based on AFS, NET, and State data, as described in Section 6.3. The median stack height at the 2-digit SIC code level was calculated according to the hierarchy used for the 3-digit SIC code analysis, presented in Section 6.2. Stack heights were estimated at the 2-digit SIC code level for 27 facilities. The stack heights for the remaining 156 facilities were estimated using the median stack height of all 108,590 stacks (10.67 m). Two significant figures are used for all stack heights in the Indicators Model.

7. ANALYSES OF EXIT GAS VELOCITIES

7.1 FACILITY-SPECIFIC EXIT GAS VELOCITIES

An analysis similar to that performed for stack heights was conducted for exit gas velocities. Exit gas velocity data were available from AFS, NET, and the New York and Wisconsin databases. (Data from California did not include exit gas velocities.) For the 216 New York and Wisconsin facilities and the 850 facilities in common to the TRI and AFS databases with non-zero exit gas velocities, a representative exit gas velocity for each facility was estimated by calculating the *median* exit gas velocity for all of a facility's stacks with non-zero height and non-zero exit gas velocity. As was done for stack heights, the median exit gas velocity was chosen rather than the mean because exit gas velocities may not be normally distributed. No matter how the exit gas velocities are distributed, the median is the appropriate measure of central tendency. Therefore, for a given facility, the median of its exit gas velocities was used as that facility's exit gas velocity in the Indicators Model. As with the stack height analysis, not all facilities provided by New York and Wisconsin could be matched to TRI facilities with non-zero stack air releases.

7.2 ESTIMATED EXIT GAS VELOCITIES

For the remaining TRI facilities with non-zero stack releases and non-zero stack heights for which facility-specific data were not available, exit gas velocities were estimated from AFS and NET based on facility 3-digit SIC codes. As previously mentioned, EPA determined that of the 37,390 stacks being analyzed from AFS and the 90,167 stacks being analyzed from NET, there were 18,967 stacks in common to the two databases. To avoid double-counting these stacks in the analysis, the Agency used the exit gas velocity data from AFS for these stacks and removed the exit gas velocity data in NET from further consideration. Therefore, augmenting the stacks from AFS with the non-duplicative stacks from NET resulted in 108,590 stacks (37,390 from AFS and 71,200 from NET).

Each TRI facility within a 3-digit SIC code group was assigned the median exit gas velocity of the AFS and NET stacks within that 3-digit SIC group according to the following hierarchy:

1. If the combined AFS and NET stack height data for that 3-digit SIC code group indicated no statistically significant difference between the mean exit gas velocity of stacks emitting possible TRI chemicals and the mean exit gas velocity of stacks emitting non-TRI chemicals, then the median was estimated over all stacks in that group, regardless of whether the stack emitted possible TRI chemicals. This median exit gas velocity was then used as the estimated exit gas velocity for all TRI facilities in the 3-digit SIC code group that did not have facility-specific data in AFS or in the New York and Wisconsin databases.

2. If the AFS and NET exit gas velocity data for that 3-digit SIC code group *did* indicate a statistically significant difference between the mean exit gas velocity of stacks emitting possible TRI chemicals and the mean exit gas velocity of stacks emitting non-TRI chemicals, then the median for *only* those stacks emitting possible TRI chemicals was used as the estimated exit gas velocity for all TRI facilities in that 3-digit SIC code group.

In both approaches, the exit gas velocities of facilities that occur in both TRI and AFS (i.e., facility-specific data) are included in the calculation of the median exit gas velocity of their 3-digit SIC code groups. State data are not included in these analyses because of the potential of double-counting with NET data, which includes data from New York and Wisconsin. (Recall that NET facilities cannot be matched to TRI facilities because there is no facility identifier in common.) Table 3 presents the number of 3-digit SIC codes with median exit gas velocities falling in a particular exit gas velocity range for 137 of the 140 unique 3-digit SIC codes reported in TRI. (No estimates of exit gas velocities were available for facilities in SIC codes 236 (girls', children's, and infants' outerwear), 316 (luggage manufacturing), and 317 (handbags and other personal leather goods).) Note that for all 3-digit SIC codes in the range of 201 to 399, the median exit gas velocity is greater than or equal to 4.0 m/sec.

Table 3 Median Exit Gas Velocities by SIC Code	
Range of Exit Gas Velocities (m/sec)	**Number of 3-Digit SIC Codes with Median Exit Gas Velocity in Range**
4.0 to 4.9 m/sec	3
5.0 to 5.9 m/sec	4
6.0 to 6.9 m/sec	4
7.0 to 7.9 m/sec	12
8.0 to 8.9 m/sec	44
9.0 to 9.9 m/sec	26
10.0 to 10.9 m/sec	26
11.0 to 11.9 m/sec	8
12.0 to 12.9 m/sec	7
13.0 to 13.9 m/sec	1
14.0 to 14.9 m/sec	2
TOTAL:	137

7.3 COMPARISON TO PRIOR ASSUMPTION OF 0.01 m/sec EXIT GAS VELOCITY

The mean exit gas velocity for all TRI facilities reporting non-zero stack air releases is estimated to be 9.92 meters per second (32.5 feet per second), with a standard deviation of 11.0 meters per second (36.0 feet per second), and a median exit gas velocity of 8.90 meters per second (29.2 feet per second). Note that these exit gas velocities are quite different than the previously assumed value of 0.01 meters per second. Of the 13,204 TRI facilities with non-zero stack air releases in 1995, 13,192 are estimated to have exit gas velocities above 0.01 meters per second. Only twelve facilities are estimated to have exit gas velocities less than or equal to 0.01 meters per second.

7.4 ESTIMATION OF EXIT GAS VELOCITIES FOR TRI FACILITIES WITH MISSING OR INVALID 3-DIGIT SIC CODES

Of the 13,204 TRI facilities with non-zero stack air releases reported in 1995, exit gas velocities were estimated for 13,016 facilities. The estimation approaches used included: 850 facilities estimated directly from AFS; 192 facilities estimated from New York State data; 24 facilities estimated from Wisconsin State data; and 11,950 estimated based on the facilities' 3-digit SIC code. The remaining 188 facilities (13,204 facilities minus 13,016 facilities) reported SIC codes outside the range of 201 to 399, at the 3-digit level, or reported no SIC code. For these facilities, an exit gas velocity was assigned based on either the 2-digit SIC code (if a valid one was available) or on the median exit gas velocity for all 108,590 stacks. The median exit gas velocity for all 108,590 stacks from AFS and NET is 8.80 m/sec (28.9 ft/sec). This median exit gas velocity of 8.80 m/sec for *stacks* should not be confused with the median exit gas velocity of 8.90 m/sec for all TRI *facilities*, described in Section 7.3. The median exit gas velocity at the 2-digit SIC code level was calculated according to the hierarchy used for the 3-digit SIC code analysis, presented in Section 7.2. Table A-2 in Appendix A indicates each 3-digit SIC code group present in TRI, the median exit gas velocity as estimated from the AFS and NET data, the estimation technique used (whether the median was calculated over all stacks or only those emitting possible TRI chemicals), and the number of 1995 TRI facilities using that value. Table A-2 also presents the median exit gas velocities and the estimation technique used for 2-digit and 4-digit SIC codes, within the ranges of 20 to 39 and 2011 to 3999, respectively. Two significant figures are used for all exit gas velocities in the Indicators Model.

8. REFERENCES

Bouwes, Sr., N.W., and S.M. Hassur. 1998. Ground-Truthing of the Air Pathway Component of OPPT's Risk-Screening Environmental Indicators Model. U.S. EPA, Office of Pollution Prevention and Toxics, Economics, Exposure, and Technology Division. October. Draft.

APPENDIX A

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 20	2837	13.72	5034	15.54	Unequal	13.72	2837	
SIC 201	307	11.28	67	9.75	Equal	10.97	374	34
SIC 2011	153	11.28	35	9.14	Equal	10.67	188	
SIC 2013	108	12.19	19	10.67	Equal	12.19	127	
SIC 2015	46	9.91	12	11.13	Equal	10.06	58	
SIC 2017			1	9.14	N/A***			
SIC 202	213	14.94	147	13.72	Equal	14.63	360	17
SIC 2021	15	12.19	9	15.24	Equal	12.80	24	
SIC 2022	72	14.33	51	13.72	Equal	14.02	123	
SIC 2023	103	18.29	63	18.29	Equal	18.29	166	
SIC 2024	1	12.19	5	10.06	Unequal	12.19	1	
SIC 2026	22	12.80	19	9.75	Equal	10.36	41	
SIC 203	232	12.19	150	12.19	Equal	12.19	382	18
SIC 2032	6	11.89	3	6.10	Equal	11.58	9	
SIC 2033	142	12.19	67	11.58	Equal	11.89	209	
SIC 2034	2	18.29			N/A***	18.29	2	
SIC 2035	10	7.62	11	12.19	Equal	11.58	21	
SIC 2037	59	16.76	64	12.19	Equal	12.19	123	
SIC 2038	13	8.53	5	11.89	Equal	10.82	18	
SIC 204	501	17.07	2795	18.29	Equal	18.29	3296	86
SIC 2041	58	16.31	480	20.12	Equal	20.12	538	
SIC 2042			5	9.14	N/A***			
SIC 2043	105	22.56	666	23.77	Equal	23.47	771	
SIC 2044			16	22.86	N/A***			
SIC 2045	11	10.67	28	12.19	Equal	12.19	39	
SIC 2046	135	27.43	846	18.29	Equal	18.29	981	
SIC 2047	44	12.19	159	15.24	Unequal	12.19	44	
SIC 2048	148	10.36	595	12.19	Equal	12.19	743	
SIC 205	355	11.58	211	11.89	Unequal	11.58	355	17
SIC 2051	286	10.97	131	10.06	Equal	10.97	417	
SIC 2052	69	11.89	80	15.39	Unequal	11.89	69	
SIC 206	284	19.81	463	17.07	Equal	18.29	747	34
SIC 2061	77	22.86	41	23.16	Unequal	22.86	77	
SIC 2062	50	39.62	83	20.73	Equal	22.86	133	
SIC 2063	67	19.81	81	18.29	Equal	18.90	148	
SIC 2064	16	13.26	86	9.60	Equal	11.13	102	
SIC 2065	1	17.37	1	2.13	Unequal	17.37	1	
SIC 2066	19	14.33	69	13.72	Equal	13.87	88	
SIC 2067	25	13.11	79	18.90	Equal	13.11	104	
SIC 2068	29	8.84	23	9.14	Equal	9.14	52	
SIC 207	209	13.72	570	15.24	Equal	15.24	779	85
SIC 2074	11	12.19	23	12.19	Equal	12.19	34	
SIC 2075	100	15.24	482	15.24	Equal	15.24	582	
SIC 2076	13	18.29	17	12.19	Equal	12.19	30	
SIC 2077	63	12.19	30	11.89	Equal	12.19	93	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 2079	22	14.78	18	17.53	Equal	15.70	40	
SIC 208	437	17.98	273	15.24	Equal	16.46	710	30
SIC 2082	275	21.34	144	15.54	Equal	18.59	419	
SIC 2083	12	24.54	51	18.29	Equal	19.51	63	
SIC 2084	6	11.73	2	15.24	Equal	12.95	8	
SIC 2085	102	17.98	26	35.81	Unequal	17.98	102	
SIC 2086	21	9.14	13	10.67	Equal	9.45	34	
SIC 2087	21	10.36	37	10.06	Equal	10.06	58	
SIC 209	299	12.19	358	12.19	Equal	12.19	657	22
SIC 2091	33	12.80	12	15.85	Equal	13.11	45	
SIC 2092	8	12.19	1	12.19	Unequal	12.19	8	
SIC 2095	55	18.29	105	18.29	Equal	18.29	160	
SIC 2096	19	15.24	17	17.68	Equal	15.24	36	
SIC 2098	6	9.14	11	12.80	Unequal	9.14	6	
SIC 2099	178	11.43	212	10.67	Equal	10.67	390	
SIC 21	160	18.14	48	9.14	Equal	17.98	208	
SIC 211	101	20.73	23	15.85	Equal	19.96	124	20
SIC 2111	101	20.73	23	15.85	Equal	19.96	124	
SIC 212	9	10.97	11	9.14	Equal	9.14	20	1
SIC 2121	9	10.97	11	9.14	Equal	9.14	20	
SIC 213	15	12.19	8	8.99	Equal	10.67	23	1
SIC 2131	15	12.19	8	8.99	Equal	10.67	23	
SIC 214	35	15.24	6	9.75	Equal	15.24	41	4
SIC 2141	35	15.24	6	9.75	Equal	15.24	41	
SIC 22	1049	11.89	247	18.29	Unequal	11.89	1049	
SIC 221	101	15.24	28	20.73	Unequal	15.24	101	20
SIC 2211	101	15.24	28	20.73	Unequal	15.24	101	
SIC 222	74	11.73	15	10.36	Equal	10.67	89	13
SIC 2221	74	11.73	15	10.36	Equal	10.67	89	
SIC 223	38	10.52	12	21.95	Unequal	10.52	38	3
SIC 2231	38	10.52	12	21.95	Unequal	10.52	38	
SIC 224	15	11.89	3	21.03	Unequal	11.89	15	1
SIC 2241	15	11.89	3	21.03	Unequal	11.89	15	
SIC 225	86	9.14	26	12.34	Equal	10.67	112	14
SIC 2251	7	12.19	3	2.74	Equal	10.67	10	
SIC 2252			2	3.81	N/A***			

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 2253	46	9.14	7	10.36	Equal	10.36	53	
SIC 2254	2	17.07	1	42.67	Unequal	17.07	2	
SIC 2257	18	5.79			N/A***	5.79	18	
SIC 2258	12	8.69	9	15.24	Unequal	8.69	12	
SIC 2259	1	12.80	4	15.24	Unequal	12.80	1	
SIC 226	323	12.19	59	20.73	Unequal	12.19	323	70
SIC 2261	133	11.58	19	22.86	Unequal	11.58	133	
SIC 2262	137	12.19	25	20.73	Equal	12.80	162	
SIC 2269	53	12.19	15	20.73	Unequal	12.19	53	
SIC 227	18	8.38	23	25.91	Unequal	8.38	18	26
SIC 2273	18	8.38	23	25.91	Unequal	8.38	18	
SIC 228	105	7.62	36	17.53	Unequal	7.62	105	15
SIC 2281	25	12.19	29	15.85	Equal	15.24	54	
SIC 2282	5	15.24	1	13.72	Unequal	15.24	5	
SIC 2284	75	5.49	6	25.30	Unequal	5.49	75	
SIC 229	289	11.58	45	14.63	Unequal	11.58	289	67
SIC 2291	3	10.97	4	7.62	Equal	9.75	7	
SIC 2295	156	11.58	19	14.63	Unequal	11.58	156	
SIC 2296	27	18.59	3	22.56	Equal	18.59	30	
SIC 2298	68	15.70	13	9.75	Equal	12.50	81	
SIC 2297	11	10.36	1	27.13	Unequal	10.36	11	
SIC 2299	24	11.58	5	20.73	Equal	12.80	29	
SIC 23	138	9.75	31	9.14	Equal	9.14	169	
SIC 231	3	8.84			N/A***	8.84	3	0
SIC 2311	3	8.84			N/A***	8.84	3	
SIC 232	28	11.73	7	9.14	Equal	10.67	35	1
SIC 2321	6	12.19	1	15.24	Unequal	12.19	6	
SIC 2322	8	14.63	3	9.14	Equal	10.67	11	
SIC 2325	7	12.19			N/A***	12.19	7	
SIC 2326	2	11.28			N/A***	11.28	2	
SIC 2329	5	10.67	3	9.14	Equal	9.75	8	
SIC 233	19	10.97	3	10.97	Equal	10.97	22	1
SIC 2335	10	10.97			N/A***	10.97	10	
SIC 2337	1	3.66			N/A***	3.66	1	
SIC 2339	8	6.86	3	10.97	Unequal	6.86	8	
SIC 234	8	7.77			N/A***	7.77	8	0
SIC 2341	6	8.99			N/A***	8.99	6	
SIC 2342	2	6.86			N/A***	6.86	2	
SIC 235	21	6.40	3	15.24	Equal	7.16	24	5
SIC 2353	21	6.40	3	15.24	Equal	7.16	24	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 236	3	6.10			N/A***	6.10	3	0
SIC 2369	3	6.10			N/A***	6.10	3	
SIC 237	1	6.10			N/A***	6.10	1	0
SIC 2371	1	6.10			N/A***	6.10	1	
SIC 238	7	7.92	1	5.79	Equal	7.77	8	6
SIC 2384	6	8.08			N/A***	8.08	6	
SIC 2385	1	7.92			N/A***	7.92	1	
SIC 2387			1	5.79	N/A***			
SIC 239	48	10.82	17	9.14	Equal	9.14	65	11
SIC 2391			1	4.88	N/A***			
SIC 2392	13	27.43	11	9.14	Equal	11.58	24	
SIC 2394	2	11.28			N/A***	11.28	2	
SIC 2396	29	8.84	3	9.14	Equal	9.14	32	
SIC 2399	4	6.86	2	6.55	Equal	6.71	6	
SIC 24	1771	10.97	1076	11.89	Equal	10.97	2847	
SIC 241	6	8.08	5	12.19	Equal	10.06	11	0
SIC 2411	6	8.08	5	12.19	Equal	10.06	11	
SIC 242	463	13.72	303	12.19	Equal	13.11	766	17
SIC 2421	342	14.94	233	12.19	Equal	13.72	575	
SIC 2426	115	11.58	62	11.43	Equal	11.58	177	
SIC 2429	6	22.10	8	16.61	Equal	17.68	14	
SIC 243	728	9.45	371	10.67	Equal	10.06	1099	142
SIC 2431	171	9.14	111	10.67	Equal	9.45	282	
SIC 2434	302	8.23	57	9.14	Equal	8.53	359	
SIC 2435	78	13.72	39	9.14	Equal	12.19	117	
SIC 2436	163	14.63	158	12.19	Equal	13.72	321	
SIC 2439	14	14.94	6	19.05	Equal	16.00	20	
SIC 244	24	12.04	18	7.32	Equal	9.14	42	1
SIC 2441	3	23.77	3	7.32	Equal	8.69	6	
SIC 2448	8	11.43	6	6.71	Equal	10.06	14	
SIC 2449	13	12.19	9	8.53	Equal	9.14	22	
SIC 245	22	8.38	9	4.88	Equal	7.01	31	3
SIC 2451	20	7.62	8	4.88	Equal	6.86	28	
SIC 2452	2	10.67	1	0.30	Unequal	10.67	2	
SIC 249	528	11.13	370	12.19	Equal	11.89	898	254
SIC 2491	66	9.30	31	9.75	Equal	9.45	97	
SIC 2493	158	14.94	242	13.72	Equal	14.02	400	
SIC 2499	304	9.14	97	10.67	Equal	9.75	401	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 25	2355	9.14	922	9.45	Equal	9.14	3277	
SIC 251	1454	9.14	375	9.14	Equal	9.14	1829	249
SIC 2511	1087	9.75	285	9.14	Equal	9.14	1372	
SIC 2512	170	9.14	39	10.67	Equal	9.45	209	
SIC 2514	95	8.23	30	8.84	Equal	8.53	125	
SIC 2515	11	6.10	2	11.58	Equal	11.58	13	
SIC 2517	43	7.62	15	4.57	Equal	6.71	58	
SIC 2519	48	6.10	4	19.20	Equal	6.55	52	
SIC 252	364	10.21	255	11.58	Equal	10.97	619	66
SIC 2521	174	10.06	97	12.19	Equal	11.58	271	
SIC 2522	190	10.67	158	10.97	Equal	10.97	348	
SIC 253	157	9.45	106	9.45	Unequal	9.45	157	23
SIC 2531	157	9.45	106	9.45	Unequal	9.45	157	
SIC 254	216	9.14	95	7.62	Equal	8.23	311	43
SIC 2541	99	7.92	34	7.62	Equal	7.92	133	
SIC 2542	117	9.14	61	7.62	Equal	9.14	178	
SIC 259	164	8.53	91	7.62	Equal	8.23	255	32
SIC 2591	40	7.62	17	7.62	Equal	7.62	57	
SIC 2599	124	8.53	74	7.77	Equal	8.53	198	
SIC 26	2858	14.02	1153	18.90	Unequal	14.02	2858	
SIC 261	284	42.98	195	35.05	Equal	38.10	479	86
SIC 2611	284	42.98	195	35.05	Equal	38.10	479	
SIC 262	952	23.77	385	22.86	Equal	23.47	1337	89
SIC 2621	952	23.77	385	22.86	Equal	23.47	1337	
SIC 263	262	28.96	180	27.43	Equal	28.96	442	42
SIC 2631	262	28.96	180	27.43	Equal	28.96	442	
SIC 264	47	13.72	1	10.67	Equal	13.41	48	7
SIC 2641	38	14.02			N/A***	14.02	38	
SIC 2646	4	13.72			N/A***	13.72	4	
SIC 2647	2	27.43			N/A***	27.43	2	
SIC 2649	3	8.23	1	10.67	Unequal	8.23	3	
SIC 265	443	9.75	124	10.52	Equal	10.06	567	25
SIC 2651								
SIC 2652	19	10.97	2	13.87	Equal	11.28	21	
SIC 2653	175	10.67	69	10.67	Equal	10.67	244	
SIC 2655	38	9.14	10	8.08	Equal	9.14	48	
SIC 2656	84	10.06	15	9.75	Equal	10.06	99	
SIC 2657	127	9.14	28	14.94	Unequal	9.14	127	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 267	870	9.14	268	10.67	Unequal	9.14	870	126
SIC 2671	351	9.14	100	10.67	Equal	9.14	451	
SIC 2672	188	10.06	60	9.14	Equal	9.75	248	
SIC 2673	108	7.92	11	7.62	Equal	7.62	119	
SIC 2674	30	7.92	7	9.14	Equal	7.92	37	
SIC 2675	20	15.70	1	5.79	Unequal	15.70	20	
SIC 2676	31	12.80	16	10.67	Equal	12.50	47	
SIC 2677	14	7.92	2	9.14	Equal	9.14	16	
SIC 2678	10	5.79	1	6.40	Unequal	5.79	10	
SIC 2679	118	10.06	70	14.63	Equal	11.89	188	
SIC 27	2348	9.14	364	10.67	Unequal	9.14	2348	
SIC 271	83	14.94	2	18.75	Equal	14.94	85	1
SIC 2711	83	14.94	2	18.75	Equal	14.94	85	
SIC 272	52	10.21	17	12.19	Unequal	10.21	52	0
SIC 2721	52	10.21	17	12.19	Unequal	10.21	52	
SIC 273	248	11.58	81	14.63	Unequal	11.58	248	4
SIC 2731	74	11.58	7	9.14	Equal	10.97	81	
SIC 2732	174	11.58	74	15.24	Unequal	11.58	174	
SIC 274	25	8.84	6	10.36	Equal	8.84	31	0
SIC 2741	25	8.84	6	10.36	Equal	8.84	31	
SIC 275	1796	9.14	231	10.06	Unequal	9.14	1796	139
SIC 2751	30	9.60	6	8.23	Equal	9.14	36	
SIC 2752	841	9.75	111	10.67	Unequal	9.75	841	
SIC 2754	409	9.14	58	11.13	Unequal	9.14	409	
SIC 2759	516	8.84	56	7.62	Equal	8.53	572	
SIC 276	52	10.36	11	7.32	Equal	9.14	63	3
SIC 2761	52	10.36	11	7.32	Equal	9.14	63	
SIC 277	39	7.62			N/A***	7.62	39	1
SIC 2771	39	7.62			N/A***	7.62	39	
SIC 278	26	9.45	3	12.19	Equal	9.75	29	1
SIC 2782	16	10.06	2	9.60	Equal	10.06	18	
SIC 2789	10	9.14	1	18.29	Unequal	9.14	10	
SIC 279	27	7.62	13	7.92	Equal	7.77	40	23
SIC 2791	3	7.92	10	7.92	Equal	7.92	13	
SIC 2796	24	7.32	3	7.32	Equal	7.32	27	
SIC 28	20449	9.14	6914	13.72	Unequal	9.14	20449	
SIC 281	1306	13.11	1544	16.46	Unequal	13.11	1306	366

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 2812	187	15.24	116	14.63	Equal	14.63	303	
SIC 2813	190	9.14	61	13.41	Unequal	9.14	190	
SIC 2816	71	21.34	301	18.29	Equal	18.29	372	
SIC 2819	858	13.72	1066	16.76	Unequal	13.72	858	
SIC 282	3553	11.89	877	14.63	Unequal	11.89	3553	389
SIC 2821	2450	12.19	735	13.72	Unequal	12.19	2450	
SIC 2822	732	8.69	40	14.94	Unequal	8.69	732	
SIC 2823	38	12.19	12	12.50	Equal	12.19	50	
SIC 2824	333	18.29	90	18.14	Equal	18.29	423	
SIC 283	1029	13.11	584	11.28	Equal	12.19	1613	145
SIC 2831			3	12.19	N/A***			
SIC 2833	361	15.24	164	10.67	Equal	13.72	525	
SIC 2834	664	12.19	414	11.73	Equal	12.19	1078	
SIC 2835	3	10.67	1	9.45	Unequal	10.67	3	
SIC 2836	1	5.18	2	12.50	Unequal	5.18	1	
SIC 284	502	7.92	417	16.46	Unequal	7.92	502	180
SIC 2841	184	13.11	317	19.81	Equal	17.98	501	
SIC 2842	45	9.14	29	10.36	Equal	9.14	74	
SIC 2843	205	4.88	48	4.72	Equal	4.88	253	
SIC 2844	68	9.14	23	11.28	Unequal	9.14	68	
SIC 285	702	8.84	257	9.14	Unequal	8.84	702	400
SIC 2851	702	8.84	257	9.14	Unequal	8.84	702	
SIC 286	11353	7.62	1815	12.19	Unequal	7.62	11353	428
SIC 2861	122	14.02	35	14.63	Equal	14.02	157	
SIC 2865	462	12.19	202	13.11	Equal	12.19	664	
SIC 2869	10769	7.62	1578	12.19	Unequal	7.62	10769	
SIC 287	736	12.19	625	21.34	Unequal	12.19	736	205
SIC 2873	249	18.29	237	23.47	Unequal	18.29	249	
SIC 2874	104	11.89	222	26.67	Unequal	11.89	104	
SIC 2875	9	10.67	17	6.10	Equal	9.60	26	
SIC 2879	374	9.14	149	11.89	Equal	9.45	523	
SIC 289	1268	7.62	795	12.50	Unequal	7.62	1268	397
SIC 2891	227	10.06	142	10.97	Equal	10.67	369	
SIC 2892	172	15.24	130	14.78	Equal	15.24	302	
SIC 2893	77	7.92	21	10.67	Unequal	7.92	77	
SIC 2895	106	24.99	222	21.34	Equal	24.08	328	
SIC 2899	686	6.10	280	10.82	Unequal	6.10	686	
SIC 29	8960	12.19	2247	13.72	Unequal	12.19	8960	
SIC 291	7373	12.19	1320	30.18	Unequal	12.19	7373	146
SIC 2911	7373	12.19	1320	30.18	Unequal	12.19	7373	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 295	1423	9.14	846	9.14	Unequal	9.14	1423	30
SIC 2951	1078	9.14	699	9.14	Equal	9.14	1777	
SIC 2952	345	7.62	147	10.67	Unequal	7.62	345	
SIC 299	164	10.67	81	13.41	Unequal	10.67	164	64
SIC 2992	71	7.62	20	9.75	Equal	8.84	91	
SIC 2999	93	13.11	61	14.63	Unequal	13.11	93	
SIC 30	2738	9.14	1251	9.75	Unequal	9.14	2738	
SIC 301	228	9.75	187	10.67	Unequal	9.75	228	55
SIC 3011	228	9.75	187	10.67	Unequal	9.75	228	
SIC 302	10	8.08			N/A***	8.08	10	4
SIC 3021	10	8.08			N/A***	8.08	10	
SIC 304	8	7.62			N/A***	7.62	8	3
SIC 3041	8	7.62			N/A***	7.62	8	
SIC 305	142	8.23	61	9.75	Unequal	8.23	142	60
SIC 3052	45	6.40	13	9.75	Equal	7.32	58	
SIC 3053	97	9.14	48	9.75	Equal	9.14	145	
SIC 306	546	9.14	283	9.14	Equal	9.14	829	178
SIC 3061	21	9.14	27	10.97	Equal	10.67	48	
SIC 3069	525	9.14	256	9.14	Equal	9.14	781	
SIC 307	106	7.92	69	9.14	Equal	8.23	175	53
SIC 3079	106	7.92	69	9.14	Equal	8.23	175	
SIC 308	1698	9.14	651	9.14	Equal	9.14	2349	765
SIC 3081	204	10.36	33	7.62	Equal	9.14	237	
SIC 3082	26	8.53	2	7.47	Equal	8.53	28	
SIC 3083	80	9.14	13	9.14	Equal	9.14	93	
SIC 3084	8	5.33	8	9.14	Equal	6.10	16	
SIC 3085	235	10.36	46	17.83	Unequal	10.36	235	
SIC 3086	209	9.14	83	8.84	Equal	8.84	292	
SIC 3087	125	9.45	134	9.75	Equal	9.45	259	
SIC 3088	46	7.62	5	7.62	Equal	7.62	51	
SIC 3089	765	9.14	327	9.14	Equal	9.14	1092	
SIC 31	272	10.06	116	8.38	Equal	9.75	388	
SIC 311	158	12.19	49	16.46	Unequal	12.19	158	23
SIC 3111	158	12.19	49	16.46	Unequal	12.19	158	
SIC 313	16	6.10	1	7.32	Equal	6.10	17	1
SIC 3131	16	6.10	1	7.32	Unequal	6.10	16	
SIC 314	90	6.40	64	7.32	Equal	7.16	154	17

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 3143	65	7.32	46	7.32	Equal	7.32	111	
SIC 3144	7	6.10			N/A***	6.10	7	
SIC 3149	18	4.88	18	7.01	Equal	6.86	36	
SIC 315	1	6.71	2	12.19	Equal	6.71	3	0
SIC 3151	1	6.71	2	12.19	Unequal	6.71	1	
SIC 317	1	19.51			N/A***	19.51	1	1
SIC 3172	1	19.51			N/A***	19.51	1	
SIC 319	6	6.40			N/A***	6.40	6	0
SIC 3199	6	6.40			N/A***	6.40	6	
SIC 32	2006	12.19	4639	12.19	Equal	12.19	6645	
SIC 321	60	20.57	68	9.91	Equal	12.80	128	7
SIC 3211	60	20.57	68	9.91	Equal	12.80	128	
SIC 322	300	22.86	190	17.22	Equal	20.42	490	57
SIC 3221	154	23.32	107	15.24	Equal	20.12	261	
SIC 3229	146	19.66	83	21.34	Equal	21.34	229	
SIC 323	95	9.14	37	10.36	Equal	9.91	132	23
SIC 3231	95	9.14	37	10.36	Equal	9.91	132	
SIC 324	117	32.00	1198	19.81	Equal	21.34	1315	48
SIC 3241	117	32.00	1198	19.81	Equal	21.34	1315	
SIC 325	261	9.75	380	9.14	Equal	9.14	641	70
SIC 3251	111	9.14	70	9.14	Equal	9.14	181	
SIC 3253	55	12.50	93	10.06	Equal	10.67	148	
SIC 3255	92	10.67	196	9.14	Equal	9.14	288	
SIC 3259	3	11.58	21	2.13	Equal	4.88	24	
SIC 326	119	10.67	94	9.14	Equal	9.45	213	27
SIC 3261	16	8.08	19	9.14	Equal	8.23	35	
SIC 3262			1	9.14	N/A***			
SIC 3263	1	4.88			N/A***	4.88	1	
SIC 3264	82	12.50	27	13.41	Unequal	12.50	82	
SIC 3269	20	8.38	47	7.32	Equal	7.62	67	
SIC 327	420	12.04	1416	11.13	Equal	11.58	1836	12
SIC 3271	26	7.16	44	7.16	Equal	7.16	70	
SIC 3272	75	6.10	184	11.58	Unequal	6.10	75	
SIC 3273	103	9.14	556	9.45	Equal	9.45	659	
SIC 3274	65	21.95	307	12.50	Equal	15.24	372	
SIC 3275	151	15.24	325	15.85	Equal	15.85	476	
SIC 328	19	6.71	26	6.10	Equal	6.10	45	8

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 3281	19	6.71	26	6.10	Equal	6.10	45	
SIC 329	615	12.19	1230	12.19	Equal	12.19	1845	123
SIC 3291	88	10.52	107	9.14	Equal	9.45	195	
SIC 3292	36	11.73	53	18.29	Unequal	11.73	36	
SIC 3293	6	10.67	2	12.80	Equal	10.67	8	
SIC 3295	179	12.19	780	12.19	Equal	12.19	959	
SIC 3296	193	13.72	153	14.02	Equal	13.72	346	
SIC 3297	70	12.19	104	9.14	Equal	10.67	174	
SIC 3299	43	7.62	31	21.95	Unequal	7.62	43	
SIC 33	3909	13.11	5112	12.19	Equal	12.50	9021	
SIC 331	1152	24.38	1377	22.25	Equal	22.86	2529	228
SIC 3312	912	30.48	1128	24.99	Equal	26.82	2040	
SIC 3313	13	23.47	43	12.19	Equal	12.19	56	
SIC 3315	57	11.58	59	10.67	Equal	10.97	116	
SIC 3316	59	17.07	89	11.28	Equal	13.72	148	
SIC 3317	111	7.62	58	9.75	Equal	9.14	169	
SIC 332	925	11.58	1778	10.67	Equal	10.97	2703	222
SIC 3321	733	11.89	1352	10.97	Equal	11.58	2085	
SIC 3322	18	10.97	157	12.19	Unequal	10.97	18	
SIC 3324	12	8.23	54	7.92	Equal	7.92	66	
SIC 3325	162	10.67	215	9.14	Equal	9.75	377	
SIC 333	414	16.15	570	16.46	Equal	16.31	984	55
SIC 3331	43	12.19	72	14.48	Equal	13.72	115	
SIC 3334	307	17.68	404	17.68	Equal	17.68	711	
SIC 3339	64	10.97	94	15.09	Equal	12.34	158	
SIC 334	305	12.19	380	11.28	Equal	12.19	685	138
SIC 3341	305	12.19	380	11.28	Equal	12.19	685	
SIC 335	624	12.50	384	12.19	Equal	12.19	1008	220
SIC 3351	74	12.50	80	10.67	Equal	11.13	154	
SIC 3353	227	14.33	84	14.63	Equal	14.63	311	
SIC 3354	99	11.89	44	8.53	Equal	10.67	143	
SIC 3355	23	14.33	16	16.31	Unequal	14.33	23	
SIC 3356	16	11.89	70	14.17	Unequal	11.89	16	
SIC 3357	185	10.97	90	10.67	Equal	10.97	275	
SIC 336	305	9.14	355	8.53	Equal	9.14	660	213
SIC 3361	5	9.14	17	7.32	Equal	7.32	22	
SIC 3362	6	9.60	16	7.77	Equal	8.08	22	
SIC 3363	114	9.30	99	12.19	Unequal	9.30	114	
SIC 3364	8	9.60	10	8.53	Equal	8.84	18	
SIC 3365	111	10.67	112	7.62	Equal	8.53	223	
SIC 3366	18	7.92	57	7.62	Equal	7.92	75	
SIC 3369	43	6.10	44	11.28	Equal	7.62	87	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 339	184	9.45	268	9.14	Equal	9.14	452	111
SIC 3398	86	9.14	112	8.84	Equal	8.84	198	
SIC 3399	98	9.45	156	9.14	Equal	9.14	254	
SIC 34	4406	9.45	2209	9.14	Equal	9.14	6615	
SIC 341	776	12.19	168	11.58	Equal	11.89	944	185
SIC 3411	609	12.80	131	11.58	Equal	12.19	740	
SIC 3412	167	9.14	37	9.14	Equal	9.14	204	
SIC 342	266	8.99	227	7.62	Equal	7.92	493	70
SIC 3421	19	11.89			N/A***	11.89	19	
SIC 3423	77	7.92	73	6.10	Equal	7.62	150	
SIC 3425	7	10.67	2	21.64	Unequal	10.67	7	
SIC 3429	163	9.14	152	7.92	Equal	7.92	315	
SIC 343	70	9.14	91	9.14	Equal	9.14	161	36
SIC 3431	4	18.44	29	10.67	Equal	10.67	33	
SIC 3432	19	9.14	46	9.14	Equal	9.14	65	
SIC 3433	47	8.84	16	11.58	Equal	9.14	63	
SIC 344	615	9.14	251	9.14	Equal	9.14	866	181
SIC 3441	96	11.28	53	7.92	Equal	9.14	149	
SIC 3442	139	9.14	38	8.99	Unequal	9.14	139	
SIC 3443	89	7.62	59	8.23	Equal	7.92	148	
SIC 3444	148	9.60	67	10.36	Equal	10.06	215	
SIC 3446	36	10.06	8	7.62	Equal	9.75	44	
SIC 3448	52	9.60	18	10.67	Equal	10.36	70	
SIC 3449	55	9.45	8	5.94	Equal	9.14	63	
SIC 345	97	9.14	97	9.14	Equal	9.14	194	45
SIC 3451	26	7.92	14	9.91	Equal	8.69	40	
SIC 3452	71	9.14	83	8.84	Equal	9.14	154	
SIC 346	422	10.36	288	12.19	Unequal	10.36	422	150
SIC 3462	54	10.67	133	12.19	Equal	12.19	187	
SIC 3463	10	8.08	6	9.14	Equal	8.69	16	
SIC 3465	79	10.97	40	12.19	Equal	11.28	119	
SIC 3466	39	10.06	19	9.75	Equal	9.75	58	
SIC 3469	240	9.91	90	10.67	Unequal	9.91	240	
SIC 347	1275	9.14	711	7.92	Equal	8.53	1986	479
SIC 3471	411	9.14	437	7.92	Equal	8.53	848	
SIC 3479	864	9.14	274	7.92	Equal	8.84	1138	
SIC 348	222	10.52	43	9.14	Equal	10.06	265	26
SIC 3482	13	10.06	2	3.66	Equal	8.53	15	
SIC 3483	100	9.14	19	11.89	Unequal	9.14	100	
SIC 3484	18	10.21	1	8.23	Unequal	10.21	18	
SIC 3489	91	12.19	21	8.23	Equal	10.67	112	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 349	663	9.14	333	8.23	Equal	9.14	996	305
SIC 3491	33	9.14	14	9.14	Equal	9.14	47	
SIC 3492	14	9.14	12	9.14	Equal	9.14	26	
SIC 3493	26	7.01	35	6.40	Equal	6.40	61	
SIC 3494	46	7.62	16	8.23	Equal	8.08	62	
SIC 3495	14	10.67	16	6.71	Equal	7.47	30	
SIC 3496	59	9.14	44	10.36	Equal	9.14	103	
SIC 3497	15	15.24	2	16.92	Equal	15.24	17	
SIC 3498	42	6.10	18	6.55	Equal	6.10	60	
SIC 3499	414	9.45	176	8.23	Equal	9.14	590	
SIC 35	2250	9.75	1393	9.14	Equal	9.14	3643	
SIC 351	269	11.28	131	10.67	Equal	10.97	400	30
SIC 3511	48	11.58	13	11.89	Unequal	11.58	48	
SIC 3519	221	10.97	118	10.36	Equal	10.67	339	
SIC 352	258	10.36	135	9.14	Equal	10.06	393	74
SIC 3523	217	10.67	104	9.14	Equal	10.36	321	
SIC 3524	41	9.14	31	9.14	Equal	9.14	72	
SIC 353	401	10.06	195	9.75	Equal	10.06	596	86
SIC 3531	156	12.95	114	10.36	Equal	12.19	270	
SIC 3532	34	9.30	14	9.45	Equal	9.45	48	
SIC 3533	63	6.10	31	6.10	Equal	6.10	94	
SIC 3534	43	10.36	7	11.58	Equal	11.13	50	
SIC 3535	48	7.77	8	9.30	Equal	8.53	56	
SIC 3536	30	9.30	11	7.32	Equal	9.14	41	
SIC 3537	27	12.50	10	11.28	Equal	12.19	37	
SIC 354	176	9.14	316	9.14	Equal	9.14	492	60
SIC 3541	55	10.97	62	9.14	Equal	9.14	117	
SIC 3542	20	10.36	17	10.67	Equal	10.67	37	
SIC 3543	5	7.32	11	10.06	Equal	8.69	16	
SIC 3544	18	8.38	29	8.53	Equal	8.53	47	
SIC 3545	33	10.06	130	9.75	Equal	9.75	163	
SIC 3546	22	9.14	44	9.14	Equal	9.14	66	
SIC 3547	3	13.72	9	5.49	Equal	8.84	12	
SIC 3548	11	8.84	5	17.07	Unequal	8.84	11	
SIC 3549	9	9.75	9	9.14	Equal	9.14	18	
SIC 355	178	9.75	148	8.23	Equal	9.14	326	42
SIC 3552	24	11.43	61	7.32	Equal	8.53	85	
SIC 3553	3	9.14	13	9.14	Equal	9.14	16	
SIC 3554	17	10.97	6	7.16	Equal	10.67	23	
SIC 3555	44	8.53	15	8.53	Equal	8.53	59	
SIC 3556	19	9.14	23	9.14	Unequal	9.14	19	
SIC 3559	71	10.67	30	7.92	Equal	9.14	101	
SIC 356	324	9.14	191	7.92	Equal	8.84	515	90

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 3561	64	7.92	55	7.92	Equal	7.92	119	
SIC 3562	53	10.06	33	10.67	Equal	10.36	86	
SIC 3563	29	9.45	2	9.30	Equal	9.45	31	
SIC 3564	28	10.21	16	9.14	Equal	9.75	44	
SIC 3565	2	7.32			N/A***	7.32	2	
SIC 3566	15	7.62	1	3.35	Unequal	7.62	15	
SIC 3567	23	10.06	20	7.47	Equal	9.14	43	
SIC 3568	46	8.53	39	7.32	Equal	7.32	85	
SIC 3469	64	9.60	25	7.01	Equal	9.14	89	
SIC 357	227	10.67	94	9.30	Equal	10.36	321	21
SIC 3571	73	10.36	18	10.36	Equal	10.36	91	
SIC 3572	16	13.87			N/A***	13.87	16	
SIC 3573	2	7.62	1	12.80	Unequal	7.62	2	
SIC 3575	25	14.94	8	10.06	Equal	14.94	33	
SIC 3577	41	9.14	9	6.71	Equal	7.92	50	
SIC 3579	70	10.21	58	9.30	Equal	9.75	128	
SIC 358	303	9.14	83	9.14	Equal	9.14	386	91
SIC 3581	7	12.19			N/A***	12.19	7	
SIC 3582	5	7.92	5	12.19	Equal	11.43	10	
SIC 3585	237	9.14	60	9.14	Equal	9.14	297	
SIC 3586	30	8.53	3	12.19	Equal	8.53	33	
SIC 3589	24	9.14	15	12.50	Equal	10.67	39	
SIC 359	114	7.92	100	6.10	Equal	7.32	214	35
SIC 3592	36	8.23	56	1.68	Equal	4.57	92	
SIC 3593	4	5.94			N/A***	5.94	4	
SIC 3594	4	7.47	2	11.28	Equal	7.47	6	
SIC 3596	6	7.77	1	6.10	Unequal	7.77	6	
SIC 3599	64	7.92	41	7.62	Equal	7.62	105	
SIC 36	3004	9.60	1330	9.14	Equal	9.14	4334	
SIC 361	244	11.43	135	9.14	Equal	10.36	379	45
SIC 3612	209	12.19	80	9.91	Equal	11.89	289	
SIC 3613	35	9.14	55	7.62	Equal	7.77	90	
SIC 362	494	8.99	213	8.53	Equal	8.84	707	96
SIC 3621	312	8.53	81	7.92	Equal	8.53	393	
SIC 3622	1	7.62	6	7.16	Unequal	7.62	1	
SIC 3624	54	15.85	58	12.65	Equal	15.24	112	
SIC 3625	93	9.14	38	9.91	Equal	9.14	131	
SIC 3629	34	10.06	30	8.23	Equal	9.14	64	
SIC 363	257	10.36	153	9.14	Equal	10.06	410	45
SIC 3631	55	10.97	70	7.62	Equal	9.14	125	
SIC 3632	68	12.19	36	10.82	Equal	12.04	104	
SIC 3633	19	11.28	14	10.82	Equal	10.97	33	
SIC 3634	61	8.23	13	9.75	Equal	8.23	74	
SIC 3635	2	10.06	3	5.49	Equal	8.53	5	
SIC 3639	52	10.21	17	12.19	Equal	10.67	69	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 364	275	11.58	126	7.92	Equal	10.97	401	86
SIC 3641	59	12.19	21	10.67	Equal	12.19	80	
SIC 3643	48	10.67	23	7.92	Equal	8.53	71	
SIC 3644	31	11.58	17	6.10	Equal	10.06	48	
SIC 3645	50	9.14	19	14.02	Unequal	9.14	50	
SIC 3646	38	11.89	7	12.80	Equal	12.19	45	
SIC 3647	26	10.67	32	6.10	Equal	6.40	58	
SIC 3648	23	12.19	7	20.73	Unequal	12.19	23	
SIC 365	65	9.75	14	12.19	Equal	10.67	79	10
SIC 3651	52	9.75	12	13.72	Equal	9.75	64	
SIC 3652	13	11.58	2	11.43	Equal	11.58	15	
SIC 366	289	9.14	75	10.67	Unequal	9.14	289	21
SIC 3661	180	9.60	48	10.67	Equal	9.75	228	
SIC 3662	1	6.40	2	9.91	Unequal	6.40	1	
SIC 3663	63	9.75	16	15.24	Unequal	9.75	63	
SIC 3669	45	7.01	9	10.97	Unequal	7.01	45	
SIC 367	1208	9.14	405	8.53	Equal	9.14	1613	365
SIC 3671	123	7.62	37	6.71	Equal	7.62	160	
SIC 3672	84	8.69	102	9.75	Equal	9.14	186	
SIC 3674	422	10.06	127	8.23	Equal	9.75	549	
SIC 3675	32	9.14	2	4.88	Equal	8.84	34	
SIC 3676	16	5.79	12	6.86	Equal	6.10	28	
SIC 3677	6	6.55	4	6.25	Equal	6.25	10	
SIC 3678	8	12.34			N/A***	12.34	8	
SIC 3679	517	9.14	121	8.84	Equal	9.14	638	
SIC 369	172	9.14	209	9.75	Equal	9.14	381	138
SIC 3691	26	7.01	109	9.14	Equal	9.14	135	
SIC 3692	17	8.53	8	11.58	Equal	9.14	25	
SIC 3694	93	9.14	71	11.89	Unequal	9.14	93	
SIC 3695	4	10.67	5	33.53	Unequal	10.67	4	
SIC 3699	32	7.47	16	6.10	Equal	6.71	48	
SIC 37	4500	11.28	4944	12.80	Unequal	11.28	4500	
SIC 371	2586	11.89	4391	13.41	Unequal	11.89	2586	449
SIC 3711	910	18.59	1584	23.77	Unequal	18.59	910	
SIC 3713	192	9.14	83	12.19	Equal	10.06	275	
SIC 3714	1353	10.67	2702	11.28	Equal	10.97	4055	
SIC 3715	89	9.14	3	6.10	Equal	9.14	92	
SIC 3716	42	8.84	19	9.14	Equal	9.14	61	
SIC 372	1094	11.28	229	9.75	Equal	11.28	1323	151
SIC 3721	532	10.97	59	11.89	Unequal	10.97	532	
SIC 3724	320	12.19	99	13.72	Equal	12.80	419	
SIC 3728	242	9.14	71	7.62	Equal	8.53	313	

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 373	395	9.14	131	9.14	Equal	9.14	526	125
SIC 3731	210	9.14	24	9.14	Equal	9.14	234	
SIC 3732	185	9.45	107	9.14	Equal	9.14	292	
SIC 374	157	11.89	67	11.58	Equal	11.89	224	28
SIC 3743	157	11.89	67	11.58	Equal	11.89	224	
SIC 375	47	10.67	39	10.67	Equal	10.67	86	6
SIC 3751	47	10.67	39	10.67	Equal	10.67	86	
SIC 376	100	12.19	36	10.67	Equal	12.04	136	22
SIC 3761	69	12.19	24	14.78	Equal	12.19	93	
SIC 3764	28	7.32	12	8.38	Equal	7.47	40	
SIC 3769	3	9.14			N/A***	9.14	3	
SIC 379	121	8.23	51	10.67	Unequal	8.23	121	40
SIC 3792	62	7.16	10	6.55	Equal	7.16	72	
SIC 3795	24	9.14	9	15.24	Unequal	9.14	24	
SIC 3799	35	9.14	32	11.58	Unequal	9.14	35	
SIC 38	955	10.06	273	8.23	Equal	9.14	1228	
SIC 381	258	10.06	47	7.62	Equal	9.75	305	12
SIC 3811	2	5.18	29	6.10	Equal	6.10	31	
SIC 3812	256	10.06	18	7.62	Equal	10.06	274	
SIC 382	198	6.55	82	6.55	Equal	6.55	280	59
SIC 3821	10	7.32	3	8.23	Equal	7.62	13	
SIC 3822	37	10.06	12	9.75	Equal	10.06	49	
SIC 3823	30	6.55	19	6.10	Equal	6.40	49	
SIC 3824	7	5.49	1	7.62	Unequal	5.49	7	
SIC 3825	33	6.10	1	8.53	Unequal	6.10	33	
SIC 3826	47	6.40	31	6.10	Equal	6.10	78	
SIC 3827	17	9.14	8	6.71	Equal	7.92	25	
SIC 3829	17	9.14	7	4.88	Equal	9.14	24	
SIC 384	190	9.14	76	9.14	Equal	9.14	266	80
SIC 3841	110	9.75	43	8.84	Equal	9.75	153	
SIC 3842	43	9.14	8	9.91	Equal	9.14	51	
SIC 3843	7	6.71	16	6.10	Equal	6.10	23	
SIC 3844	22	9.75	8	12.19	Equal	10.36	30	
SIC 3845	8	6.10	1	9.14	Unequal	6.10	8	
SIC 385	14	7.92	9	9.14	Equal	9.14	23	11
SIC 3851	14	7.92	9	9.14	Equal	9.14	23	
SIC 386	292	12.19	52	13.11	Equal	12.19	344	33
SIC 3861	292	12.19	52	13.11	Equal	12.19	344	
SIC 387	3	24.38	7	8.23	Equal	8.38	10	2

See notes at end of table.

Table A-1
Summary of Median Stack Height by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (meters)	Non-TRI Chemicals Number of Stacks	Median (meters)	Equal Stack Pop. Means? *	Median Height for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Height of their SIC code**
SIC 3873	3	24.38	7	8.23	Equal	8.38	10	
SIC 39	1870	9.75	452	9.30	Equal	9.75	2322	
SIC 391	22	12.80	1	10.97	Equal	12.50	23	14
SIC 3911	4	14.78			N/A***	14.78	4	
SIC 3914	17	10.97	1	10.97	Unequal	10.97	17	
SIC 3915	1	17.07			N/A***	17.07	1	
SIC 393	56	9.14	13	8.84	Equal	9.14	69	12
SIC 3931	56	9.14	13	8.84	Equal	9.14	69	
SIC 394	158	9.14	53	11.28	Equal	9.14	211	43
SIC 3942	3	15.85	1	4.88	Unequal	15.85	3	
SIC 3944	57	10.97	43	11.28	Unequal	10.97	57	
SIC 3949	98	9.14	9	9.14	Equal	9.14	107	
SIC 395	59	9.14	30	9.45	Equal	9.14	89	14
SIC 3951	12	12.65	4	10.06	Equal	12.19	16	
SIC 3952	29	7.92	20	9.14	Equal	9.14	49	
SIC 3955	18	9.14	6	9.45	Equal	9.14	24	
SIC 396	20	9.14	5	21.34	Unequal	9.14	20	18
SIC 3961	8	9.91	2	22.71	Equal	11.13	10	
SIC 3965	12	7.01	3	21.34	Unequal	7.01	12	
SIC 399	1555	9.75	350	9.14	Equal	9.75	1905	116
SIC 3991	8	9.14	6	4.88	Equal	8.38	14	
SIC 3993	119	7.92	21	8.23	Equal	7.92	140	
SIC 3995	98	9.45	28	9.14	Equal	9.14	126	
SIC 3996	16	13.72	20	15.24	Equal	15.24	36	
SIC 3999	1314	10.06	275	9.45	Equal	10.06	1589	

*Is mean height of TRI chemical emitting stacks equal to mean height of non-TRI chemical emitting stacks? If unequal, use data from stacks emitting TRI chemicals.
**Approximately 87% of TRI facilities use heights based on their 3-digit SIC codes.
***Stack height data unavailable for one or both stack categories (emitting TRI chemicals and emitting only non-TRI chemicals).

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 20	2175	7.92	4099	11.94	Unequal	7.92	2175	
SIC 201	223	7.00	60	8.17	Equal	7.28	283	34
SIC 2011	128	6.21	32	9.44	Equal	6.64	160	
SIC 2013	62	8.96	17	4.57	Equal	7.59	79	
SIC 2015	33	7.00	11	8.31	Equal	7.68	44	
SIC 202	70	10.01	103	8.31	Equal	9.18	173	17
SIC 2021	1	6.46	5	6.46	Unequal	6.46	1	
SIC 2022	16	10.84	33	8.94	Equal	9.47	49	
SIC 2023	40	10.06	51	8.62	Equal	9.18	91	
SIC 2024	1	3.60	5	4.91	Unequal	3.60	1	
SIC 2026	12	7.50	9	13.01	Equal	12.44	21	
SIC 203	150	6.80	80	4.04	Equal	5.97	230	19
SIC 2032	4	13.43	3	0.06	Equal	13.26	7	
SIC 2033	77	8.41	43	7.16	Equal	8.31	120	
SIC 2035	5	5.97	11	15.09	Unequal	5.97	5	
SIC 2037	57	0.43	22	0.21	Equal	0.31	79	
SIC 2038	7	9.08	1	10.12	Unequal	9.08	7	
SIC 204	414	9.32	2320	12.53	Equal	11.94	2734	88
SIC 2041	48	8.31	401	13.42	Equal	13.42	449	
SIC 2043	96	11.45	587	12.80	Equal	12.80	683	
SIC 2044			16	6.74	N/A***			
SIC 2045	7	6.18	26	14.74	Unequal	6.18	7	
SIC 2046	106	11.22	659	14.66	Equal	13.98	765	
SIC 2047	40	8.04	133	12.62	Unequal	8.04	40	
SIC 2048	117	7.95	498	11.73	Equal	10.89	615	
SIC 205	298	7.93	174	7.19	Equal	7.65	472	18
SIC 2051	234	7.93	111	7.18	Equal	7.83	345	
SIC 2052	64	7.62	63	8.38	Equal	7.62	127	
SIC 206	238	8.75	404	9.11	Unequal	8.75	238	34
SIC 2061	65	0.84	32	8.28	Unequal	0.84	65	
SIC 2062	47	10.67	64	9.57	Equal	10.67	111	
SIC 2063	66	9.75	72	12.94	Equal	10.12	138	
SIC 2064	14	6.31	82	13.14	Unequal	6.31	14	
SIC 2065	1	274.32	1	188.37	Unequal	274.32	1	
SIC 2066	7	6.07	59	6.95	Equal	6.95	66	
SIC 2067	25	12.97	79	9.69	Equal	9.97	104	
SIC 2068	13	6.00	15	7.92	Equal	7.62	28	
SIC 207	178	10.79	466	13.61	Unequal	10.79	178	91
SIC 2074	11	8.31	9	15.24	Equal	15.24	20	
SIC 2075	85	11.26	397	14.81	Equal	13.98	482	
SIC 2076	9	10.85	13	8.34	Equal	9.60	22	
SIC 2077	51	10.95	30	6.73	Equal	9.00	81	
SIC 2079	22	8.17	17	8.90	Unequal	8.17	22	
SIC 208	364	6.55	182	11.43	Unequal	6.55	364	31
SIC 2082	246	6.19	104	11.71	Equal	6.55	350	
SIC 2083	1	67.51	19	11.13	Unequal	67.51	1	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 2084	6	12.41			N/A***	12.41	6	
SIC 2085	87	7.88	12	13.42	Equal	7.88	99	
SIC 2086	11	4.00	11	7.62	Equal	4.37	22	
SIC 2087	13	3.11	36	12.80	Equal	9.51	49	
SIC 209	240	7.29	310	8.63	Equal	8.26	550	23
SIC 2091	23	6.10	11	9.18	Equal	6.61	34	
SIC 2092	4	7.77	1	15.24	Unequal	7.77	4	
SIC 2095	48	12.19	84	7.92	Equal	8.38	132	
SIC 2096	9	3.73	13	10.91	Equal	9.38	22	
SIC 2098	6	8.31	11	4.27	Equal	6.58	17	
SIC 2099	150	6.92	190	10.15	Unequal	6.92	150	
SIC 21	141	12.41	29	7.44	Equal	12.41	170	
SIC 211	88	12.41	8	10.30	Equal	12.41	96	20
SIC 2111	88	12.41	8	10.30	Equal	12.41	96	
SIC 212	3	219.46	7	2.04	Equal	7.50	10	1
SIC 2121	3	219.46	7	2.04	Equal	7.50	10	
SIC 213	15	11.73	8	5.75	Equal	8.31	23	1
SIC 2131	15	11.73	8	5.75	Equal	8.31	23	
SIC 214	35	12.95	6	9.14	Equal	12.77	41	4
SIC 2141	35	12.95	6	9.14	Equal	12.77	41	
SIC 22	849	10.44	189	9.08	Equal	10.15	1038	
SIC 221	97	11.98	23	9.08	Equal	11.26	120	20
SIC 2211	97	11.98	23	9.08	Equal	11.26	120	
SIC 222	64	11.11	6	8.45	Equal	10.72	70	13
SIC 2221	64	11.11	6	8.45	Equal	10.72	70	
SIC 223	26	9.18	9	9.18	Equal	9.18	35	3
SIC 2231	26	9.18	9	9.18	Equal	9.18	35	
SIC 224	15	9.14	3	8.00	Equal	9.13	18	1
SIC 2241	15	9.14	3	8.00	Equal	9.13	18	
SIC 225	62	10.47	21	8.31	Equal	9.18	83	14
SIC 2251	6	5.42			N/A***	5.42	6	
SIC 2253	38	10.33	7	9.08	Equal	9.14	45	
SIC 2254	2	138.16	1	9.18	Unequal	138.16	2	
SIC 2257	6	10.48			N/A***	10.48	6	
SIC 2258	9	14.01	9	6.83	Equal	9.13	18	
SIC 2259	1	11.13	4	10.18	Unequal	11.13	1	
SIC 226	266	10.66	57	9.18	Equal	10.43	323	70
SIC 2261	117	10.65	19	9.18	Equal	10.43	136	
SIC 2262	97	12.01	23	10.21	Equal	10.72	120	
SIC 2269	52	9.18	15	8.31	Equal	8.49	67	
SIC 227	18	9.04	21	9.18	Equal	9.18	39	26
SIC 2273	18	9.04	21	9.18	Equal	9.18	39	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 228	62	10.66	8	10.72	Equal	10.72	70	16
SIC 2281	24	9.18	3	10.72	Equal	9.18	27	
SIC 2282	5	10.67	1	3.72	Unequal	10.67	5	
SIC 2284	33	11.26	4	10.72	Equal	10.76	37	
SIC 229	239	10.43	41	7.59	Equal	9.57	280	74
SIC 2291	3	5.73	4	5.11	Equal	5.73	7	
SIC 2295	116	10.43	16	6.70	Equal	10.43	132	
SIC 2296	26	10.52	2	8.12	Equal	10.52	28	
SIC 2298	61	9.57	13	7.59	Equal	9.57	74	
SIC 2297	11	10.52	1	1.00	Unequal	10.52	11	
SIC 2299	22	10.34	5	8.31	Equal	9.18	27	
SIC 23	120	10.58	28	10.97	Equal	10.97	148	
SIC 231	2	13.72			N/A***	13.72	2	0
SIC 2311	2	13.72			N/A***	13.72	2	
SIC 232	23	11.22	6	10.74	Equal	10.97	29	1
SIC 2321	4	44.07	1	1.22	Unequal	44.07	4	
SIC 2322	8	14.54	2	11.00	Equal	14.54	10	
SIC 2325	5	6.71			N/A***	6.71	5	
SIC 2326	2	13.25			N/A***	13.25	2	
SIC 2329	4	9.82	3	10.97	Equal	10.97	7	
SIC 233	17	8.00	3	6.00	Equal	6.95	20	1
SIC 2335	9	28.75			N/A***	28.75	9	
SIC 2337	1	3.05			N/A***	3.05	1	
SIC 2339	7	6.10	3	6.00	Equal	6.10	10	
SIC 234	6	12.97			N/A***	12.97	6	0
SIC 2341	5	12.97			N/A***	12.97	5	
SIC 2342	1	9.14			N/A***	9.14	1	
SIC 235	19	9.14	3	13.00	Equal	9.14	22	5
SIC 2353	19	9.14	3	13.00	Equal	9.14	22	
SIC 237	1	4.00			N/A***	4.00	1	
SIC 2371	1	4.00			N/A***	4.00	1	
SIC 238	7	7.26	1	12.25	Equal	7.76	8	6
SIC 2384	6	7.36			N/A***	7.36	6	
SIC 2385	1	7.26			N/A***	7.26	1	
SIC 2387			1	12.25	N/A***			
SIC 239	45	11.49	15	11.09	Equal	11.49	60	11
SIC 2392	13	6.10	11	11.09	Unequal	6.10	13	
SIC 2394	2	11.39			N/A***	11.39	2	
SIC 2396	26	16.96	3	10.97	Equal	15.91	29	
SIC 2399	4	11.86	1	14.90	Unequal	11.86	4	
SIC 24	1271	10.53	607	9.14	Equal	10.53	1878	
SIC 241	3	1.51	4	10.85	Equal	7.16	7	0
SIC 2411	3	1.51	4	10.85	Equal	7.16	7	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 242	348	10.53	163	10.53	Unequal	10.53	348	18
SIC 2421	259	10.53	123	10.53	Unequal	10.53	259	
SIC 2426	87	10.53	35	10.53	Equal	10.53	122	
SIC 2429	2	5.29	5	3.05	Equal	3.05	7	
SIC 243	511	10.53	202	7.91	Equal	10.00	713	151
SIC 2431	101	9.93	43	11.00	Equal	9.98	144	
SIC 2434	223	10.53	40	6.87	Equal	10.18	263	
SIC 2435	42	10.53	14	7.80	Equal	9.91	56	
SIC 2436	135	10.91	100	5.18	Equal	9.14	235	
SIC 2439	10	13.71	5	25.30	Equal	14.01	15	
SIC 244	10	8.91	12	11.90	Equal	10.26	22	1
SIC 2441	1	7.50	3	16.95	Unequal	7.50	1	
SIC 2448	4	10.53	4	15.35	Equal	10.53	8	
SIC 2449	5	8.37	5	4.63	Equal	8.19	10	
SIC 245	11	10.03	3	15.12	Unequal	10.03	11	3
SIC 2451	9	10.09	3	15.12	Equal	10.09	12	
SIC 2452	2	6.02			N/A***	6.02	2	
SIC 249	388	10.91	223	8.56	Equal	10.53	611	258
SIC 2491	48	10.18	29	6.10	Equal	7.84	77	
SIC 2493	135	12.80	151	9.60	Equal	12.04	286	
SIC 2499	205	10.44	43	8.60	Equal	9.89	248	
SIC 25	1855	10.45	611	10.21	Equal	10.42	2466	
SIC 251	1170	10.67	216	11.37	Equal	10.72	1386	262
SIC 2511	900	10.72	155	12.62	Unequal	10.72	900	
SIC 2512	114	12.34	20	7.78	Equal	11.49	134	
SIC 2514	92	10.12	26	7.83	Equal	9.75	118	
SIC 2515	5	4.57			N/A***	4.57	5	
SIC 2517	33	10.15	13	11.80	Equal	10.60	46	
SIC 2519	26	13.47	2	5.73	Equal	13.47	28	
SIC 252	272	10.18	202	9.65	Equal	10.16	474	72
SIC 2521	127	10.76	75	8.29	Equal	10.26	202	
SIC 2522	145	10.00	127	10.18	Equal	10.15	272	
SIC 253	129	8.55	49	9.69	Equal	9.60	178	23
SIC 2531	129	8.55	49	9.69	Equal	9.60	178	
SIC 254	181	8.83	82	9.24	Unequal	8.83	181	45
SIC 2541	73	9.00	27	8.37	Equal	8.87	100	
SIC 2542	108	8.43	55	9.39	Unequal	8.43	108	
SIC 259	103	8.55	62	11.06	Unequal	8.55	103	34
SIC 2591	30	9.69	17	9.91	Equal	9.69	47	
SIC 2599	73	8.55	45	13.69	Unequal	8.55	73	
SIC 26	2128	10.44	840	9.18	Equal	10.09	2968	
SIC 261	232	10.63	144	12.47	Unequal	10.63	232	88
SIC 2611	232	10.63	144	12.47	Unequal	10.63	232	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 262	708	10.00	257	9.41	Equal	10.00	965	92
SIC 2621	708	10.00	257	9.41	Equal	10.00	965	
SIC 263	222	11.15	118	10.15	Equal	10.74	340	43
SIC 2631	222	11.15	118	10.15	Equal	10.74	340	
SIC 264	4	24.51	1	80.01	Unequal	24.51	4	7
SIC 2647	1	5.18			N/A***	5.18	1	
SIC 2649	3	35.17	1	80.01	Unequal	35.17	3	
SIC 265	341	8.41	104	6.16	Equal	8.10	445	27
SIC 2652	19	11.87	2	6.26	Equal	11.01	21	
SIC 2653	107	8.60	57	5.36	Equal	7.98	164	
SIC 2655	31	9.04	10	7.23	Equal	8.03	41	
SIC 2656	80	6.19	10	2.15	Equal	6.10	90	
SIC 2657	104	9.75	25	8.31	Equal	9.18	129	
SIC 267	621	10.76	216	8.30	Equal	10.15	837	135
SIC 2671	257	11.00	87	9.08	Equal	10.44	344	
SIC 2672	139	10.67	49	11.26	Equal	11.01	188	
SIC 2673	60	12.36	1	10.79	Unequal	12.36	60	
SIC 2674	30	11.28	4	3.55	Equal	11.26	34	
SIC 2675	18	7.10	1	12.68	Unequal	7.10	18	
SIC 2676	18	8.37	14	2.07	Equal	8.05	32	
SIC 2677	8	11.08	2	13.21	Equal	11.08	10	
SIC 2678	10	11.18	1	3.23	Unequal	11.18	10	
SIC 2679	81	8.03	57	6.40	Equal	7.01	138	
SIC 27	1769	10.97	264	7.54	Equal	10.18	2033	
SIC 271	75	6.71	1	2.74	Equal	6.71	76	1
SIC 2711	75	6.71	1	2.74	Unequal	6.71	75	
SIC 272	41	12.01	17	22.43	Unequal	12.01	41	0
SIC 2721	41	12.01	17	22.43	Unequal	12.01	41	
SIC 273	132	11.13	21	6.00	Equal	9.85	153	5
SIC 2731	41	7.53	7	5.00	Equal	6.26	48	
SIC 2732	91	11.87	14	7.97	Equal	10.76	105	
SIC 274	14	10.47	1	5.46	Equal	9.08	15	0
SIC 2741	14	10.47	1	5.46	Unequal	10.47	14	
SIC 275	1398	11.20	202	7.13	Equal	10.44	1600	149
SIC 2751	20	3.20	5	5.06	Equal	3.66	25	
SIC 2752	646	10.47	102	7.13	Equal	9.75	748	
SIC 2754	346	11.67	51	6.00	Equal	11.28	397	
SIC 2759	386	11.36	44	8.93	Equal	11.25	430	
SIC 276	47	8.03	8	3.52	Equal	8.03	55	3
SIC 2761	47	8.03	8	3.52	Equal	8.03	55	
SIC 277	21	11.21			N/A***	11.21	21	1

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 2771	21	11.21			N/A***	11.21	21	
SIC 278	18	8.61	1	8.37	Equal	8.37	19	1
SIC 2782	14	9.83	1	8.37	Unequal	9.83	14	
SIC 2789	4	6.16			N/A***	6.16	4	
SIC 279	23	8.10	13	10.12	Unequal	8.10	23	23
SIC 2791	3	12.19	10	10.12	Equal	10.12	13	
SIC 2796	20	6.61	3	5.12	Equal	5.12	23	
SIC 28	10267	7.03	5076	10.09	Unequal	7.03	10267	
SIC 281	889	9.08	1209	11.28	Unequal	9.08	889	378
SIC 2812	98	8.44	104	14.36	Equal	10.09	202	
SIC 2813	131	9.14	36	14.97	Unequal	9.14	131	
SIC 2816	66	9.99	241	11.19	Unequal	9.99	66	
SIC 2819	594	8.96	828	11.28	Unequal	8.96	594	
SIC 282	2290	8.31	675	9.02	Equal	8.35	2965	402
SIC 2821	1641	8.03	600	9.13	Equal	8.31	2241	
SIC 2822	343	7.01	33	9.18	Equal	7.04	376	
SIC 2823	38	13.50	11	8.29	Equal	12.41	49	
SIC 2824	268	9.14	31	4.00	Equal	9.09	299	
SIC 283	732	7.03	453	9.70	Unequal	7.03	732	150
SIC 2831			3	256.03	N/A***			
SIC 2833	220	7.03	134	7.03	Unequal	7.03	220	
SIC 2834	509	7.25	313	11.89	Unequal	7.25	509	
SIC 2835	2	11.98	1	5.49	Unequal	11.98	2	
SIC 2836	1	10.37	2	9.62	Unequal	10.37	1	
SIC 284	259	6.34	241	9.70	Equal	8.03	500	183
SIC 2841	126	7.03	185	11.28	Equal	9.42	311	
SIC 2842	43	8.65	27	5.79	Equal	8.03	70	
SIC 2843	28	3.81	9	10.33	Unequal	3.81	28	
SIC 2844	62	5.74	20	9.18	Equal	5.74	82	
SIC 285	512	5.56	169	6.71	Unequal	5.56	512	414
SIC 2851	512	5.56	169	6.71	Unequal	5.56	512	
SIC 286	4354	5.61	1289	8.72	Unequal	5.61	4354	434
SIC 2861	94	9.00	15	9.06	Equal	9.00	109	
SIC 2865	377	6.55	174	10.24	Unequal	6.55	377	
SIC 2869	3883	5.46	1100	8.52	Unequal	5.46	3883	
SIC 287	512	8.90	405	12.47	Equal	10.43	917	209
SIC 2873	213	14.23	208	15.24	Equal	14.65	421	
SIC 2874	80	0.97	70	9.01	Unequal	0.97	80	
SIC 2875	6	2.01	16	13.41	Equal	11.67	22	
SIC 2879	213	7.62	111	10.36	Unequal	7.62	213	
SIC 289	719	8.00	635	10.45	Unequal	8.00	719	407
SIC 2891	205	7.44	75	6.47	Equal	7.22	280	
SIC 2892	49	7.03	127	16.15	Unequal	7.03	49	
SIC 2893	67	5.15	17	7.10	Equal	5.53	84	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 2895	92	13.87	201	11.28	Equal	12.62	293	
SIC 2899	306	7.14	215	10.42	Unequal	7.14	306	
SIC 29	4399	5.49	1797	7.83	Unequal	5.49	4399	
SIC 291	3265	4.51	1057	5.73	Equal	4.94	4322	157
SIC 2911	3265	4.51	1057	5.73	Equal	4.94	4322	
SIC 295	1015	14.14	670	13.78	Equal	14.02	1685	30
SIC 2951	775	15.46	558	15.46	Equal	15.46	1333	
SIC 2952	240	6.82	112	6.40	Equal	6.82	352	
SIC 299	119	3.35	70	12.97	Equal	8.31	189	65
SIC 2992	45	5.74	18	7.54	Equal	6.43	63	
SIC 2999	74	3.18	52	13.91	Equal	10.70	126	
SIC 30	1859	10.09	865	9.60	Equal	10.01	2724	
SIC 301	186	10.62	171	13.66	Unequal	10.62	186	57
SIC 3011	186	10.62	171	13.66	Unequal	10.62	186	
SIC 302	8	9.77			N/A***	9.77	8	4
SIC 3021	8	9.77			N/A***	9.77	8	
SIC 305	118	8.27	49	4.91	Equal	7.84	167	63
SIC 3052	37	10.45	12	9.13	Equal	10.01	49	
SIC 3053	81	7.10	37	3.00	Equal	5.24	118	
SIC 306	339	9.18	172	7.71	Equal	8.90	511	186
SIC 3061	15	8.14	2	12.19	Unequal	8.14	15	
SIC 3069	324	9.27	170	7.71	Equal	9.07	494	
SIC 307	24	10.09	50	10.09	Equal	10.09	74	53
SIC 3079	24	10.09	50	10.09	Equal	10.09	74	
SIC 308	1184	10.52	423	9.08	Equal	10.01	1607	801
SIC 3081	149	10.67	30	9.91	Unequal	10.67	149	
SIC 3082	22	11.39	1	5.33	Unequal	11.39	22	
SIC 3083	64	6.85	11	9.08	Equal	7.01	75	
SIC 3084	6	11.25	7	36.09	Equal	13.87	13	
SIC 3085	178	11.40	30	13.70	Unequal	11.40	178	
SIC 3086	166	9.13	69	8.08	Equal	8.31	235	
SIC 3087	52	11.30	51	15.09	Unequal	11.30	52	
SIC 3088	36	11.81	4	15.74	Equal	11.81	40	
SIC 3089	511	10.43	220	8.53	Equal	9.48	731	
SIC 31	222	9.08	100	8.45	Equal	8.80	322	
SIC 311	129	9.12	43	9.08	Equal	9.12	172	26
SIC 3111	129	9.12	43	9.08	Equal	9.12	172	
SIC 313	10	6.59	1	8.31	Equal	7.18	11	1
SIC 3131	10	6.59	1	8.31	Unequal	6.59	10	
SIC 314	81	8.10	54	7.48	Equal	7.84	135	17
SIC 3143	62	8.37	41	5.88	Equal	7.50	103	
SIC 3144	6	8.55			N/A***	8.55	6	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	Median Exit Gas Velocity for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 3149	13	2.62	13	9.28	Unequal	2.62	13	
SIC 315	1	4.70	2	0.91	Unequal	4.70	1	0
SIC 3151	1	4.70	2	0.91	Unequal	4.70	1	
SIC 319	1	12.01			N/A***	12.01	1	0
SIC 3199	1	12.01			N/A***	12.01	1	
SIC 32	1593	10.76	3298	12.01	Unequal	10.76	1593	
SIC 321	46	11.53	56	11.11	Equal	11.17	102	7
SIC 3211	46	11.53	56	11.11	Equal	11.17	102	
SIC 322	237	11.26	157	9.18	Equal	10.87	394	58
SIC 3221	122	10.01	79	8.26	Equal	10.00	201	
SIC 3229	115	13.01	78	9.31	Equal	11.83	193	
SIC 323	64	8.37	36	13.35	Equal	10.53	100	23
SIC 3231	64	8.37	36	13.35	Equal	10.53	100	
SIC 324	90	12.19	942	15.42	Unequal	12.19	90	50
SIC 3241	90	12.19	942	15.42	Unequal	12.19	90	
SIC 325	214	9.33	308	12.94	Unequal	9.33	214	70
SIC 3251	83	12.94	59	15.24	Equal	12.94	142	
SIC 3253	52	4.15	74	5.07	Equal	4.95	126	
SIC 3255	76	9.05	162	12.94	Unequal	9.05	76	
SIC 3259	3	11.16	13	14.89	Equal	14.89	16	
SIC 326	109	9.28	84	9.80	Equal	9.28	193	27
SIC 3261	14	9.61	15	15.51	Equal	9.92	29	
SIC 3262			1	14.36	N/A***			
SIC 3263	1	14.30			N/A***	14.30	1	
SIC 3264	80	8.75	25	12.95	Unequal	8.75	80	
SIC 3269	14	4.02	43	6.31	Equal	6.31	57	
SIC 327	287	8.31	1060	7.65	Equal	7.65	1347	13
SIC 3271	21	8.31	32	4.00	Equal	4.60	53	
SIC 3272	45	5.13	150	6.00	Unequal	5.13	45	
SIC 3273	59	8.31	457	7.65	Equal	7.65	516	
SIC 3274	60	12.39	246	12.76	Equal	12.68	306	
SIC 3275	102	7.90	175	13.66	Unequal	7.90	102	
SIC 328	17	11.49	13	8.87	Equal	9.69	30	8
SIC 3281	17	11.49	13	8.87	Equal	9.69	30	
SIC 329	529	12.13	642	12.80	Unequal	12.13	529	123
SIC 3291	84	8.83	90	8.31	Unequal	8.83	84	
SIC 3292	34	10.24	52	12.77	Equal	11.26	86	
SIC 3293	1	53.34	2	11.87	Unequal	53.34	1	
SIC 3295	152	16.43	305	14.39	Unequal	16.43	152	
SIC 3296	165	14.16	96	13.01	Equal	13.44	261	
SIC 3297	58	11.71	68	12.94	Unequal	11.71	58	
SIC 3299	35	10.33	29	11.49	Equal	10.74	64	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	Median Exit Gas Velocity for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 33	2641	9.30	3707	10.45	Equal	10.03	6348	
SIC 331	912	8.90	1049	8.31	Unequal	8.90	912	238
SIC 3312	751	8.37	837	7.77	Equal	8.09	1588	
SIC 3313	13	27.60	42	20.95	Equal	21.01	55	
SIC 3315	46	10.13	52	8.53	Equal	9.81	98	
SIC 3316	37	7.37	67	9.57	Unequal	7.37	37	
SIC 3317	65	9.14	51	8.23	Equal	9.10	116	
SIC 332	451	11.49	1205	14.30	Unequal	11.49	451	233
SIC 3321	361	11.61	883	14.57	Unequal	11.61	361	
SIC 3322	7	24.23	148	11.16	Equal	11.40	155	
SIC 3324	9	10.17	35	13.23	Unequal	10.17	9	
SIC 3325	74	10.50	139	13.44	Unequal	10.50	74	
SIC 333	305	11.28	397	11.26	Equal	11.27	702	57
SIC 3331	36	10.21	49	13.75	Equal	11.28	85	
SIC 3334	230	13.46	281	10.61	Equal	11.50	511	
SIC 3339	39	10.06	67	11.37	Unequal	10.06	39	
SIC 334	213	9.30	315	9.91	Equal	9.30	528	142
SIC 3341	213	9.30	315	9.91	Equal	9.30	528	
SIC 335	499	9.14	309	8.39	Equal	9.00	808	233
SIC 3351	47	11.22	59	13.38	Unequal	11.22	47	
SIC 3353	196	9.22	81	5.03	Equal	8.37	277	
SIC 3354	84	9.00	41	6.31	Equal	9.00	125	
SIC 3355	20	7.04	16	5.03	Equal	5.55	36	
SIC 3356	15	13.78	64	3.41	Equal	5.27	79	
SIC 3357	137	9.08	48	13.58	Equal	9.92	185	
SIC 336	132	8.12	239	8.26	Equal	8.19	371	221
SIC 3361	3	7.25	6	3.89	Equal	5.64	9	
SIC 3362	5	5.97	16	13.14	Unequal	5.97	5	
SIC 3363	53	4.15	68	5.15	Equal	4.85	121	
SIC 3364	1	8.87	7	2.44	Unequal	8.87	1	
SIC 3365	46	10.80	59	9.30	Equal	10.38	105	
SIC 3366	4	10.55	48	14.36	Equal	14.36	52	
SIC 3369	20	8.98	35	5.49	Equal	5.74	55	
SIC 339	129	7.83	193	9.51	Equal	8.69	322	115
SIC 3398	40	10.18	67	9.36	Equal	9.36	107	
SIC 3399	89	7.83	126	10.04	Unequal	7.83	89	
SIC 34	3304	8.90	1679	8.93	Unequal	8.90	3304	
SIC 341	716	8.31	148	4.60	Unequal	8.31	716	198
SIC 3411	558	8.31	112	4.11	Unequal	8.31	558	
SIC 3412	158	8.31	36	7.03	Equal	8.14	194	
SIC 342	187	8.40	174	9.69	Unequal	8.40	187	72
SIC 3421	14	8.38			N/A***	8.38	14	
SIC 3423	47	8.40	58	11.43	Unequal	8.40	47	
SIC 3425	7	10.76	2	13.07	Unequal	10.76	7	
SIC 3429	119	8.31	114	9.54	Equal	8.90	233	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	Median Exit Gas Velocity for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 343	47	8.59	83	12.41	Unequal	8.59	47	37
SIC 3431	4	0.33	25	12.41	Unequal	0.33	4	
SIC 3432	11	8.90	44	15.64	Unequal	8.90	11	
SIC 3433	32	8.75	14	5.11	Equal	7.99	46	
SIC 344	438	9.14	191	7.28	Equal	8.63	629	183
SIC 3441	71	11.10	29	8.32	Equal	10.98	100	
SIC 3442	107	9.60	32	5.46	Equal	8.60	139	
SIC 3443	59	9.00	42	9.53	Equal	9.14	101	
SIC 3444	99	7.95	60	6.64	Equal	7.95	159	
SIC 3446	25	6.10	8	5.00	Equal	6.10	33	
SIC 3448	40	10.44	16	14.75	Unequal	10.44	40	
SIC 3449	37	10.00	4	6.46	Equal	10.00	41	
SIC 345	53	6.40	82	8.60	Equal	8.17	135	45
SIC 3451	21	3.78	11	7.30	Equal	3.89	32	
SIC 3452	32	8.47	71	8.93	Equal	8.93	103	
SIC 346	308	8.96	177	8.31	Equal	8.37	485	156
SIC 3462	33	8.10	68	6.94	Equal	7.86	101	
SIC 3463	4	12.42	1	8.11	Unequal	12.42	4	
SIC 3465	59	10.06	27	9.27	Equal	9.27	86	
SIC 3466	37	9.14	6	10.65	Equal	9.69	43	
SIC 3469	175	8.90	75	8.08	Equal	8.36	250	
SIC 347	960	8.90	586	9.89	Unequal	8.90	960	493
SIC 3471	322	8.40	360	9.71	Unequal	8.40	322	
SIC 3479	638	9.02	226	10.06	Equal	9.17	864	
SIC 348	135	10.58	29	9.18	Equal	10.12	164	26
SIC 3482	5	9.84	2	11.23	Equal	9.84	7	
SIC 3483	36	8.90	16	8.11	Equal	8.65	52	
SIC 3484	11	9.18			N/A***	9.18	11	
SIC 3489	83	14.63	11	13.01	Equal	14.32	94	
SIC 349	460	8.90	209	8.69	Equal	8.90	669	317
SIC 3491	26	7.95	4	6.27	Equal	7.95	30	
SIC 3492	11	5.76	11	10.06	Unequal	5.76	11	
SIC 3493	22	9.86	21	17.86	Equal	13.38	43	
SIC 3494	27	8.96	11	9.08	Equal	9.02	38	
SIC 3495	11	7.37	9	17.22	Unequal	7.37	11	
SIC 3496	45	10.76	39	7.10	Equal	8.95	84	
SIC 3497	10	5.00	1	7.32	Unequal	5.00	10	
SIC 3498	22	5.46	10	13.47	Equal	7.74	32	
SIC 3499	286	9.04	103	7.80	Equal	8.80	389	
SIC 35	1500	9.11	1095	8.60	Equal	9.00	2595	
SIC 351	141	9.14	105	9.11	Equal	9.11	246	34
SIC 3511	38	9.04	13	12.01	Equal	9.18	51	
SIC 3519	103	9.14	92	8.66	Equal	9.11	195	
SIC 352	131	11.10	114	8.19	Equal	9.60	245	74
SIC 3523	116	11.10	94	7.92	Equal	9.49	210	
SIC 3524	15	10.42	20	9.51	Equal	10.42	35	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 353	297	10.03	162	10.73	Equal	10.15	459	88
SIC 3531	128	11.05	106	11.61	Equal	11.20	234	
SIC 3532	22	10.77	10	9.39	Equal	10.77	32	
SIC 3533	37	9.14	20	8.84	Equal	9.14	57	
SIC 3534	26	9.33	3	10.52	Equal	9.66	29	
SIC 3535	42	9.01	7	13.05	Unequal	9.01	42	
SIC 3536	26	9.11	11	10.67	Equal	9.33	37	
SIC 3537	16	11.49	5	9.18	Equal	11.10	21	
SIC 354	124	8.53	285	5.73	Equal	7.25	409	61
SIC 3541	39	7.95	53	7.25	Unequal	7.95	39	
SIC 3542	16	8.85	15	3.51	Equal	6.04	31	
SIC 3543	3	8.84	8	0.94	Equal	5.36	11	
SIC 3544	18	12.16	28	9.69	Equal	10.42	46	
SIC 3545	32	8.10	119	8.11	Equal	8.10	151	
SIC 3546	5	10.00	44	2.47	Equal	2.87	49	
SIC 3547	3	6.22	9	2.07	Equal	2.48	12	
SIC 3548	1	10.76	3	3.32	Unequal	10.76	1	
SIC 3549	7	8.69	6	15.76	Equal	9.45	13	
SIC 355	131	7.89	131	9.69	Equal	8.37	262	43
SIC 3552	20	9.85	61	12.25	Unequal	9.85	20	
SIC 3553	3	11.10	13	6.40	Equal	6.40	16	
SIC 3554	7	8.29	3	11.80	Equal	10.04	10	
SIC 3555	41	8.37	15	12.10	Equal	9.60	56	
SIC 3556	4	8.15	12	5.20	Equal	6.16	16	
SIC 3559	56	7.01	27	3.00	Equal	5.74	83	
SIC 356	182	8.37	118	9.57	Unequal	8.37	182	93
SIC 3561	41	8.44	50	9.81	Unequal	8.44	41	
SIC 3562	24	8.85	13	5.15	Equal	8.80	37	
SIC 3563	22	1.67			N/A***	1.67	22	
SIC 3564	24	7.89	12	8.61	Equal	7.89	36	
SIC 3565	2	10.90			N/A***	10.90	2	
SIC 3566	11	8.37	1	11.03	Unequal	8.37	11	
SIC 3567	18	7.85	20	13.20	Unequal	7.85	18	
SIC 3568	8	8.86	8	5.99	Equal	8.82	16	
SIC 3469	32	10.84	14	6.87	Equal	10.45	46	
SIC 357	180	9.18	83	9.02	Equal	9.12	263	22
SIC 3571	58	8.25	11	7.30	Equal	8.10	69	
SIC 3572	15	4.21			N/A***	4.21	15	
SIC 3573			1	6.31	N/A***			
SIC 3575	25	10.18	8	8.70	Equal	10.18	33	
SIC 3577	38	9.10	9	2.07	Equal	8.56	47	
SIC 3579	44	10.01	54	9.21	Equal	9.28	98	
SIC 358	221	8.59	49	8.60	Equal	8.59	270	95
SIC 3581	4	11.73			N/A***	11.73	4	
SIC 3582	3	7.95	5	8.84	Equal	8.11	8	
SIC 3585	179	8.70	30	6.80	Equal	8.55	209	
SIC 3586	14	7.99			N/A***	7.99	14	
SIC 3589	21	8.59	14	12.88	Unequal	8.59	21	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 359	93	10.18	48	8.14	Equal	9.18	141	36
SIC 3592	27	9.45	9	10.42	Equal	9.80	36	
SIC 3593					N/A***			
SIC 3594	3	24.23	2	27.52	Equal	24.23	5	
SIC 3596	6	8.55	1	5.09	Unequal	8.55	6	
SIC 3599	57	11.26	36	7.42	Equal	9.00	93	
SIC 36	2324	8.90	1033	7.89	Unequal	8.90	2324	
SIC 361	192	9.64	121	8.00	Equal	9.18	313	45
SIC 3612	163	10.06	71	7.23	Equal	9.18	234	
SIC 3613	29	7.35	50	10.18	Unequal	7.35	29	
SIC 362	355	9.00	150	9.08	Unequal	9.00	355	103
SIC 3621	208	8.49	54	8.31	Unequal	8.49	208	
SIC 3622	1	7.68	6	43.83	Unequal	7.68	1	
SIC 3624	54	9.45	28	8.00	Equal	9.45	82	
SIC 3625	63	8.80	34	11.06	Equal	8.91	97	
SIC 3629	29	8.90	28	9.18	Equal	8.90	57	
SIC 363	183	8.80	133	10.58	Unequal	8.80	183	48
SIC 3631	53	8.80	58	10.59	Equal	9.05	111	
SIC 3632	40	8.58	34	11.00	Unequal	8.58	40	
SIC 3633	11	10.03	12	17.82	Unequal	10.03	11	
SIC 3634	40	8.24	10	11.17	Equal	8.34	50	
SIC 3635	2	9.38	2	5.39	Equal	8.17	4	
SIC 3639	37	10.54	17	5.67	Equal	10.53	54	
SIC 364	217	9.00	77	8.23	Equal	8.90	294	88
SIC 3641	55	9.59	18	10.48	Equal	9.69	73	
SIC 3643	41	9.08	21	9.08	Equal	9.08	62	
SIC 3644	21	10.76	5	8.31	Equal	10.76	26	
SIC 3645	43	7.84	19	5.55	Equal	7.84	62	
SIC 3646	23	7.95	7	7.71	Equal	7.95	30	
SIC 3647	11	7.95			N/A***	7.95	11	
SIC 3648	23	9.17	7	5.00	Equal	8.31	30	
SIC 365	42	8.80	7	8.05	Equal	8.80	49	10
SIC 3651	38	8.80	7	8.05	Equal	8.80	45	
SIC 3652	4	8.87			N/A***	8.87	4	
SIC 366	271	8.90	69	6.00	Equal	8.34	340	21
SIC 3661	173	9.75	45	5.73	Equal	8.93	218	
SIC 3662	1	7.25			N/A***	7.25	1	
SIC 3663	59	10.06	15	8.08	Equal	9.04	74	
SIC 3669	38	4.65	9	6.00	Equal	5.00	47	
SIC 367	972	8.44	341	6.18	Unequal	8.44	972	387
SIC 3671	101	7.84	30	3.00	Equal	7.62	131	
SIC 3672	53	7.89	90	6.72	Equal	7.65	143	
SIC 3674	375	8.90	100	7.28	Equal	8.84	475	
SIC 3675	26	8.90	1	1.98	Unequal	8.90	26	
SIC 3676	13	5.06			N/A***	5.06	13	
SIC 3677	4	10.47	4	11.17	Equal	10.47	8	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	Median Exit Gas Velocity for SIC code	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 3678	8	4.83			N/A***	4.83	8	
SIC 3679	392	8.17	116	5.32	Unequal	8.17	392	
SIC 369	92	8.85	135	8.47	Equal	8.75	227	144
SIC 3691	17	9.09	92	8.21	Equal	8.47	109	
SIC 3692	3	22.30	4	0.98	Equal	15.01	7	
SIC 3694	58	8.80	19	9.00	Equal	8.87	77	
SIC 3695	4	11.49	5	8.09	Equal	9.31	9	
SIC 3699	10	5.58	15	9.08	Unequal	5.58	10	
SIC 37	3368	9.17	3589	11.05	Unequal	9.17	3368	
SIC 371	2108	9.85	3243	11.43	Equal	10.76	5351	481
SIC 3711	800	11.08	1375	12.19	Equal	11.89	2175	
SIC 3713	130	10.52	51	12.92	Equal	11.10	181	
SIC 3714	1103	9.05	1817	10.06	Equal	9.72	2920	
SIC 3715	66	9.75			N/A***	9.75	66	
SIC 3716	9	11.49			N/A***	11.49	9	
SIC 372	651	7.74	127	6.10	Equal	7.62	778	159
SIC 3721	407	7.74	54	2.26	Equal	7.62	461	
SIC 3724	94	8.10	26	5.97	Equal	7.90	120	
SIC 3728	150	7.92	47	7.62	Equal	7.62	197	
SIC 373	281	8.55	67	7.89	Equal	8.10	348	127
SIC 3731	134	7.95	17	10.33	Equal	7.95	151	
SIC 3732	147	10.76	50	7.89	Equal	8.31	197	
SIC 374	140	9.81	59	10.97	Equal	10.00	199	28
SIC 3743	140	9.81	59	10.97	Equal	10.00	199	
SIC 375	31	8.31	20	8.05	Equal	8.26	51	7
SIC 3751	31	8.31	20	8.05	Equal	8.26	51	
SIC 376	95	10.44	34	4.00	Equal	8.90	129	23
SIC 3761	65	11.49	23	4.00	Equal	9.40	88	
SIC 3764	27	3.66	11	8.31	Equal	5.47	38	
SIC 3769	3	8.90			N/A***	8.90	3	
SIC 379	62	11.10	39	16.15	Equal	11.49	101	46
SIC 3792	20	11.49	1	36.27	Unequal	11.49	20	
SIC 3795	23	9.00	8	10.00	Equal	9.66	31	
SIC 3799	19	13.32	30	16.15	Equal	16.15	49	
SIC 38	851	8.00	203	8.00	Equal	8.00	1054	
SIC 381	251	6.71	16	7.03	Equal	6.74	267	13
SIC 3811			1	15.67	N/A***	15.67	1	
SIC 3812	251	6.71	15	6.89	Equal	6.72	266	
SIC 382	153	6.22	58	3.00	Equal	5.64	211	62
SIC 3821	10	7.53	3	3.00	Equal	5.74	13	
SIC 3822	27	7.95	11	5.96	Equal	7.61	38	
SIC 3823	26	4.42	4	3.60	Equal	4.26	30	
SIC 3824	7	6.00			N/A***	6.00	7	
SIC 3825	25	7.10	1	6.61	Unequal	7.10	25	

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**
SIC 3826	34	6.68	27	0.61	Equal	3.08	61	
SIC 3827	7	4.00	8	13.31	Unequal	4.00	7	
SIC 3829	17	5.07	4	4.00	Equal	5.00	21	
SIC 384	147	8.03	66	8.31	Equal	8.10	213	81
SIC 3841	94	8.07	35	8.31	Equal	8.31	129	
SIC 3842	28	5.78	8	11.54	Equal	7.12	36	
SIC 3843	7	5.74	16	8.58	Equal	8.26	23	
SIC 3844	13	6.71	6	4.21	Equal	5.21	19	
SIC 3845	5	10.67	1	11.89	Unequal	10.67	5	
SIC 385	14	6.92	9	8.00	Equal	8.00	23	11
SIC 3851	14	6.92	9	8.00	Equal	8.00	23	
SIC 386	283	9.30	47	9.18	Equal	9.18	330	34
SIC 3861	283	9.30	47	9.18	Equal	9.18	330	
SIC 387	3	14.54	7	135.33	Unequal	14.54	3	2
SIC 3873	3	14.54	7	135.33	Unequal	14.54	3	
SIC 39	537	9.20	181	8.00	Equal	8.90	718	
SIC 391	22	8.50	1	11.26	Equal	8.90	23	14
SIC 3911	4	7.51			N/A***	7.51	4	
SIC 3914	17	8.90	1	11.26	Unequal	8.90	17	
SIC 3915	1	8.10			N/A***	8.10	1	
SIC 393	35	7.77	8	9.18	Equal	8.08	43	13
SIC 3931	35	7.77	8	9.18	Equal	8.08	43	
SIC 394	109	9.18	49	8.31	Equal	8.60	158	46
SIC 3942	3	10.76	1	5.61	Unequal	10.76	3	
SIC 3944	46	10.30	43	8.60	Equal	8.60	89	
SIC 3949	60	9.13	5	2.19	Equal	8.10	65	
SIC 395	48	8.63	15	9.08	Equal	8.66	63	14
SIC 3951	7	8.27	3	8.31	Equal	8.31	10	
SIC 3952	29	8.00	7	9.08	Equal	8.54	36	
SIC 3955	12	9.79	5	9.18	Equal	9.18	17	
SIC 396	18	9.21	5	2.41	Equal	8.90	23	18
SIC 3961	8	10.74	2	4.75	Equal	9.95	10	
SIC 3965	10	8.90	3	2.41	Equal	8.90	13	
SIC 399	305	10.18	103	6.43	Equal	9.04	408	123
SIC 3991	8	9.31	6	7.25	Equal	8.08	14	
SIC 3993	82	11.04	17	3.00	Equal	9.72	99	
SIC 3995	65	10.78	4	1.80	Equal	10.18	69	
SIC 3996	16	11.00	20	7.50	Equal	8.00	36	
SIC 3999	134	8.50	56	7.65	Equal	8.34	190	

*Is mean exit gas velocity of TRI chemical emitting stacks equal to mean exit gas velocity of non-TRI chemical emitting stacks? If unequal, use data from stacks emitting TRI chemicals.
**Approximately 91% of TRI facilities use exit gas velocities based on their 3-digit SIC codes.
***Stack exit gas velocity data unavailable for one or both both stack categories (emitting TRI chemicals and emitting only non-TRI

See notes at end of table.

Table A-2
Summary of Exit Gas Velocity by SIC Code

SIC Code	TRI Chemicals Number of Stacks	Median (m/s)	Non-TRI Chemicals Number of Stacks	Median (m/s)	Equal Stack Pop. Means? *	**Median Exit Gas Velocity for SIC code**	Number of Stacks for SIC code	Number of TRI Facilities Using Median Exit Gas Velocity of their SIC code**

chemicals).