# EXECUTIVE SUMMARY

# Executive Summary

The Multiple Air Toxics Exposure Study III (MATES III) is a monitoring and evaluation study conducted in the South Coast Air Basin (Basin). The study is a follow on to previous air toxics studies in the Basin and is part of the South Coast Air Quality Management District (SCAQMD) Governing Board Environmental Justice Initiative.

The MATES III Study consists of several elements. These include a monitoring program, an updated emissions inventory of toxic air contaminants, and a modeling effort to characterize risk across the Basin. The study focuses on the carcinogenic risk from exposure to air toxics. It does not estimate mortality or other health effects from particulate exposures. The latter analysis was conducted as part of the 2007 Air Quality Management Plan and is not included here.

A network of ten fixed sites was used to monitor toxic air contaminants once every three days for two years. The location of the sites was the same as in the previous MATES II Study to provide comparisons over time. The one exception is the West Long Beach site, which was about 2.5 miles east of the Wilmington location used in MATES II. The locations of the sites are shown in Figure ES-1.

The initial scope of the monitoring was for a one-year period from April 2004 through March 2005. Due to the heavy rains in the Basin in the fall and winter of this period, there was concern that the measurements may not be reflective of typical meteorology. The study was thus extended for a second year from April 2005 through March 2006.

In addition to the fixed sites, five additional locations were monitored for periods of several months using moveable monitoring platforms. These microscale sites were chosen to determine if there were gradients between communities that would not be picked up by the fixed locations.

The study also included an update of the toxics emissions inventories for the Basin and computer modeling to estimate toxics levels throughout the Basin. This allows estimates of air toxics risks in all areas of the Basin, as it is not feasible to conduct monitoring in all areas.

To provide technical guidance in the design of the study, a Technical Advisory Group was formed. The panel of experts from academia, environmental groups, industry, and public agencies provided valuable insights on the study design. Components of the study recommended by the Advisory Group included monitoring for longer periods at the microscale sites, including naphthalene in the monitoring program, and including more up-to-date methods to estimate the contribution of diesel exhaust to ambient particulate levels. In the monitoring program, over 30 air pollutants were measured. These are listed in Table ES-1. These included both gaseous and particulate air toxics.

The monitored and modeled concentrations of air toxics were then used to estimate the carcinogenic risks from ambient levels. Annual average concentrations were used to estimate a lifetime risk from exposure to these levels, consistent with guidelines established by the Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency (EPA).

**Table ES-1 Substances Measured in MATES III**

| | | |
|---|---|---|
| Benzene | 1,3-Butadiene | Carbon Tetrachloride |
| Chloroform | Dichlorobenzene | Methylene Chloride |
| MTBE | Perchloroethylene (Tetrachloroethylene) | Dichloroethane |
| Dibromoethane | Ethyl Benzene | Toluene |
| Trichloroethylene | Xylene | Styrene |
| Vinyl Chloride | Acetaldehyde | Formaldehyde |
| Acetone | Methyl ethyl ketone | |
| Arsenic | Cadmium | Hexavalent Chromium |
| Copper | Lead | Manganese |
| Nickel | Selenium | Zinc |
| Elemental Carbon | Organic Carbon | Naphthalene |
| PAHs | $PM_{10}$ | $PM_{2.5}$ |

To assess the potential carcinogenic risk, at least one full year of data is preferred to represent exposure potential. Thus, the fixed site data was used to calculate risk estimates and the microscale sites used solely to determine any gradients compared to the nearest fixed monitoring site. To estimate the risks from the fixed sites, the concentrations measured over each of the two years were averaged to estimate exposure. The Huntington Park and Pico Rivera sites did not have a full year of data for the second year of the study; thus, only the first year of data was used for these two sites.

In the MATES II Study, elemental carbon (EC) was used as a surrogate for diesel particulate levels, as staff determined that this was the best method available during the MATES II Study. For the present study, staff used the Chemical Mass Balance (CMB) source apportionment technique to estimate the contribution from diesel, as well as from other major source categories, to the measured particulate levels.

Key results of the study are presented below.

**Fixed Site Monitoring**

The carcinogenic risk from air toxics in the Basin, based on the average concentrations at the fixed monitoring sites, is about 1,200 per million. This risk refers to the expected number of additional cancers in a population of one million individuals that are exposed over a 70-year lifetime. Using the MATES III methodology, about 94% of the risk is attributed to emissions associated with mobile sources, and about 6% of the risk is attributed to toxics emitted from stationary sources, which include industries, and businesses such as dry cleaners and chrome plating operations. The average risks from the annual average levels of air toxics calculated from the fixed monitoring sites data are shown in Figure ES-2.

The air toxics risk at the fixed sites ranged from 870 to 1,400 per million. The risk by site averaged over the two study years is depicted in Figure ES-3. For the second year of the study, a full year of data was not collected at two of the sites (the Huntington Park site access was not extended for the second year; and the Pico Rivera site was moved during the second year resulting in several months without data). The second year data include results for only eight sites. Sites with higher levels of risk include Burbank, Central Los Angeles, Inland Valley San Bernardino, Huntington Park, and West Long Beach. The site with the lowest risk is Anaheim.

The results indicate that diesel exhaust is the major contributor to air toxics risk, accounting on average for about 84% of the total.

To compare different methods used to estimate diesel particulate levels, the method used in MATES II, which was based on the emissions ratios of diesel particulate and elemental carbon from a study conducted in the South Coast in the 1980's, and a method based on the ratio of $PM_{2.5}$ emissions from the 2005 emissions inventory were both calculated. For MATES II, the $PM_{10}$ elemental carbon levels were multiplied by 1.04 to estimate diesel particulate. The 2005 $PM_{2.5}$ inventory finds a ratio of diesel particulate to elemental carbon emissions of 1.95. Multiplying the $PM_{2.5}$ elemental carbon levels by the 1.95 ratio gives another estimate of diesel particulate. The estimates using these methods compared to using the CMB model are shown in Table ES-2. Should one use the same diesel particulate estimation methodology as MATES II, there is about a 30% reduction in ambient levels between the two studies. Based on comparisons of the three methods to estimate diesel particulate, the method used for MATES II gives the lowest estimates of ambient diesel particulate.

For the CMB model, the estimates were sensitive to the species profile used for gasoline vehicles. Table ES-2 shows the range of values using two different gasoline profiles. The estimates used for the risk calculations were the midpoint of the range. As shown in the table, both the CMB model and the $PM_{2.5}$ emissions ratio from the 2005 emissions inventory method give similar estimates, and both are higher than the MATES II method. Thus the MATES II Study method is likely underestimating the levels of diesel particulate.

**Table ES-2 CMB Estimate of Diesel Particulate Compared to Emissions Inventory Ratio Methods.**

| **Estimation Method** | **MATES III Diesel PM μg/m3** |
|---|---|
| MATES II Method:<br>$PM_{10}$ EC x 1.04 | 2.16 |
| 2005 Inventory Method:<br>$PM_{2.5}$ EC x 1.95 | 3.5 |
| CMB Method | 3.20 – 3.49 |

Note: Year 2 includes data for eight sites only. The MATES II diesel particulate was estimated at 3.4 $\mu g/m^3$.

**Modeling**

Several updates to the modeling platform were included in this study compared to MATES II. The model used was the Comprehensive Air Quality Model with Extensions (CAMx). This model is consistent with that used in the 2007 Air Quality Management Plan. A grid size of 2 kilometers was used.

In addition to using an updated air toxics emissions inventory, an improved geographical allocation of diesel emissions was employed.

The modeling results are shown in Figure ES-4. The grid cell with the highest air toxics risk was at the ports. The grid cells near the ports ranged from about 1,100 to 3,700 in a million. In addition to the ports, an area of elevated risk is shown near the Central Los Angeles area with grid cells ranging from about 1,400 to 1,900 per million. There are also higher levels of risk that track transportation corridors and freeways.

Since the modeling platform and emissions inventory methods are different in MATES III than those used in MATES II, the CAMx model was applied to the MATES II time frame for a more ”apples to apples” assessment. The MATES III methodology was also used to back-cast the estimates of air toxics emissions for the MATES II timeframe. Comparing the results, a lesser level of carcinogenic risk was estimated across the Basin for MATES III compared to the MATES II time period. The model also shows the dominant contribution from mobile sources and diesel emissions to air toxics risk in the MATES II timeframe as well.

For comparison purposes, Table ES-3 shows the estimated population weighted risk across the Basin for the MATES III and MATES II periods. The population weighted risk was about 8% lower compared to the MATES II period.

The MATES III modeling analysis represents several improvements over that used in MATES II and represents the state-of-science application of regional modeling tools and chemistry applied to an updated set of meteorological and emissions data input.

**Table ES-3 Modeled Air Toxics Risk Comparisons Using the CAMx Model**

| | MATES III | MATES II | Change |
|---|---|---|---|
| Population weighted risk (per million) | 853 | 931 | -8% |

Figure ES-5 depicts the 1998-99 to 2005 change in air toxics risk for each model grid cell estimated from the CAMx simulations. Overall, air toxics risk improves to varying levels in most of the Basin with the exceptions of the areas directly downwind of the ports and those areas heavily impacted by activities associated with goods movement. The model comparison shows an increase in air toxics risk occurred in the immediate areas encompassing the ports of more than 800 in a million between the two periods. This increase correlates with the increased container cargo moving through the ports and increases in goods movement that occurred between the MATES II and MATES III time periods.

**Noncancer Assessment**

To assess the potential for noncancer health risks, the monitored average levels were compared to the Chronic Reference Exposure Levels (RELs) established by OEHHA. The chronic REL is the air concentration at or below which adverse noncancer health effects would not be expected in the general population with exposure for at least a significant fraction of a lifetime. In general, the measured concentrations of air toxics were below the RELs.

The exception is formaldehyde. The chronic REL is 3 µg/m3 (2ppb). All of the fixed site annual averages were above this concentration, ranging from 2.9 ppb for Anaheim to 4.5 ppb at Los Angeles. Formaldehyde effects include eye irritation, injury to nasal tissue, and respiratory discomfort. OEHHA, however, is proposing revisions to the RELs for several toxic air contaminants. For formaldehyde, the proposed chronic REL is 9 µg/m3 (7 ppb). If the proposed level is promulgated, then all sites would be under the chronic REL.

**Caveats and Uncertainty**

One source of uncertainty is that currently there is no technique to directly measure diesel particulates, the major contributor to risk in this study, so indirect estimates based on components of diesel exhaust must be used. The method chosen to estimate diesel particulate is the CMB source apportionment model. This method is a weighted multiple linear regression model based on mass balance of each chemical species applied to apportion contributions to ambient particulates using measured source profiles. The CMB method accounts for major source categories and geographic differences in source contributions and was recommended by the Technical Advisory Group. It is staff's judgment that this is the most appropriate method to estimate the ambient levels of diesel particulate matter.

The MATES II Study used elemental carbon as a surrogate for diesel particulate. Elemental carbon, however, is not a unique tracer for diesel, as there are additional emission sources of elemental carbon. Using the CMB model takes advantage of the specific profile of chemical species emitted from different particulate matter sources. Twenty-three species were used in the CMB model to reconcile source contributions to observed ambient concentrations. This results in a more robust apportionment of source contributions to ambient particulate matter levels, since all major sources of particulate matter and elemental carbon are considered.

The CMB model uses the profile of chemical tracer chemical species from different source categories to estimate the contribution to ambient particulates. Some tracers are unique to a given source, such as levoglucosan from biomass burning, whereas other sources show specific chemical profiles that can be used to apportion these sources, such as gasoline and diesel combustion. The advantage of the CMB model is that it can apportion several sources to ambient levels. Additional discussion is provided in Chapter 2 and Appendix VII on the CMB methodology.

The Positive Matrix Factorization (PMF) model was also evaluated for estimation of diesel particulate. The PMF model is an alternating least squares method that estimates source profiles and source contributions from the ambient data. Since possible solutions to this model can be negative, the procedure uses restrictive functions so that no sample can have a negative source contribution and no species can have a negative fraction in any source profile. Estimated source profiles are then attributed to specific sources using experienced judgment. However, using the MATES III data, the initial attempts at source apportionment found that some source profiles could not be interpreted, and some profiles could not be confirmed with confidence.

Additionally, the statistical parameters of the PMF model performance were outside of the bounds used to determine adequate performance of the model. Also, in perusing the literature of applications of PMF approach, it was found that substantial amounts of measured data were sometimes excluded from the analyses, and an uncertainty parameter for some variables was altered to improve the model performance. Staff did not censor any data or alter certain parameters in the model in an attempt to improve the model performance statistics. The uncertainties used for the ambient measurements were those provided by the laboratory analyses. Thus, the PMF method was not pursued.

When compared to the MATES II method, the CMB model available from the U.S. EPA gives higher estimates of diesel particulates. The CMB model estimate for diesel particulate was found to be sensitive to the gasoline emissions profile used. To account for this, the midpoint of a range of estimates using two different gasoline profiles was used.

There are also uncertainties in the risk potency values used to estimate lifetime risk of cancer. This study used the unit risks for cancer potency established by OEHHA and the annual average concentration measured or modeled to calculate risk. This methodology has long been used to estimate the relative risks from exposure to air toxics in California and is useful as a yardstick to compare potential risks from varied sources and emissions and to assess any changes in risks over time that may be associated with changing air quality.

The estimates of health risks are based on the state of current knowledge, and the process has undergone extensive scientific and public review. However, there is uncertainty associated with the processes of risk assessment. This uncertainty stems from the lack of data in many areas necessitating the use of assumptions. The assumptions are consistent with current scientific knowledge, but are often designed to be conservative and on the side of health protection in order to avoid underestimation of public health risks.

As noted in the OEHHA risk assessment guidelines, sources of uncertainty, which may either overestimate or underestimate risk, include: (1) extrapolation of toxicity data in animals to humans, (2) uncertainty in the estimation of emissions, (3) uncertainty in the air dispersion models, and (4) uncertainty in the exposure estimates. Uncertainty may be defined as what is not known and may be reduced with further scientific studies. In addition to uncertainty, there is a natural range or variability in the human population in such properties as height, weight, and susceptibility to chemical toxicants.

Thus, the risk estimates should not be interpreted as actual rates of disease in the exposed population, but rather as estimates of potential risk, based on current knowledge and a number of assumptions. However, a consistent approach to risk assessment is useful to compare different sources and different substances to prioritize public health concerns.

**Conclusion**

Compared to previous studies of air toxics in the Basin, this study found a decreasing risk for air toxics exposure, with the estimated Basin-wide population-weighted risk down by 8% from the analysis done for the MATES II time period. The ambient air toxics data from the ten fixed monitoring locations also demonstrated a reduction in air toxic levels and risks.

**Policy Implications**

While there has been improvement in air quality regarding air toxics, the risks are still unacceptable and are higher near sources of emissions such as ports and transportation corridors. Diesel particulate continues to dominate the risk from air toxics, and the portion of air toxic risk attributable to diesel exhaust is increased compared to the MATES II Study.

The highest air toxics risks are found near the port area, an area near Central Los Angeles, and near transportation corridors. The results from this study underscore that a continued focus on reduction of toxic emissions, particularly from diesel engines, is needed to reduce air toxics exposure.

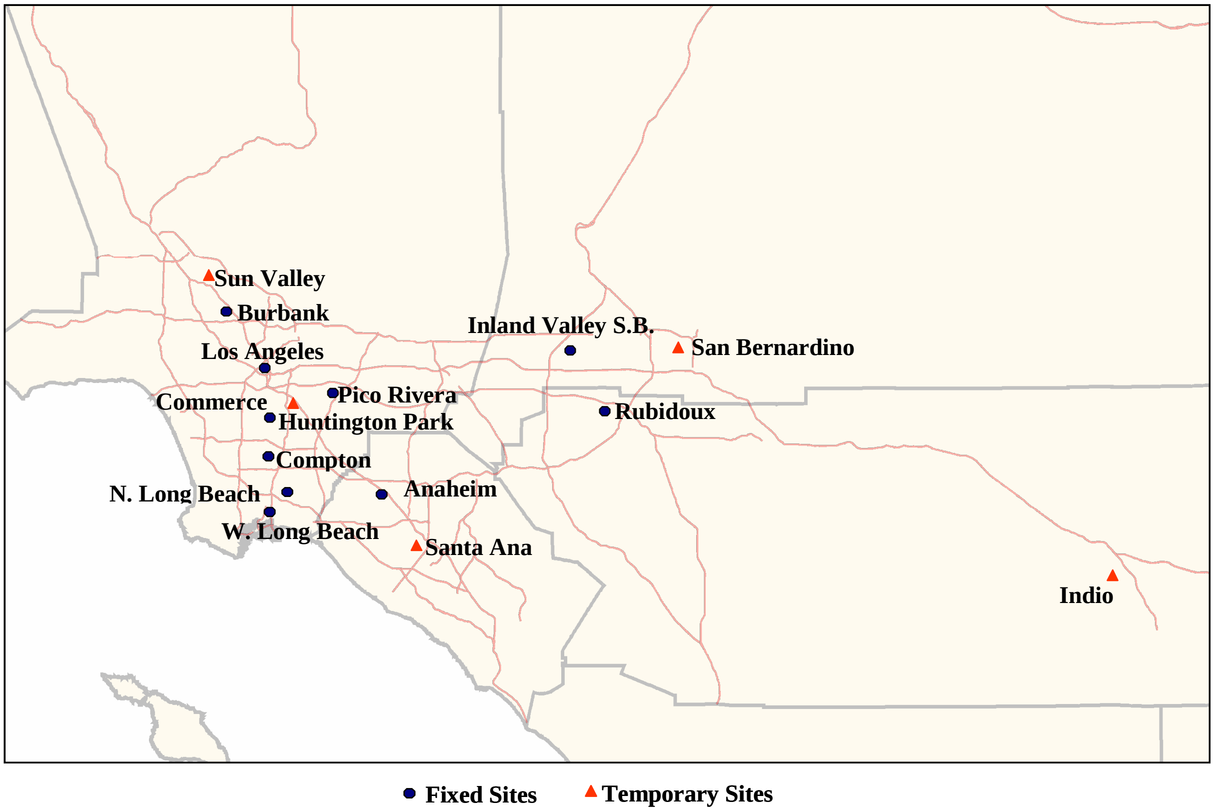


**Figure ES-1 Map of MATES III Monitoring Sites**

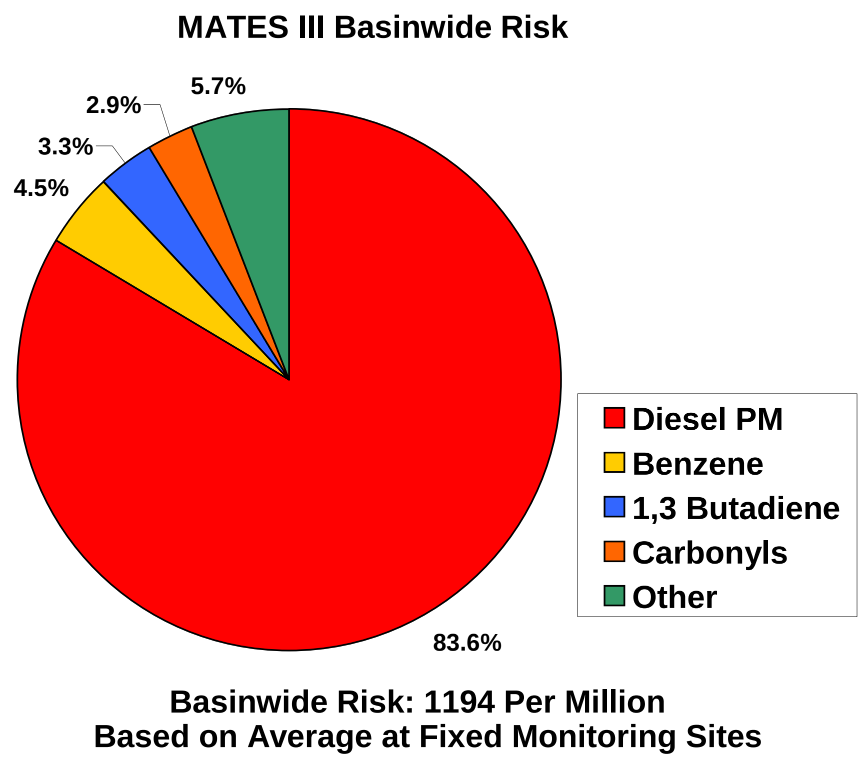


**Figure ES-2**

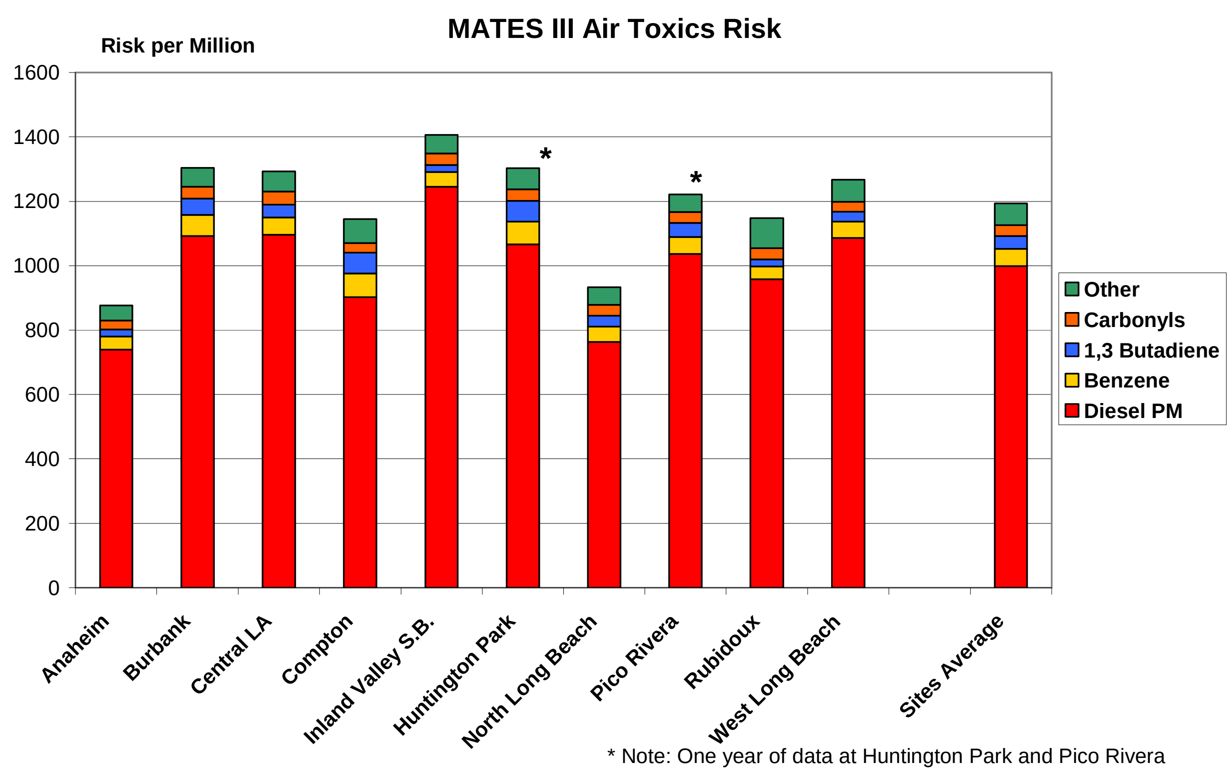


**Figure ES-3**

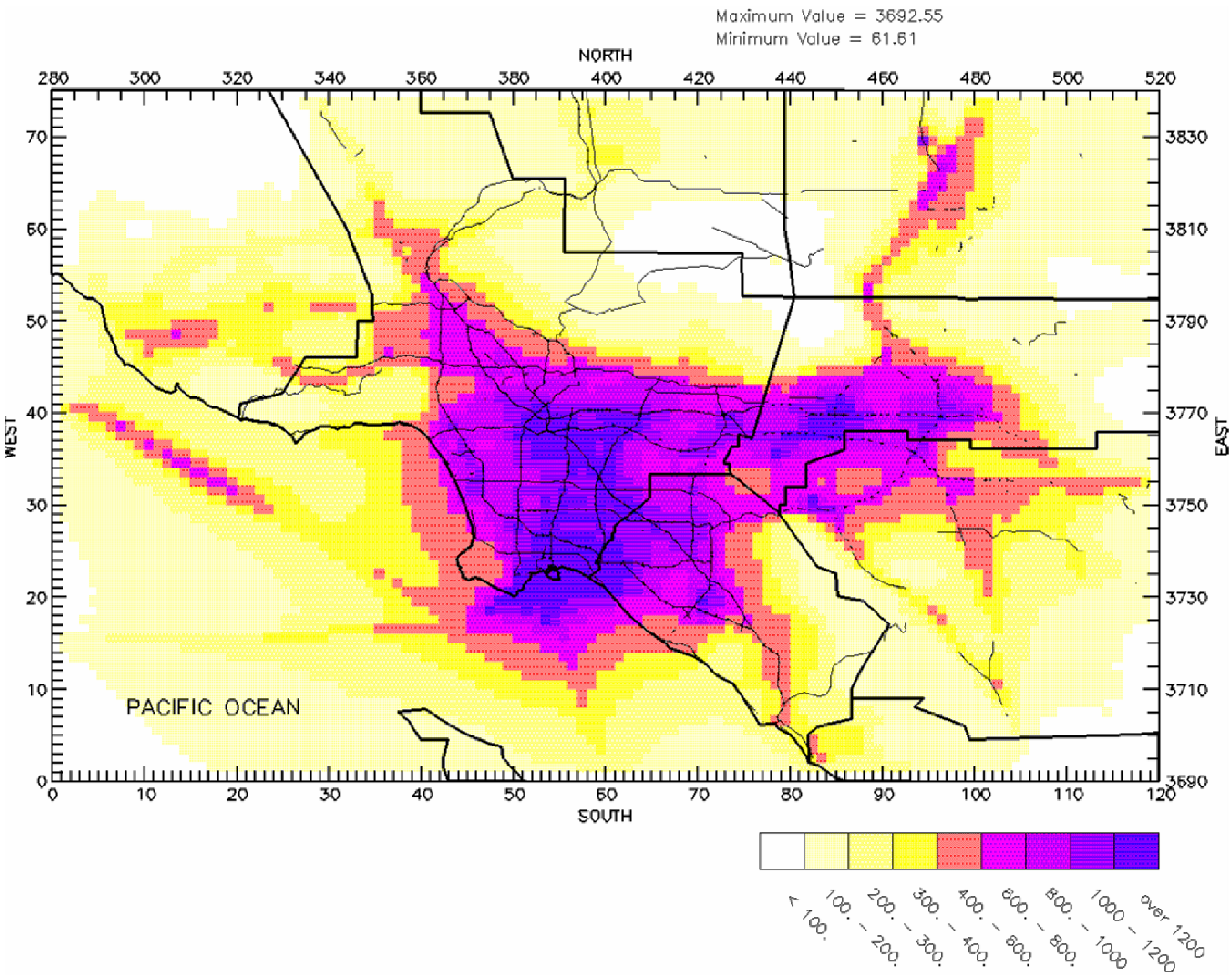


**Figure ES-4**
**MATES III Model Estimated Risk**

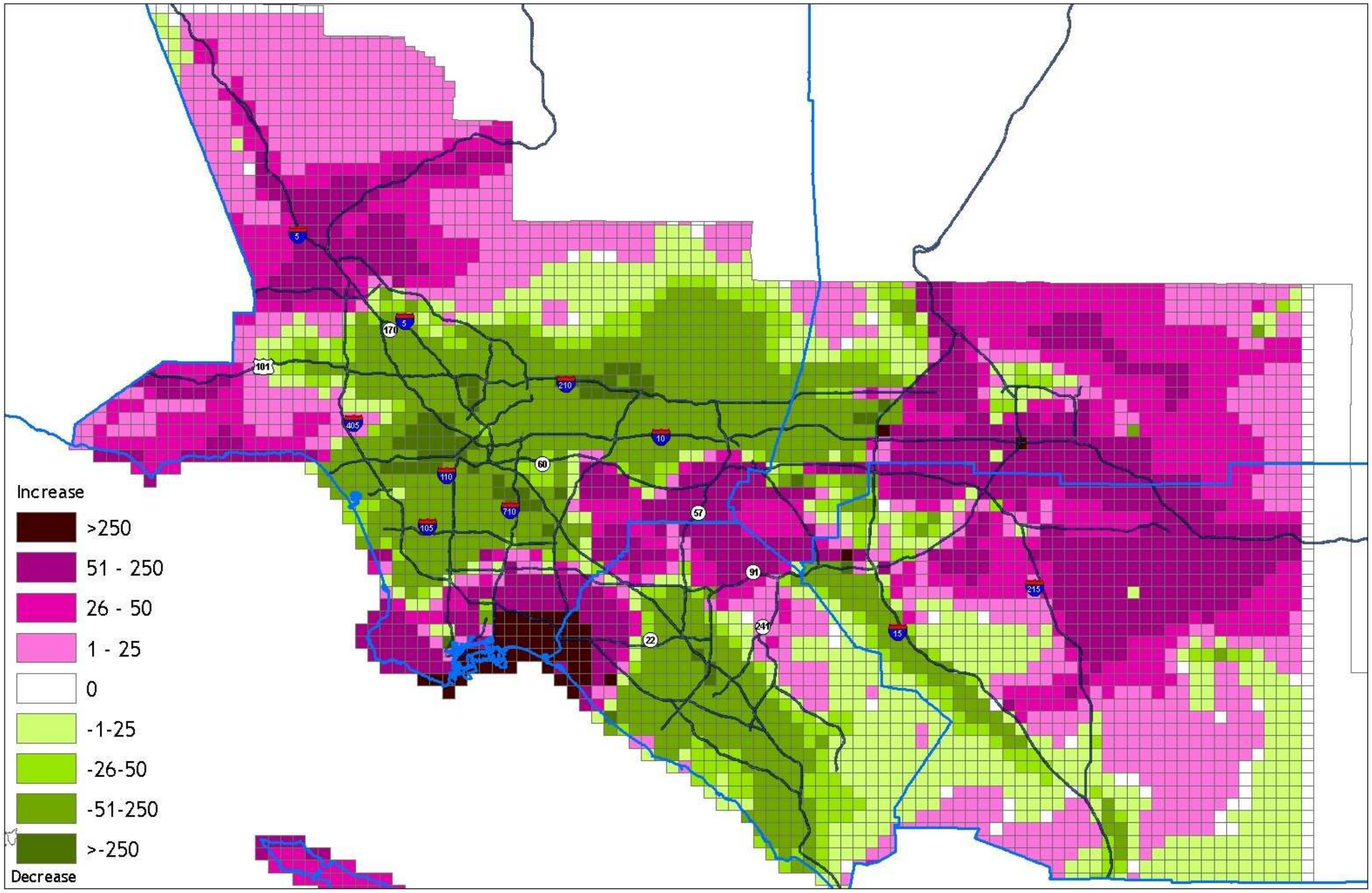


**Figure ES-5**
**Change in CAMx RTRAC Air Toxics Simulated Risk (per million) from 1998-99 to 2005 Using Back-Cast 1998 Emissions and 1998-99 MM5 Generated Meteorological Data Fields**