Regional Air Toxics Modeling in California's San Francisco Bay Area

P. Martien[1], S. Tanrikulu[1], C. Tran[1], D. Fairley[1], Y. Jia[1], A. Fanai[1], S. Reid[2], G. Yarwood[3], C. Emery[3]

[1]Bay Area Air Quality Management District, [2]Sonoma Technology Inc., [3]ENVIRON Corp.

AGU Fall Meeting 2011

Introduction

Observed concentrations of toxic air contaminants (TAC) have declined significantly over recent decades in the San Francisco Bay Area, California, USA. However, these contaminants continue to pose serious health concerns, particularly in communities near busy roads and heavy industry. Projected future infill development will bring more residents into dense urban areas, which will support public transit, reduce per capita emissions, and help protect surrounding green space, but which could potentially increase exposures to direct sources of air pollution.

To monitor ambient concentrations and track trends, the Bay Area Air Quality Management District (BAAQMD) has established a TAC monitoring network. Recently, the BAAQMD developed gridded estimates of TAC emissions and used grid-based modeling with high grid resolution (1 km) to determine the spatial distribution of TAC concentrations and exposures. The results of regional air quality modeling have helped direct local-scale studies and aided in the design of mitigation measures aimed at reducing TAC exposures.

Estimating Air Pollutant Emissions

- Emissions estimates were developed for the BAAQMD in 2005 and 2015 for major source categories:
  - On-road mobile (EMFAC2007, spatial allocation with Caltran's DTIM4)
  - Permitted stationary (BAAQMD TAC inventory)
  - Area and non-road mobile (OFFROAD2007 with 50% reduction of diesel emissions based on estimates of non-taxed diesel fuel use)
- Particulate matter (PM) and organic gases were speciated to TAC using source-specific speciation profiles
- TAC emissions were gridded to 1 km x 1 km (US EPA SMOKE)
- Gridded emissions for photochemical modeling were developed for summer and winter periods (SAPRC 2009 chemical speciation)
- 2015 emissions include significant reductions from vehicle fleet turnover/replacement (including grant & incentive programs) and California Air Resources Board's diesel regulations
- Potential cancer risk from TAC compounds, including diesel PM, were estimated using unit risk factors (Office of Environmental Health Hazard Assessment; OEHHA)

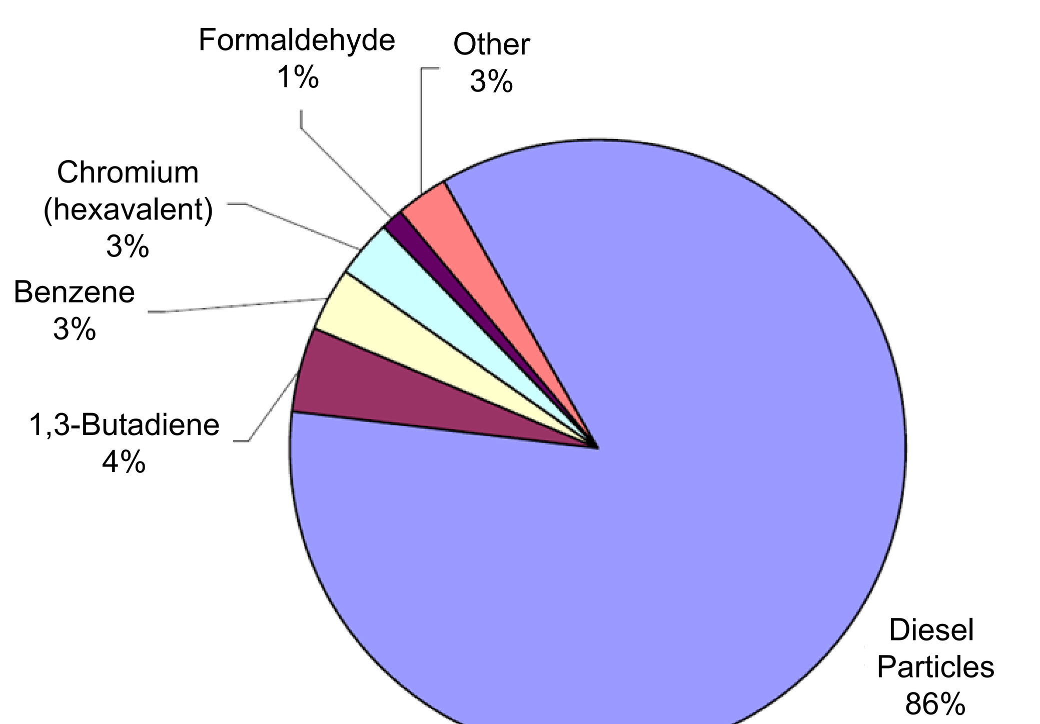

Figure 1. BAAQMD TAC emissions estimates (2005), weighted by cancer risk.

Of the TAC emissions, diesel PM contributes the largest potential cancer risk (Figure 1); major sources of diesel PM include trucks, construction equipment, ships, and rail.

Air Toxics Modeling

- Meteorological inputs were generated using Mesoscale Meteorological Model v.5 (MM5) for July and December, 2000
- Comprehensive Air Quality Model with Extensions (CAMx; v.4.50) was used to predict TAC concentrations
  - Inert tracer for diesel PM
  - SAPRC99 chemical mechanism for formaldehyde, acetaldehyde, and reactive oxidant compounds
  - Reactive Tracer Chemical Mechanism Compiler and Reactive Tracer modules for benzene, 1,3-butadiene, and acrolein
  - Annual TAC: weighted average of summer/winter simulations
- Air quality model performance was evaluated with observed TAC
  - Simulated seasonal averages of gaseous TACs near measurement sites were compared to observed seasonal (July and December) averages over years 2004 – 2006
  - Simulated diesel PM was compared to observed seasonal averages of elemental carbon (EC) for 2005 – 2006
- Predicted cancer risk from TAC assumed 70-year exposures at modeled TAC concentrations and used OEHHA unit risk factors

Results – Simulated Cancer Risk, 2005

Simulated potential cancer risk from TAC is highest near sources of diesel PM: near freeways and shipping lanes. **Peak risk** (Figure 2) **is east of San Francisco, near the Maritime Port of Oakland**.

Simulated gaseous TAC levels were generally not statistically different from observed levels, with the exception of acrolein where observed levels were much larger (Figure 3a) but where there is a high degree of uncertainty associated with the measurements.

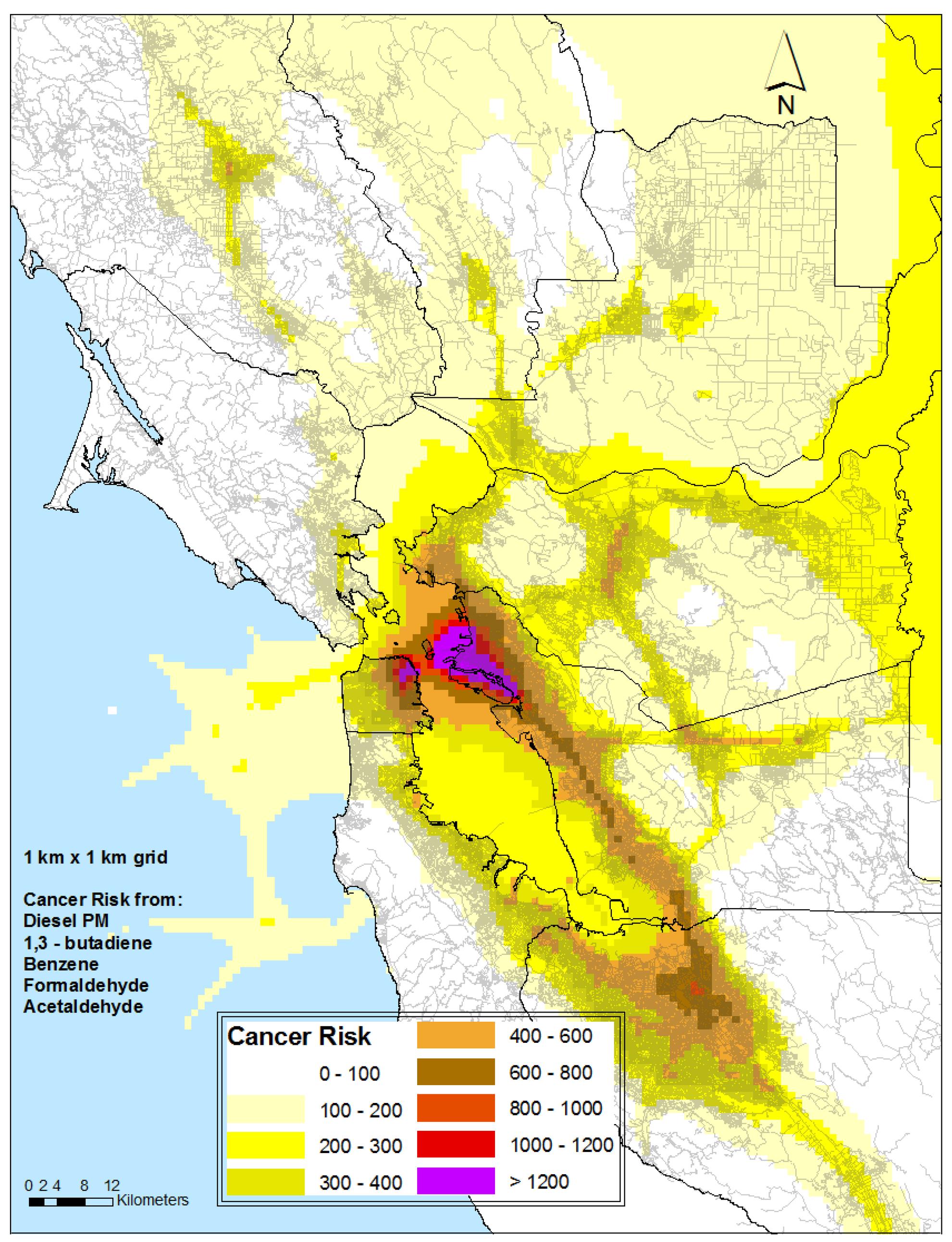

Figure 2. Predicted potential cancer risk in 2005 from toxic air contaminants (per million exposed population).

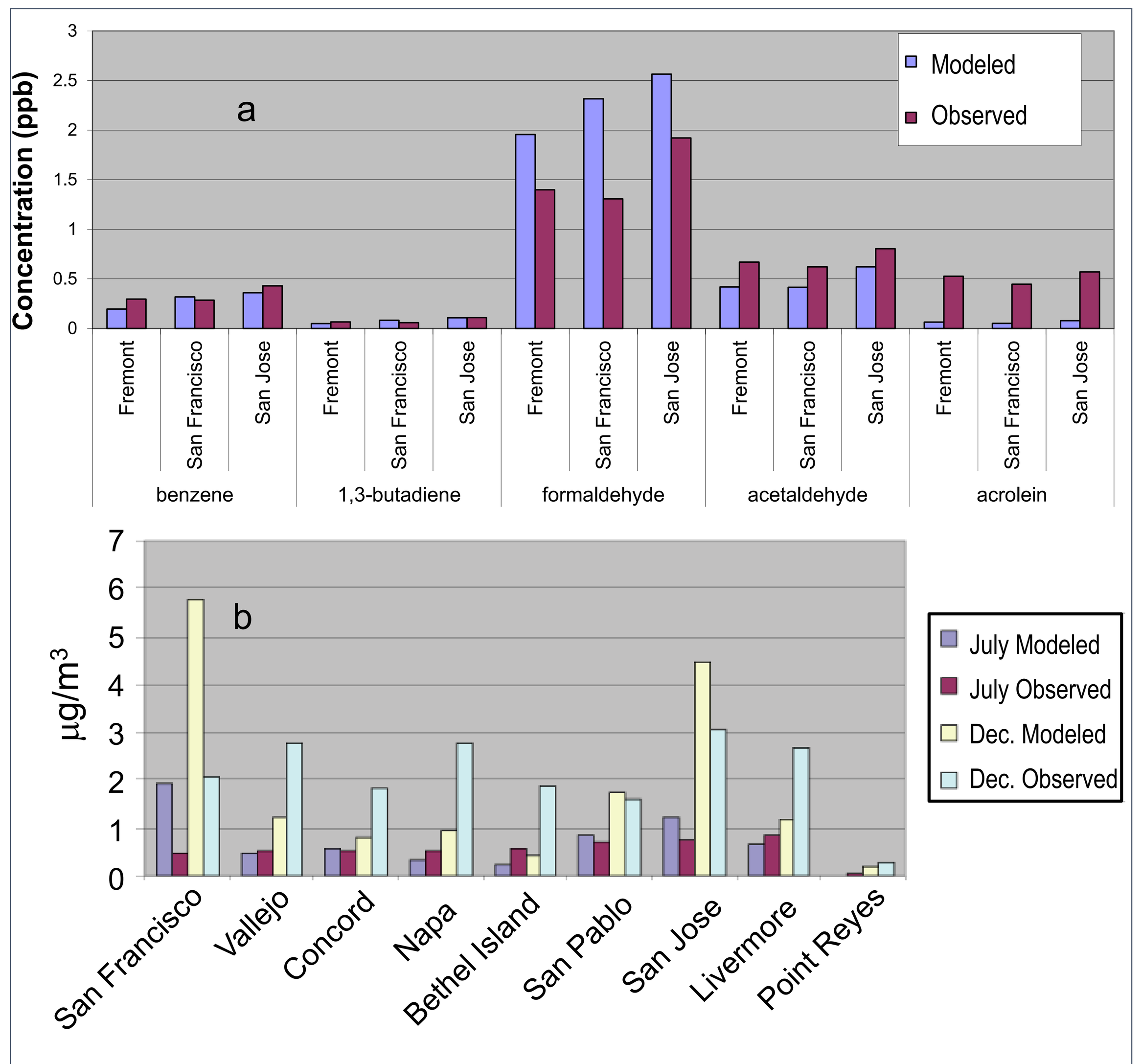

Figure 3. (a) Modeled annual averages of gaseous TAC compared to observed annual average values in 2004-2006. (b) Modeled diesel PM compared to observed EC (IMPROVE method) averages for July and Dec. in 2005-2006.

Simulated diesel PM and observed EC are close in July at a number of sites where December EC is substantially higher (Figure 3b); wood smoke may be contributing to EC at these sites. Simulated diesel PM is three to four times observed EC levels in San Francisco, where off-road diesel emissions are likely to be overstated.

Results – Simulated Cancer Risk, 2015

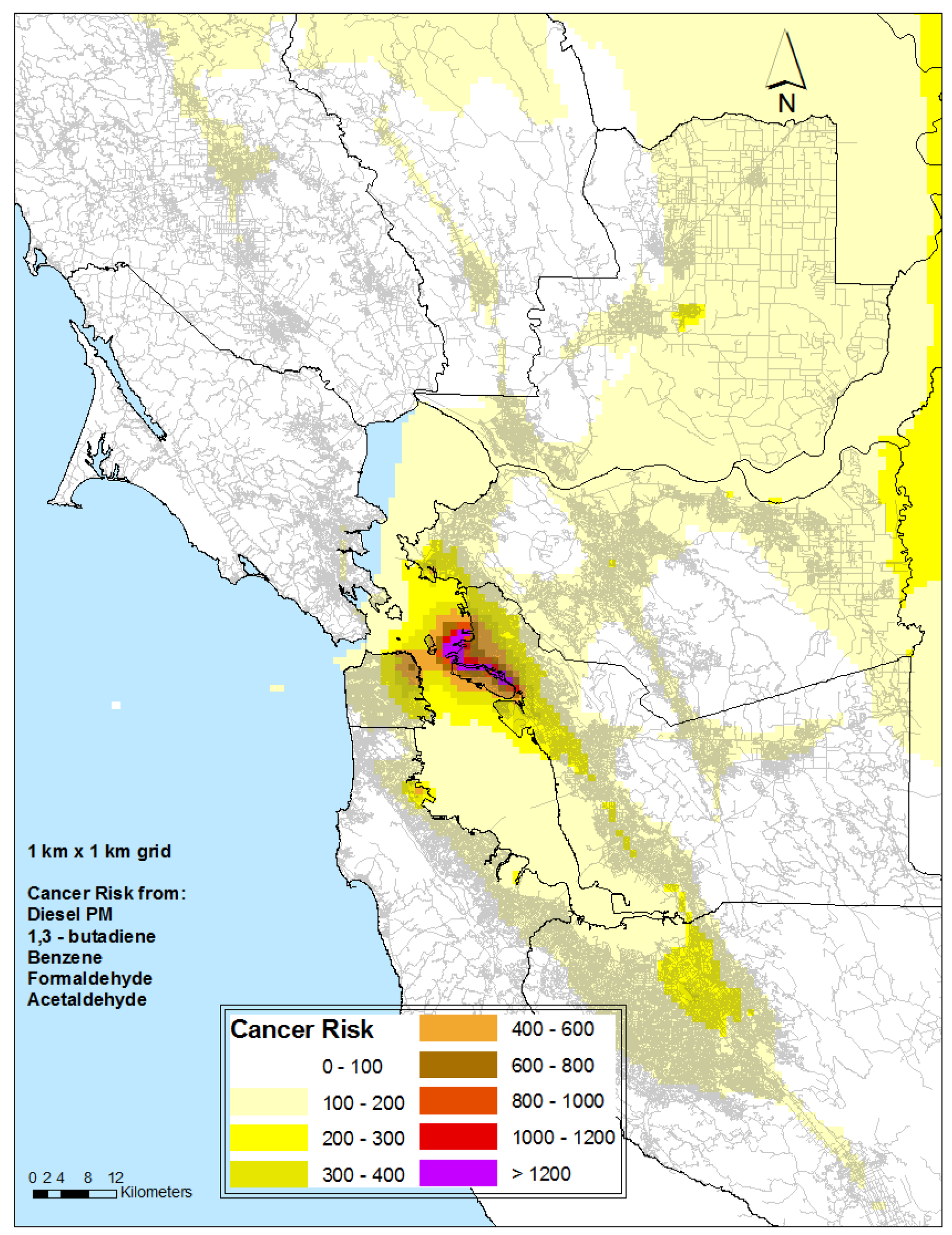

Figure 4. Predicted potential cancer risk in 2015 from toxic air contaminants (per million exposed population).

The locations of areas with highest potential cancer risk in 2015 (Figure 4) are similar to those in 2005 (Figure 2). **Risk values are predicted to drop by more than 50% in most areas between 2005 and 2015, mostly due to significant reductions in diesel PM.** Risk near the San Francisco International Airport increased slightly (30 per million) due to projected increased activity.

Results–Population-Weighted Risks, 2005 - 2015

Cancer incidence from TAC at 2005 and 2015 levels (70 year exposure) was estimated by multiplying simulated risk at each location by the population. Differences in cancer incidence (Figure 5) reflect changes in both risk and population distributions. **In most areas, cancer incidence drops; however, some areas (red, orange cells in Figure 5) show increases because of projected infill near large sources of TAC emissions, such as freeways.**

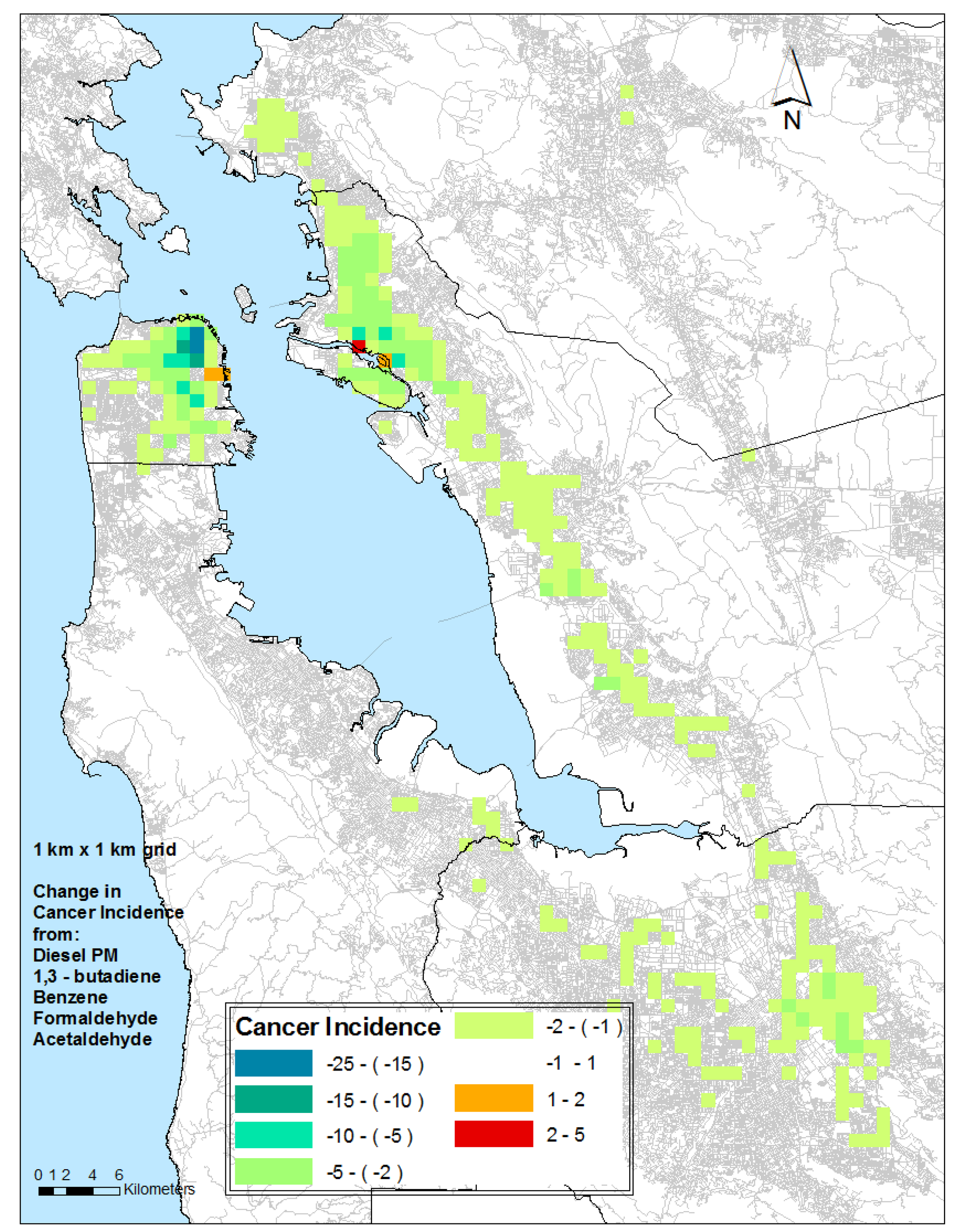

Figure 5. Predicted change in cancer incidence from changes in toxic air contaminants and changes in population between 2005 and 2015.

Summary and Next Steps

This study of projected cancer risk and incidence from TAC illustrates the need for thoughtful planning and design of infill development to avoid or mitigate increased air pollution exposures. Future work will

- **Continue to focus air pollution reduction efforts in areas with high risk and planned densification**
- **In participation with cities, develop Community Risk Reduction Plans to help ensure healthy infill development**

More Information

"Toxics Modeling to Support the Community Air Risk Evaluation (CARE) Program," BAAQMD, June, 2009.
"2015 Toxics Modeling to Support the Community Air Risk Evaluation (CARE) Program," BAAQMD, January, 2011.
Both studies are available online at http://www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling/Publications.aspx

Contact: Phil Martien at pmartien@baaqmd.gov