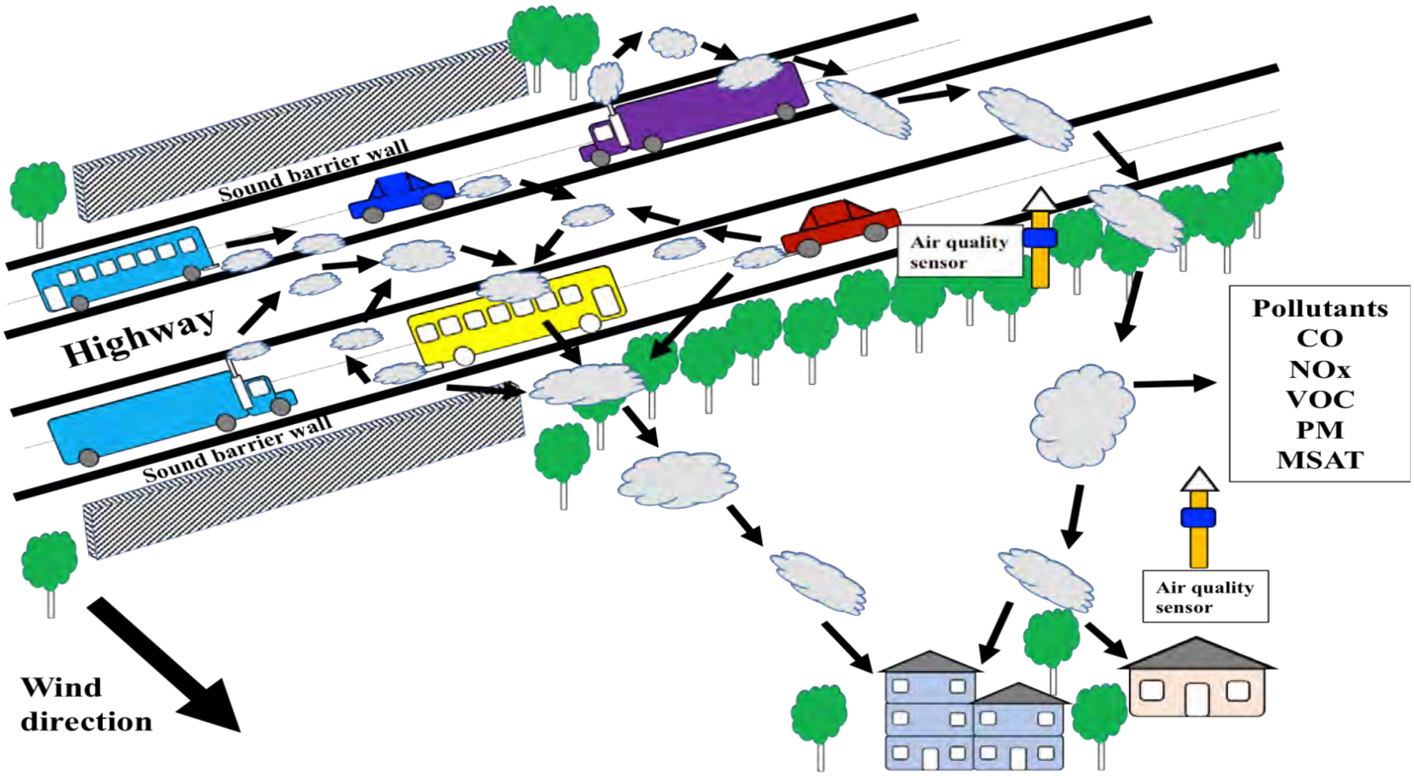
Ineligible Project Related Comments

Volkswagen Content Decree Environmental Mitigation Trust Project Ideas in Response to NC DEQ RFI



The University of North Carolina at Chapel Hill
Institute for the Environment

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

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Section 1 – Project Applicant Information

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Section 2 – VW Program and Solicitation Design Questions

1. How should DEQ prioritize projects?
   - Technical merit followed by a metric like $/ton.

2. What is the anticipated demand for each eligible project type?
   - Can't answer this question till one sees the full spectrum of proposed ideas

3. The percentage of trust funds, if any, that DEQ should devote to Light Duty Zero Emission Vehicle Supply Equipment?
   - < 10%

4. What is the anticipated demand for specific types of diesel emission reduction projects not eligible under the VW settlement but otherwise eligible under DERA or other state programs?
   - Unsure

5. Should a certain percentage of available VW funds be allocated to each eligible project type and if so how should the percentage be determined?
   - Yes. Through analyses of emissions.

6. Should a certain percentage of available Mitigation Trust funds be reserved for government projects?
   - Yes.

7. Should funds be geographically distributed, and if so how?
   - Based on VW sales figures by county. This will make sure that most of the impacts are felt where excess emissions occurred, and is in line with how VW made the overall settlement by each state in the U.S.

8. Should governmental entities be required to provide matching funds and if so, how much?
   - No, but suggest making it optional.

9. Should DEQ establish a minimum project size and if so, what size?

- Yes, $50,000

10. In addition to evaluating a proposed project's total cost effectiveness ($/ton), what other key factors should DEQ consider when evaluating projects?

- Novelty of idea, technical qualifications of project team

11. What other feedback do you have on project evaluation and/or scoring criteria?

- Create a panel of peer reviewers from diverse disciplines and stakeholder community to ensure that diverse viewpoints are considered. Develop an objective set of scoring criteria that are then uniformly applied across all proposals during evaluation.

12. What publicly available tool(s) should be used to quantify anticipated emission reductions/offsets for eligible mitigation projects? What, if any, additional resources should be provided and made available?

- It will help for DEQ to create a repository / warehouse of all publicly available tools, and provide limited training and documentation of these tools for the general public and novice users
- There are many tools in the public domain, but DEQ should ensure that these use solid and published science (peer-reviewed), and have adequate documentation and training. These include the following:
  - EPA:
    - Diesel Emissions Quantifier Tool
    - Control Strategy Tool (CoST)
    - Avoided Emissions and Generation Tool (AVERT)
    - Environmental Benefits Mapping and Analyses Program (BenMAP)
    - Co-Benefits Risk Assessment and Screening Model (COBRA)
  - DOE Argonne
    - Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool
    - Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model (GREET)
  - UNC CMAS Center:
    - Community Tools (C-TOOLS) including C-LINE, C-PORT and C-AIRPORT

13. What methods could DEQ employ to reduce barriers and increase participation in future solicitations for projects?

- Provide at least 2 to 3-month notice for responses, and not require submission during a popular holiday weekend (for e.g. Dec 31)
- Encourage email or electronic submission
- Encourage small businesses, NGOs and University participation

14. What information/resources would be most valuable for stakeholders interested in submitting projects and what is the best way to communicate those?

- N/A

Section 3: Project Information

Identify Applicable Eligible Mitigation Project Category:

1. Class 8 Local Freight Trucks and Port Drayage Trucks with 1992-2009 model year engines and a Gross Vehicle Weight Rating (GVWR) greater than 33,000 pounds (lbs.)

- Yes.

2. Class 4-8 School, Shuttle, or Transit Buses with model year 2009 or older engines and a GVWR greater than 14,001 lbs. and used for transporting people.

- Yes.

3. Class 4-7 Local Freight Trucks with 1992-2009 model year engines and a GVWR between 14,001 and 33,000 lbs.

- Yes.

4. Freight Switchers with pre-tier 4 engines and operating more than 1,000 hours per year.

- Yes.

5. Ferries/Tugs with unregulated Tier 1 - Tier 2 marine engines.

- Yes.

6. Ocean-Going Vessels Shorepower.

- Yes.

7. Airport Ground-Support Equipment with Tier 0 - Tier 2 diesel engines, and uncertified or certified to 3 grams per brake horsepower-hour spark ignition engines.

- Yes.

8. Forklifts with greater than 8,000 lbs. lift capacity and/or Port Cargo Handling Equipment.

- Yes.

9. Light Duty (LD) zero emission vehicle (ZEV) Supply Equipment (Level 1, Level 2, or fast charging equipment) and hydrogen fuel dispensing equipment.

- Yes.

Project Summary:

We propose 2 projects here:

Project 1:

This project involves the use and expansion of C-TOOLS and its members (C-LINE, C-PORT and C-AIRPORT) to identify multiple emissions sources at the Ports of Wilmington, and airports such as Raleigh-Durham and Charlotte and create a suite of what-if scenarios that will be used to (a) identify specific vehicles/vessels/engines that can be considered for emissions reductions, and (b) to quantity actual reductions in emissions and associated air quality in the vicinity of the source regions. This project will involve a partnership from UNC's Institute for the Environment with two stakeholders – Community organization such as Clean Air Carolina and local transportation related authority such as NC State Port Authority, Raleigh-Durham Airport Authority, and City of Charlotte (that runs the Charlotte Airport) to work closely to develop the emissions mitigation scenarios, identify strengths and weaknesses of C-TOOLS for future expansion and actual implementation to quantify benefits in air quality and damage/ton metrics.

Project 2:

Project #2 involves the use of GREET for individual emissions sectors as identified by the VW settlement, and performing a full life-cycle analyses of the changes in emissions augmented by associated health and economic benefits. The project would estimate the value of clean energy policies such as energy efficiency or fuel switching, and will help local governments and DEQ to consider both the costs and benefits of policy choices and support a balanced decision-making process. Again, the project team would include UNC-IE collaborating with North Carolina State University's Clean Energy Technology Center, Clean Air Carolina and DEQ staff to identify specific emissions sectors eligible under the VW settlement for this study. The geographic scope would include the top ranking counties in North Carolina that have the highest emissions of NOx and that would yield the most benefit in terms of $/ton. Actual technology that are available would be generated from EPA's Control Strategy Tool (CoST) and other sources from the literature.

Project Detail:

C-TOOLS (or C-Tools), a robust software system developed and maintained by the UNC Institute for the Environment (UNC-IE), combine air dispersion models with evolving web-based and visualization technologies to provide an easy-to-access screening tool for community users. It is a tool to inform public policy and has been used to train scientists throughout the world on how to use air quality modeling to study the formation, transport and health effects of air pollution. The models produced with C-Tools helped scientists aid the public in areas such as emissions and storm surge predictions. C-Tools simulate dispersion of primary pollutants (CO, NOx, SO2, primary PM2.5 [including EC2.5], and some air toxics: benzene, formaldehyde, acetaldehyde, acrolein) using meteorological conditions for the region of interest.

C-Tools sits on the Community Modeling and Analysis (CMAS) website www.cmascenter.org, a global resource for air quality modeling and tools, that supports over 5,000 users at no cost. In partnership with the U.S. EPA, scientists in the UNC-IE Center for Environmental Modeling for Policy Development (CEMPD) have created a Web tool that enables local policymakers to plug various scenarios into Google Maps to predict the impact of transportation emissions on their communities. They provide an accessible, quick and easy-to-use suite of tools for air quality screening analysis. Through CMAS, C-Tools has enabled nearly 500 community users to explore local air quality impacts due to transportation-related sources (road and rail networks, ports, airports, energy facilities) in their region of interest. Users can perform numerous simulations – at no cost – to assess and quantify the benefits of various "what-if" scenarios and identify areas that have the most damage or benefits due to a given emissions source. C-Tools have been leveraged to demonstrate the health implications of widening a road or building a school near a major highway and the following:

- Examine what-if scenarios of changes in emissions under varying activity conditions;
- Enable comparison and contrasting of alternative emissions management scenarios; and
- Allow export of results to use in other applications u Provide sufficient online support to users, including caveats and limitations.

The C-TOOLS includes several modules: C-LINE to model roadway emissions (see Barzyk et al, 2015); C-PORT to model additional sources related to port activities i.e., rail, port terminals, ships (see Isakov et al, 2017); and C-AIRPORT to model aircraft sources at an airport (see Arunachalam et al, 2017).

The targeted user community for C-Tools includes a variety of users and applications that NC DEQ can leverage to utilize its findings and create action items in affected areas.

Users	Application
Community Organizations	• Target education/outreach to affected areas • Identify field sites for monitors • Provide context for local issues
Local Authorities	• Preliminary scoping of alternative decision scenarios • Explore alternatives to mitigate risk (e.g. electrification, fleet turnover, ship speeds and types) • Publicize "greening" efforts
EPA & Other Federal Agencies	• Quantify direct, indirect, and cumulative impacts of decision alternatives • Weigh public trade-offs associated with port expansions
EPA Regions	• Inform preliminary environmental reviews associated with Federal actions • Examine potential impacts to vulnerable populations • Identify options for exposure reduction and risk mitigation
EPA Program Offices	• Screen locations and topics for further analysis • Provide initial assessment based on available emissions inventory • Consider alternatives in fuels and mobile source infrastructure • Examine ports in context of ambient pollution and other sources
International Partners	• Examine effects of changes in mobile sources • Consider mobile sources in context of overall exposure

C-Line

C-LINE computes dispersion of primary mobile source pollutants using meteorological conditions for the region of interest and computes AQ concentrations corresponding to these selected conditions u The dispersion routines used are in the analytical version of R-LINE Ø C-LINE provides a web-based platform u Specific emissions for each road link are calculated by combining national database information on traffic volume (AADT) and fleet mix with emissions factors from the EPA's MOVES modeling system. The user can modify the emissions for each road link by changing the traffic composition, speed, and/or volume. For more details, see Barzyk et al, Environ. Modeling Software, 2015.

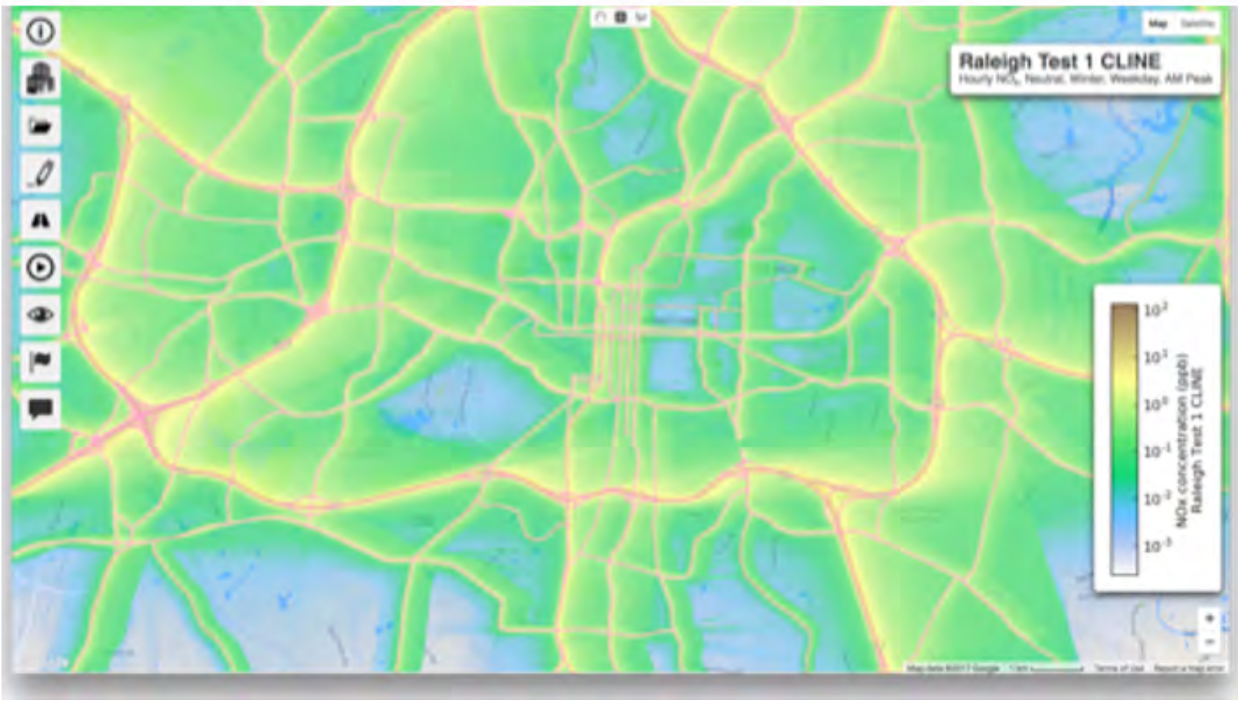

Figure 1: C-Line application in Raleigh

C-Port

C-PORT builds upon C-LINE, for comparing and contrasting the relative impacts that alternative port activities may have on air pollution u Includes road, rail, ship and on-terminal emissions sources u C-PORT is an easy-to-use, web-based tool for estimating the potential impacts of alternative planning scenarios and prioritizing follow-up actions (e.g., research into emissions reductions activities) at ports u Geographical Coverage: u C-PORT currently includes data from 22 seaports mainly in the southeastern U.S., and 2 ports in the Pacific Northwest. Recently, we have added the ports of Houston, Texas and Chicago, Illinois. For more details, see Isakov et al, Environ. Modeling Software, 2017.

Figure 2: Overview of Graphic User Interface.

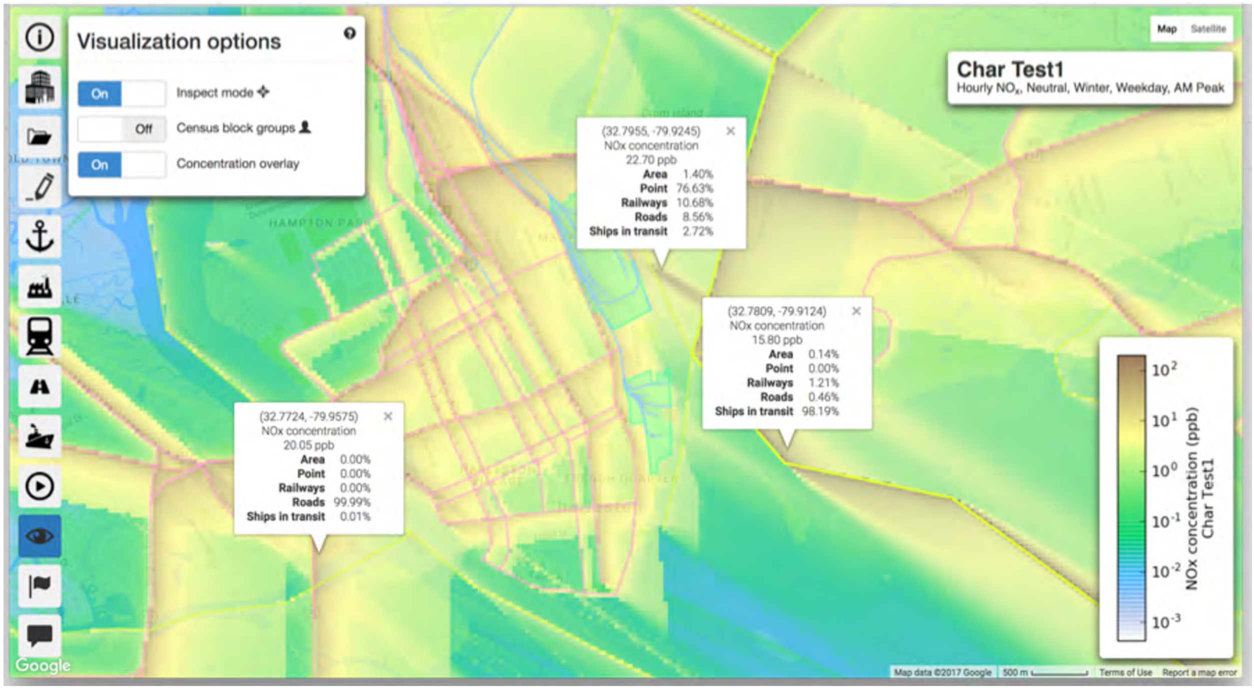

Figure 3: C-Port with Source Apportionment

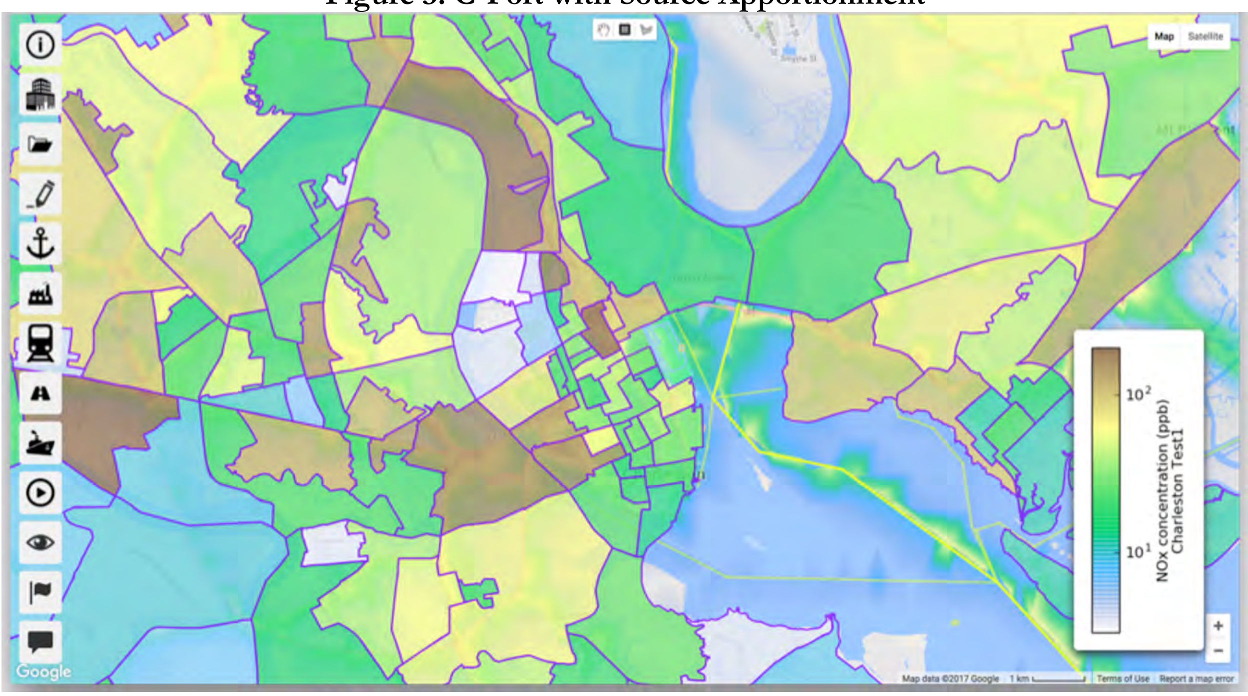

Figure 4: C-PORT with Census Block Overlay

C-Airport
C-Airport allows C-Tools users to explore options for changing aircraft emissions (fleet mix, emissions indices due to fuel change, or changes in combustion technology. Options for the change in aircraft flight paths and the impact in changes of Ground Support Equipment (GSE) emissions.

C-Airport is initially being designed and developed for the Los Angeles International Airport (LAX) and future efforts can include additional airports such as Raleigh – Durham (RDU), Charlotte Douglas (CLT) International – 2 of the largest airports in North Carolina, both with growing passenger and airport operations year-over-year.

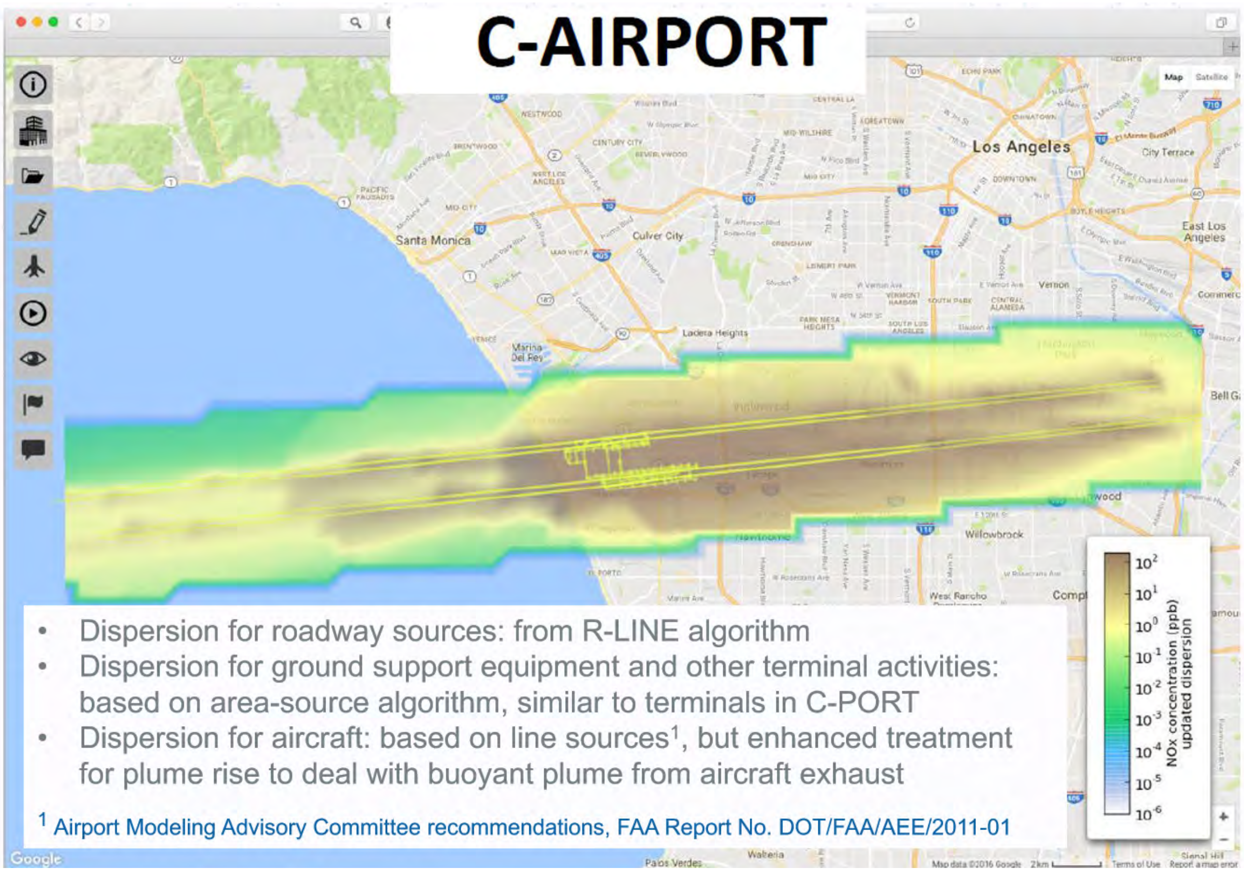

Figure 5. C-AIRPORT Application in LAX airport.

UNC-IE has continued to develop C-Tools to incorporate the following features in its latest version (V5.0) released to the public:

- Incorporated feedback from external peer review conducted;
- Ability to upload custom input data for all source types through GUI: Road, Rail, Ship, Point and Terminal sources
- Ability to add custom but pre-processed meteorological data to backend; and
- For annual averages, ability to include background concentration from EPA's AQS data, and allow user to change value if necessary for view domain
- Ability to select multiple pollutants in single model execution
- Distinguish between "Background" and "non-Background" designated sites in AQS, during overlay
- Show locations of meteorological stations as overlay, along with WMO and ICAO IDs for global network of stations
- Improved quality of concentration plots for representative short term (1-hr) simulations, using a high-resolution receptor network that varies by zoom level
- Add caption and scenario description on each mapped output; and
- Add background column to list of model runs.
- Add population demographics from the recent American Community Survey (ACS) 2011 – 2015 provided by the U.S. Census, at census block level.

Examples of C-Line and C-Port Success

1) In *Portland, Oregon* C-Tools was used to identify potential locations for a monitoring project in northern and northeast Portland by Citizen Science to Assess and Address Children's Environmental Health from Transit and Air Pollution.
2) In *Kansas City, Kansas*, the C-Port application is an integral part of the Kansas City Transportation and Local Air Quality Study (KC-TRAQS). It provides tools to the Argentine, KS community to aid in the assessment of the significance of air quality measurements. EPA's monitoring capabilities characterized the spatial and temporal impact of local air pollution sources on the Argentine (KS) community, while C-Tools augments the assessment through a model-based approach. The project utilizes citizen science-based sensor packages and modeling tools in a real-world field study.
3) In the *New York city* metropolitan area, C-Port applications were used in the Citizen Science project in the Ironbound community surrounding the Newark Airport (EWR) to measure the impact of roadways, railways, port terminals, ship emissions and emissions from the airport.
4) Abroad, C-PORT has been to used model the air-quality at a local scale in the harbor area of *Porto, Portugal*. For three years, C-Port applications tracked the emission inventory development for Porto harbor and the surrounding urban area. The findings were used to evaluate the impact of different emission scenarios on the air-quality of the near-port area.

Proposed Ideas for this project:

We will use C-Line and C-Airport to develop multiple emissions and activity scenarios that accomplish the following objectives in the state of North Carolina:

1) Eliminate diesel engines in school buses and transit vehicles to protect our most vulnerable populations.
2) Create electric vehicle corridors with charging stations along major interstates and in rural areas to support the next generation of vehicles.
3) Replace airport ground support equipment that is some of the highest emitters of pollution.

Capital and Project Costs:

We include only project costs below. The capital costs will be estimated as part of the project and working with additional stakeholders.

Project 1: $300,000 - $500,000 (depending on the number of sectors included in the C-Tools analyses)

Project 2: $400,000 - $600,000 (depending on the number of sectors included in the analyses)

Partial cost-share for C-Tools development is provided by the U.S. EPA under an ongoing agreement.

Expected Proposed Project Benefits:

Project 1:
The outcomes of this project will be identifying specific emissions reduction technologies, and the associated benefits in air quality and $/ton in areas that had high levels of nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$). A potential key outcome can be identifying reductions in NOx emissions from Ground Support Equipment (GSE) at the CLT and RDU airports. Even though the Charlotte region is in attainment of the NAAQS for O_3, identifying additional sources of NOx reduction in the Charlotte region will help reducing O_3 and possible issues as the NAAQS for O_3 is continuously lowered.

Project 2:
The outcomes of this project will include a complete lifecycle and cost/benefit analyses for targeted emissions reductions for specific emissions sources.

Attachments

1) Barzyk, T.M., V. Isakov, S. Arunachalam, A. Venkatram, R. Cook, B. Naess (**2015**). A Near-Road Modeling System for Community-Scale Assessments of Mobile-Source Air Toxics: The Community Line Source (C-LINE) Modeling System, *Environ. Model. Software,* 66:46-56.
2) Isakov, V., T. Barzyk, E. Smith, S. Arunachalam, B. Naess and A. Venkatram (**2017**). A Web-based Modeling System for Near-Port Air Quality Assessments, *Environ. Model. Software*, 98:21-34.

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A near-road modeling system for community-scale assessments of traffic-related air pollution in the United States

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A B S T R A C T

The Community Line Source (C-LINE) modeling system estimates emissions and dispersion of toxic air pollutants for roadways within the continental United States. It accesses publicly available traffic and meteorological datasets, and is optimized for use on community-sized areas (100–1000 km^2). The user is not required to provide input data, but can provide their own if desired. C-LINE is a modeling and visualization system that access inputs, performs calculations, visualizes results, provides options to manipulate input variables, and performs basic data analysis. C-LINE was applied to an area in Detroit, Michigan to demonstrate its use in an urban environment. It was developed in ArcGIS, but a prototype web version is in development for wide-scale use. C-LINE is not intended for regulatory applications. Its local-scale focus and ability to quickly (run time < 5 min) compare different roadway pollution scenarios supports community-based applications and help to identify areas for further research.

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1. Introduction

Living, working, and going to school near roadways has been associated with a number of adverse health effects, including asthma exacerbation, cardiovascular impairment, and respiratory symptoms (see HEI, 2007 for a comprehensive review). In the United States, 30%–45% of urban populations live or work in the near-road environment, with a greater percentage of blacks, Hispanics, and low-income residents than whites living in areas of highly-trafficked roadways (Tian et al., 2012). Near-road studies typically use surrogates of exposure to evaluate potential causality of health effects (Lipfert and Wyzga, 2008). Surrogates include proximity, traffic counts, or total length of roads within a given radius around the impacted location (HEI, 2010; Ryan et al., 2007).

In the United States, modeling efforts related to a state or federal policy initiative (EPA, 2008) require detailed analyses using specific datasets and highly-structured models to produce the most accurate estimates possible of actual pollutant concentrations. Typical modeling efforts for these applications require the use of separate emissions and dispersion models, with subsequent visualization being performed separately as needed. Applications are often related to specific projects and regions, such as highway expansions or traffic re-routing for an urban area. Therefore, users might require modeling expertise to run the models and collect the local input datasets necessary for their performance, and then to subsequently interpret results (Cook et al., 2006).

Community groups are becoming increasingly active in local initiatives that seek to mitigate potentially harmful environmental conditions. Community-based participatory research is an example where community residents work directly with the scientific community to identify these situations. Studies are typically independent, locally-based, and solution-oriented. As such, they are not required to follow regulatory procedures to collect information and make decisions, but instead utilize information sources relevant to their defined objectives. While these sources may not be adequate to meet regulatory requirements, they can meet the goal of informing local decision making. For example, an integrated modeling system that includes an activity-based

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transport demand model, a traffic emission model, a dispersion model and a concentration measurement interpolation model has been developed and applied in Europe, in the regions of Flanders and Brussels, Belgium (Lefebvre et al., 2013). Another example of using models to inform local decision making is the CARBOTRAF system implemented and evaluated in Graz, Austria and Glasgow, UK with the purpose to reduce BC and CO_2 emissions and improve air quality by optimizing the traffic flows (Lefebvre et al., 2014). In community-scale modeling in support of local decision making, an accurate assessment of relative conditions (e.g., one area compared to another, or what-if scenarios that elucidate differences in two or more sets of conditions) can be sufficient for the user's needs. In these cases, simplified modeling systems can provide valuable insights to assist with the decision-making process.

Simplified models provide an opportunity to examine how changes in input parameters, such as vehicle counts or speeds, can affect results (Batterman et al., 2010). The structure of these models can vary depending on the developers or application. Typically, they maintain the same or similar algorithms most responsible for characterizing model uncertainty. Components that are not as influential in model performance or the desired outputs, or structured for a specific model function, could be omitted or parameterized (Batterman et al., 2010). Simplified modeling systems like C-LINE allow users to ask what-if questions, such as, “What will happen if diesel traffic doubles on this roadway?” or “How is near-road air quality affected by a traffic jam?” and then to assess the relative changes in near-road air toxics concentrations that could occur (Batterman et al., 2010; Mejia et al., 2011; Vette et al., 2013). For C-LINE, the user is not required to provide any input datasets, and they can manipulate the existing ones or upload their own if desired.

This paper describes the input parameters, analytical procedures, visualization routines, and software considerations for C-LINE, including a discussion of the dispersion algorithm and an example application for an area of Detroit, Michigan. C-LINE is being developed by the United States Environmental Protection Agency (US EPA, or EPA) Office of Research and Development (ORD) as part of the Sustainable and Healthy Communities (SHC) research program, which is designed to empower and inform communities by providing decision support tools, models, and metrics that promote efficient, balanced, and equitable sustainability initiatives (see http://www.epa.gov/research/research-programs.htm for more information).

2. Model inputs and outputs

This section describes C-LINE input variables and datasets, and the outputs provided by the modeling system. Potential future additions are described in Section 6 (Discussion). C-LINE automatically accesses publicly available datasets with nationwide coverage and provides results for the user-defined geographic area as both visualized maps and tabular data. Users are also able to upload their own (e.g., locally-derived) datasets on traffic activity and/or meteorology to perform model runs.

2.1. Emissions

C-LINE calculates emissions for each road segment using three inputs: 1) the road network (e.g., roadway types and locations); 2) traffic activity on the network (e.g., traffic counts); and 3) vehicle emission factors (i.e., emitted pollutants based on vehicle type, speed, and outdoor temperature). It currently accesses data from calendar year 2010.

2.1.1. Road network

The first input variable to consider is the road network for a given area. A road network is the system of interconnected roadways, and a description of their types (e.g., principal arterials such as interstates). The roadway files are cross-referenced with traffic activity data in order to determine the number and types of vehicles on each roadway. Road network is also used in the dispersion component of C-LINE in order to distribute receptor locations across the spatial domain (described below) where concentrations are calculated.

Road networks are downloaded as shape files from the Freight Analysis Framework (FAF), available from the U.S. Department of Transportation Federal Highway Administration (DOT-FHWA). Files provide a GIS-based centerline representation of the roadway network in the United States (see http://faf.ornl.gov/fafweb/Default.aspx for more information). The overall network is divided into approximately 171,000 links (or *segments*) representing nearly 448,000 miles of roads. Each road segment is also designated by type: urban or rural; arterials, collectors, and local. Arterials provide the highest level of mobility and highest speed for long uninterrupted travel, and include highways and interstates. Arterials are further classified as principal or minor. Collectors provide lower mobility than arterials, and are designed for lower speeds and shorter distances; they are generally two lane roads that collect traffic from local roads and distribute it to arterials. Collectors in rural areas are further designated as major or minor. Local roads are all public roads below the collector classification.

2.1.2. Traffic activity

Traffic activity describes the number, types, and speeds of vehicles on a given roadway and for a given time period. For example, one might expect a higher number of gasoline cars traveling at lower speeds on an urban highway during the morning commute. Therefore, in order to calculate emissions, one needs to determine the total number of vehicles, distribution of vehicle types, and vehicle speeds for a given time period and road segment.

In addition to the road network data, FAF also provides information on annual average daily traffic (AADT), which is then used to calculate vehicle miles traveled (VMT) for each road segment. VMT is AADT multiplied by the length of the road segment. As the name implies, AADT for a given road segment is the average number of vehicles that travel a road segment in a single day, based on the total volume of vehicular traffic for a year divided by 365 days. AADT is a rate that cannot be summed across all roadways, so VMT is a more useful measure of the total amount of traffic in a given area.

FAF does not include detailed fleet mix data (e.g., number of gas and diesel) for each road segment, but it provides distribution tables that describe the typical fleet mix for a given roadway type based on a classification of the roadway segments for each state (see http://www.fhwa.dot.gov/policyinformation/statistics/2010/vm4.cfm for more information). For example, an urban (rural information in parentheses) interstate for Michigan in 2010 had an estimated distribution of 72% (67%) passenger cars, 18% (19%) light trucks, and 7% (11%) combination trucks. Distributions from these tables are applied to the given VMT for a road segment to determine its fleet mix. Vehicle classes from FAF include passenger vehicles (cars, motorcycles, buses, and light trucks (two-axle, four-tire models)); single-unit trucks having six or more tires; and combination trucks, including trailers and semitrailers.

The fleet distribution tables provide a daily estimate of the number and types of vehicles on a given roadway. That total daily traffic count must then be allocated to different time periods throughout the day. For example, a road segment will experience the majority of its daily VMT on weekday rush hour periods during the morning and afternoon commutes. These periods would likely account for correspondingly higher near-road air toxics concentrations. C-LINE distributes VMT by time of day (AM or PM rush; mid-day; and off-peak), week (weekday, weekend), and year (summer, winter) based on temporal allocation factors (TAFs) generated by the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system (Houyoux et al., 2000). TAFs are national and not region-specific.

C-LINE also requires vehicle speed in order to estimate emissions. C-LINE uses FAF 2007 estimated peak period link speed, which includes consideration of the travel demand and road capacity for a given segment. The user is allowed to modify these values to assess variations in conditions, or in case of discrepancies between national and local data.

2.1.3. Emissions factors

Emission factors (EF) for all pollutants are a function of speed, composition and age of the fleet, ambient temperature and fuel composition. EFs are normalized by an activity basis, such as mass of pollutant per unit time or mile. Combined with EF tables, C-LINE inputs meteorology (outdoor temperature) and traffic distributions to calculate pollutant concentrations at the source of emissions; in this case, traffic type and volume multiplied by the EFs. EF tables were provided by the Multi-scale mOtor Vehicle and equipment Emission System (MOVES, version 2010b; EPA, 2012), an emissions model maintained by the EPA (http://www.epa.gov/otaq/models/moves/). MOVES was run for representative counties across the United States to determine county-specific emissions factors using highly-detailed, locally-derived input datasets. A representative county is the county with the highest VMT among counties in a State with similar fuels and temperature regimes. The representative county approach is used in EPA regulatory analyses (e.g., EPA, 2013). The representative county emissions factors were then assigned to other counties that shared attributes with the representative counties, such as fleet age, mix, and fuel composition, thus providing emissions factor estimates for the entire U.S. on a county-level basis in the form of tables. C-LINE utilizes these tables, supporting its simplified approach and precluding the need to run an emissions model separately for each application (but using results from an established model). C-LINE is intended to incorporate updated EF tables as they become available, which are useful for evaluating changes due to new technologies or stringent control measures.

The FAF vehicle-distribution tables uses a different vehicle classification system than the MOVES emissions factor tables. C-LINE maps the FAF vehicle types to the corresponding MOVES vehicle types, which are labeled as motorcycles, light-duty gas vehicles, light-duty diesel vehicles, two light-duty gas truck sizes, light-duty diesel trucks, heavy duty gas vehicles, and heavy duty diesel vehicles.

C-LINE includes running evaporative emissions in addition to the running exhaust emissions. Given its focus on roadway emissions (i.e., emissions that occur on highways), cold-start emissions are not included.

2.2. Meteorology

Meteorological inputs include wind speed and direction, outdoor temperature, and atmospheric boundary layer conditions such as mixing height, friction velocity (u-star), and Monin–Obukhov length. C-LINE uses hourly weather measurements from the National Weather Service monitoring site is nearest to the study location. Then, in order to calculate additional parameters for the dispersion component (i.e., mixing height, u-star, Monin–Obukhov length), the hourly meteorological data are processed using the EPA meteorological pre-processor, AERMET (http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet).

To preserve the simplified functionality of C-LINE, hourly meteorological measurements are binned into the user-selected time interval, including morning peak (7–9a.m.), mid-day (9a.m.–3p.m.), afternoon peak (3–6p.m.), and off-peak (6p.m.–7a.m.). Season (summer, winter) and time of week (weekday, weekend) are also considered. In order to represent a prevailing wind direction for the area, wind direction is calculated as the median value for daytime hours based on the annual distribution of hourly observations. Like the other input parameters, the user is allowed to change the wind direction or upload their own meteorological datasets for processing, if desired.

Atmospheric conditions can vary significantly during a given day and between seasons. The variations in atmospheric conditions can alter the rate of dispersion of pollutants in the atmosphere, and hence the resulting pollutant concentrations. To account for these variations in atmospheric conditions, C-LINE allows the user to select one of three dispersion conditions that they would like to represent: “typical,” “favorable,” or “unfavorable.” These conditions are related to atmospheric stability.

“Typical” dispersion conditions are based on median values of meteorological parameters (wind speed, friction velocity, and Monin–Obukhov lengths), the user-selected time interval, and season; for example, a selection of Summer Off-Peak represents overnight summer values. Weekday/Weekend has no effect on meteorology. “Favorable” and “unfavorable” are based on the upper and lower 95th percentiles, respectively, of the distribution for the selected time interval. “Favorable” conditions contribute to high dispersion and mixing and relatively lower pollutant concentrations; they are characterized by high wind speeds, higher friction velocity (u-star), and a mid-range negative Monin–Obukhov lengths. “Unfavorable” conditions contribute to low dispersion and mixing, resulting in higher concentration gradients; they are characterized by low wind speeds, low u-star, and small positive Monin–Obukhov lengths.

2.3. Model outputs

C-LINE calculates air toxic concentrations (in $\mu g/m^3$) at a set of points located perpendicular to the roadway segments; these points are termed, “receptors.” Receptors align with the midpoints of each road segment and are distributed out to 500 m from the road. The model is designed for estimating the impact of traffic emissions in the “near-road” environment. The 500 m buffer is large enough to capture the near-road impacts. Recognizing that the impact of traffic emissions can extend father that 500 m, especially for busy, heavily trafficked highways, the main focus of this project is the “near-road” zone. Karner et al. (2010) found that all pollutants decay to near background levels at distances of 150–570 m from edge of roadway. Future versions may extend the dispersion profile, but the near-road domain would remain the same.

Receptor concentrations are then spatially joined (described in Section 3.4 Visualization). Thus, C-LINE outputs are air toxic concentrations displayed as continuous, adjacent buffers alongside the roads. Air toxics include both carcinogenic and non-carcinogenic pollutant species (Barzyk et al., 2012). As stated previously, results represent mean concentrations (calculations described below) for the user-selected time period. We continue to explore the utility and feasibility of storing hourly results for other uses, such as for the calculation of annual averages or for use in health and epidemiological studies.

3. Model functionality

This section details each step and calculation that C-LINE uses to produce the near-road air toxic concentration gradients. Some aspects were covered in previous sections, but here we elucidate the processing sequence and calculations in more detail. Emissions and dispersion are covered first, and then visualization procedures. Then we discuss the features and inputs that a user can modify to run and analyze variations of a given scenario (i.e., *what-if* scenarios).

3.1. Model calculations

The three general steps that C-LINE takes to calculate near-road concentrations include: 1) creation of the receptor network, 2) calculation of emissions based on vehicle counts and types, and 3) prediction of dispersion profiles based on meteorological parameters. A user selects the geographic domain within which the near-road concentrations will be produced, and C-LINE automatically downloads the road network for this area. Once the network is downloaded, C-LINE identifies the midpoint of each road segment, and creates the receptor network (at 50 m, 100 m, 200 m, 300 m, 400 m, and 500 m).

VMT is then assigned to each road segment and the fleet mix (e.g., car/truck ratio) is adjusted based on roadway type, time period, and geographic region; this provides total car and truck VMT. Emission factors are multiplied by the number of each corresponding vehicle type, such that total emissions are calculated by, $E_i(s) = EF_i(s) \times A(s)$, where $E_i(s)$ is emission rate (mass per unit time) for pollutant i from a source s (e.g., a given road segment); $EF_i(s)$ is the emissions factor (mass per unit activity) for pollutant i from a source s; and $A(s)$ is the activity level for source s (e.g., vehicle miles traveled) by time-of-day and day-of-week.

The dispersion component then calls the meteorological inputs and calculates the unit value dispersion profiles, which describes the relative concentration at a given distance as a function of the total source emission (e.g., 0.5 × total source emissions at 100 m). This profile is valid for non-chemically-reactive air pollutants. These unit-values are then multiplied by the source emission values to generate concentrations at each receptor. Details of the dispersion algorithm are provided below.

3.2. Dispersion algorithm

One of the novel features of the C-LINE modeling system is the dispersion algorithm that calculates near-road pollution profiles. The dispersion algorithm is designed to specifically model line sources such as highways; it utilizes scientifically established methods to calculate dispersion; and it is streamlined for use in a simplified modeling system. The dispersion algorithm treats each lane of a highway as a line source that is located along the center of that lane. A set of elemental point sources represents each line source (Fig. 1). The contribution of the elemental point source, dC, located at $(0,Y_s)$ to the concentration at (X_r, Y_r, Z_r) is given by the Gaussian plume formulation.

The contribution of a line source to concentrations at a receptor (X_r, Y_r) is given by the integral of the contributions by the point sources along the line of length (L),

$$C(X_r, Y_r) = \int_{Y_1}^{Y_1+L} dC. \tag{1}$$

This integral is approximated by the formulation given by Venkatram and Horst (2006), which is strictly accurate when both

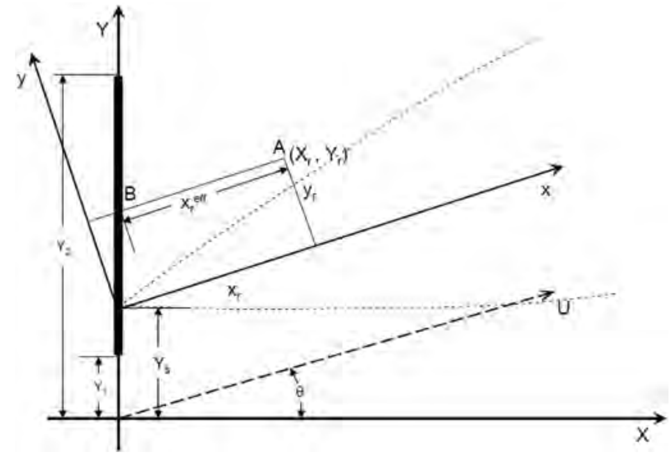

Fig. 1. Coordinate system used to calculate contribution of the point source at Y_s to concentrations at (X_r, Y_r). The system x–y has the x-axis along the mean wind direction, which is at an angle θ to the fixed X axis. The dotted lines represent the plume originating from an elemental point source at $(0, Y_s)$.

the release height and the receptor height are zero. The approximate solution is

$$C_p(X_r, Y_r) \approx \frac{qF(Z_r)}{\sqrt{2\pi} U \sigma_z \left(x_r^{eff}\right) cos\theta} [erf(t_1) - erf(t_2)]. \tag{2}$$

Where

$$x_r^{eff} = X/cos\theta, \tag{3}$$

$$t_i = \frac{(Y_r - Y_i)cos\theta - X_r sin\theta}{\sqrt{2}\sigma_y\left(x_i\right)}, \tag{4}$$

and q is the emission rate per unit length of the line source. Here σ_y is evaluated at $x_i \equiv x_r\ (Y_S = Y_i)$. The definitions of t_1 and t_2 correspond to downwind distances, x_r, from the end points Y_1 and Y_2 of the line to the receptor at (X_r, Y_r).

Under low wind speeds, horizontal meandering of the wind spreads the plume over large azimuth angles, which might lead to concentrations upwind relative to the vector-averaged wind direction. A common approach to treat this situation is to assume that when the mean wind speed is close to zero, the horizontal plume spread covers 360° (Cimorelli et al., 2005; Carruthers et al., 1994). In the random spread state, the release is allowed to spread radially in all horizontal directions. Here, we approximate the integral of the contributions from the meandering components of the point sources along the line source using a method by Venkatram et al. (2013a):

$$C_m(X_r, Y_r) \approx \sqrt{\frac{2}{\pi}} \frac{qF(Z_r)}{U\sigma_z(X_r)} \frac{\theta_s}{2\pi} \tag{5}$$

where θ_S is the angle subtended by the line source at the receptor,

$$\theta_s = tan^{-1}\left(\frac{Y_2 - Y_r}{X_r}\right) + tan^{-1}\left(\frac{Y_r - Y_1}{X_r}\right). \tag{6}$$

and σ_v is estimated from other meteorological variables using an approximation given by Cirillo and Poli (1992),

$$\sigma_v^2 = u^2 sinh\left(\sigma_\theta^2\right), \tag{7}$$

where σ_θ is the measured standard deviation of the horizontal velocity fluctuations.

Then, the concentration at a receptor is taken as a weighted average of concentrations of a random spread, and a plume state:

$$C = C_p(1 - f_r) + C_m f_r \tag{8}$$

where the weight for the random component is:

$$f_r = \frac{2\sigma_v^2}{U_e^2}, \tag{9}$$

This ensures that the weight for the random component goes to unity when the mean wind approaches zero.

For the formulation of vertical and horizontal spreads of the plume, σ_y (Equation (2)) and σ_z (Equation (4)), C-LINE incorporates a reformulated equation previously developed for RLINE, a new line source dispersion model, described in Snyder et al. (2013) and Venkatram et al. (2013a).

3.3. Dispersion model evaluation and sources of uncertainty

Prior to its incorporation in the C-LINE modeling system, the dispersion algorithm had been evaluated using measurements from two field studies. The first field study was conducted by CALTRANS in 1982 in which sulfur hexafluoride (SF_6) a tracer gas, was released from the tailpipes of eight specially outfitted automobiles that traveled with traffic on Highway 99 outside of Sacramento, California (Benson, 1989). Details of the evaluation of the dispersion are described in Venkatram et al. (2013a). The results of the evaluation indicate that the dispersion algorithm performs adequately to estimate downwind concentrations with 84% of the estimates within a factor of two of the observations, and an overall bias of 2%. The dispersion estimates do not provide a representative description of the upwind concentrations.

The second field study was conducted during July and August, 2006 in Raleigh, NC along a busy section of Interstate 440, supporting approximately 125,000 vehicles per day (Baldauf et al., 2008). The study was designed to obtain highly time-resolved measurements of traffic activity, meteorology, and air quality concentrations at varying distances from the road. A unique feature of this field study was the application of optical remote sensing (ORS) to measure NO and other pollutant concentrations along multiple paths near the highway (Thoma et al., 2008). Dispersion estimates were compared with the NO measurements collected at 7 m and 17 m from the roadway shoulder at a height of 2 m and found to be consistent with observations: 87% of the estimates were within a factor of two of the observations, and the under-prediction bias is about 10% (Venkatram et al., 2013b).

Based on these results, the dispersion model represents downwind concentrations with reasonable accuracy (within a factor or two). Therefore, given accurate emissions data as inputs, the model will estimate near-road concentrations with appropriate certainty. However, if the emissions information is not accurate then neither will the resulting air quality concentrations. The publicly-available, national datasets that C-LINE utilizes provide a consistent format, reporting standard, and geographical coverage, but they are provided by state and local government authorities and not subject to subsequent verification or evaluation. C-LINE documentation acknowledges this potential source of uncertainty and users are advised to independently evaluate and cross-check the accuracy of source emissions-related information whenever possible.

3.4. Visualization

Visualization occurs automatically within C-LINE. Receptor concentrations are spatially joined to produce continuous road segment buffers of air quality concentrations. At intersections or other areas where road segments are within 500 m of each other, buffers will overlap, and the spatial join will sum the concentrations of the overlapping buffers. The buffer concentrations are then mapped to a 50 m grid over the domain. The resulting 50 m grid with concentrations for each of the pollutants is then rasterized for each pollutant to improve display speed. These single-pollutant raster files can subsequently be overlaid upon the road network. Due to the geospatial nature of C-LINE, a user may also wish to overlay additional shapefiles, such as income, demographics, or locations of certain buildings or other pollutant sources. Also, a user may zoom into certain areas of their domain in order to examine them in more detail, or to focus what-if scenarios on a specific location or set of roadways. While a user is not limited in the size of the area that they wish to model, geographic extent does become a limiting factor in model performance due to the density of the receptors. C-LINE is optimized to run for an area on the order of 100–1000 km^2.

3.5. Scenario analysis capabilities

C-LINE's simplified modeling approach facilitates the ability to modify input parameters, re-run the simulation, and compare the modified results with the unaltered ("base-case") scenario. Users have two options to manipulate input variables: 1) they can modify existing values through the system interface, or 2) they can upload their own input datasets. A user can alter any input variable, since they are available as text files. However, C-LINE provides "short-cuts" in the graphical user interface (GUI) to modify certain parameters that are of most use to stakeholders.

A user can choose to alter conditions for the entire geographic domain, or they may select any number of specific road segments to modify individually or as a subset. The variables that are available through the GUI to facilitate manipulation include VMT (total or by vehicle type), vehicle type (e.g., gas cars and heavy duty diesel), vehicle speed, time period (time of day, week, and season), atmospheric stability (i.e., mixing conditions), and wind direction. Once the new conditions are specified, the simulation is re-run; however, C-LINE retains the base case as a stored file. The user can then examine the new conditions independently of the base case, or they may choose an option to produce a spatial map of the concentration differences between the base case and the new scenario.

4. Software implementation

C-LINE was developed in ArcGIS (ESRI ArcGIS Desktop: Release 10; ArcInfo License; Spatial Analyst Extension). ArcGIS provides all the necessary components to develop C-LINE as a modeling system, including the ability to call various datasets, perform calculations, and visualize geospatial results.

An ArcGIS Toolbox with three Python-based ArcGIS scripts are run sequentially to calculate and visualize C-LINE outputs. The first script creates the receptor network; the resulting network shapefile serves as an input to the second script. The second script incorporates meteorology to calculate unit concentrations at each receptor; this shapefile served as input to the third script. The third script then multiplies unit concentrations by emissions for the dispersion profiles; in this script, the user is allowed to adjust meteorological values (i.e., choose the atmospheric conditions) prior to the calculations. The final outputs from this script are separate raster images for each pollutant representing their

Fig. 2. Selecting geographic domain in the Detroit, Michigan metropolitan area. C-LINE then access national datasets for respective roadway and meteorological information.

concentration gradient along the roadways, which are then overlaid onto the road network.

The ArcGIS platform provided a stable research and development platform, but has a number of challenges for making C-LINE available for wide-scale use. The ArcGIS application requires a user to purchase the software and a license for use. The software can be a challenge for inexperienced users to understand. Model runs took upwards of 10–20 min to finish, which is not limiting for research purposes, but can be limiting for general use and assessing community-scale applications, where users prefer a real-time manipulation of model runs. Web-based applications could reduce the run time by an order of magnitude, as mentioned in the Discussion.

5. Illustrative example of C-LINE application for an area of Detroit, Michigan

We applied C-LINE to a portion of Detroit, Michigan to demonstrate its use. Data sources, vehicle distributions, and meteorological inputs are described in previous sections. Those relevant to the study area were extracted and applied to the geographic domain. First, we selected a portion of the greater metropolitan area upon which to focus (Fig. 2).

Then, receptors were distributed at 50 m, 100 m, 200 m, 300 m, 400 m, and 500 m from the midpoint of each road segment (Fig. 3). C-LINE stores the attributes for each road segment, so this information can be saved as a separate file for other analyses.

The next step was to run the dispersion algorithm. The time period for this example was winter, weekday AM peak (morning rush), and the atmospheric conditions were defined as typical. The resulting output was unit-value concentrations at each receptor, which were then combined with emissions profiles in order to calculate the outdoor concentrations. AADT for calendar year 2010 and roadway link lengths for over 9700 road links in the geographic domain were used to calculate VMT. The final fleet distribution for the Detroit application is given in Table 1.

Pollutant-specific emissions factors were then assigned to each of the ~9700 road-links in the study domain to generate a link-by-link emissions inventory for the region. These emissions were then multiplied by the unit values at each receptor to calculate near-road concentrations for, in this illustrative case, six different pollutants (benzene, $EC_{2.5}$, $OC_{2.5}$, NO_x, CO, and $PM_{2.5}$; non-air toxics were included for testing). C-LINE benzene concentrations are shown in Fig. 4.

An important feature of C-LINE is the ability to examine how changes in traffic can affect near-road air toxics concentrations. To illustrate this feature, we increased total VMT by 20% and overall speed by 10% for the geographic domain, and compared resulting benzene concentrations with the original scenario. A map of differences between the base case and selected scenario is shown in Fig. 5.

EFs are a function of fleet age and composition, ambient temperature, fuel, and speed. The EFs for benzene are highest at low speeds and drop off drastically after about 20 mph. The rate of reduction in EFs from 2.5 mph to 20 mph varies for the different vehicle types. Thus, when VMT and speed are increased in the illustrative example shown, in most cases on primary roads, the increase in total emissions (due to higher VMT) overwhelms the decrease in emissions (due to lower EFs), and hence lead to increases in Benzene concentrations. However, in some secondary roads (with relatively lesser traffic volumes and having vehicle

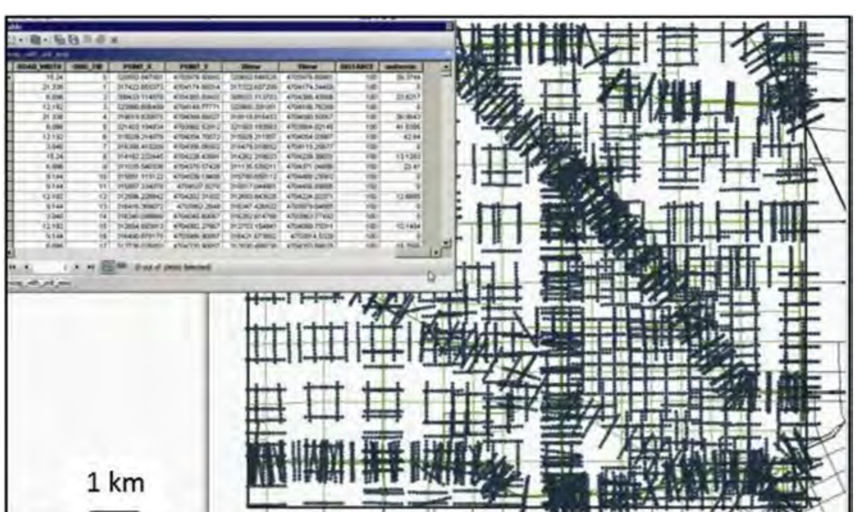

Fig. 3. C-LINE assigns near-road receptor points at 50 m, 100 m, 200 m, 300 m, 400 m, and 500 m from the midpoint of each road segment, and accesses road link information (inset).

Table 1
Distribution of vehicles by roadway type for Detroit application of C-LINE. MC = motorcycles, LDGV = light-duty gasoline vehicles, LDGT1 = light-duty gasoline trucks with gross vehicle weight less than 6001 pounds, LDGT2 = light-duty gasoline trucks with gross vehicle weight 6001 pounds or greater, LDDT = light-duty diesel trucks, LDDV = light-duty diesel vehicles, HDGV = heavy-duty gasoline vehicles, HDDV = heavy-duty diesel vehicles.

Vehicle type	Rural	Rural	Rural	Urban	Urban	Urban
	Principal arterials (interstates)	Secondary arterials	Other	Principal arterials (interstates)	Secondary arterials	Other
MC	0.90%	1.10%	1.60%	0.40%	0.20%	2.10%
LDGV	65.99%	65.00%	70.72%	70.82%	75.66%	50.50%
LDGT1	12.04%	14.94%	15.45%	11.59%	11.08%	24.98%
LDGT2	6.13%	7.61%	7.87%	5.90%	5.64%	12.72%
LDDT	0.53%	0.65%	0.68%	0.51%	0.49%	1.09%
LDDV	0.91%	0.90%	0.98%	0.98%	1.04%	0.70%
HDGV	2.40%	2.41%	1.24%	2.21%	2.20%	1.15%
HDDV	11.1%	7.39%	1.46%	7.69%	3.70%	6.75%

types that exhibit less steep drop-off in EFs with speed, the increase in emissions (due to higher VMT) are not enough to compensate for the decrease in emissions (due to lower EFs), and hence lead to overall decreases in Benzene concentrations in the near-road environment. Also, in the secondary roads (where most decreases are seen), the base case speeds are usually low to begin with, and hence see a steeper drop in EFs, compared to the primary roads where the base case speeds are usually high to begin with, and hence undergo a relatively smaller reduction in EFs due to increased speed.

C-LINE also allows the user to examine changes on specific roads. This situation is illustrated in Fig. 6 where we selected specific road segments and modified the fraction of heavy duty traffic. An example of benzene concentrations for a scenario representing a 20% increase in diesel trucks and a 20% increase in gasoline trucks is shown in Fig. 7. A map of concentration differences between the base case and selected scenario is shown in Fig. 8.

6. Discussion

6.1. Model advantages

As mentioned, an important feature of C-LINE is its ability to assess variations of a given scenario (i.e., its *what-if* capabilities), accurately describing relative differences between various roadways within the modeling domain, or relative changes in pollutant levels for a given roadway under different conditions. When initiated, C-LINE uses the available nationwide inputs for a given area to estimate near-road air quality for the user-specified time period and atmospheric conditions. However, users may wish to assess geographic changes in pollution when traffic shifts from one roadway to another; or the implications of an increase in traffic (or decrease in speed) during the morning commute; or how population growth of a given area may impact its near-road air toxics concentrations.

To be clear, C-LINE does not have a button that states, “increase population for this area and assess changes,” or “evaluate public transportation options on resulting air quality.” If a user knows how population growth (or public transportation options) could influence traffic counts or fleet mix (or other C-LINE parameters) then these activity patterns can be used as C-LINE inputs and results can be compared to the base case. C-LINE inputs that can be manipulated for individual road segments or a larger set include: 1) traffic counts; 2) vehicle-types (for six different vehicle types); and 3) vehicle speed. Inputs that can be manipulated only for the entire geographic region (i.e., all road segments only), include 1) emission factors; 2) meteorological conditions (wind speed and direction, outdoor temperature); 3) atmospheric conditions (typical, favorable, unfavorable); and 7) timing: time-of-day (a.m. peak: 7–9 a.m.; mid-day: 9 a.m.–3 p.m.; p.m. peak: 3–6 p.m.; and off-peak: 6 p.m.–7 a.m.), time-of-week (weekday, weekend), and season (summer or winter).

C-LINE what-if scenarios can be applied to a number of local, community-scale applications. For example, local groups may be interested in the effects of decreased traffic on air pollution in order to promote exercise campaigns (Whitlow et al., 2011). They may

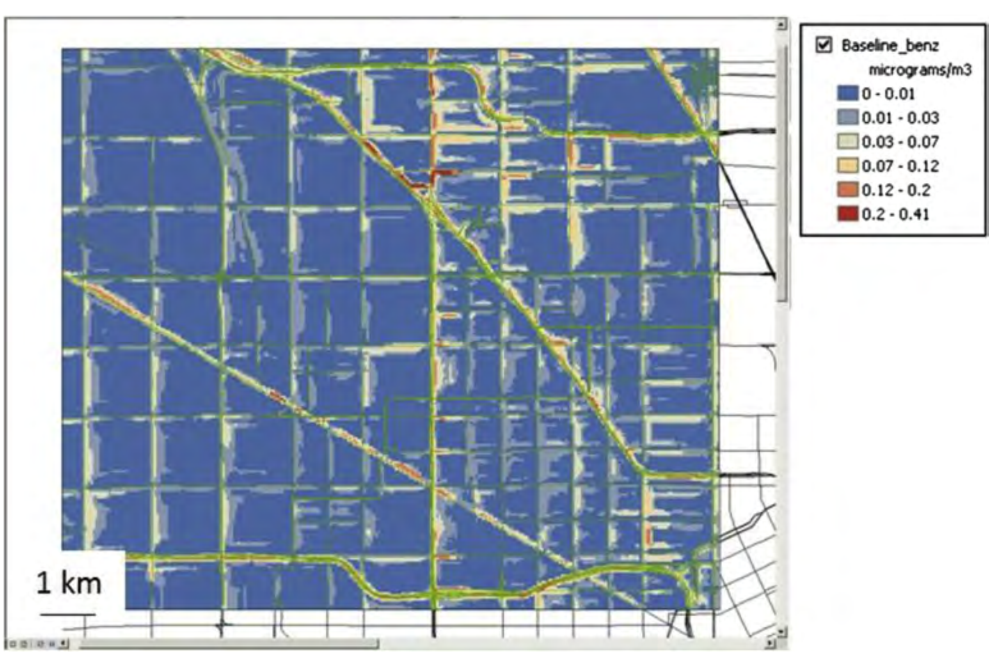

Fig. 4. Example of C-LINE model results: benzene concentrations ($\mu g/m^3$) out to 500 m from each roadway segment.

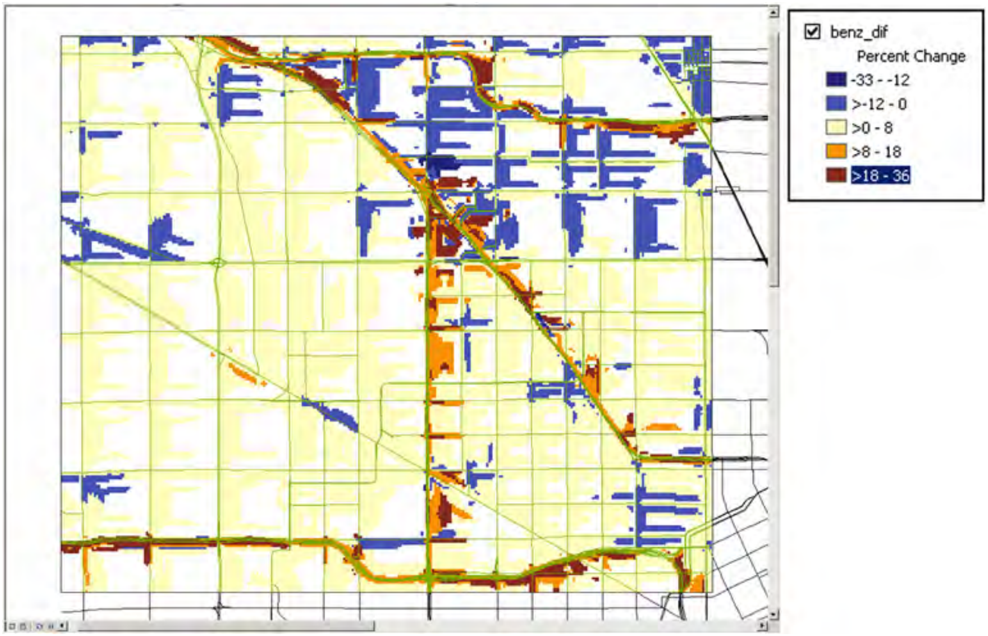

Fig. 5. Example of benzene concentration percent differences when VMT is increased by 20% and overall speed by 10%.

wish to identify areas heavily impacted by diesel truck routes due to commercial activities, and assess potential results of re-routing traffic (Rioux et al., 2010) Community groups may be interested in assessing air quality by schools located near busy roadways (Wu and Batterman, 2006; Spira-Cohen et al., 2011; Patel et al., 2009), or demographic distributions associated with low-income or minority populations living near roadways (Tian et al., 2012), and the differential impact on them compared to other areas. C-LINE could also be used to assist researchers with identifying areas in which to focus near-road monitoring or health studies; for example, during the site selection process. C-LINE facilitates these applications because of its nationwide coverage, local focus, and ease of manipulating inputs. Results can be overlaid with other shapefiles, such as for demographics (e.g., race/ethnicity, income), locations of other pollution sources or places of interest (e.g., industrial sites, schools, or parks). To reiterate, it is not intended to replace the models that are required for policy-related statutes and regulations, such as transportation conformity or the National Ambient Air Quality Standards (NAAQS). C-LINE has not been approved for these applications; its use of simplified meteorology and default emission factors, along with the inability to model concentrations through time, prevent its application in these cases.

Fig. 6. Example of selection of specific road segments in order to modify traffic conditions and examine resulting differences in air toxics concentrations.

6.2. Model limitations

It is important to note that C-LINE is not designed to model conditions through time or outside the near-road environment. It only provides estimates for selected meteorological conditions: "typical" and "favorable/unfavorable". The next version will include annual averages, therefore the model would be more useful for applications in support of health studies.

While other pollution sources are being considered for incorporation, currently, C-LINE only uses roadways as the pollution source. C-LINE does not take into account background pollutant levels or contributions by other sources, such as industry, ports, or rail yards; however, we continue to evaluate the incorporation of these and they may be included in future versions.

We are currently examining the feasibility of including housing-related information, such as age and square-footage, from national datasets in order to predict indoor concentrations for some areas, which would be a more accurate estimate of personal exposure (Breen et al., 2013; Wu et al., 2011).

Traffic activity is based on a single annual value which is then distributed across roadway types and through time using distributional tables and temporal allocation factors, but traffic conditions in the real-world could easily vary throughout the day and deviate from the conditions based on the national datasets. Even though the user could manipulate these values based on better information, they still provide a source of potential uncertainty.

6.3. Future development and availability

Preliminary tests for an online system have proved very promising, and the next version is being developed along these lines. A

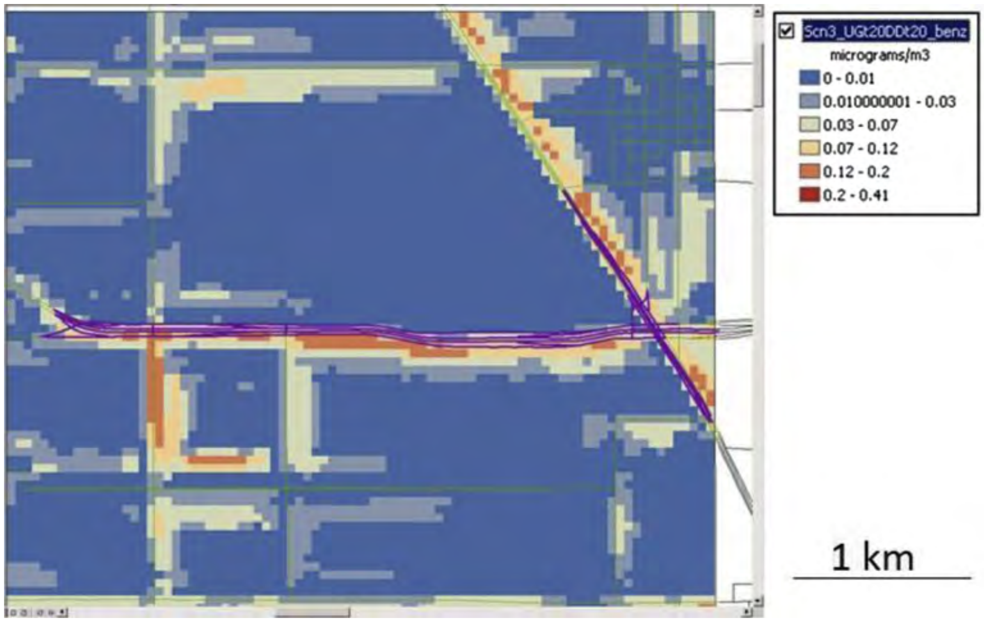

Fig. 7. Example of modeled benzene concentrations ($\mu g/m^3$) for selected road segments as a base case scenario using unaltered input data.

web-based prototype has been developed with an intuitive, familiar, user-friendly point-and-click interface. It also had a number of technical advantages, including: 1) faster performance than the ArcGIS version (on the order of a minute instead of 5–10 min); 2) results visualized on web-based geospatial maps; and 3) increased flexibility in modifying road segment conditions. We are continuing to develop C-LINE as an online, web-based application, with a timeline for completion of a beta version around the latter half of 2014, and subsequent wider-scale distribution by 2015. To-date, the prototype features a Google Earth-based front-end with a Google Web Toolkit (GWT) wrapper hosted on a Tomcat web server that interacts with a PostgreSQL/PostGIS database server. Model updates will be available from the Community Modeling & Analysis System (CMAS; http://www.cmascenter.org) during development and potential users are encouraged to check there for updates.

The C-LINE modeling system lends itself to expansion and customization because of its streamlined geospatially-based approach. Areas of ongoing research include the incorporation of exposure surrogates, additional terrain features, port emissions and dispersion, and including other pollution sources, such as industry, rail yards, and multi-modal distribution facilities. Exposure surrogates could include residential type (e.g., single-family homes) and age, which could then be used to estimate infiltration of outdoor air to

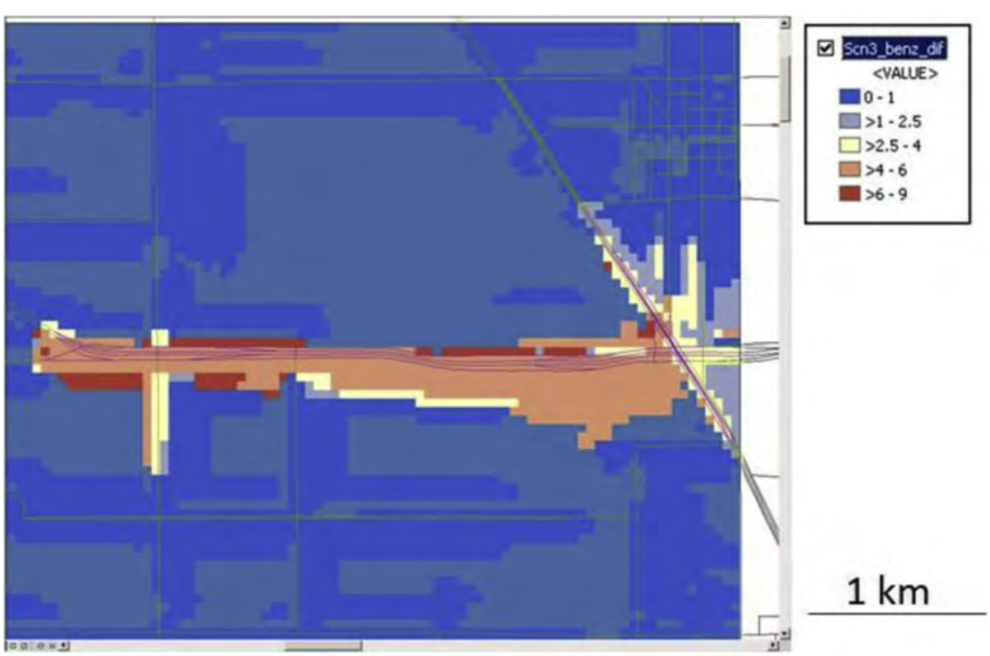

Fig. 8. Example of benzene percent differences from the base-case scenario for selected roads, when both gasoline and diesel trucks are increased by 20%.

the indoors, thus providing a better estimate of personal exposure. Currently, C-LINE dispersion is over a flat terrain, so incorporation of buildings, road configurations, depressed or elevated road sections, and noise barriers are being considered (Finn et al., 2010). We are also exploring the option of drawing or adding hypothetical sources into the modeling domain to examine potential future scenarios, such as the siting of a new facility or other source. These options are a current area of research, yet the primary consideration is to retain the simplified approach of the C-LINE modeling system.

C-LINE models idealized conditions and so a strict measurement-based evaluation of its results would be based more upon consistency and relative differences than absolute predictions of air toxics; for example, the model would accurately predict hot-spot distributions across the domain, but the values of the model (with, e.g., Summer and Weekday chosen) would not mimic any given weekday in the summer when someone went outside with a sensor. However, the model would help locate areas for sensor placement, and relative changes in traffic and meteorological conditions should be reflected in both model and measurements (McAdam et al., 2011). Efforts are currently underway to include C-LINE in field studies, including citizen-science measurements of near-road pollutants, to inform sensor placement and evaluate the modeling system as a whole.

7. Conclusions

The Community Line Source (C-LINE) modeling system incorporates a novel atmospheric dispersion algorithm, parameterized emission sources, and local meteorology to estimate air toxic concentration gradients in the near-road environment (within 500 m of roadways) for the continental United States. C-LINE uses a number of input parameters based on publicly available datasets to provide nationwide coverage, but it also allows a user to upload and utilize local datasets. C-LINE facilitates relative comparisons between different roadways, or for a given roadway under different sets of input conditions.

The dispersion model used in C-LINE demonstrated good agreement with measurement studies, and accurately predicted resulting air pollutant concentrations under a given set of emissions and meteorological conditions. We presented a case study example for Detroit, Michigan to illustrate potential changes in pollutant concentrations due to changes in traffic and showed that the model performs well in these applications.

This is the first instance where a modeling system has been designed to access readily-available datasets and provide national coverage for near-road air quality modeling. Community-scale and research applications include helping to identify potentially exposed populations, assessing changes in air quality due to roadway conditions, and assisting researchers with site selection for monitoring or health-related near-road studies. The flexible nature of C-LINE helps to inform community stakeholders of the contributing factors to near-road pollution, in order to help develop strategies that could improve community health and the environment.

Disclaimer

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A web-based screening tool for near-port air quality assessments

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A B S T R A C T

The Community model for near-PORT applications (C-PORT) is a screening tool with an intended purpose of calculating differences in annual averaged concentration patterns and relative contributions of various source categories over the spatial domain within about 10 km of the port. C-PORT can inform decision-makers and concerned citizens about local air quality due to mobile source emissions related to commercial port activities. It allows users to visualize and evaluate different planning scenarios, helping them identify the best alternatives for making long-term decisions that protect community health and sustainability. The web-based, easy-to-use interface currently includes data from 21 seaports primarily in the Southeastern U.S., and has a map-based interface based on *Google Maps*. The tool was developed to visualize and assess changes in air quality due to changes in emissions and/or meteorology in order to analyze development scenarios, and is not intended to support or replace any regulatory models or programs.

1. Introduction

Ports are a critical feature of the U.S. economy. Seaport cargo activity supports the employment of more than 23 million people in the United States and contributes nearly $4.6 trillion in total economic activity (AAPA, 2016). But for all the economic benefit they provide, the influx of ship, train, truck, and other activities of commercial ports can also negatively impact the local environment, putting residents of neighboring communities at higher risk to health impacts associated with increased air and water pollution (Rosenbaum et al., 2011). Because many of the nation's 360 commercial ports are located near disadvantaged and lower-income communities, ports also raise environmental justice issues. Community groups are becoming increasingly active in local initiatives that seek to mitigate potentially harmful environmental conditions. However, there is a lack of accessible tools that can be easily applied to study near-source pollution, and rapidly explore the benefits of improvements to air quality or to weigh trade-offs associated with port expansion or modernization. To address this need, US EPA has developed several tools designed for communities to assess environmental hazards and find ways to mitigate exposures. These include a suite of web-based applications such as C-FERST (Zartarian et al., 2011), EJSCREEN (U.S. EPA, 2016) and C-LINE (Barzyk et al., 2015). To add to this suite of community tools, we are developing the Community model for near-PORT applications (C-PORT) to help assess air quality impacts from port terminals, ships, roadway traffic and other port-related sources potentially affecting the local community. The multiple modeling options within C-PORT are designed for a quick assessment and require limited technical expertise. The power of such a screening tool is to facilitate assessments through reduced computational time, and to evaluate and compare a suite of "what-if" scenarios. Thus, these web-based, easy-to-use tools can provide valuable insights for the community and can also assist with the decision-making process.

C-PORT currently has data for 21 sea-ports, mostly in the Southeastern U.S. The model represents multiple source types: Ships (while docked at terminal and underway), Rail, Road, On-terminal activity, and provides the opportunity to add/modify individual sources. C-PORT models multiple primary pollutants that are directly emitted: CO, SO_2, NO_x, $PM_{2.5}$ and select Mobile Source Air Toxics (benzene, formaldehyde, acetaldehyde, and acrolein). The model shows absolute concentrations as well as relative changes, and also displays monitor information from EPA's Air Quality System (AQS). C-PORT model formulations are derived from

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dispersion theory, turbulence theory, and boundary layer meteorology. The algorithm for line sources is based on the analytical approximation for line sources (Venkatram and Horst, 2006), consistent with the US EPA research model for line sources R-LINE (Snyder et al., 2013). Algorithms for stationary and area sources are similar to AERMOD (Cimorelli et al., 2005), but optimized for computational efficiency to allow user interaction with the web-based modeling simulations in real-time. For example, C-PORT provides an initial parameterization of both meteorological (using National Weather Service data) and emissions data (based on spatially-allocated emissions values from EPA's National Emissions Inventory) to facilitate the creation of dispersion scenarios.

We refer to C-PORT as a "screening" tool, designed to encourage its use by a non-expert stakeholder through computational efficiency coupled with a default set of emissions and meteorological inputs. The results obtained through its application are reliable enough to screen for situations that might require further analysis to examine the impact of the source under a range of inputs not included in the default set. The term "screening" should not be confused with the formal term "screening model" defined in the Guideline on Air Quality Models (https://www.federalregister.gov/documents/2017/01/17/2016-31747/revisions-to-the-guideline-on-air-quality-models-enhancements-to-the-aermod-dispersion-modeling) as a model that provides conservative (maximum) estimates of the air quality impact of a specific source. C-PORT is not intended for regulatory applications, enforcement, or refined analysis intended to meet EPA Guideline on Air Quality Models Appendix W requirements (40 CFR Appendix W to part 51).

This paper describes the model structure, input parameters, dispersion algorithms and evaluation, mapping and visualization routines, and software considerations for C-PORT. We also discuss the model functionality using an example application for an area in the port of Charleston, SC.

2. Methods

2.1. Model design

The modeling system includes dispersion algorithms for area, point, and line sources related to freight-movement activities, and emissions from the port terminals. C-PORT automatically accesses pre-loaded emissions and meteorological datasets with nationwide coverage and provides results for the user-defined geographic area as both visualized maps and tabular data. The key model inputs include emissions and meteorology, and model outputs are presented as geospatial maps with some options to save the results as GIS shape files for further analysis.

C-PORT also allows the user to add, delete, and modify emissions sources. For example, in a hypothetical scenario where the port wants to expand a terminal (e.g. a bulk cargo terminal), C-PORT can simulate the effect of additional berth and cargo handling facilities in the port terminal. The user can manually draw a polygon to represent a new terminal using the web-interface, and double click on the last vertex to finish the polygon. For convenience, C-PORT assigns pre-populated emissions values for the new source. These values are computed as an average of the 10 nearest area sources. If additional emissions information for the new source is available, the user can edit the default values to reflect the new values. Similar to the area source representing a new terminal, the user can add a new point source to represent the hoteling location, or new roadway or rail line.

Analysis capabilities are provided through an easy-to-use GUI that can be used by community planners, port authority, and federal and state/local agency analysts, to assess air quality impacts of 'what if' scenarios for planning a sustainable development at community scales. These scenarios can help to anticipate potential growth in port activities (increased ships, trucks, etc.), assess impacts of improved energy efficiency and other voluntary actions in port terminal area activities (such as electrification of cranes or rubber tire gentries), and quantify reductions in emissions due to regulatory programs related to commercial marine vessels, rail, trucks, etc.

2.1.1. Dispersion model algorithms

This section describes dispersion algorithms used in C-PORT to produce the near-source air pollutant concentration gradients. C-PORT has several options for simulating dispersion of primary pollutants from emission sources in the port areas: on-terminal activity including drayage and cargo handling equipment (modeled as area sources); facilities with known latitude/longitude location within the port's terminal (modeled as point sources); roads and rail (modeled as line sources); and finally ships-in-transit (modeled as line sources with plume rise). The dispersion algorithms in C-PORT are similar to the dispersion tools used by regulators and research scientists, but have been modified slightly to speed computational time and enable quick access to results. The dispersion code for area and point sources is based upon model formulations used in AERMOD (Cimorelli et al., 2005), while the road and rail are modeled as line sources, based upon an analytical approximation (Venkatram and Horst, 2006) that is used in the C-LINE modeling system (Barzyk et al., 2015).

The C-PORT modeling system achieves its computational efficiency by 1) using analytical forms when possible to replace the numerical schemes in AERMOD, 2) using less-stringent iteration schemes for convergence than those in AERMOD, and 3) avoiding computationally demanding, iterative algorithms. These differences include limiting the number of line sources in the area source algorithm to 30 for computational efficiency as opposed to the iterative process in AERMOD. For point sources, dispersion in the Convective Boundary Layer (CBL) is modeled using the Gaussian dispersion equation in which the plume spreads are formulated in terms of turbulence parameters computed at effective plume height. Also, C-PORT applies a simple algorithm that does not re-entrain plume material to determine the fraction of the emissions that can potentially affect ground-level concentrations. In the Stable Boundary Layer (SBL), vertical plume spread during stable conditions is limited by the height of the boundary layer. Unlike AERMOD, C-PORT does not treat dispersion in complex terrain and does not account for building effects like downwash.

Normalized concentration estimates from C-PORT were compared with estimates from AERMOD and R-LINE for several scenarios of hypothetical source configurations over a range of meteorological conditions. The sources consisted of 1) a point source representing a stationary source at port terminals, 2) an area source representing a port terminal, and 3) a line source, representing a portion of a highway. For the point source test, we ran C-PORT and AERMOD for several configurations as a function of stack height: 10 m, 20 m, 30 m; stack diameter: 0.5 m; stack temperature: 100 and 200 °C; and, exit velocity: 5 and 10 m/s. Receptors were placed 100 m apart up to 5000 m downwind from the source to capture the impact of the plume. For the area source test, we ran C-PORT and AERMOD for a single configuration, a 500 m $\times$ 400 m rectangular area source with downwind receptors at 10 m resolution within the first 100 m from the source, then at 50 m resolution in the 100–350 m zone, and at 100 m resolution beyond 300 m up to 3 km. For the line source test, we ran C-PORT and R-LINE for a single configuration, 1-km long line source and, with downwind receptors at 10 m resolution within 100 m from the source, 50 m resolution in the 100–350 m zone, and at 100 m resolution in the 300–3000 m zone. The sensitivity runs were conducted for a range of various meteorological conditions, stable, neutral, and convective stability conditions in summer and winter, and wind directions varying from 0 to 80°. Meteorological parameters are shown in the Appendix, Table S1.

For the area and point source tests, the model comparison measures are described in terms of the deviation of C-PORT estimates from those of AERMOD using the normalized residual, ε=($C_{C\text{-}PORT}$-C_{AERMOD})/*mean*(C_{AERMOD}), where $C_{C\text{-}PORT}$ and C_{AERMOD} refer to concentration estimates from these two models. For the line source test, the comparison was between C-PORT and R-LINE. The residuals are computed using concentration estimates at receptors within the first 1000 m from the source for the line and area source tests and within the 5000 m from the source for the point source test. Zero values were excluded. The mean of ε measures the bias of the model relative to AERMOD for the area and point source tests and R-LINE for the line source test, and the standard deviation measures the scatter of the bias. We used normalized bias $NB = (\overline{C_1 - C_2})/\ (\overline{C_2})$ and standard error $SE = std(C_1 - C_2)\ /sqrt(N)$ as quantitative model comparison measures. Normalized bias is a measure of the systematic bias of the model and is ideally equal to zero. Standard error measures the relative scatter and is smaller for better model performance (=0, ideally). These metrics are typically used to evaluate the model performance against observational data, but here we use them to quantify differences between two models ($\overline{C_1}$ refers to concentrations from C-PORT and $\overline{C_2}$ refers to concentrations from AERMOD for area and point source tests and R-LINE for the line source test). The plots comparing C-PORT estimates to corresponding estimates from AERMOD and R-LINE and tables of quantitative model comparison measures are shown in the Appendix (Figs. S1–S13). For these simplified scenarios of hypothetical source configurations (e.g., flat terrain, no building effects), the comparison indicates that the differences between C-PORT model algorithms and AERMOD are on average within 15% or better for area sources and within a factor of 2 for point sources. For line sources, the C-PORT predictions are within 5% of the corresponding R-LINE results.

2.1.1.1. Dispersion algorithm for point sources. The dispersion algorithm for point sources is designed to model point sources representing emissions from stacks or ships docked at the port terminals (Fig. 1). As in AERMOD, the model assumes that the concentration distributions in the vertical and horizontal are Gaussian except for convective conditions, where AERMOD uses a bi-Gaussian distribution.

The plume rise is calculated using the following equations. The plume rise h_p, is taken to be (Weil, 1988)

$$h_p = \left[\left(\frac{r_s}{\beta}\right)^3 + \frac{3}{U\beta^2}\left(F_m t + \frac{F_b}{2}t^2\right)\right]^{1/3} - \frac{r_s}{\beta} \quad (1)$$

where $\beta = 0.6$ is an entrainment coefficient, r_s is the stack exit radius, U is the average wind speed that governs plume rise, and $t = x/U$ is the travel time to the downwind distance, x. In the equation, F_m and F_b are the momentum and buoyancy parameters given by

$$\begin{aligned} F_m &= r_s^2 v_s^2 \\ F_b &= \frac{g}{T_s} v_s r_s^2 (T_s - T_a) \end{aligned} \quad (2)$$

where the subscript 's' refers to stack parameters, 'a' refers to ambient conditions, v_s is the stack exit velocity and T_s is stack exit temperature. In most cases, the momentum flux can be neglected in comparison to the buoyancy flux.

The plume rise is limited either by the temperature gradient in a stable boundary layer or the turbulence in a convective boundary layer. In a stable boundary layer, the maximum plume rise is given by

$$h_p(\max) = \left(\frac{6}{\beta^2}\frac{F_b}{UN^2}\right)^{1/3}, \quad (3)$$

where N is the Brunt-Vaisala frequency $N = \left(\frac{g}{T}\frac{d\theta}{dz}\right)^{1/2}$ at plume height.

Under unstable conditions, we assume that the plume rise achieves its maximum rise when $\frac{dh}{dt} = \sigma_w$, which yields

$$h_p(\max) = \left(\frac{2}{3\beta^2}\right)\frac{F_b}{U\sigma_w^2} \quad (4)$$

The meteorological parameters (i.e. Brunt-Vaisala frequency N, wind speed U, and vertical velocity fluctuation σ_w), are evaluated at $h_e = h_s + h_p/2$ by using boundary layer profiles. Because the plume rise is not known, the meteorological parameters at stack height are first used to calculate plume rise. Then, plume rise is calculated again using the meteorological parameters corresponding to the first estimate of plume rise.

As in AERMOD, the vertical plume spread is calculated by interpolating between surface formulations, and those corresponding to elevated releases. The vertical spread of the plume σ_z, for a surface release is described by equations used in AERMOD

Fig. 1. Emission sources at a port terminal represented by point sources.

(Cimorelli et al., 2005), which is representative of the current generation of dispersion models:

$$\begin{aligned}\sigma_z &= \sqrt{\frac{2}{\pi}}\,\frac{u_* x}{U}\left(1+0.7\frac{x}{L}\right)^{-1/3} \quad L>0.0\\ &= \sqrt{\frac{2}{\pi}}\,\frac{u_* x}{U}\left(1+0.006\left(\frac{x}{|L|}\right)^2\right)^{1/2} \quad L<0.0\end{aligned} \tag{5}$$

where L is the Monin-Obukhov length defined by $L = -T_0 u_*^3/(\kappa g Q_0)$, where Q_0 is the surface kinematic heat flux, u_* is the surface friction velocity, g is the acceleration due to gravity, T_0 is a reference temperature, and κ is the Von Karman constant taken to be 0.40.

The horizontal spread of the plume is based on the equations in AERMOD (Cimorelli et al., 2005):

$$\begin{aligned}&\sigma_y = \frac{\sigma_v x}{U}(1+78X)^{-0.3}\\ &\text{where}\\ &X = \frac{\sigma_v x}{U z_i}\end{aligned} \tag{6}$$

and z_i is the mixed layer height.

The vertical spread of an elevated release is taken to be

$$\sigma_z = \frac{\sigma_w t}{(1+t/2T_{Lw})^{1/2}} \tag{7}$$

Under stable conditions, the Lagrangian time scale, T_{Lw}, is taken to be (Venkatram et al., 1984)

$$\begin{aligned}&T_{Lw} = \frac{l}{\sigma_w}\\ &\frac{1}{l} = \frac{1}{l_s} + \frac{1}{l_n}\\ &l_s = 0.27\frac{\sigma_w}{N}; \quad l_n = 0.36 h_e\end{aligned} \tag{8}$$

Under unstable conditions, the expression is

$$\begin{aligned}&T_{Lw} = \frac{l}{\sigma_w}\\ &l = 0.36 h_e\end{aligned} \tag{9}$$

In Equations (8) and (9), h_e is the effective plume height. The expressions for σ_z corresponding to surface and elevated releases are combined using a weighting factor that accounts for the effective plume height relative to the boundary layer height,

$$\begin{aligned}&\sigma_z = (1-f)\sigma_{z(surface)} + f\sigma_{z(elevated)}\\ &f = \min\left(1, h_{eff}\big/0.1 z_i\right)\end{aligned} \tag{10}$$

so that a source with an effective height of greater than $0.1z_i$ is taken to be an elevated source.

When the plume penetrates the capping inversion at the top of the mixed layer, z_i, only part of the plume material contributes to ground-level concentrations. We account for this effect using a simple formulation similar to one included in the Danish "*Operationelle Meteorologiske Luftkvalitetsmodeller*" (OML) model (Olesen et al., 2007), where the emission rate, Q, is multiplied by a plume penetration factor, p_f

$$p_f = \min\left(\max\left((z_i - h_s)/h_p, 0\right), 1\right) \tag{11}$$

and when the plume penetrates the capping inversion, the effective stack height is taken to be z_i,

$$h_e = p_f h_p + h_s \tag{12}$$

2.1.1.2. Dispersion algorithm for line sources. The dispersion algorithm for line sources is designed to efficiently model line sources representing emissions from roadway traffic and rail (Fig. 2). The dispersion algorithm that calculates near-road pollution profiles is described in more detail in Barzyk et al. (2015). Here we present the main features of the algorithm.

We represent a highway as a set of line sources located at the center of each lane of the highway. Each line source is represented as a set of elemental point sources. The contribution of the elemental point source, dC, located at $(0,Y_s)$ to the concentration at (X_r, Y_r, Z_r) is taken to be given by the Gaussian plume formulation,

$$dC = \frac{q\,dY_s}{2\pi U \sigma_y(X_r)\sigma_z(X_r)}\exp\left(-\frac{Y_r^2}{2\sigma_y^2(X_r)}\right)F(Z_r) \tag{13}$$

where $F(Z_r)$ is the vertical distribution function given by

$$F(Z_r) = \exp\left(-\frac{(z_s - Z_r)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z_s + Z_r)^2}{2\sigma_z^2}\right) \tag{14}$$

where σ_y and σ_z are the horizontal and vertical plume spreads. The second term on the right hand side of Equation (14) accounts for plume reflection from the ground.

The contribution of a line source to the concentrations at a receptor (X_r, Y_r) is given by the integral of the contributions of the point sources along the line,

$$C(X_r, Y_r) = \int_{Y_1}^{Y_1+L} dC \tag{15}$$

This integral can be integrated numerically but the computational cost becomes unmanageable if we have to estimate the impact of the large number of roads typical of an urban area. So the model is based on an analytical approximation to the integral, given by Venkatram and Horst (2006),

$$C_p(X_r, Y_r) \approx \frac{qF(Z_r)}{\sqrt{2\pi}U\sigma_z\left(X_r^{eff}\right)\cos\theta}\left[erf(t_1) - erf(t_2)\right] \tag{16}$$

where

$$X_r^{eff} = X_r/\cos\theta \tag{17}$$

$$t_i = \frac{(Y_r - Y_i)\cos\theta - X_r\sin\theta}{\sqrt{2}\sigma_y(X_i)}, \tag{18}$$

where q is the emission rate per unit length of the line source and θ is the angle between wind direction and normal to the road. Here σ_y is evaluated at $X_i \equiv X_r(Y_s = Y_i)$. The definitions of t_1 and t_2 correspond to downwind distances, X_r, from the end points Y_1 and Y_2 of the line to the receptor at (X_r, Y_r). We see from Fig. 3 that the vertical spread in Equation (16) is evaluated at a downwind distance from the line source along the wind direction. The vertical and horizontal

Fig. 2. Emissions from roadways and rail represented by line sources.

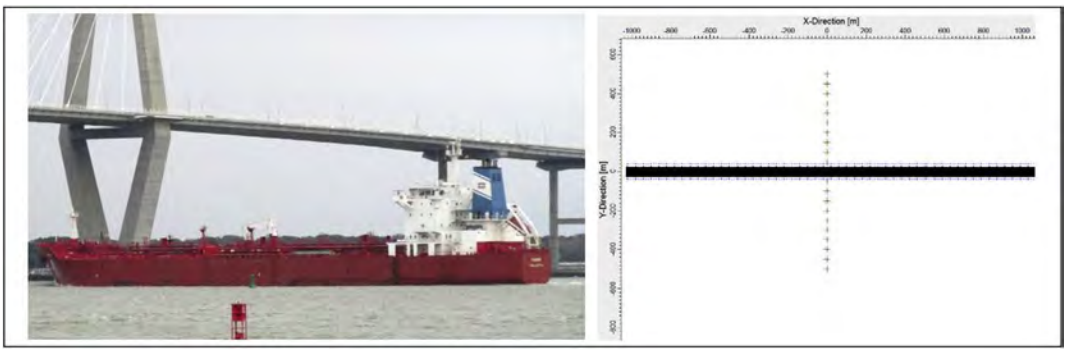

Fig. 3. Emission from ships in transit represented by buoyant line sources.

plume spreads are computed using formulations, described earlier, for point sources.

Equation (16) breaks down at $\theta = 90^0$ because of the term $cos\theta$ in the denominator. We can avoid the problem at $\theta = 90^0$ by noticing that for linear vertical spread the product $\sigma_z\left(\frac{X_r}{cos\theta}\right)cos\theta = \sigma_z(X_r)$ in the denominator of Equation (16). It turns out that this limit is consistent with the exact solution of the integral for a parallel wind when the vertical and horizontal plume spreads are linear. So we account for this limit by setting the denominator in the equation to $(\sigma_z(X_r) + \sigma_z(X_r/cos\theta)cos\theta)/2$. Comparison with the numerical solution indicates that this approach leads to an error of less than 25% when θ approaches 90°.

Under low wind speeds, horizontal meandering of the wind spreads the plume over large azimuth angles, which might lead to concentrations upwind relative to the vector averaged wind direction. AERMOD (Cimorelli et al., 2005), and other currently used regulatory models (e.g. ADMS (Atmospheric Dispersion Modeling System), Carruthers et al., 1994), attempt to treat this situation by assuming that when the mean wind speed is close to zero, the horizontal plume spread covers 360°. In the random spread state, the release is allowed to spread radially in all horizontal directions. The concentration from a point source with an emission rate, Q, is then given by:

$$C(x,y) = \sqrt{\frac{2}{\pi}}\frac{Q}{2\pi r U_e \sigma_z(r)} \tag{19}$$

where r the distance between the source and receptor and the plume spread covers 2π radians. The plume is transported at an effective velocity given by

$$U_e = \left(\sigma_u^2 + \sigma_v^2 + U^2\right)^{1/2} = \left(2\sigma_v^2 + U^2\right)^{1/2} \tag{20}$$

where U is the mean vector velocity, and the expression assumes that $\sigma_v \approx \sigma_u$. Note that the effective velocity is non-zero even when the mean velocity is zero. The minimum value of the transport wind, U_e, is $\sqrt{2}\sigma_v$.

If we assume that the vertical plume spread is linear with distance, the integral of the contributions of the meandering components of the point sources along the line source can be written as

$$C_m(X_r, Y_r) = \sqrt{\frac{2}{\pi}}\frac{qF(Z_r)}{U\sigma_z(X_r)}\frac{\theta_s}{2\pi} \tag{21}$$

where θ_s is the angle subtended by the line source at the receptor,

$$\theta_s = \tan^{-1}\left(\frac{Y_2 - Y_r}{X_r}\right) + \tan^{-1}\left(\frac{Y_r - Y_1}{X_r}\right) \tag{22}$$

We assume that Equation (21) is a useful approximation even when vertical plume spread is not linear. Note that θ_s is the angle subtended by the line source at the receptor. So the maximum value of this subtended angle is π when the receptor is very close to the line.

The success of this meandering adjustment in AERMOD depends on measurements of σ_v, which reflect meandering when the wind speed is close to zero. If measurements are not available σ_v is estimated from the approximation (Cirillo and Polli, 1992)

$$\sigma_v^2 = u^2 \sinh\left(\sigma_\theta^2\right) \tag{23}$$

where σ_θ is the measured standard deviation of the horizontal velocity fluctuations.

Then, the concentration at a receptor is taken to be a weighted average of concentrations of two possible states: a random spread state, Equation (21), and a plume state, Equation (16).

$$C = C_p(1 - f_r) + C_m f_r \tag{24}$$

The weight for the random component in Equation (24) is taken to be

$$f_r = \frac{2\sigma_v^2}{U_e^2} \tag{25}$$

This ensures that the weight for the random component goes to unity when the mean wind approaches zero.

The need to specify an effective wind speed, U, used in the dispersion model highlights a problem with the application of the Gaussian dispersion equation to releases in the surface layer, where the wind speed varies with height. However, if the source height and the receptor height are close to zero, and the receptor is close to the line source, the ground-level concentration is insensitive to the choice of the height to evaluate the wind speed because the ground-level concentration is inversely proportional to the product $\sigma_z U$, which is independent of U. At this point, there is no consensus on the evaluation of the effective wind speed. The wind speed, U, is computed at the mean plume height, $\bar{z}$, by solving the following equation iteratively,

$$\sigma_z = f(x, u_*, L, U(\bar{z})) \tag{26}$$

where the mean plume height for a Gaussian distribution is given by

$$\bar{z} = \sigma_z \sqrt{\frac{2}{\pi}} exp\left[-\frac{1}{2}\left(\frac{z_s}{\sigma_z}\right)^2\right] + z_s erf\left(\frac{z_s}{\sqrt{2}\sigma_z}\right) \tag{27}$$

where the right hand side of Equation (26) corresponds to the expressions for vertical spread given by Equation (5).

2.1.1.3. Dispersion algorithm for buoyant line sources. One of the novel features of the C-PORT modeling system is the dispersion algorithm that calculates near-source pollution gradients for buoyant line sources. The dispersion algorithm is designed to specifically model moving line sources such as ships in transit (Fig. 3).

A moving ship is essentially a point source that moves along a line. Assuming that the averaging time for the calculation is long compared to the transit time of the ship, we can model the moving ship as a line source laid along its path. This source has buoyancy corresponding to the exhaust gases of the ship. We describe the line source using the earlier equations, where the effective release height is the stack height plus plume rise, computed using an algorithm for a point source. C-PORT assigns the following stack parameters as a default option: stack height h = 20 m, stack diameter $d = 0.8$ m, temperature $T = 282$C, exit velocity $v = 4$ m/s. C-PORT also allows the user to change the default stack parameters for each segment of the shipping channel.

2.1.1.4. Dispersion algorithm for area sources. The dispersion algorithm is designed to efficiently model area sources representing emission sources such as dray trucks or rubber tire gentry at port terminals (Fig. 4). As in AERMOD, an area source is treated as a polygon as shown in Fig. 4. The emissions from the area source are distributed among a set of line sources that are perpendicular to the near surface wind.

Because the wind is perpendicular to each line source, the expression for the contribution for each line source becomes:

$$C_p(X_r, Y_r) = \frac{qF(Z_r)}{\sqrt{2\pi}U\sigma_z(X_r - X_s)}[erf(t_1) - erf(t_2)] \tag{28}$$

where

$$t_i = \frac{(Y_r - Y_{si})}{\sqrt{2}\sigma_y(X_r - X_s)}, \tag{29}$$

and X_r and Y_r are the co-ordinates of the receptor in the co-ordinate system with the x-axis along the mean wind. Here X_s is the co-ordinate of the line source with end points, Y_{si}, determined by the intersection of the line with the sides of the polygon. In AERMOD, the number of line sources is increased until the successive values of the sums of their contributions is smaller than a specified value: the integral representing the area source converges within a specified error. In the C-PORT version of the algorithm, we reduce the computational demands of the area source algorithm by restricting the number of line sources to 30.

2.1.2. Model inputs - emissions

C-PORT includes emissions inventories based on EPA National Emissions Inventories (NEI)-2011 (https://www.epa.gov/air-emissions-inventories/2011-national-emissions-inventory-nei-data) from the following key source categories: 1) port terminals, 2) ships, 3) roadways, 4) rail. Users can run the model with the included data or input their own locally-derived values. Then, emissions are spatially allocated at the local level.

The first category, port terminals, includes emissions from drayage and cargo handling equipment, and all other "on-terminal" activities. Non-mobile sources include facilities with latitude/longitude coordinates located within terminal boundaries (port

Fig. 4. Emission sources at a port terminal represented by an area source.

terminal boundaries were identified using ArcGIS). Any facilities with latitude/longitude location (and not rail), and that falls within the port's terminal boundary is modeled as an explicit point source. The drayage and cargo handling equipment, and all other “on-terminal” activities emissions are allocated to terminals and modeled as area sources.

The ship emissions include ocean going vessels (Class III) and harbor craft emissions from Class I and II vessels. Harbor craft emissions are allocated to terminals and modeled as area sources. Class I, II emissions are also allocated to the channels. Emissions from ocean going vessels hoteling at the terminal are allocated to terminals and modeled as point sources, and emissions from ships underway are allocated to shipping channels representing a path to the terminal from the sea (based on US Army Corps of Engineers shipping lane segments with freight activity), and modeled as line sources with plume rise.

The rail category includes emissions from railroad equipment, line haul locomotives and yard locomotives. Railroad emissions are allocated to railroads using ArcGIS and modeled as line sources, and rail yard emissions are allocated to rail yard polygons in ArcGIS modeled as area sources. Users can assign their own emissions inputs for these locations or use the default estimates provided, based upon NEI 2011.

Roadway emissions are based on a combination of road network, traffic activity and emissions factors. The first input variable to consider is the road network for a given area. A road network is the system of interconnected roadways, and a description of their types (e.g., principal arterials such as interstates). In C-PORT version 3.0, the source for the road network is HPMS 2013 (https://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/). The HPMS road network consists of the National Highway System (NHS) routes (including intermodal connectors) and all other roads, excluding those functionally classified as minor collectors in rural areas and local roads. Traffic activity describes the number, types, and speeds of vehicles on a given roadway and for a given time period. Emissions factors are emission rates normalized by an activity basis, such as mass of pollutant per unit time or per mile, and based on vehicle type. The on-road data (activities, emission factor tables, monthly and county cross reference) were used from NEI2011v1, which were based on MOtor Vehicle Emission Simulator (MOVES) 2010b (U.S. EPA, 2012) in C-PORT version 3.0. The updated emissions, based on MOVES2014a emission factors and road types are used in C-PORT beta version 4.0. The activity data include annual average daily traffic (AADT) per road segment from the HPMS 2013 database. Most road segments have AADT values. For those segments that don't have corresponding AADT values, county-wide (or statewide in some cases) AADT averages by road type are used. Speeds for road segments come from NEI2011 v2 values. These are assigned to road segments by county average speeds by road class. For those road type combinations that don't have corresponding values in NEI, the national average values are used for the closest road type match. The emission factor (EF) tables include factors for three modes: rate per distance, rate per vehicle, and rate per profile, and we chose the EFs for rate per distance. The EFs were available for two separate months: January representing winter months such as Jan, Feb, Mar, Apr, Oct, Nov, and Dec; and July representing summer months such as May, Jun, Jul, Aug, and Sep. The roadways emissions in C-PORT are consistent with C-LINE web-based model (Barzyk et al., 2015) that estimates air quality impacts of traffic emissions for roadways in the U.S. (https://www.epa.gov/healthresearch/community-line-source-model-c-line-estimate-roadway-emissions). Specific emissions for each road link are calculated by combining national database information on traffic volume and fleet mix with emissions factors from EPA's MOVES modeling system, as described in more detail in Barzyk et al. (2015).

2.1.3. Model inputs - meteorology

Meteorological inputs include hourly observations of wind speed and direction, ambient temperature, and other atmospheric boundary layer parameters needed for dispersion modeling. For calculating the representative hours, C-PORT uses hourly weather measurements from the National Weather Service (NWS) monitoring site that is nearest to the study location for 2011 and allows the user to simulate hourly concentrations for any of five representative meteorological conditions: 1) Stable, 2) Slightly Stable, 3) Neutral, 4) Slightly Convective, and 5) Convective), and for each season (Winter & Summer). These data were processed through AERMET, a meteorological data preprocessor for AERMOD (https://www3.epa.gov/scram001/metobsdata_procaccprogs.htm).
November–March and May–September periods are categorized as winter and summer seasons, respectively. To find the representative meteorological conditions, the valid measured hours are separated into Stable (Monin-Obukov Length (L) > 0) and Convective ($L < 0$) conditions. These subsets are then ranked by L-value, from smallest to largest. The “Stable” hour is selected as the 5th-percentile ranked hour, then “Slightly Stable” hour is selected as the 50th-percentile ranked hour. Likewise, when the convective hours are ranked from smallest to largest (L is negative in Convective conditions), the “Convective” hour is selected as the 95th-percentile ranked hour, and the “Slightly Convective” hour is selected as the 50th-percentile ranked hour. The “Neutral” hour is selected when all hours are ranked by the absolute value of their L-value and the 99th-percentile ranked hour is selected. In all cases, the selected hour contains the wind speed, *uStar*, *wStar*, convective mixing height, mechanical mixing height, L, surface roughness, and reference height.

The same 2011 NWS measurements are used to estimate annual averages. The annual averaging procedure is based on 100 representative meteorological hours for each station. These 100 h include a combination of 5 wind speeds, 4 wind directions and 5 stability conditions. The dispersion algorithm is run explicitly for the 100 h, and then weighted by frequency (how often these 100 h occur in the annual dataset) to estimate the annual averages. This method called the METeorologically-weighted Averaging for Risk and Exposure (METARE) is described further in Chang et al. (2015). Chang et al. (2015) compared model results using the METARE method (100 h) versus the explicit annual average method (based on full set of 8760 h) and found less than 10% difference over all receptors in a large urban area.

2.1.4. Model receptors and maps

C-PORT calculates air pollutant concentrations at a set of points in the modeling domain; these points are termed, “model receptors.” A regularly-spaced grid of receptors is generated for all source types. The grid consists of 50 by 50 evenly spaced grid points, which span the entire user's view window depending on zoom level. For line sources (roads, railways, and ships in transit), a series of receptors are placed perpendicular to each line source. Each perpendicular series consists of 5 receptors: one on the source, two at 5 m off the source in each direction, and two at 25 m off the source. These perpendicular transects are created along the length of the line source. The spacing along the length of the source (for these transects; again, depending on the zoom level) can be 200 m, 500 m, or 1000 m. For shorter line segments, transects are placed at the midpoint of the segment. To reduce run complexity, annual average runs only use the uniform grid of receptors, not source-specific receptors. Hourly concentrations are calculated at all receptor locations. These calculated concentrations are used to generate the maps that C-PORT presents to users. We use a bi-linear interpolation algorithm from Scientific python (http://docs.scipy.org/doc/scipy-0.15.1/reference/generated/scipy.interpolate.griddata.html) to produce a gradient map of estimated pollutant concentrations. The color scheme used is in log-scale for better visualization purposes and for improved characterization of the near-source gradients.

C-PORT allows the user to view maps of pollutant concentrations, as well as difference maps between alternative scenarios. In addition to concentration maps, there is an option to download a shape file of the census block groups with the average concentration in each block group. Currently, a shape file is generated only for annual average model runs.

2.2. Software architecture

C-PORT is a web application consisting of a web interface, accessed via a web browser, a web service for retrieving and storing user data, a compute server for calculating dispersion results, and a database server. C-PORT can be run on any desktop/laptop computer, tablets, mobile devices, in any modern web browser and has been tested in Google Chrome, Firefox, and Safari. The most recent version of any browser is recommended. In order to use C-PORT, the browser must have JavaScript and cookies enabled. The recommended window size is at least 1200 by 800 pixels. The C-PORT web interface uses the Angular JavaScript framework with the Google Maps APIs. The web interface communicates with a web service built using the Python web framework Flask, running via the Gunicorn WSGI server behind the nginx web server. The web service makes use of several Python frameworks including SQLAlchemy, GeoAlchemy, pyproj (an interface to the PROJ4 library), Matplotlib, NumPy, SciPy, and PyShp. Dispersion model runs are submitted to a Linux compute cluster running RHEL 5.11 (Tikanga), to run a Fortran-based executable. Input source data, user data, and model run results are stored in a PostgreSQL database server, with the PostGIS extension to enable geographic support. See more info about the Linux Cluster at: http://help.unc.edu/help/getting-started-on-killdevil/. For more information on software/data availability, please contact The University of North Carolina at Chapel Hill, Institute for the Environment, 100 Europa Drive, Suite 490, Chapel Hill, NC 27517, T: (919) 966–2126, F: (919) 966–9920, Email: cmas@unc.edu. C-PORT is currently available as a research grade screening tool in a password-protected status via CMAS (https://www.cmascenter.org/c-tools/). The user needs to register at the CMAS web site (https://www.cmascenter.org/register/create_account.cfm), and then use the CMAS account and password to access C-PORT. After logging in to the CMAS website, the user can access C-PORT for free and also get additional updates on C-PORT development, technical notes, and video tutorials.

2.3. Experimental testing of C-PORT

C-PORT has a map-based interface incorporating widely used Google Map (Fig. 5) as the underlying map engine. The web-based, interface is intended to provide nationwide coverage but currently includes data from 21 coastal ports (Baltimore, MD; Brunswick, GA; Charleston, SC; Gulfport, MS; Jacksonville, FL; Miami, FL; Mobile, AL; Morehead City, NC; New York/New Jersey; Palm Beach, FL; Panama City, FL; Pascagoula, MS; Pensacola, FL; Portland, OR; Port Canaveral, FL; Port Manatee, FL; Port of Virginia, VA; Savannah, GA; Seattle, WA; Tampa, FL; Wilmington, NC).

To test the functionality of the C-PORT, we selected Charleston, SC from the list of 21 coastal ports available in C-PORT (Fig. 6). After choosing a location, C-PORT loads all of the port-related data within the viewing window. Shipping channels are colored yellow, road links are colored pink, and rail lines are colored blue. Terminal polygons are colored green, while rail yard polygons are colored blue. Point sources are colored in orange. Squares represent the ship hoteling locations, while circles represent point sources (like a boiler) located within the terminal boundaries. For each source type, the user can modify existing data, as well as add or remove sources.

The “Perform Analysis” button opens a box that describes the model scenario. The user provides a scenario name, type of simulation (e.g. hourly diagnostic analysis, annual concentrations), selects the pollutant(s) of interest, selects meteorological conditions, and time period to be modeled (representative hourly or annual). In addition, the user can select individual or all source types to be included in the analysis. After submitting the model scenario for simulation, the user can click on the “View Results” box to check on the progress of the analysis, and when the run has completed, click on the “Eye Icon” and C-PORT will display the results of model simulations for selected scenario (Fig. 7). Similar analysis could be done for any of the 21 ports from the C-PORT menu.

C-PORT also allows the user to compare the model results with monitor data. The “Air Quality Monitors” button shows the location of Air Quality System (AQS) monitors that record ambient air pollution data. C-PORT displays the location of the AQS monitors and provides maximum and mean 1-h concentrations for recent years (2011–2015) for NO_x, CO, SO_2, and $PM_{2.5}$. The AQS data summary, ingested from the EPA's Air Data website (https://www.epa.gov/outdoor-air-quality-data) is a useful reference point for comparing C-PORT outputs. However, C-PORT does not consider background concentrations from other sources or regional background in the modeling domain. Therefore, C-PORT only provides estimates of the air quality impact of port operations at the local scale above regional background.

3. Results

We applied C-PORT to a portion of Charleston, SC to demonstrate its use. We used the results of a mobile monitoring study in Charleston to compare the relative contributions of various port terminals predicted by C-PORT to observed contributions during the monitoring study. These measurements represented the best data available for a comparison at this location and scale.

3.1. Case study area

The Port of Charleston, South Carolina, is currently one of the largest container ports in the United States, ranking 10th in terms of number of containers, and 40th by tons of cargo (*Statistical Abstract of the United States: 2012 (131st Edition). Tables 1086 and 1087.*). The South Carolina State Ports Authority (SCSPA) currently manages five facilities in the area: 1) the North Charleston terminal, handling primarily containers; 2) Wando Welch, the largest container terminal in the area; 3) Veterans terminal, designated as project cargo, including bulk materials; 4) Columbus Street terminal, also designated project cargo, including roll-on/roll-off; and 5) Union Pier terminal, used mostly for cruise ship operations.

Port trucks typically access I-26 and I-526 as the main transportation corridors (Fig. 6). They continue on these routes out of the city, or use them to deliver cargo to nearby multi-modal and rail yard facilities (other sources of port-related pollution) for subsequent distribution. Short-range drayage trucks typically deliver goods to these facilities, and are often the older and more polluting trucks of the fleet. The already congested I-26 is of particular concern due to expansion of the North Charleston terminal scheduled for completion in 2017, which is expected to increase traffic in the area by up to 7000 new truck trips per day, a 70% increase over the 10,000 truck trips that currently support

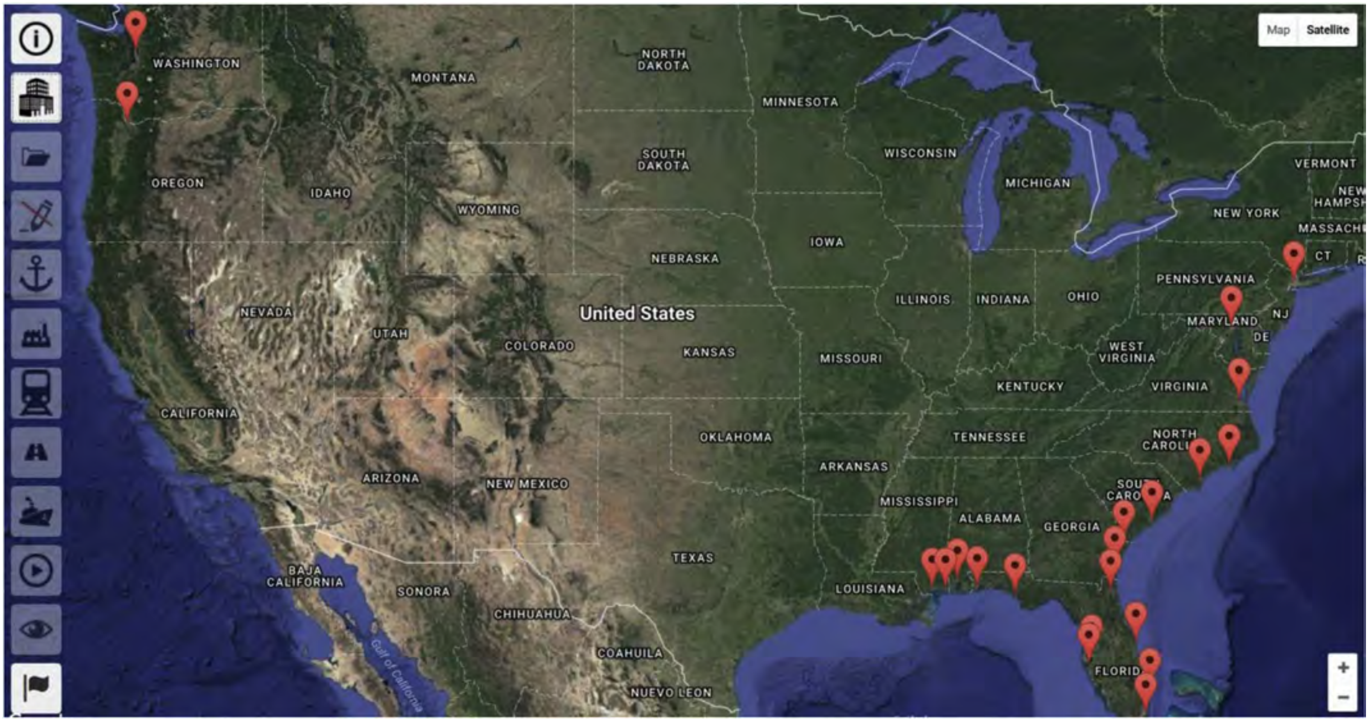

Fig. 5. C-PORT interface showing locations of available coastal sea ports.

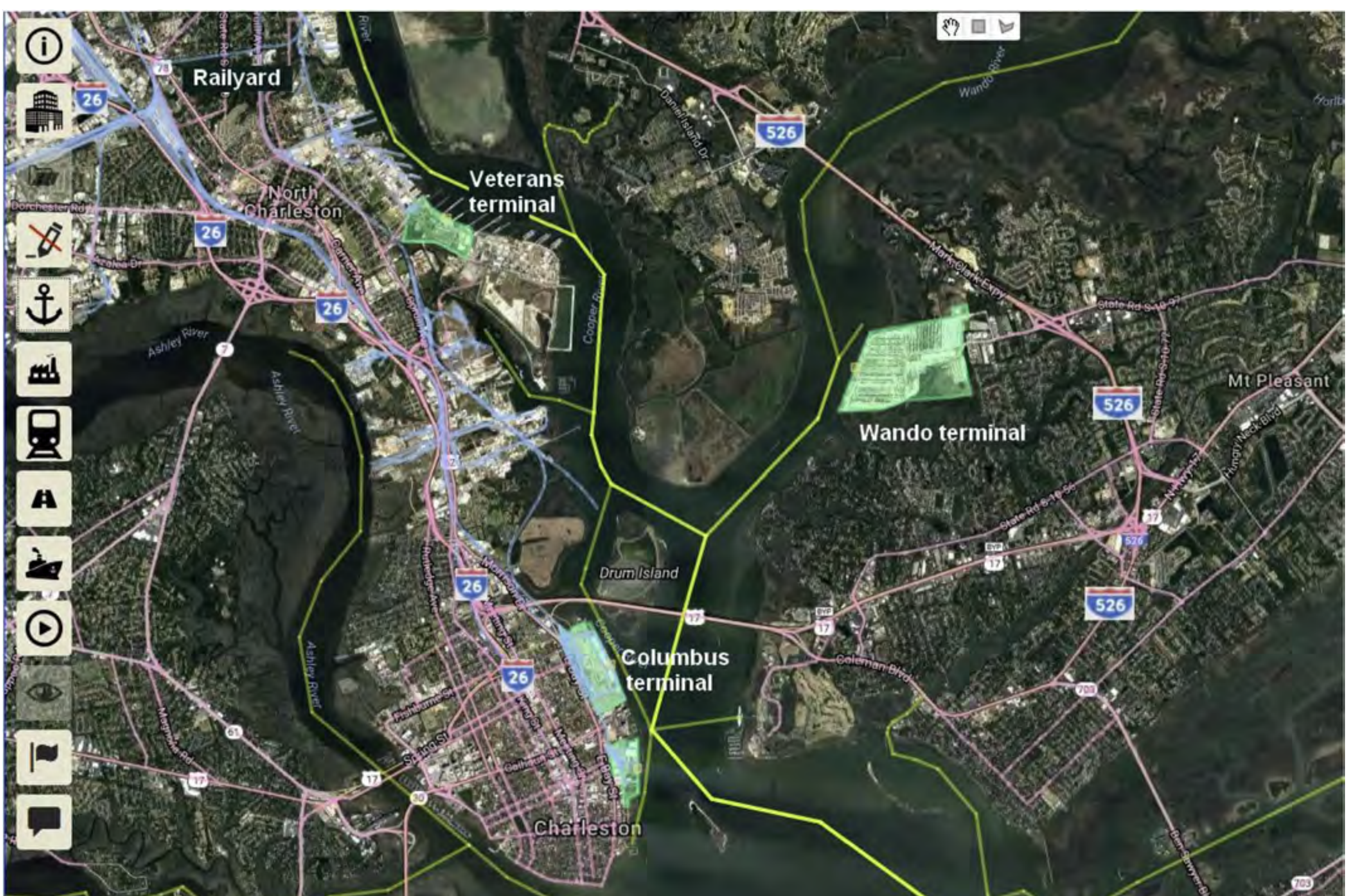

Fig. 6. Geographic domain in Charleston, SC showing locations of port terminals, roadways, railyards, shipping lanes, and main transportation corridors I-26 and I-526.

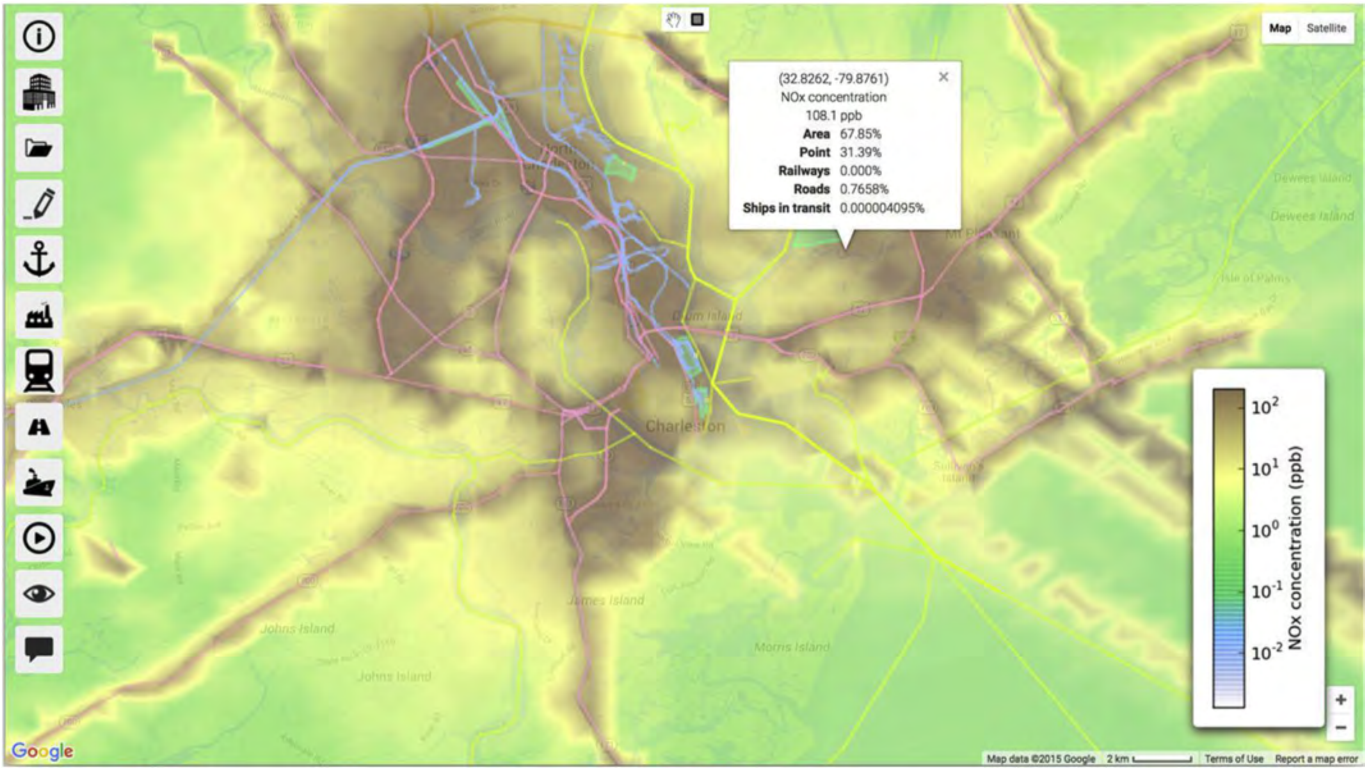

Fig. 7. Example of C-PORT application in Charleston, SC, showing NOx concentrations.

container distribution.

The Charleston area has 14% of its population living below the federal poverty line and 25% in the low socio-economic category. Diverse neighborhoods surround the Charleston port areas, with relatively affluent communities also being located near ports; however, the low-income communities tend to be in closer proximity to multiple sources in their local areas. Residents in North Charleston, for example, are concerned about emissions from a nearby chemical plant, a cement factory, and wind-blown dust from coal piles. Low income communities tend to be concentrated near the roadways and rail yards as well, experiencing potential exposures from both onsite port operations as well as related traffic.

3.2. Mobile monitoring campaign

Mobile monitoring was conducted in Charleston, South Carolina from February 20, 2014 to March 13, 2014 (Steffens et al., 2017). The measurements were obtained using EPA's GMAP vehicle, an all-electric converted PT Cruiser designed for driving-mode high-resolution mobile sampling along roadways. It is outfitted with an array of on-board monitoring equipment to measure concentrations of various pollutants. Measured pollutants include ultrafine particles (EEPS, model 3090, TSI, Inc.), larger particles (APS, Model 3321, TSI, Inc.), NO_2 (CAPS, Aerodyne Research, Inc.), CO (quantum cascade laser, Aerodyne Research, Inc.), CO_2 (LI-COR), and black carbon (BC) (Aethalometer, Magee Scientific). Pollutant measurements are taken in real time at a 1 Hz sampling rate while vehicle latitude and longitude are recorded with on-board GPS (Crescent R100, Hemisphere GPS). Additionally, a portable stationary sampling station was used to capture 3D wind speed and direction (ultrasonic anemometer, RM Young).

Sampling occurred over 24 sessions. During each session, the GMAP vehicle was driven continuously along one of four predetermined routes. Sampling start times were selected to be 4 a.m. for week one, 1:30 p.m. for week two, and 9 a.m. for week three. These times were chosen so as to not coincide with high-traffic times of day and to capture a variety of port operational hours. Normal port hours of operation are weekdays from 7 a.m. to 7 p.m. Each route requires approximately 30 min to complete. Vehicle battery allowed for approximately 3–4 h of continuous sampling, allowing for multiple laps per session. Three of the routes were selected for their proximity to different port terminals: Wando Welch Terminal, Columbus Street/Union Pier Terminals, and Veteran's Terminal (Fig. 6). The final route was near the Bennett Rail Yard. These routes are shown in Fig. 8. The routes are designed to be near the facility of interest and include at least one residential neighborhood.

Fig. 9 show the distribution of pollutant concentrations over all samples collected by mobile monitoring in four selected areas. These plots show concentration measurements under all meteorological and temporal conditions. As expected, the distributions of downwind concentrations are generally higher than upwind distributions, indicating the impact of the sources on nearby communities. The only exception is BC during stable conditions which could be due to a presence of a local source upwind of the Wando Welch terminal during this period of mobile measurements. The analysis also indicates a strong impact of atmospheric stability on levels of concentrations in the study areas.

3.3. Comparison with measurements

C-PORT provides estimates of air pollutant concentrations for a set of pre-selected representative weather categories (unstable, neutral and stable for winter and summer) based on hourly meteorological observations from the nearest National Weather

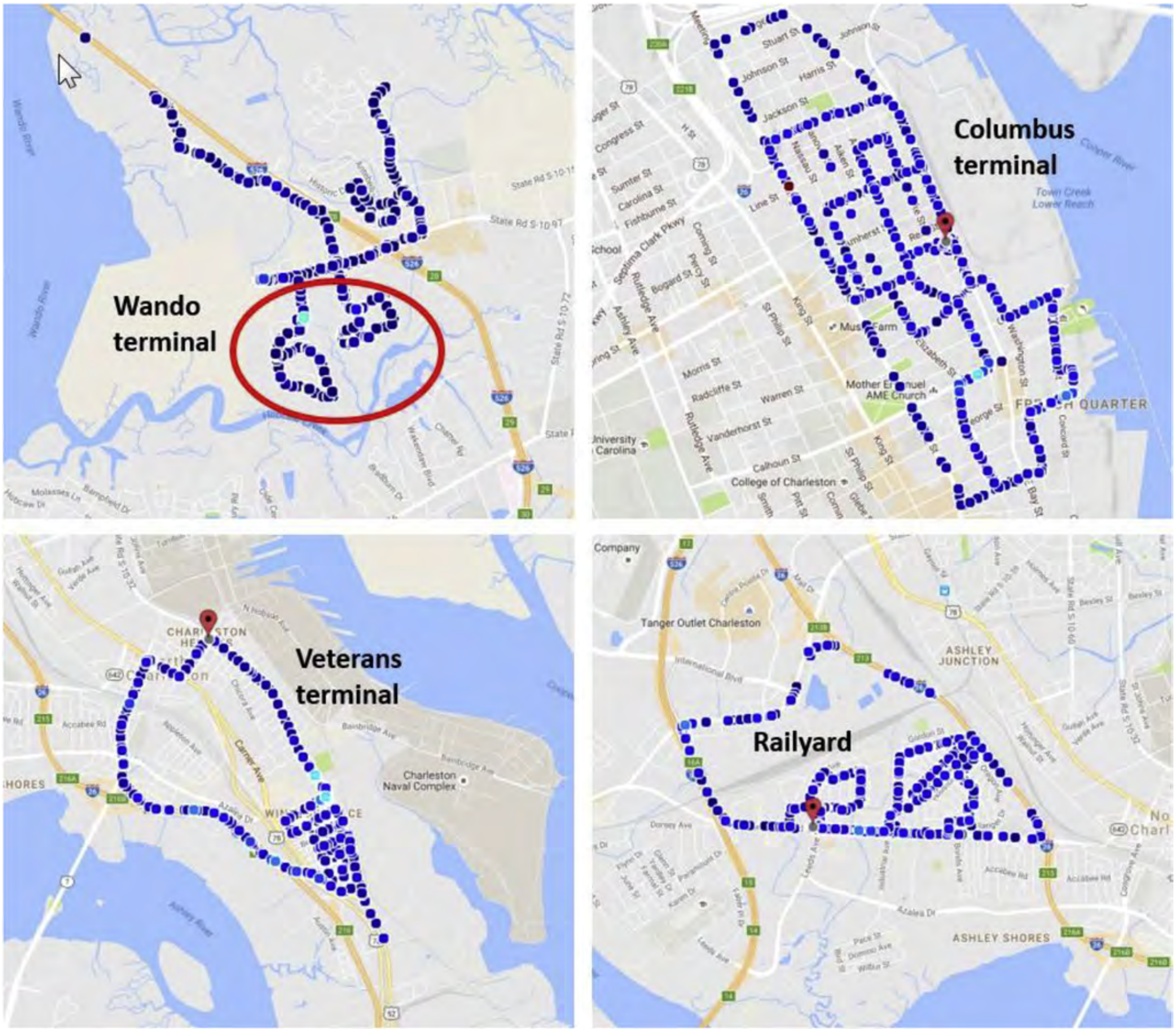

Fig. 8. GMAP driving routes in four monitoring sections around port terminals.

Service (NWS) Station for 2011. Since the measurement campaign was conducted in 2014, direct model-to-monitor comparison would not be possible. Instead, we conducted a qualitative comparison to see if the model is capable of predicting spatial patterns of pollutant concentrations, and adequately responds to changes in meteorological conditions (e.g. slightly stable, neutral, and slightly convective conditions, and wind directions representing upwind/downwind conditions in residential communities near Wando Welch terminal). In this comparison, we focused on carbon monoxide, nitrogen oxides and carbon fraction of particulate matter as commonly used markers of traffic-related air pollution. While C-PORT provide estimates of primary CO, NO_x and $EC_{2.5}$ (the portion of $PM_{2.5}$ consisting of elemental carbon), GMAP mobile measurements consisted of CO, nitrogen dioxide (NO_2) and aethalometer-based BC. EC2.5 is a model-based measure of a carbon fraction of particular matter while BC is a measurements-based measure of the carbon fraction, which is a commonly used marker of traffic-related air pollution, especially for diesel sources. Most NO_x from combustion sources are emitted as NO, which is then readily converted to NO_2 in the ambient air; therefore, NO_x and NO_2 will have similar concentrations for comparison purposes. C-PORT does not account for a portion of ambient NO_2 formed due to secondary production in the atmosphere. Also, C-PORT does not account for the background contribution, which is especially important for CO, yet near-source trends are comparable due to the impact of emission sources (see Fig. 9a).

Since a direct model-to-monitor comparison is not possible, we focused on a general comparison of upwind versus downwind concentrations for both C-PORT and GMAP analysis, and subtracted the upwind portion of concentrations from the downwind to estimate a direct impact of emissions sources at Wando Welch terminal. We ran C-PORT for the Charleston domain for various meteorological conditions to estimate a range of air pollutant concentrations in areas where GMAP measurements were taken.

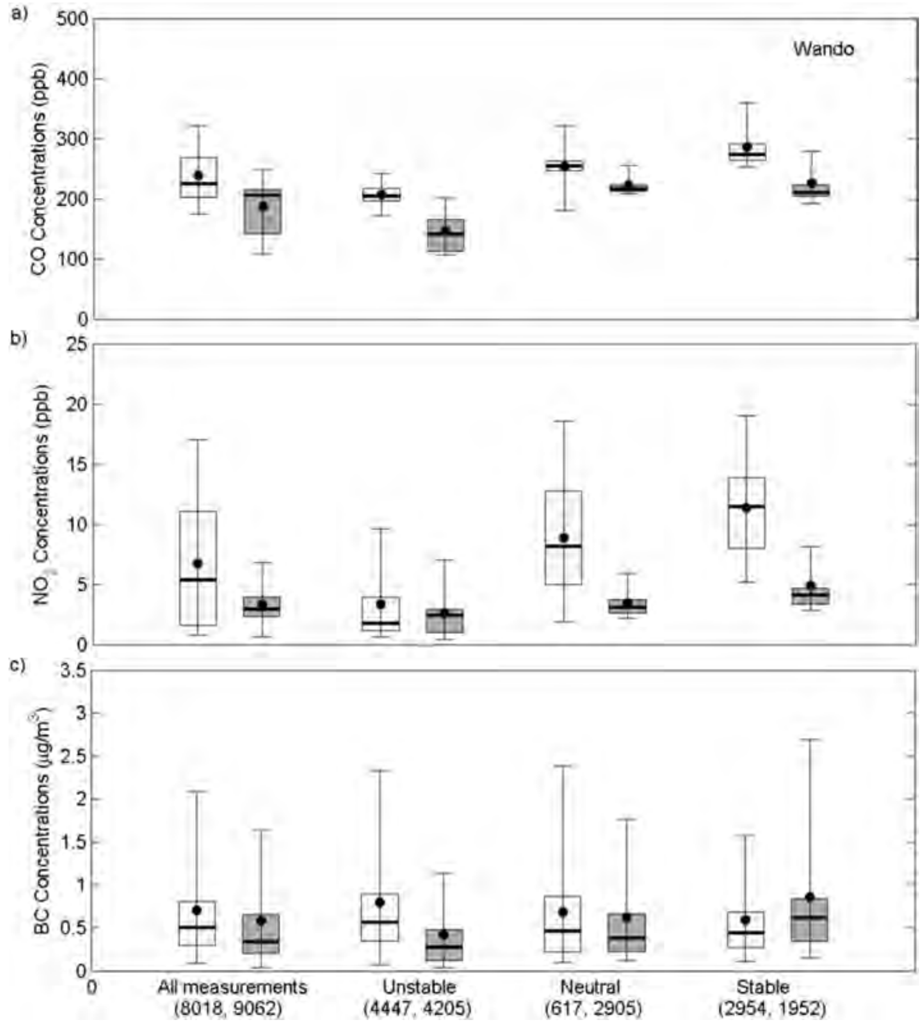

Fig. 9. Distributions of observed CO (a), NO_2 (b), and BC (c) concentrations from mobile monitoring downwind (light gray) and upwind (dark gray) of Wando Welch terminal for various stability conditions during the entire study. Each distribution is based on *n* observations (shown in parentheses below labels). The middle line represents the median, the box the 25th and 75th percentiles, and the whiskers the 5th and 95th percentiles. The data point represents the mean value of the distribution.

Because GMAP monitoring campaign was from February 20, 2014, to March 13, 2014, we ran C-PORT for the winter weekday morning in slightly stable, neutral, and slightly convective conditions with a west-northwesterly winds to estimate pollutant concentrations in residential communities downwind of Wando Welch terminal. We also ran C-PORT for east-southwesterly winds to simulate the upwind conditions. The inspect mode in C-PORT allowed us to click anywhere on the map in the community downwind of Wando Welch terminal and get a predicted value for the concentration of the pollutants modeled.

The results of comparison between C-PORT and GMAP observations are shown in Table 1. As expected, C-PORT responds to changes in meteorological conditions, predicting higher concentrations during stable conditions and lower concentrations during unstable conditions. The model captures the impact of emission sources at Wando Welch terminal and predicts a range of concentrations at downwind receptors that overlaps with the 25–75 percentile range of observed concentrations from GMAP mobile measurements for all pollutants except CO during unstable conditions and BC during unstable and stable conditions. This discrepancy might be explained by a presence of some local sources or other confounding factors not captured by C-PORT.

4. Discussion and conclusions

C-PORT is a web-based, easy-to-use model that allows users to visualize and evaluate different planning scenarios to identify potential impacts, or weigh trade-offs among alternatives to facilitate decisions that protect community health and promotes sustainable solutions. C-PORT allows the user to modify input parameters, rerun the simulation, and compare the modified results with the unaltered ("base-case") scenario. C-PORT also allows the user to add, delete, and modify emissions sources.

C-PORT offers the capability of producing scenario comparison maps. In the "View Results" menu, there is a tab for "Comparisons". The user can run either "Absolute Difference" or "Relative Difference" comparison between two scenarios. Using the "Inspect Tool", the user can develop a sense for how far the plume can impact the local community due to proposed changes in input conditions at the port.

4.1. Model advantages

The C-PORT modeling system incorporates a scientifically robust atmospheric dispersion algorithm, parameterized emission

Table 1
Comparison between estimates of impact of emissions from the Wando Welch terminal on downwind concentrations based on GMAP measurements and estimates based on C-PORT model predictions.

Carbon monoxide		
Atmospheric stability	25-75 percentile range of difference between downwind and upwind CO (ppb) concentrations from GMAP measurements	Range of differences between downwind and upwind CO (ppb) concentrations from C-PORT model predictions
unstable	50.5–84.3	0.3–11
neutral	34.4–39.6	0.5–42
stable	59.9–67.4	2–84
Nitrogen oxides		
Atmospheric stability	25-75 percentile range of difference between downwind and upwind NO_2 (ppb) concentrations from GMAP measurements	Range of differences between downwind and upwind NO_x (ppb) concentrations from C-PORT model predictions
unstable	0.09–1.0	0.4–1.9
neutral	2.3–9.1	0–2.6
stable	4.6–9.2	0–6.1
Carbon fraction of particulate matter		
Atmospheric stability	25-75 percentile range of difference between downwind and upwind BC ($\mu g/m^3$) concentrations from GMAP measurements	Range of differences between downwind and upwind EC_{25} ($\mu g/m^3$) concentrations from C-PORT model predictions
unstable	0.22–0.41	0–0.1
neutral	0.01–0.20	0–0.3
stable	−0.07–−0.15	0–0.7

sources, and local meteorology to estimate air pollutant concentrations in the near-port communities. C-PORT uses a number of input parameters based on pre-loaded emissions and meteorological datasets with nationwide coverage but it also allows a user to upload and utilize local datasets that are likely of higher fidelity. An important feature of C-PORT is its ability to assess variations of a given scenario (i.e., its "*what-if*" capabilities), accurately describing relative differences between various inputs within the modeling domain, or relative changes in pollutant levels for a given port under different conditions. For example, C-PORT can be used to: 1) identify potentially exposed populations to target resources and exposure-reduction efforts; 2) target outreach, education, and possible intervention for highly impacted community areas; 3) facilitate citizen science efforts to conduct air quality measurements by identifying areas for sensor-based measurements; 4) provide preliminary estimates of exposure to support subsequent detailed analyses; and, 5) examine potential concentration and spatial changes in air pollution given various emissions reductions strategies, such as alternative routes or clean fuels.

4.2. Model limitations

It is important to note that C-PORT is not designed to be used for regulatory applications but instead should be considered a screening tool to specifically investigate air impacts associated with port operations, including major freight corridors for traffic, rail, and ships. C-PORT predicts long-term (annual average) and short-term (representative hourly) concentrations of multiple criteria and toxic air pollutants from port activities at very fine spatial scales in the near-source environment, with access through a web-based platform that requires minimal technical expertise to use. The model should not be used to calculate concentrations at specific locations for specific hours (e.g., using meteorological data from 1 p.m. on 20 January 2017). Instead, we recommend using C-PORT as a "diagnostic" tool to explore the impact of emission sources on a nearby community for a range of pre-selected meteorological conditions for shorter time periods, i.e. for a single hour which is considered to be representative of classic meteorological conditions that are conducive (or not) for dispersion of air pollutants. These meteorological conditions are based on hourly observations from the nearest NWS stations. The air dispersion calculations in C-TOOLS are based on scientifically robust formulations similar to those employed in regulatory models, but efficiencies are derived from specification of representative scenarios for the input data. Though functionally, C-TOOLS and regulatory models are similar in that they predict near source air quality, their application and intended purpose are distinctly different. Due to the specificity of a regulatory application, the use of such tools needs to follow strict protocols for data specification and model calculations. However, many community-scale applications require a quick initial assessment of air quality impacts to characterize the scope of the problem and guide more detailed analysis, and often do not require the rigor of a regulatory model application. C-TOOLS attempts to bridge this gap by combining air dispersion models with evolving web-based and visualization technologies to provide an easy-to-access and rapid screening tool for users to undertake such initial air quality impact assessments.

4.3. Future development and availability

C-PORT is a part of the community-scale suite of screening tools called C-TOOLS (Community Air Quality Tools), developed by the US EPA to support community-level assessments of air quality scenarios. C-TOOLS are designed to provide an easily-accessible way to prioritize mitigation activities and evaluate the holistic trade-offs associated with many types of development (port, roadway, airport, energy facilities). The C-TOOLS suite includes several models: 1) C-LINE (already developed), 2) C-PORT (ongoing beta-testing), and 3) C-AIRPORT (currently under development).

C-LINE - the first member of the C-TOOLS suite - is a web-based modeling system whose front-end predicts concentrations of multiple air pollutants due to traffic emissions near roadways. C-LINE functionality has been expanded to model emissions from port-related activities (e.g. ships, trucks, cranes, etc.) to support a second, port-specific screening tool. The Community near-PORT modeling system (C-PORT) is capable of identifying potential locations of elevated air pollution concentrations near ports. As an easy to use alternative-scenario screening tool, C-PORT can be used by decision-makers, including port authorities, state and local governments, as well as local stakeholder groups who are concerned about environmental impacts and have an interest in identifying mitigation options. C-AIRPORT is intended to inform community decision-makers of local air quality impacts due to airport-related sources in their region of interest using an interactive, web-based modeling approach. Thus, all members of C-TOOLS modeling systems are intended to provide an accurate representation of near-source environmental conditions for a suite of important emission sources.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.envsoft.2017.09.004.

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VOLKSWAGEN CONSENT DECREE ENVIRONMENTAL MITIGATION TRUST PROJECT

PROJECT TITLE: TRANSPORTATION ELECTRIFICATION INITIATIVES

Section 1 Applicant Information

Organization Name: Energy Production Infrastructure Center (EPIC), University of North Carolina at Charlotte

Contact Person: Dr. Shen-En Chen

Nature of Organization: State Government

Mailing Address: 9201 University City Boulevard, Charlotte, NC 28223-0001

Phone Number: 704-687-1218

Email: schen12@uncc.edu

Section 2 VW Program and Solicitation Design Questions

1) **How should DEQ prioritize projects?**

DEQ should prioritize projects based on a) project readiness; b) long term potential impact; c) educational values to NC citizens; and d) technology innovations. While "shovel-ready" projects are the target of this solicitation, there is no reason to deviate from applied research which often results in innovations. This proposed study is representative of projects that can have long term impacts on the citizens of North Carolina in gaining awareness of air quality issues and the benefits of zero emission public transportation.

2) **What is the anticipated demand for each eligible project type?**

The anticipated demand for each eligible project type should include: 1) measureable assessment of project impacts; 2) management accountability; 3) refereed publications.

3) **The percentage of trust funds, if any, that DEQ should devote to Light Duty Zero Emission Vehicle Supply Equipment?**

Purchase of equipment has limited long term benefits due to vehicle depreciations from standard wear and teas. It is more advisable for the trust funds to be invested in enhancing citizen education on air quality mitigations. Hence, the trust fund expenditure to light duty zero emission vehicle supply equipment should not exceed 50% of the trust funds.

4) **What is the anticipated demand for specific types of diesel emission reduction projects not eligible under the VW settlement but otherwise eligible under DERA or other state programs?**

The anticipated demand for each DERA or other state program should include: a) relevant enhancement to state air quality; b) relevance to state commerce and air quality improvement; and c) innovation.

5) Should a certain percentage of available VW funds be allocated to each eligible project type and if so how should the percentage be determined?
No comment.

6) Should a certain percentage of available Mitigation Trust funds be reserved for government projects?
Yes – Government projects often have significant impact to the citizens.

7) Should funds be geographically distributed, and if so how?
It is not necessary to have the projects geographically distributed.

8) Should governmental entities be required to provide matching funds and if so, how much?
If matching funds are necessary, then 25% to 100% should be required.

9) Should DEQ establish a minimum project size and if so, what size?
Suggest $100,000.

10) In addition to evaluating a proposed project's total cost effectiveness ($/ton), what other key factors should DEQ consider when evaluating projects?
Other considerations may include the users of the technologies (who benefits from the project).

11) What other feedback do you have on project evaluation and/or scoring criteria?
No comment.

12) What publicly available tool(s) should be used to quantify anticipated emission reductions/offsets for eligible mitigation projects? What, if any, additional resources should be provided and made available?
No comment.

13) What methods could DEQ employ to reduce barriers and increase participation in future solicitations for projects?
No comment.

14) What information/resources would be most valuable for stakeholders interested in submitting projects and what is the best way to communicate those?
Public forum with Q/A sessions – would be very helpful to solicit public interests and to clarify project requirements.

Section 3: Project Information

Identify Applicable Eligible Mitigation Project Category:

Identify Applicable Eligible Mitigation Project Category:

1. **Class 8 Local Freight Trucks and Port Drayage Trucks with 1992-2009 model year engines and a Gross Vehicle Weight Rating (GVWR) greater than 33,000 pounds (lbs.)**
2. **Class 4-8 School, Shuttle, or Transit Buses with model year 2009 or older engines and a GVWR greater than 14,001 lbs. and used for transporting people.**
3. **Class 4-7 Local Freight Trucks with 1992-2009 model year engines and a GVWR between 14,001 and 33,000 lbs.**
4. **Freight Switchers with pre-tier 4 engines and operating more than 1,000 hours per year.**
5. **Ferries/Tugs with unregulated Tier 1 -Tier 2 marine engines.**
6. **Ocean-Going Vessels Shorepower.**
7. **Airport Ground-Support Equipment with Tier 0 -Tier 2 diesel engines, and uncertified or certified to 3 grams perbrake horsepower-hour spark ignition engines.**
8. **Forklifts with greater than 8,000 lbs. lift capacity and/or Port Cargo Handling Equipment.**
9. **Light Duty (LD) zero emission vehicle (ZEV) Supply Equipment (Level 1, Level 2, or fast charging equipment) and hydrogen fuel dispensing equipment.**

UNCC believes that this project is an acceptable fit for Category 9. Light Duty (LD) zero emission vehicles (ZEV) Supply Equipment (Level 1, Level 2, or fast charging equipment) and hydrogen fuel dispensing equipment, and could be funded accordingly. Otherwise UNCC requests that funding for this project be made available via the VW DERA funding path.

Project Summary:

With CATS Blue Line LYNX light rail reaching into UNC Charlotte campus, there is a great opportunity for the campus to demonstrate transportation electrification with rail-to-rail and rail-to-non-rail connectivity, zero emission public transportation and related energy infrastructure. UNC Charlotte has terrain challenges and the transportation challenges for students to drive to campus resulting in pollution issues. To reduce emissions, this project targets the last mile mobility of the campus fleet using a piece-meal approach with different LD ZEVs (vehicle replacement with innovative transport technologies) including small electric automobiles, electric bikes and electric guided locomotives, and will entail the design of electrified transportation to move students from light rail stations to different parts of campus. Teaming with CATS, Duke Energy, and potentially various government agencies, it is estimated that the project will cost $3,276,576 ($2,276,576 with $1,000,000 matching) and will have benefits including displacing significant emission issues on UNC Charlotte campus.

Project Details:

As an inner city campus, UNC Charlotte is located on the northeast edge of Charlotte, NC with close physical connectivity to Charlotte proper via the CATS bus service line. The main campus is within the satellite region called the University City, which is a major commerce and industry region (University City Park) in Charlotte with several industry and commercial entities including TIAA-CREF, Areva, Wells Fargo, EPRI, etc. Figure 1 shows the geographic relations between

Charlotte metropolitan, uptown, University City and UNC Charlotte. Ranked #8 with the highest ozone pollution in the nation in 2009, the City of Charlotte has since actively improved its air quality and now has a "moderate" air quality rating throughout the year. The population density at UNC Charlotte main campus can reach 18,250 per square mile, which is equivalent to the population density of a major city in the US (as examples – New York, NY at 26,403 per square mile, Charlotte at 2,457 per square mile)[2]. Being at the far northeast corner of the metropolitan area, for most students coming to school would mean either move to a residence close to campus or drive to campus – this is a critical connectivity issue for UNC Charlotte and the population that it is serving. With CATS completing its Blue Line light rail stop at UNC Charlotte, students from uptown and along the light rail line can now travel to campus by public transport. However, there is still the last mile connection between the light rail stations and the main campus, which currently requires students to walk to the campus. This challenging task can be a significant deterrent for students to switch from cars to public transport.

The main campus has six parking decks (North, East, West, CRI, Union, Cone and South Village Decks) and several uncovered parking lots. The total parking space on campus is about 1,000 spots. With a student capacity close to 30,000 and over 2,000 staff, UNC Charlotte is heavily landlocked with only four exits to leave campus. Another critical consideration associated with the challenges of local landscape is that the student residents are mostly at least a quarter mile away from the main campus and downhill. Hence, to reach the campus, students require longer travel times. This physical challenge can be a significant hindrance to students who are mobility-restricted, and it limits their course time and access to resources. Figure 2 shows the UNC Charlotte campus layout including the two stops of the light rail, campus buildings and the student resident hall and off campus living distributions. Arrows in Figure 2 show the directions of the upward landscape, each representing upward movements at least a quarter mile long (based on existing built walking paths such as sidewalks).

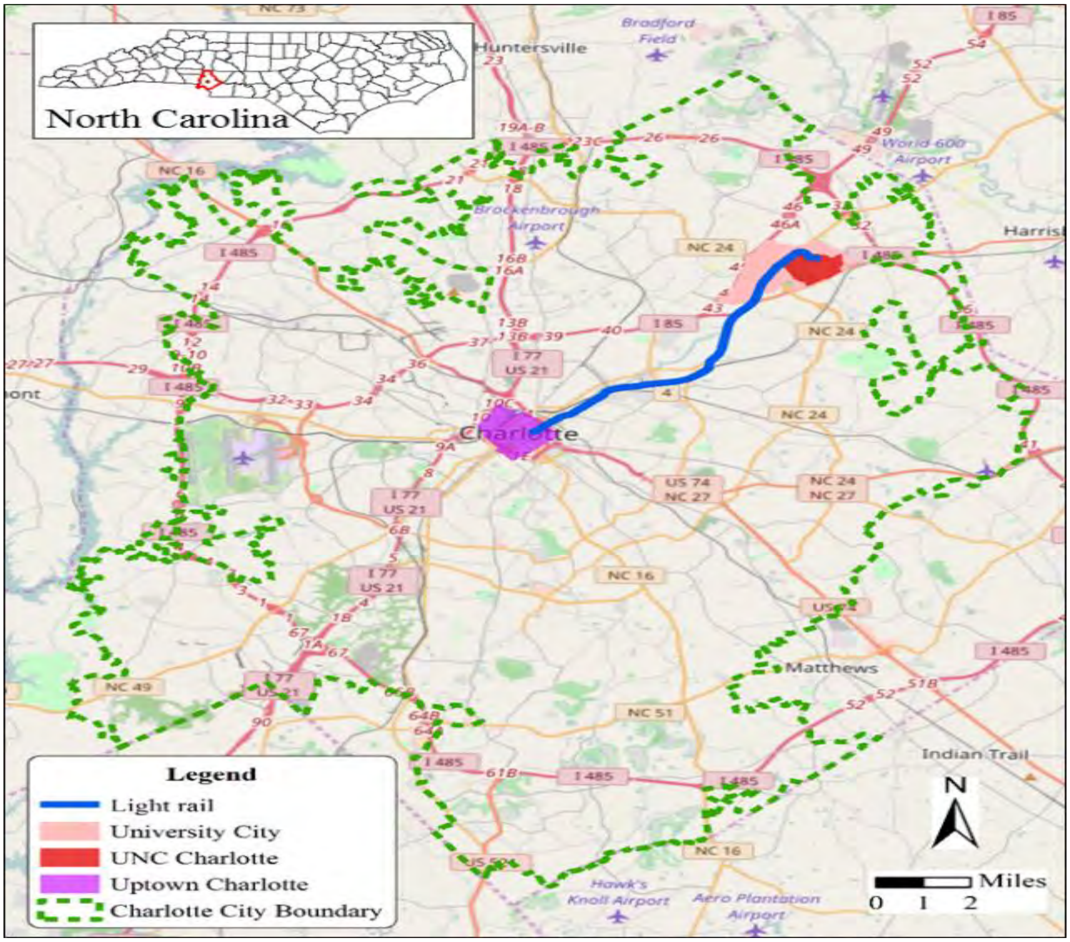


Figure 1: Physical Geographic Relations between metropolitan Charlotte, Charlotte uptown, University City and UNC Charlotte.

The CATS LYNX Blue Line is a state of the art light rail system with 15 stations. The light rail extension to UNC Charlotte will have two stations close to the campus with the last terminal (UNC Charlotte) located on campus near the North deck, which is at a topographical low point and require riders to walk uphill to the campus. The station (JW Clay Boulevard) on Tryon Street across from CRI has a parking deck and would require riders to walk downhill to the CRI campus. From the CRI campus to the main campus is a 10 minute minimum walk with partial upward slope, hence it can be physically challenging for many people.

The objectives of this feasibility/research/demonstration project are to solve the last mile connectivity issue in bringing people from the light rail stations to the hilltop campus and to optimize the use of parking facilities near the light rail stations. We anticipate this project would not only help reduce emission problems on campus, but will also improve the traffic and handicap access on campus.

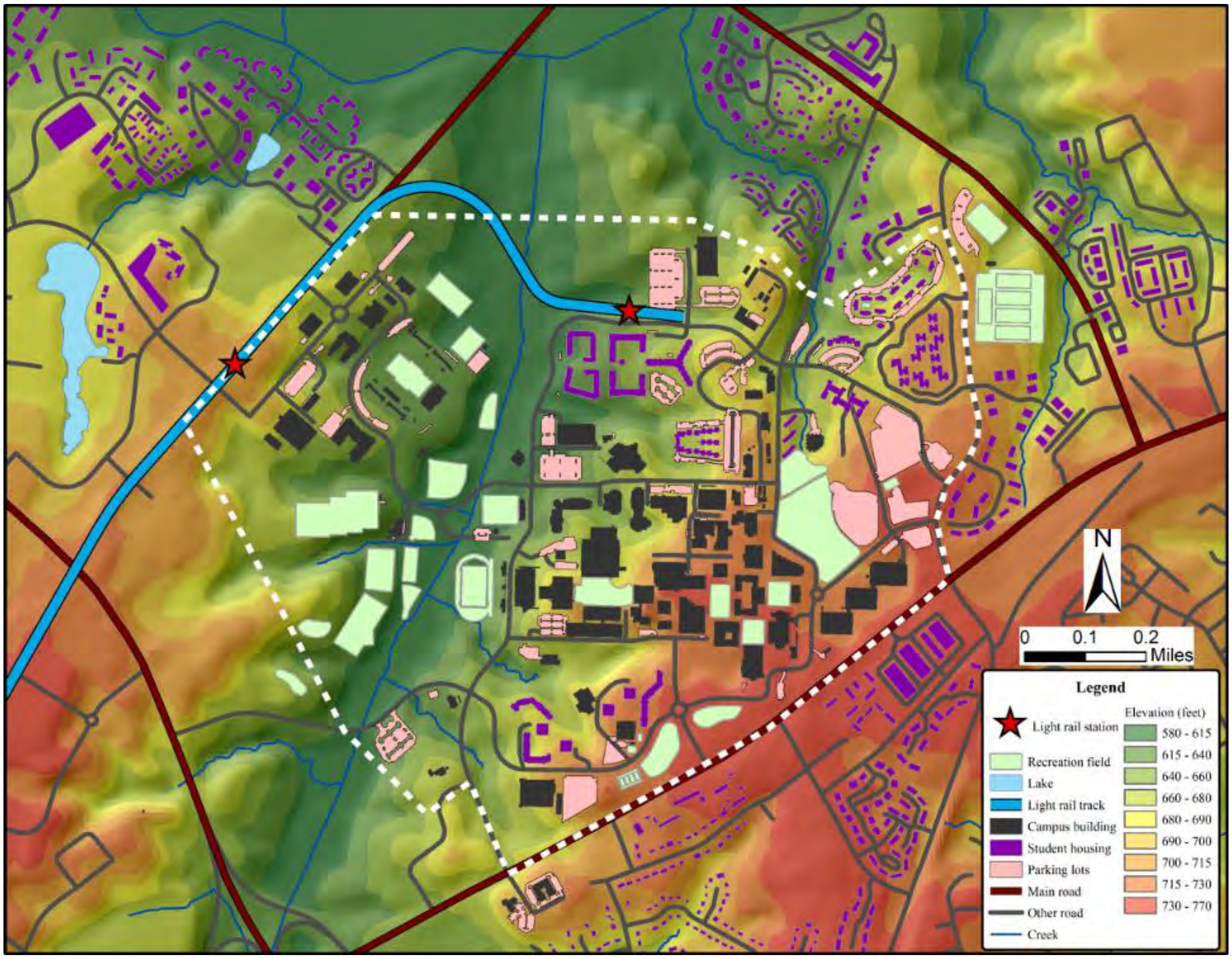


Figure 2: The UNC Charlotte Campus Layout and Simplified Landscape Scenario

The proposed project aims to transform the UNC Charlotte campus into an innovative integration of zero emission vehicles (ZEV) with plug-in or wireless power charging capabilities including two electric automobiles (Class 2 passenger cars for 2 to 4 passengers), ten electric bicycles (Class 1), 2 electric guided people movers (not classified):

1) The two electric automobiles will be Chevrolet Bolt EV or equivalent with a 60 kWh battery and 150 kW motor.
2) Ten electric bicycles will be Addmotor MOTAN electric bicycles with a 48V / 500 W motor or equivalent.
3) Two electric Super Mack rail locomotives with 1/3 Hp, 3000 rpm motor with a 24 V power supply or equivalent.

This project will utilize light duty electric vehicles that can be charged, hence there will be no fuel used and no emissions on the UNC Charlotte campus. It is anticipated that all LD ZEVs used in this project will be powered by lithium ion batteries. The diesel emission reduction technology to be used is transportation electrification allowing zero emission at the target site. If sufficient students were to utilize the CATS light rail and proposed connectivity solutions, then significant diesel and gasoline emissions can be removed from the campus.

To supplement the proposed mobility solution, there is a need for a customized electric supply system for the battery charging – in collaboration with Duke Energy, different grade power charging stations will be design and installed at various campus locations. The power charging units will accommodate different levels of power grades. The project tasks include emission impacts, transportation electrification design, routing layout studies, user analysis and also energy use studies. Furthermore, the team will manage operations and repairs of the vehicles. It anticipated that the project will last two years. A breakdown of actual tasks is shown below:

No.	Task No.	Activity/Deliverable	Quarter	Expected Completion
1	1.1	Conduct kickoff meeting	1	2 months
2	1.2	Quarterly reports	1	12 months
3	2.1	Identify connectivity solutions	1	3 months
4	2.2	Website creation	1	3 months
5	2.3	Equipment purchases	1	3 months
6	3.1	CATS data collection	1	3 months
7	3.2	Annual reports	2	12 months
8	3.3	Campus data analysis	2	6 months
9	3.4	Well-to-wheel energy use analysis	2	9 months
10	4.1	Power supply system data analysis	2	3 months
11	4.2	Electric infrastructure design/build	2	5 months
12	4.4	Conduct air quality analysis	2	3 months
13	4.5	Technical reports	3	12 months
14	5.1	Campus mobility analysis	4	2 months
15	5.2	Critical path analysis	4	3 months
16	5.3	Final report	4	2 months

Several of the tasks will be conducted simultaneously, which will be concurrent with close communications with Duke and CATS. After the study, the equipment will be turned over to the university facilities management team to continue the operations of the mobility solutions, thus, promotes continued and long term benefits to the students.

How should determination be made on whether a proposed project will benefit areas that have been disproportionately impacted by emissions of nitrogen oxides (NOx) or other pollutants?

Billed as an inner city university, UNC Charlotte's physical location actually makes it hard for local low income students to attend the university – this includes University City South, which is considered a low income neighborhood. CATS light rail solves this problem by allowing local residents to reach the campus. This project addresses the last mile mobility issue and would further help the students to reach their classrooms.

Furthermore, significant amount of UNC Charlotte students currently drive to school and their vehicles are the main contributors to NOx emissions. It significantly increases the emission level within campus versus the neighboring areas. The proposed vehicle replacement with all-electric vehicles represents a 100% mitigation of emissions. Detailed project impact analysis (Task 3.1 and Task 3.3) will help demonstrate the actual vehicles displaced by students using light rail and the campus electrified vehicles. It is anticipated that at least 1,000 diesel or gas vehicles will be replaced by the proposed technologies integrating CATS light rail and electrified campus transportation.

<u>Capital and Project Costs</u>

The Capital cost for this project entails the purchase of the equipment, the power infrastructure for the charging stations and the rail track setups. The total capital cost is $149,000. The project total cost is $3,276,576 including approximately $1,000,000 matching support. Below is a breakdown of the project cost:

itemized	**Description**	**Budget Explanation**
Personnel	Participating faculties, students and facilities employees	Total Labor (with benefits): $1,000,000
Equipment	2 electric automobiles ($37,000 each) 10 electric bicycles ($1,500 each) Electric park gauge locomotives plus rail ($30,000)	$149,000.
Materials	Consumables (electronics) $20,000. Computer and data storage $10,000. Network Upgrade $30,000. Solar panel and batteries $10,000	$80,000.
Lab fee and tuition	Lab fees - $8,000 In-state Tuition - $39,576	$47,576
Matching Support	In-kind support from CATS in terms of transportation data donations and from Duke Energy for power supply infrastructure	CATS - $200,000. Duke Energy - $800,000.
(f) Indirect (G & A)	51% of MTDC*	$1,000,000
Total Budget	Year 1 total: $1,056,349; Federal $816,349; in-kind matching $3,276,576	

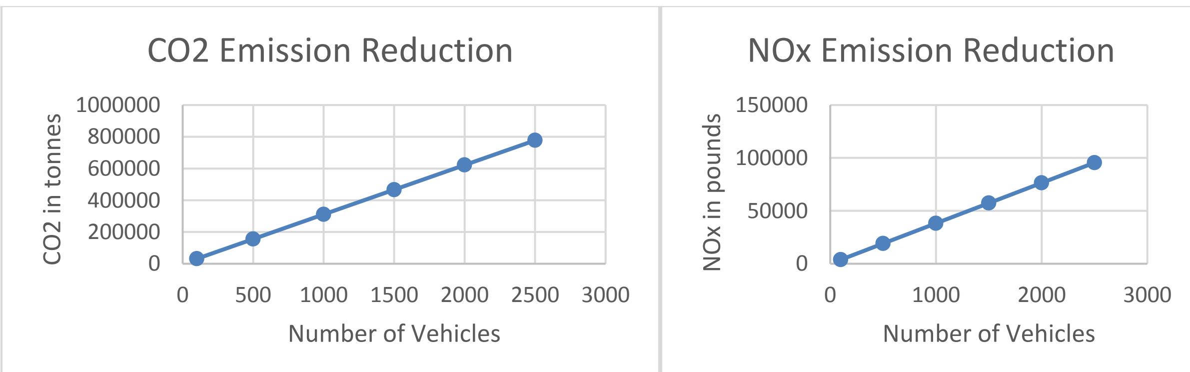
***No federal cost sharing is involved in this research. The provisions of 23 CFR, Section 19, Subsection C, are understood and will be followed.**

<u>Expected Proposed Project Benefits:</u>

The benefits of the proposed project are many folds and can be anticipated from several aspects:

1) Direct diesel emission reductions

The proposed project will improve air quality and standard of living on UNC Charlotte campus – Multiple ZEV types are suggested in current study and all equipment belong to the horsepower groups < 49 hp. As these are all new equipment and not directly replacing existing vehicles, standard EPA diesel emission reductions and capital and total cost effectiveness calculation cannot be used. Instead, we compute the amount of emission reduction on campus using an analysis of likely vehicles that will not be used to reach campus: Using US EPA April 2000 emission estimates for average passenger cars (38.2 lb NO_x, 11 tonnes CO_2), the amount of reduction is linearly correlated to number of cars that will not be driving on campus. Figure 3 shows the amount of emissions that can be eliminated on UNC Charlotte campus as a function of number of vehicles. The results are encouraging – If 2,500 cars can be avoided from the campus, it represents 800,000 tonnes of CO_2 and 100,000 lbs of NO_x can be eliminated from the campus air.



a) CO_2 emission reduction potential b) NO_x emission reduction potential

Figure 3 Amount of Pollution Reduction Potentials (a) CO_2 and b) NO_x) as a Function of Vehicle Removed

2) Advancement of zero emission transportation and clean energy technologies

This project provides a unique, applied research opportunity to energy efficiency of different zero emission transportation technologies. It allows us to study approaches in zero emission energy supply infrastructures, technologies and downstream solutions such as re-use of batteries (second life), disposal issues of fuel cells, batteries, etc. It also allows study of mixed mode transportation energy use in congested city scenarios.

3) Promoting a zero emission city culture –

UNC Charlotte has the characteristics of a microcosm of any city, hence it can be established as an ideal zero emission campus model that can be scaled to any city scenarios. The focus on the development of multi-modal, non-standard passenger vehicles, transportation modes, is ideal for short range travel and further allowed the project to promote and advance zero emission and clean energy transportation technologies. Typical of most campuses, our campus population is characteristic of aging faculty and staffs and millennial students. US millennials are characterized as eco-friendly and more receptive to public transportation systems. The promotion of nonpassenger vehicle transportation integrated with eco-friendly public transportation systems fits well with the millennial student culture and can make the campus more attractive to future students.

It is anticipated that this project can help modify people travel behaviors based on two obvious benefits: 1) It helps to accommodate non-facility staff to be able to move around campus quickly without having to drive their own cars; 2) it allows students to reach their classroom rapidly (including staging on and off to within minutes). As a result, we can phase out driving of emission cars within campus and further optimize the use of existing parking spaces on campus. Additionally, the reduction of passenger cars can actually allow route for safe evacuation and also limit constrains to cargo flows on campus - until such a time that the campus is ready for a central cargo receiving location.

We envision that this project will be a model for a more sustainable environment for congested inner cities. The success of this project will be used for the creation of a model for ZERO (Zero Emission Resource Organization) cities with high population density as well as a small size inner city.

From a public relations viewpoint, this project provides innovative and sustainable connectivity solutions to UNC Charlotte and University City Region and allows the development of an integration strategy to benefit the University City Areas with UNC Charlotte. Thus, this project can help promote clean air strategies beyond the campus.

Section 1 – Project Applicant Information

- **Company/Agency/Organization Name:** University of North Carolina at Charlotte – William S. Lee College of Engineering
- **Contact Person Name:** Shen-En Chen
- **Government/Non-Government:** Government
- **Mailing Address:** 9201 University City Blvd, Charlotte NC 28223
- **Phone Number:** (704) 305-6866
- **Email Address:** schen12@uncc.edu

Section 2 – VW Program and Solicitation Design Questions

Respondents should consider providing information in response to the following questions:

1. **How should DEQ prioritize projects?**
   Recommend that DEQ should consider the following when determining priority of projects:
   - Most optimal air pollution improvements per dollar spent
   - Opportunities to introduce new emissions reduction technologies. Embracing new technologies will establish North Carolina as a national leader in air pollution reduction efforts, which will in turn put the State at the forefront of opportunities for future funding for additional emissions reduction.
   - Ability of agencies to pay for projects without VW money; i.e. projects that otherwise may not be accomplished without VW funding should take priority over agencies that possess means to pay for emissions reduction efforts

2. **What is the anticipated demand for each eligible project type?**
   It is anticipated that there will be a significant demand for each project type.

3. **The percentage of trust funds, if any, that DEQ should devote to Light Duty Zero Emission Vehicle Supply Equipment?**
   The percentage of funds devoted to LDZEV supply equipment should be proportional to the amount these vehicles contribute to total air pollution for the State.

4. **What is the anticipated demand for specific types of diesel emission reduction projects not eligible under the VW settlement but otherwise eligible under DERA or other state programs?**
   There will be a significant demand for DERA-eligible projects under the VW settlement. UNC Charlotte's request is in fact a good example of this – emissions testing equipment is not eligible for VW funds directly but could be funded as a DERA project, and if funded would have a significant impact on emissions reduction. Acquisition of the proposed RAVEM system would allow UNC Charlotte to be able to quantitatively measure emissions reductions due to any type of improvements that are made on any diesel engine by any agency using a CFR-

compliant system; this capability restricted to only a few agencies in the United States, none of which are located in the Southeastern United States.

5. **Should a certain percentage of available VW funds be allocated to each eligible project type and if so how should the percentage be determined?**
   DEQ should determine how much each project type contributes to overall levels of air pollution across the State, taking into account regional “hot spots” and cost of upgrades/replacement vs. amount of pollution generated.

6. **Should a certain percentage of available Mitigation Trust funds be reserved for government projects?**
   Yes. UNC Charlotte strives to be an academic and technical leader in emissions reduction, and having a system that would allow for convenient emissions testing (via DERA funding) will be an excellent opportunity to continue this effort. With strong environmental research and motorsports technology studies, close vicinity to over 200 energy companies, and situated in the largest city in North Carolina, UNC Charlotte has the potential of impacting the Carolinas region in promoting clean and zero emission technologies. This project represents a group of several dedicated faculties and researchers interested in zero emission transportation energies within the college of engineering.

7. **Should funds be geographically distributed, and if so how?**
   Funds should be distributed in a manner that results in the maximum reduction of air pollution across the State, in keeping with the criteria suggested in Question #1 above.

8. **Should governmental entities be required to provide matching funds and if so, how much?**
   Recommend that DEQ abide by the indicated VW criteria for percent matching funds for indicated projects; this should be applied equally to governmental and non-governmental agencies.

9. **Should DEQ establish a minimum project size and if so, what size?**
   Recommends that DEQ consider all projects regardless of size and provide funding in accordance with the criteria indicated in Question #1 above.

10. **In addition to evaluating a proposed project’s total cost effectiveness ($/ton), what other key factors should DEQ consider when evaluating projects?**
    DEQ should also consider the impact of implementing new technologies to combat air pollution. Continuing to embrace new technologies will establish North Carolina as a national leader in air pollution reduction efforts, which will in turn put the State at the forefront of opportunities for future funding for additional emissions reduction.

    Furthermore, as an educational institution, UNC Charlotte can be a strong entity to influence future generations in raising awareness in clean air quality technologies and the importance of clean air for the environment.

11. **What other feedback do you have on project evaluation and/or scoring criteria?**
    Request that DEQ continue to keep all interested parties apprised of the project schedule to ensure that all critical applications and other documentation is received within proper timeframes.

12. **What publicly available tool(s) should be used to quantify anticipated emission reductions/offsets for eligible mitigation projects? What, if any, additional resources should be provided and made available?**
    The emissions reduction calculation tools provided in this RFI are acceptable. UNCC believes DEQ has done a commendable job to date regarding rollout of the VW application process. DEQ should continue to make itself available as a resource to all parties interested in VW funding.

13. **What methods could DEQ employ to reduce barriers and increase participation in future solicitations for projects?**
    UNCC believes that DEQ does a good job of communicating solicitations for projects. Continued communication of future solicitations to previous applicants is important to ensure these solicitations receive positive feedback. DEQ should continue to encourage applicants to communicate opportunities for funding to their colleagues to increase interest and potential number of applicants.

14. **What information/resources would be most valuable for stakeholders interested in submitting projects and what is the best way to communicate those?**
    Information such as scope, funding limits, and application requirements are critical for submitting proposals. DEQ communicates this information well in RFPs and announcements associated with funding solicitations.

Section 3 – Submitting Your Project Information

Identify Applicable Eligible Mitigation Project Category:

1. **Class 8 Local Freight Trucks and Port Drayage Trucks with 1992-2009 model year engines and a Gross Vehicle Weight Rating (GVWR) greater than 33,000 pounds (lbs.)**
2. **Class 4-8 School, Shuttle, or Transit Buses with model year 2009 or older engines and a GVWR greater than 14,001 lbs. and used for transporting people.**
3. **Class 4-7 Local Freight Trucks with 1992-2009 model year engines and a GVWR between 14,001 and 33,000 lbs.**
4. **Freight Switchers with pre-tier 4 engines and operating more than 1,000 hours per year.**
5. **Ferries/Tugs with unregulated Tier 1 -Tier 2 marine engines.**
6. **Ocean-Going Vessels Shorepower.**
7. **Airport Ground-Support Equipment with Tier 0 -Tier 2 diesel engines, and uncertified or certified to 3 grams perbrake horsepower-hour spark ignition engines.**
8. **Forklifts with greater than 8,000 lbs. lift capacity and/or Port Cargo Handling Equipment.**
9. **Light Duty (LD) zero emission vehicle (ZEV) Supply Equipment (Level 1, Level 2, or fast charging equipment) and hydrogen fuel dispensing equipment.**

UNCC UNCC's proposal does not fit into any of the pre-designated VW project categories as it is focused on acquiring diesel engine testing equipment in order to more efficiently facilitate emissions testing vs. traditional methods. Accordingly, UNCC requests that the DERA funding path be used for these emissions reduction projects. Note that all non-LDZEV equipment indicated above would be potential candidates for testing using the RAVEM system.

Project Summary:
Briefly describe the proposed project, including:

Geographic area where vehicles/vessels/engines are operated (e.g., city/cities, county/counties, and/or neighborhoods); This proposal would affect diesel vehicles/engines across the State of North Carolina.

Fleet type (e.g., ports, airports, marine, school buses); All diesel vehicles/engines, with specific focus on large offroad vehicles such as railroad and marine diesel engines.

Mitigation action (e.g., engine repower, vehicle replacement, deployment of LD ZEV supply equipment/Shorepower systems); acquisition of emissions testing equipment

Number of engines/vehicles/vessels/equipment targeted for emission reductions; Application of this technology would be statewide – all marine, railroad, and other offroad vehicles would be candidates for testing

Emission reduction/offset technology to be used; An emissions testing system known as a Ride Along Vehicle Emissions Measurement (RAVEM) system – a 40CFR1033 and 1065 compliant system that allows for portable, on-site emissions testing of diesel engines. RAVEN is based on the state-of-the-art gas measurement technology based on heated chemiluminescent and heated flame ionization analysis principles, which has been optimized for transport and on-site testing.

Estimated cost of project; $700,000 (including equipment purchase, labors and training)

A description of the expected overall benefits of the proposed mitigation activity, including a description of how the proposed project mitigates the impacts of nitrogen oxides (NOx) emissions:
With the advent of cleaner-burning diesel engines coming available and increased federal/EPA requirements for replacing older engines, agencies that use diesel equipment need a mechanism to quantify emissions improvement upon engine upgrades/replacement. Quantitative emissions testing of diesel engines in a manner that complies with the Code of Federal Regulations (CFR) has historically been an expensive, arduous, and time consuming process, particularly for large offroad vehicles. Traditionally any engine testing has involved sending a vehicle to an offsite agency such as the Southwest Research Institute (SWRI) in San Antonio, TX or Detroit Diesel

Company in Detroit, MI. Transporting vehicles to these locations is often an expensive endeavor, and the testing process can take weeks, which results in extended down time for the vehicle and thus lost revenue for the owning agency.

This emissions testing and quantification process can be improved substantially via portable emissions testing equipment – the technology is available to allow a CFR compliant testing system to be equipped into a standard utility truck or van, driven to the site that is requesting the testing, and performing the testing on site. The flagship standard for this type of testing equipment is known as a Ride Along Vehicle Emissions Measurement (RAVEM) system. A technical summary of the RAVEM including schematics of the testing configuration are provided in Reference 1 of this document. There is currently one (1) RAVEM system in the United States, located in California, and thus suboptimal for use by customers in the eastern half of the country. Acquisition of a second RAVEM system by UNCC would allow the University's College of Engineering to be a hub of state-of-the-art emissions testing and accordingly provide a cost-effective testing mechanism for all agencies across North Carolina and the Southeastern United States.

The RAVEM system is specifically designed to test for the EPA pollutants identified in 40CFR1033, including NOx. The RAVEM system would be the system of choice for quantifying emissions reduction for agencies that implement emissions reduction systems, i.e. SCR, biodiesel, etc. onto their diesel engines, and would do so in a cost effective and logistically uncomplicated manner. New diesel engines typically afford NOx reduction of approximately 80% or more vs. unregulated engines; the RAVEM system could specifically quantify this percent reduction.

Note that the requested cost of acquiring a RAVEM system is $400,000, this includes system maintenance and operating costs; it is expected that agencies would be charged $40,000 - $50,000 for testing using the RAVEM system, thus the ROI would occur within approximately ten uses. If testing is conservatively estimated to occur once per quarter the RAVEM would see a positive return within 2-3 years. Note that agencies generally pay approximately $100,000 to send vehicles to outside agencies such as SWRI plus transportation costs and lost revenue while the vehicle is being tested, thus the RAVEM provides a minimum 60% cost savings opportunity. Standard RAVEM testing would take approximately one week, which is a significant improvement over the 4-8 weeks typically experienced by testing at outside agencies. The RAVEM system is expected to be fully functional within 12 months after award of the requested VW funding.

Project Detail:

Provide information on specific engines/vehicles/vessels/equipment targeted for emission reductions, including (where applicable):

- **Number of vehicles** – as this request is for testing equipment, all diesel vehicles/engines across North Carolina and the surrounding States are potential candidates for testing. As testing is expected to take approximately one week per vehicle, a reasonable upper limit considering testing logistics would be 30 tests per year; a more reasonable estimate would be ten or fewer tests per year.

- **Class or equipment type** – all diesel vehicles/engines are candidates for testing; focus would be on railroad and marine agencies as these would see the greatest cost savings from using a RAVEM vs. sending a vehicle to an outside agency for testing.
- **Engine make, engine model, engine model year, current tier level or emission standards** – customer specific; any diesel engine is a potential candidate.
- **Fuel type, amount of fuel used, annual miles travelled or annual usage rate, annual idling hours.**
  The RAVEM itself does not consume fuel during testing but runs off electricity and testing gases. The system can be used to test any type of diesel fuel on any engine.

Provide information on the new eligible verified and/or certified diesel emission reduction technology(s) to be implemented under the proposed project, including (where applicable):

- **Technology type, make, and model** – RAVEM is a mobile gaseous emission measurement technology that can be transported to site of needs. The gas measurement technique is based on state-of-the-art heated chemiluminescent and heated flame ionization analysis principles and is ideal for testing of undiluted gas. A technical description of the RAVEM system including testing schematics are provided in Reference 1 of this document.
- **engine model year, horsepower, tier level or emission standards** – N/A for RAVEM system
- **Fuel type and annual idling hours reduced** – N/A for RAVEM system

Provide information on LD ZEV supply equipment (electric or hydrogen), including (where applicable):

- **number,**
- **equipment type (Level 1/2/fast chargers or hydrogen dispensing), and**
- **location (public place, workplace, or multi-unit dwelling)**

Not Applicable for UNCC proposal

How should determination be made on whether a proposed project will benefit areas that have been disproportionately impacted by emissions of nitrogen oxides (NOx) or other pollutants?

- **Whether a project applicant is low income, minority, or disadvantaged or operates vehicles in these communities.**
- **Benefits to areas that have been disproportionately impacted by NOx and other pollutants**

It is common for low income / minority / disadvantaged communities to be located near agencies that are prime candidates for diesel engine improvements and thus RAVEM testing. There are multiple examples of these types of areas across North Carolina, and as such the residents of these communities are directly impacted by air pollution. Thus any air pollution reduction efforts will have a direct positive impact on low income / minority / disadvantaged communities across the major population centers of North Carolina, and the RAVEM system is the tool to confirm quantification of improvements.

Furthermore, many counties across North Carolina, specifically in urban areas, are designated as EPA non-attainment areas for one or more pollutants; reducing air pollution levels will have a direct positive impact on reducing pollutants in these counties.

<u>Capital and Project Costs</u>:

Calculate and provide projected capital cost ($/unit) and total project cost. Note calculations for proposed LD ZEV projects should include operation and maintenances cost, and calculations for eligible all-electric mitigation actions should include charging infrastructure cost (where applicable)

UNCC requests $400,000 for acquisition of a RAVEM emissions testing system. Cost breakdown is as follows:

- RAVEM capital equipment costs – $200,000
- Setup, calibration, and testing – $100,000
- Training and PM – $100,000
- Personnel Costs and Campus Supports - $300,000

UNCC will share further cost breakdowns of the above items as necessary.

Identify projected cost share and, if applicable, what additional sources of funds may be utilized as matching funds.
No matching funds are planned at this time due to the comparatively low cost of this project compared to others. However, UNCC would be open to discussion of cost sharing to facilitate acquisition of the RAVEM system.

<u>Expected Proposed Project Benefits</u>:

Calculate and provide capital cost effectiveness ($/short ton of NOx reduced for each unit) and total cost effectiveness ($/short ton of NOx reduced for the entire project).

Calculate and provide the expected annual and lifetime project emissions reductions/offsets for NOx.

Calculate and provide capital cost effectiveness ($/short ton of NOx reduced for each unit) and total cost effectiveness ($/short ton of NOx reduced for the entire project).

The RAVEM system is unique in that it does not directly provide emissions reduction, but rather is a tool used to quantify emissions reduction, and does so at a fraction of the cost of traditional emissions testing. Agencies would be expected to save approximately $60,000 per test of their diesel equipment vs. traditional methods, in addition to significantly reduced logistical issues and equipment down time. As noted earlier it is expected that the ROI for the RAVEM would be 2-3 years.

Reference:

1. *EF&EE Response to California Air Resources Board Information Request*, C. Weaver, 5/2/2013

Software tools available to calculate projected emissions reductions and capital and total cost effectiveness of proposed mitigation projects:

Environmental Protection Agency's (EPA) Diesel Emissions Quantifier Tool: https://www.epa.gov/cleandiesel/diesel-emissions-quantifier-deq

Argonne National Laboratory Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool (2016 rev1): https://greet.es.anl.gov/afleet

Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model (GREET 2012): https://greet.es.anl.gov/carbon_footprint_calculator
Identity the method(s) used to calculate the emissions reductions/offsets and cost, and describe and document your methods.

Phillips, Brian

From: Annette Guidry <amguidry@clevelandcountyschools.org>
Sent: Sunday, December 31, 2017 4:49 PM
To: daq.NC_VWGrants
Subject: [External]

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Please use a portion of these funds for the rail project in Cleveland County. It would be of great benefit to the community and business. Thank you!

Annette Guidry
Sent from my iPhone

Phillips, Brian

From: Arlette Lackey <arlette@bellsouth.net>
Sent: Sunday, December 31, 2017 4:42 PM
To: daq.NC_VWGrants
Subject: [External] Rail Trail

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Phillips, Brian

From: Beverly Whisnant <whisbev@bellsouth.net>
Sent: Sunday, December 31, 2017 4:25 PM
To: daq.NC_VWGrants
Subject: [External] Cotton Bale Rail Trail, Cleveland County NC

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Sent from Yahoo Mail for iPhone

Phillips, Brian

From: BKL Bicycles <bklbicycles@gmail.com>
Sent: Sunday, December 31, 2017 4:04 PM
To: daq.NC_VWGrants
Subject: [External] Volkswagen Settlement money

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-Howard Liss, bklbicycles@ gmail.com

From: Chrissy Helton <chrissy.helton67@icloud.com>
Sent: Sunday, December 31, 2017 4:43 PM
To: daq.NC_VWGrants
Subject: [External] Shelby, NC

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project.

Thank you,
Chrissy Helton

Sent from my iPhone

Phillips, Brian

From: Davis Thompson <davethompson@alumni.unc.edu>
Sent: Friday, December 29, 2017 5:20 PM
To: daq.NC_VWGrants
Subject: [External] VW money

Hello,

1) Put solar panels on the roofs of poor people's houses.

2) Don't wait for Duke-clean up the coal ash stored near Mountain Island Lake and send Duke the bill.

3) Retain a consulting firm to assess the cost of burying the power lines across the state. Use the remaining money to help pay power bills for poor people in the winter and/or extreme summer heat.

Thank you,

Dave Thompson

Phillips, Brian

From: Dwight Manuel <dwightdm@hotmail.com>
Sent: Friday, December 29, 2017 5:34 PM
To: daq.NC_VWGrants
Subject: [External] Response to NC VW RFI

Dear Board Members
I believe these funds should be used to implement enforceable laws to shut down these repair shops which are performing illegal modifications to diesel vehicles, they are eliminating catalytic converters and modifying engine controls parameters. Which is causing excessive and dangerous exhaust emissions and extreme sooting.
And these vehicle modifications should be reversed, meaning, force the owners to return these modified to their original manufactures design.
I and a Mercedes Benz trained diesel technician.
It is as of now left to a powerless state inspection system.
If you have any questions, please feel free to contact me.

Dwight D Manuel
828-409-3386
39 Mildred Ave.
Asheville,NC

The Allen J. Lynch
Medal of Honor
Veterans Foundation

Veterans and the Volkswagen Settlement

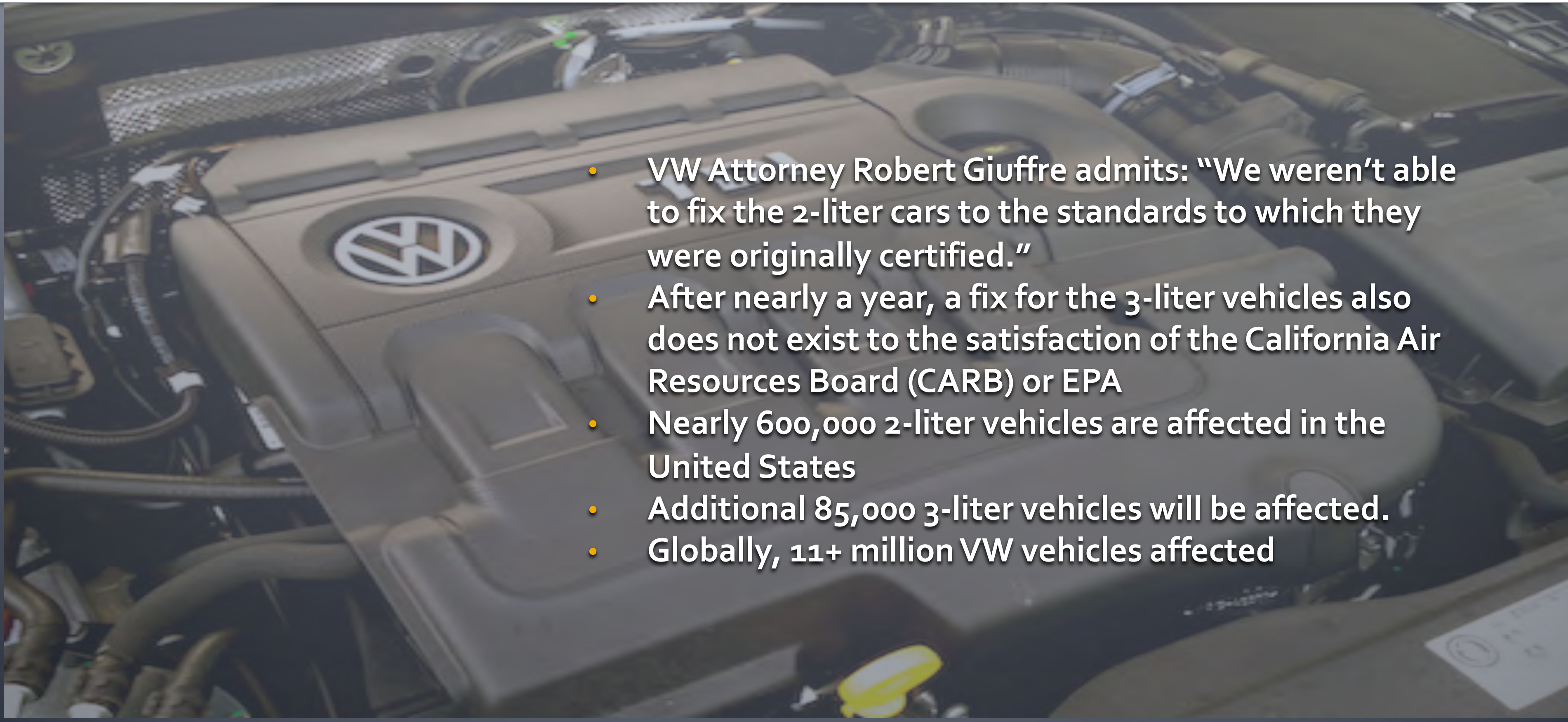
The VW Dieselgate Scandal

Mission Statement for problem remediation

Resolve the Dieselgate scandal in a public-private partnership—P3—in association with the U.S. Department of Justice

Immutable facts 1:

Volkswagen hacked itself to beat the EPA regulations



- VW Attorney Robert Giuffre admits: "We weren't able to fix the 2-liter cars to the standards to which they were originally certified."
- After nearly a year, a fix for the 3-liter vehicles also does not exist to the satisfaction of the California Air Resources Board (CARB) or EPA
- Nearly 600,000 2-liter vehicles are affected in the United States
- Additional 85,000 3-liter vehicles will be affected.
- Globally, 11+ million VW vehicles affected

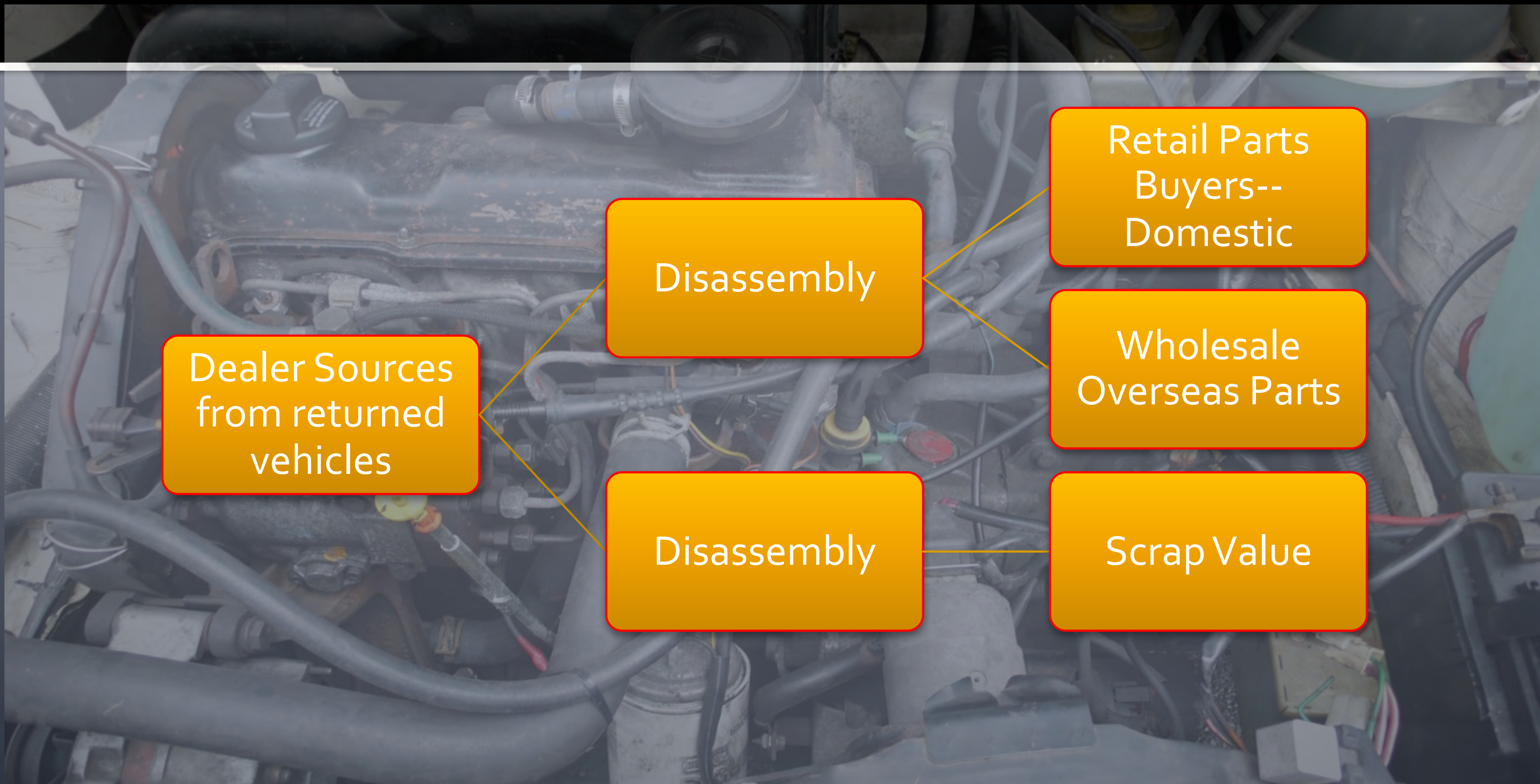
Immutable facts 2:

- No "**fix" exists** to remediate the problems created when VW hacked its own systems
- After a year of Wolfsburg's top people trying to remediate the problem, they neither have one, nor are going to find one
- Disassembly of the vehicles involved is the only true solution
- Concurring with the disassembly and scrap program is US District Court Judge Charles Breyer who has already approved a pilot program to scrap the vehicles for salvage.

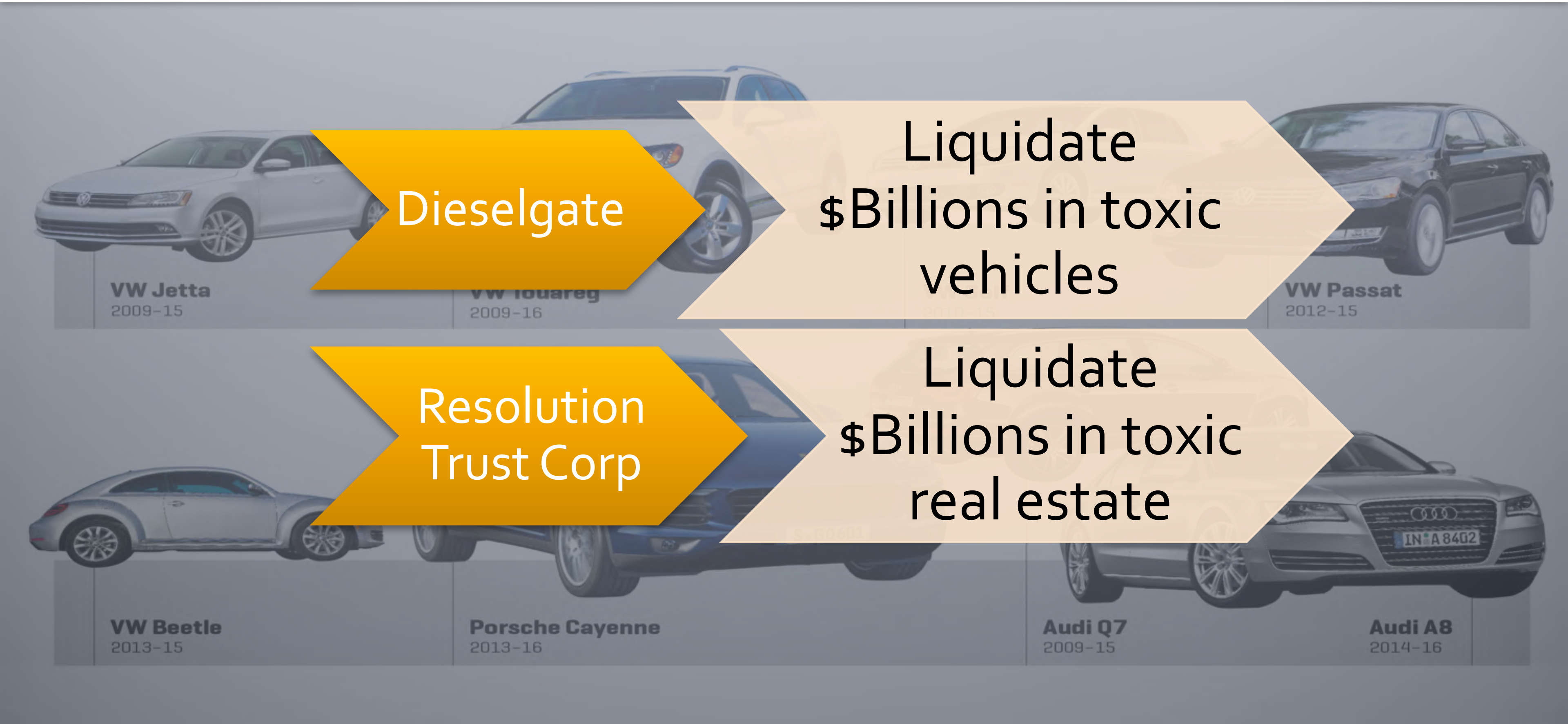
Immutable facts 3:

- There is no reason in heaven or on earth where it makes sense for the US taxpayer to assist Volkswagen in its recovery from cheating customers, the EPA, the DOT and NHTSA
- Now that they have been found at fault, why do they get to rebuild their company on its abandonment of diesel technology and embracing of electric vehicles?
- By assisting them, their own engineering hubris turns into a benefit to them—only to sell that new tech to other car companies. This is blatantly unfair.
- It is even more unfair to allow these funds to be allocated without veteran preference for use.

Processing Model



P3 Precedent and Parallel:



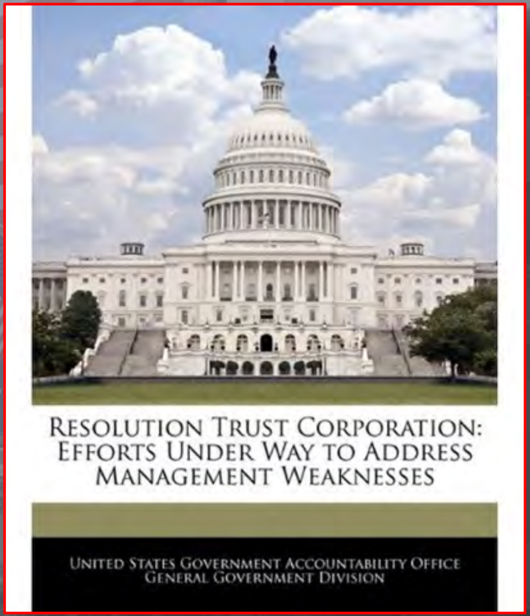
Dieselgate → Liquidate $Billions in toxic vehicles

Resolution Trust Corp → Liquidate $Billions in toxic real estate

Precedent and Parallel:

The Resolution Trust Corporation 1989-1995

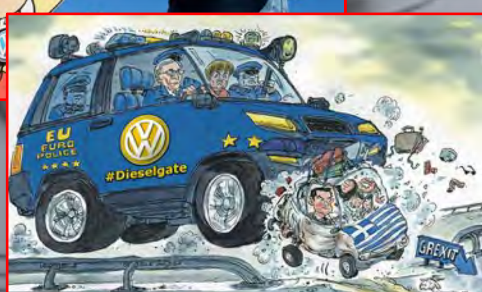
- The Resolution Trust Corporation (RTC) was a U.S. government-owned asset management company charged with liquidating assets, primarily real estate-related assets such as mortgage loans, that had been assets of savings and loan associations (S&Ls) declared insolvent by the Office of Thrift Supervision (OTS) as a consequence of the savings and loan crisis of the 1980s.
- Between 1989 and mid-1995, the Resolution Trust Corporation closed or otherwise resolved 747 thrifts with total assets of $394 billion. Its funding was provided by the Resolution Funding Corporation (REFCORP) which still exists to support the debt obligations it created for these functions.
- Initiated greater than 1,000 felony convictions brought by the Department of Justice.



Why VW cannot be the contractor

—or—

The Perp simply can't be the Prime



As a result of Volkswagen's lack of transparency—from the initial hack to discovery to admission to finding and effecting a fix—The Department of Justice will by necessity need to maintain an arm's length entity to implement the solution.

The ideal candidate for the Prime Contractor on this program will optimally embrace America's most underappreciated technical and skilled manpower force: the veteran community.

Creating good paying jobs careers for U.S. veterans

The Allen J. Lynch
Medal of Honor
Veterans Foundation

The primary mission of disassembling this massive number of vehicles is merely the start of what this program can realize for job-hungry veterans. In addition, we'll need:

- Financial and Legal
- Manufacturing
- Logistics
- Communications
- High tech anti-hacking personnel for DOT, NHTSA and FBI units
- Autonomous driving infrastructure development

The Allen J. Lynch Medal of Honor Foundation will coordinate and prioritize the employment and talent utilization of under- and unemployed US military veterans.

Next Steps

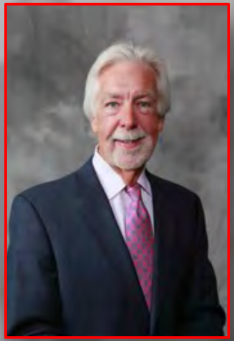
#dieselgate

- Immediately halt the ability for VW to benefit from its own cheating scandal
- Coordinate with the Congress and Department of Justice to direct the Volkswagen emissions cheating scandal settlement to the benefit of American veterans.

P3 Performance Timeline

- As soon as possible: Submit business plan to Department of Justice
- January 2017: Launch disassembly facilities
- 2020: Finish processing
  - Cars
  - SUVs/CUVs
  - *NB—We anticipate diesel trucks and buses will eventually fall beneath emission standards, even with DEF tech*

Prioritizing Veterans a Prime Contractor Mission



The Paul Brian Group has assembled an all-star team with decades of experience in the automotive sector who are ready to tackle this mission:

- Financial and Legal
- Manufacturing
- Logistics
- Communications

The Allen J. Lynch Medal of Honor Veterans Foundation

The Allen J. Lynch Medal of Honor Foundation will coordinate and prioritize the employment and talent utilization of under- and unemployed US military veterans.

From: Gayla Little <kajeka14@icloud.com>
Sent: Sunday, December 31, 2017 4:48 PM
To: daq.NC_VWGrants
Subject: [External] Cotton bale rail trail Shelby nc

Please consider granting Shelby nc cotton bale rail trail. The city is small but very forward thinking and is supported by it's citizens and surrounding communities

Thanks in advance. Gayla Little Bessemer City NC

Sent from my iPhone

From: George McDowell <george@beautifycary.org>
Sent: Monday, December 11, 2017 4:56 PM
To: daq.NC_VWGrants
Subject: [External] Comments on VW funds

Ladies and Gentlemen,

The Piedmont Plateau, of which Wake County is a part, had, at the time the first white man set foot on it, a tree cover of 99.5%. Since then trees have been harvested and cut down for shipbuilding, fuel, buildings and homes construction, and cleared so the land could be farmed and otherwise developed. Today the tree cover is about 40 to 45%. The process of deforestation continues apace.

Because of this, we have filthy water flowing from the land into our streams, rivers, and lakes. Every time it rains more than four inches in Wake County in 24 hours, the four counties to our south and east experience flooding because our rate of stormwater runoff is so high.

Our air, though not as bad as parts of India and China, is nevertheless polluted. Wake County's "typical" Air Quality Index is "Moderate Pollution." The rate of childhood asthma in Wake County has tripled in the last 30 years. Adults have experienced a rise in bronchial problems in the same time, although not as severe.

Our municipalities, counties, and the state have fallen victim to the widespread but grossly mistaken belief that the human method of planting and nurturing trees is superior to Mother Nature's way. Because of this, our downtown streets, the medians of our boulevards and parkways, just about all commercial parking lots, and many of our parks manifest misshapen, unhealthy, and desiccated trees, most of which grow at a rate much less than the norm. Most die young.

I note that the examples of how VW's fine can be spent all do no more than slow the rate of pollution, and do nothing to actually remediate existing pollution or to actually improve the quality of our air and water. I respectfully suggest that some of the windfall funds be put toward a massive tree-planting campaign in Wake County -- but only after credentialed scientists have demonstrated the proper way to plant a tree in the ground, and the proper way to nurture it.

This is a quote from Jim Robbins, science writer for The New York Times and author of The Man Who Planted Trees:

“Planting trees, I myself thought for a long time, was a feel-good thing, a nice but feeble response to our litany of modern-day environmental problems. In the last few years, though, as I have read many dozens of articles and books and interviewed scientists here and abroad, my thinking on the issue has changed. Planting trees may be the single most important ecotechnology that we have to put the broken pieces of our planet back together.”

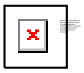
I truly hate to take advice from a Yankee, but all evidence shows him to be right.

Respectfully submitted,

~George McDowell

2220 W Marilyn Circle

Cary, North Carolina 27513



From:	Jamie Auch
To:	daq.NC_VWGrants
Subject:	[External] Grant
Date:	Tuesday, January 09, 2018 1:48:27 PM

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Sent from my iPhone

Phillips, Brian

From: Johnson Kelly <jhk28150@icloud.com>
Sent: Saturday, December 30, 2017 12:41 AM
To: daq.NC_VWGrants
Subject: [External] allocation of Volkswagen's federal settlement.

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

I would like to see at least some of the money from Volkswagen's federal settlement be used to support bicycle transportation. I live in Shelby of Cleveland County. Even though it is a small town rural community we have a real shortage of bicycle safe lanes and byways. I know that there is local interest in a "rails to trails" project to convert abandoned tracks to bicycle paths. Some of this money should be considered for this project. Pollution free, healthy living, public safety, recreational . . .

We would appreciate your consideration

Johnson Kelly, MD
jhk28150@icloud.com

Phillips, Brian

From: Juan Sánchez <juan.sanchez.pabon@gmail.com>
Sent: Sunday, December 31, 2017 5:18 PM
To: daq.NC_VWGrants
Subject: [External] Cotton BaleRail Trail

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-Juan Sanchez juan.sanchez.pabon@ gmail.com

Sent from my iPad

Phillips, Brian

From: Leonard Allman <leonard_allman@yahoo.com>
Sent: Friday, December 29, 2017 4:42 PM
To: daq.NC_VWGrants
Subject: [External] Volkswagen Fine Money

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Use the money to extend the LINX light rail to the Charlotte Douglas Airport and/or down the middle of Independence Blvd.

Best regards
Leonard Allman
Hickory NC 28601

Phillips, Brian

From: Paul Suddes <paulsuddes@gmail.com>
Sent: Friday, December 29, 2017 5:13 PM
To: daq.NC_VWGrants
Subject: [External] Volkswagen Settlement

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

I suggest that you use the funding that you receive from the Volkswagen settlement to ban two cycle leaf blowers that exceed 50 dB. They cause significant air and noise pollution. For example, use the money to buy them from companies (landscapers) and households that currently own them, and require that they replace them with electric, low noise devices. Sort of like a gun buyback program.

Thanks and good luck.

Paul Suddes
5204 Rialto Street
Belmont, NC 28012

Phillips, Brian

From: Ralph Nappi <rnappi@mindspring.com>
Sent: Friday, December 29, 2017 5:00 PM
To: daq.NC_VWGrants
Subject: [External] Use of VW grants

Grants should be used for new light rail extention to Charlotte airport. New biodiesel buses for Raliegh, Wilmington,and Greensboro Airports.
Thanks,
Ralph Nappi

Sent from Mail for Windows 10

Phillips, Brian

From: N A <ranlenn@yahoo.com>
Sent: Sunday, December 31, 2017 4:24 PM
To: daq.NC_VWGrants
Subject: [External] Cotton Bale Rail Trail

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project.

Thank you for your consideration and assistance,

Randy Davis •

Phillips, Brian

From: Richard A Usanis <info@usanisphotography.com>
Sent: Tuesday, December 12, 2017 9:08 PM
To: daq.NC_VWGrants
Subject: [External] Comments on VW funds

TO Whomever,

All the VW funds should go to putting in light rail transportation. Everything else is short sighted and ineffective in reducing dependence on cars. Putting in charging stations only changes where the pollution occurs not the amount which would be the same or more.

Wishing You A Joyful Holiday Season!,
Richard

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818 Woodburn Road
Raleigh, NC 27605
An Artistic Endeavor based on Photographic Images
http://UsanisPhotography.com
(O) 919-831-0305 (C) 919-633-0110

Phillips, Brian

From: Robert Buchanan <rbuchanan4@carolina.rr.com>
Sent: Sunday, December 31, 2017 5:05 PM
To: daq.NC_VWGrants
Subject: [External] FW:

From: Robert Buchanan [mailto:rbuchanan4@carolina.rr.com]
Sent: Sunday, December 31, 2017 5:04 PM
To: 'daq.nc_vwgrants@ncdenr.cov'
Subject:

Too Whom It May Concern:
We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC.
The reasons for this are numerous.
This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region.
It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and
it will
serve to increase revenues for local businesses that serve the
visitors who come here for use of the trail.
Please consider using a portion of this windfall to help our community with this rail trail project.
Thank you-Robert Buchanan

Phillips, Brian

From: Robert Kilby <mbkilby@icloud.com>
Sent: Sunday, December 31, 2017 4:30 PM
To: daq.NC_VWGrants
Subject: [External] Cotton Bale Rail Trail

Too Whom It May Concern

We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Miranda Kilby

Sent from my iPhone

Phillips, Brian

From: rtsiu <rtsiu@aol.com>
Sent: Friday, December 29, 2017 4:14 PM
To: daq.NC_VWGrants
Subject: [External] Windfall

Educational programs related to pitfalls of texting and driving.

Roman Tsiukes

Sent from my Verizon, Samsung Galaxy smartphone

Phillips, Brian

From: Sandy Tarantino <sandy.tarantino@gmail.com>
Sent: Friday, December 29, 2017 11:31 PM
To: daq.NC_VWGrants
Subject: [External] VW money

Please consider funding greenways in Asheville. We have the population that wants to bike instead of drive, but it's unsafe to commute on bike here. Having travel paths well away from cars would be a boon to us!

Sandy Tarantino
91 Alpine Way
Asheville, NC 28805

Phillips, Brian

From: S. McElhone <sean.mcelhone@icloud.com>
Sent: Saturday, December 30, 2017 9:36 AM
To: daq.NC_VWGrants
Subject: [External] VW grants

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Hello,

I strongly believe that the 92 million reserved for environmental mitigation should be handed over to the state's land conservation trust funds, Clean Water, Parks and Recreation, etc.

These agencies and trust funds have a historic record of successfully spending funding on land conservation and water quality protection.

-Sean McElhone
Conover, NC

Phillips, Brian

From: Shea Stuart <lstuart@Gardner-Webb.edu>
Sent: Sunday, December 31, 2017 4:21 PM
To: daq.NC_VWGrants
Subject: [External] Settlement and rail trail

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Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project.
Thank you,
Shea Stuart
Shelby, NC

Shea Stuart
Department of English
Gardner-Webb University

Phillips, Brian

From: Sherry Henderson <sherry_henderson@att.net>
Sent: Sunday, December 31, 2017 4:35 PM
To: daq.NC_VWGrants
Subject: [External] NC grants

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Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Sent from AT&T Mail on Android

Phillips, Brian

From: Stanr Martin <stanr.martin@allentate.com>
Sent: Sunday, December 31, 2017 4:23 PM
To: daq.NC_VWGrants
Subject: [External] Rail trail project

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Too Whom It May Concern: We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project. Thank you-

Sent from my iPhone
--

Phillips, Brian

From: Susan Pearson <spearson97@gmail.com>
Sent: Sunday, December 31, 2017 4:45 PM
To: daq.NC_VWGrants
Subject: [External] Volkswagen Dispersement [Cotton Bale Rail Trail - Cleveland County]

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To Whom It May Concern:

We feel that an excellent use of this money would be to help complete the proposed Cotton Bale Rail Trail here in Shelby (Cleveland County) NC. The reasons for this are numerous. This 13 mile project will promote healthy living and lifestyles for the residents of N.C. and help spur growth in our region. It will give families and individuals a way to safely exercise and enjoy the outdoors without creating more traffic congestion and it will serve to increase revenues for local businesses that serve the visitors who come here for use of the trail. Please consider using a portion of this windfall to help our community with this rail trail project.

Thank you-

Susan Pearson

Sent from my iPhone

Phillips, Brian

From: Wendy Patoprsty <wendy@blueridgeconservancy.org>
Sent: Tuesday, December 05, 2017 1:56 PM
To: daq.NC_VWGrants
Subject: [External] VW Settlement

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Hi,
Just read that DEQ is looking for ideas for air quality from the VW settlement for the $92 million. It would be great if funding could go into building greenways for alternative transportation. The state PARTF grants keep getting cut, and there is SO much competition!! NC needs way more greenways - especially in Western NC. I specifically need funds to build 5.5 miles to connect Blowing Rock to Boone!!!
Great way to reduce traffic, improve air quality, and enhance the quality of life!!!
Thanks!
Wendy

--
Wendy Patoprsty
Middle Fork Greenway Director
Blue Ridge Conservancy
828-264-2511

Phillips, Brian

From: William Moss <violet321@icloud.com>
Sent: Friday, December 29, 2017 5:02 PM
To: daq.NC_VWGrants
Subject: [External] VW settlement

Use the money for greenways, bike lanes and multi-use paths.

Bill Moss
Editor
Hendersonville Lightning
HendersonvilleLightning.com
Office: 828.698.0407
Cell: 828.674.0942

Phillips, Brian

From: Zhane Lester <zmanlester@gmail.com>
Sent: Saturday, December 30, 2017 1:31 AM
To: daq.NC_VWGrants
Subject: [External] What to do with the money

CAUTION: External email. Do not click links or open attachments unless verified. Send all suspicious email as an attachment to report.spam@nc.gov.

Give it to all teachers for a Christmas bonus. Sharie Lester at Crown Point Elementary School is a amazing teacher she works so hard to make sure her kids learn. She also had a brain tumor removed last year. I'm sure she could use that money to pay medical bills.

Zhane,704-222-1952

Sent from my iPhone