REPORT ON NEW YORK STATE'S PLUME MODELING CAPABILITIES

New York State Disaster Preparedness Commission

PREPARED BY THE NEW YORK STATE
EMERGENCY RESPONSE COMMISSION

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Report on New York State's Plume Modeling Capabilities

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This report was developed by the State Emergency Response Commission (SERC) Working Group, in collaboration and input from the following agencies and organizations:

NYS Division of Homeland Security and Emergency Services

- State Office of Emergency Management
- State Office of Counter Terrorism
- Office of Fire Prevention and Control

NYS Department of Environmental Conservation
NYS Division of Military and Naval Affairs
NYS Department of Health
NYS Department of Transportation

Defense Threat Reduction Agency
National Oceanic and Atmospheric Administration/Office of Response and Restoration

Note:
This document was updated in June 2015 to meet the new State branding guidelines.

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Executive Summary

Purpose

In recognition of the risk of accidents and public safety concerns associated with the increased volume of crude oil being transported through New York State, Governor Andrew M. Cuomo issued Executive Order 125 (EO 125) on January 28, 2014, directing state agencies to immediately conduct a coordinated review of New York State's crude oil incident prevention and response capacity. As a result of EO 125, the "Transporting Crude Oil in New York State: A review of Incident Prevention and Response Capacity" report was created in April with the input of several state agencies including the New York State Departments of Environmental Conservation (DEC), Health (DOH), and Transportation (NYSDOT), along with the Division of Homeland Security and Emergency Services (DHSES) and New York State Energy Research and Development Authority (NYSERDA).

The report on Transporting Crude Oil in New York State identified several findings and many areas where improvements in safety and preparedness are needed. Finding #10 was related to plume modeling:

- State Finding 10: New York State's toxic plume modeling capabilities are limited. A large-scale emergency exhausts resources at the municipal and county levels of government and warrants support from the State to effectively respond to the event.

Plume modeling provides the capability to predict the geographic extent, or hazard area affected by an incident, in this scenario due to an accident/explosion involving a rail car carrying crude oil. This analysis then informs first responders and public officials on areas that may need to be evacuated due to health and safety issues.

Several State agencies (DHSES, DEC, DOH, and DMNA[1]) possess some capability to support or conduct plume hazard prediction modeling and environmental assessments. Typically, these assessments are restricted in scope and application, and are aimed at supporting the agency's statutory role. Additional support for plume modelling may be available through federal agencies including the National Oceanic and Atmospheric Administration (NOAA), Defense Threat Reduction Agency (DTRA), and the Interagency Modeling and Atmospheric Assessment Center (IMAAC). The rail industry contracts with private vendors to conduct plume modeling as well.

[1] Weapons of Mass Destruction Civil Support Team (CST), advises civilian responders in the event of a suspected weapon of mass destruction attack. CSTs are federally funded National Guard units established under Presidential Decision Directive 39.

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Emergency air plume modeling poses a variety of challenges, particularly with regard to interpreting model results given the uncertain nature of what is released during an emergency, and the capability to conduct modeling given the overall mission or focus of an agency, and the resources that it employs. This was noted in the April 2014 Governor's Transporting Crude Oil in NYS Report, which states:

- <u>Recommendation: New York State should develop more effective plume modeling capability to assist first responders.</u>

  The Joint Agency Report issued in April of this year directed the Disaster Preparedness Commission to establish a Plume Modeling Working Group to study and report by December 31, 2014 covering the following four areas:

  a) Identify current capabilities;
  b) Ascertain the most appropriate modeling tools available;
  c) Investigate mechanisms to raise awareness and advance training to assist public and private partners in their planning; and
  d) Provide recommendations to bridge various agency jurisdictions and gaps.

The Plume Modeling Working Group was established under the State Emergency Response Commission, and included invitations to industry and federal partners to participate.

This report provides an overview of New York State's capability and capacity to effectively direct, control and implement plume modeling activities. The report contains findings and recommendations that will help build and establish a robust capacity for New York State to conduct plume modeling for Bakken Crude Oil, and to support incident response involving other types of hazardous materials.

Major Findings

- New York State does not have a robust capacity to quickly and accurately provide detailed intermediate and advanced plume modeling assessment and analysis in the event of an emergency to state and local authorities.
- The State has not designated one office or agency with the responsibility for modeling hazardous threats in the event of an emergency.
- Limited plume modeling capabilities exist among some agencies, but there is no written plan or procedure that formally brings them together during a hazardous materials emergency.
- 90% of the local hazardous materials teams along the Bakken Crude virtual pipeline possess a rudimentary plume modeling capability to support the initial phase of an incident.
- None of the currently available modeling software has Bakken Crude as a specific source term (or input) into that model. Other products that have similar physical and/or chemical

properties such as paraffin hydrocarbons (n-hexane) can be used to make a determination of a plume associated with a spill or release (not combustion), but will come with a degree of uncertainty as to the exact contents of that plume.

Major Recommendations

- The State should officially designate the Plume Modeling Working Group as a standing task force under the SERC.
- One agency should be designated as the lead state agency in response to an emergency for all plume modeling efforts associated with hazardous materials/crude oil emergencies.
- A task force comprised of State and Federal subject matter experts, should be convened and include invitations to local government and private sector representatives to participate.
- The task force should draft an operational plan to establish effective policies and procedures regarding plume modeling capabilities in the State.
- The task force should meet regularly to ensure continuous engagement and increased capability/capacity in a unified fashion.
- The task force should report on the readiness of the State to deploy and conduct on-scene assessments to validate plume modeling predictions, including equipment availability and the training status of personnel.

Overview and Goals of the Report

This report grows out of New York's continuing commitment to its citizens and public safety. A multi-agency group directed this analysis for the purpose of producing recommendations on how to develop a more effective plume modeling capability to assist first responders. The multi-agency group tasked the Disaster Preparedness Commission to work collaboratively to assess how plume modeling can more effectively be used in New York State in response to a major event. The multi-agency group investigated several specific areas of inquiry to be answered in a "final report of recommendations [served] to the Governor." This report seeks to respond to these specific requirements.

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Section 1: Introduction/Overview

Background

The production of North American crude oil has grown rapidly in the last five years. Much of the growth is from production areas in North Dakota and Montana in the US and Manitoba and Saskatchewan in Canada from shale oil known as Bakken formation. According to the American Association of Railroads the crude oil is being transported along "virtual pipelines" by railroads across the country and has grown by over 4,000 percent. This growth includes Canadian tar sands, which is also shipped by rail in the U.S.

In New York State, as much as 1,000 miles of the State's 4,100 mile rail network are part of this virtual pipeline. Large-scale shipments of crude oil pass through almost every area of the State. The Port of Albany has become a major hub for crude transshipment and storage, receiving crude oil shipments by rail, and transferring them to ships or barges that further transport the crude oil down the Hudson River. Another transshipment hub is being contemplated for the Mid-Hudson Town of New Windsor. Communities in 22 counties, including Buffalo, Syracuse, Utica, Albany, and Plattsburgh and nearly all of the State's major waterways are subject to this network.

Regardless of the specific transportation route, the potential for a catastrophic event involving crude oil does exist. Several accidents and emergency events have occurred in the last five years, including several in recent history that have had extenuating consequences, and put large populations at risk. In some cases, these events were spills that were accompanied by a fire that propagated a plume of combustion by-products that extended miles downwind, potentially exposing citizens, communities, agriculture, and the environment to toxic chemicals.

Plume modeling is one of many capabilities that is sometimes employed during a crude oil or chemical emergency by providing government officials with information as to where the plume is likely headed. Should sufficient information be available about an emergency event's release to the atmosphere, plume models can provide estimates of potential air concentrations downwind of the release. In turn, this helps government to assess what is in the plume, which can support decision-making in regards to implementing protective actions that can be undertaken in an attempt to protect public health and safety, the environment, and properly recover from the emergency.

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Basic Concepts of Atmospheric Plume Modeling

For practical reasons, it is essential that the initial response to an emergency be decisive and yet in full recognition of the potential consequences. As such, plume modeling provides incident commanders and decision makers with the ability to provide initial "forecasting" of the consequences of an event and implement initial protective actions.

Plume modeling takes into account a host of "inputs" or variables that serve as the factors in the model's predictions. These factors include: the type of material involved, the quantity/ rate of release, topography, meteorological data, temperature of the fire, the rate and height of the release, and many other factors that need to be considered in the evaluation of the plume. Model's predictions help to identify locations where people may need to take protective actions, such as evacuating or sheltering in-place. In a broader scope, plume modeling is one of the tools that can assist decision makers at all levels of government make predictions based on the best information available to the modeler so they may implement protective measures to address the issue or concern at hand, such as deciding where samples of food/crops may need to be collected or advice may be given in regards to personal consumption; to predict what chemical exposures may be present in the area and several miles downwind, and to make thoughtful and deliberate decisions regarding decontamination needs.

It must be noted that no plume modeling capability is 100% accurate and should not guide all decision making. All plume models represent the "best guess" using the information available at the time and therefore should not guide all decision making. Depending on the quality of the source term and weather information available, plume models may differ from reality by orders of magnitude. At best, plume modeling can provide government officials with a basic assessment of where, and to what extent, exposure or contamination may occur. From there, properly trained and equipped personnel may be needed to evaluate potential exposures. This evaluation may include actual observations of field conditions, physical sampling and measurements or other means of assessing potential exposures. From the incipient phase of an event to its conclusion, accurate modeling takes coordination, technical subject matter expertise, technology, training, and constant validation from the field to properly and accurately identify a plume and its associated risks.

Section 2: NYS Needs and Modeling Phases

Plume modeling can be conducted several times during the life cycle of an emergency. Model runs are sometimes associated with or linked to operational phases that are inherent to an emergency, and the response that is needed for that event. Prior to the emergency, plume modeling can be used for planning. General information on potentially affected areas can be identified by running iterations of the model (varying source term, weather, and exposure time). Early in an emergency, plume modeling can be used to help inform protective actions. As the emergency continues, modeling can be used to revise protective actions and determine what (if any) sampling needs to be performed. Later in the emergency, plume modeling can be used to recreate the incident in order to perform exposure assessments and recovery work, as well as to inform subsequent planning.

Atmospheric plume modeling can range from the very simple to the very complex models, and can be separated into three general categories: an initial assessment; a more detailed intermediate assessment with a more sophisticated modeling approach which takes advantage of available data and information input from specialists; or an advanced approach with the most sophisticated and complex modeling which incorporates actual analytical sample results into the modeling runs to show actual impacts and improve future recovery and remediation planning. Of course, the more sophisticated the model, the higher the requirement for high quality inputs (including digitized elevation data) and additional computing time.

a. Initial Response Modeling Approaches

Upon arrival to an incident, local responders typically make use of the Emergency Response Guidebook (ERG) to determine initial restricted or exclusion areas. Basic modeling is then usually performed by first responder organizations in order to make immediate safety-based decisions (need for or initial extent of evacuation or in-place sheltering). Due to time constraints, normally a single technical specialist will generate a work product to the best of their ability, using the best information available that they have at the time. There is usually little or no quality assurance/quality control of the input information or the results generated and detailed source term and meteorological data is not used.

b. Intermediate Response Modeling Approaches

At times, a more sophisticated modeling approach to basic modeling is undertaken as an intermediate step in support of the first responders. During this step, the complexity of information on the source terms and associated conditions increases. As it does, so does the potential for plume projection errors due to the increased complexity of the inputs to the model. For any model, uncertainties in model assumptions (including release rates) significantly affect confidence in model outputs (predicted air concentrations). Thus, to the maximum extent practicable, subject matter specialists should be involved in making best estimates of source terms, meteorology conditions, etc. This step may also include information or depiction of actual observations that can be used to guide further modeling work and may include integration with GIS based maps and data sets.

c. Advanced Modeling Approaches

Following the initial and intermediate response steps, advanced modeling analysis can be performed to assist in the determination of likely areas of impacts from releases which are ongoing. In addition, this level of modeling is useful as a planning tool in simulating likely scenarios of plume release and guiding the response efforts. This modeling level would involve specialists with expertise in the numerous source term variables, dispersion and meteorological variables, health effects, computer data base access and mapping. Specialists would determine the model input components, as well as help to develop maps of affected areas and interpret/explain model outputs. These refined models can generate numerous products, including statistical analysis of concentrations, dosage, population health effects, and the like. As stated above, any uncertainties in model assumptions (including release rates) will significantly decrease confidence in model outputs (predicted air concentrations).

Overview of Modeling Software

There are several models that are available to the State to conduct plume modeling. These models vary in capability and applicability including some that are in use by local response agencies, and some that are only available to the State or Federal agencies. The following is a brief overview of modeling software. For the purposes of brevity, most of the models outlined below are those the State has direct access to or uses.

1. **HPAC V5.0 (Hazard Prediction and Assessment Capability)**
HPAC predicts hazards and provides exposure information for populations in the vicinity of accidents involving releases from nuclear and chemical facilities, and facilities/transportation containers. HPAC models atmospheric dispersion of vapors, particles, or liquid droplets from multiple sources using pre-defined (not site-specific) release rates, using meteorological input that may range from wind speed and direction at only a single measurement location to 4-dimensional gridded wind and temperature fields.

2. **WISER (Wireless Information System for Emergency Responders)**
WISER is a system designed to assist emergency responders in hazardous material incidents. WISER provides a wide range of information on hazardous substances, including substance identification support, physical characteristics, health information (e.g., Material Safety Data Sheets and Emergency Response Guidelines), and containment and suppression advice. WISER is an emergency "look-up" resource and not a dispersion model.

3. CAMEO/ALOHA/MARPLOT (Areal Locations of Hazardous Atmospheres)

The CAMEO (Computer Aided Management of Emergency Operations) suite of software contains several separate integrated software applications, including ALOHA and MARPLOT. The programs can provide users with initial guidance on protective action decisions for chemical releases, and can model plumes to give users predictions of what level of contamination may exist. Data extrapolated from the model can then be used to make decisions regarding dose/exposure and any follow-on protective actions.

4. HYSPLIT (Hybrid Single Particle Lagrangian Trajectory Model)

The HYSPLIT model is a complete system for computing simple air parcel trajectories to complex dispersion and deposition simulations. The program includes the integration of ALOHA, and advanced advection algorithms, updated stability and dispersion equations, and the option to include modules for chemical transformations. Without the additional dispersion modules, HYSPLIT computes the advection of a single pollutant particle, or simply its trajectory. Some of the applications include tracking and forecasting the release of radioactive material, volcanic ash, wildfire smoke, and pollutants (such as mercury) from various stationary emission sources.

5. CAL3QHC, CAL3QHCR, and AERMOD

The CAL3QHC and CAL3QHCR are steady-state Gaussian based dispersion models, and the AERMOD is a dispersion model capable of providing hourly pollutant concentrations due to various sources (point, areas, volume). These models are used for regulatory compliance purposes to demonstrate compliance with National Ambien Air Quality Standards (NAAQS) of criteria pollutants, and are not suitable for plume modeling for emergency applications.

6. SAFER STAR

Center for Toxicology & Environmental Health LLC (*CTEH*®) is an Environmental Consulting company engaged by the rail industry for plume modeling. According to the CTEH web site, they use SAFER STAR (SAFER) program to help manage an emergency and to provide early warning to those who may risk exposure to a potentially harmful substance. The site claims that SAFER accurately models the effects of chemical accidents (toxic releases, fires and explosions), and that the program includes state-of-the-science algorithms for addressing atmospheric dispersion, thermal radiation and blast overpressure modeling. In addition, SAFER provides mapping and topographical databases for the region of interest. Once the release is identified, SAFER rapidly assembles appropriate maps and topographical data.

Model Applications

The State has access to several plume modeling tools for a variety of scenarios and uses. Some of the models, such as HPAC and HYSPLIT for example, have a broad range of applicability, while others such as CAL3QHC are limited in their application. There are pros and cons with every software model. Some models can only evaluate the release and transport of one chemical at a time. Some models can predict the radiant heat hazards, while other models are not useful for fire scenarios. Some models do not incorporate the effect of wind at varying heights (i.e., ground-level vs elevated winds). The technical aspects of each model can be found in Appendix B.

It is important to recognize that follow-up field assessments are necessary to validate any model, though depending on the particular situation, actual validation may not be necessary. Since most counties do not possess such a capability, the State would deploy staff to the field to validate (and update) and model predictions, as needed. A specific monitoring, sampling and analysis plan would need to be developed prior to performing field assessments. In that regard, the State does possess some capability to do so, and is most proficient in employing radiological rather than chemical detection instrumentation and personnel to support plume assessments.

Section 3: Assessment of Current Capabilities

Plume Modeling Workshop/Exercise

As a standing group under the Disaster Preparedness Commission's (DPC), the State Emergency Response Commission (SERC) Working Group identified and solicited the input from appropriate plume modeling subject matter experts from State and Federal agencies, and the private sector. The Working Group was comprised of agency personnel who currently use air plume modeling, and/or have used various forms of models in real-time during an emergency. The Working Group assessed the current air modeling capabilities, identified the appropriate applications and limitations of current modeling, and made broad-based recommendations on improving this capability and capacity in New York State.

Working Group members were initially brought together via conference call to discuss the overarching purpose and scope of the Working Group's tasking per EO 125. From that starting point, the agencies were asked to provide a list of "inputs" and "outputs" that are needed or can be obtained from each of the software models.

The State developed a credible, worst case scenario to model plumes in the event of a rail car accident involving Bakken crude oil. The scenario considered specific variables, including track speed, and the quantity of product, and was derived from actual historical rail car incidents that have recently occurred in the United States. Plume subject matter experts were presented with the scenario during a one day workshop. Participants were provided the opportunity to model the event, display their modeling results, and discuss the nuances/limitations of each model. Subject matter experts ran the various models in real-time while their counterparts were able to observe, compare inputs, and ask questions. Representatives from the rail industry were invited to participate in this workshop, but were unable to attend.

Participants were given the core circumstances to be used in an attempt to provide an accurate comparison of technology and techniques utilized. Areas or capabilities where the use of the models specific to a Bakken crude oil emergency could be improved were then identified.

Summary of Workshop Findings and Recommendations

The workshop identified the following shortfalls and recommendations:

- None of the currently available models have Bakken Crude as a "source term" or product-specific input. A source term is the contaminant of concern or chemical reference that each model uses to produce its product. Other source terms can be used as a "surrogate", but may provide some scientific inaccuracy in the projected plume. The most information that can be obtained from any of these models specific to Bakken crude emergencies is the direction and possibly the relative concentration of the material in the plume.
- A good knowledge of potential human exposure and chemical toxicity is important to make decisions on health effects. Toxicity of the various surrogates (hexane, n-heptane, generic particles) used to model the plume during the workshop will not be the same as toxicity of the Bakken crude, and therefore model outputs using surrogates can't be solely used as the basis for health decisions. Additionally, some emergency response models compare estimates of dose to emergency planning guidelines, such as Acute Exposure Guidelines (AEGLs) or Temporary Emergency Exposure Limits (TEELs). These guidelines are derived assuming exposure to a single chemical (not mixtures) and are associated with frank health effects. These kinds of values should only be used when more appropriate values are not available and if used, AEGL-1 or TEEL-1 values should be used for determining protective actions since these are levels that are not associated with death, impaired abilities, or irreversible effects (see Appendix B for more information).
- Bakken is currently modeled as a generic hydrocarbon, which may underestimate the rate of release. The use of hexane may overestimate the rate of release. Supplemental models can generate the appropriate source term parameters. The hazards of the products of combustion are primarily from the minor constituents such as carbon monoxide, soot, sulfur dioxide, etc.
- For this exercise, hexane was used as a surrogate for crude oil for estimating the health effects of spilled (not burning) oil. N-heptane was used solely for modeling heat output from burning oil. Combustion products associated with Bakken crude are not known with certainty but likely contain a mixture of gases and particulates. Exposure to dense smoke is hazardous depending on the amount and duration of smoke exposure.
- Plume modeling takes time to complete, requires practice, and involves a series of inputs (e.g., weather, rate of release, etc.) to accomplish. This data must be acquired from the field during the incident. Variables in data will affect the accuracy of the plume model's

concentration estimates and therefore affect protective action recommendations/decisions.

- The State has established a plume modeling Working Group that will continue to better prepare and advance the State's plume modeling capabilities. This Working Group will coordinate its activities under the SERC, and will work to build the State's modeling capability for all spills/fires, not just limited to incidents involving Bakken Crude Oil.
- In response to EO 125, the State has, and will continue to, engage the private sector in its plume modeling efforts.
- Any plume model and the corresponding dose/response projections are subject to validation by properly trained and equipped officials on the ground that can verify exposure levels. The State needs to possess the capability and capacity to deploy persons to the field to conduct such testing when warranted.
- The State does not have access to some of the current models being used. These models are under development and/or being updated at the Federal-level and are not being made available to the States. The State has requested access to the latest software as it is developed and tested/issued by the Federal government.
- There are only a handful of State employees that have the proper training and routinely use modeling software that is available. The State has requested additional training for modeling software.
- Proficiency in the use of the software is not the same as proficiency in estimating a hazard/risk. Scientifically-defensible source terms need to be developed and model outputs (i.e., estimates of dose or air concentrations) need to be interpreted by subject matter experts (*e.g.,* toxicologists) with sufficient knowledge of any uncertainties and limitations associated with outputs. It can be dangerous to make decisions based solely on model outputs that are based on highly uncertain assumptions and that have not been vetted by persons with the appropriate expertise.
- State agencies have very few, if any, staff that can proficiently use models. Emergency-based plume modeling is often an added-on responsibility to an employee's daily job functions. Agencies need staff whose primary responsibility is to perform plume modeling in response to emergencies. Agencies should pursue full-time positions to fulfill this responsibility.
- Dispersion of a ground-level plume is significantly affected by local topography. For the initial response models, the topography is limited to a 12-kilometer grid. The low resolution of this data will decrease the confidence in modeled outputs. Higher resolution topography data can be used by refined models, but these data greatly increase computational time therefore delaying response time.
- Some models provide their projections for short-range distances, while other models are applicable for modeling longer distances downwind. Therefore, models can and should be used in tandem as conditions warrant. The State will run multiple models to validate and assess plumes.

- The Radiological Emergency Preparedness (REP) Program includes the most proficient operational process for emergency plume modeling and assessment in the State. The REP model should be adopted for use with all forms of plume modeling in the future.
- The State needs to have a formal procedure to request modeling assistance from the IMAAC. The procedure should include how that model is requested, interpreted, and disseminated.
- The State needs to identify a procedure to deploy the Civil Support Team (CST) to an affected area to conduct modeling/sampling in chemical emergencies.
- The State should create a fact sheet for local responders regarding burning hazards, specifically Bakken Crude, to outline the concerns associated with such events. DOH and OFP&C currently have factsheets posted on their websites at:
  http://www.health.ny.gov/environmental/outdoors/air/what_to_know.htm
  http://www.health.ny.gov/environmental/outdoors/air/fires.htm
  http://www.dhses.ny.gov/ofpc/alerts-bulletins/information/documents/2014/crude-oil.pdf
- The State should invest in a research project to identify and assess the by-products of combustion of an emergency involving Bakken Crude Oil. This research should strive to develop source terms based on realistic scenarios and consider the range of potential air contaminants and emissions.
- Following the research project, the State should prepare a Bakken crude oil plume modeling worksheet of potential emission estimates to allow modelers to develop sound source terms. Uncontrolled fires result in smoke that has not been characterized and the specific components of which depend on what is being burned, the temperature of the fire and available oxygen to the fire. A literature review and/or study are required to summarize Bakken crude oil combustion byproducts to help develop the fact sheet.

Assessment of Capabilities

There is not one plume modeling tool than can satisfy all plume modeling needs or requirements. For example, some models are specific to assessing or delineating plumes for radiological emergencies, while others are specifically engineered for chemical emergencies (i.e., release of individual chemicals, not intended for mixtures or combustion), or just show particle trajectories. Some models only provide outputs in terms of concentration; others provide outputs in terms of dose, or in terms of specific protective actions that should be taken. In addition, one model that the State could employ is currently unavailable to the State as it is being revised by defense contracting companies that make models for specific military and non-military applications. Further, some models are designed and used solely by private industry in assessing consequences specific to their needs.

The following is a composite of capabilities, the agency or entity that uses them, and what types of capabilities are associated with each organization.

a. Assessment of private/industry modeling capabilities

During the plume assessment process, the Working Group learned that the rail industry conducts its own plume modeling through the use of a vendor. Representatives from the rail industry were invited to participate in this assessment process, but declined.

The Working Group learned that one vendor, Center for Toxicology & Environmental Health LLC (*CTEH)*, has been used in response to crude oil emergencies. CTEH promotes that it has extensive experience in combustion permitting, chemical spill and fire emergency response, and off-site consequence analysis. CTEH also provides services to depict the distances to toxic endpoints through application of software models (e.g., ALOHA, SLAB, and SAFER STAR (SAFER).

It is unclear as to the level and depth of experience CTEH has in providing guidance to state and local response officials for a Bakken Crude Oil emergency. The State will continue outreach to the industry to garner their participation moving forward.

b. Assessment of local modeling capabilities

In response to an emergency, many local response agencies refer to the U.S. Department of Transportation (USDOT) Emergency Response Guidebook (ERG). The ERG does not provide any plume modeling, but includes protective actions in regards to safe operating distances for response forces, and includes guidance on implementing immediate and down-wind protective actions, such as evacuating or sheltering in-place. Traditionally, the capability of the guide is exhausted after the first fifteen minutes of an incident and responders defer to a more refined level of modeling capability.

Apart from the ERG, most local response agencies do not possess any plume modeling capabilities. However, most counties in New York State are served by a hazardous materials team which possesses some plume modeling capability. Traditionally, the software employed by local hazardous materials teams is the CAMEO/ALOHA/MARPLOT platform, both of which are described in detail below. Counties are also beginning to use WISER, which is similar to the CAMEO platform but easier to use.

Whether the choice of the local responder is CAMEO or WISER, the models require some level of expertise in running and interpreting the model. Modeling can be labor intensive. Proficiency in model use is the key to understanding the limitations of the model and its results. However, changes or inaccuracies in the input or source terms (e.g., what is being released and how much) of these models can provide different and sometimes contradictory results, and dispersion relies on a single point of meteorological data.

Depending on the model, one alteration of an input can dramatically affect the output that is produced.

Regardless of the modeling capabilities at the local level, the production of any model to make definitive protective action decisions must be validated by personnel in the field. In most cases, the counties possess limited capability or capacity to conduct field monitoring or testing.

c. Assessment of State Agency Plume Modeling Capability and Capacity

New York State does not have a robust capacity to quickly and accurately provide detailed intermediate and advanced plume modeling assessment and analysis in the event of an emergency. The State does not have any one Office or Agency expressly responsible for modeling crude oil threats in the event of an emergency.

It is important to reiterate that follow-up field assessments are essential to validate the results of any model. Since most counties do not possess such a capability, the State would need to deploy staff to the field to validate (and update) model predictions, as needed. A specific monitoring, sampling and analysis plan would need to be developed prior to performing field assessments. In that regard, the State does possess some capability to do so, and is most proficient in employing radiological rather than chemical detection instrumentation and staff to support plume assessments.

The following is a summary of agency plume modeling capability, and the number of trained personnel that can run their respective model.

<u>NYS Department of Environmental Conservation</u>

NYS DEC has two full time staff that possess modeling skills. DEC does have toxicologists, chemists, and environmental remediation staff that can interpret model results to make decisions in regards to environmental remediation and protective measures from a public health standpoint. DEC has the capability of using HPAC and ALOHA in addition to HYSPLIT.

<u>NYS Department of Health</u>

NYS DOH is the lead state agency for response to radiological emergencies. DOH possesses three staff members that are proficient in the use of RASCAL, URI and MIDAS for commercial nuclear power plant emergencies, as well as another 6-10 staff who are semi-proficient.

DOH would defer to DEC for plume modeling associated with Bakken crude emergencies. However, DOH notes that in the absence of accurate site-specific information (including on-site weather data) or validated model results; there would be considerable uncertainty in making public health protective decisions based on the use of plume models alone to estimate exposures. A more technically sound approach is to evaluate all the available site-related information (e.g., emergency medical diagnoses and treatment data, bio-monitoring data, field measurements/observations, modeling results, and meteorological conditions, etc.) to assess public health exposures and provide recommendations for the protection of public health.

DOH has a protocol for 24/7/365-assistance in the public health response in the event of an emergency. DOH has a limited number of trained staff who can conduct environmental exposure investigations, as well as trained medical professionals, toxicologists and health physicists.

NYS Division of Military and Naval Affairs

NYS DMNA's Civil Support Teams (CSTs) possess a handful of staff members that can run HPAC and CAMEO. The organization possesses the capability to use these models and can aid in interpreting results in regards to public health protective measures. DMNA also possesses the capability to acquire assistance or "reach-back" from the Defense Threat Reduction Agency (DTRA) and the Interagency Modeling and Atmospheric Assessment Center (IMACC).

NYS Division of Homeland Security and Emergency Services

NYS DHSES collectively has been contributing to improving plume modeling through the core Working Group, and has also participated in the SERC Working Group efforts in response to EO 125. Specifically, the Office of Fire Prevention and Control, the Office of Emergency Management and the Office of Counter Terrorism have provided staff and support in all efforts by the SERC Working Group on assessing current capabilities, plume modeling software and identifying agency gaps. The SERC Working Group is led by State OEM.

NYS Office of Counter Terrorism

NYS OCT uses HPAC Version 5.0. OCT has one staff member trained to a basic level of proficiency using HPAC software. OCT staff is available during normal business hours, but OCT does not have staff trained or qualified to conduct field air sampling.

NYS Office of Emergency Management

NYS OEM uses HYSPLIT and possesses one staff member that has any modeling skills. Like DOH, OEM would defer to DEC or other agencies for plume modeling associated with Bakken crude emergencies. OEM does not have practitioners that can interpret model results to make decisions in regards to environmental remediation or protective measures from a public health standpoint. OEM does not have any trained staff that can deploy to the field and conduct sampling to confirm or deny a plume pathway.

<u>NYS Office of Fire Prevention and Control</u>
NYS OFPC is likely to utilize ERG immediate isolation areas as guidance for plume avoidance during an initial response to a crude incident, with ALOHA being used in conjunction with downwind monitoring to track plume movement. OFPC currently has up to 20 individuals trained in the use of ALOHA. With the nature of the agency's mission, OFPC would have to look to other State agencies to aid in long-term or technical plume assessment.

Overall, the State Agencies that use these various tools are limited in their experience and proficiency using the modeling tools noted above. For the most part, staff with some plume modeling experience has little time to devote to developing or maintaining proficiency as plume modeling is only a small part of their overall job responsibilities.

In summary:

- The State has not developed any of its own modeling software and relies on external sources for any models, updates, and training.
- The agencies that use the models often do so as an additional responsibility to an employee's daily job functions, rather than having a staff member(s) dedicated to doing modeling. Therefore, the agencies struggle to become proficient in using the software and producing models. This creates gaps in an agency's capability to use the models.
- With the exception of DOH and DEC, most agencies do not have staff that can interpret model results in regards to public protective measures or the environment.
- DMNA, DEC, OFPC and DOH (radiological events only) possess some ability to deploy staff to collect environmental samples to confirm or deny a plume pathway or potential exposures with sampling techniques, which may take time to activate and deploy. It should be note that except for some direct reading equipment which provides "real time" results for specified target analyses, environmental sampling results are not immediately available since they depend on laboratory analysis, which may take from hours to days. There have been very few incidents where the State was engaged in tracking plumes from fires, such as the fire in 2012 in the Town of Ghent, Columbia County. In this case, US EPA regional staff provided operational support to conduct plume sampling.
- There are multiple or updated versions of some of the computer models, such as HPAC that are currently unavailable to the State.
- State staff has not received advanced training on some models, which hampers the State's ability to properly run the models, stay current with software changes, or be aware of changes in the application of that model.
- The use of model outputs alone to guide public health protective decisions is not recommended by DOH staff given the inherent uncertainties (e.g., unknown source term) in the use of models for estimating human exposure, particularly with the use of

emergency guidelines that are not designed for mixtures or that do not offer sufficient margin of protections.

d. **Assessment of Federal capabilities**

Federal response agencies employ the same modeling tools as described above. As such, the same limitations with source term (inputs) and outputs (projections) exist as in the State's usage of such models. However, some Federal agencies, such as DTRA and the National Oceanic and Atmospheric Administration (NOAA), have greater experience in modeling emergency releases. In addition, some Federal agencies are privy to the latest models and updates, are aware of the current trends and sciences in modeling, and have a wealth of experience in using and interpreting models. These agencies can certainly aid the State in running models and making initial and long-term projections in response to an emergency.

In response to an emergency, the State can request Federal assistance to conduct plume modeling through the Interagency Modeling and Atmospheric Assessment Center or IMAAC. The IMAAC draws on federal plume modeling expertise and predictions from any of the IMAAC federal agencies, including the Department of Defense/DTRA, Department of Energy, and the Department of Commerce. The IMAAC can coordinate and disseminate all Federal atmospheric dispersion modeling and hazard prediction product to provide 24/7 support to the State to aid in the decision making process to protect the public and the environment. The IMACC can provide a model to the State typically within one hour of the request of that model. In order to do so, the State must possess the required set of source terms or inputs to provide to the IMACC in an attempt to get accurate modeling results.

Section 4: Recommendation of Most Appropriate Modeling Tools

There are advantages and disadvantages to each plume modeling software and often determining appropriate model inputs, such as what and how much is released, is a source of significant uncertainty. Some models can only evaluate the release and transport of one chemical at a time. Some models can predict the radiant heat hazards, while other models are not useful for fire scenarios. Some models do not incorporate the effect of wind at varying heights (i.e., ground-level versus elevated winds) or the influence of topography. Based on the strengths and weaknesses of each model, State and Federal subject matter experts attempted to make the determination as to the most appropriate model or combination of models that should be used to support informed decision making. The result is that the appropriate model may vary depending on the type of incident and the time during the incident at which the modeling was conducted.

None of the currently available models have Bakken Crude as a specific source term (or input) into that model. As such, other surrogates that have of similar physical and/or chemical properties, such as paraffin hydrocarbons (n-hexane), will be used to make a determination of the plume. Until such a time where the models specifically include the source term for Bakken crude oil, the State could use the following models (with significant limitations) as part of a comprehensive, coordinated emergency response:

- The local responder usage of the ERG, followed by a CAMEO platform or WISER application, should continue to be used by local first responders. These programs provide good results to begin initial protective actions.

- Plume modeling during an event is an evolutionary process. Multiple plume model runs should be conducted as better information becomes available, as the situation warrants, or to get an updated picture of the hazard/risk associated with the emergency.

- A good knowledge of the source term toxicity is important to help inform decisions on health effects. Toxicity of the various surrogates (hexane, n-heptane, generic particles) used to model the plume during the workshop will not be the same as toxicity of the Bakken crude, and therefore these models should not be used to make health decisions. The models, however, can provide the direction and relative concentration of the material in the plume.

- Until a specific source term is identified for Bakken Crude Oil spill, the chemical source term that should be used for a spill not involved in fire is a refined paraffin hydrocarbon, such as N-Hexane. If the material is on fire, the State can make use of the DTRA's generic "oil fire" source term, and request additional interpretation for that model run.

- Since the source term for Bakken Crude Oil spills do not exist, the composition of the plume and any deposition will be assumed to be similar to that of the surrogate paraffin hydrocarbon. From that standpoint, State personnel can be deployed to obtain samples in an attempt to identify, confirm or deny the presence of contamination synonymous with Bakken Crude or any another hydrocarbon.

- No one single model can model everything. The selection of which model to use depends on the incident, the efficacy and viability of choosing that model, and the outputs that are desired.

- Models do not account for multiple products that are burning and generate a plume. Therefore, a crude oil fire that ignites other chemicals will not be able to be modeled in real-time with any degree of accuracy. Such events can only be forecasted and assumed by practitioners that are aware of all the products involved in the fire.

- Although various emergency guidelines are integrated into some model tools, DOH recognizes that most of these guidelines are derived for individual chemical exposures rather than chemical mixtures, and that most, if not all events, will involve chemical mixtures. This fact is a limitation with using models and surrogates to estimate health hazards. Additionally, health protective values that offer a margin of protection for short-term inhalation exposures should be used to evaluate exposures and risks. These guideline values include chemical-specific comparison values derived by the Agency for Toxic Substances and Disease Registry (Acute Minimal Risk Levels) or California Environmental Protection Agency (Acute Reference Exposure Levels). Other available short-term guideline values are available (such as Acute Exposure Guidelines (AEGLs) or Temporary Emergency Exposure Limits (TEELs)) but these are associated with frank health effects. These kinds of values should only be used when more appropriate values are not available and if used, AEGL-1 or TEEL-1 values should be used for determining protective actions since these are levels that are not associated with death, impaired abilities, or irreversible effects (see Appendix B).

- The use of model outputs alone to guide public health protective decisions is not recommended by DOH given the inherent uncertainties in the use of models for estimating human exposure and potential health risks (e.g., unknown source term reducing confidence in estimated air concentrations). Additionally, DOH has not reviewed the health basis of emergency planning guidelines (EPGs) that are incorporated into some models, but understand that EPGs are chemical-specific and are not for chemical mixtures. Also, DOH staff understand that some tiers of EPGs do not offer sufficient margin of protections from adverse health outcomes (i.e., some EPGs are associated with disabling, life-threatening health effects, see Appendix B).

- The State should leverage the ability of the State of New York Mesonet which is now in the early stages of construction. The Mesonet will consist of a high-resolution network of weather monitoring stations that will provide continuous high-quality weather observations from 125 locations in New York. The data from the Mesonet is intended to improve the capability for monitoring and predicting severe weather events, but also has potential to be very useful for plume modeling purposes. It will make available quality-controlled current weather observations from a location close to the scene of any incident, which in itself will improve our capabilities. More importantly, the data could also be used as input to a high-resolution meteorological modeling system. This modeling system would be run hourly and would produce meteorological data in a gridded format that could be used by HYSPLIT and/or HPAC. This would also increase the resolution of the terrain data used for plume prediction, since the terrain data that the plume models use is combined with the meteorological data and is on the same scale. Use of such data would enable the plume models

(HYSPLIT/HPAC) to produce significantly more precise and accurate predictions of plume travel and dispersion. Developing and operating such a high-resolution meteorological model is not a trivial task, but would add significant value to the Mesonet data.

Section 5: Awareness / Training Mechanisms

Training and practical application of models are keys to ensuring that the plume modeling capability exists so that it can be used in times of emergency. However, the awareness that such models even exist, and the limitations of which, are of concern. There are versions of models that are so closely controlled that they are just now being made available to the States.
In addition to making those models available to the State, there should be training at the beginner, intermediate, and advanced levels to help create a strong modeling capability in New York State. County and local government could also benefit from the availability of these models and their corresponding training.

Following the State's receipt of these tools and training, the State would be in a better position to assist local and private partners in their training and planning, and identifying how best to incorporate those models in response to a variety of incidents. The Working Group suggests that this would best accomplished by having day-long sessions, at least quarterly, where the State could convene training and exercise workshops for all of the potential modeling experts. The workshops could include the following:

- Updates to current models, latest trends in models, best practices.
- Determining source terms.
- Determining appropriate meteorology.
- Expectations in modeling; validating the model with personnel in the field.
- Brief of model results, model comparisons, and nuances of specific models.
- A forum for questions and answers to assist all users.
- Modeling guides – to allow all subject matter experts to have fact sheets that they can refer to in times of emergency.
- Aid in the development of operational procedures on how to use the models, conduct field testing, and make dose/response predictions.
- Training for local/state staff that may be deployed to conduct testing to validate the models.

Section 6: Recommendations to Bridge Agency Jurisdiction and Gaps

The Working Group identified jurisdictional and other interagency gaps. Recommendations for closing those gaps are provided below:

1. New York State does not have a robust capacity to quickly and accurately provide detailed intermediate and advanced plume modeling assessment and analysis in the event of an emergency, nor does the State have an Office or Agency expressly responsible for modeling hazardous threats in the event of an emergency.

   Recommendation: Establish said responsibility through legislative means or executive order to establish a formal protocol to manage plume modeling and respond to hazardous emergencies across the State, as well as authorize the Working Group to bring together the appropriate subject matter experts to establish and maintain proficiency and respond during events and emergencies to produce plume modeling.

2. There are a variety of models available to the State, some of which are used by one agency or another. As such, there is no connectivity or relationship of model sharing information across the agencies.

   Recommendation: The plume modeling Working Group established to meet this Executive Order should remain as a standing task force under the SERC. Continuous engagement will ensure agencies remain active and can grow capability/capacity in a unified fashion. The working group should be comprised of State and Federal subject matter experts, and will extend invitations to local government and the private sector.

3. The Division of Military and Naval Affairs and the State Department of Environmental Conservation are the only two agencies in State Government that possess any modeling capabilities specific to this Executive Order. DEC and other state agencies have limited access or practice with the above referenced models.

   Recommendation: Under the SERC, ensure that the appropriate agencies have access to the appropriate plume modeling software, training on the use of models and chemical considerations associated with emission estimates, and be fully aware of limitations associated with interpreting models for health protective actions given the inherent uncertainties.

4. Subject matter experts that are conducting plume modeling in a given agency do so as an additional responsibility to their existing role. As a result, the subject matter experts cannot commit the required time to become proficient in modeling. Plume modeling is a specialty that requires constant involvement, practice, and usage to become proficient.

Recommendation: Agencies that are designated to respond to emergency events, such as chemical spills, fires, and radiological releases, should be allocated staff resources whose primary role is to conduct plume modeling. These staff members should be provided the continuous opportunity to work collaboratively with their state/federal counterparts in the plume modeling arena to share skills, ideas, and create new best practices. Under the SERC, all of the agencies should test, train and exercise together as part of an annual training program.

5. In most cases, the agencies that possess plume modeling capabilities only have one or two persons to serve as plume modeling subject matter experts.

   Recommendation: Agencies that have a response to such events should possess multiple staff that can conduct plume modeling. By building additional capacity, this allows for better availability from that agency to conduct the modeling during an actual emergency. Building capacity also provides for a progression in that agency to support succession planning.

6. Due to statutory responsibilities, some agencies look at plume modeling from their discipline-specific perspective, rather than an overall "State" perspective.

   Recommendation: Each agency that possesses plume modeling capabilities should participate in an ongoing test, training and exercise program to ensure that viewpoints of plume models can be consistent across the agencies.

7. Plume modeling requires tactical level support in the field. Plume models are only reliable when sufficient information is available to estimate site-specific releases and weather conditions, and is supported and validated by staff being deployed to a given area and implementing testing measures to validate the plume pathway, chemical composition, and potential dose/exposures.

   Recommendation: Under the SERC, appropriate State agencies need to have properly trained and equipped staff to deploy to an event location to conduct on-scene assessment to validate each plume modeling effort.

8. In addition to functions directly related to plume modeling and field sampling (e.g., to validate model predictions), agencies also have critical staffing needs to maintain agency capacity to meet statutory requirements and provide support for emergency functions. For example, during a major oil spill or fire, protecting public health and safety will be the highest priority for NYS, and DOH will lead the public health response. Each agency's ability to maintain the necessary level of readiness going forward has been reduced as attrition due to an aging workforce and lack of recruitment has led to critical staff shortages in environmental health and preparedness programs.

Recommendation: Budget authorization should be sought for agencies to hire additional staff with expertise in health risk analysis, toxicology, chemistry, environmental exposure assessment, emergency planning and response in order to maintain sufficient capabilities and readiness going forward to respond to major events, to help train local government, and to assist local agencies with emergency response and recovery.

Appendix A: Data Summary of NYS Agency Modeling Capabilities

This table shows a summary of the information provided by the state and federal agencies listed as part of the DPC SERC Air Plume Modeling Working Group. It shows the type of software used by each agency, what the software is primarily used for, the number of personnel currently trained in plume modeling, the proficiency level of those modelers, the number of full-time employees (FTEs) considered an ideal number to maintain agency statutory requirements and provide support for emergency functions, how many FTEs are available to conduct field monitoring or sample collections and whether or not the personnel are available 24/7.

AGENCY or ENTITY	SOFTWARE NAME	PRIMARY PURPOSE	CURRENT PERSONNEL	PROFICIENCY LEVEL	DESIRED PERSONNEL	FIELD STAFF	24/7
NYS DOH	Rascal	Radiological plume modeling only	2	High	6[1]	Need 24[1]	Y
NYS DEC	HYSPLIT ALOHA HPAC	Air dispersion modeling	2	High	Unknown	Varies	N
NYS DOT	CAL3QHC	CO* and PM** Transportation projects only	2	High	0	0	N
NYS OFPC	ERG WISER ALOHA	Initial response evaluation	0	High Basic	4	20	Y
NYS DMNA/ CST	HPAC	Air dispersion modeling	2	Basic	0	0	y
NYS OEM	HPAC	Air dispersion Modeling	1	Basic	4	0	N
NYS OCT	HPAC	Air dispersion modeling	1	Basic	3	0	N
Federal: NOAA	ALOHA HYSPLIT	Air dispersion modeling	3	High	0	0	Y
Federal: DTRA	HPAC	Air dispersion modeling	3	High	0	0	Y
Private: CTEH (Rail Plume Vendor)	N/A	Air dispersion modeling	N/R	N/R	N/R	N/R	N/R

[1] These estimates represent the number personnel necessary to conduct the Radiological Emergency Program, and do not represent a request for new staff.

<u>Key</u>: *CO = Carbon Monoxide; **PM = Particulate Matter; N/R = No Response Provided

Appendix B: Workshop After-Action Notes/Technical Information on Models

Section I: Model Information

The following is a technical overview of each model, outlining the list of inputs (source terms) and outputs that each model can produce. The summary also indicates that some models are capable of comparing estimated air concentrations with emergency planning health-based comparison values (e.g., US Department of Energy Temporary Emergency Exposure Limits (TEELs), US Environmental Protection Agency's Acute Exposure Guideline Levels (AEGLs) and the American Industrial Hygiene Association's Emergency Response Planning Guidelines (ERPGs). The DOH noted that these kind of values that were developed for emergency planning purposes and are designed for individual chemicals and not mixtures. For example, there are three tiers that both AEGLs and TEELs address. Each of these tiers represents severity of the expected effects associated with a particular chemical's exposure, and do not offer a margin-of-protection intended to prevent adverse health effects as do the Agency for Toxic Substances and Disease Registry's Acute Inhalation Minimal Risk Levels or Cal-EPA's Acute Reference Exposure Levels. The following list defines the tiers of AEGLs and TEELs:

- AEGL-1 or TEEL-1 is the airborne concentration, expressed as parts per million or milligrams per cubic meter (ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. TEEL-1 is the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor

- AEGL-2 or TEEL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape. TEEL-2 is the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

- AEGL-3 or TEEL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death. TEEL-3 is the maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

1. HPAC V5.0 (Hazard Prediction and Assessment Capability)

Inputs:

The model input requirements will depend on the incident type, but the basics are always:

- Where: latitude, longitude as precise as possible.
- When: date/time and duration of the incident.
- What: What is the material spilled/released? What is the amount released? The version to which NYS has access can estimate a single chemical release.
- Weather: can be obtained directly from the DTRA's met data server if we have Internet access.
- For incidents involving the rail tanks, "Industrial transportation" module can be used. Depending on the material transported the rail tanks are assumed to be certain type/size. For example, for HC fuel the tank options are DOT105S300A and DOT105S300ALW that can carry 25700 gallons and DOT 112J340W that can carry 33800 gallons when full. So, for the industrial transportation modeling additional input questions are:
- What type of rail tank is involved in the incident?
- What is the amount of the liquid in the tank (gallons) or an estimate of what percentage of the tank was full before it got damaged.
- How big is the damage:
- Light (minor leakage, no major structural failure)
- Moderate (major leakage, no major structural failure)
- Severe (major structural failure)
- Total (complete failure of the tank wall)
- Was this an accident (overturn or collision?)
- Was there an explosion (car bomb or truck bomb?)

Outputs of HPAC

The default output plot from the Industrial Transportation module is the 12 hour "Surface Dosage" plot. It displays contours in terms of Temporary Emergency Exposure Limit (TEEL) values. Depending on the incident size and material released it may be possible to get plots of surface deposition, air concentrations, dosage duration, AEGLs (Acute Exposure Guideline Levels) or AEGL duration tables.

There needs to be clear distinction with HPAC in regards to a spill or fire. An explosion, in the context of HPAC, usually refers to an explosion that causes a breach of a vessel containing hazardous materials, causing those materials to be dispersed into the air. It does not normally refer to the hazardous material itself exploding or combusting. Most of the health effect predictions that come from HPAC would be invalid if the specified substance was combusted. The products of combustion may also be hazardous, but may be completely different in terms of toxicity.

The latest version of the model, version 5.3-2, has demonstrated its ability to simulate the plume trajectory based on the 3-D meteorological fields, which is similar to the HYSPLIT demonstration. The dosage capability can be useful. The model uses an adaptive grid in the horizontal grid size.

2. ALOHA (Areal Locations of Hazardous Atmospheres)

ALOHA is one of four separate integrated software applications under the CAMEO (Computer Aided Management of Emergency Operations) suite of software.

ALOHA Inputs (As provided by NOAA):

a. Location
b. Type of structures in the vicinity of the release
c. Date / time of release
d. Chemical Released (a single chemical model)
e. Wind Speed and Direction
f. Measurement Height
g. Ground Roughness
h. Cloud Cover
i. Air Temperature
j. Stability Class
k. Presence of an Inversion
l. Humidity
m. Source:
n. Direct = Mass or Volume; Instantaneous or Continuous; Amount Entering the Atmosphere, Source Height
o. Puddle = Evaporating or Burning (Pool Fire); Area; Volume; Ground Type
p. Tank = Size and Orientation; Chemical State (liquid or gas); Amount in Tank; Type of Tank Failure; Area and Type of Leak; Height of Tank Opening
q. Gas Pipeline = Burning or Not Burning; Diameter and Length of Pipe; Closed or Open, Roughness of Pipe; Pressure; Temperature
r. Duration of release (or model can calculate)

ALOHA outputs

s. Threat Zones: As determined by multiple hazards (toxicity, flammability, thermal radiation, or overpressure). The thermal radiation thread zones simulated with ALOHA can be useful in case of fire associated with Bakken crude train accident. Since it only needs a single point meteorological data near the source, the plume prediction can only be useful close to the source.
t. Toxicity is generally displayed using Levels of Concern (LOCs) the default being AEGLs, but can be user specified concentrations (odor thresholds, arbitrary safety levels, etc.). To assess the toxicity threat, you must choose one or more toxic LOCs. A

toxic LOC tells you what level (threshold concentration) of exposure to a chemical could hurt people if they breathe it in for a defined length of time (exposure duration).

u. Flammability uses LEL (lower explosive limit) and UEL (upper explosive limit).

v. Thermal Radiation Level of Concern (LOC) measures the threat associated with releases that are on fire; a thermal radiation LOC is a threshold level of thermal radiation (heat), usually the level above which a hazard may exist. When you run a pool fire, jet fire, or boiling liquid expanding vapor explosion (BLEVE) scenario in ALOHA, thermal radiation is the hazard that is modeled.

w. Overpressure Level of Concern (LOC) is a threshold level of pressure from a blast wave, usually the pressure above which a hazard may exist. When you run a vapor cloud explosion scenario in ALOHA, overpressure is the hazard that is modeled. (ALOHA does not model the threat from hazardous fragments, which may travel far beyond the predicted overpressure threat zones.)

3. <u>HYSPLIT (Hybrid Single Particle Lagrangian Trajectory Model)</u>

There are currently two version of HYSPLIT (one with ALOHA integrated and one without).

<u>HYSPLIT Inputs</u>

- The web version already has the forecasted meteorology for the model.
- Will need location (Lat/Long), the emission (or the incident) duration, the emission release top (assuming the bottom is surface), and the total amount of pollutant released during the incident.

- When a chemical release is modeled in HYSPLIT, one needs to select a chemical and enter information about how that chemical is escaping from containment. That is, you'll enter details about whether the chemical is released from a tank or gas pipeline—or if the chemical has already formed a puddle on the ground or escaped directly into the atmosphere as a gas.

- This information is used to create time-dependent source strength estimates about how much chemical is released as a vapor and the rate at which that release occurs. Then HYSPLIT models the dispersion of the gas downwind, adjusting for the time-dependent release rate.

- In order to provide these source strength estimates, parts of the ALOHA program were recently integrated into the HYSPLIT website. ALOHA is a short-range air dispersion model, and it is a part of the CAMEO software suite developed by NOAA and the Environmental Protection Agency for emergency responders and planners.

- The online version of this model is easy and simple to use. Since it utilizes forecasted three-dimensional meteorological fields, the model is able to predict the trajectory of the plume further down the wind. Since the model has a horizontal grid size of 12 km, there could be numerical dilution in the estimated pollutant concentrations. In addition, based on the model description, the concentrations predicted by the model within 1 km of the source is not reliable due to the minimum time step size in the numerical integration.

<u>HYSPLIT Outputs</u>
HYSPLIT does not incorporate the effects of:

- concentrations < 1 km from the release location due to a minimum 1 minute time step of model
- chemical reactions
- dense gases near the source
- byproducts from fires, explosions, or chemical reactions
- materials with a plume rise due to heat release (explosions, fire, *etc.*) - unless the user enters the heat release rate or sets the top and bottom of the initial stable plume
- deposition - unless the user enters appropriate wet and dry deposition parameters
- particulate transport - unless the user enters information about the particle (size, deposition rates, etc.)
- complex terrain - other than what is resolved by the meteorological model's terrain
- time-varying emission rate (except for wild fire simulations)
- radiological daughter product generation

In most cases, HYSPLIT will provide default LOC values using values according to the following hierarchy:

- AEGLs are used preferentially because they are the best public exposure guidelines to date. They undergo a rigorous review process, have multiple exposure durations, and are designed as guidelines for nearly all members of the general public—including sensitive individuals.
- ERPGs (Emergency Response Planning Guidelines) are used next. They are based on experimental data, but—unlike AEGLs—they are only available for a 60-minute exposure duration and they are not designed as guidelines for sensitive individuals.
- PACs (Protective Action Criteria for Chemicals) are used last. This dataset combines three common public exposure guideline systems (AEGLs, ERPGs, and TEELs) and implements a hierarchy-based system for you.

4. <u>CAL3QHC, CAL3QHCR, and AERMOD</u>

The dispersion models used by NYSDOT are CAL3QHC, CAL3QHCR, and AERMOD. All three models are EPA's regulatory models, and are not a good application for this task.

- The CAL3QHC, CAL3QHCR are line source dispersion model and the AERMOD works for all source types.
- All models needs source locations and strength and meteorological data, but CAL3QHC only needs single specified wind speed, direction, stability, and mixing height information. The other two models require hourly meteorological data.

- CAL3QHC is a line source dispersion model that provides one-hour maximum concentrations of carbon monoxide (CO) or particulate matter (PM) at specified locations due to on-road vehicle emissions. It uses a single hour meteorological data (wind speed, mixing layer height, wind direction). The running time of this model is in minutes.
- CAL3QHCR is similar to CAL3QHC but uses hourly meteorological data from national weather service and provide hourly concentrations of CO or PM at specified locations due to on-road vehicle emissions. The running time is within an hour for one year simulation in general.
- AERMOD is a dispersion model capable of providing hourly pollutant concentrations due to various sources (point, areas, volume). The model uses hourly meteorological data from national weather service. The running time is within an hour for one year simulation in general.

5. **WISER:** This model is quick and convenient and can be useful within minutes of a major event associated Bakken crude train derailment/explosion. It can be useful for the area close to the disaster. Since the model only relies on surface wind speed and direction near the source, it may not provide good estimate of plume dispersion and direction further down the wind.

Section II: Workshop After-Action Notes

Below is a collection of notes obtained from the workshop. Workshop attendees were presented with the same scenario. Each agency that possesses modeling capabilities ran a model in real-time. In doing so, the source terms were discussed to be consistent across the models.

<u>Scenario Exercise:</u>

What: CSX Unit Train Derailment; Bakken Crude; Full Breach of 3 Cars (DOT-111 34,500 gallons each); Major Fire; Where: Rome, NY: Latitude 43.2000; Longitude -75.4573; Weather: Current conditions at time of exercise.

<u>What Agencies Observed and Noted:</u>

DTRA: GIS CATS Emergency Response Guide tool is demonstrated. Has automated search for nearest weather. A fire involving hydrogen sulfide is used for this scenario. Results provide map of "initial isolation" and "protective action" zones. Zones are capable of being exported to Google Earth to provide commanders a more useful perspective of the geographic area encompassed by the zones.

DEC: Duration of fire was 30 minutes; duration of dispersion forecast was 1 hour. The four output plots depicted predicted particulate matter concentrations for four 15-minute periods following the start of the incident. The concentrations were based on an estimate of total soot (particulate matter) emission from the combustion of the specified quantity of oil. That estimate was provided by the DTRA personnel, as was the 30 minute duration of the fire. DEC also demonstrate similar ERG guidance mapping tool but run a mobile application: "Wireless Information System for Emergency Responders (WISER)".

NOAA: ALOHA is used to model thermal radiation threat zone. N-Heptane is used as surrogate for Bakken crude. Results show threat zones: Red – "potentially lethal within 60 seconds"; Orange – "2^{nd} degree burns within 60 seconds"; Yellow – "pain within 60 seconds". In a real event NOAA would do several runs varying the most uncertain input variable to provide a range of impact.

DEC: HYSPLIT is demonstrated. Release height assumption is 25-100 meters (smoke height before turning in direction of wind). Duration of the fire is 1 hour with 4 output plots: 15, 30, 45, 60 minutes. Output shows particulate concentrations. Plume is shown to be headed north-north east reflecting the upper atmosphere winds from the NAM forecast.

CST: Ran scenario using HPAC's "Industrial Facility" module with total volume of Bakken from the three breached cars handled as an industrial storage facility fire. Hexane is used as surrogate chemical. Results show Acute Exposure Guideline Levels (AEGL) zones: mean area AEGL-3 "death possible"; mean area AEGL-2 "injury possible"; area of concern AGEL-2 injury possible. The population within each contour is also provided.

OFPC: Advanced plume models such as HYSPLIT may be excellent for long range projection, but are too complicated for short term answers typically required of OFPC first responders. Even ALOHA is fairly complicated, from the perspective of an immediate responder. OFPC is much more likely to utilize ERG immediate isolation areas as guidance for plume avoidance during an initial response to a crude oil incident, with ALOHA being used in conjunction with downwind monitoring to track plume movement. Due to the complicated nature of the HYSPLIT and HPAC models, advanced training is required to operate them properly and interpret the data successfully. This workshop made it abundantly clear that a simplified answer does not exist where meteorological projection is concerned. Any DHSES pursuit of quality plume modeling capability would require the acquisition of at least one qualified meteorologist who can interpret the data and make it accessible to DHSES staff on a simplified level that can be used expediently in the field during an emergency.

DTRA: Using HPAC, plume opacity and dosage is modeled. Assumes 20% of hydrocarbons become soot. For source term inputs a conversion of gallons to kilograms is made. Release rate is based assumption of a 36 meter pool which is based on car length. Repeated emphasis on understanding that HPAC dosage output reflects a 24 hour exposure. Similar to HYSPLIT output, plume trajectory is shown to be north-northeast.

DTRA's primary model is HPAC. Bakken is currently modeled as a generic hydrocarbon, which would probably underestimate the rate of release. The use of hexane would probably overestimate the rate of release. Once a fire begins, DTRA and the IMAAC have a series of supplemental models that generate the appropriate source term parameters. The hazards of the products of combustion do not arise, primarily, from the majority constituents – carbon dioxide and water – but from the minor constituents such as carbon monoxide, soot, sulfur dioxide, etc. Some quantitative data is available on the toxicity of these separately, but combining them is a questionable because of the possibility of unfavorable or even favorable synergisms. There is also some data on the smoke inhalation hazard aimed at fire fighters, and DTRA has attempted to incorporate these. It is important to note that a concentration, itself, is meaningless without knowing the length of time of exposure. DTRA and the IMAAC are still working on all of these variables, but do not feel it is reliably systematized for general release.

The model run used pool size dimensions for release rate calculations with no adjustment for porous surfaces. (Note: release rates totally different if fire is on water). Impermeable spill surface assumption results in error on conservative side (overstates). Pool size is based on number of cars breached. Transport/dispersion based on SCHIPUFF model with meteorology based on 12 KM North American Model (NAM). Long-term forecast can use GSF. Wind direction/speed doesn't affect burn (treated as turbulent jet). Model includes particulates (milligram/cubic meter), density and visibility. Assumes percent soot based on mass extinction coefficient. Toxicity models in HPAC based on legacy generic smoke particulates studies that assume low sulfur. Dose calculations based on 24 hour exposure which results in outputs that are easy to misinterpret. For IMAAC activation, DHS declared incident is required. IMAAC products published on HSIN. Current version is HPAC 5.3.2 which is not currently available to the public.

(Note: OCT has HPAC version 5.2; DEC uses 5.0; DOH looking to get approval to acquire software; 2nd CST uses 5.3.1.

<u>Summary of Models:</u>

The **ERG** "model" is the most basic tool and would be used by field personnel as a first step to determine safe distances. ERG and/or ALOHA would be the initial tools in the case of burning oil, as the emissions from such a fire are generally considered to be low in toxicity, so the primary health concern would be in the immediate vicinity of the incident.

ALOHA is likely to be the most useful model to quickly provide information to responders at an incident involving spilled or released hazardous substances. Its advantages are that it is quick and easy to use, and the only meteorological inputs needed are the current weather conditions at the scene of the incident. Those can be measured or estimated by personnel on the scene, or estimated by a forecast meteorologist on duty at DEC or NWS. ALOHA does not need a meteorological data file, so internet access is not required. ALOHA's usefulness is limited to short-duration incidents where the health and safety concerns are limited to areas within about 1km of the incident site. In those cases, it may actually be better than trying to use HPAC or HYSPLIT, especially if we have reliable measurements of weather at the incident site. That is because the meteorological data used by HPAC and HYSPLIT is on a 12km grid, and thus is unable to accurately reproduce small-scale wind differences caused by local terrain. ALOHA is not intended for use in the case of a fire. It simulates the dispersion of specific chemicals following airborne releases or volatilization from a spilled liquid. It does have the capability of simulating a heavy gas release, though it does not incorporate terrain information.

HPAC is intended to provide predictions of health effects from releases of known substances, usually as the result of damage to a facility or transportation container. It includes a component to estimate the amount of hazardous material that would be released, based on the type of incident. The incident types are pre-programmed in the model, and most of them are based on the assumption that whatever hazardous material is released is not being combusted. The version of HPAC that is currently available to us is not intended to simulate a fire. There is a newer version (that the State doesn't have) that has an "oil-fire smoke" module that is intended to show health/safety effects of emissions from burning oil. However, the State has not had the training to use that, and questions how accurate it would be anyway, given the wide variation in the composition of crude oil. During our HPAC level one training, staff was told that the only way to effectively use HPAC in the case of a fire is to use the analytic mode, which staff was told it cannot use it without HPAC level two training. A point that may be lost on some is that the health concerns from a spill of a substance are entirely different from those if the same substance is combusted. HPAC output can be put on GIS map backgrounds, but the version of HPAC which we currently have does not produce kmz files for Google Earth. HPAC is capable of integrating dosage over time, which is useful if the substance involved is known, as is the amount being emitted. HPAC is software that needs to be installed on one's PC, since it does not have a version that can be used remotely via a web browser. It can use an internet connection to obtain the needed meteorological data, but has the option of accepting manually entered data. At times, the meteorological data servers have been unreachable, making it impossible to use HPAC. Additional HPAC training here in Albany is desired, but funding is an issue to obtain it.

HYSPLIT has the same capabilities as HPAC as far as predicting dispersion is concerned. It does not have the components for estimating the amount of a substance that would be released in the event of an incident, or for predicting health effects. Its advantages are that it is easier and quicker to use than HPAC, its output can quickly be put into Google Earth or GIS to show in map form, and it can be used over the web by any computer that has a web browser and an internet connection. Another advantage is that the release height can be set to simulate plume rise in the event of a large fire. In the event of a large fire, it is unlikely that the State will have good information in real time on what substances are being released and at what rate. Thus, HPAC output would not be particularly useful, since it would be trying to predict health effects based on a guess as to what is coming out of the fire. Therefore, the most useful thing that could be provided would be a general prediction of how the plume is expected to travel and how quickly it is likely to disperse. This can be done with HYSPLIT by doing a dispersion forecast based on unit emission, which will produce contours of dilution factor as output. HYSPLIT has options enabling us to set release duration, quantity, mass, and height, as well as concentration averaging period, deposition, and several other factors. HYSPLIT can also plot trajectory lines of how a single particle released from a given location would be expected to travel. Both of these types of output can be prepared and placed on map backgrounds within about 15 minutes. They can be distributed as pdf files, kmz files for Google Earth, or whatever is needed. If time is short, the kmz files, or static screenshots from Google Earth, are usually the quickest. HYSPLIT requires an internet connection to obtain the meteorological data, even if the model is being run on the local PC. In our experience, the website and data have always been reliably available, although NOAA does have a disclaimer stating that the server is not considered "operational", meaning that there are no guarantees against outages.

Summary: ALOHA is best for a first-look product in smaller incidents not involving fire. HPAC is best for larger-scale releases of known toxic substances. If fire is involved, HPAC is not recommended for use by non-experts. HYSPLIT is best in our view for use in the case of a fire, and in some other incidents where we don't know how much of what substances are being emitted. Both HPAC and HYSPLIT output in GIS format can be used with other GIS layers for many different purposes.

NOAA:

NOAA has extensive experience with modeling. Primary models used are ALOHA and HYSPLIT. HYSPLIT can do extensive modeling of smoke. ALOHA is a "scaling" model suitable for distances up to 1000 yards downwind from a site. ALOHA does not factor terrain. HYSPLIT uses the 12KM grid NAM which is suitable for longer range forecasting. NOAA plans to make 4KM grid available on NAM which should result in significant improvements, particularly for areas with localized weather variations that are not well addressed by the current 12KM grid. NWS Forecast Offices are capable of customized modeling using WRF model (a mesoscale numerical weather prediction system). ALOHA models pure chemicals, not crude oil. ALOHA can model toxics, explosions and thermal hazards (heat). Bakken is extremely light crude almost like gasoline with very large carbon molecules and aromatic resins. Explosion hazard if runoff into a sewer. To model Bakken a surrogate is used: N-Heptane. ALOHA thermal hazard modeling factors wind. Thermal hazard is reduced by smoke.

DMNA/CST: Uses HPAC. Modeling begins enroute to incident with model outputs subsequently refined through direct contact to DTRA Reachback. There is a tiered response in the use of the software packages. First responders will initiate ALOHA, which will be followed by HPAC or HYSPLIT (depending on the agency), and the IMAAC will refine any HPAC or HYSPLIT models. There is a wide variance in the personnel using the software. None of the HPAC users were as proficient as DTRA when it came to the manipulation of the parameters within the Analytical function. The software needs to be standardized for all agencies. There were many different HPAC versions presented at the meeting. Also, when doing a hazard model one needs to decide what the desired output is. During the exercise, the model should have been showing particulate matter coming off the fire. This was not possible for ALOHA, needed a lot of manipulation for HPAC, and HYSPLIT was able to give a linear idea of where to find the particulate matter.

DEC: Uses ALOHA, HPAC and HYSPLIT. Staff of 3 but not required to be available 24/7 (Spill Response Bureau is 24/7 but has limited modeling capabilities and is focused on spills as opposed to plumes). Prefer to work from DEC Headquarters where there is access to chemists, etc. Understanding protocols for federal-state agency coordination and communication during an incident is critical and needs to be documented in final report.

DOT: Uses a line source dispersion models (CAL3QHC, CAL3QHCR, AERMOD) that are not suited to model emergency incidents. The NYS DOT Statewide Transportation and Information Coordination Center (STICC) core operations are 24/7. Additional staff is made available for response to emergency events when needed. Recommend that all models demonstrated in the workshop be used so that they can complement each other. For the HYSPLIT and HPAC model, there should be contingency measures in case of loss of internet/network connection since online 3-D meteorological data are used. Recommend that a simple emission processor be developed to standardize model inputs for emissions. All the models should use the same emissions for the same pollutants for consistency and comparison.

DHSES-OCT: Has HPAC but defers to experts. DHSES leadership has expectation that OCT is capable. Need level 2 training. Being able to interpret model results is key.

DOH: DOH would defer to DEC modeling for non-radiological events. DOH observed that the various models used during the workshop provided different predictions depending on the assumptions and the capabilities of the model. Therefore, DOH recommends avoiding over-reliance on plume dispersion models when making evacuation, shelter-in-place, and re-entry decisions. Observations by field personnel will provide the most reliable information for immediate decision-making purposes, with plume modeling perhaps providing secondary input. Model limitations, the lack of a Bakken crude source term, high-resolution topography, and weather considerations, result in considerable uncertainty in model output, significantly limiting the use of models to evaluate potential toxicity, exposure, and health effects. More research is needed to identify contaminants of potential concern and characterize potential release estimates for Bakken Crude. DOH has general guidance on the hazards of smoke and sampling considerations posted on its website:

http://www.health.ny.gov/environmental/outdoors/air/what_to_know.htm and http://www.health.ny.gov/environmental/outdoors/air/fires.htm

For radiological release events, DOH has field monitoring capabilities that can be used to verify the extent of the plume, and as such, will design a sampling strategy to measure contaminant levels to best characterize exposures.