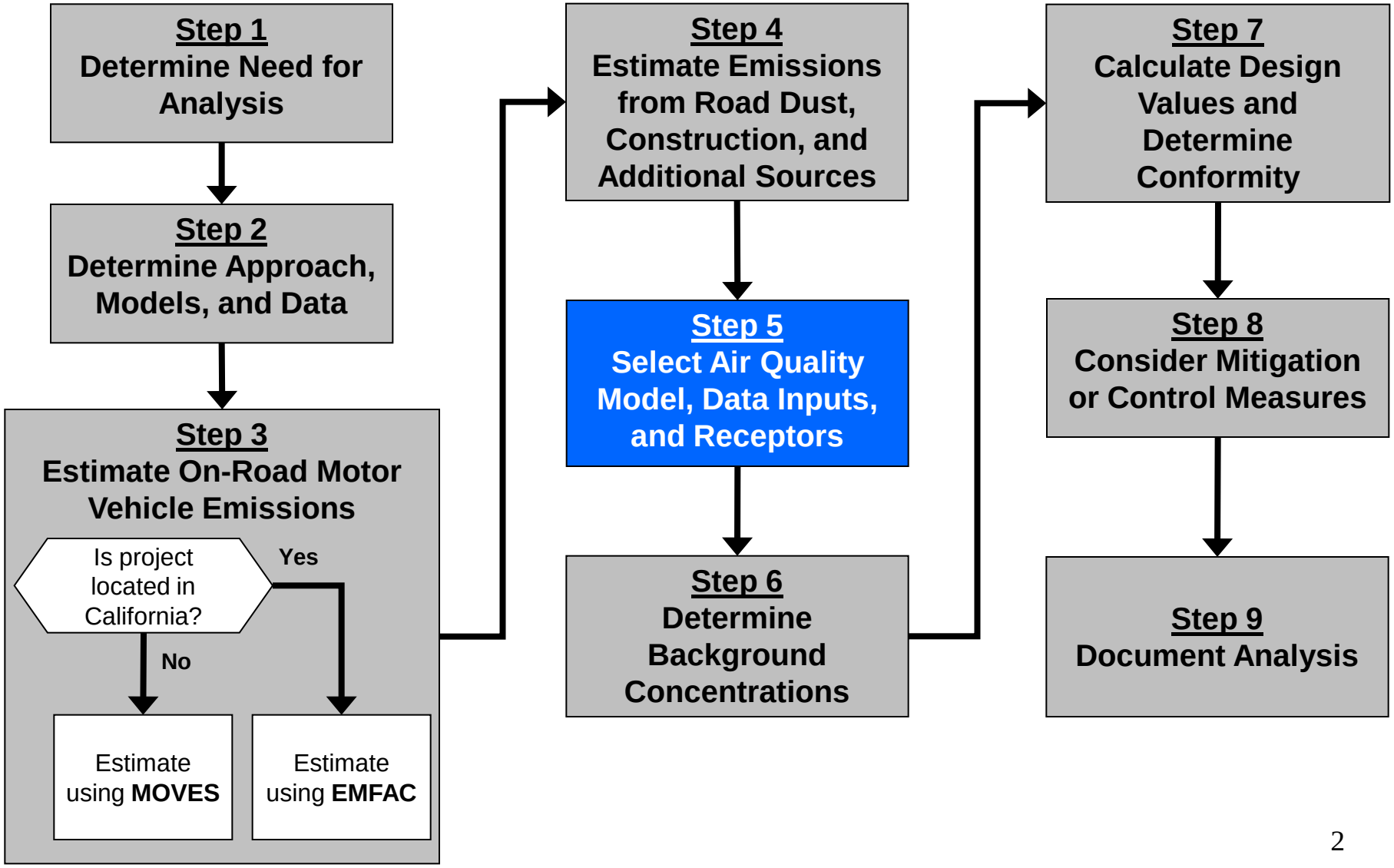
Module 3

Selecting an Air Quality Model, Data Inputs, and Receptors

Completing a PM Hot-spot Analysis



Module Overview

- Recommended air quality models for hot-spot analyses
- Characterizing emission sources
- The importance of using meteorological data that is representative of the project area
- Types of met data required for PM hot-spot analyses
- Considerations when placing receptors for air quality modeling
- Class Exercise: What is the Project Area?

Key References

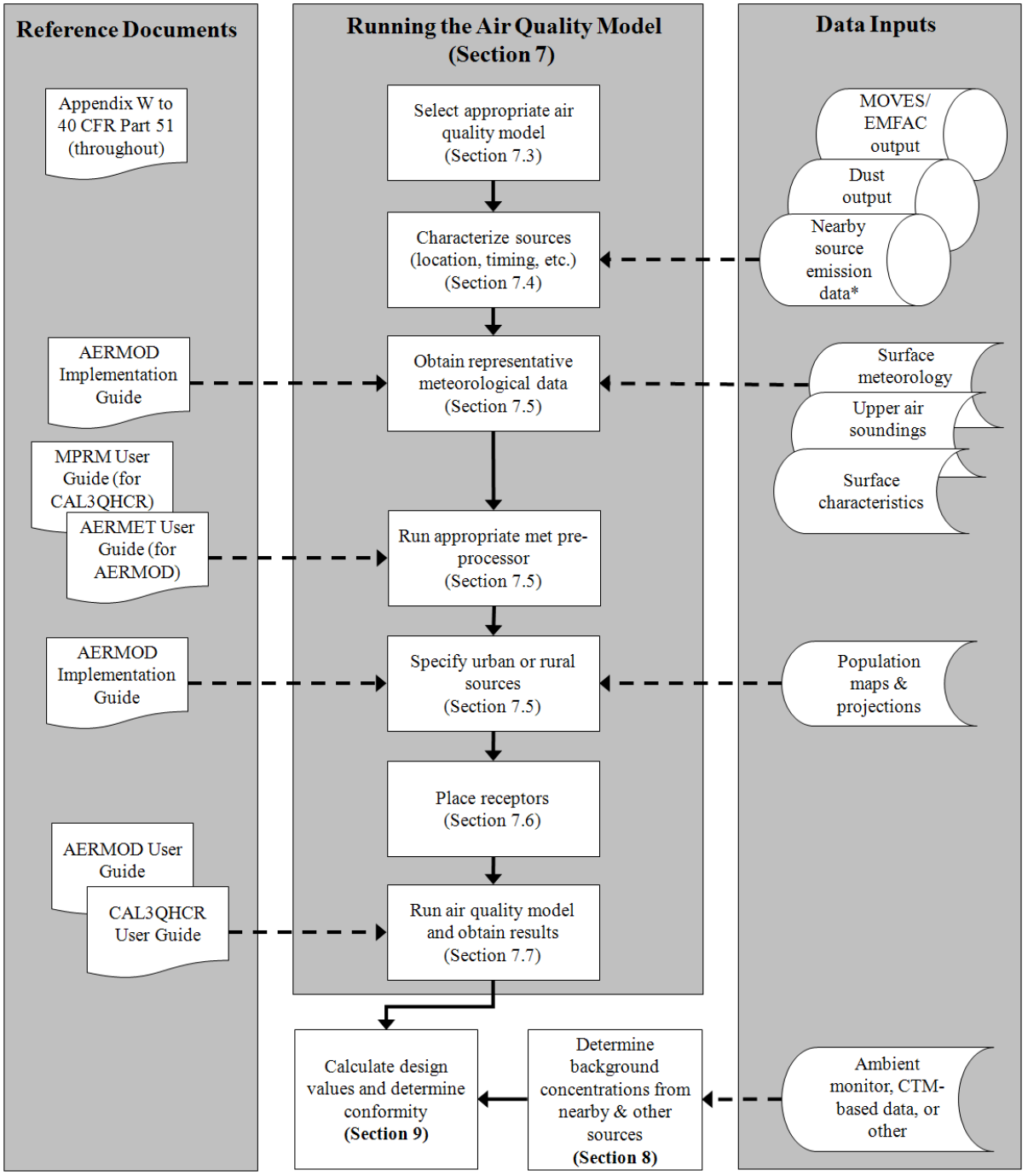
- PM Hot-spot Guidance, Section 7
- Conformity rule, Sections 93.105(c)(1)(i), 93.110 and 93.123(c)
- 40 CFR Part 51, Appendix W
  - » www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf
- AERMOD/CAL3QHCR User Guides

Key References

- AERMET/MPRM User Guides
- AERMOD Implementation Guide
- EPA SCRAM website: www.epa.gov/scram001/

General Overview of Air Quality Modeling

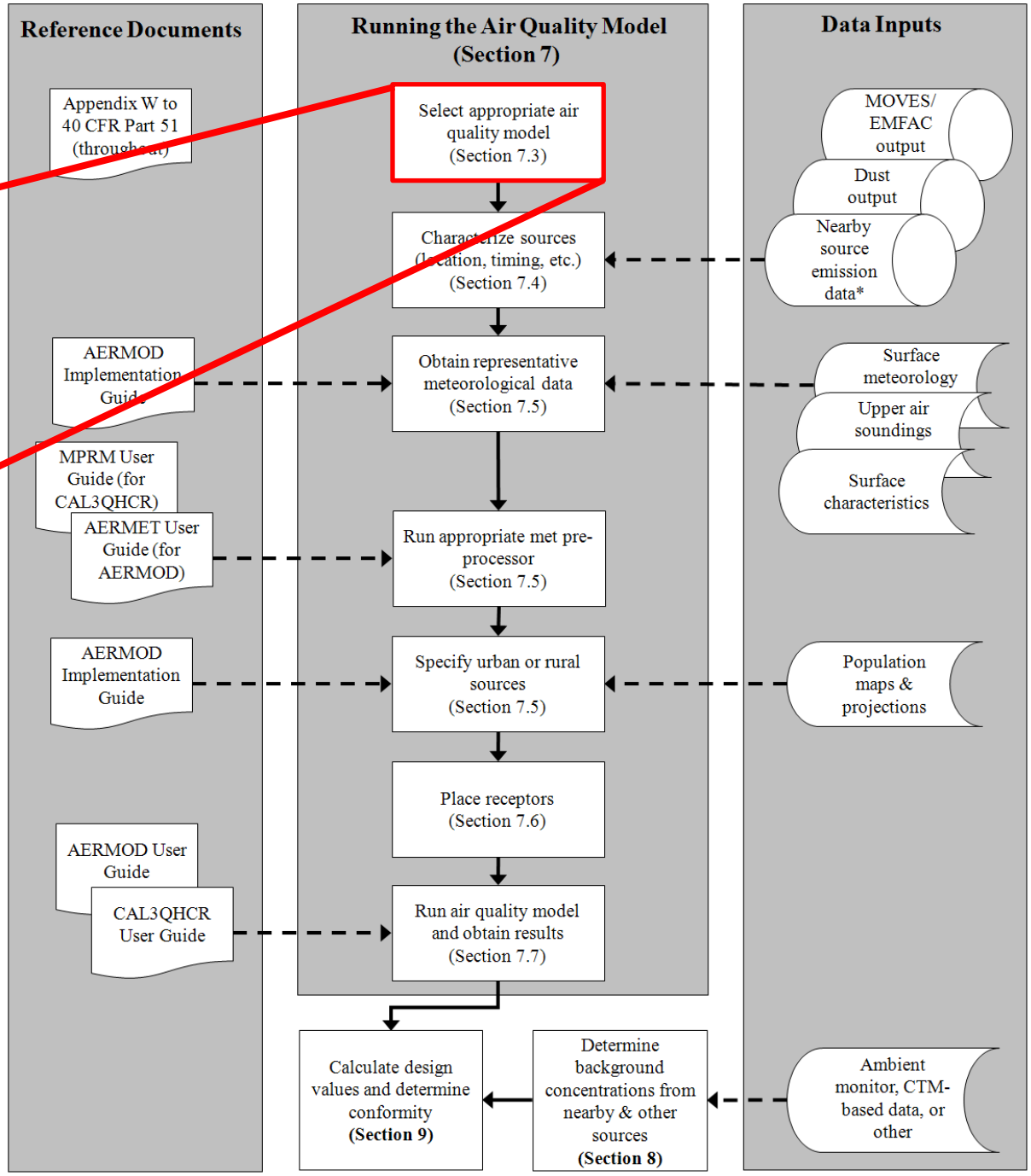
- PM Hot-spot Guidance is consistent with the recommendations for air quality modeling in 40 CFR 51, App. W
- Air quality modeling for hot-spot analyses must meet conformity rule general requirements (93.123(c))
- Air quality models, methods, and assumptions need to be determined for each PM hot-spot analysis through interagency consultation process (93.105(c)(1)(i))
- Project sponsors will need to refer to the latest user guides and available guidance for complete instructions



Guidance Reference:

Exhibit 7-1

Select appropriate air quality model (Section 7.3)



Selecting an Appropriate Air Quality Model

Type of Project	Recommended Model
Highway and intersection projects	AERMOD, CAL3QHCR
Transit, freight, and other terminal projects	AERMOD
Projects that involve both highway/intersections and terminals, and/or nearby sources	AERMOD

- Recommendations are consistent with EPA's current recommended models in 40 CFR Part 51, App. W
- CAL3QHC is not appropriate for modeling refined PM hot-spot analyses

Guidance Reference:
Exhibit 7-2 & Sec. 7.3.1

Selecting an Appropriate Air Quality Model

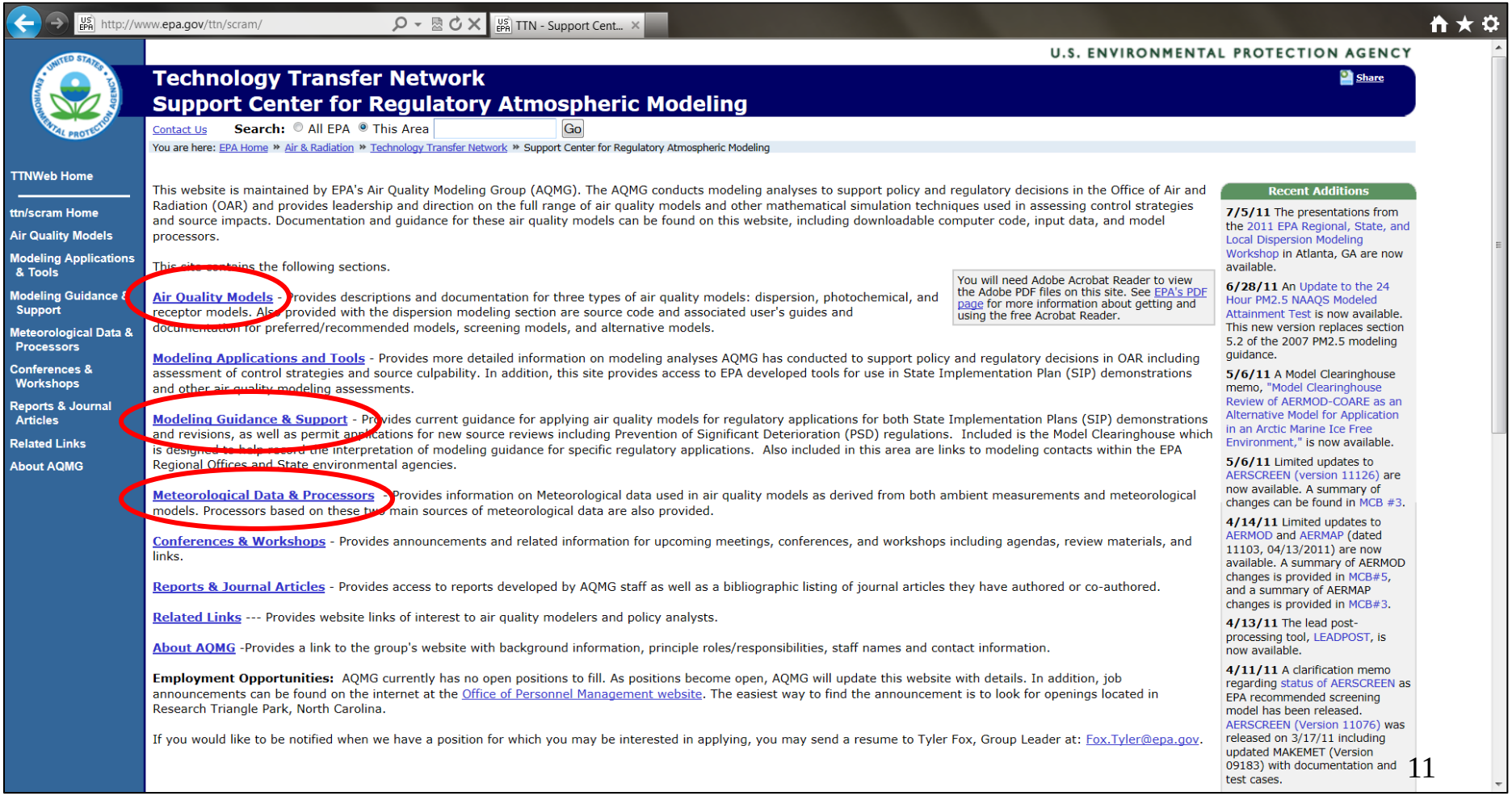
- Same model should be used for entire project
- Selecting a model early in the process can facilitate collection of appropriate data
- Interagency consultation process must be used (93.105(c)(1)(i))
- Models can be found on EPA's SCRAM website

Guidance Reference:

Section 7.3

Air Quality Modeling Resources

www.epa.gov/ttn/scram



http://www.epa.gov/ttn/scram/ — TTN - Support Cent...

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This website is maintained by EPA's Air Quality Modeling Group (AQMG). The AQMG conducts modeling analyses to support policy and regulatory decisions in the Office of Air and Radiation (OAR) and provides leadership and direction on the full range of air quality models and other mathematical simulation techniques used in assessing control strategies and source impacts. Documentation and guidance for these air quality models can be found on this website, including downloadable computer code, input data, and model processors.

This site contains the following sections.

You will need Adobe Acrobat Reader to view the Adobe PDF files on this site. See EPA's PDF page for more information about getting and using the free Acrobat Reader.

Air Quality Models - Provides descriptions and documentation for three types of air quality models: dispersion, photochemical, and receptor models. Also provided with the dispersion modeling section are source code and associated user's guides and documentation for preferred/recommended models, screening models, and alternative models.

Modeling Applications and Tools - Provides more detailed information on modeling analyses AQMG has conducted to support policy and regulatory decisions in OAR including assessment of control strategies and source culpability. In addition, this site provides access to EPA developed tools for use in State Implementation Plan (SIP) demonstrations and other air quality modeling assessments.

Modeling Guidance & Support - Provides current guidance for applying air quality models for regulatory applications for both State Implementation Plans (SIP) demonstrations and revisions, as well as permit applications for new source reviews including Prevention of Significant Deterioration (PSD) regulations. Included is the Model Clearinghouse which is designed to help record the interpretation of modeling guidance for specific regulatory applications. Also included in this area are links to modeling contacts within the EPA Regional Offices and State environmental agencies.

Meteorological Data & Processors - Provides information on Meteorological data used in air quality models as derived from both ambient measurements and meteorological models. Processors based on these two main sources of meteorological data are also provided.

Conferences & Workshops - Provides announcements and related information for upcoming meetings, conferences, and workshops including agendas, review materials, and links.

Reports & Journal Articles - Provides access to reports developed by AQMG staff as well as a bibliographic listing of journal articles they have authored or co-authored.

Related Links --- Provides website links of interest to air quality modelers and policy analysts.

About AQMG -Provides a link to the group's website with background information, principle roles/responsibilities, staff names and contact information.

Employment Opportunities: AQMG currently has no open positions to fill. As positions become open, AQMG will update this website with details. In addition, job announcements can be found on the internet at the Office of Personnel Management website. The easiest way to find the announcement is to look for openings located in Research Triangle Park, North Carolina.

If you would like to be notified when we have a position for which you may be interested in applying, you may send a resume to Tyler Fox, Group Leader at: Fox.Tyler@epa.gov.

Recent Additions

7/5/11 The presentations from the 2011 EPA Regional, State, and Local Dispersion Modeling Workshop in Atlanta, GA are now available.

6/28/11 An Update to the 24 Hour PM2.5 NAAQS Modeled Attainment Test is now available. This new version replaces section 5.2 of the 2007 PM2.5 modeling guidance.

5/6/11 A Model Clearinghouse memo, "Model Clearinghouse Review of AERMOD-COARE as an Alternative Model for Application in an Arctic Marine Ice Free Environment," is now available.

5/6/11 Limited updates to AERSCREEN (version 11126) are now available. A summary of changes can be found in MCB #3.

4/14/11 Limited updates to AERMOD and AERMAP (dated 11103, 04/13/2011) are now available. A summary of AERMOD changes is provided in MCB#5, and a summary of AERMAP changes is provided in MCB#3.

4/13/11 The lead post-processing tool, LEADPOST, is now available.

4/11/11 A clarification memo regarding status of AERSCREEN as EPA recommended screening model has been released. AERSCREEN (Version 11076) was released on 3/17/11 including updated MAKEMET (Version 09183) with documentation and test cases.

Air Quality Modeling Resources

www.epa.gov/ttn/scram/aqmindex.htm

http://www.epa.gov/ttn/scram/aqmindex.htm

Air Quality Models |...

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Air Quality Models

Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Based on inputs of meteorological data and source information like emission rates and stack height, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere. These models are important to our air quality management system because they are widely used by agencies tasked with controlling air pollution to both identify source contributions to air quality problems and assist in the design of effective strategies to reduce harmful air pollutants. For example, air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. In addition, air quality models can also be used to predict future pollutant concentrations from multiple sources after the implementation of a new regulatory program, in order to estimate the effectiveness of the program in reducing harmful exposures to humans and the environment.

The most commonly used air quality models include the following:

Dispersion Modeling - These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.

Photochemical Modeling - These models are typically used in regulatory or policy assessments to simulate the impacts from all sources by estimating pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales.

Receptor Modeling - These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations.

Additional Information about air quality models can be found at **Related Links**.

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http://www.epa.gov/ttn/scram/aqmindex.htm
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Air Quality Modeling Resources

www.epa.gov/ttn/scram/dispersionindex.htm

http://www.epa.gov/ttn/scram/dispersionindex.htm

Dispersion Modelin...

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Dispersion Modeling

Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations. These air quality models are used to determine compliance with National Ambient Air Quality Standards (NAAQS), and other regulatory requirements such as New Source Review (NSR) and Prevention of Significant Deterioration (PSD) regulations. These models are addressed in Appendix A of EPA's *Guideline on Air Quality Models* (also published as Appendix W (PDF) of 40 CFR Part 51), which was originally published in April 1978 to provide consistency and equity in the use of modeling within the U.S. air quality management system. These guidelines are perodically revised to ensure that new model developments or expanded regulatory requirements are incorporated.

This site provides links for dispersion models and other related tools and information as follows:

Preferred/Recommended Models - Refined air quality models that are currently listed in Appendix W (PDF) and are required to be used for State Implementation Plan (SIP) revisions for existing sources and NSR and PSD programs.

Alternative Models - Models, not listed in Appendix W (PDF), that can be used in regulatory applications with case-by-case justification to the Reviewing Authority as noted in Section 3.2, "*Use of Alternative Models*", in Appendix W (PDF).

Screening Tools - Models that are often applied before applying a refined air quality model to determine if refined modeling is needed.

Related Programs - Programs and utilities that are used in support of some of the dispersion models listed here. Note that utilities designed for use with particular models will be found with those models.

The EPA's Air Quality Modeling Group uses dispersion models as part of its modeling analyses for which information can be found at **Modeling Applications & Tools** and provides guidance on the use of these models for permit modeling available at **Modeling Guidance & Support**. Additional information about dispersion models can be found at **Related Links**.

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http://www.epa.gov/ttn/scram/dispersionindex.htm
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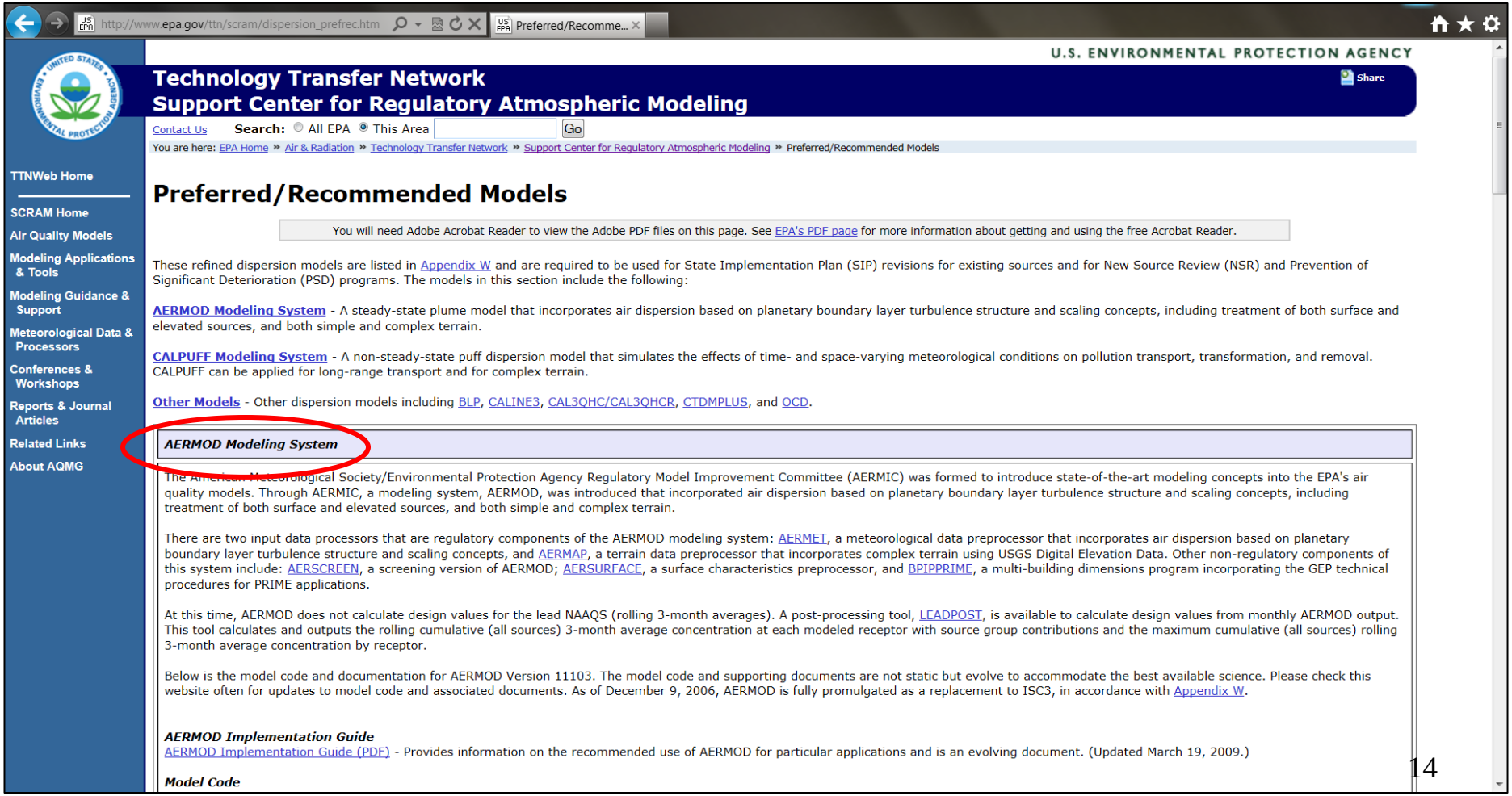
Air Quality Modeling Resources

www.epa.gov/ttn/scram/dispersion_prefrec.htm



http://www.epa.gov/ttn/scram/dispersion_prefrec.htm

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Preferred/Recommended Models

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These refined dispersion models are listed in Appendix W and are required to be used for State Implementation Plan (SIP) revisions for existing sources and for New Source Review (NSR) and Prevention of Significant Deterioration (PSD) programs. The models in this section include the following:

AERMOD Modeling System - A steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

CALPUFF Modeling System - A non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain.

Other Models - Other dispersion models including BLP, CALINE3, CAL3QHC/CAL3QHCR, CTDMPLUS, and OCD.

AERMOD Modeling System

The American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) was formed to introduce state-of-the-art modeling concepts into the EPA's air quality models. Through AERMIC, a modeling system, AERMOD, was introduced that incorporated air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET, a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include: AERSCREEN, a screening version of AERMOD; AERSURFACE, a surface characteristics preprocessor, and BPIPPRIME, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

At this time, AERMOD does not calculate design values for the lead NAAQS (rolling 3-month averages). A post-processing tool, LEADPOST, is available to calculate design values from monthly AERMOD output. This tool calculates and outputs the rolling cumulative (all sources) 3-month average concentration at each modeled receptor with source group contributions and the maximum cumulative (all sources) rolling 3-month average concentration by receptor.

Below is the model code and documentation for AERMOD Version 11103. The model code and supporting documents are not static but evolve to accommodate the best available science. Please check this website often for updates to model code and associated documents. As of December 9, 2006, AERMOD is fully promulgated as a replacement to ISC3, in accordance with Appendix W.

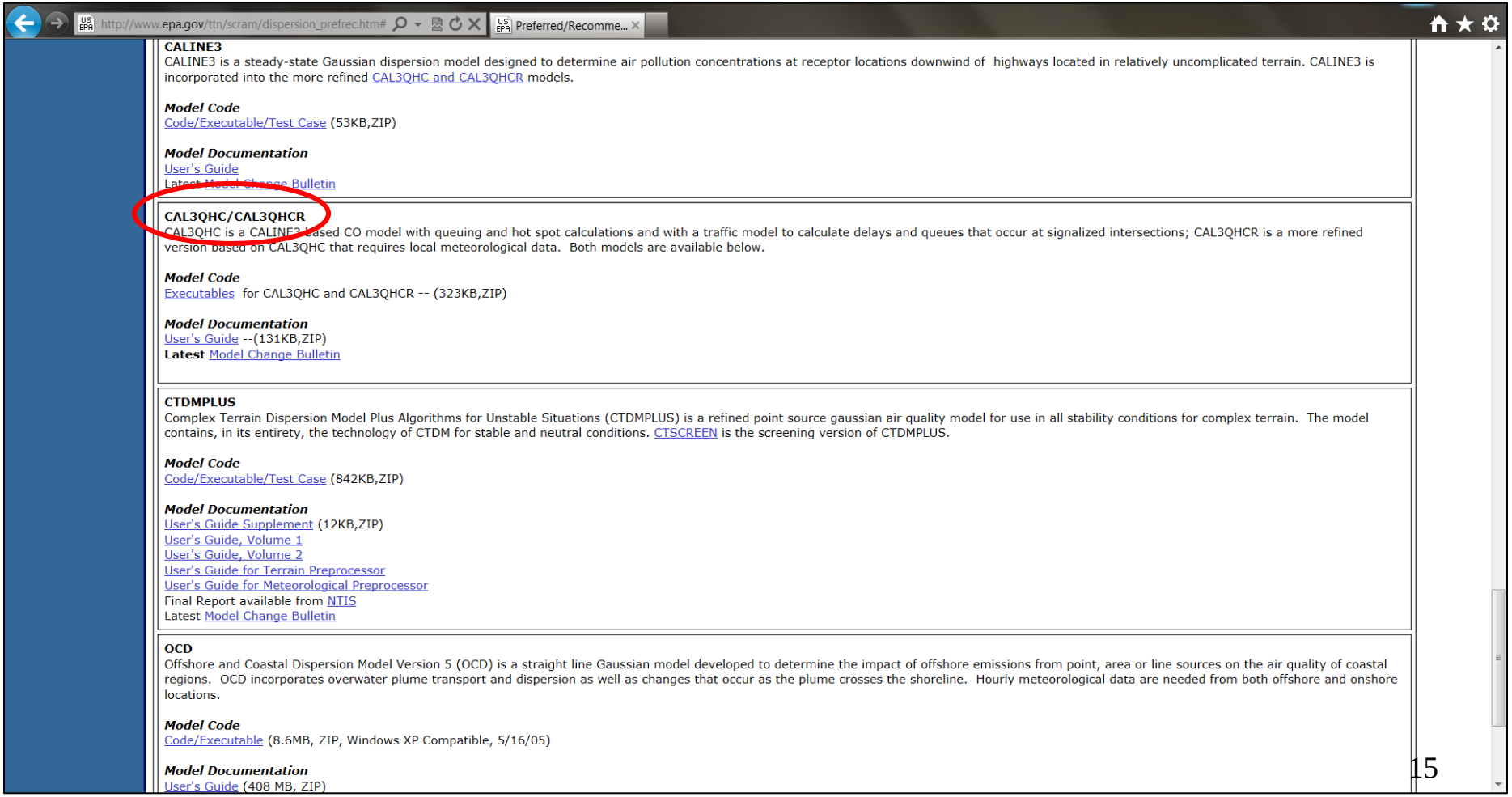
AERMOD Implementation Guide

AERMOD Implementation Guide (PDF) - Provides information on the recommended use of AERMOD for particular applications and is an evolving document. (Updated March 19, 2009.)

Model Code

Air Quality Modeling Resources

www.epa.gov/ttn/scram/dispersion_prefrec.htm



http://www.epa.gov/ttn/scram/dispersion_prefrec.htm# Preferred/Recomme...

CALINE3
CALINE3 is a steady-state Gaussian dispersion model designed to determine air pollution concentrations at receptor locations downwind of highways located in relatively uncomplicated terrain. CALINE3 is incorporated into the more refined CAL3QHC and CAL3QHCR models.

Model Code
Code/Executable/Test Case (53KB,ZIP)

Model Documentation
User's Guide
Latest Model Change Bulletin

CAL3QHC/CAL3QHCR
CAL3QHC is a CALINE3 based CO model with queuing and hot spot calculations and with a traffic model to calculate delays and queues that occur at signalized intersections; CAL3QHCR is a more refined version based on CAL3QHC that requires local meteorological data. Both models are available below.

Model Code
Executables for CAL3QHC and CAL3QHCR -- (323KB,ZIP)

Model Documentation
User's Guide --(131KB,ZIP)
Latest Model Change Bulletin

CTDMPLUS
Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS) is a refined point source gaussian air quality model for use in all stability conditions for complex terrain. The model contains, in its entirety, the technology of CTDM for stable and neutral conditions. CTSCREEN is the screening version of CTDMPLUS.

Model Code
Code/Executable/Test Case (842KB,ZIP)

Model Documentation
User's Guide Supplement (12KB,ZIP)
User's Guide, Volume 1
User's Guide, Volume 2
User's Guide for Terrain Preprocessor
User's Guide for Meteorological Preprocessor
Final Report available from NTIS
Latest Model Change Bulletin

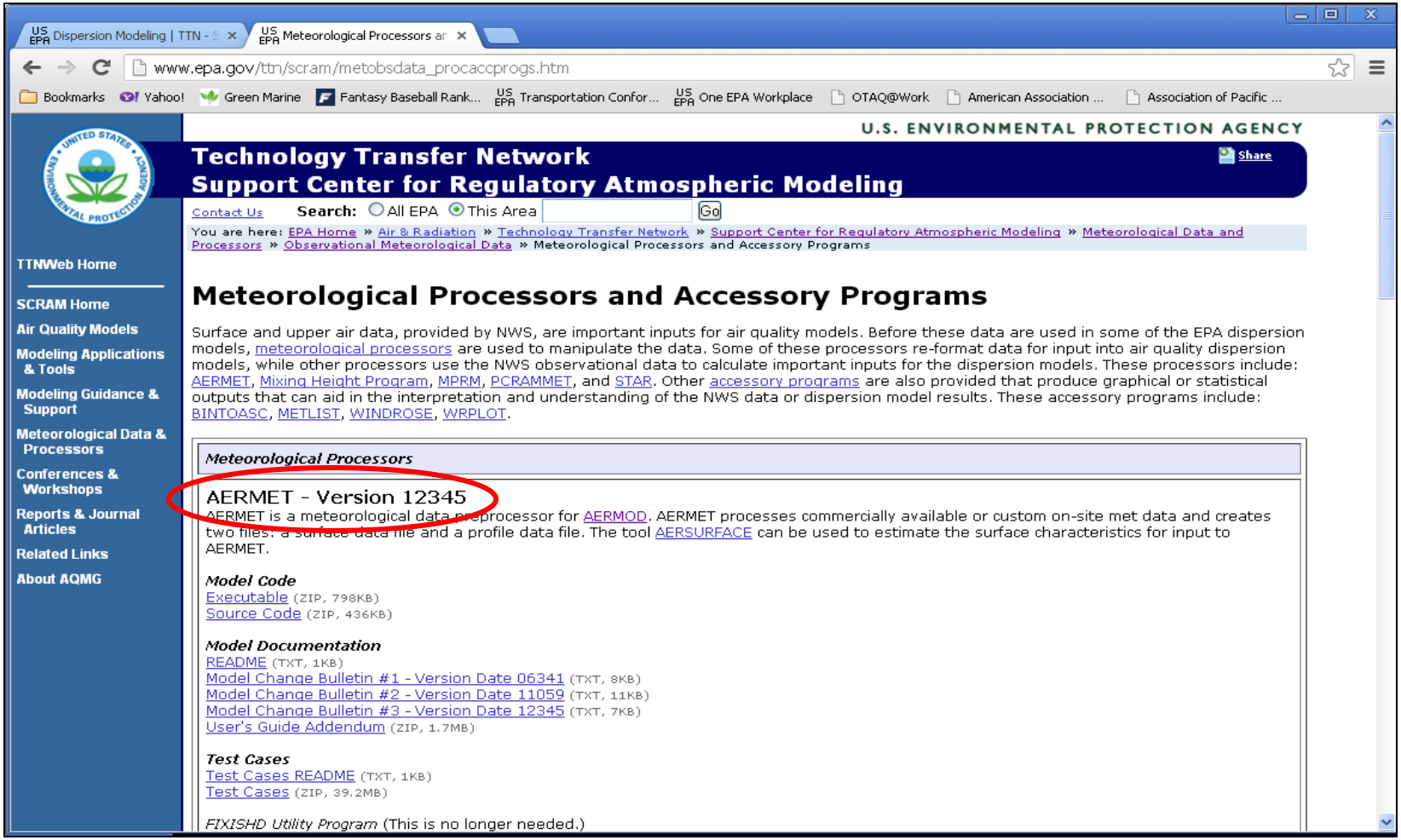
OCD
Offshore and Coastal Dispersion Model Version 5 (OCD) is a straight line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations.

Model Code
Code/Executable (8.6MB, ZIP, Windows XP Compatible, 5/16/05)

Model Documentation
User's Guide (408 MB, ZIP)

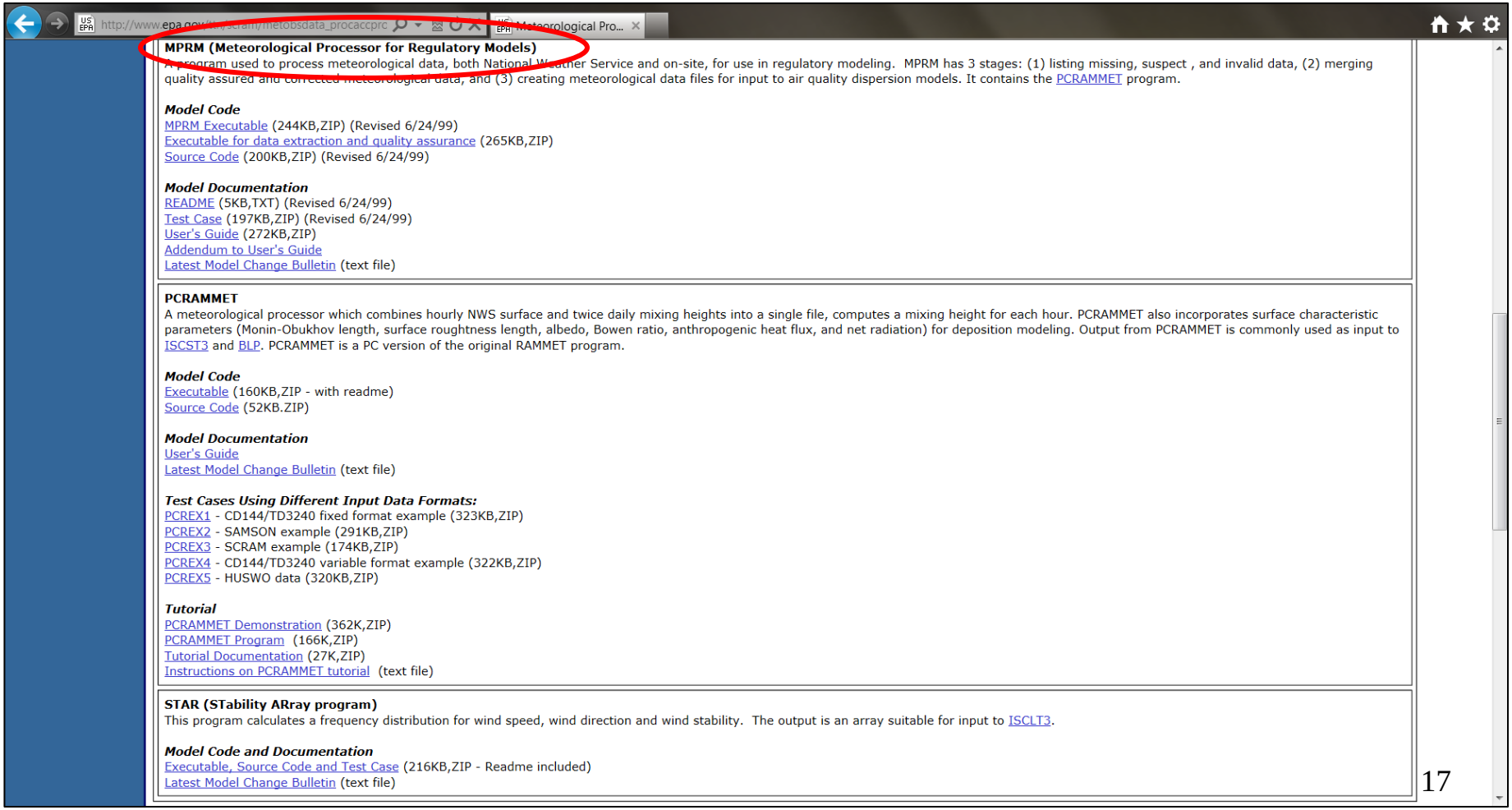
Air Quality Modeling Resources

www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm



Air Quality Modeling Resources

www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm



MPRM (Meteorological Processor for Regulatory Models)
A program used to process meteorological data, both National Weather Service and on-site, for use in regulatory modeling. MPRM has 3 stages: (1) listing missing, suspect , and invalid data, (2) merging quality assured and corrected meteorological data, and (3) creating meteorological data files for input to air quality dispersion models. It contains the PCRAMMET program.

Model Code
MPRM Executable (244KB,ZIP) (Revised 6/24/99)
Executable for data extraction and quality assurance (265KB,ZIP)
Source Code (200KB,ZIP) (Revised 6/24/99)

Model Documentation
README (5KB,TXT) (Revised 6/24/99)
Test Case (197KB,ZIP) (Revised 6/24/99)
User's Guide (272KB,ZIP)
Addendum to User's Guide
Latest Model Change Bulletin (text file)

PCRAMMET
A meteorological processor which combines hourly NWS surface and twice daily mixing heights into a single file, computes a mixing height for each hour. PCRAMMET also incorporates surface characteristic parameters (Monin-Obukhov length, surface roughness length, albedo, Bowen ratio, anthropogenic heat flux, and net radiation) for deposition modeling. Output from PCRAMMET is commonly used as input to ISCST3 and BLP. PCRAMMET is a PC version of the original RAMMET program.

Model Code
Executable (160KB,ZIP - with readme)
Source Code (52KB.ZIP)

Model Documentation
User's Guide
Latest Model Change Bulletin (text file)

Test Cases Using Different Input Data Formats:
PCREX1 - CD144/TD3240 fixed format example (323KB,ZIP)
PCREX2 - SAMSON example (291KB,ZIP)
PCREX3 - SCRAM example (174KB,ZIP)
PCREX4 - CD144/TD3240 variable format example (322KB,ZIP)
PCREX5 - HUSWO data (320KB,ZIP)

Tutorial
PCRAMMET Demonstration (362K,ZIP)
PCRAMMET Program (166K,ZIP)
Tutorial Documentation (27K,ZIP)
Instructions on PCRAMMET tutorial (text file)

STAR (STability ARray program)
This program calculates a frequency distribution for wind speed, wind direction and wind stability. The output is an array suitable for input to ISCLT3.

Model Code and Documentation
Executable, Source Code and Test Case (216KB,ZIP - Readme included)
Latest Model Change Bulletin (text file)

Using Alternative Models

- 40 CFR 51, App. W establishes a process for EPA Regional Offices to consider alternate models, when applicable
  - » Process is separate from conformity rule's interagency consultation process
- Section 3.2 of 40 CFR 51, App. W sets out objective criteria to consider such models
- May only occur in limited cases. EPA Regional Offices to consult with EPA HQ, when appropriate

Guidance Reference:

Section 7.3

Types of Emission Sources

	Line Source	Point Source	Area Source	Volume Source
Different source types can be used in a hot-spot analysis to represent…	• Highways and intersections	• Bus garage or transit terminal exhaust stacks	• Transit or freight terminals • Parking lots • Highways and intersections	

Guidance Reference:
Sect 7.3.2, App J.3.3-3.3.4

How Models Represent Emissions

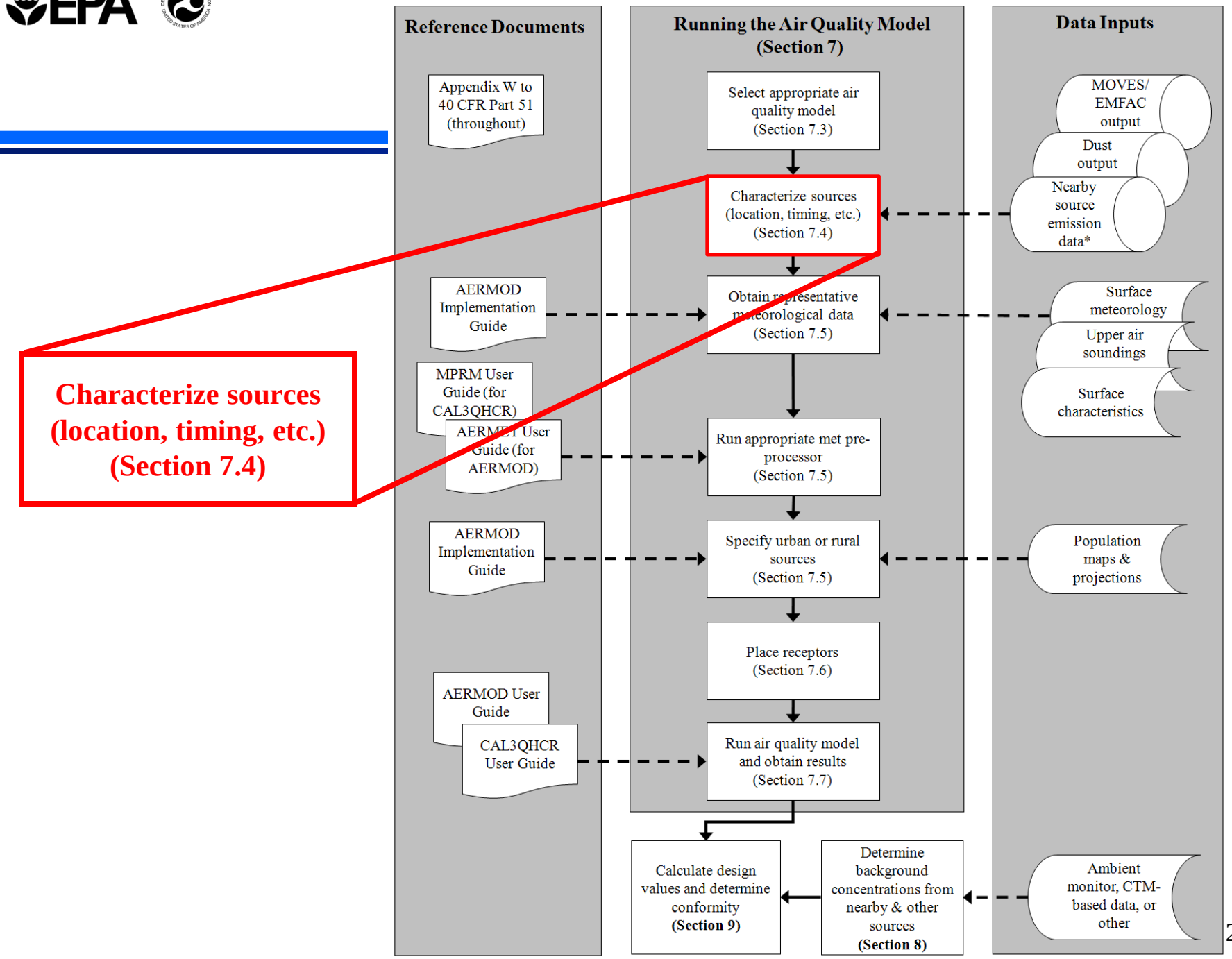
	Line Source	Point Source	Area Source	Volume Source
AERMOD	√ *	√	√	√
CAL3QHCR	√			

* AERMOD can simulate line sources using a series of adjacent area or volume sources; new AERMOD feature allows area sources to be described as a line

- Sources handled vary by model
- We will cover more in **Module 4** (AERMOD) and **Module 5** (CAL3QHCR)

Guidance Reference:

Sect 7.3.2, App J.3.3-3.3.4


Reference Documents
Running the Air Quality Model (Section 7)
Data Inputs
Appendix W to 40 CFR Part 51 (throughout)
Select appropriate air quality model (Section 7.3)
MOVES/ EMFAC output
Dust output
Nearby source emission data*
Characterize sources (location, timing, etc.) (Section 7.4)
AERMOD Implementation Guide
Obtain representative meteorological data (Section 7.5)
Surface meteorology
Upper air soundings
Surface characteristics
MPRM User Guide (for CAL3QHCR)
AERMET User Guide (for AERMOD)
Run appropriate met pre-processor (Section 7.5)
AERMOD Implementation Guide
Specify urban or rural sources (Section 7.5)
Population maps & projections
Place receptors (Section 7.6)
AERMOD User Guide
CAL3QHCR User Guide
Run air quality model and obtain results (Section 7.7)
Calculate design values and determine conformity (Section 9)
Determine background concentrations from nearby & other sources (Section 8)
Ambient monitor, CTM-based data, or other
Characterize sources (location, timing, etc.) (Section 7.4)

Characterizing Emission Sources

- "Characterization" is the way the project's features and emissions are represented within an AQ model
- There may be several different sources within the project area
- Will help ensure that the locations with greatest impacts on PM concentrations are identified
- To describe a source, characterization includes:
  - Physical characteristics and location
  - Emissions rates/emission factors, and
  - Timing of emissions

Guidance Reference:

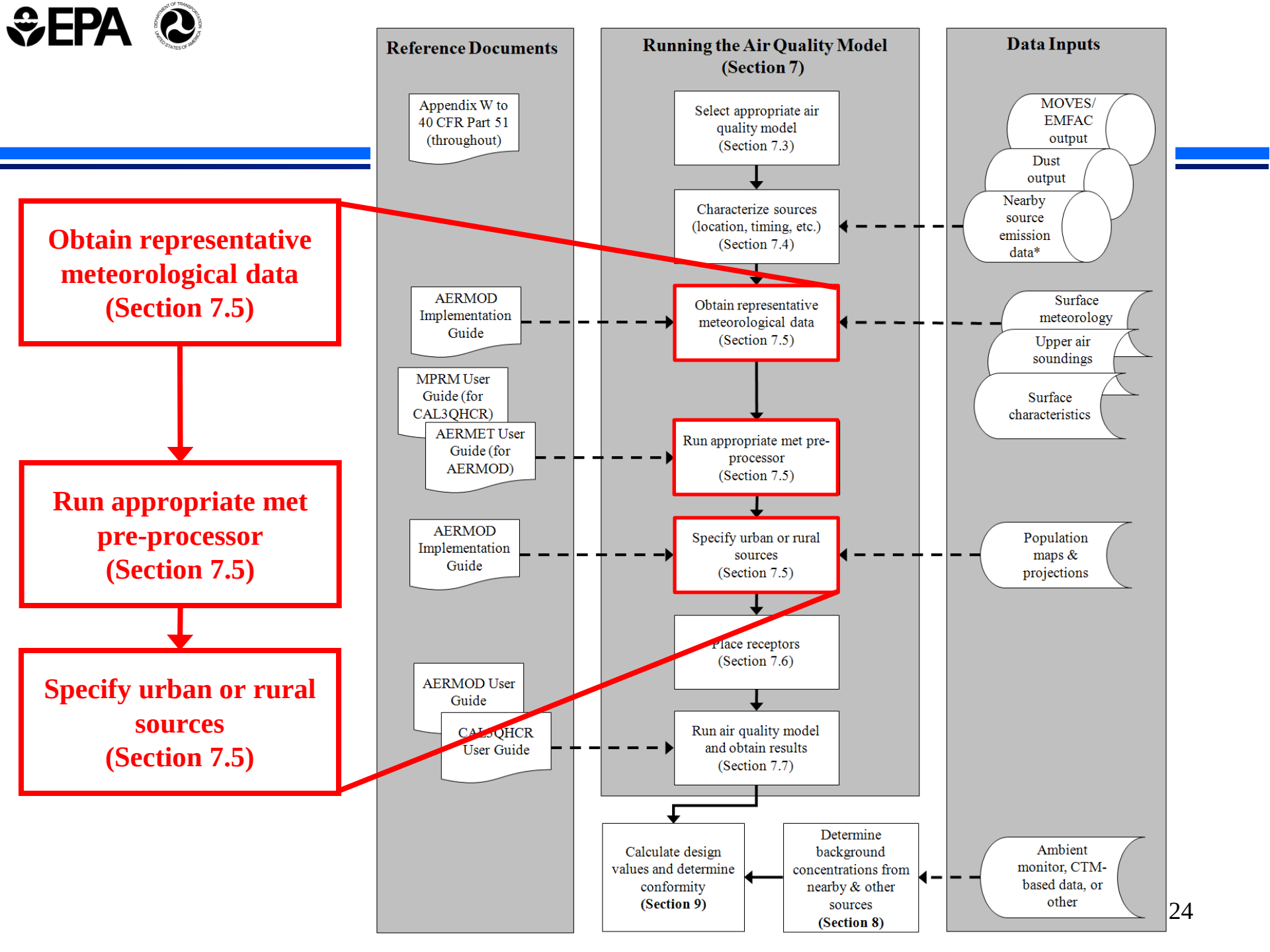
Section 7.4

Characterizing Emission Sources

- Some characterization already occurred when identifying project links for emissions modeling
- Emissions rates/emission factors are from the MOVES output
- For air quality modeling, physical characteristics and locations are assigned to the links developed for emissions modeling in MOVES
- Timing of emissions – need to describe emissions across time of year, day of week, and hour of day
  - » Decided when determining number of MOVES runs for analysis year
  - » Same approach applied to AQ modeling
- More details on characterization will be covered in **Module 4** and **Module 5**

Guidance Reference:

Section 7.4


Obtain representative meteorological data (Section 7.5)
Run appropriate met pre-processor (Section 7.5)
Specify urban or rural sources (Section 7.5)
Reference Documents
Appendix W to 40 CFR Part 51 (throughout)
AERMOD Implementation Guide
MPRM User Guide (for CAL3QHCR)
AERMET User Guide (for AERMOD)
AERMOD Implementation Guide
AERMOD User Guide
CAL3QHCR User Guide
Running the Air Quality Model (Section 7)
Select appropriate air quality model (Section 7.3)
Characterize sources (location, timing, etc.) (Section 7.4)
Obtain representative meteorological data (Section 7.5)
Run appropriate met pre-processor (Section 7.5)
Specify urban or rural sources (Section 7.5)
Place receptors (Section 7.6)
Run air quality model and obtain results (Section 7.7)
Calculate design values and determine conformity (Section 9)
Determine background concentrations from nearby & other sources (Section 8)
Data Inputs
MOVES/ EMFAC output
Dust output
Nearby source emission data*
Surface meteorology
Upper air soundings
Surface characteristics
Population maps & projections
Ambient monitor, CTM-based data, or other

Selecting Meteorological Data For Air Quality Modeling

- **Using meteorological data representative of project area is critical for PM hot-spot analyses**
  - » Key factor in producing credible results

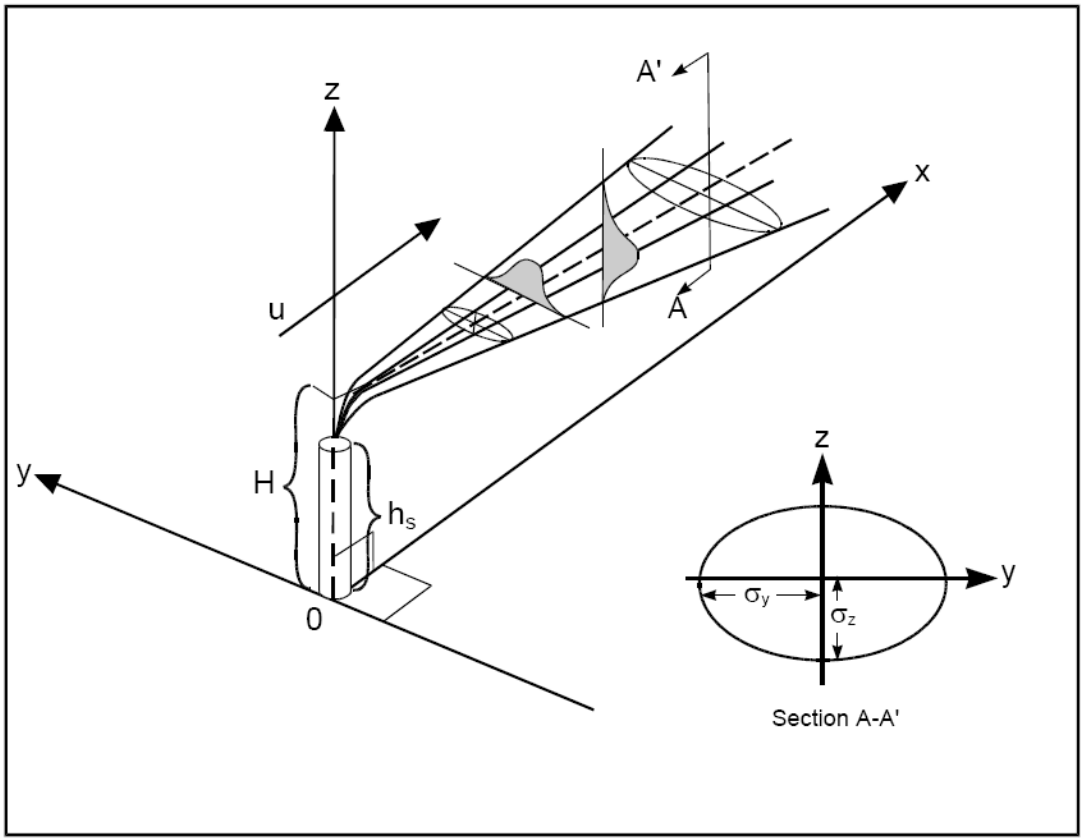
- Let's next discuss some air pollution dispersion and meteorology basics to help:
  - » Understand how meteorology affects dispersion
  - » See how this data is used by air quality models for these analyses and understand recommendations in the guidance
  - » Determine representativeness of met data

Guidance Reference:

Section 7.5

A Geometric Depiction of Dispersion

- Both AERMOD and CAL3QHCR are **steady-state Gaussian dispersion models**
  - Emission rate, wind speed, wind direction, and atmospheric stability are constant during the life of the plume
  - Concentrations are assumed to follow a Gaussian distribution in the cross-wind horizontal and vertical directions
  - Assumes dispersion along the transport wind direction has a small effect on the plume
  - Computationally simple



Gaussian Plume Equation Basics

$$\chi_{avg} = \frac{Q}{u \times A}$$

where χ_{avg} is the average pollutant concentration in the plume cross-section (g/m^3);

Q is the pollutant emission rate (g/s);

u is the transport wind speed (m/s); and

A is the plume cross-sectional area (m^2)

Gaussian Plume Equation Basics

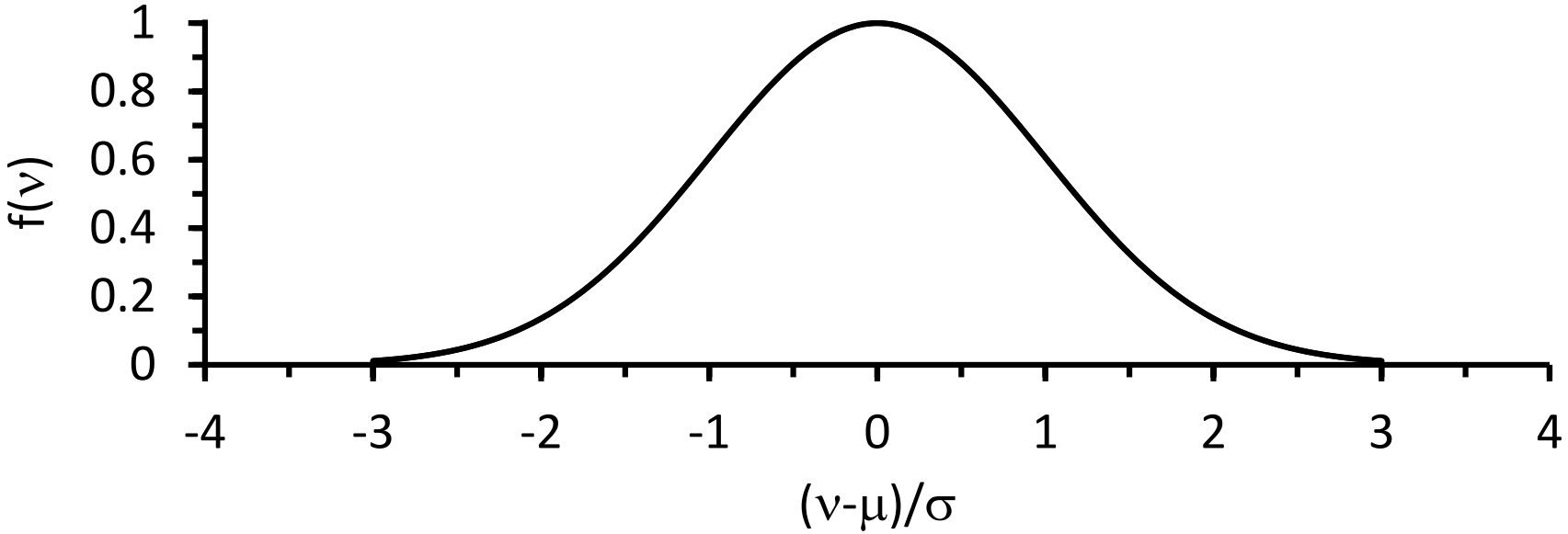
$$g/m^3 \triangleq \frac{g/s}{m/s \times m^2}$$

$$\chi_{avg} = \frac{Q}{u \times \pi \, r_y \, r_z}$$

where r_y is the horizontal radius of the plume (m) and

r_z is the vertical radius of the plume (m)

Gaussian Plume Equation Basics



The Gaussian or normal distribution can be expressed mathematically:

$$f(\nu) = \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left[-\frac{1}{2}\left(\frac{\nu-\mu}{\sigma}\right)^2\right]$$

Gaussian Plume Equation Basics

$$\chi = \frac{Q}{2\pi\, u\, \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Dilution Term | Crosswind Term | Vertical Term | Reflection Term

What is the form of this equation for:

ground-level concentrations (z = 0)
on plume centerline (y = 0)
due to a ground-level source (H = 0)?

HINT: $\exp(0) = ?$

Gaussian Plume Equation Basics

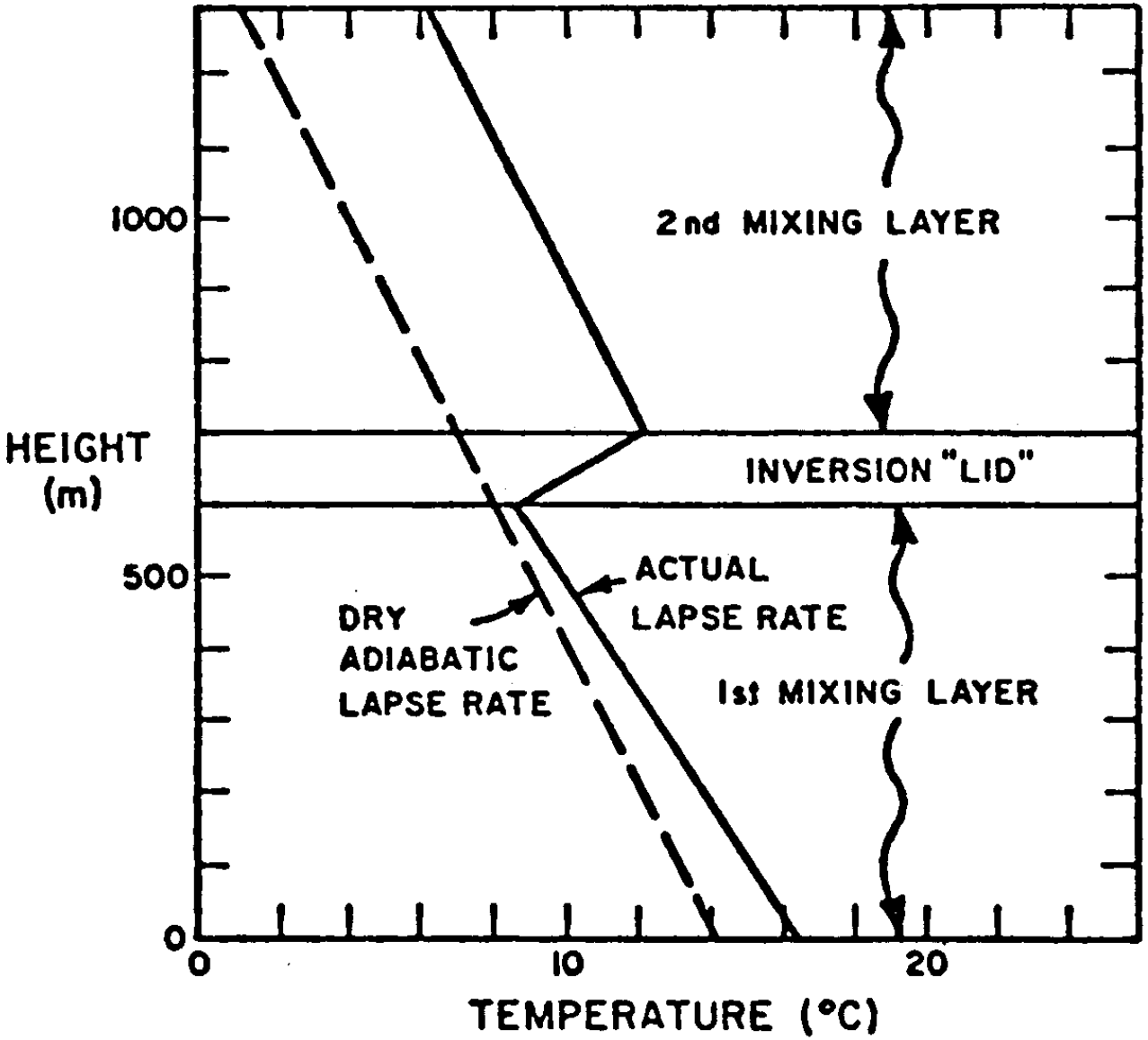
$$\chi = \frac{Q}{\pi \, u \, \sigma_y \, \sigma_z}$$

Gaussian Plume Equation Basics

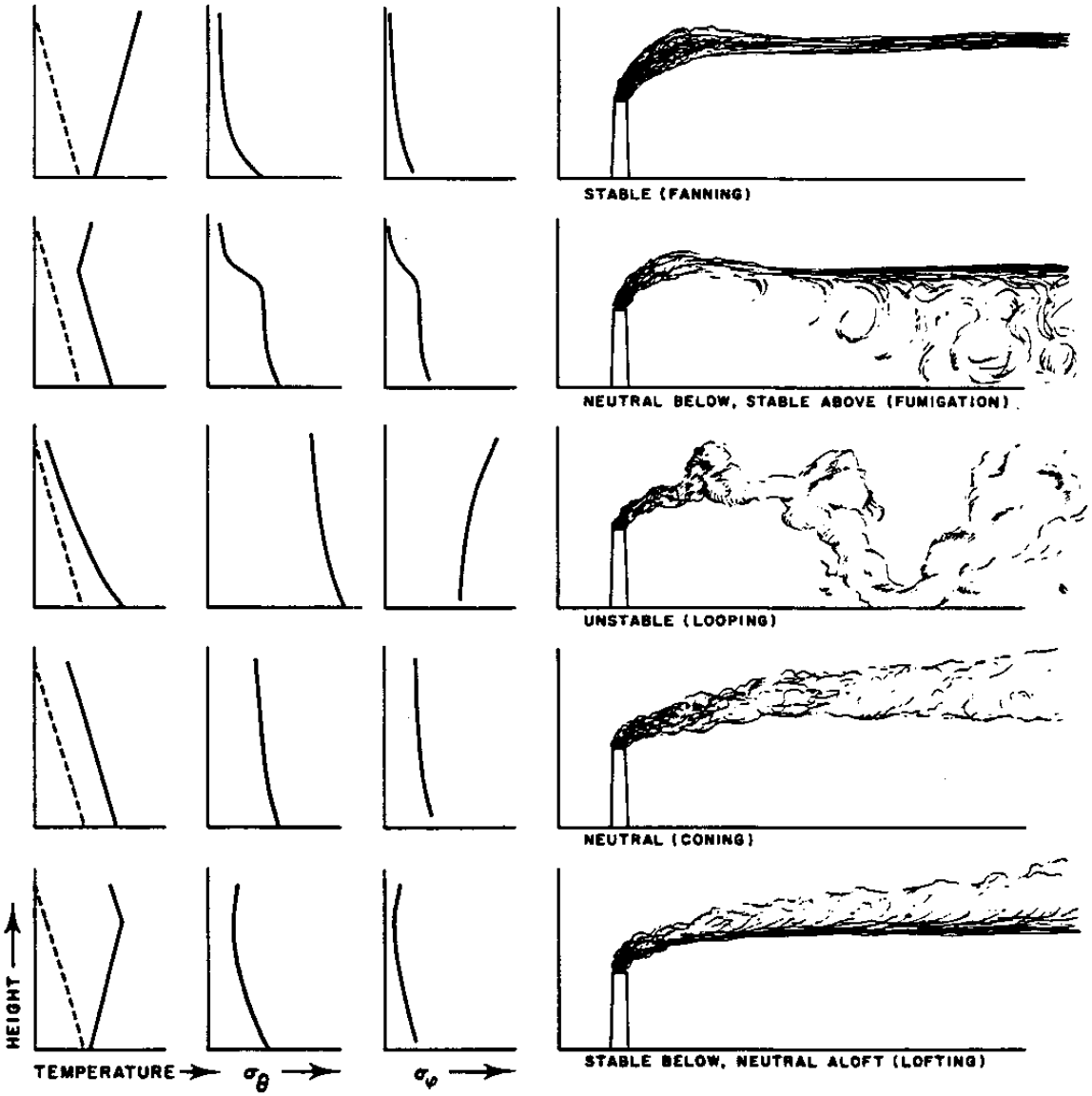
$$\chi = \frac{Q}{\pi \, u \, \sigma_y \, \sigma_z}$$

$$\chi_{avg} = \frac{Q}{\pi \, u \, r_y \, r_z}$$

Mixing Height



Vertical Plume Dispersion



How Air Quality Models Consider Met Data

- Following met data is typically required…
  - Upper air data
  - Surface data
  - Surface characteristics
  - Population data to account for urban heat island effect

- Air quality models require processed met data
  - AERMET is the preprocessor for AERMOD
  - MPRM is the preprocessor for CAL3QHCR
  - Consult respective user guides for specifics on what met data is required, etc.

- State and local air agencies have experience finding representative met data
  - May have preprocessed met data available

Guidance Reference:

Section 7.5.1

How Air Quality Models Consider Met Data

Air Quality Model	Upper Air Data	Surface Data		Surface Characteristics			Urban Dispersion
	Vertical temp profile, etc.	Wind/ temp	Cloud cover	Albedo	Bowen ratio	Surface roughness	Urban population
AERMOD							√ **(if modeling urban source)**
CAL3QHCR						√	√ **(if modeling urban source)**

Necessary met preprocessor input (will be included in preprocessed met data)

√ Necessary dispersion model input

Upper Air Data

- Upper air data in this context refers to the gradients in the vertical temperature and other measurements of the atmosphere
- Upper air data is collected by weather balloons launched twice daily from sites around the country
- Results in a vertical profile of temperature and other factors

Upper Air Data - Guidance

- **Use upper air data that is most representative of the project area**
  - Upper air data tends to be regionally uniform; therefore, upper air data obtained from the nearest met data site will often be most representative
  - Exception: this may not always be the case for projects located near large bodies of water, other unusual geographic features
  - Assess data case-by-case
  - Interagency consultation can be used to determine whether preprocessed met data are available

- Upper air data is needed for both AERMOD and CAL3QHCR models.
  - Establishes height of mixing layer
  - This is usually contained in a file from a met preprocessor
  - Consult AERMOD & MPRM user guides for more

Guidance Reference:

Section 7.5.1

Surface Data

- Surface data refers to met data describing conditions near the ground (usually 10m tower)
  - Most frequently obtained from airports as collected by the National Weather Service ("NWS" in user guides)

- Surface data used by dispersion models:
  - Wind speed and direction – we will describe this in more detail, following slide
  - Temperature
  - Cloud cover/sky cover (% obscuring ground)
  - Atmospheric pressure

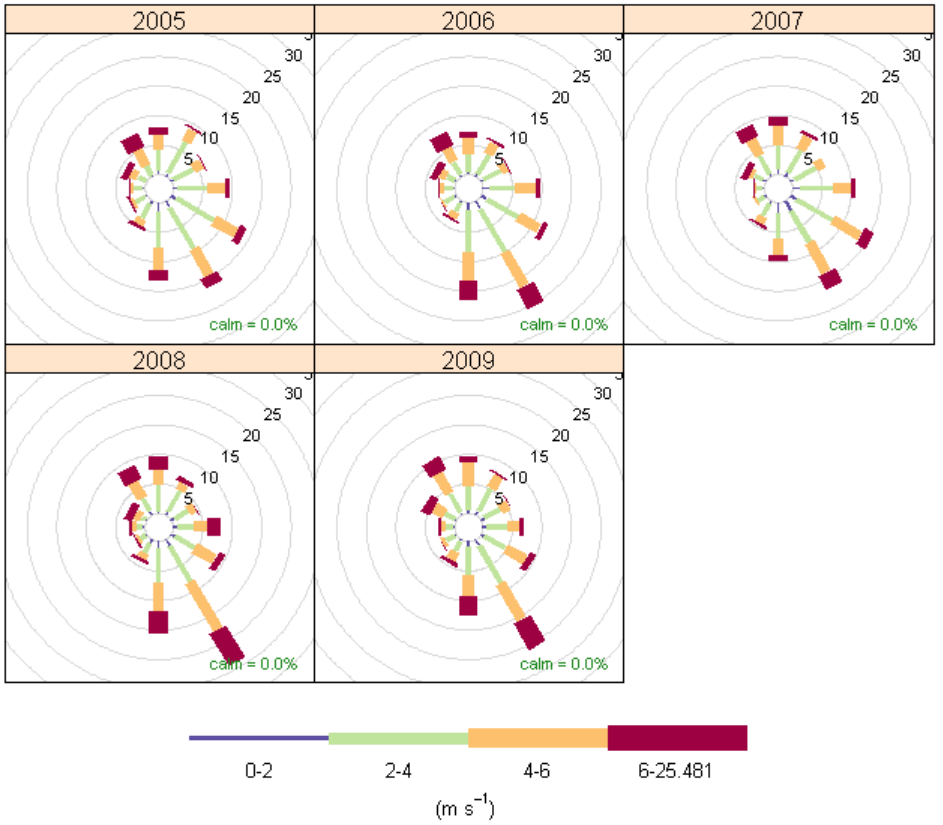
- Also used by MOVES:
  - Temperature
  - Relative humidity

Guidance Reference:

Section 7.5.2

Surface Data - Wind

- Wind roses represent the distribution of wind speed and direction in a given place over a given time
  - » Direction of “petals” indicate wind direction
  - » Length of petals indicate frequency of wind direction
  - » Color or width within the petal denotes wind speed
- Winds are described by the direction from which they blow
  - » “Westerly” = from the west
  - » “Southerly” = from the south



Wind roses from openair package for R (free) using Houston Elliston airport data from NCDC CDO web site (free).

Surface Data - Guidance

- **Use surface data that is most representative of the project area**
  - » Key factor in producing credible results
  - » Representativeness needs to be assessed independent of upper air data
  - » Following slides will get into details

- In addition to being an air quality model input, the prevailing winds in the project area should be looked at to:
  - » Help determine the placement of receptors in air quality modeling
  - » Assess if a background monitor is representative, as will be discussed in **Module 6**

- Surface data is needed for both AERMOD and CAL3QHCR

Guidance Reference:

Section 7.5.1 and 7.5.2

Surface Data - Guidance

- How to determine if surface data is representative of project area? Some factors….
  - **Similarity of data to project area's surface characteristics**
  - Proximity to project area
  - Time period of data collection
  - Topographic characteristics
  - Year-to-year variations in weather conditions

- The similarity of data to project area's surface characteristics to the location of the surface meteorological monitor used is very important
  - These characteristics discussed on next slides

Guidance Reference: Section 7.5

AERMOD Implementation Guide

Surface Characteristics

Surface characteristics affect meteorology. Air quality models handle this data differently.

- **Albedo** – The amount of solar radiation reflected by the surface
  - » Needed for AERMOD
- **Bowen ratio** – How much energy goes to evaporation vs. warming the surface
  - » Needed for AERMOD
- **Surface roughness** – The effect of surface features on wind movement (more on next slides)
  - » Needed for both AERMOD and CAL3QHCR
  - » Also referred to as "roughness length"

Guidance Reference:

Section 7.5.4

Surface Characteristics – Surface Roughness

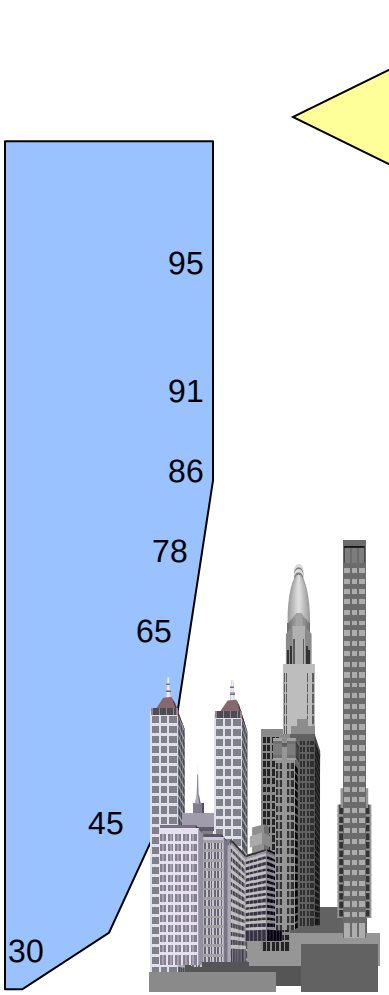
- Tall obstacles slow wind more than short obstacles
- "Roughness length" helps describe the amount of mechanical turbulence that wind faces when blowing across a surface

SURFACE ROUGHNESS LENGTH (METERS)
BY LAND-USE AND SEASON

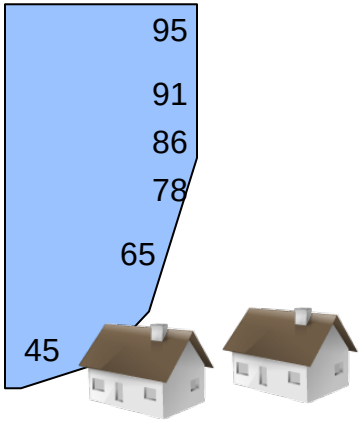
Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated Land	0.03	0.20	0.05	0.01
Urban	1.00	1.00	1.00	1.00
Desert Shrubland	0.30	0.30	0.30	0.15

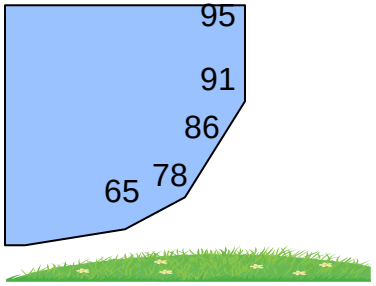
From AERMET User Guide

Surface Characteristics – Surface Roughness



When surface is “smoother,” wind speeds are higher at surface level and peak speeds are reached at a lower height.





Numbers indicate wind speed (m/s)

Years of Met Data Needed

- How many years of met data are needed?
  - » Off-site data (e.g., from NWS): **5 consecutive years**
  - » Site-specific data: **at least 1 year**
  - » This is consistent with 40 CFR 51, App. W

- Site-specific refers to surface data; upper air data will not be site-specific

- Since site-specific data is not typically available, most PM hot-spot analyses will be based on 5 years of met data
  - » 5 consecutive years of the most recent representative met data should be used
  - » Allows for variation in met conditions to be considered

- Preprocessed met data may be available/appropriate to use (more later)

Guidance Reference:

Section 7.5

Air Quality Model Capabilities for Met Data

Air Quality Model	Number of Runs with 5 Years of Off-Site Met Data	Number of Runs with 1 year of Site-Specific Met Data
AERMOD	1-5 (Can run 5 years met data at once, or in individual runs)	1 (1 run X 1 year met data)
CAL3QHCR	20 (4 quarterly runs X 5 years met data)	4 (4 quarterly runs X 1 year met data)

- Number of runs depends on the model, years of met data used, and number of quarters to be modeled for each analysis year
- Per guidance, it will generally be necessary to model all quarters for each analysis year (see **Module 1**)
- Consult Section 8.3.1 of 40 CFR 51, App. W

Guidance Reference:

Section 7.5

Where to Obtain Meteorological Data

- Upper air and surface data:
  - State and local air agencies
  - National Weather Service
  - NOAA National Climatic Data Center (www.ncdc.noaa.gov)
  - Federal Aviation Administration, universities, military bases, industrial facilities
  - EPA's SCRAM website

- Surface characteristics data:
  - U.S. Geological Survey land use/land cover maps
  - National land cover database (www.mlrc.gov)
  - Some MPOs may have data

- Note: may need to use different sources for upper air, surface data, and surface characteristics data to ensure representativeness

Guidance Reference:

Section 7.5

Met Data Processing Steps

1. Obtain Surface Meteorology
   - Most surface data are 1-hour measurements or observations
   - More recent data are collected in 1-minute resolution
2. Obtain Upper Air Meteorology
   - If radiosonde data are obtained, process the data using EPA's Mixing Height Program to obtain mixing heights
3. Quality Assurance/ Quality Control
   - Refer to EPA's Quality Assurance/Quality Control requirements
4. Convert Surface Data Into an Accessible Format, if Needed
   - Refer to EPA's guidance
5. Process Surface and Mixing Height Data to Obtain Met Data Files
   - Use AERMET (if using AERMOD) or MPRM (CAL3QHCR)

Using Preprocessed Met Data

- **Some state and local agencies may already have 5 years of preprocessed data available**

- If available, this will save effort
  - » Will not be necessary to run AQ model met preprocessor
  - » Already be formatted for use by AQ models
  - » More likely available for AERMOD

- However, if using preprocessed data, sponsor still must ensure it is representative of project area
  - » Do not use simply because available
  - » Same guidance for determining if data is representative applies to preprocessed data

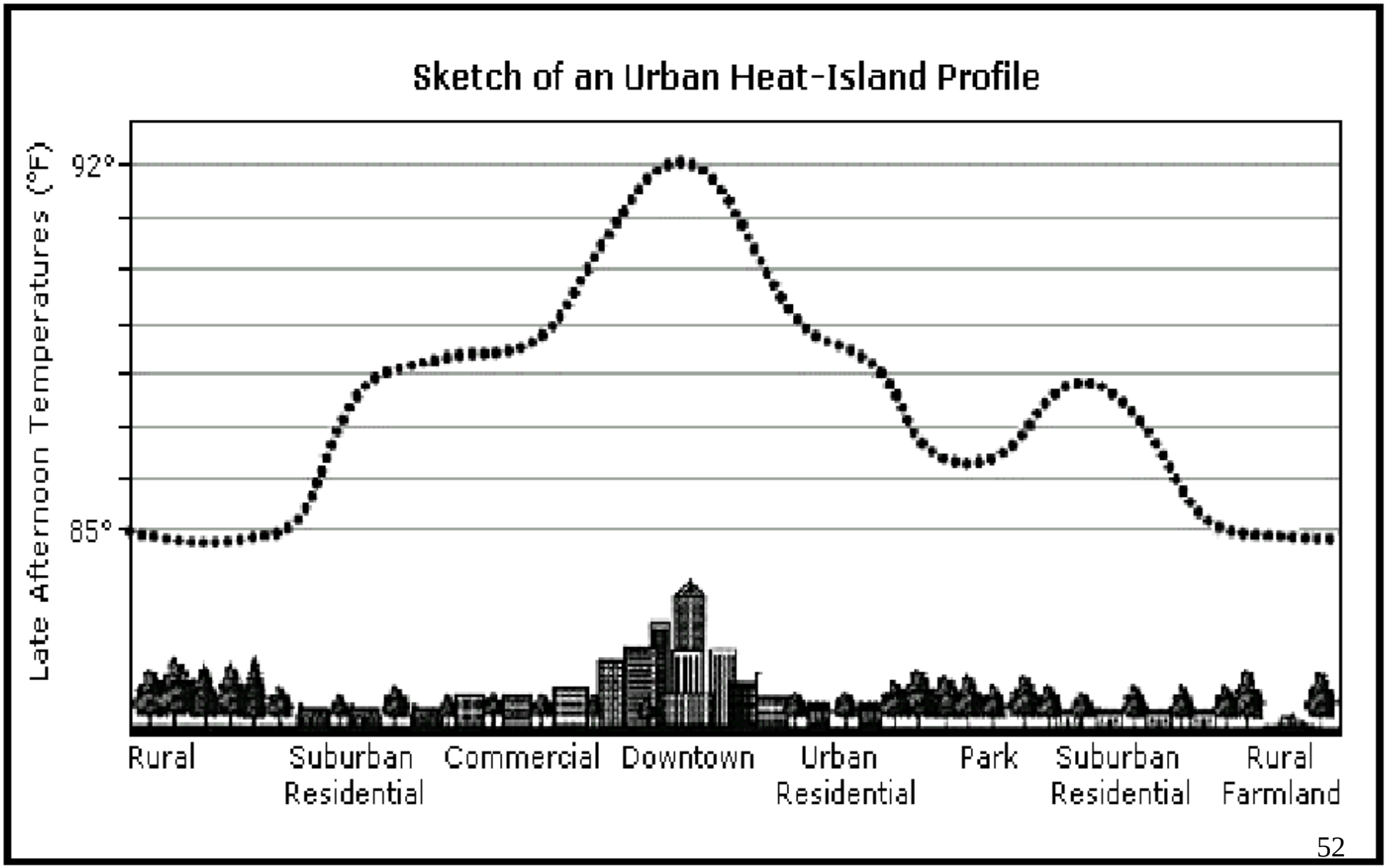
Guidance Reference:

Section 7.5

Urban Dispersion

- Buildings, asphalt, and other elements of urban areas absorb heat well during daytime and release it slowly at night
- Urban sources like vehicles and furnaces add heat. Rural areas cool more quickly than urban areas
- The urban heat island produces greater vertical mixing ("instability") than present in surrounding areas
  - » Creates a "hot zone" within the first few hundred meters that can last overnight
  - » Enhances urban dispersion
- Important to account for this in air quality modeling, as it affects pollutant dispersion, particularly at night

Urban Dispersion



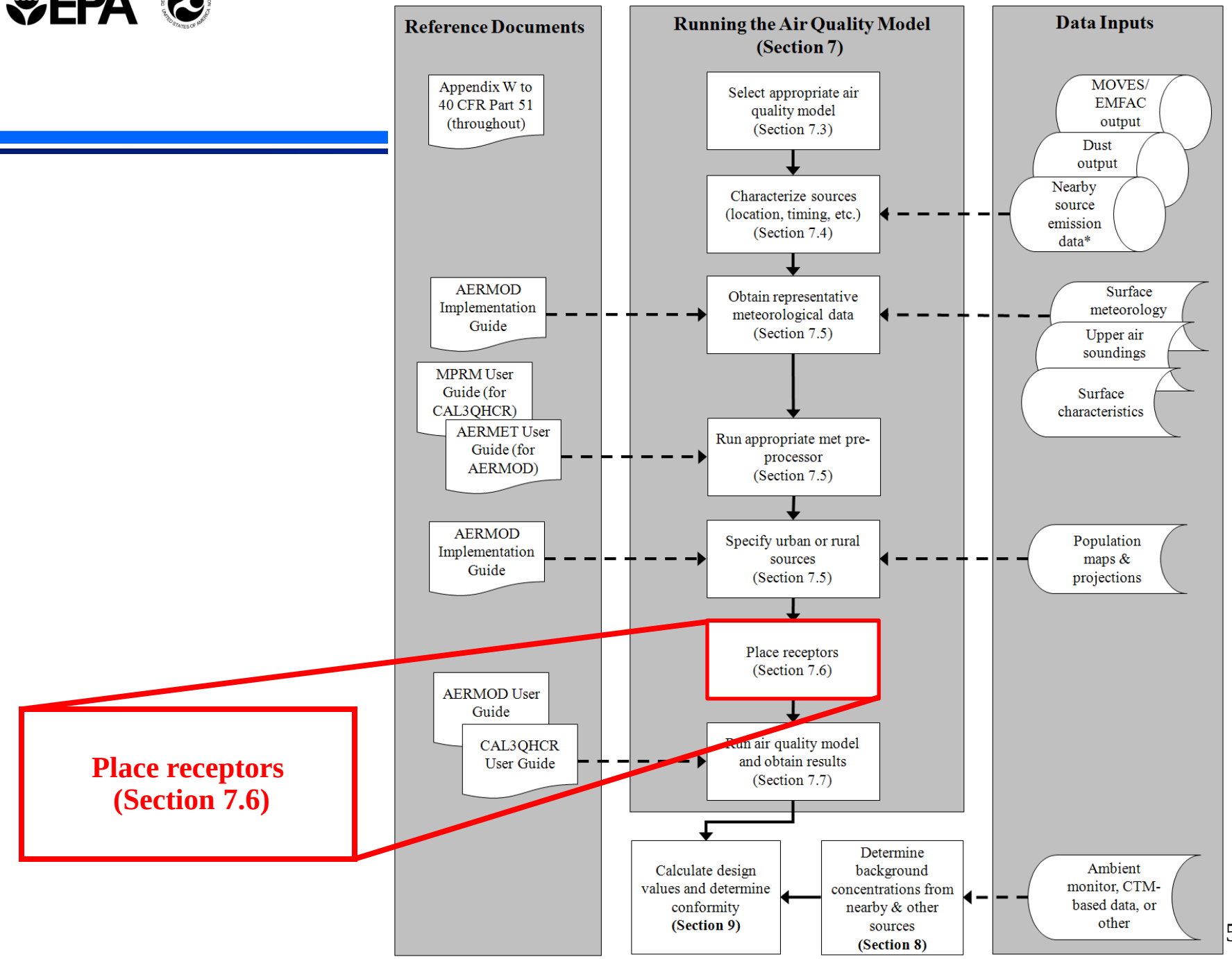
Urban Dispersion – Guidance

- Both AERMOD and CAL3QHCR can account for urban dispersion
  - » Population is a required input if using AERMOD

- For PM hot-spot analyses:
  - » In urban areas – treat sources as **urban**
  - » In isolated rural areas – treat sources as **rural**
  - » Near the edge of urban area – **use interagency consultation process**

Guidance Reference:

Section 7.5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CAL3QHCR User Guide
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Calculate design values and determine conformity (Section 9)
Determine background concentrations from nearby & other sources (Section 8)
Ambient monitor, CTM-based data, or other
Place receptors (Section 7.6)

Placing Receptors

- A “receptor” is a location in an air quality model where pollutant concentrations are estimated
- Receptors must be placed in appropriate locations in “the area substantially impacted by the project” (in the “project area”) (93.123(c)(1))
  - The “area substantially impacted” will vary by project
- An “appropriate location” is one suitable for comparison to the relevant PM NAAQS and varies by NAAQS
- Should take into account project emissions and any modeled nearby sources
- State and local agencies have significant expertise in AQ modeling

Guidance Reference: Section 7.6.1

Receptor Guidance for All PM NAAQS

NAAQS	Applicable Receptor Guidance
24-hour PM_{10} NAAQS	Section 7.6.2
24-hour $PM_{2.5}$ NAAQS	Section 7.6.2
Annual $PM_{2.5}$ NAAQS	Sections 7.6.2 and 9.4

Guidance Reference:

Section 7.6.2

Receptor Guidance for All PM NAAQS

- PM hot-spot guidance reflects 40 CFR 51, App. W guidance on receptor placement
- Receptor placement should take into account factors like:
  - Prevailing wind directions
  - Monitor locations
  - Topography
  - Other factors
- Emphasis should be on resolution and location, not total number of receptors
- Use process established by the interagency consultation procedures to determine where to place receptors (93.105(c)(1)(i))

Guidance Reference:

Section 7.6.2

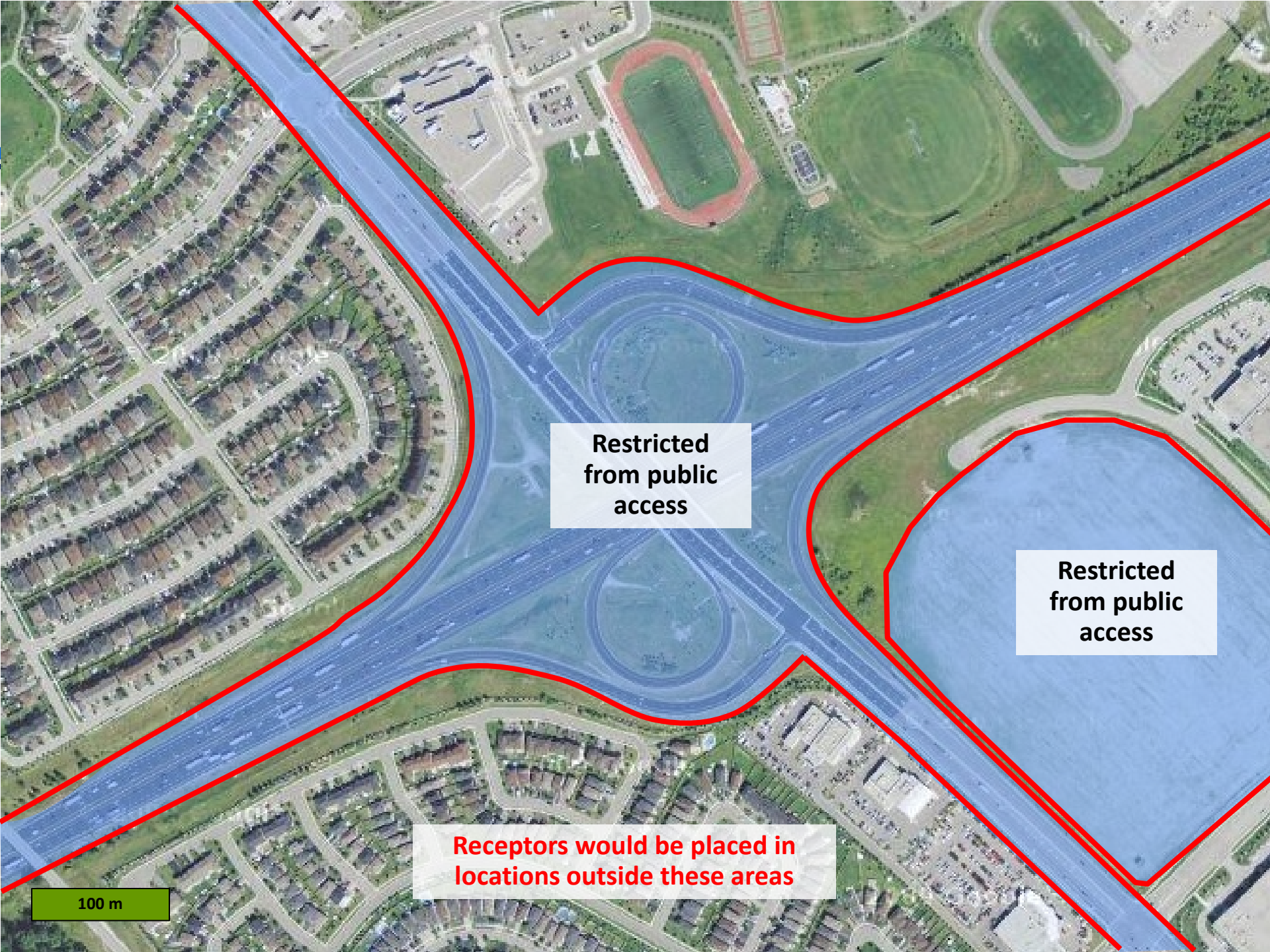
Receptor Guidance for All PM NAAQS

- When placing receptors, consider if certain locations should be excluded, such as….
  - » Areas restricted from public access
  - » Areas public is in for only very brief periods of time
  - » Examples:
    - A highway median strip or fenced business property
    - The approach to a tunnel
    - Within the right-of-way line of limited access highway, etc.
- However, do place receptors in locations public can access, such as…
  - » Sidewalks
  - » Neighborhoods
  - » Parks

Guidance Reference:

Section 7.6.2


Where could receptors be excluded?
New highway interchange
School
Residential
Fenced commercial property
Residential
Retail
100 m


Restricted from public access
Restricted from public access
Receptors would be placed in locations outside these areas
100 m

Receptor Guidance for All PM NAAQS

- Place receptors…
  - » At all locations where high concentrations may occur – not just the worst case location(s)
  - » In all directions from the project
  - » In locations that will capture the impacts of the project and any nearby sources that need to be modeled
  - » At near-ground level (1.8 m or less) – but higher if needed
- Receptors should be located in the same places for build and no-build scenarios
- How close do I place receptors?
  - » To within 5 m of source (if urban canyon: 2-10 m)
  - » Consistent with 40 CFR Part 58:
    - – Appendix D, Section 4.7.1(c)(1)
    - – Appendix E, Section 6.3(b) and Table E-4

Guidance Reference:

Section 7.6.2

Receptor Guidance for All PM NAAQS

- How far away do I place receptors?
  - » Receptors must be placed in appropriate locations in "the area substantially affected by the project" (93.123(c)(1))
  - » Highest concentrations may not be captured at those receptors closest to the source due to project geometry, nearby sources, etc.
  - » Receptors should be located at a sufficient distance from sources being modeled to account for this dispersion and other emissions in project area (e.g., up to 500 m). This distance can vary around project.
  - » Details will depend on the project. Considerations may include:
    (1) Wind, topography, proximity of emissions sources relative to each other
    (2) What would show the air gradient around modeled sources

Guidance Reference:

Section 7.6.2

Receptor Guidance for All PM NAAQS

- How should I space receptors throughout the project area?
  - » Between the nearest and farthest receptors – spacing can vary
  - » Consider finer spacing (e.g., 25 m) closer to near-ground source and wider spacing (e.g., 100 m) farther from source

Guidance Reference:

Section 7.6.2

Class Exercise:
What is the Project Area?

Notes on Project Area Cases

- Projects are hypothetical and are presented for discussion purposes only
- Specifics presented here may not directly apply to real world projects/scenarios
- Projects presented are assumed to have been determined to be projects of air quality concern requiring a PM hot-spot analysis

Determining the Project Area: Case A

- The project is an expansion of an existing highway segment (~4 miles) with associated interchange reconfiguration.

- The highway is located in an urban area and primarily runs through residential and commercial neighborhoods.


Case A:
Highway widening & intersection reconstruction
Hypothetical situation
Project footprint
1/2 mile
500 m

Determining the Project Area: Case A

- What considerations should be taken when determining project area?
- Where would receptors be placed for air quality modeling?

Where would receptors be placed?

Hypothetical situation

Where would receptors be placed?

Hypothetical situation

Determining the Project Area: Case A

- What considerations should be taken when determining project area?
  - The project area would include the project itself and any roads whose emissions are expected to be affected by the project. These roads would also be included in emissions modeling
  - Roads within project area not affected by project need not be modeled.
  - Project area would also include the area where receptors would be placed for air quality modeling (see below).

- Where would receptors be placed for air quality modeling?
  - Receptors should be placed in appropriate locations to estimate the highest concentrations and possible violation of a NAAQS
  - Receptors are not needed in the highway right-of-way, locations not accessible to the public, etc.

Determining the Project Area: Case B

- The proposed project is a new bus terminal being built on a city lot that is currently vacant
- The terminal is to be located on the edge of the central business district and near both residential and commercial neighborhoods
- There are no nearby sources that need to be included in air quality modeling


Case B:
New bus terminal
Hypothetical situation
Project footprint
100 m

Determining the Project Area: Case B

- What considerations should be taken when determining project area?
- Where would receptors be placed for air quality modeling?

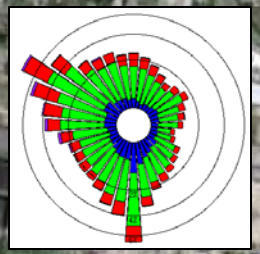
What is the project area?

Hypothetical situation

What is the project area?

Hypothetical situation

Receptor density can decrease away from project



500 m

Roads affected by project

Emissions modeling

Project area boundary

Air quality modeling

Determining the Project Area: Case B

- What considerations should be taken when determining project area?
  - The project area would include the project itself and any roads whose emissions are expected to be affected by the project. These roads would also be included in emissions modeling.
  - Roads within project area not affected by project need not be modeled.
  - Project area would also include the area where receptors would be placed for air quality modeling (see below).

- Where would receptors be placed for air quality modeling?
  - Receptors should be placed in appropriate locations to estimate the highest concentrations and possible violation of a NAAQS
  - Receptors are not needed in the highway right-of-way, locations not accessible to the public, etc.

Determining the Project Area: Case C

- The proposed project is a long highway segment (~30 miles) that is being expanded with reconfiguration of the associated interchanges.
- The highway is located on a city edge and runs through residential/rural settings with some commercial uses near interchanges.
- There are no nearby sources that need to be included in air quality modeling.
- Based on traffic modeling, the southernmost interchange of project is expected to experience the highest AADT and longest traffic delay. An adjacent interchange (not part of the project) will be affected by the project and also expected to have high emissions relative to the rest of the project.

Where would receptors be placed?

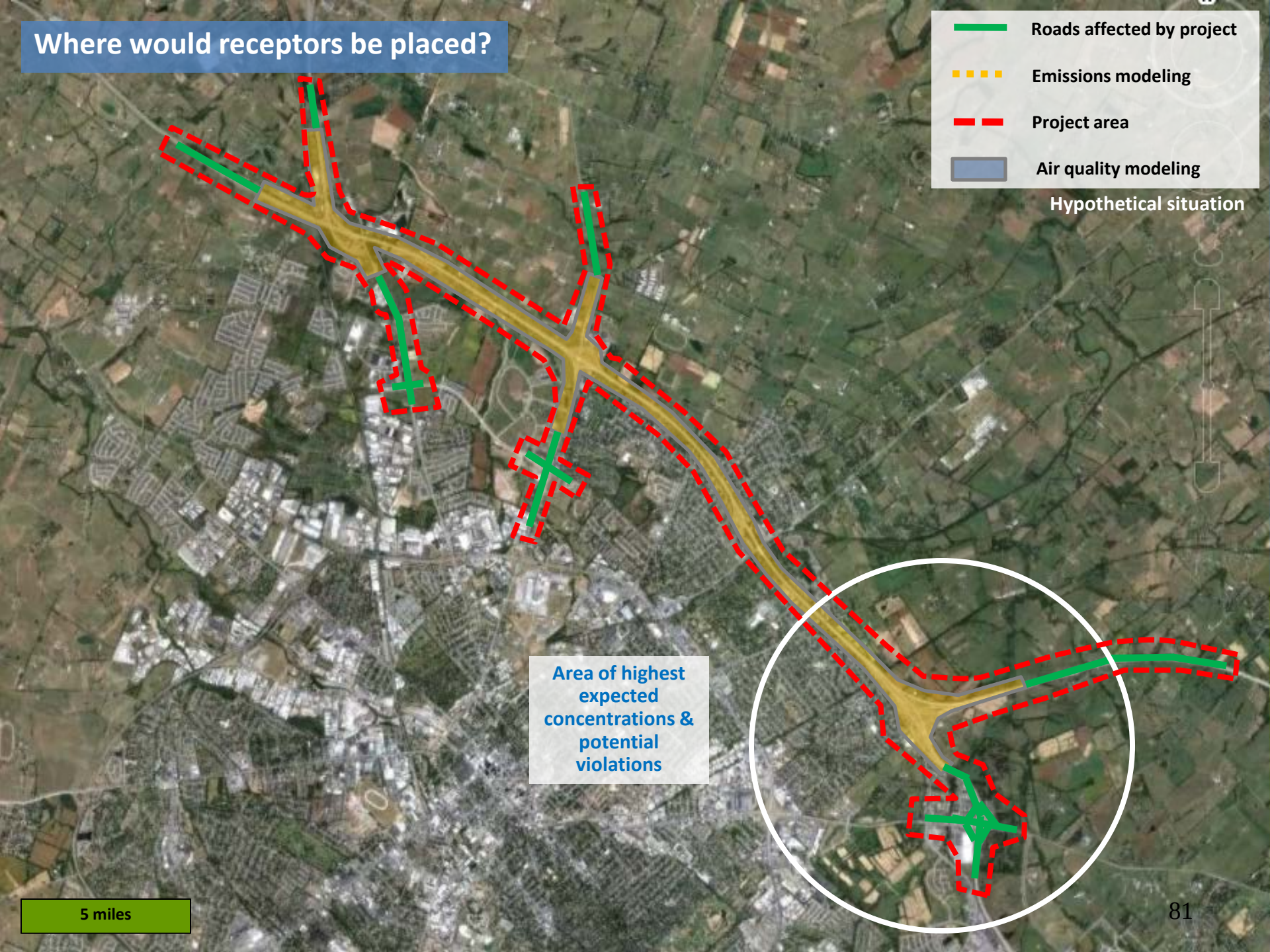
Hypothetical situation

Determining the Project Area: Case C

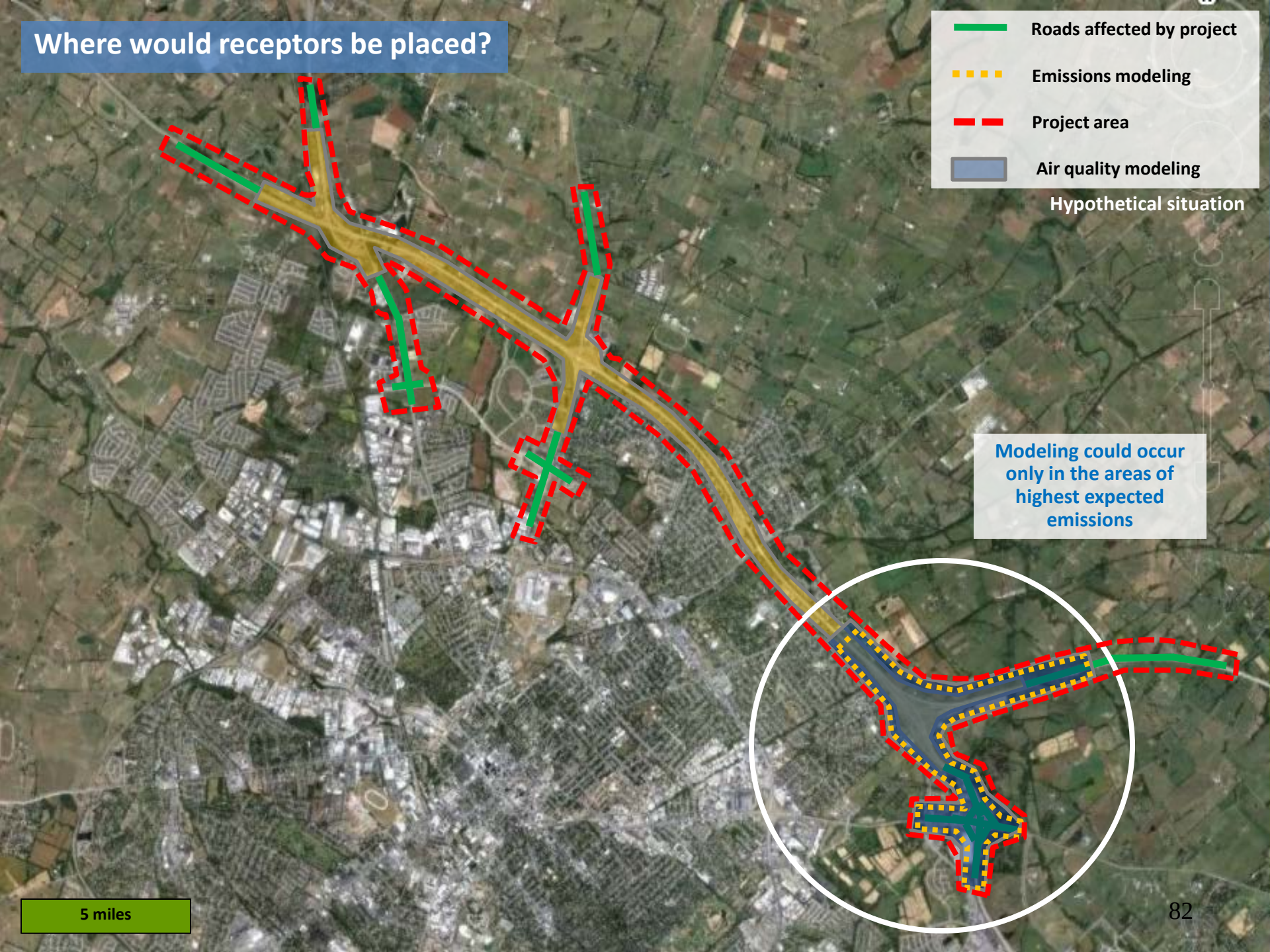
- For this project, what considerations might be taken when determining project area, given its size and the location of expected highest emissions?

- Where would receptors be placed for air quality modeling?

Where would receptors be placed?



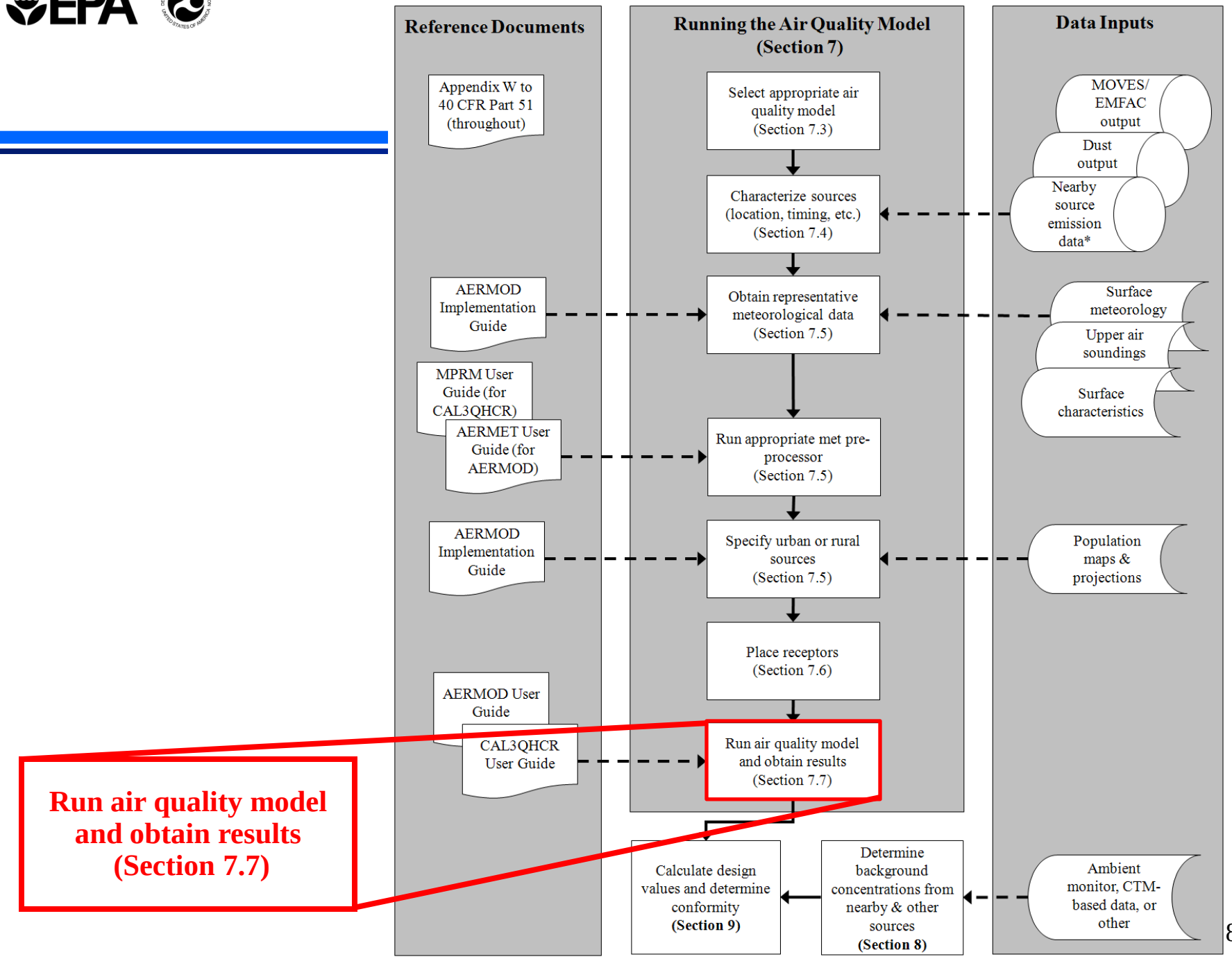
Where would receptors be placed?



Determining the Project Area: Case C

- For this project, what considerations might be taken when determining project area, given its size and the location of expected highest emissions?
  - » In this case, only the portion of the project area expecting to show the highest emissions could be selected for emissions and air quality modeling (see next question).
  - » Background concentrations would be the same in all parts of the project area

- Where would receptors be placed for air quality modeling?
  - » It may be appropriate to model only the part(s) of the project area where project emissions and background data are expected to be highest and violations most likely to occur. In this case, based on traffic data, the southernmost interchange and the adjacent interchange are expected to have the highest emissions.
  - » If the design values in the portion of the project area modeled show conformity, then the entire project could then be considered to conform.
  - » If the design values in the portion of the project area modeled do not show conformity, the entire project area (or additional parts thereof) would then be modeled.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End of Module 3

Questions?