Module 3
Selecting an Air Quality Model, Data Inputs, and Receptors

Completing a PM Hot-spot Analysis

Step 1
Determine Need for Analysis

Step 2
Determine Approach, Models, and Data

Step 3
Estimate On-Road Motor Vehicle Emissions

Is project located in California?

No: Estimate using MOVES

Yes: Estimate using EMFAC

Step 4
Estimate Emissions from Road Dust, Construction, and Additional Sources

Step 5
Select Air Quality Model, Data Inputs, and Receptors

Step 6
Determine Background Concentrations

Step 7
Calculate Design Values and Determine Conformity

Step 8
Consider Mitigation or Control Measures

Step 9
Document Analysis

<u>Reminder:</u> Interagency consultation process is essential throughout

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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?
- Reference: More In Depth Look at Gaussian Dispersion; CAL3QHCR surface roughness values

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
- AERMOD/CAL3QHCR User Guides
- AERMET User's Guide
- Meteorological Processor for Regulatory Models (MPRM) User's Guide
- AERMOD Implementation Guide
- EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) website

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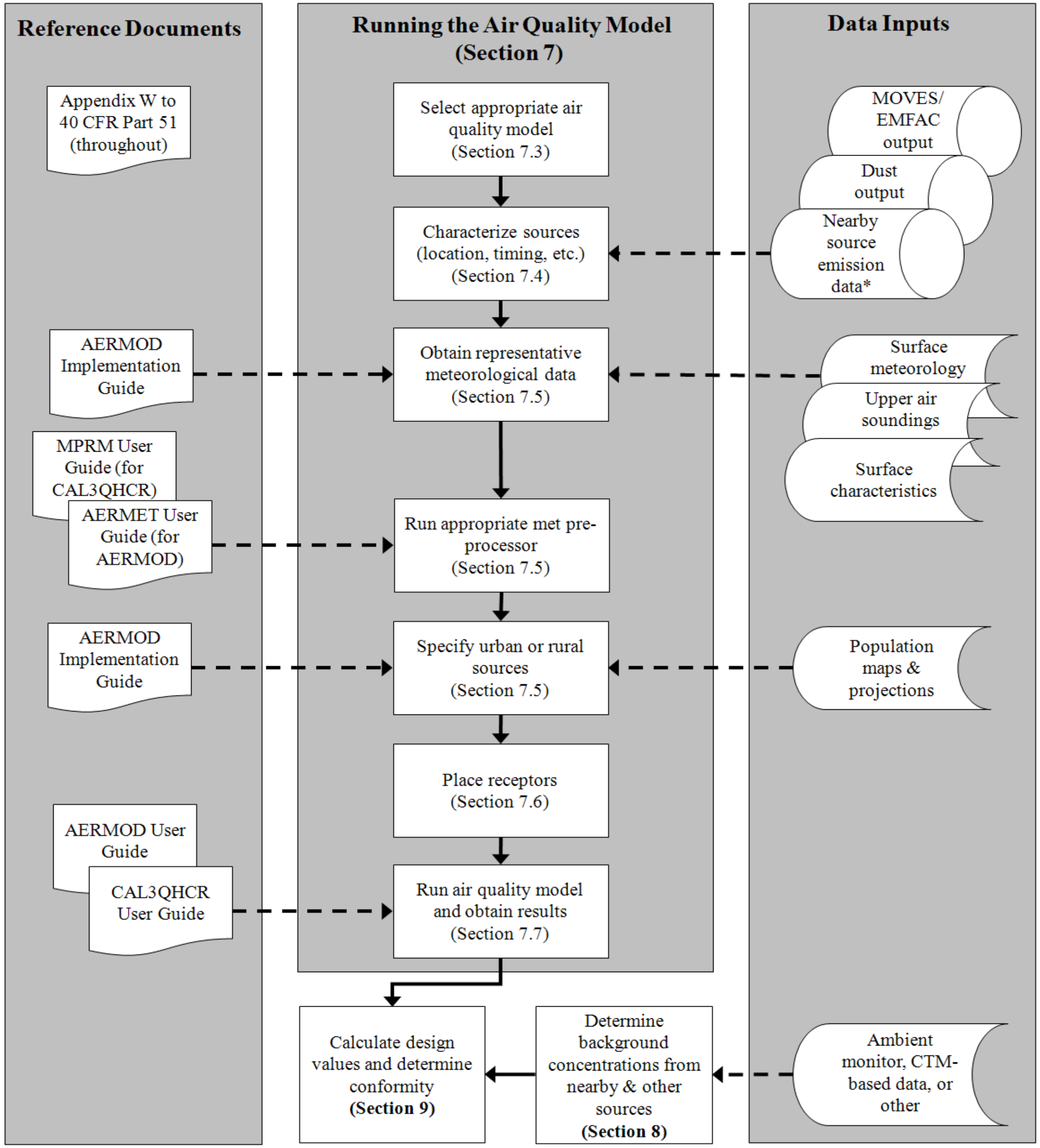
General Overview of Air Quality Modeling

- PM Hot-spot Guidance is consistent with the recommendations for air quality modeling in 40 CFR 51, Appendix W

- Air quality modeling for hot-spot analyses must meet conformity rule general requirements (40 CFR 93.123(c))

- Air quality models, methods, and assumptions need to be determined for each PM hot-spot analysis through interagency consultation process (40 CFR 93.105(c)(1)(i))

- Project sponsors will need to refer to the latest user guides and available guidance for complete instructions



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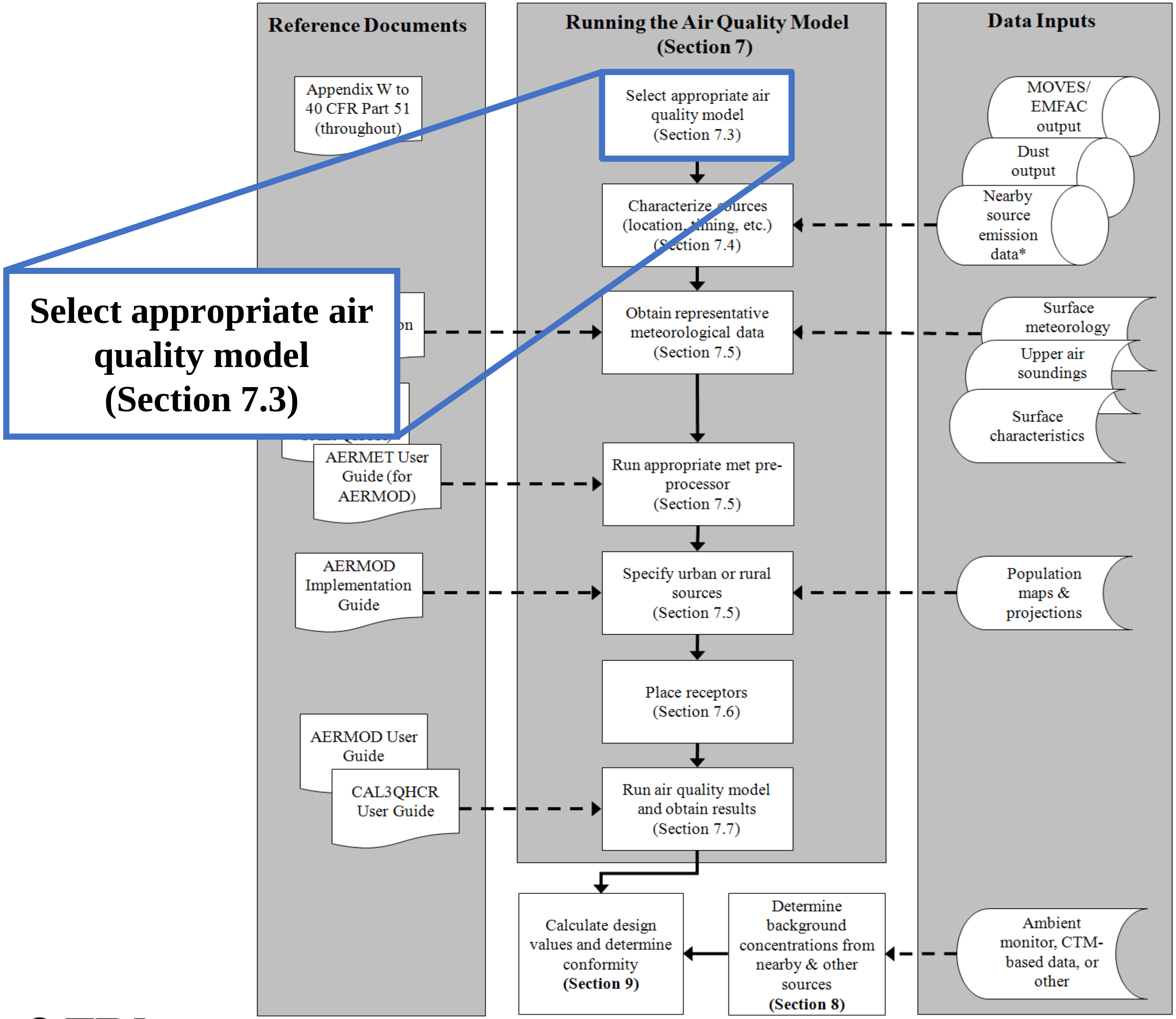
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AERMOD User Guide
CAL3QHCR User Guide
Select appropriate air quality model (Section 7.3)

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:
  - App W lists AERMOD as the preferred model for mobile source applications
  - CAL3QHCR can continue to be used during a 3-year transition period, until January 2020
  - Analyses begun with CAL3QHCR prior to 1/17/20 can be completed after this date
- Note that CAL3QHC is not appropriate for modeling refined PM hot-spot analyses

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

Air Quality Modeling Resources

www.epa.gov/scram

Air Quality Modeling Resources

www.epa.gov/scram/air-quality-dispersion-modeling

Secure | https://www.epa.gov/scram/air-quality-dispersion-modeling

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Air Quality 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) (45 pp, 803 K, About 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

Air Quality Modeling Resources

www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

Secure | https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

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Air Quality Dispersion Modeling - Preferred and Recommended Models

These refined dispersion models are listed in Appendix W (PDF) (45 pp, 803 K, About PDF) 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

Air Quality Modeling Resources

www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#cal3qhc

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

CAL3QHC Executable (ZIP) (235 K)
CAL3QHCR Executable (ZIP) (917 K)

Model Documentation

CAL3QHC User's Guide (PDF) (98 pp, 2.4 M, 1995)
Latest CAL3QHC Model Change Bulletin (TXT) (5 K, 2004)

CAL3QHCR User's Guide (PDF) (96 pp, 209 K, 1995)
Latest CAL3QHCR Model Change Bulletin (TXT) (3 K, 2013)

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.

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Air Quality Modeling Resources

www.epa.gov/scram/meteorological-processors-and-accessory-programs

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Meteorological Processors and Accessory Programs

Surface and upper air data, provided by NWS, are important inputs for air quality models. Before these data are used in some of the EPA dispersion models, meteorological processors are used to manipulate the data. Some of these processors re-format data for input into air quality dispersion models, while other processors use the NWS observational data to calculate important inputs for the dispersion models. These processors include: AERMET, MIXHGT, MPRM, PCRAMMET, and STAR.

Other accessory programs are also provided that produce graphical or statistical outputs that can aid in the interpretation and understanding of the NWS data or dispersion model results. These accessory programs include: BINTOASC, METLIST, WINDROSE, WRPLOT.

Meteorological Processors

Models
AERMET - Version 16216
AERMET is a meteorological data preprocessor for AERMOD. AERMET processes commercially available or custom on-site met data and creates two files: a surface data file and a profile data file. The tool AERSURFACE can be used to estimate the surface characteristics for input to AERMET.
Model Code

Air Quality Modeling Resources

www.epa.gov/scram/meteorological-processors-and-accessory-programs

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Model Documentation

Test Case (ZIP) (827 K)
User's Guide (ZIP) (11 K)
Latest Model Change Bulletin (TXT) (1 K, 1998)

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 (ZIP) (244 K) - Revised June 24, 1999
Executable for data extraction and quality assurance (ZIP) (265 K)
Source Code (ZIP) (200 K) - Revised June 24, 1999

Model Documentation

README (TXT) (5 K) - Revised June 24, 1999
Test Case (ZIP) (197 K) - Revised June 24, 1999
User's Guide (ZIP) (272 K)
Addendum to User's Guide (12 pp, 42 K)
Latest Model Change Bulletin (TXT) (2 K, December 1999)

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 (ZIP) (160 K) - README included

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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

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Guidance Reference: Section 7.3

Types of Emission Sources

- Different source types can be used in a hot-spot analysis to represent various aspects of transportation projects

Type of Source	Example
Line Source	Highways and intersections
Point Source	Bus garage or transit terminal exhaust vent
Area Source	Transit or freight terminals Parking lots Highways and intersections
Volume Source	Transit or freight terminals Parking lots Highways and intersections

How Models Represent Emissions

- Sources handled vary by model

Type of Source	AERMOD	CAL3QHCR
Line Source	X*	X
Point Source	X	
Area Source	X	
Volume Source	X	

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

- These models covered more in depth in Module 4 (AERMOD) and the reference Module 5 (CAL3QHCR)

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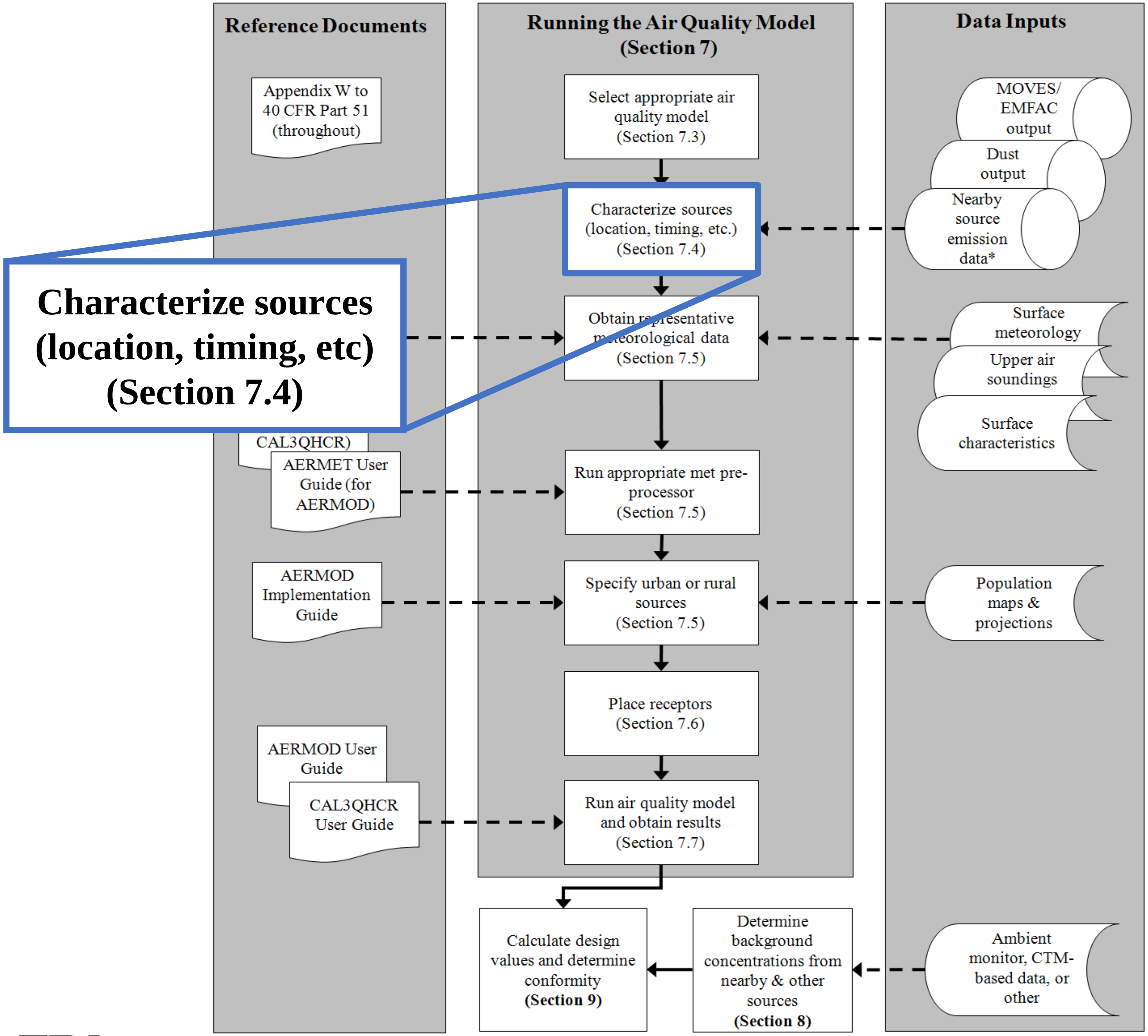
Guidance Reference: Sect 7.3.2, App J.3.3-3.3.4



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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

- Good source characterization helps to ensure that the locations with greatest impacts on PM concentrations are identified

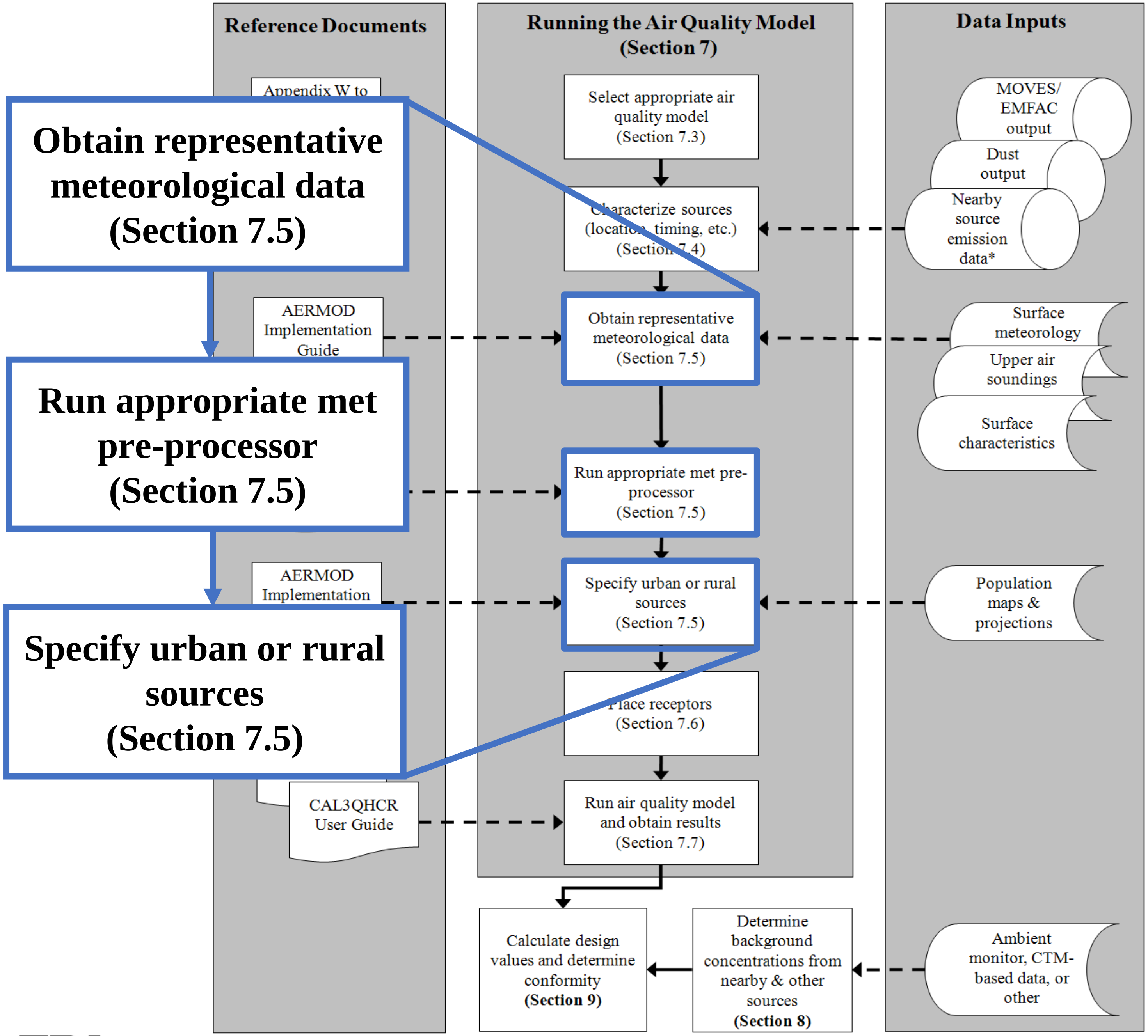
- To describe a source, characterization includes:
  - Physical characteristics and location
  - Emissions rates/emission factors, and
  - Timing of emissions

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

Guidance Reference: Section 7.4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Selecting Meteorological Data For Air Quality Modeling

- **Using meteorological data representative of the project area is critical for PM hot-spot analyses and a key factor in producing credible results**

- Next, we'll cover air pollution dispersion and meteorology basics to help the user:
  - 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
  - Next slides describe Gaussian dispersion; see Module 3 "For Reference" section for additional information

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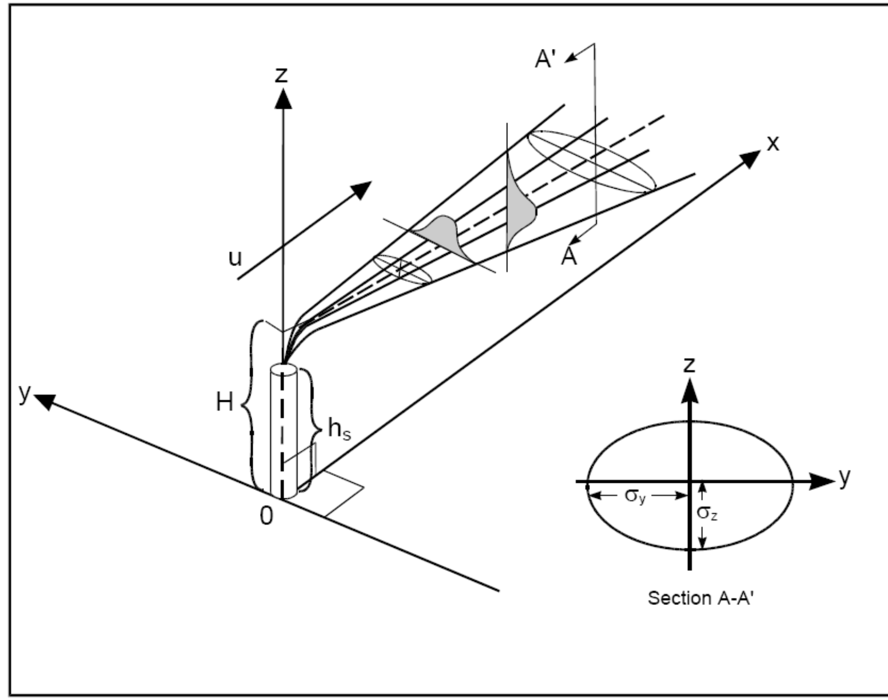
Guidance Reference: Section 7.5

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



Schematic representation of Gaussian plume
Source: Adapted from Turner 1970.

Gaussian Plume Equation Basics

$$\chi \propto \frac{\mathrm{Q}}{2*\mathrm{u}*A} = \frac{\mathrm{Q}}{2*\mathrm{u}*(\pi * \sigma_y * \sigma_z)}$$

$$\chi = \frac{\mathrm{g/s}}{\mathrm{m/s}*m^2} = \frac{\mathrm{g}/\cancel{\mathrm{s}}}{\mathrm{m}/\cancel{\mathrm{s}}*m^2} = \frac{\mathrm{g}}{m^3}$$

where,

χ is the pollutant concentration (g/m^3);

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

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

A is the plume cross-section (m^2) such that A $= \pi * \sigma_y * \sigma_z$;

where,

σ_y is the horizontal dispersion coefficient (m); and

σ_z is the vertical dispersion coefficient (m).

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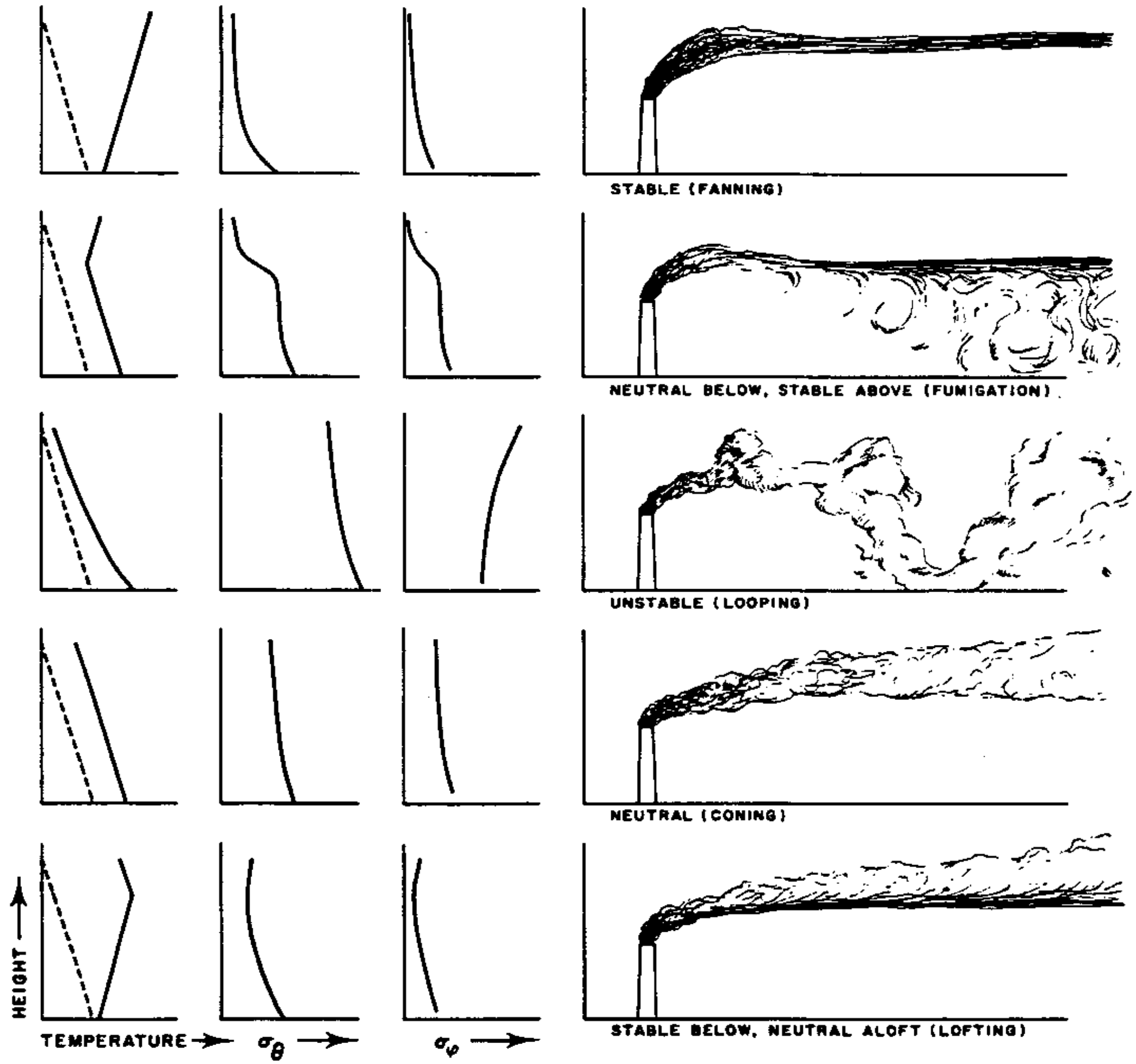
Vertical Plume Dispersion



Source: Slade et al "Meteorology and Atomic Energy, 1968"

How Air Quality Models Consider Met Data

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

- Air quality models need processed met data
  - AERMET is the preprocessor for AERMOD
  - MPRM is the preprocessor for CAL3QHCR
  - Consult respective user guides for specifics met data needed, 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	X	X	X	X	X	X	√ (if modeling urban source)
CAL3QHCR	X	X	X			√	√ (if modeling urban source)

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

√ - Necessary dispersion model input

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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

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

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

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<u>Guidance Reference: Section 7.5.1</u>

Surface Data

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

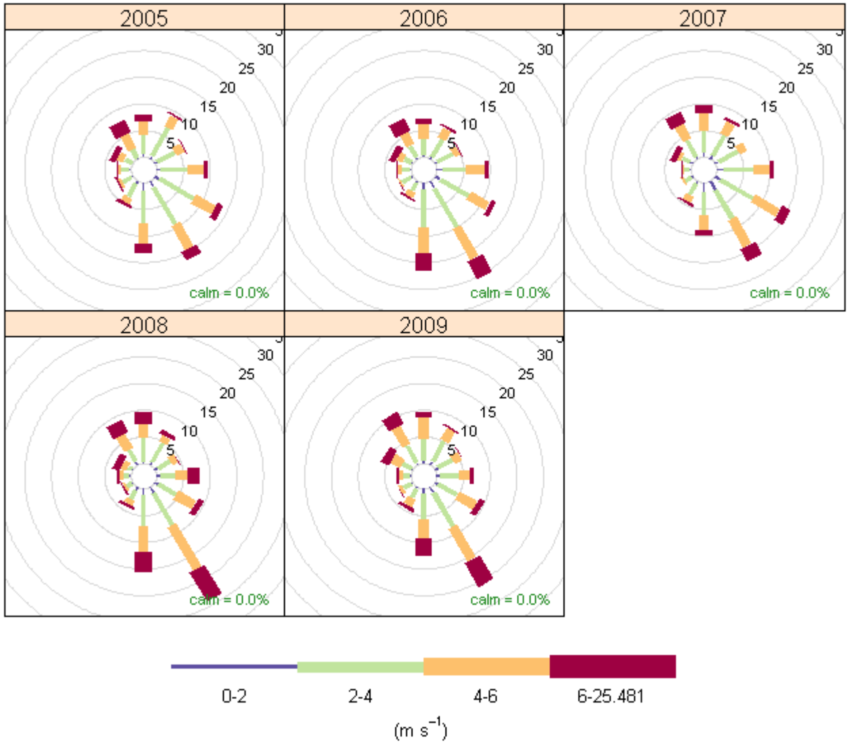
- Surface data used by dispersion models:
  - Wind speed
  - Wind direction
  - Measure of atmospheric stability
  - More details on following slide

- Also used by MOVES:
  - Temperature
  - Relative humidity

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

- Surface data is needed for both AERMOD and CAL3QHCR

- **Use surface data that is most representative of the project**
  - 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

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

Surface Characteristics

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

- Such surface characteristics include:
  - 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"

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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 FOR USE IN AERMOD				
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

Adapted from AERMET User Guide

- ***Note:*** *Roughness factors for a given surface type vary between AERMOD or CAL3QHCR. See Module 3 Reference section for CAL3QHCR surface roughness values*

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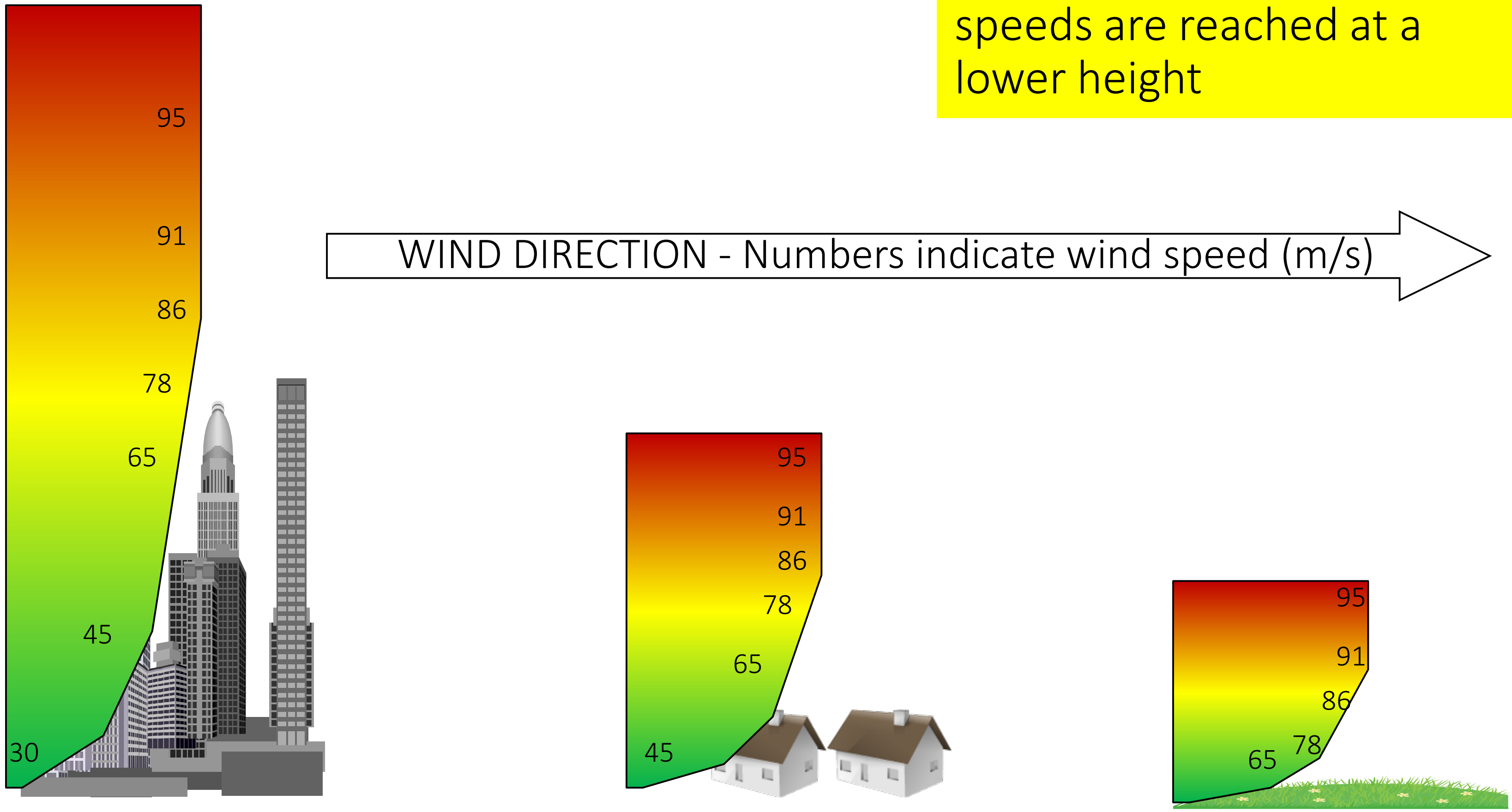
Surface Characteristics – Surface Roughness

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



Years of Met Data Required

- How many years of met data are **required**?
  - 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 sec. 8.4.2(e)

- Site-specific refers to <u>surface data</u>; 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 <u>most recent representative met data</u> should be used
  - Allows for variation in met conditions to be considered

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

<u>Guidance Reference: Section 7.5</u>

Air Quality Model Capabilities for 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

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 or 5 (Can run 5 yrs met data at once, or in individual runs)	1 (1 run X 1 yr met data)
CAL3QHCR	20 (4 quarterly runs X 5 yrs met data)	4 (4 quarterly runs X 1 yr met data)

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.mrlc.gov)
  - Some MPOs may have data

- ***Note:*** *Different sources for upper air, surface data, and surface characteristics data may be needed to ensure representativeness*

Guidance Reference: Section 7.5

Obtaining Met Data

- In most cases, transportation agencies (e.g., state DOTs) can acquire representative processed met data for AERMOD from state air agencies
  - E.g., most recent 5 consecutive years of representative off-site data (most common)
  - Assess representativeness based on latest *AERMOD Implementation Guide*
  - Note, the met data set needed for AERMOD is different from the met data imported in MOVES, but the two should be consistent

- Surface station data should be from an ASOS station
  - Met data should be processed with AERMINUTE and the most recent version of AERMET
  - Appropriate threshold value: 0.5 m/s (Consistent with *OAQPS guidance in March 8, 2013 memo)*

- Latest version of AERMOD (version 18081):
  - Will run with met data from AERMET version 16216, however, EPA strongly encourages using met data from the latest version of AERMET, v18081

Met Data Processing Steps

1. Obtain Surface Meteorology
2. Obtain Upper Air Meteorology
3. Quality Assurance/ Quality Control
4. Convert Surface Data Into an Accessible Format, if Needed
5. Process Surface and Mixing Height Data to Obtain Met Data Files

- Most surface data are 1-hour measurements or observations
- More recent data are collected in 1-minute resolution
- If radiosonde data are obtained, process the data using EPA’s Mixing Height Program to obtain mixing heights
- Refer to EPA’s Quality Assurance/Quality Control requirements
- Refer to EPA’s guidance
- Use AERMET (if using AERMOD) or MPRM (CAL3QHCR)

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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

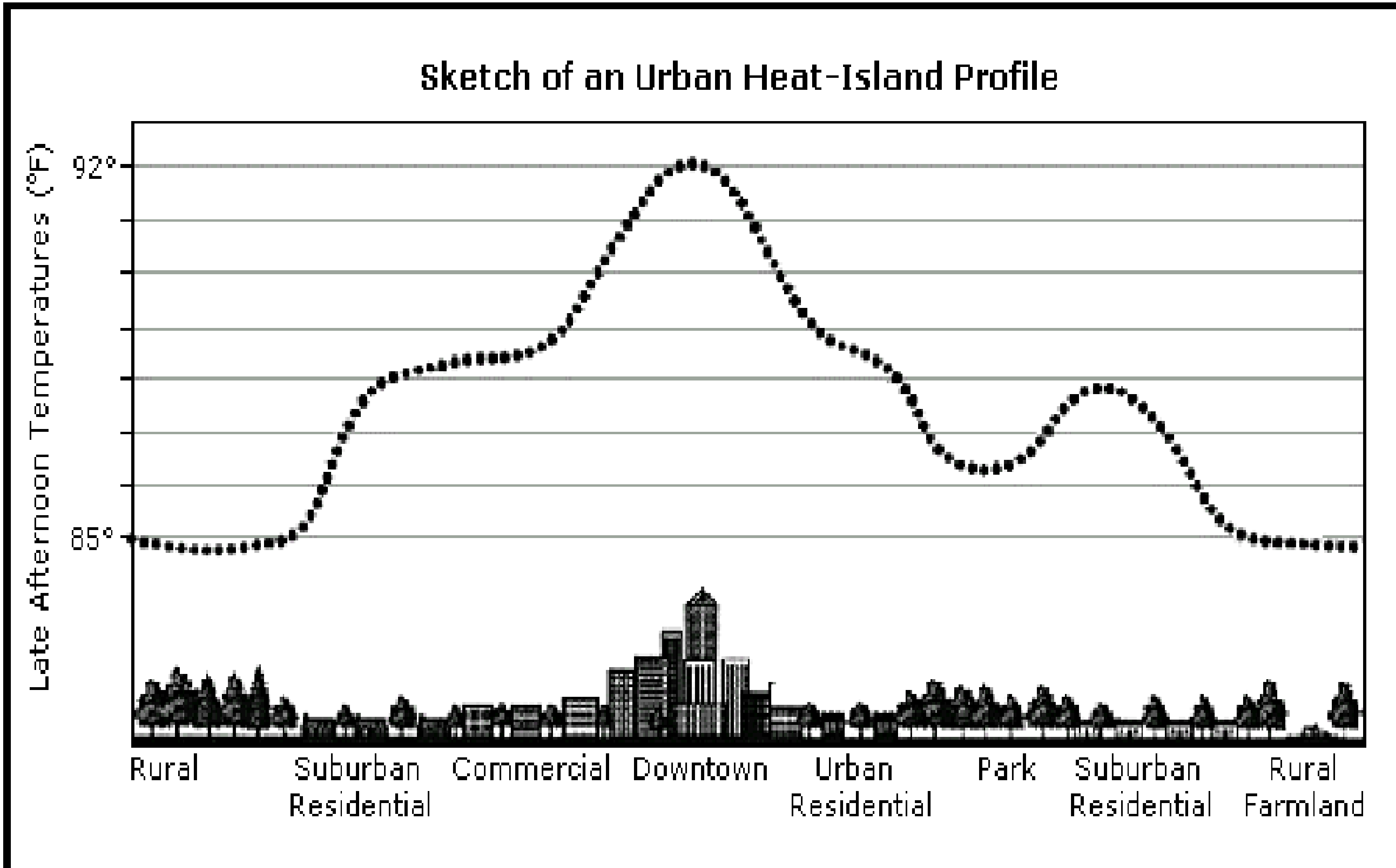
- However, if using preprocessed data, project sponsor still must ensure it is representative of project area
  - Do not use simply because available
  - Same guidance for determining if data is representative applies to preprocessed data

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

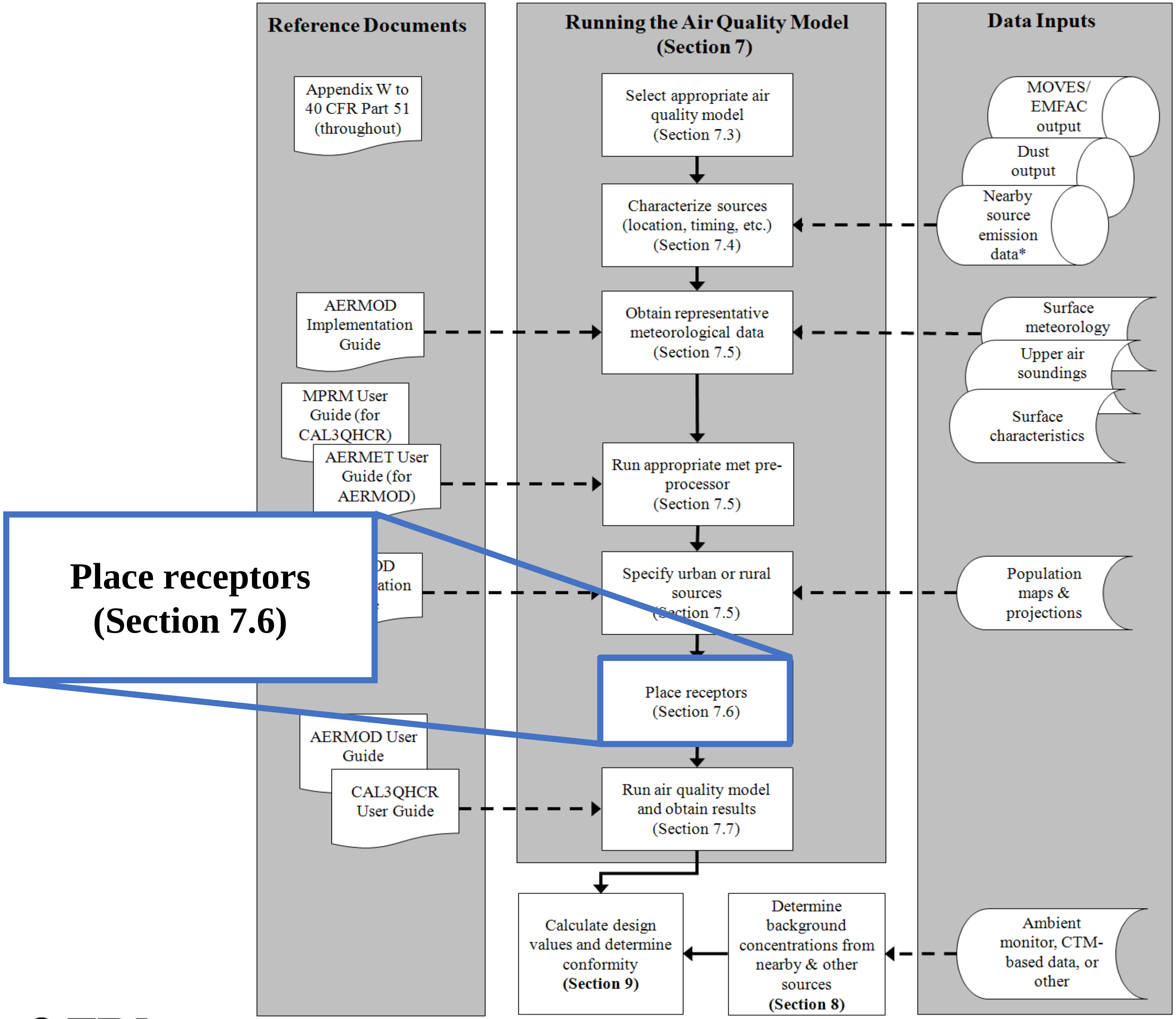


Urban Dispersion – Guidance

- 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


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)
Specify urban or rural sources (Section 7.5)
Population maps & projections
Place receptors (Section 7.6)
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

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

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<u>*Guidance Reference: Section 7.6.1*</u>

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

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:
  - 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
  - <u>Examples</u>:
    - a median strip of a highway
    - the approach to a tunnel
    - within the right-of-way line of limited access highway, etc.

- However, place receptors in locations that the public can access:
  - Sidewalks
  - Neighborhoods
  - Parks

Given the land use contexts, where should receptors be placed or excluded for the analysis of this proposed new highway interchange?


Place Receptors Here
Exclude Receptors Here

Receptor Guidance for All PM NAAQS

- Place receptors…
  - at all locations at which high concentrations may occur, rather than simply focusing on the expected worst case location
  - 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.

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
- Receptors should be placed with
  - finer spacing (e.g., 25 m) closer to near-ground source, and
  - wider spacing (e.g., 100 m) farther from a source

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

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
Emissions of project and any affected roads would be modeled
Roads affected by project
Emissions modeling
Project area
Air quality modeling
1/2 mile
500 m

Where would receptors be placed?

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 unaffected by project do not need to be modeled.
  - Project area would also include the area where receptors would be placed for air quality modeling (see below).

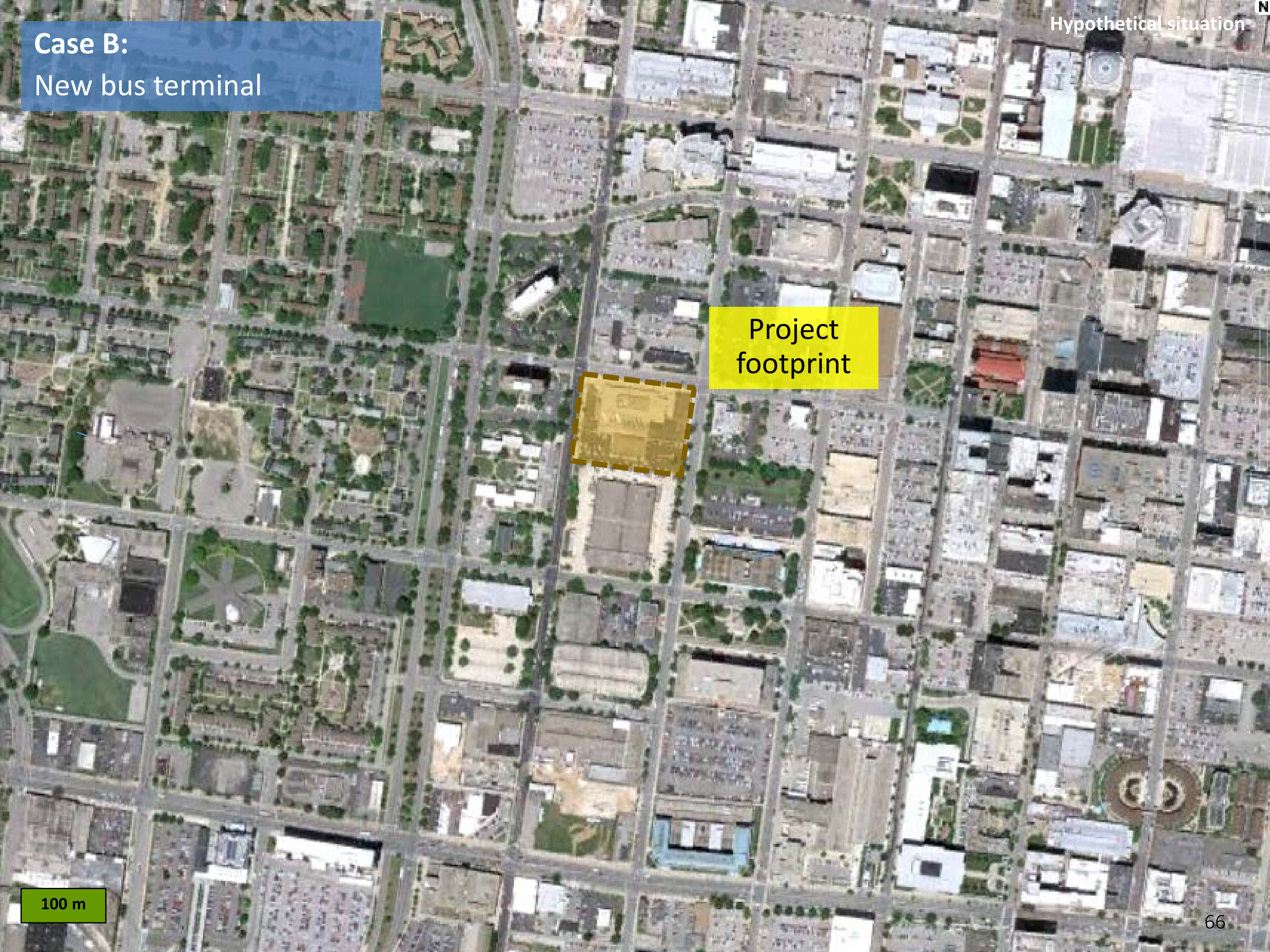
- Where would receptors be placed for air quality modeling?
  - Receptors should be placed in appropriate locations to estimate the highest concentrations and possible violation of a NAAQS
  - Receptors are not needed in the highway right-of-way, etc.

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
N
Project
footprint
100 m

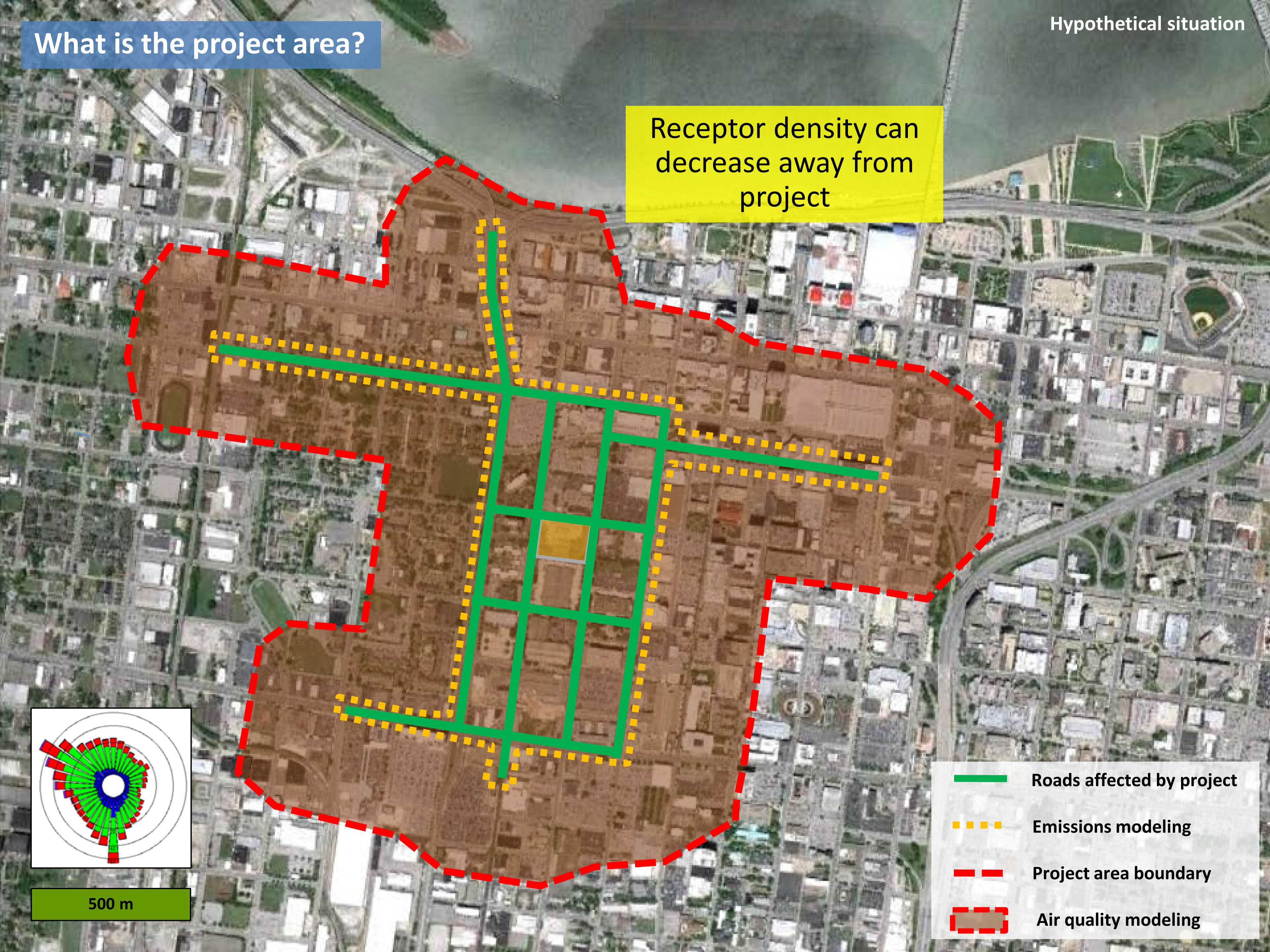
Determining the Project Area: Case B

- 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

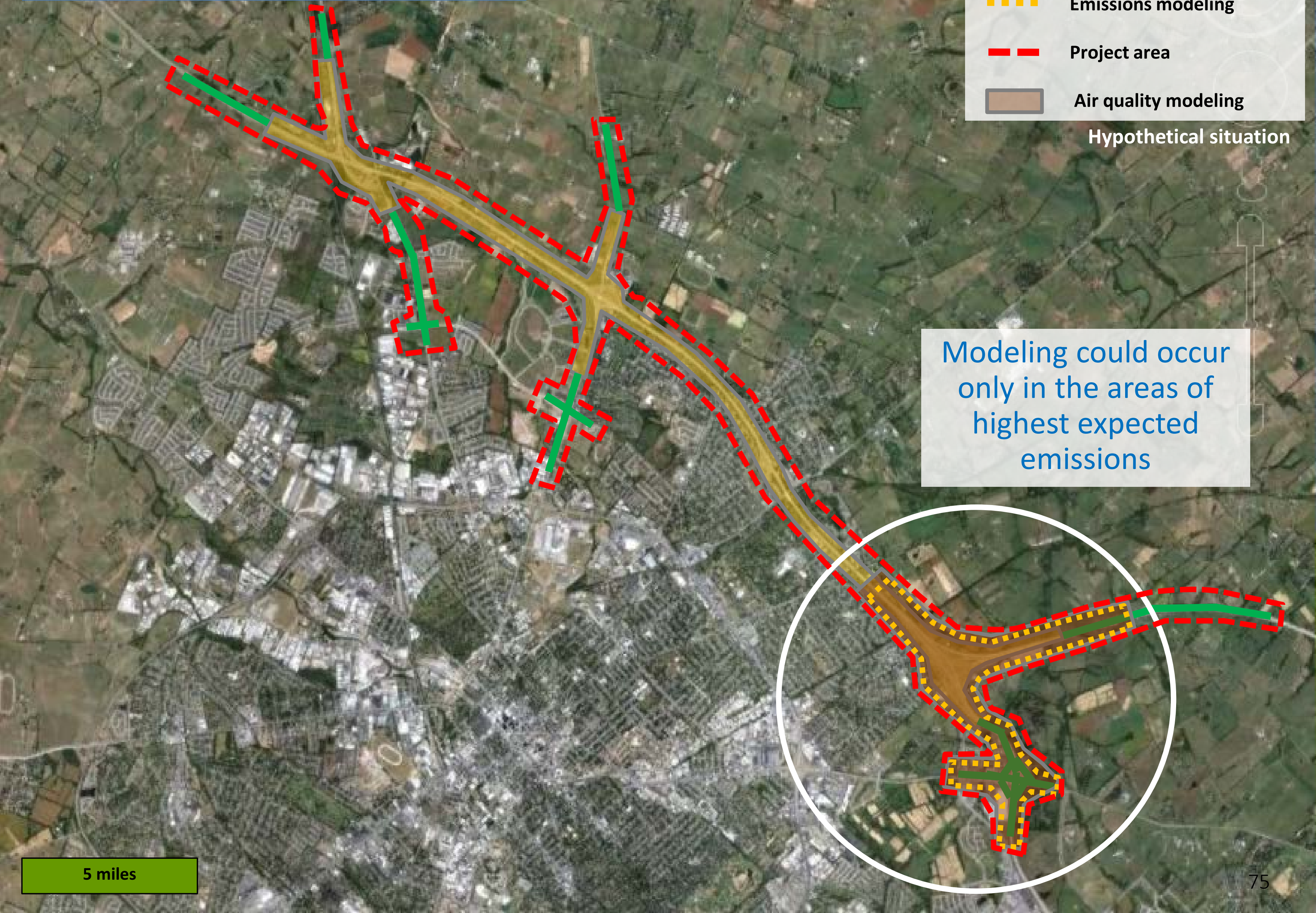
Determining the Project Area: Case C

- 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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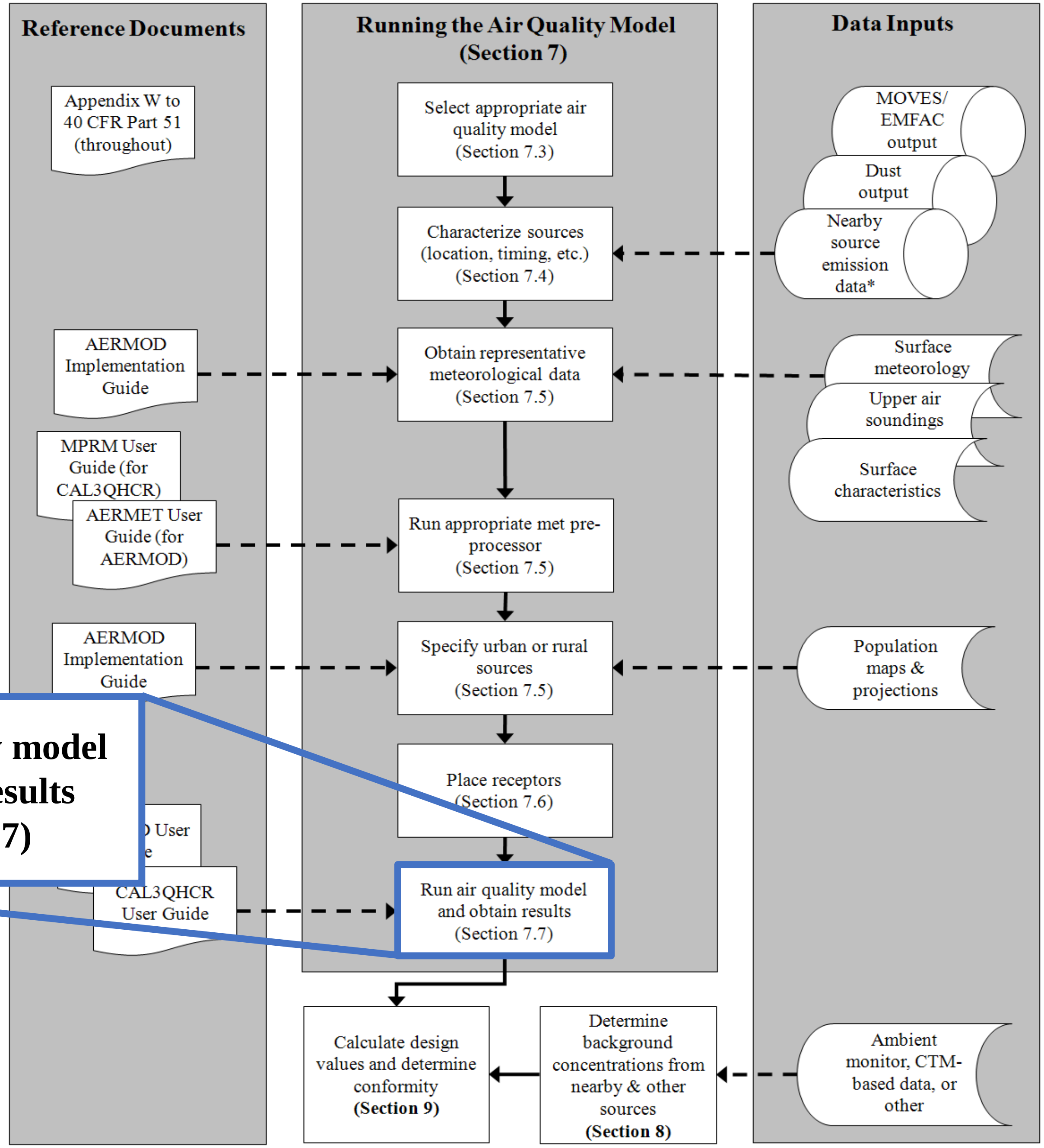
Run air quality model and obtain results (Section 7.7)



End of Module 3
Questions?

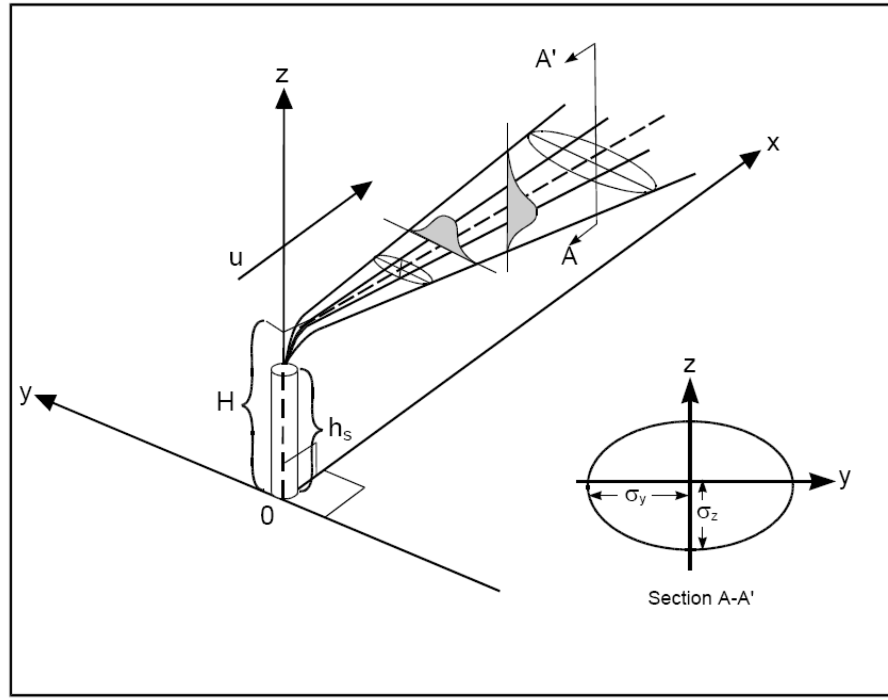
Additional material follows in the Reference Section

Reference

A More In Depth Look at Gaussian Dispersion
CAL3QHCR surface roughness values

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



Schematic representation of Gaussian plume
Source: Adapted from Turner 1970.

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

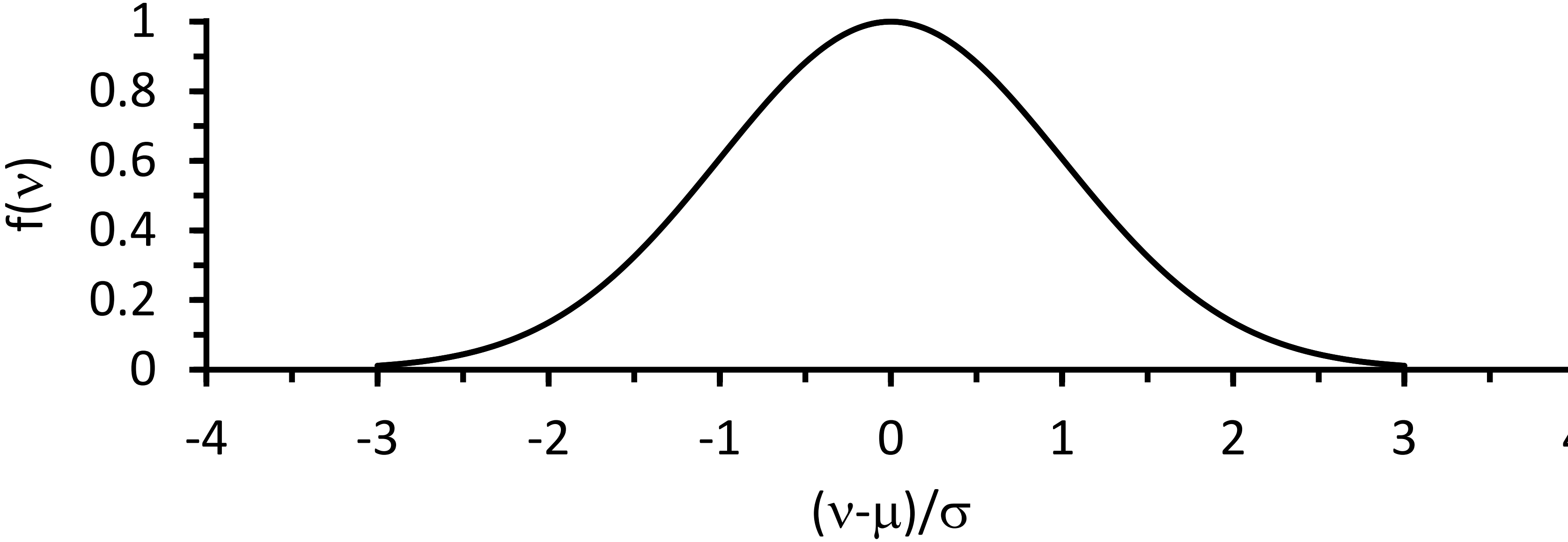
$$g/m^3 \triangleq \frac{g/s}{m/s \times m^2}$$

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

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)?

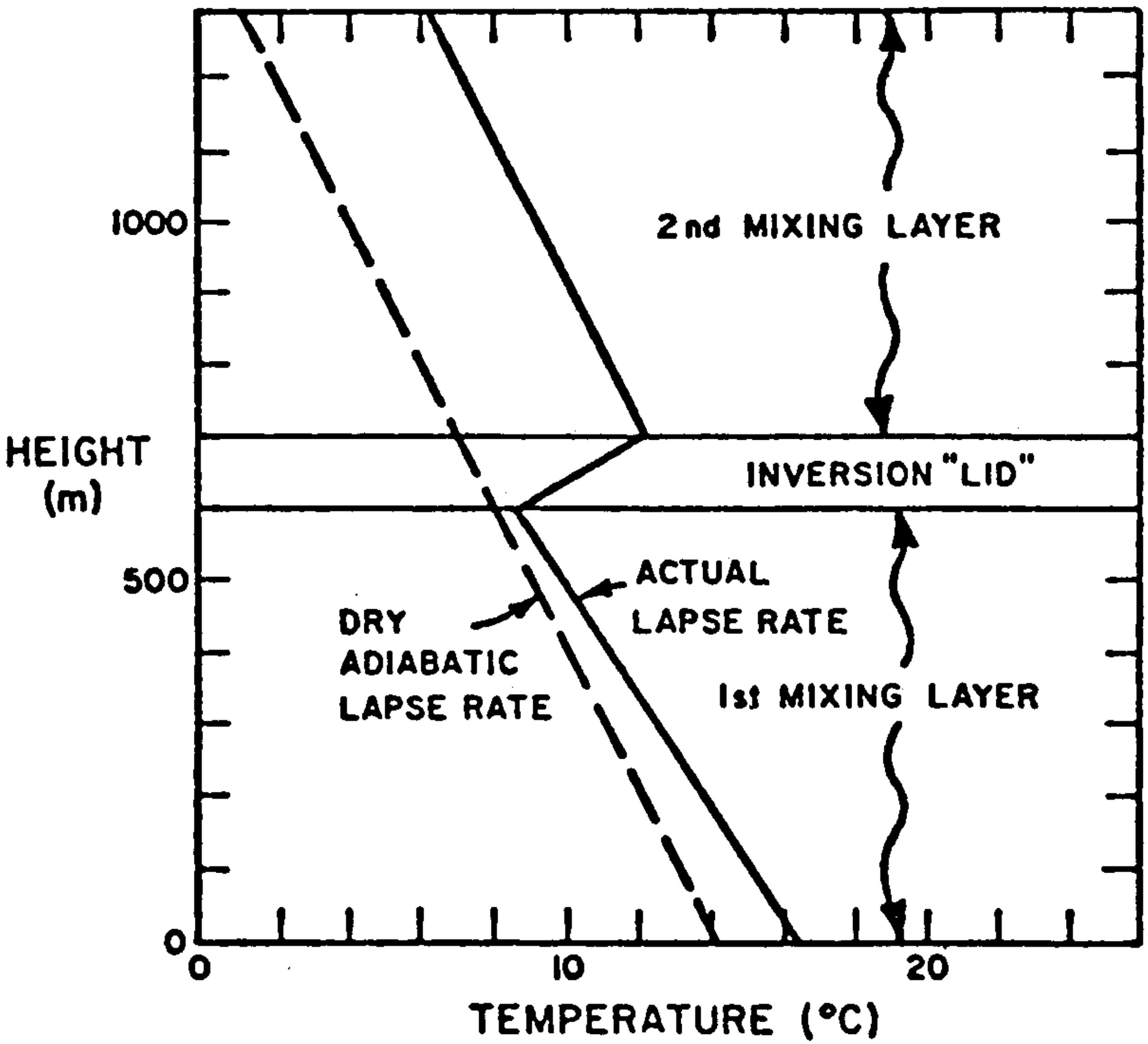
HINT: $\exp(0)$ = ?

Gaussian Plume Equation Basics

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

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

Mixing Height



CAL3QHCR Surface Roughness Values

Type of Surface	z_0 (cm)
Smooth mud flats	0.001
Tarmac (pavement)	0.002
Dry lake bed	0.003
Smooth desert	0.03
Grass (5-6 cm)	0.75
Grass (4 cm)	0.14
Alfalfa (15.2 cm)	2.72
Grass (60-70 cm)	11.4
Wheat (60 cm)	22
Corn (220 cm)	74
Citrus orchard	198
Fir forest	283
City land use	
Single family Residential	108
Apartment residential	370
Office	175
Central Business District	321
Park	127

from Benson, 1979

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