Attachment 2

FHWA-VDOT PROGRAMMATIC AGREEMENT FOR PROJECT-LEVEL AIR QUALITY ANALYSES FOR CARBON MONOXIDE

Based on the NCHRP 25-25 Task 104 Template

October 2020

FHWA-VDOT Programmatic Agreement for Project-Level Air Quality Analyses for Carbon Monoxide

This Programmatic Agreement (PA) between the Virginia Department of Transportation (VDOT) and the Virginia Division of the Federal Highway Administration (FHWA) applies for analyses or assessments of potential carbon monoxide (CO) impacts for projects undergoing environmental studies for purposes of the National Environmental Policy Act (NEPA). Background information and analyses are provided in an associated Technical Support Document (TSD)[1] to this PA.

MAIN AGREEMENT

Elimination of CO Analyses or Assessments: Modeling analyses (project-specific or otherwise) and/or screening assessments are not required and do not need to be included in NEPA documents or supporting air quality studies, although they may be conducted on a discretionary basis as outlined below. This agreement to eliminate CO analyses or assessments for all projects is based on the weight-of-evidence presented in the TSD, which supports a conclusion that the time and cost for project-specific modeling or assessments for CO are not warranted moving forward given the typically foregone conclusion that the NAAQS for CO would be met and usually by a substantial margin.

Therefore, as a reasonable and prudent approach to streamlining environmental clearances consistent with federal and state streamlining efforts including the FHWA *Every Day Counts* initiative, NEPA documentation (including the air quality report) will simply reference this PA for all non-exempt projects[2] moving forward in lieu of project-specific CO modeling or assessments. A summary of the weight-of-evidence may be included as appropriate with the air quality report. Template text is provided below in the section on "NEPA Documentation" for this purpose.

Discretionary Analyses and Assessments: Notwithstanding the elimination of modeling analyses and screening assessments under this PA, VDOT retains the option to conduct at its discretion (and FHWA may request) project-specific CO modeling analyses and/or screening assessments for purposes of transparency, i.e., to show that there would be no significant CO impacts and that the project would reasonably be expected to meet the NAAQS. If the option is selected to conduct a CO screening assessment for purposes of NEPA, the screening procedures as provided in the appendix to this Agreement will apply. The screening procedures are based on the templates developed in the NCHRP 25-25 Task 104 study[3].

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[1] VDOT, "*FHWA-VDOT Programmatic Agreement for Project-Level Air Quality Analyses for Carbon Monoxide - Technical Support Document, Based on the NCHRP 25-25 Task 104 Template*", 2020. See: http://www.vdot.virginia.gov/projects/environmental_air_section.asp

[2] Specifically, those projects that are not on the list of exempt projects (40 CFR 93.126) or otherwise exempted in the transportation conformity rule and its future updates.

[3] E. Carr, S. Hartley, G. Noel & A. Eilbert, NCHRP 25-25 Task 104, "*Streamlining Carbon Monoxide Project-Level Air Quality Analyses with Programmatic Agreements*", March 2020 http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4100

Federal Guidance: FHWA guidance[4] for NEPA air quality analyses states that *"A microscale CO analysis is unnecessary where such impacts (project CO contribution plus background) can be judged to be well below the 1- and 8-hour National Ambient Air Quality Standards (or other applicable State or local standards). This judgment may be based on (1) previous analyses for similar projects; (2) previous general analyses for various classes of projects; or (3) simplified graphical or "look-up" table evaluations. In these cases, a brief statement stating the basis for the judgment is sufficient*."

In keeping with FHWA NEPA guidance, a weight-of-evidence assessment, as provided above and detailed in the TSD that references prior modeling assessments and programmatic agreements for which worst-case modeling was conducted for typical project types and configurations, suffices for determining that CO analyses or assessments should not be routinely required moving forward as it may reasonably be expected that the CO NAAQS would be met in all cases. Conducting project-specific modeling therefore has diminishing utility, is not cost-effective, and runs counter to state and federal streamlining efforts including the FHWA *Every Day Counts* initiative. Further, allowing for discretionary modeling analyses and/or screening assessments as outlined above provides reasonable assurance that any specific cases of interest could still be addressed. This PA, which eliminates all CO analyses and assessments moving forward with appropriate allowance for discretionary analyses or assessments, is therefore reasonable, consistent with FHWA guidance, and supports implementation of state and federal streamlining initiatives.

Locally Administered Projects (LAPs): This PA, including the allowance with VDOT approval for discretionary modeling analyses and/or screening assessments as outlined above, may also be applied for LAPs, i.e., those implemented by cities, towns and counties within Virginia. For the project's environmental document, the local public agency will include the same or similar statement(s) provided herein.

NEPA Documentation: The project's environmental document developed by VDOT (or local public agency for LAPs) will reference this PA and include the following statement (or similar) in the air quality report. For the NEPA document, an abbreviated version of the statement should be used[5].

"As the project is located in a region that is attainment of the CO NAAQS, EPA project-level ("hot-spot") transportation conformity requirements do not apply. As only NEPA applies, a project-specific analysis and/or assessment for carbon monoxide (CO) is not needed under the terms of the programmatic agreement between FHWA and VDOT for project-level air quality analyses for CO. As documented in that agreement, which is based on the analysis and information presented in the template Programmatic Agreement and Technical Support

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[4] FHWA, "*Guidance for Preparing and Processing Environmental and Section 4(F) Documents*", Technical Advisory T6640.8A, October 30, 1987, Section 8(b). See: https://www.environment.fhwa.dot.gov/legislation/nepa/guidance_preparing_env_documents.aspx

[5] For example, the text for the NEPA document may be limited to just the first paragraph, concluding with "…*will be met*." The summary of the weight of evidence given in the subsequent four bullet points would be excluded for the NEPA document, but would be included in a separate air quality report if one is prepared for the project.

Document (TSD) developed in the National Cooperative Highway Research Program (NCHRP) 25-25 Task 104 study (2020), the weight-of-evidence shows that it may reasonably be concluded that the national ambient quality standard (NAAQS) for CO will be met for all projects given:

- *Continued implementation of effective emission control technology, increasingly more stringent motor vehicle emission and fuel quality standards implemented over the past few decades by the Environmental Protection Agency (EPA) that have had the combined effect of substantially reducing CO emission rates nationwide, resulting in long-term downward trends in emissions and near-road ambient concentrations of CO despite increasing vehicle-miles-travelled (VMT);*
- *Extensive experience in project-specific modeling for CO for a wide variety of project types, configurations and operating conditions in which compliance with the national ambient air quality standards (NAAQS) established by EPA for CO is readily demonstrated given the substantially reduced CO emission rates, and despite the use of multiple worst-case assumptions for emission and dispersion modeling that have a compounding effect such that emissions and near-road ambient concentrations are substantially over-estimated;*
- *Extensive experience in programmatic agreements for project-level agreements for CO that establish ever-increasing thresholds for such analyses given the substantially reduced emission rates; and*
- *The results of worst-case modeling conducted for this PA for typical highway project types, configurations and operating conditions in which compliance with the NAAQS is readily demonstrated, and by a substantial safety margin."*

General Terms

These terms apply to both the main agreement and the screening procedures provided in the appendix.

Effective Dates: The terms of this PA are effective immediately upon the signature of both parties. This PA supersedes all previous agreements executed between FHWA and VDOT for project-level air quality (CO) analyses. For any future projects or updates to previous projects, this PA will apply.

All projects cleared using any prior agreement as well as, at VDOT discretion, those in process (e.g., air clearances completed but NEPA not completed) at the time of execution of this agreement may be grandfathered.

Updates to the Screening Procedures and the impact on the PA: The main agreement to eliminate CO analyses and assessments will remain in place and effective should any updates to the discretionary screening procedures in the appendix or to the TSD (including the underlying modeling) be needed, or upon mutual VDOT-FHWA agreement to remove the screening procedures altogether.

Relationship to VDOT Project-Level Air Quality Analysis Resource Document[6] (Resource Document): Nothing in this PA precludes or is intended to preclude the application of the models, methods, protocols, assumptions and data specified or otherwise referenced in the VDOT Resource Document and its associated online data repository and their respective future updates.

Termination of Agreement: Should either VDOT or the FHWA Virginia Division determine it is necessary to terminate the PA and/or appendix screening procedures, they may do so by written notification to the other party. The PA will terminate 30 days after the date of the notification. Projects for which clearances were initiated on the basis of the PA before the effective termination date may be grandfathered, including projects for which discretionary screening was conducted based on the procedures specified in the appendix.

Value of the PA: The PA is beneficial to both VDOT and FHWA Virginia Division. It reduces costs by eliminating unnecessary analyses, enhances efficiency and certainty in the environmental review process, and facilitates project scoping and scheduling.

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[6] VDOT "*Project-Level Air Quality Analysis Resource Document*", 2018. A 2020 update is currently in development. Links to current versions of the VDOT Resource Document and other VDOT guidance documents and resources are posted at: http://www.vdot.virginia.gov/projects/environmental_air_section.asp

Appendix

Screening Based on the 2020 NCHRP 25-25 Task 104 Templates

VDOT may at its discretion (including at the request of FHWA) conduct project-specific modeling analyses and/or screening assessments for CO. The terms of the PA for screening are provided below. Note these terms apply only to projects for which discretionary screening is being done following the procedures specified in this appendix.

Basis of Agreement: These screening procedures were developed based on an extensive history of modeling potential CO impacts for highway projects at both the state and national levels, as documented in detail in the TSD. At the national level, work began on the development of a template programmatic agreement (PA) and technical support document (TSD) with a National Cooperative Highway Research Project (NCHRP) 25-25 ("Task 78") study[7] initiated in 2012 to build upon successful state experiences[8] in streamlining project-level air quality clearances for purposes of NEPA with state-specific PAs. The Task 78 PA and TSD templates were updated to cover a broader range of project configurations in a subsequent NCHRP study ("Task 104")[9], which was completed in 2020. The screening procedures presented in this PA and TSD are based on the updated templates developed in the Task 104 study, adjusted as appropriate for local background concentrations and persistence factors.

Application of the PA for Project-Specific Screening Assessments:

1. For the project type and condition of interest, determine from the appropriate table (**Table A-1** for freeways and arterials; **Table A-2** for intersections; **Table A-3** for interchanges) the corresponding one-hour concentration value (either black font, or ~~red strikeout~~ font).

2. The one-hour concentration listed in the tables is for the project contribution only, and therefore needs to be adjusted for Virginia-specific background concentrations (one- and eight-hour) and persistence factor (eight-hour only). Therefore:

    a. To determine the worst-case one-hour concentration for comparison to the NAAQS, use the following equation:

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7 ICF, Zamurs and Associates, and Volpe Transportation Center, NCHRP 25-25 Task 78, "*Programmatic Agreements for Project-Level Air Quality Analyses*", 2015.
See: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3311

8 As noted in the NCHRP 25-25 Task 78 report, following a review of state agreements in place at that time, the 2009 FHWA-Virginia DOT PA and TSD were selected as the model for the NCHRP national templates. Due to limited funding, however, the Task 78 templates did not include skew angles, which had been included in the Virginia DOT version.

9 E. Carr, S. Hartley, G. Noel & A. Eilbert, NCHRP 25-25 Task 104, "*Streamlining Carbon Monoxide Project-Level Air Quality Analyses with Programmatic Agreements*", March 2020
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4100
The Task 104 study updated the Task 78 templates, adding coverage of skew angles and expanding coverage of road grades.

One-hour concentration (ppm) = One-Hour concentration from the table + Local Background Concentration (One-Hour) as specified or referenced in the VDOT Resource Document[10]

b. To determine the corresponding eight-hour concentration for comparison to the NAAQS, use the following equation with values for Virginia for eight-hour background concentration and persistence factor:

Eight-hour concentration (ppm) = One-Hour concentration from the table x Local Persistence Factor as specified by or referenced in the VDOT Resource Document + Local Background Concentration (Eight-Hour) as specified by or referenced in the VDOT Resource Document

3. Compare the calculated Virginia-specific one- and eight-hour concentrations to the applicable NAAQS. If both concentrations are less than the applicable NAAQS, then the project is covered by the screening procedures under this PA. The eight-hour NAAQS is typically the limiting value.
4. If the project is covered by the screening procedures while using Virginia-specific background concentrations and persistence factor, the qualitative text provided in the NEPA Documentation section below should be included in the air quality report and overall NEPA document as appropriate.

Project Types and Conditions: For projects for which discretionary screening is being conducted, the screening procedures presented below apply for the referenced project types and associated project conditions.

Freeways and Arterials

Table A-1, attached, shows the conditions for urban and rural arterials and freeways that would meet the one- and eight-hour NAAQS and would be covered by the screening procedures presented here[11]. The table shows one-hour concentrations, not including background concentrations, based on national-level conservative and worst-case modeling input assumptions.

To apply the table for conditions in Virginia, the table entry (black text or red strikethrough) corresponding to the project (based on the facility type, setting, number of lanes, and road grade) must be calculated as specified above using a Virginia-specific background concentration and persistence factor specified in the VDOT Resource Document for the area in which the project is located. If the resulting adjusted concentration is below the CO NAAQS, then the project is covered by the screening procedures.

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[10] VDOT Project-Level Air Quality Analysis Resource Document, 2018. Links to current versions of the VDOT Resource Document and other VDOT guidance documents and resources are posted at: http://www.vdot.virginia.gov/projects/environmental_air_section.asp

[11] These findings apply to scenarios with average speed ranging from 15 to 56 mph for arterials and 19 to 75 mph for freeways. For application of the PA, posted speeds may be assumed in place of forecast speeds.

Intersections

Table A-2,[12] attached, shows the conditions for urban and rural intersections that would meet the one- and eight-hour NAAQS and would be covered by the screening procedures presented here. The table shows one-hour concentrations, not including background concentrations, based on national-level conservative and worst-case modeling input assumptions.

To apply the table for conditions in Virginia, the table entry corresponding to the project (based on the setting, skew angle and road grade) must be calculated as specified above using a Virginia-specific background concentration and persistence factor specified in the VDOT Resource Document for the area in which the project is located. If the resulting adjusted concentration is below the CO NAAQS, then the project is covered by the screening procedures.

Note Table A-2 applies for urban and rural intersections with a road grade of 7% (or less), skew angle not less than 15 degrees and otherwise within the ranges specified in the table, six approach lanes or less, and posted approach speeds in the 15-45 mph range. More specifically, and as documented in the TSD, the intersection analysis assumes four through-lanes on approach in each direction, four departure lanes in each direction, and two left turn lanes for each approach. Additionally, after testing a variety of configurations, the worst-case configuration for the intersection was determined to be one on the side of a hill, angled (at 45°) so that the northbound approach and westbound approaches are both uphill. Road grades were modeled for a range of zero to seven percent. The angle between the approach and departure lanes were modeled not only for a typical square intersection (90 degrees) but also for intersections skewed at 60, 45, 30, and 15 degrees. The analysis placed the skew at the intersection with the highest emission rates which is associated with the upgrade links, as a worst-case configuration. The right lanes in each direction were modeled as including both through and right turn movements and included left-turn queue idling. The same MOVES model inputs and assumptions were used for both the freeway and arterial analyses. Similar CAL3QHC model inputs and assumptions were also used, although intersections were modeled with lanes 11 feet wide in all cases.

Interchanges

Tables A-3(a) to 3(c) attached, shows the conditions for urban and rural interchanges with adjacent intersections that would meet the one- and eight-hour NAAQS and would be covered by the screening procedures presented here. The tables show one-hour concentrations, not including background levels, based on national-level conservative and worst-case modeling input assumptions for a freeway-arterial street interchange with an adjacent signalized intersection. As the modeled concentrations may be considered conservatively high for interchanges *without* adjacent intersections, given that intersection contributions to near-road concentrations are included along with the interchange contributions in the modeling for this PA and TSD, the tables may serve as a conservative means to screen such projects. Similarly, and given the substantial safety margin afforded by the use of multiple worst-case modeling

[12] These findings apply to scenarios with average speed ranging from 15 to 45 mph for intersections. For application of the PA, posted speeds may be assumed in place of forecast speeds.

assumptions as summarized below, the tables may also serve as a conservative means to screen *freeway-freeway* (free-flow) interchanges.

To apply a table for conditions in Virginia, the table entry corresponding to the project (based on the setting, number of lanes, road grade skew angle, and distance) must be calculated as specified above using a Virginia-specific background concentration and persistence factor specified in the VDOT Resource Document for the area in which the project is located. If the resulting adjusted concentration is below the CO NAAQS, then the project is covered by the screening procedures.

Note, although intersections were considered on either side of the freeway, Tables A-3(a) to (c) only report the higher of these. The same speed limitations for freeways and arterials from above also apply here. Also, the worst-case modeling for this project type assumes that the adjacent intersection to the interchange is between two arterial streets, each with worst-case traffic in both directions; this represents a very conservative approach for cases in which the adjacent intersection is limited to a low-volume unsignalized free-flow ramp intersection, or even a higher volume signalized ramp intersection, which in either case typically have only one- or two-lane ramps approaching or departing from the intersection and not the four through-lanes of traffic in both directions plus two left turn lanes that were assumed for the modeling.

For reference, and as documented in the TSD, interchanges were analyzed using the MOVES and CAL3QHC models, with a combination of the grade separated intersection and freeway separated at various distances. The intersection and freeway analyses geometry and traffic inputs are as described in the preceding cases, other than for a simplified receptor set. Interchange scenarios were modeled with the freeway at a 0% grade and intersection (the non-freeway portion) at a 0, 1, 3, 4, 5, 6 and 7% grade. Both rural and urban locations were considered. The total number of freeway lanes analyzed ranged from 2 to 12 lanes, in 2 lane increments. As above, intersection remains a signalized six lane intersection. A variety of assumed distances between the edge of the nearest freeway travel lane to the edge of the nearest travel lane on the intersection were analyzed. These included distances of 20, 30, 60, 80, 100, 125, 150, 175, 300, 500 and 1,000 feet. Modeled concentrations diminish as distance between the interchange and adjacent intersection increases, and for distances beyond 1000 ft may be considered de minimis. The roadway link connecting the freeway to the intersection was modeled at skew angles of 90, 60, and 45-degrees. Intersections were considered on either side of the freeway.

General Terms for the Screening Procedures

Deference to Professional Judgment on Determinations of Substantive Differences: Consistent with our agreement for revising air studies, under these screening procedures, FHWA will defer to the professional judgment of VDOT air quality staff to apply the screening procedures for projects that are substantively (as defined in the Resource Document) consistent with the project types and configurations specified in these screening procedures. For example, if an intersection is slightly more skewed than modeled for these screening procedures, these screening procedures may be applied using the criteria for the intersection skew angle as modeled if the difference is not substantive in the professional opinion of VDOT Air Quality staff and therefore not expected to result in a modeled exceedance of the applicable NAAQS.

Exempt Projects: Projects that would qualify as exempt under one or more of the categories specified in the federal transportation conformity rule (whether or not conformity applies for the area in which the project is located) do not require project-specific modeling for CO for purposes of NEPA. A qualitative statement noting the exempt status of the project may be included as appropriate in the project environmental document.

Projects of De Minimis Scope: Consistent with Protocol 2.5.3.1 in the VDOT Resource Document, "*Modeling or analyses (qualitative or quantitative) are only conducted for projects that change (add, delete, relocate or otherwise modify) roadway capacity, intermodal facilities, and/or transit service in areas with significant traffic volume*." Conversely, projects that are not exempt but do not change (add, remove or relocate) roadway capacity or transit services do not require either qualitative or quantitative project-level air quality analyses for purposes of NEPA. A qualitative statement noting the de minimis status of the project for air quality may be included as appropriate in the project environmental document.

Project Alternatives: These screening procedures are intended to cover all build alternatives for the above-listed projects, as well as the no-build alternative. If one or more alternatives are not included in the list of project types above, VDOT and FHWA Virginia Division will coordinate to determine the applicability of the screening procedures for that alternative(s). It may be that one alternative that is covered by the screening procedures would effectively represent the worst-case for all of the alternatives, e.g., if one alternative has more congested conditions than the others.

Project Types Not Covered by These Screening Procedures: Examples of project types that are not specifically covered by these screening procedures include but are not limited to intermodal transfer yards, tunnels, intersections that have more than four legs, and intersections with approach speeds less than 15 mph. Note, while park and ride lots and parking garages were not specifically covered as separate project types, they may be cleared in most cases using other project types covered in these screening procedures, e.g., the intersection project type for intersections located next to the parking facility that are impacted by traffic from that facility. For those project types and conditions where applicability of these screening procedures is not certain, VDOT and FHWA Virginia Division will coordinate to determine the applicability.

Years of Analysis: These screening procedures cover projects of the types and conditions listed above whose opening year (year of completion) is 2020 or later.

Technical Approach: The modeling and associated assumptions used to support these screening procedures are described in detail in the accompanying TSD. In general, a worst-case modeling approach was applied following EPA guidance. In all cases EPA's MOVES2014a emission model was used to generate emission estimates and CAL3QHC (version 04244) was used for the dispersion analysis. EPA's current guidance for modeling CO Hot-Spots (*Guideline* *for Modeling Carbon Monoxide from Roadway Intersections*, U. S. EPA, EPA-454/R-92-005, November 1992) was also applied.

The assumptions and inputs used in the model were worst-case or highly conservative, leading to higher emission estimates and less dispersion (that is, greater forecast ambient concentrations) than would be expected under real-world conditions. Consequently, if a project does not cause a modeled exceedance of the NAAQS with these worst-case or conservative inputs and assumptions, then it may be stated with high confidence that an exceedance under real-world conditions would not be expected.

Note, although the worst-case modeling for these screening procedures specifically tested lane widths of 12 feet or more (typical) for freeway and arterial project types and 11 feet or more for intersections, lane width has only a relatively minor effect on the modeled concentrations based on the sensitivity analysis conducted for the prior programmatic agreement[13] and much less than the safety margin afforded by the conservative or worst-case modeling approach undertaken for these screening procedures as summarized below. Therefore, given the limited sensitivity and the substantial safety margin, lane widths of 11 feet or more are covered for all project types addressed in these screening procedures, which is expected to cover all roadways of interest in Virginia. Lanes widths are therefore not a specified criterion for applicable of the tables for screening purposes.

Finally, VDOT consulted with the Virginia Department of Environmental Quality (VDEQ) in the development of the Resource Document, which includes separate memoranda documenting background concentrations and persistence factors to be applied for projects in Virginia. They are to be used to determine the Virginia-specific 8-hour total CO concentration for comparison with the 8-hour CO ambient air quality standard.

Safety Margin from Worst-Case Modeling Assumptions: The safety margin for the modeling for these screening procedures is substantial, as documented in the TSD. It includes: 1) the differences in modeling results based on worst-case modeling assumptions as applied for these screening procedures relative to what they would have been using typical or representative inputs, and 2) wide margins between the CO NAAQS and typical near-road concentrations, as observed in long-term trend data from EPA monitoring stations. Note the use of multiple worst-case modeling assumptions versus just one or a few has a cumulative effect that markedly increases modeled air concentrations over what might be expected.

For emission modeling, worst-case modeling assumptions include:

1. *Usage of current year emission factors instead of (lower) future year values*: Emission factors for 2020 were used for all future years, despite that emission factors are

[13] As reported in Section 7.2.1 of the TSD from NCHRP 25-25/Task 78 (previously referenced), sensitivity testing showed that only slightly higher CO concentrations resulted from lane widths of 11 feet rather than the typical value of 12 feet. *Excerpt:* "*To assess the impact of lane width on modeled concentration, 10, 12, 14, 16, 18, 20 and 22-lane urban freeways were modeled using an 11 foot lane width. The 22-lane freeway showed the maximum response to this change in lane width, with a relative increase in concentration of 2%. … Based on this minimal impact on CO levels between the 11 and 12 foot lanes, both widths are covered by the draft PA and TSD templates for freeway and arterial project types*."

projected to decline over time with continued fleet turnover (to vehicles built to meet more stringent EPA Tier 3 emission standards) along with more stringent fuel quality standards,

2. *Exclusion of emission inspection and maintenance program benefits* as applicable,

3. *Increased percentages of high-emitting vehicle types over low-emitting ones*: High percentages (link-source-type-hour fractions) were assumed for single unit gasoline trucks, which have relatively high CO emission factors compared to other vehicle types. At the same time, the percentages for short- and long-haul combination truck were set to zero, as these vehicles are largely diesel-powered and have relatively low CO emission factors. The combination significantly increased modeled fleet-average emission factors.

4. *Fleet-average emission factors not weighted for typical annual mileage accumulation rates (MARs)*: On average, newer vehicles have lower emission factors and higher annual MARs than older vehicles, so weighting fleet-average emission factors by annual MARs can substantially decrease modeled fleet-averages. Conversely, not doing so (as a worst-case assumption) results in higher modeled fleet-average emission factors than what would be expected to actually occur.

5. *High ambient temperature*, which results in higher air conditioner usage which significantly increases energy (fuel) usage and modeled emissions.

6. *Fuel Formulation:* As noted in the TSD, the FHWA CF found one specific fuel formulation (ID 3812) yielded higher CO emission rates than other relevant fuel formulations, so that formulation was assumed as a worst-case assumption for these screening procedures.

7. *Maximum emission factors for speed range*: Emission factors vary by speed so, as a worst-case modeling assumption, the maximum emission factors for the speed ranges tested for both freeways and arterial streets were selected.

For dispersion modeling, worst-case modeling assumptions include:

1. *Maximum capacity traffic volumes* for each road type.

2. *Nearest-possible receptor locations*: Receptor locations were located on the edge of the roadway right-of-way, i.e., at the closest point to the roadway. Modeled concentrations decrease with increasing distance from the roadway traffic, so placing receptors as close as possible to the roadway maximizes the modeled concentrations.

3. *Worst-case facility configurations*: Geometric assumptions for each project type that serve to concentrate traffic, emissions and concentrations to the greatest extent possible, including:

    a. An angled "hillside" configuration for intersection modeling, so that the upgrade links are adjacent for one corner. Upgrade links have higher power demand and emission rates, which leads to higher concentrations. Modeled concentrations are therefore maximized for upgrade links that are adjacent, and even further increased for skewed intersections in which the upgrade links are closer together.

b. Zero vertical separation for the interchange and mainline roadway, and

c. Zero median widths for arterial streets and minimum distance for highways.

4. *Worst-case number of lanes for interchange ramps*: Interchange ramps were assumed to have more lanes of traffic (each with worst-case volumes) than would typically or reasonably be expected.

5. *EPA default meteorological data for screening*: EPA default screening values for wind speeds (1.0 m/s), surface roughness, and stability class were assumed, which results in higher modeled estimates of ambient concentrations than are expected to occur in practice.

6. *Background concentrations*: Current national-average and Virginia background concentrations are assumed to be the same in the future as they are today, whereas they are actually expected to continue to decline given ongoing fleet turnover nationally to vehicles constructed to more stringent EPA emission standards (including Tier 3).

Each of these conservative choices for the emission estimate and dispersion modeling assumptions is discussed in the TSD.

Mutual Applicability of the Screening Procedures and FHWA Categorical Finding for CO[14]: As supported by protocols established in the VDOT Resource Document, which was subjected to inter-agency consultation for conformity purposes in December 2015, and for these screening procedures, VDOT at its discretion may apply the screening procedures and the currently-available FHWA categorical finding for CO either individually or together (without one limiting the utility of the other in clearing projects) for air quality clearances.

- By the protocol established in section 3.2.3 (*Application of Programmatic Agreements for Conformity Purposes*) of the VDOT Resource Document, these screening procedures are also applicable for projects subject to transportation conformity requirements for CO.
- By the protocol established in section 4.2.3 (*Application of Categorical Findings for Purposes of NEPA*) of the VDOT Resource Document, projects that meet the technical criteria specified in a categorical finding or findings may also be cleared for purposes of NEPA for the pollutant(s) for which the criteria are met. Note the application of a US DOT or FHWA categorical finding is not intended to and does not in any way limit the applicability of these screening procedures and this PA between FHWA and VDOT.

Interpolation or Proration: As the modeling results presented in these screening procedures are for specific roadway configurations (number of lanes, skew angle, road grade etc.), interpolation or proration of the data presented in the tables may be necessary for application

[14] http://www.fhwa.dot.gov/environment/air_quality/conformity/policy_and_guidance/cmcf/hotspot_memo.cfm

of these screening procedures and may be conducted as appropriate at the discretion of VDOT, in consultation and coordination with the FHWA Virginia Division as appropriate.

Enduring Applicability of the Screening Procedures in the Absence of Substantive Changes[15] to the Models or Guidance: These screening procedures may continue to be applied by VDOT if EPA updates its official emission and/or dispersion models and/or associated guidance for CO screening analyses from the ones applied for these screening procedures (MOVES2014a and CAL3QHC version 04244, respectively) if there is a reasonable expectation or it can otherwise be shown or concluded that the update(s) to the model(s) and/or associated guidance would not substantively change the modeled CO emission rates and/or ambient concentrations and hence not the underlying modeling, criteria or conclusions for these screening procedures.

NEPA Documentation for Project Screening: For the project's environmental document, VDOT will include a statement that the project under review meets the project types and conditions covered in these screening procedures and conclude with one of the following statements (or similar):

"The project does not exceed the project types and conditions included in the screening procedures specified in the programmatic agreement between the Federal Highway Administration and the Virginia Department of Transportation for streamlining the project-level air quality analysis process for carbon monoxide. Modeling using "worst-case" parameters has been conducted for these project types and conditions. It has been determined that projects such as this one may reasonably be expected to not significantly impact air quality and cause or contribute to a new violation of the National Ambient Air Quality Standards for carbon monoxide."

or

"An air quality analysis is not necessary as this project will not increase traffic volumes, reduce source-receptor distances, or change other existing conditions to such a degree as to jeopardize attainment of the National Ambient Air Quality Standards for carbon monoxide."

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[15] Substantive changes, differences or variances are as defined in the VDOT Project-Level Air Quality Analysis Resource Document, namely ones that would significantly affect the modeling results and/or the analysis to the degree that it would reasonably be expected to change a finding, determination or conclusion that all applicable requirements for the air quality analysis for the project would be met and the project cleared, with the determination to be made by VDOT (in consultation with the FHWA Division office as appropriate), consistent with the general terms of these screening procedures.

Addendum to the Screening Procedures Appendix

Tables of results based on national-level (not Virginia-specific) conservative and worst-case modeling inputs are presented in this Addendum.

- Table entries in black font correspond to project types, settings (urban/rural) and configurations for which compliance with the NAAQS is demonstrated based on *national-level* inputs.
- Table entries in ~~red strikethrough~~ font correspond to project types, settings and configurations that do not show compliance based on the *national-level* inputs but may with *Virginia-specific* inputs for background concentrations and persistence factor, following the adjustment specified in the screening procedures above. This is because background concentrations in Virginia are substantially lower than the national default value used in the modeling described in the Technical Support Document. Background concentrations and persistence factors for Virginia are specified in the VDOT Resource Document.

To apply the tables for projects located in Virginia, the concentration value in the table (black text or red strikethrough) with the setting and configuration corresponding to each project type must be adjusted using the appropriate Virginia-specific background concentration and persistence factor as described in the screening procedures above. If the resulting one- and eight-hour concentrations are less than the CO NAAQS, then the project is covered by the screening procedures.

Table A-1. One-hour CO Concentrations (ppm) for Freeways and Arterials* in Urban and Rural Locations of Varying Lane and Grade Configuration (not including background concentrations)

Facility Type	Location	Number of Lanes	Grade (percent)							
			0	1	2	3	4	5	6	7
Arterials	Rural	2	3	3	3.3	3.4	3.7	4	4.4	4.8
Arterials	Rural	4	6.5	6.9	7.3	7.7	8.4	9	~~9.9~~	~~10.5~~
Arterials	Rural	6	8.7	9.3	~~9.9~~	~~10.5~~	~~11.4~~	~~12.3~~	~~13.4~~	~~14.6~~
Arterials	Rural	8	~~10.7~~	~~11.3~~	~~12.1~~	~~12.8~~	~~14~~	~~15.1~~	~~16.5~~	~~17.9~~
Arterials	Rural	10	~~12.3~~	~~13.1~~	~~14.1~~	~~15~~	~~16.2~~	~~17.6~~	~~19.2~~	~~20.8~~
Arterials	Rural	12	~~13.6~~	~~14.6~~	~~15.8~~	~~16.7~~	~~18.2~~	~~19.7~~	~~21.6~~	~~23.4~~
Arterials	Urban	2	1.8	1.9	2.1	2.1	2.3	2.4	2.7	2.8
Arterials	Urban	4	4	4.3	4.6	4.9	5.2	5.7	6.2	6.7
Arterials	Urban	6	5.5	5.7	6.2	6.7	7.2	7.7	8.5	9.2
Arterials	Urban	8	6.6	7.1	7.6	8.1	8.8	~~9.6~~	~~10.5~~	~~11.4~~
Arterials	Urban	10	7.5	8.2	8.8	9.4	~~10.3~~	~~11.1~~	~~12.3~~	~~13.3~~
Arterials	Urban	12	8.4	9.1	~~9.8~~	~~10.5~~	~~11.5~~	~~12.5~~	~~13.8~~	~~15~~
Freeways	Rural	2	1.4	1.7	1.9	2.1	2.4	2.8	3	3.2
Freeways	Rural	4	3.7	4.2	5	5.7	6.6	7.5	8.2	8.6
Freeways	Rural	6	5.3	6.1	7.1	8.2	~~9.5~~	~~10.8~~	~~11.8~~	~~12.4~~
Freeways	Rural	8	6.6	7.6	9.2	~~10.6~~	~~12.2~~	~~13.9~~	~~15.2~~	~~16.1~~
Freeways	Rural	10	7.8	9.1	~~10.9~~	~~12.6~~	~~14.7~~	~~16.7~~	~~18.3~~	~~19.3~~
Freeways	Rural	12	8.9	~~10.4~~	~~12.5~~	~~14.6~~	~~16.9~~	~~19.3~~	~~21.1~~	~~22.4~~
Freeways	Rural	14	~~9.8~~	~~11.5~~	~~13.9~~	~~16.3~~	~~18.9~~	~~21.6~~	~~23.7~~	~~25~~
Freeways	Rural	16	~~10.7~~	~~12.6~~	~~15.2~~	~~17.8~~	~~20.7~~	~~23.6~~	~~25.9~~	~~27.4~~
Freeways	Rural	18	~~11.3~~	~~13.6~~	~~16.4~~	~~19.1~~	~~22.3~~	~~25.6~~	~~28~~	~~29.6~~
Freeways	Rural	20	~~12~~	~~14.3~~	~~17.5~~	~~20.4~~	~~23.7~~	~~27.2~~	~~29.8~~	~~31.6~~
Freeways	Rural	22	~~12.5~~	~~15.1~~	~~18.4~~	~~21.5~~	~~25.1~~	~~28.7~~	~~31.6~~	~~33.5~~
Freeways	Urban	2	0.9	1	1.1	1.3	1.5	1.7	1.9	1.9
Freeways	Urban	4	2.3	2.6	3.1	3.6	4.1	4.7	5.2	5.5
Freeways	Urban	6	3.2	3.7	4.5	5.2	6	6.9	7.6	8
Freeways	Urban	8	4	4.8	5.8	6.7	7.8	8.9	~~9.7~~	~~10.4~~
Freeways	Urban	10	4.8	5.7	6.8	8	9.3	~~10.7~~	~~11.8~~	~~12.4~~
Freeways	Urban	12	5.4	6.5	7.8	9.2	~~10.7~~	~~12.3~~	~~13.5~~	~~14.3~~
Freeways	Urban	14	5.9	7.2	8.8	~~10.3~~	~~11.9~~	~~13.8~~	~~15.1~~	~~16~~
Freeways	Urban	16	6.4	7.8	~~9.5~~	~~11.2~~	~~13.1~~	~~15~~	~~16.5~~	~~17.5~~
Freeways	Urban	18	6.9	8.4	~~10.3~~	~~12.1~~	~~14.1~~	~~16.2~~	~~17.8~~	~~18.9~~
Freeways	Urban	20	7.2	8.9	~~10.9~~	~~12.9~~	~~15~~	~~17.2~~	~~19~~	~~20.1~~
Freeways	Urban	22	7.5	9.3	~~11.5~~	~~13.5~~	~~15.8~~	~~18.2~~	~~20~~	~~21.2~~

Notes: Red strikethrough values indicated exceedances of the standard, based on national-level (not Virginia-specific) conservative and worst-case modeling assumptions. To apply the table above for a project located in Virginia, the value in the table (black text or red strikethrough) with the setting and configuration corresponding to the project must be adjusted using the appropriate Virginia-specific background concentration and persistence factor.

* These findings apply to scenarios with average speed ranging from 15 to 56 mph for arterials and 19 to 75 mph for freeways, for which posted speeds in those ranges may be applied as reasonable proxies.

Table A-2. One-hour CO concentrations (not including background concentrations) for Rural and Urban Intersections* at Varying Skew Angles and Intersection Grades for a Six Approach Lane Intersection

Location	Skew Angle	Grade (Percent)							
		0	1	2	3	4	5	6	7
Rural	15	8.6	9.1	~~9.8~~	~~10.2~~	~~11.1~~	~~11.9~~	~~13~~	~~13.9~~
Rural	30	6.3	6.7	7.1	7.5	8.2	8.8	9.4	~~10.1~~
Rural	45	6.2	6.4	6.9	7.2	7.8	8.4	9	~~9.9~~
Rural	60	5.6	5.9	6.2	6.5	7	7.5	8	8.7
Rural	90	5.4	5.6	6	6.3	6.8	7.3	7.8	8.4
Urban	15	4.7	4.9	5.3	5.6	6.1	6.7	7.1	7.7
Urban	30	4.5	4.8	5	5.5	6.1	6.4	6.7	7.2
Urban	45	4.1	4.4	4.6	4.8	5.2	5.7	6.2	6.5
Urban	60	3.8	4.1	4.3	4.5	5	5.3	5.9	6.3
Urban	90	3.6	3.9	4.1	4.3	4.5	5	5.4	5.9

Notes: Red strikethrough values indicated exceedances of the standard, based on national-level (not Virginia-specific) conservative and worst-case modeling assumptions. To apply the table above for a project located in Virginia, the value in the table (black text or red strikethrough) with the setting and configuration corresponding to the project must be adjusted using the appropriate Virginia-specific background concentration and persistence factor.
* These findings apply to scenarios with average speed ranging from 15 to 45 mph for intersections, for which posted speeds in that range may be applied as a reasonable proxy.

Table A-3 (a). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 45° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	2	0%	6.9	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.2
Rural	2	1%	7.3	6.7	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.5
Rural	2	2%	7.7	7.3	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Rural	2	3%	8.1	7.6	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Rural	2	4%	8.5	8.1	8	8	8	8	8	8	8	8	7.9
Rural	2	5%	8.9	8.8	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Rural	2	6%	~~9.7~~	9.4	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2
Rural	2	7%	~~10.3~~	~~10.3~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~	~~10.1~~
Rural	4	0%	9.4	7.9	7.1	7	6.9	6.8	6.8	6.8	6.6	6.6	6.4
Rural	4	1%	~~9.8~~	8.3	7.3	7.2	7.1	7	7	7	6.9	6.8	6.7
Rural	4	2%	~~10.2~~	8.7	7.7	7.7	7.7	7.6	7.5	7.5	7.5	7.3	7.3
Rural	4	3%	~~10.6~~	9.1	8	8	8	7.9	7.8	7.8	7.8	7.6	7.6
Rural	4	4%	~~11~~	~~9.5~~	8.5	8.5	8.5	8.4	8.4	8.4	8.3	8.2	8.1
Rural	4	5%	~~11.4~~	~~9.9~~	9.2	9.2	9.2	9.1	9	9	9	8.8	8.8
Rural	4	6%	~~12.2~~	~~10.7~~	~~9.8~~	~~9.8~~	~~9.8~~	~~9.7~~	~~9.6~~	~~9.6~~	~~9.6~~	9.4	9.4
Rural	4	7%	~~12.7~~	~~11.2~~	~~10.7~~	~~10.7~~	~~10.7~~	~~10.6~~	~~10.5~~	~~10.5~~	~~10.5~~	~~10.3~~	~~10.3~~
Rural	6	0%	~~10.5~~	8.7	7.7	7.6	7.5	7.3	7.2	7.2	6.9	6.8	6.6
Rural	6	1%	~~10.9~~	9.1	7.9	7.8	7.7	7.5	7.4	7.4	7.1	7	6.8
Rural	6	2%	~~11.3~~	~~9.5~~	8.3	8.2	8.1	7.9	7.9	7.9	7.7	7.5	7.3
Rural	6	3%	~~11.7~~	~~9.9~~	8.6	8.5	8.4	8.2	8.2	8.2	8	7.8	7.6
Rural	6	4%	~~12.1~~	~~10.3~~	9.1	9	8.9	8.8	8.8	8.8	8.5	8.4	8.2
Rural	6	5%	~~12.5~~	~~10.7~~	~~9.7~~	~~9.5~~	~~9.5~~	9.4	9.4	9.4	9.2	9	8.8
Rural	6	6%	~~13.3~~	~~11.5~~	~~10.3~~	~~10.1~~	~~10.1~~	~~10~~	~~10~~	~~10~~	~~9.8~~	~~9.6~~	9.4
Rural	6	7%	~~13.8~~	~~12~~	~~11.2~~	~~11~~	~~11~~	~~10.9~~	~~10.9~~	~~10.9~~	~~10.7~~	~~10.5~~	~~10.3~~
Rural	8	0%	~~11.4~~	9.4	8.3	8.1	8	7.8	7.6	7.4	7.3	7	6.8
Rural	8	1%	~~11.8~~	~~9.8~~	8.5	8.3	8.2	8	7.8	7.6	7.5	7.2	7
Rural	8	2%	~~12.2~~	~~10.2~~	8.9	8.7	8.6	8.4	8.2	8.1	8	7.8	7.5
Rural	8	3%	~~12.6~~	~~10.6~~	9.2	9	8.9	8.7	8.5	8.4	8.3	8.1	7.8
Rural	8	4%	~~13~~	~~11~~	~~9.7~~	~~9.5~~	9.4	9.2	9	9	8.9	8.6	8.4
Rural	8	5%	~~13.4~~	~~11.4~~	~~10.2~~	~~10~~	~~9.9~~	~~9.7~~	~~9.7~~	~~9.6~~	~~9.5~~	9.3	9
Rural	8	6%	~~14.2~~	~~12.2~~	~~10.8~~	~~10.6~~	~~10.5~~	~~10.3~~	~~10.3~~	~~10.2~~	~~10.1~~	~~9.9~~	~~9.6~~
Rural	8	7%	~~14.7~~	~~12.7~~	~~11.6~~	~~11.5~~	~~11.4~~	~~11.2~~	~~11.2~~	~~11.1~~	~~11~~	~~10.8~~	~~10.5~~
Rural	10	0%	~~12~~	~~9.9~~	8.8	8.6	8.4	8.1	7.9	7.7	7.4	7.2	7

Table A-3 (a). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 45° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	10	1%	~~12.4~~	~~10.3~~	9	8.8	8.6	8.3	8.1	7.9	7.7	7.4	7.2
Rural	10	2%	~~12.8~~	~~10.7~~	9.4	9.2	9	8.7	8.6	8.4	8.3	7.9	7.7
Rural	10	3%	~~13.2~~	~~11.1~~	~~9.7~~	~~9.5~~	9.3	9	8.9	8.7	8.6	8.2	8
Rural	10	4%	~~13.6~~	~~11.5~~	~~10.2~~	~~10~~	~~9.8~~	~~9.5~~	9.4	9.2	9.1	8.8	8.6
Rural	10	5%	~~14~~	~~11.9~~	~~10.7~~	~~10.5~~	~~10.3~~	~~10.2~~	~~10.1~~	~~9.9~~	~~9.8~~	9.4	9.2
Rural	10	6%	~~14.8~~	~~12.7~~	~~11.3~~	~~11.1~~	~~10.9~~	~~10.8~~	~~10.7~~	~~10.5~~	~~10.4~~	~~10~~	~~9.8~~
Rural	10	7%	~~15.3~~	~~13.2~~	~~12~~	~~11.8~~	~~11.8~~	~~11.7~~	~~11.6~~	~~11.4~~	~~11.3~~	~~10.9~~	~~10.7~~
Rural	12	0%	~~12.6~~	~~11~~	9.3	9.1	8.8	8.5	8.2	8	7.6	7.5	7.1
Rural	12	1%	~~13~~	~~11.1~~	~~9.5~~	9.3	9	8.7	8.4	8.3	7.9	7.7	7.3
Rural	12	2%	~~13.4~~	~~11.1~~	~~9.9~~	~~9.7~~	9.4	9.1	8.9	8.9	8.5	8.2	7.9
Rural	12	3%	~~13.8~~	~~11.4~~	~~10.2~~	~~10~~	~~9.7~~	9.4	9.2	9.2	8.8	8.5	8.2
Rural	12	4%	~~14.2~~	~~11.8~~	~~10.7~~	~~10.5~~	~~10.2~~	~~9.9~~	~~9.7~~	~~9.7~~	9.3	9.1	8.7
Rural	12	5%	~~14.6~~	~~12.2~~	~~11.2~~	~~11~~	~~10.7~~	~~10.5~~	~~10.4~~	~~10.4~~	~~10~~	~~9.7~~	9.4
Rural	12	6%	~~15.4~~	~~13~~	~~11.8~~	~~11.6~~	~~11.3~~	~~11.1~~	~~11~~	~~11~~	~~10.6~~	~~10.3~~	~~10~~
Rural	12	7%	~~15.9~~	~~13.5~~	~~12.5~~	~~12.3~~	~~12.2~~	~~12~~	~~11.9~~	~~11.9~~	~~11.5~~	~~11.2~~	~~10.9~~
Urban	2	0%	4.6	4.4	4.3	4.3	4.3	4.3	4.3	4.3	4.2	4.1	4.1
Urban	2	1%	4.8	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.4	4.4
Urban	2	2%	5.1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.6	4.6
Urban	2	3%	5.3	5.1	5	5	5	5	5	5	4.9	4.8	4.8
Urban	2	4%	5.7	5.5	5.4	5.4	5.4	5.4	5.4	5.4	5.3	5.2	5.2
Urban	2	5%	6.2	6	5.9	5.9	5.9	5.9	5.9	5.9	5.8	5.7	5.7
Urban	2	6%	6.7	6.5	6.4	6.4	6.4	6.4	6.4	6.4	6.3	6.2	6.2
Urban	2	7%	7	6.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.5	6.5
Urban	4	0%	5.9	5.2	4.7	4.7	4.6	4.6	4.5	4.5	4.4	4.3	4.2
Urban	4	1%	6.2	5.5	5	5	5	5	4.9	4.8	4.8	4.6	4.6
Urban	4	2%	6.5	5.8	5.2	5.2	5.2	5.2	5.1	5	5	4.8	4.8
Urban	4	3%	6.7	6	5.4	5.4	5.3	5.3	5.2	5.2	5.1	5	4.9
Urban	4	4%	6.9	6.2	5.8	5.8	5.7	5.7	5.6	5.6	5.5	5.4	5.3
Urban	4	5%	7.3	6.6	6.3	6.3	6.2	6.2	6.1	6.1	6	5.9	5.8
Urban	4	6%	7.8	7.1	6.8	6.8	6.7	6.7	6.6	6.6	6.5	6.4	6.3
Urban	4	7%	8.2	7.5	7.1	7.1	7.1	7.1	7	6.9	6.9	6.7	6.7
Urban	6	0%	6.8	5.9	5	5	4.9	4.8	4.8	4.7	4.6	4.4	4.2
Urban	6	1%	7.1	6.2	5.3	5.3	5.2	5.2	5.2	5.1	5	4.8	4.6

Table A-3 (a). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 45° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Urban	6	2%	7.4	6.5	5.5	5.5	5.4	5.4	5.4	5.3	5.2	5	4.8
Urban	6	3%	7.6	6.7	5.7	5.7	5.6	5.5	5.5	5.5	5.3	5.1	4.9
Urban	6	4%	7.8	6.9	6.1	6.1	6	5.9	5.9	5.8	5.7	5.5	5.3
Urban	6	5%	8.2	7.3	6.6	6.6	6.5	6.4	6.4	6.3	6.2	6	5.8
Urban	6	6%	8.7	7.8	7.1	7.1	7	6.9	6.9	6.8	6.7	6.5	6.3
Urban	6	7%	9.1	8.2	7.4	7.4	7.3	7.3	7.3	7.2	7.1	6.9	6.7
Urban	8	0%	7.4	6.4	5.3	5.3	5.2	5.1	5	5	4.8	4.6	4.4
Urban	8	1%	7.7	6.7	5.7	5.7	5.5	5.5	5.4	5.4	5.2	5	4.8
Urban	8	2%	8	7	5.9	5.9	5.7	5.7	5.6	5.6	5.4	5.2	5
Urban	8	3%	8.2	7.2	6	6	5.9	5.8	5.8	5.7	5.5	5.3	5.1
Urban	8	4%	8.4	7.4	6.4	6.4	6.3	6.2	6.1	6.1	5.9	5.7	5.5
Urban	8	5%	8.8	7.8	6.9	6.9	6.8	6.7	6.6	6.6	6.4	6.2	6
Urban	8	6%	9.3	8.3	7.4	7.4	7.3	7.2	7.1	7.1	6.9	6.7	6.5
Urban	8	7%	~~9.7~~	8.7	7.8	7.8	7.6	7.6	7.5	7.5	7.3	7.1	6.9
Urban	10	0%	7.9	7.2	5.6	5.5	5.5	5.3	5.3	5.2	5	4.7	4.4
Urban	10	1%	8.2	7.4	6	5.9	5.9	5.7	5.7	5.6	5.4	5.1	4.8
Urban	10	2%	8.5	7.5	6.2	6.1	6.1	5.9	5.9	5.8	5.6	5.3	5
Urban	10	3%	8.7	7.7	6.4	6.3	6.2	6.1	6	6	5.7	5.4	5.1
Urban	10	4%	8.9	7.9	6.7	6.6	6.6	6.4	6.4	6.3	6.1	5.8	5.5
Urban	10	5%	9.3	8.2	7.2	7.1	7.1	6.9	6.9	6.8	6.6	6.3	6
Urban	10	6%	~~9.8~~	8.7	7.7	7.6	7.6	7.4	7.4	7.3	7.1	6.8	6.5
Urban	10	7%	~~10.2~~	9.1	8.1	8	8	7.8	7.8	7.7	7.5	7.2	6.9
Urban	12	0%	8.6	7.8	6	5.8	5.7	5.6	5.5	5.5	5.1	4.9	4.4
Urban	12	1%	8.8	8	6.4	6.2	6.1	6	5.9	5.9	5.5	5.3	4.8
Urban	12	2%	9	8.1	6.6	6.4	6.3	6.2	6.1	6.1	5.7	5.5	5
Urban	12	3%	9.2	8.3	6.7	6.6	6.5	6.4	6.3	6.2	5.8	5.6	5.1
Urban	12	4%	9.4	8.5	7.1	6.9	6.8	6.7	6.6	6.6	6.2	6	5.5
Urban	12	5%	~~9.8~~	8.8	7.6	7.4	7.3	7.2	7.1	7.1	6.7	6.5	6
Urban	12	6%	~~10.3~~	9.2	8.1	7.9	7.8	7.7	7.6	7.6	7.2	7	6.5
Urban	12	7%	~~10.7~~	~~9.6~~	8.5	8.3	8.2	8.1	8	8	7.6	7.4	6.9

Notes: Red strikethrough values indicated exceedances of the standard, based on national-level (not Virginia-specific) conservative and worst-case modeling assumptions. To apply the table above for a project located in Virginia, the value in the table (black text or red strikethrough) with the setting and configuration corresponding to the project must be adjusted using the appropriate Virginia-specific background concentration and persistence factor.

* These findings apply to scenarios with the intersection average speed ranging from 15 to 45 mph and the freeway average speed ranging from 19 to 75 mph, for which posted speeds in those ranges may be applied as reasonable proxies.

Table A-3 (b). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 60° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	2	0%	6.7	6.2	6	6	6	6	6	5.9	5.8	5.6	5.6
Rural	2	1%	7	6.5	6.3	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.9
Rural	2	2%	7.4	6.8	6.6	6.6	6.6	6.6	6.6	6.5	6.4	6.2	6.2
Rural	2	3%	7.8	7.1	6.9	6.9	6.9	6.9	6.9	6.8	6.7	6.5	6.5
Rural	2	4%	8.2	7.6	7.4	7.4	7.4	7.4	7.4	7.3	7.2	7	7
Rural	2	5%	8.8	8.1	7.9	7.9	7.9	7.9	7.9	7.8	7.7	7.5	7.5
Rural	2	6%	9.4	8.7	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8	8
Rural	2	7%	~~9.9~~	9.3	9.1	9.1	9.1	9.1	9.1	9	8.9	8.7	8.7
Rural	4	0%	9.1	7.6	6.9	6.8	6.7	6.6	6.5	6.4	6	5.8	5.6
Rural	4	1%	9.4	7.9	7.2	7.1	7	6.9	6.8	6.7	6.3	6.1	5.9
Rural	4	2%	~~9.8~~	8.3	7.5	7.4	7.3	7.2	7.1	7	6.6	6.4	6.2
Rural	4	3%	~~10.2~~	8.7	7.8	7.7	7.6	7.5	7.4	7.3	6.9	6.7	6.5
Rural	4	4%	~~10.6~~	9.1	8.3	8.2	8.1	8	7.9	7.8	7.4	7.2	7
Rural	4	5%	~~11.2~~	~~9.7~~	8.8	8.7	8.6	8.5	8.4	8.3	7.9	7.7	7.5
Rural	4	6%	~~11.8~~	~~10.3~~	9.3	9.2	9.1	9	8.9	8.8	8.4	8.2	8
Rural	4	7%	~~12.3~~	~~10.8~~	~~10~~	~~9.9~~	~~9.8~~	~~9.7~~	~~9.6~~	~~9.5~~	9.1	8.9	8.7
Rural	6	0%	~~10.3~~	8.5	7.5	7.4	7.3	7.1	6.9	6.7	6.3	6	5.8
Rural	6	1%	~~10.6~~	8.8	7.8	7.7	7.6	7.4	7.2	7	6.6	6.3	6.1
Rural	6	2%	~~11~~	9.2	8.1	8	7.9	7.7	7.5	7.3	6.9	6.6	6.4
Rural	6	3%	~~11.4~~	~~9.6~~	8.4	8.3	8.2	8	7.8	7.6	7.2	6.9	6.7
Rural	6	4%	~~11.8~~	~~10~~	8.9	8.8	8.7	8.5	8.3	8.1	7.7	7.4	7.2
Rural	6	5%	~~12.4~~	~~10.6~~	9.4	9.3	9.2	9	8.8	8.6	8.2	7.9	7.7
Rural	6	6%	~~13~~	~~11.2~~	~~9.9~~	~~9.8~~	~~9.7~~	~~9.5~~	9.3	9.1	8.7	8.4	8.2
Rural	6	7%	~~13.5~~	~~11.7~~	~~10.6~~	~~10.5~~	~~10.4~~	~~10.2~~	~~10~~	~~9.8~~	9.4	9.1	8.9
Rural	8	0%	~~11.1~~	9.2	8.1	7.9	7.8	7.6	7.4	7.2	6.5	6.2	6
Rural	8	1%	~~11.4~~	~~9.5~~	8.4	8.2	8.1	7.9	7.7	7.5	6.8	6.5	6.3
Rural	8	2%	~~11.8~~	~~9.9~~	8.7	8.5	8.4	8.2	8	7.8	7.1	6.8	6.6
Rural	8	3%	~~12.2~~	~~10.3~~	9	8.8	8.7	8.5	8.3	8.1	7.4	7.1	6.9
Rural	8	4%	~~12.6~~	~~10.7~~	~~9.5~~	9.3	9.2	9	8.8	8.6	7.9	7.6	7.4
Rural	8	5%	~~13.2~~	~~11.3~~	~~10~~	~~9.8~~	~~9.7~~	~~9.5~~	9.3	9.1	8.4	8.1	7.9
Rural	8	6%	~~13.8~~	~~11.9~~	~~10.5~~	~~10.3~~	~~10.2~~	~~10~~	~~9.8~~	~~9.6~~	8.9	8.6	8.4
Rural	8	7%	~~14.3~~	~~12.4~~	~~11.2~~	~~11~~	~~10.9~~	~~10.7~~	~~10.5~~	~~10.3~~	~~9.6~~	9.3	9.1
Rural	10	0%	~~11.8~~	~~9.7~~	8.6	8.4	8.1	7.9	7.7	7.5	6.6	6.4	6.2

Table A-3 (b). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 60° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	10	1%	~~12.1~~	~~10~~	8.9	8.7	8.4	8.2	8	7.8	6.9	6.7	6.5
Rural	10	2%	~~12.5~~	~~10.4~~	9.2	9	8.7	8.5	8.3	8.1	7.2	7	6.8
Rural	10	3%	~~12.9~~	~~10.8~~	~~9.5~~	9.3	9	8.8	8.6	8.4	7.5	7.3	7.1
Rural	10	4%	~~13.3~~	~~11.2~~	~~10~~	~~9.8~~	~~9.5~~	9.3	9.1	8.9	8	7.8	7.6
Rural	10	5%	~~13.9~~	~~11.8~~	~~10.5~~	~~10.3~~	~~10~~	~~9.8~~	~~9.6~~	9.4	8.5	8.3	8.1
Rural	10	6%	~~14.5~~	~~12.4~~	~~11~~	~~10.8~~	~~10.5~~	~~10.3~~	~~10.1~~	~~9.9~~	9	8.8	8.6
Rural	10	7%	~~15~~	~~12.9~~	~~11.7~~	~~11.5~~	~~11.2~~	~~11~~	~~10.8~~	~~10.6~~	~~9.7~~	~~9.5~~	9.3
Rural	12	0%	~~12.3~~	~~10.7~~	9.1	8.9	8.6	8.2	8	7.8	6.8	6.7	6.4
Rural	12	1%	~~12.6~~	~~10.8~~	9.4	9.2	8.9	8.5	8.3	8.1	7.1	7	6.7
Rural	12	2%	~~13~~	~~10.9~~	~~9.7~~	~~9.5~~	9.2	8.8	8.6	8.4	7.4	7.3	7
Rural	12	3%	~~13.4~~	~~11.1~~	~~10~~	~~9.8~~	~~9.5~~	9.1	8.9	8.7	7.7	7.6	7.3
Rural	12	4%	~~13.8~~	~~11.5~~	~~10.5~~	~~10.3~~	~~10~~	~~9.6~~	9.4	9.2	8.2	8.1	7.8
Rural	12	5%	~~14.4~~	~~12.1~~	~~11~~	~~10.8~~	~~10.5~~	~~10.1~~	~~9.9~~	~~9.7~~	8.7	8.6	8.3
Rural	12	6%	~~15~~	~~12.7~~	~~11.5~~	~~11.3~~	~~11~~	~~10.6~~	~~10.4~~	~~10.2~~	9.2	9.1	8.8
Rural	12	7%	~~15.5~~	~~13.2~~	~~12.2~~	~~12~~	~~11.7~~	~~11.3~~	~~11.1~~	~~10.9~~	~~9.9~~	~~9.8~~	~~9.5~~
Urban	2	0%	4.4	4.1	4	4	4	4	4	4	3.8	3.8	3.8
Urban	2	1%	4.6	4.4	4.3	4.3	4.3	4.3	4.3	4.3	4.1	4.1	4.1
Urban	2	2%	4.8	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.3	4.3	4.3
Urban	2	3%	5.1	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.5	4.5	4.5
Urban	2	4%	5.5	5.3	5.2	5.2	5.2	5.2	5.2	5.2	5	5	5
Urban	2	5%	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.5	5.3	5.3	5.3
Urban	2	6%	6.4	6.2	6.1	6.1	6.1	6.1	6.1	6.1	5.9	5.9	5.9
Urban	2	7%	6.8	6.6	6.5	6.5	6.5	6.5	6.5	6.5	6.3	6.3	6.3
Urban	4	0%	5.8	5.1	4.4	4.4	4.3	4.2	4.2	4.2	4	4	3.8
Urban	4	1%	5.9	5.2	4.7	4.7	4.6	4.5	4.5	4.5	4.3	4.3	4.1
Urban	4	2%	6.2	5.5	4.9	4.9	4.8	4.7	4.7	4.7	4.5	4.5	4.3
Urban	4	3%	6.5	5.8	5.1	5.1	5	4.9	4.9	4.9	4.7	4.7	4.5
Urban	4	4%	6.8	6.1	5.6	5.6	5.5	5.4	5.4	5.4	5.2	5.2	5
Urban	4	5%	7.1	6.4	5.9	5.9	5.8	5.7	5.7	5.7	5.5	5.5	5.3
Urban	4	6%	7.6	6.9	6.5	6.5	6.4	6.3	6.3	6.3	6.1	6.1	5.9
Urban	4	7%	7.9	7.2	6.9	6.9	6.8	6.7	6.7	6.7	6.5	6.5	6.3
Urban	6	0%	6.7	5.8	4.8	4.7	4.6	4.5	4.4	4.4	4.2	4	3.8
Urban	6	1%	6.8	5.9	5	5	4.9	4.8	4.7	4.7	4.5	4.3	4.1

Table A-3 (b). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 60° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Urban	6	2%	7.1	6.2	5.2	5.2	5.1	5	4.9	4.9	4.7	4.5	4.3
Urban	6	3%	7.4	6.5	5.5	5.4	5.3	5.2	5.1	5.1	4.9	4.7	4.5
Urban	6	4%	7.7	6.8	5.9	5.9	5.8	5.7	5.6	5.6	5.4	5.2	5
Urban	6	5%	8	7.1	6.2	6.2	6.1	6	5.9	5.9	5.7	5.5	5.3
Urban	6	6%	8.5	7.6	6.8	6.8	6.7	6.6	6.5	6.5	6.3	6.1	5.9
Urban	6	7%	8.8	7.9	7.2	7.2	7.1	7	6.9	6.9	6.7	6.5	6.3
Urban	8	0%	7.3	6.4	5.1	4.9	4.9	4.7	4.7	4.6	4.4	4.2	4
Urban	8	1%	7.4	6.4	5.3	5.2	5.2	5	5	4.9	4.7	4.5	4.3
Urban	8	2%	7.7	6.7	5.5	5.4	5.4	5.2	5.2	5.1	4.9	4.7	4.5
Urban	8	3%	8	7	5.8	5.6	5.6	5.4	5.4	5.3	5.1	4.9	4.7
Urban	8	4%	8.3	7.3	6.2	6.1	6.1	5.9	5.9	5.7	5.5	5.4	5.2
Urban	8	5%	8.6	7.6	6.5	6.4	6.4	6.2	6.2	6	5.8	5.7	5.5
Urban	8	6%	9.1	8.1	7.1	7	7	6.8	6.8	6.6	6.4	6.3	6.1
Urban	8	7%	9.4	8.4	7.5	7.4	7.4	7.2	7.2	7	6.8	6.7	6.5
Urban	10	0%	7.9	7.2	5.6	5.2	5.1	5	4.9	4.9	4.5	4.3	4
Urban	10	1%	7.9	7.2	5.6	5.5	5.4	5.3	5.2	5.2	4.8	4.6	4.3
Urban	10	2%	8.2	7.5	5.9	5.7	5.6	5.5	5.4	5.4	5	4.8	4.5
Urban	10	3%	8.5	7.6	6.2	5.9	5.8	5.7	5.6	5.6	5.3	5	4.7
Urban	10	4%	8.8	7.9	6.5	6.4	6.2	6.1	6.1	5.9	5.7	5.4	5.2
Urban	10	5%	9.1	8	6.8	6.7	6.5	6.4	6.4	6.2	6	5.7	5.5
Urban	10	6%	~~9.6~~	8.5	7.3	7.3	7.1	7	7	6.8	6.6	6.3	6.1
Urban	10	7%	~~9.9~~	8.8	7.7	7.7	7.5	7.4	7.4	7.2	7	6.7	6.5
Urban	12	0%	8.6	7.8	6	5.6	5.4	5.3	5.2	5.1	4.7	4.4	4.2
Urban	12	1%	8.6	7.8	6	5.8	5.7	5.6	5.5	5.4	5	4.7	4.5
Urban	12	2%	8.9	8.1	6.3	6	5.9	5.8	5.7	5.6	5.2	4.9	4.7
Urban	12	3%	9	8.2	6.4	6.2	6.1	6	5.9	5.8	5.4	5.2	4.9
Urban	12	4%	9.3	8.5	6.7	6.6	6.4	6.4	6.2	6.1	5.8	5.6	5.4
Urban	12	5%	~~9.6~~	8.6	7	6.9	6.7	6.7	6.5	6.4	6.1	5.9	5.7
Urban	12	6%	~~10.1~~	9	7.6	7.5	7.3	7.3	7.1	7	6.7	6.5	6.3
Urban	12	7%	~~10.4~~	9.3	8	7.9	7.7	7.7	7.5	7.4	7.1	6.9	6.7

Notes: Red strikethrough values indicated exceedances of the standard, based on national-level (not Virginia-specific) conservative and worst-case modeling assumptions. To apply the table above for a project located in Virginia, the value in the table (black text or red strikethrough) with the setting and configuration corresponding to the project must be adjusted using the appropriate Virginia-specific background concentration and persistence factor.

* These findings apply to scenarios with average speed ranging from 15 to 56 mph for arterials and 19 to 75 mph for freeways, for which posted speeds in those ranges may be applied as reasonable proxies.

Table A-3 (c). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 90° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	2	0%	6.7	6	5.8	5.8	5.8	5.8	5.8	5.6	5.6	5.6	5.4
Rural	2	1%	7	6.3	6	6	6	6	6	5.8	5.8	5.7	5.6
Rural	2	2%	7.4	6.7	6.4	6.4	6.4	6.4	6.4	6.2	6.2	6.2	6
Rural	2	3%	7.8	7.1	6.7	6.7	6.7	6.7	6.7	6.5	6.5	6.3	6.3
Rural	2	4%	8.1	7.4	7.2	7.2	7.2	7.2	7.2	7	7	6.8	6.8
Rural	2	5%	8.8	8.1	7.7	7.7	7.7	7.7	7.7	7.5	7.5	7.3	7.3
Rural	2	6%	9.4	8.7	8.2	8.2	8.2	8.2	8.2	8	8	7.8	7.8
Rural	2	7%	~~9.9~~	9.2	8.8	8.8	8.8	8.8	8.8	8.6	8.6	8.4	8.4
Rural	4	0%	9	7.6	6.7	6.6	6.5	6.4	6.3	6.2	5.8	5.8	5.6
Rural	4	1%	9.3	7.9	6.9	6.8	6.7	6.6	6.5	6.4	6	5.9	5.7
Rural	4	2%	~~9.7~~	8.3	7.3	7.2	7.1	7	6.9	6.8	6.4	6.4	6.2
Rural	4	3%	~~10.1~~	8.7	7.6	7.5	7.4	7.3	7.2	7.1	6.7	6.5	6.3
Rural	4	4%	~~10.4~~	9	8.1	8	7.9	7.8	7.7	7.6	7.2	6.9	6.8
Rural	4	5%	~~11.1~~	~~9.7~~	8.6	8.5	8.4	8.3	8.2	8.1	7.7	7.4	7.3
Rural	4	6%	~~11.7~~	~~10.3~~	9.1	9	8.9	8.8	8.7	8.6	8.2	7.9	7.8
Rural	4	7%	~~12.2~~	~~10.8~~	~~9.7~~	~~9.6~~	~~9.5~~	9.4	9.3	9.2	8.8	8.5	8.4
Rural	6	0%	~~10.3~~	8.5	7.3	7.1	7	6.9	6.7	6.5	6	6	5.8
Rural	6	1%	~~10.6~~	8.8	7.5	7.3	7.2	7.1	6.9	6.7	6.2	6.1	5.9
Rural	6	2%	~~11~~	9.2	7.9	7.7	7.6	7.5	7.3	7.1	6.6	6.6	6.4
Rural	6	3%	~~11.4~~	~~9.6~~	8.2	8	7.9	7.8	7.6	7.4	6.9	6.7	6.5
Rural	6	4%	~~11.7~~	~~9.9~~	8.7	8.5	8.4	8.3	8.1	7.9	7.4	7.1	6.9
Rural	6	5%	~~12.4~~	~~10.6~~	9.2	9	8.9	8.8	8.6	8.4	7.9	7.5	7.3
Rural	6	6%	~~13~~	~~11.2~~	~~9.7~~	~~9.5~~	9.4	9.3	9.1	8.9	8.4	8	7.8
Rural	6	7%	~~13.5~~	~~11.7~~	~~10.3~~	~~10.1~~	~~10~~	~~9.9~~	~~9.7~~	~~9.5~~	9	8.6	8.4
Rural	8	0%	~~11.1~~	9	7.9	7.7	7.5	7.2	7.1	6.9	6.3	6.2	6
Rural	8	1%	~~11.4~~	9.3	8.1	7.9	7.7	7.4	7.3	7.1	6.4	6.3	6.1
Rural	8	2%	~~11.8~~	~~9.7~~	8.5	8.3	8.1	7.8	7.7	7.5	6.9	6.8	6.6
Rural	8	3%	~~12.2~~	~~10.1~~	8.8	8.6	8.4	8.1	8	7.8	7.1	6.9	6.7
Rural	8	4%	~~12.5~~	~~10.4~~	9.3	9.1	8.9	8.6	8.5	8.3	7.6	7.3	7.1
Rural	8	5%	~~13.2~~	~~11.1~~	~~9.8~~	~~9.6~~	9.4	9.1	9	8.8	8.1	7.7	7.5
Rural	8	6%	~~13.8~~	~~11.7~~	~~10.3~~	~~10.1~~	~~9.9~~	~~9.6~~	~~9.5~~	9.3	8.6	8.2	8
Rural	8	7%	~~14.3~~	~~12.2~~	~~10.9~~	~~10.7~~	~~10.5~~	~~10.2~~	~~10.1~~	~~9.9~~	9.2	8.8	8.6
Rural	10	0%	~~11.8~~	~~9.5~~	8.4	8.2	7.9	7.7	7.5	7.2	6.5	6.3	6
Rural	10	1%	~~12.1~~	~~9.8~~	8.6	8.4	8.1	7.9	7.7	7.4	6.6	6.4	6.1

Table A-3 (c). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 90° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Rural	10	2%	~~12.5~~	~~10.2~~	9	8.8	8.5	8.3	8.1	7.8	7.1	6.9	6.6
Rural	10	3%	~~12.9~~	~~10.6~~	9.3	9.1	8.8	8.6	8.4	8.1	7.3	7	6.7
Rural	10	4%	~~13.2~~	~~10.9~~	~~9.8~~	~~9.6~~	9.3	9.1	8.9	8.6	7.8	7.4	7.1
Rural	10	5%	~~13.9~~	~~11.6~~	~~10.3~~	~~10.1~~	~~9.8~~	~~9.6~~	9.4	9.1	8.3	7.8	7.5
Rural	10	6%	~~14.5~~	~~12.2~~	~~10.8~~	~~10.6~~	~~10.3~~	~~10.1~~	~~9.9~~	~~9.6~~	8.8	8.3	8
Rural	10	7%	~~15~~	~~12.7~~	~~11.4~~	~~11.2~~	~~10.9~~	~~10.7~~	~~10.5~~	~~10.2~~	9.4	8.9	8.6
Rural	12	0%	~~12.3~~	~~10.6~~	8.9	8.5	8.3	8	7.8	7.5	6.7	6.5	6.2
Rural	12	1%	~~12.6~~	~~10.7~~	9.1	8.7	8.5	8.2	8	7.7	6.8	6.6	6.3
Rural	12	2%	~~13~~	~~10.7~~	~~9.5~~	9.1	8.9	8.6	8.4	8.1	7.3	7.1	6.8
Rural	12	3%	~~13.4~~	~~11~~	~~9.8~~	9.4	9.2	8.9	8.7	8.4	7.4	7.2	6.9
Rural	12	4%	~~13.7~~	~~11.3~~	~~10.3~~	~~9.9~~	~~9.7~~	9.4	9.2	8.9	7.9	7.6	7.3
Rural	12	5%	~~14.4~~	~~12~~	~~10.8~~	~~10.4~~	~~10.2~~	~~9.9~~	~~9.7~~	9.4	8.4	8	7.7
Rural	12	6%	~~15~~	~~12.6~~	~~11.3~~	~~10.9~~	~~10.7~~	~~10.4~~	~~10.2~~	~~9.9~~	8.9	8.5	8.2
Rural	12	7%	~~15.5~~	~~13.1~~	~~11.9~~	~~11.5~~	~~11.3~~	~~11~~	~~10.8~~	~~10.5~~	~~9.5~~	9.1	8.8
Urban	2	0%	4.5	4.2	3.9	3.8	3.8	3.8	3.8	3.8	3.7	3.6	3.6
Urban	2	1%	4.6	4.3	4.1	4.1	4.1	4.1	4.1	4.1	3.9	3.9	3.9
Urban	2	2%	4.9	4.6	4.3	4.3	4.3	4.3	4.3	4.3	4.1	4.1	4.1
Urban	2	3%	5.2	4.9	4.6	4.5	4.5	4.5	4.5	4.5	4.3	4.3	4.3
Urban	2	4%	5.4	5.1	4.8	4.7	4.7	4.7	4.7	4.7	4.5	4.5	4.5
Urban	2	5%	5.8	5.5	5.2	5.2	5.2	5.2	5.2	5.2	5	5	5
Urban	2	6%	6.3	6	5.7	5.6	5.6	5.6	5.6	5.6	5.4	5.4	5.4
Urban	2	7%	6.7	6.4	6.1	6.1	6.1	6.1	6.1	6.1	5.9	5.9	5.9
Urban	4	0%	5.9	5.2	4.5	4.2	4.2	4	4	4	3.9	3.8	3.8
Urban	4	1%	6	5.3	4.6	4.5	4.4	4.3	4.3	4.3	4.1	4.1	4
Urban	4	2%	6.3	5.6	4.9	4.7	4.6	4.5	4.5	4.5	4.3	4.3	4.1
Urban	4	3%	6.6	5.9	5.2	4.9	4.9	4.7	4.7	4.7	4.5	4.5	4.3
Urban	4	4%	6.8	6.1	5.4	5.1	5.1	4.9	4.9	4.9	4.7	4.7	4.5
Urban	4	5%	7.2	6.5	5.8	5.6	5.5	5.4	5.4	5.4	5.2	5.2	5
Urban	4	6%	7.7	7	6.3	6	6	5.8	5.8	5.8	5.6	5.6	5.4
Urban	4	7%	8.1	7.4	6.7	6.5	6.4	6.3	6.3	6.3	6.1	6.1	5.9
Urban	6	0%	6.8	5.9	4.9	4.6	4.4	4.3	4.2	4.2	4	4	3.8
Urban	6	1%	6.9	6	5	4.8	4.7	4.6	4.5	4.5	4.3	4.2	4
Urban	6	2%	7.2	6.3	5.3	5	4.9	4.8	4.7	4.7	4.5	4.3	4.1
Urban	6	3%	7.5	6.6	5.6	5.3	5.1	5	4.9	4.9	4.7	4.5	4.3

Table A-3 (c). One-hour CO Concentrations at Varying Intersection-Freeway Distances, Intersection Grade, and Lane Configurations for 90° Skew Angle (not including background concentrations)*

Location	Number of Lanes	Intersection Grade	Distance between Freeway and Intersection (ft)										
			20	30	60	80	100	125	150	175	300	500	1000
Urban	6	4%	7.7	6.8	5.8	5.5	5.3	5.2	5.1	5.1	4.9	4.7	4.5
Urban	6	5%	8.1	7.2	6.2	5.9	5.8	5.7	5.6	5.6	5.4	5.2	5
Urban	6	6%	8.6	7.7	6.7	6.4	6.2	6.1	6	6	5.8	5.6	5.4
Urban	6	7%	9	8.1	7.1	6.8	6.7	6.6	6.5	6.5	6.3	6.1	5.9
Urban	8	0%	7.4	6.4	5.2	4.9	4.7	4.5	4.5	4.4	4.2	4.1	4
Urban	8	1%	7.5	6.5	5.3	5	5	4.8	4.8	4.6	4.4	4.3	4.2
Urban	8	2%	7.8	6.8	5.6	5.3	5.2	5	5	4.8	4.6	4.4	4.3
Urban	8	3%	8.1	7.1	5.9	5.6	5.4	5.2	5.2	5	4.8	4.6	4.5
Urban	8	4%	8.3	7.3	6.1	5.8	5.6	5.4	5.4	5.2	5	4.8	4.7
Urban	8	5%	8.7	7.7	6.5	6.2	6.1	5.9	5.9	5.7	5.5	5.3	5.2
Urban	8	6%	9.2	8.2	7	6.7	6.5	6.3	6.3	6.1	5.9	5.7	5.6
Urban	8	7%	~~9.6~~	8.6	7.4	7.1	7	6.8	6.8	6.6	6.4	6.2	6.1
Urban	10	0%	7.9	7.1	5.6	5.2	4.9	4.7	4.7	4.6	4.4	4.2	4
Urban	10	1%	8	7.2	5.7	5.3	5.1	5	4.9	4.8	4.6	4.4	4.2
Urban	10	2%	8.3	7.5	6	5.6	5.3	5.2	5.1	5	4.7	4.5	4.3
Urban	10	3%	8.6	7.6	6.3	5.9	5.6	5.4	5.3	5.2	4.9	4.7	4.5
Urban	10	4%	8.8	7.8	6.5	6.1	5.8	5.6	5.5	5.4	5.1	4.9	4.7
Urban	10	5%	9.2	8.1	6.9	6.5	6.2	6.1	6	5.9	5.6	5.4	5.2
Urban	10	6%	~~9.7~~	8.6	7.4	7	6.7	6.5	6.4	6.3	6	5.8	5.6
Urban	10	7%	~~10.1~~	9	7.8	7.4	7.1	7	6.9	6.8	6.5	6.3	6.1
Urban	12	0%	8.5	7.7	5.9	5.4	5.1	5	4.9	4.8	4.6	4.4	4.2
Urban	12	1%	8.6	7.8	6	5.5	5.3	5.3	5.1	5	4.8	4.6	4.4
Urban	12	2%	8.9	8.1	6.3	5.8	5.5	5.5	5.3	5.2	4.9	4.7	4.5
Urban	12	3%	9.1	8.2	6.5	6	5.7	5.7	5.5	5.4	5.1	4.9	4.7
Urban	12	4%	9.3	8.4	6.7	6.2	5.9	5.9	5.7	5.6	5.3	5.1	4.9
Urban	12	5%	~~9.7~~	8.7	7.1	6.6	6.4	6.4	6.2	6.1	5.8	5.6	5.4
Urban	12	6%	~~10.2~~	9.1	7.6	7.1	6.8	6.8	6.6	6.5	6.2	6	5.8
Urban	12	7%	~~10.6~~	~~9.5~~	8	7.5	7.3	7.3	7.1	7	6.7	6.5	6.3

Notes: Red strikethrough values indicated exceedances of the standard, based on national-level (not Virginia-specific) conservative and worst-case modeling assumptions. To apply the table above for a project located in Virginia, the value in the table (black text or red strikethrough) with the setting and configuration corresponding to the project must be adjusted using the appropriate Virginia-specific background concentration and persistence factor.

* These findings apply to scenarios with average speed ranging from 15 to 56 mph for arterials and 19 to 75 mph for freeways, for which posted speeds in those ranges may be applied as reasonable proxies.