Product 0-6864-P1

Decision Support Tool for Nighttime Construction and Air Quality - User's Guide

Project 0-6864

Project Title: Investigate the Air Quality Benefits of Nighttime Construction in Non-Attainment Counties

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16. Abstract
The Texas Department of Transportation (TxDOT) Research Project 0-6864 *Investigate the Air Quality Benefits of Nighttime Construction in Non-attainment Counties* investigated the potential air quality benefits of shifting construction/maintenance activities to the nighttime. A decision-support framework in the form of a spreadsheet tool was developed as part of this study to put the findings on the air quality benefits into the broader context of decision making for nighttime construction. The framework is developed to help TxDOT make systematic decisions on whether a project is suited for nighttime construction activity, taking into account numerous factors including potential air quality benefits.

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Disclaimer

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

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Introduction

The Texas Department of Transportation (TxDOT) Research Project 0-6864 *Investigate the Air Quality Benefits of Nighttime Construction in Non-Attainment Counties* investigated the potential air quality benefits of shifting construction/maintenance activities to the nighttime. The final task of this project put the findings on the air quality benefits in the broader context of decision making for nighttime construction. The framework is developed to help TxDOT make systematic decisions on whether a project is suited for nighttime construction activity, taking into account numerous factors including potential air quality benefits.

The final project report, 0-6864-1, published in late 2017, contains further information on the research findings and background on the development of this tool. For more information, please contact the research supervisor:

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Overview of Decision-Support Tool

BACKGROUND AND APPROACH

Researchers' findings from a state-of-practice review and interviews with TxDOT staff revealed that:

- The decision to pursue nighttime construction is done at the local level, usually by the area engineer in charge.
- There is no formal process used by TxDOT for decision making on nighttime construction, though some districts have checklists or supporting documentation that they use.
- Air quality is currently not a factor that influences decision making when considering nighttime construction.

Based on these findings, the researchers' approach to the development of a decision-support framework is as follows:

- To provide a simple, flexible framework that can help formalize the process of making decisions on nighttime construction.
- Acknowledge that air quality is not the primary motivating factor, but incorporate air quality-related findings so that they can be used in the decision-making process if needed.

The framework is envisioned to provide different levels of insight for the practitioner based on the findings from the project. The first level provides general guidance and a list of resources for practitioners to consult. This is followed by a screening checklist that can be used to evaluate factors that may affect nighttime construction. Finally, a quantitative calculator module is provided that can estimate the emissions impacts for a lane closure under nighttime and daytime construction scenarios.

The decision-support tool is not meant to completely replace engineering judgment or existing processes for making decisions on nighttime construction. Rather, it aims to provide practitioners with relevant information and considerations in a systematic manner for potential consideration as part of their decision-making process.

INSTALLATION AND GETTING STARTED

The analysis tool is in the form of a standalone Microsoft Excel® workbook that is available as web download or in CD format, along with this user guide. The workbook can be saved to any location on a computer for use. It is recommended that the user save a copy of the workbook onto a local drive on their computer before starting. The user will then need to open the analysis tool workbook and enable active content (macros) to allow for full functionality. Figure 1 shows an example of how the option to enable content appears in the Excel® 2013 interface.

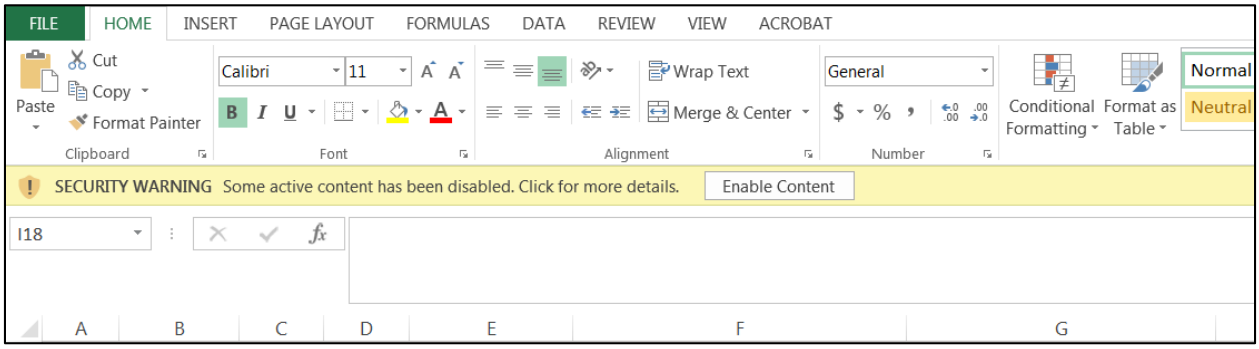


Figure 1. Enable Content Option in Excel® 2013.

Figure 2 shows a screenshot of the main screen on the tool that appears when the workbook is opened. From this page, the user can navigate through each of the worksheets using either the hyperlinks or the tabs at the bottom of the sheet. The worksheets include color coding, to distinguish user inputs cells, and are designed to allow for printing to a page width. They also contain basic instructions for the user where required.

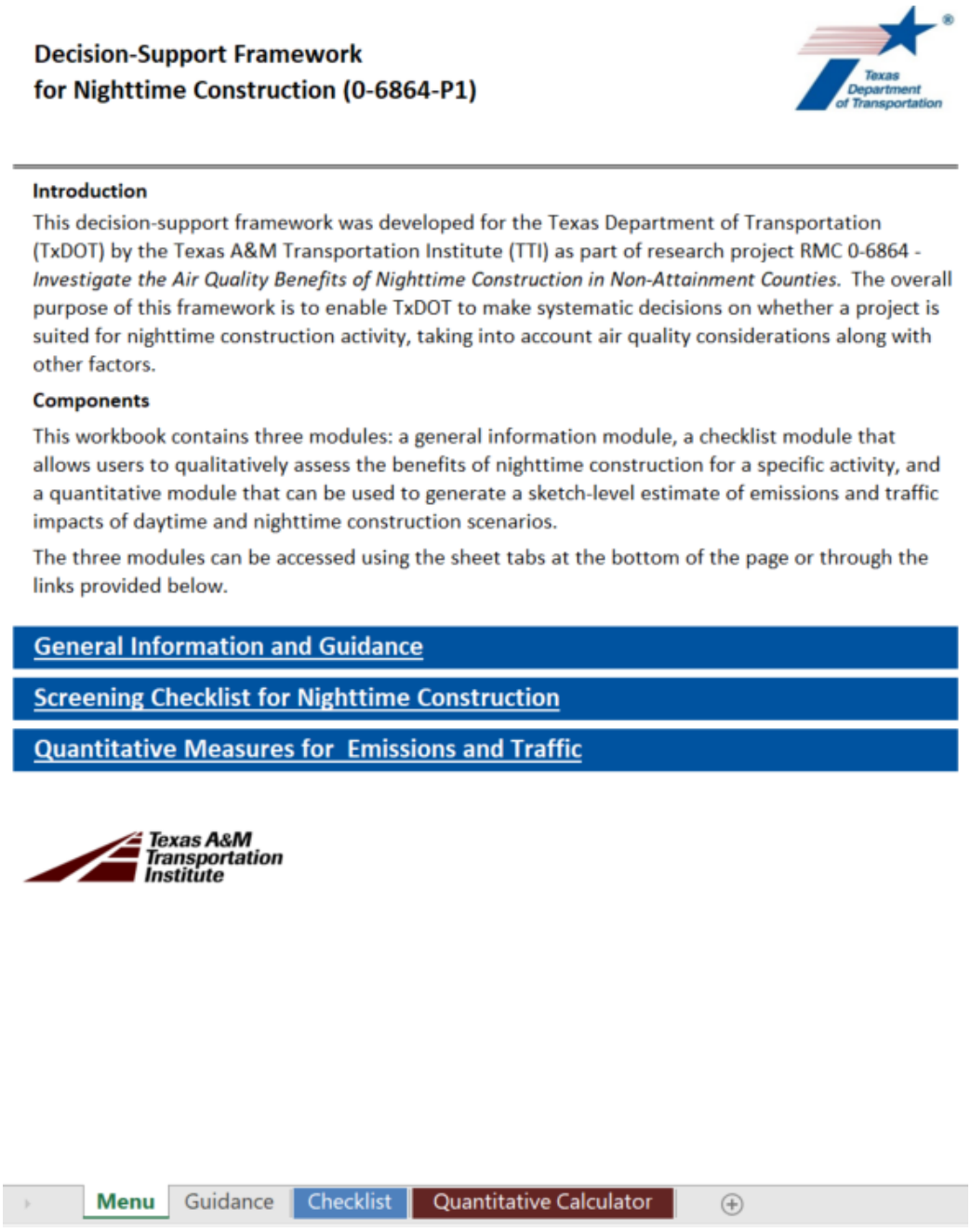


Figure 2. Main Menu for Excel Tool.

SECURITY

The spreadsheet is not password protected, through some sheets and calculations have been locked without password protection. To unprotect protected material, click the Review tab in the Excel® menu and select Unprotect Sheet. Additional hidden sheets containing reference tables and calculations are also contained in the workbook, though these elements are not required by the user.

COMPONENTS

This workbook contains three modules that can be navigated by clicking the hyperlinks in the main menu or by clicking on the sheet tabs at the bottom of the main page. The main components of the workbook include:

- A general guidance module that summarizes key project findings.
- A screening checklist module that allows users to qualitatively assess the benefits of nighttime construction for a specific activity.
- A quantitative module that can be used to generate a sketch-level estimate of emissions and traffic impacts of daytime and nighttime construction scenarios involving lane closures.

Using the Decision-Support Tool

NAVIGATION

The three modules of the spreadsheet can be accessed by clicking the hyperlinks in the main menu or using the tabs at the bottom of the workbook, as shown in Figure 2. Each of the modules has a Return to Menu hyperlink at the top left, allowing the user to return to the main menu and navigate between the different modules.

GENERAL INFORMATION AND GUIDANCE

The General Information and Guidance module provides a brief compilation of information related to nighttime construction practices gathered as part of project 0-6864. It includes the following sections:

- Introduction.
- Definition of nighttime construction in the context of project 0-6864.
- Advantages and disadvantages of nighttime construction (with a link to a detailed table developed as part of earlier study tasks).
- Findings from a survey of TxDOT practice (with a link to a detailed table of construction and maintenance activities ranked in terms of suitability for nighttime construction).
- List of additional resources discussing research and practical guidance on nighttime construction activities, as well as general guidance and best practices related to work zones.

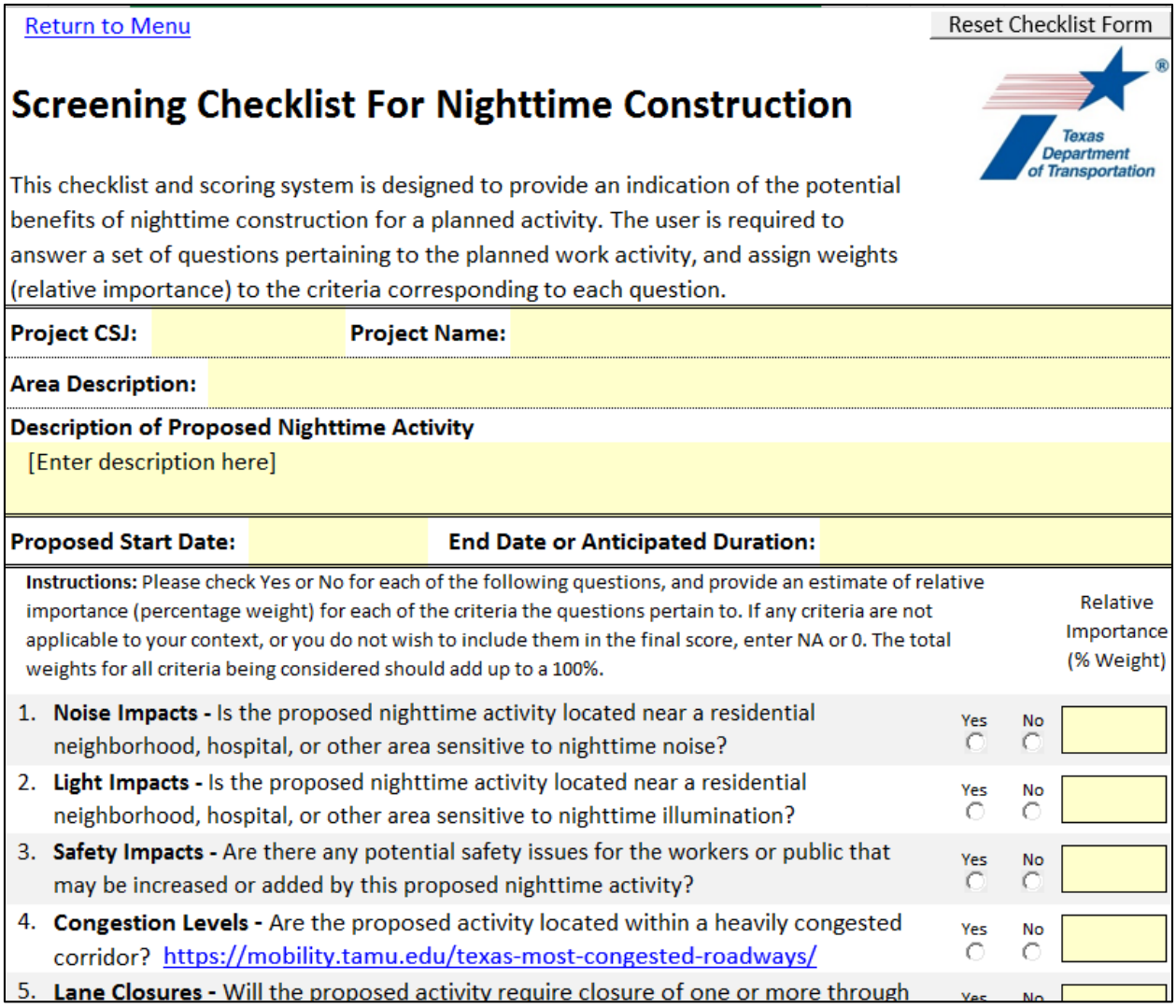
SCREENING CHECKLIST

This checklist and scoring system is designed to provide an indication of the potential benefits of nighttime construction for a planned activity, based on user inputs and priorities assigned to a set of 10 criteria. Researchers identified the criteria based on findings from the literature review and interviews, and the criteria cover the following elements:

- Noise impacts.
- Light impacts.
- Safety impacts.
- Congestion levels.
- Lane closures.
- Cost impacts.
- Access to worksite.
- Work quality.
- Air quality.
- Project-specific factors.

Each of the above criteria are associated with a question that can be answered qualitatively as a yes or no by the user. For some questions, a yes response would indicate that nighttime construction may be feasible or beneficial for the specific criterion. In other cases, a no response would indicate the same. The user is also required to provide an estimate of relative importance (expressed as a percentage weight) for each of the criteria. The user can enter 0 or NA to eliminate criteria from the final scoring, and the total weights assigned to the criteria of relevance must add up to a 100 percent. The checklist then generates a score as the weighted sum of the individual scores, with each response where nighttime construction is feasible or advantageous receiving a score of 1. Thus, the total weighted score is also expressed on a 0–1 scale, with a higher score indicating that there are more factors (or important/higher weight factors) that support the case for nighttime construction.

Figure 3 shows the screening checklist. It is designed to allow the form to be filled out and printed for documentation purposes, with details of the proposed activity included in the appropriate spaces in the form. The form also contains brief instructions for the user, instructing them to answer yes or no and assign weights to the criteria of relevance in the checklist. There is also a button on the top right of the form that allows for it to be reset.



Return to Menu

Reset Checklist Form

Screening Checklist For Nighttime Construction

Texas Department of Transportation

This checklist and scoring system is designed to provide an indication of the potential benefits of nighttime construction for a planned activity. The user is required to answer a set of questions pertaining to the planned work activity, and assign weights (relative importance) to the criteria corresponding to each question.

Project CSJ: **Project Name:**

Area Description:

Description of Proposed Nighttime Activity

[Enter description here]

Proposed Start Date: **End Date or Anticipated Duration:**

Instructions: Please check Yes or No for each of the following questions, and provide an estimate of relative importance (percentage weight) for each of the criteria the questions pertain to. If any criteria are not applicable to your context, or you do not wish to include them in the final score, enter NA or 0. The total weights for all criteria being considered should add up to a 100%.

Relative Importance (% Weight)

1. **Noise Impacts -** Is the proposed nighttime activity located near a residential neighborhood, hospital, or other area sensitive to nighttime noise? Yes No
2. **Light Impacts -** Is the proposed nighttime activity located near a residential neighborhood, hospital, or other area sensitive to nighttime illumination? Yes No
3. **Safety Impacts -** Are there any potential safety issues for the workers or public that may be increased or added by this proposed nighttime activity? Yes No
4. **Congestion Levels -** Are the proposed activity located within a heavily congested corridor? https://mobility.tamu.edu/texas-most-congested-roadways/ Yes No
5. **Lane Closures -** Will the proposed activity require closure of one or more through Yes No

Figure 3. Screening Checklist.

Once all the required data are entered, the results will be displayed at the bottom of the checklist, as shown in Figure 4, along with a brief explanation to interpret the score. The spreadsheet also provides a color-coded check to ensure the weights assigned to the different criteria add up to a 100 percent. As seen in the top right section of Figure 4, the total percentage cell is highlighted in green when the weights add to a 100 percent. If the weights do not add to a 100 percent, the cell will be shaded in red, as shown in Figure 5, and the final weighted score will not be displayed.

Total of Percentages (Should equal 100%):	100%
Weighted Score:	**0.80**
The score represents the weighted sum of the criteria listed, with each response where nighttime construction is feasible or advantageous receiving a score of 1. Thus, the weighted score is expressed on a scale of 0-1, with a higher score making a better case for nighttime construction.	
Name:	Date:

Figure 4. Checklist Scoring Result Example.

Total of Percentages (Should equal 100%):	90%
Weighted Score:	-

Figure 5. Error Check for Total Weight.

QUANTITATIVE MEASURES FOR EMISSIONS AND TRAFFIC

The quantitative calculator module is designed to supplement the screening checklist by providing an estimate of emissions and traffic impacts for nighttime and daytime construction scenarios. The calculations are based on a simplified, sketch-level analysis and are to be used for planning purposes only to assess potential differences based on the time of lane closures. The emissions results are not to be used for any regulatory or official reporting purposes, such as the congestion mitigation and air quality program reporting or for state implementation plan credits.

Consistent with the case study analyses conducted as part of the main research project, lane closures are used to represent the presence of a construction/maintenance activity from a traffic and emissions modeling perspective. Simplified calculation methodologies consistent with the case study approach are then used to compute the differences in emissions impact between the baseline (i.e., no lane closure), nighttime lane closure, and daytime lane closure scenarios. The estimated emissions from light plants required for nighttime construction is also included in the results. Further description of the methodologies used are provided in the appendix.

Figure 6 shows the layout and user input section of this module.

Quantitative Measures for Emissions and Traffic

This quantitative calculator provides rough, sketch-level estimates of emissions and traffic parameters for daytime and nighttime lane closure scenarios, as a representation of daytime and nighttime construction activity. The results are to be used for planning purposes only, to assess potential differences based on the time of lane closures. The emissions results are not be used for any regulatory or official reporting purposes, such as the congestion mitigation and air quality (CMAQ) program reporting or for State Implementation Plan (SIP) credits.

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User Inputs

Required Inputs (Required for Calculations)	
Area Type	Please Select
Roadway Type	Please Select
Total Number of Lanes (In Direction of Lane Closure)	
Number of Lanes Closed (In Direction of Lane Closure)	
Average Daily Traffic Volume - vehicles per day (In Direction of Lane Closure)[1]	
Affected Roadway Length - miles	
Duration of Planned Construction Activity - days	
Optional Inputs (Default Values will be Used if Not Specified)	
Truck Percentage - %	
Posted Speed Limit on Affected Roadway - mph	
Number of Light Plants Required for Nighttime Construction	

[1] *If the traffic volume in direction of lane closure is not known, the annual average daily traffic (AADT) volume multiplied by a directional factor of 0.55 can be used.*

Figure 6. Quantitative Measure Module.

The user is required to enter or select the following inputs to perform calculations:

- Area type (select from urban, small urban, or rural).
- Roadway type (select from interstate, freeway, principal arterial, minor arterial, major collector, minor collector, or local).
- Total number of lanes in direction of lane closure.
- Number of lanes to be closed.
- Average daily traffic volume[1] (in direction of lane closure).
- Affected roadway length.
- Duration of planned construction activity.

In addition, the user can also specify optional inputs of percentage trucks in traffic, posted speed limit (i.e., work zone speed), and the number of light plants[2] required to provide lighting during the nighttime construction scenario. If the user does not enter values for these inputs, default values (as explained in the appendix) are used.

[1] It is expected that the user would enter traffic volumes that are realistic for a given roadway; while the results will be computed for any number that is entered, they may not always be meaningful in the case of extreme input values. When volumes exceed the 24-hour capacity of the roadway, a warning will be displayed in the calculator though values will still be computed. If the user does not have average daily volumes in the direction of lane closure, it can be estimated by multiplying a directional factor of 0.55 to the bidirectional volumes or average annual daily traffic (AADT) values.

[2] If the user wants to disregard light plant emissions from the analysis (for example, in cases where the worksite has access to electric power and does not require diesel-powered lighting plants) or to only consider traffic emissions, enter a value of 0 for the number of light plants in the input field.

Once the user has entered the required information, a set of summary tables is generated (as shown in Figure 7), reporting the following parameters for baseline, daytime lane closure, and nighttime lane closure scenarios:

- The change in emissions (daily and for the total construction period) of carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs), and particulate matter (PM10) between the nighttime scenario and the baseline, and the daytime scenario and the baseline.
- The change in emissions (daily and for the total construction period) attributable to nighttime lane closure instead of daytime lane closure (i.e., the net difference between the differences reported previously).
- Average speed, total delays, and average delays per vehicle.

Results

Emission Type	Scenarios	Total Change in Emissions during Construction (lb)	Daily Change in Emissions (lb)
Carbon Monoxide (CO)	Daytime Lane Closure: Change in Emissions over Baseline	3117.6	207.8
	Nighttime Lane Closure: Change in Emissions over Baseline	89.4	6.0
	Change in Emissions (Nighttime - Daytime)	**-3028.2**	**-201.9**
Oxides of Nitrogen (NOx)	Daytime Lane Closure: Change in Emissions over Baseline	3262.4	217.5
	Nighttime Lane Closure: Change in Emissions over Baseline	203.3	13.6
	Change in Emissions (Nighttime - Daytime)	**-3059.1**	**-203.9**
Volatile Organic Compounds (VOCs)	Daytime Lane Closure: Change in Emissions over Baseline	757.2	50.5
	Nighttime Lane Closure: Change in Emissions over Baseline	75.9	5.1
	Change in Emissions (Nighttime - Daytime)	**-681.3**	**-45.4**
Particulate Matter (PM10)	Daytime Lane Closure: Change in Emissions over Baseline	182.9	12.2
	Nighttime Lane Closure: Change in Emissions over Baseline	27.3	1.8
	Change in Emissions (Nighttime - Daytime)	**-155.7**	**-10.4**

Traffic Impact Factors	Scenarios	Quantity
Average Delay (minute/veh)	Baseline (No Lane Closure)	0.91 minute/veh
	Daytime Lane Closure	12.72 minute/veh
	Nighttime Lane Closure	2.03 minute/veh
Total 24-Hour Delay (veh-hours/day)	Baseline (No Lane Closure)	905.4 veh-hours/day
	Daytime Lane Closure	12723.3 veh-hours/day
	Nighttime Lane Closure	2033.7 veh-hours/day
Average Speed (mph)	Baseline (No Lane Closure)	58.3 mph
	Daytime Lane Closure	24.1 mph
	Nighttime Lane Closure	53.2 mph

Figure 7. Results Example—Summary Table.

As seen in Figure 7, for the example results shown, the daytime lane closure results in CO emissions that exceed the baseline by 3117.6 lb over the duration of construction. The nighttime closure scenario, on the other hand, is seen to increase the emissions by 89.4 lb. Therefore, the change in emissions attributable to moving the lane closures from the daytime to

nighttime is −3028.2 lb (i.e., closing the lanes at night instead of the daytime could reduce CO emissions by that amount).

Appendix – Calculation Methodologies

OVERVIEW

The case studies conducted as part of Task 4 of the project used results from the modeling of traffic, via microsimulation of specific case study work zones. In this calculator, simplified, deterministic methods were used to allow for developing more generic estimations based on simple user inputs. The calculations were checked for consistency with Task 4 results. Results from Task 3 were also used to estimate the additional emissions impacts from lighting plants required for nighttime construction. This appendix provides a brief summary of the emissions, traffic estimation process, and data sources used.

ANALYSIS SCENARIOS

The traffic analysis is over a 24-hour period, for three scenarios: baseline (no lane closure), daytime lane closure (lane closure between 6 a.m. and 6 p.m.), and nighttime lane closure (lane closure between 6 p.m. and 6 a.m.). The emissions analysis is also conducted for the 24-hour period and aggregated over the duration of the construction activity.

CONGESTION/TRAFFIC CALCULATIONS

The hourly traffic demand is estimated using the user input average daily traffic (ADT), distributed by default hourly traffic distribution data that are used in regional emissions estimation procedures in Texas. The spreadsheet has the default hourly traffic distributions built into the spreadsheet. The hourly distributions from El Paso region, used in regional emissions analyses (*1*), are used to represent the distribution for Texas.

The capacity per lane is selected automatically based on the user input area type and roadway (*2*), with a maximum capacity set at 2000 vehicles per hour per lane for freeways and interstate highways. In the case of lane closures, the lane capacity of the remaining open lanes is also reduced (for example, 1350 vehicles per hour per lane for freeways and interstates), consistent with existing lane closure analysis models (*3*) and the findings from Task 4. The

roadway capacity is then obtained by multiplying by number of lanes (with the number of lanes reduced for the lane closure scenarios based on user inputs). For operating speed and delay calculations, the user supplied ADT is converted to passenger car equivalents (PCE) by applying a multiplicative factor of two for the truck volumes. The volume over capacity ratio (v/c) is calculated using the PCE volumes and estimated roadway capacity. A delay equation consistent with established traffic and emissions analysis procedures used for regional emissions estimation and other purposes (*4*) is then used to estimate hourly average vehicle delays and hourly average congested speeds.

In cases where v/c exceeds one, Greenberg's model (*5*) is used to calculate the actual traffic flow (i.e., throughput) under oversaturated conditions. In this model, if a posted speed limit is provided by the user, it will be used in the calculations. Otherwise, a default free-flow speed based on roadway type is used in this model.

For each scenario, the traffic volume is then redistributed based on actual traffic flow estimated on an hourly basis, with any residual volume assigned to subsequent hours until the traffic is recovered to normal. During this extended congested period, the roadway is assumed to operate at capacity. The calculated delays and speeds for the extended congested period are then adjusted accordingly.

EMISSIONS CALCULATIONS

The user-provided value for affected roadway length is required and used as the distance over which emissions are calculated. If the user enters a heavy-duty vehicle (truck) percentage, it is used to estimate the split between light-duty (LD) and heavy-duty (HD) traffic volumes. Otherwise, default heavy-duty percentage of different area-roadway combinations (*1*) is used in this calculation.

The LD vehicle group consists of vehicle types 21, 31, and 32. The HD vehicle group consists of vehicle type 61 and 62. The composite rates are obtained for the corresponding vehicles in each category by aggregating them on the basis of their vehicle miles traveled mix ratios from the El Paso region. Composite, speed-based emissions rate lookup tables are then developed for LD and HD vehicle groups and are used to estimate emissions.

The estimated hourly average speeds are then used to look up and interpolate the hourly emissions rates for CO, NOx, PM10, and VOCs. The total hourly emissions for the LD vehicle

and HD vehicle groups are obtained by multiplying hourly volumes. Hourly traffic emissions are the sum of LD and HD emissions, which are then aggregated over a daily basis and for the duration of the construction period.

For the baseline and daytime construction scenario, daily total emissions are the summation of hourly traffic emissions. For the nighttime lane closure scenario, the daily traffic emissions are added with light plant emissions (obtained from the Task 3 results of this study) to calculate the daily total emissions. If the number of light plants under nighttime construction is provided by the user, then user provided information is used. Otherwise, a default value of eight light plants operating for 11 hours/day (representative level established from our case studies) is used in the calculation, based on the findings from this research project. For each scenario, the daily total emissions are multiplied by the duration of planned construction activity to calculate total emissions.

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