Traffic Technical Report

I-270 Corridor Improvements

September 2022

Prepared For:
CDOT Region 1
2829 West Howard Place
Denver, CO 80204

CDOT Project No.
STU 2706-043

CDOT Project Code
23198

Version Tracking

Version	Date	Change Status

Contents

Acronyms and Abbreviations ix

1.0 Introduction 1

2.0 Analysis and Methodology 1
- 2.1 Operating Options and No Action Alternative 1
- 2.2 Study Time Periods 5
- 2.3 Analysis Years 5
- 2.4 Traffic Forecasting 6
- 2.5 Freeway Analysis Methodology 7
  - 2.5.1 Peak Hour Volumes Served 7
  - 2.5.2 Average Travel Time 7
  - 2.5.3 Average Speed 7
  - 2.5.4 Vehicle Hours of Delay 7
  - 2.5.5 Average Delay per Vehicle 7
  - 2.5.6 Average Density 7
  - 2.5.7 Vehicle Hours Traveled 7
  - 2.5.8 Vehicle Miles Traveled 8
  - 2.5.9 Travel Time Reliability 8
  - 2.5.10 Truck Miles Traveled 8
- 2.6 Intersection Analysis Methodology 9

3.0 2016 Existing Conditions 10
- 3.1 Peak Hour Volumes 10
- 3.2 Performance Measures 12
- 3.3 Speed Plots 12
- 3.4 Travel Time Reliability 14
  - 3.4.1 I-270 Westbound: Travel Time Reliability 15
  - 3.4.2 I-270 Eastbound: Travel Time Reliability 18
- 3.5 Intersection Operations 20

4.0 2040 No Action Alternative 21
- 4.1 Peak Hour Volumes 21
- 4.2 Performance Measures 23
- 4.3 Speed Plots 24
- 4.4 Travel Time Reliability 25
- 4.5 Intersection Operations 26

5.0 2040 General Purpose Lane 1 (GP Version 1) 27
- 5.1 Peak Hour Volumes 27
- 5.2 Performance Measures 29
- 5.3 Speed Plots 30
- 5.4 Travel Time Reliability 31
- 5.5 Intersection Operations 32

6.0 2040 General Purpose Lane 2 (GP Version 2) 33
- 6.1 Peak Hour Volumes 33
- 6.2 Performance Measures 35
- 6.3 Speed Plots 35
- 6.4 Travel Time Reliability 37

6.5 Intersection Operations ... 37

7.0 2040 General Purpose Lane 3 (GP Version 3) - Proposed Action (General Purpose Lane Operating Option) ... 39
7.1 Peak Hour Volumes ... 39
7.2 Performance Measures ... 41
7.3 Speed Plots ... 41
7.4 Travel Time Reliability ... 43
7.5 Intersection Operations ... 43

8.0 2040 Express Lane 1 (EL Version 1) ... 45
8.1 Peak Hour Volumes ... 45
8.2 Performance Measures ... 47
8.3 Speed Plots ... 48
8.4 Travel Time Reliability ... 51
8.5 Intersection Operations ... 52

9.0 2040 Express Lane 2 (EL Version 2) ... 53
9.1 Peak Hour Volumes ... 53
9.2 Performance Measures ... 55
9.3 Speed Plots ... 56
9.4 Travel Time Reliability ... 59
9.5 Intersection Operations ... 60

10.0 2040 Express Lane 3 (EL Version 3) - Proposed Action (Express Lane Operating Option) ... 61
10.1 Peak Hour Volumes ... 61
10.2 Performance Measures ... 63
10.3 Speed Plots ... 64
10.4 Travel Time Reliability ... 67
10.5 Intersection Operations ... 68

11.0 Overview of Findings ... 69
11.1 Average Travel Time ... 75
11.2 Average Speed ... 76
11.3 Total Delay ... 77
11.4 Vehicle Miles Traveled ... 79
11.5 Vehicle Hours Traveled ... 81
11.6 Travel Time Reliability ... 83
11.7 Truck Miles Traveled ... 84

12.0 Summary ... 86

13.0 References ... 87

Appendixes

A Base and Design Years for Traffic Analysis
B I-270 Corridor Sensitivity Test – Focus 2.1 2040 TDM Compared with Focus 2.3 2050 TDM
C I-270 Travel Time Reliability – Existing Conditions Assessment

Figures

Figure 2-1. Design Year (2040) No Action Alternative Improvements 3
Figure 3-1. Existing Peak Hour Volumes 11
Figure 3-2. Existing Conditions Peak Period Speed Plot in Westbound Direction 13
Figure 3-3. Existing Conditions Peak Period Speed Plot in Eastbound Direction 14
Figure 3-4. I-270 Westbound – All Days (2016) 16
Figure 3-5. I-270 Westbound – All Days (2019) 17
Figure 3-6. I-270 Eastbound – All Days (2016) 19
Figure 3-7. I-270 Eastbound – All Days (2019) 19
Figure 4-1. No Action Peak Hour Volumes 22
Figure 4-2. No Action Peak Period Speed Plot, Westbound Direction 24
Figure 4-3. No Action Peak Period Speed Plot, Eastbound Direction 25
Figure 5-1. General Purpose Lane Operating Option Version 1 Peak Hour Volumes 28
Figure 5-2. GP Version 1 Peak Period Speed Plot, Westbound Direction 30
Figure 5-3. GP Version 1 Peak Period Speed Plot, Eastbound Direction 31
Figure 6-1. General Purpose Lane Operating Option Version 2 Peak Hour Volumes 34
Figure 6-2. GP Version 2 Peak Period Speed Plot, Westbound Direction 36
Figure 6-3. GP Version 2 Peak Period Speed Plot, Eastbound Direction 37
Figure 7-1. General Purpose Lane Operating Option Version 3 Peak Hour Volumes 40
Figure 7-2. GP Version 3 Peak Period Speed Plot, Westbound Direction 42
Figure 7-3. GP Version 3 Peak Period Speed Plot, Eastbound Direction 43
Figure 8-1. Express Lane Operating Option Version 1 Peak Hour Volumes 46
Figure 8-2. EL Version 1 Peak Period Speed Plot for General Purpose Lanes, Westbound Direction 48
Figure 8-3. EL Version 1 Peak Period Speed Plot for Express Lane, Westbound Direction 49
Figure 8-4. EL Version 1 Peak Period Speed Plot for General Purpose Lanes, Eastbound Direction 50
Figure 8-5. EL Version 1 Peak Period Speed Plot for Express Lane, Eastbound Direction 51
Figure 9-1. Express Lane Operating Option Version 2 Peak Hour Volumes 54
Figure 9-2. EL Version 2 Peak Period Speed Plot of General Purpose Lanes, Westbound Direction 56
Figure 9-3. EL Version 2 Peak Period Speed Plot for Express Lane, Westbound Direction 57
Figure 9-4. EL Version 2 Peak Period Speed Plot for General Purpose Lanes, Eastbound Direction 58
Figure 9-5. EL Version 2 Peak Period Speed Plot for Express Lane, Eastbound Direction 59
Figure 10-1. Express Lane Operating Option Version 3 Peak Hour Volumes 62
Figure 10-2. EL Version 3 Peak Period Speed Plot of General Purpose Lanes, Westbound Direction 64
Figure 10-3. EL Version 3 Peak Period Speed Plot of Express Lane, Westbound Direction 65
Figure 10-4. EL Version 3 Peak Period Speed Plot of General Purpose Lanes, Eastbound Direction 66
Figure 10-5. EL Version 3 Peak Period Speed Plot of Express Lane, Eastbound Direction 67
Figure 11-1. Average Travel Time, Westbound Direction 75
Figure 11-2. Average Travel Time, Eastbound Direction 75
Figure 11-3. Average Speed, Westbound Direction 76
Figure 11-4. Average Speed, Eastbound Direction 77
Figure 11-5. Total Delay, Westbound Direction 78
Figure 11-6. Total Delay, Eastbound Direction 79
Figure 11-7. Vehicle Miles Traveled, Westbound Direction 80
Figure 11-8. Vehicle Miles Traveled, Eastbound Direction 81
Figure 11-9. Vehicle Hours Traveled, Westbound Direction 82
Figure 11-10. Vehicle Hours Traveled, Eastbound Direction 82
Figure 11-11. Travel Time Index, Westbound Direction 83
Figure 11-12. Travel Time Index, Eastbound Direction 83
Figure 11-13. Truck Miles Traveled, Westbound Direction 84
Figure 11-14. Truck Miles Traveled, Eastbound Direction 85

Tables

Table 2-1. Geometry Comparison 4
Table 2-2. I-270 Traffic Study – Operating Options Analyzed 5
Table 2-3. Travel Time Thresholds 8
Table 2-4. HCM-based Level of Service Criteria for Signalized Intersections 9
Table 3-1. Existing Performance Measures in the Westbound Direction 12
Table 3-2. Existing Performance Measures in the Eastbound Direction 12
Table 3-3. I-270 Westbound: Reliability Rating 15
Table 3-4. I-270 Westbound: Frequency of Congestion 16
Table 3-5. I-270 Westbound: Causal Factor Summary 17
Table 3-6. I-270 Eastbound: Reliability Rating 18
Table 3-7. I-270 Eastbound: Frequency of Congestion 18
Table 3-8. I-270 Eastbound: Causal Factor Summary 20
Table 3-9. Existing Conditions Peak Hour Intersection Operations 20
Table 3-10. Existing Conditions Peak Period I-270 Off-ramps Queue length 21
Table 4-1. No Action Performance Measures, Westbound Direction 23
Table 4-2. No Action Performance Measures, Eastbound Direction 23
Table 4-3. No Action Peak Hour Intersection Operations 26
Table 4-4. No Action Peak Period I-270 Off-ramps Queue Length 27
Table 5-1. GP Version 1 Performance Measures, Westbound Direction 29
Table 5-2. GP Version 1 Performance Measures, Eastbound Direction 29
Table 5-3. GP Version 1 Peak Hour Intersection Operations 32
Table 5-4. GP Version 1 Peak Period I-270 Off-ramps Queue Length 33
Table 6-1. GP Version 2 Performance Measures, Westbound Direction 35
Table 6-2. GP Version 2 Performance Measures, Eastbound Direction 35
Table 6-3. GP Version 2 Peak Hour Intersection Operations 38
Table 6-4. GP Version 2 Peak Period I-270 Off-ramps Queue Length 38
Table 7-1. GP Version 3 Performance Measures, Westbound Direction 41
Table 7-2. GP Version 3 Performance Measures, Eastbound Direction 41
Table 7-3. GP Version 3 Peak Hour Intersection Operations 44
Table 7-4. GP Version 3 Peak Period I-270 Off-ramps Queue Length 44
Table 8-1. EL Version 1 Performance Measures, Westbound Direction 47
Table 8-2. EL Version 1 Performance Measures, Eastbound Direction 47
Table 8-3. EL Version 1 Peak Hour Intersection Operations 52
Table 8-4. EL Version 1 Peak Period I-270 Off-ramps Queue Length 52
Table 9-1. EL Version 2 Performance Measures, Westbound Direction 55
Table 9-2. EL Version 2 Performance Measures, Eastbound Direction 55
Table 9-3. EL Version 2 Peak Hour Intersection Operations 60
Table 9-4. EL Version 2 Peak Period I-270 Off-ramps Queue Length 60
Table 10-1. EL Version 3 Performance Measures, Westbound Direction 63
Table 10-2. EL Version 3 Performance Measures, Eastbound Direction 63
Table 10-3. EL Version 3 Peak Hour Intersection Operations 68
Table 10-4. EL Version 3 Peak Period I-270 Off-ramps Queue Length 68
Table 11-1. Comparison of Performance Measures in A.M. Peak Period, Westbound Direction 70
Table 11-2. Comparison of Performance Measures in P.M. Peak Period, Westbound Direction 71
Table 11-3. Comparison of Performance Measures in A.M. Peak Period, Eastbound Direction 72
Table 11-4. Comparison of Performance Measures in P.M. Peak Period, Eastbound Direction 73
Table 11-5. Comparison of Performance Measures in Both Directions 74

Acronyms and Abbreviations

Acronym	Definition
a.m.	morning [period]
CDOT	Colorado Department of Transportation
DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EL Version #	Express Lane Operating Option Version #
FHWA	Federal Highway Administration
Focus	DRCOG's Travel Demand Model
GP Version #	General Purpose Lane Operating Option Version #
HCM	*Highway Capacity Manual*
I-25	Interstate 25
I-70	Interstate 70
I-76	Interstate 76
I-270	Interstate 270
ID	identification
LOS	level of service
MOE	measure of effectiveness
mph	mile(s) per hour
NEPA	National Environmental Policy Act
OD	origin-destination
pc/mi/ln	passenger car per mile per lane
p.m.	afternoon [period]
project	I-270 Corridor Improvements Project
PSA	public service announcement
TDM	Travel Demand Model
TTI	Travel Time Index
US-#	U.S. Highway #
VHD	vehicle hours of delay
VHT	vehicle hours traveled
VMT	vehicle miles traveled

1.0 Introduction

The Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA), in conjunction with local partners Adams County and Commerce City, are proposing improvements to 6 miles of Interstate 270 (I-270) in Adams County, Commerce City, and the City and County of Denver, Colorado, between Interstate 25 (I-25) and Interstate 70 (I-70). This undertaking is referred to as the I-270 Corridor Improvements Project (project). As part of this project, a traffic operations and analysis technical report has been prepared. It is provided in Appendix A2 of the Environmental Assessment (EA) and is summarized in this report. The traffic report addresses changes in overall corridor operations by comparing performance metrics for the No Action Alternative and the design versions (with general purpose or express lane operating options), including the Proposed Action. This report focuses on the findings of that analysis; information on the study area, project setting, description of the Proposed Action (with two operating options), and description of the No Action Alternative is provided in Appendix B2 of the project EA.

In 2019, CDOT commissioned Atkins to do a traffic study along the I-270 corridor in advance of initiating the EA. The *I-270 Traffic Study* (Atkins 2019) involved traffic modeling and calibration of the existing conditions, No Action Alternative, and potential I-270 mainline preliminary alternatives. These preliminary alternatives were developed to address the preliminary purpose and need of the project, which has since been refined for the I-270 EA. The results of this analysis helped inform the decision to carry forward a three-lane configuration into the I-270 Corridor Improvements project as the Proposed Action. Additional details and analysis of the process are provided in the *I-270 EA: Proposed Action Development* report (Appendix B1 of the EA).

In this study, TransModeler traffic simulation models developed for the previous traffic analysis (Atkins 2019) were adjusted and refined for the design year 2040 No Action Alternative and the operating options, including the Proposed Action. The operating options in this study are named differently from the preliminary alternatives included in the *I-270 Traffic Study* (Atkins 2019).

2.0 Analysis and Methodology

This section includes an overview of the design operating options analyzed and the methodology of this study.

2.1 Operating Options and No Action Alternative

The following 2 years were analyzed in this study: the base year (2016) and a future design year (2040). For the future design year, the analysis includes the 2040 No Action Alternative and the 2040 design operating options.

The base year condition TransModeler model developed by Atkins for the pre–National Environmental Policy Act (NEPA) traffic analysis was processed again to extract the performance measures. These performance measures were evaluated and verified. No changes were made to the base year network.

The design year (2040) No Action Alternative included other planned or programmed projects in the study area. The 2040 No Action Alternative developed in 2019 by Atkins is based on the calibrated 2016 model and includes the improvements on I-25 that are part of the I-25 (US-36 to 104th Avenue) Improvements project and on I-70 that are part of the Central 70 project. Additional storage and minor improvements to avoid queueing were added to these models as detailed in the final report submitted by Atkins (Atkins 2019).

A review of the 2040 No Action Alternative model developed by Atkins was performed for this study. As identified in the No Action Alternative model, multiple regional and local planned improvements within the *2040 Fiscally Constrained Regional Transportation Plan* (DRCOG 2015) are coded in the Focus 2.1 Travel Demand Model (TDM) network. The following is a list of the local improvements that are in the vicinity of the study area or are regional improvements with impact on the study corridor in the *2040 Fiscally Constrained Regional Transportation Plan* (Figure 2-1); note that the list does not include all planned improvements in the Regional Transportation Plan (DRCOG 2015):

- Reconstruction of I-70 from Brighton Boulevard to Chambers Road
- Widening on I-25 from 84th Avenue to Thornton Parkway
- Addition of Express Lanes along I-25, US-36, and I-70
- Widening of State Highway 7 (East of I-25)
- Widening of Pena Boulevard from I-70 to E-470
- Interchange improvements at US-36/Wadsworth Boulevard/120th Avenue
- Interchange improvements at US-36/Sheridan Boulevard
- Vasquez Boulevard/60th Avenue and 62nd Avenue Intersection Improvements
- Addition of Through Lanes on Quebec Street at I-70/Quebec Interchange
- Widening of York Street
- Miscellaneous safety and maintenance projects along I-270 (such as guardrail updates, bridge repairs, and mill/overlays)

In addition to those planned improvements, I-25 geometry updates included adding an ingress/egress weave area for the express lane north of the I-25 on-ramp from I-270. Lane change prohibitions were added at the deceleration lanes and the change from one lane to two lanes at the northbound exit ramp to Thornton Parkway. In addition, the number of general purpose lanes was kept as four within the 84th Street interchange.

For I-70, the geometry changes included adjustments to the lane configurations at intersections, alignment of the express lanes, and location of the beginning and exit locations of the express lanes. The changes along I-70 are based on the Central 70 project that is slated for substantial construction completion by end of 2022.

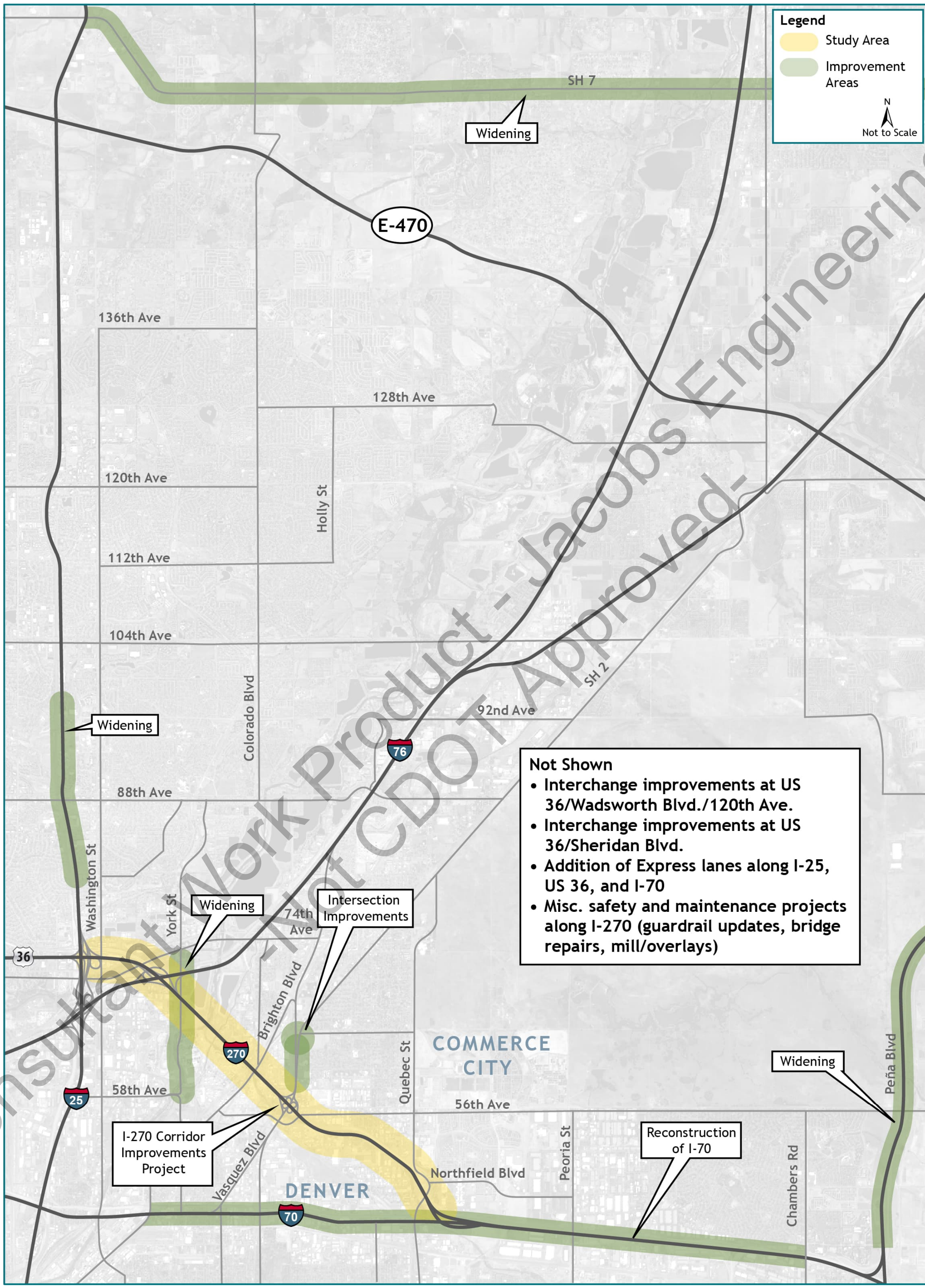

Figure 2-1. Design Year (2040) No Action Alternative Improvements
Source: Jacobs

The Proposed Action identified for the *I-270 Traffic Study* is discussed in detail in the *I-270 EA: Proposed Action Development* report (Appendix B1 of the EA). The traffic analysis considered two main operational improvements to provide additional capacity, as listed in Section 1 of this report: general purpose lane operating options (that is, General Purpose [GP] Versions 1, 2, and 3) and express lane operating options (that is, Express Lane [EL] Versions 1, 2, and 3).

Version 3 is identified as the Proposed Action with either a general purpose lane operating option or an express lane operating option.

The express lane operating options would implement real-time pricing strategies to manage demand on the highway facility. This is accomplished by providing a tolled express travel lane for vehicles to avoid congestion and travel at a higher speed compared to the general purpose lanes. The express lane operating options do not preclude the potential for future direct connections between I-270 and US-36 and at the I-270/I-25, I-270/I-76, and I-270/I-70 interchanges. Table 2-1 summarizes the configurations that are specific to each of the operating options (or versions of traffic runs) considered for the analysis. The different configurations were applied to gauge the operational benefits, if any, of the operating options.

Table 2-1. Geometry Comparison

Corridor and Ramp Configurations	Version 1	Version 2	Version 3
Westbound Off-ramp to Quebec Street	X	X	
Westbound Auxiliary Lane from Quebec Street to Vasquez Boulevard	X		X
Westbound Auxiliary Lane from Vasquez Boulevard to York Street	X	X	X
Splitting of York Street and I-76 Westbound Off-ramps			X
Eastbound Collector Ramp for I-76 On-ramps	X	X	X
Eastbound Auxiliary Lane from York Street to Vasquez Boulevard	X	X	X
Eastbound Dual-exit-lane Off-ramp for Vasquez Boulevard			X
Eastbound Auxiliary Lane East of Vasquez Boulevard	X	X	X
Eastbound On-ramp from Northbound Vasquez Boulevard	X	X	X
Reconfigure Interchange Ramps at Vasquez Boulevard for Partial Cloverleaf	X	X	X
Corridor and Ramp Configurations Specific to the Express Lane	**Version 1**	**Version 2**	**Version 3**
Express Lanes in Each Direction between I-25 and I-70	X	X	X
Start of Eastbound Express Lane approximately 1 mile from Southbound I-25 On-ramp			X

Source: Jacobs

Table 2-2 defines and provides additional details for the operating options analyzed in the study.

Table 2-2. I-270 Traffic Study – Operating Options Analyzed

Version	2040 Operating Options	Model Description (lanes noted for each travel direction on I-270 – Eastbound and Westbound)
	No Action	2 general purpose lanes and the planned improvements shown on Figure 2-1.
Version 1	GP	3 general purpose lanes with westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), and with westbound Quebec Street off-ramp.
	EL	Two general purpose lanes and one express lane with westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), and with westbound Quebec Street off-ramp.
Version 2	GP	3 general purpose lanes without westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), and with westbound Quebec Street off-ramp.
	EL	Two general purpose lanes and one express lane without westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), and with westbound Quebec Street off-ramp.
Version 3 (Proposed Action)	GP	Three general purpose lanes with westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), without westbound Quebec Street off-ramp, with added capacity with separate off-ramps to York Street and I-76, added capacity at eastbound off-ramp to Vasquez Boulevard.
	EL	Two general purpose lanes and one express lane with westbound auxiliary lane between Quebec Street and Vasquez Boulevard (includes continuous eastbound and westbound auxiliary lanes between York Street and Vasquez Boulevard), without westbound Quebec Street off-ramp, with added capacity with separate off-ramps to York Street and I-76, added capacity at eastbound off-ramp to Vasquez Boulevard, and the eastbound express lane entrance shifted 0.9 mile east from the EL Version 2 entrance.

Source: Jacobs

Detailed analysis of the No Action Alternative and design operating options are presented in Sections 4 through 10.

2.2 Study Time Periods

Two peak periods were simulated for each model: a.m. (6:30 a.m. to 9:00 a.m.) and p.m. (3:00 p.m. to 7:15 p.m.). These analysis time periods are the same simulation periods used in the *I-270 Traffic Study* (Atkins 2019). To compare the performance of the different operating options, the measures of effectiveness (MOEs) from the models were extracted for 7 a.m. to 9 a.m. in the a.m. peak period and 4 p.m. to 7 p.m. in the p.m. peak period.

2.3 Analysis Years

For the traffic analysis and operations comparison, 2016 is considered the existing year condition and 2040 as the design year. Additional details on process and decisions determining the analysis years is provided in Appendix A of this report, *Base and Design Years for Traffic Analysis*.

The *I-270 Traffic Study* (Atkins 2019) included the traffic forecasts for future year 2040 to represent the traffic patterns along the I-270 corridor for various options (Build and No Build) that were analyzed. The forecasts were based on the activity-based TDM, Focus 2.1 (Cycle RTP-2017) from the Denver Regional Council of Governments (DRCOG). Atkins used the Focus 2.1 TDM for 2015 as a starting point to develop the 2016 (base year) model. Focus models typically are developed by DRCOG in 5-year increments.

Because Atkins' project started in 2019, it used the 2040 Focus 2.1 TDM as the approved model and horizon year.

The 2040 MVRTP was the approved model when the EA process, and its supporting traffic analysis, were initiated. During preparation of the EA, DRCOG transitioned from the approved Focus 2.2 TDM with a 2040 horizon year to an updated Focus 2.3 TDM with a 2050 horizon year.

When the 2050 model became available, the study team completed a sensitivity analysis to determine the potential need to change from the Focus 2.1 2040 TDM to the Focus 2.3 2050 TDM. As discussed in Section 2.5.1 of the FHWA *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA* (FHWA 2010), a sensitivity test can be conducted to determine whether the changes caused by the introduction of the new data or TDM version would change the conclusions made from the previous analysis. If there is no change, then the study team could "simply document the change and the sensitivity analysis in the project administrative record and move on instead of re-doing the analysis" (FHWA 2010).

The results of the sensitivity analysis indicate that the peak hour traffic volumes from the 2040 TDM to 2050 TDM increase between 12 and 40 percent depending on which segment of the road you are using. The worst section, eastbound I-270 between Vasquez Boulevard and Quebec Street, would have a highway density of up to 45.0 passenger cars per mile per lane (pc/mi/ln) along the mainline and operate at LOS E. In assessing whether switching to the 2050 TDM would alter key decisions made based on the 2040 TDM, the sensitivity analysis indicated that such a switch would not alter these key decisions. Specifically, switching to the 2050 TDM is not expected to change the following:

- Proposed Action design or impact limits
- Travel time reliability from the Proposed Action
- Key results of the noise analysis

Based on the previous considerations, FHWA and CDOT have agreed to use the DRCOG Focus 2.1 2040 TDM as a basis for its project-level analysis. Details on the sensitivity analysis are provided in Appendix B of this report, *I-270 Corridor Sensitivity Test – Focus 2.1 2040 TDM Compared with Focus 2.3 2050 TDM*.

2.4 Traffic Forecasting

Travel demand modeling and forecasting is a common process used in regional planning to estimate the amount of travel on regional transportation facilities. The *I-270 Traffic Study* (Atkins 2019) prepared the traffic forecasts for the future year 2040 to represent the traffic patterns through the I-270 corridor for various preliminary alternatives that were analyzed. The forecasts were based on the latest version of the activity-based TDM, Focus 2.1 (Cycle RTP-2017) from DRCOG. The 2019 traffic study used the Focus model for 2015 as a starting point to develop the 2016 existing year model. Focus models are developed by DRCOG in 5-year increments, and the Focus model for 2040 was used for the future design year.

The Atkins 2016 existing year model was calibrated and validated for a subarea that included all study area links against the collected field data. The subarea a.m. and p.m. peak period OD matrices were used as input for the traffic simulation models in TransModeler.

The calibration adjustments made to the 2016 model were carried to the future year models for the 2040 No Build and preliminary alternatives. The forecasts for the alternatives were developed by adjusting the roadway network in the 2040 No Build Alternative model reflecting the specific improvements and capturing the effects of the geometry and capacity changes within the corridor.

As noted in Section 2.3, the project uses 2040 as the design year, similar to the Atkins 2019 study. The forecasted OD trip tables from the Atkins models were used for the traffic analysis of the 2040 No Action Alternative and the operating options analyzed in this study.

2.5 Freeway Analysis Methodology

Freeway analysis for all the operating options was performed using the TransModeler traffic simulation package (Version 5 SW Build 7305), which uses mathematical models of driver behavior and traffic flow theory to simulate traffic, in accordance with the CDOT traffic modeling guidelines (CDOT 2018). TransModeler models the dynamic route choices of drivers based upon historical or simulated time dependent travel times, as well as on OD trip tables or turning movement volumes at intersections. TransModeler was used to simulate operations along the I-270/I-70/I-25/I-76 corridors, including mainline segments, ramps, and freeway connections and ramp–terminal intersections.

The existing conditions calibrated TransModeler models completed as part of the *I-270 Traffic Study* (Atkins 2019) were used as the calibrated existing conditions model for this study. Review of the original models revealed that those were well calibrated for the I-270 operations.

The traffic operational performance measures are reported for the a.m. and p.m. peak periods on I-270 based on 10 simulation runs. Sections 4 through 10 present the results for the No Action Alternative and each of the operating options. The outputs and MOEs for freeway operations in the following sections are reported from the TransModeler analysis per CDOT traffic modeling guidelines (CDOT 2018).

2.5.1 Peak Hour Volumes Served

Traffic volumes served are the vehicles that are able to cross a particular roadway segment and not the traffic demand for that segment. Traffic volumes served are extracted from the models for each hour in the a.m. and p.m. peak periods. The peak hour volumes for 7 a.m. to 8 a.m. in the a.m. peak period and 5 p.m. to 6 p.m. in the p.m. peak period are reported in vehicles per hour.

2.5.2 Average Travel Time

Average travel time is the elapsed time taken by vehicles to travel on I-270 from I-70 to I-25 during the peak periods. Express lane average travel time is the time taken by a vehicle to travel the length of the express lanes.

2.5.3 Average Speed

The average speed of vehicles traveling on I-270 from I-70 to I-25 in each hour in the peak periods is reported from the TransModeler output.

2.5.4 Vehicle Hours of Delay

Vehicle hours of delay (VHD) is related to travel time and is the time spent in traffic beyond what would normally occur if traffic were moving at the free-flow speed. Either measure (that is, VHD or travel time) is typically applied to the peak periods of travel to assess the impact of congestion on the reliability of travel. VHD is calculated by summing up the delay experienced by individual vehicles on I-270 during the peak period. This measure is reported as time in hours.

2.5.5 Average Delay per Vehicle

Average delay per vehicle is the average time spent by any vehicle in traffic beyond what would normally occur if traffic were moving at the free-flow speed. It is reported as time in minutes.

2.5.6 Average Density

Average density is the number of vehicles occupying the lanes in 1 mile of I-270 during peak periods. Average density is reported as vehicles per mile, per lane.

2.5.7 Vehicle Hours Traveled

Vehicle hours traveled (VHT) is the total number of hours traveled by vehicles on a specific roadway network during the analysis time period. VHT for this project is calculated by multiplying the traffic volumes for a time period on a roadway segment by congested travel time on the segment during the same time period, and then summing all the segments' VHT for the total VHT on I-270.

2.5.8 Vehicle Miles Traveled

Vehicle miles traveled (VMT) is the total distance traveled by vehicles on a specific roadway network during the analysis time period. VMT for this project is calculated by multiplying the traffic volumes for a time period on a roadway segment by the length of the segment, and then summing all the segments' VMT for the total VMT on I-270.

2.5.9 Travel Time Reliability

Travel time reliability is a measure of the consistency or dependability in the travel time of a trip, or time to traverse a road segment, as experienced in different hours of the day and days of the week. It is measured in terms of the additional time (that is, time cushion or buffer) that drivers need to allocate to compensate for unexpected delays (FHWA 2017).

Travel time reliability for the I-270 corridor is measured using a threshold Travel Time Index (TTI), the ratio of the actual travel time to the free-flow travel time. Because this analysis includes only freeway segments, the threshold TTI used for comparison is 1.33 (Transportation Research Board 2014). Travel times with a TTI value of 1.33 or less are considered reliable.

In addition to TTI calculation, an extensive travel time reliability analysis for existing conditions is performed using two different measures: reliability rating and frequency of congestion. The reliability rating is the percentage of trips that are serviced at or less than the threshold TTI. The frequency of congestion measure is typically expressed as the percentage of days or time that travel times exceed a pre-established number of minutes (FHWA 2017). Table 2-3 illustrates the thresholds for the free-flow (posted speed limit), good, fair, and poor travel times. The average travel times and 95th percentile travel times are calculated as daily average for weekdays and weekends, and as a.m. and p.m. peak period average for weekdays, for all the days of data available.

For future travel conditions, the analysis will measure TTI and secondarily consider operating options with an average speed of 45 miles per hour (mph) or greater.

Table 2-3. Travel Time Thresholds

Reliability Categories	Thresholds in Minutes
Free Flow	Above free-flow travel time (min)
Good	Between free-flow travel time (min) and average travel time (min)
Fair	Between average travel time (min) and 95th percentile travel time (min)
Poor	Above 95th percentile travel time (min)

Source: Jacobs
min = minute(s)

2.5.10 Truck Miles Traveled

Truck miles traveled is the total distance traveled by trucks only on a specific roadway network during analysis time period. Truck miles traveled for this project is calculated by multiplying the truck volumes for a time period on a roadway segment by the length of the segment, and then summing all the segments' truck miles traveled for the truck miles traveled on I-270 for the base and design years. Truck volumes from the Focus 2.3 2050 TDM are used in the project EA to analyze air quality for the project. More information about traffic and truck volumes for the air quality analysis can be found in Appendix A4 of the EA

2.6 Intersection Analysis Methodology

The intersection analysis evaluated any potential impacts to the ramp terminuses and the adjacent local intersections as a result of the No Action Alternative and the design operating options. Intersection analysis was conducted for the No Action Alternative and all the operating options. Intersection analysis was performed at the following intersections:

- Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp
- Quebec Street/I-270 westbound on-ramp
- Vasquez Boulevard/East 56th Avenue
- Vasquez Boulevard/East 60th Avenue
- York Street/I-270 eastbound on-ramp
- York Street/I-270 westbound off-ramp
- Vasquez Boulevard/I-270 eastbound off-ramp (evaluated only when intersection is signalized in the design operating options)
- Vasquez Boulevard/I-270 westbound off-ramp (evaluated only when intersection is signalized in the design operating options)

All the study intersections are signalized. The following outputs and MOEs for intersection operations are reported from the TransModeler analysis based on the *Highway Capacity Manual* (HCM) 6th Edition (Transportation Research Board 2010) methodology for the signalized intersections:

- Level of service (LOS)
- Queue length

The intersection LOS is determined based on the average delay per vehicle at the intersection. The HCM methodology for intersections uses average delay per vehicle based upon peak hourly traffic volumes, peak hour factors, number of lanes, type of operation (signalized or unsignalized), and other factors. The HCM delay assessment translates to a LOS grade, ranging from LOS A to LOS F, as shown in Table 2-4. At signal-controlled intersections, the average delay of all four approaches was used to determine the LOS.

Table 2-4. HCM-based Level of Service Criteria for Signalized Intersections

Level of Service	Average Control Delay (sec/veh)
A	≤10
B	>10 to 20
C	>20 to 35
D	>35 to 55
E	>55 to 80
F	>80

Source: Transportation Research Board 2010

sec/veh = second(s) per vehicle

The queue lengths at the ramp terminuses for the off-ramp approaches were studied for this project. The 95th percentile queue lengths for the movements on the off-ramp approaches are extracted from TransModeler to determine the required storage length for each intersection.

The intersection analysis was performed using Synchro and TransModeler as follows:

- Study intersections were initially coded in Synchro to determine signal timing (cycle length, splits, and offsets).
- Study intersections were also coded into the TransModeler models, which contain the entire study area (freeway network and local intersections). Coordinated signal timing from Synchro was coded into TransModeler and simulations run to report the delay and LOS.
- For this study, the HCM methodology was implemented in TransModeler and used to estimate the intersection delay and LOS. Intersections that are closely spaced or are known to be part of a coordinated corridor were coded in TransModeler with optimized, actuated-coordinated traffic signal timing. Isolated intersections were coded with optimized, actuated-uncoordinated traffic signal timing.

3.0 2016 Existing Conditions

The existing conditions operational analysis was completed to understand the current traffic performance and travel experience on the I-270 facility. This section describes the existing traffic volumes and patterns and the results of the operational analysis.

The TransModeler models were completed and performance measures extracted using the existing calibrated files from the *I-270 Traffic Study* (Atkins 2019). The following sections provide details of these performance measures.

3.1 Peak Hour Volumes

The peak hour volumes from 7 a.m. to 8 a.m. in the a.m. peak period and 5 p.m. to 6 p.m. in the p.m. peak period are shown on Figure 3-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 1,800 vehicles crossing the segment between Central Park Boulevard and Quebec Street and 3,700 vehicles crossing the segment between Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves a lower range of traffic volumes during the a.m. peak hour, with approximately 1,600 vehicles crossing the segment west of I-25 ramps and the high end of the range (3,200 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

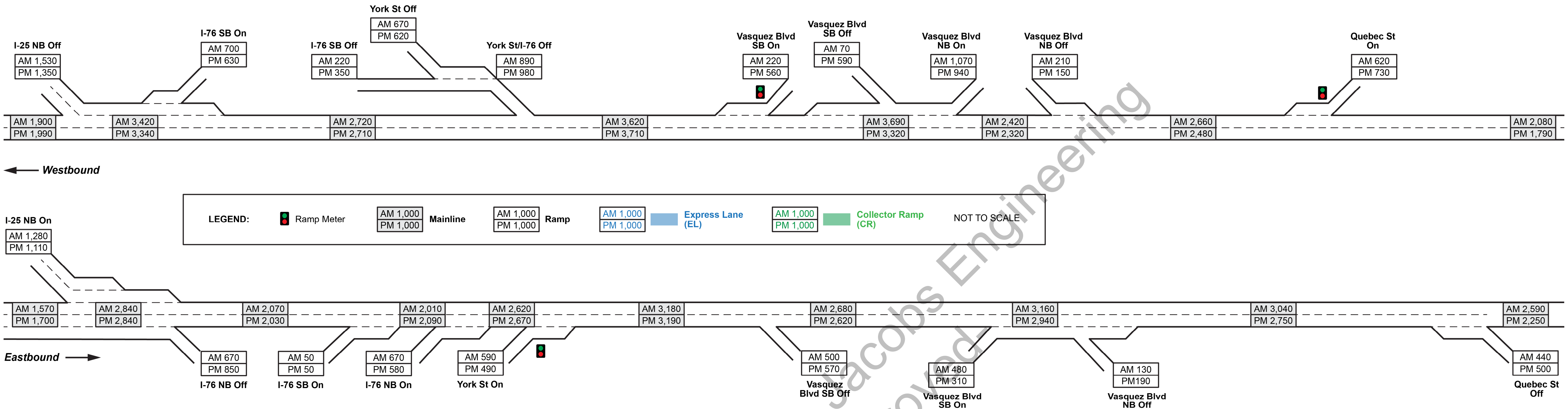

Figure 3-1. Existing Peak Hour Volumes
Source: Jacobs

3.2 Performance Measures

Tables 3-1 and 3-2 summarize the peak period performance measures for the existing conditions in the a.m. and p.m. peak periods in the westbound and eastbound directions.

Table 3-1. Existing Performance Measures in the Westbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	13.8	14.3	12.3	16.4	17.6
Average Speed (mph)	28	27	30	23	22
VHD (hours)	366	357	304	467	465
Average Delay per Vehicle (minutes)	8.1	8.6	6.7	10.7	12.0
Average Density (pc/mi/ln)	55.0	57.0	49.4	62.4	69.3
VMT (vehicle-miles)	17,539	16,717	17,070	16,950	15,801
VHT (vehicle-hours)	636	614	566	728	709
TTI	2.06	2.13	1.84	2.44	2.63
Truck Miles Traveled (truck-miles)[a]	2,730		3,056		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

Table 3-2. Existing Performance Measures in the Eastbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	15.5	20.2	15.8	15.7	13.2
Average Speed (mph)	25	20	24	24	29
VHD (hours)	439	566	456	429	303
Average Delay per Vehicle (minutes)	9.8	14.5	10.1	10.0	7.5
Average Density (pc/mi/ln)	64.4	73.3	64.1	66.1	58.3
VMT (vehicle-miles)	17,541	16,263	17,386	16,655	15,528
VHT (vehicle-hours)	709	817	723	685	541
TTI	2.31	3.00	2.35	2.33	1.96
Truck Miles Traveled (truck-miles)[a]	3,029		3,619		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

3.3 Speed Plots

The speed contours for the a.m. and p.m. periods in the westbound and eastbound directions are plotted using the TransModeler output. The left side of the graph (Figure 3-2) shows the speed contours for the a.m. peak period, and the right shows the p.m. peak period. The middle of the graph depicts the I-270 highway with cross streets and general purpose lane indicators for the speed plots. Yellow to green shades indicate higher speeds (40 mph and higher), orange shades indicate speeds between 30 and 40 mph, and red shades indicate speeds under 30 mph. In general, bottleneck locations are where transitions occur between the red and green areas. The congestion is shown by red shades upstream of the bottleneck locations. The speed contour plots were a critical tool to identify the location of bottlenecks, duration and extent of congestion, and traffic patterns in the network.

Figure 3-2 provides the speed plot for the a.m. and p.m. peak periods in the westbound direction. In the a.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange, York Street/I-76 off-ramp, and Quebec Street on-ramp. The congestion develops early in the a.m. peak period and does not dissipate until after 9 a.m. Congestion from these bottlenecks spills back to I-70 and Central Park Boulevard, with speeds as low as 10 to 20 mph (as indicated by the predominantly red color in the a.m. peak period along the bottom edge of Figure 3-2).

In the p.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange and York Street/I-76 off-ramp. The congestion develops early in the p.m. peak period, starting at 4 p.m., and does not dissipate until after 7 p.m. The congestion from these bottlenecks in the p.m. peak period spills back toward I-70, with speeds as low as 10 to 20 mph.

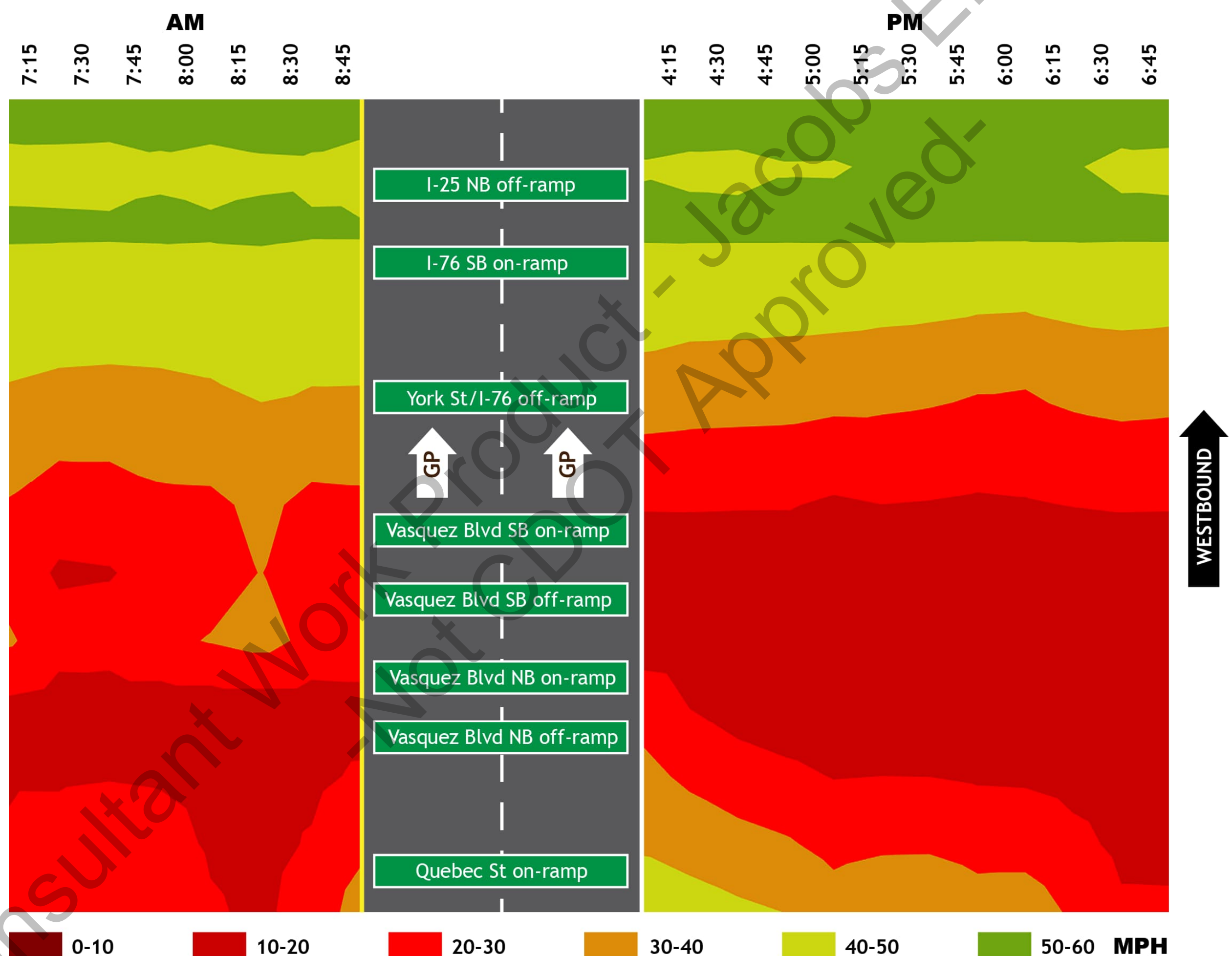

Figure 3-2. Existing Conditions Peak Period Speed Plot in Westbound Direction
Source: Jacobs

Figure 3-3 provides the speed plot for the a.m. and p.m. peak periods in the eastbound direction. In the a.m. peak period, bottlenecks at the York Street on-ramp and Vasquez Boulevard interchange are observed in the speed plot. The congestion develops early in the a.m. peak period and continues even after 9 a.m. Congestion from these bottlenecks spills back to the I-25 interchange, with speeds as low as 0 to 20 mph.

In the p.m. peak period, bottlenecks are observed at the York Street on-ramp and Vasquez Boulevard interchange. The congestion develops early in the p.m. period, starting at 4 p.m., and does not dissipate until after 7 p.m. The congestion from these bottlenecks in the p.m. peak period spills back toward the I-25 on-ramp, with speeds as low as 0 to 20 mph.

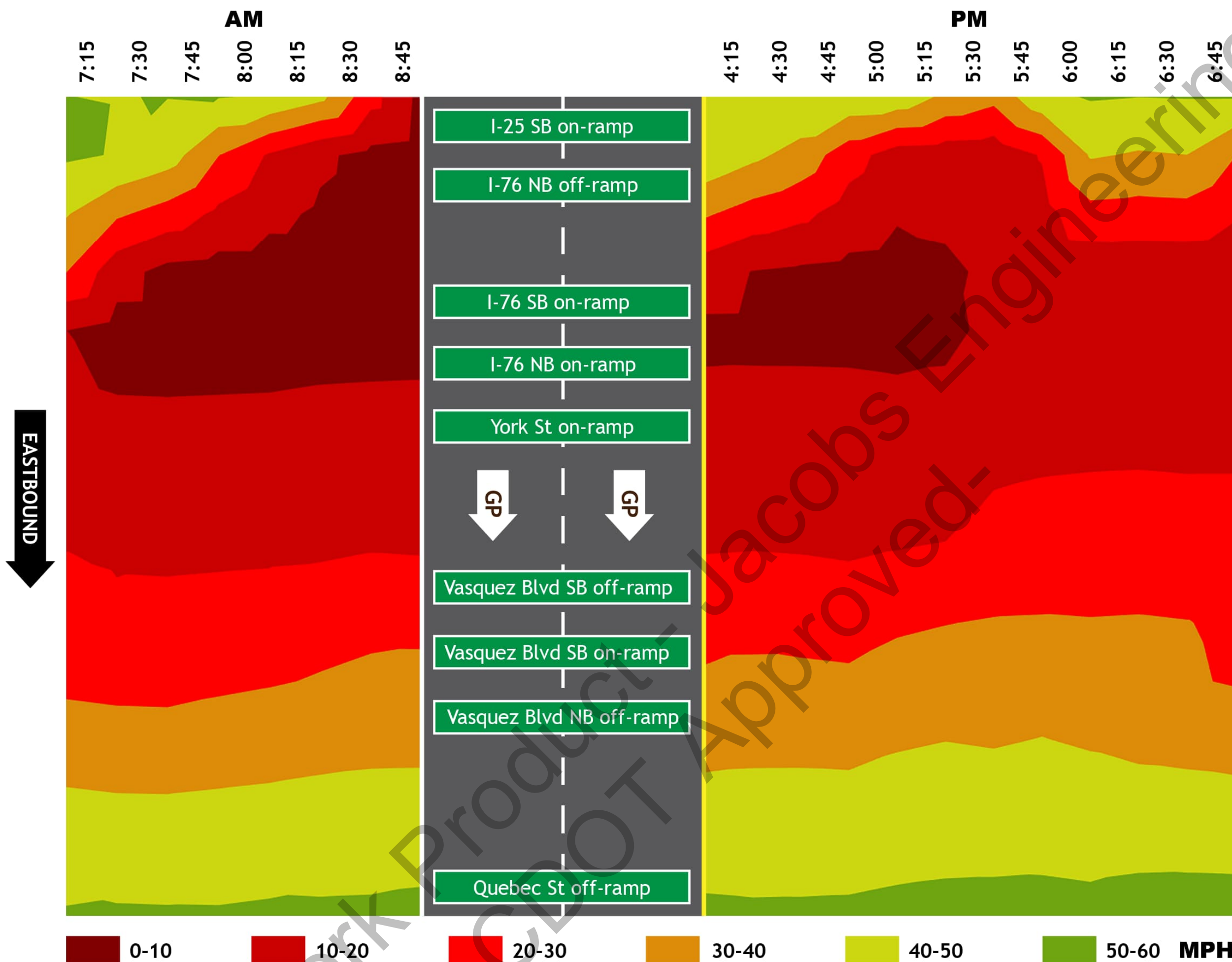

Figure 3-3. Existing Conditions Peak Period Speed Plot in Eastbound Direction
Source: Jacobs

3.4 Travel Time Reliability

Travel time reliability analysis was conducted for the I-270 corridor between I-25 and I-70. With an influx of residents and increasing number of drivers on the state's roadways, nearly all Colorado drivers experience and plan travel around traffic congestion as part of their daily activities. I-270's existing highway infrastructure does not meet local and regional transportation demands. Based on travel conditions in 2019 and previous years, daily traffic congestion patterns begin on I-270 earlier than any other freeway in Colorado (CDOT 2020).

With predictable travel times, drivers can plan their trips and be relatively confident that they will arrive on time. Because drivers on I-270 (an urban freeway) regularly experience congestion, delay, and turbulence in the traffic stream not commonly found on rural freeways, the study team assessed corridor travel time reliability to best represent these known corridor conditions. This assessment helped the team understand the level of congestion, changing traffic conditions, and factors contributing to delay. Both westbound and eastbound travel times were studied for I-270 (between I-70 and I-25 for westbound travelers and between I-25 and I-70 for eastbound travelers).

The TTI values with existing travel times on the corridor ranged between 1.84 and 3.00, which is higher than the threshold value of 1.33 considered reliable for urban roadways. This shows that current traffic conditions are not providing reliable travel times.

The study team performed additional analysis comparing travel time data for the years 2016 and 2019 to determine the changes in reliability trends between the existing conditions and recent data. The results of the comparative analysis indicate that reliability decreased in 2019 compared to 2016. In future year with increased traffic on the corridor, the reliability is expected to degrade further if no improvements are made.

Data for 2016 and 2019 were also summarized as the percentage of trips with travel times in each threshold category. The data were plotted on three-dimensional graphs, Figures 3-4 through 3-7, with the X-axis representing the day of the year, the Y-axis representing the time of day, and the Z-axis representing the calculated travel time.

For 2016 and 2019, the 15-minute period travel time data for all the days in the year were collected. The travel time reliability was assessed separately by direction for westbound and eastbound I-270. The data were further analyzed by day of the week to understand the effects of typical weekday commuter travel during the week, as well as recreational travel occurring on weekends. The data was then stratified into weekdays (Monday through Friday) and weekends (Saturday through Sunday). The weekday data were also analyzed separately for a.m. peak and p.m. peak periods.

Days with fair or poor travel time reliability were investigated to determine if any specific causal factor might have contributed to the decreased reliability. A causal factor is defined as a major unplanned, unintended contributor to an incident (a negative event or undesirable condition), that if eliminated would have either prevented the occurrence of the incident or reduced its severity or frequency. For travel time reliability analysis, the causal factor is a contributor to decreased reliability. Days that did not demonstrate an apparent causal factor were grouped into the “unaccounted” type when traffic volume was the most likely cause of the degraded travel time reliability. Days demonstrating multiple 15-minute periods of fair or poor travel time reliability and more than one apparent contributing factor were listed in the “multiple event” type.

3.4.1 I-270 Westbound: Travel Time Reliability

Reliability ratings for I-270 westbound (Table 3-3) were generally lower in 2019 than 2016 for the same time period or days in a week. Travel times in the p.m. peak period were less reliable than in the a.m. peak periods and, as expected, weekdays were less reliable than weekends.

Table 3-3. I-270 Westbound: Reliability Rating
(Percentage of 15-minute time periods less than 1.33 TTI factor)

	Weekdays		Weekdays A.M. Peak Period		Weekdays P.M. Peak Period		Weekends	
Segment	2016	2019	2016	2019	2016	2019	2016	2019
I-270 Westbound – I-70 to I-25	68.45%	60.27%	30.52%	19.31%	14.90%	13.24%	96.65%	92.42%

Source: Jacobs
% = percent

Table 3-4 displays the travel time reliability analysis based on the frequency of congestion for I-270 westbound during different times in 2016 and 2019. A higher percentage of trips experienced poor travel time reliability on I-270 westbound during p.m. peak period for both 2016 and 2019. The analysis showed that most of the poor travel times on I-270 westbound during 2016 occurred in the evening hours and are more prominent in the summer and end-of-the-year holiday season (Figure 3-4). While this same trend for time of day appeared in 2019 for the evening hours, it occurred mainly in the earlier months of the year (Figure 3-5). The duration of poor travel reliability and number of poor travel days increased in 2019 compared to 2016.

Table 3-4. I-270 Westbound: Frequency of Congestion
(Percent of 15-minute time periods in each category)

Reliability Category	Weekdays		Weekdays A.M. Peak Period		Weekdays P.M. Peak Period		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
Free Flow	57.3%	47.6%	11.5%	8.0%	8.4%	6.8%	89.2%	79.3%
Good	8.7%	12.6%	14.1%	11.3%	4.9%	6.4%	6.1%	13.1%
Fair	27.0%	32.9%	72.2%	77.0%	52.8%	55.6%	4.5%	7.2%
Poor	6.9%	6.8%	2.2%	3.7%	33.9%	31.2%	0.2%	0.4%

Source: Jacobs

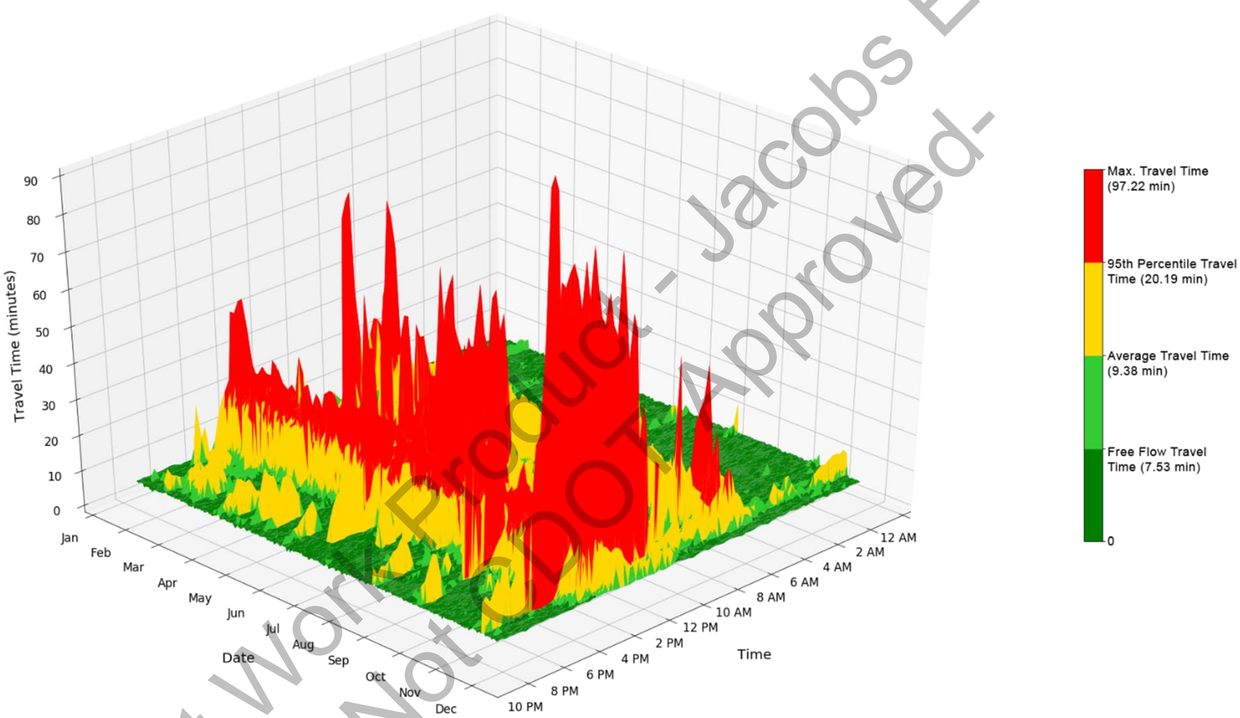

Figure 3-4. I-270 Westbound – All Days (2016)
Source: Jacobs

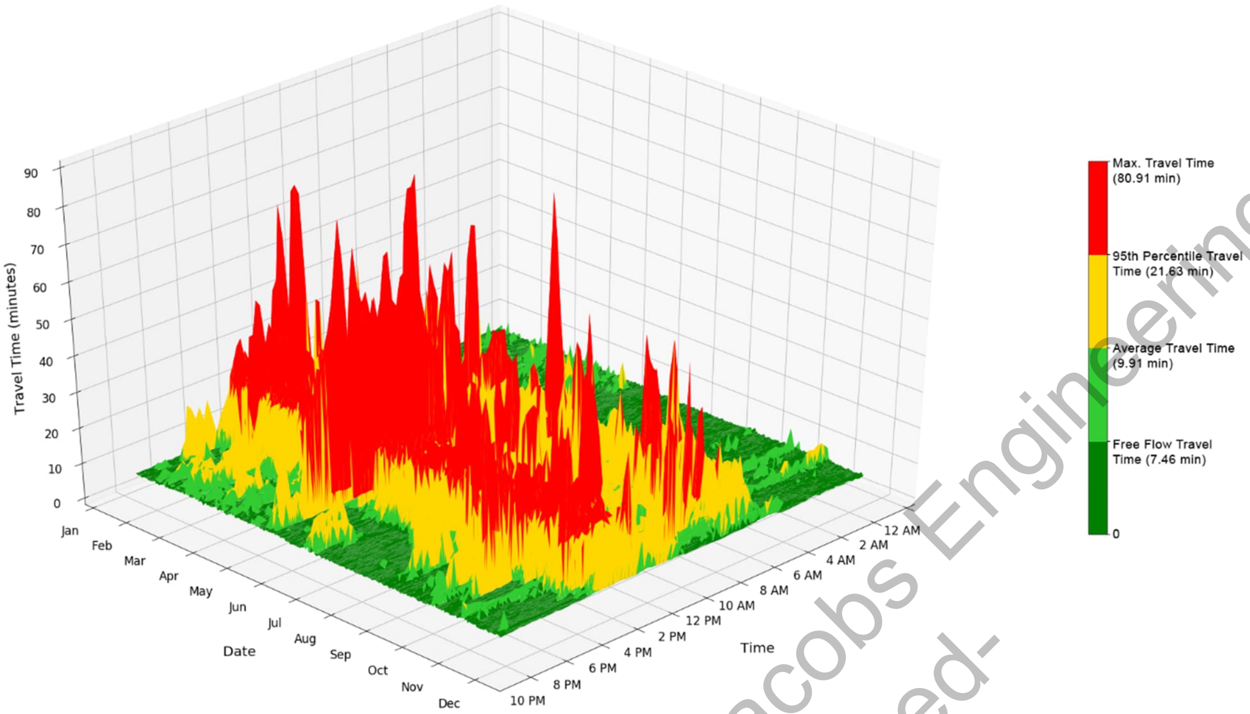

Figure 3-5. I-270 Westbound – All Days (2019)
Source: Jacobs

Table 3-5 summarizes the causal factor evaluation for I-270 westbound. From 2016 to 2019, the total number of days with fair or poor travel times increased 6 percent, which can be primarily attributed to the occurrence of multiple events (66 percent) and roadwork (24 percent) in 2019. Data for 2016 show that 48 percent of the unreliable travel with fair or poor travel times was caused by congestion during the commuter peak hours. For 2019, the unreliable travel with fair and poor travel times was caused by the ongoing roadwork construction and other events. No days with fair or poor travel times fall under the congestion-related poor reliability. This indicates that occurrence of different events during the peak period might have negatively affected the commuter peak hour congestions.

Table 3-5. I-270 Westbound: Causal Factor Summary

Event Type	Number of Days		Percentage of Days	
	2016	2019	2016	2019
Incidents	10	0	3%	0%
Planned Event	25	0	7%	0%
PSA on Variable Message Sign Boards	0	0	0%	0%
Roadwork	88	89	24%	24%
Multiple Events[a]	14	241	4%	66%
Unaccounted Congestion	174	0	48%	0%
Uncongested	55	35	15%	10%
Total Days Analyzed	366	365	100%	100%

Source: Jacobs

[a] Occurrence of two or more events includes incidents, planned events, PSAs, roadwork, or some combination thereof.

PSA = public service announcement

3.4.2 I-270 Eastbound: Travel Time Reliability

The reliability ratings for I-270 eastbound (Table 3-6) were generally lower in 2019 than in 2016 for the same time period or days in a week. The travel times were the least reliable during the a.m. peak period and most reliable during weekends in both 2016 and 2019. The combined analysis of reliability ratings on both I-270 westbound and I-270 eastbound (Tables 3-3 and 3-6) show that the I-270 westbound weekday p.m. peak had the lowest reliability ratings.

Table 3-6. I-270 Eastbound: Reliability Rating
(Percentage of 15-minute time periods less than 1.33 TTI factor)

Segment	Weekdays		Weekdays A.M. Peak Period		Weekdays P.M. Peak Period		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
I-270 Eastbound – I-25 to I-70	78.72%	69.6%	25.78%	14.9%	43.61%	27.55%	97.52%	93.72%

Source: Jacobs

Table 3-7 displays the travel time reliability analysis based on the frequency of congestion on I-270 eastbound during different times in 2016 and 2019. A higher percentage of trips experienced poor travel time reliability on I-270 eastbound during the a.m. peak period for both 2016 and 2019. The analysis showed that most of the poor travel times on I-270 eastbound during 2016 occurred in the morning hours and are more prominent in the summer months (Figure 3-6). While this same trend occurred in 2019 for the morning hours, it did so mainly in the earlier months of the year (Figure 3-7). The duration of poor travel reliability and the number of poor travel days increased in 2019 compared to 2016.

Table 3-7. I-270 Eastbound: Frequency of Congestion
(Percentage of 15-minute time periods in each category)

Reliability Category	Weekdays		Weekdays A.M. Peak Period		Weekdays P.M. Peak Period		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
Free Flow	66.2%	50.1%	9.8%	6.7%	18.4%	9.6%	92.7%	78.9%
Good	3.1%	13.2%	2.6%	4.2%	4.3%	8.7%	1.9%	10.4%
Fair	24.0%	30.0%	55.9%	61.1%	63.8%	70.9%	4.9%	9.8%
Poor	6.7%	6.7%	31.7%	28.0%	13.5%	10.8%	0.6%	0.8%

Source: Jacobs

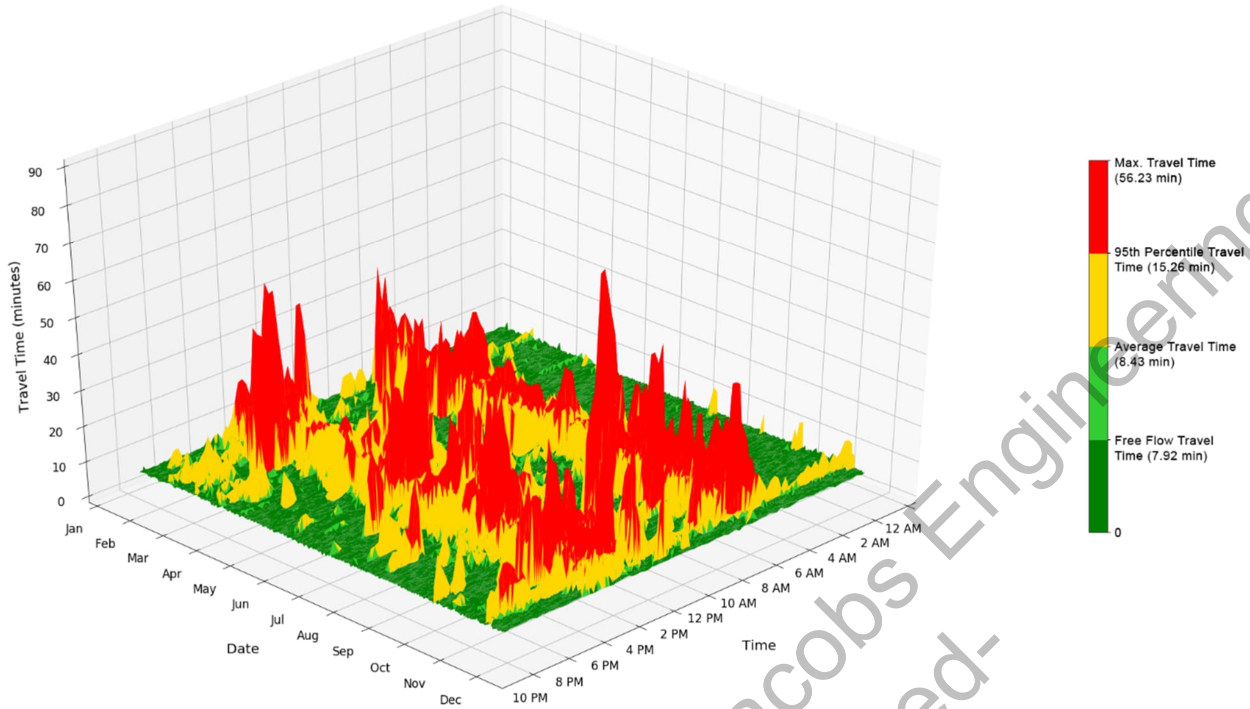

Figure 3-6. I-270 Eastbound – All Days (2016)
Source: Jacobs

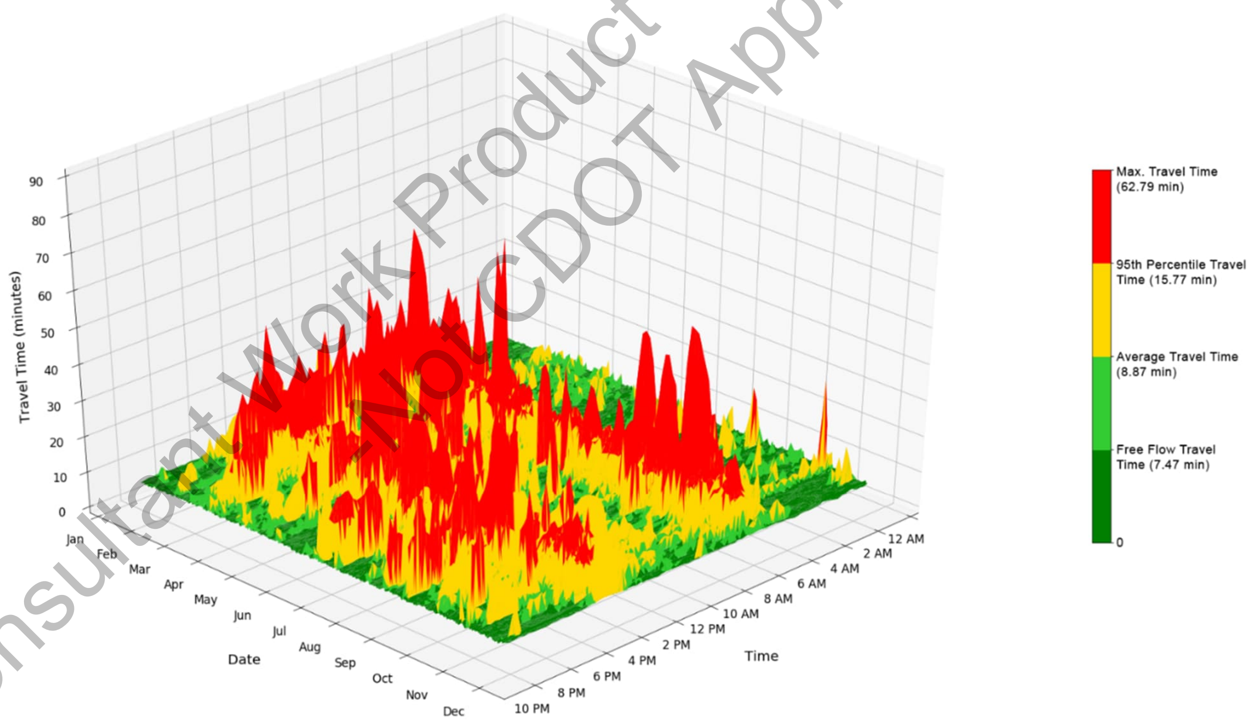

Figure 3-7. I-270 Eastbound – All Days (2019)
Source: Jacobs

Table 3-8 summarizes the causal factor evaluation on I-270 eastbound. From 2016 to 2019, a 7 percent increase occurred in the total number of days with fair or poor travel times. As on I-270 westbound, this can be primarily attributed to the occurrence of multiple events (55 percent) and roadwork (25 percent) in 2019.

Table 3-8. I-270 Eastbound: Causal Factor Summary

Event Type	Number of Days		Percentage of Days	
	2016	2019	2016	2019
Incidents	7	11	2%	3%
Planned Event	18	3	5%	1%
PSA	2	0	1%	0%
Roadwork	90	92	25%	25%
Multiple Events[a]	16	201	4%	55%
Unaccounted Congestion	186	34	51%	9%
Uncongested	47	24	13%	7%
Total Days Analyzed	366	365	100%	100%

Source: Jacobs

[a] Occurrence of two or more events includes incidents, planned events, PSAs, roadwork, or some combination thereof.

The detailed analysis and findings for the existing travel time reliability are provided in Appendix C, *I-270 Travel Time Reliability – Existing Conditions Assessment.*

3.5 Intersection Operations

The intersection performance measures were extracted from TransModeler for the a.m. and p.m. peak hours to assess delay and LOS for all study intersections. Table 3-9 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

The following intersections operate at LOS E or F with existing conditions:

- Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp (LOS E in p.m.)
- Quebec Street/I-270 westbound on-ramp (LOS E in a.m.)
- Vasquez Boulevard/East 56th Avenue (LOS F in p.m.)
- York Street/I-270 westbound off-ramp (LOS E in a.m. and p.m.)

Table 3-9. Existing Conditions Peak Hour Intersection Operations

ID	Intersection	7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	53.6	D	73.1	E
2	Quebec Street/I-270 Westbound On-ramp	58.1	E	32.9	C
3	Vasquez Boulevard/East 56th Avenue	28.0	C	119.5	F
4	Vasquez Boulevard/East 60th Avenue	36.3	D	45.1	D
5	York Street/I-270 Eastbound On-ramp	24.6	C	29.1	C
6	York Street/I-270 Westbound Off-ramp	58.0	E	64.3	E

Source: Jacobs

ID = identification

Table 3-10 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods. It also shows the available storage length on the off-ramps from the exit ramp gore point to the intersection. Because of the cloverleaf configuration with no signals at the Vasquez Boulevard interchange, no queue lengths are reported at this location.

Table 3-10. Existing Conditions Peak Period I-270 Off-ramps Queue length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet)	
					7:00 a.m. to 9:00 a.m.	4:00 p.m. to 7:00 p.m.
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	Westbound	Left	1,130	84	106
			Through		0	0
			Right		0	0
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	108	68
			Right		0	0

Source: Jacobs

Although many of the intersections would operate at LOS E and F, the queues from the ramp–terminal intersections do not overlap onto the I-270 freeway. The queues at the other approaches at these ramp terminals are operating within the available approach storage lengths, except for the eastbound approach to Quebec Street from Sand Creek Drive.

4.0 2040 No Action Alternative

This section summarizes the traffic operations conditions anticipated in the design year 2040 under a No Action Alternative. The 2040 No Action Alternative TransModeler network received from Atkins was revised to include the improvements detailed in Section 2 of this report. The revised network is used for the 2040 No Action Alternative analysis.

The problem areas or bottleneck locations described in Section 3, 2016 Existing Conditions, are projected to get worse in the 2040 No Action Alternative as a result of traffic growth. Worsening traffic conditions in the No Action Alternative may lead to the following:

- Longer periods of congestion
- Extended queue lengths
- Reduced speeds on freeways
- Increased travel times and delay

Performance measure details similar to those in Section 3 are summarized in the following sections for the No Action Alternative.

4.1 Peak Hour Volumes

The peak hour volumes for the No Action Alternative from 7 a.m. to 8 a.m. in the a.m. peak period and 5 p.m. to 6 p.m. in the p.m. peak period are shown on Figure 4-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 1,350 vehicles crossing the segment between Central Park Boulevard and Quebec Street and the highest volumes (3,700 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,000 vehicles crossing the segment east of Quebec Street off-ramp and the high end of the range (3,200 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

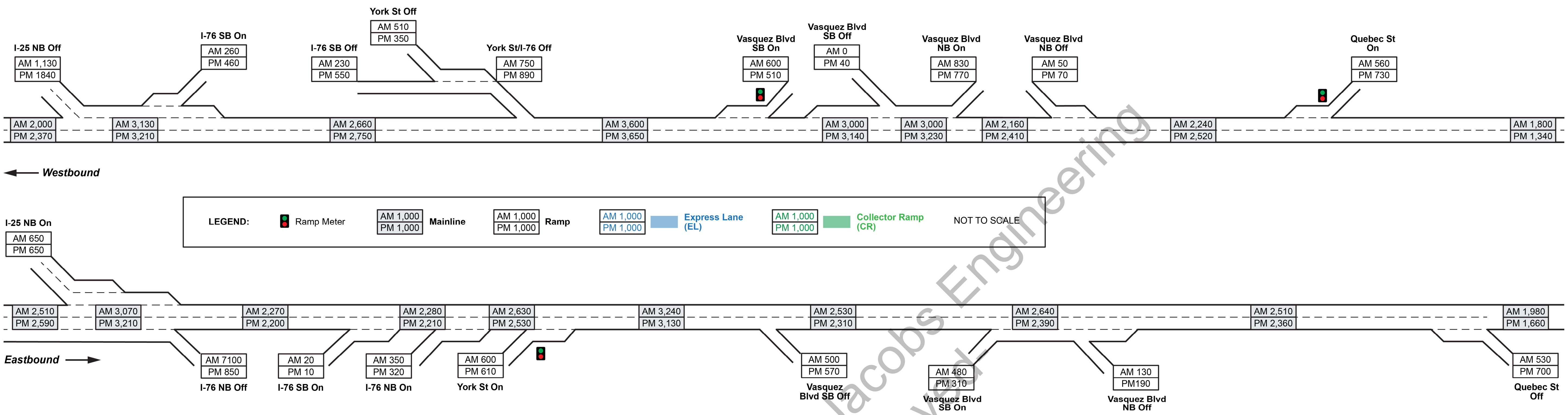

Figure 4-1. No Action Peak Hour Volumes

Source: Jacobs

It was observed that the peak hour volumes for the No Action Alternative are similar to the 2016 existing conditions volumes. This can be attributed to the at-capacity conditions at which I-270 is currently operating. In addition, the construction of the Central 70 project is expected to attract traffic from the adjacent facilities such as I-270.

4.2 Performance Measures

Tables 4-1 and 4-2 summarize the peak period performance measures for the 2040 No Action Alternative in the westbound and eastbound directions.

Table 4-1. No Action Performance Measures, Westbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	20.7	19.4	12.6	15.4	19.7
Average Speed (mph)	20	21	30	25	21
VHD (hours)	571	481	296	424	555
Average Delay per Vehicle (minutes)	15.0	13.7	6.9	9.8	14.1
Average Density (pc/mi/ln)	75.0	74.1	49.1	61.7	75.2
VMT (vehicle-miles)	16,452	15,297	16,168	17,147	16,932
VHT (vehicle-hours)	824	716	545	687	815
TTI	3.09	2.89	1.87	2.30	2.94
Truck Miles Traveled (truck-miles)[a]	4,222		5,475		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

Table 4-2. No Action Performance Measures, Eastbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	18.0	19.9	16.5	17.4	18.3
Average Speed (mph)	21	19	22	21	20
VHD (hours)	543	609	442	498	541
Average Delay per Vehicle (minutes)	12.3	14.2	10.8	11.7	12.6
Average Density (pc/mi/ln)	68.1	72.3	62.3	65.8	69.9
VMT (vehicle-miles)	16,368	16,133	14,888	15,588	16,180
VHT (vehicle-hours)	795	857	671	738	789
TTI	2.67	2.95	2.46	2.58	2.72
Truck Miles Traveled (truck-miles)[a]	3,711		5,869		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

The traffic on the I-270 corridor under the 2040 No Action conditions performs worse than with the existing conditions. The increased traffic congestion along with increased capacity on I-70 with the Central 70 project completion results in changed entry and exit traffic patterns on I-270. This results in similar peak hour volume ranges for both the existing and 2040 No Action conditions, but the overall performance based on different MOEs is worse with the No Action conditions.

As shown on Figures 3-2 and 4-2, I-270 in the westbound direction experiences more congestion with the 2040 No Action conditions between I-70 and the Vasquez Boulevard interchange compared to the existing conditions due to the increased traffic in the Vasquez Boulevard southbound entrance ramp, causing delays for vehicles entering the corridor from I-70. Similarly, as shown on Figures 3-3 and 4-3, I-270 in the eastbound direction experiences more congestion with the 2040 No Action conditions between I-25 and the Vasquez Boulevard interchange compared to the existing conditions, causing increased delays for vehicles entering the corridor from I-25.

4.3 Speed Plots

Figure 4-2 provides the speed plot for the a.m. and p.m. peak periods in the westbound direction. In the a.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange, I-76 off-ramp, and Quebec Street on-ramp. Congestion from these bottleneck spills back toward I-70 and Central Park Boulevard, with speeds as low as 0 to 20 mph.

In the p.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange and York Street/I-76 off-ramp. The congestion develops early in the p.m. peak period, starting at 4 p.m., and does not dissipate until after 7 p.m. The congestion from these bottlenecks in the p.m. peak period spills back toward I-70, with speeds as low as 0 to 20 mph.

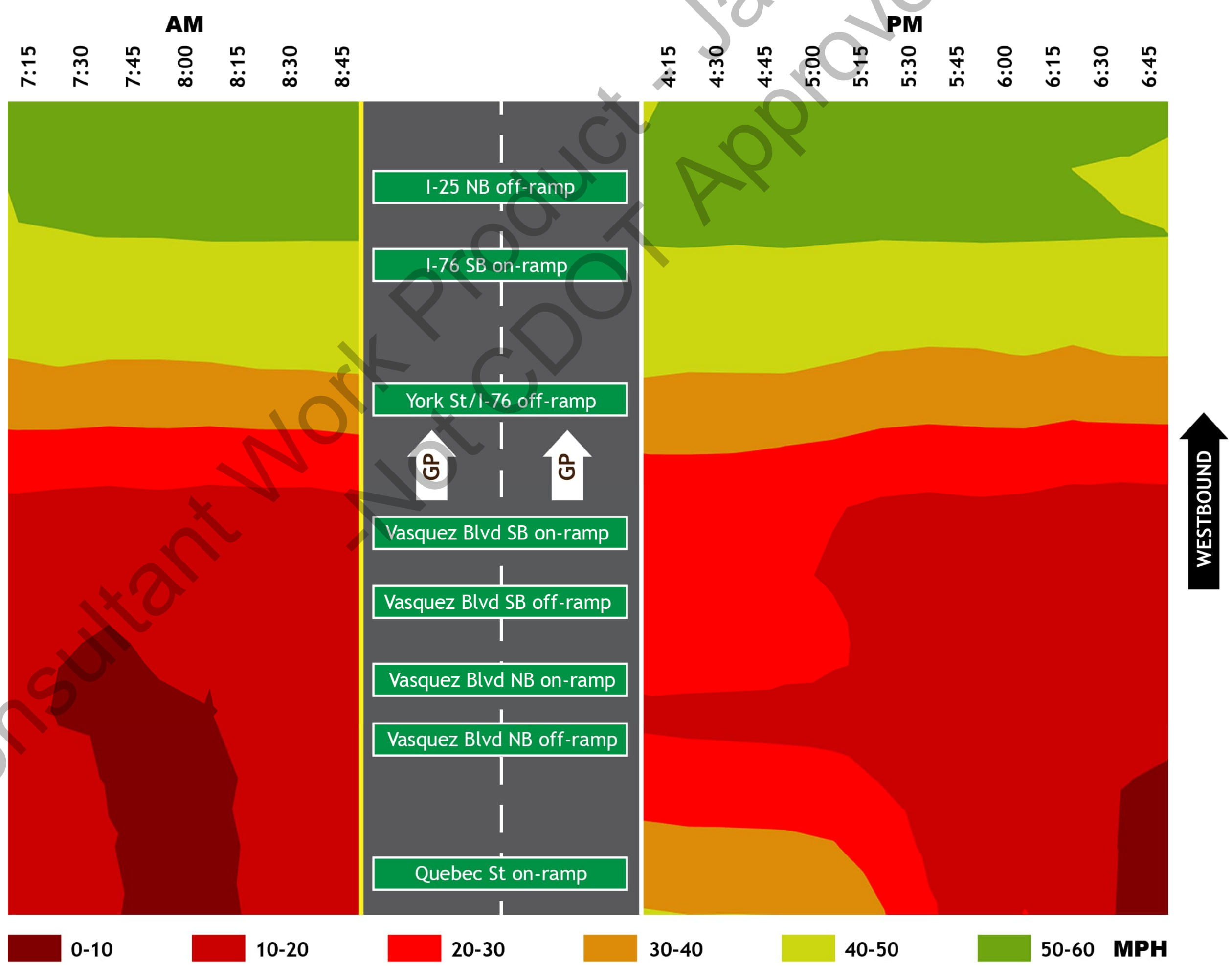

Figure 4-2. No Action Peak Period Speed Plot, Westbound Direction
Source: Jacobs

Figure 4-3 provides the speed plot for the a.m. and p.m. peak periods in the eastbound direction. In the a.m. peak period, bottlenecks at the York Street on-ramp and Vasquez Boulevard interchange are observed in the speed plot. The congestion develops early, before the a.m. peak period, and continues even after 9 a.m. Congestion from these bottlenecks spills back toward the I-25 interchange, with speeds as low as 0 to 20 mph (as indicated by the predominantly red color in the a.m. peak period along the top edge of Figure 4-3).

In the p.m. peak period, bottlenecks are observed at the York Street on-ramp, Vasquez Boulevard interchange, and Quebec Street on-ramp. The congestion develops before 4 p.m. and does not dissipate until after 7 p.m. The congestion from these bottlenecks in the p.m. peak period spills back toward the I-25 on-ramp, with speeds as low as 10 to 20 mph.

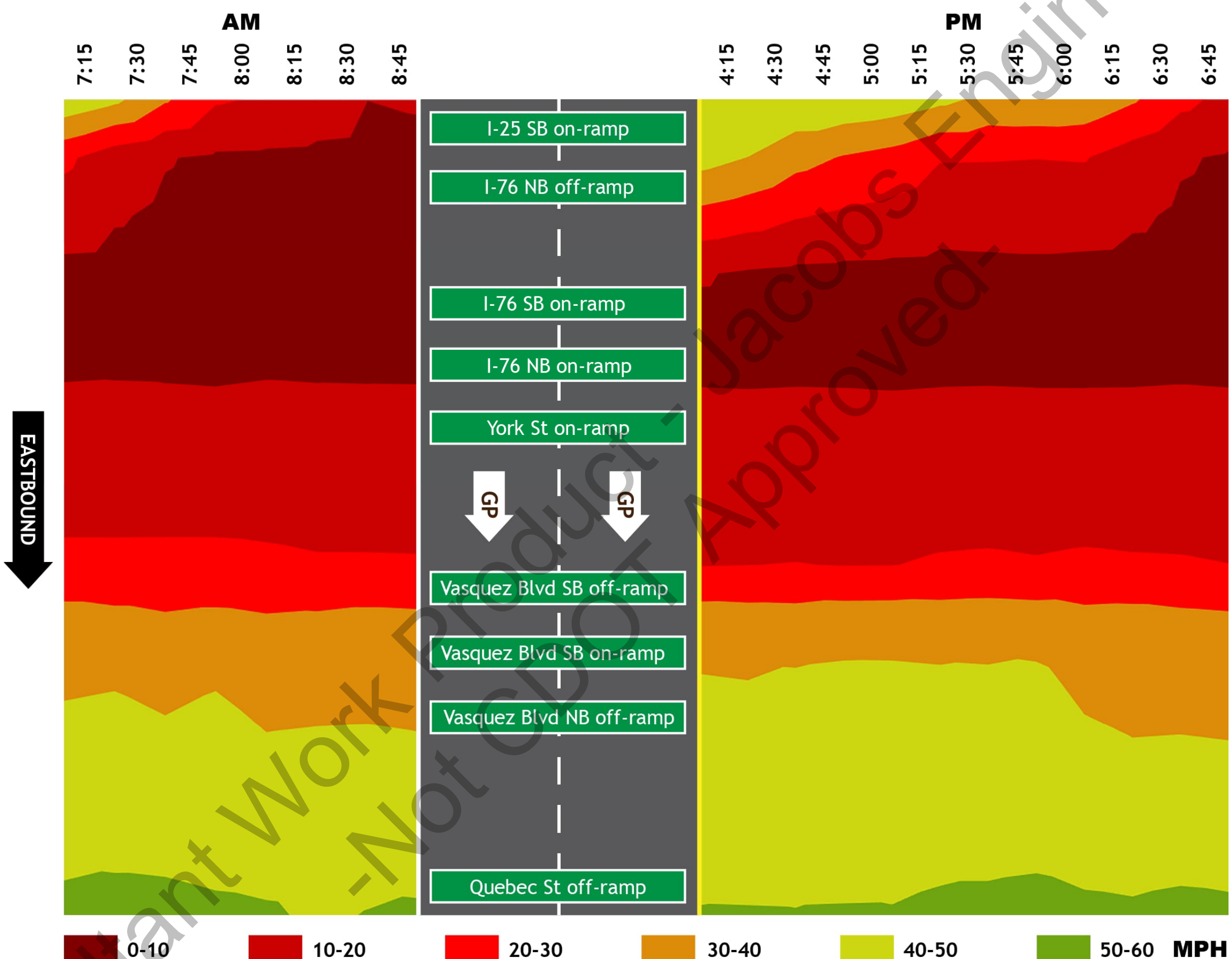

Figure 4-3. No Action Peak Period Speed Plot, Eastbound Direction
Source: Jacobs

A substantial portion of the freeway traffic is projected to operate at low speeds during peak periods in the 2040 No Action Alternative because of traffic congestion. If no improvements are made on I-270, by 2040, 48 percent of the freeway system would operate at speeds less than 25 mph in the a.m. peak period and 41 percent in the p.m. peak period. In addition, only 13 percent of the freeway segments in the a.m. peak period and 15 percent in the p.m. peak period are projected to operate at speeds greater than 50 mph.

4.4 Travel Time Reliability

Travel time reliability related to traffic congestion was evaluated for the different operating options. With no capacity improvements in the No Action Alternative, overall the average travel times are similar or slightly increased on the corridor compared to existing conditions. This is because the I-270 corridor is already at capacity. The TTI values under No Action conditions for the corridor ranged between 1.87 and 3.09, which is higher than the threshold value of 1.33 considered reliable for urban roadways.

For future year operating options, the average speed on the segment compared to the free-flow speed is also considered to indicate the travel time reliability. Tables 4-1 and 4-2 illustrate that in the westbound and eastbound directions, the average speed on I-270 for the No Action Alternative is between 20 and 30 mph in the peak periods.

With TTI higher than 1.33 and average speed much lower than the free-flow speed on I-270, which is 55 mph, travel on I-270 in the No Action Alternative is not reliable, with heavy congestion in the peak periods.

4.5 Intersection Operations

Table 4-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

LOS on arterials will vary with changing traffic patterns; factoring traffic growth of 24 years (2016 existing conditions to 2040 No Action conditions), some of the study intersections experience decreases in LOS. The following intersections are projected to operate at LOS E or F with the No Action Alternative:

- Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp (LOS E in p.m.)
- Vasquez Boulevard/56th Avenue (LOS E in p.m.)
- York Street/I-270 eastbound on-ramp (LOS E in p.m.)
- York Street/I-270 westbound off-ramp (LOS E in a.m.)

Although many of the intersections would operating at LOS E, the queues from the ramp–terminal intersections do not overlap onto the I-270 freeway.

Table 4-3. No Action Peak Hour Intersection Operations

ID	Intersection	7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	53.2	D	66.6	E
2	Quebec Street/I-270 Westbound On-ramp	8.9	A	5.8	A
3	Vasquez Boulevard/East 56th Avenue	45.7	D	64.7	E
4	Vasquez Boulevard/East 60th Avenue	44.7	D	44.6	D
5	York Street/I-270 Eastbound On-ramp	40.0	D	60.3	E
6	York Street/I-270 Westbound Off-ramp	65.6	E	51.2	D

Source: Jacobs

Table 4-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods for the 2040 No Action Alternative. Because of the cloverleaf configuration with no signals at the Vasquez Boulevard interchange, no queue lengths are reported at this location.

Table 4-4. No Action Peak Period I-270 Off-ramps Queue Length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet)	
					7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	Westbound	Left	1,130	137	220
			Through		55	52
			Right		107	90
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	376	162
			Right		0	0

Source: Jacobs

As shown in Table 4-4, the queues from the ramp–terminal intersections are not overlapping onto the I-270 freeway. The queues at the other approaches at these ramp terminals are not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

5.0 2040 General Purpose Lane 1 (GP Version 1)

Sections 5 through 10 provide the details for the traffic operational analysis and performance measures used to evaluate and compare the different operating options.

The configuration for GP Version 1 would modify the freeway and interchange access between the local roads and freeway system as follows:

- Reconstruct and widen the I-270 mainline in both directions to accommodate one additional general purpose travel lane (three general purpose lanes each direction).
- Reconstruct the Quebec Street interchange to add an off-ramp from I-270 in the westbound direction.
- Construct an auxiliary lane between the Quebec Street on-ramp and the Vasquez Boulevard off-ramp in the westbound direction.
- Construct an auxiliary lane between the Vasquez Boulevard on-ramp and the I-76/York Street off-ramp in the westbound direction.
- Construct an I-76 collector ramp for the southbound and northbound I-76 on-ramps in the eastbound direction (shown in green on Figures 5-1, 6-1, and 7-1).
- Construct an auxiliary lane between the I-76 collector ramp and Vasquez Boulevard off-ramp in the eastbound direction.
- Reconstruct the I-270/Vasquez Boulevard interchange into a partial cloverleaf design (removing the two exit loop ramps) and add two signals on Vasquez Boulevard.
- Add ramp metering at select locations as shown on Figures 5-1, 6-1, and 7-1.

Figure 5-1 illustrates the geometric layout for this operating option.

5.1 Peak Hour Volumes

The peak hour volumes for GP Version 1 are shown on Figure 5-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 2,800 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (5,500 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange.

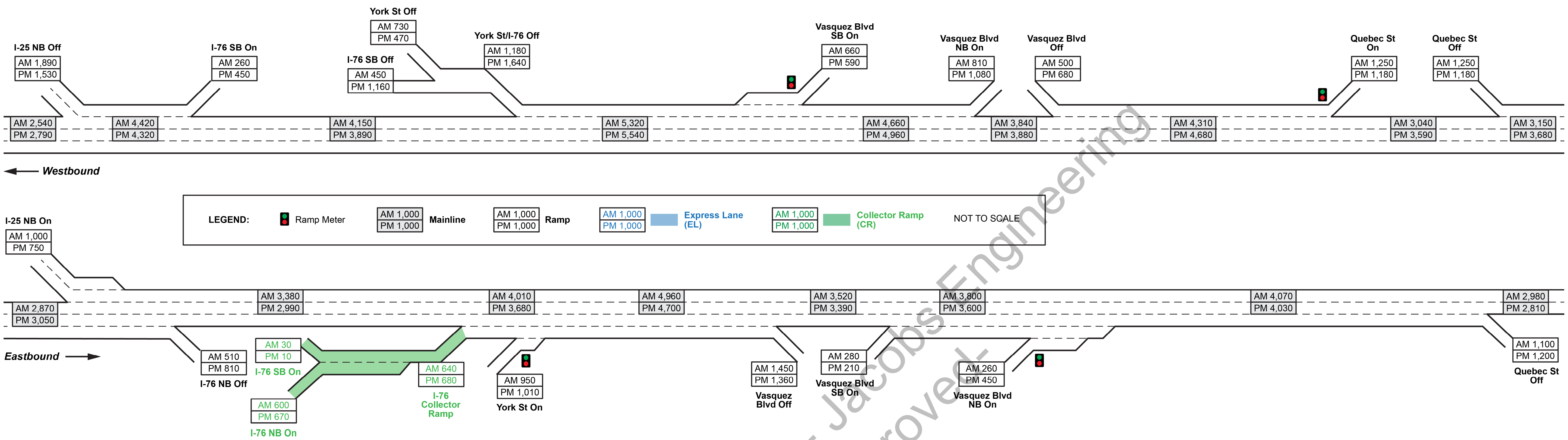

Figure 5-1. General Purpose Lane Operating Option Version 1 Peak Hour Volumes
Source: Jacobs

The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (4,900 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

5.2 Performance Measures

Tables 5-1 and 5-2 summarize the peak period performance measures for the proposed GP Version 1 conditions in the westbound and eastbound directions.

Table 5-1. GP Version 1 Performance Measures, Westbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	9.0	9.4	8.3	10.1	11.1
Average Speed (mph)	41	39	45	37	33
VHD (hours)	229	260	163	322	409
Average Delay per Vehicle (minutes)	3.3	3.7	2.6	4.4	5.4
Average Density (pc/mi/ln)	32.0	34.6	26.3	37.9	43.3
VMT (vehicle-miles)	26,307	25,813	23,384	27,615	28,564
VHT (vehicle-hours)	634	657	523	747	848
TTI	1.33	1.40	1.23	1.49	1.65
Truck Miles Traveled (truck-miles)[a]	5,831		6,550		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

Table 5-2. GP Version 1 Performance Measures, Eastbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	8.2	8.2	8.2	8.2	7.9
Average Speed (mph)	46	46	46	45	47
VHD (hours)	169	163	153	166	140
Average Delay per Vehicle (minutes)	2.4	2.4	2.4	2.5	2.2
Average Density (pc/mi/ln)	29.3	28.7	26.5	28.5	26.5
VMT (vehicle-miles)	24,897	23,979	21,937	23,868	23,073
VHT (vehicle-hours)	552	532	490	533	495
TTI	1.21	1.21	1.21	1.21	1.17
Truck Miles Traveled (truck-miles)[a]	4,266		6,201		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

5.3 Speed Plots

Figure 5-2 provides the speed plot for the a.m. and p.m. peak periods in the westbound direction. In the a.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange and Quebec Street on-ramp at the end of simulation from 8:45 to 9:00 a.m.

In the p.m. peak period, bottlenecks are observed at the Vasquez Boulevard interchange and Quebec Street on-ramp from 5 to 7 p.m. The congestion from the Quebec Street on-ramp in the p.m. peak period spills back toward I-70, with speeds as low as 0 to 20 mph.

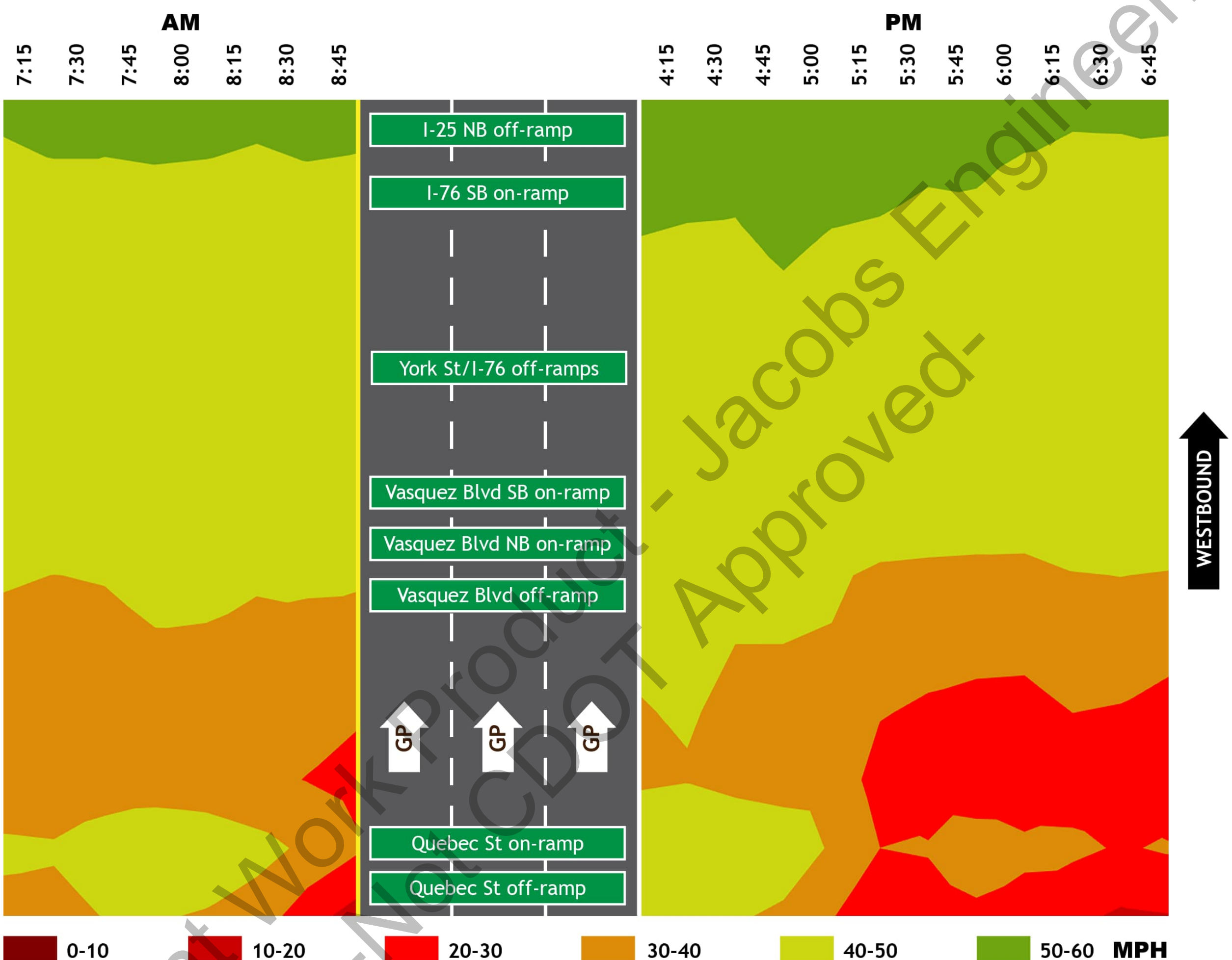

Figure 5-2. GP Version 1 Peak Period Speed Plot, Westbound Direction
Source: Jacobs

Figure 5-3 provides the speed plot for the a.m. and p.m. peak periods in the eastbound direction. In the a.m. and p.m. peak periods, no bottlenecks are observed in the speed plot. A reduced speed of 30 to 40 mph is observed between the York Street on-ramp and Vasquez Boulevard off-ramp in the a.m. and p.m. peak periods.

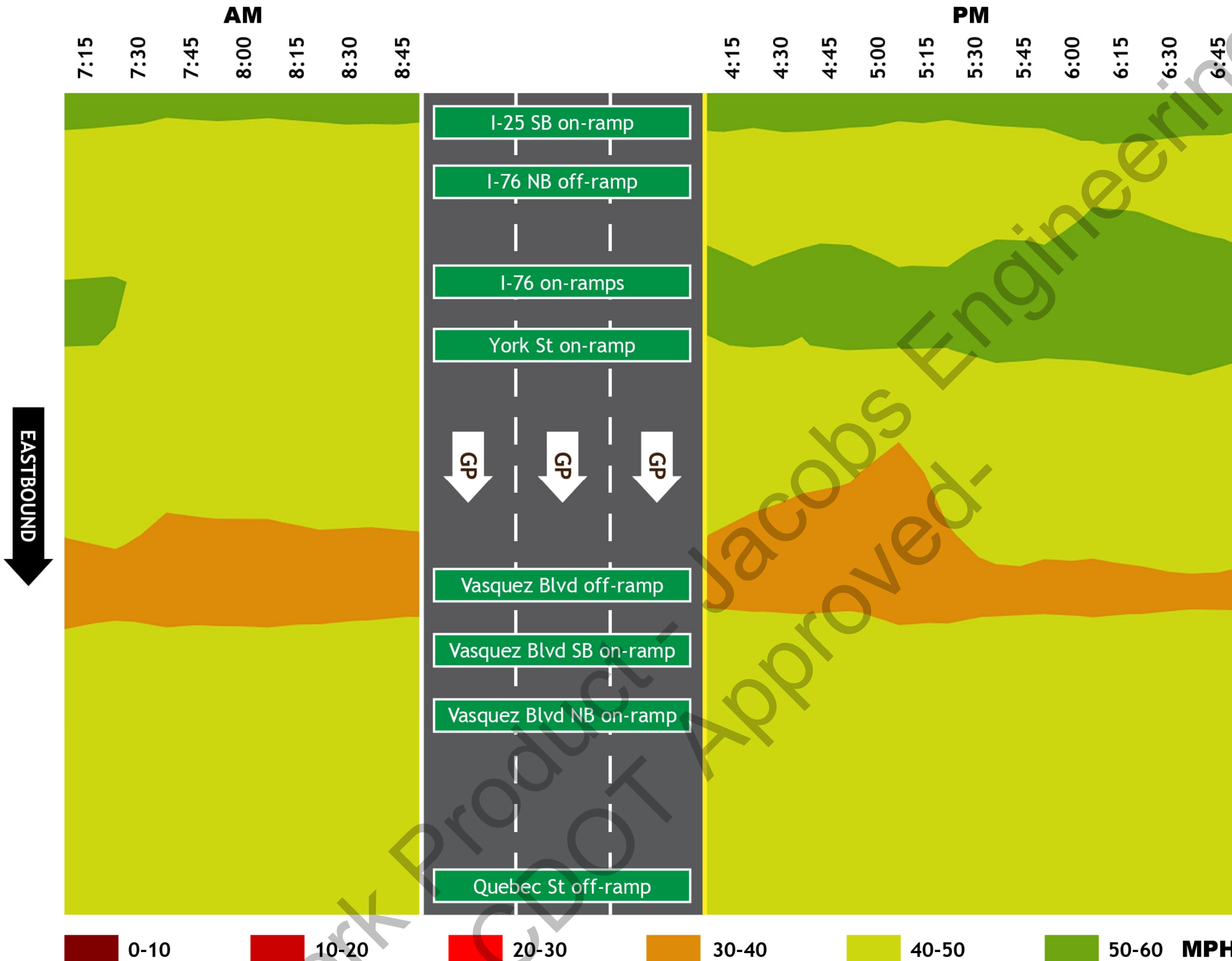

Figure 5-3. GP Version 1 Peak Period Speed Plot, Eastbound Direction
Source: Jacobs

A substantial portion of the freeway traffic is projected to operate at high speeds during peak periods. With the GP Version 1 improvements, 88 percent of the freeway system would operate at between 30 mph and 50 mph in the a.m. peak period and 68 percent would in the p.m. peak. In addition, only 3 percent of the freeway segments are projected to operate at speeds less than 25 mph in the a.m. and p.m. peak periods.

5.4 Travel Time Reliability

For GP Version 1, TTI values for the corridor ranged between 1.17 and 1.65, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours.

The average travel speeds on I-270 in the westbound during the a.m. and p.m. peak periods are at or less than 45 mph. In the eastbound direction, the average speeds during the peak periods are at or greater than 45 mph. The additional capacity helps improve the travel speeds on I-270 compared to the No Action Alternative but is not able to maintain an average speed of 45 mph or greater.

With TTI not meeting thresholds in the westbound direction for all the hours in a.m. and p.m. peak periods, and the average speed less than 45 mph, travel on I-270 for the GP Version 1 is not reliable. Tables 5-1 and 5-2 provide the average speed data during the peak periods.

5.5 Intersection Operations

Table 5-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

In the operating options, the interchange at Vasquez Boulevard is improved to add the following two intersections:

- Vasquez Boulevard/I-270 eastbound off-ramp
- Vasquez Boulevard/I-270 westbound off-ramp

With added capacity on I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative. The following intersections are projected to operate at LOS E or F with GP Version 1:

- Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp (LOS E in a.m. and p.m.)
- Vasquez Boulevard/East 56th Avenue (LOS F in p.m.)

Queues from the ramp–terminal intersections do not extend up to the freeway.

Table 5-3. GP Version 1 Peak Hour Intersection Operations

		7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
ID	Intersection	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	67.3	E	75.2	E
2	Quebec Street/I-270 Westbound Ramps	16.6	B	27.1	C
3	Vasquez Boulevard/East 56th Avenue	26.1	C	108.2	F
4	Vasquez Boulevard/East 60th Avenue	37.0	D	41.0	D
5	York Street/I-270 Eastbound On-ramp	20.5	C	52.2	D
6	York Street/I-270 Westbound Off-ramp	44.3	D	47.9	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	7.4	A	8.9	A
8	Vasquez Boulevard/I-270 Westbound Off-ramp	0.6	A	10.9	B

Source: Jacobs

For the operating options with the interchange configuration changes, additional ramp terminuses were evaluated for queue backup on the freeway. Table 5-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 5-4. GP Version 1 Peak Period I-270 Off-ramps Queue Length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet)	
					7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	266	253
			Right			
2	Quebec Street/ I-270 Westbound Ramps	Westbound	Through/Left	1,900	0	31
			Right			
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	534	151
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	59	96
			Right		2	179
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	52	307
			Right		0	0

Source: Jacobs

As shown in Table 5-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on traffic movement on the I-270 freeway. The queues at the other approaches at these ramp terminals are not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

6.0 2040 General Purpose Lane 2 (GP Version 2)

The configuration for GP Version 2 includes all the improvements detailed in GP Version 1 except the construction of the auxiliary lane between Quebec Street on-ramp and Vasquez Boulevard off-ramp in the westbound direction. Figure 6-1 illustrates the geometric layout for this operating option.

6.1 Peak Hour Volumes

The peak hour volumes for GP Version 2 are shown on Figure 6-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 2,700 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (5,100 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (5,000 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

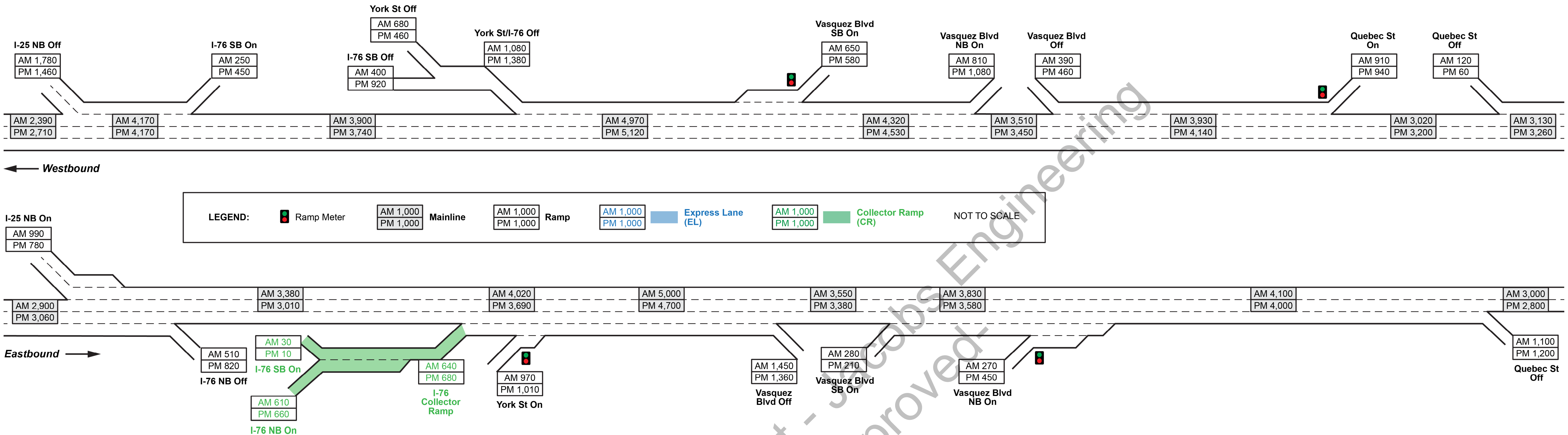

Figure 6-1. General Purpose Lane Operating Option Version 2 Peak Hour Volumes

Source: Jacobs

6.2 Performance Measures

Tables 6-1 and 6-2 summarize the peak period performance measures for the proposed GP Version 2 conditions in the westbound and eastbound directions.

Table 6-1. GP Version 2 Performance Measures, Westbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	11.5	11.5	9.0	11.2	12.8
Average Speed (mph)	32	32	41	33	29
VHD (hours)	373	363	212	371	446
Average Delay per Vehicle (minutes)	5.8	5.9	3.4	5.7	7.2
Average Density (pc/mi/ln)	42.9	44.5	31.2	43.1	50.3
VMT (vehicle-miles)	24,531	23,352	22,584	24,558	24,340
VHT (vehicle-hours)	751	723	559	749	821
TTI	1.71	1.72	1.34	1.67	1.90
Truck Miles Traveled (truck-miles)[a]	4,945		5,715		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

Table 6-2. GP Version 2 Performance Measures, Eastbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	8.2	8.2	8.1	8.1	8.0
Average Speed (mph)	45	46	46	46	46
VHD (hours)	174	164	150	157	148
Average Delay per Vehicle (minutes)	2.5	2.4	2.4	2.4	2.3
Average Density (pc/mi/ln)	29.6	28.7	26.4	27.9	27.1
VMT (vehicle-miles)	25,045	24,030	21,991	23,861	23,128
VHT (vehicle-hours)	559	534	488	524	504
TTI	1.21	1.21	1.20	1.19	1.19
Truck Miles Traveled (truck-miles)[a]	4,314		6,140		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

6.3 Speed Plots

Figure 6-2 provides the speed plot for the a.m. and p.m. peak periods in the westbound direction. In the a.m. peak period, bottleneck is observed at Quebec Street on-ramp.

In the p.m. peak period, a bottleneck is observed at the Quebec Street on-ramp. The congestion develops early in the p.m. peak period, starting at 4:15 p.m., and does not dissipate until after 7 p.m.

The congestion from this bottleneck in the p.m. peak period spills back toward I-70, with speeds as low as 20 to 30 mph.

The additional congestion and slower speeds in the westbound direction is attributable to removing the westbound auxiliary lane between the Quebec Street on-ramp and Vasquez Boulevard off-ramp.

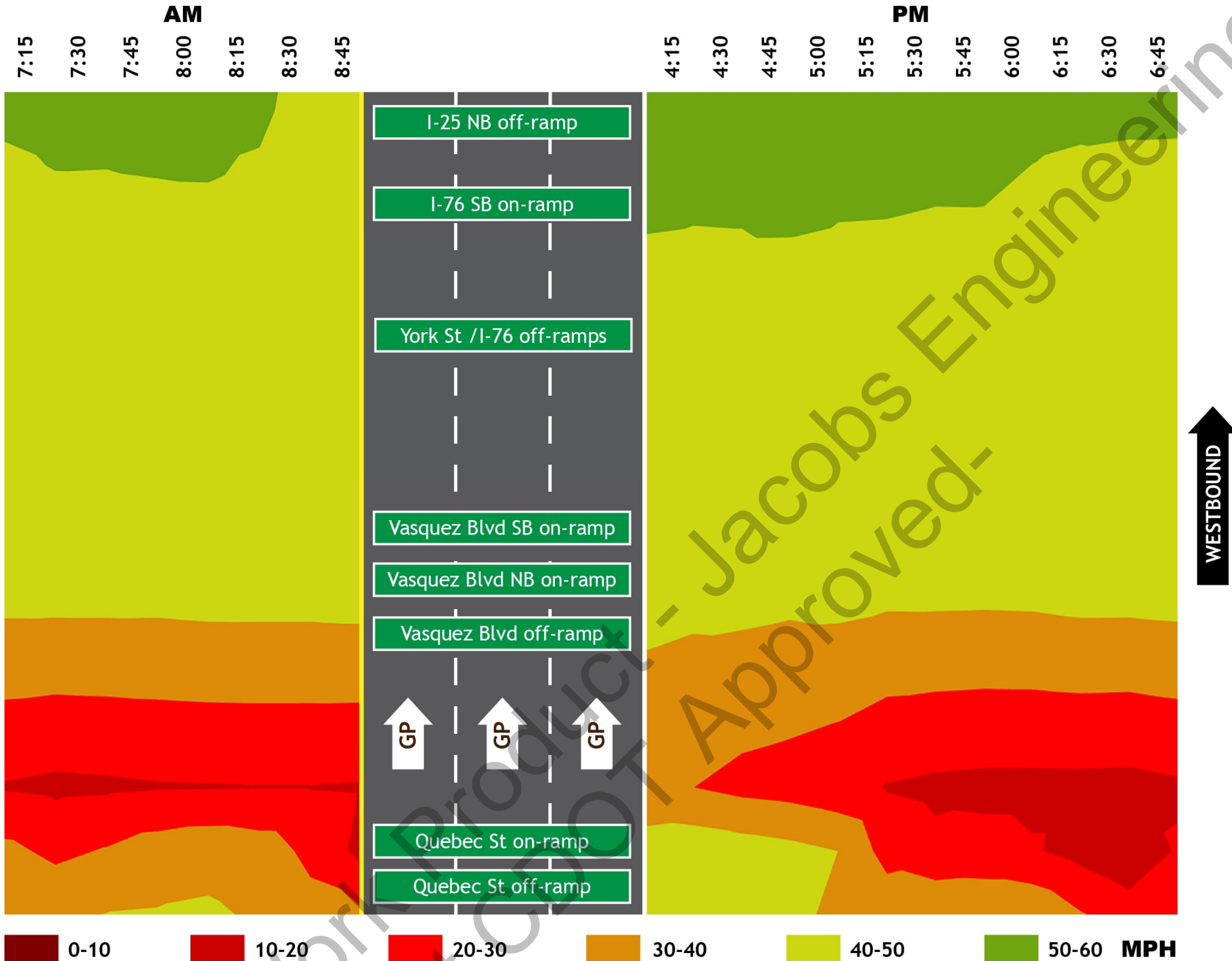

Figure 6-2. GP Version 2 Peak Period Speed Plot, Westbound Direction
Source: Jacobs

Figure 6-3 provides the speed plot for the a.m. and p.m. peak periods in the eastbound direction. No bottlenecks are observed in the speed plot for either the a.m. or p.m. peak periods. A reduced speed of 30 to 40 mph is observed between the York Street on-ramp and Vasquez Boulevard off-ramp in the a.m. and p.m. peak periods.

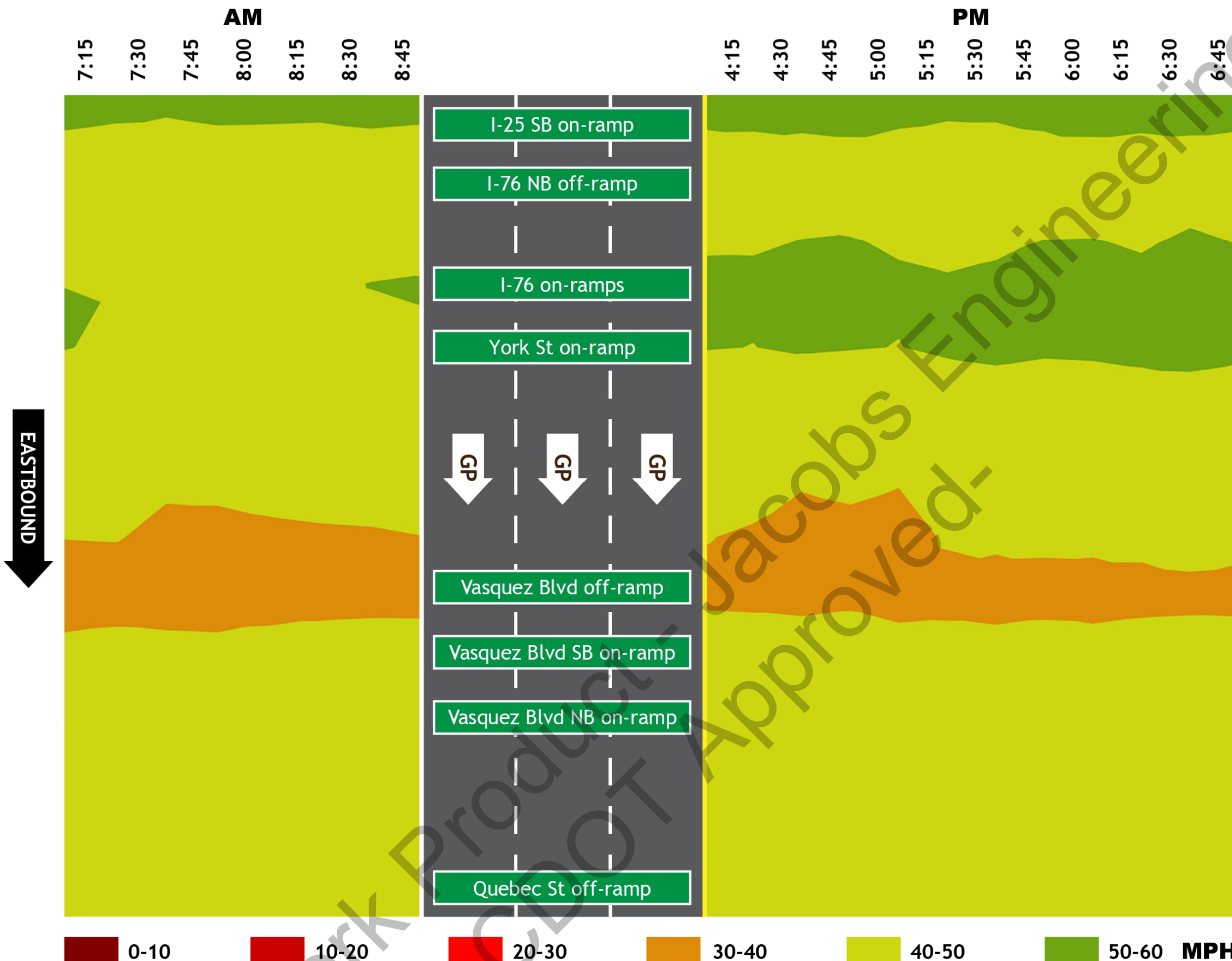

Figure 6-3. GP Version 2 Peak Period Speed Plot, Eastbound Direction
Source: Jacobs

6.4 Travel Time Reliability

For GP Version 2, TTI values for the corridor ranged between 1.19 and 1.9, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours.

The average travel speeds on I-270 in the westbound direction during the a.m. and p.m. peak periods are at or less than 41 mph. In the eastbound direction, the average speeds during the peak periods are at or greater than 45 mph. The additional capacity helps improve the travel speeds on I-270 compared to the No Action Alternative but is not able to maintain an average speed of 45 mph or greater.

With TTI not meeting thresholds in the westbound direction for all the hours in a.m. and p.m. peak periods, and the average speed less than 45 mph, travel on I-270 for GP Version 2 is not reliable. Tables 6-1 and 6-2 provide the average speed data during the peak periods.

6.5 Intersection Operations

Table 6-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

With added capacity on the I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative. The following intersections are projected to operate at LOS E or F with GP Version 2:

- Quebec Street/Sand Creek Drive/I-270 eastbound off-ramp (LOS E in a.m., LOS F in p.m.)
- Vasquez Boulevard/East 56th Avenue (LOS F in p.m.)

Even though two intersections would operate at LOS E and F, the queues from the ramp–terminal intersections do not extend up to the freeway.

Table 6-3. GP Version 2 Peak Hour Intersection Operations

		7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
ID	Intersection	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	66.8	E	83.3	F
2	Quebec Street/I-270 Westbound Ramps	26.8	C	35.0	C
3	Vasquez Boulevard/East 56th Avenue	25.8	C	109.0	F
4	Vasquez Boulevard/East 60th Avenue	36.6	D	40.5	D
5	York Street/I-270 Eastbound On-ramp	19.3	B	52.0	D
6	York Street/I-270 Westbound Off-ramp	33.2	C	48.7	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	7.5	A	7.5	A
8	Vasquez Boulevard/I-270 Westbound Off-ramp	0.4	A	4.0	A

Source: Jacobs

Table 6-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 6-4. GP Version 2 Peak Period I-270 Off-ramps Queue Length

					95th Percentile Queue (feet)	
ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	265	306
			Right		153	166
2	Quebec Street/ I-270 Westbound Ramps	Westbound	Through/Left	1,900	0	38
			Right		67	70
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	346	147
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	65	97
			Right		0	102
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	18	82
			Right		0	0

Source: Jacobs

As shown in Table 6-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on the traffic movement on the I-270 freeway. The queues at the other approaches at these ramp terminals are not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

7.0 2040 General Purpose Lane 3 (GP Version 3) - Proposed Action (General Purpose Lane Operating Option)

The configuration for GP Version 3 includes all the improvements detailed in GP Version 1 except the reconstruction of Quebec Street interchange to add an off-ramp from I-270 in the westbound direction. In addition, to modify the freeway and interchange access between the local roads and freeway system, GP Version 3 would add capacity to the York Street off-ramp by constructing separate off-ramps to York Street and I-76 in the westbound direction and adding an optional exit lane to the I-76 off-ramp. Figure 7-1 illustrates the geometric layout for this operating option.

7.1 Peak Hour Volumes

The peak hour volumes for GP Version 3 are shown on Figure 7-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 2,800 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (5,700 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (5,000 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

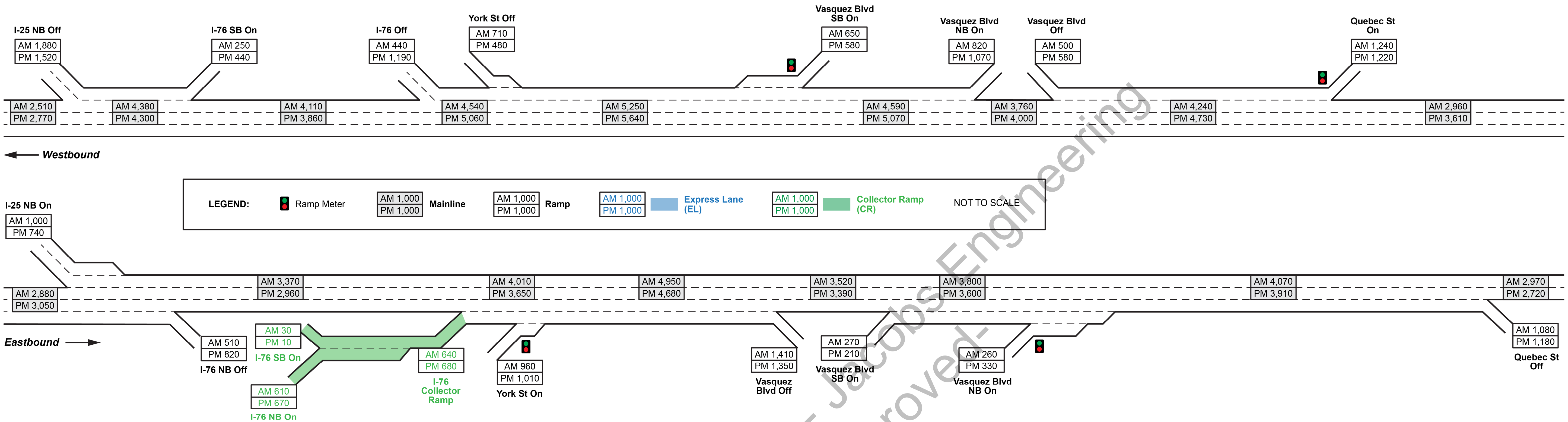

Figure 7-1. General Purpose Lane Operating Option Version 3 Peak Hour Volumes
Source: Jacobs

7.2 Performance Measures

Tables 7-1 and 7-2 summarize the peak period performance measures for the proposed GP Version 3 conditions in the westbound and eastbound directions.

Table 7-1. GP Version 3 Performance Measures, Westbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	8.9	9.2	8.4	10.4	11.0
Average Speed (mph)	42	40	44	35	34
VHD (hours)	221	232	180	363	404
Average Delay per Vehicle (minutes)	3.2	3.5	2.8	4.7	5.3
Average Density (pc/mi/ln)	31.1	31.9	27.6	39.7	42.6
VMT (vehicle-miles)	25,889	24,423	24,192	28,086	28,410
VHT (vehicle-hours)	619	608	553	795	841
TTI	1.32	1.37	1.26	1.55	1.64
Truck Miles Traveled (truck-miles)[a]	5,585		6,707		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

Table 7-2. GP Version 3 Performance Measures, Eastbound Direction

Performance Measures	A.M. Peak Period		P.M. Peak Period		
	7 to 8	8 to 9	4 to 5	5 to 6	6 to 7
Average Travel Time (minutes)	8.2	8.6	8.2	8.2	8.0
Average Speed (mph)	45	43	45	45	47
VHD (hours)	173	182	154	163	143
Average Delay per Vehicle (minutes)	2.5	2.9	2.5	2.5	2.2
Average Density (pc/mi/ln)	29.6	34.5	24.7	26.4	24.7
VMT (vehicle-miles)	24,857	22,452	21,617	23,452	22,996
VHT (vehicle-hours)	556	527	486	524	497
TTI	1.21	1.27	1.21	1.21	1.18
Truck Miles Traveled (truck-miles)[a]	4,142		6,152		

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods except for truck miles traveled, which is presented per peak period.

7.3 Speed Plots

Figure 7-2 provides the speed plot for the a.m. and p.m. peak periods in the westbound direction. In the a.m. peak period, a bottleneck is observed at the Quebec Street on-ramp at 8:30 a.m.

A bottleneck is also observed at the Quebec Street on-ramp in the p.m. peak period. The congestion develops starting at 5:15 p.m. and does not dissipate until after 7 p.m. The congestion from this bottleneck in the p.m. peak period spills back toward I-70, with speeds as low as 20 to 30 mph. An additional bottleneck during the p.m. peak period is observed at the York Street off-ramp starting at 4:15 p.m. and not dissipating before 6:15 p.m.

The additional congestion and slower speeds in the westbound direction are attributable to the proposed separate off-ramps to York Street and I-76.

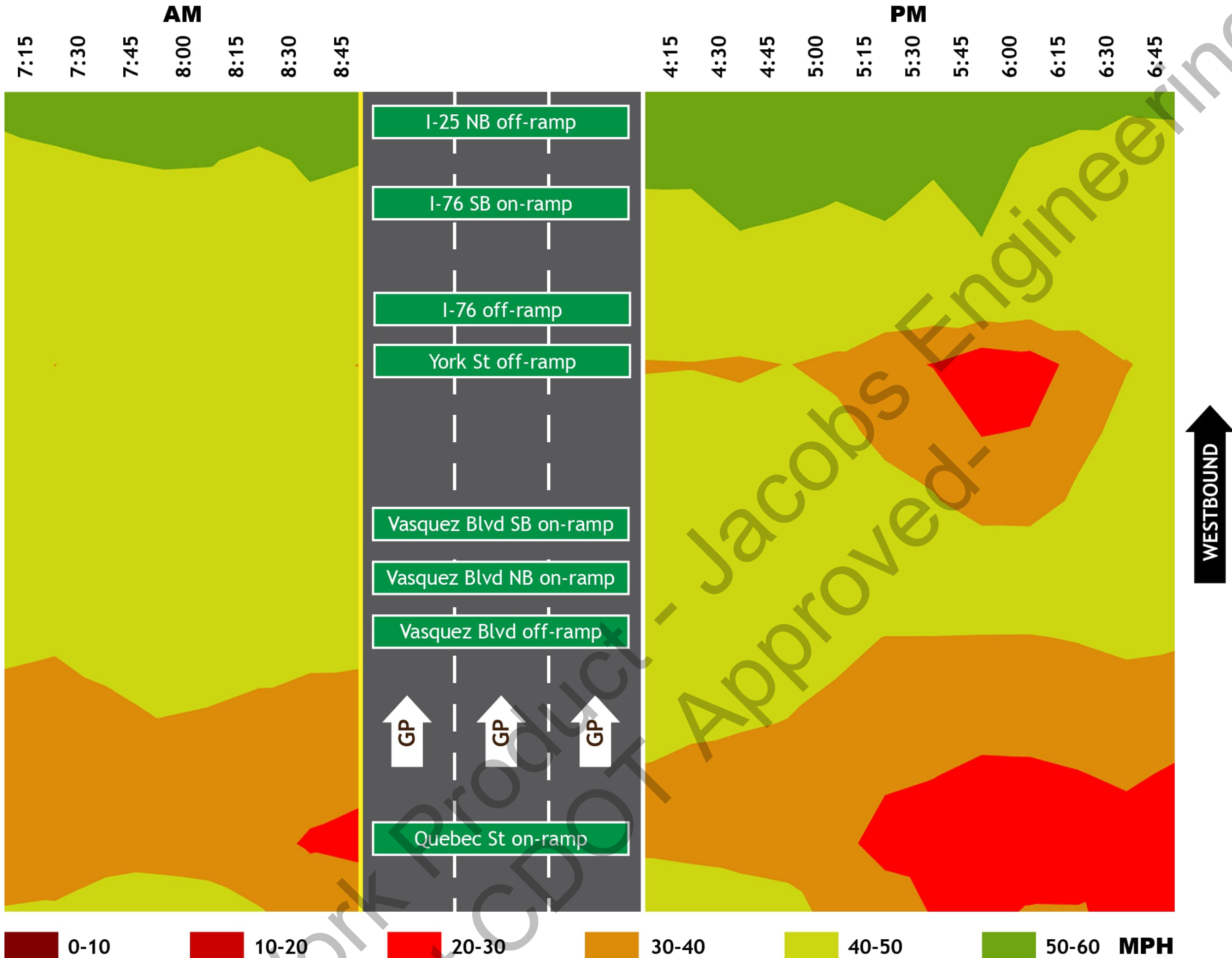

Figure 7-2. GP Version 3 Peak Period Speed Plot, Westbound Direction
Source: Jacobs

Figure 7-3 provides the speed plot for the a.m. and p.m. peak periods in the eastbound direction. As in the previous operating option, no bottlenecks are observed in the speed plot in either the a.m. or p.m. peak periods. A reduced speed of 30 to 40 mph is observed between the York Street on-ramp and the Vasquez Boulevard off-ramp in the a.m. and p.m. peak periods.

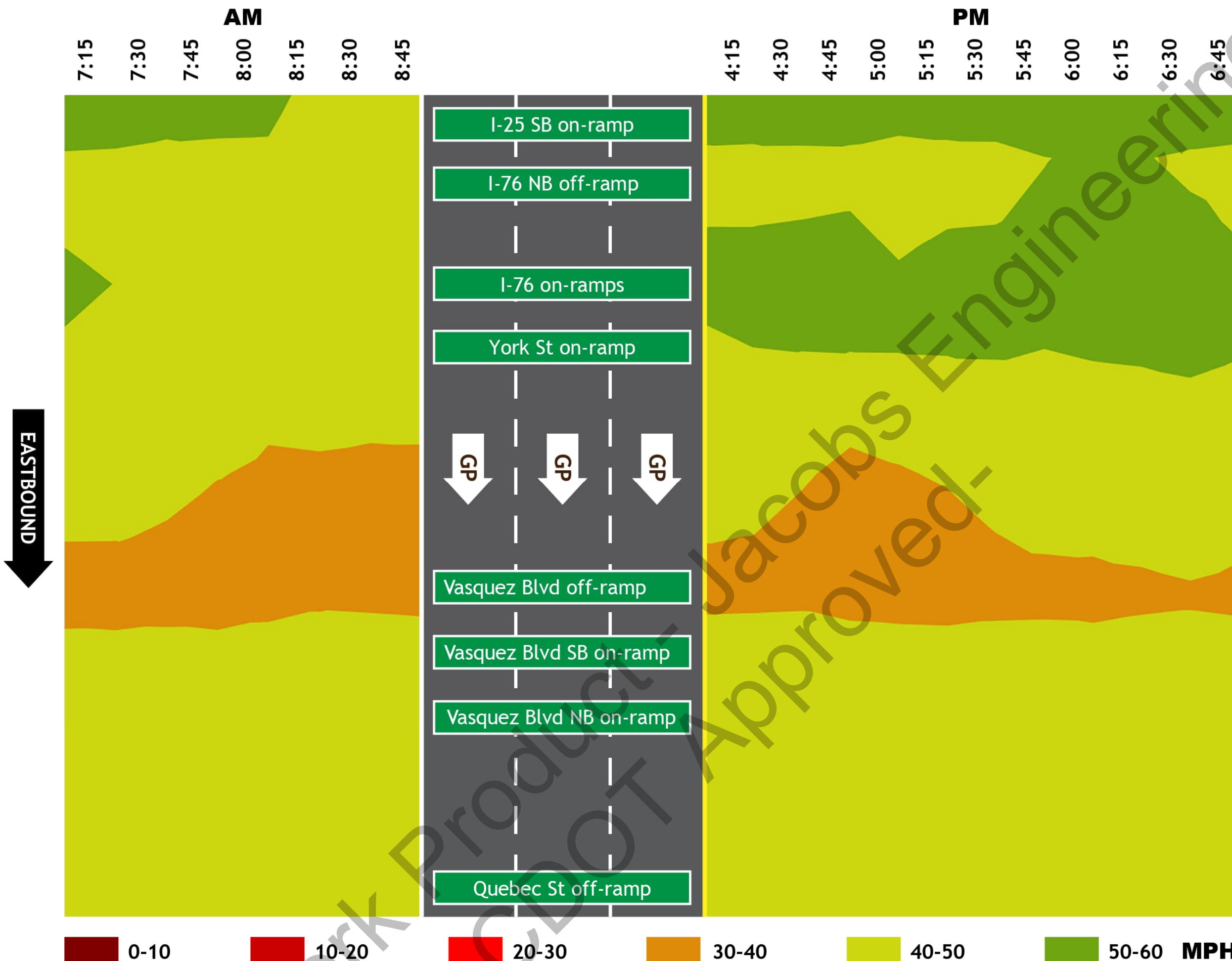

Figure 7-3. GP Version 3 Peak Period Speed Plot, Eastbound Direction
Source: Jacobs

7.4 Travel Time Reliability

For GP Version 3, TTI values for the corridor ranged between 1.18 and 1.64, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours.

The average travel speeds on I-270 in the westbound direction during the a.m. and p.m. peak periods are at or less than 44 mph. In the eastbound direction, the average speeds during the peak periods are at or greater than 43 mph. The additional capacity helps improve the travel speeds on I-270 compared to the No Action Alternative but is not able to maintain average speed of 45 mph or greater.

With TTI not meeting thresholds in the westbound direction for all the hours in a.m. and p.m. peak periods, and the average speed less than 45 mph, travel on I-270 for GP Version 3 is not reliable. Tables 7-1 and 7-2 provide the average speed data during the peak periods.

7.5 Intersection Operations

Table 7-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

With added capacity on the I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative.

The intersection of Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp is projected to operate at LOS E in both the a.m. and p.m. peak hours. Even though this intersection is operating at LOS E, the queues from the ramp–terminal intersection do not extend up to the freeway.

Table 7-3. GP Version 3 Peak Hour Intersection Operations

		7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
ID	Intersection	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	57.4	E	67.7	E
2	Quebec Street/I-270 Westbound Ramps	15.3	B	17.8	B
3	Vasquez Boulevard/East 56th Avenue	27.7	C	50.1	D
4	Vasquez Boulevard/East 60th Avenue	36.6	D	41.9	D
5	York Street/I-270 Eastbound On-ramp	20.3	C	51.9	D
6	York Street/I-270 Westbound Off-ramp	42.7	D	48.3	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	6.8	A	10.4	B
8	Vasquez Boulevard/I-270 Westbound Off-ramp	0.8	A	5.4	A

Source: Jacobs

Table 7-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 7-4. GP Version 3 Peak Period I-270 Off-ramps Queue Length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet) 7 a.m. to 9 a.m.	95th Percentile Queue (feet) 4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	362	276
			Right		153	165
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	524	154
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	57	94
			Right		145	389
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	109	253
			Right		0	0

Source: Jacobs

As shown in Table 7-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on traffic movement on the I-270 freeway. The queues at the other approaches at these ramp terminals are not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

8.0 2040 Express Lane 1 (EL Version 1)

The operating option for EL Version 1 would modify the freeway and interchange access between the local roads and freeway system as follows:

- Reconstruct and widen I-270 in both directions to accommodate one express lane (with two general purpose lanes and one express lane in each direction).
- Construct ingress points for the express lane on the west and east ends of I-270.
- Construct an express lane ingress and egress location between Vasquez Boulevard and York Street in both directions.
- Reconstruct the Quebec Street interchange to add an off-ramp from I-270 in the westbound direction.
- Construct an auxiliary lane between the Quebec Street on-ramp and Vasquez Boulevard off-ramp in the westbound direction.
- Construct an auxiliary lane between the Vasquez Boulevard on-ramp and I-76/York Street off-ramp in the westbound direction.
- Construct an I-76 collector ramp for the southbound and northbound I-76 on-ramps in the eastbound direction (shown in green on Figures 8-1, 9-1, and 10-1).
- Construct an auxiliary lane between the I-76 collector ramp on-ramp and Vasquez Boulevard off-ramp in the eastbound direction.
- Reconstruct the I-270/Vasquez Boulevard interchange into a partial cloverleaf design (removing the two exit loop ramps) and add two signals on Vasquez Boulevard.
- Add ramp metering at select locations as shown on Figures 8-1, 9-1, and 10-1.

Figures 8-1 illustrates the geometric layout for this operating option.

8.1 Peak Hour Volumes

The peak hour volumes for EL Version 1 are shown on Figure 8-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 2,800 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (4,900 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (4,700 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

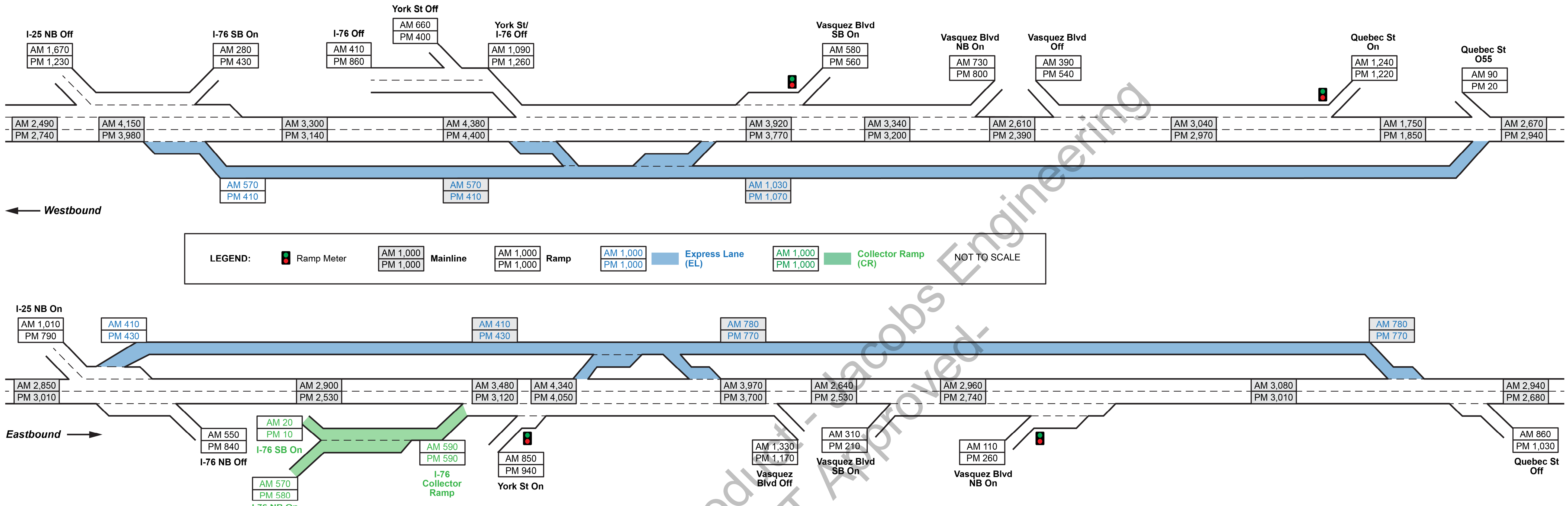

Figure 8-1. Express Lane Operating Option Version 1 Peak Hour Volumes
Source: Jacobs

8.2 Performance Measures

Tables 8-1 and 8-2 summarize the peak period performance measures for the general purpose lanes and express lane in the westbound and eastbound directions.

Table 8-1. EL Version 1 Performance Measures, Westbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	11.6	7.6	10.9	11.7	7.7	10.9	9.2	7.3	8.9	10.2	7.7	9.8	10.7	7.8	10.2
Average Speed (mph)	33	50	36	32	49	35	41	52	43	37	50	39	35	49	38
VHD (hours)	296	16	312	299	18	317	147	12	159	225	17	241	259	16	276
Average Delay per Vehicle (minutes)	5.7	1.1	4.9	5.8	1.1	4.9	3.3	1.0	3.0	4.4	1.1	3.8	4.9	1.1	4.2
Average Density (pc/mi/ln)	39.7	17.2	35.7	40.8	18.4	36.5	27.3	13.1	24.9	34.5	17.2	31.3	37.8	17.2	34.3
VMT (vehicle-miles)	20,541	4,457	24,998	19,998	4,781	24,779	17,572	3,440	21,011	20,179	4,445	24,624	21,363	4,413	25,776
VHT (vehicle-hours)	612	85	697	607	92	698	417	65	482	535	85	620	588	84	672
TTI	1.68	1.11	1.58	1.70	1.13	1.59	1.33	1.06	1.29	1.49	1.12	1.42	1.56	1.13	1.48
Truck Miles Traveled (truck-miles)[a]	6,319						6,629								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

Table 8-2. EL Version 1 Performance Measures, Eastbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	9.2	7.7	9.0	9.1	8.0	8.9	8.4	7.3	7.9	8.8	7.6	8.6	8.5	7.6	8.4
Average Speed (mph)	41	49	42	41	48	42	45	52	48	43	50	44	44	50	45
VHD (hours)	195	12	207	180	16	196	132	7	140	159	12	171	142	11	153
Average Delay per Vehicle (minutes)	3.4	1.1	3.1	3.3	1.3	3.0	2.6	1.0	2.4	3.0	1.1	2.7	2.7	1.1	2.5
Average Density (pc/mi/ln)	38.5	12.1	35.0	36.9	13.9	33.5	31.2	8.5	28.6	34.4	12.0	31.3	32.6	11.5	29.7
VMT (vehicle-miles)	20,784	3,239	24,023	19,826	3,493	23,319	18,317	2,315	20,632	19,617	3,198	22,815	19,114	3,055	22,169
VHT (vehicle-hours)	515	62	576	485	70	555	414	43	457	461	61	522	436	58	494
TTI	1.35	1.04	1.21	1.33	1.15	1.30	1.23	1.06	1.15	1.28	1.10	1.26	1.25	1.09	1.23
Truck Miles Traveled (truck-miles)[a]	4,343						6,217								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

8.3 Speed Plots

Figure 8-2 provides the speed plot for the general purpose lanes in the westbound direction. In the a.m. and p.m. peak periods, reduced-speed areas as low as 20 to 30 mph are observed at the Vasquez Boulevard ramps and the Quebec Street on-ramp. Additional reduced-speed areas are shown at the Quebec Street off-ramp, which spill back toward I-70 with speeds as low as 20 to 30 mph.

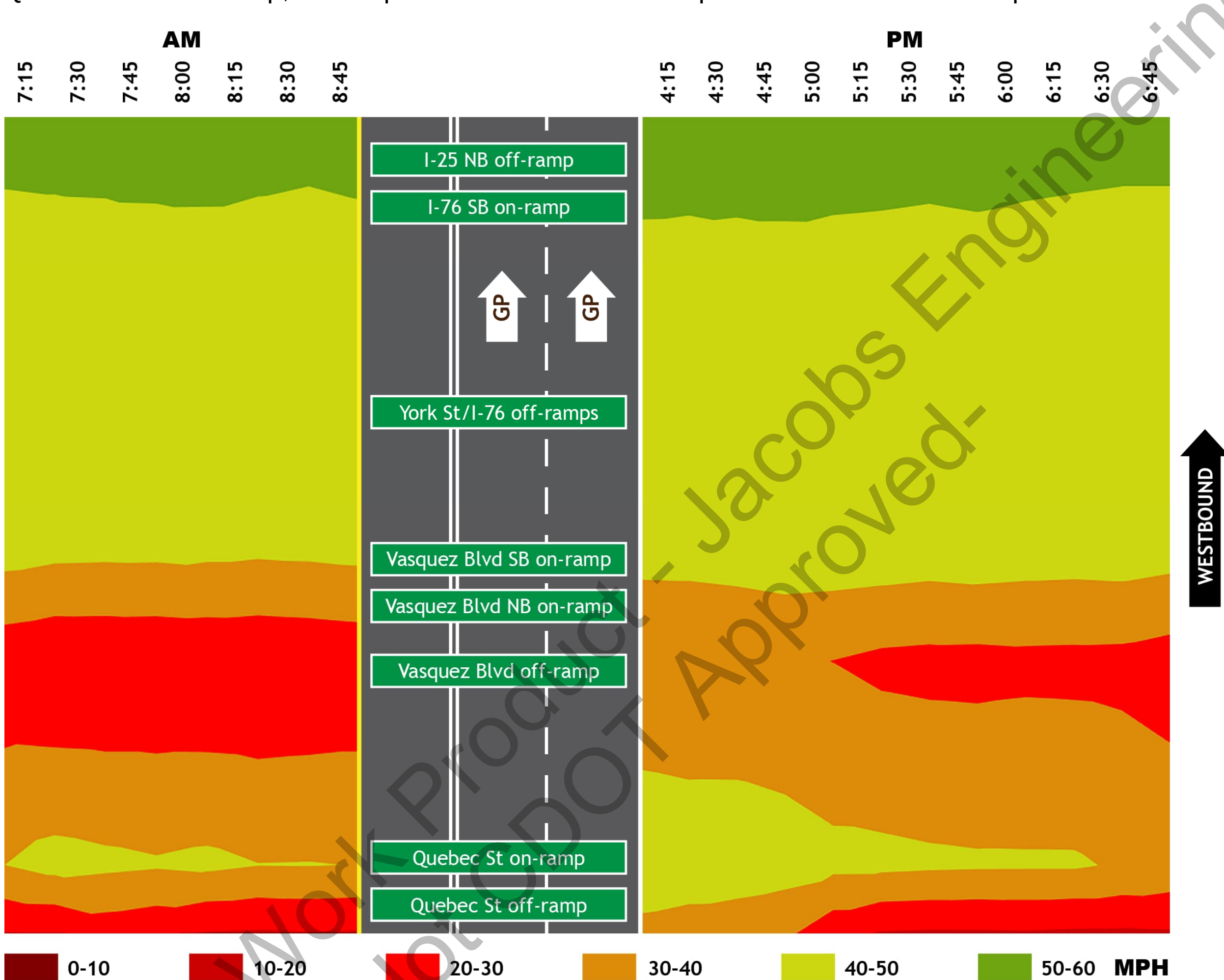

Figure 8-2. EL Version 1 Peak Period Speed Plot for General Purpose Lanes, Westbound Direction
Source: Jacobs

Figure 8-3 provides the speed plot for the express lane in the westbound direction. In the a.m. and p.m. peak periods, the speed on the express lane is higher than 50 mph. During the a.m. peak period, there is a reduced-speed area observed at the westbound express lane ingress/regress zone after 8:30 a.m.

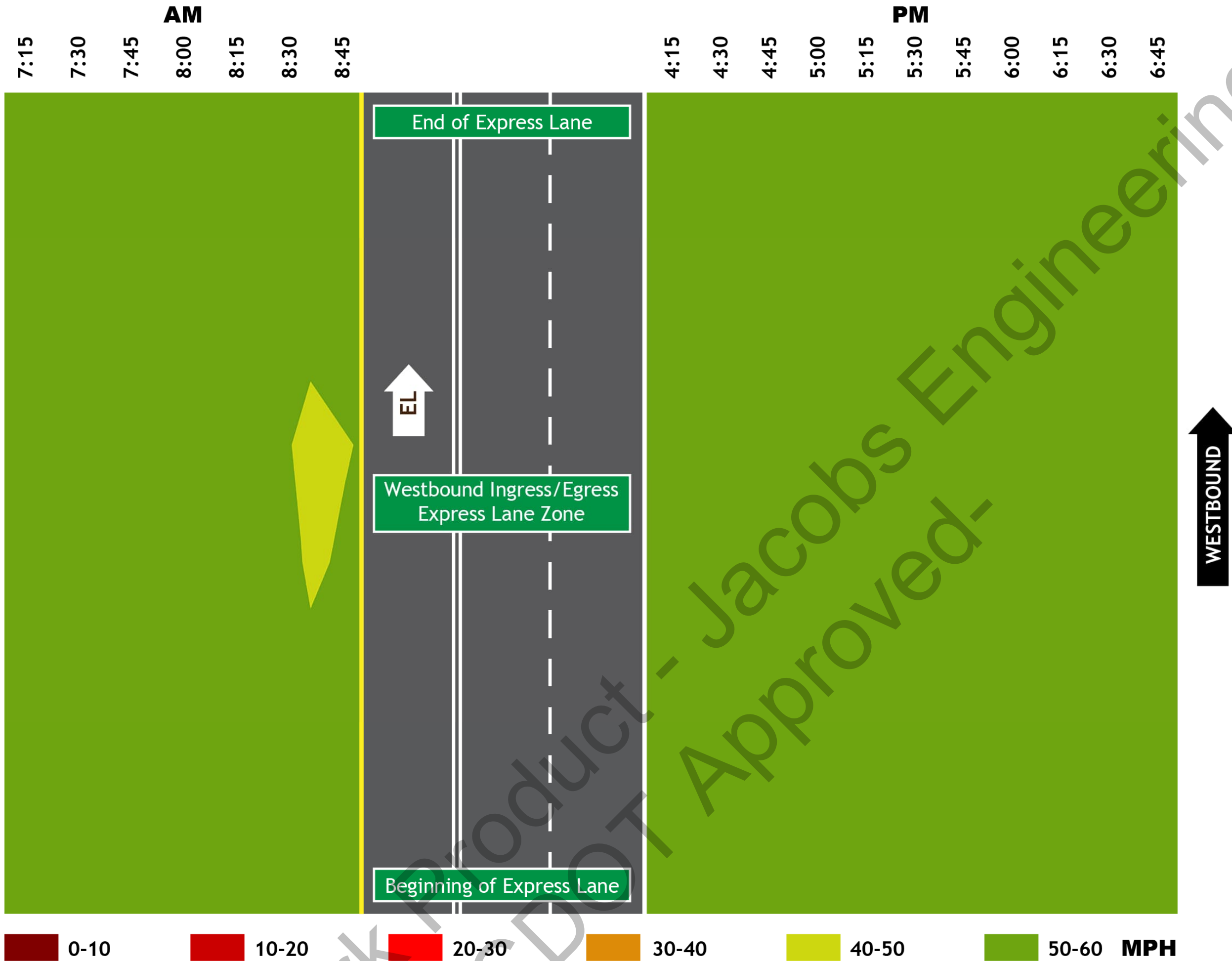

Figure 8-3. EL Version 1 Peak Period Speed Plot for Express Lane, Westbound Direction

Source: Jacobs

Figure 8-4 provides the speed plot for the general purpose lanes in the eastbound direction for the a.m. and p.m. peak periods. No bottlenecks are observed in the speed plot in either the a.m. or p.m. peak periods. A reduced speed of 30 to 40 mph is observed at the Vasquez Boulevard interchange in the a.m. and p.m. peak periods.

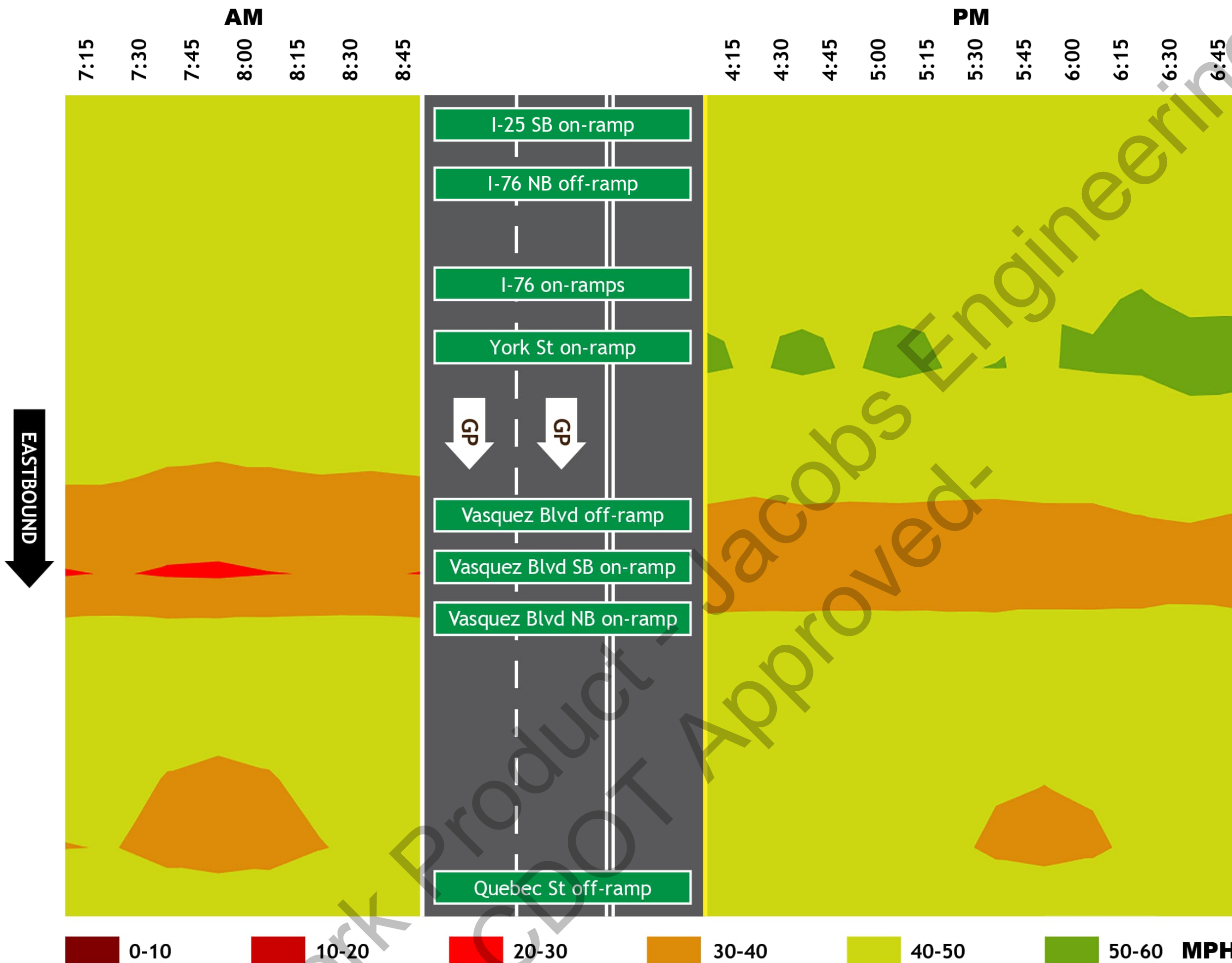

Figure 8-4. EL Version 1 Peak Period Speed Plot for General Purpose Lanes, Eastbound Direction
Source: Jacobs

Figure 8-5 provides the speed plot for the express lane in the eastbound direction. In the a.m. peak period, the speed on the express lane is higher than 50 mph at all the segments except at the end of the express lane where the express lane merges into the general purpose lanes. In the p.m. peak period, the speed on the express lane is higher than 50 mph.

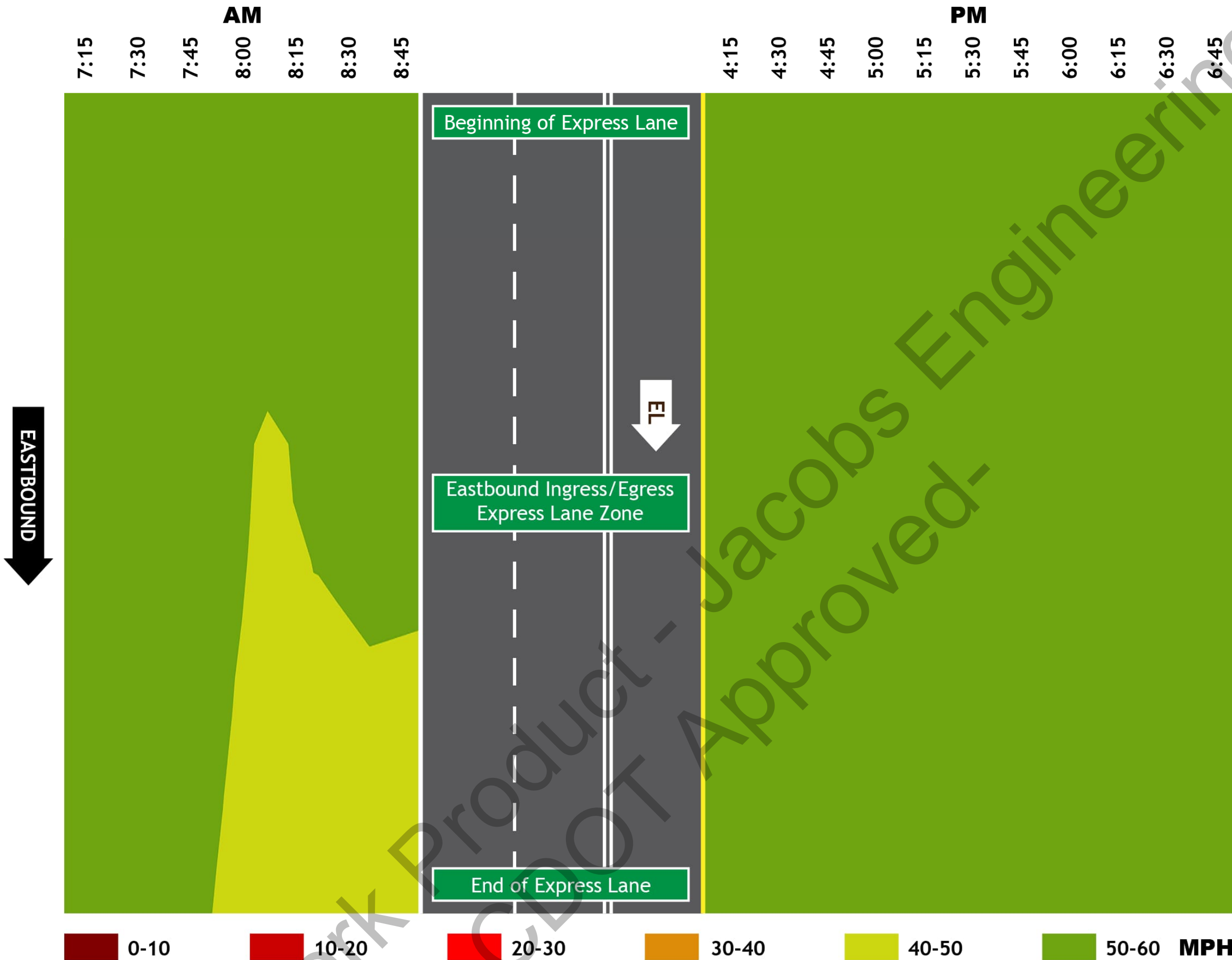

Figure 8-5. EL Version 1 Peak Period Speed Plot for Express Lane, Eastbound Direction
Source: Jacobs

8.4 Travel Time Reliability

Express lanes provide a dedicated travel lane where the average travel speeds are maintained by variable tolling. For EL Version 1, TTI values for the corridor with weighted average of both general purpose and express lanes ranged between 1.15 and 1.59, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours. The TTI values for the express lanes ranged between 1.04 and 1.15, which is within threshold of 1.33, whereas the TTI values for general purpose lanes ranged between 1.23 and 1.7, with westbound failing the threshold for all peak hours.

Tables 8-1 and 8-2 illustrate that in the westbound and eastbound directions, the average speed on the express lane is higher than 50 mph in the peak periods. The average end-to-end corridor travel time on the I-270 general purpose lanes is between 9 to 12 minutes in EL Version 1 compared to 16 to 20 minutes with the No Action conditions. The average end-to-end corridor travel time on I-270 for vehicles traveling on the express lane is under 8 minutes, which is 10 to 35 percent less than the travel time for vehicles traveling only on the general purpose lanes.

With TTI on express lanes meeting the threshold and average speeds on express lane higher than 50 mph, proposed EL Version 1 provides reliable travel times to the vehicles using the express lane during the peak periods.

8.5 Intersection Operations

Table 8-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

With added capacity on I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative. The following intersections are projected to operate at LOS E or F with EL Version 1:

- Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp (LOS E in a.m. and p.m.)
- Vasquez Boulevard/East 56th Avenue (LOS F in p.m.)

Even though two intersections would operate at LOS E and F, the queues from the ramp–terminal intersections do not extend onto the freeway.

Table 8-3. EL Version 1 Peak Hour Intersection Operations

ID	Intersection	7 a.m. to 8 a.m.		5 p.m. to 7 p.m.	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	56.2	E	71.5	E
2	Quebec Street/I-270 Westbound Ramps	16.2	B	14.4	B
3	Vasquez Boulevard/East 56th Avenue	10.9	B	88.8	F
4	Vasquez Boulevard/East 60th Avenue	39.6	D	41.0	D
5	York Street/I-270 Eastbound On-ramp	14.2	B	52.1	D
6	York Street/I-270 Westbound Off-ramp	36.2	D	49.6	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	3.7	A	2.4	A
8	Vasquez Boulevard/I-270 Westbound Off-ramp	3.2	A	10.0	B

Source: Jacobs

Table 8-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 8-4. EL Version 1 Peak Period I-270 Off-ramps Queue Length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet)	
					7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	221	275
			Right		119	135
2	Quebec Street/I-270 Westbound Ramps	Westbound	Through/Left	1,900	0	0
			Right		29	37
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	321	152
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	76	80
			Right		0	0
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	83	124
			Right		0	0

Source: Jacobs

As shown in Table 8-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on traffic movements on the I-270 freeway. The queues at the other approaches at these ramp terminals are either not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

9.0 2040 Express Lane 2 (EL Version 2)

EL Version 2 includes all the improvements detailed for EL Version 1 except the construction of an auxiliary lane between the Quebec Street on-ramp and Vasquez Boulevard off-ramp in the westbound direction.

Figure 9-1 illustrates the geometric layout for this operating option.

9.1 Peak Hour Volumes

The peak hour volumes for EL Version 2 are shown on Figure 9-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the p.m. peak hour, with approximately 2,800 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (4,800 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (4,700 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

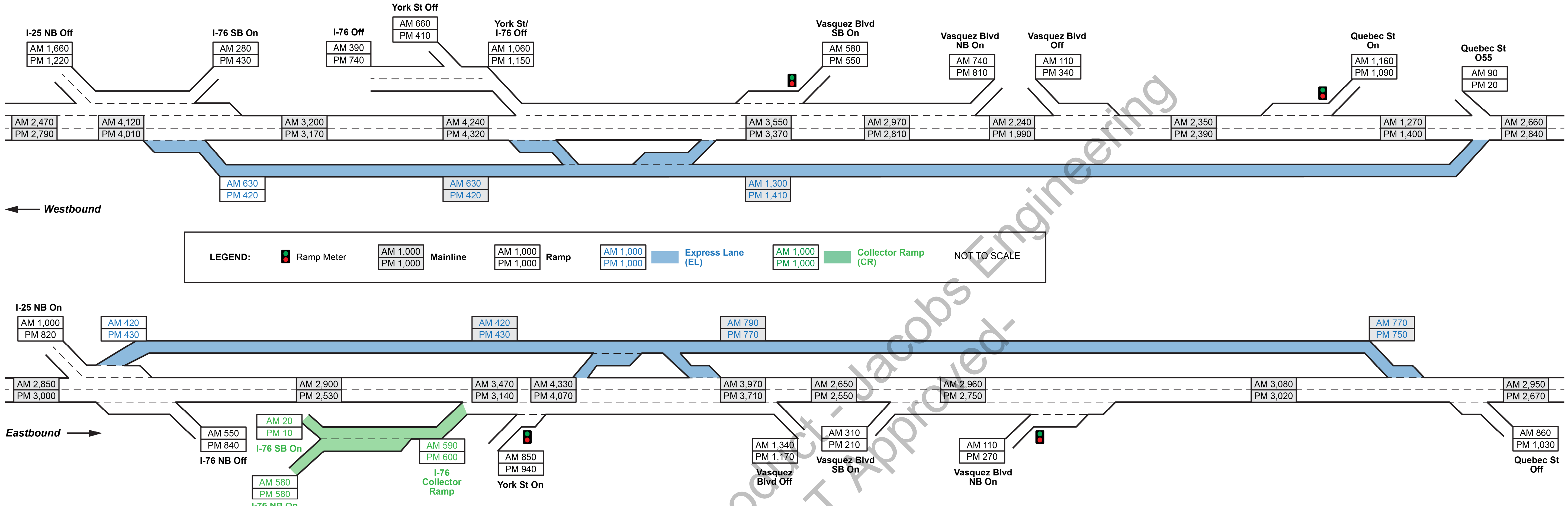

Figure 9-1. Express Lane Operating Option Version 2 Peak Hour Volumes

Source: Jacobs

9.2 Performance Measures

Tables 9-1 and 9-2 summarize the peak period performance measures for the general purpose lanes and express lane in the westbound and eastbound directions.

Table 9-1. EL Version 2 Performance Measures, Westbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	11.6	8.4	10.9	12.0	8.6	11.2	9.6	8.1	9.3	10.9	8.4	10.3	11.5	8.7	10.9
Average Speed (mph)	32	44	35	31	43	34	39	46	40	34	44	36	32	43	35
VHD (hours)	250	21	271	252	22	273	149	16	165	223	22	245	245	20	265
Average Delay per Vehicle (minutes)	5.8	1.1	4.7	6.2	1.1	4.9	3.8	1.0	3.2	5.1	1.1	4.2	5.7	1.1	4.7
Average Density (pc/mi/ln)	39.9	21.4	35.6	41.4	21.6	36.6	29.5	16.7	26.8	37.7	21.6	34.0	42.9	20.0	38.0
VMT (vehicle-miles)	18,371	5,483	23,853	17,105	5,520	22,625	16,339	4,335	20,674	18,439	5,491	23,930	18,880	5,145	24,025
VHT (vehicle-hours)	532	106	638	515	107	621	400	83	483	507	107	614	536	99	635
TTI	1.69	1.22	1.58	1.74	1.24	1.62	1.40	1.17	1.35	1.59	1.22	1.50	1.68	1.26	1.59
Truck Miles Traveled (truck-miles)[a]	5,499						6,250								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

Table 9-2. EL Version 2 Performance Measures, Eastbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	9.0	7.5	8.8	9.2	7.8	9.0	8.5	7.3	8.3	8.9	7.5	8.7	9.3	7.8	9.1
Average Speed (mph)	41	50	43	40	48	41	44	51	45	42	50	43	40	48	41
VHD (hours)	188	12	200	189	16	205	140	7	147	169	12	181	180	13	193
Average Delay per Vehicle (minutes)	3.3	1.0	3.0	3.5	1.3	3.2	2.8	1.0	2.6	3.2	1.1	2.9	3.6	1.2	3.3
Average Density (pc/mi/ln)	38.0	12.2	34.5	38.0	13.9	34.4	32.4	8.7	29.7	35.7	12.0	32.4	43.3	12.4	39.0
VMT (vehicle-miles)	20,492	3,236	23,727	19,596	3,455	23,051	18,045	2,321	20,366	19,456	3,155	22,611	18,152	2,936	21,088
VHT (vehicle-hours)	504	61	565	491	69	560	418	43	461	469	60	529	459	58	517
TTI	1.34	1.11	1.31	1.36	1.16	1.33	1.26	1.07	1.24	1.31	1.11	1.28	1.38	1.15	1.35
Truck Miles Traveled (truck-miles)[a]	4,221						6,122								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

9.3 Speed Plots

Figure 9-2 provides the speed plot for the general purpose lanes in the westbound direction. In the a.m. and p.m. peak periods, a bottleneck is observed at the Quebec Street on-ramp and Vasquez Boulevard off-ramp, with a speed as low as 0 to 10 mph. Additional reduced-speed areas are shown at the Quebec Street off-ramp, which spill back toward I-70 with speeds as low as 20 to 30 mph.

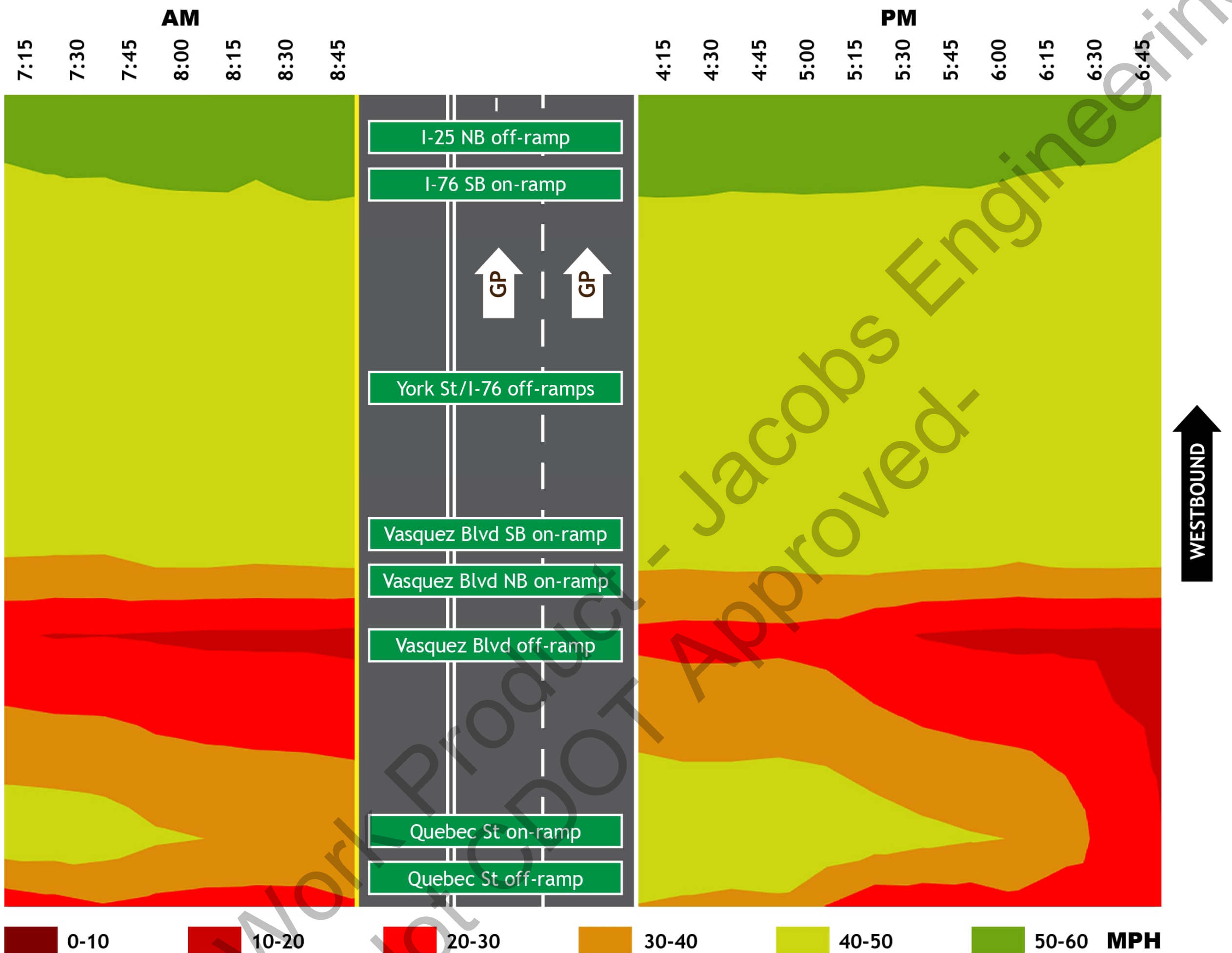

Figure 9-2. EL Version 2 Peak Period Speed Plot of General Purpose Lanes, Westbound Direction
Source: Jacobs

Figure 9-3 provides the speed plot for the express lane in the westbound direction. In the a.m. and p.m. peak periods, the speed on the express lane is higher than 50 mph on all the segments except the ingress/egress segment between Vasquez Boulevard and York Street. The ingress/egress segment between Vasquez Boulevard and York Street has speeds higher than 40 mph.

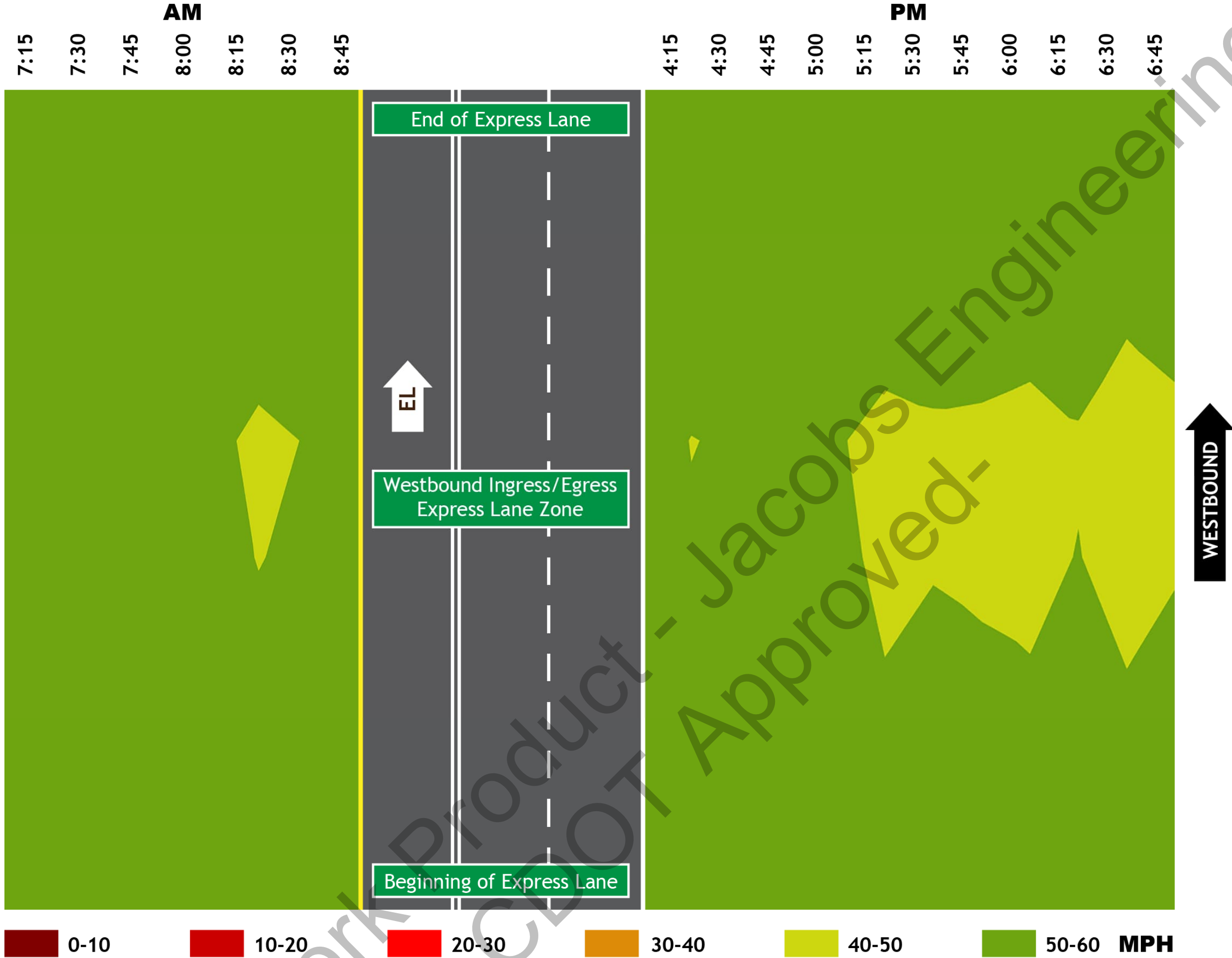

Figure 9-3. EL Version 2 Peak Period Speed Plot for Express Lane, Westbound Direction
Source: Jacobs

Figure 9-4 provides the speed plot for the general purpose lanes in the eastbound direction. No bottlenecks are observed in the speed plot in either the a.m. or p.m. peak periods. A reduced speed of 30 to 40 mph is observed at the Vasquez Boulevard interchange in the a.m. and p.m. peak periods.

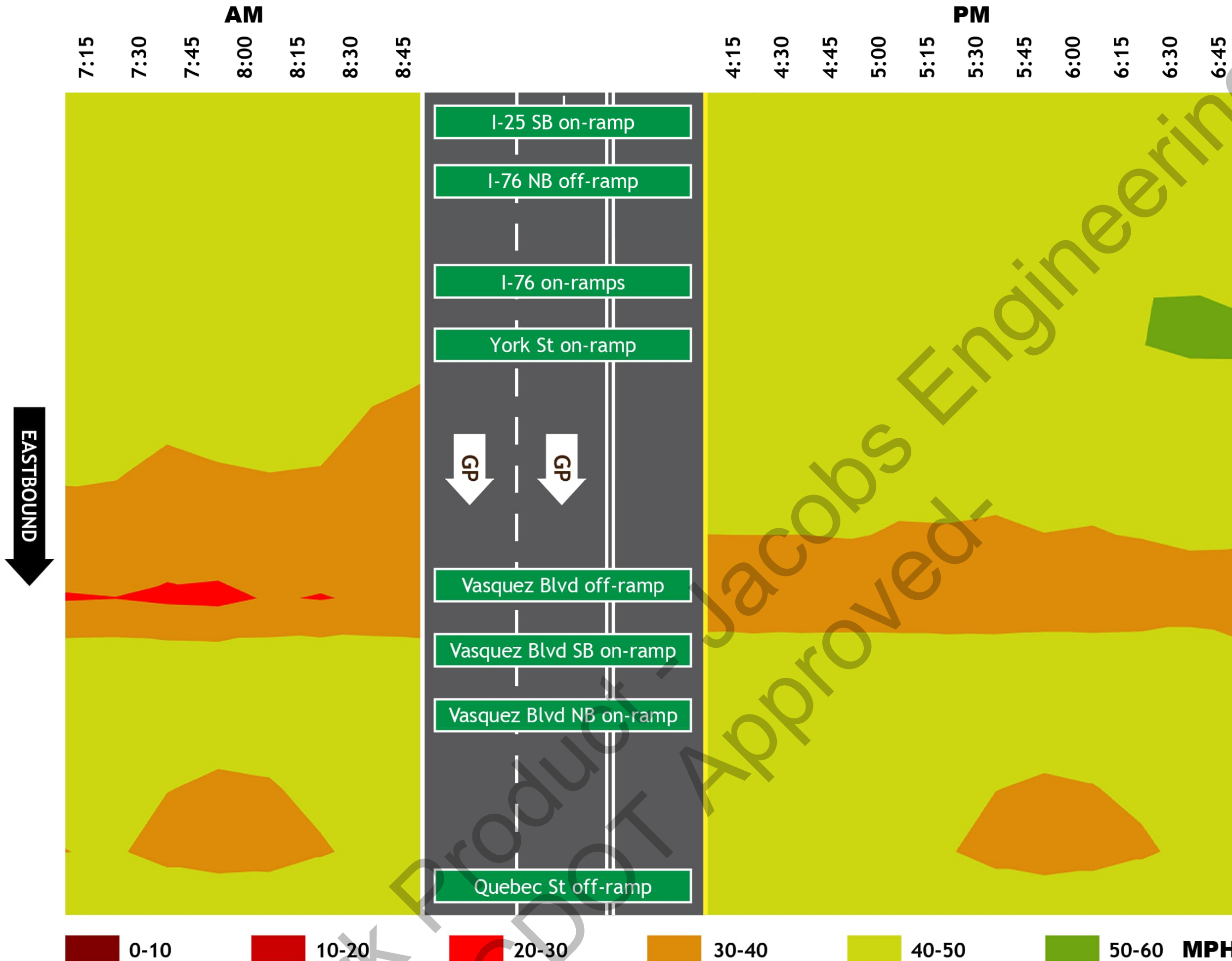

Figure 9-4. EL Version 2 Peak Period Speed Plot for General Purpose Lanes, Eastbound Direction
Source: Jacobs

Figure 9-5 provides the speed plot for the express lane in the eastbound direction. In the a.m. peak period, the speed on the express lane is higher than 50 mph at all the segments except at the end of the express lane where the express lane merges into the general purpose lanes. In the p.m. peak periods, the speed on the express lane is higher than 50 mph.

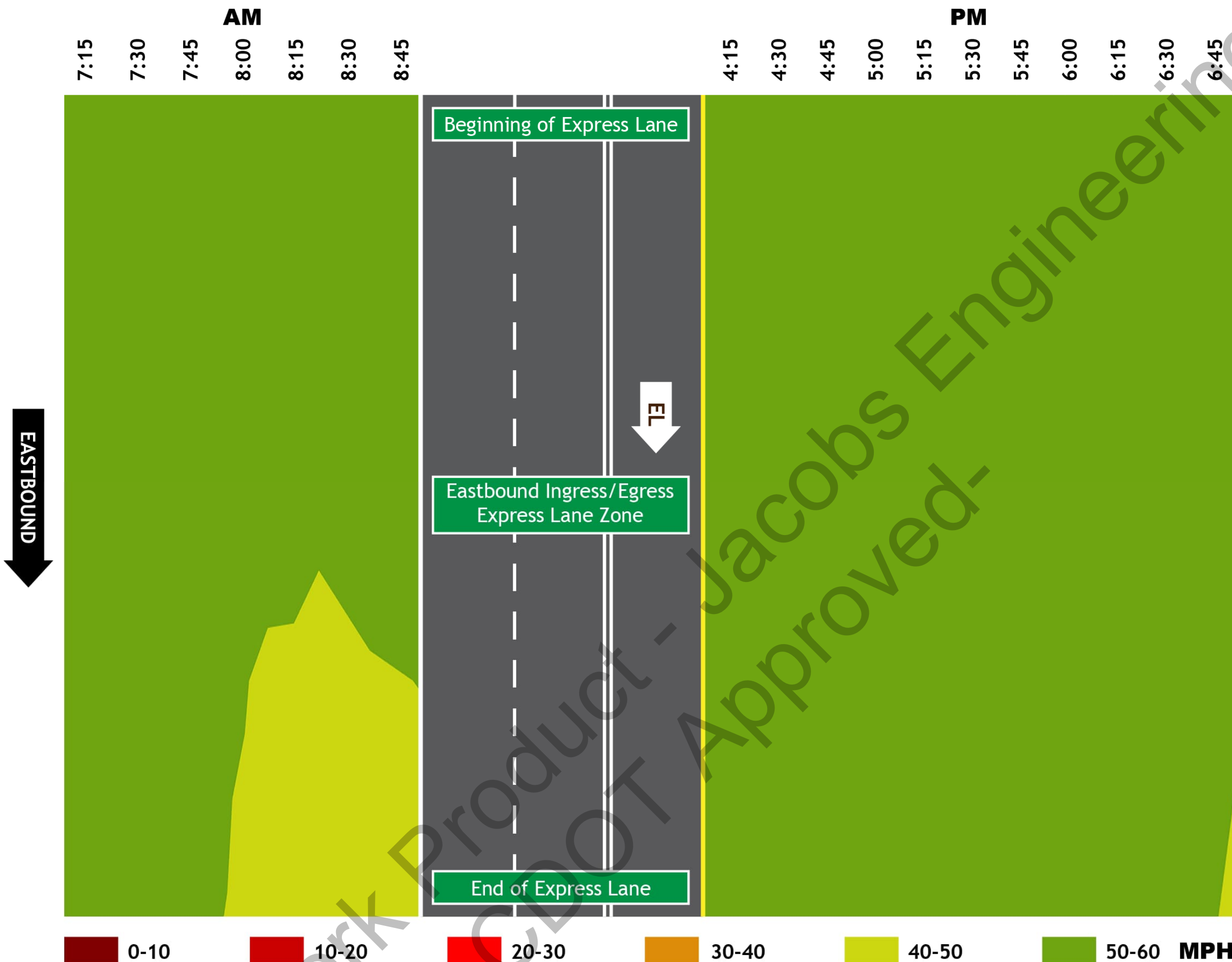

Figure 9-5. EL Version 2 Peak Period Speed Plot for Express Lane, Eastbound Direction
Source: Jacobs

9.4 Travel Time Reliability

For EL Version 2, TTI values for the corridor with weighted average of both general purpose and express lanes ranged between 1.24 and 1.62, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours. The TTI values for the express lanes ranged between 1.07 and 1.26, which is within threshold of 1.33, whereas the TTI values for general purpose lanes ranged between 1.26 and 1.74, with westbound failing the threshold for all peak hours.

As Tables 9-1 and 9-2 illustrate, the average speed in the express lane is higher than 50 mph in the peak periods in both the westbound and eastbound directions. The average end-to-end corridor travel time on the I-270 general purpose lanes is between 10 and 12 minutes in EL Version 2 compared to 16 to 20 minutes with the No Action conditions. The average end-to-end corridor travel time on I-270 for vehicles traveling on the express lane is less than 9 minutes, which is 10 to 25 percent less than the travel time for vehicles traveling only on the general purpose lanes.

With TTI on express lanes meeting the threshold and average speeds on express lane higher than 50 mph, proposed EL Version 2 provides reliable travel times to the vehicles using the express lane in the peak periods.

9.5 Intersection Operations

Table 9-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

With added capacity on the I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative. The intersection of Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp is projected to operate at LOS E in the a.m. and p.m. peak hours.

Queues from the ramp–terminal intersections do not extend up to the freeway.

Table 9-3. EL Version 2 Peak Hour Intersection Operations

		7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
ID	Intersection	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	58.3	E	70.7	E
2	Quebec Street/I-270 Westbound Ramps	15.5	B	14.4	B
3	Vasquez Boulevard/East 56th Avenue	15.1	B	33.5	C
4	Vasquez Boulevard/East 60th Avenue	39.0	D	42.8	D
5	York Street/I-270 Eastbound On-ramp	13.8	B	52.6	D
6	York Street/I-270 Westbound Off-ramp	21.3	C	50.4	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	6.3	A	7.2	A
8	Vasquez Boulevard/I-270 Westbound Off-ramp	0.7	A	5.8	A

Source: Jacobs

Table 9-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 9-4. EL Version 2 Peak Period I-270 Off-ramps Queue Length

					95th Percentile Queue (feet)	
ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	240	343
			Right		122	137
2	Quebec Street/I-270 Westbound Ramps	Westbound	Through/Left	1,900	0	0
			Right		33	42
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	304	156
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	75	80
			Right		129	0
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	77	52
			Right		0	0

Source: Jacobs

As shown in Table 9-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on traffic movements on the I-270 freeway. The queues at the other approaches at these ramp terminals are either not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

10.0 2040 Express Lane 3 (EL Version 3) - Proposed Action (Express Lane Operating Option)

The project team reviewed the analysis and findings of the operating options in Sections 5 through 9 and developed an additional operating option, EL Version 3, as the Proposed Action for the Express Lane Operating Option. Comparing the results for the general purpose lane and express lane operating options indicated that the most viable approach for the additional lane would be to have it operate as an express lane. The results also indicated that the Quebec Street off-ramp in the westbound direction provided minimal benefits and did not add much to improve the overall traffic movement on I-270 westbound.

EL Version 3 was modeled by revising EL Version 1 with the following changes:

- Remove the Quebec Street off-ramp in the westbound direction.
- Add capacity to the York Street off-ramp by constructing separate off-ramps to York Street and I-76 in the westbound direction and adding an optional exit lane to I-76 off-ramp.
- Add capacity to the Vasquez Boulevard off-ramp by adding an optional exit lane in the eastbound direction.
- Shift the eastbound express lane entrance 0.9 mile east to provide additional access to vehicles.

Figure 10-1 illustrates the geometric layout for this configuration.

10.1 Peak Hour Volumes

The peak hour volumes for EL Version 3 are shown on Figure 10-1. The I-270 corridor in the westbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,500 vehicles crossing the segment west of the ramp to I-25 northbound and the high end of the range (5,000 vehicles) crossing the segment between the Vasquez Boulevard interchange and York Street/I-76 interchange. The I-270 corridor in the eastbound direction serves the lowest range of traffic volumes during the a.m. peak hour, with approximately 2,900 vehicles crossing the segment west of the ramp from I-25 southbound and the high end of the range (4,700 vehicles) crossing the segment between the York Street on-ramp and Vasquez Boulevard interchange.

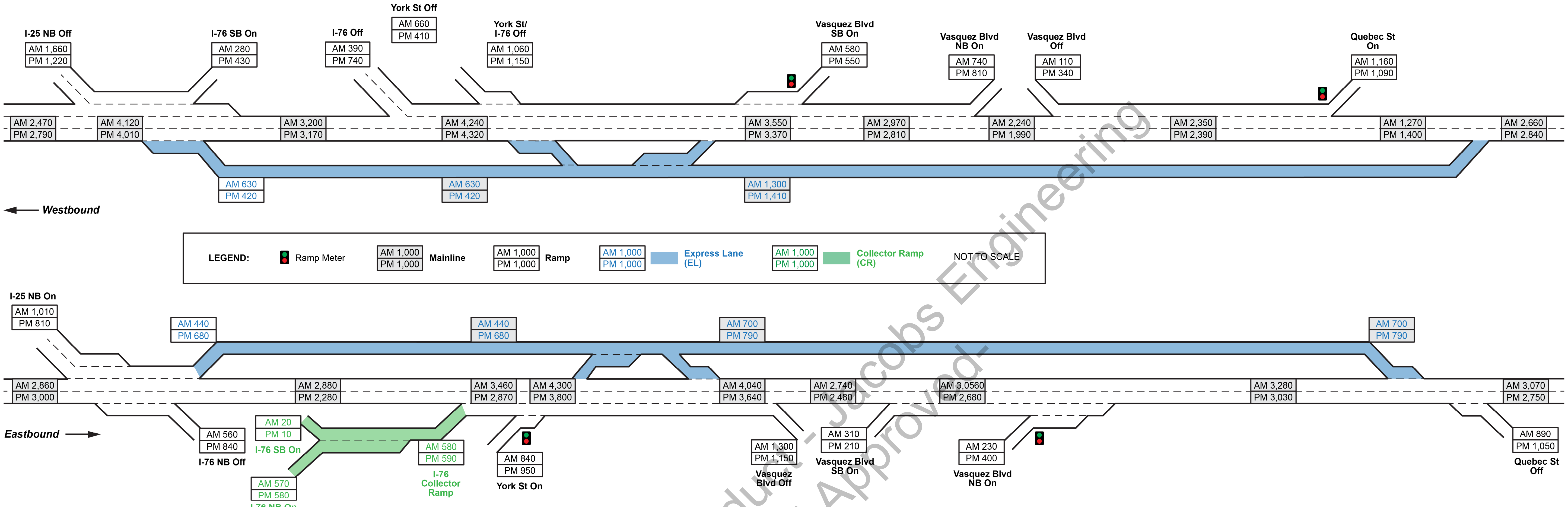

Figure 10-1. Express Lane Operating Option Version 3 Peak Hour Volumes
Source: Jacobs

10.2 Performance Measures

Tables 10-1 and 10-2 summarize the peak period performance measures for the general purpose lanes and express lane in the westbound and eastbound directions.

Table 10-1. EL Version 3 Performance Measures, Westbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	11.7	7.4	10.9	11.9	7.5	11.0	9.2	7.3	8.9	10.0	7.5	9.5	11.1	7.7	10.5
Average Speed (mph)	31	49	35	31	49	34	40	50	42	37	49	39	33	48	36
VHD (hours)	297	17	314	307	18	325	145	13	159	200	19	219	266	16	281
Average Delay per Vehicle (minutes)	5.8	1.1	4.9	6.0	1.1	5.1	3.3	1.0	2.9	4.1	1.1	3.5	5.2	1.1	4.5
Average Density (pc/mi/ln)	38.4	17.8	34.6	40.1	18.2	35.9	26.0	14.2	23.9	31.1	18.6	28.6	37.1	16.3	33.5
VMT (vehicle-miles)	20,633	4,626	25,259	20,223	4,738	24,961	17,454	3,737	21,191	19,260	4,862	24,123	20,331	4,220	24,550
VHT (vehicle-hours)	615	88	703	618	91	709	414	71	485	496	94	590	578	80	659
TTI	1.68	1.08	1.57	1.71	1.08	1.59	1.32	1.06	1.28	1.44	1.09	1.37	1.59	1.12	1.51
Truck Miles Traveled (truck-miles)[a]	6,237						6,410								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

Table 10-2. EL Version 3 Performance Measures, Eastbound Direction

	A.M. Peak Period						P.M. Peak Period								
	7 to 8			8 to 9			4 to 5			5 to 6			6 to 7		
Performance Measures	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL	GP	EL	GP+EL
Average Travel Time (minutes)	8.4	7.1	8.3	8.5	7.1	8.3	7.9	7.1	7.8	8.3	7.2	8.2	9.1	7.5	8.9
Average Speed (mph)	43	52	45	43	52	44	46	52	47	44	51	45	40	49	41
VHD (hours)	166	9	175	168	8	177	111	10	121	144	13	157	169	14	183
Average Delay per Vehicle (minutes)	2.8	0.8	2.6	2.9	0.8	2.6	2.3	0.9	2.1	2.7	1.0	2.5	3.5	1.1	3.1
Average Density (pc/mi/ln)	35.0	11.8	32.4	35.4	11.1	32.8	28.1	13.3	25.9	34.3	15.0	31.5	44.8	15.3	40.3
VMT (vehicle-miles)	21,040	2,637	23,677	20,780	2,476	23,256	17,463	2,959	20,422	19,049	3,237	22,286	17,430	3,101	20,531
VHT (vehicle-hours)	490	50	540	488	46	534	379	10	435	437	13	499	437	14	499
TTI	1.27	1.07	1.24	1.28	1.07	1.25	1.19	1.06	1.17	1.25	1.09	1.23	1.37	1.12	1.33
Truck Miles Traveled (truck-miles)[a]	4,489						6,298								

Source: Jacobs

[a] All performance measures in this table are presented per hour during peak periods for both express lanes and general purpose lanes except for truck miles traveled, which is presented per peak period for general purpose lanes.

10.3 Speed Plots

Figure 10-2 provides the speed plot for the general purpose lanes in the westbound direction. In the a.m. and p.m. peak periods, reduced-speed areas of as low as 20 to 30 mph are observed between the Quebec Street on-ramp and Vasquez Boulevard off-ramp, which in the p.m. peak period after 6:15 p.m. spill back toward I-70 with speeds as low as 20 to 30 mph.

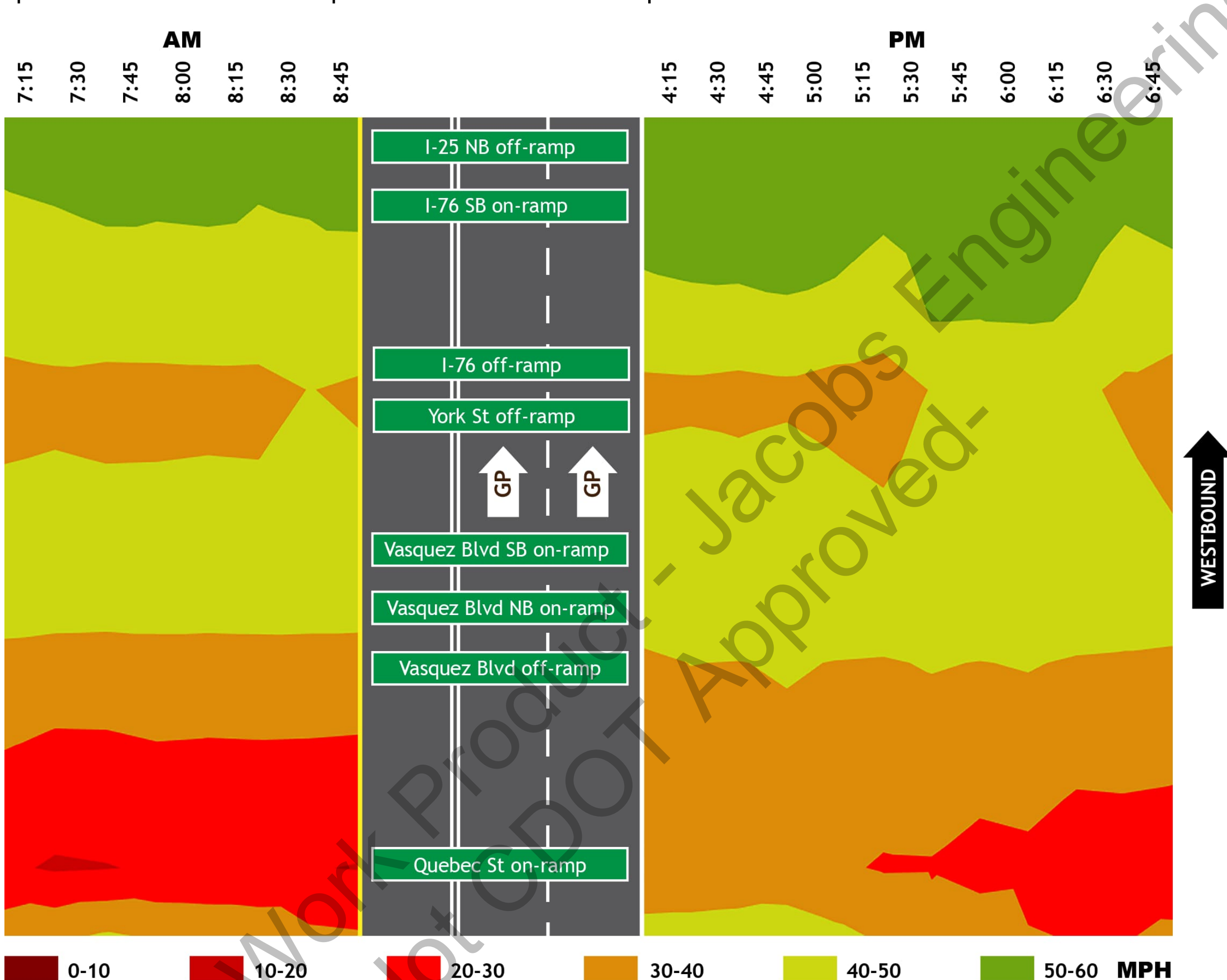

Figure 10-2. EL Version 3 Peak Period Speed Plot of General Purpose Lanes, Westbound Direction
Source: Jacobs

Figure 10-3 provides the speed plot for the express lane in the westbound direction. In the a.m. peak and p.m. peak periods, the speed on the express lane at all the segments is higher than 50 mph.

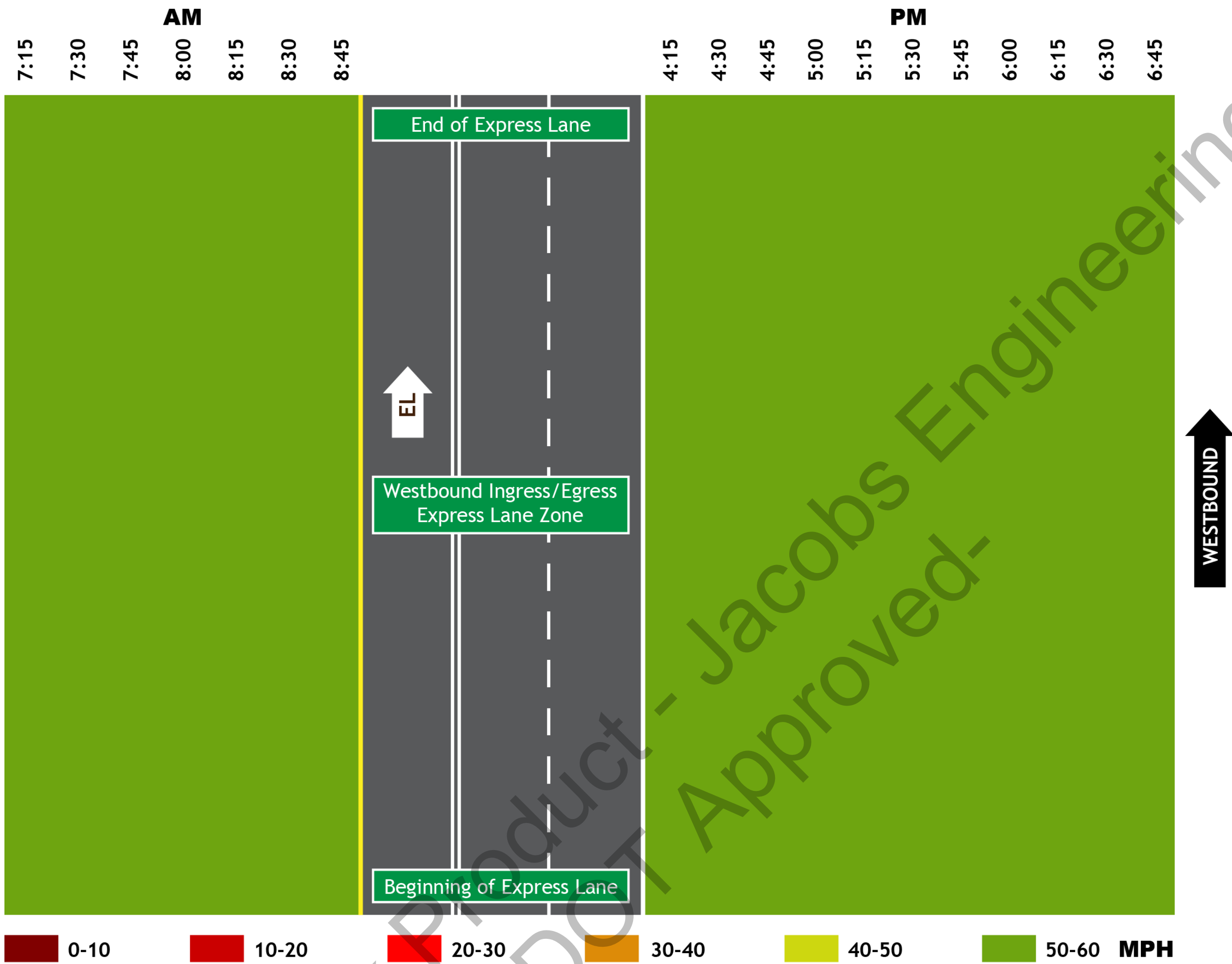

Figure 10-3. EL Version 3 Peak Period Speed Plot of Express Lane, Westbound Direction
Source: Jacobs

Figure 10-4 provides the speed plot on general purpose lanes for the a.m. and p.m. peak periods in the eastbound direction. A reduced speed of 20 to 30 mph is observed at the Vasquez Boulevard interchange in the a.m. peak period. In the p.m. peak period, no bottlenecks are observed in the speed plot except a reduced-speed area of 20 to 30 mph at the Vasquez Boulevard interchange.

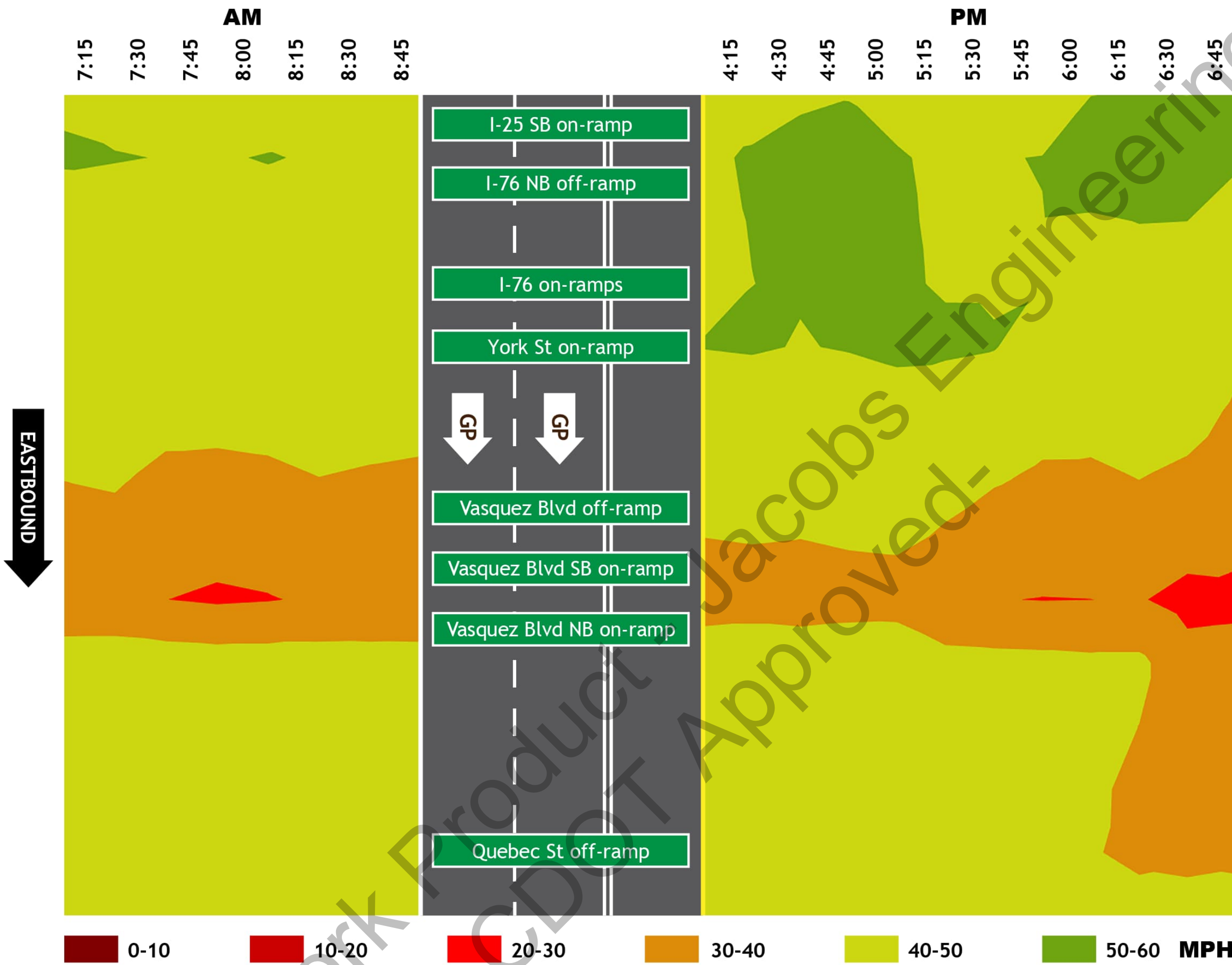

Figure 10-4. EL Version 3 Peak Period Speed Plot of General Purpose Lanes, Eastbound Direction
Source: Jacobs

Figure 10-5 provides the speed plot for the express lane in the eastbound direction. In the a.m. peak period, the speed on the express lane is higher than 50 mph along all the segments. In p.m. peak periods, the speed on the express lane is higher than 50 mph except at the end of the express lane where the express lane merges into the general purpose lanes.

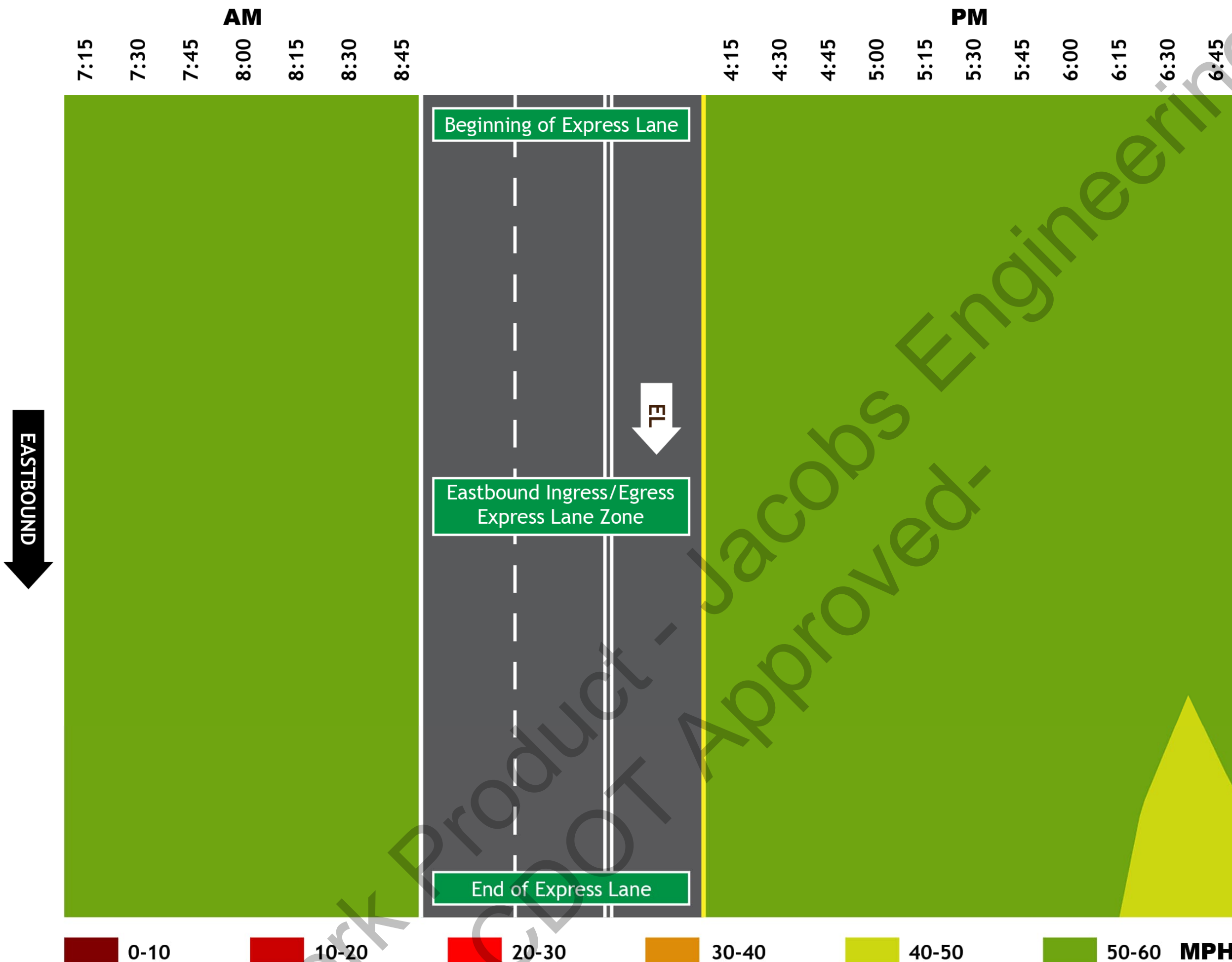

Figure 10-5. EL Version 3 Peak Period Speed Plot of Express Lane, Eastbound Direction
Source: Jacobs

10.4 Travel Time Reliability

For EL Version 3, TTI values for the corridor with weighted average of both general purpose and express lanes ranged between 1.17 and 1.59, with eastbound under the threshold of 1.33 and westbound failing to meet threshold during peak hours. The TTI values for the express lanes ranged between 1.06 and 1.12, which is within threshold of 1.33, whereas the TTI values for general purpose lanes ranged between 1.19 and 1.71, with westbound failing the threshold for all peak hours.

Tables 10-1 and 10-2 illustrate that in the westbound and eastbound directions, the average speed on the express lane is higher than 50 mph in the peak periods. The average end-to-end corridor travel time on the I-270 general purpose lanes is between 8 and 12 minutes in EL Version 3 compared to 16 to 20 minutes with the No Action conditions. The average end-to-end corridor travel time on I-270 for vehicles traveling on the express lane is 7 to 8 minutes, which is 10 to 35 percent less than the travel time for vehicles traveling only on the general purpose lanes.

With TTI on express lanes meeting the threshold and average speeds on express lane higher than 50 mph, the proposed EL Version 3 provides reliable travel times to the vehicles using the express lane in the peak periods.

10.5 Intersection Operations

Table 10-3 shows the average intersection control delay and LOS during the hours from 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

With added capacity on I-270 corridor for this operating option, in general there is increase in arterial volumes and change in traffic patterns compared to the No Action Alternative, resulting in some of the study intersections experiencing decreased LOS compared to the No Action Alternative. The intersection of the Quebec Street/Sand Creek Drive South/I-270 eastbound off-ramp is projected to operate at LOS E in the p.m. peak hour. All other intersections would operate at LOS D or better.

The queues from the ramp–terminal intersections are not extending up to the freeway.

Table 10-3. EL Version 3 Peak Hour Intersection Operations

ID	Intersection	7 a.m. to 8 a.m.		5 p.m. to 6 p.m.	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Quebec Street/Sand Creek Drive South/ I-270 Eastbound Off-ramp	47.0	D	74.6	E
2	Quebec Street/I-270 Westbound On-ramp	5.5	A	6.9	A
3	Vasquez Boulevard/East 56th Avenue	20.3	C	39.8	D
4	Vasquez Boulevard/East 60th Avenue	39.3	D	41.9	D
5	York Street/I-270 Eastbound On-ramp	13.8	B	52.5	D
6	York Street/I-270 Westbound Off-ramp	21.2	C	49.6	D
7	Vasquez Boulevard/I-270 Eastbound Off-ramp	6.1	A	4.7	A
8	Vasquez Boulevard/I-270 Westbound Off-ramp	1.3	A	11.4	B

Source: Jacobs

Table 10-4 shows the 95th percentile queue lengths at the ramp terminuses within the study area during the a.m. and p.m. peak periods.

Table 10-4. EL Version 3 Peak Period I-270 Off-ramps Queue Length

ID	Intersection	Off-ramp Approach	Lane Group	Storage Length (feet)	95th Percentile Queue (feet)	
					7 a.m. to 9 a.m.	4 p.m. to 7 p.m.
1	Quebec Street/Sand Creek Drive South/I-270 Eastbound Off-ramp	Westbound	Through/Left	1,130	249	164
			Right		133	49
6	York Street/I-270 Westbound Off-ramp	Westbound	Left	1,280	294	55
			Right		0	0
7	Vasquez Boulevard/ I-270 Eastbound Off-ramp	Eastbound	Left	1,140	71	27
			Right		0	0
8	Vasquez Boulevard/ I-270 Westbound Off-ramp	Westbound	Left	1,080	39	98
			Right		0	0

Source: Jacobs

As shown in Table 10-4, the queues from the ramp–terminal intersections do not reach back to the freeway and would not have any impact on traffic movements on the I-270 freeway. The queues at the other approaches at these ramp terminals are either not getting worse compared to the existing conditions or continue operating within the available storage lengths at these approaches.

11.0 Overview of Findings

The purpose of this report is to provide a general overview of the traffic operations for each operating option for ease of comparison, and this section summarizes the overall findings of the traffic analysis to assist in that comparison.

This section compares the following MOEs on I-270 for the existing conditions, No Action Alternative, and design operating options (including the Proposed Action):

- Average travel time
- Average speed
- Vehicle delay
- VMT
- VHT
- TTI
- Truck miles traveled

Tables 11-1 and 11-2 compare how the No Action Alternative and each operating option addresses the congestion in the westbound direction. GP Version 3 shows the highest average speed and lowest total vehicle delay compared to other versions in the a.m. peak period. In the p.m. peak period, EL Version 3 (Proposed Action) has the highest speed with lowest total delay and performs better than any other operating option.

Table 11-1. Comparison of Performance Measures in A.M. Peak Period, Westbound Direction
(7 a.m. to 9 a.m.)

Performance Measures	Existing	No Action	Version 1		Version 2		Version 3 (Proposed Action)	
			GP	EL	GP	EL	GP	EL
Average Travel Time (minutes)	14	20	9.2	10.9	11.5	11	9	11
Average Speed (mph)	27	21	40	36	33	34	41	34
VHD (hours)	723	1,052	489 *-54%*	629 *-40%*	736 *-30%*	544 *-48%*	453 *-57%*	639 *-39%*
VMT (vehicle-miles)	34,256	31,749	52,121 *64%*	49,777 *57%*	47,883 *51%*	46,478 *46%*	50,312 *58%*	50,220 *58%*
VHT (vehicle-hours)	1,250	1,540	1,291 *-16%*	1,395 *-9%*	1,473 *-4%*	1,259 *-18%*	1,227 *-20%*	1,412 *-8%*
TTI	2.1	2.99	1.37	1.59	1.72	1.6	1.35	1.58
Truck Miles Traveled (truck-miles)	2,730	4,222	5,831 *38%*	6,319 *50%*	4,945 *17%*	5,499 *30%*	5,585 *32%*	6,237 *48%*

Source: Jacobs

GP Version 3 and EL Version 3 are the Proposed Action for their respective operating options

Green Font = Best performance when the operating option is compared with the No Action Alternative

Table 11-2. Comparison of Performance Measures in P.M. Peak Period, Westbound Direction
(4 p.m. to 7 p.m.)

Performance Measures	Existing	No Action	Version 1		Version 2		Version 3 (Proposed Action)	
			GP	EL	GP	EL	GP	EL
Average Travel Time (minutes)	15.4	15.9	9.8	9.6	11	10.2	9.9	9.6
Average Speed (mph)	25	25	38	40	34	37	38	39
VHD (hours)	1,236	1,274	894 *-30%*	676 *-47%*	1,029 *-19%*	676 *-47%*	947 *-26%*	659 *-48%*
VMT (vehicle-miles)	49,821	50,246	79,563 *58%*	71,411 *42%*	71,482 *42%*	68,629 *37%*	80,688 *61%*	89,864 *39%*
VHT (vehicle-hours)	2,003	2,047	2,118 *3%*	1,775 *-13%*	2,129 *4%*	1,731 *-15%*	2,188 *7%*	1,734 *-15%*
TTI	2.3	2.37	1.46	1.4	1.64	1.48	1.48	1.39
Truck Miles Traveled (truck-miles)	3,056	5,475	6,550 *20%*	6,629 *21%*	5,715 *4%*	6,250 *14%*	6,707 *23%*	6,410 *17%*

Source: Jacobs

GP Version 3 and EL Version 3 are the Proposed Action for their respective operating options

Green Font = Best performance when the operating option is compared with the No Action Alternative

Tables 11-3 and 11-4 compare how the No Action Alternative and each operating option performs in the eastbound direction. GP Version 1 shows the highest average speed and lowest total vehicle delay compared to other versions in the a.m. peak period. In the p.m. peak period, GP Version 2 shows the highest average speed and lowest total vehicle delay. In the eastbound direction, the express lane operating option versions have equal or lower average speed compared to the general purpose lane operating option versions because of the bottleneck at the merge area of the express lane into the general purpose lanes. Adding capacity at this location would increase the average speed and VMT for EL Version 3.

Table 11-3. Comparison of Performance Measures in A.M. Peak Period, Eastbound Direction
(7 a.m. to 9 a.m.)

Performance Measures	Existing	No Action	Version 1		Version 2		Version 3 (Proposed Action)	
			GP	EL	GP	EL	GP	EL
Average Travel Time (minutes)	17.9	18.9	8.2	9	8.2	8.9	8.4	8.3
Average Speed (mph)	22	20	46	42	45	42	44	44
VHD (hours)	1,005	1,152	332 *-71%*	403 *-65%*	338 *-71%*	406 *-65%*	355 *-69%*	405 *-65%*
VMT (vehicle-miles)	33,804	32,501	48,876 *50%*	47,342 *46%*	49,076 *51%*	46,819 *44%*	47,308 *46%*	46,778 *44%*
VHT (vehicle-hours)	1,525	1,652	1,084 *-34%*	1,131 *-32%*	1,093 *-34%*	1,125 *-32%*	1,083 *-34%*	1,074 *-35%*
TTI	2.66	2.81	1.21	1.26	1.21	1.32	1.24	1.25
Truck Miles Traveled (truck-miles)	3,029	3,711	4,266 *15%*	4,343 *17%*	4,314 *16%*	4,221 *14%*	4,142 *12%*	4,489 *21%*

Source: Jacobs

GP Version 3 and EL Version 3 are the Proposed Action for their respective operating options

Green Font = Best performance when the operating option is compared with the No Action Alternative

Table 11-4. Comparison of Performance Measures in P.M. Peak Period, Eastbound Direction
(4 p.m. to 7 p.m.)

Performance Measures	Existing	No Action	Version 1		Version 2		Version 3 (Proposed Action)	
			GP	EL	GP	EL	GP	EL
Average Travel Time (minutes)	14.9	17.4	8.1	8.3	8.1	9.7	8.1	8.3
Average Speed (mph)	26	21	46	46	46	43	46	44
VHD (hours)	1,187	1,481	458 *-69%*	463 *-69%*	454 *-69%*	521 *-65%*	459 *-69%*	461 *-69%*
VMT (vehicle-miles)	49,569	46,656	68,877 *48%*	65,616 *41%*	68,981 *48%*	64,064 *37%*	68,066 *46%*	63,239 *36%*
VHT (vehicle-hours)	1,950	2,199	1,518 *-31%*	1,473 *-33%*	1,515 *-31%*	1,507 *-31%*	1,507 *-31%*	1,434 *-35%*
TTI	2.21	2.59	1.2	1.21	1.19	1.29	1.2	1.24
Truck Miles Traveled (truck-miles)	3,619	5,862	6,201 *6%*	6,217 *6%*	6,140 *5%*	6,122 *4%*	6,152 *5%*	6,298 *7%*

Source: Jacobs

GP Version 3 and EL Version 3 are the Proposed Action for their respective operating options

Green Font = Best performance when the operating option is compared with the No Action Alternative

Table 11-5 compares how each operating option addresses the congestion expected in the 2040 No Action Alternative based on average speeds, VMT, VHT, and total delay. Table 11-5 illustrates the performance measures for all the operating options for both peak hour periods in both directions on I-270. All the performance measures are improved with all the versions.

Table 11-5. Comparison of Performance Measures in Both Directions

Performance Measures	Existing	No Action	Version 1		Version 2		Version 3 (Proposed Action)	
			GP	EL	GP	EL	GP	EL
Average Travel Time (minutes)	15.6	18.1	8.8	9.4	9.7	9.7	8.9	9.3
Average Speed (mph)	25	22	43	41	39	39	42	40
VHD (hours)	4,152	4,958	2,173 *-56%*	2,171 *-56%*	2,558 *-48%*	2,147 *-57%*	2,214 *-55%*	2,165 *-56%*
VMT (vehicle-miles)	167,450	161,153	249,437 *55%*	234,146 *45%*	237,421 *47%*	225,991 *40%*	246,374 *53%*	230,102 *43%*
VHT (vehicle-hours)	6,728	7,438	6,011 *-19%*	5,773 *-22%*	6,211 *-16%*	5,623 *-24%*	6,005 *-19%*	5,654 *-24%*
TTI	2.32	2.69	1.31	1.27	1.44	1.33	1.32	1.25
Truck Miles Traveled (truck-miles)	12,434	19,270	22,849 *19%*	23,508 *22%*	21,114 *10%*	22,093 *15%*	22,585 *17%*	23,434 *22%*

Source: Jacobs

GP Version 3 and EL Version 3 are the Proposed Action for their respective operating options

Green Font = Best performance when the operating option is compared with the No Action Alternative

Further comparison and analysis of the study MOEs for general purpose lanes and the express lane on I-270 for the existing condition, No Action Alternative, and design operating options are provided in the following sections.

11.1 Average Travel Time

Figures 11-1 and 11-2 compare each operating option's average travel time on I-270 in the westbound and eastbound directions. Compared to the No Action Alternative, travel times are projected to improve with all the operating options to various degrees.

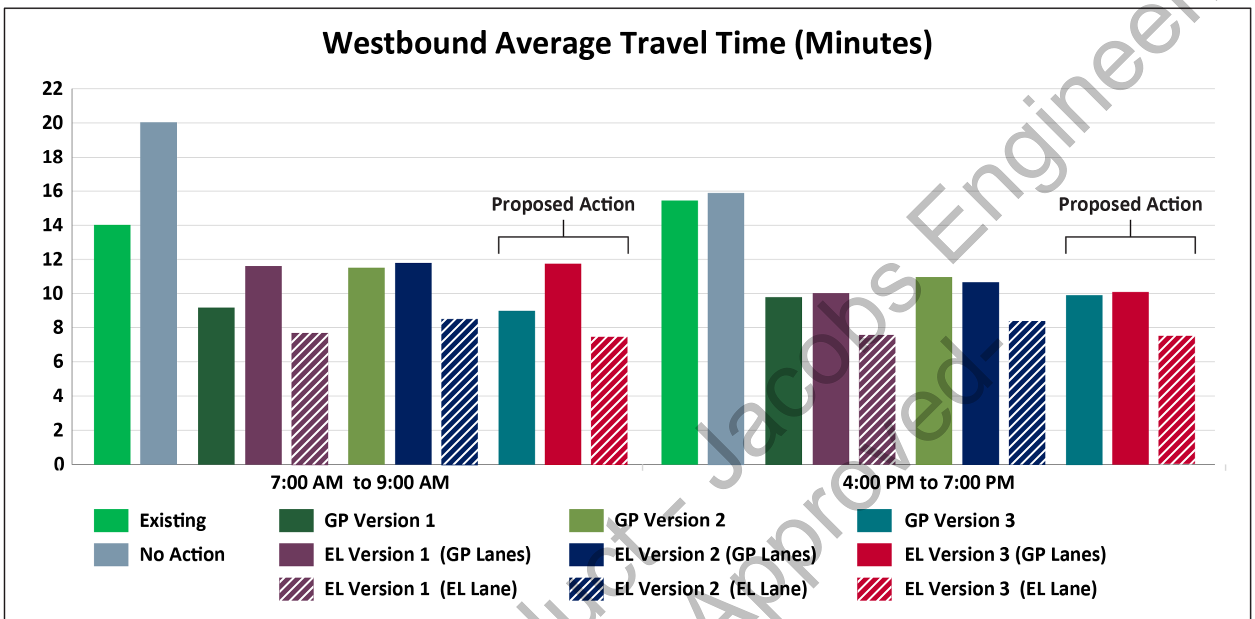

Figure 11-1. Average Travel Time, Westbound Direction

Source: Jacobs

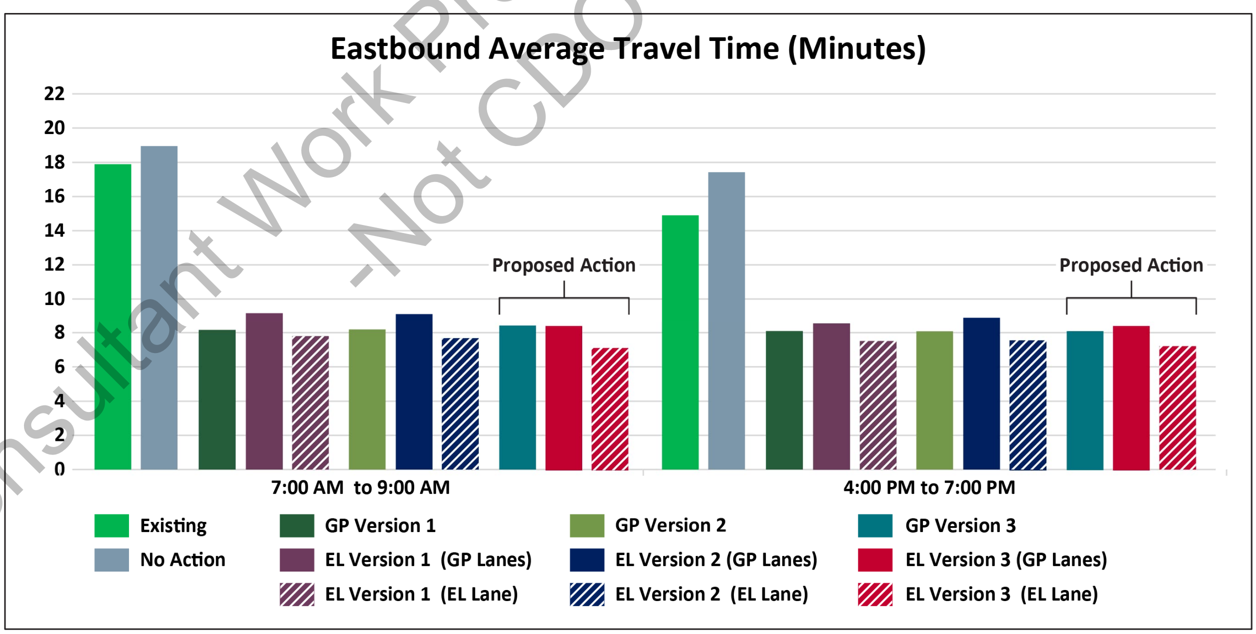

Figure 11-2. Average Travel Time, Eastbound Direction

Source: Jacobs

11.2 Average Speed

Figures 11-3 and 11-4 compare each operating option's average speed on I-270 in the westbound and the eastbound directions. Average speeds are projected to improve with all the operating options to various degrees.

In the a.m. peak period westbound direction, no portion of I-270 is projected to operate at speeds less than 32 mph on general purpose lanes and 52 mph on the express lane with any of the operating options, which is a substantial improvement in comparison to the 2040 No Action Alternative.

In the p.m. peak period westbound direction, no portion of I-270 is projected to operate at speeds less than 34 mph on general purpose lanes and 52 mph on the express lane with any of the operating options.

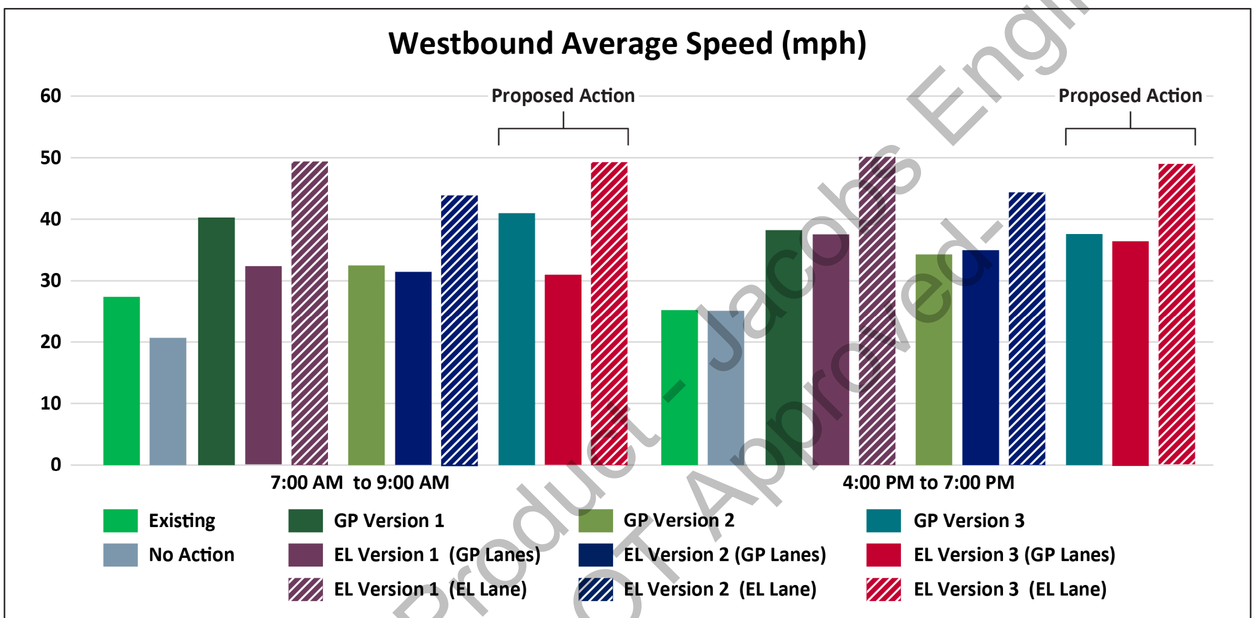

Figure 11-3. Average Speed, Westbound Direction
Source: Jacobs

In the a.m. peak period eastbound direction, no portion of the freeway is projected to operate at speeds less than 41 mph on the general purpose lanes and 52 mph on the express lane with any of the operating options.

In the p.m. peak period eastbound direction, no portion of the freeway is projected to operate at speeds less than 42 mph on the general purpose lanes and 52 mph on the express lane with any of the operating options.

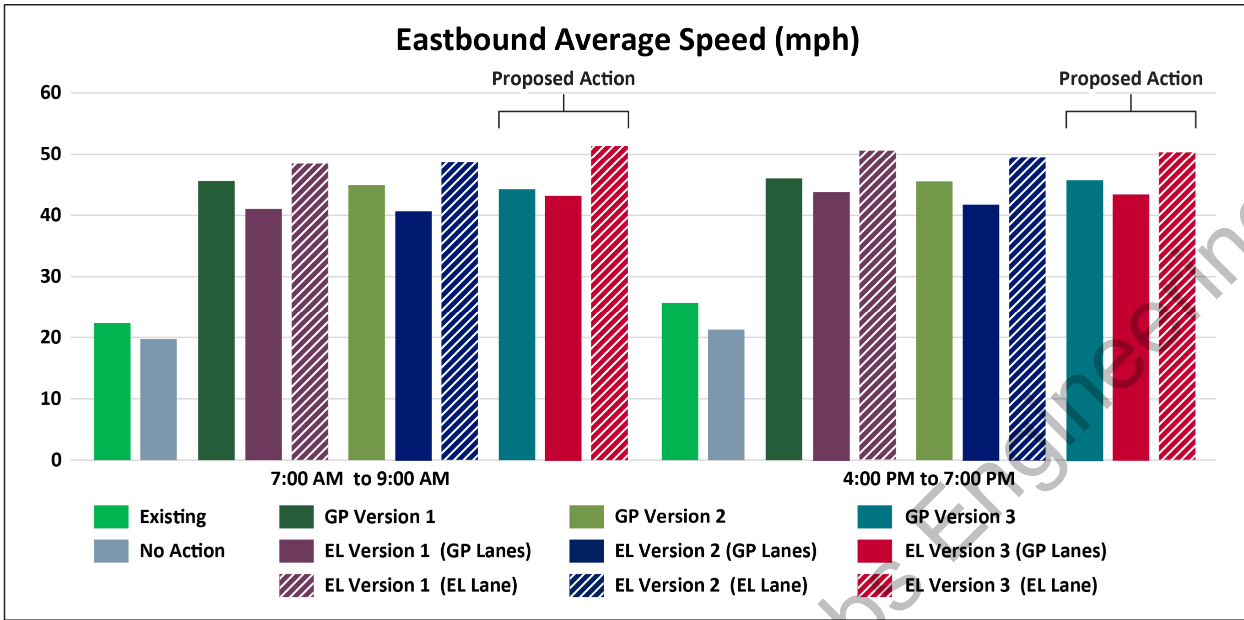

Figure 11-4. Average Speed, Eastbound Direction
Source: Jacobs

11.3 Total Delay

Figures 11-5 and 11-6 illustrate each operating option's total vehicle delay on I-270 in the westbound and eastbound directions. The total delay is projected to decrease with all the operating options to various degrees.

In the a.m. peak period westbound direction, the total delay on I-270 varies from 453 to 736 vehicle hours for the operating options. In the p.m. peak period, the total delay varies from 659 to 1,029 vehicle hours for the operating options. In each peak period, express lane delay is a minor subset of the total delay in the express lane versions.

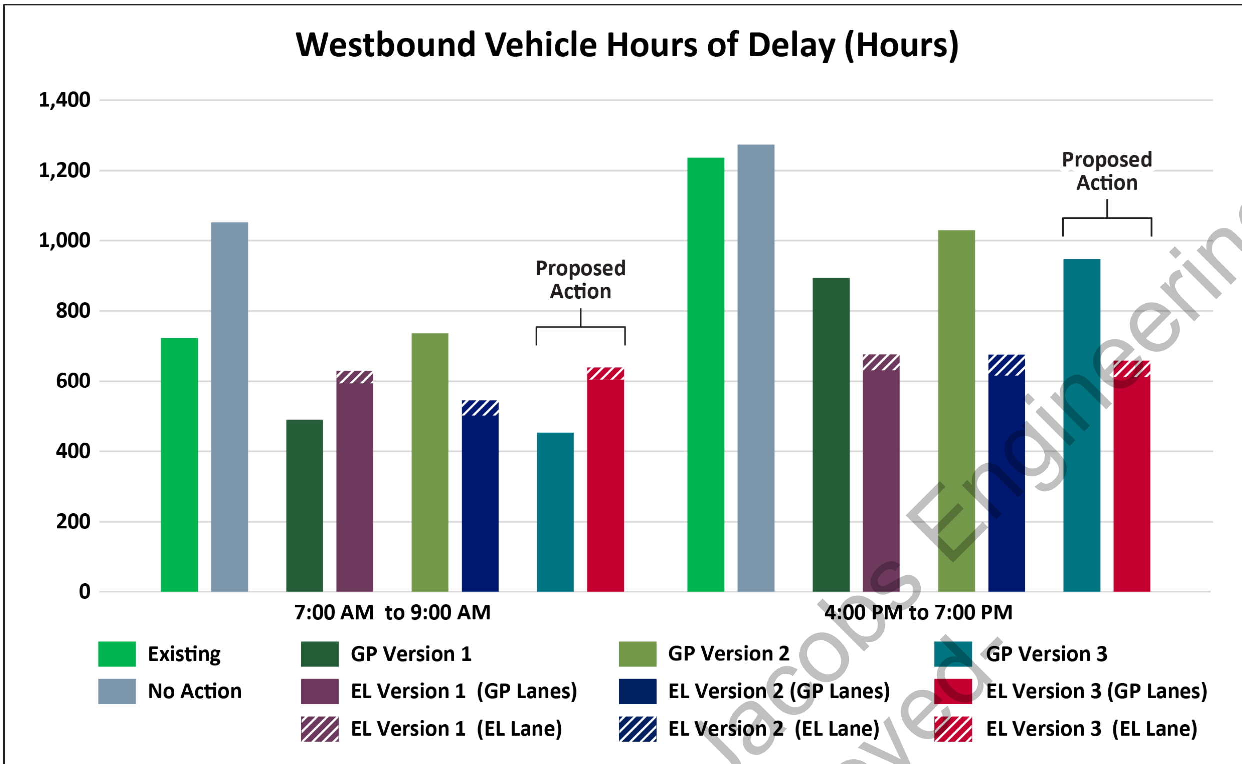

Figure 11-5. Total Delay, Westbound Direction
Source: Jacobs

In a.m. peak period eastbound direction, the total delay on I-270 varies from 332 to 405 vehicle hours for the operating options. In the p.m. peak period, the total delay varies from 454 to 521 vehicle hours for the operating options. In each peak period, express lane delay is a minor subset of the total delay in the express lane versions.

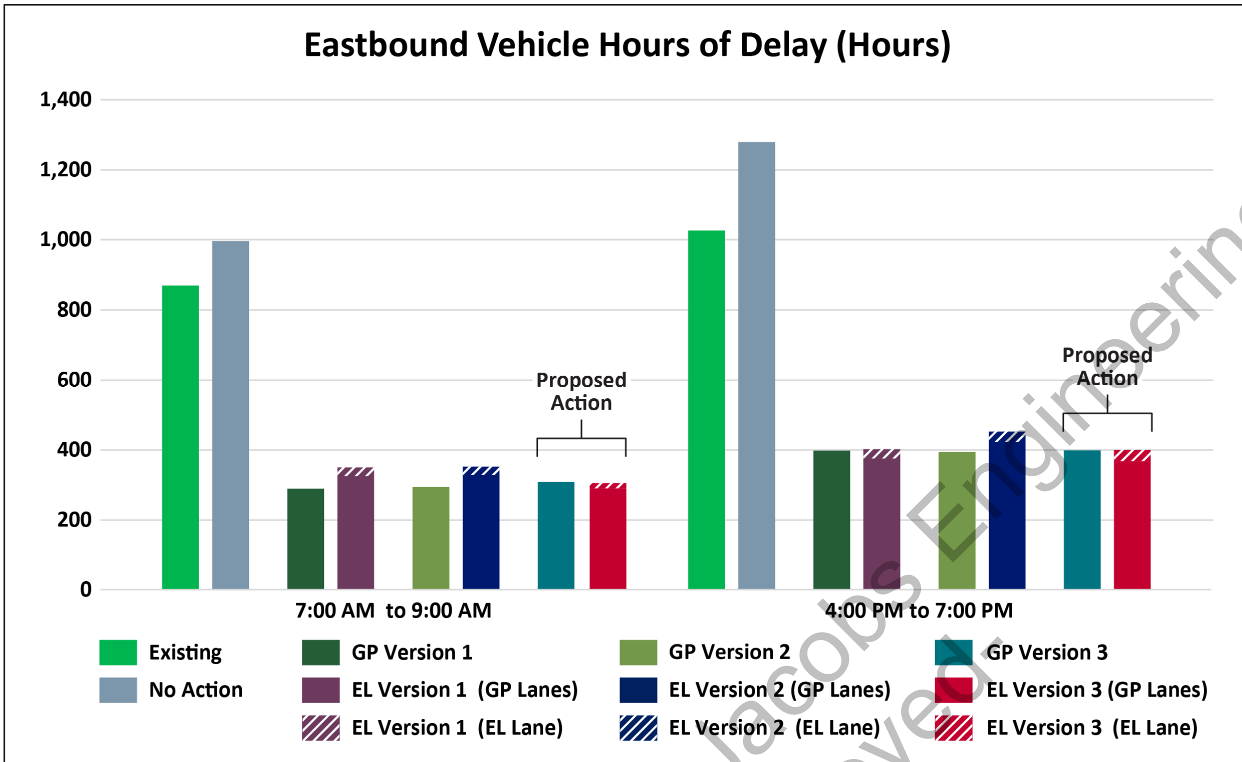

Figure 11-6. Total Delay, Eastbound Direction
Source: Jacobs

11.4 Vehicle Miles Traveled

Figure 11-7 is a comparison of VMT for the existing conditions, No Action Alternative, and design operating options in the westbound directions. With the added third lane in all the operating options, the corridor is able to serve more traffic; therefore, the VMT is substantially higher for the future year compared to the No Action Alternative.

In the westbound direction, all the operating options have a more than 46 percent increase in total VMT in the a.m. peak period compared to the No Action Alternative. Even though all the versions show an increase in VMT, GP Version 1 has the highest VMT. EL Version 2 has the lowest VMT in the a.m. peak period, and EL Version 1 has the lowest VMT in the p.m. peak period. In the proposed express lane operating option versions, EL Version 3 has the highest VMT in the a.m. peak period and EL Version 1 has the highest VMT in the p.m. peak period.

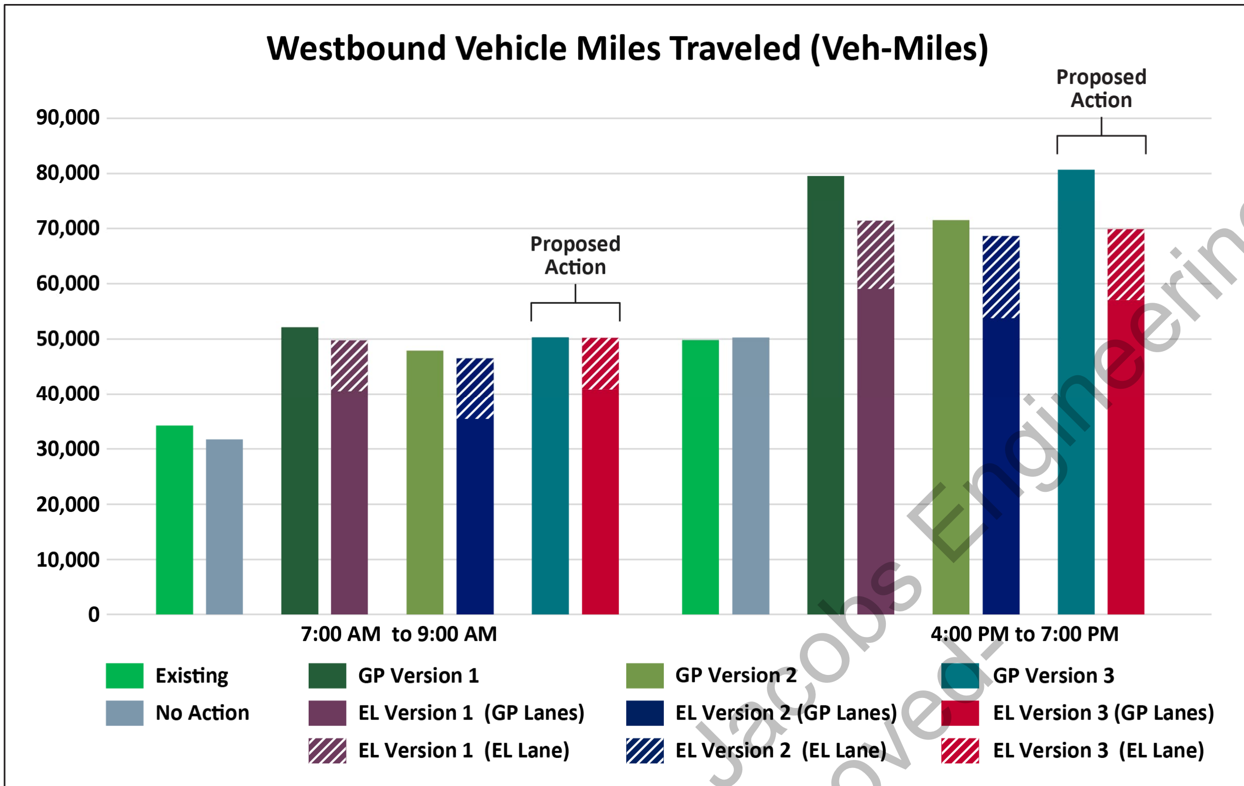

Figure 11-7. Vehicle Miles Traveled, Westbound Direction
Source: Jacobs

Figure 11-8 is a comparison of VMT for the existing conditions, No Action Alternatives, and design operating options in the eastbound direction. In the eastbound direction, all the operating options have a more than 26 percent increase in total VMT in the a.m. peak period and p.m. periods compared to the No Action Alternative. All versions show an increase in VMT, with GP Version 1 and GP Version 2 having higher VMT compared to other versions.

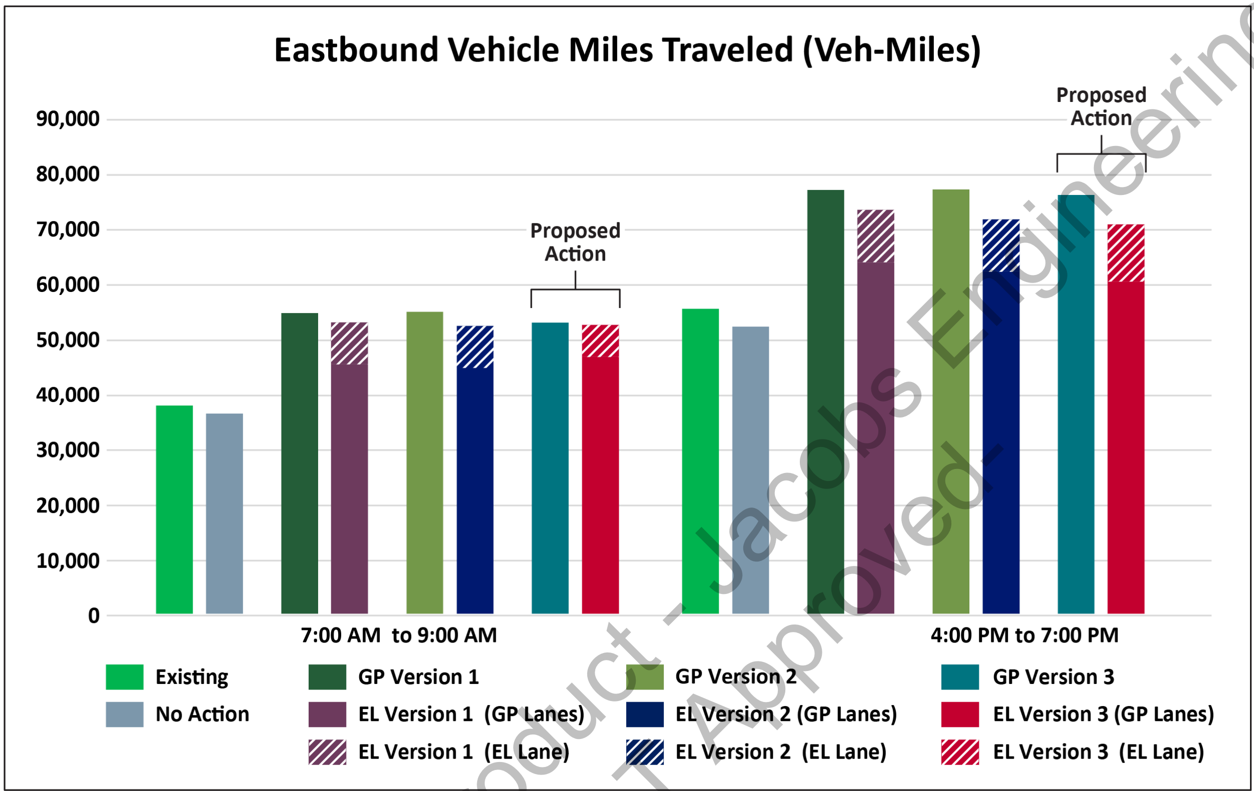

Figure 11-8. Vehicle Miles Traveled, Eastbound Direction

Source: Jacobs

11.5 Vehicle Hours Traveled

Figures 11-9 and 11-10 illustrate each operating option's VHT on I-270 in the westbound and eastbound directions. Compared to the 2040 No Action Alternative, VHT is projected to decrease with all the operating options to various degrees.

During the p.m. peak period, with the added third lane in the general purpose lane operating option versions, the corridor carries more vehicles with average vehicle speed not improving enough, resulting in higher VHT compared to the No Action Alternative. During the a.m. peak period, the average vehicle speeds improve enough to result in lower VHT compared to the No Action Alternative.

In express lane operating option versions, the added third lane increases the traffic served and improves the average vehicle speed, resulting in lower VHT compared to the No Action Alternative.

In the westbound direction, GP Version 3 has the lowest VHT in the a.m. peak period and EL Version 2 has the lowest VHT in the p.m. peak period. In the eastbound direction, all the operating options have a minimum of 31 percent decrease in VHT compared to the No Action Alternative.

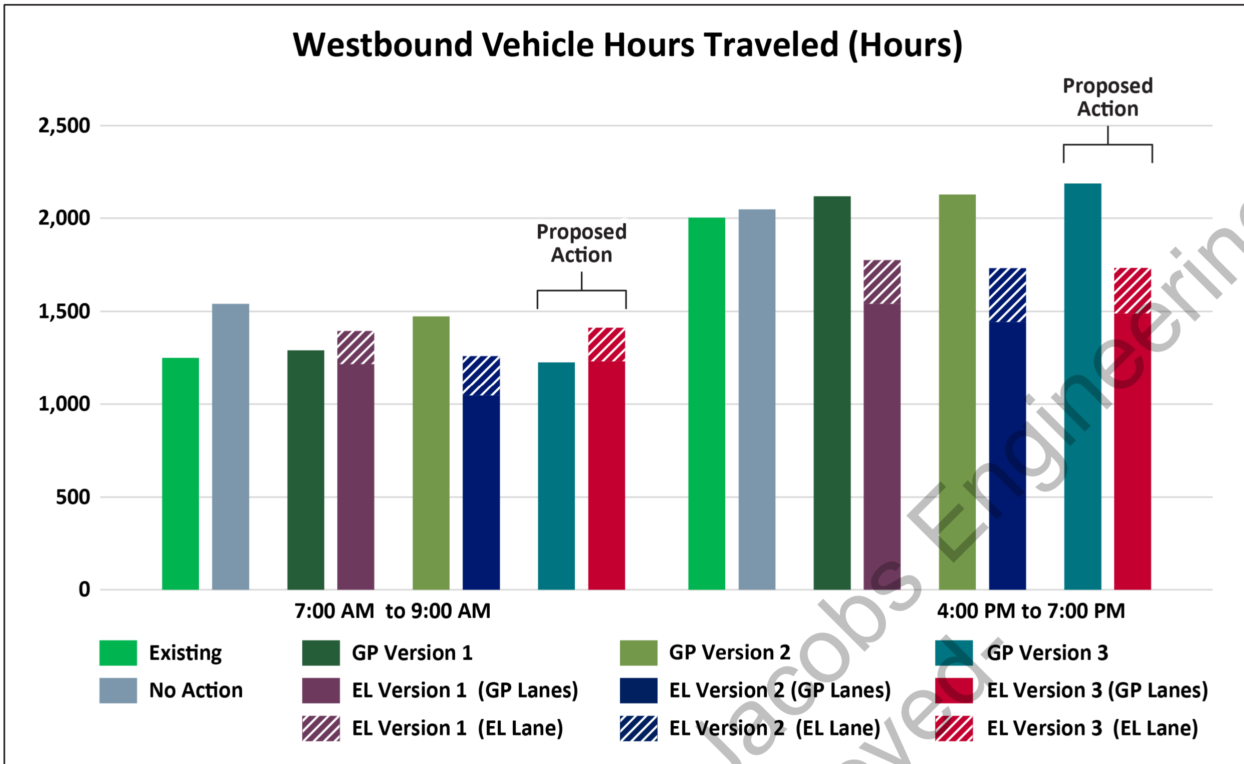

Figure 11-9. Vehicle Hours Traveled, Westbound Direction
Source: Jacobs

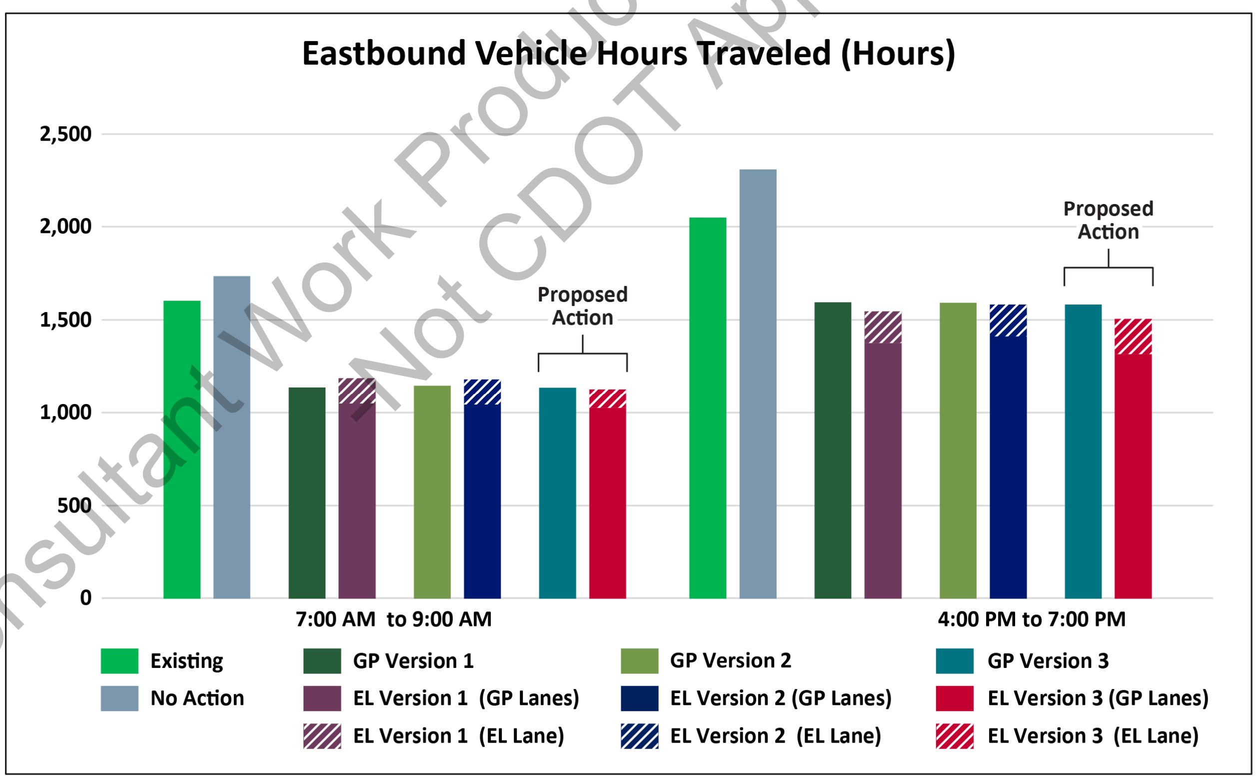

Figure 11-10. Vehicle Hours Traveled, Eastbound Direction
Source: Jacobs

11.6 Travel Time Reliability

Figure 11-11 illustrates each operating option's TTI on I-270 in the westbound direction. Compared to the 2040 No Action Alternative, TTI is projected to improve with all the operating options to various degrees.

In the westbound direction, all the operating options show substantially improved TTI (closer to or even below the threshold number) compared to the No Action Alternative.

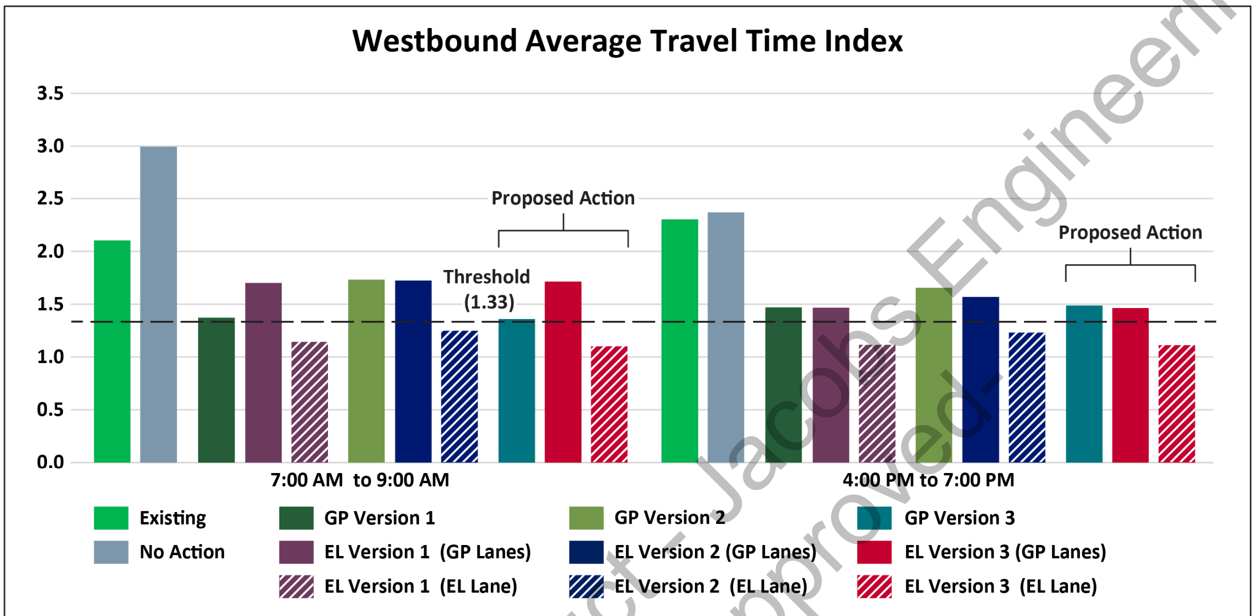

Figure 11-11. Travel Time Index, Westbound Direction

Source: Jacobs

Figure 11-12 illustrates each operating option's TTI on I-270 in the eastbound direction. Compared to the 2040 No Action Alternative, TTI is projected to improve with all the operating options to various degrees.

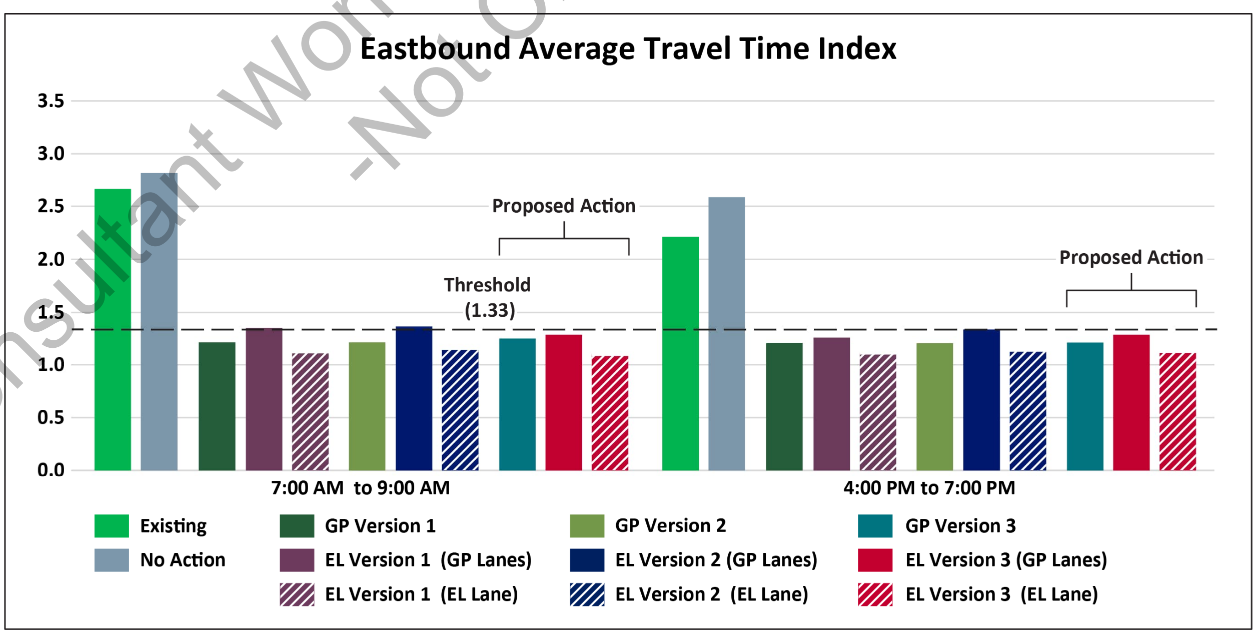

Figure 11-12. Travel Time Index, Eastbound Direction

Source: Jacobs

11.7 Truck Miles Traveled

Figure 11-13 illustrates each operating option's truck miles traveled on I-270 in the westbound direction. Compared to the 2040 No Action Alternative, truck miles traveled is projected to increase to various degrees because the truck throughput increases with all the operating options.

In the westbound direction, all the operating options have a more than 17 percent increase in the total truck miles traveled in the a.m. peak period compared to the No Action Alternative. Although all operating options show an increase, GP Version 3 has the highest truck miles traveled in the a.m. peak period and EL Version 1 has the highest truck miles traveled in the p.m. peak period. GP Version 2 has the lowest truck miles traveled.

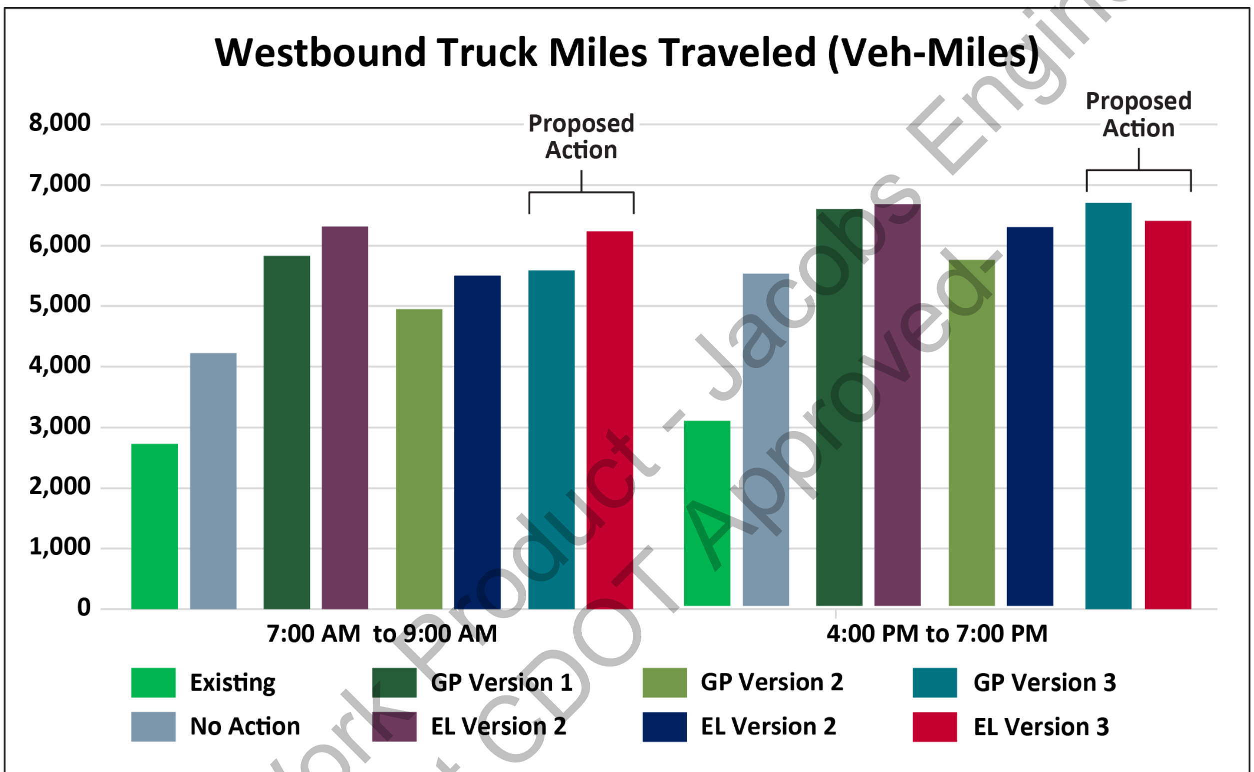

Figure 11-13. Truck Miles Traveled, Westbound Direction
Source: Jacobs

Figure 11-14 is a comparison of total truck miles traveled for the existing conditions, No Action Alternative, and design operating options in the eastbound direction. Compared to the No Action Alternative, all the operating options have a more than 12 percent increase in the total truck miles traveled in the a.m. peak period and a more than 4 percent increase in p.m. peak period. Even though all the versions are showing an increase in truck miles traveled, EL Version 3 has the highest truck miles traveled. GP Version 3 has the lowest truck miles traveled in the a.m. peak period, and EL Version 2 has the lowest truck miles traveled in the p.m. peak period.

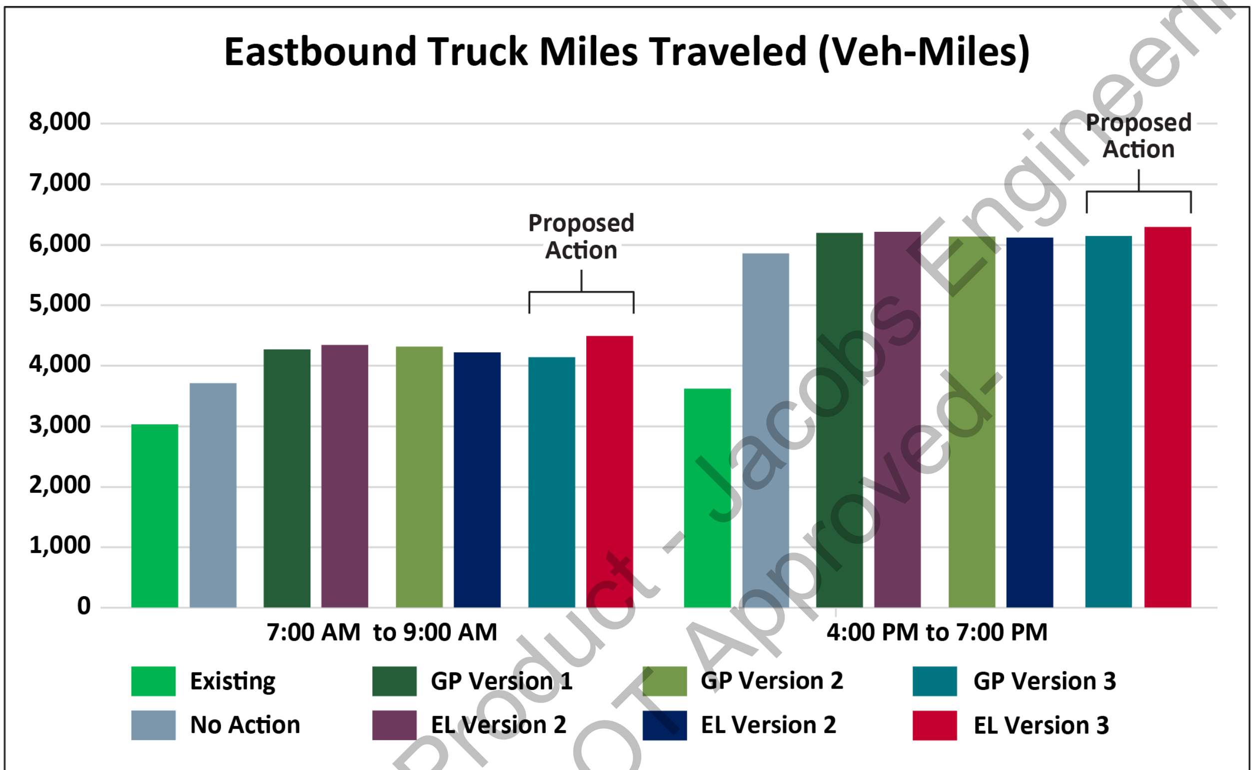

Figure 11-14. Truck Miles Traveled, Eastbound Direction
Source: Jacobs

In 2040, truck miles traveled is showing increasing for all design operating options relative to the No Action Alternative. This is directly related to the unique configurations of each operating option. Trucks and specifically diesel trucks are an important component for analyzing air quality in the corridor. Air quality analysis was based on 2050 traffic and diesel truck percentages, detailed in Appendix A4 of the EA.

12.0 Summary

This section summarizes the conclusion of traffic analysis performed for all the operating options. When comparing the operating options, all the performance measures are reviewed as to how each version addresses the purpose and need defined for this analysis. The express lane operating options (EL Versions 1, 2, and 3) have average speeds on the corridor of 40 mph or greater, while the general purpose lane operating options (GP Versions 1, 2, and 3) have average speeds of 38 to 42 mph. GP Version 1 scores best for this MOE, with a difference of only 1 mph in average speed. The express lane operating options have lower VHD, lower VMT, lower VHT, and higher truck miles traveled when compared to the general purpose lane operating options. Although GP Version 1 shows a higher average speed, the express lane operating options show high speed reliability on the express lanes. Figures 11-3 and 11-4 show a speed of approximately 50 mph on the express lanes when averaged, while GP Version 1 has an average speed of 42 mph with congestion on the general purpose lanes. This suggests that, overall, the express lane operating options perform better and address the project's purpose and need statement better.

When comparing between express lane operating options, evaluating performance measures alone is not enough to determine a differentiator. Performance measures are generally similar across all categories for the three express lane operating options. Because the express lane operating options all have slight variances in geometry, it is necessary to go a step further and examine safety of the corridor and ramp operations for each version. Table 2-1 summarizes the geometric similarities and differences among the three express lane operating options along with the general purpose lane operating options.

For safety, the eastbound collector ramp is needed to reduce accidents on eastbound I-270, and each express lane operating option offers that design. The next safety element is near the southbound I-25 on-ramp to eastbound I-270, which is already in a complex weaving area. Starting the eastbound express lane so close to this entrance point would only complicate weaving and likely induce additional safety concerns. Of the express lane operating options, EL Version 3 starts the express lane entrance the farthest from this on-ramp, increasing available weave distance. All general purpose and express lane operating options reconfigure the I-270/Vasquez Boulevard full cloverleaf interchange into a partial cloverleaf interchange, reducing conflict points and improving safety.

Ramp capacity, acceleration, and deceleration are also important to the design. Each express lane operating option implements auxiliary lanes between York Street and Vasquez Boulevard in both the eastbound and westbound direction. However, EL Version 2 does not have a westbound auxiliary lane between Quebec Street and Vasquez Boulevard, while EL Versions 1 and 3 do. EL Version 3 has a double-lane exit for the eastbound I-270 off-ramp to Vasquez Boulevard, while EL Versions 1 and 2 use a single-lane off-ramp. EL Versions 1 and 2 both included a westbound I-270 off-ramp at Quebec Street, while EL Version 3 did not. However, a closer look at this ramp design reveals negative trail impacts to the park property, which is owned by the City and County of Denver. EL Version 3 implemented a split-ramp design for westbound York Street and the I-76 off-ramps, while EL Versions 1 and 2 used a shared off-ramp. Because of the ramp capacity and auxiliary lane design, EL Version 3 provides the necessary ramp capacity, acceleration, and deceleration for the project.

In summary, operational performance measures are similar among the three express lane versions, while safety and right-of-way acquisition favors Version 3. This assessment concludes that, moving forward, Version 3 should be the Proposed Action with the following two operating options:

1. Proposed Action with Express Lane Operating Option
2. Proposed Action with General Purpose Lane Operating Option

Considering the project's purpose and need of travel time reliability, the Proposed Action with Express Lane Operating Option is superior to the Proposed Action with General Purpose Lane Operating Option.

When comparing the Proposed Action with the Express Lane Operating Option (EL Version 3) to the No Action Alternative, the differences in performance measures that factor time and reliability during the peak period are clear. When combining a.m. and p.m. MOEs, the Proposed Action with Express Lane Operating Option benefits to travelers include the following:

- Westbound travelers on average will spend nearly 39 percent less travel time in the general purpose lanes and 59 percent less in the express lanes.
- Eastbound travelers on average will spend nearly 54 percent less travel time in the general purpose lanes and 60 percent less in the express lanes.
- Westbound average speeds in the corridor are approximately 11 mph higher in the general purpose lanes and 26 mph higher in the express lanes.
- Eastbound average speeds in the corridor are approximately 23 mph higher in the general purpose lanes and 31 mph higher in the express lanes.
- Total vehicle delay in hours on the corridor drops approximately 44 percent for westbound and 67 percent for eastbound.

Considering performance measures such as travel delays and speed, the Proposed Action with Express Lane Operating Option is superior to the No Action Alternative. The No Action Alternative provides only minimal safety improvements and does not provide improvements to travel delay and congestion.

13.0 References

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Appendix A
Base and Design Years for Traffic Analysis

Base and Design Years for Traffic Analysis

PREPARED FOR:	Colorado Department of Transportation (CDOT) Region 1
COPY TO:	Federal Highway Administration (FHWA) Colorado Division
PREPARED BY:	Jacobs
DATE:	July 15, 2022

This memo discusses the process of determining the base year and design year to be used in various analyses involving traffic data for the Interstate 270 (I-270) Corridor Improvements Project. The selected base year and design year traffic volumes will be used as input for the following project tasks:

- Roadway
  - Traffic operations analysis
  - Traffic safety analysis
  - Roadway design
- Environmental
  - Noise analysis

1.0 Base Year

The Denver Regional Council of Governments (DRCOG) activity-based travel demand model (TDM) version Focus 2.1 (Cycle RTP-2017) was used by Atkins in the pre-National Environmental Policy Act (NEPA) traffic analysis, documented in the *I-270 Traffic Study Final Report* (Atkins 2019). Focus models developed by DRCOG are updated every 5 years. The 2015 model with base year 2015 was used in the Atkins report as a starting point to develop the analysis for the 2016 Existing Conditions year. Atkins performed refinements and updates to the 2015 model based on aerial photography to represent the 2016 roadway conditions. Atkins used 2016 data collected for the *North Metropolitan Industrial Area Connectivity Study* (Atkins 2018a) and the Vasquez Boulevard PEL Study (CDOT 2018) in their analysis as shown in the *Traffic Modeling and Data Collection Methodology Memorandum* (Atkins 2018). The Central 70 Project (part of the larger I-70 Environmental Impact Study) is currently in the construction phase and partially overlaps with the I-270 study area; the current traffic data may not be representative of typical traffic patterns along I-270 as well as other study roadways. Therefore, the traffic data collected for the studies mentioned were used for model calibration by Atkins.

The major tasks performed by Atkins to develop the 2016 Existing Conditions Year analyses included the following:

- Adjustment and calibration of the study's TDM sub-area from the Focus 2.1 model
- Development of the microsimulation model for the sub-area in TransModeler software
- Calibration of the microsimulation model to 2016 data

Jacobs organized annual average daily traffic values from Colorado Department of Transportation's (CDOT's) Data Management System (2022) for I-270 and other major study area freeways from the years 2016 to 2021 (Table 1). Table 1 shows that all four study area freeways have comparable volumes between years 2016 and 2021. These trends indicate that recent 2021 traffic levels are approaching a return to pre-COVID levels (in 2019). Table 1 trends also indicate slower traffic growth than compared to regional traffic, possibly attributed to these freeways having reached operating capacity, particularly during the weekday peak periods, for the past several decades.

Future design years will consist of a longer projection timeline using 2016 as the base year, therefore future design years would have a higher percentage growth using 2016 as the base year. The system-wide assessment of traffic in Table 1 informs the general sense of magnitude when collecting new traffic counts. Since system-wide traffic volume is not anticipated to increase by replacing 2016 data with 2021 volumes, especially during traffic peaks which have flatlined in magnitude on I-270 for several decades, using 2016 data was found to be a conservative approach to peak traffic modeling.

For the purpose of this study, year 2016 will be used as the base year because it best represents the traffic patterns and volumes of a typical day.

Table 1. 2016 to 2021 Annual Average Daily Traffic

	Location			
Year	I-270 btwn I-76 and Vasquez Blvd. (000507)	I-70 West of I-270 (103077)	I-76 East of I-270 (103384)	I-25 South of I-76 (101016)
2016	102,543	157,320	88,410	227,254
2017	105,092	161,882	90,974	217,190
2018	106,265	154,106	93,339	222,837
2019	105,048	156,726	96,266	225,000
2020	96,812	136,195	83,655	195,525
2021	102,891	154,718	90,374	222,116
% Change (2016-2021)	0.3%	-1.7%	2.2%	-2.3%

Source: CDOT 2022

2.0 Design Year

The DRCOG developed the *Metro Vision Regional Transportation Plan* (MVRTP) to guide the region's future multimodal transportation system. The 2040 MVRTP was adopted in April 2017 and includes the 2040 Fiscally Constrained RTP as an incorporation. The 2040 MVRTP was the approved model when the environmental assessment (EA) process, and its supporting traffic analysis, were initiated.

The project team will use the 2040 TransModeler microsimulation models developed by Atkins using the approved DRCOG 2040 model as a basis for its project-level analysis. The 2040 microsimulation models were adjusted with the parameters resulting from the calibration using 2016 traffic data. These 2040 models will be further analyzed for the No Action and Build alternatives. The operational performance of the alternatives will be evaluated with additional design and operational options including express lane and general purpose lane options.

The study team completed a sensitivity analysis to determine the potential need to change from the Focus 2.1 2040 TDM to the Focus 2.3 2050 TDM to support the EA and its associated technical analysis (refer to *I-270 Corridor Sensitivity Test – Focus 2.1 2040 TDM Compared with Focus 2.3 2050 TDM* Appendix B of the *Traffic Technical Report* [A2 of the EA]).

Because most of the resource analyses, including traffic operations, focus on the peak periods, the 2040 TDM traffic volumes appear to represent a scenario of similar conditions to the 2050 TDM. In assessing whether switching to the 2050 TDM would alter key decisions made based on the 2040 TDM, the sensitivity analysis indicates that such a switch would not alter these key decisions. Specifically, switching to the 2050 TDM is not expected to change the following:

- Proposed Action design or impact limits
- Travel time reliability from the Proposed Action
- Key results of the noise analysis

Based on the previously mentioned considerations, Federal Highway Administration (FHWA) and CDOT have agreed to use the approved DRCOG Focus 2.1 2040 TDM as a basis for its project-level analysis.

3.0 Considerations for Environmental Analyses

The project-level noise analysis will use year 2016 for the base year and 2040 for the design year for traffic inputs. As shown in Table 1, traffic volumes from years 2016 are comparable to year 2021 volumes.

The methods and approach for the project air quality analysis was determined through agency coordination meetings led by FHWA and CDOT staff and held with the Colorado Department of Public Health and Environment Air Pollution Control Division and U.S. Environmental Protection Agency (EPA). These methods are detailed in the *Air Quality Technical Report* (Appendix A4 of the EA).

A quantitative carbon monoxide (CO) hot spot analysis is being conducted for the project's Proposed Action, because the proposed project is anticipated to affect intersection(s) at level of service (LOS) D, E, or F, or those that will change to LOS D, E, or F due to the project. The CO hot spot analysis will use worst-case emission factors and future traffic data of the Proposed Action. The emission factors of 2016 will be used for CO hot spot analysis because emission factors would be higher in 2016 than in future years due to the phasing out of older, less efficient vehicles and implementation of EPA engine regulations.

The project was determined to not be a Project of Air Quality Concern. However, a project-level particulate matter hot spot analysis is being conducted to support the NEPA analysis and to go above state requirements.

The hot spot analyses will use the year 2050 traffic data based on the DRCOG Focus 2.3 TDM model, which is the latest approved model at the time of the analysis. Although the air quality analysis is not being done under transportation conformity requirements, use of the latest approved model does meet the planning assumption requirements of Section 93.109 (b) of the conformity rule.

4.0 Summary

Jacobs will use 2016 as the base year for the I-270 Corridor Improvements project, found to be a conservative and resourceful approach versus collecting and using more recent data. This study will use 2040 as the project design year to analyze traffic operations, found to be a comparable and resourceful approach versus using and calibrating the 2050 forecast model. The exception to this is the project-level air quality analysis requirements that, per Section 93.109 (b), must use the latest approved travel demand model. For this analysis, the project will use the DRCOG Focus 2.3 TDM with a 2050 design year.

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Appendix B
I-270 Corridor Sensitivity Test – Focus 2.1 2040 TDM Compared with Focus 2.3 2050 TDM

I-270 Corridor Sensitivity Test – Focus 2.1 2040 TDM Compared with Focus 2.3 2050 TDM

July 15, 2022

1.0 Introduction

This document is intended to capture the sensitivity test to determine whether switching to the new Focus 2.3 2050 Transportation Demand Model (TDM) would change the conclusions made in the project analysis based on the Focus 2.1 2040 TDM for the Interstate 270 (I-270) Corridor Improvements Environmental Assessment (EA). This document will achieve the following:

- Discuss the background and history of the various TDMs used during the development of the EA
- Summarize the sensitivity test performed that compared the traffic volume differences between the Focus 2.1 2040 TDM and the Focus 2.3 2050 TDM
- Discuss whether switching to the Focus 2.3 2050 TDM would alter key decisions or impacts relative to traffic operations and travel time reliability, the proposed roadway design, and environmental resources
- Summarize the results of the analysis and decision

2.0 Travel Demand Models and Forecasts

Travel demand modeling and forecasting is a common process used in regional planning to estimate the amount of travel on regional transportation facilities. The traffic forecasts for the I-270 Corridor Improvements project (project) were developed for horizon year 2040, based on Focus 2.1, the planning model from the Denver Regional Council of Governments (DRCOG). During preparation of the EA, DRCOG released Focus 2.2 TDM with 2040 as the horizon year and Focus 2.3 TDM with 2050 as the horizon year. This section discusses the different models and forecasts for the I-270 corridor.

2.1 Base Year and Design Year for Traffic Analysis

The *I-270 Traffic Study* (Atkins 2019) included the traffic forecasts for future year 2040 to represent the traffic patterns along the I-270 corridor for various scenarios (Build and No Build) that were analyzed. The forecasts were based on the activity-based TDM, Focus 2.1 (Cycle RTP-2017) from DRCOG. Atkins used the Focus 2.1 TDM for 2015 as a starting point to develop the 2016 (base year) model. Focus models typically are developed by DRCOG in 5-year increments. Because the project started in 2019, it used the 2040 Focus 2.1 TDM as the modeled and horizon year.

The rationale for using 2016 and 2040 as the base year and design year, respectively, for the project was detailed in the *Base and Design Years for Traffic Analysis* technical memorandum, which is Appendix A to the *Traffic Technical Report* (Appendix A2 of the EA).

2.2 Travel Demand Model and I-270 Traffic Forecasts

Figure 1 shows the history of traffic forecast development for the project and its placement with the release of recent versions of DRCOG's Focus models. The figure shows that the traffic forecasts used for the EA were developed based on the Focus 2.1 TDM.

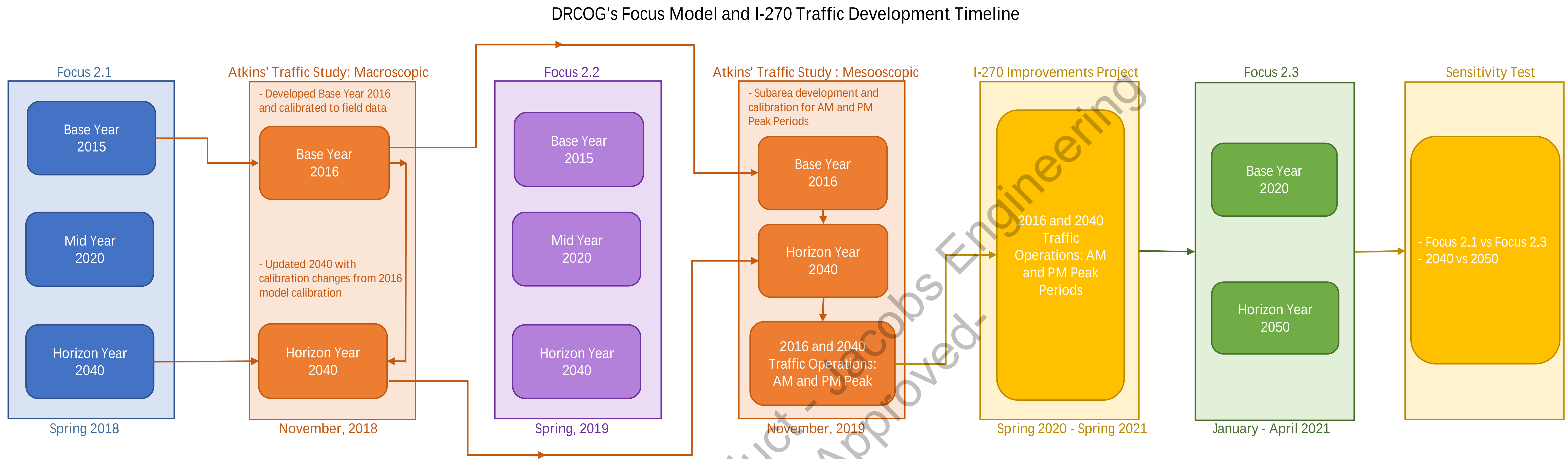

Figure 1. DRCOG's Focus Model and I-270 Traffic Development Timeline
Source: Jacobs

The details about how the traffic forecasts were developed for traffic models and operational analysis are provided in the *I-270 Traffic Study* (Atkins 2019). The figure also shows that the updated DRCOG model, Focus 2.3, was available in early 2021.

After the DRCOG Focus 2.3 models were obtained, the roadway networks were reviewed and then saved as a 2050 No Action model and a 2050 Proposed Action model. Within each model, the roadway networks were developed to match the following:

- 2050 No Action – For design year 2050, the No Action Alternative includes the DRCOG 2050 roadway network minus the proposed project improvements, notably the I-270 express lanes, auxiliary lanes, and ramp improvements at the interchanges. The 2050 TDM No Action network includes express lanes on U.S. Highway 36 (US-36), I-25, and I-70 because these are included in the fiscally constrained long-range plan.
- 2050 Proposed Action (Express Lane Operating Option) – The adopted 2050 TDM includes the express lanes for I-270. However, minor modifications were needed to make the 2050 TDM accurately reflect the Proposed Action. The traffic engineers modified the roadway network to reflect the interchange geometry and other improvements of the project.

For sensitivity analysis, the 2050 updated planning TDM model outputs were used to compare the forecasts with 2040 forecasts used for traffic analysis. The microsimulation models (developed in TransModeler) used for peak period traffic operations analysis were not updated with 2050 forecasts.

3.0 Sensitivity Test (Focus 2.1 versus Focus 2.3)

As discussed in Section 2.5.1 of the Federal Highway Administration (FHWA) *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA* (2010), a sensitivity test can be conducted to determine whether the changes caused by the introduction of the new data or TDM version would change the conclusions made from the previous analysis. If there is no change, then the study team could "simply document the change and the sensitivity analysis in the project administrative record and move on instead of re-doing the analysis" (FHWA 2010).

Underlying questions regarding the sensitivity analysis include the following:

- How do the updated 2050 TDM volumes compare with the 2040 TDM volumes, and should the project team make a switch to the updated 2050 TDM?
- Would the updated 2050 TDM volumes result in a need for additional lanes on I-270 between Interstate 25 (I-25) and Interstate 70 (I-70)? What other changes in the Proposed Action design would updated volumes necessitate?
- How would the updated 2050 TDM volumes change environmental impacts?

The following sections summarize the sensitivity tests performed and provide answers to these questions.

3.1 Model Inputs Comparison (Focus 2.1 versus Focus 2.3)

The Focus 2.3 model was adopted April 2021 and is aligned with DRCOG's new *2050 Metro Vision Regional Transportation Plan* (MVRTP; DRCOG 2021a). The Focus 2.3 TDM has considerable updates in the inputs and assumptions compared with the previous versions of the Focus model.

The following notes some of the changes reflected in the new Focus 2.3 that affect the I-270 study corridor:

- Land Use Data – The Focus 2.3 model uses updated population and households assumptions in the region.

- Commercial Vehicle (CV) Model
  - CV trips now stratified by three vehicle types: light duty, medium duty (MDCV), and heavy duty (HDCV)
  - Explicit modeling of truck tolls (MDCV and HDCV)
  - Easier control of passenger car–equivalent assumptions for MDCV and HDCV
  - Consideration of trucks (MDCV and HDCV) making internal-to-external and external-to-external trips
  - Improved CV trip rates
- Network Changes
  - On I-270 between I-70 and I-25, Focus 2.3 assumes two general purpose lanes and one express lane in each direction, while previous versions of the Focus model assume three general purpose lanes in each direction.
  - Express lanes have different capacity and truck restrictions when compared with general purpose lanes.
  - Focus 2.3 assumes direct express lane/managed lane connections to/from U.S. Highway 36 (US-36) managed lanes, I-25 North managed lanes, and I-70 East managed lanes.
- Other Model Improvements
  - Household size distribution
  - Updated utility parameters to fine-tune work at home trip share
  - Transit skimming
  - Bus rapid transit treatment
  - Walk and bike network updates

A full summary of the changes incorporated in the Focus 2.3 model can be found in Attachment 1.

3.2 Forecast Comparison for Study Corridor (I-270)

The study team reviewed the forecasts from Focus 2.1 and Focus 2.3 for the study corridor to better understand the changes in traffic forecasts based on two different models and how it would impact the EA and its outcomes. Figure 2 shows the study corridor.

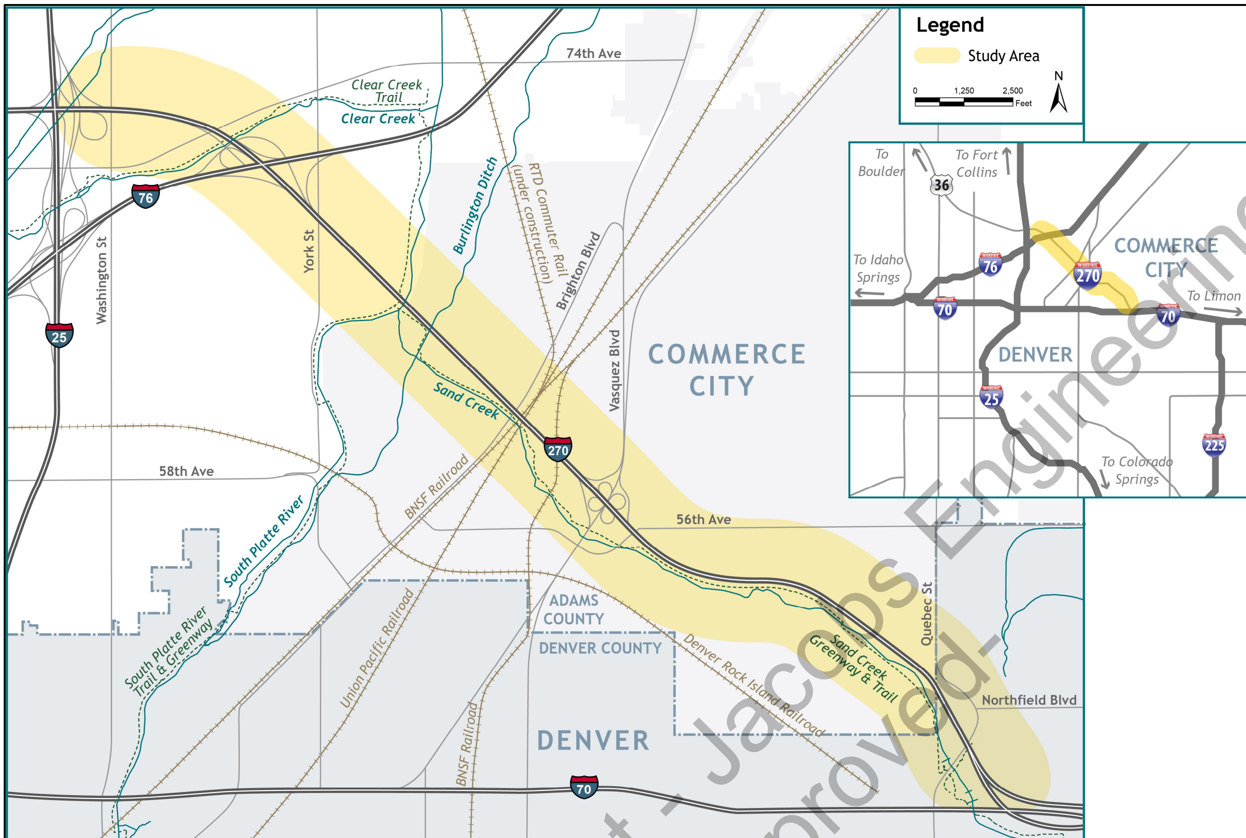

Figure 2. Study Corridor

Source: Jacobs

3.2.1 Comparing Study Corridor Traffic Forecasts from Focus 2.1 2040 and Focus 2.3 2050

To understand how the traffic forecasts would change with using Focus 2.3 horizon year 2050, daily traffic volume were compared to Focus 2.1 2040 (Atkins) forecasts. This section shows how the Focus 2.1 2040 (Atkins) and Focus 2.3 2050 (Jacobs) forecasted volumes compare for the different segments and different time periods. Table 1 shows the comparison between the two forecasted traffic volumes from each Focus model. These volumes are used as raw traffic data for our sensitivity analysis and are not detailed in the final traffic report analysis.

Table 1. Focus 2.1 2040 Forecast versus Focus 2.3 2050 Forecast for the Study Corridor

Time Period	Facility	Segment	CDOT Field Counts (Rounded) 2020	Focus 2.1 Model Annual Growth Rate (%) 2020-2040	Focus 2.1 Model Volumes 2040 (Atkins)	Focus 2.3 Model Annual Growth Rate (%) 2020-2050	Focus 2.3 Model Volumes 2050 (Jacobs)	Focus 2.1 2040 versus Focus 2.3 2050 % Change in Volumes
Daily	I-270	Quebec Street to Vasquez Boulevard	86,000	1.2	144,000	1.3	194,000	35
		Vasquez Boulevard to York Street	97,000	1.3	172,000	1.6	240,000	40
		I-76 to I-25	69,000	1.1	168,000	1.4	223,000	33
Peak Hour	I-270	Quebec Street to Vasquez Boulevard	6,000	1.2	9,600	1.2	12,400	29
		Vasquez Boulevard to York Street	6,800	1.3	11,300	1.6	15,500	37
		I-76 to I-25	4,800	0.9	10,900	1.3	14,400	32

Source: CDOT 2020, DRCOG 2021b

I-76 = Interstate 76

Table 1 shows that daily traffic volume, based on the planning model outputs, increases between 32 and 40 percent from Focus 2.1 2040 (Atkins) to Focus 2.3 2050 (Jacobs). The planning level models provide the traffic demands within the corridor segments and for traffic operations analysis, the traffic volumes that are anticipated to be served during the peak hours. The project team used the National Cooperative Highway Research Program Report 765 (TRB 2014) and standard practices to develop 2050 a.m. and p.m. peak hour traffic forecasts for each segment. Table 2 shows the comparison between the peak hour traffic volumes for both 2040 and 2050 forecast years.

Table 2. Peak Hours Traffic Forecasts - Focus 2.1 2040 versus Focus 2.3 2050 for the Study Corridor

		a.m. Peak Hour			p.m. Peak Hour		
Facility	Segment	2040	2050	% Change in Volumes	2040	2050	% Change in Volumes
I-270 WB	Quebec Street On-ramp to Vasquez Boulevard Off-ramp	4,030	4,610	14	3,970	4,430	12
	Vasquez Boulevard On-ramp to York Street Off-ramp	4,980	6,190	24	4,620	5,600	21
	I-76 SB On-ramp to I-25 NB Off-ramp	4,190	4,940	18	3,910	4,370	12
I-270 EB	I-25 SB On-ramp to I-76 NB Off-ramp	3,880	4,340	12	3,800	4,730	24
	York Street On-ramp to Vasquez Boulevard Off-ramp	4,740	6,310	33	4,430	6,180	40
	Vasquez Boulevard On-ramp to Quebec Street Off-ramp	3,980	5,060	27	3,820	4,320	13

Source: Jacobs

EB = eastbound
NB = northbound
SB = southbound
WB = westbound

The study team examined the growth on each segment in the study corridor, shown in Table 2, and performed a freeway density analysis using Highway Capacity Software (HCS7), which determined the level of service (LOS) for each segment during both a.m. and p.m. peak hours. The HCS7 follows the *Highway Capacity Manual* (HCM) methodology (TRB 2016) and LOS criteria as shown in Table 3 and Table 4. The model outputs indicate high traffic volumes on eastbound mainline facilities, but based on engineering judgement, when congestion increases on the mainline, some traffic will be willing to pay a toll and shift into the faster-moving express lane.

Table 3. HCM-based Level of Service Criteria for Urban and Rural Freeway Facilities

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤11
B	>11 to 18
C	>18 to 26
D	>26 to 35
E	>35 to 45
F	>45

Source: TRB 2016, Exhibit 10-6

pc/mi/ln = passenger car(s) per mile per lane

Table 4. HCM-based Level of Service Criteria for Weaving Segments

Level of Service	Freeway Facility Density (pc/mi/ln)
A	≤10
B	>10 to 20
C	>20 to 28
D	>28 to 35
E	>35 to 43
F	>43, or demand exceeds capacity

Source: TRB 2016, Exhibit 13-6

Table 5 shows the density and LOS for the segments in the study corridor. With the increased traffic volumes in 2050, the highest density is seen during the a.m. peak hour for the eastbound direction on the segment between the Vasquez Boulevard on-ramp and Quebec Street off-ramp, with density of 43.0 pc/mi/ln at LOS E. The LOS for the different segments in the study corridors slightly degrades with 2050 traffic volumes compared to 2040 traffic volumes. Per the HCM (TRB 2016), LOS E or better are within acceptable operation and LOS F represents demand that exceeds the capacity of a freeway segment. Table 5 shows all the segments in 2050 operates at LOS E or better. The density increase, and slight LOS degradation are considered negligible for this segment of roadway and should easily be handled with the proposed improvements. This indicates that the corridor design is resilient even into 2050.

Table 5. Summary of Freeway Density and Level of Service: I-270 between I-25 and I-76

				a.m. Peak Hour				p.m. Peak Hour			
		I-270 Segment Location		2040		2050		2040		2050	
Facility	Direction	From	To	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS	Density (pc/mi/ln)	LOS
I-270	WB	Quebec Street On-ramp	Vasquez Boulevard Off-ramp	17.7	B	21.3	C	16.8	B	19.3	C
		Vasquez Boulevard On-ramp	York Street Off-ramp	30.3	D	32.5	D	28.6	D	30.2	D
		I-76 SB On-ramp	I-25 NB Off-ramp	18.7	C	17.6	B	17.7	B	16.3	B
	EB	I-25 SB On-ramp	I-76 NB Off-ramp	25.4	C	30.5	D	24.8	C	27.3	D
		York Street On-ramp	Vasquez Boulevard Off-ramp	28.1	D	43.4	E	24.8	C	36.7	E
		Vasquez Boulevard On-ramp	Quebec Street Off-ramp	32.0	D	45.0	E	29.8	D	44.8	E

Source: Jacobs

Note: Assumes some vehicles shift to express lanes to attain LOS E.

EB = eastbound
WB = westbound

Table 5 notes that LOS E is attained when some drivers decide to pay the toll and move into the express lane to avoid congestion. The numbers needed to make that shift is manageable for the express lane. Table 6 shows peak hour traffic in the express lanes by segment and direction.

Table 6. Peak Hour Express Lane Volumes (2040 and 2050)

Facility	Segment	a.m. Peak Hour		p.m. Peak Hour	
		2040	2050	2040	2050
I-270 WB	I-70 to WB Ingress/Egress 2	1,020	830	1,120	1,120
	WB Ingress/Egress 2 to WB Ingress/Egress 1		1,020		1,170
	WB Ingress/Egress 1 to I-25/US-36	710	790	620	660
I-270 EB	I-25/US-36 to EB Ingress/Egress 1	440	630	680	1,010
	EB Weave 1 to EB Weave 2	700	1,250	790	1,470
	EB Weave 2 to I-70		1,070		1,210

Source: Jacobs

Note: Ingress/Egress denotes a space in the corridor where WB and EB traffic enters or exits the Express Lane. Ingress/Egress 1 is located between York Street and Vasquez Boulevard (2040 and 2050). Ingress/Egress 2 is located between Vasquez Boulevard and Quebec Street (2050 only).

4.0 Evaluating Reanalysis Need

Section 2.5.1 in the FHWA *Interim Guidance on the Application of Travel and Land Use Forecasting in NEPA* (2010) provides guidelines for determining the need to reevaluate an analysis. It states the following:

> *The study team may need to conduct sensitivity tests to assess the magnitude of differences from prior analyses resulting from use of new data and their effects on past decisions. Depending on the outcome of such tests, the study team may need to decide how to choose the best and most appropriate way to address the new information.*
>
> *... On the other hand, a sensitivity test may reveal that the changes caused by the introduction of the new data or model version do not change the conclusions made from the previous analysis. In this case, the study team would incorporate the updates to the model at a future milestone, such as for the final environmental impact statement, or simply document the change and the sensitivity analysis in the project administrative record and move on.*

To determine if changing to the Focus 2.3 2050 TDM is warranted, the study team focused on conclusions made based on the previous analysis regarding the following:

- Traffic operations and travel time reliability
- Roadway design
- Environmental impacts

4.1 Traffic Operations and Travel Time Reliability

The study team compared traffic forecasts from different models to understand the traffic operational impacts for the study corridor (I-270). The comparison between traffic forecasts from Focus 2.1 2040 and from Focus 2.3 2050 in the previous section shows that the peak hour traffic volumes will grow in the range of 12 to 40 percent in the 10 years from 2040 to 2050.

The difference in additional freeway density (Table 5) for both I-270 eastbound and westbound is modest for the peak-hour volumes on the roadway segments for a cross-section capacity of three to five lanes through the corridor (depending on location and direction). There would be increased traffic volumes for 2050 with the worst operating segment at LOS E; the HCM guidelines (TRB 2016) suggest that a LOS E or better is acceptable and LOS F would represent a demand that exceeds the capacity of a freeway segment. The additional freeway density would slightly impair the traffic operations by lowering the average speeds on the corridor, but the roadway facility would be able to absorb the additional needs and are therefore acceptable.

Because the additional peak-hour increase in freeway density is within acceptable limits per HCM guidelines (TRB 2016), it would be reasonable to consider that a separate traffic performance analysis for year 2050 would yield similar results as the 2040 forecasts and would not impact any design capacity decisions made based on the 2040 traffic analysis (refer to Section 4.2 for a discussion on roadway design). The system is operationally resilient for future year 2040 as well as 2050.

The traffic analysis results for the EA Proposed Action show average speeds around 40 miles per hour (mph) on general purpose lanes and around 45 mph and above on express lanes during the a.m. and p.m. peak hours. The additional freeway density during the congested hours would reduce the average speeds and reduce LOS slightly. However, the average speeds on the express lanes of the corridor would still be above 45 mph. The traffic analysis for the EA Proposed Action, based on 2040 forecasts, shows no slowdowns on express lanes, and this would remain the case with a slight increase in traffic volumes on the express lanes. Even if these additional vehicles forecasted for 2050 TDM slowed down the facility, in either the general purpose or the express lane, then the Colorado Department of Transportation (CDOT) has a tool to mitigate the effects by managing express lane demand through dynamic pricing, which can improve throughput. Therefore, considering the additional 2050 traffic volumes and CDOT's tool for dynamic pricing, the express lanes would still provide the travel time reliability to meet the project Purpose and Need.

4.2 Roadway Design

The study team reviewed the different traffic forecasts to determine whether the increase in volumes noted previously could affect the Proposed Action design for the mainline and the ramps.

The Proposed Action would add an additional lane, resulting in a three-lane facility in each direction on I-270 between I-25/US-36 and I-70. To address whether traffic increases from the 2050 Focus 2.3 TDM could necessitate adding highway capacity, the study team made several observations.

In addition to the additional lane in each direction, the Proposed Action includes improvements that would help accommodate additional vehicles. These include the following:

- Auxiliary lanes on the high-traffic segments on I-270. Westbound auxiliary lanes are proposed between Quebec Street and Vasquez Boulevard and from Vasquez Boulevard to the I-76 off-ramp. An auxiliary lane also is assumed in the eastbound direction between York Street and Vasquez Boulevard continuing east of the Vasquez Boulevard for about 3,500 feet. These auxiliary lanes would provide smooth merging and diverging for traffic and are long enough to provide additional storage in these segments.
- In the I-270 eastbound direction, a proposed new collector ramp that consolidates incoming movements from the consecutive I-76 entrance ramps. The collector ramp would be barrier separated from the I-270 mainline and would reduce traffic merging/diverging and accidents identified on I-270 eastbound near I-76. As I-270 traffic increases, the eastbound collector ramp will help move traffic more efficiently and safely in the I-76 area.
- Additional capacity for off-ramps. The I-76 off-ramp in the westbound direction is designed with a second optional exit lane that would increase capacity for traffic exiting I-270 and minimize any

backups on the mainline. Similarly, the Vasquez Boulevard off-ramp from I-270 eastbound includes an optional exit lane for the off-ramp.

Dynamic ramp meters are planned for the high-volume on-ramps (Quebec Street westbound, Vasquez Boulevard westbound, York Street eastbound, and Vasquez Boulevard eastbound). These systems will employ video detection systems with adaptive algorithms to monitor mainline traffic and ramp queues to help meter or flush ramp flow when peak-hour conditions warrant.

Collectively, the Proposed Action improvements are resilient and will accommodate the additional freeway density (increasing up to 15.3 pc/mi/ln) during the peak hours and still operate at LOS E or better, therefore requiring no changes to lane geometry.

4.3 Environmental Impacts

Environmental resources analyzed in the EA to date were reviewed to determine whether changing traffic models from Focus 2.1 2040 to Focus 2.3 2050 would alter key findings or conclusions made. Environmental impact analysis most affected by traffic data and changes include air quality and traffic noise. Changing traffic models would not affect key findings from the other environmental impact analysis. An air quality analysis has not been prepared for traffic modeled with Focus 2.1 2040; therefore, a sensitivity test is not needed.

4.3.1 Noise

Per the CDOT *Noise Analysis and Abatement Guidelines*, design year noise levels were modeled to determine whether the proposed project would impact noise-sensitive receptors and whether noise mitigation should be considered (CDOT 2020). The project noise analysis was initiated in late 2020 using the project-level traffic forecasts based on Focus 2.1 and a 2040 horizon year. The project TDM was used to generate traffic volumes along I-270 and local roadways (York Street, East 56th Avenue, and Sand Creek Drive). Project-specific traffic volumes were not available for I-25, I-70, I-76, Vasquez Boulevard, and Quebec Street. Therefore, traffic data were obtained from CDOT Online Transportation Information Systems (OTIS) for those roadways.

Based on the noise analysis being conducted in support of the EA, the 2040 Proposed Action General Purpose and Express Lane Operating Options are expected to impact 32 noise-sensitive receptors (20 activity category B and 12 activity category C) within 11 impacted areas. Barrier analyses were conducted in two locations, but neither barrier met the cost-reasonable criterion.

A sensitivity analysis was performed to determine whether any increase in traffic from Focus 2.3 2050 traffic volumes could potentially change the noise analysis results. Forecasted peak-hour volumes and truck percentages for years 2040 and 2050 were reviewed to gauge the potential change in design year noise levels. As shown in Table 1 compared to 2040 forecasted volumes, 2050 traffic volumes would be higher along I-270 mainlines and ramps depending on location. The 2050 truck percentages would be lower compared to 2040 truck percentages. Areas with higher traffic volumes in 2050 would see potential increase in design year noise levels. However, even if traffic increases, the change in noise levels is not anticipated to be perceptible. Per the FHWA *Highway Traffic Noise: Analysis and Abatement Guidance*, a doubling of the noise source (that is, traffic volume) would result in an increase of only 3 decibels, which is barely perceptible (FHWA 2011).

Along I-270 between I-25 and I-76, 2050 traffic volumes would increase compared to 2040 traffic volumes. Along I-270 eastbound, only one recreational receptor would be impacted per the noise analysis based on 2040 volumes. Noise levels from 2050 volumes would not result in any additional noise impacts along this segment. Most of the noise-sensitive receptors located along I-270 westbound are located farther from I-270 (near the outer edge of the 500-foot noise study zone) and would not be impacted. Noise levels from 2050 volumes would not result in any additional noise impacts.

Along I-270 between I-76 and York, 2050 traffic volumes would increase compared to 2040 traffic volumes. The increase in 2050 traffic volumes along I-270 eastbound could result in one impacted receptor in the southwest quadrant of I-270 and York Street where the 2040 noise level at this receptor was just below the noise abatement criteria (NAC) of 66 A-weighted decibels (dBA). The 2040 noise levels at other receptors were estimated around 61 dBA. Even if traffic doubled with 2050 traffic volumes, noise levels would still be below the NAC of 66 dBA for those residential receptors and, therefore, no additional receptors would be impacted that would warrant evaluation of noise abatement. Along eastbound I-270 and the York Street on-ramp, traffic volumes would increase and could result in one additional impacted receptor in the southeast quadrant of I-270 and York Street. Because the 2040 analysis resulted in two residential receptors in this quadrant, noise abatement assessment would be warranted based on an additional impact from 2050 volumes. However, based on barrier dimensions and cost per benefited receptor, a noise barrier will not meet the cost-reasonable criteria. The increase in 2050 traffic volumes and slight shift in travel lanes along I-270 westbound near York Street, due to the separation of the I-76 system ramp from the York Street service ramp, could result in additional impacted receptors near the York Street off-ramp where the 2040 noise levels at other nearby receptors were estimated around 63 dBA. However, a noise barrier would not be feasible in this area because gaps for access would render the barrier ineffective.

Along I-270 between York Street and Vasquez Boulevard, all recreational receptors are impacted. There are no additional recreational receptors that would be impacted under 2050 conditions.

Along I-270 between Vasquez Boulevard and Quebec Street, 2050 traffic volumes would increase compared to 2040 traffic volumes. Along eastbound I-270, there are several recreational receptors associated with the Sand Creek Trail, one of which would be impacted under 2040 Build conditions. Considering the traffic increase in 2050 is less than double, additional noise impacts are unlikely and, even if impacted, would not warrant noise abatement assessment because there would be fewer than three impacted receptors behind a prospective barrier.

Vasquez Boulevard would be reconfigured as a partial cloverleaf interchange with exit ramps terminating at Vasquez Boulevard signals. The purpose of this configuration is to increase green-time around the newly installed signals by introducing a Turbo-T design for the ramp legs of the intersection. The only receptor near this interchange includes a recreational receptor that is impacted based on the modeled design and 2040 traffic volumes. There are no additional receptors that would be impacted in this area. Along westbound I-270, the 2050 traffic volumes would increase compared to 2040 traffic volumes. Two noise barriers were modeled in this area for the impacted receptors based on 2040 traffic volumes. Even if the increase in traffic volumes resulted in additional impacts, this would not trigger additional noise barrier analysis because noise barriers were already considered and modeled in this area. In addition, the change in traffic volumes would not result in additional benefited receptors that would change the results of the noise barrier analysis; the noise barriers would still not meet the reasonable criteria of the CDOT noise policy.

Along I-270 between Quebec Street and I-70, there are impacted recreational areas. Considering the increase in 2050 traffic, additional noise impacts are unlikely and, even if impacted, would not warrant noise abatement assessment because there would be fewer than three impacted receptors behind a prospective barrier.

5.0 Conclusions

The study team has completed the sensitivity analysis to determine the potential need to change from the Focus 2.1 2040 TDM to the Focus 2.3 2050 TDM to support the EA and its associated technical analysis.

The results of the comparative analysis indicate that the peak-hour traffic volumes from the 2040 TDM to 2050 TDM are only degrading higher volume sections from a LOS D to LOS E (Table 5). Because most of the resource analyses, including traffic operations, focus on the peak periods, the 2040 TDM traffic volumes appear to represent a scenario of similar conditions to the 2050 TDM. In assessing whether switching to the 2050 TDM would alter key decisions made based on the 2040 TDM, the sensitivity analysis indicates that such a switch would not alter these key decisions. Specifically, switching to the 2050 TDM is not expected to change the following:

- Proposed Action design or impact limits
- Travel time reliability from the Proposed Action
- Key results of the noise analysis

Based on the above considerations, FHWA and CDOT have agreed to use the approved DRCOG Focus 2.1 2040 TDM as a basis for its project-level analysis.

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Attachment 1

DRCOG Releases Focus 2.3

Memorandum

To: Member Governments, Planning Partners, Project Consultant Staff

From: DRCOG Travel Model Team

Date: January 22, 2021

Re: DRCOG Releases Focus 2.3

DRCOG is pleased to announce the completion of the latest update to its regional activity-based travel demand forecasting model. Focus version 2.3 was used in support of DRCOG's new 2050 Metro Vision Regional Transportation Plan, which is anticipated to be adopted by the DRCOG Board of Directors in April 2021.

Model runs for the years 2020, 2023, and 2050 are currently available. Note that the 2020 model run was based on travel conditions prior to the impacts of the COVID-19 Pandemic. Additional model years (2030, 2040, and 2045) will be available by the end of the January. If you plan to use the model for a study requiring a federal action (e.g., an EA or EIS), note that Focus 2.3 is not technically "official" until after the 2050 MVRTP is adopted by the DRCOG board in April. However, we are very confident that it will be adopted and thus deem the current Focus 2.3 official.

As always please use the model request process and applicable form on the DRCOG website depending on if you wish to use the model itself, or if you want to receive data output files.

Key Changes within Focus 2.3:

ABM Changes

Telework

- Adjusted utility functions and other factors to reflect increase in Work at Home share to a target of 20% (instead of 12%) for 2023 staging year and after. This assumption and target were based on an analysis of data observed between 2010 and 2019, as well as an extensive literature and research review of expectations for the future.

Improved ABM Logic to Ensure Simulated Activity and Travel Schedules are Feasible and Reasonable

- Additional utility parameters to balance Worker/Jobs by Area Type.
- Additional utility parameters to fine tune Work at Home.
- Improved transit with drive and walk access distance and time calculations for Inbound and Outbound directions.

Tripod Changes

Household Size Distribution

- Airport, commercial vehicle, and external trip generation is now based on explicit household size distributions, rather than on regional distributions.

Commercial Vehicle (CV) Model

- CV trips now stratified by three vehicle types: light-duty, medium duty, and heavy duty (LD, MD, and HD)
- Explicit modeling of truck tolls (MDCV & HDCV)
- Easier control of PCE assumptions for MDCV and HDCV
- Consideration of trucks (MDCV & HDCV) making IE and EE trips
- Improved CV trip rates

Transit Skimming

- Updated path-building to better model skims when multi-pathing combines routes from different service classes.
- Now supports a single "master" shadow price file with entries for each of the four transit time periods.

BRT

- Special treatment for new BRT systems
  - Introduce Freeway BRT (Mode 22)
  - Introduce Arterial BRT (Mode 21)
  - Remove Metro BRT (Mode 13)
  - Remove Urban BRT (Mode 16)

Walk and Bike Networks

- Now use link types 98 and 99 in addition to the link type 1 already used.

Additional Tripod Utilities for Preparation and Reporting

Several changes to the Tripod GISDK script were made to simplify preparing and running Focus:

- The "Create DTT Tour Origin Layer" analyzes ABM output for Park-n-Ride commuter-shed mapping.
- The "Map Jobs-Worker Balance" now calculates workers by the industry sector of the job point they choose (useful for calibrating the Work Location Choice mode) as well as their sector of training.
- The "Network Consistency Check" now explicitly checks that each PnR in the node layer has an entry in the shadow price file, and vice versa.

Appendix C

I-270 Travel Time Reliability – Existing Conditions Assessment

I-270 Travel Time Reliability – Existing Conditions Assessment Technical Memorandum

PREPARED FOR: CDOT Region 1
COPY TO: FHWA CO Division
PREPARED BY: EA Team
DATE: June 4, 2021

1.0 Introduction

With an influx of residents and increasing number of drivers on our roadways, nearly all Colorado drivers experience and plan around traffic congestion as part of their daily activities. However, on many primary roadways like interstates, travel times vary greatly from day to day, and travelers are less tolerant of unexpected delays. Comments and complaints received from Interstate 270 (I-270) corridor travelers through project outreach events indicate they are frustrated with regular congestion and delays from incidents, weather, work zones, or other factors. Travelers notice and remember the bad days over those with no problems, and the perception is that the bad days are becoming more common and even the norm (CDOT 2018). The following analysis will show a clear need for the I-270 Corridor Improvements Project (project) to improve travel time and reduce delays in the corridor.

2.0 Methodology

When drivers have a predictable travel time, they are able to plan their trips and be relatively confident that they will arrive on time. However, as shown on Figure 1, the heavily congested days when they are late for work or miss an important appointment, or when freight deliveries are impacted, are the ones they remember.

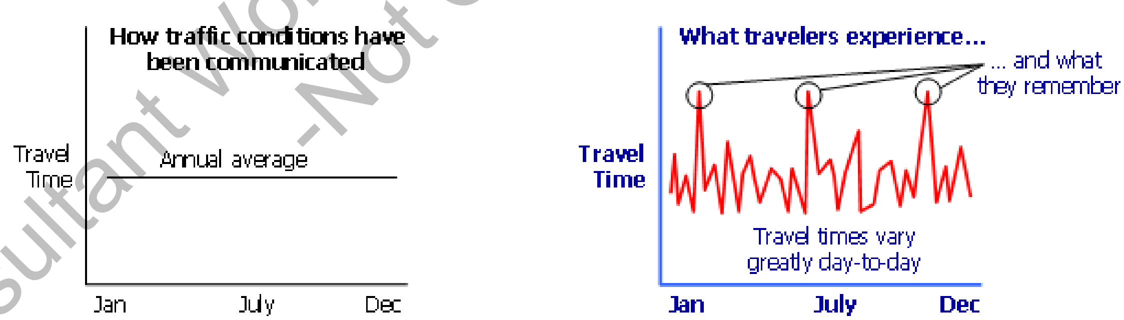

Figure 1. Typical Travel Times
Source: FHWA 2017

Drivers on I-270 between Interstate 70 (I-70) and Interstate 25 (I-25) regularly and sometimes unexpectedly experience congestion, delay, and turbulence in the traffic stream not commonly found on rural freeways. As part of the project, the study team assessed corridor travel time reliability to best represent these known corridor conditions. This assessment helped understand the level of congestion, changing traffic conditions, and factors contributing to delay.

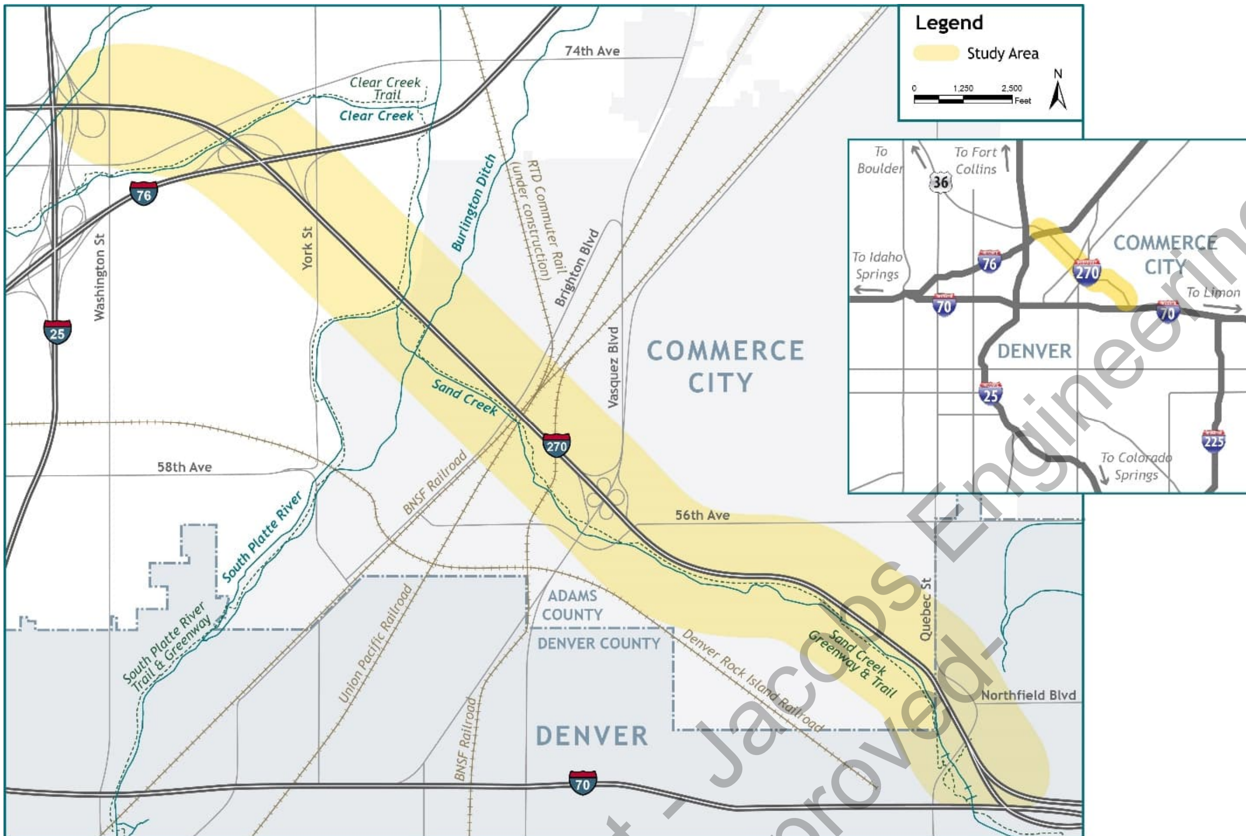

Figure 2. Study Area
Source: Jacobs

Travel times on westbound and eastbound I-270 were obtained from INRIX, a company that collects roadway speeds from over 250 million real-time anonymous cell phones worldwide. Raw point-to-point travel times between exits were compiled from the INRIX database in 15-minute time periods for 2016 and 2019. CDOT has completed an assessment of INRIX travel time data and has validated its reliability.

For travel time purposes, each direction of the study corridor was studied separately. I-270 westbound in the study area is from I-70 to I-25 and I-270 eastbound is from I-25 to I-70 (Figure 2).

Travel time reliability for the study corridor was analyzed using two different measures: reliability rating and frequency of congestion. The reliability rating is the percentage of trips that is serviced at or below a threshold Travel Time Index (TTI), the ratio of the actual travel time to the free-flow travel time. The TTI thresholds generally selected are 1.33 for freeways and 2.50 for urban streets (Transportation Research Board 2014).

The frequency of congestion measure is typically expressed as the percentage of days or time that travel times exceed pre-established number of minutes (FHWA 2017). Table 1 illustrates the thresholds with a color gradient from dark green to light green to yellow to red was used to display the free-flow (posted speed limit), good, fair, and poor travel times, respectively. The data for 2016 and 2019 were also summarized as the percentage of trips with travel times in each threshold category. The data were also plotted on three-dimensional graphs, with the X-axis representing the day of the year, the Y-axis representing the time of day, and the Z-axis representing the calculated travel time.

Table 1. Travel Time Thresholds

Reliability Categories	Thresholds in Minutes
Free-Flow	Free-Flow Travel Time
Good	Free-Flow Travel Time to Average Travel Time
Fair	Average Travel Time to 95th Percentile Travel Time
Poor	> 95th Percentile Travel Time

Source: Jacobs

Travel time reliability was assessed separately by direction for westbound and eastbound I-270 for both data years (2016 and 2019). The data were further analyzed by day of the week to understand the effects of both typical weekday commuter travel and recreational travel occurring on weekends. The data were stratified into weekdays (Monday through Friday) and weekends (Saturday through Sunday). The weekday data were also analyzed separately for a.m. and p.m. peak periods.

Finally, days with fair or poor travel time reliability were investigated to determine if any specific causal factor might have contributed to the decreased reliability. Those causes were categorized as follows:

- The incidents event category included events such as recorded stalled vehicles, police enforcement, and crashes.
- Impacts due to weather were determined from CDOT logs and National Oceanic and Atmospheric Administration (NOAA) data.
- The planned and special events category included events such as the Renaissance Festival, U.S. Air Force Academy athletics, Denver Broncos football games, and scheduled CDOT maintenance activities.
- The unaccounted category was used for days that had no apparent causal factor, when traffic volume alone was the most likely cause of the degraded travel time reliability.
- The multiple events category was used when days had multiple 15-minute periods of fair or poor travel time reliability and there was more than one apparent contributing factor.

3.0 Corridor Travel Time Reliability Assessment

Travel time reliability was assessed as noted in Section 2, Methodology. Sections 3.1 and 3.2 present the analyses for I-270 westbound and I-270 eastbound, respectively.

3.1 I-270 Westbound

Table 2 shows the reliability rating on I-270 westbound for four time periods in 2016 and 2019: weekdays overall, weekdays a.m. peak, weekdays p.m. peak, and weekends. The reliability ratings in 2019 were generally lower than the ratings in 2016 for the same time period or days of the week. On I-270 westbound in both years, travel times were least reliable during the p.m. peak period and most reliable on the weekends.

Table 2. Reliability Rating, I-270 Westbound

Segment	Weekdays		Weekdays a.m. Peak		Weekday p.m. Peak		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
I-270 Westbound, I-70 to I-76	68.45%	60.27%	30.52%	19.31%	14.90%	13.24%	96.65%	92.42%

Source: Jacobs

% = percent

Table 3 and Figure 3 through Figure 12 display the travel time reliability analysis based on the frequency of congestion on I-270 westbound in 2016 and 2019 during those same time periods. Table 2 shows that a higher percentage of trips experienced poor travel time reliability on I-270 westbound during the p.m. peak period for both 2016 and 2019. In addition, as shown on Figure 3, most of the poor travel times on I-270 westbound in 2016 occurred in the evening hours and were more prominent in the summer and holiday seasons. While this same trend appears for the 2019 evening hours (Figure 8), it occurred mainly in the earlier months of the year. The duration of poor travel reliability and number of poor travel days increased in 2019 compared to 2016.

Table 3. Frequency of Congestion, I-270 Westbound

Threshold Category	Weekdays		Weekdays a.m. Peak		Weekday p.m. Peak		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
Free Flow	57.3%	47.6%	11.5%	8.0%	8.4%	6.8%	89.2%	79.3%
Good	8.7%	12.6%	14.1%	11.3%	4.9%	6.4%	6.1%	13.1%
Fair	27.0%	32.9%	72.2%	77.0%	52.8%	55.6%	4.5%	7.2%
Poor	6.9%	6.8%	2.2%	3.7%	33.9%	31.2%	0.2%	0.4%

Source: Jacobs

The travel time reliability on I-270 westbound based on both measures was worse on weekdays (particularly in the p.m. peak period) when compared to the weekends in both 2016 and 2019. The weekend data in Table 3 show an increase in the occurrence of fair or poor travel time reliability in 2019 compared to 2016. There was a higher percentage of trips in the fair or poor travel time category in 2019 than 2016. Overall, the travel time reliability decreased from 2016 to 2019.

Table 4 and Table 5 show the I-270 westbound causal factor analyses for 2016 and 2019, respectively. In 2016, 85 percent of the days of the year (311 out of 366, as 2016 was a leap year) had at least one 15-minute period experiencing fair or poor travel time reliability. This number increased to 330 days, or 90 percent, in 2019. Multiple events (that is, a combination of two or more events including incidents, public service announcements [PSAs], planned events, or roadwork occurring on a single day) comprised most of the fair or poor travel time reliability days (66 percent) in 2019. Roadwork was a strong causal factor of fair or poor travel time reliability in both 2016 and 2019. During the weekends, unaccounted congestion and roadwork were prevalent causal factors in 2016 and roadwork was the main casual factor in 2019. It should be noted that I-70 was under construction during 2019 and likely diverted traffic to I-270.

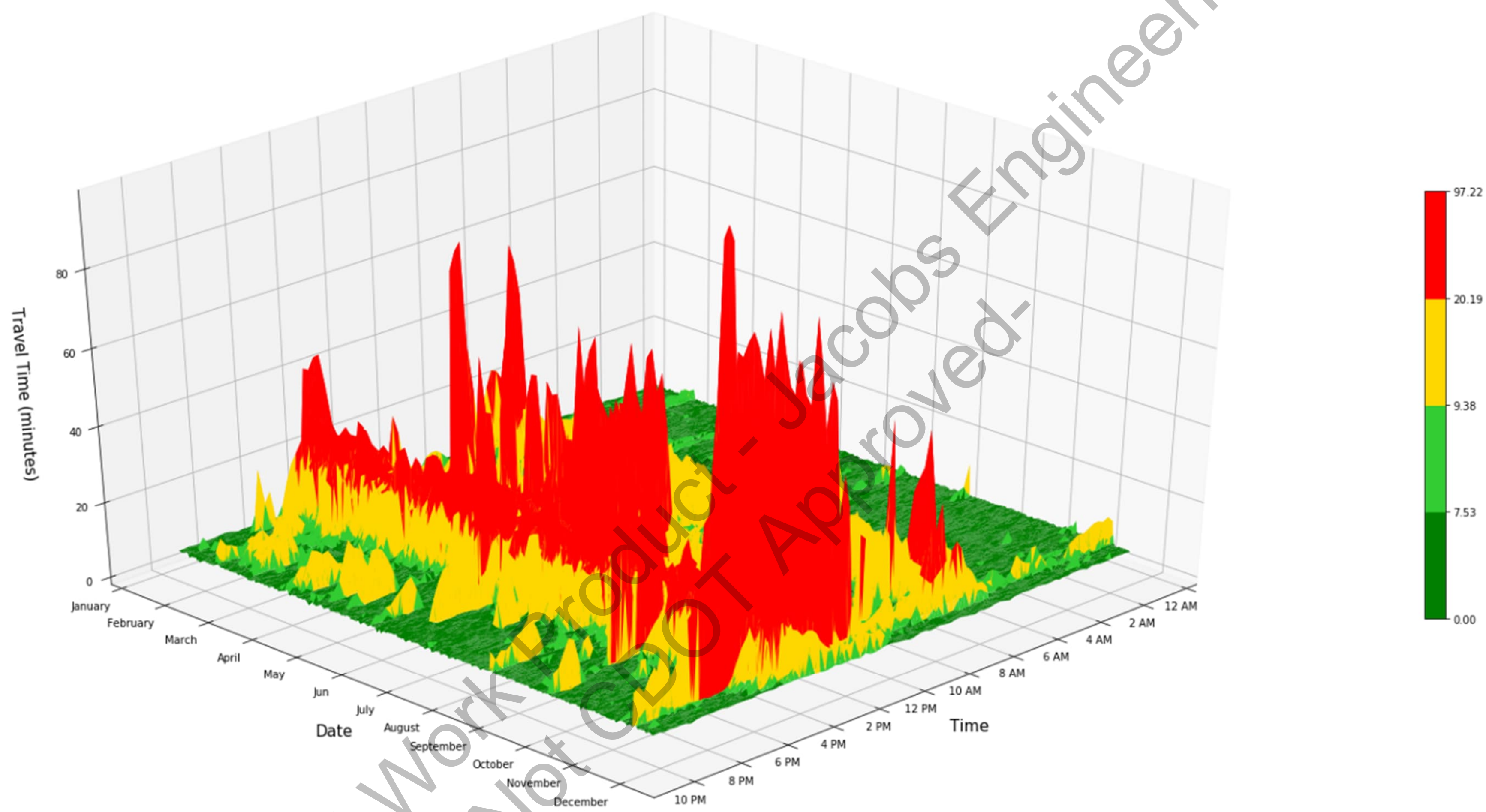

Figure 3. I-270 Westbound—All Days 2016
Source: Jacobs

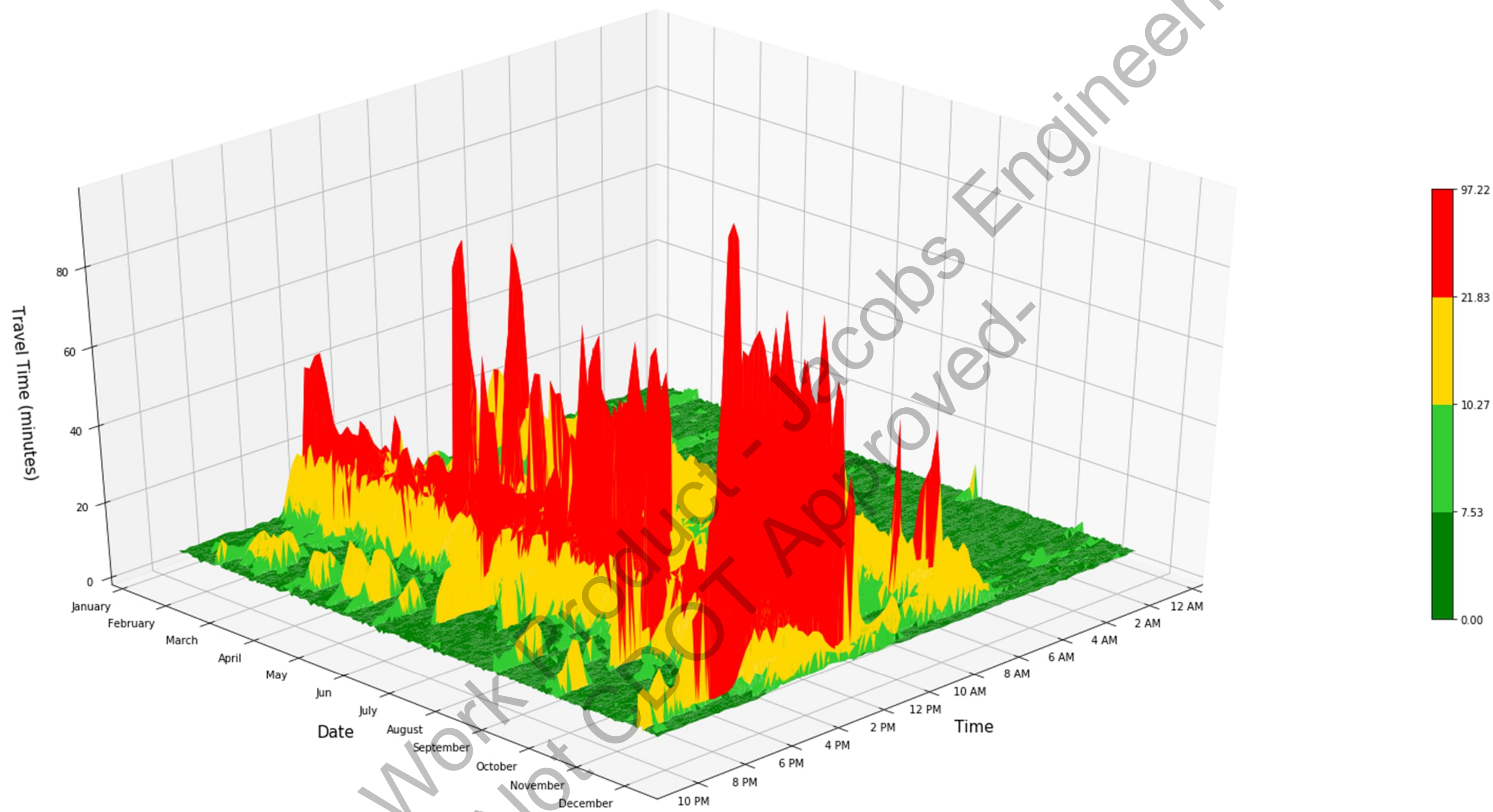

Figure 4. I-270 Westbound—Weekdays 2016
Source: Jacobs

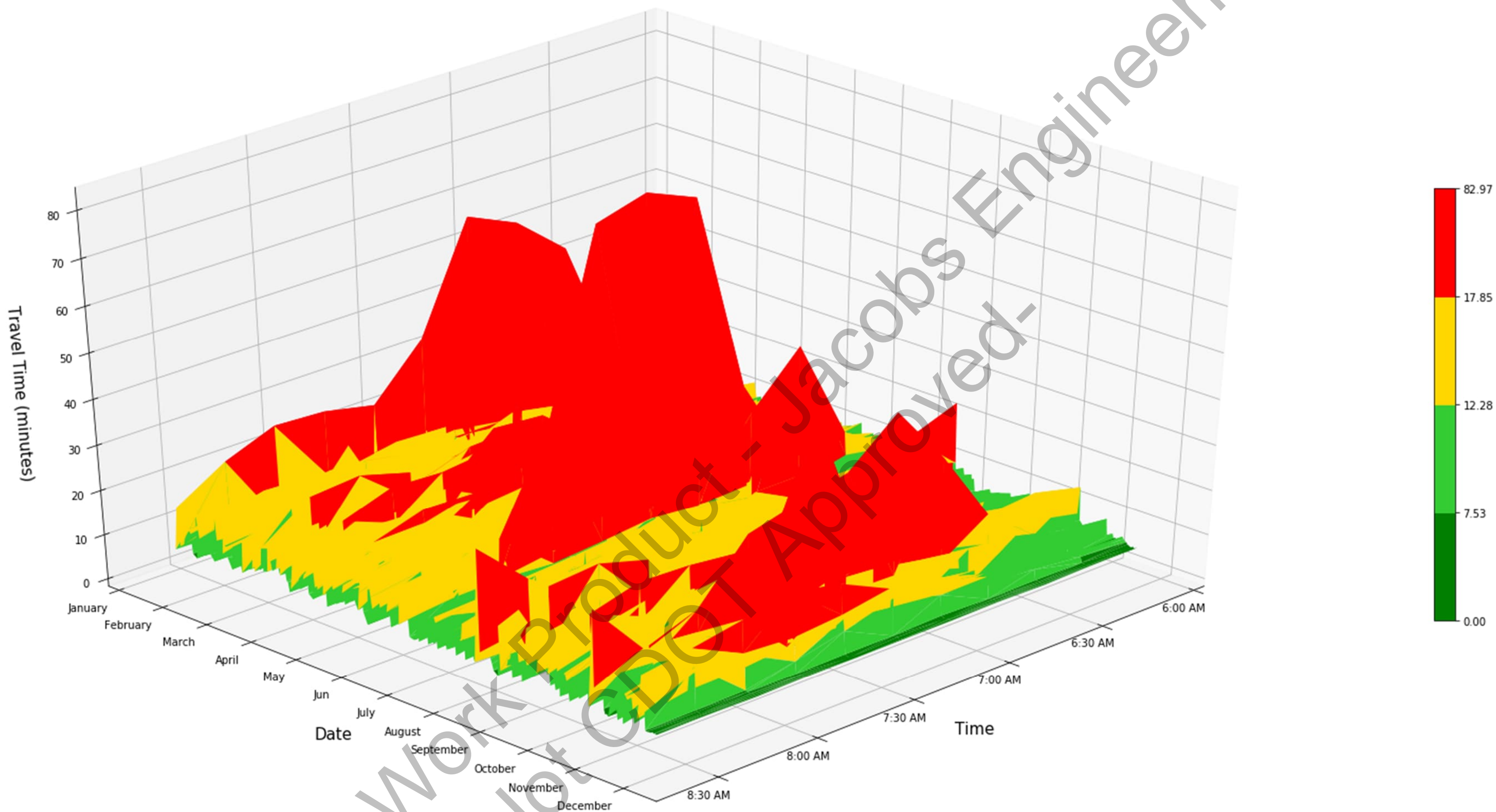

Figure 5. I-270 Westbound—Weekdays a.m. Peak 2016
Source: Jacobs

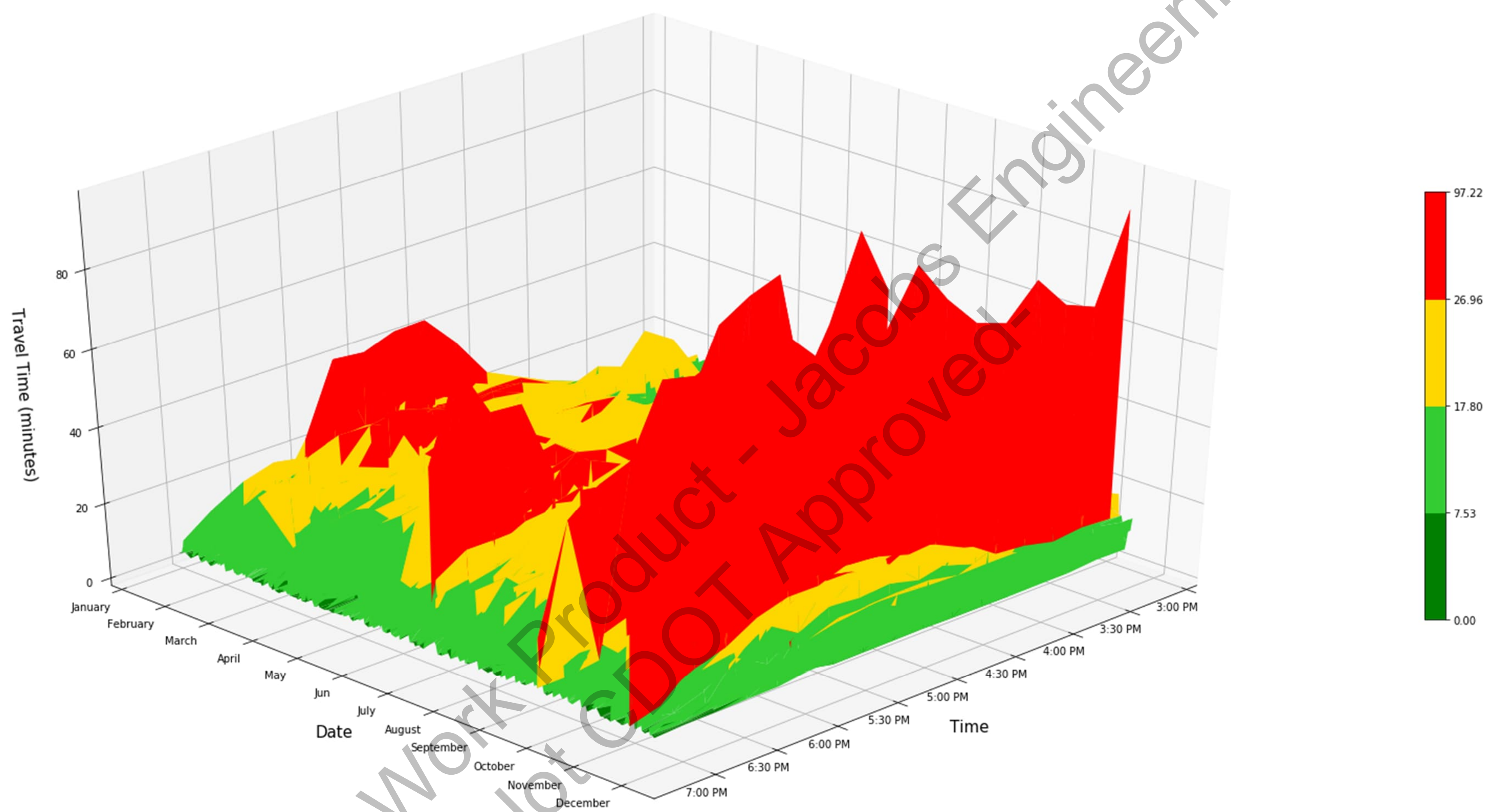

Figure 6. I-270 Westbound—Weekdays p.m. Peak 2016
Source: Jacobs

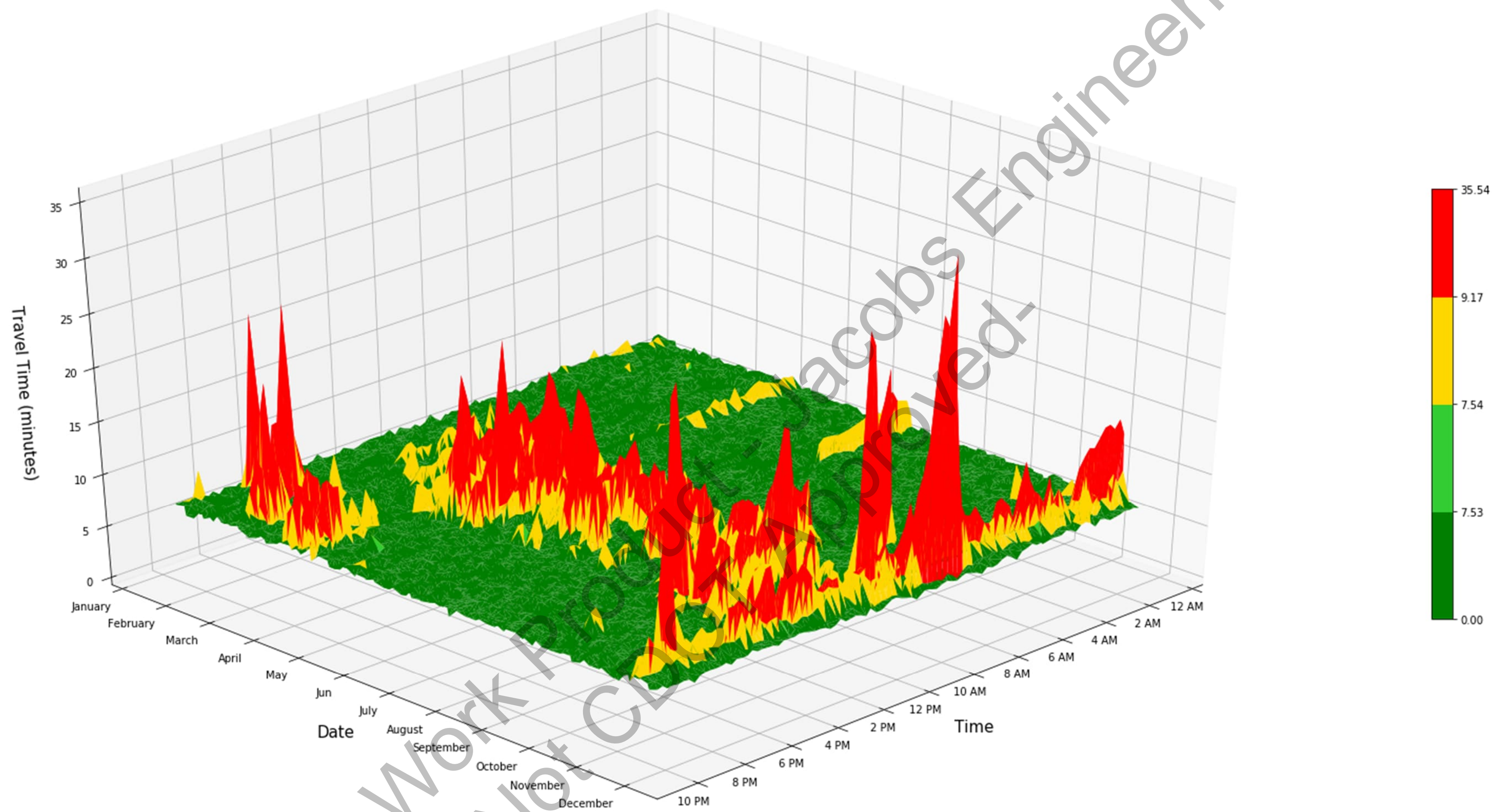

Figure 7. I-270 Westbound—Weekends 2016
Source: Jacobs

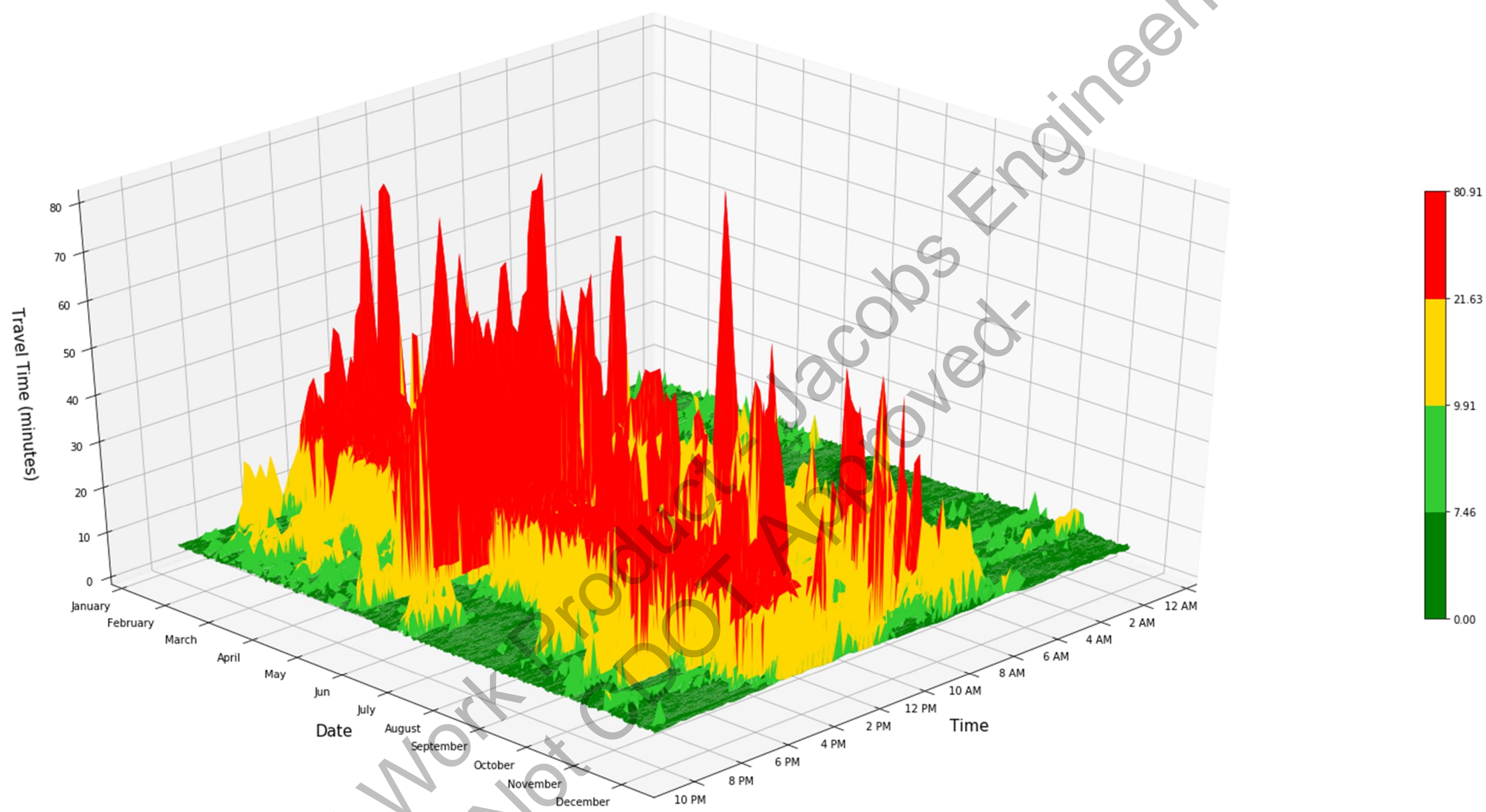

Figure 8. I-270 Westbound—All Days 2019
Source: Jacobs

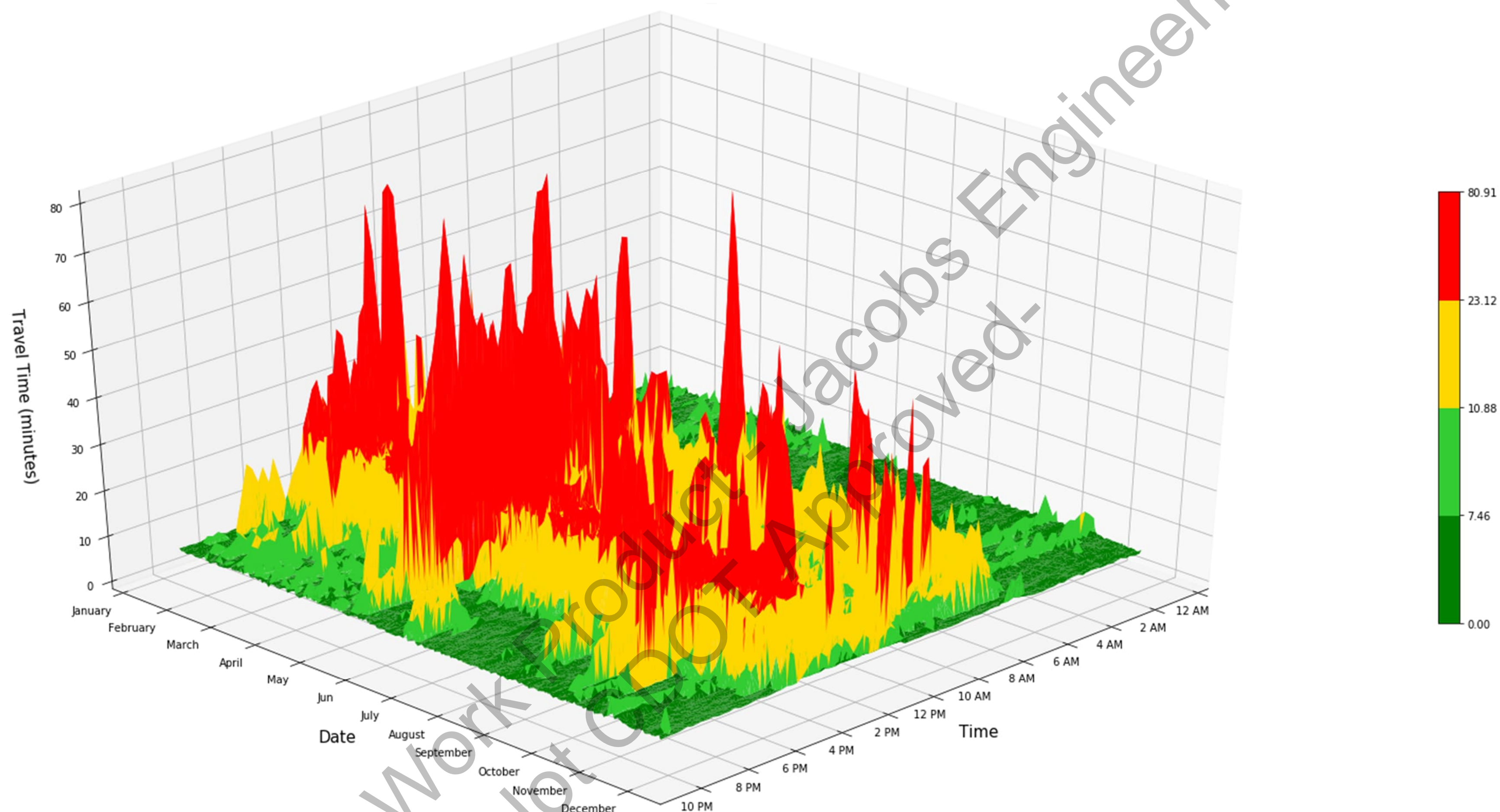

Figure 9. I-270 Westbound—Weekdays 2019
Source: Jacobs

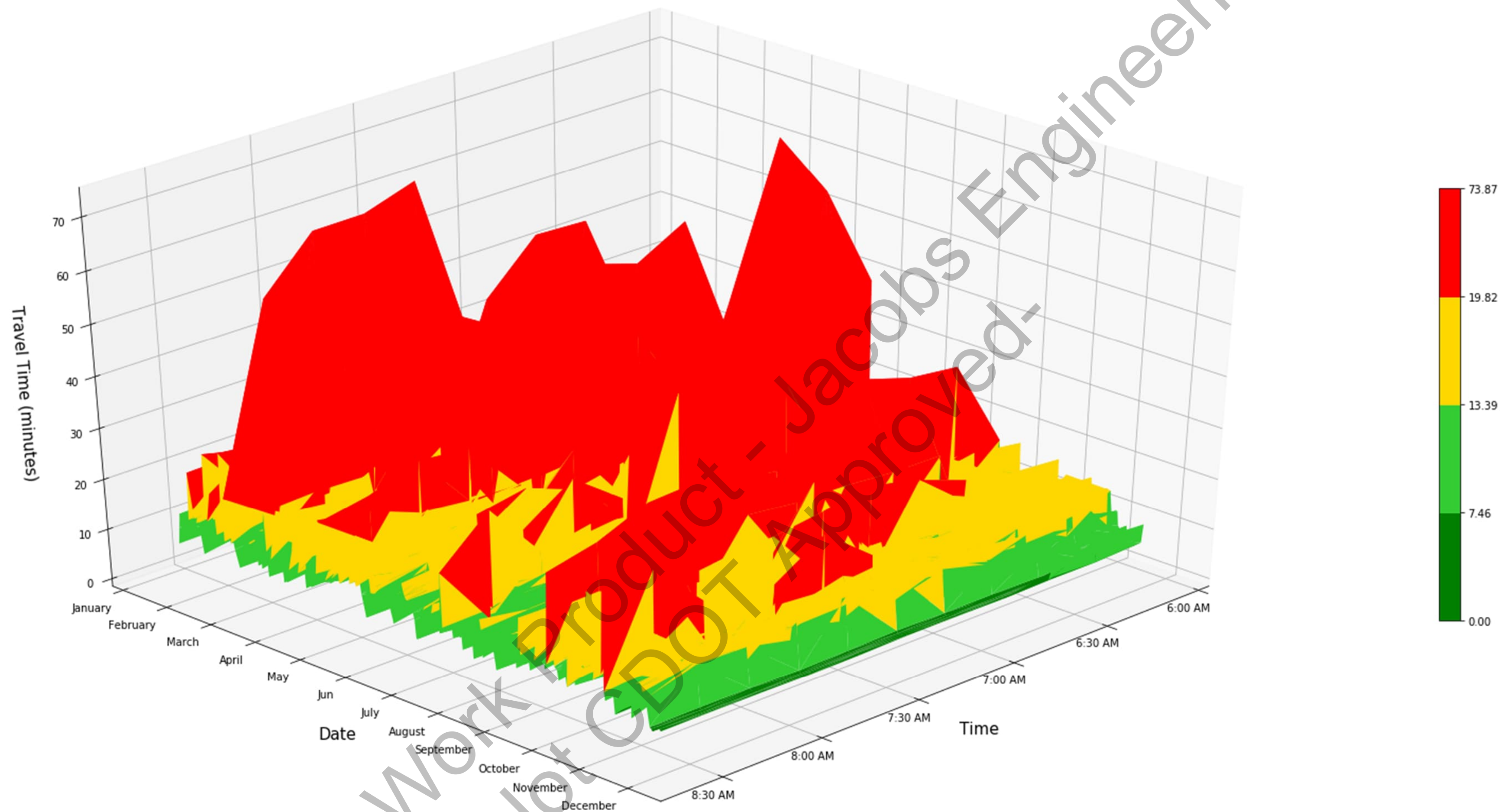

Figure 10. I-270 Westbound—Weekdays a.m. Peak 2019
Source: Jacobs

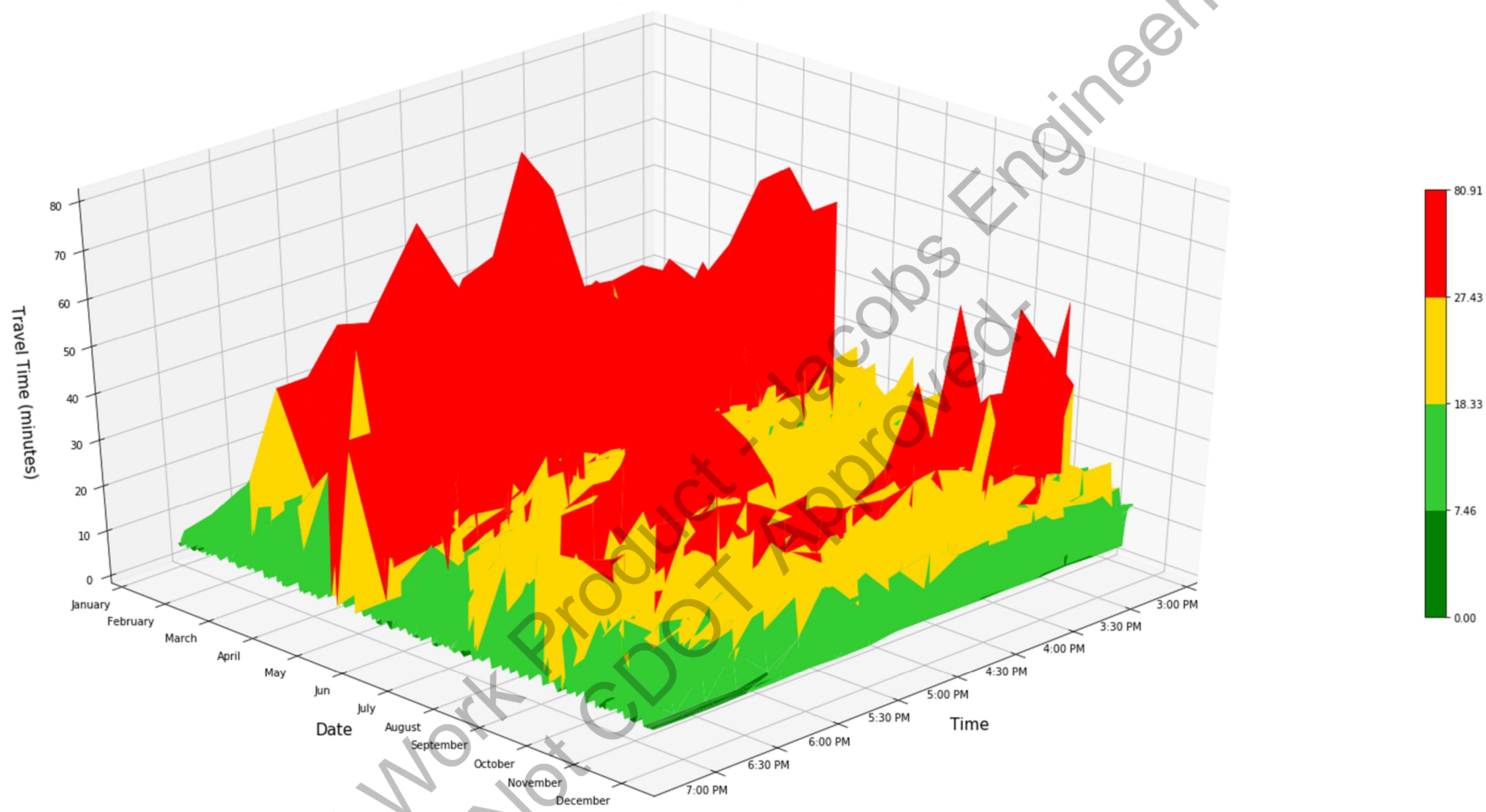

Figure 11. I-270 Westbound—Weekdays p.m. Peak 2019
Source: Jacobs

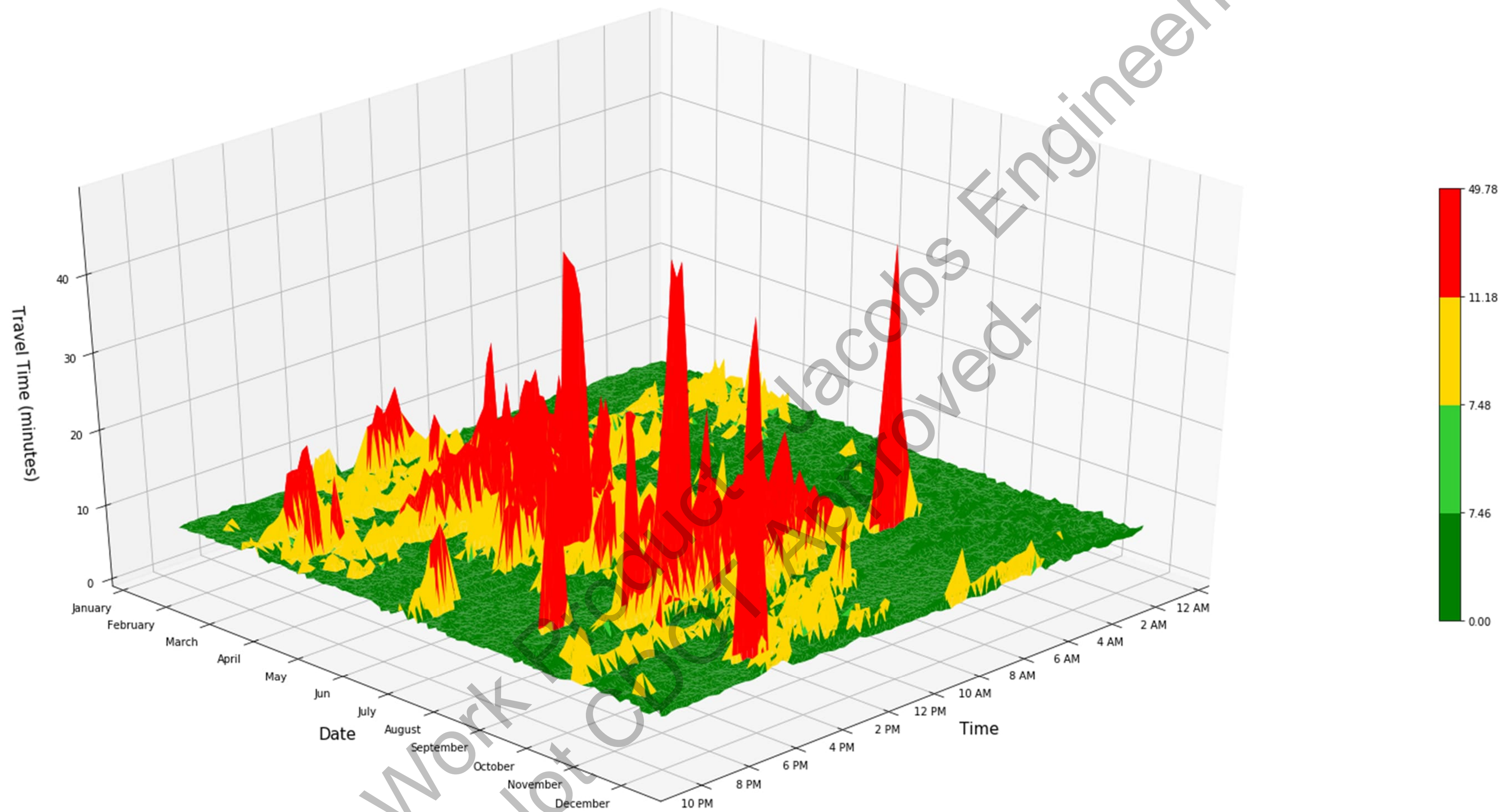

Figure 12. I-270 Westbound—Weekends 2019
Source: Jacobs

Table 4. I-270 Westbound: Causal Factor Analysis for Fair or Poor Days of 2016

		Total Year 2016				Day of Week							
						Count				% of Total for Event Type			
Event Type		Count		% of Total Events		Weekday		Weekend		Weekday		Weekend	
Incident		10		3.22%		10		0		100.00%		0.00%	
Planned Event		25		8.04%		20		5		80.00%		20.00%	
PSA[a]		-		-		-		-		-		-	
Roadworks		88		28.30%		71		17		80.68%		19.32%	
Multiple Events[b]		14		4.50%		9		5		64.29%		35.71%	
Unaccounted/ Congestion	Monday	29	174	9.32%	55.95%	29	144	-	30	16.67%	82.76%	-	17.24%
	Tuesday	27		8.68%		27		-		15.52%		-	
	Wednesday	26		8.36%		26		-		14.94%		-	
	Thursday	31		9.97%		31		-		17.82%		-	
	Friday	31		9.97%		31		-		17.82%		-	
	Saturday	21		6.75%		-		21		-		12.07%	
	Sunday	9		2.89%		-		9		-		5.17%	
TOTAL		311		100.00%		254		57		81.67%		18.33%	

Source: Jacobs

[a] PSAs on VMS boards.

[b] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

VMS = variable message sign

Table 5. I-270 Westbound: Causal Factor Analysis for Fair or Poor Days of 2019

Event Type		Total Year 2019		Day of Week			
				Count		% of Total for Event Type	
		Count	% of Total Events	Weekday	Weekend	Weekday	Weekend
Incident[a]		-	-	-	-	-	-
Planned Event[a]		-	-	-	-	-	-
PSA[b]		-	-	-	-	-	-
Roadworks		89	26.97%	69	20	77.53%	22.47%
Multiple Events[c]		241	73.03%	186	55	77.18%	22.82%
Unaccounted/ Congestion	Monday	- -	- -	- -	- -	- -	- -
	Tuesday	-	-	-	-	-	-
	Wednesday	-	-	-	-	-	-
	Thursday	-	-	-	-	-	-
	Friday	-	-	-	-	-	-
	Saturday	-	-	-	-	-	-
	Sunday	-	-	-	-	-	-
TOTAL		330	100.00%	255	75	77.27%	22.73%

Source: Jacobs

[a] Incidents and planned events did occur but were captured in the multiple events type for this dataset.

[b] PSAs on VMS boards.

[c] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

32 I-270 Eastbound

Table 6 shows the reliability rating on I-270 eastbound for the assessment time periods in 2016 and 2019.

Table 6. Reliability Rating, I-270 Eastbound

Segment	Weekdays		Weekdays a.m. Peak		Weekday p.m. Peak		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
I-270 Eastbound, I-70 to I-76	78.72%	69.6%	25.78%	14.9%	43.61%	27.55%	97.52%	93.72%

Source: Jacobs

As shown in Table 6, the reliability ratings in 2019 were generally lower than the ratings in 2016 for the same time period or days of the week. For both years, the travel time was the least reliable during the a.m. peak periods and most reliable on the weekends. The combined analysis of reliability ratings for both I-270 westbound and I-270 eastbound (Table 2 and Table 6) shows that the I-270 westbound weekday p.m. peak has the lowest reliability ratings.

Table 7 and Figure 13 through Figure 22 display the travel time reliability analysis based on the frequency of congestion on I-270 eastbound for the subject time periods. Table 7 shows that a higher percentage of trips experienced poor travel time reliability on I-270 eastbound during the a.m. peak period for both 2016 and 2019. In addition, as shown on Figure 13, most of the poor travel times on the I-270 eastbound in 2016 occurred in the morning hours and were more prominent in the summer months. While this same trend appears in 2019 for the morning hours (Figure 18), it occurred mainly in the earlier months of the year. The duration of poor travel reliability and number of poor travel days increased in 2019 compared to 2016.

Table 7. Frequency of Congestion, I-270 Eastbound

Threshold Category	Weekdays		Weekdays a.m. Peak		Weekday p.m. Peak		Weekends	
	2016	2019	2016	2019	2016	2019	2016	2019
Free Flow	66.2%	50.1%	9.8%	6.7%	18.4%	9.6%	92.7%	78.9%
Good	3.1%	13.2%	2.6%	4.2%	4.3%	8.7%	1.9%	10.4%
Fair	24.0%	30.0%	55.9%	61.1%	63.8%	70.9%	4.9%	9.8%
Poor	6.7%	6.7%	31.7%	28.0%	13.5%	10.8%	0.6%	0.8%

Source: Jacobs

As on I-270 westbound, the travel time reliability on I-270 eastbound based on both measures was worse on the weekdays (though particularly in the a.m. peak period) when compared to the weekends in both 2016 and 2019. Again similarly to I-270 westbound, the I-270 eastbound weekends data in Table 7 show an increase in the occurrence of fair or poor travel time reliability in 2019 compared to 2016. There was a higher percentage of trips in the fair or poor travel time category in 2019 than 2016. Overall, the travel time reliability decreased from 2016 to 2019. There were more occurrences of fair or poor travel time reliability on I-270 westbound than I-270 eastbound (Tables 3 and 7).

Table 8 and Table 9 show the I-270 eastbound causal factor analyses for 2016 and 2019, respectively. In 2016, 87 percent of the days of the year (319 out of 366) had at least one 15-minute period experiencing fair or poor travel time reliability. This number increased to 341 days, or 93 percent, in 2019. This increase may be explained by the occurrence of multiple events on the study days (59 percent) and by roadwork (27 percent). On a percentage basis, the causal factors from multiple events dramatically increased (from 5 percent to 59 percent), with congestion comprising approximately 93 percent of the days of fair or poor travel time reliability.

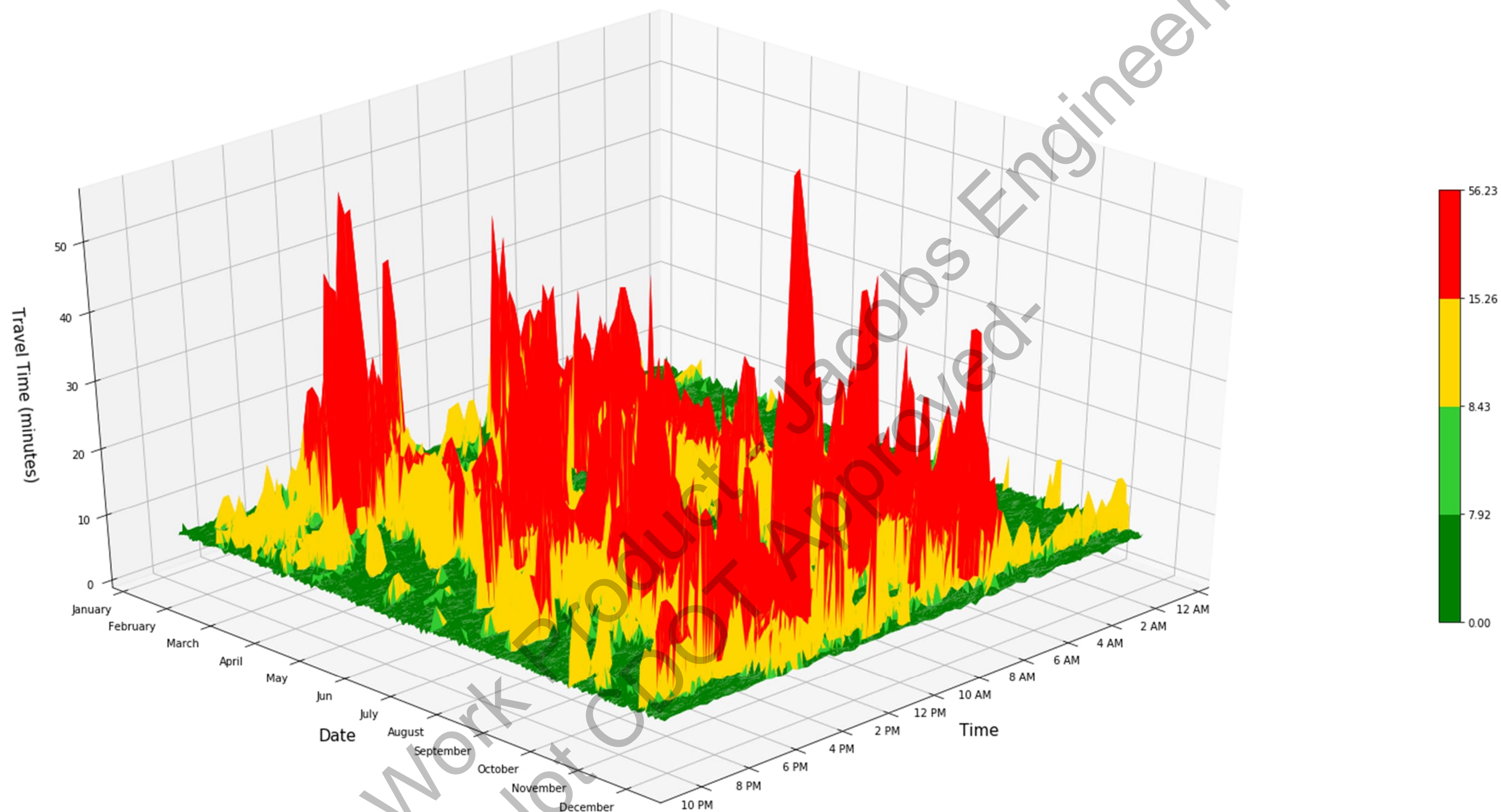

Figure 13. I-270 Eastbound—All Days 2016
Source: Jacobs

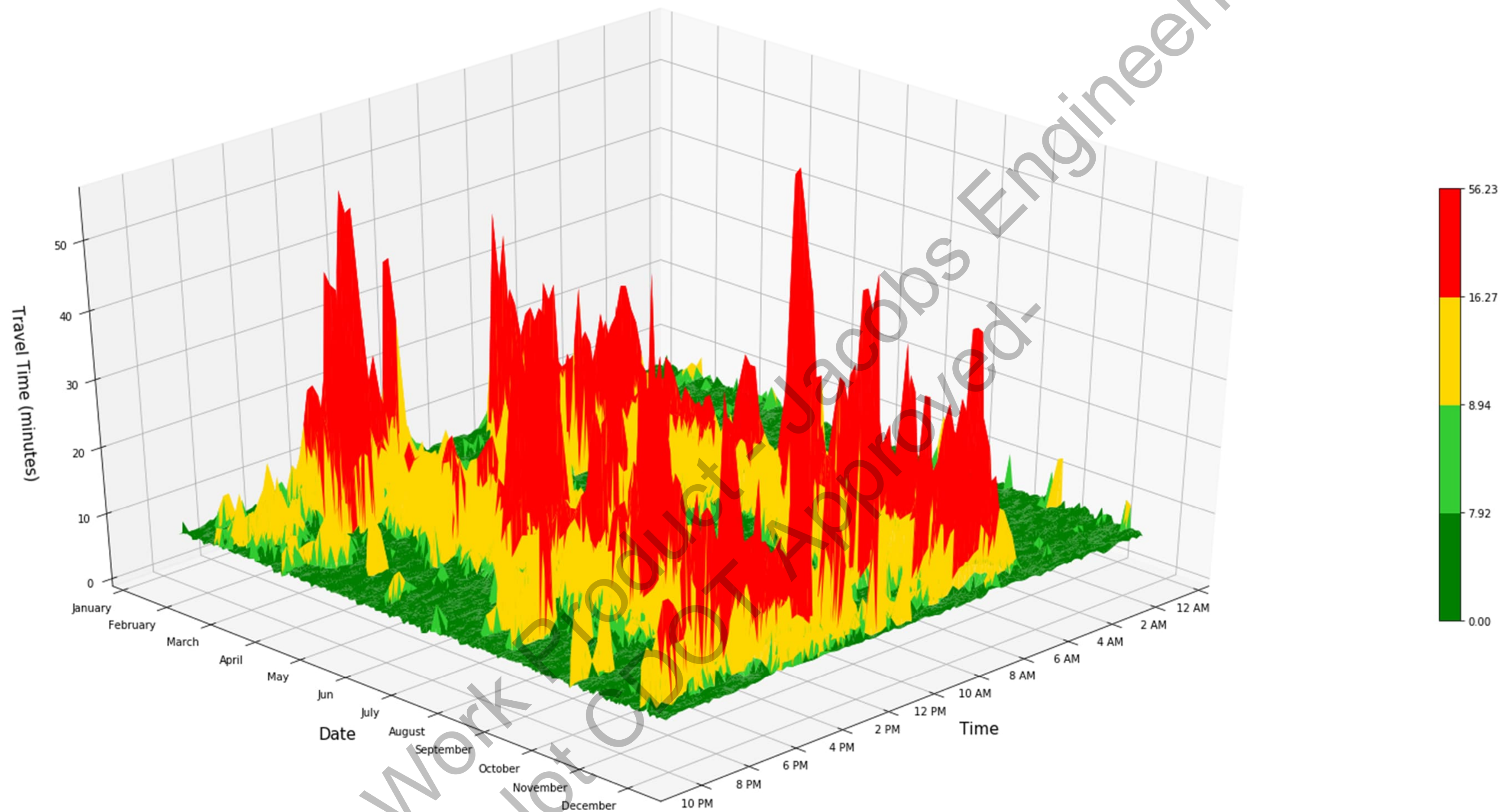

Figure 14. I-270 Eastbound—Weekdays 2016
Source: Jacobs

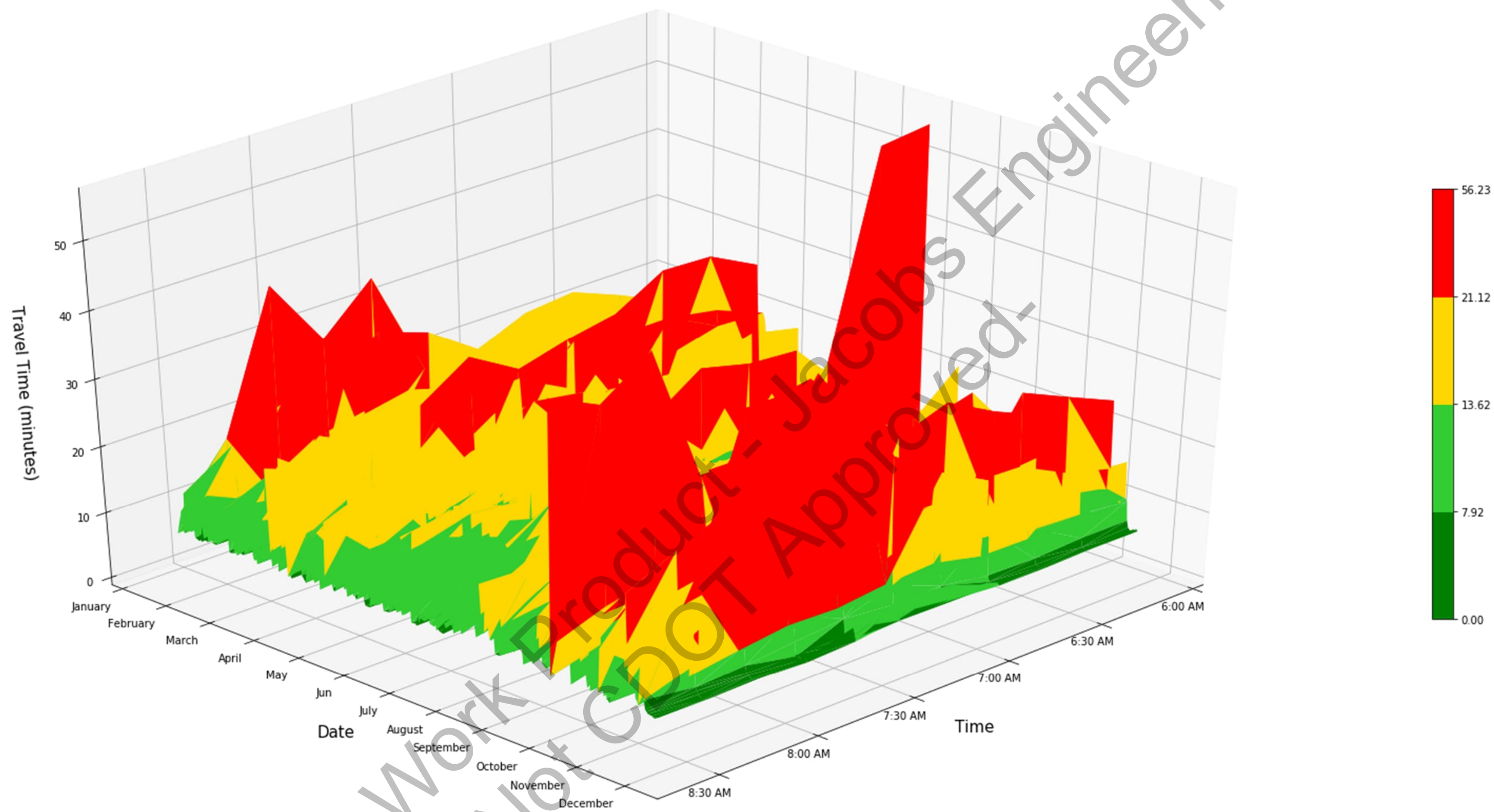

Figure 15. I-270 Eastbound—Weekdays a.m. Peak 2016
Source: Jacobs

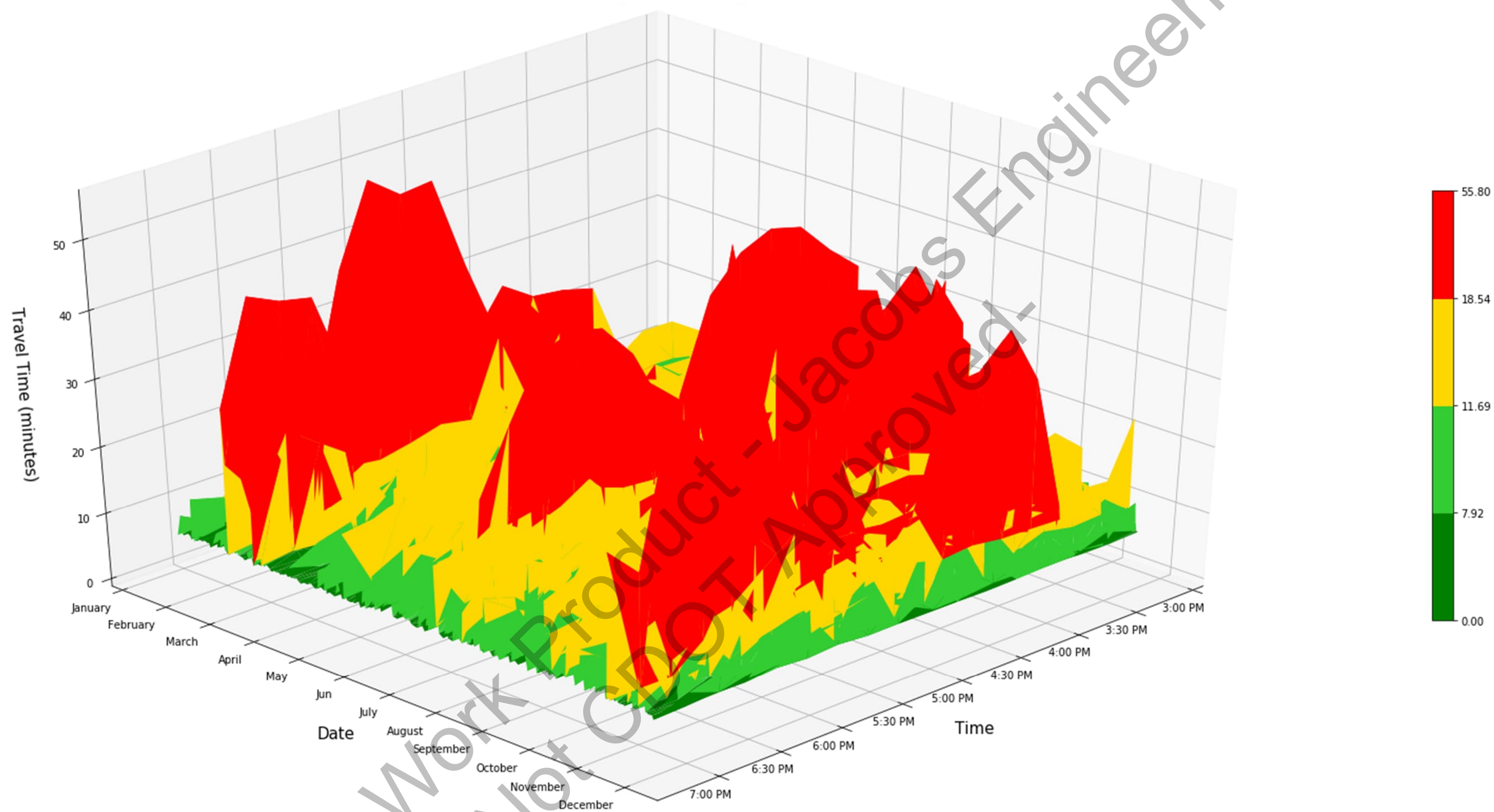

Figure 16. I-270 Eastbound—Weekdays p.m. Peak 2016
Source: Jacobs

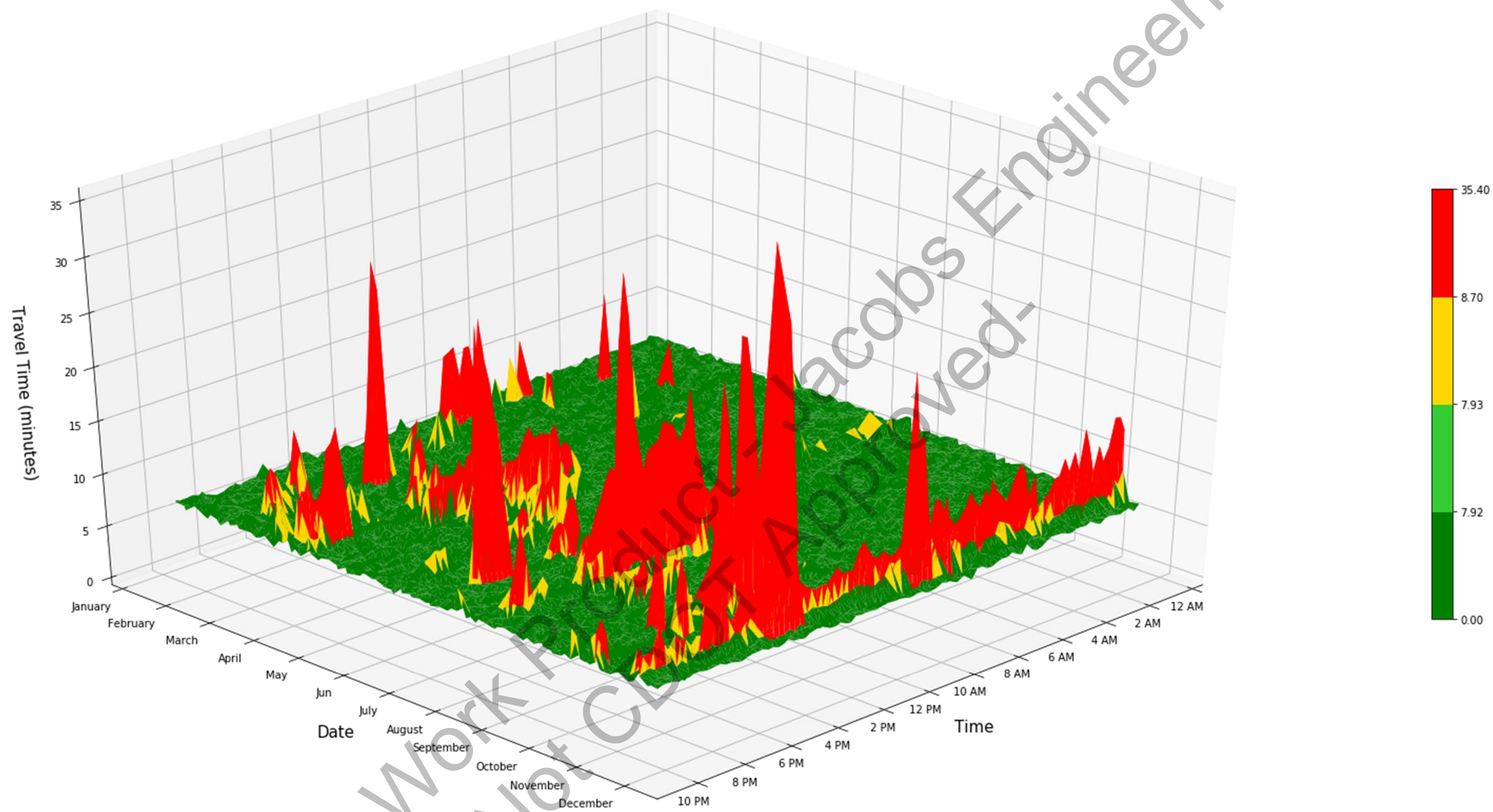

Figure 17. I-270 Eastbound—Weekends 2016
Source: Jacobs

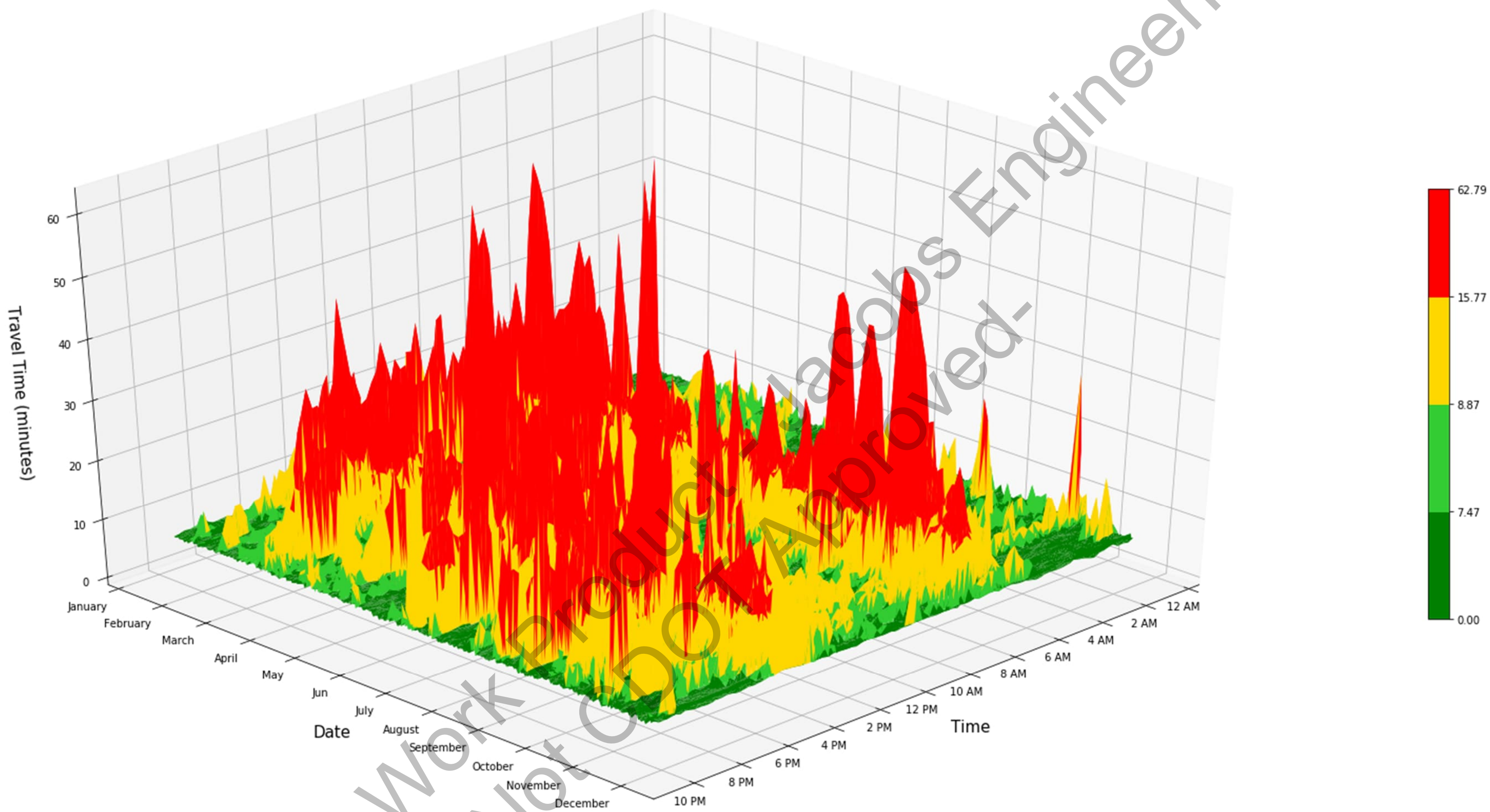

Figure 18. I-270 Eastbound—All Days 2019
Source: Jacobs

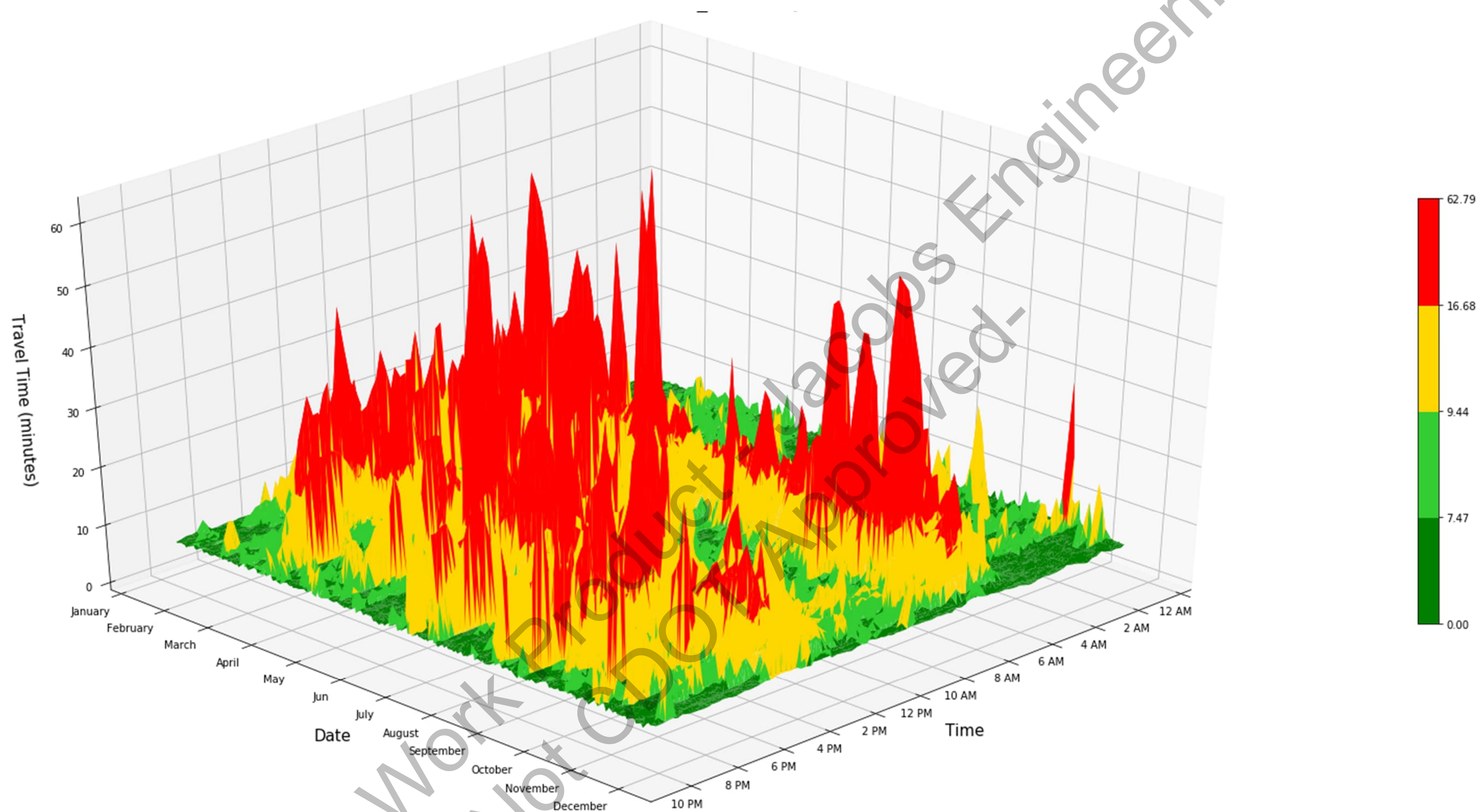

Figure 19. I-270 Eastbound—Weekdays 2019
Source: Jacobs

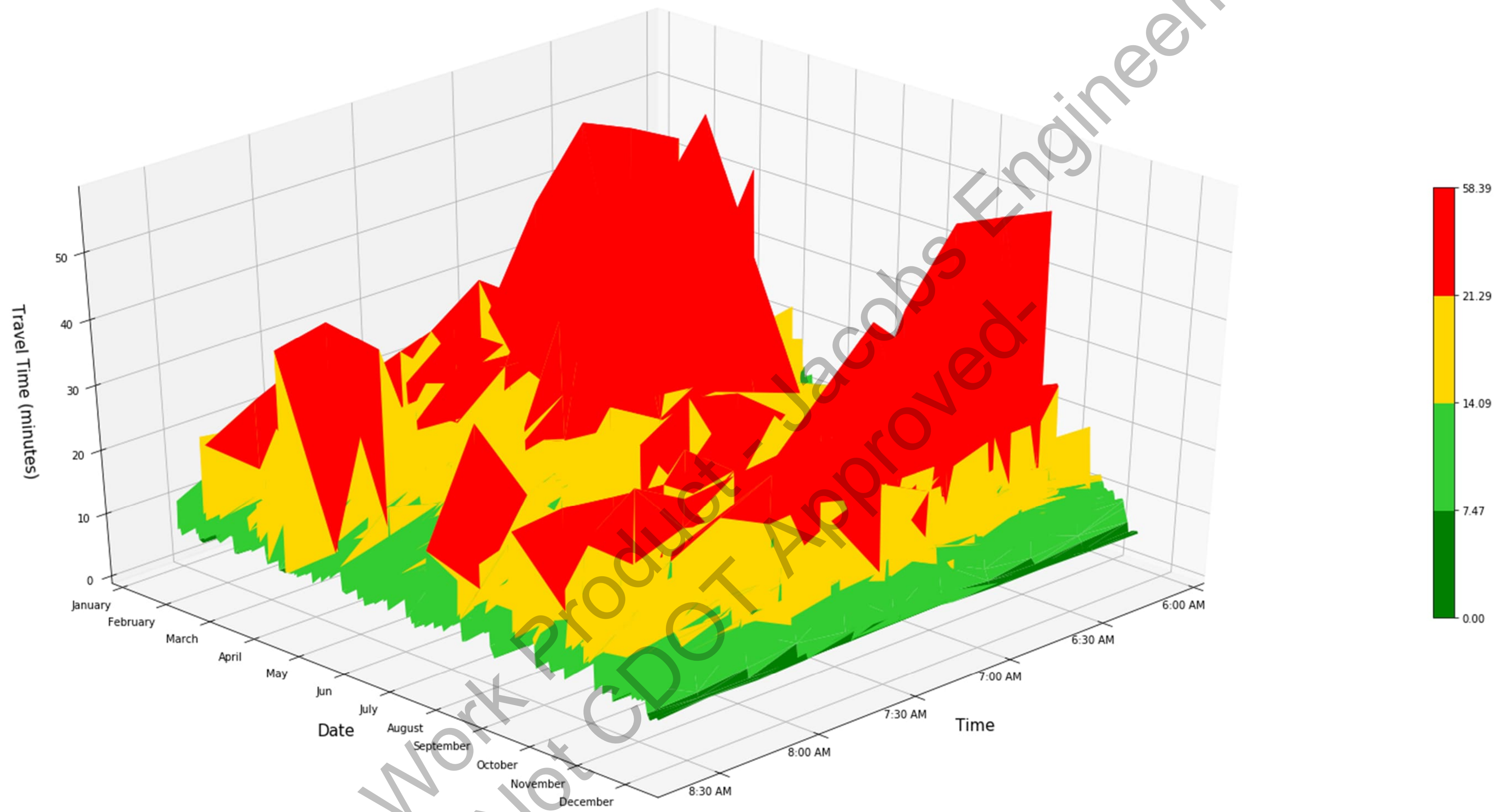

Figure 20. I-270 Eastbound—Weekdays a.m. Peak 2019
Source: Jacobs

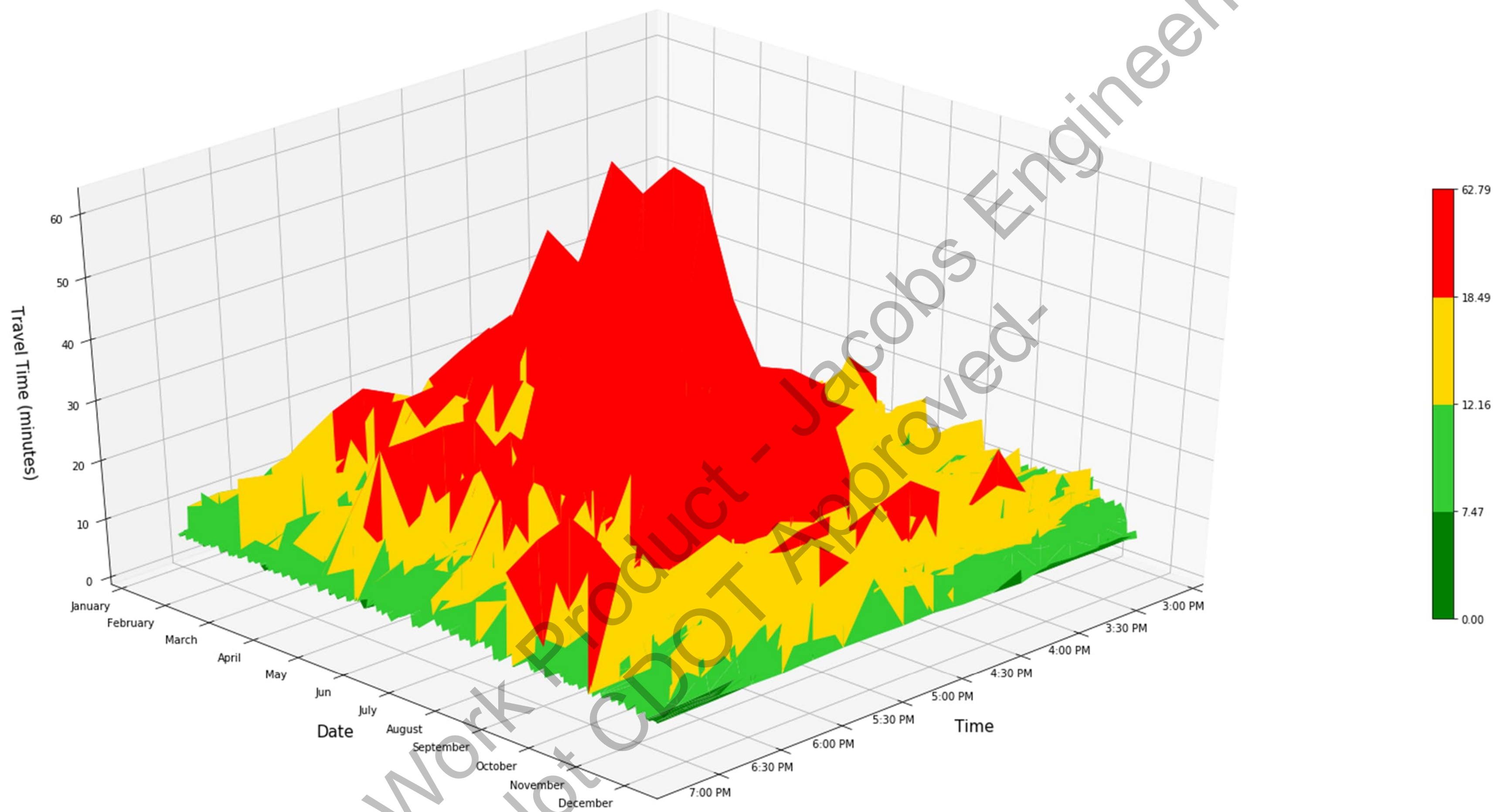

Figure 21. I-270 Eastbound—Weekdays p.m. Peak 2019
Source: Jacobs

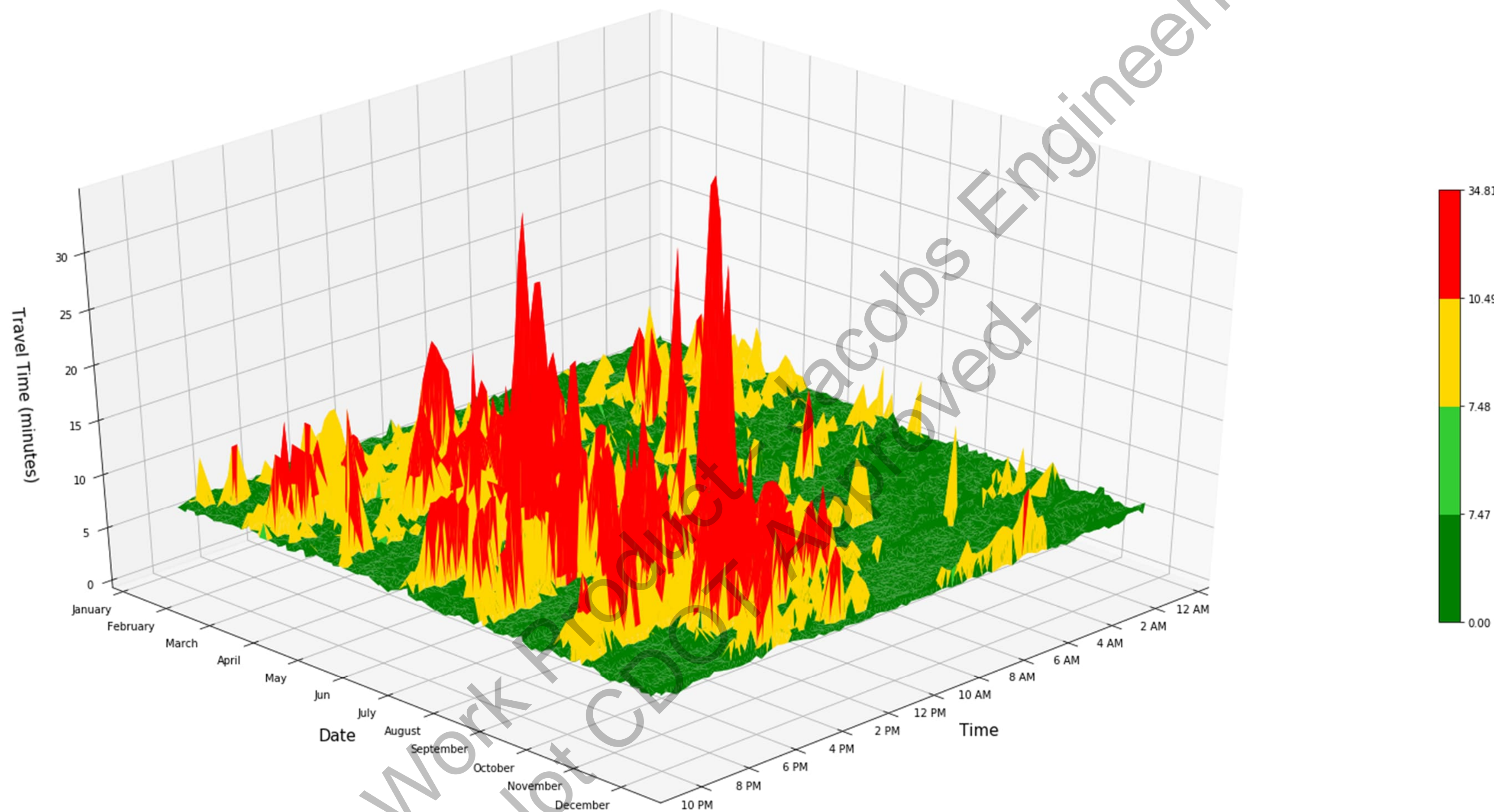

Figure 22. I-270 Eastbound—Weekends 2019
Source: Jacobs

Table 8. I-270 Eastbound: Causal Factor Analysis for Fair or Poor Days of 2016

Event Type		Total Year 2016				Day of Week							
						Count				% of Total for Event Type			
		Count		% of Total Events		Weekday		Weekend		Weekday		Weekend	
Incident		7		2.19%		6		1		85.71%		14.29%	
Planned Event		18		5.64%		15		3		83.33%		16.67%	
PSA[a]		2		0.63%		2		0		100.00%		0.00%	
Roadworks		90		28.21%		71		19		78.89%		21.11%	
Multiple Events[b]		16		5.02%		14		2		87.50%		12.50%	
Unaccounted/ Congestion	Monday	29	186	9.09%	58.31%	29	150	-	36	15.59%	80.65%	-	19.35%
	Tuesday	30		9.40%		30		-		16.13%		-	
	Wednesday	28		8.78%		28		-		15.05%		-	
	Thursday	31		9.72%		31		-		16.67%		-	
	Friday	32		10.03%		32		-		17.20%		-	
	Saturday	27		8.46%		-		27		-		14.52%	
	Sunday	9		2.82%		-		9		-		4.84%	
Total		319		100.00%		258		61		80.88%		19.12%	

Source: Jacobs

[a] PSAs on VMS boards.

[b] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

Table 9. I-270 Eastbound: Causal Factor Analysis for Fair or Poor Days of 2019

Event Type		Total Year 2019				Day of Week							
						Count				% of Total for Event Type			
		Count		% of Total Events		Weekday		Weekend		Weekday		Weekend	
Incident		11		3.23%		10		1		90.91%		9.09%	
Planned Event		3		0.88%		3		0		100.00%		0.00%	
PSA[a]		-		-		-		-		-		-	
Roadworks		92		26.98%		65		27		70.65%		29.35%	
Multiple Events[b]		201		58.94%		152		49		75.62%		24.38%	
Unaccounted/ Congestion	Monday	4	34	1.17%	9.97%	4	24	-	10	11.76%	70.59%	-	29.41%
	Tuesday	4		1.17%		4		-		11.76%		-	
	Wednesday	4		1.17%		4		-		11.76%		-	
	Thursday	5		1.47%		5		-		14.71%		-	
	Friday	7		2.05%		7		-		20.59%		-	
	Saturday	7		2.05%		-		7		-		20.59%	
	Sunday	3		0.88%		-		3		-		8.82%	
Total		341				254		87		74.49%		25.51%	

Source: Jacobs

[a] PSAs on VMS boards.

[b] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

4.0 Conclusions

On I-270 westbound, the highest percent of trips with fair or poor travel times occurred during weekday evenings. From 2016 to 2019, there was a 6 percent increase in the total number of days with fair or poor travel times. This can be primarily attributed to the occurrence of excessive multiple events (66 percent) and roadwork (24 percent) in 2019. Data for 2016 show that 48 percent of congestion occurred during the commuter (a.m. and p.m.) peak hours and was likely the result of traffic volume, while in 2019, no days with fair or poor travel times fall under congestion-related poor reliability. The 2019 poor reliability is the result of ongoing construction and other events, which indicates that the occurrence of different events during the commuter peak periods may have negatively affected congestion at those times. Table 10 summarizes the casual factor evaluation for I-270 westbound.

Table 10. I-270 Westbound: Causal Factor Summary

Event Type	Number of Days		Percentage of Days		Change From 2016 to 2019
	2016	2019	2016	2019	
Incidents	10	0	3%	0%	
Planned Event	25	0	7%	0%	
PSA	0	0	0%	0%	
Roadworks	88	89	24%	24%	
Multiple Events[a]	14	241	4%	66%	
Unaccounted Congestion	174	0	48%	0%	
Uncongested	55	35	15%	10%	
Total Days Analyzed	366	365	100%	100%	

Source: Jacobs

[a] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

On I-270 eastbound, the highest percentage of trips with fair or poor travel times occurred during weekday mornings. Sun glare could have contributed to some eastbound travel times that were less reliable. From 2016 to 2019, there was a 7 percent increase in the total number of days with fair or poor travel times. As with I-270 westbound, this can be primarily attributed to the occurrence of excessive multiple events (59 percent) and roadwork (27 percent) in 2019. Table 11 summarizes the casual factor evaluation on I-270 eastbound.

Table 11. I-270 Eastbound: Causal Factor Summary

Event Type	Number of Days		Percentage of Days		Change From 2016 to 2019
	2016	2019	2016	2019	
Incidents	7	11	2%	3%	
Planned Event	18	3	5%	1%	
PSA	2	0	1%	0%	
Roadworks	90	92	25%	25%	
Multiple Events[a]	16	201	4%	55%	
Unaccounted Congestion	186	34	51%	9%	
Uncongested	47	24	13%	7%	
Total Days Analyzed	366	365	100%	100%	

Source: Jacobs

[a] Occurrence of two or more events, including incidents, planned events, PSAs, or roadworks.

5.0 References

Colorado Department of Transportation (CDOT). 2018. *Planning and Environmental Linkages (PEL) Study for Vasquez Boulevard*. https://www.codot.gov/library/studies/study-archives/vasquez-pel-study.

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