MEMO

ATKINS

To:	Mr. Joe Mahoney, Colorado Department of Transportation		
From:	Atkins	**Email:**	Rami.Harb@atkinsglobal.com
Phone:	720-475-7079	**Date:**	4/21/2015
Ref:	Tolling Advisory Services	**cc:**	
Subject:	I-70 PPSL Toll Rates MEMO		

1. Document Purpose

The Louis Berger team conducted a level I Traffic and Revenue Study for the I-70 PPSL. In addition, the Louis Berger team elicited the value of time based on the US-36 stated preference survey conducted by CDM Smith. FHU conducted an I-70 Mountain Corridor traffic volume study and analyzed the value of time while taking into account the average occupancy of vehicles on the PPSL. Atkins has been tasked with setting toll rates on the PPSL based on the abovementioned studies.

2. Project Limits

The section of I-70 between the Eisenhower-Johnson Memorial Tunnels (EJMT) and the Denver Metro Area experiences recurring peak period congestion on weekends and holidays during winter and summer peak recreational travel seasons. This 45-mile, four-lane section of I-70 is the primary access route from the Denver Metro Area to the mountains of central Colorado where there are numerous opportunities for outdoor activities, such as skiing in the winter as well as camping, hiking, biking, and sightseeing in the summer and fall. Consequently, this corridor experiences heavy flows of eastbound and westbound traffic on **Friday afternoons** as well as on **Saturday and Sunday mornings** for both the summer and winter seasons. On Fridays traffic is the highest in the westbound direction and on Sundays traffic is highest in the eastbound direction (See Figures A-1 and A-2 in Appendix A). The majority of this congestion happens in the segment between Georgetown and the Floyd Hill area.

The I-70 Eastbound Peak Period Shoulder Lane (PPSL) project ("Project") will utilize the inside shoulder to provide a third, eastbound travel lane during peak periods along the I-70 Mountain Corridor from US 40 at Empire Junction to the Twin Tunnels (See Figure 1). The peak period shoulder lane will serve as a direct connection to the third, eastbound lane that has recently been constructed through the Twin Tunnels and is also designated as a tolled express lane.

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Figure 1: I-70 West Mountain Corridor and PPSL Project Limits Source: ConOps Apex Design, 2014

3. Traffic Characteristics

I-70 currently carries two travel lanes in each direction within the Project corridor, with the exception of the Twin Tunnels segment to the east of the project which was recently widened to include a third eastbound lane. At least one, two-lane local road is also present through the entire corridor, running approximately parallel to I-70. There are a total of eight grade-separated interchanges along I-70 within the Project limits, including a Commercial Vehicle Weigh Station near milepost (MP) 234. The eastbound and westbound lanes of I-70 are separated by a narrow median with guardrail or concrete barrier. The speed limit is posted at 65 miles per hour (mph) entering the west end of project corridor, but is reduced to 60 mph at MP 238, and further reduced to 55 mph at MP 242. The corridor's Annual Average Daily Traffic (AADT) ranges from 39,000 to 44,570 vehicles per day (CDOT 2011), with Design Hourly Volumes (DHV) in the peak direction at approximately 7.5 percent of the AADT. Table A-1 in Appendix A shows the highest seasonal eastbound daily volumes for years 2009-2011 in the summer and winter seasons. Figure 2 (page 3) depicts eastbound I-70 average hourly traffic volumes during the peak travel period, based on data from the 2013 No Action DynusT model of the corridor.

Figures A-1 and A-2 in Appendix A show the summer and winter average daily traffic eastbound and westbound at the Twin tunnels (Data from Twin Tunnels ATR). Summer and winter volumes follow the same trend with high volumes on Fridays, Saturdays, and Sundays. Westbound traffic is highest on Fridays and eastbound traffic is highest on Sundays depicting traffic to and from the mountains area.

Figures A-3 and A-4 in Appendix A show the eastbound hourly volumes from 7:00 am through 8:00 pm for the summer and winter peak day (Data from Twin Tunnels ATR). The figures illustrates that the pattern of congestion is similar during the summer and the winter seasons with higher volumes from 10:00 AM to 7:00PM.

Looking closer at traffic characteristics, Figures A-5 in Appendix A shows the hourly eastbound and westbound traffic volume at the Twin Tunnels and Figure A-6 in Appendix A shows travel speeds along the length of the project. As depicted, the highest eastbound traffic occurs between 1:00 PM and 6:00 PM and the lowest speed occuring at the same time.

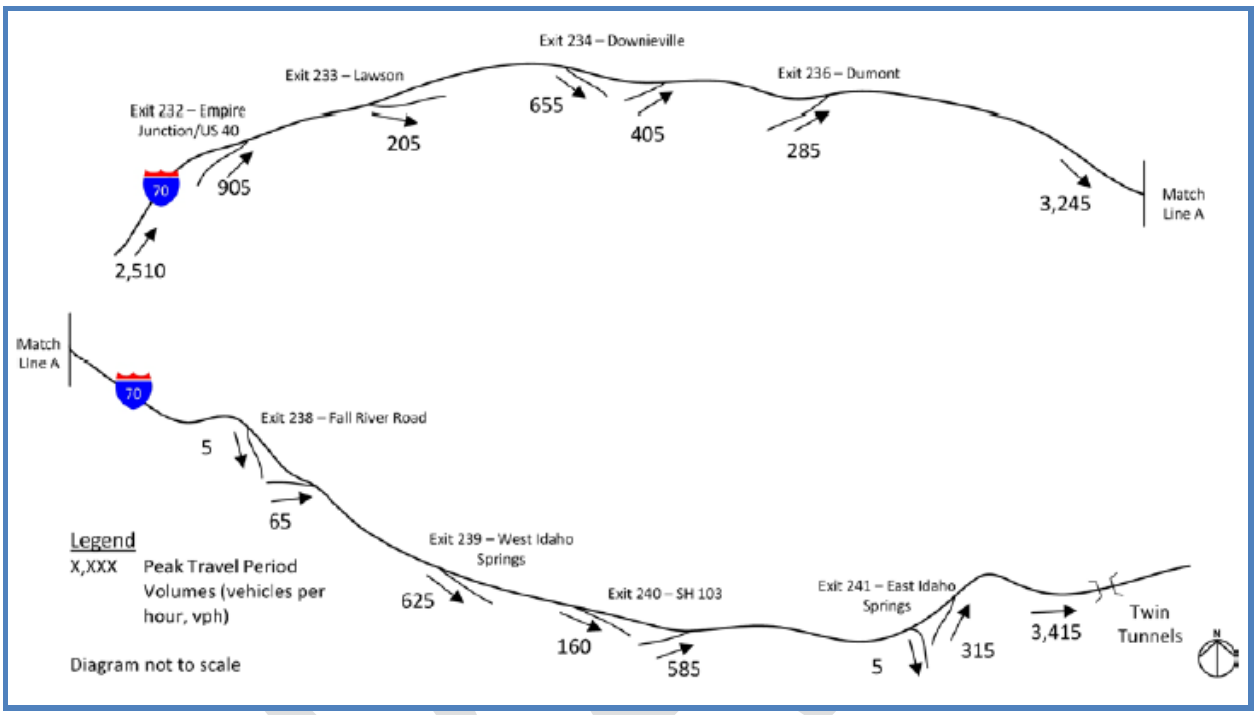


Figure 2: DynusT output, No Action 2013 eastbound I-70 Average Hourly Traffic Volumes (Peak Travel Period) Source: ConOps Apex Design, 2014

4. Value of Time VOT (value of travel time Savings [VTTS]) analysis

Value of time is important in cost-benefit analyses as well as in developing road pricing policies. The estimation of VOT can be accomplished by approximation or more accurately by empirical studies such as stated or revealed preference surveys. The value of time determines how much drivers are willing to pay in tolls to save travel time.

4.1 Colorado Value of time for managed lanes discussion

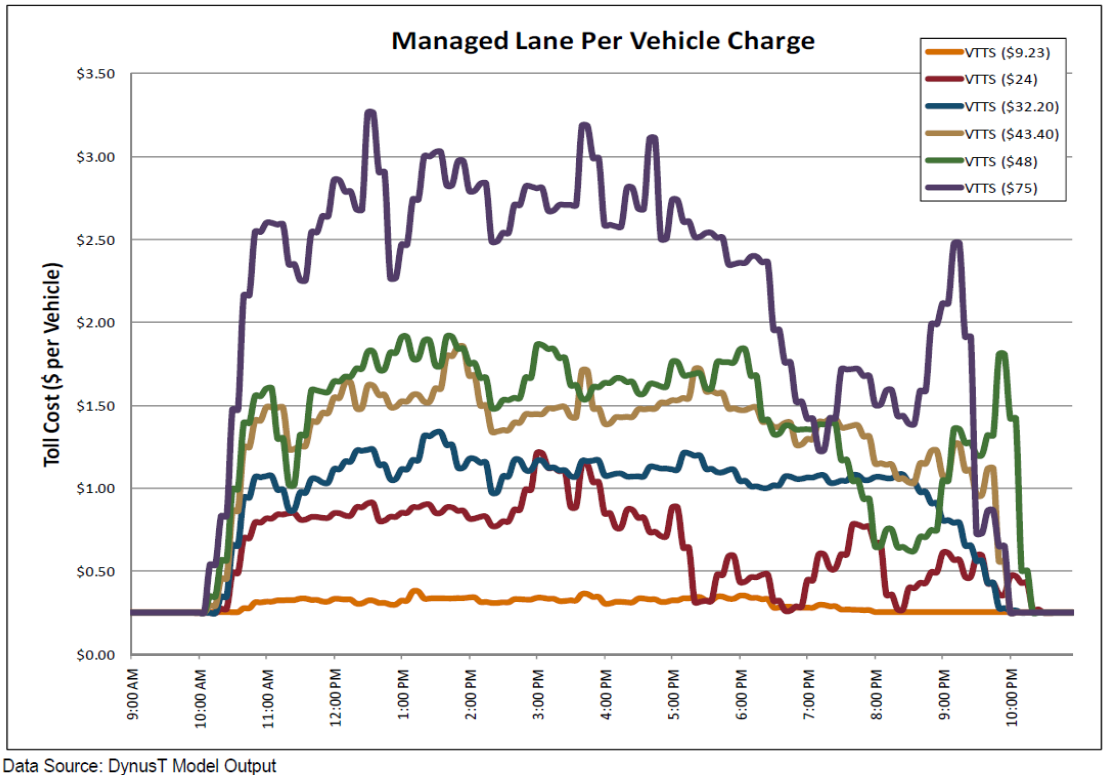
A stated preference survey was conducted to elicit the value of time for travelers on **US-36** in 2011. Different factors were included in their multinomial models including trip distance, household income, and trip purpose (peak-work, peak-non-work, off-peak-work, and off-peak-non-work). The value of time varied within a range of $6.00-$18.00.

An I-70 Mountain Corridor report By FHU provides a summary of value of travel time savings used in their study as the following:

Table 1: Value of time used in the twin tunnels technical memorandum (2012)

VTTS	Comments
$ 9.23	Derived from the I-70 West PEIS
$ 24	PEIS VTTS multiplied by 2.6 (average vehicle occupancy on the PPSL)
$ 32.20	PEIS value inflated from 2000 to 2011
$ 43.40	FHWA Guidance. (Intercity Value of time recommended at $16.70 per passenger multiplied by 2.6 occupants per vehicle)
$ 75	High value of time to test model sensitivity

In FHU's Twin Tunnels Transportation Technical Memorandum, the DynusT model was run with different VTTS. The minimum toll was set **at $0.25**, a maximum toll per passenger car was set at $50, a maximum toll rate of $68 was set for trucks, and a preferred operating speed in the managed lane was set at 45 mph. Figure 3 shows the dynamic toll rates on the PPSL with different value of travel time savings.



Data Source: DynusT Model Output

Figure 3: Charge per vehicle in ML with various VTTS, 2035 volumes (Source: Twin Tunnels Technical Memorandum, May 2012)

FHWA, as shown in the FHU study, recommends using $16.70 per person as an appropriate intercity personal travel. The average occupancy on the PPSL is 2.6 passengers per vehicle. Therefore the VOT or VTTS per vehicle is $43.40. Therefore, in our assessment the value of travel time savings will be $43.40.

5. National Scan of Maximum Toll Rates per mile

A National scan of maximum toll rates per mile was conducted to support finding from this report (See Table 2 and Figure 4). The maximum toll rate per mile (As depicted in Figure 4) varies from $0.10 (Utah) to $1.40 (California). Applying that to the PPSL would results in a maximum toll rate for the trip ranging from $1.00 to $14.00 for the entire 10 miles.

Table 2: National Scan of toll rates per mile, as of December 2014

State	Facility Name	Lane Type	Distance (mile)	Minimum Toll	Maximum Toll	Traditional	Express Lane	
						Per Mile Avg	Max/mi	Per Mile Avg
California	South Bay Expressway	Toll	-		$3.50	$0.35	-	-
California	I-680 SB Express Lanes	Express Lane	14	$0.30	$7.50	-	$0.54	-
California	I-10 Express Lanes	Express Lane	14	-		-	$1.40	-
California	I-110 Express Lanes	Express Lane	11	-		-	$1.40	-
California	I-15 Express Lanes	Express Lane	20	$0.50	$8.00	-	$0.40	-
Colorado	I-25 Express	Express Lane	7	$0.50	$4.00	-	$0.57	-
Delaware	Delaware DOT	Toll	multiple networks	$0.25	$4.00	$0.04	-	-
Florida	FL Turnpike Mainline	Toll	265	$0.50	$25.00	$0.55	-	-
Florida	I-95 Express	Express Lane	10	$0.25	$7.10	-	$0.75	-
Florida	CFX "SR 408"	Toll	22	$0.25	$4.50	$0.20	-	-
Florida	THEA Express Lanes	Toll	11	$0.75	$2.70	$0.25	-	-
Georgia	SRTA I-85	Express Lane	16	$0.16	$7.00	-	$0.44	-
Illinois	Illinois Tata Toll Highway Authority	Traditional	120	-	$14.50	$0.12	-	-
Indiana	Indiana Toll Road	Traditional	152	-	$10.00	$0.07	-	-
Kansas	Kansas Turnpike Authority	Traditional	232	$0.30	$10.75	$0.05	-	-
Maine	Maine Turnpike Authority	Toll	multiple networks	$0.00	$3.00	$0.08	-	-
Maryland	I95 Express Lanes	Express Lane	7	$0.70	$1.75	-	$0.25	-
Massachusetts	Mass DOT	Toll	135	$0.45	$10.60	$0.08	-	-
Minnesota	I-35 W Express Lanes	Express Lane	16	$0.25	$8.00	-	$0.50	-
Minnesota	I-394 Express Lanes	Express Lane	11	$0.25	$9.00	-	$0.82	-
North Carolina	NCTA	Toll	15	$0.30	$2.20	$0.15	-	-
Ohio	Ohio Turnpike	Toll	237	-	$17.00	$0.07	-	-
Oklahoma	Oklahoma Turnpike Authority	Toll	multiple networks	$0.25	$4.00	$0.05	-	-
Pennsylvania	Pennsylvania Turnpike	Toll	357	$1.00	$43.90	$0.12	-	-
Texas	IH 45 South	Express Lane	15.5	$1.00	$10.00	-	$0.65	$0.12
Texas	IH 45 N (North Freeway)	Express Lane	20.6	$1.00	$10.00	-	$0.49	$0.06
Texas	Katy Managed Lanes	Express Lane	12	$1.00	$4.00	-	$0.33	
Texas	US 59 North (Eastex Freeway)	Express Lane	20	$1.00	$10.00	-	$0.50	$0.17
Utah	I-15 Hot Lanes	Express Lane	40	$1.00	$4.00	-	$0.10	-
Virginia	I-495 Express Lanes	Express Lane	14	-	$4.80	-	$1.25	-
Washington	SR 167 HOT Lanes	Express Lane	9	$0.50	$9.00	-	$1.00	-

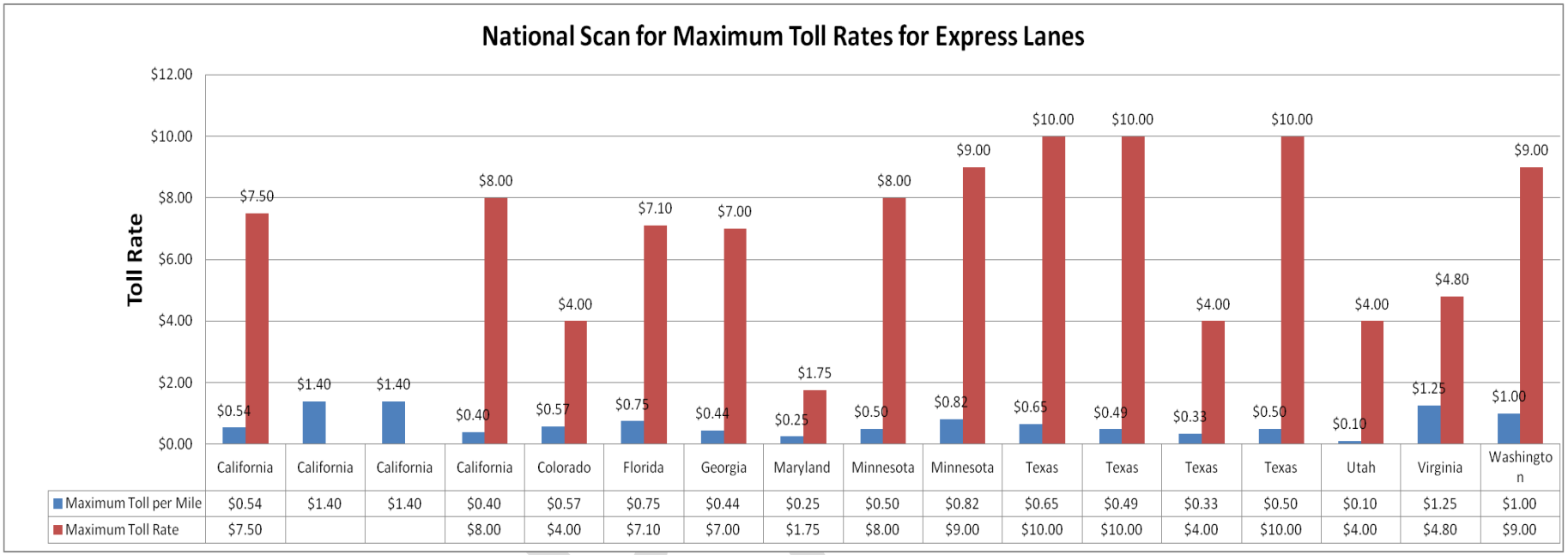


Figure 4: National Scan of toll rates per mile (Blue) and cumulative toll rates (Red) [As of December 2014]

6. Toll Collection cost per trip and Minimum toll rates

According to E470 public highway authority, 23% of their Transactions are License Plate Tolling (LPT) and 77% are transponder tolling (AVI). The cost for processing an LPT transaction is $0.62 versus $0.18 for AVI. Therefore, the average transaction cost is $0.28 cents. The PPSL currently comprises three tolling points, thus the average cost of transaction processing (collection cost) per trip is 3x$0.28=$0.84 (See Figure 5 below). It is expected that the traffic on the mountain corridor will have more LPT transactions which would increase the trip toll collection cost. It is recommended that the minimum toll rate charged on the PPSL cover the associated toll collection cost. When LPT transactions reach 100%, the toll collection cost for a vehicle-trip reaches $1.86. When AVI transactions reach 100%, the toll collection cost for a vehicle-trip is reduced to $0.54.

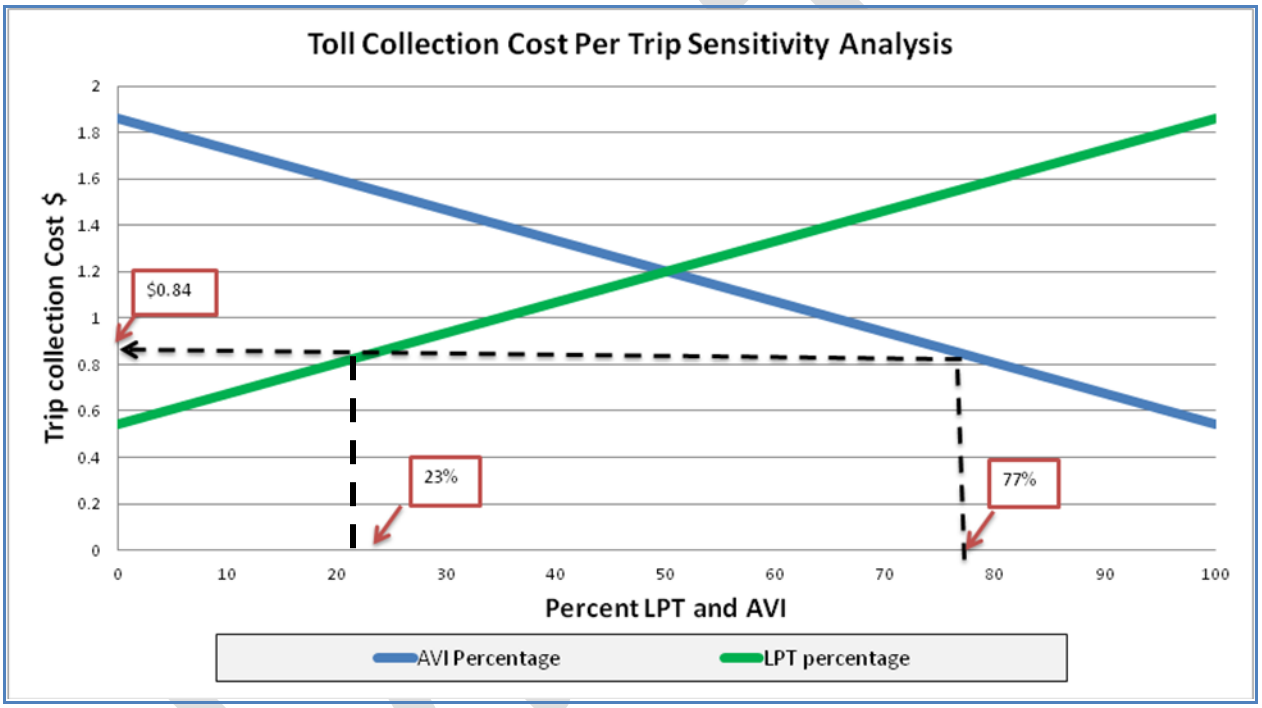


Figure 5: Trip toll collection cost sensitivity analysis

7. DynusT Model

The DynusT model for the future peak day 2015 was evaluated. The Dynamic Traffic assignment (DTA) capabilities of DynusT, combined with the congestion pricing function, resulted in eastbound I-70 traffic being assigned between the two general purpose lanes and the PPSL. DynusT assigns traffic based on a defined VTTS value, DTA principles, and managed lane principles that attempt to balance out travel times between all lanes. Figure 6 shows the DynusT model.

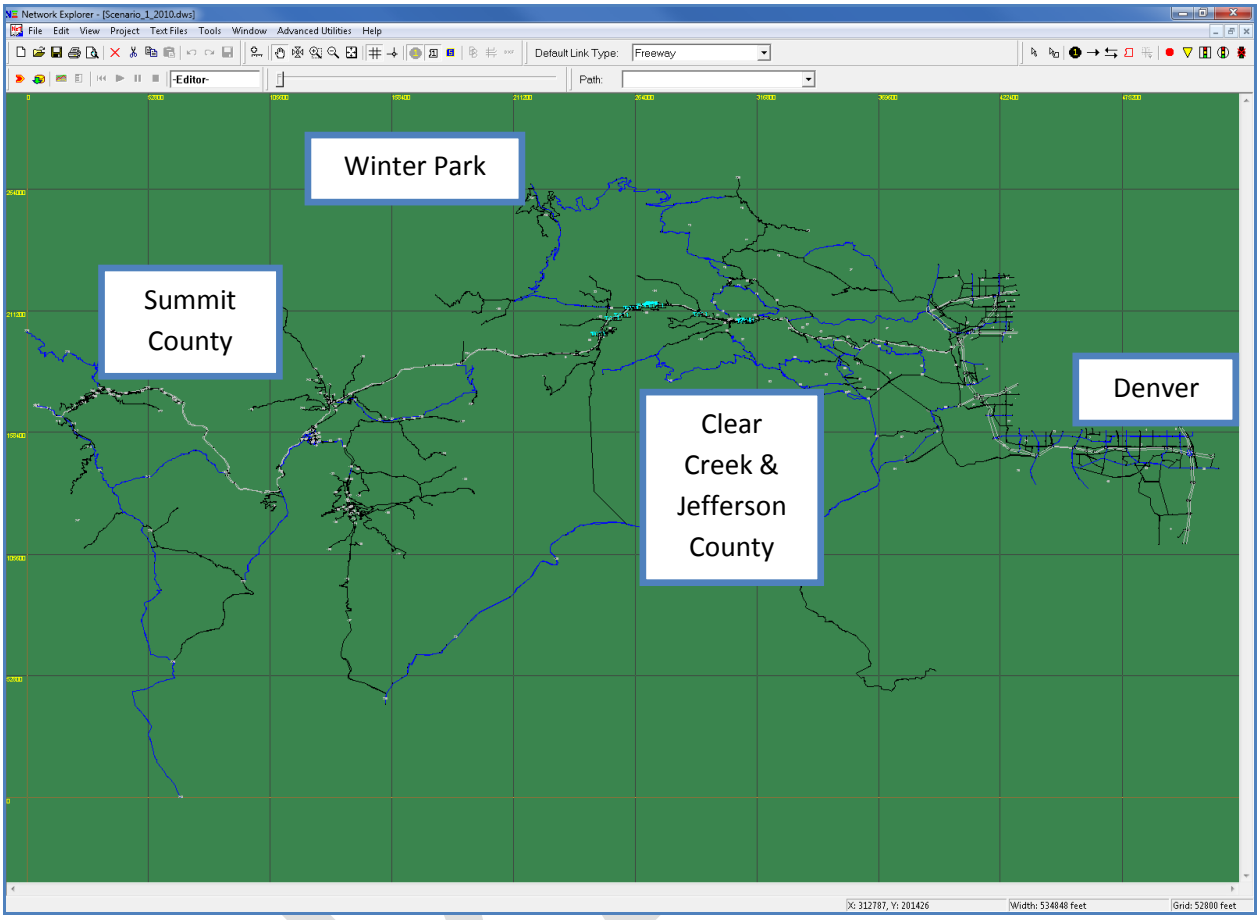


Figure 6: DynusT model for the PPSL

7.1 Minimum toll sensitivity analysis

Four DynusT Scenarios were run. The Value of time was set at $43.40 per hour and the maximum toll rate was set at $50 for passenger cars. Desired speed in the PPSL was set at 45 mph. Scenarios only differed in the minimum toll rates (i.e. $0.25, $ 1.00, $2.00, $3.00). Figure 7 below shows the resulting congestion pricing toll rates for a 2015 peak day from 9:00 AM to 11:00 PM for the four different scenarios. For the same day, time period, and scenarios, Figure 8 shows the **15-minute hourly rates** in the PPSL, Figure 9 shows the cumulative volume in the PPSL, and Figure 10 shows the net revenue after deducting toll collection cost assuming that the average vehicle-trip cost is $0.84, as discussed in section 6 of this report.

As shown by Figure 10, for a minimum toll rate of $0.25, the cumulative net revenue for the 2015 peak day is negative until 3:00PM and amounts to $286 by 11:00PM. The cumulative net revenue for a minimum toll rate of $1.00 for a peak day is $6,457 given an average toll collection cost per trip of $0.84. Since it is anticipated to have a higher percentage of LPT transactions on the PPSL, we

anticipate having lower net revenue for a minimum toll rate of $1.00. Therefore, it is recommended to have a minimum toll rate of $2.00.

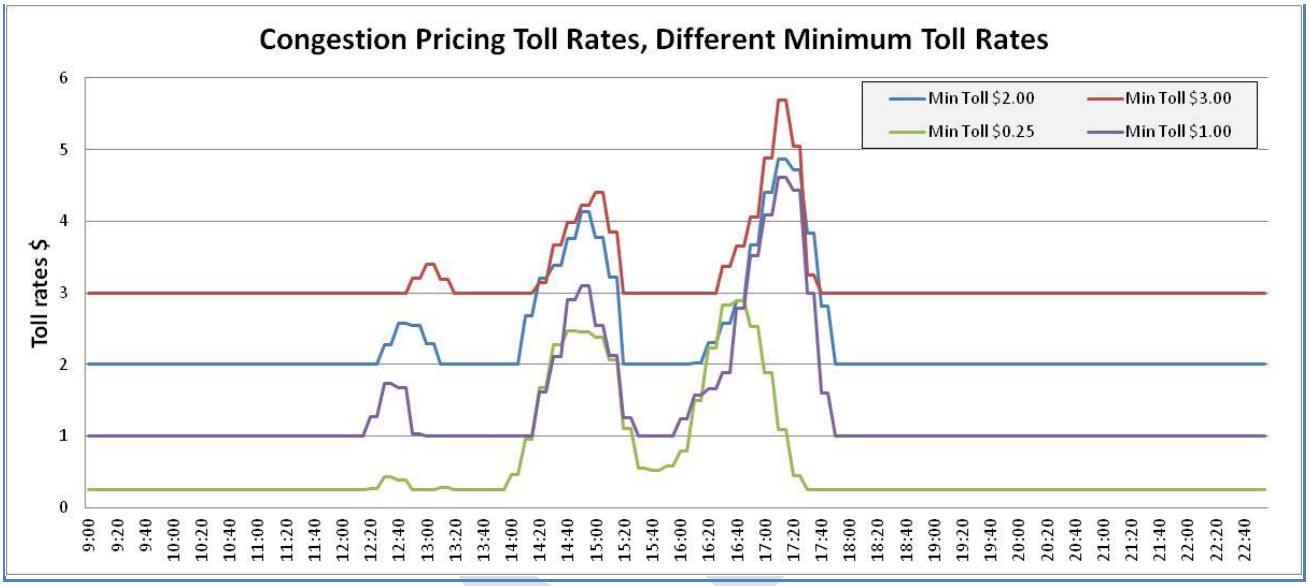


Figure 7: DynusT Congestion pricing results, peak day 2015

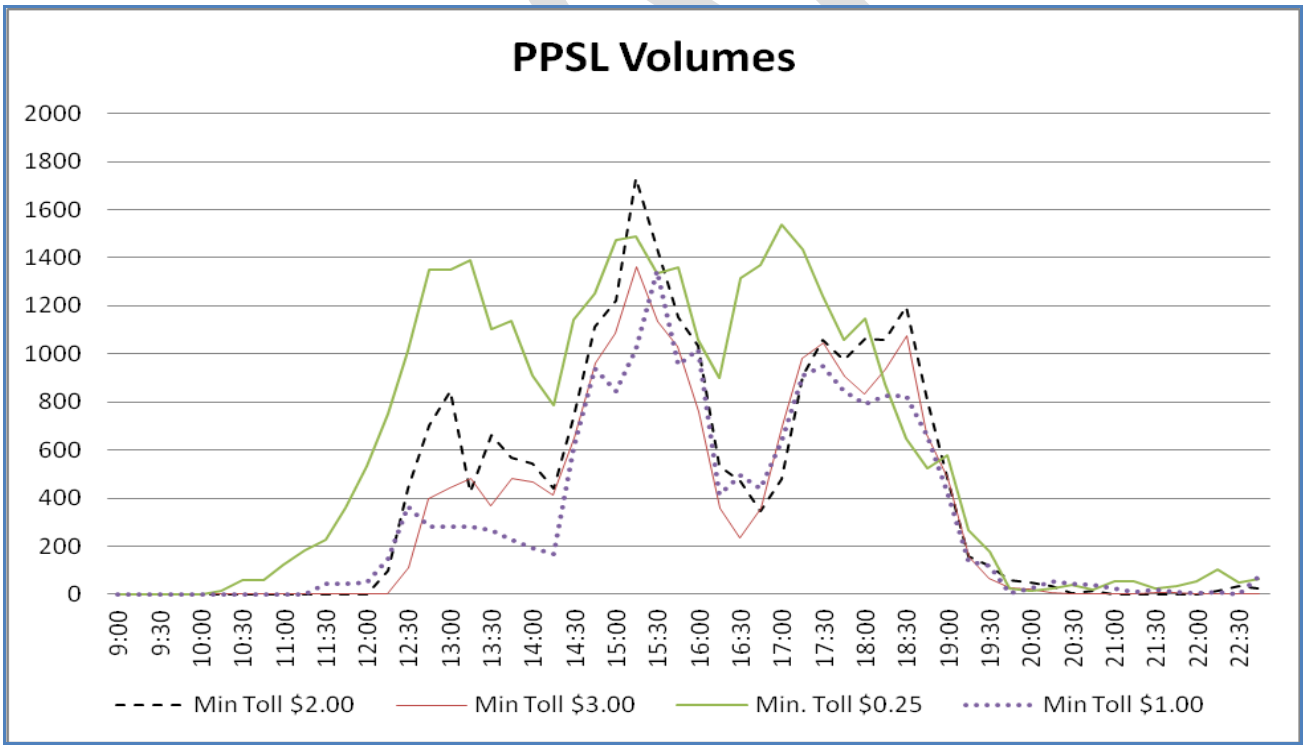


Figure 8: PPSL Volumes Peak day, 2015

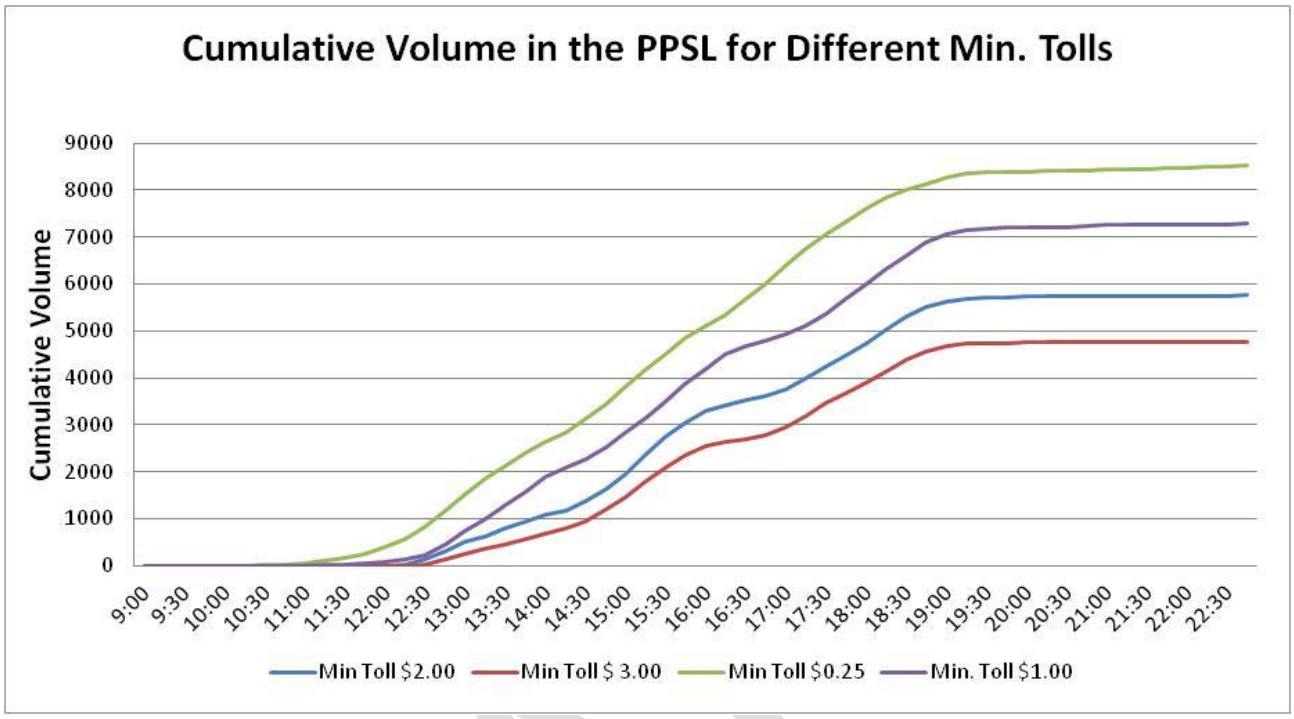


Figure 9: PPSL cumulative volumes for peak day, 2015

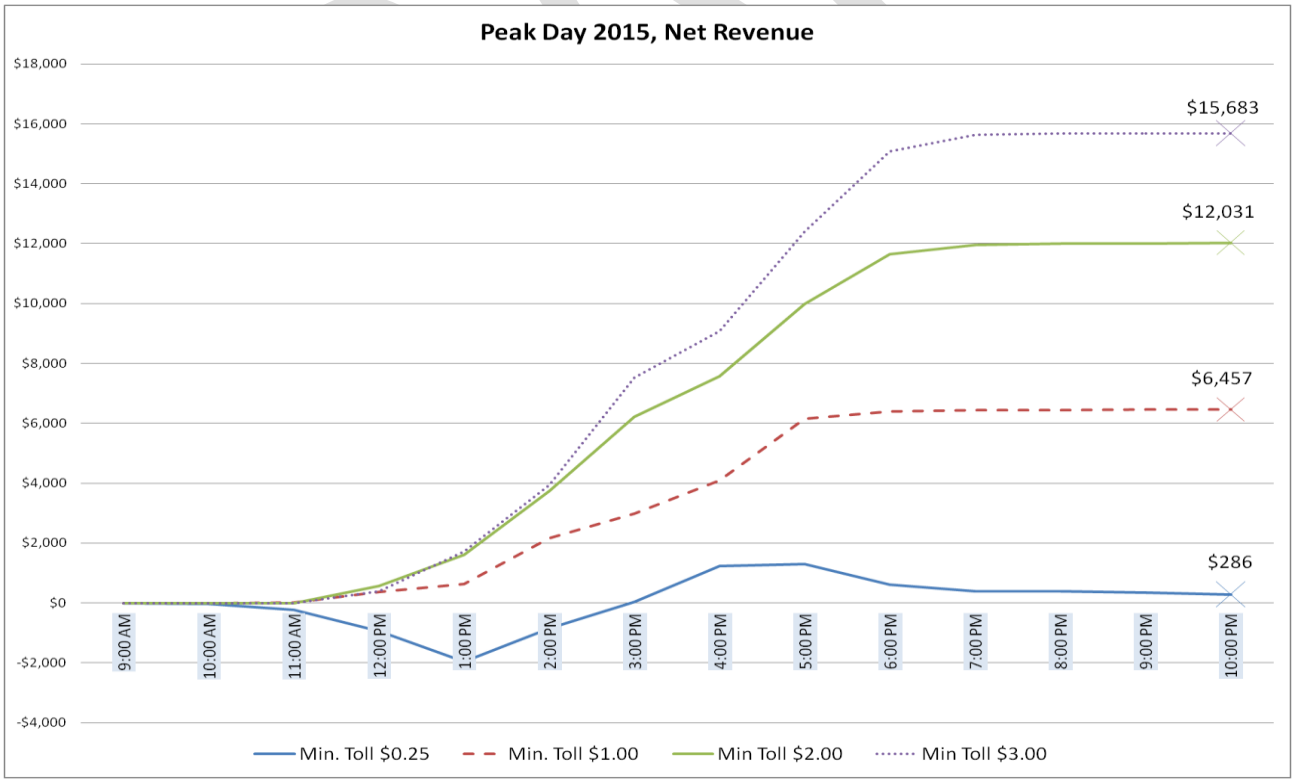


Figure 10: PPSL cumulative net revenue for peak day, 2015 (toll collection cost at 84 cents per trip)

7.2 Traffic analysis: minimum toll rates $2.00 and $3.00

The section shows DynusT's output for minimum toll rates of $2.00 and $3.00. Figures 10 and 11 depict volumes downstream of US40, throughput at the Twin tunnels, volumes in the PPSL, congestion pricing toll rates, and travel time savings, from 9:00 AM to 11:00 PM for the 2015 peak day and minimum toll rate of $2.00 and $3.00 respectively. Figure 12 shows the PPSL volumes and the speeds in the PPSL as well as the GP lanes for minimum toll rates of $2.00 and $3.00.

- Figures 10 and 11 show the travel time savings for minimum toll rates of $2.00 and $3.00 respectively. Both Figures show negative travel time savings during the off-peak indicating that travel times on the GP lanes are lower than travel times on the PPSL. This is due to geometric restriction of the PPSL. However, during the peak time, travel time savings become positive indicating a faster commute on the PPSL compared to the GP lanes. The maximum travel time savings are 5.5 minutes and 6 minutes for minimum toll rates of $2.00 and $3.00.
- Figures 10 and 11, in bold blue solid line, show the throughput volumes at the Twin Tunnels. The maximum throughputs are 4,280 vehicles/hour and 3,900 vehicles/hour for minimum toll rates of $2.00 and $3.00.
- Figures 10 and 11, in bold green, show congestion pricing toll rates base on the DynusT dynamic pricing algorithm. The maximum, rounded up to the nearest dollar, toll rates are **$5.00** and **$6.00** for minimum toll rates of $2.00 and $3.00 respectively.
- Figure 12 shows similar speeds for minimum toll rates of $2.00 and $3.00 in the PPSL as well as the GP lanes. Volumes in the PPSL for a minimum toll rate of $2.00 are higher than PPSL volumes for a minimum toll rate of $3.00 throughout most of the day.
- In both scenarios (i.e. minimum toll rate $2.00 and $3.00) the Dynust model does not allow access to the PPSL downstream of the first access point until the Twin Tunnels. In reality, it is anticipated that an unknown percentage of drivers will enter and exit the PPSL at various locations which will increase delays on the GP lanes as well as the PPSL. Hence, it is envisioned that toll rates will be higher than the congestion pricing toll rates from DynusT.

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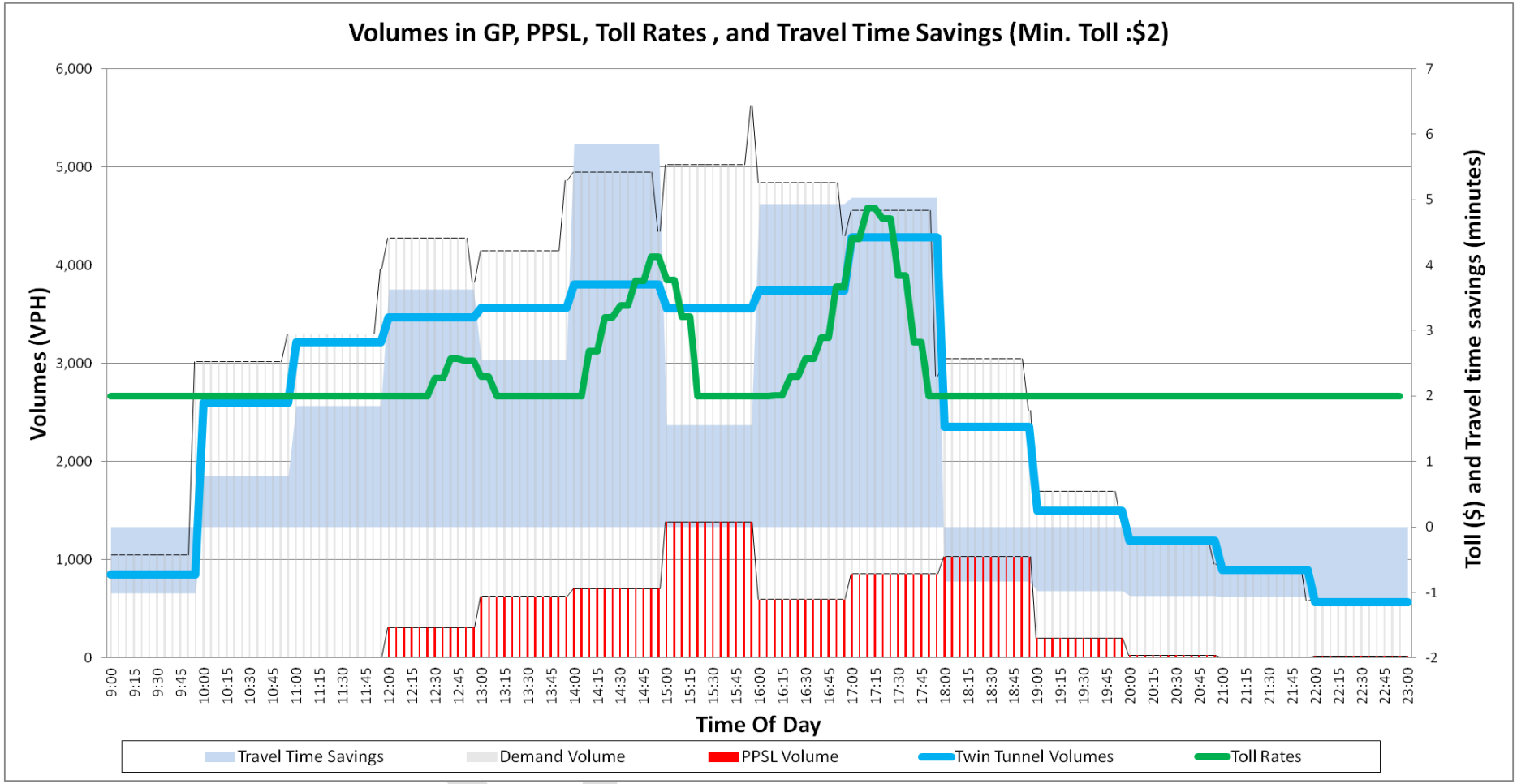

Figure 10: DynusT output, volumes, tolls, and travel time savings for minimum toll of $2.00

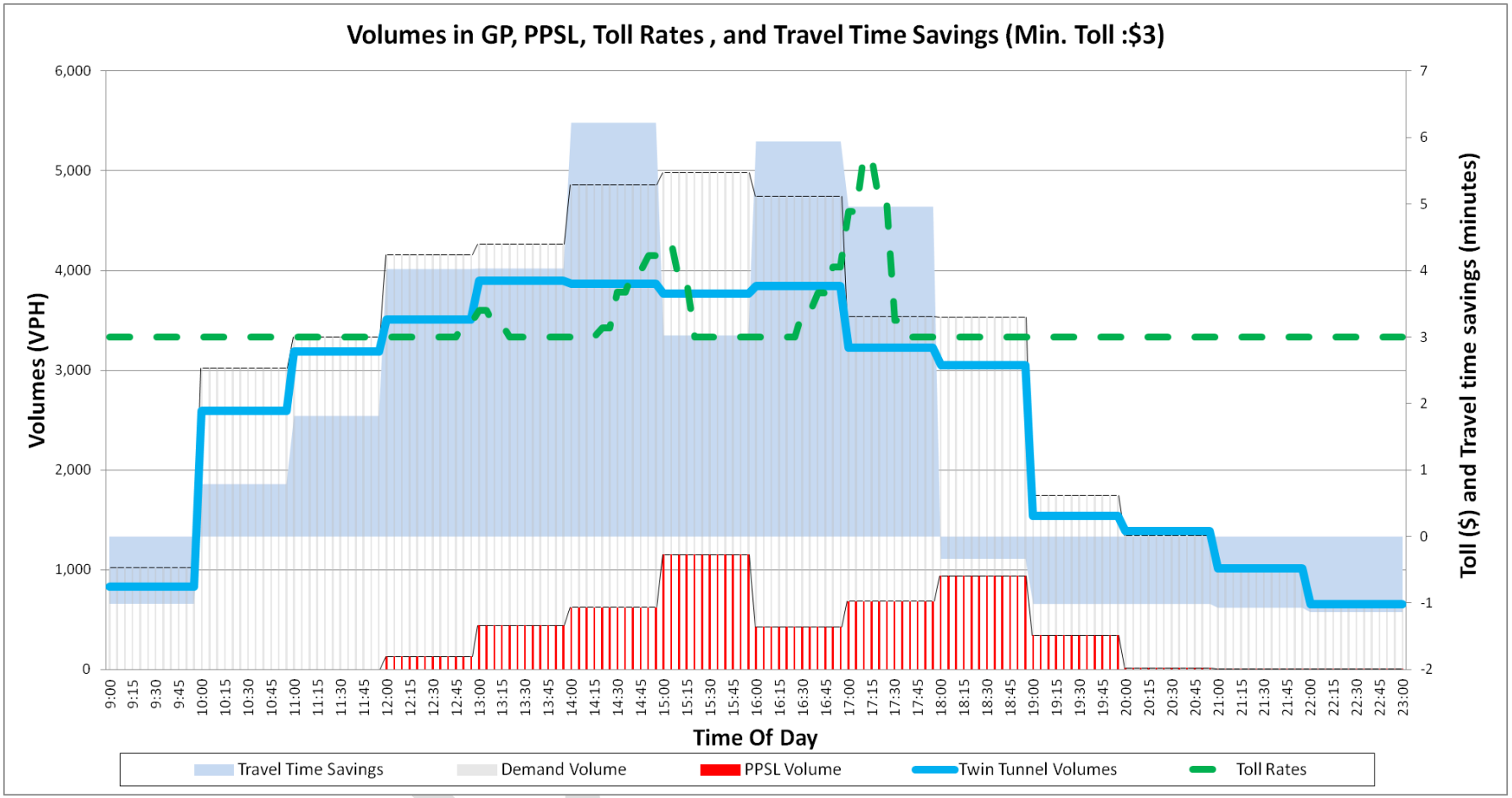

Figure 11: DynusT output, volumes, tolls, travel time savings for minimum toll of $3.00

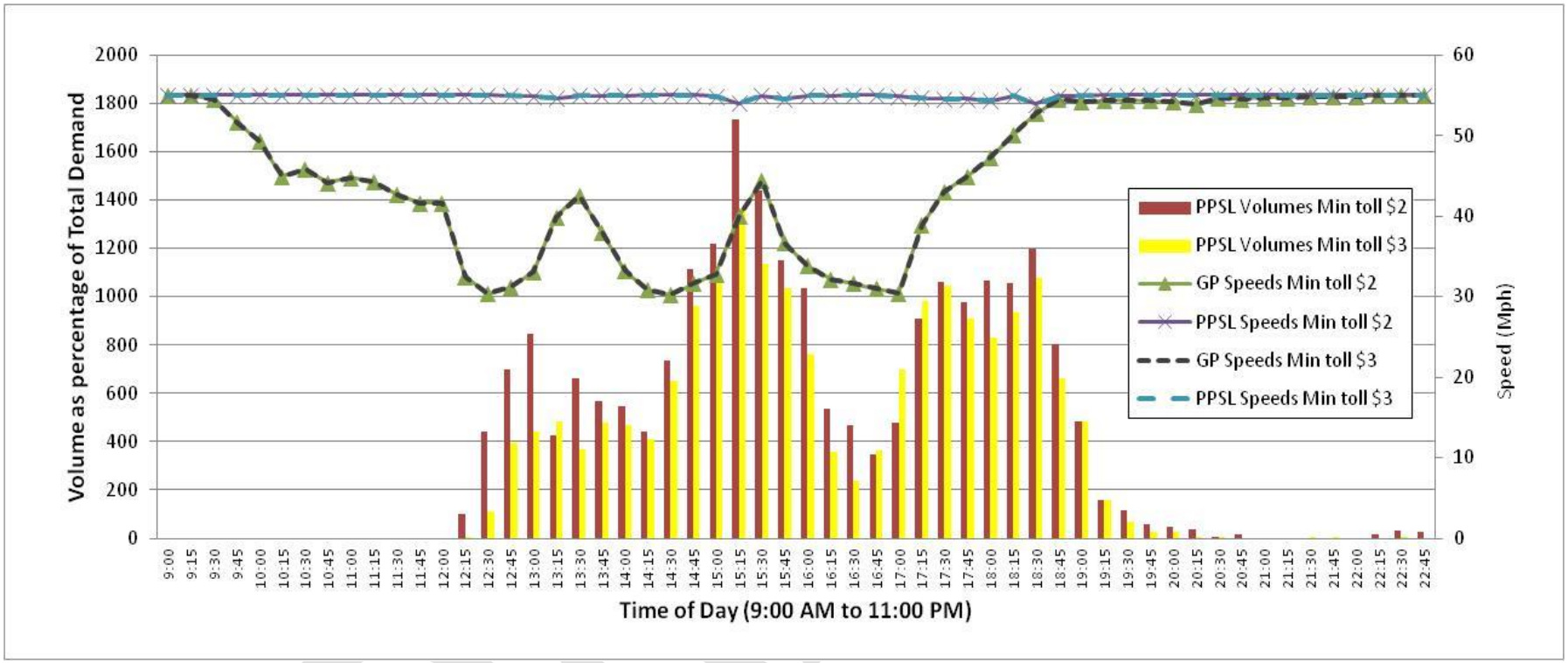

Figure 12: DynusT output, Speeds and PPSL retention volumes for minimum toll of $2.00 and $3.00

Toll Rates Recommendations

There is national interest within the tolling industry as to how toll rates will be initiated and adjusted during operations of the PPSL. Nationally, toll operations focus on metro-area commuter corridors, while the I-70 PPSL is the first toll operation focused on a recreational corridor. Commuter corridors experience week day congestion while the I-70 PPSL focuses on weekend congestion. As the PPSL is only open during peak periods, the toll rate upon opening should be sufficient to cover toll collection costs and low enough, subsequent to the lane opening procedures, to attract a customer to the toll lane even though traffic in the GP lanes is relatively light and the corridor is free flowing.

Over the course of a year, the mountains offer summer recreation, concerts, sporting events as well as winter recreation as I-70 West is the primary access for seven world class ski resorts. As a result, Interstate traffic volumes can increase by 200% to 300% over 2 – 3 hours. PPSL operations will require a high level of flexibility as the adjusting the toll rate is the sole mechanism to better ensure a reliable through trip for the toll customer. As a result, two toll rates are referenced, the Base Rate (see Table 3) provides toll parameters that align more to a commuter type corridor and recommends rates that allow opening procedures and address toll rates when the corridor is relatively uncongested. The Toll Rate Range (see Table 4) provides an open range that will allow the operations center the tools to increase rates in response to dramatically increasing corridor congestion.

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Table 3: Expected Base Toll Rates

BASE		ExpressToll	LPT
9:00 AM	**12:15 PM**	$ 3.00	$ 4.32
12:15	**2:15 PM**	$ 3.50	$ 4.82
2:15Pm	**5:00 PM**	$ 4.50	$ 5.82
5:00	**6:15**	$ 6.00	$ 7.32
6:15 PM	**11PM**	$ 3.00	$ 4.32

Table 4: Toll Rate Range

		ExpressToll		License Plate Tolling	
From	**To**	MIN	MAX	MIN	MAX
9:00 AM	**12:15 PM**	$ 3.00	$ 30.00	$ 4.32	$ 31.32
12:15 PM	**2:15 PM**	$ 3.50	$ 30.00	$ 4.82	$ 31.32
2:15 PM	**5:00 PM**	$ 4.50	$ 30.00	$ 5.82	$ 31.32
5:00 PM	**6:15 PM**	$ 6.00	$ 30.00	$ 7.32	$ 31.32
6:15 PM	**11:00 PM**	$ 3.00	$ 30.00	$ 4.32	$ 31.32

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APPENDIX-A

Traffic Characteristics

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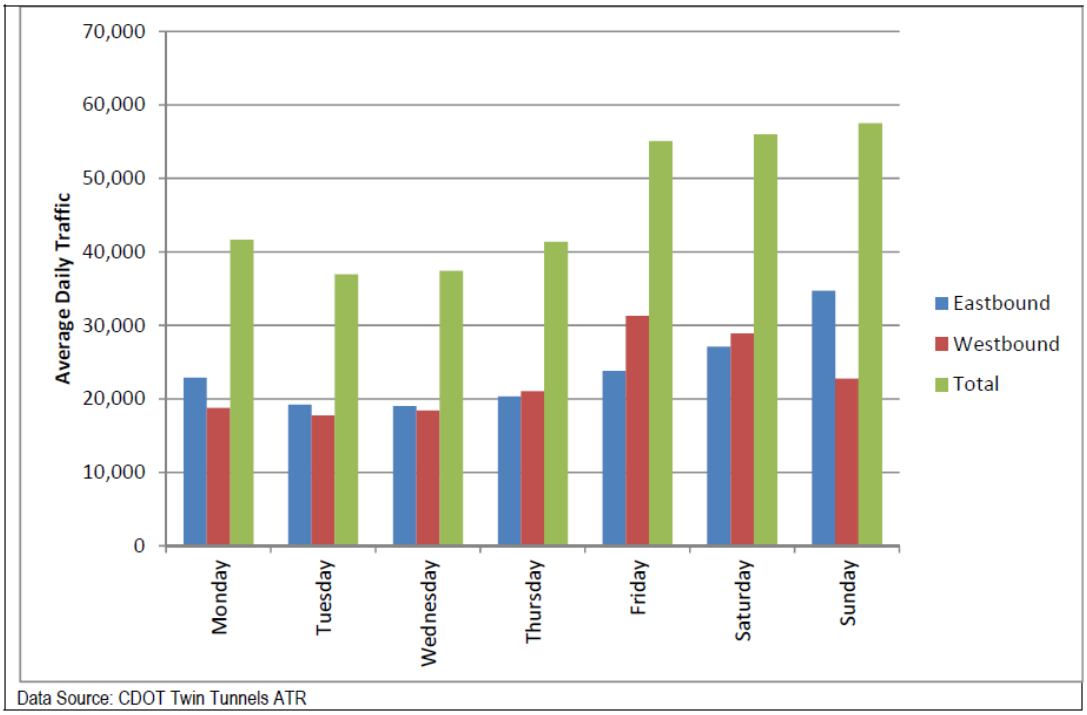


Figure A-1: Twin Tunnels ADT (**summer**: June through September) Source: Twin Tunnel Transportation Technical Memorandum, 2012

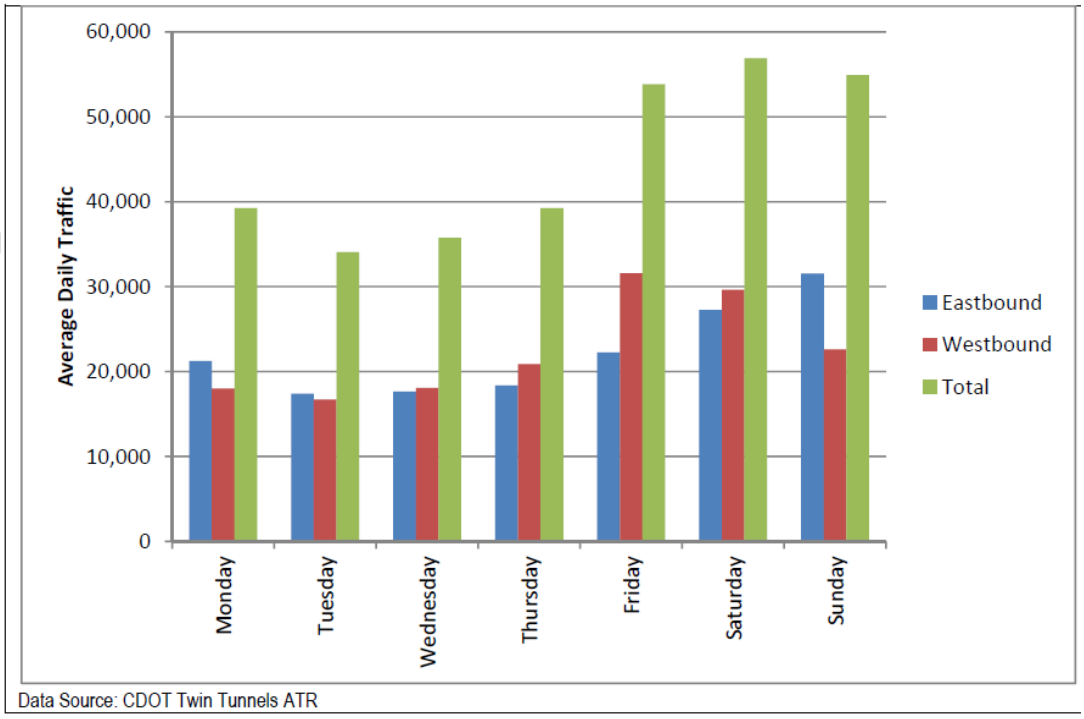
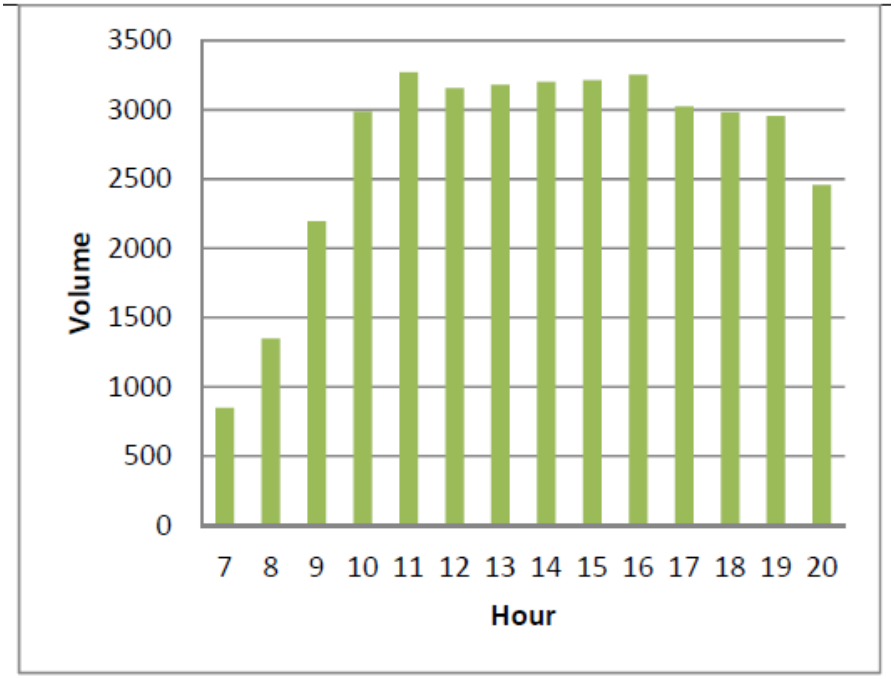
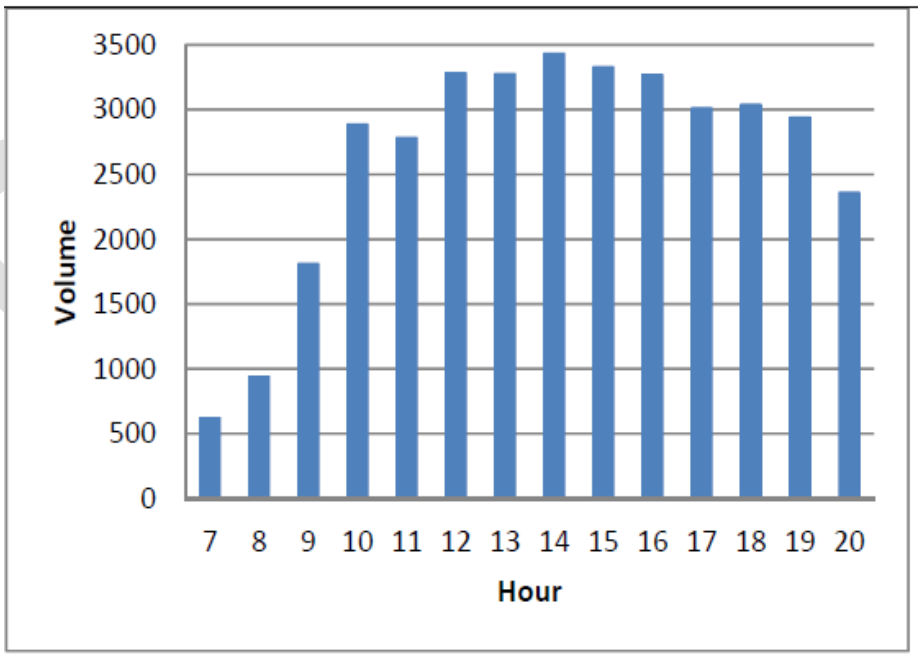


Figure A-2: Twin Tunnels ADT (**winter**: December through March) Source: Twin Tunnel Transportation Technical Memorandum, 2012



Data Source: CDOT Twin Tunnels ATR

Figure A-3: Summer Peak Day Eastbound I-70 Twin Tunnels Hourly Volumes Source: Twin Tunnel Transportation Technical Memorandum, 2012



Data Source: CDOT Twin Tunnels ATR

Figure A-4: Winter Peak Day Eastbound I-70 Twin Tunnels Hourly Volumes Source: Twin Tunnel Transportation Technical Memorandum, 2012

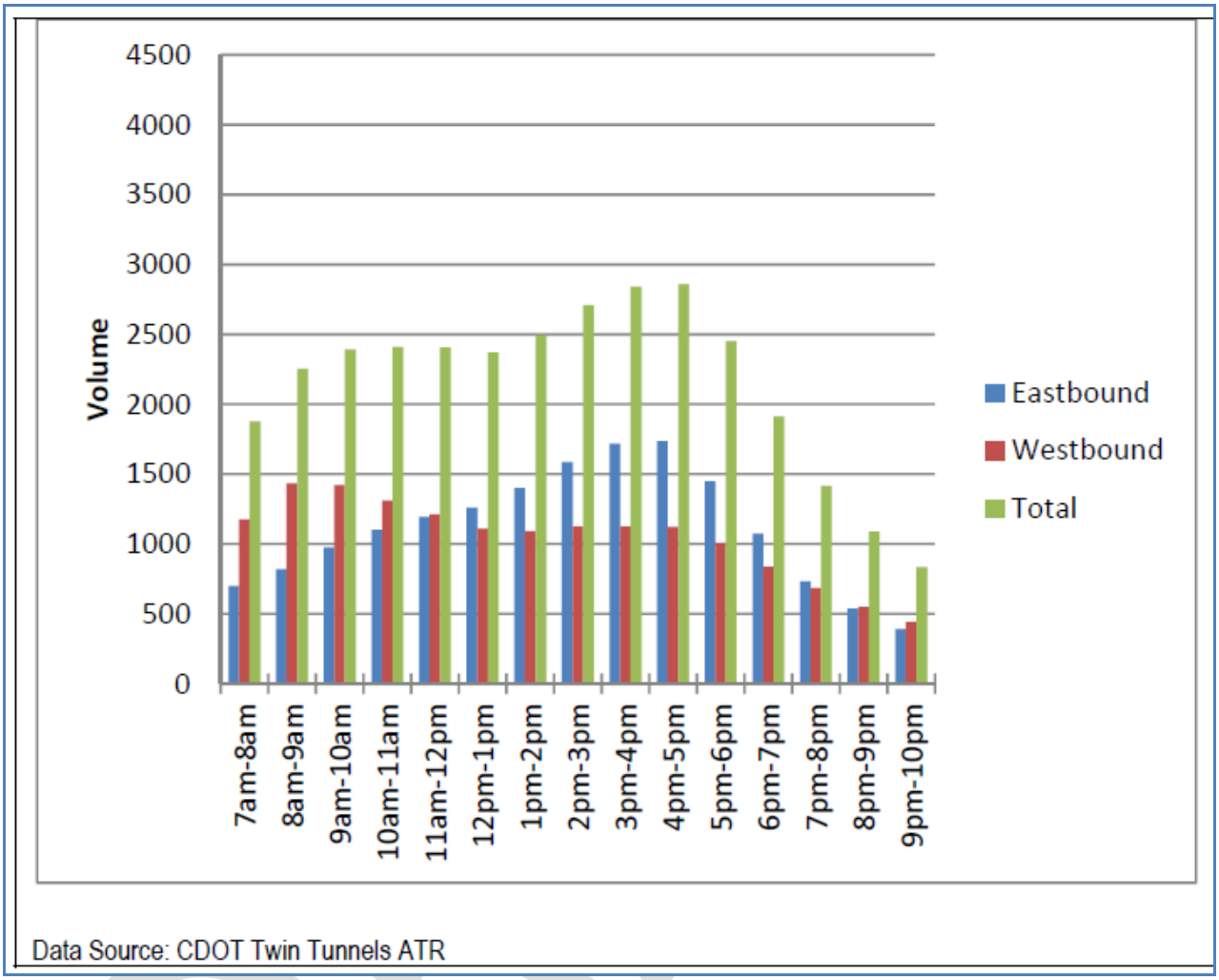


Figure A-5: Existing Average Weekday Volume by Hour of Day (I-70 at TwinTunnels) Source: Twin Tunnel Transportation Technical Memorandum, 2012

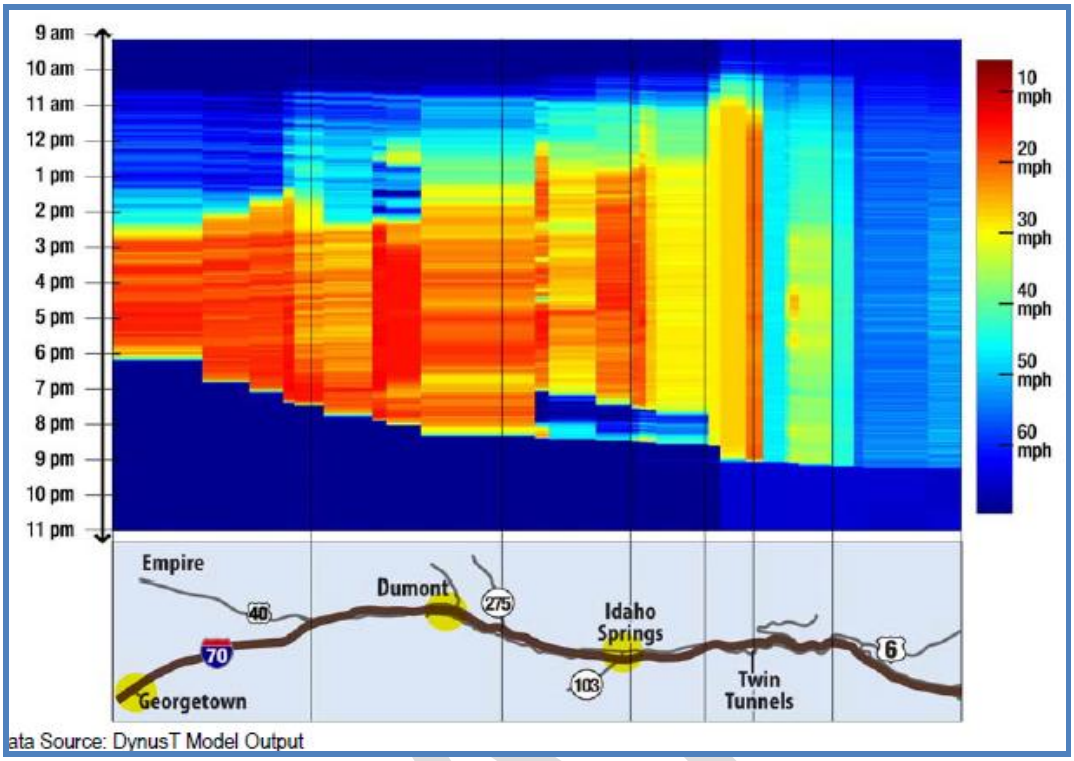


Figure A-6: 2010 Average Peak Day Eastbound Speeds by Segment between Georgetown and the top of Floyd Hill, Source: Twin Tunnel Transportation Technical Memorandum, 2012

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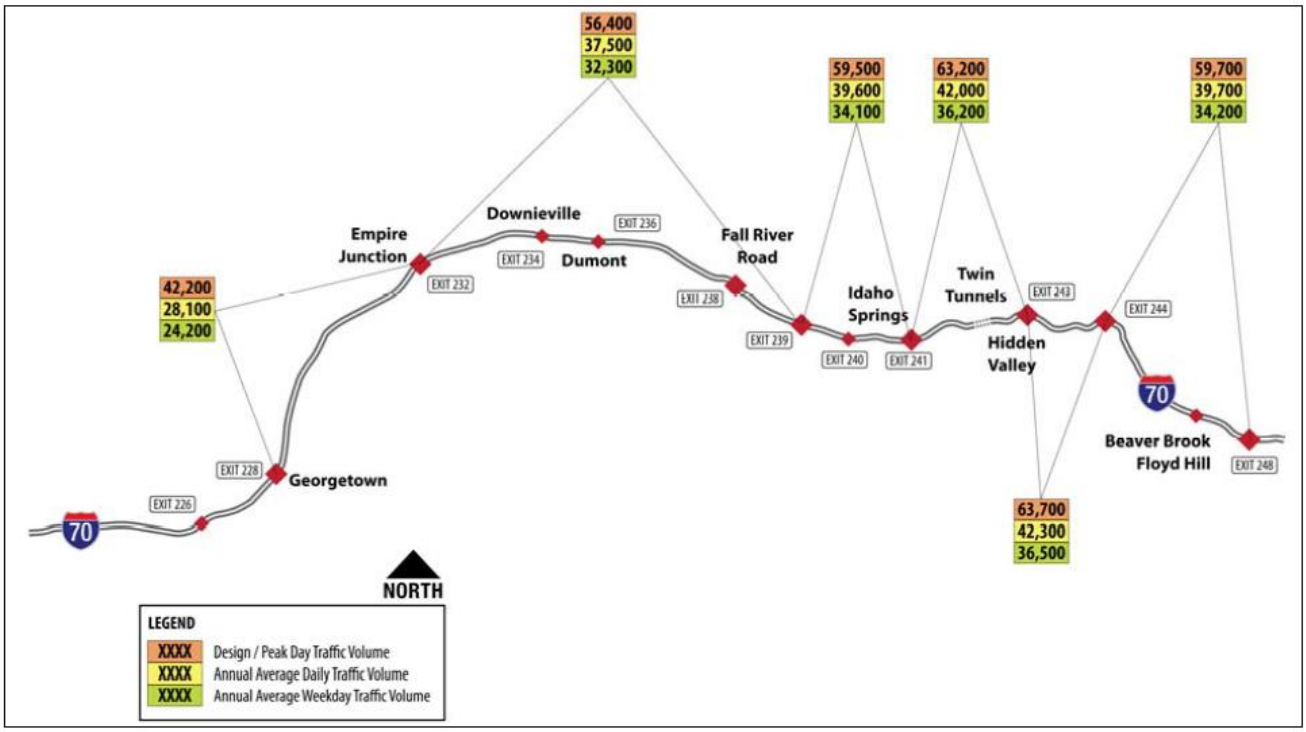

Figure A-7: 2010 Daily Volumes, Source: Twin Tunnel Transportation Technical Memorandum, 2012

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Table A-1: Highest Seasonal Eastbound I-70 Daily Traffic Volumes (1/2009—9/2011), Source: Twin Tunnel Transportation Technical Memorandum, 2012

Highest Summer Days (2009—2011)				Highest Winter Days (2009—2011)			
Rank	Date	Day	Daily Volume	Rank	Date	Day	Daily Volume
1	7/5/2009	Sun	44,570	1	1/30/2011	Sun	40,038
2	7/5/2010	Mon	44,249	2	1/31/2010	Sun	39,700
3	8/7/2011	Sun	41,531	3	3/1/2009	Sun	37,979
4	7/31/2011	Sun	41,284	4	2/13/2011	Sun	37,665
5	7/18/2010	Sun	41,168	5	1/2/2010	Sat	37,627
6	9/5/2011	Mon	41,165	6	2/22/2009	Sun	37,262
7	8/8/2010	Sun	41,149	7	3/6/2011	Sun	36,634
8	8/22/2010	Sun	40,509	8	1/19/2009	Mon	35,986
9	7/19/2009	Sun	40,483	9	2/28/2010	Sun	35,714
10	7/24/2011	Sun	40,406	10	1/3/2010	Sun	35,690
Top 10 Average			41,651	Top 10 Average			37,430
Top 5 Average			42,560	Top 5 Average			38,602

Data Source: CDOT Twin Tunnels ATR

DRAFT