

CITY OF HAMILTON

**RED HILL VALLEY PARKWAY AND LINCOLN ALEXANDER PARKWAY
ORIGIN-DESTINATION ANALYSIS**

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City of Hamilton

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Final Report

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1. Introduction

The traffic between Queen Elizabeth Way (QEW) East and Highway 403 South may use Red Hill Valley Parkway (RHVP) and Lincoln Alexander Parkway (LAP) as a shortcut, instead of going around Hamilton via provincial highway system that would result in additional traffic congestion along RHVP and LAP. The provincial highway route length is approximately 31 km whereas the shortcut route length is approximately 21 km, making it an attractive alternative. Figure 1 shows the two options available.

CIMA+ was retained by the City of Hamilton (the City) to assess the shortcut traffic on RHVP and LAP. The key objectives of this study can be summarized as follows:

- Differentiate between pass-through traffic and local traffic for vehicles travelling on RHVP and LAP
- Determine the pass-through traffic volume by vehicle class, time of day, and direction of traffic

The shortcut route along RHVP and LAP is the focus of this study, and the study area extends from the QEW/RHVP interchange on the east to Highway 403/LAP interchange on the west.

This report summarizes the data collection, review and processing methodology, and provides total pass-through traffic volumes by vehicle class, time of day, and direction of traffic.

Figure 1: Route Choices



2. Data Collection

To determine the pass-through traffic along the study corridor, two types of data were collected: 1) Origin-Destination (OD) data for the eastbound and westbound routes along RHVP and LAP and 2) traffic volume data at each end of study routes. The traffic data was collected along the shortcut route to study the eastbound and westbound pass-through traffic on RHVP/LAP.

2.1 Origin-Destination (OD) Data

Two routes were defined for the OD survey as follows:

- RHVP/LAP Westbound Route: This route starts at RHVP westbound at Barton Street East interchange (between the on and off ramps) and ends at LAP westbound at Mohawk Road interchange (west of the off ramp). This route will cover all vehicles which enter RHVP from QEW and access Highway 403 through LAP and will be referred to as the westbound route throughout this report.

- LAP/RHVP Eastbound Route: This route starts at LAP eastbound at Mohawk Road interchange (east of the off ramp) and ends at RHVP eastbound at Barton Street East interchange (east of the off ramp). This route will cover all vehicles which enter LAP from Highway 403 and access QEW through RHVP and will be referred to as the eastbound route throughout this report.

The OD data was collected using license plate recognition cameras. For each study route, license plate recognition cameras were installed at the start and end locations. One camera was assigned to each lane of traffic. License plates were recorded at the start and end locations. License plates which were recorded at both ends of a study route represent vehicles which travelled along the entire route. To identify vehicles which may have stopped for an activity along the route, travel times were also recorded by comparing the detection time at the start and end of the route. The locations of license plate recognition cameras are shown in Figure 2.

Figure 2: License Plate Recognition and Automatic Traffic Recorder Camera Locations



In addition to the license plate numbers, a photo of each vehicle was captured. The photos were used to manually determine vehicle type. Four vehicle types were considered in the vehicle classification including (1) Light Vehicles, (2) Single-Unit Trucks, (3) Articulated Trucks, and (4) Buses. The Single-Unit Trucks and Articulated Trucks were aggregated as Trucks.

The OD data was collected at the four locations on May 15th, 2019 for the 24-hour period.

2.2 Traffic Volume Data

Traffic volumes were collected using Miovision Automatic Traffic Recorder (ATR) cameras. The ATR counts were conducted to analyze the detection error of the license plate recognition system and estimate expansion factors for the OD Survey counts. The locations of the ATR cameras are shown in Figure 2. The ATR counts were conducted for the same period as the OD data and identical vehicle classification was utilized.

3. Traffic Volumes

Table 1 shows a summary of the 24-hour vehicle counts at the four data collection locations. Over 31,000 vehicles were recorded to enter the westbound route in a 24-hour period. 8.6% of these vehicles were recorded to be trucks. The 24-hour volume for vehicles entering the eastbound route was recorded to be over 33,000 vehicles with 7.9% trucks.

Table 1: 24-hour ATR Traffic Volume (% of traffic detected by License Plate Recognition System)

Location	Light Vehicles	Trucks	Buses	Total
RHVP-EB	32490 (91.4%)	2972 (8.4%)	95 (0.3%)	35557 (100%)
RHVP-WB	28810 (91.3%)	2699 (8.6%)	46 (0.1%)	31555 (100%)
LAP-EB	30602 (91.7%)	2637 (7.9%)	148 (0.4%)	33387 (100%)
LAP-WB	33789 (92.0%)	2771 (7.5%)	167 (0.5%)	36727 (100%)

Hourly variation of traffic volumes at the four data collection locations is shown in Figure 3 and Figure 4. The following observations were made:

- The AM peak hour traffic at RHVP WB (start of the westbound route) is 2068 vehicles and the PM peak hour traffic is 2470 vehicles
- The truck traffic at RHVP WB accounts for 10% during the AM peak hour and 6% during the PM peak hour
- The AM peak hour traffic at LAP EB (start of the eastbound route) is 2331 vehicles and the PM peak hour traffic is 2786 vehicles
- The truck traffic at LAP EB accounts for 9% during the AM peak hour and 6% during the PM peak hour
- The bus traffic is negligible (<1% of hourly traffic), on an hourly basis.

Figure 3: RHVP ATR Traffic Volume

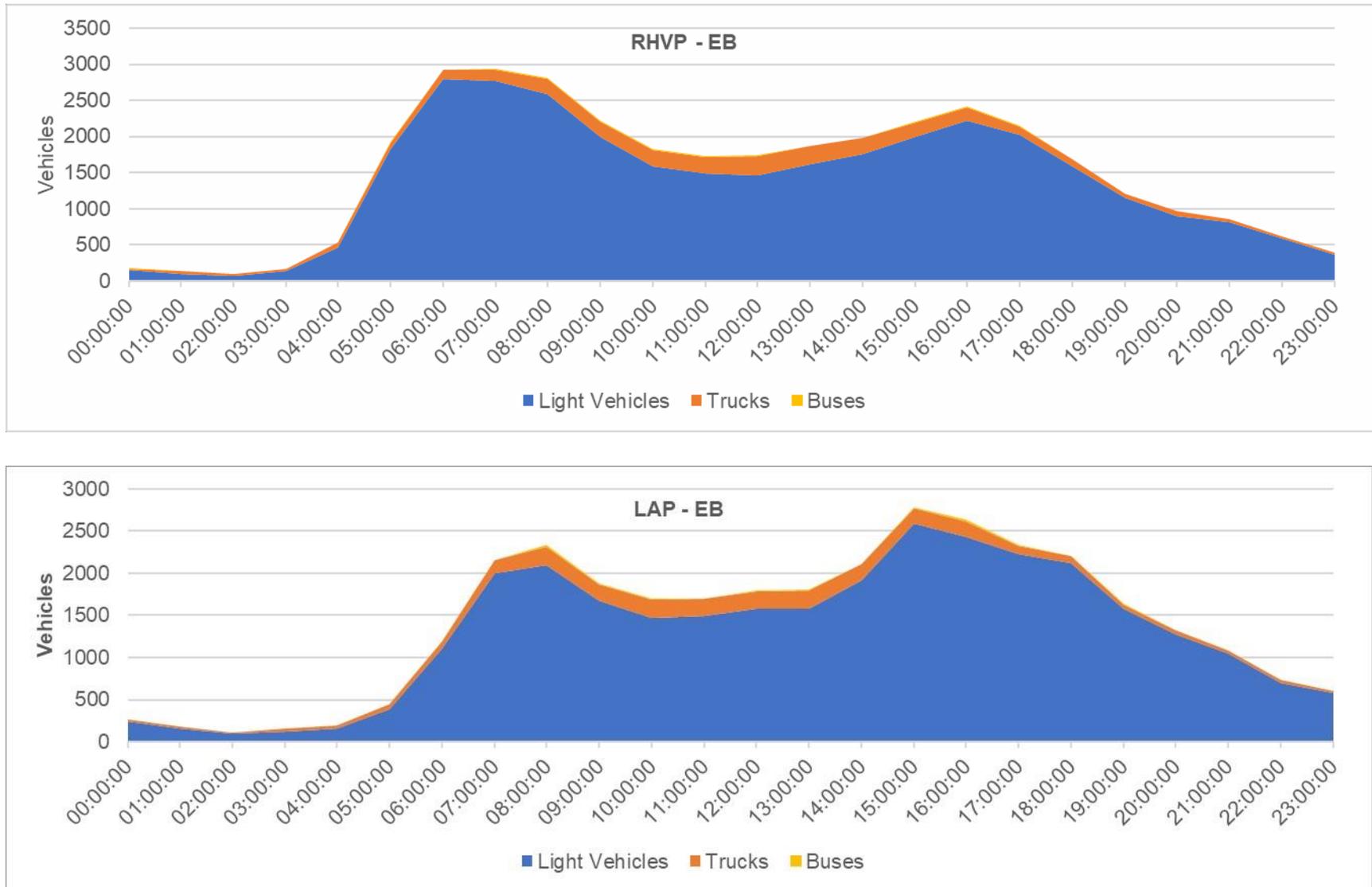
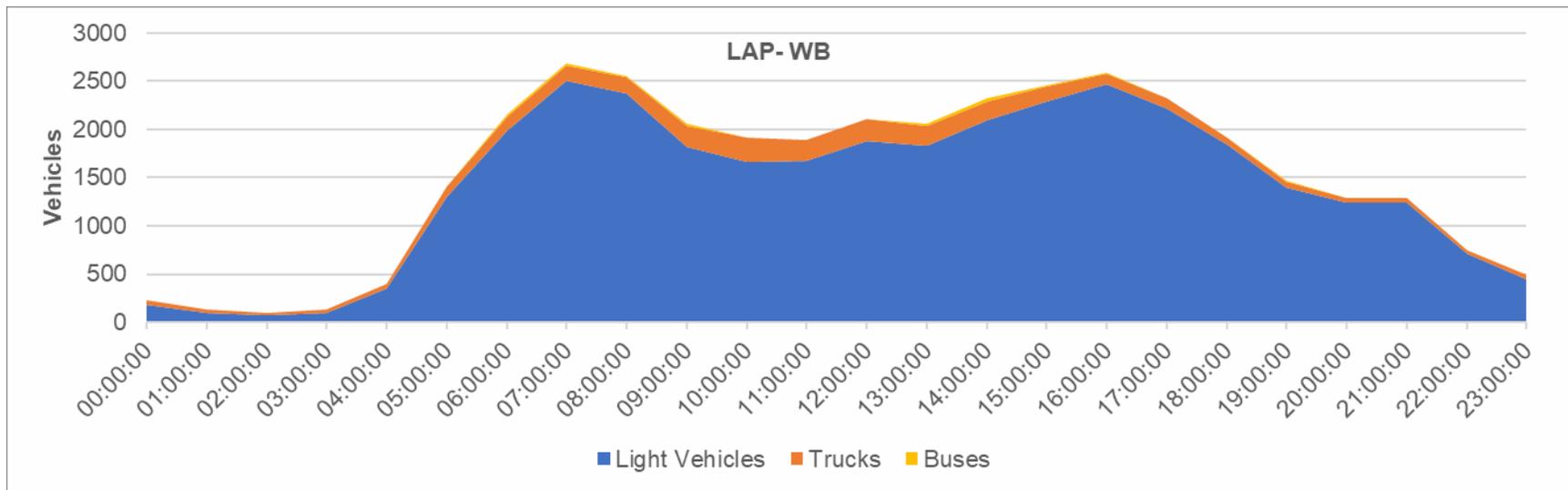
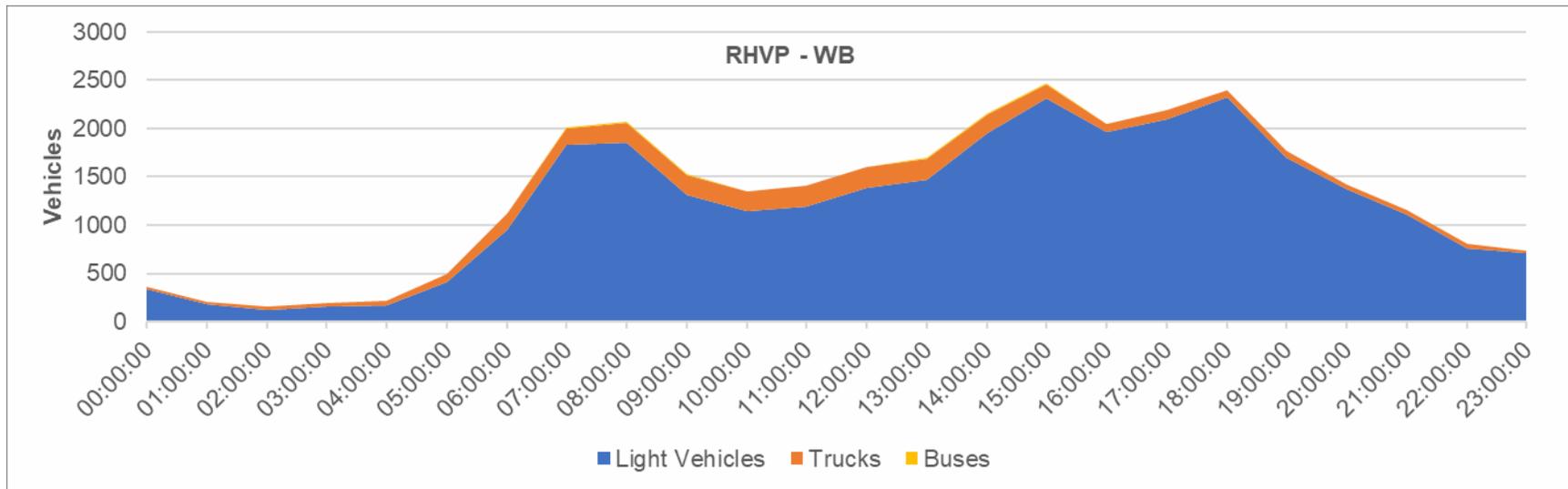


Figure 4: LAP ATR Traffic Volume



4. License Plate Detection

As discussed earlier, cameras were installed at the four data collection locations to record license plates of the passing vehicles. A traffic volume count can be established based on the number of vehicles which were detected by the license plate recognition system as shown in Table 2. It should be noted that these numbers only include vehicles which were detected by the license plate recognition system, and represent a subset of total vehicles. Therefore, the counts from the license plate recognition system is expected to be lower than the ATR counts which cover all vehicles. A manual process was undertaken to classify vehicles through a visual inspection of vehicle images attached to each detected license plate. The license plate matching, in eastbound and westbound direction, is described later in the report to determine the pass-through traffic.

Table 2: License Plate Recognition System - 24-Hour Traffic Volume

Location	Light Vehicles	Trucks	Buses	Total
<i>RHVP-EB</i>	25601 (91.0%)	2453 (8.7%)	82 (0.3%)	28136 (100%)
<i>RHVP-WB</i>	22237 (91.4%)	2062 (8.5%)	33 (0.1%)	24332 (100%)
<i>LAP-EB</i>	22269 (91.1%)	2048 (8.4%)	130 (0.5%)	24447 (100%)
<i>LAP-WB</i>	26440 (91.5%)	2301 (8.0%)	150 (0.5%)	28891 (100%)

The license plate recognition system volumes are approximately 77% of the ATR traffic volumes, across all locations i.e. the license plate recognition system detected approximately 3 out of 4 vehicles. This is a significantly larger sample size compared to alternative technologies such as Bluetooth sensors which have sample rate of 2-3%, and the Hybrid Bluetooth/Wi-Fi sensors that have sampling rate of 15-20%.¹

The vehicle classification from the license plate recognition system is very similar to that from the ATR counts. The truck percentage across all locations is 8.1% from the ATR counts and 8.4% from the license plate recognitions system. This suggests that the detection rate is almost the same for different vehicle types, and no detection bias can be recognized.

Figures 5 and Figure 6 summarize the hourly variation of license plate detection volumes throughout the 24-hour study period. The AM peak hour detected traffic at RHVP WB (start of the westbound route) is 1516 vehicles and at LAP EB (start of the eastbound route) is 1354 vehicles, which occurs at 8:00-9:00 AM. The PM peak hour detected traffic at RHVP WB is 2276 vehicles and at LAP EB is 2186 vehicles, which occurs at 3:00-4:00 PM.

¹ Based on Travel Time Detection Technology Options Study conducted within GTA by CIMA+ to evaluate Bluetooth and other travel time technologies.

Figure 5: RHVP License Plate Recognition System - Detected Traffic Volume

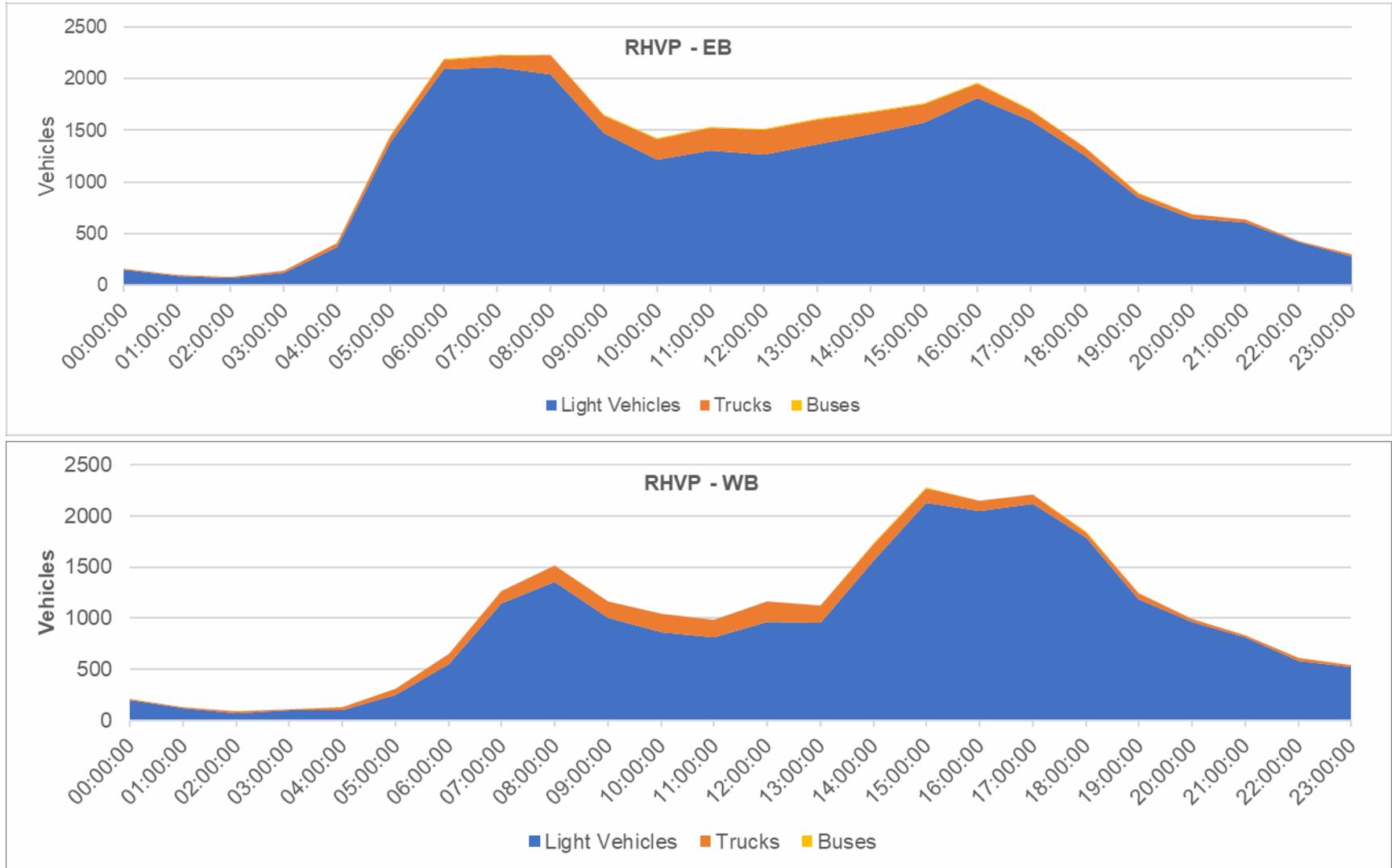
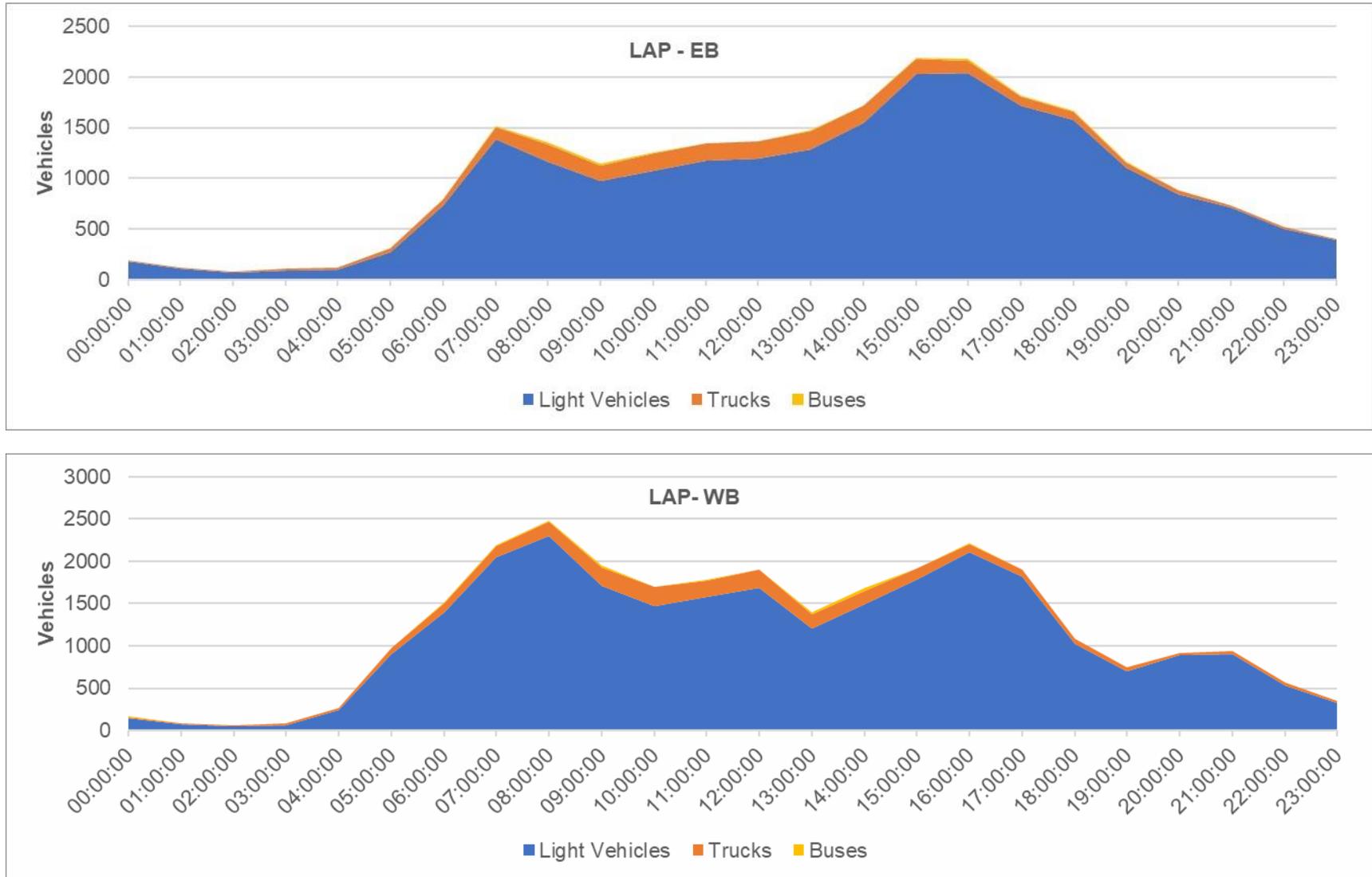


Figure 6: LAP License Plate Recognition System - Detected Traffic Volume



5. Detection Ratio

The detection ratio refers to number of vehicles detected by license plate recognition system versus the ATR traffic volume, over the same period of time. Equation 1 provides the formula for calculating Detection Ratio. Table 3 provides the total traffic counts from ATR and License Plate Detection System, per location. LAP-EB and RHVP-WB represents the start locations of the eastbound and westbound routes. According to the ATR counts, the total number of vehicles entering the eastbound route is 33387 and the total number of vehicles entering the westbound route is 31555.

$$Detection\ Ratio_{hour} = \frac{License\ Plate\ Recognition\ System\ Traffic\ Counts_{hour}}{ATR\ Traffic\ Counts_{hour}} \quad (Equation\ 1)$$

Table 3: Traffic Counts Overview

Location	ATR Counts	License Plate Detection Counts	Detection Ratio
RHVP - EB	35557	28136	79.1%
RHVP - WB	31555	24432	77.4%
LAP - EB	33387	24447	73.2%
LAP - WB	36727	28891	78.7%

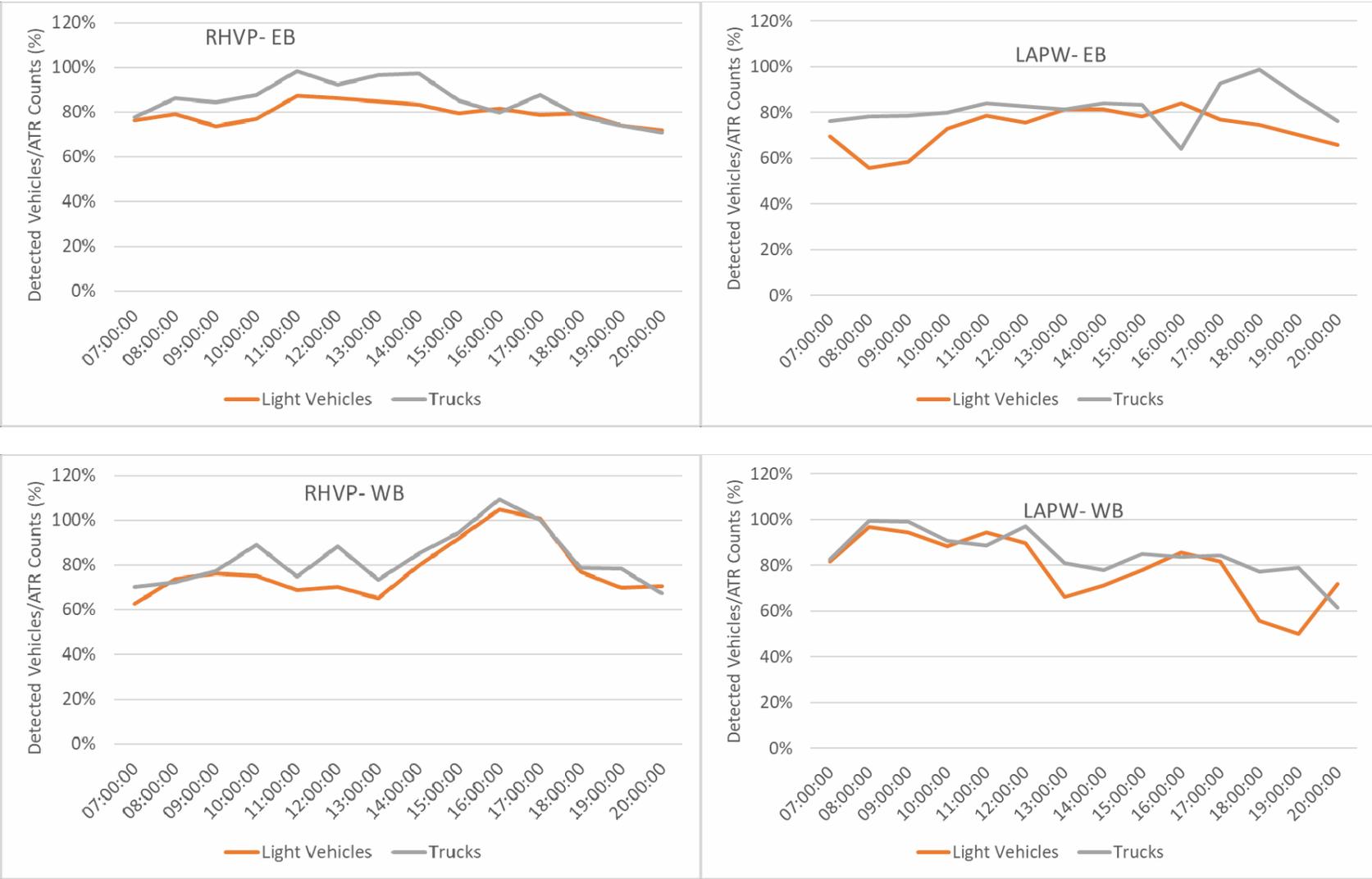
The accuracy of visual vehicle classification process drops significantly during dark hours when environmental light is not enough to differentiate between different vehicle types. Therefore, the analysis in this section and next section was completed for different time periods as follows:

- Day Time: from 7:00 AM to 8:00 PM when vehicles were accurately classified. All analyses were conducted for light vehicles and trucks separately.
- Dark Time: from 12 AM to 7:00 AM and 8 PM to 12 AM when vehicles cannot be visually classified. The OD analysis was conducted for total vehicles.

Figure 7 shows the detection ratio during Day Time at each of the four data collection locations, per vehicle classification. The hourly bus detection ratio is excluded due to small sample size. Across all locations, 78% of light vehicles; 84% of trucks; and 88% of buses were detected during the Day Time. This suggests that the sample size for all vehicle types are large enough for OD analysis during the Day Time. Both light vehicle and truck detection ratios slightly fluctuate throughout the day; however, the detection ratio remains above 55% at any given hour during the Day Time. For RHVP-WB, the detection ratio slightly exceeds 100% at 4 PM for both light vehicles and trucks. This is the result of license plate detection counts exceeding the ATR counts, which

could be due to partial-license plate recognition. The partial-license recognition may result in more than one count for a single license plate, resulting in overestimation of traffic counts from license plate recognition system.

Figure 7: Day Period Detection Ratio per location and vehicle classification



6. Pass-Through Traffic

For both eastbound and westbound routes, vehicles were detected at an upstream (start) and a downstream (end) location. Recorded license plates at the upstream and downstream locations for each route were compared, and the license plates that were recorded at both upstream and downstream locations were identified. The pass-through traffic was determined using the following methodology:

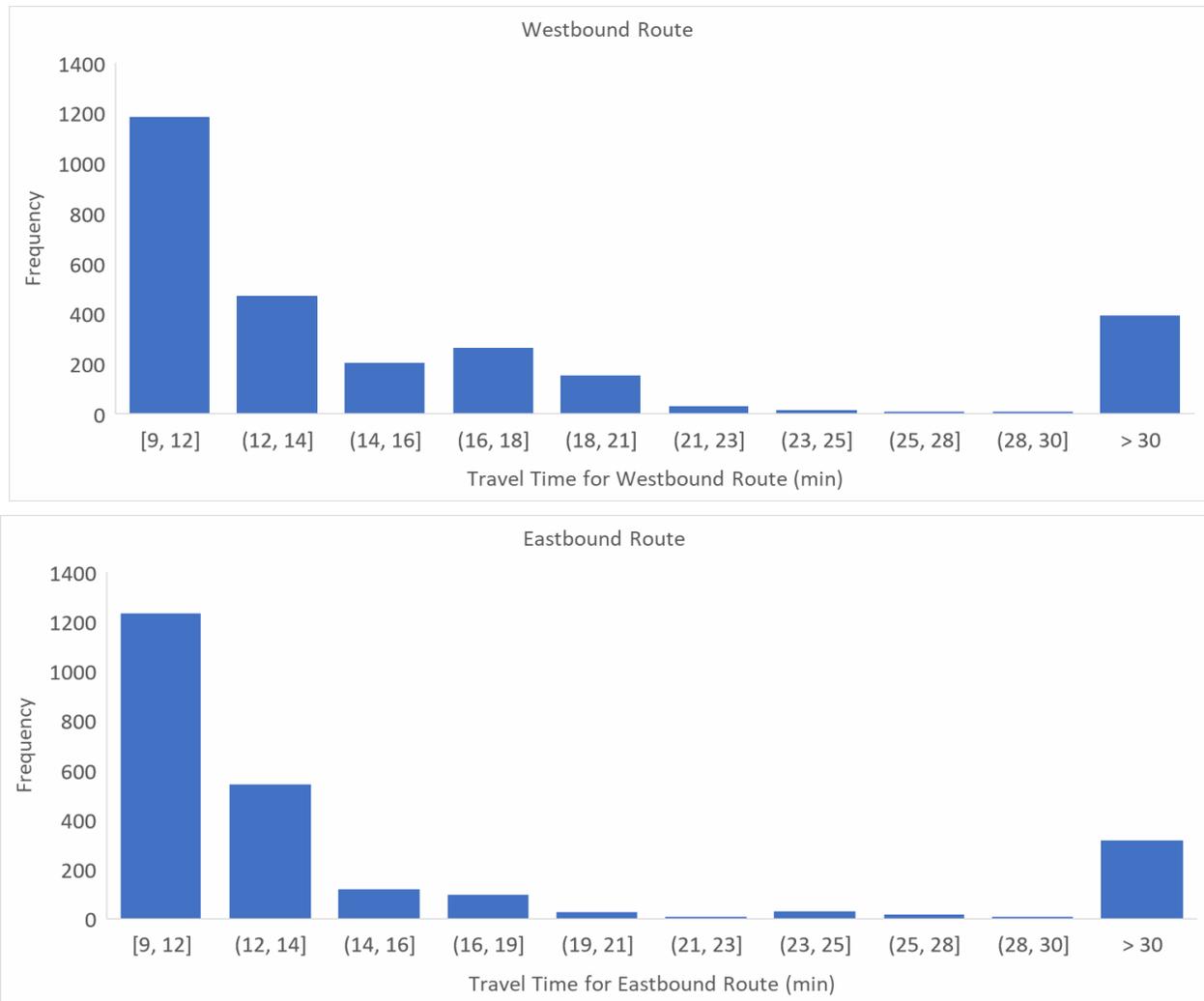
1. Vehicles detected only on one end of the route were considered local trips.
2. Vehicles detected on both ends of the route were considered to be either pass-through or stopped traffic, based on the travel time of the trip
3. The travel time of vehicles detected on both ends of the route was compared to the *travel time threshold* (will be described in the next section) as follows:
 - a. The vehicles with travel time less than the threshold were considered to be pass-through traffic.
 - b. The vehicles with travel time greater than the threshold were considered to be traffic that made a stop (i.e. delivery), hence the trip does not classify as pass-through.
4. The total number of pass-through trips was calculated as the ATR traffic count at the start of the route multiplied by the *pass-through probability* (will be described in the next section).

6.1 Travel Time Threshold

Since travel time along the study routes would change throughout the day, a static threshold may not appropriately differentiate between pass-through traffic with those who made a stop to do an activity (e.g. delivery). A dynamic travel time threshold for each observation (a vehicle which was detected on both ends of the route) was defined based on the moving average of ten adjacent observations. Observations with travel time up to 20% higher than the moving average travel time were considered acceptable. If a vehicle's travel time is greater than the threshold (120% of the moving average), the trip is considered non-pass through since it most likely made a stop. For example, at 8:00 AM, Trip A is completed in 13 minutes. The average travel time for the next 10 completed trips is 12 minutes. The resulting threshold is 14.4 minutes (12 minutes + 20% additional allowance). Hence, Trip A is completed within the travel time threshold and is considered a pass-through trip. Opposingly, Trip B is completed in 25 minutes during the same time period. Since Trip B is not completed within the travel time threshold, it is considered a stopped trip. The travel time threshold is dynamically updated for each time period based on the next 10 completed trips.

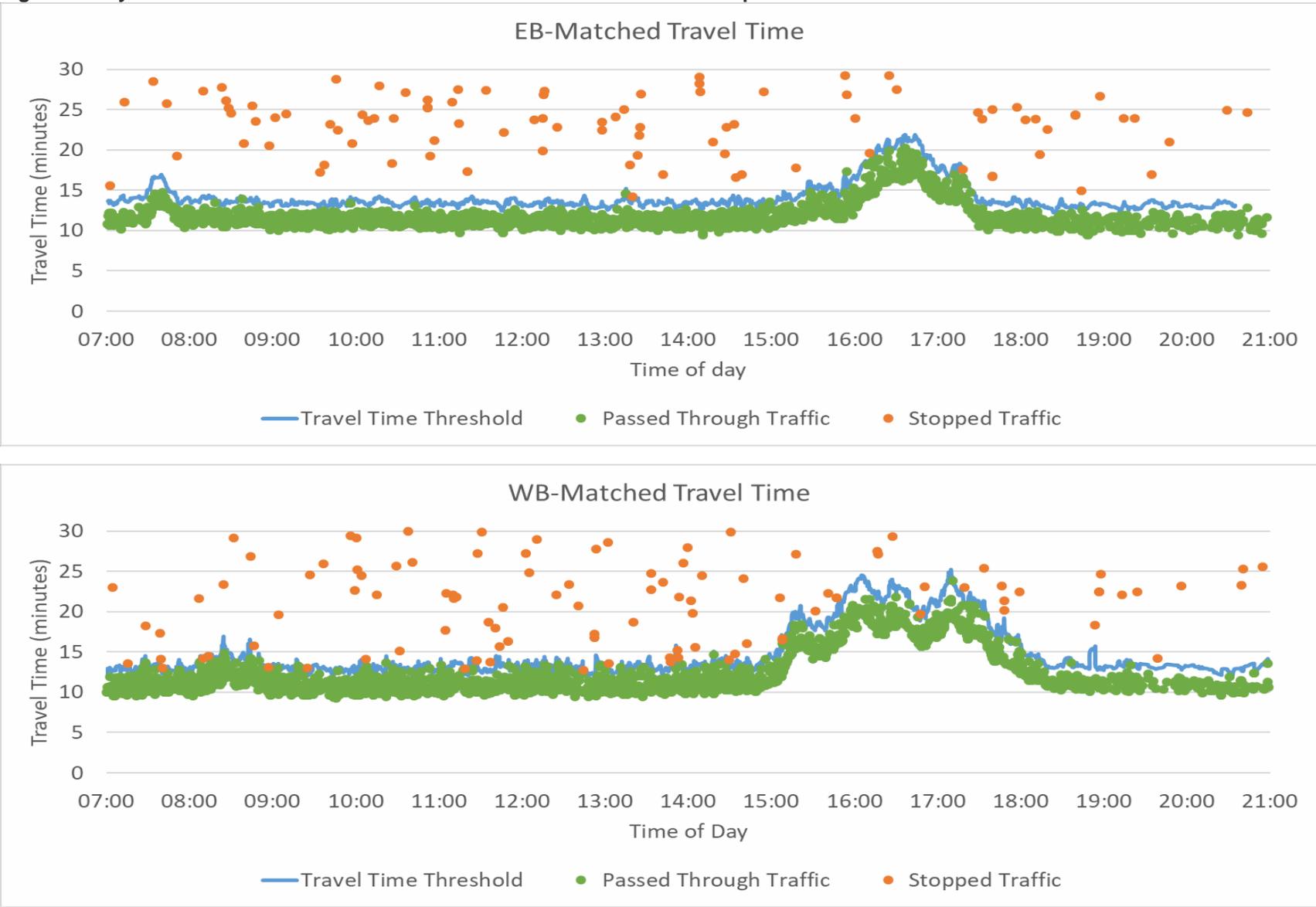
Figure 8 shows the histogram of travel time values for vehicles which completed the eastbound and westbound routes. The travel time ranges between 9 to 650 minutes for the Westbound trips and 9 to 600 minutes for the Eastbound trips. Travel time of greater than 30 minutes was determined to be the cut-off, meaning any completed trip greater than 30 minutes was considered a stopped trip². If travel time is less than 30 minutes, the dynamic travel time threshold was applied as shown in Figure 9.

Figure 8: Observed Travel Time for completed Eastbound and Westbound trips



² Peak travel time, according to Google Travel Data, is 22 minutes across the study area, hence 30 minutes is utilized as a conservative cut-off point. It means any travel time longer than 30 minutes is considered as a stopped trip. For travel times shorter than 30 minutes, the dynamic threshold was applied to determine whether it was a stopped trip or a pass-through trip.

Figure 9: Day Time Travel Time Threshold for Eastbound and Westbound Trips



Approximately 18% of completed eastbound trips were classified as “stopped” and 15% of completed westbound trip were classified as “stopped”, meaning these trips’ travel time was greater than the threshold and are not considered passed-through.

6.2 Pass-Through Probability

The Pass-Through Probability, which represents the probability of a vehicle at one end of the study area to complete the entire route, is utilized to determine the total number of pass-through trips in the eastbound and westbound direction. The Pass-Through Probability is described in Equation 2.

$$P(\text{Passing Through})_{\text{hour}} = \frac{\text{Pass Through Trips}_{\text{hour}}}{\text{License Plates Detected}_{\text{hour}}} \quad (\text{Equation 2})$$

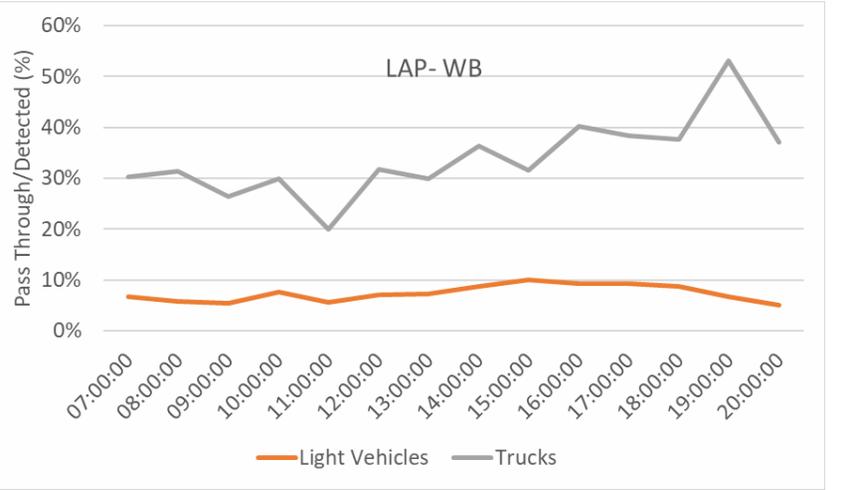
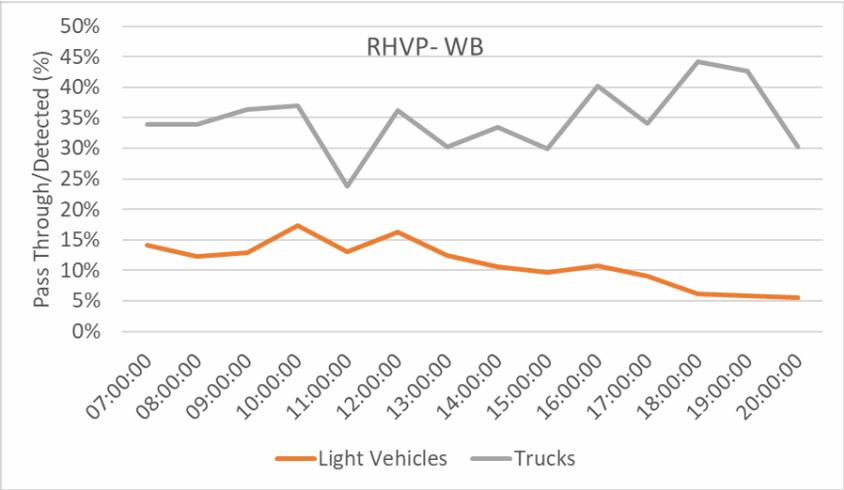
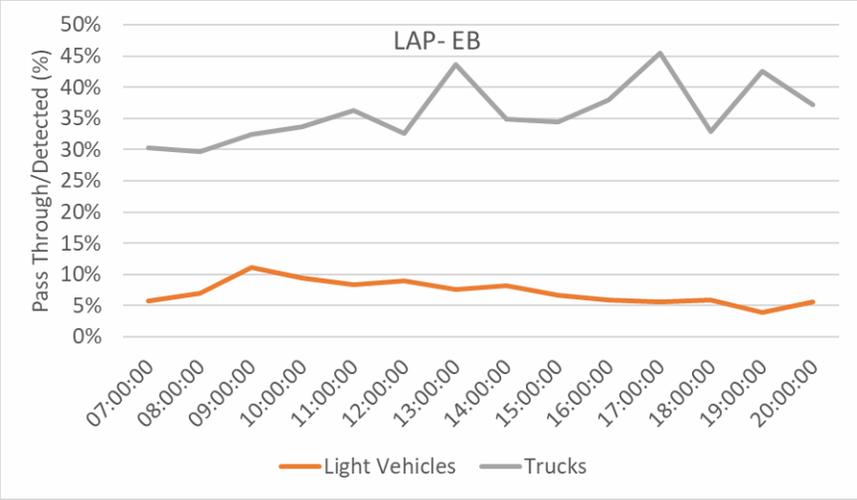
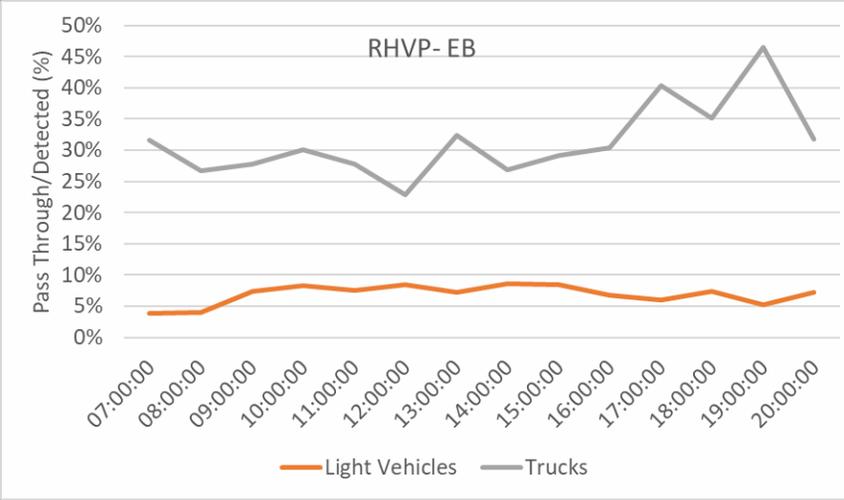
The Stopped Vehicle Percentage, represents the percentage of vehicles that completed the entire route with travel time greater than travel time threshold, meaning the vehicle did have a destination along the route. The Stopped Vehicle Probability is described in Equation 3.

$$P(\text{Stopped Vehicle})_{\text{hour}} = \frac{\text{Stopped Trips}_{\text{hour}}}{\text{License Plates Detected}_{\text{hour}}} \quad (\text{Equation 3})$$

For example, during the AM peak hour, 2233 vehicles were detected to enter the eastbound route (LAP-EB). 162 of these vehicles were observed to complete the route (i.e. they were also detected at RHVP-EB). Travel time for 29 out of 162 vehicles exceeded the travel time threshold and were classified as stopped vehicles. The rest (133 vehicles) completed the route with travel times shorter than the threshold and were classified as pass-through traffic. Therefore, for the AM peak hour, the Pass-Through Probability for the eastbound route is 6% (133 divided by 2223), and the Stopped Vehicle Probability for the eastbound route is 1% (29 divided by 2223). It means 6% of vehicles entering the eastbound route are expected to be pass-through traffic; 1% are expected to have a stop along the way and then complete the route, and the rest (93%) are expected to be destined to a local destination along the route.

Figure 10 shows the Pass-Through Probability per location, per vehicle type. Across all locations, 7% of light vehicles, 33% of trucks, and 7% of buses were passing through the study area. In other words, approximately 1 out of every 3 trucks on RHVP WB or LAP EB are using the RHVP/LAP as a shortcut. As shown in Figure 10, the probability of a truck passing through is significantly higher than a light vehicle. For instance, 36% of trucks entering RHVP WB at 2:00 PM are passing through the entire study area whereas 11% of light vehicles are expected to pass through the study area in the same time period.

Figure 10: Day-Time Pass Through Probability



6.3 Pass-Through Traffic Volume

To calculate the pass-through traffic volumes for each route, the ATR Traffic counts at the entrance of the study routes was multiplied by the Pass-Through Probability, per vehicle type. Similar to Pass-Through Probability, Stopped Vehicle Probability was defined to determine total stopped trips across the study area. The pass through and stopped traffic volumes are summarized in Figures 11 and 12.

Table 4 presents a summary of pass-through traffic by vehicle type for the eastbound and westbound routes. The eastbound AM peak hour pass-through traffic is comprised of 187 light vehicles and 64 trucks. Additionally, the eastbound PM peak hour pass-through traffic is comprised of 172 light vehicles and 69 trucks. The westbound AM peak hour pass-through traffic is comprised of 222 light vehicles and 73 trucks, and the westbound PM peak hour pass-through traffic is comprised of 186 light vehicles and 43 trucks.

The eastbound Day Time through traffic is comprised of 1831 light vehicles, 795 trucks and 9 buses. Additionally, the westbound Day Time pass through traffic is comprised of 2072 light vehicles, 732 trucks and 2 trucks.

Table 4: Pass Through Traffic Summary

Period	Vehicle Type	Eastbound Trip (vehicles)			Westbound Trip (vehicles)		
		Total Traffic	Pass Through Traffic	Pass Through %	Total Traffic	Pass Through Traffic	Pass Through %
AM Peak Hour	Light Vehicles	1672	187	11%	1833	222	12%
	Trucks	215	64	30%	216	73	34%
PM Peak Hour	Light Vehicles	2593	172	7%	1960	186	9%
	Trucks	181	69	38%	145	43	30%
Day Time	Light Vehicles	26017	1831	7%	23909	2072	9%
	Trucks	2250	795	35%	2169	732	34%
	Buses	146	9	6%	37	2	5%
24 Hour	All Vehicles	33387	3140	9%	31555	3490	11%

Figure 11: Light Vehicles Day-Time Pass-Through and Stopped Traffic Volume

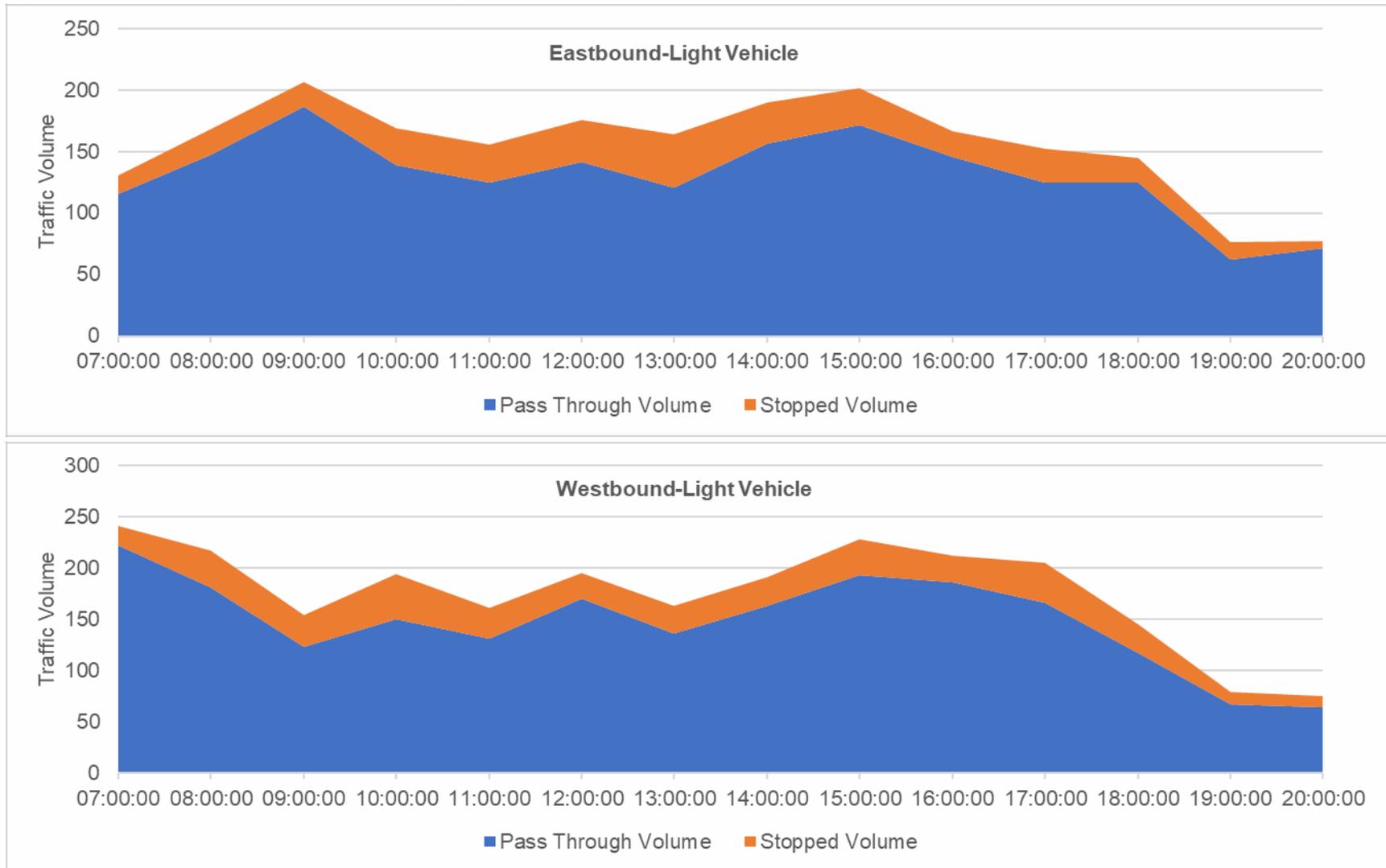
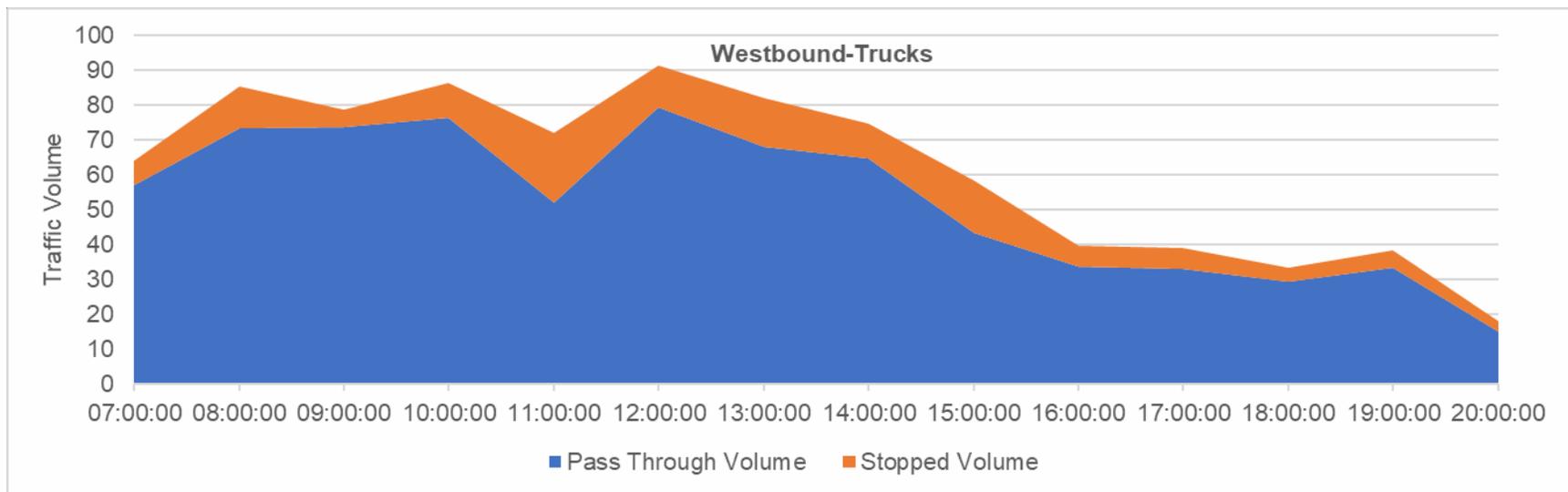
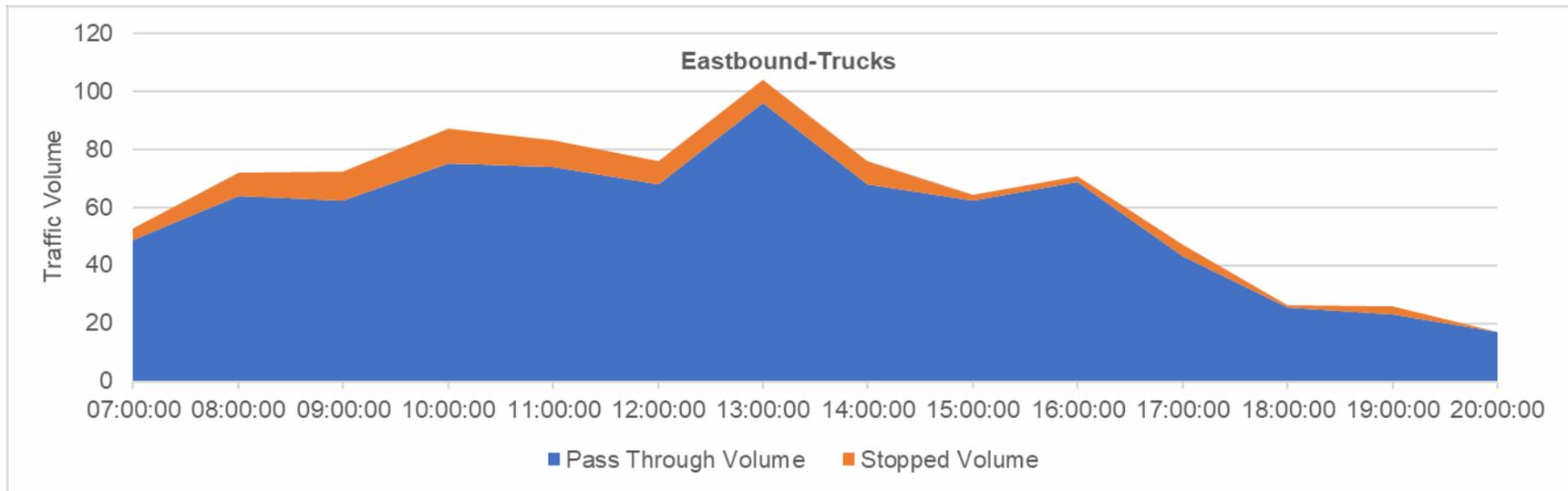


Figure 12: Trucks Day-Time Pass-Through and Stopped Traffic Volume



7. Summary

A 24-hour data collection was conducted on May 15th, 2019 to review pass-through traffic along Red Hill Valley Parkway (RHVP) and Lincoln Alexander Parkway (LAP). Two types of data were collected: 1) Origin-Destination (OD) data for the eastbound and westbound routes along RHVP and LAP using license plate recognition system and 2) traffic volume data at each end of study routes using ATR recorders.

According to the ATR counts, the total number of vehicles entering the eastbound route is 33387 and the total number of vehicles entering the westbound route is 31555. On average, 78% of light vehicles; 84% of trucks; and 88% of buses were detected during Day Time (7 AM to 8 PM) by the license plate recognition system.

Recorded license plates at both ends of each route were compared, and vehicles which completed the entire routes were identified. It is estimated that, on average, 7% of light vehicles, 33% of trucks, and 7% of buses were passing through the study area. The eastbound Day Time pass through traffic is comprised of 1831 light vehicles, 795 trucks and 9 buses. Additionally, the westbound Day Time pass through traffic is comprised of 2072 light vehicles, 732 trucks and 2 buses.