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To:	Doug McDonald, AICP City of Richardson Planning Projects Manager
From:	Nathan New, P.E. Christian DeLuca, P.E. Kimley-Horn and Associates, Inc. F-928
Date:	November 10, 2019
Subject:	Greenville Avenue Road Diet Evaluation – Data Collection, Richardson, TX

EXECUTIVE SUMMARY

In conjunction with the Collins/Arapaho TOD and Innovation District Study, the City of Richardson is evaluating the Greenville Avenue Corridor from Campbell Road to Jackson Street for road diet consideration. The road diet will consist of removing a lane of travel in each direction and installing bike lanes and improved pedestrian accommodations along the corridor. This report gathered and analyzed a variety of data to evaluate the proposed improvements. Traffic data was gathered on Greenville Avenue in its 6-lane configuration and again gathered after a temporary lane closure was installed in each direction along with a temporary pedestrian crossing at the Arapaho Center station. The two data sets were used to evaluate impacts of the lane closure and temporary pedestrian crossing.

Traffic volumes as indicated in the City of Richardson annual traffic count program show that Greenville Avenue has not had any significant increase in traffic over the last two decades. The before and after traffic data collected on Greenville Avenue indicate that volumes only varied by one percent before and after implementation of the road diet. It can further be concluded that vehicles are continuing to choose Greenville Avenue, instead of diverting to neighboring arterials such as Plano Road because of the lane reduction.

A Link Capacity analysis was performed on Greenville Avenue in accordance with thresholds established by North Central Texas Council of Governments (NCTCOG). The link capacity analysis examines the operating conditions of roadway links, using the daily volumes passing a fixed point. The operating condition is defined by the ratio of link volume to link capacity, or V/C. Capacity analysis results are listed in terms of Level of Service (LOS). The daily and hourly link analysis performed shows that Greenville Avenue has excess capacity in its six-lane configuration. When reduced to four-lanes the facility still has excess capacity with all analysis periods performing at a LOS C or better. The City of Richardson considers LOS D at capacity. The link analysis supports the feasibility of the lane reduction on Greenville Avenue.

Kimley-Horn obtained crowd-sourced probe-based data from INRIX for the study corridor. This data gathers hundreds of travel time runs to further evaluate the study corridor and is often found to be more reliable than floating car travel time runs due to the large number of data points. With the temporary

lane reduction in place, average travel time for both directions and peak hours increased by 4% (11.5 seconds), speed decreased by 4% (0.5 mph) and delay increased by 10% (11.5 seconds). When compared to other similar arterials in Richardson, Greenville Avenue has low delay for an arterial roadway and will continue to operate at LOS A/B conditions with the lane reduction.

Greenville Avenue was also evaluated as a reliever route when an accident occurs on US 75. Results indicate that delay and travel times do increase by 10-30% depending on the severity of the incident; however, the frequency of these incidents are not enough to justify the need to keep Greenville Avenue 6-lane facility.

After reviewing and comparing existing traffic volumes, historical data, performing a link analysis, observing video recordings, evaluating pedestrian data and INRIX data; it can be concluded that one lane can be removed from northbound and southbound Greenville Avenue and still operate well within acceptable conditions.

To mitigate travel time impacts on Greenville Avenue in support of the lane reduction, the City should re-evaluate signal timing on Greenville Avenue since there is one less lane of capacity in each direction. Specifically, signal timing at the intersection of Greenville Avenue & Jackson Street should be retimed to ensure the lengthened queue for the northbound approach can be cleared during the PM peak hour. Since no signal timing adjustments were made during the temporary lane closure, the actual delay and travel time on Greenville Avenue ultimately can be expected to be improved upon what was documented in this analysis.

The temporary at-grade crossing that was installed in September of 2019 is being utilized frequently. The mid-block crosswalk between the parking lot, bus station and the DART train station was shown to have the highest percentages of pedestrians of any of the crossing locations; demonstrating that the new direct access is attractive for DART transit users. After evaluating the number of pedestrians utilizing the new crosswalk, it is recommended that the crossing remain in place.

Ultimately, the temporary at-grade crossing should be improved to the current Richardson standard with retroreflective pavement markings. To further enhance the crossing, a Rectangular Rapid Flashing Beacon (RRFB) with passive pedestrian detection is recommended to improve pedestrian and driver yield compliance. The flashing lights will indicate to traffic that a pedestrian wants or is crossing at the location; additionally, the lights are proven to be an effective safety enhancement in low-light conditions. Pedestrian lighting at the crossing location should be improved to improve visibility. After implementation of the RRFB, it is recommended that the crossing continue to be evaluated for safety, pedestrian compliance, and vehicular speeds & yield compliance.

INTRODUCTION

The City of Richardson is in the process of studying the Greenville Avenue Corridor from Campbell Road to Jackson Street for road diet consideration, installation of bike lanes, and improved pedestrian accommodations along the corridor to align with the recommendations of the Collins/Arapaho TOD and Innovation District Study.

As part of the assessment, Kimley-Horn was tasked with performing strategic data collection to evaluate the corridor during the following times:

1. Initial (Before) assessment and data collection of existing conditions of Greenville Avenue,
2. Secondary (After) assessment and data collection of Greeneville Avenue with the temporary lane reduction and new at-grade crosswalk in place.

Temporary installation of the improvements was installed on September 18th, 2019.

Initially, Kimley-Horn gathered data to set baseline traffic operational conditions on Greenville Avenue from Jackson Street to Campbell Road. The data collected included:

- Historical average daily traffic counts at two locations along the corridor,
- 7-day machine counts at two locations along the corridor,
- 6-hour pedestrian counts on a typical weekday at three (3) locations near the Arapaho Center station,
- Floating car travel time runs, and
- Crowd-sourced probe-based data via INRIX.

Kimley-Horn gathered the same data after the implementation of the temporary lane reduction to reevaluate traffic operational conditions on Greenville Avenue from Jackson Street to Campbell Road.

This memorandum describes the before and after conditions based on various collected data.

HISTORICAL TRAFFIC COUNTS

As part of the corridor evaluation, it was important to look at yearly trends on Greenville Avenue to understand growth and traffic patterns over the last several years.

The City of Richardson provided historic traffic count data at two locations on Greenville Avenue within the study area. The first location is between Campbell Road and Alma Road, just north of the Arapaho Center Station and the second location is south of Arapaho Road near Hilltop Avenue.

The opening of transit facilities at the Arapaho Center Station appears to have some correlation with increases in average daily vehicle traffic count increases along Greenville Avenue. The Richardson Transit Center opened in 1990, and light rail began in 2002. However; over the past 30 years, average daily traffic counts have not exceeded 19,000 on any portion of Greenville Avenue, north of Beltline

Road and the roadway has observed very little traffic growth; the average annual growth rate has been 0.1%.

Greenville Avenue between Campbell Road & Alma Road:

The City of Richardson has average daily traffic counts for this location dating back to 1987. The peak traffic year at this location was in 1987 with 13,678 vehicles per day (vpd). This link of Greenville Avenue has observed no traffic growth and has a calculated annual growth rate of 0.0% since 1987. **Figure 1** shows the average daily traffic on Greenville Avenue between Campbell Road & Alma Road from 1987-2018.

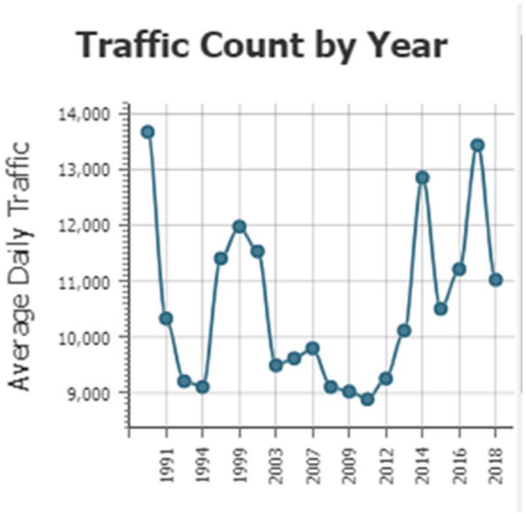

Figure 1. Greenville Avenue Average Daily Traffic Between Campbell Road & Alma Road

Greenville Avenue between Arapaho Road & Hilltop Avenue:

The City of Richardson has average daily traffic counts for this location dating back to 1979. The traffic on Greenville Avenue has not experienced growth, and the peak traffic year at this location was in 1988 with 18,734. This link of Greenville Avenue has observed negligible traffic growth with a calculated annual growth rate of 0.1% since 1979. The Richardson Transit Center opened in 1990 and rail operations started in 2002. **Figure 2** shows the average daily traffic on Greenville Avenue between Arapaho Road & Hilltop Avenue from 1979-2018.

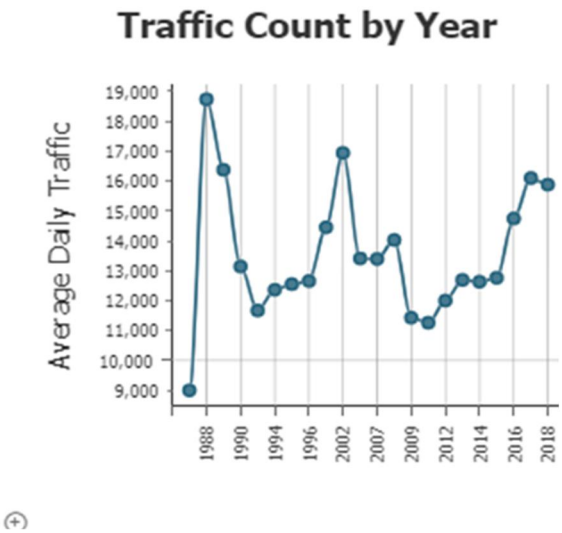

Figure 2. Greenville Avenue Average Daily Traffic Between Arapaho Road & Hilltop Avenue

The traffic volumes as indicated in the City of Richardson annual traffic count program show that Greenville Avenue has not had any significant increase in traffic over the last two decades. Therefore, it can be anticipated that traffic volumes will remain constant in future years.

AVERAGE DAILY VOLUMES – BEFORE & AFTER LANE REDUCTION

Machine counts were collected May 15th, 2019 to May 21st, 2019 and October 8th – October 14th, 2019 at the following locations:

- Greenville Avenue south of Arapaho Road; and
- Greenville Avenue south of Campbell Road.

The two locations were selected to compare with the historical count locations collected as part of the City's annual count program. Average daily volumes were calculated from the combined before and after bidirectional seven-day machine counts on Greenville Avenue.

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Table 1 - Average Daily Traffic on Greenville Avenue

South of Arapaho Road				
	Weekday	Saturday	Sunday	Average
Before	13,427	7,095	6,932	11,594
After	14,031	8,355	6,326	12,119
Δ	604	1,260	-606	525
%Δ	4%	18%	-9%	5%
South of Campbell Road				
	Weekday	Saturday	Sunday	Average
Before	11,310	5,026	4,680	9,465
After	10,846	5,721	4,140	9,156
Δ	-464	695	-540	-309
%Δ	-4%	14%	-12%	-3%
Average				
	Weekday	Saturday	Sunday	Average
Before	12,368	6,061	5,806	10,530
After	12,439	7,038	5,233	10,638
Δ	70	978	-573	108
%Δ	0%	16%	-10%	1%

To confirm that drivers were not diverting to other adjacent parallel routes during the temporary lane closure, 24-hour count were obtained on Plano Road. Counts were compared on Plano Road before and after implementation of the lane closure on Greenville Avenue. While the lane reduction was active on Greenville Avenue, counts were taken on Plano Road on October 8th, 2019 south of Campbell Road. These counts were compared to previously taken counts provided by the City of Richardson that were collected on May 15th, 2018.

Table 2 -Average Daily Traffic Comparison on Plano Road

South of Campbell Road			
	Southbound	Northbound	Total
Before (2018)	15,500	15,300	30,800
After	15,297	15,795	31,092
Δ	-203	495	292
%Δ	-1.3%	3.2%	0.9%

Table 2 shows that volumes on Plano Road, south of Campbell Road have remained relatively unchanged. Volumes have increased by less than 1% or 292 vehicles in approximately a year and a half time span which is less than the anticipated growth rate in the area.

The before and after traffic data collected on Greenville Avenue indicate that volumes stayed relatively the same before and after implementation of the road diet. It can further be concluded that vehicles are still choosing to utilize Greenville Avenue, instead of diverting to neighboring arterials such as Plano Road because of the lane reduction on Greenville Avenue. To support this conclusion, volumes on Plano Road, south of Campbell Road were found to have remained relatively unchanged.

LINK CAPACITY

A Link Capacity analysis was performed on Greenville Avenue to determine the before and after roadway segment operations according to thresholds established by North Central Texas Council of Governments (NCTCOG).

Machine counts were collected May 15th, 2019 to May 21st, 2019 (Before) and October 8th – October 14th, 2019 (After) at the following locations:

- Greenville Avenue south of Arapaho Road; and
- Greenville Avenue south of Campbell Road.

Average daily volumes were calculated from the combination of the two weeks of bidirectional Seven-day Machine Counts, one week before and one week after.

NCTCOG has established roadway service link volumes (see **Attachments**) through their travel demand model to establish roadway capacities throughout DFW. Roadway segment capacities are determined by their functional classification and an hourly capacity per lane is established. The link capacity analysis examines the operating conditions of roadway links, using the daily volumes passing a fixed point. The operating condition is defined by the ratio of link volume to link capacity, or V/C. Capacity analysis results are listed in terms of Level of Service (LOS). LOS is a qualitative term describing operating conditions a driver will experience while traveling on a particular street during a specific time interval. It ranges from A (very little delay) to F (long delays and congestion).

Table 3 - Volume to Service Ratio

Volume to Service (Capacity) Ratio		LOS Ranking
Greater Than	Less Than / Equal To	
-	0.45	A or B
0.45	0.65	C
0.65	0.80	D
0.80	1.00	E
1.00	-	F

This segment of Greenville Avenue is considered a principal arterial in a suburban residential area that has a resulting hourly capacity of 925 vehicles per hour per lane (vphpl) or 55,000 vehicles per day (vpd) for a six-lane roadway. This hourly capacity equates to LOS E conditions according to NCTCOG. The City of Richardson considers LOS D at capacity, thereby reducing the hourly volume to 740 vphpl or 44,000 vpd for a six-lane roadway.

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Table 4 shows the volume to capacity ratios for the ADT on Greenville Avenue before and after the lane reduction took place. Also included in the table is nearby roadways to evaluate the excess capacity of Greenville Avenue in comparison to other City of Richardson thoroughfares.

Table 4 – V/C and LOS Comparison

Roadway Link		Time Frame	# of Lanes	Volume	Capacity	V/C Ratio	LOS
From	To						
Greenville Avenue		**Before**	6	11,594	55,000	0.21	A/B
Arapaho Road	**Main Street**	**After**	4	12,119	36,667	0.33	A/B
Greenville Avenue		**Before**	6	9,465	55,000	0.17	A/B
Campbell Road	**Arapaho Road**	**After**	4	9,156	36,667	0.25	A/B
Plano Road		**Before (2018)**	6	30,800	55,000	0.56	C
Campbell Road	**Arapaho Road**	**After**	6	31,092	55,000	0.57	C
Jupiter Road		**Before (2018)**	6	33,600	55,000	0.61	C
Arapaho Road	**Collins Boulevard**						
Collins Boulevard		**Before (2018)**	4	11,200	36,667	0.31	A/B
Greenville Avenue	**Plano Road**						

Greenville Avenue south of Arapaho Road – Count Location 1

The bidirectional average daily traffic (ADT) collected on Greenville Avenue south of Arapaho Road with the 6-lane scenario was 11,594 vpd. The bidirectional ADT collected on Greenville Avenue south of Arapaho Road with the 4-lane reduced section was 12,119 vpd. The total bidirectional ADT averaged in both weeks was 11,857 vpd. In the 6-lane configuration, Greenville Avenue has a v/c ratio of 0.21 and; in the 4-lane configuration, Greenville Avenue has a v/c of 0.33. Using NCTCOG's link capacity, the collected ADT equates to 1.55 bidirectional lanes of traffic. If the lower volume weekend counts are excluded, the average weekday bidirectional ADT was 13,427 vpd, the equivalent of 1.79 lanes of traffic.

The peak hours on Greenville Avenue south of Arapaho Road are as follows and **Figure 3** displays the hourly flow rate:

- AM – 7:30 AM – 8:30 AM
- Midday – 12:15 PM – 1:15 PM
- PM – 5:00 PM – 6:00 PM
- Saturday – 12:30 PM – 1:30 PM

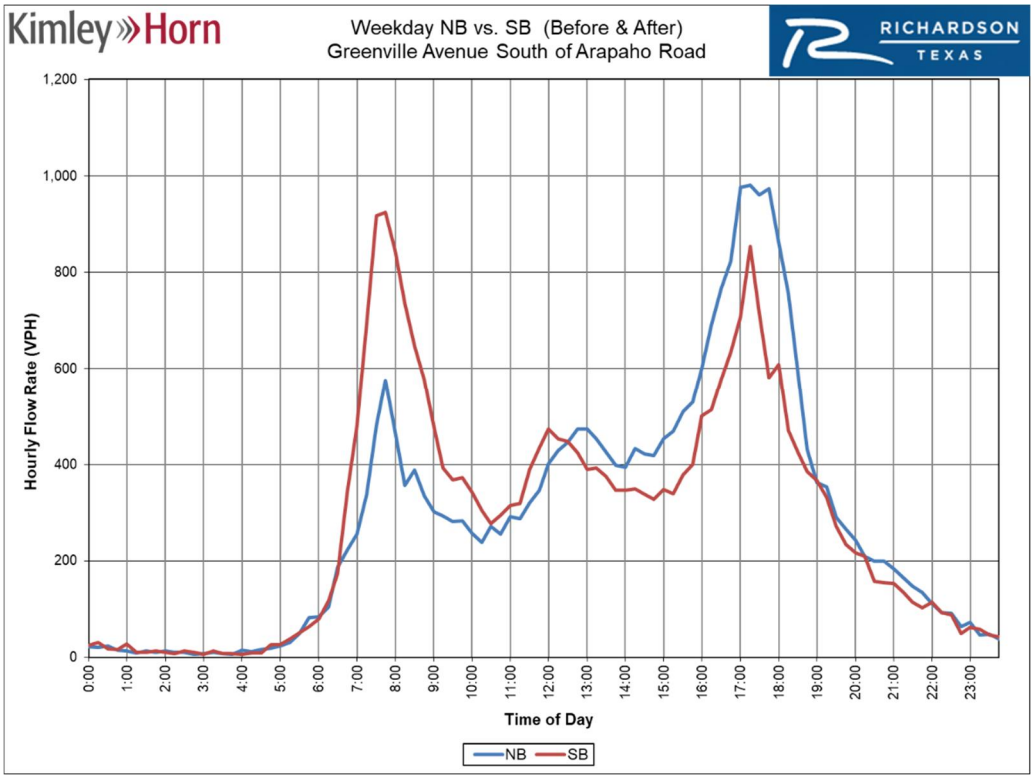

Figure 3. Weekday Hourly Flow Rate (Before & After) on Greenville Avenue South of Arapaho Road

The peak hour capacity was also calculated for the AM and PM peak hours in both the six-lane and four-lane configuration. The results are shown below in **Table 5.**

Table 5 - Greenville Avenue, south of Arapaho Road Hourly Capacity

Roadway Link		Time Frame		# of Lanes	Volume	Capacity	V/C Ratio	LOS
From	To							
Greenville Avenue		AM	Before	6	1,220	5,550	0.22	A/B
			After	4	1,465	3,700	0.40	A/B
Arapaho Road	Main Street	PM	Before	6	1,713	5,550	0.31	A/B
			After	4	1,717	3,700	0.46	C

Greenville Avenue south of Campbell Road – Count Location 2

The bidirectional ADT collected on Greenville Avenue south of Campbell Road for the 6-lane section was 9,465 vpd which equates to a 0.17 v/c. The bidirectional ADT collected on Greenville Avenue south of Campbell Road for the 4-lane section was 9,156 vpd which equates to a 0.25 v/c. Excluding weekend counts, the average weekday bidirectional ADT was 11,078 vpd, the equivalent of 1.48 lanes of traffic. Using the weekday ADT on a 4-lane facility would result in a v/c ratio of 0.30.

The peak hours on Greenville Avenue south of Campbell Road are as follows and **Figure 4** displays the hourly flow rate:

- AM – 7:30 AM – 8:30 AM
- Midday – 12:15 PM – 1:15 PM
- PM – 5:00 PM – 6:00 PM
- Saturday – 1:45 PM – 2:45 PM

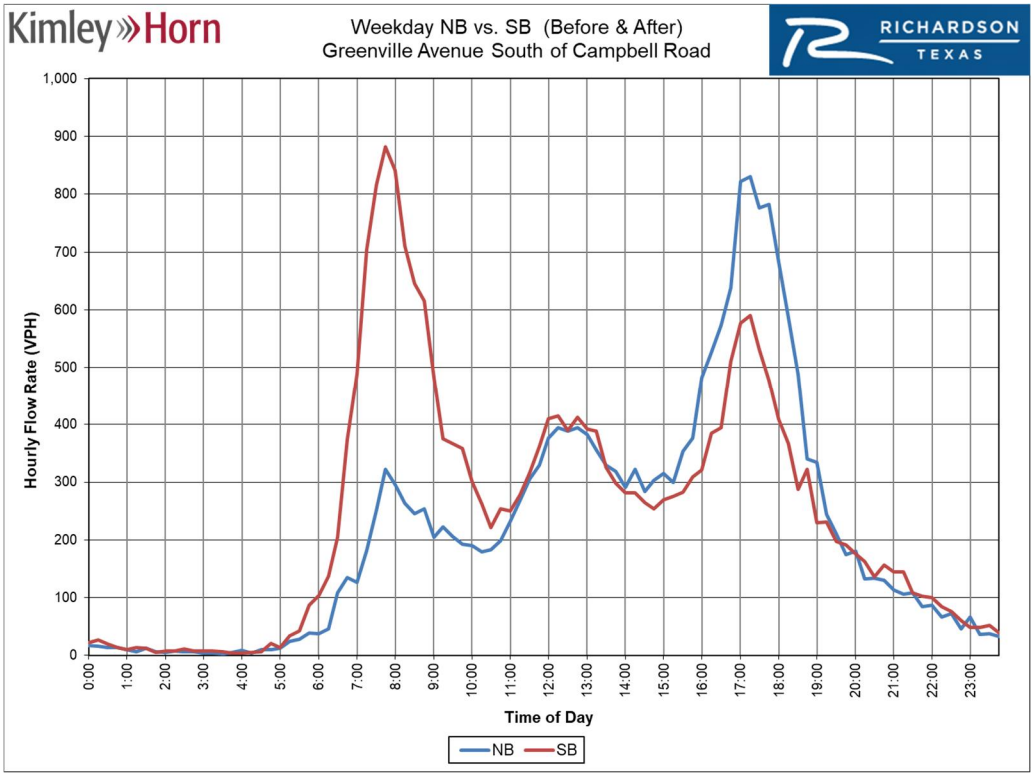

Figure 4. Weekday Hourly Flow Rate on (Before & After) Greenville Avenue South of Campbell Road

The peak hour capacity was also calculated for the AM and PM peak hours in both the six-lane and four-lane configuration. The results are shown below in **Table 6.**

Table 6 - Greenville Avenue, south of Campbell Road Hourly Capacity

Roadway Link		Time Frame		# of Lanes	Volume	Capacity	V/C Ratio	LOS
From	To							
Greenville Avenue		AM	Before	6	1,082	5,550	0.19	A/B
			After	4	1,142	3,700	0.31	A/B
Campbell Road	Arapaho Road	PM	Before	6	1,457	5,550	0.26	A/B
			After	4	1,262	3,700	0.34	A/B

The daily and hourly link analysis performed shows that Greenville Avenue has excess capacity in its six-lane configuration. When reduced to four-lanes the facility still has excess capacity with all analysis periods performing at a LOS C or better. The link analysis supports the road diet of Greenville Avenue.

PEDESTRIAN COUNTS

Pedestrian and bicycle counts were taken on May 16, 2019 and on October 10, 2019 on Greenville Avenue near the existing grade-separated pedestrian tunnel. Counts were taken during the following times both before and after the lane reduction on Greenville Avenue.

AM Peak: 6:30 AM – 8:30 AM
Midday Peak (MD): 11:00 AM – 1:00 PM
PM Peak: 4:00 PM – 6:00 PM

The primary purpose of this evaluation was to better understand the pedestrian patterns around the station and how that would change with the introduction of a new at-grade crosswalk

The north and south median openings remain unmarked in both before and after scenarios. Prior to the lane reduction on Greenville Avenue, the only designated pedestrian walkway from the parking lots on east side of Greenville Avenue to the Arapaho Center station was the grade-separated pedestrian tunnel under Greenville Avenue.

In conjunction with the road diet implementation, The City of Richardson has installed an additional crossing to connect the Arapaho Center station with the parking lots on the east side of Greenville Avenue. The new crossing is at-grade with Greenville Avenue and provides more direct access than the grade-separated pedestrian tunnel. The crosswalk was constructed in-September 2019 between the two count dates above.

Table 7 summarizes pedestrian activity near the Arapaho Center station before the installation of the at-grade crosswalk.

Table 7. Before Pedestrian Count Summary

Before Installation of Midblock Crosswalk									
	AM Peak 6:30 AM - 8:30 AM			MD Peak 11:00 AM - 1:00 PM			PM Peak 4:00 PM - 6:00 PM		
Crossing Location	Peds	%	Bikes	Peds	%	Bikes	Peds	%	Bikes
Greenville Avenue at North Median Opening	2	0%	0	5	4%	0	2	0%	0
Greenville Avenue at South Median Opening	15	3%	1	8	6%	1	7	2%	4
Grade-Separated Pedestrian Tunnel at Greenville Avenue	442	96%	3	115	90%	3	415	98%	8
Total:	459	100%	4	128	100%	4	424	100%	12

Results of the counts from May 16, 2019 indicate that most pedestrians, (96%) use the grade-separated pedestrian tunnel. This is not unexpected as the grade-separated pedestrian tunnel is the only pedestrian access designed and constructed to connect the east side of Greenville Avenue (DART

parking/bus operations) to the DART light rail platform. Additionally, the landscaping and fences along DART's property and multiple posted signs prohibiting at-grade crossings prevent and discourage pedestrians from crossing at-grade. The data shows the MD Peak had the highest percentage of crossers (both pedestrians and bicyclists) at median opening locations, with nearly 11%. The pedestrians crossing at the median opening locations had a consistent flow of people between 9 and 17 people in each peak period.

The south median opening at Woodall Drive has more at-grade pedestrian crossings when compared to the north median opening. This is likely because the fencing along Greenville Avenue ends at Woodall Drive, allowing an easier access to cross the street. A summary of these counts is presented in **Exhibits 1-3.** Further analysis is provided in the *Arapaho Rail Station Pedestrian and Bicycle Crossing Evaluation Memorandu*m dated July 22nd, 2019.

Table 8 summarizes pedestrian activity near the Arapaho Center station after the installation of the at-grade crosswalk and lane reduction on Greenville Avenue.

Table 8. After Pedestrian Count Summary

After Installation of Midblock Crosswalk									
	AM Peak 6:30 AM - 8:30 AM			MD Peak 11:00 AM - 1:00 PM			PM Peak 4:00 PM - 6:00 PM		
Crossing Location	Peds	%	Bikes	Peds	%	Bikes	Peds	%	Bikes
Greenville Avenue at North Median Opening	4	1%	0	1	1%	0	3	0%	2
Greenville Avenue at South Median Opening	6	1%	1	5	3%	0	2	0%	0
Grade-Separated Pedestrian Tunnel at Greenville Avenue	206	44%	0	93	54%	0	181	30%	3
New Midblock Crosswalk at Greenville Avenue	*249*	*54%*	*1*	*74*	*43%*	*0*	*418*	*69%*	*5*
Total:	465	100%	2	173	100%	0	604	100%	10

The crosswalk was officially open and operational on October 1, 2019. Results of the counts ten days after opening from October 10, 2019 indicate that most pedestrians, (59%) use the new at-grade pedestrian crossing. This is not unexpected as the grade-separated pedestrian tunnel is less direct than the new midblock at-grade crosswalk. Pedestrians tend to use the shortest and fastest path of travel. However, a large portion of pedestrians (39%) still utilize the grade-separated pedestrian tunnel. A small amount of pedestrians (2%) chose to cross at the unmarked locations at the two median openings. The data shows the MD Peak had the highest percentage of crossers (both pedestrians and bicyclists) at median opening locations, with 4%. The pedestrians crossing at the median opening locations had between 5 and 10 people in each peak period.

A summary of these counts is presented in **Exhibits 4-6.** Further analysis is provided in the *Arapaho Rail Station Pedestrian and Bicycle Crossing Evaluation Memorandum* 2019 which was developed at the request of DART to evaluate location alternatives for the at-grade crossing.

Table 9 summarizes pedestrian activity changes near the Arapaho Center station after the installation of the at-grade crosswalk.

Table 9- Before & After Pedestrian Count Summary

Before & After Comparison of Midblock Crosswalk									
	AM Peak 6:30 AM - 8:30 AM			MD Peak 11:00 AM - 1:00 PM			PM Peak 4:00 PM - 6:00 PM		
Crossing Location	Δ Peds	Δ%	Δ Bikes	Δ Peds	Δ%	Δ Bikes	Δ Peds	Δ%	Δ Bikes
Greenville Avenue at North Median Opening	2	100%	0	-4	-80%	0	1	50%	2
Greenville Avenue at South Median Opening	-9	-60%	0	-3	-38%	-1	-5	-71%	-4
Grade-Separated Pedestrian Tunnel at Greenville Avenue	-236	-53%	-3	-22	-19%	-3	-234	-56%	-5
New Midblock Crosswalk at Greenville Avenue	*249*	-	*1*	*74*	-	*0*	*418*	-	*5*
Total:	6	1%	-2	45	35%	-4	180	42%	-2

The grade-separated pedestrian tunnel and the south median opening locations saw a large shift in volume to the new crossing. Pedestrian volumes were higher in both the midday peak (35% increase) and PM peak (42% increase) in October when compared to the volumes collected in May. The AM peak hour roughly had the same amount of pedestrian (1% increase). In all three peak hours the total pedestrian volumes increased with the largest increase in the PM peak hour, the overall increase in pedestrians is likely due to the State Fair being open during this time which increases ridership.

The at-grade crossing is being utilized frequently. The mid-block crosswalk between the parking lot, bus station and the DART train station was shown to have the highest percentages of pedestrians of any of the crossing locations; demonstrating that the new direct access is attractive for DART transit users. After evaluating the number of pedestrians utilizing the new crosswalk, it is recommended that the crossing remain in place. Recommendations on how to improve the crossing location are in the recommendations section of this report.

SPOT SPEED STUDY

A spot speed survey was conducted on Tuesday, August 30, 2019 (before the lane reduction) and October 8th, 2019 (after the lane reduction) during an off-peak period, free-flow conditions, for the northbound and southbound traffic on Greenville Avenue just north of the Arapaho Center station. Evaluating speeds on a corridor is important to evaluate congestion and to determine if speeds are higher than the posted speed limit. The spot speed survey results indicate that speeds on Greenville Avenue are higher than the posted speed limit. The posted speed limit on Greenville Avenue is 40 mph at the speed study location. Before the lane reduction on Greenville Avenue was implemented, the 85th percentile speeds were found to be 47 mph and 48 mph for northbound and southbound traffic, respectively. After the lane reduction on Greenville Avenue was implemented, the 85th percentile speeds were found to be 43 mph and 48 mph for northbound and southbound traffic, respectively. The

data shows that speeds decreased for the northbound direction, but southbound vehicles saw no decrease in speeds from the lane reduction. The spot speed study results are shown in **Table 10** below.

Table 10 – Spot Speed Study

Direction	Time Period	Average Speed (mph)	85th Percentile Speed (mph)
Northbound	Before	41	47
	After	39	43
Southbound	Before	43	48
	After	43	48

The speeds on Greenville Avenue are substantially faster than the posted speed limit. There are two possible countermeasures to reduce the speeding on Greenville Avenue. The speed limit on Greenville Avenue can be reduced from 40 mph to 35 mph to match the segment along Greenville Avenue, south of Arapaho Road. Changing the speed limit alone would not reduce speeds; it would need to be paired with enforcement from City of Richardson PD. The second alternative is to reduce roadway lane width which is a proven FHWA countermeasure to reduce speeds.

INRIX DATA

Kimley-Horn obtained crowd-sourced probe-based data from INRIX for the study corridor. This data gathers hundreds of travel time runs to further evaluate the study corridor and is often found to be more reliable than floating car travel time runs due to the large number of data points.

Data from INRIX was used to evaluate the existing conditions of the corridor and establish a baseline condition. The data was also used to assist in understanding how the corridor serves as a reliever route when there is an incident on US 75. The measures of effectiveness (MOEs) evaluated include:

- Speed;
- Travel time;
- Delay.

The data was examined during two time periods: weekday AM and PM peaks. The specific time periods were matched to the floating car travel time runs presented in the next section of this document. Data from INRIX was averaged across all weekdays in May 2019 (before the lane reduction) and in the first two full weeks of October 2019 (after the lane reduction).

Traditional measures of effectiveness (MOEs) include travel time, speed, delay, and stops. INRIX, like all segment-based probe data, is capable of measuring travel time and speed; delay can be calculated as the difference between measured travel time and free flow travel time (based on speed limit). Stops are only available from traditional travel time runs. Travel Time Index (TTI) was also considered and included as an MOE since it is a normalized measure of delay. TTI is the ratio of travel time in the peak period to the travel time at free-flow conditions. At free flow conditions, TTI is equal to 1.0. The higher the TTI is over 1.0, the greater the delay on the corridor.

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Table 11 summarizes the INRIX data from May 2019 before the lane reduction. **Table 12** summarizes the INRIX data from October 2019 after the lane reduction. **Table 13** compares the MOE's from before and after.

Table 11. Probe-Based Data Summary (Before)

Greenville Avenue Before Probe-Based Travel Time Data Jackson Street to Campbell Road					
Peak Period	***Direction***	***Average Travel Time (sec)***	***Average Speed (mph)***	***Travel Time Index***	***Average Delay (sec)***
AM Peak 7:00 AM - 8:00 AM	*NB*	280	25.5	1.16	114
	SB	271	26.2	1.18	105
	Average	***275***	***25.8***	***1.17***	***110***
PM Peak 4:30 PM - 5:30 PM	*NB*	284	25.1	1.18	118
	SB	280	25.5	1.21	114
	Average	***282***	***25.3***	***1.19***	***116***

Table 12 - Probe Based Data Summary (After)

Greenville Avenue After Probe-Based Travel Time Data Jackson Street to Campbell Road					
Peak Period	***Direction***	***Average Travel Time (sec)***	***Average Speed (mph)***	***Travel Time Index***	***Average Delay (sec)***
AM Peak 7:00 AM - 8:00 AM	*NB*	283	25.1	1.16	117
	SB	278	25.6	1.18	112
	Average	***281***	***25.4***	***1.17***	***115***
PM Peak 4:30 PM - 5:30 PM	*NB*	313	23.1	1.26	147
	SB	286	25.0	1.21	120
	Average	***300***	***24.1***	***1.24***	***134***

Table 13 - Probe Based Data Summary (Before vs After)

Greenville Avenue Before vs. After Probe-Based Travel Time Data Jackson Street to Campbell Road									
Peak Period	Direction	Average Travel Time (sec)		Average Speed (mph)		Travel Time Index		Average Delay (sec)	
		Δ	Δ%	Δ	Δ%	Δ	Δ%	Δ	Δ%
AM Peak 7:00 AM - 8:00 AM	*NB*	3	1%	0	-1%	0.00	0%	3	3%
	SB	7	3%	-1	-2%	0.00	0%	7	7%
	Average	***5***	***2%***	***0***	***-2%***	***0.00***	***0%***	***5***	***5%***
PM Peak 4:30 PM - 5:30 PM	*NB*	29	10%	-2	-8%	0.08	7%	29	25%
	SB	7	2%	0	-2%	0.00	0%	6	5%
	Average	***18***	***6%***	***-1***	***-5%***	***0.04***	***3%***	***18***	***15%***

The INRIX data shows that the road diet caused an increase in travel time in some directions and peak hours; the increases were observed in the peak directions; southbound traffic in the AM and northbound traffic in the PM. Results from the INRIX data are consistent with the results from the floating car travel times. Average travel time for both directions and peak hours increased by 4% (11.5 seconds), speed decreased by 4% (0.5 mph) and delay increased by 10% (11.5 seconds).

Note: The INRIX segments extended from Campbell Road to Main Street; Jackson Street is approximately 2000 feet north of Main Street. To make a direct comparison with the floating car data, which ran from Campbell Road to Jackson Street, the average travel times provided by INRIX were reduced to match the floating car travel time data length.

FLOATING CAR TRAVEL TIME RUNS

Travel time runs (three in each direction per period) were conducted on Wednesday, May 22nd, 2019, (before the lane reduction) and on Thursday October 10th, 2019 (after the lane reduction). Travel time runs are recorded with an instrumented vehicle using "floating car" techniques – the driver of the test vehicle took care to travel at the pace set by other traffic. Software electronically recorded the vehicle's speed along with the distance traveled, and a time stamp was made as the vehicle passed through each signalized intersection. From this data, average travel time, number of stops, speed, and delay were calculated as shown in **Table 14.**

On Greenville Avenue the peak direction is southbound in the AM peak and northbound in the PM peak. In both the before and after travel time runs there was over a minute of delay (approximately 30% of total travel time) in the peak directions.

The posted speed limit on the corridor is 40 mph north of Arapaho Road and 35 mph south of Arapaho Road. Expected travel time for the length of the 1.85-mile corridor is 167 seconds if there were no stops at signals or congestion.

There are four traffic signals on the corridor in the study area (Jackson Street, Arapaho Road, Collins Boulevard, and Campbell Road). The travel time runs started at signalized intersections at Jackson

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Street (northbound) or Campbell Road (southbound); there were three signalized intersections which are possible stops along the corridor in each direction The floating car on average stopped at two out of three signals in the AM and PM peaks. The number of stops is random since the corridors traffic signals are not coordinated and are pre-empted by the DART train.

Floating car travel time runs were completed before and after Greenville Avenue was reduced from six-lanes to four-lanes for evaluation of the effects of the road diet. The road diet caused an increase in travel time for southbound traffic in the AM and northbound traffic in the PM. The northbound AM travel time decreased and the southbound PM stayed relatively the same. Average travel time for both directions and peak hours increased by 5% (12 seconds), number of stops increased by 8% (0.15 stops), speed decreased by 8% (2 mph) and delay increased by 13% (12 seconds).

Detailed comparison between the before and after can be found in **Table 15**

Table 14. Floating Car Travel Time Run Summary

Greenville Avenue Before and After Travel Time Run Data Jackson Street to Campbell Road									
Peak Period	Direction	Travel Time (sec)		# of Stops		Average Speed		Delay (sec)	
		Before	After	Before	After	Before	After	Before	After
AM Peak 7:00 AM - 8:00 AM	**NB**	335	290	2.7	2.0	20.5	23.7	158	113
	SB	235	292	0.7	2.3	31.0	23.7	72	129
	Average	**285**	**291**	**1.7**	**2.2**	**25.8**	**23.7**	**115**	**121**
PM Peak 4:30 PM - 5:30 PM	**NB**	278	311	2.3	2.3	24.9	21.5	101	134
	SB	241	244	1.7	1.3	27.5	27.2	78	81
	Average	**260**	**278**	**2.0**	**1.8**	**26.2**	**24.4**	**90**	**108**

Table 15. Floating Car Travel Time Run Before & After Comparison

Greenville Avenue Before and After Travel Time Run Data Jackson Street to Campbell Road									
Peak Period	Direction	Δ Travel Time		Δ Stops		Δ Average Speed		Δ Delay	
		Sec.	Percent	Total	Percent	mph	Percent	Sec.	Percent
AM Peak 7:00 AM - 8:00 AM	**NB**	-45	-13%	-0.7	-26%	3.2	16%	-45	-28%
	SB	57	24%	1.6	229%	-7.3	-24%	57	79%
	Average	**6**	**2%**	**0.5**	**26%**	**-2.1**	**-8%**	**6**	**5%**
PM Peak 4:30 PM - 5:30 PM	**NB**	33	12%	0.0	0%	-3.4	-14%	33	33%
	SB	3	1%	-0.4	-24%	-0.3	-1%	3	4%
	Average	**18**	**7%**	**-0.2**	**-10%**	**-1.9**	**-7%**	**18**	**20%**

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US 75 INCIDENT DATA

In considering the road diet, a concern Richardson had was the impact an incident on US 75 has on Greenville Avenue. INRIX data was used to better understand how the corridor serves as a reliever route when there is an incident on US 75. The City of Richardson Transportation and Mobility Department and Police Department provided 48 traffic incidents on US 75 over the past three years to analyze. Of these 48 incidents, 13 were categorized as "A – Most Severe" or "B - Severe" based on injuries, lane closures, and time for clearing the incident. After reviewing the 13 incidents, 3 were included in the analysis based on the date, time, and location of the incident. Ideal incidents occurred during rush hour, while schools are in session, and on the northbound lanes where diversion is most likely to occur to Greenville Avenue. The three reports are summarized below.

A. 2/13/19 - Northbound US 75 (AM Peak)
    a. Ideal candidate for consideration, used for comparison
    b. Identified as Incident A in this report
B. 11/29/2018 – Northbound US 75 (PM Peak)
    a. Included in analysis, but incident occurred near Galatyn Parkway one mile north of study area
    b. Identified as Incident B in this report
C. 9/18/2019 – Southbound US 75 (AM Peak)
    a. Included in analysis, incident occurred in Dallas a few miles south of study area
    b. Identified as Incident C in this report

Incident A occurred on February 13, 2019 at 7:55 AM, involving seven vehicles across five lanes of northbound US 75 near Spring Valley Road. One lane of traffic remained open on US 75 mainlanes. The roadway was cleared at 9:26 AM. While the incident occurred south of the study area, the INRIX data showed an increase in travel time, travel time index, and delay and a decrease in speed during the incident.

Table 16 - INRIX Data Comparison for Incident A

Greenville Avenue									
Jackson Street to Campbell Road		Travel Time (s)		Speed (mph)		Travel Time Index		Delay (s)	
		NB	SB	NB	SB	NB	SB	NB	SB
AM 8:45 AM - 9:45 AM	Typical	287	249	24.89	28.21	1.11	1.07	121	83
	Incident	367	293	21.94	28.22	1.27	1.11	201	127
	Δ	+80	+43	-2.95	+0.02	+0.16	+0.04	+80	+44
	Δ%	+28%	+17%	-12%	+0%	+14%	+4%	+66%	+53%

When compared to the average weekday (Tuesday – Thursday) of the following month (February 14th – March 14th, 2019), the peak hour of incident traffic (8:45 – 9:45 AM) created the following effects:

- Northbound travel time increased 28% (80 seconds)
- Northbound speed decreased 12% (nearly 3 MPH)
- Delay increased 66% (80 seconds)

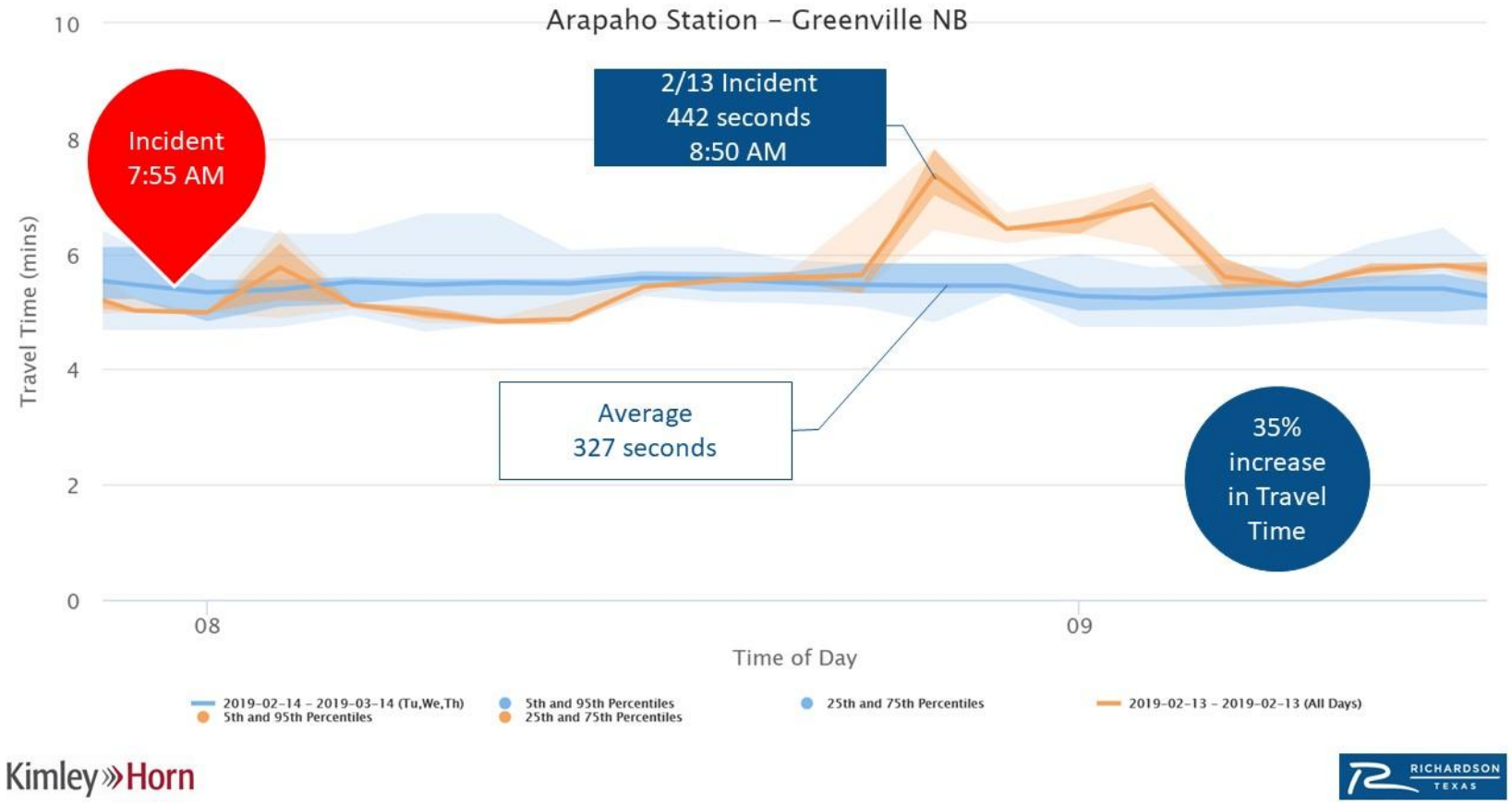

Figure 5. Average Travel Times for Incident A

Incident B occurred on December 20, 2018 at 4:16 PM. Two vehicles were involved in the two outside lanes of US 75 traveling northbound near Galatyn Parkway, more than a mile north of the study area. Based on the incident report, it does not appear that any lanes on US 75 were closed. The scene was cleared at 6:12 PM. The INRIX data showed an increase in travel time, travel time index, and delay and speed remained constant during the incident.

Table 17 - INRIX Data Comparison for Incident B

Greenville Avenue									
Jackson Street to Campbell Road		Travel Time (s)		Speed (mph)		Travel Time Index		Delay (s)	
		NB	SB	NB	SB	NB	SB	NB	SB
PM Incident 4:15 PM - 6:15 PM	Typical	275	264	25.89	26.81	1.06	1.12	109	98
	Incident	313	279	25.89	28.83	1.08	1.05	147	113
	Δ	+37	+15	+0.00	+2.02	+0.01	-0.07	+38	+15
	Δ%	+14%	+6%	+0%	+8%	+1%	-6%	+35%	+15%

When compared to the average weekday (Tuesday – Thursday) of the following month (December 20th, 2018 – January 20th, 2019), the peak hour of incident traffic (4:15 PM – 6:15 PM) created the following effects:

- Northbound travel time increased 14% (37 seconds)
- Northbound speed was unchanged (25.89 mph)
- Delay increased 35% (38 seconds)

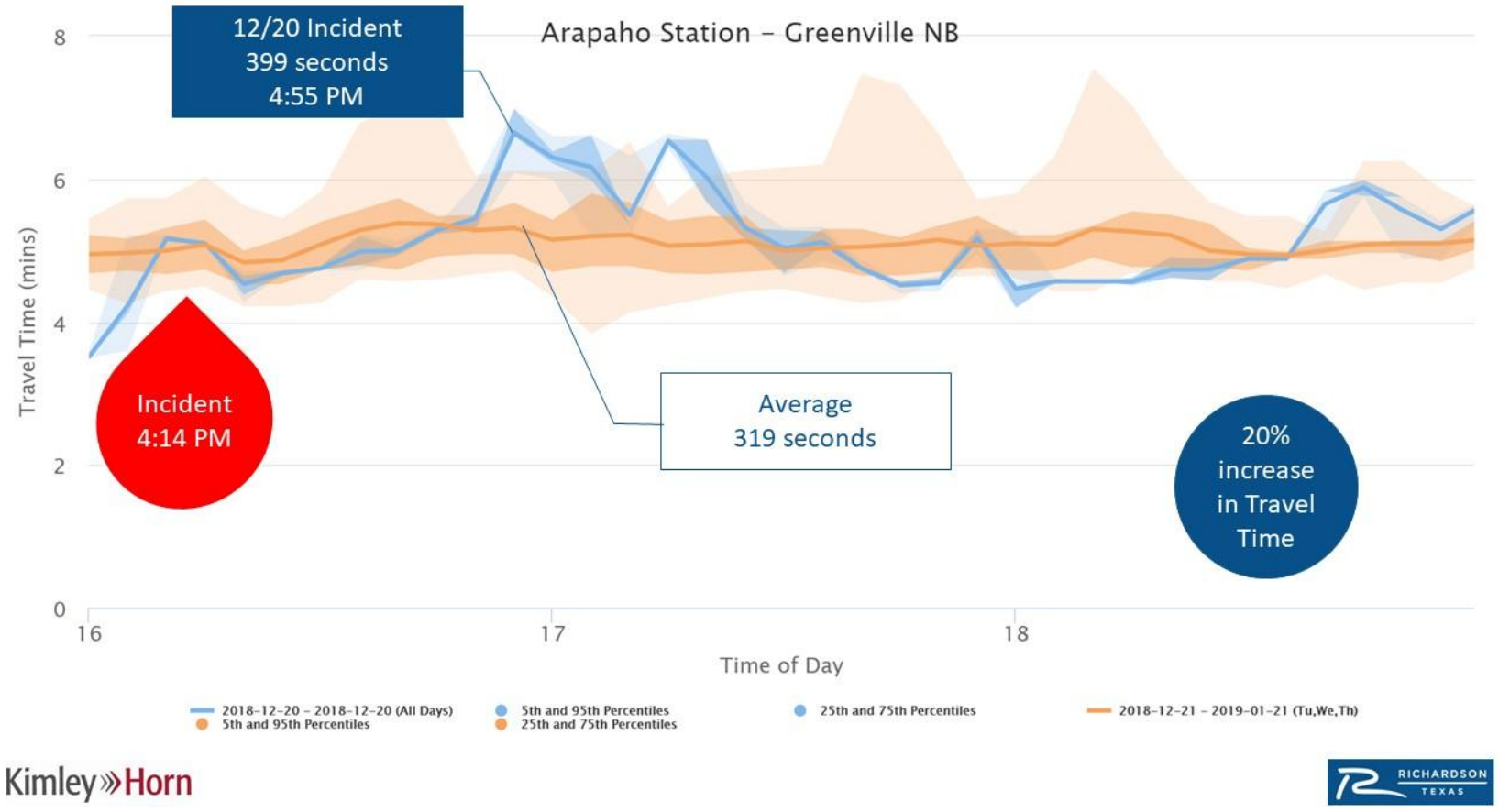

Figure 6. Average Travel Times for Incident B

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Incident C occurred on September 18th, 2019 in the AM peak hour. There was a large incident in Dallas that backed up through Richardson. Several reports from Police and Fire indicated the backups on Greenville on this date. This incident occurred in the first phase of the road diet when barricades were deployed to remove driving lanes to evaluate the effects of the proposed road diet. The INRIX data showed an increase in travel time, travel time index, and delay and a decrease in speed during the incident.

Table 18 - INRIX Data Comparison for Incident C

Greenville Avenue									
Jackson Street to Campbell Road		Travel Time (s)		Speed (mph)		Travel Time Index		Delay (s)	
		NB	SB	NB	SB	NB	SB	NB	SB
AM Incident 7:00 AM - 9:00 AM	Typical	276	263	25.81	26.90	1.07	1.12	110	97
	Incident	341	323	23.50	24.94	1.26	1.26	175	157
	Δ	+65	+60	-2.31	-1.96	+0.20	+0.14	+65	+60
	Δ%	+23%	+23%	-9%	-7%	+18%	+13%	+59%	+62%

When compared to the average weekday (Tuesday – Thursday) of the following month (November 30th, 2018 – December 30th, 2018), the peak hour of incident traffic 7:00 AM – 9:00 AM) created the following effects:

- Northbound travel time increased 23% (65 seconds)
- Southbound travel time increased 23% (60 seconds)
- Northbound speed decreased 9% (more than 2 mph)
- Southbound speed decreased 7% (approx. 2 mph)
- Northbound delay increased 59% (65 seconds)
- Northbound delay increased 62% (60 seconds)

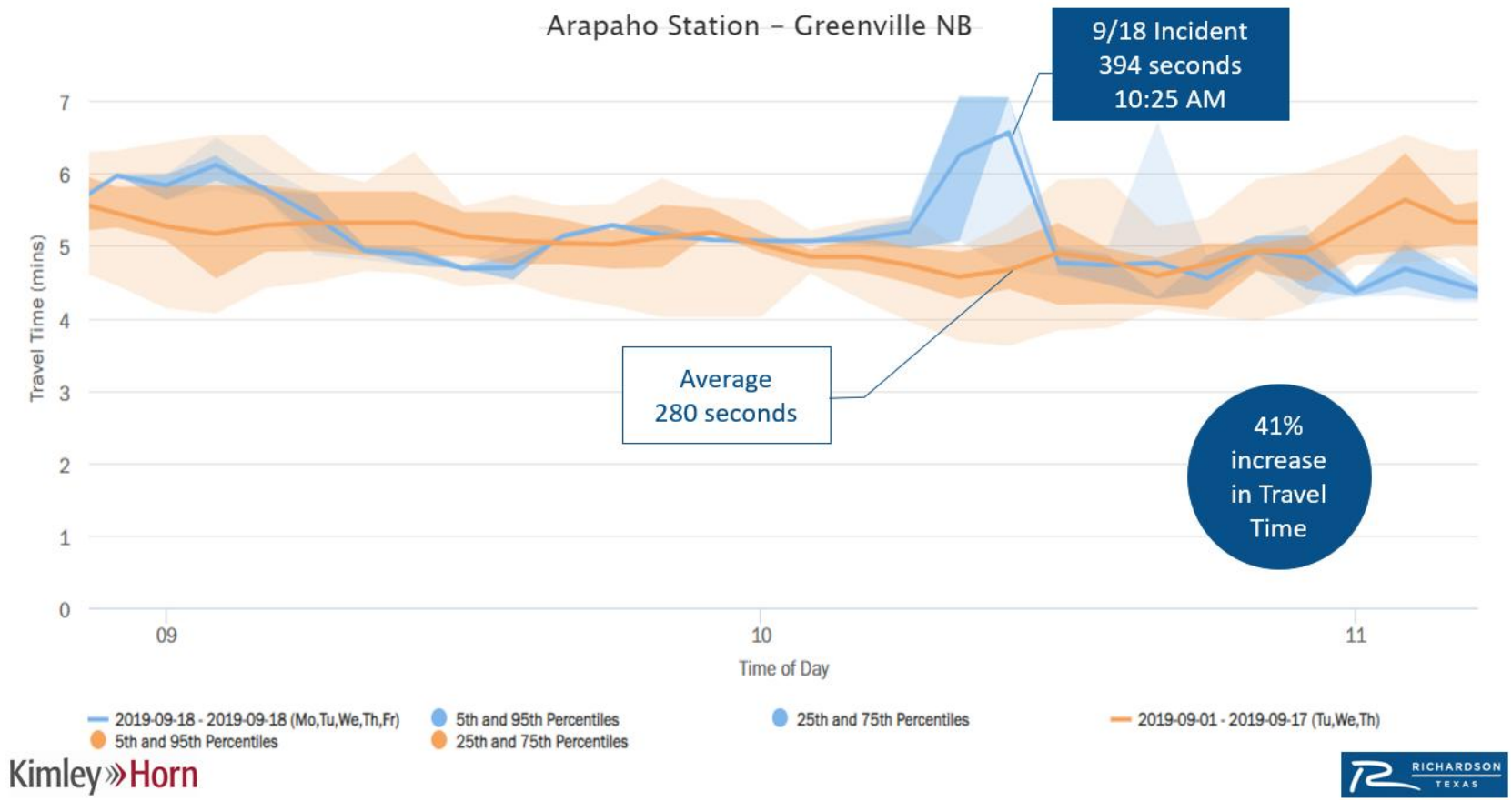


Figure 7. Average Travel Times for Incident C

Based on three years of incident data provided by the City, major incidents on US 75 sufficient to divert traffic to Greenville Avenue are infrequent. In cases when traffic does divert to Greenville Avenue, the crowd-sourced probe-based data collected during the analyzed incidents shows that impacts to Greenville Avenue in the study area are unpredictable, but typically increase the travel time 10-30%. However, it must be noted that these impacts were observed only twice in three years of provided data. The September 18, 2019 incident observed after the road diet on Greenville Avenue showed that travel time increased approximately 40% on Greenville Avenue. The lane reduction may slightly decrease the ability of Greenville Avenue to offer relief during an incident on US 75, however incidents large enough to divert traffic to Greenville Avenue are infrequent. Incidents A & B occurred prior to the road diet where Incident C occurred after the road diet; when comparing the before and after, the delay increase is similar despite Greenville Avenue being only four lanes during Incident C.

LANE REDUCTION VIDEO

In considering the road diet, a concern Richardson had was the delay from the merge condition at the end points of the road diet where the roadway transitions from a six-lane to four-lane facility. The lane reductions take place north of Campbell Road for southbound traffic on Greenville Avenue and south of Jackson Street for northbound traffic on Greenville Avenue. The southbound lane reduction at Campbell Road was recorded on October 15th and the northbound lane reduction at Jackson Street was recorded on October 17th. Both the AM and PM peak periods were captured.

Northbound Greenville Avenue at Jackson Street

At this location, the lane reduction was completed by repurposing the third lane as a right-turn only lane, this forces through traffic to merge into two through lanes. Northbound Greenville Avenue traffic volumes are largest in the PM peak period. The video recording for the entire PM period was observed to understand the delay implications involved where the number of through lanes was reduced. Northbound through vehicles in the third lane are expected to merge into the two lanes which can cause congestion with high volumes. The Greenville Avenue intersection with Jackson Street is signalized and has rail preemption when the DART train crosses Jackson Street, west of the intersection.

Northbound vehicle queue lengths were observed to be the longest when the DART train passed through, queue lengths when this occurred maxed out at approximately 300 feet, or 12 vehicles in depth. In these instances, the entirety of the queued vehicles did not always clear through the intersection on the next green signal phase and the end of the platoon was cut off. When there is no train that adjusts the signal timing, the queue is always cleared by the following green signal phase. Additionally, very few people utilize the third travel lane that turns right into the Richard Terrace Shopping Center. Driver's on this corridor likely use the roadway routinely and know they need to merge left at an earlier point if they desire to continue northbound on Greenville Avenue. To mitigate this condition, advanced warning signs have been added to notify drivers of the lane reduction, which notifies them to merge into the two through lanes at an earlier point on Greenville Avenue.

The Greenville Avenue at Jackson Street lane drop has been improved by the City of Richardson since the video was recorded by eliminating the merge condition at this intersection. The roadway now is

continuously two through lanes from south of Main Street through the study area. The third lane has been repurposed as an auxiliary lane for the multiple driveways along the corridor.

Southbound Greenville Avenue at Campbell Road

At this location, the lane reduction was completed by repurposing the third lane as a bike lane, this forces through traffic to merge into the two through lanes or the right-turn lane. Southbound Greenville Avenue traffic volumes are largest in the AM peak period. The video recording for the entire AM period was observed to understand the delay implications involved where the number of through lanes was reduced. Southbound through vehicles in the third lane are expected to merge into the two lanes which can cause congestion with high volumes.

Southbound through vehicle queue lengths were observed to be on average 125 feet or approximately 5 cars in depth. The queue is always cleared by the following green signal phase. Some vehicles were observed making a merge at the last possible moment, but this happened infrequently in the two-hour peak period.

The lane reduction videos showed that there is not significant adverse effects for Greenville Avenue vehicles at the lane reduction locations. The northbound lane reduction at Jackson Street has since been improved to help mitigate the observed delays that were primarily caused by the DART train.

RECOMMENDATIONS

Greenville Avenue Lane Reduction

After reviewing and comparing existing traffic volumes, historical data, performing a link analysis, observing video recordings, evaluating pedestrian data and INRIX data; it can be concluded that one lane can be removed from northbound and southbound Greenville Avenue and still operate within acceptable conditions.

Volumes on the corridor and link analysis results indicate that Greenville Avenue can be expected to operate at a 0.40 v/c ratio after the lane reduction, leaving adequate room for future growth along the corridor. The probe-based data (INRIX) and floating car travel times indicate delay and travel time will increase some in the peak directions. For delay and travel time, INRIX data is a more reliable indication of corridor operations when compared to floating car travel times. INRIX data uses hundreds of data points to determine key MOE's while the floating car is an average of only 3 runs. '

With the temporary lane reduction in place, average travel time for both directions and peak hours increased by 4% (11.5 seconds), speed decreased by 4% (0.5 mph) and delay increased by 10% (11.5 seconds). The before and after traffic data collected on Greenville Avenue indicated that volumes stayed relatively the same before and after implementation of the road diet. It can further be concluded that vehicles are still choosing to utilize Greenville Avenue, instead of diverting to neighboring arterials such as Plano Road because of the lane reduction on Greenville Avenue.

Since Greenville Avenue is close to US 75 and can be used as a reliever route to US 75, the corridor was also evaluated when incidents occurred on US 75. Results indicate that delay and travel times do increase by 10-30% depending on the severity of the incident; however, the frequency of these incidents are not enough to justify the need to keep Greenville Avenue 6-lane facility. As Richardson improves its signal system and signal communications; when an incident does occur on US 75, a signal timing flush pattern can be initiated on Greenville Avenue to reduce delay and travel times. The temporary lane closure that was implemented on September 18th, 2019 was not coupled with any signal timing adjustments on Greenville Avenue. The City should re-evaluate signal timing on Greenville Avenue after the permanent road diet is in place. The intersection of Jackson Street and Greenville Avenue should be retimed to ensure the queue for the northbound approach can be cleared during the PM peak hour. Since no signal timing adjustments were made during the temporary lane closure, the actual delay and travel time on Greenville Avenue ultimately can be expected to be improved upon what was documented in this analysis.

Arapaho Station At-grade Crossing

The at-grade crossing that was installed is being utilized frequently. The mid-block crosswalk between the parking lot, bus station and the DART train station was shown to have the highest percentages of pedestrians of any of the crossing locations; demonstrating that the new direct access is attractive for DART transit users. Currently, the temporary crosswalk is a two-stage z-pattern crosswalk where pedestrians cross two lanes of traffic at a time. The Federal Highway Administration's (FHWA) *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations* was considered in evaluating the proposed location. According to the guide, a 4-lane crossing with a posted speed limit of 40 mph and an AADT between 9,000 – 15,000 vehicles should have a pedestrian refuge island, which it currently has. Additionally, yield lines and yield to pedestrian signs have been installed to improve driver compliance.

After evaluating the number of pedestrians utilizing the new crosswalk, it is recommended that the crossing remain in place and a Rectangular Rapid Flashing Beacon (RRFB) be installed at the location to improve pedestrian and driver compliance. The flashing lights will indicate to traffic that a pedestrian wants or is crossing at the location; additionally, the lights are proven to be an effective safety enhancement in low-light conditions. The pedestrian lighting at the crossing location should be improved and the crosswalk should be permanently installed with thermoplastic in a high-visibility pattern. It is also recommended that passive detection should be used at the RRFB to detect pedestrians that do not stop to press the button. After implementation of the RRFB, it is recommended that the crossing continue to be evaluated for safety, pedestrian compliance, and vehicular speeds & compliance. As the corridor re-develops, consideration should be made for the installation of a pedestrian hybrid beacon. Examples of a RRFB and a pedestrian hybrid beacon are shown in **Figure 8** and **Figure 9**, respectively.

Furthermore, it is recommended that Greenville Avenue lane widths be reduced as a countermeasure to slow vehicles down through this section of Greenville Avenue.

Figure 8 - Example of Rectangular Rapid Flashing Beacon

Figure 9 - Example of Pedestrian Hybrid Beacon

ATTACHMENTS

1. NCTCOG Service Volumes
2. Exhibit 1: Arapaho Rail Station Pedestrian Counts (Before) 7:00 - 8:00 AM
3. Exhibit 2: Arapaho Rail Station Pedestrian Counts (Before) 11:00 AM - 1:00 PM
4. Exhibit 3: Arapaho Rail Station Pedestrian Counts (Before) 4:00 - 6:00 PM
5. Exhibit 4: Arapaho Rail Station Pedestrian Counts (After) 7:00 - 8:00 AM
6. Exhibit 5: Arapaho Rail Station Pedestrian Counts (After) 11:00 AM - 1:00 PM
7. Exhibit 6: Arapaho Rail Station Pedestrian Counts (After) 4:00 - 6:00 PM
8. Greenville Avenue South of Arapaho Road Volume Graphs
9. Greenville Avenue South of Campbell Road Volume Graphs

NCTCOG SERVICE VOLUMES

NCTCOG Transportation Department
Travel Model Development Group

DALLAS-FORT WORTH REGIONAL TRAVEL MODEL (DFWRTM):

MODEL DESCRIPTION

Travel Model Development Group
NCTCOG Transportation Department
September 2009

Roadway Preparation

The Roadway Preparation program imports a TransCAD roadway file which contains approach links, and prepares the roadway for skimming by creating fields that will be used downstream in the model run and initializing values of some of these fields.

Inputs

APPRDWY.DBD – A TransCAD geographic file that contains the approach links.

ACTRDWY.DBD – A TransCAD geographic file from another model run from which initial times will be borrowed.

FreeSpeedParameters.DBF – a Free Speed Parameters file which relates functional class, area type, control A and control B with a value for delay in the AB and BA direction.

CPIFactors.DBF – A CPI Factors file where each row lists a year and the Consumer Price Index for that year.

TSZ.DBD – The zone layer file which will be used to identify the TSZ which each link belongs to; this process is called tagging in TransCAD.

PATRIPS.DBF – A file produced from the Trip Generation module which associates the TSZ with an area type. This PATRIPS.DBF used will correspond to the Zonal Activity folder chosen.

Toll Value Year – A year for which toll values are adjusted to 1999 based on CPI Factors. It should represent the year for which toll values have been coded.

Steps

The Roadway Preparation Program proceeds through the following steps.

1. Set up the data arrays.

    a. AMFactor, PMFactor, OPFactor – These factors are used in the conversion of capacity from hourly to time period. Factors are defined by functional class 1-8 and listed in Exhibit 3-11. These factors were changed in July 2005 and documented in "Capacity factors_RE 1999 New Run vs. Run 243 Comparison."

Exhibit 3-11: Capacity Conversion of Factors from Hourly to Time Period

TIME PERIOD	FUNCTIONAL CLASS						
	Freeway	Principal Arterial	Minor Arterial	Collector	Freeway Ramp	Frontage Road	HOV
AM	2.3	2.1	2.1	2.1	2.3	2.1	2.3
PM	3.2	2.9	2.9	2.9	3.2	2.9	3.2
OP	10.0	9.2	9.2	9.2	10.0	9.2	10.0

b. Roadway Approach Link Speeds – The Roadway Approach Link speeds are off-peak and peak speeds for each area type; the speeds are listed in Exhibit 3-12.

Exhibit 3-12: Centroid Speed by Area Type and Time Period

Area Type	Off-Peak Speed	Peak Speed
Central Business District (CBD)	15	11
Outer Business District	23	13
Urban Residential	27	17
Suburban Residential	33	21
Rural	39	23

c. Hourly Capacity Per Lane (Divided or One-Way Roads) – The hourly capacity per lane for divided roads is given by area type and functional class in Exhibit 3-13. [1]

Exhibit 3-13: Hourly Capacity Per Lane – Divided or One-Way Roads[1]

Area Type	Functional Class						
	Freeway	**Principal Arterial**	**Minor Arterial**	**Collector**	**Freeway Ramp**	**Frontage Road**	**HOV**
CBD	2050	725	725	475	1250	725	2050
Outer Business District	2125	775	775	500	1375	775	2125
Urban Residential	2150	850	825	525	1425	850	2150
Suburban Residential	2225	925	900	575	1600	900	2225
Rural	2300	1025	975	600	1725	975	2300

d. Hourly Capacity Per Lane (Undivided Roads) – The hourly capacity per lane for undivided roads is given by area type and functional class in Exhibit 3-14.

[1] The values in the body of the table are expressed in passenger cars per hour per lane (pcphpl). They correspond to volumes at level-of-service (LOS) E. The calculation of LOS requires the conversion of the model volume to passenger car equivalents (PCE). These adjustments are treated in an aggregate manner in the travel model based on the actual field data on the freeway network as follows:

LOS	AM Volume Adjustment Factor	PM Volume Adjustment Factor	Upper Threshold for Volume to Capacity Ratio
A, B, C	1.06	1.00	0.65
D or E	1.18	1.25	1.00

The model volumes are taken from the AMHRVOL_AB / AMHRVOL_BA or PMHRVOL_AB / PMHRVOL_BA fields. The corresponding capacity values are taken from the AMHRCAP_AB / AMHRCAP_BA or PMHRCAP_AB / PMHRCAP_BA fields respectively.

Exhibit 3-14: Hourly Capacity Per Lane – Undivided Roads[1]

Area Type	Functional Class						
	Freeway	Principal Arterial	Minor Arterial	Collector	Freeway Ramp	Frontage Road	HOV
CBD	N/A	650	650	425	1250	650	N/A
Outer Business District	N/A	725	725	450	1375	725	N/A
Urban Residential	N/A	775	750	475	1425	750	N/A
Suburban Residential	N/A	875	825	525	1600	825	N/A
Rural	N/A	925	875	550	1725	875	N/A

e. Peak and off-peak ratios are used for estimating the initial loaded travel times. The peak and off-peak ratios are calculated for each functional class and area type pair.

$$pkRatio_{fa} = \begin{cases} \dfrac{\sum \lfloor \text{Old PKFRTIME} \rfloor_{fa}}{\sum \lfloor \text{Old PKTIME} \rfloor_{fa}}, & if \sum \lfloor \text{Old PKTIME} \rfloor_{fa} > \sum \lfloor \text{Old PKFRTIME} \rfloor_{fa} \text{ and } \sum \lfloor \text{Old PKTIME} \rfloor_{fa} > 0, \\ 0.999, & Otherwise \end{cases} \quad (3\text{-}1)$$

$$opRatio_{fa} = \begin{cases} \dfrac{\sum \lfloor \text{Old OPFRTIME} \rfloor_{fa}}{\sum \lfloor \text{Old OPTIME} \rfloor_{fa}}, & if \sum \lfloor \text{Old OPTIME} \rfloor_{fa} > \sum \lfloor \text{Old OPFRTIME} \rfloor_{fa} \text{ and } \sum \lfloor \text{Old OPTIME} \rfloor_{fa} > 0, \\ 0.999, & Otherwise \end{cases} \quad (3\text{-}2)$$

where

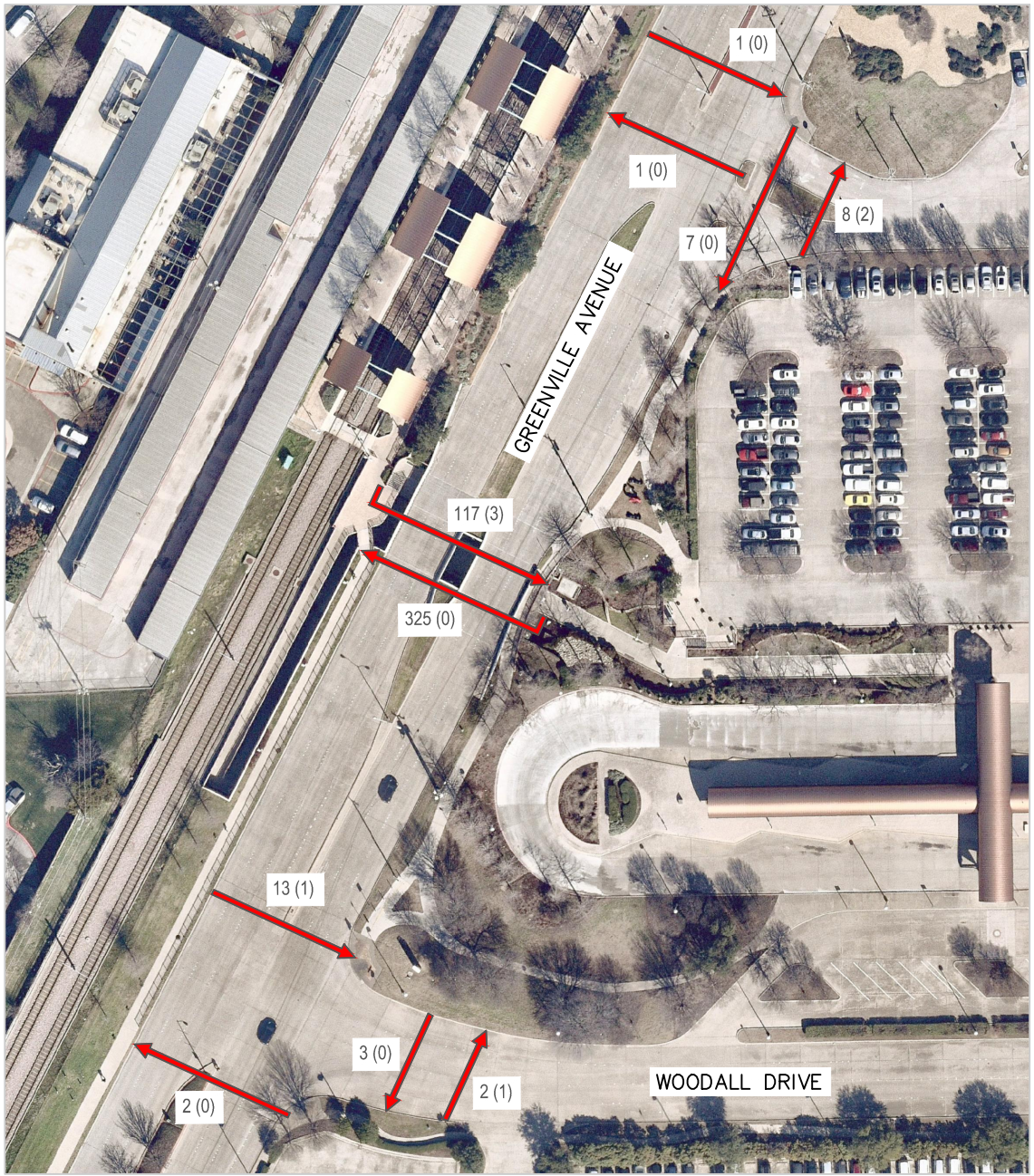
f = functional class between 1 and 8.

a = area type.

$\sum \lfloor \text{Old PKFRTIME} \rfloor_{fa}$ = Sum of peak free travel time from the "Copy From" roadway for functional class *f* and area type *a*. The peak free travel times are taken from the PKFRTIME_AB and PKFRTIME_BA fields from the ACTRDWY.DBD.

$\sum \lfloor \text{Old PKTIME} \rfloor_{fa}$ = Sum of peak loaded travel time from the "Copy From" roadway for functional class *f* and area type *a*. The peak loaded travel times are taken from the PKTIME_AB and PKTIME_BA fields from the ACTRDWY.DBD.

PEDESTRIAN COUNT EXHIBITS



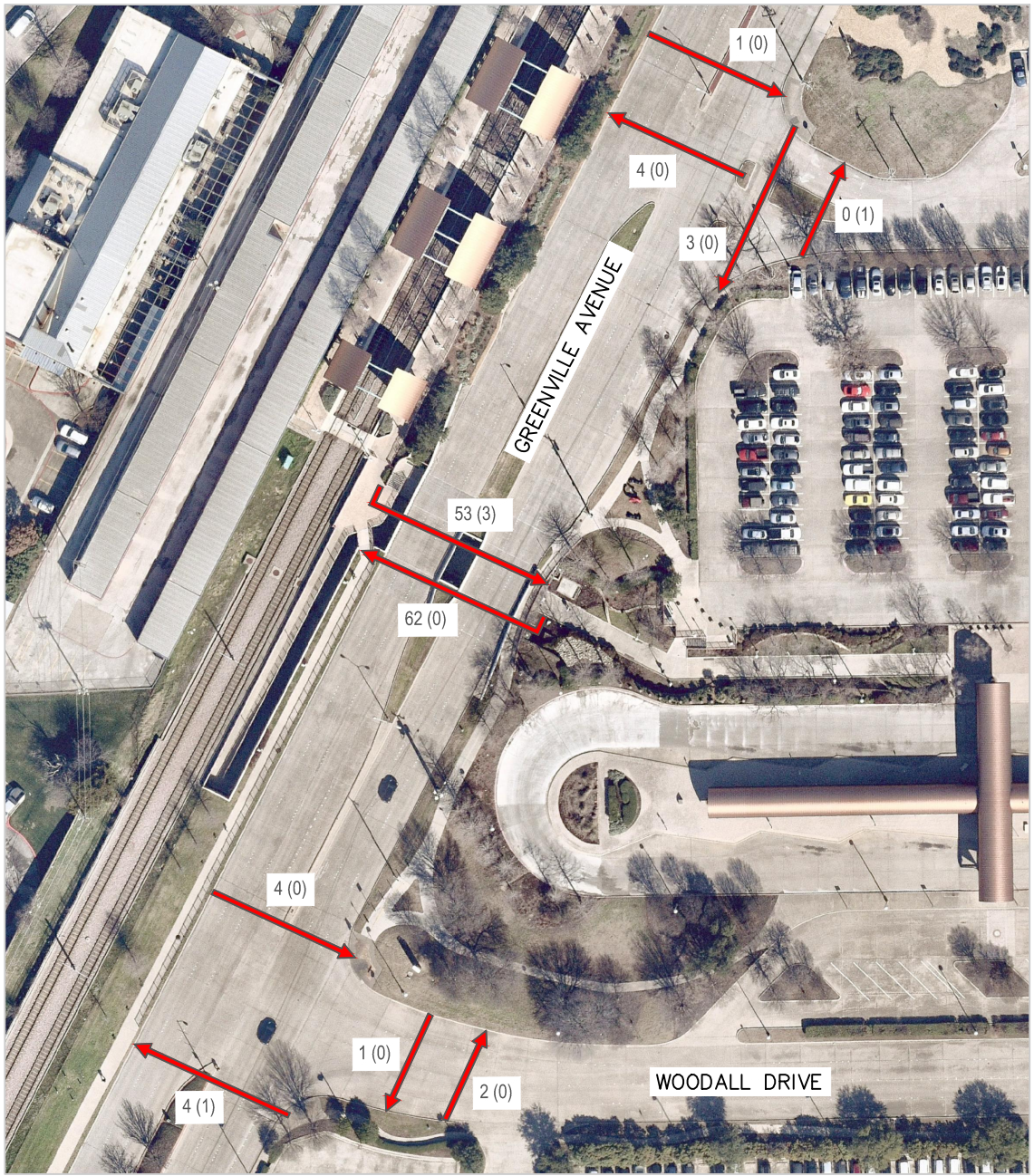
NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 1:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
6:30 - 8:30 AM
DATE COUNTED: MAY 16, 2019

Kimley»Horn



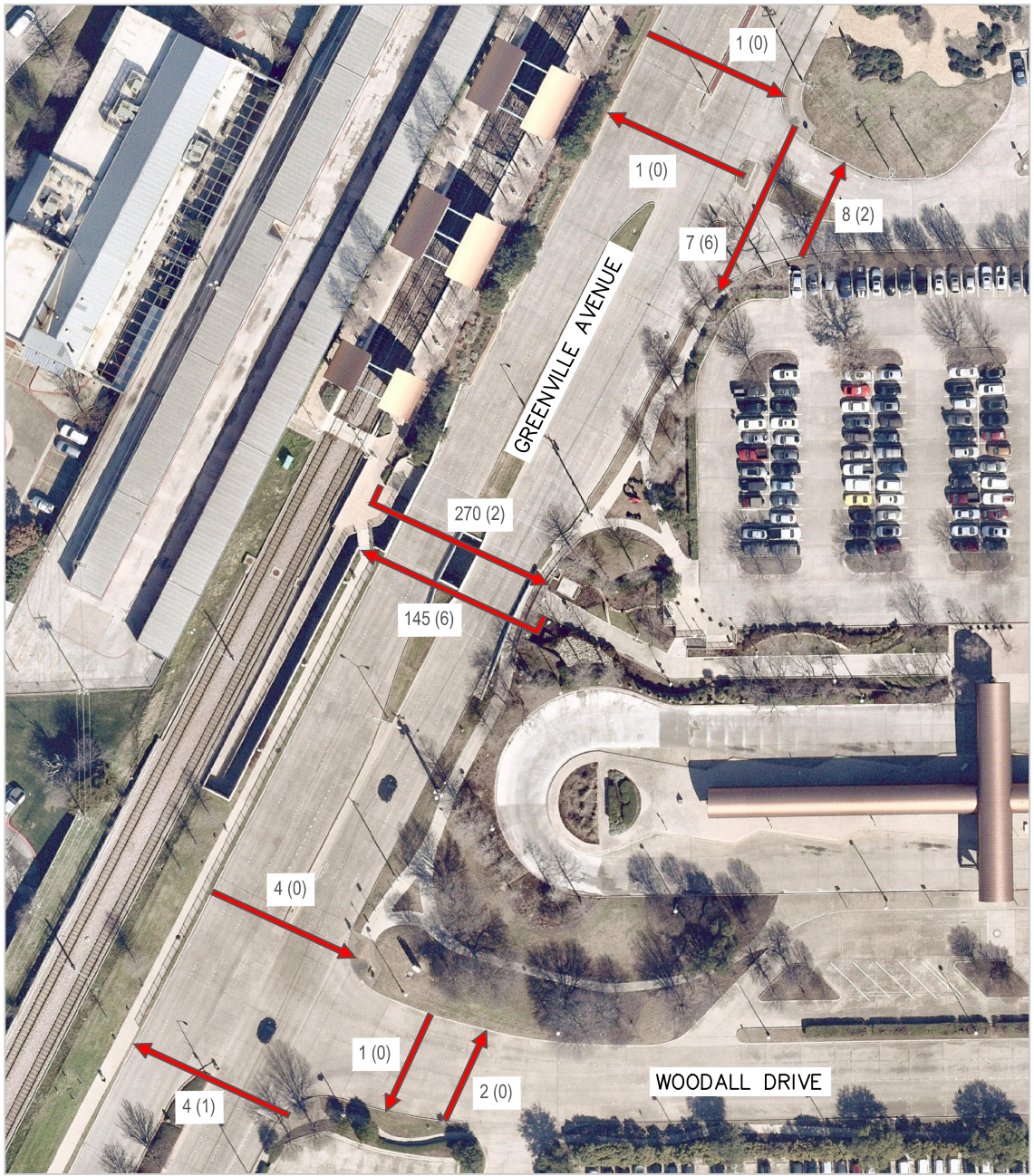
NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 2:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
11:00 - 1:00 PM
DATE COUNTED: MAY 16, 2019

Kimley»Horn



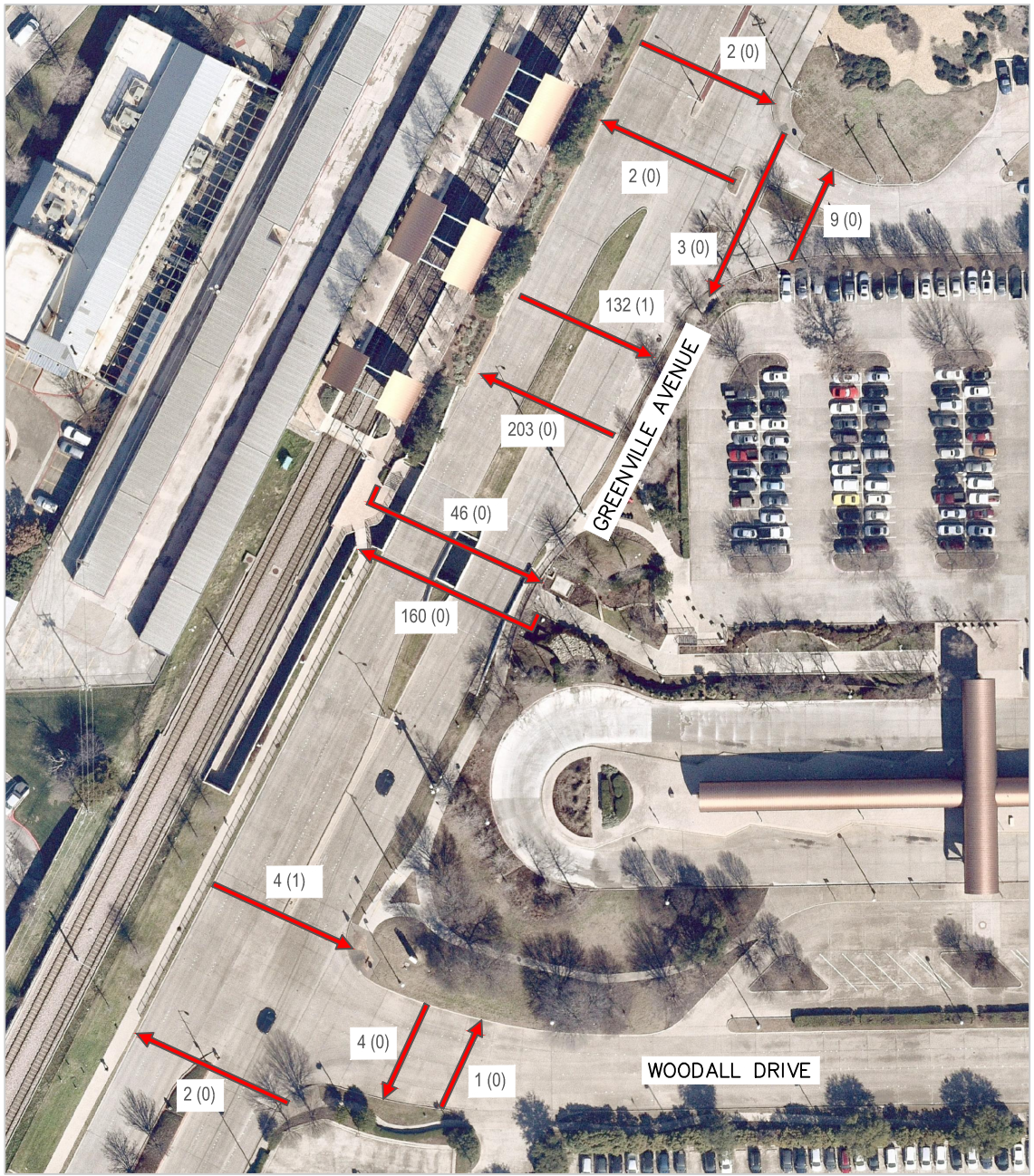
NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 3:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
4:00 - 6:00 PM
DATE COUNTED: MAY 16, 2019

Kimley»Horn



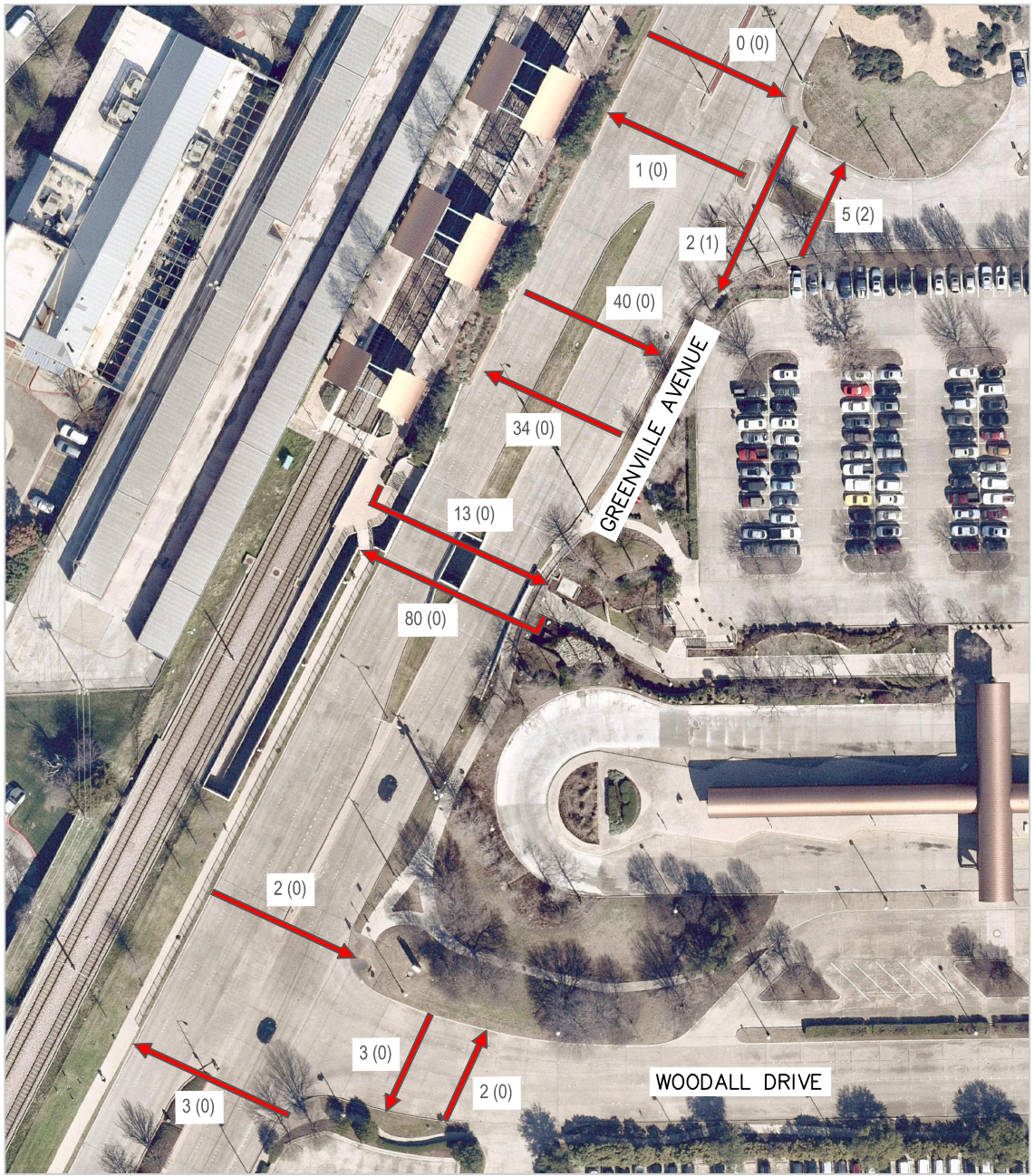
NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 4:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
6:30 - 8:30 AM
COUNTED: OCTOBER 10, 2019

Kimley»Horn



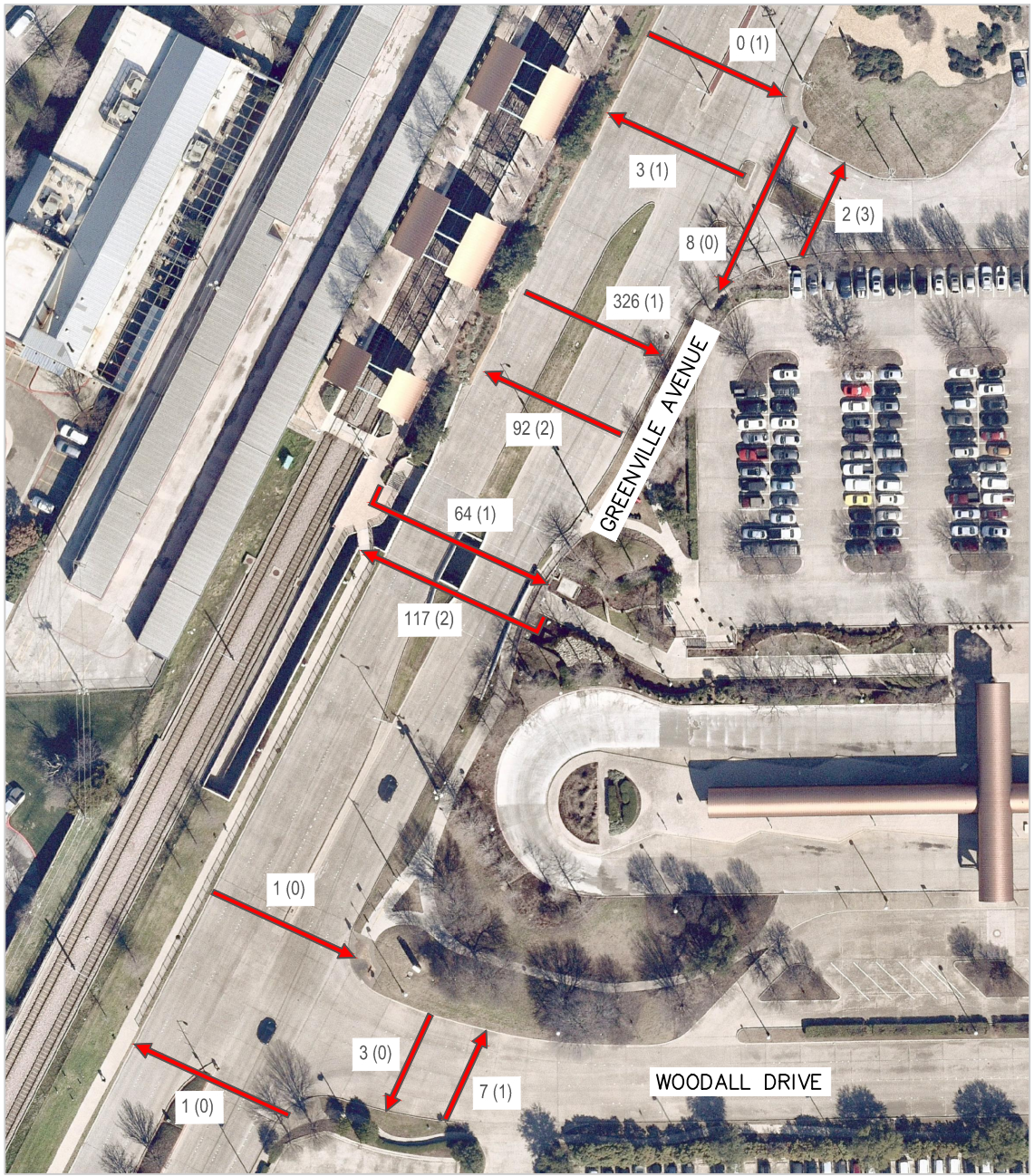
NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 5:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
11:00 - 1:00 PM
COUNTED: OCTOBER 10, 2019

Kimley»Horn



NORTH

LEGEND

X (Y)
X = PEDESTRIANS
Y = BIKES

EXHIBIT 6:
ARAPAHO RAIL STATION
PED & BIKE COUNTS
4:00 - 6:00 PM
COUNTED: OCTOBER 10, 2019

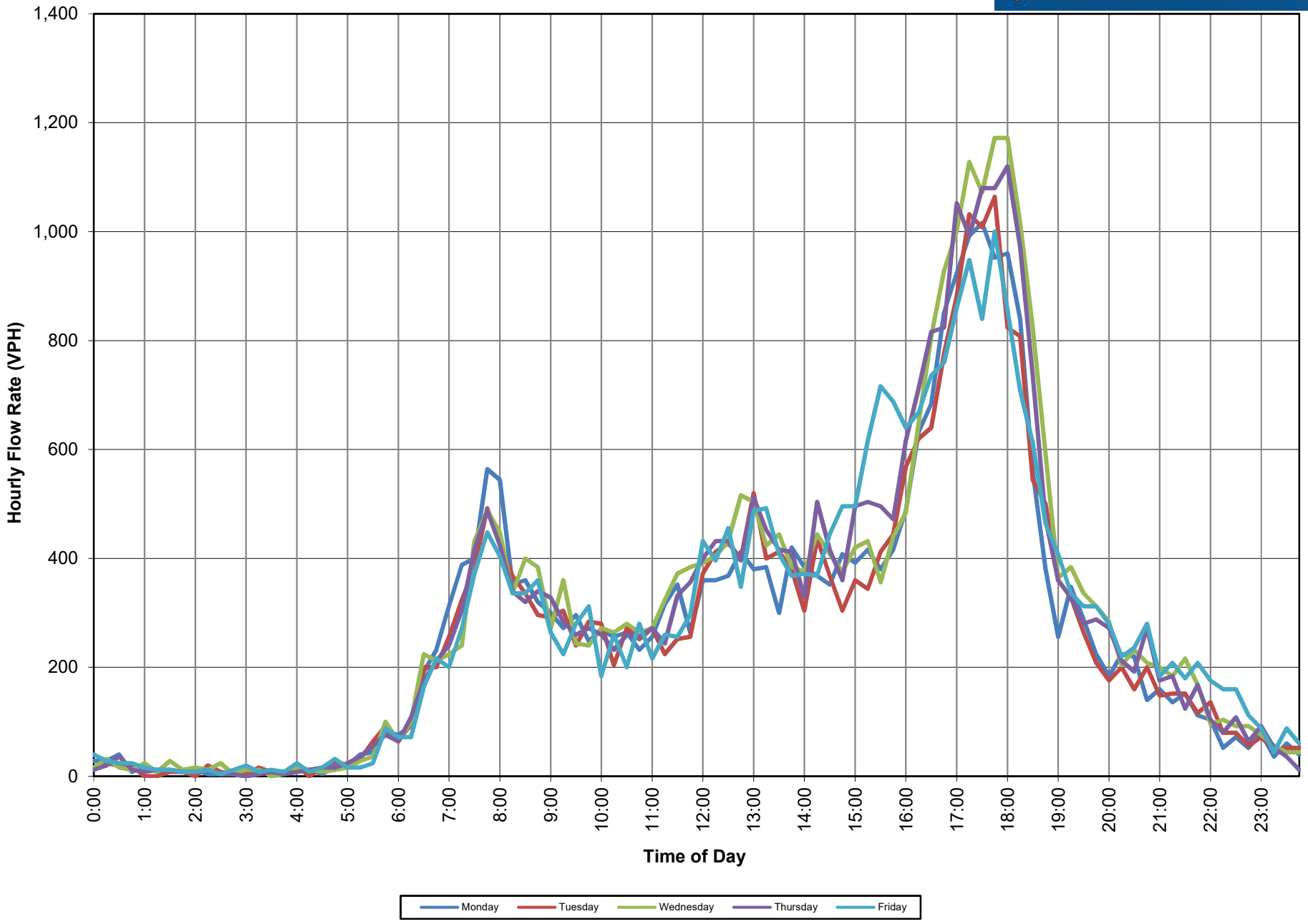
Kimley»Horn

VOLUME GRAPHS

Kimley»Horn

NB Weekdays (Before)
Greenville Avenue South of Arapaho Road

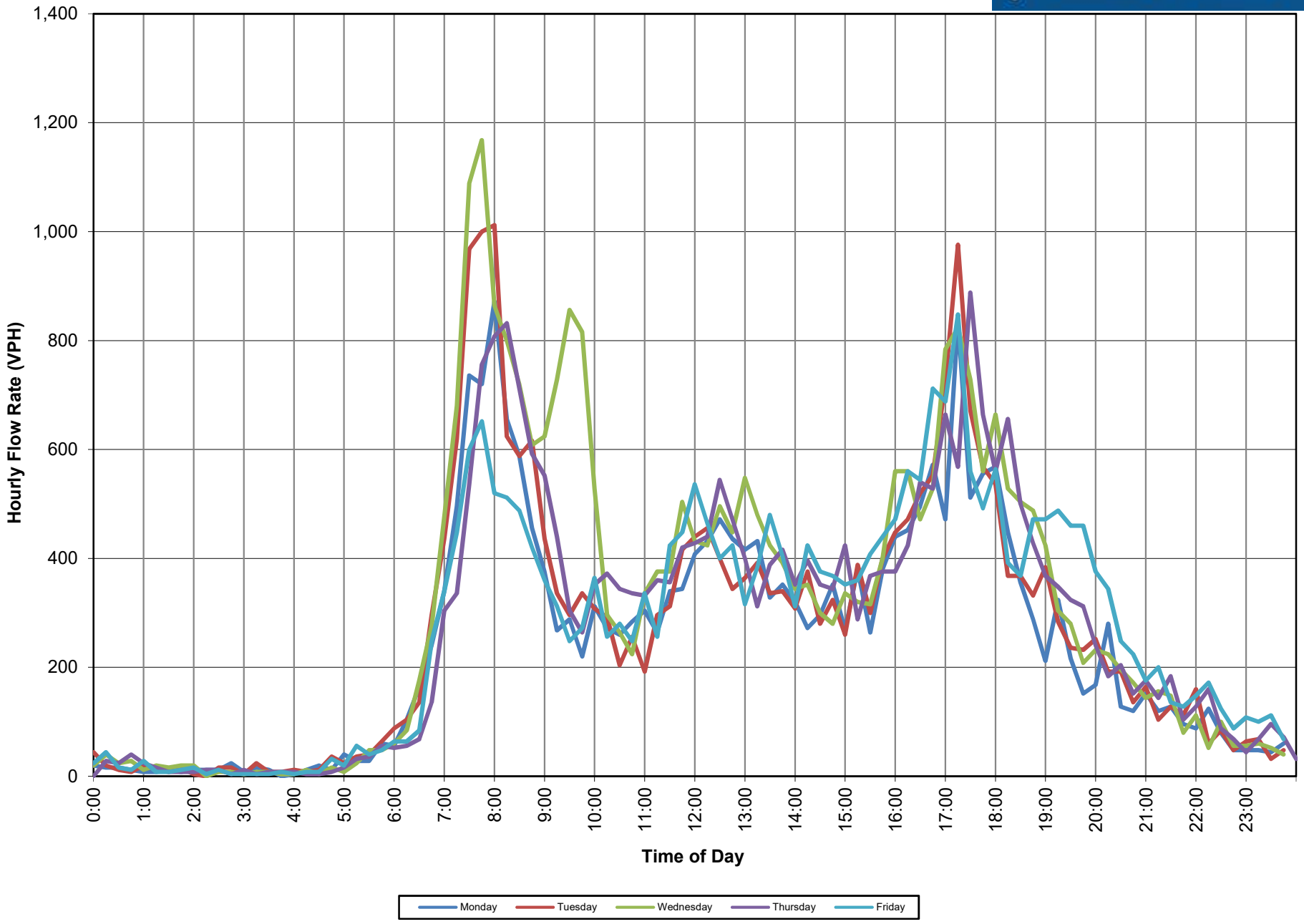
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (Before)
Greenville Avenue South of Arapaho Road

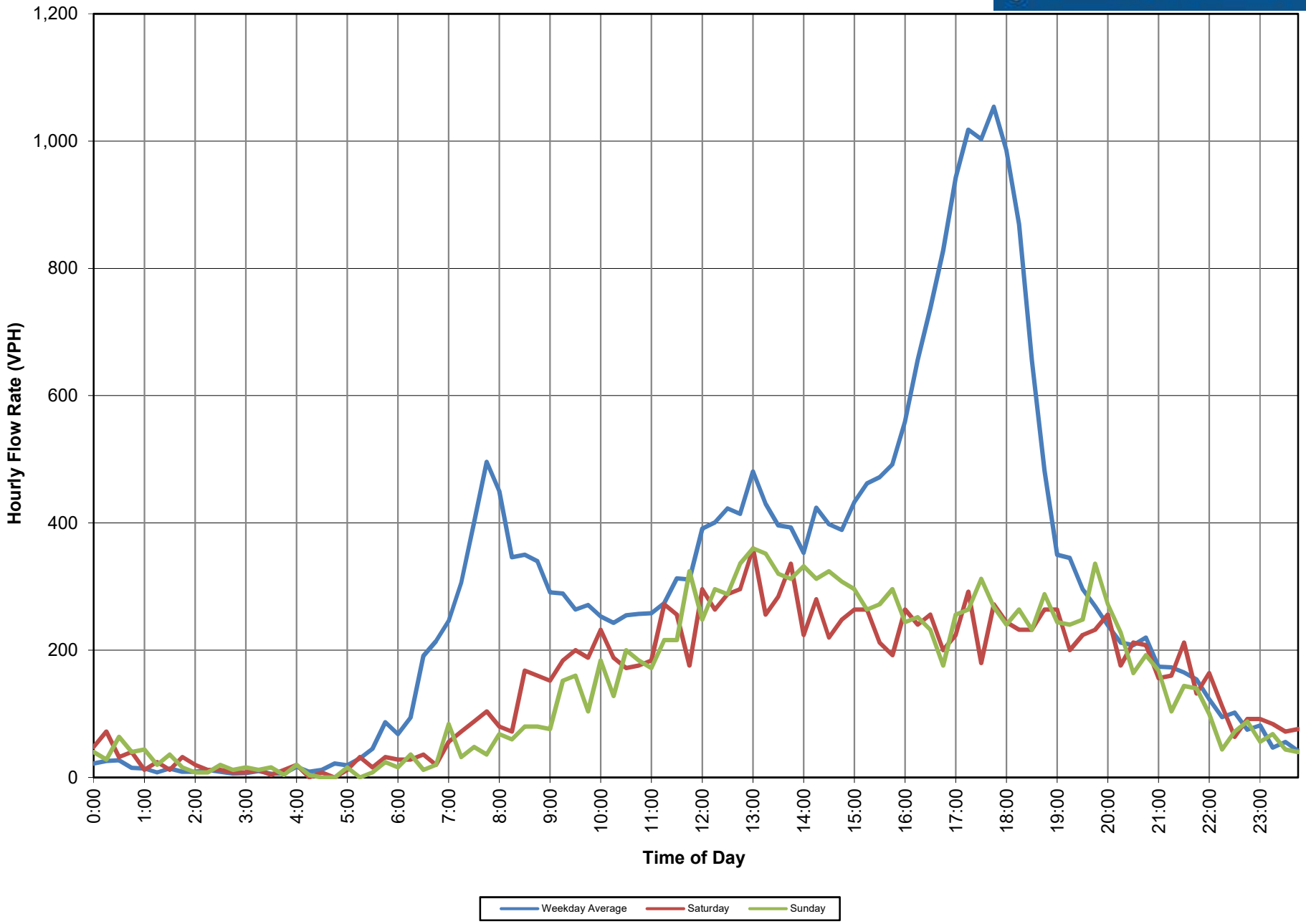
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (Before)
Greenville Avenue South of Arapaho Road

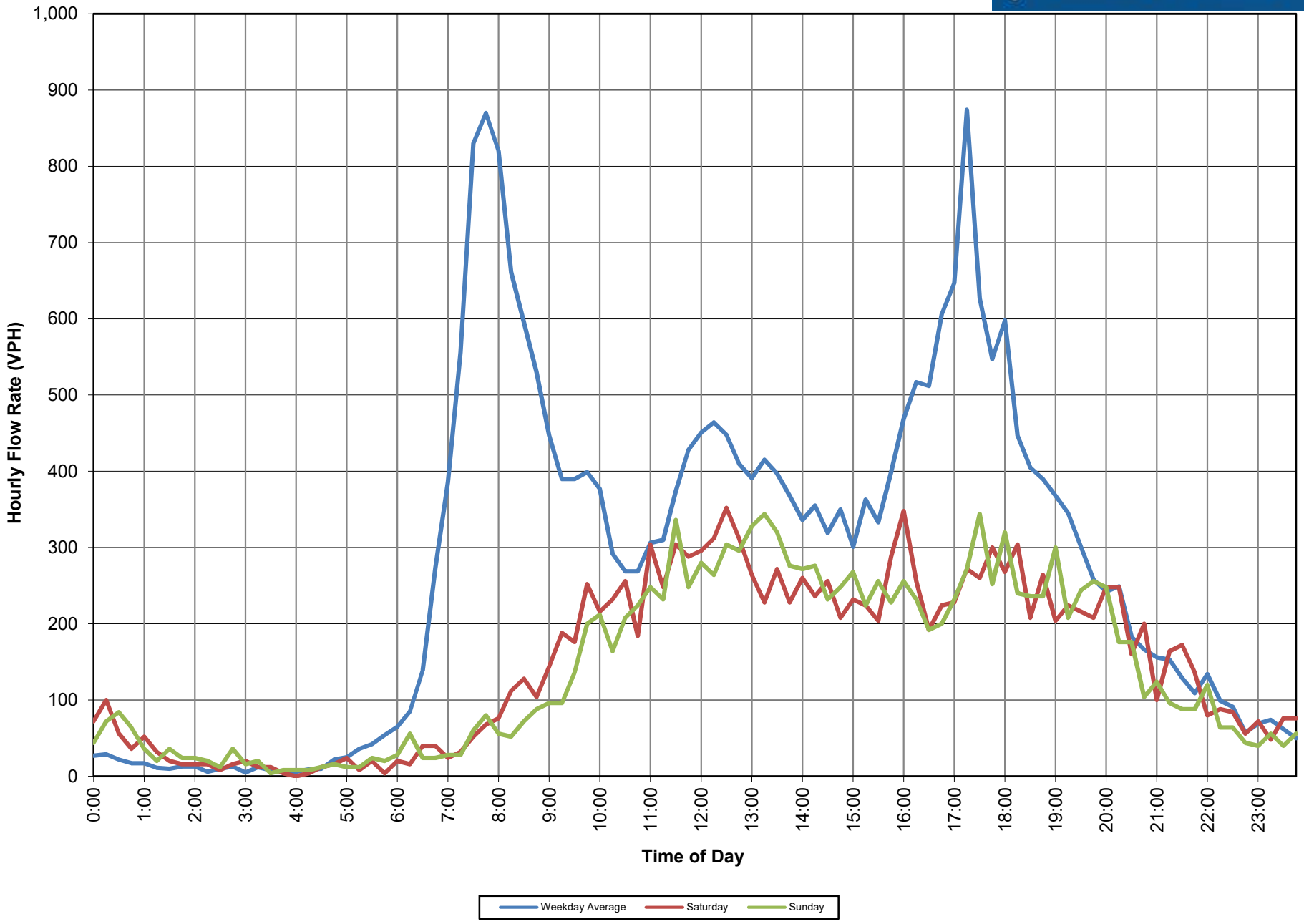
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (Before)
Greenville Avenue South of Arapaho Road

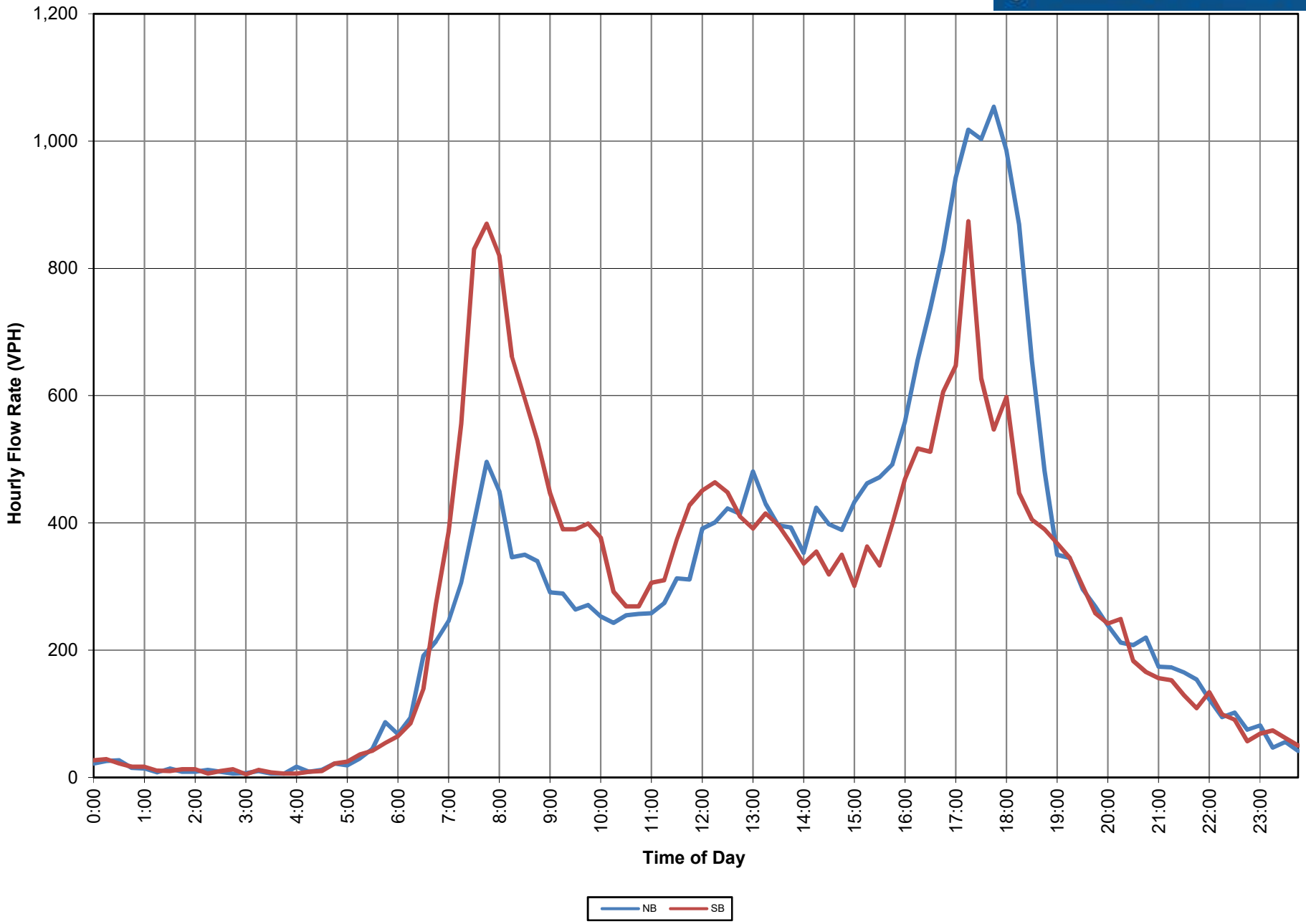
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (Before)
Greenville Avenue South of Arapaho Road

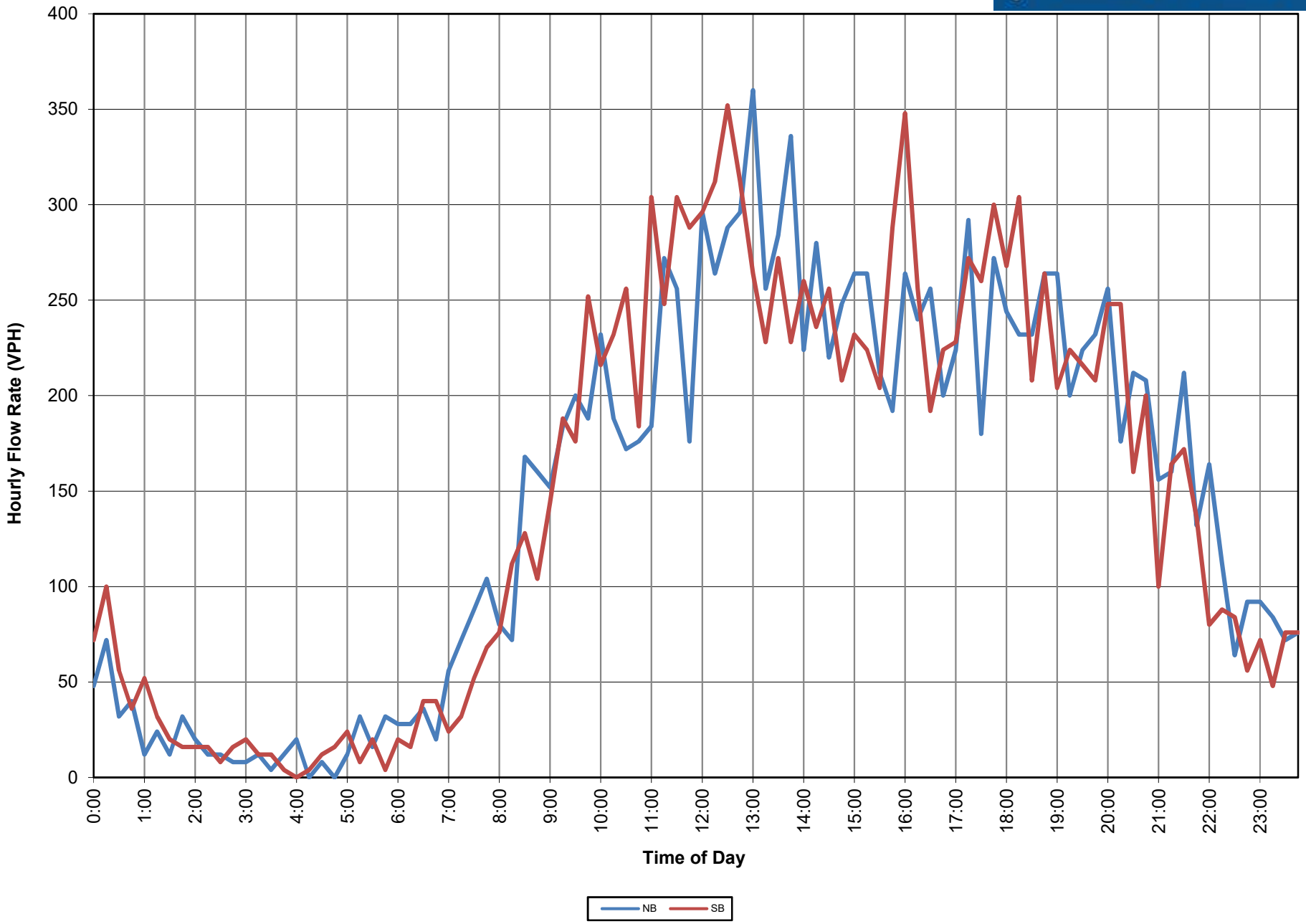
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (Before)
Greenville Avenue South of Arapaho Road

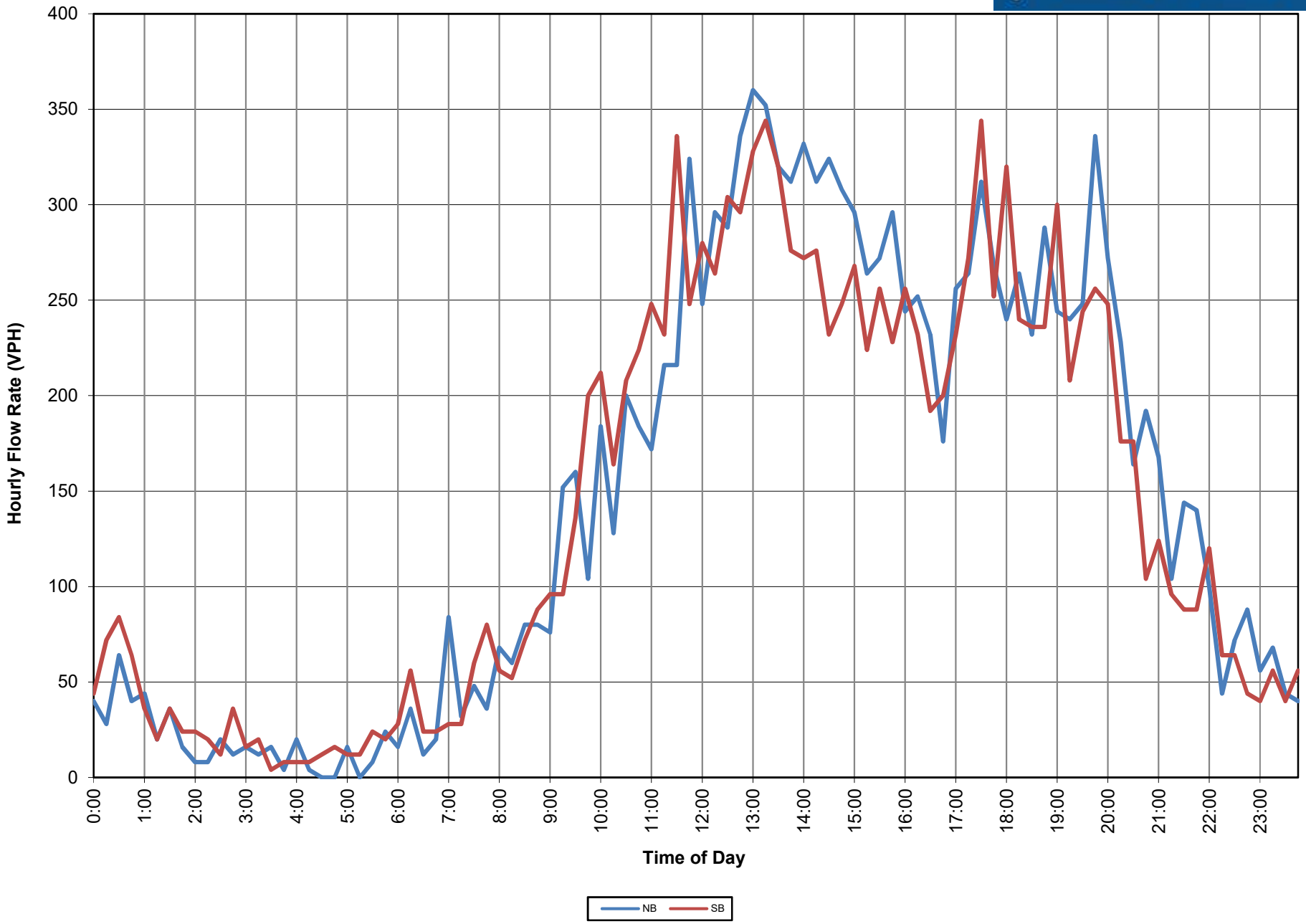
RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (Before)
Greenville Avenue South of Arapaho Road

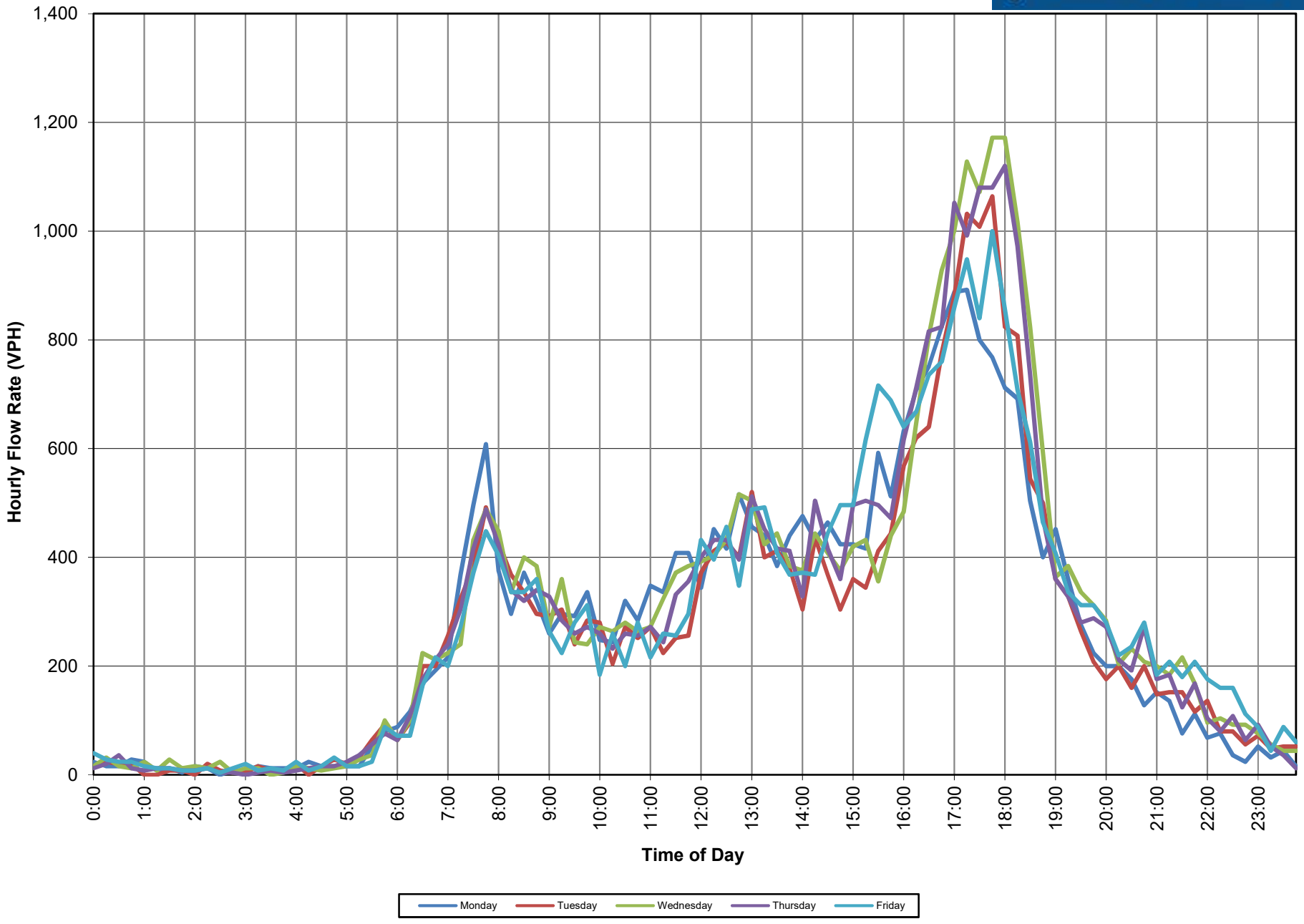
RICHARDSON TEXAS



Kimley»Horn

NB Weekdays (After)
Greenville Avenue South of Arapaho Road

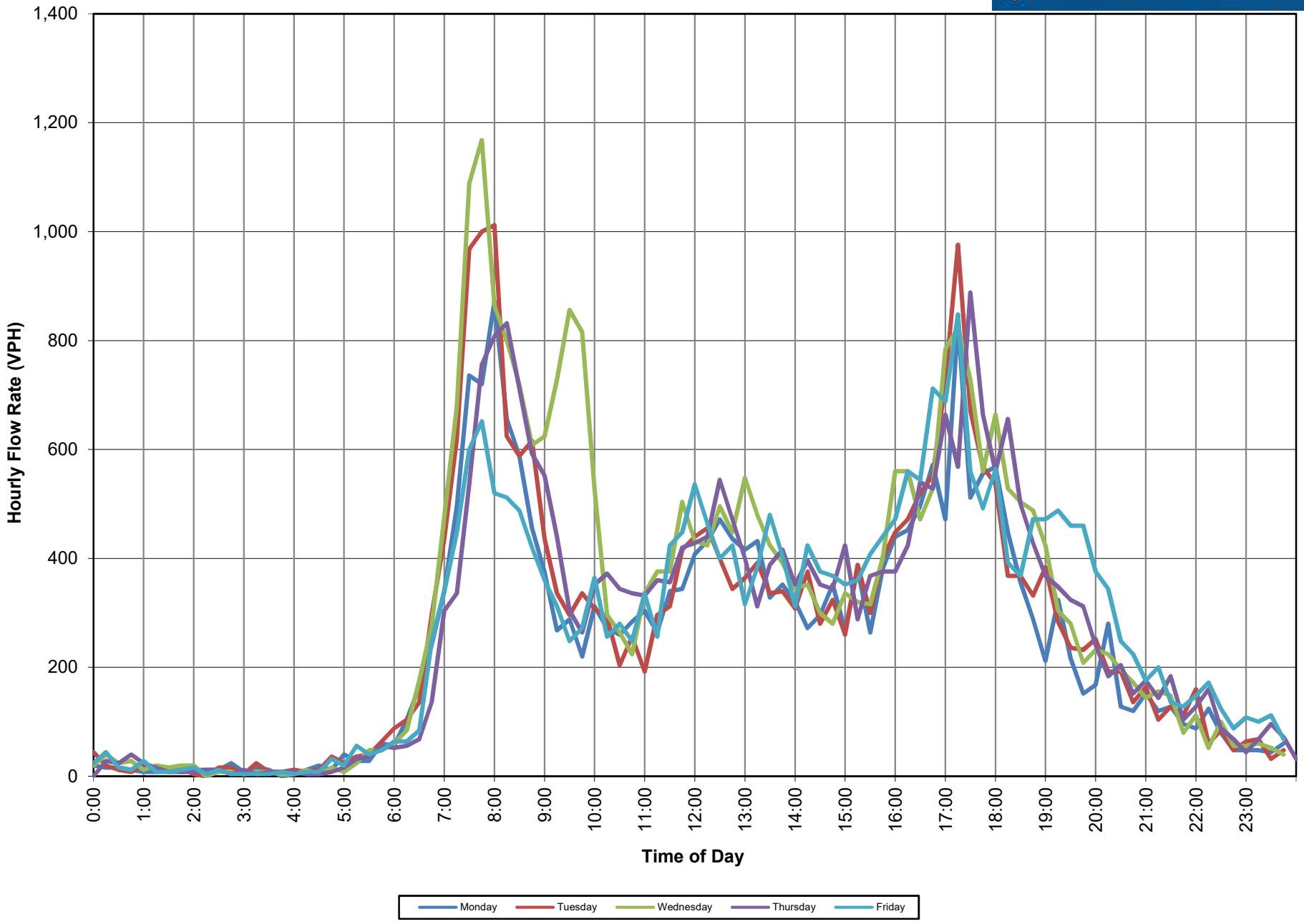
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (After)
Greenville Avenue South of Arapaho Road

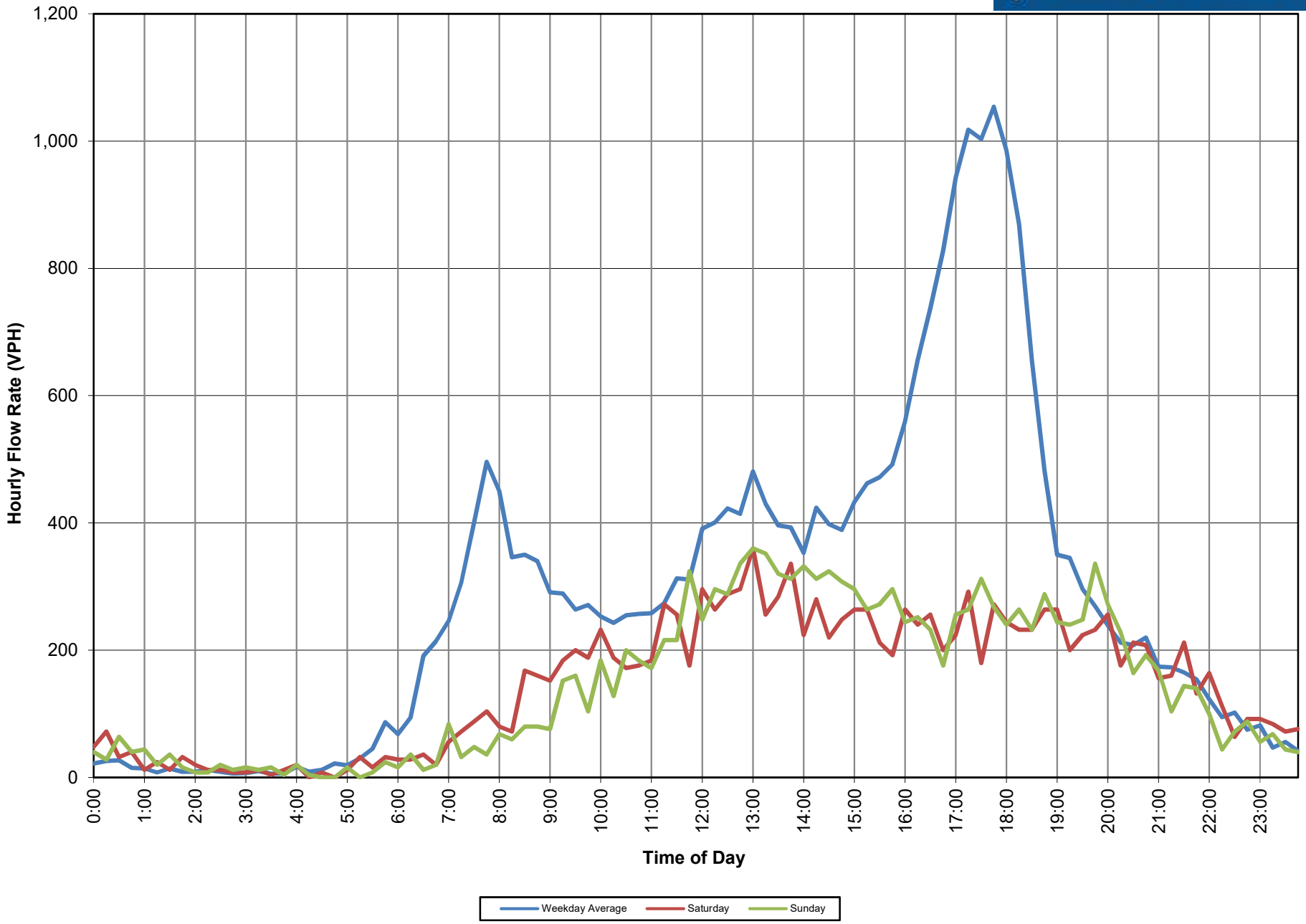
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (After)
Greenville Avenue South of Arapaho Road

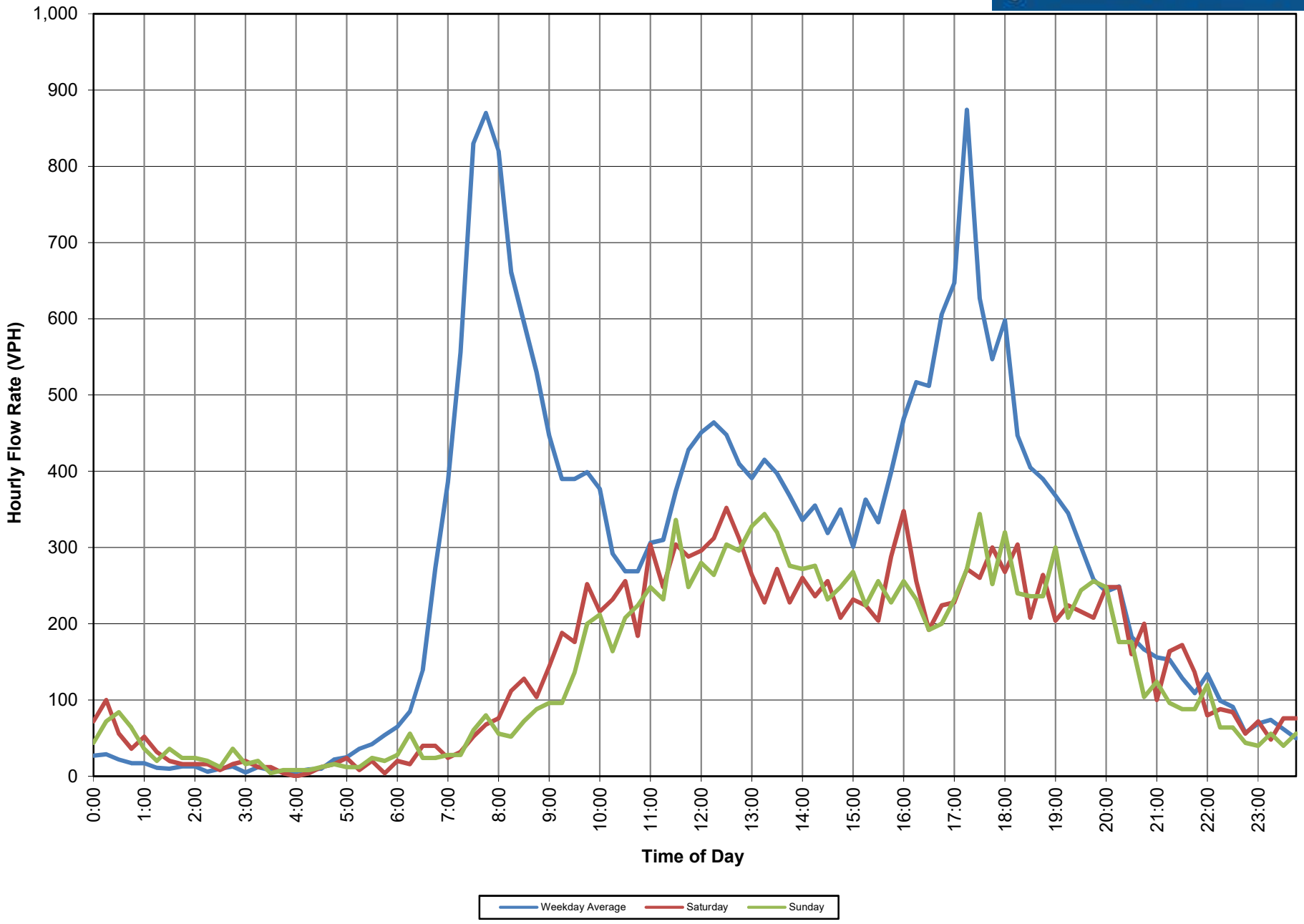
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (After)
Greenville Avenue South of Arapaho Road

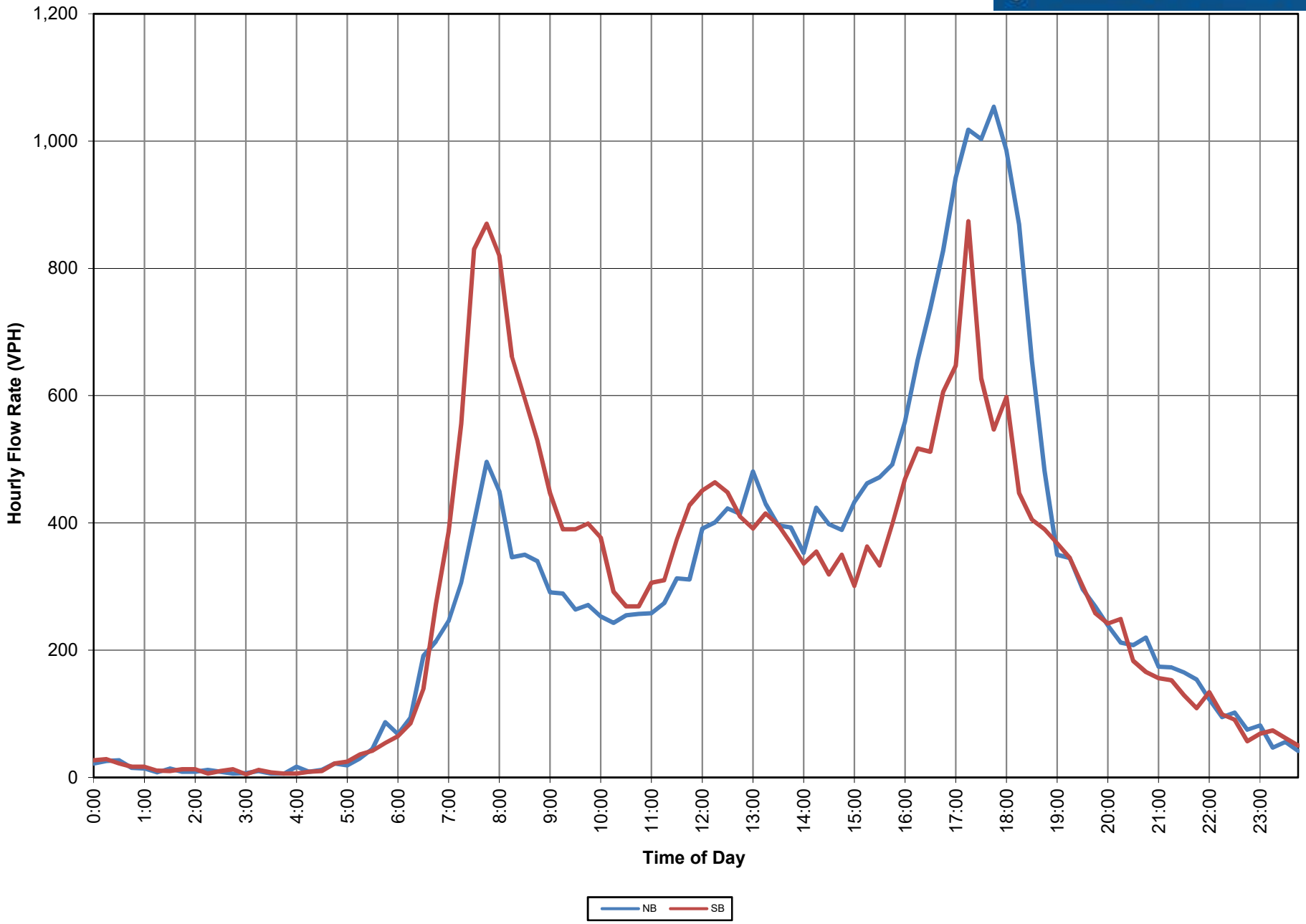
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (After)
Greenville Avenue South of Arapaho Road

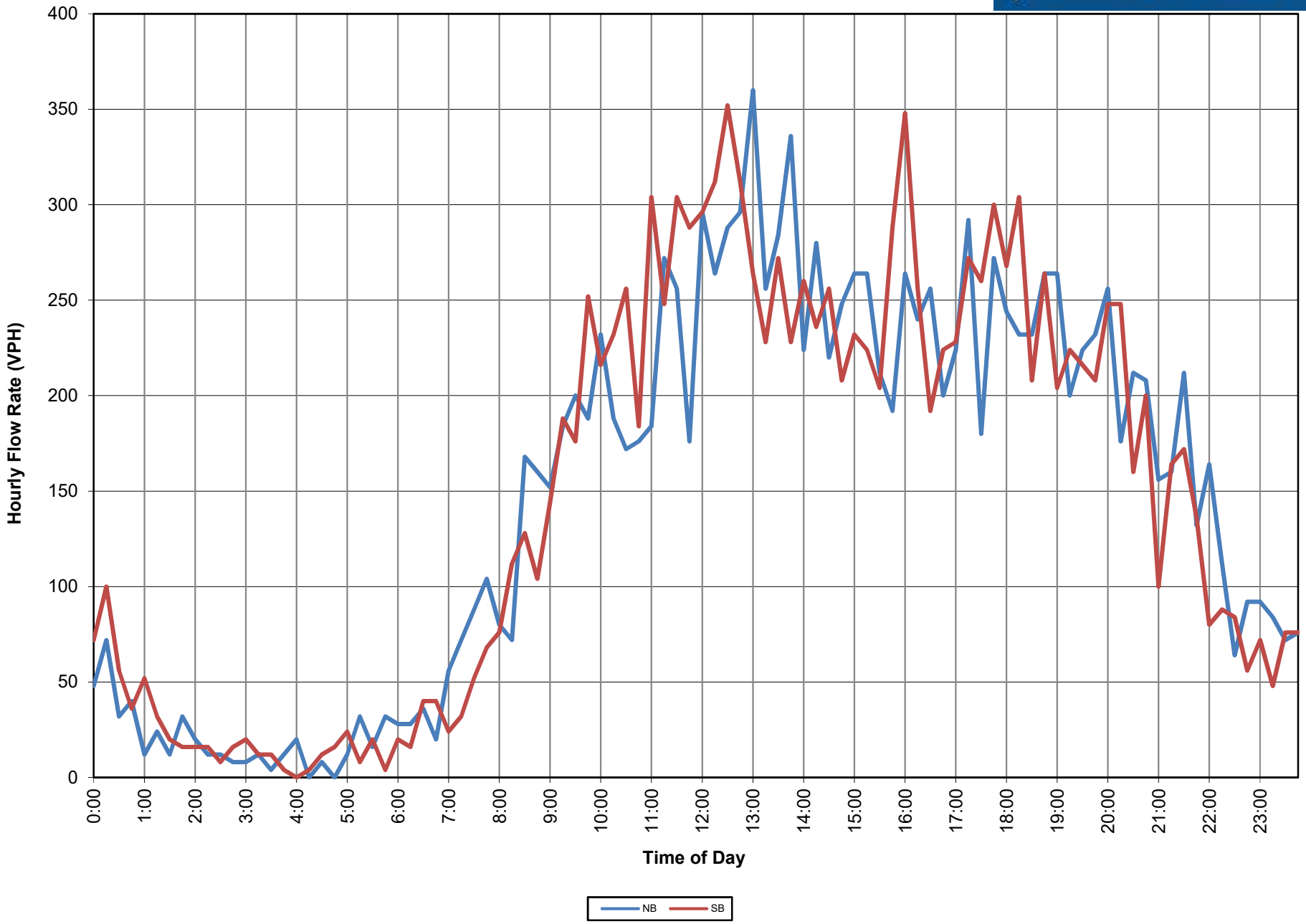
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (After)
Greenville Avenue South of Arapaho Road

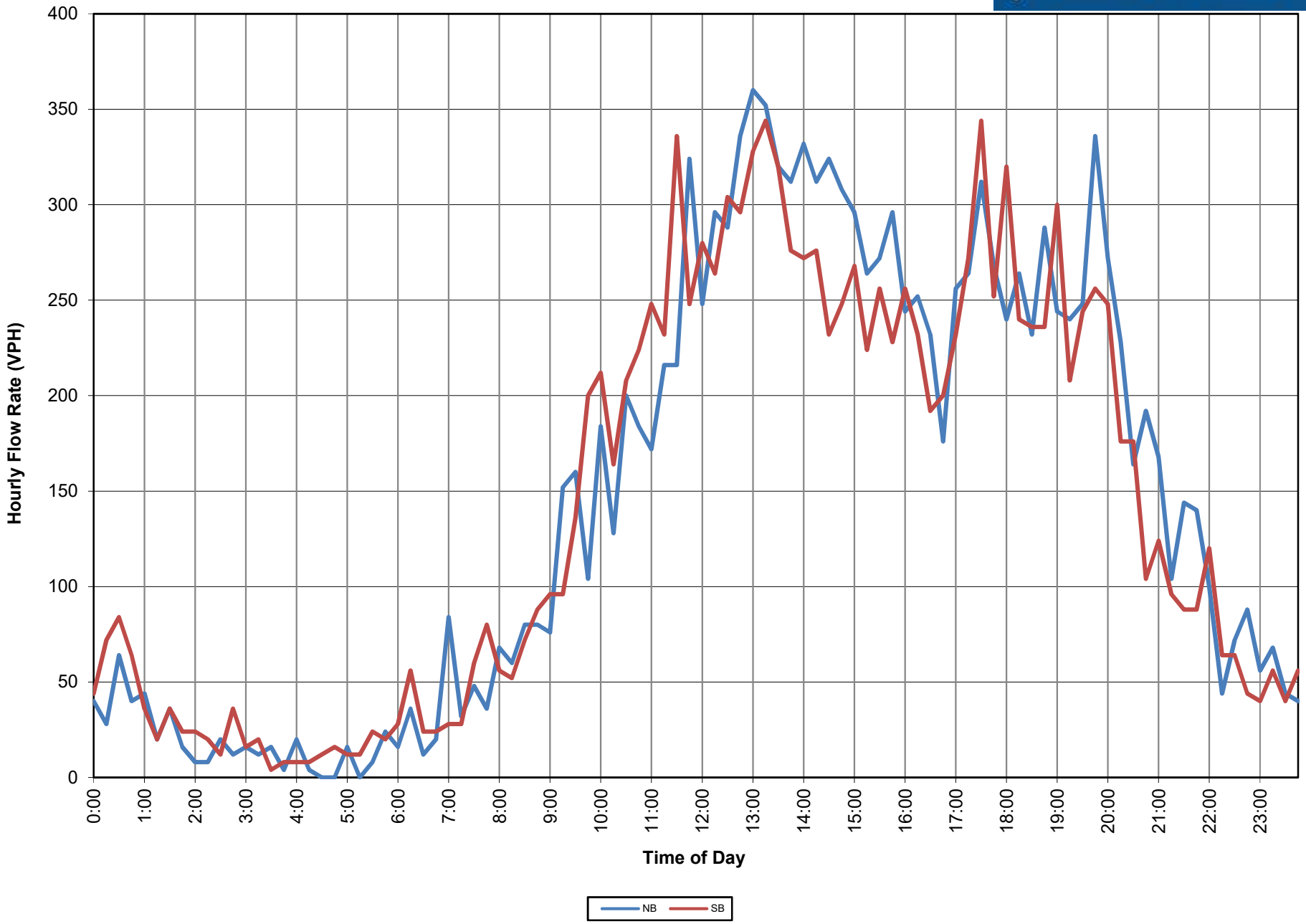
RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (After)
Greenville Avenue South of Arapaho Road

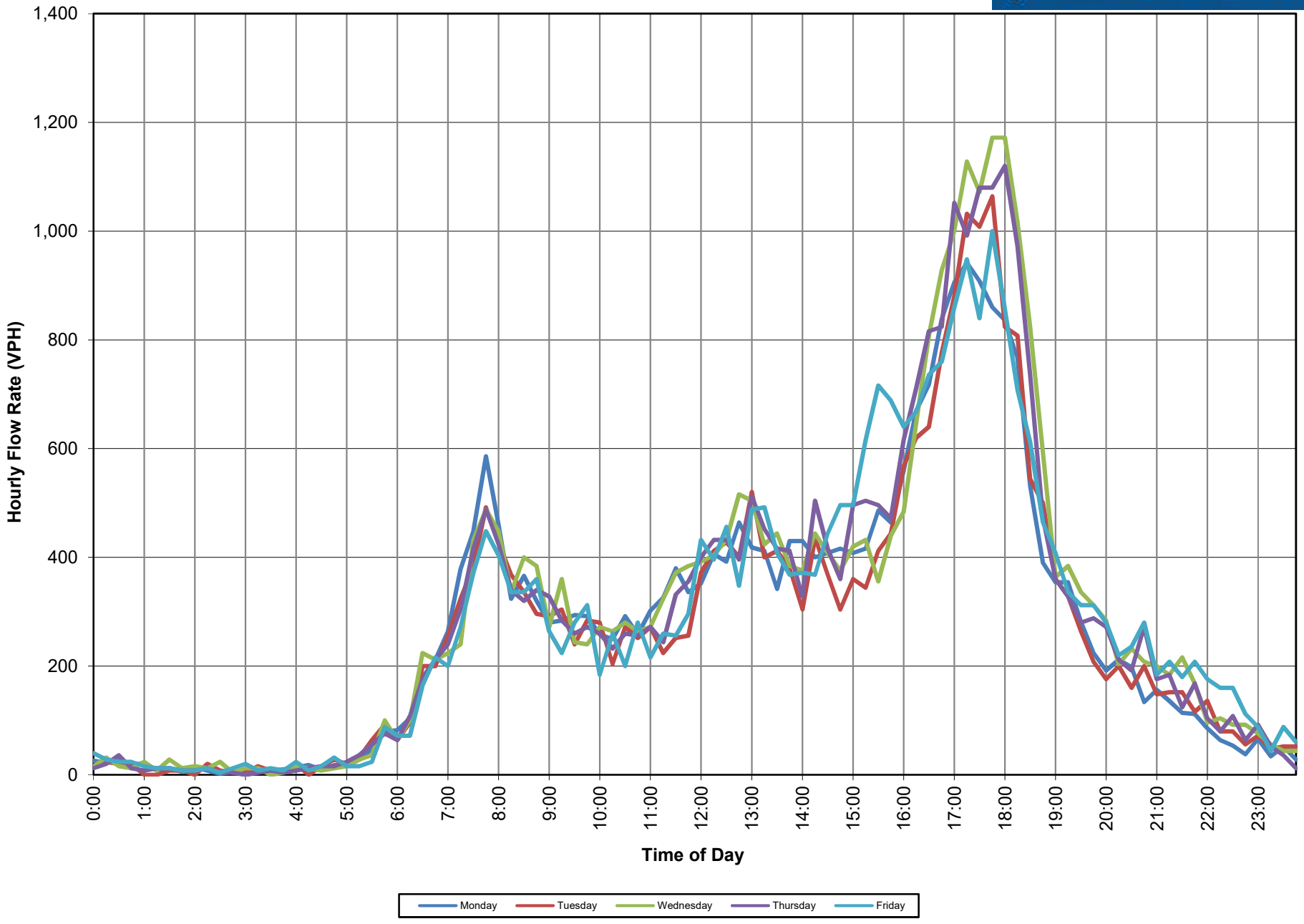
RICHARDSON TEXAS



Kimley»Horn

NB Weekdays (Before & After)
Greenville Avenue South of Arapaho Road

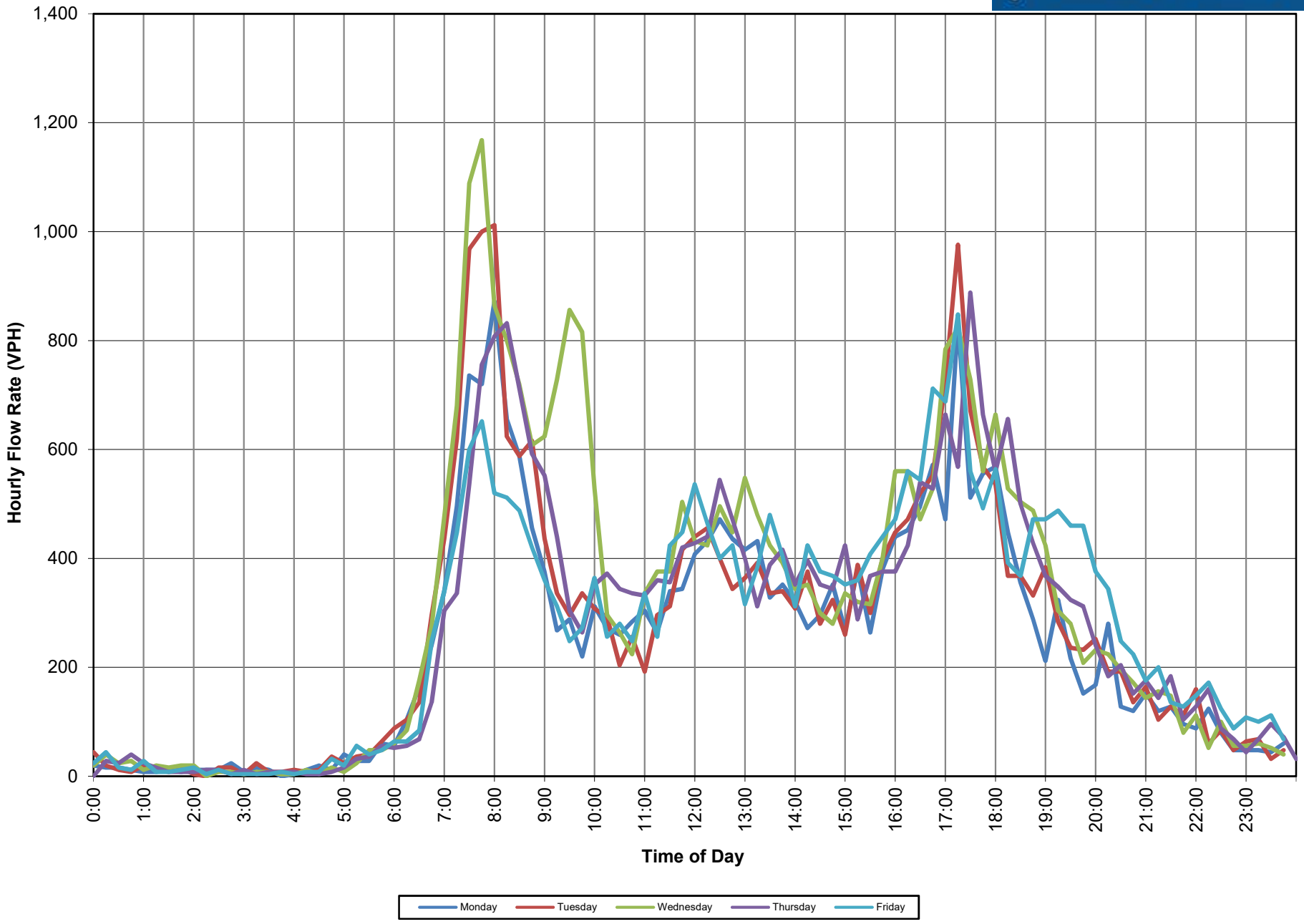
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (Before & After)
Greenville Avenue South of Arapaho Road

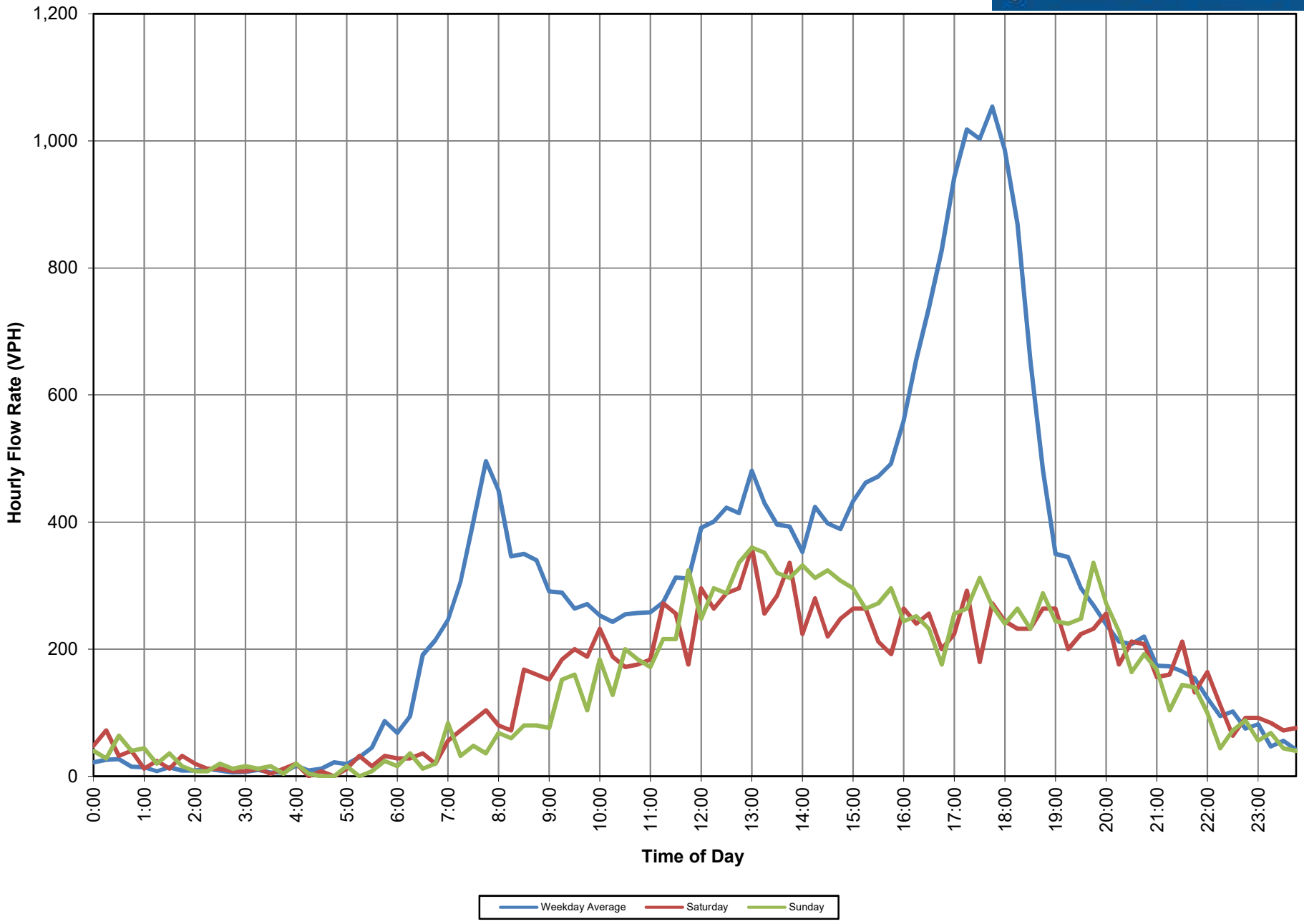
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (Before & After)
Greenville Avenue South of Arapaho Road

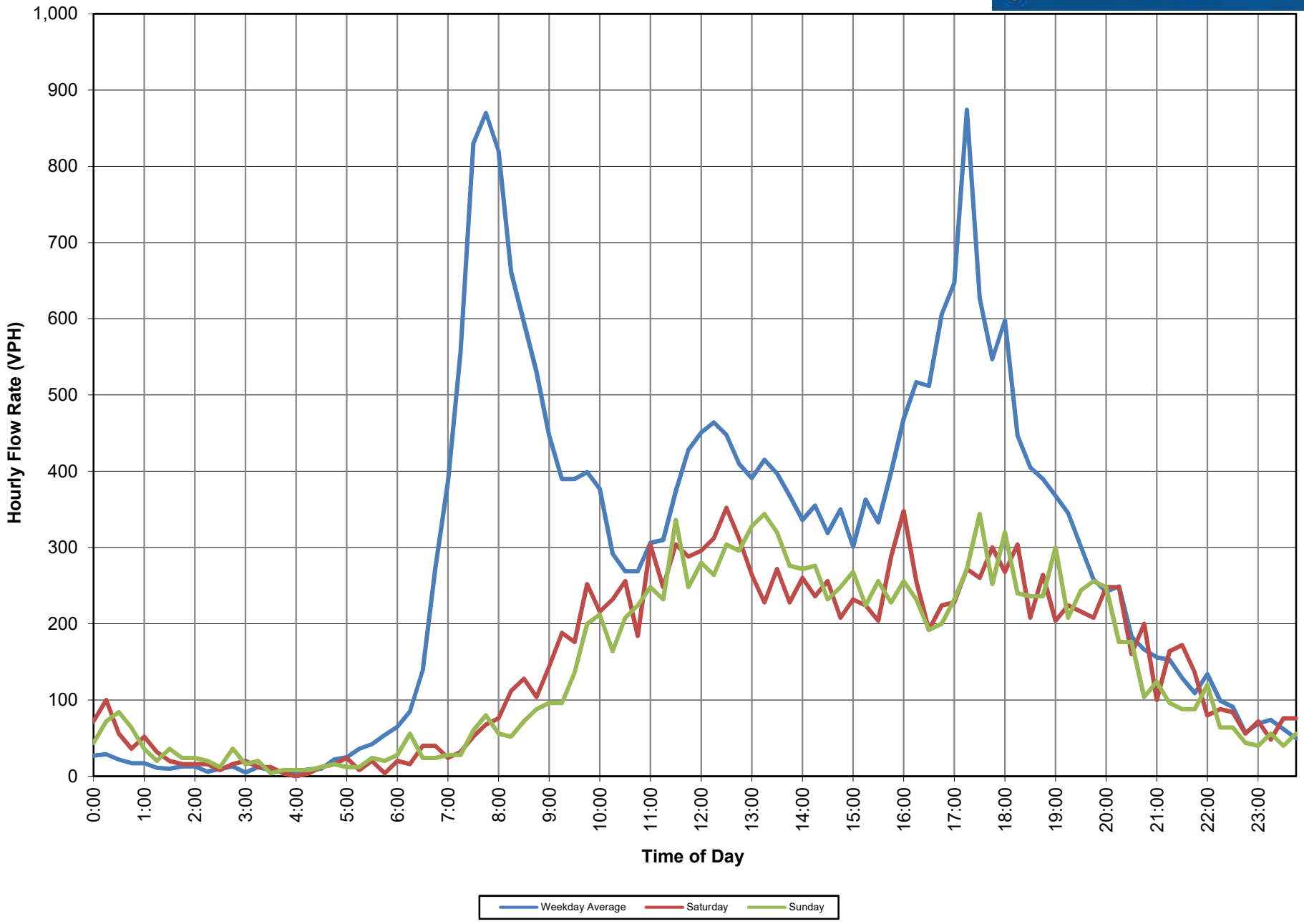
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (Before & After)
Greenville Avenue South of Arapaho Road

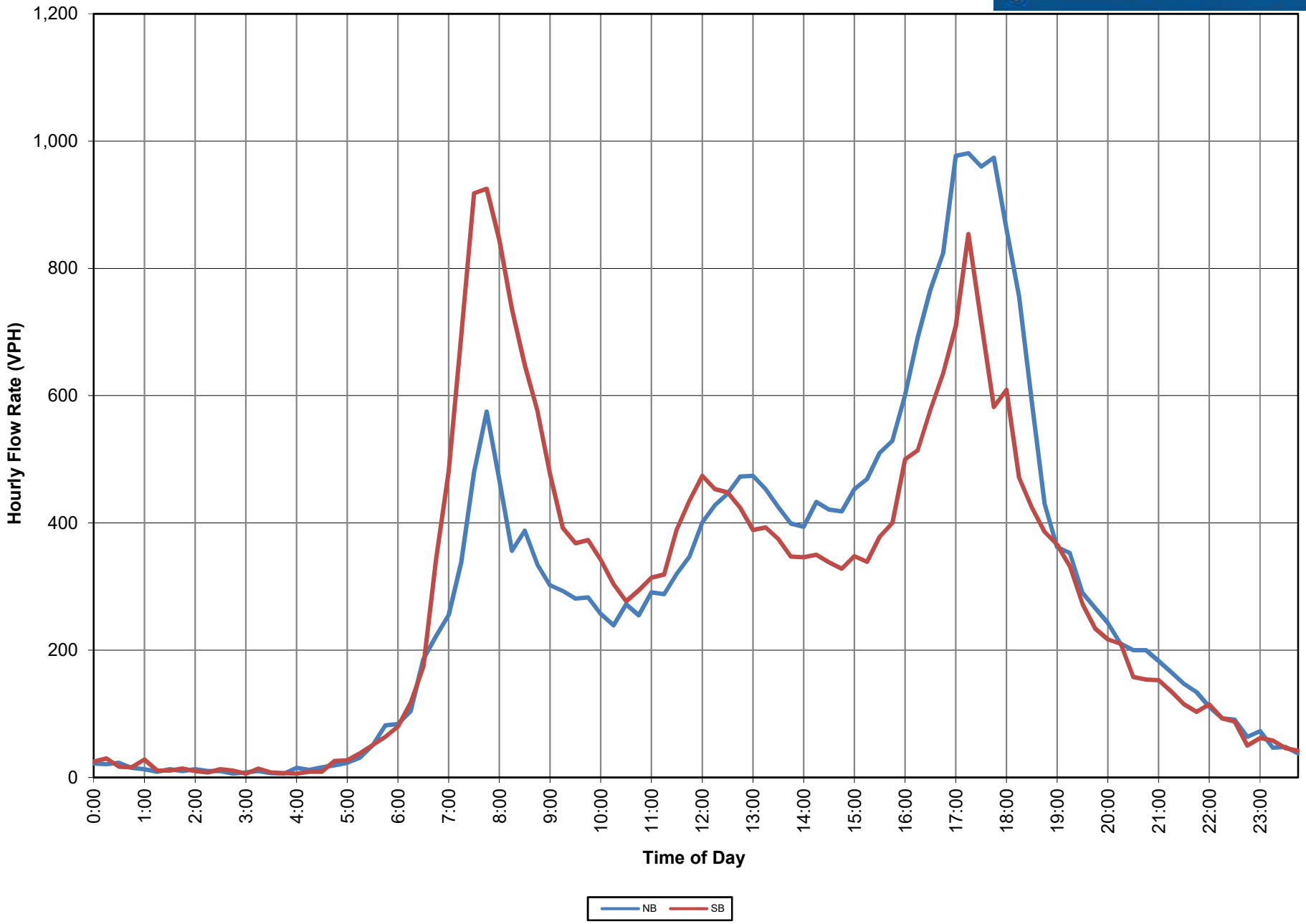
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (Before & After)
Greenville Avenue South of Arapaho Road

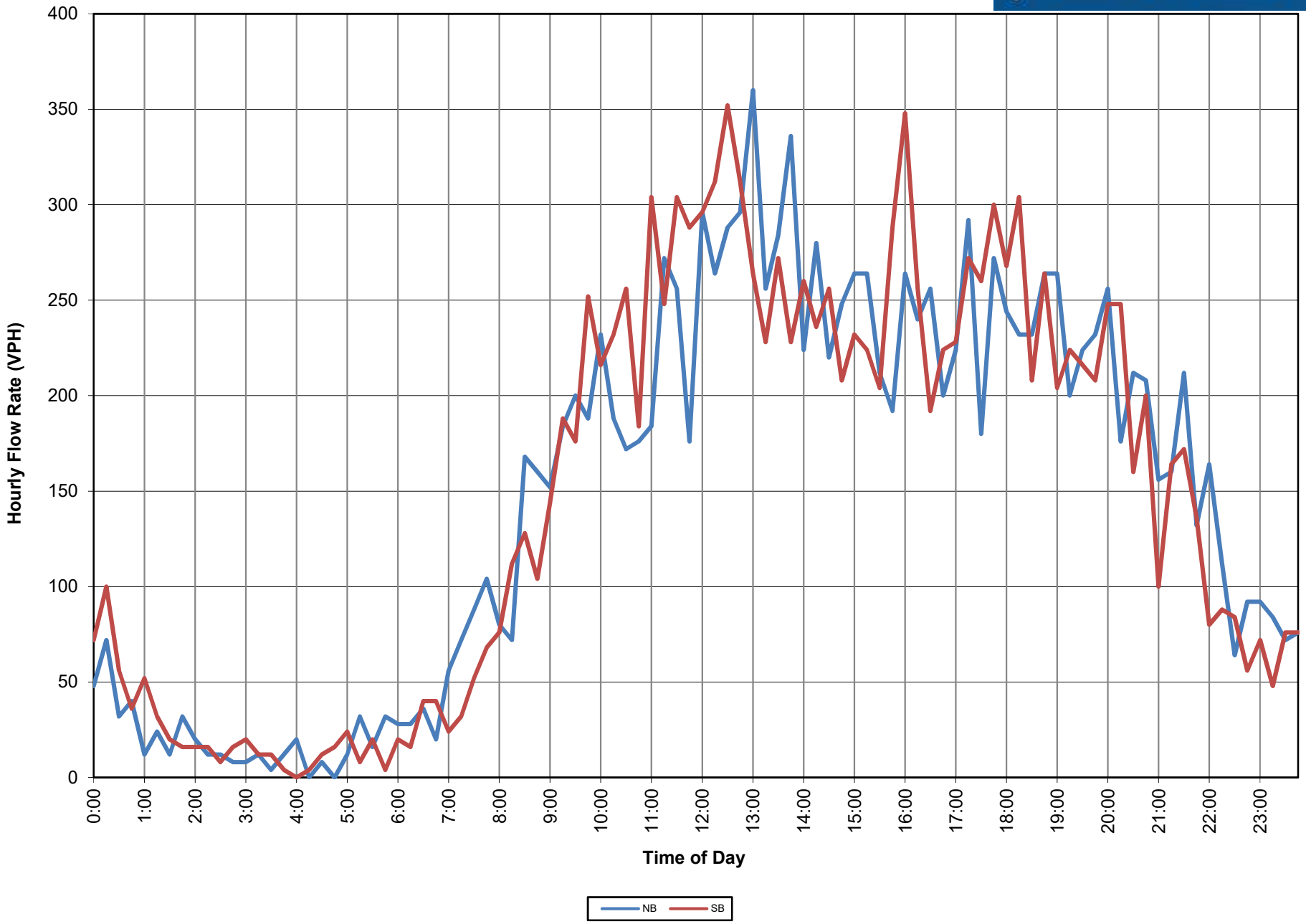
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (Before & After)
Greenville Avenue South of Arapaho Road

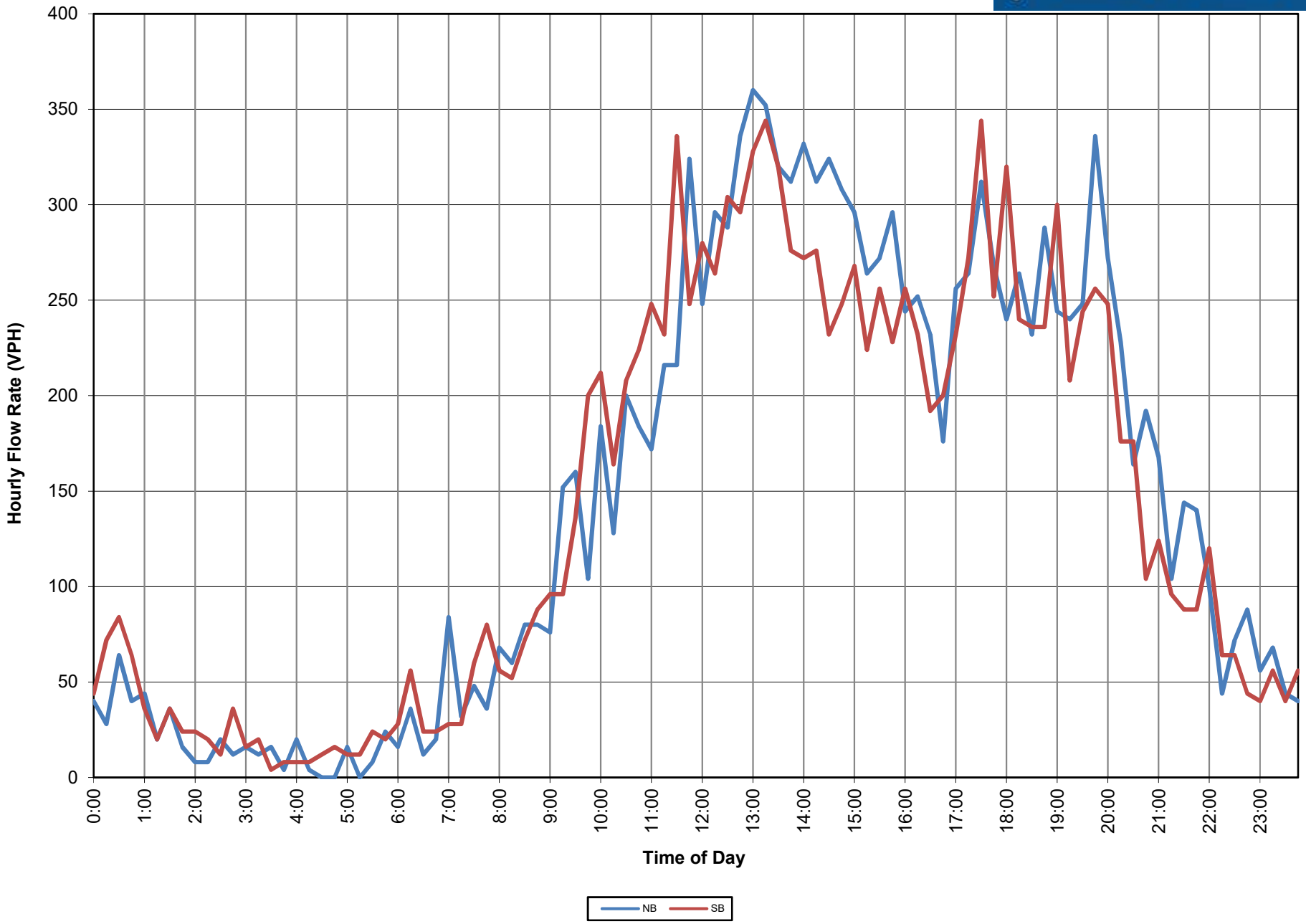
RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (After)
Greenville Avenue South of Arapaho Road

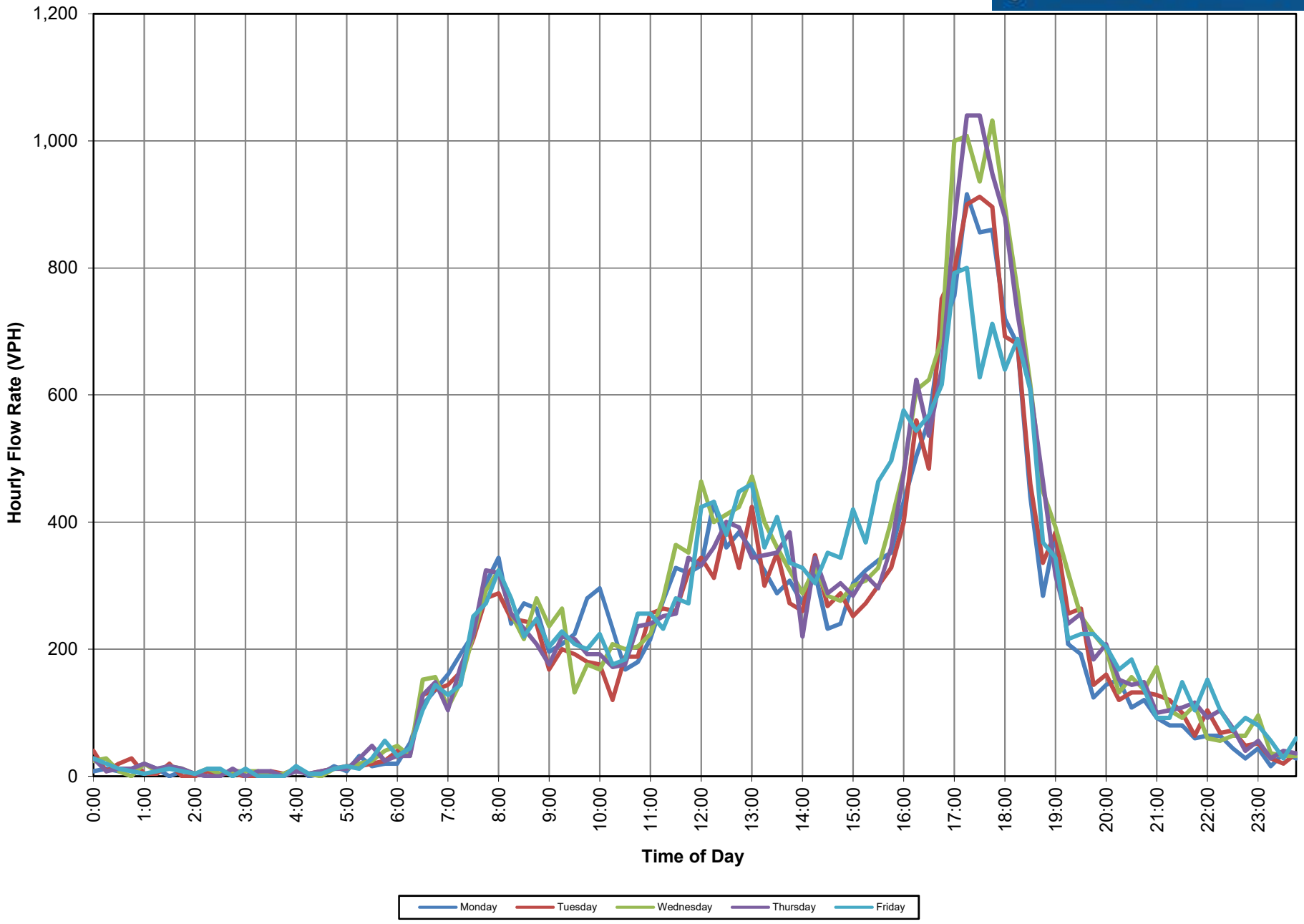
RICHARDSON TEXAS



Kimley»Horn

NB Weekdays (Before)
Greenville Avenue South of Campbell Road

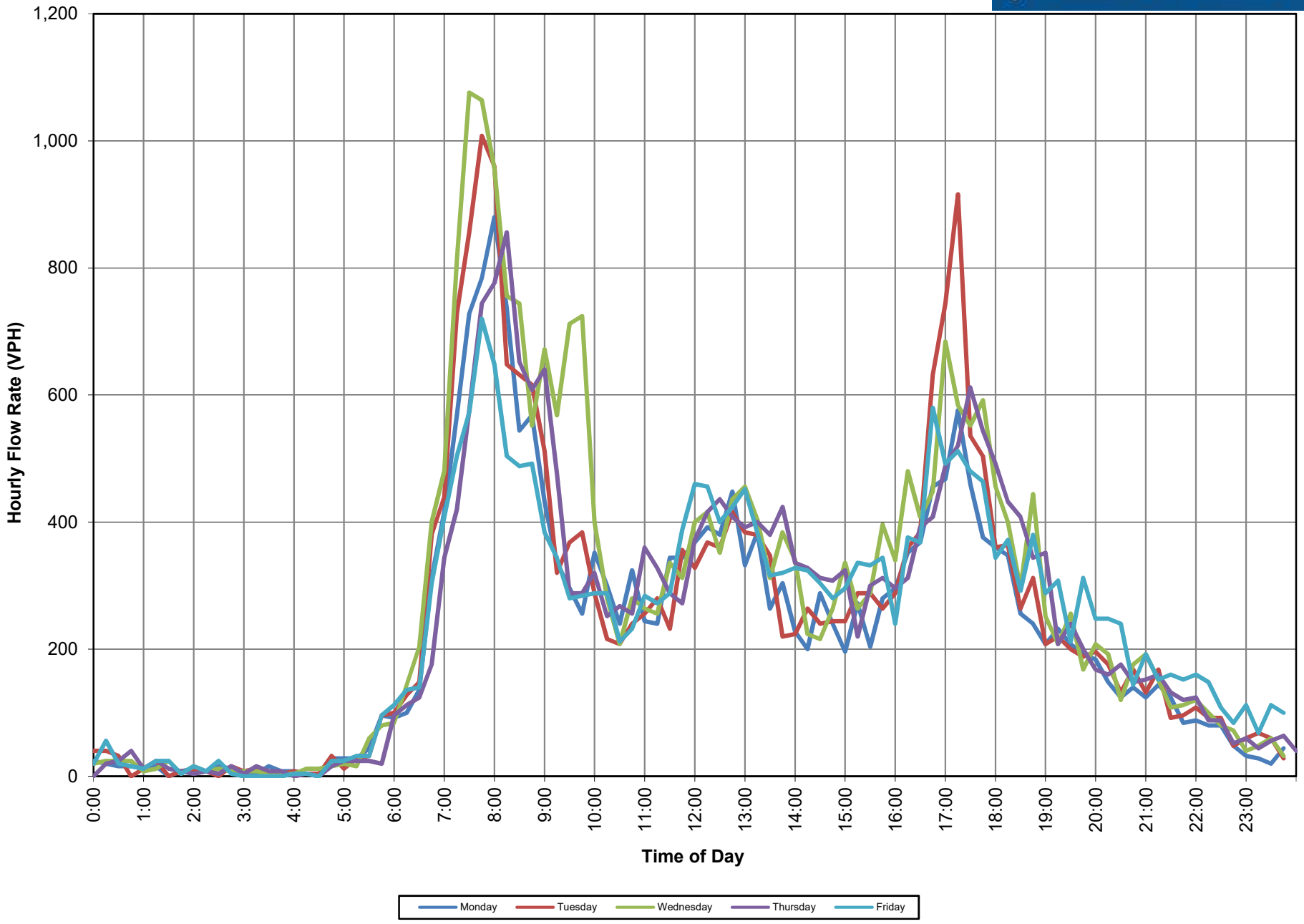
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (Before)
Greenville Avenue South of Campbell Road

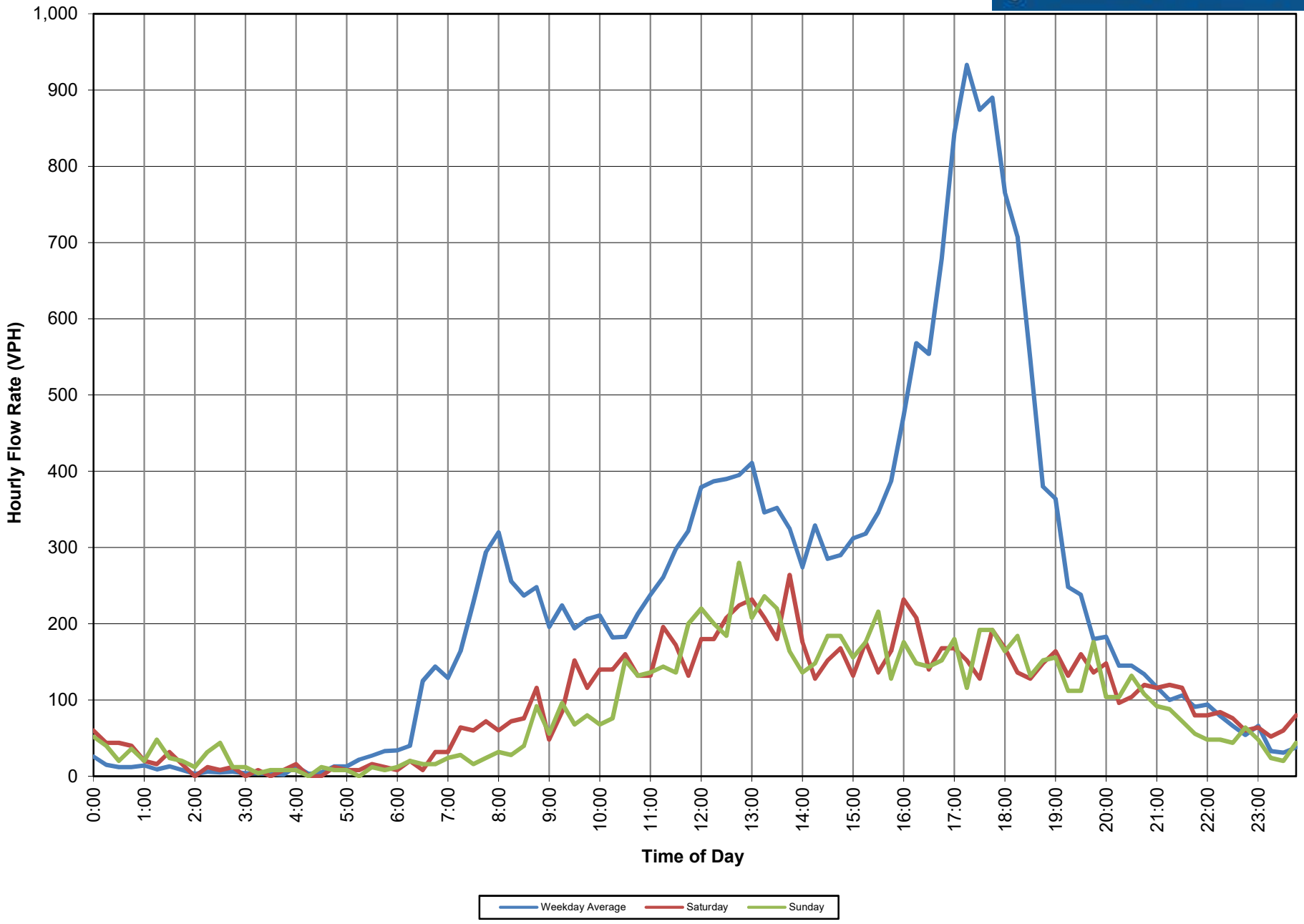
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (Before)
Greenville Avenue South of Campbell Road

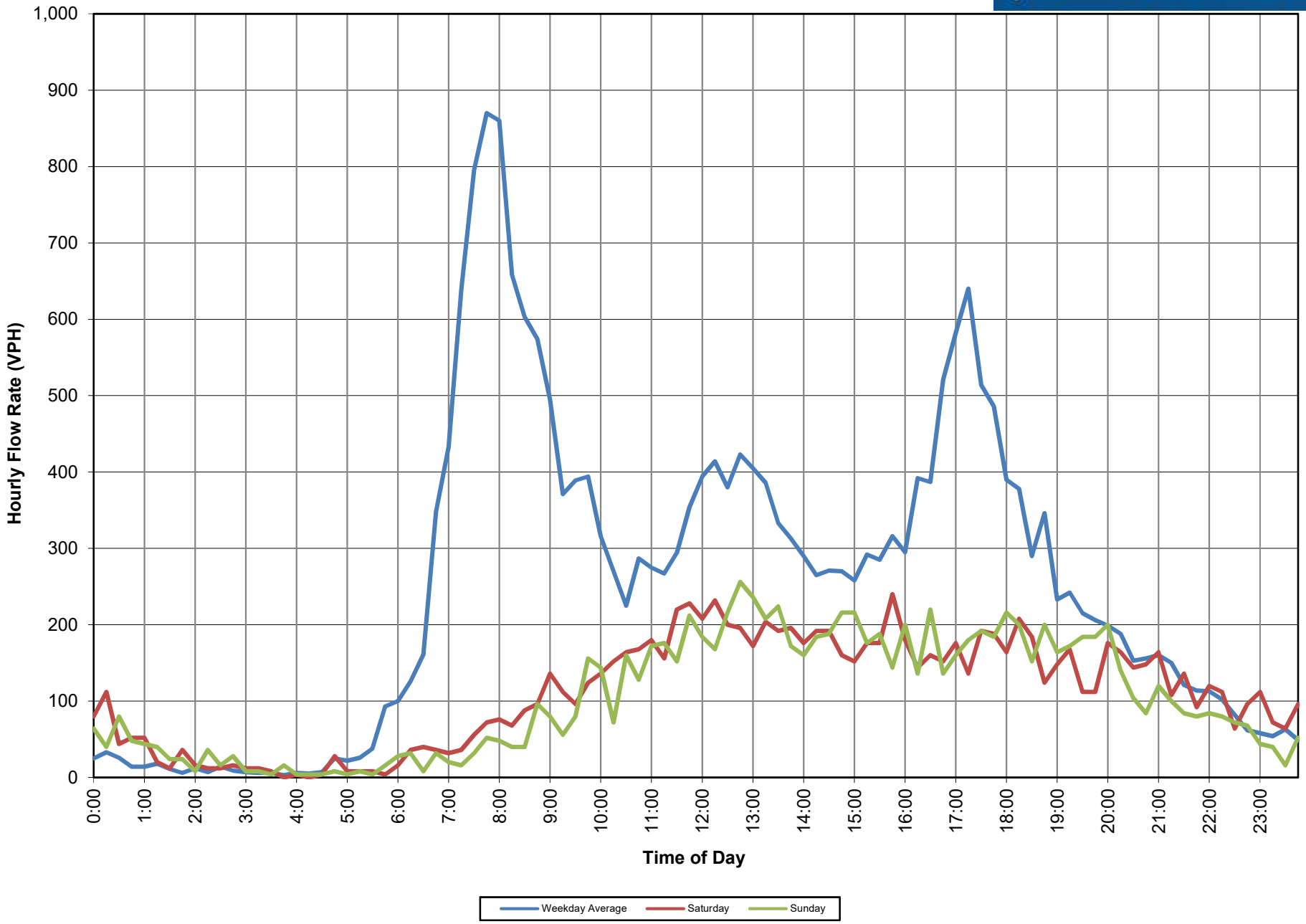
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (Before)
Greenville Avenue South of Campbell Road

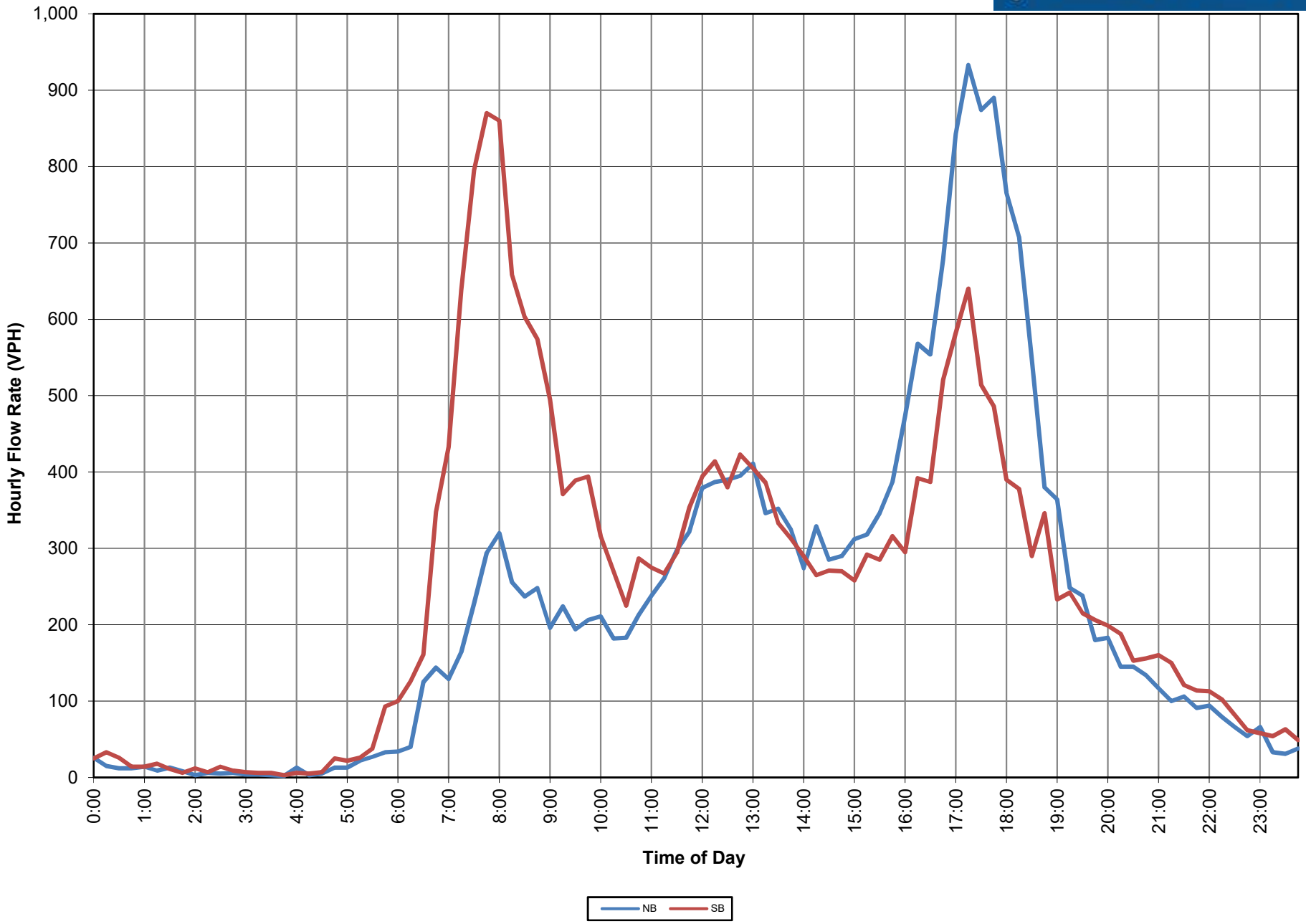
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (Before)
Greenville Avenue South of Campbell Road

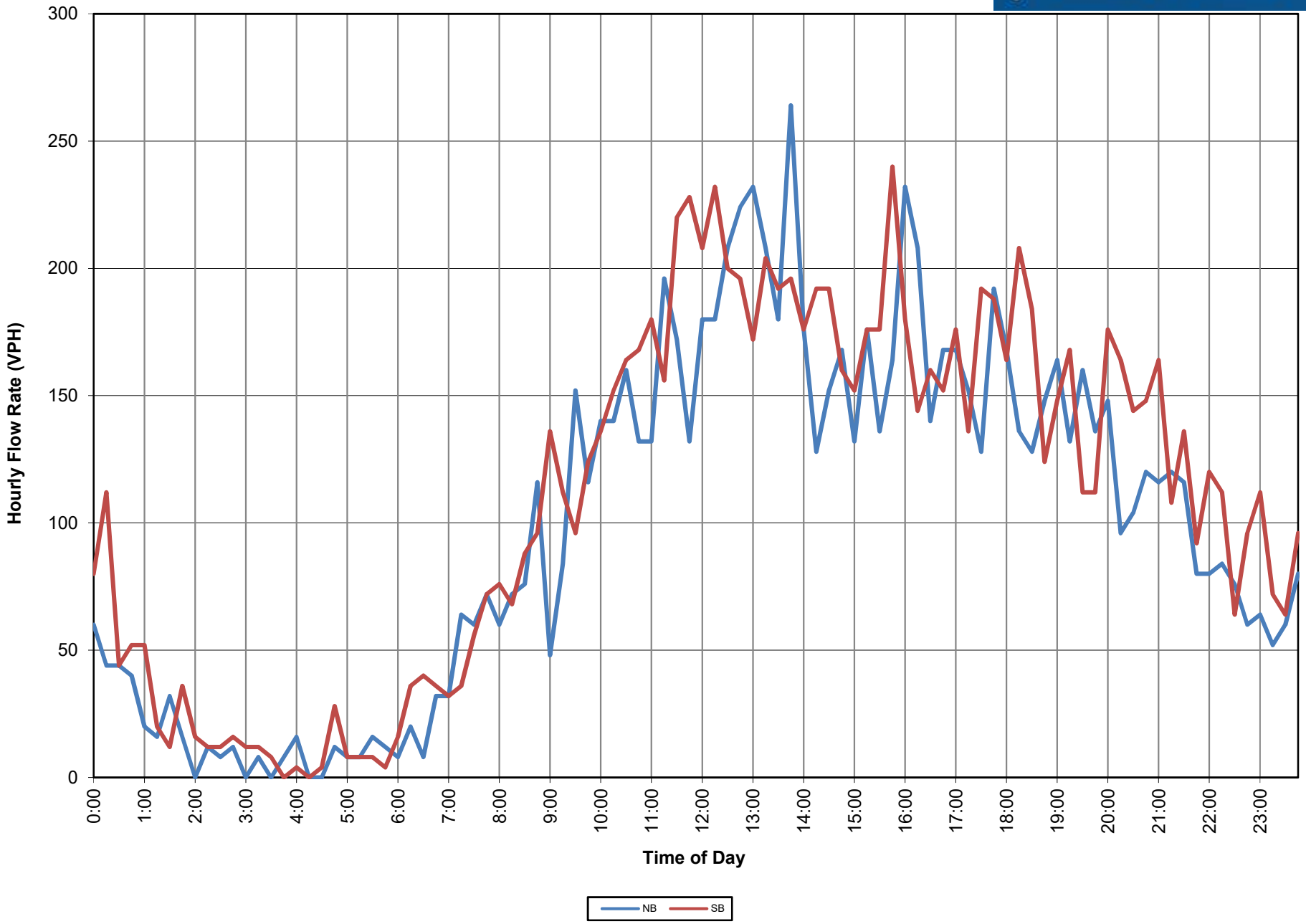
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (Before)
Greenville Avenue South of Campbell Road

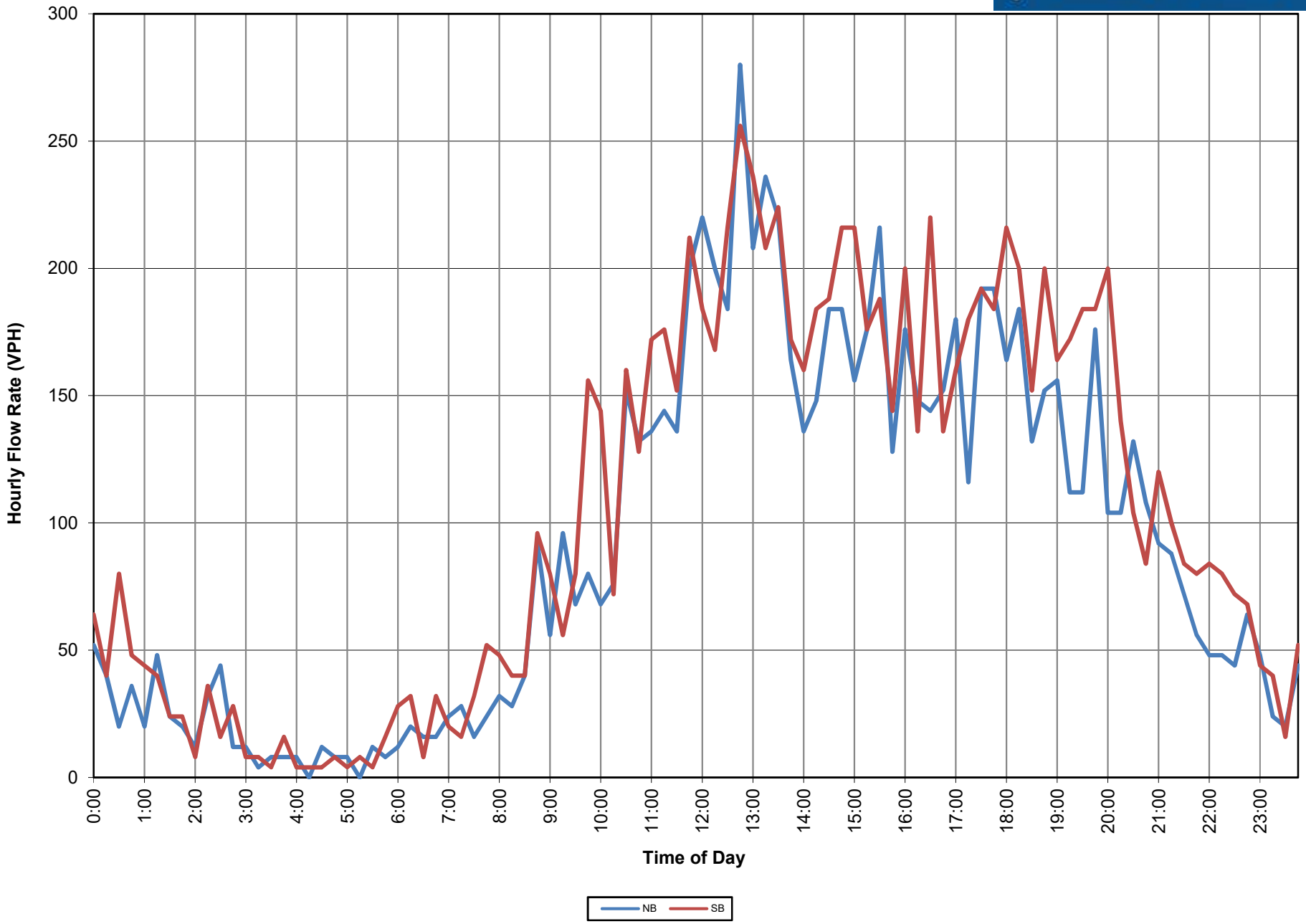
RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (Before)
Greenville Avenue South of Campbell Road

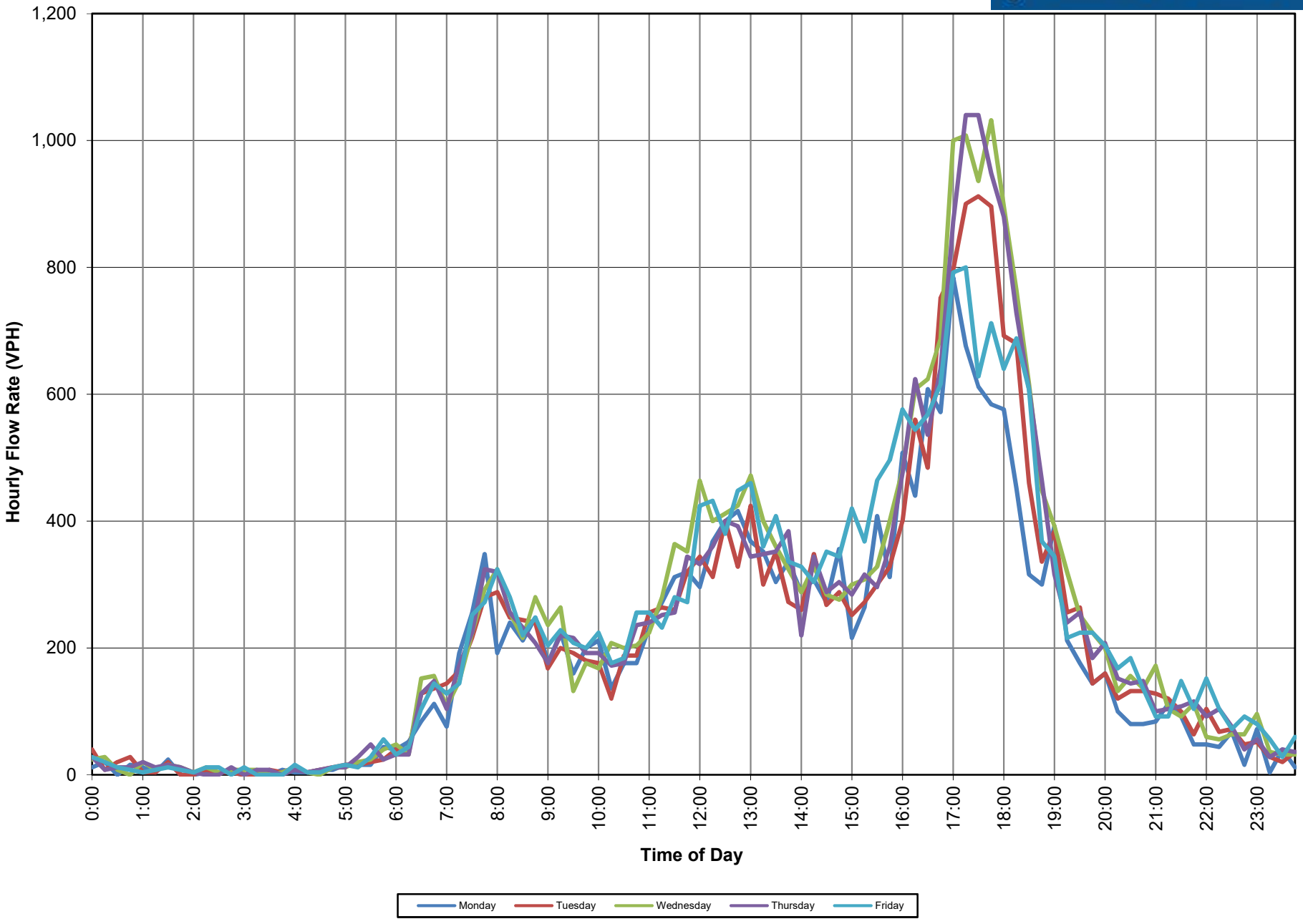
RICHARDSON TEXAS



Kimley»Horn

NB Weekdays (After)
Greenville Avenue South of Campbell Road

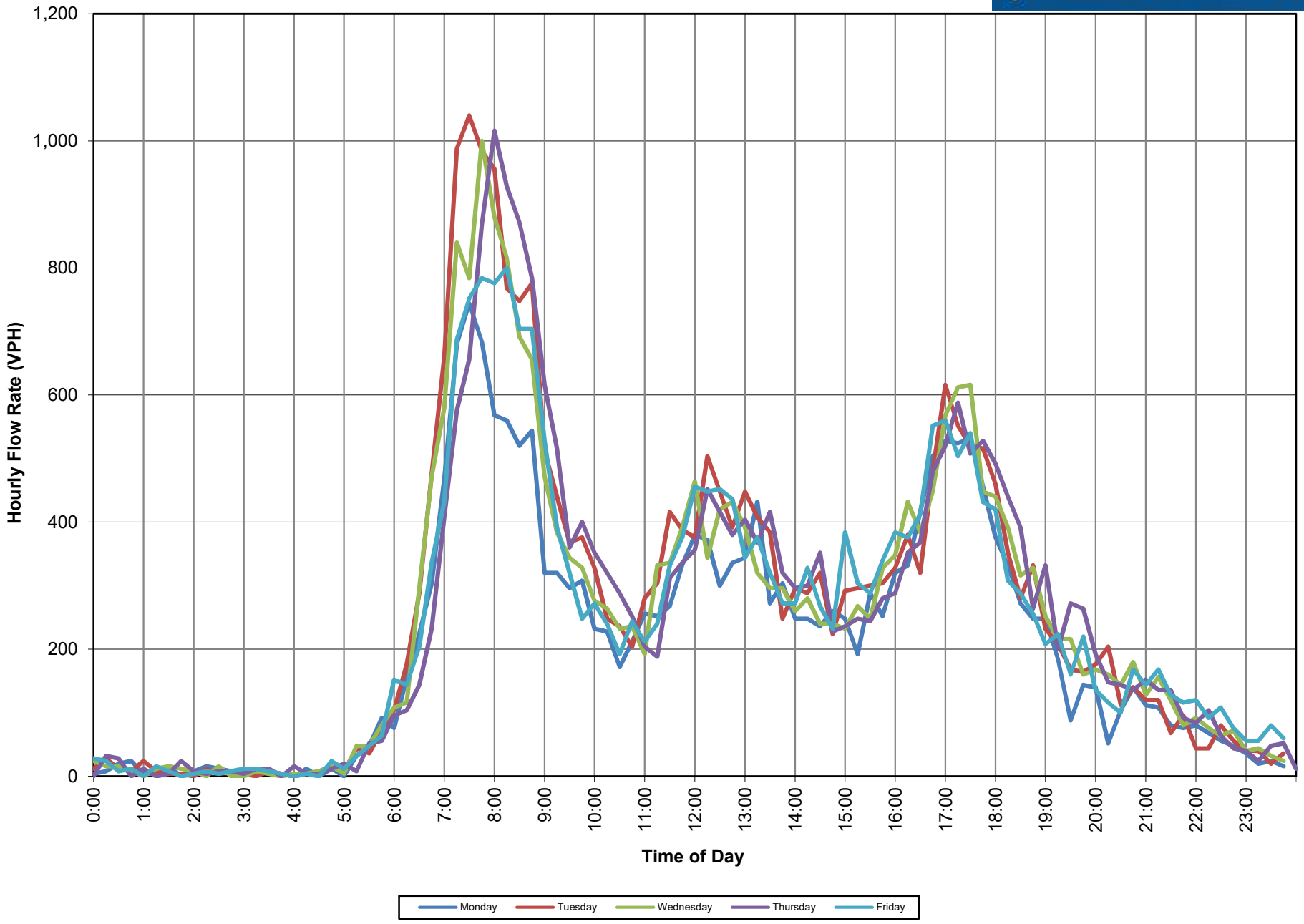
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (After)
Greenville Avenue South of Campbell Road

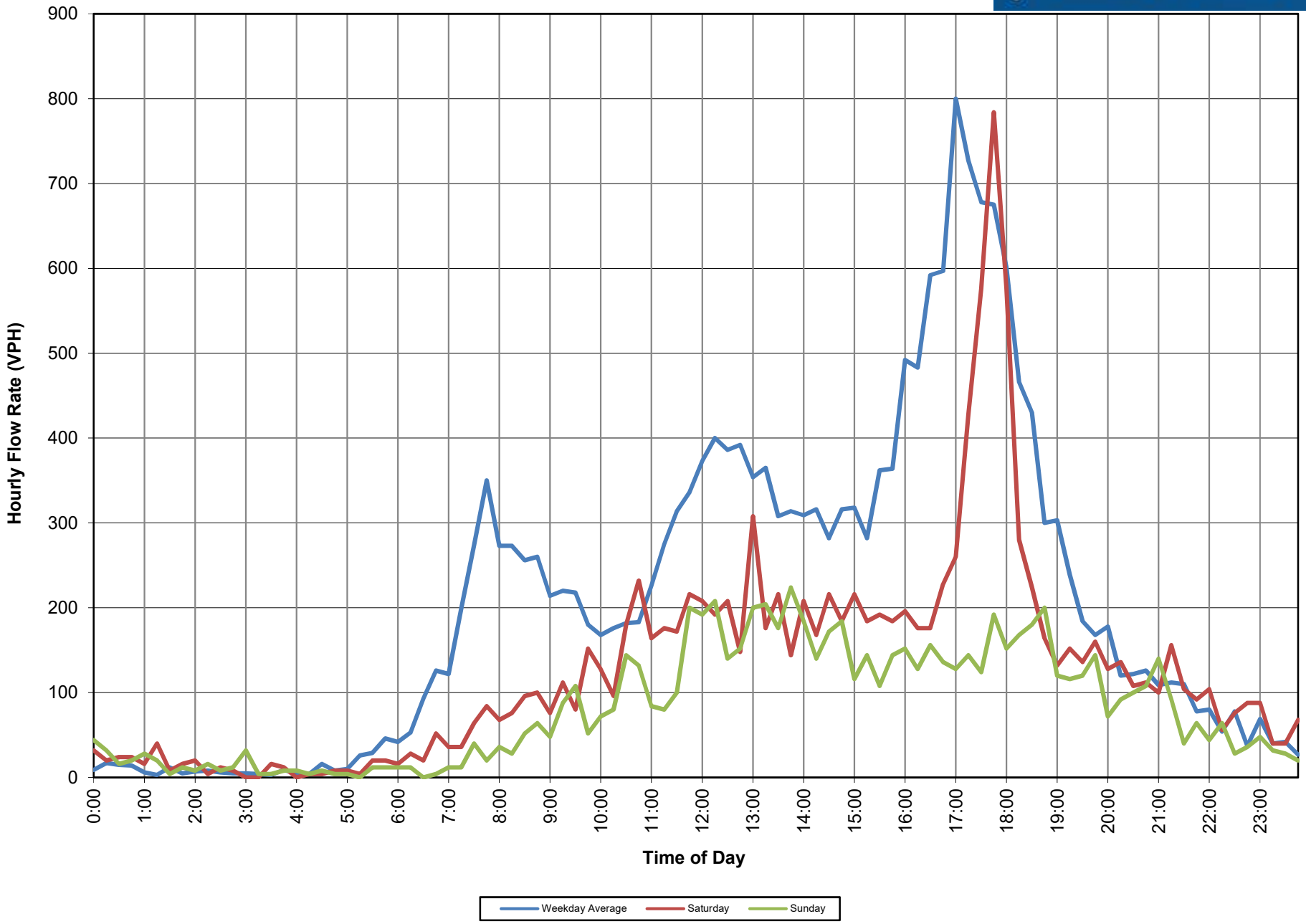
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (After)
Greenville Avenue South of Campbell Road

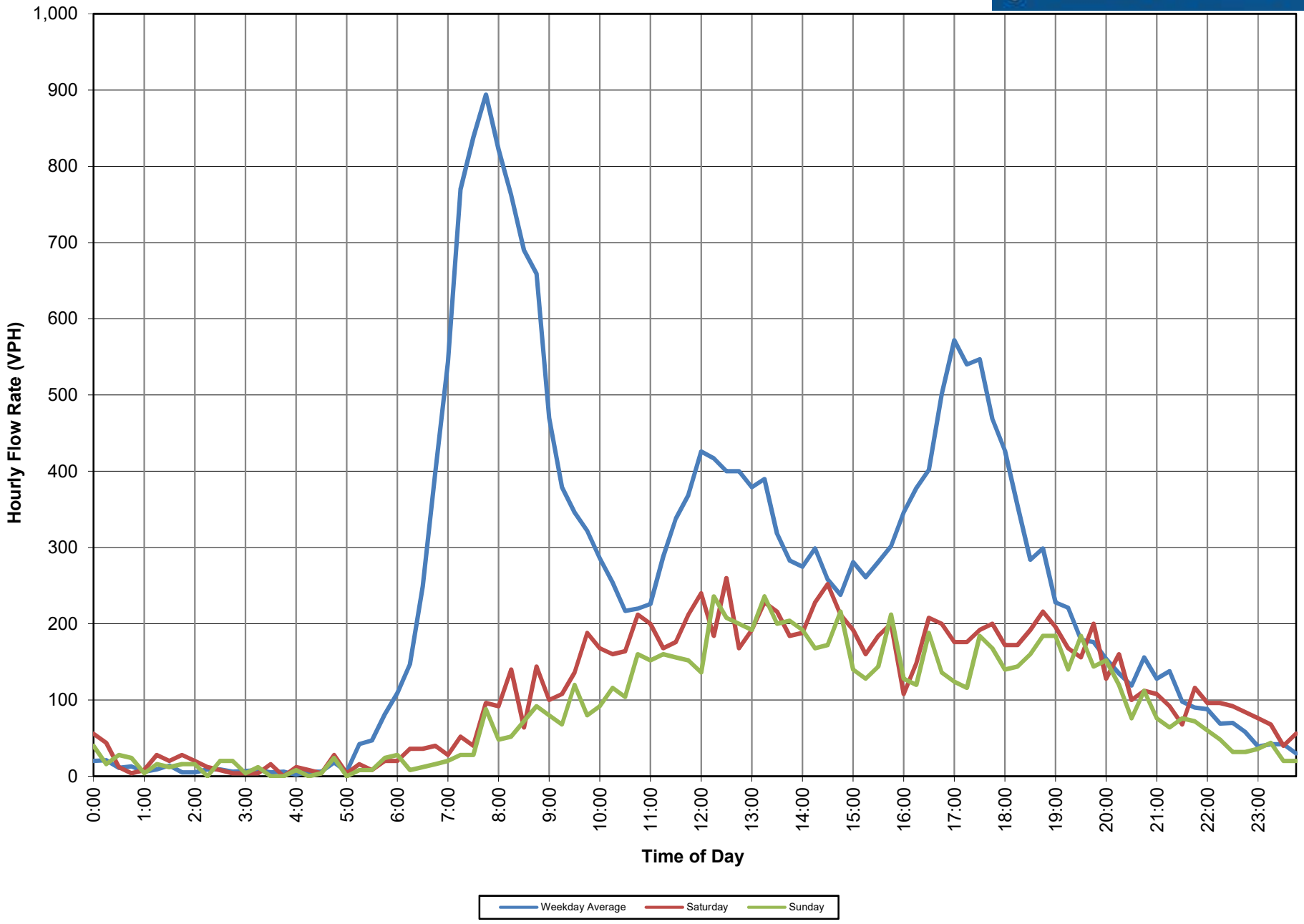
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (After)
Greenville Avenue South of Campbell Road

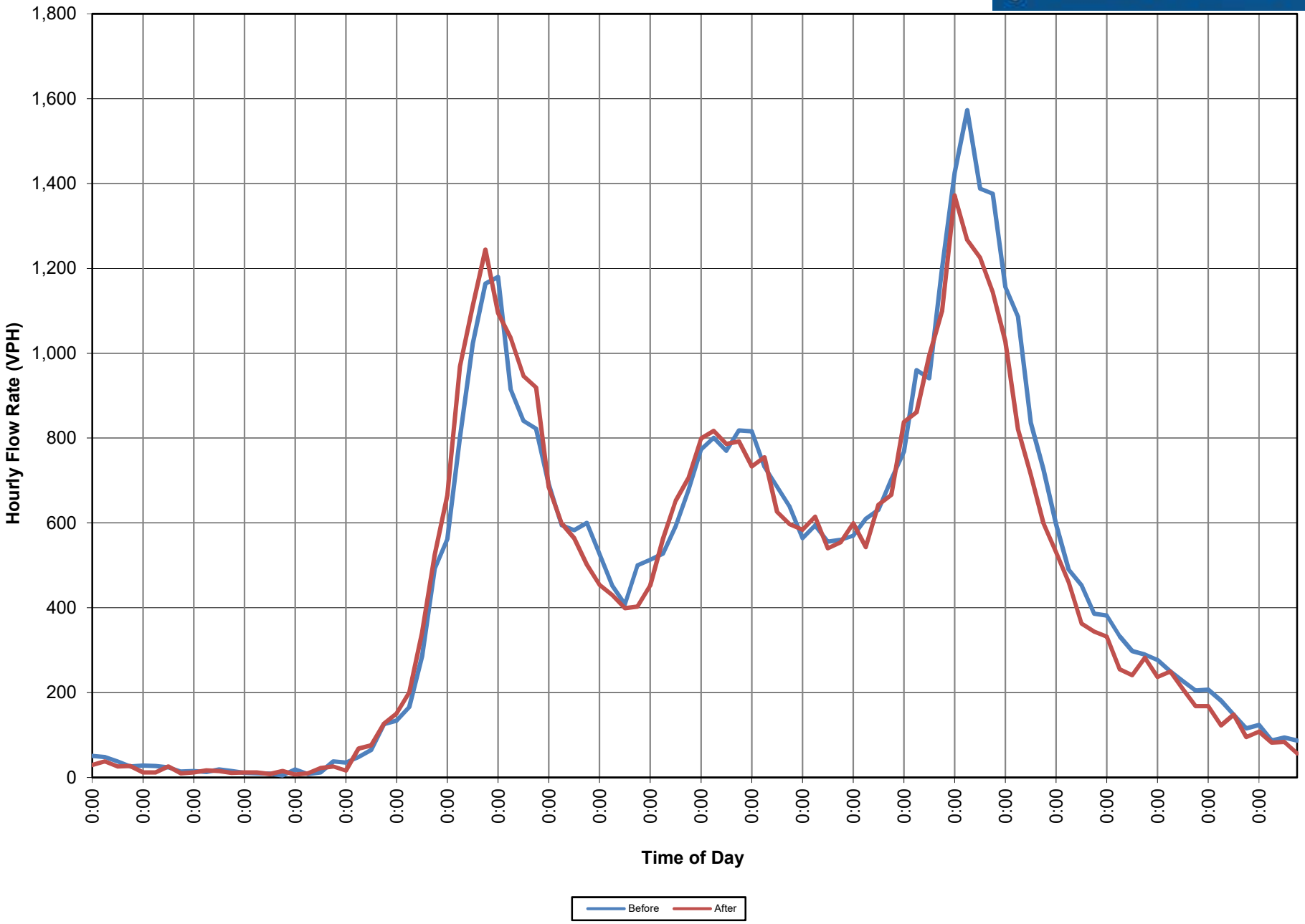
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (After)
Greenville Avenue South of Campbell Road

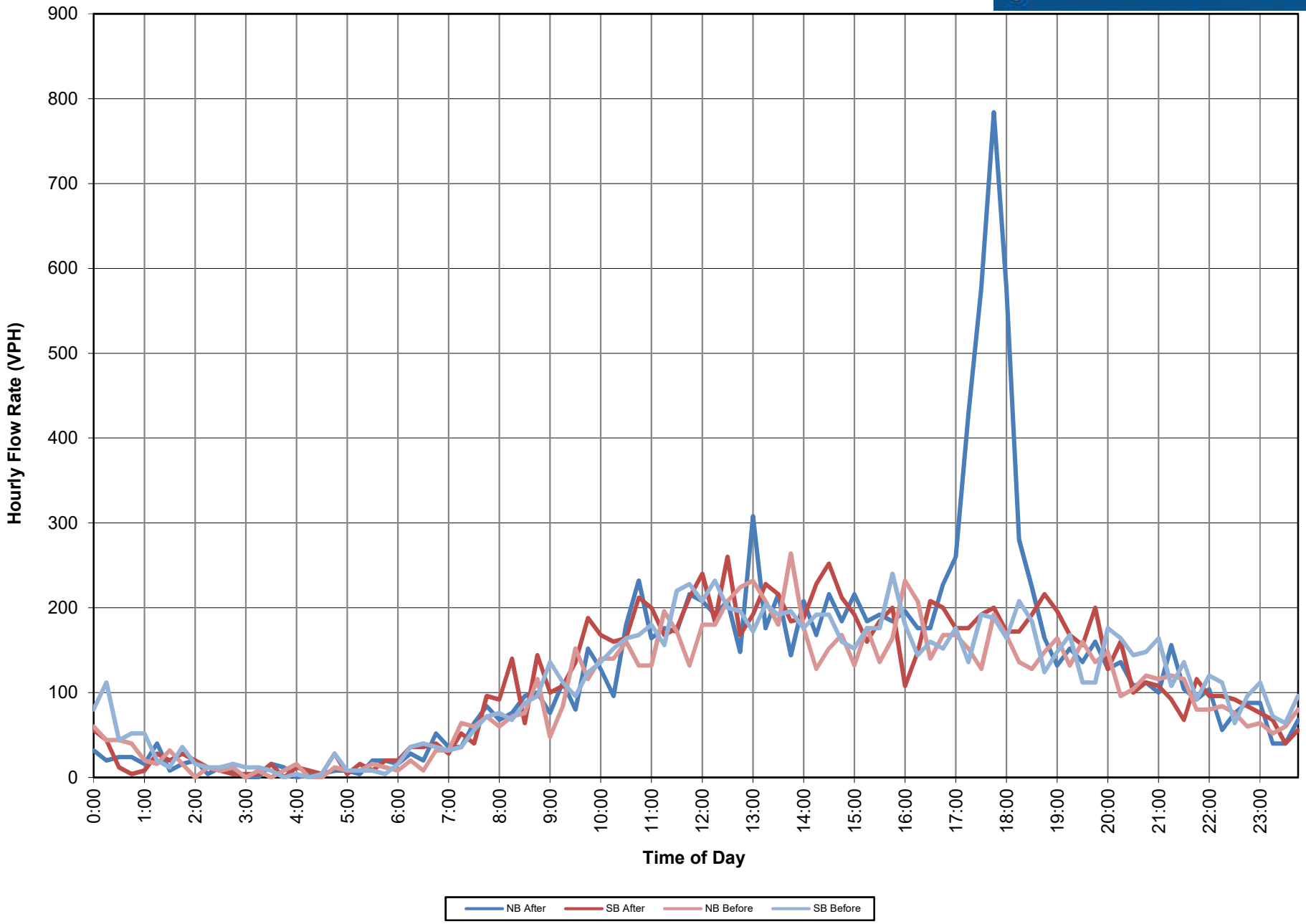
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (After)
Greenville Avenue South of Campbell Road

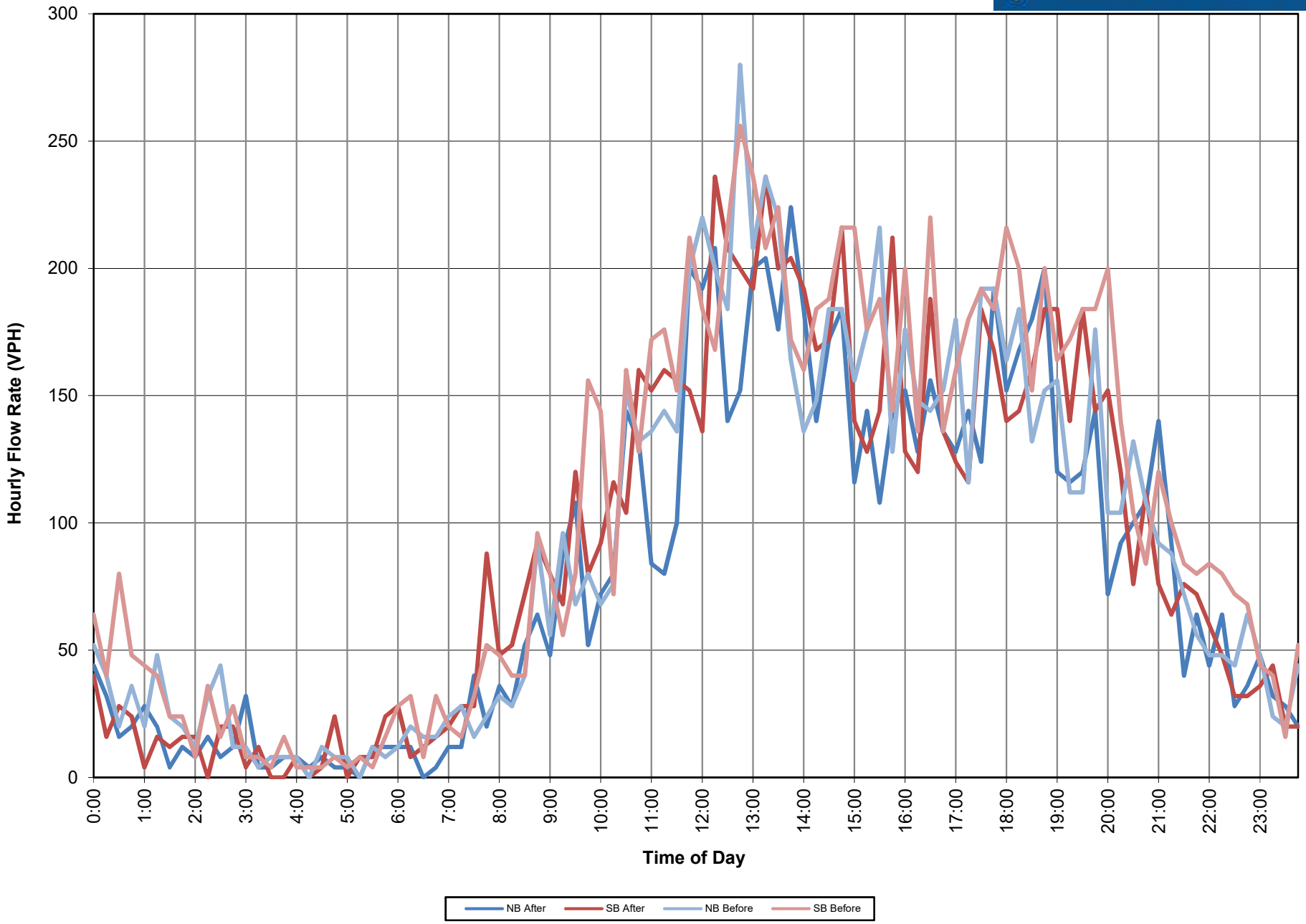
RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (After)
Greenville Avenue South of Campbell Road

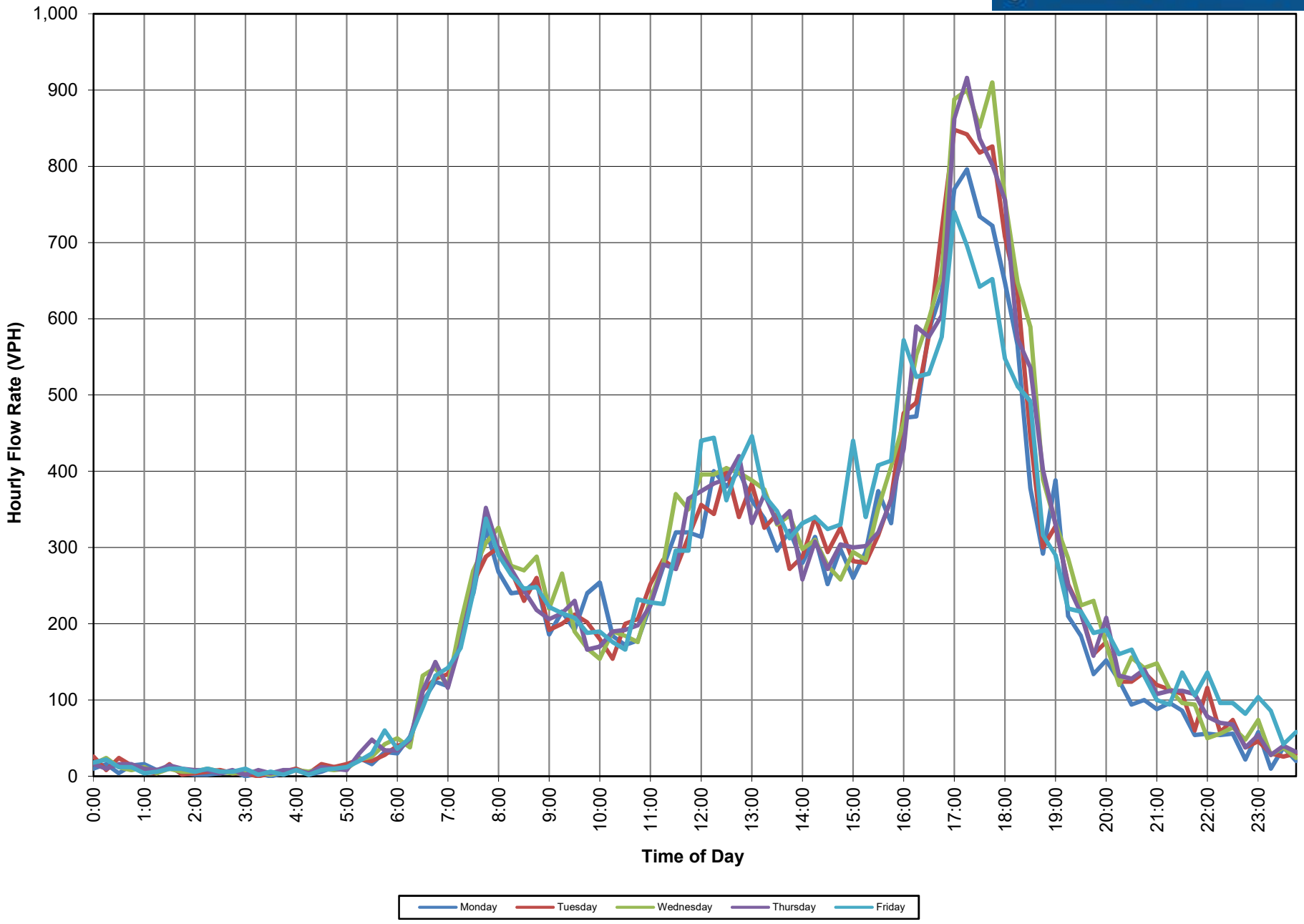
RICHARDSON TEXAS



Kimley»Horn

NB Weekdays (Before & After)
Greenville Avenue South of Campbell Road

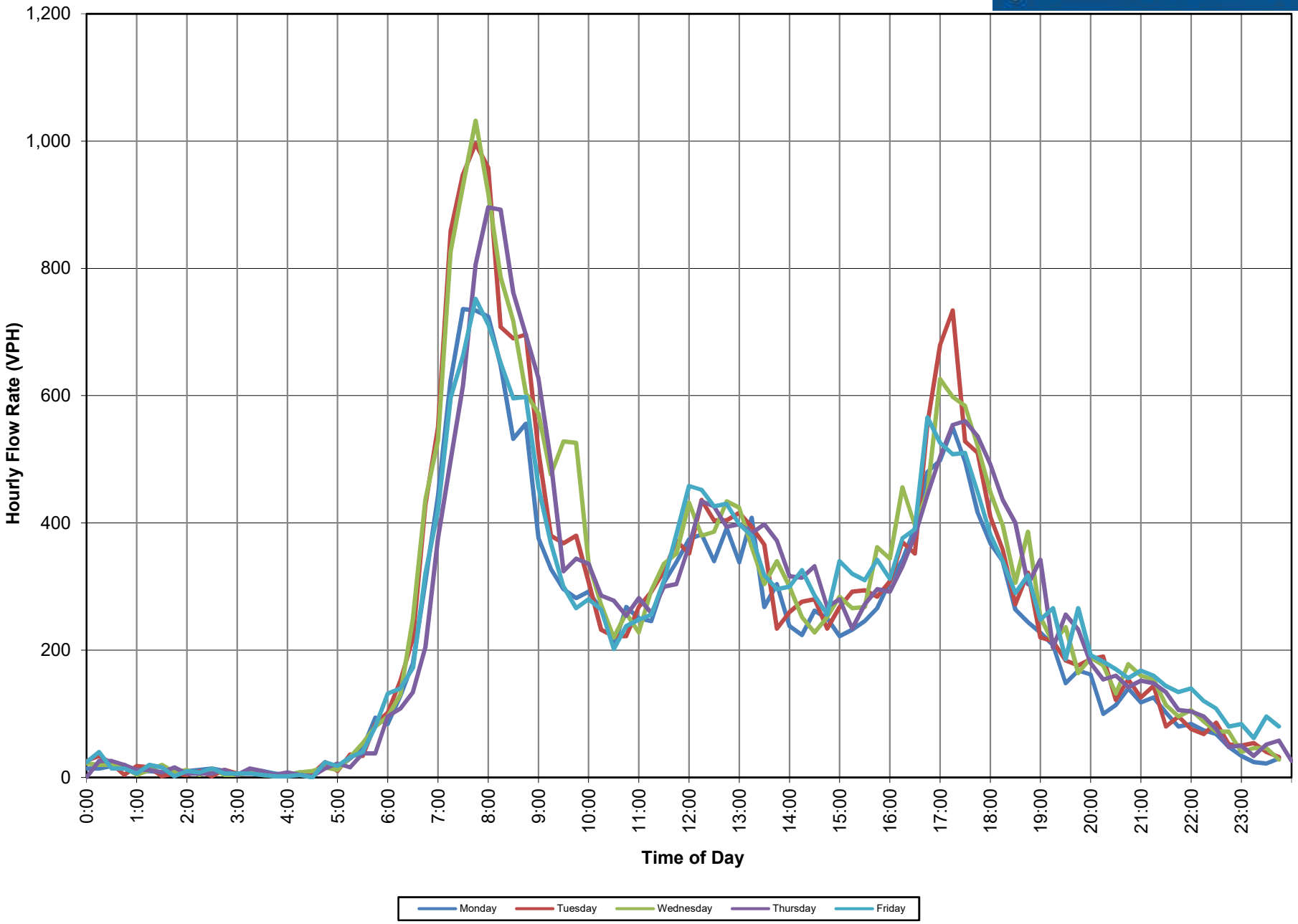
RICHARDSON TEXAS



Kimley»Horn

SB Weekdays (Before & After)
Greenville Avenue South of Campbell Road

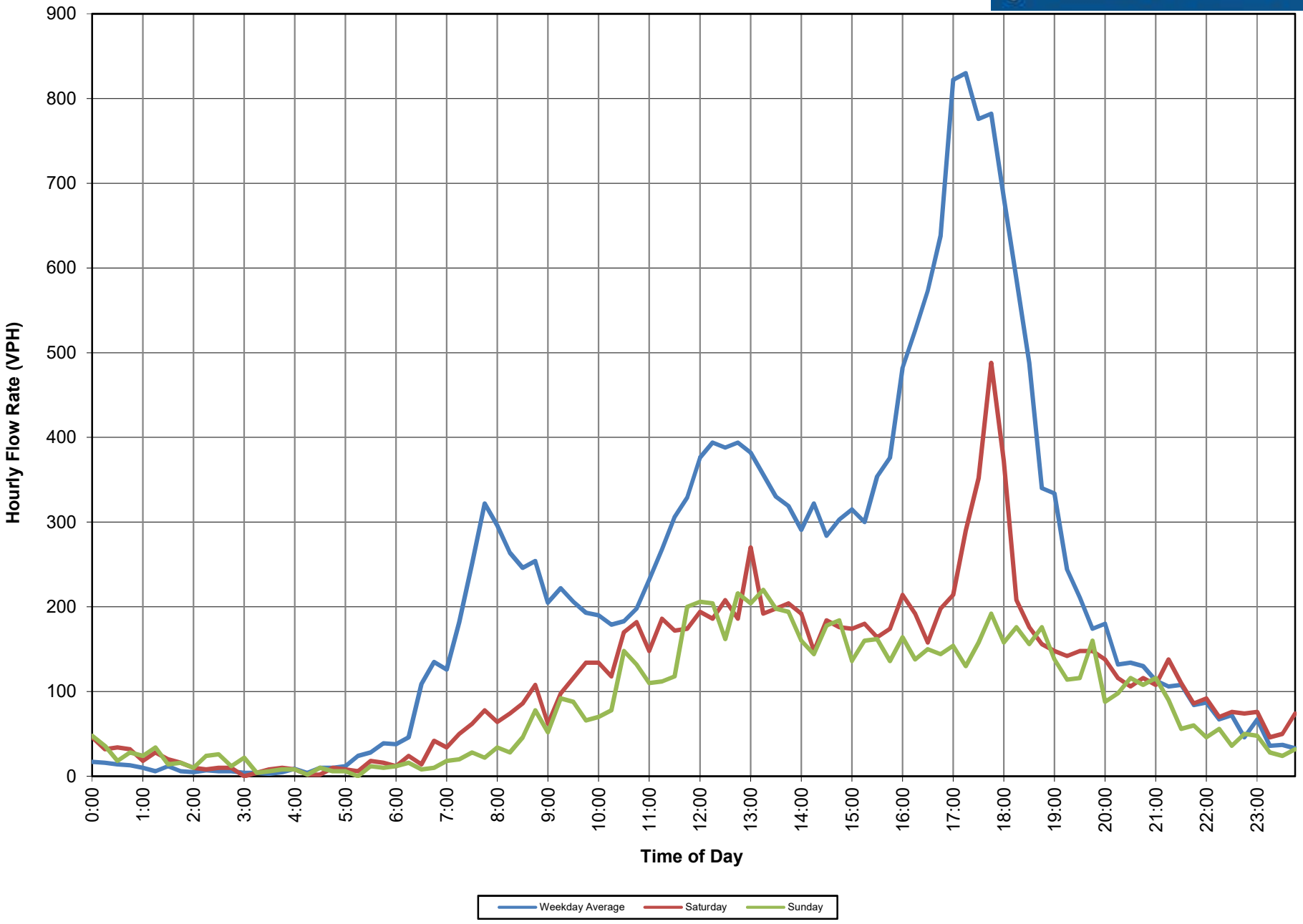
RICHARDSON TEXAS



Kimley»Horn

NB Weekend vs. Weekday Average (Before & After)
Greenville Avenue South of Campbell Road

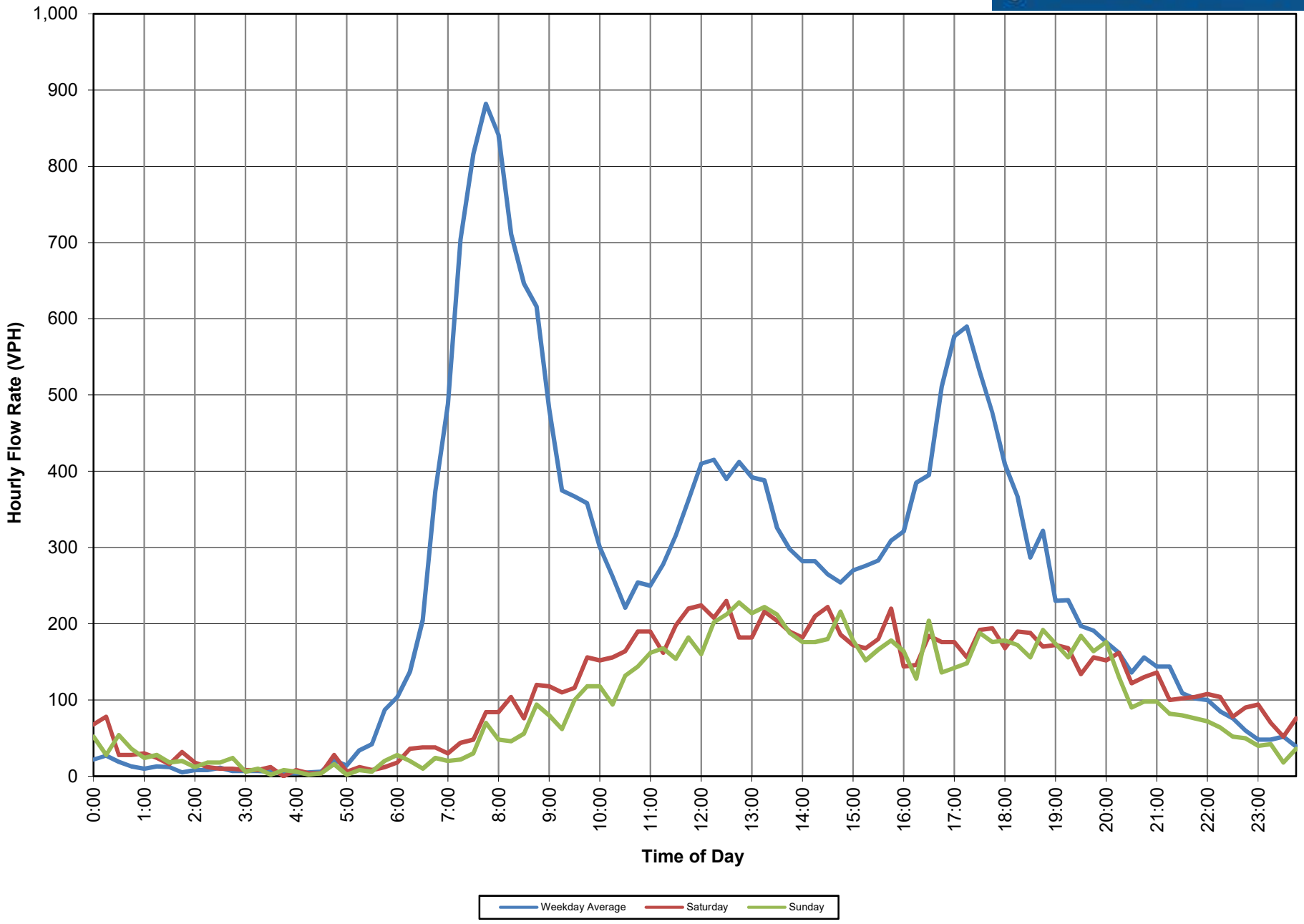
RICHARDSON TEXAS



Kimley»Horn

SB Weekend vs. Weekday Average (Before & After)
Greenville Avenue South of Campbell Road

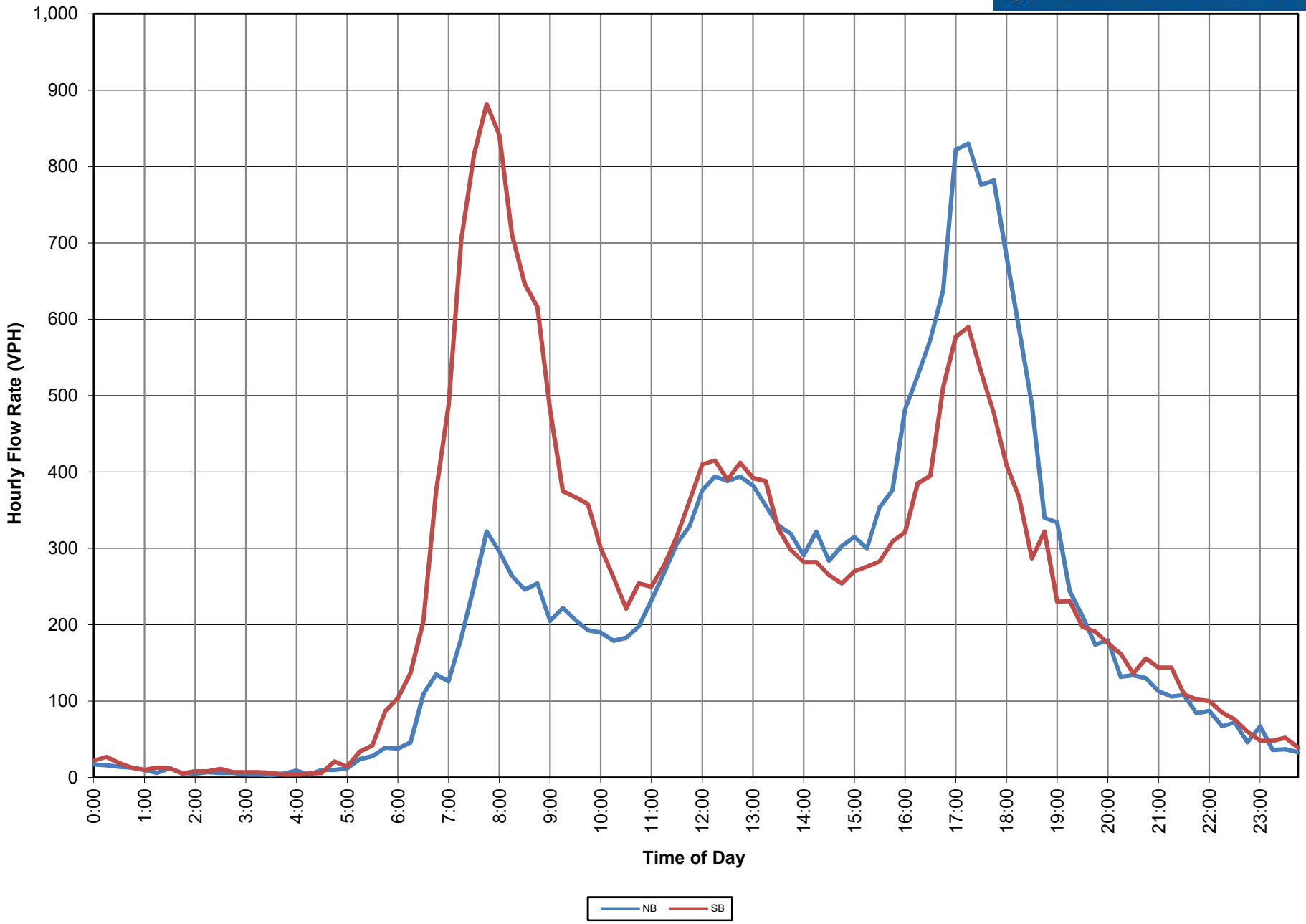
RICHARDSON TEXAS



Kimley»Horn

Weekday NB vs. SB (Before & After)
Greenville Avenue South of Campbell Road

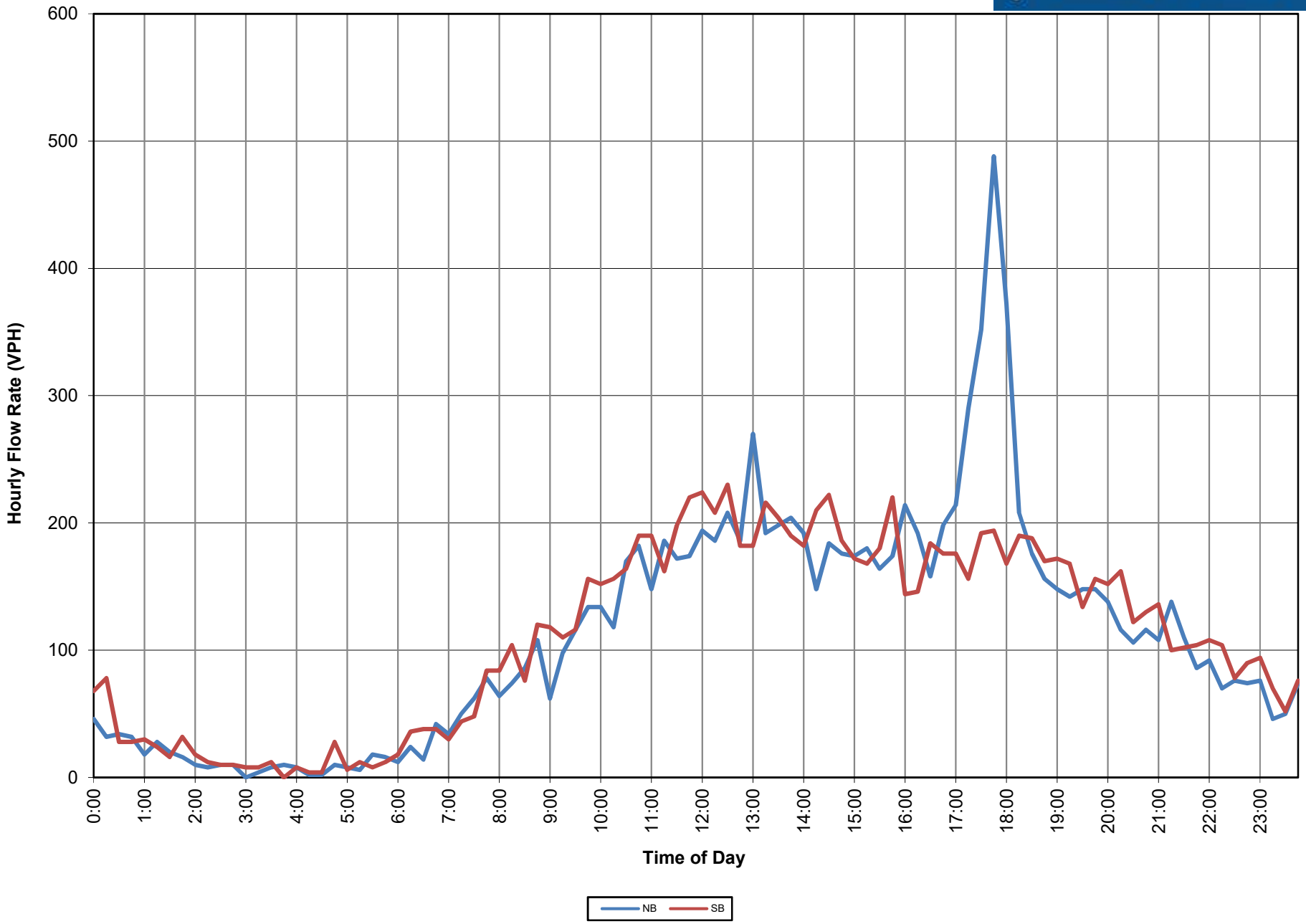
RICHARDSON TEXAS



Kimley»Horn

Saturday NB vs. SB (Before & After)
Greenville Avenue South of Campbell Road

RICHARDSON TEXAS



Kimley»Horn

Sunday NB vs. SB (Before & After)
Greenville Avenue South of Campbell Road

RICHARDSON TEXAS