Evaluating Traffic Performance Measures at Urban Work Zones Using Traffic Surveillance Systems

-Case Study of Jane and Finch Junction-

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Research Background

WHAT and WHY is this study/project?

Highway work zones reduce the available roadway space creating adverse traffic mobility and safety impacts.

On the other hand, new technologies have made it possible to collect and manage smart traffic data by deploying smart traffic sensors and detectors.

This project explores new techniques for managing traffic at highway work zone locations using smart systems, smart data, and smart vehicles (connected and automated) and how these techniques can be deployed to enhance traffic flow performance.

Study Background

WHY work zones are especially important in Toronto?

> Toronto is the **fastest growing city** in North America **.**
> Toronto is the **most congested** Canadian city.
> The congestion cost per capita in **Toronto is higher as compared to New York and Chicago.**

> Congestion is very costly!
>The cost of congestion in the GTHA is around $6 billion annually based on 2006 data (forecasted to increase to **$15 billion per year** by 2031).
> The US FHWA estimated that construction causes around **10% of the total road delay** in the USA.

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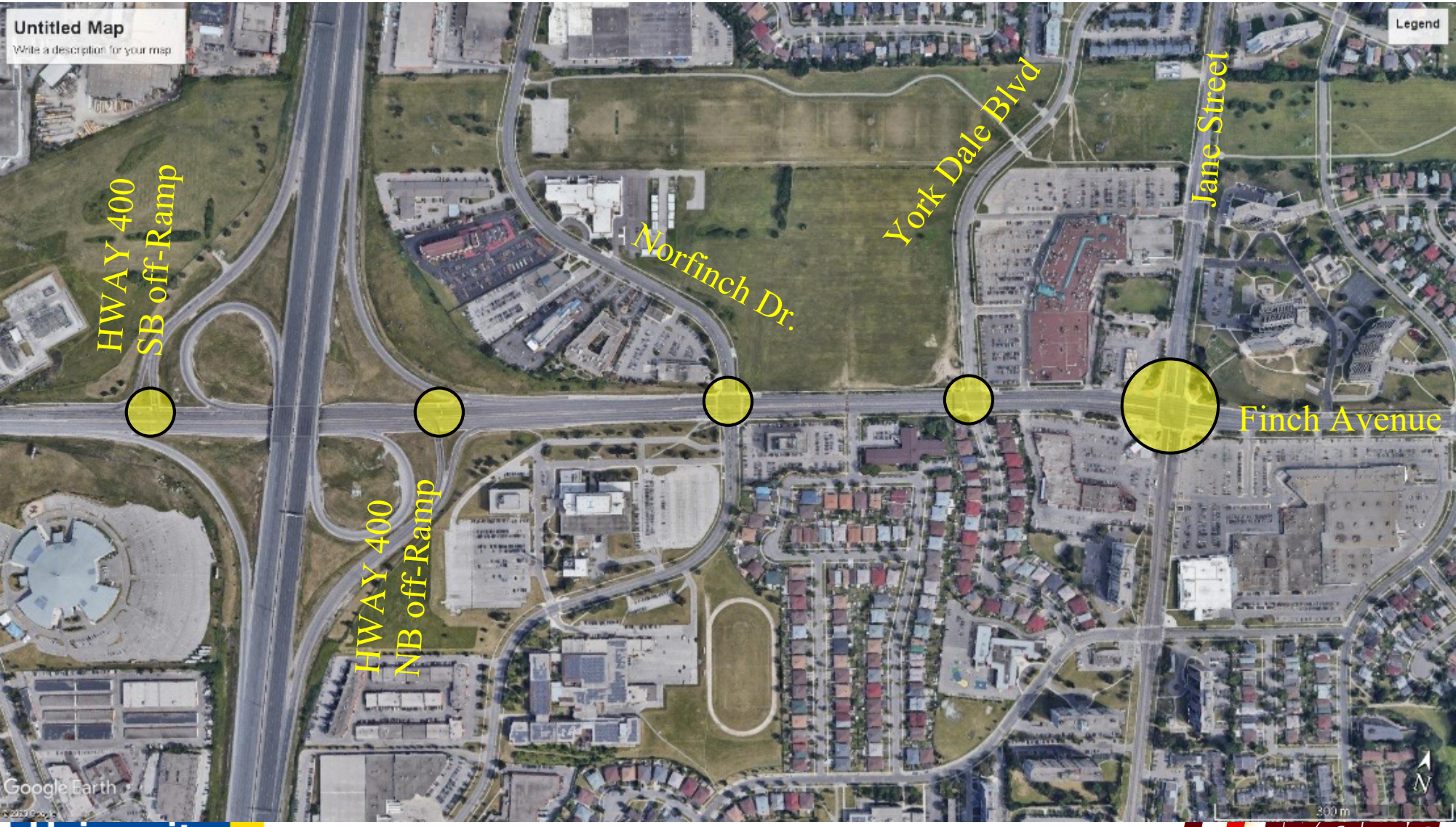
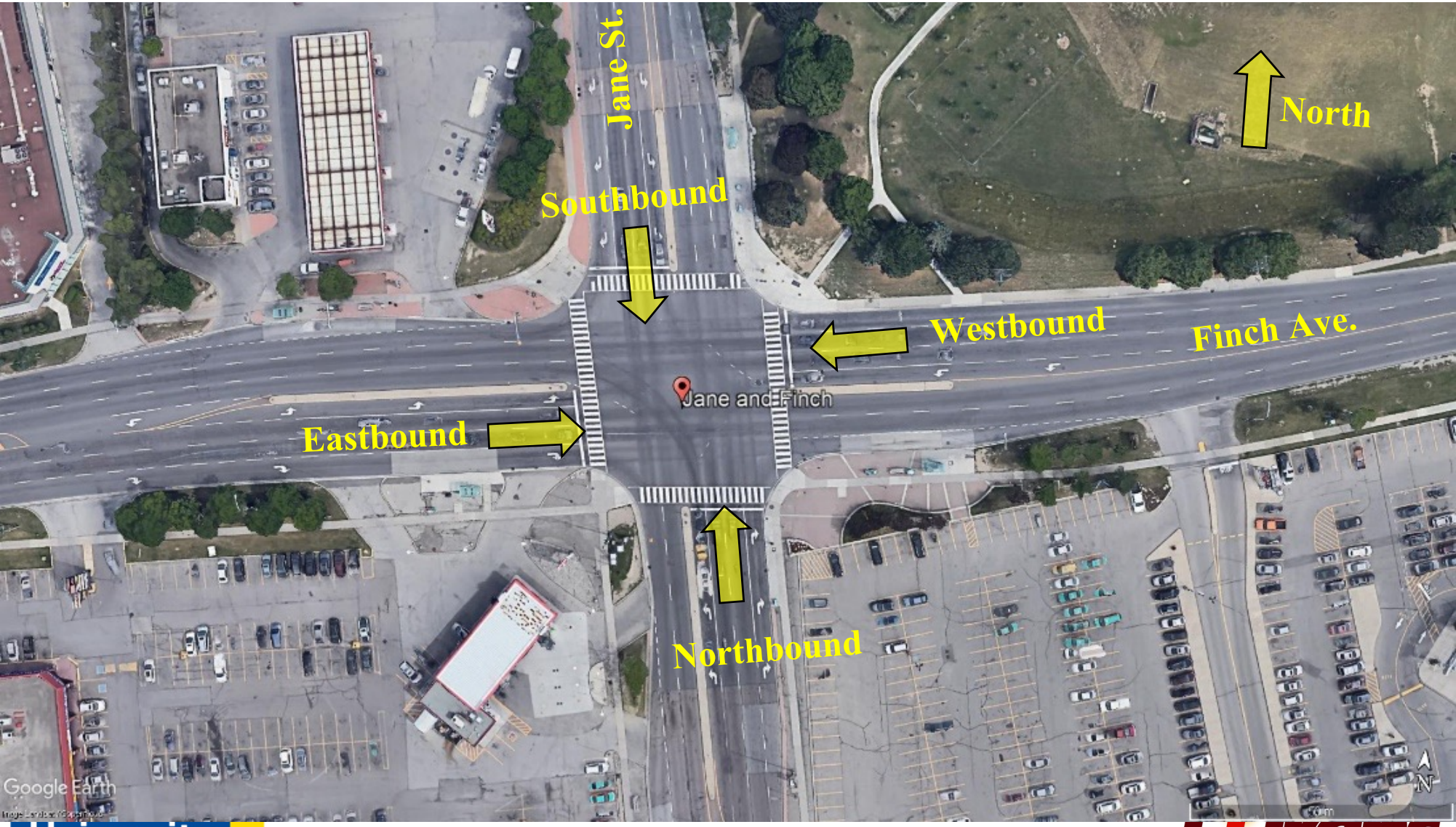
Jane and Finch Area – Aerial Image

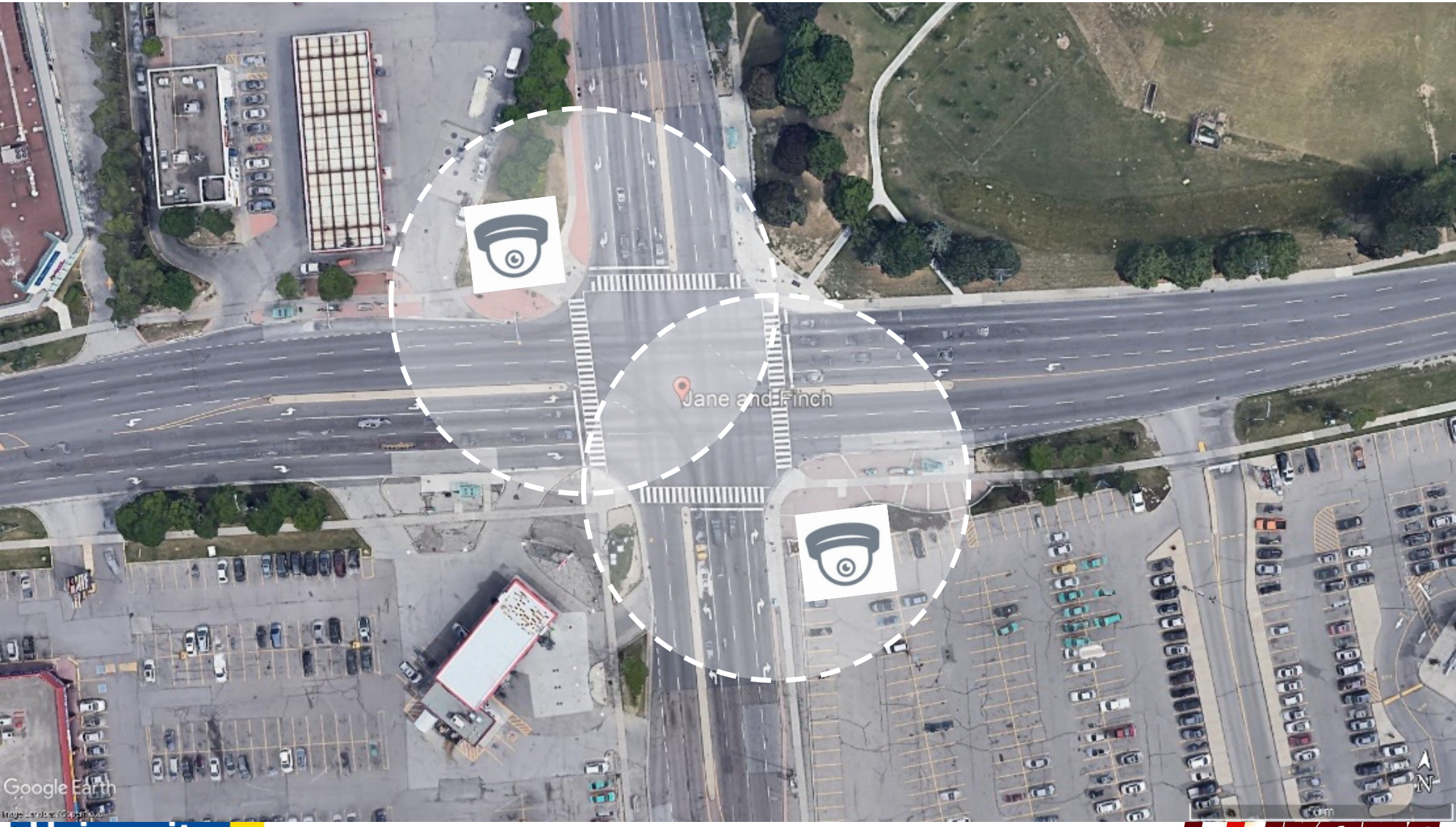
Jane and Finch Area



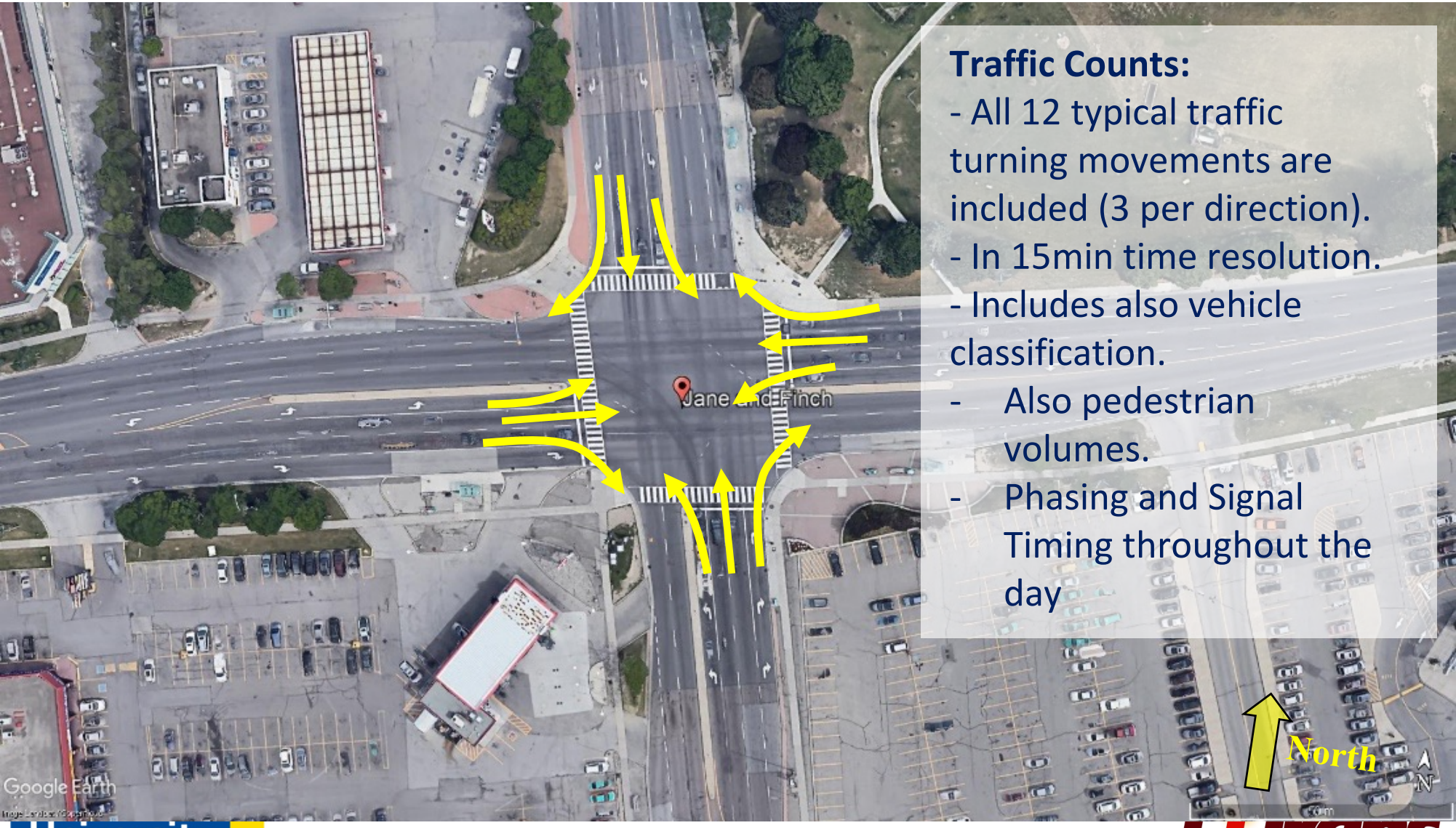
Jane and Finch – Full Intersection



Data Available (by MIOVISION and STINSON ITS)



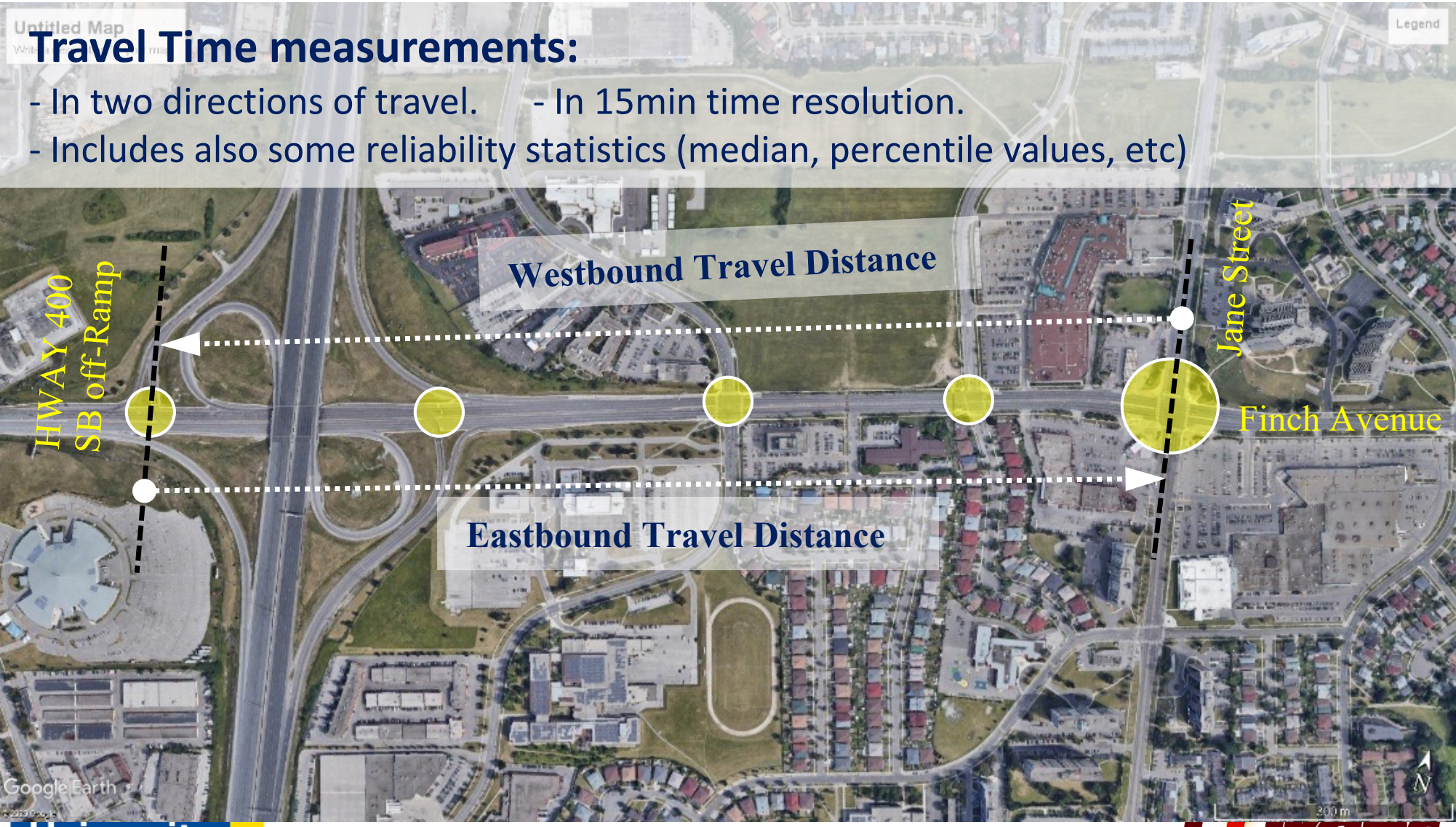
Data Available (by MIOVISION and STINSON ITS)



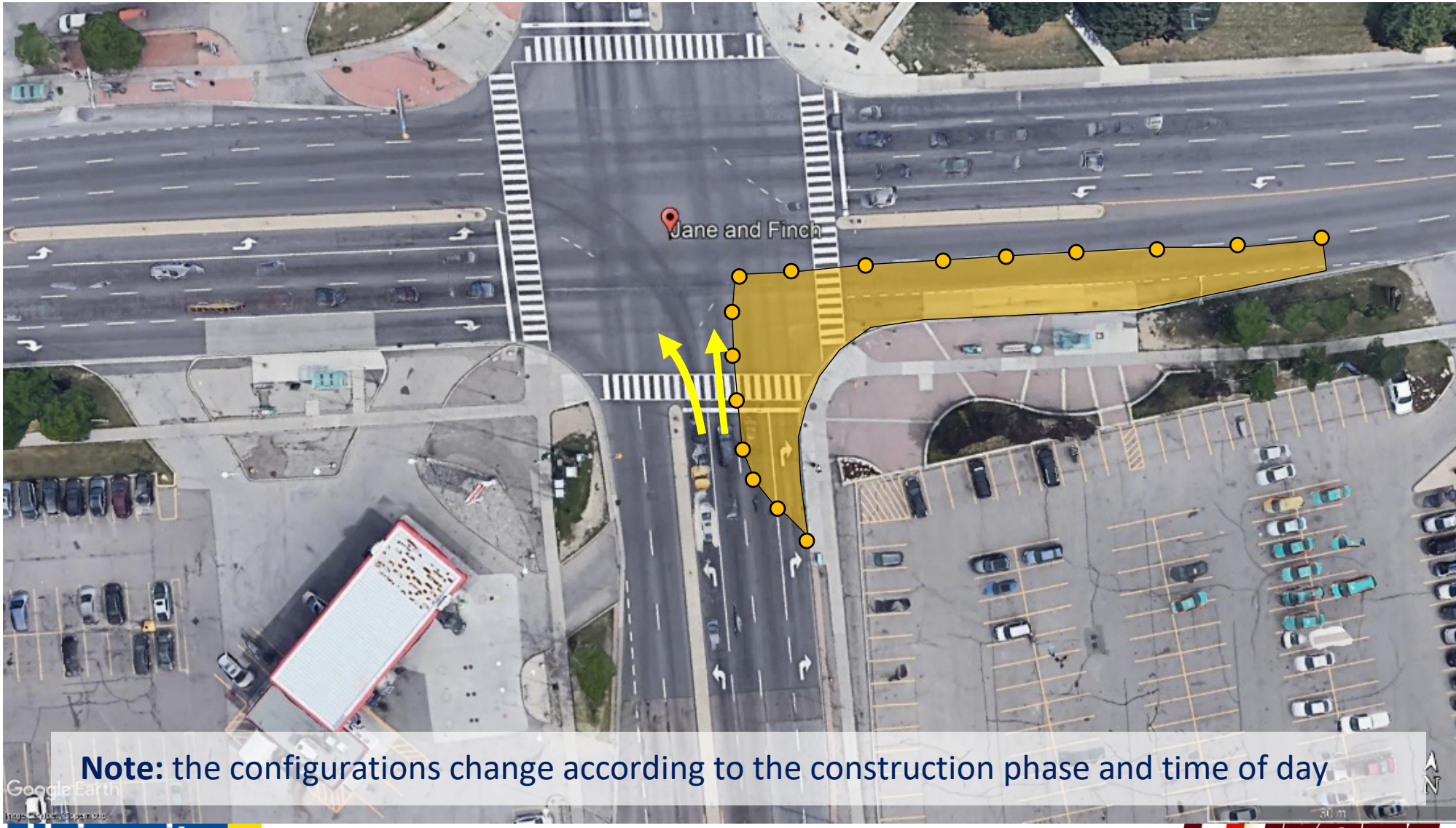
Traffic Counts:

- All 12 typical traffic turning movements are included (3 per direction).
- In 15min time resolution.
- Includes also vehicle classification.
  - Also pedestrian volumes.
  - Phasing and Signal Timing throughout the day

Data Available (by MIOVISION and STINSON ITS)

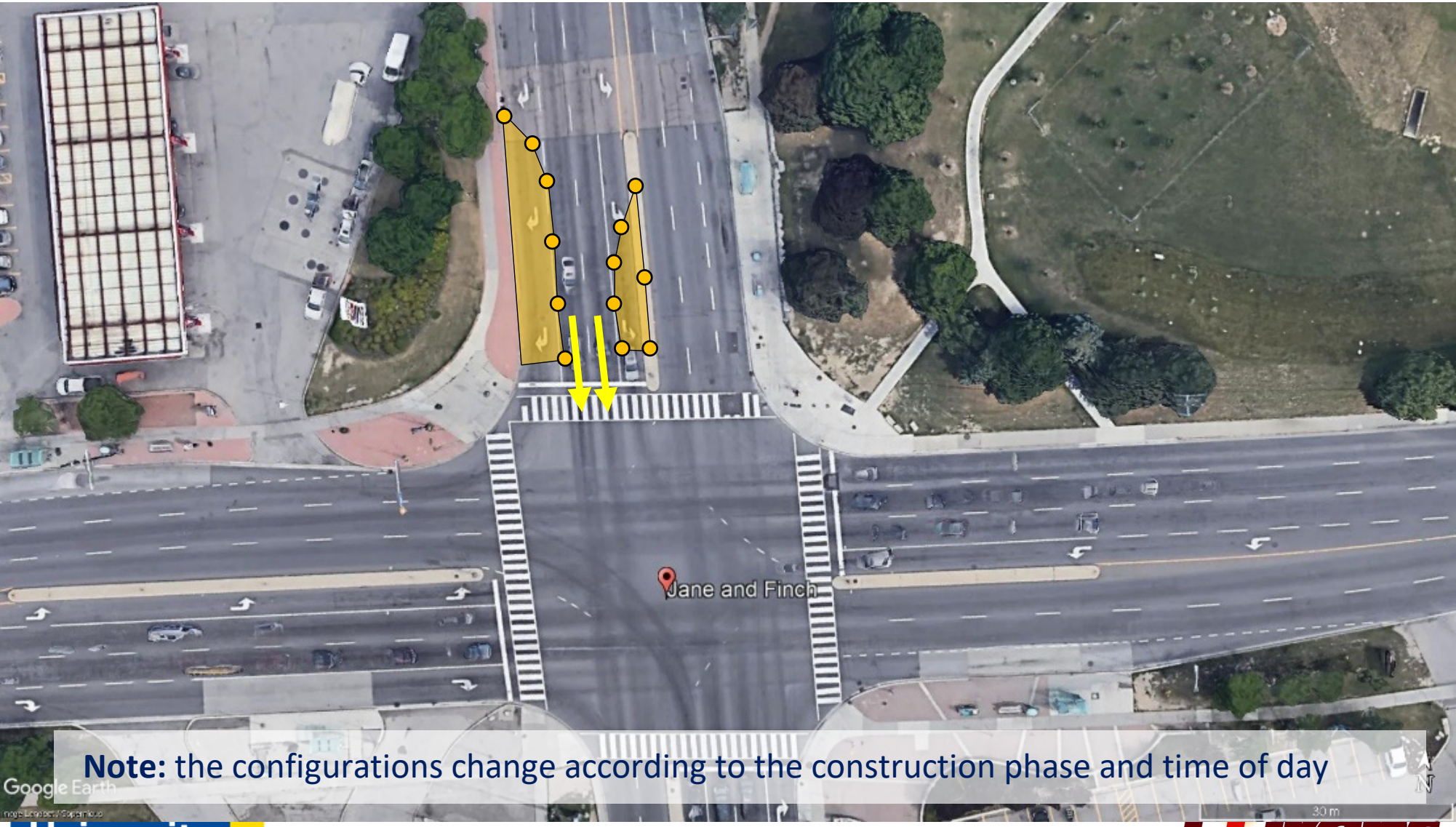


North Bound Closure



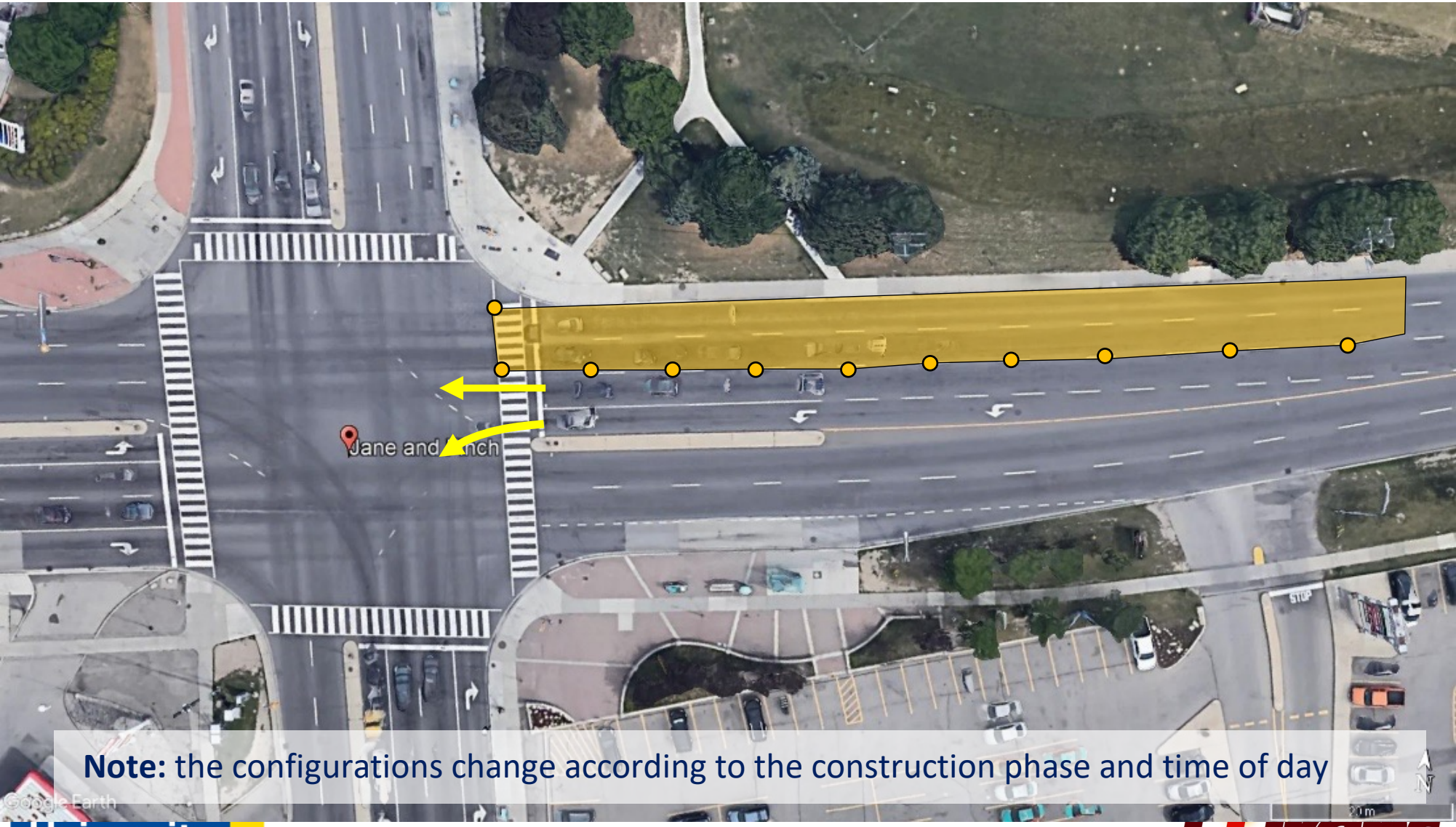
Note: the configurations change according to the construction phase and time of day

South Bound Closure



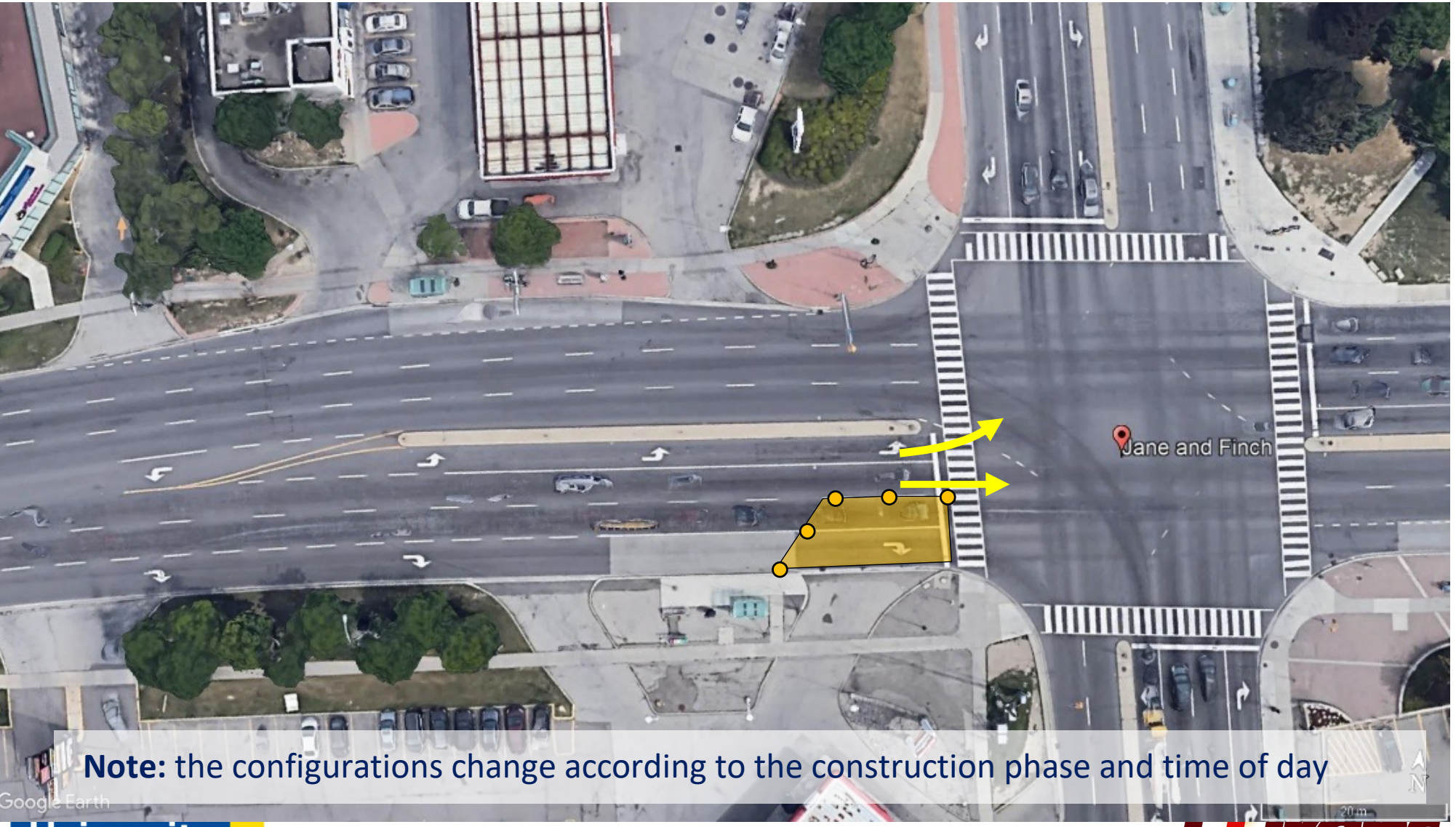
Note: the configurations change according to the construction phase and time of day

West Bound Closure



Note: the configurations change according to the construction phase and time of day

East Bound Closure



Note: the configurations change according to the construction phase and time of day

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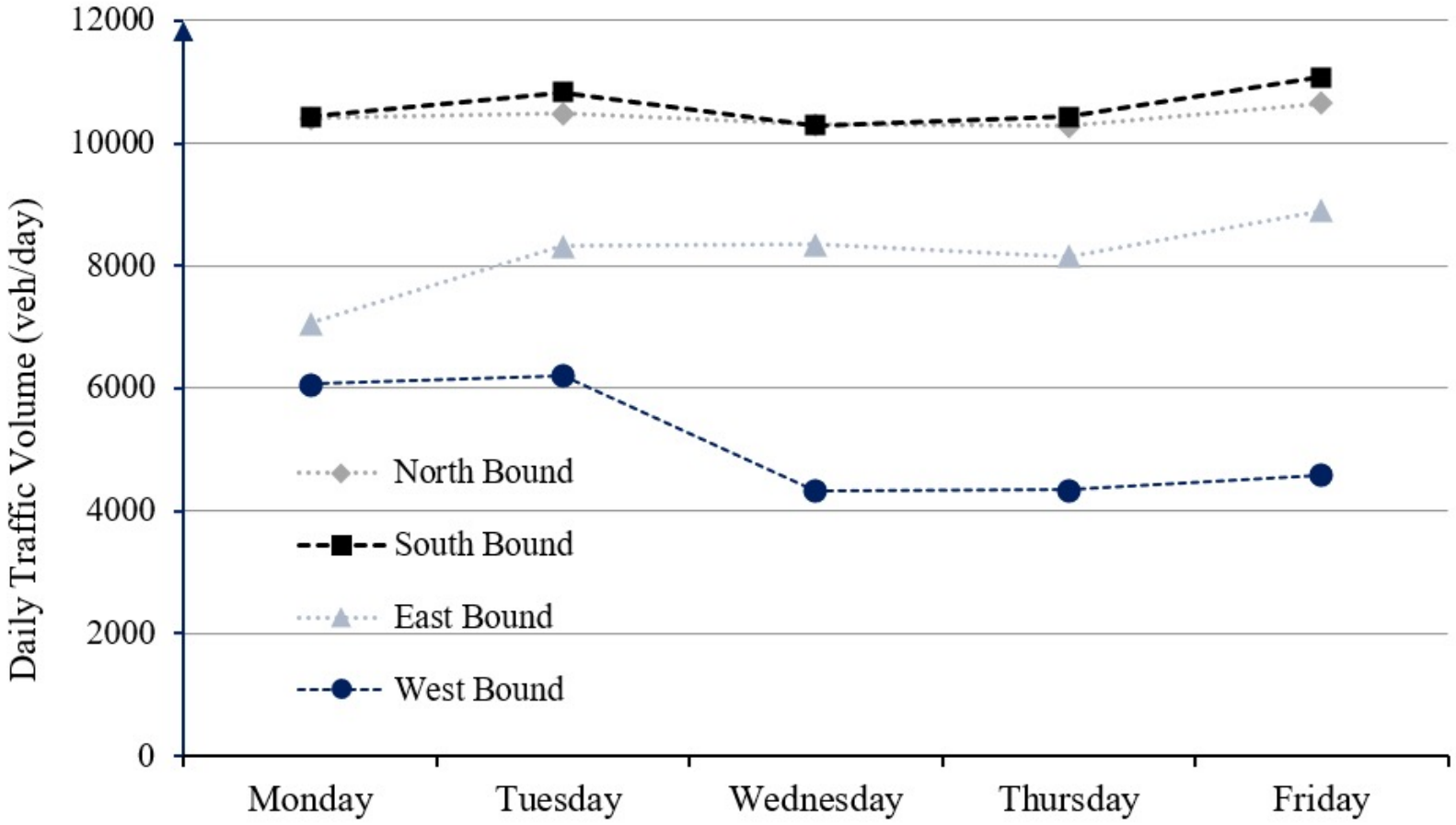
Intersection Traffic Volume Trends

Date	Day	Traffic Vol (veh/day)	Pedestrian Vol (ped/day)	Truck %	AM Peak hr	AM Peak Vol (veh/hr)	PM Peak hr	PM Peak Vol (veh/hr)
09/11/2020	**Monday**	34010	5030	6%	7:00 to 8:00	1879	5:00 to 6:00	2504
10/11/2020	**Tuesday**	35858	4727	6%	11:00 to 12:00	1947	5:00 to 6:00	2541
11/11/2020	**Wednesday**	33295	4779	6%	8:00 to 9:00	1792	4:00 to 5:00	2141
12/11/2020	**Thursday**	33227	5210	6%	7:45 to 8:45	1802	5:30 to 6:30	2171
13/11/2020	**Friday**	35205	6139	7%	11:00 to 12:00	1856	5:45 to 6:45	2189
14/11/2020	**Saturday**	34422	5011	4%	11:00 to 12:00	2050	1:30 to 2:30	2305
15/11/2020	**Sunday**	29071	2602	4%	11:00 to 12:00	1863	3:30 to 4:30	2201

-Mid of the week (Wednesday & Thursday) showed slightly lower traffic demand.
-During weekdays, the intersection AM peak period sometimes spilled to noon time whereas the PM peak hour was observed during the 4:00-to-6:00 PM period.

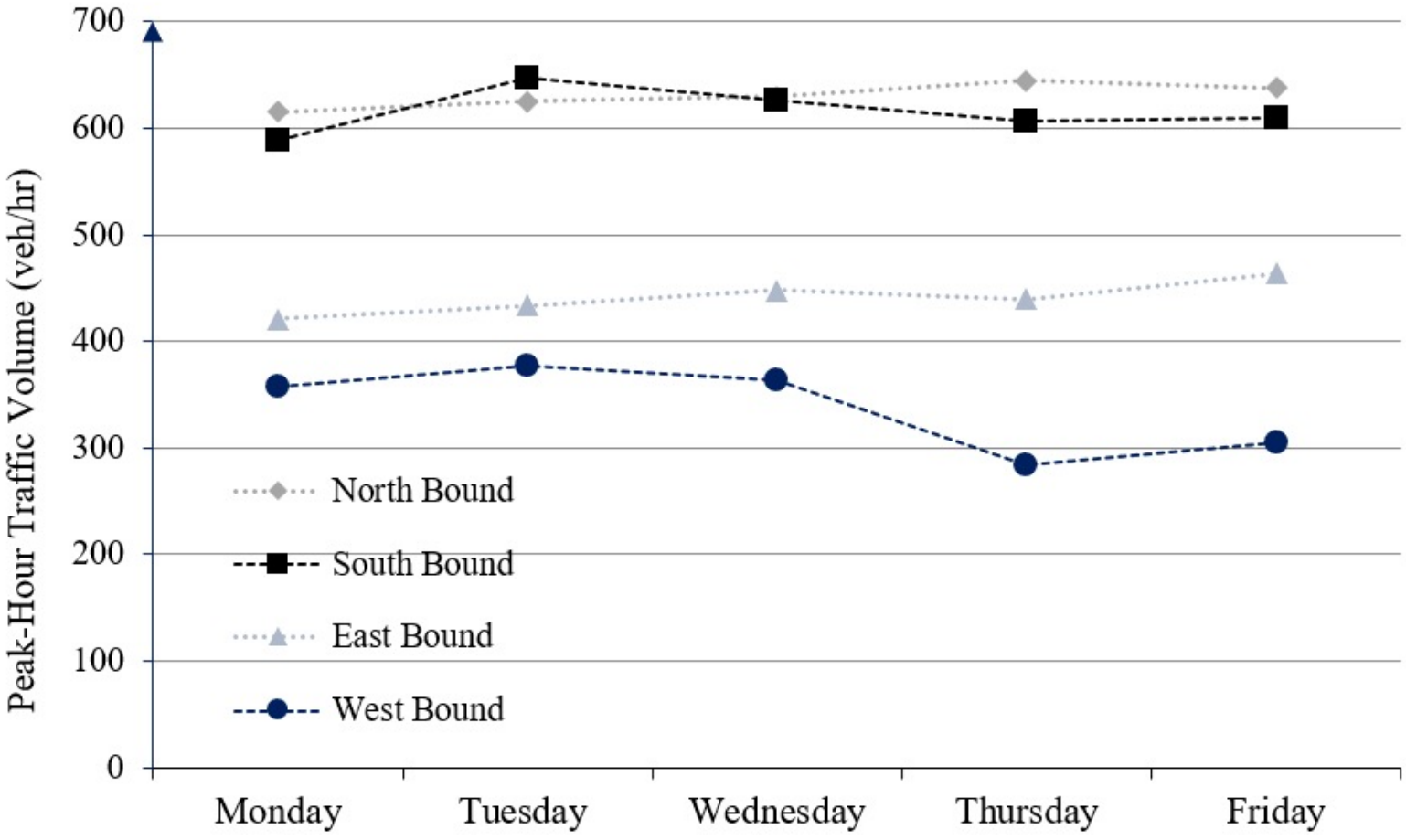
Daily Traffic Volume by Direction



Note: the analysis herein and in the following slides is for the week of 9th to 15th November, 2020

-The west and east bounds showed less daily traffic demand consistency as compared to the north and south bounds.
-The west bound showed significant demand fluctuation

AM Peak-Hour Traffic Volume by Bound and by Day



-The west bound showed the largest traffic demand fluctuation in the AM peak-hour

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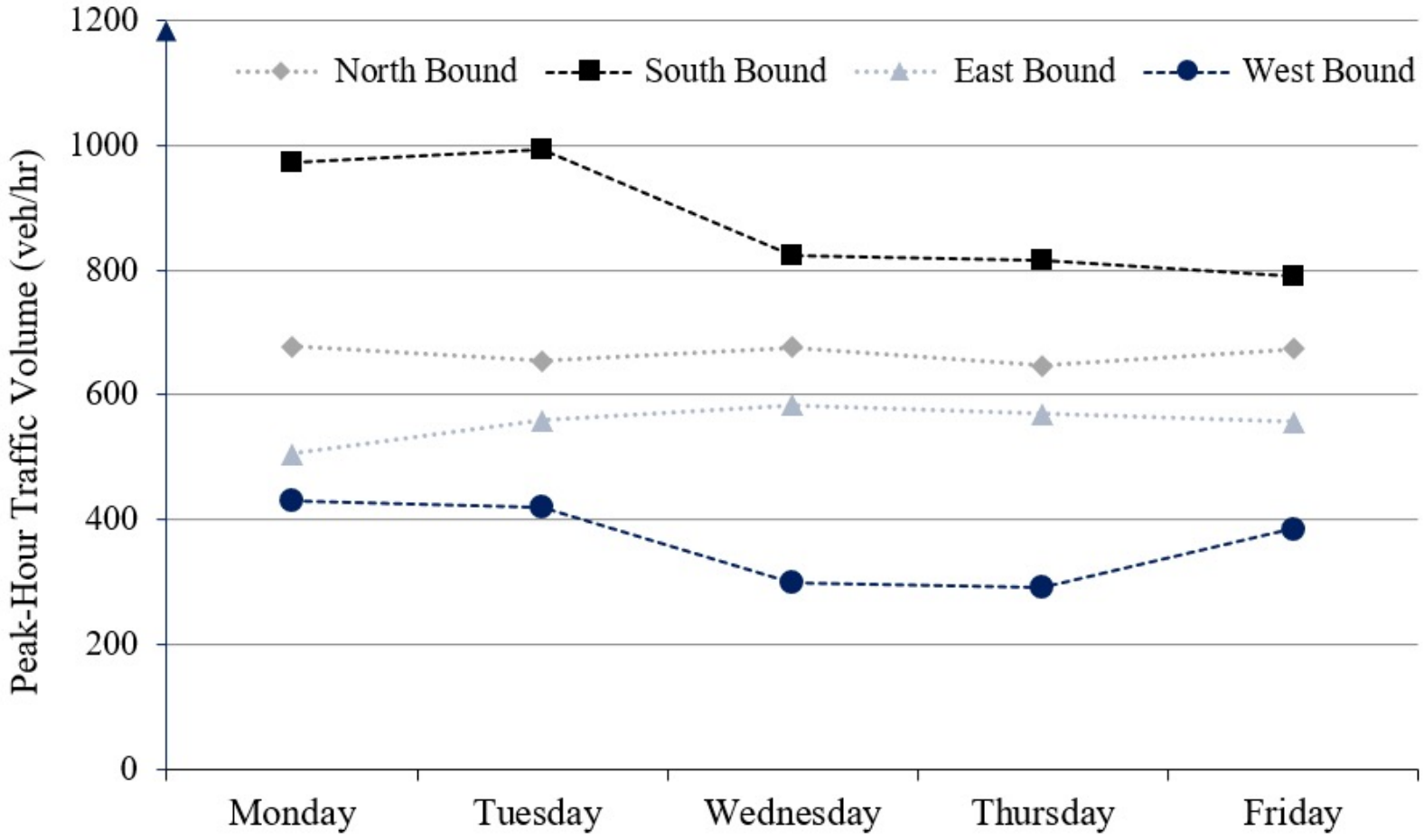
PM Peak-Hour Traffic Volume by Bound and by Day



-Both the south and the west bounds showed significant traffic demand fluctuations in the PM peak-hour

Peak-Hour Analysis - AM Period - until 12:00 PM

	AM Peak Hour Time (in 15min Resolution)						
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Entire Intersection	7:00	11:00	8:00	7:45	11:00	11:00	11:00
North Bound	6:15	6:00	6:00	6:00	11:00	11:00	10:30
South Bound	8:15	11:00	8:00	8:30	8:00	11:00	11:00
East Bound	6:45	6:30	10:30	7:15	11:00	11:00	11:00
West Bound	5:30	6:00	5:45	7:15	5:30	8:15	10:45

-The AM peak-hour analysis reveals a slim consistency, the peak-hour slides significantly from day-to-day.

Peak-Hour Analysis - PM Period - after 12:00 PM

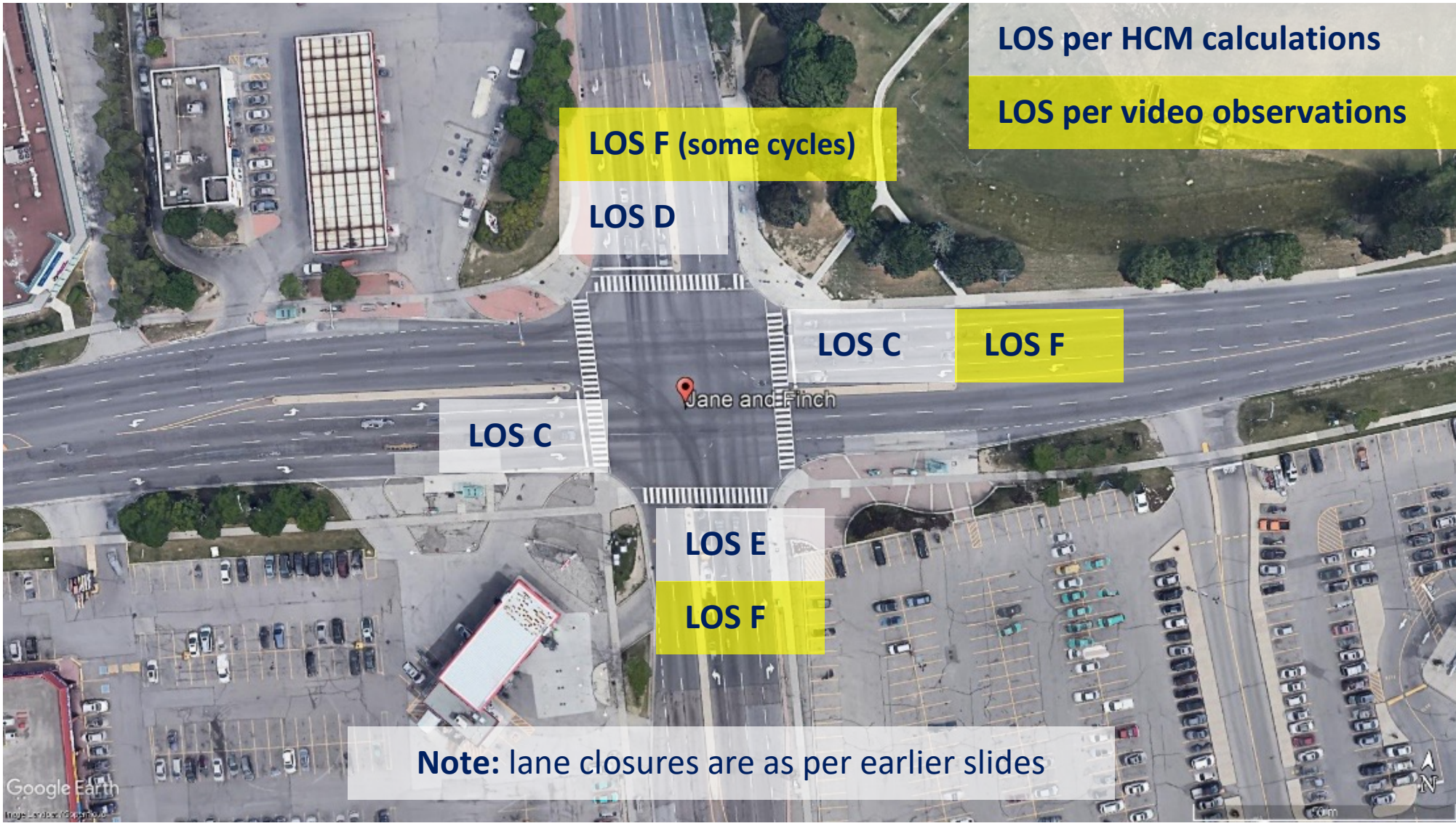
	PM Peak Hour Time (in 15min Resolution)						
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Entire Intersection	17:00	17:00	16:00	17:30	17:45	13:30	15:30
North Bound	14:15	13:30	12:15	17:45	18:45	17:45	13:00
South Bound	16:30	16:45	16:00	17:00	15:45	13:30	14:00
East Bound	16:45	16:00	15:30	16:45	16:30	14:45	15:30
West Bound	17:30	17:30	18:45	18:00	20:15	18:45	12:30

-The PM peak-hour appears to be more consistent as compared to the AM peak-hour except in the north bound where it slides heavily.

Level of Service Analysis
(Friday 13 Nov – Intersection AM peak-hour: 11:00 to 12:00)

Note: lane closures are as per earlier slides

Level of Service Analysis
(Friday 13 Nov – Intersection PM peak-hour: 05:45 to 06:45)



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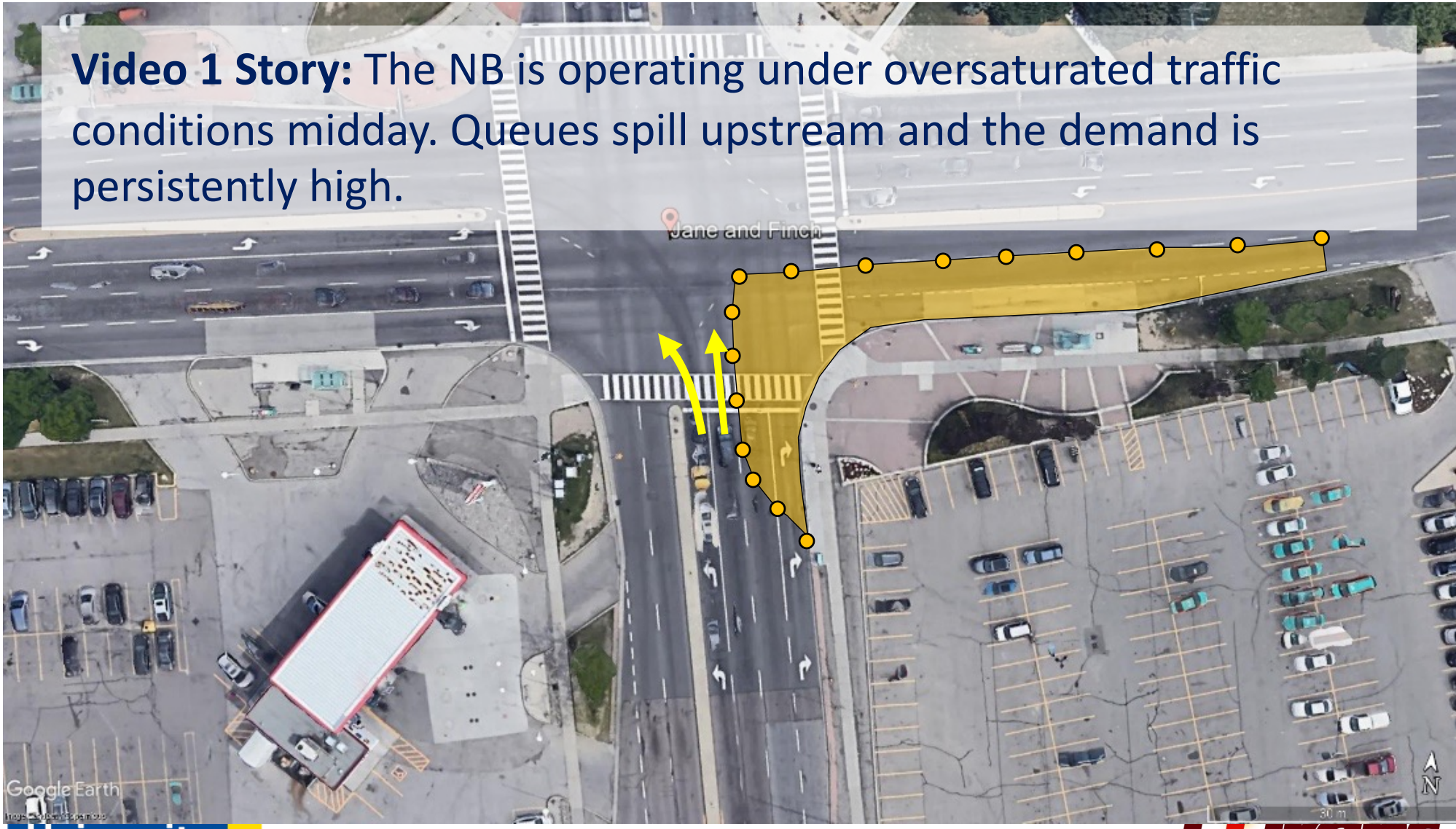
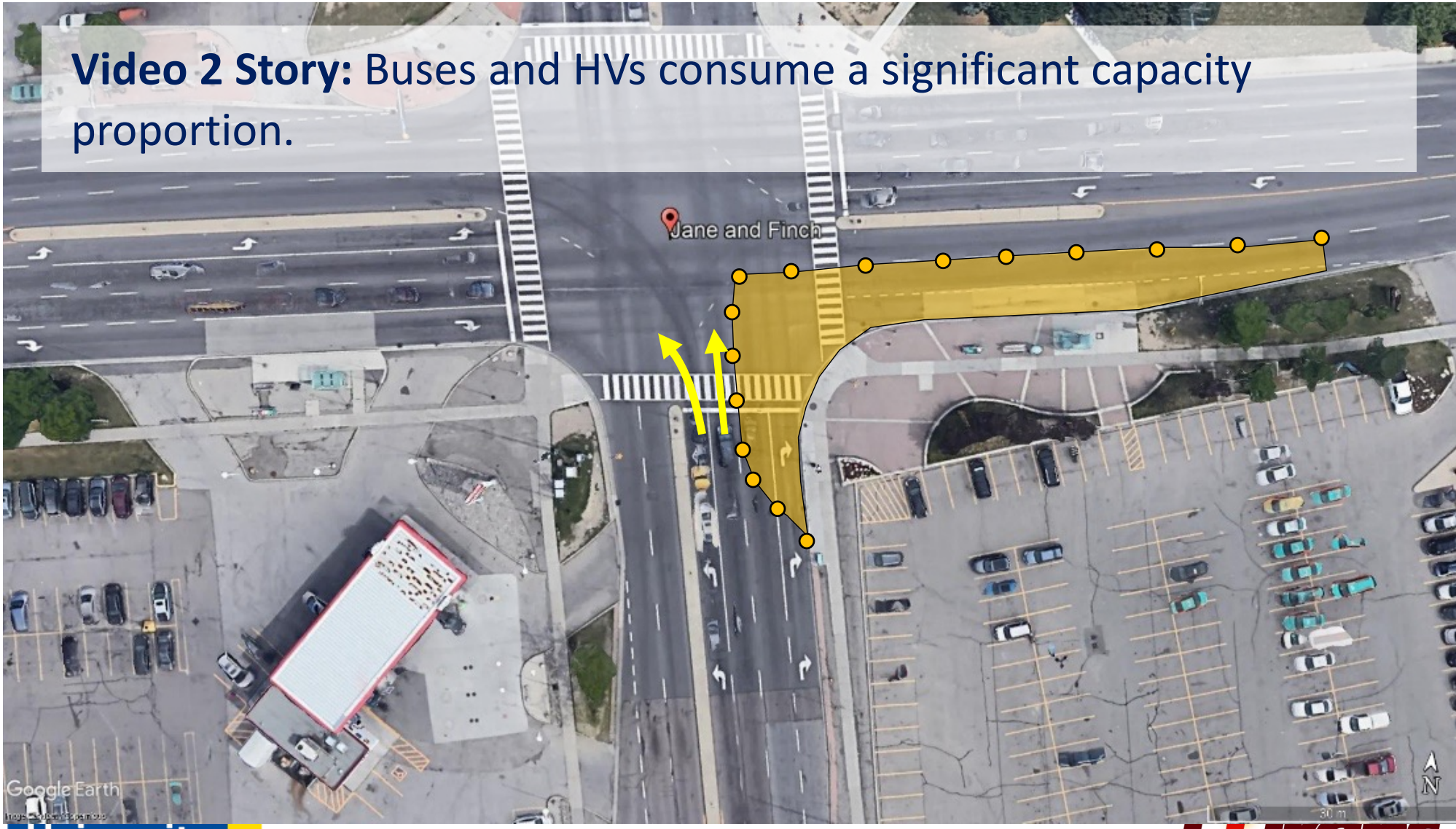
North Bound Closure



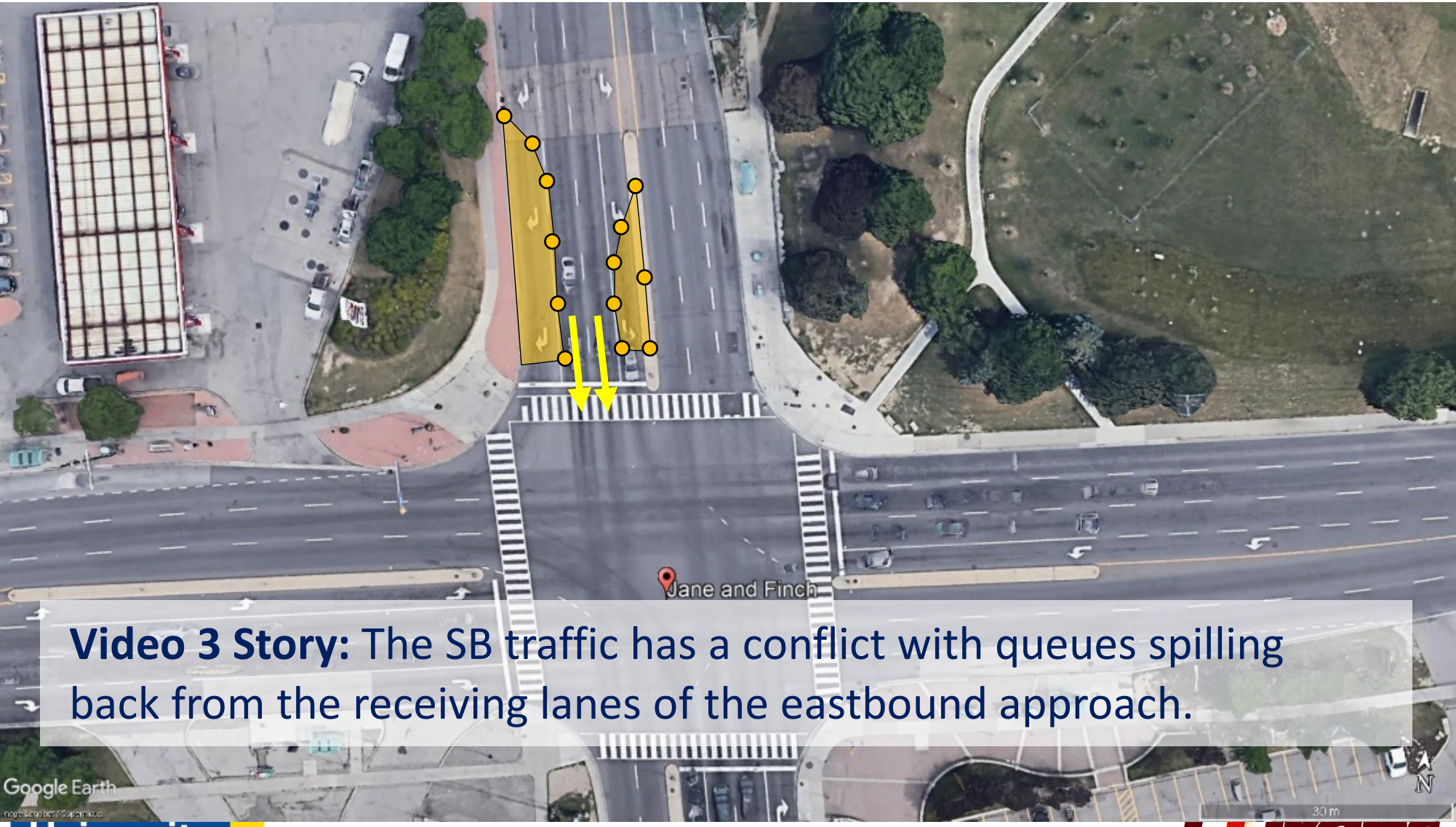
Video 1 Story: The NB is operating under oversaturated traffic conditions midday. Queues spill upstream and the demand is persistently high.

North Bound Closure – Configuration Two



Video 2 Story: Buses and HVs consume a significant capacity proportion.

South Bound Closure



Video 3 Story: The SB traffic has a conflict with queues spilling back from the receiving lanes of the eastbound approach.

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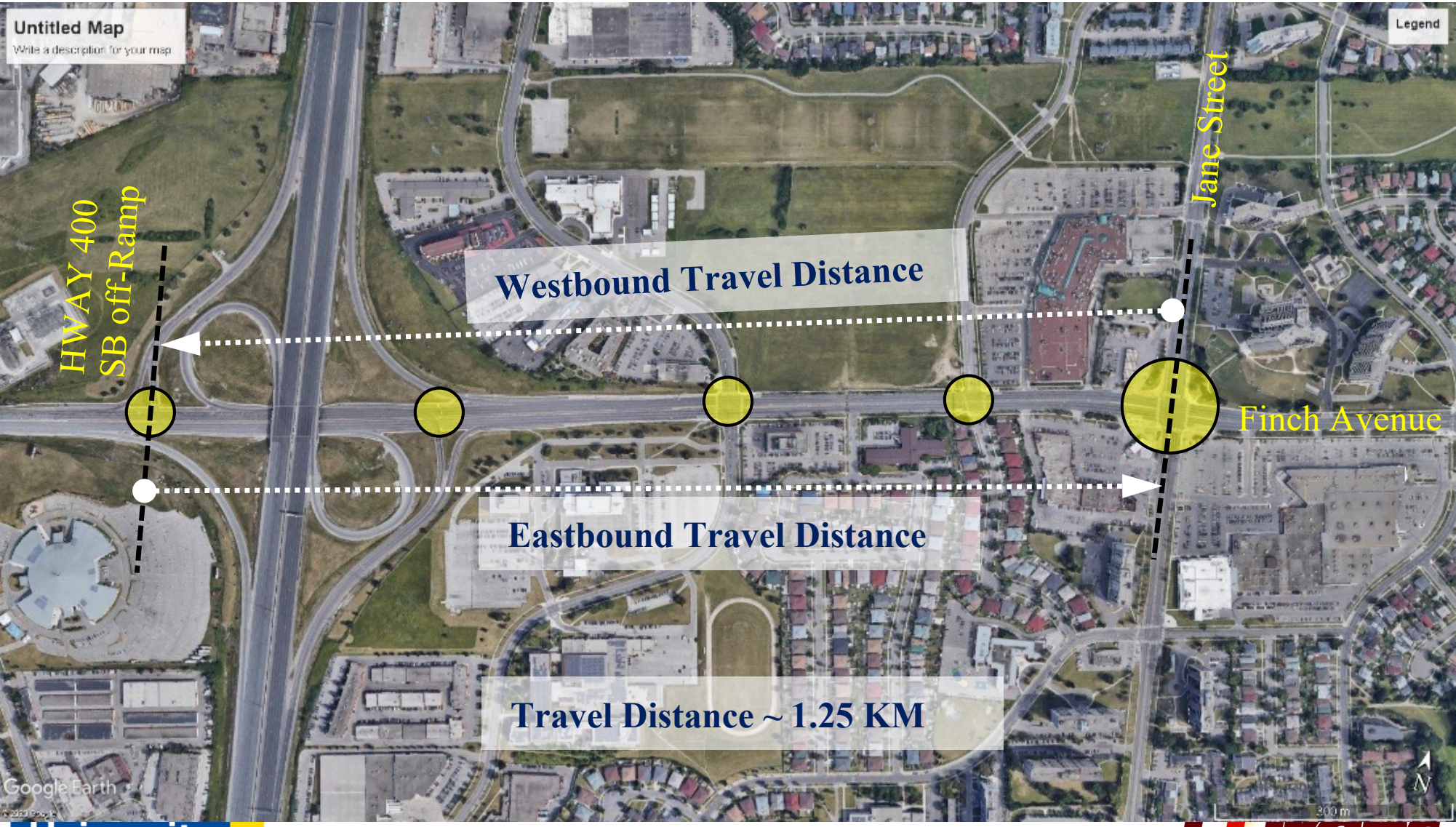
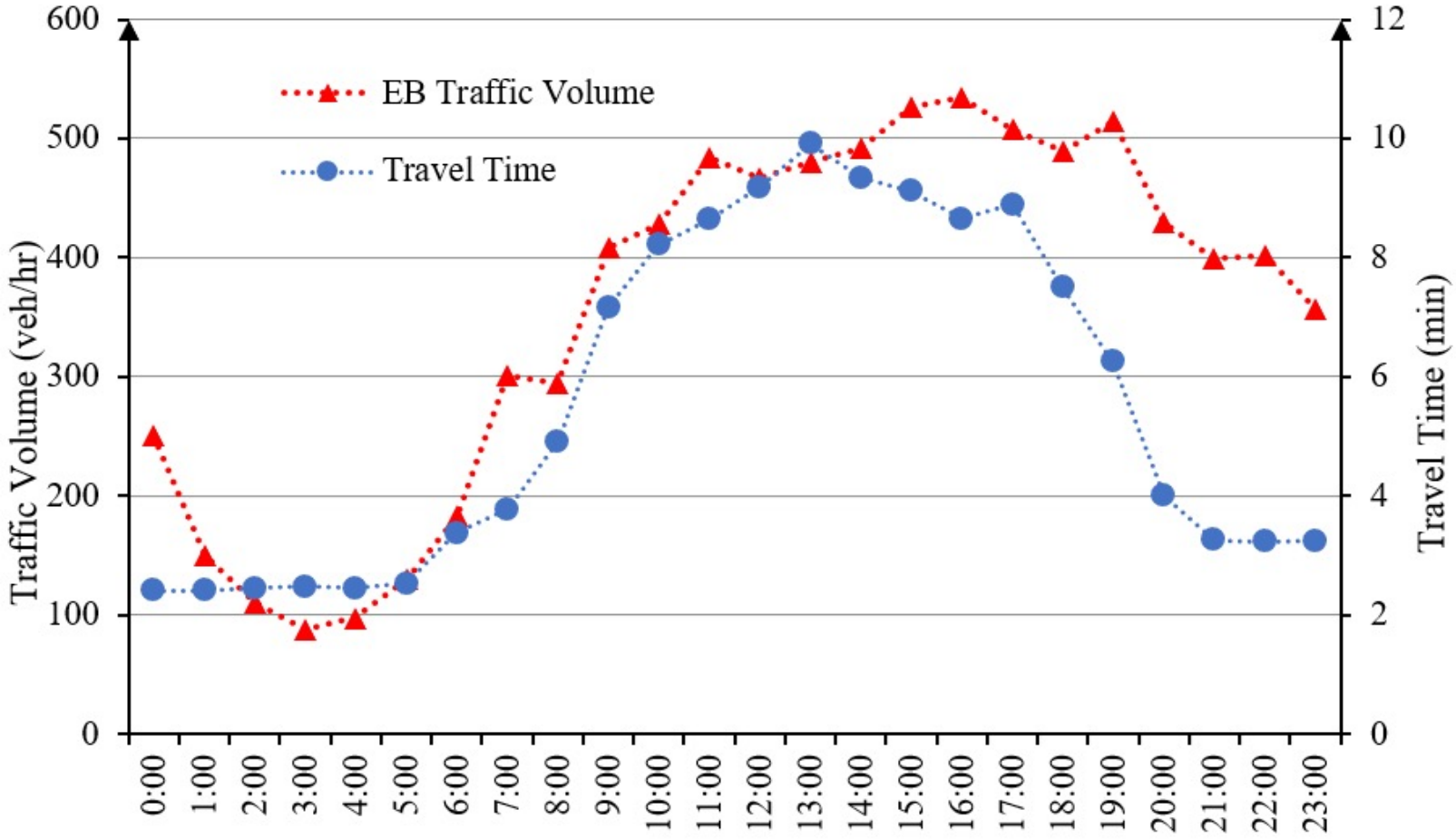
Jane and Finch Area

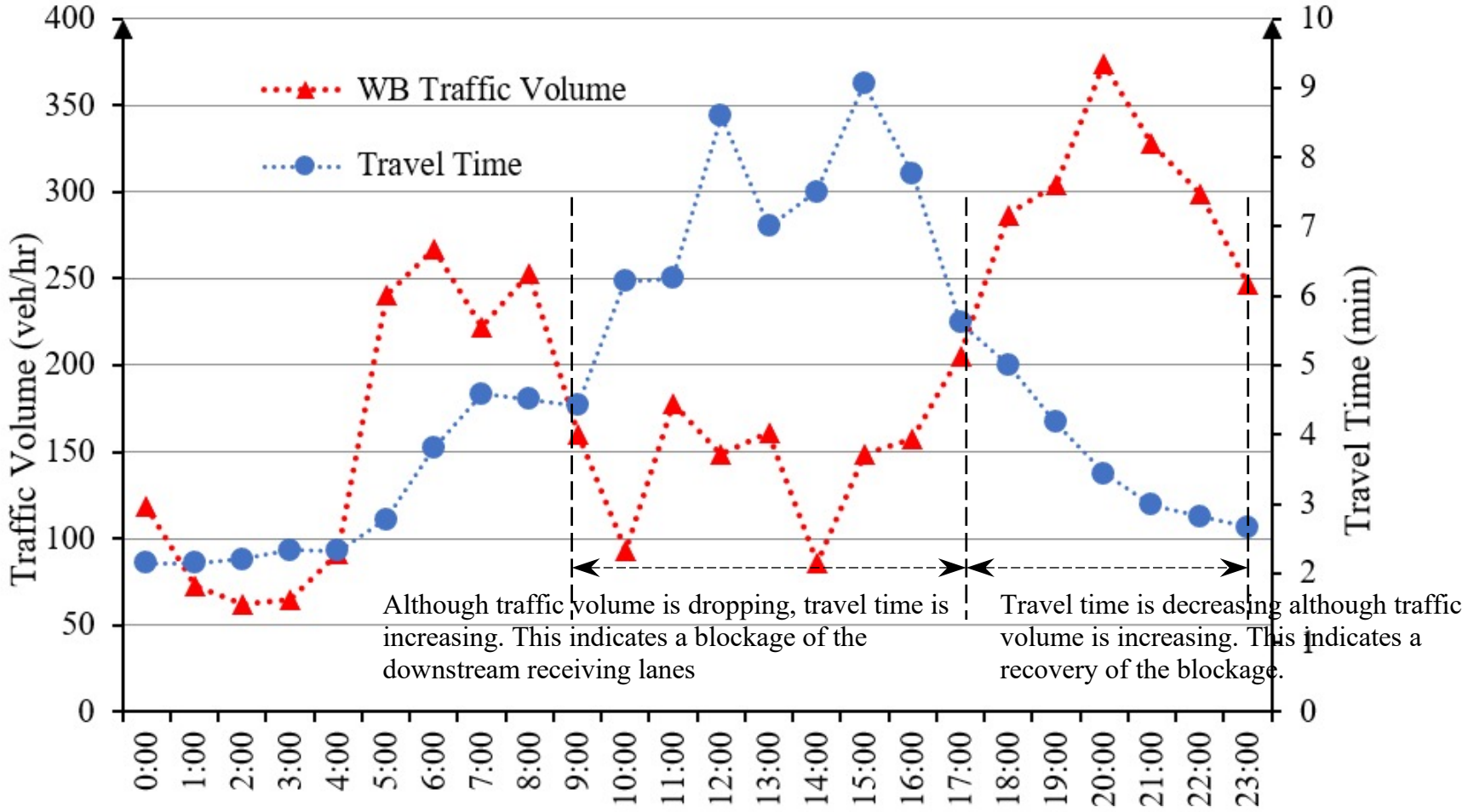


Travel Time versus Traffic Volume (EB on Friday 13th Nov)



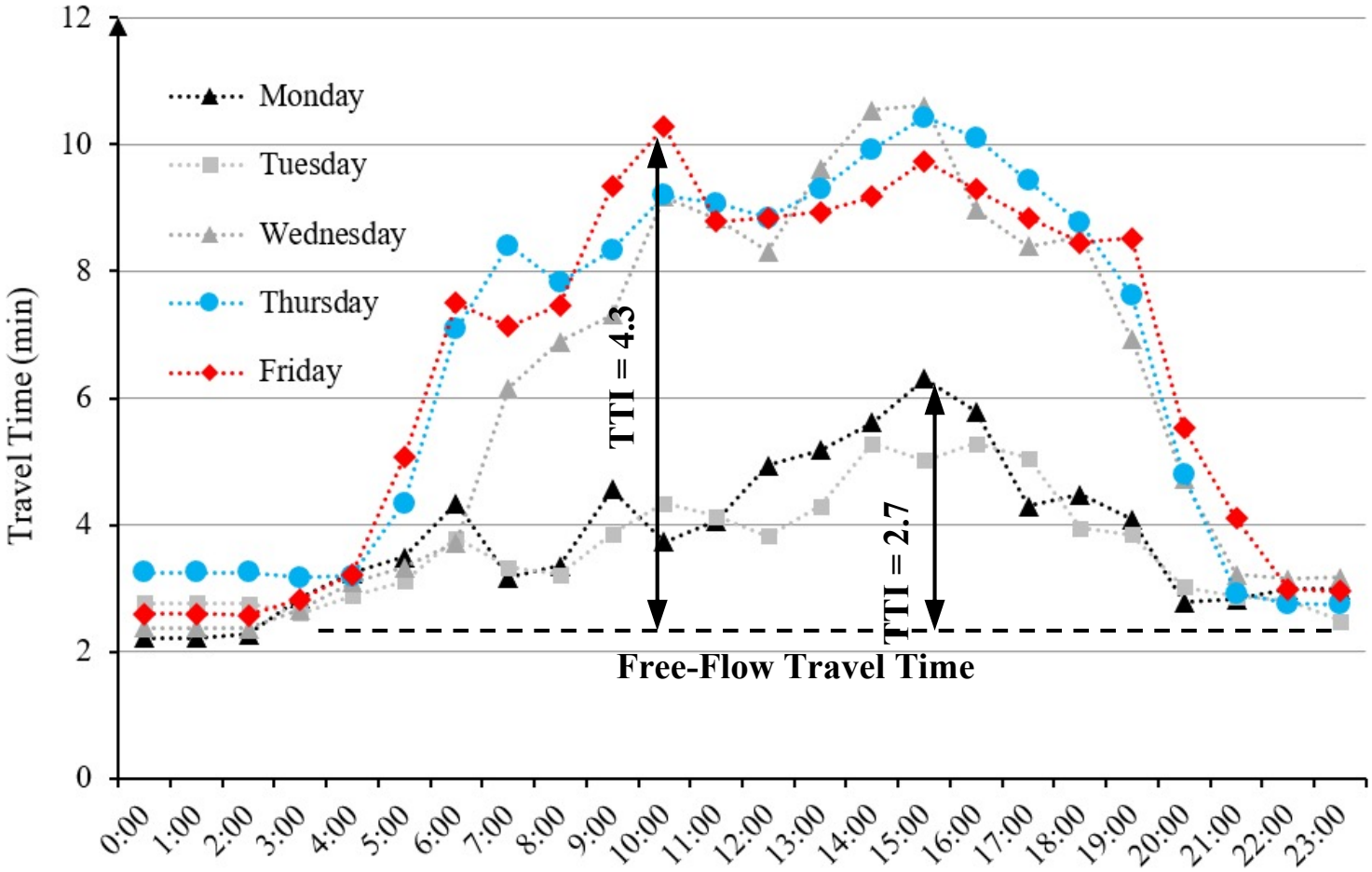
-The travel time overall follows the traffic volume logically, i.e., when the volume increases the travel time increases and vice versa.

Travel Time versus Traffic Volume (WB on Friday 13th Nov)



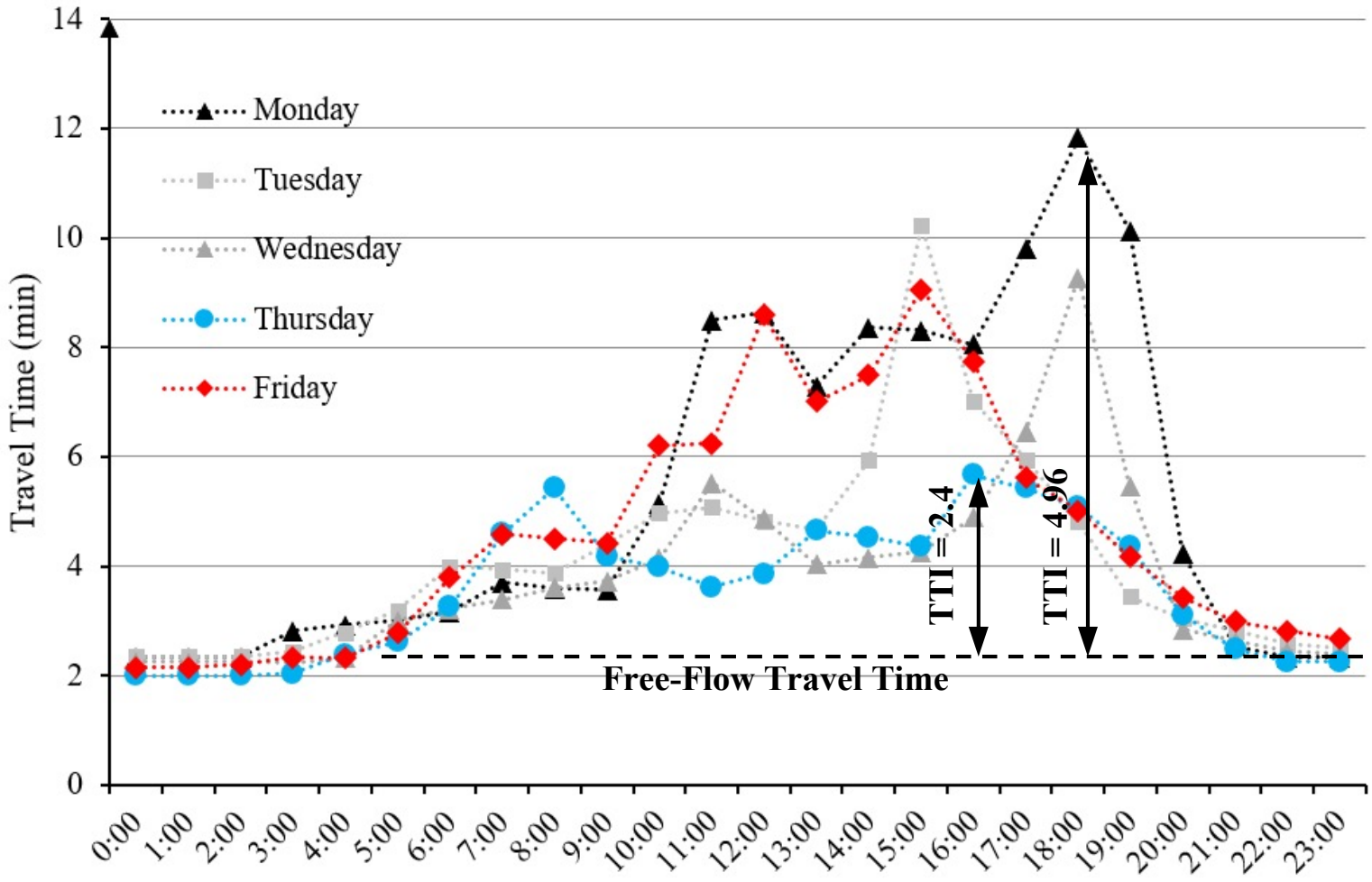
-There is an oversaturation-induced relationship between the travel time and the traffic volume, e.g., the travel time increases when the volume decreases.

Travel Time by Day and Hour (EB)



-EB travel time shows wide variation by day and by hour. The travel time increased substantially throughout the second part of the week (i.e., Wednesday through Friday).

Travel Time by Day and Hour (WB)



-The travel time variability is high in the west bound direction especially in the PM period.

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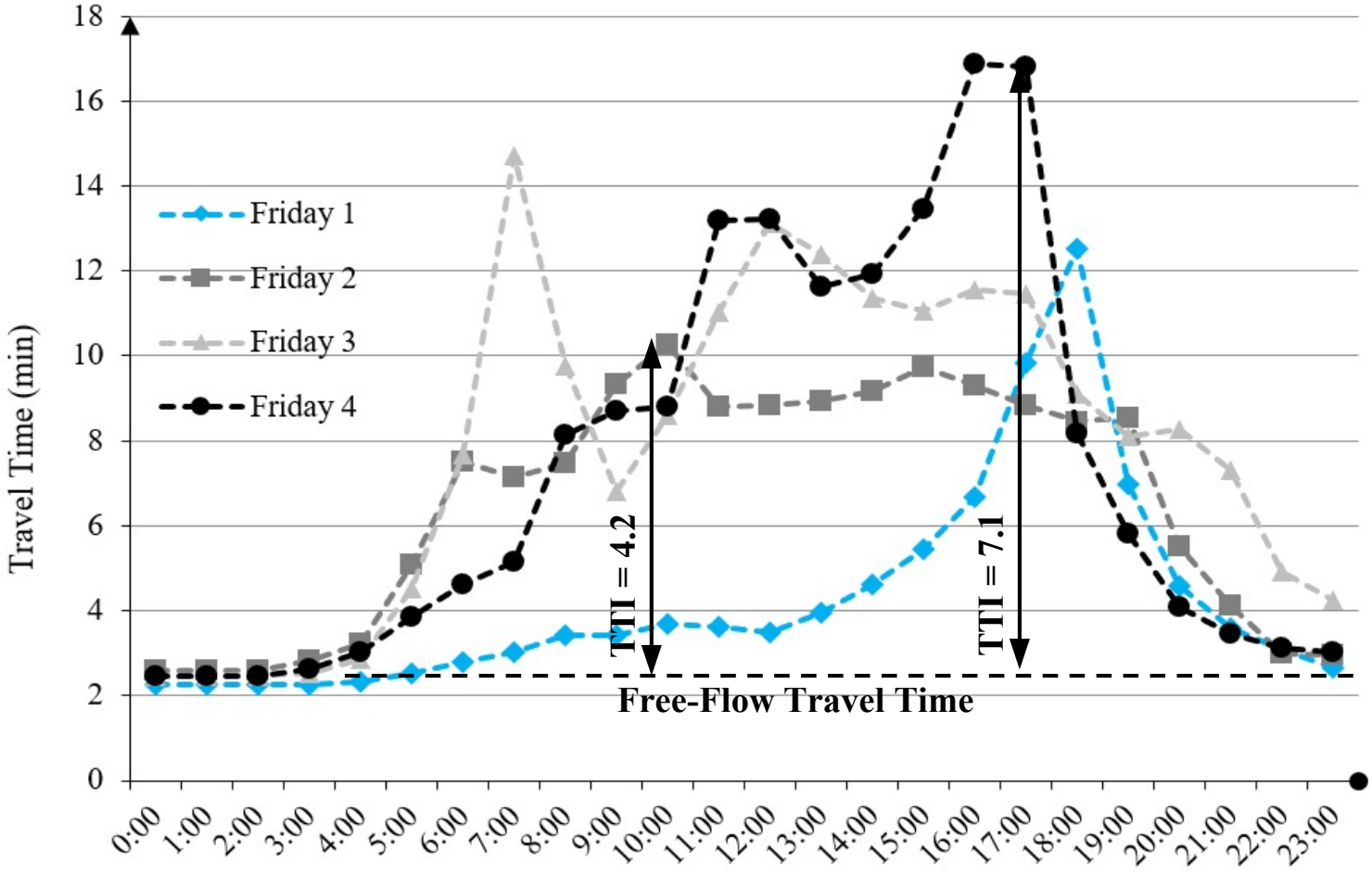
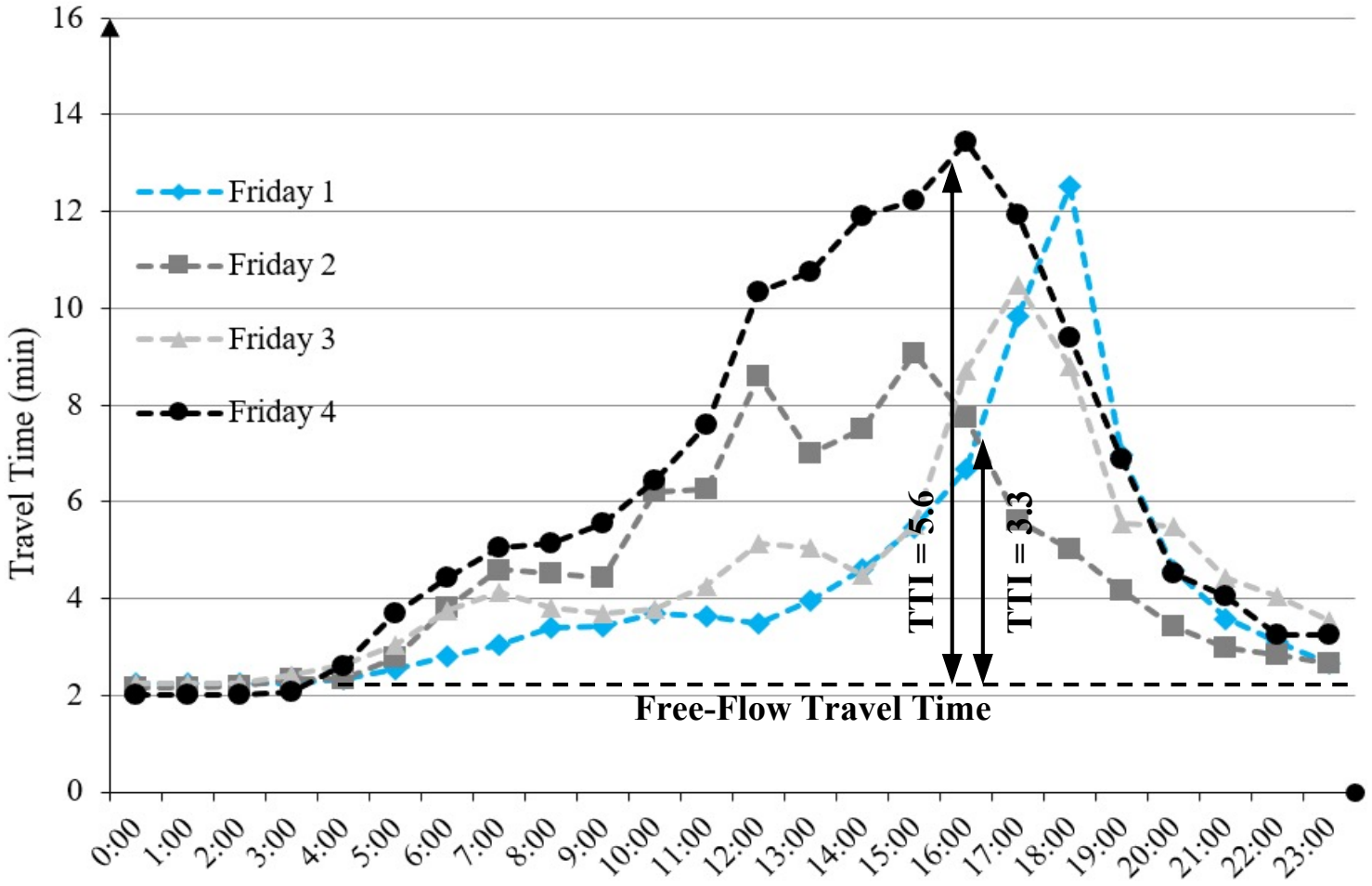
Travel Time from Friday-to-Friday (EB – November)



-Travel time also fluctuates widely from week to week even throughout the same day of the week (Fridays of November as an example). The longest travel time and its timing are not consistent.

Travel Time from Friday-to-Friday (WB – November)



- WB travel time also fluctuates widely from week to week (Fridays of November).

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General Findings, Advices, Recommendations

- Traditional HCM-based calculations using traffic volume counts retrieved from traffic counter may provide misleading level-of-service results if the intersection suffers from congestion, blockage, and starvation problems.
- *This traditional LOS approach failed to detect many LOS F cases in the study site at Jane and Finch junction.*
- In these scenarios, a video-based evaluation of the level-of-service is vitally needed to inform the public and transport agencies of the correct traffic situation.
- The video-based traffic surveillance also provided a key tool to understand the causes of traffic congestion and from where the traffic blockage or starvation is originated.
- Archiving traffic videos on 24/7 bases can also be useful to analyze the existing day/week traffic conditions in order to better manage the next day/week traffic.

General Findings, Advices, Recommendations

- Traffic agencies are advised to consider making video-based traffic surveillance at least highly recommended at key congested corridors/intersections where work zone activities may create long-term traffic challenges or where neighbouring intersections may create complex blockage/starvation problems.
- The need for such surveillance tools increases for work zones that operate for longer durations and that also encounter frequent changes in their geometries.
- These videos should be reviewed on regular bases along with the other traditional traffic performance measures.
- For moderately congested corridors, the traditional HCM-based level-of-service calculations using traffic counts should provide reliable results, i.e., assuming no blockage/starvation problems are created.

General Findings, Advices, Recommendations

- Travel time variability is very large at work zone locations and corridors accommodating construction activities.
- This large variability is also observed for the same day-of-the-week when moving from week-to-week in the same month. For example, the travel time index (TTI) of the WB approach changed from 3.3 to 5.6 for the same time-of-day, i.e., across different Fridays in the same month.
- The variability in travel time can be attributed to: background traffic demand fluctuation, interaction between nearby corridors/intersections, and COVID19-induced traffic demand fluctuation.
- The variability can be heavily impacted by changes in construction phases, closures, and activities along the corridor.

General Findings, Advices, Recommendations

- This large work zone-induced variability calls for more real-time travel time recording and updates at work zone locations.
- Travellers need more frequent update on travel time through websites or portable variable message signs.
- Traffic agencies are also advised to consider making the use of real-time travel information systems at least highly recommended at congested corridors that have construction activities.

General Findings, Advices, Recommendations

- In the analysed period, the north bound was operating under oversaturated conditions in the midday and during PM peak (approximately during 2-to-6 PM) **-->** good to measure capacity at work zones.
- The south and west bounds also show oversaturated cycles from time-to-time because of the queue spillage along the westbound direction.

Next Study Directions

Measuring **work zone capacity** under oversaturated conditions

- What are the influential factors?
- Can capacity be different by day of the week, time of day, work zone duration?
- Is the current HCM analysis accurate?
- How weather impacts capacity?
- What is the impact of HV and buses?

Next Study Directions

Measuring **work zone performance metrics** under different traffic mix conditions (using simulation platforms).

- Mainly looking at the impact of connected automated vehicles
- How different MPR can enhance WZ capacity and reduce delay?
- What is the impact of platooning/clustering?
- When it is feasible to use dedicated CAV-lane at WZs?

Acknowledgements

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Canada

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Thank you!