Measuring Goods Movement Travel Time and Reliability: Proposed Methodology

Cheryl Szuch, P. Eng., Transportation Systems Engineer, The City of Calgary, and

Zorana McDaniel, P. Eng., Transportation Systems Engineer, The City of Calgary

Paper prepared for presentation

at the Goods Movement Successes – Meeting Freight Challenges through

Effective Planning, Partnerships and Innovations Session

of the 2011 Annual Conference of the

Transportation Association of Canada

Edmonton, Alberta

ABSTRACT

Trucking is the primary mode for the movement of goods within Alberta. As a trucking hub, Calgary plays an important role in providing a safe, efficient and connected goods movement network. By monitoring the speed and travel time reliability of the goods movement network over time, the effects of network improvements and the impacts of congestion and delay on commercial vehicle movement can be measured.

Day-to-day travel time can be significantly different than the average travel time, with unexpected delays due to weather, traffic congestion or traffic incidents, to name a few. To account for variability, drivers usually build a time buffer into their trip planning to avoid arriving late.

The Office of Operations of the U.S. Department of Transportation's Federal Highway Administration has developed a methodology for calculating travel time reliability. One of the recommended reliability measures is the buffer index. The buffer index represents the extra buffer time that most drivers add to their average travel time when planning trips to ensure on-time arrival. The travel time buffer index increases as the travel time reliability worsens. The 95th percentile travel time indicates how bad delay is on the heaviest travel days.

In Calgary, BluFax units are being used to measure travel time and reliability. BluFax units operate by monitoring Bluetooth signals at several points along a roadway. By tracking when individual signals reach various points along the route, travel time can be determined. BluFax technology provides data similar to toll tag monitoring systems without the need for toll tag infrastructure.

The BluFax results summary includes daily weekday 95th percentile travel time, average travel time, free-flow time, as well as segment lengths (km) and daily vehicle kilometres travelled on that segment. The buffer index and planning time index are then calculated.

The methodology and technology used in this study is a cost-effective way for municipalities in Canada to measure travel time without major infrastructure changes.

INTRODUCTION

The Municipal Development Plan (MDP) and the Calgary Transportation Plan (CTP) recognize the important economic role of goods movement. A safe, efficient and connected goods movement network contributes to a prosperous economy. Trucking is the primary mode for the movement of goods within Alberta. As a trucking hub, Calgary plays an important role in providing a safe, efficient and connected goods movement network.

Calgary is an intersection of two major transportation corridors: the Trans-Canada Highway that provides east/west connectivity across Canada and the Queen Elizabeth II Highway (Deerfoot Trail in Calgary) that provides a major north/south connection as part of the CANAMEX highway system.

Calgary is a key distribution centre of Asia-Pacific related imports and exports. Trucking accounts for 46 per cent of imports and 64 per cent of exports. Commercial vehicles made over 265,000 trips a day in 2006. Out of those vehicle trips, nearly 80 per cent had origins and destinations within the city limits.

The Monitoring and Reporting Program (The Program) provides a mechanism through which the goals, objectives and policies of the MDP and CTP are being assessed. The Program identifies several citywide indicators that are relevant for the implementation of these plans. The travel time reliability and average speed on the goods movement network are two of the citywide supplementary indicators monitored by The Program. By monitoring the average speed and travel time reliability on selected goods movement corridors over time, the effects of network improvements and the impacts of congestion and delay on commercial vehicle movement can be measured and mitigated as necessary.

Historically, The City of Calgary used the floating car method to determine average travel speeds. This method has drawbacks as it produces only a few data points and introduces the opportunity for systematic errors depending on how the floating car is driven.

To fulfil the mandate of The Program, The City has investigated opportunities to use new technologies, including Bluetooth travel time monitoring equipment. The objective was to develop a methodology that has the following characteristics:

- Repeatable from year to year using available data
- Simple and easy to understand
- Cost-effective data collection
- Easily and reliably measured data

In addition, during the research, several questions came to mind:

- How do we determine which corridors are to be measured?
- What is the sample size needed to measure travel time reliability?
- How should travel time reliability be measured?

This paper will answer these questions.

METHODOLOGY

After the research, it was evident that the Bluetooth travel time methodology fulfils the above objective. This methodology provides many data points and the opportunity to measure the travel time.

Bluetooth travel time monitoring works by mounting stationary sensors along the route being studied. These sensors detect and record Bluetooth signals as they come in range. Each signal's unique Media Access Control (MAC) address is recorded along with the date and time it was detected. By comparing the records from different sensors, the travel time for MAC addresses detected at multiple sensors can be calculated. These travel times can then be analyzed and used for the average speed and travel time reliability calculation.

It was determined that BluFax units will be used to measure travel time. BluFax units operate by monitoring Bluetooth signals at several points along a roadway. By tracking when individual signals reach various points along the route, travel time can be determined. Bluetooth detection technology provides data similar to toll tag monitoring systems without the need for toll tag infrastructure.

Records from each BluFax unit are compared to determine which MAC addresses have been observed by more than one unit and when they were observed at each location. From this a travel time in minutes is derived, together with a starting and ending time for each segment. Based on the starting time, travel time data can be grouped into different time periods, such as a.m. peak, p.m. peak, and weekday. From this, averages and 95^{th} percentile travel times can be calculated for each segment along a roadway.

The important goods movement corridors were identified based on the Primary Goods Movement Network map (Figure 1), the truck route map and the periodically produced map of Calgary showing the percentage of traffic consisting of trucks. The routes chosen for monitoring are as follows:

- Barlow Trail S (from Peigan Trail to Deerfoot Trail SE)
- 52 St. E (from Peigan Trail to 114 Avenue SE)
- Glenmore Trail (from Deerfoot Trail to east city limits)
- Peigan Trail (from Deerfoot Trail to east city limits)
- Deerfoot Trail (from Peigan Trail to McKnight Blvd NE)

Beside these five corridors, an additional three corridors were identified as potential future corridors:

- Glenmore Trail (from west city limits to Deerfoot Trail SE)
- Stoney Trail E (from Glenmore Trail SE to 16 Avenue NE)
- Métis Trail (from McKnight Blvd NE to Stoney Trail N)

Based on available resources, it was decided to do three routes in the first year. Initially, the routes chosen were Barlow Trail, Glenmore Trail, and Deerfoot Trail. Due to data gathering constraints including safety, it was not possible to collect data along Deerfoot Trail.

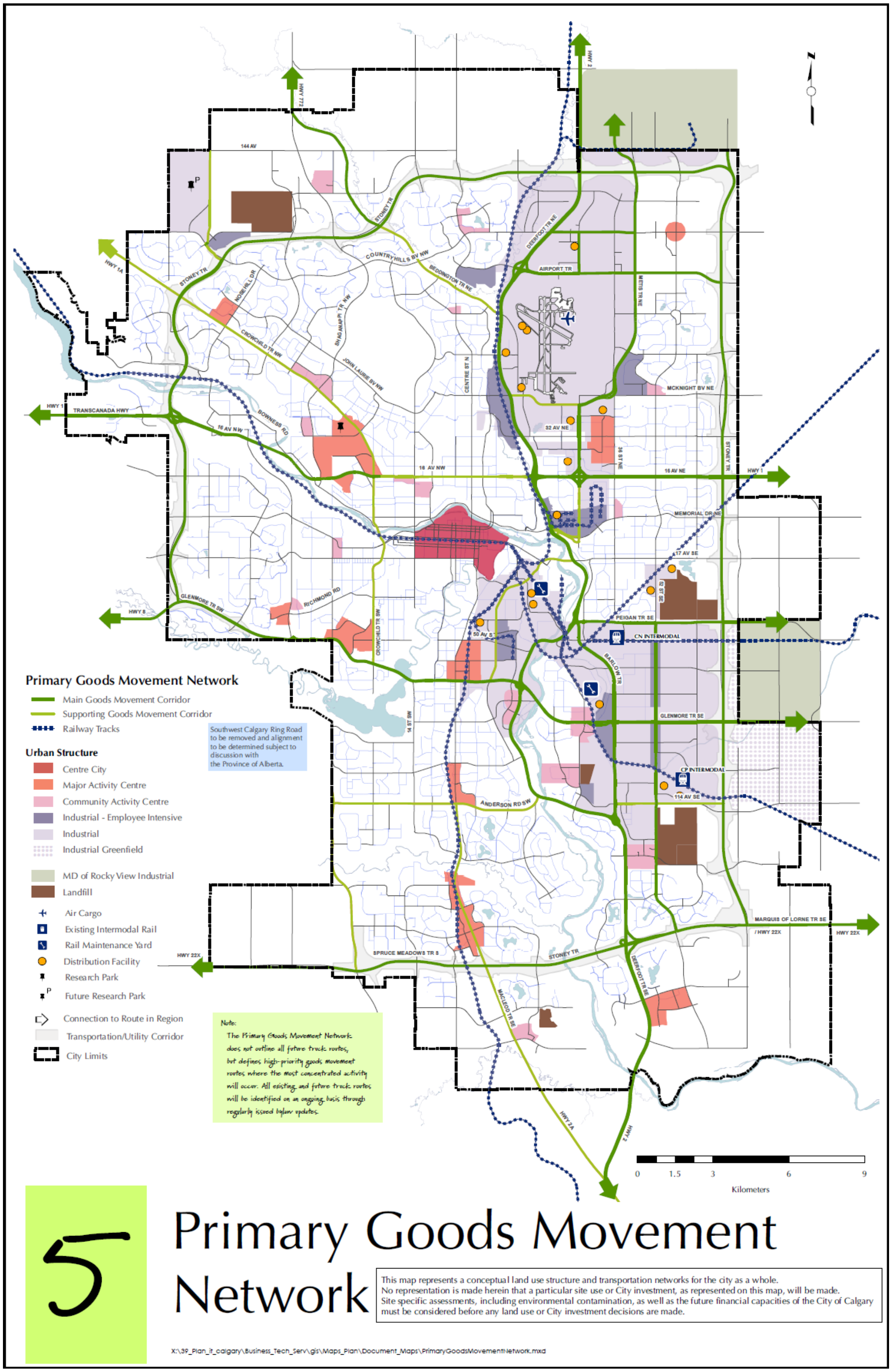

Figure 1. Calgary Transportation Plan 2009: Primary Goods Movement Network map

Based on the research on sample size for travel time estimation, it was concluded that the sample size should be 3% of the total vehicle volume within the monitored time period and that a minimum of 20 days of data collection is needed to determine travel time reliability. Furthermore, measuring the corridors three times a year would give us a seasonal variation and 60 days of data. To better understand the total vehicle volume and BluFax sample size relationship, using automatic hoses or similar means to count the traffic volume is recommended at least once during the measurement period (three times during a 3-month period). It was decided to exclude all outliers due to extreme weather, holidays, major incidents and extensive stops from the sample.

To ensure sufficient sample size along corridors, the routes were broken into segments. BluFax units were placed at locations between the segments to capture data from vehicles that do not travel the entire length of the corridor. The data from these segments were then aggregated into a single dataset for the entire corridor.

Both the average speed and travel time reliability indicators, included in the MDP/CTP Monitoring and Reporting Program, can be measured using the Bluetooth monitoring technology. The average speed will be used as a "customer" mobility indicator as it is easily understood by the public. The travel time reliability on selected goods movement corridors indicator is further discussed in the paper.

What is travel time reliability?

Day-to-day travel time can be significantly different than the average travel time with unexpected delays due to weather, traffic congestion or traffic incidents, to name a few. To account for variability, drivers usually build a time buffer into their trip planning to avoid arriving late.

How do we measure travel time reliability?

The Office of Operations of the U.S. Department of Transportation's Federal Highway Administration (FHWA) has developed a methodology for calculating travel time reliability. One of the recommended reliability measures is the buffer index. The buffer index represents the extra buffer time that most drivers add to their average travel time when planning trips to ensure on-time arrival. The travel time buffer index increases as travel time reliability worsens. The 95th percentile travel time is an indicator of how much delay there is on the heaviest travel days.

Using the buffer time or buffer index as a metric for travel time reliability is a better option than calculating and reporting the standard deviation of the travel time data. Standard deviation is a common statistical tool used in data analysis; however, it is not a concept that is readily understood by laypeople, including politicians and the general public. Once explained, the buffer time is a much more intuitive measure of the irregularities in travel time. People can relate to building a buffer into their travelling schedule. Even the idea of the 95th percentile travel time is easily explained as 'not late more than once in twenty trips.'

The buffer time (from FHWA definition) is the additional time that must be budgeted for in planning a trip to ensure arriving on-time. It is a measure of the expected variability in the time spent travelling a route. While most trips will not take as long as the buffer time, this time is still important as it is effectively lost to travel.

The 95th percentile and average travel times are calculated from the raw datasets.

The travel time buffer index is calculated as the difference between the 95th percentile travel time and average travel time, divided by the average travel time for a specific segment and time period.

$$Travel\ Time\ Buffer\ index\ (\%) = \frac{95th\ percentile\ travel\ time\ [minutes] - average\ travel\ time\ [minutes]}{average\ travel\ time\ [minutes]}$$

The travel time buffer index increases as the travel time reliability worsens. The 95th percentile travel time indicates how bad delay is on the worst travel days.

Planning Time Index is another metric for measuring travel time reliability. It represents the total travel time including typical and unexpected delays during the travel. The planning time index is calculated as the ratio of the 95th percentile travel time to free flow travel time.

$$Planning\ Time\ Index\ (\%) = \frac{95th\ percentile\ travel\ time\ [minutes]}{free\ flow\ travel\ time\ [minutes]}$$

The length of segment is the driving distance between two points, not the straight line distance as calculated between GPS points. The free-flow time was calculated as the travel time needed to drive the segment at the speed limit without stopping; theoretically, this is the "minimum" (legal) travel time.

As the selected corridors consist of several segments, the vehicle kilometres travelled are used as a weighting factor to calculate the average buffer index and planning time index values for the whole corridor.

$$Average\ index\ value = \frac{\sum_{i=1}^{n}(\text{index value n} \times \text{VKT n})\ \text{each section and time period}}{\sum_{i=1}^{n}(\text{VKT n})\ \text{each section and time period}}$$

The City of Calgary calculates daily vehicle kilometres travelled (VKT) annually. The calculation is based on the average daily, weekday traffic volumes on primary roadways as defined by the CTP. These average, 24-hour annual weekday traffic volumes are then multiplied by the single centre-line of the primary roadways to get daily vehicle kilometres travelled. The calculation is done in the GIS environment and the VKT value for each segment on the goods movement network is easily accessible.

ANALYSIS AND DISCUSSION

Tables 1 to 4 show the data measured and calculated for two corridors: Barlow Trail and Glenmore Trail. The data have been compiled by segment for different directions and time periods. Barlow Trail shows very little variability between the two periods in which data were collected. The greater variability in the Glenmore Trail data may be due to a shorter period of data collection the second time.

Due to the presence of drivers who made stops along the corridor, there are many extraneous data points or outliers in the data. The software included with the BluFax units was able to automatically flag most of these data points to be removed from the analysis. Sometimes, either due to significant congestion or a lack of good data to compare to, the software was unable to flag all of the outliers. All the data for all segments were not manually reviewed for the possible presence of these outliers. The segments that were checked varied. Some had excellent outlier identification and others segments did not have all outliers flagged. Failing to flag a significant portion of these outliers can impact the 95th percentile values, creating a source of error in the calculation of both indices.

Of particular note is the significant delay westbound on Glenmore Trail from 116 Street to 68 Street in the AM peak. The high index values for this segment and time period are an indicator of the variability of the travel time in the AM peak. The planning time index of 871% for this segment and time period indicates that the amount of time that drivers need to schedule to plan for the worst travel days is almost 9 times the free-flow travel time. The buffer index value of 195% indicates that drivers need to schedule their trips to allow three times the average travel time for the AM peak period. This means that, on average, twice the actual time spent travelling is wasted in arriving early and cannot be used for other activities.

On the Glenmore Trail segment between Deerfoot Trail and 18 Street E, the Graves Bridge over the Bow River was under construction. Surprisingly, this was not the greatest source of congestion and delay on this corridor. The worst segment on westbound Glenmore Trail is between 18 Street and 52 Street. There is an at-grade rail crossing on this segment. Further investigation into the causes of the delay on this segment is warranted to determine whether opportunities for mitigation exist.

The Barlow Trail data (Tables 1 and 2) show that the areas of greatest variability in delay are northbound from 114 Avenue to Glenmore Trail in the AM peak (Figure 2) and northbound from 61 Avenue to Peigan Trail (Figure 3).

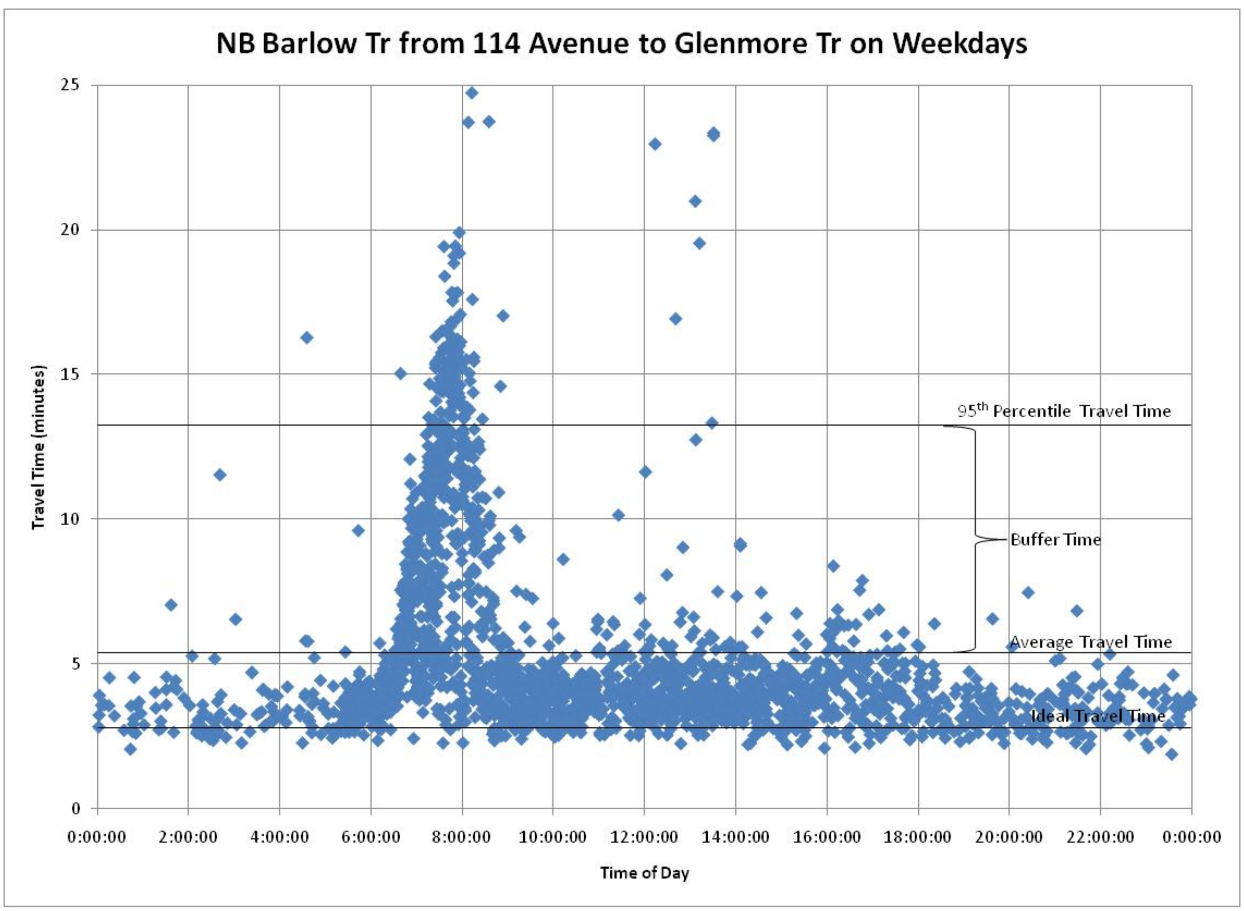

Figure 2. Northbound Barlow Trail from 114 Avenue to Glenmore Trail

The peak direction in the AM is primarily northbound, particularly at the south end of Barlow Trail. The data indicate this area and time period is experiencing congestion. Figure 2 shows the difference between 95th percentile travel time, buffer time, average travel time and ideal (free-flow) travel time on the northbound segment of Barlow Trail from 114 Avenue to Glenmore Trail on weekdays, over a 24-hour period. The duration of congestion can easily be seen, as the travel time has a very distinctive spike. This is a type of recurring congestion that is predictable and that drivers can plan for. This type of graph is common in the analysis.

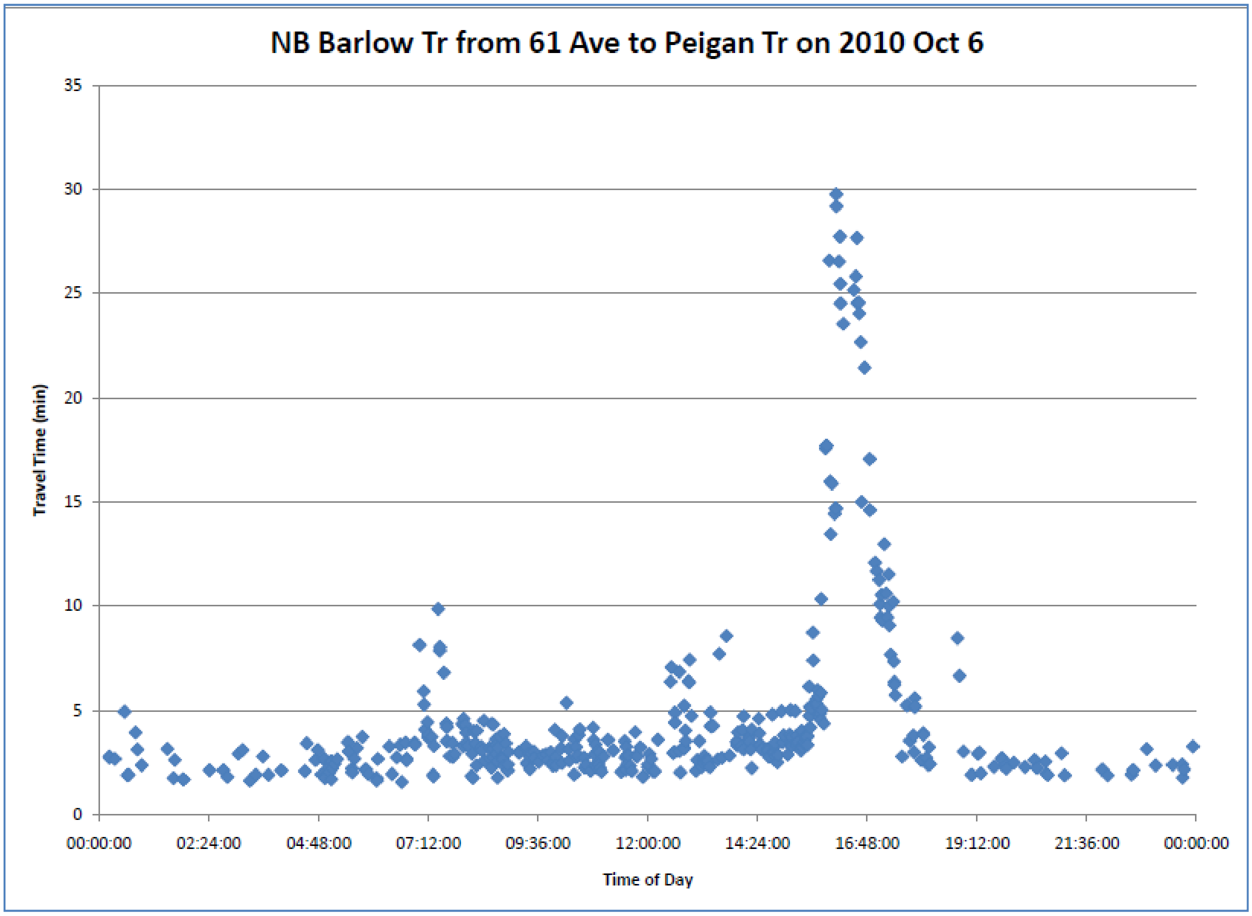

Figure 3. Northbound Barlow Trail from 61 Avenue to Peigan Trail on 2010 October 6

The congestion indicated on northbound Barlow Trail from 61 Avenue to Peigan Trail in the PM peak is due to an at-grade rail crossing that is frequently used for shunting trains in the adjacent rail yard. Figure 3 shows the travel time delay due to the train crossing northbound Barlow Trail between 61 Avenue and Peigan Trail. This type of delay can be just as severe as peak period congestion, but without the predictability of duration and when it will occur.

Figure 4 is a view of several days of data. The spikes show how common the train crossing is at this location.

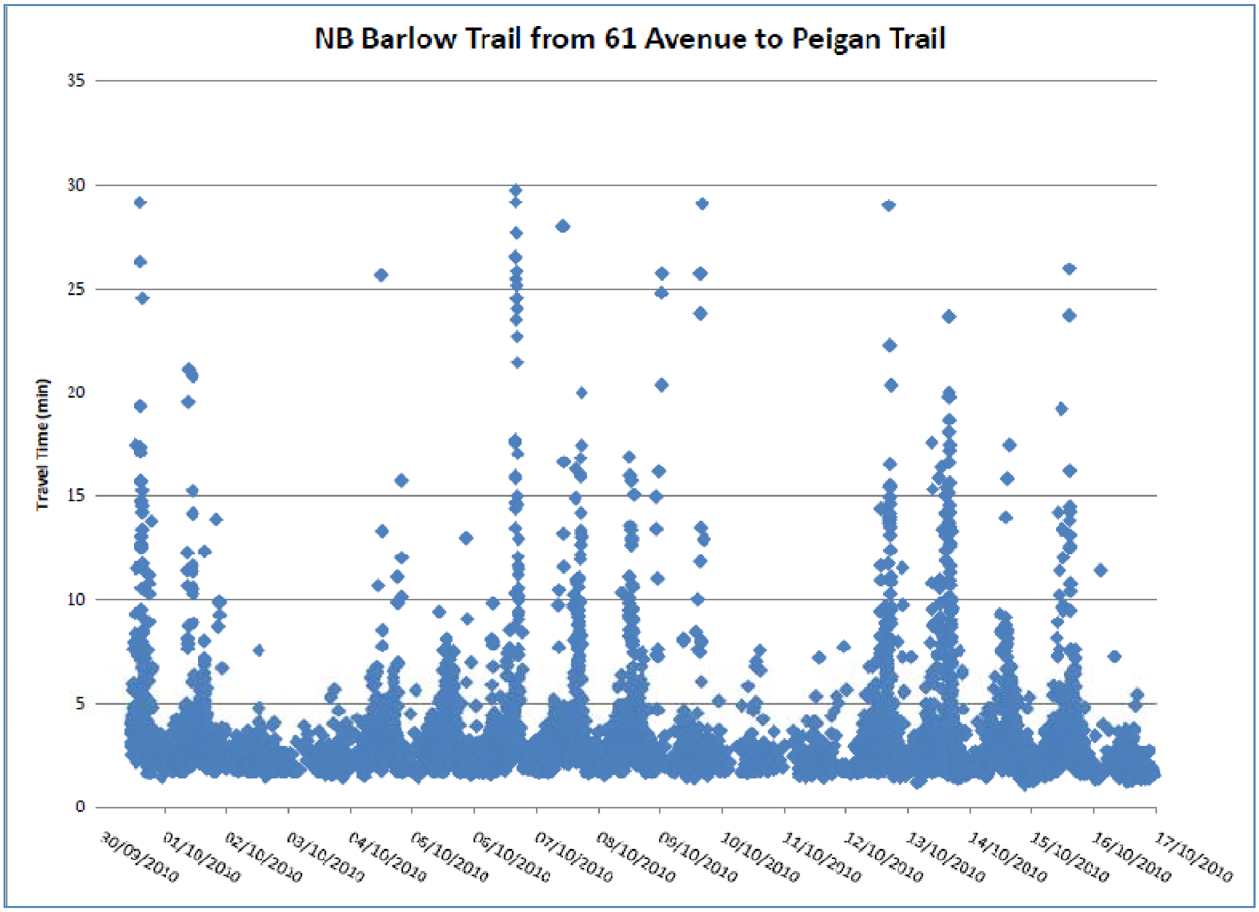

Figure4. Northbound Barlow Trail from 61 Avenue to Peigan Trail from 2010 Sep 30 to Oct 17

By applying the formula used to average the index values, it is possible to obtain one number representing the average state of the goods movement network. For the two corridors studied, the average buffer index is 72% for weekdays. This means on these corridors, drivers need to add 72% more time to their trip planning than they will need on average to be on time. The average planning index is 302% for the same corridors. When on-time arrival is critical, drivers must plan for three times the ideal travel time. There is greater volatility in the travel times on Barlow Trail as evidenced by the higher than average buffer index values for the Barlow Trail segments.

CONCLUSIONS AND RECOMMENDATIONS

The travel time studies undertaken on the selected goods movement corridors gave us several findings as noted in the following conclusions and lessons learned.

It is evident that Bluetooth technology is an effective way to measure travel time and reliability. It fulfilled the objective originally set at the beginning of the project. Bluetooth detection technology is cost effective as it does not need additional infrastructure such as toll tag infrastructure.

One of our next steps will be to compare the performance of the BluFax brand units to some of the other Bluetooth detection units on the market.

The sample size of 3% of the total vehicle volume within the monitored time period is sufficient for good representation of travel time reliability. In addition, chosen time period (60 days of data) is adequate for a statistical analysis if permanent data collection is not available.

The results of the travel time studies will be used to determine a baseline and a 10-year target for the goods movement indicators. The travel time reliability and average speed on selected goods movement corridors are included in the MDP/CTP supplementary indicators set. The travel time monitoring program has been developed on the goods movement corridors as shown in Figure 5. During the research, it was determined that when reporting the travel time reliability indicator to the public, the buffer time or buffer travel time index concept is readily understood compared to reporting the standard deviation of the travel time.

Furthermore, the results of the travel time studies will help identify possible infrastructure improvement projects in the future (e.g., a corridor with an at-grade rail crossing). Travel time reliability is an excellent criterion to include in the evaluation of these projects.

Having BluFax units permanently installed along selected corridors gives us an advantage by using the daily average (travel time and speed) for goods movement and the peak period (travel time and speed) for commuters. Installation of permanent Bluetooth detection on Deerfoot Trail, Crowchild Trail, and Glenmore Trail, as part of real-time traffic monitoring by the Roads Operations Centre, could directly benefit all drivers. The drivers can obtain the real-time travel information through The City's Traveller Information System map and roadside dynamic message signs.

Bluetooth technology can be used to monitor performance not only on the goods movement network, but on other transportation networks such as commuter routes. These multi-purpose results can be used for real-time travel information, infrastructure projects prioritization and MDP/CTP reporting.

Goods Movement Corridors Selected for Monitoring

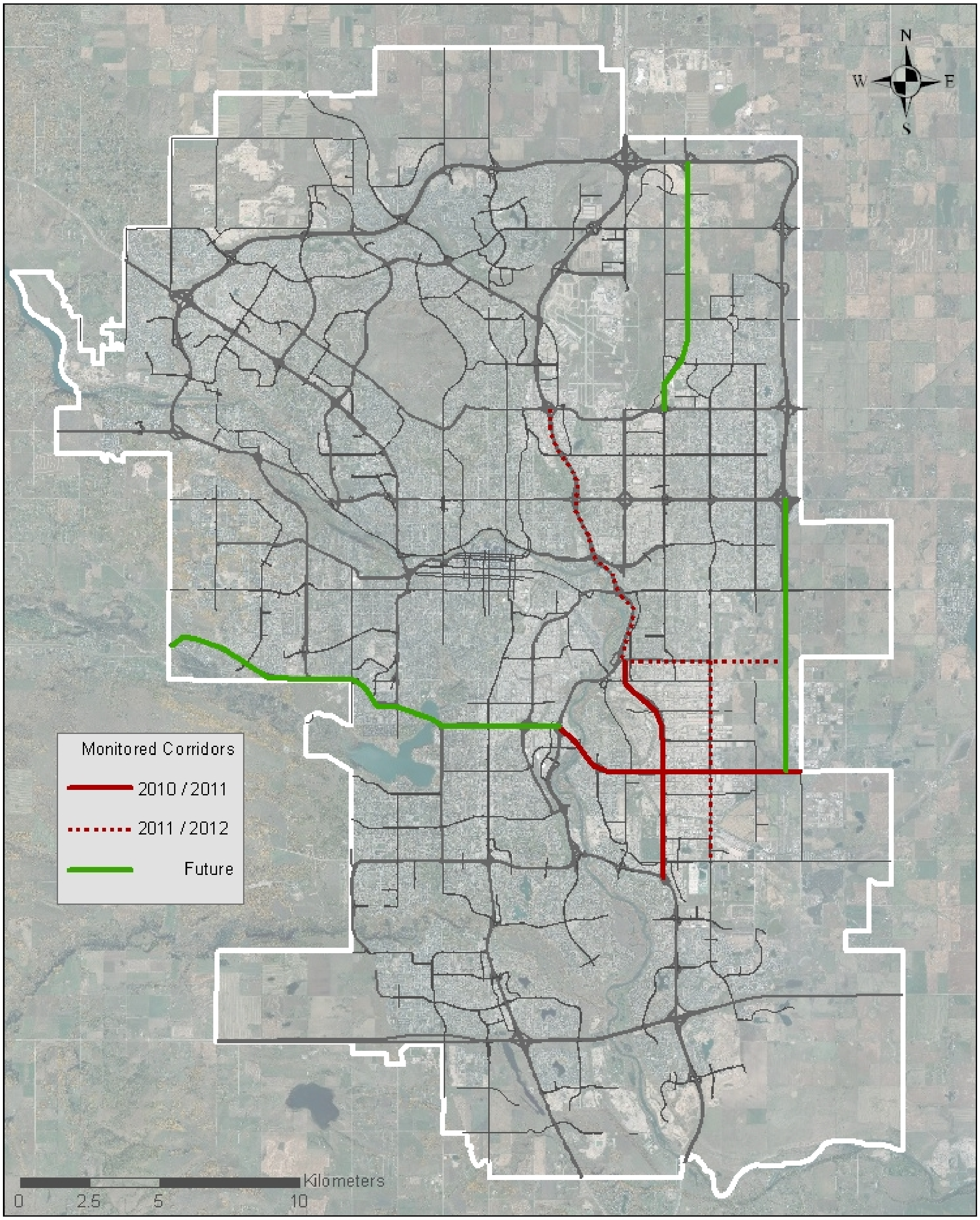

Figure 5 – Goods Movement Corridors Selected for Monitoring

REFERENCES

1. Office of Operations of the U.S. Department of Transportation's Federal Highway Administration. http://ops.fhwa.dot.gov/publications/tt_reliability/TTR_Report.htm

2. City of Calgary. Municipal Development Plan, 2009. http://www.calgary.ca/mdp

3. City of Calgary. Calgary Transportation Plan, 2009. http://www.calgary.ca/ctp

4. City of Calgary. Transportation Planning. Transportation Data Division. http://www.calgary.ca/portal/server.pt/gateway/PTARGS_0_0_780_237_0_43/http%3B/content.calgary.ca/CCA/City+Hall/Business+Units/Transportation+Planning/Transportation+data/Transportation+Data.htm

5. City of Calgary. Vehicle Kilometres Travelled in Calgary: Proposed Methodology. http://www.calgary.ca/docgallery/bu/trans_planning/data/vehicle_km_travelled_calgary.pdf

6. City of Calgary. Roads. Traffic Division. Truck Route Map. http://www.calgary.ca/docgallery/BU/engineering_services/emaps/calgary_truck_routes_map.pdf

7. Traffax, Inc. Manufacturer of BluFax. http://www.traffaxinc.com/

TABLES

Barlow Trail S.E.	SB				NB				Total
	north	middle	south	Total SB	south	middle	north	Total NB	Total
(speed limit 70km/h) 2010 Sep 30 - 2010 Oct 17	Peigan to 61 Ave	61 Ave to Glenmore	Glenmore to 114 Ave		114 Ave to Glenmore	Glenmore to 61 Ave	61 Ave to Peigan		
length of segment (km)	2.36	2.20	3.24	7.80	3.24	2.20	2.36	7.80	7.80
free-flow time (min)	2.0	1.9	2.8	6.7	2.8	1.9	2.0	6.7	6.7
24-hr weekday Vehicle Kilometres Travelled (VKT)	34220	34100	59130	127450	59130	34100	34220	127450	254900
AM peak period (7-9am) average travel time (min)	3.5	3.0	4.1		9.4	3.5	3.4		
AM peak period 95th percentile travel time (min)	5.5	4.1	5.6		16.2	4.7	4.9		
Buffer index (%)	57%	37%	37%	43%	73%	36%	47%	56%	49%
planning time index (%)	274%	215%	202%	225%	585%	250%	245%	404%	314%
number of AM peaks	15	13	13	-	13	13	15	-	-
number of records	1231	551	293	-	587	779	990	-	-
PM peak period (4-6pm) average travel time (min)	3.8	4.0	5.7		4.5	3.3	5.4		
PM peak period 95th percentile travel time (min)	7.2	7.6	10.1		6.4	4.7	13.8		
Buffer index (%)	90%	89%	77%	84%	44%	43%	155%	73%	79%
planning time index (%)	357%	405%	364%	373%	231%	248%	681%	356%	364%
number of PM peaks	16	14	14	-	14	14	16	-	-
number of records	953	1031	1536	-	138	416	1178	-	-
24-hr weekday average travel time (min)	4.1	3.3	4.2		5.7	3.3	4.1		
weekday 95th percentile travel time (min)	8.2	5.6	7.8		14.0	4.7	9.8		
Buffer index (%)	102%	69%	88%	87%	143%	44%	141%	116%	101%
planning time index (%)	405%	298%	282%	319%	503%	248%	483%	429%	374%
number of weekdays*	17	16	16	-	16	16	17	-	-
number of records	7379	2084	4955	-	2415	3564	7313	-	-

* includes partial days where data was not recorded for a full 24 hours

Table 1. Barlow Trail SE from Peigan Trail to 114 Avenue S (data collected from 2010 Sep 30 to 2010 Oct 17)

Barlow Trail S.E.	SB				NB				Total
	north	middle	south	Total SB	south	middle	north	Total NB	Total
(speed limit 70km/h) 2011 Jan 12 - 2011 Feb 18-22	Peigan to 61 Ave	61 Ave to Glenmore	Glenmore to 114 Ave		114 Ave to Glenmore	Glenmore to 61 Ave	61 Ave to Peigan		
length of segment (km)	2.36	2.20	3.24	7.80	3.24	2.20	2.36	7.80	7.80
free-flow time (min)	2.0	1.9	2.8	6.7	2.8	1.9	2.0	6.7	6.7
24-hr weekday Vehicle Kilometres Travelled (VKT)	34220	34100	59130	127450	59130	34100	34220	127450	254900
AM peak period (7-9am) average travel time (min)	3.6	3.1	3.8		7.9	3.6	3.6		
AM peak period 95th percentile travel time (min)	5.3	4.4	5.3		14.9	4.8	5.3		
Buffer index (%)	47%	43%	39%	42%	89%	35%	48%	64%	53%
planning time index (%)	262%	236%	192%	222%	535%	256%	261%	387%	305%
number of AM peaks	27	27	27	-	27	27	27	-	-
number of records	1624	740	583	-	1244	953	1363	-	-
PM peak period (4-6pm) average travel time (min)	3.5	4.5	5.7		4.8	3.3	4.7		
PM peak period 95th percentile travel time (min)	5.6	8.4	10.0		7.0	4.8	11.8		
Buffer index (%)	59%	88%	75%	74%	48%	44%	154%	75%	75%
planning time index (%)	278%	448%	358%	361%	253%	255%	583%	343%	352%
number of PM peaks	28	27	27	-	27	27	28	-	-
number of records	1320	1422	2518	-	185	305	1423	-	-
24-hr weekday average travel time (min)	4.0	3.5	4.2		5.8	3.5	4.0		
weekday 95th percentile travel time (min)	8.3	5.8	7.7		13.7	4.9	8.9		
Buffer index (%)	105%	68%	82%	84%	138%	39%	122%	107%	96%
planning time index (%)	409%	309%	276%	321%	494%	260%	441%	417%	369%
number of weekdays*	28	28	28	-	28	28	28	-	-
number of records	10450	6442	7925	-	3718	3423	9713	-	-

* includes partial days where data was not recorded for a full 24 hours

Table 2. Barlow Trail SE from Peigan Trail to 114 Avenue S (data collected from 2011 Jan 12 to 2011 Feb 22)

Glenmore Trail S.E.	EB					WB					Total
	Segment 1	Segment 2	Segment 3	Segment 4	Total EB	Segment 4	Segment 3	Segment 2	Segment 1	Total WB	
(speed limit 80km/h) 2010 Oct 20-26, 2010 Nov 15-Dec 22	Deerfoot Tr to 18 St	18 St SE to 52 St SE	52 St SE to 68 St SE	68 St SE to 116 St SE		116 St SE to 68 St SE	68 St SE to 52 St SE	52 St SE to 18 St SE	18 St to Deerfoot		
length of segment (km)	3.20	3.20	2.17	4.10	12.67	4.10	2.17	3.20	3.20	12.67	12.67
free-flow time (min)	2.4	2.4	1.6	3.1	9.5	3.1	1.6	2.4	2.4	9.5	9.5
24-hr weekday Vehicle Kilometres Travelled (VKT)	100800	51200	20615	34850	207465	34850	20615	51200	100800	207465	414930
AM peak period (7-9am) average travel time (min)	2.8	4.9	2.6	4.6	15.0	9.1	2.5	6.3	2.8	20.7	17.9
AM peak period 95th percentile travel time (min)	4.1	7.8	3.5	6.1	20.7	26.8	3.6	10.3	4.1	33.9	27.3
Buffer index (%)	45%	58%	34%	32%	45%	195%	40%	64%	44%	74%	60%
planning time index (%)	170%	325%	217%	199%	218%	871%	218%	431%	170%	357%	287%
number of AM peaks	22	22	23	23	-	23	23	21	22	-	-
number of records	1400	560	471	148	-	253	456	267	649	-	-
PM peak period (4-6pm) average travel time (min)	2.8	4.9	3.3	6.0	16.9	5.1	2.6	8.7	2.7	18.9	17.9
PM peak period 95th percentile travel time (min)	3.8	7.9	6.7	8.6	23.4	7.0	3.6	18.7	4.0	31.8	27.6
Buffer index (%)	39%	62%	104%	43%	52%	38%	42%	116%	52%	64%	32%
planning time index (%)	160%	329%	410%	279%	247%	227%	224%	780%	168%	334%	291%
number of PM peaks	21	21	24	24	-	24	24	20	21	-	-
number of records	1209	615	922	604	-	180	513	274	797	-	-
24-hr weekday average travel time (min)	2.7	4.4	2.7	5.0	14.7	5.8	2.5	5.7	2.5	16.4	15.6
weekday 95th percentile travel time (min)	3.4	7.3	3.7	7.4	19.7	9.0	3.5	11.6	3.3	24.4	22.0
Buffer index (%)	28%	68%	38%	47%	42%	57%	41%	105%	29%	54%	27%
planning time index (%)	143%	304%	225%	240%	207%	294%	213%	485%	136%	256%	232%
number of weekdays*	24	24	27	26	-	26	27	24	24	-	-
number of records	10266	4856	5699	2596	-	1654	3549	2137	5643	-	-

* includes partial days where data was not recorded for a full 24 hours

Table 3. Glenmore Trail SE from Deerfoot Trail to 116 Street E (data collected on 2010 Oct 20-26 and from 2010 Nov 15 to 2010 Dec 22)

Glenmore Trail S.E. (speed limit 80km/h) 2011 Apr 8 - 2011 Apr 29	EB					WB					Total
	Segment 1	Segment 2	Segment 3	Segment 4	Total EB	Segment 4	Segment 3	Segment 2	Segment 1	Total WB	
	Deerfoot Tr to 18 St	18 St SE to 52 St SE	52 St SE to 68 St SE	68 St SE to 116 St SE		116 St SE to 68 St SE	68 St SE to 52 St SE	52 St SE to 18 St SE	18 St to Deerfoot		
length of segment (km)	3.20	3.20	2.17	4.10	12.67	4.10	2.17	3.20	3.20	12.67	12.67
free-flow time (min)	2.4	2.4	1.6	3.1	9.5	3.1	1.6	2.4	2.4	9.5	9.5
24-hr weekday Vehicle Kilometres Travelled (VKT)	100800	51200	20615	34850	207465	34850	20615	51200	100800	207465	414930
AM peak period (7-9am) average travel time (min)	3.1	5.4	2.5	4.6		11.9	2.3	6.5	2.4		
AM peak period 95th percentile travel time (min)	6.1	8.3	3.4	5.9		23.2	3.1	14.9	3.0		
Buffer index (%)	100%	53%	35%	28%	70%	96%	34%	130%	26%	64%	67%
planning time index (%)	255%	345%	209%	191%	262%	755%	190%	620%	125%	359%	311%
number of AM peaks	12	10	7	6	-	6	7	10	12	-	-
number of records	1794	581	256	78	-	179	263	423	1605	-	-
PM peak period (4-6pm) average travel time (min)	2.7	5.0	4.9	6.4		5.0	2.3	10.1	2.2		
PM peak period 95th percentile travel time (min)	4.2	8.3	11.5	8.3		6.2	3.1	19.6	2.6		
Buffer index (%)	57%	67%	137%	29%	63%	25%	36%	94%	17%	39%	20%
planning time index (%)	177%	346%	708%	269%	287%	202%	191%	818%	108%	307%	297%
number of PM peaks	13	12	9	8	-	8	9	12	13	-	-
number of records	1693	725	581	395	-	82	317	501	2280	-	-
24-hr weekday average travel time (min)	2.6	4.7	3.6	5.3		6.8	2.3	6.3	2.3		
weekday 95th percentile travel time (min)	3.7	7.5	10.3	8.1		17.8	3.2	13.7	2.7		
Buffer index (%)	40%	59%	182%	52%	61%	162%	39%	118%	19%	69%	65%
planning time index (%)	154%	314%	630%	262%	259%	578%	197%	572%	112%	312%	285%
number of weekdays*	13	12	9	8	-	8	9	12	13	-	-
number of records	13497	5215	3078	1414	-	943	2151	3714	13575	-	-

* includes partial days where data was not recorded for a full 24 hours

Table 4. Glenmore Trail SE from Deerfoot Trail to 116 Street E (data collected from 2011 Apr 8 to 2011 Apr 29)