
2611 Queensview Drive, Ottawa, ON K2B 8K2
Telephone: 613-829-2800 ~ Fax: 613-829-8299 ~ www.genivar.com

To: Matt Morkem **Date:** 23 April 2014
From: Daniel Riendeau **Project No.:** 131-18048-00
Project: Portsmouth Pumping Station Flow Direction and Front Road Trunk Water Main Interconnection
Subject: Traffic Analysis of Lane Closure on King Street and Front Road, Revision 2

Introduction

The purpose of this memo is to analyse the traffic impact of the construction of a force main and water main along the Front Road / King Street / Union Street corridor between Sand Bay Lane and Gardiner Street in Kingston, Ontario. During construction, it will be necessary to reduce or close lanes to facilitate the installation of the pipes.

Existing Configuration

Front Road is a 50 km/h arterial that extends from Kingston Airport to Cataraqui Bay and widens to a 4-lane undivided roadway east of Days Road. It becomes King Street east of Cataraqui Bay and narrows to a 2-lane roadway at McDonald Avenue (upstream of Union Street). Speed is reduced to 40 km/h between Portsmouth Avenue and Gardiner Street.

Traffic Volumes

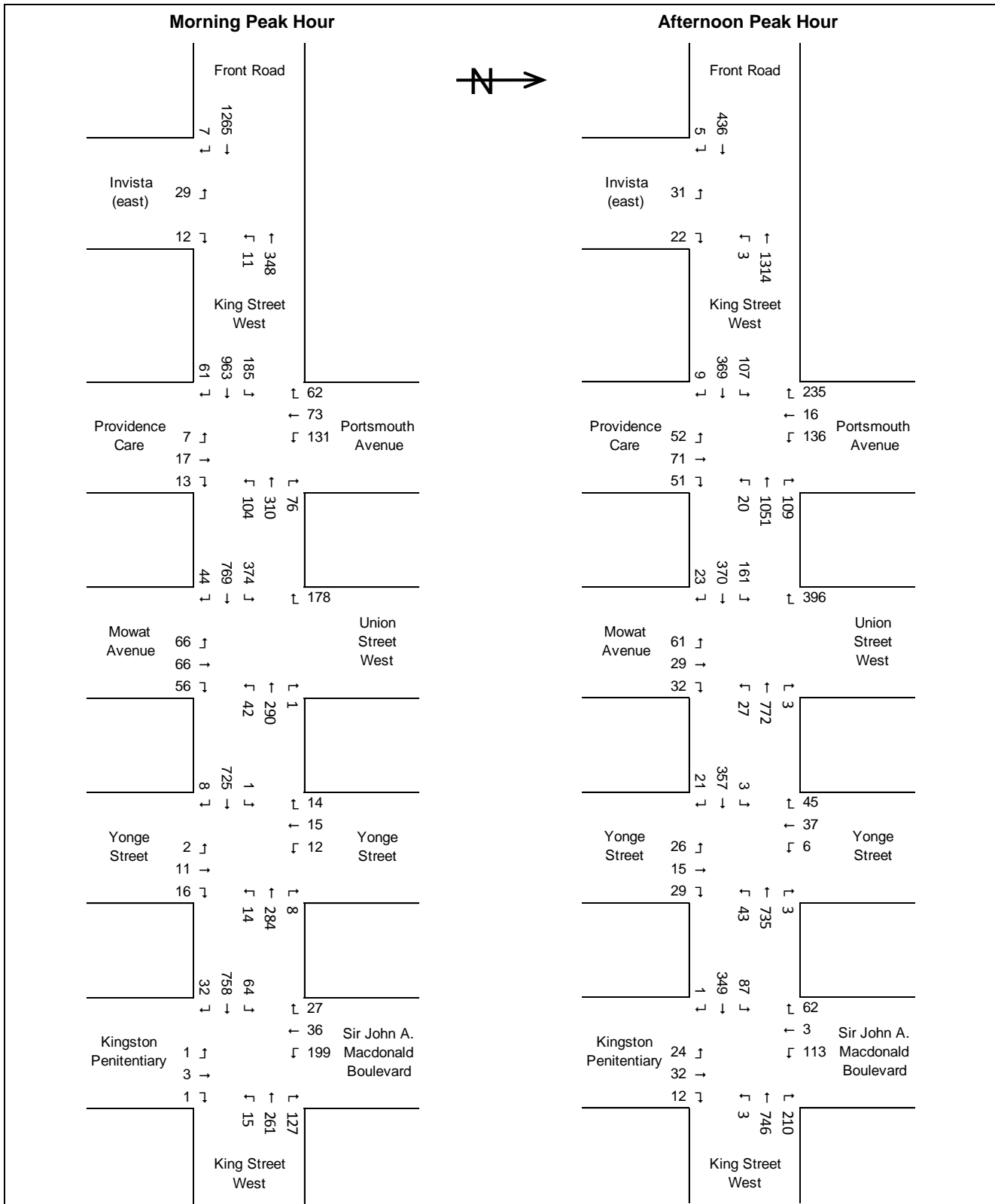
Table 1 presents the traffic counts that were used to determine the traffic volumes for this analysis.

Table 1 – Turning Movement Counts Used for Analysis

| Intersection | Date |
|---|-----------------------------|
| Front Road / Days Road | Thursday, 8 November 2012 |
| Front Road / west access to Invista | Thursday, 11 April 2013 |
| Front Road / Sand Bay Lane (east access to Invista) | Thursday, 11 April 2013 |
| King Street / Portsmouth Avenue | Wednesday, 11 May 2011 |
| King Street / Union Street / Mowat Avenue | Wednesday, 11 April 2012 |
| King Street / Yonge Street | Wednesday, 23 November 2011 |
| King Street / Sir John A. Macdonald Boulevard | Thursday, 9 June 2011 |

Count volumes were balanced to ensure consistent volumes between intersections, with more weight given to the most recent counts. The balanced volumes are presented in **Figure 1**.

Figure 1 – Balanced Traffic Volumes



Synchro Parameters

The analysis of traffic operations was performed using the software tool Synchro 8 implementing the Highway Capacity Manual (HCM) 2000 methodology.

The traffic performance results should be interpreted as follows:

- **Volume-to-Capacity (V/C) Ratio:** represents the level of utilization of a turning movement. Typically, a V/C value below 0.85 indicates efficient operations whereas a value above 1 indicates congestion problems.
- **Average Delay per Vehicle and Level of Service (LOS):** represents the drivers' level of satisfaction. The LOS is directly based on the average delay. A level of service 'E' or 'F' may require corrective measures depending on the context.

Traffic signal timings are assumed to be optimized for analysis purpose.

Traffic Analysis of the Existing Conditions

Table 2 shows the Synchro results for the balanced traffic volumes.

Table 2 – Intersection Performance, Existing Conditions

| Intersection | Morning Peak Hour | | | | Afternoon Peak Hour | | | |
|---|--------------------------|-------------------|--------------------------------|--------------------------------|--------------------------|-------------------|--------------------------------|--------------------------------|
| | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | |
| | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² |
| Front Road / Sand Bay Lane | 0.50 | EBT/R | 5 A | NBL | 0.55 | WBL/T | 5 A | NBL |
| King Street / Portsmouth Avenue | 0.78 | SBL/T | 19 B | SBL/T | 0.75 | SBL/T | 15 B | SBL/T |
| King Street / Union Street / Mowat Avenue | 0.73 | NBL/T/R | 11 B | NBL/T/R | 0.95 | SBR | 22 C | SBR |
| King Street / Yonge Street | 0.54 | EBL/T/R | 5 A | SBL | 0.63 | WBL/T/R | 9 A | NBL |
| King Street / Sir John A. Macdonald Boulevard | 0.79 | SBL | 17 B | SBL | 0.77 | WBT | 17 B | SBL |

1. Level of Service or LOS is based on average control delay (in seconds) - For signalized intersections, "LOS" represents the overall intersection LOS.

2. Represents the movement with the worst LOS.

Near Capacity (V/C ≥ 0.85)

The results indicate that none of the intersections under study experience any traffic capacity problem. The intersection at Union Street / Mowat Avenue appears close to capacity in the afternoon, but this is caused by the Stop sign located on the southbound right turn channelization.

Routing Options

During the evaluation of the potential options for routing, it was determined that there are minimal variations to the route for the infrastructure west of Portsmouth Avenue. Therefore, it was concluded that the infrastructure west of Portsmouth Avenue would follow King Street West / Front Road until approximately Sandy Bay Lane, at which point it would turn south and connect to the Cataraqui Bay Wastewater Treatment Plant. Below is a description of the routing options east of Portsmouth Avenue.

Option 5: King Street

This option includes installing the force main from the Portsmouth pumping station (in Aberdeen Park near Gardiner Street) along the King Street right-of-way (ROW) to Portsmouth Avenue at which point it follows the alignment indicated above.

Option 6: Kennedy Street, Union Street, King Street

This option includes installing the force main from the Portsmouth pumping station along the Kennedy Street ROW to Union Street West, then southwest along the Union Street West ROW to King Street West and then along the King Street West ROW to Portsmouth Avenue, at which point it follows the alignment indicated above.

Option 7: Kennedy Street, Baiden Street, King Street

This option includes installing the force main from the Portsmouth pumping station along the Kennedy Street ROW to Church Street, then, on a short distance, along the Church Street ROW to Baiden Street, then along the Baiden Street ROW to Portsmouth Avenue and south along the Portsmouth Avenue ROW on a short distance to King Street West, at which point it follows the alignment indicated above.

Option 5: Route on King Street and Front Road

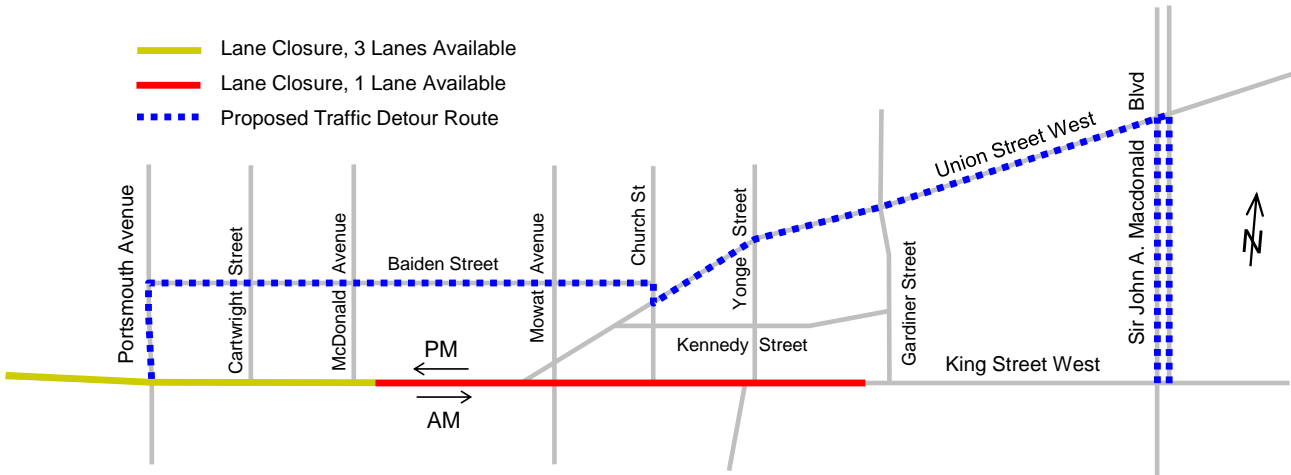
The construction of the pipe requires the closure of one lane between Sand Bay Lane and Gardiner Street. This means that only three lanes will be available from Sand Bay Lane to McDonald Avenue and only one lane will be available from McDonald Avenue to Gardiner Street.

Because of the relatively high traffic on King Street (more than 800 vehicles per hour in the peak direction) and of the presence of intersections within the construction zone, alternate traffic flow on a single lane (by having traffic control persons or temporary signals, for example) is not feasible.

Therefore, only one direction of traffic should be allowed during a certain period and the other direction will have to be diverted to a detour route.

Figure 2 illustrates the lane closure and the proposed traffic detour route for this routing option.

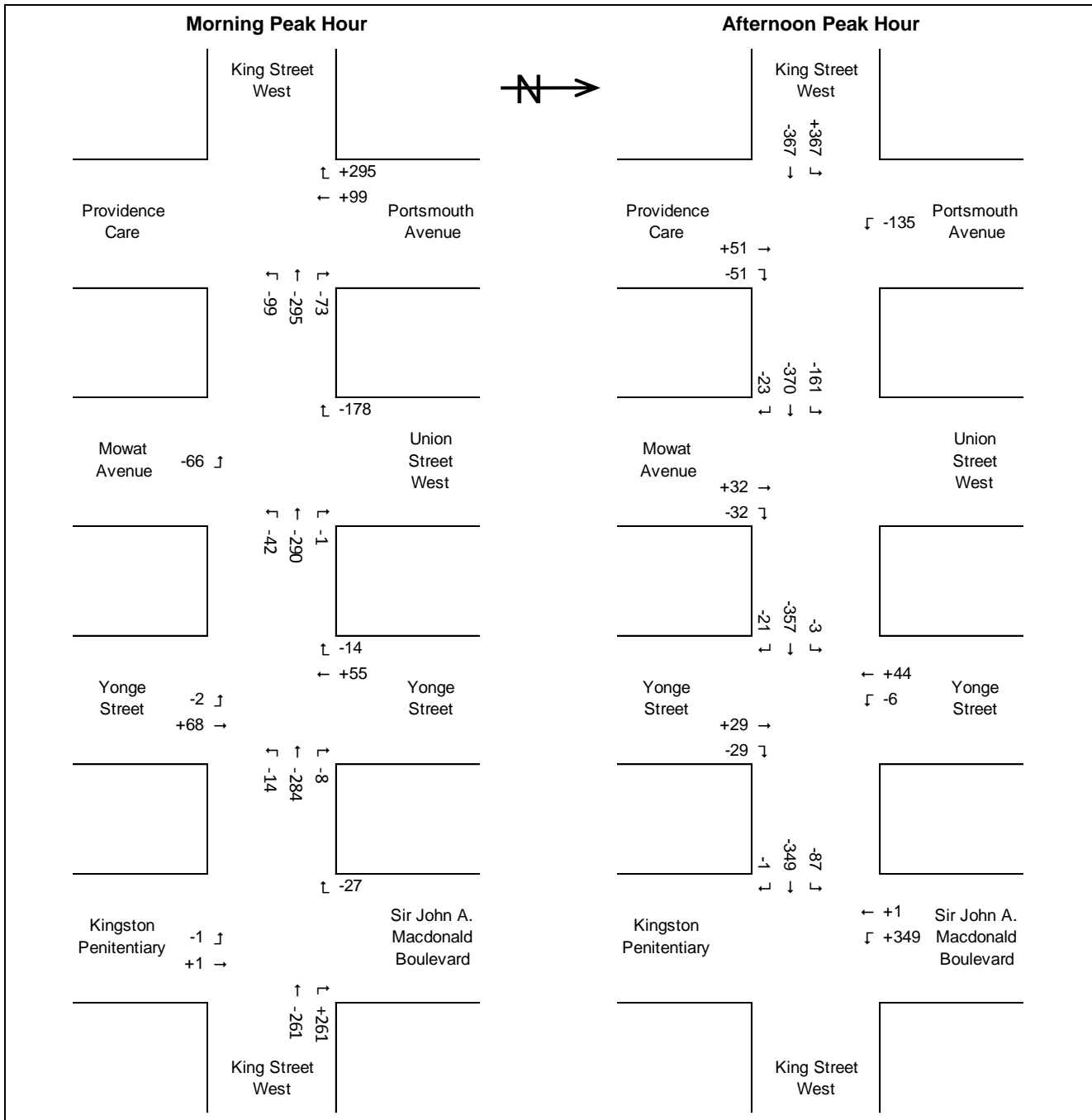
Figure 2 – Lane Closure and Proposed Traffic Detour Route, Option 5



The present analysis assumes that the peak direction will be allowed (eastbound in the morning, westbound in the afternoon) between Portsmouth Avenue and Sir John A. Macdonald Boulevard while the non-peak direction will be diverted through Baiden Street and Union Street. The analysis also assumes all movements will be allowed at all intersections (except the movements in the direction being diverted).

Figure 3 presents the impact of the lane closure on traffic volumes. The diverted traffic volumes vary from 260 to 370 vehicles per hour.

Figure 3 – Changes in Traffic Volumes Caused by Lane Closure on King Street and Front Road



It is expected that, between Sand Bay Lane and Portsmouth Avenue, 2 lanes will be provided for the peak direction and 1 lane for the opposite direction (i.e. the middle lane will change direction between the morning and the afternoon peak hours). It is also assumed that, between Portsmouth Avenue and Sir John A. Macdonald Boulevard, 1 lane will be provided for the peak direction while the opposite direction will be diverted through Baiden Street and Union Street.

Table 3 shows the Synchro results for the scenario with the removal of one lane.

Table 3 – Intersection Performance, Lane Removal on King Street and Front Road

| Intersection | Morning Peak Hour | | | | Afternoon Peak Hour | | | |
|---|--------------------------|-------------------|--------------------------------|--------------------------------|--------------------------|-------------------|--------------------------------|--------------------------------|
| | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | |
| | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² |
| Front Road / Sand Bay Lane | 0.50 | EBT/R | 5 A | NBL | 0.55 | WBL/T | 5 A | NBL |
| King Street / Portsmouth Avenue | 0.90 | SBL/T | 19 B | SBL/T | 1.06 | WBT/R | 54 D | WBT/R |
| King Street / Union Street / Mowat Avenue | 0.99 | EBL/T/R | 36 D | NBT/R | 0.94 | SBR | 22 C | SBR |
| King Street / Yonge Street | 0.58 | EBL/T/R | 12 B | SBT | 0.66 | WBL/T/R | 16 B | NBL |
| King Street / Sir John A. Macdonald Boulevard | 0.79 | SBL | 16 B | SBL | 1.06 | WBT | 60 E | SBL |

1. Level of Service or LOS is based on average control delay (in seconds) - For signalized intersections, "LOS" represents the overall intersection LOS.
2. Represents the movement with the worst LOS.

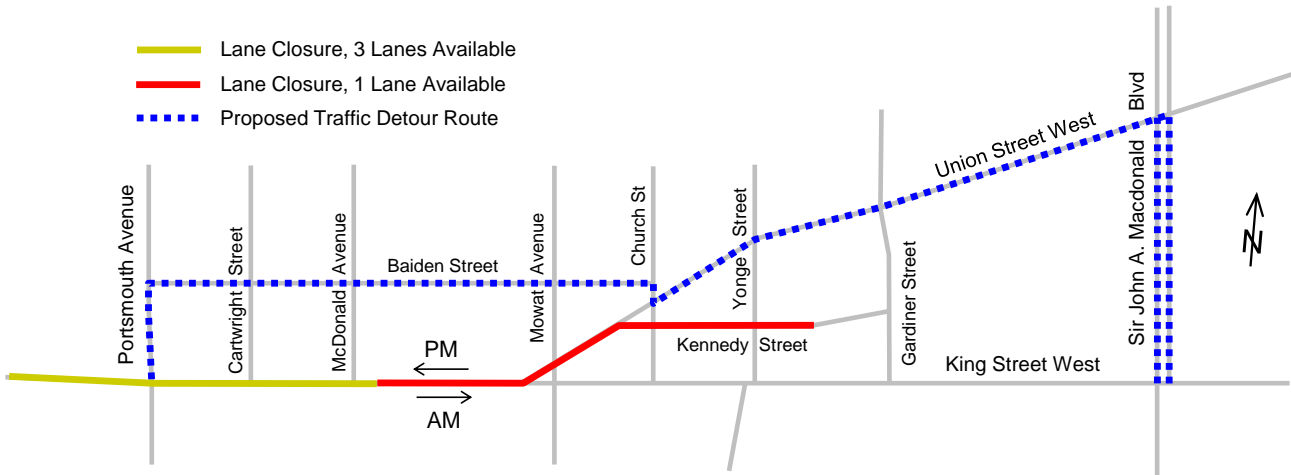
Near Capacity (V/C ≥ 0.85)
Above Capacity (V/C ≥ 1.00)

The intersections at Portsmouth Avenue and Sir John A. Macdonald Boulevard are expected to operate slightly (6%) above capacity during the afternoon peak hour. This is because of the diverted (eastbound) traffic having to cross the path of the non-diverted (westbound) traffic. In reality, once drivers are aware of the presence of the construction zone, they will tend to avoid the area. Therefore, traffic operations are expected to be better than what the results indicate.

Option 6: Route on Kennedy Street, Union Street, King Street, and Front Road

Same as for Option 5, the construction of the pipe requires the closure of one lane between Sand Bay Lane and Gardiner Street. However, the difference with Option 5 is that east of Mowat Avenue the pipe routing is located along Union Street and Kennedy Street instead of King Street, as illustrated on **Figure 4**.

Figure 4 – Lane Closure and Proposed Traffic Detour Route, Option 6



The impact on traffic of this routing option is expected to be the same as for Option 5 since the segment of King Street between McDonald Avenue and Union Street will be reduced to one lane all the same, forcing the non-peak direction of traffic to be diverted to Baiden Street.

As for Kennedy Street, the traffic volume is expected to be very low and both Union Street and King Street may be used as a detour route. Therefore, the closure of one lane on Kennedy Street will not have a significant impact on traffic operations.

Option 7: Route on Kennedy Street, Baiden Street, King Street, and Front Road

From Portsmouth Avenue to Gardiner Street, an alternative option to constructing the force main underneath King Street is to build it underneath Portsmouth Avenue, Baiden Street, Church Street, and Kennedy Street. This implies the closure of one lane on these streets, as shown on **Figure 5**. This would allow 2-way traffic on King Street during construction and the overall impact on traffic will be lesser since Baiden Street, Church Street and Kennedy Street are local residential streets with assumedly low traffic. If a usable width of 6 m (3 m per direction) can be maintained, then these streets may be kept as 2-way roadways and “Local Traffic Only” tab signs (TC7-tB) should be installed along with the Detour-Turn Off/Diversion signs (TC-7R). Otherwise, they should be signed as one-way roadways.

Figure 5 – Lane Closure, Option 7



This alternative implies that part of the force main will have to be constructed underneath Portsmouth Avenue between King Street and Baiden Street. This will require the closure of one lane on Portsmouth Avenue between King Street and Baiden Street. At this location, Portsmouth Avenue contains 3 lanes and is sufficiently wide to allow one lane per direction during construction. Therefore, two options may be considered:

Option 7A: Closure of the southbound right turn lane including the channelization

This option would allow full traffic in both directions on Portsmouth Avenue but will require that the southbound right turn movement be performed on the same lane as the through and the left turn movements.

A Synchro analysis reveals that the intersection at King Street / Portsmouth Avenue would operate satisfactorily during both peak hours (with optimized timings). Results are shown in **Table 4** (the traffic at other intersections does not change; see **Table 3** for the intersection of Front Road / Sand Bay Lane and **Table 2** for the intersections east of Portsmouth Avenue);

Table 4 – Intersection Performance, Alternative Option 7A

| Intersection | Morning Peak Hour | | | | Afternoon Peak Hour | | | |
|---------------------------------|--------------------------|-------------------|--------------------------------|--------------------------------|--------------------------|-------------------|--------------------------------|--------------------------------|
| | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | |
| | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² |
| King Street / Portsmouth Avenue | 0.86 | SBL/T/R | 22 C | SBL/T/R | 0.90 | SBL/T/R | 28 C | SBL/T/R |

1. Level of Service or LOS is based on average control delay (in seconds) - For signalized intersections, "LOS" represents the overall intersection LOS.

2. Represents the movement with the worst LOS.

Near Capacity (V/C ≥ 0.85)
 Above Capacity (V/C ≥ 1.00)

Option 7B: Closure of the southbound through / left turn lane

This option would allow full traffic in the northbound direction but only the southbound right turn movement will be possible (through the channelization). Therefore, a detour route will have to be implemented for the traffic heading to the Providence Care facilities or to King Street eastbound (for example through Johnson Street and Sir John A. Macdonald Boulevard).

Figure 6 presents the changes in traffic volumes caused by this option. A Synchro analysis reveals that the intersections on King Street between Portsmouth Avenue and Sir John A. Macdonald Boulevard perform satisfactorily during both peak hours (with optimized timings at Sir John A. Macdonald Boulevard). Results are shown in **Table 5** (see **Table 3** for the intersection of Front Road / Sand Bay Lane). The improvement at Portsmouth Avenue is simply due to the elimination of the southbound through and left movements whereas the minor degradation at Sir John A. Macdonald Boulevard is caused by the detour traffic.

Figure 6 – Changes in Traffic Volumes Caused by Lane Closure on Portsmouth Avenue (Option 7B)

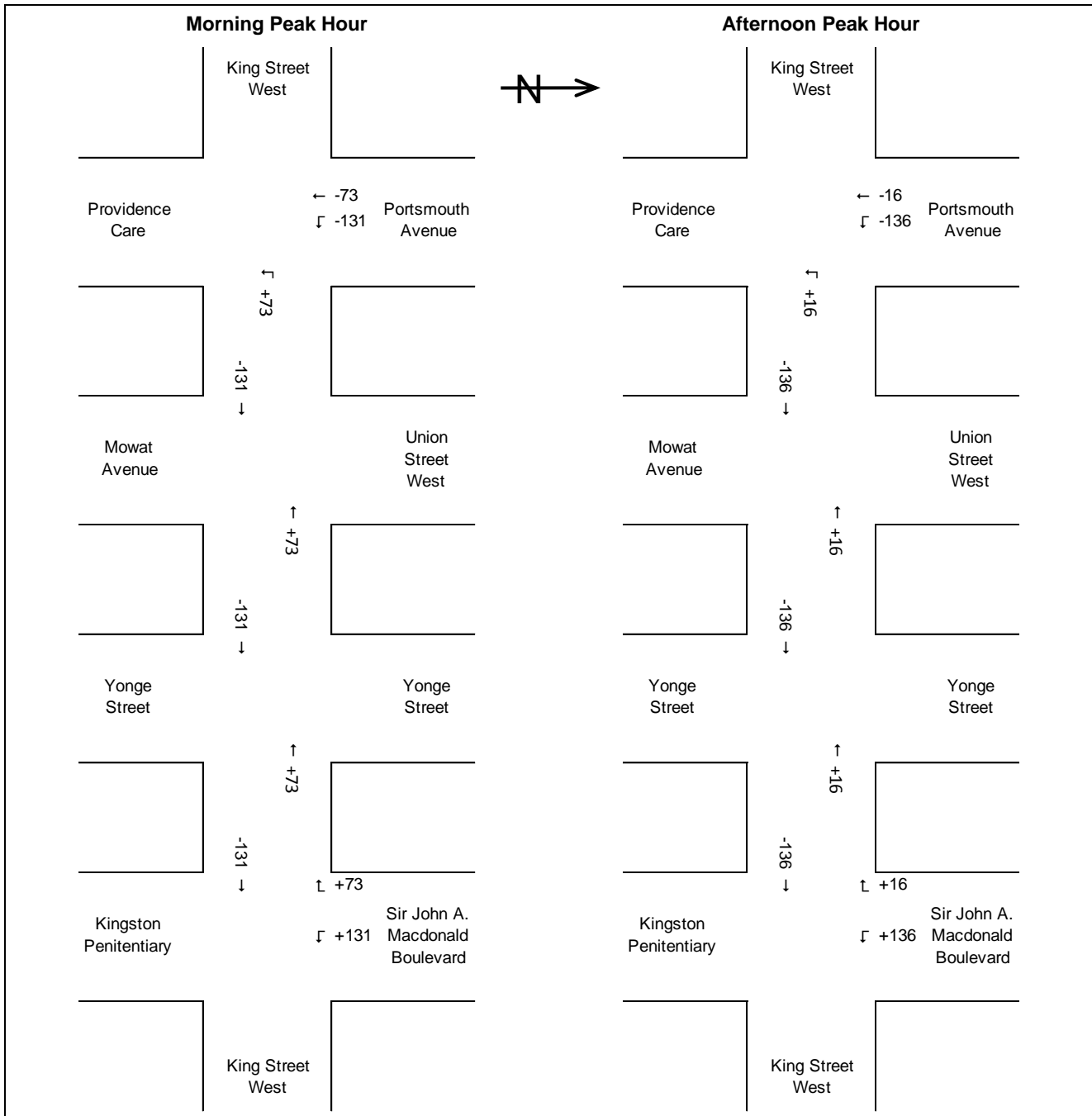


Table 5 – Intersection Performance, Alternative Option 7B

| Intersection | Morning Peak Hour | | | | Afternoon Peak Hour | | | |
|---|--------------------------|-------------------|--------------------------------|--------------------------------|--------------------------|-------------------|--------------------------------|--------------------------------|
| | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | | Volume-to-Capacity Ratio | | Delay (s) and Level of Service | |
| | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² | Critical Ratio | Critical Movement | Overall LOS ¹ | Critical Movement ² |
| King Street / Portsmouth Avenue | 0.50 | EBT/R | 8 A | NBL/T | 0.63 | WBT/R | 10 A | NBL/T |
| King Street / Union Street / Mowat Avenue | 0.73 | NBL/T/R | 14 B | NBL/T/R | 0.95 | SBR | 24 C | SBR |
| King Street / Yonge Street | 0.44 | EBL/T/R | 4 A | SBL | 0.64 | WBL/T/R | 7 A | NBL |
| King Street / Sir John A. Macdonald Boulevard | 0.89 | SBL | 22 C | SBL | 0.89 | WBT | 28 C | SBL |

1. Level of Service or LOS is based on average control delay (in seconds) - For signalized intersections, "LOS" represents the overall intersection LOS.

2. Represents the movement with the worst LOS.

Near Capacity (V/C ≥ 0.85)
 Above Capacity (V/C ≥ 1.00)

Overall, the alternative option 7A provides better results than option 7B and is less likely to cause traffic problems at intersections on an eventual detour route.

Conclusion

The proposed construction of a force main and water main between Sand Bay Lane and Gardiner Street will require the closure of at least one lane along the Front Road / King Street / Union Street and potentially the diversion of traffic between Portsmouth Avenue and Sir John A. Macdonald Boulevard in the non-peak direction. Three routing options were considered, Options 5, 6, and 7.

Option 5 (King Street) and Option 6 (Kennedy Street, Union Street, King Street) have the most impact on traffic as they both reduce the capacity on King Street to one lane during construction, requiring one-way traffic in the peak direction and a detour route through Union Street and Baiden Street in the non-peak direction. Two intersections are expected to operate slightly above capacity but, considering the temporary nature of this change and the availability of alternate routes, this result is considered acceptable. Option 6 has the most impact on traffic since it also removes one lane on Kennedy Street. However, since Kennedy Street is a low volume street, the difference is considered minimal.

Option 7 (Kennedy Street, Baiden Street, King Street) will have the least impact since it would prevent a lane closure on King Street and would yield a better traffic performance during construction. This option would potentially require a lane closure on Baiden Street but the impact

will be minor since Baiden Street is a local residential street. It will also require a lane closure on Portsmouth Avenue but, as demonstrated above, the impact will be less important than a lane closure on King Street east of Portsmouth Avenue. The alternative option 7A (closure of the southbound right turn channelization at King Street / Portsmouth Avenue) has less impact on traffic than option 7B (closure of the southbound through / left turn lane).