Appendix N

Appendix N

Roundabout Implementation Guidelines

Burnside

Innisfil

Town of Innisfil | Transportation Master Plan

Appendix N | Roundabout Implementation Guidelines

Date: November 14, 2022 **Project No.:** 300053011.0000

Project Name: Innisfil Transportation Master Plan Update

To: Town of Innisfil

From: R.J. Burnside & Associates Limited

1.0 Background and Objective

Roundabouts are circular intersection where two or more roads meet. Vehicles will circulate through in a counter-clockwise direction (in North America and other right-hand traffic countries) around a central island. Traffic entering the roundabout will need to yield to circulating traffic. Over the recent years, this form of traffic control has become a popular alternative in Canada. When used in an appropriate location and setting, roundabouts can provide better operational (better traffic flow, more efficient) and safety (fewer / less severe collisions) characteristics in comparison to stop-controlled, signalized and other circular intersections such as rotaries, signalized traffic circles and neighborhood traffic circles.

Currently, a roundabout at Webster Road and 20th Sideroad intersection is under construction. The Town does not have any other roundabouts. However, in the 2018 Transportation Master Plan (the TMP), roundabouts at the following intersections were proposed::

- 20th Sideroad and Lockhart Road.
- 20th Sideroad and 9th Line.
- 20th Sideroad and 6th Line.
- 20th Sideroad and 5th Line,
- 25th Sideroad and Big Bay Point Road/ 13th Line.
- 25th Sideroad and 9th Line.
- St. John's Road and 7th Line.

In addition, the previous TMP consisted of a draft roundabout policy recognizing the benefits and advantages of this type of traffic control. This memorandum will provide an update to the previous draft policy and update the initial screening process to better assess suitable intersections to convert to roundabouts and / or implementation of new roundabouts.

2.0 Roundabout Principle and Guidelines

The initial draft policy had referenced and derived their guidelines based two documentations, which are considered the leading sources of information on roundabouts:

- Canadian Roundabout Design Guide (CRDG), dated January 2017, prepared by Transportation Association of Canada (TAC).
- Roundabouts: An Information Guide Second Edition (NCHRP Report 672), dated 2010, prepared by National Cooperative Highway Research Program (NCHRP).

The documentations provide guidance on planning, design and implementation of roundabouts. Key information is presented in the proceeding sections and help inform the recommended guideline the Town should considered for roundabout installation. In addition, the Town should consider the advantages and disadvantages to roundabouts. Table N-1 outlines the advantages and disadvantages across multiple performance measures.

Table N-1: Advantages and Disadvantages

Performance Measure	Advantages	Disadvantages
Safety	Reduce crash frequency and severity in comparison to other traffic controls. Allow safer merges into circulating traffic. Lower speed so more time can be allocated for users to make decisions or detect mistakes. Fewer conflict points. No right-angle and left turn conflicts.	Increase in single-vehicle and fixed-object crashes in comparison to other traffic control. Individual with low vision will have difficulty detecting gaps at a multi-lane roundabout.
Traffic Operation	Potential for lower delays and smaller queues in comparison to other traffic controls. Reduce unnecessary stops Provides safer movements as it eliminates midblock lefts. Reduce lane requirement between intersections. Upstream / downstream signals will operate more efficiently.	All movements are given equal priority; as a result, high volume movement may experience higher than normal delays. May reduce the number of available gaps of mid-block stop-controlled intersection. Downstream queues may extend into the roundabout and disrupt flow and operations. Cannot provide explicit priority for other users (pedestrian, transit, emergency vehicle). Roundabout near railroad crossing may result in delay and would require further investigation.
Traffic Calming	Reduce speed. Provides a transition between rural and urban areas.	More expensive than other forms of traffic calming.
Environmental Factors	Reduce of noise, air, fuel consumption. Elimination of energy consumption in comparison to signals. Overall minimized carbon footprint.	As it requires more space, it may potentially impact natural and cultural resources.
Space	Less queue storage will be needed and can allow for closer intersection and access spacing.	Requires more space at the intersection than other forms of traffic control. Require more property beyond the limits of a typical road allowance.

Performance Measure	Advantages	Disadvantages
Maintenance	No signal hardware and equipment maintenance.	Landscape maintenance.
Pedestrians and Cyclists	Pedestrian will only need to consider one direction of conflicting traffic. Cyclist will have the options of riding within the roundabout or use bike lane / multi-use path.	Individuals with vision impairment may have difficulty finding crosswalks and determining when it is safe to cross. Bicycle ramps may be easily confused as pedestrian ramps.
Aesthetics	More landscape opportunities within central island. Can be used as a gateway feature to enhance and define community. Help separate different land uses.	If hard objects are placed in central island, it may be hazardous.
Economics	Lower maintenance cost in comparison to other types of traffic control. Time and fuel saving for drivers. Reduce life-cycle cost of operation and maintenance.	More expensive to construct and longer construction period.

2.1 Design Elements

It is essential to understand the design elements of the roundabout as the safety and operational performance are depended on these characteristics. Figure N-1 is an excerpt from the CRDG, Figure 1.1 and it illustrates the key characteristics of a roundabout. These design elements are further explained in Table N-2.

Figure N-1: Roundabout Characteristics (excerpt from CRDG Figure 1.1)

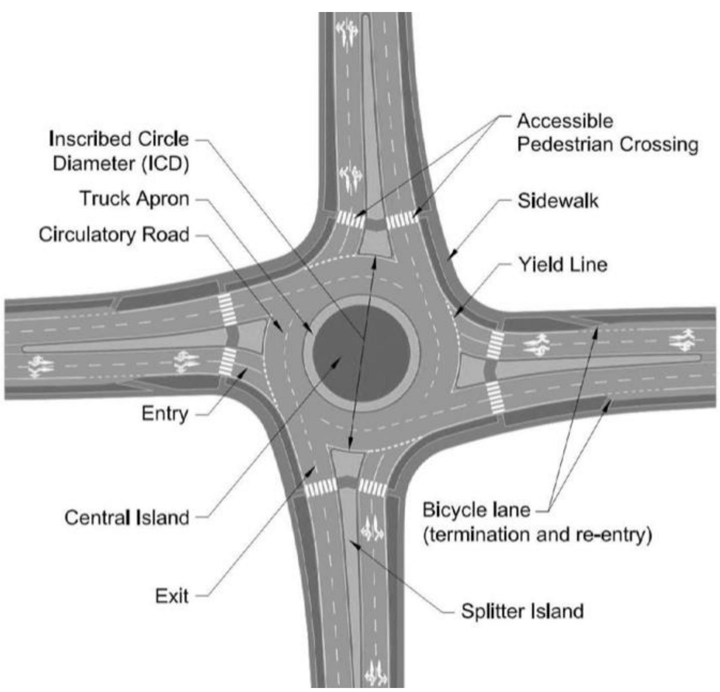


Table N-2: Roundabout Characteristics

Design Element	Description
Central Island	Central island is a raised area in the center of the roundabout, which traffic circulates. It will not always be circular shape and may be mountable.
Splitter Island	Splitter island is a raised or painted area used to separate traffic entering and exiting. It is designed to slow down vehicular entry and provide a two-stage pedestrian crossing.
Circulatory Roadway	Circulatory roadway is the curved path around the center island. It is the vehicle's path of travel.
Truck Apron	Truck apron is a mountable portion of the center island adjacent to the circulatory roadway. It is used to accommodate wheel tracking of larger vehicles. The truck apron can also be provided outside of the circulatory roadway.
Entrance Line	The entrance line functions as a yield line and is the point of entry into the circulatory roadway. Vehicles entering the roundabout will need to yield to circulating traffic from the left before crossing this line onto the circulatory roadway.
Pedestrian Crossing	Pedestrian crossing is the crossing location.
Landscape Buffer	Landscape buffer provides a space between vehicular and pedestrian traffic. It helps guide pedestrian to crossing locations on the roundabout. The landscaping will contribute to the aesthetic of the roundabout.
Inscribed Circle Diameter (ICD)	ICD is the diameter of the largest circle within the intersection outline. Different types of roundabouts will have different ICD. This is a critical design characteristic that influences operation and safety.

2.2 Types of Roundabouts

The CRDG and NCHRP Report 672 describe the three most common types of roundabouts in North America. The roundabout types are distinguished based on size, number of lanes. Note that the.

Table N-3 is based on Table 1.2 from the CRDG, which provides a comparison of the characteristics for the three types of roundabouts. Note that pedestrian and cycling facilities are designed in all three categories. However, some jurisdiction may choose not to provide these features depending on location and users need.

Table N-3: Types of Roundabout Comparison

Design Element	Mini-Roundabout	Single-lane Roundabout	Multi-lane Roundabout
Maximum Number of Entry Lanes per Approach	1	1	2 or more
Typical Inscribed circle diameter, ICD (m)	14 to 27	28 to 60	46 to 100
Central Island Treatment	Fully traversable	Raised (may have traversable apron)	Raised (may have traversable apron)
Typical Daily Volumes for Four-Legged Roundabout (vpd)	Up to approx. 15,0000	Up to approx. 25,0000	Two lane roundabout: Up to approx. 45,0000

A detailed description of each type of roundabout is provided below.

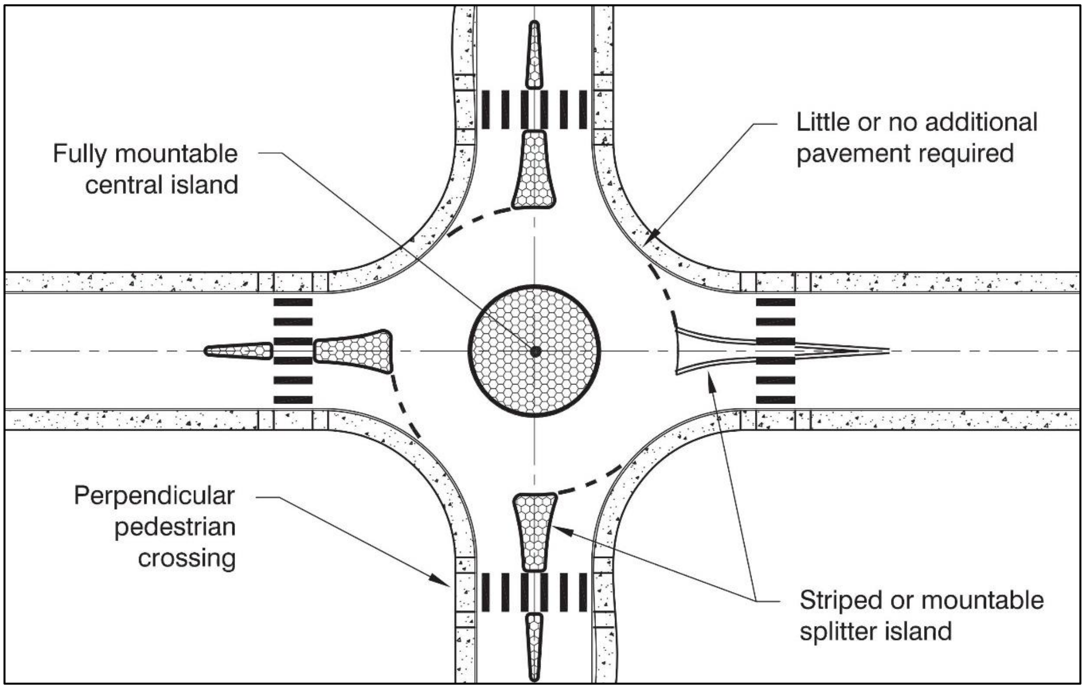
Mini-Roundabout

As described in Table N-3, mini-roundabouts are smaller in size and have fully mountable central island. They are common in low-speed (50 km/h or less) urban environment. Benefits of these type of roundabout includes:

- Less right-of-way constraints.
- Inexpensive as it usually will require minimal pavement and minor road widening.
- Mountable central island to accommodate for larger vehicles.
- Pedestrian-friendly as crossing occurs in shorter distance and at low speed environment.

The mountable nature of the island also reduces the safety of this type of roundabout. Figure N-2 is an excerpt from the NCHRP Report 672, Exhibit 1-10, and it illustrates the key characteristics of a mini-roundabout.

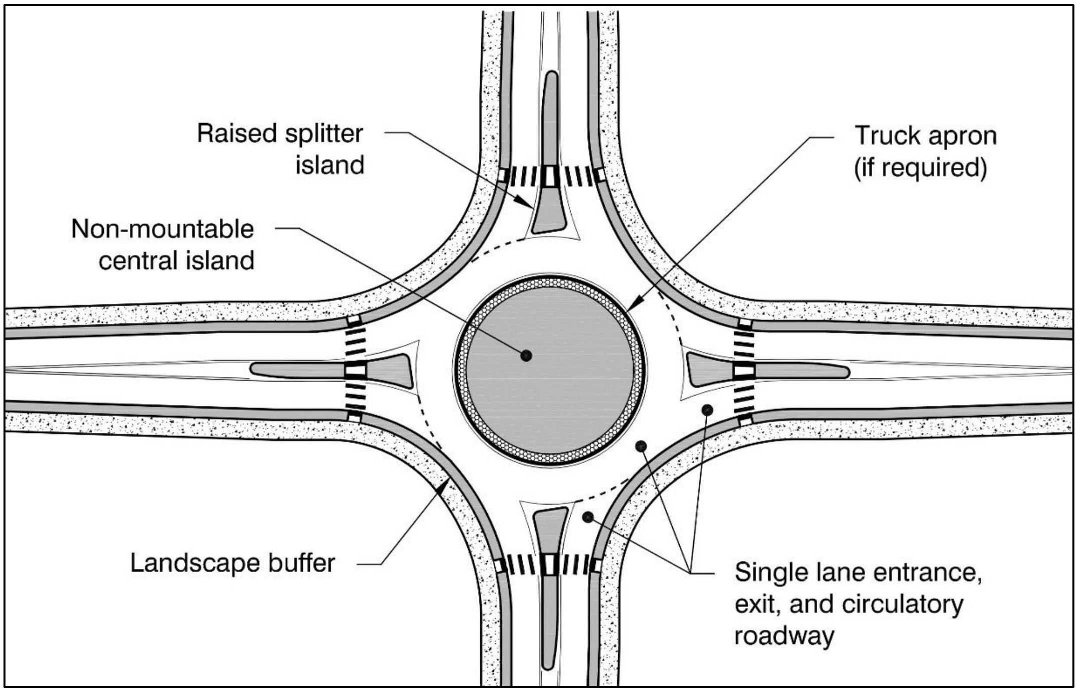
Figure N-2: Typical Mini-Roundabout (Excerpt from NCHRP Report 672 Exhibit 1-10)



Single-Lane Roundabout

Single-lane roundabout is characterized by one land entries on all approaches and one circulatory lane. They have a larger inscribed circle diameter and allows for slightly higher entry speed in comparison to a mini-roundabout. To provide additional safety, the central island is not mountable. However, a mountable apron can be considered to help accommodate larger vehicles. Figure N-3 is an excerpt from the NCHRP Report 672, Exhibit 1-12, and it illustrates the features of a single-lane roundabout.

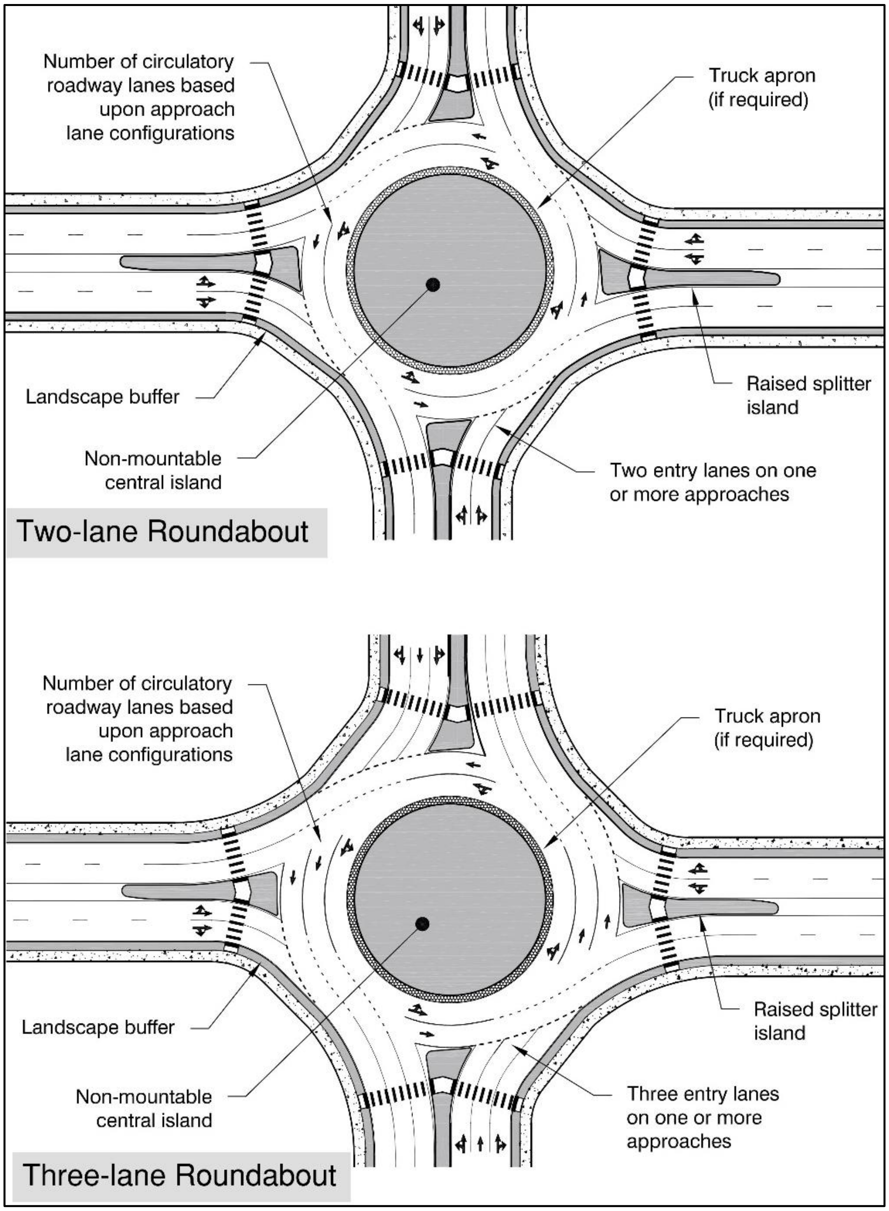
Figure N-3: Typical Single-Lane Roundabout (Excerpt from NCHRP Report 672 Exhibit 1-12)



Multi-Lane Roundabout

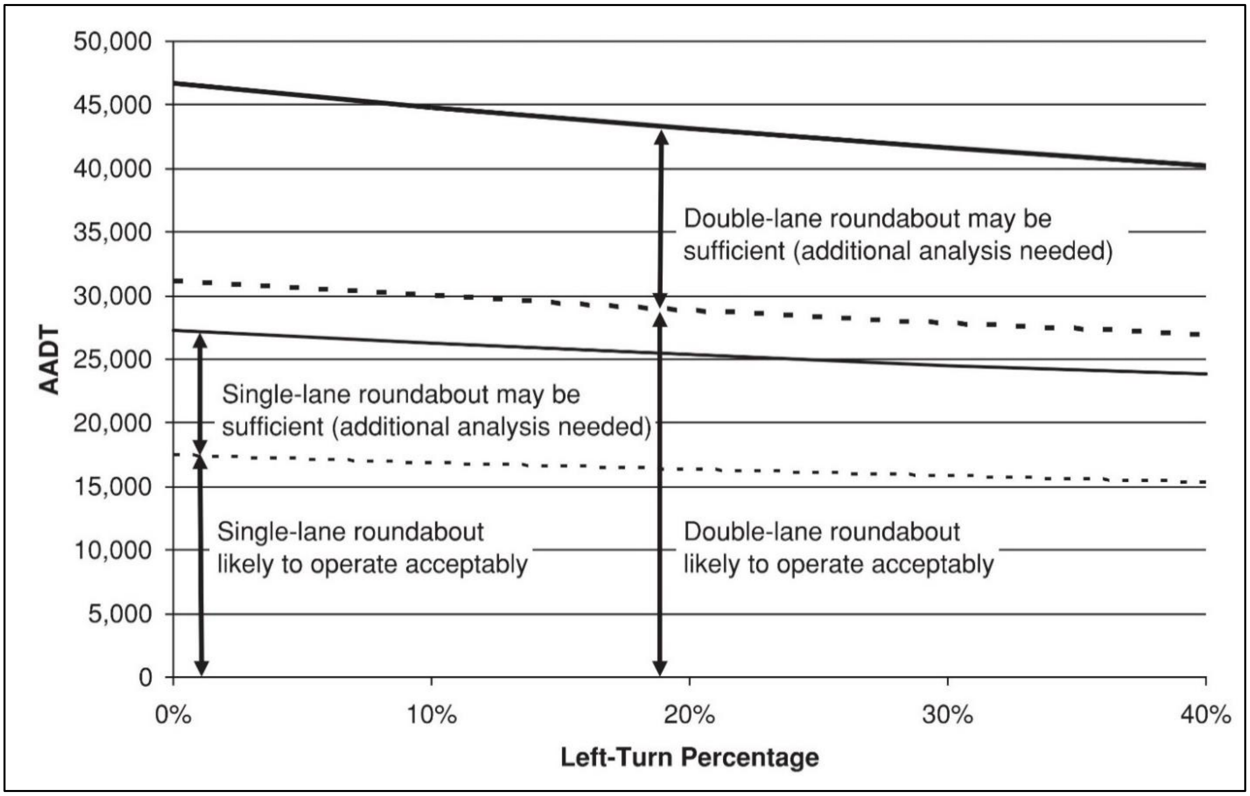
Multi-lane roundabout will have two or more entry lanes for at least one approach. They will require a wider circulatory lane to help accommodate more vehicles travelling side by side. There are some challenges for pedestrians and cyclists as it will take longer to cross. Multi-lane roundabouts are also more difficult and costly to implement. Figure N-4 is an excerpt from the NCHRP Report 672, Exhibit 1-14, and it illustrates the key characteristics of a multi-roundabout.

Figure N-4: Typical Two and Three-Lane Roundabout (Excerpt from NCHRP Report 672 Exhibit 1-14 and 1-15)



NCHRP Report 672 provides a high-level review that determines the appropriate roundabout type based on average annual daily traffic and the percentage of left-turns. This is illustrated in Figure N-5 which is an excerpt from the NCHRP Report 672, Exhibit 3-12.

Figure N-5: Consideration for the Types of Roundabout (Excerpt from NCHRP Report 672 Exhibit 3-12)



2.3 Comparison with Other Intersection Control

There are two important factors when determining a suitable traffic control for an intersection – capacity and safety. A roundabout will have capacity and safety benefits over other traffic control depending on the total traffic volumes and percentage of main street traffic volumes. The benefits of roundabout over other traffic control are summarized below.

Two-way stop control (TWSC)

Delays on minor street caused by inadequate capacities and difficult for left-turns to merge to through traffic. Roundabouts provide solution for these concerns. All movements are treated equally and can accommodate a high number of lefts. Also, capacity is greater than TWSC except when major street exceeds 90% of total traffic. In addition, there is a reduction of crashes at intersections that were TWSC. Based on NCHRP Report 672, an average of approximately 44% crashes are reduced when converted from TWSC to roundabout.

All-way stop control (AWSC)

In comparison to AWSC, roundabouts can improve capacity, reduce delays and minimize crash severity (i.e., reduce angle collision). During off-peak, all vehicles are expected to stop at an AWSC intersection even when there are no other vehicles presented. Roundabout can eliminate this. According to NCHRP Report 672, as traffic volume increases and left-turn increases; the use of roundabout can reduce delay exponentially.

Traffic Signal

Similar to AWSC, during off-peak period and when there are heavy left turns, the delay reduction will be prominent if the intersection was a roundabout. However, if a multi-lane is required, a more detail review and analysis should be conducted in order to determine if roundabout will be appropriate. It is more beneficial installing a roundabout when volumes between major and minor street approaches are balanced.

As roundabouts encourage lower speed, eliminate red-light turns and reduce conflict points in comparison to traffic signal. Based on NCHRP Report 672, average crash reduction is approximately 47.8% when signalized intersections are converted to roundabouts.

2.4 Roundabout Policies from Other Jurisdictions

As mentioned, roundabouts are becoming increasingly popular tool to manage traffic. Several municipalities have implemented roundabouts and development policies to help guide consideration of the roundabout and it is summarized in Table N-4. Most of the jurisdiction recommends considering roundabouts at any new location with potential new traffic signal and for existing intersection with current / projected operation problems. In addition to Table N-4, other jurisdiction that have general policies that discuss the use of roundabout includes:

- **Regional Municipality of York and Peel and City of Markham:** screening tools to determine if a roundabout is suitable and can address intersection improvements.
- **Town of Whitchurch Stouffville:** their TMP recommends considering roundabout at new intersection and / or for intersection improvements.
- **City of St. Thomas**: their TMP there is a list of potential criteria to evaluate whether implementing a roundabout would be appropriate including traffic capacity, traffic flow, accommodation of pedestrians and cyclists, constructability, cost, property/land acquisition, environmental impact, safety and percent grade.

Table N-4: Roundabout Use / Policy Comparison with Other Jurisdictions

Jurisdiction	Policy Document	Guidelines within Policy		
		Initial Screening	Operational Analysis	Detail Design
Ontario Ministry of Transportation (MTO)	Traffic Impact Study Guideline, dated September 2014	✗	✓ Evaluate capacity, delay and queue Include capacity. reduction to account for driver familiarity with roundabout. Guidance on analysis technique / modelling software (ARCADY, AIMSUM, PARAMICS, VISSIM)	✓ Illustrate all geometric parameters. Evaluate fastest path. Speed and radius relationship.
County of Simcoe	Roundabout feasibility guideline in their Transportation Master Plan, dated Oct 2014.	✓ Review advantage and disadvantage of roundabout vs other traffic control. Safety consideration. High level operation review. Benefit – cost assessment.	✓ Capacity analysis including delay and queue to help identify geometric design. Performance analysis done on SIDRA, ARCADY or RODEL.	✓ Illustrate all geometric parameters. Identify design vehicle, path of vehicle and speed. Provide elements for pedestrian and cyclists. Pavement marking and signage. Landscape plans.
Regional Municipality of Waterloo	Region of Waterloo Transportation Impact Study Guideline, dated Sept. 2013.	✓ Complete a traffic flow sheet to determine feasibility of a roundabout and preliminary lane configuration. Develop 10-year AADT forecast for the use of collision cost estimates Preliminary cost of construction and installation. Comparison of cost with other traffic control. Develop 20-year collision cost analysis.	✓ Detailed intersection control study. Specific modelling parameters in Region of Waterloo Requirements for Capacity Analysis, Roundabouts, Signal Warrant documentation, including: Use of RODEL or ARCADY, Geometric parameters to consider, Other calibration needed in the models	✓ Adequate size to accommodate 10-year traffic volume. Sized to accommodate the appropriate design vehicle. Consider geometric parameter to help achieve required speed reduction. Consider property, access and utility impact, Include cyclists and pedestrians' infrastructure

Jurisdiction	Policy Document	**Guidelines within Policy**		
		Initial Screening	Operational Analysis	Detail Design
Niagara Region	Niagara Region Transportation Master Plan – Operating Policies Review Technical Paper (Niagara Region TMP Policy Paper), June 2017 Require justification report to be submitted to Commissioner of Public Works and includes: Safety and community benefits, Capacity and operational analysis, Pedestrian and cyclist considerations, Design elements Property acquisition if any, Life cycle cost benefit comparison to other traffic controls, and Public education	✓ Screening information is provided in the Niagara Region's Guidelines Transportation Impact Studies. It includes: Illustrate that alternatives have been considered, Preliminary lane configuration, Preliminary cost estimates, and Developing 20-year injury collision cost.	✓ 10-year sensitivity analysis. Use of RODEL or approved equivalent for capacity analysis. Adjust RODEL confidence level.	✓ As per the Niagara Region's TMP Policy Paper. Consider design vehicle of at least a WB-20. Follow CRDG.
City of Hamilton	Use of Roundabouts in the City of Hamilton (PW 08078) policy, dated June 6, 2008 Stakeholders will be contacted, and public advised of any roundabout projects. Public information centres (PIC) should be held.	✓ Checklist as per PW08078 which includes review of right-of-way, intersection geometry, safety, delays, traffic flow, land use context etc.	✓ Performance measure includes: Collision frequency reduction study. Capacity analysis (delay and queue). Preliminary cost assessment (construction, maintenance, staging and property acquisition). Qualitative criteria review: ensure equity, natural and social impacts.	✓ Once it passes the initial screening engineering drawing will be required based on good design principles.
City of Brantford	Roundabout Installation Policy and Associated Traffic and Parking By-law Amendments, dated Sept. 2020.	✓ Suitability check. Feasibility check. Determine lane requirements.	✗ No detail on the criteria for operation analysis.	✓ As per CRDG and NCHRP Report 672 City's Design and Construction Manual: Linear Municipal Infrastructure Standards.

3.0 Recommendations

Based on the information from the previous section, the proceeding sections provide an update to the recommendation on implementation of roundabouts from the initial draft policy.

3.1 Initial Screening Process

The initial screening process provides a preliminary assessment of whether roundabout is suitable and feasible alternative to consider. The following should be considered:

Review of Safety and Operation Benefits

As mentioned previously, roundabouts are generally safer than other traffic controls as vehicles will be travelling slower and there are less conflict points (safer movements). Operationally, roundabouts experience lower delays and smaller queues as unnecessary stops are reduced. However, the safety and operation benefits should still be reviewed and quantified including:

- Determine crash frequency reduction and reduction of collision severity of implementing a roundabout.
- Estimate the delay time, queue, fuel consumption and emission reduction from installing a roundabout in comparison to other traffic control.
- Review the safety and operational concerns experienced at the location.

Traffic Volume Consideration

As stated in the previous draft policy, both multi-lane and mini-roundabout roundabout are not recommended at this time. However, it may be considered in the long term once the public become more comfortable maneuvering in a roundabout. For a single lane roundabout, the following traffic volume threshold is recommended:

- Based on AADT summarized in Figure N-5: between 16,000 and 25,000 vehicles per day, a single lane roundabout may be feasible.
- Single lane roundabout can serve a maximum entry and circulating flow of 1,400 vehicles per hour and exit flow of 1,200 vehicles per hour.
- Beyond the above, a signal warrant may be investigated.

Preliminary Life Cycle Cost Estimate

Based on the information from the Region of Waterloo’s Initial Screening Tool, a 20-year life-cycle cost comparison can be considered. This method reviews the implementation and injury collision cost of other traffic control versus roundabouts. Figure N-6 is an excerpt from that documentation and it illustrates the cost considered.

Figure N-6: 20-Year Life-Cycle Cost (Excerpt from Waterloo's Initial Screening Tool)

15) 20-Year Life Cycle Cost Estimate

Injury Collision Cost (ICC): ______________________

Discount Rate: (i): ______________________

20 YEAR LIFE-CYCLE COST COMPARISON		
Cost Item	**Other Traffic Control**	**Roundabout**
Implementation Cost	$	$
Injury Collision Cost (Present Value)	$	$
Total Life Cycle Cost	**X**	**Y**

Notes:

- Implementation Cost
  = sum of costs for construction, property utility relocations, illumination, engineering (20%), contingency (20%) and maintenance (5%);
- Present Value of 20 Year Injury Collision Cost
  = expected annual collision frequency x ICC $((1 + i)^{20}-1) / i(1+i)^{20}$
- Monte Carlo Analysis may be required. If so, a range for the implementation cost (i.e. 10%, 50%, 90% probability) is required

Other Considerations

A more detailed assessment maybe required for the following scenarios:

- If the desired roundabout is located less than 215 m away from a signalized intersection, coordinated signal system or railway crossing, a detailed assessment will be required to demonstrate that downstream queues from the signalized intersection and rail crossing will not impact the roundabout operations.
- If the proposed roundabout is within a significant environmental area outlined in the Town’s Official Plan.
- If the roundabout will be in close proximity to potential vulnerable users such as within 200 m walking distance of long-term care facilities, facilities that may house mobility or visually impaired individuals, within a designated Retirement Residential Area and near school zones.

3.2 Operational Analysis

Once a roundabout is deemed suitable and appropriate, a detailed operational analysis will be required. Following the MTO, Region of Waterloo and County of Simcoe guidelines, the following is recommended to be assessed:

- Conduct capacity analysis by converting turning movement counts into entry and circulating flows for each approach.
- Identify geometric design parameters based on the guidelines in CRDG and NCHRP Report 672.
- The use of ARCADY or equivalent accepted roundabout software for design and operational analysis.
- The operation analysis should include a capacity reduction to account for driver familiarity of roundabouts. This includes the following:
  - A 15% capacity reduction (85% y-intercept) for within 10 years horizon analysis period,
  - A 10% capacity reduction (90% y-intercept) for 10 to 20 years horizon and
  - A 5% capacity reduction (95% y-intercept) for beyond 20 years horizon.
- Consider pedestrian volume within the analysis.
- The following performance measure needs to be reviewed:
  - Entering, circulating and departing traffic volume,
  - Average delay per vehicle and total delay,
  - 95th Percentile queue,
  - Volume to capacity ratio, and
  - Level of service.

3.3 Engineering Design

Based on guidelines from other jurisdictions, careful consideration will be needed at this stage including:

- Identifying all geometric parameters and design elements of a roundabout.
- Evaluate the fastest path, speed and radius relationships.
- Assess the maneuver of the largest expected design vehicle and ensure the roundabout can accommodate.
- Conduct a sightline analysis.
- Design for pedestrian and cyclists including bike lanes, sidewalks and multi-use paths.
- Incorporate appropriate signages, pavement markings, illumination, and landscape.
- Determine the land required to fit the designed roundabout.

The design should follow CRDG and NCHRP Report 672 guidelines and be designed and reviewed by a licensed Professional Engineer.

3.4 Education and Public Consultation

In the Town's case, as currently there are no roundabouts, public awareness and education will be essential when implementing a roundabout. It is recommended that public information sessions, media announcements, promotional materials, educational videos consisting of information on what a roundabout is and how to properly maneuver through a roundabout be distributed to everyone in Town. Prior to implementing a roundabout, similar approach should be taken as with Municipal Class Environmental Assessment where stakeholder consultation is required. The same level of public outreach will be required with every new roundabout that is proposed.