Report

Roundabout Traffic & Safety Assessment and Functional Design Review

Airport Road Environmental Assessment, King Street to Huntsmill Drive

Prepared for Region of Peel
by IBI Group
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1 Introduction

IBI Group Professional Services Inc. ("IBI Group") was retained by the Region of Peel to perform a Roundabout Traffic & Safety Assessment and Functional Design Review for three locations along Airport Road: Castlederg Side Road / Boston Mills Road, Olde Base Line Road, and Cranston Drive (illustrated in Exhibit 1-1). The purpose of this study is to examine operational, functional and safety performance impacts associated with constructing roundabouts at each locations and provide recommendations based on results.

1.1 Background

This report is supplement to *Transportation Planning Report*, *draft* dated August 24th 2018 as a component of Environmental Assessment (EA) for Airport Road from north of King Street to Huntsmill Drive. The EA planning report identified five potential locations for roundabouts, with three being chosen for this review. The purpose of the report is to satisfy the Region's policy, to explore a roundabout design at intersections where signals or other improvements are under consideration.

Well-designed roundabouts have a number of benefits over traditional intersections, including: better safety performance, lower traffic speeds, higher capacity, fewer stop and shorter delays, less idling and air pollution, lower maintenance costs, and better aesthetics.

Building on the EA planning report, this IBI Group study focuses on the chosen roundabout locations to present a summary and review of the future traffic operations, functional design performance, needs and justification, and to provide preliminary recommendations.

The findings and recommendations of this report require future assessment as a part of the EA process. This report provides recommendations from a traffic perspective and requires additional assessment of impacts, further consultation with stakeholders and residents, revisions to design concepts, and detailed costing.

1.2 Study Area

The three study intersections are as follows:

(1) **Castlederg Side Road / Boston Mills Road** is a two-lane east-west major arterial road that intersects Airport Road at an offset intersection with no turning lanes provided. The EA planning report suggests realigning the minor approaches to standard 4-leg two-way stop-control (TWSC) intersection and is assumed the "base improvement alternative" for this review.

This intersection was selected as a potential location for a roundabout because of current geometric deficiencies (offset intersection, lack of turn lanes). In addition, the Region has received a number of traffic and safety complaints for the entrance of a local nursery business (220m north), which is affected by the misaligned intersection.

(2) **Olde Base Line Road** is a two-lane east-west major arterial road that intersects Airport Road at a signalized T-intersection. The EA planning report suggests adding turning lanes to this configuration and is assumed as the "base improvement alternative" for this review.

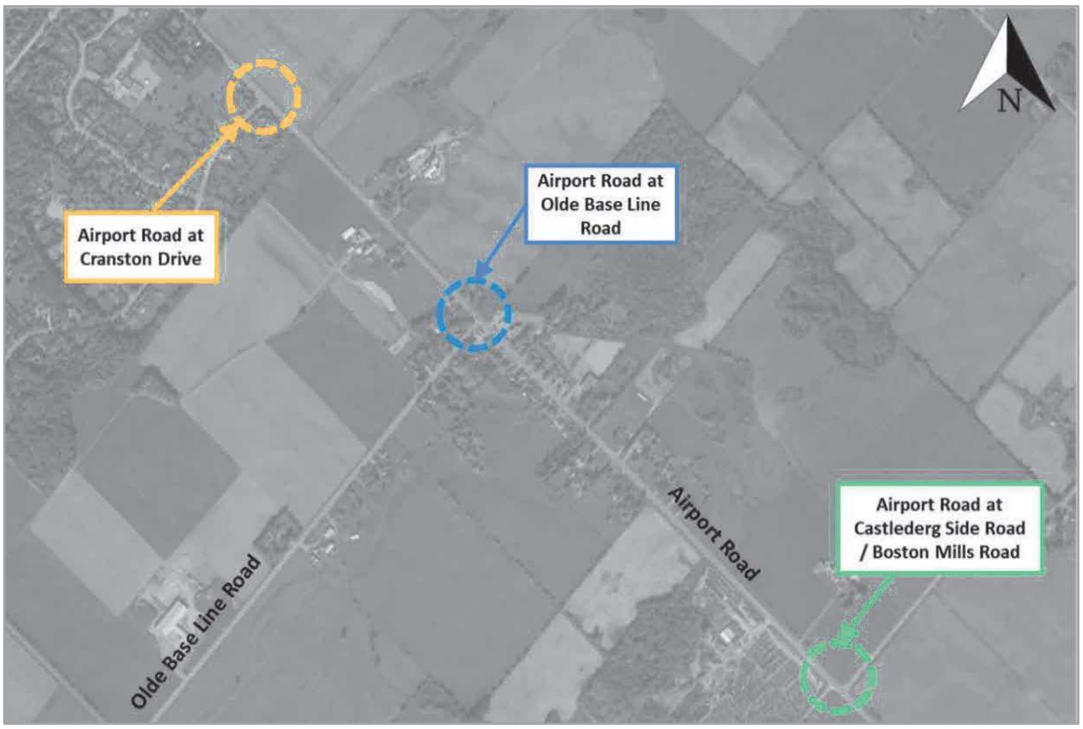
This location was chosen for a potential roundabout because the current layout will not sufficiently accommodate expected traffic demands, with significant delays anticipated on all approaches by year 2041. Olde Base Line Road has also been identified in

Region of Peel's *Strategic Goods Movement Network Study (SGMNS)* as a potential truck route and can provide an alternative to Airport Road in directing heavy through trucks away from Mono Road and Caledon East. Truck diversion would support a roundabout at this location.

(3) **Cranston Drive** is a two-lane east-west local road that intersects Airport Road at a T-intersection, with a stop-control provided on it's the minor approach. There is a development plan for 15717 Airport Road which is a new residential subdivision located east of Airport Road. The south access of the development is currently proposed to connect to Airport Road at Cranston Drive. A 4-leg TWSC is assumed as the "base improvement alternative" for this review.

This intersection was selected as a potential location for a roundabout because of the new development, as described, and the side-street approaches expected to operate poorly with long delays.

Exhibit 1-1: Roundabout Locations



2 Approach

The following provides the approach taken for each roundabout location:

- Traffic Operations
- Safety Performance
- Functional Design Review (2 Review Memos)
- Cost Estimate
- Cost / Benefit (Roundabout Screening Tool)

2.1 Traffic Operations

2.1.1 Roundabout Analysis

Roundabout analysis was conducted previously as part of the EA planning report using ARCADY software and following Region of Peel guidelines. The analysis is reproduced in this report for information purposes. The geometric parameters in Exhibit 2-1 were used, with detailed outputs provided in Appendix A.

Exhibit 2-1: ARCADY Geometric Parameters

PARAMETERS	SINGLE-LANE ENTRY	FLARED TWO LANE ENTRY	TWO-LANE APPROACH AND ENTRY*
R (Entry Radius)	25	25	25
Phi (Conflict Angle)	20	20	20
V (Approach Half Width)	4.25	4.25	4
E (Entry Width)	4.25	8	8
L’ (Flare Length)	0	20	10
D (Inscribed Circle Diameter)	55	49	49

**Two-lane roundabouts are not recommended at this time*

Additional assumptions used in the analysis, detailed in the EA planning report, are as follows:

- Annual traffic growth of 1.75% and1.5%, for peak and off peak directions, respectively
- ARCADY Network Capacity Scaling factor of 90% (10% reduction in roundabout capacity)

It is noted that the analysis is somewhat conservative, as drivers will likely gain familiarity by horizon year 2041 and the growth rates reflect strong development assumptions.

2.1.2 Traffic Analysis – Base Improvement

Intersection analysis was conducted previously as part of the EA planning report using Synchro 9 software and following Highway Capacity Manual (HCM 2000) methodologies of intersection operation analysis. Default parameter values listed in the Region’s Traffic Impact Study (TIS) guidelines were assumed. Detailed synchro outputs are provided in Appendix B.

2.1.3 Signal Warrants

Signal warrants were completed following Ontario Traffic Manual (OTM) Book 12 guidelines using the 2041 forecast (taken from EA planning report). Full signal warrants for each roundabout location are attached in Appendix C.

2.1.4 Traffic Calming

Field traffic speeds counts and the collision analysis completed in the EA planning report is summarized as part of this review. Likely speed reduction effects from the roundabouts are also discussed for both the community of Mono Road and Caledon East.

2.2 Safety Performance

The objective of the safety analysis was to determine what, if any, safety benefit could be realized by implementing a roundabout for each locations. Therefore, safety benefit is defined as the total reduction of societal collision costs between the do-nothing and roundabout alternative for a 20-year analysis period (2021-2041). It is noted that this analysis only accounts for performance impacts of intersections only.

To first assess the safety performance, historical Average Annual Daily Traffic (AADT) volumes were reviewed and projected to 2041 using growth rates outlined in Section 2.1.1. Collision frequency was then predicted using Safety Performance Functions (SPFs).

- For unsignalized and signalized intersection alternatives, the collision frequency was predicted using Ministry of Transportation, Ontario (MTO) performance functions.
- For the roundabout alternatives, the collision frequency was predicted using the Safety Performance Function published in the *National Cooperative Highway Research Programs (NCHRP) Report 672*. Currently, there are no available SPFs for single-lane roundabouts with dual-flared entry lanes, therefore, SPFs for two-lane roundabouts was assumed. This is appropriate because with dual-flared entry lanes, higher operating speeds and more conflict points can be achieved than traditional single-lane roundabouts.

Collision Modification Factors (CMFs) were used to adjust the number of predicted collisions generated by SPFs to account for site conditions that differed significantly from the base conditions for which the SPFs were developed. Calibration factors were also applied to adjust expected collisions based on historical collision data.

The societal cost of collisions was estimated based on MTO's current guidance on costs of societal collisions (*Collision Costs in Engineering Analysis Updated, 2012*). The expected collisions were monetized based on the assumed costs of collisions of $1,582,000 for a fatal collision, $59,000 for an injury collision, and $8,000 for a property damage only collision. A fatal-to-injury collision ratio of 0.012 was assumed based on review of historical collisions from the study area and statistics from the *Ontario Safety Annual Report (2016)*. Finally, a discount rate of 2.52% was used for calculation of all net present values which is based average rate of return from the Government of Canada bonds.

2.3 Functional Design Review

A *Roundabout Functional Design Review – 1st Review draft* was completed on September 18, 2018 by John Bayley, P.Eng and Mr. Sergei Filippov, C.E.T. The design review provided observations, suggestions and comments on the functional aspects of each of the three roundabouts with inputs later incorporated into the designs, dated October 12 (refer to Exhibit 3-3, Exhibit 4-3, and Exhibit 5-3). Following the first review, *Roundabout Functional Design*

Review – 2nd Review – Rev.1 was completed, dated February 21, 2019. The second review memo provided updated comments that focused on fastest path analysis as well as truck turning paths for the roundabout. These comments have yet to be incorporated into the design. Both of the review memos are attached in Appendix D and E, respectively.

2.4 Cost Estimate

Preliminary cost estimates were developed following MTO's *Parametric Estimating Guide (2016)* and should reflect present day estimates. These cost estimates are considered to be high-level and would be expected to be refined during the detailed design phase. The analysis can be found in Appendix F.

The cost estimates accounts for the following:

- Property and building acquisition;
- Approach widening;
- New road (approach);
- Utility relocation;
- Traffic Signal / Electrical work; and
- Design fees.

Property and building acquisition values are to be confirmed with the Region of Peel.

2.5 Cost / Benefit (Roundabout Screening Tool)

The Region of Peel's *Roundabout Screening Tool* is a planning-level document that determines whether potential roundabout locations warrants a more detailed analysis. This tool takes into consideration the traffic volumes, operational concerns, proximity to adjacent signals, vertical geometry, and property constraints. Notably, the screening tool also considers a cost component for both the base and roundabout alternatives. Construction (Section 2.4) and collision (Section 2.2) estimated values were populated into the tool to compare their 20 year life cycle cost.

Each of above listed items is then identified as roundabout supportive, non-supportive or neutral, and an overall recommendation items above is provided in terms of proceeding with the planning of a roundabout. Completed screening tool for each location is attached in Appendix G.

3 Airport Road at Castlederg Side Road / Boston Mills Road

The latest concept drawing, dated October 12th, for Airport Road at Castlederg Side Road / Boston Mills Road was provided by Region staff and is illustrated in Exhibit 3-3.

3.1 Traffic Operations

3.1.1 Roundabout Analysis

The ARCADY analysis based on both 2021 and 2031 traffic volumes indicate that a single-lane entry roundabout at this location is expected to operate well during both the AM and PM peak periods. Summary results are shown in Exhibit 3-1.

Exhibit 3-1: ARCADY Analysis for Castlederg Side Road / Boston Mills Road (2021 & 2031 Volumes)

APPROACH	ENTRY LANES	2021 VOLUMES		2031 VOLUMES	
		AM LOS (V/C)	PM LOS (V/C)	AM LOS (V/C)	PM LOS (V/C)
Boston Mills Road EB	Single	A (0)	A (0)	A (0)	A (0)
Airport Road NB	Single	A (0.14)	A (0.63)	A (0.17)	B (0.75)
Castlederg Side Road WB	Single	A (0.08)	A (0.09)	A (0.10)	A (0.11)
Airport Road SB	Single	A (0.66)	A (0.23)	B (0.79)	A (0.27)

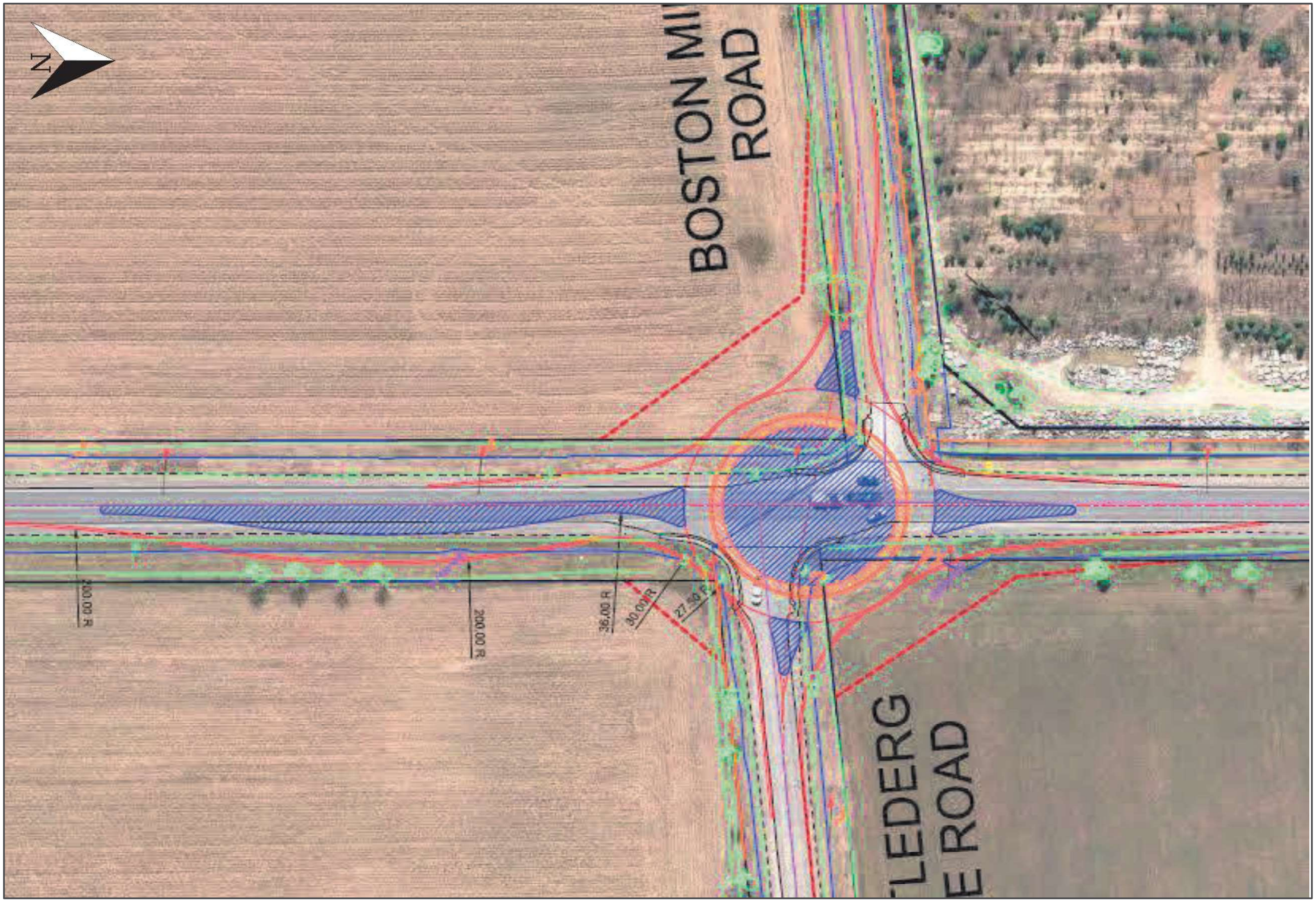
A summary of the 2041 operation analysis is illustrated below in Exhibit 3-2.

Exhibit 3-2: ARCADY Analysis for Castlederg Side Road / Boston Mills Road (2041 Volumes)

APPROACH	SINGLE-LANE (2041 VOLUMES)		
	ENTRY LANES	AM LOS (V/C)	PM LOS (V/C)
Boston Mills Road EB	Single	A (0)	A (0)
Airport Road NB	Single	A (0.20)	D (0.89)
Castlederg Side Road WB	Single	A (0.12)	A (0.15)
Airport Road SB	Single	E (0.94)	A (0.31)

With the 2041 traffic volumes, the analysis indicate moderate delays and queuing for the SB approach in the AM and NB approach in the PM. It is expected that the two most critical movements will still operate under capacity, and is therefore concluded that single-lane configuration works well to 2041.

Exhibit 3-3: Roundabout Concept Drawing (October 12th) for Castlederg Side Road / Boston Mills Road



3.1.2 Traffic Analysis – Base Improvement

For comparison, the results of the synchro analysis for the base improvement alternative were reproduced in this report. Results are summarized in Exhibit 3-4 with detailed outputs provided in Appendix B.

Exhibit 3-4: Synchro Analysis for Castlederg Side Road / Boston Mills Road (2041 Volumes)

Improvement Description	Peak Hour	Overall LOS	Critical Movements				
			Mvmt	LOS	Delay (s)	V/C	95th %ile Queue (m)
Realign east and west leg, and add EBL, EBR, WBL, WBR turning lanes	AM	-	EBL	A	0	0.00	0
			EBT	C	21	0.01	0
			EBR	C	21	0.01	0
			WBL	F	69	0.63	25
			WBT	B	11	0.04	1
			WBR	B	11	0.04	1
	PM	-	EBL	E	48	0.03	1
			EBT	F	Err	Err	Err
			EBR	F	Err	Err	Err
			WBL	E	36	0.09	2
			WBT	C	21	0.25	8
			WBR	C	21	0.25	8

With 2041 volumes, the base improvement alternative operates with delays on the street-streets at LOS F, through sufficient capacity, which is considered acceptable traffic operations.

3.1.3 Signal Warrant

Using the 2041 traffic volumes, results indicate that a traffic signal is not warranted and is summarized in Exhibit 3-5.

Exhibit 3-5: Signal Warrant for Airport Road at Castlederg Side Road / Boston Mills Road

Justification		Compliance	Signal Justified
1) Minimum Vehicular Volume	A). Total Volume	91%	NO
	B). Crossing Volume	50%	
2) Delay to Cross Traffic	A). Total Volume	89%	NO
	B). Crossing Volume	40%	
3) Combination	A). Justification 1	50%	NO
	B). Justification 2	40%	
4) Four-Hour Volume		66%	NO

**2041 traffic volumes*

3.1.4 Traffic Calming

Field traffic speed counts collected by the Region shows a speeding concern south of the study intersection, where the 85th percentile speeds are 20 km/h over the posted speed limit.

A collision analysis was also completed between Cranston Drive to Castlederg Side Road / Boston Mills Road, with results showing a total of five rear-end collisions, two of which resulted in injury. These collision patterns do suggest that speeding may have been a factor. However, these collisions across a five year period does not appear to be unusual given the nature of a rural highway. Additional safety analysis is provided below in Section 3.2.

Implementing a roundabout at Airport Road at Castlederg Side Road / Boston Mills Road would facilitate lower traffic speeds. The roundabout can potentially be a transition point or a gateway feature for vehicles going northbound along Airport Road into the rural community of Mono Road. It is noted, that the subject intersection currently lies approximately 550 m south of the community, which is far enough for drivers to resume speeding.

The Region has received complaints about traffic and safety issues at the entrance of a local nursery business 220 m north of the subject intersection. With the speed reduction from roundabouts, northbound and southbound vehicles will allow safer gaps for egressing and accessing vehicles of the nursery.

3.2 Safety Performance

Future collision costs were predicted following the approach described in Section 2.2. For the purpose of this analysis, a single-lane configuration was assumed to year 2041. The expected yearly collision cost is summarized in Exhibit 3-6.

Exhibit 3-6: Safety Performance Analysis for Castlederg Side Road / Boston Mills Road (2021-2041)

YEAR	DO-NOTHING (OFFSET)	BASE IMPROV	ROUNDABOUT	
	All Collision Types	All Collision Types	Configuration	All Collision Types
2022	$18,900	$14,700		$20,300
2023	$19,100	$14,700		$20,600
2024	$19,200	$14,800		$20,800
2025	$19,300	$14,800		$21,100
2026	$19,400	$14,900		$21,300
2027	$19,600	$15,100		$21,500
2028	$19,700	$15,200		$21,700
2029	$20,000	$15,300		$22,000
2030	$20,100	$15,500		$22,200
2031	$20,200	$15,600		$22,500
2032	$20,500	$15,700	Single-Lane Roundabout	$22,700
2033	$20,600	$16,000		$23,000
2034	$20,900	$16,100		$23,200
2035	$21,100	$16,200		$23,400
2036	$21,400	$16,400		$23,700
2037	$21,500	$16,500		$24,000
2038	$21,800	$16,900		$24,200
2039	$22,100	$17,000		$24,500
2040	$22,400	$17,200		$24,800
2041	$22,700	$17,400		$25,000
Total	$366,000	$282,000		$399,000
NPV	$317,000	$244,000		$349,000

From the above safety performance analysis, it is estimated that the total collision cost that will be incurred for the 20 year period under the do-nothing alternative is $317,000. For the base improvement alternative, the total collision cost was estimated to $244,000. Meanwhile, the roundabout alternative estimated at $349,000. Comparing the do-nothing to the roundabout alternative, there is an overall safety cost of $32,000. This behaviour is likely attributed to the fact that the existing offset intersection has a better safety performance history than average 4-leg intersections with only two reported collisions in the past five years. The best safety performance arises from a 4-leg intersection.

3.3 Functional Design Review

For the roundabout at Airport Road and Castlederg Side Road / Boston Mills Road, the design review details observations, suggestions and comments on the required geometric design inputs. This includes lane requirements, inscribed circle diameters (ICD), lane width minimums, active transportation provisions, as well as swept path and fastest path analyses. The review makes several recommendations for incorporation into design, which include prioritizing the safe movement of goods through further analyses of truck turning paths and fastest paths, developing a plan that minimizes impacts to the surrounding community when future widening is desired, as well as designing the approach geometry of roads to ensure safe operation of the roundabout with widening considerations.

The following outlines the changes made to the design after the 1st design review:

- Shift roundabout centerline by 3.8 m north;
- Reduce back approach curb radius from 250 m to 200 m – entry path radius is kept at 30 m;
- Revise property requirements based on a two-lane roundabout size; and
- Adjust westbound approach.

Updated comments of the 2nd review are summarized as follows:

- West leg appears to be too narrow to accommodate WB-20 truck movements;
- Inscribed Circle Diameter (ICD) from 56m to 55m for Ultimate, 48m to 55m for Interim;
- Current interim design layout SB fastest path speeds approximately 33-25-37 km/h (R_1, R_2, and R_3) while NB fastest path speeds are approximately 34-26-53 km/h and a worst case maximum entry speed of 42 km/h on right turn movements.
- Future and ultimate design layout (following future widening inside the ICD) SB fastest path speeds approximately 56-31-54 km/h (R_1, R_2, and R_3) while NB fastest path speeds are approximately 48-35-87 km/h and a worst case maximum entry speed of 56 km/h on SB movements

The review concludes that the proposed geometric design constraints mentioned above meet the standards set out by NCHRP, and advises that the design should be checked against AODA guidelines to ensure compliance and make provisions to consider short and long term needs of the community (traffic management, minimize future costs, inconvenience to public due to upgrading and retrofitting, among others). It is important to note that comments and inputs from the 2nd review have yet to be incorporated in the design. Following this, IBI Group supports the functional design of the roundabout at Castlederg Side Road / Boston Mills Road as part of EA.

3.4 Cost Estimate

The construction cost estimates are presented in Exhibit 3-7.

Exhibit 3-7: Cost Estimates for a Roundabout at Castlederg Side Road / Boston Mills Road

ITEM	ESTIMATED COST
Construction	$3,250,940
Design	$325,094
Property	$311,250
Grand Total:	**$3,887,284**

3.5 Cost / Benefit (Roundabout Screening Tool)

The Region of Peel's *Roundabout Screening Tool* was used to assess this location and is attached in Appendix E. The life cycle cost comparison suggests both the base improvement and roundabout alternatives are comparable as they have similar cost at roughly $4 million over the 20 year analysis. However, the roundabout alternative has a slightly higher cost than the unsignalized four-leg intersection.

The safety performance values considered for the roundabout alternative do not take into account the potential safety benefit realized by lower traffic speeds for midblocks, even if the benefit is likely to be minor. In addition, it also does not account for potential truck diversions away from the community of Mono Road and the Town of Caledon, though again that benefit is likely to be minor.

Overall the screening tool shows more non-supportive considerations than supportive.

4 Airport Road at Olde Base Line Road

The latest concept drawing, dated October 12th, for Airport Road at Olde Base Line Road was provided by Region staff and is illustrated below in Exhibit 4-3.

4.1 Traffic Operations

4.1.1 Roundabout Analysis

The ARCADY analysis for 2021 and 2031 traffic volumes indicate that a single-lane entry roundabout at this location is expected to operate well. However, by 2031, the SB and NB approach will be critical in the AM and PM respectively. This is summarized in Exhibit 4-1.

Exhibit 4-1: ARCADY Analysis at Olde Base Line Road (2021 & 2031 Volumes)

APPROACH	ENTRY LANES	2021 VOLUMES		2031 VOLUMES	
		AM LOS (V/C)	PM LOS (V/C)	AM LOS (V/C)	PM LOS (V/C)
Olde Base Line Road EB	Single	A (0.29)	A (0.32)	A (0.36)	A (0.39)
Airport Road NB	Single	A (0.16)	B (0.73)	A (0.18)	D (0.89)
Airport Road SB	Single	B (0.71)	A (0.35)	C (0.85)	A (0.40)

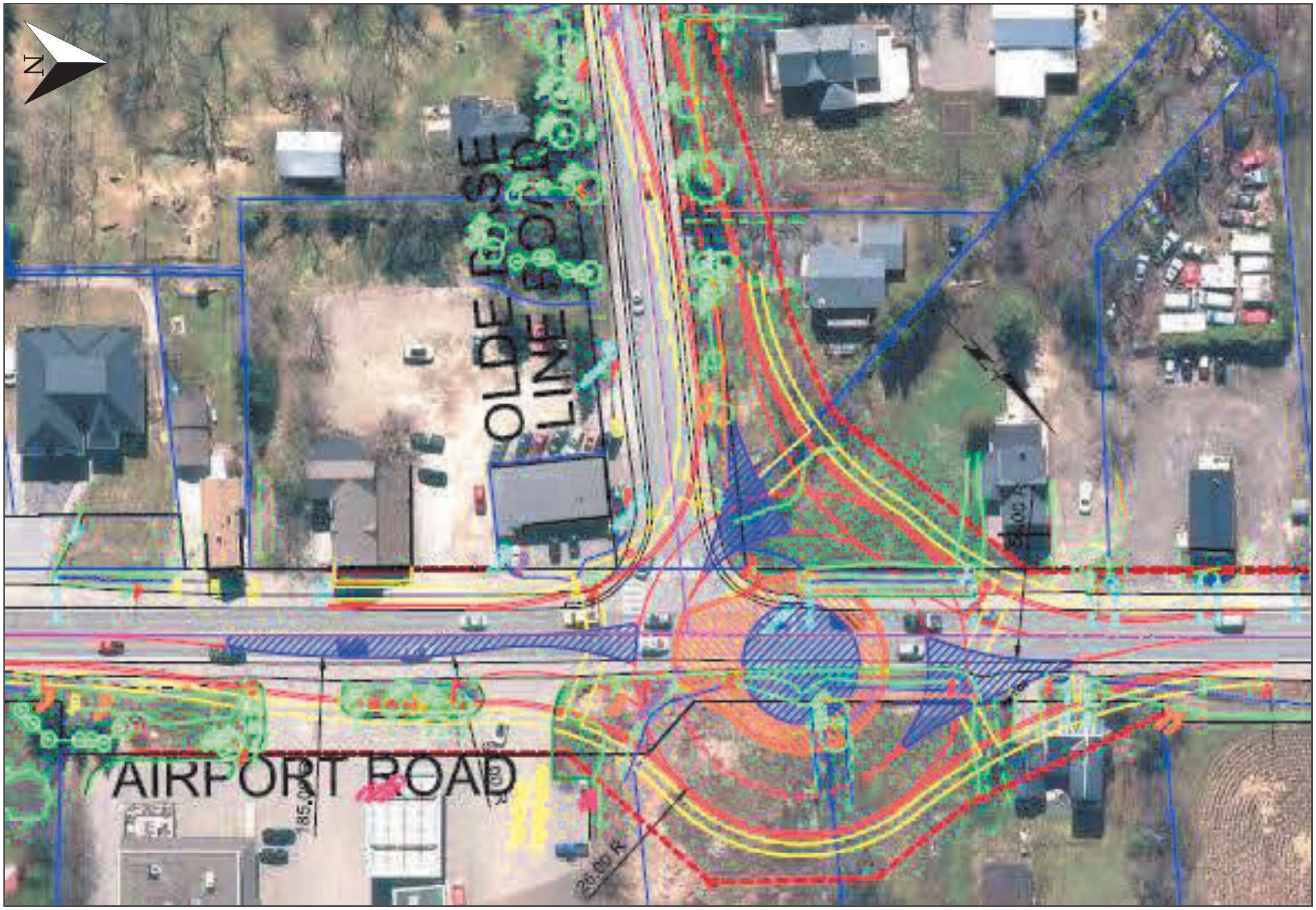
A summary of the 2041 operation analysis is also presented below in Exhibit 4-2.

Exhibit 4-2: ARCADY Analysis at Olde Base Line Road (2041 Volumes)

APPROACH	SINGLE-LANE (2041 VOLUMES)			WITH IMPROVEMENTS (2041 VOLUMES)		
	ENTRY LANES	AM LOS (V/C)	PM LOS (V/C)	ENTRY LANES	AM LOS (V/C)	PM LOS (V/C)
Olde Base Line Road EB	Single	A (0.46)	A (0.47)	Single	A (0.46)	A (0.47)
Airport Road NB	Single	A (0.22)	F (1.09)	Dual	A (0.14)	A (0.68)
Airport Road SB	Single	F (1.01)	A (0.47)	Single with By-Pass Right Turn	B (0.72)	A (0.31)

With the 2041 traffic volumes, the analysis indicate that a single-lane entry roundabout for this location is expected to operate poorly, with both the northbound and southbound approaches operating overcapacity. From a traffic standpoint, flared two-lane entry for the northbound approach and a by-pass lane for the southbound approach will likely be required by 2031 to accommodate future traffic demand.

Exhibit 4-3: Roundabout Concept Drawing (October 12th) for Olde Base Line Road



4.1.2 Traffic Analysis – Base Improvement

For comparison, the results of the synchro analysis for the base improvements were reproduced in this report. Results are summarized in Exhibit 4-4 with detailed outputs provided in Appendix B.

Exhibit 4-4: Synchro Analysis for Olde Base Line Road (2041 Volumes)

Improvement Description	Peak Hour	Overall LOS	Critical Movements				
			Mvmt	LOS	Delay (s)	V/C	95th %ile Queue (m)
Add NBL, SBR, EBR turning lanes	AM	B	(no critical movements)				
	PM	C	EBL	E	60	0.93	118

With 2041 volumes, the base improvement alternative operates well with LOS B and C during AM and PM peak, respectively. During the PM peak, the eastbound left-turn movement will operate at LOS E, but still under capacity, which is considered acceptable traffic operations.

4.1.3 Signal Warrant

Using the 2041 traffic volumes, results indicate that a traffic signal is warranted and is summarized in Exhibit 4-5.

Exhibit 4-5: Signal Warrant for Airport Road at Olde Base Line Road

Justification		Compliance	Signal Justified
1) Minimum Vehicular Volume	A). Total Volume	99%	NO
	B). Crossing Volume	85%	
2) Delay to Cross Traffic	A). Total Volume	94%	NO
	B). Crossing Volume	100%	
3) Combination	A). Justification 1	85%	YES
	B). Justification 2	94%	
4) Four-Hour Volume		100%	YES

**2041 traffic volumes*

4.1.4 Traffic Calming

Field traffic speed counts were previously collected by the Region along Airport Road with results showing a significant speeding concern for the rural stretch between Cranston Drive and Old Base Line Road.

A collision analysis was also completed at Airport Road and Olde Base Line Road with results showing a total of 12 reported collisions. The most prominent collision types were rear-end (9) and is likely attributed to the lack of a designated northbound left-turn lane. Left turning vehicles can potentially get rear-ended by the fast moving northbound vehicles wishing to go through the intersection. This does suggest speeding as a concern, however, 12 collisions over a 5 year period is not excessive for Ontario. Additional safety analysis is provided in Section 4.2.

A roundabout at this location would encourage lower traffic speeds and provide a clear transition point or a gateway feature for the small community of Mono Road immediately south of the intersection.

4.2 Safety Performance

Future collision costs were predicted following the approach described in Section 2.2. Based on the results from the roundabout operational analysis (Section 4.1.1) single-lane roundabout is assumed to year 2031. Dual-flared lane entry of the NB approach and additional by-pass lane for the SB approach were also assumed for years 2031 to 2041 as illustrated in Exhibit 4-6.

Exhibit 4-6: Safety Performance Analysis for Olde Base Line Road (2021-2041)

YEAR	DO-NOTHING	BASE IMPRV	ROUNDABOUT	
	All Collision Types	All Collision Types	Configuration	All Collision Types
2022	$48,900	$40,000	Single-Lane Roundabout	$15,100
2023	$49,300	$40,200		$15,200
2024	$49,500	$40,400		$15,400
2025	$49,800	$40,700		$15,600
2026	$50,100	$40,900		$15,800
2027	$50,500	$41,200		$15,900
2028	$50,800	$41,400		$16,100
2029	$51,200	$41,700		$16,200
2030	$51,600	$42,000		$16,400
2031	$51,800	$42,400		$16,500
2032	$52,300	$42,700	Single-Lane Roundabout with NB Dual-Flared Entry and SB By-pass lane	$21,800
2033	$52,600	$42,900		$22,000
2034	$53,000	$43,300		$22,300
2035	$53,400	$43,600		$22,500
2036	$53,900	$44,000		$22,800
2037	$54,200	$44,300		$23,000
2038	$54,700	$44,600		$23,300
2039	$55,100	$44,900		$23,500
2040	$55,500	$45,200		$23,800
2041	$56,000	$45,600		$24,100
Total	$936,000	$764,000		$387,300
NPV	$808,000	$659,000		$294,000

From the above safety performance analysis, it is estimated that the total collision cost that will be incurred for the 20 year period under the do-nothing alternative is $808,000. For the base improvement alternative, the total collision cost was estimated as $659,000. Meanwhile, the roundabout alternative is estimated at $294,000. Comparing the do-nothing to the roundabout alternative, there is a safety benefit of $514,000 over the 20 year analysis period.

4.3 Functional Design Review

For the roundabout at Airport Road and Olde Base Line Road, the design review details observations, suggestions and comments on the required geometric design inputs. This includes lane requirements, inscribed circle diameters (ICD), lane width minimums, active transportation provisions, as well as swept path and fastest path analyses. The review makes several recommendations for incorporation into design, which include prioritizing the safe movement of goods through further analyses of truck turning paths and fastest paths, developing a plan that minimizes impacts to the surrounding community when future widening is desired, as well as designing the approach geometry of roads to ensure safe operation of the roundabout with widening considerations.

The following outlines the changes made to the design after the 1st design review:

- Shift roundabout centerline by 10 m north;
- Adjust the eastbound connection to the roundabout while maintaining truck turning movement; and
- Revise proposed property line.

Updated comments of the 2nd review are summarized as follows:

- Inscribed Circle Diameter (ICD) from 53m to 52m for Ultimate, 46m to 40m for Interim (irregular shape);
- Current interim design layout SB fastest path speeds approximately 62-34-49 km/h (R_1, R_2, and R_3) while NB fastest path speeds are approximately 56-40-40 km/h and a worst case maximum entry speed of 41 km/h on right turn movements.
- Ultimate design layout SB fastest path speeds approximately 50-40-76 km/h (R_1, R_2, and R_3) while NB fastest path speeds are approximately 63-37-64 km/h and a worst case maximum entry speed of 41 km/h on right turn movements.

The review concludes that the proposed geometric design constraints mentioned above meet the standards set out by NCHRP, and advises that the design should be checked against AODA guidelines to ensure compliance and make provisions to consider short and long term needs of the community (traffic management, minimize future costs, inconvenience to public due to upgrading and retrofitting, among others). It is important to note that comments and inputs from the 2nd review have yet to be incorporated in the design. Following this, IBI Group supports the functional design of the roundabout at Olde Base Line Road as part of EA.

4.4 Cost Estimate

The construction cost estimates are presented in Exhibit 4-7.

Exhibit 4-7: Cost Estimates for a Roundabout at Olde Base Line Road

ITEM	ESTIMATED COST
Construction	$1,883,903
Design	$188,390
Property	$850,000
Building	$1,200,000
Grand Total:	**$4,122,293**

4.5 Cost / Benefit (Roundabout Screening Tool)

The Region of Peel's *Roundabout Screening Tool* was used to assess this intersection. The screening tool showed equal amounts of supportive and non-supportive elements. From the life cycle cost comparison, both the signalized 3-leg with turn lanes and the roundabout alternatives are comparable as they have similar cost at roughly $4.4 million (over a 20 year analysis).

However, the safety values considered for the roundabout alternative do not take into account the likely safety benefit realized by lower traffic speeds for midblocks. In addition, it also does not account for likely truck diversions due to roundabouts away from the community of Mono Road and the Town of Caledon.

Overall the screening tool shows more neutral considerations for a roundabout.

5 Airport Road at Cranston Drive

The latest concept drawing, dated October 12th, for Airport Road at Cranston Drive was provided by Region staff and is illustrated below in Exhibit 5-3.

5.1 Traffic Operations

5.1.1 Roundabout Analysis

The ARCADY analysis for 2021 traffic volumes indicate that a single-lane entry roundabout at this location is expected to operate well during both peak periods. However, by 2031, the analysis show that the NB approach will be overcapacity in the PM peak.

Exhibit 5-1: ARCADY Analysis at Cranston Drive (2021 & 2031 Volumes)

APPROACH	ENTRY LANES	2021 VOLUMES		2031 VOLUMES	
		AM LOS (V/C)	PM LOS (V/C)	AM LOS (V/C)	PM LOS (V/C)
Cranston Drive EB	Single	A (0.04)	A (0.03)	A (0.06)	A (0.04)
Airport Road NB	Single	A (0.22)	B (0.79)	A (0.28)	F (1.06)
15717 Airport road – Access (S) WB*	Single	-	-	A (0)	A (0.04)
Airport Road SB	Single	A (0.69)	A (0.32)	C (0.84)	A (0.38)

*proposed build out year for 15717 Airport Road is 2022

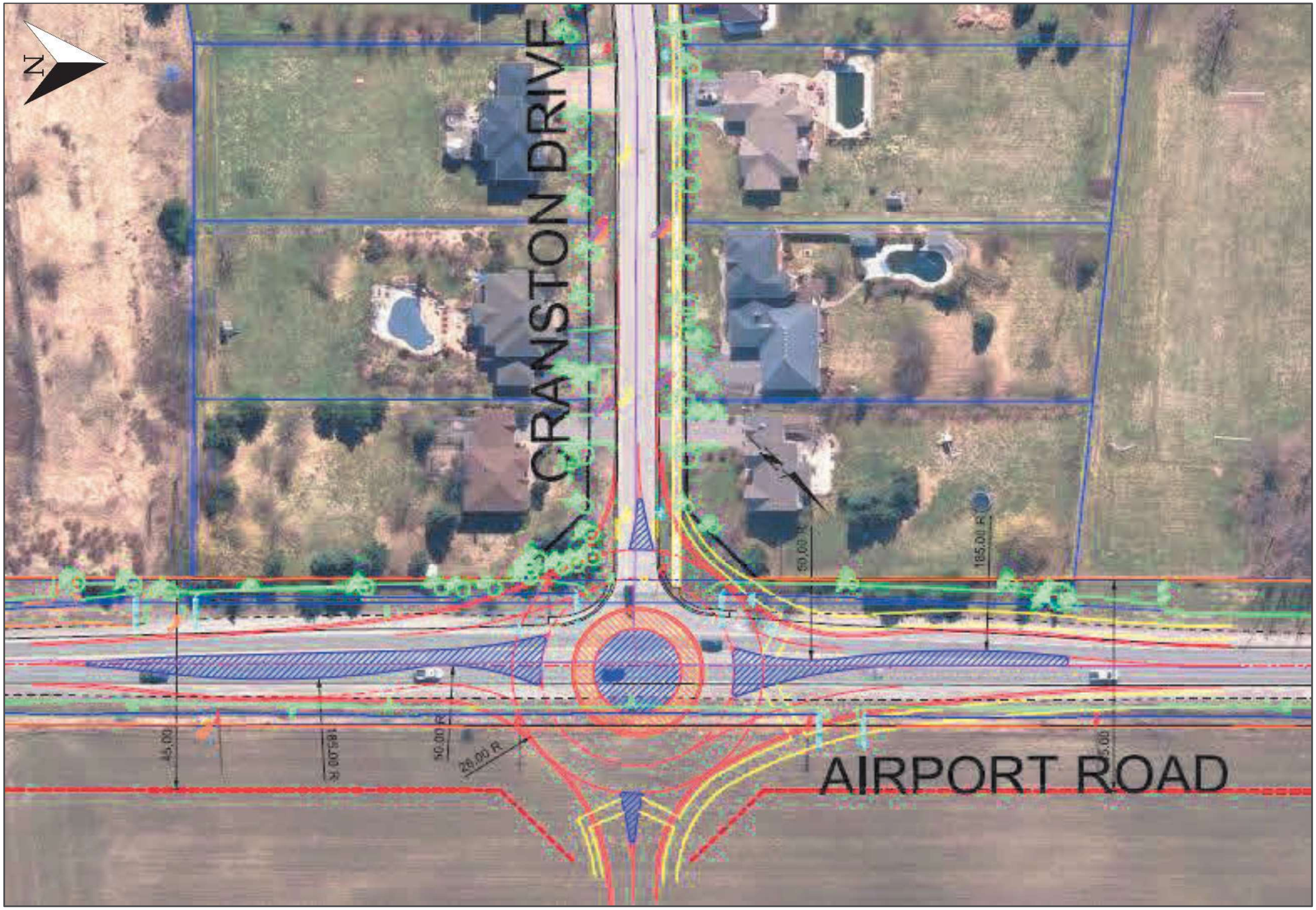
A summary of the 2041 operation analysis is also presented below in Exhibit 5-2.

Exhibit 5-2: ARCADY Analysis at Cranston Drive (2041 Volumes)

APPROACH	SINGLE-LANE (2041 VOLUMES)			WITH IMPROVEMENTS (2041 VOLUMES)		
	ENTRY LANES	AM LOS (V/C)	PM LOS (V/C)	ENTRY LANES	AM LOS (V/C)	PM LOS (V/C)
Cranston Drive EB	Single	A (0.08)	A (0.08)	Single	A (0.08)	A (0.04)
Airport Road NB	Single	A (0.32)	F (1.24)	Dual	A (0.21)	A (0.80)
15717 Airport road – Access (S) WB	Single	A (0.08)	A (0.04)	Single	A (0.08)	A (0.05)
Airport Road SB	Single	F (1.00)	A (0.44)	Dual	A (0.64)	A (0.28)

With the 2041 traffic volumes, the analysis indicate that single-lane entry roundabout at this location is expected to operate poorly, with both the northbound and southbound approaches operating overcapacity. From a traffic standpoint, flared two-lane entry configuration for both the NB and SB approaches will likely be required by 2031 to accommodate future traffic demand.

Exhibit 5-3: Roundabout Concept Drawing (October 12th) for Cranston Drive



5.1.2 Traffic Analysis – Base Improvement

For comparison, the results of the synchro analysis for the base improvements were reproduced in this report. Results are summarized in Exhibit 5-4 with detailed outputs provided in Appendix B.

Exhibit 5-4: Base Improvement Analysis for Cranston Drive (2041 Volumes)

Improvement Description	Peak Hour	Overall LOS	Critical Movements				
			Mvmt	LOS	Delay (s)	V/C	95th %ile Queue (m)
Unsignalized intersection with dedicated EBL and WBL	AM	-	EBL	F	77	0.21	5
			EBTR	C	22	0.13	3
			WBL	F	265	1.07	38
			WBTR	B	10	0.02	1
	PM	-	EBL	F	81	0.23	6
			EBTR	B	11	0.04	1
			WBL	F	95	0.33	9
			WBTR	C	21	0.03	1

With 2041 volumes, the base improvement alternative operates with delays on the street-streets at LOS F, through sufficient capacity, which is considered acceptable traffic operations.

5.1.3 Signal Warrant

Using the 2041 traffic volumes, results indicate that a traffic signal is not warranted, although nearly met. The signal warrant is summarized below in Exhibit 5-5.

Exhibit 5-5: Signal Warrant for Airport Road at Cranston Drive

Justification		Compliance	Signal Justified
1) Minimum Vehicular Volume	A). Total Volume	100%	NO
	B). Crossing Volume	65%	
2) Delay to Cross Traffic	A). Total Volume	99%	NO
	B). Crossing Volume	83%	
3) Combination	A). Justification 1	65%	NO
	B). Justification 2	83%	
4) Four-Hour Volume		78%	NO

**2041 traffic volumes*

5.1.4 Traffic Calming

Field traffic speed counts were collected by the Region shows a significant speeding concern at the intersection, where 85th percentile speeds are 14 km/h over the posted speed limit.

A collision analysis was also completed between Cranston Drive to Castlederg Side Road / Boston Mills Road with a total of five rear-end collisions, two of which resulted in injury. These collision patterns do suggest that speeding may have been a factor. However, these collisions across a five year period does not appear to be unusual given the nature of a rural highway. Additional safety analysis is provided in Section 5.2.

It is noted that there are significant development plans on the east side of Airport Road. Due to signals not being warranted at this location, a roundabout will help facilitate lower traffic speeds in the area. This is of particular importance due the speeding concerns south of the intersection and the Caledon Public School located 300m north of Cranston Drive. However, it is expected that with the development, this section of Airport Road will be urbanized and that traffic speeds will naturally reduce through visual and physical cues to drivers.

5.2 Safety Performance

Future collision costs were predicted following the approach described in Section 2.2. Based on the results from the roundabout operational analysis (Section 5.1) it was assumed in this analysis that the single-lane entry configuration will be kept up to 2031 with construction of dual-flared entry for northbound and southbound approaches for 2031 to 2041. The expected yearly collision cost is summarized in Exhibit 5-6.

Exhibit 5-6: Safety Performance Analysis for Cranston Drive (2021-2041)

YEAR	DO-NOTHING (3-LEG)	STANDARD 4-LEG (BASE)	ROUNDABOUT	
	All Collision Types	All Collision Types	Configuration	All Collision Types
2022	$7,000	$5,800	Single-Lane Roundabout	$22,500
2023	$7,000	$5,900		$22,700
2024	$7,000	$6,000		$23,000
2025	$7,000	$6,200		$23,200
2026	$7,200	$6,200		$23,500
2027	$7,200	$6,300		$23,800
2028	$7,200	$6,500		$24,000
2029	$7,300	$6,600		$24,200
2030	$7,300	$6,700		$24,600
2031	$7,500	$6,800	Single-Lane Roundabout with Dual-Flared Entry NB/SB	$33,600
2032	$7,600	$7,000		$34,000
2033	$7,600	$7,100		$34,400
2034	$7,700	$7,200		$34,700
2035	$7,800	$7,300		$35,200
2036	$7,800	$7,600		$35,500
2037	$7,900	$7,700		$35,900
2038	$7,900	$7,800		$36,400
2039	$8,200	$8,100		$36,700
2040	$8,200	$8,300		$37,200
2041	$8,200	$8,600		$33,600
Total	$134,000	$120,000		$589,900
NPV	**$116,000**	**$107,000**		**$447,000**

From the above safety performance analysis, it is estimated that the total collision cost that will be incurred for the 20 year period under the do-nothing alternative is $116,000. For the base improvement alternative, the total collision cost was estimated to $107,000. Meanwhile, the roundabout alternative is estimated at $447,000. Comparing the do-nothing to the roundabout alternative, there is an overall societal cost of $331,000. This is likely attributed to the better safety performance history of the existing 3-leg intersection with the dedicated NBL and SBR lanes.

5.3 Functional Design Review

For the roundabout at Airport Road and Cranston Drive, the design review details observations, suggestions and comments on the required geometric design inputs. This includes lane requirements, inscribed circle diameters (ICD), lane width minimums, active transportation provisions, as well as swept path and fastest path analyses. The review makes several recommendations for incorporation into design, which include prioritizing the safe movement of goods through further analyses of truck turning paths and fastest paths, developing a plan that minimizes impacts to the surrounding community when future widening is desired, as well as designing the approach geometry of roads to ensure safe operation of the roundabout with widening considerations.

The following outlines the changes made to the design after the 1st design review:

- Apply a 100 m merge taper on both North and South ends of the roundabout; and
- Update right-of-way limit to 45 m.

Updated comments from the 2nd review are summarized as follows:

- Inscribed Circle Diameter (ICD) to 52m for muti-lane roundabout;
- Current design layout SB fastest path speeds approximately 49-40-68 km/h (R_1, R_2, and R_3) while NB fastest path speeds are approximately 51-37-109 km/h and a worst case maximum entry speed of 38 km/h on right turn movements. The higher than desirable exit velocity for the NB fastest path (109 km/h) should be refined to lower the speed in the area of the pedestrian crossing and as such have included an example modification (refer to Appendix E) that will achieve lower exit velocity (69 km/h) at the departure for the NB through movement (NE quadrant). Similar considerations should be given to the SB movement and further refined for NB movement using both lane narrowing and possible ICD reduction combined with modified deflection of the departure geometries to further reduce exit velocities.

The overall review concludes that the proposed geometric design constraints mentioned above meet the standards set out by NCHRP, and advises that the design should be checked against AODA guidelines to ensure compliance and make provisions to consider short and long term needs of the community (traffic management, minimize future costs, inconvenience to public due to upgrading and retrofitting, among others). It is important to note that comments and inputs from the 2nd review have yet to be incorporated in the design. Following this, IBI Group supports the functional design of the roundabout at Cranston Drive as part of EA.

5.4 Cost Estimate

The construction cost estimates are presented in Exhibit 5-7.

Exhibit 5-7: Cost Estimates for a Roundabout at Cranston Drive

ITEM	ESTIMATED COST
Construction	$1,760,190
Design	$176,019
Property	$425,000
Grand Total:	**$2,361,209**

5.5 Cost / Benefit (Roundabout Screening Tool)

The Region of Peel's *Roundabout Screening Tool* was used to assess this intersection. The screening tool has more non-supportive elements than supportive. The life cycle cost comparison points towards the lower cost alternative which is the base alternative (TWSC).

However, the safety performance values considered for the roundabout alternative do not take into account the likely benefit realized by lower traffic speeds for the midblock crossing to the north. In addition, it also does not account for likely truck diversions away from the community of Mono Road and the Town of Caledon. Given the potential school crossing to the north, the slower speed of traffic may be considered a significant benefit.

Overall the screening tool shows more non-supportive considerations than supportive.

6 Summary and Recommendations

This report provides a technical / peer review of proposed roundabouts on Airport Road at Boston Mills Road / Castlederg Side Road, Olde Base Line Road, and Cranston Drive. The review is part of the Airport Road Environmental Assessment undertaken by Region of Peel. The conclusions of this report relate only to the roundabout alternatives at the three subject locations, and the overall Environmental Assessment may review or develop other solutions or recommendations for the intersections.

6.1 Boston Mills Road / Castlederg Side Road

The intersection of Airport Road and Boston Mills Road / Castlederg Side Road has an offset configuration with no turning lanes. There is also a greenhouse business located approximately 220m north without turning lanes. The lack of turning lanes and offset at the intersection are a safety concern. A roundabout was considered given these factors and for consideration to accommodate 2041 traffic forecasts.

The findings of the analysis are that a roundabout is difficult to justify:

- Following OTM Book 12, this intersection is not warranted for traffic signals through 2041. A stop controlled intersection continues to provide sufficient capacity.
- The safety performance found a slight penalty to safety with the introduction of a roundabout, likely due to the new requirement for through traffic to slow and negotiate the roundabout.
- Following further provisions to incorporate comments from the 2nd functional design review, it is concluded that the design of a roundabout is supportable and suitable at this location from a functional design perspective.
- The overall cost between a roundabout and an intersection was similar with the intersection costing slightly less.

It was noted that the costs and benefits did not account for the benefits of slightly slower traffic speed at the greenhouse, and potential for some heavy trucks to divert to other corridors due to the need for slowing. However, both of these benefits are likely minor.

The analysis also did not account for significant growth in traffic entering Airport Road from Boston Mills Road or Castlederg Side Road, as no developments are planned and the surrounding land is designated agricultural and not planned for development.

Under the EA process, further assessment of impacts, consultation with stakeholders and residents, and detailed costing is advised and are outside of the scope of this memo.

Based on the findings of this analysis, the Region should consider property protection for a future long-term roundabout as this would entail moderate cost. Realignment to a four-legged intersection is recommended.

6.2 Olde Base Line Road

The intersection of Airport Road and Olde Base Line Road is a three-legged intersection in the community of Mono Road. There are nearby houses and businesses. The current intersection configuration with a signal and no turning lanes is not expected to operate well in the planning horizon. A roundabout was considered along with improvements to the signalized intersection. In addition, as part of the functional design component of the study, it was found that a roundabout is supportable and suitable at this location – assuming further provisions to incorporate comments from 2nd design review into the design.

Overall, the findings of the analysis are that a roundabout is unlikely to be found appropriate. A roundabout would work well at this location, and it would otherwise appear a good candidate, however there are significant property impacts to nearby houses and businesses. Considering that an at-grade intersection also operates well, the roundabout appears to be too costly with too high of impacts to the community.

6.3 Cranston Drive

The intersection of Airport Road and Cranston Drive is currently an unsignalized T-intersection. A large development is proposed on the east side of Airport Road connecting to the intersection and making it a four-legged intersection. A roundabout was considered on the basis of traffic calming and to accommodate future traffic volumes.

The analysis determined that a roundabout is not supported by the cost analysis, but should be considered subject to further study of community impacts and further consultation:

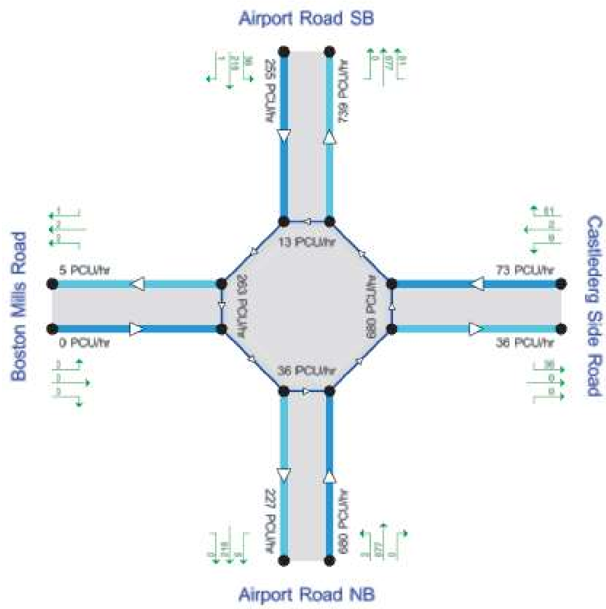
- Following OTM Book 12, this intersection is not warranted for traffic signals through 2041. A stop controlled intersection continues to provide sufficient capacity.
- The safety performance found a penalty to safety with the introduction of a roundabout, likely due to the new requirement for through traffic to slow and negotiate the roundabout. However, the safety performance looked at the intersection in isolation, whereas a roundabout would likely improve safety for a proposed pedestrian crosswalk to Caledon East public school, located approximately 300m north of the intersection. It is also desirable to encourage slower speeds through the community of Caledon East.
- Following further provisions to incorporate comments from the 2nd functional design review, it is concluded that the design of a roundabout is supportable and suitable at this location from a functional design perspective.
- The roundabout implementation cost was significantly higher than the at-grade intersection.

Altogether, the Region's screening tool shows more non-supportive than supportive elements, indicating that the roundabout is difficult to justify. However, it is also difficult to quantify the benefit of encouraging lower traffic speeds through the community of Caledon East. Therefore, the Region could pursue one under further review and consultation in the EA.

APPENDIX A

ARCADAY Analysis Results

Airport Road at Boston Mills Road / Castlederg Side Road



Single-Lane Entry

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Boston Mills Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
Castlederg Side Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

2021 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Boston Mills Road	0.00	0.00	0.00	A	7.70	A	39 % [Airport Road SB]
Airport Road NB	0.17	3.62	0.14	A			
Castlederg Side Road	0.09	3.54	0.08	A			
Airport Road SB	1.93	9.11	0.66	A			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Boston Mills Road	0.00	0.00	0.00	A	6.90	A	46 % [Airport Road NB]
Airport Road NB	1.68	8.22	0.63	A			
Castlederg Side Road	0.10	4.61	0.09	A			
Airport Road SB	0.30	3.96	0.23	A			

2031 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Boston Mills Road	0.00	0.00	0.00	A	11.92	B	16 % [Airport Road SB]
Airport Road NB	0.20	3.74	0.17	A			
Castlederg Side Road	0.11	3.65	0.10	A			
Airport Road SB	3.65	14.68	0.79	B			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Boston Mills Road	0.00	0.00	0.00	A	9.68	A	23 % [Airport Road NB]
Airport Road NB	2.93	12.14	0.75	B			
Castlederg Side Road	0.13	5.12	0.11	A			
Airport Road SB	0.37	4.17	0.27	A			

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Boston Mills Road	0.00	0.00	0.00	A	32.79	D	-2 % [Airport Road SB]
Airport Road NB	0.25	3.89	0.20	A			
Castlederg Side Road	0.14	3.78	0.12	A			
Airport Road SB	12.08	42.36	0.94	E			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Boston Mills Road	0.00	0.00	0.00	A	19.72	C	4 % [Airport Road NB]
Airport Road NB	7.33	26.54	0.89	D			
Castlederg Side Road	0.17	5.87	0.15	A			
Airport Road SB	0.46	4.44	0.31	A			

Single-Lane Entry with NB By-Pass Lane

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Boston Mills Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
Castlederg Side Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

Bypass

Name	Arm Has Bypass	Bypass Utilisation (%)
Boston Mills Road		
Airport Road NB	✓	100
Castlederg Side Road		
Airport Road SB		

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry with NB By-Pass - 2041						
Boston Mills Road	0.00	0.00	0.00	A	32.78	D	-2 % [Airport Road SB]
Airport Road NB	0.24	3.86	0.19	A			
Castlederg Side Road	0.14	3.78	0.12	A			
Airport Road SB	12.08	42.36	0.94	E			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry with NB By-Pass - 2041						
Boston Mills Road	0.00	0.00	0.00	A	14.97	B	9 % [Airport Road NB]
Airport Road NB	5.23	19.62	0.85	C			
Castlederg Side Road	0.17	5.88	0.15	A			
Airport Road SB	0.46	4.44	0.31	A			

SB Flared Two-Lane Entry with NB By-Pass Lane

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Boston Mills Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
Castlederg Side Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	8.00	20.00	25.00	49.00	20.00	

Bypass

Name	Arm Has Bypass	Bypass Utilisation (%)
Boston Mills Road		
Airport Road NB	✓	100
Castlederg Side Road		
Airport Road SB		

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	SB Flared Two-Lane Entry with NB By-Pass - 2041						
Boston Mills Road	0.00	0.00	0.00	A	4.79	A	55 % [Airport Road SB]
Airport Road NB	0.24	3.86	0.19	A			
Castlederg Side Road	0.14	3.78	0.12	A			
Airport Road SB	1.54	5.10	0.60	A			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	SB Flared Two-Lane Entry with NB By-Pass - 2041						
Boston Mills Road	0.00	0.00	0.00	A	14.49	B	9 % [Airport Road NB]
Airport Road NB	5.23	19.62	0.85	C			
Castlederg Side Road	0.17	5.88	0.15	A			
Airport Road SB	0.25	2.46	0.20	A			

N/S Flared Two-Lane Entry (no By-Pass Lane)

Roundabout Geometry

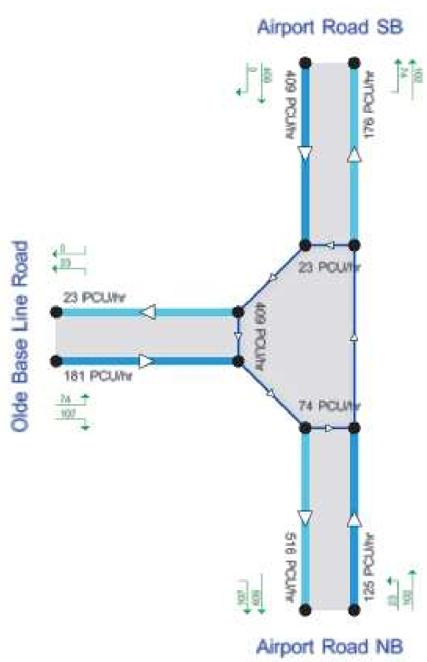
Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Boston Mills Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	8.00	20.00	25.00	49.00	20.00	
Castlederg Side Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	8.00	20.00	25.00	49.00	20.00	

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	N/S Flared Two-Lane Entry - 2041						
Boston Mills Road	0.00	0.00	0.00	A	4.54	A	55 % [Airport Road SB]
Airport Road NB	0.15	2.29	0.13	A			
Castlederg Side Road	0.14	3.78	0.12	A			
Airport Road SB	1.54	5.10	0.60	A			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	N/S Flared Two-Lane Entry - 2041						
Boston Mills Road	0.00	0.00	0.00	A	4.20	A	65 % [Airport Road NB]
Airport Road NB	1.35	4.65	0.57	A			
Castlederg Side Road	0.17	5.88	0.15	A			
Airport Road SB	0.25	2.46	0.20	A			

Airport Road at Olde Base Line Road



Single-Lane Entry

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Olde Base Line Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

2021 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Olde Base Line Road	0.41	5.59	0.29	A	8.54	A	30 % [Airport Road SB]
Airport Road NB	0.19	3.76	0.16	A			
Airport Road SB	2.42	10.50	0.71	B			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Olde Base Line Road	0.48	4.97	0.32	A	8.79	A	22 % [Airport Road NB]
Airport Road NB	2.63	12.53	0.73	B			
Airport Road SB	0.54	4.86	0.35	A			

2031 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Olde Base Line Road	0.57	6.62	0.36	A	14.69	B	9 % [Airport Road SB]
Airport Road NB	0.23	3.92	0.18	A			
Airport Road SB	5.22	19.48	0.85	C			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Olde Base Line Road	0.64	5.61	0.39	A	17.65	C	2 % [Airport Road NB]
Airport Road NB	7.01	29.21	0.89	D			
Airport Road SB	0.69	5.39	0.40	A			

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Olde Base Line Road	0.84	8.24	0.45	A	55.49	F	-8 % [Airport Road SB]
Airport Road NB	0.28	4.11	0.22	A			
Airport Road SB	27.04	80.62	1.01	F			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Olde Base Line Road	0.89	6.60	0.47	A	89.90	F	-14 % [Airport Road NB]
Airport Road NB	55.59	168.23	1.09	F			
Airport Road SB	0.91	6.11	0.47	A			

Single-Lane Entry with SB By-Pass Lane

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Olde Base Line Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

Bypass

Name	Arm Has Bypass	Bypass Utilisation (%)
Olde Base Line Road		
Airport Road NB		
Airport Road SB	✓	100

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry With SB By-Pass - 2041						
Olde Base Line Road	0.86	8.45	0.46	A	9.44	A	28 % [Airport Road SB]
Airport Road NB	0.28	4.11	0.22	A			
Airport Road SB	2.52	10.85	0.72	B			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry With SB By-Pass - 2041						
Olde Base Line Road	0.89	6.60	0.47	A	89.53	F	-14 % [Airport Road NB]
Airport Road NB	55.59	168.23	1.09	F			
Airport Road SB	0.45	4.66	0.31	A			

NB Flared Two-Lane Entry with SB By-Pass Lane

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Olde Base Line Road	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	8.00	20.00	25.00	49.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

Bypass

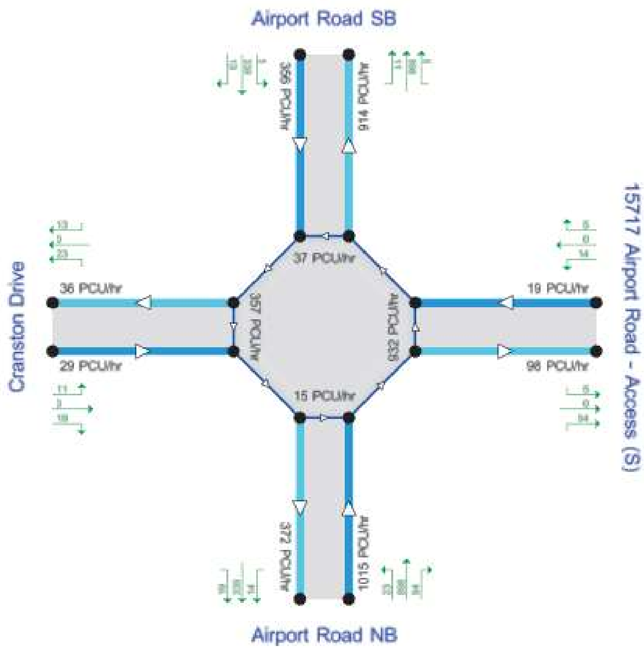
Name	Arm Has Bypass	Bypass Utilisation (%)
Olde Base Line Road		
Airport Road NB		
Airport Road SB	✓	100

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	NB Flared Two-lane Entry with SB By-Pass Lane - 2041						
Olde Base Line Road	0.86	8.45	0.46	A	9.21	A	28 % [Airport Road SB]
Airport Road NB	0.16	2.38	0.14	A			
Airport Road SB	2.52	10.85	0.72	B			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	NB Flared Two-lane Entry with SB By-Pass Lane - 2041						
Olde Base Line Road	0.89	6.60	0.47	A	6.40	A	31 % [Airport Road NB]
Airport Road NB	2.14	7.14	0.68	A			
Airport Road SB	0.46	4.70	0.31	A			

Airport Road at Cranston Drive



Single-Lane Entry

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Cranston Drive	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	4.25	0.00	25.00	55.00	20.00	
15717 Airport Road - Access (S)	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	4.25	0.00	25.00	55.00	20.00	

2021 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Cranston Drive	0.05	4.71	0.04	A	8.24	A	34 % [Airport Road SB]
Airport Road NB	0.29	3.91	0.22	A			
15717 Airport Road - Access (S)	0.00	0.00	0.00	A			
Airport Road SB	2.22	9.78	0.69	A			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2021						
Cranston Drive	0.03	3.66	0.03	A	11.58	B	16 % [Airport Road NB]
Airport Road NB	3.78	14.67	0.79	B			
15717 Airport Road - Access (S)	0.00	0.00	0.00	A			
Airport Road SB	0.48	4.50	0.32	A			

2031 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Cranston Drive	0.06	5.50	0.06	A	14.79	B	9 % [Airport Road SB]
Airport Road NB	0.40	4.24	0.28	A			
15717 Airport Road - Access (S)	0.09	3.77	0.08	A			
Airport Road SB	5.19	19.69	0.84	C			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2031						
Cranston Drive	0.04	3.84	0.04	A	96.80	F	-13 % [Airport Road NB]
Airport Road NB	51.39	133.97	1.06	F			
15717 Airport Road - Access (S)	0.04	5.52	0.04	A			
Airport Road SB	0.62	4.99	0.38	A			

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Cranston Drive	0.09	6.28	0.08	A	55.36	F	-8 % [Airport Road SB]
Airport Road NB	0.48	4.50	0.32	A			
15717 Airport Road - Access (S)	0.09	3.87	0.08	A			
Airport Road SB	25.45	77.71	1.00	F			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Single-lane Entry - 2041						
Cranston Drive	0.05	4.01	0.04	A	367.45	F	-26 % [Airport Road NB]
Airport Road NB	171.36	511.46	1.24	F			
15717 Airport Road - Access (S)	0.04	5.62	0.04	A			
Airport Road SB	0.80	5.52	0.44	A			

N/S Flared Two-lane Entry

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
Cranston Drive	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road NB	4.25	8.00	20.00	25.00	49.00	20.00	
15717 Airport Road - Access (S)	4.25	4.25	0.00	25.00	55.00	20.00	
Airport Road SB	4.25	8.00	20.00	25.00	49.00	20.00	

2041 Volumes

	AM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Flared Two-lane Entry - 2041						
Cranston Drive	0.09	6.44	0.08	A	4.85	A	47 % [Airport Road SB]
Airport Road NB	0.27	2.48	0.21	A			
15717 Airport Road - Access (S)	0.09	3.87	0.08	A			
Airport Road SB	1.83	5.63	0.64	A			

	PM Peak						
	Queue (PCU)	Delay (s)	RFC	LOS	Junction Delay (s)	Junction LOS	Network Residual Capacity
	Flared Two-lane Entry - 2041						
Cranston Drive	0.05	4.01	0.04	A	7.90	A	19 % [Airport Road NB]
Airport Road NB	3.98	9.82	0.80	A			
15717 Airport Road - Access (S)	0.06	6.98	0.05	A			
Airport Road SB	0.40	2.78	0.28	A			

APPENDIX B

Traffic Analysis – Base Improvement Synchro Outputs

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	1	3	85	3	33	3	199	6	71	924	0
Future Volume (Veh/h)	0	1	3	85	3	33	3	199	6	71	924	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	0	1	3	85	3	33	3	199	6	71	924	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)			4			4						
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1292	1277	924	1276	1274	202	924			205		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1292	1277	924	1276	1274	202	924			205		
tC, single (s)	7.1	6.5	6.7	7.1	6.5	6.2	4.1			4.2		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.8	3.5	4.0	3.3	2.2			2.3		
p0 queue free %	100	99	99	37	98	96	100			95		
cM capacity (veh/h)	128	158	268	135	159	844	748			1337		

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	0	4	85	36	208	995
Volume Left	0	0	85	0	3	71
Volume Right	0	3	0	33	6	0
cSH	1700	357	135	921	748	1337
Volume to Capacity	0.00	0.01	0.63	0.04	0.00	0.05
Queue Length 95th (m)	0.0	0.3	25.3	0.9	0.1	1.3
Control Delay (s)	0.0	20.9	68.6	11.0	0.2	1.4
Lane LOS	A	C	F	B	A	A
Approach Delay (s)	20.9		51.5		0.2	1.4
Approach LOS	C		F			

Intersection Summary			
Average Delay	5.8		
Intersection Capacity Utilization	84.9%	ICU Level of Service	E
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	3	1	0	12	3	82	3	907	48	48	290	1
Future Volume (Veh/h)	3	1	0	12	3	82	3	907	48	48	290	1
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	3	1	0	12	3	82	3	907	48	48	290	1
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)			4			4						
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1366	1348	290	1324	1324	931	291			955		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1366	1348	290	1324	1324	931	291			955		
tC, single (s)	7.1	6.5	6.2	7.1	7.0	6.2	4.1			4.2		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.5	3.3	2.2			2.3		
p0 queue free %	97	99	100	91	97	75	100			93		
cM capacity (veh/h)	87	142	753	126	116	324	1282			704		

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	3	1	12	85	958	339
Volume Left	3	0	12	0	3	48
Volume Right	0	0	0	82	48	1
cSH	87	0	126	335	1282	704
Volume to Capacity	0.03	Err	0.09	0.25	0.00	0.07
Queue Length 95th (m)	0.8	Err	2.3	7.5	0.1	1.7
Control Delay (s)	47.8	Err	36.4	20.5	0.1	2.2
Lane LOS	E	F	E	C	A	A
Approach Delay (s)	Err		22.4		0.1	2.2
Approach LOS	F		C			

Intersection Summary			
Average Delay	Err		
Intersection Capacity Utilization	69.2%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	133	202	41	183	773	315
Future Volume (vph)	133	202	41	183	773	315
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.6	6.6	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1690	1541	1755	1562	1812	1601
Flt Permitted	0.95	1.00	0.30	1.00	1.00	1.00
Satd. Flow (perm)	1690	1541	552	1562	1812	1601
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	133	202	41	183	773	315
RTOR Reduction (vph)	0	174	0	0	0	53
Lane Group Flow (vph)	133	28	41	183	773	262
Heavy Vehicles (%)	8%	6%	4%	23%	6%	2%
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	11.9	11.9	62.9	62.9	62.9	62.9
Effective Green, g (s)	11.9	11.9	62.9	62.9	62.9	62.9
Actuated g/C Ratio	0.14	0.14	0.72	0.72	0.72	0.72
Clearance Time (s)	6.6	6.6	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	230	209	397	1124	1304	1152
v/s Ratio Prot	c0.08			0.12	c0.43	
v/s Ratio Perm		0.02	0.07			0.16
v/c Ratio	0.58	0.13	0.10	0.16	0.59	0.23
Uniform Delay, d1	35.4	33.2	3.7	3.9	6.0	4.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	3.5	0.3	0.5	0.3	2.0	0.5
Delay (s)	38.9	33.5	4.2	4.2	8.0	4.6
Level of Service	D	C	A	A	A	A
Approach Delay (s)	35.6			4.2	7.0	
Approach LOS	D			A	A	

Intersection Summary			
HCM 2000 Control Delay	12.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	87.4	Sum of lost time (s)	12.6
Intersection Capacity Utilization	63.7%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	393	49	151	841	318	170
Future Volume (vph)	393	49	151	841	318	170
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.6	6.6	6.0	6.0	6.0	6.0
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.95	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	1807	1498	1807	1830	1671	1617
Flt Permitted	0.95	1.00	0.56	1.00	1.00	1.00
Satd. Flow (perm)	1807	1498	1056	1830	1671	1617
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	393	49	151	841	318	170
RTOR Reduction (vph)	0	21	0	0	0	64
Lane Group Flow (vph)	393	28	151	841	318	106
Heavy Vehicles (%)	1%	9%	1%	5%	15%	1%
Turn Type	Prot	Perm	Perm	NA	NA	Perm
Protected Phases	4			2	6	
Permitted Phases		4	2			6
Actuated Green, G (s)	21.0	21.0	56.0	56.0	56.0	56.0
Effective Green, g (s)	21.0	21.0	56.0	56.0	56.0	56.0
Actuated g/C Ratio	0.23	0.23	0.63	0.63	0.63	0.63
Clearance Time (s)	6.6	6.6	6.0	6.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	423	351	660	1143	1044	1010
v/s Ratio Prot	c0.22			c0.46	0.19	
v/s Ratio Perm		0.02	0.14			0.07
v/c Ratio	0.93	0.08	0.23	0.74	0.30	0.11
Uniform Delay, d1	33.6	26.8	7.4	11.7	7.8	6.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	26.5	0.1	0.8	4.2	0.8	0.2
Delay (s)	60.1	26.8	8.2	15.9	8.5	7.0
Level of Service	E	C	A	B	A	A
Approach Delay (s)	56.4			14.7	8.0	
Approach LOS	E			B	A	

Intersection Summary			
HCM 2000 Control Delay	22.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	89.6	Sum of lost time (s)	12.6
Intersection Capacity Utilization	76.5%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	13	0	32	59	0	16	10	315	26	3	1058	9
Future Volume (Veh/h)	13	0	32	59	0	16	10	315	26	3	1058	9
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	13	0	32	59	0	16	10	315	26	3	1058	9
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1415	1425	1058	1431	1408	315	1067			341		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1415	1425	1058	1431	1408	315	1067			341		
tC, single (s)	7.2	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.6	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	88	100	88	39	100	98	98			100		
cM capacity (veh/h)	106	133	269	97	136	725	661			1218		

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	13	32	59	16	10	315	26	3	1058	9
Volume Left	13	0	59	0	10	0	0	3	0	0
Volume Right	0	32	0	16	0	0	26	0	0	9
cSH	106	269	97	725	661	1700	1700	1218	1700	1700
Volume to Capacity	0.12	0.12	0.61	0.02	0.02	0.19	0.02	0.00	0.62	0.01
Queue Length 95th (m)	3.1	3.0	21.9	0.5	0.4	0.0	0.0	0.1	0.0	0.0
Control Delay (s)	43.6	20.2	87.1	10.1	10.5	0.0	0.0	8.0	0.0	0.0
Lane LOS	E	C	F	B	B			A		
Approach Delay (s)	26.9		70.7		0.3			0.0		
Approach LOS	D		F							

Intersection Summary			
Average Delay	4.3		
Intersection Capacity Utilization	72.3%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	14	0	25	19	0	7	31	1199	125	6	451	17
Future Volume (Veh/h)	14	0	25	19	0	7	31	1199	125	6	451	17
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	14	0	25	19	0	7	31	1199	125	6	451	17
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	1731	1849	451	1749	1741	1199	468			1324		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1731	1849	451	1749	1741	1199	468			1324		
tC, single (s)	7.1	6.5	6.3	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.4	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	79	100	96	70	100	97	97			99		
cM capacity (veh/h)	66	71	600	62	83	226	1078			522		

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	14	25	19	7	31	1199	125	6	451	17
Volume Left	14	0	19	0	31	0	0	6	0	0
Volume Right	0	25	0	7	0	0	125	0	0	17
cSH	66	600	62	226	1078	1700	1700	522	1700	1700
Volume to Capacity	0.21	0.04	0.30	0.03	0.03	0.71	0.07	0.01	0.27	0.01
Queue Length 95th (m)	5.5	1.0	8.3	0.7	0.7	0.0	0.0	0.3	0.0	0.0
Control Delay (s)	74.0	11.3	86.2	21.4	8.4	0.0	0.0	12.0	0.0	0.0
Lane LOS	F	B	F	C	A			B		
Approach Delay (s)	33.8		68.7		0.2			0.2		
Approach LOS	D		F							

Intersection Summary			
Average Delay	1.8		
Intersection Capacity Utilization	77.5%	ICU Level of Service	D
Analysis Period (min)	15		

APPENDIX C

Signal Warrants

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Airport Road / Boston Mills Road / Castlederg Side Rd   Count Date: 2016

Justification 1: Minimum Vehicle Volumes

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
1A	480	720	600	900	1,293	1,056	634	679	759	1,121	1,273	1,284		
	COMPLIANCE %				100	100	70	75	84	100	100	100	730	91
1B	120	170	120	170	112	75	57	58	59	128	84	110		
	COMPLIANCE %				66	44	34	34	35	75	49	65	402	50

Restricted Flow Signal Justification 1:			
	Both 1A and 1B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
	Lesser of 1A or 1B at least 80% fulfilled each of 8 hours	Yes ☐	No ☑

Justification 2: Delay to Cross Traffic

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
2A	480	720	600	900	1,181	981	577	621	700	993	1,189	1,174		
	COMPLIANCE %				100	100	64	69	78	100	100	100	711	89
2B	50	75	50	75	79	52	12	13	15	28	18	24		
	COMPLIANCE %				100	69	16	17	20	37	24	32	316	40

Restricted Flow Signal Justification 2:			
	Both 2A and 2B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
	Lesser of 2A or 2B at least 80% fulfilled each of 8 hours	Yes ☐	No ☑

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☐	NO ☑	YES ☐	NO ☑
Justification 2	Delay Cross Traffic	YES ☐	NO ☑		NOT JUSTIFIED

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main) X	Heaviest Minor Approach Y (actual)	Required Value Y (warrant threshold)	Average % Compliance	Overall % Compliance
Justification 4	9:00	1,181	106	142	75 %	66 %
	16:00	1,174	103	143	72 %	
	17:00	1,189	80	140	57 %	
	16:00	993	114	197	58 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Airport Road / Cranston Dr

Count Date: 2016

Justification 1: Minimum Vehicle Volumes

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
1A	480	720	600	900	1,586	1,405	864	884	964	1,414	1,793	1,804		
	COMPLIANCE %				100	100	96	98	100	100	100	100	794	99
1B	180	255	180	255	274	327	124	163	175	286	390	454		
	COMPLIANCE %				100	100	49	64	69	100	100	100	681	85

Restricted Flow Signal Justification 1:			
Both 1A and 1B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
Lesser of 1A or 1B at least 80% fulfilled each of 8 hours	Yes ☑	No ☐

Justification 2: Delay to Cross Traffic

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
2A	480	720	600	900	1,312	1,078	740	721	789	1,128	1,403	1,350		
	COMPLIANCE %				100	100	82	80	88	100	100	100	750	94
2B	50	75	50	75	97	180	94	111	145	240	356	410		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100

Restricted Flow Signal Justification 2:		
Both 2A and 2B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
Lesser of 2A or 2B at least 80% fulfilled each of 8 hours	Yes ☑	No ☐

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☑	NO ☐	YES ☑	NO ☐
Justification 2	Delay Cross Traffic	YES ☑	NO ☐	JUSTIFIED	

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main) X	Heaviest Minor Approach Y (actual)	Required Value Y (warrant threshold)	Average % Compliance	Overall % Compliance
Justification 4	16:00	1,350	454	115	100 %	100 %
	17:00	1,403	390	115	100 %	
	9:00	1,312	274	116	100 %	
	16:00	1,128	286	155	100 %	

Analysis Sheet

Input Sheet | Results Sheet | Proposed Collision

GO TO Justification:

Intersection: Airport Road / Cranston Dr   Count Date: 2016

Justification 1: Minimum Vehicle Volumes

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 Lanes		2 or More Lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
1A	480	720	600	900	1,619	1,568	961	938	1,036	1,500	1,872	1,827		
	COMPLIANCE %				100	100	100	100	100	100	100	100	800	100
1B	120	170	120	170	207	341	65	70	53	125	111	122		
	COMPLIANCE %				100	100	38	41	31	73	65	72	521	65

Restricted Flow Signal Justification 1:			
	Both 1A and 1B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
	Lesser of 1A or 1B at least 80% fulfilled each of 8 hours	Yes ☐	No ☑

Justification 2: Delay to Cross Traffic

Restricted Flow Urban Conditions

Justification	Guidance Approach Lanes				Percentage Warrant								Total Across	Section Percent
	1 lanes		2 or More lanes		Hour Ending									
Flow Condition	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☑	9:00	10:00	13:00	14:00	15:00	16:00	17:00	16:00		
2A	480	720	600	900	1,412	1,227	896	868	983	1,375	1,761	1,705		
	COMPLIANCE %				100	100	100	96	100	100	100	100	796	99
2B	50	75	50	75	139	260	44	48	30	113	80	91		
	COMPLIANCE %				100	100	59	64	40	100	100	100	663	83

Restricted Flow Signal Justification 2:			
	Both 2A and 2B 100% Fullfilled each of 8 hours	Yes ☐	No ☑
	Lesser of 2A or 2B at least 80% fulfilled each of 8 hours	Yes ☑	No ☐

Justification 3: Combination

Combination Justification 1 and 2

Justification Satisfied 80% or More				Two Justifications Satisfied 80% or More	
Justification 1	Minimum Vehicular Volume	YES ☐	NO ☑	YES ☐	NO ☑
Justification 2	Delay Cross Traffic	YES ☑	NO ☐		NOT JUSTIFIED

Justification 4: Four Hour Volume

Justification	Time Period	Total Volume of Both Approaches (Main) X	Heaviest Minor Approach Y (actual)	Required Value Y (warrant threshold)	Average % Compliance	Overall % Compliance
Justification 4	17:00	1,761	62	115	53 %	78 %
	16:00	1,705	68	115	59 %	
	9:00	1,412	134	115	100 %	
	10:00	1,227	253	131	100 %	

APPENDIX D

Roundabout Functional Design Review – 1st Review

IBI GROUP
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Waterloo ON N2L 3V3 Canada
tel 519 585 2255
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Memorandum

To/Attention	Scott Johnston, P.Eng.	**Date**	September 18, 2018
From	John Bayley, P.Eng.	**Project No**	109535 - Airport Road EA Study
cc	File, Sergei Filippov, Hailey McWilliam		
Subject	Roundabout Functional Design Review - 1st Review		

The following summarizes the observations, suggestions and comments that have resulted from a first independent technical review of proposed modern roundabout intersections at Airport Road, at Caledon, Ontario. The subject intersections are all two way stop controlled with free flow permitted in the north – south direction on Airport Road.

The following proposed intersections were reviewed:

1. Airport Road at Castlederg Side Road/Boston Mills Road
2. Airport Road at Olde Base Line Road
3. Airport Road at Cranston Drive

The subject intersections are all located within the Region of Peel municipal boundary near Caledon, Ontario. The initial review is in support of the overall Airport Road EA study and was undertaken by the undersigned task lead, John Bayley, P.Eng. Manager of Transportation Engineering and transportation engineering designer Mr. Sergei Filippov, C.E.T., Design Technologist both resident in the Transportation Engineering section at the Waterloo, Ontario office of IBI Group.

The concepts that were reviewed had been prepared by Region of Peel Engineering staff and offered to IBI Group as part of the defined project scope for comment by qualified members of the IBI Group project study team.

This is the first technical review to be undertaken on the roundabout design aspects for the project and is being completed in advance of presentation of three roundabout intersection concepts to the public later in the study. Five designs were prepared by the Region but only three were presented specifically for technical review. The current purpose is to identify concerns and challenges that may arise from the technical, environmental, operational, and administrative and potentially legal (future property, etc.) perspectives.

The overall intent of the first review is to identify pertinent functional aspects of the designs and permit Region staff to refine the design presentations and address as many identified concerns as possible before the alternative roundabout intersection concepts are evaluated against other options and presented in summary to the public.

Scott Johnston, P.Eng. – September 18, 2018

The following presents the detail of the roundabout reviews and each roundabout is summarized separately for clarity and is presented in order from South to North.

Geometric Design Criteria

Roadway Geometric design criteria were not specifically presented prior to review but the following have been assumed:

Roadway Classification – Rural Arterial Roadway - Semi Urban Design

Traffic Volumes (AADT) - refer to current Draft project traffic study by IBI Group, dated August 24, 2018.

Existing – Base year 2016 - ~5,700 NB / ~5,900 SB (Source : Exhibit 4-5: Existing AADT on Airport Road - Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)

2021 – Short range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)

2031 – Mid range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)

2041 – Long range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)

Turning Volumes Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018. (see above)

Truck Route: Yes

Truck Percentages: Not provided, Light - __%, Medium - __%, Heavy - __%

Design Vehicle: WB-20

Design Speed – 70 kph

Posted Speed - 50 kph

Minimum Lane widths:

Curb Lane - 3.50 m

Through Lane – 3.50 m

Pavement Surface – Asphaltic concrete

Active Transportation Provisions:

Multi Use trail

Sidewalk

Cycling – off road - TBC

Public Transit – TBC

Community Trail Linkages – TBC

Rest Areas – TBC

Functional Design Review Summary

The attached plan view layouts overlaid on the topographic photo imagery base plan (Figures 1 2 and 3) are to be viewed along with the following summary of comments, suggestions and opinion.

All feedback provided is based on current knowledge and past experience with the design and "in service" operational aspects related to numerous modern roundabout intersection functional and detailed designs and constructed roundabouts within the Regional Municipality of Waterloo and surrounding area. The Region of Waterloo has for many years had "in-service" roundabouts in isolated areas, in partially and fully built up urban areas, in remote locations, in commercial and industrial zones with heavy traffic and high truck percentages, some in couplets, in continuous series with continuous medians, and others separated by traditional signalized and un-signalized intersections with and without access restrictions between roundabouts. Each has their own benefits and detractors.

Airport Road at Castlederg Side Road/Boston Mills Road

Single Lane - E-W on side roads and initially on Airport Road

Multi-lane - TBC

Inscribed Circle Diameter (ICD) = ~56m Ultimate, ~ 48 m Interim assumed (widen to inside in future – TBC)

Lane width minimum – see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Transit Service – TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Refer to markup Figure 1 for specifics of review.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 1and 1A

Fastest Path Analysis: Preliminary review – see attached Figure 1and 1A

Comments and Observations: as noted on markup figure and summarized as follows:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for each for the interim single lane and ultimate multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, the ultimate multi-lane ICD is proposed in the interim and as such satisfies both the single lane and multi-lane requirements.

Fastest Path – see Figure 1 and 1A example.

An ideal design will satisfy the maximum entry speed requirement and mimic a consistent circulatory road speed within a reasonable range of speed and will permit acceptable acceleration at the departure leg allowing for a sudden stop without endangering pedestrians where crossings are provided on the departure leg. For this to occur, each fastest path must be analysed with the others to create an acceptable balance between speed, safety and efficiency.

The following extract from NCHRP 672 summarizes the maximum desirable entry speeds for the various roundabouts configurations.

Exhibit 6-47
Recommended Maximum Entry Design Speeds

Site Category	Recommended Maximum Theoretical Entry Design Speed
Mini-Roundabout	20 mph (30 km/h)
Single Lane	25 mph (40 km/h)
Multilane	25 to 30 mph (40 to 50 km/h)

For the current design layout the SB fastest path speeds are approximately 45-28-40 km/hr (R_1, R_2 and R_3) while NB fastest path speeds are approximately 35-25-42 km/hr and a worst case maximum speed of 47 km/h on right turn movements. The SB entry speed exceeds the desirable maximum for a single lane entry but would be acceptable for a future multi-lane roundabout.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 1A. West leg appears to be too narrow to accommodate WB-20 truck movements. The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal.

Where possible, and in consideration the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements shall be refined during the design development process.

Conflict Zones – In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – adjacent land uses at the roundabout and approaches include primarily agriculture and open space.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout the access points are not anticipated. For future planning and development should consider access restrictions and relocations outside the weaving areas associated with the entries and departures.

Environmental considerations – at this roundabout there are no obvious environmental concerns aside from the economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 1. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Airport Road at Olde Base Line Road

Single Lane - E-W on side roads and initially on Airport Road

Multi-lane - TBC

Inscribed Circle Diameter (ICD) = ~46m Interim, ~53 Ultimate assumed (widen to outside in future)

Lane width minimum – (see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Transit Service - TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Refer to markup Figure 2 for specifics of review.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 2 and 2A.

Fastest Path Analysis: Preliminary review – see attached Figure 2 and 2A

Comments: as noted on markup figure and summarized as follows:

Comments and Observations: as noted on markup figure and summarized as follows:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for each for the interim single lane and ultimate multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, the ultimate single lane ICD is proposed in the interim and as such satisfies the single lane requirement and multi-lane ICD of approximately 53m would result and be satisfactory to NCHRP 672.

Fastest Path - For the current design layout the SB fastest path speeds are approximately 42-34-50 km/hr (R1, R2 and R3) while NB fastest path speeds are approximately 50-35-57 km/hr and a worst case maximum speed of 45 km/h on right turn movements.

The SB and NB entry speeds both exceed the desirable maximum for a single lane entry but would be acceptable for a future multi-lane roundabout.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

The entry speeds should all be reviewed to lower them below the maximum desirable entry speed and the departures should be reviewed to address the potential for pedestrian and vehicle conflicts along with the reduced overall sightline created by the typical roundabout geometry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 2A. West leg appears to be too narrow to accommodate WB-20 truck movements.

The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal. Where possible, and in consideration the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements will be refined during the design development process.

Conflict Zones – There is potential design vehicle conflict on the west leg at this location. In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – adjacent land uses at the roundabout and approaches include commercial properties and an existing petroleum fueling station.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout the access points will include existing commercial sites and petroleum filling station entrances, Future planning and development should consider access relocations outside the weaving areas associated with the entries and departures.

Environmental Considerations – Soil conditions may exhibit environment impact, acquisition of land for roundabout construction should include due diligence and environmental site assessment to ascertain environmental impacts and mitigation strategy. Economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 2. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Airport Road at Cranston Drive

Single Lane - E-W on side roads and initially on Airport Road

Multi-lane - TBC

Inscribed Circle Diameter (ICD) = ~40m – single lane, Multi-lane - not specified – ~48m assumed (widen to outside in future)

Lane width minimum – (see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Transit Service – TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Refer to markup Figure 3 for specifics of review.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 3 and 3A.

Fastest Path Analysis: Preliminary review see attached figure – see attached Figure 3 and 3A.

Comments and Observations: as noted on markup figures and summarized as follows:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for each for the interim single lane and ultimate multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, the ultimate single lane ICD is proposed in the interim and marginally satisfies the NCHRP recommendation for the single lane requirement and an assumed 48 m multi-lane ICD of approximately would be less than desirable according to NCHRP 672.

Fastest Path - For the current design layout the SB fastest path speeds are approximately 43-34-48 km/hr (R1, R2 and R3) while NB fastest path speeds are approximately 45-33-52 km/hr and a worst case maximum speed of 42 km/h on right turn movements.

The SB and NB entry speeds both exceed the desirable maximum for a single lane entry while both the NB and SB entry speeds would be acceptable for a future multi-lane roundabout.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

The entry speeds should all be reviewed to lower them below the maximum desirable entry speed and the departures should be reviewed to address the potential for pedestrian and vehicle conflicts along with the reduced overall sightline created by the typical roundabout geometry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 3A.

All right turning swept paths can be accommodate with the proposed side road geometry.

The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal. Where possible, and in consideration the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements shall be refined during the design development process.

Conflict Zones – There is potential design vehicle conflict on the west leg at this location. In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – Adjacent land uses at the roundabout and approaches include street fronting residential properties at west side on Cranston Drive, and agricultural land use at east side which is scheduled for future development.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout the access points will include street fronting residential properties at west side on Cranston Drive and for future planning and future development should consider access locations outside the weaving areas associated with the entries and departures.

Environmental Considerations – at this roundabout there are no obvious environmental concerns aside from the direct impacts on residential properties and the economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 3. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Overall General Opinion:

The comments provided in the desktop review of the proposed functional designs for each roundabout intersection are founded on experience and knowledge of current design standards and practical applications. Each aspect that has been noted should be considered going forward and reviewed and refined prior to presentation of the proposed functional designs to the public.

Current AODA requirements, guidelines and standards must be considered and incorporated in the design.

Further consideration of the truck turning and fastest path analyses should be completed for each of the subsequent refined roundabout designs including the side road legs. The intent of this is to ensure that the desired outcome is achieved and that current guidelines and accepted practises are applied throughout the design, construction and maintenance of the facilities.

Formal design checks should be documented later in the design process including 30% and 60% designs before final design commitments are made.

The designer and owner should consider both the short and long term needs of the community and construct a facility that maximizes current and future user safety (all modes), minimizes future costs (present worth or future value analysis might be considered) and recognizes the potential for excessive inconvenience to the public in the longer term due to upgrading and retrofitting needs. Traffic management and staging of construction are primary considerations in the ultimate decision making that should occur.

If the potential to require future lanes for a multi-use roundabout operation is possible or of high potential then it is suggested that alternatives to construct the full roundabout and to minimize future in-service disruptions to maintain and/or upgrade the roundabout be considered fully in the immediate design timeframe.

Some of the options available include:

1.) Construct the full roundabout including all lanes with suitably designed departures and acceleration lanes and tapers;

2.) Construct the full roundabout and in the interim place traffic on the outer or inner lanes only;

3.) Construct the full roundabout and close the second or third lanes either through markings, delineators or physical means including temporary curbs and boulevard;

4.) Variation or combination of the above; or,

5.) Single lanes only.

The number and orientation of lanes on the tangent roadway and the approach geometry has a very significant impact on the overall safe operation of the roundabout. If not carefully planned and designed a single lane conversion to a multi-lane facility the result may include excessive operating speed on the approaches and in the circulatory roadway, lane conflicts in the circulatory roadway, as a result of improper ICD, approach geometry, and unsuitable entry and exit angles that are committed during a focussed interim design.

Some impacts of expansion without careful design of the interim facility can be increases in fastest path speed, non-compliance with markings in the off peaks hours and additional property required to expand the facility in the future which will be much more difficult and expensive to obtain.

The width of future side roads will have direct impact on approach geometry and entry angles. Other factors to be considered are the need for divided/undivided approaches, future extension of splitter islands, access control, the need for single lane/multi-lane circulatory roadway and overall site specific future development.

A flared throat is traditionally used for the entry and departure design and the reviewer's observations confirm generally acceptable functionality but suggest caution where a multi lane cross section is provided in the roundabout and then tapered immediately following departure through the pedestrian crossing zone.

Pedestrian crossings must be located 12.0m from the splitter island bullnose to permit two passenger vehicles or one single unit truck to react to pedestrian presence at the departures and clear the circulatory roadway. Lane merging in pedestrian crossing areas is strongly discouraged, we suggest that a parallel auxiliary acceleration lane of suitable length and taper for the intended design speed be provided following the pedestrian crossing area.

Conclusion

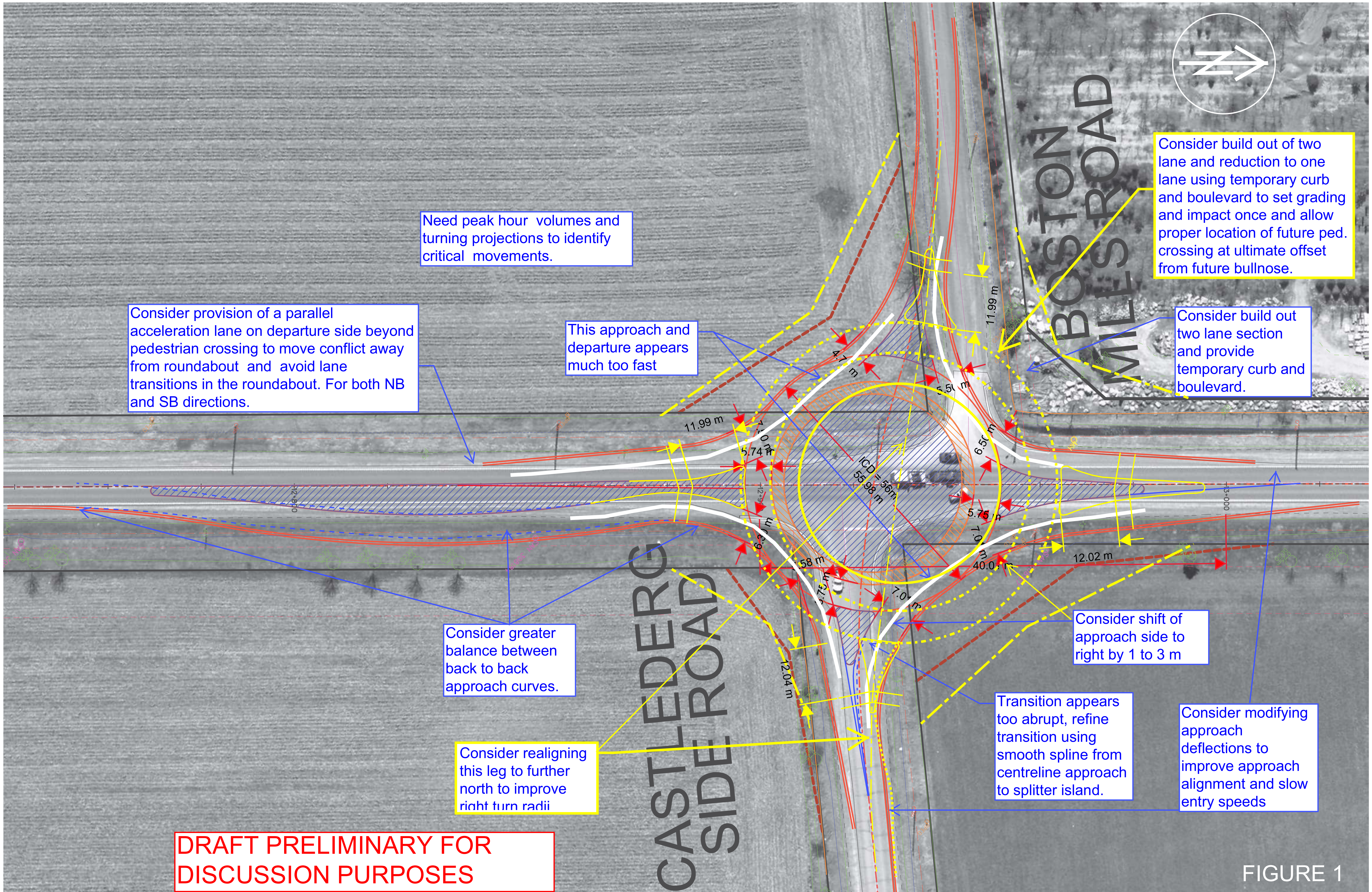
The foregoing is a first review of the intended functional design alternatives and should be followed by a formal detailed design checks review after refinements are made to the roundabout designs. The design reviews should be completed at the 30% and 60% design stages and in the pre-tender stage for any subsequent work.

Respectfully,

IBI Group Professional Services (Canada) Inc.

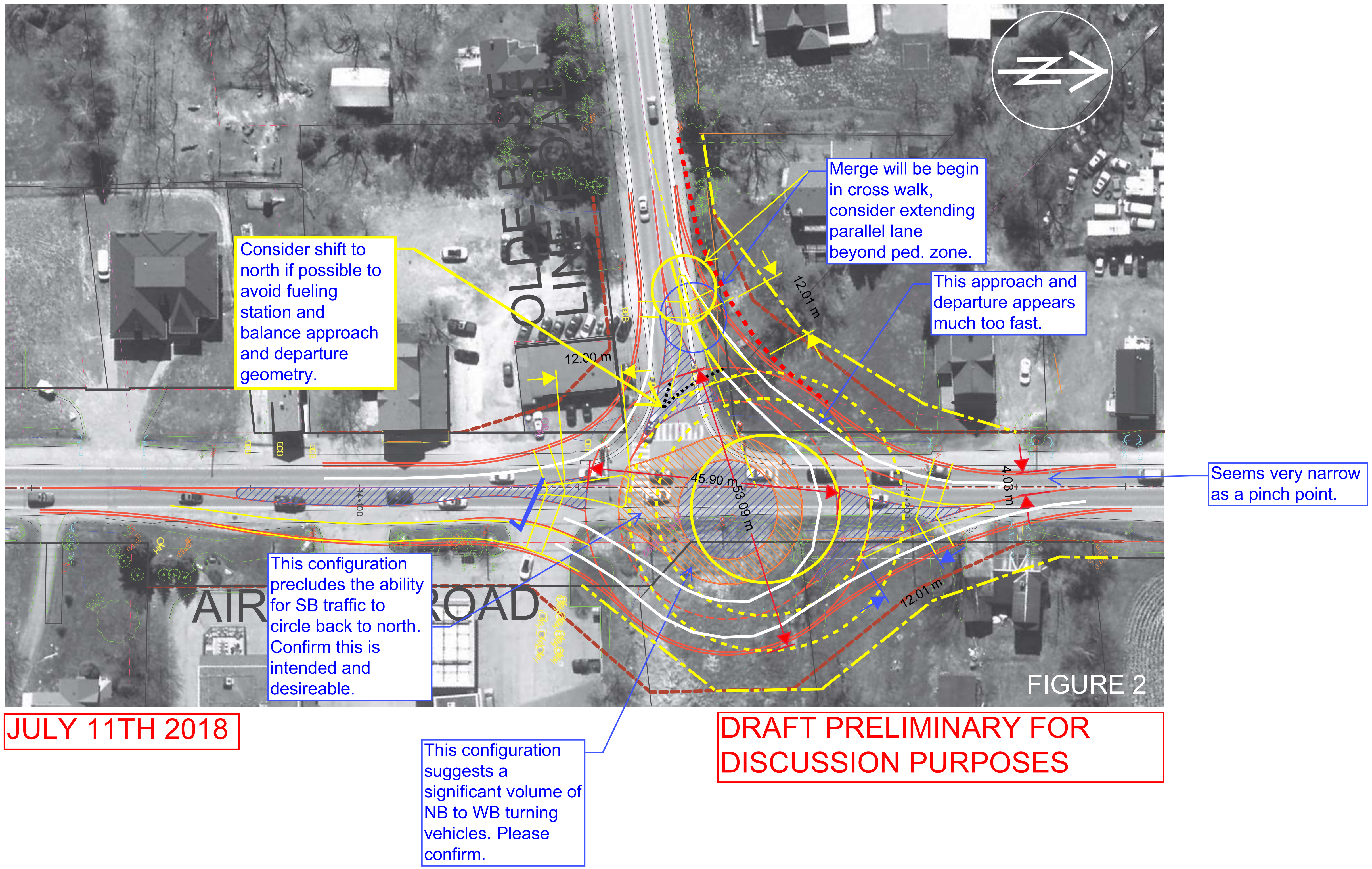
John Bayley, P.Eng.

AIRPORT ROAD ROUNDABOUT DESIGN



JULY 11TH 2018

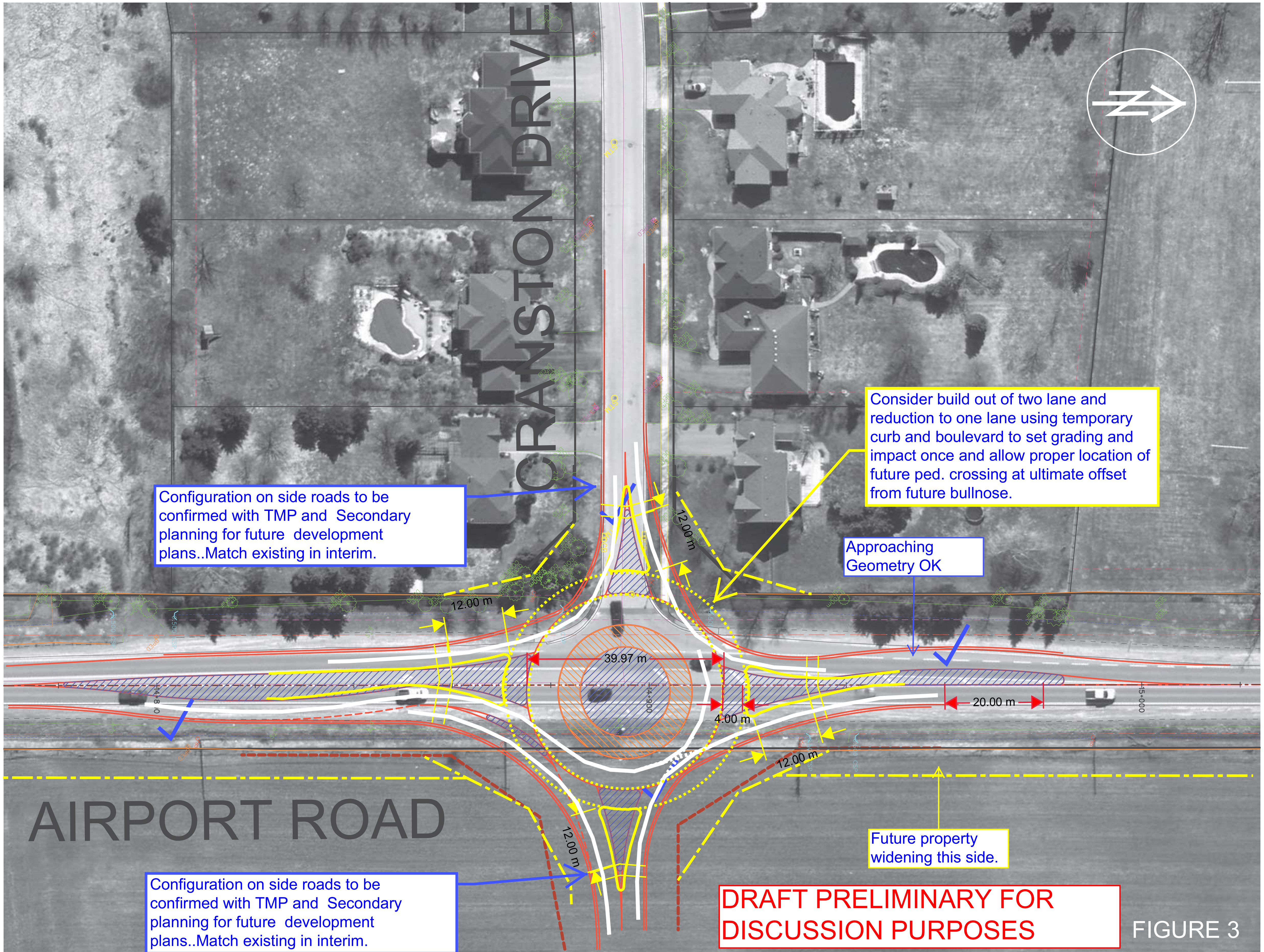
AIRPORT ROAD ROUNDABOUT DESIGN



JULY 11TH 2018

DRAFT PRELIMINARY FOR DISCUSSION PURPOSES

AIRPORT ROAD ROUNDABOUT DESIGN



JULY 11TH 2018

APPENDIX E

Roundabout Functional Design Review – 2nd Review

IBI GROUP
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Waterloo ON N2L 3V3 Canada
tel 519 585 2255
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Memorandum

To/Attention	Scott Johnston, P.Eng.	**Date**	February 21, 2019
From	John Bayley, P.Eng.	**Project No**	109535 - Airport Road EA Study
cc	File, Sergei Filippov, Hailey McWilliam		
Subject	Roundabout Functional Design Review - 2nd Review – Rev.2		

The following summarizes the observations, suggestions and comments that have resulted from a second independent technical review of proposed modern roundabout intersections at Airport Road, at Caledon, Ontario. This second review is in response to modifications made by the design team following the initial independent review and follow-up on-line meeting. The subject intersections are all presently two way stop controlled with free flow permitted in the north – south direction on Airport Road.

The following proposed intersections were reviewed:

1. Airport Road at Castlederg Side Road/Boston Mills Road
2. Airport Road at Olde Base Line Road
3. Airport Road at Cranston Drive

The subject intersections are all located within the Region of Peel municipal boundary near Caledon, Ontario. The current review is in support of the overall Airport Road EA study and was undertaken by the undersigned task lead, John Bayley, P.Eng. Manager of Transportation Engineering and transportation engineering designer Mr. Sergei Filippov, C.E.T., Design Technologist both resident in the Transportation Engineering section at the Waterloo, Ontario office of IBI Group.

The concepts that were reviewed had been prepared by Region of Peel Engineering staff and offered to IBI Group as part of the defined project scope for comment by qualified members of the IBI Group project study team.

This is the second technical review to be undertaken on the roundabout design aspects for the project and is being completed in advance of presentation of three roundabout intersection concepts to the public later in the study. Five designs were prepared by the Region but only three were presented specifically for an in depth technical review. The current purpose is to identify concerns and challenges that may arise from the technical, environmental, operational, and administrative and potentially legal (future property, etc.) perspectives.

The overall intent of the technical review is to identify pertinent functional aspects of the designs and permit Region staff to refine the design presentations and address as many identified concerns as possible before the alternative roundabout intersection concepts are evaluated against other options and presented in summary to the public.

Scott Johnston, P.Eng. – February 21, 2019

The following presents the detail of the roundabout reviews and each roundabout is summarized separately for clarity and is presented in order from South to North.

Geometric Design Criteria

Roadway Geometric design criteria were not specifically presented prior to review but the following have been assumed:

Roadway Classification – Rural Arterial Roadway - Semi Urban Design

Traffic Volumes (AADT) - refer to current Draft project traffic study by IBI Group, dated August 24, 2018.

> Existing – Base year 2016 - ~5,700 NB / ~5,900 SB (Source : Exhibit 4-5: Existing AADT on Airport Road - Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)
>
> 2021 – Short range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)
>
> 2031 – Mid range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)
>
> 2041 – Long range forecast (Source : Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018.)

Turning Volumes Draft Report, Airport Road EA, King Street to Huntsmill Drive Transportation Study dated August 24, 2018. (see above)

Truck Route: Yes

Truck Percentages: Not provided, Light - TBC%, Medium - TBC%, Heavy – TBC%

Design Vehicle: WB-20

Design Speed – 70 kph

Posted Speed - 50 kph

Minimum Lane widths:

Curb Lane - 3.50 m

Through Lane – 3.50 m

Pavement Surface – Asphaltic concrete

Active Transportation Provisions:

Multi Use trail

Sidewalk

Cycling – off road - TBC

Public Transit – TBC

Community Trail Linkages – TBC

Rest Areas – TBC

Functional Design Review Summary

The attached plan view layouts (Figures 1, 2 and 3) are to be viewed along with the following summary of comments, suggestions and opinion.

All feedback provided is based on current knowledge and past experience with the design and “in service” operational aspects related to numerous modern roundabout intersection functional and detailed designs and constructed roundabouts within the Regional Municipality of Waterloo and surrounding area. The Region of Waterloo has for many years had “in-service” roundabouts in isolated areas, in partially and fully built up urban areas, in remote locations, in commercial and industrial zones with heavy traffic and high truck percentages, some in couplets, in continuous series with continuous medians, and others separated by traditional signalized and un-signalized intersections with and without access restrictions between roundabouts. Each has their own benefits and detractors.

Airport Road at Castlederg Side Road/Boston Mills Road

Single Lane with flared approaches - E-W on side roads and initially on Airport Road

Multi-lane - TBC

Inscribed Circle Diameter (ICD) = ~55m Ultimate, ~ 55m Interim assumed (widen to inside in future – TBC)

Lane width minimum – see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Scott Johnston, P.Eng. – February 21, 2019

Transit Service – TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 1A

Fastest Path Analysis: Preliminary review – see attached Interim Design and Ultimate Design Fastest Path Roundabout Review.

Comments and Observations: as noted on markup figure and summarized as follows:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for each for the interim single lane and ultimate multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, the ultimate multi-lane ICD is proposed in the interim and as such satisfies both the single lane and multi-lane requirements.

Fastest Path

An ideal design will satisfy the maximum entry speed requirement and mimic a consistent circulatory road speed within a reasonable range of speed and will permit acceptable acceleration at the departure leg allowing for a sudden stop without endangering pedestrians where crossings are provided on the departure leg. For this to occur, each fastest path must be analysed with the others to create an acceptable balance between speed, safety and efficiency.

The following extract from NCHRP 672 summarizes the maximum desirable entry speeds for the various roundabouts configurations.

Exhibit 6-47
Recommended Maximum Entry Design Speeds

Site Category	Recommended Maximum Theoretical Entry Design Speed
Mini-Roundabout	20 mph (30 km/h)
Single Lane	25 mph (40 km/h)
Multilane	25 to 30 mph (40 to 50 km/h)

For the current interim design layout the SB fastest path speeds are approximately 33-25-37 km/hr (R_1, R_2 and R_3) while NB fastest path speeds are approximately 34-26-53 km/hr and a worst case maximum entry speed of 42 km/h on right turn movements. The SB entry speed exceeds the desirable maximum for a single lane entry but would be acceptable for a future multi-lane roundabout.

Additional consideration should be given for future and ultimate design layout. Following future widening inside the ICD the SB fastest path speeds are approximately 56-31-54 km/hr (R_1, R_2 and R_3) while NB fastest path speeds are approximately 48-35-87 km/hr and a worst case maximum entry speed of 56 km/h on SB movements. The SB entry speed exceeds the desirable maximum for a multi-lane entry and should be refined to fall below recommended entry speeds.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 1A. West and East legs appears to be too narrow to accommodate WB-20 truck movements. The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal.

Where possible, and in consideration of the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements shall be refined during the design development process.

Conflict Zones – In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – adjacent land uses at the roundabout and approaches include primarily agriculture and open space.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout additional access points are not anticipated. For future planning and development should consider access restrictions and relocations outside the weaving areas associated with the entries and departures.

Environmental Considerations – at this roundabout there are no obvious environmental concerns aside from the economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 1. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Airport Road at Olde Base Line Road

Single Lane with Flared approaches - E-W on side roads and initially on Airport Road

Multi-lane - TBC

Inscribed Circle Diameter (ICD) = ~40m Interim (irregular shape), ~52m Ultimate assumed (widen to outside in future)

Lane width minimum – (see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Transit Service - TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 2A.

Fastest Path Analysis: Preliminary review – Interim Design and Ultimate Design Fastest Path Roundabout Review.

Comments and Observations:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for each for the interim single lane and ultimate multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Scott Johnston, P.Eng. – February 21, 2019

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, the ultimate multi-lane ICD is proposed in the interim and as such satisfies the single lane requirement and multi-lane ICD of approximately 53m would result and be satisfactory to NCHRP 672.

Fastest Path - For the current interim design layout the SB fastest path speeds are approximately 62-34-49 km/hr (R1, R2 and R3) while NB fastest path speeds are approximately 56-40-40 km/hr and a worst case maximum speed of 41 km/h on right turn movements.

Fastest Path - For the ultimate design layout the SB fastest path speeds are approximately 50-40-76 km/hr (R1, R2 and R3) while NB fastest path speeds are approximately 63-37-64 km/hr and a worst case maximum speed of 41 km/h on right turn movements.

The SB and NB entry speeds both exceed the desirable maximum for a single lane entry and future multi-lane roundabout and should be refined to fall below recommended entry speeds.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

The entry speeds should all be reviewed to lower them below the maximum desirable entry speed and the departures should be reviewed to address the potential for pedestrian and vehicle conflicts along with the reduced overall sightline created by the typical roundabout geometry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 2A. The revised design appears to be acceptable to accommodate all WB-20 truck movements.

The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal. Where possible, and in consideration of the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements shall be refined during the design development process.

Conflict Zones – There is potential design vehicle conflict on the west leg at this location. In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

For this specific roundabout, the proposed irregular (cam) shaped central island will restrict the opportunity for SB to NB U-turns which should be considered further by the design team to ensure that access can be provided to all adjacent properties should the roadway be continuously divided north of the proposed roundabout.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – adjacent land uses at the roundabout and approaches include commercial properties and an existing petroleum fueling station.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout the access points will include existing commercial sites and petroleum filling station entrances, Future planning and development should consider access relocations outside the weaving areas associated with the entries and departures.

Environmental Considerations – Soil conditions may exhibit environment impact, acquisition of land for roundabout construction should include due diligence and environmental site assessment to ascertain environmental impacts and mitigation strategy. Economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 2. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Airport Road at Cranston Drive

Single Lane - E-W on side roads

Single lane with Flared approaches - N-S on Airport Road

Scott Johnston, P.Eng. – February 21, 2019

Inscribed Circle Diameter (ICD) = ~52m – Multi- lane roundabout

Lane width minimum – (see study recommendations (Assumed 3.75 through lanes and 3.5 turn lanes)

Cycling Provisions – not included

Sidewalks – TBC

Multi-use Trail – TBC

Transit Service – TBC

Signage: Not currently designed or presented for review.

Illumination: Not currently designed or presented for review.

Pedestrian Actuated Signals: Not proposed, designed or reviewed.

Swept Path Analysis: Preliminary review – WB-20 design vehicle – see attached Figure 3A.

Fastest Path Analysis: Preliminary review – see attached Interim Design Fastest Path Roundabout Review.

Comments and Observations:

Inscribed Circle Diameter (ICD) – the proposed inscribed circle diameter for multi-lane roundabouts shall satisfy the requirements of NCHRP 672.

Exhibit 6-9
Typical Inscribed Circle Diameter Ranges

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

In this case, a multi-lane circulatory roadway with ICD of ~52 m proposed approach conditions satisfies the recommendation for a two lane multi-lane roundabout and would be acceptable for WB-20 trucks according to NCHRP 672.

Fastest Path - For the current design layout the SB fastest path speeds are approximately 49-40-68 km/hr (R1, R2 and R3) while NB fastest path speeds are approximately 51-37-109 km/hr and a worst case maximum speed of 38 km/h on right turn movements. The higher than desirable exit velocity for the NB fastest path (109 km/hr) should be refined to lower the speed in the area of the pedestrian crossing and as such we have included an example modification that will achieve lower exit velocity (69 km/hr) at the departure for the NB through movement (NE quadrant). Similar consideration should be given to the SB movement and further refined for the NB movement using both lane narrowing and possible ICD reduction combined with modified deflection of the departure geometries to further reduce the exit velocities.

The SB and NB entry speeds are marginally acceptable for a multi-lane roundabout.

The speed balance for the circulatory road in each of the isolated directions is generally within acceptable speed range but the entry speeds should all be revisited to fall below the desired maximum.

All through movement speeds should be reviewed together and optimized to promote consistent entry and circulatory road speeds thus providing a reasonable merge between vehicles approaching in the circulatory road and the vehicle at the entry.

The entry speeds should all be reviewed to lower them below the maximum desirable entry speed and the departures should be reviewed to address the potential for pedestrian and vehicle conflicts along with the reduced overall sightline created by the typical roundabout geometry.

Generally the moderately higher speeds on the departures will avoid conflict with those vehicles immediately to the right on the adjacent entry. A reasonable progression of 35-30-40 km/hr would be acceptable as a target for these designs as single lane roundabouts and say entry speeds of 45 km/hr for future multi-lane roundabouts.

Truck Turning – See Swept Path analyses in Figure 3A. The design appears to be acceptable to accommodate WB-20 truck movements.

The study report confirms that Airport Road is a designated truck route and as such the safe movement of goods is a study goal. Where possible, and in consideration the forgoing fastest path design geometry, the central island, circulatory roadway and associated splitter islands and pavement markings should be designed to accommodate typical design vehicle (WB-20) trucks using the full available circulatory roadway width without encroachments on the apron area.

Since varying degrees of driver capability and non-standard vehicle use may also be experienced, the roundabout apron area will allow for those exceptions allowing for supplementary vehicle off-tracking where necessary.

Property – General anticipated property impacts are shown schematically on the figure. Property requirements shall be refined during the design development process.

Conflict Zones – There is potential design vehicle conflict on the west leg at this location. In general the other conflict zones are at the merge between the entry and departures and the circulatory road, and the pedestrian crossing zones for each entry and departure. See previous comments regarding lane transition and merging in the pedestrian zones.

Constructability – Not reviewed in detail at this time, is site specific and typically investigated in detail at the 60% design and pre-tender stage. Early identification of possible staging approach is worthwhile and should be considered for designs that are subject to numerous access points, complex utility installations, and under highly constrained conditions.

Adjacent Land Uses – Adjacent land uses at the roundabout and approaches include street fronting residential properties at west side on Cranston Drive, and agricultural land use at east side which is scheduled for future development.

Compatibility and Access – Access points within the approach and departure zones is not favoured but may be required nonetheless. For this roundabout the access points will include street fronting residential properties at west side on Cranston Drive and for future planning and future development should consider access locations outside the weaving areas associated with the entries and departures.

Environmental Considerations – at this roundabout there are no obvious environmental concerns aside from the direct impacts on residential properties and the economic, social and technical aspects associated with typical roundabout installations.

Daylighting and Sight Lines – refer to Figure 3. Typical daylight areas are illustrated on the plans and will be subject to a detailed review at the 30% design stage and beyond. Property acquisition, environmental concerns and required design elements and vertical obstructions, including signs, utility poles, controller cabinets, trees, fences and buildings, etc. should be reviewed in further detail from a three dimensional perspective prior to finalizing the preferred roundabout siting.

Signage and Markings – to be investigated further at the 30 and 60% design stages.

Grading and Drainage – to be investigated further at the 30 and 60% design stages.

Access Control – to be investigated further at the 30 and 60% design stages.

Other considerations: TBC

Overall General Opinion:

The comments provided in the desktop review of the proposed functional designs for each roundabout intersection are founded on experience and knowledge of current design standards and practical applications. Each aspect that has been noted should be considered going forward and reviewed and refined prior to presentation of the proposed functional designs to the public.

Current AODA requirements, guidelines and standards must be considered and incorporated in the design.

Further consideration of the truck turning and fastest path analyses should be completed for each of the subsequent refined roundabout designs including the side road legs. The intent of this is to ensure that the desired outcome is achieved and that current guidelines and accepted practises are applied throughout the design, construction and maintenance of the facilities.

Formal design checks should be documented later in the design process including 30% and 60% designs before final design commitments are made.

The designer and owner should consider both the short and long term needs of the community and construct a facility that maximizes current and future user safety (all modes), minimizes future costs (present worth or future value analysis might be considered) and recognizes the potential for excessive inconvenience to the public in the longer term due to upgrading and retrofitting needs. Traffic management and staging of construction are primary considerations in the ultimate decision making that should occur.

If the potential to require future lanes for a multi-use roundabout operation is possible or of high potential then it is suggested that alternatives to construct the full roundabout and to minimize future in-service disruptions to maintain and/or upgrade the roundabout be considered fully in the immediate design timeframe.

Some of the options available include:

1.) Construct the full roundabout including all lanes with suitably designed departures and acceleration lanes and tapers;

2.) Construct the full roundabout and in the interim place traffic on the outer or inner lanes only;

3.) Construct the full roundabout and close the second or third lanes either through markings, delineators or physical means including temporary curbs and boulevard;

4.) Variation or combination of the above; or,

Scott Johnston, P.Eng. – February 21, 2019

5.) Single lanes only.

The number and orientation of lanes on the tangent roadway and the approach geometry has a very significant impact on the overall safe operation of the roundabout. If not carefully planned and designed a single lane conversion to a multi-lane facility the result may include excessive operating speed on the approaches and in the circulatory roadway, lane conflicts in the circulatory roadway, as a result of improper ICD, approach geometry, and unsuitable entry and exit angles that are committed during a focussed interim design.

Some impacts of expansion without careful design of the interim facility can be increases in fastest path speed, non-compliance with markings in the off peaks hours and additional property required to expand the facility in the future which will be much more difficult and expensive to obtain.

The width of future side roads will have direct impact on approach geometry and entry angles. Other factors to be considered are the need for divided/undivided approaches, future extension of splitter islands, access control, the need for single lane/multi-lane circulatory roadway and overall site specific future development.

A flared throat is traditionally used for the entry and departure design and the reviewer's observations confirm generally acceptable functionality but suggest caution where a multi lane cross section is provided in the roundabout and then tapered immediately following departure through the pedestrian crossing zone.

Pedestrian crossings must be located 12.0m from the splitter island bullnose to permit two passenger vehicles or one single unit truck to react to pedestrian presence at the departures and clear the circulatory roadway. Lane merging in pedestrian crossing areas is strongly discouraged, we suggest that a parallel auxiliary acceleration lane of suitable length and taper for the intended design speed be provided following the pedestrian crossing area.

Conclusion

The foregoing is a follow-up review of the intended functional design alternatives and should be followed by a formal detailed design checks review after refinements are made to the roundabout designs. The design reviews should be completed at the 30% and 60% design stages and in the pre-tender stage for any subsequent work.

Respectfully,

IBI Group Professional Services (Canada) Inc.

John Bayley, P.Eng.

Interim Design

@ Boston Mills	R1	R2	R3	R4	R5
NB	42.8	22	139		
Velocity	34.2	26.8	52.8	0.0	0.0
SB	38.8	17.8	52		
Velocity	33.0	24.8	36.8	0.0	0.0
WB					75
Velocity	0.0	0.0	0.0	0.0	42.1
EB					75
Velocity	0.0	0.0	0.0	0.0	42.1

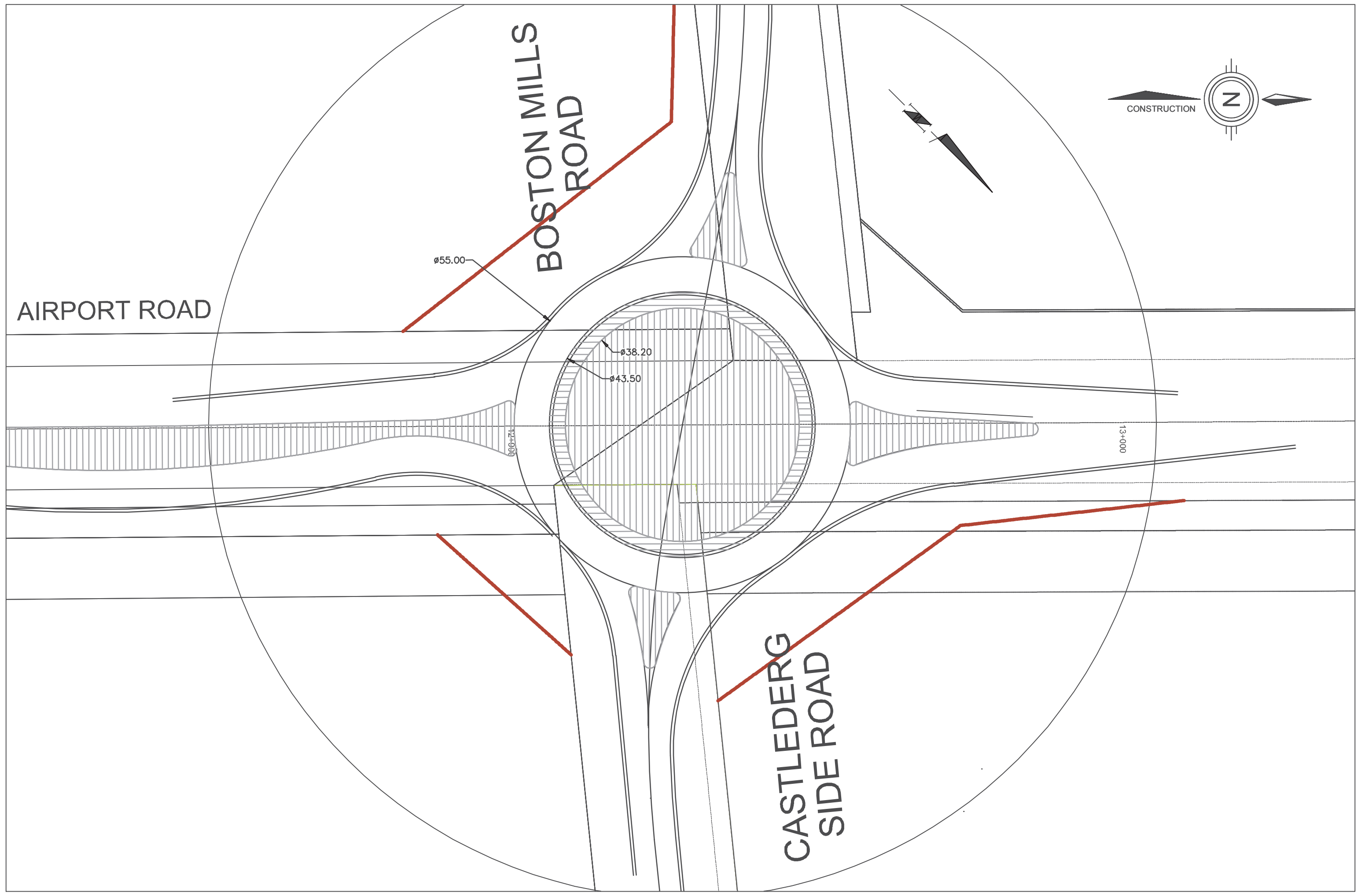
@ Olde Base Line Road	R1	R2	R3	R4	R5
NB	160	68.9	68		
Velocity	55.6	40.8	40.6	0.0	0.0
SB	214	43	115		70
Velocity	61.8	34.3	49.2	0.0	41.0
EB					32
Velocity	0.0	0.0	0.0	0.0	30.8

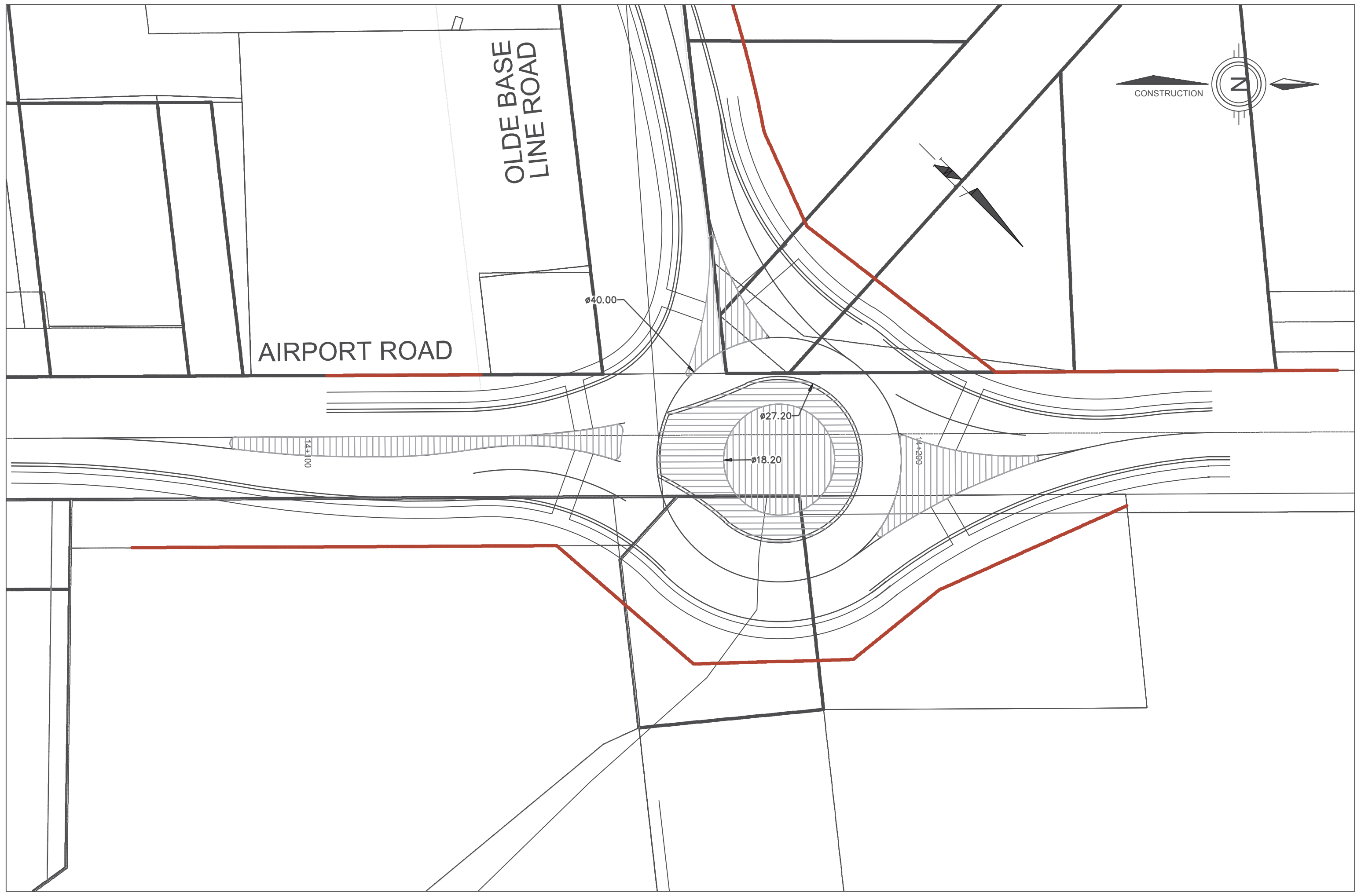
@ Cranston Drive	R1	R2	R3	R4	R5
NB	129	52	995		
Velocity	51.4	36.8	108.7	0.0	0.0
SB	115	67	282		
Velocity	49.2	40.4	68.4	0.0	0.0
WB					46
Velocity	0.0	0.0	0.0	0.0	35.2
EB					57
Velocity	0.0	0.0	0.0	0.0	38.0

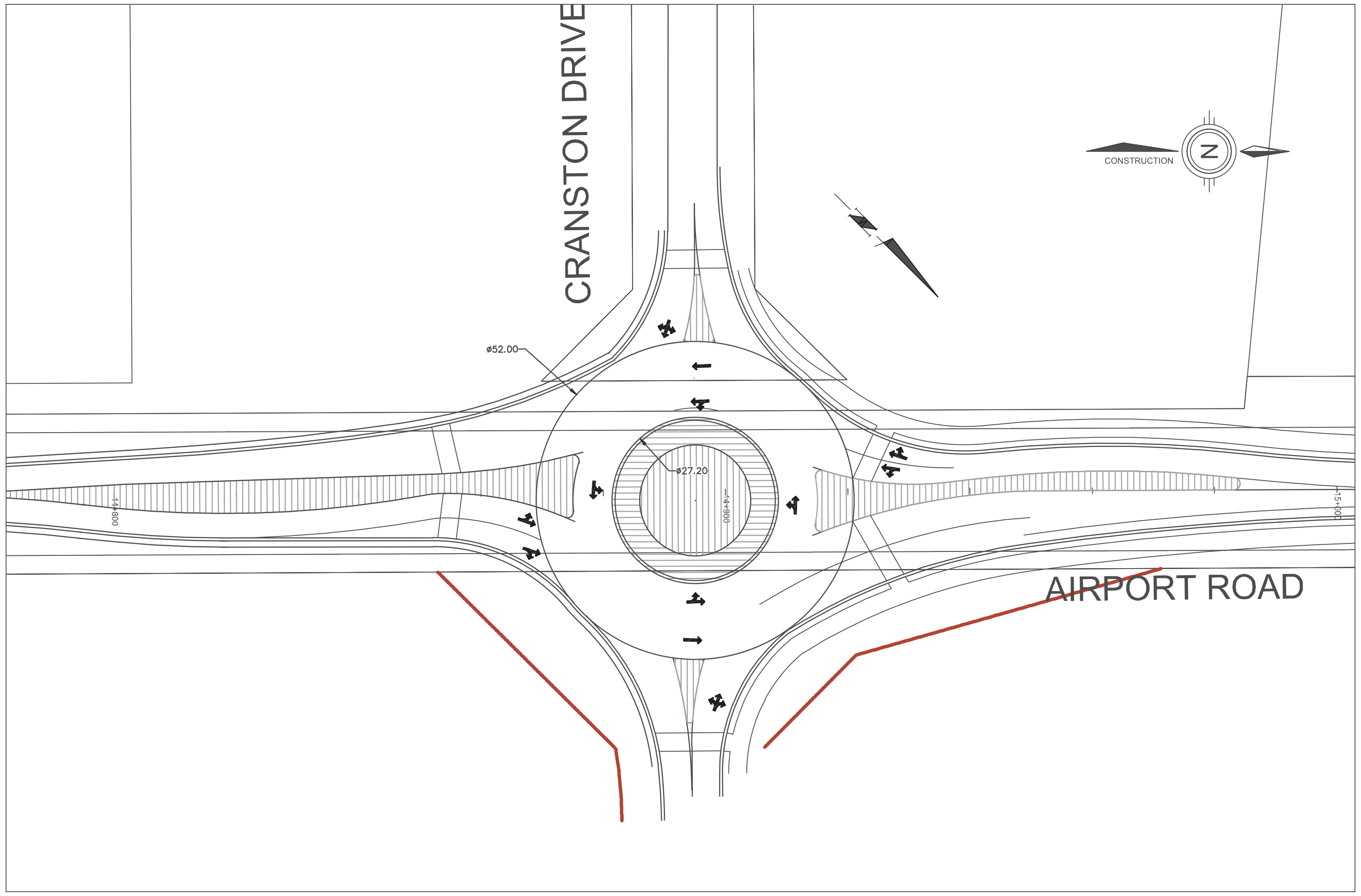
Ultimate Design

@ Boston Mills	R1	R2	R3	R4	R5
NB	108.4	44			536
Velocity	48.2	34.6	0.0	0.0	86.6
SB	164.5	32			144.8
Velocity	56.1	30.8	0.0	0.0	53.6
WB					75
Velocity	0.0	0.0	0.0	0.0	42.1
EB					75
Velocity	0.0	0.0	0.0	0.0	42.1

@ Olde Base Line Road	R1	R2	R3	R4	R5
NB	228	52	232		
Velocity	63.3	36.8	63.7	0.0	0.0
SB	120	67	370		73
Velocity	50.0	40.4	75.6	0.0	41.7
EB					32
Velocity	0.0	0.0	0.0	0.0	30.8







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ROUNDABOUT REVIEW 2

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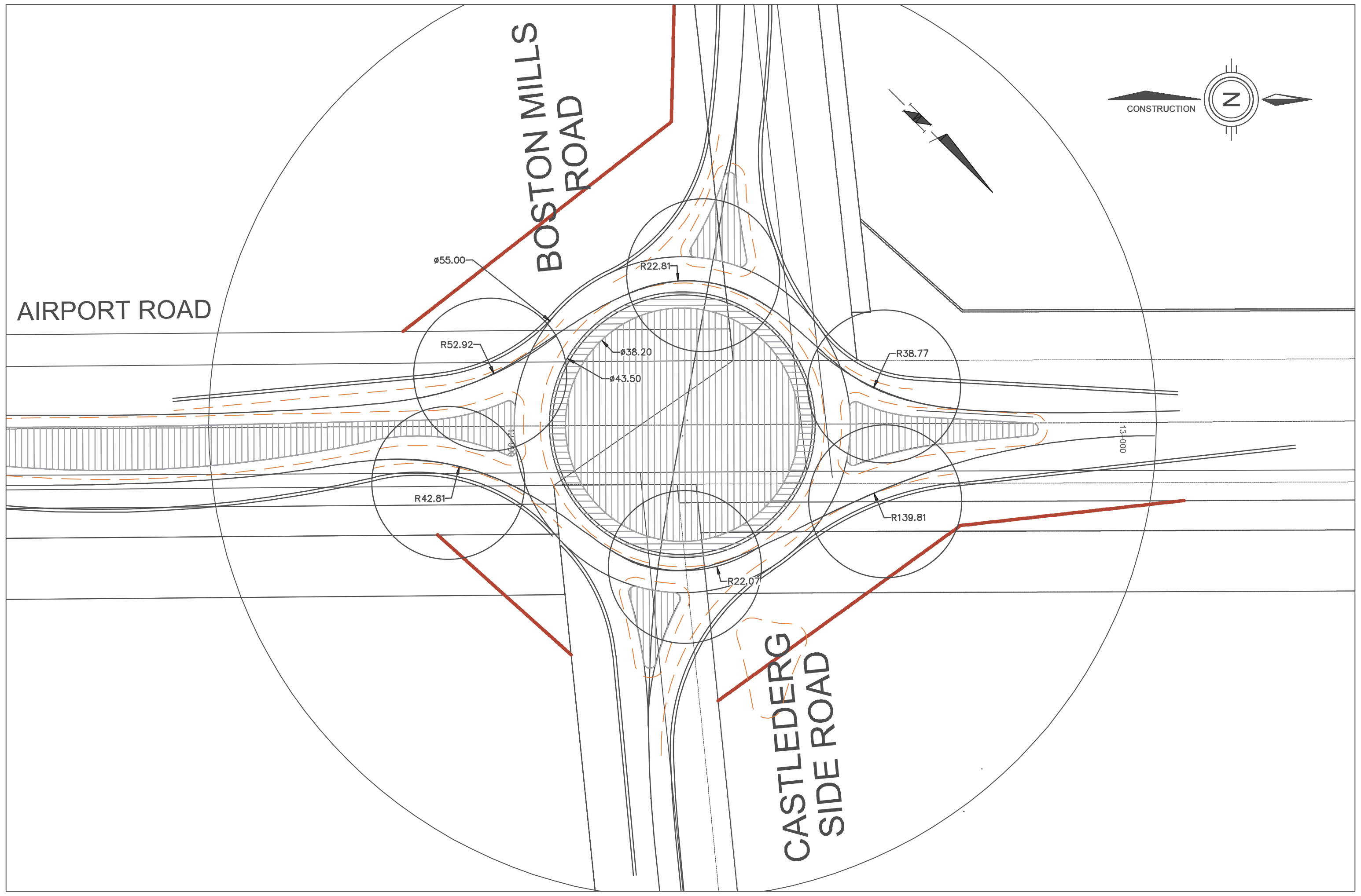

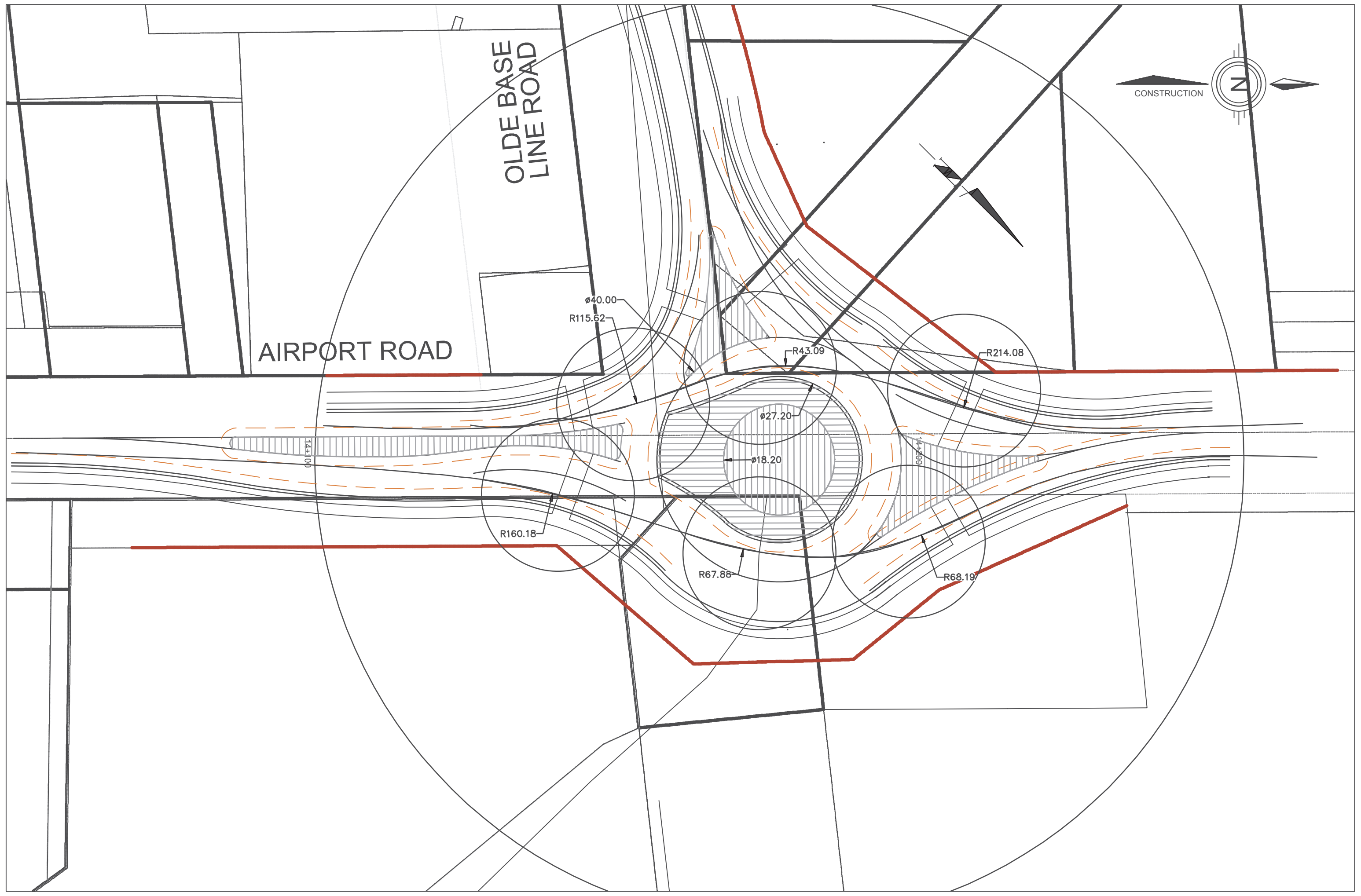

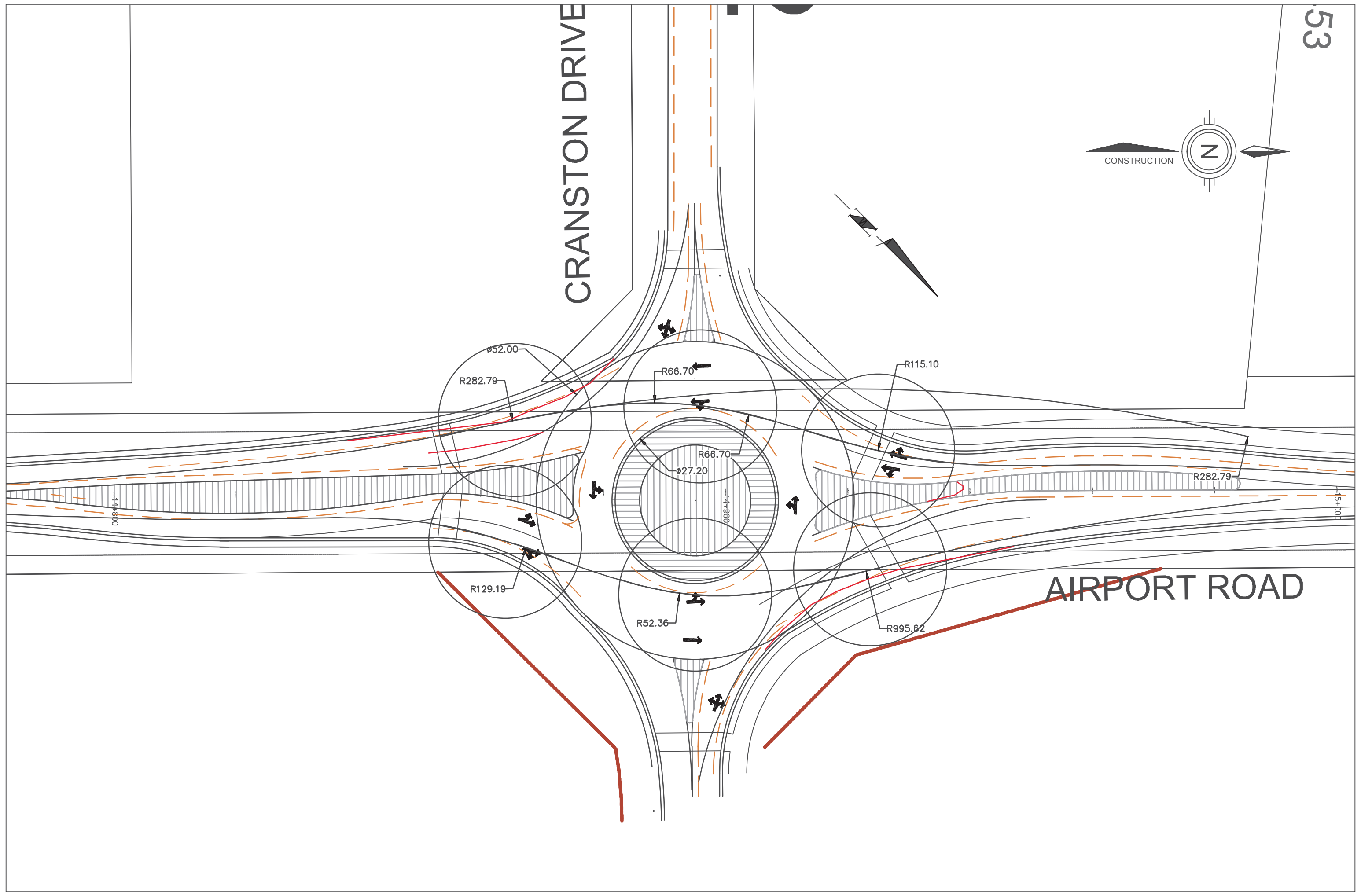

INTERIM DESIGN
FASTEST PATH
ROUNDABOUT REVIEW 2

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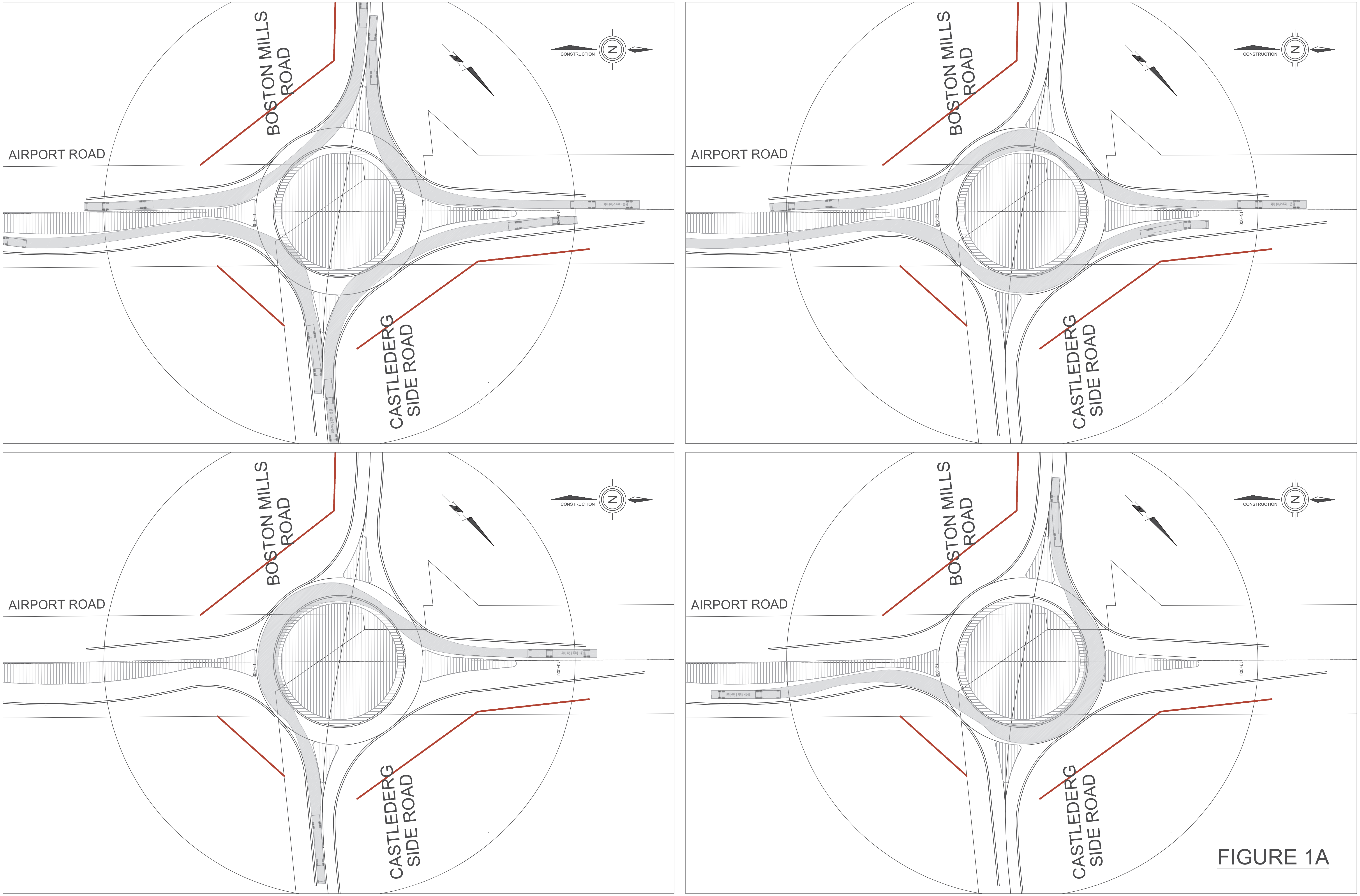
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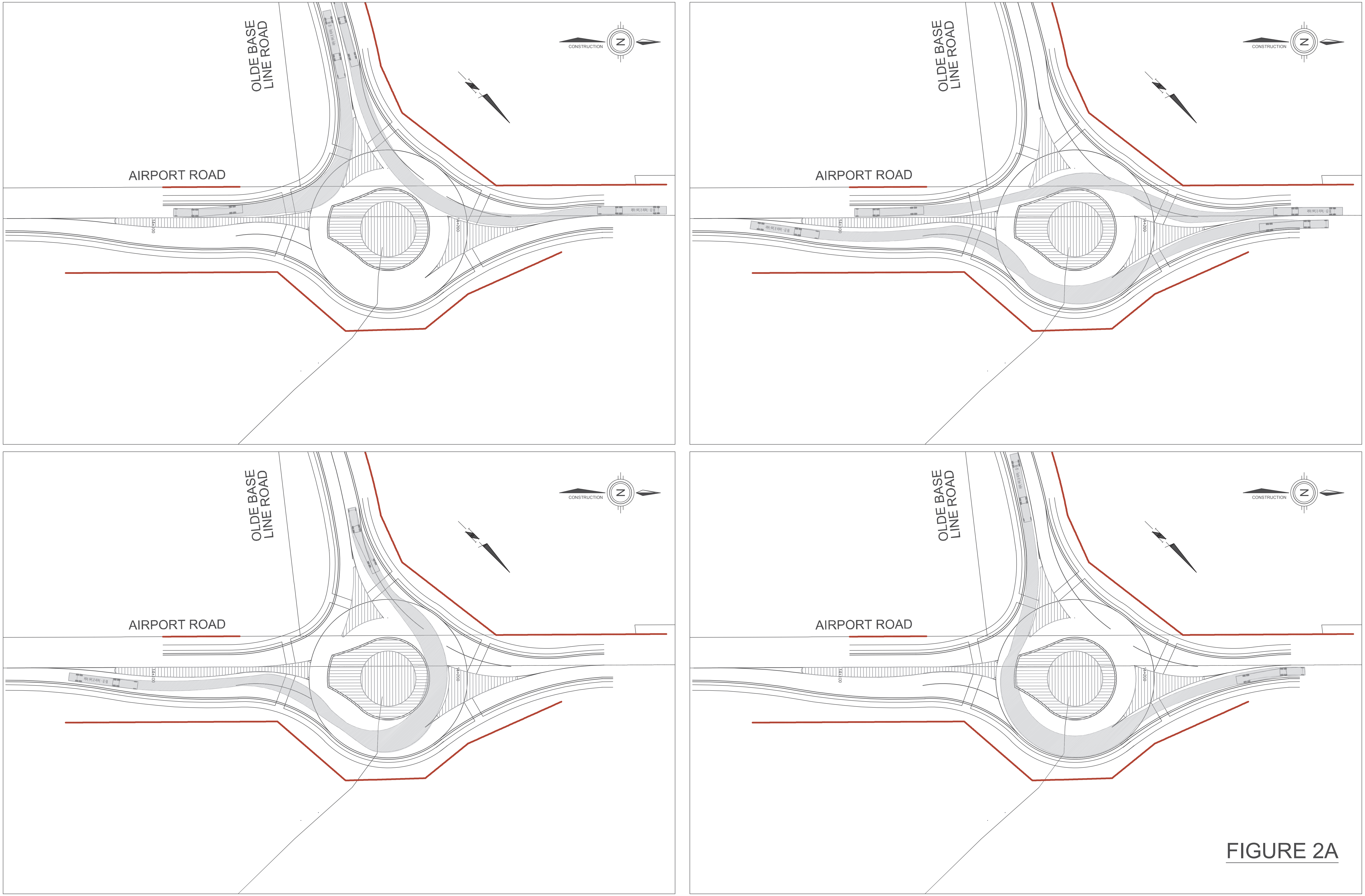
AIRPORT ROAD
CASTLEDERG SIDE ROAD
CONSTRUCTION
N
BOSTON MILLS ROAD
AIRPORT ROAD
CASTLEDERG SIDE ROAD
CONSTRUCTION
N
BOSTON MILLS ROAD
AIRPORT ROAD
CASTLEDERG SIDE ROAD
CONSTRUCTION
N
BOSTON MILLS ROAD
AIRPORT ROAD
CASTLEDERG SIDE ROAD
CONSTRUCTION
N

FIGURE 1A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AIRPORT ROAD
CONSTRUCTION
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AIRPORT ROAD
CONSTRUCTION
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CONSTRUCTION
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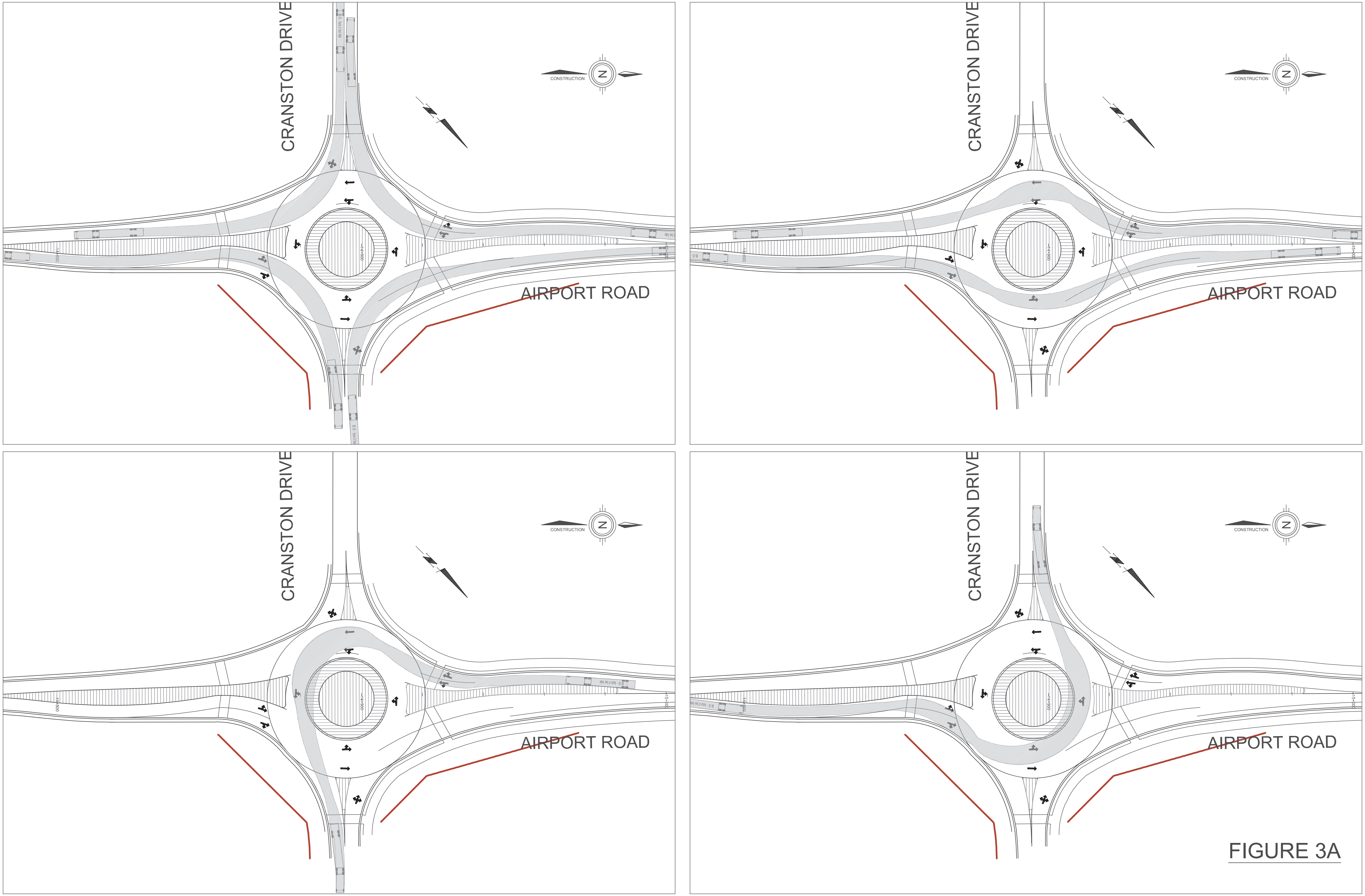
OLDE BASE LINE ROAD
AIRPORT ROAD
CONSTRUCTION
N

FIGURE 2A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AIRPORT ROAD
CONSTRUCTION
N
CRANSTON DRIVE
AIRPORT ROAD
CONSTRUCTION
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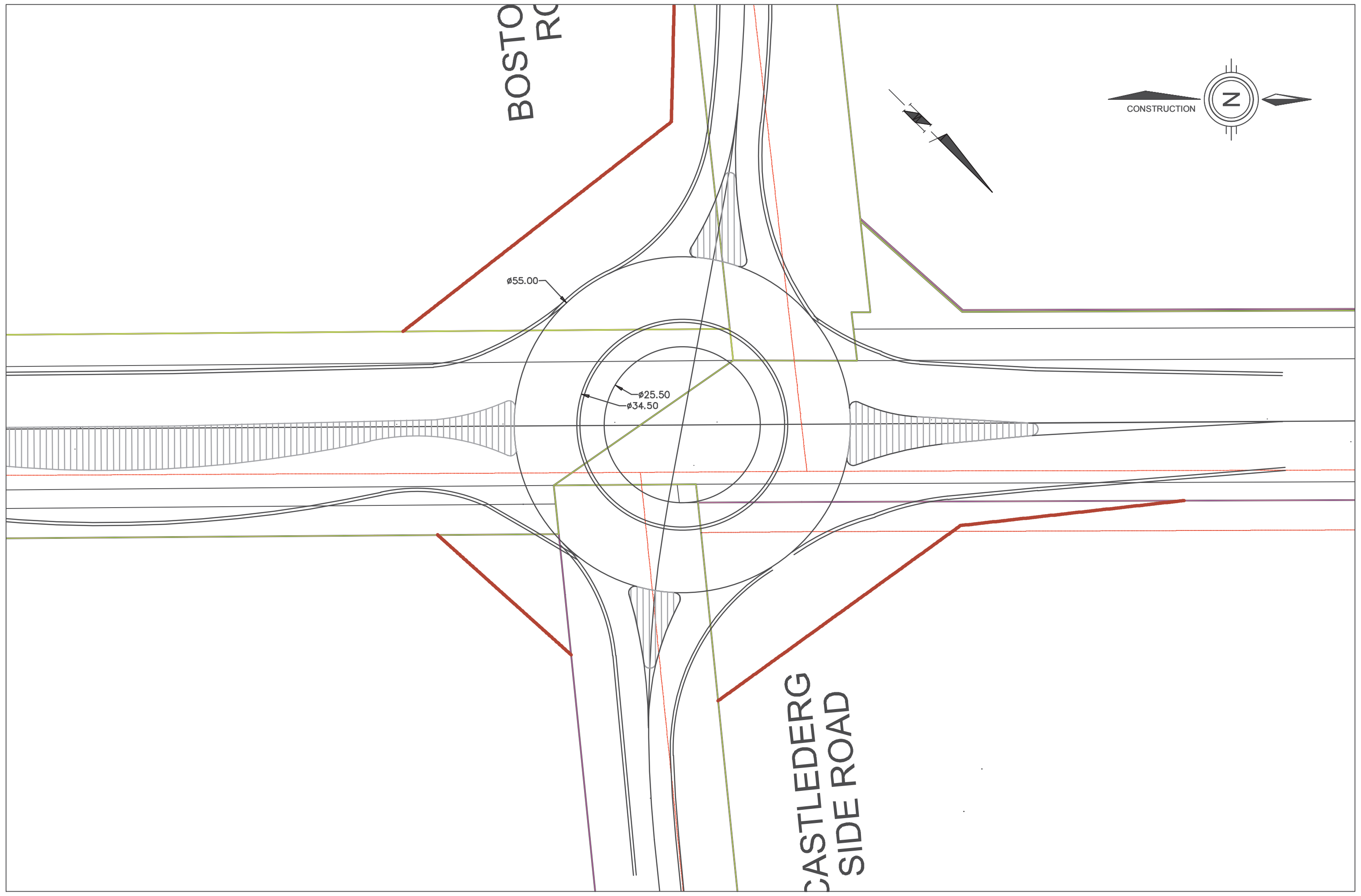
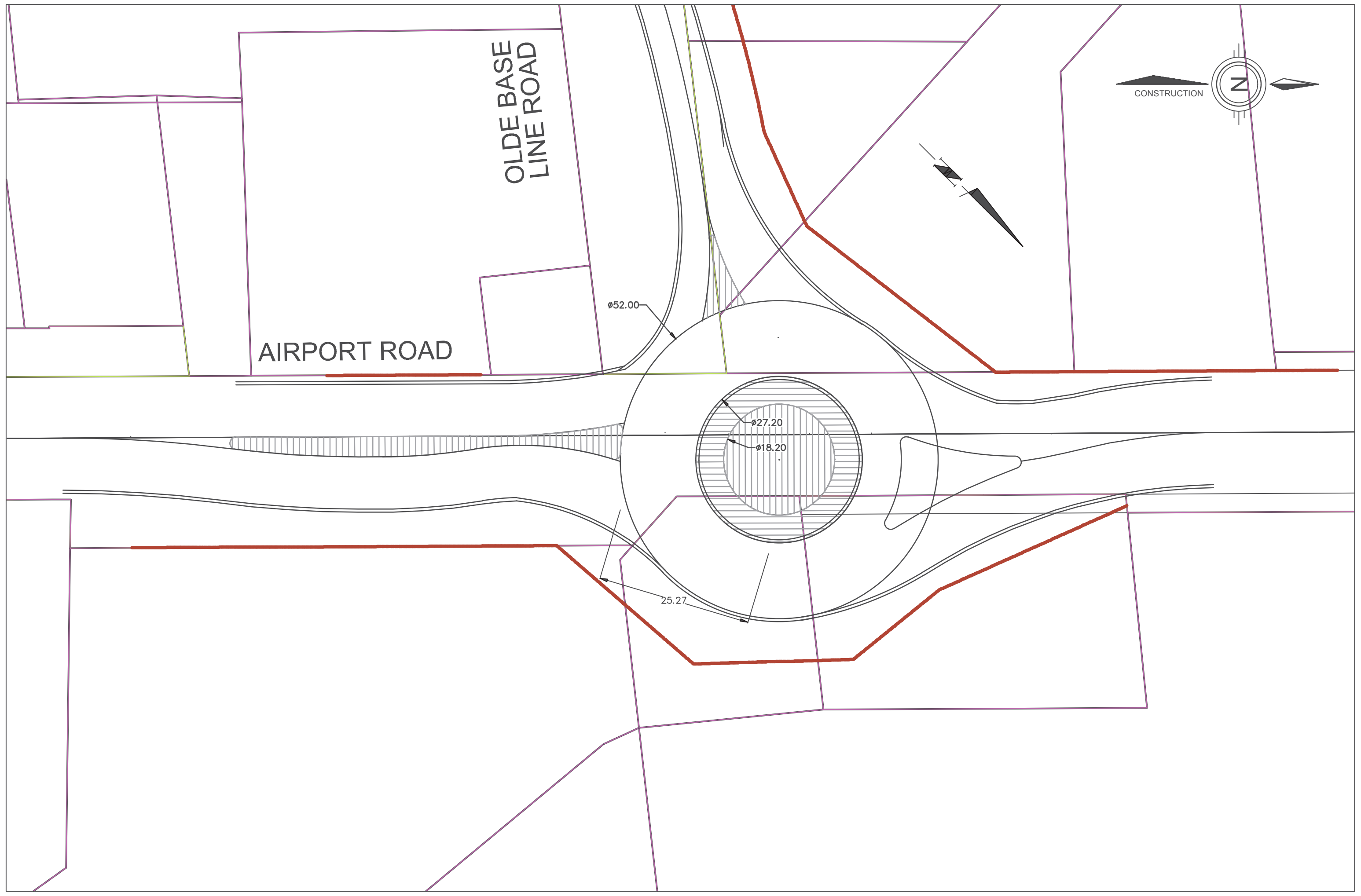
CONSTRUCTION
N
CRANSTON DRIVE
AIRPORT ROAD
CONSTRUCTION
N

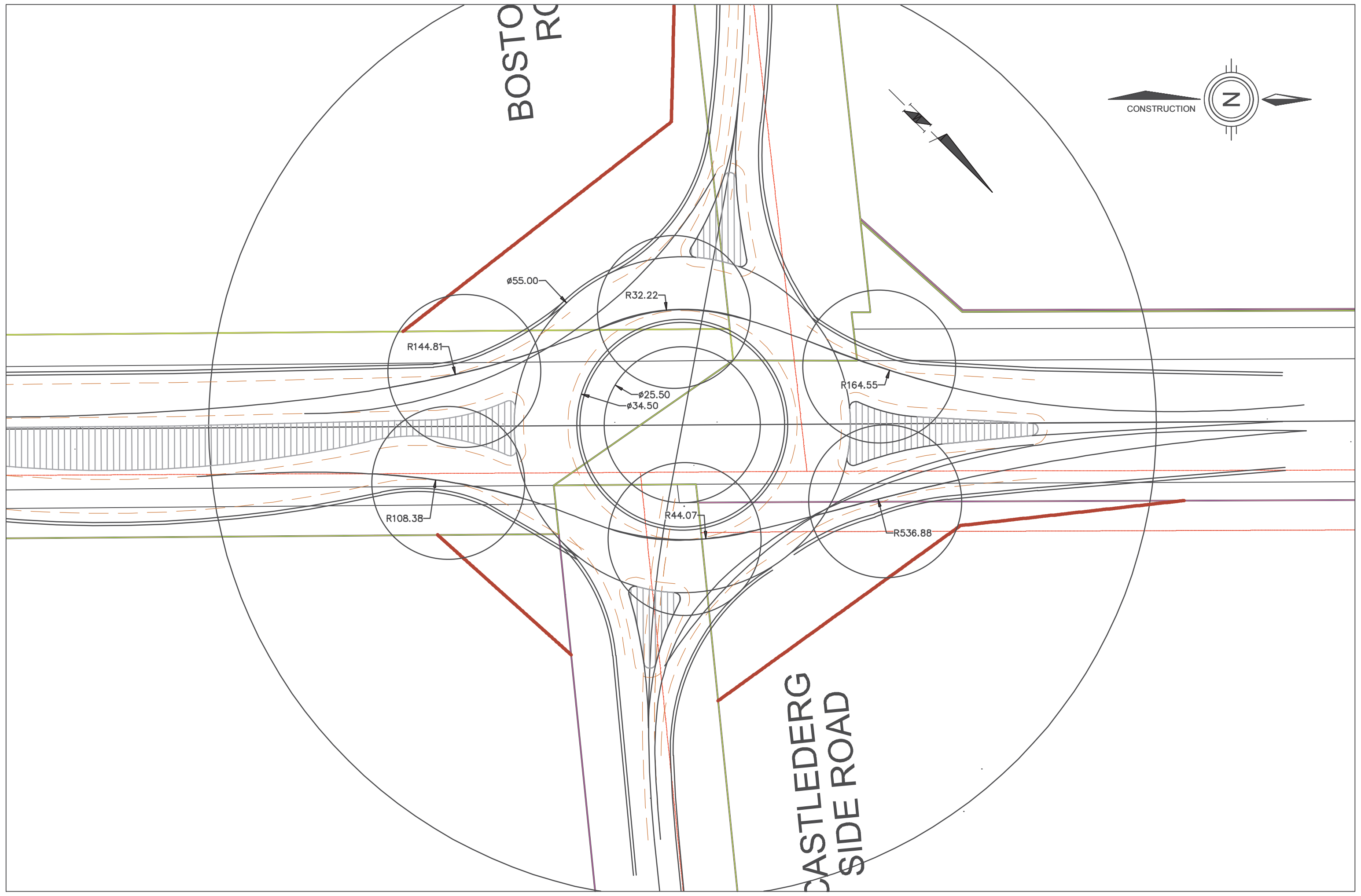
FIGURE 3A

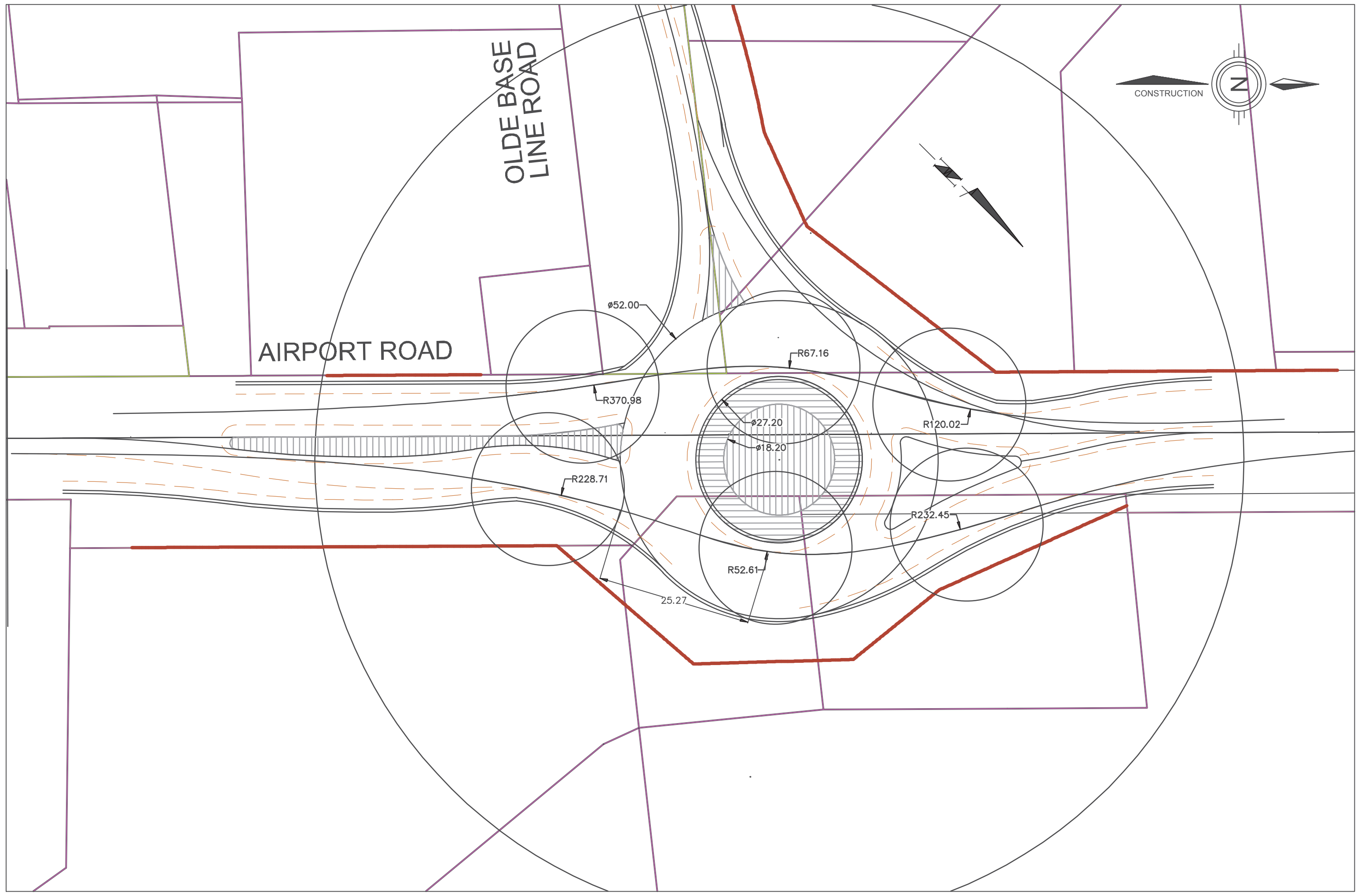




ULTIMATE DESIGN
ROUNDABOUT REVIEW 2

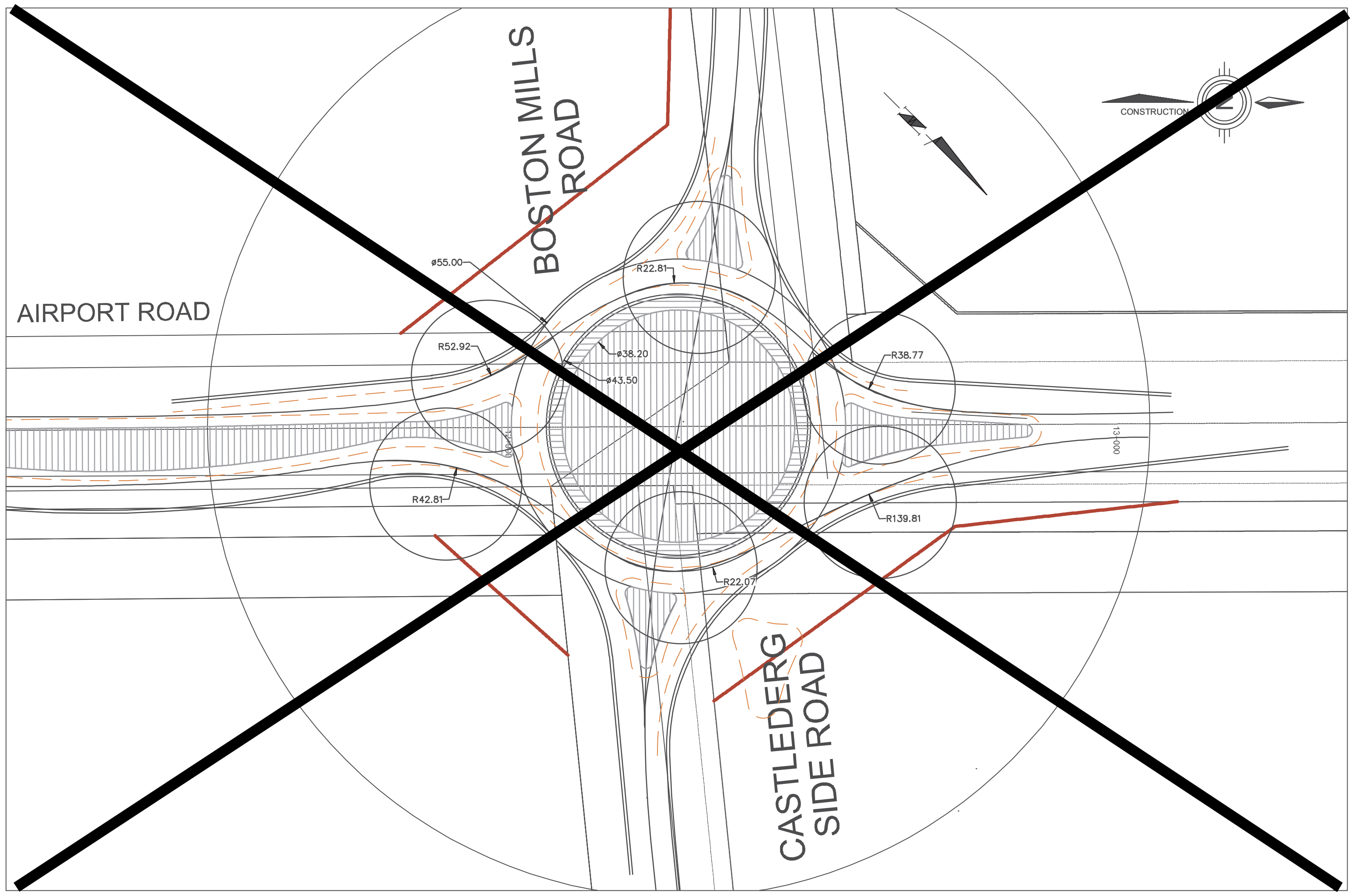
SCALE 1:500

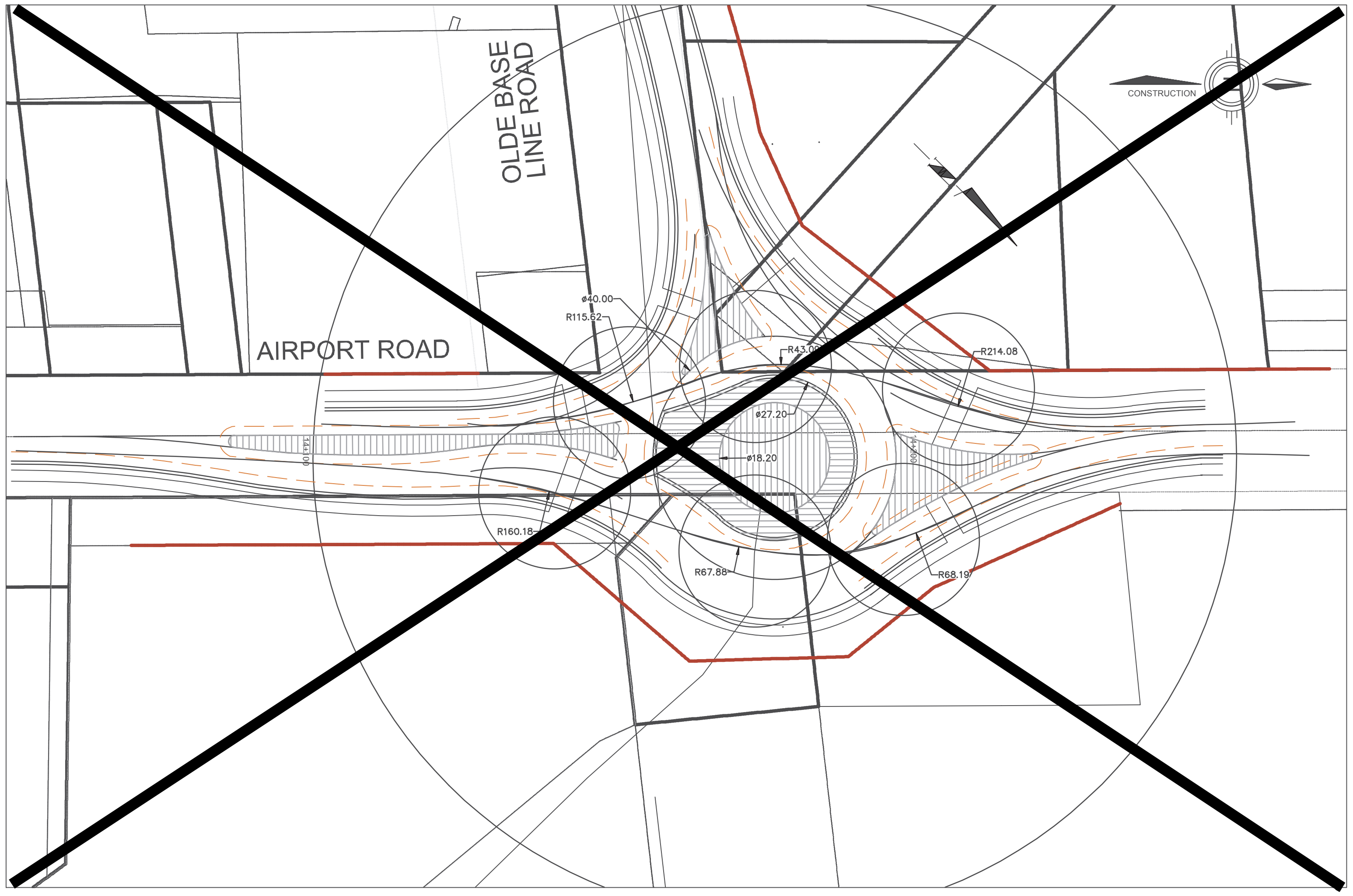


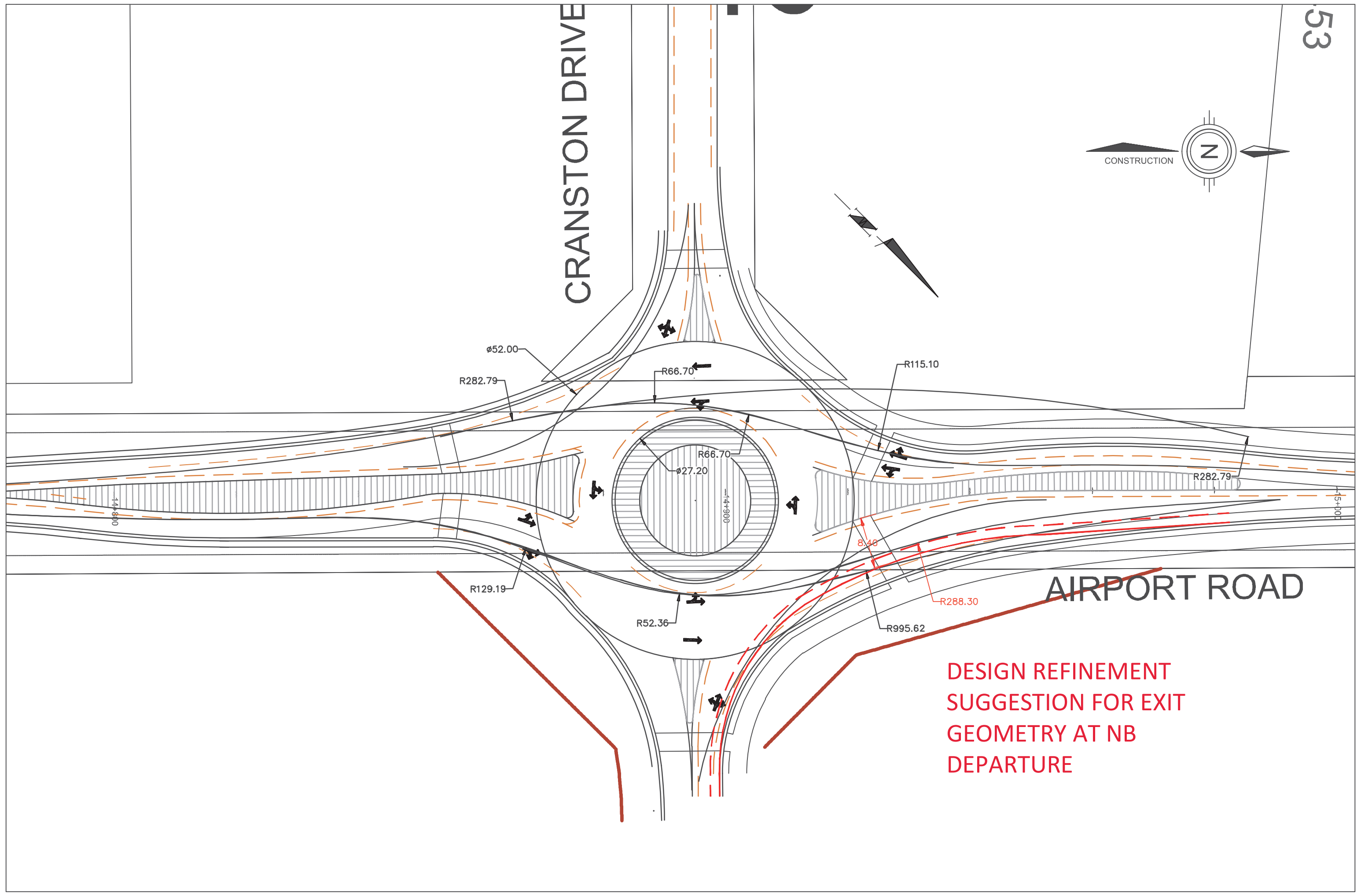


ULTIMATE DESIGN
FASTEST PATH
ROUNDABOUT REVIEW 2

SCALE 1:500







REVISED GEOMETRY AIRPORT ROAD AT CRANSTON DRIVE

FASTEST PATH ROUNDABOUT REVIEW 2

SCALE 1:500

APPENDIX F

Cost Estimate Analysis

Airport Road at Castlederg Side Road / Boston Mills Road - Roundabout		**Unit**	**Rate**	**Cost ($)**
Construction				
Roundabout only	1	Each	$70,000	$70,000
Approach roads major widening/Upgradation	0.48	km	$5,254,250	$2,522,040
Approach roads New	0.1	km	$5,839,000	$583,900
Utility relocations				
Electricals	1	LS	75000	$75,000
Design	0.1		$3,250,940	$325,094
Property Sqm	2490	sqm	$125	$311,250
				$3,887,284

Property Area

SW Boston/ Air	1140
SE Boston/ Air	500
NE Boston/ Air	850
	2490

Airport Road at Castlederg Side Road / Boston Mills Road - Base		**Unit**	**Rate**	**Cost ($)**
Construction				
Approach Roads Major Widening/Upgradation	0.43	km	$5,254,250	$2,259,328
Approach Roads - New	0.15	km	$5,839,000	$875,850
Utility Relocations				
Electricals	1	LS	75000	$75,000
Design	0.1		$3,210,178	$321,018
Property Sqm	5000	m2	$50	$250,000
				$3,781,195

Property Area

SW Boston/ Airport	4350
SE Boston/ Airport	250
NE Boston/ Airport	400
Total	5000

Airport Road at Olde Base Line Road - Roundabout

		Unit	Rate	Cost ($)
Construction				
Roundabout only	1	Each	$70,000	$70,000
Approach roads major widening/Upgradation	0.33	km	$5,254,250	$1,733,903
Utility relocations				
Electricals	1	LS	75000	$75,000
Traffic light removals	1	LS	$5,000	$5,000
Design	0.1		$1,883,903	$188,390
Property Sqm	6800	sqm	$125	$850,000
Building	1		$500,000	$500,000
	1		$400,000	$400,000
	1		$300,000	$300,000
				$4,122,293

Property Area

E	3600
NW	3200
	6800

Airport Road at Olde Base Line Road - Base		Unit	Rate	Cost ($)
Construction				
Approach Roads Major Widening/Upgradation	0.33	km	$5,254,250	$1,733,903
Utility Relocations				
Electricals	1	LS	75000	$75,000
Traffic Light Removal & Installation	1	LS	$6,500	$6,500
Design	0.1		$1,815,403	$181,540
Property Sqm	8620	m2	$75	$646,500
Buildings	1		$450,000	$450,000
	1		$350,000	$350,000
	1		$250,000	$250,000
				$3,693,443

Property Area

E Old Baseline / Airport	1720
NW Old Baseline / Airport	3800
SW Olde Baseline / Airport	3100
Total	8620

Airport Road at Cranston Drive - Roundabout

		Unit	Rate	Cost ($)
Construction				
Roundabout only	1	Each	$70,000	$70,000
Approach roads major widening/Upgradation	0.28	km	$5,254,250	$1,471,190
New const area East	360	sqm	$400	$144,000
Utility relocations				
Electricals	1	LS	75000	$75,000
Design	0.1		$1,760,190	$176,019
Property Sqm	3400	sqm	$125	$425,000
				$2,361,209

Property Area

	East	3400

Airport Road at Cranston Drive – Base Alternative

$50,000 maintenance

APPENDIX G

Roundabout Feasibility Screening Tool

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Roundabout Feasibility Screening Tool

		Roundabout Supportive?
1)	Project name, File #, Intersection Location (B/C/M, Street name, distance from major intersections, etc.): Airport Road EA King Street to Huntsmill Drive – intersection of ***Airport Road and Olde Base Line Road***, approximately 1 km from the nearest unsignalized intersections at Boston Mills Rd (to the south) and Cranston Drive (to the north). Nearest major intersection to the south is King Street at 4 km. This intersection is within the small community of Mono Road.	
2)	Brief description of Intersection (No. of legs, Lanes on each leg, Total AADT, ADDT on each road). Attach or sketch a diagram of existing and horizon year TMCs: Three legged T-intersection. Single lane approaches on all sides with no turning lanes. 2016 AADT north of Olde Base Line Road – 11,600 AADT Olde Base Line Rd (estimate using 10.0 factor of AM PH) 5,000 TMC included in report / appendix.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
3)	What operational problems are being experienced at this location? Currently operating well with LOS B overall and no critical movements. Lack of turning lanes is a concern for safety and delay to through traffic.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
4)	Is it a new intersection or a retrofit of an existing intersection? If existing, what is the existing type of traffic control? Currently signalized. The EA will recommend either local widening to provide NBL, SBR, and EBL/EBR turning lanes, or a roundabout.	**YES** ☒ **NO** ☐ **NEUTRAL** ☐

5)	Is the intersection near a major intersection or a railroad crossing? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem? Describe the corridor (eg.: average intersection spacing). The nearest major intersection is at King Street at 4 km, which is planned as a two-lane roundabout. There is a two-way stop control intersection to the south at Boston Mills which by 2041 will require signals or a roundabout. There is a two-way stop control to the north at Cranston Drive at which signals are not warranted, however high traffic on Airport Road plus crossing pedestrians may warrant a pedestrian signal and/or intersection traffic control.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
6)	Would the intersection be located within a coordinated signal network? Signals are too far away to coordinate.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
7)	Would the intersection be located on a preferred roundabout corridor? If yes why? The Region is planning two roundabouts to the south as part of prior EA. This corridor is a good candidate for roundabouts because they can help reduce traffic speeds through these smaller communities, and background traffic speeds and truck traffic have been identified as concerns.	**YES** ☒ **NO** ☐ **NEUTRAL** ☐
8)	What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed? 12 collisions over past 5 years, 9 of which are rear end. This collision rate is not excessive for Ontario. Rear end collisions frequency will likely be reduced should either a roundabout or widening for turning lanes be implemented.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
9)	Is the intersection scheduled for improvements or is it located within a corridor that is scheduled for improvements in the next 10 years? What is the ultimate cross-section of the approaching legs? Improvements are likely warranted within 10 years due to the geometric deficiencies (lack of turning lanes). The EA is recommending that the corridor remain two lanes, as widening through Mono Road and Caledon East would not be supportable by the community (insufficient right-of-way).	**YES** ☒ **NO** ☐ **NEUTRAL** ☐

10)	Are there expected to be special users at this intersection in the near future (ie. a person with disability, pedestrians, cyclists, large agricultural machinery, horses, etc.)? If yes, what special considerations would be required? There is potential for some pedestrian traffic with the small community, though lack of sidewalks and busy nature of road seem to keep pedestrian volumes low. Airport Road is part of Regional cycling network with paved shoulders planned.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
11)	What traditional improvements are proposed for this intersection (traffic signals, all-way stop, auxiliary lanes, off-set re-alignment, etc)? Widening to provide northbound left, southbound right, and eastbound left/right turning lanes would be recommended.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
12)	If traffic signals are considered, does it meet the warrant for the horizon year? Signals currently exist and are warranted under base and future conditions.	**YES** ☒ **NO** ☐ **NEUTRAL** ☐
13)	What size of roundabout is being considered for this intersection (ie. single, two, three lane entry)? Please attach a Traffic Flow Worksheet, a lane configuration diagram and a sketch of how a roundabout would fit into the ROW. Analysis shows single lane operations are near thresholds in 2041. Flaring to two entry lanes and potentially a southbound bypass lane may be required.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
14)	Are there property constraints at/near the intersection or is it restricted by a watercourse/parks/cemeteries/etc? If yes, what are they? Several constraints. There is a wetland opposite Olde Base Line Road however it is not provincially significant – therefore compensation should be an option. On the SW corner there is an auto shop which would need to be acquired / removed for a roundabout, and likely for signalized improvements as well. A roundabout will also require some property on NW corner though the property take is small and not likely to require acquiring the homes.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐

15)	Terrain – Is the area on a grade/flat/rolling? Flat terrain	**YES** ☐ **NO** ☐ **NEUTRAL** ☒

16)	20 Year Life Cycle Cost Estimate Injury Collision Cost (ICC): $258,000 Discount Rate (i): 2.52%	**YES** ☐ **NO** ☐ **NEUTRAL** ☒

20 YEAR LIFE- CYCLE COST COMPARISON		
Cost Item	Signalized 3-Leg With Turn Lanes	Roundabout
Implementation Cost	$ 3,693,443	$ 4,122,293
Injury Collision Cost (Present Value)	$ 659,000	$ 258,000
Total Life Cycle Cost	$ 4,352,443	$ 4,380,293

Notes:

- Implementation Cost
  = sum of costs for construction, property, utility relocation, 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

17)	Conclusions and Recommendations: The findings of the screening tool suggests that a roundabout at this location is unlikely to be found appropriate. A roundabout would work well at this intersection, and otherwise appear a good candidate, however there are significant property impacts to nearby houses, businesses and wetlands. Considering that an at-grade intersection also operates well, the roundabout appears to be too costly with too high impacts to Mono Road community. Yes – 4, No – 4, Neutral – 8 (neutral)	**YES** ☐ **NO** ☒

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Roundabout Feasibility Screening Tool

		Roundabout Supportive?
1)	Project name, File #, Intersection Location (B/C/M, Street name, distance from major intersections, etc.): Airport Road EA King Street to Huntsmill Drive – ***Airport Road and Cranston Drive***. Approximately 300 m from nearest unsignalized intersection to the north and approximately 1 km and 750 m away from nearest signalized intersection to the north and south respectively.	
2)	Brief description of Intersection (No. of legs, Lanes on each leg, Total AADT, ADDT on each road). Attach or sketch a diagram of existing and horizon year TMCs: Currently 3 legs T-intersection, however development is currently at site-plan-application which proposes fourth leg to east serving residential community. AADT on Airport Road – 11,600 AADT Cranston Drive (estimate using 10.0 factor of AM PH) – 800 TMC included in report / appendix.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
3)	What operational problems are being experienced at this location? Intersection currently operates well as two-way stop control. In the AM peak the eastbound approach operates at LOS C with some delay for gaps in traffic. There is a northbound left and southbound right turn lane which limit delay to through traffic.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
4)	Is it a new intersection or a retrofit of an existing intersection? If existing, what is the existing type of traffic control? Currently unsignalized two-way stop control. The new development to the east will construct a fourth leg to the intersection.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒

5)	Is the intersection near a major intersection or a railroad crossing? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem? Describe the corridor (eg.: average intersection spacing). There is a grocery store / retail access approximately 370m north but queues are not likely to reach this far.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
6)	Would the intersection be located within a coordinated signal network? Signalized intersections generally too far away for significant coordination.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
7)	Would the intersection be located on a preferred roundabout corridor? If yes why? The Region is planning two roundabouts to the south as part of prior EA. This corridor is a good candidate for roundabouts because they can help reduce traffic speeds through these smaller communities, and background traffic speeds and truck traffic have been identified as concerns.	**YES** ☒ **NO** ☐ **NEUTRAL** ☐
8)	What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed? Over the past five years this intersection has had two collisions, indicating that there is no significant problem to address.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
9)	Is the intersection scheduled for improvements or is it located within a corridor that is scheduled for improvements in the next 10 years? What is the ultimate cross-section of the approaching legs? The intersection will change with the construction of the east leg, however further improvements / widening are not justified. There is potential for future pedestrian crossings between the planned residential development and the school (northwest of intersection). Given the potential for increased traffic volumes and pedestrians, the intersection is a candidate for signalization or a roundabout.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐

10)	Are there expected to be special users at this intersection in the near future (ie. a person with disability, pedestrians, cyclists, large agricultural machinery, horses, etc.)? If yes, what special considerations would be required? There is likely potential for school children walking across Airport Road between the residential development and the school northwest of the intersection. Because Airport Road is a busy corridor with heavy trucks plus concerns about speeds, a signal may be preferable to a roundabout to accommodate pedestrians safely. However, traffic signals may be located further north closer to the public school and may allow a roundabout at this location.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
11)	What traditional improvements are proposed for this intersection (traffic signals, all-way stop, auxiliary lanes, off-set re-alignment, etc)? Aside from the construction of the east leg, warrants indicate no major improvements are required. Minor flaring / widening of west leg (eastbound approach) to accommodate a left/through lane and separate right turning lane would improve traffic operations.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
12)	If traffic signals are considered, does it meet the warrant for the horizon year? Signal is not warranted for 2041 traffic volumes.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
13)	What size of roundabout is being considered for this intersection (ie. single, two, three lane entry)? Please attach a Traffic Flow Worksheet, a lane configuration diagram and a sketch of how a roundabout would fit into the ROW. Analysis shows single-lane operations are near thresholds in 2031 and is overcapacity in 2041. Flaring to two-lane entry may be required. Traffic flow is included in report.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
14)	Are there property constraints at/near the intersection or is it restricted by a watercourse/parks/cemeteries/etc? If yes, what are they? A roundabout would have little to no impact on existing residences. The roundabout would require some property from the undeveloped lands to the east. It is likely that the property take between a roundabout and a road with left turn lane are similar.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒

15)	Terrain – Is the area on a grade/flat/rolling? Flat terrain, although there is a down gradient to the north (at approximately 400 m - beyond minimum sight lines).	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
16)	20 Year Life Cycle Cost Estimate Injury Collision Cost (ICC): $447,000 Discount Rate (i): 2.52%	**YES** ☐ **NO** ☒ **NEUTRAL** ☐

20 YEAR LIFE- CYCLE COST COMPARISON		
Cost Item	Standard TWSC	Roundabout
Implementation Cost	$ 50,000	$ 2,361,209
Injury Collision Cost (Present Value)	$ 107,000	$ 447,000
Total Life Cycle Cost	$ 157,000	$ 2,808,209

Notes:

- Implementation Cost
  = sum of costs for construction, property, utility relocation, 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

17)	Conclusions and Recommendations:	**YES** ☐ **NO** ☒

	The signal warrant indicates that two-way stop control may be sufficient to 2041, though a signal / roundabout may be considered for other network reasons including the potential for pedestrians and the lack of gaps in traffic especially by 2041. Overall the analysis indicates a signal may be preferable mainly on the basis of enabling pedestrians to safely cross. If a separate pedestrian crossing / signal is provided further north, this intersection would likely remain two-way stop control. Yes – 1, No – 8, Neutral – 7 (more non-supportive)	

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Roundabout Feasibility Screening Tool

		Roundabout Supportive?
1)	Project name, File #, Intersection Location (B/C/M, Street name, distance from major intersections, etc.): Airport Road EA King Street to Huntsmill Drive – intersection of ***Airport Road & Castlederg Side Road / Boston Mills Road.*** Approximately 1.2 km and 3.1 km away from the nearest signalized intersection to the north and south respectively.	
2)	Brief description of Intersection (No. of legs, Lanes on each leg, Total AADT, ADDT on each road). Attach or sketch a diagram of existing and horizon year TMCs: 4-leg offset unsignalized intersection, single lane on all four approaches. Existing AADT on Airport Road = 8700 Existing AADT on Boston Mills Road (estimate using 10.0 factor of AM PH) – 30 Existing AADT on Castlederg Side Road (estimate using 10.0 factor of AM PH) – 800 TMC included in report / appendix.	YES ☐ NO ☐ NEUTRAL ☒
3)	What operational problems are being experienced at this location? Eastbound and westbound approaches are offset, which is a safety concern. All approaches operate at LOS C or better under existing conditions	YES ☒ NO ☐ NEUTRAL ☐
4)	Is it a new intersection or a retrofit of an existing intersection? If existing, what is the existing type of traffic control? Currently unsignalized with two-way stop control on minor approaches. The EA will recommend either realign eastbound/westbound, and implement EBL/EBR, WBL/WBR, NBL, SBL turning lanes, or a roundabout.	YES ☒ NO ☐ NEUTRAL ☐

5)	Is the intersection near a major intersection or a railroad crossing? If so, how close and what type of traffic control exists at the adjacent intersection(s)? Will queues be a problem? Describe the corridor (eg.: average intersection spacing). The nearest intersection is at Olde Base Line Road which is a signalized T-intersection at a distance of 1.2 km. This intersection is may be a potential roundabout location.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
6)	Would the intersection be located within a coordinated signal network? Signals are too far away to coordinate.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
7)	Would the intersection be located on a preferred roundabout corridor? If yes why? The Region is planning two roundabouts to the south as part of prior EA. This corridor is a good candidate for roundabouts because they can help reduce traffic speeds through these smaller communities (Mono Road), and background traffic speeds and truck traffic have been identified as concerns.	**YES** ☒ **NO** ☐ **NEUTRAL** ☐
8)	What is the collision history of the intersection over the past five years? Is there a collision problem that needs to be addressed? Over the past five years this intersection has had two collisions, indicating that there is no significant problem to address.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
9)	Is the intersection scheduled for improvements or is it located within a corridor that is scheduled for improvements in the next 10 years? What is the ultimate cross-section of the approaching legs? Improvements are likely warranted within 10 years due to the geometric deficiencies (offset intersection, lack of turning lanes). The EA is recommending that the corridor remain two lanes, as widening through Mono Road and Caledon East would not be supportable by the community (insufficient right-of-way).	**YES** ☒ **NO** ☐ **NEUTRAL** ☐

10)	Are there expected to be special users at this intersection in the near future (ie. a person with disability, pedestrians, cyclists, large agricultural machinery, horses, etc.)? If yes, what special considerations would be required? Airport Road is part of Regional cycling network with paved shoulders planned.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
11)	What traditional improvements are proposed for this intersection (traffic signals, all-way stop, auxiliary lanes, off-set re-alignment, etc)? Realigning eastbound/westbound approaches, as well as widening to provide northbound left, southbound left, eastbound left and right, westbound left and right turning lanes would be recommended.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
12)	If traffic signals are considered, does it meet the warrant for the horizon year? Signal is not warranted for 2041 traffic volumes.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐
13)	What size of roundabout is being considered for this intersection (ie. single, two, three lane entry)? Please attach a Traffic Flow Worksheet, a lane configuration diagram and a sketch of how a roundabout would fit into the ROW. Analysis shows single lane operations are near thresholds in 2041. Flaring to two entry lanes and potentially a northbound bypass lane may be required.	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
14)	Are there property constraints at/near the intersection or is it restricted by a watercourse/parks/cemeteries/etc? If yes, what are they? A roundabout would have little to no impact on existing properties, requiring mostly acquisition of farmland, however, there are also few residences nearby.	**YES** ☐ **NO** ☒ **NEUTRAL** ☐

15)	Terrain – Is the area on a grade/flat/rolling? Flat terrain	**YES** ☐ **NO** ☐ **NEUTRAL** ☒
16)	20 Year Life Cycle Cost Estimate Injury Collision Cost (ICC): $349,000 Discount Rate (i): 2.52%	**YES** ☐ **NO** ☒ **NEUTRAL** ☐

20 YEAR LIFE- CYCLE COST COMPARISON		
Cost Item	Standard 4-Leg (Realignment)	Roundabout
Implementation Cost	$3,781,195	$ 3,887,284
Injury Collision Cost (Present Value)	$ 244,000	$ 349,000
Total Life Cycle Cost	$ 4,025,195	$ 4,236,284

Notes:

- Implementation Cost
  = sum of costs for construction, property, utility relocation, 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

17)	Conclusions and Recommendations: Because the intersection operates well as two-way stop control, a roundabout is not recommended as part of the EA. However, traffic growth may occur due to developments, and this location is a good candidate for a roundabout. Therefore, protection of property for a future roundabout is recommended. Yes – 4, No – 6, Neutral – 6 (more non supportive)	**YES** ☐ **NO** ☒