Sturgeon Road at Murray Park/Silver Avenue Roundabout - Preliminary Design Report - FINAL

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Sign-off Sheet

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1.0 BACKGROUND AND PROJECT DESCRIPTION

1.1 BACKGROUND

The existing four-way stop-controlled intersection of Sturgeon Road at Murray Park Road / Silver Avenue is under evaluation by The City of Winnipeg in consideration of operational improvements required in the near-term. With growing pressure of daily traffic through the intersection and with increased commercial truck traffic, this intersection is experiencing congestion. There are also geometric challenges with commercial trucks turning at the intersection combined with increased volumes of passenger vehicle traffic.

As part of a due-diligence exercise, *The City of Winnipeg* (The City) retained *Stantec Consulting Ltd. (Stantec)* to complete a Preliminary Design Study with consideration of roundabout operations for the intersection of Sturgeon Road at Murray Park Road / Silver Avenue.

1.2 FUNCTIONAL DESIGN STUDY SCOPE

The scope of this Preliminary Design Study includes evaluation of the intersection of Sturgeon Road at Murray Park Road / Silver Avenue, with the following items or work to be included:

- Determine the extents of site investigations with the Streets Project Engineer, Mr. Ryan Cunningham, P. Eng.
- Acquire historical and as-built drawings within the project limits from The City of Winnipeg Underground Structures.
- Call for all utility locates for on-site identification of shallow (i.e. MTS, Shaw, Fibre Optic) and deep utilities (i.e. water, sewer, LDS).
- Complete required topographic field surveys within the project limits. This task will be completed by Stantec forces.
- Complete a geotechnical borehole testing program. For purposes of this preliminary design, six testholes are deemed appropriate. This task will be completed by the Stantec Geotechnical Group (formerly National Testing Laboratories).
- Complete an analysis of the projected traffic volumes with the traffic volumes provided by The City of Winnipeg. Determine the measures of effectiveness (i.e. level of service, delays, queue lengths) based on a single-lane roundabout and two-lane roundabout to project future operational conditions. Consideration for the use of slip / by-pass lanes at the roundabout to extend capacity and operation. Stantec used SIDRA for the roundabout operational analysis.
- Complete the preliminary design (plan and profile) for the two-lane roundabout for long-term consideration needs, then identify the preliminary design (plan and profile) of a

single-lane roundabout for near-term construction. Knowledge of increased truck percentages will be considered in the preliminary design due to potential expansion of local commercial truck facilities.

- Design the approach roadways in consideration of approaching and departing vehicular speed control. Stantec will establish fastest path speed profiles during the preliminary design.
- Incorporate a connection of the existing *Yellow Ribbon Greenway* trail multi-use pathway through the roundabout. Current alignment of the Greenway is on the southeast and northwest corners.
- Incorporate a connection of the existing concrete sidewalks into the roundabout.
- Consider Winnipeg Transit needs adjacent to the roundabout and ensure appropriate bus stop location for sidewalk and multi-use connectivity.
- Identify appropriate right-of-way requirements for the roundabout, sidewalk and multi-use pathway construction. Identify necessary property acquisition, if required.
- Confirm the existing Sturgeon Road right-of-way from Silver Avenue to Saskatchewan Avenue to support future twinning of Sturgeon Road. Discussions will be held with The City of Winnipeg on required road cross-section (i.e. rural, urban, semi-urban) to identify the needs of surface drainage via open ditches or below surface drainage with land drainage systems.
- Design a concrete pavement roundabout with asphalt pavement for the approach legs. A concrete pavement jointing diagram is not required for this preliminary design.
- Develop a preliminary pavement cross-section for both concrete and asphalt pavements.
- Develop a preliminary construction staging plan for construction of the roundabout while maintaining access through the intersection. Accommodation for high volume large trucks is essential for staging.
- Develop Class 3 (+/- 30%) opinions of probable costs for construction and associated works, including surface pavements, sewer works, LDS works, watermain works, utility relocations (if required). The Opinion of cost is to exclude engineering, property acquisition, legal costs and in-house City of Winnipeg Administrative costs.

1.3 PROJECT DESCRIPTION

The location of the study area, identified in Figure 1, is in the west fringe of the Murray Industrial Park and north of the Sturgeon Creek, Booth and Heritage Park residential developments. Area roadways serve the needs of commuter traffic and local commercial traffic. Immediate area facilities include:

- CenterPort Canada Way to the north
- *Skateboard West* skateboard Park on the southwest corner of Sturgeon Road at Silver Avenue.
- Heritage Park at the southwest corner of Sturgeon Road at Silver Avenue.
- Yellow Ribbon Greenway multi-use path on the southeast and northwest corners of the intersection.
- Heritage Victoria Community Club with soccer pitches and a baseball fields north and south of Silver Avenue.
- The Silver Avenue Extension right-of-way to the east and southeast.
- Boeing / MacDon Industrial Development to the northeast.

1.3.1 Existing Cross-Section, Geometry and Roadway Classification

1.3.1.1 Sturgeon Road

The cross-section of Sturgeon Road from Woodgreen Place to south of Silver Avenue is a rural cross-section with two 3.7 meter wide asphalt lanes, 2.3 meter granular shoulders and open ditch drainage, as identified in Photo 1. The posted speed from Ness Avenue to Murray Park Road / Silver Avenue is 60 km/h and north of Murray Park Road / Silver Avenue the posted speed increases to 70 km/h.

Photo 1 - Sturgeon Road - Looking South

Photo 2 - Sturgeon Road Looking North

Based on information received from The City of Winnipeg Public Works Department, the Average Daily Traffic on Sturgeon Road north of Murray Park Road is 9,900 vehicles per day (2014 data) and south of Murray Park Road yields 9,400 vehicles per day (2014 data).

Right-of-way within the study area intersection is non-standard and highly variable as it is assumed this intersection was planned for an interchange based on the available right-of-way. However, south of the intersection and within the Sturgeon Creek and Booth residential subdivision, the right-of-way is 30.48 meters. The right-of-way on Sturgeon Road south of Saskatchewan Avenue is approximately 85.50 meters.

1.3.1.2 Murray Park Road

The cross-section of Murray Park Road from Moray Street to 430 meters east of Sturgeon Road includes a City of Winnipeg standard four-lane divided minor arterial road with 4.0 meter wide lanes, a 5.0 meter boulevard and land drainage systems. From Sturgeon Road to 430 meters east (see Photo 3), the road cross-section modifies to a rural section with two 3.7 meter asphalt lanes, 2.5 meter granular shoulders and open ditch drainage. The posted speed on Murray Park Road within the study area is 60 km/h.

Photo 3 - Murray Park Road Looking East

The Average Daily Traffic on Murray Park Road east of Sturgeon Road is 6,500 vpd (2014 data) as provided by *The City of Winnipeg Public Works Department*.

The right-of-way within the study area is highly variable due to the planned area to include an interchange. However, east of Sturgeon and fronting the Boeing Building, the right-of-way is 30.48 meters.

1.3.1.3 Silver Avenue

The cross-section of Silver Avenue west of Sturgeon Road includes a two-lane rural residential collector with 2.5 meter granular shoulders and open ditch drainage. The posted speed on Murray Park Road within the study area is 60 km/h.

The Average Daily Traffic on Silver Avenue based on 2014 data provided by *The City of Winnipeg Public Works Department* is 3,300 vpd.

Photo 4 - Silver Avenue Looking West

The right-of-way within the study area is highly variable due to the planned area to include an interchange. However, 225 meters east of Hamilton Avenue the right-of-way is approximately 54.80 meters.

1.3.2 Natural Grassland Area

Natural grasslands currently exist within the study area based on The City of Winnipeg Parks and Open Spaces inventory. These grasslands are located on the east side of Sturgeon road both north and south of Murray Park Road. The high desire is to minimize impacts on these natural grasslands during any stages of design and construction. The grasslands start east of the existing

lanes of Sturgeon Road and extend to the tree-line on the northeast and southeast corners of the exiting intersection. No natural grasslands are known to exist on the west side of Sturgeon road within the study area.

1.3.3 Multi-Use Path

The existing *Yellow Ribbon Greenway* is along east-west Silver Avenue / Murray Park Road. From the west, the path begins at Hamilton Avenue with connections to Sturgeon Creek and extends easterly though the future Silver Avenue Extension to Moray Street and continues along Silver Avenue east of Winchester Street.

Within the study area and starting from the west, the path is 3.0 meters wide and the alignment is on the north side of Silver Avenue, crosses Silver Avenue west of Sturgeon Road, crosses Sturgeon Road south of Murray Park Road / Silver Avenue, then continues east-west on the south side of Murray Park Road.

The *Yellow Ribbon Greenway* multi-use path is an important factor in the design of the roundabout to maintain good, safe access to users of the pathway and to maintain continuity of the multi-use path.

Photo 5 - Yellow Ribbon Greenway

The current intent and alignment of the *Yellow Ribbon Greenway* is in adherence to *The City of Winnipeg Transportation Master Plan, Map 4*.

1.3.4 Sidewalk

A concrete sidewalk exists along the east and west sides of Sturgeon Road and extends from the Heritage Park residential development to the south heading northerly to Murray Park Road / Silver and terminating at the connection to the *Yellow Ribbon Greenway*.

The east side sidewalk was constructed in fall 2014. Both the east and west sidewalks terminate at Sturgeon Road at the connection to the Yellow Ribbon Greenway.

Both concrete sidewalk connections must be considered for the new roundabout construction, with allowance and consideration of extending the sidewalks north of this intersection. Sidewalk connection to the current transit bus stops must also be considered to provide adequate connectivity and safe passage for transit users.

1.3.5 Transit

Winnipeg Transit operates Bus Route 83 along Sturgeon Road, with current far-side stops northbound and southbound at Murray Park Road / Silver Avenue (see Photo 5). Consideration for maintaining and improving transit service both during and post-construction must be included to maintain this vital transit link.

Photo 5 - Transit Stop on Sturgeon SB

During the conceptual and future detailed design phases, connectivity of these bus stops must be considered.

1.3.6 Study Area Utilities

Deep Services – Water, Sewer LDS

Based on review of LBIS records provided by The City of Winnipeg Underground Structures, there is a 300 millimeter water line running north-south along the west side of the existing lanes of Sturgeon Road within the study area. A 300 millimeter water line also exists along the north side of Murray Park Road within the study area. No known water lines exist along Silver Avenue.

There are no known land drainage systems or wastewater sewer services in the immediate area of the existing intersection of Sturgeon Road at Murray Park Road / Silver Avenue. Overland surface drainage is accommodated via open ditches and culverts. Within the study area is a high point of the drainage system near the intersection of Sturgeon Road at Murray Park Road. As such, major culvert crossings are not anticipated for inclusion into the final design and drainage is likely to be accommodated with minor culvert installations (i.e. 450 millimeter) for immediate and local drainage. Continuity of the ditch on the northeast corner of the intersection must be considered.

A 600 millimeter feedermain is within the south portion of the study area and extends north of Woodgreen Place by approximately 180 meters, then redirects westerly along Carriage Road. Due to the proximity of the feedermain to the project site, it is not anticipated that there are any impacts on the feedermain during construction.

Shallow Services – Manitoba Hydro, MTS

Manitoba Hydro has overhead distribution lines on wood poles along the east side of the existing lanes of Sturgeon Road, including a 2 x 24kV line and a 1 x 24 kV line. These same wooden poles also include streetlights for Sturgeon Road and an MTS line serving the area.

On the north side of Murray Park Road, there are wood pole lines that carry streetlights and a 24kV line. North of the wooden pole line is a buried 24 kV line.

Streetlights also exist on wooden poles along the south side of Silver Avenue and along

MTS had a surface mount pedestal on the northeast corner of Sturgeon Road at Murray Park / Silver Avenue intersection.

Also, a 100 mm gas line exists along the west side of Sturgeon Road within the study area.

Pedestrian level lighting also exists along the Yellow Ribbon Greenway along the path west of Sturgeon Road.

1.4 FUTURE DEVELOPMENT

There has been much activity within this general area of the City of Winnipeg which has significant immediate and long-term impacts to the area, including operations of the proposed roundabout at the intersection of Sturgeon Road and Murray Park Road / Silver Avenue. Recent and future developments include:

- *Construction of CentrePort Canada Way* – CentrePort Canada is a growing inland port located in the northwest portion of The City of Winnipeg and offers 20,000-acres of high-quality, affordable industrial land and unique access to tri-modal transportation including three railways. In 2014, portions of CentrePort Canada Way was opened to the travelling public, including Summit Road; the northerly extension of Sturgeon Road north of Saskatchewan Avenue.

- *Silver Avenue Extension* – Silver Avenue is planned for future extension from City Route 90 to Sturgeon Road; connecting with the southern leg of existing Sturgeon Road at Saskatchewan Avenue intersection. As per The City of Winnipeg Transportation Master Plan, Map 7, this extension is a long-term commitment. Timing for the construction of this link is unknown at the time of this report.

- *William R. Clement Parkway* – Similar to Silver Avenue, the William R. Clement Parkway extension south of Grant Avenue is unknown for the time of construction, but may play a significant role in future traffic volumes at the intersection of Sturgeon at Murray Park Road. As per The City of Winnipeg Transportation Master Plan, Map 7, this extension is a long-term commitment.

- *Commercial Trucking Operations* – it is understood that considerable trucking expansions and continued growth is expected within the Murray Industrial Park, including MacDon, Boeing Expansion (expansion from 2014), Northern, etc. Significant interest has been expressed by various trucking companies in the area for future growth with CentrePort Canada Way construction.

- *Murray Park Road Twinning* – Murray Park Road includes a four-lane section from Moray Street to approximately 430 meters east of Sturgeon Road. Potential for four-laning the remainder of Murray Park Road is to be considered for long-term traffic volumes.

2.0 TRAFFIC ANALYSIS

2.1 EXISTING AND PROJECTED TRAFFIC VOLUMES

The City of Winnipeg Public Works Department supplied the existing traffic volumes, including the 2014 AM Peak Hour, the 2014 PM peak Hour and the 2014 Average Daily Traffic for use on this project. The City of Winnipeg Public Works Department collected comprehensive traffic count data in early 2014 and supplied this collected data for use on this project. The 2014 traffic count data extended from 07:00-09:00 and 15:00-18:00, including passenger vehicles, commercial trucks, pedestrian activity, etc. The counts were collected on February 25, 2014 for the PM peak hours and on February 26, 2014 for the AM Peak hours.

The City also provided the projected traffic volumes based on their internal models developed for the entire City of Winnipeg area. The projected traffic volumes supplied included the AM and PM peak hours for the 2021 and 2031 design years.

A summary of the 2014, 2021 and 2031 data for the AM and PM peak hour is provided in Figure 2.

These peak hour traffic volumes were used to form the basis of the traffic analysis based on roundabout intersection operations at the intersection of Sturgeon Road and Murray Park Road / Silver Avenue.

2.2 SIDRA SOFTWARE

Sidra Intersection (previously called Sidra and aaSidra) is a software package used for intersection and network capacity, level of service and performance analysis by traffic design, operations and planning professionals.

Sidra Intersection is a micro-analytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models. It can be used to compare alternative treatments of individual intersections and networks of intersections involving signalized intersections (fixed-time/pre-timed and actuated), roundabouts (un-signalized), roundabouts with metering signals, fully signalized roundabouts, two-way stop and give-way (yield) sign control, all-way (four-way and three-way) stop sign control, merging, single-point urban interchanges, traditional diamond and diverging diamond interchanges, basic freeway segments, signalized and un-signalized midblock crossings for pedestrians, and merging analysis.

Sidra Intersection allows modelling of separate Movement Classes (Light Vehicles, Heavy Vehicles, Buses, Bicycles, Large Trucks, Light Rail/Trams and two User Classes) with different vehicle characteristics. These movements can be allocated to different lanes, lane segments and signal phases; for example for modelling bus priority lanes and signals.

In Australia and New Zealand, Sidra Intersection is endorsed by Austroads. In the USA, Sidra Intersection is recognized by the US Highway Capacity Manual, TRB/FHWA 2010 Roundabout Guide (NCHRP Report 672) and various local roundabout guides.

2.2.1 Roundabout Level of Service Characteristics

Traffic analyses for various intersections are typically conducted using methodology developed by the Transportation Research Board (TRB) and published in the *Highway Capacity Manual* (HCM). Most of the analyses are based on vehicle delay under various traffic volumes, roadway configurations, and traffic control strategies. The delay estimates are used as the basis for evaluating intersection performance. According to the HCM, the relative performance of an intersection can be measured using a number of different factors including:

- **Level of Service (LOS)** – Based on the average vehicle delay during a 15-minute analysis period. Levels of Service range from A (minimal delay) to F (unacceptable delay) and may be measured on an intersection, approach, or movement basis.
- **Degree of Saturation** – The ratio of demand flow rate (v) to maximum capacity (c). Where the v/c ratio is 1.0 or greater, the intersection is operating at full capacity and experiencing major congestion.
- **Vehicle Delay** – The average time which vehicles are delayed on an intersection, approach, or movement basis. Measured in seconds of delay per vehicle or total hours of delay during the peak hour being analyzed.

For design and planning purposes, LOS D or better under peak hour conditions is considered acceptable. Table 1 describes the characteristics of each LOS for un-signalized intersections, respectively, as listed in the HCM.

Table 1: Un-Signalized Intersections - HCM Level of Service Characteristics

Control Delay	Level of Service by Volume-to-Capacity Ratio (sec/veh) v/c ≤ 1.0 v/c > 1.0		Characteristics
≤ 10	A	F	Free flow, low volumes and high speeds, most drivers can select own speed
> 10 and ≤ 15	B	F	Stable flow, speed restricted slightly by traffic
> 15 and ≤ 25	C	F	Stable flow, speed controlled by traffic
> 25 and ≤ 35	D	F	Approaching unstable flow, low speed
> 35 and ≤ 50	E	F	Unstable flow & speeds, volumes at/near capacity
> 50	F	F	Forced flow, low speed, volume above capacity

2.2.2 Traffic Analysis Assumptions

In order to perform the roundabout traffic analysis, a number of assumptions were made regarding existing traffic conditions at the study intersections. These assumptions include:

- Inscribed Circle: In review of the *FHWA – Roundabouts: An Informational Guide,* the range of a rural two-lane roundabout for a WB-20 design vehicle is 55-60 meters. For purposes of the roundabout analysis, Stantec selected a 55 meter inscribed circle.
- Analysis was limited to a single lane roundabout. Pending operational failure, improvements would be limited to slip lanes, as required.
- All lanes were assumed to be 3.7 m wide approaching the roundabout and flaring to a maximum of 5.0 meters at the yield line.
- The circulating lane is 5.0 meters from face-of-curb to face-of-curb.
- Truck percentages: In review of the COW PWD completed traffic counts, the following truck percentages were implemented into the analysis:
    - Northbound approach – 2% left, 5% thru, 5% right
    - Westbound approach – 8% left, 2% thru, 8% right
    - Southbound approach – 8% left, 5% thru, 2% right
    - Eastbound approach – 2% left, 2% thru, 2% right

2.3 AM (PM) PEAK HOUR TRAFFIC ANALYSIS

To start the analysis, the assumptions listed in 2.2.1 above were implemented and also included a single lane approach for all approaches to the roundabout. As such, the intersection of Sturgeon Road at Murray Park Drive / Silver Avenue was modelled using SIDRA under the following scenarios:

- 2014 AM (PM) Peak Hour Conditions (Existing)
- 2021 AM (PM) Peak Hour Conditions (Projected)
- 2031 AM (PM) Peak Hour Conditions (Projected)

No slip lanes were assumed as part of the initial analysis and are to be included only if required to improve approach and intersection level of service.

2.3.1 2014 AM (PM) Peak Hour Results (Existing)

Under the 2014 AM (PM) Peak Hour conditions, Table 1 identifies the results of the intersection operations from the SIDRA analysis.

Table 2: 2014 AM (PM) Peak Hour Analysis

Intersection	Intersection Performance LOS / Delay / v/c	LOS / Delay (sec) / 95th Percentile Queue (m) / v/c			
		EB Approach	WB Approach	NB Approach	SB Approach
Sturgeon Road at Murray Park / Silver	A / 3.7 / 0.332 (A / 3.7 / 0.332)	A / 3.7 / 12.4 / 0.27 (A / 3.6 / 3.5 / 0.08)	A / 4.6 / 5.0 / 0.12 (A / 4.7 / 15.7 / 0.33)	A / 3.3 / 15.9 / 0.33 (A / 2.7 / 10.9 / 0.25)	A / 3.8 / 15.7 / 0.32 (A / 3.5 / 16.0 / 0.33)

Based on the above results, the single lane roundabout can accommodate the 2014 AM (PM) Peahe k Hour volume with ease and is projected to operate at a LOS = A for all approaches with minimal delay and queuing. Appendix A provides the printed results directly from SIDRA.

2.3.2 2021 AM (PM) Peak Hour Results (Projected)

Under the 2021 AM (PM) Peak Hour conditions, the results of the intersection operations from the SIDRA analysis are identified in Table 3.

Table 3: 2021 AM (PM) Peak Hour Analysis

Intersection	Intersection Performance LOS / Delay / v/c	LOS / Delay (sec) / 95th Percentile Queue (m) / v/c			
		EB Approach	WB Approach	NB Approach	SB Approach
Sturgeon Road at Murray Park / Silver	A / 7.8 / 0.813 (A / 7.7 / 0.767)	B / 10.1 / 27.5 / 0.45 (A / 8.2 / 10.6 / 0.19)	A / 7.5 / 18.8 / 0.32 (B / 14.4 / 70.3 / 0.72)	B / 13.7 / 99.7 / 0.81 (A / 3.1 / 41.1 / 0.61)	A / 3.7 / 50.6 / 0.62 (A / 7.4 / 81.9 / 0.77)

Based on the above results, the single lane roundabout can accommodate the 2021 AM (PM) Peak Hour volume, with relatively low approach delays of under 15 seconds. However, during the AM peak hour, queue lengths are a concern as the northbound approach yields a queue length of 100 meters and the southbound approach has an 82 meter queue during the PM peak hour. Also, the v/c ratios are increasing for the northbound and southbound approaches during the same periods.

The increased queuing and v/c is caused by conflict between the southbound left-turns and the northbound thru movement. Consideration of improvements to the roundabout may be required if queuing is a concern, and may include the use of slip / by-pass lanes or the need for a two-lane roundabout.

2.3.3 2031 AM (PM) Peak Hour Results (Projected)

Table 4 identifies the results of the intersection operations from the SIDRA analysis arising from the 2031 AM (PM) Peak Hour analysis through use of a single lane roundabout.

Table 4: 2031 AM (PM) Peak Hour Analysis

Intersection	Intersection Performance LOS / Delay / v/c	LOS / Delay (sec) / 95th Percentile Queue (m) / v/c			
		EB Approach	WB Approach	NB Approach	SB Approach
Sturgeon Road at Murray Park / Silver	F / 34.6 / 1.042 (F / 30.3 / 1.00)	D / 39.5 / 96.1 / 0.81 (B / 13.1 / 16.8 / 0.27)	B / 11.8 / 39.4 / 0.54 (F / 70.0 / 262 / 1.00)	F / 73.1 / 436 / 1.04 (A / 10.5 / 76.8 / 0.75)	A / 4.2 / 69.0 / 0.73 (C / 29.1 / 262 /0.97)

Based on the above results, the single lane roundabout cannot accommodate the 2031 AM (PM) Peak Hour projected volumes as acceptable delays, queue lengths and v/c ratios are exceeded. Additional intersection improvements are required to improve intersection operations.

Causation of the poor performance is generally due to the high volumes, specifically the high northbound thru volume at 770 (880) vph, the high southbound thru volume at 680 (770) and the high southbound left-turn volume at 310 (220) vph.

Further geometric improvements are required at this intersection to achieve appropriate roundabout operations.

2.3.4 2031 AM (PM) Peak Hour Results – Northbound Right Slip-Lane

In review of the volumes and the level of service, a possible improvement was to include a northbound right-turn slip-lane and remove the northbound right-turn volume of 130 vph out of the roundabout. With this geometric change, the operation of the roundabout is provided in Table 5 with printed SIDRA results provided in Appendix A.

Table 5: 2031 AM (PM) Peak Hour Analysis – Northbound Right-Turn Slip-Lane

Intersection	Intersection Performance LOS / Delay / v/c	LOS / Delay (sec) / 95th Percentile Queue (m) / v/c			
		EB Approach	WB Approach	NB Approach	SB Approach
Sturgeon Road at Murray Park / Silver	B / 11.2 / 0.81 (C / 22.9 /0.97)	D / 39.7 / 96.1 / 0.81 (B / 13.1 / 16.8 / 0.27)	B / 12.8 / 40.9 / 0.55 (D / 42.5 / 174 / 0.93)	A / 6.8 / 70.2 / 0.71 (A / 3.1 / 39.6 / 0.58)	A / 4.2 / 69.0 / 0.73 (C / 29.1 / 264 / 0.97)

Intersection operations are considerably improved for the northbound approach and some minor improvements are recognized by the westbound approach. The single lane roundabout with the northbound right-turn slip-lane operates at an acceptable level of service under this configuration.

However, another iteration of the roundabout was conducted to identify enhancement to the intersection in an effort to improve the projected operational performance.

2.3.5 2031 AM (PM) Peak Hour Results – Northbound and Westbound Slip-Lane

Another iteration of the roundabout was conducted to recognize the westbound right-turn volume of 220 (310) vph and the potential improvement to include a westbound slip-lane couple with the northbound right slip-lane. The result of this iteration is identified in Table 6 below:

Table 6: 2031 AM (PM) Peak Hour Analysis – Northbound Right-Turn and Westbound Right-Turn Slip-Lane

Intersection	Intersection Performance LOS / Delay / v/c	LOS / Delay (sec) / 95th Percentile Queue (m) / v/c			
		EB Approach	WB Approach	NB Approach	SB Approach
Sturgeon Road at Murray Park / Silver	B / 10.1 / 0.80 (B / 13.6 /0.97)	D / 38.8 / 94.9 / 0.81 (B / 13.1 / 16.8 / 0.27)	A / 4.6 / 7.7 / 0.13 (A / 5.2 / 21.3 / 0.33)	A / 6.8 / 70.2 / 0.71 (A / 3.1 / 39.6 / 0.58)	A / 4.2 / 67.9 / 0.73 (C / 27.7 / 253 / 0.97)

Intersection operations are further enhanced with the inclusion of the westbound right-turn slip lane in combination with the northbound right-turn lane. Under this configuration of the two slip lanes, the intersection operations are considered very acceptable.

2.3.6 Recommended Roundabout Configuration

Based on the traffic analysis and the SIDRA results, a single lane roundabout will likely not accommodate the projected traffic volumes to 2031.

However, based on the projected traffic volumes and the SIDRA analysis, it is suggested that the roundabout be constructed as a single-lane roundabout without slip-lanes for the near term based on operational considerations. Slip lanes are relatively easy to construct while maintaining existing traffic and may be required for this project to support the truck-turning movements due to the potential of a skewed intersection. As volumes increase and actual site counts are obtained to justify the need, the inclusion of slip lanes for the various approaches can be considered.

As such, the Preliminary Design with future consideration of staging can be considered.

3.0 ROUNDABOUT PRELIMINARY DESIGN STANDARDS

Prior to developing the conceptual roundabout alignment options, the roadway design criteria is required to be established to properly identify alignment options and the required geometry to support the design and is based on standard practices for two-lane roundabout design. The intent is to identify long-term roundabout needs based on the two-lane roundabout design, then accommodate the intermediate term needs of a single-lane roundabout.

The road geometries are based on best practices using the *Transportation Association of Canada Guidelines and* the *NCHRP Report 672 Roundabouts: An Informational Guide*. The geometric guidelines are based on current posted speeds on each approaching leg of the roundabout. A summary of recommended geometric design standards and practices are included in Table 7.

Table 7: Roadway Design Criteria

Intersection Leg	Sturgeon Road (North Leg)	Sturgeon Road (South Leg)	Murray Park Road	Silver Avenue
Posted Speed	70 km/h	60 km/h	60 km/h	50 km/h
Design Speed	80 km/h	70 km/h	70 km/h	60 km/h
High Speed Approach	NCHRP – No	No	No	No
Maximum Super-Elevation	4.0%	4.0%	4.0%	4.0%
Minimum Radius				
At 4.0% (preferred) Super-Elevation	280m	200m	200m	150m
At 6.0% Super-Elevation	250m	190m	190m	130m
Design Vehicle	WB-20	WB-20	WB-20	WB-20
Shoulder Width	2.5m	2.5m	2.5m	2.0m
Minimum Vertical Curve "k" Values				
Sag (Headlight Control)	25-32	20-25	20-25	15-18
Crest (SSD)	24-36	16-23	16-23	10-13
Roundabout Features	Minimum Circulatory Lane Width			5.0 m
Range of Inscribed Circle (2-lane roundabout)	2-Lane Inscribed Circle			50-67 m
Acceleration Lane	TAC Range = 160-225 Use 180 m	n/a	n/a	n/a
Deceleration Lane	TAC Range – 130-170 Use 150m	n/a	n/a	n/a

Other considerations for design include the development of fastest path to ensure all radii and corresponding travel speeds are within acceptable parameters. Speed differentials between radii should be <20 km/h (i.e. R1-R2, R2-R3, R1-R4, R2-R4).

In review of the north side approach, or southbound approaching the roundabout, the table above identifies the need for a high-speed approach with the design speed of 80 km/h. This requirement was discussed with *The City of Winnipeg Public Works Department* as a suggested requirement.

However, according to NCHRP *Report 672 – Roundabouts: An Information Guide*, the suggestion of high speed approach applies to entry roads with a posted speed of 80 km/h or higher. Development of the high-level conceptual design options did not include the high-speed southbound approach; however, further design of the preferred alignment did include the high-speed entry treatment. Impacts of the high-speed entry feature are discussed in greater detail in preliminary design options below.

4.0 ROUNDABOUT CONCEPTUAL DESIGN OPTIONS

In discussions *with The City of Winnipeg Public Works Department*, the desire of the roundabout conceptual design was to not impact properties on the west side of Sturgeon Road which include the Skateboard Park and residential properties. Options either on-line of Sturgeon and Murray Park are considered, or within the considerable right-of-way to the east of Sturgeon road.

However, to identify the needs of the near-term single-lane roundabout, long-term planning and due diligence requires the development of the preferred alignment of a two-lane roundabout. Various two-lane roundabout options were identified as potential candidates for this conceptual design in an effort to move to the single-lane roundabout conceptual design.

4.1 TWO-LANE ROUNDABOUT CONCEPTUAL DESIGN – OPTION 1

4.1.1 Site Location

Roundabout Conceptual Option 1 is identified in Figure 3 and places the two-lane roundabout immediately east of the intersection of Sturgeon Road at Murray Park / Silver Avenue with consideration of impacting existing features to the west, including the Skateboard Park and a City owned lots. The intent of this alignment is to preserve as much of the existing asphalt pavement on Sturgeon Road, Silver Avenue and Murray Park Road as practical and minimize the impacts on the natural grasslands to the east of Sturgeon Road.

The roundabout includes a 55.0 meter inscribed circle for the two-lane option and a slip-lane for the westbound-to-northbound right-turn movement. The slip lane is required from both an intersection operations perspective and arises from the geometric functional design and the need for supporting the turning movement of the WB-20 commercial truck requirements due to the skew angle. For this option and due to the volume of commercial trucks, it is not anticipated that The City would permit commercial trucks to "overtake the roundabout" and use both lanes at their discretion.

The west leg maintains much of the existing Silver Avenue roadbed with the two-lane alignment. The north and south legs accommodate long-term growth potential for Sturgeon Road to be constructed to a four-lane divided section. To the east, the potential for extending the current limits of the existing four-lane section of Murray Park Road is also accommodated.

Other considerations of Option 1 include:

- The need to realign portions of the Yellow Ribbon Path on Murray Park Road
- The need for sidewalk realignment on the east side of Sturgeon Road south of Murray Park Road / Silver Avenue
- The need for Transit stop relocations along Sturgeon Road

4.1.2 Opportunities

The most significant opportunity of this conceptual alignment is the overall project cost due to the use of existing road structures on Sturgeon Road, Murray Park Road and Silver Avenue. This applies to the near-term construction of the one lane-roundabout and for the future planning consideration for Sturgeon Road and Murray Park Road to be four-lanes.

Another benefit of this Conceptual Alignment Option 1 is the maintenance of existing access to the Skateboard Park and the residential property on the north side of Silver Avenue. The Skateboard Park access becomes a right-in / right-out, but may be expanded to an all-directional approach if the intersection is constructed to a two-lane roundabout in the future. This option may also minimize impacts to the natural grassland on the east side of Sturgeon Road.

4.1.3 Challenges

A challenge with this alignment is the current land use on the west side of Sturgeon Road, including the existing Skateboard Park on the southwest corner and City of Winnipeg Park land use on the northwest corner. Some of this impact is dependent on the needs for sidewalk and the multi-use path. It is important to note that all the land in the area is within a right-of-way secured for a system interchange from many years ago.

Another challenge with this alignment is the needs for staging of construction and the likely need for temporary roads during construction. With the roundabout constructed on-line with the existing roads, temporary staging of traffic and/or complete road closures may be required.

Initial discussions with *The City of Winnipeg Public Works Department* suggested the potential for complete road closures of Silver Avenue to the west and complete road closure of Murray Park Road. The potential of complete road closures arises due to the availability of adjacent roads for detouring, including the use of the Hamilton-to-Saskatchewan link in lieu of Silver Avenue and the Moray-Ness-Sturgeon link in lieu of Murray Park Road. Traffic volume analysis and intersection operations are recommended to be investigated for mitigation measures as part of the detailed design phase.

4.1.4 Utilities

Utility considerations on this concept alignment include the realignment of portions of the overhead streetlights, distribution lines and MTS lines. Due diligence must be exercised for identifying the depth of shallow utilities, including the gas line and the electrical distribution along Murray Park Road.

Additional intersection lighting will likely be required for consideration of roundabout lighting requirements and must be considered for future detail design phases.

4.2 TWO-LANE ROUNDABOUT CONCEPTUAL DESIGN – OPTION 2

4.2.1 Site Location

Option 2 moves the centroid of the roundabout north and west of the existing intersection of Sturgeon Road at Murray Park / Silver Avenue and is identified in Figure 4. This general location was identified as a potential location with consideration of the significant right-of-way availability and the potential reduction in construction staging as a considerable portion of the roundabout can be constructed off-line from the existing road alignments. However, this alignment has significant impact to the existing natural grassland on this quadrant of the project.

Similar to Option 1, this option includes a 55.0 meter diameter inscribed circle and still requires an eastbound-to-southbound right-turn slip lane due to geometry considerations for commercial truck (i.e. WB-20) turning movements.

The center of the proposed roundabout is approximately 50 meters west of Sturgeon Road. Under this alignment, the north lanes extend approximately 340 meters to match existing; to the east the lanes extend approximately 200 meters; to the south the lanes extend approximately 275 meters and to the west the lanes extend approximately 145 meters to match existing.

This conceptual alignment also requires an eastbound-to-southbound right-turn lane to accommodate the needs of commercial trucks (i.e. WB-20) due to the acute angle of the approach. Although not impacted by space and right-of-way, further refinement of this specific lane alignment can be investigated and if provision for a WB-20 commercial truck needs to be accommodated for this specific movement and the impacts of the geometry to the existing Skateboard Park. As Silver Avenue is not a truck route, alternate WB-20 routes are available for access to and from the area.

Other considerations of Option 2 include:

- The need to realign portions of the Yellow Ribbon Path on Murray Park Road
- The need for sidewalk realignment on the east side of Sturgeon Road south of Murray Park Road / Silver Avenue
- The need for Transit stop relocations along Sturgeon Road

4.2.2 Opportunities

Much of the roundabout and approach roads can be constructed with little impact to existing intersection operations, with the exception of tie-in to existing roads and where new construction is required over existing lanes.

It is perceived that the length of existing road closures is reduced, specifically along Sturgeon Road and road closures may be further reduced to limited lane closures with good construction staging.

Access to the Skateboard Park is maintained and would likely use portions of the existing lanes of Sturgeon Road with new access construction to the realigned lanes of Sturgeon Road. The existing residential home access is maintained.

4.2.3 Challenges

With this alignment, the challenge becomes the initial capital cost due to the requirement of constructing considerably more approach roads to the roundabout, as well as utility relocation / installation needs.

There is also a significant loss of existing natural grassland under this option and the compensation amount for disturbed naturalized areas is approximately $32.50/s.m. This cost is substantial and the final alignment of the roundabout should consider this impact for grassland disturbance, requirement for detour roads and the associated costs for replanting the native grasslands.

A significant deterrent to choosing this alignment was the long-term planning potential for the Silver Avenue Extension. Although the alignment of the Silver Avenue Extension is unknown regarding lane positioning, it is perceived that this Conceptual Alignment Option 2 would be significantly impacted should construction of Silver Avenue move forward. It is unknown when, or if, the Silver Avenue Extension would occur, but does play a role in the evaluation of options for this study.

4.2.4 Utilities

This concept alignment will require relocation or installation of streetlights along Sturgeon Road and along Murray Park Road as the proposed lanes are a significant realignment from existing lanes.

A number of the existing overhead distribution lines will also need to be relocated to accommodate the new road realignment as the road deviates from the existing road structure. Streetlight relocation affects all legs of the intersection.

Also, the MTS line depths and underground electrical distribution lines will need to be investigated as the conceptual ditch alignment crosses over MTS and underground electrical lines in new locations and may not have adequate vertical clearances.

4.3 TWO-LANE ROUNDABOUT CONCEPTUAL DESIGN – OPTION 3

4.3.1 Site Location

The Two-Lane Roundabout Conceptual Alignment 3 is identified in Figure 5 and places the centroid of the roundabout south and east of the existing intersection. Similar to Option 2, this

location was chosen based on the significant right-of-way within the study area, but with the understanding of the potential alignment issues with the Silver Avenue Extension.

This option maintains the 55.0 meter diameter inscribed circle. Due to the location of the roundabout, the need for the eastbound-to-southbound right-turn lane is eliminated as approach geometry is altered from the previous two options. However, there is similar need for the slip lane in the westbound-to-northbound right-turn movement as the road geometry required for the WB-20 commercial truck turning will likely require this slip-lane. Similar to Option 1, it is not anticipated that The City would permit commercial trucks to "overtake the roundabout" and use both lanes at their discretion.

With southbound Sturgeon Road carrying a posted speed of 70 km/h (design speed of 80 km/h), roundabout design literature does not suggest the need for a high-speed approach feature for the southbound approaching lanes. For this option specifically, a high-speed entry was not included.

The center of the proposed roundabout is approximately 65 meters east of Sturgeon Road and 40 meters north of Murray Park Road. The north lanes extend approximately 360 meters to match existing; to the east the lanes extend approximately 265 meters; to the south the lanes extend approximately 365 meters, to the west the lanes extend approximately 120 meters to match existing.

Other considerations of Option 3 include:

- The need to realign portions of the Yellow Ribbon Path on Murray Park Road
- The need for sidewalk realignment on the east side of Sturgeon Road south of Murray Park Road / Silver Avenue
- The need for Transit stop relocations along Sturgeon Road

4.3.2 Opportunities

The opportunities under Concept Alignment Option 3 are similar to that of Option 2; a considerable portion of the roundabout and approach roads can be constructed with little impact to existing intersection operations. The exception to road/lane closures is for portions where tie-ins are required to existing roads and where new construction is required over existing lanes.

It is perceived that the length of road closures is reduced in comparison to Option 1 (without temporary roads).

4.3.3 Challenges

The challenge with this alignment becomes the initial capital cost due to the requirement of constructing considerably more approach roads to the roundabout as well as shallow utility (i.e. streetlights, distribution and MTS) relocation or new installation.

This alignment also identifies a significant impact to the existing Skateboard Park as the alignment of Silver Avenue will require relocation southerly and may impact the existing berm, trees and parking requirements.

Another challenge is the Silver Avenue extension with similar comments identified in Section 4.2.3 regarding timing, alignment and compatibility of the Silver Avenue Extension.

This option also has a significant impact on the existing natural grassland on this quadrant of the existing intersection and is not measurable in costs.

4.3.4 Utilities

Concept Alignment Option 3 will require relocation or installation of streetlights along Sturgeon Road and along Murray Park Road as the proposed lanes are a significant realignment from existing lanes.

A number of the existing overhead distribution lines will also need to be relocated to accommodate the new road realignment as the road deviates from the existing road structure. Streetlight relocation affects all legs of the intersection. Also, due diligence must be exercised for identifying the depth of shallow utilities, including the gas line and the electrical distribution along Murray Park Road for purposes of road construction and ditch alignment / elevation. Minimum depths of cover must be maintained or risk further relocation of gas or underground hydro lines.

4.4 TWO-LANE ROUNDABOUT CONCEPTUAL DESIGN – OPTION 4

4.4.1 Site Location

Option 4 is a derivative of Option 1 but with consideration of a high-speed entry feature for the southbound approaching lane to the roundabout. Option 4 is identified in Figure 6 for consideration.

As discussed in the option above, NCHRP 672 does not suggest the need for a high-speed entry for the southbound approaching lane(s). However, following additional discussions with The City of Winnipeg Public Works Department, there is a strong desire to include the high speed entry for this southbound approach in consideration of safety and driver expectations. Therefore, Option 4 implements the high-speed approach for the southbound approaching leg of the intersection.

Option 4 also places consideration to maintaining as much of the existing lanes on Sturgeon / Murray Park / Silver as possible for the benefit of overall project cost.

In an attempt to not disturb the current land use on the northwest corner of the intersection and using a southbound high-speed entry feature, the centroid of the roundabout is required to move further east on Murray Park Road when compared to Option 1. From the center of the existing intersection to the center of the roundabout, Option 1 yields an offset of 10 meters and Option 4 yields an offset of 30 meters.

The roundabout under Conceptual Alignment Option 4 includes a 55.0 meter inscribed circle for the two-lane option and a slip-lane for the westbound-to-northbound right-turn movement. The slip lane is required from both an intersection operations perspective and arises from the geometric functional design and the needs for supporting the turning movement of the WB-20 commercial truck requirements.

The west leg to Silver Avenue and the east leg to Murray Park Road maintains most of the roadbed with the two-lane alignment. The north and south legs accommodate long-term growth potential for Sturgeon Road to be constructed to a four-lane divided section.

With the identified high-speed approach, the north lanes extend approximately 310 meters to match existing; to the east the lanes extend approximately 200 meters; to the south the lanes extend approximately 380 meters, to the west the lanes extend approximately 90 meters to match existing.

Other considerations of Option 4 include:

- The need to realign portions of the Yellow Ribbon Path on Murray Park Road
- The need for sidewalk realignment on the east side of Sturgeon Road south of Murray Park Road / Silver Avenue
- The need for Transit stop relocations along Sturgeon Road

4.4.2 Opportunities

One opportunity under Conceptual Alignment Option 4 is that the total construction cost is anticipated to be less than Options 2 and 3 due to the re-use of portions of the existing roads. The southbound exiting lane from the roundabout can return to the existing Sturgeon Road alignment quickly and the Silver Avenue eastbound thru lane requires minor improvements, but does require the construction of a slip lane. Also, portions of Murray Park Road can likely be implemented into the final design

4.4.3 Challenges

One challenge with this alignment is the need for staging of construction and the likely need for temporary roads during construction. With the roundabout constructed on-line with the existing

roads, specifically Murray Park Road, temporary staging of traffic and/or complete road closure of Murray Park Road may be required.

Road closures are similar to that discussed in Section 4.1.3, and may need to be further investigated with *The City of Winnipeg – Public Works Department* to identify the viability of complete road closures and the impacts to increased volumes at affected intersections.

4.4.4 Utilities

Utility considerations on this concept alignment include the existing streetlights along the east edge of the existing travel lanes of Sturgeon Road and the potential for MTS above ground box relocations. Shallow utility depths (i.e. Manitoba Hydro and MTS) are unknown at the time of this report and should be identified to allow for design and appropriate vertical clearances from affected utilities.

Also, additional intersection lighting will likely be required for consideration of roundabout lighting requirements.

5.0 GEOTECHNICAL INVESTIGATION

A geotechnical investigation was completed as part of this Functional Design Study within the study area to identify the sub-grade conditions with consideration of road pavement design. The geotechnical investigation is dated January 30, 2015 and is included in Appendix B for reference.

The investigation included six boreholes drilled to a depth of 2.1 meters. One borehole was taken on each of the four legs of the intersection and one borehole was obtained on each of the northeast and southeast corners of the intersection.

In general terms, Sturgeon Road includes 100 millimeter depth of asphalt pavement, 300 millimeter depth of granular material following by compacted clay fill to termination of the borehole at 2.1 meters. For Murray Park Road and Silver Avenue, the asphalt pavement depth was 100 millimeter; the granular was approximately 200 millimeter, followed by compacted clay fill to the end of the borehole.

Of particular interest are Boreholes #5 and #6 which are the northeast and southeast corners respectively and are located in the natural grassland area. The layers included a minor depth of topsoil followed by typical clay depths to a depth of approximately 1.75 meters. At approximately 1.75 meters the boreholes encountered silt till which contained fine to course gravel. The shallow depth of till is known in this area of Winnipeg and is confirmed with the geotechnical borehole program.

Based on the geotechnical borehole program, the soils appears to be reasonable for purposes of construction and provides some confidence in the soil conditions for purposes of pavement design.

6.0 ROUNDABOUT PAVEMENT DESIGN

A pavement design was completed for the single-lane roundabout using the 2031 projected volumes provided by *The City of Winnipeg Public Works Department*.

For purposes of this Functional Design Report, the assumptions for pavement types for this project included asphalt approach roads to the far-side crossing of the pedestrians and concrete pavement from the far-side pedestrian crossings to within the circulating roadway within the roundabout, including the truck apron.

The Pavement Design report is provided in Appendix C for review and consideration and includes the background for the intersection growth rates, the development of ESALS, the pavement design parameters, methodologies, structural number requirements, optional pavement design and supporting printout documentation from the various software design packages.

The asphalt pavement design of this project implemented the use of two methods; the *AASHTO 1993 Guide for the Design of Pavement Structures* and *Tensar's SpectraPave Pro 4* software for asphalt pavement design incorporating geogrid. The concrete pavement design for this project used Streetpave 12.

A summary of the recommended pavement design developed within the report is as follows:

- Concrete Pavement Design (Roundabout)
    - 230 millimeter plain dowelled concrete
    - 100 millimeter of 19 millimeter limestone base course
    - 150 millimeter of 50 millimeter limestone sub-base
    - 400 millimeter of 150 millimeter limestone sub-base
    - Non-Woven geotextile (NO GEOGRID)
        - Total Structure Thickness – 880 millimeter
- Asphalt Pavement Design (Approach Roads)
    - 150 millimeter asphaltic concrete
    - 100 millimeter of 19 millimeter limestone base course
    - 150 millimeter of 50 millimeter limestone sub-base
    - 850 millimeter of 150 millimeter limestone sub-base
    - Tensar BX1200 Geogrid and Non-Woven Geotextile
        - Total Structure Thickness – 1,250 millimeter

7.0 TWO-LANE FUNCTIONAL DESIGN – DECISION MATRIX

A decision matrix was formed with the information presented above and includes consideration for long-term compatibility with future four-lanes of the study area roads, ease of construction while accommodating the existing traffic volumes, the opinion of probable construction cost, utility impacts, etc.

With four options, the scores range from 1-4 with the lower number representing a less desirable result and the higher numbers representing a more desirable result. Also, weighting was implemented to identify the increased impact or importance of certain criteria to the decision making process.

In discussion with The City of Winnipeg, an item by item evaluation was conducted for each option based on engineering judgment, with Table 8 providing the net results.

Table 8: Decision Matrix

Criteria Description	Weighting	Option 1	Option 2	Option 3	Option 4
Compatibility with Long-Range Plans	1	4	2	2	3
User Expectation	1	3	2	2	2
Impacts to Natural Grassland	1	3	2	2	2
Utility Impacts	1	3	2	2	3
Ease of Construction	1	1	3	3	1
Overall Project Cost	2	4	2	2	3
TOTAL SCORE		**22**	**15**	**15**	**17**

In review of the scores, a relatively wide spread of results are identified and range from 15 points to 21 points. Option 1, with a total of 22 points, appears to be moderately higher than Options 4 with 17 points and significantly better than Options 2 and 3. The most significant contributor was the Overall Project Cost line item and it's 2x weighting.

The net result of this exercise identifies Option 1 as the preferred option for consideration, followed by Option 4.

With the preferred alignment of the two-lane roundabout identified as Option 1 and Option 4 being in second place, it was agreed with The City of Winnipeg to include both as a Functional Design of the one-lane Option.

8.0 CONCEPTUAL ALIGNMENT DESIGN MODIFICATIONS

Following the development of the above mentioned four Conceptual Alignment Options, The City of Winnipeg had internal discussions regarding the long-term needs of this intersection and the requirement for a two-lane roundabout. Subsequent discussions identified the desire to develop a single-lane roundabout only and not to identify the long-term needs of this intersection.

It was also identified that the Open Space land on the northwest corner of the existing intersection did not need to be protected and the southbound high-speed entry lane to the roundabout could extend beyond the Sturgeon Road "right-of-way" and into the Open Space.

With much of the due-diligence completed from identifying the two-lane roundabout options describe in above sections of this report, single-lane roundabout options were developed and are "derivatives" from previous design work. The common understanding is that two of the four roundabouts previously developed are highly unlikely candidates; Option 2 on the northeast corner of the existing intersection and Option 3 on the southeast corner of the intersection.

At this stage of development, Stantec and The City also discussed the limits of shoulders vs. raised curbs for purposes of functional design. For development of the conceptual design alignments, curbs are extended to past the splitter islands before "turning out" to the shoulder. The circulating road, truck apron and splitter islands would include raised curbs for better definition of the roundabout and to properly identify assignment of the travel lane.

With this new information, two single-lane roundabouts were established as suggested options; Single-Lane Roundabout Option 1 and Single-Lane Roundabout Option 2.

9.0 SINGLE LANE ROUNDABOUT OPTIONS

The single-lane roundabout options are developed using similar design parameters as previously described in Section 3 of this report and the options were developed with construction of the outside lane of the two-lane roundabout. There are two rationale for developing the outside lane of a two-lane roundabout first; the first consideration is the increased percentage of large, commercial trucks using this intersection and the increase ease of use with the outside lane of travel; the second consideration is with consideration of time of use of the single-lane roundabout prior to implementation or conversion to a two-lane roundabout.

As such, the two single-lane roundabout options are described below.

9.1 SINGLE LANE ROUNDABOUT OPTION 1

The overall geometry and intent for detailed design of Single Lane Roundabout Option 1 is identified on Figure 7 and is a derivative of Two-Lane Roundabout Option 1 presented on Figure 3.

With consideration of minimizing overall project costs, the centroid of the roundabout is maintained on the existing centerline of the stop-controlled intersection. The 55 meter outside diameter single-lane roundabout includes two slip lanes; one for the westbound-to-northbound right and one for the eastbound-to-southbound right.

The westbound-to-northbound right includes the development of deceleration and acceleration lanes with consideration of the increased volumes of overall traffic and for ease of use for the increase volumes of commercial trucks. The taper length for both the deceleration and acceleration lane is 65 meters, the deceleration lane length is 110 meters and the acceleration lane length is 120 meters, in accordance with TAC design standards assuming the right-turn cut-off yields a 20 km/h travel speed.

The eastbound-to-southbound right-turn lane is not required as a function of projected volumes, but may be required to satisfy the needs of a WB-20 commercial truck. Without use of a right-turn slip-lane, there is potential for the pavement widening adjacent the circulatory roadway to be too large (>2.0 meters) and may provide undesirable roundabout traits due to the considerably wider pavement. However, use of the slip-lane may also significantly impact the Skateboard Park due to the proximity of the slip-lane and the existing Skateboard Park features, including the skateboard ramps, earth berming, etc.

Under final design, additional discussions must be held with The City of Winnipeg Public Works to ensure if the design vehicle must include the WB-20 vehicle and if other forms of "treatment" may be applied to eliminate the need for the eastbound-to-southbound slip-lane. Creative thoughts may include the use of thickened concrete splash strip behind the circulatory roadway

curbing (i.e. concrete apron) or stabilizing the turf grass and topsoil behind the circulatory road curb with cellular confinement.

9.1.1 Opportunities

The most significant opportunity on this roundabout alignment is the overall project cost. By using much of the existing pavement on Sturgeon Road, Murray Park Road and Silver Avenue, it is expected that new pavement construction will be reduced.

Designing the roundabout on the existing intersection also reduces the impact and costs for surrounding utilities, both overhead and underground. As previously described, due diligence needs to be exercised to confirm the depth of the affected underground utilities, but as this intersection is generally a high-point of the open ditch drainage system, detailed design may further mitigate impacts to affected utilities.

This option also has the least impact on the existing natural grassland areas on the northeast and southeast quadrants of the intersection due to its smallest deviation from the existing roads and the projected footprint for construction.

To a lesser extent, this option also has the benefit of reducing the impacts to the existing sidewalks and multi-use paths.

9.1.2 Challenges

Two challenges are identified for this single-lane roundabout option; the eastbound-to-southbound slip-lane and constructability.

The challenges of the eastbound-to-southbound slip lane are described above and include the impacts to the Skateboard Park. Further discussions on the design vehicle required for this movement and creative solutions to minimize impacts should be strongly encouraged during detailed design.

Constructability is also a challenge as the proposed roundabout is centrally located on an existing intersection. If complete road closures of Silver Avenue and Murray Park Road are permitted by The City of Winnipeg Public Works Department and the traffic operations on the affected intersection are acceptable, then construction staging becomes considerably easier. This option will highly likely require temporary roads regardless for maintaining northbound and southbound traffic through the intersection.

To a lesser extent, a challenge may include placement of the bus stop, specifically for the north side location. This challenge is due to the acceleration lane for the westbound-to-northbound movement. Relocation of the bus stop to the south side of the roundabout may provide a reasonable solution.

9.2 SINGLE LANE ROUNDABOUT OPTION 2

Single-lane Roundabout Option 2 is a derivative of the previously described Two-Lane Roundabout Option 4 with the centroid of the roundabout east of the existing intersection. The intent with developing this option is to mitigate impacts of the eastbound-to-southbound right-turn lane on the Skateboard Park.

Many features are similar with Option 2 to that of Option 1, with that of a westbound-to-northbound right slip lane and the westbound-to-southbound right-turn slip lane.

However, with moving the centroid of the roundabout, the length of required new lane construction is considerably extended to match back to the existing lanes of Sturgeon Road, leading to considerably more costs from a road construction perspective and from a utility / streetlight relocation perspective. The costs associated with matching the existing lanes of Murray Park Road and on Silver Avenue are not anticipated to be extensive.

Similar to Option 1, Option 2 will likely require the construction of an eastbound-to-southbound right-turn slip lane. This slip lane is not required as a function of projected volumes, but may be required to satisfy the needs of a WB-20 commercial truck. Without use of a right-turn slip-lane, there is potential for the pavement widening adjacent the circulatory roadway to be too large (>2.0 meters) due to the acute angle. Similar to Option 1, this widened pavement for Option 2 may provide undesirable roundabout traits due to the considerably wider pavement and potential for driver confusion or. However, use of the slip-lane may also significantly impact the Skateboard Park due to the proximity of the slip-lane and the existing Skateboard Park features, including the skateboard ramps, earth berming, etc.

Under final design, additional discussions must be held with The City of Winnipeg Public Works to ensure if the design vehicle must include the WB-20 vehicle and if other forms of "treatment" may be applied to eliminate the need for the eastbound-to-southbound slip-lane. Creative thoughts may include the use of thickened concrete splash strip behind the circulatory roadway curbing (i.e. concrete apron) or stabilizing the turf grass and topsoil behind the circulatory road curb with cellular confinement.

9.2.1 Opportunities

An opportunity of Single Lane Roundabout Option 2 is the potential for reducing road closures along Sturgeon Road and the reduced need for temporary roads on Sturgeon Road. This assumes that Silver Avenue and Murray Park Road can be closed and traffic operations on affected intersections are within acceptable parameters.

The other opportunity is regarding the reduced impact of the eastbound-to-southbound right-turn lane to the Skateboard Park. As the skateboard Park is a recent addition to the area, minimizing impacts are highly desirable.

9.2.2 Challenges

A significant challenge to Option 2 over Option 1 is impacts to the natural grasslands and overall project cost.

Under Option 2, the natural grassland area is significantly impacted over Option 1 for the immediate area. This is based solely on the footprint of the final roundabout construction and does not include consideration for construction staging.

Project cost for Option 2 is also anticipated to be significant increase over Option 1 due to the length of new road construction to tie into existing road alignment, including Sturgeon Road both north and south of the proposed roundabout and for matching existing Murray Park Road.

9.3 SINGLE LANE ROUNDABOUT SUGGESTED RECOMMENDATIONS

Based on the above discussions from an overall loss of natural grasslands, project cost and long-term needs, the suggestion is to develop Single Lane Roundabout Option 1 further to refine the suggestions listed above.

A few items are to be discussed in great detail to enhance the design and advance the drawings to detail design, including;

- What is the design vehicle for the eastbound-to-southbound right? (i.e. WB-20 or other?). This will define the need for a right-turn slip lane or creative solutions for pavement widening beyond the circulatory roadway.
- Is Silver Avenue and Murray Park Road allowed to include complete road closure during construction?
- What are the traffic operations at affected intersections if Silver Avenue and Murray Park are closed during construction?
- What is the true impact for the loss of natural grassland? Natural grassland is irreplaceable and cannot be identified as a "replacement" cost.
- What are the true costs for overhead and shallow utility relocations? As depth of underground utilities are unknown, this is a risk for costs of relocation.
- Secure actual utility costs under detailed design. Assumptions were made as part of this Functional Design Study for relocation costs of affected utilities. However, with considerable infrastructure on the wood pole lines on the east side of Sturgeon Road, costs will need to be refined further through discussions with affected utilities.

10.0 SINGLE-LANE ROUNDABOUT OPINION OF PROBABLE COST

Stantec developed Class "3" Opinions of Construction cost for each of the two single-lane roundabout options described above.

The Opinions of Probable Cost were developed using 2014 / 2015 standard costs for roads within The City of Winnipeg market area and were developed on a cost per lineal meter basis. For purposes of the costs, Stantec assumed that the approaching roads to the roundabout are constructed in an asphalt pavement design. The concrete pavement design would apply for the circulating roadway in the roundabout and the approaches outbound of the roundabout to the far –side of the pedestrian crossings.

The pavement design used for the development of construction costs are identified in Section 6 above; however many other considerations to develop the construction costs are required, including:

- Staging of construction
- Asphalt pavement removals
- Abandoned road alignment re-grading
- Sidewalk removals and installation
- Multi-use pathway removals and installation
- Access reinstatement or realignment
- Concrete roundabout installation
- Asphalt approach road construction
- Topsoil and seeding
- Signing removals and new signing / striping installations

Items that are not included in the Class "3" Opinion of Probable Cost are:

- Shallow utility relocations (i.e. MB Hydro , MTS)
- Grassland revegetation
- City of Winnipeg Administration costs

Appendix D provides the supporting documentation for the development of lineal meter costs and overall costs for each Two-Lane Roundabout Option.

Intersection Option	Design Option 1	Design Option 2
Road Construction Cost	$2,304,000	$3,827,000
Contingencies (20%)	$460,800	$765,400
Sub-Total	$2,764,800	$4,592,400
Engineering (15%)	$417,720	$688,860
Total Cost	*$3,179,520*	*$5,281,260*
ROUNDED	**$3,200,000**	**$5,300,000**
NOTE: Costs do not include utility relocations, grassland revegetation, City Administration Costs		

11.0 CONCLUSIONS

Below is a list of conclusions based on the information presented above to be considered for potential future phases of detailed design.

11.1 BACKGROUND

- Natural Grasslands – the natural grasslands on the northeast and southeast corners of the project limits needs to be considered and impacts should be mitigated while developing construction and staging drawings

- Yellow Ribbon Multi-Use Path – continuity of the multi-use pathway must be maintained with safe and appropriate crossings through the roundabout and to reconnecting links.

- Pedestrian sidewalk – continuity of the existing sidewalks must be maintained with safe and appropriate crossings parallel the roads and through the roundabout.

- Transit – transit operates Route 83 within the study area. Transit service must be incorporated into the design and maintained during construction. Due to the desire for the westbound-to-northbound acceleration lane, discussions should be held with transit to discuss the potential for relocating the transit stop from the north side of the intersection to the south side.

- Underground Utilities – determining the depth of underground utilities, including gas, Manitoba Hydro and others, should be confirmed for detail design to mitigate any potential relocation challenges.

- Overhead Utilities – Confirmation of actual costs must be developed with each affected utility, including Manitoba Hydro, Gas, Shaw, etc. For purpose so this report, high level costs are provided but were not confirmed with each affected utility.

11.2 TRAFFIC OPERATIONS

- Based on the available data provided by The City of Winnipeg, a single lane roundabout is not projected to operate satisfactorily to the 2031 design year.

- A single lane roundabout is projected to operate satisfactorily to 2021.

- It is preferred to include a westbound-to-northbound slip lane with appropriate acceleration and deceleration lanes for ease of commercial truck movements and to enhance roundabout traffic operations in the intermediate term.

- It is recommended to secure additional site counts based and review long-term projected volumes prior to finalizing the roundabout configuration and detail design.

11.3 GEOMETRIC DESIGN

- Critical geometric design criteria is identified on Table 7 within the report. Prior to detail design, this must be updated as required, reviewed and approved by The City of Winnipeg Public Works Department.

- Special consideration of the approaching lanes to the roundabout must be reviewed to ensure appropriate deflection angle and speed control entering / exiting the roundabout. Fastest path alignments must be completed and meet the design requirements.

- The southbound approach lane of the roundabout should include a high-speed entry; based on The City of Winnipeg Public Works recommendation.

- The single-lane roundabout drawings depict the construction of the outside lane of a two-lane roundabout with an inscribed diameter of 55 meters. Economies of space and cost may be realized if there is a desire to reduce the inscribed circle as part of the detailed design.

11.4 GEOTECHNICAL INVESTIGATION

The geotechnical investigation did not reveal any major sub-grade concerns based on the completed testholes. The depth of till at 1.75 meters is not anticipated to provide any major obstacles in design or construction. The completion of the geotechnical report does not limit the design the designer or construction from taking provisions in the event of poor subgrade conditions (i.e. silt). Due-diligence must be exercised during detailed design.

11.5 PAVEMENT DESIGN

The pavement design provided within this report was completed based on the available traffic data and projected growth conditions provided by The City of Winnipeg using the following:

- AASHTO 1993 Guide for the Design of Pavement Structures for non-reinforced (i.e. no geogrid) flexible pavement design,

- Tensar's SpectraPave Pro 4 for flexible pavement design using geogrids,

- Regional Municipality of Waterloo methodology for concrete pavement design.

11.6 ROUNDABOUT ALIGNMENTS

- Four two-lane roundabout alignments were identified within this Functional Design Study; one on-line to the existing intersection, one to the northeast of the existing intersection, one to the southeast of the existing intersection and one east of the intersection.

- Based on various impacts identified in the evaluation criteria, the two highest rated roundabout locations are:
    - on-line of the existing intersection of Sturgeon Road at Murray Park / Silver Avenue,
    - west of the existing intersection of Sturgeon Road at Murray Park / Silver Avenue intersection.

- Two single-lane roundabouts are developed to a functional / preliminary stage of design for consideration in developing future detailed design. With further enhancements of various elements of the roundabout features, the design included in this report is only provided as a design intent. Changes to the design would include
    - Change in design criteria (i.e. commercial truck size for eastbound-to-southbound right-turn lane),
    - refinements of design (i.e. inscribed circle diameter, pavement design),
    - construction staging requirements (i.e. temporary access roads)
    - approvals (i.e. natural grassland area),
    - utility impacts (i.e. proofing of overhead costs as well as underground utility elevations and costs)

12.0 RECOMMENDATIONS

The following is a list of recommendations to be considered as part of this Functional Design Study:

- Re-evaluation of existing and projected traffic volumes to ensure the adequacy of single-lane roundabout operations and identify the need for right-turn slip-lanes as part of extending adequate traffic operations.

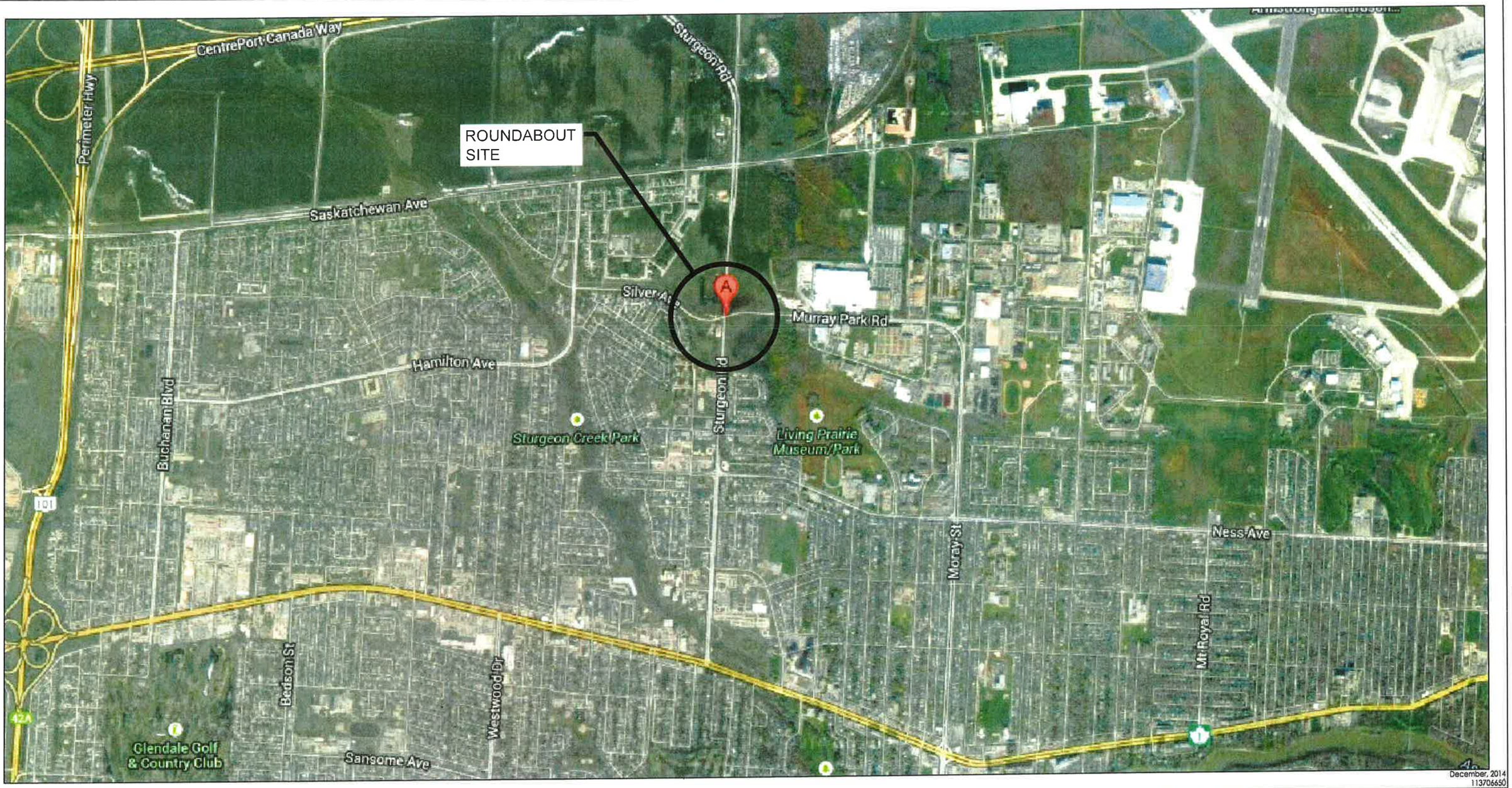
- Recommendation of developing the two-lane roundabout option under preliminary and detail design to secure impacted right-of-way, identify the exact location of the inscribed circle and ensure future compatibility with long-term needs from one-lane roundabout operations to two-lane roundabout operations.

- Confirm the actual design vehicle requirements, specifically for the eastbound-to-southbound right-turn lane to optimize roundabout geometries.

- Determine traffic operations on surrounding area intersections if closure of Murray Park Road and/or Silver Avenue is considered. Road closures would enhance the efficiencies of construction if project duration is a concern.

Sturgeon Road at Murray Park / Silver Avenue Roundabout - Preliminary Design Report

Functional Design Study – Report Figures



ORIGINAL SHEET - ISO 11x17 v13.12

December, 2014
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V:\1137\active\113706650\drawing\407_sketches\sheet_files\06650c-location_plan.dwg FIGURE_4
2015/01/26 2:50 PM By: Paradoski, Gordon

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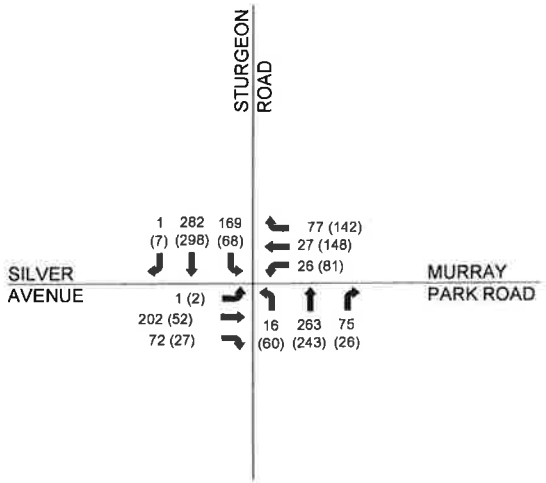
THE CITY OF WINNIPEG PUBLIC WORKS DEPARTMENT
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
1

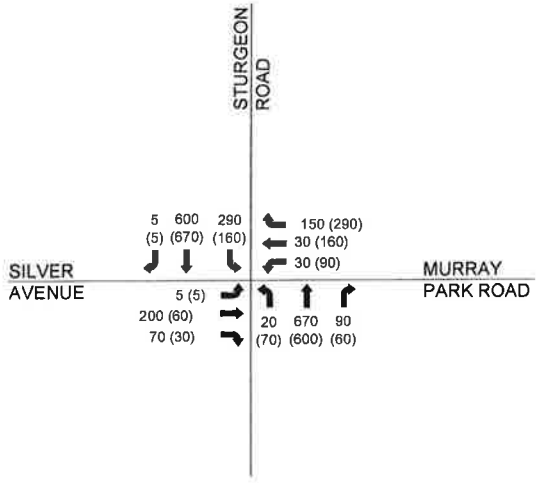
Title
SITE LOCATION PLAN

V:\1137\active\113706650\drawing\407_sketches\sheet_files\06650c-skt-traffic Count.dwg peak hour volumes
2015/01/26 2:50 PM By: Paradoski, Gordon

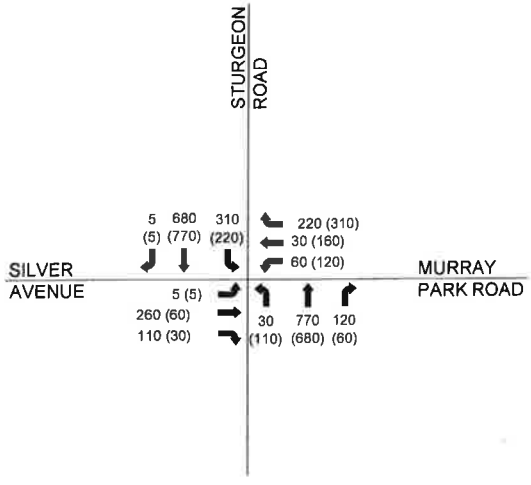
2014 AM (PM) PEAK HOUR



2021 AM (PM) PEAK HOUR



2031 AM (PM) PEAK HOUR



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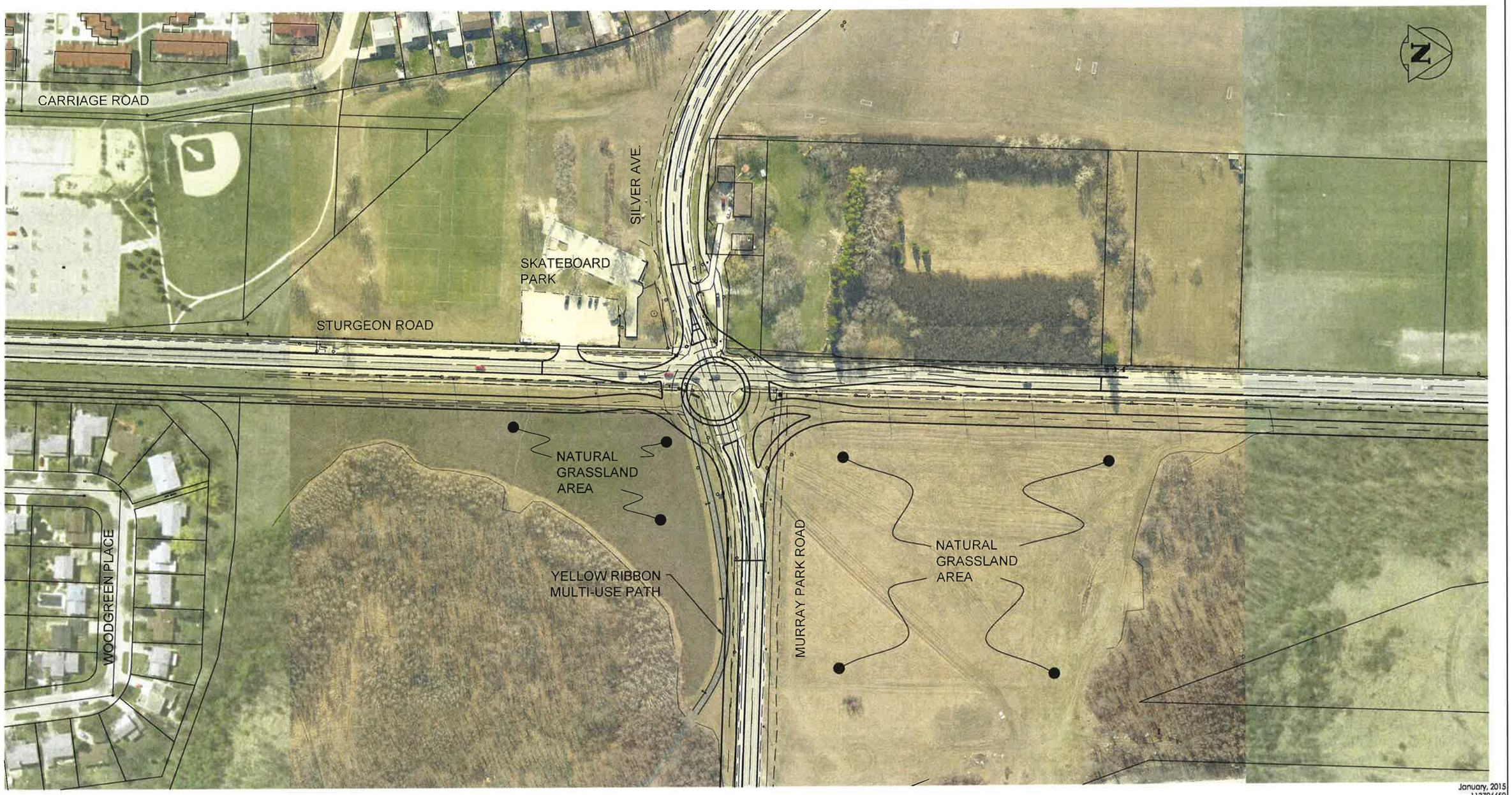
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
2

Title
CITY OF WINNIPEG SUPPLIED AM/PM PEAK HOUR VOLUMES



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2015/03/02 9:01 AM By: Paradoski, Gordon

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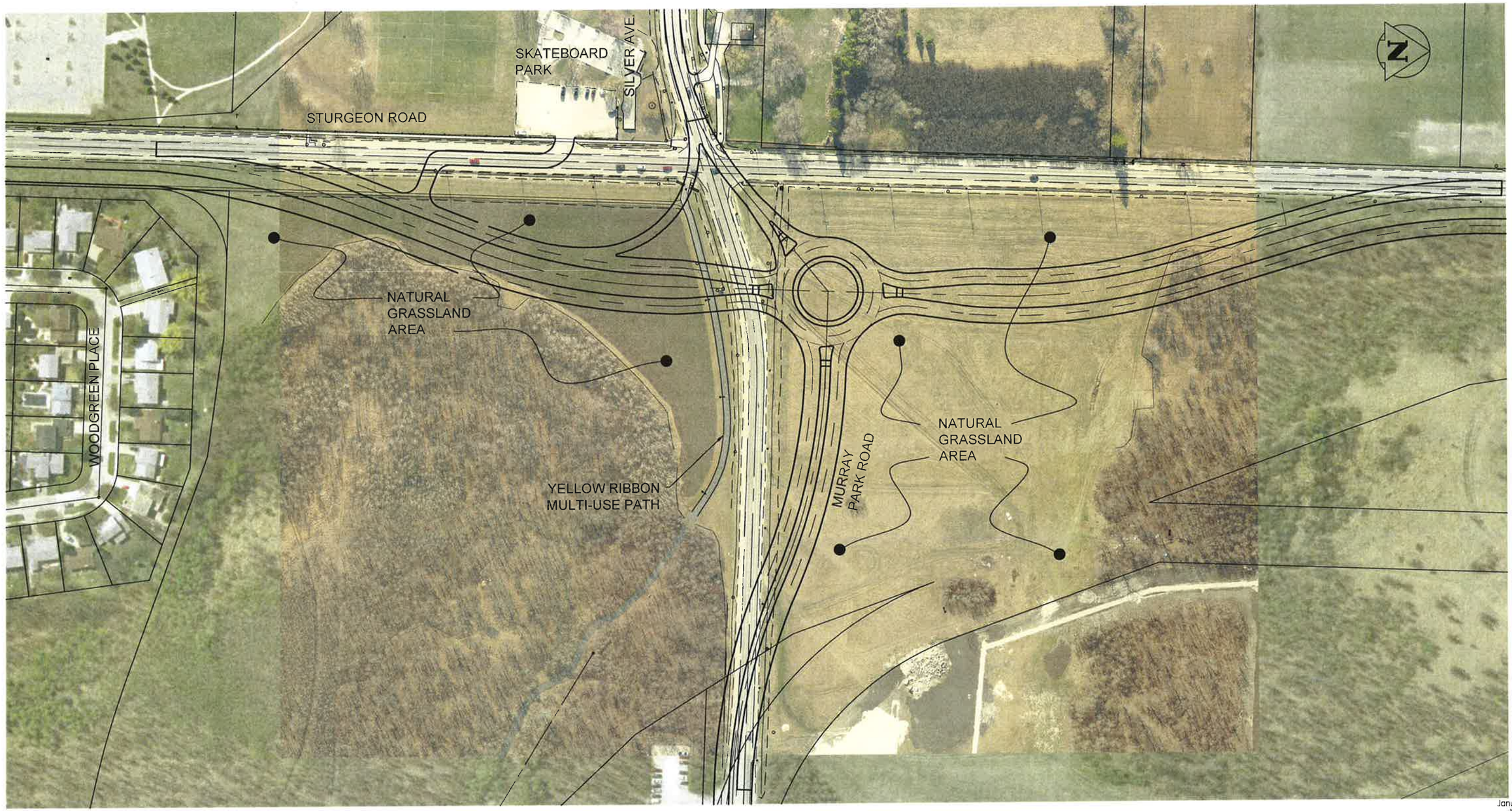
THE CITY OF WINNIPEG PUBLIC WORKS DEPARTMENT
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
3

Title
CONCEPTUAL ALIGNMENT - TWO LANE ROUNDABOUT OPTION 1



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Notes

1:2000 0 20 60 100m

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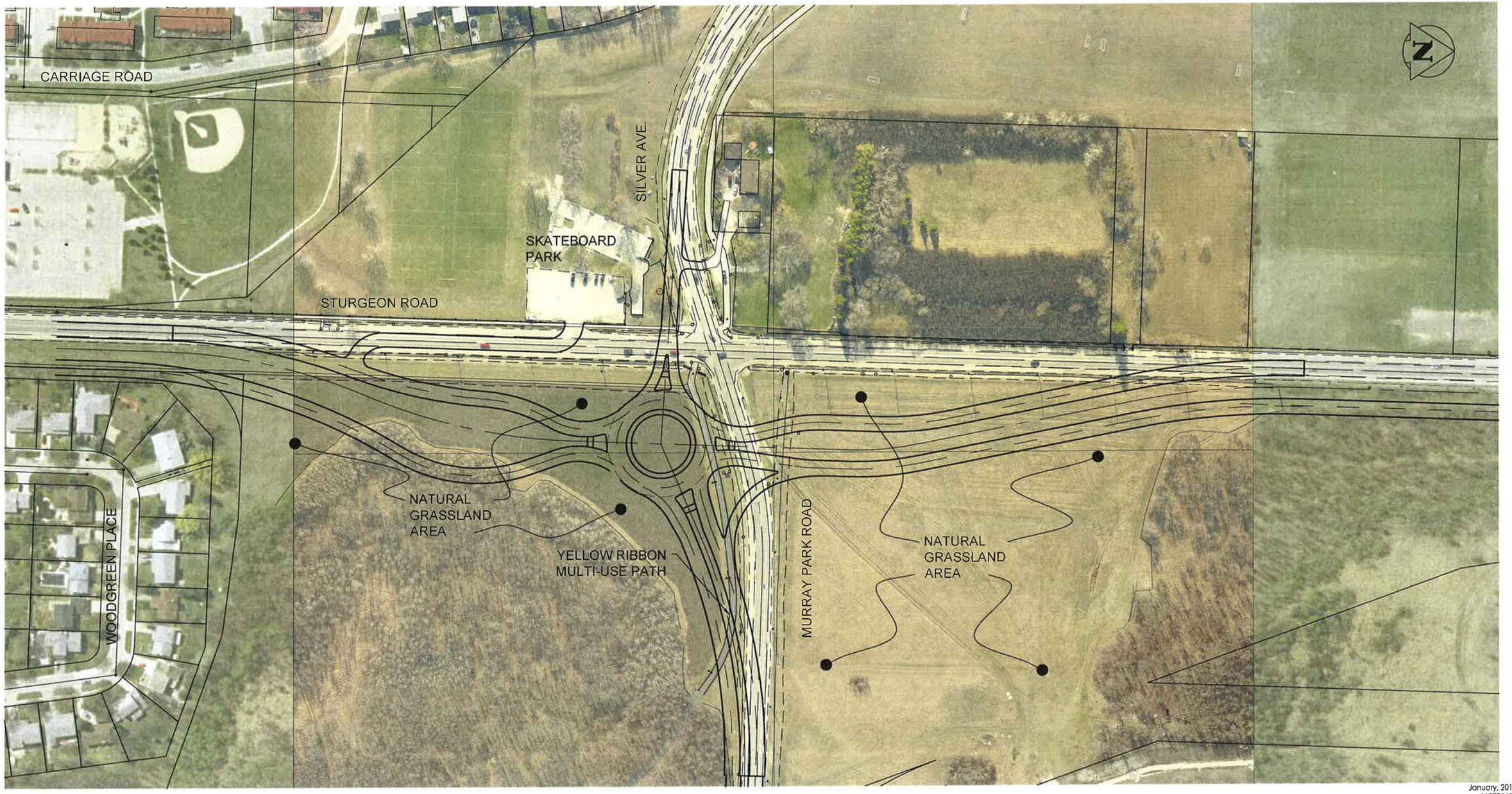
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
4

Title
CONCEPTUAL ALIGNMENT - TWO LANE ROUNDABOUT OPTION 2



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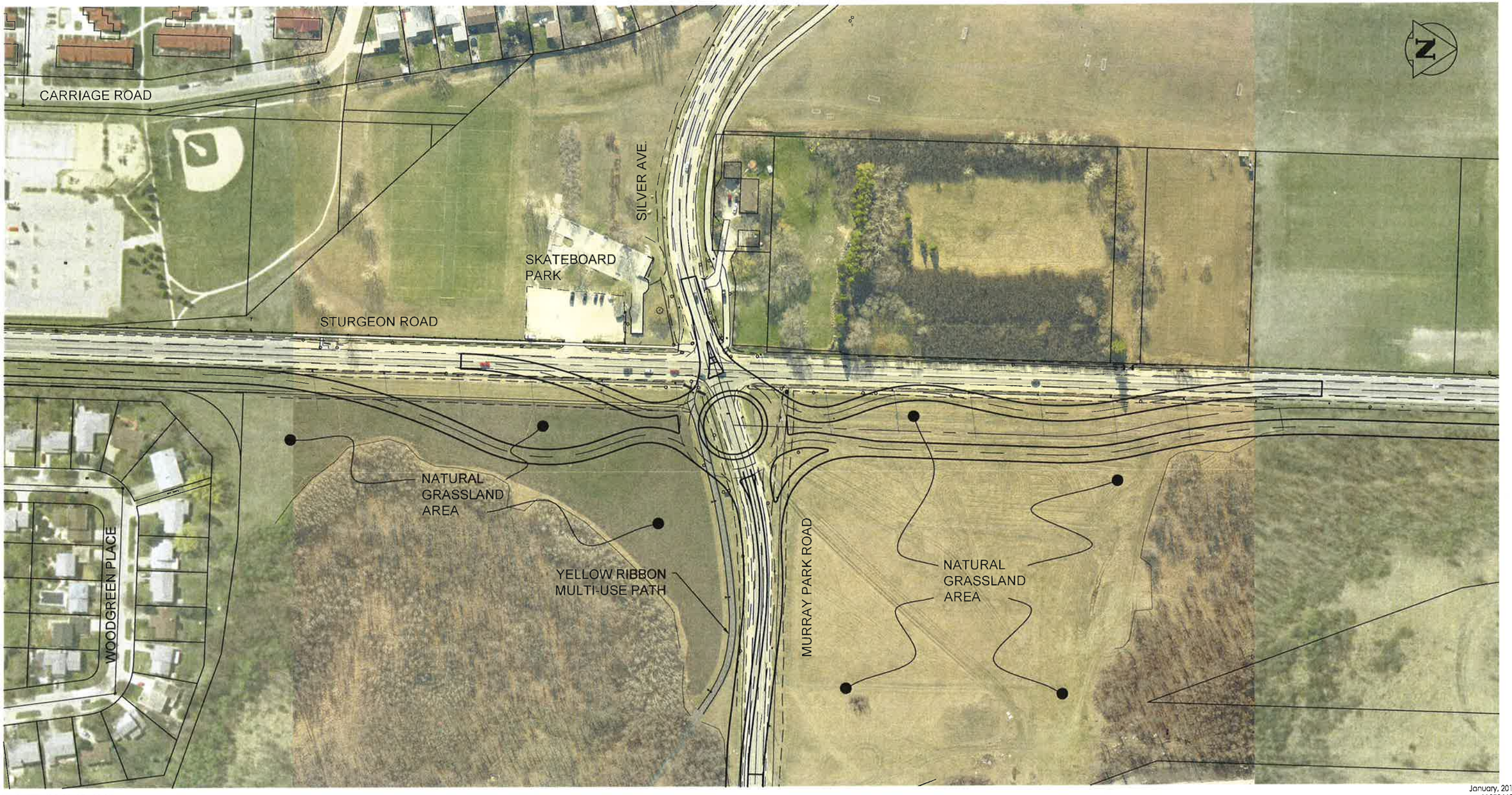
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
5

Title
CONCEPTUAL ALIGNMENT - TWO LANE ROUNDABOUT OPTION 3



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FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
6

Title
CONCEPTUAL ALIGNMENT - TWO LANE ROUNDABOUT OPTION 4

CARRIAGE ROAD

SILVER AVE.

SKATEBOARD PARK

STURGEON ROAD

NATURAL GRASSLAND AREA

YELLOW RIBBON MULTI-USE PATH

MURRAY PARK ROAD

NATURAL GRASSLAND AREA

WOODGREEN PLACE

N

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THE CITY OF WINNIPEG PUBLIC WORKS DEPARTMENT
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
7

Title
CONCEPTUAL ALIGNMENT - SINGLE LANE ROUNDABOUT - OPTION 1

CARRIAGE ROAD

SILVER AVE.

SKATEBOARD PARK

STURGEON ROAD

WOODGREEN PLACE

NATURAL GRASSLAND AREA

YELLOW RIBBON MULTI-USE PATH

MURRAY PARK ROAD

NATURAL GRASSLAND AREA

N

ORIGINAL SHEET - ISO 11x17 v13.12

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1:2000 0 20 60 100m

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THE CITY OF WINNIPEG PUBLIC WORKS DEPARTMENT
FUNCTIONAL DESIGN OF STURGEON ROAD / MURRAY PARK ROUNDABOUT

Figure No.
8

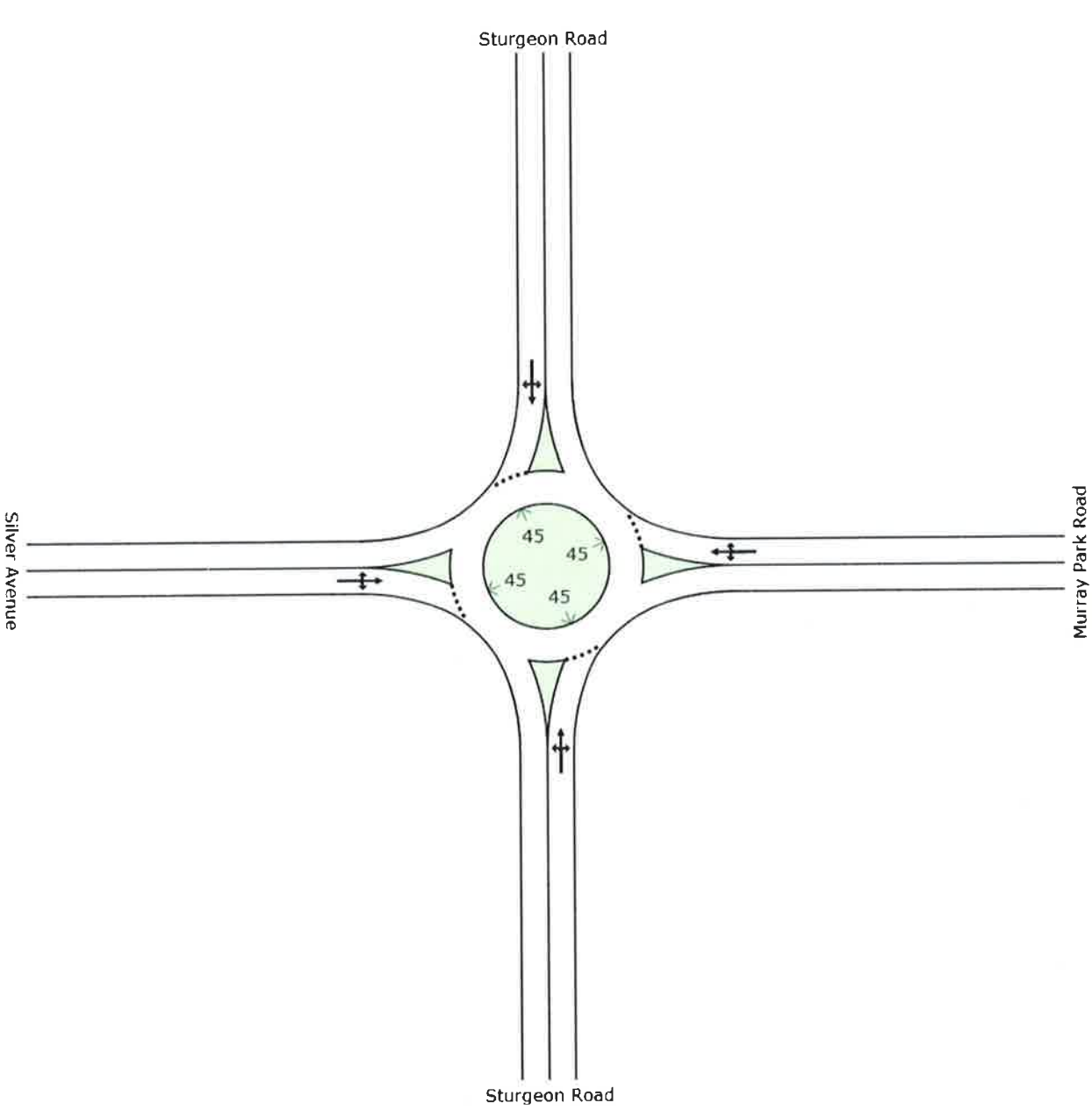
Title
CONCEPTUAL ALIGNMENT - SINGLE LANE ROUNDABOUT - OPTION 2

Appendix A
SIDRA Traffic Analysis Results

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1283 veh/h	1898 pers/h
Percent Heavy Vehicles (Demand)	4.9 %	
Degree of Saturation	0.332	
Practical Spare Capacity	156.1 %	
Effective Intersection Capacity	3866 veh/h	
Control Delay (Total)	1.33 veh-h/h	1.60 pers-h/h
Control Delay (Average)	3.7 sec	3.0 sec
Control Delay (Worst Lane)	4.6 sec	
Control Delay (Worst Movement)	11.2 sec	11.2 sec
Geometric Delay (Average)	2.3 sec	
Stop-Line Delay (Average)	1.5 sec	
Idling Time (Average)	0.0 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	2.2 veh	
95% Back of Queue - Distance (Worst Lane)	15.9 m	
Queue Storage Ratio (Worst Lane)	0.04	
Total Effective Stops	535 veh/h	642 pers/h
Effective Stop Rate	0.42 per veh	0.34 per pers
Proportion Queued	0.47	0.38
Performance Index	30.7	30.7
Travel Distance (Total)	507.6 veh-km/h	609.1 pers-km/h
Travel Distance (Average)	396 m	321 m
Travel Time (Total)	12.1 veh-h/h	14.5 pers-h/h
Travel Time (Average)	33.9 sec	27.5 sec
Travel Speed	42.0 km/h	42.0 km/h
Cost (Total)	435.45 $/h	435.45 $/h
Fuel Consumption (Total)	36.8 L/h	
Carbon Dioxide (Total)	87.1 kg/h	
Hydrocarbons (Total)	0.032 kg/h	
Carbon Monoxide (Total)	0.257 kg/h	
NOx (Total)	0.239 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	615,916 veh/y	910,889 pers/y
Delay	639 veh-h/y	767 pers-h/y
Effective Stops	256,788 veh/y	308,145 pers/y
Travel Distance	243,656 veh-km/y	292,387 pers-km/y
Travel Time	5,802 veh-h/y	6,963 pers-h/y
Cost	209,015 $/y	209,015 $/y
Fuel Consumption	17,668 L/y	
Carbon Dioxide	41,788 kg/y	
Hydrocarbons	15 kg/y	
Carbon Monoxide	123 kg/y	
NOx	115 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	17	2.0	0.332	10.7	LOS B	2.2	15.9	0.60	0.80	38.4
2	T1	277	5.0	0.332	2.5	LOS A	2.2	15.9	0.60	0.80	38.4
3	R2	79	5.0	0.332	4.6	LOS A	2.2	15.9	0.60	0.80	38.4
Approach		373	4.9	0.332	3.3	LOS A	2.2	15.9	0.60	0.40	38.4
East: Murray Park Road											
4	L2	27	8.0	0.118	9.9	LOS A	0.7	5.0	0.48	0.88	38.8
5	T1	28	2.0	0.118	1.7	LOS A	0.7	5.0	0.48	0.88	38.8
6	R2	81	8.0	0.118	3.8	LOS A	0.7	5.0	0.48	0.88	38.8
Approach		137	6.8	0.118	4.6	LOS A	0.7	5.0	0.48	0.44	38.8
North: Sturgeon Road											
7	L2	178	8.0	0.318	8.9	LOS A	2.1	15.7	0.26	0.81	44.9
8	T1	297	5.0	0.318	0.8	LOS A	2.1	15.7	0.26	0.81	44.9
9	R2	5	2.0	0.318	2.8	LOS A	2.1	15.7	0.26	0.81	44.9
Approach		480	6.1	0.318	3.8	LOS A	2.1	15.7	0.26	0.40	44.9
West: Silver Avenue											
10	L2	5	2.0	0.276	11.2	LOS B	1.7	12.4	0.64	0.90	38.9
11	T1	213	2.0	0.276	3.0	LOS A	1.7	12.4	0.64	0.90	38.9
12	R2	76	2.0	0.276	5.1	LOS A	1.7	12.4	0.64	0.90	38.9
Approach		294	2.0	0.276	3.7	LOS A	1.7	12.4	0.64	0.45	38.9
All Vehicles		1283	4.9	0.332	3.7	LOS A	2.2	15.9	0.47	0.42	42.0

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

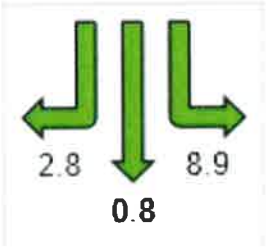
Average control delay per vehicle, or average pedestrian delay (seconds)

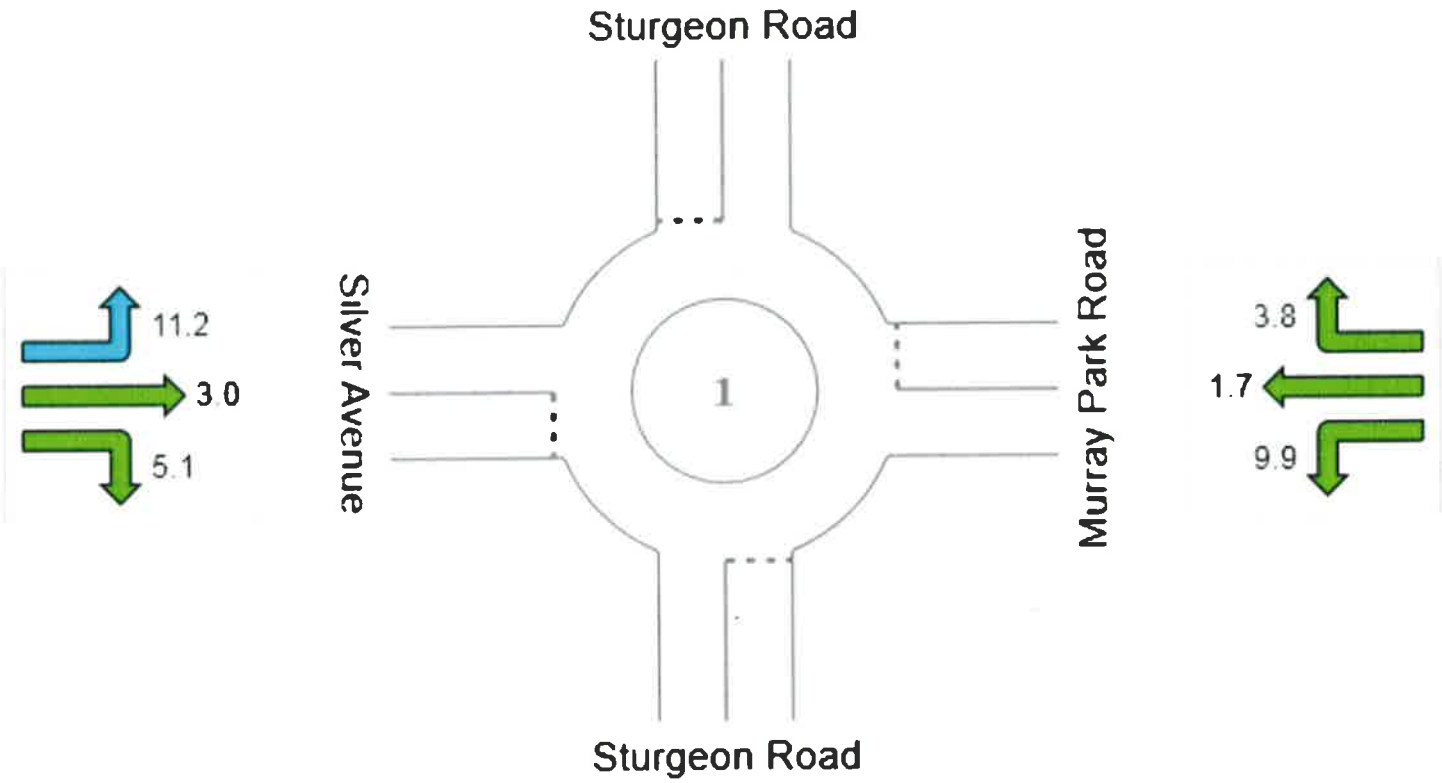
Site: Sturgeon Road at Murray Park Road

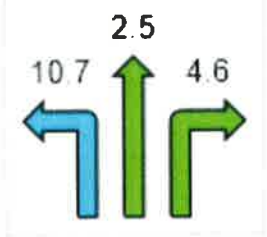
Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	3.3	4.6	3.8	3.7	3.7
LOS	A	A	A	A	A



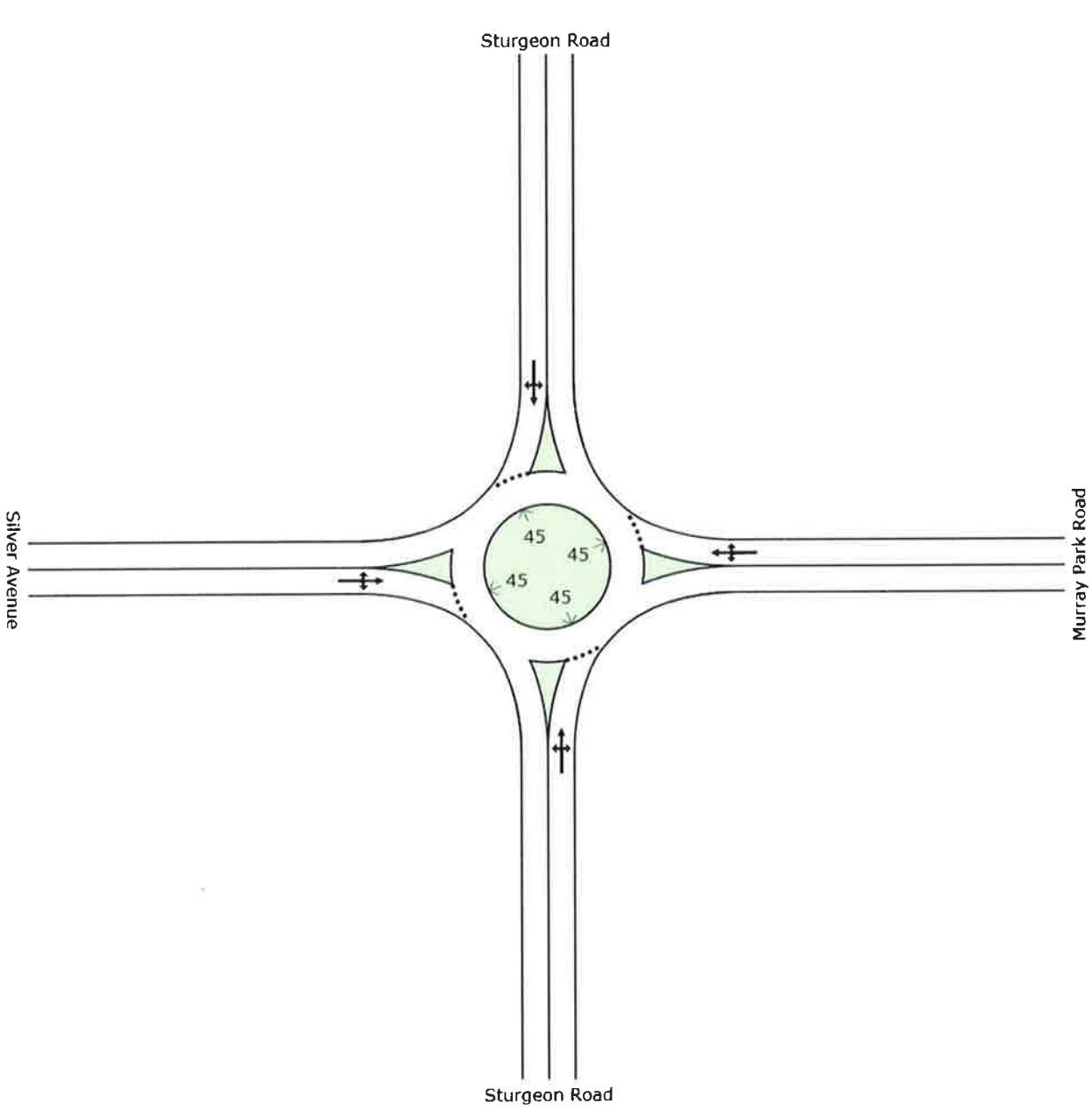




SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1222 veh/h	1824 pers/h
Percent Heavy Vehicles (Demand)	5.0 %	
Degree of Saturation	0.332	
Practical Spare Capacity	155.9 %	
Effective Intersection Capacity	3679 veh/h	
Control Delay (Total)	1.25 veh-h/h	1.50 pers-h/h
Control Delay (Average)	3.7 sec	3.0 sec
Control Delay (Worst Lane)	4.7 sec	
Control Delay (Worst Movement)	10.6 sec	10.6 sec
Geometric Delay (Average)	2.3 sec	
Stop-Line Delay (Average)	1.4 sec	
Idling Time (Average)	0.1 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	2.2 veh	
95% Back of Queue - Distance (Worst Lane)	16.0 m	
Queue Storage Ratio (Worst Lane)	0.03	
Total Effective Stops	500 veh/h	600 pers/h
Effective Stop Rate	0.41 per veh	0.33 per pers
Proportion Queued	0.49	0.39
Performance Index	28.6	28.6
Travel Distance (Total)	464.9 veh-km/h	557.8 pers-km/h
Travel Distance (Average)	380 m	306 m
Travel Time (Total)	11.2 veh-h/h	13.4 pers-h/h
Travel Time (Average)	32.9 sec	26.4 sec
Travel Speed	41.7 km/h	41.7 km/h
Cost (Total)	407.07 $/h	407.07 $/h
Fuel Consumption (Total)	34.9 L/h	
Carbon Dioxide (Total)	82.6 kg/h	
Hydrocarbons (Total)	0.030 kg/h	
Carbon Monoxide (Total)	0.240 kg/h	
NOx (Total)	0.235 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	586,545 veh/y	875,643 pers/y
Delay	599 veh-h/y	719 pers-h/y
Effective Stops	239,804 veh/y	287,765 pers/y
Travel Distance	223,131 veh-km/y	267,757 pers-km/y
Travel Time	5,356 veh-h/y	6,427 pers-h/y
Cost	195,396 $/y	195,396 $/y
Fuel Consumption	16,759 L/y	
Carbon Dioxide	39,628 kg/y	
Hydrocarbons	14 kg/y	
Carbon Monoxide	115 kg/y	
NOx	113 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	63	2.0	0.248	9.2	LOS A	1.5	10.9	0.33	0.63	40.9
2	T1	256	5.0	0.248	1.0	LOS A	1.5	10.9	0.33	0.63	40.9
3	R2	31	5.0	0.248	3.1	LOS A	1.5	10.9	0.33	0.63	40.9
Approach		350	4.5	0.248	2.7	LOS A	1.5	10.9	0.33	0.32	40.9
East: Murray Park Road											
4	L2	85	8.0	0.332	10.3	LOS B	2.1	15.7	0.55	0.96	38.4
5	T1	156	2.0	0.332	2.2	LOS A	2.1	15.7	0.55	0.96	38.4
6	R2	149	8.0	0.332	4.2	LOS A	2.1	15.7	0.55	0.96	38.4
Approach		391	5.6	0.332	4.7	LOS A	2.1	15.7	0.55	0.48	38.4
North: Sturgeon Road											
7	L2	72	8.0	0.331	10.2	LOS B	2.2	16.0	0.55	0.83	44.1
8	T1	314	5.0	0.331	2.0	LOS A	2.2	16.0	0.55	0.83	44.1
9	R2	7	2.0	0.331	4.1	LOS A	2.2	16.0	0.55	0.83	44.1
Approach		393	5.5	0.331	3.5	LOS A	2.2	16.0	0.55	0.42	44.1
West: Silver Avenue											
10	L2	5	2.0	0.083	10.6	LOS B	0.5	3.5	0.58	0.84	39.2
11	T1	55	2.0	0.083	2.4	LOS A	0.5	3.5	0.58	0.84	39.2
12	R2	28	2.0	0.083	4.5	LOS A	0.5	3.5	0.58	0.84	39.2
Approach		88	2.0	0.083	3.6	LOS A	0.5	3.5	0.58	0.42	39.2
All Vehicles		1222	5.0	0.332	3.7	LOS A	2.2	16.0	0.49	0.41	41.7

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

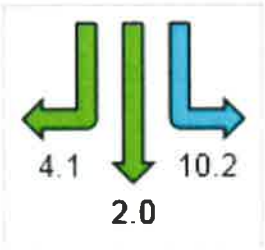
Average control delay per vehicle, or average pedestrian delay (seconds)

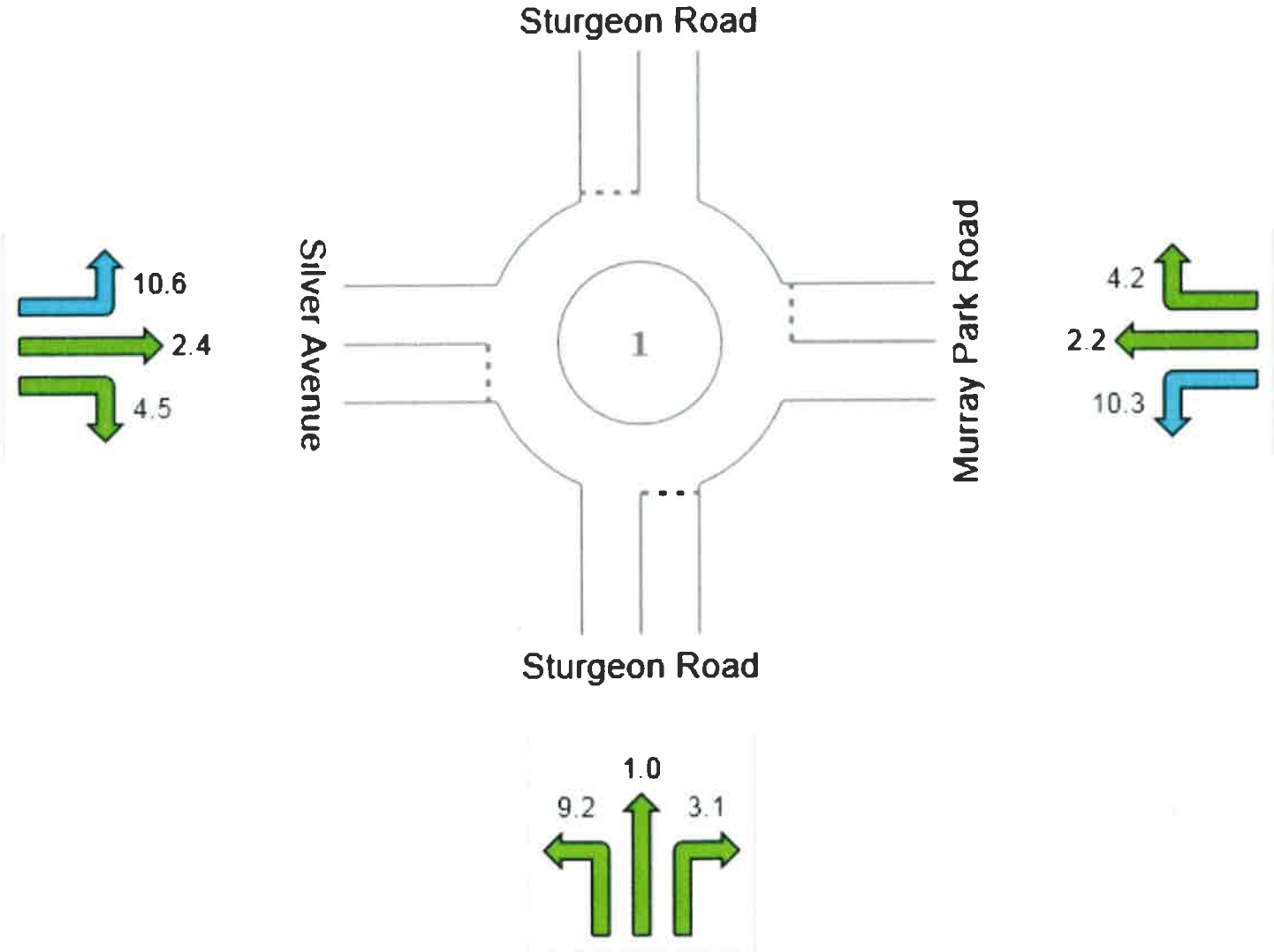
Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	2.7	4.7	3.5	3.6	3.7
LOS	A	A	A	A	A

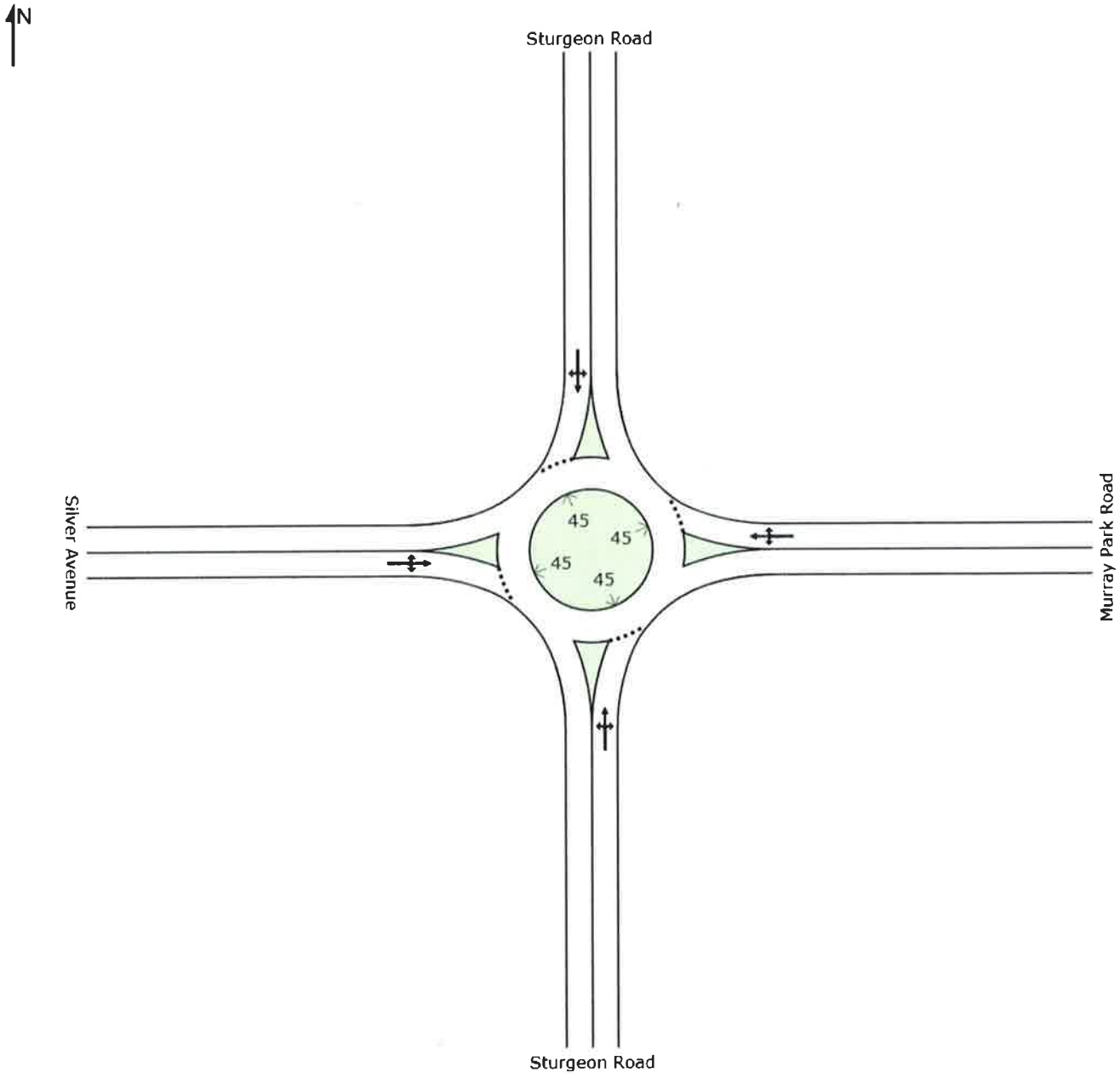




SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	2278	veh/h	3091	pers/h
Percent Heavy Vehicles (Demand)	5.2	%		
Degree of Saturation	0.813			
Practical Spare Capacity	4.6	%		
Effective Intersection Capacity	2802	veh/h		
Control Delay (Total)	4.94	veh-h/h	5.92	pers-h/h
Control Delay (Average)	7.8	sec	6.9	sec
Control Delay (Worst Lane)	11.7	sec		
Control Delay (Worst Movement)	19.4	sec	19.4	sec
Geometric Delay (Average)	2.0	sec		
Stop-Line Delay (Average)	5.8	sec		
Idling Time (Average)	0.3	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	13.7	veh		
95% Back of Queue - Distance (Worst Lane)	99.7	m		
Queue Storage Ratio (Worst Lane)	0.23			
Total Effective Stops	1782	veh/h	2138	pers/h
Effective Stop Rate	0.78	per veh	0.69	per pers
Proportion Queued	0.76		0.67	
Performance Index	98.2		98.2	
Travel Distance (Total)	920.4	veh-km/h	1104.4	pers-km/h
Travel Distance (Average)	404	m	357	m
Travel Time (Total)	24.0	veh-h/h	28.8	pers-h/h
Travel Time (Average)	37.9	sec	33.5	sec
Travel Speed	38.4	km/h	38.4	km/h
Cost (Total)	868.52	$/h	868.52	$/h
Fuel Consumption (Total)	71.5	L/h		
Carbon Dioxide (Total)	169.0	kg/h		
Hydrocarbons (Total)	0.065	kg/h		
Carbon Monoxide (Total)	0.500	kg/h		
NOx (Total)	0.473	kg/h		

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	1,093,324	veh/y	1,483,778	pers/y
Delay	2,369	veh-h/y	2,843	pers-h/y
Effective Stops	855,192	veh/y	1,026,230	pers/y
Travel Distance	441,770	veh-km/y	530,124	pers-km/y
Travel Time	11,504	veh-h/y	13,805	pers-h/y
Cost	416,890	$/y	416,890	$/y
Fuel Consumption	34,298	L/y		
Carbon Dioxide	81,135	kg/y		
Hydrocarbons	31	kg/y		
Carbon Monoxide	240	kg/y		
NOx	227	kg/y		

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	21	2.0	0.813	19.4	LOS B	13.7	99.7	0.99	2.33	30.4
2	T1	705	5.0	0.813	11.3	LOS B	13.7	99.7	0.99	2.33	30.4
3	R2	99	5.0	0.813	13.3	LOS B	13.7	99.7	0.99	2.33	30.4
Approach		825	4.9	0.813	11.7	LOS B	13.7	99.7	0.99	1.16	30.4
East: Murray Park Road											
4	L2	32	8.0	0.321	13.1	LOS B	2.5	18.8	0.90	1.54	35.2
5	T1	32	2.0	0.321	4.9	LOS A	2.5	18.8	0.90	1.54	35.2
6	R2	158	8.0	0.321	7.0	LOS A	2.5	18.8	0.90	1.54	35.2
Approach		221	7.1	0.321	7.5	LOS A	2.5	18.8	0.90	0.77	35.2
North: Sturgeon Road											
7	L2	305	8.0	0.624	9.2	LOS A	6.9	50.6	0.45	0.78	44.1
8	T1	632	5.0	0.624	1.1	LOS A	6.9	50.6	0.45	0.78	44.1
9	R2	5	2.0	0.624	3.1	LOS A	6.9	50.6	0.45	0.78	44.1
Approach		942	6.0	0.624	3.7	LOS A	6.9	50.6	0.45	0.39	44.1
West: Silver Avenue											
10	L2	5	2.0	0.446	17.6	LOS B	3.9	27.5	0.97	1.95	33.2
11	T1	211	2.0	0.446	9.5	LOS A	3.9	27.5	0.97	1.95	33.2
12	R2	74	2.0	0.446	11.5	LOS B	3.9	27.5	0.97	1.95	33.2
Approach		289	2.0	0.446	10.1	LOS B	3.9	27.5	0.97	0.97	33.2
All Vehicles		2278	5.2	0.813	7.8	LOS A	13.7	99.7	0.76	0.78	38.4

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

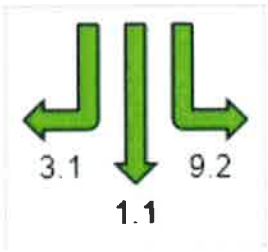
Average control delay per vehicle, or average pedestrian delay (seconds)

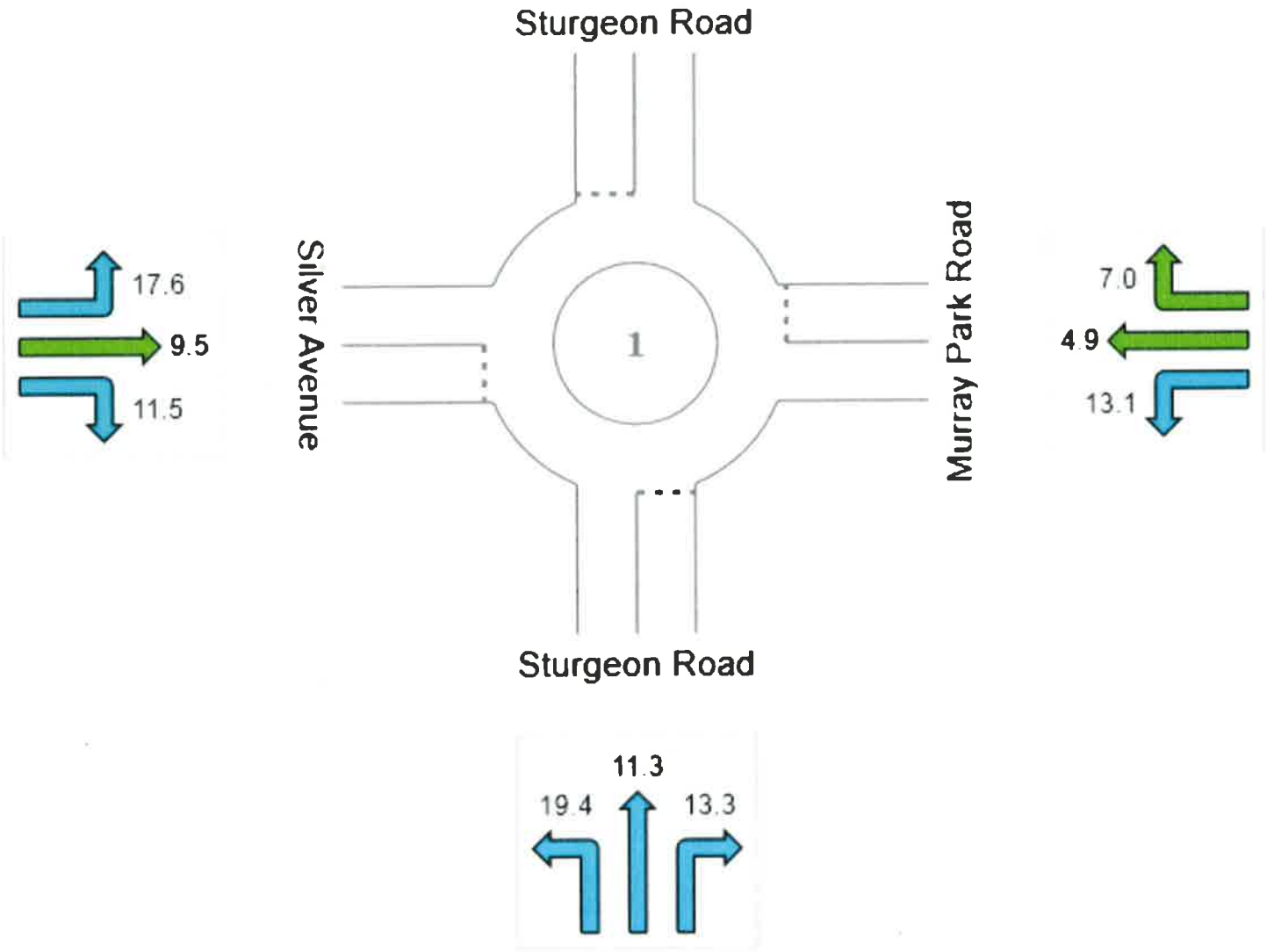
Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	11.7	7.5	3.7	10.1	7.8
LOS	B	A	A	B	A

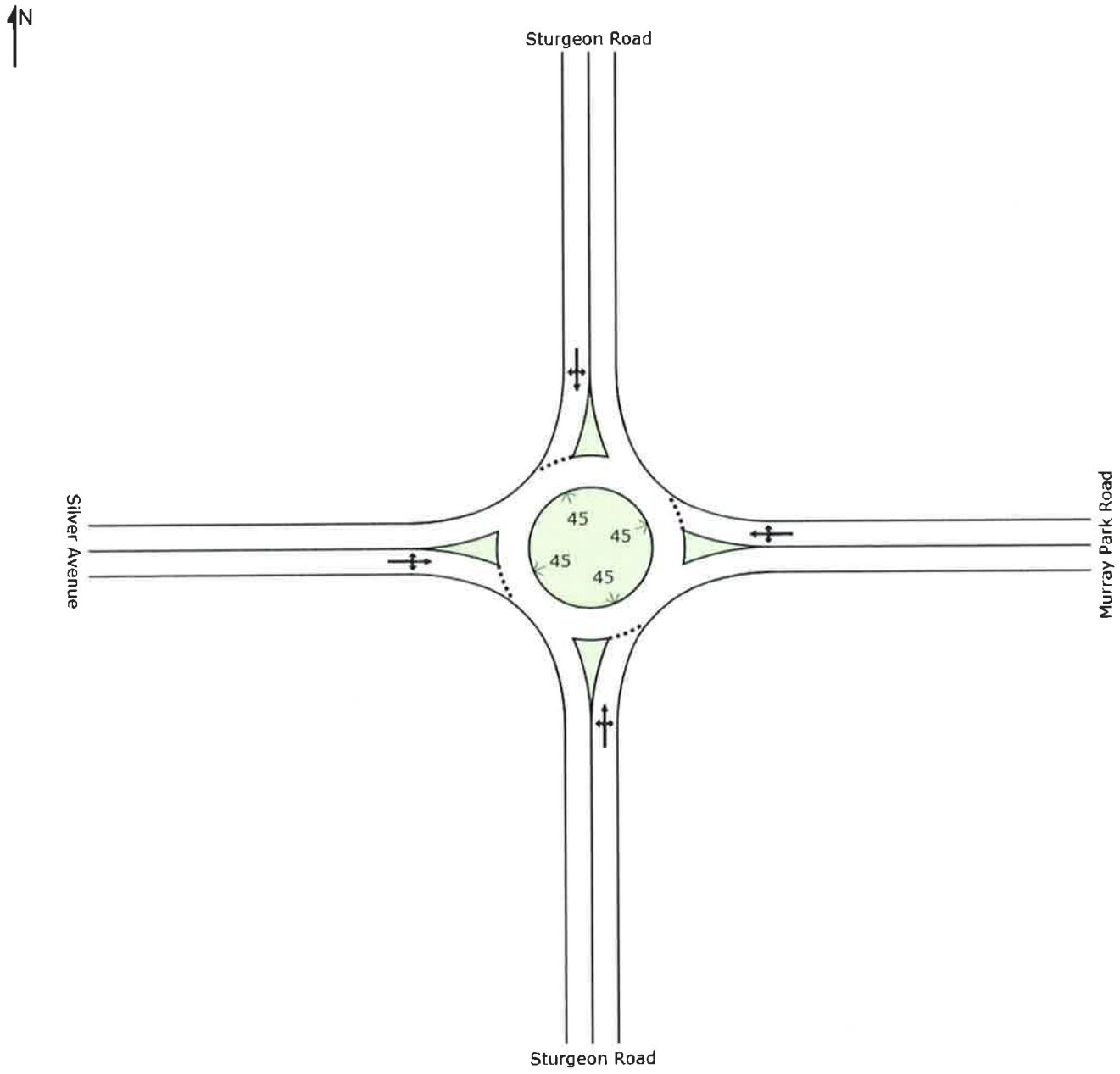




SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2320 veh/h	3142 pers/h
Percent Heavy Vehicles (Demand)	5.3 %	
Degree of Saturation	0.767	
Practical Spare Capacity	10.8 %	
Effective Intersection Capacity	3023 veh/h	
Control Delay (Total)	4.96 veh-h/h	5.95 pers-h/h
Control Delay (Average)	7.7 sec	6.8 sec
Control Delay (Worst Lane)	14.4 sec	
Control Delay (Worst Movement)	20.1 sec	20.1 sec
Geometric Delay (Average)	2.0 sec	
Stop-Line Delay (Average)	5.7 sec	
Idling Time (Average)	0.8 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	11.2 veh	
95% Back of Queue - Distance (Worst Lane)	81.9 m	
Queue Storage Ratio (Worst Lane)	0.14	
Total Effective Stops	1790 veh/h	2148 pers/h
Effective Stop Rate	0.77 per veh	0.68 per pers
Proportion Queued	0.86	0.76
Performance Index	100.3	100.3
Travel Distance (Total)	913.2 veh-km/h	1095.9 pers-km/h
Travel Distance (Average)	394 m	349 m
Travel Time (Total)	24.2 veh-h/h	29.0 pers-h/h
Travel Time (Average)	37.5 sec	33.3 sec
Travel Speed	37.7 km/h	37.7 km/h
Cost (Total)	884.17 $/h	884.17 $/h
Fuel Consumption (Total)	73.4 L/h	
Carbon Dioxide (Total)	173.6 kg/h	
Hydrocarbons (Total)	0.066 kg/h	
Carbon Monoxide (Total)	0.509 kg/h	
NOx (Total)	0.502 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,113,534 veh/y	1,508,031 pers/y
Delay	2,379 veh-h/y	2,855 pers-h/y
Effective Stops	859,009 veh/y	1,030,811 pers/y
Travel Distance	438,343 veh-km/y	526,012 pers-km/y
Travel Time	11,612 veh-h/y	13,935 pers-h/y
Cost	424,404 $/y	424,404 $/y
Fuel Consumption	35,231 L/y	
Carbon Dioxide	83,338 kg/y	
Hydrocarbons	32 kg/y	
Carbon Monoxide	244 kg/y	
NOx	241 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	74	2.0	0.605	10.3	LOS B	5.6	41.1	0.67	0.73	37.7
2	T1	632	5.0	0.605	2.1	LOS A	5.6	41.1	0.67	0.73	37.7
3	R2	67	5.0	0.605	4.2	LOS A	5.6	41.1	0.67	0.73	37.7
Approach		772	4.7	0.605	3.1	LOS A	5.6	41.1	0.67	0.37	37.7
East: Murray Park Road											
4	L2	95	8.0	0.723	20.1	LOS C	9.5	70.3	1.00	2.34	29.7
5	T1	168	2.0	0.723	11.9	LOS B	9.5	70.3	1.00	2.34	29.7
6	R2	305	8.0	0.723	14.0	LOS B	9.5	70.3	1.00	2.34	29.7
Approach		568	6.2	0.723	14.4	LOS B	9.5	70.3	1.00	1.17	29.7
North: Sturgeon Road											
7	L2	168	8.0	0.767	14.0	LOS B	11.2	81.9	0.91	1.72	41.5
8	T1	705	5.0	0.767	5.8	LOS A	11.2	81.9	0.91	1.72	41.5
9	R2	5	2.0	0.767	7.9	LOS A	11.2	81.9	0.91	1.72	41.5
Approach		879	5.6	0.767	7.4	LOS A	11.2	81.9	0.91	0.86	41.5
West: Silver Avenue											
10	L2	5	2.0	0.186	15.3	LOS B	1.5	10.6	0.97	1.70	35.0
11	T1	63	2.0	0.186	7.2	LOS A	1.5	10.6	0.97	1.70	35.0
12	R2	32	2.0	0.186	9.2	LOS A	1.5	10.6	0.97	1.70	35.0
Approach		100	2.0	0.186	8.2	LOS A	1.5	10.6	0.97	0.85	35.0
All Vehicles		2320	5.3	0.767	7.7	LOS A	11.2	81.9	0.86	0.77	37.7

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

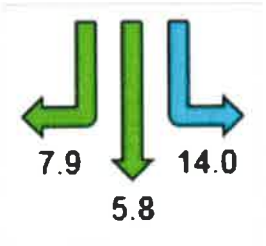
Average control delay per vehicle, or average pedestrian delay (seconds)

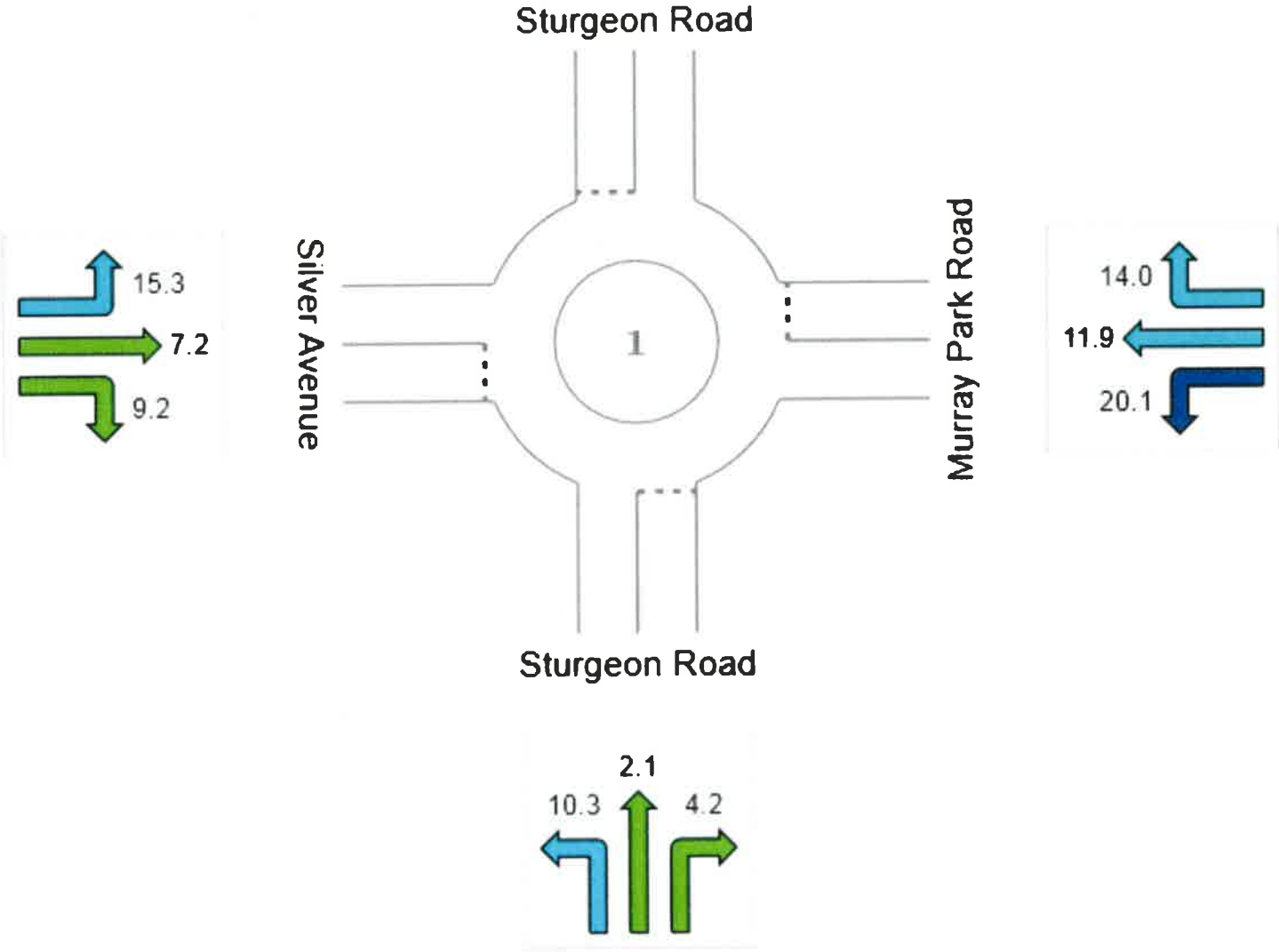
Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	3.1	14.4	7.4	8.2	7.7
LOS	A	B	A	A	A



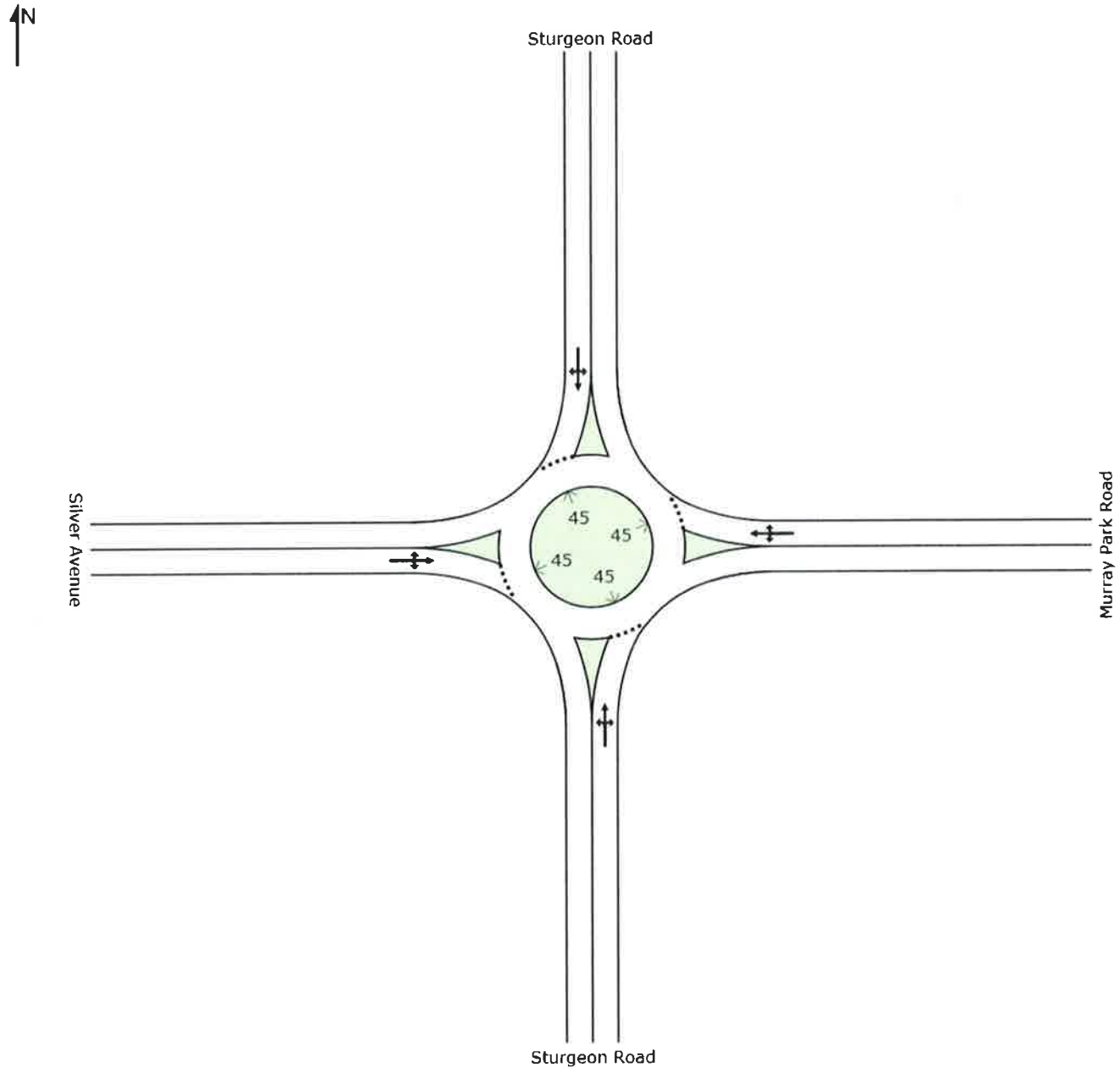


Colour code based on Level of Service

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2741 veh/h	3647 pers/h
Percent Heavy Vehicles (Demand)	5.2 %	
Degree of Saturation	1.042	
Practical Spare Capacity	-18.4 %	
Effective Intersection Capacity	2631 veh/h	
Control Delay (Total)	26.36 veh-h/h	31.64 pers-h/h
Control Delay (Average)	34.6 sec	31.2 sec
Control Delay (Worst Lane)	73.1 sec	
Control Delay (Worst Movement)	80.7 sec	80.7 sec
Geometric Delay (Average)	2.1 sec	
Stop-Line Delay (Average)	32.6 sec	
Idling Time (Average)	17.3 sec	
Intersection Level of Service (LOS)	LOS C	
95% Back of Queue - Vehicles (Worst Lane)	59.7 veh	
95% Back of Queue - Distance (Worst Lane)	435.7 m	
Queue Storage Ratio (Worst Lane)	1.00	
Total Effective Stops	4232 veh/h	5079 pers/h
Effective Stop Rate	1.54 per veh	1.39 per pers
Proportion Queued	0.87	0.78
Performance Index	283.7	283.7
Travel Distance (Total)	1081.8 veh-km/h	1298.1 pers-km/h
Travel Distance (Average)	395 m	356 m
Travel Time (Total)	48.8 veh-h/h	58.6 pers-h/h
Travel Time (Average)	64.1 sec	57.8 sec
Travel Speed	22.2 km/h	22.2 km/h
Cost (Total)	1689.36 $/h	1689.36 $/h
Fuel Consumption (Total)	113.9 L/h	
Carbon Dioxide (Total)	269.3 kg/h	
Hydrocarbons (Total)	0.130 kg/h	
Carbon Monoxide (Total)	0.835 kg/h	
NOx (Total)	0.658 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,315,640 veh/y	1,750,557 pers/y
Delay	12,654 veh-h/y	15,185 pers-h/y
Effective Stops	2,031,487 veh/y	2,437,785 pers/y
Travel Distance	519,241 veh-km/y	623,089 pers-km/y
Travel Time	23,426 veh-h/y	28,111 pers-h/y
Cost	810,894 $/y	810,894 $/y
Fuel Consumption	54,650 L/y	
Carbon Dioxide	129,241 kg/y	
Hydrocarbons	62 kg/y	
Carbon Monoxide	401 kg/y	
NOx	316 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	32	2.0	1.042	80.7	LOS F	59.7	435.7	1.00	5.87	10.0
2	T1	811	5.0	1.042	72.6	LOS E	59.7	435.7	1.00	5.87	10.0
3	R2	130	5.0	1.042	74.6	LOS E	59.7	435.7	1.00	5.87	10.0
Approach		972	4.9	1.042	73.1	LOS E	59.7	435.7	1.00	2.93	10.0
East: Murray Park Road											
4	L2	63	8.0	0.539	16.9	LOS B	5.3	39.4	1.00	2.06	32.2
5	T1	32	2.0	0.539	8.8	LOS A	5.3	39.4	1.00	2.06	32.2
6	R2	232	8.0	0.539	10.8	LOS B	5.3	39.4	1.00	2.06	32.2
Approach		326	7.4	0.539	11.8	LOS B	5.3	39.4	1.00	1.03	32.2
North: Sturgeon Road											
7	L2	326	8.0	0.730	9.8	LOS A	9.4	69.0	0.65	0.85	43.1
8	T1	716	5.0	0.730	1.6	LOS A	9.4	69.0	0.65	0.85	43.1
9	R2	5	2.0	0.730	3.7	LOS A	9.4	69.0	0.65	0.85	43.1
Approach		1047	5.9	0.730	4.2	LOS A	9.4	69.0	0.65	0.43	43.1
West: Silver Avenue											
10	L2	5	2.0	0.807	47.0	LOS D	13.5	96.1	1.00	3.02	16.8
11	T1	274	2.0	0.807	38.8	LOS D	13.5	96.1	1.00	3.02	16.8
12	R2	116	2.0	0.807	40.9	LOS D	13.5	96.1	1.00	3.02	16.8
Approach		395	2.0	0.807	39.5	LOS D	13.5	96.1	1.00	1.51	16.8
All Vehicles		2741	5.2	1.042	34.6	LOS C	59.7	435.7	0.87	1.54	22.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

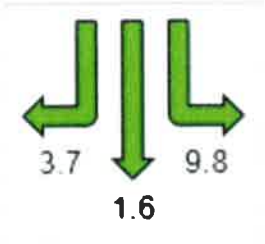
Average control delay per vehicle, or average pedestrian delay (seconds)

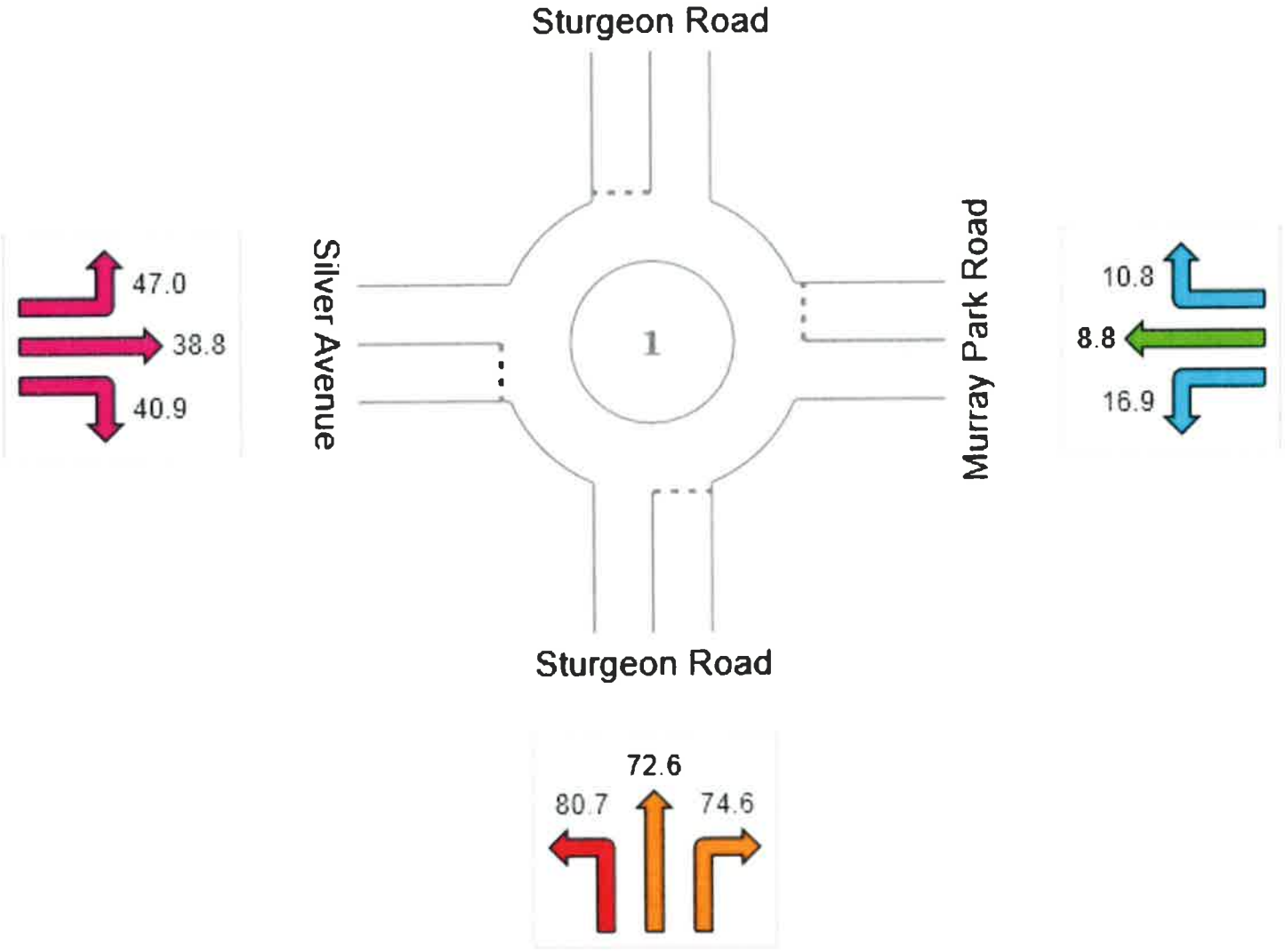
Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	73.1	11.8	4.2	39.5	34.6
LOS	E	B	A	D	C



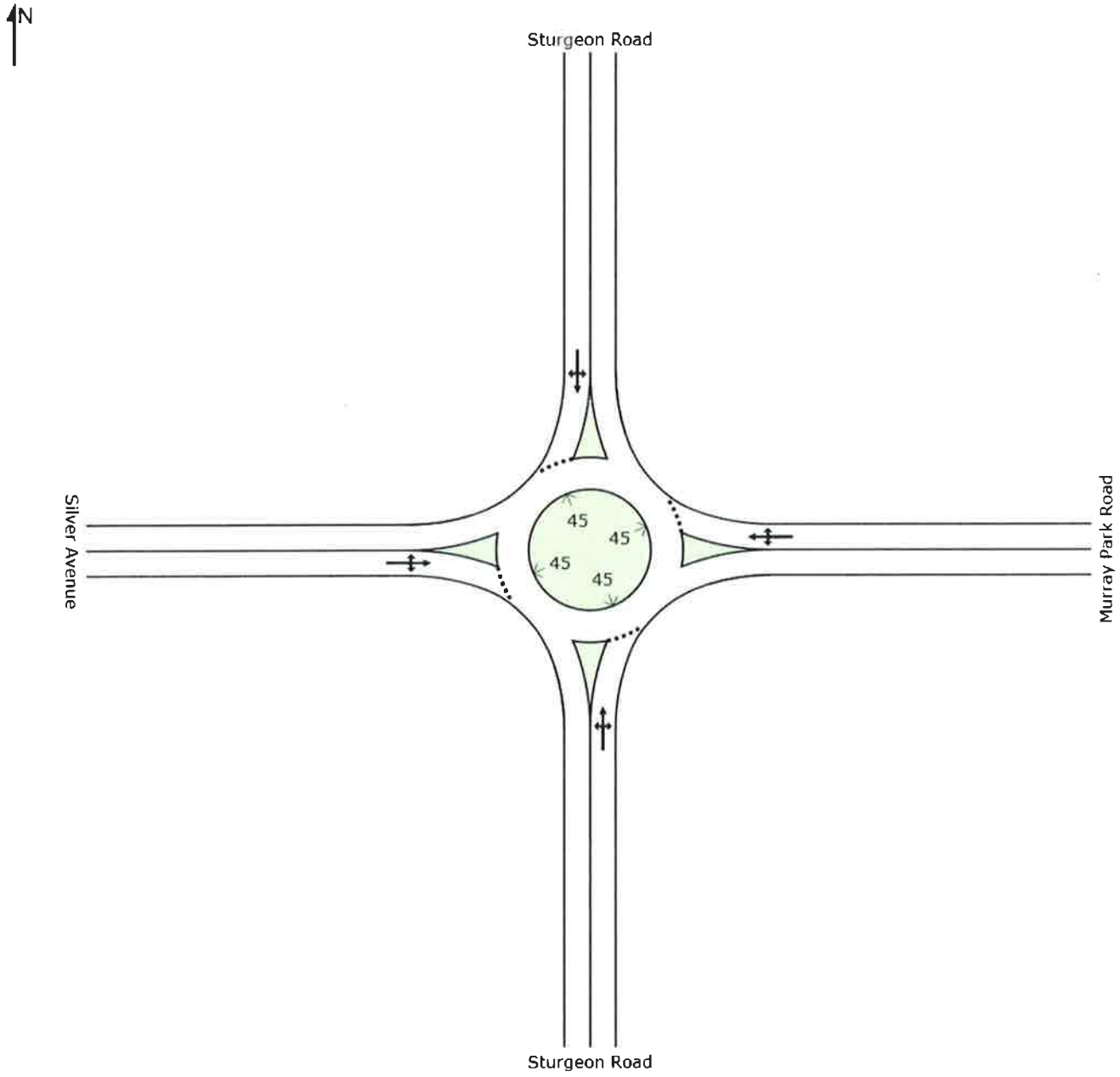


Colour code based on Level of Service

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2667 veh/h	3559 pers/h
Percent Heavy Vehicles (Demand)	5.4 %	
Degree of Saturation	1.001	
Practical Spare Capacity	-15.1 %	
Effective Intersection Capacity	2665 veh/h	
Control Delay (Total)	22.42 veh-h/h	26.91 pers-h/h
Control Delay (Average)	30.3 sec	27.2 sec
Control Delay (Worst Lane)	70.0 sec	
Control Delay (Worst Movement)	75.4 sec	75.4 sec
Geometric Delay (Average)	2.2 sec	
Stop-Line Delay (Average)	28.0 sec	
Idling Time (Average)	14.3 sec	
Intersection Level of Service (LOS)	LOS C	
95% Back of Queue - Vehicles (Worst Lane)	35.8 veh	
95% Back of Queue - Distance (Worst Lane)	262.8 m	
Queue Storage Ratio (Worst Lane)	0.53	
Total Effective Stops	3924 veh/h	4709 pers/h
Effective Stop Rate	1.47 per veh	1.32 per pers
Proportion Queued	0.96	0.86
Performance Index	268.7	268.7
Travel Distance (Total)	1067.3 veh-km/h	1280.7 pers-km/h
Travel Distance (Average)	400 m	360 m
Travel Time (Total)	44.3 veh-h/h	53.1 pers-h/h
Travel Time (Average)	59.8 sec	53.7 sec
Travel Speed	24.1 km/h	24.1 km/h
Cost (Total)	1556.91 $/h	1556.91 $/h
Fuel Consumption (Total)	109.6 L/h	
Carbon Dioxide (Total)	259.3 kg/h	
Hydrocarbons (Total)	0.119 kg/h	
Carbon Monoxide (Total)	0.794 kg/h	
NOx (Total)	0.684 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,280,271 veh/y	1,708,115 pers/y
Delay	10,763 veh-h/y	12,916 pers-h/y
Effective Stops	1,883,596 veh/y	2,260,316 pers/y
Travel Distance	512,286 veh-km/y	614,743 pers-km/y
Travel Time	21,250 veh-h/y	25,500 pers-h/y
Cost	747,318 $/y	747,318 $/y
Fuel Consumption	52,598 L/y	
Carbon Dioxide	124,449 kg/y	
Hydrocarbons	57 kg/y	
Carbon Monoxide	381 kg/y	
NOx	329 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	116	2.0	0.753	13.0	LOS B	10.5	76.8	0.88	1.50	35.1
2	T1	716	5.0	0.753	4.9	LOS A	10.5	76.8	0.88	1.50	35.1
3	R2	67	8.0	0.753	6.9	LOS A	10.5	76.8	0.88	1.50	35.1
Approach		899	4.8	0.753	6.1	LOS A	10.5	76.8	0.88	0.75	35.1
East: Murray Park Road											
4	L2	126	8.0	1.001	75.4	LOS E	35.4	261.6	1.00	4.59	11.6
5	T1	168	2.0	1.001	67.2	LOS E	35.4	261.6	1.00	4.59	11.6
6	R2	326	8.0	1.001	69.3	LOS E	35.4	261.6	1.00	4.59	11.6
Approach		621	6.4	1.001	70.0	LOS E	35.4	261.6	1.00	2.29	11.6
North: Sturgeon Road											
7	L2	232	8.0	0.972	35.5	LOS D	35.8	262.8	1.00	3.31	29.7
8	T1	811	5.0	0.972	27.3	LOS C	35.8	262.8	1.00	3.31	29.7
9	R2	5	2.0	0.972	29.4	LOS C	35.8	262.8	1.00	3.31	29.7
Approach		1047	5.6	0.972	29.1	LOS C	35.8	262.8	1.00	1.66	29.7
West: Silver Avenue											
10	L2	5	2.0	0.274	20.2	LOS C	2.4	16.8	1.00	1.85	30.3
11	T1	63	2.0	0.274	12.0	LOS B	2.4	16.8	1.00	1.85	30.3
12	R2	32	2.0	0.274	14.1	LOS B	2.4	16.8	1.00	1.85	30.3
Approach		100	2.0	0.274	13.1	LOS B	2.4	16.8	1.00	0.93	30.3
All Vehicles		2667	5.4	1.001	30.3	LOS C	35.8	262.8	0.96	1.47	24.1

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

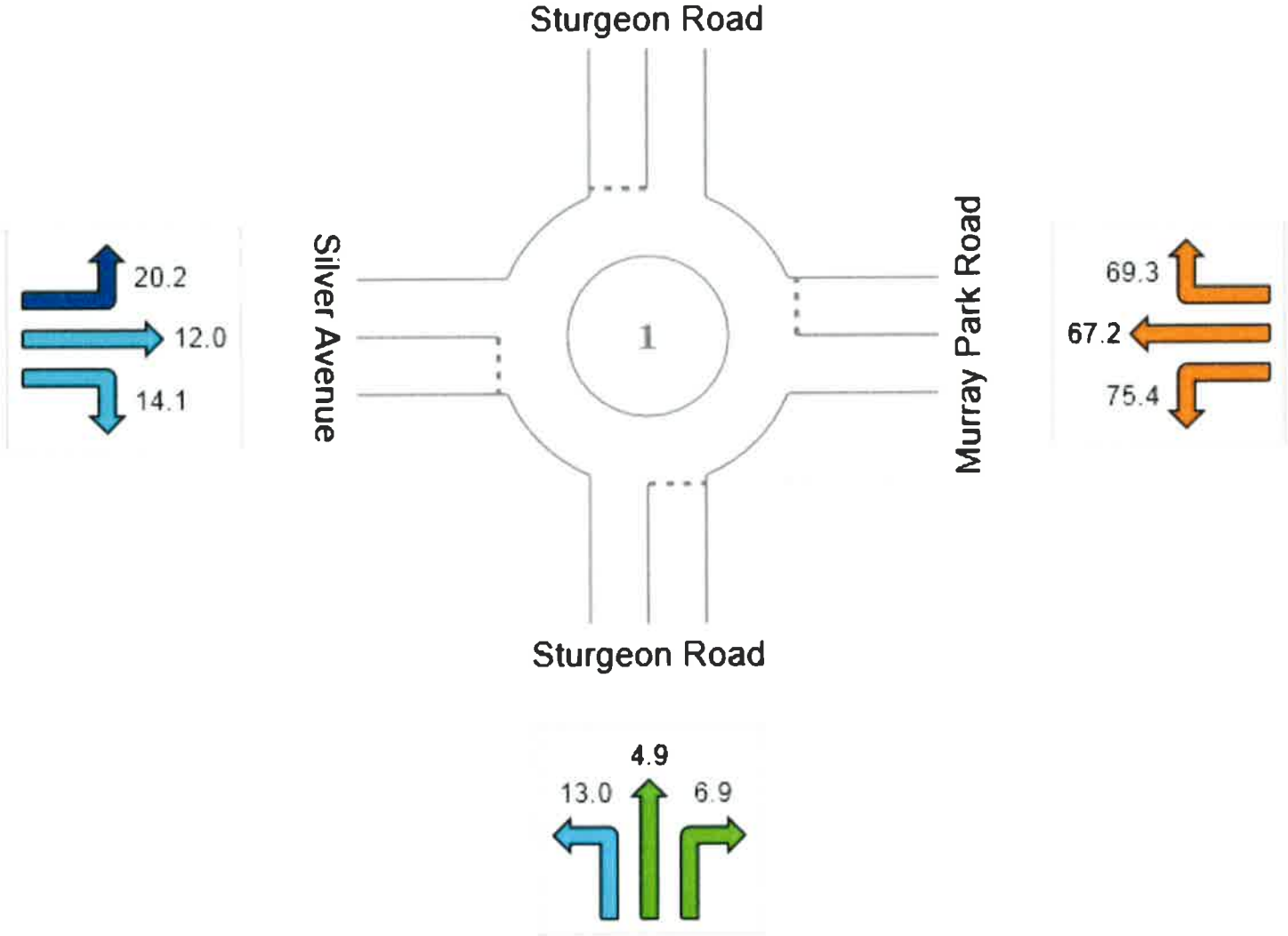
Average control delay per vehicle, or average pedestrian delay (seconds)

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	6.1	70.0	29.1	13.1	30.3
LOS	A	E	C	B	C

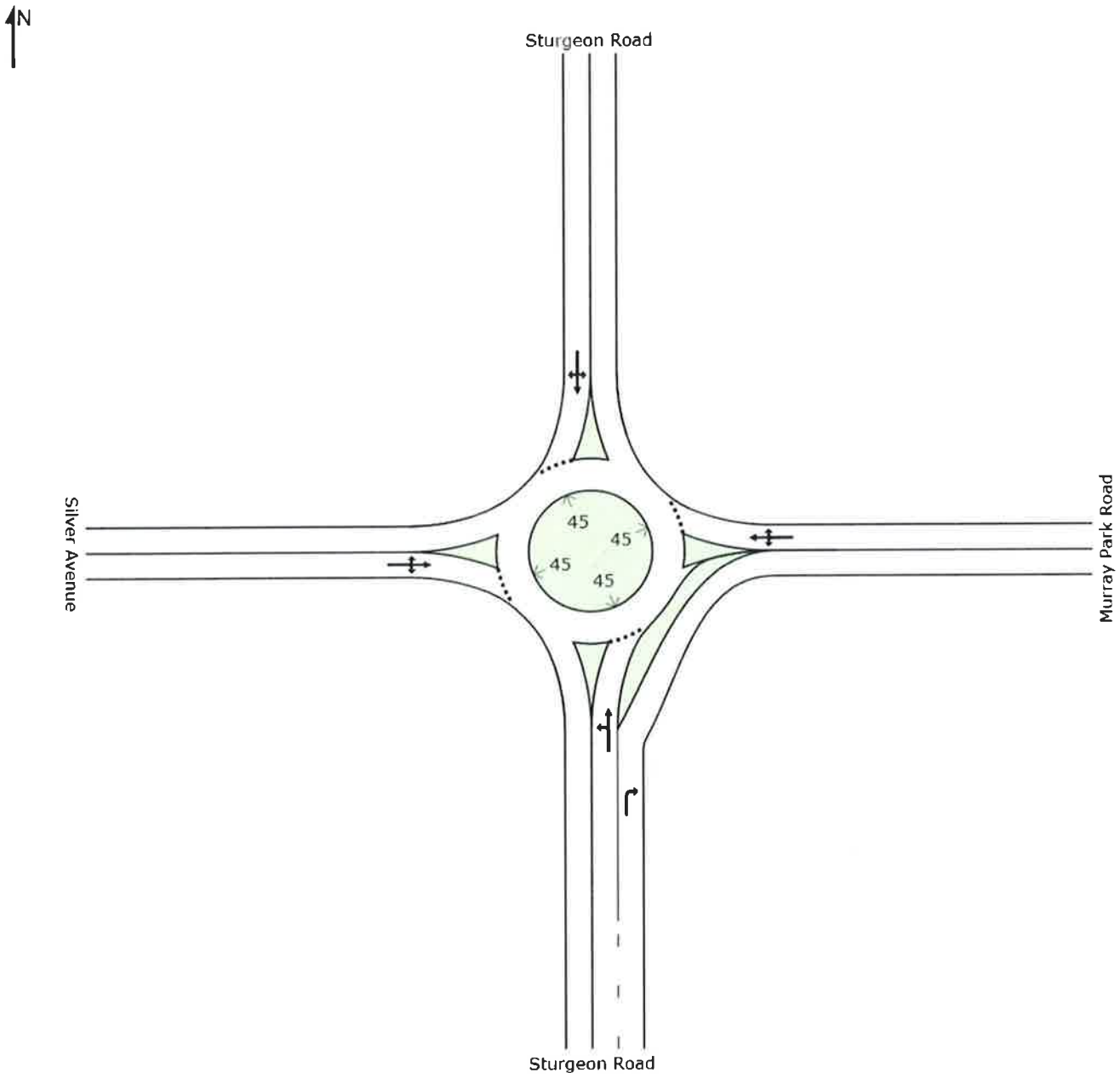


Colour code based on Level of Service

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2741 veh/h	3647 pers/h
Percent Heavy Vehicles (Demand)	5.2 %	
Degree of Saturation	0.808	
Practical Spare Capacity	5.2 %	
Effective Intersection Capacity	3392 veh/h	
Control Delay (Total)	8.55 veh-h/h	10.26 pers-h/h
Control Delay (Average)	11.2 sec	10.1 sec
Control Delay (Worst Lane)	39.7 sec	
Control Delay (Worst Movement)	47.1 sec	47.1 sec
Geometric Delay (Average)	2.0 sec	
Stop-Line Delay (Average)	9.2 sec	
Idling Time (Average)	3.8 sec	
Intersection Level of Service (LOS)	LOS B	
95% Back of Queue - Vehicles (Worst Lane)	13.5 veh	
95% Back of Queue - Distance (Worst Lane)	96.4 m	
Queue Storage Ratio (Worst Lane)	0.19	
Total Effective Stops	2223 veh/h	2667 pers/h
Effective Stop Rate	0.81 per veh	0.73 per pers
Proportion Queued	0.80	0.72
Performance Index	126.6	126.6
Travel Distance (Total)	1081.7 veh-km/h	1298.0 pers-km/h
Travel Distance (Average)	395 m	356 m
Travel Time (Total)	31.0 veh-h/h	37.3 pers-h/h
Travel Time (Average)	40.8 sec	36.8 sec
Travel Speed	34.8 km/h	34.8 km/h
Cost (Total)	1109.47 $/h	1109.47 $/h
Fuel Consumption (Total)	88.0 L/h	
Carbon Dioxide (Total)	208.2 kg/h	
Hydrocarbons (Total)	0.083 kg/h	
Carbon Monoxide (Total)	0.619 kg/h	
NOx (Total)	0.568 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,315,640 veh/y	1,750,557 pers/y
Delay	4,104 veh-h/y	4,925 pers-h/y
Effective Stops	1,066,971 veh/y	1,280,365 pers/y
Travel Distance	519,204 veh-km/y	623,045 pers-km/y
Travel Time	14,902 veh-h/y	17,883 pers-h/y
Cost	532,544 $/y	532,544 $/y
Fuel Consumption	42,248 L/y	
Carbon Dioxide	99,925 kg/y	
Hydrocarbons	40 kg/y	
Carbon Monoxide	297 kg/y	
NOx	273 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	32	2.0	0.707	15.3	LOS B	9.6	70.2	0.93	1.91	35.1
2	T1	811	5.0	0.707	7.2	LOS A	9.6	70.2	0.93	1.91	35.1
3	R2	130	5.0	0.070	2.1	LOS A	0.0	0.0	0.00	0.42	44.8
Approach		972	4.9	0.707	6.8	LOS A	9.6	70.2	0.80	0.86	36.2
East: Murray Park Road											
4	L2	63	8.0	0.551	17.9	LOS B	5.5	40.9	1.00	2.10	31.3
5	T1	32	2.0	0.551	9.7	LOS A	5.5	40.9	1.00	2.10	31.3
6	R2	232	8.0	0.551	11.8	LOS B	5.5	40.9	1.00	2.10	31.3
Approach		326	7.4	0.551	12.8	LOS B	5.5	40.9	1.00	1.05	31.3
North: Sturgeon Road											
7	L2	326	8.0	0.731	9.8	LOS A	9.4	68.9	0.65	0.86	43.1
8	T1	716	5.0	0.731	1.6	LOS A	9.4	68.9	0.65	0.86	43.1
9	R2	5	2.0	0.731	3.7	LOS A	9.4	68.9	0.65	0.86	43.1
Approach		1047	5.9	0.731	4.2	LOS A	9.4	68.9	0.65	0.43	43.1
West: Silver Avenue											
10	L2	5	2.0	0.808	47.1	LOS D	13.5	96.4	1.00	3.02	16.8
11	T1	274	2.0	0.808	39.0	LOS D	13.5	96.4	1.00	3.02	16.8
12	R2	116	2.0	0.808	41.0	LOS D	13.5	96.4	1.00	3.02	16.8
Approach		395	2.0	0.808	39.7	LOS D	13.5	96.4	1.00	1.51	16.8
All Vehicles		2741	5.2	0.808	11.2	LOS B	13.5	96.4	0.80	0.81	34.8

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

DELAY (AVERAGE)

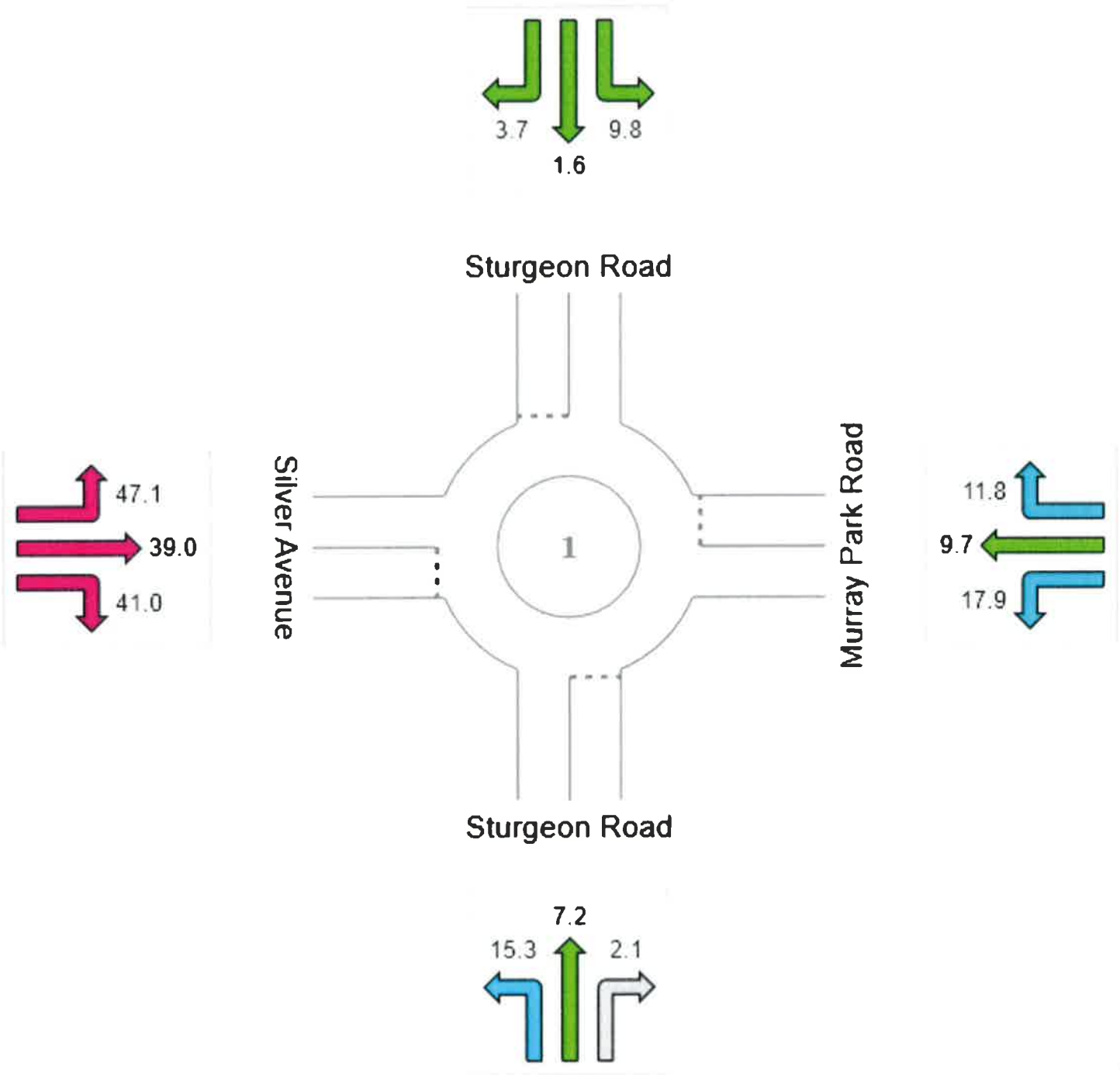
Average control delay per vehicle, or average pedestrian delay (seconds)

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	6.8	12.8	4.2	39.7	11.2
LOS	A	B	A	D	B

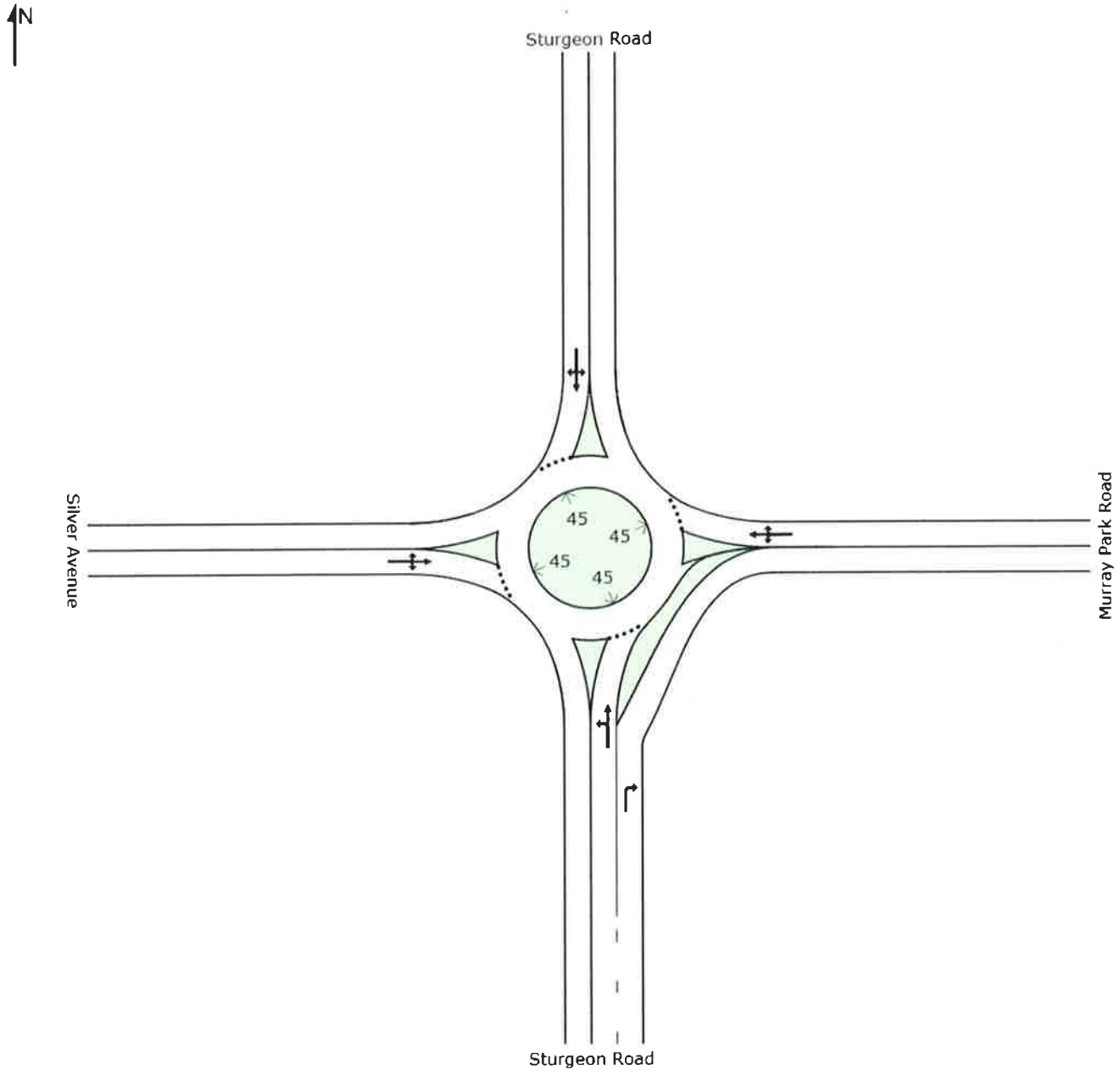


Colour code based on Level of Service

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2667 veh/h	3559 pers/h
Percent Heavy Vehicles (Demand)	5.4 %	
Degree of Saturation	0.972	
Practical Spare Capacity	-12.6 %	
Effective Intersection Capacity	2744 veh/h	
Control Delay (Total)	16.97 veh-h/h	20.37 pers-h/h
Control Delay (Average)	22.9 sec	20.6 sec
Control Delay (Worst Lane)	42.5 sec	
Control Delay (Worst Movement)	47.9 sec	47.9 sec
Geometric Delay (Average)	2.2 sec	
Stop-Line Delay (Average)	20.7 sec	
Idling Time (Average)	9.4 sec	
Intersection Level of Service (LOS)	LOS C	
95% Back of Queue - Vehicles (Worst Lane)	35.9 veh	
95% Back of Queue - Distance (Worst Lane)	263.5 m	
Queue Storage Ratio (Worst Lane)	0.35	
Total Effective Stops	3285 veh/h	3943 pers/h
Effective Stop Rate	1.23 per veh	1.11 per pers
Proportion Queued	0.88	0.79
Performance Index	214.6	214.6
Travel Distance (Total)	1067.2 veh-km/h	1280.7 pers-km/h
Travel Distance (Average)	400 m	360 m
Travel Time (Total)	39.1 veh-h/h	46.9 pers-h/h
Travel Time (Average)	52.7 sec	47.4 sec
Travel Speed	27.3 km/h	27.3 km/h
Cost (Total)	1391.07 $/h	1391.07 $/h
Fuel Consumption (Total)	102.3 L/h	
Carbon Dioxide (Total)	241.9 kg/h	
Hydrocarbons (Total)	0.106 kg/h	
Carbon Monoxide (Total)	0.731 kg/h	
NOx (Total)	0.658 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,280,271 veh/y	1,708,115 pers/y
Delay	8,146 veh-h/y	9,775 pers-h/y
Effective Stops	1,577,009 veh/y	1,892,411 pers/y
Travel Distance	512,261 veh-km/y	614,713 pers-km/y
Travel Time	18,757 veh-h/y	22,509 pers-h/y
Cost	667,713 $/y	667,713 $/y
Fuel Consumption	49,083 L/y	
Carbon Dioxide	116,128 kg/y	
Hydrocarbons	51 kg/y	
Carbon Monoxide	351 kg/y	
NOx	316 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

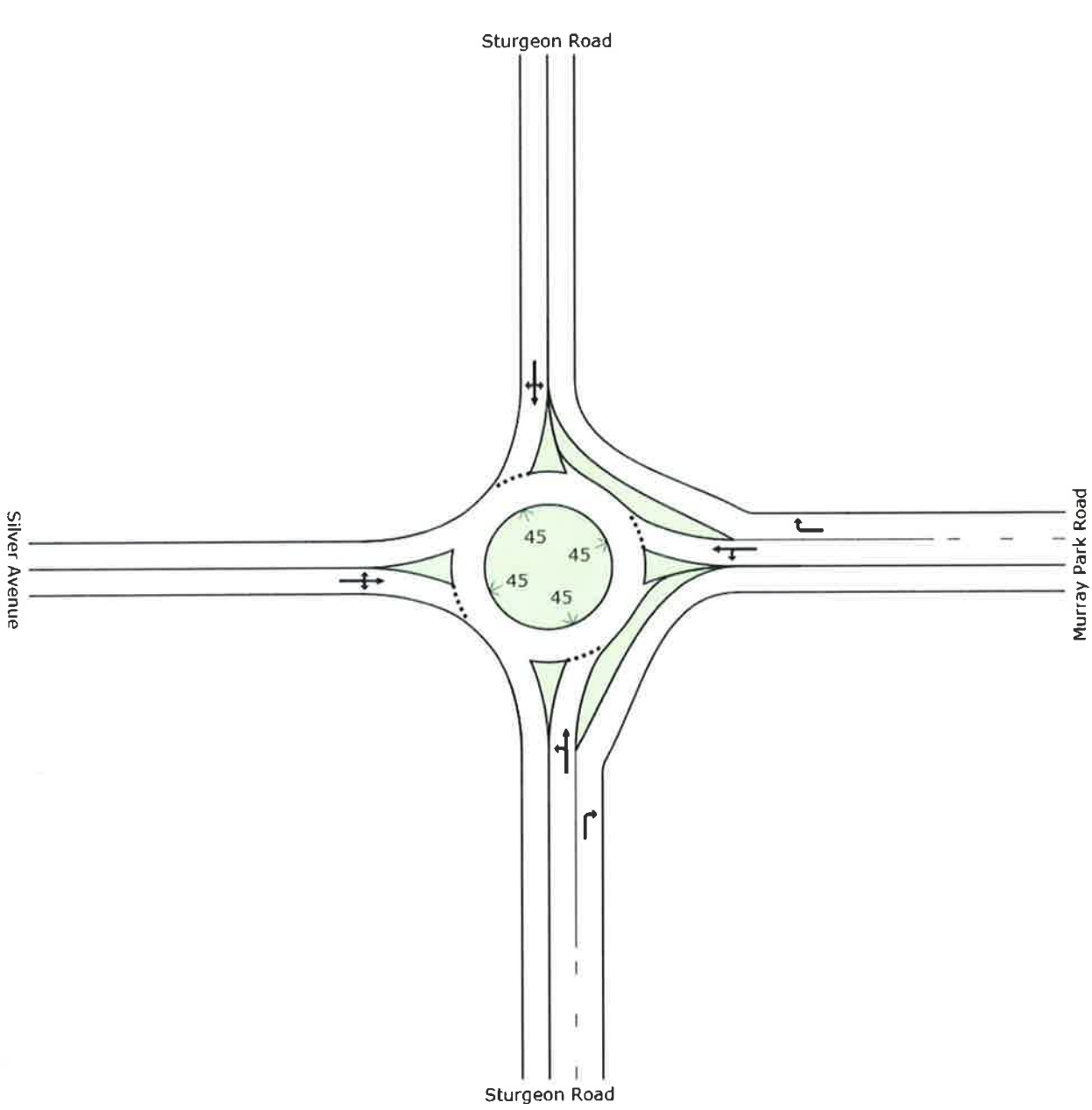
Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	116	2.0	0.584	10.2	LOS B	5.4	39.6	0.69	0.75	37.4
2	T1	716	5.0	0.584	2.0	LOS A	5.4	39.6	0.69	0.75	37.4
3	R2	67	8.0	0.037	2.1	LOS A	0.0	0.0	0.00	0.39	44.8
Approach		899	4.8	0.584	3.1	LOS A	5.4	39.6	0.64	0.36	37.9
East: Murray Park Road											
4	L2	126	8.0	0.929	47.9	LOS D	23.6	174.2	1.00	3.64	16.6
5	T1	168	2.0	0.929	39.8	LOS D	23.6	174.2	1.00	3.64	16.6
6	R2	326	8.0	0.929	41.8	LOS D	23.6	174.2	1.00	3.64	16.6
Approach		621	6.4	0.929	42.5	LOS D	23.6	174.2	1.00	1.82	16.6
North: Sturgeon Road											
7	L2	232	8.0	0.972	35.6	LOS D	35.9	263.5	1.00	3.32	29.6
8	T1	811	5.0	0.972	27.4	LOS C	35.9	263.5	1.00	3.32	29.6
9	R2	5	2.0	0.972	29.5	LOS C	35.9	263.5	1.00	3.32	29.6
Approach		1047	5.6	0.972	29.2	LOS C	35.9	263.5	1.00	1.66	29.6
West: Silver Avenue											
10	L2	5	2.0	0.274	20.2	LOS C	2.4	16.8	1.00	1.85	30.3
11	T1	63	2.0	0.274	12.0	LOS B	2.4	16.8	1.00	1.85	30.3
12	R2	32	2.0	0.274	14.1	LOS B	2.4	16.8	1.00	1.85	30.3
Approach		100	2.0	0.274	13.1	LOS B	2.4	16.8	1.00	0.93	30.3
All Vehicles		2667	5.4	0.972	22.9	LOS C	35.9	263.5	0.88	1.23	27.3

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



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INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2741 veh/h	3647 pers/h
Percent Heavy Vehicles (Demand)	5.2 %	
Degree of Saturation	0.803	
Practical Spare Capacity	5.9 %	
Effective Intersection Capacity	3415 veh/h	
Control Delay (Total)	7.71 veh-h/h	9.26 pers-h/h
Control Delay (Average)	10.1 sec	9.1 sec
Control Delay (Worst Lane)	38.8 sec	
Control Delay (Worst Movement)	46.3 sec	46.3 sec
Geometric Delay (Average)	2.0 sec	
Stop-Line Delay (Average)	8.1 sec	
Idling Time (Average)	3.5 sec	
Intersection Level of Service (LOS)	LOS B	
95% Back of Queue - Vehicles (Worst Lane)	13.3 veh	
95% Back of Queue - Distance (Worst Lane)	94.9 m	
Queue Storage Ratio (Worst Lane)	0.19	
Total Effective Stops	1994 veh/h	2392 pers/h
Effective Stop Rate	0.73 per veh	0.66 per pers
Proportion Queued	0.71	0.64
Performance Index	112.1	112.1
Travel Distance (Total)	1082.3 veh-km/h	1298.7 pers-km/h
Travel Distance (Average)	395 m	356 m
Travel Time (Total)	30.2 veh-h/h	36.3 pers-h/h
Travel Time (Average)	39.7 sec	35.8 sec
Travel Speed	35.8 km/h	35.8 km/h
Cost (Total)	1071.92 $/h	1071.92 $/h
Fuel Consumption (Total)	84.7 L/h	
Carbon Dioxide (Total)	200.2 kg/h	
Hydrocarbons (Total)	0.080 kg/h	
Carbon Monoxide (Total)	0.600 kg/h	
NOx (Total)	0.530 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,315,640 veh/y	1,750,557 pers/y
Delay	3,703 veh-h/y	4,443 pers-h/y
Effective Stops	956,999 veh/y	1,148,399 pers/y
Travel Distance	519,488 veh-km/y	623,385 pers-km/y
Travel Time	14,507 veh-h/y	17,409 pers-h/y
Cost	514,523 $/y	514,523 $/y
Fuel Consumption	40,634 L/y	
Carbon Dioxide	96,099 kg/y	
Hydrocarbons	39 kg/y	
Carbon Monoxide	288 kg/y	
NOx	254 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	32	2.0	0.707	15.3	LOS B	9.6	70.2	0.93	1.91	35.1
2	T1	811	5.0	0.707	7.2	LOS A	9.6	70.2	0.93	1.91	35.1
3	R2	130	5.0	0.070	2.1	LOS A	0.0	0.0	0.00	0.42	44.8
Approach		972	4.9	0.707	6.8	LOS A	9.6	70.2	0.80	0.86	36.2
East: Murray Park Road											
4	L2	63	8.0	0.120	12.8	LOS B	1.0	7.7	0.93	1.48	33.9
5	T1	32	2.0	0.120	4.7	LOS A	1.0	7.7	0.93	1.48	33.9
6	R2	232	8.0	0.127	2.3	LOS A	0.0	0.0	0.00	0.42	45.5
Approach		326	7.4	0.127	4.6	LOS A	1.0	7.7	0.27	0.36	41.0
North: Sturgeon Road											
7	L2	326	8.0	0.730	9.8	LOS A	9.2	67.9	0.65	0.86	43.1
8	T1	716	5.0	0.730	1.6	LOS A	9.2	67.9	0.65	0.86	43.1
9	R2	5	2.0	0.730	3.7	LOS A	9.2	67.9	0.65	0.86	43.1
Approach		1047	5.9	0.730	4.2	LOS A	9.2	67.9	0.65	0.43	43.1
West: Silver Avenue											
10	L2	5	2.0	0.803	46.3	LOS D	13.3	94.9	1.00	3.00	17.0
11	T1	274	2.0	0.803	38.1	LOS D	13.3	94.9	1.00	3.00	17.0
12	R2	116	2.0	0.803	40.2	LOS D	13.3	94.9	1.00	3.00	17.0
Approach		395	2.0	0.803	38.8	LOS D	13.3	94.9	1.00	1.50	17.0
All Vehicles		2741	5.2	0.803	10.1	LOS B	13.3	94.9	0.71	0.73	35.8

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

2031 AM

SIDRA INTERSECTION 6

DELAY (AVERAGE)

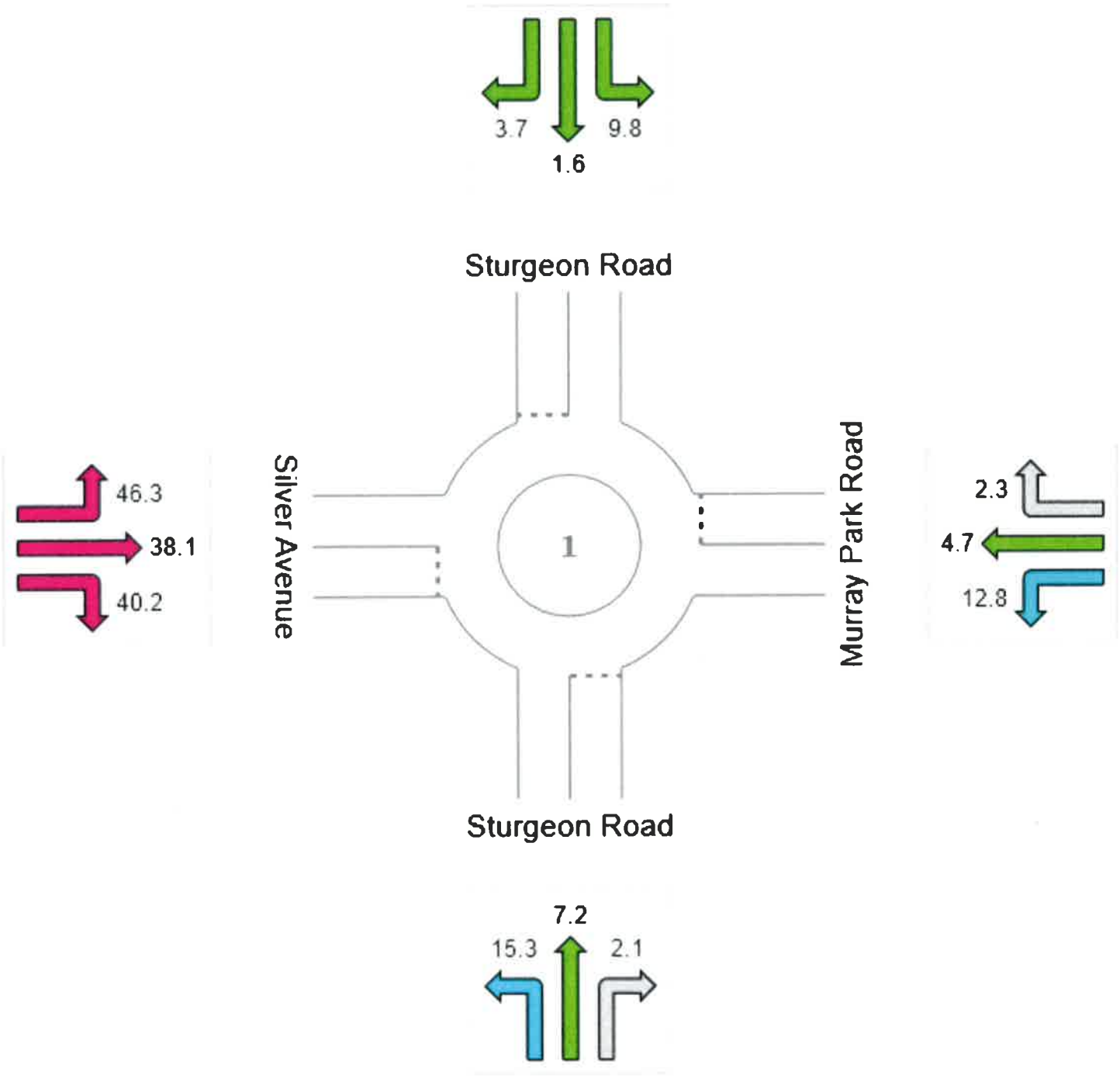
Average control delay per vehicle, or average pedestrian delay (seconds)

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	6.8	4.6	4.2	38.8	10.1
LOS	A	A	A	D	B

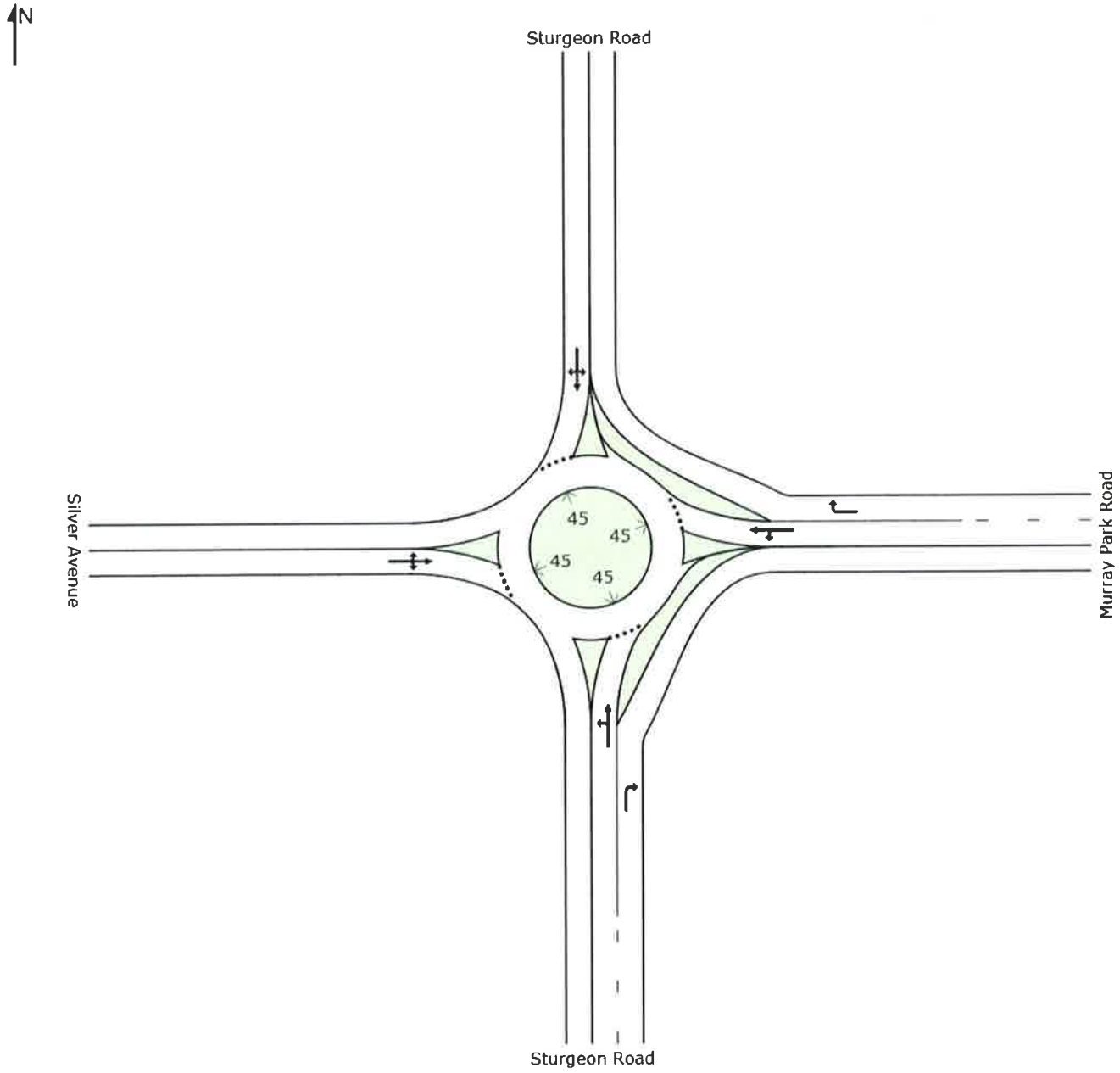


Colour code based on Level of Service

SITE LAYOUT

Site: Sturgeon Road at Murray Park Road

Roundabout



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SIDRA INTERSECTION 6

INTERSECTION SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	2667 veh/h	3559 pers/h
Percent Heavy Vehicles (Demand)	5.4 %	
Degree of Saturation	0.967	
Practical Spare Capacity	-12.1 %	
Effective Intersection Capacity	2758 veh/h	
Control Delay (Total)	10.08 veh-h/h	12.09 pers-h/h
Control Delay (Average)	13.6 sec	12.2 sec
Control Delay (Worst Lane)	27.7 sec	
Control Delay (Worst Movement)	34.0 sec	34.0 sec
Geometric Delay (Average)	2.2 sec	
Stop-Line Delay (Average)	11.4 sec	
Idling Time (Average)	4.0 sec	
Intersection Level of Service (LOS)	LOS B	
95% Back of Queue - Vehicles (Worst Lane)	34.5 veh	
95% Back of Queue - Distance (Worst Lane)	253.1 m	
Queue Storage Ratio (Worst Lane)	0.20	
Total Effective Stops	2400 veh/h	2881 pers/h
Effective Stop Rate	0.90 per veh	0.81 per pers
Proportion Queued	0.75	0.67
Performance Index	147.2	147.2
Travel Distance (Total)	1068.0 veh-km/h	1281.6 pers-km/h
Travel Distance (Average)	400 m	360 m
Travel Time (Total)	32.3 veh-h/h	38.8 pers-h/h
Travel Time (Average)	43.6 sec	39.2 sec
Travel Speed	33.1 km/h	33.1 km/h
Cost (Total)	1157.20 $/h	1157.20 $/h
Fuel Consumption (Total)	89.4 L/h	
Carbon Dioxide (Total)	211.5 kg/h	
Hydrocarbons (Total)	0.087 kg/h	
Carbon Monoxide (Total)	0.637 kg/h	
NOx (Total)	0.573 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	1,280,271 veh/y	1,708,115 pers/y
Delay	4,837 veh-h/y	5,805 pers-h/y
Effective Stops	1,152,220 veh/y	1,382,664 pers/y
Travel Distance	512,625 veh-km/y	615,150 pers-km/y
Travel Time	15,510 veh-h/y	18,612 pers-h/y
Cost	555,458 $/y	555,458 $/y
Fuel Consumption	42,920 L/y	
Carbon Dioxide	101,536 kg/y	
Hydrocarbons	42 kg/y	
Carbon Monoxide	306 kg/y	
NOx	275 kg/y	

MOVEMENT SUMMARY

Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Sturgeon Road											
1	L2	116	2.0	0.584	10.2	LOS B	5.4	39.6	0.69	0.75	37.4
2	T1	716	5.0	0.584	2.0	LOS A	5.4	39.6	0.69	0.75	37.4
3	R2	67	8.0	0.037	2.1	LOS A	0.0	0.0	0.00	0.39	44.8
Approach		899	4.8	0.584	3.1	LOS A	5.4	39.6	0.64	0.36	37.9
East: Murray Park Road											
4	L2	126	8.0	0.330	13.0	LOS B	2.9	21.3	0.94	1.51	34.5
5	T1	168	2.0	0.330	4.9	LOS A	2.9	21.3	0.94	1.51	34.5
6	R2	326	8.0	0.179	2.3	LOS A	0.0	0.0	0.00	0.42	45.5
Approach		621	6.4	0.330	5.2	LOS A	2.9	21.3	0.45	0.47	39.3
North: Sturgeon Road											
7	L2	232	8.0	0.967	34.0	LOS C	34.5	253.1	1.00	3.23	30.3
8	T1	811	5.0	0.967	25.9	LOS C	34.5	253.1	1.00	3.23	30.3
9	R2	5	2.0	0.967	27.9	LOS C	34.5	253.1	1.00	3.23	30.3
Approach		1047	5.6	0.967	27.7	LOS C	34.5	253.1	1.00	1.62	30.3
West: Silver Avenue											
10	L2	5	2.0	0.274	20.2	LOS C	2.4	16.8	1.00	1.85	30.3
11	T1	63	2.0	0.274	12.0	LOS B	2.4	16.8	1.00	1.85	30.3
12	R2	32	2.0	0.274	14.1	LOS B	2.4	16.8	1.00	1.85	30.3
Approach		100	2.0	0.274	13.1	LOS B	2.4	16.8	1.00	0.93	30.3
All Vehicles		2667	5.4	0.967	13.6	LOS B	34.5	253.1	0.75	0.90	33.1

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

2031 PM

SIDRA INTERSECTION 6

DELAY (AVERAGE)

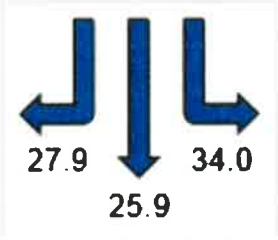
Average control delay per vehicle, or average pedestrian delay (seconds)

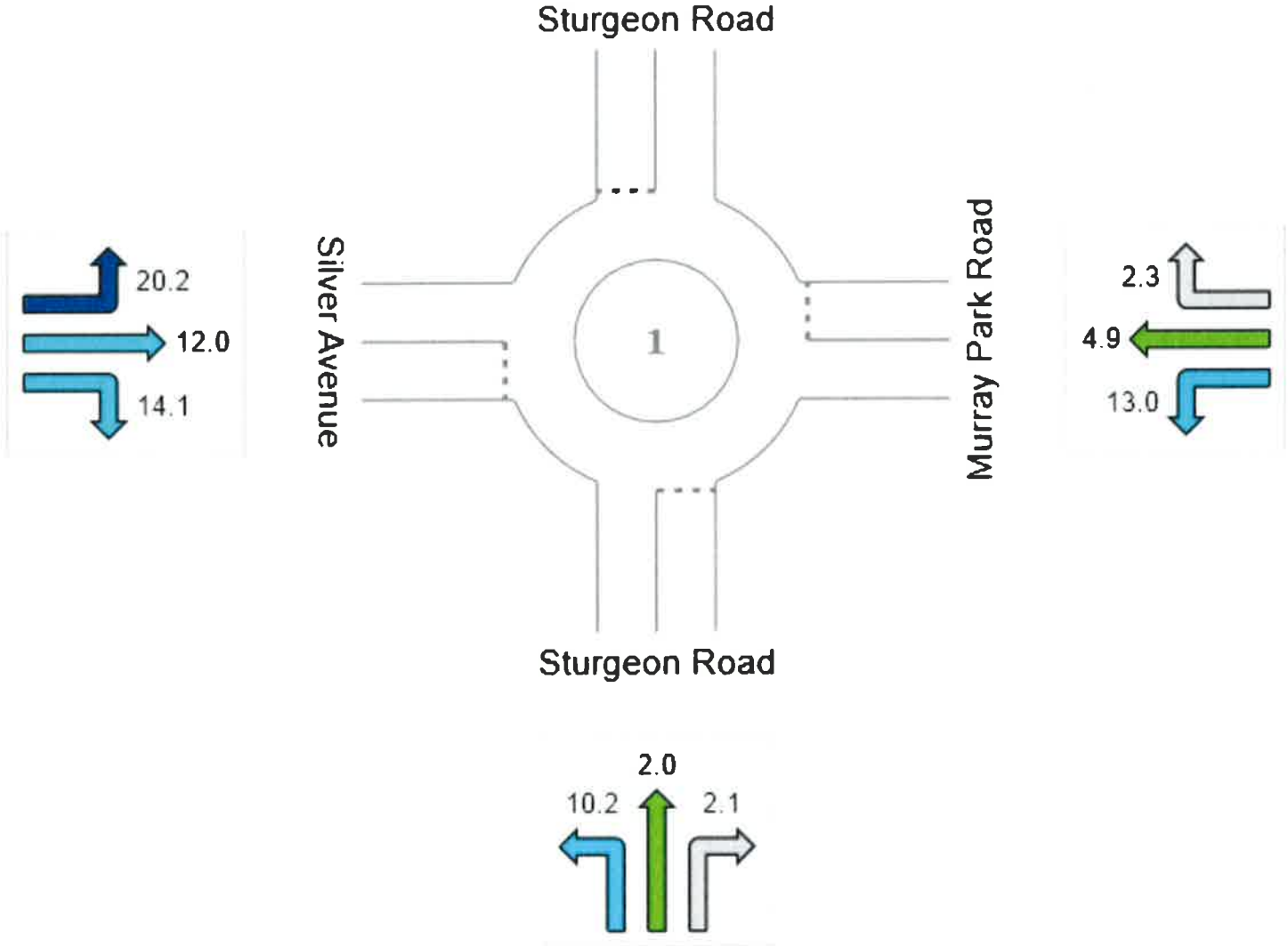
Site: Sturgeon Road at Murray Park Road

Roundabout
Roundabout

All Movement Classes

	South	East	North	West	Intersection
Delay (Average)	3.1	5.2	27.7	13.1	13.6
LOS	A	A	C	B	B





Colour code based on Level of Service

Sturgeon Road at Murray Park / Silver Avenue
Roundabout - Preliminary Design Report

Appendix B
Geotechnical Investigation

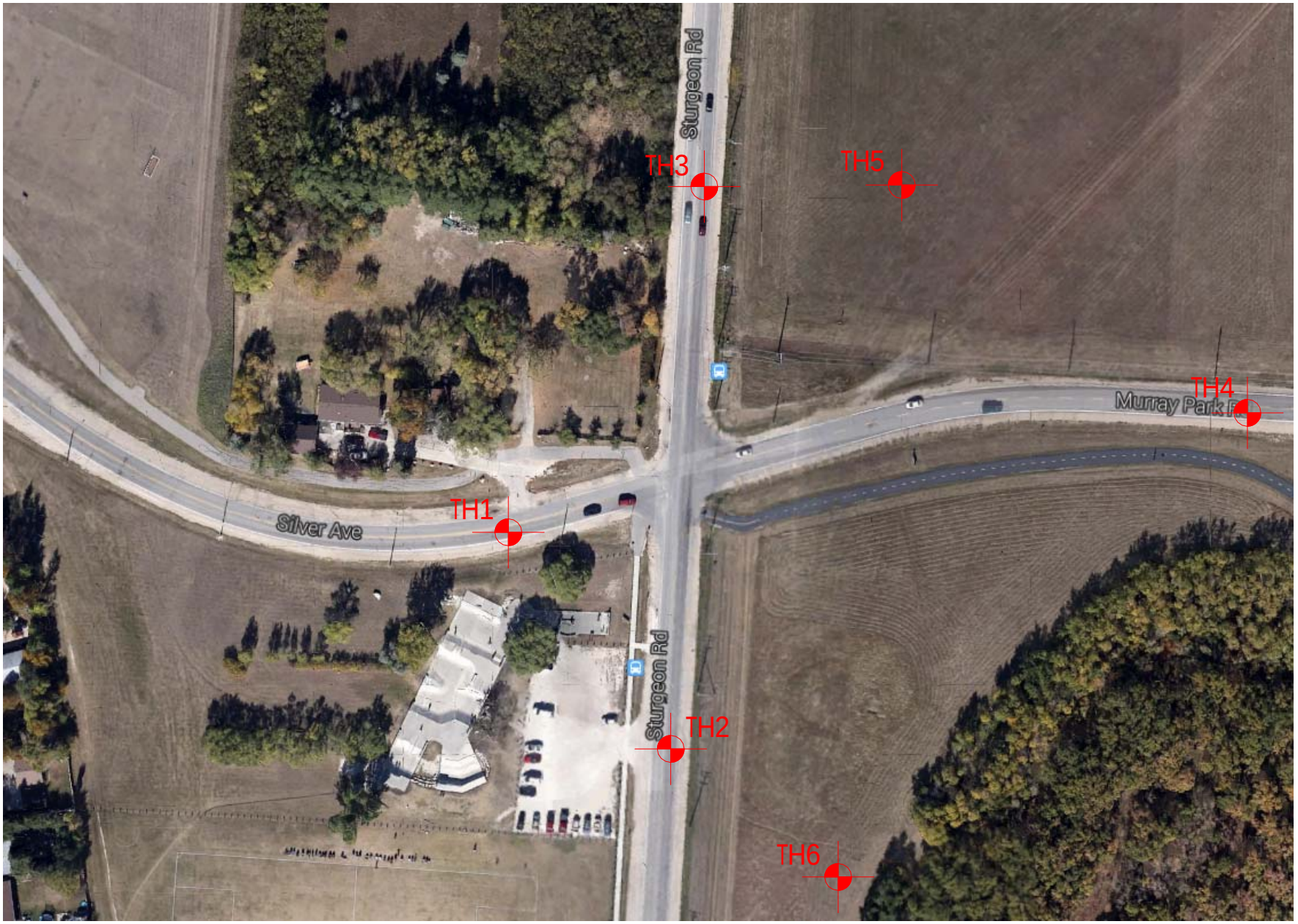
CITY OF WINNIPEG
ROUNDABOUT PD STURGEON ROAD

GEOTECHNICAL INVESTIGATION

Prepared for:
Stantec Consulting Ltd.
100-1355 Taylor Avenue
Winnipeg, Manitoba
R3M 3Y9

Prepared by:
Stantec Consulting Ltd.
199 Henlow Bay
Winnipeg, Manitoba
R3Y 1G4

January 30, 2015
Project No. 113706650



Stantec	Project No. 113706650	Drawn by: SB	Figure: 1
	Date: January 27, 2015	Reviewed by: GL	Scale: NTS

Testhole Location Plan
City of Winnipeg Roundabout
PD Sturgeon Road
Winnipeg, Manitoba

TABLE 1
CITY OF WINNIPEG ROUNDABOUT PD STURGEON ROAD
GEOTECHNICAL INVESTIGATION

Testhole ID	Testhole Location	Pavement Surface		Pavement Structure Material		Sample Description	Sample Depth (m)	Moisture Content (%)	Particle Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)				Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index
TH1	40.0 m West of Southwest corner of Sturgeon Road and Silver Avenue on East bound Lane Centreline	Asphalt	105	Crushed Limestone	175	-	-	-	-	-	-	-	-	-	-
TH2	75.0 m South of Southeast corner of Sturgeon Road and Murray Park Road on North bound Lane Centreline	Asphalt	125	Crushed Limestone	330	-	-	-	-	-	-	-	-	-	-
TH3	70.0 m North of Northeast corner of Sturgeon Road and Murray Park Road on North bound Lane Centreline	Asphalt	140	Crushed Limestone	315	Clay Fill	0.9	25	0.9	10.0	16.5	72.6	67	22	45
TH4	110.0 m East of Southwest corner of Sturgeon Road and Murray Park Road on East bound Lane Centreline	Asphalt	105	Crushed Limestone	125	-	-	-	-	-	-	-	-	-	-
TH5	40.0 m East of Northeast corner of Sturgeon Road and Murray Park Road, 66.0 m North	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TH6	95.0 m South of Southeast corner of Sturgeon Road and Murray Park Road, 35.0 m East	-	-	-	-	Clay	0.9	27	0.4	4.6	17.8	77.2	76	24	52

TESTHOLE RECORD TH1

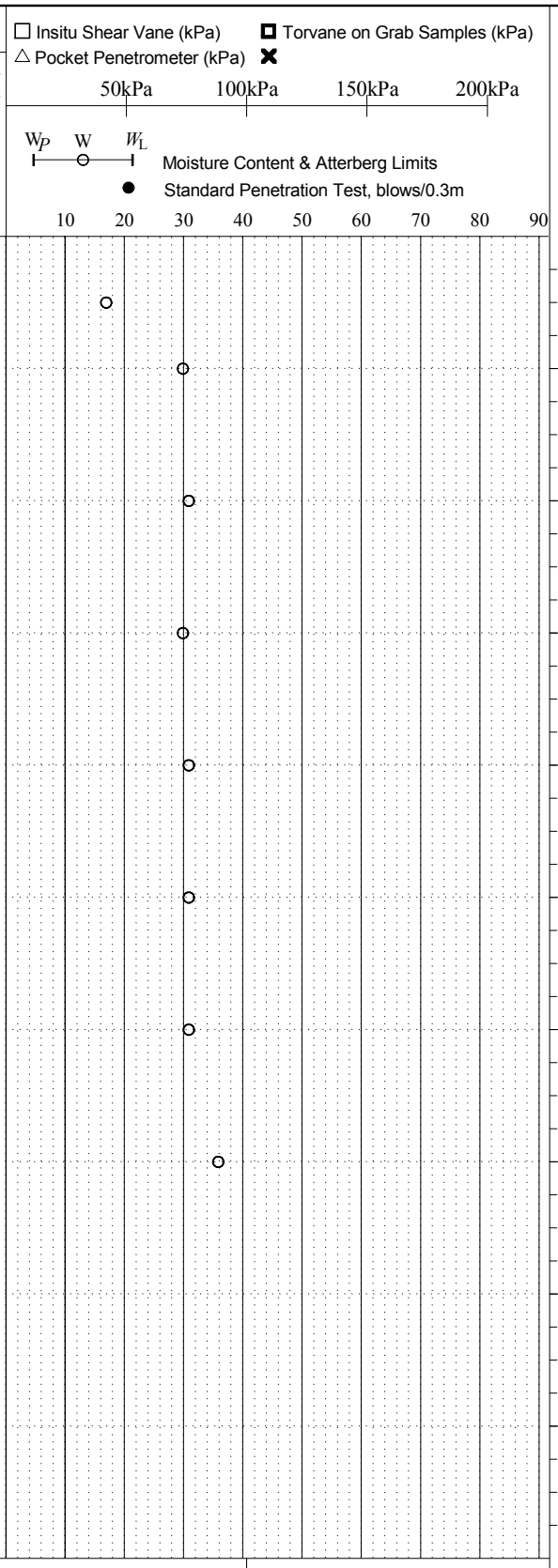
CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	AS	Asphalt		CORE		
	GW	Crushed Limestone - 20 mm maximum size aggregate		GS		17
	CH	Clay Fill - black, stiff, moist, high plasticity - some silt - trace fine to coarse sand - trace fine gravel		GS		30
				GS		31
1				GS		30
				GS		31
				GS		31
				GS		31
2	CH	Clay - brown, stiff, moist, high plasticity - silty		GS		36
		TESTHOLE LOCATION: 40.0 m West of Southwest corner of Sturgeon Road and Silver Avenue on East bound Lane Centreline. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.				
3						



DEPTH (ft): 0, 2, 4, 6, 8, 10

Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite Drill Cuttings Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec

TESTHOLE RECORD TH2

CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	AS	Asphalt		CORE		
	GW	Crushed Limestone - 20 mm maximum size aggregate		GS		4
	CH	Clay Fill - black, stiff, moist, high plasticity - some silt - trace fine to coarse sand - trace fine gravel		GS		30
1				GS		27
				GS		28
				GS		33
	CH	Clay - brown, stiff, moist, high plasticity		GS		25
2				GS		28
		TESTHOLE LOCATION: 75.0 m South of Southeast corner of Sturgeon Road and Murray Park Road on North bound Lane Centreline. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.				
3						

☐ Insitu Shear Vane (kPa) ■ Torvane on Grab Samples (kPa)
△ Pocket Penetrometer (kPa) ✖

50kPa 100kPa 150kPa 200kPa

W_P W W_L Moisture Content & Atterberg Limits

● Standard Penetration Test, blows/0.3m

10 20 30 40 50 60 70 80 90

DEPTH (ft): 0, 2, 4, 6, 8, 10

Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite Drill Cuttings Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec

TESTHOLE RECORD TH3

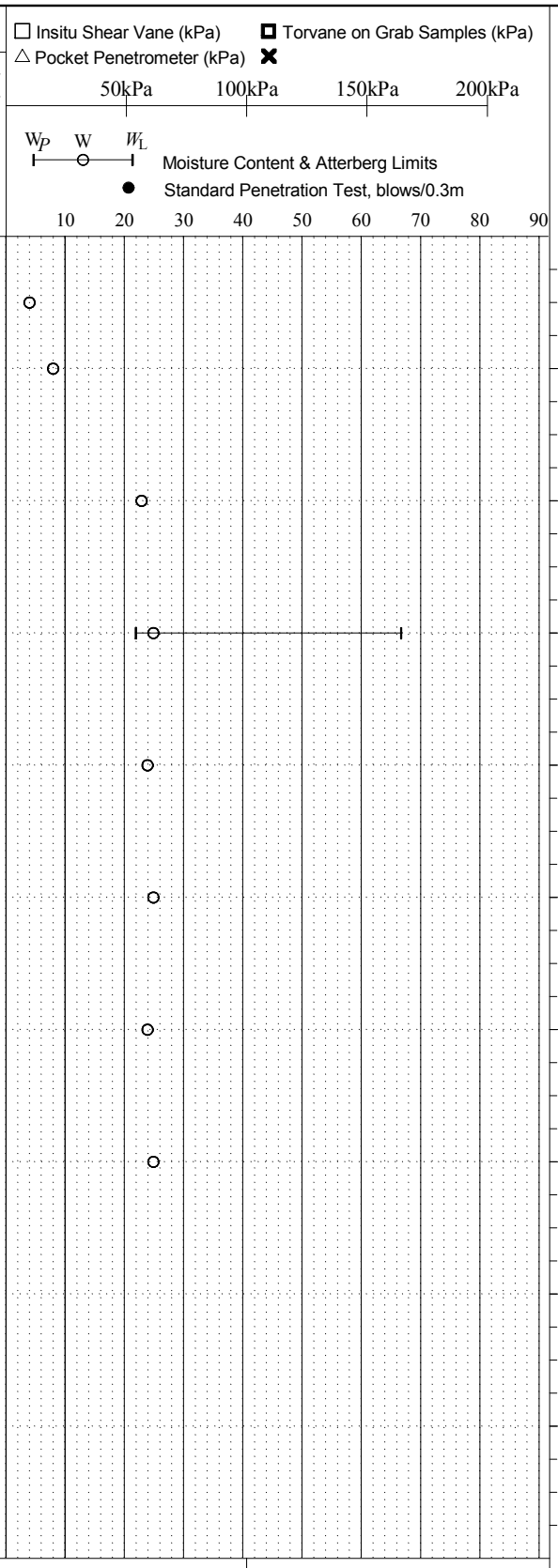
CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	AS		Asphalt		CORE		
	GW		Crushed Limestone - 20 mm maximum size aggregate		GS		4
					GS		8
	CH		Clay Fill - black, stiff, moist, high plasticity - some silt - trace fine to coarse sand - trace fine gravel		GS		23
1			Particle Size Analysis at 0.9 m: 0.9% Gravel, 10.0% Sand, 16.5% Silt, 72.6% Clay		GS		25
					GS		24
					GS		25
2					GS		24
			TESTHOLE LOCATION: 70.0 m North of Northeast corner of Sturgeon Road and Murray Park Road on North bound Lane Centreline. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.		GS		25
3							



DEPTH (ft): 0, 2, 4, 6, 8, 10

Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite Drill Cuttings Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec

TESTHOLE RECORD TH4

CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	AS	Asphalt		CORE		
	GW	Crushed Limestone - 20 mm maximum size aggregate		GS		9
		Clay Fill - black, stiff, moist, high plasticity - some silt - trace fine to coarse sand - trace fine gravel		GS		11
				GS		25
1	CH			GS		24
				GS		20
				GS		19
				GS		21
2	CH	Clay - brown, stiff, moist, high plasticity - silty - some fine to coarse sand - trace fine to coarse gravel		GS		18
		TESTHOLE LOCATION: 110.0 m East of Southwest corner of Sturgeon Road and Murray Park Road on East bound Lane Centreline. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.				
3						

☐ Insitu Shear Vane (kPa) ◘ Torvane on Grab Samples (kPa)
△ Pocket Penetrometer (kPa) ✖

50kPa 100kPa 150kPa 200kPa

W_P W W_L Moisture Content & Atterberg Limits

● Standard Penetration Test, blows/0.3m

10 20 30 40 50 60 70 80 90

DEPTH (ft): 0 2 4 6 8 10

Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite Drill Cuttings Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec

TESTHOLE RECORD TH5

CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	TP		Topsoil				
	CH		Clay - black, stiff, moist, high plasticity - brown, below 0.8 m - some silt - trace fine to coarse sand - trace gravel		GS		39
					GS		42
					GS		39
1					GS		30
					GS		29
					GS		30
2	ML		Silt Till - tan, compact, moist - some clay - some fine to coarse gravel		GS		20
					GS		16
3			TESTHOLE LOCATION: 40.0 m East of Northeast corner of Sturgeon Road and Murray Park Road, 66.0 m North. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.				

☐ Insitu Shear Vane (kPa) ■ Torvane on Grab Samples (kPa)
△ Pocket Penetrometer (kPa) ✖

50kPa 100kPa 150kPa 200kPa

W_P W W_L Moisture Content & Atterberg Limits

● Standard Penetration Test, blows/0.3m

10 20 30 40 50 60 70 80 90

DEPTH (ft): 0 2 4 6 8 10

Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: ■ Bentonite ⊠ Drill Cuttings ⁘ Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec

TESTHOLE RECORD TH6

CLIENT Stantec Consulting Ltd. PROJECT No. 113706650

PROJECT City of Winnipeg Roundabout PD Sturgeon Road DATUM

LOCATION Winnipeg, Manitoba ELEVATION

DRILLING DATE January 22, 2015 DRILLING CO. Maple Leaf Drilling Ltd. DRILLING METHOD 125 mm Auger

DEPTH (m)	USC	SOIL DESCRIPTION	WELL DATA	SAMPLES TYPE	SAMPLES NUMBER	MOISTURE CONTENT (%)
0	TP	Topsoil				
	CH	Clay - brown, stiff, moist, high plasticity - some silt - trace fine to coarse sand - trace fine gravel Particle Size Analysis at 0.9 m: 0.4% Gravel, 4.6% Sand, 17.8% Silt, 77.2% Clay		GS		53
				GS		31
				GS		29
1				GS		27
				GS		29
				GS		27
2	ML	Silt Till - tan, compact, moist - some fine to coarse gravel		GS		14
				GS		9
		TESTHOLE LOCATION: 95.0 m South of Southeast corner of Sturgeon Road and Murray Park Road, 35.0 m East. • The soil was frozen to a depth of 0.8 m. • No groundwater seepage or soil sloughing was observed during or upon completion of drilling. • Testhole terminated at a depth of 2.1 m.				
3						

□ Insitu Shear Vane (kPa) ■ Torvane on Grab Samples (kPa)
△ Pocket Penetrometer (kPa) ✖

50kPa 100kPa 150kPa 200kPa

W_P W W_L Moisture Content & Atterberg Limits

● Standard Penetration Test, blows/0.3m

10 20 30 40 50 60 70 80 90

DEPTH (ft): 0 2 4 6 8 10

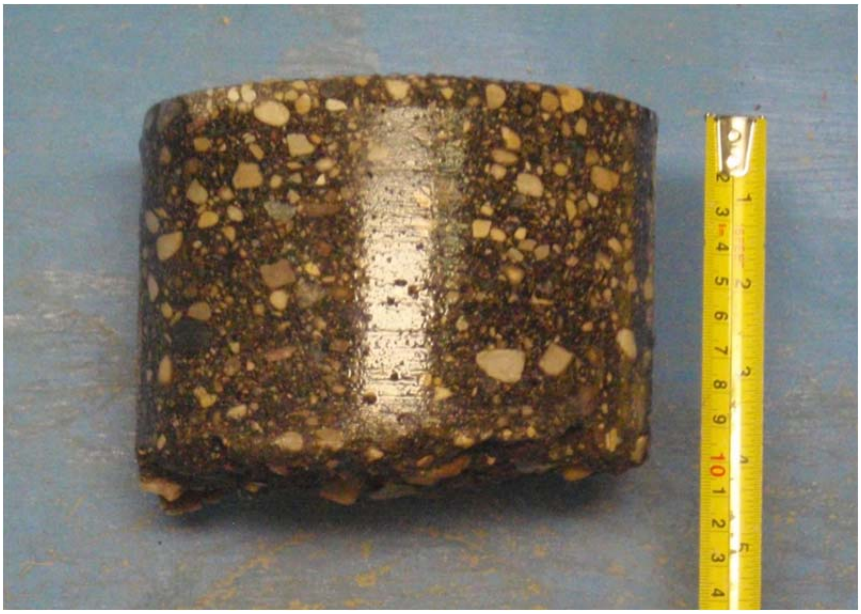
Sample Type: GS - Grab Sample SPT - Standard Penetration Test
ST - Shelby Tube PT - Piston Tube VT - Shear Vane Test

Piezometer Backfill Type: Bentonite Drill Cuttings Sand

Logged by: Larry Presado

Reviewed by: German Leal

Stantec



Core sample from Testhole TH1

Core sample from Testhole TH2

Core sample from Testhole TH3

Core sample from Testhole TH4

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

Stantec Consulting Ltd.
100-1355 Taylor Avenue
Winnipeg, Manitoba
R3M 3Y9

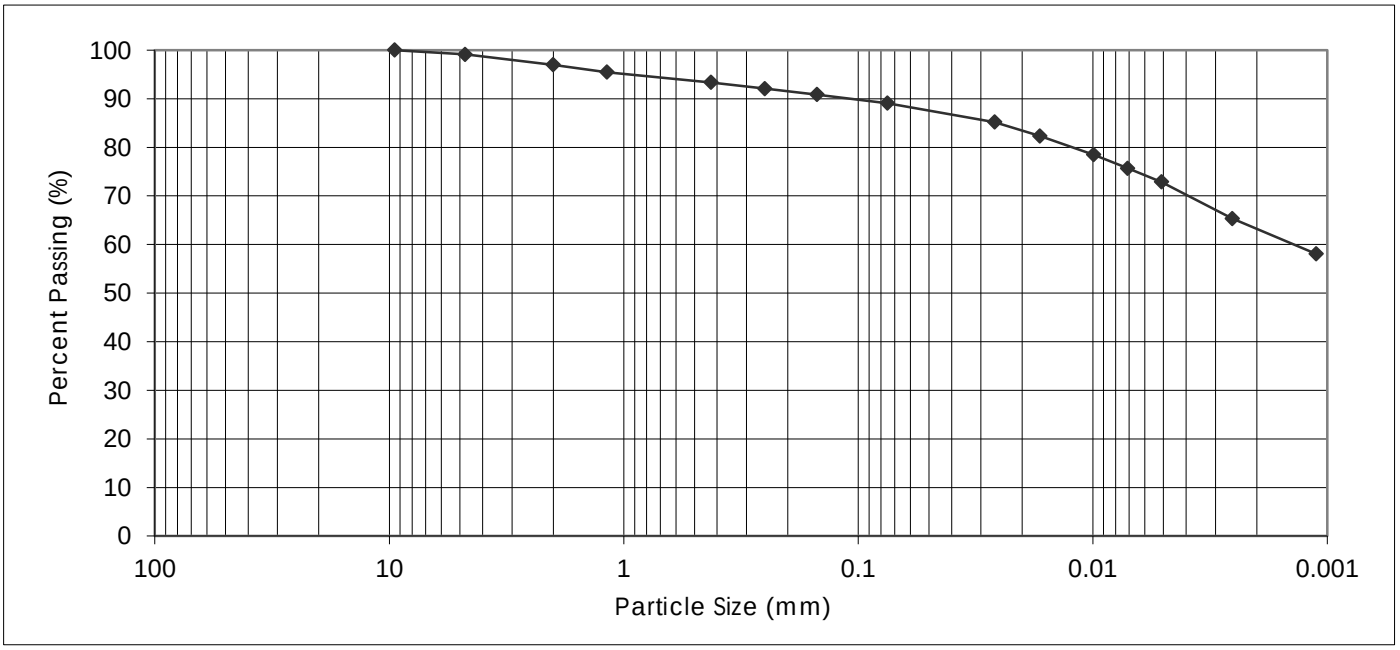
PROJECT: City of Winnipeg
Roundabout PD
Sturgeon Road

Attention: Wayne Byczek

PROJECT NO.: 113706650

SAMPLED BY: Larry Presado, C.Tech
SAMPLE ID: TH3 @ 0.9 m

DATE RECEIVED: January 22, 2015
TESTED BY: Sothea Bun, C.E.T.



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.1
2.00 mm	97.0

PARTICLE SIZE	PERCENT PASSING
1.18 mm	95.5
0.425 mm	93.3
0.250 mm	92.1
0.150 mm	90.9
0.075 mm	89.1
0.005 mm	72.6
0.002 mm	62.6
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.9	2.1	3.7	4.2	16.5	72.6	NT*

NT* Sample not tested for colloids

January 30, 2015

REVIEWED BY: German E. Leal, B.Sc., P. Eng.

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

Stantec Consulting Ltd.
100-1355 Taylor Avenue
Winnipeg, Manitoba
R3M 3Y9

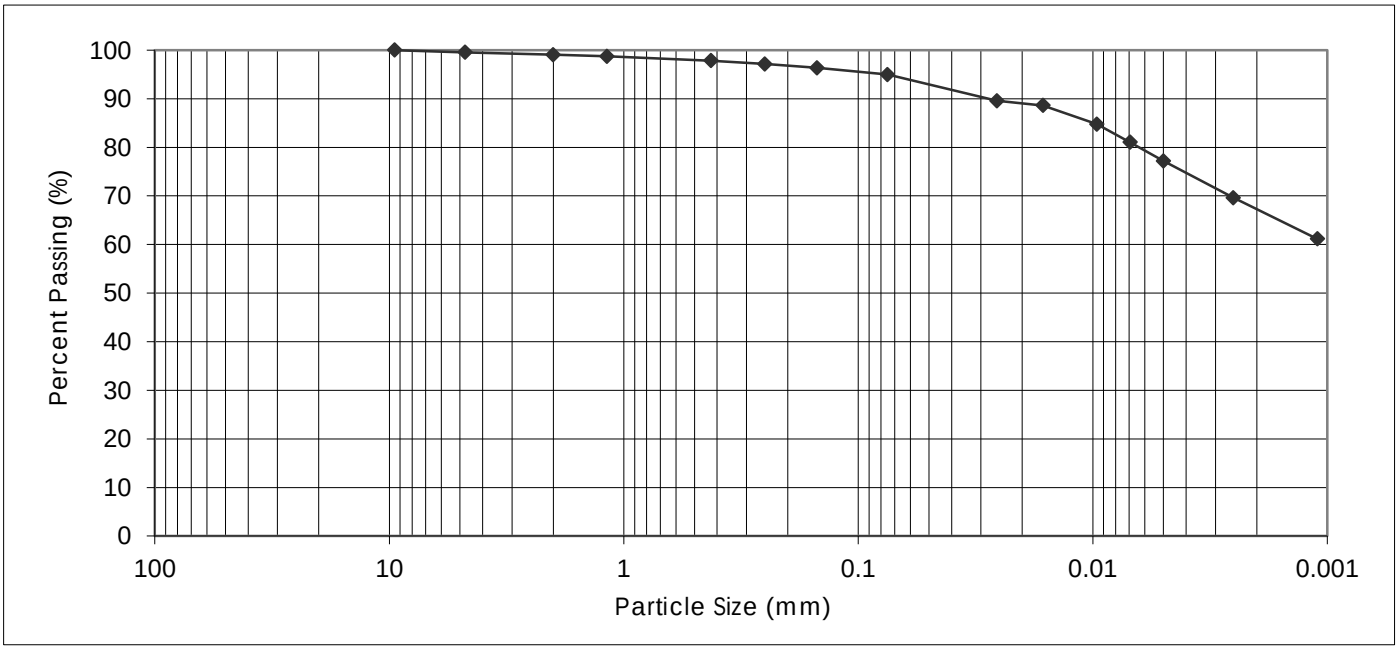
PROJECT: City of Winnipeg
Roundabout PD
Sturgeon Road

Attention: Wayne Byczek

PROJECT NO.: 113706650

SAMPLED BY: Larry Presado, C.Tech
SAMPLE ID: TH6 @ 0.9 m

DATE RECEIVED: January 22, 2015
TESTED BY: Sothea Bun, C.E.T.



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.6
2.00 mm	99.1

PARTICLE SIZE	PERCENT PASSING
1.18 mm	98.7
0.425 mm	97.8
0.250 mm	97.2
0.150 mm	96.3
0.075 mm	95.0
0.005 mm	77.2
0.002 mm	66.5
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.4	0.5	1.3	2.8	17.8	77.2	NT*

NT* Sample not tested for colloids

January 30, 2015

REVIEWED BY: German E. Leal, B.Sc., P. Eng.

Sturgeon Road at Murray Park / Silver Avenue
Roundabout - Preliminary Design Report

Appendix C
Pavement Design Report

Pavement Design Report
Sturgeon Road & Murray Park Road Roundabout
Winnipeg, Manitoba

Prepared for:
Stantec Consulting Ltd.
100 – 1355 Taylor Avenue
Winnipeg, Manitoba R3M 3Y9

Prepared by:
Stantec Consulting Ltd.
49 Frederick Street
Kitchener, ON N2H 6M7

February 26, 2015

Table of Contents

1.0 Introduction

It is understood that existing Sturgeon Road and Murray Park Road/Silver Avenue intersection in Winnipeg, Manitoba will be replaced with a roundabout. The location of the intersection is depicted in Figure 1 below.

Asphalt and concrete pavement options were considered for the proposed roundabout, while only asphalt pavement options were considered for reconstructing the intersection approaches to the roundabout. The asphalt and concrete pavement design analysis for the proposed roundabout and approaches are provided in the following sections.

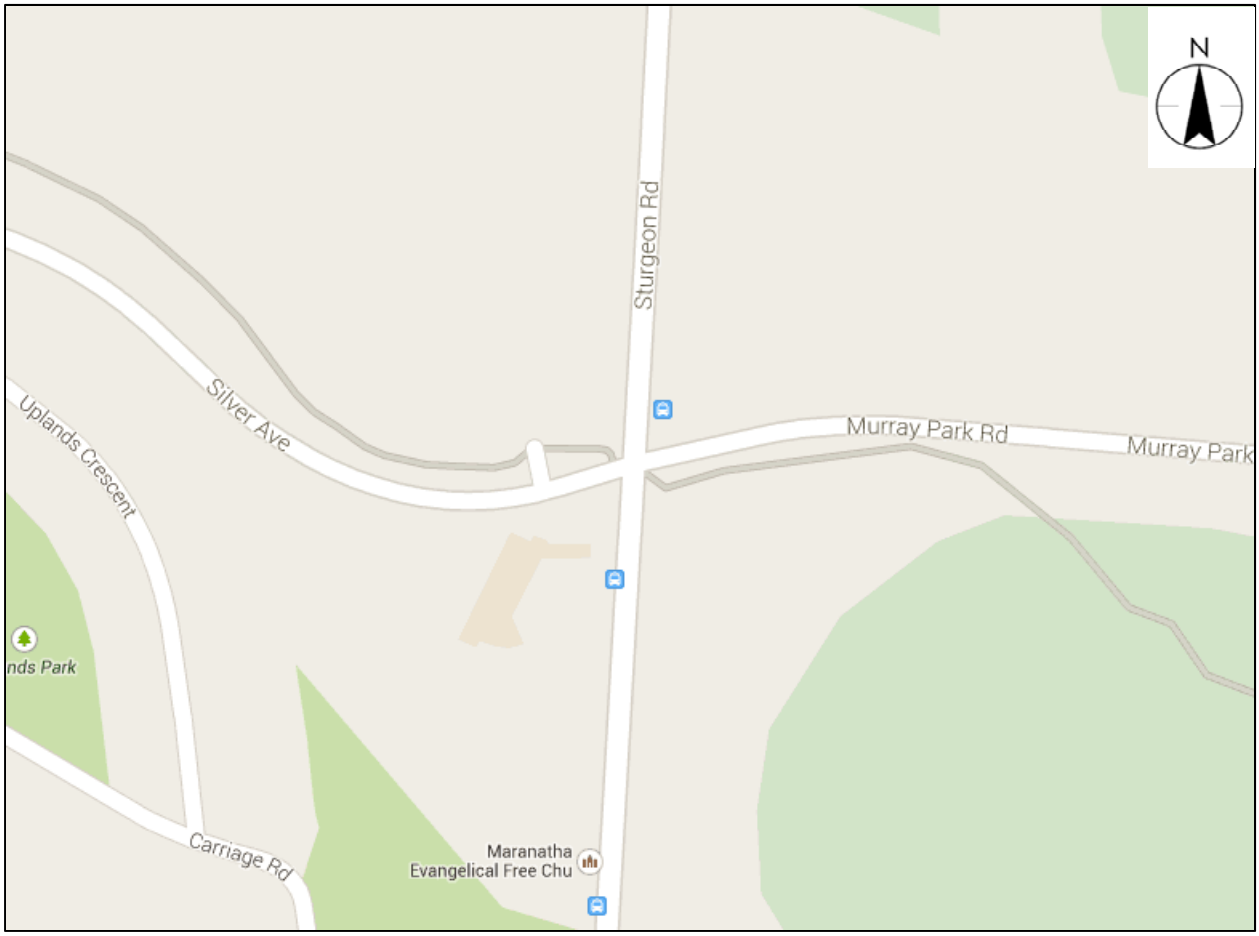


Figure 1: Project Location

2.0 Traffic

Traffic data including projected vehicles per day figures and truck percentages were provided by the City of Winnipeg. The traffic information used in the pavement design analysis is presented in Table 1 below.

Table 1: Traffic Data

Road	Section	Projected 2031 Vehicles Per Day (VPD)	% Comm	Projected 2031 Trucks per Day
Sturgeon Road	North Leg	28,000	12	3,360
	South Leg	25,000	8	2,000
Silver Avenue	West Leg	6,000	5	300
Murray Park Road	East Leg	14,000	12	1,680

Notes: Trucks per day derived from percentage commercial and projected vehicles per day.

Using peak traffic volumes provided by the City for 2014, 2021, and 2031 annual growth rates were calculated. The calculated traffic growth on Sturgeon Road, Murray Park Road, and Silver Avenue are approximately 12.1%, 7.8%, and 2.5% respectively per year from 2014 to 2021, and approximately 1.8%, 4%, and 3.1% respectively between 2022 and 2031.

Most pavement design procedures use a singular growth rate. An equivalent growth rate was calculated that equaled the same total cumulative traffic loads over a 25 and 40 year period as the dual growth rate model. The total cumulative traffic loads for 25 and 40 years under the dual growth rate and single grow rate models for the proposed roundabout for example, are presented in Figures 2 and 3 below.

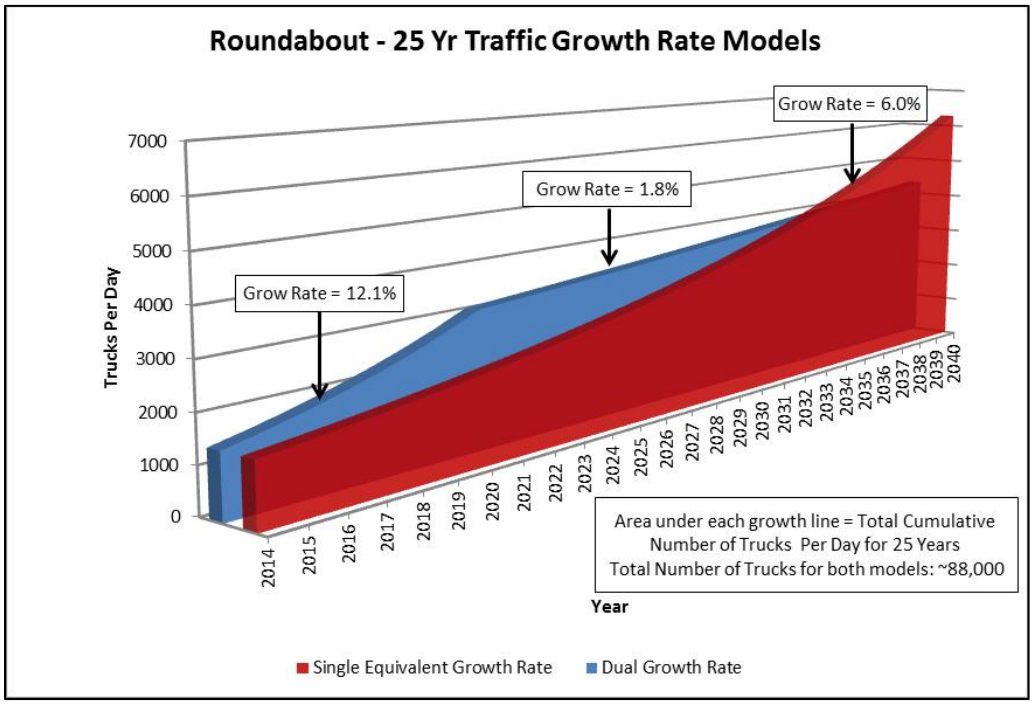


Figure 2: Sturgeon Rd & Murray Park Rd Roundabout, 25 Year Traffic Growth Rate Models

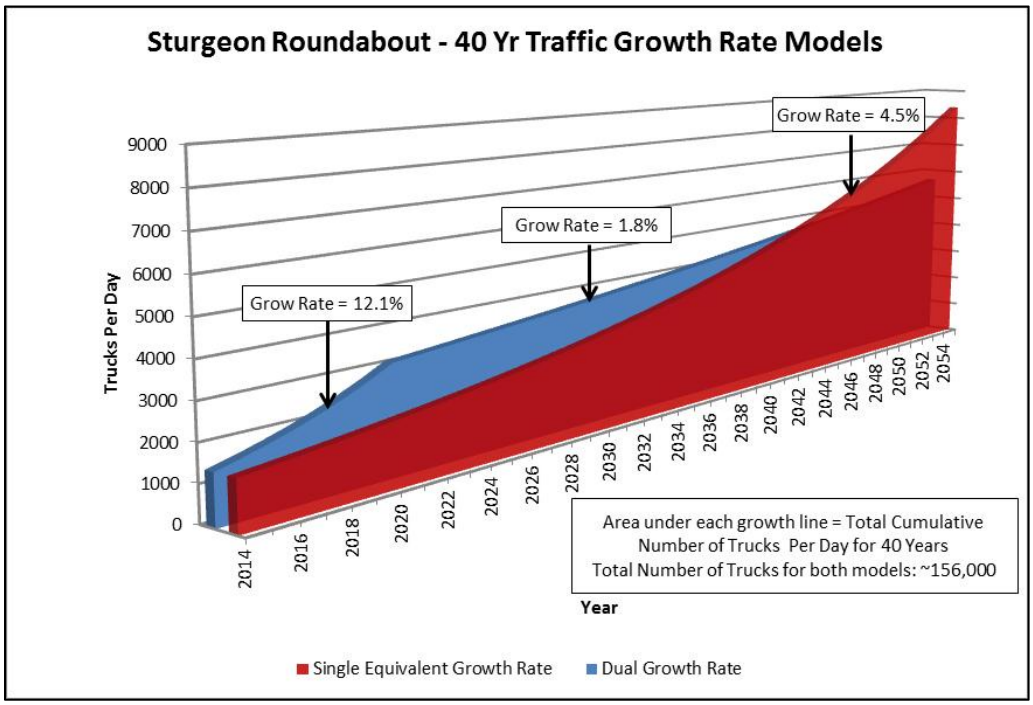


Figure 3: Sturgeon Rd & Murray Park Rd Roundabout, 40 Year Traffic Growth Rate Models

3.0 Pavement Design

The flexible pavement design analysis was completed using the AASHTO 1993 *Guide for the Design of Pavement Structures*. The AASHTO 93 analysis Flexible Pavement Design was completed using a spreadsheet utility developed by Stantec Consulting Ltd. The analysis for a flexible pavement design incorporating geogrids was completed using Tensar's SpectraPave Pro 4 software. The concrete pavement was analyzed using the ACPA, StreetPave software.

The traffic loads are converted to an Equivalent Single Axle Load (ESAL) for use in the AASHTO pavement design procedure. The design ESALs are based on the total cumulative truck traffic loads over the design life.

For pavement design within the roundabout, design traffic loads were based on the procedures used by the Regional Municipality of Waterloo, Ontario for roundabout design. Using the Waterloo approach design traffic in the roundabout equals the total vehicles per day from all approaches divided in half. The design ESALs are presented in Table 2 below.

Information on the subgrade soils was not available at the time of writing. However, it is understood that the subgrade conditions for the City are generally uniform and consistent. Subgrade data used for this design is based on previous pavement designs completed by Stantec for the City.

Additional design parameter information was extracted from *The City of Winnipeg Construction Specification* documents. The design parameters used in the analysis are presented in Table 2 below.

Table 2: Pavement Design Parameters – Roundabout and Roundabout Approaches

Traffic **Roundabout**	Trucks Per Day: 3,670 (2031) Number of Lanes: 1 Annual Growth Rate: From 2014 to 2021: 12.1% From 2022 onwards: 1.8% Growth Rate for 25 Yrs of Total Cumulative Traffic: 6.0% Growth Rate for 40 Yrs of Total Cumulative Traffic: 4.5% 19.19 MESALS for 25 year design life 36.90 MESALS for 40 year design life	**SN Required** 167 181
Traffic **Sturgeon Road Approaches**	Trucks Per Day: 3,360 (2031) Number of Lanes: 1 Annual Growth Rate: From 2014 to 2021: 12.1% From 2022 onwards: 1.8% Growth Rate for 25 Yrs of Total Cumulative Traffic: 6.0% 17.59 MESALS for 25 year design life	**SN Required** 165

Traffic **Murray Park Road Approach**	Trucks Per Day: 1,680 (2031) Number of Lanes: 1 Annual Growth Rate: From 2014 to 2021: 7.8% From 2022 onwards: 4.0% Growth Rate for 25 Yrs of Total Cumulative Traffic: 5.4% 8.84 MESALS for 25 year design life	**SN Required** 151
Traffic **Silver Avenue Approach**	Trucks Per Day: 300 (2031) Number of Lanes: 1 Annual Growth Rate: From 2014 to 2021: 2.5% From 2022 onwards: 3.1% Growth Rate for 25 Yrs of Total Cumulative Traffic: 2.9% 1.30 MESALS for 25 year design life	**SN Required** 117
Design Life	25 years (Flexible) 40 years (Rigid)	
Reliability	90%	
Serviceability	Flexible Initial: 4.5 Terminal 2.5 Rigid Slabs Cracked at End of Design Life: 15%	
Asphalt Pavement Material Structural Layer Coefficients	**New Structures** Hot Mix Asphalt, Type 1A & Type III 20 mm crushed limestone base 50 mm crushed limestone subbase 150 mm crushed limestone subbase	**SLC** 0.42 0.12 0.10 0.08
Concrete Pavement Material Properties and Design Features	Flexural Strength: 5.0 MPa Elastic Modulus: 30 GPa	
Subgrade & Drainage	Firm to Stiff Silty Clay	M_R: 25 MPa K: 54 MPa/m

Using the design parameters noted above pavement options were developed for the roundabout and the roundabout approaches. The pavement deign options are presented in Tables 3 and 4 below.

Table 3: Pavement Design Options – Roundabout

Pavement Design Option	Pavement Structure Details	Service Life (yrs)
Roundabout **Asphalt Pavement**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • 1000 mm granular subbase (150 mm crushed limestone) **1,400 mm total thickness**	25

Pavement Design Option	Pavement Structure Details	Service Life (yrs)
Roundabout **Asphalt Pavement with Geogrid**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • Tensar BX1200 Geogrid • 850 mm granular subbase (150 mm crushed limestone) **1,250 mm total thickness**	25
Roundabout **Concrete Pavement**	• 230 mm plain doweled concrete • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • 400 mm granular subbase (150 mm crushed limestone) **880 mm total thickness ***	40+

Note: *Granular subbase thickness for the rigid pavement is based on local experience to provide buffering for frost action.

Table 4: Pavement Design Options – Roundabout Approaches

Pavement Design Option	Pavement Structure Details	Service Life (yrs)
Sturgeon Road Approaches **Asphalt Pavement**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • 950 mm granular subbase (150 mm crushed limestone) **1,350 mm total thickness**	25
Murray Park Road Approach **Asphalt Pavement**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • 800 mm granular subbase (150 mm crushed limestone) **1,200 mm total thickness**	25
Silver Avenue Approach **Asphalt Pavement**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • 350 mm granular subbase (150 mm crushed limestone) **750 mm total thickness**	25

Pavement Design Option	Pavement Structure Details	Service Life (yrs)
Sturgeon Road Approaches **Asphalt Pavement with Geogrid**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • Tensar BX1200 Geogrid • 800 mm granular subbase (150 mm crushed limestone) **1,200 mm total thickness**	25
Murray Park Road Approach **Asphalt Pavement with Geogrid**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 100 mm granular base (19 mm crushed limestone) • 150 mm granular subbase (50 mm crushed limestone) • Tensar BX1200 Geogrid • 650 mm granular subbase (150 mm crushed limestone) **1,050 mm total thickness**	25
Silver Avenue Approach **Asphalt Pavement with Geogrid**	• 150 mm hot mix asphalt (65 mm Type 1A Surface Course on 85 mm Type III Binder Course) • 150 mm granular base (19 mm crushed limestone) • Tensar BX1200 Geogrid • 250 mm granular subbase (50 mm crushed limestone) **550 mm total thickness**	25

3.1 Concrete Pavement Joint Design

Joint spacing and dowel sizes are based on the design traffic volumes in the StreetPave software. For the design thickness and percent cracked slabs noted above, the maximum joint spacing is approximately 4.7 m as per Figure 3.4.1.15 in the Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures dated March 2004.

The dowel bar sizes recommended in StreetPave is 28.6 mm for slab thickness varying from 200 mm to 250 mm.

4.0 Closure

This report presents the results of a pavement design analysis completed by Stantec for the City of Winnipeg.

This report was prepared by Stantec Consulting, and reflects Stantec Consulting's best judgment in light of the information available at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the

responsibility of such third parties. Stantec Consulting accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We trust the information presented herein meets your present requirements. Should you have any questions for comments please call:

Stantec Consulting Ltd.

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Report Author
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Appendix A: Pavement Design Analysis

Appendix A: Pavement Design Analysis

1993 AASHTO Flexible Pavement Design

Stantec

AASHTO Version 2.0

Project	City of Winnipeg
Location	Roundabout
Date / Time	1/22/2015 13:47
JWA Analyser	LW

Flexible Design Input Parameters

Design Lane 18-kip ESALs Over Initial Performance Period	19,187,157	
Initial Serviceability	4.5	
Terminal Serviceability	2.5	
Reliability Level	90	%
Overall Standard Deviation	0.49	
Roadbed Soil Resilient Modulus	25.00	MPa
Calculated Design Structural Number	166.81	mm

Specified Layer Design

Layer	Material Description	Struct. Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Calculated SN (mm)
1	Asphalt	0.42	1	150.00	63.00
2	19mm Base	0.12	1	100.00	12.00
3	50mm Subbase	0.1	1	150.00	15.00
4	150mm Subbase	0.08	1	1000.00	80.00
Total	-	-	-	1400.00	170.00

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Figure A.1: AASHTO 93 Pavement Design Analysis for Roundabout – 25 Year Design Life

Appendix A: Pavement Design Analysis

1993 AASHTO Flexible Pavement Design

Stantec

AASHTO Version 2.0
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Project	City of Winnipeg
Location	Sturgeon Rd Approaches
Date / Time	1/22/2015 11:07
JWA Analyser	LW

Flexible Design Input Parameters

Design Lane 18-kip ESALs Over Initial Performance Period	17,588,228	
Initial Serviceability	4.5	
Terminal Serviceability	2.5	
Reliability Level	90	%
Overall Standard Deviation	0.49	
Roadbed Soil Resilient Modulus	25.00	MPa
Calculated Design Structural Number	164.97	mm

Specified Layer Design

Layer	Material Description	Struct. Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Calculated SN (mm)
1	Asphalt	0.42	1	150.00	63.00
2	19mm Base	0.12	1	100.00	12.00
3	50mm Subbase	0.1	1	150.00	15.00
4	150mm Subbase	0.08	1	950.00	76.00
Total	-	-	-	1350.00	166.00

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Figure A.2: AASHTO 93 Pavement Design Analysis for Sturgeon Road Approaches – 25 Year Design Life

Appendix A: Pavement Design Analysis

1993 AASHTO Flexible Pavement Design

Stantec

AASHTO Version 2.0

Project	City of Winnipeg
Location	Murray Park Rd Approach
Date / Time	1/22/2015 13:25
JWA Analyser	LW

Flexible Design Input Parameters

Design Lane 18-kip ESALs Over Initial Performance Period	8,834,472	
Initial Serviceability	4.5	
Terminal Serviceability	2.5	
Reliability Level	90	%
Overall Standard Deviation	0.49	
Roadbed Soil Resilient Modulus	25.00	MPa
Calculated Design Structural Number	151.03	mm

Specified Layer Design

Layer	Material Description	Struct. Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Calculated SN (mm)
1	Asphalt	0.42	1	150.00	63.00
2	19mm Base	0.12	1	100.00	12.00
3	50mm Subbase	0.1	1	150.00	15.00
4	150mm Subbase	0.08	1	800.00	64.00
Total	-	-	-	1200.00	154.00

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Figure A.3: AASHTO 93 Pavement Design Analysis for Murray Park Road Approaches – 25 Year Design Life

Appendix A: Pavement Design Analysis

1993 AASHTO Flexible Pavement Design

Stantec

AASHTO Version 2.0

Project	City of Winnipeg
Location	Silver Ave Approach
Date / Time	1/22/2015 13:25
JWA Analyser	LW

Flexible Design Input Parameters

Design Lane 18-kip ESALs Over Initial Performance Period	1,298,641	
Initial Serviceability	4.5	
Terminal Serviceability	2.5	
Reliability Level	90	%
Overall Standard Deviation	0.49	
Roadbed Soil Resilient Modulus	25.00	MPa
Calculated Design Structural Number	116.50	mm

Specified Layer Design

Layer	Material Description	Struct. Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Calculated SN (mm)
1	Asphalt	0.42	1	150.00	63.00
2	19mm Base	0.12	1	100.00	12.00
3	50mm Subbase	0.1	1	150.00	15.00
4	150mm Subbase	0.08	1	350.00	28.00
Total	-	-	-	750.00	118.00

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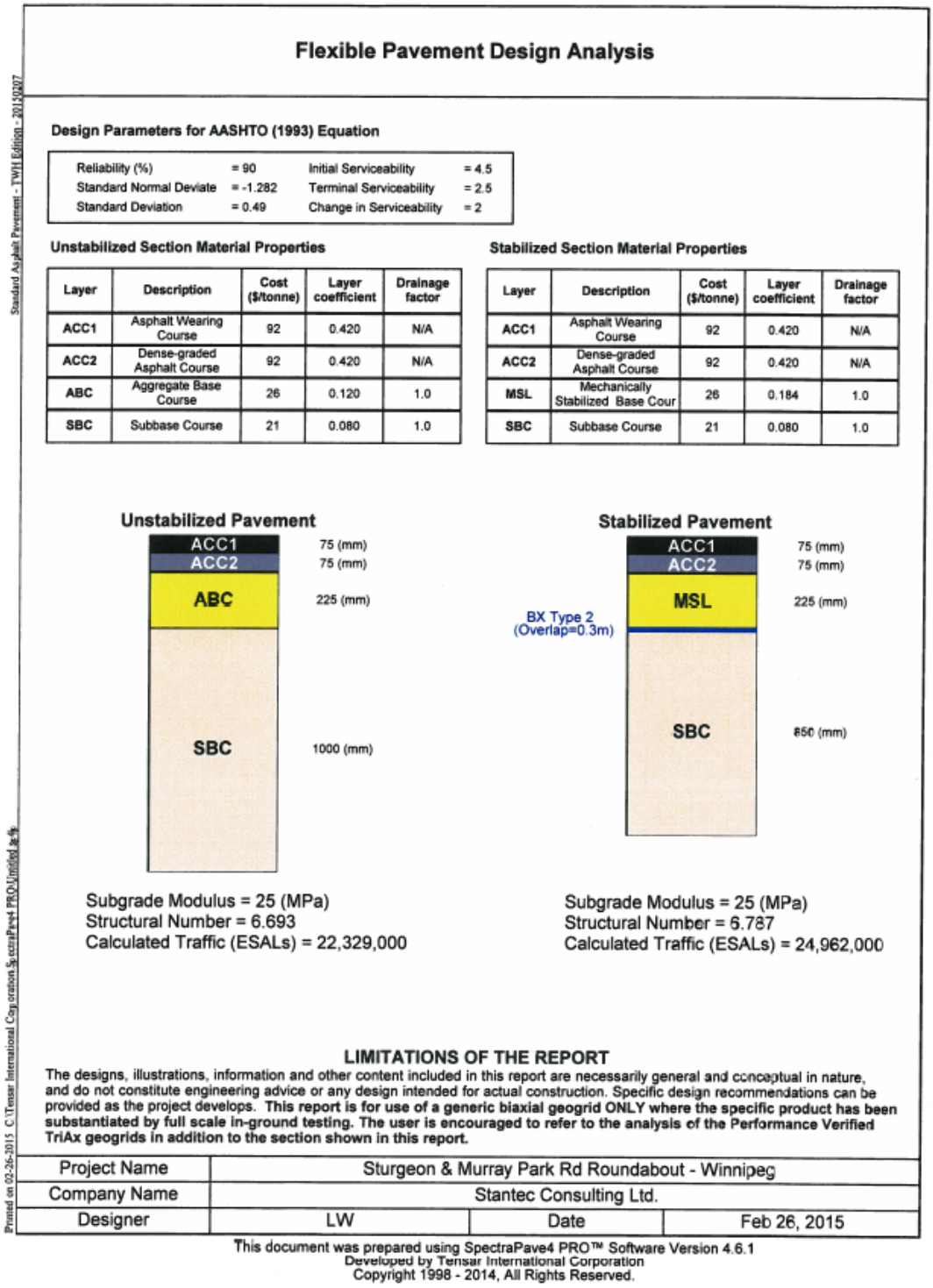
Figure A.4: AASHTO 93 Pavement Design Analysis for Silver Avenue Approaches – 25 Year Design Life

Appendix A: Pavement Design Analysis



Flexible Pavement Design Analysis

Standard Asphalt Pavement - TWH Edition - 20130207

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 90	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.282	Terminal Serviceability	= 2.5
Standard Deviation	= 0.49	Change in Serviceability	= 2

Unstabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
ABC	Aggregate Base Course	26	0.120	1.0
SBC	Subbase Course	21	0.080	1.0

Stabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
MSL	Mechanically Stabilized Base Cour	26	0.184	1.0
SBC	Subbase Course	21	0.080	1.0

Unstabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.693
Calculated Traffic (ESALs) = 22,329,000

Stabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.787
Calculated Traffic (ESALs) = 24,962,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops. **This report is for use of a generic biaxial geogrid ONLY where the specific product has been substantiated by full scale in-ground testing. The user is encouraged to refer to the analysis of the Performance Verified TriAx geogrids in addition to the section shown in this report.**

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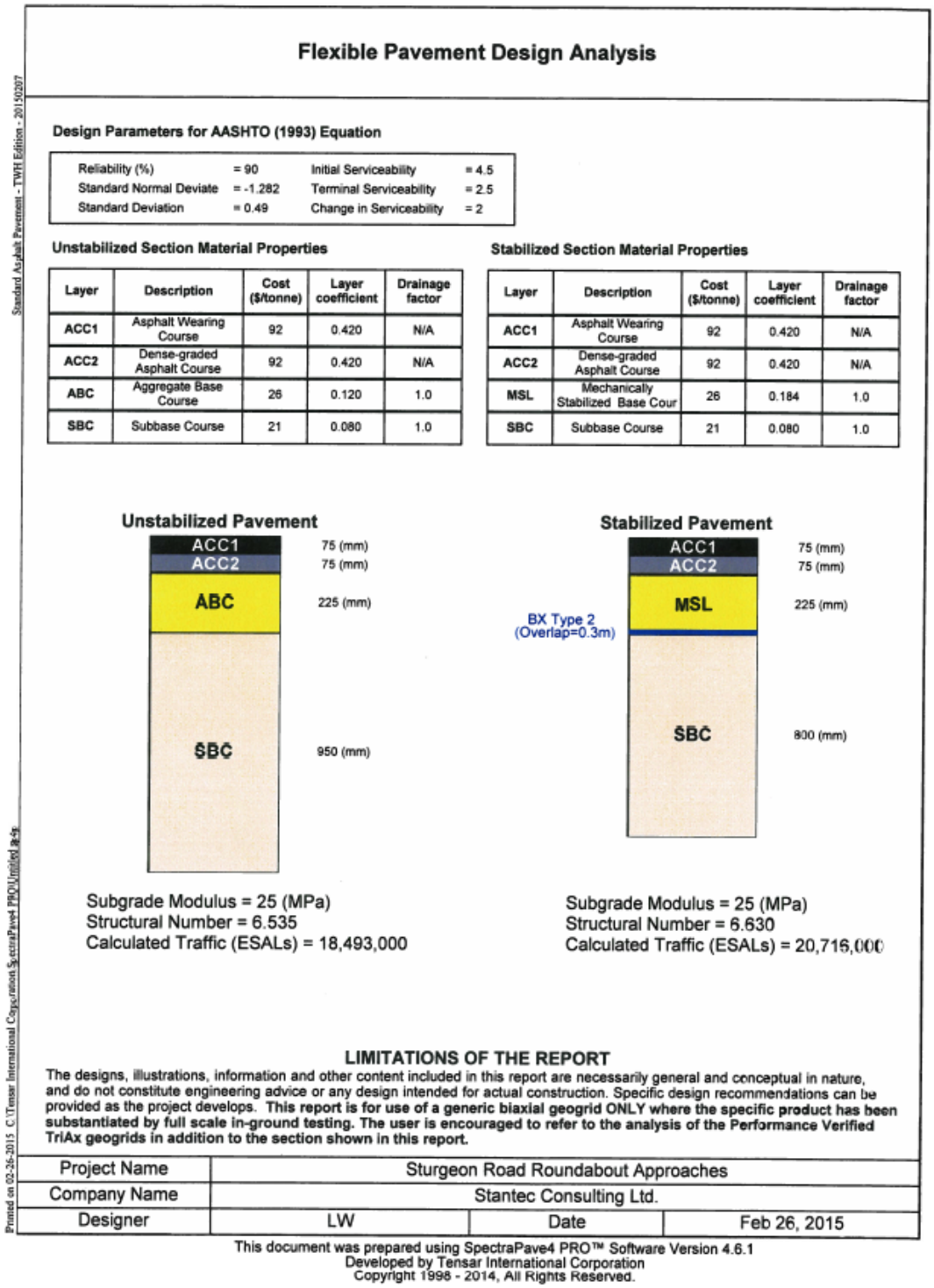
Project Name	Sturgeon & Murray Park Rd Roundabout - Winnipeg		
Company Name	Stantec Consulting Ltd.		
Designer	LW	Date	Feb 26, 2015

This document was prepared using SpectraPave4 PRO™ Software Version 4.6.1
Developed by Tensar International Corporation

Figure A.5: SpectraPave Flexible Pavement Design Analysis with Geogrid for Roundabout – 25 Year Design Life

Appendix A: Pavement Design Analysis



Flexible Pavement Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 90	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.282	Terminal Serviceability	= 2.5
Standard Deviation	= 0.49	Change in Serviceability	= 2

Unstabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
ABC	Aggregate Base Course	26	0.120	1.0
SBC	Subbase Course	21	0.080	1.0

Stabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
MSL	Mechanically Stabilized Base Cour	26	0.184	1.0
SBC	Subbase Course	21	0.080	1.0

Unstabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.535
Calculated Traffic (ESALs) = 18,493,000

Stabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.630
Calculated Traffic (ESALs) = 20,716,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops. **This report is for use of a generic biaxial geogrid ONLY where the specific product has been substantiated by full scale in-ground testing. The user is encouraged to refer to the analysis of the Performance Verified TriAx geogrids in addition to the section shown in this report.**

Project Name	Sturgeon Road Roundabout Approaches		
Company Name	Stantec Consulting Ltd.		
Designer	LW	Date	Feb 26, 2015

This document was prepared using SpectraPave4 PRO™ Software Version 4.6.1
Developed by Tensar International Corporation
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Standard Asphalt Pavement - TWH Edition - 20150207

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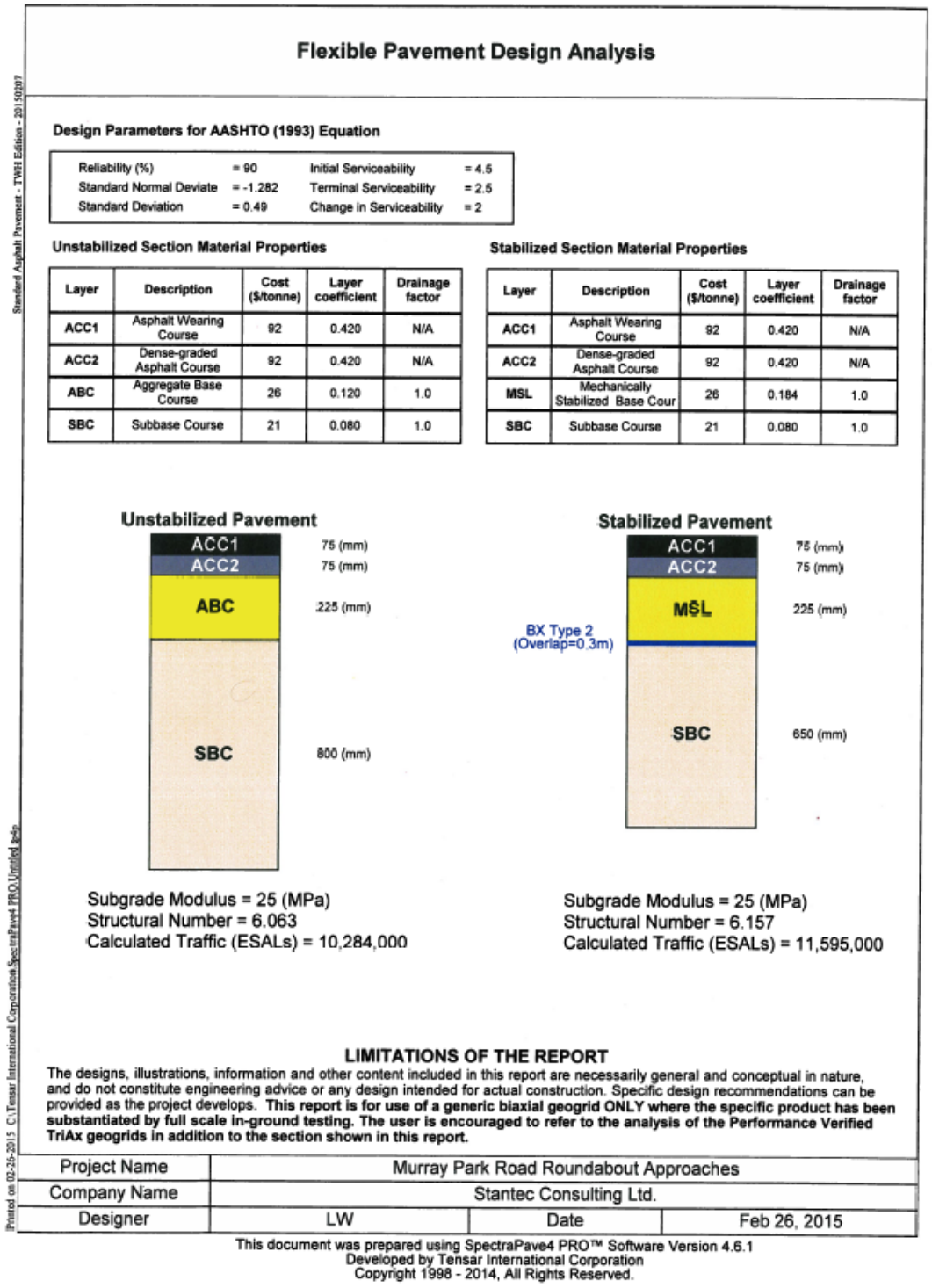
Figure A.6: SpectraPave Flexible Pavement Design Analysis with Geogrid for Sturgeon Road Approaches – 25 Year Design Life

Appendix A: Pavement Design Analysis



Flexible Pavement Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 90	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.282	Terminal Serviceability	= 2.5
Standard Deviation	= 0.49	Change in Serviceability	= 2

Unstabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
ABC	Aggregate Base Course	26	0.120	1.0
SBC	Subbase Course	21	0.080	1.0

Stabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
MSL	Mechanically Stabilized Base Cour	26	0.184	1.0
SBC	Subbase Course	21	0.080	1.0

Unstabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.063
Calculated Traffic (ESALs) = 10,284,000

Stabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 6.157
Calculated Traffic (ESALs) = 11,595,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops. **This report is for use of a generic biaxial geogrid ONLY where the specific product has been substantiated by full scale in-ground testing. The user is encouraged to refer to the analysis of the Performance Verified TriAx geogrids in addition to the section shown in this report.**

Project Name	Murray Park Road Roundabout Approaches		
Company Name	Stantec Consulting Ltd.		
Designer	LW	Date	Feb 26, 2015

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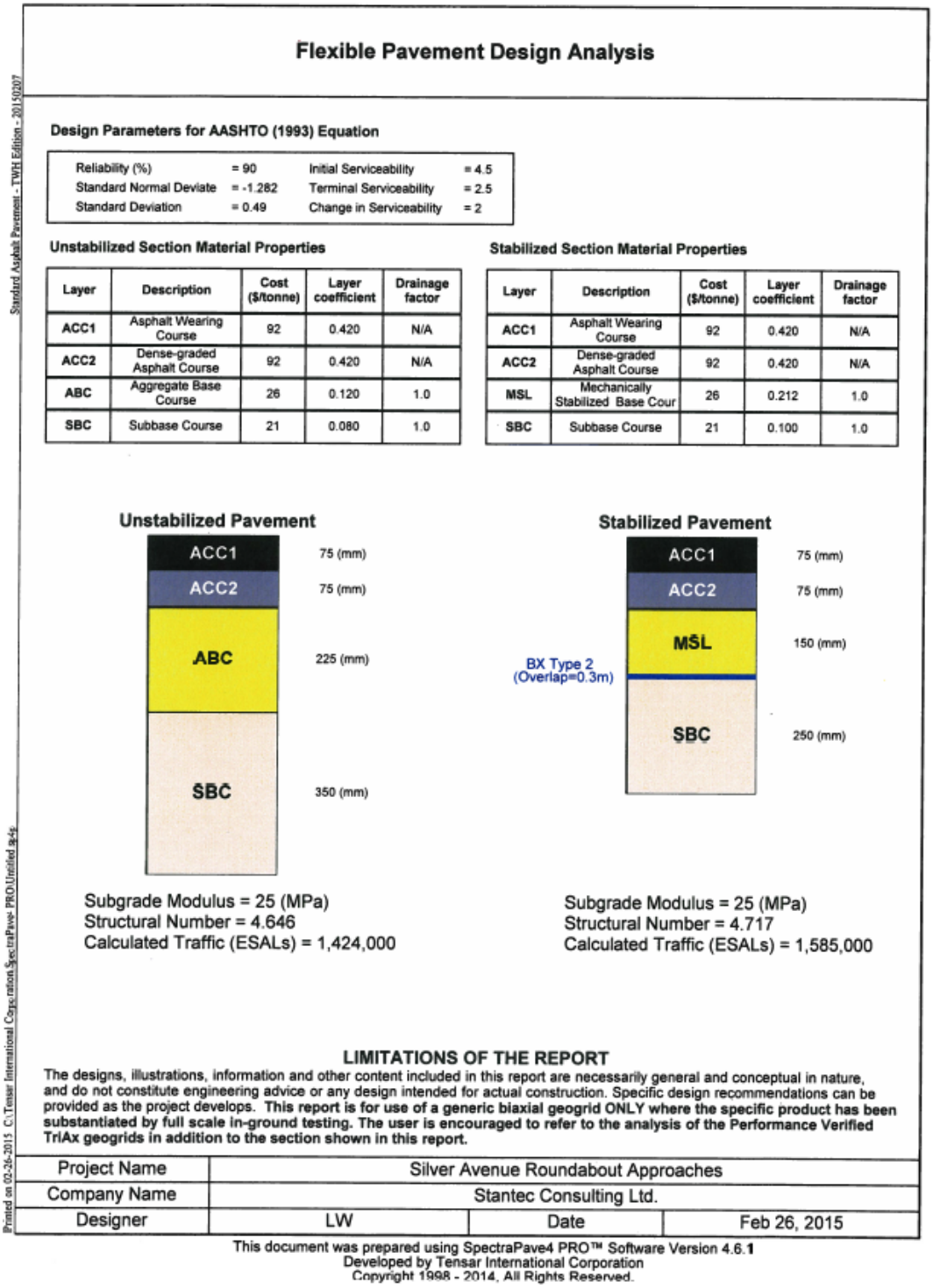
Figure A.7: SpectraPave Flexible Pavement Design Analysis with Geogrid for Murray Park Road Approaches – 25 Year Design Life

Appendix A: Pavement Design Analysis



Flexible Pavement Design Analysis

Design Parameters for AASHTO (1993) Equation

Reliability (%)	= 90	Initial Serviceability	= 4.5
Standard Normal Deviate	= -1.282	Terminal Serviceability	= 2.5
Standard Deviation	= 0.49	Change in Serviceability	= 2

Unstabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
ABC	Aggregate Base Course	26	0.120	1.0
SBC	Subbase Course	21	0.080	1.0

Stabilized Section Material Properties

Layer	Description	Cost ($/tonne)	Layer coefficient	Drainage factor
ACC1	Asphalt Wearing Course	92	0.420	N/A
ACC2	Dense-graded Asphalt Course	92	0.420	N/A
MSL	Mechanically Stabilized Base Cour	26	0.212	1.0
SBC	Subbase Course	21	0.100	1.0

Unstabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 4.646
Calculated Traffic (ESALs) = 1,424,000

Stabilized Pavement

Subgrade Modulus = 25 (MPa)
Structural Number = 4.717
Calculated Traffic (ESALs) = 1,585,000

LIMITATIONS OF THE REPORT

The designs, illustrations, information and other content included in this report are necessarily general and conceptual in nature, and do not constitute engineering advice or any design intended for actual construction. Specific design recommendations can be provided as the project develops. **This report is for use of a generic biaxial geogrid ONLY where the specific product has been substantiated by full scale in-ground testing. The user is encouraged to refer to the analysis of the Performance Verified TriAx geogrids in addition to the section shown in this report.**

Project Name	Silver Avenue Roundabout Approaches		
Company Name	Stantec Consulting Ltd.		
Designer	LW	Date	Feb 26, 2015

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Figure A.8: SpectraPave Flexible Pavement Design Analysis with Geogrid for Silver Avenue Approach – 25 Year Design Life

StreetPave 12

Report for Concrete Pavement Design

Project Name: Sturgeon & Murray Park Rd Roundabout
Route: Sturgeon Road & Murray Park Road
Location: Winnipeg, Manitoba
Project Description:
Owner/Agency: City of Winnipeg, Manitoba
Design Engineer: LW

Recommended Concrete Pavement Design

Min. Required Thickness = 195.58 mm

Design Thickness = 200.00 mm

Max. Joint Spacing = 4.57 m

Failure Controlled By = Faulting

Rounding Considerations:

Thickness Adjustment	Thickness (mm)	Reliability at Specified Design Life (%)	Theoretical Life at Specified Reliability (yrs)
Rounded-Down	187.30	<25	31
None (As-Designed)	195.58	90	40
Rounded-Up (Recommended)	200.00	98.6	44

Inputs

Design Life: 40 years

Reliability

Reliability: 90 %

Percent of Slabs Cracked at End of Design Life: 15 %

Traffic

Traffic Category: Minor Arterial

Direction Distribution: 50

Design Lane Distribution: 100

Trucks per Day (two-way, at time of construction: 1500 per day

Truck Traffic Growth: 4.5 % per year

Rigid ESALs =

Support Conditions

Subgrade

Resilient Modulus of the Subgrade 25.00 MPa

Subbase

Top Layer: Not Selected
Modulus: 0 MPa
Thickness : 0 mm

Layer 2: Not Selected
Modulus: 0 MPa
Thickness: 0 mm

Layer 3: Not Selected
Modulus: 0 MPa
Thickness: 0 mm

Composite Modulus of Subgrade Reaction (k-Value):

k = 54 MPa/m

Concrete Properties

28-Day Flexural Strength (MR): 5 MPa

Macrofibers in Concrete? No

Residual Strength: N/A %

Modulus of Elasticity (E): 33750 MPa

Modulus of Elasticity (E) = 6750 x MR

Design Features

Load Transfer Devices (Dowel Bars)? No

Diameter = NA

Edge Support Provided? Yes
(e.g., tied concrete shoulder, curb and gutter, or widened lane)

Fatigue & Erosion Calculations

Traffic Category: Minor Arterial			Cracking Analysis			Faulting Analysis		
Axle Load, kips	Axles per 1000 Trucks	Expected Repetitions	Stress Ratio	Allowable Repetitions	Fatigue Consumed	Power	Allowable Repetitions	Erosion Consumed
Single Axles								
133.4	0.45	13194	0.484	1649878	0.8	25.096	340595	3.87
124.5	0.85	24922	0.454	15205056	0.16	21.859	547943	4.55
115.6	1.78	52189	0.423	242888635	0.02	18.846	951241	5.49
106.8	5.21	152755	0.393	unlimited	0	16.086	1839421	8.3
97.9	7.85	230159	0.362	unlimited	0	13.517	4383425	5.25
89	16.33	478789	0.331	unlimited	0	11.171	16636019	2.88
80.1	25.15	737388	0.3	unlimited	0	9.048	unlimited	0.01
71.2	31.82	932950	0.269	unlimited	0	7.15	unlimited	0.01
62.3	47.73	1399425	0.237	unlimited	0	5.474	unlimited	0.01
53.4	182.02	5336757	0.205	unlimited	0	4.022	unlimited	0.05
Tandem Axles								
231.3	1.19	34890	0.362	unlimited	0	23.918	400529	8.71
213.5	2.91	85320	0.336	unlimited	0	20.379	706740	12.07
195.7	8.01	234850	0.309	unlimited	0	17.122	1402663	16.74
177.9	21.31	624801	0.283	unlimited	0	14.149	3417845	18.28
160.1	56.25	1649229	0.256	unlimited	0	11.459	13341008	12.36
142.3	103.63	3038392	0.229	unlimited	0	9.053	unlimited	0.04
124.5	121.22	3554124	0.202	unlimited	0	6.93	unlimited	0.03
106.8	72.54	2126845	0.175	unlimited	0	5.099	unlimited	0.02
89	85.94	2519728	0.148	unlimited	0	3.541	unlimited	0.02
71.2	99.34	2912611	0.12	unlimited	0	2.266	unlimited	0.03
Tridem Axles								
311.4	0	0	0.292	unlimited	0	143.685	2113	0
284.7	0	0	0.268	unlimited	0	120.102	3510	0
258	0	0	0.244	unlimited	0	98.631	6111	0
231.3	0	0	0.22	unlimited	0	79.273	11288	0
204.6	0	0	0.196	unlimited	0	62.028	22532	0
177.9	0	0	0.172	unlimited	0	46.895	50104	0
151.2	0	0	0.148	unlimited	0	33.875	131274	0
124.5	0	0	0.123	unlimited	0	22.968	460499	0
97.9	0	0	0.098	unlimited	0	14.202	3352247	0
71.2	0	0	0.073	unlimited	0	7.512	unlimited	0
			Total Fatigue Used %:		**3.61**	**Total Erosion Used %:**		**94.94**

Appendix D
Opinion of Probable Cost – Preferred Alignment of One-Lane Roundabout Option 1 and Option 2

Sturgeon Road at Murray Park Road / Silver Avenue
Recommended Alignment - One-Lane Roundabout - Option 1
On-Line to Existing Intersection, High-Speed SB Approach with Slip-Lanes EB-SB & WB-NB
Class "D" Opinion of Probable Cost

	DESCRIPTION OF WORK	Quantity	Unit	Unit Price	Cost	Rounded Costs
	Construction Access Road	1	ea.	$200,000.00	$200,000.00	$200,000.00
	Asphalt Pavement Removals	3,800	s.m.	$5.00	$19,000.00	$20,000.00
	Sidewalk Removals	100	s.m.	$12.00	$1,200.00	$1,500.00
	Path Removals	175	s.m.	$12.00	$2,100.00	$2,500.00
	Asphalt Road Construction	680	l.m.	$1,300.00	$884,000.00	$884,000.00
	Concrete Road Construction	3,200	s.m.	$205.00	$656,000.00	$660,000.00
	Curb Installation					
	- barrier curb	720	l.m.	$65.00	$46,800.00	$47,000.00
	- modified barrier curb	470	l.m.	$70.00	$32,900.00	$33,000.00
	- lip curb	125	l.m.	$45.00	$5,625.00	$6,000.00
	- ramp curb	70	l.m.	$80.00	$5,600.00	$6,000.00
	Concrete Median	865	s.m.	$110.00	$95,150.00	$96,000.00
	Brick Pavers	330	s.m.	$125.00	$41,250.00	$42,000.00
	Detectable Warning Surface Tiles	28	ea.	$380.00	$10,640.00	$11,000.00
	Installation of New Sidewalk	275	s.m.	$85.00	$23,375.00	$24,000.00
	Installation of New MUP	350	s.m.	$100.00	$35,000.00	$35,000.00
	Ditching	1,200	l.m.	$30.00	$36,000.00	$36,000.00
	New Transit Stops	2	ea.	$8,000.00	$16,000.00	$16,000.00
	Driveway Renewals	2	ea.	$15,000.00	$30,000.00	$30,000.00
	Rough Grading Abandoned Road Alignment	1	ea.	$15,000.00	$15,000.00	$15,000.00
	Grading	11,000	s.m.	$2.50	$27,500.00	$28,000.00
	Topsoil and Sod	5,000	s.m.	$10.00	$50,000.00	$50,000.00
	Topsoil and Hydroseeding	6,000	s.m.	$6.00	$36,000.00	$36,000.00
	New Signing / Striping	1	ea.	$25,000.00	$25,000.00	$25,000.00
	Sub-Total Construction Cost					$2,304,000.00
	20% Contingencies					$460,800.00
	Sub-Total Construction Cost					$2,764,800.00
	15% Engineering					$414,720.00
	Sub-Total Project Cost					**$3,179,520.00**
	ROUND					***$3,200,000.00***
	Other Costs					
	Manitoba Hydro Relocations					???
	MTS Relocations					???

Sturgeon Road at Murray Park Road / Silver Avenue
Recommended Alignment - One-Lane Roundabout - Option 2
East of Existing Intersection, High-Speed SB Approach with Slip-Lanes EB-SB & WB-NB
Class "D" Opinion of Probable Cost

	DESCRIPTION OF WORK	Quantity	Unit	Unit Price	Cost	Rounded Costs
	Construction Access Road	1	ea.	$200,000.00	$200,000.00	$200,000.00
	Asphalt Pavement Removals	6,000	s.m.	$5.00	$30,000.00	$30,000.00
	Sidewalk Removals	370	s.m.	$12.00	$4,440.00	$4,500.00
	Path Removals	260	s.m.	$12.00	$3,120.00	$3,500.00
	Asphalt Road Construction	1,700	l.m.	$1,300.00	$2,210,000.00	$2,210,000.00
	Concrete Road Construction	3,200	s.m.	$205.00	$656,000.00	$656,000.00
	Curb Installation					
	- barrier curb	870	l.m.	$65.00	$56,550.00	$57,000.00
	- modified barrier curb	570	l.m.	$70.00	$39,900.00	$40,000.00
	- lip curb	125	l.m.	$45.00	$5,625.00	$6,000.00
	- ramp curb	70	l.m.	$80.00	$5,600.00	$6,000.00
	Concrete Median	865	s.m.	$110.00	$95,150.00	$96,000.00
	Brick Pavers	330	s.m.	$125.00	$41,250.00	$42,000.00
	Detectable Warning Surface Tiles	28	ea.	$380.00	$10,640.00	$11,000.00
	Installation of New Sidewalk	715	s.m.	$85.00	$60,775.00	$61,000.00
	Installation of New MUP	200	s.m.	$100.00	$20,000.00	$20,000.00
	Ditching	1,600	l.m.	$30.00	$48,000.00	$48,000.00
	New Transit Stops	2	ea.	$8,000.00	$16,000.00	$16,000.00
	Driveway Renewals	2	ea.	$15,000.00	$30,000.00	$30,000.00
	Rough Grading Abandoned Road Alignment	1	ea.	$30,000.00	$30,000.00	$30,000.00
	Grading	25,000	s.m.	$2.50	$62,500.00	$65,000.00
	Topsoil and Sod	5,000	s.m.	$10.00	$50,000.00	$50,000.00
	Topsoil and Hydroseeding	20,000	s.m.	$6.00	$120,000.00	$120,000.00
	New Signing / Striping	1	ea.	$25,000.00	$25,000.00	$25,000.00
	Sub-Total Construction Cost					$3,827,000.00
	20% Contingencies					$765,400.00
	Sub-Total Construction Cost					$4,592,400.00
	15% Engineering					$688,860.00
	Sub-Total Project Cost					**$5,281,260.00**
	ROUND					***$5,300,000.00***
	Other Costs					
	Manitoba Hydro Relocations					???
	MTS Relocations					???