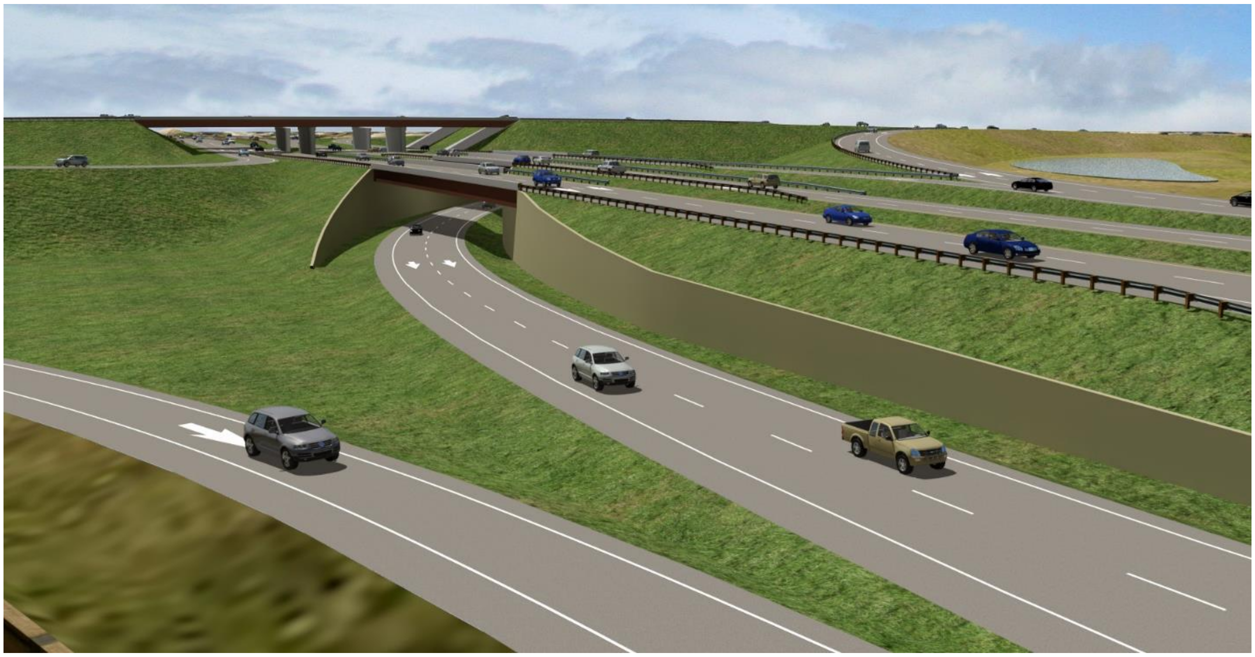

Highway 11 and 16 Interchange Functional Planning Study, Saskatoon, Saskatchewan

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Paper prepared for presentation at the

Geometric Design Considerations and Emerging Issues Session

of the 2018 Conference of the

Transportation Association of Canada

Saskatoon, SK

Background

In 2015, the City of Saskatoon began an important journey to upgrade the existing 1960s cloverleaf interchange at the junction of Highway 11 and Highway 16 in southern Saskatoon. Serving traffic from both the Yellowhead Highway and Circle Drive (the City's ring road), the interchange is nearing the end of its functional lifespan and has long been identified as a priority for improvement to relieve significant daily congestion, delays to goods movements and citizens, reduce collisions caused by stop and go and short weave conditions, and unnecessary emissions. Additionally, due to substandard 4.7 m vertical clearance under the overpass, high trucks collide with the structure on a regular basis. Refer to Figure 1 for the study area and Figure 2 for the existing interchange configuration.

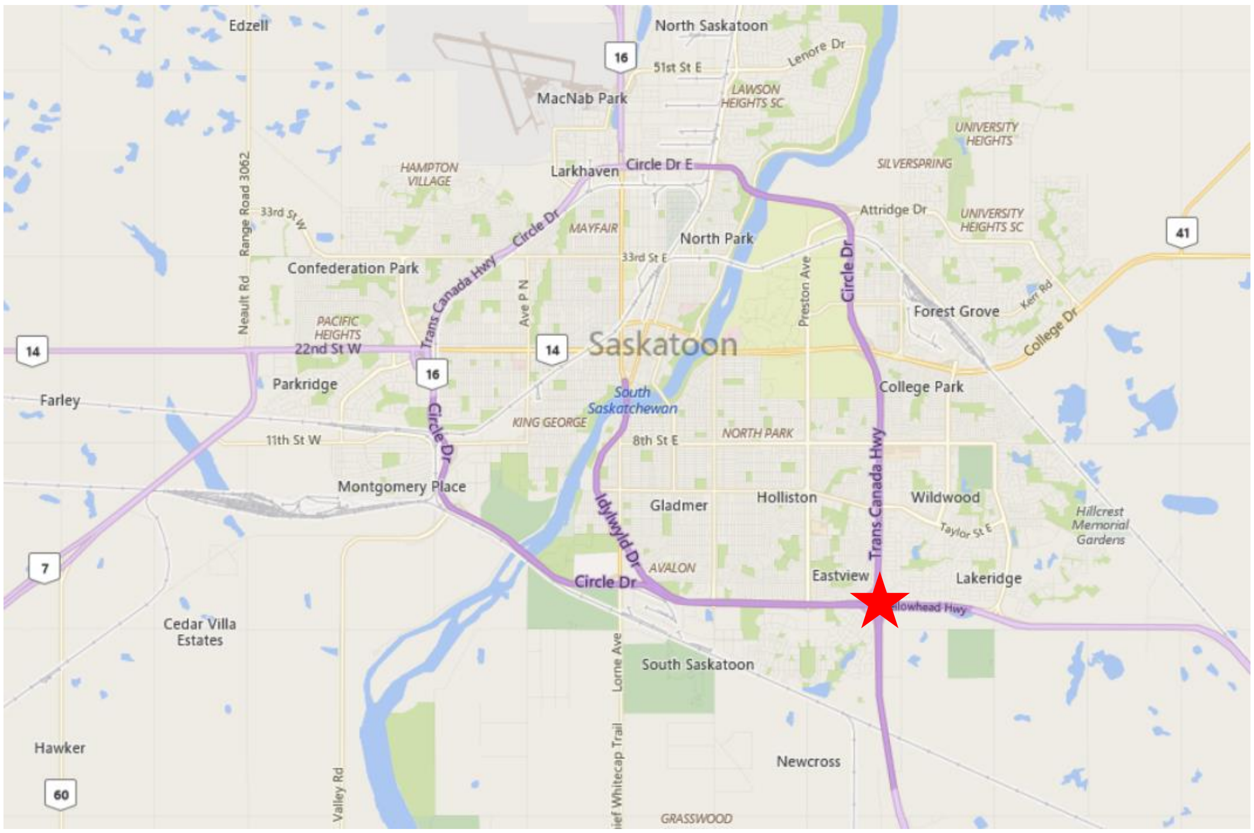


Figure 1: Project Location

Figure 2: Existing Cloverleaf Interchange, Looking South

To complicate the improvements, the existing interchange is located in an established area of Saskatoon, with residential development built up to the road right-of-way in three of the four quadrants. Access to these neighbourhoods is at adjacent interchanges, located between 1.2 km and 2.1 km from the cloverleaf interchange, refer to Figures 3 and 4. The proximity to these interchanges limits weaving opportunities and impacts traffic operations in the area.

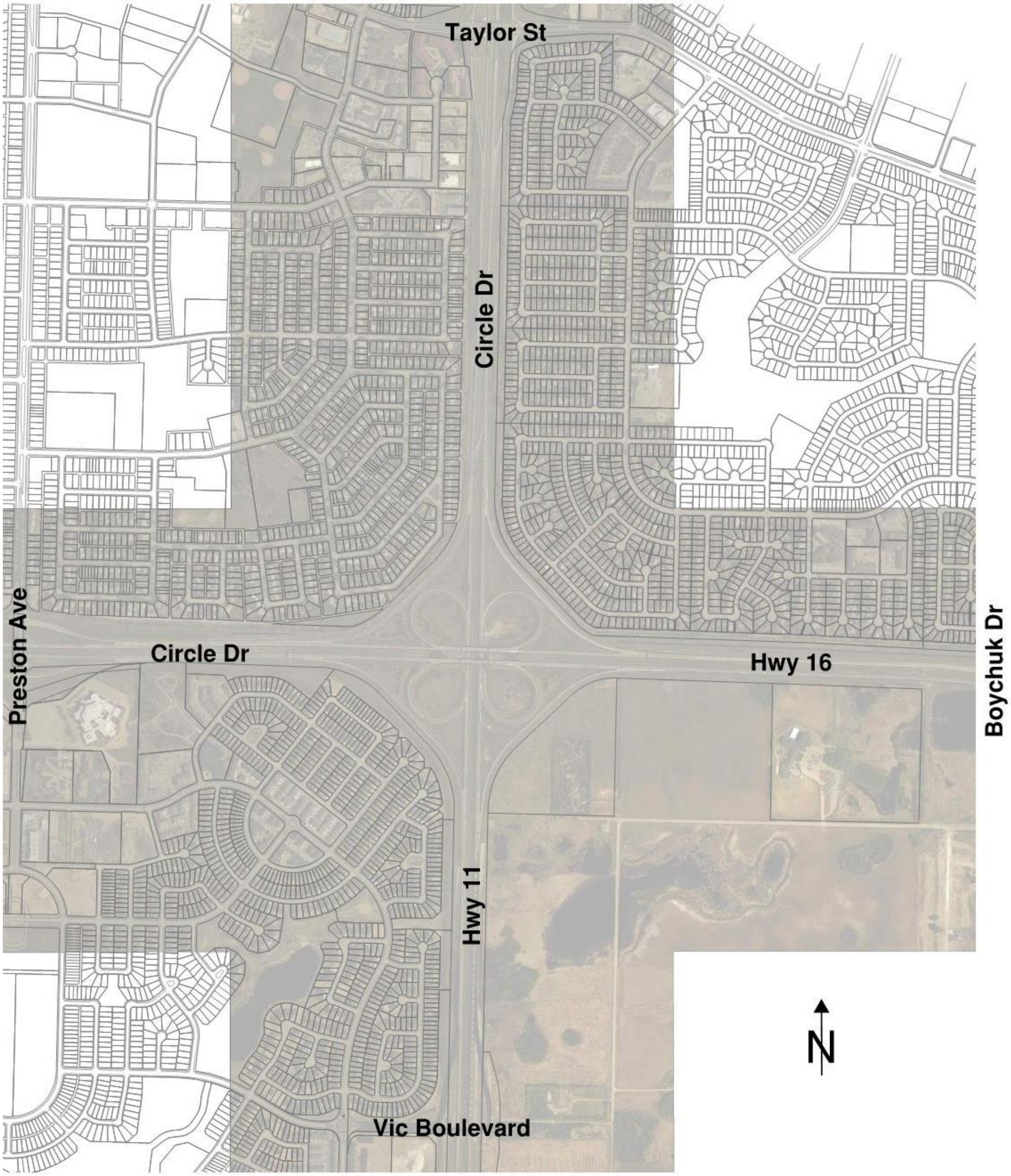


Figure 3: Study Area Map

Figure 4: Weave to Vic Boulevard

The City of Saskatoon retained ISL Engineering and Land Services (ISL) to complete a Functional Planning Study to improve overall traffic operations at this junction, both for the short- and long-term operations of the interchange to determine possible solutions to the collisions with the bridge structure due to the clearance issues. Specifically, this included:

- reducing collisions and improving safety;
- adding capacity for critical movements;
- facilitating good interconnections between the two provincial highways;
- minimizing environmental impacts;
- minimizing right-of-way acquisitions and impacts to adjacent lands; and
- optimizing costs and benefits.

Traffic Volumes

Representing a 260,000 population (in 2005), the existing traffic volumes show an atypical traffic pattern. The City's ring road, which includes the north and west legs of the interchange, serves significantly more traffic in the peak hours than the highway through volumes, resulting in the southbound right turn and eastbound left turn being the predominant turning movements within the interchange. The existing peak hour volumes are shown below in Figure 5.

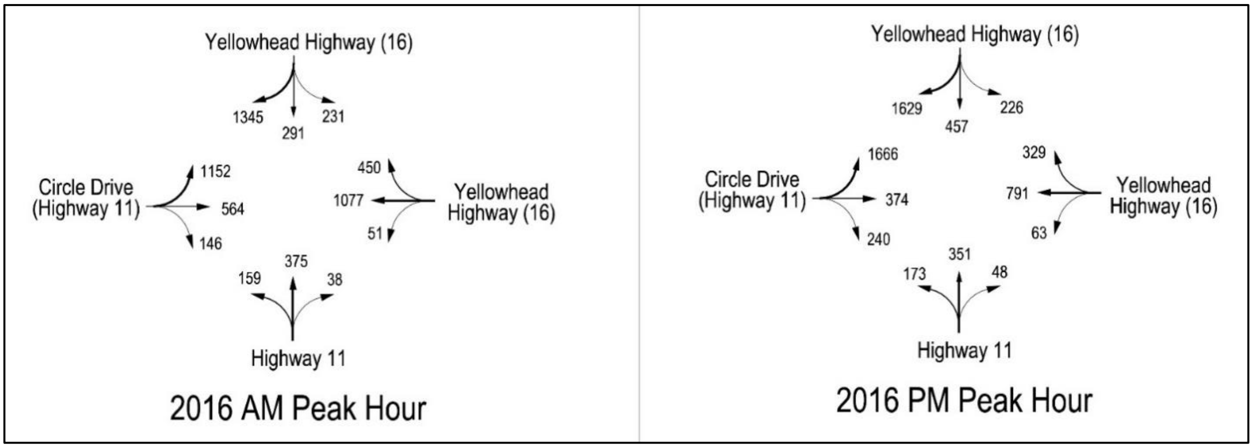


Figure 5: Existing Peak Hour Volumes

The future interchange was to be designed to accommodate traffic and population growth for the 500,000 population horizon, by approximately 2041. A review of the City's VISUM based Travel Demand Model (TDM) volumes for this time horizon showed overall growth in traffic through the interchange; however, the volumes for both the southbound right turn and eastbound left turn were considerably less than present volumes. These shortfalls could not be explained, so the project team developed an alternate set of project volumes based on existing volumes and a 2% growth scenario. The 2041 peak hour volumes are shown in Figure 6.

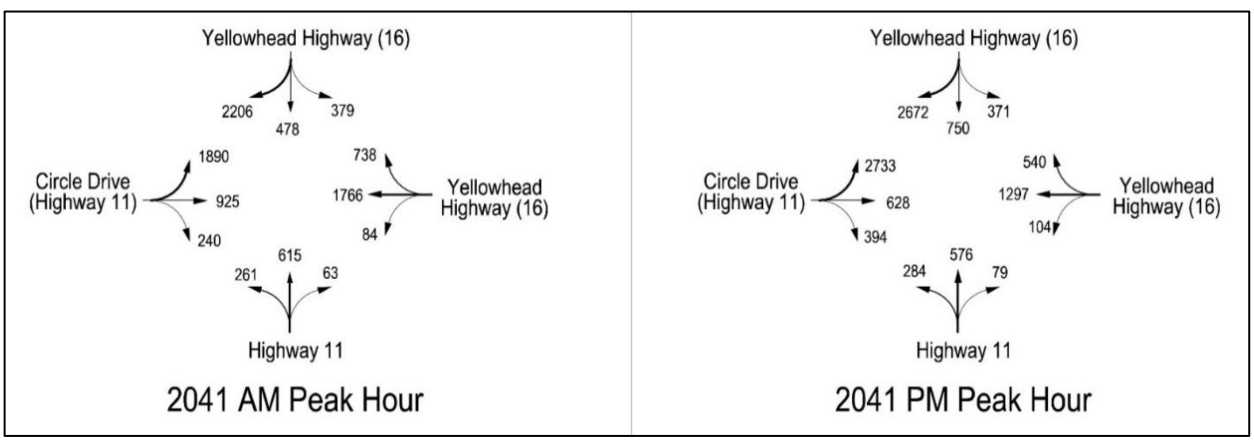


Figure 6: 2041 Project Volumes Based on 2% Growth

The two sets of future traffic volumes present difficulties in planning for the future. The TDM model predicts the existing high volume turning movements will be much lower than at present, thus the existing interchange may operate more effectively as travel patterns change over time. The 2% growth rate volumes present a very different problem, with those predominant turning movements much higher and likely requiring two free flow lanes. Subject to upstream lane configurations, it may not even be possible to feed such high volumes onto a double lane ramp. Both sets of traffic volumes were then tested on the future interchange configurations to ensure the design was robust, and could handle either scenario.

Collision History

Historical data from 2010 to 2015 showed that 44% of collisions at the interchange were rear-end collisions. Due to the stop-and-go conditions, which currently exist within the short weave sections between the cloverleaf loop ramps and at the yield conditions on the ramps, these of collisions are to be expected. It is expected that without substantial changes, the frequency of such collisions will continue to increase as traffic volumes rise.

Development of Interchange Configuration Options

As part of this project, an extensive public consultation initiative was undertaken with:

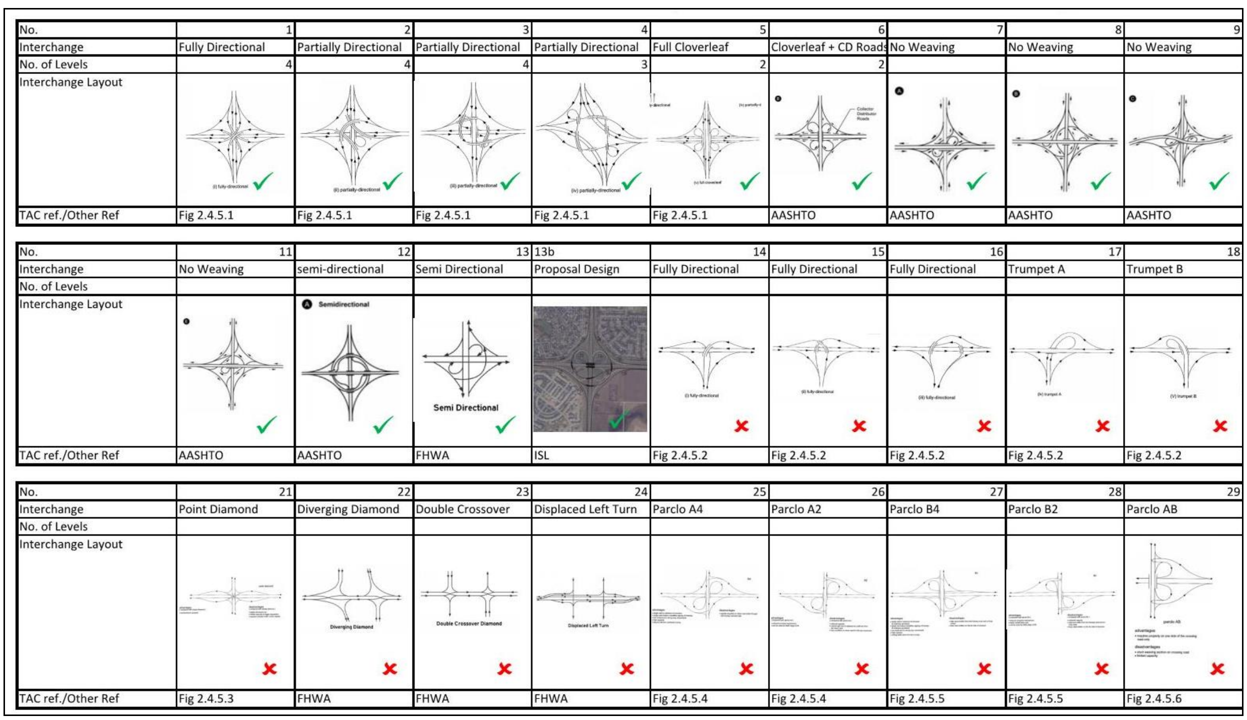
- the citizens of Saskatoon (via public open houses),
- Regional Municipality of Corman Park,
- Cowessess First Nation,
- Saskatoon Trucking Association,
- utility companies in the area, and
- various City departments.

Based on the feedback from the consultation process, the following project priorities were identified:

- Safety - Improvements must be safe for all users, resulting in reduced frequency of collisions.
- Accommodating Oversize Goods Movement - Corridor must be able to handle oversized loads (and in fact regular sized loads).
- Improving Weaving - Weaving lengths for some movements are too short and must be improved.
- Minimizing Resident Impacts - There should be minimal impacts to existing residents in Stonebridge, Eastview and Lakeview, including visual impacts and noise etc.

- Flexibility for Change in the Future - Because of uncertainty with the traffic volumes, plans should allow some flexibility for the addition of lanes in future should the traffic volumes warrant it.
- Meeting Driver Expectations - Traffic movements should be easy for drivers to understand so that sudden movements and quick decisions are not required.
- Constructability/Traffic Accommodation during Construction - This interchange cannot be closed during construction and therefore the area must be able to accommodate traffic during this time.

As an initial starting point for the project, ISL conducted a high level evaluation of standard interchanges referenced in well known documents, such as: the Transportation of Canada's (TAC) Geometric Design Guide of Canadian Roads, the American Association of State Highway and Transportation Officials' (AASHTO), A Policy on Geometric Design of Highways and Streets, and the Institute of Transportation Engineers' (ITE) Freeway and Interchange Geometric Design Handbook, to review configurations that may be feasible for this location. A sample of this evaluation is shown on Figure 7. Options that were deemed possible at this location were considered further at the Value Engineering Session.



No.	1	2	3	4	5	6	7	8	9
Interchange	Fully Directional	Partially Directional	Partially Directional	Partially Directional	Full Cloverleaf	Cloverleaf + CD Roads	No Weaving	No Weaving	No Weaving
No. of Levels	4	4	4	3	2	2			
Interchange Layout	✓	✓	✓	✓	✓	✓	✓	✓	✓
TAC ref./Other Ref	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	AASHTO	AASHTO	AASHTO	AASHTO

No.	11	12	13	13b	14	15	16	17	18
Interchange	No Weaving	semi-directional	Semi Directional	Proposal Design	Fully Directional	Fully Directional	Fully Directional	Trumpet A	Trumpet B
No. of Levels									
Interchange Layout	✓	✓	✓	✓	✗	✗	✗	✗	✗
TAC ref./Other Ref	AASHTO	AASHTO	FHWA	ISL	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2

No.	21	22	23	24	25	26	27	28	29
Interchange	Point Diamond	Diverging Diamond	Double Crossover	Displaced Left Turn	Parclo A4	Parclo A2	Parclo B4	Parclo B2	Parclo AB
No. of Levels									
Interchange Layout	✗	✗	✗	✗	✗	✗	✗	✗	✗
TAC ref./Other Ref	Fig 2.4.5.3	FHWA	FHWA	FHWA	Fig 2.4.5.4	Fig 2.4.5.4	Fig 2.4.5.5	Fig 2.4.5.5	Fig 2.4.5.6

Figure 7: Sample of High Level Option Evaluation

Value Engineering Session and Dual Matrix Comparison

A Value Engineering session was held with experts from the City, the RM, local industry, and ISL staff. The Value Engineering workshop attendees completed a Paired Comparison Analysis to determine the relative importance of each of the criteria previously identified by stakeholders. A summary of the findings is shown in Figure 8. It should be noted that Safety was not included in the evaluation criteria because it is always the top priority, and an unsafe interchange would never be considered. Once safety is removed from the weighting, it is easier to identify the relative importance of the other criteria.

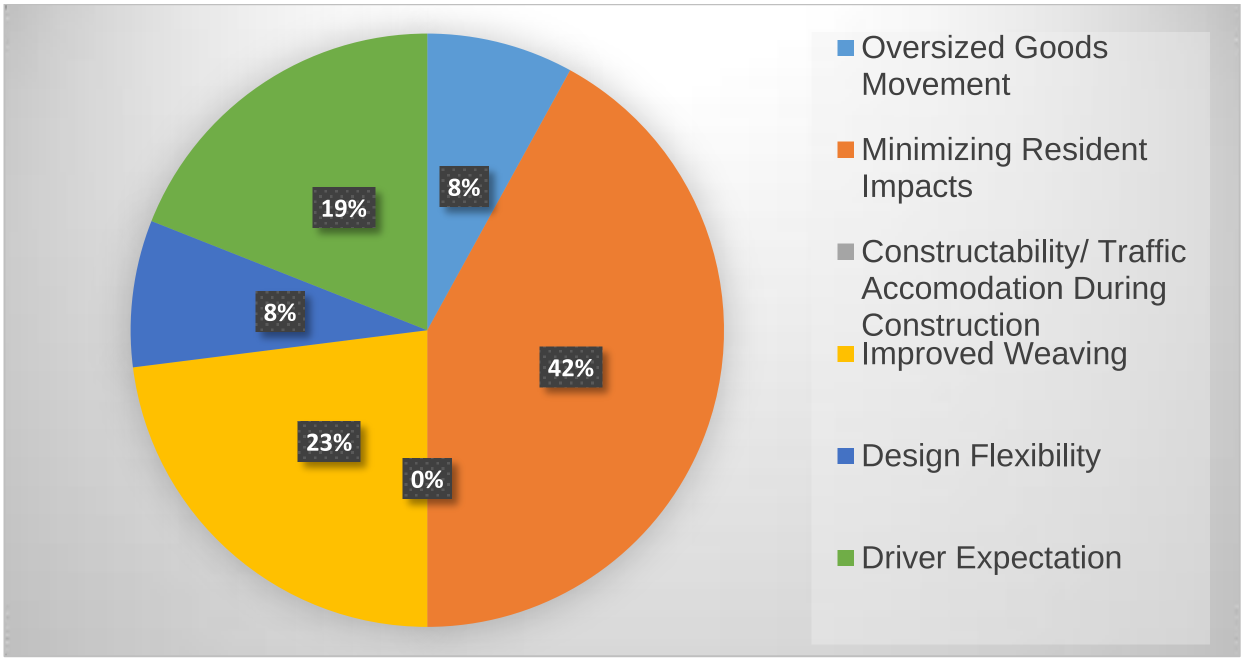


Figure 8: Weighting Importance of Each Evaluation Criteria

In addition to the preliminary options identified prior to the Value Engineering Session, members of the workshop were then given the opportunity to create interchange options that would address the issues. In total, eleven interchange options were developed and ranked against the criteria identified above:

1. Parclo AB with 2 directional tunnels
2. Making Circle Drive continuous, with an offset cloverleaf in the southeast quadrant for the remaining movements
3. Turbine interchange
4. Roundabout interchange
5. Star interchange
6. Making Circle Drive continuous, with an offset roundabout in the southeast quadrant for the remaining movements

7. Cloverleaf with a half-diamond at Preston Avenue to the west (removed weaving concern)
8. Partial Cloverleaf with a eastbound to northbound directional ramp
9. Parclo AB with 2 directional ramps
10. Cloverleaf with collector/distributor roads
11. Parclo A2 with 2 directional ramps

The top four ranked interchange configurations (Options 2, 6, 8 and 11) were developed further. Plan and profile drawings were prepared for each of these options to confirm compliance with the design criteria and adequately quantify right-of-way impacts. For this project, the key design criteria included:

- Mainline will be a rural, 4-lane divided free-flow facility with a design speed of 110 km/h
- All interchange ramp exits and entrances will be located on the right-hand side
- Lane balance shall be provided
- The use of combinations of inter-related minimum design criteria was not permitted
- Directional Ramp Design Speed – 80 km/h
- Loop Ramp Design Speed – 40 km/h
- Design Vehicle is a WB-20
- Vertical grade maximums will be no more than 4% on the mainline and exit ramps, and 6% on the ramp entrances
- Vertical clearance within the corridor will be no less than 5.6m for structures and 6.0m for signs
- Reducing cuts to less than 6m, ensuring that they could drain by gravity to adjacent storm water facilities

Due to the extensive development adjacent to the road right-of-way land acquisition was strongly discouraged. From this work, Options 2 and 6 were then rejected from further consideration, and Options 8 and 11 were further refined and presented at a public open house.

The public strongly supported Option 11 at the public open house because it:

- removed the weave between the existing loop ramps,
- was more intuitive to drivers,
- depressed some of the highest volume ramps (potentially helping with noise suppression), and
- moved roadways away from the existing residential areas.

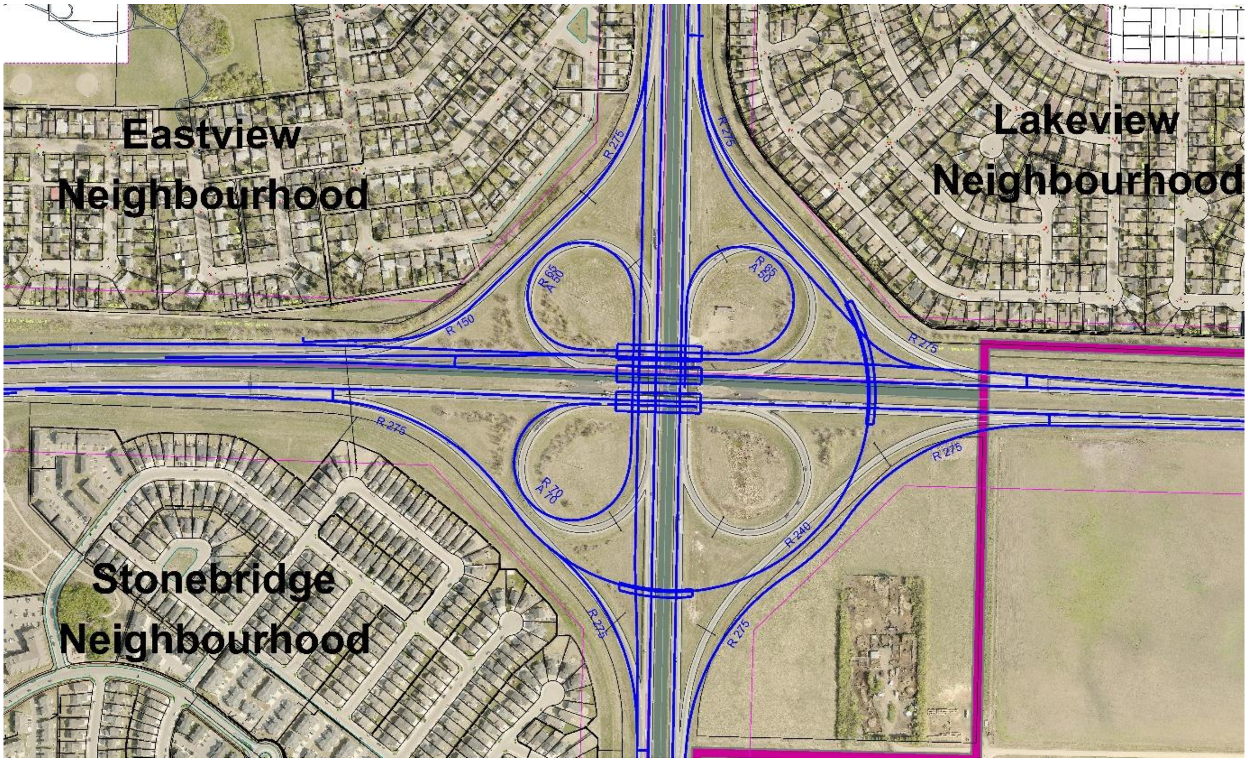


Figure 9: Option 8 - Partial Cloverleaf with an EB-NB Directional Ramp

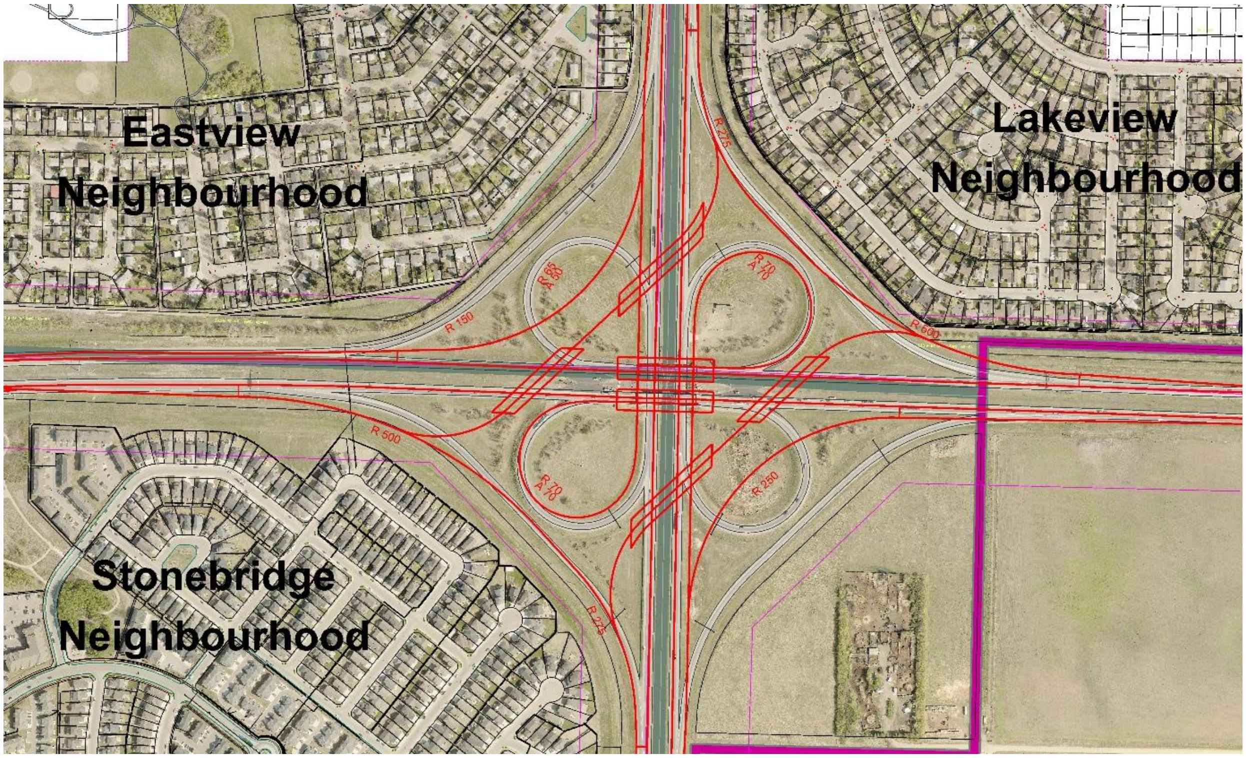


Figure 10: Option 11 - Parclo A2 with 2 Directional Ramps

The preferred configuration was further refined to optimize the design, taking into account the current operational and clearance issues. Solutions for these issues are discussed more in the next section.

As part of the overall functional plan, ISL also addressed geotechnical considerations, environmental restrictions, historical resource protection, bridge and retaining wall structure requirements, stormwater management, utility accommodation, and noise attenuation.

Ultimate Configuration

The ultimate interchange configuration, shown in Figure 11, was developed to support the long-term travel demands in this region. In addition to improving the operations of this location and addressing the low bridge clearance issues that exist today, the new design will provide additional benefits to Saskatoon by reducing fuel use, emissions and delays to the travelling public. Over the life of the interchange, these savings provide significant economic benefits.

Figure 11: Rendering of Recommended Interchange, looking North

It is anticipated that major improvements to the interchange are several years out, and would likely not occur until the existing bridge structures are at or near the end of their service lives, which is approximately 10 to 15 years away.

The main features of the long-term recommended plan are outlined below:

- System interchange maintains free-flow movements in all directions. As shown in Figure 12, there will be three levels of travel:
    - East-west highway will be approximately 4m higher than existing.
    - North-south highway will be approximately 2m higher than existing.
    - Eastbound to northbound directional and westbound to southbound directional will be approximately 6m below existing ground.

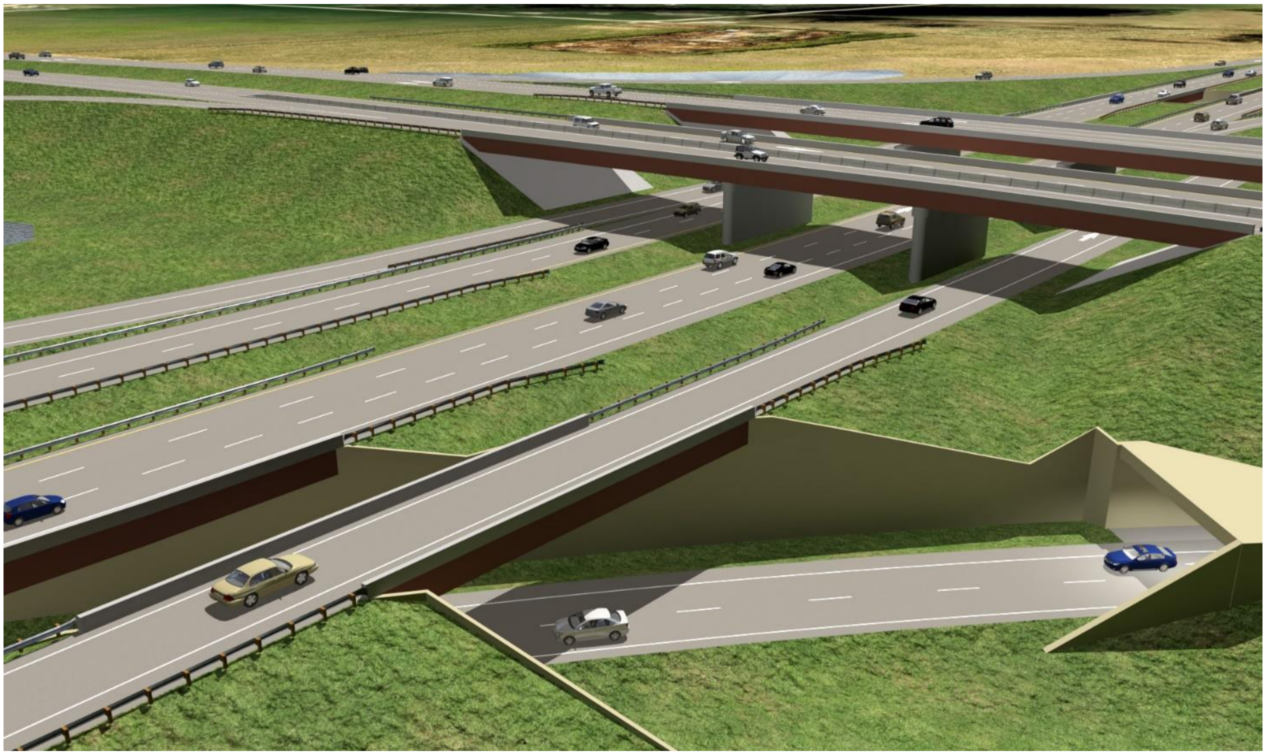


Figure 12: Rendering of Three Level Interchange with Bridges and Tunnels

- Collector/Distributor Roads are provided between this interchange and the interchanges at Preston Avenue (to the west) and Vic Boulevard (to the south) to accommodate weaving. By separating the weaving volumes from the mainline, and allowing the weaves to occur at lower speeds, the short weave distances will operate acceptably.
- A two-lane exit ramp onto the eastbound Collector/Distributor Roads has been included upstream of the Preston Avenue bridge structure to maximize weaving distances. If the eastbound to northbound volumes are lower than expected, starting the ramp taper immediately after the bridge structure may still provide sufficient weaving space, removing the need for bridge modifications. The exit ramp for Preston Avenue and the eastbound Collector/Distributor Road was combined to obtain proper lane balance. If Circle Drive (west leg) is widened to 6 basic lanes, separate exits would be preferred.

- A two-lane entrance ramp onto Circle Drive (west leg) has been included from the westbound Collector/Distributor Road to accommodate the high volume southbound to westbound movement. Both lanes have fully merged with the westbound lanes prior to the bridge structure; however, if Highway 11 (Circle Drive) is widened to 6 basic lanes and the bridge structure is being widened anyway, the merge lengths can be extended to improve operations. However, for Circle Drive to be widened, the Preston Avenue bridge structure will also need to be widened.
- Loop ramps accommodate the southbound to eastbound and northbound to westbound movements. These are low volume movements, which can easily be accommodated on the low speed ramps.
- The new plan will require seven new bridge structures, one bridge widening, two tunnels, and significant amounts of retaining and noise walls.
- The northbound to eastbound ramp and the southbound to westbound ramps are moved closer to the centroid of the interchange, maximizing the potential weave distance to the adjacent ramps.
- The northbound to eastbound ramp and the southbound to westbound ramps are shown with tunnels under the east/west highway, and bridges under the north-south highway.
- Right-of-way requirements are limited to some berm areas along the right-of-way, and some landscaping areas within 3 parcels in the southwest quadrant.

To complete our consultation with the public, a final Open House was held to present the options. To help the public navigate their way through the proposed changes, we prepared a video showing a 3D model of the "before" and "after" of the interchange, with a fly thru view of each major movement. Refer to Figure 13.

Figure 13: Image from Fly Thru Video Shown at the Final Open House

Stage 1 Improvements

To address the existing operational issues, short-term improvements have been identified based on the assumption that no modifications would be made to the existing structures themselves.

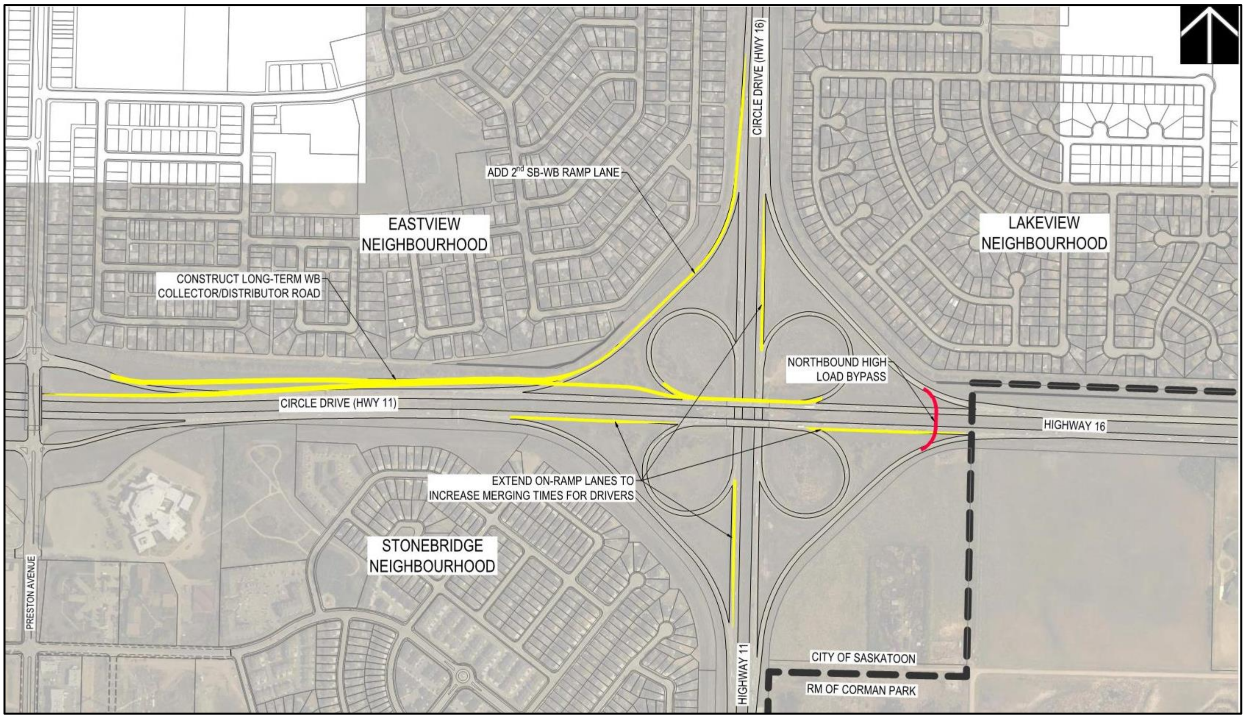


Figure 14: Recommended Stage 1 Improvements

Based on the problem areas identified during traffic analysis, the recommended Stage 1 improvements are shown in Figure 14 and explained below:

- Adding a second lane for the southbound to westbound ramp will address the capacity issues on the ramp and improve the southbound through movements as well.
- Constructing the future westbound Collector/Distributor (C/D) Road, including the connection from the westbound exit ramp, a new entrance ramp onto the mainline, and changes to the Preston Avenue off-ramp. This construction will remove the weaving condition from the mainline and allow the weaves to occur at lower speeds.
- Extending the third eastbound auxiliary lane between Preston Avenue and this interchange, allowing vehicles greater time to complete weaves.
- Extending the downstream weave lanes on the cloverleaf past the exit ramp gore to extend the distance for these vehicles to merge into mainline traffic. This allows drivers extra time to merge onto the mainline.
- Including a low-speed high-load bypass lane for northbound traffic to prevent the structures from being struck. An upstream sensor at the Vic Boulevard

interchange would notify drivers that their loads are too tall to pass under the interchange, and they would be directed to use the bypass lane. The sensors would activate the traffic lights on Highway 16 eastbound and westbound to stop traffic, allowing the high load to cross the highway.

- Replacing the yield signs on the loop ramps with merge signs to alert drivers that they need to find an acceptable gap and proceed. Currently, many drivers are incorrectly treating the yield condition as a stop condition, which has resulted in a high rate of rear-end type collisions.

Lowering the mainline under the bridges to increase the vertical clearance was considered, but ultimately rejected because the long-term plan will be raising the northbound and southbound lanes, and the remaining life of the structures themselves suggests future investment dependent on their lifecycle should not be made.

Study Recommendations

To address the current operational and vertical clearance issues with the existing interchange, the Stage 1 improvements should be implemented as soon as funding is available.

To address the long-term uncertainty for this project, the following recommendations were made:

- Monitoring traffic patterns over the coming years to better understand which traffic volumes are changing.
- Completing further examination of the regional Travel Demand Model to better understand how the forecast volumes were produced and confirming if the growth scenarios are valid.
- Updating the Travel Demand Model to reflect the major projects as they come operational and change the network travel patterns.
- Reviewing the long-term plan every few years to determine if it is still valid based on current travel patterns.

Conclusions

This project presented several engineering challenges that required a unique interchange configuration to meet the local needs. Team members worked together using engineering principles to develop a three-level interchange in the constrained corridor that addresses the evolving traffic demands, limited interchange spacing, and constrained right-of-way. Although the solution is complex, the project achieved stakeholder support because it was presented in a way that everyone could understand.