Glenmore Trail East

Functional Planning Study Report

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ISL Engineering and Land Services

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Document Authentication

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APPENDICES

List of Acronyms and Abbreviations

ASP	Area Structure Plan
AT	Alberta Transportation
AADT	Annual Average Daily Traffic
CTP	Calgary Transportation Plan
DDI	Diverging Diamond Interchange
DGSS	Design Guidelines for Subdivision Servicing
EB	Eastbound
ESA	Ecological Screening Assessment
FPS	Functional Planning Study
HCM	Highway Capacity Manual
HCS	Highway Capacity Software
HGDG	Highway Geometric Design Guide
ITE	Institute of Transportation Engineers
LOS	Level of Service
LUN	Land Use Network
MAE	Multiple Account Evaluation
MDP	Municipal Development Plan
PDO	Property Damage Only
PV	Present Value
RRHPA	Ring Road and Highway Penetrators Agreement
RVC	Rocky View County
TIA	Transportation Impact Assessment
The City	City of Calgary
TUC	Transportation Utility Corridor
TZ	Transportation Zone
VPD	Vehicles Per Day
WB	Westbound
WB36	Double Trailer Transport Truck Design Vehicle
WID	Western Irrigation District

Executive Summary

E.1 Introduction

The primary objective of the study is to determine the ultimate access and land acquisition requirements along Glenmore Trail, that align with the area structure plans prepared by The City - Shepard Industrial ASP and RVC - Janet ASP and since AT prepared the Highway 560:02 study in 2007. This study was also prepared in response to existing operational and safety deficiencies associated with the corridor and the impediment these deficiencies place on planned growth within the area. The functional outcomes of the study provide improvements for the transportation network operation by reducing delays and improving capacity of the intersections within the study area. Moreover, the project recommendations will improve safety while minimizing impacts to road users, land owners, and the environment.

The recommendations of this study have been developed with a multi-jurisdictional review team which included The City of Calgary (The City), Rocky View County (RVC) and Alberta Transportation (AT).

The purpose of this report is to document the process and recommendations of the Glenmore Trail East Functional Planning Study along Glenmore Trail (Highway 560) from Stoney Trail to Rainbow Road. This report replaces the westerly 6 km of the previously proposed 17 km transportation infrastructure improvements documented in AT's 2007 Functional Planning Study for Highway 560:02 from Calgary to Highway 797.

STUDY BACKGROUND

The 2007 Highway 560 Functional Planning Study completed by AT is the approved long-term plan for the corridor. The plan calls for the upgrade of Highway 560 to a high-speed, six-lane divided highway with diamond interchanges. The 2007 Study provided no access to 100 St SE and the two originally-planned interchanges were located 400 m west of 116 St SE and along the existing alignment of Rainbow Road. Based on an updated assessment by The City, a half diamond interchange at 100 St SE was reviewed and tentatively approved by AT in 2009.

Later, based on assessment by area landowners, a Parclo A-B interchange at 116 St SE with a 100 m realignment to the west was reviewed and tentatively approved by AT in 2013. Both approvals were subject to completion of an updated functional planning study in the area, which has now been addressed by the findings of this report.

STUDY PROCESS

The functional planning study process included four phases with stakeholder and public engagement completed throughout the project. The four phases are Identify, Develop, Evaluate, and Refine and Recommend.

Phase 1: Identify

- A review of the strategic transportation context for the Glenmore Trail East corridor including the intersections with 100 St SE and 116 St SE;
- The identification of site constraints and challenges within the study area;

- The development of a comprehensive engagement plan that allowed key stakeholders and the general public to provide critical input at key study intervals to inform the study team with respect to community needs, impacts, and improvement considerations for all modes of travel;
- A review and assessment of current and future traffic conditions within the study area;
- Stakeholder workshop to identify issues, opportunities and constraints; and
- Public information session to introduce the study and establish existing conditions.

Phase 2: Develop

- The development of multiple preliminary options to take to a preliminary evaluation;
- The development of an appropriate evaluation framework to be applied to the options in order to determine a short-list of potential solutions that accommodate all modes of travel; and
- Public information session on short-term improvements for 100 St SE and long- term improvements for 100 St SE and 116 St SE.

Phase 3: Evaluate

- The completion of a Multiple Account Evaluation (MAE) process, informed by stakeholder and public engagement feedback;
- The inclusion of the Triple Bottom Line framework that considers social, economic and environmental themes in the evaluation process;
- Development of a conceptual layout at Rainbow Road to allow an evaluation of traffic and safety performance east of 116 St SE (see note below);
- The recommendation of a preferred option based on the evaluation results; and
- The documentation and summation of the evaluation process and results.

Phase 4: Refine and Recommend

- The preparation of a functional design of the recommended solution, including horizontal and vertical geometry, active transportation infrastructure, stormwater management, construction staging, right-of-way requirements, property acquisition, and implementation costs;
- The documentation of the study findings in a comprehensive report; and
- Public information session on the recommended plan and conversations with stakeholder groups.

INCLUSION OF RAINBOW ROAD INTERCHANGE

It is important to note, that due to the close spacing of the proposed interchanges from Rainbow Road to Stoney Trail, it was necessary to include Rainbow Road in the analysis in determining the overall recommended configuration for the corridor. The decision to include Rainbow Road occurred after the MAE and adoption of the DDI as the recommended plan for 100 St SE and 116 St SE.

STUDY AREA

The study area, shown in ***Figure E.1,*** consists of the Glenmore Trail corridor from Stoney Trail to about 800 m east of Rainbow Road.

FIGURE E.1: GLENMORE TRAIL EAST FUNCTIONAL PLANNING STUDY AREA

E.2 Engagement Summary

From the outset, public engagement was identified as a priority for the Glenmore Trail East Study and the project team made the commitment to engage with impacted stakeholders and the public early and often throughout the process. The engagement approach reflected and upheld the guiding principles established in The City's 2014 engage! Framework & Tools, and in the Engagement/Communications Standards for Consultants provided by Transportation Planning.

The project team developed a three-phase engagement process which provided stakeholders and the broader public with multiple opportunities to provide feedback throughout each phase of the project. The goals of the engagement process and highlights of each phase included:

- Phase 1 - Understand stakeholder and public issues:
    - Information Session (June 15, 2015) – introduced the project team, provided information about the study and discussed any issues or concerns about the proposed interchange at 100 St SE. Sixty-four people attended, and 64 comment forms were submitted, either in-person or online.
    - Issues Scoping Workshop (June 25, 2015) – Technical representatives from The City, RVC, AT and power transmission utilities (AltaLink, Alberta Electric System Operator and ENMAX) were invited to identify issues, concerns and constraints prior to concept development.
    - Scope Expanded to include 116 St SE – During the initial public consultation, stakeholders asked the project team to investigate the possibility of a full interchange at 116 St SE as well as identify possible short-term improvements to reduce congestion at the intersection.

- Phase 2 - Develop options recognising stakeholder and public identified issues:
    - Landowner Meetings (August and September of 2016) – all adjacent landowners – seven groups in total – were invited to review the preliminary interchange options. Landowners were most interested in minimizing right-of-way requirements, providing a full interchange at 100 St SE and keeping 116 St SE on the current alignment.
    - Information Session (November 16, 2016) – held to gather feedback on the short-term improvements at 100 St SE and the proposed interchange options for 100 St SE and 116 St SE. Eighty-three per cent of respondents' feedback indicated that the proposed short-term improvements at 100 St SE would improve traffic flow and responses varied for which interchange configuration (diamond or diverging diamond) was best suited for 100 St SE and 116 St SE.
- Phase 3 - Recommend a plan that considered stakeholder and public input:
    - Information Session (April 24, 2018) – held at the HeatherGlen Golf Course (and online from April 24 – May 4, 2018). Received 30 feedback comments and 61 people attended the Information Session. Over 80% of participants felt their input was used to develop the study recommendations, and that they were provided with enough information and opportunity to effectively share their feedback throughout the project.

E.3 Existing Conditions

Glenmore Trail – AT controlled Glenmore Trail, is currently a two-lane paved Skeletal Road with posted speed limit of 80 km/h approximately 550 m west of 116 St SE and 100 km/h to the east.

100 St SE – This road is currently a two-way, two lane paved Industrial Arterial road with a posted speed of 80 km/h. South of Glenmore Trail, 100 St SE is under the jurisdiction of The City. North of Glenmore Trail, 100 St SE is under the jurisdiction of the RVC.

116 St SE – This road north of Glenmore Trail is currently a two-way, two lane paved Rural Road, under the jurisdiction of RVC. South of Glenmore Trail, 116 St SE is currently a two-lane unpaved Rural Local Road with a posted speed of 80 km/h, providing access to a small number of rural residences.

Rainbow Road – Under the jurisdiction of the RVC, Rainbow Road is a two-lane paved Rural Local road with a posted speed of 80km/h.

INTERCHANGE AND INTERSECTION SPACING

The distance between the Stoney Trail interchange centreline and the centreline of the 100 St SE intersection is 2,200 m. The spacing between the intersections located within the study corridor are shown in ***Table E.1***.

TABLE E.1: INTERSECTION SPACING

INTERSECTION SEGMENTS	DISTANCE (M)
Stoney Trail SE – 100 St. SE	2,200
100 St. SE – 116 St. SE	1,600
116 St. SE – Rainbow Rd	1,600
Rainbow Road – Hwy 791	4,900

EXISTING TRAFFIC CONDITIONS

Traffic congestion at the existing intersection of 100 St SE forms part of the justification for this study. A level of service assessment and safety review was conducted for the 100 St SE and Glenmore Trail intersection to identify deficiencies and to determine possible short and long-term solutions. It is noted that a similar short-term assessment of 116 St SE or Rainbow Road was not within the scope of the study, due to the longer-term nature of the planning at those locations. ***Figure E.2*** and ***Figure E.3*** show the existing traffic volumes and truck volumes for the AM and PM peak hours as provided by The City. The LOS analysis results summary for the AM and PM peak hours follow in ***Table E.2***.

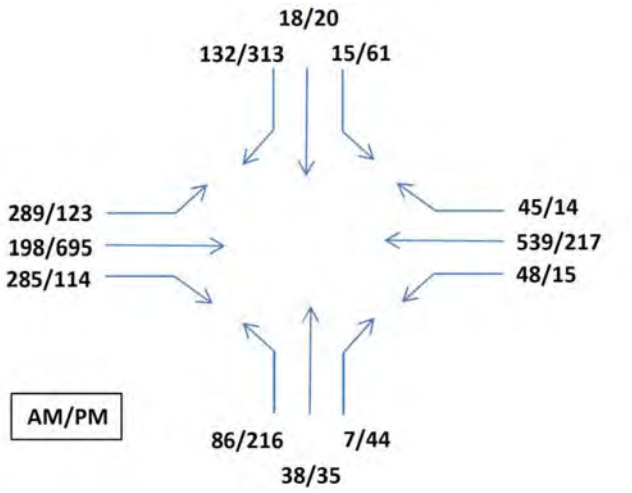


FIGURE E.2: 100 ST SE - ALL VEHICLE VOLUMES

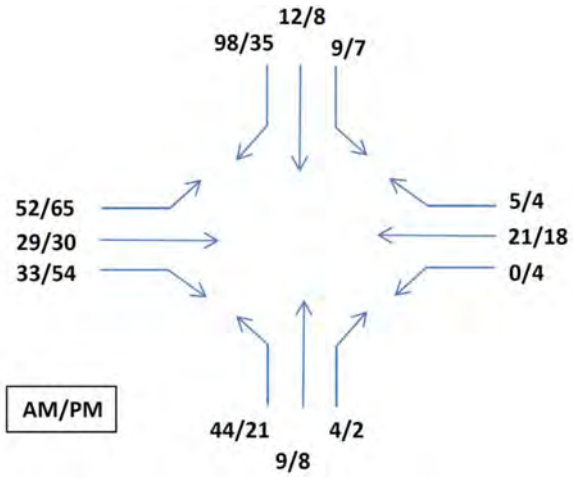


FIGURE E.3: 100 ST SE - HEAVY VEHICLE VOLUMES

TABLE E.2: 100 ST SE - SYNCHRO ANALYSIS SUMMARY (2015 AM AND PM PEAK HOURS)

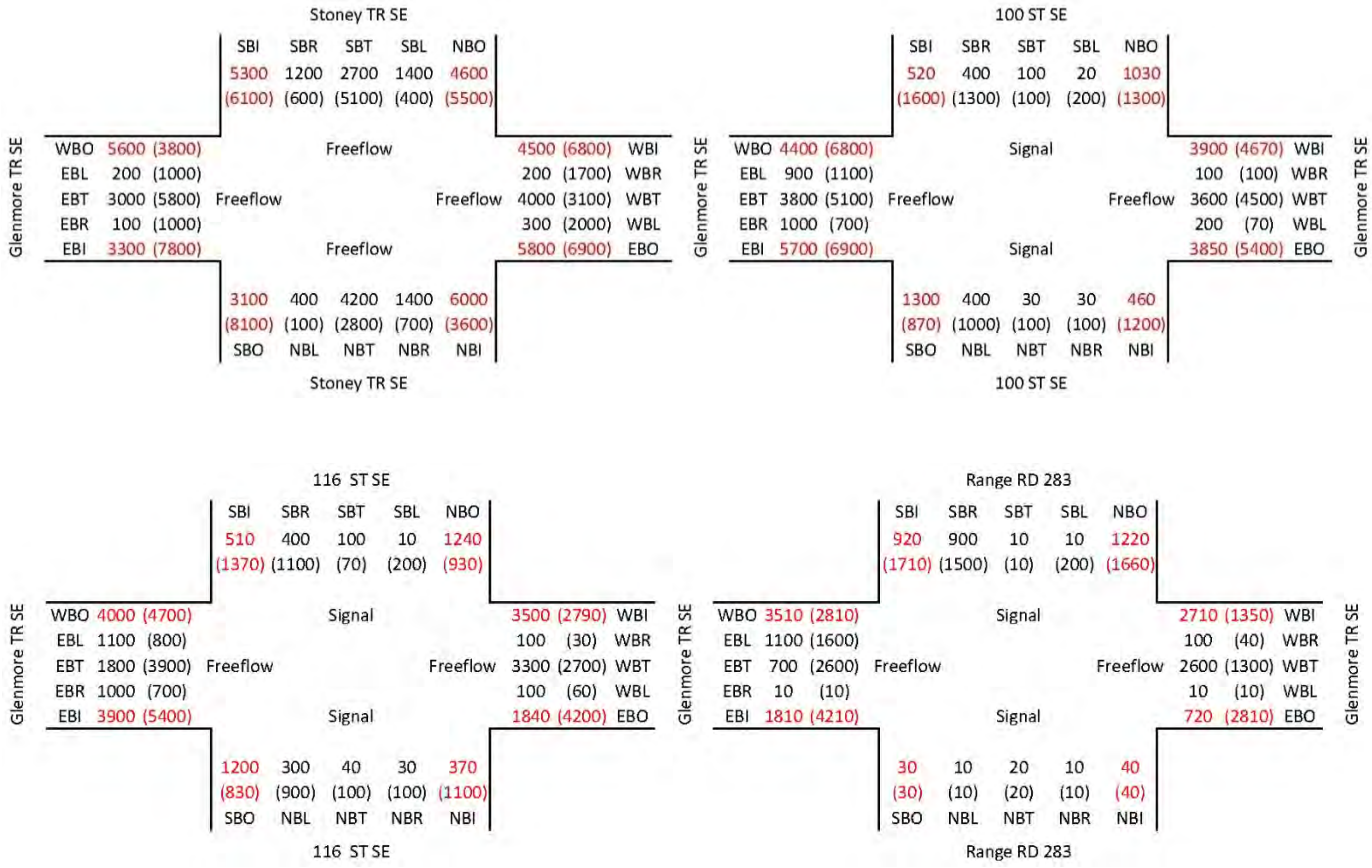
AM						PM				
MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH		MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH
EBL	294.5	1.55	F			EBL	52.4	0.81	D	
EBT	19.8	0.26	B	F		EBT	125.3	1.17	F	F
EBR	3.4	0.44	A			EBR	6.9	0.3	A	
WBL	13.0	0.1	B			WBL	23.3	0.2	C	
WBT	51.0	0.91	D	D		WBT	42.0	0.65	D	D
WBR	-	-	-			WBR	-	-	-	
NBL	113.8	0.89	F			NBL	56.2	0.76	E	
NBT	57.1	0.29	E	F		NBT	35.4	0.15	D	D
NBR	0.4	0.05	A			NBR	1.7	0.15	A	
SBL	-	-	-			SBL	-	-	-	
SBT	66.3	0.41	E	C		SBT	52.9	0.51	D	C
SBR	19.4	0.65	B			SBR	12.7	0.71	B	
Intersection	76.3	-	E	-		Intersection	64.5	-	E	-

EXISTING SAFETY REVIEW

The historic collision data provided by AT for the intersection of 100 St SE and Glenmore Trail was reviewed for the 5-year period between 2008 and 2012. The data includes incidents occurring at the intersection and within 400 m of Glenmore Trail. A total of seven collisions were reported within the study area over the analysis period, all of which were property damage only (PDO) incidents with no fatal or injury collisions reported. The data provided by AT indicated that the study site has a collision rate of 91.08 collisions per 100 MVKM.

E.4 Future Traffic Conditions

The future traffic volumes were developed using the 2039 traffic forecast provided by The City as a base and adjusted based on the anticipated land uses, population and employment from reference reports including approved Area Structure Plans (ASP) in both Calgary (Shepard Industrial ASP - 2013) and RVC (Janet ASP – 2014). Hence, the design traffic was developed for a full build out of the lands identified by The City and RVC for future development and not for a specific design year. The future design traffic volumes are shown in ***Figure E.4***.



NOTES

- Traffic Volumes less than 100 are rounded to the nearest 10
- Traffic Volumes larger than 100 are rounded to the nearest 100
- AM (PM) - Brackets designate PM volumes
- Red figures indicate volumes entering or exiting the intersection

FIGURE E.4: FULL BUILD-OUT DESIGN TRAFFIC VOLUMES

E.5 Option Development

Strategic options to improve the Glenmore Trail were developed considering a range of engineering, traffic, safety and cost aspects. The options were focussed on 100 St SE and 116 St SE and did not include Rainbow Road as the functional planning updates for the latter pertained primarily to ramp / weaving analysis. The basic option arrangements were developed using design features including:

- Provision of a single exit from the mainline for each interchange; and
- Full movement interchanges considered at each junction.

INITIAL OPTIONS AND CORRIDOR OPTION SCREENING

An initial corridor option screening was undertaken to better understand what lane configurations between interchanges would best support weaving operations along Glenmore Trail between Stoney Trail and Rainbow Road. Seven corridor options were developed and evaluated using a VISSIM microsimulation model.

- Option 1: Diamond interchanges with single lane on ramps;
- Option 2: Diamond interchanges with westbound dual lane on ramps;
- Option 3: Diamond interchanges with basketweave to Stoney Trail;
- Option 4: Loop ramp at 100 St SE and diamond interchanges at 116 St SE and Rainbow Road;
- Option 5: Loop ramp at 100 St SE with lane away and diamond interchanges at 116 St SE and Rainbow Road;
- Option 6: Loop ramp at 100 St SE with a basketweave and diamond interchanges at 116 St SE and Rainbow Road;
- Option 7: Diamond interchange at 100 St SE and Rainbow Road and Parclo A-B at 116 Street.

The following findings were observed from the VISSIM analysis:

- Option 2, Option 3, and Option 7 showed very similar weaving operations between interchanges and these three options performed the best among the seven corridor options;
- The corridor operates best with dual westbound entrance ramps;
- The corridor operates best with dual westbound exit ramps;
- The corridor operates best with single eastbound entrance ramps;
- The corridor operates best with dual eastbound exit ramps;
- Diamond interchanges operate best with the above entrance and exit ramp laning;
- Westbound Glenmore Trail operates best with two auxiliary lanes;
- A basketweave improves the westbound weaving operation between 100 St SE and Stoney Trail; and
- Option 7 operates well, however, the weaving distance between 100 St SE and 116 St SE is the shortest with a Parclo A-B at 116 St SE.

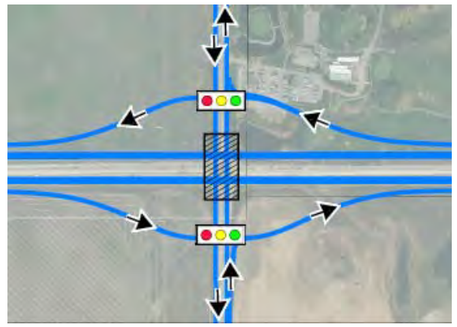
SECOND ROUND OF OPTION DEVELOPMENT AND SCREENING

Different types of interchange options were reviewed in greater detail. Six options were developed for 100 St SE, and three options were developed for 116 St SE. The options developed during this stage and the design features of each option are illustrated in ***Figure E.5*** and ***Figure E.6***.

OPTION A: DO NOTHING (BASE CASE)

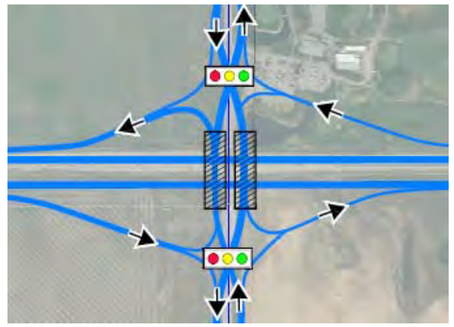
- The status quo assumes a “do-nothing” scenario, includes no changes to the study area and its intersections and no alteration to the surrounding network. This option represents the Base Case.

OPTION B - FULL DIAMOND INTERCHANGE



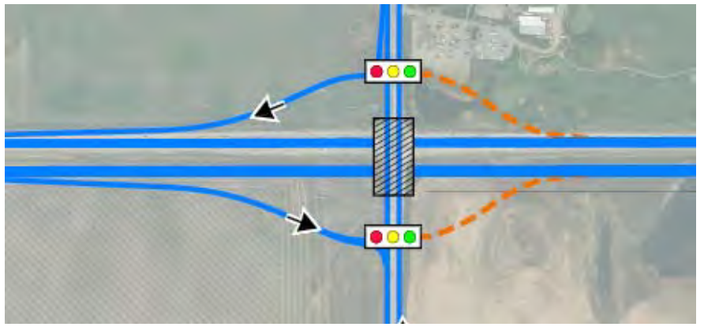
- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION C - DIVERGING DIAMOND INTERCHANGE



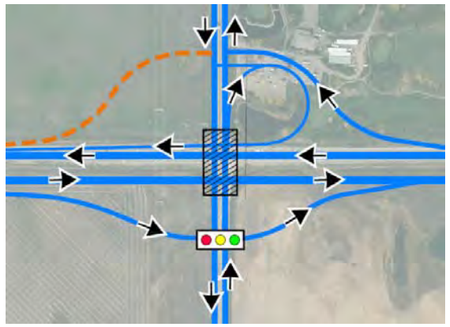
- Full movements are provided at this interchange.
- This option involves traffic along 100 St SE “crossing sides at grade” to create free-flow left turns through the interchange.
- High loads can use the same ramps as the general traffic to approach the interchange junctions. However, unique intersections will be required to allow high load movements to pass through.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION D - HALF DIAMOND INTERCHANGE



- Access provided to and from the west side only (City of Calgary side).
- Additional ramps are required on the east side to accommodate high load movement through the interchange. These ramps will not be available for use to general traffic.
- Limiting access at 100 St SE forces EB traffic to other access points.

OPTION E - HALF PARCLO HALF DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.
- This option has the largest impact on the HeatherGlen golf course.
- Alternative to this option would be to provide a separate ramp for the southbound to westbound movement, to remove conflict with the northbound to westbound movement as these two movements have very high volumes.

SUB OPTION - BASKET WEAVE CONNECTION TO STONEY TRAIL

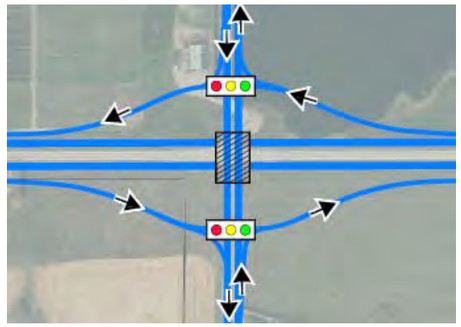
- Minimum desirable weaving distance has provided between adjacent interchanges in the eastbound direction.
- The basketweave will grade separate the entrance ramp from 100 St SE and the exit ramp to Stoney Trail thereby eliminating any potential weaving issues between these two interchanges.
- Compatible with all options and can be implemented at later stages.

FIGURE E.5: INTERCHANGE OPTIONS FOR 100 ST SE

OPTION A – DO NOTHING (BASE CASE)

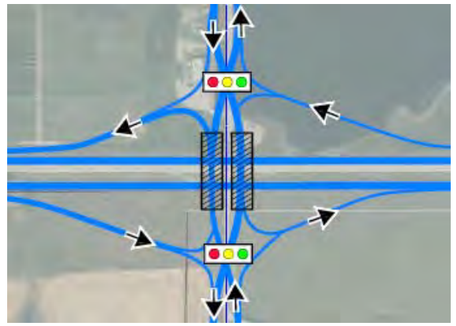
- The status quo assumes a 'do-nothing' scenario, includes no changes to the study area and its intersections and no alteration to the surrounding network. This option represents the Base Case.

OPTION B - FULL DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION C – DIVERGING DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- More wetland impacted than full diamond.
- This option involves traffic along 116 St SE "crossing sides at grade" to create free-flow left turns through the interchange.
- High loads can use the same ramps as the general traffic to approach the interchange junctions. However, unique intersections will be required to allow high load movements to pass through.
- Minimum desirable weaving distance is provided between adjacent interchanges.

FIGURE E.6: INTERCHANGE OPTIONS FOR 116 ST SE

A total of six criteria were selected to screen the second round of options. The six criteria are traffic capacity, property impacts, weaving analysis, accessibility, wetland impacts and utility impacts. The ratings from the application of these criteria with respect to each initial option have been summarized in ***Table E.3*** and ***Table E.4*** for the 100 St SE options and the 116 St SE options. The lower scoring options were screened out from further consideration.

TABLE E.3: 100 ST SE INITIAL OPTIONS SCREENING

	OPTION A – DO NOTHING (BASE CASE)	OPTION B - FULL DIAMOND INTERCHANGE	OPTION C - DIVERGING DIAMOND INTERCHANGE	OPTION D - HALF DIAMOND INTERCHANGE	OPTION E - HALF PARCLO HALF DIAMOND INTERCHANGE	SUB OPTION - BASKETWEAVE CONNECTION TO STONEY TRAIL
Traffic Capacity	×	✓	✓	×	×	✓
Property Impacts	✓	×	×	×	×	×
Weaving Analysis	✓	✓	✓	✓	✓	✓
Accessibility	✓	✓	✓	×	×	×
Wetland Impacts	✓	×	×	✓	×	✓
Utility Impacts	✓	×	×	×	×	×
Recommendation		✓✓✓ More favourable	✓✓✓ More favourable			✓✓✓ More favourable

TABLE E.4: 116 ST SE INITIAL OPTIONS SCREENING

	OPTION A- DO NOTHING (BASE CASE)	OPTION B - FULL DIAMOND INTERCHANGE	OPTION C – DIVERGING DIAMOND INTERCHANGE
Traffic Capacity	×	✓	✓
Property Impacts	✓	×	×
Weaving Analysis	✓	✓	✓
Accessibility	✓	✓	✓
Wet Land Impacts	✓	×	×
Utility Impacts	✓	×	×
Recommendation		✓✓✓ More favourable	✓✓✓ More favourable

RECOMMENDATIONS FOR SHORT-LISTED OPTIONS

Based on the screening evaluation, the short-listed options included either a full diamond interchange or a diverging diamond interchange (DDI) for both 100 St SE and 116 St SE. It was also recommended to further evaluate the sub-option of a basketweave connection from 100 St SE to Stoney Trail.

E.6 Option Evaluation and Summary

The short-listed options were further evaluated using a Multiple Account Evaluation (MAE) process. The MAE was created with reference to The City's Triple Bottom Line framework which considers social, environmental and economic aspects in the evaluation process. It was determined that both the conventional diamond interchange and diverging diamond interchange options require a similar footprint and have comparable traffic performance and overall project costs. The overall evaluation results are summarized in ***Table E.5.*** with the key differences described below.

TABLE E.5: DIAMOND VS DDI SUMMARY

TBL	ISSUE	INDICATOR	DIAMOND	DDI
Economic	Financial	Operating and maintenance costs / efforts	✓	
		Utility relocation costs	=	=
		Present value of project cost	✓	✓
	Transportation	High load access	✓	
		Heavy vehicle usability		✓
		Accommodates Transit	✓	
		Accommodates cycling and walking		✓
		Travel time savings		✓
		Traffic safety		✓
		Reduction in traffic congestion and improved capacity		✓
	Feasibility and Deliverability	Constructability		✓
		Staging opportunity	=	=
Social	Community Impacts	Accessibility to network	=	=
		Visual aesthetics	=	=
		Construction impact to residences and businesses	=	=
		Private property impacts	✓	
		Land consumption	✓	
	Stakeholders	Public acceptability	=	=
Environ-mental	Environmental	Impacts on indigenous species, removal of habitat	✓	
	Cultural Heritage	Impact on historical sites	✓	
	Pollution	Impact on air quality	=	=

Conventional diamond interchange was evaluated favourably on the financial, community and environmental aspects, due to:

- Lower construction cost;
- Less property impact; and
- Less environmental impact.

Diverging diamond interchange was evaluated favorably on the transportation aspect, due to:

- Better accommodation of heavy vehicles;
- Better accommodation of transit, cycling and walking;
- Shorter travel time; and
- Higher capacity.

Based on the results of the evaluation, no option clearly out-performs the other. The adoption of either option will meet the requirements of the functional planning study.

As the footprint of the conventional diamond can be fully encompassed within the footprint of the DDI, selecting the DDI layout over the diamond will allow the flexibility of adopting either layout in the future, therefore allowing the interchange to be adapted to best suit the needs of the surrounding land build-out. Given the purpose of the study is to preserve the corridor for future requirements, a project decision was made to progress the DDI option to a full functional plan design.

Although the DDI requires modestly more acquired land, it has a significantly smaller footprint than the 2007 Highway 560 Functional Plan (rural-style diamond interchange), therefore reducing the overall impacts to the surrounding properties and wetlands. The additional land required for the DDI compared to the diamond interchange has the significant benefit of ensuring full flexibility for the interchange to be adapted to future needs, which is a key consideration at this stage of planning, given that build-out of the area is likely on a 30+ year time horizon.

E.7 Recommended Plan

The recommended plan for Glenmore Trail East includes interchanges at 100 St SE, 116 St SE, and Rainbow Road. The key components and features of the recommended plan include:

- Glenmore Trail ultimately widened to a six-lane divided skeletal freeway (note that the initial stage twinning requirement for Glenmore Trail is to be determined by a future study).
- 100 St SE, 116 St SE, and Rainbow Road upgraded to four lane urban arterial streets;
- Diverging diamond interchanges at 100 St SE, 116 St SE, and Rainbow Road;
- An option to include basketweave ramp structures in the westbound direction between 100 St and Stoney Trail;
- New grade separated pedestrian and cycling crossings of Glenmore Trail at 100 St SE, 116 St SE, and Rainbow Road, as part of the interchanges.

Figures E.7 to ***E.9*** show the recommended plan for the 100 St SE, 116 St SE, and Rainbow Road interchanges. ***Figure E.10*** shows the recommended plan with the optional basketweave.

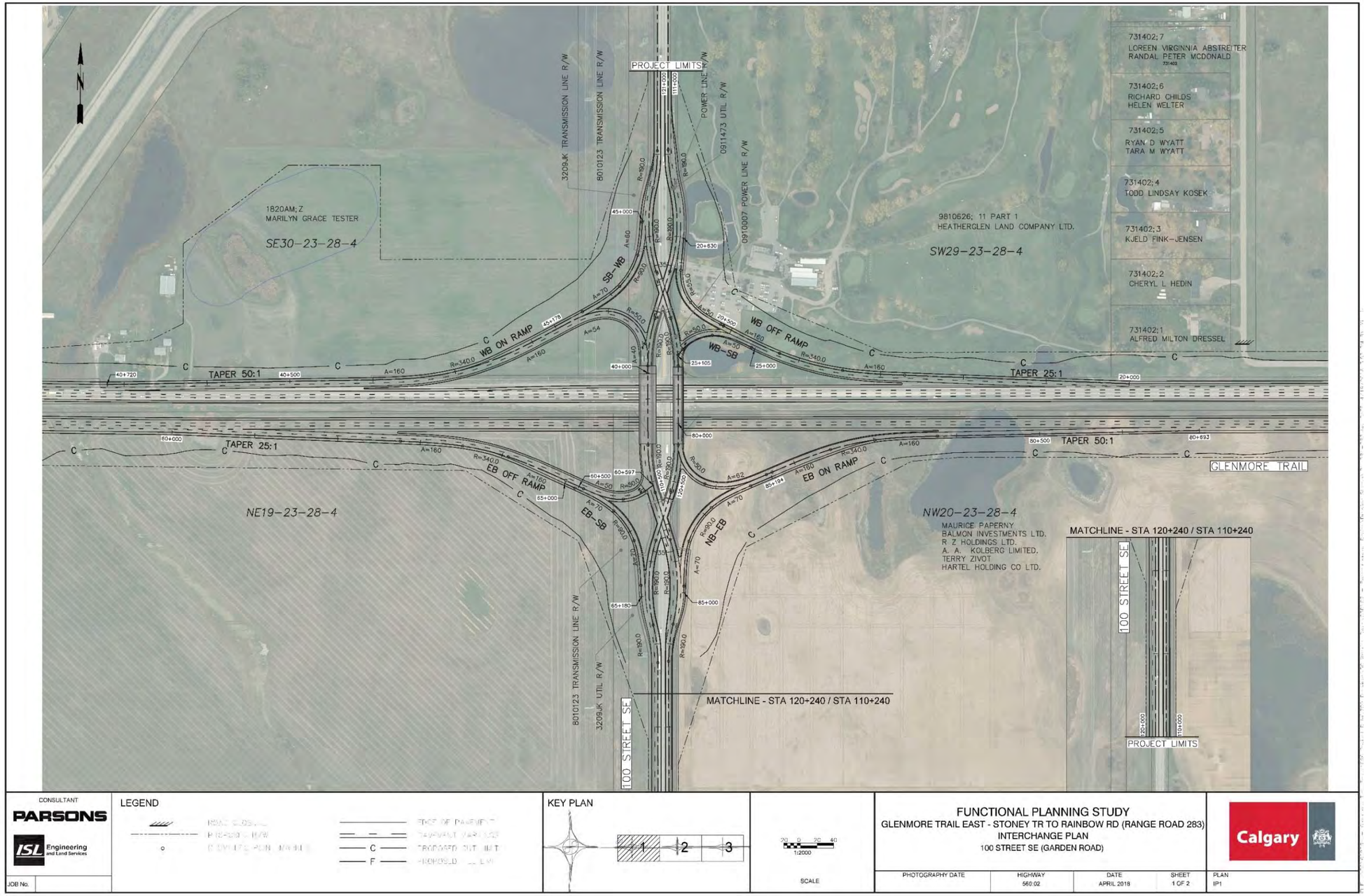


FIGURE E.7: RECOMMENDED PLAN - 100 ST SE

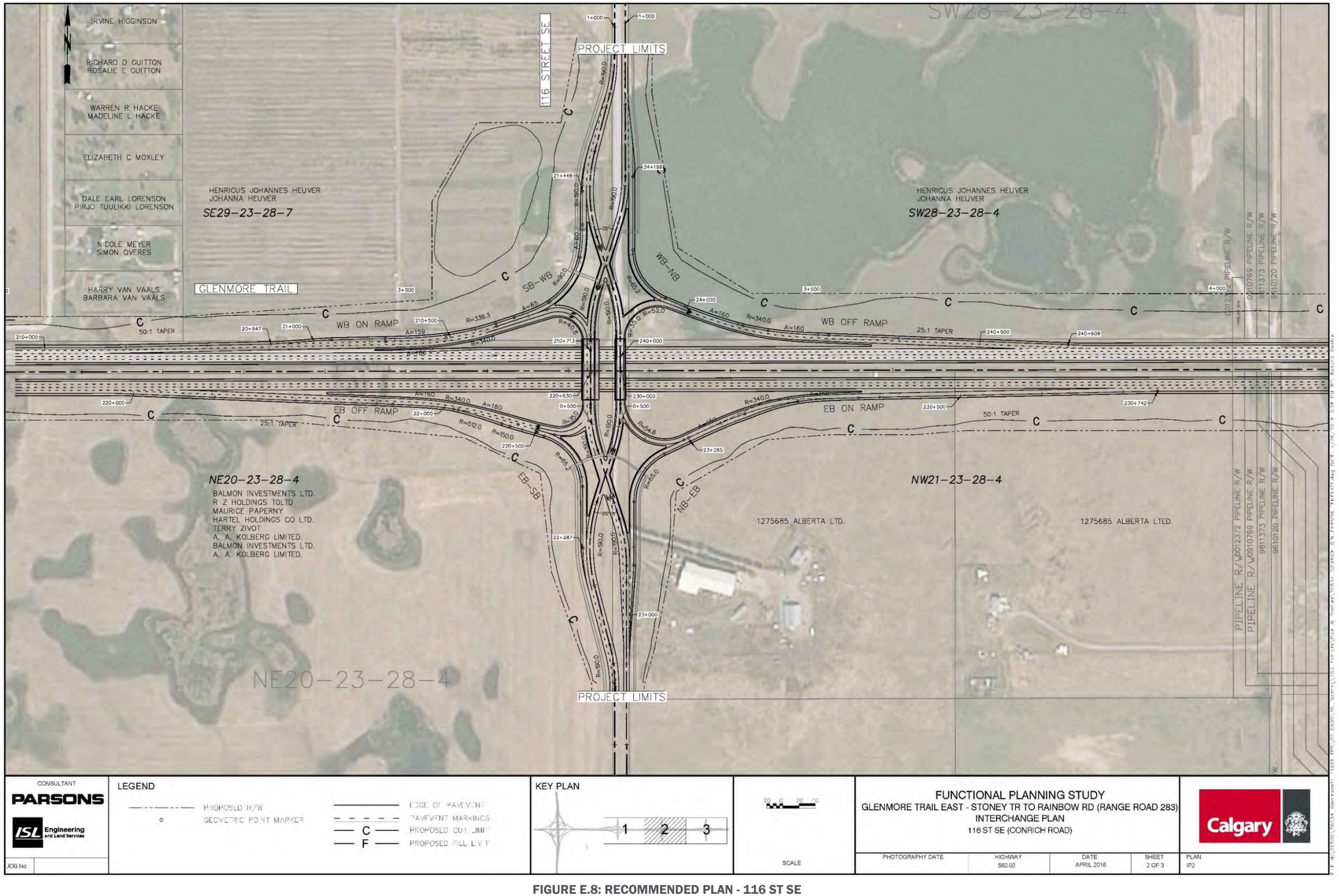


FIGURE E.8: RECOMMENDED PLAN - 116 ST SE

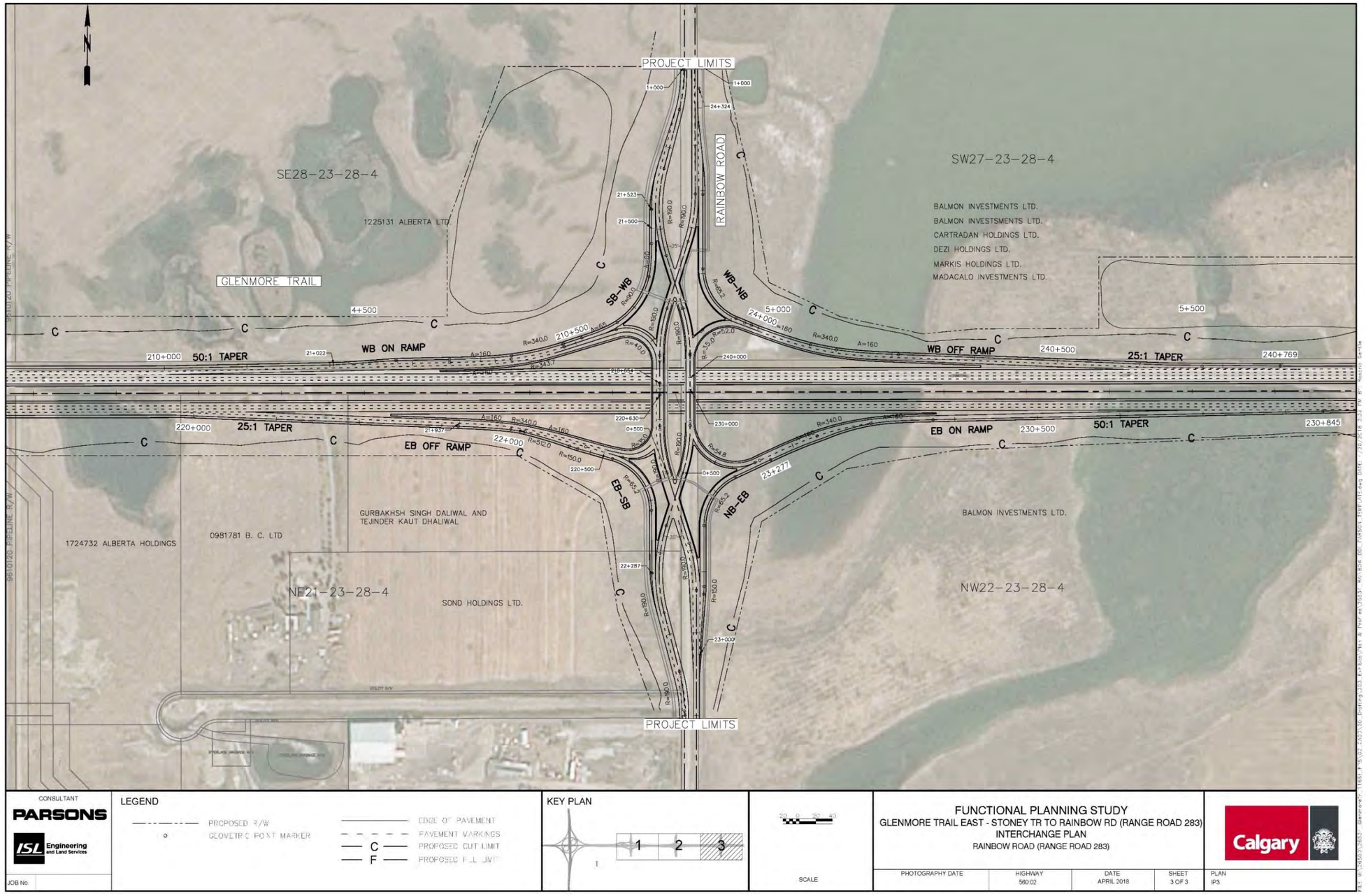
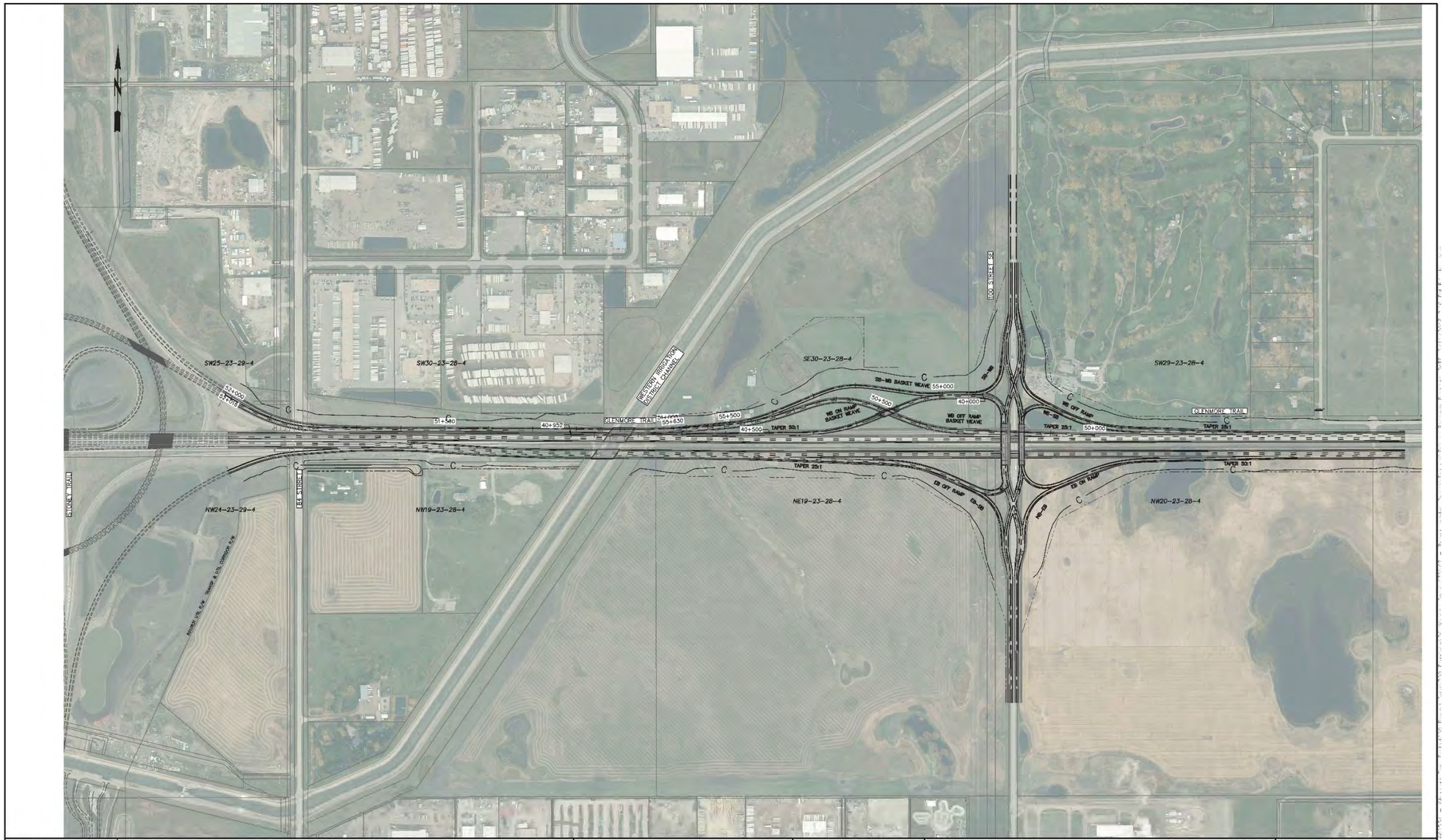


FIGURE E.9: RECOMMENDED PLAN –RAINBOW ROAD



CONSULTANT
PARSONS
ISL Engineering and Land Services
JOB No.

LEGEND
ROAD CLOSURE
PROPOSED R/W
SLOVETRIC POINT VARIES
CURB & PAVEMENT
LANEWAY MARKINGS
C PROPOSED CUT LINE
F PROPOSED FILL LINE

KEY PLAN

10 0 10 20
1:4000
SCALE

FUNCTIONAL PLANNING STUDY
GLENMORE TRAIL EAST - STONEY TR TO RAINBOW RD (RANGE ROAD 283)
EXHIBIT ROADWAY PLAN
FROM STONEY TRAIL TO 100 STREET SE (GARDEN ROAD) - BASKET WEAVE OPTION

PHOTOGRAPHY DATE	HIGHWAY	DATE	SHEET
	560:02	JUNE 2018	1 OF 1

Calgary
PLAN
EXHIBIT

FIGURE E.10: RECOMMENDED PLAN - BASKETWEAVE OPTION

FEATURES OF THE RECOMMENDED PLAN

The following sections summarize the key components of the recommended functional plan.

Pedestrian and Cycling Facilities

The recommended plan includes a 3 m multi-use pathway along the west side and 2 m sidewalk along the east side of the northbound bridges on 100 St SE, 116 St SE and Rainbow Road. As the multi-use pathway and sidewalk approach the interchange at Glenmore Trail, they are channelized into the inside of the west structure, into a single multi-use pathway. This is consistent with typical practice for a DDI interchange.

Property Acquisition

The property requirements from the Highway 560 Functional Planning Study completed by AT in 2007 have been re-evaluated given that the recommended DDI require less property than the 2007 plan. The updated land requirements were calculated based on the areas needed to build the road network and interchange and provisions for additional stormwater ponds.

The assessment process identified a number of properties that, based on current drawings, require partial acquisition. However, with refinements to the alignment, acquisition of these properties may be avoided. The assessment also identified one potential property where full acquisition might be required due to impacts to several structures on the property. A summary of the potential property impacts for each interchange is provided in ***Table E.6***.

TABLE E.6: SUMMARY OF TOTAL POTENTIAL PROPERTY IMPACTS

OPTION	PLAN REF #	LOT NO. (LINC #)	AREA (HA)	FULL/PARTIAL	NOTES
Stoney Trail to 100 St SE	1	30984653	0.48	Partial	
	2 and 3	18104083	2.94	Partial	
	4	N/A	0.57	Partial	Service road
	5	18104091	10.10	Partial	
100 St SE	6	33448499	8.26	Partial to full	
	7	19956085 and 33448481	4.15	Partial	
	8	33448507	7.82	Partial	
	9	19955260	1.71	Partial	Same parcel as #12
	10	23862089	1.97	Partial	Includes service road to the east
116 St SE	11	30931604	7.53	Full	
	12	19955260	7.72	Partial	Same parcel as #9
	13	21608393	5.90	Partial	
	14	27711720	5.00	Partial	
	15	27424407	2.49	Partial	

OPTION	PLAN REF #	LOT NO. (LINC #)	AREA (HA)	FULL/PARTIAL	NOTES
Rainbow Rd	16	17196791	12.33	Partial	
	17	36715614 and 36715622	2.96	Partial	
	18	36372886	4.39	Partial	
	19	36715648	1.25	Partial	
	20	21593050	8.13	Partial	
	21	21607528	7.62	Partial	
	22	27355727	0.75	Partial	

COST ESTIMATES

Preliminary Cost Estimates—as defined in AT Engineering Consulting Guidelines for Highway, Bridge, and Water Projects Volume 1 - Design and Tender (2011)—were developed for each of the recommended segments along Glenmore Trail. The estimates do not include property acquisition, engineering and testing costs.

The estimates, including a -40% and +75% variance, are provided in ***Table E.7***. The resulting preliminary cost estimates are an opinion of probable costs and should be refined further during the detailed design phase.

TABLE E.7: ORDER OF MAGNITUDE COST ESTIMATES

SEGMENT	UPGRADES	COST ESTIMATES (2017 $)			
		TOTAL	COMBINED	-40% VARIANCE	+75% VARIANCE
Stoney Trail to east of 100 St SE	• Upgrade existing roadway to six lanes divided cross section on Glenmore Trail • Upgrade existing 100 St SE to four lane cross section • New signals at Glenmore Trail / 100 St SE • Intersection upgrade	$61,550,000	**$135,510,000**	*$81,310,000*	*$237,140,000*
	• Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$56,750,000			
	Additional upgrades: • Basket weave between Stoney Trail and 100 St SE	$17,210,000			
East of 100 St SE to east of 116 St SE	• Upgrade existing roadway to six lane divided cross section on Glenmore Trail • Upgrade existing 100 St SE to four lane cross section • Install traffic signals at Glenmore Trail / 116 St SE • Upgrade at-grade Intersection	$28,080,000	**$77,200,000**	*$46,320,000*	*$135,100,000*
	Additional upgrades: • Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$49,120,000			
East of 116 St SE to east of Rainbow Road	• Upgrade existing roadway to six lane divided cross section on Glenmore Trail • Upgrade existing Rainbow Road to four lane cross section • Install traffic signals at Glenmore Trail / Rainbow Road • Upgrade at-grade Intersection	$29,020,000	**$80,470,000**	*$48,282,000*	*$140,820,000*
	Additional upgrades: • Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$51,450,000			

BENEFIT COST ANALYSIS

A benefit cost analysis based on vehicle delay cost was performed independently for the recommended 100 St SE, 116 St SE and Rainbow Road interchange configurations. The analysis was conducted over a 30 year period with implementation assumed to begin in 2037. The present value (PV) delay costs and construction costs were calculated and a benefit cost ratio determined based on the following general assumptions:

- Base case for benefit cost analysis includes widening on Glenmore Trail to six lanes, but retains an at-grade intersection;
- Forecasted traffic for the base case six-lane corridor associated with the 2039 land use assumptions;
- 30 year analysis period;
- Construction beginning in 2037 with a duration of two years;
- 4% internal discount rate;
- 2.5% annual traffic growth rate;
- Only travel time savings (reduction in existing delays) were assessed as benefits;
- Average value of time (blended between autos and trucks) of $35.74; and
- Property acquisition, engineering and testing costs were not included in the calculation.

The results of the analysis indicated the following:

- 100 St SE DDI with the basketweave — 15.4 B/C Ratio (>3 year payback period)
- 116 St SE DDI — 10.1 B/C Ratio (>4 year payback period)
- Rainbow Road DDI — 9.39 B/C Ratio (> 5 year payback period)

As mentioned, only travel time benefits were included in the analysis. The inclusion of other elements such as vehicle operating cost savings, safety benefits, and salvage value should be included in future traffic analysis. However, future benefit cost analysis should also include deriving more accurate traffic forecasts for the base case where the above assumptions can be refined.

E.8 Construction Staging

The four distinct construction stages for delivering the recommended plan were identified and these are described below.

Stage 1 – Short-Term Improvements at Glenmore Trail East and 100 St SE

As a result of feedback received from the public engagement early during the planning study, a focussed analysis was conducted to fully explore the scope of any short-term improvements that could provide immediate benefits to the intersection of Glenmore Trail East and 100 St SE. ***Figure E.11*** shows the extent of the short-term improvement scope. The short-term improvements for 100 St SE are summarized below:

- Additional westbound through lane on Glenmore Trail;
- Additional eastbound through lane on Glenmore Trail;
- Additional northbound left turn lane added for a total of two left turn lanes;

- Add dedicated protected southbound left turn lane;
- Add protected southbound right turn slip-lane;
- Provide longer acceleration length for northbound traffic from 100 St SE merging onto eastbound traffic on Glenmore Trail;
- Provide longer acceleration length for southbound traffic from 100 St SE merging onto westbound traffic on Glenmore Trail;
- Improve westbound right turn lane with increase deceleration length; and
- Improve eastbound right turn slip-lane with longer deceleration length.

With a 30% contingency and 10% mobilization, the total construction cost is estimated at $4.3 million.

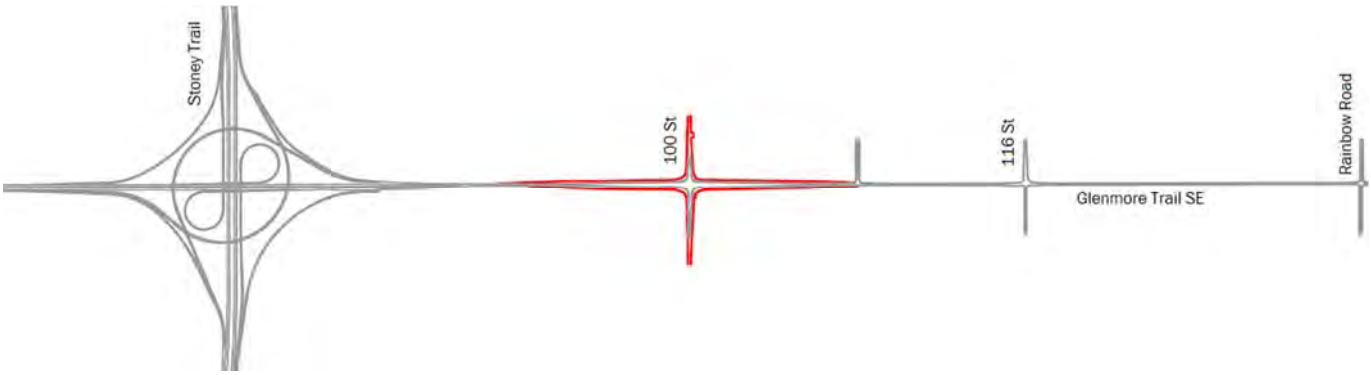


FIGURE E.11: SHORT-TERM IMPROVEMENTS AROUND 100 ST SE

Stage 2 – Glenmore Trail Twinning

Glenmore Trail east of Stoney Trail is classified as a Service Classification Level 3 highway. In the event that twinning is warranted for Glenmore Trail, it will involve the twinning of Glenmore Trail to the south, to accommodate a minimum of two lanes of traffic in either direction and include a new bridge across the Western Irrigation Canal. Refer to ***Figure E.12***. The timing of upgrading the Glenmore Trail from four lanes to six lanes will be determined in the future stage of the design based on traffic studies.

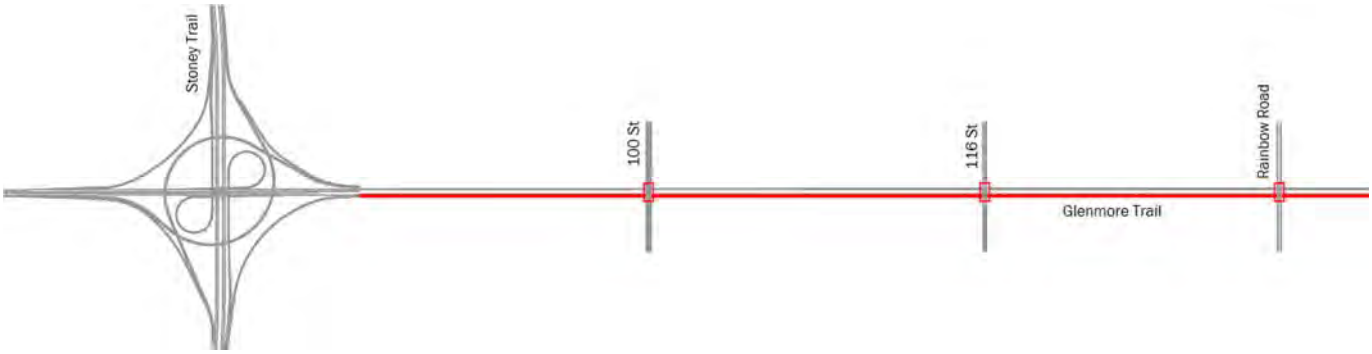


FIGURE E.12: ADDITIONAL EASTBOUND LANES AND TWINNING OF GLENMORE TRAIL

Stage 3 – Grade Separation

As land is developed, traffic demand will increase resulting in the at-grade intersections reaching capacity. Future traffic analysis along Glenmore Trail will be required to determine the timing in which the intersection(s) will require grade separation. Stage 3 could extend over a number of years with each intersection grade-separated individually or grouped together as determined by traffic demand. New ramps and bridges are required to grade separate across Glenmore Trail. ***Figure E.13*** shows the grade separation of Glenmore Trail at 100 St SE, 116 St SE and Rainbow Road. This study identified a series of temporary roads that may be required to build the bridges and ramps to minimize disruption to traffic during construction.

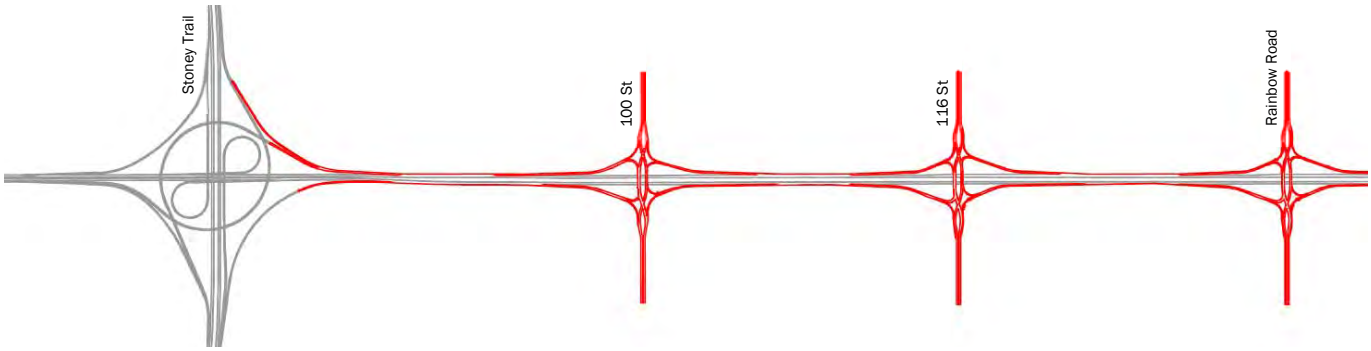


FIGURE E.13: GRADE SEPARATION OF GLENMORE TRAIL

Stage 4 – Westbound Basketweave

A westbound basketweave was proposed as a long-term solution to address potential weaving problems due to the close proximity of Stoney Trail to 100 St SE. Refer to ***Figure E.14***. If the traffic review carried out in the previous stage warrants the need for a basketweave, the basketweave can be constructed at this stage. All property acquisitions and utility relocations should have occurred during Stage 3. Hence, there should be minimal temporary traffic diversion required during construction.

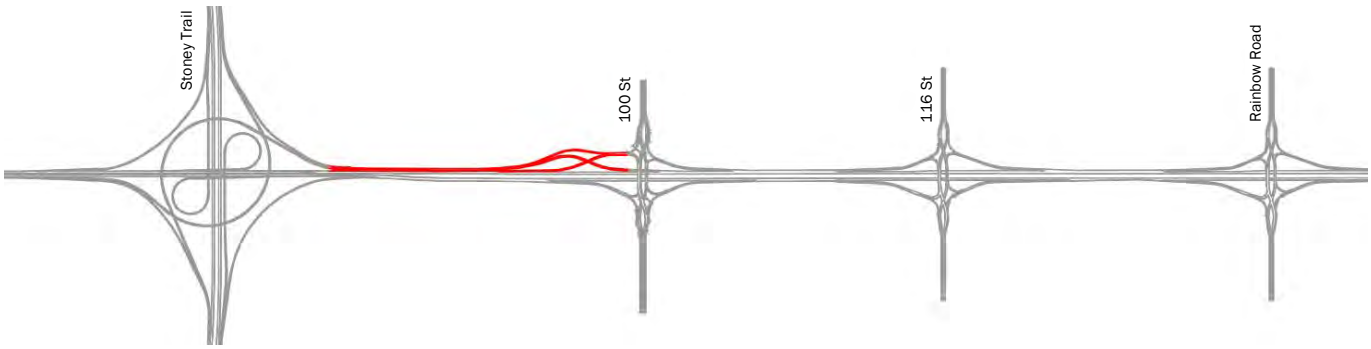


FIGURE E.14: BASKETWEAVE FROM 100 ST SE TO STONEY TRAIL

E.9 Conclusion

A comprehensive functional planning process was completed for 100 St SE, 116 St SE and Rainbow Road interchanges along Glenmore Trail under the guidance of the Technical Review Committee. Options were developed and evaluated for the study area. Three diverging diamond interchanges are recommended as the optimum interchange configuration for the junctions at 100 St SE, 116 St SE and Rainbow Road along Glenmore Trail. The recommended plan includes an option to include a basketweave structure in the westbound direction between 100 St SE and Stoney Trail to address potential weaving problems.

1. Introduction

1.1 Study Purpose

The primary objective of the study is to determine the ultimate access and land acquisition requirements along Glenmore Trail, that align with the area structure plans prepared by The City - Shepard ASP and RVC - Janet ASP and since AT prepared the Highway 560:02 study in 2007. This study was also prepared in response to existing operational and safety deficiencies associated with the corridor and the impediment these deficiencies place on planned growth within the area. The functional outcomes of the study provide improvements for the transportation network operation by reducing delays and improving capacity of the intersections within the study area. Moreover, the project recommendations will improve safety while minimizing impacts to road users, land owners, and the environment.

The recommendations of this study have been developed with a multi-jurisdictional review team which included The City of Calgary (The City), Rocky View County (RVC) and Alberta Transportation (AT).

The issues listed below are outside the scope of the Glenmore Trail East Functional Planning study.

- Upgrades to connecting local arterial roads beyond the interchange, unless they are considered part of an option;
- Amendments to provincial or municipal land use policies or objectives;
- Future unknown or emerging vehicle technologies; and
- Noise study (due to all surrounding land being planned for commercial / industrial / agricultural use).

The purpose of this report is to document the process and recommendations of the Glenmore Trail East Functional Planning Study along Glenmore Trail (Highway 560) from Stoney Trail to Rainbow Road. This report replaces the westerly 6 km of the previously proposed 17 km transportation infrastructure improvements documented in AT's 2007 Functional Planning Study for Highway 560:02 from Calgary to Highway 797.

1.2 Study Process

The functional planning study process included four phases with stakeholder and public engagement completed throughout the project. The phases and associated activities and deliverables are summarized below. The functional planning process key (see figure) is included in each study section to emphasize where the information being presented aligns with the overall planning process.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

Phase 1: Identify

- A review of the strategic transportation context for the Glenmore Trail East corridor including the intersections with 100 St SE and 116 St SE;
- The identification of site constraints and challenges within the study area;
- The development of a comprehensive engagement plan that allowed key stakeholders and the general public to provide critical input at key study intervals to inform the study team with respect to community needs, impacts, and improvement considerations for all modes of travel;

- A review and assessment of current and future traffic conditions within the study area;
- Stakeholder workshop to identify issues, opportunities and constraints; and
- Public information session to introduce the study and establish existing conditions.

Phase 2: Develop

- The development of multiple preliminary options to take to a preliminary evaluation;
- The development of an appropriate evaluation framework to be applied to the options in order to determine a short-list of potential solutions that accommodate all modes of travel; and
- Public information session on short-term improvements for 100 St SE and long- term improvements for 100 St SE, and 116 St SE.

Phase 3: Evaluate

- The completion of a Multiple Account Evaluation (MAE) process, informed by stakeholder and public engagement feedback;
- The inclusion of the Triple Bottom Line framework that considers social, economic and environmental themes in the evaluation process;
- Development of a conceptual layout at Rainbow Road to allow an evaluation of traffic and safety performance east of 116 St SE (see note below);
- The recommendation of a preferred option based on the evaluation results; and
- The documentation and summation of the evaluation process and results.

Phase 4: Refine and Recommend

- The preparation of a functional design of the recommended solution, including horizontal and vertical geometry, active transportation infrastructure, stormwater management, construction staging, right-of-way requirements, property acquisition, and implementation costs;
- The documentation of the study findings in a comprehensive report; and
- Public information session on the recommended plan and conversations with stakeholder groups.

INCLUSION OF RAINBOW ROAD INTERCHANGE

It is important to note, that due to the close spacing of the proposed interchanges from Rainbow Road to Stoney Trail, it was necessary to include Rainbow Road in the analysis in determining the overall recommended configuration for the corridor. The decision to include Rainbow Road occurred after the MAE and adoption of the DDI as the recommended plan for 100 St SE and 116 St SE.

1.3 Study Area

The Glenmore Trail East Functional Planning study area is located on Glenmore Trail (Highway 560), through southeast Calgary and Rocky View County, Alberta, as shown in ***Figure 1.1***.

The study area consists of the Glenmore Trail corridor between Stoney Trail Interchange and just east of the Rainbow Road intersection, as shown in ***Figure 1.2***.

The study area passes through The City, RVC, and the Stoney Trail right-of-way owned by AT. Major north-south corridors along this section of Glenmore Trail East include: Stoney Trail, 100 St SE, 116 St SE, and Rainbow Road.

FIGURE 1.1: REGIONAL CONTEXT OF STUDY AREA

FIGURE 1.2: GLENMORE TRAIL EAST FUNCTIONAL PLANNING STUDY AREA

Many of the roadways within the study cross municipal boundaries, and so, have several names. For the simplicity and consistency of the report, the street names shown in ***Table 1.1*** will be used.

TABLE 1.1: STREET NAMES USED IN REPORT

NAME USED IN THIS REPORT	COMMON NAMES
Stoney Trail	Highway 201 / Calgary Ring Road
Glenmore Trail SE	Highway 560
100 St SE	Garden Road, Range Road 285
116 St SE	Conrich Road, Range Road 284
Rainbow Road	Range Road 283

For much of the report, the corridor has been divided into two parts:

1. Stoney Trail to 870m east of 100 St SE, and
2. 870m east of 100 St SE to 700m east of Rainbow Road.

The segmentation reflects the different land uses, transportation challenges and corridor requirements that are exhibited in the study area.

1.4 Study Background

The 2007 Highway 560 Functional Planning Study completed by AT is the approved long-term plan for the corridor. The plan calls for the upgrade of Highway 560 to a high-speed, six-lane divided highway with diamond interchanges. The 2007 Study provided no access to 100 St SE and the two originally-planned interchanges were located 400 m west of 116 St SE and along the existing alignment of Rainbow Road. Based on an updated assessment by The City, a half diamond interchange at 100 St SE was reviewed and tentatively approved by AT in 2009. The correspondence is included in ***Appendix M***. Later, based on assessment by area landowners, a Parclo A-B interchange at 116 St SE with a 100 m realignment to the west was reviewed and tentatively approved by AT in 2013. The correspondence is included in ***Appendix M***. Both approvals were subject to completion of an updated functional planning study in the area, which has now been addressed by the findings of this report.

In 2016, a joint review committee began assessing the potential for providing all-turns access at 100 St SE. Members of the committee included: AT, The City and RVC. The committee reviewed updated traffic forecasts, interchange junction analysis, highway weaving operations analysis and interchange configurations. It was ultimately agreed that the best overall solution consisted of three diamond interchanges at 100 St SE, 116 St SE and Rainbow Road.

1.5 Stakeholders

Stakeholders refer to any interested or impacted parties. The study team sought to involve and inform stakeholders early on and throughout the process. The engagement process and a summary of engagement results to date are provided in Section 2 of this report. ***Table 1.2*** provides a list of stakeholders consulted during the study.

TABLE 1.2: PROJECT STAKEHOLDERS

STAKEHOLDER	INTEREST IN POTENTIAL PROJECT
Alberta Transportation	Glenmore Trail is a key component of the province-controlled road network that supports both the region's and province's economic development. The Glenmore Trail corridor is part of the Provincial highway system, and a key high-load corridor.
City of Calgary	Specific to this study, Glenmore Trail serves an important function for access to/from the Shepard Industrial Park and lands controlled by the Shepard Industrial Area Structure Plan. Access along this section of Glenmore Trail would provide additional or increased access to current and future industrial and commercial development. Additionally, several local roads and cross streets under The City's jurisdiction perform an important supporting function with the greater Glenmore Trail corridor. These roads may also require upgrades to complement proposed upgrades of Glenmore Trail to ensure safe and efficient operation.
Rocky View County	Glenmore Trail is an important highway connection between communities and serves as a major access point. Glenmore Trail also provides access to lands controlled by the Janet Area Structure Plan which includes current and future industrial and commercial development, country residential, and regional recreational sites like the HeatherGlen Golf Course.

STAKEHOLDER	INTEREST IN POTENTIAL PROJECT
Adjacent Businesses	Includes all businesses that have direct access to Glenmore Trail or are adjacent to the corridor. These businesses range in use, from agricultural to transportation to industrial.
Utility Companies	Includes shallow and deep utility providers.
Prairie Schooner Estates	30 lot (approximately 112 acres) country residential subdivision north of Glenmore Trail that abuts the HeatherGlen Golf Course to the east. Currently the development has direct all-turn access to Glenmore Trail.
HeatherGlen Golf Course	The privately owned 110 acres, 27-hole golf course, adjoins Glenmore Trail and Garden Road. Upgrading either road will require property acquisition likely impacting the layout of the golf course and potentially the Golf Club's parking lot and clubhouse.
Private Landholders (other)	Many of the land holdings around Glenmore Trail are now owned by developers, with the intent to develop in accordance with the City and RVC area structure plans. Upgrading of Glenmore Trail East is likely to result in property acquisition from adjacent land owners.

1.6 Relevant Regulations and Plans

There are several government policy and strategic planning documents that were available during the course of the planning study. These documents set the strategic framework for the planning and delivery of infrastructure within the study area. These documents have been reviewed to provide the strategic planning context along with existing and futures needs for upgrading the corridor.

ALBERTA TRANSPORTATION

Highways Development and Protection Regulation 326/2009

The Highways Development and Protection Act provides for the administrative structure of Alberta's highway network and emphasizes public safety through regulating the physical condition of the highway network. The Act also coordinates the administrative relationship between municipal transportation systems and the province's highway network.

INTERMUNICIPAL PLANS

The Shepard Plan – 2001, last amended 2014

The plan classifies land uses north and south of Glenmore Trail as primarily business uses. The plan identifies 100 St SE and 116 St SE as major connectors and Glenmore Trail as a freeway. The 30-year conceptual transportation network includes three interchanges: the existing interchange at Stoney Trail at Glenmore Trail, 100 St SE at Glenmore Trail (recommended), and 116 St SE at Glenmore Trail (recommended) as shown in ***Figure 1.3***.

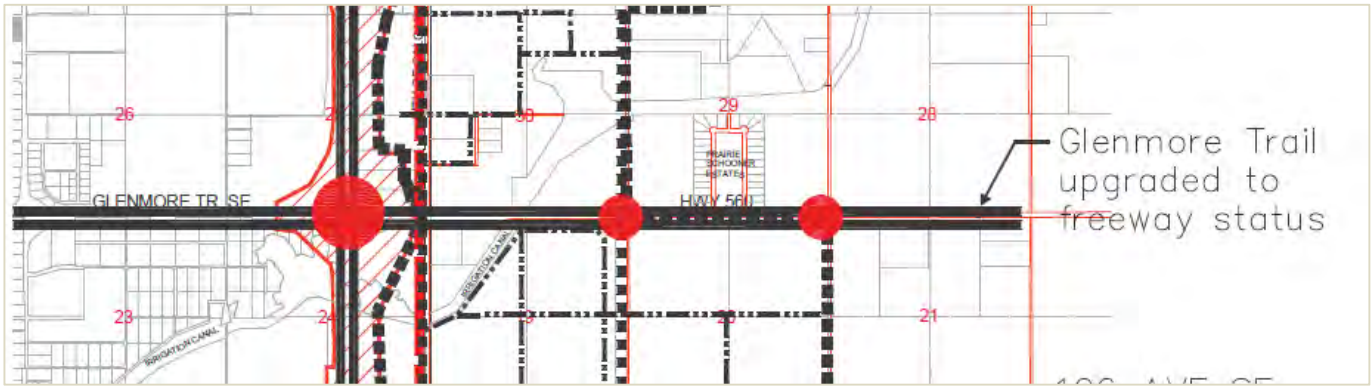


FIGURE 1.3: SHEPARD PLAN 30-YEAR CONCEPTUAL TRANSPORTATION NETWORK
SOURCE: CITY OF CALGARY SHEPARD PLAN (2001)

Rocky View County / City of Calgary Intermunicipal Development Plan – 2012 (IDP)

The purpose of the IDP is to identify areas of mutual interest, minimize land use conflicts across and along borders, provide opportunities for collaboration, and outline processes for the resolution of issues that may arise within the plan area. Key focus areas include the Glenmore Trail Joint Industrial Corridor. The area represents long-term industrial growth for both municipalities. A significant feature along this corridor is the Shepard Wetland Complex which serves as stormwater management for RVC and The City.

THE CITY OF CALGARY

Calgary Municipal Development Plan – 2009 (MDP)

The MDP classifies the area as Greenfield Industrial connected east-west by Glenmore Trail, classified as a skeletal roadway and cross streets, such as 100 St SE as Industrial Arterials. Mobility policies related to industrial areas include:

- A road network that supports the efficient movement of trucks, goods and services;
- The design of new streets or retrofit of existing streets should refer to complete streets guidance;
- Mobility in the area should protect primary goods movement corridors by limiting direct access from truck routes to adjacent properties;
- Sidewalks should be provided to connect transit stops to major businesses in the surrounding industrial areas;
- Transit waiting facilities should be provided in public rights-of-way or, where possible, integrated with adjacent industrial or commercial developments.

Calgary Transportation Plan – 2009 (CTP)

The CTP classifies Glenmore Trail as a skeletal road and a primary goods movement corridor. The CTP notes that along skeletal roads, the accommodation of walking and cycling along the facility is not required. The regional Western Headworks Canal multi-use pathway connects across Glenmore at the west end of the study area.

Shepard Industrial Area Structure Plan – 2009, Amended 2013 (ASP)

The Shepard Industrial ASP includes the land to the south of Glenmore Trail from 84 St SE to 116 St SE. Some of the policy and constraints identification include:

- Transmission lines - 240 kV power lines are located on the west side of 100 St SE;
- Land use - the area immediately south of Glenmore Trail has been designated as full serviced industrial with some commercial along major roadways (see ***Figure 1.4***);
- Transportation network - a partial Interchange, which is to be approved by AT, is shown at the intersection of Glenmore Trail and 100 St SE with a proposed regional pathway on the west side of 100 St SE. Full interchanges are shown on Glenmore Trail at the intersections of Stoney Trail and a realigned 116 St SE;
- Transit - A crosstown route is proposed for 100 St SE from 114 Ave SE to north of Glenmore Trail;
- Wetland complexes - There are two complexes that will be impacted in the study area. The first is a Type 3 wetland located near the west limit of the project and will likely be impacted by ramps and widening. The second is in the south east corner of the intersection and consists of Type 1 to Type 5 wetlands; and
- Storm services - A conceptual conveyance system is proposed to cross Glenmore Trail just west of 100 St SE.

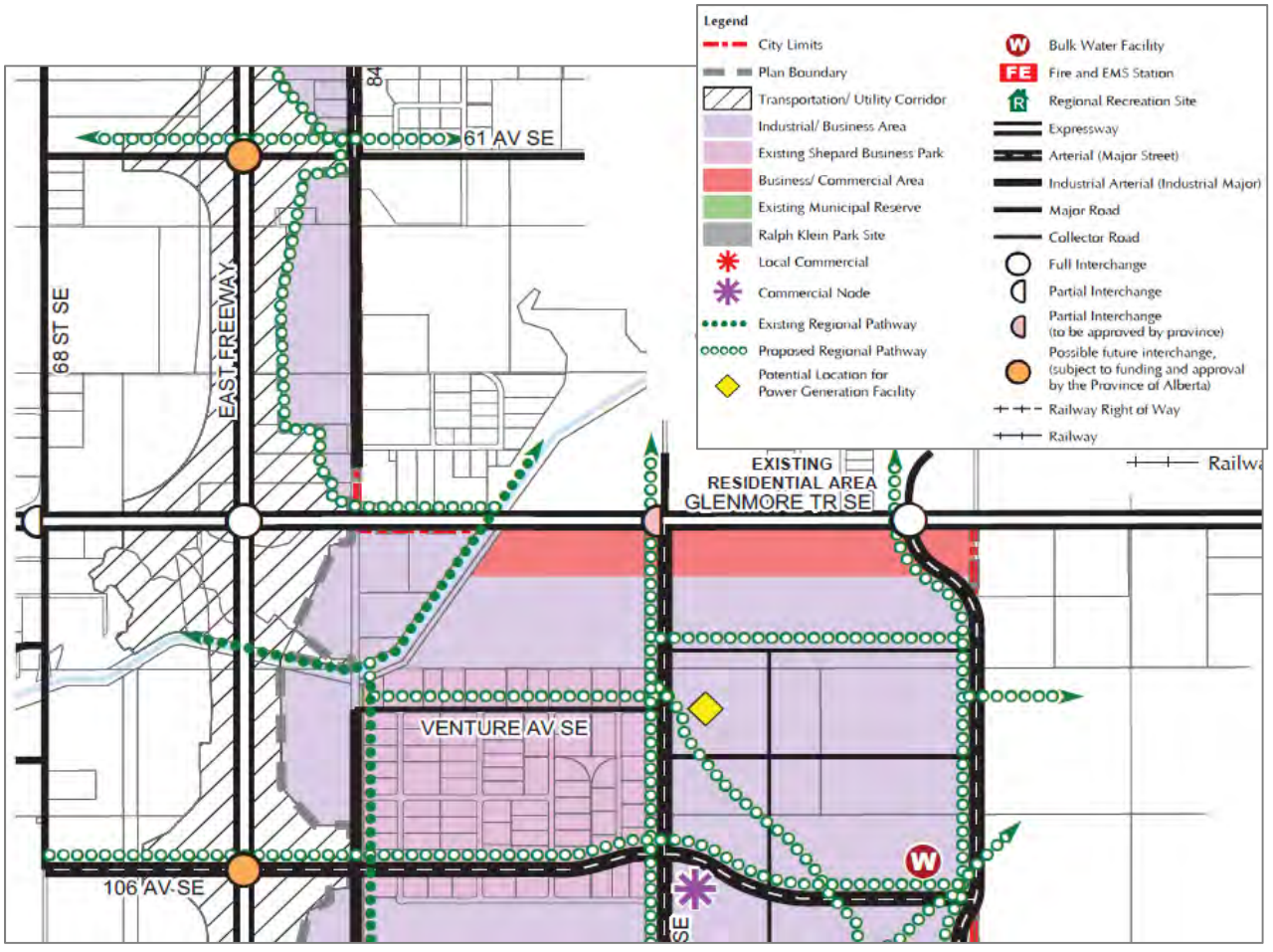


FIGURE 1.4: LAND USE CONCEPT
SOURCE: SHEPARD AREA STRUCTURE PLAN (2013)

ROCKY VIEW COUNTY

County Plan 2013 – Amended in 2017

The County Plan provides a framework for long-term growth in RVC. Glenmore Trail is identified as a highway connecting to the Shepard (now referred to as Janet) regional business centre as well as the full-service hamlet, Langdon, which is east of the study area.

Janet Area Structure Plan – 2014 (Janet ASP)

The Janet ASP includes the land to the north of Glenmore Trail from 84 St SE to Range Road 282. The ASP designates land use from 84 St SE to 116 St SE as long-term unserviced industrial with some commercial development. The lands east of 116 St SE are designated as long-term businesses uses. The ASP maintains Prairie Schooner Estates as country residential uses. The infrastructure proposed along the Glenmore Trail corridor include two full interchanges at Stoney Trail and at 116 St SE and a fly over at 100 St SE. The ASP also proposes a regional pathway from south of Glenmore Trail to north of Peigan Trail along the west side of 100 St SE. Land uses are depicted in ***Figure 1.5***.

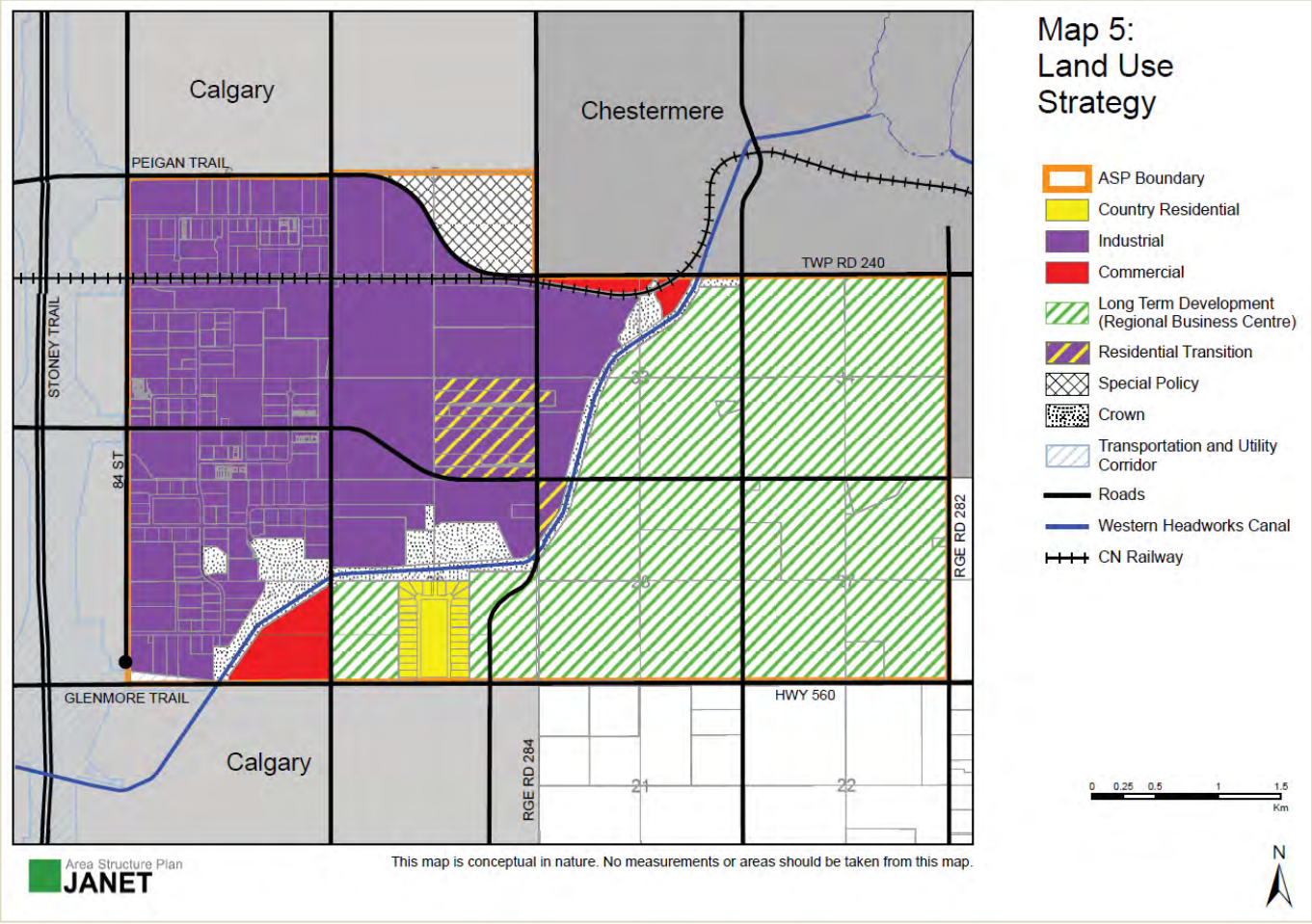


FIGURE 1.5: JANET AREA STRUCTURE PLAN LAND USES
SOURCE: JANET ASP (2014)

1.7 Relevant Studies

Several studies pertaining to the transportation network in and around the Glenmore Trail East corridor have been conducted over the last decade. The key studies and how they relate to this planning study summarized in ***Table 1.3*** below.

TABLE 1.3: SUMMARY OF PREVIOUS STUDIES

STUDY	YEAR	KEY POINTS RELEVANT TO GLENMORE TRAIL EAST STUDY
Highway 560:02 - From Calgary to Highway 797 Functional Planning Study (UMA |AECOM)	Feb. 2007	• Twinning recommended within 10 years (2017) • Existing lanes retained as future WB lanes, with proposed twinning to construct future EB lanes to the south of existing lanes • 6-lane configuration proposed for Glenmore Trail • Closure of the Glenmore and 100 St SE intersection in 40 years (2047)
Glenmore Trail and Garden Road Interchange Memorandum (ISL Engineering)	Nov. 2008	• Weaving issues anticipated to the east of the Glenmore Trail and 100 St SE interchange due to 116 St SE realignment to the west • Recommend the Glenmore and 100 St SE interchange only provide ramps to the west
East Regional Context Study (City of Calgary)	Apr. 2009	• Adjacent land use to the south of Glenmore Trail has been designated as industrial • Proposed pathway connection has been identified on the west side of 100 St SE across Glenmore Trail
Shepard Industrial Park Traffic Impact Assessment (D.A. Watt Consulting)	May 2009	• Glenmore Trail and 100 St SE at-grade intersection will operate beyond capacity during the peak hours by 2035 • Construction of a partial interchange at Glenmore and 100 St SE could reduce the congestion to acceptable levels • An interchange will be required at 116 St SE if no access to Glenmore Trail is allowed at 100 St SE
Southeast Industrial Corridor Growth Area Plan Transportation Plan (iTRANS Consulting)	Jun. 2009	• 100 St SE north of Glenmore Trail is to be designated as a Major Street with a 4-lane divided cross section • 36m right-of-way required
Shepard Industrial Area Functional Planning Study (D.A. Watt Consulting)	Nov. 2009	• 100 St SE requires a modified 4-lane divided major roadway cross section • 29.5 m right-of-way required
Highway 560 / Conrich Road Proposed Interchange Memo (ISL)	2012	• Evaluation and update to the long-range traffic forecasts and analysis for the Glenmore Trail and 116 St SE interchange • Part of the land-use application for the Glenmore Business Park • Concluded that Highway 560 FPS (2007) required moderate adjustments to reflect intensified land uses, Diamond/Parclo A-B or Parclo A4 would operate well with a 4-lane cross road, if 100 St SE half interchange is considered.
EMCOR Business Park Traffic Impact Assessment (D.A. Watt Consulting)	2015	• Glenmore Trail to be upgraded to 4 lanes up to 116 St SE, • A half interchange at Glenmore Trail and 100 St SE in 2020 • Upgrade Glenmore Trail and 116 St SE intersection to a full interchange in 2035

HIGHWAY 560:02, CALGARY TO HIGHWAY 797 – FUNCTIONAL PLANNING STUDY- 2007

The focus of this study was to define the future highway right-of-way along Glenmore Trail from 84 St SE to Highway 797 in Langdon. The study found that twinning was warranted along Highway 560 and proposed the construction of interchanges at 116 St SE, 100 St SE and Highway 791 for the ultimate configuration.

Three staging periods were used for this study, 10, 20 and 40 years. The short-term staging plan (10 years) for the intersection at Glenmore Trail and 100 St SE included widening the southeast and southwest corners to accommodate a WB-21 design vehicle. Additionally, Glenmore Trail is recommended to be twinned with the new lanes being built on the south side of the existing highway.

In the ultimate 40-year plan, the 100 St SE intersection is recommended to be closed due to space constraints with the Stoney Trail interchange ramps. A six-lane configuration with three lanes required in each direction is anticipated based on traffic volume projections. The proposed right-of-way requirement for Glenmore Trail is 100 m with an additional 25 m of right-of-way included if a service road is proposed. A plan of the ultimate configuration is shown in ***Figure 1.6***. This study is the current AT approved plan for the Glenmore Trail corridor from 84 St to Highway 797:02, except for areas where later status identified revisions on an approved-in-principle basis.

FIGURE 1.6: ULTIMATE 100 ST SE AND 116 ST SE CONFIGURATION
SOURCE: HIGHWAY 560:02 FUNCTIONAL PLANNING STUDY – (2007)

GLENMORE TRAIL / GARDEN ROAD INTERCHANGE – MEMORANDUM – 2008

A memorandum, completed by ISL Engineering for The City, summarizes preliminary geometric and weaving analysis for a partial interchange at Glenmore Trail and 100 St SE, with the proposed interchange at Stoney Trail and Glenmore Trail. The concept for the partial interchange provides a west access to Garden Road, as depicted in ***Figure 1.7***.

It was recognized that the interchange spacing to Stoney Trail is less than the desired 3 km (AT standards), however, a minimum weave zone length of 800 m can be readily maintained. The memo determined that a partial interchange is a viable alternative for access to the Shepard Industrial area. AT supported these findings in principle, subject to completion of an updated functional planning study which is now reflected in this report.

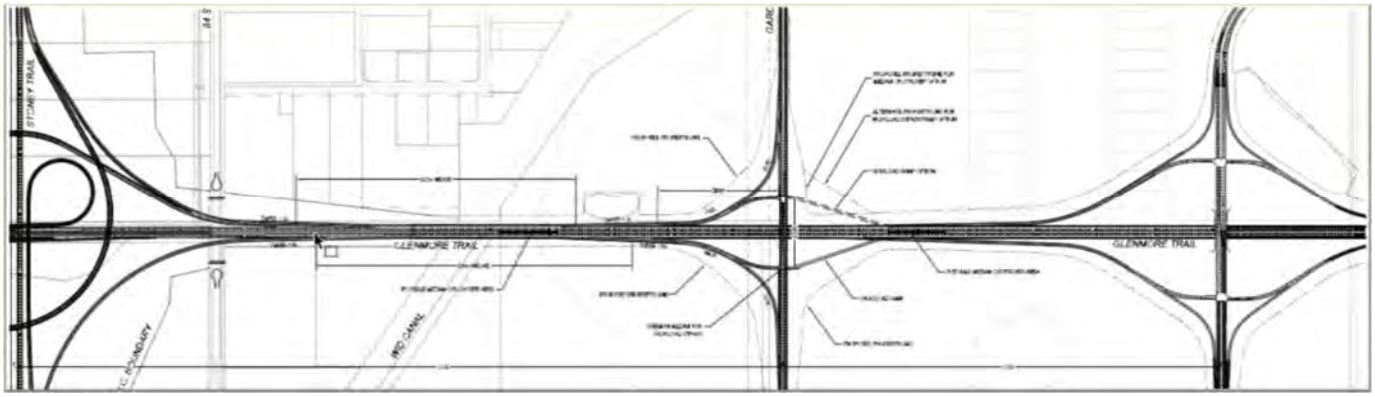


FIGURE 1.7: PROPOSED PARTIAL INTERCHANGE CONFIGURATION
SOURCE: GLENMORE TRAIL / GARDEN ROAD INTERCHANGE MEMORANDUM (2018)

EAST REGIONAL CONTEXT STUDY – 2009

This document provides the framework for ASP along the east side of The City. The study area is bounded by 8 Ave NE to the north, the Bow River to the south, the Transportation and Utility Corridor (TUC) to the west, and 116 St SE / 120 St to the east. The study area does not include the lands between Peigan Trail and Glenmore Trail since they are under the jurisdiction of RVC.

According to the study, the area directly south of Glenmore Trail has been designated as industrial, with a proposed partial interchange at the intersection of 100 St SE and Glenmore Trail. A note was made in the document indicating the potential partial interchange has yet to be approved by AT. A proposed pathway connection was also identified on the west side of 100 St SE across Glenmore Trail.

SHEPARD INDUSTRIAL PARK – TRAFFIC IMPACT ASSESSMENT – 2009

A traffic impact assessment (TIA) was requested by The City to assess the impact of a proposed development in the Shepard Industrial Park on the transportation network. The focus of this study was to estimate vehicular trip generation and analyze long-term traffic conditions and operations for key intersections in the area. Two potential road network scenarios were identified and analyzed at Glenmore Trail and 100 St SE: a signalized intersection and a flyover.

The traffic analysis results for the first scenario (signalized intersection) determined that the intersection at Glenmore Trail and 100 St SE will be operating beyond its capacity during the peak hours by the year 2035. This analysis included optimization of the signal timing and adding dual left turns for two major movements (northbound to westbound and eastbound to northbound). A comment was made in the study that congestion levels during peak periods could be reduced to acceptable levels with the construction of a partial interchange at this location.

The second scenario (flyover) required 116 St SE to be the main access point into the Shepard Industrial Park since no access would be allowed from 100 St SE. The study determined that an interchange will be required at the 116 St SE and Glenmore Trail if no connection is provided to Glenmore Trail from 100 St SE.

SOUTHEAST INDUSTRIAL CORRIDOR GROWTH AREA PLAN – TRANSPORTATION STUDY – 2009

The focus of this study was to identify the road network, classify all arterial roads in the study area, and develop designs for required cross-sections (right-of-way requirements, number of lanes and intersection layouts and traffic control types). The study encompasses an area from Township Road 241 to Township Road 233 (north to south) and 84 St to Range Road 275 (west to east).

100 St SE was included in this study starting from Glenmore Trail and continuing north, however Glenmore Trail was not included since it is classified as a provincial highway. 100 St SE north of Glenmore was designated to be a Major Street with a four-lane divided road cross-section and a 36 m right-of-way, which is equivalent to a City Arterial standard.

SHEPARD INDUSTRIAL AREA - FUNCTIONAL PLANNING STUDY – 2009

The purpose of this study was to determine the alignment, cross-section, profile and right-of-way for the major roads located in the Shepard ASP. The study looked at three major corridors including 100 St SE, starting at Glenmore Trail and continuing south.

This study used information gathered from the Shepard Industrial Park TIA to determine whether 100 St SE would require a modified four-lane divided major roadway cross section. Due to the existing overhead powerline corridor located on the west side of 100 St SE, the existing road would need to be widened to the east. The total right-of-way required for 100 St SE would be 29.5 m. ***Figure 1.8*** outlines the proposed cross-section.

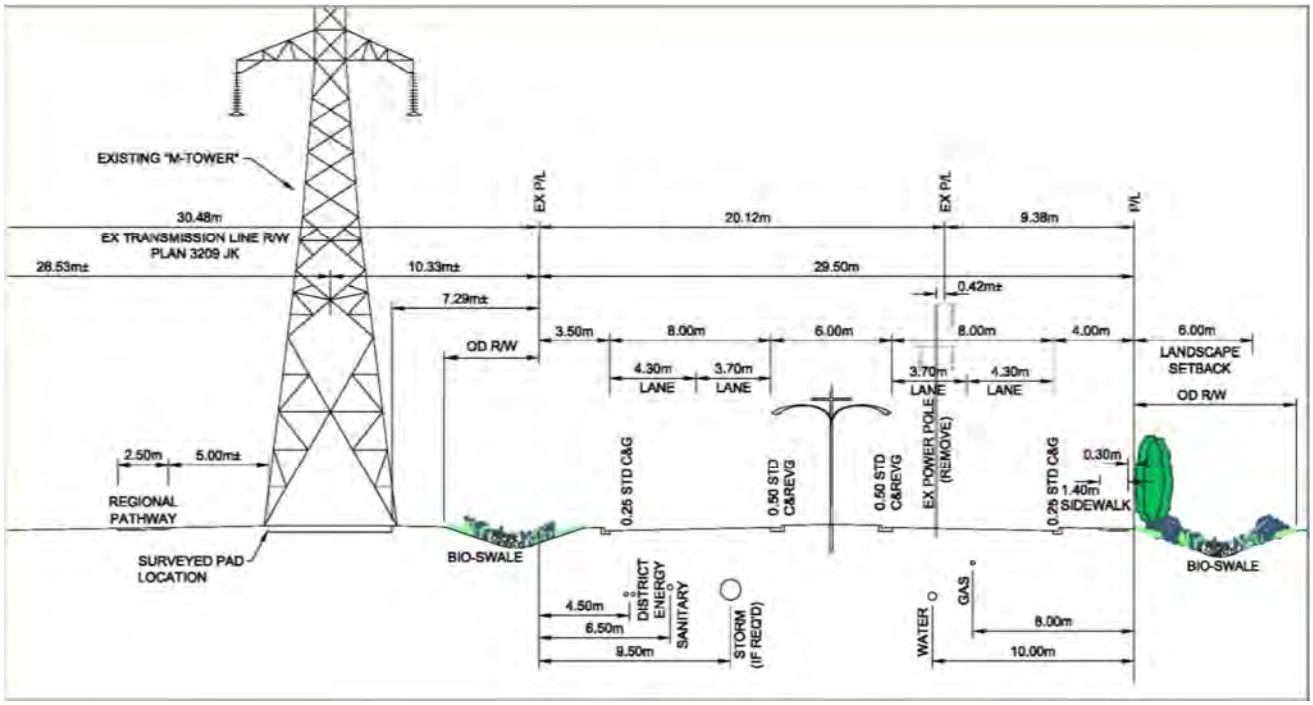


FIGURE 1.8: PROPOSED 100 ST SE CROSS-SECTION
SOURCE: SHEPARD INDUSTRIAL AREA FPS (2009)

HIGHWAY 560 / CONRICH ROAD PROPOSED INTERCHANGE MEMO – 2012

This memorandum, prepared by ISL Engineering for Ronmor Developers, provided updated forecasting and network analysis related to the 100 St SE and 116 St SE interchanges. The primary intent of the memo was to support reconsideration of the prior plan to relocate 116 St SE about 400 m to the west at the time of interchange construction. Alternative options for an interchange at 116 St SE were evaluated, concluding that a Parclo A-B near the original alignment of 116 St SE was a viable alternative to the original functional plan. AT supported these findings in principle, subject to completion of an updated functional planning study which is now reflected in this report.

EMCOR BUSINESS PARK TRANSPORTATION IMPACT ASSESSMENT – 2015

This TIA was prepared to assess the impact of a proposed industrial development located east of 100 St SE and north of Glenmore Trail. The focus of this study was to analyze road improvement required in 2020 and 2035 with the proposed development. This study has also outlined the road improvement required for both horizon years without the proposed development. A recommendation was for to upgrade Glenmore Trail to four lanes up to 116 St SE in 2020. It was identified that the intersection of Glenmore Trail and 100 St SE cannot be improved to the point of acceptable operating conditions in 2020 by modifying signal timing and introducing additional lanes. A comment was made in this TIA that a previous D.A. Watt report recommended a partial interchange for this intersection for 2020. It was also identified in this TIA that without the proposed development, some movements will operate at a level of service F with a signalized intersection at the intersection of Glenmore Trail and 116 St SE in 2020, and that a signalized intersection is insufficient in brining this intersection to meet the RVC's operational requirement in 2035.

2. Engagement

From the outset, public engagement was identified as a priority for the Glenmore Trail East Study and the project team made the commitment to engage with impacted stakeholders and the public early and often throughout the process. The engagement approach reflected and upheld the guiding principles established in The City's 2014 engage! Framework & Tools, and in the Engagement/Communications Standards for Consultants provided by Transportation Planning.

The project team developed a three-phase engagement process which provided stakeholders and the broader public with multiple opportunities to provide feedback throughout each phase of the project. The goals of the engagement process were to:

- Understand stakeholder and public issues;
- Develop options using stakeholder and public issues; and
- Recommend a plan that considered stakeholder and public input.

Figure 2.1 depicts how engagement was incorporated into the overall project milestones.

At the completion of each public engagement piece, an Engagement Summary Report was prepared summarizing the findings and feedback from stakeholders. All Engagement Summary Reports are included in ***Appendix B***.

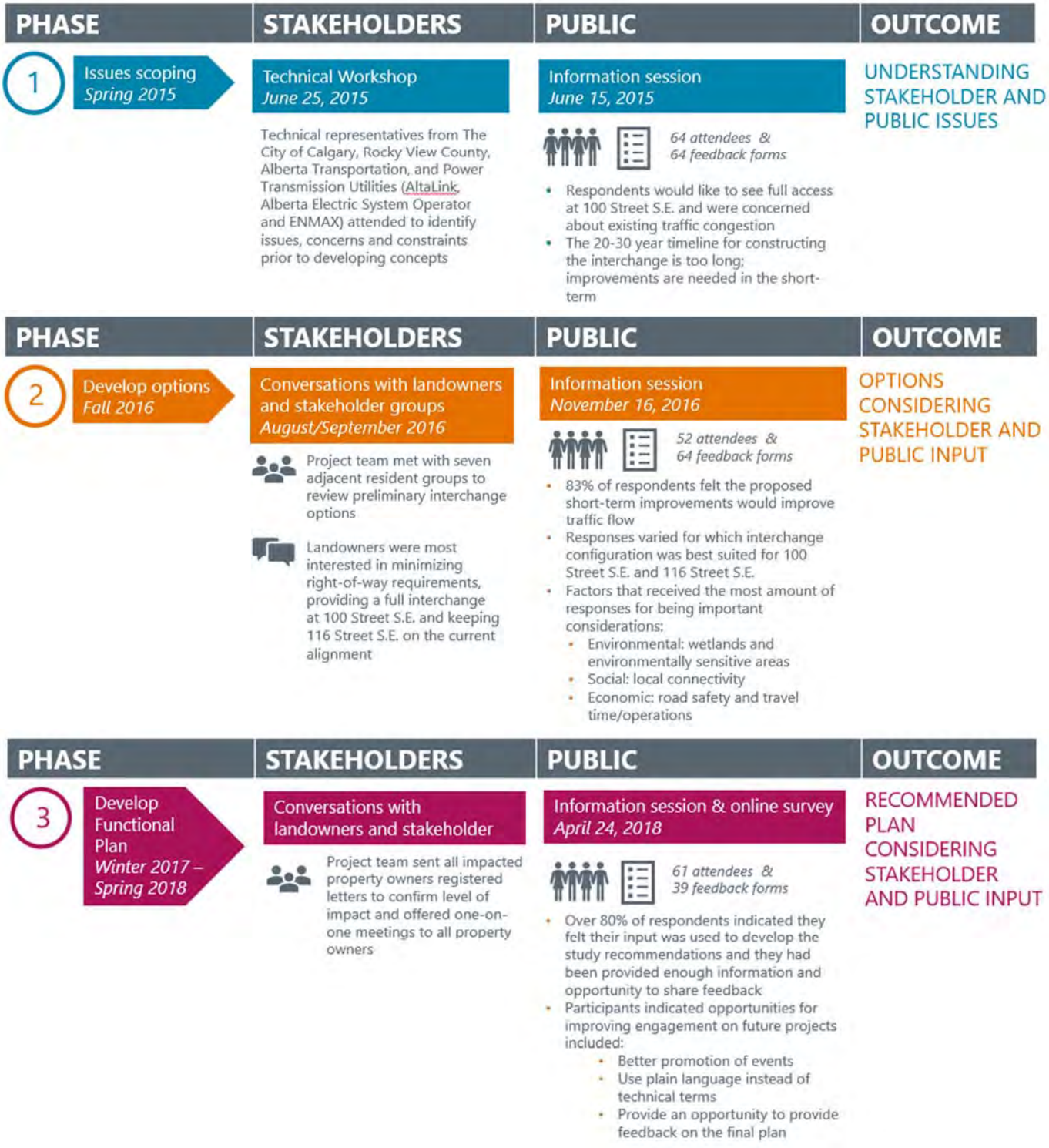


FIGURE 2.1: ENGAGEMENT PROCESS OVERVIEW

PHASE 1 - ISSUES SCOPING (SPRING 2015)

During the first phase of the study, which at this point was referred to as the Glenmore Trail / 100 St SE Interchange, the project team learned about stakeholder goals, perspectives, issues and concerns about the proposed interchange design. The purpose of this study was to capture and incorporate feedback (as much as possible) into the preliminary designs. The project team also sought to proactively mitigate any identified issues and/or concerns whenever possible in design options.

Information Session

A public information session was held on June 15, 2015 to introduce the project team, provide information about the study and discuss any issues or concerns about the proposed interchange. At the time of the first information session, the study was for a half-interchange at 100 St SE. Sixty-four people attended, and 64 comment forms were submitted, either in-person or online. Respondents were most concerned about maintaining full access at 100 St SE and existing traffic congestion. Several respondents indicated that a 20- to 30-year timeline for constructing the interchange was too long and that short-term improvements were needed.

Issues Scoping Workshop

Technical representatives from The City, RVC, AT and power transmission utilities (AltaLink, Alberta Electric System Operator and ENMAX) were invited to attend an Issues Scoping Workshop on June 25, 2015, to identify issues, concerns and constraints prior to concept development. Some of the topics discussed included high-load ramps and high-load traffic requirements, preserving or managing the surrounding wetlands, accommodating wildlife movement, the existing power lines, residential access and the local road network. The input received was used to help develop preliminary interchange options.

Scope Expanded to Include 116 St SE

During the initial public consultation for the Glenmore Trail / 100 St SE interchange, stakeholders asked the project team to investigate the possibility of a full interchange as well as identify possible short-term improvements to reduce congestion at the intersection.

Based on several factors, including public input, planned development in the area and the shifting role and function of 116 St SE in the transportation network, AT agreed to expand the study area to include 116 St SE so that both interchanges could be reviewed together to identify the best access at both intersections. The scope was also expanded to include identifying possible short-term improvements to reduce congestion at the intersection of Glenmore Trail and 100 St SE. The study name was revised to The Glenmore Trail East Study to reflect the new study area.

PHASE 2 - DEVELOP OPTIONS (FALL 2016)

During the second phase, the public was asked to review the proposed interchange options for 100 St SE and 116 St SE, and to help the project team refine and select one recommended plan.

Landowner Meetings

In August and September of 2016, the project team invited key stakeholders and all adjacent landowners—seven groups in total—to review the preliminary interchange options. Landowners were most interested in minimizing right-of-way requirements, providing a full interchange at 100 St SE and keeping 116 St SE on the current alignment.

Information Session

A public information session was held on November 16, 2016 to gather feedback on proposed interchange options for 100 St SE and 116 St SE. Fifty-two people attended and 63 comment forms were collected. Most respondents (83 percent) felt the proposed short-term improvements at 100 St SE would improve traffic flow and responses varied for which interchange configuration (diamond or diverging diamond) was best suited for 100 St SE and 116 St SE. Respondents were also concerned with wetlands and environmentally sensitive areas, local connectivity, and road operations and safety.

PHASE 3 - DEVELOP FUNCTIONAL PLAN (2017)

While developing the functional plan for 100 St SE and 116 St SE, it was decided that due to the close spacing of the proposed interchanges along Glenmore Trail from Rainbow Road to Stoney Trail, it was appropriate to include Rainbow Road in the overall recommended configuration for the corridor.

The project team evaluated the interchange options with both the public input from Phases 1 and 2, and a triple bottom line analysis, then selected and refined the recommended plans for 100 St SE, 116 St SE and Rainbow Road.

Phase 3 included three opportunities for stakeholders, landowners and the public to view the final study recommendations and provide feedback on the overall engagement process for the project. An Information Session was held on April 24, 2018, at the HeatherGlen Golf Course, with the information boards and survey available online from April 24 – May 4, 2018. In addition, impacted and immediately adjacent landowners (including those around Rainbow Road) were contacted directly and offered an opportunity to meet one-on-one with the project team to review and discuss the final plans. Sixty-one people attended the Information Session and another thirty submitted feedback online. Only one impacted landowner requested a meeting with the project team.

Feedback from the Information Session and online survey indicated that participants were satisfied with the engagement process for the Glenmore Trail East Study. Over 80% of participants felt their input was used to develop the study recommendations, and that they were provided enough information and opportunity to effectively share their feedback throughout the project.

Participants indicated there are opportunities for improving engagement on future projects. These include better promotion of events and providing an opportunity to share feedback on the final recommendations.

3. Existing Conditions

A major component of any functional planning study is to first identify any potential issues that may form a constraint to, or provide opportunities for, the development of any improvement plans for Glenmore Trail and the intersections at 100 St SE, 116 St SE and Rainbow Road.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

3.1 General Conditions

The following roadway classifications and design speeds are listed below. Future design criteria elements for each roadway is summarized in Section 5.5 – Design Criteria.

Glenmore Trail – AT controlled Glenmore Trail, is currently a two-lane paved Skeletal Road with a posted speed limited of 80 km/h approximately 550 m west of 116 St SE and 100 km/h to the east.

100 St SE – This road is currently a two-way, two lane paved Industrial Arterial Road with a posted speed of 80 km/h. South of Glenmore Trail, 100 St SE is under the jurisdiction of The City. North of Glenmore Trail, 100 St SE is under the jurisdiction of the RVC.

116 St SE – This road north of Glenmore Trail is currently a two-way, two lane paved Rural Road, under the jurisdiction of RVC. South of Glenmore Trail, 116 St SE is currently a two-lane unpaved Rural Local Road with a posted speed of 80 km/h, providing access to a small number of rural residences.

Rainbow Road – Under the jurisdiction of the RVC, Rainbow Road is a two-lane paved Rural Local road with a posted speed of 80km/h.

3.2 Existing Geometric Conditions

This section examines the existing intersection spacing, grades, access conditions, interchange configurations and operations.

INTERCHANGE AND INTERSECTION SPACING

The primary geometric issue for planning interchanges at 100 St SE, 116 St SE and Rainbow Road is the proximity of these intersections. Interchange ramps require a significant distance to accommodate grade changes, acceleration and deceleration, and possibly vehicle storage at the ramp terminal depending on the ramp configuration. In addition, the distance between sequential entrance and exit ramps needs to be sufficient to accommodate the anticipated weaving manoeuvres between entering and exiting vehicles. The Calgary Ring Road and Highway Penetrators Agreement, which governs joint planning of Glenmore Trail in the vicinity of Stoney Trail, identifies a minimum weaving distance of 600 m. To achieve this weaving distance or more, AT identifies a desired interchange spacing of 2,000 m between service interchanges or 3,000 m from systems interchanges in urban areas.

As shown in the ***Table 3.1***, the distance between the Stoney Trail interchange centreline and the centreline of the 100 St SE intersection is 2,200 m. The spacing between 100 St SE and 116 St SE, and between 116 St SE and Rainbow Road is less, at 1,600 m. Because these figures are under the desired values, first-principle assessments were warranted to confirm that the governing weaving distances could achieve satisfactory operations.

TABLE 3.1: INTERSECTION SPACING

INTERSECTION SEGMENTS	DISTANCE (M)
Stoney Trail SE – 100 St. SE	2,200
100 St. SE – 116 St. SE	1,600
116 St. SE – Rainbow Rd	1,600
Rainbow Road – Hwy 791	4,900

ADJACENT INTERCHANGE CONFIGURATION

The study focus is to develop recommendations for interchange configurations at the intersections of Glenmore Trail and at 100 St SE, 116 St SE and Rainbow Road. Due to the close spacing of the interchanges and Stoney Trail, the configuration of Stoney Trail, especially exit and/or entrance ramps, will need to be considered and recommendations for the integration with the proposed interchange at 100 St SE provided.

GRADES AND DRAINAGE

Glenmore Trail Existing Profile and Drainage

The existing Glenmore Trail is a two-lane undivided roadway with ditches on both sides. Glenmore Trail sheds water directly to the roadside ditches. Overland flows channel along the north side and all current run-off flows into the adjacent ponds and waterbodies. The existing profile of Glenmore Trail has grade changes of less than two percent. Since it is relatively flat, the grade is a non-issue for a free flow highway facility. The existing profile of Glenmore Trail can be described in sections, from west to east:

- Grades along Glenmore Trail east of Stoney Trail flow east and drain into the WID channel.
- Grades along Glenmore Trail between the WID channel and 100 St SE drain west and the overland flow discharges into the wetlands north of Glenmore Trail.
- Grades along Glenmore Trail between 100 St SE and 116 St SE generally drain towards the east; however, there is no visible connections between the runoff ponds in the ditch along 116 St SE and the wetland to the east.
- Grades along Glenmore Trail from 116 St SE up to 400 m to the east drains west toward the wetland east of 116 St SE.
- Grades along Glenmore Trail, 400 m east of 116 St SE and up to 440 m west of Rainbow Road, drain east towards the wetland at the northwest quadrant of Glenmore Trail / Rainbow Road intersection.
- The remaining section along Glenmore Trail, drains toward Shepard Slough located in the northeast quadrant of the Glenmore Trail / Rainbow Road intersection, part of the Shepard Wetland Complex that extends from Chestermere Lake.

Cross-Streets Existing Profiles

Cross streets existing profiles include:

- 100 St SE: existing grades of less than two percent;
- 116 St SE: has ditches on both sides. The profiles on 116 St SE north and south of Glenmore Trail drain towards the existing Glenmore Trail / 116 St SE intersection; and
- Rainbow Road: has ditches on both sides with drainage flows toward the south side of Glenmore Trail.

ACCESS

Currently several properties have direct access to Glenmore Trail. Between Stoney Trail and 100 St SE, there are accesses to the Western Headworks Canal on both the north and south side of Glenmore Trail. There are also three private property accesses as shown in ***Figure 3.1***.

In general, all the areas with affected accesses fall within the planned development areas inside The City and RVC. For the purposes of this study, it is assumed that these accesses will all be replaced or superseded by internal road networks within each of the adjacent development cells, and that purpose-built alternative access routes such as service roads will not be necessary. In the event that the highway is twinned prior to any other development or planning, short service road sections may be needed to remove at-grade access from Glenmore Trail.

FIGURE 3.1: ACCESSES ALONG GLENMORE TRAIL BETWEEN STONEY TRAIL AND 100 ST SE

Between 100 St SE and 116 St SE there is direct access to Prairie Schooner Estates on the north side of Glenmore Trail, as shown in ***Figure 3.2***. Previous planning has provided for relocation of the access to the north side of the subdivision, through future internal road networks.

FIGURE 3.2: ACCESSES ALONG GLENMORE TRAIL BETWEEN 100 ST SE AND 116 ST SE

Between 116 St SE and Rainbow Road there are several accesses located on the north and south side of Glenmore Trail, as illustrated in ***Figure 3.3***.

FIGURE 3.3: ACCESSES ALONG GLENMORE TRAIL BETWEEN 116 ST SE AND RAINBOW ROAD

3.3 Existing Traffic Conditions

Traffic congestion at the existing intersection of 100 St SE forms part of the justification for this study. A level of service assessment and safety review was conducted for the 100 St SE and Glenmore Trail intersection to identify deficiencies and to determine possible short and long-term solutions. It is noted that a similar short-term assessment of 116 St SE or Rainbow Road was not within the scope of the study, due to the longer-term nature of the planning at those locations.

EXISTING TRAFFIC VOLUMES

Vehicle turning movement counts and a truck survey were carried out on 24th April 2015 (Friday) by The City at the Glenmore Trail / 100 St. SE intersection. The time periods for the survey were 07:00 to 09:00 and 16:00 to 18:00. These volumes have been used as the existing volumes for the study. The peak hours for AM and PM were 07:15 to 08:15 and 16:00 to 17:00 respectively. ***Figure 3.4*** and ***Figure 3.5*** show the existing traffic volumes and truck volumes for the AM and PM peak hours as provided by The City.

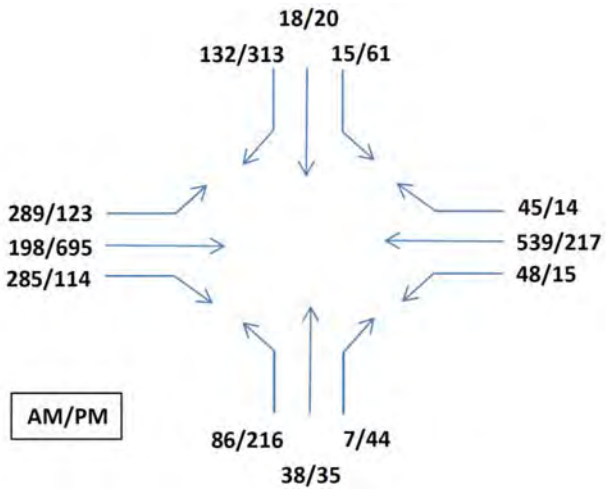


FIGURE 3.4: 100 ST SE - ALL VEHICLE VOLUMES

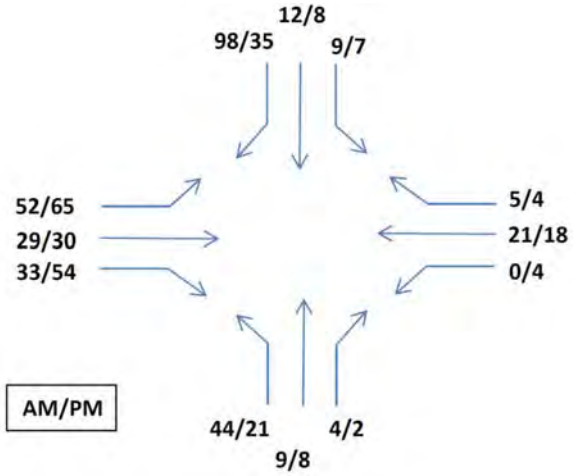


FIGURE 3.5: 100 ST SE - HEAVY VEHICLE VOLUMES

EXISTING LEVEL OF SERVICE ASSESSMENT

Existing signal timings for 100 St SE were also provided by The City. The LOS analysis results summary for the AM and PM peak hours follow in *Table 3.2*. It should be noted that the eastbound and westbound truck volumes/percentages are lower during the mid-day peak period compared to the AM peak period. In the north-south direction, overall volumes during the mid-day are lower than the AM, however truck percentages are higher by approximately 10%.

TABLE 3.2: 100 ST SE - SYNCHRO ANALYSIS SUMMARY (2015 AM AND PM PEAK HOURS)

AM						PM					
MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH		MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH	
EBL	294.5	1.55	F			EBL	52.4	0.81	D		
EBT	19.8	0.26	B	F		EBT	125.3	1.17	F	F	
EBR	3.4	0.44	A			EBR	6.9	0.3	A		
WBL	13.0	0.1	B			WBL	23.3	0.2	C		
WBT	51.0	0.91	D	D		WBT	42.0	0.65	D	D	
WBR	-	-	-			WBR	-	-	-		
NBL	113.8	0.89	F			NBL	56.2	0.76	E		
NBT	57.1	0.29	E	F		NBT	35.4	0.15	D	D	
NBR	0.4	0.05	A			NBR	1.7	0.15	A		
SBL	-	-	-			SBL	-	-	-		
SBT	66.3	0.41	E	C		SBT	52.9	0.51	D	C	
SBR	19.4	0.65	B			SBR	12.7	0.71	B		
Intersection	76.3	-	E	-		Intersection	64.5	-	E	-	

SENSITIVITY ANALYSIS

A sensitivity analysis has been carried out for heavy vehicles by adding 10% and 25% heavy vehicles for each approach for both the AM and PM peak hours. The results of the sensitivity analysis are summarized in *Table 3.3* and *Table 3.4* for increases in heavy vehicle percentages of 10% and 25% respectively.

TABLE 3.3: HEAVY VEHICLE SENSITIVITY ANALYSIS SUMMARY – ADDITIONAL 10% HEAVY VEHICLES

AM						PM				
MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH		MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH
EBL	517.5	2.05	F	F		EBL	52.4	0.81	D	F
EBT	21.1	0.3	C			EBT	125.3	1.17	F	
EBR	3.9	0.5	A			EBR	6.9	0.3	A	
WBL	13.4	0.12	B	F		WBL	23.3	0.2	C	D
WBT	88.2	1.07	F			WBT	42.0	0.65	D	
WBR	-	-	-			WBR	-	-	-	
NBL	162.2	1.07	F	F		NBL	56.2	0.76	E	D
NBT	60.1	0.36	E			NBT	35.4	0.15	D	
NBR	0.5	0.06	A			NBR	1.7	0.15	A	
SBL	-	-	-	C		SBL	-	-	-	C
SBT	70.7	0.49	E			SBT	52.9	0.51	D	
SBR	20.5	0.69	C			SBR	12.7	0.71	B	
Intersection	126.3	-	F	-		Intersection	64.5	-	E	-

TABLE 3.4: HEAVY VEHICLE SENSITIVITY ANALYSIS SUMMARY – ADDITIONAL 25% HEAVY VEHICLES

AM						PM				
MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH		MOVEMENT	DELAY (S)	V/C	LOS	LOS APPROACH
EBL	930.8	2.99	F	F		EBL	52.4	0.81	D	F
EBT	28.0	0.45	C			EBT	125.3	1.17	F	
EBR	6.0	0.65	A			EBR	6.9	0.3	A	
WBL	16.2	0.17	B	F		WBL	23.3	0.2	C	D
WBT	291.3	1.56	F			WBT	42.0	0.65	D	
WBR	-	-	-			WBR	-	-	-	
NBL	319.1	1.53	F	F		NBL	56.2	0.76	E	D
NBT	70.6	0.51	E			NBT	35.4	0.15	D	
NBR	0.8	0.08	A			NBR	1.7	0.15	A	
SBL	-	-	-	D		SBL	-	-	-	C
SBT	67.2	0.5	E			SBT	52.9	0.51	D	
SBR	48.0	0.88	D			SBR	12.7	0.71	B	
Intersection	270.0	-	F	-		Intersection	64.5	-	E	-

3.4 Existing Safety Review

The historic collision data provided by AT for the intersection of 100 St SE and Glenmore Trail was reviewed for the 5-year period between 2008 and 2012. The data includes incidents occurring at the intersection and within 400 m of Glenmore Trail. A total of seven collisions were reported within the study area over the analysis period, all of which were property damage only (PDO) incidents with no fatal or injury collisions reported. The data provided by AT indicated that the study site has a collision rate of 91.08 collisions per 100 MVKM.

Collision Severity

A total of seven collisions were reported within the study time period, or an average of 1.4 collisions (all PDO) per year.

Collision Type

Three of the seven collisions were rear-end incidents, which is typically the most common collision occurrence. The other collisions involved left turn across path (two collisions), right-angle (one collision) and sideswipe same-direction (one collision).

Temporal Collision Data

Analysis of the temporal distribution of collision data included review of the occurrence year, month, day of the week, as well as the time of day for each incident. There were no discernible trends in the annual collision frequency at the intersection. The distribution of collisions is relatively uniform relative to the occurrence months, though two incidents were noted to occur in October, while other months had only single incidents, if any. Although the sample size is small, there is a clear trend of collisions occurring on Fridays. Although Fridays typically experience higher collision rates, the proportion occurring at the study intersection is significantly higher than normal. Other than higher traffic volumes departing the City at the start of the weekend (and associated motorist impatience), no other factors contributing to this trend were identified. A review of the collision data indicated that all collisions occurred during daylight hours. The distribution of collisions by time of day is relatively consistent with peak morning and afternoon traffic volumes.

Safety Review Conclusion

The collision trends were consistent with expectations for a signalized intersection within a semi-urban area with a high proportion of commuter traffic. The majority of collisions were reported to be low severity, rear-end incidents that took place during daylight hours, typically within the morning and afternoon peak periods. Despite the close proximity of the intersection to the nearby urban city setting, the frequency of collisions was low with only seven collisions over five years.

It should be noted the collision analysis only included collisions that were reported to the police. Additional collisions may have occurred that were not investigated by or reported to the police, particularly property damage only collisions which are more likely to go unreported.

3.5 Environmental

An Environmental Screening Assessment (ESA) was performed for the study area from Stoney Trail to 116 St SE. The ESA provides a coarse characterization of the area, reviews the terrestrial resources (wildlife, soils and vegetation), identifies potential environmental constraints which can be used to scope future assessments, and provides mitigation measures to minimize project effects. The full report is included in ***Appendix C***. A summary of the findings are provided below.

Vegetation

The ESA found the potential for the occurrence of patches of native upland habitat. Within this habitat there is the potential for rare plants and rare plant communities to occur. Prior to future construction, it is recommended to carry out vegetation mapping in addition to an early and late season rare plant survey and vegetation cover mapping.

Wetlands

There are several wetlands located within the study area and many are likely to be impacted by the project. Preliminary assessment indicates that some of these wetlands area likely to be permanent. Should any wetlands be impacted or encroached upon, a wetland assessment impact report will be required prior to future construction.

Wildlife

It is recommended that wildlife species at risk surveys be completed prior to future construction as a result of the number of the wetlands on the property. The potential/observed species at risk in the study area and the intersection of several sensitive species ranges.

Pre-disturbance surveys may be required depending upon the timing of any ground disturbance. To comply with the Migratory Birds Convention Act (MBCA), it is recommended that any clearing activity be limited to dates outside of the peak breeding and nesting season (May 1 to August 20 in upland areas and April 15 to August 20 in wetlands). If land clearing must be completed within the restricted activity periods, then a nest search needs to be completed prior to clearing. If an active or indicated nest is found, an appropriate buffer must be applied and it cannot be disturbed until vacated.

3.6 Geotechnical

Preliminary geotechnical input was provided for the Glenmore Trail and 100 St SE intersection and the Glenmore Trail and 116 St SE intersection. The geotechnical input includes a review of existing geotechnical information, a preliminary assessment of the soil and groundwater conditions, identification of any major geotechnical issues that could impact the project, a preliminary assessment of grading requirements, and the identification of potential foundation options for structures. The preliminary review found no major geotechnical issues; however, soft sub-grade conditions, especially along the shoulder or ditch of the existing roads and areas where pond sediments have been identified, may require reworking or replacement. It is recommended to test the soft areas as identified in the full report in ***Appendix D***, as part of detailed design.

4. Future Traffic Conditions

This section summarizes the traffic forecast and derivation for the study area, including four interchanges along Glenmore Trail, between Stoney Trail and Rainbow Road (Stoney Trail, 100 St SE, 116 St SE and Rainbow Road).

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

4.1 Traffic Forecast

As discussed in Section 1.7, there have been several previous Traffic Impact Assessments (TIA) and Functional Planning Studies (FPS); however, the past studies were all based on different design parameters (land use, trip generation rates, trip distributions, etc.), and all had different design traffic volumes at the four interchanges. These studies also had different horizon years for the forecasts, but in general, each study anticipated substantial build-out of the region within the next 25 years. Therefore, the design traffic was developed for full- build out of the lands identified by The City and RVC for future development and not for a specific design year.

For this study, the methodology to derive design traffic included the following steps:

1. Requested data from The City Forecasting division, including: 2039 forecast data of the four studied interchanges, land use assumptions, and Select Zone analysis of the adjacent land parcels. Select Zone analysis are a measure of trip generation and distribution assumptions of each land parcel.
2. Compared The City Forecasting division land use, population, and employment assumptions to the assumptions in the following resource documents:
    - Watt Consulting Group “Shepard Industrial Park Traffic Impact Assessment (TIA)”, May 2009;
    - ISL “Glenmore Business Park TIA”, August 2012;
    - Rocky View County “Janet Area Structure Plan (ASP)”, November 2014;
    - Watt Consulting Group “EMCOR Business Park TIA”, April 2015; and
    - Institute of Transportation Engineers (ITE), “Trip Generation Manual, 9th Edition”.
3. For the lands where there was data available, subtracted traffic data from the forecast model based on the inbound and outbound trips in the Select Zone analysis and added the actual traffic from the above sources.

LAND USE ASSUMPTIONS

Lands that were assumed to generate traffic to/from the studied interchanges are shown in ***Figure 4.1*** over page. The land uses analyzed for this study are bounded by Stoney Trail to the west, Highway 791 to the east, Township Road 240 to the north, and 114 Ave to the south. The assumed land uses are based on the information reported in the various ASP, TIA, and previous studies. Since there is no definitive horizon year associated with the land use forecasts, design traffic was based simply on a full build scenario with no specific growth rate.

Transportation Zones (TZ) from The City’s Forecasting division are shown in ***Figure 4.1*** over page.

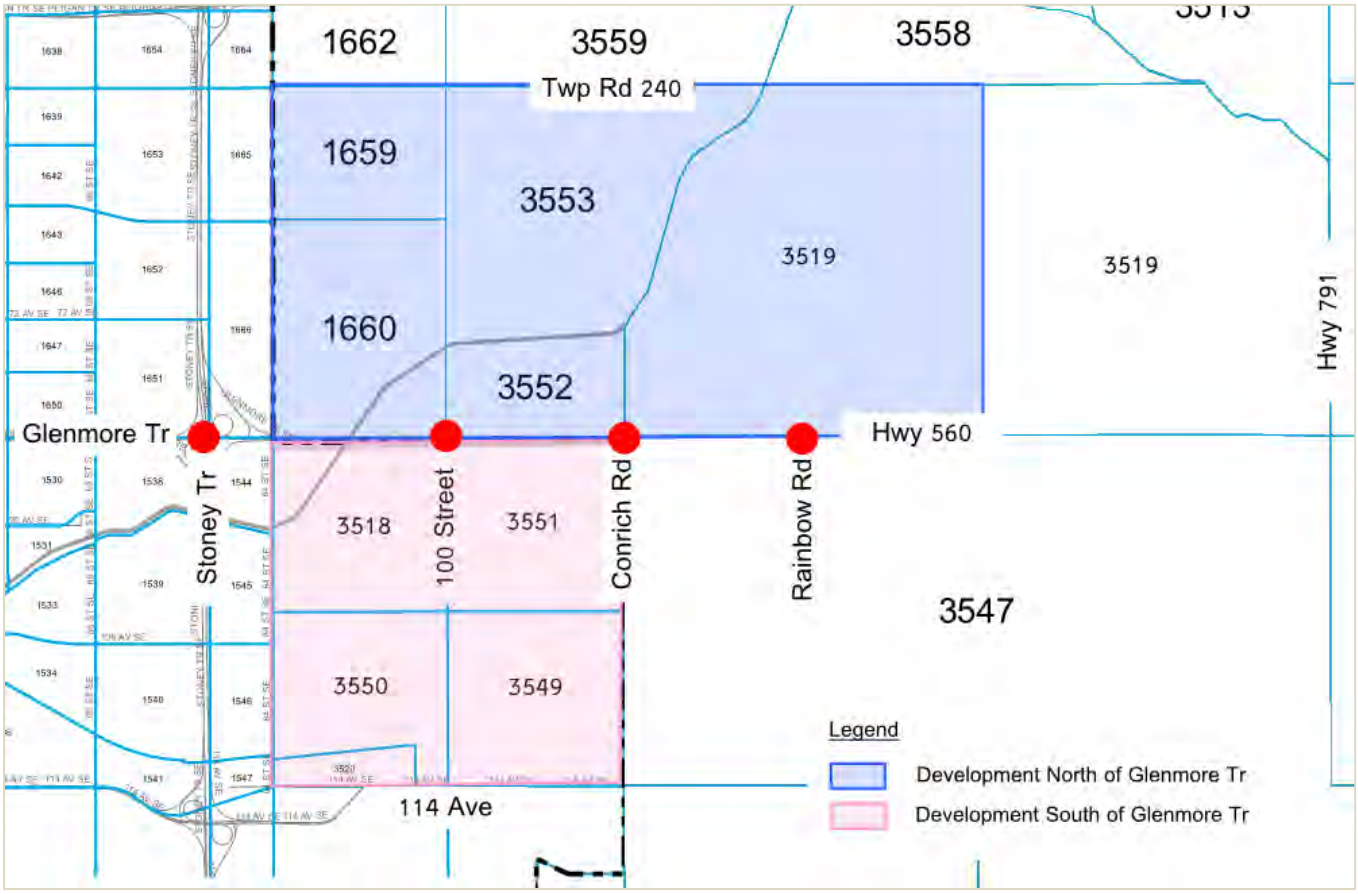


FIGURE 4.1: LAND USES NORTH AND SOUTH OF GLENMORE TRAIL

As illustrated in ***Figure 4.2***, land use assumptions north of Glenmore Trail are based on the Janet ASP and the EMCOR Business Park TIA. Development north of Glenmore Trail is composed of industrial, commercial and regional business centre (mixed commercial and industrial) uses, and country residential.

Land use on the south side of Glenmore Trail is based on the Glenmore Business Park TIA by ISL, Shepard Industrial Park TIA by Watt, and the existing land use on the Walton Industrial and Reid Industrial areas. These TIA provided a greater level of detail than the Shepard ASP.

In The City's traffic forecast, lands within and outside of The City are divided into parcels and assigned a TZ. In each TZ, population and employment assumptions are made in the forecast. A summary of land use assumptions is provided in ***Appendix E*** Section 1.1.

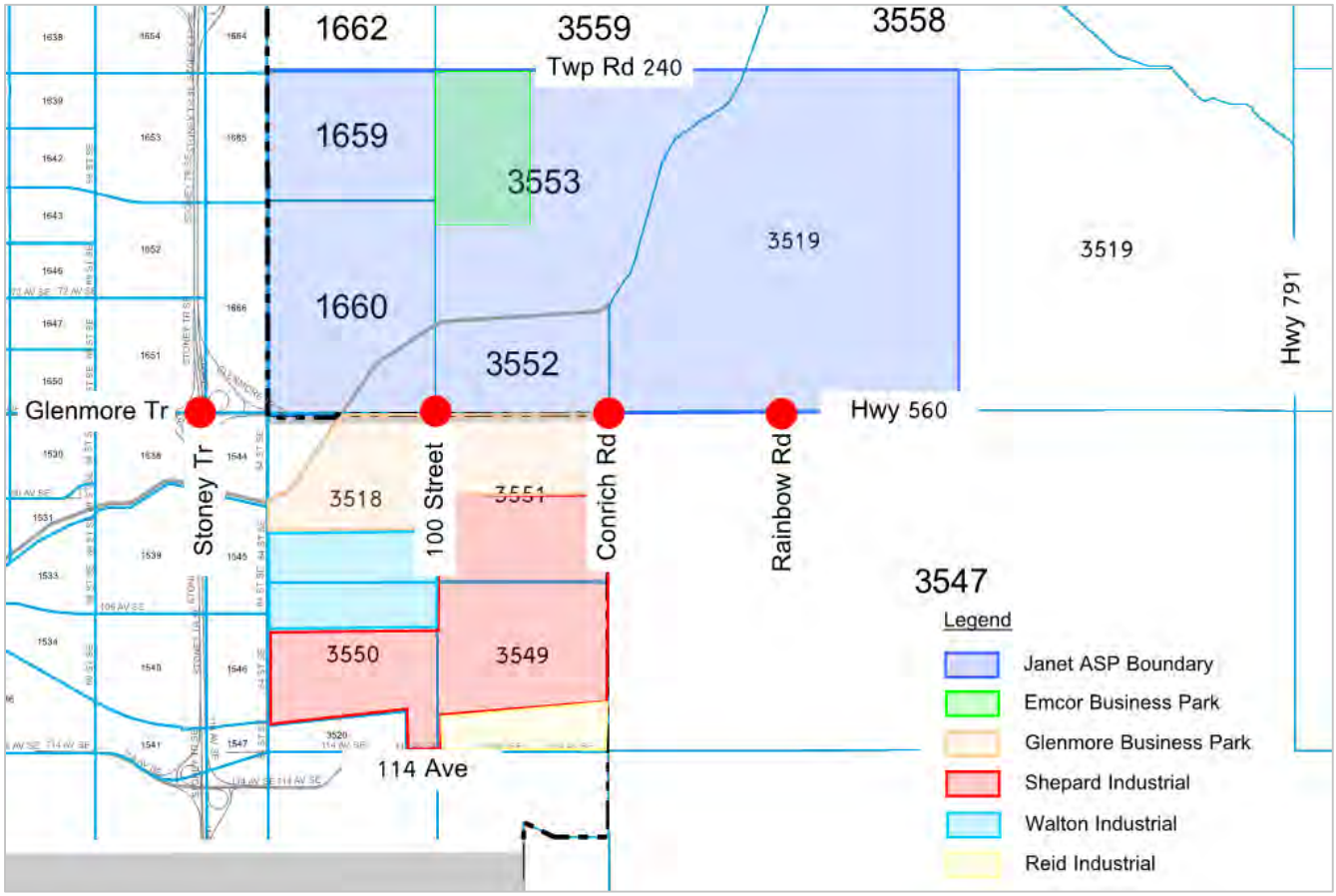


FIGURE 4.2: REFERENCED PLANS AND STUDIES. INTERCHANGE LOCATIONS ARE SHOWN IN RED

TRIP GENERATION

Comparison and Adjustments to City Forecasting

The 2039 traffic forecast was provided by The City's Forecasting division and is based on the 2039 Land Use and Network (LUN) model run. The model run includes a system interchange at Glenmore Trail / Stoney Trail and full interchanges at Glenmore Trail / 100 St SE, Glenmore Trail / 116 St SE, and Glenmore Trail / Rainbow Road. The LUN model run is a more conservative model as compared to The City's other model, the TARGET model run. The LUN model does not take into consideration auto cost or walking / cycling / transit behavior change over time, thus resulting in a lower transit ridership and higher volumes of traffic as compared to the TARGET model run. This was determined to be appropriate for the area, given the remoteness from the City centre and expected low-intensity industrial uses.

The anticipated land uses, population and employment from the referenced reports were compared to the respective TZs in the 2039 horizon model run. The detail adjustments made for each TZ are summarized in ***Appendix E*** Section 1.1.4 as well as in ***Appendix E*** Exhibit 1.0 and 2.0.

Based on land use assumptions for each zone, trip generation rates were calculated based on full buildout for the lands north of Glenmore Trail in ***Table 4.1*** and the lands south of Glenmore Trail as shown in ***Table 4.2*** over page.

Trip Generation Summary

The trip generation for the additional traffic to be added to the 2039 network was based on the following: City of Calgary rates, ITE Trip Generation Manual, 9th Edition, and trip generation studies as summarized in the Shepard TIA and EMCOR TIA. The detailed trip generation rates used in this study can be found in ***Appendix E*** Section 1.1.5 and the trip generation is summarized in ***Table 4.1*** and ***4.2*** below for north and south of Glenmore Trail respectively.

TABLE 4.1: LAND USE ASSUMPTION FOR DEVELOPMENT NORTH OF GLENMORE TRAIL

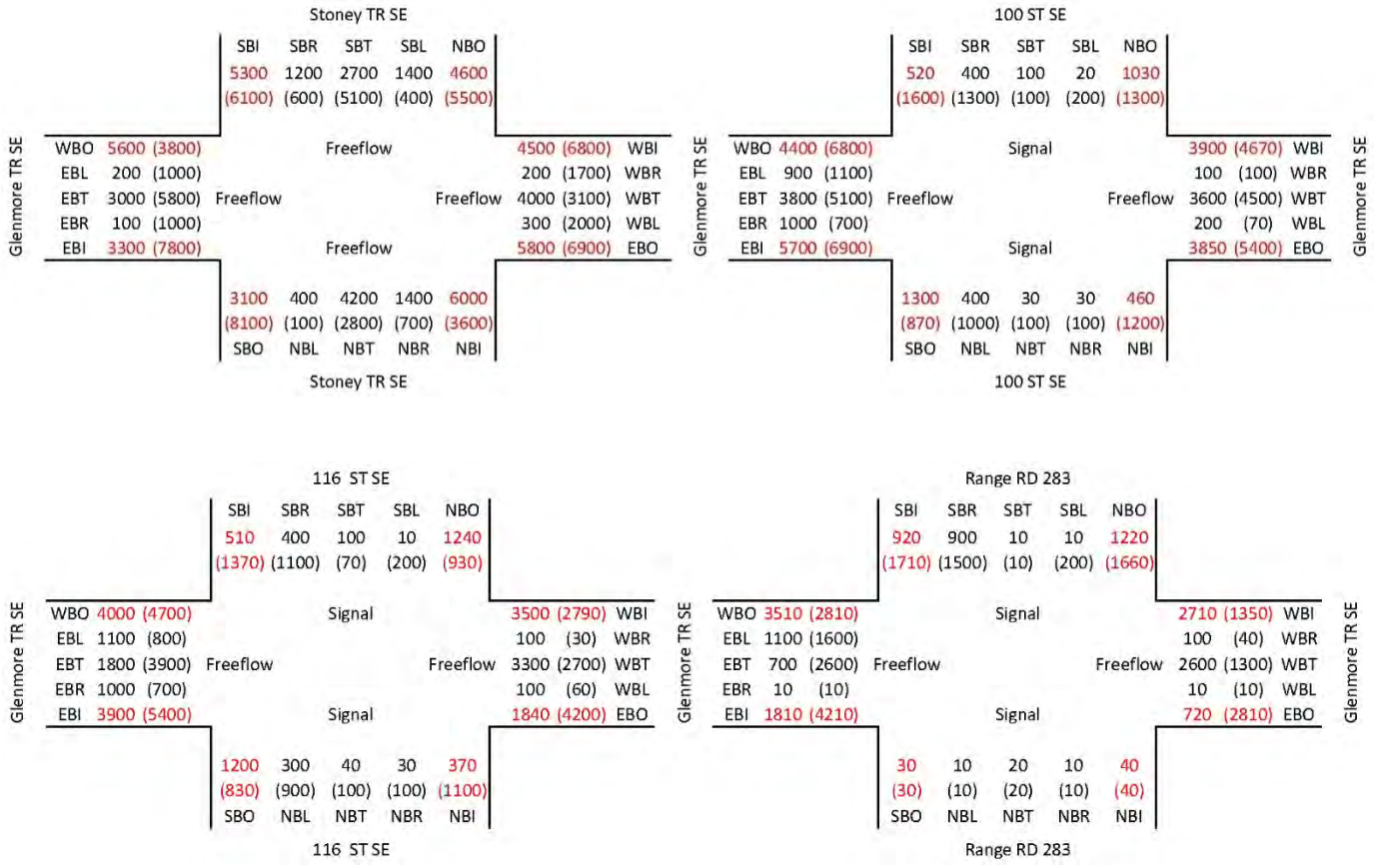
TZ	SOURCE	LAND USE	NET DEV AREA (ACRES)	TRIP GEN. RATE	AM PEAK HOUR TRIPS			PM PEAK HOUR TRIPS		
					IN	OUT	TOTAL	IN	OUT	TOTAL
TZ 3553	EMCOR TIA	Light Industrial	169.53	ITE Equation	712	146	858	189	669	858
		Comm.	30.53	ITE Rate	198	121	319	592	641	1,233
		Rail Yard Access	37.1	EMCOR TIA Trip Gen Study	28	42	70	42	28	70
TZ 3553	Janet ASP	Light Industrial	541	ITE Equation	1,750	358	2,108	464	1,644	2,108
Sub-Total:					2,688	667	3,355	1,287	2,982	4,269
TZ 1660	Janet ASP	Comm.	72	ITE Equation	340	209	549	1,146	1241	2,387
Sub-Total:					340	209	549	1,146	1,241	2,387
TZ 3552	Janet ASP	Comm.	15	ITE Rate	79	48	127	236	256	492
		Light Industrial	91	ITE Equation	376	77	453	100	353	453
		Heavy Industrial	46	ITE Rate	75	15	90	22	77	99
Sub-Total:					530	140	670	358	686	1,044
TZ 3519	Janet ASP	Comm.	158	ITE Equation	479	294	773	1,668	1,807	3,475
		Light Industrial	950	ITE Equation	2,997	614	3,611	795	2,817	3,611
		Heavy Industrial	475	ITE Rate	780	160	940	226	800	1,026
Sub-Total:					4,256	1,068	5,324	2,689	5,424	8,112
Total Trips:					7,814	2,084	9,898	5,480	10,333	15,812
Total Internal Trips (10%):					781	208	990	548	1,033	1,581
Total Trips (with Internal Trips):					7,033	1,876	8,908	4,932	9,300	14,231
Total None Pass-by Trips (75%):					6,785	1,725	8,510	4,113	8,412	12,523
Total Pass-By Trips (25%):					248	151	398	819	888	1,708

TABLE 4.2: LAND USE ASSUMPTION FOR DEVELOPMENT SOUTH OF GLENMORE TRAIL

TZ	SOURCE	LAND USE	NET DEV AREA (ACRES)	TRIP GEN. RATE	AM PEAK HOUR TRIPS			PM PEAK HOUR TRIPS		
					IN	OUT	TOTAL	IN	OUT	TOTAL
TZ 3518 and 3551	Glenmore Bus Park TIA	Comm.	50	ITE Equation	272	167	438	895	970	1,865
		General Industrial	281	City Rate	2,025	276	2,301	408	1,991	2,399
		Business Industrial	15	City Rate	356	49	405	66	323	389
Sub-Total:					2,653	492	3,144	1,369	3,284	4,653
TZ 3549 and 3551	Shepard TIA	Comm.	11	ITE Rate	71	44	115	214	232	447
		Industrial. Park	39	ITE Rate	273	56	329	71	269	340
		Direct Control	60 Acres / 20 Emp.	Shepard TIA Trip Gen. Study	7	1	9	2	7	9
		Light Industrial	382.45	ITE Equation	1,265	259	1,524	335	1,189	1,524
TZ 3550		Light Industrial	191.23	ITE Equation	681	139	821	181	640	821
Sub-Total:					2,297	499	2,798	803	2,337	3,141
TZ 3549	Shepard TIA (Reid Ind.)	Light Industrial	39.62	ITE Equation	218	45	263	58	205	263
Sub-Total:					218	45	263	58	205	263
TZ 3518	Shepard TIA (Walton Ind.)	Un-Serviced Industrial	206.51	Shepard TIA Trip Gen Study	224	67	291	55	218	273
TZ 3550			120.65		131	39	170	32	127	159
Sub-Total:					355	106	461	87	345	432
Total Trips:					5,523	1,142	6,666	2,317	6,171	8,489
Total Internal Trip (10%):					552	114	667	232	617	849
Total Trips (with Internal Trips):					4,971	1,028	5,999	2,085	5,554	7,640
Total None Pass-by Trip:					4,894	981	5,874	1,836	5,284	7,120
Total Pass-By Trip (25%):					77	47	125	249	270	520

4.2 Design Traffic Derivation

The steps used to estimate full build-out design traffic volumes north and south of Glenmore Trail are summarized in ***Appendix E*** Section 1.1.6. The full build-out design volumes with full access at 100 St SE, 116 St SE and Rainbow Road were used as the basis for this study. ***Figure 4.3*** summarizes the full build-out design traffic volumes with full access at each interchange.



NOTES

- Traffic Volumes less than 100 are rounded to the nearest 10
- Traffic Volumes larger than 100 are rounded to the nearest 100
- AM (PM) - Brackets designate PM volumes
- Red figures indicate volumes entering or exiting the intersection

FIGURE 4.3: FULL BUILD-OUT DESIGN TRAFFIC VOLUMES

5. Design Criteria

Specific design criteria have been established to guide the development of potential improvements to the corridor. In addition, the design criteria will be applied in the preparation of the functional design for the recommended plan. The design criteria have been developed in consideration of the current and planned classifications of the affected roadways, as well as the local context.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

5.1 Design Guidance

DESIGN GUIDANCE FOR GLENMORE TRAIL SE

AT and both municipalities designate Glenmore Trail as a six-lane divided freeway. This type of road provides free-flow movement of vehicular traffic at high operating speeds over long distances. Facilities for walking and cycling are not recommended within the ROW of this type of road.

The following references were used to develop the design criteria for Glenmore Trail:

- Alberta Transportation – Highway Geometric Design Guide (HGDG) 1999;
- Alberta Transportation and City of Calgary – Ring Road and Highway Penetrators Agreement (RRHPA) 1991; and
- Highway 560:02 - From Calgary to Highway 797 Functional Planning Study (UMA |AECOM).

DESIGN GUIDANCE FOR 100 ST SE, 116 ST SE, AND RAINBOW ROAD

Planning in both municipalities concurs that 100 St SE, 116 St SE and Rainbow Road will be four-lane divided Arterial Streets (or Major Roads) and cross between The City and RVC. This type of road is one of the most common urban roads and provides a reasonably direct connection between major destinations. Pedestrian and cyclist facilities are integrated into the overall design.

The following references were used to develop the design criteria for the cross streets:

Alberta Transportation

- HGDG Urban Supplement - DRAFT (2003)

The City of Calgary

- Shepard Area Structure Plan (2014)
- Complete Streets Policy (2014)
- Design Guidelines for Subdivision Servicing (DGSS) – Section II (2015)

Rocky View County

- County Servicing Standards (2013)
- Janet Area Structure Plan (2013)

For the south side of Glenmore Trail, the Shepard Industrial Park – Functional Planning Study, 2009 was used to determine the classification of these roadways and the base for determining the cross-section elements. It is recommended for both roadways to have a design and posted speed of 60 km/h. This specifically reflects The City's recent decision to discontinue designing urban streets with design speeds 10 km/h over the posted speed limit, consistent with emerging national practice.

For the north side of Glenmore Trail, the Southeast Industrial Corridor Growth Area Plan – Transportation Study was used to determine the classification of these roadways and the base for developing the cross sections.

The 100 St SE, 116 St SE and Rainbow Road corridors are recommended to be Divided Streets within RVC. Therefore, it is recommended that consistent design criteria be used for each road, both north and south of Glenmore Trail, within the project limits.

5.2 Design Vehicles

Glenmore Trail and 100 St SE are designated as provincial high load corridors. The required vertical clearance for a high load corridor is 9.14 m. All interchange options must accommodate oversized loads such as a Heavy Hauler, Platform Trailer, and Reactor Transporter.

Although 116 St SE is designated locally as a high load corridor as well, The City's classification for high load corridors requires less vertical clearance, at 5.44 m.

Land uses accessed by 100 St SE and 116 St SE intersections are planned to be mainly industrial business parks, and so, a large design vehicle is recommended for these interchanges and associated ramp intersection junctions. The HGDG Urban Supplement (2003) recommends a WB-36 design vehicle for provincial highways, municipal truck routes, and interchange ramp terminals.

Intersection turning movements, especially left turn movements for all single left turn movements and opposing left turns will be required to accommodate a Modified WB-36 vehicle; dual left turns will be required to accommodate a Modified WB-36 vehicle alongside a passenger car.

5.3 Intersection and Interchange Spacing

Intersection spacing defined in The City DGSS for an Arterial Street is 300 m typical. According to AT's HGDG for service interchanges, the first intersection centerline along an Arterial Street should be at least 400 m from the interchange ramp terminal.

The 100 St SE, 116 St SE and Rainbow Road interchanges along Glenmore Trail are all considered service level interchanges. The spacing of these interchanges will be as such that sufficient weaving can be provided between the merge / diverge ramps. As per RRHPA, the minimum weaving distance of 600 m is allowable if confirmed sufficient through a detailed weave analysis.

The Stoney Trail interchange along Glenmore Trail is ultimately considered a systems level interchange. As per RRHPA, the minimum desirable weaving distance between a systems level (Stoney Trail) and a service level (100 St SE) interchange is 800 m if confirmed sufficient through detailed weaving analysis.

5.4 Right Turn Treatments

Channelization is often used for interchange junctions. When designed appropriately, channelization can increase both safety and capacity of an intersection. In addition to channelization, right turn design principles from The City's Complete Streets guidelines will be considered:

- Safely accommodate all modes of transportation, including cyclists and pedestrians;
- Compact designs that accommodate the design vehicle are more favorable;
- Crossing roadways at 90-degree, or as close as possible are desired;
- Sightlines are a critical consideration for crosswalks on free-flowing movements; and
- Yield condition shall be the preferred right turn treatment. However, in high volume areas, free flowing movements may be considered.

YIELD CONDITION

The following design elements from The City's Complete Streets policy and the design vehicle will help with the creation of a unique smart right turn design for this project:

- An entry angle of at least 60-degree shall be used;
- The separation island must be roughly twice as long as it is wide;
- Corner radius will be larger (45 - 90 m) at the beginning of the island and smaller (6 – 15 m) where it merges with the cross street. Note: Other radii will be required to accommodate the modified WB-36;
- When creating this design, it is necessary to allow for large trucks turning into multiple receiving lanes; and
- The crosswalk is desired to be a minimum of one car length back from the crossroad.

FREE-FLOW CONDITION

Free-flow right turns accommodate larger right turning volumes more readily than the yield condition previously discussed. However, free flow right turns can be restrictive to pedestrian movement. To maximize safety and efficiency for free flow right turn ramps, the following principles shall be considered:

- The controlling curve for free-flow right turns shall be in the range of 15 – 20 m to help keep speeds lower at pedestrian crossings;
- Pedestrian crossings shall be located in the initial third of the right turn island to ensure maximum visibility; and
- The merge treatment shown in DGSS Figure 52 can be used but use a controlling curve in line with a 90-degree intersection as shown in Table D.5.2a from AT's HGDG.

5.5 Design Criteria

The design criteria elements for each roadway are summarized in ***Table 5.1*** and the typical cross sections are shown in sheet TS2 to TS6 in ***Appendix F***.

TABLE 5.1: DESIGN CRITERIA FOR EACH MAJOR ROADWAY IN STUDY AREA

ITEM	GLENMORE TR SE	100 ST SE	116 ST SE	RAINBOW ROAD	RAMPS
General					
Design Classification	RFD-616.6-110	Arterial St	Arterial St	Arterial St	N/A
Design Speed (km/h)	110	60	60/70*	70	90km/h (gore) 50km/h (junction)
Posted Speed (km/h)	100	60	60/70*	70	N/A
Intersection Spacing	N/A	400 m to ramps 300 m (min.)	400 m to ramps 300 m (min.)	400 m to ramps 300 m (min.)	N/A
Active Modes	Grade Separated	At-Grade	At-Grade	At-Grade	At-Grade
Bus Route	Limited	Yes	Yes – 116 ST SE	TBD – Rainbow Road	Limited
Truck Route	Yes (AT high load)	Yes (AT high load)	Yes (City high load)	Yes	Yes (AT high load)
On St Parking	No	No	No	No	N/A
Sound Attenuation	N/A	N/A	N/A	N/A	N/A
Horizontal Geometry					
Min Radius (m)	600	130	130 (60 km/h) 190 (70 km/h)	190	Loop ramp radius = 70 Direct ramp radius = 340
Max Superelevation (m/m)	0.06	0.06	0.06	0.06	0.06
Exit/Entrance Treatments	Exit 25:1 ratio Entrance 50-55:1 ratio	TBD by traffic analysis	TBD by traffic analysis	TBD by traffic analysis	N/A
Min Weaving (m)	600	N/A	N/A	N/A	N/A
Vertical Geometry					
Max Grade (%)	3 (des.), 5 (max.)	6	6	6	4 (des.), 7 (max.)
Min Grade (%)	0.6 (min.), 0.8 (des.)	0.6 (min.), 0.8 (des.)	0.6 (min), 0.8 (des.)	0.6 (min), 0.8 (des.)	0.6 (min.), 0.8 (des.)
Max Grade Intersections	N/A	4%	4%	4%	4%
Min Stopping Sight Distance (m)	235	85	85 (60 km/h) 110 (70 km/h)	110	Gore = 170 Junc = 65
Min Crest Curve (SSD) (m)	K = 100, L = 110	K = 55, L = 60	K = 55, L = 60 (60 km/h) K = 85, L = 70 (70 km/h)	K = 85, L = 70	Junc, K=10, L=30

ITEM	GLENMORE TR SE	100 ST SE	116 ST SE	RAINBOW ROAD	RAMPS
Min Sag Curve (SSD) (m)	K = 55, L = 110	K = 20, L = 60 (Kmax for non-draining sag = 43)	K = 20, L = 60 (60 km/h) K = 25, L = 70 (70 km/h) (Kmax for non-draining sag = 43)	K = 25, L = 70 (Kmax for non-draining sag = 43)	Gore, K=21, L=90
Vertical Clearance (m)	9.14	9.14	5.5	5.5	9.14
Cross Sectional Elements (Widths)					
Basic ROW Width (m)	100	36	36	36	N/A
Through Lane (m)	3.7	3.5 (inside) 3.7 (outside)	3.5 (inside) 3.7 (outside)	3.5 (inside) 3.7 (outside)	4.8 (single) 3.7 (dual)
Left Turn Lane (m)	N/A	3.5	3.5	3.5	N/A
Inside Shoulder (m)	2.5 with median ditch	N/A	N/A	N/A	1 (single), 2 (dual)
Outside Shoulder (m)	3.0 with roadside ditches	N/A	N/A	N/A	2.5 (single), 3 (dual)
Ditch (m)	4.0 (rounded)	N/A	N/A	N/A	4.0 (rounded)
Median (m)	23.2 (6 lanes)	6.0 (single left turn) 9.5 (dual left turn)	6.0 (single left turn) 9.5 (dual left turn)	6.0 (single left turn) 9.5 (dual left turn)	N/A
Sideslope Ratio	6:1 (des.) 4:1 (max.) 3:1 (over 6.5 m)	N/A	N/A	N/A	6:1 (des.) 4:1 (max.) 3:1 (over 6.5 m)
Backslope Ratio	5:1 (nom.) 3:1 (max.)	N/A	N/A	N/A	5:1 (nom.) 3:1 (max.)
Active Modes (m)	Not allowed on facilities directly adjacent to freeways/highways	2 m sidewalk on one side and 3 m path on other	2 m sidewalk on one side and 3 m path on other	2 m sidewalk on one side and 3 m path on other	N/A

* The design and posted speed on 116 St SE Road and Rainbow Road, north and south of the interchange, vary by jurisdiction (The City 60 km/h and RVC 70 km/h). However, the design and posted speed at the DDI interchange to be maintained at 50 km/h for safe operation.

5.6 Diverging Diamond Interchange (DDI) Design Criteria

Following the Initial Options and Corridor Option Screening, both The City and AT requested that a DDI be investigated as a potential solution for both the 100 St SE and 116 St SE interchange locations. ***Table 5.2 and Figure 5.1*** summarize key design criteria described in The Federal Highway Administration (FHWA) August 2014 Diverging Diamond Interchange Informational Guide.

TABLE 5.2: DIVERGING DIAMOND INTERCHANGE (DDI) DESIGN CRITERIA

DESIGN ELEMENT	DESIGN VALUE
Crossover Alignment Design	See figure 5.2. 100 St SE is proposed to be symmetrical. 116 St SE and Rainbow are proposed to be west shift.
Crossover Alignment Design and Posted Speed	Through lanes = 50 km/h Note: this is a 10km/h reduction of design and posted speed along 100 St SE, 116 St SE and Rainbow Road
Curvature Design Low-Speed Urban St Design [Speed (km/h), R(m), e (%)]	S = 50 km/h, R = 120 m, e = - 2% Note: Proposed current approach/departure radii = 190 m Proposed current bridge adjacent radii = 190 m
Super-elevation / Cross –Slope Development	Approaches: -2% (Normal Crown) Crossovers: 0% Bridge structure: -2% (Normal Crown)
Through Design Vehicles	Simultaneous: WB-21 Single: Modified WB-36
Lane Widths	4.3 m through lanes Note: Proposed concept lane widths are based on Autoturn with WB-21 at 30 km/h with 1 m separation between vehicles
Crossover Angle (desired range)	30-50 degrees Note: Proposed current concept design are 35 degrees
Tangent Length Between Crossovers	This value varies to achieve tangents on the bridge when the DDI is above the freeway
Crossover Tangent Length Extensions	Desired = width of lanes plus (6 m before the crossover), and (4.5 m after the crossover)
Distance Between Crossovers	Width driven by many factors such as: cross over angle, number of lanes, width of lanes, and crossover tangent length extensions
Width Between Crossover Centerlines	Width driven by many factors such as: cross over angle, number of lanes, width of lanes and length extensions Note: current design is 36.6 m
Left / Right Turn Design Vehicles	Single: Modified WB-36 Double: WB-21 on outside and car on inside
Right Turn Treatments	TBD – yield, free-flow, signal
Left Turn Treatment Types	Free-flow
Pathways	We recommend pathways to be placed in between the bridges

Another consideration for DDI design is alignment. The Federal Highway Administration's Diverging Diamond Interchange Informational Guide (2014) provides several options for DDI alignments: symmetrical, offset, and shift, as illustrated in *Figure 5.2*.

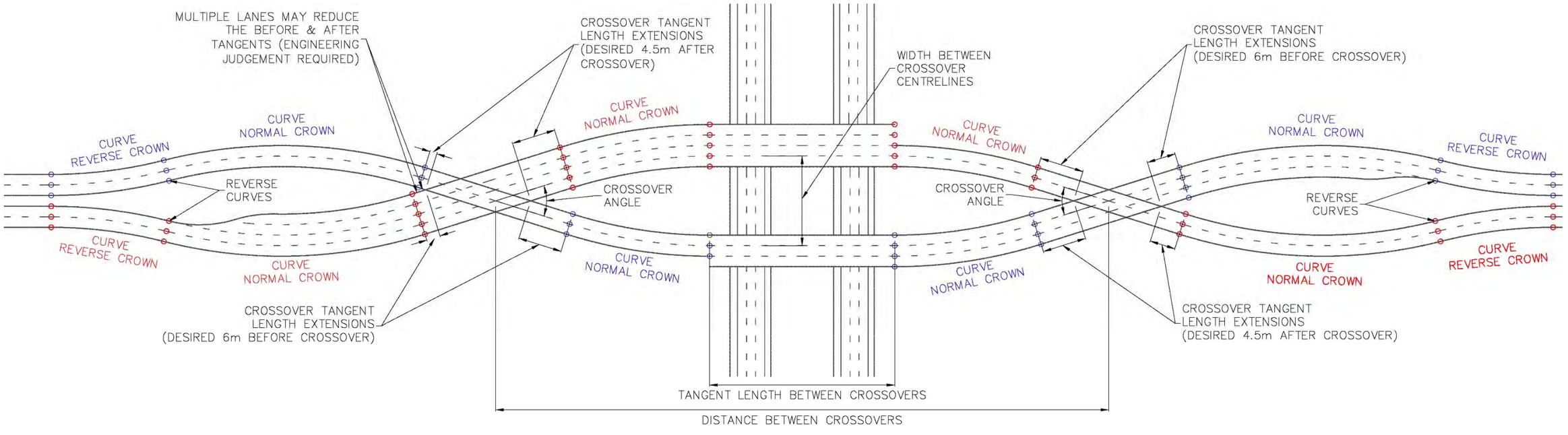


FIGURE 5.1: DDI GEOMETRIC DESIGN DETAILS
SOURCE: FEDERAL HIGHWAY ADMINISTRATION (2014)

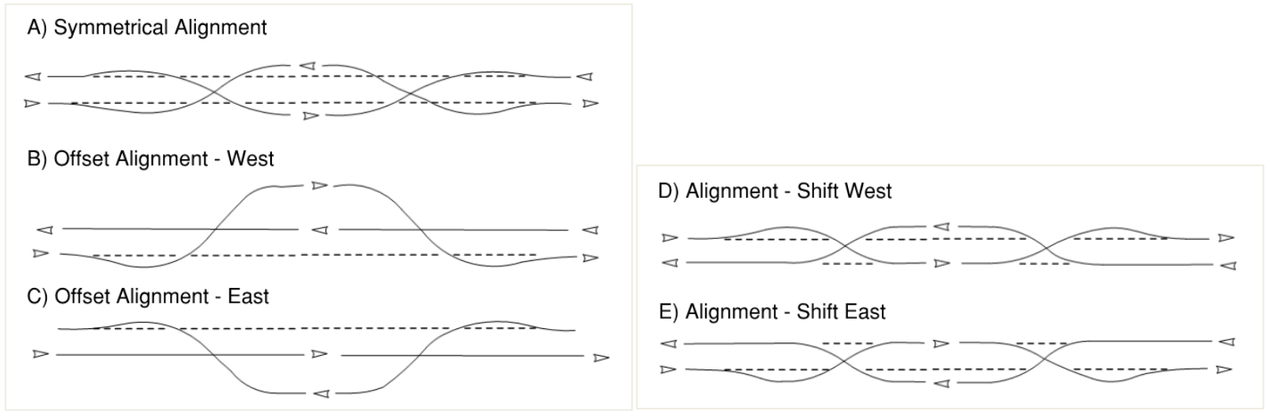


FIGURE 5.2: DDI CONCEPTS
SOURCE: FEDERAL HIGHWAY ADMINISTRATION (2014)

6. Option Development

The following section describes the process and outcomes from the development of options for the study corridor. The process started with the development of an initial list of strategic options based on the most recent ASPs (Section 1.6) and previous studies (Section 1.7). The following iterative steps in the option development process resulted in a short-listed set of options, ready for the next level of detailed analysis and evaluation.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

6.1 Approach to Option Development

Strategic options to improve the Glenmore East corridor were developed considering a range of engineering, traffic, safety and cost aspects. The options build on the potential options identified in the 2007 Functional Planning Study Highway 560:02 from Calgary to Highway 797, and preceding studies listed in Section 1.7 of this report. The framework for the development of the strategic options is outlined below:

- Generation of ideas for a range of potential solutions. The potential solutions identified would be based on the key strategic priorities for the study and surrounding areas.
- Develop basic option arrangements from these ideas. These include:
    - Provision of a single exit from the mainline for each interchange;
    - Full movement interchanges considered at each junction.
- Prepare a traffic model for each option to test performance and refine the basic arrangements.
- Develop geometric layouts for each option based on the model results to identify potential property impacts and to prepare comparative cost estimates.

At this stage of the option development process, options were developed at a high level and along specific themes to address the range of transportation issues identified within the study area. Intentionally, the options have been kept noticeably different from one another. By isolating key variables, “what works well” and “what doesn’t” can be easily identified for each option. From this, opportunities can be identified to combine elements that work well in different options to form a hybrid that may provide, on balance, a better outcome.

The development of these strategic options was the first step in identifying the recommended option for the corridor. Further development of these options was then completed through a second stage of evaluation, which included:

- Confirmation and development of project objectives and corresponding evaluation criteria;
- Refinement of options to reduce impacts and improve performance. Identification of opportunities to create hybrid options;
- Assessment of the refined options against the evaluation criteria to identify the best performing options; and
- Refinement of the best performing option and development of staged solutions.

Interchange options were focussed on 100 St SE and 116 St SE, and did not include Rainbow Road as the functional planning updates for the latter pertained primarily to ramp / weaving analysis.

6.2 Initial Options and Corridor Option Screening

An initial corridor option screening was undertaken to better understand the lane configurations and weaving impacts between interchanges. The initial screening evaluation set the basic laning parameters for the ramps along Glenmore Trail. The second round of option development sought to confirm the final corridor configuration by analyzing different interchange configurations in detail.

Seven corridor options were developed and evaluated using various traffic modelling tools. The modelling software tools used to perform the analysis and simulation were chosen based on the needs of a particular problem. The modelling tools selected for the study included HCS, Synchro and VISSIM.

On a freeway section, performance is measured based on LOS. LOS is evaluated based on traffic density, which in turn correlates with operating speed and risk of traffic turbulence. This differs from LOS on a signalized corridor, which is evaluated based on average vehicle delay.

VISSIM was used to determine the density output, given as 15-minute averages, over three runs in the AM and PM peak hours. For the purpose of presenting the results of the analysis, a typical peak hour segment (average of the four 15-minute segments) was selected. ***Table 6.1*** summarizes the LOS criteria based on density ranges, measured in passenger cars per kilometre per lane (pc/km/ln), including the colour legend used to illustrate density ranges from the VISSIM model. In this update study, an additional gradation was added to the VISSIM density outputs representing a density greater than 35 pc/km/ln and this level is shown in maroon. This additional level is intended to differentiate the LOS F areas that are modestly over-capacity from those that are substantially beyond capacity.

TABLE 6.1: LEVEL OF SERVICE CRITERIA FOR FREEWAYS

LOS	DENSITY RANGE (PC/KM/LN)	VISSIM OUTPUT COLOUR LEGEND
A	< 7	
B	> 7 - 11	
C	> 11 – 16	
D	> 16 – 22	
E	> 22 – 28	
F	> 28 – 35	
F	> 35	

Option 1: Diamond Interchanges with Single Lane on Ramps

This corridor option is based on Glenmore Trail consisting of a six-lane cross-section with three general purpose lanes per direction. This option proposed three conventional diamond interchanges along Glenmore Trail at 100 St SE, 116 St SE and Rainbow Road. Each interchange has a single lane entrance ramp joining Glenmore Trail as an auxiliary lane (fourth lane) and dual lane exit ramp. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.1*** and ***Figure 6.8*** for the AM and PM peak periods respectively.

Option 2: Diamond Interchanges with WB Dual Lane on Ramps

This corridor option is based on Glenmore Trail consisting of a six-lane cross-section with three basic lanes per direction. This option proposed three conventional diamond interchanges along Glenmore Trail at 100 St SE, 116 St SE and Rainbow Road. Each interchange has a dual lane westbound entrance ramp joining Glenmore Trail as the fourth and fifth lane; and a single lane eastbound entrance ramp. Each interchange has a dual lane exit ramp off Glenmore Trail. The fifth lane becomes an auxiliary lane while the fourth lane splits into the second auxiliary lane and a lane-away which drops before each interchange structure. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.2*** and ***Figure 6.9*** for the AM and PM peak periods respectively.

Option 3: Diamond Interchanges with Basket Weave to Stoney Trail

This corridor option is very similar to Option 2 where Glenmore Trail between 100 St SE and Rainbow Road is the same as Option 2. Option 3 proposed a westbound basketweave segment between Stoney Trail and 100 St SE. Two southbound to westbound lanes from 100 St SE are joined by a single northbound to westbound lane and these drop to two lanes prior to the start of basketweave. The basketweave provides grade-separated lanes for westbound traffic entering and existing Glenmore Trail, between 100 St SE and Stoney Trail. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.3*** and ***Figure 6.10*** for the AM and PM peak periods respectively.

Option 4: Loop Ramp at 100 St SE with Merge Condition and Diamond Interchanges at 116 St SE and Rainbow Road

This corridor option is very similar to Option 2 with diamond interchanges at 116 St SE and Rainbow Road. However, a half Parclo and half diamond interchange is provided at 100 St SE, with the northbound to westbound movement accommodated by a single lane loop ramp with a 300 m merge lane. The southbound to westbound movement from 100 St SE joins the Glenmore Trail main line as an auxiliary lane. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.4*** and ***Figure 6.11*** for the AM and PM peak periods respectively.

Option 5: Loop Ramp at 100 St SE with Lane Away and Diamond Interchanges at 116 St SE and Rainbow Road

Option 5 is identical to Option 4, with the only exception being that the northbound to westbound movement at 100 St SE is accommodated by a loop ramp with a lane away joining Glenmore Trail as the fourth lane. The southbound to westbound movement from 100 St SE also becomes an auxiliary lane (lane 5) to Stoney Trail. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.5*** and ***Figure 6.12*** for the AM and PM peak periods respectively.

Option 6: Loop Ramp at 100 St SE with Basketweave and Diamond Interchanges at 116 St SE and Rainbow Road

Option 6 is identical to Option 5 except that a basketweave is provided for westbound Glenmore Trail between 100 St SE and Stoney Trail. The basketweave is identical to the configuration included in Option 3. Two southbound to westbound lanes from 100 St SE are joined by a single northbound to westbound loop ramp and the drop to two lanes prior to the basketweave cross-over. The basketweave provides grade-separated lanes for westbound traffic entering and exiting Glenmore Trail, between 100 St SE and Stoney Trail. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.6*** and ***Figure 6.13*** for the AM and PM peak periods respectively.

Option 7: Diamond Interchange at 100 St SE and Rainbow Road and Parclo A-B at 116 Street

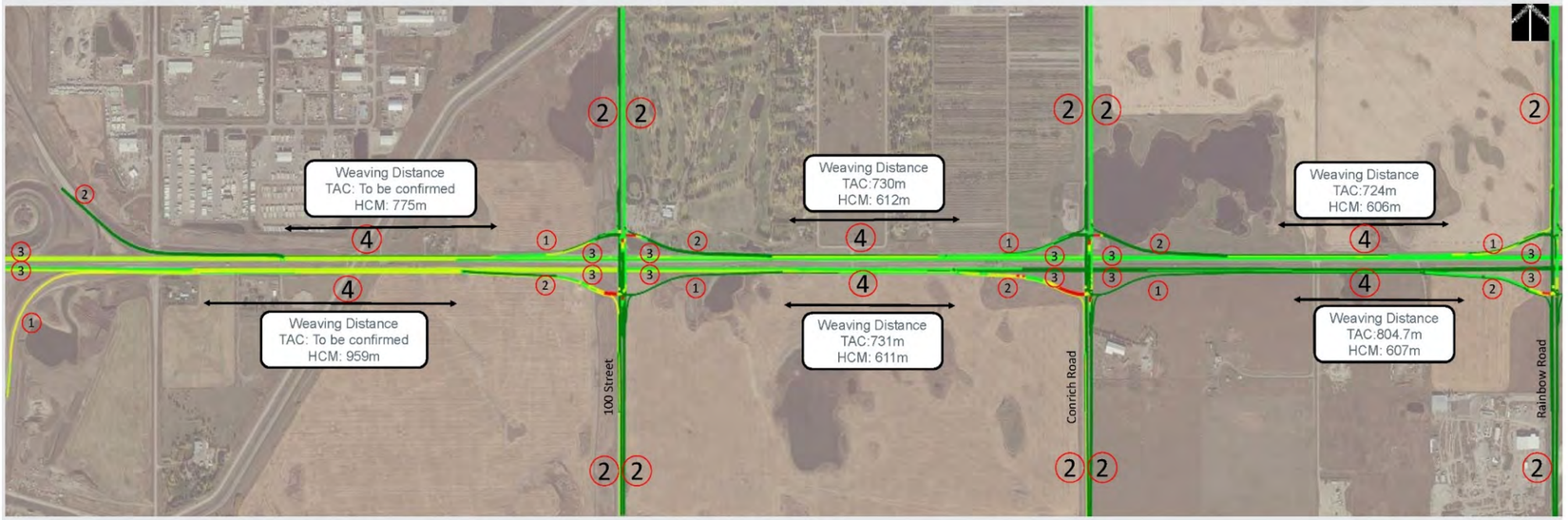
Option 7 is very similar to Option 2, except that a Parclo A-B interchange is proposed at 116 St SE. The Parclo A-B has a dual lane westbound entrance, a single lane eastbound entrance loop ramp, a dual lane eastbound exit ramp and a dual lane westbound exit loop ramp. The weaving distance, laning and VISSIM results are illustrated in ***Figure 6.7*** and ***Figure 6.14*** for the AM and PM peak periods respectively.

Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

Option 1: Diamonds with Single Lane on Ramps (**AM Peak**)

Figure 6.1



Option 2: Diamonds with WB Dual Lane on Ramps (**AM Peak**)

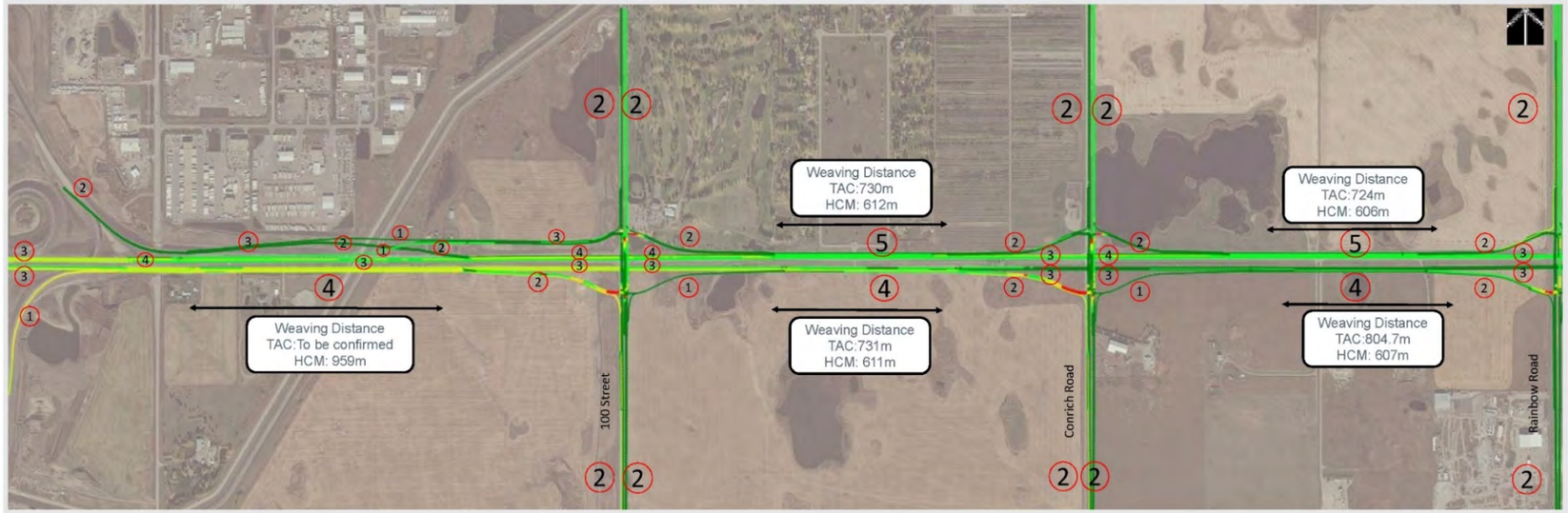
Figure 6.2

Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

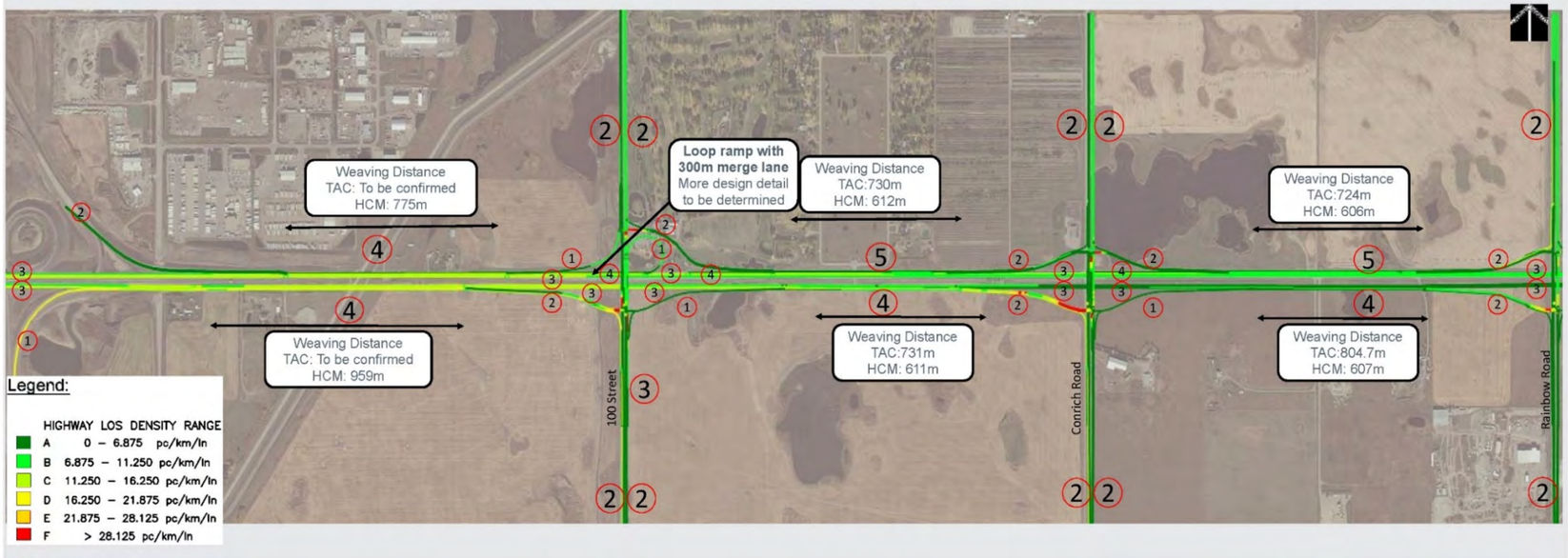
Option 3: Diamonds with Basket Weave to Stoney Tr (**AM Peak**)

Figure 6.3



Option 4: 100 Street Loop Ramp (Merge) (**AM Peak**)

Figure 6.4

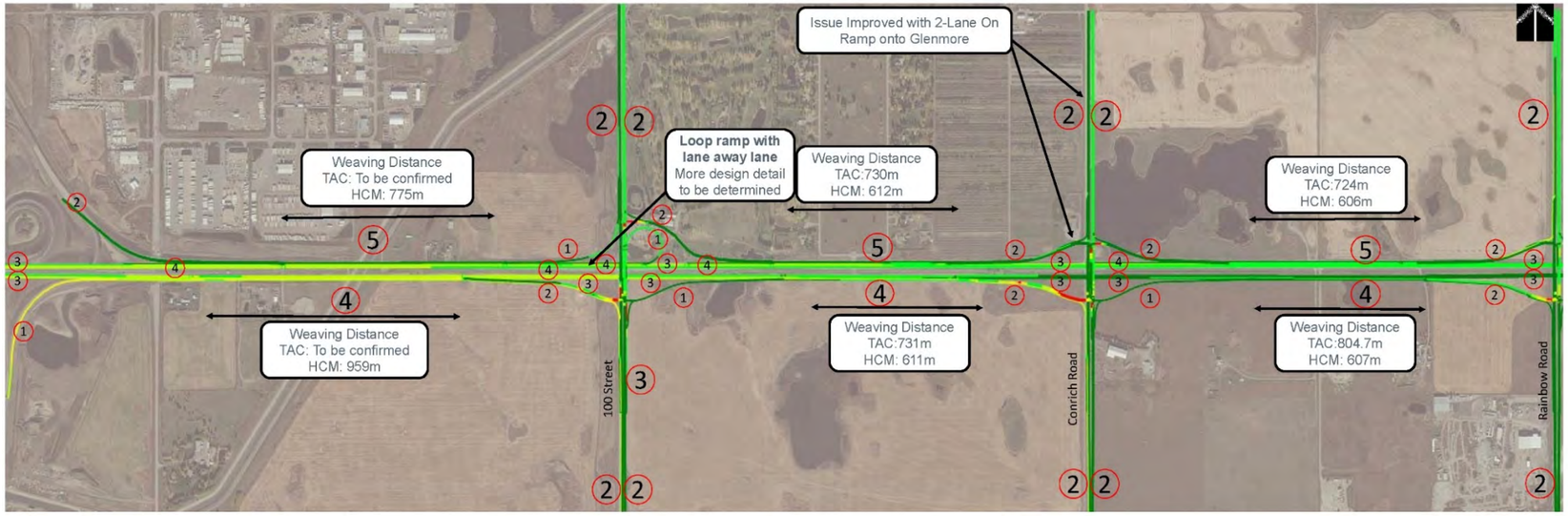


Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

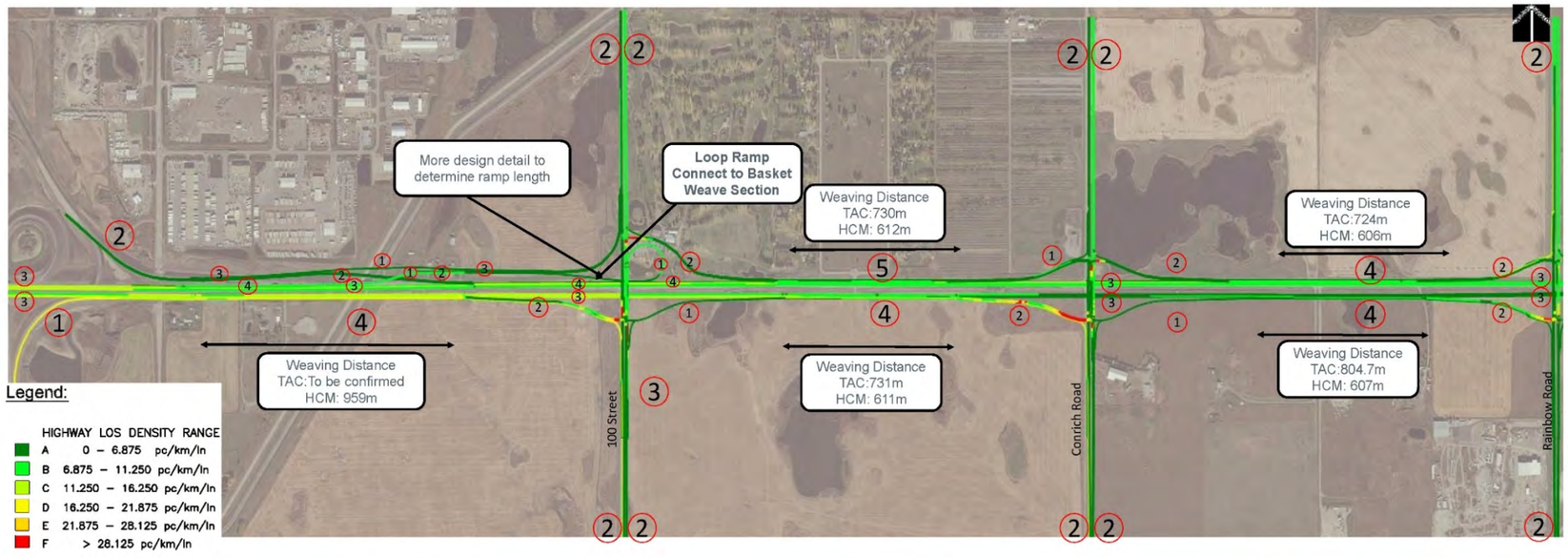
Option 5: 100 Street Loop Ramp (Lane Away) (**AM Peak**)

Figure 6.5



Option 6: 100 Street Loop Ramp with Basket Weave to Stoney Tr (**AM Peak**)

Figure 6.6

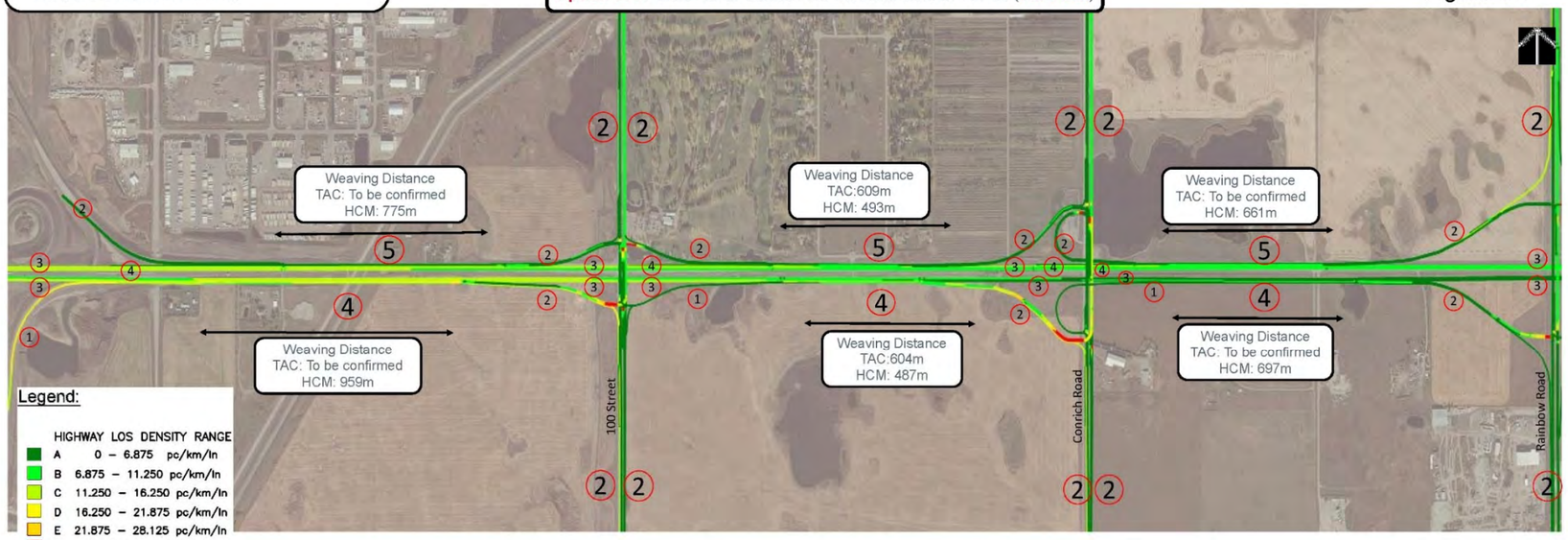


Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

Option 7: : Parclo AB at Conrich Rd with Diamond at 100 St (**AM Peak**)

Figure 6.7

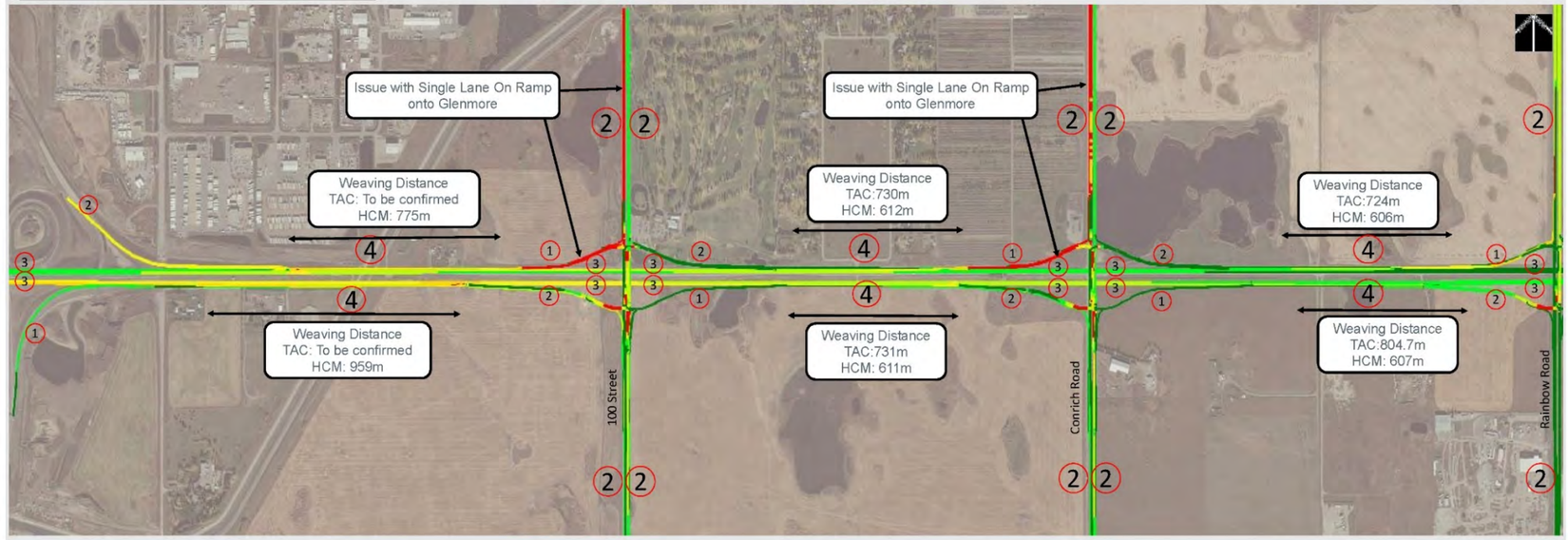


Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

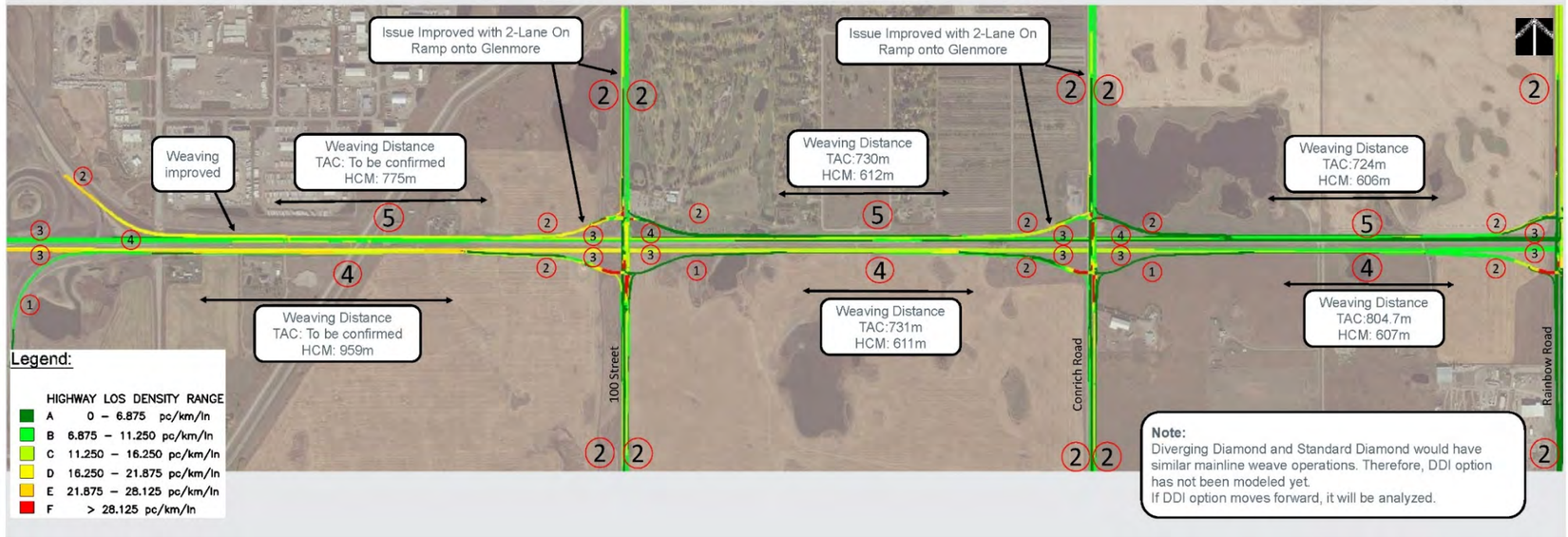
Option 1: Diamonds with Single Lane on Ramps (**PM Peak**)

Figure 6.8



Option 2: Diamonds with WB Dual Lane on Ramps (**PM Peak**)

Figure 6.9

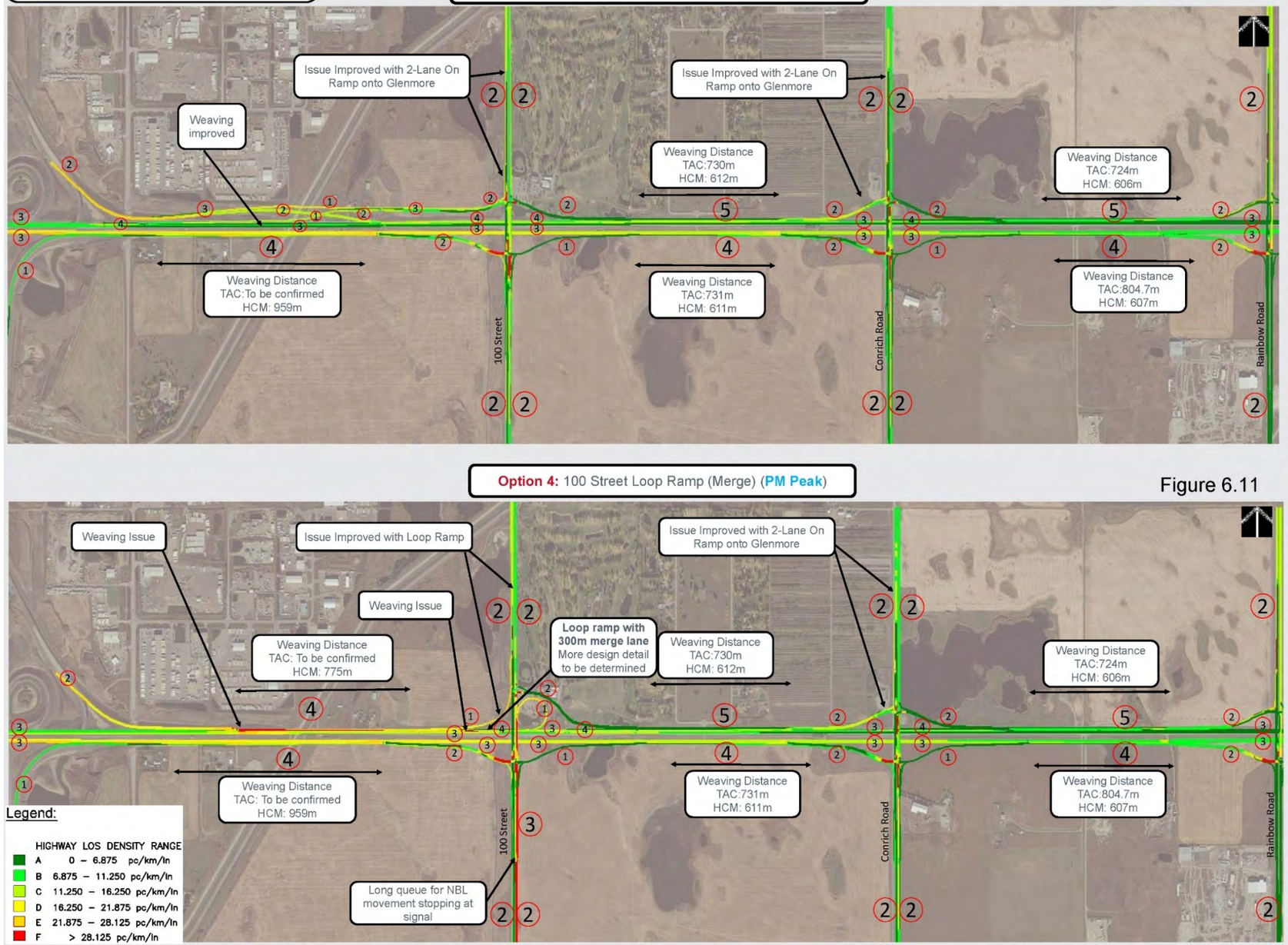


Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

Option 3: Diamonds with Basket Weave to Stoney Tr (**PM Peak**)

Figure 6.10



Option 4: 100 Street Loop Ramp (Merge) (**PM Peak**)

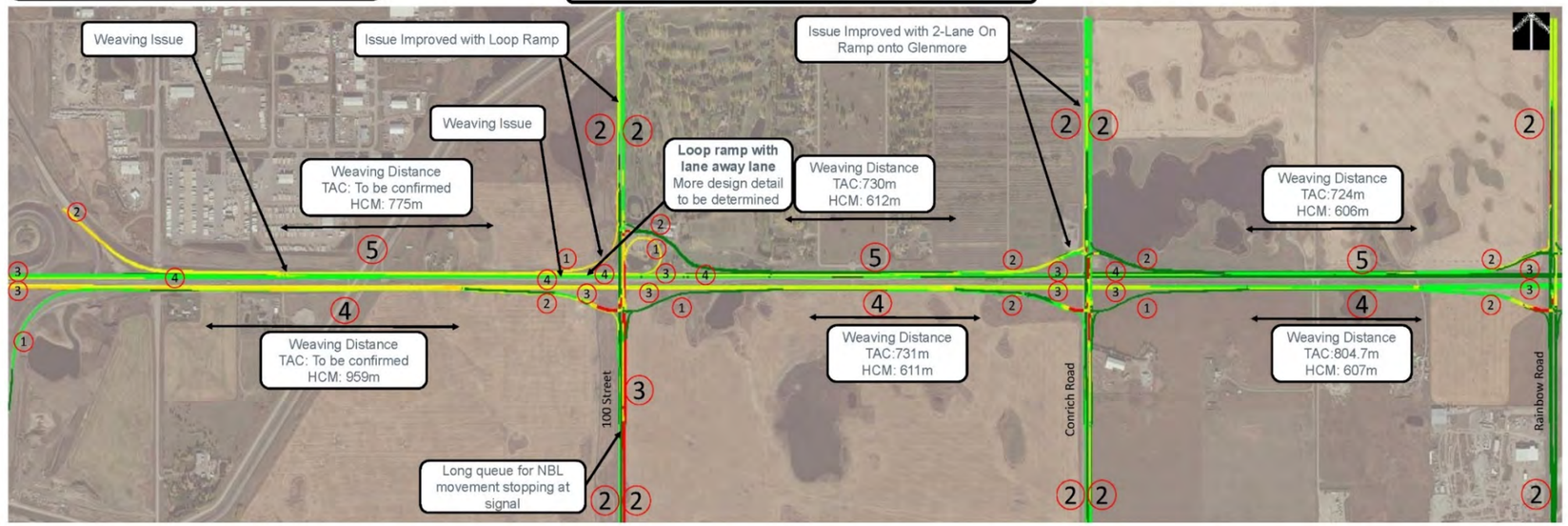
Figure 6.11

Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

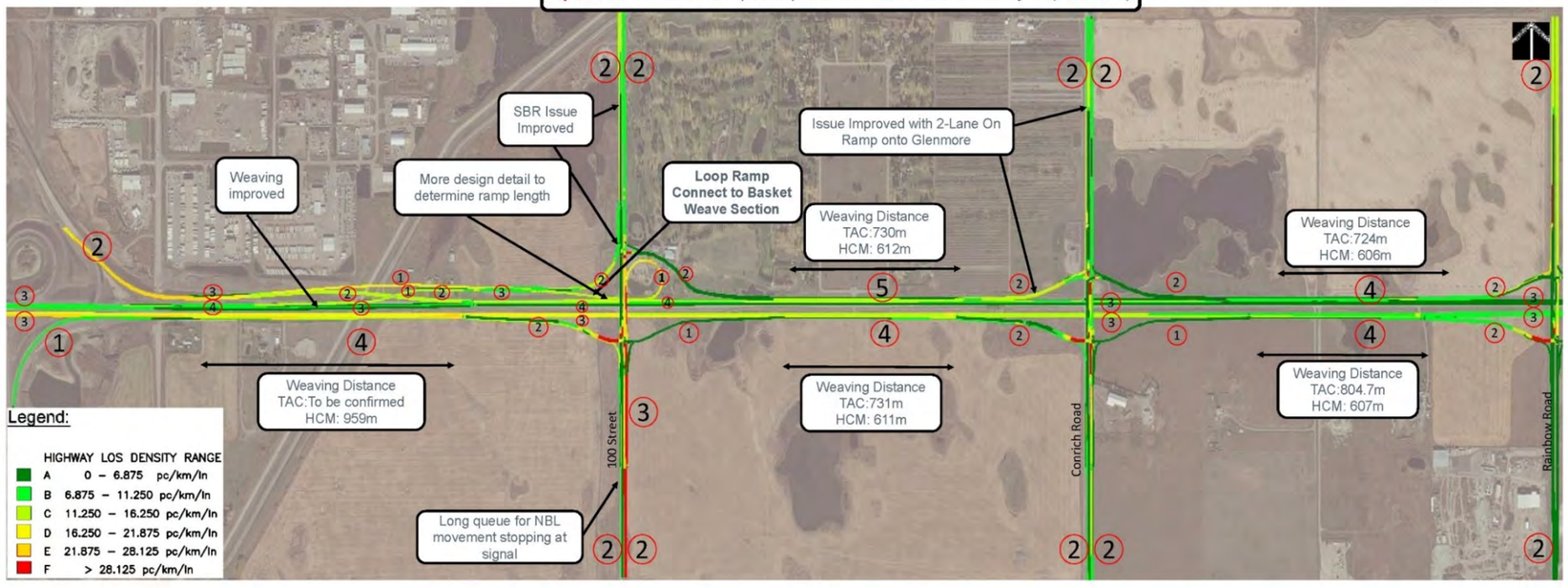
Option 5: 100 Street Loop Ramp (Lane Away) (**PM Peak**)

Figure 6.12



Option 6: 100 Street Loop Ramp with Basket Weave to Stoney Tr (**PM Peak**)

Figure 6.13

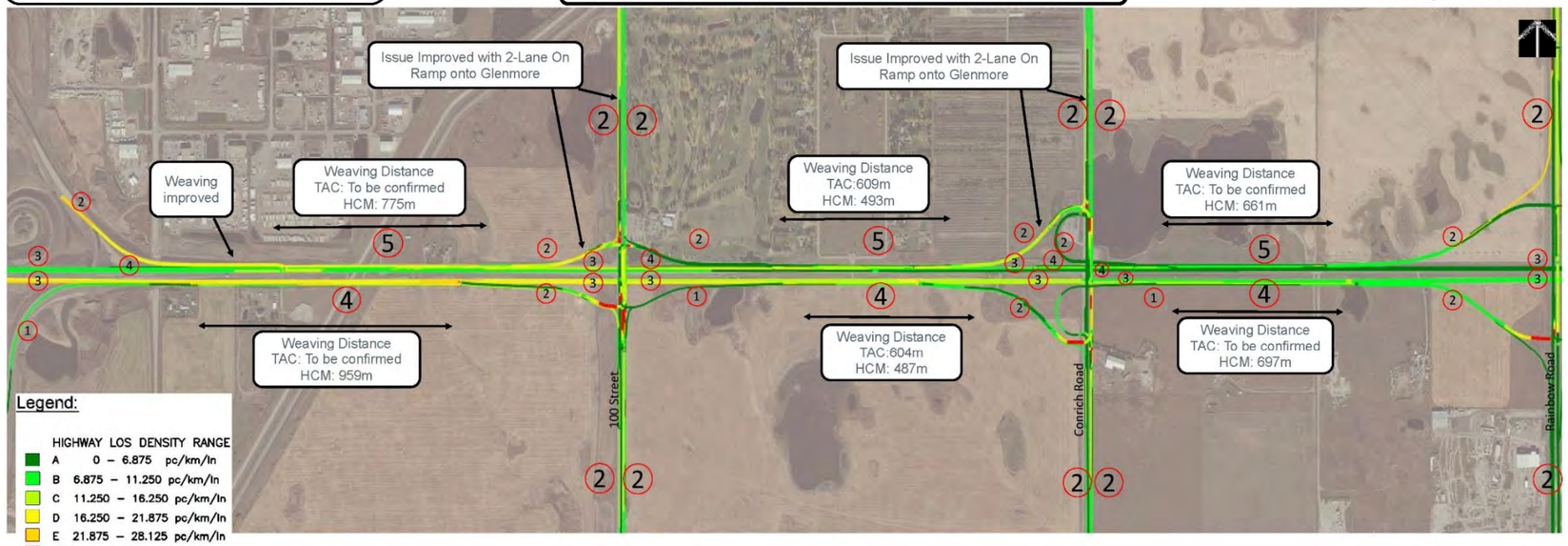


Note:
- HCM weave distance are measured from painted gore to painted gore.
- All weaving distance to be reviewed and confirmed during preferred plan double lining

VISSIM Analysis LOS PLOT

Option 7 : Parclo AB at Conrich Rd with Diamond at 100 St (**PM Peak**)

Figure 6.14



Initial Corridor Option Screening VISSIM Results

The seven options described above were evaluated in VISSIM. Both westbound and eastbound Glenmore Trail sections between Stoney Trail and Rainbow Road were analyzed as weaving segments in VISSIM. From the VISSIM results, all options operated well at LOS A to C in the AM peak between interchanges. However, PM peak analysis revealed different operations for each option as described below.

- Option 1: The single lane westbound entrance ramps at 100 St SE and 116 S SE are over capacity and operate at LOS F.
- Option 2: Operates well in both directions. The dual lane entrance ramps and two westbound auxiliary lanes resolved the issues observed with Option 1.
- Option 3: Operates well in both directions. The dual lane entrance ramps and two westbound auxiliary lanes resolve the issues observed with Option 1. The basketweave between Stoney Trail and 100 St SE also improved the mainline operation from LOS C to LOS A.
- Option 4: The single lane northbound to westbound loop ramp at 100 St SE operates poorly at LOS F. The westbound weave segment between 100 St SE and Stoney Trail also operates at LOS F.
- Option 5: The single lane northbound to westbound loop ramp at 100 St SE operates poorly at LOS F. The westbound weave segment from 100 St SE to Stoney Trail improved with the additional lane; the weave segment changing from LOS E/F to LOS C/D.
- Option 6: Operates similar to Option 3 except that long queues were observed in the northbound and westbound movement. Long queues were observed for the northbound to westbound movement approaching the single lane loop ramp.
- Option 7: Operates well in all directions.

Initial Corridor Option Screening Findings

Based on the VISSIM analysis from the initial corridor option screening, the following findings were observed:

- Option 2, Option 3, and Option 7 show very similar weaving operations between interchanges and these three options performed the best among the seven corridor options.
- The corridor operates best with dual westbound entrance ramps.
- The corridor operates best with dual westbound exit ramps.
- The corridor operates best with single eastbound entrance ramps.
- The corridor operates best with dual eastbound exit ramps.
- Diamond interchanges operate best with the above entrance and exit ramp laning.
- Westbound Glenmore Trail operates best with two auxiliary lanes.
- A basketweave improves the westbound weaving operation between 100 St SE and Stoney Trail.
- Option 7 operates well, however, the weaving distance between 100 St SE and 116 St SE is the shortest with a Parclo A-B at 116 St SE.

These findings identified the best performing corridor components which allowed the study to progress to the next phase of option development.

6.3 Second Round of Option Development

The initial screening evaluation set the basic laning parameters for the ramps along Glenmore Trail. The second round of option development sought to confirm the final corridor configuration by analyzing different interchange configurations in detail. There are a range of potential options that could be considered to address the traffic and transportation issues identified in Section 3. All option concepts are summarized in ***Table 6.2*** and are illustrated in ***Figure 6.15*** and ***Figure 6.16***.

TABLE 6.2: INITIAL OPTIONS FOR GLENMORE TRAIL AT 100 ST SE AND 116 ST SE

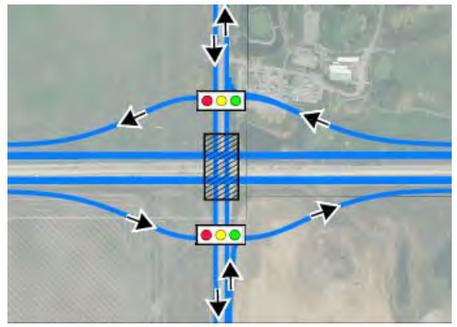
100 ST SE	
Option A	Do-Nothing (Base Case)
Option B	Full Diamond Interchange
Option C	Diverging Diamond Interchange
Option D	Half Diamond Interchange (Base Case)
Option E	Half Parclo Half Diamond Interchange
Sub-Option	Basketweave connection 100 St SE to Stoney Trail

116 ST SE	
Option A	Do-Nothing (Base Case)
Option B	Full Diamond Interchange
Option C	Diverging Diamond Interchange

OPTION A: DO NOTHING (BASE CASE)

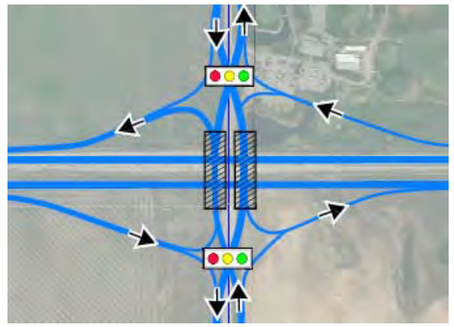
- The status quo assumes a “do-nothing” scenario, includes no changes to the study area and its intersections and no alteration to the surrounding network. This option represents the Base Case.

OPTION B - FULL DIAMOND INTERCHANGE



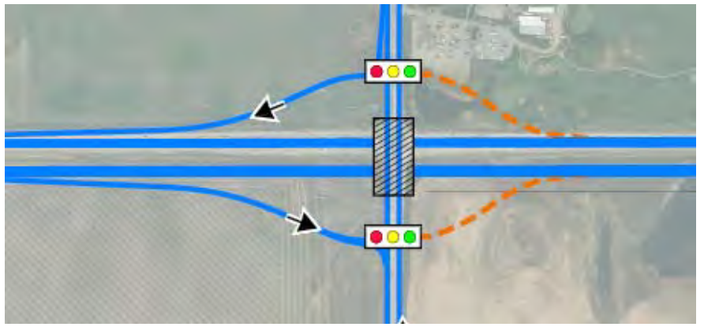
- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION C - DIVERGING DIAMOND INTERCHANGE



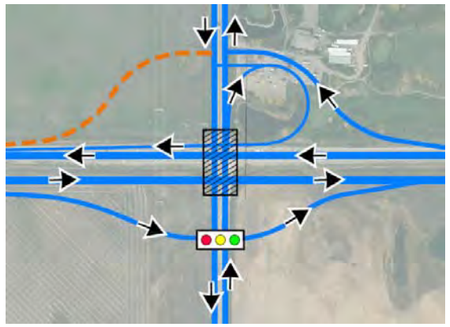
- Full movements are provided at this interchange.
- This option involves traffic along 100 St SE “crossing sides at grade” to create free-flow left turns through the interchange.
- High loads can use the same ramps as the general traffic to approach the interchange junctions. However, unique intersections will be required to allow high load movements to pass through.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION D - HALF DIAMOND INTERCHANGE



- Access provided to and from the west side only (The City side).
- Additional ramps are required on the east side to accommodate high load movement through the interchange. These ramps will not be available for use to general traffic.
- Limiting access at 100 St SE forces EB traffic to other access points.

OPTION E - HALF PARCLO HALF DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.
- This option has the largest impact on the HeatherGlen golf course.
- Alternative to this option would be to provide a separate ramp for the southbound to westbound movement, to remove conflict with the northbound to westbound movement as these two movements have very high volumes.

SUB OPTION - BASKET WEAVE CONNECTION TO STONEY TRAIL

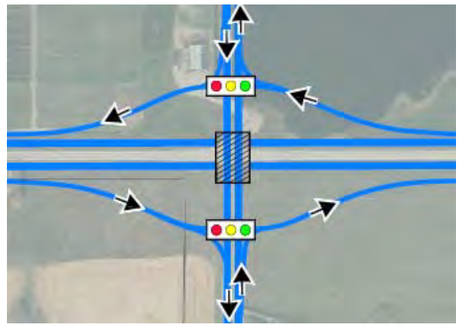
- Minimum desirable weaving distance has provided between adjacent interchanges in the eastbound direction.
- The basketweave will grade separate the entrance ramp from 100 St SE and the exit ramp to Stoney Trail thereby eliminating any potential weaving issues between these two interchanges.
- Compatible with all options and can be implemented at later stages.

FIGURE 6.15: INTERCHANGE OPTIONS FOR 100 ST SE

OPTION A – DO NOTHING (BASE CASE)

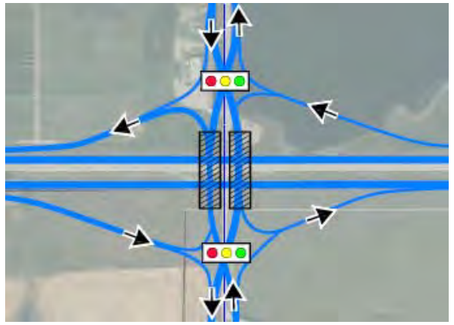
- The status quo assumes a 'do-nothing' scenario, includes no changes to the study area and its intersections and no alteration to the surrounding network. This option represents the Base Case.

OPTION B - FULL DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- High loads can use the same ramps as the general traffic to navigate the interchange.
- Minimum desirable weaving distance is provided between adjacent interchanges.

OPTION C – DIVERGING DIAMOND INTERCHANGE



- Full movements are provided at this interchange.
- More wetland impacted than full diamond.
- This option involves traffic along 116 St SE "crossing sides at grade" to create free-flow left turns through the interchange.
- High loads can use the same ramps as the general traffic to approach the interchange junctions. However, unique intersections will be required to allow high load movements to pass through.
- Minimum desirable weaving distance is provided between adjacent interchanges.

FIGURE 6.16: INTERCHANGE OPTIONS FOR 116 ST SE

6.4 Additional Option Screening

With multiple initial options being developed as potential solutions for interchanges at 100 St SE and 116 St SE, significant analysis is required to evaluate each option in order to identify a recommended plan. To reduce the subsequent detailed analysis and evaluation effort, the remaining options were assessed such that only the most applicable options would be taken to the next steps of detailed evaluation. The goal of this additional option screening process was to reduce the set of options to approximately two or three of the most practical options.

A series of high-level criteria were used to assess each of the options such that the lower scoring options could be screened out from further consideration. A total of six criteria were selected to screen the options, as described in ***Table 6.3*** below.

TABLE 6.3: INITIAL STRATEGIC OPTIONS FOR GLENMORE TRAIL FUNCTION PLANNING STUDY

INITIAL CRITERIA	DESCRIPTION
Traffic Capacity	Indicates the level interrupted flow of east-west traffic due to at-grade signalized intersections. The assessment is based on the number of at-grade signalized intersections on a roadway; where "✓" indicates no at-grade signalized intersections or free flow and "✗" represents higher number of at-grade intersections interrupting the east-west Glenmore Trail traffic.
Property Impacts	Provides a representation of the impact to the number of properties and severity of the impacts required for construction. Assessment includes consideration of the loss or negative impact to property access. Summary of assessment based on range where "✓" indicates little to no impacts and "✗" indicates a significant impact.
Weaving Analysis	Represents the results from the Highway Capacity Manual (HCM) operational analysis of the weaving and merging/diverging segments within each option, where "✓" is anticipated to operate the best and "✗" is anticipated to operate poorly.
Accessibility	Provides an overview of the accessibility to key connecting roadways in the study area, where "✓" represents full access is maintained to all key routes and "✗" represents severely limited access to key routes.
Wetland Impacts	Provides a representation of the impact to the wet lands and wet land complexes, where "✓" represents minimal or no wetland impacts and "✗" represents significant wetland impacts.
Utility Impacts	Provides a representation of impacts to existing major utilities, where "✓" represents minimal or no utility impacts and "✗" represents significant utility impacts.

The ratings from the application of these criteria with respect to each initial option have been summarized in ***Table 6.4*** and ***Table 6.5***. This final summary provides a direct comparison between options, to assist in identifying which options should be removed or retained for further consideration. It is important to note, that despite scoring well under these criteria, Option A: Do Nothing (Base Case), is not recommended since the existing at-grade intersections do not adequately support future traffic volumes. Option A has been included as a base case, for comparison purposes only.

TABLE 6.4: 100 ST SE INITIAL OPTIONS SCREENING

	OPTION A – DO NOTHING (BASE CASE)	OPTION B - FULL DIAMOND INTERCHANGE	OPTION C - DIVERGING DIAMOND INTERCHANGE	OPTION D - HALF DIAMOND INTERCHANGE	OPTION E - HALF PARCLO HALF DIAMOND INTERCHANGE	SUB OPTION - BASKETWEAVE CONNECTION TO STONEY TRAIL
Traffic Capacity	×	✓	✓	×	×	✓
Property Impacts	✓	×	×	×	×	×
Weaving Analysis	✓	✓	✓	✓	✓	✓
Accessibility	✓	✓	✓	×	×	×
Wetland Impacts	✓	×	×	✓	×	✓
Utility Impacts	✓	×	×	×	×	×
Recommendation		✓✓✓ More favourable	✓✓✓ More favourable			✓✓✓ More favourable

TABLE 6.5: 116 ST SE INITIAL OPTIONS SCREENING

	OPTION A- DO NOTHING (BASE CASE)	OPTION B - FULL DIAMOND INTERCHANGE	OPTION C – DIVERGING DIAMOND INTERCHANGE
Traffic Capacity	×	✓	✓
Property Impacts	✓	×	×
Weaving Analysis	✓	✓	✓
Accessibility	✓	✓	✓
Wet Land Impacts	✓	×	×
Utility Impacts	✓	×	×
Recommendation		✓✓✓ More favourable	✓✓✓ More favourable

Based on the screening results, the recommended short-listed options include either a full diamond interchange or a diverging diamond interchange at both 100 St SE and 116 St SE. It is also recommended to further evaluate the sub-option of a basketweave connection from 100 St SE to Stoney Trail.

The next step is to take the short-listed options to the next level of design to provide enough detail to fully evaluate each option using a comprehensive evaluation framework. The evaluation framework detailed options are discussed in Section 7.

7. Option Evaluation

This section provides a description of the evaluation framework and criteria used to assess each of the short-listed options along with a summary of the evaluation results for each individual criterion. An overall summary of the evaluation is provided along with the identification of the recommended plan.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

7.1 Multiple Account Evaluation

The MAE was created with reference to The City's Triple Bottom Line framework, which considers social, environmental and economic in the evaluation process. Inputs from stakeholder and public engagement sessions identified priority evaluation areas: financial, transportation, feasibility/delivery, community impact, stakeholders, environmental, cultural heritage and pollution.

The issue areas can be further broken down into two types of indicators:

- **Qualitative indicators**: measure the relative impact and evaluate the effects and benefits of the two interchange option layouts.
- **Quantitative indicators**: evaluate the outcomes of the design and provide quantitative (measurable) results based on each interchange option layout.

These indicators are further described in ***Table 7.1*** below:

TABLE 7.1: QUALITATIVE AND QUANTITATIVE INDICATORS

THEME	ISSUE AREA	QUALITATIVE OR QUANTITATIVE	MEASUREMENT METHOD	INDICATOR
Economic	Financial	Qualitative	-	Operating and maintenance costs / efforts
			-	Utility relocation costs
		Quantitative	$ - Total project costs	Present value of project cost
	Transportation	Qualitative	-	High load access
			-	Heavy vehicle usability
			-	Accommodates transit
			-	Accommodates cycling and walking
		Quantitative	Minutes of travel time saved	Travel time savings
			Reduction in number of conflict points	Traffic safety
			Level of Service	Reduction in traffic congestion and improved capacity
	Feasibility and Deliverability	Qualitative	-	Constructability
			-	Staging opportunity

THEME	ISSUE AREA	QUALITATIVE OR QUANTITATIVE	MEASUREMENT METHOD	INDICATOR
Social	Community Impacts	Qualitative	-	Accessibility to network
			-	Visual aesthetics
			-	Construction impact to residences and businesses
		Quantitative	Total private property impacted (acres)	Private property impacts
			Total land required including land within RoW (acres)	Land consumption
	Stakeholders	Qualitative	-	Public acceptability
Environmental	Environmental	Quantitative	Total wetland impacted (acres)	Impacts on indigenous species, removal of habitat
	Cultural Heritage		Total land impacted (acres)	Impact on historical sites
	Pollution		-	Impact on air quality

7.2 Evaluation and Results

Representatives from The City, AT and RVC were invited to join ISL and Parsons in a MAE workshop, held in Parsons office on January 31, 2017. The purpose of the workshop was to have technical experts evaluate the two interchange options against the predefined qualitative criteria, previously listed in ***Table 7.1***. The discussions and results from the workshop are outlined below and also include the results from the technical analysis related to the quantitative criteria.

FINANCIAL

Operating and Maintenance Costs / Efforts

AT and the bordering municipalities will be maintaining the future infrastructure over its service lifetime. The expected lifetime is 30 years for roads and 75 years for bridges. The purpose of this indicator is to compare effort on operating and maintenance for the two interchange option layouts. ***Table 7.2*** below, summarizes the pros and cons for each interchange option layout in terms of operating and maintenance. The diamond option layout has a minor advantage of operating and maintenance costs / efforts over the DDI.

TABLE 7.2: DIAMOND VS. DDI OPERATING AND MAINTENANCE COMPARISON

OPERATIONS AND MAINTENANCE	DIAMOND	DDI
Lighting	✓ Regular lighting	× May require additional lighting / high-mast system
Snow removal	× Less snow storage space than DDI	✓ More snow storage space
Mowing	✓	× Small spaces required for mowing
Operations	× Signalized left turns onto freeway	✓ Free-flowing for left turns onto freeway
Signage / pavement markings	✓ Less signage and pavement markings	× Additional signage and pavement markings are needed beyond the levels of diamond option layout
Result	✓✓✓ More favourable	✓✓

Legend: ✓ - Indicates criteria is more favourable × - Indicates criteria is less favourable

Utility Relocation Costs

The purpose of this indicator is to evaluate the impact of the surrounding utility for the two interchange options. The existing utilities at 100 St SE and 116 St SE were reviewed. A preliminary investigation determined both options had a similar footprint and there were no significant differences in the impacts on utilities.

Project Costs

Order of magnitude cost estimates were developed for each interchange option. Due to the high level of detail at this stage of the study, only five of the most critical construction items are selected to compare between the two interchange option layouts. Detailed option evaluation cost estimates are provided in ***Appendix K*** and summarized in ***Table 7.3***. Exhibit 1.0 to 4.0 in ***Appendix K*** illustrate the respective areas for the earthworks quantity calculations for the Diamond and DDI interchange configurations. Exhibit 4.0 to 8.0 in ***Appendix K*** illustrate the respective areas for the pavement quantity calculations for the Diamond and DDI interchange configurations.

The costs for the conventional diamond interchange were slightly lower than the DDI, primarily due to the larger footprint and property acquisition for the latter. However, it should be noted the costs differences are within 5%, well within the budgetary variances and indicative that, at this level of planning, the options are essentially similar with respect to costs.

TABLE 7.3: DIAMOND VS. DDI CONSTRUCTION COST COMPARISON

CONSTRUCTION ITEMS	DIAMOND		DDI	
	100 ST SE	116 ST SE	100 ST SE	116 ST SE
Glenmore Trail widening (from existing 2 lanes to 6 lane section)	$9,210,890	$9,455,325	$9,245,900	$9,342,075
Ramps	$5,444,825	$5,784,015	$6,917,330	$5,382,865
North-south connector widening (from existing 2 lanes to 4 lane section)	$4,468,835	$4,948,675	$4,540,525	$6,675,785
Bridge structure	$11,864,000	$11,228,000	$10,440,000	$10,180,000
CONSTRUCTION COST SUB-TOTAL (ROUNDED):	$30,989,000	$31,500,000	$31,144,000	$31,600,000
Contingency (30%):	$9,296,700	$9,450,000	$9,343,200	$9,480,000
TOTAL INCL. CONTINGENCY:	$40,285,700	$40,950,000	$40,487,200	$41,080,000
Engineering and testing (15%):	$6,042,855	$6,142,500	$6,073,.080	$6,162,000
Property acquisition:	$38,332,500	$37,732,748	$41,947,500	$42,769,242
TOTAL CLASS 4 ESTIMATE: (2017 DOLLARS)	$84.700,000	$84,900,000	$88,500,000	$90,100,000
- 40% budgeting variance:	$50,800,000	$50,900,000	$53,100,000	$54,100,000
+ 75% budgeting variance:	$148,200,000	$148,500,000	$154,900,000	$157,600,000
Result	✓	✓	✓	✓

TRANSPORTATION

High Load Access

Glenmore Trail is designated as a provincial high load corridor. The City and RVC both designate 100 St SE as high load corridor. Opportunities for high load access for each interchange option were reviewed, including all north-south and east-west movements. High load operation will require on-site traffic control and adjustment of traffic control signs and signals, as is normal practice for permitted and escorted loads. However, the DDI will require a special connection road between the off and on-ramps, including crossing over a pedestrian sidewalk in order for high load traffic to pass through the intersection.

Based on this, the conventional diamond option is more easily traversable for high load vehicles. Implementation of a connection road for the DDI is feasible but may cause confusion at the already unconventional intersection. Should the DDI be selected to move forward to the functional plan design, special consideration will be required for a connection road.

Heavy Vehicle Usability

With the amount of future industrial land uses proposed north and south of Glenmore Trail, there will be a significant amount of heavy vehicle usage at 100 St SE and 116 St SE. Heavy vehicle usability is a very important component for selecting the interchange layout. ***Table 7.4*** summarizes the pros and cons for each interchange option layout with respect to heavy vehicle usability. Overall, the DDI layout is less restrictive and therefore more accommodating of heavy vehicles.

TABLE 7.4: DIAMOND VS. DDI HEAVY VEHICLE USABILITY COMPARISON

HEAVY VEHICLE USABILITY	DIAMOND	DDI
Lane width	×	✓ Wider lane widths
Turning radius	×	✓ Larger design radius allowing for easier maneuvering of heavy vehicles
Dual left turn movements	× Requires large space to accommodate side-by-side left turning heavy vehicles	✓
Clearance requirement	× Signalized left turn phasing	✓ No opposing turns for left turn; therefore, no clearance requirements
Through movements	✓ North–south through can accommodate pedestrians direct movement	×
Likelihood of truck stopping at intersection	× Two signalized intersections	✓ One signalized intersection
Result	✓	✓✓✓✓✓ More favourable

Legend: ✓ - Indicates criteria is more favourable × - Indicates criteria is less favourable

Transit Accommodation

It is essential that transit accommodation is considered for future design and planning processes. Opportunities to accommodate transit were evaluated for the two interchange options. ***Table 7.5*** below summarizes the pros and cons for each interchange option. The evaluation confirmed that the DDI is preferred.

TABLE 7.5: DIAMOND VS. DDI TRANSIT ACCOMMODATIONS COMPARISON

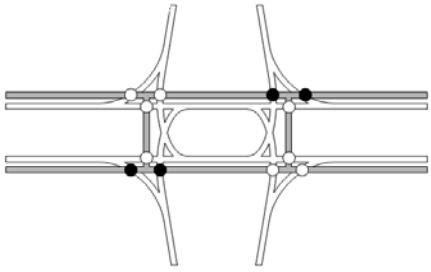
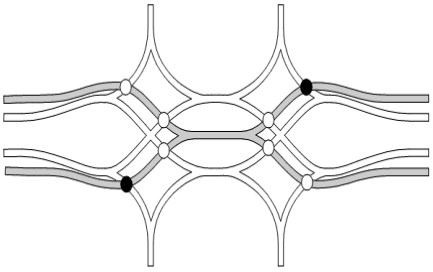
TRANSIT	DIAMOND	DDI
Queue jump	× Not easily accommodated.	✓ More flexibility for NB queue jump and reduced number of signal phases and potentially lower delay.
Transit stop location (north-south)	× Transits require lane change in order for NBL movement.	× Transits require lane change in order for NBL movement.
Transit stop location (east-west)	✓ Transit exit using the off ramp, cross the arterial at the ramp terminal intersection, and serve a far-side stop before re-entering the freeway via on ramp.	✓ Utilizing the high load connection design where a special connection road constructed between the off and on-ramps. Transit exit using the off ramp, cross the arterial at the ramp terminal intersection, and serve a far-side stop before re-entering the freeway via on ramp.
Result	✓	✓✓ More favourable

Legend: ✓ - Indicates criteria is more favourable × - Indicates criteria is less favourable

Walking and Cycling Accommodation

It is essential that active modes are considered in future design and planning processes. Opportunities to provide safe, direct and comfortable crossings for cyclists and pedestrians are important. This indicator evaluated the ability to accommodate cycling and walking for the two interchange option layouts. In this evaluation, it is assumed that cyclists and pedestrian facilities will be provided on the outside of the travelling lanes (standard for most diamond interchanges with pedestrian facilities) or that cyclists and pedestrian facilities will be provided at the centre of the interchange for a diverging diamond interchange. ***Table 7.6*** summarizes the pros and cons for each interchange option for cycling and walking accommodations. The evaluation confirmed that the DDI option layout with facilities located within the median is more desirable for cycling and walking.

TABLE 7.6: DIAMOND VS. DDI CYCLING AND WALKING ACCOMMODATION COMPARISON

ACCOMMODATING CYCLING AND WALKING	DIAMOND	DDI
Pedestrian-vehicle conflict points	 ● Free-Flowing or Accelerating Conflict ○ Stopped or Decelerating Conflict × 12 conflict points.	 ● Free-Flowing or Accelerating Conflict ○ Stopped or Decelerating Conflict ✓ 8 conflict points.
Number of signal phases	× Multi-phases signal.	✓ 2 signal phases– better serve non-motorized movements.
Crossing distance	× Crossing both directions of traffic at a time. Longer crossing distance.	✓ Only cross one direction of traffic at a time. Shorter crossing distance.
Result	×	✓✓✓ More favourable

Legend: ✓ - Indicates criteria is more favourable × - Indicates criteria is less favourable

Travel Time Savings

Travel times were measured in VISSIM (v 8.00) to provide relative comparison of the options. For each interchange option, the travel time from each approach to the other three directions (for instance from A to B, C, and D) were measured to/from the quarter section away from the centre of the interchange. The total travel time was calculated by multiplying the average travel time by the number of vehicles that travelled along the respective route. ***Figure 7.1*** below illustrates the location of the start and end points of each route, and the summaries of the travel time results are provided in ***Table 7.7*** and ***Table 7.8*** for AM and PM peak hours respectively.

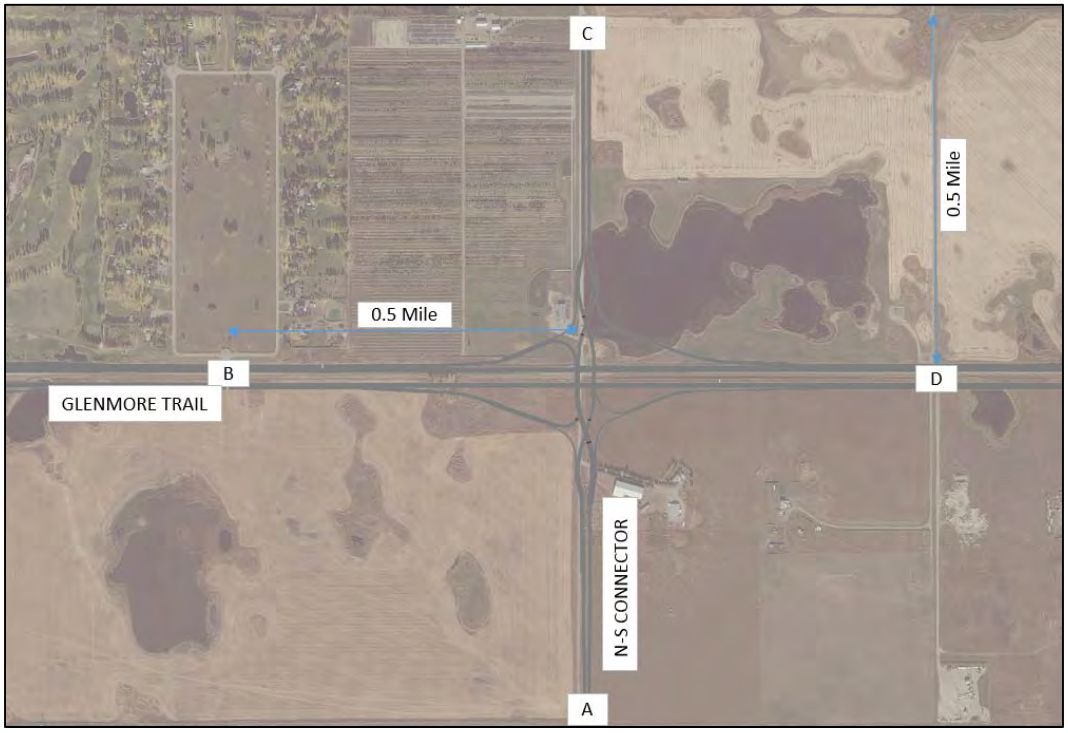


FIGURE 7.1: LOCATION OF THE START AND END POINTS FOR TRAVEL TIME MEASURE

TABLE 7.7: DIAMOND VS. DDI TOTAL TRAVEL TIME COMPARISON IN AM PEAK

ROUTE		DIAMOND		DDI	
		100 ST SE	116 ST SE	100 ST SE	116 ST SE
FROM	TO	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)
A	B	832	684	664	623
A	C	70	85	68	94
A	D	73	41	70	42
B	A	1,244	1,265	1,308	1,287
B	C	1,682	1,902	1,853	2,060
B	D	3,765	1,677	3,886	1,678
C	B	532	493	543	510
C	A	189	223	194	245
C	D	85	23	81	19
D	C	234	120	238	122
D	A	371	246	327	160
D	B	3,551	3,077	3,635	3,077
TOTAL TRAVEL TIME IN AM PEAK (MIN)		12,628 (1.86% FASTER)	9,837 (0.8% FASTER)	12,868	9,917
Results		✓	✓	✓	✓

TABLE 7.8: DIAMOND VS. DDI TOTAL TRAVEL TIME COMPARISON IN PM PEAK

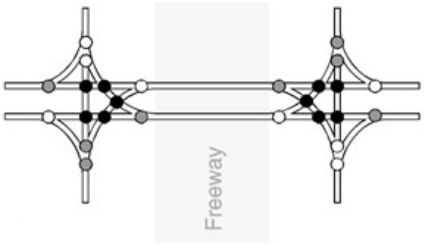
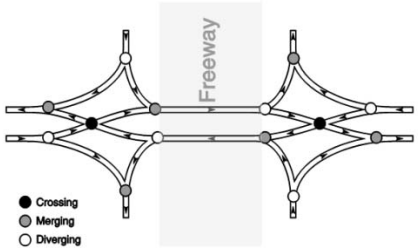
ROUTE		DIAMOND		DDI	
		100 ST SE	116 ST SE	100 ST SE	116 ST SE
FROM	TO	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)	TOTAL TRAVEL TIME (MIN)
A	B	2,464	2,238	1,898	1,779
A	C	198	199	196	235
A	D	123	130	121	131
B	A	894	853	951	867
B	C	2,154	1,647	2,359	1,549
B	D	5,440	3,842	5,332	3,852
C	B	1,851	1,456	1,767	1,522
C	A	190	180	192	173
C	D	426	531	378	384
D	C	106	45	107	44
D	A	139	181	109	126
D	B	4,489	2,522	4,518	2,523
TOTAL TRAVEL TIME IN PM PEAK (MIN)		12,628 (1.86% FASTER)	18,475	13,824	17,927 (3.05% FASTER)
Results		✓	×	×	✓ MORE FAVOURABLE

In the AM peak, the travel times for the diamond and DDI at 116 St SE are very similar, with only 0.8% difference. In the PM peak, the total travel times for DDI at 116 St SE Road is 4.8% less than the diamond configuration. Combining both the AM and PM peak travel times, the DDI provides overall better travel time for users.

Traffic Safety

The DDI is a relatively new type of interchange in Canada. The first DDI in Canada recently opened at Macleod Trail /162 Avenue in Calgary. As with any new infrastructure design, there is a risk associated with user unfamiliarity and reduced driver comfort levels. These risks are expected to reduce over time and are generally not identified as a specific issue. There is little data available to accurately analyze historical collision factors for DDIs; therefore, a measure of safety for comparing the two options was determined by counting the number of conflict points as described in ***Table 7.9***. The DDI has fewer conflict points. The DDI curves typically calm traffic, and U-turns are generally easier for motorists who missed their exit.

TABLE 7.9: DIAMOND VS. DDI TRAFFIC SAFETY COMPARISON

TRAFFIC SAFETY	DIAMOND	DDI
Conflict Points	 × 26 Conflict Points	 ✓ 14 Conflict Points More Favourable

Reduction in Traffic Congestion and Improved Capacity

The two interchange layouts were modelled using Synchro 9 to analyze the operational characteristics of the signalized intersections. Measures of performance include intersection delay, measured as seconds per vehicle (s/veh); intersection utilization, as a ratio of volume-to-capacity (v/c) for each movement and queue lengths for each movement, defined as the 95-percentile queue length.

Intersection delay is the LOS, rated on a scale, A through F. LOS A represents the highest level of service, generally “free flowing conditions” while LOS F typically represents a “breakdown” or “gridlock” condition in vehicular flow.

There are varying degrees of delay and congestion introduced at the intermediate LOS B, C, D, and E levels. LOS D is representative of “normal” peak hour congestion, while LOS E is representative of an intersection nearing its capacity.

Typically, LOS D or better is the accepted standard for peak hour operations in urban areas, with LOS E accepted where limited to certain movements. LOS criteria for intersections are based on average delay per vehicle and are summarized in *Table 7.10*.

TABLE 7.10: LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS

LOS	AVERAGE DELAY PER VEHICLE (S/VEH)
A	< 10
B	10 – 20
C	20 – 35
D	35 – 55
E	55 – 80
F	> 80

The v/c ratio for each movement provides an indication of intersection utilization. A v/c ratio of 1.0 represents an intersection or movement at full capacity with no ability to facilitate extra vehicles. Typically, a v/c ratio of 0.90 or better for all intersection movements is the accepted standard for peak hour operations in urban areas.

Finally, Synchro also calculates the 95-percentile vehicle queue length for each intersection movement, which provides the criteria for left and right turn storage requirements. This output assumes the queue length is exceeded 5% of the time, which is accepted practice for normal peak hour operation in urban areas.

Detailed summaries of the operational analyses are provided in ***Appendix K*** and the results for the key movements are summarized in ***Table 7.11*** and ***Table 7.12***. Based on the operational results from the key movements for both interchange options, the DDI shows better traffic performance than the diamond configuration.

TABLE 7.11: KEY MOVEMENTS SYNCHRO RESULTS COMPARISON AT 100 ST SE

MOVEMENTS		AM PEAK				PM PEAK			
		NORTH JUNCTION		SOUTH JUNCTION		NORTH JUNCTION		SOUTH JUNCTION	
		NBL	NBT	EBL	NBT	NBL	NBT	EBL	NBT
VOLUMES		400	930	900	430	1,000	1,200	1,100	1,100
DIAMOND	LOS	C	B	C	B	C	A	C	D
	V/C RATIO	0.66	0.59	0.88	0.20	0.84	0.57	0.90	0.86
DDI	LOS	FREE FLOW	A	A	A	FREE FLOW	A	B	B
	V/C RATIO	-	0.52	0.60	0.18	-	0.65	0.69	0.70

TABLE 7.12: KEY MOVEMENTS SYNCHRO RESULTS COMPARISON AT 116 ST SE

MOVEMENTS		AM PEAK				PM PEAK			
		NORTH JUNCTION		SOUTH JUNCTION		NORTH JUNCTION		SOUTH JUNCTION	
		NBL	NBT	EBL	NBT	NBL	NBT	EBL	NBT
VOLUMES		300	1,140	1,100	340	900	900	800	1,000
DIAMOND	LOS	A	A	B	D	A	A	D	D
	V/C RATIO	0.27	0.61	0.68	0.32	0.71	0.44	0.86	0.79
DDI	LOS	FREE FLOW	B	A	C	FREE FLOW	B	A	C
	V/C RATIO	-	0.74	0.66	0.40	-	0.77	0.70	0.72

Traffic Sensitivity Analysis

Traffic operations were reviewed with sensitivity test for a 25% increase in traffic for the two interchange options. Detailed summaries of the operational analyses are provided in ***Appendix K*** and the results for the key movements are summarized in ***Table 7.13*** and ***Table 7.14***.

Based on operational results for the key movements at both interchange options, the DDI layout shows better performance and room for expansion than the diamond configuration when considering a 25% increase in traffic. The diamond configuration at 100 St SE would notably be over-capacity in the PM peak period.

TABLE 7.13: KEY MOVEMENTS SYNCHRO RESULTS COMPARISON (WITH 25% MORE TRAFFIC) AT 100 ST SE

MOVEMENTS		AM PEAK				PM PEAK			
		NORTH JUNCTION		SOUTH JUNCTION		NORTH JUNCTION		SOUTH JUNCTION	
		NBL	NBT	EBL	NBT	NBL	NBT	EBL	NBT
VOLUMES		500	1,163	1,125	538	1,250	1,500	1,375	1,375
DIAMOND	LOS	C	C	C	C	B	A	E	E
	V/C RATIO	0.76	0.75	0.92	0.30	0.82	0.76	1.08	1.04
DDI	LOS	FREE FLOW	B	B	A	FREE FLOW	B	C	B
	V/C RATIO	-	0.65	0.80	0.23	-	0.81	0.86	0.88

TABLE 7.14: KEY MOVEMENTS SYNCHRO RESULTS COMPARISON (WITH 25% MORE TRAFFIC) AT 116 ST SE

MOVEMENTS		AM PEAK				PM PEAK			
		NORTH JUNCTION		SOUTH JUNCTION		NORTH JUNCTION		SOUTH JUNCTION	
		NBL	NBT	EBL	NBT	NBL	NBT	EBL	NBT
VOLUMES		375	1,425	1,375	425	1,125	1,125	1,000	1,250
DIAMOND	LOS	B	A	B	D	B	A	D	D
	V/C RATIO	0.36	0.76	0.81	0.44	0.77	0.53	0.96	0.91
DDI	LOS	FREE FLOW	A	B	D	FREE FLOW	B	C	D
	V/C RATIO	-	0.82	0.68	0.59	-	0.84	0.77	0.86

FEASIBILITY AND DELIVERABILITY

Constructability

Projects with relatively easy or straightforward constructability generally have lower risks, costs, and reduce construction impact on the network. This indicator, which evaluated the constructability of the two interchange options, is summarized below in ***Table 7.15***.

TABLE 7.15: DIAMOND VS. DDI CONSTRUCTABILITY COMPARISON

CONSTRUCTABILITY	DIAMOND	DDI
Temporary traffic accommodation during construction	× Temporary road will be required off current alignment to accommodate existing traffic while the interchange bridge is being constructed.	✓ First bridge can be constructed while maintaining the existing traffic pattern.
Traffic transition from at-grade to interchange	× At-grade traffic can only be switched after the whole interchange is constructed.	✓ At-grade traffic can be switched to the first bridge while the second bridge is being constructed.
Result	×	✓✓ More favourable

Legend: ✓ - Indicates criteria is more favourable × - Indicates criteria is less favourable

The DDI option provides greater flexibility due to offline construction and a wider bridge, therefore making it easier to construct.

Staging Opportunity

The ability to stage infrastructure over time is of value to AT and the bordering municipalities by allowing capital costs to be spread over a longer period. After evaluation, it was determined neither option could be implemented in a staged approach due to the large number of turning vehicles requiring grade separation. Therefore, both options require a full build out.

COMMUNITY IMPACTS

Accessibility to Network

Access to Glenmore Trail from adjacent properties will be limited to the connecting roads (100 St SE and 116 St SE). Both options have similar configurations on the approach to the interchange. Therefore, there were no significant differences in accessibility between the two options.

Visual Aesthetics

Both options require a similar footprint for the grade separated interchanges at each junction. For the purposes of the design, Glenmore Trail as the mainline over was adopted at both interchanges. Therefore, visual impact will be the same for either option. It is recommended to review Glenmore Trail over/under at both locations during the final functional plan design.

Construction Impact to Residences and Businesses

Similar to the accessibility to the network issue, there were no noticeable differences between the two options for accessibility during construction.

STAKEHOLDERS

Based on the feedback from the public information session held on November 16, 2016, citizens and stakeholders did not indicate a preference towards either option.

COMMUNITY IMPACTS

Private Property Impacts

The purpose of this indicator is to evaluate the private property impacts in the two interchange option layouts. ***Table 7.16*** summarizes the total private property impacted for each interchange option.
Based on the total private property impacted, the diamond interchange layout has a modestly smaller footprint and less impact on private property than the DDI.

Furthermore, a comparison of the proposed diamond and DDI interchanges against the 2007 Highway 560 Functional Plan (rural-style diamond interchange) was conducted. The private property requirements of the diamond and DDI layouts were less than the previous functional plan.

TABLE 7.16: DIAMOND VS. DDI PRIVATE PROPERTY IMPACTS COMPARISON

	DIAMOND		DDI	
	100 ST SE	116 ST SE	100 ST SE	116 ST SE
Total private property impacted (Acre)	✓ 51.11	✓ 50.31	× 55.93	× 57.03
Result	✓ More favourable	✓ More favourable		

Land Consumption

The purpose of this indicator is to evaluate the land consumption within the right-of-way for the two interchange options. The measured footprint areas for the two interchange options are included in ***Table 7.17***, which summarizes the total land consumption for each interchange layout. The conventional diamond interchange shows slightly less land consumption over the DDI.

TABLE 7.17: DIAMOND VS. DDI LAND CONSUMPTION COMPARISON

	DIAMOND		DDI	
	100 ST SE	116 ST SE	100 ST SE	116 ST SE
Total Land Consumption (Acre)	✓ 71.34	✓ 70.05	× 76.16	× 76.77
Result	✓ More favourable	✓ More favourable		

ENVIRONMENT

Impacts on Indigenous Species and Removal of Habitat

The purpose of this indicator is to evaluate the impact on environmental features for the two interchange options. The two junction locations are distinctly different in regard to environmental considerations. During preliminary investigations, no environmentally sensitive areas were identified at the junction of 100 St SE and Glenmore Trail.

116 St SE has a large wetland in the northeast corner of the intersection. With the slightly larger footprint of the DDI layout, the area of wetland being impacted in the DDI option is 1.73 Ha more than the diamond interchange layout. ***Table 7.18*** summarizes the total amount of wetland impacted for each interchange layouts.

Based on the total wetland impacted, the diamond interchange layout has a smaller footprint than the DDI layout and will have slightly less impact on the wetland. Further investigation during the Functional Plan design is required to minimize the impacts on the wetland.

TABLE 7.18: DIAMOND VS. DDI ENVIRONMENTAL IMPACT COMPARISON

	DIAMOND		DDI	
	100 ST SE	116 ST SE	100 ST SE	116 ST SE
Total Wetland Impacted (Acre)	= 0	✓ 8.89	= 0	× 10.62
Result		✓ More favourable		

CULTURAL HERITAGE

Parsons carried out a historical site review for the corridor, including the two interchange locations at 100 St SE and 116 St SE. This corridor includes connection upgrades with the existing Stoney Trail and Glenmore Interchange. No historical resources were identified in the proposed corridor or interchange areas based on Alberta Culture Provincial Inventory and Historical Resources Listing of Significant Sites and Areas screening tool (accessed most current 2017 Online System OPAC Database).

Based on this review, neither of the interchanges is favored by this parameter. However, there is still a "Chance Encounter" provision for all Historical Resource Clearances on projects. If there are resources encountered during construction a "stop work" order is implemented until these resources have been appropriately addressed and mitigated through contact with Alberta Culture. The highest potential for such archaeological resource encounters are in buried wetland deposits, e.g. bison kill, or campsite remnants associated with and potentially preserved in anaerobic conditions. Thus, the reduced impact on or near a wetland area will reduce potential for a "chance encounters" issue with historical resources. The smaller footprint option would then be given a slight preference.

POLLUTION

Impact on Air Quality

The study did not have sufficient information available to carry out an accurate measurement and comparison of the two options, therefore the impacts were considered equal for the MAE.

7.4 EVALUATION SUMMARY AND RECOMMENDATION

Both the diamond and DDI option require a similar footprint and have comparable traffic performance and overall project costs. The overall evaluation results are summarized in ***Table 7.19*** with the following key differences summarized below.

The conventional diamond interchange was evaluated favourably on the financial, community and environmental aspects, due to:

- Lower construction cost;
- Less property impact; and
- Less environmental impact.

The diverging diamond interchange was evaluated favorably on the transportation aspect, due to:

- Better accommodation of heavy vehicles;
- Less conflict points for transit, cycling and walking;
- Shorter travel time; and
- Higher capacity.

Based on the results of the evaluation, no option clearly out-performs the other. The adoption of either option will meet the requirements of the functional planning study.

TABLE 7.19: DIAMOND VS. DDI SUMMARY

TBL	ISSUE	INDICATOR	DIAMOND	DDI
Economic	Financial	Operating and maintenance costs / efforts	✓	
		Utility relocation costs	=	=
		Present value of project cost	✓	✓
	Transportation	High load access	✓	
		Heavy vehicle usability		✓
		Accommodates Transit	✓	
		Accommodates cycling and walking		✓
		Travel time savings		✓
		Traffic safety		✓
		Reduction in traffic congestion and improved capacity		✓
	Feasibility and Deliverability	Constructability		✓
		Staging opportunity	=	=
Social	Community Impacts	Accessibility to network	=	=
		Visual aesthetics	=	=
		Construction impact to residences and businesses	=	=
		Private property impacts	✓	
		Land consumption	✓	
	Stakeholders	Public acceptability	=	=
Environ-mental	Environmental	Impacts on indigenous species, removal of habitat	✓	
	Cultural Heritage	Impact on historical sites	✓	
	Pollution	Impact on air quality	=	=

As the footprint of the conventional diamond configuration can be fully encompassed within the footprint of the DDI, selecting the DDI layout over the diamond configuration will allow the flexibility of adopting either layout in the future, therefore allowing the interchange to be adapted to best suit the needs of the surrounding land build-out. Given that the purpose of the study is to preserve the corridor for future requirements, a project decision was made to progress with the DDI option to a full functional plan design.

Although the DDI requires modestly more acquired land, it has a significantly smaller footprint than the 2007 Highway 560 Functional Plan (rural-style diamond interchange), therefore reducing the overall impacts to the surrounding properties and wetlands. The additional land, in comparison to the diamond interchange configuration, required for the DDI compared to the diamond interchange has the significant benefit of ensuring full flexibility for the interchange to be adapted to future needs, which is a key consideration at this stage of planning, given that build-out of the area is likely on a 30+ year time horizon.

8. Functional Design for the Recommended Plan

Before progression of the recommended plan to final functional design, a series of analysis and reviews were carried out on the preliminary functional plan (see Sections 8.1 – 8.3). The reviews sought to identify any safety, arterial and freeway performance issues, before commencing the final functional design.

Following the reviews, a functional design was developed for the recommend plan with the purposes of documenting the key roadway design components along the corridor. The following sections describes the key components of the recommended DDI option.

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

8.1 Safety Audit

A fully independent Road Safety Audit (RSA) was carried out for each of the recommended interchanges 100 St SE, 116 St SE and Rainbow Road. The safety audit report is included in ***Appendix H***. The purpose of the RSA was to identify safety issues at the design and implementation stage, promote awareness of safe design practices, integrate multi-modal safety concerns, and consider human factors in the design.

SUMMARY OF POTENTIAL SAFETY BENEFITS

Overall, the construction of diverging diamond interchanges at 100 St SE, 116 St SE and Rainbow Road are found to improve safety in the following ways:

- Grade separation reduces the number of at-grade intersections along Glenmore Trail;
- The twinning of Glenmore Trail reduces the risk of head-on collisions and improves capacity;
- Where provided, wide medians eliminate the fixed-object collision risk associated with a median barrier;
- Wide shoulders and clear zones reduce the collision risk association with run-off-road movements;
- A reduced number of conflict points;
- Decreased stacking of vehicles making turning movements due to increased capacity;
- Conflict points spread out through the interchange;
- Improved sight distance turns;
- Wrong way entry to ramps difficult;
- Shorter pedestrian crossings;
- Simplified signal phasing; and
- Consistent design that reduces driver confusion and related collision risk.

SUMMARY OF IDENTIFIED SAFETY ISSUES

The RSA was conducted based on the functional planning design drawings, and the identified safety issues. Mitigation suggestions have been developed with consideration for the type of improvements that are feasible at the current design stage. A detailed description of each issue is included in ***Appendix H***.

Risk ratings are associated with each issue. Risk ratings were developed based on the expected frequency (from less than once per year to more than five times per year) and severity (property damage only to fatality). A risk rating of A is low frequency and severity while a risk rating of F is high frequency and high severity.

Table 8.1 lists all the safety issues and how they were addressed. The final functional plan has been updated to address the safety issues.

TABLE 8.1: SUMMARY OF SAFETY ISSUES BASED ON RECOMMENDED PLAN

#	ISSUE	RISK RATING	MITIGATION SUGGESTION	DESIGN RESPONSE
1	Lane balance on westbound Glenmore Trail	C-D	Merging the on-ramps upstream of Glenmore Trail such that there is one added lane instead of two at each interchange could result in four basic lanes along Glenmore Trail and reduce the amount of lane changing taking place.	An initial corridor option screening was undertaken in Section 6.2 of the report. The different scenarios with different weaving segments were analyzed in VISSIM to better understand the lane configurations between interchanges that would best support weaving operation along Glenmore Trail. The results show that the corridor operates best with dual westbound entrance and exit ramps and that westbound Glenmore Trail operates best with two auxiliary lanes. No changes have been made to the design.
2	Inadequate weave / sight distance for basketweave at 100 St SE	C-D	• Increase the length of the weaving section. • Relocated the weave further west of the intersection. • Consider alternate basketweave or interchange configuration.	The design speed for curves preceding the weave section is 40 km/h. Available weave distance between entrance and exit is 125 m, which meets the requirement from traffic modelling. The minimum distance required for 40 km/h speed is 89 m (reading distance of 11 m + reaction distance of 14 m + lane change distance of 62 m). Increasing weave distance is preferable from a sightline perspective. However, this will result in requirement of much larger area of land and will also make it difficult to accommodate a pond in the available area and an alternative design is not considered.
3	Visibility of traffic lights at terminal intersections	C-D	• Optimize the angle of the traffic signal heads to maximize the sight distance for the vehicles on the ramp, while minimizing the visibility of the signal for through traffic. • Provide lane designation signs over the signal heads. • Provide a secondary signal that is visible further upstream on the ramps.	It is not an issue for the functional planning stage. It will be addressed in detail design stage
4	Offset stop lines	C-D	• Align stop bars with the stop bar furthest from the intersection. • Ensure signal timings and clearance provide sufficient yellow and red times to clear the intersection.	It is not an issue for the functional planning stage. It will be addressed in detail design stage.
5	Potential for wrong-way movements	C	This risk is common with diverging diamonds, particularly in areas unfamiliar with the configuration. The risk of wrong-way movements can be mitigated during future design stages through clear pavement markings (potentially including leader lines) and signage, including “Do Not Enter” and “Turns Prohibited” signs.	It is not an issue for the functional planning stage. It will be addressed in detail design stage.
6	Left-turns entering exit Lane	C	The addition of leader line pavement markings and appropriate overhead guide signage may improve lane delineation and help guide motorists to turn into the appropriate travel lanes.	It is not an issue for the functional planning stage. It will be addressed in detail design stage.
7	Lack of pedestrian facilities	C	• Provide pedestrian (and potentially bicycle) facilities on 116 St SE and Rainbow Road; or, • Provide multi-use trail overpasses over Glenmore Trail.	Pedestrian and cyclist facilities are designed in all three interchanges. Pathways are provided on both side of the road, on the north side and south side of the interchange terminal. Pathway is only provided on one side (east side of the northbound bridge) within the interchange terminals.
8	Lane drops obscured by bridge	B	• Relocate lane drop east of bridge structure. • See Issue 1 regarding suggestions for WB Glenmore laning.	This can be further reviewed at the detail design stage.
9	Merge on a horizontal curve	B	Consideration should be given to extending the merge lane to enter 100 St SE on a tangent section north of the reverse curve to improve the visibility of the ending lane and vehicles in adjacent lanes.	Agreed. Design has been modified accordingly.
10	Pedestrian crosswalks on high speed ramps	B	Consider relocating the pedestrian crosswalks further upstream, closer to the slower speed cross-street, where operating speeds are likely lower and motorists are more likely to anticipate pedestrians.	We agreed that the pedestrian crosswalks location should be reconsidered and place where there is more direct sightline. No change will be made in the design in the functional planning stage, but future design team should review and determine the exact pedestrian crossing location in detail design stage.
11	Short merge lengths on Glenmore on-ramps	B	Extend the parallel section of the right-turn lanes where they merge with the left-hand exit.	Agreed. Design has been modified accordingly.
12	Limited through lane storage space	B	• Advance overhead signage could encourage through traffic to use the right most lane. • Review traffic model for likelihood of queue spillback. Consider timing revisions to minimize blockage. • Consider storage extension if feasible.	The queue situation has been reviewed in SimTraffic for all three interchanges during design stage to ensure there is enough storage for NBT traffic at the north terminals in both AM and PM peak and do not block access to the NB to WB traffic. Design of the interchanges has considered this factor. This should be re-evaluated at the beginning of preliminary design.
13	Close proximity of exit ramps	B	Increase separation distance between interchange off-ramps.	Successive exits are measured from physical gore to gore. HGDG DSD for 110km/h require 330-430m. In our design, the design speed is 110km/h and our design provide 378m from physical gore to gore. We don’t disagree that more is better, but it is not required.
14	Through traffic may enter long left-turn lanes	B	Guide signs could be used to inform motorists of the lane designation. However, consideration should be given to where those signs can be placed as the curvilinear alignments could make it difficult for motorists to see the signs on the approach.	It is not an issue for the functional planning stage. It will be addressed in detail design stage.

8.2 Arterial Operations Analysis

Synchro 9 was used to evaluate the signalized interchange junctions of the recommended plan for 100 St SE, 116 St SE and Rainbow Road. A diverging diamond interchange will be implemented on Glenmore Trail at 100 St SE, 116 St SE and Rainbow Road. Also, all existing local access on Glenmore Trail between Stoney Trail and Rainbow Road will be closed.

Similar lane configurations used in Section 7 - Option Evaluation were used at 100 St SE, 116 St SE and Rainbow Road interchanges. The lane configurations for all three interchanges are as follows:

- North junction:
    - one northbound through lane, one northbound shared through / left turn lane,
    - one northbound left turn lane;
    - two southbound through lanes;
- South junctions:
    - three northbound through lanes,
    - one southbound through lane, one southbound shared through / left turn lane.

The Synchro results for the recommended diverging diamond interchange for 100 St SE, 116 St SE and Rainbow Road for the ultimate horizon traffic volumes are shown in ***Appendix L*** and summarized in ***Table 8.2***.

TABLE 8.2: SYNCHRO RESULTS – DIVERGING DIAMOND INTERCHANGE AT 100 ST SE, 116 ST SE AND RAINBOW ROAD

INTERSECTION	MOVEMENTS		AM PEAK			PM PEAK		
			V/C RATIO	LOS	QUEUE LENGTH 95TH (M)	V/C RATIO	LOS	QUEUE LENGTH 95TH (M)
Glenmore Trail / 100 St SE (north junction)	WB	L*	YIELD					
		R	FREE FLOW					
	NB	LL	FREE FLOW					
		TT	0.65	B	57.4	0.81	B	89.9
	SB	TT	0.16	B	13.6	0.43	B	31.2
		R	FREE FLOW					
Glenmore Trail / 100 St SE (south junction)	EB	LL	0.8	B	63.4	0.86	C	115.9
		R	FREE FLOW					
	NB	TT	0.23	A	18.3	0.88	B	83.5
		R	FREE FLOW					
	SB	L	FREE FLOW					
		TT	0.35	B	31.6	0.58	B	52.4
Glenmore Trail / 116 St SE (north junction)	WB	R	FREE FLOW					
		L	YIELD					
	NB	LL	FREE FLOW					
		TT	0.74	B	44.3	0.77	B	36.9
	SB	TT	0.18	C	17.2	0.28	C	29.4
		R	FREE FLOW					
Glenmore Trail / 116 St SE (south junction)	EB	LL	0.66	A	64.3	0.70	C	74.2
		R	FREE FLOW					
	NB	TTT	0.40	C	30.9	0.72	C	74.9
		R	FREE FLOW					
	SB	TT	0.12	B	23.3	0.10	B	17.5
		L	FREE FLOW					
Glenore Trail / Rainbow Road (north junction)	WB	R	FREE FLOW					
		L	YIELD					
	NB	LL	FREE FLOW					
		TT	0.64	B	105.2	0.90	C	216.9
	SB	TT	0.03	C	4.7	0.45	D	39.2
		L	FREE FLOW					
Glenore Trail / Rainbow Road (south junction)	EB	LL	0.49	A	0.0	0.71	A	5.4
		R	YIELD					
	NB	TTT	0.03	C	4.3	0.05	D	5.8
		R	0.01	A	0.0	0.01	A	0.0
	SB	TT	0.01	A	4.7	0.01	A	3.4
		R	FREE FLOW					

* Legend: L = left, T = through, R = right. For example: LL represents dual left turn lanes and TTT represent three through lanes, etc.

The Synchro analyses demonstrated that all three interchanges operate well except for the northbound through movement at the Rainbow Road north junction, which operates with a 105 m queue in the AM peak and 220 m queue in the PM. Synchro indicates that the northbound queue will spill back and block the northbound left turn movement. Further review was conducted in Sim Traffic to confirm the northbound through queue in both the AM and PM peak periods.

Sim Traffic results show that the 95-percentile queue length for northbound through traffic at Rainbow Road interchange north junction will be 45 m in the AM peak and 65 m in the PM peak. Since the northbound left turn movement has a very low volume of traffic (10 vehicles per hour), and the majority of the traffic travels from the eastbound exit ramps to northbound Rainbow Road, there is minimum impact to other movements. Thus, the northbound through movement is considered to operate acceptably and no further upgrades are recommended. The Sim Traffic results are illustrated in ***Figure 8.1*** and ***Figure 8.2***. At all other movements, the Synchro analysis demonstrated that all interchange junctions provide sufficient operational capacity.

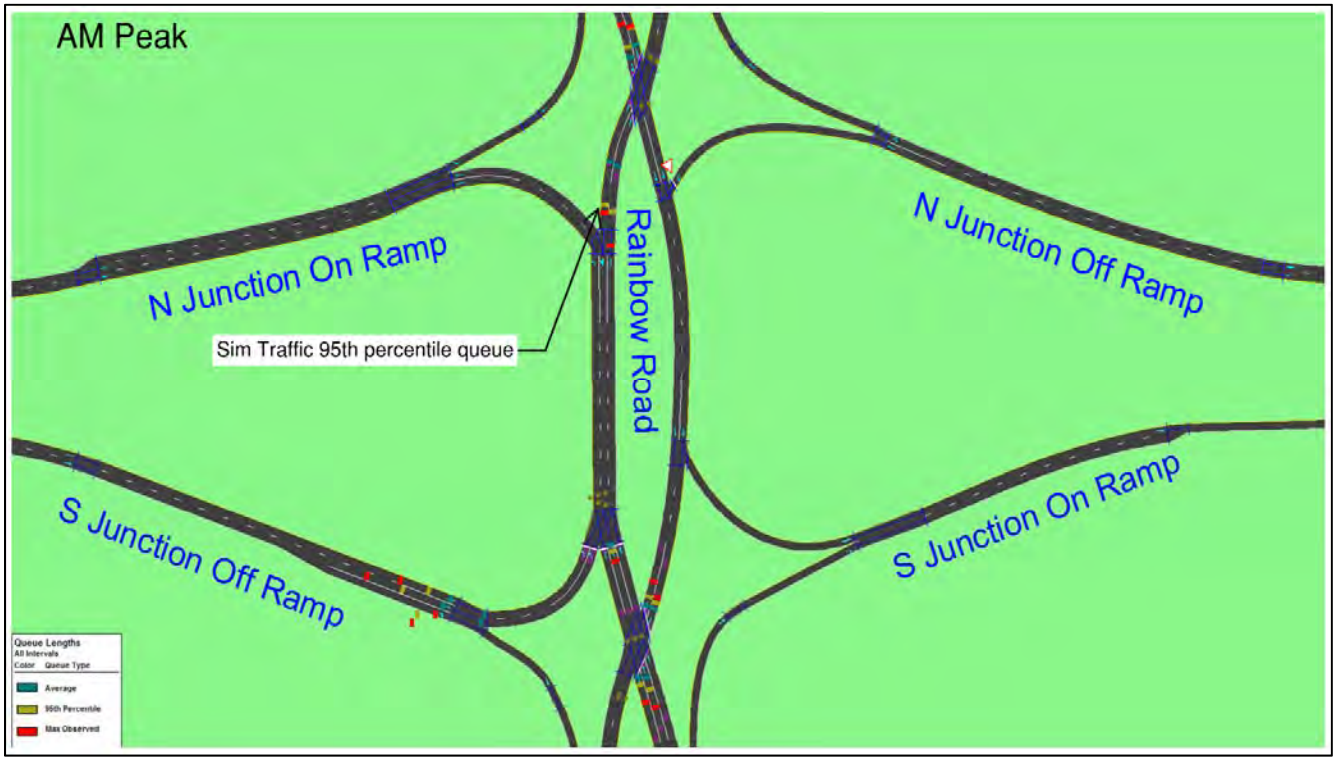


FIGURE 8.1: SIM TRAFFIC QUEUE RESULTS AT RAINBOW ROAD AM PEAK

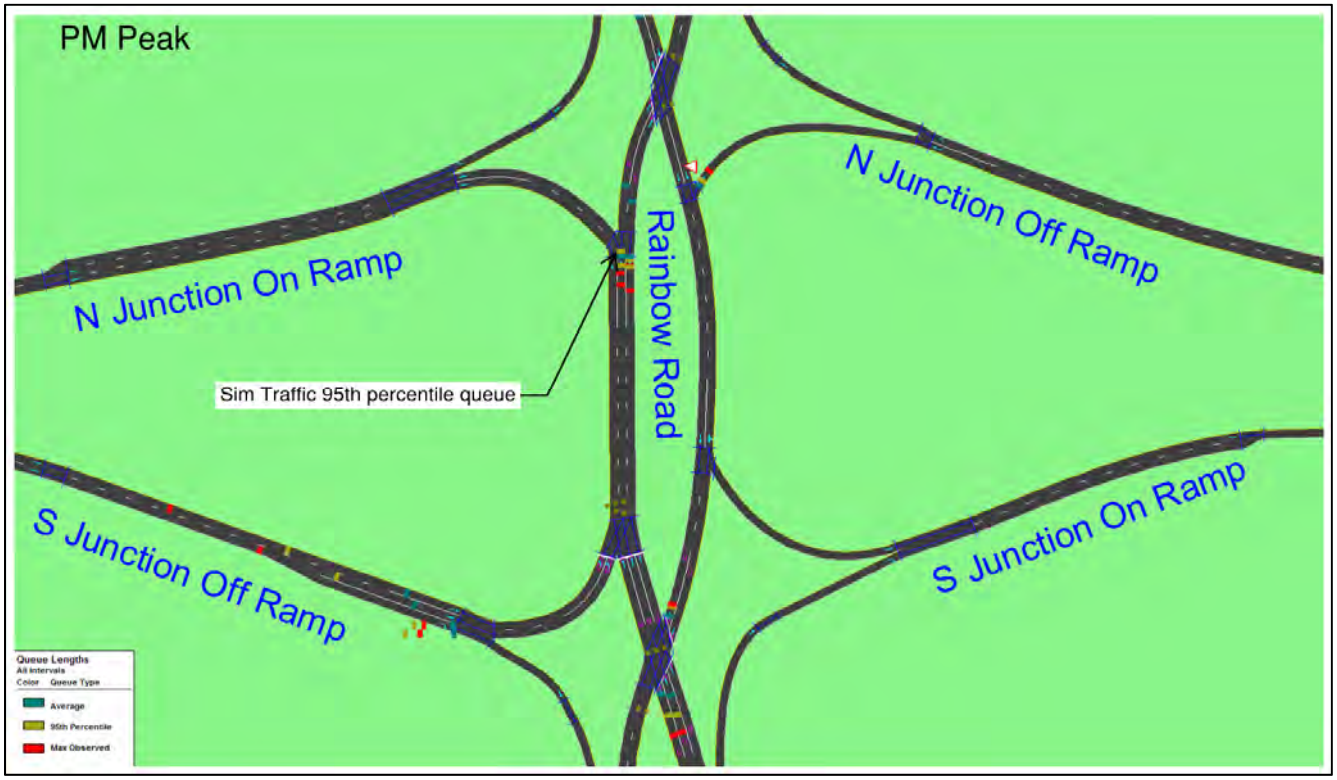


FIGURE 8.2: SIM TRAFFIC QUEUE RESULTS AT RAINBOW ROAD PM PEAK

8.3 Freeway Operations Analysis

WEAVING ANALYSIS

Analysis of the freeway weaving performance was completed using HCS 2010. Analyses have been completed for the recommended plan between the Stoney Trail interchange, 100 St SE, 116 St SE and Rainbow Road interchanges along Glenmore Trail. See ***Appendix L***.

The LOS in a freeway weaving segment is related to the density in the segment. Similar to intersection delay, the freeway weaving segment LOS, rated on a scale, A through F. LOS A represents the highest LOS, generally “free- flow conditions” while LOS F typically represents a “breakdown” or “gridlock” condition in vehicular flow. There are varying degrees of delay and congestion introduced at the intermediate LOS B, C, D, and E levels.

Typically, LOS D or better is the accepted standard for freeway operation. LOS criteria for basic freeway segments are summarized in ***Table 8.3*** below.

TABLE 8.3: LEVEL OF SERVICE CRITERIA FOR BASIC FREEWAY

LOS	DENSITY RANGE (PC/MI/LN)
A	< 10
B	10 – 20
C	20 – 28
D	28 – 35
E	35 – 43
F	> 43

The weaving sections along Glenmore Trail, between Stoney Trail and Rainbow Road, were analyzed for both the eastbound and westbound directions for the ultimate horizon. ***Table 8.4*** and ***Table 8.5*** show the weaving distance for each segment measured using the TAC method and HCS method. The weaving length using the TAC method is measured from the point where lane edges at the merge is 0.5 m apart to where lane edges at the diverge is 3.7 m apart. The weaving length using the HCS method is measured from the painted gore line at the entrance ramp to the painted gore line at the exit ramp. Exhibits showing the weaving distances between interchanges measured using the TAC method and the HCS method are included in ***Appendix A***.

The trip distribution between ramp and freeway is based on the trip distribution from select zone analyses from each transportation zone within the study area. The pass-by and non pass-by trip have been integrated in the trip distribution. Detailed trip distributions are documented in ***Appendix E*** under Future Traffic Forecast – Design Traffic Derivation Section. HCS analysis results are summarized in ***Table 8.4*** and ***Table 8.5***.

TABLE 8.4: WB HCS WEAVING ANALYSIS RESULTS

PEAK	WEAVING SEGMENT	% SPLIT	WB	# OF VEH	TAC'S METHOD FOR MEASURING WEAVING DISTANCE (M)	HCM'S METHOD FOR MEASURING WEAVING DISTANCE (M)	HCS RESULTS
AM	100 St SE to Stoney Trail	13%	Ramp to ramp	100	796 m	668 m	B
		88%	Ramp to freeway	700			
		8%	Freeway to ramp	300			
		92%	Freeway to freeway	3,300			
	116 St SE to 100 St SE	29%	Ramp to ramp	200	659 m	539 m	B
		71%	Ramp to freeway	500			
		9%	Freeway to ramp	200			
		91%	Freeway to freeway	3,100			
	Rainbow Road to 116 St SE	12%	Ramp to ramp	105	631 m	514 m	B
		88%	Ramp to freeway	805			
		4%	Freeway to ramp	105			
		96%	Freeway to freeway	2,495			
PM	100 St SE to Stoney Trail	57%	Ramp to ramp	1,300	796 m	668 m	F
		43%	Ramp to freeway	1,000			
		53%	Freeway to ramp	2,400			
		47%	Freeway to freeway	2,100			
	116 St SE to 100 St SE	5%	Ramp to ramp	100	659 m	539 m	B
		95%	Ramp to freeway	1,900			
		4%	Freeway to ramp	100			
		96%	Freeway to freeway	2,600			
	Rainbow Road to 116 St SE	4%	Ramp to ramp	55	631 m	514 m	B
		96%	Ramp to freeway	1,455			
		4%	Freeway to ramp	55			
		96%	Freeway to freeway	1,245			

TABLE 8.5: EB HCS WEAVING ANALYSIS RESULTS

PEAK	WEAVING SEGMENT	% SPLIT	WB	# OF VEH	TAC'S METHOD FOR MEASURING WEAVING DISTANCE (M)	HCM'S METHOD FOR MEASURING WEAVING DISTANCE (M)	HCS RESULTS
AM	Stoney Trail to 100 St SE	33%	Ramp to ramp	500	1,009 m	886 m	D
		67%	Ramp to freeway	1,000			
		33%	Freeway to ramp	1,400			
		67%	Freeway to freeway	2,900			
	100 St SE to 116 St SE	50%	Ramp to ramp	50	626 m	511 m	B
		50%	Ramp to freeway	50			
		54%	Freeway to ramp	2,050			
		46%	Freeway to freeway	1,750			
	116 St SE to Rainbow Road	50%	Ramp to ramp	20	602 m	487 m	A
		50%	Ramp to freeway	20			
		39%	Freeway to ramp	1,090			
		61%	Freeway to freeway	710			
PM	Stoney Trail to 100 St SE	30%	Ramp to ramp	200	1,009 m	886 m	D
		70%	Ramp to freeway	500			
		26%	Freeway to ramp	1,600			
		74%	Freeway to freeway	4,500			
	100 St SE to 116 St SE	50%	Ramp to ramp	150	626 m	511 m	D
		50%	Ramp to freeway	150			
		26%	Freeway to ramp	1,350			
		74%	Freeway to freeway	3,750			
	116 St SE to Rainbow Road	50%	Ramp to ramp	155	602 m	487 m	C
		50%	Ramp to freeway	155			
		37%	Freeway to ramp	1,455			
		63%	Freeway to freeway	2,445			

From the HCS weaving analysis, it was found that five of the six weaving segments along Glenmore Trail are operating at LOS D or better, with the exception of the westbound weave segment between Stoney Trail and 100 St SE in the PM peak. For this segment, the weaving segment operates at LOS F in the PM Peak based on the HCS weaving analysis. Although the LOS for this weaving segment fails in the HCS analysis, this weaving segment was tested in a microsimulation model and the weaving operation appears to perform at an acceptable level.

The recommended plan also includes a basketweave option. The basketweave option provides grade separated ramps for the on ramp from 100 St SE on Glenmore Trail and the off ramp to Stoney Trail from Glenmore Trail. The basketweave option removes the weaving operation completely in the westbound direction between Stoney Trail and 100 St SE.

Based on the confirmation of the arterial and freeway operations analysis, the DDI was approved to progress to final functional design for the recommended plan

8.4 Horizontal and Vertical Geometry

The following section provides a brief description of the horizontal and vertical geometry of each individual interchange forming the recommended plan. The functional design was prepared in accordance to the design criteria outlined in Section 5.

100 ST SE INTERCHANGE

The recommended interchange option at 100 St SE is a symmetrical diverging diamond interchange, where 100 St SE is elevated to cross over Glenmore Trail. The DDI involves two separate structures for the northbound and southbound lanes of 100 St SE and supporting ramp terminals. The horizontal geometry including alignment information and laning is shown on Sheet IP1 in ***Appendix F***.

100 St SE north and south of Glenmore Trail is designed as a four-lane divided Arterial Street. The northbound and southbound lanes of 100 St SE split as they approach Glenmore Trail. The northbound lanes run on the west side and southbound runs on east side, between the two crossover intersections of the diverging diamond interchange. The two southbound lanes continue through the interchange. The northbound lanes have an added auxiliary lane from the south crossover intersection to serve the northbound to westbound ramp, making a total of three lanes though the bridge section.

The angle of crossover between northbound and southbound alignments is 35° at both intersections. The alignments for the northbound and southbound lanes are designed with 190 m radius curves and tangents with no spirals. Wider width of lane (4.3m) is provided for all lanes within the interchange to accommodate simultaneous movement of two WB-21 trucks on adjacent lanes. The lane widths are transitioned back to 3.7 m outer and 3.5 m inner lanes as the northbound and southbound alignments turn into the straight section of 100 St SE at each end of the interchange.

The connection of 100 St SE with Glenmore Trail is provided by ramps. As seen on the Sheet IP1, the westbound off-ramp, westbound on-ramp and eastbound off-ramp at Glenmore Trail are dual lane ramps. The eastbound on-ramp is a single lane ramp. The ramp alignments are designed as per AT's Design Guide. All right turning ramps connecting 100 St SE are single lane while the ramp for northbound to westbound is a dual lane ramp. All merge taper and acceleration lanes confirm to the design standard as per TAC and the AT Design Guide requirements.

The vertical geometry for 100 St SE and ramps are shown on Sheets PR1, PR2 and PR3 in ***Appendix F***. The maximum grade of 4.0% is used for all ramps and 100 St SE at this interchange. The profiles of both the northbound and southbound lanes of 100 St SE are designed to achieve a 1% grade sloping down towards the north side. The profile for 100 St SE is also designed to achieve the minimum vertical clearance of 5.5 m over the finished grade of Glenmore Trail. The grades through the intersections at the ramp terminals and at the crossovers between the northbound and southbound lanes of 100 St SE are well below the maximum 3.0%.

116 ST SE INTERCHANGE

The primary change at 116 St SE involves the construction of two diverging diamond interchange structures and supporting ramp terminals. The horizontal geometry for the 116 St SE interchange is shown on drawing Sheet IP2 in ***Appendix F***.

The recommended interchange configuration for 116 St SE is a diverging diamond where it is elevated to fly over Glenmore Trail. Unlike 100 St SE, which is directly centred on its existing alignment, the proposed 116 St SE interchange alignment is shifted west. The proposed alignment is approximately 18 m to the west of the existing 116 St SE intersection centre line. This alignment is optimal for several reasons:

- Reduces the impact on the wetland located on the NW corner of the intersection;
- Allows the west bridge to be constructed west of the existing intersection, with minimal detours; and
- Allows for effective construction staging with minimum impact on existing at grade traffic operation.

Despite the benefit of the "shift west" alignment, there are a few trade-offs, including:

- Requires longer distance to tie-in to the north and south collector;
- Requires more land from property owners west of 116 St SE; and
- Modestly reduces the weaving distance between 100 St SE and 116 St SE (though the minimum of 600 m is still met).

116 St SE, north and south of Glenmore Trail, includes an ultimate four-lane cross-section. Southbound 116 St SE starts with two basic lanes before the north junction of the interchange. The two lanes cross over the north intersection to the east side of the road and over the main structure. The far-left lane then becomes a shared left-through lane. The two through lanes then cross back over to the west side at the south junction. The two through lanes are then joined by an auxiliary lane from the eastbound to southbound turn ramp. The three lanes are carried through to the next intersection to the south.

Northbound 116 St SE starts with the two basic lanes with a left-turn lane added before the south junction of the interchange. The three lanes cross over at the south intersection to the opposite side of the road and over the main structure. The two left lanes are dropped onto the northbound to westbound ramp, while the second left lane and the third lane cross back to the normal side of the road at the north junction.

The northbound to eastbound movement is configured as a single right-turn lane. The right-turn lane ends as it merges onto the southbound to eastbound single lane ramp. Maximum grade is 4%.

The eastbound to southbound ramp includes two lanes at the exit from Glenmore Trail and an additional right-turn lane is added. The added third lane takes the eastbound to southbound traffic onto southbound 116 St SE as an added auxiliary lane. The eastbound to northbound ramp ends at a tee intersection with the 116 St SE northbound lanes controlled by the main south intersection traffic signal. The maximum grade is 4%.

The southbound to westbound movement is accommodated with a simple right-turn lane with additional length on the approach to provide additional queuing capacity. The right-turn lane ends as it merges onto the northbound to westbound dual lane ramp. Maximum grade is 4.65%.

The westbound to southbound ramp includes two lanes at the exit from Glenmore Trail. The dual lane exit ramp is split into two with the right lane merging onto northbound 116 St SE and the left lane yielding to the southbound 116 St SE movement. The maximum grade is 4%.

The vertical geometry for 116 St SE through the Glenmore Trail interchange is shown in Sheet PR6, PR7 and PR9 in ***Appendix F***. The vertical geometry for the northbound and southbound lanes along 116 St SE meet the design criteria with the grades not exceeding 4%.

A westbound weaving section of approximately 659 m is provided between 116 St SE and 100 St SE while the eastbound weaving distance is approximately 626 m. To Rainbow Road, the westbound weaving section is approximately 631 m while the eastbound weaving segment is approximately 602 m.

RAINBOW ROAD INTERCHANGE

The horizontal design of the Rainbow Road Interchange follows the design for the 116 St SE DDI; however, the vertical design is different.

The vertical geometry for Rainbow Road through the Glenmore Trail interchange is shown in Sheet PR9, PR10 and PR 11 as found in ***Appendix F***. The vertical geometry for the northbound and southbound lanes along Rainbow Road meet the design criteria with the grades not exceeding 4%.

BASKETWEAVE

With the implementation of the Glenmore Trail/100 St SE interchange, a weaving section of approximately 796 m is created between westbound 100 St SE and Stoney Trail. An analysis of this weaving segment using the HCS methodology indicated an unacceptable LOS F (see ***Table 8.4***) for westbound traffic on Glenmore Trail during the PM peak between 100 St SE and Stoney Trail.

In order to have a proper LOS in this segment and meet the AT standards for a weaving section, a basketweave is proposed on the north side of Glenmore Trail between the 100 St SE and Stoney Trail interchanges. ***Figure 8.3*** illustrates the proposed geometry (yellow hatch).

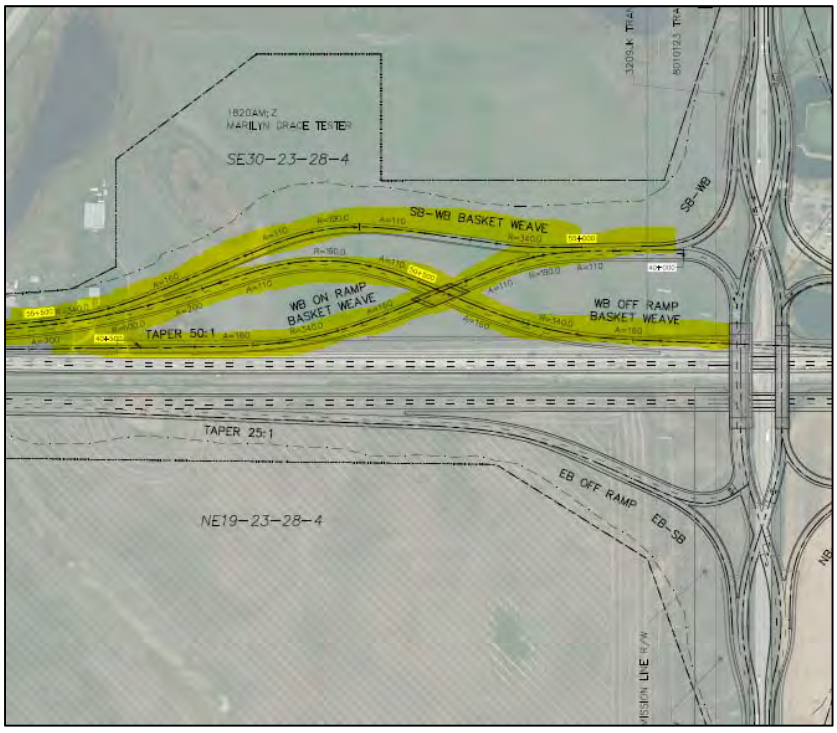


FIGURE 8.3: SIM TRAFFIC QUEUE RESULTS AT RAINBOW ROAD PM PEAK

8.5 Structural Components

REPLACEMENT WESTBOUND GLENMORE TRAIL OVER WID CANAL

Glenmore Trail East has an existing bridge over the WID canal. Information on this existing bridge was obtained from the AT Transportation Information Management System (TIMS). The bridge comprises two travel lanes, with one lane in each direction. It has four spans at 11 m each for a total length of 44 m. The bridge has open abutments and uses a 125 mm deck overlay over SLC girders supported on the abutments at both bridge ends and three intermediate piers in the canal. The existing bridge is at a skew angle of 32°.

It is proposed to replace the existing bridge with construction of a new two-span bridge configuration. Construction of the new westbound bridge is proposed in two stages. In the first phase (interim phase), there will be five lanes for westbound traffic on Glenmore Trail with a shoulder on both sides. The overall bridge deck width will be approximately 25 m for the interim stage. The ultimate stage will accommodate an additional middle barrier and ramp taper separating three of the lanes from the two lanes merging on to Glenmore Trail East westbound. Two shoulders will be added at this stage on either side of the middle barrier and taper. The overall bridge width in the ultimate stage will be approximately 32.5 m. The pier columns and cap and the abutment seats will be built to the ultimate stage width so only the deck and diaphragms will need to be widened. The new bridge will use the same 32° skew angle as the existing bridge.

The proposed two span configuration with a centre pier in the canal can be accommodated with 800 mm deep side-by-side prestressed precast single void concrete box girders. The precast girders shall be topped with a 225 mm cast-in-place composite reinforced concrete deck and shall be made continuous over the intermediate pier via a cast-in-place reinforced concrete diaphragm. An integral connection with the central pier can be achieved by extending the pier column reinforcement into the diaphragm.

The new top of pavement will be approximately 0.5 m higher than the existing Glenmore Trail to accommodate the proposed bridge section without changing the envelope for the waterway. To avoid expansion joints and bearings for this bridge, the girders at the abutments can be cast-in integrally with the abutment seats. The abutment seats can likely be supported on driven (to bedrock) steel H-piles. The pier columns can likely be reinforced concrete monopiles executed to a load bearing soil level (to bedrock).

At future design stages, accommodation for inspection under the girders at the abutments will need to be considered.

A single span configuration was considered but the structure depth would increase substantially causing the roadway to be that much higher than the existing road to maintain the existing water envelope. These deeper girders are typically more expensive than using a single centre pier. Drainage water needs to be collected and treated prior to its release from the bridge deck.

A general arrangement plan for this new structure is depicted on Sheet B3 as found in ***Appendix F***.

EASTBOUND GLENMORE TRAIL OVER WID CANAL

The new eastbound Glenmore Trail bridge will be built adjacent to the existing bridge over the WID canal to provide four lanes for eastbound traffic on Glenmore Trail East and shoulders on both sides. The overall bridge width will be approximately 21.3 m. The new bridge will use the same 32° skew as the existing bridge over the WID canal.

A proposed two span configuration with a centre pier in the canal can be accommodated with 800 mm deep side-by-side prestressed precast single void concrete box girders. The precast girders shall be topped with a 225 mm cast-in-place composite reinforced concrete deck and shall be made continuous over the intermediate pier via a cast-in-place reinforced concrete diaphragm. An integral connection with the central pier can be achieved by extending the pier column reinforcement into the diaphragm.

The new top of pavement will be approximately 0.5 m higher than the existing Glenmore Trail to accommodate the proposed bridge section without changing the envelope for the waterway. To avoid expansion joints and bearings for this bridge, the girder at the abutments can be cast-in integrally with the abutment seats. The abutment seats can likely be supported on driven (to bedrock) steel H-piles. The pier columns can likely be reinforced concrete monopiles executed to a load bearing soil level (to bedrock).

At future design stages, accommodation for inspection under the girders at the abutments will need to be considered.

A single span configuration was considered but the structure depth would increase substantially causing the roadway to be that much higher than the existing road to maintain the existing water envelope. These deeper girders are typically more expensive than using a single centre pier. Drainage water needs to be collected and treated prior to its release from the bridge deck.

A general arrangement plan for this new structure is depicted on Sheet B2 as found in ***Appendix F***.

BASKETWEAVE BRIDGE

A new bridge will be built to carry two lanes for westbound traffic merging on to Glenmore Trail from 100 St SE southbound over the Glenmore Trail westbound exit ramp to Stoney Trail. There will be shoulders on both sides. The overall bridge width will be approximately 13.4 m. Per the AT Bridge Structures Design Criteria Version 8.0, clause 6.4.3, the bridge MSE walls and abutments will be at a skew angle of approximately 38° to match the road underneath.

A proposed 36 m single span configuration can be accommodated with 1,600 mm deep prestressed precast concrete NU girders. A 225 mm cast-in-place composite reinforced concrete deck slab is then poured on top of the girders. The required minimum clearance is 5.5 m which is provided with the chosen design. To avoid expansion joints and bearings for this bridge, the girders at the abutments can be cast-in integrally with the abutment seats. The abutment seats can likely be supported on driven (to bedrock) steel H-piles. MSE walls will be needed at both abutments.

A general arrangement plan for this new structure is depicted on Sheet B1 as found in ***Appendix F***.

100 ST SE INTERCHANGE

Two new grade separated bridge are proposed to provide the north and south connection for 100 St SE. The west bridge will accommodate three lanes for the northbound traffic and a multi-use pathway while the east bridge will accommodate two lanes for the southbound traffic. Both the west bridge and east bridges are aligned perpendicular across Glenmore Trail. The cross-section dimensions for the two bridges are: 90 mm ACP, 225 mm deck, 100 mm haunch and 2.4 m NU girder for a total depth of 2.8 m plus cross fall. The proposed design includes the required minimum 5.5 m clearance. The bridge abutments would need to be slightly flared to match the current roadway geometry. A description of the design of the two bridges is provided below.

West Bridge:

- The transverse dimensions for the west bridge starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, three lanes at 4.3 m each, 1.4 m Shoulder, 0.66 m concrete barrier, 3.0 m pathway and 0.66 m concrete barrier for a total width of 20.68 m.
- The west bridge is built on a tangent with a span of 91.7 m based on 2:1 head slopes.

East Bridge:

- The transverse dimensions starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, two lanes at 4.3 m each, 1.4 m. Shoulder and 0.66 m concrete barrier for a total width of 12.72 m.
- The east bridge is built on a tangent with a span of 90.1 m based on 2:1 head slopes.

The bridge arrangement drawings are shown in Sheet B4 and B5 in ***Appendix F***.

116 ST SE INTERCHANGE

Two new grade separated bridges are proposed to provide north and south connections for 116 St SE. The west bridge will accommodate three lanes for northbound traffic and a multi-use pathway. The east bridge will accommodate two lanes for the southbound traffic. Both the west bridge and east bridge are perpendicular across Glenmore Trail. The cross-section dimensions for the two bridges are: 90 mm ACP, 225 mm deck, 100 mm haunch and 2.0 m NU girder for a total depth of 2.4 m plus cross fall. The proposed design includes the required minimum 5.5 m clearance. The bridge abutments would need to be slightly flared to match the current roadway geometry.

A description of the design of the two bridges is provided below:

West Bridge:

- The transverse dimensions for the west bridge starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, three lanes at 4.3 m each, 1.4 m Shoulder, 0.66 m concrete barrier, 3.0 m pathway and 0.66 m concrete barrier for a total width of 20.68 m.
- The west bridge is built on a tangent with a span of 83.5 m based on 2:1 head slopes.

East Bridge:

- The transverse dimensions starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, two lanes at 4.3 m each, 1.4 m. Shoulder and 0.66 m concrete barrier for a total width of 12.72 m.
- The east bridge is built on a tangent with a span of 84.1 m based on 2:1 head slopes.

The bridge arrangement drawings are shown in Sheet B6 and B7 in ***Appendix F***.

RAINBOW ROAD STRUCTURES

The Rainbow Road structure is similar to the 116 St SE DDI. Two new grade separated bridges provide north and south connections across Glenmore Trail. The west bridge will accommodate three lanes for the northbound traffic plus a pathway while the east bridge will accommodate two lanes for the southbound traffic. Both the west bridge and the east bridge are perpendicular to Glenmore Trail. The cross-section dimensions for the two bridges are: 90 mm ACP, 225 mm deck, 100 mm

haunch and 2.0 m NU girder for a total depth of 2.4 m plus cross fall. The required minimum clearance is 5.5 m which is provided with the chosen design. The bridge abutments would need to be slightly flared to match the current roadway geometry.

A description of the design of the two bridges is provided below:

West Bridge:

- The transverse dimensions for the west bridge starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, three lanes at 4.3 m each, 1.4 m Shoulder, 0.66 m concrete barrier, 3.0 m pathway and 0.66 m concrete barrier for a total width of 20.68 m.
- The west bridge is built on a tangent with a span of 85.3 m based on 2:1 head slopes.

East Bridge:

- The transverse dimensions starting from the west edge are: 0.66 m concrete barrier, 1.4 m shoulder, two lanes at 4.3 m each, 1.4 m. Shoulder and 0.66 m concrete barrier for a total width of 12.72 m.
- The east bridge is built on a tangent with a span of 85.4 m based on 2:1 head slopes.

The bridge arrangement drawings are shown in Sheet B8 and B9 in ***Appendix F***.

8.6 Pedestrian and Cycling Facilities

This section describes the recommendations for active travel facilities within the study area. Active travel refers to pedestrians, runners, wheelchair users, cyclists, and users of other wheeled or mobility aids. The City's Complete Streets guidance does not recommend including pedestrian or cycling facilities along high speed skeletal roadways like Glenmore Trail. It does recommend pedestrian and cycling facilities along arterial roads such as 100 St SE, 116 St SE and Rainbow Road. This recommendation is consistent with both the Shepard Industrial and Janet ASPs. Both ASPs propose Regional Pathways on 100 St SE, north and south of Glenmore Trail, and on 116 St SE south of Glenmore Trail. The Janet ASP also proposed a regional pathway along the WID which connects to 116 St SE and Rainbow Road to the north. ***Figure 8.4*** shows the future pathways proposed by the ASPs, along with the existing regional pathways, and the new facilities proposed by this study.

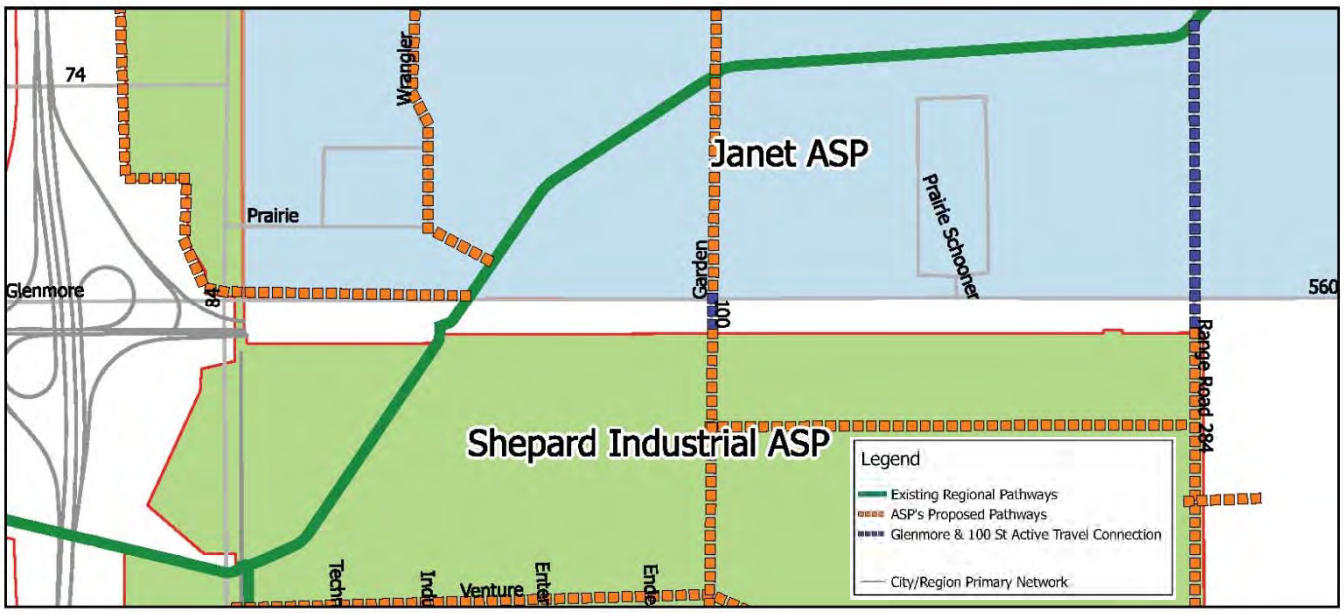


FIGURE 8.4: RECOMMENDED ACTIVE TRANSPORTATION PATHWAYS

The recommended plan includes enhancements to the active travel network in an area that was previously not served or underserved by active transportation facilities. New at-grade and grade separated active travel facilities allow for connections to the regional pathway system, specifically the existing Western Headworks Pathway in addition to safer grade-separation over Glenmore Trail.

New north-south active travel facilities include a 3 m multi-use pathway along the west side and a 2 m sidewalk along the east side of 100 St SE, 116 St SE and Rainbow Road, as shown in ***Figure 8.5***.

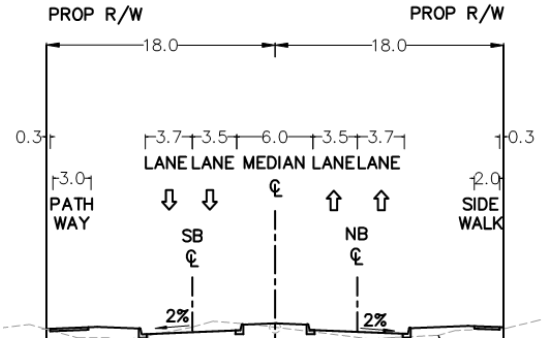


FIGURE 8.5: NORTH OF GLENMORE TRAIL, 100 ST SE CROSS SECTION (LOOKING NORTH)

As the multi-use pathway and sidewalk approach the interchange at Glenmore Trail, they are channelized into the inside of the west structure, into a single multi-use pathway, as shown in ***Figure 8.6*** (with sidewalk shown in yellow and multi-use pathway in red). Barriers provide separation between active travel facilities and vehicle lanes, as shown in the inset cross-section in ***Figure 8.6***.

Active travel facilities along the inside of the structure minimizes conflicts with left-turning traffic to and from Glenmore Trail, and allows crossing the interchange in all directions (travel along the arterials and crossing the arterials). Crossings to the centre of the westbound structure are signal controlled, providing pedestrians with a walk signal from the outside to the inside median pathway. The number of times a pedestrian or cyclist must cross the roadway unprotected is reduced and decreases the exposure to free flowing turning movements.

With only one pathway along the interchange structure results in a smaller bridge area and narrower roadway. Despite being in the inside median of the interchange, the spacing between the structures can make the pathway feel less confined than if only one bridge were used.

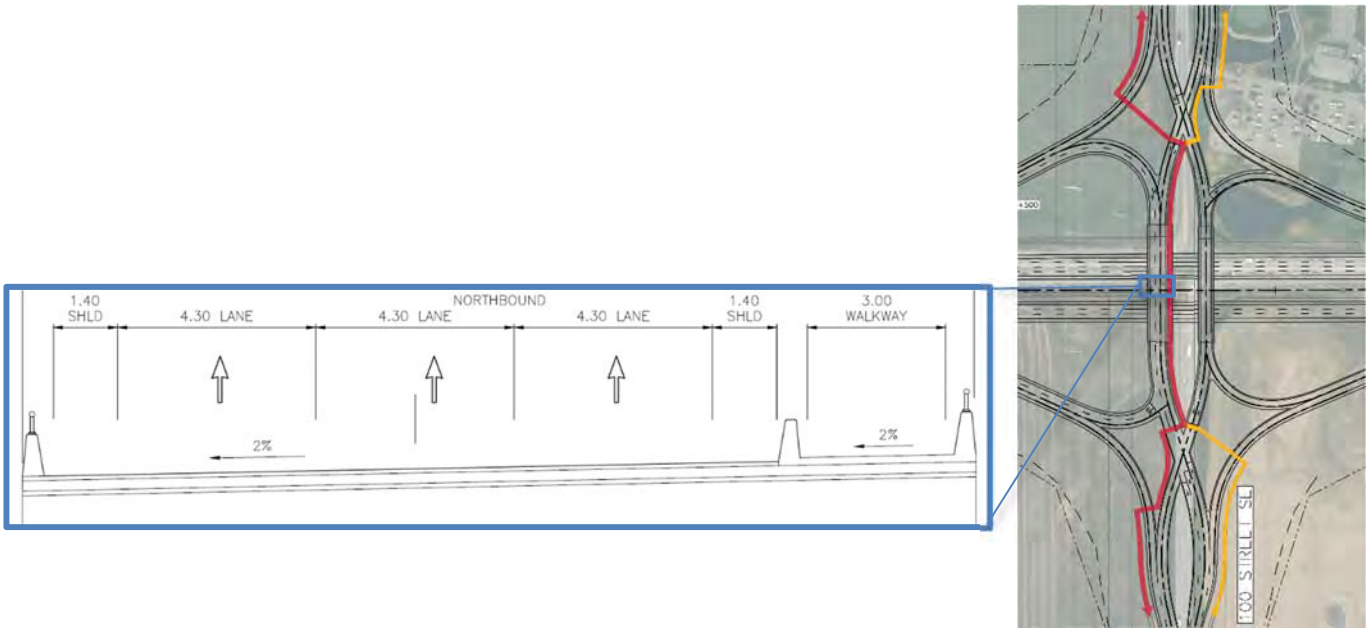


FIGURE 8.6: 100 ST SE INTERCHANGE ACTIVE TRAVEL FACILITIES (RIGHT) AND CROSS SECTION (LEFT INSET CROSS SECTION)

8.7 Transit Facilities

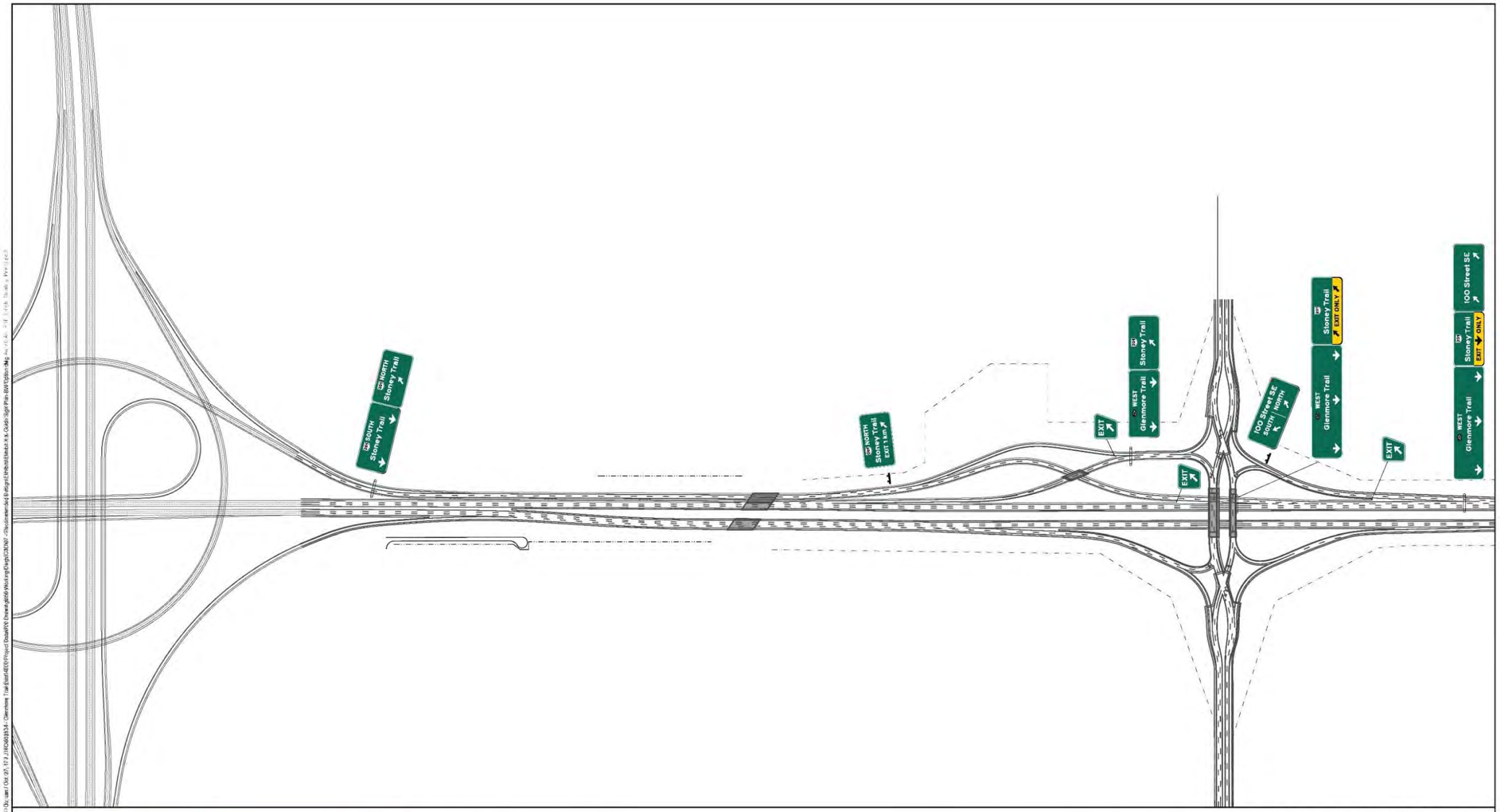
There is no existing transit service in the study area. However, there are conceptual provisions for future transit in the Shepard Industrial ASP. A bus service will be provided along 100 St SE, connecting to the 52 St corridor and the Douglasglen bus rapid transit and light rail transit station.

With the proposed interchanges at 100 St SE, 116 St SE, and Rainbow Road, bus stops for future transit service may be considered at either side of the ramp terminal intersections. No provisions for future transit stations along any of the proposed interchanges is provided since there is no connecting future transit service planned for this section of Glenmore Trail. Further route planning is to be determined with the alignment of the local road network at the outline plan and land use amendment stage.

8.8 Signing and Way Finding

During the development of the options and during the functional design for the recommended plan, guide sign locations represented a fundamental consideration. All signage should conform to the AT Highway Guide and Information Sign Manual (2006). However, there is one recommended modification for the basketweave option from 100 St SE to Glenmore Trail.

According to Highway Guide and Information Sign Manual, an exit direction sign should be placed at the beginning of the deceleration lane or at the location of the gore. Along westbound Glenmore Trail, the Stoney Trail exit ramp gore is located 60 m east of structure. Due to the proximity of the gore point to the structure, it is recommended to mount the exit sign directly onto the bridge structure. The modification is shown in ***Exhibit 8.7-1*** over page.



PARSONS

ISL Engineering and Land Services

Calgary

NOTE: ALL DRAWINGS ARE PRINTED AT HALF SCALE WHEN IN 11" x 17" FORMAT

PRELIMINARY
FOR DISCUSSION ONLY
SUBJECT TO REVISION

FUNCTIONAL PLANNING STUDY
GLENMORE TRAIL EAST - STONEY TR TO RAINBOW RD (RANGE ROAD 283)
100 STREET SE (GARDEN ROAD) INTERCHANGE

BASKET WEAVE SIGNAGE PLAN

EXHIBIT 8.7-1
AUGUST 2017

8.9 Utility Impacts

Several utility impacts have been identified in the study area to accommodate the recommended plan for the new interchanges at 100 St SE, 116 St SE, and Rainbow Road, and the modifications to existing structures along the Western Headworks Canal. The potential utility impacts are depicted in ***Appendix F*** in drawings U1 to U4. It is important to note that this is not a comprehensive utility impact plan, since information collected is based on as-built records provided by others and may not be complete. A summary of the potential utility impacts associated with the recommended plan is also provided below.

GAS LINE

A north-south gas line runs approximately 50 m west of 84 St that may be impacted by Glenmore Trail widening and modification to the Stoney Trail exit ramps.

STORM SEWER

There are two storm sewers along 84 St immediately south of Glenmore Trail that might be impacted by the widening of Glenmore Trail and modifications to the Stoney Trail off ramps. There are also three storm sewers along 100 St SE on the south side of Glenmore Trail that may be impacted by the widening of Glenmore Trail, 100 St SE, and the interchange.

TELECOMMUNICATIONS NO NUMBERS REQUIRED

There are telecommunications lines that run along the existing right-of-way edge, south of Glenmore Trail between Stoney Trail and 100 St SE. As Glenmore Trail is widened, these lines will have to be relocated to the new right-of-way boundary. There are also telecommunications lines north of Glenmore Trail at 100 St SE. These lines would be impacted by the widening of 100 St SE. There is also a telecommunication line on the north side of Glenmore Trail, west of 116 St SE.

OVERHEAD POWER LINES

There are several overhead power lines potentially impacted by the proposed design. There is a continuous Enmax distribution line north of Glenmore Trail, starting just before the Western Headworks Canal crossing to approximately 320 m past Rainbow Road. There are also several north-south overhead power lines that would be impacted by the widening of roads or new interchanges including:

- Line approximately 280 m east of 84 St;
- Two transmission lines 10 m and 40 m west of 100 St SE;
- One AltaLink transmission line immediately east of 100 St SE; and
- One line immediately east of 116 St SE.

UNDERGROUND POWER LINES

As shown on Plan U1, there are several underground power lines just east of 84 St that may be impacted by the widening of Glenmore Trail.

8.10 Stormwater Management

To satisfy the requirements of stormwater management, as a result of widening Glenmore Trail and the development of new interchanges at 100 St SE, 116 St SE and Rainbow Road, a preliminary stormwater drainage plan was developed. An overview of the proposed stormwater functional drainage plan is provided below in terms of the objective, design criteria, and recommendations. The full drainage plan is provided in ***Appendix G***.

STORMWATER MANAGEMENT FUNCTIONAL DESIGN OBJECTIVE

The drainage design builds upon the Master Drainage Plan prepared by AECOM in 2006 and proposes an overall concept for the project, while also assessing the preliminary sizes of culverts and ponds.

The City's Stormwater Management and Design Manual (2011) has been adopted as the primary source for design criteria. Additionally, the drainage design philosophy followed the original Highway 560 study. The development of the drainage network in the future, needs to be developed in coordination with the land build-out and consideration should be given to the Cooperative Stormwater Management Initiative (CSMI) system in consultation with the WID.

EXISTING STORMWATER CONDITIONS

There are two existing sub-catchments east of Stoney Trail. The runoff from these sub-catchments flows east until it is intercepted by a ditch paralleling the WID canal. The runoff pools in the ditch and then overflows into the canal through two 300 mm culverts. East of the WID canal and west of 100 St SE, overland flow from the sub-catchments discharge into two wetlands north of Glenmore Trail.

Between 100 St SE and 116 St SE the topography generally drains southeast. The runoff collects in the ditch along 116 St SE. There are no visible connections between this standing water and the wetland east of 116 St SE.

Between 116 St SE and Rainbow Road, there is a drainage divide that separates the basin into two sub-catchments. One sub-catchment generally drains to the southwest, towards the wetland complex east of 116 St SE. The other sub-catchment drains to the southeast towards the wetlands west of Rainbow Road.

East of Rainbow Road, the drainage basin of Shepard Slough encompasses the drainage basin.

PROPOSED STORMWATER AND DRAINAGE PLAN

The design philosophy for this project followed the storm water design strategy outlined the AECOM Master Drainage Plan. The design of the detention ponds has been updated, but the locations stayed the same as to what were planned in the UMA Master Drainage Plan, north of Glenmore Trail. Surface water from catchments south of Glenmore Trail will therefore be conveyed to proposed detention ponds north of the proposed road. Cross-sections of the proposed finished road prism were generated and a surface model was created in C3D to locate and design culverts to convey water through the road. The finished ground model is only provided at functional study level. As a result, the location and elevations of the culvert inlets and outlets are approximations and must be refined during detailed design.

A maximum spacing of 600 m was assumed for the culverts which convey water from the median ditch. Where the road surface elevations were unknown, a minimum slope of 0.2% was adopted. Proposed sub-catchments were developed for each culvert based on their assumed location. These catchments are presented in ***Figures 8.7*** to ***8.9***. Analysis and

proposed structures are included in ***Appendix G***, Section 3. For functional design stormwater and drainage plans see ***Appendix F***, Sheets ST1 to ST6.

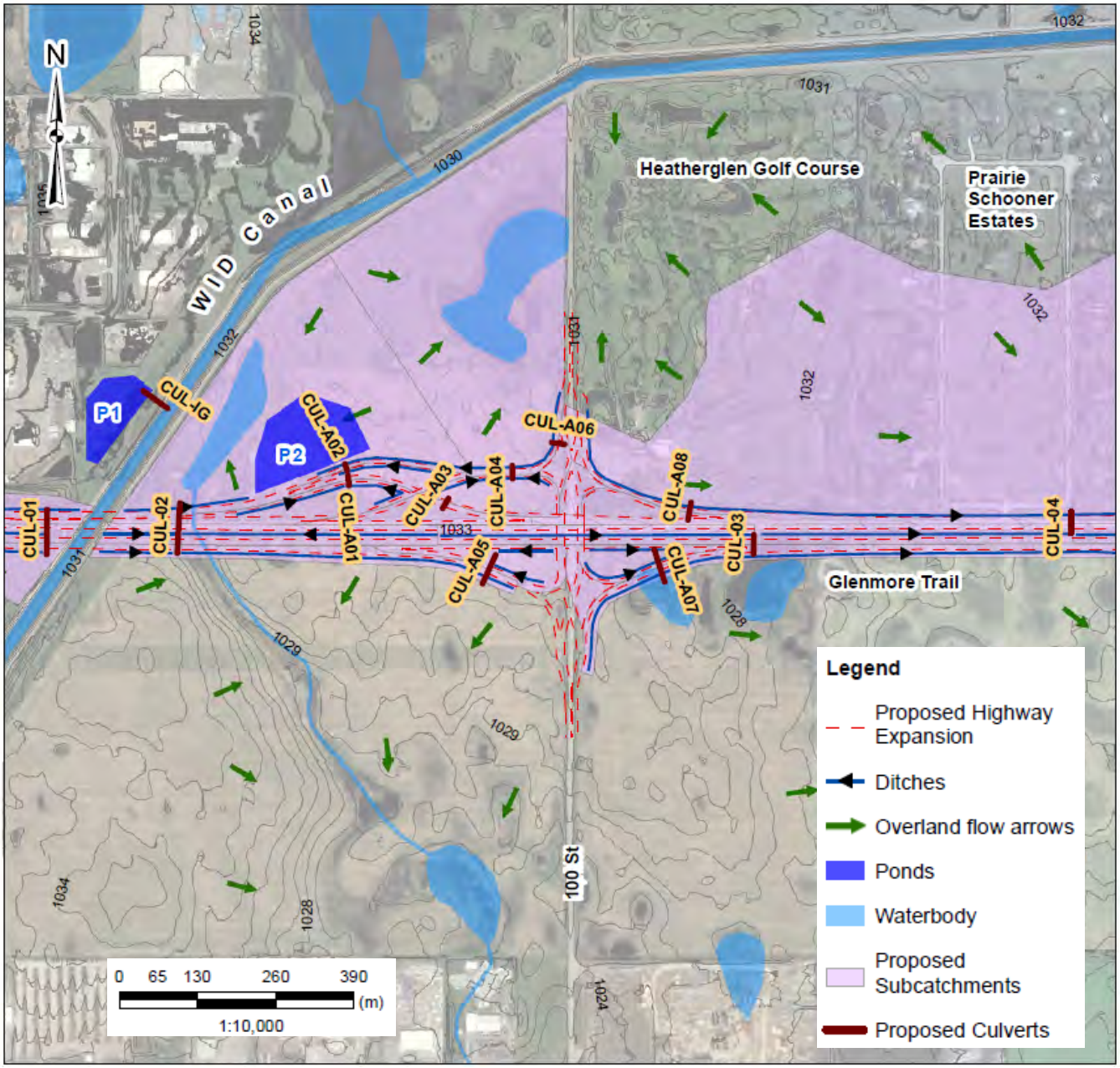


FIGURE 8.7: 100 ST SE INTERCHANGE AND BASKETWEAVE STORMWATER AND DRAINAGE PLAN

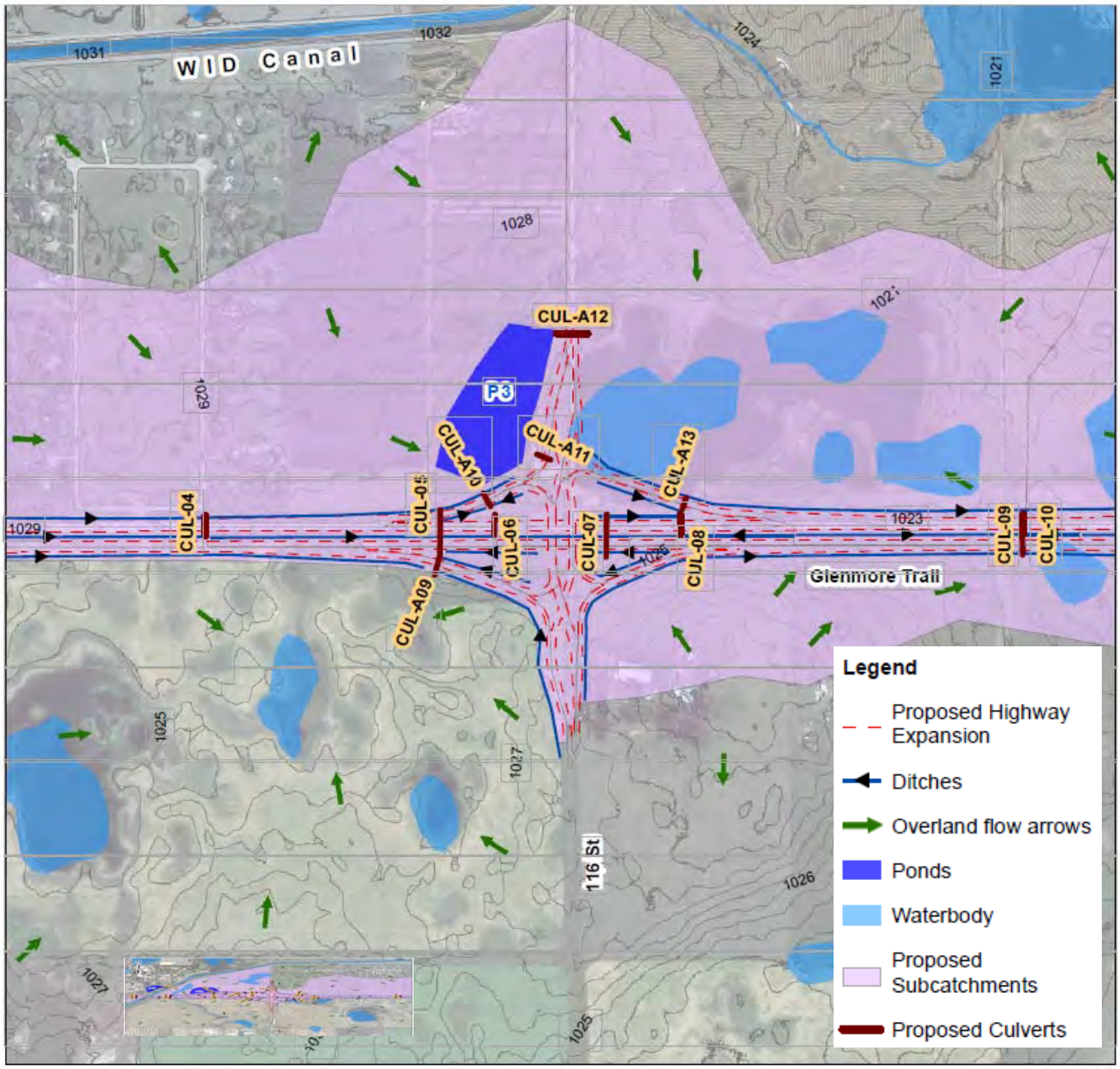


FIGURE 8.8: 116 ST SE INTERCHANGE STROMWATER AND DRAINAGE PLAN

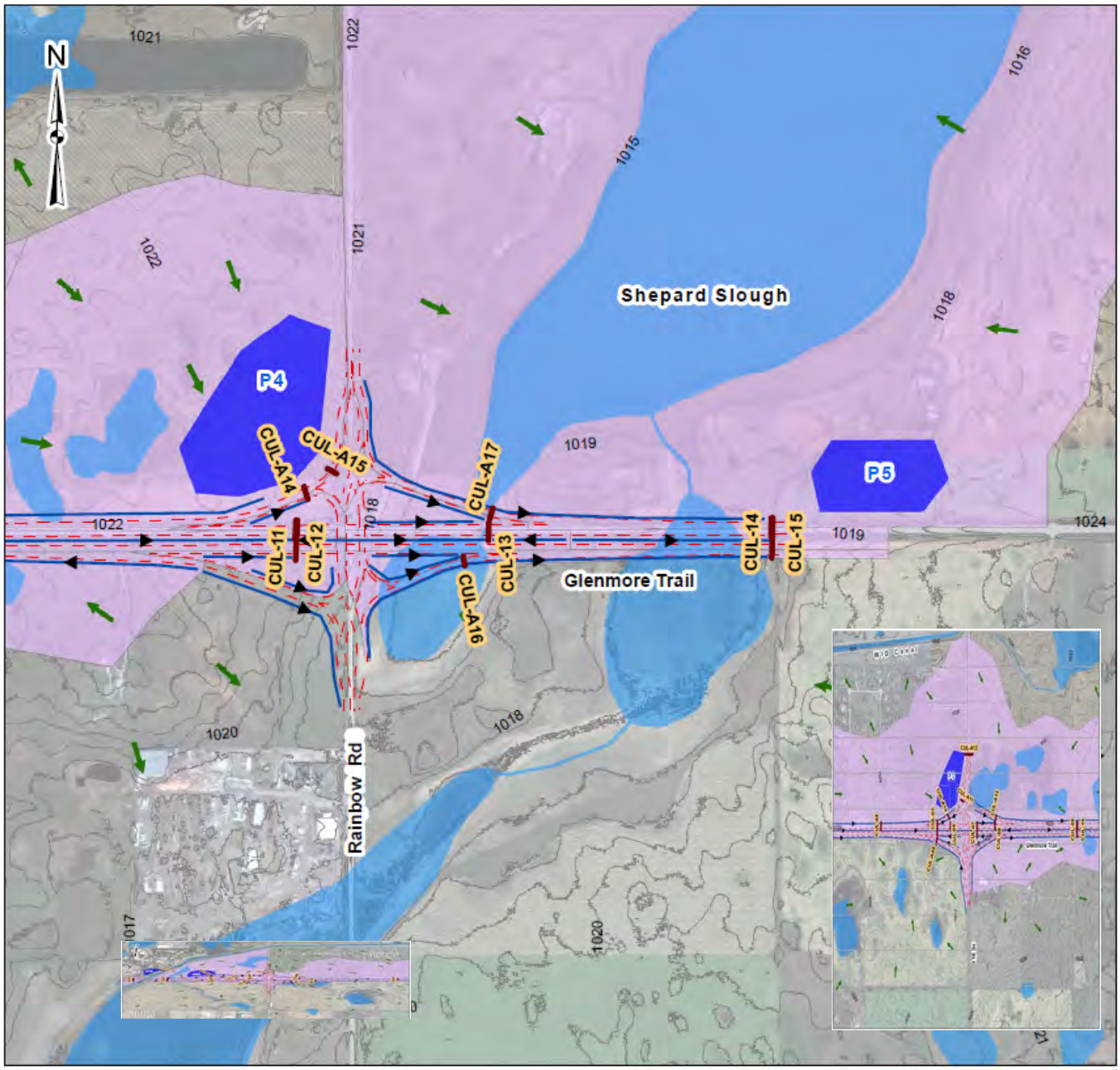


FIGURE 8.9: RAINBOW ROAD INTERCHANGE STORMWATER AND DRAINAGE PLAN

8.11 Property Acquisition

Each of the potential options has direct impacts on adjacent properties requiring partial or full acquisition depending on the degrees of impact and the ultimate negotiation with each specific landowner. Based on the layouts for each option, an assessment of the affected properties was undertaken to determine whether a partial or full acquisition would likely be required. This assessment was based on the criteria described in ***Table 8.6***.

TABLE 8.6: PROPERTY ACQUISITION CRITERIA

ACQUISITION TYPE	CRITERIA
Full acquisition	• Buildings or structures need to be demolished; • Access or parking is significantly impacted; or • Adequate setbacks between the road and building would no longer be achieved.
Partial acquisition	• Land is required but the premises can still adequately operate for its intended use. • Land is intended for future development, with interchange footprints likely acquired at time of future subdivision.
Avoidable	• Based on current drawings, land is required, however, with refinements to the alignment at detailed design, acquisition of land may be avoided.

The property requirements from the Highway 560 Functional Planning Study completed by AT in 2007 have been re-evaluated given that the recommended DDI requires less property than the 2007 plan. The updated land requirements were calculated based on the areas needed to build the road network and interchange and provisions for additional stormwater ponds.

The assessment process identified a number of properties that, based on current drawings, require partial acquisition. However, with refinements to the alignment, acquisition of these properties may be avoided. The assessment also identified one potential property where full acquisition might be required due to impacts to several structures on the property.

A summary of the potential property impacts for each option for each interchange is provided in ***Table 8.7***. Plans for impacted properties are included in ***Appendix F***. Specifically, Stoney Trail to 100 St SE impacts are outlined in PI1, 100 St SE property impacts are outlined in Plan PI2, 116 St SE in PI3 and Rainbow Road in PI4. It is important to note that while PI1 shows a conventional DDI, the protected right of way includes the basketweave option and associated ramps.

A drawing has been included to show the properties impacted by the recommended functional plan, in comparison to the properties previously required for the original Highway 560 Functional Planning Study, (see ***Appendix O***).

TABLE 8.7: SUMMARY OF TOTAL POTENTIAL PROPERTY IMPACTS

OPTION	PLAN REF #	LOT NO. (LINC #)	AREA (HA)	FULL/PARTIAL	NOTES
Stoney Trail to 100 St SE	1	30984653	0.48	Partial	
	2 and 3	18104083	2.94	Partial	
	4	N/A	0.57	Partial	Service road
	5	18104091	10.10	Partial	
100 St SE	6	33448499	8.26	Partial to full	
	7	19956085 and 33448481	4.15	Partial	
	8	33448507	7.82	Partial	
	9	19955260	1.71	Partial	Same parcel as #12
	10	23862089	1.97	Partial	Includes service road to the east
116 St SE	11	30931604	7.53	Full	
	12	19955260	7.72	Partial	Same parcel as #9
	13	21608393	5.90	Partial	
	14	27711720	5.00	Partial	
	15	27424407	2.49	Partial	
Rainbow Rd	16	17196791	12.33	Partial	
	17	36715614 and 36715622	2.96	Partial	
	18	36372886	4.39	Partial	
	19	36715648	1.25	Partial	
	20	21593050	8.13	Partial	
	21	21607528	7.62	Partial	
	22	27355727	0.75	Partial	

8.12 Project Cost Estimate

Order of magnitude cost estimates were prepared for each interchange. The classification of this estimate falls into Type A "Preliminary Cost Estimate" category, as defined in the AT Engineering Consulting Guidelines for Highway, Bridge, and Water Projects Volume 1 - Design and Tender (2011). Unit costs used in the estimates were taken from Parsons database and represent the current industry standards in Calgary. Other considerations include:

- The preliminary cost estimates for each option include major cost areas;
- For other minor or miscellaneous items, the tentative cost is broadly accounted for in contingency;
- Construction costs are largely based on the following categories: removal, grading, pavement structure, concrete, traffic control, utilities and structures;
- Property acquisition costs are excluded; and
- Contingency is set at 30% and Engineering fee/testing fee is set at 15%.

The preliminary comparative cost estimates for each option are provided in ***Table 8.8***. The estimates have been rounded to the nearest $10,000 to reflect the planning phase and preliminary nature of the drawings. A complete summary of the estimates, including -40% and +75% variance and is provided in ***Appendix I***. The resulting preliminary cost estimates are an opinion of probable costs and should be refined further during the detailed design phase.

TABLE 8.8: ORDER OF MAGNITUDE COST ESTIMATES

SEGMENT	UPGRADES	COST ESTIMATES (2017 $)			
		TOTAL	COMBINED	-40% VARIANCE	+75% VARIANCE
Stoney Trail to east of 100 St SE	• Upgrade existing roadway to six lanes divided cross section on Glenmore Trail • Upgrade existing 100 St SE to four lane cross section • New signals at Glenmore Trail / 100 St SE • Intersection upgrade	$68,650,000	**$151,150,000**	*$92,700,000*	*$264,510,000*
	• Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$63,300,000			
	Additional upgrades: • Basket weave between Stoney Trail and 100 St SE	$19,200,000			
East of 100 St SE to east of 116 St SE	• Upgrade existing roadway to six lane divided cross section on Glenmore Trail • Upgrade existing 100 St SE to four lane cross section • Install traffic signals at Glenmore Trail / 116 St SE • Upgrade at-grade Intersection	$31,322,000	**$86,105,000**	*$51,665,000*	*$150,700,000*
	Additional upgrades: • Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$54,800,000			
East of 116 St SE to east of Rainbow Road	• Upgrade existing roadway to six lane divided cross section on Glenmore Trail • Upgrade existing Rainbow Road to four lane cross section • Install traffic signals at Glenmore Trail / Rainbow Road • Upgrade at-grade Intersection	$32,370,000	**$89,800,000**	*$53,855,000*	*$157,080,000*
	Additional upgrades: • Construct diverging diamond interchange and ramps • Construct auxiliary lanes on Glenmore Trail	$57,400,000			

8.13 Benefit Cost Analysis

A benefit cost analysis based on vehicle cost delay was performed for the recommended ultimate interchange plan at 100 Street SE, 116 Street SE and Rainbow Road.

To determine the benefit cost ratios the following steps and assumptions were taken:

1. Intersection vehicle delay was obtained from Synchro analysis at the signalized intersections at 100 Street SE, 116 Street SE, and Rainbow Road along Glenmore Trail during the AM and PM peak:
    a. The at-grade intersection scenario Synchro model was prepared using the full-build out traffic volumes and based on 6 lane cross section on Glenmore Trail and 4 lane cross section on the adjacent arterial road.
    b. The DDI interchange scenario Synchro model was prepared for the recommended plan and are the same Synchro files used in Section 8 of the report.
2. Average cost of time is $35.74/hr which calculated based on the following assumptions as per the AT Benefit Cost Model:
    a. Single Unit Truck: $26/hr work business cost; $13 leisure cost
    b. Passenger Car: $26/hr work business cost; $13 leisure cost
    c. Single Unit Truck: 95% work business trips; 5% leisure trip
    d. Passenger Car: 63% work business trips; 38% leisure trip
    e. Occupancy: 1.7 per vehicle for both single unit truck and passenger car
    f. Truck %: 30%
3. To obtain a cumulative cost for a 30-year period for the vehicle delay costs, the analysis assumed construction will occur in 2037 for the duration of two year. The upgraded intersection or the upgraded interchange were assumed to open in 2039.
4. A delay cost value of 2.5% linear growth was applied to the 2039 delay cost.

The results of the analysis indicated the following:

- 100 St SE DDI with the basketweave — 10.98 B/C Ratio (>3 year payback period)
- 116 St SE DDI — 8.44 B/C Ratio (>4 year payback period)
- Rainbow Road DDI — 7.93 B/C Ratio (> 5 year payback period)

As mentioned, only travel time benefits were included in the analysis. The inclusion of other elements such as vehicle operating cost savings, safety benefits, and salvage value should be included in future traffic analysis. However, future benefit cost analysis should also include deriving more accurate traffic forecasts for the base case where the above assumptions can be refined.

8.14 Glenmore Business Park Access Review

The future Glenmore Business Park located south of Glenmore Trail from the WID Canal to 116 St SE will have challenges finding access solutions due to the physical constraints of these lands, once the ultimate interchanges are constructed. It was agreed amongst the study partners that the access locations would not be approved as part of this study, however technical guidance for the access locations was documented for future development applications. This technical guidance is documented in the Glenmore Trail East FPS Glenmore Business Park Access memo, dated April 13, 2018, and attached in ***Appendix N***. The following provides a summary of the findings of the memo:

- The Glenmore Business Park will have internal public street networks that connect to the broader network via 100 St SE and 116 St SE;
- Network access is not possible via other routes given either their higher road classifications (for Glenmore Trail to the north) or due to pre-existing land-locking of the development (by the canal to the west or by prior development to the south);
- Two accesses are required off 100 St SE based on the size of the development and emergency servicing requirements, traffic operations, and the land-locking constraint;
- Two side- by- side development accesses to the future Glenmore Business park on either 100 St SE or 116 St SE is not feasible while meeting both AT and The City's access management standards;
- A design exception request on 100 St SE will be required at the time of Outline Plan development in order to provide the required number of accesses for the development for safety and accessibility purposes; and
- A design exception request on 116 St SE should be considered at the time of Outline Plan development in order to balance site functionality and intersection operations.

9. Construction Staging

FUNCTIONAL PLANNING PROCESS

1	IDENTIFY
2	DEVELOP
3	EVALUATE
4	REFINE & RECOMMEND

To develop a possible construction staging strategy, the recommended plan was reviewed with respect to a number of key issues and challenges including utility conflicts, property impacts, costs, and overall ease of construction. Through this review, four distinct stages were identified in which the recommended plan could be delivered over a number of years. Sequencing of individual staging, including components within individual stages (e.g. 100 St SE vs 116 St SE interchanges), will be determined by the development of the adjacent land, on an as-needed basis.

Notwithstanding, the ideal sequence for constructability purposes, the following four stages have been identified for delivering the recommended plan. These stages are described in the following sections. Construction staging plans are provided as part of the complete functional design drawing set found in ***Appendix F*** Sheets CS1 to CS15.

- Stage 1 – Short-term Improvements at Glenmore Trail East and 100 St SE
- Stage 2 – Glenmore Trail Twinning
- Stage 3 – Grade Separation
- Stage 4 – Westbound Basketweave

9.1 Stage 1 – Short-term Improvements

As a result of feedback received from the public engagement early during the planning study, a focussed analysis was conducted to fully explore the scope of any short-term improvements that could provide immediate benefits to the intersection of Glenmore Trail East and 100 St SE. The study steering team requested the short-term improvements be progressed to a functional plan level of detail. A description of the short-term improvements (Stage 1) is provided in a technical memorandum (*Short-Term Option Recommendation*), refer to attached ***Appendix J***. The short-term improvements scope of work was only limited to 100 St SE and that 116 St SE and Rainbow Road were not included as part of the scope of work.

In summary, the short-term improvements constructed in Stage 1 will provide increased capacity at the intersection of Glenmore Trail East and 100 St SE. Additional through lanes on Glenmore Trail East will be provided, along with extra turning lanes for critical movements. There are no changes to the horizontal alignment.

The recommended configuration and the extent of the short-term improvements, as shown in ***Figure 9.1***, will utilize existing infrastructure (pavement and medians) while minimizing impacts to utilities, drainage and property. The required land acquisition for short-term improvements is well within the ultimate land requirements. Existing pavement is assumed in good condition and meets the 10-year lifespan where it needs only mill and inlay. Pavement widening on roadway edges and shoulder reconstruction are part of the improvements. The costs were estimated at a functional design level which includes pavement work, base, sub base, earthworks, concrete work, traffic signals, landscaping, erosion / sediment control, pavement marking, signage, traffic control, etc. The unit costs were based on Parsons database and Calgary area projects. With a 30% contingency, 15% Engineering fee/testing fee and 10% mobilization, the total construction cost is estimated at $4.7 M.

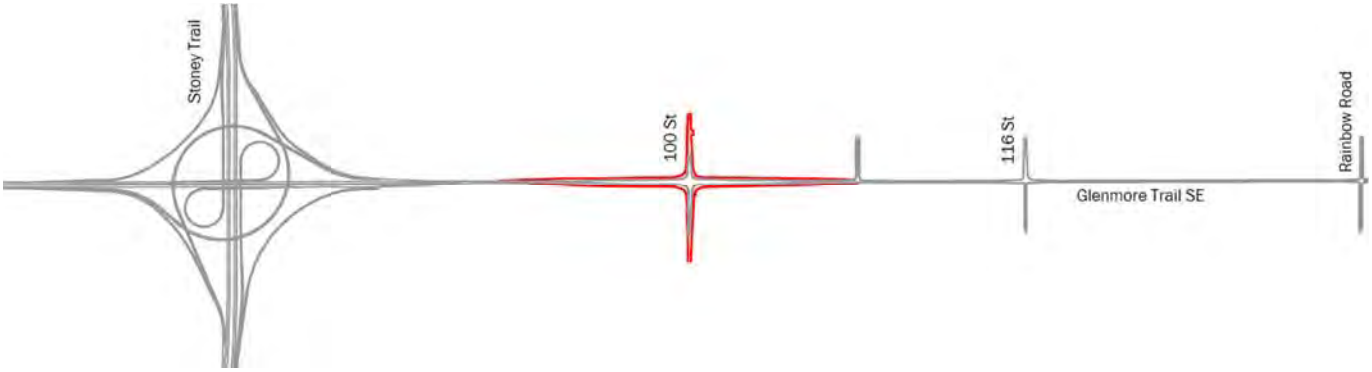


FIGURE 9.1: SHORT-TERM IMPROVEMENTS AROUND 100 ST SE

9.2 Stage 2 – Glenmore Trail Twinning

Glenmore Trail from east of Stoney Trail to east of Rainbow Road is currently a two-lane, undivided rural highway with 3.5 m lane widths and 2 m shoulders. Glenmore Trail is currently classified as Service Classification Level 3. The twinning requirement for Glenmore Trail is to be studied in a future stage of the design.

In the event that twinning is required for Glenmore Trail, as shown in ***Figure 9.2***, it will involve the twinning of Glenmore Trail to the south, to accommodate a minimum of two lanes of traffic in either direction and include a new bridge across the Western Irrigation Canal. Additionally, each junction will be required to be upgraded to signalized intersections with slotted left-turn lanes. This new configuration will provide additional capacity, in particular, additional turn lanes which will more green-time to be allocated to through movements on Glenmore Trail.

The timing of upgrading the Glenmore Trail from four lanes to six lanes will be determined in a future stage of the design based on traffic studies.

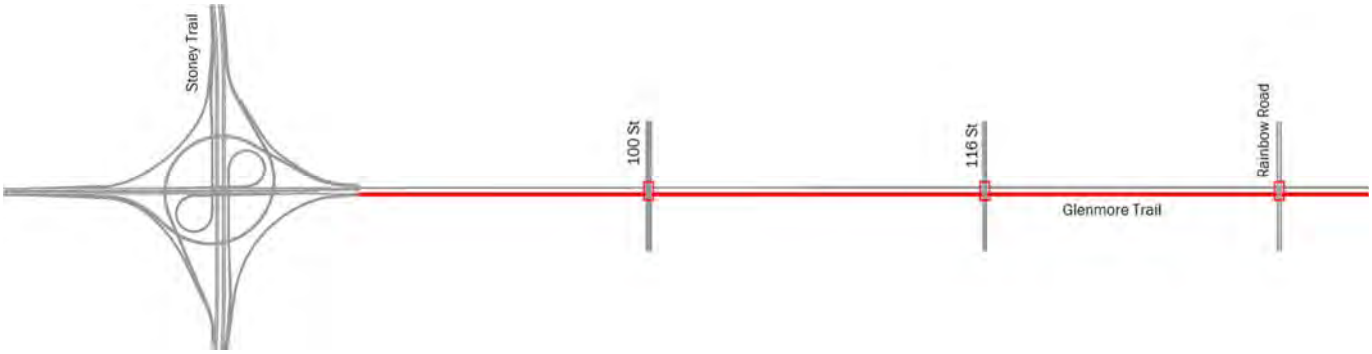


FIGURE 9.2: ADDITIONAL EASTBOUND LANES AND TWINNING OF GLENMORE TRAIL

Unlike the other construction stages, this phase of the implementation was not detailed as part of the functional planning study. This is primarily due to the large number of land development scenarios in the vicinity of Glenmore Trail. The sequence of intersection upgrades and twinning of Glenmore Trail will best be determined as land is developed. It is therefore recommended to carry out a traffic impact assessment in coordination with the development of the land, complementary to the ultimate functional plan in Stages 3 and 4.

Due to the previous stage maximising the existing infrastructure and right-of-way, Stage 2 will require property acquisition and the relocation of major utilities. Again, this should be carried out in consideration of the ultimate functional plan in Stages 3 and 4.

9.3 Stage 3 – Grade Separation

As land is developed, traffic demand will increase resulting in the at-grade intersections reaching capacity. Similar to Stage 2, a future traffic review along Glenmore Trail will be required to determine the timing of which intersection(s) requires grade separation. Stage 3 could extend over a number of years with each intersection grade-separated individually or grouped together as determined by traffic demand.

Along with the grade separation across Glenmore Trail, as shown in ***Figure 9.3***, new ramps to the bridges are required. In order to build the bridges and ramps, a series of temporary roads are required to minimize disruption to traffic during construction. A construction staging study was carried out to determine the construction phases, traffic diversions and extents of temporary works. Refer to ***Appendix F***. Sheets CS1 to CS15 for drawings showing a proposed solution for the completion of each grade separated interchange.

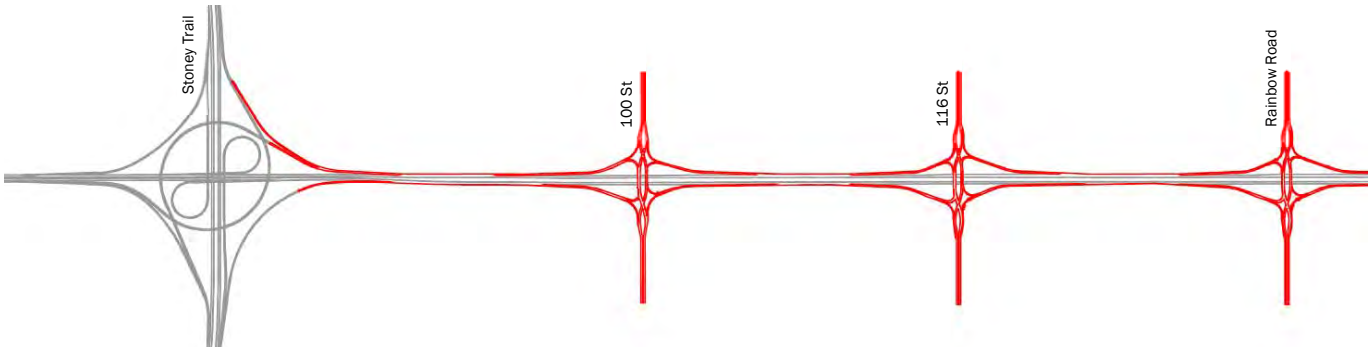


FIGURE 9.3: GRADE SEPARATION OF GLENMORE TRAIL

9.4 Stage 4 – Westbound Basketweave

A basketweave solution, as shown in ***Figure 9.4***, was proposed to address potential weaving problems due to the close proximity of Stoney Trail to 100 St SE. All property acquisitions and utility relocations should have occurred during Stage 3. Additionally, there should be minimal temporary traffic diversion required during construction.

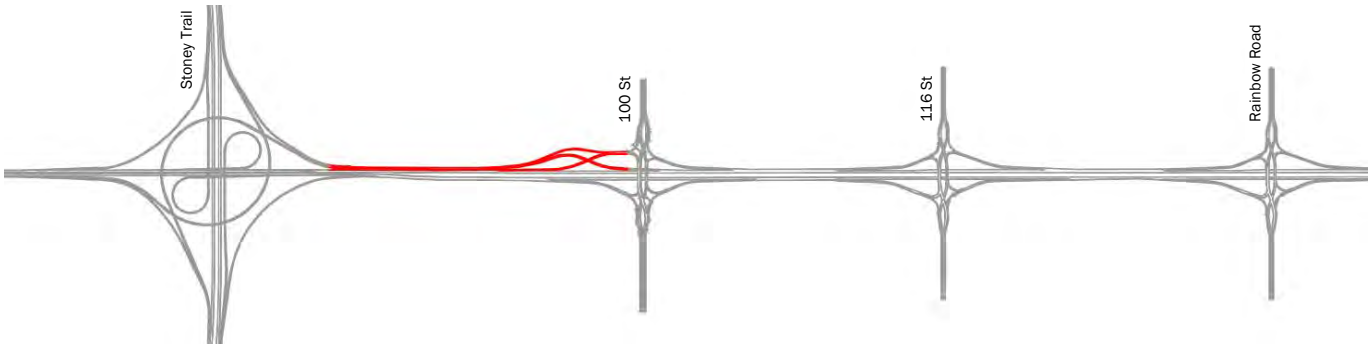


FIGURE 9.4: BASKETWEAVE FROM 100 ST SE TO STONEY TRAIL

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