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Main Roads Supplement to the Austroads Guide to Road Design

Part 4C: Interchanges

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Contents

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Amendments

Revision Number	Revision Date	Description of Key Changes	Section / Page No.
1	December 2011	Guideline developed.	All
2	May 2015	Guideline revised.	All
3	June 2015	Guideline amended.	All
3A	May 2016	Links to ramp guideline drawings updated.	All
3B	January 2017	Contact person changed to Kyle Smith.	Header
3C	October 2017	Horizontal Curve Tables updated to rev 3A	8
4	October 2017	Guideline reviewed.	All
4A	June 2018	Drawing 201131-0023 amended.	6.4.1
4B	August 2018	Horizontal Curve Tables amended to Version 4A.	8.4.3
4C	February 2019	Document hierarchy clarified.	All
4D	March 2019	Drawing 201431-0053 amended and 201431-0017 removed.	6.4.1
4E	August 2019	Drawings 201231-0027, 201231-0028, 201231-0029, 201231-0030, 201231-0031 and 201231-0032 amended.	Appendix C
4F	September 2019	Ramp grades clarified and drawing 20131-0053 amended.	9.3.2 and Appendix C
4G	January 2020	Drawing 201231-0027 amended.	Appendix C
4H	May 2020	Drawings 201131-0020, 201131-0023, 201131-0024, 201431-0053 and 201531-0020 amended.	6.4.1

4I	September 2020	Added section 17.4.2 with drawings 202031-0034 and 202031-0088. Amended broken and missing links.	5.2.1, 11.4, 17.3 and 17.4.2
5	November 2023	Guideline reviewed and updated to reference the 2023 version of the Austroads Guide.	All
5A	May 2025	Drawings 201431-0053, 201431-0055, 201731-0001, 201731-0002, 201531-0020 and 201131-0029 amended. Additional commentary added for treatment of cyclists at interchanges and designing for future ramp traffic signals. Drawing 202431-000305 added.	6.4.1, 14.2, 17.4.1 and Appendix C

PURPOSE

The purpose of this document is to detail the requirements for the design of grade separated interchanges in Western Australia and to provide guidance in the application of those principles.

The design of grade separated interchanges has the following primary design objectives:

- Maximise safety.
- Minimise costs associated with construction, maintenance and use of the route.
- Minimise adverse impacts on the environment.
- Maximise operational efficiency - i.e. the ability to carry the required volume of traffic at a speed acceptable to the road user.
- Be aesthetically pleasing and in harmony with the surrounding environment.
- Consider the planned ultimate layout in the vicinity of the works and ensure that it can be accommodated with a minimum of reconstruction in the future.

Absolute minimum standards are to be avoided except where absolutely critical to achieving the most suitable outcome. Generally, if a minimum is used for any particular design element it becomes necessary to avoid using a minimum for any other element on that particular section of road. This is necessary to allow an appropriate factor of safety to road users.

This Supplement has been developed to be read in conjunction with the Austroads Guide to Road Design (GRD) Part 4C: Interchanges (2023), a copy of which can be obtained via the Austroads website.

This guideline applies to all new works on roads managed by Main Roads. It is noted that many existing interchanges were constructed to the design standards of the time and do not necessarily meet all current design requirements. Whilst it is not economically feasible to upgrade existing interchanges each time revisions are made to design standards, Project Managers should consider making improvements whenever major works are completed in the vicinity of existing interchanges.

In Western Australia, Main Roads' policies, guidelines and standards take precedence over Austroads Guides and Standards Australia Standards. National Guides and Standards take precedence over International Guides and Standards, unless specifically stated otherwise.

This Supplement has the same structure as the equivalent Austroads Guide and only additional requirements, clarifications, or practices different from Austroads appear. Where appropriate, this Supplement may also contain additional sections and figures not covered by Austroads, but the numbering sequence found in the Austroads Guide remains. Figures and tables in this Supplement replace those with the same figure or table number in the equivalent Austroads Guide.

Where a reference has been made to a particular Main Roads WA document or drawing within this supplement, the reference provided can be used in the search facility on the Main Roads WA website to locate the current version.

1 INTRODUCTION

Main Roads has no supplementary comments for this section.

2 DESIGN CONSIDERATIONS PROCESS AND PRINCIPLES

2.4 Principles

A minimum length equivalent to 4 seconds of travel time at the respective design speed is to be used between consecutive decision making points (e.g. Merge from two lanes to one after an intersection, lane changes after an intersection, a merge followed by a diverge). This length should be extended if:

- A traffic analysis and/or operating experience shows the need for greater separation.
- The lane has to go over a crest and suitable sight distance to the next decision making point has to be achieved (at least Approach Sight Distance).

3 FORMS OF INTERCHANGE

3.2 Other Considerations

3.2.1 General

Further guidance on the different types of interchanges can be found in:

- Austroads Guide to Traffic Management (GTM) - Part 6: Intersections, Interchanges and Crossings Management (2020).
- AASHTO - A Policy on Geometric Design of Highways and Streets (2018), Sections 10.1, 10.2, 10.9.1 to 10.9.4, 10.9.5.1 and Figure 10-57.

Parclo Interchanges

Investigations regarding the stability of heavy vehicles suggest that the safe operating speed of these vehicles on loop ramps is considerably lower than cars and may result in the need for significantly longer deceleration and acceleration lengths.

3.2.3 Grade Separated Intersections

Warrants for the left in treatment on the major road to be per Main Roads Supplement to Austroads GTM - Part 6: Intersections, Interchanges and Crossing Management, Section 3.3.6.

Left out treatment and any associated acceleration lanes are to be designed in accordance with Main Roads Intersections at Grade guideline drawings.

4 STRUCTURES

4.1 General

Structural Clearances

Structural clearances shall be designed in accordance with:

- Bridge Branch Design Information Document No. 3912/02
- Guide to Design of Oversize and Over-Mass Vehicle Corridors
- Heavy Vehicle Services requirements for oversized loads

Clearances between roadway profiles at grade separations shall allow for crossfall, gradient, bridge profile, structural depth and settlement. The design clearances shall be confirmed upon completion of the structural design of the bridge structure by the Designer.

For concept design an indicative structural depth of 1/17th of the longest span plus an allowance of 60 mm surfacing on the structure and 50 mm settlement should be used.

Horizontal Clearances

Bridge piers and abutments should be offset from the road by the dimensions shown on Figure 12.1 of the Bridge Branch Design Information Document No. 3912/02-12, Clearances and High Load Routes.

4.3 Cross-sections on Bridges

Shoulder Widths

A reduction to shoulder widths may be made where the structure length is more than 50m.

Approvals

All bridge cross sections should be determined on a case by case basis in accordance with Bridge Branch Design Information Document No. 3912/02-11, Bridge Widths.

4.9 Safety Screens

Refer to Main Roads Structures Engineering Branch Technical Guide Risk Assessment for Projectiles Thrown from Overpass Structures for safety screens on bridges over roads.

For safety screens over railways refer to Public Transport Authority for their policy.

5. CROSS-SECTION

5.2 Ramp Cross-section

5.2.1 Number of Lanes on Ramps

Exit Ramps

Refer to Main Roads drawing 201131-0028 for the transition from one lane at the nose to two for exit ramps.

Entry Ramps

Refer to Main Roads drawing 201131-0029 for the transition from two lanes to one at the nose for entry ramps.

5.2.2 Ramp Lane Widths

Main Roads generally provides a 3.0 m left shoulder on ramps and no right-hand shoulder.

For two-lane ramps, 2 x 3.5 m wide traffic lanes are to be provided. Lane widths of two-lane ramps with a radius of less than 75 m should be designed using swept path simulation software.

For ramps on High Wide Load routes a 0.3 m wide right-hand shoulder is to be provided, so that a minimum width of 7.3 m is achieved between kerbs.

Where a concrete barrier is required, the absolute minimum offset from the edge of the traffic lane shall be:

- 0.3 m for a turn pocket or road speed zoned under 70 km/h.
- 0.6 m for a road speed zoned between 70 km/h and 90 km/h.
- 1.0 m elsewhere.

Kerbs

For extent of kerbing on exit and entry ramps refer to the Main Roads drawings listed in Section 6.4.1.

6. DESIGN SPEED

6.1 General

The same design speed should be used throughout an interchange.

The design speed chosen for elements of an interchange should reflect any potential for future increases in the ultimate posted speed of the freeway/highway.

6.4 Ramps

6.4.1 Ramp Design Speed

At exit ramp noses, the ramp design speed should be equal to the posted speed of the adjacent through carriageway.

The design speed on entry ramps for passenger vehicles at the edges meet point is equal to the posted speed of the adjacent through carriageway.

The design speed of all ramp terminals shall be in accordance with Main Roads' guideline drawings:

Exit Ramps	
Single Lane Exit Ramp - Typical Tapered Design	201131-0020
Dual Lane Exit Ramp - Typical Tapered Design	201131-0022
Single Lane Exit Ramp - Typical Parallel Design	201131-0023
Dual Lane Exit Ramp - Typical Parallel Design	201131-0024
Single Lane Loop Exit Ramp – Typical Loop Ramp Exit	201131-0026
Exit Ramp Shoulder Tapers	201131-0028

Entry Ramps	
Single Lane Entry Ramp – Typical Parallel Design	201431-0053
Dual Lane Entry Ramp – Typical Parallel Design (Dual Lane Merge)	201431-0055
Dual Lane Entry Ramp – Typical Parallel Design (Merge and Added Lane)	201731-0001
Dual Lane Entry Ramp – Alternative Parallel Design (Merge and Added Lane)	201731-0002
Single Lane Loop Entry Ramp - Typical Parallel Design	201531-0020
Entry Ramp Shoulder Tapers	201131-0029

7. SIGHT DISTANCE

Approach Sight Distance (ASD) on the minor road, in between the ramp intersections, may be based on a reaction time of 2.0 seconds. All other ASD calculations must be based on a reaction time of 2.5 seconds. Refer to Main Roads Supplement to Austroads GRD - Part 4A: Unsignalised and Signalised Intersections, Table 3.1.

The absolute minimum reaction time that can be used is 2.0 seconds. Absolute minimum reaction time should not be used in combination with other minimum design standards.

7.5 Safe Intersection Sight Distance

Main Roads has not adopted Minimum Gap Sight Distance (MGSD).

8. HORIZONTAL ALIGNMENT

Interchange geometry including major and minor roadways, ramps and turning roadways shall be designed in accordance with:

- Main Roads Supplement to Austroads GRD - Part 3: Geometric Design.
- Main Roads Horizontal Curve Tables.

8.3 Ramps

8.3.1 General

Acceleration and deceleration lengths required for entry and exit ramps shall be designed in accordance with Main Roads drawings listed in Section 6.4.1.

Ramp shoulder tapers shall be designed in accordance with Main Roads Drawings 201131-0028 and 201131-0029.

8.3.4 Service Interchanges

Exit loop ramps

Large plan transitions should not be used on the approach to loop ramp exits because they may lead drivers to overestimate the safe speed of the loop ramp. If required only plan transitions based on Main Roads Horizontal Curve Tables should be used on the approach to a loop ramp.

Refer to Main Roads Drawing 201131-0020 for ramp lane and shoulder widths on single lane exit ramps. Lane widths for loop ramps with radii of less than 75 m should be designed using swept path simulation software. It is acceptable for vehicles over 19.0 m in length to track onto the ramp shoulder. Where this is required the use of long-life material for the edge line and associated pavement markings shall be used.

Entry loop ramps

The compounding of larger radius curves or adding a plan transition to the departure from a loop ramp can be used to provide the required acceleration distance for vehicles entering the through carriageway.

Refer to Main Roads Drawing 201431-0053 for ramp lane and shoulder widths on single lane entry ramps. Lane widths for loop ramps with radii of less than 75 m should be designed using swept path simulation software. It is acceptable for vehicles over 19.0 m in length to track onto the ramp shoulder. Where this is required the use of long-life material for the edge line and associated pavement markings shall be used.

Loop ramp shoulders

Loop ramp shoulders should generally be located on the outside of the ramp curve to ensure that vehicles stopped on the shoulders do not adversely impact horizontal sight distance. At the ramp nose a 3.0 m wide shoulder should be developed on the left-hand side of the ramp as per the typical entry and exit ramp details. A smooth transition of the shoulder from one side of the ramp to the other should be provided. Refer to Main Roads drawings 201131-0026 and 201531-0020.

Where horizontal sight distance on the inside of a loop ramp is affected by road safety barriers, vegetation, retaining walls or any other structure, the shoulder may be placed on the inside of the loop.

9. VERTICAL ALIGNMENT

9.3 Ramps

9.3.2 Ramp Gradients on Service Interchanges

It is recommended that the preferred maximum gradient is 3% with an absolute maximum of 5%. It should be noted that ramp grades are controlled by the distance from the ramp nose to the minor road. This in turn is controlled by the distance required for either acceleration or deceleration and storage length.

10. RAMP TERMINALS AT MAJOR ROADS

10.3 Ramp Terminal at Minor Road

It is not Main Roads preferred practice to install concrete aprons at ramp terminals with minor roads.

11. RAMP TERMINALS AT THE MAJOR ROAD

11.1 General

Ramp terminals shall generally be configured as follows:

- Parallel type entry ramp terminals shall be used on all entry ramps.
- If the exit ramp adjoins a horizontal curve with a radius less than or equal to 900 m on the main alignment, the exit ramp should be a parallel design rather than a tapered design.
- Parallel type exit ramp terminals shall be used when traffic analysis determines their use is appropriate.
- Tapered exit ramp terminals established from horizontal curves should be developed using the same taper rates as used for tapered ramp terminals on tangents.

Exit ramp terminals should desirably be located on tangents. The exit must appear as an obvious diversion from the through alignment and should be located to prevent a driver inadvertently entering the exit ramp. The exit ramp taper should not be located just beyond or straddling a curve/tangent point on the major alignment where the ramp alignment may appear to be a continuation of the through carriageway.

The distance between ramp terminals shall be designed in accordance with:

- Austroads Guide to Traffic Management - Part 6: Intersections, Interchanges and Crossings (2020), Section 7.6.6 and Table 7.3.
- AASHTO - A Policy on Geometric Design of Highways and Streets (2018), Section 10.9.6.4.6 and Figures 10-70 & 10-71.

Exit and entry ramp minimum kerbing extents are to be in accordance with Main Roads drawings listed in Section 6.4.1.

11.2 Exit Ramps

Exit ramp terminal horizontal geometry shall be designed in accordance with Main Roads drawings listed in Section 6.4.1.

For exit ramps the cross slope between the edge of the left carriageway shoulder and the ramp right lane edge in the first 60 m of the ramp beyond the nose should be a maximum of 6 horizontal to 1 vertical.

Main Roads standard practice is not to allow exiting vehicles to queue on the emergency stopping lane. In highly constrained locations where no alternative options exist this can be considered, subject to the approval of the Manager Road and Traffic Engineering (MRTE).

11.3 Entry Ramps

Entry ramp terminal horizontal geometry shall be designed in accordance with Main Roads drawings listed in Section 6.4.1.

Where a single-lane entry ramp leads into an added lane, a varying taper of approximately 1 in 30 may be used between the ramp nose and the edges-meet point.

11.4 Ramp Traffic Signals

Ramp traffic signals shall be designed in accordance with:

- Main Roads Supplement to Victoria's Managed Motorway Design Guide, Volume 2 Design Practice, Parts 2 and 3.
- Main Roads Smart Freeways guideline drawings.
- Main Roads Vehicular Signals.

11.4.3 Geometric and Layout Design

Merge geometry

Any merging of lanes on the ramp beyond the ramp signals should be completed before the ramp nose.

12. RAMPS ON TWO-LANE TWO-WAY FREEWAYS

Design of ramps are to be in accordance with Main Roads drawings listed in Section 6.4.1. Only drawings with one lane at the ramp nose will be applicable.

13. PEDESTRIANS

In general, walking infrastructure should be grade separated at interchanges. Refer to the Transport Portfolio's Active Transport Infrastructure Policy and its Supplement for further guidance.

Shared path facilities through interchanges shall be designed in accordance with Main Roads Supplement to Austroads GRD - Part 6A: Paths for Walking and Cycling.

14. CYCLISTS

In general, cycling infrastructure should be grade separated at interchanges. Refer to the Transport Portfolio's Active Transport Infrastructure Policy and its Supplement for further guidance.

Shared path facilities through interchanges shall be designed in accordance with Main Roads Supplement to Austroads GRD - Part 6A: Paths for Walking and Cycling.

14.2 Treatment at Interchanges

A policy exception is required in situations where grade separation may not be feasible or even desirable. The process to obtain this is documented in the Supplement to Active Transport Infrastructure Policy.

Where a policy exception is obtained, Main Roads practice is to use a treatment similar to that shown in Figure 14.2, except with cyclists passing through the solid median which is far enough behind the ramp nose to provide protection for riders. Typical drawings should be developed on a project-by-project basis and in consultation with local cycling groups.

15. PAVEMENT MARKINGS, SIGNS AND LIGHTING

Signing and pavement marking of interchanges shall be designed in accordance with:

- Main Roads Guideline and Standard Contract Drawings for signs and pavement markings.
- AS 1742.2: Traffic Control Devices for General Use.

15.3 Lighting of Interchanges

Interchange lighting shall be designed in accordance with Main Roads Lighting Design Guideline for Roadway and Public Spaces.

16. LANDSCAPING AND STREET FURNITURE

16.1 General

Landscaping shall be designed in accordance with Main Roads Revegetation and Landscaping.

Current Main Roads practice is to retain all existing vegetation outside the toe of batter. Horizontal clearances should allow for future services, future widening and/or run-out areas.

Fences

Fencing shall be designed in accordance with Main Roads Design of Fencing and Walls.

Road safety barriers

The assessment of the need for road safety barriers and their subsequent design shall be in accordance with Main Roads Supplement to Austroads GRD – Part 6: Roadside Design, Safety and Barriers.

Additional items

For additional items refer Main Roads Roadside Items.

17. OTHER CONSIDERATIONS

17.1 Access in the Vicinity of Interchanges

17.1.1 Access to the Freeway

On roads currently at, or planned to be upgraded to a freeway standard, control of access shall be enforced over the full length of the freeway including the interchange ramps. Special cases for direct access may exist to accommodate Freeway Service Centres, public transport facilities, enforcement sites or in extenuating circumstances where suitable access is unavailable.

17.2 Service Centres

Any proposals for development of new services centres shall be referred to the Director Road Planning for consideration.

17.3 Oversized Loads and High Wide Load Corridors

For oversized load requirements refer to Main Roads, Heavy Vehicle Services.

For minimum design requirements for High Wide Load corridors refer to Main Roads Guide to Design of Oversize and Over-mass Vehicle Corridors, Section 6.6 – Clearances.

17.4 Intelligent Transport Systems (ITS) Infrastructure

ITS requirements such as traffic cameras, variable message signs, etc. should be determined in accordance with Network Operations requirements.

17.4.1 Designing for Future Ramp Traffic Signals

The following design features should also be considered to facilitate the future retrofitting of ramp signals:

- For drawings indicating entry ramp requirements for ramp traffic signals (including heavy vehicle priority lanes), refer to Main Roads Smart Freeways Drawings.
- Entry ramp lengths to provide for future storage being a minimum of 420 m from the ramp entrance to the ramp nose (storage for flows up to 1,200 vehicles/hour).
- Vehicle detector locations on the entry ramp to suit future stop line location.
- The position and spacing of stormwater pits should be based on the future allowable spread width, assuming that the shoulder is used as a traffic lane. If the pit spacing becomes uneconomically close, it may be necessary to allow for a nominal future shoulder width to accommodate some of the flow width.
- Consideration should be given to not providing a shoulder on the ramp: the ramp would be line marked as a two-lane ramp with the "Form 1 Lane" sign and merge in its future position.
- If the implementation of ramp metering is likely to occur within a short timeframe (e.g. the next two years or so) and it is considered undesirable to provide the pavement markings in their future position, consider using an approved temporary line marking tape, which meets Main Roads Specification 604 – Pavement Marking.
- Consideration should be given to the future installation of road safety barriers to protect against crashes with the future ramp signal poles. The depth and/or positions of pipes and gullies needs to be considered in relation to the depth and spacing of barrier posts.
- Future concrete barrier placements must be considered to ensure that ramp widths comply with the minimum offset requirements from the edge of the traffic lane, as specified in Section 5.2.2.
- Consideration should be given for verge width requirements for ramp signals and other required roadside furniture, including an allowance for an appropriate pull-off area for maintenance parking.

The above must be adhered to if ramp signals are within 5 years of ramp works being completed. Serious consideration should also be given if signals are within 10 years of completion.

17.4.2 Designing for Future All Lane Running

To allow and facilitate for future All Lane Running at entry and exit ramps refer to the following Main Road guideline drawings:

Single Lane Entry Ramp – Typical Parallel Design with Allowance for Future All Lane Running	202031-0034
Single Lane Exit Ramp – Typical Tapered Design with Allowance for Future All Lane Running	202031-0088

17.5 Emergency Provisions

Emergency stopping bays and roadside help phones shall be designed in accordance with Main Roads Emergency Stopping Bays and Roadside Help Phones.

17.6 Planning Considerations

17.6.1 Lane Balance

Lane configuration, including number of lanes and lane balance, shall be designed in accordance with:

- AASHTO - A Policy on Geometric Design of Highways and Streets (2018), Section 10.9.5.8 onwards.
- Victoria's Managed Motorway Design Guide, Volume 2 Design Practice, Part 3, Section 4.3.1 and Tables 4.1 to 4.3.

Right turning traffic from an exit ramp should always be directed into through lanes on the minor road and not into shared through/right turn lanes or sole right turn lanes on the minor road.

17.6.2 Traffic Considerations

Levels of Service

Level of service (LOS) of all freeway/highway segments shall be designed in accordance with the latest version of the Transportation Research Board - Highway Capacity Manual.

The lane configuration shall generally provide level-of-service C or better for all segments of the freeway/highway and interchange during the worst 15-minute period of the day for the predicted future traffic volumes. An ultimate interchange should be designed to meet LOS C based on a 20-30 year traffic horizon and an interim stage LOS C based on 10 year traffic forecast. Isolated segments with level-of-service D may be acceptable where it is not cost effective to provide additional lanes.

The level-of-service shall remain constant or nearly constant between adjacent freeway segments. For example C-C-C-D-C-C is acceptable but C-D-C-D-C-D or C-C-C-E-C-C is not. The LOS change between segments must not be greater than one increment e.g. A-B-A-A-B-D is not acceptable. Refer to AASHTO - A Policy on Geometric Design of Highways and Streets (2018), Table 2-3.

In inner Perth areas with high traffic volumes it may not be possible to achieve a high LOS due to significant site constraints. In these circumstances, the interchange should be designed to achieve the highest LOS possible.

APPENDIX A EXAMPLE OF RAMP SPEED ANALYSIS

For loop exit ramp details refer to Main Roads drawing 201131-0026.

APPENDIX B RAMP TERMINAL LOCATION

Main Roads has no supplementary comments for this section.

APPENDIX C EXAMPLES OF RAMP SIGNAL LAYOUTS

Refer to Main Roads guideline drawings for Smart Freeways:

Smart Freeways - Typical Entry (Freeway Ramp Signals for Two Lanes Metered)	201231-0027
Smart Freeways - Typical Entry (Freeway Ramp Signals for Two Metered Lanes Plus Metered Priority Lane – Option P1)	201231-0028
Smart Freeways - Typical Entry (Freeway Ramp Signals for Two Metered Lanes Plus Metered Priority Lane – Option P2)	201231-0029
Smart Freeways – Typical Entry (Freeway Ramp Signals for Two Lanes Metered Plus Dynamic Metered Lane)	201731-0028
Smart Freeways - Merge Layouts (Freeway Ramp Signals Three Lanes Metered to One Lane at the Nose)	201231-0030
Smart Freeways - Merge Layouts (Freeway Ramp Signals Four Lanes Metered to Two Lanes at the Nose)	201231-0031
Smart Freeways - Merge Layouts (Freeway Ramp Signals Three Lanes Metered to Two Lanes at the Nose)	201231-0032
Smart Freeways - Merge Layouts (Freeway Ramp Signals Three Lanes Metered to One Lane at the Nose – Special Case)	202431-000305
Smart Freeways - Indicative Freeway Ramp Signal Infrastructure Locations (Freeway to Freeway Interchange)	201231-0053

COMMENTARY 1 - 2

Main Roads has no supplementary comments for this section.

COMMENTARY 3

Step out line markings shall only be used at the start of exit ramps with the approval of the Manager Road and Traffic Engineering.

COMMENTARY 4 - 5

Main Roads has no supplementary comments for this section.