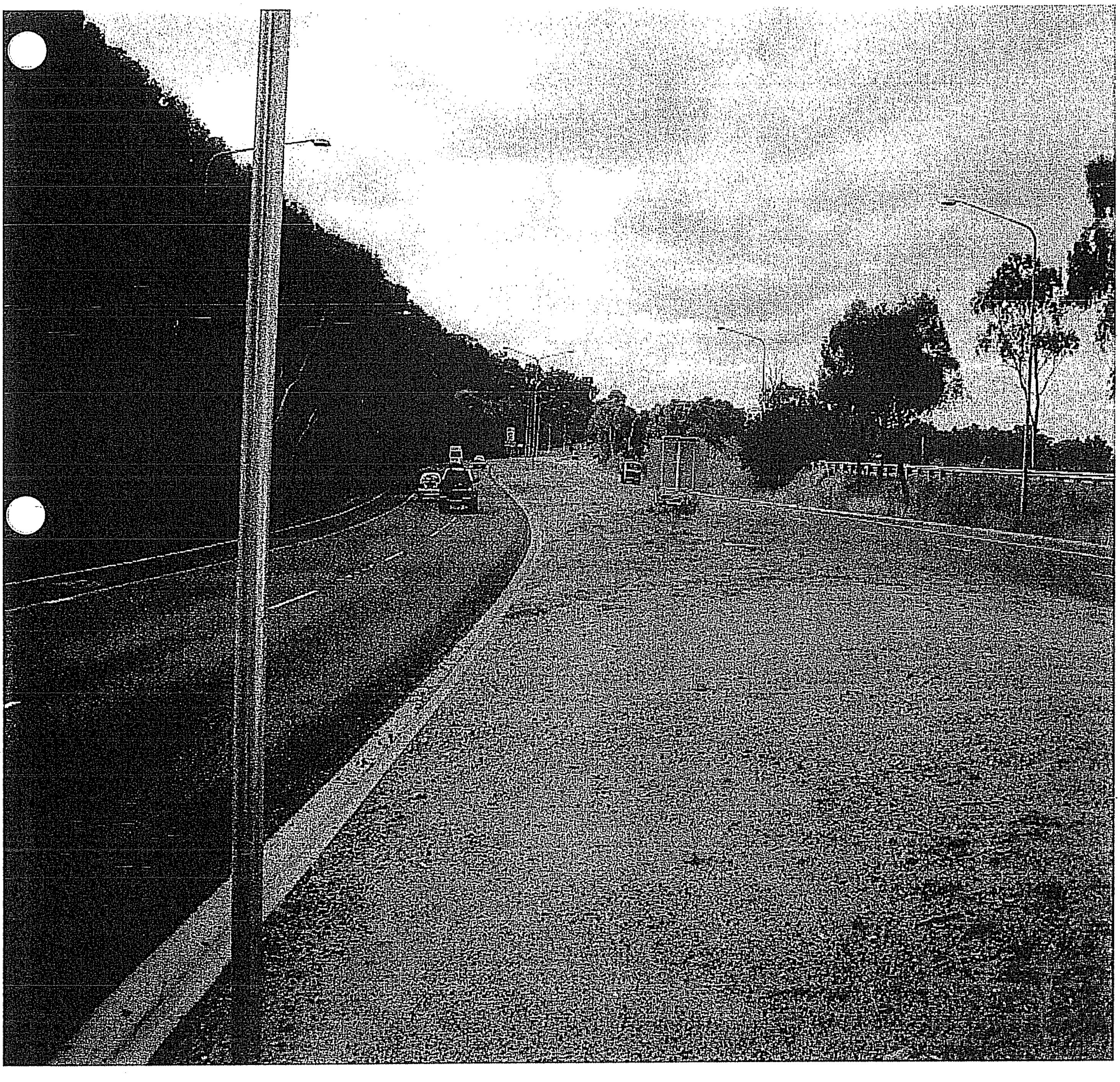
Parkes Way Widening
Roads ACT
28 September 2011

Parkes Way Widening Glenloch Interchange to Edinburgh Avenue

Parkes Way Dr Report



Parkes Way Widening Glenloch Interchange to Edinburgh Avenue

Parkes Way Dr Report

Prepared for

Roads ACT

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28 September 2011

60198222

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Quality Information

Document	Parkes Way Widening Glenloch Interchange to Edinburgh Avenue
	60198222
Ref	j:\60198222_parkes_way_widening\6. draft docs\6.1. reports\dr report\dr report.docx
Date	28 September 2011
Prepared by	J. Peters
Reviewed by	R. Weeks

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	28Sept 2011	DR Report	M. Blackmore Project Manager	

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Executive Summary

Parkes Way is an existing road in Canberra that suffers from congestion problems. Roads ACT has engaged AECOM to design, document and superintend upgrade works involving the widening of Parkes Way.

The proposed road widening into the existing median will provide an additional lane each way on Parkes Way between Glenloch Interchange and Edinburgh Avenue and includes widening of the Clunies Ross Street and Sullivans Creek bridges. Through the Acton Tunnel the compulsory left-turn lane is utilised as the 3rd lane and a new left turn slip lane to Edinburgh Avenue is provided.

The channelization of the intersection of the entry ramps to Commonwealth Avenue from the Parkes Way and London Circuit is included in the works.

The design standards selected for the project and adopted in subsequent road design are dictated by the existing design which is generally for an 80 km/h design standard. Bridge widening works will conform to current standards for SM 1600 loadings. The existing structures have been checked for SM 1600 loadings and strengthening is required.

Given the long lengths of widening, this PSP report is broken down into four segments to clearly outline the constraints imposed by the existing geometry along the Parkes Way and subsequent changes resulting from the proposed widening. The four segments along the Parkes Way are as follows:

- Glenloch Interchange to Black Mountain Peninsula
- Black Mountain Peninsula to Clunies Ross Street
- Clunies Ross Street to Acton Tunnel and
- Acton Tunnel to Edinburgh Avenue.

The residual median between the Glenloch Interchange and Clunies Ross Street will be 4.2 m. A wire rope barrier will be installed in the median and the surface paved to minimise maintenance requirements.

Between Clunies Ross Street and Edinburgh Avenue the existing guardrail arrangement will be retained albeit on the realigned kerb line.

Street lighting between the Glenloch Interchange and Clunies Ross Street will be relocated from the median to the verges.

Bridges at Clunies Ross Street and Sullivans Creek will be widened by 2.80 m and 3.755 m respectively. Super T girders and new piers will be utilised for the widening at Clunies Ross Street. Whilst at Sullivans Creek the existing form of the superstructure and substructure will be replicated using pre-stressed beams, widened pile caps and new piers.

There are minimum impacts on existing utility services.

Traffic analyses have been undertaken to determine peak volumes along Parkes Way along with the potential to channelize the Parkes Way entry ramp to Commonwealth Avenue.

The pavement profile adopted for the proposed widening is a flexible pavement with a thin asphaltic concrete surfacing course over new pavement gravels.

Included in the works is the replacement of the Acton Tunnel lighting and associated AC wall linings. It is not intended to replace the ceiling linings. Gaps resulting from the new lighting will be repaired only to the extent of the need to allow the installation of the new lights, hence gaps will result.

The existing speed limit on Parkes way between the Glenloch Interchange and Edinburgh Avenue will be reduced from 90 km/h to 80 km/h. New direction signage is restricted a new advance direction sign on the westbound approach to the Glenloch Interchange advising of the Tuggeranong Parkway exit 1 km ahead and amending the existing signage on the approach to the Edinburgh Avenue exit to remove the compulsory exit lane indication.

The probable cost for the proposed road and bridge widening works and the replacement of the Acton Tunnel lighting is $20.46M inclusive of GST.

1.0 Introduction

1.1 Background

The developments either planned or under discussion over the next twenty years will increase the road network demand in Canberra. A significant proportion of these developments are located close to the centre of the Canberra metropolitan area. It will impact the current major transport corridor that extends from the proposed district of Molonglo to the Canberra Airport/NSW border known as East West Corridor. The East West Corridor transportation study under taken by AECOM provides the recommendation for a more detailed investigation for adding an additional lane each way on Parkes Way between Glenloch Interchange and Edinburgh Avenue.

AECOM were engaged by Roads ACT to undertake the design, documentation and superintendence for the upgrade works from Glenloch Interchange to Edinburgh Avenue.

1.2 Works Approval

Documents for Works Approval were submitted to the NCA and comments received and responded to. Additional information was requested for the approval of landscaping designs and directional signage to include in the one-off approval sign-off.

Works approval has been received with a condition that the street lighting across the Black Mountain escarpment be altered from the aero screen to a full cut-off fitting. Negotiations are being undertaken with the NCA as a change will require additional columns and lights with increased annual operating costs as well as additional impact on trees.

1.3 Scope of Works

The scope of works includes the following works:

- Widening Parkes Way in both directions from the eastern side of the Glenloch Interchange to Clunies Ross Street by using part of the existing median to provide the additional lanes;
- Widening Parkes Way at the Clunies Ross Street twin bridges by construction of extensions to the median side of the bridge decks using super tee girders supported on new piers and extended abutments;
- Widening Parkes Way at the Sullivans Creek bridge by extensions to the median side of the bridge decks by constructing a new cast insitu post tensioned box girder supported on new piers and extended abutments;
- Strengthening of the Clunies Ross Street and Sullivans Creek bridges to accommodate SM 1600 loadings;
- Modifying the Clunies Ross Street ramps to integrate with the road widening works;
- Widening Parkes Way eastbound within the median from the Acton Tunnel to east of the Edinburgh Avenue overpass;
- Modifying the Edinburgh Avenue off-ramp to replace the present compulsory right-turn lane which will now form the 3rd lane;
- Adding channelization to the intersection of the on-ramp from Parkes Way to Commonwealth Avenue southbound with the on-ramp from London Circuit to Commonwealth Avenue southbound to improve traffic flow; and,
- Replacement of the Acton Tunnel lighting.

No modifications are proposed to the westbound carriageway on-ramp from Edinburgh Avenue, i.e. the lane from the ramp remains as the added 3rd lane.

1.4 Project Inputs and Assumptions

The (WA) design is based upon available information, including:

Information gathered during site visits

- Location of utilities(supplied in CAD/ DWF format by service authorities);
- Liaison with utility authorities;
- Detailed field survey;
- Peak hour traffic surveys provided by Roads ACT to establish a SIDRA model of the Parks Way on-ramp to Commonwealth Avenue intersection of the on-ramp for London Circuit to Commonwealth Avenue;
- Liaison with TaMS tree unit; and,
- Comments on intersection layout from Client.

2.0 Design Standards

2.1 Introduction

The design standards selected for the project and adopted in subsequent road and bridge design comply with the provisions detailed within the standards and guidelines listed below.

2.2 Design Standards

- Design Standards for Urban Infrastructure.
- AUSTROADS – Part 3 – Geometric Design.
- AUSTROADS – Part 4c – Interchange.
- AUSTROADS – Part 14 Bicycles.
- RTA – Road Design Guide.
- SAA – AS 5100 Bridge Design Code.
- ACTEW Water Supply and Sewerage Standards.

2.3 Previous Studies

The traffic study underpinning the warrant for the proposed widening of Parkes Way is the East to West Corridor Study which was undertaken in 2009. This study can be referred to for further details.

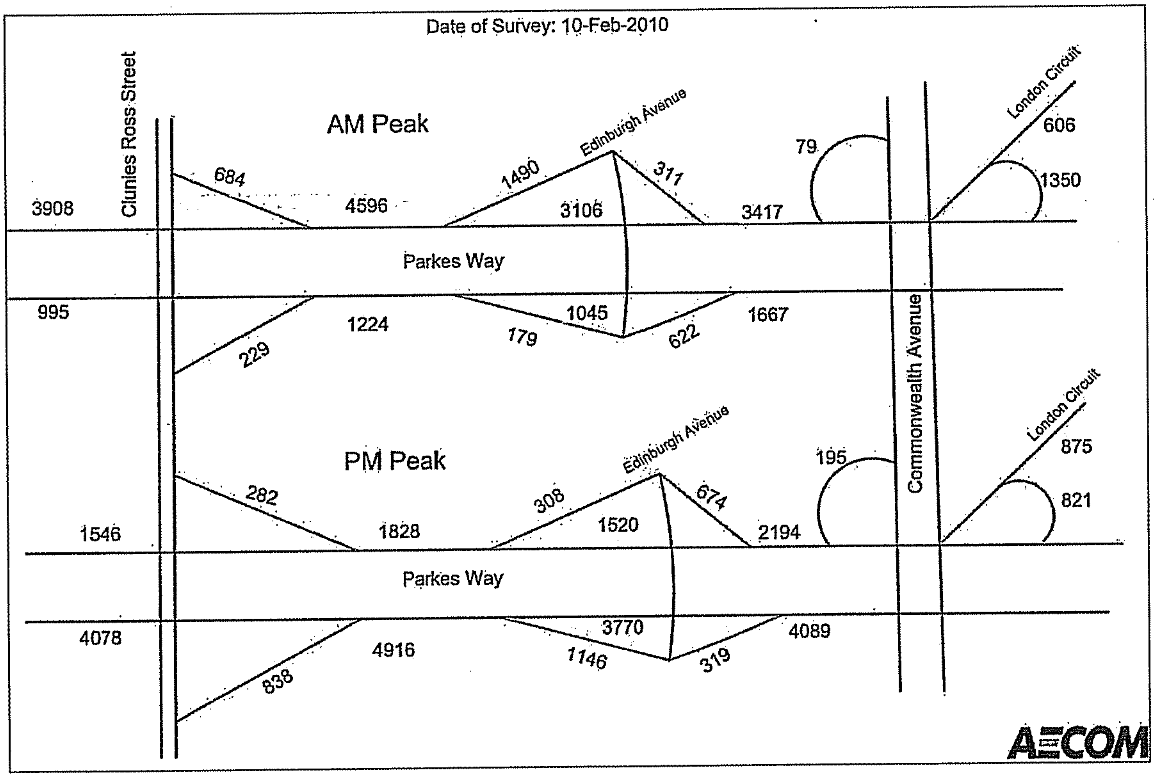
3.0 Road Capacity Analysis

3.1 Introduction

Capacity analyses were undertaken using 2010 and 2021 estimates of traffic volumes. The 2010 volumes were obtained from a recent survey of the section of Parkes Way being considered for widening, as well as the Parkes Way exit-ramp at Commonwealth Avenue and London Circuit East.

The results of the 2010 survey are summarised in Figure 3-1. Estimates of 2021 volumes were derived from the EMME modelling work done as part of the East West Corridor Study.

Figure 3-1: Existing (2010) Peak Hour Traffic Volumes



3.2 Midblock Capacity Analysis

"Level of Service" (LOS) is a measure to determine the operational conditions and efficiency of a roadway or intersection. The definition of LOS generally describes the operating conditions in terms of speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience, and road safety. There are six levels of service, A to F, with LOS A representing optimum operating conditions (free flow) and LOS F the poorest (forced or breakdown in flow).

Midblock capacity analysis was done based on the updated AustRoads, Guide to Traffic Management, Part 3 Traffic Studies and Analysis, 2009 and the Highway Capacity Manual (2000) using calculation methods for basic freeway segments.

Table 3-1 to Table 3-3 summarise the results of the AM peak hour midblock level of service analyses for the section of Parkes Way being considered in this study, for the years 2010 (existing) and 2021 respectively. This indicates that Parkes Way is already congested in the AM peak and will continue to be congested in the future.

Table 3-1 Volume Capacity Ratio – Parkes Way

Road	Section	# lanes	dir of dir 1	V/C Dir 1		V/C Dir 2		Total	
				2010	2021	2010	2021	2010	2021
Parkes Way	Glenloch Int-Clunies Ross	2	east	1.12	1.03	0.28	0.34	1.12	1.03
Parkes Way	Acton Tunnel	3	east	1.31	1.07	0.32	0.38	1.31	1.07
Parkes Way	under Edinburgh Av bridge	2	east	0.89	0.76	0.30	0.38	0.89	0.76

Table 3-2 Midblock LoS - 2010

Road	Section	# lanes	Peak Hr Direct 1	LoS1	Peak Hr Direct 2	LoS2
Parkes Way	Glenloch Int-Clunies Ross	2	3908	F	995	C
Parkes Way	Acton Tunnel	3	4596	F	1107	A-B
Parkes Way	under Edinburgh Av bridge	2	3106	F	1045	C

Table 3-3 Midblock LoS – 2021 (No Works)

Road	Section	# lanes	Peak Hr Direct 1	LoS1	Peak Hr Direct 2	LoS2
Parkes Way	Glenloch Int-Clunies Ross	2	4859	F	1183	D
Parkes Way	Acton Tunnel	3	5316	F	1335	C
Parkes Way	under Edinburgh Av bridge	2	3579	F	1331	D

A key observation from these results is that the capacity of Parkes Way needs to be increased, by widening the road. Table 3-4 shows the midblock level of service with the proposed widening. There is no widening of Acton Tunnel, so it will still exhibit some congestion when Parkes Way is widened.

Table 3-4 Midblock LoS – 2021 (With Widening)

Road	Section	# lanes	Peak Hr Direct 1	LoS1	Peak Hr Direct 2	LoS2
Parkes Way	Glenloch Int-Clunies Ross	3	4859	D	1183	A-B
Parkes Way	Acton Tunnel	3	5019	D	1335	C
Parkes Way	under Edinburgh Av bridge	3	3579	C	1331	C

3.3 Merge and Weaving

An analysis of the capacity of freeway ramps and weaving areas on Parkes Way was undertaken using procedures in the Highway Capacity Manual. The capacity of the ramps is determined from the worst level of service provided by either:

- The ramp proper
- The merge/diverge area to/from the ramp
- The section of freeway adjacent to the ramp

The results of the AM peak hour analyses of freeway ramps are summarised in Table 3-5 and Table 3-6, for the years 2010 and 2021 respectively. This analysis identified capacity problems eastbound on Parkes Way in the weaving section between the on-ramp from Clunies Ross Street and the off-ramp to Edinburgh Avenue in the AM peak. Similar problems may exist in the reverse direction in the PM peak on the Lawson Crescent off ramp onto Parkes Way (westbound).

Table 3-5 Level of Service – Existing Weaving Sections on Parkes Way

Parkes Way Eastbound (Clunies Ross Street ON ramp – Edinburgh Avenue OFF ramp)	Parkes Way Westbound (Lawson Crescent ON ramp and Lady Denman Drive OFF ramp)

2010	2021	2010	2021
F	F	A	B

Future analysis of the Clunies Ross Street ON ramp onto Parkes Way (EB) was also undertaken for the future as a merge instead of continuous lane. The results from that analysis are shown in Table 3-6. It shows that traffic from Clunies Ross Street will still have difficulty merging with eastbound Parkes Way traffic in the AM peak, although this traffic would not need to perform a weaving movement. There would be further congestion through Acton Tunnel and at the merge east of Edinburgh Avenue.

Table 3-6 Level of Service – Future Merge Segments on Parkes Way (with widening)

Parkes Way Eastbound (Clunies Ross Street ON ramp)	
2010	2021
E	E

3.4 Parkes Way to Commonwealth Avenue Entry Ramp

3.4.1 Options for Ramp

A SIDRA analysis of the Parkes Way off ramp onto Commonwealth Avenue was also undertaken as a part of this study, to help determine the design and impact of signal metering at the ramp junction with London Circuit East. The results from the analysis for the existing conditions are shown in Table 3-7, based on the give-way arrangement shown in Figure 3-2.

Figure 3-2 Intersection - Parkes Way OFF ramp / London Circuit OFF ramp

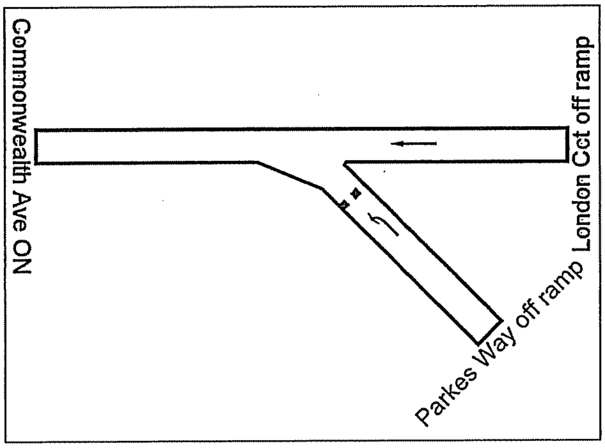


Table 3-7 SIDRA Results - Parkes Way OFF ramp / London Circuit OFF ramp GIVEWAY

Approach	Deg of Satn (v/c)	Aver Delay (sec)	Level of Service	95% Back of Queue (m)
Parkes Way off ramp	1.106	117.3	F	788
London Cct off ramp	0.327	0.0	A	0
Total	1.106	80.9		788

The results from SIDRA analysis demonstrate the current situation at the intersection in the morning peak, in which the queuing on Parkes Way ramp extents up to 800 metres on Parkes Way therefore blocking the traffic coming from Commonwealth Avenue off ramp on to Parkes Way.

The full analysis of the intersection alternative treatments is discussed in Section 7.0.

4.0 Existing Condition Analysis and Proposed Widening Constraints and Opportunities

The project has been divided into four sections for the purpose of analysing the design standards adopted when the road was designed and built in the late 1970s and the impacts the widening has on the existing road and associated infrastructure.

4.1 Glenloch Interchange to Black Mountain Peninsula

4.1.1 Existing Conditions

4.1.1.1 Horizontal Geometry

This section across the Black Mountain escarpment has a combination of curve radii beginning with 635 m (westbound) and 530 m (eastbound) left-hand curves at the west end and then two right-hand compound curves of 1800 m and 1020 m radius respectively.

In the eastbound direction the two right-hand curves have a 3% adverse cross fall which has created safety issues in the past during winter due to ice forming as a result of heavy dew or frost, or following rainfall. The road in this location does not receive the full benefit of early sun due to its low elevation and the shading created by Black Mountain; hence the icy conditions remain during the peak hours. The condition is further exacerbated by the 0.5% longitudinal gradient on the road.

The situation has been alleviated by a bituminous seal over the earlier asphaltic concrete surface to create a greater texture depth in the surface as a method of improving skid resistance.

4.1.1.2 Vertical Geometry

The crest vertical curves at the Glenloch Interchange end of the work provide the following design speeds.

i) Eastbound

The crest vertical curve at the start of the widening proposed where the existing 3 lanes merge into 2 lanes has a stopping sight distance equivalent to 80 km/h for cars and 85 km/h for trucks.

ii) Westbound

The crest vertical curve at the end of the widening proposed where the existing 2 lanes continue to William Hovell Drive and the exit lane to the Tuggeranong Parkway commences, has a stopping sight distance equivalent to approximately 80 km/h for cars and 85 km/h for trucks.

The existing diverge taper for the Tuggeranong Parkway exit ramp commences on the crest of the vertical curve and is difficult to detect for approaching traffic.

iii) Longitudinal Grading

A gradient of 0.5% connects the western end of the escarpment to a low point located prior to the rising grade of 5.7% to the Black Mountain Peninsula.

4.1.1.3 Cross Section

The existing cross section within this section is generally as follows for the eastbound and westbound carriageways:

- 2 x 2.7 m wide traffic lanes
- 3.0 m wide eastbound shoulder and 2.5 m westbound shoulder.

The median separating the carriageways is 10.4 m wide measured face to face of the mountable kerb and gutter.

The Lady Denman Drive roadway embankment lies beyond the 2.5 m wide shoulder on the westbound carriageway and the steep Black Mountain escarpment within the Nature Park abuts the shoulder of the eastbound carriageway.

4.1.1.4 Geometric Deficiencies

Deficiencies in the present design relate to:

Adverse cross fall on the eastbound carriageway pavement. AUSTROADS recommends the following speed/curve radii relationships for curves with adverse cross fall.

- 80 km/h: 1250 m
- 90 km/h: 1700 m
- 100 km/h: 2250 m

Of these compound curves the 1800 m radius meets a 90 km/h design speed. The second portion of the compound curve is only suitable for an 80 km/h design speed.

Vertical curves on the east side of the Glenloch Interchange at the limit of the proposed widening work.

Provided that the posted speed does not change to 90 km/h (eastbound) until after the merge between Belconnen and Tuggeranong traffic the AUSTROADS design criteria is met.

Similarly for westbound traffic the 80 km/h posted speed should remain prior to the crest vertical curve approaching the Glenloch Interchange for AUSTROADS Guidelines to be met.

4.1.2 Proposed Works

4.1.2.1 Carriageway Widening to Form 3 Lanes

The widening of the carriageway to accommodate the extra lane will occur in the median due to the constraints identified in Section 4.1.2.2.

By narrowing the existing 3.7 m wide lanes from 3.7 m to 3.5 m the resulting widening into the median is 3.1 m for each carriageway with a residual median width of 4.2 m.

The narrowed median will be flanked by semi-mountable kerbs which do not require any offsets from the edge of traffic lane to the kerb face for design speeds up to 100 km/h.

4.1.2.2 Median Form

The narrowed median will require:

- Stabilised decomposed granite gravel paving to eliminate maintenance requirements in this relatively narrow strip and problematic safety issues for maintenance personnel that would be associated with a vegetation solution.
- Wire rope barriers over the total length. A post spacing of 2.5 m has been and offset varied to a minimum of 1.5 m offset from the nearest kerbline. The location of the barrier varies to improve sight lines of the relative low radius curves.
- Relocation of the existing street lighting columns to the verges.

4.1.2.3 Line Marking

The carriageways will require remarking to account for the narrowing of the lanes to 3.5 m. This will affect the present lane line separating the existing two lanes.

4.1.2.4 Street Lighting

The existing twin arm street lights have been relocated to the verges as single arm columns.

Give the steep sloping areas of the Black Mountain escarpment generally 1.5 (H) to 1 (V) and the 1(H) in 1(V) batter on the Lady Denman Drive embankment the new light columns will need bases scalloped into the aforementioned batters.

Street light electrical cables will require installation at the edge of the existing paved shoulder requiring the reinstatement of trenches and pavement finishes. On the Black Mountain side the existing concrete formed high-capacity table drain will need to be cut through and reinstated following the installation of the cabling.

4.1.2.5 Stormwater Drainage

In this section the majority of the stormwater drainage sumps are located at the edge of the shoulder and hence are not affected by the works.

Notwithstanding there are several sumps on the median edge of the westbound carriageway which will need to be relocated to the new median kerb line together with their collector pipes.

The existing pavement edge sumps and collector pipe -work which are connected to transverse drainage lines discharging into Lake Burley Griffin are not affected by the works.

No new connections to Lake Burley Griffin are proposed or required.

No subsoil drains have been identified in the existing pavement. A study of the Works-Executed drawings also confirms this observation. New subsoils drains will be installed at the interface between the new and existing pavements.

The capacity and spacing of the existing sumps are acceptable for the widened road.

However, the potential for aquaplaning due to additional water flowing across the carriageway from the additional paved area has been verified and found not to be an issue. To maintain a skid resistant surface on the areas in the shadow of the Black Mountain escarpment where ice has a tendency to occur on the adverse crossfall of the road following rain in the winter months the new pavement has a stone mastic asphaltic concrete finish.

4.2 Black Mountain Peninsula to Clunies Ross Street

4.2.1 Existing Conditions

4.2.1.1 Horizontal Geometry

The horizontal curves leading up onto the Black Mountain Peninsula and around to Clunies Ross Street consist of a 310 m radius left-hand curve followed by a 420 m radius right-hand curve. Both of these curves have 3% superelevation.

These radius curves equate to 75 km/h and 83 km/h design speeds respectively adopting the linear distribution of 'f' (friction) for 'e' (superelevation) of 5% maximum.

4.2.1.2 Vertical Geometry

The crest vertical curve at Black Mountain Peninsula has a stopping sight distances equivalent to approximately 80 km/h for cars and 85 km/h for trucks whilst the crest curve approaching Clunies Ross Street has stopping sight distance equivalent to approximately 90 km/h for cars and 95 km/h for trucks.

The gradients in this section range from 5.7% on the eastern approach to the Black Mountain Peninsula to 1.95% approaching the vertical curve near Clunies Ross Street.

A sag vertical curve is located at about the midpoint of this section.

4.2.1.3 Cross section

The cross section is generally as noted in Section 4.1.1.3 the exception being the interface with Lady Denman Drive which changes from being above Parkes Way to below Parkes Way with steep batters approaching slopes of 2 (HI) and 1 (V) at the narrowest point. A narrow verge flanked by G4 type guardrail separates the westbound carriageway from the road embankment batters.

4.2.1.4 Geometric Deficiencies

The geometric deficiencies in this section relate to the:

- Posted speed limit of 90 km/h being in excess of the AUSTROADS guidelines for the Black Mountain Peninsula crest vertical curve and
- Posted speed limit of 90 km/h being in excess of the AUSTROADS guidelines for both horizontal curves.

4.2.2 Proposed Works

4.2.2.1 Carriageway Widening to Form 3 Lanes

The work is identical to that outline in Section 4.1.2.1.

4.2.2.2 Median Form

The work is identical to that outline in Section 4.1.2.2.

It should be noted that the installation of the wire rope barrier in the median in this Section will limit stopping sight distances as follows

i) Eastbound

- 310 m radius curve: 100 m (equivalent to 75 km/h design speed; cars and 68 km/h design speed; trucks)
- 420 m radius curve: 115 m (equivalent to 80 km/h design speed; cars and 70km/h design speed; trucks)

Offsetting the wire rope barrier to the 1.5 m minimum from the kerb line marginally increases the sight distance (+5%).

4.2.2.3 Line Marking

The.work is identical to that outline in Section4.1.2.3.

4.2.2.4 Street Lighting

The work is generally similar to that outlined in Section 4.1.2.4, the exception being the lighting columns on the westbound carriageway verge will need to be located behind the guardrail.

4.2.2.5 Stormwater Drainage

The work is generally similar to that outlined in Section 4.1.2.5, the exception being:

- There are a greater number of sumps located at the median edge of the carriageway which will require relocation along with the connecting pipe network and
- Issues associated with icing are not applicable in this section.

4.3 Clunies Ross Street to Acton Tunnel

4.3.1 Existing Conditions

4.3.1.1 Horizontal Geometry

Between Clunies Ross Street and the Acton Tunnel horizontal curves vary from 400 m to 550 m (at the Acton Tunnel) in radius.

Both of these curves have superelevation of 3%.

These radii and superelevation equate to design speeds of 85 km/h and 88 km/h adopting the linear distribution of 'f' (friction) for 'e' (superelevation) of 5% maximum.

4.3.1.2 Vertical Geometry

The vertical geometry in this section commences with a -2.25% gradient at Clunies Ross Street reducing to 0.7% at Sullivans Creek. This latter grading continues through the Acton Tunnel.

Apart from the sag vertical curve west of Sullivans Creek there are no other vertical curves in this Section.

4.3.1.3 Cross Section

The carriageway widens from 2 lanes to 3 lanes on the east side of Sullivans Creek which is a result of the entry ramp from Clunies Ross Street joining the eastbound carriageway.

On the westbound carriageway a 3rd add-on lane commences at the Edinburgh Avenue interchange entry ramp and continues through to Clunies Ross Street where it becomes a compulsory exit ramp to Clunies Ross Street.

Both carriageways in the 3 lane section are configured as follows:

- 3 x 3.7 m wide traffic lanes
- 3.0 m wide left-hand shoulder
- 1.2 m wide right-hand shoulder

Within the 2 lane section between Clunies Ross Street and Sullivans Creek the configuration is:

- 2 x 3.7 m wide traffic lanes
- 3.0 m wide left-hand shoulder
- 1.2 m wide right-hand shoulder

The ramps to and from Clunies Ross Street have:

- 3.7 m wide traffic lane
- 1.8 m wide shoulder

The median width varies in this section commencing with 10. 2 m at Clunies Ross Street; 15.4 m (and varies) at Sullivans Creek; and 4.8 m at the approach to the Acton Tunnel.

4.3.1.4 Geometric Deficiencies

Apart from the horizontal curves as noted in Section 4.3.1.1 being less than the presently posted speed limit there are no other deficiencies in this section.

4.3.2 Proposed Works

4.3.2.1 Carriageway Widening to Form 3 Lanes

The widening to 3 lanes will occur in the median between Clunies Ross Street and Sullivans Creek.

Beyond Sullivans Creek on the eastbound carriageway the widening in the median will taper and merge into the existing median width approximately 250 m west of Acton Tunnel.

On the westbound carriageway the widening also joins the existing median opposite that of the eastbound carriageway.

The widening described above together with the existing 3 lanes formed by the on-ramp commencing at Clunies Ross Street (eastbound) and Edinburgh Avenue (westbound) enables the 3 lanes between Clunies Ross Street and the Acton Tunnel to be formed, i.e. the existing compulsory left-turn lanes will form the 3rd lane.

The entry and exit ramps at Clunies Ross Street will be reconfigured to join/depart the main carriageways respectively as ramps with merging/diverging tapers rather than the present exit and entry lanes.

The ramp merge/diverge tapers are designed for 100 km/h design speed on Parkes Way and are largely formed by linear line markings and chevrons rather than new kerb lines.

The 1.2 m wide sealed shoulder will be maintained on the right-hand side of each carriageway as required by the location of the barrier kerb and guardrail.

4.3.2.2 Median Form

The existing median is flanked by barrier kerbs with G4 guardrail aligning with the kerb face.

The kerb and guardrail will be removed and the additional pavement extended by approximately 2.0 m into the variable width median.

It is intended that the barrier kerb and guard rail be reinstated on the new edge of the median given the need to join with the existing guardrail flanking the 4.8 m wide median at the approaches to the Acton Tunnel.

Part of the vegetation in the median will need to be removed and replaced with a stabilised decomposed granite paved surface, to remove the need for regular access for mowing the grass.

4.3.2.3 Line Marking

The line marking will require adjustment to suit the new configured lane and merge/diverge arrangements, new lane lines, and edge lines on both shoulders.

4.3.2.4 Street Lighting

The existing street lighting is located on the verges and hence will not require relocation.

4.3.2.5 Stormwater Drainage

In areas of superelevation where the sumps are located on the median edge the sumps and connecting pipe systems will require relocation to within the median.

As in Sections 4.1 and 4.2 the drainage flow paths with the widened pavement have been verified to ensure water build up on the pavement does not contribute to aquaplaning.

4.4 Acton Tunnel to Edinburgh Avenue

4.4.1 Existing Conditions

4.4.1.1 Horizontal Geometry

The horizontal curve in the tunnel is a 550 m radius left-hand curve with superelevation of 3%. This radius, when evaluated with AUSTROADS Guidelines equates to a design speed of 88 km/h adopting the linear distribution of 'f' (friction) for 'e' (superelevation) of 5% maximum.

The horizontal stopping sight distance on the westbound carriageway is controlled by the central wall of the tunnel. The available distance is 115 m which equates to a design speed of approximately 80 km/h for cars and 70 km/h for trucks.

On the eastbound carriageway the shoulder increases the sight distances to 130 m which equates to a design speed of approximately 90 km/h for cars and 80 km/h for trucks.

East of the tunnel the 550 m radius left-hand curve connects to a 450 m radius right-hand curve which has 3% superelevation and an equivalent design speed of 85 km/h adopting the aforementioned parameters.

The bridge pier at Edinburgh Avenue is the limiting factor for sight lines. A 115 m stopping sight distance is available which effectively limits speeds to approximately 80 km/h for cars and 70 km/h for trucks.

4.4.1.2 Vertical Geometry

The vertical geometry in this section consists of generally flat grades of 0.5% or less.

These gradients do not impose any restrictions on sight lines.

4.4.1.3 Cross Section

Within Acton Tunnel the cross section of each carriageway is:

- 3 x 3.7 m wide traffic lanes, one lane being the Edinburgh Avenue exit ramp
- 3.0 m wide left-hand shoulder and

- 1.2 m wide right-hand shoulder.

East of the tunnel the cross section is the same, however; at the exit ramp gore the right-hand shoulder decreases from 1.2 m to 0.6 m in width at the end of the G4 guardrail and barrier kerb.

Beyond the exit ramp gore the cross section configuration is:

- 2 x 3.7 m wide lanes
- m wide left-hand shoulder and
- 0.6 m wide right-hand shoulder.

The ramps to and from Edinburgh Avenue are configured as follows:

a) Exit ramp

- 4.3 m wide traffic lane, 2.5 m wide left-hand shoulder and
- 0.6 m wide right-hand shoulder.

b) Entry ramp

- 3.7 m (minimum) wide traffic lane at the ramp gore area widening to two lanes 7.4 m wide at the ramp commencement at Edinburgh Avenue and
- 1.8 m wide left-hand shoulder.

The median width varies from 4.8 m wide at the Acton Tunnel portal to 12.0 m at the Edinburgh Avenue overbridge.

Both edges of the median are flanked by G4 type guardrail and barrier kerbs up to the point where the median begins to widen from 4.8 m. The barrier kerb is replaced by a semi-mountable kerb east of this point which is generally coincident with the entry/exit ramp gore areas.

4.4.1.4 Geometric deficiencies

As stated in Section 6.1.1 the deficiencies are limited to restrictions imposed by the horizontal alignment and flanking guardrails and the walls of the Acton Tunnel.

4.4.2 Proposed works

4.4.2.1 Carriageway widening to form 3 lanes

i) Eastbound

The widening to 3 lanes is achieved as follows:

- Tunnel section

  The existing compulsory left-turn lane to Edinburgh Avenue becomes the 3rd lane.

- East of tunnel

A new 3.5 m wide left-turn slip lane is commenced approximately 80 m east of the tunnel portal. The lane width tapers from the full 3.5 m at this location to zero width at the point of connection to the existing construction over a distance of approximately 70 m.

A new 4m high (exposed face) retaining wall will be required to replace the existing wall which needs to be demolished as a result of the pavement widening. This wall will have a stone pitched face to match the appearance of the existing walls.

Between the Edinburgh Avenue exit ramp gore and approximately 350 m east of Edinburgh Avenue overbridge widening of approximately 3.5m into the median is required to achieve the 3rd lane and to provide stopping sight distance for cars travelling in the median lane.

The 3.5 m of widening for the additional lane is partly achieved by narrowing the existing 3.7 m wide traffic lanes to 3.5 m and the shoulder from 3.0 m to 2.5 m gaining an extra 0.9 m of width on the existing pavement.

To provide the aforementioned sight line requirements there is a need to provide a right-hand shoulder to the median lane to allow sight lines past the guardrail protecting the Edinburgh Avenue overpass. This shoulder varies in width from 1.2 m to 2.1 m.

Hence the overall widening into the median will vary between 3.8 m and 4.7 m to provide the traffic lane and shoulder for sight lines.

The variable width right-hand shoulder will be an extension of the existing 1.2 m wide shoulder occurring near the Edinburgh Avenue exit ramp (replacing the existing 0.6 m shoulder) to a point approximately 150 m past the Edinburgh Avenue overpass where the right-hand shoulder presently terminates.

ii) Westbound

The existing westbound add-lane from the Edinburgh Avenue entry ramp will be maintained thus forming the 3rd lane east of this location.

Due to the constraints of the existing Acton Tunnel it is only possible to achieve an 80 km/h design speed on the merge taper for a reconfigured entry ramp joining 3 lanes developed east of the Edinburgh Avenue overbridge.

Given the resultant sub-standard merge arrangement and the volume of traffic (1,146 vehicles/hour) entering Parkes Way from Edinburgh Avenue, a decision was made in consultation with Roads ACT to maintain the present lane-add arrangement with only 2 lanes east of the entry ramp gore.

4.4.2.2 Median form

The median width (eastbound) will be reduced in width by 3.5 m east of the Edinburgh Avenue exit ramp gore area. The new median edge will be flanked by kerbs up to and beyond the Edinburgh Avenue overbridge pier, with G4 type guardrail flanking the kerbs to provide protection for the bridge pier.

The guardrail extends approximately 150 m beyond the overbridge. It is also proposed to extend the G4 guardrail on the eastbound carriageway median to link with the eastbound carriageway guardrail east of the Edinburgh Avenue overpass.

The grassed median will be maintained beyond the extent of the guardrail.

The required clear zone is 9.0 m and as a consequence a barrier is required where the residual median width is less than this dimension. This occurs between the Edinburgh Avenue exit ramp gore and a location approximately 100 m east of the Edinburgh Avenue overbridge.

Within the area of the guardrail stabilised decomposed granite gravel paving is proposed.

4.4.2.3 Line Marking

The line marking will require adjustment to suit the new configured lane and merge/diverge arrangements, new lane lines, and edge lines on both shoulders.

4.4.2.4 Street Lighting

The existing street lighting is located within the existing median but is either protected by the G4 guardrail of the median is of adequate width to contain the columns.

4.4.2.5 Stormwater Drainage

In areas of superelevation where the sumps are located on the median edge the sumps and connecting pipe systems will require relocation to within the median.

As in Sections 4.1 and 4.2 the drainage flow paths with the widened pavement have been verified to ensure water build up on the pavement does not contribute to aquaplaning.

5.0 Bridge Widening and Strengthening

5.1 Clunies Ross Street Bridge

5.1.1 Existing Structure

The existing Parkes Way bridges over Clunies Ross Street each carry two traffic lanes, one cycle lane plus shoulders. The existing twin bridges consist of a 3 span twin cell box girder superstructure supported on skewed rectangular piers. The piers are supported by a pilecap and driven steel H piles. The twin cell box girder was constructed insitu on falsework and post tensioned. The abutment consists of a spill through headstock beam supported on driven steel H piles and is orientated at approximately 30 degree skews.

5.1.2 Bridge Widening

The Clunies Ross Street twin bridges are to be widened by 2.8 m to accommodate an additional traffic lane. The widening will take the form of a precast 1215 mm deep modified supertee girder and insitu deck. The supertee girders will be precast and prestressed in the casting yard. The supertee girders will be lifted into place and temporally supported on falsework. Continuity will be achieved by casting a small diaphragm between the ends of the beams. The continuous supertee girder will be supported on pot bearings. The new deck over the girder will be cast in a sequence to maintain stability and minimise sagging moments in the girders at midspan.

The widening will be made integral with the existing deck cantilever. This will be achieved by breaking back the edge of the existing cantilever to expose the reinforcement and the new deck tied into the exposed reinforcement using a stitch pour arrangement. Load restrictions / traffic management will be required during the casting and deck widening.

The cast insitu piers for the widening have been proportioned to match the existing piers. The piers will be finished in an exposed aggregate rope finish to provide a uniform and consistent appearance. The abutment extensions are detailed to match the existing bridge with the stone pitching batter protection to be reinstated. The piers are supported on a common pile cap and driven steel H piles. The abutments headstocks are supported on driven steel H piles, similar to the existing bridge. A corrosion allowance of 2.5mm in accordance with the bridge code has been included in the pile section detailed.

5.1.3 Bridge Strengthening

The load rating report for the original structure identified the following deficiencies under SM1600 design loading:

Component	Live Load Rating
External web of the girder Hogging	0.6
External Web of the girder Sagging	0.6
Internal web of the girder Hogging	Adequate
Internal web of the girder Sagging	Adequate
Shear and Torsion	Not Rated due to illegible drawings
Deck slab cantilever	0.88

The low load rating results apply to the outer webs of the twin cell box girder. The proposed widening changes the global behaviour of the bridge superstructure, significantly reducing the torsion in the twin cell box girder. Legible versions of the web reinforcement drawings have also been located enabling the shear and torsion capacity of the webs to be determined. The revised SM1600 load rating of the existing box girder for the widened structures is as follows:

Design Action	Live Load Rating
Girder – Flexure	
External web of the girder Hogging	1.03
External Web of the girder Sagging	0.92
Internal web of the girder Hogging	1.05
Internal web of the girder Sagging	0.80
External web of the girder (widening side) Hogging	1.15
External web of the girder (widening side) Sagging	0.99
Girder - Shear and Torsion	
Shear and torsion, inner external web (adjacent to widening)	1.05
Shear and torsion, outer external web (opposite to widening)	0.43 (web shear cracking)
Shear and torsion, internal web	0.55 (web shear cracking)
Deck Slab	
Deck slab cantilever	1.05
Deck slab between girder and supertee - Hogging	1.03
Deck slab between girder and supertee - Sagging	1.01
Substructure	
Pier bearings	0.45
Abutment bearings	1.25

The detailed checks have shown there is inadequate shear and torsion capacity in the central web and the external web (girder web furthest from the widening) for the widened superstructure for SM1600 design loading. The calculations have shown the capacity of the webs is limited by web shear cracking

A number of options were considered to strengthen the bridge superstructure. Options considered include:

- Carbon Fibre Reinforced Polymer (CFRP)
- Shear bolts
- External prestress
- Concrete deck overlay

5.1.3.1 Carbon Fibre Reinforced Polymer (CFRP) Strengthening

The CFRP strengthening solution involves epoxy gluing carbon fibre laminates or fabric to the surfaces of the girders. This method can be used to increase the moment and shear capacity of the section provided adequate anchorage of the CFRP can be achieved. In order to guard against collapse of the structure should bond or other failure of the CFRP system occur due to damage vandalism or other cause, the American Concrete institute (ACI) guidelines recommend the structure remain stable while carrying 75% of the live load and 110% of the dead load. In combination with the widening, the Clunies-Ross Street box girders are within this requirement for flexure strengthening but outside this limit for shear strengthening. Strengthening for sagging moments can be achieved by fixing the CFRP to underside of the bottom flange over the midspan region of the girders. Strengthening for hogging moments at the piers is not required. Carbon fibre strengthening for shear was ruled out due to difficult internal access to the webs of the box and the shear strengthening requirements being outside the limits set in the ACI guidelines.

CFRP strengthening works for the main box girder can be constructed from the underside of the superstructure with little impact on the Parkes Way traffic, a reduction in vertical clearance over Clunies Ross Street will be required during the strengthening works to provide temporary access to the underside of box girder. Traffic restrictions (speed and/or load) on the deck may be required for short periods while the epoxy gains strength. The carbon fibre strengthening has minimal impacts on the aesthetics of the bridge.

5.1.3.2 Shear Bolt Strengthening

Strengthening of the webs for shear using vertical bolts involves either internally bonded (grouted) bolts or stress bars placed in holes cored through the webs or external unbonded stress bars positioned adjacent to the outside faces of the webs. To address durability external stress bars need to be contained within a grouted duct or bars are to be made of stainless steel. The use of stainless steel minimises the size of the penetration required to be drilled through the flanges of the box and eliminates the secondary grouting operation thereby reducing construction time and traffic impacts. The design of the strengthening depends on the particular shear deficiency, for flexural shear web cracking the bars provide an additional area of shear reinforcement, for web shear cracking the bars can provide additional area of shear reinforcement and if the bars are stressed, can increase the concrete web capacity due to the additional vertical compression on the concrete.

5.1.3.3 External Prestress Strengthening

The external prestress strengthening solution involves the use of external post tensioning cables. The location of the tendons would be within the box girders due to difficulties of anchoring the tendons external to the box section. To anchor and deviate the tendons, anchor blocks inside the box section are required. To construct the anchors it is necessary to break out sections of the deck and to scabble the inside surface of the box. Depending on the magnitude of the forces a positive anchorage between the scabbled surface and the anchor block may be required. Positive anchors could take the form of epoxy fixed bars or transverse stressing. The Clunies Ross Street girders have a full depth diaphragm across the end of the deck requiring the anchor block to be constructed behind the diaphragm. This would complicate the construction of the end anchor blocks and complicate the reinstatement of the approach slab. At the piers there is an internal post tensioned diaphragm, avoiding the post tensioning at this location will limit the available position for the tendon. It would be necessary accurately locate the reinforcement and tendon prior to coring a hole through the diaphragm for the tendon. The vertical component of the tendons would assist in increasing the shear capacity of the webs.

Although space within the box is limited, it is considered possible to construct the deviators and install the tendons within the box. The construction of the deviators and anchors within the box requires significant localised breakouts of the deck slab, approach slab and abutment upstand wall. The external post tension option has significant staging and traffic management issues during the construction phase. External post tensioning strengthening within the box would have no impact on the appearance of the bridge.

5.1.3.4 Concrete Overlay Strengthening

Overlaying the bridge deck has been investigated as an option to strengthen the superstructure of the Clunies Ross Street bridges. The method involves removing the asphalt surfacing, preparing the deck surface and installing epoxy fixed starter bars into the deck, followed by the construction of a reinforced concrete deck. The deck slab acts compositely with the existing superstructure, increasing the depth of the superstructure to provide the required structural capacity. For Clunies Ross Street a deck overlay thickness of approximately 200-250 mm would be required to satisfy ultimate strength requirements. This would provide the required moment capacity for SM1600 loading, although additional strengthening for shear would still be required. The additional dead load in combination with the SM1600 design loading on the piers increases the load on the pier piles beyond the nominated pile capacity stated on the drawings. The barrier on the cantilever would also need to be replaced to accommodate the additional deck thickness. The concrete overlay option has significant staging and traffic management issues during the construction phase, traffic restrictions / exclusions would be required during placement and curing of the deck concrete.

5.1.3.5 Substructure

The bearings of the existing bridge consist of proprietary pot bearings. The design loading on the pier bearings under SM1600 loading exceed the rated bearing load shown on the drawing. Therefore it will be necessary to replace the bearing with a larger capacity pot bearing. The assessment has shown the pier has adequate capacity for the widened structure with the increased bearing reactions.

The capacity of the existing piles has been assessed and the calculations have shown the serviceability pile loads are within the capacity stated on the drawings. The borehole information from the existing bridge have been used for the assessment of the existing and proposed driven steel H piles.

5.1.3.6 Existing Cantilever and Box Strengthening

The detailed assessment of the existing cantilever has shown the section has adequate capacity for SM1600 design loading. The current arrangement has a 3.3 m wide cycleway running over the external cantilever. The option to prevent traffic entering the cycleway on the cantilever was explored to limit the amount of strengthening required to the main box girder. This could be achieved by raising the level of the cycleway relative to the traffic lanes. The calculations indicated there would be a small amount of saving in the strengthening required for flexure and shear, however it did not eliminate the need for strengthening to the outer or central webs.

The reduction in strengthening works was not considered sufficient to compensate for the addition cost to raise the cycleway and upgrading of the barrier. It was also considered there would also be a loss of flexibility for future traffic lane configurations with a raised cycleway option.

5.1.3.7 Strengthening Solution for Clunies Ross Bridge

The CFRP strengthening in combination with stainless steel shear bolts has been detailed for Clunies Ross Street superstructure. This option was selected as it has the least impact on the Parkes Way traffic and minimal impact on the Clunies Ross Street traffic. The strengthening solution also has a minimal impact on the aesthetics of the existing bridge. Concrete cores to determine the actual strength of the concrete are required to confirm the web shear crushing capacity. The final load rating of the structure will be a function of the actual concrete strength and the web crushing capacity of the web. The relationship between the concrete strength and load rating in combination with the web shear bolt strengthening is tabulated below.

Concrete Strength (MPa)	Central Web SM1600 Rating	Outer Web SM1600 Rating	Superstructure SM1600 Rating
38	1.00	1.00	1.00
37	1.00	0.95	0.95
36	1.00	0.90	0.90
35	0.95	0.85	0.85
34	0.90	0.80	0.80
33	0.85	0.80	0.80
32	0.80	0.75	0.75
31	0.75	0.72	0.72
30	0.72	0.70	0.70

The recovery of cores and testing of the concrete for the bridge could be undertaken as part of the bridge widening works or could be under taken as separate exercise prior to construction.

The 600 tonne capacity bearing at the piers need to be replaced with 900 tonne capacity pot bearing. A review of the geometry at the piers indicates there is sufficient space to place the larger bearing.

The abutment bearings on the westbound and eastbound bearings have a SM1600 load rating of 1.25, therefore they do not need replacing.

The existing piers, abutments and driven H piles have been assessed and have been found to have adequate capacity for SM1600 design loading.

5.2 Sullivans Creek Bridge

5.2.1 Existing Structure

The existing Sullivans Creek Bridge consists of two bridges, one for eastbound traffic and one for westbound traffic. The bridges consist of 3 span continuous post tensioned multi box girder superstructure supported on multiple tapered piers and a common pilecap. The beams were erected in segments with wet joints and post tensioned as simply supported trough girder. The girders at the piers were filled with a reinforced concrete plug to make the girders continuous and finished with a composite insitu deck. There are six girders for the eastbound carriageway and five girders for the westbound direction. The bridges are supported by concrete abutments founded on driven steel H piles and by two sets of tapered reinforced concrete piers located approximately at third points. Each set of tapered piers shares a common pile cap which is supported by steel piles driven into the creek bed below.

5.2.2 1.1.2.2 Bridge Widening

The Sullivans Creek twin bridges are to be widened by 3.8m to accommodate the additional traffic. The widening will take the form of a precast custom trough girder to match the existing beams and an insitu deck. The trough girders will be precast and post tensioned in the casting yard. The trough girder will be lifted into place and temporarily supported while the elastomeric bearings are grouted into position.. Continuity will be achieved using a reinforced concrete plug, similar to the existing bridge. The new deck over the girder will be cast in a sequence to minimise the sagging moments in the girders at midspan. The deck will be tied into the edge of the existing using a stitch pour arrangement. Load restrictions/ traffic management will be required during the casting and curing of the stitch pour. A regular performance level concrete and steel railing barrier will be provided on the edge of the deck widening.

The cast insitu piers and abutments are detailed to match the existing bridge. The substructure is supported on driven steel H piles.

The widening mimics the aesthetics of the existing bridge.

5.2.3 1.1.2.3 Bridge Strengthening

The load rating report identified the following deficiencies-under SM1600 design loadings:

Component	Live Load Rating
Girder Hogging	0.61
Girder Sagging	0.38
Shear and Torsion	0.62
Approach slab	0.77
Deck slab	0.90

The load rating results generally apply to the edge girder of the bridge on the opposite side of the pedestrian walkway. The proposed widening changes the critical edge girder to an internal girder, this improves the SM1600 load rating of the girders as follows:

Component	Live Load Rating
Girder Hogging	0.85
Girder Sagging	0.75
Shear and Torsion1	1.05
Deck slab	1.05

Note 1 - Shear and torsion assessment to AASHTO LRFD Bridge Design Code 2006, assessment to AS5100 provides a live load rating 0.95. The use of the AASHTO approach for shear and torsion design for box section is common practise in Australia and has been approved by the RTA on major bridge projects including the box girders of the WestLink M7 Motorway in Sydney.

A number of options have been considered to strengthen the bridge superstructure. Options considered include:

- Carbon Fibre Reinforced Polymer (CFRP)
- Externally Bonded Steel Plates
- External prestress
- Concrete deck overlay

5.2.3.1 Carbon Fibre Reinforced Polymer (CFRP) Strengthening

The CFRP strengthening solution involves epoxy gluing carbon fibre laminates or fabric to the surfaces of the girders. This method can be used to increase the moment and shear capacity of the section provided adequate anchorage of the CFRP can be achieved. In order to guard against collapse of the structure should bond or other failure of the CFRP system occur due to damage vandalism or other cause, the American Concrete institute (ACI) guidelines recommend the structure remain stable while carrying 75% of the live load and 110% of the dead load. In combination with the widening, the Sullivans Creek girders are within this requirement. Strengthening for sagging moments can be achieved by fixing the CFRP to the underside of the bottom flange over the midspan region of the girders. Strengthening for hogging moments at the piers could not be achieved due to the low ductility of the section in the hogging region resulting in the limiting strain criteria for the carbon fibre being exceeded. CFRP strengthening works can be constructed from the underside of the superstructure with little impact on the road users. Traffic restrictions (speed and/or load) on the deck may be required for short periods while the epoxy gains strength. The CFRP strengthening has minimal impacts on the aesthetics of the bridge.

5.2.3.2 Externally Bonded Steel Plate Strengthening

Strengthening of the section for moment capacity using steel plates involves bolting and bonding steel plates to the surfaces of the girder. Steel plates are particularly effective in regions where the limiting strain criteria of carbon fibre cannot be met. At the piers due to the low ductility of the existing section steel plates are required to be added to the bottom flange of the girder as well as the underside of the top flange to achieve the required design capacity for SM1600 loading.. The plates are fixed in place using heavy duty epoxy anchors.

5.2.3.3 External Prestress Strengthening

The external prestress strengthening solution involves the use of external post tensioning cables. The location of the tendons can be either between the girders or within the box girders. To anchor and deviate the tendons anchor blocks are required to be constructed. To construct the anchors it is necessary to break out sections of the deck and to scabble the surface of the girders. Depending on the magnitude of the forces, a positive anchorage between the scabbled surface and the anchor block may be required. Positive anchors could take the form of epoxy fixed bars, transverse collar beams or transverse stressing. The Sullivans Creek girders are open ended at the abutments, this would allow the construction of a plug and beam anchor block arrangement across the ends of the beams. At the piers there is an internal concrete plug providing continuity for shear and moments. For an internal tendon arrangement it would be necessary to core a hole though the plug for the tendon. The reinforcement of the concrete plug indicates there is potentially enough space between the existing bars to core the required hole.

Experience on recent projects has shown it is difficult to anchor external tendon deviators at the piers between girders without the use of a collar beam or transverse prestress. The use of a collar beam under the soffit of the girders extending across the full width of the deck, either side of the piers would distract from the general appearance of the bridge. The preferred location for the external tendons would to place the tendons within the existing girders. Although space within the box is limited, it is considered feasible. The construction of the deviators and anchors within the box would require significant localised breakouts of the deck slab. For either option it will be necessary to break out sections of the deck to anchor the deviators and construct the abutment anchor blocks. The external post tensioning option has significant stagging and traffic management issues during the construction phase. External tendon strengthening within the box would have no impact on the appearance of the bridge whereas placing the tendons between the girders would have a moderate impact on the appearance of the bridge. Due to the significant cost and traffic disruptions to construct an external prestress solution, this option was not considered viable compared to the carbon fibre/steel plate strengthening.

5.2.3.4 Concrete Overlay Strengthening

Overlaying the bridge deck was investigated as an option to strengthen the superstructure of the Sullivans Creek Bridges. The methods involves removing the asphalt surfacing, preparing the deck surface and installing starter bars into the deck followed by the construction of a reinforced concrete deck. The new deck slab would act compositely with the existing superstructure, increasing the depth of the superstructure to provide the required structural capacity. For Sullivans Creek, a deck overlay thickness of approximately 200-300 mm would be required to satisfy ultimate strength requirements, however stress checks under serviceability loading show the stresses across the unreinforced segment joints go into tension due to the additional dead load from the concrete overlay. Tension across the segment joints is not permitted in the bridge code, therefore this option was not considered viable for strengthening Sullivans Creek superstructure.

5.2.3.5 Substructure

The bearings of the existing bridge consist of proprietary laminated elastomeric bearings. The drawings indicated they were manufactured by Firestone, enquiries with RTA and bearing suppliers to date have indicated the bearings may have been manufactured in accordance with NAASRA Bridge Design Code 1974 which references AS1523, a copy of the draft (metric) AS1523 was available on the Standards Australia website. A copy of an old Advanx elastomeric bearings catalogue complying to NAASRA/AS1523 was provided by Ludowici Pty Ltd. Bearing matching the Sullivans Creek bearing geometry are noted in the Advanx catalogue.

Based on advice received from members of the AS5100 bridge bearing committee, it is understood that the fundamental design rules for the design of elastomeric bearings have not changed since the NAASRA/AS1523 design codes. Using the design rules in AS5100, the existing bearing have been checked for compliance for T44 and SM1600 design loadings. The results show the existing pier and abutments bearings meet the requirements of AS5100.6 for T44 design loading with the exception of the minimum steel plate thickness which does not satisfy current requirements although it satisfied the earlier design codes. The load rating under SM1600 loading is 100% for the abutment bearings with a 10% exceedance on fatigue limits. This indicates the bearings may have a reduced life under SM1600 loading. The pier bearings have a SM1600 load rating of 70%.

A recent detailed inspection of the bearing was carried out by others (ACT Bridges Difficult Access Components Inspection, Final Report 3 May 2011, SMEC). The report recommended bearings with a condition rating of 3 and 4 be replaced. The report identified nine of the ten piers on the westbound carriageway have one or more bearings rated 3 or 4. All bearings on the eastbound bridge were rated 2.

There is no like for like standard bearing in the AS5100 bearing range and there is no standard elastomeric bearing that will meet the geometric constraints of the piers and carry the SM1600 design loading. It is therefore proposed to replace the twin bearing under each web with a single larger standard bearing. As the replacement single bearing has a different configuration and stiffness to the existing twin bearings, both sets of twin bearings are required to be replaced at the pier. As nine of the ten piers on the westbound carriageway are required to be replaced due to poor inspection rating, to achieve SM1600 load rating compliance the bearings at the tenth pier have also been detailed to be replaced. Replacement of the bearings will require lane closures and traffic speed restrictions during the jacking and grouting procedures.

For the eastbound bridge, the bearing suppliers have indicated that bearings can take up to 150% of their rated load, if a bearing could be retrieved undamaged (noting the existing detail is epoxy boned to the top and bottom attachment plates) it could be tested to determine the actual ultimate capacity. Using this information a significantly higher rating for the existing pier bearings could be achieved without replacing the bearings on the eastbound bridge. A provisional item has been included in the quantities to cover the replacement of the pier bearings on the eastbound bridge.

The load rating report identified the approach slab had insufficient moment capacity for SM1600 loading. The moment carried by the approach slab is a function of the area of support provided by the embankment behind the abutment. More or less support will change the design actions in the approach slab. The approach will crack as it reaches its design capacity and will deflect and engage a larger area of supporting soil in turn reducing the moments in the slab. As the consequences of overload will only lead to cracking and deflection of the approach slab, strengthening of the approach slab is not recommended as has not been detailed in the design drawings.

The capacity of the existing piles has been assessed based on the existing drawings and borehole date. The assessment has indicated the existing steel H piles have adequate capacity for the SM1600 design loadings.

5.2.3.6 Strengthening Solution for Sullivans Creek Bridge

A carbon fibre and steel plate strengthening solution has been detailed for the flexure strengthening of the existing girders. This option was selected as it provided the necessary structural capacity with the minimal impact on the Parkes Way traffic with all the work being undertaken from the underside of the bridge deck. The strengthening solution has a minimal impact on the aesthetics of the existing bridge.

Strengthening for shear and torsion is not required with the current design having a SM1600 load rating of 1.05 using the provision of the AASHTO LRFD Bridge Design Code.

The pier bearings for the westbound bridge are detailed to be replaced based on the recommendations of earlier study by others. The pier bearings for the eastbound bridge have not been detailed to be replaced, this will be subject to successful recovery and testing of the bearings from the westbound bridge to determine load capacity. Based on design calculations the bearings have a SM1600 load rating of 0.70. The abutment bearings on the westbound and eastbound bridges have a SM1600 load rating of 1.0, therefore they do not need replacing.

The existing piers, abutments and driven H piles have been assessed and have been found to have adequate capacity for SM1600 design loading.

6.0 Acton Tunnel Lighting

6.1 Acton Tunnel Lighting Design

TaMS engaged AECOM to complete an investigation of lighting upgrades to the Acton Tunnel as part of a program to progressively upgrade street lighting in the ACT. A copy of the complete report is included in Appendix A.

Acton Tunnel on Parkes Way is Canberra's longest tunnel, at approximately 190 metres long and caters for large volumes of traffic on a daily basis.

The majority of the tunnel's existing lighting infrastructure is original equipment from building of the tunnel approximately 30 years ago. The tunnel has separate carriageways for east and west bound traffic, each with three lanes and a bicycle/emergency stopping lane. The tunnel floor is concrete, and the walls clad in 9 mm thick AC sheeting. The extent of other services in the tunnel is limited to fire sprinklers. Ventilation systems only occur in the car-parks located over the tunnel.

6.1.1.1.1 Interior Wall Surface Finishes

To achieve the best possible lighting design for the tunnel in terms of Standards compliance, energy use minimisation, long-term maintenance and driver seeing conditions, the lighting upgrade design allows for the existing wall cladding to be replaced with new cladding which will give higher light reflectivity and greater resistance to dirt build-up. An example of an appropriate cladding material is Alpolic aluminium panels. The preferred solution of TaMS is to use 2.4 m high panelling on the lower portion of the wall, and to paint the remaining upper portion of the wall with suitable high-reflectivity paint.

6.1.1.1.2 Building Impacts of Lighting Works

The removal of the existing lighting will create a continuous gap the length of each tunnel on each side of the ceiling. This gap will open into the ceiling void. Remedial work to these ceilings was not included in the scope of the lighting upgrade design, and it may be appropriate to incorporate this work into the Parkes Way widening project.

6.1.1.1.3 Fire Sprinkler System

The state of the fire sprinkler system in the tunnel is unknown at this stage. It may be appropriate to investigate the state of repair and code compliance of the fire systems in the tunnel as part of the Parkes Way widening works.

6.1.1.1.4 Asbestos in Tunnel

The existing work-as executed drawings for the tunnel indicates that the wall cladding material and ceiling panelling contains asbestos. The removal and replacement of wall linings is part of the works under the contract.

Where lights are placed in the ceiling sufficient portions of the lining will be removed to allow the installation of the new lights. There will be gaps in the ceiling lining following the installation of the lighting.

7.0 Improvements to the Intersection of the entry ramps from Parkes Way and London Circuit to Commonwealth Avenue

Improvements to the intersection of the entry ramps to Commonwealth Avenue from the Parkes Way and London Circuit are included in the works.

The East West corridor Study identified that queue on the ramp from Parkes Way to Commonwealth Avenue will increase with increased growth along the Parkes Way corridor primarily as a result of the development in Molonglo and also from increased demand from the GDE connection to Parkes Way at Glenloch Interchange.

This report investigates and documents the findings of a scheme to signalise the intersection of these ramps as a low cost interim measure until such time as the NCA fund an interchange that connects all movements to these two arterial roads.

7.1 Location

The location of the study is focussed on the intersection of the London Circuit and Parkes Way ramps as shown in Figure 7-1.

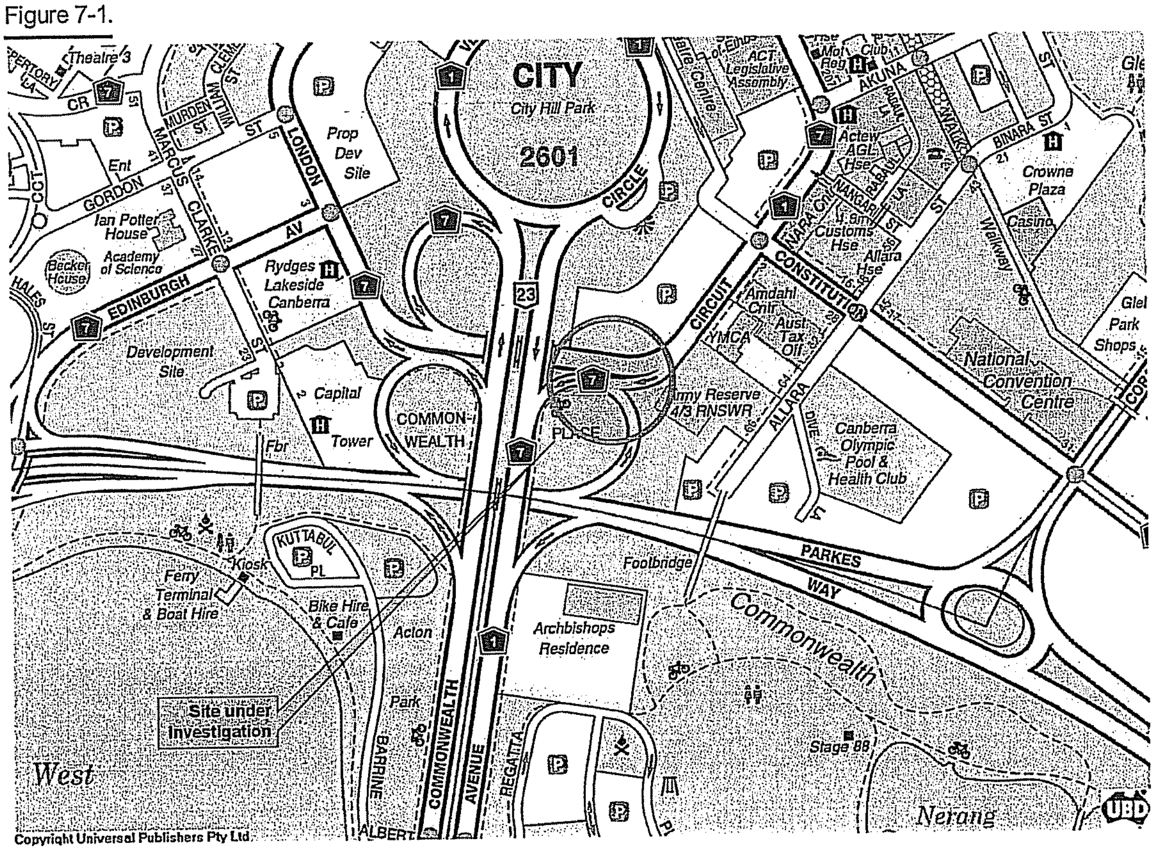


Figure 7-1 Location of Study

7.2 Existing Situation

The existing situation at this interchange is that the off ramp from London Circuit to connect to Commonwealth Avenue has priority over the Parkes Way ramp connection to Commonwealth Avenue. This control provides priority for buses but results in queues onto Parkes Way.

The observed traffic volumes in February 2010 are shown in Figure 7-2.

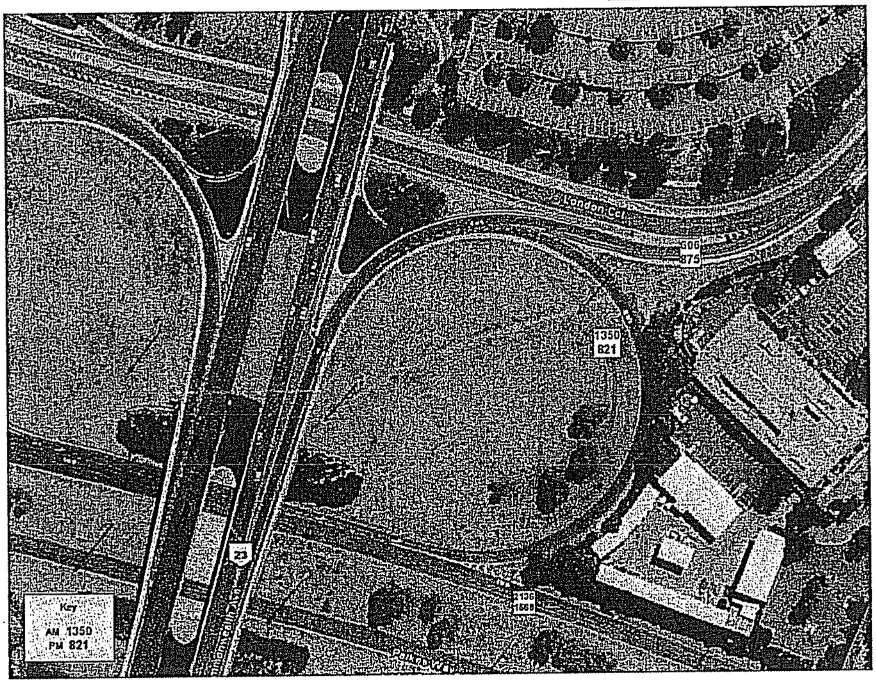


Figure 7-2 Observed Traffic volumes February 2010

Source AECOM 2010

The intersection was modelled using AA Sidra 3.2 with the 2010 existing traffic flows. On site observations showed that the queue often extends back to the Acton Hotel on ramp so as to block joining traffic. The Sidra analysis showed that the intersection is currently performing as shown in and is considered to reasonably represent the existing traffic conditions.

Performance Measure	AM		PM	
	Parkes Way Ramp	London Circuit Ramp	Parkes Way Ramp	London Circuit Ramp
Degree of Saturation	1.106	0.327	1.019	0.472
Average delay seconds	117.3	0	64.1	0
Level of Service	F	A	E	A
Queue m	599	0	222	0

This quantifies the extent of congestion and delay at this intersection and demonstrates that during peak periods there are extensive delays and queues on the Parkes Way ramp.

7.3 Proposal

The proposal to reduce the queuing back onto Parkes Way is to channelize the intersection and create a merge from the two segregated lanes at the junction with Commonwealth Avenue.

Signalisation of the intersection was investigated. However, in order to minimise queues the SIDRA analysis indicated it was also necessary for the signal cycle times to be kept quite short. It is also necessary to ensure that buses exiting the City along London Circuit were not unduly delayed. Therefore as a result of this analysis it was shown to be necessary for the ramp signals to do four cycles to one as at the adjacent intersection of Constitution Avenue / London Circuit i.e. runs at a 30 second cycle time with a 3 second yellow and a one second all red period

Two options were tested:

- Retaining the existing lane configuration and
- Adding a short lane to Parkes Way ramp.

These configurations are shown in Figure 7-3 and Figure 7-4.

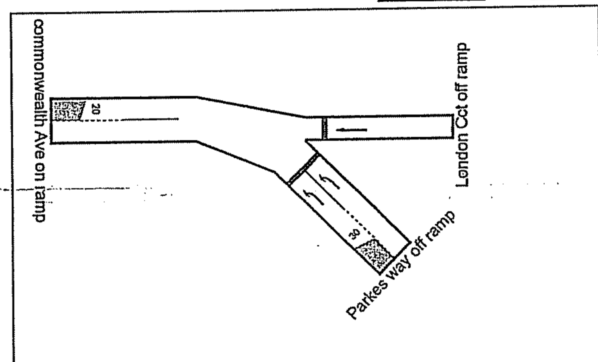


Figure 7-3 Indicative current geometry

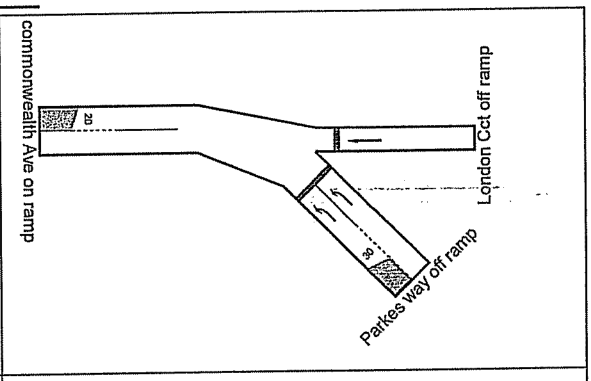


Figure 7-4 Two lane Approach from Parkes Way

The results of the analysis are shown in Table 7-1and Table 7-2.

Table 7-1 Intersection Performance Characteristics Signalised Existing Geometry

Performance Measure	AM		PM	
	Parkes Way Ramp	London Circuit Ramp	Parkes Way Ramp	London Circuit Ramp
Degree of Saturation	1.,843	0.787	1.121	1.138
Average delay seconds	1542	2.3	248.3	254.1
Level of Service	F	A	F	F
Queue m	3416	26	571	640

Table 7-2 Intersection Performance Two Lane Approach on Parkes Way Ramp

Performance Measure	AM		PM	
	Parkes Way Ramp	London Circuit Ramp	Parkes Way Ramp	London Circuit Ramp
Degree of Saturation	1.010	1.049	0.84	0.976
Average delay seconds	57.9	99.4	24.3	25.5
Level of Service	E	F	B	B
Queue m	263	233	56	157

Note assumed that 3 second yellow and 1 second all red to take account of lower speeds in this environment

If it were possible to operate the signals more like ramp metering with very quick cycle times of 20 seconds and only a 2 second yellow period with a one second all red, then the scheme would operate very well at Los C in both the AM and the PM. The practicality of such a scheme however would need to be assessed not only against the signal performance but also the safety aspects of very short displays which generally do not operate in Canberra – (an exception being the pedestrian signals on Bunda Street at the Canberra Centre).

The results from this assumption are shown in the table below.

Performance Measure	AM		PM	
	Parkes Way Ramp	London Circuit Ramp		
Degree of Saturation	1.028	0.866	0.840	0.854
Average delay seconds	59.1	3.4	24.3	5.7
Level of Service	E	A	B	A
Queue m	230	36	56	69

The conclusion from all of this analysis is that it is possible to improve the delays at the intersection of these two ramps from existing. In the peak periods the cycle time would need to operate at 30 seconds but with only 2 seconds yellow display period and one second all red.

This shows that the solution is extremely sensitive to the yellow and all red times and also the driver reaction times in stopping and starting.

As a result of these negative aspects a decision was made to channelize the junction adopting 4.3 m wide traffic lanes separated by a 2m wide median. The 2 m wide median allows on road cyclists to safely cross the 2 lanes near the Commonwealth Avenue as a two stage crossing.

The merge of the two segregated lanes prior to Commonwealth Avenue is 50 m long allowing a diverge rage of 1.0 m/s at a 50 Km/h design speed.

8.0 Existing Utilities

8.1 Sewer

There is a 750 mm diameter trunk sewer main (North Canberra MOS) crossing Parkes Way at a 45 degree skew between Sullivans Creek Bridge and the Action Tunnel. This main connects to two maintenance pits on the outer verge of each carriageway. This main should have sufficient cover depth so as not to be impacted on by the proposed road widening; however, care will need to be taken during construction works to ensure the integrity of the asset. There are also two 150 m diameter risings mains, operational and decommissioned, crossing Parkes Way at Black Mountain Peninsula to the north of Garryowen Drive.

8.2 Water Supply

There is a 450 mm diameter bulk supply water main crossing Parkes Way to the west of Clunies Ross Street Bridge. There are also two 150 mm diameter reticulation mains crossing Parkes Way to the east and west of the Acton Tunnel. The proposed work should not impact on these services.

8.3 Electricity

There is a 50 mm diameter streetlight cable along the outer verge of each carriageway at the Glenloch Interchange. These cables then move to the median to service the existing street light columns between Glenloch Interchange and near Clunies Ross Street and then move back to the outer carriageway verges. The cables extend along the outer verges of Parkes Way to the Acton Tunnel. The streetlight cabling crosses Parkes Way at the following locations:

- Midway between Glenloch Interchange and Clunies Ross Street Bridge
- Either side of Sullivans Creek Bridge and
- Either side of the Acton Tunnel.

There is a second electrical cable running parallel to the existing street lighting cable located in the Parkes Way median between the Black Mountain escarpment area and the last median located streetlight immediately west of Clunies Ross Street. At present the function of this cable is unknown and therefore requires confirmation in the final stage of design.

There are two locations where HV electrical cables cross the Parkes Way carriageways, there is an overhead HV cable crossing Parkes Way to service Black Mountain Peninsula along Garryowen Drive, and the other instance the underground cable approximately 200 m east of the Acton Tunnel.

There are 6 x 100 mm diameter conduits in a 2 x 3 configuration located in the east-bound shoulder of the road through the ACTON tunnel and continuing to the end of the retaining wall. These cables do not appear to be affected by the works. Discussion will continue with ActewAGL relating to the status of this cable.

8.4 Stormwater

There is no accurate stormwater information available along Parkes Way between Glenloch Interchange and Sullivans Creek Bridge. Previous survey has identified a number of sumps within the median which will require relocation for the proposed widening.

The extent of relocation work is discussed in the carriageway analysis Section of this Report.

8.5 Communications

There are existing 100 m PVC TELSTRA conduits located along the outer verge of the westbound carriageway between Sullivans Creek and Garryowen Drive. These services should not be impacted by the proposed widening.

8.6 Proposed Utilities

No additional provisions for utilities are proposed as part of this project.

However ActewAGL is installing a HV main from the Black Mountain sub-station to the new Nishi hotel site on Edinburgh Avenue. This route of the cable is along Clunies Ross Street crossing Sullivans Creek upstream of Parkes Way prior to passing beneath the eastern bridges (within the cycle path), and continuing on the southern side of Parkes Way, clear of the road works prior to crossing Parkes Way near the Edinburgh Avenue exit ramp.

The crossing of Parkes Way at this location will be via a bored crossing.

ActewAGL have advised that these works will be carried out in June 2011.

9.0 Pavements

The existing pavement configurations as noted on the works-as-executed drawing are as follows:

Glenloch Interchange to Clunies Ross Street:

i) Traffic lanes:

- 50 mm asphaltic concrete
- 100 mm fine crushed rock
- 100 mm crushed rock base
- 300 mm select fill..

ii) Shoulders:

- 10 mm flush seal
- 100 mm fine crushed rock
- 250 mm select fill

Clunies Ross Street to Edinburgh Avenue

i) Traffic lanes and shoulders:

- 100 mm asphaltic concrete
- 200 mm fine crushed rock base
- 180 mm crushed rock base

ii) Ranges

- 100 mm asphaltic concrete
- 200 mm fine crushed rock base
- There have been at least two applications of seals to the pavement since construction as well as some crack sealing prior to the re-seals.

The final pavement design for the pavement widening is as follows

- 50 mm SMA 14 (A15E)
- 10 mm seal
- Prime
- 170 mm DGB 20
- 150 mm DGS20:

This pavement design is based on:

- Design in accordance the Austroads AGPT02-10 "Guide to Pavement Technology Part 2: Pavement Structural Design" (the Guide) and ACT Design Specification 06 Pavement Design.
- A design subgrade CBR value of 10% as recommended in the geotechnical investigation report prepared by ACT Geotechnical Engineers Pty Ltd.
- The average AADT between Glenloch Interchange and Clunies Ross Street of 44,000 in 2011, 48,000 in 2021 and 1,000 in 2031 in accordance with the East-West Corridor Infrastructure Study, of which 3% are assumed to be heavy vehicles (Austroads Classes 3 to 12).
- The traffic load between Clunies Ross Street and Edinburgh Avenue being 18% greater than the traffic between Glenloch Interchange and Clunies Ross Street, based on the measured 2010 peak hour volumes.
- A pavement design life of 20 years.

- A lane factor of 0.5 in accordance as recommended in the Austroads Guide for the median lane of a three-lane carriageway.
- 1.8 Equivalent Standard Axles (ESA) per heavy vehicle, being the Austroads presumptive urban axle load distribution.

Based on the above information the design traffic load is 7.7 x 10^6 ESA between Glenloch Interchange and Clunies Ross Street and 9.1 x 10^6 ESA between Clunies Ross Street and Edinburgh Avenue. As there is little difference in the pavement thickness between these two traffic loads a design for the higher value has been used.

Based on the above data, the pavement thickness design was obtained from the Austroads Guide. A stone mastic asphalt (SMA) surface is recommended to provide adequate texture and friction, particularly in the potential icy areas at the foot of Black Mountain.

10.0 Environmental Considerations

10.1 Introduction

The proposal, while not located on Commonwealth land, is adjacent to and 'upstream' from Lake Burley Griffin. Lake Burley Griffin is Commonwealth owned and controlled land. It is therefore subject to the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Lake Burley Griffin possesses a broad array of natural and cultural heritage values. This array includes the natural values of the wetlands and aquatic habitat provided by the Lake; historic heritage values relating to the shape and form of the Lake as a designed landscape; its foreshore plantings; designed foreshore parklands; the Lake's role as the setting for the surrounding national institutions; its reflective qualities; lake-based activities and uses; and the relationship to views and vistas of surrounding land, particularly Mount Ainslie, Black Mountain and the Parliament House Vista (land axis). The following sections detail impact assessment of the proposal against these key values.

10.2 Heritage and Ecological Aspects

Although the proposed works are actually outside of the Lake Burley Griffin heritage listed area, the works border the area in some parts, particularly in the vicinity of the Sullivans Creek outlet. Accordingly, consideration has been given to the potential implications of the proposed works, in relation to the heritage values ascribed to the area.

Lake Burley Griffin is Commonwealth owned and controlled land. It is therefore subject to the provisions of the EPBC Act. Lake Burley Griffin possesses a broad array of heritage values which meet the threshold for Commonwealth Heritage value under criteria A (historic), B (rarity), C (scientific), D (representative), E (aesthetic), F (creative and technical), G (social) and H (associative). They also contribute to the identified National Heritage values of the Lake Burley Griffin under criteria E (aesthetic) and F (creative and technical).

This array of heritage values includes the natural values of the wetlands and aquatic habitat provided by the lake; historic heritage values relating to the shape and form of the lake as a designed landscape; its foreshore plantings; designed foreshore parklands; its role as the setting for the surrounding national institutions; its reflective qualities; lake based activities and uses; and the relationship to views and vistas of surrounding land, particularly Mount Ainslie, Black Mountain and the Parliament House Vista (land axis).

To guide the management of Lake Burley Griffin and Adjacent Lands the NCA has prepared a heritage management plan (HMP) to identify, protect and manage the heritage values. The HMP has been prepared in accordance with the heritage management principles and requirements for management plans set out in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The EPBC Act requires places with Commonwealth and National Heritage values to be managed according to established conservation principles. Schedules 5B and 7B of the *Environment Protection and Biodiversity Conservation Regulations 2000* set out seven Commonwealth Heritage management principles. They encourage the identification of a place's heritage values and their conservation and presentation through the application of the best available skills and knowledge. They also encourage community (including Indigenous community) involvement and co-operation between the various levels of government.

Within the HMP key heritage management policies and actions for Lake Burley Griffin are put forward. The following components of these policies and actions are relevant to the proposed works:

- Component 1 - The lake as a designed landscape.
- Component 2 - Water body of the lake as an ecosystem and aquatic habitat.
- Component 7 - Westlake.

Table 3 provides a response to the relevant actions identified within each of these components. A response is provided as to how the proposed works respond to these actions.

Table 3 Details of the proposed works in relation to relevant actions for the Lake Burley Griffin Heritage area

Actions	Relevance to the proposed works
Component 1 - The lake as a designed landscape	

Actions	Relevance to the proposed works
C1-1 Conserve and manage the integrity of the formal design elements of the Study Area deriving from the Griffin plan and the later design and construction of the lake and its foreshores.	The proposed works are located outside of the Lake Burley Griffin heritage area. Notwithstanding, planning has sought to reflect the current design elements present within the vicinity of the Sullivans Creek area. Specifically, the design of the additional pile caps to be placed in stream has been matched to existing structures. As a result the proposed works are expected to have a negligible impact on the integrity of the formal design elements of the Lake Burley Griffin heritage area.
C1-3 Conserve and manage the aesthetic values of the lake which are particularly valued by the community.	As noted above, the proposed works are not expected to impact on the aesthetic values of the lake, given that the works themselves are located outside of the Lake Burley Griffin heritage areas, and the design of the works has been matched to existing structures.
C1-7 Provide the public with free and open access to the lake's waters.	The proposed works would not impede the public's access to the lake. Whilst there may be some temporary difficulties accessing the lake via Sullivans Creek during works, these impacts are expected to be minor. Effective consultation with the local community and up to date information on the status of the works, and access arrangements would assist in mitigating any minor impacts during construction.
C1-8 Ensure the lake is available and accessible for a range of uses at all times.	The proposed works would likely involve some short term disruptions to access of the lake from Sullivans Creek during construction. It is proposed however to maintain access as far as practicable for recreational water craft during in stream works. Effective consultation with the local community and up to date information on the status of the works, and access arrangements would assist in mitigating any minor impacts during construction. Following construction, accessibility of the lake would remain unchanged from the current situation.
C1-10 Recognise the strong community attachment to the heritage values of Lake Burley Griffin through regular liaison on proposals affecting the future uses and development of the place.	The proposed works would involve a complimentary consultation programme that would seek to provide regular community information on the status of works, and provide opportunities for members of the public to voice concerns, raise complaints, or enquire about the status of works.
Component 2 - Water body of the lake as an ecosystem and aquatic habitat	
C2-1 Manage the lake as an aquatic habitat for a range of native species including the Murray cod.	The proposed works would have the potential to impact on the water quality of Sullivans Creek, and therefore Lake Burley Griffin, particularly during the emplacement of structures to support the pile caps. The development of site specific management measures to address potential impacts is expected to effectively mitigate potential for adverse impacts. Such mitigation measures could include the emplacement of a silt curtain around in stream works to minimise the potential for sedimentation of the lake, and the implementation of supporting construction management arrangements to manage the potential for spills, or other adverse environmental impacts. The combination of these measures would be included in a construction environmental management plan (CEMP) adopted for the proposed works.
C2-2 Manage the water quality of the lake in order to maintain recreational uses (yachting, boating, swimming, etc.).	As noted above, works would be subject to a number of site specific mitigation measures to be incorporated into a CEMP. It is expected that the implementation of these measures would effectively manage potential for adverse impacts, such that water quality would not be impacted by the proposed works.

Actions	Relevance to the proposed works
C2-3 Ensure that Service Contracts for asset management of the lake and foreshores are consistent with the protection and conservation of identified historic, indigenous and natural heritage values.	Asset management arrangements for the proposed works would be consistent with existing arrangements. It is expected that on-going management of these assets would therefore be consistent with the protection and conservation of identified historic, indigenous and natural heritage values.
Component 7 - Westlake	
C7-1 Conserve and manage the aesthetic and other heritage values of Westlake.	The proposed works would result in the addition of four pile caps in Sullivans Creek, wholly consistent with the existing pile caps currently in place. The addition of extra carriageway on Parkes Way over Sullivans Creek is expected to have negligible impact on the aesthetic and heritage values of Westlake.
C7-2 Conserve and manage the lakeside vegetation on 'soft' foreshore edges for shoreline stability, aesthetic values and visual amenity.	The proposal would not result in any changes to the current foreshore arrangements in the long term. Some construction work may involve activities that utilise access from the shoreline within Sullivans Creek. These works would be short term, and subject to controls developed in the CEMP to be implemented during the works.
C7-3 Manage the lakeside vegetation on 'soft' foreshore edges to protect and enhance habitat values.	The proposed works would not adversely impact the 'soft' foreshore edges of Lake Burley Griffin. Site specific mitigation measures developed in the CEMP would ensure that habitat values of Lake Burley Griffin would be protected during works.

Based on the consideration of the actions identified for the relevant components of the HMP for the Lake Burley Griffin heritage area, and how these might apply to the proposed works, it is expected that no significant adverse impacts to the heritage values of the lake would result from the proposed works. Based on this consideration, it is therefore not necessary to complete a heritage impact statement for the proposed works.

10.3 EPBC Self Assessment

In the interests of completeness, a self-assessment was conducted to determine if there was any likelihood of the Proposal having a significant impact on matters protected under the EPBC Act. The report (included in Appendix B) presents the results of the self-assessment, in accordance with significance criteria set out in the Significant Impact Guidelines 1.1 (DEWHA 2009) and 1.2 (DEWHA, 2010).

The assessment determined whether a referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) for a decision by the Commonwealth environment Minister on whether further assessment and approval may be needed for the Proposal.

A self-assessment under the EPBC Act was deemed necessary in regards to the following criteria:

- Any person who proposes to take an action which is either situated on Commonwealth land or which may Impact on Commonwealth land.
- Whether the action will have, or is likely to have, a significant impact on a matter of national environmental significance.

Taking the above information into consideration, impacts from the Proposal on matters of NES were expected to be minor to negligible. On this basis, a referral to the Commonwealth Department of Sustainability, Environment, Water and Communities was deemed unnecessary.

11.0 Construction Phasing and Temporary Traffic Management

11.1 Construction Phasing

The traffic will be diverted to the shoulder and the adjacent traffic lane. Temporary traffic management is dependent on the length of sections of the road that would be tolerable to motorists travelling at low speeds through the work area.

The works will be staged as follows:

i) Separable Portion 1: Bridge widening works

ii) Separable Portion 2: Street lighting relocations

iii) Separable Portion 3: Pavement widening and retaining wall reconstruction works

iv) Separable Portion 4: Bridge strengthening works

11.2 Temporary Traffic Management

The widening into the median allows the creation of suitable work spaces by relocating the outer traffic lanes onto the existing sealed shoulders.

The through lanes are narrowed to 3.0 m in width and work spaces of 3.0 m width can be created between the edge of the construction and temporary concrete barriers flanking both sides of the median works area. A width of 1.0 m is allowed to accommodate any deflection in the barrier within the 3.0 m work zone.

The Works-as Executed drawings show the shoulders of Parkes Way between Glenloch Interchange and Clunies Ross Street as having reduced pavement layers and no asphaltic concrete surfacing, only 10 mm flush seal.

To minimise potential damage to the shoulder from trucks it is proposed to sign the left lane (shoulder) to exclude trucks. An assessment

There will be a permanent 60 Km/h speed limit through the works area. Construction works will be permitted at all times with no interruptions to traffic during the morning and evening peak hour periods Monday to Friday.

These arrangements, which are generally typical for the whole length of Parkes Way, are shown on the drawings.

11.3 Construction Site Compounds

The major construction compound is proposed to be located in the median between the Clunies Ross Street and Sullivans Creek bridges.

Secondary site compounds are proposed within the median at the Glenloch Interchange and Edinburgh Avenue ends of the project.

12.0 Landscaping

12.1 Tree Removal

The areas of tree removal are:

- Median: 46 trees.
- Above retaining wall: 10 trees.
- Verges between Glenloch Interchange and Clunies Ross Street: 5 trees related to the relocation of street lighting columns. These numbers are presently under review given the NCA response to the DA where they have requested that full cut-off lighting be used inlieu of the designed aero screen fittings. Additional trees will probably need to be removed if this requirement is non-negotiable.

A tree assessment report was prepared and submitted with the Works Approval plans to the NCA.

A copy of the tree assessment report is contained in Appendix C.

12.2 New Works

Landscaping on the project is proposed as follows:

i) Replacing the residual grass median between Glenloch Interchange and the west portal of the Acton Tunnel with stabilised decomposed granite gravel paving.

ii) Revegetating, consisting of dryland grassing and new Eucalyptus Pauciflora trees, of the Parkes Way median between Clunies Ross Street and immediately west of the Acton Tunnel portal.

iii) Reinstating the landscape removed above the retaining wall between the eastern portal of the Acton Tunnel and the Edinburgh Avenue exit ramp

The extent of the reinstatement is approximately 10 m behind the existing wall based on preliminary designs for the replacement walls and envisaged temporary batter slopes of 1(H) to 4(V) with soil railing stabilisation of the batter slope.

The Work-as-Executed drawings indicate that the original plantings were Eucalyptus Mannifera at approximately 8 to 10 m spacing within a rock mulch bed. The new planting will consist of Eucalyptus Pauciflora trees and Acacia, Callistemon and Grevillea shrubs.

iv) The median treatment between the Edinburgh Avenue exit ramps and the end of the G4 guardrail approximately 150 m north of the Edinburgh Avenue overpass will be stabilised decomposed granite gravel paving given the flanking guardrail and difficulties of maintaining soft landscape surfaces. At the end of the guardrail the treatment will revert back to the present dry land grass surface.

13.0 Estimate of Cost

The estimate of cost for the proposed works based on the DR designs is $20.46M inclusive of GST, broken down as follows:

Preliminaries	$475,000
Traffic management	$320,000
Earthworks	$1,179,200
Utilities generally	$193, 800
Stormwater drainage	$562,900
Subsoil drainage	$278,600
Pavements	$1,901,5 00
Kerbing and paving	$794,000
Road furniture	$503,400
Incidental works	$1,045,000
Landscape	$32,300
Road signs	$15,200
Pavement marking	$46,300
Street lighting	$304,400
Clunies Ross Street bridge widening	$2,442,500
Clunies Ross Street bridge strengthening	$1,053,900
Sullivans Creek bridge widening	$2,888,700
Sullivans Creek bridge strengthening	$985,000
Acton Tunnel Lighting	$3,577,600
Sub Total	**$18,599,300**
GST	$1,860,000
TOTAL	**$20,459,300**

AECOM Australia Pty Ltd has no control over the cost of labour, materials, equipment or services furnished by others, neither has it control over contractors methods for determining prices, competitive bidding or market conditions. The assessment of probable construction cost produced by AECOM will be made on the basis of our best judgement as an experienced and qualified engineering consultant, familiar with the construction industry. As AECOM is not a qualified Quantity Surveyor, nor does it employ quantity surveyors, AECOM cannot and will not guarantee that any tenders or actual construction costs will not vary from this assessment of probable construction cost.

Appendix A

Acton Tunnel Lighting Upgrade Report

Appendix A Acton Tunnel Lighting Upgrade Report