Main Roads WA

Concept Design Report

Bridge 3950A, Cundinup West Rd over Padbury Brook, Shire of Nannup

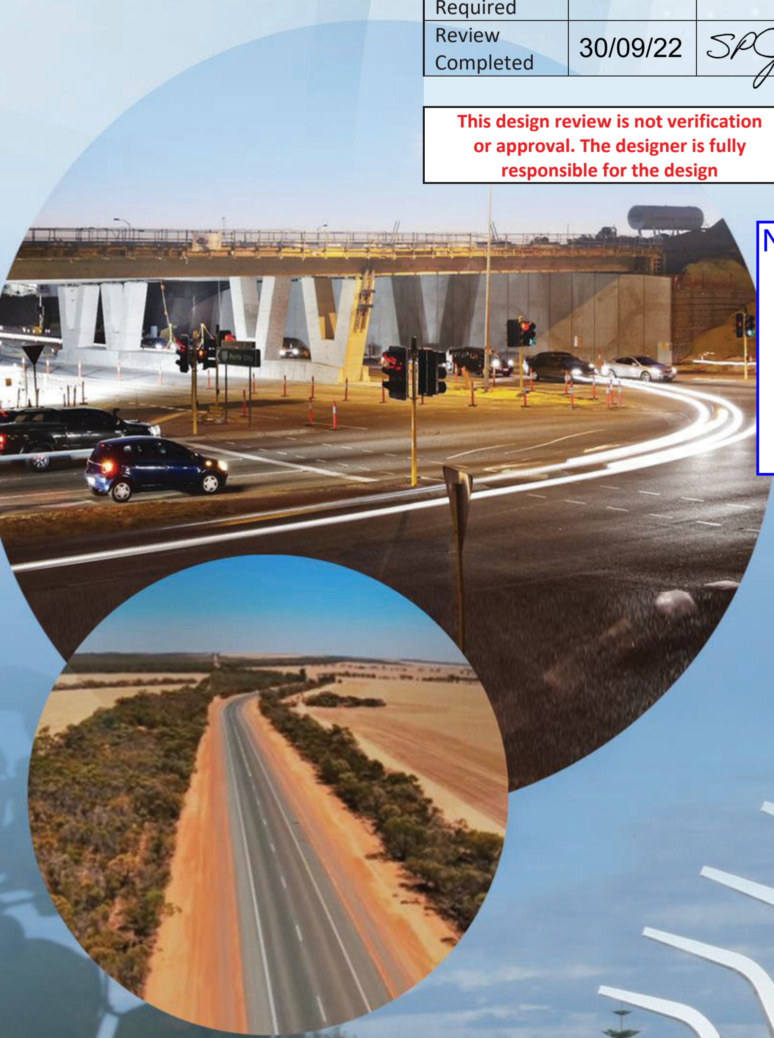
CW1200141

September 2022

15% Revew	Date	Signed
	19/9/2022	[signature]
Review Required		
Review Not Required		
Review Completed	30/09/22	[signature]

This design review is not verification or approval. The designer is fully responsible for the design

No further comments



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Bridge 3950A, Cundinup West Rd over Padbury Brook, Shire of Nannup

CW1200141

Prepared for:
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9 September 2022

CW1200141

Revision History

Version	Effective Date	Revision Description
A	16 Jun 2022	Internal Review
B	05 Jul 2022	Client Review
C	09 Sep 2022	Addressing Client Comments

	Name	Date	Signature
Author	Minhao Dong	09 Sep 2022	Digitally signed by Minhao Dong Date: 2022.09.19 12:43:33+08'00'
Reviewer	Kris Hird	09 Sep 2022	
Approver	Chin Lu	09 Sep 2022	

Acknowledgement of Country

Stantec acknowledges the traditional custodians of the land on which this project will be undertaken. We pay our respects to Elders past, present and emerging. Stantec is committed to honouring Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.

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1 Introduction

1.1 SCOPE

This Concept Design Report presents and discusses the options considered for the replacement of Bridge 3950 with a new structure.

The new structure will be denoted Bridge 3950A.

1.2 EXISTING BRIDGE DETAILS

Bridge 3950 is located at SLK 4.13 on Cundinup West Rd and is a local authority (Shire of Nannup) bridge with a width of 7.28 m between kerbs and 7.88 m overall width and has a total length of 6.35 m (single span). The bridge comprises:

- Concrete overlay on timber decking;
- Round timber stringers;
- Bedlog abutments.

Bridge 3950 was constructed in 1962 (60 years old).

No traffic data can be found on Main Roads WA Traffic Map. The shire has been requested by Main Roads WA to provide traffic counts.

1.3 EMERGENCY REPAIRS REQUIRED

Emergency repairs are required as an interim measure until Bridge 3950 is replaced. These repairs are:

- Packing Abutment 1 end of Span 1 Stringer 7
- Packing or propping Abutment 2 end of Span 1 Stringer 1, 5, 6 & 7

1.4 JUSTIFICATION

Bridge 3950 has been identified for replacement. Deterioration of the bedlogs at Abutment 1 has resulted in ongoing settlement of the bridge deck at Abutment 1 end, contributing in part to several accidents and requiring the Shire to undertake regular surface corrections. Additionally, the bridge has 2x 3.3m lanes with a 0.6m shoulder on one side only, therefore replacing the bridge with the full formation width (2x 3.5m lanes + 2x 1.5m sealed shoulders) will improve road safety.

2 Stakeholders

2.1 MAIN ROADS WESTERN AUSTRALIA

Main Roads WA is the technical authority responsible for compliance with technical standards, and for detailed inspection.

2.2 LOCAL GOVERNMENT

Shire of Nannup is the asset owner and is responsible for level 1 inspection and maintenance of the bridge.

2.3 SERVICES

At present, detailed service investigations have not been undertaken. Preliminary searches (Dial Before You Dig) have indicated that following services may be affected by the bridge replacement works, see Table 2-1.

Table 2-1 Service Stakeholders

Service Owner	Details
Telstra	Cables running along Cundinup West Rd

2.4 ENVIRONMENTAL APPROVALS

2.4.1 Aboriginal Heritage

Consideration shall be given to the need for approval for the project to proceed from the Department of Planning, Lands and Heritage. It is understood that this will be completed by others.

2.4.2 Bed and Banks

A permit to interfere with bed and banks may be required from the Department of Water and Environmental Regulations to allow for the proposed works in the watercourse and the banks. It is understood that this will be completed by others.

2.4.3 Vegetation Clearing

A native vegetation clearing permit may be required to form the Department of Water and Environment Regulations for clearing of native vegetation. It is understood that this will be completed by others.

3 Design Criteria

3.1 DESIGN STANDARDS

Except where detailed within this design report, design shall comply with:

- AS5100:2017 Bridge Design
- AS/NZS 3725:2007 Design for Installation of Buried Concrete Pipes
- AS/NZS 4058:2017 Precast concrete pipes (pressure and non-pressure)
- AS 1597.2:2013 Precast Reinforced Concrete Box Culverts
- AS 3600:2018 Concrete Structures, Steel & Tendons (for durability)
- Main Roads WA and Austroads guidelines, standards and practices.

Where departure from a standard is required, approval with be sought from Main Roads WA.

3.2 DESIGN VEHICLES

The bridge shall be designed to accommodate:

- AS5100.2:2017
  - SM1600
  - HLP400
- Bridge Branch Design Information Manual
  - Group 2 Vehicle 4
  - Group 2 Vehicle 5

3.3 DESIGN INPUTS

A Detailed Inspection Report (DIR, reference number 04/4407) was completed on 16 Oct 2014.

A site inspection was carried out on 28 Jan 2022. Nimal Jayasekera, Peter Newhouse & Wayne Spencer of Main Roads WA, and Kris Hird & Owen Keenan of KBR+CCS were present during the inspection.

A survey has been carried out by BCE Surveying on 30 March 2022.

3.4 DURABILITY AND DESIGN LIFE

In accordance with AS5100:2017 and AS1597.2:2013, the design life of box culvert structural elements shall be 100 years excluding replaceable components.

The design life for the replaceable components shall be in accordance with Table 3-1.

Table 3-1 Minimum Design Life

Component	Details
Structural elements	100 years minimum

Barriers and end treatmetns	20 years minimum

3.4.1 Exposure Environment

The bridge is located approximately 37 km from the western coast of WA, in the temperate climate zone, and classified as Near Coastal.

Atmospheric

The exposure classification for concrete exposed to the atmosphere is B1 in accordance with AS5100.5:2017.

Soils

The exposure classification for concrete in contact with soils is assumed to be B2 in accordance with AS5100.5:2017 based on past project experiences in the region. This should be confirmed prior to detailed design.

3.5 GEOTECHNICAL

No geotechnical investigations have been undertaken for Bridge 3950.

For the design, conservative material properties been adopted and should be confirmed following geotechnical investigations, which may be carried out prior to or at the construction stage using Perth Sand Penetrometer and test pits or hand augurs.

3.6 ROAD

The road is in a rural environment and the current design speed is unknown. Based on the existing road geometry of approx. 5% superelevation on a 150 m radius horizontal curve, a design speed of 60km/h has been assumed.

The existing road has two 3.3m wide lanes with approx. 1.5 m unsealed shoulders narrowing down to 0.6 m sealed shoulders at the bridge location, which creates a safety risk to road users. The proposed replacement bridge will have the full formation width (2×3.5m lanes and 2×1.5m sealed shoulders) and will improve road safety on the bridge. No curve widening is proposed at this stage based on the existing superelevation and curve radius (MRWA Supplement to Austroads Guide to Road Design - Part 3 and MRWA Horizontal Curve Table for General Road Design).

However, the acceptance of the current road geometry is to be confirmed by road design prior to detailed design.

3.7 BARRIERS

Traffic barriers shall be provided along the bridge and the approaches. A preliminary assessment of the barrier performance level has been completed (see Table 3-2). No traffic data is available at this location, assumptions are to be confirmed prior to detailed design.

Table 3-2 Barrier Design Criteria

Component	Details	
Traffic count (vpd)	Assumed value, TBC prior to detailed design	500
RT; AS5100.1:2017 Table A1	Two-way undivided	1.5

GD; AS5100.1:2017 Figure A2	Longitudinal grade < 2%	1
CU; AS5100.1:2017 Figure A3	Approach curvature radius is 150m	3
US; AS5100.1:2017 Table A4	Low occupancy land use or shallow water	1
Adjusted traffic count (vpd)		2,250
Design speed (km/h)	Assumed value, TBC prior to detailed design	60
Heavy vehicle proportion (%)	Assumed value, TBC prior to detailed design	10
Barrier offset (m)	Design Criteria	1.5
Barrier Performance Level; AS5100.1:2017 Figure A5 (60 km/h)		Low

This concludes that as a minimum, a Low performance level barrier should be provided on the bridge. However, due to the relatively low cost differential in implementing a regular performance barrier system, it is proposed to adopt Regular performance level barrier (top mounted Thriebeam) for this structure transitioning to low performance level barrier on the approaches.

3.8 WATERWAYS

A waterways investigation has been undertaken (refer to Appendix E) to assess the existing serviceability of the bridge, assess suitable replacement options and provide design requirements for the selected option. The assessment has been carried out prior to the completion of detailed design works and was developed using the best available data and designs.

Bridge 3950 was assessed to provide a 100-year ARI dry serviceability level at the Cundinup West Road crossing of Padbury Brook. The maximum flow velocity of 0.760 m/s in the 100-year ARI event indicates that facing class or lesser rock protection is required. The existing bridge has a minor skew of 13° to creek centreline. Two culvert options (reinforced concrete box culvert RCBC, reinforced concrete pipe RCP) with skew were considered and the box culvert option with no skew was developed as an additional option.

Table 3-3 Summary of Bridge No. 3950 and replacement hydraulic results

Structure Type	Material	Dimensions	Scour Protection	Serviceability Level	Backwater (100-year ARI)
Existing Bridge	Timber	6.4 m bridge	None	100-year (dry)	40mm
Option 1. Box Culvert	Reinforced Concrete	2 x 2100 x 1200 mm (no skew)	None	100-year ARI (dry)	110mm (0.92 m/s max. velocity)
Option 2. Pipe Culvert	Reinforced Concrete	4 x 1200 mm (with skew)	None	100-year (dry)	160 mm (0.81 m/s max. velocity)
Option 3. Box Culvert	Reinforced Concrete	2 x 2100 x 1200 mm (with skew)	None	100-year ARI (dry)	80mm (1.04 m/s max. velocity)

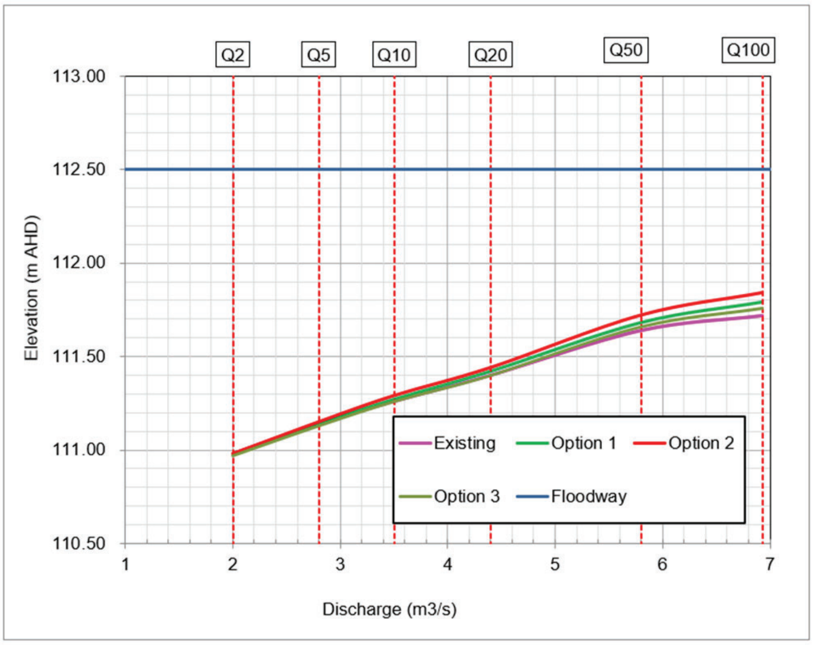


Figure 3-1 Stage discharge curve for Bridge No. 3950.

The proposed culvert replacement options do not substantially differ in hydraulic performance and all offer dry serviceability up to 100-year ARI. The main difference was the backwater depth at 100-year ARI. The max 160mm backwater is considered acceptable as no buildings will be affected. All culvert options require widening of the main channel area. Both box culvert options (1 and 3) offer better hydraulic performances than the pipe culvert option (2) in terms of backwater depths but have higher flow velocities. Option 1 is more favourable than Option 2 due to its smaller footprint and better hydraulic performance. Option 1 has superior constructability than Option 3 due to no skew while offering similar levels of hydraulic performance. Therefore, Option 1 was recommended as a replacement option.

3.9 SERVICES

A detailed service investigation will be carried out prior to construction. The following service stakeholders have been identified in a Dial Before You Dig search.

Table 3-4 Service Stakeholders

Service Owner	Details	Proposed Actions
Telstra	Cables running along Cundinup West Rd	Identify by detailed service investigation prior to construction and plan construction and excavation accordingly.

3.10 SAFETY IN DESIGN

Fundamentals of safety in design considerations for maintenance and inspection are discussed in Appendix B and Section 3.11. This is not a full review but has been used to inform the design development. Further safety in design considerations during construction, operation and decommissioning will be discussed at later design stages.

3.11 INSPECTION & MAINTENANCE

Regular inspection and maintenance play an important part in ensuring that the structure achieves its minimum design life. While the complete elimination of all maintenance items is desirable it may not be practicable or cost-effective. Measures should, therefore, be taken in the design to reduce and facilitate inspection and maintenance.

Consideration for inspection and maintenance shall be included in the design in accordance with cl.19 of AS5100.1:2017 and the Safety in Design requirements in the Work Health and Safety Act 2020. This includes providing access for inspection and maintenance.

Areas requiring attention for the culvert options include:

- Traffic barriers and balustrades; barriers and balustrades should be modular and replaceable in the event of impact damage or deterioration;
- Service conduits and supports; services should be installed independent of the bridge wherever possible or service conduits and supports should be designed using standard components for ease of replacement;
- Accumulation of debris; blockages from the accumulation of debris will reduce the hydraulic performance of the culverts therefore should be monitored during inspections.

3.12 AESTHETICS

The proposed bridge is classified as Aesthetic Design Category C (rural area, over minor creeks) in accordance with Main Roads Structures Engineering Design Manual. The use of culverts may be allowed.

3.13 DEPARTURES FROM STANDARD

Design shall progress with the following approved departures from standard:

- None

4 Bridge Design

4.1 GEOMETRY

4.1.1 Road

It is proposed to maintain the existing vertical and horizontal alignment over the bridge subject to road design.

4.1.2 Bridge

Based upon current and projected traffic growth, the minimum width between kerbs will be not less than 10.0 m and will comprise:

- 2×3.5 m traffic lanes
- 1.5m minimum sealed shoulders

The proposed structure will be square to road centreline. No curve widening is required with 60km/h design speed and 150m horizontal curve radius. This is to be confirmed subject to road design.

4.2 DESIGN OPTIONS

Several design options have been considered in the waterways assessment in Section 3.8. Based upon an initial review of these options (See Table 4-1), it is proposed to progress a 2x 2100X1500 RCBC structure.

Table 4-1 Design Options

Option	Details
1	2×2100×1500 (W×H) box culverts This option was based on the preferred option from the waterways assessment. The leg length is increased to 1500 from 1200 to optimise the headwall geometry. The box culvert offers an effective use of the space and will require minimal earth work for channel widening compared to the pipe culvert option. The box culverts require low maintenance and have a longer design life.
2	4×DN1200 RCP culverts The advantage of the pipe culverts is the low maintenance. However, this option has a greater footprint which means more excavation and backfilling. In addition, the structure depth cannot be easily increased without greatly increasing the overall footprint, which will lead to less optimal design of the headwalls and wingwalls. This option also has a lower hydraulic performance and a shorter design life.

4.3 PROPOSED STRUCTURE

The proposed bridge has 2 Nos. 2100×1500/1.2-A concrete box culverts.

4.3.1 Culvert Arrangement

2 Nos. 2100X1500/1.2-A concrete box culverts × 12,180mm long (10 No. 1,200 mm long units with 20mm nominal gaps in between) are proposed for Bridge 3950A. Drawings of this arrangement can be found in Appendix C.

The proposed box culverts will be installed side by side. The overall length is approximately 5000 mm. The culvert will be square to the road centreline and have a 13° skew to the existing creek centreline.

The proposed culvert will be installed on a ~0.9% grade to accommodate flow. This will require some adjustment to the existing channel on the approaches.

Grouted facing class grouted rock protection will be provided at the culvert inlet and outlet. A nominal 4.5m rock protection apron has been proposed at the culvert outlet shaped to follow the creek centreline based on a 1.04 m/s 100-year flow velocity.

4.3.2 Concrete Box Culverts

The box culverts are 2100X1500/1.2 strength class A culverts design to AS 1597:2 with a nominal max 1.2m fill including pavement.

The headwalls, wingwalls and apron slabs will be cast in-situ at the inlets and outlets. The wingwall on the right-hand side (inlet side) will be made parallel to road due to the proximity to cadastral boundary. The headwalls are nominal 1350mm deep on the right-hand side and 900mm deep on the left-hand side. They will support the guardrails at the bridge and will be supported by the wingwalls at the ends. A nominal thickness of 450mm was used to achieve a headwall design without an additional footing on top of the box culvert units on the right hand side.

It is proposed that the top 500mm of native soil be removed below the culvert base slab and backfilled with select fill in accordance with AS 1597:2 and MRWA specification 801. The box culverts will be founded on a base slab.

4.3.3 Surfacing

It is proposed that the road surfacing will be chip seal.

4.3.4 Barriers

The bridge barrier will comply with bridge design code AS5100:2004 and Main Roads' standard barriers. MRWA approved regular performance road safety barrier will be adopted over the culvert. The barrier connection and the deck will be designed for barrier loads as specified in AS5100:2017.

The barrier will be terminated with flared extruder-type TL3 end terminals at all four corners. Width markers will be provided at all four corners. HyLyte delineators or approved equivalent will be used on guardrails.

For concept design purposes, it is estimated that the barriers will extend:

- 94m on approaches (A1 side); 57m on approaches (A2 side)
- 79m on departures (A1 side); 70m on departures (A2 side)

The barriers on the right-hand side are extended to the road intersections while those on the left-hand side have been obtained by point of need analysis.

It should be noted that the embankment needs to be widened along the full extent of the barriers and tied back into existing beyond the ends of the barriers. This may result in vegetation impact, which will be assessed with necessary permits obtained by others in the next design stage.

4.3.5 Drainage

Spoon drains will be provided at Abutment 1 and 2 left-hand sides.

4.4 MAINTENANCE AND INSPECTION

The structure should require minimal maintenance. Regular routine inspection and maintenance will be required to be undertaken according to MRWA standard inspection guidelines. Parking for inspection and maintenance is available on the local road on the western approach. The culverts may be subject to blockage due to a build-up of debris. This debris should be monitored and cleaned regularly and as required.

4.5 CONSTRUCTION CONSIDERATIONS

A two-stage construction sequence can be developed to allow for construction within the cadastral boundaries. This will require cutting back the existing bridge for side-track construction as indicated in Appendix C. Temporary barrier on existing bridge and embankment stabilisation may be required. A traffic management plan is to be developed to ensure the road stays open for the duration of the construction. The temporary side-track will be constructed on the DN600 temporary pipe culverts with a min. 350mm cover.

Alternatively, a temporary side-track off-site will be used to allow for single stage construction. The design can be progressed upon receiving MRWA inputs.

4.5.1 Construction Sequence

The proposed construction sequence will comprise:

Stage 1:

- Cut existing bridge back, install temporary barriers and embankment stabilisation as required;
- Excavate and prepare the ground and construct temporary side-track;
- Install temporary barriers and divert traffic to temporary side-track;
- Deconstruct remaining existing bridge, timber to be carefully removed from existing bridge and timber in good condition to be retained by MRWA;
- Place stage 1 culvert boxes (refer to Appendix C 3950A-SKT-0002-A section A), wingwall, headwall, permanent barriers on the right-hand side and temporary barriers on the left-hand side, backfill and finish with pavement, stabilise temporary embankment as required;

Stage 2:

- Deconstruct temporary side-track and divert traffic to the replacement bridge;
- Excavate and prepare the ground, and install stage 2 culvert boxes (refer to Appendix C 3950A-SKT-0002-A section A);
- Backfill and finish with pavement;
- Install wingwall, headwall and permanent barriers.

5 Recommendations

It is recommended that the 2x 2100x1500 RCB culvert option be accepted and progressed to the detailed design due to its better hydraulic performance, constructability and lower maintenance than the other options. The proposed structure minimises the space required for the bridge and reduces the impact on the operation of Cundinup West Rd.

5.1 FURTHER WORKS

To progress to detailed design, it is recommended that the following activities are completed:

- Acceptance of proposed design option
- Confirm road alignment and design criteria
- Confirm temporary side-track alignment
- Confirm services impacted and potential relocation strategies

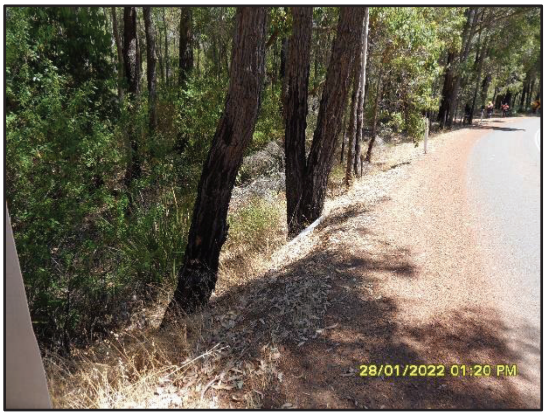
Appendix A

Photographs

SITE PHOTOGRAPHS

Photograph 1 – Abutment 1 Approach

Photograph 2 – Abutment 1 Approach



Photograph 3 – Abutment 1 Approach

Photograph 4 – Abutment 1 Approach

Photograph 5 – Abutment 1 Approach

Photograph 6 – Abutment 1 Approach

Photograph 7 – Abutment 1 Approach

Photograph 8 – Abutment 1 LHS

Photograph 9 – Abutment 1 RHS

Photograph 10 – Abutment 1 RHS

Photograph 11 – Abutment 1 RHS

Photograph 12 – Abutment 1 RHS

Photograph 13 – Abutment 1 RHS

Photograph 14 – Abutment 1 RHS

Photograph 15 – Abutment 1 RHS

Photograph 16 – Abutment 1 RHS

Photograph 17 – Abutment 2 Approach

Photograph 18 – Abutment 2 LHS

Photograph 19 – Abutment 2 RHS

Photograph 20 – Abutment 2 RHS

Photograph 21 – Abutment 2 RHS

Photograph 22 – Abutment 2 RHS

Photograph 23 – Abutment 2 RHS

Photograph 24 – Abutment 2 Approach

Photograph 25 – Termite Inspection

Photograph 26 – Waterway RHS

Photograph 27 – Waterway RHS

Photograph 28 – Waterway RHS

Photograph 29 – Waterway LHS

Photograph 30 – Waterway LHS

Appendix B

Safety in Design

Table B-1 Likelihood

RATING	DESCRIPTION	FREQUENCY
1 Rare	The event may occur only in exceptional circumstances	Less than once every 50 years
2 Unlikely	The event could occur at some time	Once every 10-50 years
3 Possible	The event might occur at some time	Once every 1-10 years
4 Likely	The event will probably occur in most circumstances	More than once per year
5 Almost certain	The event is expected to occur in most circumstances	More than once per month

Table B-2 Risk matrix

LIKELIHOOD & CONSEQUENCE	1 INSIGNIFICANT	2 MINOR	3 MODERATE	4 MAJOR	5 CATASTROPHIC
5 Almost certain	5 Low	10 High	15 High	20 Very High	25 Very High
4 Likely	4 Low	8 Medium	12 High	16 Very High	20 Very High
3 Possible	3 Low	6 Low	9 Medium	12 High	15 High
2 Unlikely	2 Low	4 Low	6 Low	8 Medium	10 High
1 Rare	1 Low	2 Low	3 Low	4 Low	5 Medium

Table B-3 Risk Acceptance Criteria

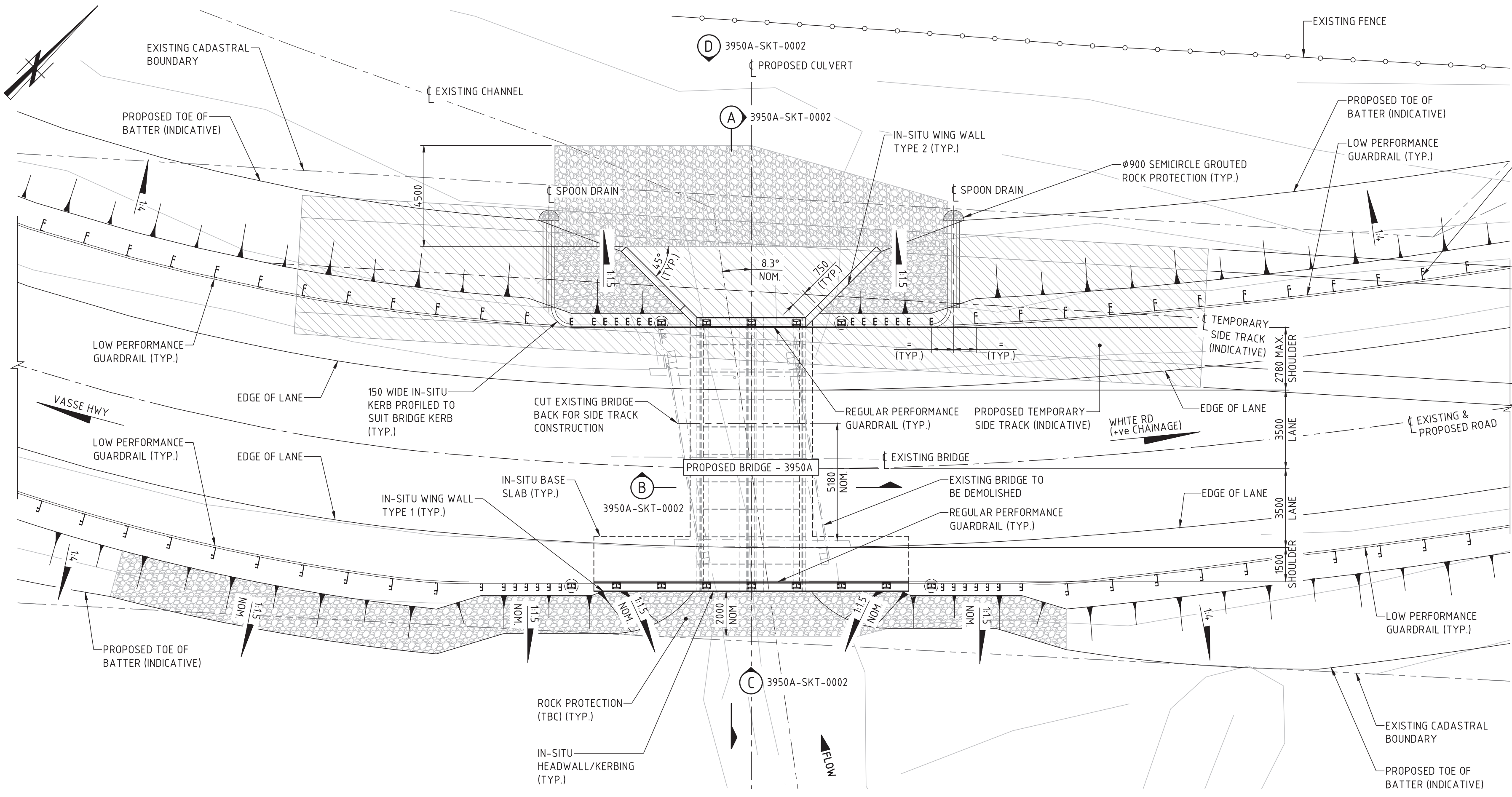
RATING	LEVEL OF RISK	MANAGEMENT OVERSIGHT
Low (<6)	Risk is generally acceptable.	Reviewed & accepted by Risk Owner.
Medium (7-9)	Risk is acceptable with adequate controls. Treatment action plan required if consequence is Catastrophic.	As low, plus Manager
High (10-15)	Risk may be acceptable with adequate controls. Treatment action plan required to reduce risk level further where possible.	As low, plus Director, Executive Director, General Manager or Manager.
Very High (>15)	Risk is generally not acceptable. Treatment action plan required to reduce the risk.	As high, plus Office of DG or Executive Committee.

Table B-4 Risk Assessment

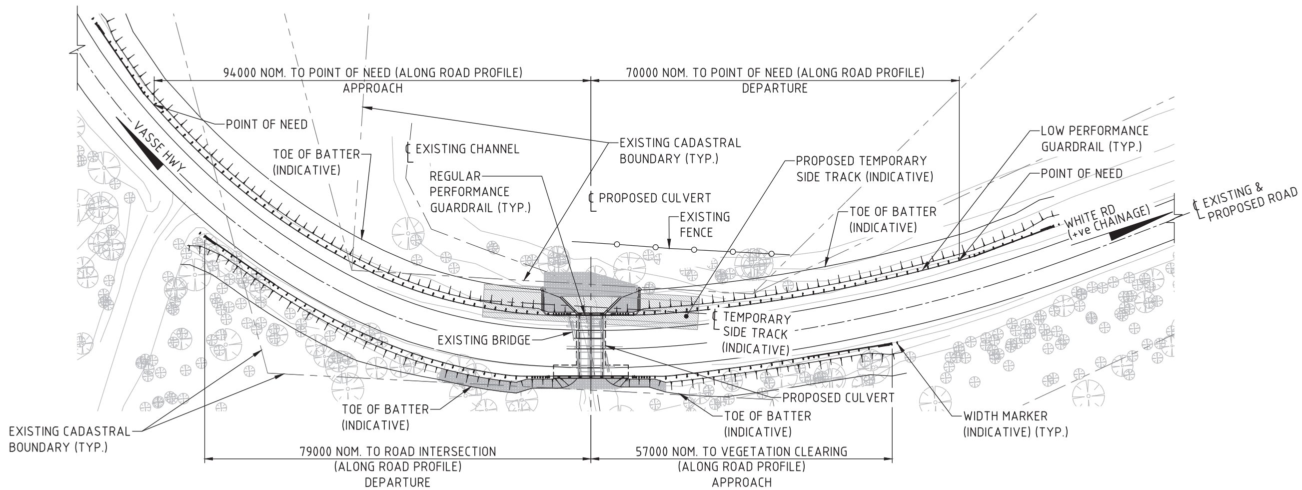
ACTIVITY	DESIGN IDENTIFIED HAZARD	LIKELIHOOD LEVEL	CONSEQUENCE LEVEL	ASSESSMENT OF RISK	ACTION DESIGNER HAS TAKEN TO REDUCE RISK	RESIDUAL RISK RATING	RESIDUAL RISK ACCEPTABLE (AFARP)
Foundation condition	Unknown existing foundation condition that lead to failure of the structure	4	3	12 - High	Conservative geotechnical parameters adopted for preliminary design, to be confirmed on completion of geotechnical investigation.	8 – Medium	Yes
Operation	Narrow shoulder on existing bridge that may cause traffic accidents	4	3	12 - High	Adopt 2x 3.5m lanes and 2x 1.5m shoulders that tie in to existing Cundinup West Rd to reduce the effect of narrowing of the roads on bridge	4 – Low	Yes
Construction	Side-track construction leading to traffic accidents	4	3	12 – High	Appropriate signages and traffic control where necessary, design the side-track with 600mm shoulders each side, reduce speed to 40km/h on side-track, install temporary barriers	8 - Medium	Yes
Operation	Level difference between the road and invert of the culvert. Requirement for slope at edge of the road	4	3	12 – High	Guardrail has been adopted for the required length of need as per AS5100.1 2017, Appendix A and MRWA Supplement to Austroads Guide to Road Design - Part 6. Width markers to be provided along shoulders to delineate the edge of the road.	8 – Medium	Yes
Culvert placement/ construction and maintenance	Crushing or overstressing of culverts during construction or service	3	3	9 – Medium	Design the culverts to AS5100, AS1597.2 and supplier specifications.	3 – Low	Yes
Maintenance	Long-term maintenance requirements which may expose inspection and maintenance personnel to risks of accidents	3	3	9 – Medium	Culvert structure has been chosen in lieu of bridge structure which requires less inspections and maintenance which reduces the exposure to the risks.	6 - Low	Yes

Appendix C

Drawings



PLAN
1:100



ROAD LAYOUT PLAN
1:500

PRELIMINARY
SUBJECT TO ALTERATION

SCALE 1:100 0 1m 2 3 4 5 6 7 8 9 10
1:500 0 5m 10 15 20 25 30 35 40 45 50

No.	DATE	DESCRIPTION	AUTHORISED
B	26.08.22	ISSUED FOR INFORMATION	
A	05.07.22	ISSUED FOR INFORMATION	

AMENDMENTS

CLIENT
SOUTH WEST REGION
Telephone (08) 9724 5677 Fax (08) 9724 5656

APPROVED FOR IMPLEMENTATION

FILE NUMBER	FOLIO	DATE	APPROVAL NUMBER

AUTHORISED
APPROVED

CONSULTANT
KBR + CCS Calibre, Cardno & SMEC

DOC No.	CW1200141-3950A-SKT-0001-B		
FILE No.		JOB No.	CW1200141
DRAWN	A. YAMADA JUNE '22	DESIGNED	M. DONG JUNE '22
CHECKED	D. CARROLL JULY '22	VERIFIED	
APPROVED			

MICROFILM DATE
A1

mainroads WESTERN AUSTRALIA

STRUCTURES ENGINEERING

CUNDINUP WEST RD No. 0093 (SLK 4.13)
BRIDGE No. 3950A OVER PADBURY BROOK
DESIGN CONCEPT
SHEET 1 OF 2

LOCAL AUTHORITY (216) SHIRE OF NANNUP

DRAWING NUMBER AMEND.
3950A-SKT-0001-B

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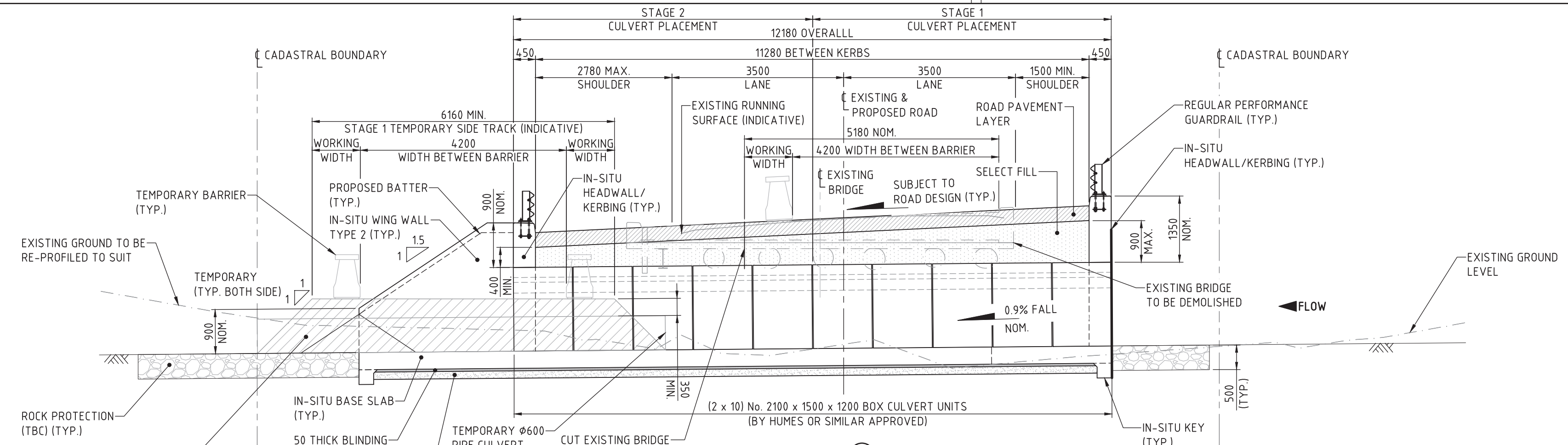

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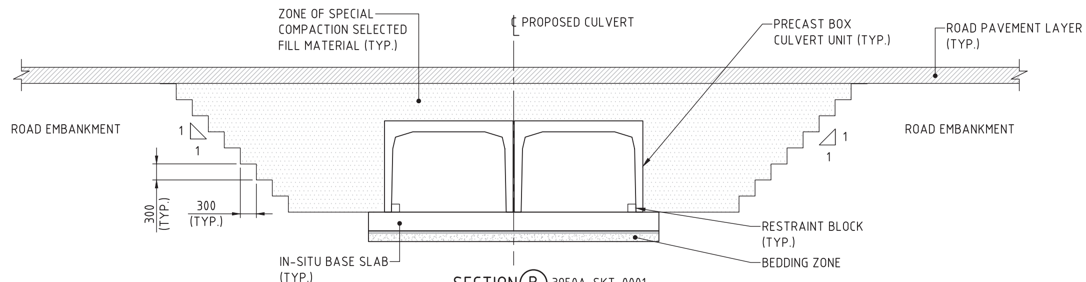

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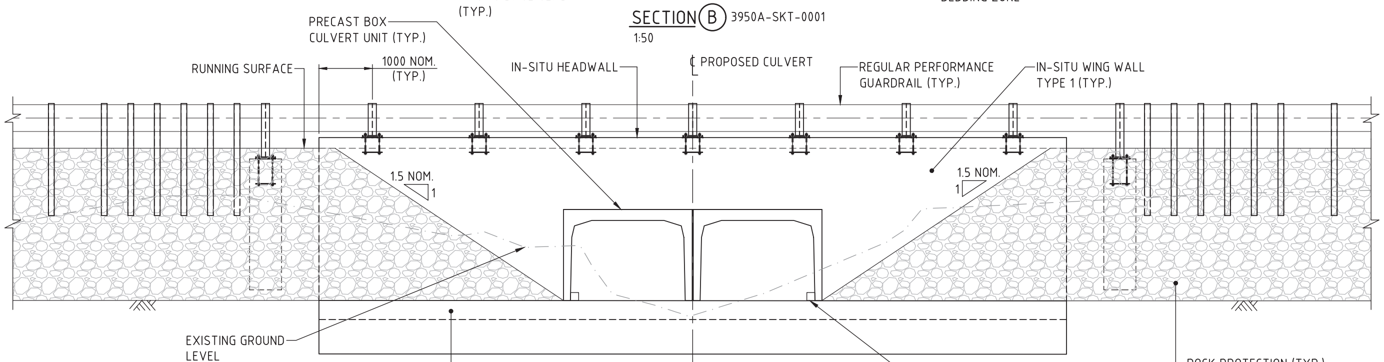

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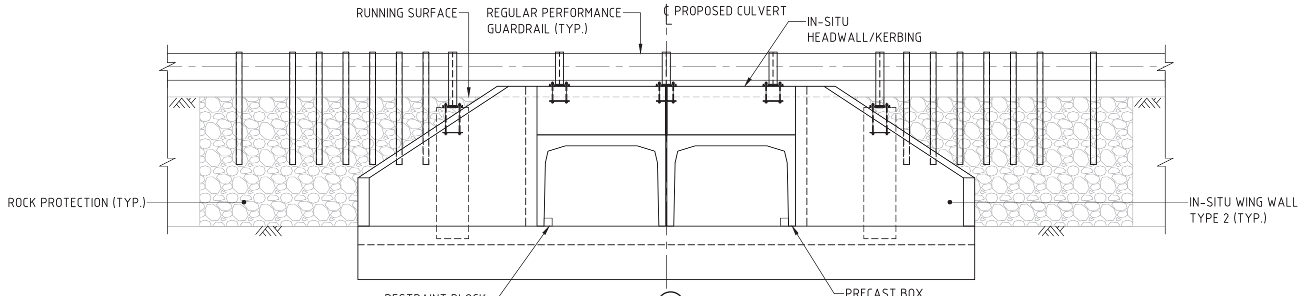

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PRELIMINARY
SUBJECT TO ALTERATION

SCALE 1:50 — 0 0.5m 1 1.5 2 2.5 3 3.5 4 4.5 5

No.	DATE	DESCRIPTION	AUTHORISED
B	26.08.22	ISSUED FOR INFORMATION	
A	05.07.22	ISSUED FOR INFORMATION	

AMENDMENTS

CLIENT
SOUTH WEST REGION
Telephone (08) 9724 5677 Fax (08) 9724 5656

APPROVED FOR IMPLEMENTATION

FILE NUMBER	FOLIO	DATE	APPROVAL NUMBER

AUTHORISED

APPROVED

CONSULTANT
KBR + CCS (Calibre, Cardno & SMEC)

DOC No.	CW1200141-3950A-SKT-0002-B		
FILE No.		JOB No.	CW1200141
DRAWN	A. YAMADA JUNE '22	DESIGNED	M. DONG JUNE '22
CHECKED	D. CARROLL JULY '22	VERIFIED	
APPROVED			

MICROFILM DATE

A1

mainroads WESTERN AUSTRALIA

STRUCTURES ENGINEERING

CUNDINUP WEST RD No. 0093 (SLK 4.13)
BRIDGE No. 3950A OVER PADBURY BROOK
DESIGN CONCEPT
SHEET 2 OF 2

LOCAL AUTHORITY (216) SHIRE OF NANNUP

DRAWING NUMBER AMEND.
3950A-SKT-0002-B

PATH: C:\Users\ayano.yamada\ACCDocs\Cardno\CW1200141_BR_3950A\Project Files\04_Delivery\01_WIP\Structural\Auto CAD\Sketches\3950A-SKT-0002.dwg LAST SAVED BY: Ayano.yamada DATE: 9 September 2022 3:09 PM

Appendix D

Review Comments

MAIN ROADS WA REGION

Revision: B

Date received: 13 July 2022

Comments received from: Peter Newhouse, AMS, MRWA

Ref	Comment	Response
1.	Include a new section covering emergency repairs. These repairs are required now as an interim measure until Bridge 3950 is replaced. The emergency repairs agreed onsite are: • Pack Abut 1 end of Span 1 Stringer 7 • Pack or prop Abut 2 end of Span 1 Stringer 1, 5, 6 & 7.	Added new Section 1.3.
2.	Section 1.1, Page 1 – capital Bridge x2 and elsewhere in the report.	Updated.
3.	Section 1.2, Page 1 – the Shire has been requested to provide traffic counts. This will be forwarded as soon as it becomes available.	Noted.
4.	Section 1.3, Page 1 – remove reference to the Bridges Renewal Program as this project could be funded on a number of different programmes. Also, add the following justifications: • The Shire has to undertake regular surface corrections due to the ongoing settlement at Abutment 1. • There have been a number of accidents due in part to the step down at Abutment 1.	Removed reference to the Bridges Renewal Program. Added justifications to Section 1.3.
5.	Section 2.4.1, Page 2 – change to " … Department of Planning, Lands and Heritage."	Updated.
6.	Section 3.3, Page 3 – change DIR date to 16/10/2014 and site inspection date to 28/01/2022.	Updated.
7.	Section 3.4, Page 3 – confirm whether design life for culvert is 100 years or 50 years.	Design life for the box culvert can be 100 years when designed to AS1597.2:2013
8.	Section 3.5, Page 4 – confirm what, if any geotechnical investigation will be required. Onsite we discussed that probably no geotechnical investigation was required. Is there a case for a simple (backhoe pit) investigation?	Simple geotechnical investigations can be carried out during construction to confirm the geotechnical parameters used in design. Section 3.5 has been amended.
9.	Section 3.6, Page 4 – clarify "The current road has 2x3.3m wide traffic lanes and no shoulders (2x0.76m shoulders on DIR)." Is this referring to the road width on the bridge and it is unclear about the reference to the DIR shoulder widths.	Updated.
10.	Section 3.6, Page 4 – clarify reference to full road design. Is this in relation to the tie into the existing road. The Shire's input to the report in relation to the road design will be sought and forwarded as soon as it becomes available. The Region's understanding is that no significant road alignment changes will be made and that the new structure will tie into the existing road geometry.	Yes. The acceptance of the current road geometry is to be confirmed by road design prior to detailed design.
11.	Section 3.7, Page 5 – clarify that regular performance guardrail will be top mounted Thriebeam.	Updated.

12.	Section 3.8, Page 5 – where is the waterways report. Has it been reviewed by MRWA Senior Waterways Engineer. Include the report in an appendix.	The waterways report has been included as Appendix E and will be sent to SE separately for review.
13.	Section 3.8, Page 6, Table 3-3 – under Structure Type change to "Option 1. Box Culvert" and Option 2. Pipe Culvert" and Option 3. Box Culvert. Under Material for Existing Bridge change to "Timber", for Option 2 change to Reinforced Concrete. Under Dimensions change Option 2 to "4 x 1200 mm (with skew)."	Updated.
14.	Section 3.8, Page 6, paragraph under Figure 3-1 – clarify why 160mm of backwater is acceptable (e.g. not buildings affected). Also clarify that the box culverts provide better hydraulic performance compared to the pipe culvert in relation to lower backwatering but have higher velocities.	Updated.
15.	Section 4.1.1, Page 8 – as above feedback will be sought form the Shire in relation to road design issues (and speed limits – refer Section 4.1.2).	Noted.
16.	Section 4.3.1, Page 8 – change culvert details to 2 No. 2100x1500/1.2-A.	Updated.
17.	Section 4.3.2, Page 9, 1st paragraph – fill appears to be > 1.2m – please confirm.	Currently shown as <1.2m but will be revised subject to road design.
18.	Section 4.3.3, Page 9 – surfacing to be chip seal.	Updated.
19.	Section 4.3.4, Page 9, 2nd paragraph – include HyLyte (or similar) delineators on the guardrail.	Updated.
20.	Section 4.3.4, Page 9, 5th paragraph – the Shire's input will be requested in relation to embankment widening, cadastral boundaries and clearing requirements.	Noted.
21.	Section 4.3.4, Page 9, 6th paragraph – delete as repeated from above in this section.	Deleted.
22.	Section 4.3.5, Page 10 – spoon drains only required at Abutment 1 & 2 LHS due to the supe-elevation on the road.	Updated.
23.	Section 4.5, Page 10 – two stage construction is preferred to the side track. Please provide a staging sketch for the two staged construction.	Updated.
24.	Section 4.5.1, Page 10 – revise section based on two stage construction.	Updated.
25.	Section 5, Page 11 – change to "It is recommended that the 2 x 2100 x 1500 RCB culvert option be accepted …"	Updated.
26.	Section 5.1, Page 11- revised based on two stage construction preference.	Updated.
27.	Appendix C, Drawing 3950A-SKT-0001-A, Plan – delete RHS spoon drains. Show skew angle to Brook. Part of the embankment widening at Abut 1 RHS encroaches outside the road reserve, The Shire's feedback will be sought on this matter – either land take required or retaining wall.	Updated.

MAIN ROADS WA STRUCTURES ENGINEERING

Revision: B

Date received: 15 August 2022

Comments received from: Mark Watkins, SBDE, MRWA

Ref	Comment	Response
1.	No feedback on the above design report.	Noted.

Appendix E

Waterways Report

Main Roads WA

Waterways Report

Bridge 3950A, Cundinup West Rd over Padbury Brook, Shire of Nannup

CW1200141

September 2022

Waterways Report

Bridge 3950A, Cundinup West Rd over Padbury Brook, Shire of Nannup

CW1200141

Prepared for:
MAIN ROADS WA
Don Aitken Centre
1 Waterloo Crescent, East Perth |
Western Australia 6004 | Australia

Prepared by:
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11 Harvest Terrace, West Perth |
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8 September 2022

CW1200141-WA-RP-002

Revision History

Version	Effective Date	Revision Description
A	20 Jun 2022	Internal Review
B	08 Sep 2022	Client Review

	Name	Date	Signature
Author	Shiheng Cui	08 Sep 2022	
Reviewer	Shafiqul Alam	08 Sep 2022	
Approver	Riccardo Divita	08 Sep 2022	

Acknowledgement of Country

Cardno now Stantec acknowledges the traditional custodians of the land on which this project will be undertaken. We pay our respects to Elders past, present and emerging. Stantec is committed to honouring Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.

Contents

1 Introduction

Bridge No. 3950 is a single span bridge with a concrete deck supported by universal beams and timber girders located on Cundinup West Road in the Shire of Nannup. The bridge spans Padbury Brook. This bridge is considered for replacement. The location of the structure is shown in Figure 1-1.

Cardno now Stantec (Stantec) has been engaged by Main Roads WA to complete a waterways investigation to assess the existing serviceability of the bridge, assess suitable replacement options and provide design requirements for the selected option.

The scope of this investigation includes both hydrological and hydraulic tasks:

- Site visit to review site specific conditions and characteristics.
- Collection and review of survey data, historical data and related reports.
- Design peak flow estimation for the bridge for flood events up to and including the 100-year ARI (Average Recurrence Interval).
- Calculation of appropriate structure sizing for a minimum dry serviceability level of 20-year ARI. If the serviceability level of the existing bridge is greater than 20-year ARI dry, then options will be presented to at least match the existing serviceability level.
- Stage/discharge curves for considered options and calculation of flow velocities within structures and natural channels.
- Recommendation of scour protection for culvert structures.
- Recommendation of a preferred replacement option.

This report has been prepared prior to the completion of detailed design works and was developed using the best available data and designs.

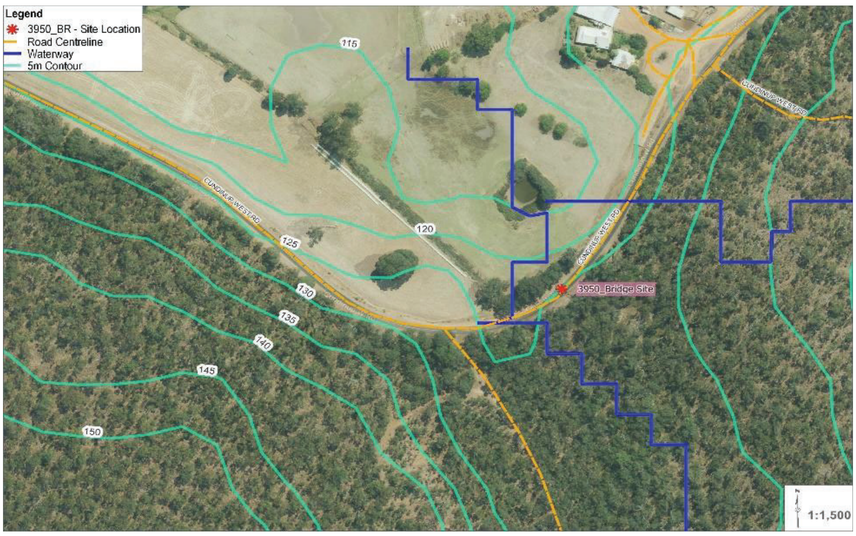

Figure 1-1 Locality Plan

2 Bridge Structure Details

The structure details of Bridge 3950 as reported on the MRWA IRIS system are summarised in Table 2-1. The complete IRIS data sheets are included in Appendix B.

Table 2-1 Structure Properties (MRWA, 2022)

Item	Bridge No. 3950
Crossing name	Padbury Brook
Road name	Cundinup West Road
Functional class / road type	Rural Highway
Structure type	Universal Beam Composite with Concrete Deck
Skew (°)	13*
Number of spans	1
Total length (m)	8.00
Maximum span length (m)	6.35
Total width (m)	7.88
Width between kerbs (m)	7.28
Maximum head room (m)	2.00
Minimum head room (m)	0.8

* Approximated to be perpendicular to waterway

3 Basis of Design

3.1 SERVICEABILITY LEVEL AND FLOOD IMPACT CONSIDERATIONS

In accordance with "Floodway Design Guide" (MRWA, 2006), there must be a balance between the road serviceability, its cost, and its sustainability against failure during events greater than the design flows. Examples of typical serviceability levels are presented in Table 3-1, and are used as an indicative guide to serviceability design. The required serviceability for any road must be assessed on a case-by-case and site-specific basis (MRWA & BG&E, 2006). This report is to establish the serviceability level of the existing bridge and the proposed replacement structures.

Table 3-1 Indicative typical serviceability levels (MRWA, 2006)

Functional class / road type	Typical serviceability levels (ARI, indicative only)
Freeways and arterial roads	50 – 100 year
Minor urban roads	20 – 50 year ARI
Rural main roads	**20 – 50 year ARI**
Rural minor roads	10 – 20 year ARI
Rural local access roads	5 – 10 year ARI

3.2 SCOUR PROTECTION

3.2.1 Embankments, bridge abutments and guide banks

Scour protection for bridges shall be specified in accordance with Austroads Guide to Bridge Technology Part 8 Hydraulic Design of Waterways Structures (Austroads, 2019). A summary of the recommended classes of rocks based on flow velocities is presented in Table 3-2. The adopted velocity will depend on whether flow at the bridge element is impinging or parallel. For parallel flow, the adopted velocity is 67% of the mean flow velocity, and for impinging flow the adopted flow is 133% of the mean flow velocity.

Table 3-2 Design rock slope protection (Austroads, 2018)

Velocity (m/s)	Class of rock protection (tonne)	Section thickness (m)
< 2	None	-
2.0 – 2.6	Facing	0.5
2.6 – 2.9	Light	0.75
2.9 -3.9	¼	1.00
3.9 – 4.5	½	1.25
4.5 – 5.1	1.0	1.60
5.1 – 5.7	2.0	2.00
5.7 – 6.4	4.0	2.50
> 6.4	Special	-

3.2.2 Floodways

Design of floodway scour protection shall be in accordance with Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways (Austroads, 2021), the associated MRWA supplement, and the MRWA Floodway Design Guide (MRWA, 2006). For the purposes of this report, it is assumed that the floodway, which forms part of the bridge crossing, will have no changes to its horizontal or vertical geometry at the road centreline.

3.2.3 Culverts

Scour protection for the Bridge 3950 replacement culverts shall be specified in accordance with Austroads Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways. A summary of the recommended classes rocks of for culverts outlets based on flow velocities is presented in Figure 3-1 and Table 3-3.

Austroads (2018) notes "The key design parameters for sizing the culvert outlet protection are the average rock size (d_{50}) and the length of rock protection (L)." Austroads (2018) Figure 3.16 was used to determine the length (L) and minimum size (d_{50}) of rock protection according to pipe diameter and outlet velocity for proposed culvert banks. The class of rock protection was selected according to Austroads (2018) Table 4.2. Outlet velocities were limited to 5.0 m/s in the design process to ensure rock protection was an appropriate scour protection measure. A minimum of Facing class was adopted in all cases.

Table 3-3 Rock size (d50) conversion to Rock Protection Class (Adapted from Table 4.2, Austroads 2018)

Rock Size (d_{50}, mm)	Protection Type
100	None – adopt facing
200	None – adopt facing
300	Facing
400	Light
500	1/4 tonne
600	1/2 tonne

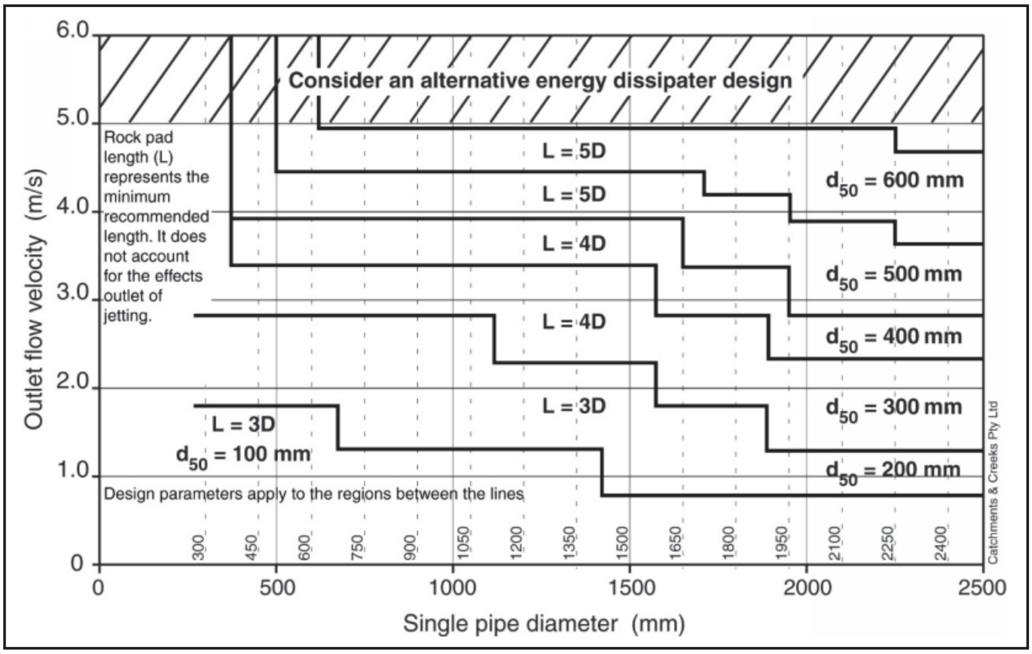

Figure 3-1 Minimum rock size and length of apron for a multi-pipe outlet (Figure 3.16, Austroads 2018)

3.3 CLIMATE CHANGE

MRWA has prepared a climate change guideline (available from the online Technical Library) which considers impacts of climate change on MRWA assets, including impacts from changing rainfall patterns. The guideline recommends that climate change considerations be addressed in the MRWA design process. The potential impacts to rainfall patterns are based on guidance in ARR 2019, Commonwealth Scientific and Industrial Research Organisation research and Bureau of Meteorology research which suggest that increases in temperate could lead to increases in rainfall intensity.

A separate MRWA guideline 'Climate Change Risk Assessment' (Colegate, 2019) recommends the consideration of greenhouse gas Representative Concentration Pathways (RCP) 4.5 and 8.5. Increases in rainfall intensities based on different concentration pathways are presented in Table 3-4 and the equation below (adapted from ARR 2019). The temperature increases for this site are the same as those for the majority of the Southwest and South West regions of Western Australia and have been sourced from the ARR Data Hub.

$$I = 1.05^{\Delta T} - 1$$
$$I = \text{Rainfall inrease factor}$$
$$\Delta T = \text{Temperature increase midpoint}$$

Given the uncertainty regarding climate change predictions it is difficult to exactly determine future impacts. A reasonable means of allowing for climate change induced rainfall impacts on projects could be to consider an event one larger than the current design event. For example, this would mean considering the 50-year ARI event instead of the 20-year ARI event. This is a simplified methodology; however, it does not substantially change the amount of design work required for projects, and the allowance is understandable to project stakeholders. Many of the increases presented in Table 3-4 are of the order of magnitude which would cause a rainfall event to increase to the next level.

Table 3-4 Predicted midpoint temperature increases and rainfall intensity increases for various climate change scenarios

Year	Temperature Increase	Increase in Rainfall Intensity	Temperature Increase	Increase in Rainfall Intensity
RCP 4.5			RCP 8.5	
2030	0.758	3.80%	0.782	3.90%
2040	0.970	4.80%	1.132	5.70%
2050	1.179	5.90%	1.501	7.60%
2060	1.370	6.90%	1.9	9.70%
2070	1.526	7.70%	2.342	12.10%
2080	1.631	8.30%	2.839	14.90%
2090	1.667	8.50%	3.404	18.10%

3.4 WATERWAYS ASSESSMENT APPROACH

3.4.1 Hydrological modelling

The hydrological methodology and approach used to assess Bridge No. 3950 was developed from relevant guidance provided in ARR 1987 and ARR 2019 for estimation of peak flows and runoff response of ungauged catchments in the South West region.

3.4.2 Hydraulic Analysis

The hydraulic analysis software HEC-RAS Version 6.1.0 was used to assess the existing performance of Bridge 3950 under peak flood conditions and to assess appropriate bridge and culvert replacement options. 1D hydraulic analysis approaches was adopted for this assessment.

3.4.3 Optioneering

The design methodology and assumptions made to determine suitable replacement options for Bridge No. 3950 are as follows:

- If the serviceability level of the existing bridge is greater than 20-year ARI dry, then options will be presented to at least match the existing serviceability level.
- Bridge and culvert structures will be considered for replacement options. Given the size and flows of the watercourse, preference will be given to the culvert options.
- All proposed replacement options will be designed to maintain the existing vertical and horizontal road profile.
- Replacement options considered will be RCP culverts and RCBCs.

4 Available Data and Information

4.1 SURVEY

Two survey datasets are available for the existing bridge:

- A point cloud survey data was provided by MRWA covering the road corridor and its immediate areas. This survey coverage was insufficient for the hydrology and hydraulic analysis and therefore was not used in this study.
- A detail ground survey and an aerial survey of the existing bridge was procured through BCE Surveying. Refer to Figure 4- 1 and Figure 4- 2 for the survey extent.
- The detail survey indicated a road deck level of 112.5 m AHD and a creek level of 109.58 m AHD upstream of the bridge.

Prior to construction, these survey datasets should be compared to the current conditions to confirm that they are a reasonable representation. Measurements and inspections from the site visit indicated that the surveys generally match current conditions. The survey works undertaken for this investigation are fit for purpose but may not be suitable for construction.

Figure 4- 1 Survey Extent (part 1)

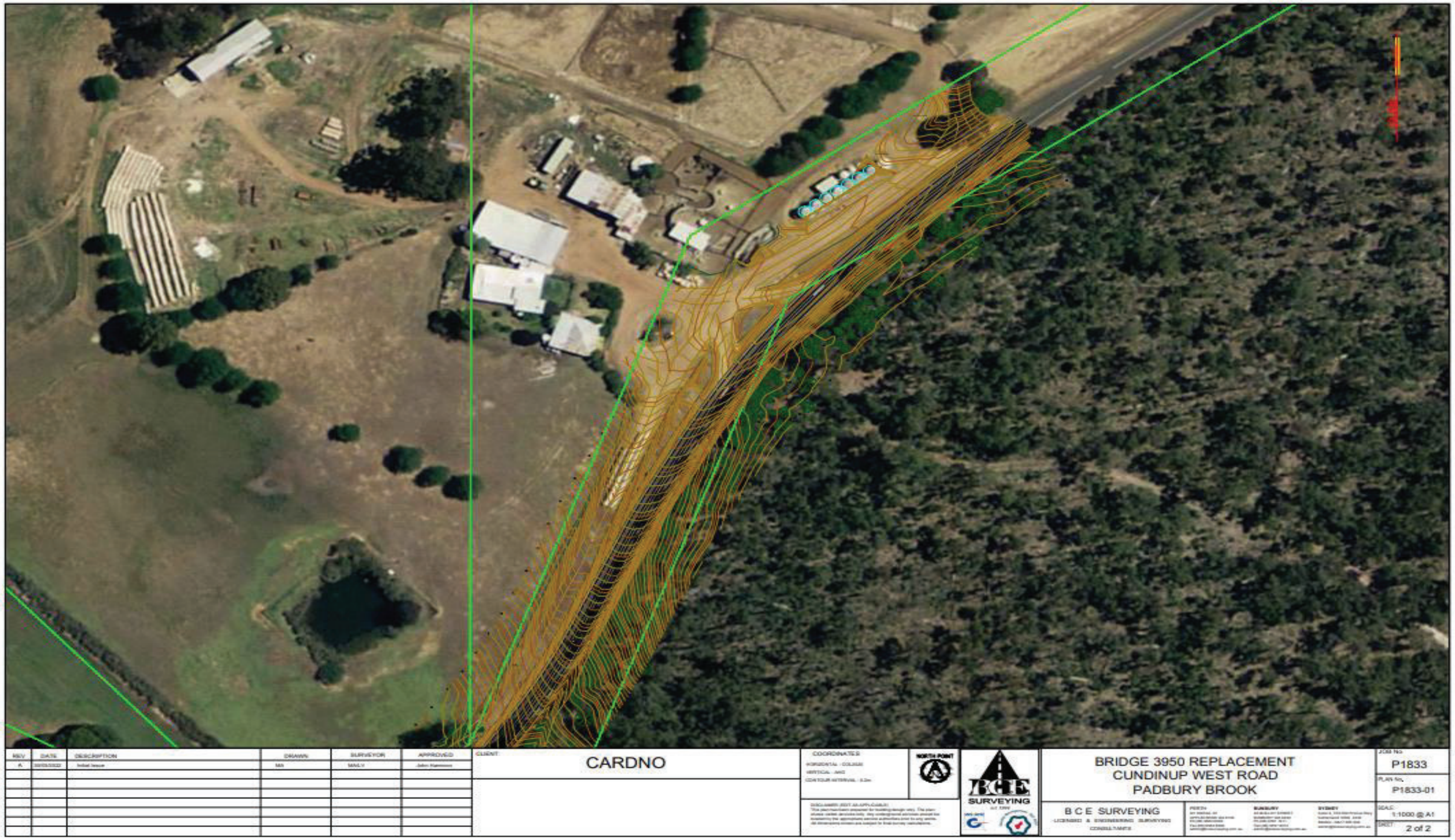

Figure 4- 2 Survey Extent (part 2)

4.2 OTHER DATASETS

The following datasets and information were reviewed for use in the assessment of Bridge No. 3950.

- MRWA Structures and Culverts datasets.
- IRIS Structures Detail Information.

4.3 PREVIOUS STUDIES

Stantec is not aware of any previous studies conducted in the vicinity of Bridge No. 3950.

4.4 ANECDOTAL INFORMATION AND SITE VISIT

A site inspection was conducted by Stantec and MRWA on 28 January 2022 to review the site and condition of the bridges. Relevant photographs have been included in Appendix C.

5 Hydrology

5.1 CLIMATIC REGION

Based on ARR 1987 the catchment is in the Southwest climatic region and falls under the ARR 2019 classification Fringe - SW WA & Arid and Semi-arid.

5.2 CATCHMENT CHARACTERISTICS

The Padbury Brook catchment downstream of Bridge No. 3950 is approximately 38 km^2, forming part of the greater Great Ouse Upper Catchment.

Table 5-1 Bridge 3950 Catchment Characteristics

Characteristic	Unit	Value
Area	km^2	38.8
Length	km	6.35
Average annual precipitation (P)	mm	900
Percentage cleared (C_L)	%	5
Centroid		115.748 E, -33.837 S
Outlet		115.735 E, -33.8225S
Time of Concentration ($2.31A^{0.54}$)	hours	16.66

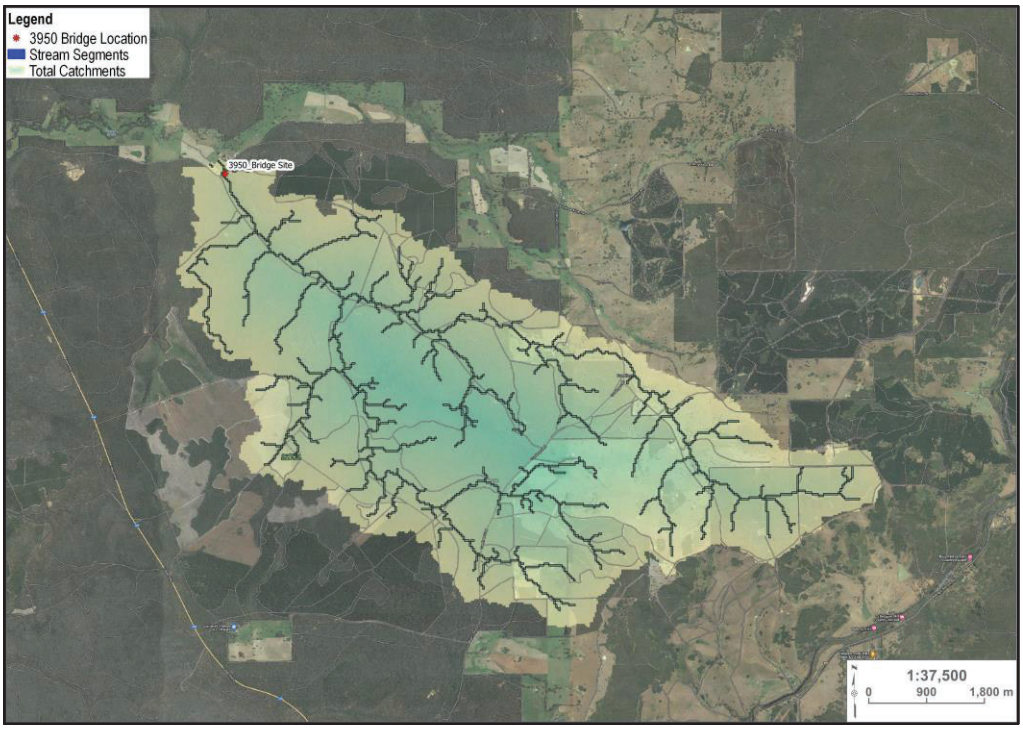

Figure 5-1 Catchment Plan Bridge No. 3950

5.3 IFD CHART

The ARR87 IFD values were used when adopting the ARR87 Rural Probabilistic Rational Method (Section 5.4) for peak flow estimation for catchment in the South West Region. A copy of this IFD data is available in Appendix D.

5.4 REGIONAL METHODS

Several regional methods were used to estimate peak flows at Bridge No. 3950 which are based on regression techniques and gauge data in a particular region.

- Regional Flood Frequency Estimation (RFFE) (ARR 2019)
  - The South West region located within the Southwest Western Australia zone adopted for the RFFE technique in Australia.
  - The RFFE technique uses a data-driven approach, which attempts to transfer flood characteristics from a group of gauged catchments to ungauged locations of interest.
  - The two basic types of data required for the development and application of RFFE techniques are the flood data at gauged sites and the catchment characteristics relevant to production of floods in both gauged and ungauged catchments.
  - An important assumption in all RFFE techniques is that the small set of predictor variables used in the regression equations is able to explain the differences in flood producing characteristics of the catchments in a region. Not all ungauged catchments located in the region satisfy this basic homogeneity assumption; some catchments may have characteristics that are substantially different from the gauged catchments in the region.
  - The RFFE Model has been developed using all suitable gauged catchments throughout Australia with catchment areas generally less than 1000 km2 and can be applied to small catchments with no lower limit.
- Rational Method (ARR87) – Catchments in South West region
  - The Rational Method uses a probabilistic or statistical method in estimating peak flow of selected ARIs from an average rainfall intensity of the same ARI derived from the IFD design curves for any location in Australia as described in ARR87 Book 2 Section 1.
  - The Rational Method for estimating the design peak flow incorporates a runoff coefficient, catchment characteristics and rainfall characteristics. The hydrology input values used in this method are provided in Appendix E.
  - Section 1.4.7 of AR&R Book 4 (ARR87) suggests that the Rational Method for the South West region of Western Australia is applicable for loamy, lateritic and sandy soils.
- Index Flood Method (ARR87) – Catchments in South West region
  - The index flood method is developed based on regression analysis of flood frequency curves derived for many locations across Western Australia with the assumption of homogeneous regions. It is important to note that most of the regressions for the runoff coefficient for the Index Flood Method are based on 2- or 5-year ARI flood data.

5.5 ESTIMATED DESIGN PEAK FLOWS

As outlined in ARR2019, regional methods more appropriate for a specific flood problem should also be investigated. As such, a number of methods of peak flow estimation were used and compared at Bridge 3950. The following peak flow estimation were used in this exercise (and are detailed in Section 5.4): Southwest Rational Method (ARR87) – Loamy and lateritic soil catchments (0-100% cleared);

- South West Index Flood Method (ARR87) – Jarrah Forest with lateritic soil (0-65% cleared);
- South West Index Flood Method (ARR87) – Jarrah Forest with lateritic soil (0-65% cleared); and
- Regional Flood Frequency Estimation (RFFE) (ARR2019).

A summary of the peak design flows for each method are summarised in Table 5-2.

Table 5-2 Bridge No.3950 estimated peak flows

Method	Peak Flows (m^3/s) for ARI (1 in X years)					
	2	5	10	20	50	100
RFFE (2019)	1.13	2.37	3.55	4.97	7.31	9.49
Rational Method – Loamy Soil	2.00	2.80	3.50	4.40	5.80	6.93
Index Flood – Loamy Soil	1.43	2.28	3.14	4.28	6.06	6.75

5.6 ADOPTED DESIGN FLOWS

The ARR87 Rational and Index Flood Method for the South West region – Loamy and Lateritic Soils (with 5% clearing applied) was adopted for Bridge No. 3950 from the various methods explored.

Adopted values are presented in Table 5-3.

Table 5-3 Adopted Design Flows

ARI (1 in X years)	2	5	10	20	50	100
Q (m^3/s)	2.00	2.80	3.50	4.40	5.80	6.93

6 Hydraulics

6.1 1D HYDRAULIC MODELLING

The hydraulic parameters used to model the performance of Bridge No. 3950 are presented in Table 6-1. The values adopted for this assessment were based on survey data, MRWA IRIS data and site observations.

The HEC-RAS v6.1.0 package developed by the Hydrologic Engineering Centre of the US Army Corps of Engineers was utilised to perform the hydraulic modelling. Further details of the HEC-RAS model are included in Appendix F. HEC-RAS is a steady-unsteady one-dimensional hydraulic model which calculates flow along a channel with constant conditions at each cross sections of the channel.

Table 6-1 Existing structures hydraulic model parameters

Structure / Location	Parameter	Unit	Value
Bridge 3950	Deck level	m AHD	112.5
	Deck thickness	m	1.5
	Soffit level	m AHD	111.0
	Channel Manning's n	$s/m^{1/3}$	0.03
	Overbank Manning's n	$s/m^{1/3}$	0.05
	Channel invert	m AHD	109.58

6.2 EXISTING BRIDGE NO. 3950 RESULTS

A stage discharge curve for the existing and replace bridge options is provided in Figure 6- 1.

- Bridge No. 3950 was assessed to provide a 100-year ARI dry serviceability level at the Cundinup West Road crossing of Padbury Brook.

The maximum flow velocity required facing class or lesser rock protection.

Table 6-2 Bridge No. 3950 Hydraulic Performance

ARI (years)	Q (m^3/s)	Stage (m AHD)	USWL (m AHD)	Backwater (mm)	Velocity (m/s)	Serviceability (Wet/Dry)	Overtopping (mm)
2	2	110.98	110.98	0	0.42	Dry	-
5	2.8	111.14	111.14	0	0.49	Dry	-
10	3.5	111.26	111.26	0	0.54	Dry	-
20	4.4	111.39	111.4	10	0.61	Dry	-
50	5.8	111.61	111.64	30	0.67	Dry	-
100	6.93	111.68	111.72	40	0.76	Dry	-

6.3 OPTIONS

Replacement options were selected based on the available depth below the roadway for culverts. These alternatives and the summary of hydraulic results are presented in Table 6-3. A stage discharge curve for the replacement options is presented in Figure 6- 1.

- The existing road level of 112.5 m AHD was adopted for all options. Culvert inverts were set at 109.58 m AHD to 109.70 m AHD and assumed some minor earthworks at the batters to tie in with downstream levels.
- It is noted that all culvert replacement options will achieve 100-year ARI dry serviceability for the Cundinup West Road crossing of Padbury Brook.
- No specific allowance has been made for culvert blockage. The site inspection of the existing bridge did not highlight any substantial debris present at the site.

Table 6-3 Summary of Bridge No. 3950 and Replacement Hydraulic Results

Scenario	Type	Material	Dimensions	Serviceability Level
Existing Bridge 3950	Bridge	Universal Beam and Timber Composite	6.8 m bridge, No pier	100-year (dry)
Option 1	Culvert	RCBC	2 x 2100mm x 1200 mm (no skew)	100-year (dry)
Option 2	Pipes	RCP	4 x 1200 mm	100-year (dry)
Option 3	Culvert	RCBC	2 x 2100mm x 1200 mm (with skew)	100-year (dry)

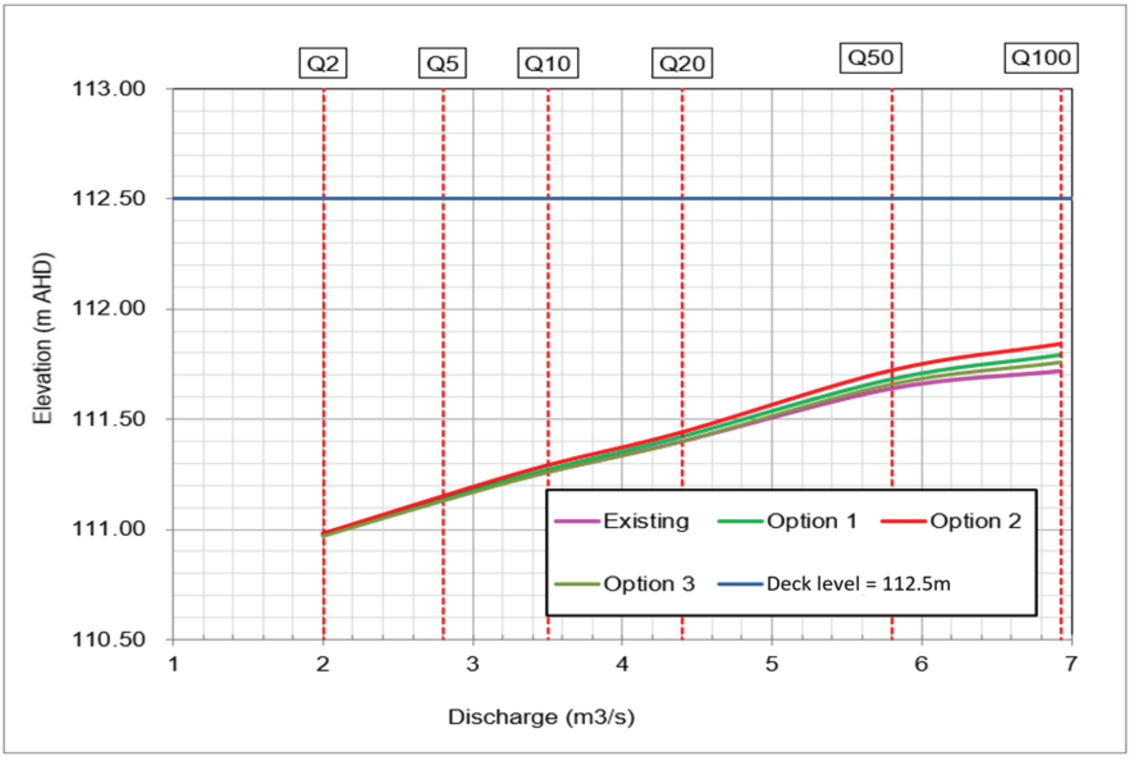

Figure 6- 1 Stage discharge curve for Bridge No. 3950

6.3.1 Option 1 – 2 x 2.1m x 1.2m RCBC (no skew)

The hydraulic modelling results for the option of replacing Bridge No. 3950 with 2 x 2.1m x 1.2m Reinforced Concrete Box Culvert (RCBC) are summarised in Table 6-4 Bridge No.3950 Option 1 Hydraulic Performance. The existing bridge has a skew of approximately 13°. The culverts were modelled as no skew to the flow using this option. The culverts were also modelled using the existing skew (Option 3) in order to compare the hydraulic performances with Option 1.

- This option provides dry serviceability across all flood events at the Cundinup West Road crossing of Padbury Brook.
- No scour protection is required since the 100-year flow velocity of 0.92 m/s is below the velocity criteria.
- Minor earthworks are required to fit the culverts within the existing channel width

Table 6-4 Bridge No.3950 Option 1 Hydraulic Performance

ARI (years)	Q (m^3/s)	Stage (m AHD)	USWL (m AHD)	Backwater (mm)	Velocity (m/s)	Serviceability (Wet/Dry)	Overtopping (mm)
2	2	110.98	110.98	0	0.46	Dry	-
5	2.8	111.14	111.14	0	0.55	Dry	-
10	3.5	111.26	111.27	10	0.62	Dry	-
20	4.4	111.39	111.42	30	0.71	Dry	-
50	5.8	111.61	111.68	70	0.8	Dry	-
100	6.93	111.68	111.79	110	0.92	Dry	-

6.3.2 Option 2 – 4 x 1200 mm RCP (no skew)

The hydraulic modelling results for the option of replacing Bridge No. 3950 with 4 x 1200 mm RCPs are summarised in Table 6-5.

- This option provides a 100- year ARI dry serviceability level at the Cundinup West Road crossing of Padbury Brook.
- This option generates a backwater level of 160 mm for a 100-year flood event.
- No scour protection is required for a 100-year flow velocity of 0.81 m/s.
- Minor earthworks is required to fit the culverts within the existing channel width.

Table 6-5 Bridge No. 3950 Option 2 Hydraulic Performance

ARI (years)	Q (m^3/s)	Stage (m AHD)	USWL (m AHD)	Backwater (mm)	Velocity (m/s)	Serviceability (Wet/Dry)	Overtopping (mm)
2	2	110.98	110.98	0	0.43	Dry	-
5	2.8	111.14	111.15	10	0.51	Dry	-
10	3.5	111.26	111.29	30	0.57	Dry	-
20	4.4	111.39	111.44	50	0.64	Dry	-
50	5.8	111.61	111.72	110	0.71	Dry	-
100	6.93	111.68	111.84	160	0.81	Dry	-

6.3.3 Option 3 – 2 x 2.1m x 1.2m RCBC (with existing skew)

The hydraulic modelling results for the option of replacing Bridge No. 3950 with 2 x 2.1m x 1.2m Reinforced Concrete Box Culvert (RCBC) with the existing skew are summarised in Table 6-6. The existing bridge has a skew of approximately 13° which was implemented in this option scenario.

- This option provides dry serviceability across all flood events at the Cundinup West Road crossing of Padbury Brook.
- No scour protection is required since the 100-year flow velocity of 1.04 m/s is below the velocity criteria.
- Minor earthworks are required to fit the culverts within the existing channel width

Table 6-6 Bridge No. 3950 Option 3 Hydraulic Performance

ARI (years)	Q (m^3/s)	Stage (m AHD)	USWL (m AHD)	Backwater (mm)	Velocity (m/s)	Serviceability (Wet/Dry)	Overtopping (mm)
2	2	110.98	110.97	-10	0.56	Dry	-
5	2.8	111.14	111.13	-10	0.68	Dry	-
10	3.5	111.26	111.26	0	0.76	Dry	-
20	4.4	111.39	111.4	10	0.85	Dry	-
50	5.8	111.61	111.66	50	0.93	Dry	-
100	6.93	111.68	111.76	80	1.04	Dry	-

6.4 FLOODWAY

It has been assumed that there if there will be no changes to the road vertical geometry at the crossing, this will leave the existing floodway in place. No existing scour protection was observed at the floodway, and no obvious signs of scour or rolling were observed.

Simplistic assessment of the bridge velocity shows no rock protection is required to the floodway for the existing bridge for the 100-year ARI event. The options considered generally provide better hydraulic performance for the floodway and are not expected to be increased for those options.

The requirement for scour protection to the floodway should be reviewed during detailed design given that there is no evidence of failure at the existing floodway.

7 Conclusions and Recommendations

This report detailed the waterways investigation for Bridge No. 3950, including hydrological and hydraulic assessment carried out to determine suitable replacement structure options.

- The design flow rates for Bridge 3950 were determined using ARR87 Index and Rational Flood Methods for loamy and lateritic soil catchments, as well as consideration of previous studies.
- The bridge deck on Bridge 3950 was assessed to have dry serviceability in its existing condition for flood events up to a 100-year ARI flood event.
- Based on the results of the hydraulic assessment of three bridge replacement options, it was established that replacing Bridge 3950 with Option 1 – box culvert (no skew) or Option 3 – box culvert (with skew) can be recommended as they do not substantially differ in hydraulic performance and would be more efficient than the Option 2 -RCP (4 x 1200 mm) in terms of backwater.
- A summary of options analysed in this investigation are presented in Table 7-1.

Table 7-1 Summary of Bridge No. 3950 and Replacement Hydraulic Results

Structure Type	Material	Dimensions	Scour Protection	Serviceability Level	Backwater (100-year ARI)
Existing Bridge	Concrete	6.35 m bridge	None	100-year (dry)	40 mm
Culvert	Reinforced Concrete	2 x 2100 x 1200 mm (no skew)	None	100-year (dry)	110 mm (0.92 m/s max. velocity)
Pipes	RCP	4 x 1200 mm	None	100-year (dry)	160 mm (0.81 m/s max. velocity)
Culvert	Reinforced Concrete	2 x 2100 x 1200 mm (with skew)	None	100-year (dry)	80 mm (1.04 m/s max. velocity)

7.1 FUTURE CONSIDERATIONS

The following items remain for consideration by the project team:

- Levels assumed in this report should be confirmed prior to construction. Should levels differ substantially then the results of this report should be recomputed using the new data.

8 References

Austroads, 2019. Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures (Edition 2.1), AGBT08-19

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Appendix A

ARR19 Probability Terminology

AUSTRALIAN RAINFALL AND RUNOFF PROBABILITY TERMINOLOGY

The new edition of ARR (2019) proposed adopting design probability terminology that differs from that used in the 1987 release. The table below is provided in ARR 2019 Section 2.2.5 to show the relationship between the previously used ARI and the new AEP frequency descriptor with the following narrative:

> *Navy outline indicates preferred terminology. Shading indicates acceptable terminology which is depends on the typical use. For example in floodplain management 0.5% AEP might be used while in dam design this event would be described as a 1 in 200 AEP."* (Ball et al., 2019)

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

This proposed change has resulted in discrepancies between the terminology used in previous study reports, design standards and regulatory requirement specifications. However, it is noted that the use of AEP terminology is currently stated as a preference by the publishers of ARR 2019.

Therefore, for this study and report the use of ARI frequency descriptors will be retained for practical application and congruency with regulatory compliance requirements. The ARR 2019 extracted table presented in this section can be used as reference as required.

Appendix B

IRIS Data

TIMBER BRIDGE
DETAILED INSPECTION REPORT

mainroads WESTERN AUSTRALIA

GENERAL INFORMATION - SHEET 1

Bridge No.: 3950

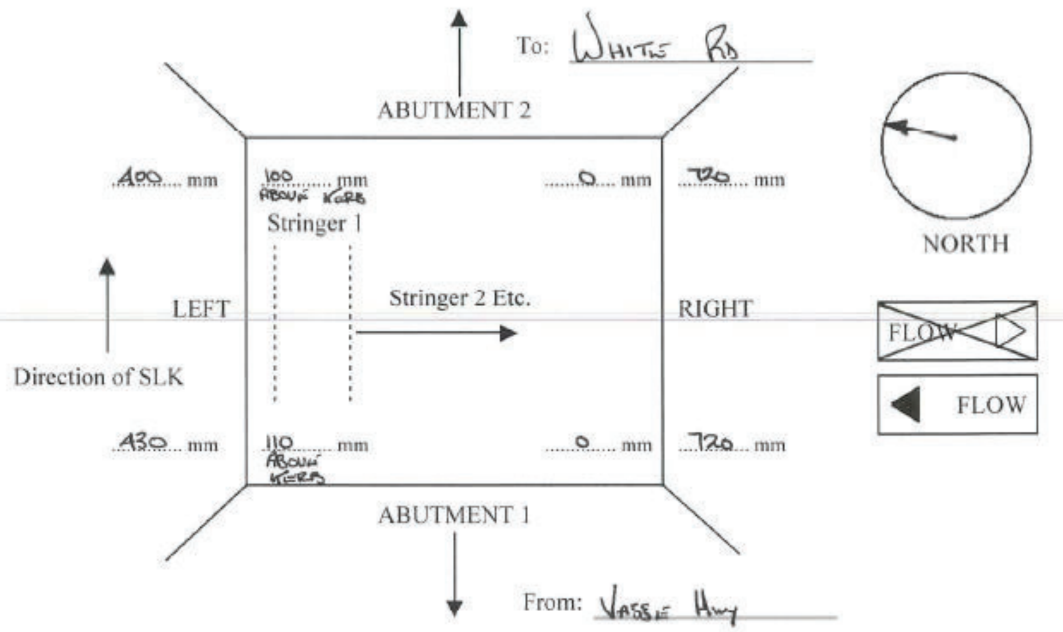
Region:	South West	Latitude (S):	-33.822574
		Longitude (E):	115.735181
Road Name:	Cundinup West Rd	Road No:	2160093
Local Government:	Nannup	Owner:	Local Authority
Crossing Name:	Padbury Brook	SLK:	4.13
Number of Lanes:	2	Length (m):	6.35

Total Width (m): 7.88 (Inc. or Excl. Footpath) Max. Head Room (m): 2.00 Min. Head Room (m): 0.80

No. of Spans: 1 Width between Kerbs (m): 7.28 Concrete Overlay (Y/N): Y

Piers are numbered along the bridge in ascending order from ABUTMENT 1 to ABUTMENT 2.
Piles are numbered across the bridge in ascending order from LEFT to RIGHT.
Stringers are numbered across the bridge in ascending order from LEFT to RIGHT.

Inside and outside kerb depths noted in corners of sketch.
Exposed Deck Ends (RCO only): LHS N RHS N



This Bridge has been inspected in accordance with the requirements of the Main Roads Western Australia Inspection Manual for Western Australian Bridges and Culverts.

Inspected by: S. Maice J. Pinye Checked by: P OLSEN J HESKETH R C-N

Date: Paper Work 10-10-14, Drilled. 16-10-14 Date: 24-10-14

MAIN ROADS Western Australia
Timber Bridge Detailed Inspection Forms

Management of Bridge Inspections
Doc 3912/01/03 Issue 20/10/2009

Form 1

Appendix C

Site Inspection Photographs

(Site Inspection by Stantec and MRWA, 28 January 2022)

SITE PHOTOGRAPHS

Photograph 1 – Bridge No. 3950 Abutment 1 Approach

Photograph 2 – Bridge No3950 Abutment 1 Approach

Photograph 3 – Bridge No. 3950, Waterways LHS

Photograph 4 – Bridge No. 3950, Abutment 1 LHS

Photograph 5 – Bridge No. 3950, Abutment 1 LHS

Photograph 6 – Bridge No. 3950, Abutment 2 Approach

Photograph 7 – Bridge No. 3950, Abutment 2 LHS

Photograph 8 – Bridge No. 3950, Abutment 2 LHS

Photograph 9 – Bridge No. 3950, Waterways RHS

Photograph 10 – Bridge No. 3950, Waterways LHS

Appendix D

IFD Chart

(ARR87 IFD used for ARR calculations)

LOCATION 33.825 S 115.725 E *

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

$ln(I) = A + B \times (ln(T)) + C \times (ln(T))^2 + D \times (ln(T))^3 + E \times (ln(T))^4 + F \times (ln(T))^5 + G \times (ln(T))^6$

T = TIME IN HOURS AND I = INTENSITY IN MILLIMETRES PER HOUR

RETURN PERIOD	A	B	C	D	E	F	G
1	2.852244	-0.63556E+0	-0.21763E-1	0.95125E-2	-0.95083E-3	-0.37535E-3	0.47798E-4
2	3.092583	-0.64867E+0	-0.22536E-1	0.79502E-2	-0.44204E-3	-0.14267E-3	-0.57283E-5
5	3.278381	-0.68320E+0	-0.22326E-1	0.66998E-2	0.10151E-3	0.13739E-3	-0.66918E-4
10	3.383471	-0.70362E+0	-0.22396E-1	0.57242E-2	0.48309E-3	0.32927E-3	-0.10894E-3
20	3.519866	-0.72140E+0	-0.22238E-1	0.49281E-2	0.76972E-3	0.48860E-3	-0.14195E-3
50	3.685122	-0.74348E+0	-0.22510E-1	0.39694E-2	0.12107E-2	0.68830E-3	-0.18743E-3
100	3.802208	-0.75881E+0	-0.22543E-1	0.33227E-2	0.14649E-2	0.81531E-3	-0.21420E-3

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	64.2	84.7	111.	130.	156.	194.	227.
6 mins	59.7	78.7	103.	120.	144.	180.	210.
10 mins	47.7	62.5	80.5	93.2	111.	136.	158.
20 mins	33.5	43.3	54.2	61.7	72.2	87.3	100.
30 mins	26.5	34.1	42.1	47.4	55.0	65.9	74.9
1 hour	17.3	22.0	26.5	29.5	33.8	39.9	44.8
2 hours	11.1	13.9	16.4	17.9	20.3	23.6	26.2
3 hours	8.49	10.6	12.3	13.4	15.0	17.3	19.1
6 hours	5.38	6.66	7.56	8.09	8.99	10.2	11.2
12 hours	3.40	4.19	4.70	5.00	5.52	6.21	6.76
24 hours	2.11	2.62	2.95	3.15	3.50	3.96	4.32
48 hours	1.27	1.59	1.83	1.98	2.22	2.56	2.82
72 hours	.921	1.15	1.34	1.46	1.65	1.91	2.12

(Raw data: 22.62, 4.28, 1.18, 35.86, 5.73, 1.76,skew= 0.630)

HYDROMETEOROLOGICAL ADVISORY SERVICE

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT LOCATION NAME.

Appendix E

Hydrology Calculations

ARR 1987 Rational Method (Wheatbelt)

Catchment	Area	Stream Length	tc	Itc, 2Y	Itc, 5Y	Itc,10Y	Itc, 20Y	Itc, 50Y	Itc, 100Y
	km^2	km	hrs	mm/h	mm/h	mm/h	mm/h	mm/h	mm/h
3950	38.8	6.35	16.66	2.84103	2.508848	2.038439	1.664032	1.535448	1.633124

Loamy Soils (75-100% Cleared)

C10	C2/C10	C5/C10	C10/C10	C20/C10	C50/C10	C100/C10	Q2	Q5	Q10	Q20	Q50	Q100
-	-	-	-	-	-	-	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s
0.159188296	0.41	0.65	1	1.54	2.2	2.471404	2	2.8	3.5	4.4	5.8	6.93

Note:
- The average rainfall intensity,Itc for the design duration of time of concentration, tc hours and ARI of Y years is calculated using the Rainfall Intensity Frequency Duration Data (IFD) obtained from BoM for the catchment.

ARR1987 Index Flood Method

Catchment	Area	P	FF (Q2/Q2)	FF(Q5/Q2)	FF (Q10/Q5)	FF (Q20/Q5)	FF (Q50/Q5)	Q2	Q5	Q10	Q20	Q50	Q100
	km^2	mm	-	-	-	-	-	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s
3950	39	900	1.0	1.6	1.4	1.9	2.7	1.43	2.28	3.14	4.28	6.06	6.75

Note:
- Frequency Factors, FF (Qy/Q5) taken from ARR87 Book IV.
- 100-year ARI flow calculated using logarithmic extrapolation on the 2 to 50-year ARI estimated peak flows.

Appendix F

HEC-RAS Outputs

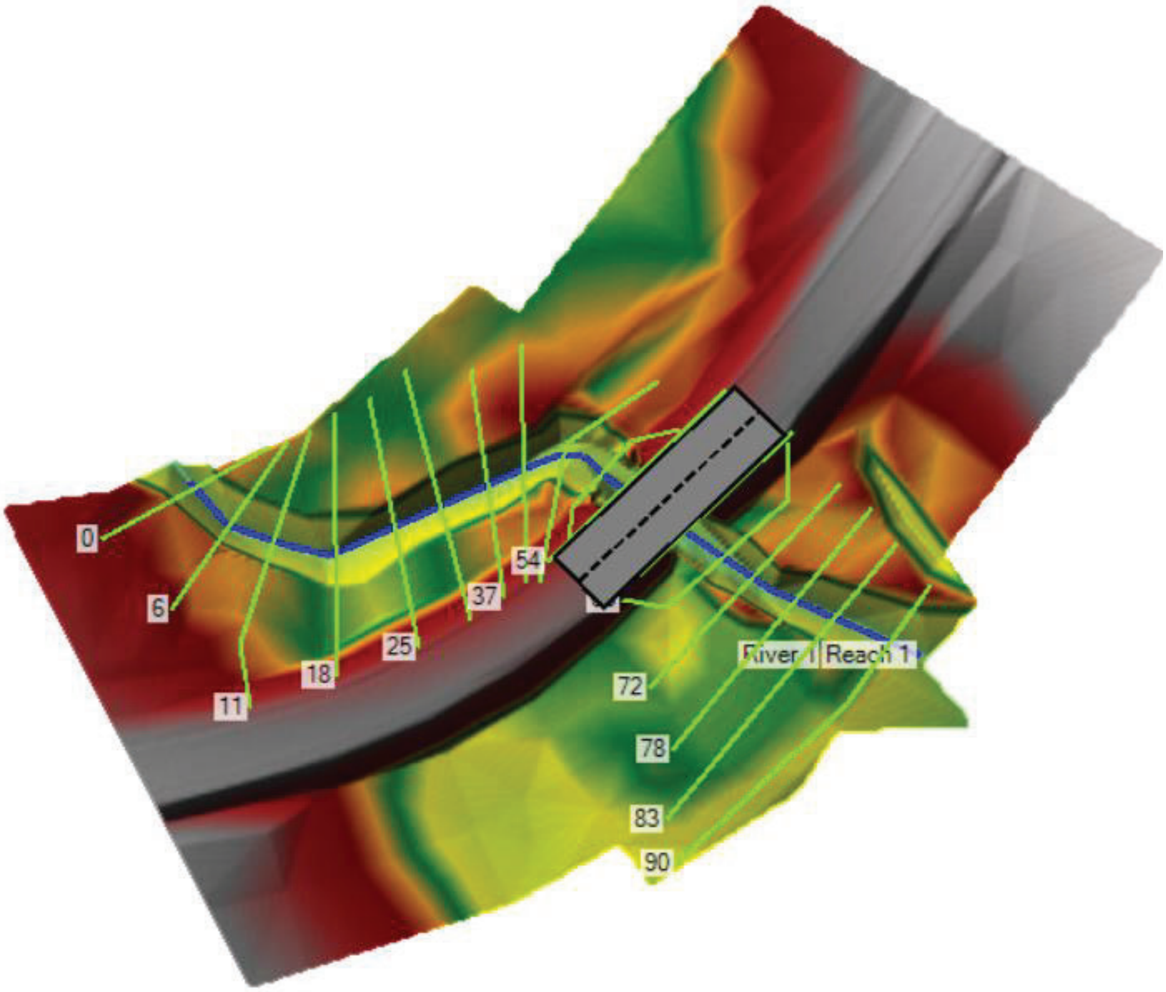


Figure F- 1 Geometry layout - Bridge No. 3950

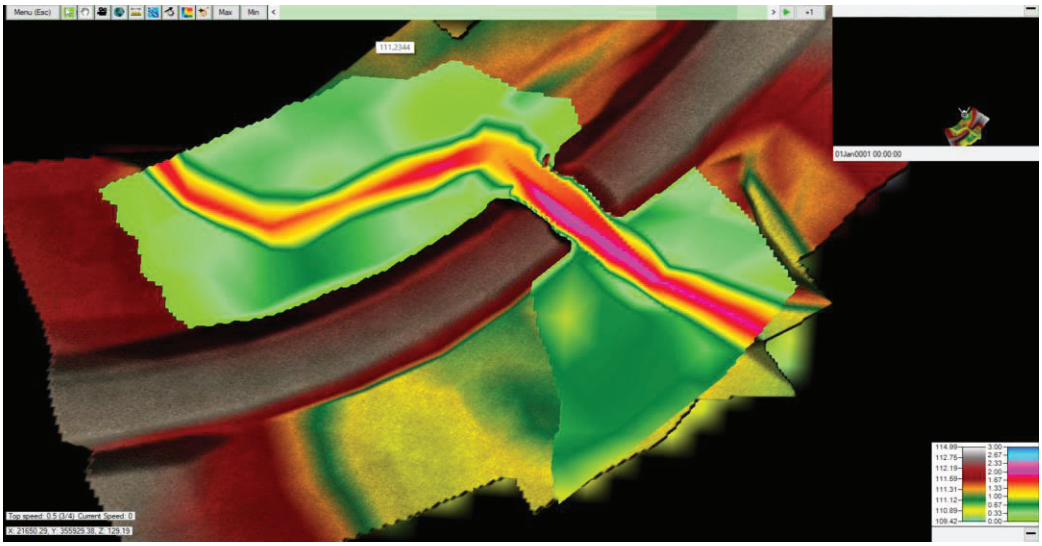


Figure F- 2 HEC-RAS 3D View - Option 1 - 2 x 2100 x 1200 mm RCBCs - 50-year ARI depth

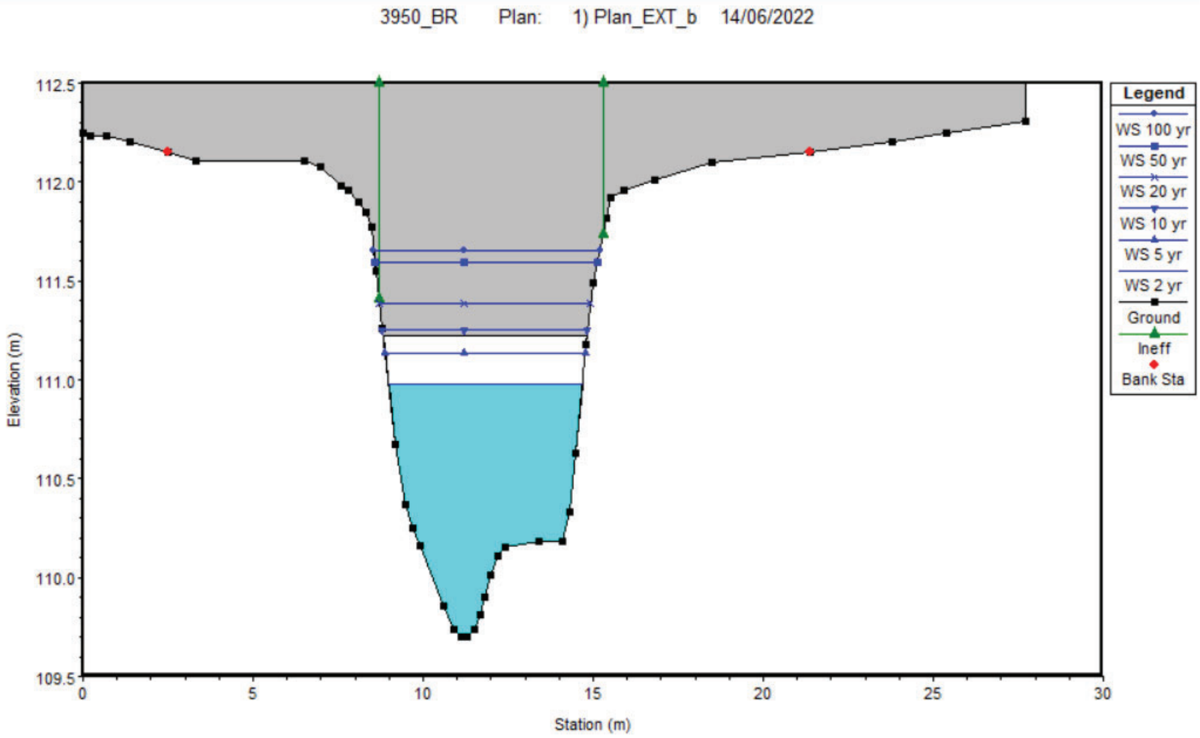


Figure F- 3 Cross Section - Existing Bridge No. 3950

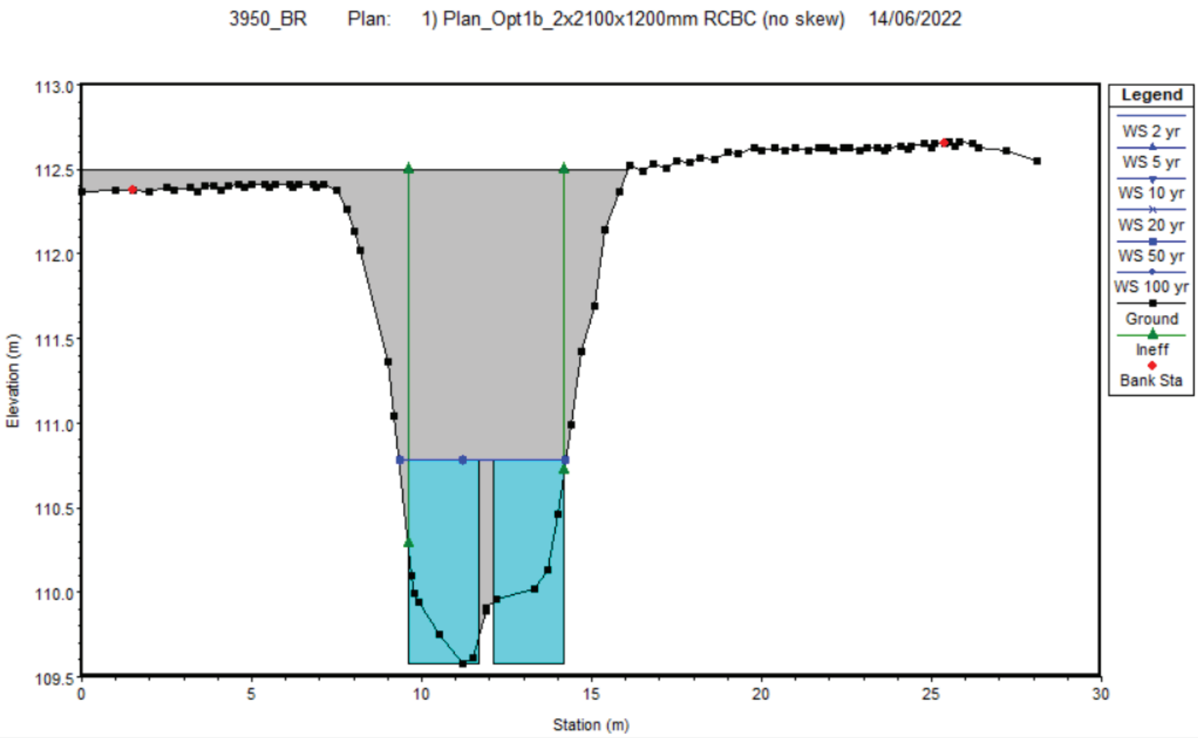


Figure F- 4 Cross Section - Option 1 - 2 x 2100 x 1200 mm RCBCs

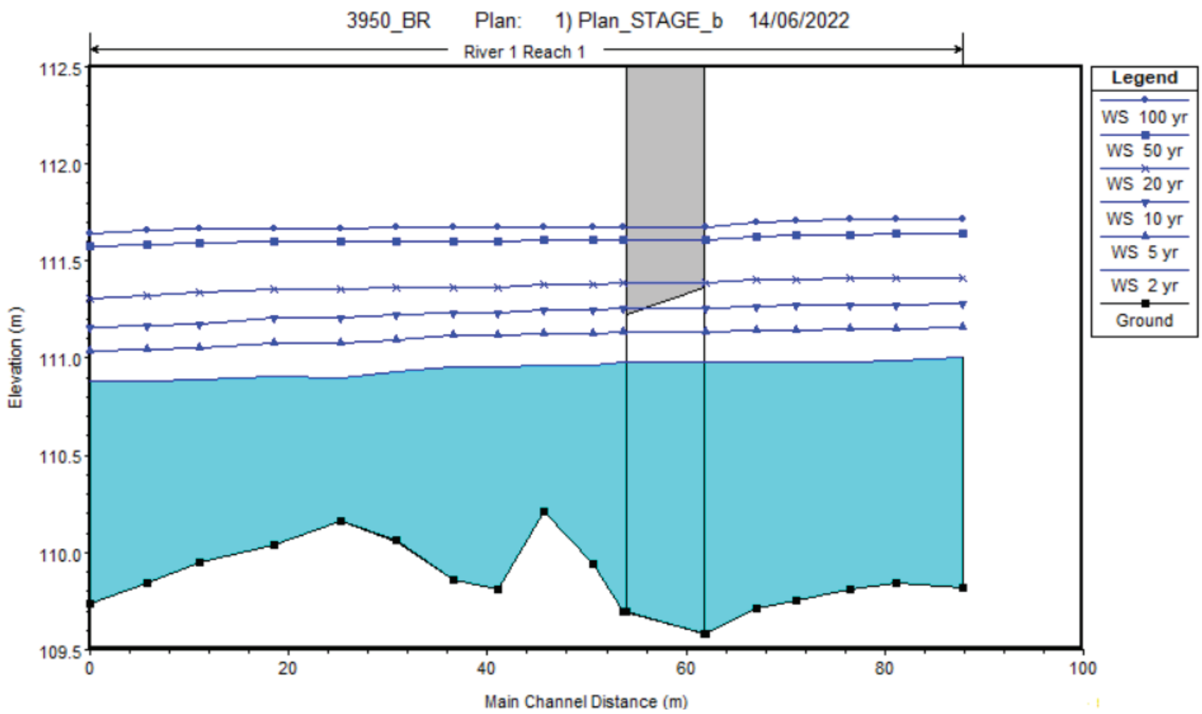


Figure F- 5 Profile - Bridge No. 3950 Existing Scenario

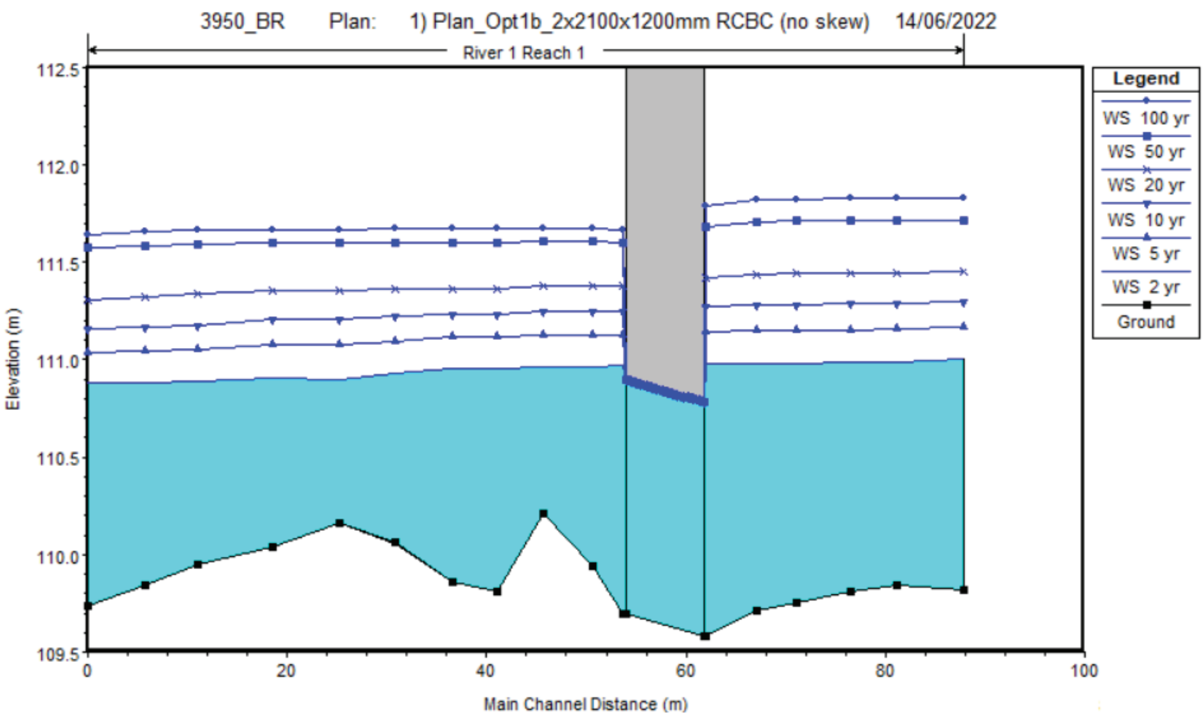


Figure F- 6 Profile - Option 1 - 2 x 2100 x 1200 mm RCBCs

Appendix G

Review Comments

MAIN ROADS WA REGION

Revision: Rev.

Date received: Date

Comments received from: Name, Title, Organisation

Ref	Comment	Response
1.		
2.		
3.		
4.		

MAIN ROADS WA STRUCTURES ENGINEERING

Revision: Rev.

Date received: Date

Comments received from: Name, Title, Organisation

Ref	Comment	Response
5.		
6.		
7.		
8.		