ATTACHMENT 4

Predicted Railway L_{max} Noise Levels


Balance Lot 5010
STAGE 3
Balance Lot 5004
Balance Lot 5003
Balance Lot 5002
Balance Lot 5001
STAGE 2e
YAAMBA
(BRUCE
HIGH
STAGE 2c
Balance Lot 5007
Balance Lot 5010
Length scale 1:3500
0 20 40 80 120 160 m
Noise level
LAmax
incl. facade reflection
in dB(A)
= 69.0
= 72.0
= 75.0
= 78.0
= 81.0
= 84.0
= 87.0
= 90.0
Legend
Cadastral
Acoustic Mound
Parkhurst 11-007
Railway Noise
LAmax Model
5.5m Mound
South of Olive St Access
October 2013
mwa
ENVIRONMENTAL

ATTACHMENT 5

Predicted Bruce Highway L_{10} (18 hr) Traffic Noise Levels

Noise level
L10(18hr)
incl. facade reflection
in dB(A)

- = 51
- = 54
- = 57
- = 60
- = 63
- = 66
- = 69
- = 72

Legend

—— Cadastral

Parkhurst 11-007

Bruce Highway Noise

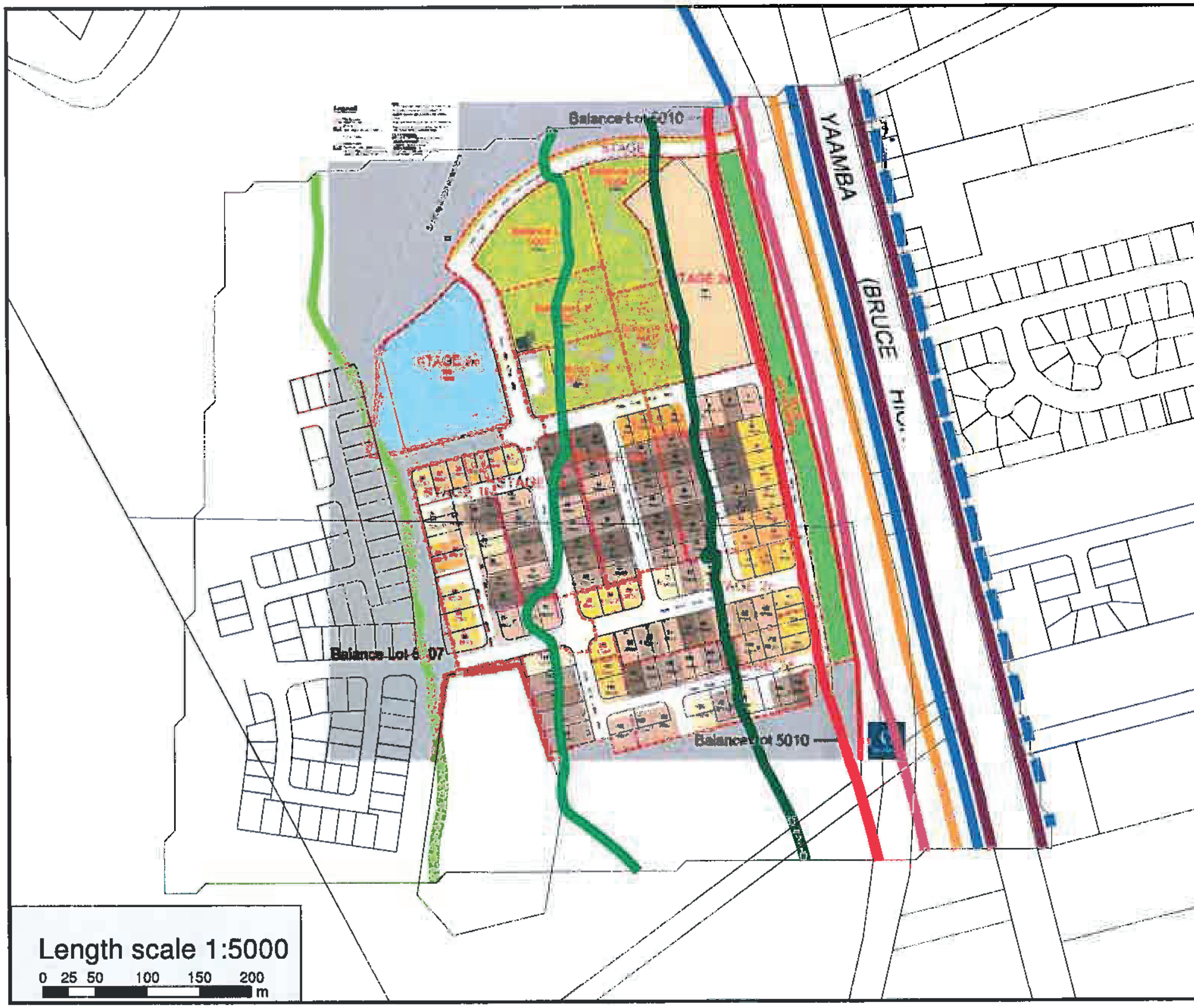
L10(18hr)
Incl. FR

Ground Level (+1.8m)

No Barrier

October 2013

mwa ENVIRONMENTAL



Noise level
L10(18hr)
incl. facade reflection
in dB(A)

= 51
= 54
= 57
= 60
= 63
= 66
= 69
= 72

Legend

Cadastral

Parkhurst 11-007

Bruce Highway Noise

L10(18hr)
Incl. FR

Upper Level (+4.3m)

No Barrier

October 2013

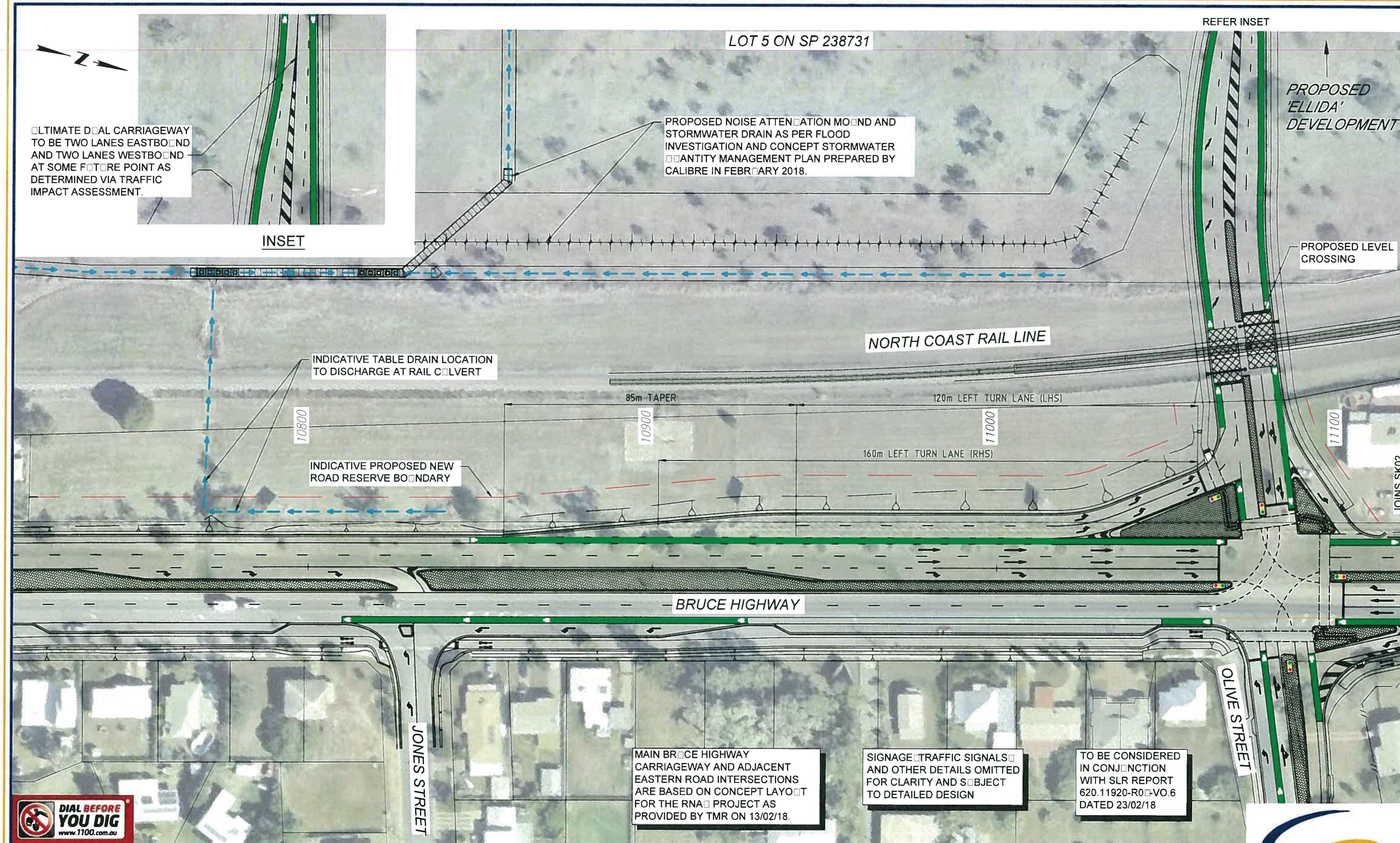
mwa ENVIRONMENTAL

Length scale 1:5000

0 25 50 100 150 200 m

Noise level
L10(18hr)
incl. facade reflection
in dB(A)
Noise Category 0
<= 57.5
Noise Category 1
57.5< <= 62.5
Noise Category 2
62.5< <= 67.5
Noise Category 3
67.5< <= 72.5
Noise Category 4
72.5<
Legend
Road Centreline
Cadastral
Road Surface
Base line
Acoustic Barrier
Parkhurst 11-007
Year 2025 Traffic Noise
MP4.4 Noise Categories
Ground Level (+1.8m)
No Barrier
October 2013
Length scale 1:5000
0 25 50 100 150 200 m


Noise level
L10(18hr)
incl. facade reflection
in dB(A)
Noise Category 0
<= 57.5
Noise Category 1
57.5< <= 62.5
Noise Category 2
62.5< <= 67.5
Noise Category 3
67.5< <= 72.5
Noise Category 4
72.5<
Legend
Road Centreline
Cadastral
Road Surface
Base line
Acoustic Barrier
Parkhurst 11-007
Year 2025 Traffic Noise
MP4.4 Noise Categories
Upper Level (+4.3m)
No Barrier
October 2013
Length scale 1:5000
0 25 50 100 150 200
m
mwa
ENVIRONMENTAL



OLIVE STREET 4 WAY SIGNALISED INTERSECTION CONCEPT

SK01 - GENERAL ARRANGEMENT PLAN
SHEET 1 OF 2

PLANS AND DOCUMENTS referred to in the REFERRAL AGENCY RESPONSE

Queensland Government

SARA ref: 1710-2243 SRA

Date: 21/03/2018

0 2.5 10.0m 1:500 (A1)
0 5.0 20.0m 1:1000 (A3)

calibre

ROCKHAMPTON BRANCH
REFERENCE: 1□-002□20
REV: C DATE: 25.02.2018
DRAWN: AB

QueenslandRail

Civil Engineering Technical Requirement

CIVIL-SR-014

PLANS AND DOCUMENTS referred to in the REFERRAL AGENCY RESPONSE

Queensland Government

SARA ref: 1710-2243 SRA

Date: 21/03/2018

DESIGN OF NOISE BARRIERS ADJACENT TO RAILWAYS

Revision: C

Updated: 30/05/2011

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B	30/09/2010		Rebranded with new disclaimer
C	30/05/2011		MCE replaced with CIVIL, rebranded.

APPROVED BY: ____________ DATE: 30 May 11
MANAGER ASSET STANDARDS

AUTHORISED BY: ____________ DATE: 30/5/11
GM ASSET STANDARDS & STRATEGIES

TABLE OF CONTENTS

1.0 INTRODUCTION

Queensland Rail requires noise barriers that provide the necessary sound attenuation, minimise ongoing maintenance, blend aesthetically and consider community issues.

This Technical Requirement details the criteria which must be met by external party designs for noise barriers adjacent to railway property. Reference is made to the following additional Queensland Rail Technical Requirements which must also be satisfied:

- CIVIL-SR-002 *Work in or about Queensland Rail property,*
- CIVIL-SR-003 *Work adjacent to overhead line equipment,* and
- EMS/STD/46/004 *Code of Practice – Railway Noise Management.*

Copies of these documents may be obtained from Queensland Rail.

All reference documents, e.g. Australian Standards, codes and Queensland Rail Technical Requirements, are to be the latest version.

2.0 SCOPE

This Technical Requirement applies to the design of new noise barriers to be constructed as part of developments adjacent to or in close proximity to Queensland Rail property.

3.0 GENERAL CONSIDERATIONS

Noise barriers will not be required for Queensland Rail stations, platforms, car parks, pedestrian access paths parallel and adjacent to the property boundary and other special areas as agreed by Queensland Rail.

Wherever practicable, noise barriers are to be constructed on the fence / property boundary. Any variation is to be decided upon in consultation with Queensland Rail.
If there is a gap between the barrier and the Queensland Rail corridor boundary which cannot be maintained by the adjoining property owner, the area is to be sealed with concrete. Unless agreed by Queensland Rail, no landscaping is required to stabilize the batter / slope or a specific need is identified.

4.0 NOISE REDUCTION REQUIREMENTS

Any noise reduction measures (including noise barriers) required must be assessed and designed to reduce noise to acceptable quantitative levels outlined in any of the following:

- current Queensland Development Code(s) relating to proposed sensitive building(s) within transport corridors,
- transport noise policy contained in the relevant local government's planning scheme used to condition proposed sensitive building(s) near a transport corridor, and
- Queensland Rail's Code of Practice - Railway Noise Management when retrofitting or augmenting the railway network.

Note: A *sensitive building* is generally considered to be for residential, educational or medical purposes. The noise assessment against these acceptable quantitative levels must be carried out by a suitably qualified noise consultant.

In the case of retrofitting or augmenting the railway network, the noise assessment must be accompanied with a report which must be approved by Queensland Rail. In the case of sensitive buildings, the noise assessment must be accompanied by a report verified by at least the responsible building certifier, but often also Queensland Rail.

5.0 SERVICEABILITY REQUIREMENTS

Service life of materials used in noise barriers is to exceed 40 years with minimal maintenance. Maintenance required during the service life is to be for aesthetic purposes only.

Barrier materials must be fire resistant, and must not produce toxic fumes when burnt. On ignition, flames must not spread easily. The ash left from any burnt material must not be toxic or harmful to the environment.

Panels must be vandal resistant and must pass the Impact Load Tests described in Appendix A.

The panel material must not be easily disfigured by scratching with sharp implements.

Noise barriers must have faces which are not climbable. They are to be environmentally safe and aesthetically pleasing.

6.0 DOCUMENTATION

The drawings and design details for each type of barrier are to be supplied to Queensland Rail. All drawings must be certified as complying with this Technical Requirement by a Registered Professional Engineer of Queensland with RPEQ Number shown on the drawings.

A site plan is also to be provided and is to show:

- track location,
- railway corridor property boundaries,
- contours at 200 mm intervals,

- location of proposed noise barriers,
- type / material selected,
- location of access gates,
- special features,
- drainage, and
- buried services

as appropriate.

Note: Service searches must be undertaken prior to commencing design and construction. Information from DBYD alone is not enough.

7.0 STRUCTURAL DESIGN REQUIREMENTS

All noise barrier components must be designed in accordance with the relevant Australian Standard(s) for the material being used. Loading combinations are to be determined from AS/NZS 1170.0, and as specified within this document.

All calculations (including serviceability design) are to be based on material properties at an ambient temperature of 40 °C.

7.1 Wind Loads

Wind loads are to be calculated in accordance with AS/NZS1170.2:

- Ultimate – 1000 year ARI
- Permissible – 100 year ARI
- Serviceability – 20 year ARI

The minimum net pressure coefficient to be used is 1.2.

Attention is drawn to the requirements of Table D2(C) of AS/NZS 1170.2 for end and internal panels, where different pressure coefficient values will be required. Where shown on the drawings, barrier overlaps are not to be classified as end panels.

7.2 Posts

7.2.1 Post Materials

Posts are to be structurally designed Universal Beam (UB) section, unless at a bend or gate. All posts must conform to the relevant Australian Standard(s). Base plates and associated supports are to conform to AS 3678 and AS/NZS 3679.1.

All steel components are to be hot dip galvanised after fabrication in accordance with AS 4680. Damaged areas of galvanising must be made good in accordance with AS 1650.

Timber posts are not to be used.

7.2.2 Post Serviceability Design

The horizontal deflection of the noise barrier post is to be limited to (Height of Barrier)/150 under serviceability wind load.

7.2.3 Post Structural Design

Design of steel components is to be in accordance with AS4100 or AS4600.

Steel posts are to have a minimum section wall thickness of 3 mm.

7.3 Panels

7.3.1 Panel Material

The panel material is to be selected on the basis of acoustic attenuation ability, strength, durability and economy.

Materials must be manufactured in accordance with the relevant Australian Standard(s). If an Australian Standard does not cover the material, full size tests are to be undertaken and certified by a Registered Professional Engineer of Queensland (RPEQ) to prove the material can satisfy the design requirements.

Patterned concrete and fibre composites are the preferred materials for noise barriers. However, plywood panels may be used if agreed to by Queensland Rail.

The panel material must be capable of meeting the following requirements whether above or in contact with the ground:

- Panels are to have a service life of at least 40 years with minimal maintenance. Accelerated testing or other approved methods are to be used to demonstrate the panels will attain the service life specified.
- Panels must be suitable for application of a fire retardant paint to mask graffiti or manufactured from a material that will allow easy removal of graffiti. The process for removal must be environmentally safe and easy to perform.

  a) It is preferable to use graffiti-resistant material for the panels.
  b) Generally panels are not required to be coated with anti-graffiti paint, except where specified. In these instances, suitable anti-graffiti paint, approved by Queensland Rail must be used.
  c) Panels are to be coloured in a way that will not be damaged / faded by graffiti removal, weather or UV light. A texture finish should be of 15 mm depth at maximum.

  - The materials comprising the barrier are to be environmentally safe.
  - The material must have a surface density of at least 15 kg/m^{2}, to reduce transmitted sound and provide structural integrity.

7.3.2 Concrete & Cementitious Panels

Precast textured concrete panels must have a minimum concrete strength of Grade N40.

The concrete panels must adhere to the *Colour and Texture in Concrete Walling*, Briefing - 03 of

Cement & Concrete Association of Australia (C&CCA).

7.3.3 Fibre Composite Panels

Fibre composite materials are to have their suitability and durability verified by relevant standards or proven by full size testing. The material is to comply with current relevant Australian / overseas standards. Information on the material is to be provided to Queensland Rail for assessment and approval.

7.3.4 Plywood Panels

If the use of plywood panels is agreed to by Queensland Rail, structural design must be in accordance with AS/NZ 2269 and AS/NZ1720.0. The panel minimum surface density of 15 kg/m^2 must be satisfied at a site equilibrium moisture content of (approx. 14%.

Structural plywood is to have a minimum Stress Grade of F14 in accordance with AS/NZS 2269. A surface grade quality of CC or better is required. Permitted imperfections under this grade may be left unfilled as long as they are within the size limitations defined in AS/NZS 2269.

Plywood veneers are to be as free of heart as possible and manufactured from hoop pine.

Plywood panels used on the bottom layer of the barrier wall are to be treated to at least Hazard Level 4. Panels used from the second layer upwards must be treated to at least Hazard Level 3 in accordance with the Timber Utilisation and Marketing Act 1987.

The plywood must be treated with ACQ 2100 or Tanalith E wood preservative chemicals. CCA preservative chemicals must not be used. All plywood panels must be free of treatment sludge deposits.

Each veneer must be treated and seasoned before the veneers are bonded.

The treated plywood is to be seasoned to a moisture content of below 18% before delivery to site. Material supplied above this value will be rejected.
The minimum thickness of plywood panels is to be 27 mm.

Slash pine veneers will not be accepted.

The finish on both sides of the panel is to be textured wood with slim line grooves to reduce checking of the surface.

Edge joints must have a strong polypropylene tongue and groove joining system to help prevent warping and eliminate gaps after shrinkage. The edge strip is to be positively fixed to one panel to ensure the strip does not move with potential vibration of the noise barrier.

Ground level panels are to be at least 400 mm high. The upper most panels are to be positively secured by bolts.

7.3.5 Panel Design

Where the method of construction requires that the top of the barrier be stepped, the Contractor is to build the noise barrier so that the top of the wall is not less than the calculated minimum height, and steps are to be equally incremented in height, as far as possible.

Top panels are to have a rounded edge to deter people walking on it, and also to improve the appearance of the barrier. Any edge capping must be suitably protected against corrosion and have the same life span as the panel.

The bottoms of noise barrier panels are to follow either ground level or an edge strip.

Where the method of construction requires that the bottom of the barrier be stepped, no gaps are to be left as a result of stepping, unless required for drainage purposes. The Contractor is to fill all gaps with concrete or other material approved by Queensland Rail.

The barrier must be continuous and solid with no visible or light gaps between panels. For maximum effectiveness, the barrier is to be continuous down to ground level, with any gaps filled (e.g. as a result of stepping).

If damming of water at the bottom of the barrier is likely, discrete drainage points are to be incorporated into the designs without compromising the barrier's ability to achieve acceptable noise levels. The drainage points must not concentrate water flow.

Panels must have positive fastening devices to deter theft. Connection details are to permit erection and removal of the panels on a regular basis.

Noise barriers located close to tracks, such that vehicles cannot gain access between track and barrier, must consist of panels that can be easily removed and manhandled.

7.3.6 Panel Serviceability Design

The horizontal deflection of the panel under serviceability wind is to be limited to Span/150.

To eliminate the need for electrical earthing, steel components from panel to panel must be insulated from each other.

7.4 Fasteners

Connections must be designed to adequately secure all members for the design loading and allow for panel movement where necessary.

Use of screws will not be permitted.

For connections involving timber components, the bolts, etc. must be retightened when the structure reaches the site equilibrium moisture content.

All bolts, nuts and washers must comply with AS 1111, 1112 and 1237, as appropriate.

All bolts, nuts and washers must be hot dip galvanised with a minimum 50 microns thickness coating in accordance with AS 1214. All washers must be hot dip galvanised in accordance with AS 4680.

Alternative coatings will be considered, provided they have at least the equivalent durability as that specified.

Zinc plated bolts or nails are not acceptable.

7.5 Footings

7.5.1 Footing Type

Footings are preferably to be *"bored"*, but *"block"* footings are allowed if circumstances render boring impractical.

7.5.2 Block Footing

The block footing may be used where one of the following constraints exists:

- access for drilling rig is not practical,
- the ground is not suitable for boring or
- the foundation depth is limited because of an underground service or culvert.

The footing must be designed to prevent instability in overturning, uplift and sliding in accordance with AS/NZS 1170.0 for ultimate loads.

To resist temperature and shrinkage cracking, reinforcement of not less than 500 mm^2/m in each direction must be used in exposed surfaces.

The top of the footing is to be at least 300 mm below ground level.

7.5.3 Bored Footing

The bored footing is to be used where access is available and the ground is suitable for boring.

The designer is to use the Broms method (refer to Appendix B) to calculate footing depth. Footing depth is to be increased by an appropriate factor (at least 1.5) if the footing is less than 1.5 m from the edge of an embankment or cutting.

It is to be assumed that existing cuttings within Queensland Rail property will be widened to within 1.0 m of the property boundary. The minimum depth of footing is to be twice the footing diameter.

7.5.4 Finish

The top of the footing must be shaped to shed water away from the post.

7.6 Protective Painting of Steel Posts and Footings

After post installation, a neat, continuous, water-based, bituminous paint *"collar"* is to be applied on every post up to 150 mm above the finished concrete footing level. This collar is to extend onto the adjacent concrete surface of the footing for a minimum 100 mm from any point on the post.

8.0 CONSTRUCTION TOLERANCES

Tolerances are only permitted in order to cater for variations caused during manufacture and construction.

The following tolerances are to apply to the construction of the noise barriers.

TABLE 1 – TOLERANCES

CRITERIA	TOLERANCE
Depth of footing	+ 200 mm - 50 mm
Centre to centre distance between posts	+ 10 mm - 10 mm
Thickness of noise barrier panels	+ 5 mm - 1 mm
Posts: Variation from vertical	5 mm/m for isolated posts Parallel for adjoining posts
Protective treatment of timber	In accordance with this document and TUMA
Hot dip galvanizing: structural members	Coating thickness of 80 microns min. in accordance with AS4680

9.0 ASSOCIATED COSTS INCURRED BY QUEENSLAND RAIL

All of Queensland Rail's costs associated with the review, design and construction of the noise barriers and the implementation of Queensland Rail's Technical Requirements will be charged to the building owner or its agent. This includes any remedial work necessary to Queensland Rail property as the result of this work and any accidental damage, as well as costs associated with train delays. Rates will be set by Queensland Rail.

APPENDIX A: IMPACT TEST FOR NOISE BARRIER PANELS

Noise Barrier Panels must be able to withstand the following Impact Test.

The test panel is to be subjected to impact energy of 150 Joule, consisting of four (4) load repetitions of an impactor. This is to simulate a concerted attack by vandals.

The impactor is to be manufactured from steel of density 7.8 t/m^3 and spherical in shape.

An impact energy of 150 Joule is achieved by dropping the impactor from a specific height, H (in mm) onto the horizontal test panel. The impactor is raised so that its centre of gravity is at height, H which is calculated from the equation:

$$H = \frac{15300}{m}$$

where	*H*	=	Drop Height in millimetres
	m	=	Mass of Impactor in kilograms

For solid panels, the point of impact is typically at mid-span and 150 mm from the free edge or in a location to give the worst effect. If the panel consists of boards that have internal voids, the point of impact must be mid-span and centrally between the internal stiffeners of the outermost board. Where applicable, the panel must not weigh more than the maximum allowable weight defined in the Technical Requirement.

The panel is considered to have passed the test if it remains serviceable after the four load repetitions. That is, it will still perform its function as a noise barrier and can withstand its design load without shortening its service life.

The results of the test are to be certified by a Registered Professional Engineer of Queensland (RPEQ).

APPENDIX B: BROMS METHOD FOR BORED FOUNDATIONS

An acceptable method for the design of footing depth is based on Brom's theory as follows.

Applicable case is short pile in cohesive soils.

$$F = \frac{H_u}{9 \times S_u \times D}$$

$$M_{\max} = H_u \times (E + 1.5D + 0.5F)$$

$$G = \sqrt{\left(\frac{M_{\max}}{2.25 \times S_u \times D}\right)}$$

$$L = 1.5D + F + G$$

Where:

D **= .... Diameter of footing (m)**

E **= .... Height of barrier / 2 (m)**

F ***........ Depth to zero shear point minus 1.5*D (m)***

G ***= .... Depth of footing minus F minus 1.5*D (m)***

H_u = ... Ultimate lateral shear (kN)

L **= .... Depth of footing (m)**

M_{max} = ... Maximum ultimate lateral bending moment in footing (kN.m)

S_u = ... Factored undrained shear strength of soil (kPa)

calibre

Ellida, Parkhurst Stage 1-3

Flood Investigation & Concept Stormwater Quantity Management Plan

PLANS AND DOCUMENTS referred to in the REFERRAL AGENCY RESPONSE

Queensland Government

SARA ref: 1710-2243 SRA

Date: 21/03/2018

PREPARED FOR STOCKLANDS DEVELOPMENT PTY LTD

Calibre Consulting (Qld) Pty Ltd
ABN 38 109 428 506

17-002720-WER02 | 19 February 2018

CONTACT US

(07) 3895 3444

Ground Floor, 545 Queen Street
Brisbane QLD 4000

WWW.CALIBREGROUP.COM

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Contents

Tables

Figures

Appendices

1 Introduction

Stockland Development Pty Ltd have engaged Calibre to prepare this Flood Investigation and Concept Stormwater Quantity Management Plan for the proposed Ellida, Parkhurst residential development. The development site is located within the Rockhampton Regional Council (RRC) Local Government Area.

This hydrologic and hydraulic investigations and analysis was developed to support the initial application for Stages 1 to 3 of the residential development. This report outlines the proposed stormwater management strategies required to manage peak flows conveyed through and leaving the proposed development in accordance with the Capricorn Municipal Development Guidelines (CMDG). Analysis of local external flows contributing to the site was also undertaken in order to facilitate the safe conveyance runoff to/through the site.

Stages 1 to 3 of the proposed development consists of 124 residential allotments and 1 mixed use allotment as detailed in the RPS Proposal Plan *Drawing No. 109116-90I* within **Appendix A**.

1.1 Scope

This investigation has addressed the following items:

Stormwater Management (Quantity)

- Hydrologic Investigation – Hydrologic analysis was undertaken using XP-RAFTS to determine local peak flows generated onsite as well as globally generated flows to Ramsey Creek for both existing and site (Stage 1 to 3) developed conditions. Local flows generated and conveyed through the development site were analysed to assist in the design of onsite stormwater management infrastructure. Global flows along Ramsey Creek were analysed to compare existing and developed scenario peak flows in order to assess the need for onsite peak flow mitigation.

  Hydraulic Investigation – Hydraulic analysis was performed for the proposed onsite stormwater quantity management measures to ensure no adverse flood impact on adjacent properties. Overland flow paths proposed for the development site were also analysed and designed in order to determine subsequent overland flow flood levels from which allotment and floor levels can be set.

It is noted that stormwater quality management for the development has been addressed in a separate report.

2 Site Characteristics

2.1 Location

The proposed development is located in Parkhurst within the RRC Local Government Area. The ultimate development is bound by Ramsey Creek to the North, Bruce Highway and the North Coast Railway Line to the East, and grazing fields to the South and West. As seen in **Figure 1.1** below, Stages 1 to 3 of the development are situated towards the eastern portion of the site. The ultimate development consists of the remainder of the site not bound within Stages 1 to 3. The 278.4 hectare site comprises of five rural allotments, which are described by the following Real Property Descriptions:

1. Lot 1 on RP602376;
2. Lot 2 on RP608099;
3. Lot 5 on SP238731; and
4. Lots 37 and 38 on RP600698.

The approximate location of Stages 1 to 3 have been depicted in **Figure 1.1** below. For a detailed plan for Stages 1 to 3 refer to the Stockland Development Pty Ltd Proposal Plan *Drawing No. 109116*-90I in **Appendix A**.

Figure 1.1- Approximate Location of North Parkhurst and Stages 1 to 3 (Source: Google Maps)

2.2 Existing Site Topography & Drainage Characteristics

The development site is located within the Ramsay Creek catchment. Ramsay Creek meanders along the northern border of the site and flows toward the west. It eventually merges with the Fitzroy River approximately 2km south-west of the site.

Under existing conditions, the northern edge of the site (including Stage 1 to 3) drains directly to Ramsay Creek, whilst the remainder of the site discharges to the creek along various downstream locations. Two primary tributaries from the subject site were identified that discharge to the west. It was verified from the DEM topographic maps that both tributaries eventually merge at a convergence point into Ramsay Creek approximately 1.2km along the main watercourse, to the west of the site. Refer to **Figure 1.1** above for details.

The entire catchment containing the area of the subject site discharging to Ramsay Creek via the convergence point of discharge has an area of 1,715ha.

3 Hydrological Investigation

Hydrologic analysis has been undertaken for the Ramsay Creek catchment in order to determine peak flows upstream, within and downstream of the site development Stages 1 to 3. An XP-RAFTS model of the Ramsay Creek catchment, (supplied by RRC) was updated in order to ascertain peak flow conditions for the existing and developed site conditions for critical locations along Ramsay Creek. Alterations to the original models catchment set up were made based on the local external catchments contributing to the site and the development layout.

3.1 Local Catchment Analysis

Under existing conditions, the development site (Stages 1 to 3) accepts runoff from a local upstream catchment of 13.69 hectares, east of the site. Runoff currently enters the site as concentrated overland flow, having to traverse the Pacific Motorway/Yamba Road and the North Coast Railway corridor via minor stormwater piped drainage infrastructure. The local upstream catchment is largely made up of low density residential allotments and the remainder made up of road and railway corridor, that being Yamba Road/Pacific Motorway with a small portion of the Yamba Road reserve and the North Coast Railway corridor.

3.1.1 Catchments

The XP-RAFTS model (supplied by RRC) indicates the development site (and the local contributing catchment) makes up a portion of a much larger subcatchment (RAM-13) contributing to Ramsey Creek. RAM 13 has an area of approximately 147 hectares, a small portion of which locally contributes to the sites via the eastern property boundary.

Refer to **Table 3.1** and **Table 3.2** below for the XP-RAFTS sub-catchment details as received from Council and the subsequent breakup of the existing catchment, representing the upstream local catchment to the east and the remaining greater catchment.

Table 3-1 - XP-RAFTS Existing Scenario Local Catchment Setup - As Received from Council

Catchment ID	Area (Ha)	Imperviousness (%)	Impervious Area (Ha)	Vectored Slope (%)	Manning's 'n'
RAM13	146.628	6.21	9.11	0.609	0.067

Table 3.2 below indicates the breakup of the greater subcatchment RAM-13 under existing conditions, representing the local upstream catchment contributing to the site from the east (RAM13-2) and the remaining greater subcatchment (RAM13-1). Refer to Calibre sketch 17-002720-SK01 in **Appendix C** for the existing catchment layout plan.

Table 3-2 - XP-RAFTS Existing Scenario Catchment Setup – Local Subcatchment Breakdown

Catchment ID	Area (Ha)	Imperviousness (%)	Impervious Area (Ha)	Vectored Slope (%)	Manning's 'n'
RAM13-2	13.690	27.7	3.80	0.609	0.067
RAM13-1	132.938	4.0	5.32	0.609	0.067
TOTAL	146.628	6.21	9.11	0.609	0.067

Table 3.3 below indicates the breakup of the greater subcatchment RAM-13 under developed conditions, representing the local upstream catchment contributing to the site from the east as per existing conditions above and the developed onsite catchments (RAM13-2C, RAM13-2D & RAM13-2E). RAM13-1 represents the remainder of RAM13 catchment as per existing conditions. Refer to Calibre sketch 17-002720-SK02 in **Appendix C** for the developed catchment layout plan.

Table 3-3 - XP-RAFTS Developed Scenario Catchment Setup – Local Subcatchment Breakdown

Catchment ID	Area (Ha)	Imperviousness (%)	Impervious Area (Ha)	Vectored Slope (%)	Manning's 'n'
RAM13-2A	12.931	29.4	3.80	0.609	0.067
RAM13-2B	0.975	0.0	0.00	0.609	0.067
RAM13-2C	7.891	82.2	6.49	0.609	0.067
RAM13-2D	5.179	0.5	0.03	0.609	0.067
RAM13-2E	8.322	80.0	6.66	0.609	0.067
RAM13-1	114.082	4.7	5.32	0.609	0.067
TOTAL	149.380	~	~	~	~

Note: Stage 1 to 3 development scenario results in added catchment area of 2.752Ha applied to RAM13-2E. This results in a reducing the adjacent RAM14 catchment area by 1.1612ha. The new RAM14 catchment area is 132.892ha all other catchment parameters are as per the Council received model.

All other catchments in the model are as per the RRC issued XP-RAFTS model.

3.1.2 Model Configuration

A summary of the modelling parameters for the existing and developed scenarios XP-RAFTS models is indicated **Table 3.4** below.

Table 3-4 - XP-RAFTS Model Parameters

XP-RAFTS Model Parameter	Parameter
Storage Multiplication Coefficient	1.0
Initial & Continuing Losses	15 & 1
Average Rainfall Intensity: IFD Data	Rockhampton, QLD
Temporal Pattern	Zone 3

3.1.3 Model Verification

The model layout, including sub-catchment boundaries is provided on Calibre sketch 17-002720-SK02 in **Appendix C.**

Table 3-5 - XP-RAFTS Model Verification Results – Existing Scenario - Local Results

AEP (%)	RAM-13: Council Issued	RAM13-1 & RAM13-2: Calibrated	Difference (%)
63	1.482	1.815	18
39	2.590	2.991	13
18	4.250	4.646	9
10	5.392	5.741	6
5	7.035	7.273	3
2	9.456	9.523	1
1	14.903	14.123	-6

The correlation of peak discharges between the local original (i.e. RRC received) existing model and the local calibrated existing model indicates that a satisfactory calibration was achieved. Refer to **Table 3.1** & **3.2** for catchment breakdown details.

Further calibration was sought for the convergence point just downstream of the site (CON-2) and is indicated in **Table 3.6** below.

Table 3-6 - XP-RAFTS Model Verification Results – Existing Scenario - Global Results

AEP (%)	CON-2: Council Issued	CON-2: Calibrated	Difference (%)
63	28.809	29.243	1
39	45.344	45.980	1
18	66.919	67.823	1
10	80.476	81.478	1
5	98.865	99.953	1
2	119.296	118.832	0
1	147.922	146.988	-1

The correlation of peak discharges between the Council received original global CON-2 results and the calibrated global CON-2 results for the existing scenario indicates that a good calibration was achieved.

3.1.4 Peak Flow Results

Table 3.7 below indicates the developed scenario cumulative peak flowrates at critical locations on site. Refer to Calibre sketch 17-002720-SK02 in **Appendix C** for the subcatchment extents and critical flow locations.

Table 3-7 - XP-RAFTS Cumulative Peak Flowrates – Developed Scenario – Local Catchments Analysis

Catchment ID	Peak Flowrates (m^3/s)						
	63% AEP	39% AEP	18% AEP	10% AEP	5% AEP	2% AEP	1% AEP
RAM13-2A	0.656	1.047	1.642	2.023	2.531	3.094	3.675
RAM13-2B	0.686	1.096	1.716	2.116	2.650	3.243	3.844
RAM13-2C	1.307	2.166	3.329	4.045	5.029	5.912	6.951
RAM13-2D	1.366	2.262	3.494	4.261	5.318	6.279	7.404
RAM13-2E	2.240	3.714	5.558	6.672	8.181	9.439	11.486
RAM13-1	26.508	41.332	60.720	72.932	89.621	113.183	140.653

The peak flow rates documented above were used to design the proposed stormwater management (mitigation) measures to convey runoff to, through and offsite. Refer to **Section 4** for the hydraulic design details**.**

3.2 Regional Catchment Analysis

In addition to analysing flows contributing to/through the site, and immediately downstream, it was also necessary to look at a number of other locations further downstream along Ramsey Creek. Peak flow comparisons were made between the original Council received XP-RAFTS model and the Calibrated developed scenario XP-RAFTS model.

Refer to Calibres Sketch 17-002720-SK01 & SK02 in **Appendix C** for the regional catchment plan for existing and developed conditions, respectively.

3.2.1 Catchments

Refer to **Table 3.3** in **Section 3.1.1** for the subcatchment breakdown of the original existing RAM13 catchment as per the developed scenario. The developed scenario will see RAM13-2E acquire an additional 2.752 hectares, with the adjacent RAM14 catchment contributing approximately 1.16 hectares of this, resulting in a revised RAM-14 catchment area of 132.892 hectares. Imperviousness remains at 0% as per the received existing XP-RAFTS model. All other catchment areas are as per the original RRC received XP-RAFTS model. The remainder of this increase is acquired south of the original RAM-13 catchment extent.

3.2.2 Model Configuration Changes

Other than the changes indicated in **Section 3.2.1** above, no further changes to the model have been made and remains the same as per the received Council model.

3.2.3 Peak flow Results

Peak flow comparisons were made at a number of additional locations downstream of the site in order to gauge whether any adverse or worsening of peak flow occurs as a result of the development. Refer to **Table 3.8** below for peak flow comparison summaries at critical locations downstream of the site. Refer to Calibre sketch plans 17-002720-SK01 Calibre sketch 17-002720-SK02 in **Appendix C** for the critical downstream flow analysis locations.

Table 3-8 - Regional XP-RAFTS Peak Flow Comparison (m3/s)

AEP (%)	EX: RAM 13	DEV:RAM 13-1	Difference	EX: RAM 15	DEV:RAM 15	Difference	EX: RAM 17	DEV:RAM 17	Difference
63	25.773	26.508	3%	30.304	31.039	2%	35.138	35.866	2%
39	40.379	41.332	2%	47.830	48.783	2%	56.135	57.075	2%
18	59.405	60.720	2%	70.802	72.117	2%	84.076	85.369	2%
10	71.446	72.932	2%	85.260	86.747	2%	101.853	103.312	1%
5	87.905	89.621	2%	104.894	106.609	2%	126.116	127.796	1%
2	112.773	113.183	0%	125.533	127.719	2%	153.352	155.564	1%
1	139.710	140.653	1%	156.825	157.842	1%	192.770	194.192	1%

The results demonstrate that the proposed development will result in negligible increases in peak flows downstream of the site. The maximum predicted increase in peak flow of 3% occurs during the minor storm events, with only a 1% increase experienced at all critical analysis points for the 1% AEP storm event. These increases in peak flow are not expected to result in any perceivable change in flood conditions, let alone an adverse impact. Therefore peak flow mitigation is neither required nor proposed as part of the Stag 1 to 3 development.

Waterway Stability Management requirements as required under the SPP (2017) have been addressed as the change in peak flows for the 63% AEP event is also negligible. Furthermore it is expected that the stormwater quality management strategies proposed for the development will assist in the reduction of 63% AEP peak flows.

4 Hydraulic Investigation

A hydraulic investigation was undertaken for the development site using the local hydrological modelling undertaken as presented in **Section 3.1**. This entailed first order hydraulic calculations to demonstrate the proposed drainage strategy for the Stage 1 to 3 development does not cause an adverse flood impact or an actionable nuisance to adjacent and downstream properties.

4.1 Drainage Strategy

The proposed drainage strategy involved analysis of a number of proposed hydraulic components designed to convey flows through the Stage 1 to 3 site in a safe and efficient manner, without causing adverse flood impacts to internal and surrounding properties.

The drainage strategy looks at a number of stormwater management related aspects associated with the proposed development and they are as follows:

- Proposed swale and culvert/inlet system adjacent acoustic mound/berm structure to cater for locally contributing catchment from the east;
- District park overland flow path to cater for some internally generated development flows and eastern flows conveyed from the proposed culvert/inlet system adjacent eastern property boundary and acoustic berm;
- Proposed internal arterial road culvert crossing to cater for district park flows, some internally generated development flows and flows contributing to the site form the east.

4.2 Hydraulic Analysis

First order hydraulic analysis was performed for a number of the proposed onsite stormwater management components.

Previously determined peak flow results at the onsite analysis locations are indicated in **Table 4.1** below. The onsite analysis locations are indicated in Calibre Sketch 17-002720-SK02 in **Appendix C**.

Table 4-1 - Cumulative 1% AEP Peak Flowrates for Onsite Analysis Point

Analysis Point ID	1% AEP Peak Flows (m3/s)
1	3.675
2*	3.844*
3	6.951
4	7.404
5	11.486

Note: Locally generated 1% AEP flow to Analysis Point 2 = 0.200m3/s. Local flow to be used for analysing proposed swale drain leading up to proposed RAM13-2B inlet structure.

4.2.1 Drainage Infrastructure Adjacent Acoustic Barrier

For runoff contributing to the development site from the east, it is proposed to implement drainage swales adjacent the acoustic mound / berm structure lining the eastern property boundary. The proposed swales will direct flows to the proposed inlet structures and underlying culvert cells to take flows under the berm structure and discharge to the onsite district park. Manning's 'n' swale calculations were undertaken in order to size the proposed swale, whereas the weir formulae was used for sizing up the inlet structures feeding the underlying culvert structures. Hydraulic grade line analysis was performed for the proposed culverts conveying flows under the acoustic berm/mound.

Table 4.1 above indicates 1% AEP peak flow rates at critical analysis points onsite. The local 1% AEP peak flowrates for analysis points 1 and 2 were used to size the proposed swale drains adjacent the acoustic mound.

A Manning's equation calculation was undertaken to determine the most suitable profile for the swales running adjacent the acoustic mound. Refer to **Appendix B** calculation details and Drawing Nos. 17-002720-SK03 and 17-002720-SK04 in **Appendix C** for the location of the proposed swales, respectively. **Figure 4-1** and **Figure 4-2** below indicates the typical section profile of Swale 1 and Swale 2. A Manning's n value of 0.033 was adopted, representing short grass, and a longitudinal slope 1.2% was based off design previously undertaken.

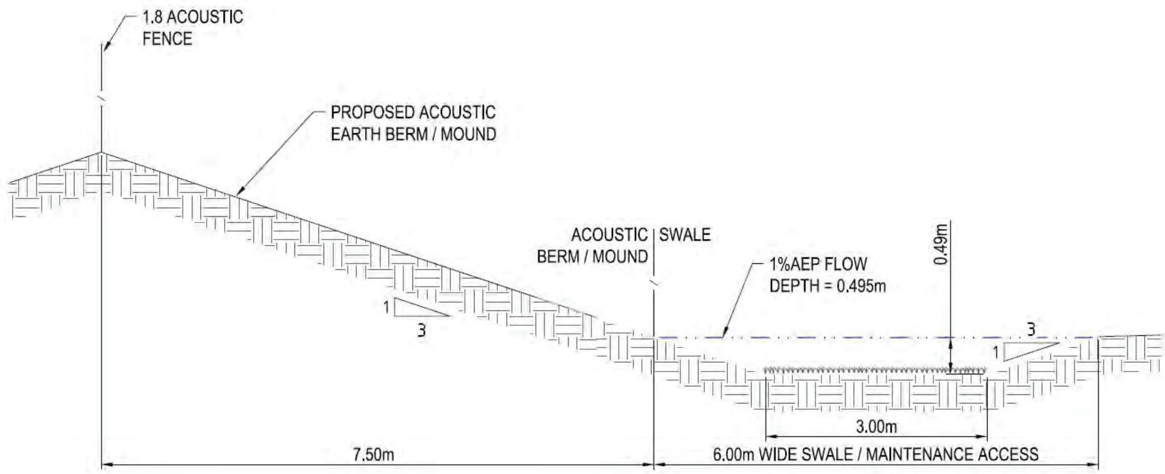

Figure 4-1 - Proposed Swale 1 Profile

The Swale 1 configuration will be adopted where runoff is received from the northern and southern ends of the acoustic mound, together with the runoff from the catchment upstream of the rail corridor.

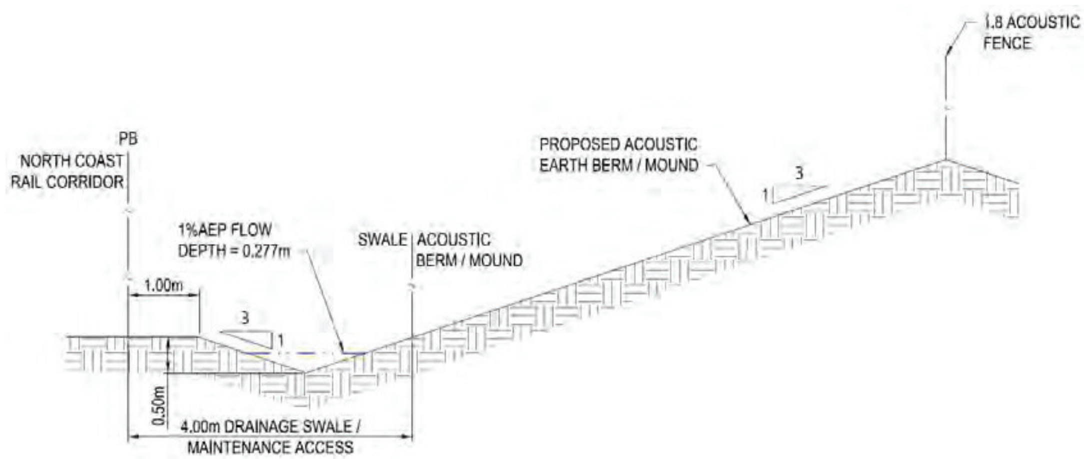

Figure 4-2 - Proposed Swale 2 Profile

The Swale 2 configuration will be adopted for the northern and southern ends of the acoustic marrier and convey runoff to proposed Swale 1 and inlet pits.

Table 4.2 below summarises the hydraulic flow conditions within the proposed swales adjacent the acoustic mound.

Table 4-2 - Manning's Calculation Summary - Drainage Swales Adjacent Acoustic Mound

Parameter	Swale 1 (RAM13-2A)	Swale 2 (RAM13-2B)
1% AEP Flow (m^3/s)	3.675	0.200
Flow Depth (m AHD)	0.488	0.277
Velocity (m/s)	1.749	0.816
Velocity-Depth Product (m^2/s)	0.866	0.134

The above mentioned swales are to feed an underlying culvert structure via two inlet systems (i.e. Inlet 1 & Inlet 2), made up of two sets of 5/900x900 field inlets, located at the analysis points associated with RAM13-2A and RAM 13-2B. Refer to Drawing No. 17-002720-SK03 in **Appendix C** for locations of inlets arrangements/analysis points.

The weir equation was used to calculate the inlet capacity of each inlet arrangement in order to ensure conveyed runoff will enter the underlying culvert system, without causing any adverse flood conditions for the neighbouring railway corridor. Refer to **Table 4.3** below for inlet capacity calculation details.

Table 4-3 - Inlet Capacity Calculation Summary – Proposed Inlets

Parameter	Inlet 1 (RAM13-2A)	Inlet 2 (RAM13-2B)
1% AEP Flow (m^3/s)	3.675	0.200
Weir Width (m)	18 (5 x (0.9mx4)	0.90
Depth of flow over Inlet (m)	0.27	0.29

Hydraulic grade line analysis was then performed for the proposed culvert and inlet structure configuration. It was determined that a 2400x900 RCBC would facilitate conveyance of flows entering the site from the eastern property boundary.

Refer to **Table 4.4** below for the proposed culvert hydraulic grade line analysis summary.

Table 4-4 – Culvert Capacity Calculation Summary – Culvert MM

Parameter	Culvert MM
1% AEP Flow (m^3/s)	3.84
Culvert Arrangement	1/2400x900 RCBC
Achieved Freeboard to Pit SL(mm)	>300

4.2.2 District Park

Flows leaving the above-mentioned Culvert MM are to be conveyed to an open channel which ultimately discharges to the district park area/open space. Runoff is the conveyed further north via a formed flow path to the proposed culvert crossing under the proposed internal arterial road.

Manning's 'n' swale calculations were undertaken in order to size the proposed open drain leading from the culvert structure under the acoustic mound.

Table 4.1 above indicates 1% AEP peak flowrates at the main analysis points onsite. The cumulative 1% AEP peak flowrates for analysis points 2 and 3 were used to size the proposed open drain and constructed overland flow path leading up to the Arterial road culvert crossing.

Manning's equation calculations were undertaken to determine the most suitable profile for the open drain leading from the acoustic mound Culverts (i.e. Culvert MM). Summarised results are presented in **Table 4-5** below. Refer to in **Appendix B** calculation details and Drawing No. 17-002720-SK03 & SK04 in **Appendix C** for the location of the proposed open drain and formed flow path, respectively.

Table 4-5 - Manning's Calculation Summary – Open Drain

Parameter	Open Drain (Section A)	Open Drain – Section B	Constructed Flow Path (Section C)
1% AEP Flow (m^3/s)	3.844	6.951	6.951
WSL (m AHD)	28.610	28.390	27.430
Flow Depth (m AHD)	0.960	1.282	0.697
Velocity (m/s)	1.120	0.590	0.690
Velocity-Depth Product (m^2/s)	1.07	0.760	0.480

4.2.3 Arterial Road Culvert Crossing

For runoff leading up to the proposed arterial road, weir and culvert calculations were undertaken in order to size the culvert crossing arrangement under the arterial road carriageway. The arterial road profile was determined during previous design studies and was retained for this culvert design component.

Table 4.1 above indicates 1% AEP peak flowrates at the main analysis points onsite. The cumulative 1% AEP peak flowrate for analysis point 4 were utilised to size the proposed culvert structure under the Arterial road culvert crossing.

Table 4.6 below indicates the culvert design parameters used and subsequent flow/flood results.

Table 4-6 – Configuration Summary – Arterial Road Crossing

Parameter	Culvert under Arterial Road
Culvert Arrangement	3/2100x750 RCBC & 2/2100 Linking Slabs
Minimum Road Crest Level (m AHD)	27.108
US Invert Level (m AHD)	25.35 (based off previous design)
1% AEP Flow (m^3/s)	7.404
US WSL (m AHD)	25.91
TW Depth (m)	0.75 (Culvert obvert)
Culvert Flow (m^3/s)	7.404
Weir Flow (m^3/s)	N/A