



RAILWAY PARADE BRIDGE OVER ELLEN BROOK PRELIMINARY DESIGN REPORT

OPTIONS ASSESSMENT



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CITY OF SWAN

RAILWAY PARADE BRIDGE OVER ELLEN BROOK

Preliminary Design Report

Options Assessment

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REVISIONS

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CONTENTS

1	Executive Summary.....	1
2	Introduction	1
2.1	Designer's Brief	1
2.2	Background to the Project	1
2.3	Project Objectives.....	1
2.4	Previous Studies.....	1
3	Site and Function.....	2
3.1	Site Location.....	2
3.2	Function of the Structure and Obstacles Crossed	2
3.3	Choice of Location.....	2
3.4	Site Description and Topography	3
3.5	Vertical and Horizontal Alignment.....	3
3.6	Cross-sectional Dimensions on the Alignments.....	3
3.7	Existing Underground and Overground Services.....	3
3.8	Geotechnical Summary	4
3.9	Hydrology and Hydraulic Summary	4
3.10	Environmental Summary	7
3.11	Heritage Summary.....	9
3.12	Survey Data.....	10
4	Design Criteria	11
4.1	Type of Traffic Carried Over	11
4.2	Traffic Volume	11
4.3	Design Speed	11
4.4	Design Life.....	11
4.5	Loading.....	11
4.6	Soil Parameters Used in the Design.....	12
4.7	Hydrology & Hydraulics	13
4.8	Lighting Requirements.....	13
4.9	Construction Methods.....	13
4.10	Inspection and Maintenance Requirements.....	13
4.11	Other Requirements	13
4.12	Cost	14
5	Proposed Structures.....	15
5.1	Option 1 – <i>Single Span T-Roff Bridge</i>	15

5.2	Option 2 – <i>Three-Span T-Roof Bridge</i>	21
5.3	Option 3 – <i>Precast Arch</i>	26
6	Preliminary Cost Estimates	31
6.1	Methodology	31
6.2	Cost Estimate of Option 1.....	32
6.3	Cost Estimate of Option 2.....	32
6.4	Cost Estimate of Option 3.....	33
6.5	Whole of Life Cost	33
6.6	Cost Estimate Summary	36
7	Options Assessment.....	37
7.1	Evaluation Criteria	37
7.2	Description of Criteria	37
7.3	Summary and Recommendations	41
8	Consultations and Approvals.....	42
9	Issues To Be Resolved.....	42
10	Safety in Design	42

APPENDICES

Appendix A	Hydrology & Hydraulic Assessment Report
Appendix B	Environmental Assessment Report
Appendix C	Flora and Vegetation Survey
Appendix D	Black Cockatoo Habitat Assessment
Appendix E	Desktop Review - Review of Aboriginal Sites
Appendix F	Preliminary Cost Estimates
Appendix G	Approvals and Consultations
Appendix H	Safety in Design
Appendix I	Dial Before You Dig
Appendix J	Pattern Finish for the Precast Arch Option
Appendix K	Preliminary Design Drawings
Appendix L	Preliminary Lighting Design

1 EXECUTIVE SUMMARY

Hyder Consulting has been engaged by the City of Swan of (CoS) to prepare a preliminary design report to investigate the options for the proposed crossing over Ellen Brook in Upper Swan.

The aim of this investigation has been to develop three distinct bridge options and to assess them against the evaluation criteria, the evaluation criteria assessed for the impact on heritage, environment, hydrology and hydraulics, bridge aesthetics, bridge cost, constructability and durability. The bridge cost criterion has been given the greatest weighting factor of sixty (60) per cent whereas the other criteria have been allocated the factor of five (5) and ten (10) per cent.

Even though the project site is located within a residential and metropolitan area it could be defined as 'greenfield' due to the lack of constraints related to under and overground services and a limited traffic management required during construction. However, the site has been classified as an 'other heritage place' by Department of Indigenous Affairs (DIA), which means that the site may become registered if sufficient evidence / information is collected during the heritage survey which currently is taking place.

Ellen Brook is zoned as 'Parks and Recreation' under Metropolitan Region Scheme and the project site crosses a section which is classified as a Conservation Category (CC) Wetland. Therefore, a full environmental assessment was undertaken to establish any potential impact of the new crossing on the local environment. Considering the state of the vegetation in this area it was concluded that the construction of the new road and bridge has a low to unlikely risk of any significant environmental impact. Potential impacts on water flow, groundwater table, discharge of pollutants shall be managed during construction through an Environmental Management Plan. Out of the group of the environmental risks construction in the wetland areas may be a concern to the Department of Environmental Protection (DEC).

During the preliminary design an extensive hydrological and hydraulic investigation assessment was carried out in order to determine suitability of options and their impact on flood immunity and afflux created. All of the proposed bridge options meet the 100 Annual Reoccurrence Interval (ARI), afflux and freeboard requirements. However, only Option 1 (single span bridge) and option 2 (three-span bridge) provide excellent hydraulic results with a very little impact (30mm and 20mm afflux respectively out of 70mm allowable). Option 3 (precast arch) also meets the criteria but only when a local realignment and deepening of the channel is undertaken. These localised works are not extensive in their magnitude, but require additional construction activities within the channel itself. Also, due to the span limitation (max 21m) the arch footings are partially located within the river channel.

In the constructability and durability category option 3 (precast arch) clearly prevails over the other two options due its simple design, smaller members allowing for easier construction, and the lack of expensive bridge elements requiring a periodic replacement.

Each of the bridge options have been subjected to the evaluation of their costs in order to establish an overall score which is used in the selection of the preferred structure. The most cost-effective crossing has been determined to be **Option 1 (\$3.144M** excl. GST) whereas the other two alternative options have been estimated at **\$5.072M** (Option 2) and **\$6.423M** (Option 3).

Following the results of this study and based on the evaluation criteria, as outlined in section 6 of this report, the preferred solution is **Option 1 (Single span T-Roff bridge)** reaching the overall score of 4.44 compared to option 2 and 3 with scores of 3.23 and 2.81 respectively. Therefore, it is recommended to proceed to the detailed design phase with **Option 1**.

2 INTRODUCTION

2.1 DESIGNER'S BRIEF

The project brief is to provide engineering consultancy services for the design of Railway Parade Bridge over Ellen Brook in Upper Swan. The proposed bridge will cross the Ellen Brook and connect the northern and southern section of Railway Parade.

The preliminary design will consider three options of crossing the Brook which will be priced and assessed against evaluation criteria in order to select the preferred option.

Structural, Hydrology and Hydraulics, Geotechnical Investigation and Lighting Design aspects form part of this scope whereas Heritage and Environmental matters are being addressed by third parties directly appointed by City of Swan.

2.2 BACKGROUND TO THE PROJECT

The proposed bridge over the Ellen Brook will connect the northern and southern sections of Railway Parade. This will facilitate a direct north-south route from the intersection of Railway Parade and Great Northern Highway along Muchea South Road to the Brand Highway.

The bridge infrastructure will provide improved road travel options through this region, inclusive of alternative options in emergency situations. The proposed bridge will be co-funded by the CoS in conjunction with financial contributions from the developers of Ellenbrook Village 8 Annie's Landing and from the developers of the future Upper Swan urban area.

2.3 PROJECT OBJECTIVES

The primary objective of the project is to deliver a high quality and durable crossing, which represents the best value for money solution for the City of Swan and its' residents.

2.4 PREVIOUS STUDIES

Big Island Research were engaged as consultants to undertake a Desktop Study for Aboriginal Heritage. Their report was completed in June 2012 and recommends that further consultations will be required during the preliminary design stage.

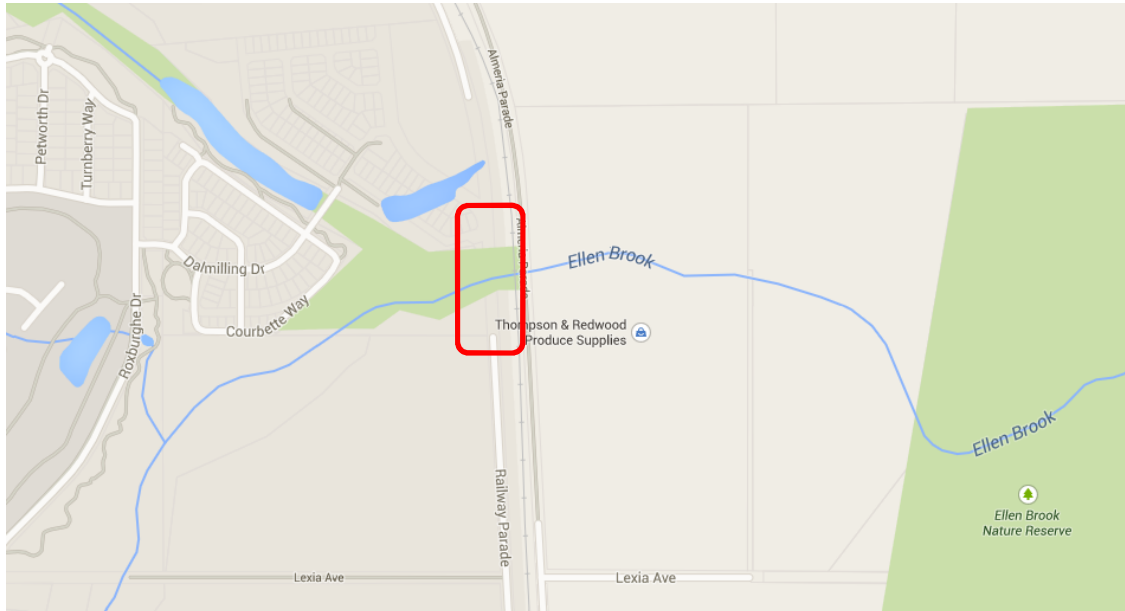
PGV Environmental were engaged as consultants to undertake a Desktop Study for Environmental Assessment. Their report was completed in April 2013. This report recommended further studies, a Level 2 Flora and Vegetation Survey and a Significant Impact Test on the site for Matters of National Environmental Significance. These studies were completed in 2013/2014.

Traffic modelling was undertaken by ARRB in 2011. Details of this investigation are included in Ellenbrook and Upper Swan Traffic Modelling – Supplementary Report, project No. 003081 dated October 2011.

3 SITE AND FUNCTION

3.1 SITE LOCATION

The proposed bridge will be at a crossing point of the Ellen Brook that will join both sides of Railway Parade, at a location approximately 1250m north of the Apple Street Railway Parade intersection.



The site is accessible via Railway Parade to both the North and South of the Ellen Brook. Railway Parade is a narrow rural road to the south (typical width 5m) and haul road to the north (typical width 9m). This haul road is used as access to The Vines residential development, which is currently being constructed as an extension of Ellenbrook development. Railway Parade intersects with Apple Street to the South and Maralla Road to the North. Both of these roads provide access to the Great Northern Highway to the east of the bridge site. There are uncontrolled railway crossings at both Apple Street and Maralla Road.

The land to the North and South of the proposed crossing is zoned Urban and Urban Deferred and the Ellen Brook is zoned as Parks and Recreation.

3.2 FUNCTION OF THE STRUCTURE AND OBSTACLES CROSSED

The proposed bridge structure will carry road and pedestrian traffic over the Ellen Brook. The channel of the Brook at the location of the proposed crossing is at approximately twenty five (25) degree angle to the proposed road alignment. The width of the existing channel narrows down towards west from its maximum width at the existing railway bridge. At the location of the crossing the minimum width of the existing channel is approximately 19m measured along the bridge.

3.3 CHOICE OF LOCATION

The location of the crossing is pre-determined by the existing southern and northern sections of Railway Parade. The new road alignment remains within the road reserve and the road centre line is located approximately in the middle of the reserve.

3.4 SITE DESCRIPTION AND TOPOGRAPHY

The local topography can be characterised as a relatively densely vegetated flat land with high points at the south bank and the existing approach embankment to the existing railway bridge on the north side of the brook.

The channel itself is well defined at the proposed crossing and it narrows down towards west.

Approximately 35m east of the proposed crossing the existing three span railway bridge is located whereas west of the proposed structure, approximately 72m away, an existing RCB culvert exists.

3.5 VERTICAL AND HORIZONTAL ALIGNMENT

The proposed alignment at the location of the crossing is as follows:

- *Horizontal alignment:* on straight
- *Vertical alignment:* 0.5% grade rising towards north

3.6 CROSS-SECTIONAL DIMENSIONS ON THE ALIGNMENTS

The proposed cross-sectional dimensions at the location of the crossing are given in Table 3 below.

Table 3.1: Bridge Cross Section

Bridge Cross-section	Width [mm]
Precast Parapet plus Kerb	740
Shoulder	600
Carriageway	2 x 3,500
Shoulder	600
Barrier Strip	536
Principal Shared Path	3,000
Precast Parapet	460
TOTAL	12,940

3.7 EXISTING UNDERGROUND AND OVERGROUND SERVICES

At the location of the crossing no other services were identified except for a damaged irrigation. An overhead line of Western Power runs parallel to the existing railway line and is located on the east side of the line.

3.8 GEOTECHNICAL SUMMARY

Due to the potential heritage significance of this area and the lack of appropriate approvals a geotechnical investigation could not be undertaken during the preliminary design.

City of Swan decided to proceed with the preliminary design on the basis of a desktop analysis using characterised geotechnical conditions and anticipated soil design parameters. A more detailed geotechnical investigation will be needed to confirm the design assumptions.

The following is the brief description of the expected ground conditions in this area, which is yet to be confirmed by the actual site investigation when required approvals are obtained.

The ground model is assumed based on available geological maps and experience in the area, with no geotechnical investigation data available from the site. The ground conditions in the area of the bridge from the top of the river channel are expected to comprise Stiff, Very Stiff sandy clay of the Guildford Formation likely to become hard sandy clay at depth. Within the river bed in the upper 1 to 2m there are likely to be loose alluvial sands. For the purposes of preliminary design it has been assumed the ground model comprises Stiff to Very Stiff sandy clay as presented in Table 3.2 below.

Table 3.2: Expected Ground Conditions

Layer	Unit Weight (kN/m ³)	Undrained Young's Modulus (MPa)	Undrained Shear Strength (kPa)	Ultimate Shaft Friction (kPa)	Ultimate End Bearing Capacity (kPa)
Very Stiff Sandy Clay (Guildford Formation)	18.0 20.0 (from 5m below ground level)	35	100 150 (from 15m below ground level)	80 (bored / CFA) 110 (driven)	2,000 (bored / CFA) 4,000 (driven)

The geotechnical parameters selected are moderately conservative typical parameters of the Guildford Formation.

The Guildford Formation in this area may comprise cemented layers of up to 2m in thickness, which may cause high pile driving resistance and pile refusal. A pile driveability analysis will need to be undertaken following completion of the geotechnical investigation to assess the suitability of using driven piles.

At this stage and based on the limited available information it is not expected Acid Sulphate Soils are present on site.

3.9 HYDROLOGY AND HYDRAULIC SUMMARY

The inputs required for the hydraulic component of the study were the peak flows at the model boundary locations for 2, 5, 10, 20, 50, 100 and 2000 year average reoccurrence interval (ARI) storm events. To obtain these peak flows at the required locations, a site-specific rainfall-runoff model was developed and calibrated using historical flow data. Section 3 below details the methodology and results of this rainfall-runoff model.

Ellen Brook starts just south of Lennard Brook and flows into the Swan River, approximately 7km southwest of the site. The Brook is fed from the Dandaragan Plateau, at the northern end of the Darling Range, as well as smaller watercourses along the way including Sawpit Gully, Ki-

It Monger Brook, Nambah Brook, Rocky Creek and Breera Brook. The total catchment area of Ellen Brook at the site is approximately 582km², with an additional catchment area of approximately 16km², joining Ellen Brook just downstream of the site via Sawpit Gully.

There is a distinct difference between the eastern and western portions of the catchment. The western segment stretches from Gingin RAAF base down to Sawpit Gully. It is relatively flat with average sub-catchment grades in the order of 0.003 m/m. The soil in this region is typically sandy, with relatively high infiltration losses as a result. The eastern segment is steeper, with average grades in the order of 0.007m/m. While both segments are comprised of a combination of agricultural land and relatively dense vegetation, the western segment has a higher proportion of dense vegetation, predominantly made up of Gngangara-Moore River State Forest.

Several gauging and rainfall stations were available for data extraction, with two Department of Water (DoW) gauging stations recording flow data within the catchment. The Railway Parade (ID 616189) gauging station will provide the most relevant flow data as it is located 60m upstream of the project site. This station has an extensive flow record spanning 50 years. The location and quality of this gauging station allows for the development of an accurate rainfall-runoff model, as it can be calibrated with no hydrologic extrapolation required. The other flow gauging station within the catchment (Brand Highway, ID: 616100) was therefore deemed superfluous and was not used for analysis.

Bureau of Meteorology (BOM) rainfall stations were also utilised for the study for input into Stage 2 of the model calibration process.

In order to develop an accurate rainfall-runoff model, the Ellen Brook and Sawpit Gully catchments were divided into subcatchments. Ellen Brook and Sawpit Gully were divided into 14 and 4 subcatchments respectively. The Ellen Brook channel itself represented a catchment boundary for many of the subcatchments. This enabled a distinction within the model between the eastern and western segments of the catchment, which possess different physiographic characteristics.

In order to produce design flows at the site, a rainfall-runoff model for Ellen Brook and Sawpit Gully was developed. The software used was XP-RAFTS, an industry standard rainfall-runoff modelling package. XP-RAFTS uses the Laurenson non-linear run-off routing procedure to develop a stormwater run-off hydrograph from either an actual event or a design storm based on BOM and AR&R data processes.

The Stage 2 calibration result was produced using only two rainfall stations throughout the 598km² catchment, when ideally more rainfall data locations would be available, whereas Stage 1 was performed based on a thorough data record. Thus the Stage 2 calibration results serve to verify the results of Stage 1, rather than override them. As a result, the Stage 1 calibration results were adopted as the design flows for this study and used as inflows for the hydraulic modelling procedure.

As part of the preliminary design process three (3) alternative bridge options were considered. Option 1, a single span bridge design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following table presents the bridge design parameters and flow characteristics in this scenario.

Table 3.3: Option 1 – Flow Characteristics

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	29.6	1	13.11	13.05	1.32	10.1

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
2000			13.99	13.89	1.51	

The hydraulic model results show that the maximum afflux in this scenario is 30mm for the 100 year ARI and it occurs between the crossing and the existing Railway Bridge. The afflux is based on the flow levels from the existing case and Alternative 1.

Option 2, a 3 span bridge design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following presents the bridge design parameters and flow characteristics in this scenario.

Table 3.4: Option 2 – Flow Characteristics

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	1(25.4)+2(11)	3	13.10	13.07	1.05	10.1
2000			13.97	13.92	1.15	

The Hydraulic model results show that the maximum afflux in this scenario is 20mm for the 100 year ARI and it occurs between the crossing and the existing Railway Bridge.

Option 3, a precast arch design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following presents the bridge design parameters and flow characteristics in this scenario.

Table 3.5: Option 3 – Flow Characteristics

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	21	1	13.20	13.09	1.36	10.1
2000			14.16	13.95	1.74	

The hydraulic modelling results show the maximum afflux in this scenario is 120mm for the 100 year flood event. This afflux is not acceptable as the allowable afflux is maximum 70mm.

The bottom width of the cross-section at the bridge location in its existing condition is 18.5m. The potential to lower this afflux to an acceptable level was investigated. A maximum afflux of 70mm was found to be achievable if the channel is excavated to lower the bed level by 0.2m to 9.9m AHD and widening the channel to 21m.

Option 1 is likely to be the most efficient bridge design and was noted to meet all design criteria. While Option 3 is able to be purchased as a modular, precast structure, the additional waterway reconfiguration works required to meet the design criteria are likely to have adverse environmental impacts and therefore is seen not to be an efficient design. Option 2 shows slightly better hydraulic performance than Option 1.

An additional scenario was set-up to assess the potential impact of removing the existing crossing, which is located downstream of the proposed Railway Parade Bridge. This modelling scenario was performed using the single span bridge design (Option 1).

Table 3.6: Option 1 incl. Culvert Removal – Flow Characteristics

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	29.6	1	12.71	12.64	1.61	10.1
2000			13.04	12.81	2.43	

As anticipated, the hydraulic model results indicate that the water surface level reduces upstream of existing culverts. This is due to the additional surface area available following the removal of the culverts. The afflux is negative, and when compared with the existing case, is 400mm lower for the 100 year flood event.

Refer to Appendix A for the full Hydrology & Hydraulic Assessment

3.10 ENVIRONMENTAL SUMMARY

An environmental assessment of the project site was prepared for the City of Swan by PGV Environmental and the findings are captured in the 'Proposed Bridge and Road Upgrade, Railway Parade, Upper Swan – Environmental Assessment' Report No. 2012-78, version 3 dated 29 May 2013.

In this study the following environmental factors were considered:

- Past and existing land use
- Surrounding land use
- Topography
- Geomorphology and soils
- Surface and groundwater
- Wetlands
- Vegetation
- Flora
- Fauna
- Heritage

As part of the environmental investigation a flora and vegetation survey along with an assessment of black Cockatoo habitat was undertaken. The details of these studies are presented in 'Proposed Bridge and Road Upgrade, Railway Parade, Upper Swan – Flora and Vegetation Survey' Report No. 2014-137 version 1, dated 5 February 2014; and 'Proposed Bridge and Road Upgrade, Railway Parade, Upper Swan – Black Cockatoo Habitat Assessment' Report No. 2014-128 version 1, dated 5 February 2014.

The project site has been identified as stretching over several different zonings under the Metropolitan Region Scheme. To the south of Ellen Brook the site and adjacent areas are zoned 'Rural' whereas Ellen Brook is zoned as 'Parks and Recreation'. The land north of Ellen Brook is zoned 'Urban' and the eastern boundary of the site abuts the Millendon Junction Narngulu Railway, which is zoned as 'Railway'. The land east of the existing railway line is zoned as 'Special Use 6' and has restrictions on subdivisions to protect the Western Swamp Tortoise. To the north-west of Ellen Brook the area is zoned 'Residential' and 'Special Use 4'. These areas are part of the Ellenbrook development and as such are zoned for a mixture of purposes and such as residential, commercial and retail.

Previous and existing land uses within the proposed road and bridge works indicate that there are no concerns for development. There has been some residential development and vegetation has been successively cleared in the area. The construction of the bridge and road upgrades will not impact on the rail or surrounding agricultural land. There may be some discontent by the local residents as the traffic load on the constructed road will be higher in volume than it currently is.

The general flow of groundwater to Ellen Brook means that any potential pollutants that could enter the groundwater during and post construction need to be managed to prevent contamination to the groundwater. The impact of the development of the road and bridge will need to be managed within the framework and process detailed in the WAPC's urban water management planning guideline document Better Urban Water Management (WAPC, 2008) and most likely will require an Urban Water Management Plan. The vegetation on the site that is to be retained along Ellen Brook relies on a high water table. In order to avoid potential impacts on groundwater levels (which in turn could affect adversely affect wetland areas), no design or construction activities should permanently alter the current groundwater levels in this area.

Surface water discharge from the bridge and upgraded road should be able to be managed using Water Sensitive Urban Design as outlined in Better Urban Water Management (WAPC, 2008). Construction methods proposed will need to prevent silt, rubbish and pollutants being discharged into Ellen Brook during construction or in the event of significant rainfall during or post construction.

Railway Parade will traverse a section of Ellen Brook which is a Conservation Category (CC) Wetland (UFI 15734). The construction of a bridge on the site will impact on riparian vegetation and has the potential to impact on the water quality and quantity downstream. This may be an impediment to the approval for the construction of the bridge. This part of Ellen Brook was included in the Riparian Concept Plan that was prepared by the Ellen Brockman Integrated Catchment Group and this group should be contacted during the rehabilitation process.

Aside from Ellen Brook there are two Multiple Use wetlands and one Resource Enhancement wetland on the site. Resource Enhancement and Multiple Use wetlands do not have statutory protection however may be considered significant by the DEC. Construction in the wetland areas may be a concern to the DEC.

The development of the site will result in clearing vegetation on the site which is mostly in Degraded to Completely Degraded condition. The vegetation is unlikely to be representative of a TEC or PEC and is unlikely to be significant. The level 2 Flora and vegetation survey did not identify any species as Threatened (Declared Rare) or Priority listed flora species or listed in Bush Forever as having conservation significance. Also, the vegetation is considered too degraded to assign a Floristic Community. Therefore the vegetation would not be considered a Threatened or Priority Ecological Community. The vegetation along Ellen Brook is part of Bush Forever site 300 and provides an ecological corridor between the balance of Bush Forever site to the west and the Ellen Brook Nature Reserve to the east. The vegetation in the road reserve is part of a tenuous north-south link, however the ecological value of the corridor is significantly diminished by the very poor condition of the vegetation.

Within the project site two Schedule 1 listed species (Carnaby's Black Cockatoo and Forest Red-tailed Black-Cockatoo) have been determined to possibly be present. The habitat requirements for Carnaby's Black Cockatoo include foraging (Banksia species, Parrot Bush and other Proteaceous shrubs), roosting (tall eucalypts and pines) or breeding habitat (Eucalypt trees). There are very few Proteaceous shrubs and no trees on the site therefore it is concluded that the site contains very little suitable habitat for Carnaby's Black Cockatoo. Development of the road and bridge is unlikely to impact on this species. The Forest Red-tailed Black Cockatoo feeds on Marri seeds and there are a few specimens of this tree on the site. While the removal of these trees is unlikely to have a significant impact on this species any trees that can be retained within the road reserve should be.

The potential for Black Cockatoo species to occur on the site was investigated with Carnaby's Black Cockatoos and Forest Red-tailed Black Cockatoos considered likely to visit the site. The field survey of the site did not identify any evidence of foraging on the site. The breeding and potential breeding habitat was limited to eight Marri trees. No evidence of breeding on the site has been recorded and there was no evidence that the site was used as roosting habitat. PGV Environmental considers the clearing for the proposed road and bridge construction would have a Low risk of a significant impact on Black Cockatoo species and in accordance with the referral guidelines, referral to the Department of the Environment under the EPBC Act is not required.

The Ellenbrook Nature Reserve is located approximately 1km upstream (of watercourse – this is approximately 500m as the crow flies) of the site. The construction of the bridge is highly unlikely to impact on the water quantity due to the separation of the site and the habitat area for the tortoise. Water quality in the reserve is highly unlikely to be impacted as the site is downstream of the habitat area. A potential for the activities listed in the EPP to degrade the Western Swamp Tortoise habitat and suggests management plans to address factors associated with development in the area. These can be addressed as part of an Urban Water Management Plan and in a Construction Environmental Management Plan.

Refer to Appendix B for the full Environmental Assessment report, to Appendix C for the Flora and Vegetation Survey and to Appendix C for Black Cockatoo Habitat Assessment.

During the preliminary design phase City of Swan has sought an advice from DPAW in relation de-classification of the wetland in advance of the required clearing permits during the construction phase. In response to that enquiry City of Swan has been informed that it would be unlikely to declassify a resource enhancement wetland and that Department of Environmental Regulation is the authority to approve any clearing permits.

3.11 HERITAGE SUMMARY

A detailed heritage survey has not been completed at the time of writing this report. However, a desktop study was undertaken by Big Island Research and its findings are provided in the 'Desktop Report – Review of Aboriginal Sites Recorded within the Vicinity of the Proposed Ellen Brook Bridge, Railway Parade, Upper Swan' and summarised hereunder.

A research of the DIA Heritage database identified nine registered sites and three other heritage places within 5km of the centre of the proposed crossing. The nature of the sites varies between mythological, ceremonial as well as comprising stone artefacts.

Only one site is located within the proposed bridge crossing (ID 3525). This site is listed as a mythological site relating to Ellen Brook itself, however it has been listed as containing 'insufficient data'. This means that the site has been assessed by the Aboriginal Cultural Material Committee, which have decided the recording conducted has not been adequate and has not provided enough detail regarding the site location and characteristics.

The only other site is located within 1km from the proposed bridge crossing in the northwest direction (ID 3441 – small scatter of stone artefacts). This site is listed as ‘stored data’, which means it does not meet the definition of a site under Section 5 and 39 of the Aboriginal Heritage Act 1972. It is recommended to undertake site recording to S.18 level if ground disturbing activity are expected at this location.

The ID 3525 site is currently categorised as an ‘other heritage place’ by DIA, which means it may become a site, however at present there is not sufficient specific information for it to be registered.

Of a particular relevance to this project are the findings made at the Upper Swan Bridge archaeological site (ID 4299) located approximately 7km from the proposed crossing, which is one of the oldest sites in Australia (over 850 stone artefacts were recovered from as shallow as 700-900mm from the surface). The site of the proposed crossing is located in a similar environmental context.

It is recommended that at the concept stage an archaeological inspection and a consultation with Noongar Traditional Owner should be undertaken, and depending upon the outcomes of such an investigation an application to disturb under Section 18 or Regulation 10 of the Aboriginal Heritage Act 1972 may be required.

A heritage survey is currently being undertaken by a consultant appointed by CoS.

Refer to the full Desktop Report provided in Appendix E.

3.12 SURVEY DATA

A feature survey of the bridge site was undertaken by Whealans and provided to the design team in PCG94 coordinate system.

4 DESIGN CRITERIA

4.1 TYPE OF TRAFFIC CARRIED OVER

The new crossing will carry road and pedestrian traffic over Ellen Brook. The road carriageway will consist of two (2) number of 3.5m wide lanes and a 3m wide Principal Shared Path PSP located on the western side of the bridge.

4.2 TRAFFIC VOLUME

An assessment of traffic volumes was undertaken by ARRB in 2011, according to which it is expected that the total traffic volume by 2021 will reach 5945 vehicles per day whereas by 2031 this volume is estimated to increase to 9042 vehicles per day.

The percentage of commercial vehicles was not known at the time of writing this report.

4.3 DESIGN SPEED

This section of the road is designed for a speed of 70 km/h whereas the posted speed is to be 60 km/h.

4.4 DESIGN LIFE

The bridge components are designed and detailed to provide the following design life:

- 100 years for concrete and steel elements.
- 25 years for elastomeric bearings
- 15 years for expansion joints
- 30 years for bridge deck and approach slab waterproofing system

4.5 LOADING

Design loads considered in this preliminary investigation are in accordance with AS 5100 Bridge Design Part 2 – Design Loads and the MRWA Structures Engineering Design Manual (SEM), Document No. 3912/03.

Table 4.1: Design Loads

Lp.	Loading	Reference	Additional Requirements
4.5.1	Dead Loads	AS 5100.2 Cl. 5.2	SEM Cl. 4.2
4.5.2	Superimposed Dead Loads	AS 5100.2 Cl. 5.3	SEM Cl. 4.2
4.5.3	Road Traffic	AS 5100.2 Cl. 6	SEM Cl. 4.3 & 4.4
4.5.4	Pedestrian Loading & Bicycle-Path Load	AS 5100.2 Cl. 7	SEM Cl. 4.3
4.5.5	Railway Traffic	AS 5100.2 Cl. 8	N/A

Lp.	Loading	Reference	Additional Requirements
4.5.6	Minimum Lateral Restraint	AS 5100.2 Cl. 9	N/A
4.5.7	Collision Loads	AS 5100.2 Cl. 10	SEM Cl. 4.5
4.5.8	Kerb and Barrier Design Loads	AS 5100.2 Cl. 11	SEM Cl. 4.6
4.5.9	Earth Pressure	AS 5100.2 Cl. 13	SEM Cl. 4.10
4.5.10	Earthquake Forces	AS 5100.2 Cl. 14	SEM Cl. 4.12
4.5.11	Forces Resulting From Water Flow	AS 5100.2 Cl. 15	SEM Cl. 4.9
4.5.12	Wind Loads	AS 5100.2 Cl. 16	SEM Cl. 4.7
4.5.13	Thermal Effects	AS 5100.2 Cl. 17	SEM Cl. 4.8
4.5.14	Shrinkage, Creep and Prestress Effects	AS 5100.2 Cl. 18	SEM Cl. 4.13 & 4.14
4.5.15	Differential Settlement	AS 5100.2 Cl. 19	SEM Cl. 4.15
4.5.16	Forces from Bearings	AS 5100.2 Cl. 20	SEM Cl. 4.11
4.5.17	Construction Forces	AS 5100.2 Cl. 21	SEM Cl. 4.16

The design live load for the structures is T44 and Network 4 vehicle in accordance with Restricted Access Vehicles – Prime Mover, Trailer Combinations – Operating Conditions published by Main Roads WA, version November 2012.

4.6 SOIL PARAMETERS USED IN THE DESIGN

Based on the desktop studies the following soil parameters have been adopted for the preliminary design of the bridge structures:

- Imported backfill material:
 - Effective internal friction angle of thirty five (35) degrees
 - Soil density of 19 kN/m³
- Parent soil (to be confirmed):
 - Effective internal friction angle of thirty five (35) degrees
 - Soil density of 18 kN/m³
 - Undrained shear strength of 100 kPa

4.7 HYDROLOGY & HYDRAULICS

The bridge elevation must provide a minimum 300mm freeboard above the 100 years ARI. The Department of Water has advised that the maximum allowable afflux created by the new structure is 70mm.

For the design storm event and the flood immunity event a value of one hundred (100) years was adopted.

4.8 LIGHTING REQUIREMENTS

The lighting scheme design is in accordance with AS/NZS 1158.1.1 Category V5.

The operating characteristics as follows:

- Mixed vehicle and pedestrian traffic
- Moderate traffic volumes
- Low pedestrian volume
- Moderate to low vehicle speeds
- Low traffic generation from abutting properties
- Point horizontal illuminance - Min 3.5 lux
- Illuminance uniformity Max/Ave 8

Refer to Appendix L for the details of preliminary lighting design.

4.9 CONSTRUCTION METHODS

Given the location of the proposed crossing, within the metropolitan region, the local topography and easy access to the site along with the proximity to Great Northern Highway the following construction methods were considered as appropriate:

- Driven and bored piles
- Lifting of precast elements into position (beams, crossheads, arch units, spandrels)

The local ground conditions (based on the limited available information) appear to be suitable for heavy equipment to operate on site but may require special working platforms to facilitate their movements. This will need to be assessed by the contractor prior to commencement of any work to ensure suitability based on construction methods and proposed machinery but may require. There are no overhead services which could potentially impose operational restrictions.

4.10 INSPECTION AND MAINTENANCE REQUIREMENTS

Adequate provisions shall be made for future inspection, maintenance and possible replacement of the elements of the bridge.

4.11 OTHER REQUIREMENTS

Four (4) number of 100mm dia. service ducts shall be provided either side of the bridge structure. Services and drainage shall be concealed from public view where possible.

4.12 COST

Cost constraints were not known at the preliminary design stage.

5 PROPOSED STRUCTURES

5.1 OPTION 1 – *SINGLE SPAN T-ROFF BRIDGE*

5.1.1 GENERAL DESCRIPTION

The development of the first option was based on maintaining the existing channel width undisturbed whilst minimising the visual impact of the bridge supports by introducing the spill-through abutments.

This single span bridge crosses the brook at the skew of twenty five (25) degrees. The superstructure consists of precast prestressed T-Roff beams and an in-situ composite deck. The precast beams are connected together at the abutment ends through an end diaphragm. The bridge superstructure is supported on bored piles through concrete abutment crossheads. The spill-through batters maintain the existing line of the banks of the brook and are provided at a grade of 1:1.5 (V:H). The batters are protected with riprap rock on a geotextile within the flood affected zone and with stone pitching above it. In front of the abutments an access / maintenance ledge is provided with access stairs leading to it. Along the length of the ledge a monowills balustrade is provided.

Refer to Appendix K for General Arrangement drawings.

5.1.2 CONCEPT DEVELOPMENT

Besides the design criteria listed out in the section 4 of this document the following factors were considered during the development of this concept.

In order to ensure that the new bridge crossing will not cause an adverse effect on the water flow a single span crossing over the brook was chosen such that no piers are placed in the channel. The position of the abutments was determined such that the width of the existing brook channel is not reduced by the proposed spill-through abutments. The choice of this type abutments reduces the amount of costly construction works associated with tall concrete wall type abutments in lieu of building abutment batters.

5.1.3 AESTHETIC CONSIDERATION

During the development of this option best aesthetics practices with respect to proportioning bridge elements were used as far as practicable.

This option is characterised by simple / clean lines underlined by the precast bridge parapet throughout the entire length of the structure. The depth of the precast parapet was determined to conceal service ducts behind and also to provide a visually 'healthy' proportion to the exposed beam depth. The elevation of the bridge was chosen to hide the existing railway bridge behind.

The length of the cantilever was proportioned such the ratio of its length to the exposed depth of the beam will maximise the shadow cast on the fascia girder resulting in an improved visual slenderness of the structure.

Another aspect of the aesthetic design which has been incorporated was to ensure that the visible height of the abutment maintains the right proportion to the exposed depth of the beam as well as to the headroom under the bridge. Also, within the body of the abutment the masking walls are provided at either end such that the bearing shelf is concealed.

A colour scheme was not established at this preliminary stage, however it is recommended to use a concrete pigment in order to achieve a long lasting effect and a further improvement of the appearance of this bridge.

5.1.4 SUPERSTRUCTURE

The superstructure consists of four (4) number of simply supported 1500mm deep prestressed precast T-Roff beams with an in-situ composite deck. The beams are tied together at the abutment ends with a reinforced concrete end diaphragm.

The in-situ deck has a minimum thickness of 210mm, which increases towards the bridge supports as a result of the hog of the prestressed beams.

5.1.5 SUBSTRUCTURE

The bridge substructure consists of reinforced concrete abutment crossheads supported on two (2) number of 1,000mm in diameter reinforced concrete bored piles. The piles are estimated to be 16m long. Wingwalls integral with the abutment body are provided to retain the soil on the approach to the bridge and their length was determined such that they are embedded in the approach embankment by at least 1m at the cantilever tip. Five (5) metre long approach slabs are provided under the carriageway and they are the surface type in accordance with Main Roads WA standards.

5.1.6 RETAINING WALLS

No retaining walls are required.

5.1.7 BRIDGE ARTICULATION

The bridge articulation is a floating deck type. The bridge superstructure is supported on elastomeric bearings, which are placed on concrete plinths.

Ausflex AC-AR Granor expansion joints with the type F seal are provided at either end of the bridge deck.

Concrete restraint blocks are provided on each bridge support in order to restrain the deck movements in the lateral direction.

5.1.8 BRIDGE PARAPETS

Either side of the carriageway a MRWA three-rail regular containment bridge parapet is provided. The parapets extend to the end of the wingwalls / approach slabs.

Along the PSP a 1,300mm tall PSP type balustrade is provided.

5.1.9 BRIDGE DRAINAGE

Due to the short length of the deck no drainage over the bridge is required.

5.1.10 WATERPROOFING

All buried faces of abutments and approach slabs will be treated with a bituminous membrane (Elastoseal or similar approved).

The top surface of the deck and the approach slabs will be treated with a sprayed-applied waterproofing membrane (Pitchmastic PMB or similar approved).

5.1.11 MINIMUM HEADROOM

The provided headroom complies with the hydraulic requirement of a minimum 300mm of freeboard. The 100 years ARI freeboard is approximately 2,000mm which is driven by the local topography / elevation of the south bank.

5.1.12 PROPOSED ARRANGEMENT FOR MAINTENANCE AND INSPECTION

An inspection and maintenance ledge is provided in front of the abutments in order to facilitate a safe access. The width of the ledge is 1,000mm and the minimum headroom under the beams is 1,500mm.

Access stairs are provided at the west side of the abutment batters and are equipped with a steel monowills balustrade. The balustrade also stretches along the ledges in order to prevent maintenance / inspection personnel from falling down.

Designated areas on abutment crossheads will be provided for the purpose of jacking the deck up in order to replace bearings.

5.1.13 MATERIALS AND FINISHES

All materials and finishes chosen for this project are in accordance with AS 3610 Formwork for Concrete and MRWA Bridge Branch Information Manual (BBM), Document No. 3912/02-01.

The bridge site is located approximately 10km from the coastline.

B1 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are not subjected to contact with ground and brook water.

B2 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are subjected to contact with ground and brook water.

All exposed accessible surfaces will be treated with a non-sacrificial anti-graffiti coating.

The bridge and retaining walls components will be constructed in accordance with the material and finishes specification as shown in Table 5.1 below.

Table 5.1: Option 1 – Finishes

Element	Material	Finish	Cover [mm]
In-situ Footings	S40	Class 4 – side faces	85 cast against ground
		Class U1 – top	65 cast against membrane
			55 elsewhere
Bored Piles	S40	N/A	85 cast against ground
			55 cast against liner
Pile-columns	S40	Class 2	55
In-situ Crosshead	S40	Class 2 – underside & sides	40
		Class 3 – top surface	

Element	Material	Finish	Cover [mm]
Precast Crosshead	S50	Class 2 – underside & sides Class 3 – top surface	40
Bearing Plinth	S50 / High Strength Mortar	Class 2 – side faces Class 3 – top surface	40
Restraint Block	S40	Class 2 – front and rear face Class 3 – top & side faces	40
Wingwalls	S40	Class 2 – external face Class 4 – buried faces Class 3 – top surface	55 in contact with ground 40 elsewhere
Approach Slab	S40	Class U3 – top surface Class 4 – buried surfaces	85 cast against ground 65 cast against membrane 40 elsewhere
Precast Beams	S50	Class U1 – top surface of top flange Class 2 – other surfaces	40
In-situ Deck	S40	Class U3 – top surface Class 3 – side faces	40
Precast Parapet Panels	S50	Class 2	40
Precast Arch Units	S50	Class 2	55 in contact with ground 40 elsewhere
Spandrel Wall	S50	Class 2X – external face Class 4 – buried face	55 in contact with ground 40 elsewhere
Precast Tilt-up Panels	S50	Class 2X – external face Class 4 – buried surfaces	45 in contact with ground 40 elsewhere
Precast Parapet Supporting Slab	S50	Class U2 – top exposed face Class 4 – buried surfaces	75 cast against ground 55 cast against membrane 40 elsewhere

Element	Material	Finish	Cover [mm]
PSP Screed	N40	Class U4	N/A
Bridge Barriers		Hot-dip galvanised	N/A
Balustrade		Hot-dip galvanised / Painted	N/A

5.1.14 RISKS AND HAZARDS CONSIDERED

During the development of this concept the main risks listed hereunder were considered and are captured in the Safety in Design report in Appendix H:

- Site Access
- Working in the vicinity of or within an area of a heritage significance
- Working near and / or over waterways
- Working at heights
- Working near operating plants
- Working near and / or in excavations
- Transportation of heavy precast bridge components
- Working near an operational railway line
- Working in the vicinity of a residential area

5.1.15 CONSTRUCTION CONSIDERATION

Well established construction techniques were chosen to ensure that the structure will be built economically with a controlled level of risks during its construction.

The T-Roff beams have been used by the local contractors for a number of years and have proven to be a very economical solution for constructing typical relatively short span crossings. Familiarity with this construction methodology ensures that a number of construction risks is better managed or eliminated through the understanding of limitations of this method and well established construction practices.

Location of the abutments a few metres away from the edge of the banks allows an easy access for a piling rig to bore / drive the piles without or with a minimised risk of affecting the stability of the bank slope.

5.1.16 RISKS AND OPPORTUNITIES

As a result of the lack of geotechnical investigation a number of assumptions had to be made with respect to the soil profile and its strength.

The Guildford Formation may consist of cemented layers through which concrete driven piles may not be able to penetrate. The accuracy of our prediction cannot be assessed and therefore for the purpose of undertaking the cost estimates bored piles will be utilised as the upper bound solution.

There is however, an opportunity to investigate the use of driven piles (steel or concrete) when the results of geotechnical investigation are available to us. A driveability analysis may be required to determine the suitability of such a solution, which could yield monetary savings.

Based upon the limited available information we do not expect acid sulphate soils in this area. This however, yet to be determined following the result of the geotechnical investigation which is scheduled later this year. Also, it is not known whether the soil / sediments within and near the river channel are contaminated. This yet to be determined by the site investigation.

5.2 OPTION 2 – *THREE-SPAN T-ROFF BRIDGE*

5.2.1 GENERAL DESCRIPTION

The development of the second option was based on maintaining the existing channel width undisturbed whilst reducing the length of the approach embankments by the implementation of side spans.

This three-span bridge crosses the brook at the skew of twenty five (25) degrees. The superstructure consists of simply supported precast prestressed T-Roff beams and an in-situ composite deck, which is continuous over the piers. The bridge superstructure is supported on bored piles through concrete abutment and pier crossheads.

To minimise the visual impact of the abutments spill-through batters are provided in order to improve the overall appearance and to reduce the overall construction cost associated with a construction of tall wall type abutments. The batters are protected with riprap rock on a geotextile within the flood affected zone and with stone pitching above it. In front of the abutments an access / maintenance ledge is provided with access stairs leading to it.

Refer to Appendix K for General Arrangement drawings.

5.2.2 CONCEPT DEVELOPMENT

Besides the design criteria listed out in the section 4 of this document the following factors were considered during the development of this concept.

In order to ensure that the new bridge crossing will not cause an adverse effect on the water flow the piers are positioned outside the brook. The position of the south abutment was established at the toe of the existing batter which in turn determined the length of the south side span. The north side span is kept of the same length for the symmetrical and more balanced visual appearance.

In order to minimise the visual impact of the abutments a spill-through option was chosen such that it also reduces the amount of costly construction works associated with tall concrete wall type abutments in lieu of building abutment batters.

5.2.3 AESTHETIC CONSIDERATION

During the development of this option best aesthetics practices with respect to proportioning bridge elements were used as far as practicable.

This option is characterised by simple / clean lines underlined by the precast bridge parapet throughout the entire length of the structure. The depth of the precast parapet was determined to conceal service ducts behind and also to provide a visually 'healthy' proportion to the exposed beam depth. The elevation of the bridge was chosen to hide the existing railway bridge behind.

The length of the cantilever was proportioned such the ratio of its length to the exposed depth of the beam will maximise the shadow cast on the fascia girder resulting in an improved visual slenderness of the structure.

Another aspect of the aesthetic design which has been incorporated was to ensure that the visible height of the abutment maintains the right proportion to the exposed depth of the beam as well as to the headroom under the bridge. Also, within the body of the abutment the masking walls are provided at either end such that the bearing shelf is concealed.

The ideal proportion of the main span to the side spans could not be provided due to the local topography / constraints and therefore in order to achieve the best possible, in these circumstances, appearance the ratio of the visible height of the abutment to the pier height is kept as close as practicable to the recommended figure whilst providing sufficient headroom for maintenance.

A colour scheme was not established at this preliminary stage, however it is recommended to use a concrete pigment in order to achieve a long lasting effect and a further improvement of the appearance of this bridge.

5.2.4 SUPERSTRUCTURE

The superstructure consists of four (4) number of simply supported 1200mm deep prestressed precast T-Roff beams per span with an in-situ composite deck. The beams are tied together at the support ends with a reinforced concrete end diaphragm. The composite deck is continuous over the piers and it takes the form of a link slab.

The in-situ deck has a minimum thickness of 210mm, which increases towards the bridge supports as a result of the hog of the prestressed beams.

5.2.5 SUBSTRUCTURE

The bridge substructure consists of reinforced concrete abutment crossheads supported on two (2) number of 1,000mm in diameter reinforced concrete bored piles. The precast pier crossheads are also supported on two (2) number of bored piles. The abutment piles are estimated to be 13m long whereas the bored piles of the piers are 28m long. Wingwalls integral with the abutment body are provided to retain the soil on the approach to the bridge and their length was determined such that they are embedded in the approach embankment by at least 1m at the cantilever tip. Five (5) metre long approach slabs are provided under the carriageway and they are the surface type in accordance with Main Roads WA standards.

5.2.6 RETAINING WALLS

No retaining walls required.

5.2.7 BRIDGE ARTICULATION

The bridge articulation is a floating deck type. The bridge superstructure is supported on elastomeric bearings which in turn are placed on concrete plinths.

Ausflex AC-AR Granor expansion joints with the type F seal are provided at the abutments.

Concrete restraint blocks are provided on each bridge support in order to restrain the deck movements in the lateral direction.

5.2.8 BRIDGE PARAPETS

Either side of the carriageway a MRWA three-rail regular containment bridge parapet is provided. The parapets extend to the end of the wingwalls / approach slabs.

Along the PSP a 1,300mm tall PSP type balustrade is provided.

5.2.9 BRIDGE DRAINAGE

Due to the short length of the deck no drainage over the bridge is required.

5.2.10 WATERPROOFING

All buried faces of abutments and approach slabs will be treated with a bituminous membrane (Elastoseal or similar approved).

The top surface of the deck and the approach slabs will be treated with a sprayed-applied waterproofing membrane (Pitchmastic PmB or similar approved).

5.2.11 MINIMUM HEADROOM

The provided headroom complies with the hydraulic requirement of a minimum 300mm of freeboard. The 100 years ARI freeboard is approximately 2,300mm which is driven by the local topography / elevation of the south bank.

5.2.12 PROPOSED ARRANGEMENT FOR MAINTENANCE AND INSPECTION

An inspection and maintenance ledge is provided in front of the abutments in order to facilitate a safe access. The width of the ledge is 1,000mm and the minimum headroom under the beams is 1,500mm.

Access stairs are provided at the west side of the abutment batters and are equipped with a steel monowills balustrade. The balustrade is also provided along the length of the ledges in order to prevent maintenance / inspection personnel from falling down.

Designated areas on abutment and pier crossheads will be provided for the purpose of jacking the deck up in order to replace bearing.

5.2.13 MATERIALS AND FINISHES

All materials and finishes chosen for this project are in accordance with AS 3610 Formwork for Concrete and MRWA Bridge Branch Information Manual (BBM), Document No. 3912/02-01.

The bridge site is located approximately 10km from the coastline.

B1 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are not subjected to contact with ground and brook water.

B2 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are subjected to contact with ground and brook water.

All exposed accessible surfaces will be treated with a non-sacrificial anti-graffiti coating.

The bridge and retaining walls components will be constructed in accordance with the material and finishes specification as shown in Table 5.2 below.

Table 5.1: Option 2 – Finishes

Element	Material	Finish	Cover [mm]
Bored Piles	S40	N/A	85 cast against ground
			55 cast against liner
Pile-columns	S40	Class 2	55

Element	Material	Finish	Cover [mm]
In-situ Crosshead	S40	Class 2 – underside & sides Class 3 – top surface	40
Precast Crosshead	S50	Class 2 – underside & sides Class 3 – top surface	40
Bearing Plinth	S50 / High Strength Mortar	Class 2 – side faces Class 3 – top surface	40
Restraint Block	S40	Class 2 – front and rear face Class 3 – top & side faces	40
Wingwalls	S40	Class 2 – external face Class 4 – buried faces Class 3 – top surface	55 in contact with ground 40 elsewhere
Approach Slab	S40	Class U3 – top surface Class 4 – buried surfaces	85 cast against ground 65 cast against membrane 40 elsewhere
Precast Beams	S50	Class U1 – top surface of top flange Class 2 – other surfaces	40
In-situ Deck	S40	Class U3 – top surface Class 3 – side faces	40
PSP Screed	N40	Class U4	N/A
Bridge Barriers		Hot-dip galvanised	N/A
Balustrade		Hot-dip galvanised / Painted	N/A

5.2.14 RISKS AND HAZARDS CONSIDERED

During the development of this concept the main risks listed hereunder were considered and are captured in the Safety in Design report in Appendix H:

- Site Access
- Working in the vicinity of or within an area of a heritage significance
- Working near and / or over waterways

- Working at heights
- Working near operating plants
- Working near and / or in excavations
- Transportation of heavy precast bridge components
- Working near an operational railway line
- Working in the vicinity of a residential area

5.2.15 CONSTRUCTION CONSIDERATION

Well established construction techniques were chosen to ensure that the structure will be built economically and with a controlled level of risks during its construction.

The T-Roff beams have been used by the local contractors for a number of years and have proven to be a very economical solution for constructing typical relatively short span crossings. Familiarity with this construction methodology ensures that a number of construction risks is better managed or eliminated through the understanding of limitations of this method and well established construction practices.

This concept utilises a number of precast elements such as prestressed beams, parapets and pier crossheads in order to achieve a high quality finish and an accelerated construction. Also, the abutments could be designed and constructed as precast elements maximising the benefits of an accelerated bridge construction.

Location of the piers a few metres away from the edge of the banks allows an easy access for a piling rig to bore / drive the piles without or with a minimised risk of affecting the bank slope stability.

The use of simply supported beams with a link slab versus a continuous deck with a continuity diaphragm simplifies the construction process of the bridge deck to the installation of the beams and pouring of the composite deck. This way the time consuming stage of constructing a heavily reinforced diaphragm is eliminated resulting in time savings.

5.2.16 RISKS AND OPPORTUNITIES

As a result of the lack of geotechnical investigation a number of assumptions had to be made with respect to the soil profile and its strength.

The Guildford Formation may consist of cemented layers through which concrete driven piles may not be able to penetrate. The accuracy of our prediction cannot be assessed and therefore for the purpose of undertaking the cost estimates bored piles will be utilised as the upper bound solution.

There is however, an opportunity to investigate the use of driven piles (steel or concrete) when the results of geotechnical investigation are available to us. A driveability analysis may be required to determine the suitability of such a solution, which could yield monetary savings.

Based upon the limited available information we do not expect acid sulphate soils in this area. This however, yet to be determined following the result of the geotechnical investigation which is scheduled later this year. Also, it is not known whether the soil / sediments within and near the river channel are contaminated. This yet to be determined by the site investigation.

5.3 OPTION 3 – *PRECAST ARCH*

5.3.1 GENERAL DESCRIPTION

The development of the third option followed the methodology of utilising a maximum number of precast components or even entire precast systems in order to minimise the time required on site to construct the crossing, and therefore to potentially achieve the greatest saving in comparison to the other two options. This option is also aesthetically focused in order to provide a more natural solution in this environment as opposed to the more industrial looking T-Roff bridges.

This bridge crosses the brook at the right angle. The precast arch consists of a number of units supported on in-situ footings. The carriageway over the arch length is retained between precast concrete spandrel walls and precast slabs supporting the barriers and the balustrade. The precast supporting structures are founded below the road layers. The upper part of the upstand of the supporting slabs (kerb-like beam) overhangs the spandrel wall and extends past its face in order to avoid staining due to water / dirt dripping down on its face.

The approach embankments in the vicinity of the arch are retained between precast tilt-up concrete retaining wall panels and the barrier supporting slabs in order to achieve a more pleasing visual appearance by the avoidance of skewed wingwalls, which disturb the elegant profile of the elevation through the abrupt interface with the embankment.

In order to maximise the visual experience the spandrel and retaining walls are proposed to provide a pattern finish which mimics stonework resulting in a more classical and aesthetically pleasing appearance.

The embankment batters are provided at a grade of 1:2 (V:H) in order to provide a smoother transition between the soil body and the bridge.

Locally the channel of the brook requires a modification (widening and deepening) in order to improve the water flow through the arch and to comply with the maximum allowable afflux criterion. The extent and magnitude of these works is relatively limited. The modified banks are proposed to be protected against scour with a riprap rock.

Refer to Appendix K for General Arrangement drawings.

5.3.2 CONCEPT DEVELOPMENT

Besides the design criteria listed out in the section 4 of this document the following factors were considered whilst shaping this concept.

The theme behind the development of this concept is Accelerated Bridge Construction (ABC) with the emphasis on aesthetics and the nature of this area, which will soon become a home to hundreds of new residents of the villages of Annies' Landing and Upper Swan.

The arch is located centrally over the brook, however due to the skew between the road alignment over and the channel some localised earthworks are required to improve water flow through. The proposed arch span is the maximum size available in Australia and therefore it was not possible not to interfere with the existing banks. An attempt to provide a larger arch unit capable of crossing the entire skewed width of the brook would have resulted in significant additional costs associated with a fabrication of steel moulds in lieu of localised alterations to the channel.

5.3.3 AESTHETIC CONSIDERATION

During the development of this option the emphasis has been placed on maximising the aesthetic qualities of the arch and the approach retaining walls. The proportions between the rise of the arch, the depth of fill over and the overall length including the approach retaining structure provide a visual balance. Due to the large area of the exposed concrete surfaces a special attention has been paid to concrete finishes in order to transform a visually plain solution into an elegant ancient looking crossing. A concrete pigment is proposed to further enhance the appearance and to bring its look even closer to an ancient sandstone arch.

5.3.4 SUPERSTRUCTURE

The superstructure consists of seven (7) precast arch units of the internal clear width of 21.0m. The shape of the arch units is the classic arch made out of two halves through an in-situ stitch at the crown. The arch units are backfilled with a well graded gravel / sandy gravel or gravelly sand with a minimum effective internal friction angle of thirty five (35) degrees.

The outermost arch units are provided with a spandrel wall which retains the backfill. The spandrel walls are connected along the circumference of the arch to the outermost units through tie bars. The cantilever ends of the spandrel walls (away from the arch curvature) are connected to each other through tie-bars placed in ducts and protected against corrosion.

The spandrel walls are topped with an overhanging kerb beam which support the bridge barrier and the balustrade.

5.3.5 SUBSTRUCTURE

The arch structure is supported by in-situ footings which also support the spandrel walls. These footing are founded below the expected scour depth and are protected against scour with riprap rock. The width of the footing is 5.0m while its depth is 1,100mm.

5.3.6 RETAINING WALLS

The approach retaining walls are envisaged as precast tilt-up panels placed on an in-situ footing and connected to it through an in-situ stitch. The footing size is 4,000mm wide by 800mm deep.

Along the retaining walls an overhanging precast kerb beam runs and which supports the bridge barrier and the balustrade.

5.3.7 BRIDGE ARTICULATION

No traditional expansion joints or bearings are required.

5.3.8 BRIDGE PARAPETS

Either side of the carriageway a MRWA three-rail regular containment bridge parapet is provided. The parapets extend to the end of the retaining walls.

Along the principal shared path a PSP type balustrade is provided.

The barriers and the balustrade are supported by an independent supporting structure such that no impact loads are transferred to the arch units or the spandrel walls. The supporting slabs are precast concrete units of 7.5m in length which are stitched together to provide the required resistance against the impact load. The upper section of the supporting unit, to which the parapets are bolted, forms a kerb beam which overhangs the spandrel and retaining walls. The

outer face of the kerb beam extends past the outer face of spandrels and retaining wall panels in order to avoid water / dirt dripping down onto them.

5.3.9 BRIDGE DRAINAGE

No drainage required. The gaps between the precast panels of the retaining walls will not be sealed in the lower section in order to allow the water to escape from behind the panels.

5.3.10 WATERPROOFING

Joints between the precast units, both the arch and retaining walls, are protected with a self-adhesive bituminous waterproofing membrane (Emer-Proof HD or similar approved) covered by a protection layer. From the inside the joints are sealed with a polysulphide sealant.

All buried faces of the footings and the slabs supporting the bridge parapets and the balustrade will be treated with a bituminous membrane (Elastoseal or similar approved).

5.3.11 MINIMUM HEADROOM

The provided headroom complies with the hydraulic requirement of a minimum 300mm of freeboard at the crown of the arch. The 100 years ARI freeboard is approximately 2,400mm which is driven by the local topography / elevation of the south bank.

5.3.12 PROPOSED ARRANGEMENT FOR MAINTENANCE AND INSPECTION

Not required. This solution does not utilise components which would require a replacement.

5.3.13 MATERIALS AND FINISHES

All materials and finishes chosen for this project are in accordance with AS 3610 Formwork for Concrete and MRWA Bridge Branch Information Manual (BBM), Document No. 3912/02-01.

The bridge site is located approximately 10km from the coastline.

B1 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are not subjected to contact with ground and brook water.

B2 exposure classification in accordance with AS 5100.5 has been adopted for bridge components, which are subjected to contact with ground and brook water.

It is proposed to provide a pattern finish of 2/311 Zyklus or 2/137 Bourgogne, as per the Reckli's Moulds for Art in Concrete 2009 Catalogue, to the exposed side face of the spandrel walls and the tilt-up panels of the approach retaining walls. Refer to Appendix J for details.

All exposed accessible surfaces will be treated with a non-sacrificial anti-graffiti coating.

The bridge and retaining walls components will be constructed in accordance with the material and finishes specification as shown in Table 5.3 below.

Table 5.3: Option 3 – Finishes

Element	Material	Finish	Cover [mm]
In-situ Footings	S40	Class 4 – side faces Class U1 – top	85 cast against ground 65 cast against membrane 55 elsewhere
Precast Arch Units	S50	Class 2	55 in contact with ground 40 elsewhere
Spandrel Walls	S50	Class 2X – external face Class 4 – buried face	55 in contact with ground 40 elsewhere
Precast Tilt-up Panels	S50	Class 2X – external face Class 4 – buried surfaces	45 in contact with ground 40 elsewhere
Precast Parapet Supporting Slab	S50	Class U2 – top exposed face Class 4 – buried surfaces	75 cast against ground 55 cast against membrane 40 elsewhere
PSP Screed	N40	Class U4	N/A
Bridge Barriers		Hot-dip galvanised	N/A
Balustrade		Hot-dip galvanised / Painted	N/A

5.3.14 RISKS AND HAZARDS CONSIDERED

During the development of this concept the main risks listed hereunder were considered and are captured in the Safety in Design report in Appendix H:

- Site Access
- Working in the vicinity of or within an area of a heritage significance
- Working near and / or over waterways
- Working at heights
- Working near operating plants
- Working near and / or in excavations
- Transportation of heavy precast bridge components
- Working near an operational railway line
- Working in the vicinity of a residential area

5.3.15 CONSTRUCTION CONSIDERATION

Well established construction techniques were chosen to ensure that the structure will be built economically with a controlled level of risks during its construction.

During the development of this option the emphasis has been placed on maximising the construction efficiency through the use of precast elements as far as practicable. The only non-prefabricated components of this structure are the in-situ footings and in-situ stitching between the arch units, spandrels and retaining walls. The near-complete precast methodology allows to advance the construction works in a precast yard (controlled environment) irrespective of weather conditions and other external factors whilst the remaining site activities are limited to very basic tasks such as shallow excavations, lifting and backfilling which do not require any highly specialised and sophisticated equipment.

It is even possible to implement prefabricated footings to further reduce the number of site activities, however at this stage in-situ footings are proposed as a more conventional solution contractors are familiar with.

This concept, however, due to its limited hydraulic efficiency requires to undertake works within the brook in order to deepen and widen the channel such that the afflux criterion is met. The overall amount of these works and their extent is still considered substantially less in the overall scheme as opposed to the two previous concepts. The localised widening and deepening will not result in large volumes of soil / river sediment needing to be removed.

5.3.16 RISKS AND OPPORTUNITIES

As a result of the lack of geotechnical investigation a number of assumptions had to be made with respect to the soil profile and its strength.

The footing size has been determined based upon the assumed soil design parameters. There is an opportunity to re-visit the footing design when the detailed information following the geotechnical investigation will become available. A soil replacement may provide an alternative solution to larger footings depending upon the required depth and volume of replaced soil.

A use of MSE walls on the approaches, instead of tilt-up precast panels, to the arch will be investigated and implemented if found more economical.

6 PRELIMINARY COST ESTIMATES

6.1 METHODOLOGY

The cost estimates of the preliminary design options have been prepared in accordance with the Main Roads' standard method of measurement for construction works.

The estimates include the construction costs and any allowances that a Contractor would make in a tender for the Railway Parade Bridge. It has been assumed that the works will be competitively tendered and the terms and conditions of engagement are standard Construct Only. For the purpose of these cost estimates it has also been assumed that access to the works is unrestricted and that construction will be carried out in the dry months.

The cost estimates contain totals for the direct cost, indirect cost and profit. The scheduled item costs have been created from first principles in a manner similar to the development of a tender by a construction contractor. Each cost estimate is based on a schedule of quantities. The cost estimates comprise the direct job costs that cover the costs of material, plant, labour and subcontractors for the construction of the physical works and the indirect costs. The indirect costs cover the recurring and non-recurring overhead costs required to deliver the project including the establishment and maintenance of requisite site facilities. An allowance for contractor's profit and head office overheads (based on current market trends and indications) has been applied to the direct and indirect costs.

Budget prices have been obtained from suppliers for the supply of the major components such as the T-Roff beams (Options 1 and 2) and the precast concrete arch and wall components (Option 3).

A contingency allowance of 15% is considered appropriate at this stage of the project development and has been included in the estimate.

At this option budget cost estimate stage, the estimate accuracy is be within the range of -15% to +30%.

The following items have not been included in the cost schedule:

- Diverting or working around existing services
- Latent ground conditions such as rock or contaminated soil
- Professional fees including design, engineering, project management
- Escalation
- Statutory fees
- Land Cost
- Finance and holding cost
- Goods and services tax
- Cost of road construction and approach embankments beyond the outer limits of the approach slabs or retaining walls.
- Diverting and / or dewatering excavations

6.2 COST ESTIMATE OF OPTION 1

This option of providing a new crossing over Ellen Brook results in the shortest structure (approximately 42m between the ends of wingwalls) out of these considered in this investigation. The summary of cost estimate is provided in Table 6.1 below.

Table 6.1: Option 1 – Cost Estimate Summary

Item / Activity	Total Cost
Net Estimated Cost	\$ 1,839,970.75
Preliminaries (19%)	\$ 350,000.00
Builders Margin (8%)	\$ 175,197.66
Sub-Total Construction Cost	\$ 2,365,168.41
Contingencies (15%)	\$ 354,775.27
Professional Fees	Excl.
Escalation	Excl.
GST	Excl.
Estimated Total Cost	\$ 2,719,943.68

Refer to Appendix F for the cost breakdown.

6.3 COST ESTIMATE OF OPTION 2

This option of providing a new crossing over Ellen Brook results in the second longest structure (approximately 63m between the ends of wingwalls) out of these considered in this investigation. The summary of cost estimate is provided in Table 6.2 below.

Table 6.2: Option 2 – Cost Estimate Summary

Item / Activity	Total Cost
Net Estimated Cost	\$ 3,031,718.50
Preliminaries (19%)	\$ 575,000.00
Builders Margin (8%)	\$ 288,537.48
Sub-Total Construction Cost	\$ 3,895,255.98
Contingencies (15%)	\$ 584,288.40
Professional Fees	Excl.
Escalation	Excl.

Item / Activity	Total Cost
GST	Excl.
Estimated Total Cost	\$ 4,479,544.38

Refer to Appendix F for the cost breakdown.

6.4 COST ESTIMATE OF OPTION 3

This option of providing a new crossing over Ellen Brook results in the longest structure (approximately 65m between the ends of wingwalls) out of these considered in this investigation. The summary of cost estimate is provided in Table 6.3 below.

Table 6.3: Option 3 – Cost Estimate Summary

Item / Activity	Total Cost
Net Estimated Cost	\$ 4,454,345.75
Preliminaries (19%)	\$ 575,000.00
Builders Margin (8%)	\$ 402,347.66
Sub-Total Construction Cost	\$ 5,431,693.41
Contingencies (15%)	\$ 814,754.02
Professional Fees	Excl.
Escalation	Excl.
GST	Excl.
Estimated Total Cost	\$ 6,246,447.43

Refer to Appendix F for the cost breakdown.

6.5 WHOLE OF LIFE COST

In the evaluation of the proposed options the aspects of the whole of life cost have been considered by taking into account the frequency of the maintenance and inspection activities related to each of the bridges options. In this assessment the following activities typical for the proposed bridge options and corresponding frequencies have been included:

- Visual inspection every 1 year
- Bridge area clean up every 1 year (removal of dirt from expansion joints and other deck areas, growing weeds, etc.)
- Re-application of joint sealants every 10 years (between precast elements, assumed 5% of overall length of joints)

- Replacement of the rubber strip seal of expansion joints including minor traffic management related to a temporary over-night closure every 5 years
- Replacement of the entire expansion joint including traffic management every 15 years
- Elastomeric bearings replacement including traffic management every 25 years
- Concrete patch repairs every 20 years (assumed 2% of surface area)
- Re-application of waterproofing of deck and approach slabs including pavement removal and re-application every 30 years
- Banks riprap repair (placement of additional rock, assumed 5% of total volume) every 10 years
- Repair to the scour protection of embankments (remodelling and / or replacement, assumed 5% of total volume / area) every 10 years

A 10% contingency has been allowed for in pricing the maintenance and inspections costs.

A low discount rate of 3.5% has been used in establishing the net present value of the costs related to inspection and maintenance works. This means that a larger consideration for future costs has been made, which is often used by public authorities (typically 2% – 5%). A high discount rate can be used when the risks of making an investment are larger and the future costs are not considered as important. This tend to be favoured by private investors.

A 'real' discount rate has been used in the assessment of whole of life costs, which means that the future costs are estimated as the 'real' present day prices (no inflation allowed for). Since the inflation is difficult to predict in the long term, 'real' discounts rates are recommended to use in Life-Cycle Costs (LCC) calculations for long term investments such as bridges.

In accordance with the above assumptions the inspection and maintenance cost comparison in provided in Table 6.4 below.

Table 6.4: Maintenance Cost Comparison

Bridge Option	Structure Type	Maintenance & Inspection Cost over the Design Life	Net Present Value
Option 1 – Single Span	T-Roff Bridge	\$ 1,926,000	\$ 424,000
Option 2 – Three Span	T-Roff Bridge	\$ 2,875,000	\$ 592,000
Option 3 – Arch	Precast Arch with Approach Retaining Walls	\$ 669,000	\$ 173,000

It should be noted that the above values are GST exclusive.

The distribution of the inspections and maintenance costs over the design life for each of the option is provided in Figure 1 to 3 presented below.

Figure 1: Option 1 – Distribution of inspections and maintenance costs.

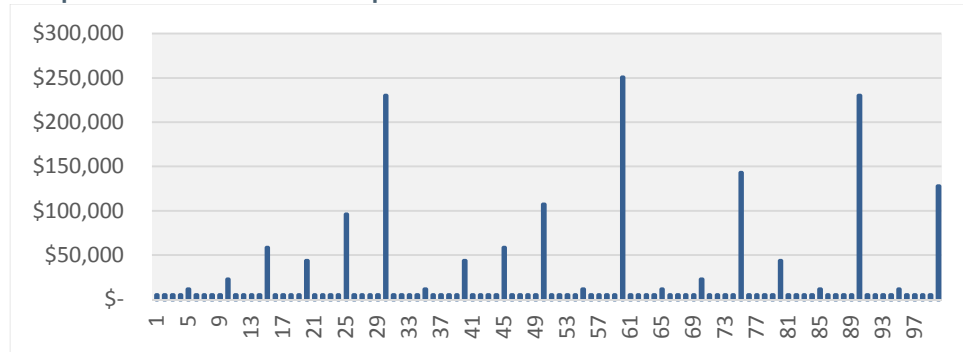


Figure 2: Option 2 – Distribution of inspections and maintenance costs.

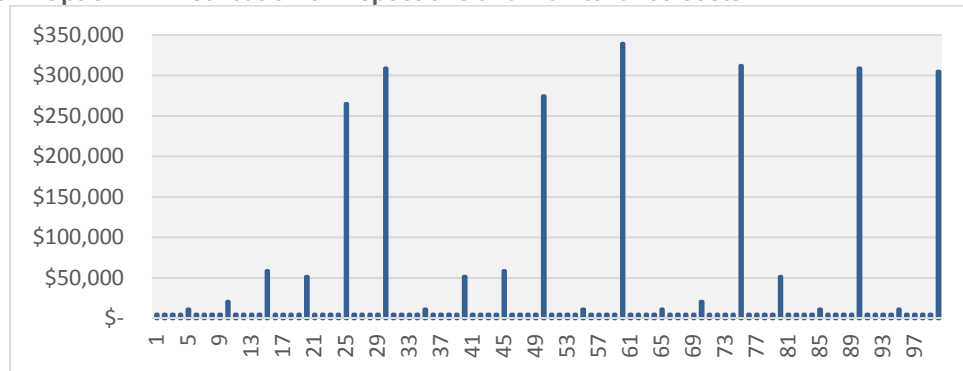
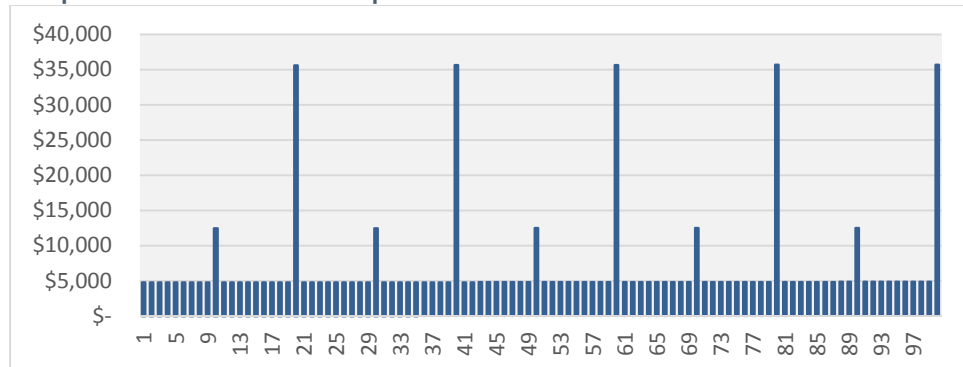


Figure 3: Option 3 – Distribution of inspections and maintenance costs.



6.6 COST ESTIMATE SUMMARY

The cost estimate investigation, which has been undertaken for the proposed bridge crossings as described in section 5, has established the estimated cost for each of the considered options in accordance with the methodology provided in section 6.1.

Following the details of this cost surveying it has become apparent that by far the least expensive solution is Option 1 (nearly \$ 2M cheaper than the next least expensive) followed by Option 2 and 3.

Table 6.5: Summary of Total Costs

Bridge Option	Structure Type	Total Cost
Option 1 – Single Span	T-Roff Bridge	\$ 3,144,000
Option 2 – Three Span	T-Roff Bridge	\$ 5,072,000
Option 3 – Arch	Precast Arch with Approach Retaining Walls	\$ 6,423,000

7 OPTIONS ASSESSMENT

7.1 EVALUATION CRITERIA

This section describes in detail each of the project evaluation criteria and presents results of the evaluation of each bridge option against these criteria. This evaluation is summarised in a selection matrix that gives each alternate a rating of between one (1) and five (5) based upon how well each criterion is satisfied. A score of one (1) indicates that the criterion is not satisfied, while a score of five (5) is the highest possible rating for the criterion. An overall rating is then calculated for each of the options and a final comparison is made to determine the bridge option that best satisfies all of the criteria and provides the best overall value to the project. This option is then the recommended structure for the Railway Parade Bridge, and with City of Swan concurrence, will be advanced into the detailed design phase.

The project evaluation criteria are based on the structural and functional requirements of the new crossing and are listed in the table below. Also included in the table, is a weighting factor associated with each criterion. In the calculation of the overall rating for each option, each criterion is given a weighting factor based on its importance in the overall project. Criteria that represent more critical issue are more heavily weighted.

Table 7.1: Evaluation Criteria

Evaluation Criteria	Weighting Factor
Heritage Impact	5%
Environmental Impact	5%
Impact on Hydrology & Hydraulics of this Area	5%
Bridge Aesthetics	5%
Bridge Cost	60%
Constructability	10%
Durability	10%

7.2 DESCRIPTION OF CRITERIA

This section describes in detail each of the evaluation criteria as they apply to construction of the Railway Parade Bridge over Ellen Brook and the specific constraints of the site and goals and critical issues of the project. Ratings that are shown in the selection matrix are described for each of the criteria.

7.2.1 HERITAGE IMPACT

The desktop review of aboriginal sites recorded within the vicinity of the proposed Ellen Brook Bridge identified the site as an area of a potential heritage significance, which requires a further study involving a heritage survey. The project site within and near the river channel may consist of heritage artefacts and human skeletal remains of a cultural value to the indigenous community.

A search of the DIA Heritage database identified nine (9) registered site within 5km from the proposed crossing. Some of these sites have mythological and ceremonial components whilst others comprise stone artefacts. One site is located within the proposed crossing, however it has not been sufficiently surveyed which would have allowed to establish its status as to whether it should be included in the State Heritage Register.

This site ID 3525 has been de-classified as a registered site due to a lack of sufficient evidence, however it retains status of an “other heritage place”, which means it may be a site when sufficient and specific ethnographic information is provided for it to be registered.

It is understood that the site for the proposed bridge is located in an area of a similar environmental context to the site ID 4299 Upper Swan Bridge, which contained large deposits of artefacts and was in fact classified as one of the oldest archaeological sites in Australia. Therefore, site activities during and prior to the construction of the bridge, which involve excavations and soil disturbance, and reveal comparable soil deposits to those distinctive at the Upper Swan Bridge should not be overlooked.

Given the history of this area and the potential significance of the site the options have been rated according to the overall footprint of the proposed bridge foundations and the extent of the works near and within the channel of the brook. However, due to the lack of detailed and suitable information to make an accurate assessment it is assumed that all options positively address the heritage aspect to a varying degree.

The least invasive from the earthworks and soil disturbance point of view is the Option 1 (single span T-Roff bridge) which is given an arbitrary rating of three (3.0) based upon the assumptions as outlined in the above paragraph. The Option 2 (three-span T-Roff bridge) and the Precast Arch are given an arbitrary rating of two and half (2.5) and two (2.0) respectively due to the increased amount of works related to soil disturbance.

7.2.2 ENVIRONMENTAL IMPACT

The project site has been identified as stretching over several different zonings under the Metropolitan Region Scheme. To the south of the Ellen Brook the site and adjacent areas are zoned ‘Rural’ whereas the Ellen Brook is zoned as ‘Parks and Recreation’. Aside from Ellen Brook there are two Multiple Use wetlands and one Resource Enhancement wetland on the site. Resource Enhancement and Multiple Use wetlands do not have statutory protection however may be considered significant by the DEC. Construction in the wetland areas may be a concern to the DEC.

The environmental assessment along with flora and vegetation survey did not identify any environmental significance in this area and the vegetation is in either Degraded or Completely Degraded state and no Threatened species were found. Also, a potential impact on Black Cockatoo habitat was investigated and the site survey did not identify any evidence of foraging on the site. The breeding and potential breeding habitat was limited to eight Marri trees. No evidence of breeding on the site has been recorded and there was no evidence that the site was used as roosting habitat. Therefore, clearing for the proposed bridge and road will have a Low risk of significant impact.

On the basis as described above each of the considered bridge options satisfy the environmental criteria, however the impact marginally varies depending on the footprint of the bridge. The length of the bridge in the overall footprint is insignificant and therefore the following rating has been allocated to the bridge options considered. A rating of three (3) to Option 2 for its openness and the least footprint in comparison to the deck area, a rating of two point seven five (2.75) to option 1 for the second least footprint and two point five (2.5) to option 3 (option with the longest embankment).

7.2.3 IMPACT ON HYDROLOGY & HYDRAULICS OF THIS AREA

The location of the proposed crossing over Ellen brook and its proximity to the gauging station requires the structure to meet hydraulic design criteria, which are defined for this project to be a 100 ARI flood immunity and storm event along with a 70mm maximum allowable afflux and a minimum 300mm freeboard for a 100 ARI flood event. Also, the hydraulic performance of the new crossing should not affect the ratings curves of the nearby gauging station.

Each of the proposed concepts comply with the required freeboard with a substantial reserve margin since the elevation of the bridges is partially driven by the local topography. Out of the three options considered in this investigation only two of them (option 1 and 2) meet the afflux criterion without any additional works within the channel in order to meet the afflux criterion. Option 2 is the most hydraulically efficient solution out of the proposed group which causes only 20mm of afflux whereas option 1 results in an afflux of 30mm. On that basis a rating of four point seven five (4.75) has been assigned to option 2 and four point five (4.5) to option 1. The precast arch bridge, which requires widening and deepening of the channel in order to meet the afflux requirement at its maximum allowable value, has been given a rating of two (2).

7.2.4 BRIDGE AESTHETICS

Aesthetics is subjective, depending upon a bridge location, could be an important factor in the overall assessment of the bridge options.

There were no specific aesthetic requirements set out for this project. However, the new structure will be located in a relatively quiet and modern residential area. Currently there are two new developments under construction in the vicinity of the bridge site. The boundary of the Annie's Landing Village 8 stretches as far to the east that only the existing access track separates the village from the new crossing and its approach embankments. It is therefore, very likely that the site surrounding the bridge may be transformed into an attractive oasis drawing attention of dog walkers and other residents.

The most architecturally pleasing solution and that which is more suitable to the area it will be built in is the precast arch. This structure has a potential to become a local icon or a feature complementing and not visually disturbing this local reserve. Therefore, for its visual values a rating of four point five (4.5) has been given.

The three-span T-Roff bridge is given a rating of three point five (3.5) for its open character and a potential it provides to develop the space underneath the structure into an attractive landscape-treated area showcasing the natural environment. Also the bridge deck, which is shallower to that of the single span, maximises the visual slenderness resulting in an optical lightness of this bridge.

The single span option constraints the space available underneath the bridge and substantially limits potential landscape options. Even though the bridge is well proportioned it cannot compete with its predecessors in the aesthetics category, and therefore a rating of two point five (2.5) has been assigned.

7.2.5 BRIDGE COST

Irrespective of other factors contributing to the overall assessment of the proposed options the cost aspects are a major consideration since the selected solution must be feasible given the budget allocated to the project.

As part of engineering studies during this phase of the project preliminary designs were completed for each of the bridge options being considered. Overall member sizes and approximate reinforcing and prestressing requirements were determined and the viability of

each option verified for preliminary design adjustment. Preliminary design level quantities were then calculated for each bridge option studied based upon which preliminary cost estimates were established.

The table below summarises the construction cost of each of the options and provides a total opinion of cost for the bridge structures for comparison purposes. The total bridge cost is the summation of the structure cost based on quantity-based estimates and the whole of life approach including aspects of inspection and maintenance activities.

Table 7.2: Summary of Bridge Costs

Bridge Option	Structure Type	Cost
Option 1 – Single Span	T-Roff Bridge	\$ 3,144,000
Option 2 – Three Span	T-Roff Bridge	\$ 5,072,000
Option 3 – Arch	Precast Arch with Approach Retaining Walls	\$ 6,423,000

In the selection matrix, a rating of five (5) is assigned to the least cost alternate, Option 1. Ratings for the other bridge options are calculated by normalising to the least cost option. A cost index is determined by dividing the cost of the option being considered by the cost of the least cost option. The least cost rating (5) is then divided by the cost index to determine a rating for each option being considered. Normalisation results and final cost ratings are presented in Table 7.3 below.

Table 7.3: Summary of Cost Rating

Bridge Option	Structure Type	Total Cost	Index	Rating
Option 1 – Single Span	T-Roff Bridge	\$ 3,144,000	1.00	5.00
Option 2 – Three Span	T-Roff Bridge	\$ 5,072,000	1.65	3.04
Option 3 – Arch	Precast Arch with Approach Retaining Walls	\$ 6,423,000	2.30	2.18

Based on the undertaken cost estimates the most economically advantageous option is Option 1 – *Single span T-Roff bridge*.

7.2.6 CONSTRUCTIBILITY

Constructability is an important consideration when evaluating different bridge options as it relates to the method of construction and access complexity of the site. Construction utilising long precast concrete elements requires large cranes and is best suited where access to site is not constrained by tight curves / steep grades and the ground conditions are suitable for heavy loads such that no expensive temporary work platforms / foundations are required.

The project site does not have any particular constraints which could have an impact on the proposed bridge solutions to a great degree. However, the arch concept is clearly the simplest option to construct out of the considered group. All its precast elements are comparatively smaller and lighter to those of the other two options, which in turn simplifies the construction and

results in the use of lighter equipment and an improved safety. For those reasons the arch option is given a score of four point five (4.5).

There is a very little noticeable difference between the constructability aspects of options 1 and 2 since they utilise the same construction methodology, yet various sizes. The deck of the Option 2 comprises lighter and shorter beams which favours maneuverability, however there is a larger number of them to be delivered and installed versus heavier but fewer girders of Option 1. Also, the three-span concept involves additional site activities related to the construction of the bridge piers, which ultimately will result in a longer construction programme. Therefore, taking into account the subtle differences option 1 has ultimately been given a higher score of four (4) versus three point five (3.5) for the option 2.

7.2.7 DURABILITY

Prestressed concrete bridges have been documented to have superior durability and require less maintenance than traditional reinforced concrete bridges. Reinforced concrete decks are prone to cracking allowing chloride penetration into the concrete body and resulting in reinforcement corrosion and deterioration of the deck. Also, the bridge articulation is an important aspect to consider while assessing the overall expected durability performance. Continuous bridge decks eliminate expansion joints which typically are the costly maintenance items. Failed and leaking joints are a major factor in substructure deterioration of bridges. Integral / jointless bridges, which eliminate the need for joints and bearings, have proven to be far superior to other bridge solutions as far as the maintenance is concerned.

All of the considered options consist of high quality precast elements which provide a better durability performance as opposed to the traditional in-situ reinforced concrete. However, only option 3 nearly entirely eliminated the use of in-situ reinforced concrete through the use of a large number of precast components. Additionally, this option does not consist of expensive in maintenance expansion joints and bearings requiring a periodic replacement. For those reasons the precast arch bridge has been given a score of five (5.0).

The other two alternative options utilise the same construction methodology and materials and hence the only difference in the assessment of the overall durability is the overall length of the bridge leading to larger area of the concrete deck and the link slab over the piers subjected to tensile forces and prone to cracking. Considering these aspects the option 2, three-span bridge, has been given a rating of three point seven five (3.75) versus four (4.0) for the single span option 1.

7.3 SUMMARY AND RECOMMENDATIONS

Ratings for each of the bridge options and each of the evaluation criteria discussed above are summarised in the Structure Selection Matrix. The bridge option that has the overall highest rating is the preferred alternate and is recommended for the detailed design.

Table 7.4: Summary of Options Rating

Option	Heritage Impact	Environmental Impact	Hydrology & Hydraulics	Bridge Aesthetics	Bridge Cost	Constructability	Durability	Overall
Option 1 – Single Span T-Roff	3.0	2.75	4.50	2.5	5.0	4.0	4.0	4.44
Option 2 – Three-span T-Roff	2.5	3.0	4.75	3.5	3.04	3.5	3.75	3.23

Option	Heritage Impact	Environmental Impact	Hydrology & Hydraulics	Bridge Aesthetics	Bridge Cost	Constructability	Durability	Overall
Option 3 – Precast Arch	2.0	2.5	2.0	4.5	2.18	4.5	5.0	2.81
Weighting Factor	0.05	0.05	0.05	0.05	0.60	0.10	0.10	

Following the assessment of this preliminary design it can be seen that the best overall score has been achieved by the Option 1 – *Single span T-Roff bridge*.

8 CONSULTATIONS AND APPROVALS

During the development of the bridge crossings at this phase of the project the Department of Water and the Swan River Trust have been contacted in order to obtain information which may have a significant impact on the type and size of the bridge options.

An input in relation to historical data and acceptable level of afflux in this area was received from the Department of Water.

The response from the Swan River Trust stated that the project site in Ellen Brook is not within the Swan River Trust's Development Control Area, and therefore the development will not require a permit from the Trust. Refer to Appendix G.

9 ISSUES TO BE RESOLVED

The heritage survey and relevant heritage approvals are critical to the successful delivery of this project.

10 SAFETY IN DESIGN

A comprehensive Safety in Design assessment has been undertaken by the design team and its findings and controls are captured in the Appendix H.

APPENDIX A

HYDROLOGY & HYDRAULIC ASSESSMENT REPORT

HYDRAULIC ASSESSMENT REPORT

To Change the Fill of a Shape to a Picture:

Note ~

It is important you choose a Picture that matches (as closely as possible) the Orientation and Height to Width Ratio of the Shape—

Width 20.0 cm x Height 28.7 cm.

- 1 Select the **Shape**
- 2 From **Shortcut Menu**—Click the **Right-Mouse** button
- 3 Select **Format Shape...**
- 3 From **Format Shape** dialogue box—Select **Fill**
- 4 Select **Picture or texture fill** optionbutton
- 5 Click **File...** button
- 6 From **Insert Picture** dialogue box—**Locate** and **Select Picture**
- 7 Click **Insert** button
- 8 Click **Close**

Once you have changed the Shape Fills—Delete this instruction Text Box...

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CITY OF SWAN

RAILWAY PARADE BRIDGE

Hydraulic Assessment Report

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Report No

Date 01/06/2015

This report has been prepared for City of Swan in accordance with the terms and conditions of appointment for Railway Parade Bridge. Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

1	Introduction	1
1.1	Background	1
1.2	Scope of Works	1
1.3	Design Criteria	2
2	Hydrology Study	3
2.1	Catchment Description	3
2.2	Gauging Stations and Data Availability.....	5
2.3	Subcatchment Delineation.....	7
2.4	IFD Curves	9
2.5	Rainfall-Runoff Model	9
2.6	Design Flows	16
3	Hydraulic Modelling	18
3.1	Methodology	18
3.2	Modelling Parameters.....	18
3.3	Modelling Requirements.....	23
3.4	Modelling Scenarios	23
4	Modelling Results	25
4.1	Model Calibration.....	25
4.2	Modelling of the Existing Condition.....	25
4.3	Alternative 1- 1 Span Bridge.....	26
4.4	Alternative 2- 3 Span Bridge.....	27
4.5	Alternative 3 - Con/Span Bridge	27
4.6	Preferred Alternative.....	28
4.7	Removal of the Existing Downstream Crossing.....	28
4.8	Scour Protection	29
5	Safety in Design	30
5.1	Stakeholder Consultation.....	30
5.2	Safety in Design Process.....	30
6	Conclusions	32

APPENDICES

Appendix A Rainfall-runoff Conceptual Model

Appendix B Design Hydrographs

Table of Acronyms

Abbreviation	Definition
1D	1-dimensional
AEP	Annual Exceedance Probability
AR&R	Australian Rainfall and Run-off
ARI	Average Reoccurrence Interval
BOM	Bureau of Meteorology
CoS	City of Swan
DEM	Digital Elevation Model
DoW	Department of Water
RAAF	Royal Australian Air Force
WIR	Water Information Reporting
WQ	Water Quality

1 INTRODUCTION

1.1 BACKGROUND

Hyder Consulting Pty Ltd (Hyder) has been commissioned by the City of Swan (CoS) to undertake preliminary through to detailed design of the Railway Parade Bridge over Ellen Brook. The Railway Parade Bridge will be upgraded to provide access to the developing areas at the Vines, Ellen brook and Aveley. Currently, the Railway Parade is discontinued at its intersection with Ellen Brook, however the new bridge, will allow the road to continue over the waterway.

The hydrology and hydraulic components of the design works are presented in this report.

1.2 SCOPE OF WORKS

The bridge design works have been divided into two stages; preliminary design and detailed design. The hydrologic and hydraulic investigations detailed in this stage of the report (001) for the proposed bridge have been completed as a part of preliminary studies. During detailed design this report will be updated to reflect the final design (002).

The purpose of the investigation is to ensure the proposed bridge alternatives meet the flood immunity criteria and will cause no unacceptable, adverse impacts to the area. The scope of works for the hydrology and hydraulic studies includes the following:

Hydrology

- Delineate the Ellen Brook sub-catchments and define the catchment parameters
- Set up a rainfall-runoff model
- Calibrate the model based on recorded historical data recorded at the Railway Parade flow gauging station
- Estimate the design ARI flows to be used in hydraulic assessments

Hydraulic

- Set up a hydraulic model of Ellen Brook in the vicinity of the bridge
- Assess the hydraulic characteristics of the bridge design alternatives
- Assess the flow conditions in Ellen Brook, pre- and post-bridge construction
- Iterate design options and alternatives:
 - Alternative 1: 1 Span Bridge
 - Alternative 2: 3 Span Bridge
 - Alternative 3: CON/SPAN Bridge¹
- Estimate the scour depth at the bridge
- Assess the impact from the potential removal of the downstream existing crossing
- Evaluate the changes to the upstream gauging station rating curve

¹ A CON/SPAN bridge is a precast, arch bridge which can be configured for multiple cells, high clearance requirements and skewed applications if required. A single cell CON/SPAN bridge was seen as the preferred option at the start of the investigation.

1.3 DESIGN CRITERIA

The hydraulic design criteria adopted for the assessment of the Ellen Brook crossing are shown in Table 1.1 below:

Table 1.1: Ellen Brook Crossing Design Criteria

Criteria	Value	Unit
Design Storm Event	100	Year
Flood Immunity Design Event	100	Year
Maximum Flood Afflux	70	mm
Minimum Freeboard	300	mm

2 HYDROLOGY STUDY

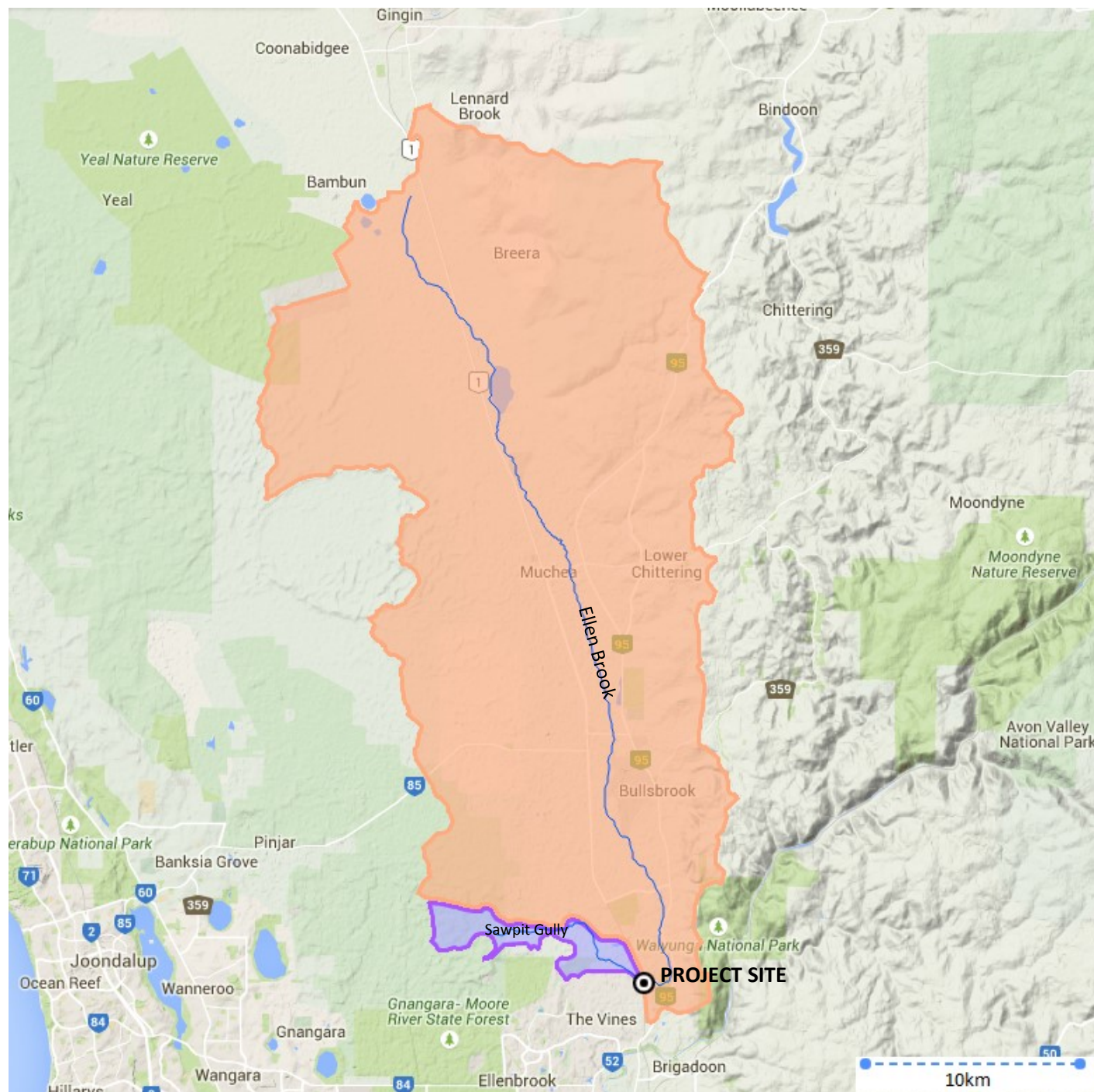
The inputs required for the hydraulic component of the study were the peak flows at the model boundary locations for 2, 5, 10, 20, 50, 100 and 2000 year average reoccurrence interval (ARI) storm events. To obtain these peak flows at the required locations, a site-specific rainfall-runoff model was developed and calibrated using historical flow data. Section 3 below details the methodology and results of this rainfall-runoff model.

2.1 CATCHMENT DESCRIPTION

Ellen Brook starts just south of Lennard Brook and flows into the Swan River, approximately 7km southwest of the site. The Brook is fed from the Dandaragan Plateau, at the northern end of the Darling Range, as well as smaller watercourses along the way including Sawpit Gully, Ki-It Monger Brook, Nambah Brook, Rocky Creek and Breera Brook. The total catchment area of Ellen Brook at the site is approximately 582km², with an additional catchment area of approximately 16km², joining Ellen Brook just downstream of the site via Sawpit Gully.

There is a distinct difference between the eastern and western portions of the catchment. The western segment stretches from Gingin RAAF base down to Sawpit Gully. It is relatively flat with average sub-catchment grades in the order of 0.003 m/m. The soil in this region is typically sandy, with relatively high infiltration losses as a result. The eastern segment is steeper, with average grades in the order of 0.007m/m. While both segments are comprised of a combination of agricultural land and relatively dense vegetation, the western segment has a higher proportion of dense vegetation, predominantly made up of Gnangara-Moore River State Forest.

Figure 2.1 overleaf shows the site location and the catchment boundaries of Ellen Brook and Sawpit Gully.



LEGEND

- Ellen Brook
- Catchment Boundary
- Sawpit Gully
- Catchment Boundary
- Major Waterway



Imagery source:
2015 Digital Globe
Google Maps

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Figure 2.1: Site Location and Catchment Delineation

2.2 GAUGING STATIONS AND DATA AVAILABILITY

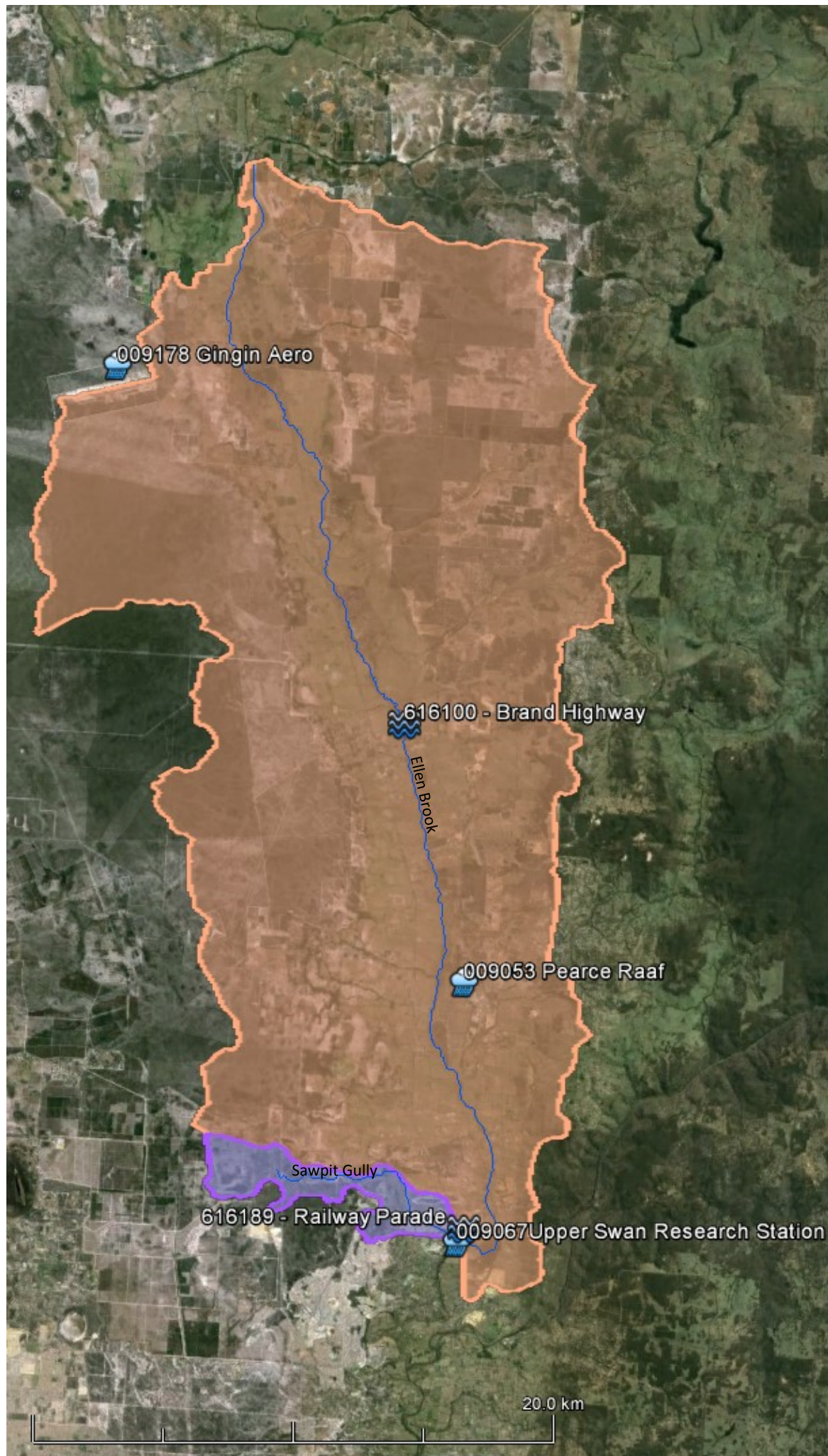
Several gauging and rainfall stations were available for data extraction, with two Department of Water (DoW) gauging stations recording flow data within the catchment. The Railway Parade (ID 616189) gauging station will provide the most relevant flow data as it is located 60m upstream of the project site. This station has an extensive flow record spanning 50 years. The location and quality of this gauging station allows for the development of an accurate rainfall-runoff model, as it can be calibrated with no hydrologic extrapolation required. The other flow gauging station within the catchment (Brand Highway, ID: 616100) was therefore deemed superfluous and was not used for analysis.

Bureau of Meteorology (BOM) rainfall stations were also utilised for the study for input into Stage 2 of the model calibration process (refer to Section 2.5.3 for details). The stations relevant to this study are shown in Table 2.1 and Figure 2.2 below.

Table 2.1: Relevant Gauging Stations and Data Availability

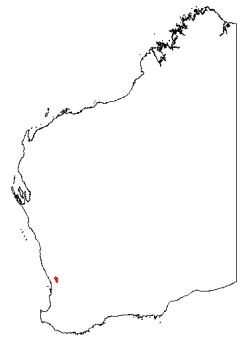
Station ID	Station Name	Data Type	Data Record / Relevant Event(s)	Data Interval Available	Data Use*
616189	Railway Parade	Flow	1965-2015	30 mins	FFA, 2013 historical event
616100	Brand Highway	Flow	n/a	30 mins	Not used
009053	Pearce RAAF	Rainfall	1987 and 2013 events	3 hrs for 1987 event [^] , 30 mins for 2013 event	2013 historical event
009067	Upper Swan Research Station	Rainfall	1987 event	3 hrs [^]	Not used
009178	Gingin Aero	Rainfall	2013 event	30 mins	2013 historical event

*Refer to Sections 2.2 and 2.5 for details. [^]BOM listed data as 3 hourly, but actual data record missing significant segments of rainfall data.



LEGEND

- Ellen Brook
- Catchment Boundary
- Sawpit Gully
- Catchment Boundary
- Major Waterway
- DoW Gauging Station
- BOM Rainfall Station



Imagery source: CNES /
Astrium, Digital Globe, Google
Earth

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Figure 2.2: DoW Gauging Stations and BOM Rainfall Stations

2.3 SUBCATCHMENT DELINEATION

In order to develop an accurate rainfall-runoff model, the Ellen Brook and Sawpit Gully catchments were divided into subcatchments. Ellen Brook and Sawpit Gully were divided into 14 and 4 subcatchments respectively. The Ellen Brook channel itself represented a catchment boundary for many of the subcatchments. This enabled a distinction within the model between the eastern and western segments of the catchment, which possess different physiographic characteristics (as described in Section 3.1).

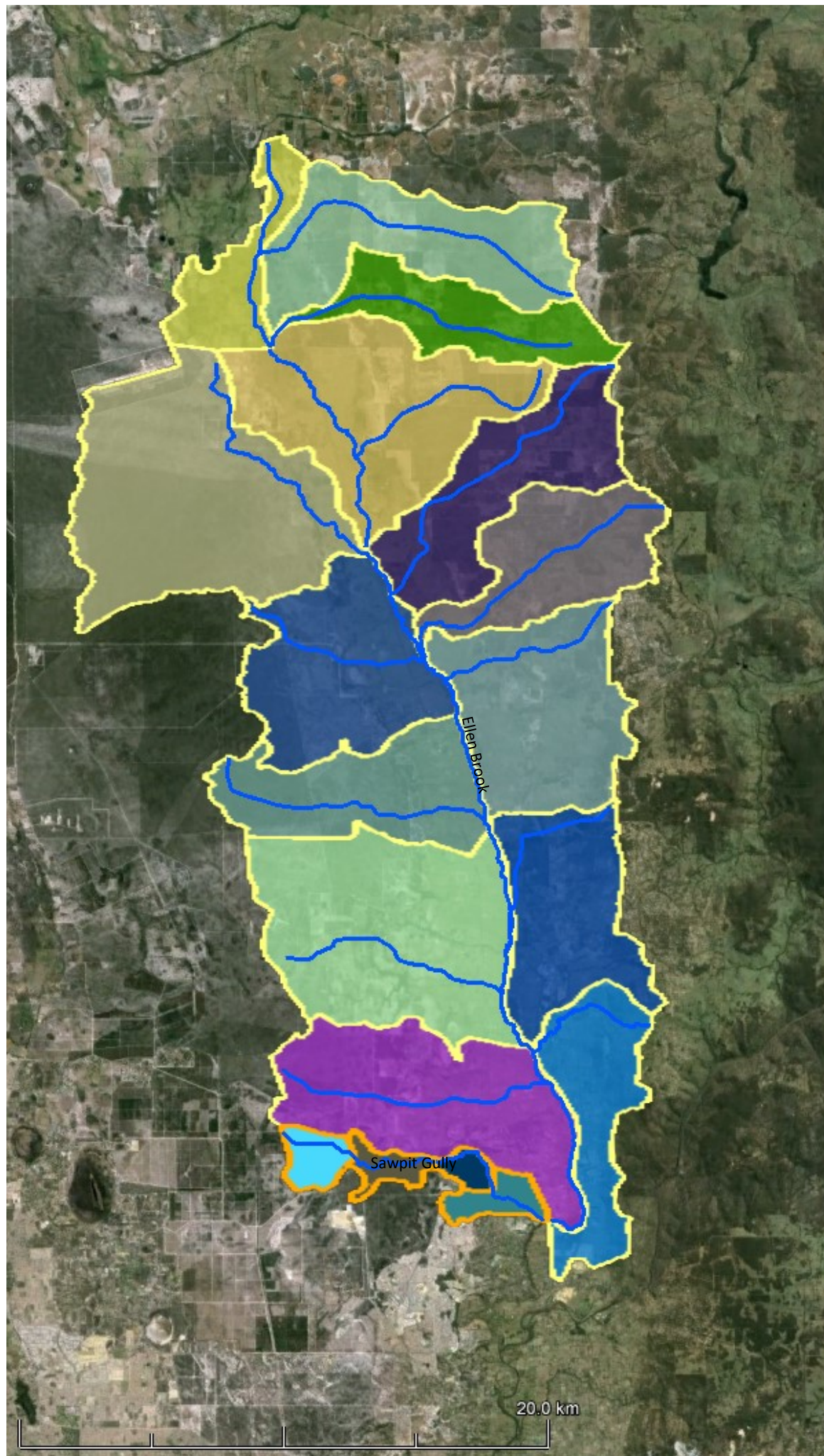
A number of information sources were used to define the catchment boundaries. Firstly, waterway tiles and contours were obtained from DoW's Water Information Reporting (WIR) portal. These enabled a good definition of catchment boundaries for the vast majority of the catchment, however some ambiguity existed at several locations, in particular at the northern side of the catchment at Lennard Brook. The region between Lennard Brook and Bambun including Lake Bambun is very flat, and contours and waterway tiles acquired from DoW provided conflicting catchment definition information at this location. Therefore, additional studies covering the hydrology of this area were sought. The findings of the following studies were considered to improve the accuracy of the northern catchment boundary:

- *Ellen brook Catchment*, Water Corporation, 2013
- *Groundwater-surface water interaction along Gingin Brook Western Australia*, DoW, 2011
- *Assessment of low-flow thresholds in maintaining the ecological health of the Lennard Brook*, DoW, 2012
- *South West WA sub-catchments*, DoW WIR, 2015
- *Natural Hazard Risk in Perth*, Department of Industry, Tourism and Resources, 2005
- *Swan Canning Water Quality Improvement Plan*, Swan River Trust, 2009

These studies once again provided conflicting information, however a general consensus was able to be achieved across the majority of these sources. Thus the final catchment boundaries were defined as per the majority of approaches found in the studies above, with some minor conservative changes to account for opposing interpretations. These subcatchments can be seen in Figure 3.3 below.

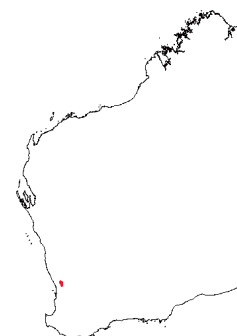
It should be noted however, that the above issue does provide some ambiguity to the developed model and potentially increases the risk to accuracy of the hydrological output.

Primary channels, overland flow paths and catchment elevations were also extracted for input into the rainfall-runoff model.



LEGEND

- Ellen Brook Sub-catchment Boundary
- Sawpit Gully Sub-catchment Boundary
- Defined Flow Path



Imagery source: CNES /
Astrium, Digital Globe, Google
Earth

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Figure 2.3: Defined subcatchments and waterway network

2.4 IFD CURVES

Intensity-Frequency-Duration (IFD) curves were acquired from BOM to provide rainfall intensity data for the design storms in the model. These were based on AR&R 1987. The curves were extracted based on a single location; the centroid of the Ellen Brook catchment. Additional IFDs were also extracted for the northern and southern sections of the catchment, however these were not required in the model due to their similarity with the IFDs for the catchment centroid.

The IFDs used for the rainfall-runoff model are shown in Figure 2.4 below.

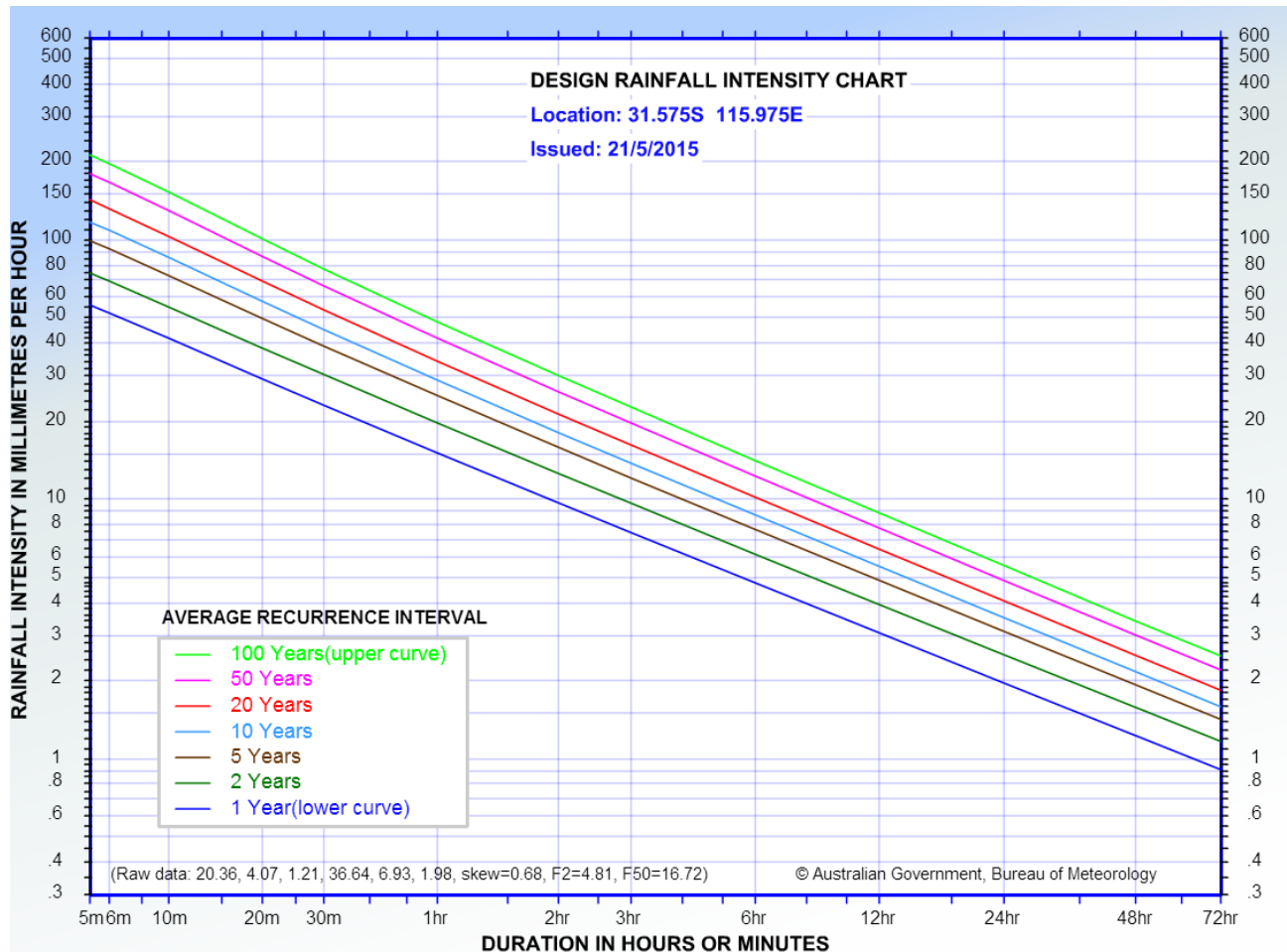


Figure 2.4: IFD curves for Ellen Brook Catchment

2.5 RAINFALL-RUNOFF MODEL

In order to produce design flows at the site, a rainfall-runoff model for Ellen Brook and Sawpit Gully was developed using the above information and processes as input data. The software used was XP-RAFTS, an industry standard rainfall-runoff modelling package. XP-RAFTS uses the Laurenson non-linear run-off routing procedure to develop a stormwater run-off hydrograph from either an actual event or a design storm based on BOM and AR&R data processes.

2.5.1 SET-UP AND INITIAL MODEL RUN

The entire network of waterways that flow to the site were incorporated into the model, with all catchment and sub-catchment parameters represented and modelled. The conceptualisation of the XP-RAFTS Ellen Brook model can be found in Appendix A.

Various catchment parameters and features, such as proportion of each subcatchment vegetated and impervious, were quantified and used as input parameters. Manning's n roughness values were then allocated based on the following:

Table 2.2: Manning's n Coefficients

Surface Type	Manning's n
Channel bed	0.04
Channel overbank	0.05
Non-vegetated area (e.g. grassy farmland)	0.05
Vegetated area	0.07

Equal area slopes for catchments and channels were calculated using elevation data from each subcatchment. Subcatchment areas and flow paths were quantified based on the subcatchment delineation detailed in Section 2.3.

With regard to losses, AR&R does not provide specific recommended values for the exact site location. AR&R does, however, reference two locations that are relevant to the site. It provides a median continuous loss of 3.8mm/hr for Ellen Brook (with no initial loss listed), and a proportional loss model for areas close to the site with sandy soils, with losses varying based on ARI. For this study, both of these loss methods (i.e. initial/continuous loss and proportional loss) were trialled, with the model proving to be highly sensitive to the proportional loss (i.e. sandy soils) method. Thus the proportional loss model was adopted and AR&R recommended values used for the pre-calibration model runs.

Based on the above, the critical storm duration was found to be 24 hours for large events (i.e. Q50 and Q100) and 72 hours for small to medium events (i.e. Q2 - Q20).

2.5.2 STAGE 1 CALIBRATION – FLOOD FREQUENCY ANALYSIS

The first stage of calibration for the model involved performing an FFA. The model was then calibrated by adjusting the various model parameters which had been assumed based on limited information (e.g. loss rates, Manning's n values, catchment storage coefficient).

In order to perform the FFA, the maximum peak discharges for each water year from the 50 years of available data were extracted from the Railway Parade gauging station record. The data was ranked in descending order and the annual exceedance probability (AEP) was calculated using the Gringorten Method based on the following formula:

$$AEP = \frac{r - \alpha}{N + 1 - 2\alpha}$$

Where: AEP = Annual Exceedance Probability

N = Number of years of record

r = Peak flow rank

α = Factor that reflects probability distribution being used

Australian Rainfall and Runoff suggests the appropriate value for α is 0.4, so this was adopted for the FFA.

In order to carry out the FFA, hydrological analysis software HEC-SSP was used. This software is based on "Bulletin 17B: Guidelines for Determining Flood Flow Frequency" (1981, USGS). The probability distribution function used by this method is the Log-Pearson III distribution, which is considered the most appropriate probability distribution function applicable to FFA and other hydrological analyses.

The first run of the FFA produced a good fit between observed data and the applied Log-Pearson Type III distribution for the majority of the data set. Table 2.3 below shows the initial FFA results, and Figure 2.5 below plots the calculated curve with respect to observed values. The mean square error for this calculation was 0.246.

Table 2.3: FFA First Run Peak Flows

ARI (years)	FFA First Run Peak Flows (m ³ /s)
100	55.5
50	52.5
20	47.2
10	41.8
5	34.7
2	21.1

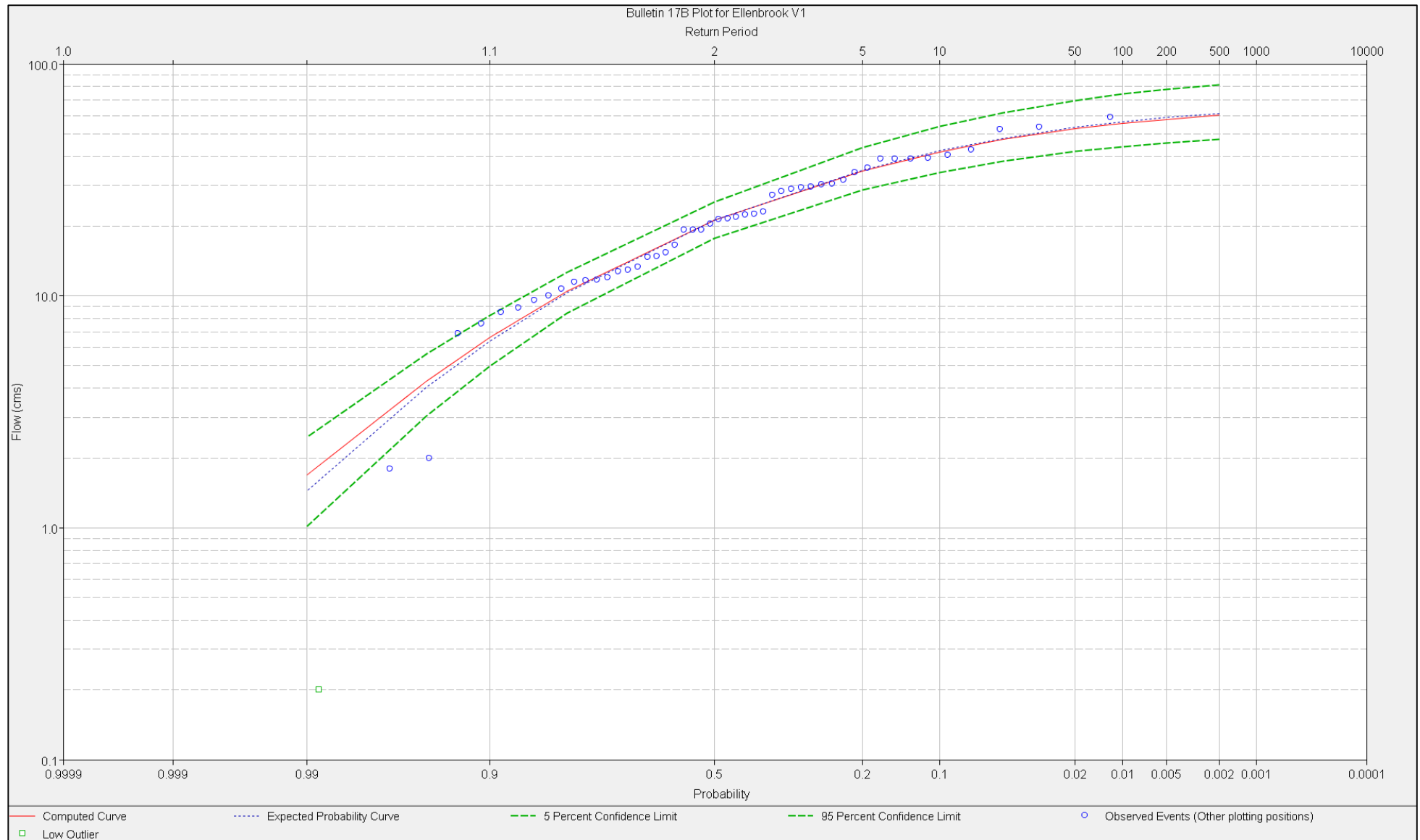


Figure 2.5: FFA First Run Flow Curve

As seen in the figure above, the highest three recorded values all lie above the calculated curve. This implies that the calculated distribution may have been underestimating flows in the 20-100 year ARI range despite the very good fit for smaller events.

In addition, the calculated Q100 flow was less than the highest observed flow despite a flow record of only 50 years. For a flow record of 50 years with no distinct high outlier(s), it would be expected that the Q100 flows would be greater than the highest observed flows. This was not the case with these initial FFA results. As seen in Table 2.3 above, Q100 calculated flow of 55.5m³/s was less than the highest recorded value of over the 50 year record of 58.8m³/s. Figure 3.5 above shows that this 58.8m³/s value was not a high outlier.

As a result, the FFA was modified to more accurately represent flows of large events (i.e. 20-100 year ARI). For the initial FFA, the low outlier threshold was calculated within HEC-SSP as 1.2m³/s, causing a single low outlier to be identified and removed (Year: 2014, Peak flow: 0.2m³/s). For the revised FFA calculation, the low outlier threshold was adjusted to 3m³/s. This adjustment excluded two additional values from the calculation (Years: 2010 & 2012, peak flows 1.8 & 2.0m³/s respectively). These two values both lie outside the 5-95% confidence limits, as seen in Figures 3.5 and 3.6.

This adjustment to the low outlier threshold produced the following results shown in Table 2.4 and Figure 2.6 below. The adjustment improved the fit of the data to the Log-Pearson Type III distribution, producing a reduced mean square error of 0.11. The revised Q100 flow of 72.9m³/s reasonably exceeds the 50-year maximum recorded flow of 58.8m³/s. Thus the results shown in Table 2.4 were adopted as the final FFA output flows.

Table 2.4: FFA Final Peak Flows

ARI (years)	FFA Final Peak Flows (m ³ /s)
100	72.9
50	63.0
20	50.5
10	41.3
5	32.3
2	20.0

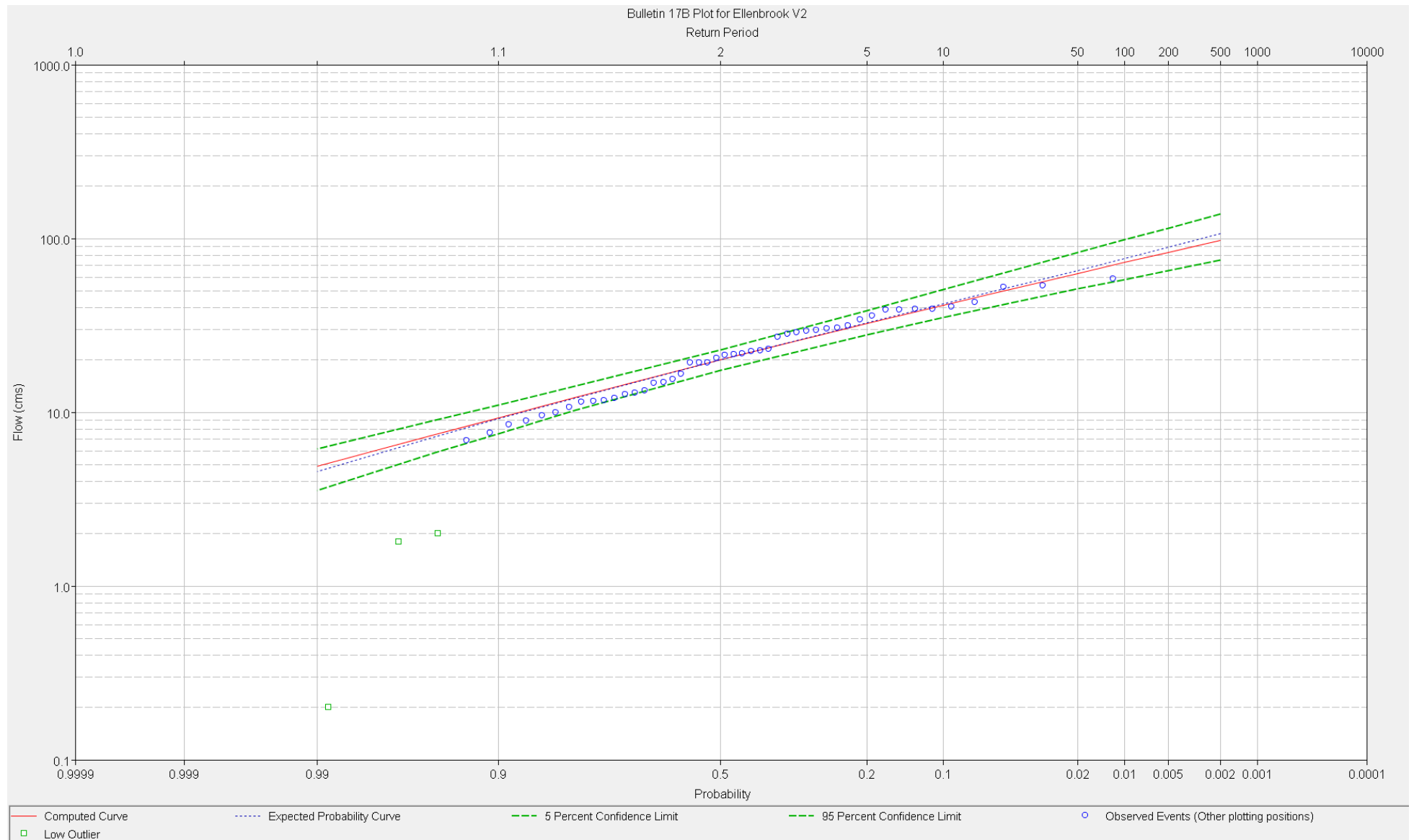


Figure 2.6: FFA Final Peak Flows Curve

The XP-RAFTS model was calibrated for each ARI event to match these FFA outputs as closely as possible. This was done by adjusting the proportional loss values, with no adjustments to the Manning's n or storage coefficient required to match peak flows. Upon completion of this Stage 1 calibration, the calibrated loss parameters were comparable to those recommended by AR&R and used in the initial model run, as shown in Table 2.5 below.

Table 2.5: Stage 1 Calibrated Flows and Losses

ARI (years)	FFA Peak Flow (m3/s)	XP-RAFTS Stage 1 Calibration Peak Flow (m3/s)	Difference in Flows (%)	AR&R Recommended Proportional Loss (%)	Stage 1 Calibration Proportional Loss (%)	Difference in Proportional Loss (%)
100	72.9	73.2	0.4	82.0	87.3	6.5
50	63.0	63.0	0.0	83.0	86.7	4.5
20	50.5	50.2	-0.6	84.0	87.2	3.8
10	41.3	41.2	-0.2	86.0	87.1	1.3
5	32.3	32.3	0.0	86.0	87.8	2.1
2	20.0	19.8	-1.0	88.0	89.5	1.7

2.5.3 STAGE 2 CALIBRATION – HISTORICAL EVENTS

Given that a high quality flow data record exists only 60m upstream from the site, the results from the FFA can be considered highly dependable. However, a second stage of model calibration was still required to further verify the results from the Stage 1 calibration. This involved modelling one or more historical rainfall events, calibrating the model such that the modelled and gauged hydrographs for the event(s) matched as closely as possible.

For the historical event calibration of the model, a comprehensive record of the rainfall during the event was required, ideally at multiple locations within and around the catchment. The entire rainfall record was analysed, with two key rainfall events identified to be used for calibration: 1987 and 2013. The 1987 event had the highest recorded flows throughout the 50 year data record, with peak flows of 58.8 m³/s (approximately 1 in 35 year ARI event based on the FFA). The other was the 2013 event, which had peak flows of 28.8 m³/s (approximately 1 in 4 year ARI event based on the FFA).

Originally the Stage 2 calibration was going to cover both these events, however it was found that the rainfall data record for the 1987 event was lacking significant segments of data, and did not actually comprise of a 3-hourly record. The implication was that an accurate representation of the 1987 rainfall event across the catchment was not able to be generated, thus making calibration to this event meaningless. As a result, Stage 2 of the calibration was performed using the 2013 rainfall event only, for which there was a near-complete rainfall data record for the entire rainfall event.

The data from the rainfall stations in and around the catchment (refer to Section 2.2 for details) was allocated to the relevant subcatchments based on proximity. Applying the parameters from the stage 1 calibration, the storm event was then simulated in the XP-RAFTS model, with

calibration (change of loss parameters only) performed to match modelled and gauged hydrographs. The results from this process are shown in Figure 2.7 below.

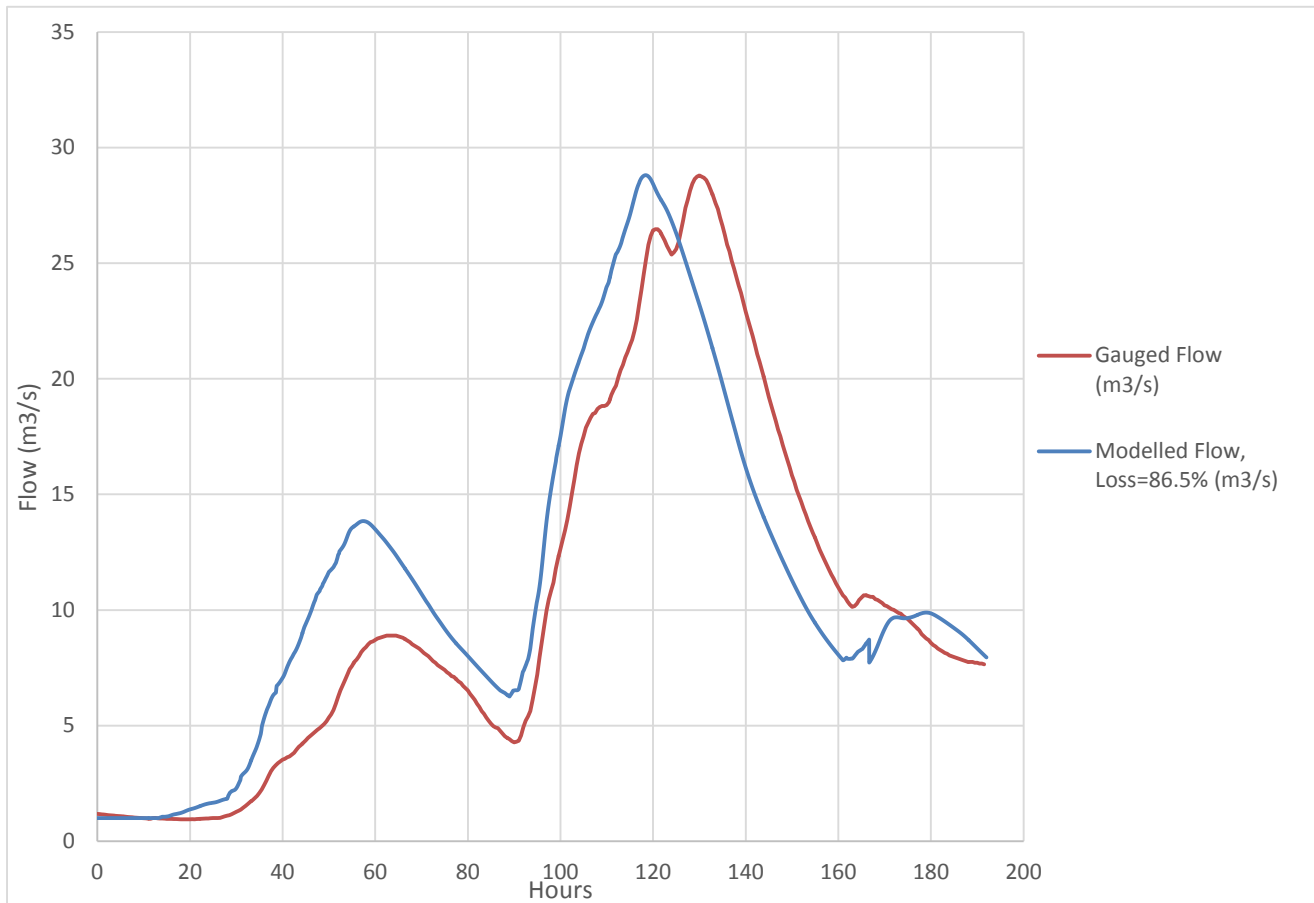


Figure 2.7: Stage 2 Calibration Results: 2013 Storm Event, Gauged vs Modelled Flows

This result produced a near-perfect match of peak flows and a good match between total run-off volumes. The proportional loss value of this Stage 2 calibrated result was 86.5%, again a good match with the Stage 1 value of 87.8% for similar sized rainfall events (as per Table 3.4).

2.6 DESIGN FLOWS

The Stage 2 calibration result was produced using only two rainfall stations throughout the 598km² catchment, when ideally more rainfall data locations would be available, whereas Stage 1 was performed based on a thorough data record. Thus the Stage 2 calibration results serve to verify the results of Stage 1, rather than override them. As a result, the Stage 1 calibration results were adopted as the design flows for this study and used as inflows for the hydraulic modelling procedure.

2000 year ARI rainfall data was not available, therefore Q2000 peak flows were calculated by logarithmically extrapolating peak flows for other event sizes.

The design flows for Ellen Brook and Sawpit Gully are as follows:

Table 2.6: Design Flows

ARI	Ellen Brook Design Flows (m³/s)	Sawpit Gully Design Flows (m³/s)
2000	120.6	5.9
100	73.2	3.7
50	63.0	3.2
20	50.2	2.3
10	41.2	1.9
5	32.4	1.5
2	19.9	0.9

3 HYDRAULIC MODELLING

A 1D hydraulic analysis has been developed to investigate the flooding dynamics of Ellen Brook Creek. The assessment was undertaken to evaluate the hydraulic performance of each bridge design alternative and the impacts on flooding conditions in neighbouring areas.

The hydraulic modelling was undertaken utilising HECRAS 4.1.0 software which is A 1D hydrodynamic modelling program. It was developed by the US Army Corps of Engineers. The program is widely used for flow regime assessment, bridge and culvert design and analysis of channel modifications.

3.1 METHODOLOGY

The hydraulic model comprises a single reach representing a section of Ellen Brook, traversing in an East-West direction. The upstream and downstream model extents covers the Railway Parade and were selected to capture all areas that may influence the hydraulics through the bridge or which are impacted by the bridge.

An existing case model was built to represent the current condition of Ellen Brook to provide for comparison of hydraulic post-developments and impact assessment. The model was set-up and then calibrated utilising the available rating curve of the Ellen Brook gauging station provided by DoW.

Three preliminary bridge design alternatives were assessed in the model. Compliance of the modelling results with the hydraulic design criteria was checked for each design alternatives. The modelling results were also checked against the existing condition to identify any adverse impacts, such as afflux.

The advantages and disadvantages of each bridge alternative in terms of their hydraulic performance, were assessed and compared with other civil and structural construction parameters. In this process three bridge design alternative selected and prioritised.

3.2 MODELLING PARAMETERS

CHANNEL ROUGHNESS

Channel roughness is represented by the Manning's n parameter and was selected based on findings from a site visit. The roughness values were also verified by generating the current rating curve of the Ellen Brook gauge station within the HEC-RAS model. The selected values are presented in Table 3.1.

Channel contraction and expansion loss parameters (based on typical values – HEC-Ras manual) have been applied in the hydraulic model. The selected values are shown in Table 3.1.

Table 3.1: 1D Hydraulic modelling parameters

Parameter	Value
Manning's n (channel)	0.03
Manning's n (overbank)	0.035
Manning's n (concrete)	0.013
Steady Flow Contraction Coefficient (minor cross-section change)	0.1
Steady Flow Expansion Coefficient (minor cross-section change)	0.3

CROSS-SECTIONS

Cross-sections were extracted from the site Digital Elevation Model (DEM) using 12D software. Aerial Laser Survey (ALS) topographical data was supplied by Landgate. Following review, it was identified that the supplied topographical data did not capture the invert of the creek in some areas where there was water, as the laser beam cannot pass through the water bodies. Therefore, the extracted cross-sections were amended for areas inside the Brook confines on the basis of the information from DoW and existing site survey.

Figure 3.1 presents the location of the model cross-sections in the study area. Cross-sections are defined perpendicular to the flow stream lines.

BOUNDARY CONDITIONS

The steady state mixed flow simulation in HECRAS was used for the hydraulic computations. Flows computed the hydrologic assessment, discussed previously, and were input into the model for the 100 and 2000 year ARI storm events.

Normal depth water level boundary condition was implemented at the furthest downstream and upstream cross-sections. An indicative channel slope was calculated in the vicinity of these cross-sections and implemented in the model for normal depth calculation.



Legend
HEC-RAS Model Cross Section



scale (1:2500 @A3)



Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA 94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 50

Railway Parade Bridge Hydraulic Assessment

HEC-RAS Cross Sections Locality Plan

HYDRAULIC STRUCTURES

The existing hydraulic structures, shown below, were included in all hydraulic models. Figure 3.3 to 3.6 shows the location of existing hydraulic structures on Ellen Brook. These existing hydraulic structures are:

- Ellen Brook Gauging Station: The weir was modelled as an in-line structure utilising the HEC-RAS model ability in modelling weir structures.
- Railway Bridge: The existing railway bridge dimensions were captured in the site visit and used in the modelling of the bridge.
- Downstream crossings: A local access road intersects Ellen Brook 75m downstream of the Railway Parade. The road crossing includes 9x1.8m RCBC culverts. This crossing was incorporated into the hydraulic model for the existing and proposed conditions. It was eliminated from the model in a later step for an assessment of flooding impacts from its demolition after construction of the subject bridge on Railway Parade.

A number of alternatives for the Railway Parade Bridge were included in the hydraulic model developed for assessment of the bridge design and the project flooding impacts.



Figure 3.3: Railway Parade gauging station - Looking upstream



Figure 3.4: Railway Parade gauging station during a flow event, provided by DoW



Figure 3.5: Railway Bridge - Looking upstream



Figure 3.6: Existing crossing on Ellen Brook with 9x1.8m RCBC downstream of proposed Railway Parade Bridge

3.3 MODELLING REQUIREMENTS

As requested by CoS, the bridge flood immunity requirement was defined based on *CoS Development Design Guideline D5 for Stormwater Drainage*. According to section 14 of the guideline, all major hydraulic structures have to be defined based on a 100 year storm event. No afflux is permitted unless the created afflux does not inundate any private property. The guideline also defines 0.3m freeboard for the bridge design. To prevent blockage, the freeboard is measured from the bridge deck soffit.

3.4 MODELLING SCENARIOS

Figure 3.7 overleaf presents the different hydraulic modelling scenarios included in this study. Each scenarios was run for the 100 and 2000 year ARI floods.

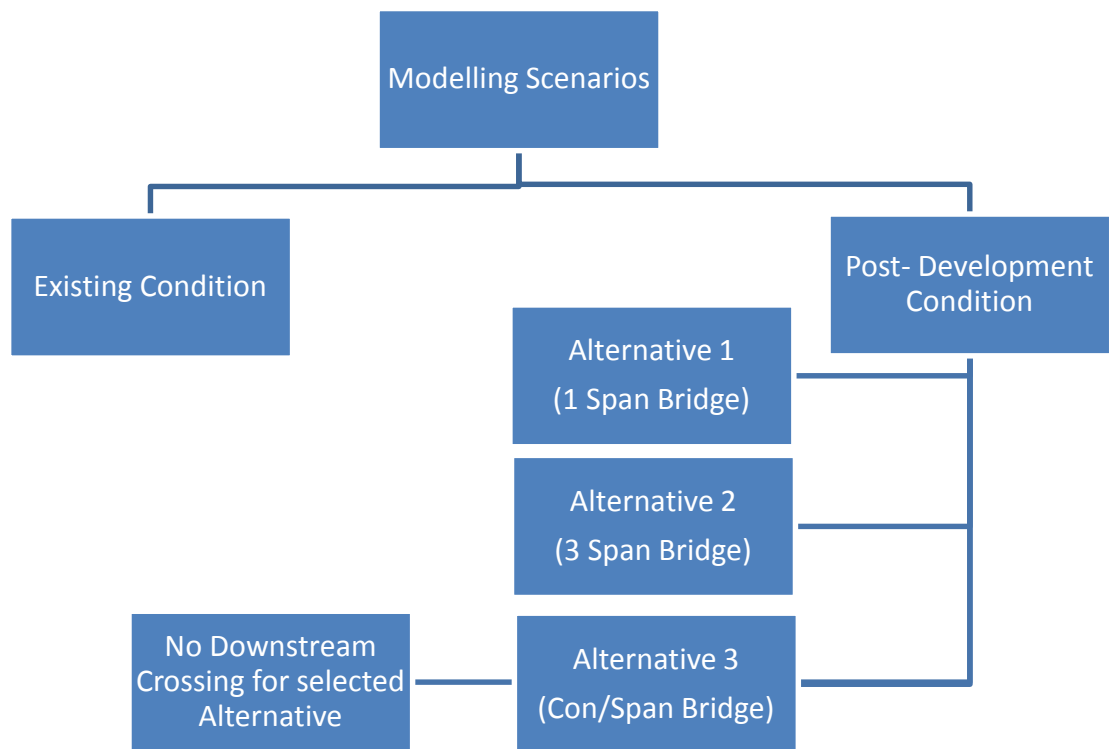


Figure 3.7: Hydraulic modelling scenarios

4 MODELLING RESULTS

4.1 MODEL CALIBRATION

The Ellen Brook gauging station rating curve was provided by DoW. The weir at the gauge station was modelled as an in-line structure in HEC-RAS and calibrated to the rating curve.

It should be noted that the supplied rating curve from DoW is based on the local elevation and for the purposes of the calibration, the model output rating curve was adjusted to the local elevation. Figure 4.1, shows a comparison between the rating curves provided by DoW and that produced in the calibrated HEC-RAS model.

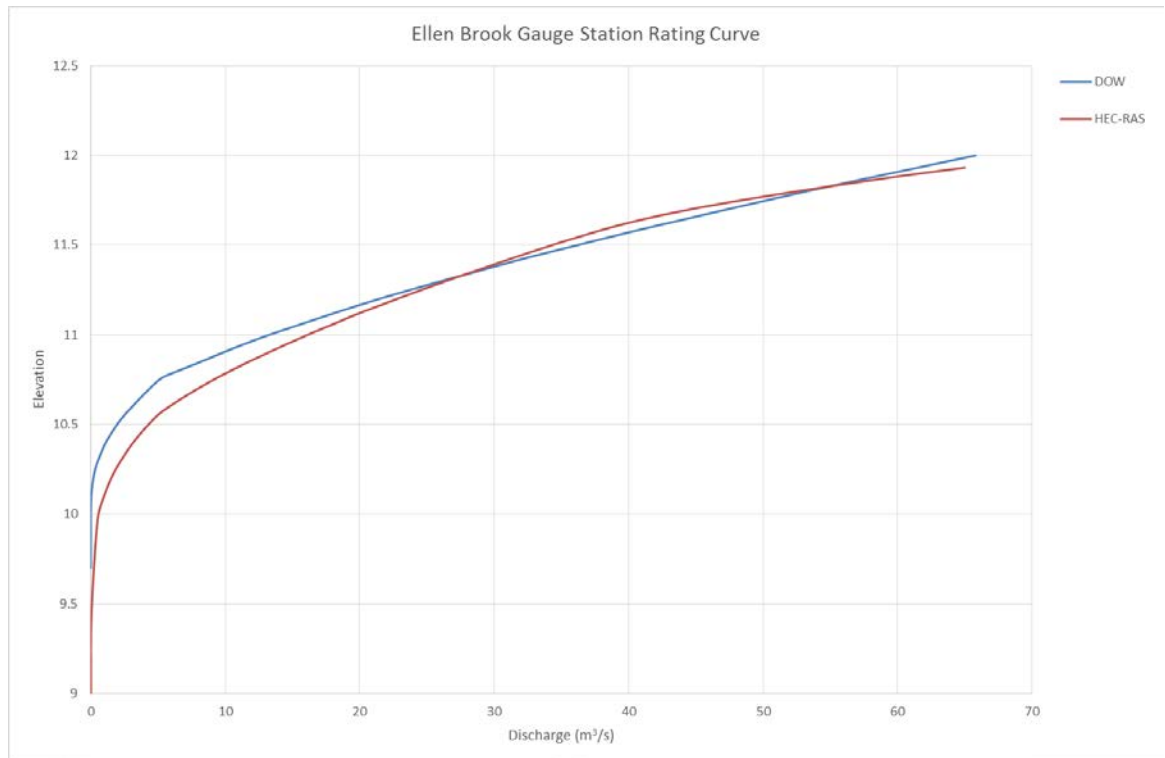


Figure 4.1: Ellen Brook Gauge Station Rating Curve

4.2 MODELLING OF THE EXISTING CONDITION

The hydraulic model was set-up to assess the flood characteristics of the existing condition of Ellen Brook in the vicinity of Railway Parade. Existing structures such as the weir, Railway Bridge and crossing downstream of Railway Parade were modelled in HEC-RAS. The model was run for 100 and 2000 year ARI storm events only.

Key flow characteristics for the existing case are summarised in table overleaf:

Table 4.1: Flow Characteristics for existing scenario summary

Design ARI Event (Year)	WSL* U/S of proposed bridge site (m AHD)	Velocity at proposed Bridge site (m/s)	Channel Invert Level at proposed bridge site (m AHD)
100	13.08	0.8	10.1
2000	13.95	0.76	

*WSL – Water Surface Level

Complete results from the hydraulic modelling of the existing condition are presented in Appendix C. The following figure shows the longitudinal profile of Ellen Brook in its existing condition.

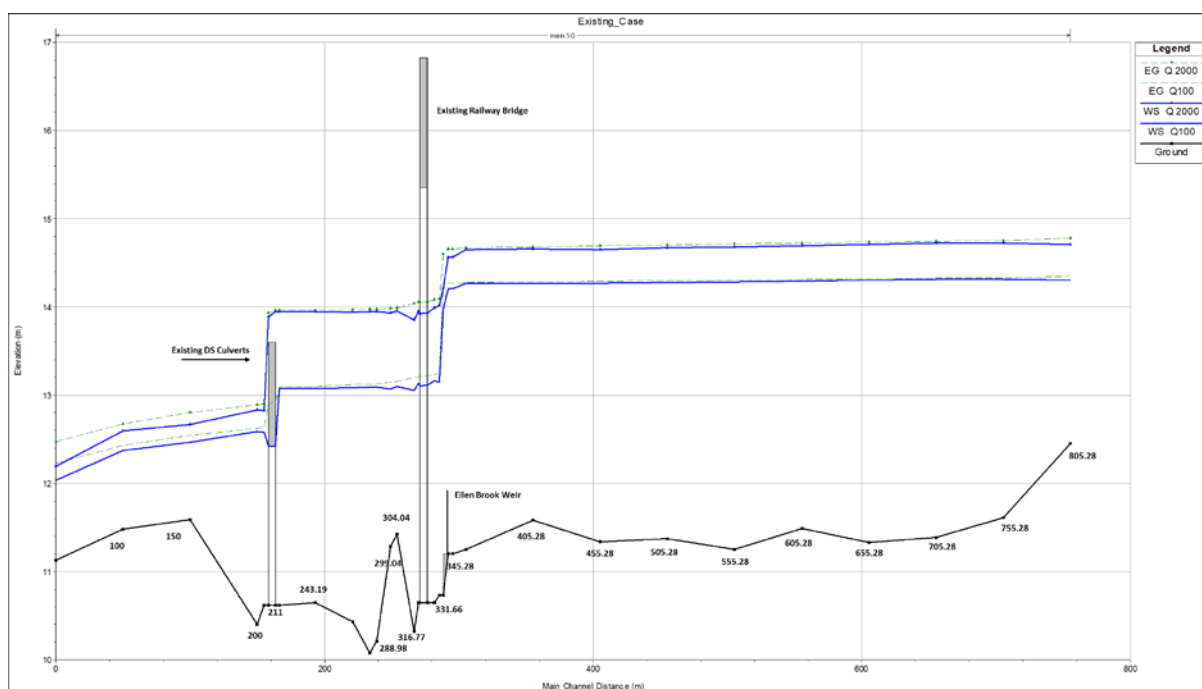


Figure 4.2: Ellen Brook Longitudinal Profile- Existing Condition

4.3 ALTERNATIVE 1- 1 SPAN BRIDGE

Alternative 1, a single span bridge design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following table presents the bridge design parameters and flow characteristics in this scenario.

Table 4.1: Flow Characteristics for Proposed Railway Parade Bridge with 1 Span

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	29.6	1	13.11	13.05	1.32	10.1
2000			13.99	13.89	1.51	

The hydraulic model results show that the maximum afflux in this scenario is 30mm for the 100 year ARI and it occurs between the crossing and the existing Railway Bridge. The afflux is based on the flow levels from the existing case and Alternative 1.

The following figure shows the longitudinal profile of Ellen Brook with the 1 span proposed bridge.

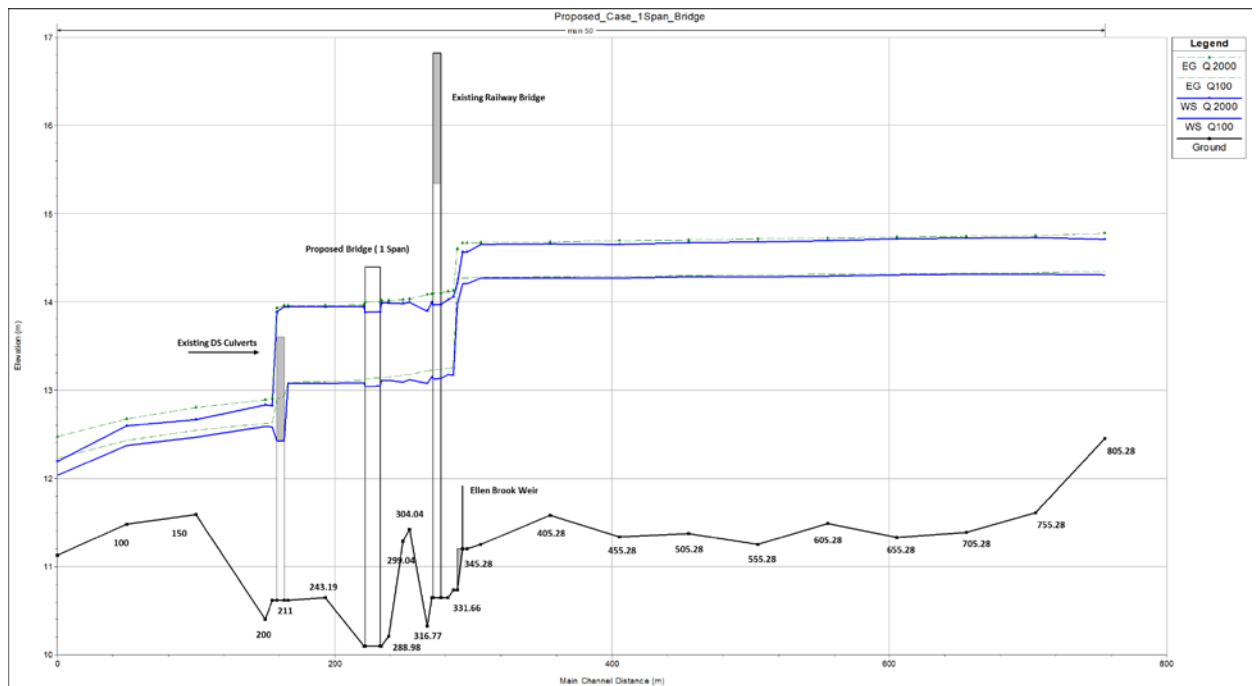


Figure 4.3: Ellen Brook Longitudinal Profile- Alternative 1

The hydraulic modelling results for this alternative are included in Appendix D.

4.4 ALTERNATIVE 2- 3 SPAN BRIDGE

Alternative 2, a 3 span bridge design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following presents the bridge design parameters and flow characteristics in this scenario.

Table 4.2: Flow Characteristics for Proposed Railway Parade Bridge with 3 Spans

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	1(25.4)+2(11)	3	13.10	13.07	1.05	10.1
2000			13.97	13.92	1.15	

The Hydraulic model results show that the maximum afflux in this scenario is 20mm for the 100 year ARI and it occurs between the crossing and the existing Railway Bridge.

The hydraulic modelling results for this alternative are included in Appendix E.

4.5 ALTERNATIVE 3 - CON/SPAN BRIDGE

Alternative 3, a CON/SPAN bridge design, was modelled downstream of the existing Railway Bridge at the Railway Parade crossing. The following presents the bridge design parameters and flow characteristics in this scenario.

Table 4.3: Flow Characteristics for Proposed Railway Parade Bridge with 1 Con/Span

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	21	1	13.20	13.09	1.36	10.1
2000			14.16	13.95	1.74	

The hydraulic modelling results show the maximum afflux in this scenario is 120mm for the 100 year flood event. This afflux is not acceptable as the allowable afflux is maximum 70mm.

The bottom width of the cross-section at the bridge location in its existing condition is 18.5m. Potential to lower this afflux to an acceptable level was investigated. A maximum afflux of 70mm was found to be achievable if the channel is excavated to lower the bed level by 0.2m to 9.9m AHD and widening the channel to 21m.

The hydraulic modelling results for this alternative are presented in Appendix F.

4.6 PREFERRED ALTERNATIVE

Alternative 1 is likely to be the most efficient bridge design and was noted to meet all design criteria, listed in section 1.3. While Alternative 3 is able to be purchased as a modular, precast structure, the additional waterway reconfiguration works required to meet the design criteria are likely to be expensive, have adverse environmental impacts and therefore is seen not to be an efficient design. Alternative 2 shows slightly better hydraulic performance than Alternative 1, however, due to the additional spans required the bridge is longer and the construction costs are likely to increase insignificantly.

On the basis of the above, Alternative 1 with a single span design, was chosen as the optimal alternative for Railway Parade.

4.7 REMOVAL OF THE EXISTING DOWNSTREAM CROSSING

An additional scenario was set-up to assess the potential impact of removing the existing crossing, which is located downstream of the proposed Railway Parade Bridge. This modelling scenario was performed using the single span bridge design (Alternative 1).

Table 4.5: Flow Characteristics for Proposed Single Span Railway Parade Bridge and Removal of Downstream Crossings

Design ARI Event (Year)	Bridge Length (m)	Number of Spans	Bridge U/S WSL (m AHD)	WSL at the Bridge (m AHD)	Velocity through Bridge (m/s)	Channel Invert Level (m AHD)
100	29.6	1	12.71	12.64	1.61	10.1
2000			13.04	12.81	2.43	

As anticipated, the hydraulic model results indicate that the water surface level reduces upstream of existing culverts. This is due to the additional surface area available following the

removal of the culverts. The afflux is negative, and when compared with the existing case, is 400mm lower for the 100 year flood event.

The hydraulic modelling results for this scenario are presented in Appendix G.

4.8 SCOUR PROTECTION

Background

Bridge scour is the result of the removal of soil material around piers and abutments which occurs with high velocities through the bridge. As part of the hydraulic assessment, an indication of scour potential is carried out.

Key to an assessment of scour is an understanding of river bed and bank material upstream and downstream of the proposed bridge location. This allows for scour depth calculations which form the basis of the scour protection design. In this instance, no site work to carry out the necessary boreholes has been carried out, therefore a detailed quantitative assessment that provides the basis of scour protection design cannot be carried out.

Qualitative assessment

In the absence of soil material information, however, a qualitative investigation was undertaken based on findings from the site visit and flow characteristics to suggest potential scour protection requirements. It should be noted that prior to construction, this assessment should be verified using soil data from the site and a quantitative assessment.

Investigation of the modelling results for the preferred Alternative 1 indicate that the flow velocity is generally low throughout the bridge and the flow regime is mainly sub-critical, with maximum flows of around 1.7m/s. It should be noted that although the velocity through the bridge is low, over the time the build-up of scour at the piers can lead to damage of the footings.

Based on flow regime, and conservatively using a velocity of 2m/s, and an estimate of a mixture of sandy and cohesive (clay soils) for river bed and banks, the following scour is estimated:

- Scouring will occur around the piers with a scour depth of up to 1.5m.
- Additional scour may occur on the river bed and banks.

To mitigate the perceived scour it is recommended that the river bed is protected with a rock bed (200-400mm thickness) at the toe of each piling. This scour protection will aid in energy and velocity dissipation at the piles, minimising scour. The rock beds shall be placed such that it does not reduce the cross-sectional area at the bridge, and shall therefore be partially buried.

The above perceived 1.5m of scour at the pier also needs to be allowed for in the bridge and piling design and an ongoing monitoring regime, so when scour protection under the abutments/spillway batter is lost, can be reinstated with a rock bed and concrete fill and monitored and maintained as required.

Again it should be noted that the above assessment is qualitative only, and needs to be verified quantitatively with soil data from the site, prior to construction, as no guarantee to the above can be given, due to lack of critical data.

5 SAFETY IN DESIGN

The Safety in Design process is used to identify potential issues with the design process to ensure input information and modelling techniques are in accordance with current standard best practices. The design process is agreed upon by the stakeholders of the project and critical inputs are checked.

5.1 STAKEHOLDER CONSULTATION

Due to the nature of the flooding and the number of stakeholders involved, the following agreements and approvals were sought and steps taken, during the development of the hydraulic assessment:

Input and Data

- Consultation with DoW regarding the Railway Parade gauging station rating curve and acquiring the river bed bathymetry data
- Defining the locations of interest for the hydraulic modelling and capturing the required information in the land survey of the site
- Checking the LiDAR survey data against the information from the land survey data

Hydrological Study and Flow Quantification

- Comparison and validation of the Ellen Brook catchment data against other reports
- Calibration of the hydrologic model using the recorded rainfall and flows for observed historical storm events

Hydraulic Modelling

- Comparison of the existing condition hydraulic model results against the Railway Parade gauging station for modelling verification purposes
- Conservative the design criteria in terms of immunity of the bridge implemented freeboard
- Minimum blockage expectation for the bridge large spans considering existence of the upstream railway bridge

5.2 SAFETY IN DESIGN PROCESS

The Safety in Design process is used to identify construction, operation, maintenance, or demolition risks inherent in the design. The identification and understanding of these risks early in the project allows risk controls to be put in place to ensure that if the risks cannot be eliminated by design, they are mitigated and managed in the design process so that the risk of occurrence is as low as practicable.

The risks identified and mitigation measures incorporated into the design are documented in the design reports. Residual risks, if any, are to be communicated to the constructors, owners/operators and maintenance representatives through the design reports, drawings and construction documentation. The following process will be carried out to manage risk for the life of the project:

- Designers identify the Hazards that may arise during the life of the project.
- Consultation with relevant stakeholders to identify specific areas of concern.
- Designers consider the elimination or control of risk in all design decisions.

- Designers inform other designers, constructors and asset owners of residual hazards.
- Constructors manage the risk from residual hazards during construction.
- Asset owners manage the risk from residual hazards during operation and maintenance.

6 CONCLUSIONS

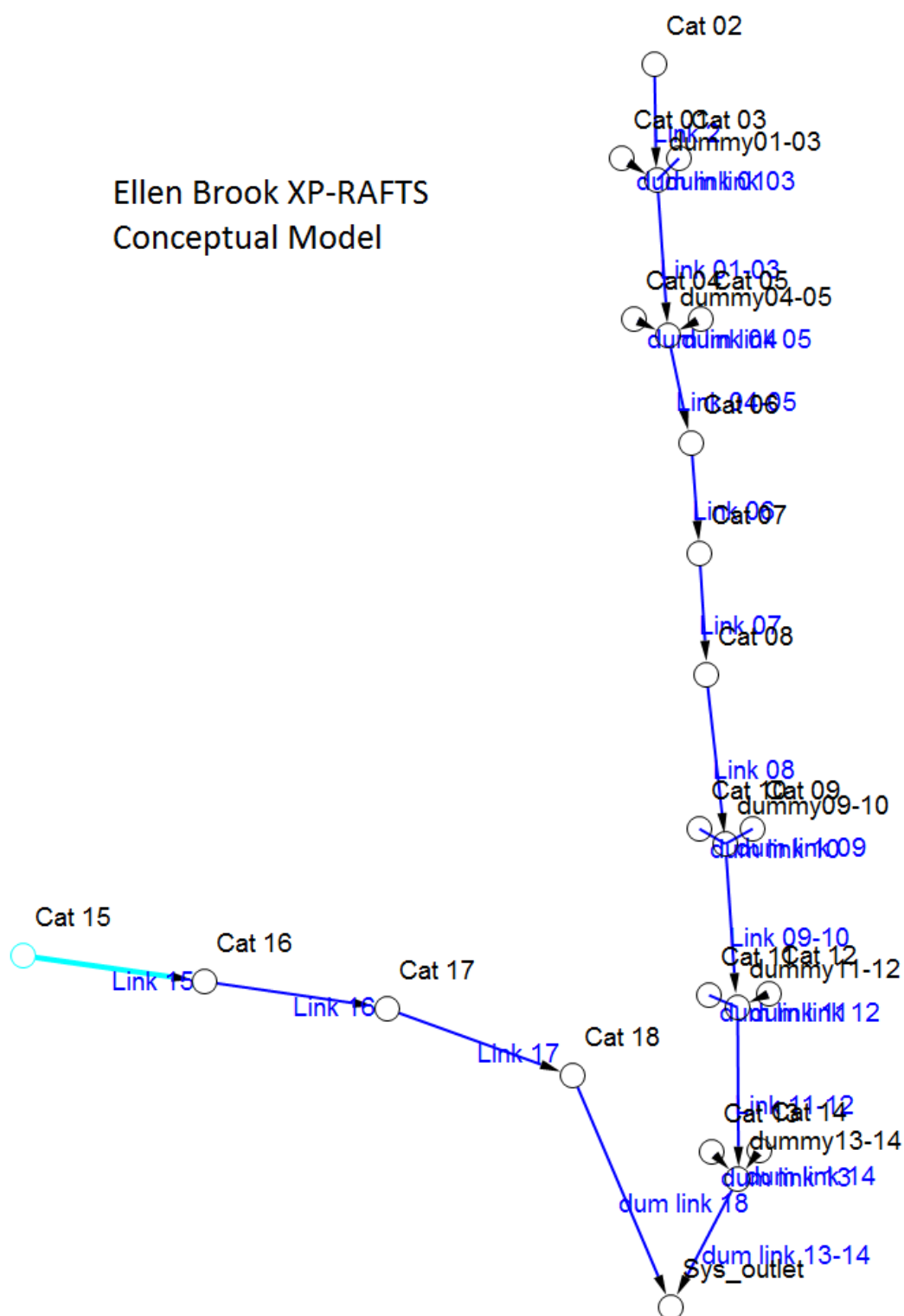
The below conclusions depict the most important outcomes of the hydrologic and hydraulic study:

- Ellen Brook flows were quantified for the catchment upstream of the bridge location using a rainfall-runoff model. The close proximity of the Railway Parade gauging station to the location of the bridge provided the opportunity to fully calibrate the rainfall-runoff model based on the observed historical data. A 100 year ARI flood peak discharge of 73.2m³/s was computed at the location of the bridge. Peak flow discharges are shown in Table 3.5 for the range of ARI events.
- In accordance with CoS defined requirements, the bridge has been designed based on a 100 year ARI flood immunity with provision of 0.3m freeboard to the bridge deck soffit. Based on this design, the only flow contraction effect will be caused by the bridge piers. Furthermore, existing Ellen Brook flow characteristics are under influence of the upstream railway bridge which is another flow control section. As a result, construction of the Railway Parade Bridge will not cause any noticeable additional afflux upstream of the Railway Bridge.
- Based on the above note, the project will not cause any changes to the current rating curve of the Ellen Brook gauging station.
- Based on the comparison of different alternatives, the 1 span bridge was selected as a chosen alternative.
- In the post-development condition some afflux will be created between the planned Railway Parade Bridge and the existing railway bridge. The maximum afflux for a 100 year ARI storm event for the chosen alternative was calculated as 30mm.
- Demolition of the existing crossing on Ellen Brook, approximately 75m downstream of the planned Railway Parade Bridge, will reduce the flood level upstream of this crossing. Following demolition the flood immunity of both Railway Parade Bridge and the existing railway bridge will be increased. The current flood immunity of the Railway Parade Bridge has been computed based on no blockage at the subject crossing.
- Based on the hydraulic model results, the flow velocity for the 100 year flood event peak discharge for the chosen alternative was estimated as 1.32 m/s.
- In the absence of soil material information, a qualitative investigation was undertaken to estimate the bridge scour based on the site visit and modelled flow characteristics. The maximum scour depth at the bridge piers is estimated to be 1.5m. This should be used to guide the quantitative assessment which is required prior to construction.

APPENDIX A

RAINFALL-RUNOFF CONCEPTUAL MODEL

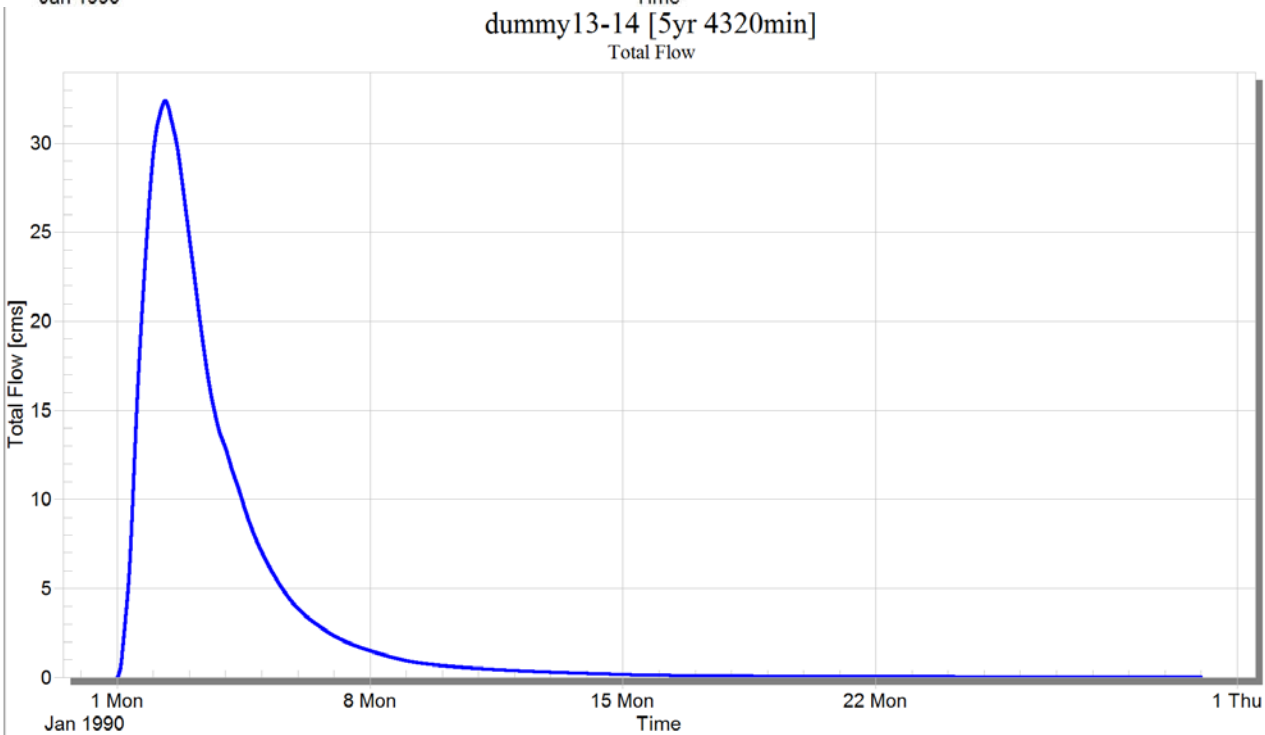
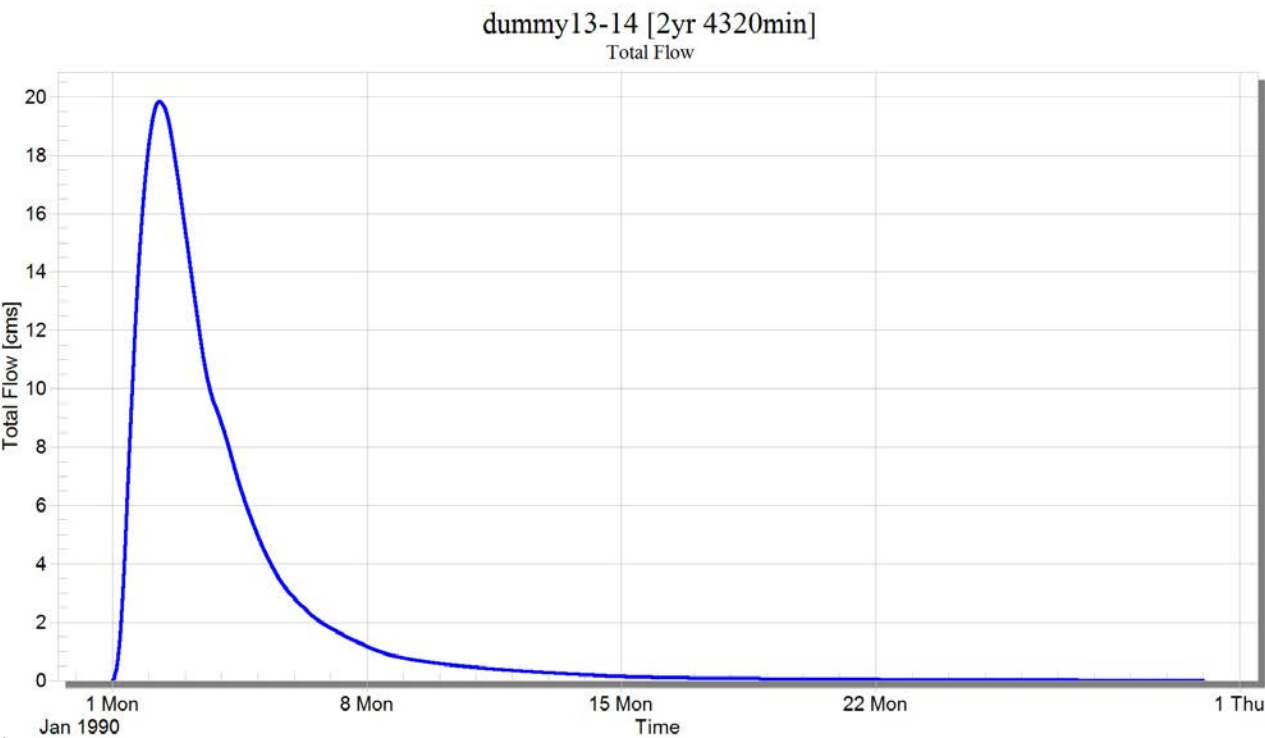
Ellen Brook XP-RAFTS Conceptual Model

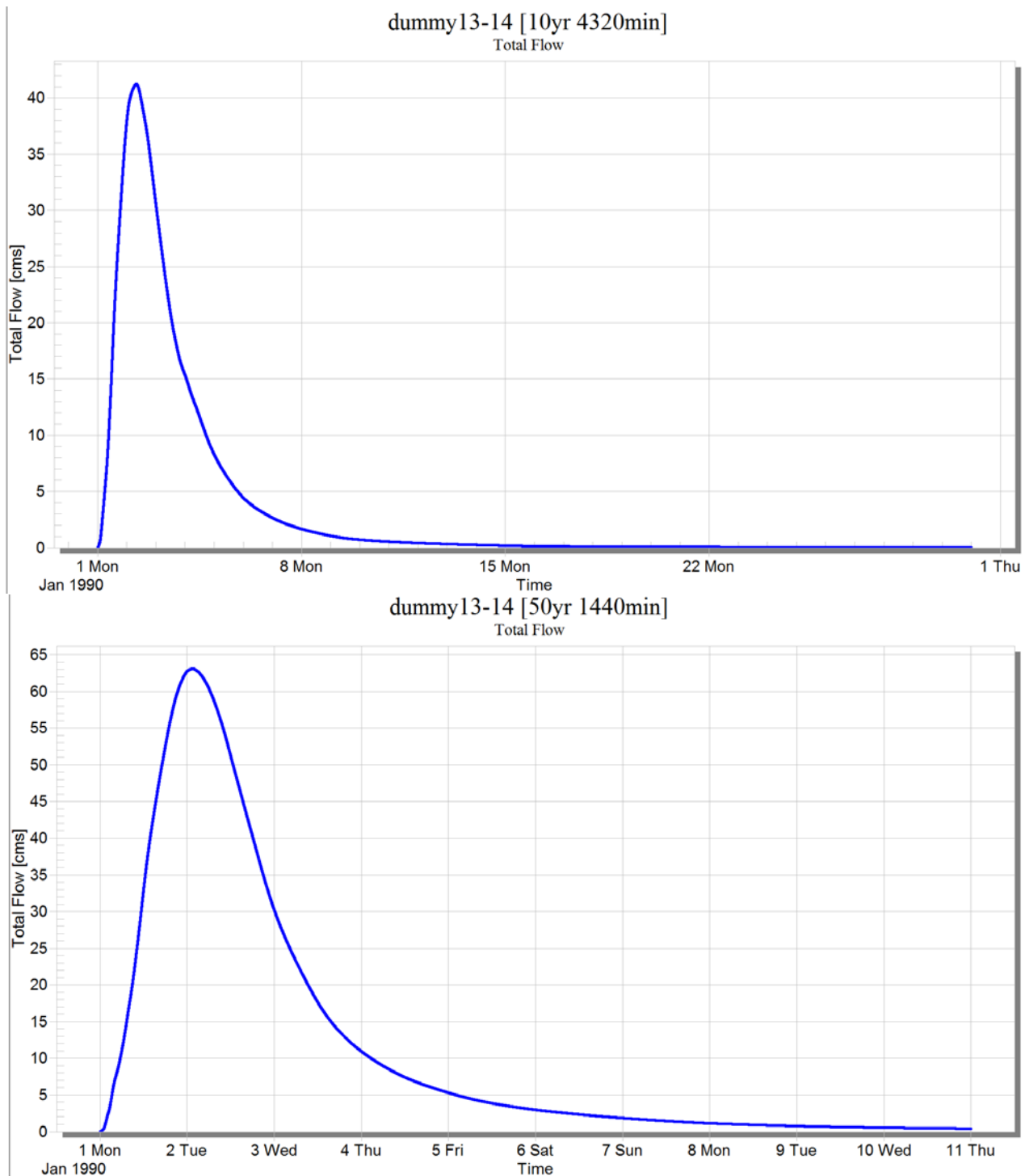


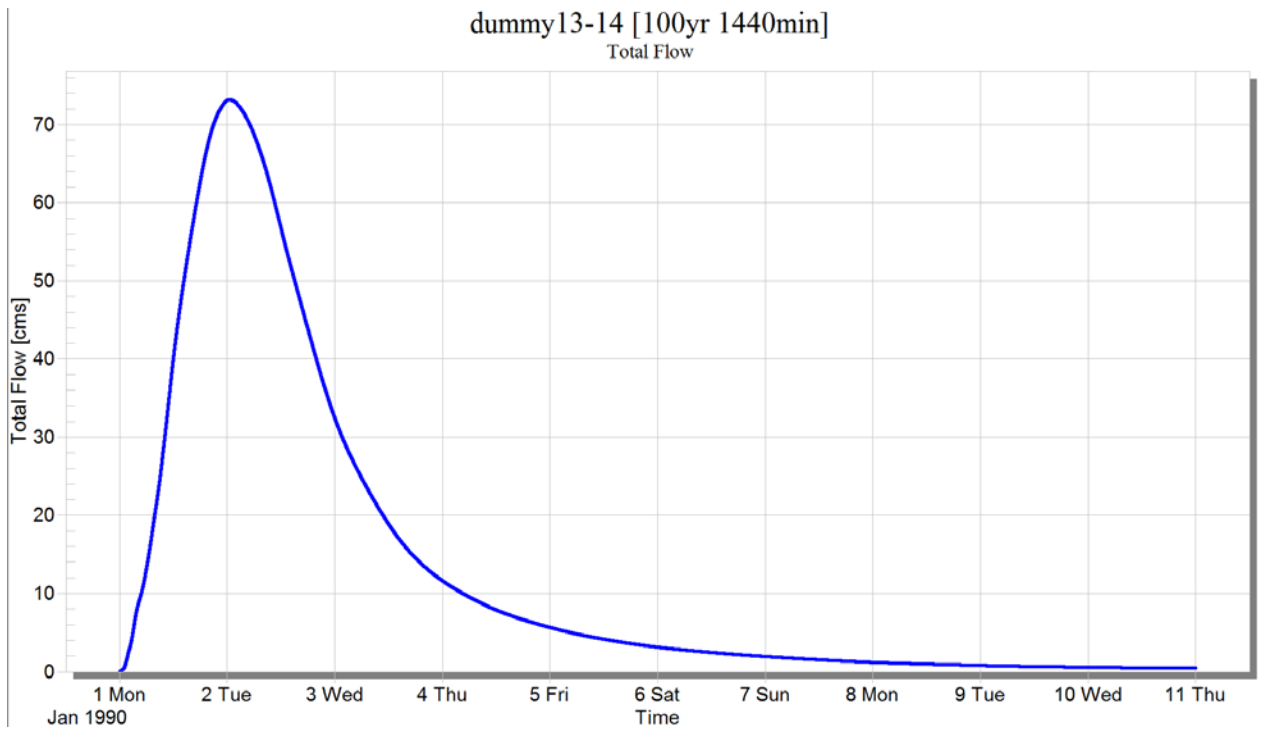
APPENDIX B

DESIGN HYDROGRAPHS

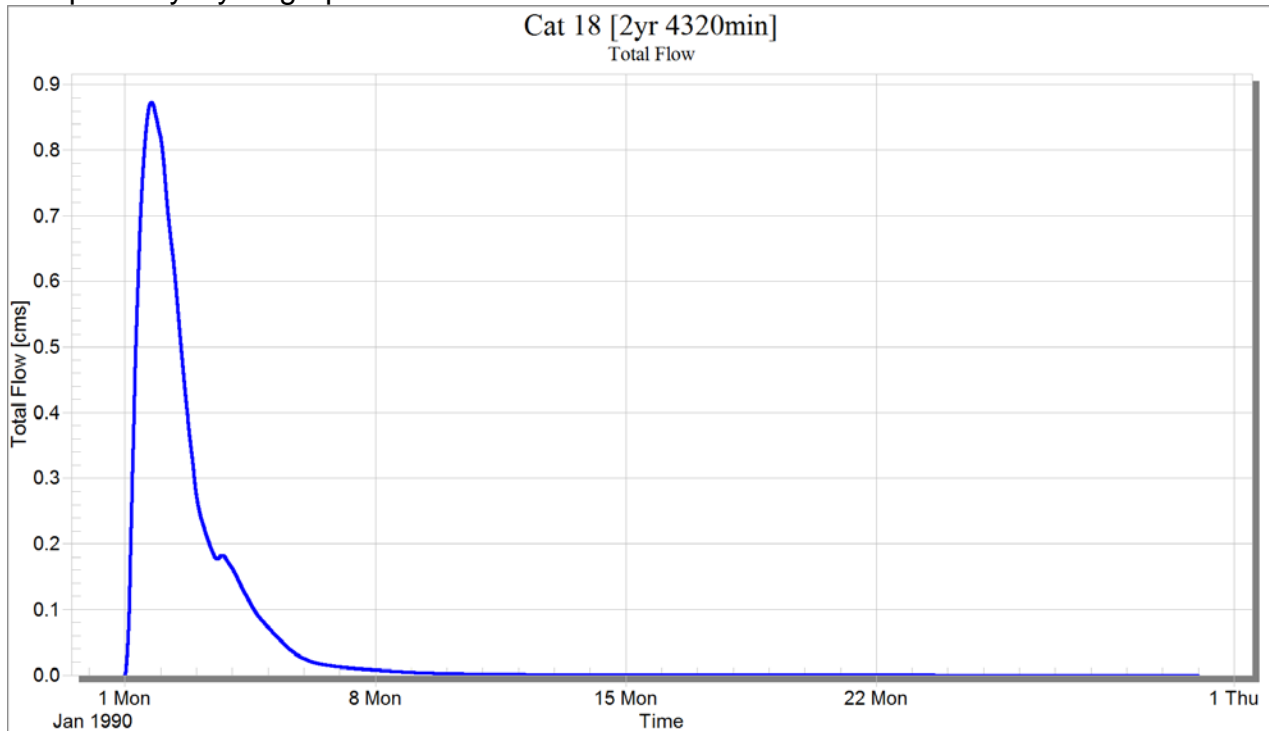
Ellen Brook Hydrographs

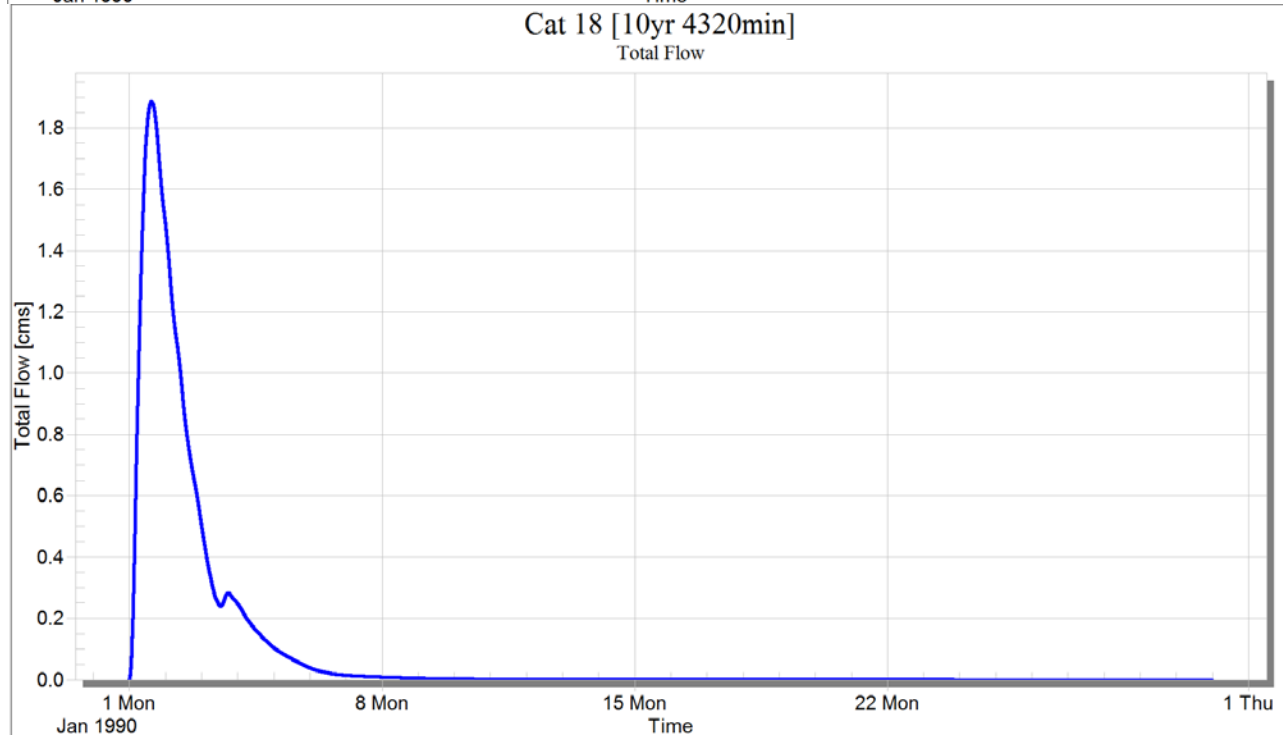
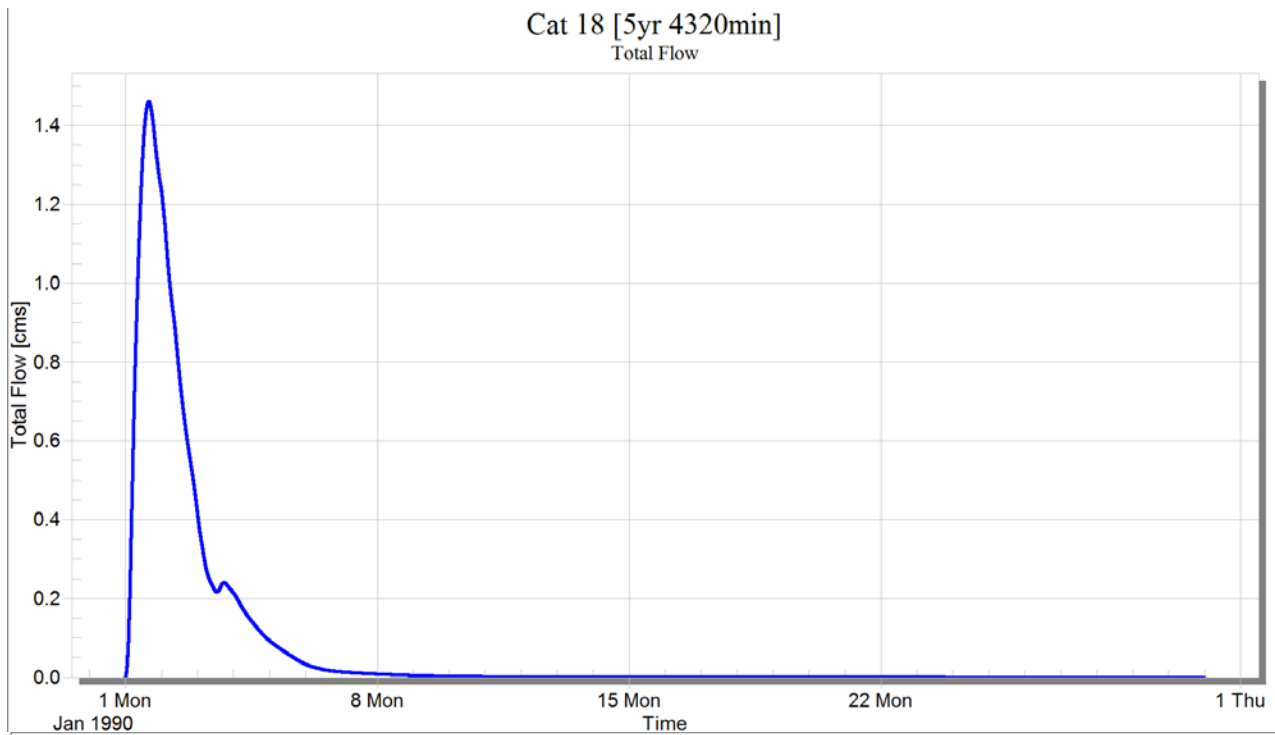


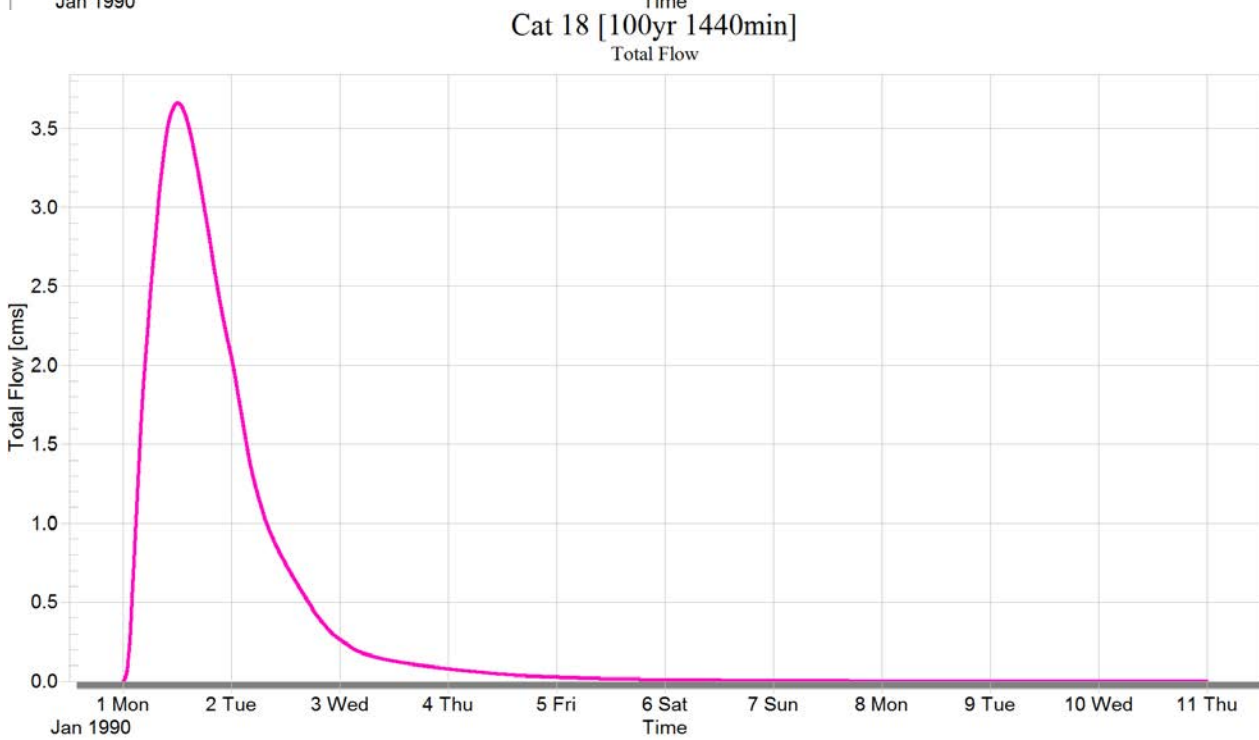
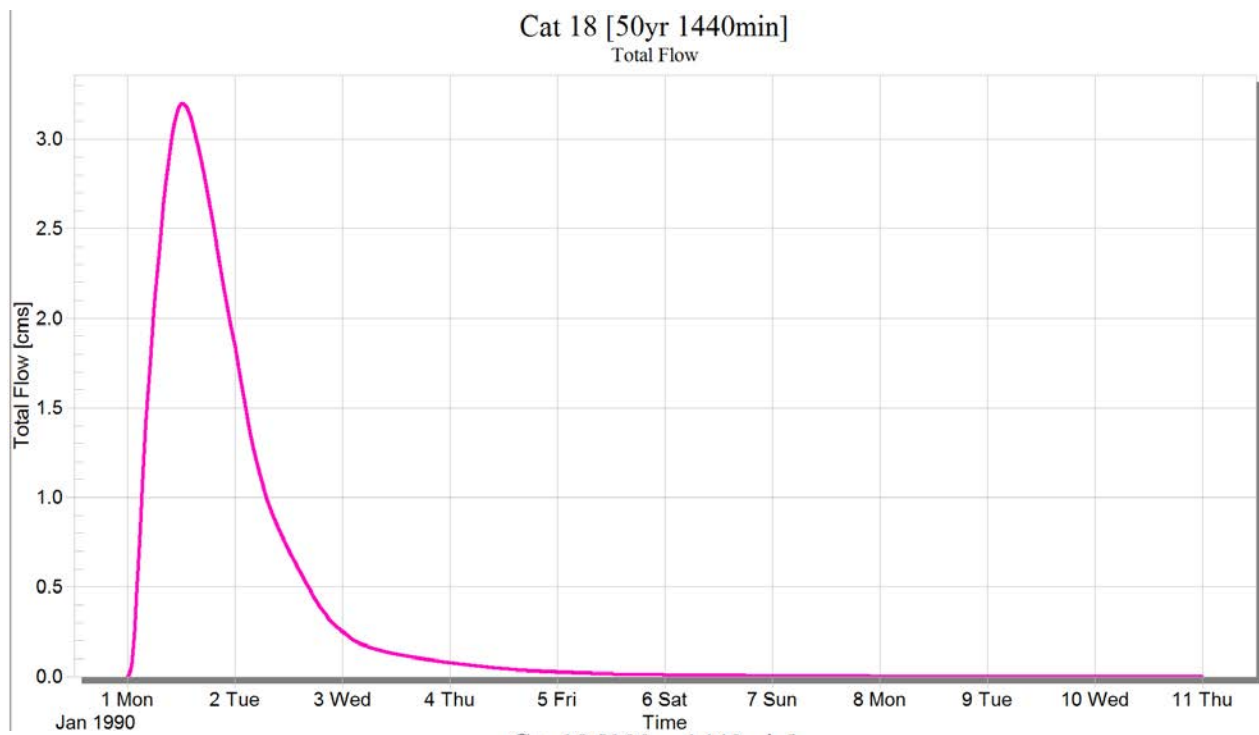




Sawpit Gully Hydrographs







APPENDIX C

HEC – RAS – OUTPUTS - EXISTING CASE

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	805.28	Q100	73.2	12.45	14.3	13.38	14.35	0.000537	0.95	76.93	55.99	0.26
50	805.28	Q 2000	120.6	12.45	14.71	13.63	14.78	0.000657	1.2	100.19	59.58	0.3
50	755.28	Q100	73.2	11.61	14.32		14.33	0.000108	0.54	136.72	70.7	0.12
50	755.28	Q 2000	120.6	11.61	14.72		14.75	0.000164	0.72	166.45	74.62	0.15
50	705.28	Q100	73.2	11.39	14.31		14.32	0.000089	0.5	147.3	73.64	0.11
50	705.28	Q 2000	120.6	11.39	14.72		14.74	0.000137	0.68	177.98	77.17	0.14
50	655.28	Q100	73.2	11.33	14.3		14.32	0.000139	0.53	137.36	86.64	0.14
50	655.28	Q 2000	120.6	11.33	14.71		14.73	0.00019	0.69	174.23	93.56	0.16
50	605.28	Q100	73.2	11.49	14.29		14.31	0.000157	0.6	121.13	68.92	0.15
50	605.28	Q 2000	120.6	11.49	14.69		14.72	0.000241	0.8	150.04	76.92	0.18
50	555.28	Q100	73.2	11.25	14.29		14.3	0.000128	0.59	124.69	63.7	0.13
50	555.28	Q 2000	120.6	11.25	14.68		14.71	0.000212	0.8	151.37	71.46	0.17
50	505.28	Q100	73.2	11.37	14.28		14.3	0.000126	0.59	124.85	63.28	0.13
50	505.28	Q 2000	120.6	11.37	14.67		14.7	0.000205	0.8	150.44	68.57	0.17
50	455.28	Q100	73.2	11.34	14.27		14.29	0.000139	0.62	117.18	57.81	0.14
50	455.28	Q 2000	120.6	11.34	14.65		14.69	0.000226	0.86	139.9	61.28	0.18
50	405.28	Q100	73.2	11.58	14.27		14.28	0.000067	0.46	160.54	73.63	0.1
50	405.28	Q 2000	120.6	11.58	14.66		14.68	0.000111	0.64	189.43	76.9	0.13
50	355.28	Q100	73.2	11.25	14.27		14.28	0.000068	0.47	156.2	69.2	0.1
50	355.28	Q 2000	120.6	11.25	14.65		14.67	0.000119	0.66	183.38	74.09	0.13
50	345.28	Q100	73.2	11.2	14.21	12.45	14.27	0.001151	1.14	64.44	58.87	0.35
50	345.28	Q 2000	120.6	11.2	14.56	12.95	14.66	0.001272	1.4	86.45	68.39	0.38
50	340		Inl Struct									
50	335.47	Q100	73.2	10.73	13.15		13.24	0.0016	1.35	54.16	51.51	0.42
50	335.47	Q 2000	120.6	10.73	14.02		14.09	0.000647	1.15	104.72	64.02	0.29
50	331.66	Q100	73.2	10.65	13.16	11.78	13.23	0.000516	1.19	61.62	30.33	0.27
50	331.66	Q 2000	120.6	10.65	13.99	12.18	14.08	0.000496	1.37	88.16	40.46	0.27
50	326		Bridge									
50	320.11	Q100	73.2	10.65	13.13		13.21	0.000536	1.2	60.8	30.21	0.27
50	320.11	Q 2000	120.6	10.65	13.96		14.05	0.000513	1.38	87.59	39.33	0.27
50	316.77	Q100	73.2	10.32	13.05		13.2	0.001123	1.68	43.53	22.24	0.38
50	316.77	Q 2000	120.6	10.32	13.85		14.04	0.001088	1.94	62.26	24.85	0.39
50	304.04	Q100	73.2	11.42	13.1		13.16	0.001286	1.09	67.35	77.17	0.37
50	304.04	Q 2000	120.6	11.42	13.95		13.99	0.00037	0.87	139.81	90.4	0.22
50	299.04	Q100	73.2	11.29	13.07		13.15	0.00163	1.24	58.81	65.63	0.42
50	299.04	Q 2000	120.6	11.29	13.93		13.98	0.000503	0.99	121.56	78.87	0.26
50	288.98	Q100	73.2	10.21	13.09		13.13	0.000556	0.84	86.86	77.15	0.25
50	288.98	Q 2000	120.6	10.21	13.95		13.97	0.000252	0.76	158.98	92.01	0.18
50	283.92	Q100	73.2	10.08	13.09		13.12	0.000452	0.8	91.6	75.65	0.23
50	283.92	Q 2000	120.6	10.08	13.94		13.97	0.00022	0.76	159.5	83.13	0.17
50	270.92	Q100	73.2	10.43	13.08		13.12	0.000533	0.83	88.43	78.47	0.25
50	270.92	Q 2000	120.6	10.43	13.94		13.97	0.00023	0.76	159.55	86.32	0.18
50	243.19	Q100	73.2	10.65	13.07		13.1	0.000408	0.72	103.32	105.45	0.22
50	243.19	Q 2000	120.6	10.65	13.94		13.96	0.000149	0.62	207.24	127.07	0.14
50	216.41	Q100	73.2	10.62	13.08	11.77	13.09	0.000177	0.5	145.7	117.97	0.14
50	216.41	Q 2000	120.6	10.62	13.95	12.22	13.96	0.000083	0.48	253.08	139.98	0.11

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	211		Culvert									
50	205	Q100	73.2	10.62	12.58		12.63	0.000695	1.22	87.48	115.88	0.29
50	205	Q 2000	120.6	10.62	12.82		12.9	0.000911	1.52	115.94	116.91	0.34
50	200	Q100	73.2	10.4	12.59		12.62	0.001021	0.87	84.29	112.69	0.32
50	200	Q 2000	120.6	10.4	12.83		12.89	0.001093	1.07	112.47	115.32	0.35
50	150	Q100	73.2	11.59	12.46		12.55	0.002347	1.27	57.47	81.36	0.48
50	150	Q 2000	120.6	11.59	12.67		12.8	0.002811	1.62	74.24	83.53	0.55
50	100	Q100	76.9	11.48	12.37		12.43	0.002031	1.02	75.4	134.31	0.43
50	100	Q 2000	126.5	11.48	12.6		12.67	0.001821	1.2	105.55	135.75	0.43
50	50	Q100	76.9	11.13	12.03	12.01	12.22	0.010015	1.95	39.54	88.72	0.93
50	50	Q 2000	126.5	11.13	12.19	12.18	12.47	0.010004	2.33	54.29	92.82	0.97

APPENDIX D

HEC – RAS – OUTPUTS - 1 SPAN BRIDGE

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	805.28	Q100	73.2	12.45	14.3	13.38	14.35	0.000536	0.95	76.95	55.99	0.26
50	805.28	Q 2000	120.6	12.45	14.71	13.63	14.78	0.000656	1.2	100.26	59.59	0.3
50	755.28	Q100	73.2	11.61	14.32		14.33	0.000108	0.54	136.75	70.71	0.12
50	755.28	Q 2000	120.6	11.61	14.73		14.75	0.000163	0.72	166.53	74.63	0.15
50	705.28	Q100	73.2	11.39	14.31		14.32	0.000089	0.5	147.32	73.64	0.11
50	705.28	Q 2000	120.6	11.39	14.72		14.74	0.000137	0.68	178.07	77.18	0.14
50	655.28	Q100	73.2	11.33	14.3		14.32	0.000139	0.53	137.39	86.65	0.14
50	655.28	Q 2000	120.6	11.33	14.71		14.74	0.00019	0.69	174.34	93.58	0.16
50	605.28	Q100	73.2	11.49	14.29		14.31	0.000157	0.6	121.16	68.93	0.15
50	605.28	Q 2000	120.6	11.49	14.69		14.72	0.000241	0.8	150.13	76.96	0.18
50	555.28	Q100	73.2	11.25	14.29		14.3	0.000128	0.59	124.71	63.71	0.13
50	555.28	Q 2000	120.6	11.25	14.68		14.71	0.000212	0.8	151.45	71.48	0.17
50	505.28	Q100	73.2	11.37	14.28		14.3	0.000126	0.59	124.87	63.28	0.13
50	505.28	Q 2000	120.6	11.37	14.67		14.7	0.000205	0.8	150.52	68.6	0.17
50	455.28	Q100	73.2	11.34	14.27		14.29	0.000139	0.62	117.2	57.82	0.14
50	455.28	Q 2000	120.6	11.34	14.65		14.69	0.000225	0.86	139.97	61.29	0.18
50	405.28	Q100	73.2	11.58	14.27		14.28	0.000067	0.46	160.56	73.63	0.1
50	405.28	Q 2000	120.6	11.58	14.66		14.68	0.000111	0.64	189.53	76.91	0.13
50	355.28	Q100	73.2	11.25	14.27		14.28	0.000068	0.47	156.23	69.2	0.1
50	355.28	Q 2000	120.6	11.25	14.65		14.67	0.000119	0.66	183.47	74.11	0.13
50	345.28	Q100	73.2	11.2	14.21	12.45	14.27	0.00115	1.14	64.47	58.88	0.35
50	345.28	Q 2000	120.6	11.2	14.56	12.95	14.66	0.001268	1.4	86.55	68.53	0.38
50	340		Inl Struct									
50	335.47	Q100	73.2	10.73	13.17		13.26	0.001509	1.32	55.27	51.85	0.41
50	335.47	Q 2000	120.6	10.73	14.06		14.12	0.000602	1.12	107.37	64.56	0.28
50	331.66	Q100	73.2	10.65	13.18	11.78	13.25	0.000501	1.18	62.22	30.41	0.26
50	331.66	Q 2000	120.6	10.65	14.03	12.18	14.12	0.000475	1.35	89.55	42.97	0.27
50	326		Bridge									
50	320.11	Q100	73.2	10.65	13.15		13.23	0.000521	1.19	61.43	30.3	0.27
50	320.11	Q 2000	120.6	10.65	14		14.09	0.00049	1.36	89.28	41.06	0.27
50	316.77	Q100	73.2	10.32	13.08		13.22	0.001086	1.66	44.04	22.31	0.38
50	316.77	Q 2000	120.6	10.32	13.9		14.08	0.001033	1.9	63.41	25.01	0.38
50	304.04	Q100	73.2	11.42	13.12		13.18	0.001184	1.06	69.15	77.53	0.36
50	304.04	Q 2000	120.6	11.42	13.99		14.03	0.000338	0.84	143.74	90.59	0.21
50	299.04	Q100	73.2	11.29	13.09		13.17	0.001497	1.21	60.47	66.02	0.4
50	299.04	Q 2000	120.6	11.29	13.98		14.03	0.000461	0.96	125.08	79.3	0.25
50	288.98	Q100	73.2	10.21	13.11		13.15	0.000523	0.83	88.72	77.71	0.25
50	288.98	Q 2000	120.6	10.21	13.99		14.02	0.000232	0.74	163.02	92.54	0.18
50	283.92	Q100	73.2	10.1	13.11	11.56	13.15	0.00041	0.8	92.05	76.13	0.22
50	283.92	Q 2000	120.6	10.1	13.99	12.19	14.02	0.000213	0.71	168.81	92.42	0.17
50	282.92		Bridge									
50	270.92	Q100	73.2	10.1	13.08	11.56	13.11	0.000442	0.82	89.77	75.51	0.23
50	270.92	Q 2000	120.6	10.1	13.94	12.19	13.97	0.000229	0.73	164.5	91.58	0.17
50	243.19	Q100	73.2	10.65	13.07		13.1	0.000408	0.72	103.32	105.45	0.22
50	243.19	Q 2000	120.6	10.65	13.94		13.96	0.000149	0.62	207.24	127.07	0.14
50	216.41	Q100	73.2	10.62	13.08	11.77	13.09	0.000177	0.5	145.7	117.97	0.14
50	216.41	Q 2000	120.6	10.62	13.95	12.22	13.96	0.000083	0.48	253.08	139.98	0.11

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	211		Culvert									
50	205	Q100	73.2	10.62	12.58		12.63	0.000695	1.22	87.48	115.88	0.29
50	205	Q 2000	120.6	10.62	12.82		12.9	0.000911	1.52	115.94	116.91	0.34
50	200	Q100	73.2	10.4	12.59		12.62	0.001021	0.87	84.29	112.69	0.32
50	200	Q 2000	120.6	10.4	12.83		12.89	0.001093	1.07	112.47	115.32	0.35
50	150	Q100	73.2	11.59	12.46		12.55	0.002347	1.27	57.47	81.36	0.48
50	150	Q 2000	120.6	11.59	12.67		12.8	0.002811	1.62	74.24	83.53	0.55
50	100	Q100	76.9	11.48	12.37		12.43	0.002031	1.02	75.4	134.31	0.43
50	100	Q 2000	126.5	11.48	12.6		12.67	0.001821	1.2	105.55	135.75	0.43
50	50	Q100	76.9	11.13	12.03	12.01	12.22	0.010015	1.95	39.54	88.72	0.93
50	50	Q 2000	126.5	11.13	12.19	12.18	12.47	0.010004	2.33	54.29	92.82	0.97

APPENDIX E

HEC – RAS – OUTPUTS -3 SPAN BRIDGE

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	805.28	Q100	73.2	12.45	14.3	13.38	14.35	0.000537	0.95	76.91	55.99	0.26
50	805.28	Q 2000	120.6	12.45	14.71	13.63	14.78	0.000656	1.2	100.25	59.59	0.3
50	755.28	Q100	73.2	11.61	14.32		14.33	0.000108	0.54	136.7	70.7	0.12
50	755.28	Q 2000	120.6	11.61	14.73		14.75	0.000163	0.72	166.53	74.63	0.15
50	705.28	Q100	73.2	11.39	14.31		14.32	0.000089	0.5	147.28	73.64	0.11
50	705.28	Q 2000	120.6	11.39	14.72		14.74	0.000137	0.68	178.06	77.18	0.14
50	655.28	Q100	73.2	11.33	14.3		14.32	0.000139	0.53	137.34	86.63	0.14
50	655.28	Q 2000	120.6	11.33	14.71		14.74	0.00019	0.69	174.33	93.58	0.16
50	605.28	Q100	73.2	11.49	14.29		14.31	0.000157	0.6	121.11	68.91	0.15
50	605.28	Q 2000	120.6	11.49	14.69		14.72	0.000241	0.8	150.13	76.96	0.18
50	555.28	Q100	73.2	11.25	14.29		14.3	0.000128	0.59	124.67	63.7	0.13
50	555.28	Q 2000	120.6	11.25	14.68		14.71	0.000212	0.8	151.44	71.48	0.17
50	505.28	Q100	73.2	11.37	14.28		14.3	0.000126	0.59	124.83	63.27	0.13
50	505.28	Q 2000	120.6	11.37	14.67		14.7	0.000205	0.8	150.51	68.59	0.17
50	455.28	Q100	73.2	11.34	14.27		14.29	0.000139	0.62	117.16	57.81	0.14
50	455.28	Q 2000	120.6	11.34	14.65		14.69	0.000225	0.86	139.97	61.29	0.18
50	405.28	Q100	73.2	11.58	14.27		14.28	0.000067	0.46	160.51	73.63	0.1
50	405.28	Q 2000	120.6	11.58	14.66		14.68	0.000111	0.64	189.52	76.91	0.13
50	355.28	Q100	73.2	11.25	14.27		14.28	0.000068	0.47	156.18	69.2	0.1
50	355.28	Q 2000	120.6	11.25	14.65		14.67	0.000119	0.66	183.46	74.11	0.13
50	345.28	Q100	73.2	11.2	14.21	12.45	14.27	0.001152	1.14	64.42	58.87	0.35
50	345.28	Q 2000	120.6	11.2	14.56	12.95	14.66	0.001268	1.4	86.54	68.52	0.38
50	340		Inl Struct									
50	335.47	Q100	73.2	10.73	13.16		13.25	0.001563	1.34	54.61	51.64	0.42
50	335.47	Q 2000	120.6	10.73	14.04		14.1	0.000625	1.14	105.95	64.27	0.28
50	331.66	Q100	73.2	10.65	13.17	11.78	13.24	0.00051	1.18	61.86	30.36	0.26
50	331.66	Q 2000	120.6	10.65	14.01	12.18	14.1	0.000486	1.36	88.81	41.59	0.27
50	326		Bridge									
50	320.11	Q100	73.2	10.65	13.14		13.21	0.00053	1.2	61.05	30.25	0.27
50	320.11	Q 2000	120.6	10.65	13.98		14.07	0.000502	1.37	88.37	40.04	0.27
50	316.77	Q100	73.2	10.32	13.06		13.2	0.001108	1.67	43.73	22.27	0.38
50	316.77	Q 2000	120.6	10.32	13.87		14.06	0.001062	1.92	62.8	24.93	0.39
50	304.04	Q100	73.2	11.42	13.11		13.16	0.001244	1.08	68.07	77.31	0.37
50	304.04	Q 2000	120.6	11.42	13.97		14.01	0.000355	0.85	141.65	90.49	0.22
50	299.04	Q100	73.2	11.29	13.08		13.16	0.001574	1.23	59.48	65.79	0.41
50	299.04	Q 2000	120.6	11.29	13.95		14	0.000483	0.98	123.2	79.07	0.25
50	288.98	Q100	73.2	10.21	13.1		13.13	0.000543	0.84	87.61	77.38	0.25
50	288.98	Q 2000	120.6	10.21	13.97		13.99	0.000243	0.75	160.87	92.25	0.18
50	283.92	Q100	73.2	10.1	13.1	11.55	13.13	0.000426	0.78	93.88	75.88	0.22
50	283.92	Q 2000	120.6	10.1	13.97	12.19	13.99	0.000221	0.72	166.65	92.01	0.17
50	282.92		Bridge									
50	270.92	Q100	73.2	10.1	13.08		13.11	0.000445	0.79	92.5	75.54	0.23
50	270.92	Q 2000	120.6	10.1	13.94		13.97	0.000229	0.73	164.5	91.58	0.17
50	243.19	Q100	73.2	10.65	13.07		13.1	0.000408	0.72	103.32	105.45	0.22
50	243.19	Q 2000	120.6	10.65	13.94		13.96	0.000149	0.62	207.24	127.07	0.14
50	216.41	Q100	73.2	10.62	13.08	11.77	13.09	0.000177	0.5	145.7	117.97	0.14
50	216.41	Q 2000	120.6	10.62	13.95	12.22	13.96	0.000083	0.48	253.08	139.98	0.11

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	211		Culvert									
50	205	Q100	73.2	10.62	12.58		12.63	0.000695	1.22	87.48	115.88	0.29
50	205	Q 2000	120.6	10.62	12.82		12.9	0.000911	1.52	115.94	116.91	0.34
50	200	Q100	73.2	10.4	12.59		12.62	0.001021	0.87	84.29	112.69	0.32
50	200	Q 2000	120.6	10.4	12.83		12.89	0.001093	1.07	112.47	115.32	0.35
50	150	Q100	73.2	11.59	12.46		12.55	0.002347	1.27	57.47	81.36	0.48
50	150	Q 2000	120.6	11.59	12.67		12.8	0.002811	1.62	74.24	83.53	0.55
50	100	Q100	76.9	11.48	12.37		12.43	0.002031	1.02	75.4	134.31	0.43
50	100	Q 2000	126.5	11.48	12.6		12.67	0.001821	1.2	105.55	135.75	0.43
50	50	Q100	76.9	11.13	12.03	12.01	12.22	0.010015	1.95	39.54	88.72	0.93
50	50	Q 2000	126.5	11.13	12.19	12.18	12.47	0.010004	2.33	54.29	92.82	0.97

APPENDIX F

HEC – RAS – OUTPUTS – CONSPAN BRIDGE

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	805.28	Q100	73.2	12.45	14.3	13.38	14.35	0.000538	0.95	76.87	55.98	0.26
50	805.28	Q 2000	120.6	12.45	14.71	13.63	14.78	0.000653	1.2	100.41	59.62	0.3
50	755.28	Q100	73.2	11.61	14.31		14.33	0.000108	0.54	136.66	70.69	0.12
50	755.28	Q 2000	120.6	11.61	14.73		14.75	0.000163	0.72	166.71	74.65	0.15
50	705.28	Q100	73.2	11.39	14.31		14.32	0.000089	0.5	147.23	73.63	0.11
50	705.28	Q 2000	120.6	11.39	14.72		14.75	0.000137	0.68	178.26	77.2	0.14
50	655.28	Q100	73.2	11.33	14.3		14.32	0.00014	0.53	137.28	86.6	0.14
50	655.28	Q 2000	120.6	11.33	14.71		14.74	0.000189	0.69	174.57	93.6	0.16
50	605.28	Q100	73.2	11.49	14.29		14.31	0.000157	0.6	121.07	68.9	0.15
50	605.28	Q 2000	120.6	11.49	14.69		14.73	0.00024	0.8	150.33	77.03	0.18
50	555.28	Q100	73.2	11.25	14.29		14.3	0.000128	0.59	124.63	63.68	0.13
50	555.28	Q 2000	120.6	11.25	14.68		14.72	0.000211	0.8	151.64	71.52	0.17
50	505.28	Q100	73.2	11.37	14.28		14.3	0.000126	0.59	124.79	63.27	0.13
50	505.28	Q 2000	120.6	11.37	14.67		14.7	0.000204	0.8	150.7	68.64	0.17
50	455.28	Q100	73.2	11.34	14.27		14.29	0.000139	0.62	117.12	57.81	0.14
50	455.28	Q 2000	120.6	11.34	14.66		14.69	0.000224	0.86	140.14	61.32	0.18
50	405.28	Q100	73.2	11.58	14.27		14.28	0.000067	0.46	160.46	73.62	0.1
50	405.28	Q 2000	120.6	11.58	14.66		14.68	0.00011	0.64	189.73	76.94	0.13
50	355.28	Q100	73.2	11.25	14.27		14.28	0.000068	0.47	156.13	69.19	0.1
50	355.28	Q 2000	120.6	11.25	14.65		14.67	0.000118	0.66	183.67	74.16	0.13
50	345.28	Q100	73.2	11.2	14.21	12.45	14.27	0.001155	1.14	64.38	58.86	0.35
50	345.28	Q 2000	120.6	11.2	14.56	12.95	14.66	0.001259	1.4	86.76	68.82	0.38
50	340		Inl Struct									
50	335.47	Q100	73.2	10.73	13.25		13.33	0.001223	1.23	59.46	53.13	0.37
50	335.47	Q 2000	120.6	10.73	14.22		14.28	0.000462	1.02	117.97	67.36	0.25
50	331.66	Q100	73.2	10.65	13.26	11.78	13.32	0.000451	1.13	64.53	30.74	0.25
50	331.66	Q 2000	120.6	10.65	14.19	12.18	14.27	0.0004	1.27	95.08	49.29	0.24
50	326		Bridge									
50	320.11	Q100	73.2	10.65	13.23		13.3	0.000466	1.15	63.8	30.63	0.25
50	320.11	Q 2000	120.6	10.65	14.16		14.25	0.000407	1.28	96.74	48.33	0.25
50	316.77	Q100	73.2	10.32	13.16		13.29	0.00096	1.59	45.94	22.57	0.36
50	316.77	Q 2000	120.6	10.32	14.08		14.24	0.000851	1.77	67.95	25.66	0.35
50	304.04	Q100	73.2	11.42	13.21		13.25	0.000888	0.96	75.9	78.84	0.31
50	304.04	Q 2000	120.6	11.42	14.16		14.19	0.000244	0.76	159.08	91.31	0.18
50	299.04	Q100	73.2	11.29	13.19		13.25	0.001117	1.1	66.6	67.48	0.35
50	299.04	Q 2000	120.6	11.29	14.15		14.19	0.000335	0.87	138.84	80.95	0.21
50	288.98	Q100	73.2	10.21	13.2		13.23	0.000417	0.77	95.61	79.05	0.22
50	288.98	Q 2000	120.6	10.21	14.16		14.18	0.000172	0.68	178.95	95.84	0.15
50	283.92	Q100	73.2	10.1	13.2	11.56	13.23	0.000337	0.74	98.27	77.79	0.2
50	283.92	Q 2000	120.6	10.1	14.16	12.19	14.18	0.000164	0.65	184.75	95.47	0.15
50	282.92		Culvert									
50	270.92	Q100	73.2	10.1	13.08	11.56	13.11	0.000442	0.82	89.77	75.51	0.23
50	270.92	Q 2000	120.6	10.1	13.94	12.19	13.97	0.000229	0.73	164.5	91.58	0.17
50	243.19	Q100	73.2	10.65	13.07		13.1	0.000408	0.72	103.32	105.45	0.22
50	243.19	Q 2000	120.6	10.65	13.94		13.96	0.000149	0.62	207.24	127.07	0.14
50	216.41	Q100	73.2	10.62	13.08	11.77	13.09	0.000177	0.5	145.7	117.97	0.14
50	216.41	Q 2000	120.6	10.62	13.95	12.22	13.96	0.000083	0.48	253.08	139.98	0.11

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	211		Culvert									
50	205	Q100	73.2	10.62	12.58		12.63	0.000695	1.22	87.48	115.88	0.29
50	205	Q 2000	120.6	10.62	12.82		12.9	0.000911	1.52	115.94	116.91	0.34
50	200	Q100	73.2	10.4	12.59		12.62	0.001021	0.87	84.29	112.69	0.32
50	200	Q 2000	120.6	10.4	12.83		12.89	0.001093	1.07	112.47	115.32	0.35
50	150	Q100	73.2	11.59	12.46		12.55	0.002347	1.27	57.47	81.36	0.48
50	150	Q 2000	120.6	11.59	12.67		12.8	0.002811	1.62	74.24	83.53	0.55
50	100	Q100	76.9	11.48	12.37		12.43	0.002031	1.02	75.4	134.31	0.43
50	100	Q 2000	126.5	11.48	12.6		12.67	0.001821	1.2	105.55	135.75	0.43
50	50	Q100	76.9	11.13	12.03	12.01	12.22	0.010015	1.95	39.54	88.72	0.93
50	50	Q 2000	126.5	11.13	12.19	12.18	12.47	0.010004	2.33	54.29	92.82	0.97

APPENDIX G

HEC – RAS – OUTPUTS – 1 SPAN BRIDGE WITH DOWNSTREAM CROSSING REMOVED

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	805.28	Q100	73.2	12.45	14.31	13.38	14.35	0.000534	0.95	77.06	56.01	0.26
50	805.28	Q 2000	120.6	12.45	14.71	13.63	14.78	0.000658	1.2	100.18	59.58	0.3
50	755.28	Q100	73.2	11.61	14.32		14.33	0.000108	0.53	136.89	70.73	0.12
50	755.28	Q 2000	120.6	11.61	14.72		14.75	0.000164	0.72	166.43	74.61	0.15
50	705.28	Q100	73.2	11.39	14.31		14.33	0.000089	0.5	147.47	73.65	0.11
50	705.28	Q 2000	120.6	11.39	14.72		14.74	0.000137	0.68	177.97	77.17	0.14
50	655.28	Q100	73.2	11.33	14.31		14.32	0.000139	0.53	137.57	86.74	0.13
50	655.28	Q 2000	120.6	11.33	14.71		14.73	0.00019	0.69	174.21	93.56	0.16
50	605.28	Q100	73.2	11.49	14.29		14.31	0.000156	0.6	121.3	68.96	0.15
50	605.28	Q 2000	120.6	11.49	14.69		14.72	0.000241	0.8	150.03	76.92	0.18
50	555.28	Q100	73.2	11.25	14.29		14.31	0.000127	0.59	124.85	63.76	0.13
50	555.28	Q 2000	120.6	11.25	14.68		14.71	0.000212	0.8	151.35	71.46	0.17
50	505.28	Q100	73.2	11.37	14.28		14.3	0.000126	0.59	125.01	63.31	0.13
50	505.28	Q 2000	120.6	11.37	14.67		14.7	0.000205	0.8	150.42	68.57	0.17
50	455.28	Q100	73.2	11.34	14.27		14.29	0.000138	0.62	117.33	57.84	0.14
50	455.28	Q 2000	120.6	11.34	14.65		14.69	0.000226	0.86	139.88	61.28	0.18
50	405.28	Q100	73.2	11.58	14.27		14.29	0.000067	0.46	160.72	73.65	0.1
50	405.28	Q 2000	120.6	11.58	14.66		14.68	0.000111	0.64	189.41	76.9	0.13
50	355.28	Q100	73.2	11.25	14.27		14.28	0.000068	0.47	156.38	69.23	0.1
50	355.28	Q 2000	120.6	11.25	14.65		14.67	0.000119	0.66	183.36	74.09	0.13
50	345.28	Q100	73.2	11.2	14.21	12.45	14.27	0.001142	1.13	64.61	58.91	0.35
50	345.28	Q 2000	120.6	11.2	14.56	12.95	14.66	0.001273	1.4	86.43	68.37	0.38
50	340		Inl Struct									
50	335.47	Q100	73.2	10.73	12.91		13.06	0.002332	1.69	43.25	38.8	0.51
50	335.47	Q 2000	120.6	10.73	13.31		13.5	0.002871	1.93	62.56	54.05	0.57
50	331.66	Q100	73.2	10.65	12.95	11.78	13.04	0.000711	1.33	55.23	29.41	0.31
50	331.66	Q 2000	120.6	10.65	13.32	12.18	13.48	0.001126	1.82	66.41	31	0.4
50	326		Bridge									
50	320.11	Q100	73.2	10.65	12.91		13	0.000754	1.35	54.15	29.26	0.32
50	320.11	Q 2000	120.6	10.65	13.25		13.43	0.00124	1.88	64.24	30.7	0.41
50	316.77	Q100	73.2	10.32	12.8		12.99	0.001674	1.93	38	21.45	0.46
50	316.77	Q 2000	120.6	10.32	12.97		13.39	0.00348	2.9	41.6	21.97	0.67
50	304.04	Q100	73.2	11.42	12.81		12.94	0.003656	1.58	46.38	66.48	0.6
50	304.04	Q 2000	120.6	11.42	13.11		13.27	0.00332	1.76	68.43	77.39	0.6
50	299.04	Q100	73.2	11.29	12.59	12.58	12.89	0.010018	2.43	30.18	48.31	0.98
50	299.04	Q 2000	120.6	11.29	12.95		13.23	0.006818	2.36	51.06	63.79	0.84
50	288.98	Q100	73.2	10.21	12.71		12.79	0.001652	1.23	59.37	67.34	0.42
50	288.98	Q 2000	120.6	10.21	13.04		13.15	0.00171	1.45	83.19	76.03	0.44
50	283.92	Q100	73.2	10.1	12.71	11.56	12.78	0.001174	1.13	64.94	68.2	0.36
50	283.92	Q 2000	120.6	10.1	13.04	12.19	13.14	0.00132	1.39	87	74.76	0.4
50	282.92		Bridge									
50	270.92	Q100	73.2	10.1	12.66	11.56	12.74	0.001297	1.18	61.9	65.02	0.38
50	270.92	Q 2000	120.6	10.1	12.91	12.19	13.03	0.001853	1.55	77.76	72.2	0.46
50	243.19	Q100	73.2	10.65	12.62		12.69	0.002158	1.21	60.64	87.2	0.46
50	243.19	Q 2000	120.6	10.65	12.86		12.97	0.00222	1.46	82.47	90.79	0.49
50	216.41	Q100	73.2	10.62	12.61	11.77	12.64	0.00082	0.8	91.28	116.02	0.29
50	216.41	Q 2000	120.6	10.62	12.86	12.22	12.92	0.000886	1	120.88	117.08	0.31

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
50	205	Q100	73.2	10.62	12.58		12.63	0.000695	1.22	87.48	115.88	0.29
50	205	Q 2000	120.6	10.62	12.82		12.9	0.000911	1.52	115.94	116.91	0.34
50	200	Q100	73.2	10.4	12.59		12.62	0.001021	0.87	84.29	112.69	0.32
50	200	Q 2000	120.6	10.4	12.83		12.89	0.001093	1.07	112.47	115.32	0.35
50	150	Q100	73.2	11.59	12.46		12.55	0.002347	1.27	57.47	81.36	0.48
50	150	Q 2000	120.6	11.59	12.67		12.8	0.002811	1.62	74.24	83.53	0.55
50	100	Q100	76.9	11.48	12.37		12.43	0.002031	1.02	75.4	134.31	0.43
50	100	Q 2000	126.5	11.48	12.6		12.67	0.001821	1.2	105.55	135.75	0.43
50	50	Q100	76.9	11.13	12.03	12.01	12.22	0.010015	1.95	39.54	88.72	0.93
50	50	Q 2000	126.5	11.13	12.19	12.18	12.47	0.010004	2.33	54.29	92.82	0.97

APPENDIX B

ENVIRONMENTAL ASSESSMENT REPORT

PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

ENVIRONMENTAL ASSESSMENT

Prepared for: City of Swan

Report Date: 29 May 2013

Version: 3

Report No. 2012-78



pgv ENVIRONMENTAL

CONTENTS

Contents	i
List of Attachments	iii
1 INTRODUCTION	1
1.1 Background.....	1
1.2 Purpose and Scope	1
1.3 Zoning.....	2
2 EXISTING ENVIRONMENT	3
2.1 Past and Existing Land Use	3
2.2 Surrounding Land Use	6
2.3 Topography	7
2.4 Geomorphology and Soils	7
2.4.1 Acid Sulphate Soils.....	8
2.5 Groundwater Hydrology.....	8
2.6 Surface Hydrology	9
2.6.1 Ellen Brook.....	9
2.6.2 Ellen Brook Floodplain.....	10
2.6.3 Flow Gauging Station.....	10
2.6.4 Wetlands	11
2.7 Vegetation	13
2.7.1 Bioregional Data	13
2.7.2 Threatened and Priority Ecological Communities	13
2.7.3 Vegetation Description.....	13
2.7.4 Vegetation Condition	16
2.8 Flora.....	16
2.9 Bush Forever.....	20
2.10 Fauna	20
2.10.1 DEC Database Search Results	20
2.10.2 Habitat	21
2.10.3 Conservation Significant Species	21
2.11 Heritage	26
2.11.1 Aboriginal heritage	26

2.11.2	European Heritage.....	26
3	IMPACT OF DEVELOPMENT	27
3.1	Past and Existing Land Use	27
3.2	Surrounding Land Use	27
3.3	Geomorphology and Soils	27
3.4	Groundwater	27
3.5	Surface Water.....	27
3.6	Ellen Brook.....	28
3.7	Wetlands	29
3.8	Gauging Station	29
3.9	Vegetation	30
3.10	Flora.....	30
3.11	Bush Forever.....	30
3.12	Fauna	31
3.13	Heritage	32
3.14	Consultation	32
3.14.1	Initial Consultations	32
3.14.2	Future Consultation.....	41
4	FUTURE REQUIREMENTS.....	42
4.1	Approvals.....	42
4.2	Further Studies	42
4.3	Design Considerations	42
4.4	Management Plans.....	43
5	SUMMARY AND CONCLUSIONS.....	45
6	REFERENCES	47

List of Attachments

Plates

Plate 1:	Aerial Photography from 1965 (Landgate 2012b)
Plate 2:	Aerial Photography from 1965 showing the bridge over the Ellen Brook (Landgate 2012b)
Plate 3:	Aerial Photography from 1979 showing land that was cleared (Landgate 2012b)
Plate 4:	Aerial Photography from 1981 showing new buildings and a dam (Landgate 2012b)
Plate 5:	Aerial Photography from 1985 showing the bridge is removed (Landgate 2012b)
Plate 6:	Old Footings of the Bridge
Plate 7:	Existing Railway Pylons in Ellen Brook
Plate 8:	‘Occupational Crossing’ of Ellen Brook
Plate 9:	Granite located to the South of Ellen Brook
Plate 10:	Ellen Brook with some Trees and a Weedy Understorey
Plate 11:	100 Year ARI Floodway Mapping
Plate 12:	Ellen Brook Flow Gauging Station
Plate 13:	Degraded Vegetation in the Resource Enhancement Wetland (UFI 15733)
Plate 14:	Excavated Area near Resource Enhancement Wetland
Plate 15:	Weedy Vegetation in the Vicinity of Ellen Brook
Plate 16:	Marri Vegetation to the South of Ellen Brook
Plate 17:	Vegetation to the North of Ellen Brook
Plate 18:	Roadside vegetation along the southern part of Railway Parade

Tables

Table 1:	Land Unit Descriptions
Table 2:	Threatened and Priority Ecological Communities Identified in Database Searches
Table 3:	Vegetation Condition Rating Scale
Table 4:	List of Flora Species Identified from Database Searches
Table 5:	Likelihood of Identified Significant Flora Species occurring on the Site

Table 6:	List of Fauna Species Identified from DEC Database Searches
Table 7:	Likelihood of Conservation Significant species being present on the site
Table 8:	Management Objectives for Conservation Category Wetlands
Table 9:	Management Objectives for Resource Enhancement and Multiple Use Wetlands
Table 10:	Results of Initial Consultations
Table 11:	Environmental Assessment

Figures

Figure 1:	Site Location and Topography
Figure 2:	Zoning under the Metropolitan Region Scheme
Figure 3:	Zoning under the City of Swan Local Planning Scheme
Figure 4:	Soil Mapping
Figure 5:	Acid Sulphate Soils Risk Mapping
Figure 6:	Geomorphic Wetlands Database Mapping
Figure 7:	Bush Forever Boundary

Appendices

Appendix 1:	Ellen Brook Floodplain Mapping
Appendix 2:	TEC and PEC Database Searches
Appendix 3:	Protected Matters Search Tool
Appendix 4:	Conservation Codes
Appendix 5:	DEC Threatened Flora Database Searches
Appendix 6:	Naturemap Database Search
Appendix 7:	DEC Threatened Fauna Database Searches
Appendix 8:	Aboriginal Heritage Inquiry System Reports

1 INTRODUCTION

1.1 Background

The City of Swan is developing rapidly and as a result an alternative transport route west from new developments in The Vines, Ellenbrook and Aveley areas is becoming increasingly a priority. In creating a new route the City of Swan proposes to upgrade the road on Railway Parade from Apple Street to Maralla Road, construct a bridge on Railway Parade over the Ellen Brook in Upper Swan and upgrade Apple Street from Railway Parade to Great Northern Hwy (Figure 1).

The requirement for road upgrades and a bridge crossing over Ellen Brook has been identified by the WAPC in approving nearby subdivisions in The Vines area.

The bridge and roadway on Railway Parade and Apple Street are to be two lanes and constructed to withstand loads in accordance with a Network 1 road that can carry traffic including the following:

- Road train to 20m and 50t (Semi and Pig);
- Articulated vehicle to 19m, 4.6m high and 42.5t (carrying livestock, vehicles, a multi-modal container or towing an over-height semi-trailer);
- B-Double to 20m and 50t; and
- Twin-steer Prime mover towing semi-trailer to 19m and 47.5t.

1.2 Purpose and Scope

PGV Environmental has been commissioned by the City of Swan to undertake an Environmental Assessment of the proposed bridge alignment and to use the results to identify the relevant stakeholders to be consulted during the design and construction stages. The assessment includes information on the following environmental factors.

Physical characteristics including a description of:

- Landform of the site;
- Drainage and water bodies;
- Geological, hydrogeological and hydrological characteristics; and
- Acid Sulphate Soil Risk Mapping.

Recent and present land use including:

- Federal, State and Local Government Environmental Policy areas search;
- Surrounding land uses;
- Any records from the Contaminated Sites Database;
- Assessment of current and historical activities on the subject site and surrounding areas which have the potential to result in contamination issues at the site; and
- Heritage features.

Flora, vegetation and fauna including:

- The results from Declared Rare and Priority Flora and Fauna and Threatened Ecological Community searches of the Department of Environment and Conservation (DEC) Databases;
- Results from the Commonwealth Protected Matters Search Tool which will identify possible matters of Environmental Significance listed under the *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) that may occur on the sites; and
- An assessment of the likelihood of conservation significant flora, vegetation and fauna being present on the sites.

The impact of the construction of the bridge and upgrade of the road on the site has been assessed in the context of impact on the above factors.

1.3 Zoning

The site has several different zonings under the Metropolitan Region Scheme (MRS). To the south of Ellen Brook the site and adjacent areas are Zoned 'Rural' (Figure 2). The area of the site that is Ellen Brook is zoned as 'Parks and Recreation'.

The land to the north of Ellen Brook is zoned 'Urban'. The eastern boundary of the site abuts the Millendon Junction Narngulu Railway which is zoned 'Railway' under the MRS. The area to the east of the Railway is zoned 'Rural' (Landgate 2012a) (Figure 2).

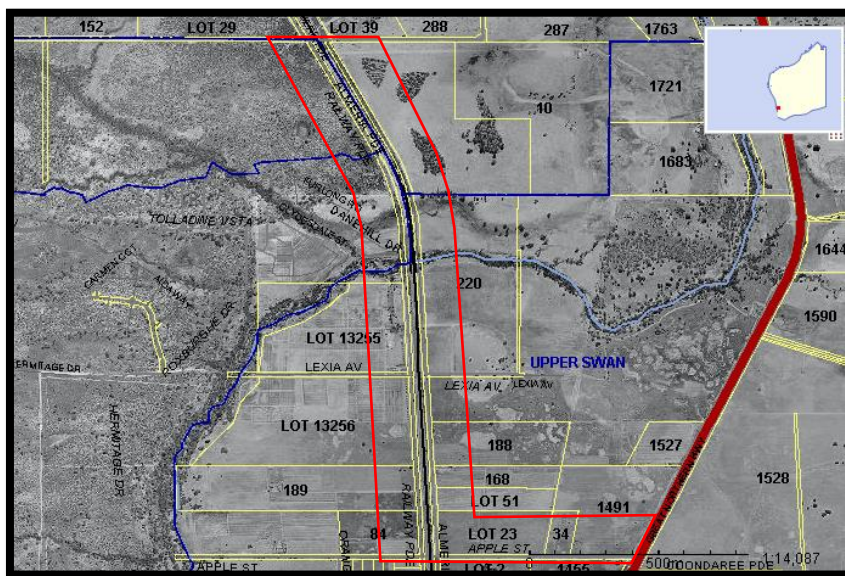
Railway Parade is gazetted as a Local Road in the *City of Swan Local Planning Scheme (LPS) No.17 District Zoning Scheme* (WAPC, 2008) (Figure 3). Ellen Brook is zoned as 'Parks and Recreation' and is shown as being flood prone. The land the south of Ellen Brook is zoned 'General Rural' in the LPS. The land to the east of the railway is zoned 'Special Use 6' which is an area that has restrictions on subdivision to protect the Western Swamp Tortoise. To the north-west of Ellen Brook is an area zoned as 'Residential Development' and 'Special Use 4' zone. These areas are part of the Ellenbrook development and as such are zoned for a mixture of purposes such as residential, commercial and retail. To the north of Lexia Drive and to the east of the railway is a small area zoned for 'Additional Use 42' which allows stockfeed manufacturing and wholesale activity (Figure 3).

2 EXISTING ENVIRONMENT

2.1 Past and Existing Land Use

The Millendon Junction Narngulu Railway has been established for more than 100 years and extends from Perth to Geraldton for 425km. Historical aerial photography from 1965 shows the railway and the adjoining Railway Parade road reserve which has been cleared. The western side of the site has mostly been cleared although native vegetation occurs a short distance to the west. Ellen Brook retains some native vegetation along its alignment (Plate 1).

Plate 1: Aerial Photography from 1965 (Landgate 2012b).



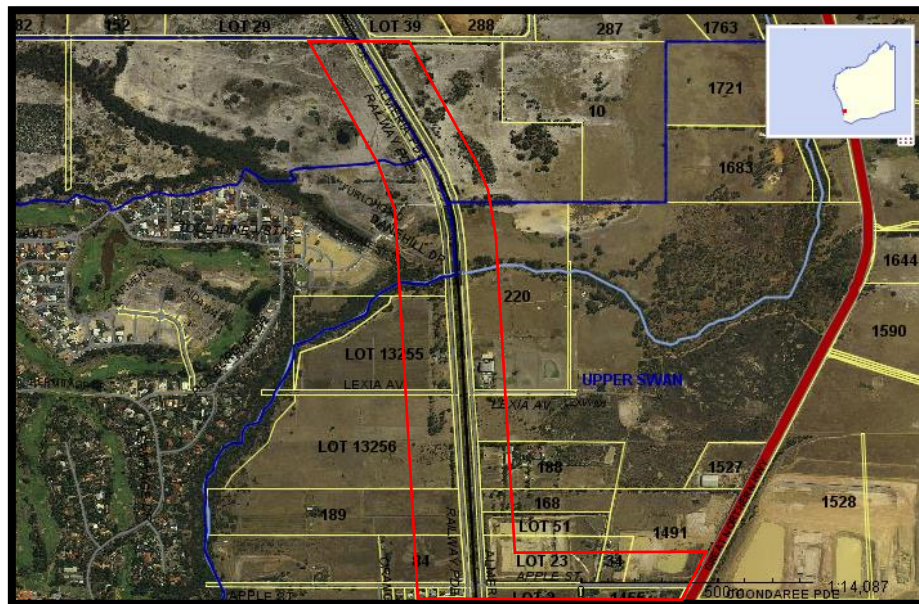
The 1965 aerial photograph shows the remains of a small bridge over Ellen Brook as well the rail bridge on the right hand side (Plate 2).

Plate 2: Aerial Photography from 1965 showing the bridge over the Ellen Brook (Landgate 2012b).



Between 1977 and 1979 the vegetation to the north of Ellen Brook was cleared up to Maralla Road (Plate 3).

Plate 3: Aerial Photography from 1979 showing land that was cleared (Landgate 2012b).



Between 1979 and 1981 there has been some development commenced in close proximity to the Ellen Brook. To the south a dwelling has been established on the site. To the north of Ellen Brook an area has been excavated to form a dam (Plate 4).

Plate 4: Aerial Photography from 1981 showing new buildings and a dam (Landgate 2012b).



The small bridge is still evident in 1981 however has been removed by 1985 (Plate 5).

Plate 5: Aerial Photography from 1985 showing the bridge is removed (Landgate 2012b).



There is evidence of the old bridge on the site in 2012 (Plate 6).

Plate 6: Old Footings of the Bridge



The existing railway bridge has two large pylons in the Ellen Brook as shown in Plate 7.

Plate 7: Existing Railway Pylons in Ellen Brook



2.2 Surrounding Land Use

Surrounding land uses include a vineyard to the south-west and cleared agricultural property to the east and north. To the west is some vegetated land and the Vines Development which is bound by Damialling Drive. A clay extraction site occurs to the south-east.

Approximately 75m downstream from the proposed crossing of Ellen Brook is an 'Occupational Crossing' (Appendix 1) consisting of 9 barrels of 1.53 x 1.53 RC box culverts (DoW, Pers comm, 2013) (Plate 8).

Plate 8: 'Occupational Crossing' of Ellen Brook



2.3 Topography

The site is very gently undulating north and south of the Ellen Brook and ranges in elevation from approximately 18 to 22m AHD (DoW, 2012). There is a small depression to the north of Ellen Brook with an elevation of approximately 15m AHD. The creek bed of Ellen Brook is at 12m AHD (Figure 1).

2.4 Geomorphology and Soils

The site is located on the eastern side of the Swan Coastal Plain. The Swan Coastal Plain is generally flat and is approximately 20 to 30 kilometres wide, consisting of a series of geomorphic entities running parallel to the coastline.

The site is predominately located on the Pinjarra System which occurs on the Swan Coastal Plain between Perth and Capel. The Pinjarra system consists of poorly drained coastal plain with variable alluvial and aeolian soils. The Pinjarra System has variable vegetation including Jarrah (*Eucalyptus marginata*), Marri (*Corymbia calophylla*), Wandoo, paperbark, sheoaks and Flooded Gum (*Eucalyptus rudis*). Soils mapped in Ellen Brook are classified in the Pinjarra Wet System which is described as undifferentiated wet soils associated with water.

The north of the site is mapped in the Yanga System which is described as poorly drained plain with pale sands and deep sandy duplex, wet, semi-wet and saline wet soils. The vegetation associated with this system is generally Banksia, Prickly-bark (*Eucalyptus tottiana*), Marri, Swamp Sheoak (*Casuarina obesa*) or paperbark woodlands.

The phases of soils within the soil systems that have been mapped on the site are outlined in Table 1 and shown on Figure 4.

Table 1: Land Unit Descriptions

Land Unit	Description
213Pj – Pinjarra Subsystem (Pj)	
213Pj_J Pinjarra, Phase J	Brown sandy loam over a yellow mottled clay and a grey mottled clay.
213Pj_VC Pinjarra, Phase VC	Variable soils associated with drainage lines
213PjSW1 Pinjarra, Phase SWSw1	River margins and low flats with poorly drained variable alluvial soils, subject to frequent flooding.
213Pj_Hsb Pinjarra, Phase Hsb	Brown sand with nil to few gravels over mottled clay.
213Pj_Hs Pinjarra, Phase Hs	Grey to greyish-brown sand with nil to few gravels over mottled clay.
213PjW Pinjarra Wet System	
231PjW_Claypan Pinjarra Wet, Claypan Phase	Claypan
213Ya – Yanga System (Ya)	
213Ya_10x Yanga 10x Phase	Very gently to gently sloping plains, well drained and some imperfectly drained. Shallow red sands with bog iron exposed in places and underlying within a metre of the surface. Low woodland of <i>Eucalyptus rudis</i> and Jam on the lower slopes.
213Ya_8x Yanga 8x Phase	Flat plain with occasional low dunes. Subject to seasonal inundation. Deep white and pale yellow sands interspersed with swamp and generally underlain by siliceous/humic pans at depth.

During the site visit it was noted that the south side of the banks of Ellen Brook had some outcropping of what is assumed to be granite (Plate 9). It is possible that the granite was placed on the site to stabilise the footings for the old bridge.

Plate 9: Granite located to the South of Ellen Brook



2.4.1 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulphides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils are prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

The ASS Risk on the site has been mapped by the DEC (Landgate, 2012b) as being Moderate to Low (<3m from the surface) in Ellen Brook and in the north of the site (Figure 5). The remainder of the site is mapped as having a Low (<3m from the surface) risk. There is a small area around Lexia Avenue that is mapped as High to Moderate (<3m from the surface).

2.5 Groundwater Hydrology

The groundwater under the site has geological formations that have been grouped into three distinct aquifers:

- Superficial Swan Aquifer (unconfined);
- Leederville Aquifer (confined); and
- Yarragadee north (confined) (DoW, 2012a)

The Superficial Aquifer is part of the Gnamptara Mound and the Kardinya Shale Member of the Osborne Formation separates this from the Leederville Aquifer (DoW, 2012a).

The depth to groundwater over the site varies with the topography from approximately 3.5m near the Ellen Brook to about 7m to the south and 4m in the north of the site (DoW, 2012b). Groundwater is at approximately 11.5 to 20m AHD.

Groundwater generally flows towards Ellen Brook (DoW, 2012b).

2.6 Surface Hydrology

Surface water on the site generally drains towards Ellen Brook and other low-lying areas within the site.

2.6.1 Ellen Brook

Ellen Brook starts below Muchea and flows into the Swan River approximately 7km to the south-west of the site. The Brook is fed from the Dandaragan Plateau which is the northern end of the Darling Range and smaller watercourses along the way including Sawpit Gully, Ki-It Monger Brook and Nambab Brook.

The part of Ellen Brook within the site is classified as a Conservation Category Floodplain called Ellen Brook Floodplain (Unique Feature Identifier (UFI) 15734) in the Department of Environment and Conservation's Geomorphic Wetland Mapping database.

The Ellen Brockman Integrated Catchment Group commissioned the *Restoration Concept Plan for the Riparian Section of the Ellen Brook* (Ecoscape, 2006). The condition of the section of Ellen Brook within the site was rated as C Grade Foreshore which is eroding or erosion prone (from Penn and Scott, 1995). This rating has been further refined and the part of Ellen Brook within the site is rated as C2 to the west of the railway which is described as:

Surface erosion exposed soil - Here the foreshore is exposed in significant areas and has begun to erode.

To the east of the railway Ellen Brook was rated as C3 which is described as:

Erosion and subsidence present - Soil is washed away from between any tree roots and trees are being undermined. Unsupported embankments are subsiding into the waterway. Localised erosion is present.

The part of Ellen Brook within the site was given a rating of Priority 6 for rehabilitation in the restoration concept plan. This is the lowest priority within Ellen Brook and was rated as such because:

- It is not accessible by the public and the land has little opportunity for interpretation due to closeness of private property and the land-uses within them;
- It is highly disturbed due to land uses;
- There is little or no understorey;
- Erosion and subsidence is present; and
- No known previous restoration works have been undertaken in this area of Ellen Brook.

A site visit conducted by PGV Environmental in November 2012 confirmed that this part of Ellen Brook is degraded with very little understorey other than weeds (Plate 10). There was some evidence of bank erosion.

Plate 10: Ellen Brook with some Trees and a Weedy Understorey



The removal of this crossing may be considered during design to

2.6.2 Ellen Brook Floodplain

Floodplain mapping supplied by the Department of Water shows the extent of a 100 year ARI event and the floodplain limit to be one and the same (Appendix 1). Digitised mapping as shown below also shows the 100 Year ARI Floodway (yellow) and the Flood Fringe (blue) to have the same extent at the site of the proposed crossing (Plate 11).

Plate 11: 100 Year ARI Floodway Mapping



2.6.3 Flow Gauging Station

The Ellen Brook Flow Gauging Station is located on the southern bank of Ellen Brook a short distance to the east of the railway bridge (Plate 12). The station was established in 1965 and contains a

tower which is linked to a telemetered pressure gauge. The station can measure water flow as well as water quality factors such as salinity, nitrogen and phosphorus levels.

Plate 12: Ellen Brook Flow Gauging Station



2.6.4 Wetlands

Three Resource Enhancement and Multiple Use Wetlands occur on the site (Figure 6).

A Multiple Use Palusplain (UFI 15282) occurs to the south of Ellen Brook. Immediately to the north of Ellen Brook is a Multiple Use Palusplain that extends north and is located on the site near Maralla Avenue (UFI 15732) (Figure 6). A Palusplain is defined as a seasonally waterlogged flat (Semeniuk, 1987). These mapped palusplain areas are highly degraded and have been mostly cleared of native vegetation.

A Resource Enhancement Palusplain (UFI 15733) occurs to the north of Ellen Brook and adjacent to the western side of the rail reserve (Figure 6). This wetland is degraded and the vegetation consists of trees over weeds (Plate 13).

Plate 13: Degraded Vegetation in the Resource Enhancement Wetland (UFI 15733)



To the west of the Resource Enhancement Wetland is an area that has been excavated to create a man-made dam and is likely to hold water for most of the year (Plate 14).

Plate 14: Excavated Area near Resource Enhancement Wetland



It is likely that the construction of this dam has impacted on the hydrology of the Resource Enhancement wetland by diverting surface water.

2.7 Vegetation

2.7.1 Bioregional Data

The site is in the Southwest Botanical Province within the northern Swan Coastal Plain Region. The vegetation is mapped as Beard vegetation type e3Mi which is Medium woodland; marri (Beard, 1990).

2.7.2 Threatened and Priority Ecological Communities

A search of the DEC's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted for the site (Appendix 2; 51-1012EC). There are no known occurrences of any TECs or PECs on the site. Six TECs and four PECs have been recorded in the vicinity of the site (Table 2). The EPBC Act Protected Matters Search Tool database search also identified two of the TECs as being present within the area (Appendix 3).

Table 2: Threatened and Priority Ecological Communities Identified in Database Searches

Community Identification	Community Name	Status under Wildlife Cons. Act	Status under EPBC Act
Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Critically Endangered	Endangered
SCP3c	<i>Eucalyptus calophylla</i> - <i>Xanthorrhoea preissii</i> woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	Endangered
SCP08	Herb rich shrublands in clay pans (Part of 'Claypans of the Swan Coastal Plain')	Vulnerable	Critically Endangered
SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	
SCP18	Shrublands on calcareous silts of the Swan Coastal Plain	Vulnerable	
SCP21c	Low lying <i>Banksia attenuata</i> woodlands or shrublands	Priority 3	
SCP22	<i>Banksia ilicifolia</i> woodlands	Priority 3	
SCP23b	Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands	Priority 3	
SCP25	Southern <i>Eucalyptus gomphocephala</i> - <i>Agonis flexuosa</i> woodlands	Priority 3	

Conservation Codes are outlined in Appendix 4

2.7.3 Vegetation Description

A site inspection was undertaken by PGV Environmental on 28 November 2012. The vegetation on most of the site was found to be highly degraded with large areas totally cleared and other areas containing native trees containing a totally weed infested understorey.

Riparian vegetation exists on the banks of the Ellen Brook and other low-lying areas (Plate 15). The vegetation consists of Flooded Gum (*Eucalyptus rudis*) and Paperbarks (*Melaleuca raphiophylla*) with an understorey consisting of weeds such as Watsonia (*Watsonia bulbifera*), Bulrush (*Typha orientalis*), Arum Lily (*Zantedeschia aethiopica*) and Wild Oats (*Avena fatua*). The upper banks of the Ellen Brook on the southern side contain some Marri trees over weeds with Cornflag dominant (Plate 16). The southern side of Ellen Brook contains scattered Flooded Gums and planted Tasmanian Blue Gums (*Eucalyptus globulus*) (Plate 17).

Plate 15: Weedy Vegetation in the Vicinity of Ellen Brook



Plate 16: Marri Vegetation to the South of Ellen Brook



Plate 17: Vegetation to the North of Ellen Brook



A section of the eastern road reserve south of Ellen Brook contained Marri vegetation with some native heath understorey including *Jacksonia sternbergiana*, *Xanthorrhoea preissii* and *Hakea prostrata* (Plate 18). While the area contained numerous weeds, especially Lovegrass (*Eragrostis curvula*), the site may contain conservation significant flora species or ecological communities. A spring flora and vegetation survey is recommended for this area.

Plate 18: Roadside vegetation along the southern part of Railway Parade



The highly degraded vegetation was considered not likely to represent any of the TECs and PECs listed. The vegetation on the eastern side of the road reserve south of Ellen Brook was in slightly better condition and could potentially represent one of the Ecological Communities in Table 2. A spring flora and vegetation survey is recommended in this area to identify the community type.

2.7.4 Vegetation Condition

The vegetation condition over the site ranged from Completely Degraded for the areas predominantly cleared of native vegetation up to Good to Degraded for the areas containing some remnant native species in the southern road reserve (Table 3).

Table 3: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

2.8 Flora

A search of the DEC Threatened Flora Database, the WA Herbarium database and the Declared Rare and Priority Flora Species List identified nine Threatened and 26 Priority plant species that have been located in the vicinity of the site (Table 4 and 5). The Naturemap database search had no additional species (DEC, 2012a; Appendix 6)

The nine Threatened species under the *Wildlife Conservation Act 1950* are also listed under the EPBC Act. Nine additional Endangered species were identified by the EPBC Act Protected Matters Search Tool (SEWPaC, 2012a) (Appendix 3).

Table 4: List of Flora Species Identified from Database Searches.

Species	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
<i>Acacia anomala</i>	Grass Wattle, Chittering Grass Wattle	Threatened	Vulnerable
<i>Andersonia gracilis</i>	Slender Andersonia	Threatened	Endangered
<i>Caladenia huegelii</i>	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	Threatened	Endangered
<i>Centrolepis caespitosa</i>		Priority 4	Endangered
<i>Darwinia foetida</i>	Muchea Bell	Threatened	Critically Endangered
<i>Drakaea elastica</i>	Glossy-leaved Hammer-orchid	Threatened	Endangered
<i>Eleocharis keigheryi</i>	Keighery's Eleocharis	Threatened	Vulnerable
<i>Eucalyptus balanites</i>	Cadda Road Mallee	Threatened	Endangered
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	Split-leafed Grevillea	Threatened	Endangered
<i>Grevillea christineae</i>	Christine's Grevillea	Threatened	Endangered
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	Curved-leaf Grevillea	Threatened	Endangered
<i>Grevillea curviloba</i> subsp. <i>incurva</i>	Narrow curved-leaf Grevillea	Threatened	Endangered
<i>Lepidosperma rostratum</i>	Beaked Lepidosperma	Threatened	Endangered
<i>Thelymitra dedmaniarum</i> (<i>Thelymitra manginii</i>)	Cinnamon Sun Orchid	Threatened	Endangered
<i>Thelymitra stellata</i>	Star-sun Orchid	Threatened	Endangered
<i>Trithuria occidentalis</i> (<i>Hydatella dioica</i>)	Swan Hydatella	Threatened	Endangered
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	Narrow-petalled Feather-flower	Threatened	Endangered
<i>Ornduffia calthifolia</i> (<i>Villarsia calthifolia</i>)	Mountain Villarsia	Threatened	Endangered
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)		Priority 2	
<i>Stenanthemum sublineare</i>		Priority 2	
<i>Stylidium aceratum</i>	Wongan Hills Triggerplant	Priority 2	
<i>Stylidium squamellosum</i>	Maze Triggerplant	Priority 2	
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	Woolly-bush	Priority 3	
<i>Chamaescilla gibsonii</i>	Blue Stars	Priority 3	
<i>Cyathochaeta teretifolia</i>		Priority 3	
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	Blue Devils	Priority 3	
<i>Guichenotia tuberculata</i>		Priority 3	
<i>Haemodorum loratum</i>		Priority 3	
<i>Halgania corymbosa</i>		Priority 3	
<i>Meionectes tenuifolia</i>		Priority 3	
<i>Platysace ramosissima</i>		Priority 3	
<i>Schoenus capillifolius</i>		Priority 3	

Species	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
<i>Schoenus</i> sp. Waroona (G.J. Keighery 12235)		Priority 3	
<i>Stylidium asteroideum</i>	Star Triggerplant	Priority 3	
<i>Stylidium longitubum</i>	Jumping Jacks	Priority 3	
<i>Stylidium trudgenii</i>		Priority 3	
<i>Tetratheca pilifera</i>	Lilac Bells	Priority 3	
<i>Cyanicula ixiooides</i> subsp. <i>ixiooides</i>	Yellow China Orchid	Priority 4	
<i>Darwinia pimelioides</i>	Sunset Bell	Priority 4	
<i>Hydrocotyle lemnooides</i>	Aquatic Pennywort	Priority 4	
<i>Oxymyrrhine coronata</i>		Priority 4	
<i>Persoonia sulcata</i>	Snottygobble	Priority 4	
<i>Schoenus natans</i>	Floating Bog-rush	Priority 4	
<i>Tripterococcus paniculatus</i>		Priority 4	

A list of the definitions of the Conservation Codes is in Appendix 4.

It is highly unlikely that any of these species would occur in the highly degraded parts of the site. It is possible that some species, particularly shrub species, occur in the slightly better condition vegetation in the southern road reserve. The likelihood of each species occurring on the site is discussed in Table 5. A flora spring flora survey is recommended for the southern road reserve vegetated area.

Table 5: Likelihood of Identified Significant Flora Species occurring on the Site

Species	Preferred Habitat*	Likelihood of presence on site
<i>Acacia anomala</i>	Lateritic soils. Slopes	Unlikely
<i>Andersonia gracilis</i>	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Possible
<i>Caladenia huegelii</i>	Grey or brown sand, clay loam	Unlikely
<i>Centolepis caespitosa</i>	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Possible
<i>Darwinia foetida</i>	Grey-white sand on swampy, seasonally wet sites and on winter-damp to wet clay	Unlikely
<i>Drakaea elastica</i>	White or grey sand. Low-lying situations adjoining winter-wet swamps	Possible
<i>Eleocharis keigheryi</i>	Clay, sandy loam. Emergent in freshwater: creeks, claypans	Possible
<i>Eucalyptus balanites</i>	Sandy soils with lateritic gravel.	Unlikely
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	Peaty sand, clay.	Possible
<i>Grevillea christineae</i>	Clay loam, sandy clay, often moist	Possible
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	Grey sand. Winter-wet heath	Possible
<i>Grevillea curviloba</i> subsp. <i>incurva</i>	Sand, sandy loam. Winter-wet heath	Possible
<i>Lepidosperma rostratum</i>	Peaty sand, clay	Possible
<i>Thelymitra dedmaniarum</i> (<i>Thelymitra manginii</i>)	Granite	Unlikely

Species	Preferred Habitat*	Likelihood of presence on site
<i>Thelymitra stellata</i>	Sand, gravel, lateritic loam	Unlikely
<i>Trithuria occidentalis</i> (<i>Hydatella dioica</i>)	Muddy (inundated) areas	Possible
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	Clay, sandy loam. Seasonally inundated swamps, road verges.	Possible
<i>Ornduffia calthifolia</i> (<i>Villarsia calthifolia</i>)	+ Restricted to the Porongurup Range where it is found in moist sheltered positions on the upper slopes of granite outcrops	Highly Unlikely
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)	Grey peaty sand. Low-lying flats	Possible
<i>Stenanthemum</i> <i>sublineare</i>	Littered white sand. Coastal plain	Possible
<i>Stylidium aceratum</i>	Sandy soils. Swamp heathland.	Possible
<i>Stylidium squamellosum</i>	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.	Unlikely
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	Grey sand, lateritic gravel	Unlikely
<i>Chamaescilla gibsonii</i>	Clay to sandy clay. Winter-wet flats, shallow water- filled claypans	Possible
<i>Cyathochaeta teretifolia</i>	Grey sand, sandy clay. Swamps, creek	Possible
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	Clay, sandy clay. Claypans, seasonally wet flats.	Possible
<i>Guichenotia tuberculata</i>	Sand clay over laterite, sand	Unlikely
<i>Haemodorum loratum</i>	Grey or yellow sand, gravel	Unlikely
<i>Halgania corymbosa</i>	Gravelly soils, soils over granite	Unlikely
<i>Meionectes tenuifolia</i>	Aquatic species	Possible
<i>Platysace ramosissima</i>	Sandy soils	Possible
<i>Schoenus capillifolius</i>	Brown mud. Claypans	Possible
<i>Schoenus</i> sp. Waroona (G.J. Keighery 12235)	Clay or sandy clay. Winter-wet flats.	Possible
<i>Stylidium asteroideum</i>	Gravelly soils	Unlikely
<i>Stylidium longitubum</i>	Sandy clay, clay. Seasonal wetlands.	Possible
<i>Stylidium trudgenii</i>	Grey sand, dark grey to black sandy peat. Margins of winter-wet swamps, depressions	Possible
<i>Tetradlea pilifera</i>	Gravelly soils	Unlikely
<i>Cyanicula ixioides</i> subsp. <i>ixioides</i>	Laterite, gravel	Unlikely
<i>Darwinia pimelioides</i>	Loam, sandy loam. Granite outcrops	Unlikely
<i>Hydrocotyle lemnoides</i>	Swamps	Possible
<i>Oxymyrrhine coronata</i>	Lateritic habitats on the Darling Range	Unlikely
<i>Persoonia sulcata</i>	Lateritic or granitic soils	Unlikely
<i>Schoenus natans</i>	Winter-wet depressions	Possible
<i>Tripterococcus</i> <i>paniculatus</i>	Grey, black or peaty sand. Winter-wet flats.	Possible

* sourced from Florabase (DEC, 2012b), SEWPaC SPRAT Database (SEWPaC, 2012b),
+ Gilfillan and Barrett, 2004, ++ Moody and Les, 2007, +++ Hort, 2013 and ++++ Rye, 2009

2.9 Bush Forever

Ellen Brook has been identified as part of Bush Forever Site 300, Maralla Road Bushland, Ellenbrook/Upper Swan. This site is 641.5ha and links to Bush Forever sites 301 and 399 (Figure 7). The part of Site 300 that is within the site has been identified as Bush Forever as it is vegetation associated with a creekline. The boundary of the Bush Forever site coincides with the Conservation Category Wetland boundary.

2.10 Fauna

2.10.1 DEC Database Search Results

A search of the DEC Threatened Fauna Database (Appendix 7) indicates that fourteen species that are listed as rare or priority have been located in the vicinity of the site. Four of these species were also identified in the Naturemap database searches (Appendix 6; DEC, 2012a). The search of the Protected Matters Search Tool (Appendix 3) identified nine additional species. The species identified in the database searches are summarised in Table 6.

Table 6: List of Fauna Species Identified from DEC Database Searches.

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
<i>Calyptorhynchus banksii</i> subsp. <i>naso</i>	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
<i>Calyptorhynchus baudinii</i>	Baudin's Cockatoo	Schedule 1	Vulnerable
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	Schedule 1	Endangered
<i>Dasyurus geoffroii</i>	Chuditch, Western Quoll	Schedule 1	Vulnerable
<i>Macrotis lagotis</i>	Greater Bilby	Schedule 1	Vulnerable
<i>Pseudemydura umbrina</i>	Western Swamp Turtle, tortoise	Schedule 1	Critically Endangered
<i>Rostratula benghalensis</i>	Painted Snipe	Schedule 1	Vulnerable
<i>Apus pacificus</i>	Fork-tailed Swift	Schedule 3	Migratory
<i>Ardea alba</i>	Great Egret	Schedule 3	Migratory/Wetland
<i>Ardea ibis</i>	Cattle Egret	Schedule 3	Migratory/Wetland
<i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle	Schedule 3	Migratory
<i>Meeorps ornatus</i>	Rainbow Bee-eater	Schedule 3	Migratory
<i>Plegadis falcinellus</i>	Glossy Ibis	Schedule 3	
<i>Rostratula australis</i>	Australian Painted Snipe	Schedule 3	Vulnerable
<i>Morelia spilota</i> subsp. <i>imbricata</i>	Carpet Python	Schedule 4	
<i>Galaxiella nigrostriata</i>	Black-stripe Minnow	Priority 3	
<i>Neelaps calonotos</i>	Black-striped Snake	Priority 3	
<i>Synomen gratiosa</i>	Graceful Sun-moth	Priority 4	
<i>Isoodon obesulus</i> subsp. <i>fusciventer</i>	Southern Brown Bandicoot	Priority 5	
<i>Macropus eugenii</i> subsp. <i>derbianus</i>	Tammar Wallaby (WA subsp)	Priority 5	

The DEC classifies fauna under five different Priority codes and rare and endangered fauna are classified under the Wildlife Conservation (Specially Protected Fauna) Notice 2008 into four schedules of taxa (DEC, 2011). These are outlined in Appendix 4.

2.10.2 Habitat

Fauna habitat can be assessed using a number of factors including, the size of the habitat, the level of habitat connectivity, availability of specific resources (e.g. tree hollows) and overall vegetation quality. The habitat was assessed according to the following categories:

High quality fauna habitat – *These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.*

Very good fauna habitat - *These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally effected by disturbance.*

Good fauna habitat – *These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.*

Disturbed fauna habitat – *These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.*

Highly degraded fauna habitat – *These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance. (Coffey Environments, 2009)*

The habitat in the vegetated areas on the site around Ellen Brook consists of mostly parkland cleared areas however this vegetated area does provide connectivity with other parts of the brook. Therefore this habitat is considered to be Good to Disturbed Fauna Habitat. In the road verge along Railway Parade to the south the existing vegetation has more understorey and therefore is considered to be Good Fauna Habitat. To the north of Ellen Brook the vegetation is more fragmented and has exotic trees planted. This area is considered to be Disturbed Fauna habitat.

2.10.3 Conservation Significant Species

Outlined below is a short description of each of the species that were identified in the database searches and their preferred habitat. The preferred habitat has been used to determine the likelihood of each species to be present on the site.

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (SEWPaC, 2012a). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Forest Red-Tailed Black Cockatoos may potentially visit the site given the presence of Marri trees.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species.

Baudin's Black Cockatoos are seasonally present on the Swan Coastal Plain however are usually found south of the Swan River (Johnstone and Kirkby, 2011). Therefore Baudin's Black Cockatoo is unlikely to be present on the site.

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia*, *Dryandra*, *Hakea*, *Eucalyptus*, *Grevillea*, *Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (SEWPaC, 2012b).

This species has been observed near the site but there is no suitable breeding habitat however there is limited feeding habitat that may be utilised the Carnaby's Black Cockatoos.

Chuditch, Western Quoll (*Dasyurus geoffroii*)

The Chuditch is Western Australia's largest carnivorous marsupial. It is found in South-west Western Australia in sclerophyll forest, dry woodland and mallee shrubland (SEWPaC, 2012b).

The Chuditch is highly unlikely to be present on the site due to the lack of suitable habitat.

Greater Bilby (*Macrotis lagotis*)

The greater Bilby is a nocturnal omnivorous marsupial that shrub species, such as *Acacia kempeana* and *A. hilliana*, which have root-dwelling larvae that provide a constant food source for the Greater Bilby. They also utilise Spinifex hummocks which are quite uniform and discrete, providing runways between hummocks, enabling easier movement and foraging (SEWPaC, 2012b.).

The Bilby is highly unlikely to be present on the site due to the lack of suitable habitat and food source.

Western Swamp Tortoise (*Pseudemydura umbrina*)

The Western Swamp Tortoise is restricted to very few wild populations. During winter and spring, the tortoises live in the water. This species is carnivorous feeding on insects, larvae and tadpoles (Burbidge and Kuchling, 1994). In the drier, hotter months they shelter under leaf litter and in holes and aestivate (sleep) (SEWPaC, 2012b).

The Western Swamp Tortoise occurs in the Ellen Brook Nature Reserve which is approximately 1km upstream from the site. The tortoise has not been recorded in this part of the Ellen Brook and is highly unlikely to be present.

Painted Snipe (*Rostratula benghalensis*)

The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses

This species is unlikely to be present.

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (SEWPaC, 2012b).

This species is unlikely to be found on the site.

Great Egret, White Egret (*Ardea alba (modesta)*)

The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters (SEWPaC, 2012b). This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals (SEWPaC, 2012b).

This species is unlikely to be present on the site due to the proximity of development and the rail.

Cattle Egret (*Ardea ibis*)

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forests (SEWPaC, 2012b). This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals (SEWPaC, 2012b).

This species could possibly occur near the site at intervals but is unlikely to be present on the site.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (SEWPaC, 2012b).

This species prefers open water and as such is unlikely to be present on the site.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eaters that breed in southern Australia are migratory. After breeding, they move north and remain there for the duration of the Australian winter. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year (SEWPaC, 2012b). The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water (SEWPaC, 2012b).

The proximity of the rail means that this species is highly unlikely to be present on the site.

Glossy Ibis (*Plegadis falcinellus*)

The Glossy Ibis is the smallest ibis known in Australia. This species preferred habitat for foraging and breeding are fresh water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation (SEWPaC, 2012b).

This species may be present on the site however is unlikely to be present for a length of time due to the proximity of human populations and the existing rail.

Australian Painted Snipe (*Rostratula australis*)

The Australian Painted Snipe is a stocky wading bird that generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (SEWPaC, 2012b).

This species may be present on the site however is unlikely to be present for a length of time on the site due to the proximity of human populations and the existing rail.

Carpet Python (*Morelia spilota imbricata*)

The Carpet Python is a large snake found across the south-west of Western Australia, from Northampton, south to Albany and eastwards to Kalgoorlie including undisturbed remnant bushland near Perth and the Darling Ranges. This subspecies has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands and grasslands (AROD, 2012). This species prefers denser understorey vegetation, which provides concealment from both predators and prey (Corey and Doody, 2010).

The vegetation on the site near the Ellen brook is largely devoid of understorey and is not suitable habitat and the presence of the road and rail in the southern part of the site means that this species is unlikely to be present.

Black-striped Minnow (*Galaxiella nigrostriata*)

The Black-striped Minnow occurs in temporary black-water swamps where the water is typically acidic (pH 4.5-6.5) (Smith *et al.*, 2002). This species feeds on small insects, larvae of aquatic insects and micro-crustaceans. Breeding is associated with winter rains (Fishbase, 2012).

This species has an outlier population recorded in Melaleuca in a temporary water body and is more common to the far south-west of Western Australia (Smith *et al.*, 2002). The site does not contain ideal habitat for this species and therefore it is unlikely to be present.

Black-striped snake (*Neelaps calonotos*)

This species occurs on dunes and sand plains vegetated with heaths and Eucalypt/*Banksia* woodlands. It feeds largely on skinks and its distribution is restricted and threatened by urban development (DEC, 2012c).

The habitat on the site is not typical of this species and therefore it is unlikely to be present.

Graceful Sun-moth (*Synemon gratiosa*)

The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of *Lomandra maritima* and *Lomandra hermaphrodita* exclusively and therefore require the presence of one or both of these species to be present in an area (Bishop *et al.* 2011).

Lomandra maritima or *L. hermaphrodita* is unlikely to be present on the site therefore the Graceful Sun-moth is unlikely to be present on the site

Southern Brown Bandicoot (*Isoodon obesulus* subsp. *fusciventer*)

Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2012c).

No individuals or typical cone like diggings of this species were identified on the site and the lack of understorey in sheltered places mean this species is unlikely to be present.

Tammar (*Macropus eugenii* subsp. *derbianus*)

Tammars are small wallabies that prefer dense, low vegetation for daytime shelter and open grassy areas for feeding. It is generally found in coastal scrub, heath, dry sclerophyll (leafy) forest and thickets in mallee and woodland (DEC, 2012c).

Tammars were once found over the south-west however in recent years they have not been recorded on the Swan Coastal Plain and are highly unlikely to be present on the site.

The likelihood of each species identified in the database searches being present on the site is summarised in Table 7.

Table 7: Likelihood of Conservation Significant species being present on the site

Scientific Name	Common Name	Likelihood to occur on the site
<i>Calyptorhynchus banksii</i> subsp. <i>naso</i>	Forest Red-tailed Black-Cockatoo	Possible
<i>Calyptorhynchus baudinii</i>	Baudin's Cockatoo	Unlikely
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	Possible
<i>Dasyurus geoffroii</i>	Chuditch, Western Quoll	Highly Unlikely
<i>Macrotis lagotis</i>	Greater Bilby	Highly Unlikely
<i>Pseudemydura umbrina</i>	Western Swamp Turtle, tortoise	Highly Unlikely
<i>Rostratula benghalensis</i>	Painted Snipe	Highly Unlikely
<i>Apus pacificus</i>	Fork-tailed Swift	Unlikely
<i>Ardea alba</i>	Great Egret	Unlikely
<i>Ardea ibis</i>	Cattle Egret	Unlikely
<i>Haliaeetus leucogaster</i>	White-bellied Sea-eagle	Unlikely
<i>Meeorps ornatus</i>	Rainbow Bee-eater	Highly Unlikely
<i>Plegadis falcinellus</i>	Glossy Ibis	Unlikely
<i>Rostratula australis</i>	Australian Painted Snipe	Unlikely
<i>Morelia spilota</i> subsp. <i>imbricata</i>	Carpet Python	Unlikely
<i>Galaxiella nigrostriata</i>	Black-stripe Minnow	Unlikely
<i>Neelaps calonotos</i>	Black-striped Snake	Unlikely
<i>Synomen gratiosa</i>	Graceful Sun-moth	Highly Unlikely
<i>Isodon obesulus</i> subsp. <i>fusciventer</i>	Southern Brown Bandicoot	Unlikely
<i>Macropus eugenii</i> subsp. <i>derbianus</i>	Tammar Wallaby (WA subsp)	Highly Unlikely

Therefore two Schedule 1 listed species (Carnaby's Black Cockatoo and Forest Red-tailed Black-Cockatoo) possibly utilise the Marri and Flooded Gums trees on the site.

2.11 Heritage

2.11.1 Aboriginal heritage

There are no registered Aboriginal Heritage Sites on the site. There is one listed 'Heritage Place' located on the site and the site ID is 3525 (DIA, 2012; Appendix 8). The Heritage Place is listed as Ellen Brook: Upper Swan and is described as a Mythological site. The City of Swan has engaged Big Island Research to conduct a *Review of Aboriginal Heritage Sites recorded within the Proposed Ellen Brook Bridge, Railway parade, Upper Swan* which was completed in June 2012.

2.11.2 European Heritage

There are no listed Heritage Sites or Interim Heritage Sites on the site (Landgate, 2012b; Heritage Council of Western Australia, 2012; SEWPac, 2012c) and none listed on the Swan Municipal Inventory (Landgate, 2012b).

3 IMPACT OF DEVELOPMENT

3.1 Past and Existing Land Use

Previous and Existing land uses within the proposed road and bridge works don't indicate that there are any concerns for development. There has been some residential development and vegetation has been successively cleared in the area. The activities are unlikely to be sources of contamination.

3.2 Surrounding Land Use

The construction of the bridge and road upgrades will not impact on the rail or surrounding agricultural land. The existing land use that may provide some impediment to the proposal is the existing residents as the traffic load on the constructed road will be higher in volume than it is now. Therefore the surrounding existing residents should be consulted at an early stage of planning.

3.3 Geomorphology and Soils

The soils on the site do not provide an impediment to the construction of the road however there are areas that have a High to Moderate and a Moderate to Low risk of ASS.

The WAPC *Acid Sulphate Soils Planning Guidelines* (WAPC, 2009) indicate that “*acid sulphate soils are technically manageable in the majority of cases*”. ASS Investigation and Management Plans will be prepared at subdivision stage once the detailed design of the site is finalised. This will be undertaken in accordance with the *Acid Sulphate Soils Guideline Series: Identification and Investigation of Acid Sulphate Soils and Acidic Landscapes* (DEC, 2009) and *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DEC, 2011). Therefore soils and geomorphology are not an impediment to the construction of the road and bridge.

3.4 Groundwater

The general flow of groundwater to Ellen Brook means that any potential pollutants that could enter the groundwater during and post construction need to be managed to prevent contamination to the groundwater. The impact of the development of the road and bridge will need to be managed within the framework and process detailed in the WAPC's urban water management planning guideline document *Better Urban Water Management* (WAPC, 2008) and most likely will require an Urban Water Management Plan.

The vegetation on the site that is to be retained along Ellen Brook relies on a high water table. To avoid potential impacts on groundwater levels (which in turn could adversely affect wetland areas), no design or construction activities should permanently alter the current groundwater levels in this area.

3.5 Surface Water

Surface water on the site adjacent to Ellen Brook is highly modified. The railway and roads constructed on the site have altered flows and these have been historically changed for at least a

century. There are also several excavated areas acting as drains and dams within the site. Surface water discharge from the bridge and upgraded road should be able to be managed using Water Sensitive Urban Design as outlined in *Better Urban Water Management* (WAPC, 2008).

Baseline studies and detailed hydrological modelling should be undertaken prior to construction to determine that the current hydrological regime can be effectively managed. Construction methods proposed will need to prevent silt, rubbish and pollutants being discharged into Ellen Brook during construction or in the event of significant rainfall during or post construction.

3.6 Ellen Brook

Railway Parade will traverse a section of Ellen Brook which is a Conservation Category (CC) Wetland (UFI 15734). The construction of a bridge on the site will impact on riparian vegetation and has the potential to impact on the water quality and quantity downstream. This may be an impediment to the approval for the construction of the bridge.

The site is not within the Swan River Trust Development Control Area and therefore this body will not be an approving authority however they should be consulted during the design process.

This part of Ellen Brook was included in the Riparian Concept Plan that was prepared by the Ellen Brockman Integrated Catchment Group. This group has significant experience in rehabilitation and weeding the riparian area within Ellen Brook and should be consulted during the rehabilitation process.

The objectives for managing Conservation Category wetlands have been defined by Hill *et al.* (1996) and in *Environmental Guidance for Planning and Development – Guidance Statement No. 33* (EPA, 2008). These are outlined below in Table 8.

Table 8: Management Objectives for Conservation Category Wetlands

Management Category	General Description	EPA Management Objectives (EPA, 2008)
Conservation Category Wetland (CCW)	Wetlands which support high levels of attributes and functions.	<p>Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including:</p> <ul style="list-style-type: none"> • reservation in national parks, • crown reserves and State owned land, • protection under Environmental Protection Policies, and • wetland covenanting by landowners. <p>No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.</p>

Revegetation and weeding of nearby sections of Ellen Brook should be investigated as an offset for the small amount of clearing that will need to occur to construct the bridge.

Operational Policy 4.3 – *Identifying and Protecting Waterways Foreshore Areas* is the policy that will apply in the flood plain area and the considerations in the policy include:

- Determining the foreshore using technical studies (to be determined by hydrological modelling for flood events);
- Employing the requirements outlined in Better Urban Water Management (WAPC, 2008) to be included in the UWMP;
- Vegetation Management in the foreshore area; and
- Rehabilitation of vegetation in the foreshore area.

During the development of the design of the bridge the Western Australian Floodplain Management Strategy may apply if released. The floodplain is narrow where the proposed bridge will be constructed and further hydrological modelling needs to be undertaken to determine the impact of the bridge on the floodplain and flood fringe.

3.7 Wetlands

Aside from Ellen Brook there are two Multiple Use wetlands and one Resource Enhancement wetland on the site. Resource Enhancement and Multiple Use wetlands do not have statutory protection however may be considered significant by the DEC. Construction in the wetland areas may be a concern to the DEC.

The management categories and objectives for these wetlands are outlined in Table 9.

Table 9: Management Objectives for Resource Enhancement and Multiple Use Wetlands

Management Category	General Description	EPA Management Objectives (EPA, 2008)
Resource Enhancement Wetland (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use Wetland (MUW)	Wetlands with few attributes which still provide important wetland functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

The Resource Enhancement wetland is highly modified and has only minimal tree cover. To protect as many of the trees as possible a wetland management plan may be required for the parts of the Resource Enhancement wetland that are not proposed to have Railway Parade constructed on it. The DEC Wetlands Branch should be consulted to ensure the Multiple Use wetlands and Resource Enhancement wetland do not pose a constraint to the development.

3.8 Gauging Station

The Ellen Brook Flow Gauging Station is an important asset used to monitor the health of Ellen Brook. The station is on the eastern side of the railway and therefore not likely to be directly

impacted. Indirect impacts may occur during construction such as dust, vibration, diversion of flows or dewatering which may impact on the accuracy of the results of the station's measurements. The construction of the bridge will need to be undertaken to minimise these possible impacts on the station. The Department of Water will need to be kept informed during all stages of works to ensure data from this period is analysed with the potential impacts in mind.

3.9 Vegetation

The development of the site will result in clearing vegetation on the site which is mostly in Degraded to Completely Degraded condition. The vegetation is unlikely to be representative of a TEC or PEC and is unlikely to be significant. Vegetation on the eastern side of Railway parade, south of Ellen Brook should be surveyed to determine its floristic type. A Vegetation and Rehabilitation Management plan may be required for the protection of the remaining vegetation and to guide the implementation of a rehabilitation program. Revegetation and weeding of nearby sections of Ellen Brook should be investigated as an offset for clearing to construct the bridge and upgrade the road.

3.10 Flora

There are a number of priority species that could possibly be present on the site. Priority species are not protected under the *Wildlife Protection Act, 1950* however the EPA may consider the vegetation to be significant if these species are present. Therefore a Level 2 spring flora survey should be undertaken prior to the road alignment being designed to ensure that any threatened or priority species present on the site are protected as much as possible. This should be undertaken in accordance with *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* - Guidance Statement No. 51 (EPA, 2004a).

3.11 Bush Forever

The Bush Forever and Related Lands MRS Amendment No. 1082/33 gave statutory effect in the MRS that applies in addition to the underlying local government town planning scheme zoning provisions. Under State Planning Policy (SPP) 2.8 *Bushland Policy for the Perth Metropolitan Region* (WAPC, 2010) there is:

a general presumption against the clearing of regionally significant bushland, or other degrading activities.

The exception relevant to the proposed road and bridge construction is:

except where a proposal or decision—

(a) is consistent with existing approved uses or existing planning/environmental commitments or approvals.

The site is shown as a local road reserve within City of Swan's LPS 17 and therefore as an existing approved use the clearing of vegetation may be permitted. The WAPC is the current approving authority for impacts on Bush Forever and therefore should be consulted during the design process.

It is likely that a vegetation management plan for the parts of the site that are not going to be cleared will be required along with methods for rehabilitation of areas that are disturbed during the construction of the road and bridge.

3.12 Fauna

A Level 2 Fauna survey as outlined by *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56*. (EPA, 2004b) is not recommended for the site for general fauna assemblages. Further fauna studies for targeted species may be required.

Two Schedule 1 listed species (Carnaby's Black Cockatoo and Forest Red-tailed Black-Cockatoo) have been determined to possibly be present on the site. The habitat requirements for Carnaby's Black Cockatoo include foraging (*Banksia* species, Parrot Bush and other Proteaceous shrubs), roosting (tall eucalypts and pines) or breeding habitat (Eucalypt trees). There are very few Proteaceous shrubs and no trees on the site therefore it is concluded that the site contains very little suitable habitat for Carnaby's Black Cockatoo. Development of the road and bridge is unlikely to impact on this species.

The Forest Red-tailed Black Cockatoo feeds on Marri seeds and there are a few specimens of this tree on the site. While the removal of these trees is unlikely to have a significant impact on this species any trees that can be retained within the road reserve should be.

The two Black Cockatoo species that have been determined to possibly be present on the site are listed under the EPBC Act and as such any impact will need to be examined in the context of the *Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2009). It is recommended that a Significance Test for Commonwealth Matters of National Environmental Significance focussed on Black Cockatoos be undertaken against the criteria set out in the *Significant Impact Guidelines 1.1* (SEWPaC, 2009).

The Western Swamp Tortoise is located in the Ellenbrook Nature Reserve which is a Class A nature reserve (which under the Western Australian Land Act the Nature Reserve cannot be cancelled, reduced in area or used for any other purpose unless by Act of Parliament). This reserve is vested in the National Parks and Nature Conservation Authority and managed by the Western Australian Department of Environment and Conservation (Burbidge and Kuchling, 1994). The *Western Swamp Tortoise Recovery Plan* looks to ensure there is no impact on the quality and quantity of water in the reserve.

The Ellenbrook Nature Reserve is located approximately 1km upstream (of watercourse – this is approximately 500m as the crow flies) of the site. The construction of the bridge is highly unlikely to impact on the water quantity due to the separation of the site and the habitat area for the tortoise. Water quality in the reserve is highly unlikely to be impacted as the site is downstream of the habitat area.

The site is on the boundary within the Environmental Protection (Western Swamp Tortoise Habitat) Policy (EPP) and as such any development in the area must not include the following activities:

- (a) the application of fertilisers and pesticides; and
- (b) the disposal of liquid and solid wastes; and
- (c) the discharge of polluting substances; and

- (d) the extraction of basic raw materials; and
- (e) the construction of drainage systems; and
- (f) the placement of fill; and
- (g) the abstraction of groundwater; and
- (h) the clearing of vegetation; and
- (i) the lighting of unauthorised fires. (EPA, 2011).

Parts e, f, g and h may describe activities to do with the construction of the bridge. Guidance Statement 7, *Protection of the Western Swamp Tortoise Habitat, Upper Swan/Bullsbrook* (EPA, 2006) states, *the Western Swamp Tortoise Habitat EPP has the purpose of protecting Western Swamp Tortoise habitat*. The statement reiterates the potential for the activities listed in the EPP to degrade the Western Swamp Tortoise habitat and suggests management plans to address factors associated with development in the area. These can be addressed as part of an Urban Water Management Plan and in a Construction Environmental Management Plan.

The relevant management plans for the construction of the road and bridge are likely to be required to address the following issues in the context of potential impacts on the Western Swamp Tortoise:

- Nutrient and drainage management;
- Fire management; and
- Native vegetation protection and revegetation.

The Western Swamp Tortoise is also listed as Critically Endangered and under the EPBC Act. Under this Act a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts. If a proposed action is deemed to have a significant impact, this action should be referred to the Minister. Therefore if any risks to groundwater quality or quantity, fire risk and impacts on the vegetation in the Western Swamp Tortoise habitat that are identified during the studies for the Urban Water Management Plan and other design studies for the site will need to be examined in the context of the *Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2009).

3.13 Heritage

The 'Heritage Place' located on the site is registered with the Department of Indigenous Affairs and as such advice on the implications under the *Aboriginal Heritage Act 1976* of the Heritage Place mapped over the site are being investigated by the Aboriginal Heritage Consultants Big Island Research.

3.14 Consultation

3.14.1 Initial Consultations

Following the preliminary studies undertaken for the preparation of this environmental assessment the following groups were consulted:

- Swan River Trust (SRT);
- Department of Environment and Conservation (DEC);

- Land Use Planning Branch; and
 - Wetlands Branch.
- Office of the Environmental Protection Authority (OEPA);
- Department of Planning (DoP); and
- Department of Water DoW.

The outcomes of the consultations are outlined in Table 11.

Table 10: Results of Initial Consultations

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
OEPA	Gerard O'Brien	Email 11/03/13. Reply received 12/03/13	<p>Contact the Department of Water regarding impacts to Ellenbrook and bed and banks permits. DEC Swan Region may also need to be contacted if Ellenbrook is mapped as a CCW.</p> <p>If after this advice has been received it is determined that the construction is considered a 'significant proposal' and needs to be referred to the EPA under section 38 of the Environmental Protection Act 1986, the OEPA should be contacted.</p>	<p>The DoW and DEC were contacted.</p> <p>The OEPA will be contacted if referral to the EPA is to be undertaken</p>
DoW	James MacKintosh and Briony Lyons	Meeting 22/03/13. Follow-up email sent 22/13/13. Confirmation of minutes sent from DoW 26/03/13	The Department of Water will be the advisory body for the Ellen Brook part of the road and bridge as this is a waterway. In this context the Conservation Category for Ellen Brook in the DEC Geomorphic Wetlands dataset is a guide for condition only. Therefore the DoW policies apply in this area.	Noted
			Although not strictly applicable the relevant policy will be <i>Operational Policy 4.3 – Identifying and Protecting Waterways Foreshore Areas</i> which superseded <i>Foreshore Policy No. 1 – Identifying Foreshore Reserve</i> in September 2012 (the draft Western Australian floodplain management strategy may apply if released).	During detailed design and modelling should be undertaken to
			The approvals required from the DoW is a Bed and Banks Licence (under the <i>Rights in Water and Irrigation Act, 1914</i>).	To be applied for in due course
			The DoW will potentially provide advice during the approvals process to the EPA if a Section 38 referral is made or to WAPC in the form of recommended conditions.	Noted
			Hydrological modelling in the brook and in the floodway will be required.	The City of Swan has already planned to undertake this as a routine part of bridge design and the results will be provided to DoW.

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
DoW	James MacKintosh and Briony Lyons	Meeting 22/03/13. Follow-up email sent 22/13/13. Confirmation of minutes sent from DoW 26/03/13	Simon Rodgers from DoW is the initial contact to discuss the potential issues in the context of the modelling and hydrological processes.	Noted – Simon Rodgers was contacted and provided information on the Floodplain and Flood Fringe
			The preference is for the bridge to not have pylons in the floodplain or waterway but could be considered in the context of hydrological modelling assuring minimal impact of the design.	Noted
			There is a possibility that the removal of the culvert, which has been constructed privately but is in Parks and Recreation zoned land, may be recommended as part of the works.	Noted
			Bernie Kelly is the initial contact regarding the gauging station and the potential impact of the construction of the bridge on the data from this station. There may be a possibility that the removal of the culvert could affect this data also.	To be contacted during the design phase
			There may be a requirement for a water management document prior to construction which will need to address sedimentation issues and silt trapping.	This is expected to be addressed in the CEMP (Section
			ASS will need to be addressed during construction.	Noted
			DoW indicated that the Swan River Trust should be consulted.	The City of Swan has consulted with the SRT
			DoW indicated vegetation could be an issue to be addressed with consultation with the DEC.	Detailed surveys have been planned for the site and initial consultation with DEC is being undertaken.

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
DoW – Floodplain Management	Simon Rodgers	Email 16/04/13 forwarded by James Mackintosh, Follow-up email 17/04/13	The Department of Water, in carrying out its role in floodplain management, provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage. The Department uses the following guiding principles to ensure proposed development in floodprone areas is acceptable with regard to major flooding: <ul style="list-style-type: none"> Proposed development has adequate flood protection. Proposed development does not detrimentally impact on the existing flooding regime of the general area. 	To be addressed during design Site Specific Floodway and Floodplain mapping to be undertaken during the design process.
			With regard to this proposal there is an existing railway bridge and DOW gauging station that need to be considered with regard to the second guiding principle above.	To be assessed after modelling information is available
DEC - Wetlands Branch	Michael Coote and Anthea Jones	Email 18/03/13; Phone Call 18/03/13 and follow-up emails 18/03/13 and 19/03/13	The DEC wetlands branch identified the following to be included, but not limited to, during the design process: <ol style="list-style-type: none"> The hydrology of the Ellen Brook would have to be maintained during and post construction The clearing of native vegetation should be minimised The Ellen Brook is a fauna corridor and the bridge should not be a barrier in the long term (ie for birds and species such as Quenda) Impact on the buffer to the Ellen Brook and designing the bridge within that buffer to have minimal impact as well as through the actual wetland 	Hydrological modelling to ensure impacts on the hydrology of Ellen Brook are minimised should be undertaken. Vegetation linkage to be investigated during design.
			The wetlands branch would also require the construction of the bridge to have as little impact as possible and should take into account: <ol style="list-style-type: none"> Construction techniques such as dewatering should be minimised Studies into time of year that will be optimal for preventing impacts downstream The impact on the movement on fauna must be minimised during construction 	A Construction Environmental Management Plan should be prepared prior to construction.

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
DoP – Policy Development (Bush Forever)	Tracey Scroop John DiRosso and Loretta Van Gasselt	Meeting 26/03/13, follow-up email 27/03/13; agreement on minutes via email 27/03/13	The Department of Planning – Bush Forever Branch (Policy Development) may be a referral body for the bridge during the approvals process to potentially the EPA under a Section 38 referral. The WAPC has a Memorandum Of Understanding with DEC which any development application sent to the WAPC for determination are referred to the DEC for comment and recommendations. Policy Development can be an informal referral agency during the design stage of the bridge/road to the local government.	The City of Swan has liaised with DEC on this project
			The site is partially in Parks and Recreation land. Policy Development would not recommend development (infrastructure/ road works/batters/ drainage etc.) in the Parks and Recreation reservation as it is inconsistent with the reservation. Tim Hillyard should be contacted regarding the proposal and liaison for confirmation of the implications of the zoning.	Tim Hillyard was consulted – outcomes are listed below
			City of Swan have indicated that works in the Parks and Recreation area would be restricted to the road alignment as shown in the cadastral boundaries.	Noted – to be part of the construction brief
			Hydrological modelling in the brook and in the floodway will be required – to ensure minimal impact on the Bush Forever site.	This is a routine part of bridge design and the results will be provided to Policy Development.
			It was flagged that the site is near the Swamp Tortoise EPP area. The site is downstream from the habitat for this species and the design and management of construction will address the Environmental Protection (Western Swamp Tortoise Habitat) Policy and will refer to EPA Guidance Statement 7, Protection of the Western Swamp Tortoise Habitat, Upper Swan/Bullsbrook.	To be included in hydrological modelling to ensure there is no risk of impact on the Western Swamp Tortoise Habitat
			Policy Development indicated there are TECs present to the east. The vegetation is Degraded and is unlikely to be a TEC	To be confirmed in detailed surveys (level 2 flora and vegetation survey).

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
DoP – Policy Development (Bush Forever)	Tracey Scroop John DiRosso and Loretta Van Gasselt	Meeting 26/03/13, follow-up email 27/03/13; agreement on minutes via email 27/03/13	It was noted that the design and construction of the bridge should: <ol style="list-style-type: none"> 1. Employ the approach of avoid the need to clear/disturb Bush Forever vegetation in the first instance and any unavoidable impacts should be minimised and offset (mitigated against). 2. Disturb as little vegetation as possible; 3. Include rehabilitation areas (potentially including some offsets); 4. Include fencing to restrict access to other parts of the Bush Forever site to prevent degradation by unauthorised access and dumping; 5. Ensure that the contractors place construction compounds in areas that are already cleared; and 6. It was noted that DOW and DEC requested minimal impact on the waterways, which is also supported by Policy Development 	A Construction Environmental Management Plan should be prepared prior to construction.
DoP	Tim Hillyard	Phone Conversation 22/04/13. Follow-up email sent 22/04/13	The crossing is supported from a planning point of view and there are precedents in the area that have been undertaken in similar circumstances in which environmental impacts have been managed appropriately. At this time a Section 48 rezoning will not be required.	Noted
SRT	Sue Osborne	Email 12/04/13, Phone Call and follow-up email 15/04/13	The Trust notes that the City of Swan is liaising with the Department of Environment and Conservation (DEC) and the Western Australian Planning Commission (WAPC) both of whom will provide advice relating to whether it is necessary to conduct an acid sulfate soil investigation and subsequently design and implement an acid sulfate soil management plan.	Acid Sulphate Spoils Management will be investigated and plans prepared once the design is complete and the disturbance areas known.

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
SRT	Sue Osborne	Email 12/04/13, Phone Call and follow-up email 15/04/13	The Trust would expect the bridge design to incorporate features to ensure the appropriate management of storm water which, where practicable, would be in line with the principles of Better Urban Water Management and include the provision of on-site retention, treatment, and infiltration infrastructure providing an effective treatment train for surface waters prior to discharge into the Brook; e.g. drainage from constructed road surfaces to be channeled through appropriate treatment infrastructure to remove gross pollutants, sediment and hydrocarbons; the surface treatments of all slopes and batters designed to minimize the risk of erosion and generation of sediment laden surface runoff.	An Urban Water Management Plan will be prepared in due course.
			Construction planning and management should incorporate provisions to prevent the discharge of sediment laden surface water runoff into the Ellen Brook at all stages of construction. In addition, industry best management practices should be adopted for any on-site storage and vehicle transfer of fuel and the storage and use of chemicals. It would be appropriate to maintain spill kits on site during construction.	A Construction Environmental Management Plan and Urban Water Management Plan should be prepared prior to construction.

Stakeholder/s	Contact	Method of Contact	Issue/Advice	Management/ Outcome
SRT	Sue Osborne	Email 12/04/13, Phone Call and follow-up email 15/04/13	<p>In relation to biodiversity:</p> <ul style="list-style-type: none"> • The Trust supports any initiative to minimize the clearing of native vegetation and fauna habitat and encourages the City of Swan to commit to reinstating native vegetation by controlling weeds and planting locally native species in disturbed areas. • The Trust notes that the proposed bridge is located adjacent to other bridges across Ellen Brook which presents the possibility of increased habitat fragmentation. While recognizing that the City is constrained, any opportunity to minimize the risk of fragmentation would be supported. • Site management during construction should minimize impacts on wildlife by implementing dieback hygiene protocols, minimizing the risk of starting bushfires and maintaining fire fighting preparedness during summer months, and preventing wildlife access to wastes, in particular waste that could attract feral animals, • While unlikely to present an issue, the Trust can provide advice if there are any concerns regarding the design of water flows beneath the bridge, to make sure that fish and other aquatic fauna barriers are not constructed inadvertently. 	A Vegetation and Rehabilitation Plan should be prepared prior to construction that addresses weed management and revegetation

3.14.2 Future Consultation

Consultation should be undertaken during the design phase and should include all parties consulted initially and:

- Existing landowners along the proposed upgraded area of the road; and
- Ellen Brockman Integrated Catchment Group.

The Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC) may need to be consulted if any Matters of National Significance are going to be impacted by the development of the road and bridge however at this point this appears to be unlikely to be required. The requirement will depend on the number of habitat trees and foraging habitat that is to be cleared in the development footprint which will be measured for the Significance Test.

4 FUTURE REQUIREMENTS

4.1 Approvals

The following environmental approvals will be required to construct the road and bridge:

- Bed and Banks Licence;
- Clearing Permit; and
- Potentially an EPA approval of a Development Application under Section 38 of the EP Act.

In accordance with advice from WAPC rezoning and therefore referral to the EPA under Section 48 of the EP Act is not required.

4.2 Further Studies

The following studies have been identified in this Environmental Assessment:

- Hydrological modelling of the Ellen Brook needs to be undertaken for the pre and post construction scenario. The modelling will need to address:
 - Impacts of the design of the bridge on the floodplain and flood fringe;
 - The design of pylons, if required, in Ellen Brook ensuring minimal impact on river flow;
 - The impact of potentially removing the culvert crossing downstream;
 - Adequate flood protection for the bridge;
 - Impact on the existing flooding regime of the general area of the upgraded road;
 - Potential impact on the Western Swamp Tortoise habitat upstream from the proposed crossing;
 - Potential impact on the results from the Gauging Station
- The development of the bridge design and construction will also require investigation of Acid Sulphate Soils in the areas of disturbance. This may be part of detailed geotechnical studies required for the road.
- A Level 2 Flora and Vegetation Survey is recommended.
- A Significant Impact Test on the site for Matters of National Environmental Significance as listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

4.3 Design Considerations

The design of the bridge should impact as little as possible on the following areas:

- Hydrological regime including ground and surface water of the site;
- Ground and surface water quality;
- Existing vegetation;
- Existing habitat values for fauna including bandicoots and avifauna;
- Potential disturbance to the Gauging Station;
- Downstream impacts in Ellen Brook including water quality and quantity; and
- Dewatering during construction.

4.4 Management Plans

The following management plans are likely to be required once the design of the road and bridge is complete.

Prior to construction an Environmental Construction Management Plan (CEMP) should be prepared and should include but not be limited to:

- Management of erosion and sedimentation;
- Waste Management (including human generated site rubbish);
- Excavation and stockpiling of soil;
- Storage and handling of fuels, chemicals and materials;
- Management of contamination;
- Dust suppression
- Site access;
- Public access and safety;
- Protection of existing vegetation;
- Machinery;
- Details of imported fill (certified clean, uncontaminated, free from rubble, weeds and dieback);
- Protection of the waterway from inputs of deleterious matter;
- Sedimentation and the turbidity management in the river;
- Management of dewatering (if any);
- Fire Management;
- Stabilisation and rehabilitation of riverbank on completion of works;
- Hours of operation including timeframes and responsibility for tasks identified; and
- Management of complaints and incidents.

An Acid Sulphate Soil Management Plan in accordance with DEC guidance *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DEC, 2011) is likely to be required once the depth and area of disturbance is known and investigations have been undertaken.

A Vegetation and Rehabilitation Plan should also be prepared for the area of disturbance for the road and bridge construction, the surrounding area and potentially for an offset area that is degraded in the surrounding Bush Forever site. This plan should address:

- Current site conditions (including existing vegetation and weed maps);
- Vegetation protection during construction;
- Objectives for the rehabilitation;
- Site preparation techniques such as soil management;
- Weed control methodology;
- Species selection for planting;
- Planting detail showing areas best suited to different species such as lower banks, mid bank and upper banks;
- Follow-up maintenance schedules; and
- Completion Criteria.

Management of surface and groundwater will need to be detailed in an Urban Water Management Plan as outlined in Better Urban Water Management and include:

- Stormwater management using Water Sensitive Urban Design;
- Management of gross pollutants;
- Management of groundwater
- Water quality monitoring program (upstream, downstream and groundwater) including:
 - Visual and physical (colours/odour, floatable matter);
 - Field monitoring of pH;
 - Temperature;
 - Turbidity;
 - Total dissolved solids;
 - Dissolved oxygen;
 - Conductivity;
 - Metals (including iron and aluminium);
 - Anions (chloride and sulphate); and
 - Total acidity
- Trigger values for water quality that require remedial action; and
- Requirements from the *Stormwater Management Manual for WA* (Department of Water, 2007).

The portion of the Resource Enhancement Wetland that is not in the road reserve and therefore not going to be developed may also require a Wetland Management Plan. The Wetland Management Plan should include:

- Description of the site characteristics including topography, flora, vegetation and fauna;
- Management of road interface;
- Fencing;
- Fire control;
- Integration of stormwater drainage features and drainage management;
- Management actions/strategies required to maintain the wetland values, and mitigate potential impacts;
- Vegetation management including weed control and revegetation;
- Flora species (native) to be used in rehabilitation of the wetland area and buffer, proposed densities and numbers, and location of planting;
- Weed management;
- Recommendations on monitoring the success of plantings within revegetation areas, wetland health, and fauna, where applicable; and
- Additional requirements from
 - *Guidelines Checklist for Preparing a Wetland Management Plan* (DEC, 2008);
 - Attachment B4-5 in *Environmental Guidance for Planning and Development* – Guidance Statement 33 (EPA, 2008);
 - *Environmental Protection of Wetlands* – Position Statement No.4 (EPA, 2001); and
 - *Wetlands Conservation Policy for Western Australia* (Government of Western Australia, 1997).

5 SUMMARY AND CONCLUSIONS

The Environmental Factors that were studied in this investigation were:

- Past and Existing Land Use;
- Surrounding Land Use;
- Topography;
- Geomorphology and Soils;
- Surface and Groundwater;
- Wetlands;
- Vegetation;
- Flora;
- Fauna; and
- Heritage.

The results of the Environmental Assessment have been summarised in Table 11.

Table 11: Environmental Assessment

Factor	Description	Constraint to Development	Further Studies Required	Future Studies/ Management Plans
Past and Existing Land Use	A road has been cleared on the site in the past, rail has been constructed for over a century	No	No	No
Surrounding Land Use	Mostly rural	No	No	No
Zoning	Part of the Railway Parade Road Reserve is zoned as Parks and Recreation under the MRS	No	No	No
Geomorphology and Soils	Varied soil types from riverine to upland	No	No	Geotechnical studies prior to construction
	ASS risk mapped on the site	No	Yes	ASS Investigation and if required Management Plan
Groundwater	Groundwater flows to Ellen Brook and therefore could have downstream impacts	Possibly	Yes	Detailed groundwater studies and modelling for the design of the bridge and Urban Water Management Plan
	Impacts to groundwater in Western Swam Tortoise habitat	Unlikely	Yes	
Surface Water	Surface Water flows to Ellen Brook	Possibly	Yes	Detailed surface water studies and modelling for the design of the bridge and Urban Water Management Plan

Factor	Description	Constraint to Development	Further Studies Required	Future Studies/ Management Plans
Ellen Brook	Ellen Brook is a main tributary to the Swan River	Possibly	No (except Surface and Groundwater studies)	Urban Water Management Plan, Vegetation and Rehabilitation Management Plan
Gauging Station	Water quality and quantity measurement for Ellen Brook	Possibly	No	Construction Environmental Management Plan
Wetlands	Two Multiple Use Wetlands	Unlikely	No	No
	One Resource Enhancement Wetland	Possibly	No	Wetland Management Plan and/or discussed in the Urban Water Management Plan
Vegetation	Vegetation mostly degraded	Unlikely	Yes	Level 2 Spring Flora Survey.
Rehabilitation	In areas disturbed by construction and potentially degraded areas as an offset	NA	No	Vegetation and Rehabilitation Management Plan
Flora	Possible Priority flora present	Possibly	Yes	Level 2 Spring Flora Survey.
Bush Forever	Ellen Brook wetland boundary is a Bush Forever site	No	No	Vegetation Management Plan and Construction Environmental Management Plan
Fauna	Fauna assemblage	No	No	Fauna relocation addressed in Construction Environmental Management Plan
	Black Cockatoos	Unlikely	Yes	Significance Test for Black Cockatoos
	Western Swamp Tortoise		No	Addressed in Urban Water Management Plan and Construction Environmental Management Plan
Heritage	Heritage Place 3525	To be advised by Big Island Research		Section 18 Clearance if required

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FIGURES

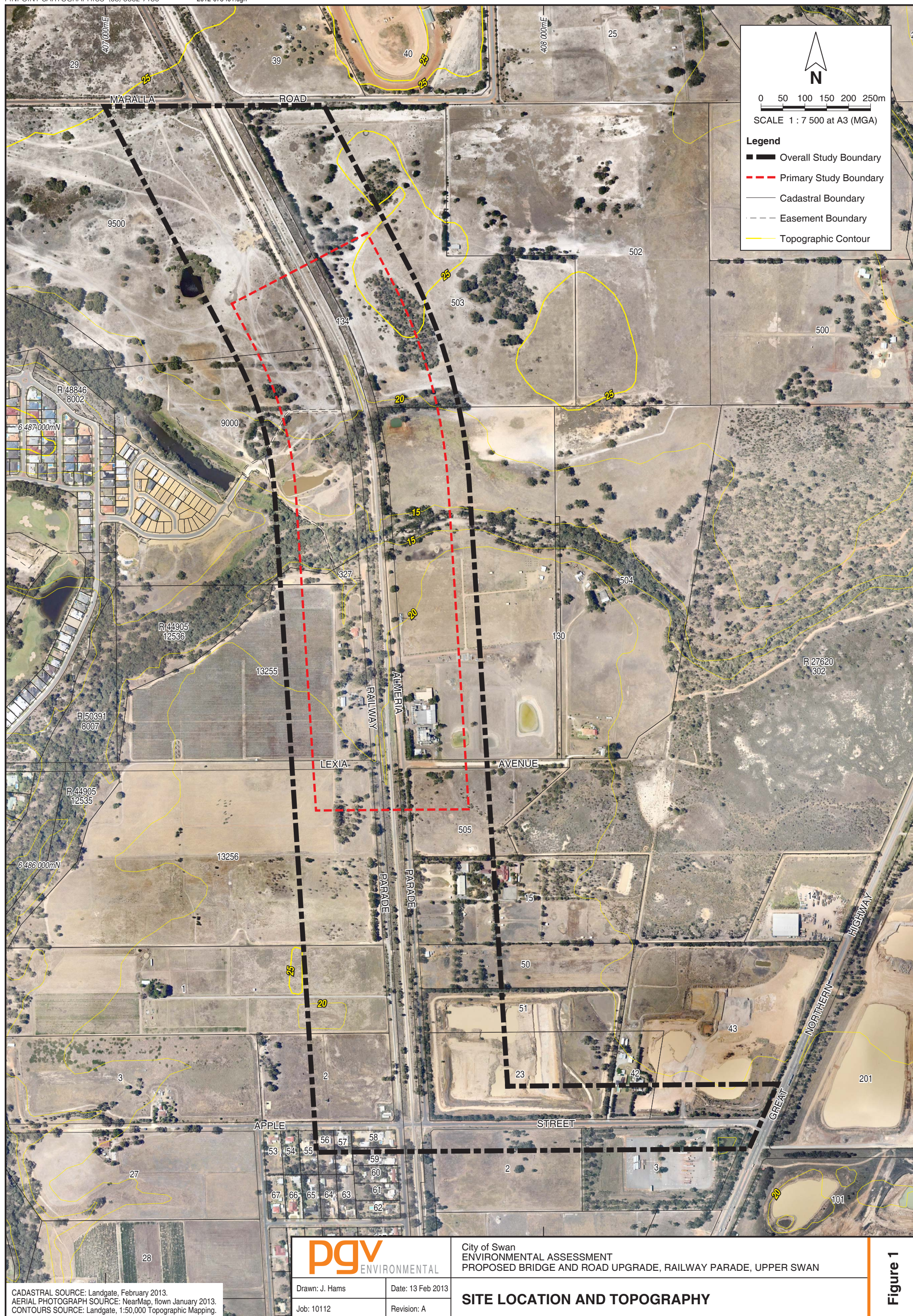
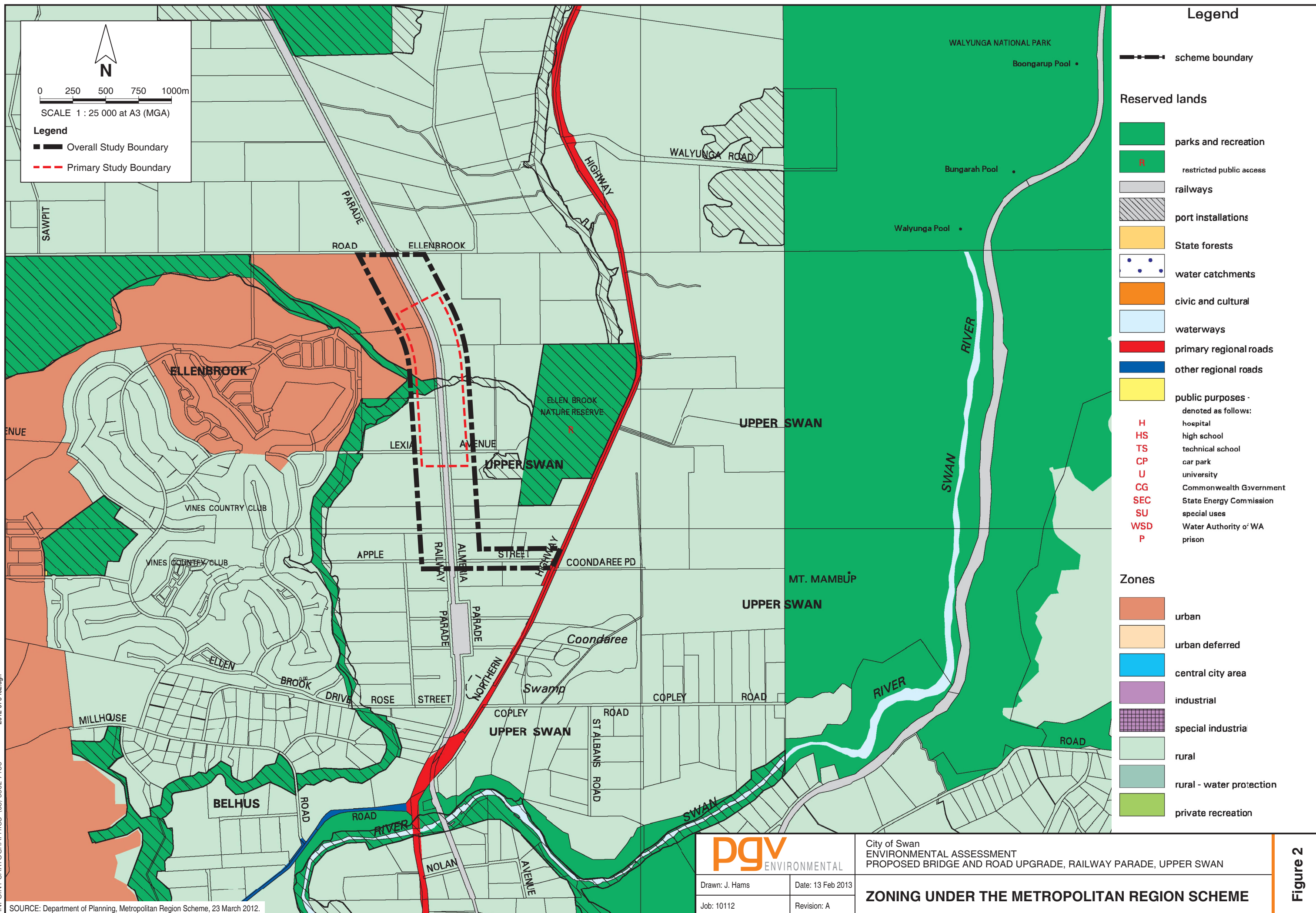
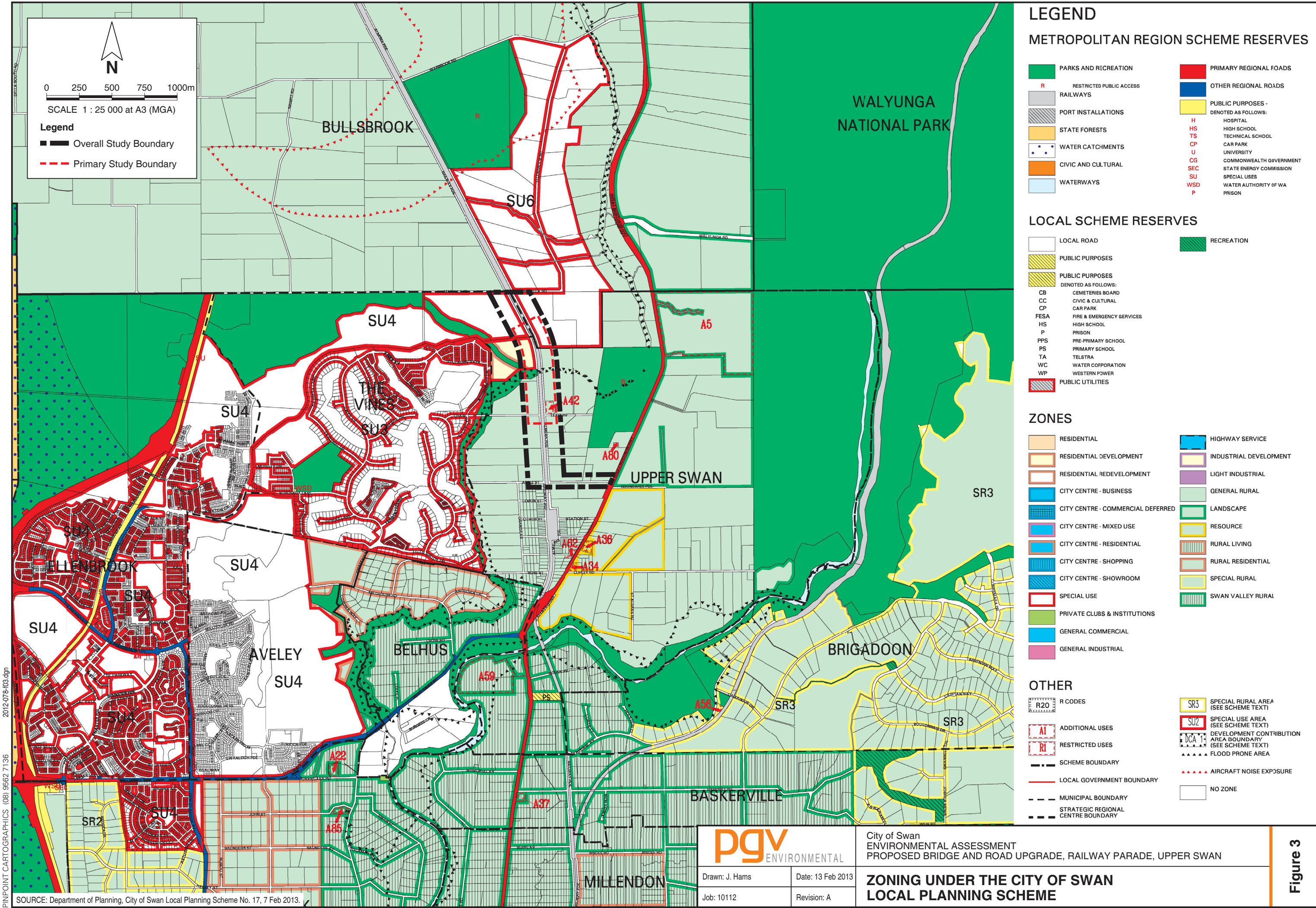


Figure 1

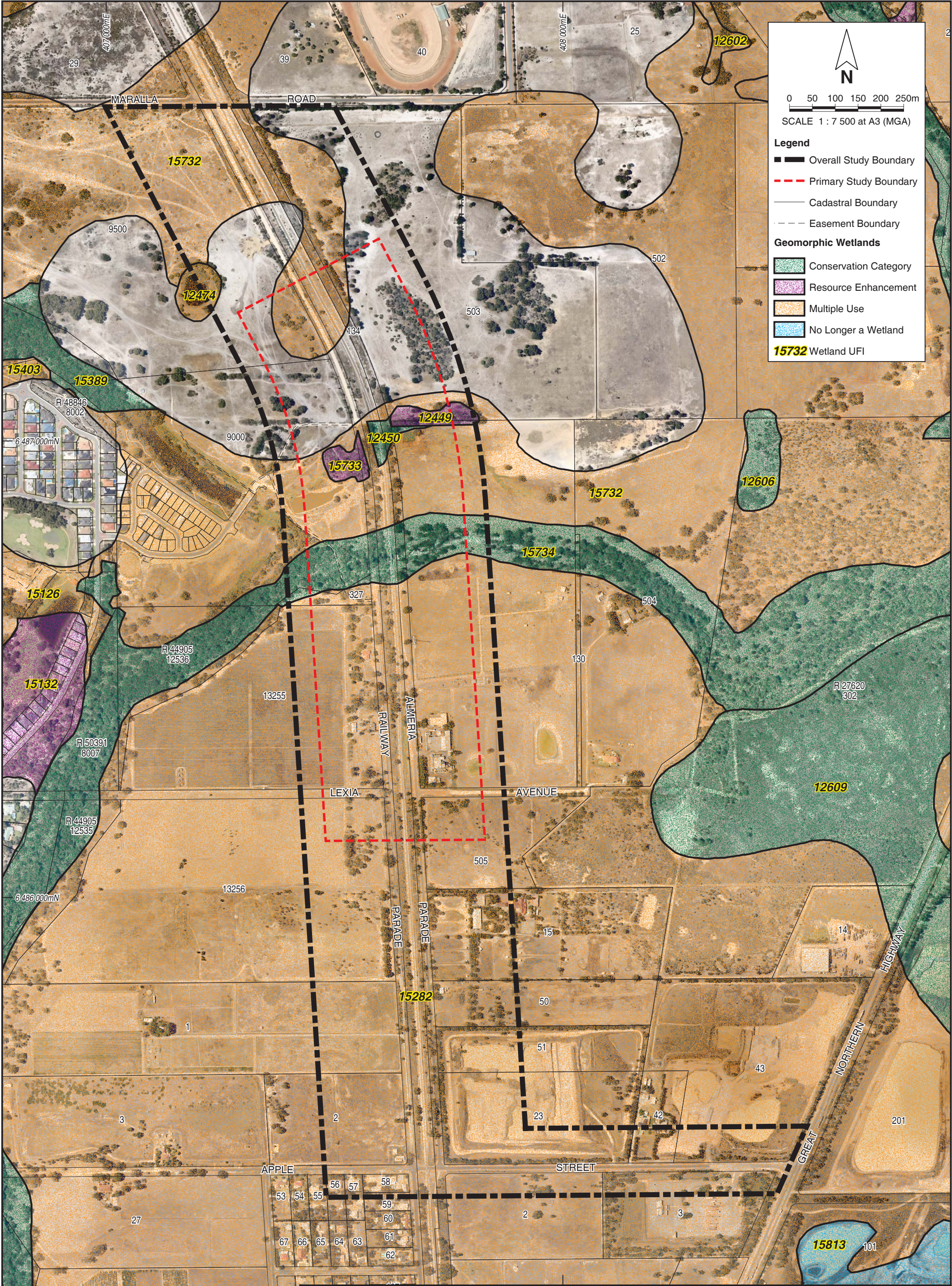




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SOURCE: Department of Planning, City of Swan Local Planning Scheme No. 17, 7 Feb 2013.





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SCALE 1 : 7 500 at A3 (MGA)

Legend

Overall Study Boundary

Primary Study Boundary

Cadastral Boundary

Easement Boundary

Geomorphic Wetlands

Conservation Category

Resource Enhancement

Multiple Use

No Longer a Wetland

15732

Wetland UFI

WETLANDS SOURCE: DEC, February 2013.
CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.

pgv

ENVIRONMENTAL

Drawn: J. Hams

Date: 13 Feb 2013

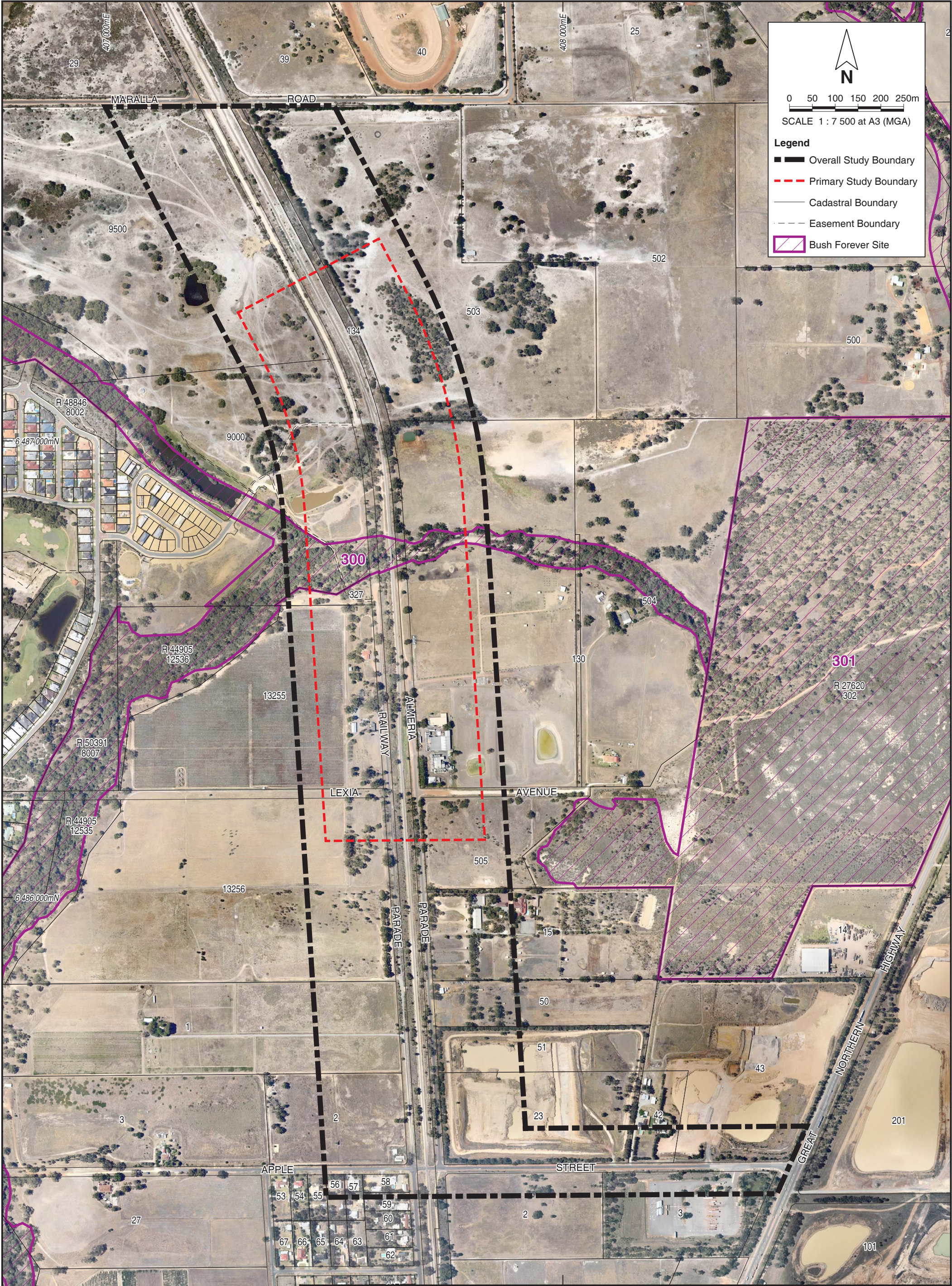
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City of Swan
ENVIRONMENTAL ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

GEOMORPHIC WETLANDS DATABASE MAPPING

Figure 6



CADASTRAL SOURCE: Landgate, February 2013.
BUSH FOREVER SOURCE: Department of Planning, 2007.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.

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ENVIRONMENTAL

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Date: 13 Feb 2013

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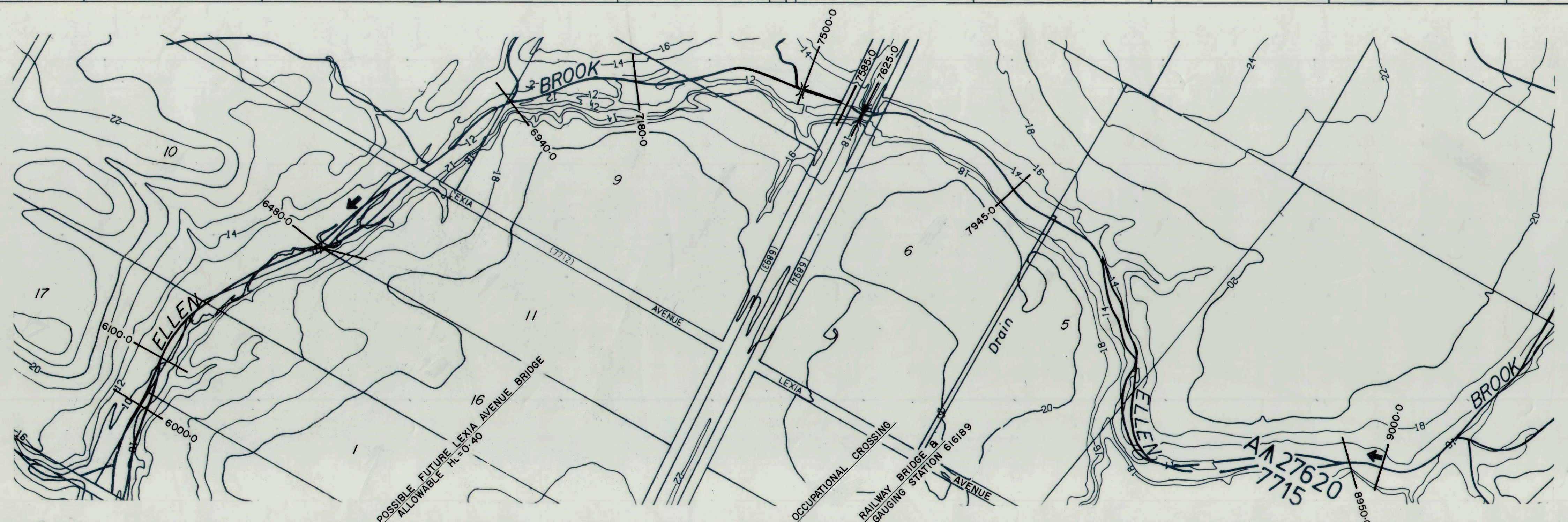
City of Swan
ENVIRONMENTAL ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

BUSH FOREVER SITES

Figure 7

APPENDIX 1

Ellen Brook Floodplain Mapping



	6000.0	6100.0	6480.0	6715.0	6940.0	7180.0	7500.0	7585.0	7625.0	7945.0	8950.0
DESIGN FLOW - CUBIC METRES / SEC - 100 YEAR - 25 YEAR		99.0 76.0								97.0 75.0	
ROUGHNESS - MANNING'S 'n'		0.052									
4.0m ABOVE DATUM											
DESIGNATED FLOOD LEVEL - FLOODWAY		10.84		12.28	12.81	12.92	13.18	13.40	13.46	14.20	15.72
100 YEAR WATER LEVEL RIVER AS EXISTING		10.74	11.76	12.28	12.78	12.90	13.17	13.34	13.45	14.00	15.72
25 YEAR WATER LEVEL RIVER AS EXISTING		10.31	11.58				12.92	13.09	13.16	13.97	15.48
AVERAGE VELOCITY { METRES / SEC 100 YEAR 25 YEAR		0.76 0.81	1.70 1.61		0.59 0.52	0.63 0.59	0.77 0.70	0.73 0.67	0.52 0.45	1.07 0.98	0.00
EXISTING INVERT LEVEL		7.23	8.46		9.51	9.84	9.01	9.01	9.01	11.54	12.64
WATERWAY DISTANCE	6000.0	6100.0	6480.0	6715.0	6940.0	7180.0	7500.0	7585.0	7625.0	7945.0	8950.0

GENERAL NOTES

1. DESIGN FLOWS FOR ELLEN BROOK WERE CALCULATED BY SURFACE WATER BRANCH, WATER RESOURCES DIRECTORATE, REPORT N° WS6.
2. WATER SURFACE PROFILES WERE CALCULATED USING THE HYDRAULIC BACKWATER ANALYSIS PROGRAM "IRWASP".

[illegible]



Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE

Ellen Brook Flood Study
Hydrology

Report No. WS 6

November 1987



WATER RESOURCES DIRECTORATE

Surface Water Branch

**Ellen Brook Flood Study
Hydrology**

**A S Waugh
Y H Ng**

Report No. WS 6

November 1987

ABSTRACT

A flood study for Ellen Brook near Perth using two runoff routing models and a flood frequency approach is described. The runoff routing models FLOUT and RORB are compared in terms of ease of application and data requirements using the same observed floods for model calibration. The results show that the two runoff routing models produced results within 8% of those from the flood frequency analysis.

The 1%, 2% and 4% AEP flood peaks at the gauging station are estimated at 97 m³/s, 86 m³/s and 75 m³/s respectively.

FLOUT requires more effort in data preparation and calibration than RORB, however FLOUT has the ability to predict flood flows well in excess of the in-bank flow capacity by accounting for the hydraulic characteristics of the flood plain in terms of cross-sectional shape and roughness effects on wave speed and attenuation. Both runoff routing models require input by the user of a runoff coefficient for flood prediction. The flood frequency method is more direct and is generally more reliable if an adequate annual flood series is available.

The study has provided a valuable introduction to the model FLOUT as an additional flood estimation method available to the Water Authority.

	CONTENTS	PAGE
	ABSTRACT	
1.	INTRODUCTION	
1.1	Objectives	1
1.2	Method of Approach	1
1.3	Catchment Description	1
2.	DATA USED - FOR FLOUT and RORB	
2.1	Rainfall	3
2.2	Streamflow	3
2.3	Site Inspection	3
2.4	River Cross Sections	3
3.	UNIT HYDROGRAPH DERIVATION - FOR FLOUT	
3.1	Introduction	5
3.2	Calibration Events	5
3.3	Baseflow Separation	6
3.4	Baseflow Simulation	7
3.5	Rainfall Excess Model	7
3.6	Antecedent Conditions	8
3.7	Deriving Unit Hydrograph	9
3.8	Averaging & Smoothing Unit Hydrograph	9
3.9	Synthetic Unit Hydrograph	10
4.	FLOOD FREQUENCY ANALYSIS	13
5.	PERCENTAGE RUNOFF ANALYSIS	
5.1	Flood Event Parameters	14
5.2	Design Runoff Coefficient	14
6.	ROUTING PARAMETER - FOR FLOUT	
6.1	Introduction	15
6.2	Wave Speed Parameter	15
6.3	Attenuation Parameter	16
7.	DESIGN RAINFALL	
7.1	Method of Calculation	17
7.2	Results	17
8.	CATCHMENT MODELLING - FLOUT	
8.1	Introduction	22
8.2	Catchment Subdivision	22
8.3	Model Calibration	23
8.4	Model Verification	24
9.	CATCHMENT MODELLING - RORB	
9.1	Introduction	25
9.2	Catchment Subdivision	25
9.3	Model Calibration	26
9.4	Model Verification	37

	CONTENTS	PAGE
10.	COMPARISON OF RORB & FLOUT	
10.1	Model Results	28
10.2	Model Limitations	29
10.3	Model Features	30
11.	CONCLUSIONS	
11.1	Modelling using FLOUT	32
11.2	Modelling using RORB	33
11.3	Comparison of Methodologies	33
12.	REFERENCES	34
13.	APPENDICES	35

LIST OF FIGURES

- 1 General Locality Plan
- 2 Physiographic Features
- 3 Rainfall and Stream Gauging Stations
- 4 Flood Frequency Diagram
- 5 Catchment Sub-division for FLOUT and RORB
- 6 Model Schematization
- 7 RORB Parameter Interaction Diagram
- 8 Design Hydrograph Comparisons

LIST OF TABLES

- 1 Events Used for Unit Hydrograph Derivation
- 2 Ellen Brook Baseflow Regression Analysis
- 3 Regression of T_p and $\log Q_p$
- 4 Regression of T_p and Area
- 5 Ellen Brook Flood Frequency Analysis
- 6 Ellen Brook Design Storms (36 to 72 hour durations)
- 7 Ellen Brook Design Rainfalls (25 to 100 year ARI's)
- 8 Flout Runoff Routing Model Calibration
- 9 Rorb Model Calibration - m and k Values
- 10 Rorb Model Calibration - Historical Flood Predictions
- 11 Design Flood Estimates - Peak Flow Summary

LIST OF APPENDICES

- A.1 Ellen Brook Catchment Subdivision - FLOUT
- A.2 Ellen Brook Catchment Subdivision - RORB
- B.1 Typical FLOUT Input File
- B.2 Typical RORB Input File
- C.1 Unit Hydrographs for FLOUT
- D.1 FLOUT Model Design Runs - Compressed Output
- D.2 RORB Model Design Runs - Compressed Output

NOTATION

The following is the notation used in this report. All units are metric.

A, AREA	catchment area (km^2).
API5	a five day antecedent precipitation index.
BF (EB)	baseflow per km^2 in Ellen Brook (m^3/s).
BF (LB)	baseflow per km^2 in Lennards Brook (m^3/s).
CWI	catchment wetness index based on antecedent precipitation index (API5) and soil moisture deficit (SMD).
k	a dimensional empirical coefficient in RORB as a measure of catchment storage effects.
L	stream length in km.
L_m	channel length of the m^{th} sub-reach.
LAG	time in hours from the centroid of the rain profile to the peak runoff or to a centroid of peaks if more than one peak.
m	dimensionless coefficient in RORB, a measure of catchment non-linearity.
P	rainfall total in mm.
P_m	plan area of the inundated flood plain over the m^{th} sub-reach.
PR	percentage runoff.
Q_p	peak of T hour unit hydrograph expressed in cubic metres/100 km^2 .
PMF	probable maximum flood.
R	correlation coefficient.
R^2	coefficient of determination.
S	stream slope in m/km.
S_m	channel bottom slope of the m^{th} sub-reach.
SMD	soil moisture deficit in mm.
T	time period of the unit hydrograph in hours.
T_b	baselength of simplified unit hydrograph in hours.
T_p	time to peak of T hour unit hydrograph, measured from start of direct runoff.
c (Q)	wave speed parameter.
α (Q)	attenuation parameter.

1 INTRODUCTION

1.1 Objectives

As part of the flood plain management activities carried out by the Water Authority of Western Australia, a study of the flood hydrology of Ellen Brook was required for the preparation of flood plain maps.

The primary objective of this report is to provide design flood estimates at the 1%, 2% and 4% annual exceedence probabilities (AEP) for several specific locations in the lower reaches of Ellen Brook.

A second objective was to provide an introduction for the Water Authority to a new flood estimation model and to gain experience in its application.

1.2 Method of Approach

The hydrologic analysis for this study was completed as a joint study with Binnie and Partners Pty. Ltd. consulting engineers of Perth.

It included the application of the runoff routing model FLOUT (Price,1977) adapted by Binnies for flood studies in Australia including the Avon Flood Study (Binnie and Partners,1985).

The runoff routing model RORB (Laurenson and Mein,1983) used extensively by the Water Authority and throughout Australia for flood estimation was also used in this study together with a standard flood frequency approach adapted to account for the relatively short period of observed flows in Ellen Brook.

Since both runoff routing models were applied using the same catchment sub-division scheme, the study provides a useful comparison of the relative merits, ease of application, and data requirements of each model.

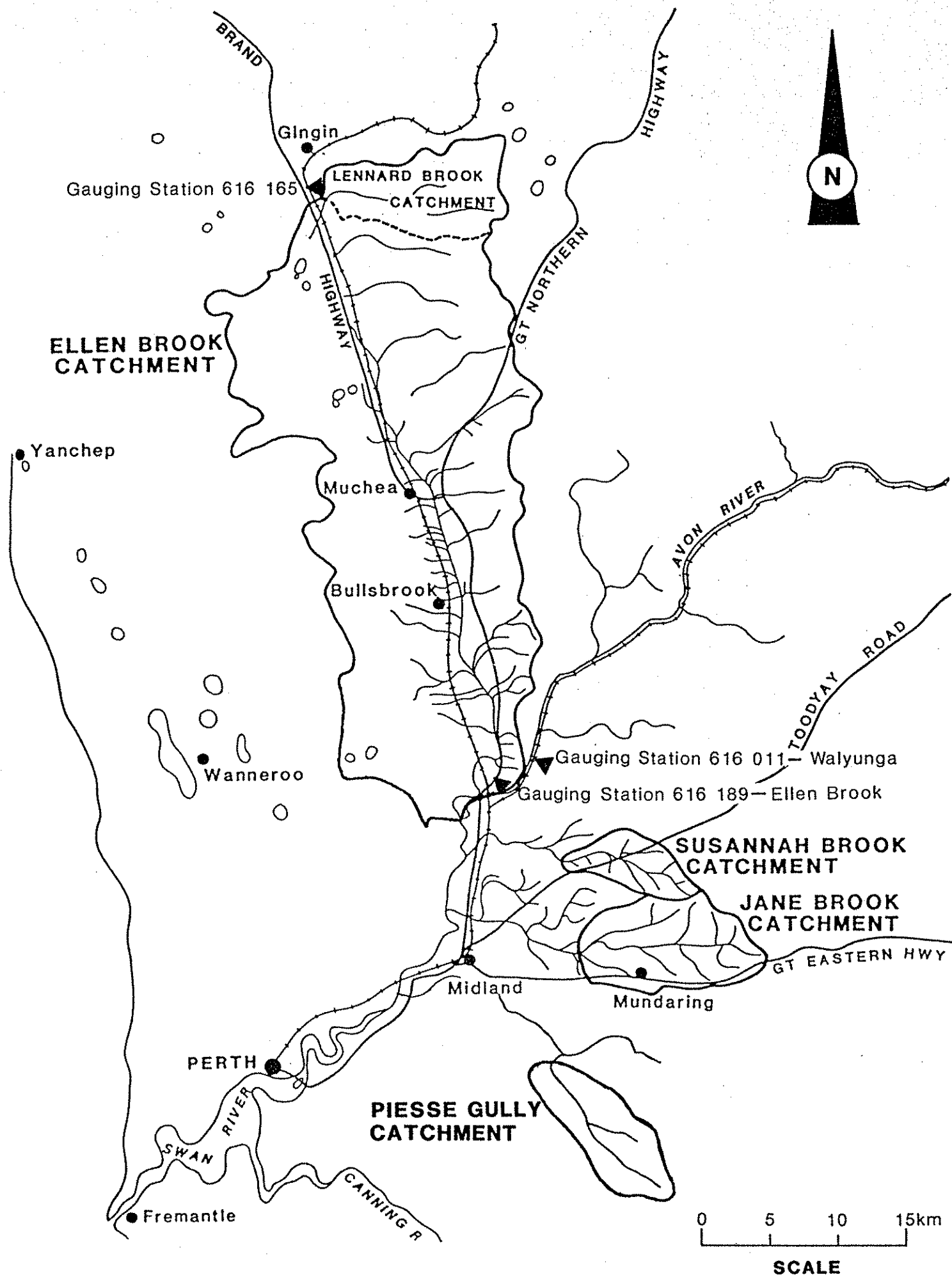
The study has also provided the Water Authority with valuable experience in the application of a new flood estimation model which, although it is not yet well known in Australia, is referred to in the new edition of Australian Rainfall and Runoff (I.E.Aust.,1987) and has been used for flood estimation in several Australian hydrologic studies.

1.3 Catchment Description

The Ellen Brook catchment located just west of the Darling Scarp between Gingin township, some 70 kilometres north of Perth, and Upper Swan about 25 kilometres north-east of Perth is shown on Figure 1.

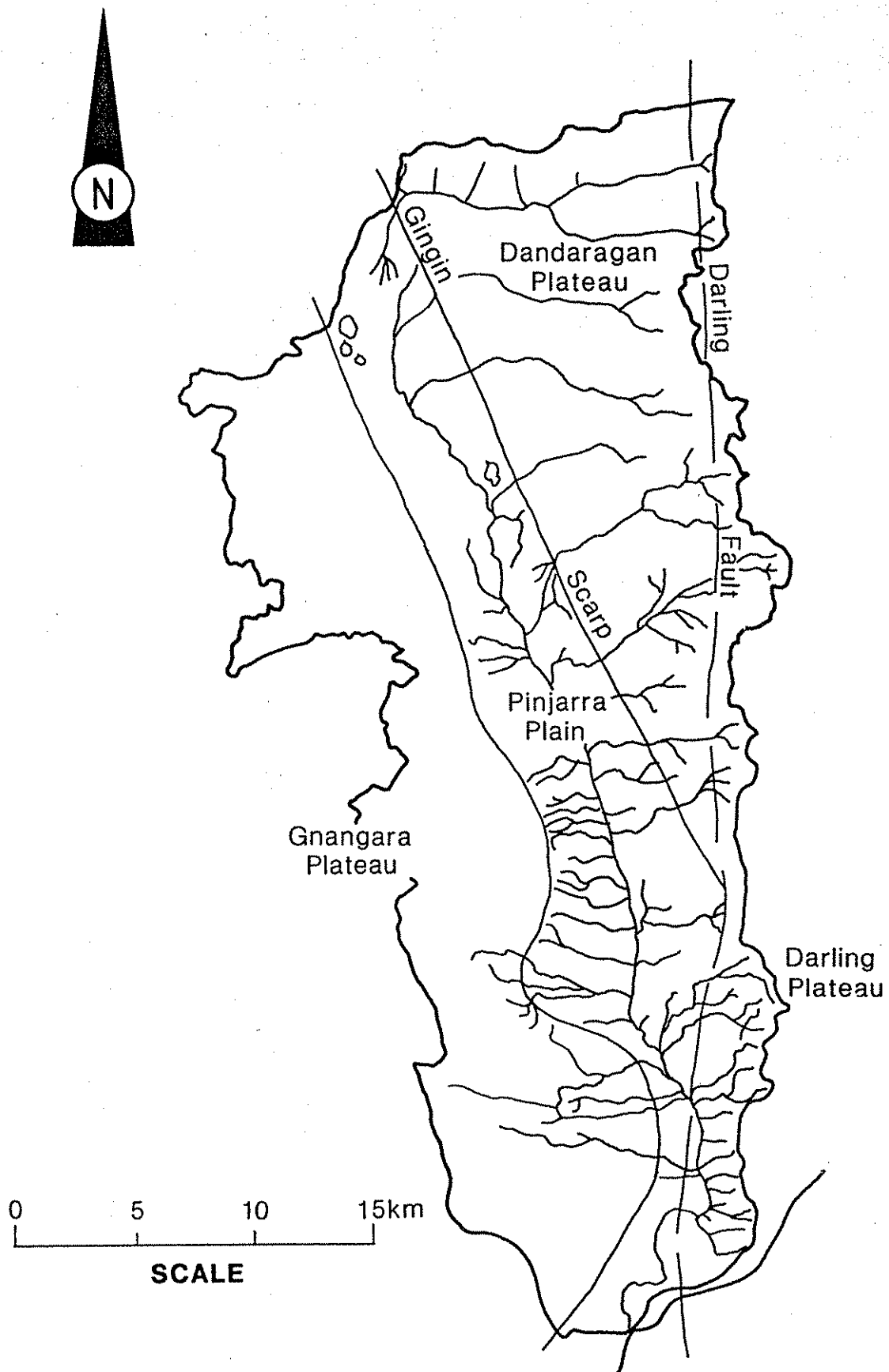
The catchment with an area of 640 square kilometres has an annual rainfall ranging from 660 mm to 820 mm. Natural vegetation is diverse with Jarrah forest, Swamp Sheoak forest and Marri and Banksia woodlands. Broad acre clearing has occurred since the 1950's over about 65% of the catchment for sheep and cattle grazing plus some vines and orchards.

The geology of the catchment is complex with outcrop including Archean granite, Cretaceous sandstone and siltstone, Tertiary laterite and Quaternary sand and clay. The Darling Fault, the most significant feature, is shown on Figure 2 with other physiographic features of the catchment.



GENERAL LOCALITY PLAN

FIGURE 1



PHYSIOGRAPHIC FEATURES
FIGURE 2

2 DATA FOR RORB AND FLOUT

2.1 Rainfall

Rainfall data for this study was available at stations shown on Figure 3. Although daily rainfall data was available at some locations over a long period, pluviograph data required for storm rainfall assessment was generally available only after 1972.

2.2 Streamflow

Ellen Brook streamflows have been recorded at the Railway Parade gauging station (616189) since April 1965 although the early rating is very unstable due to the growth of channel vegetation. The recent rating is well defined up to a flow rate of 20 cubic metres per second.

Because of pluviograph data limitations observed floods used for model calibration were limited to those after 1972, although annual flood peaks from the whole period of record were used in the flood frequency analysis.

Data from the Lennards Brook gauging station (616165) provided an indication of the flood response from the steeper Dandaragan Plateau sub-catchments.

The location of stream gauging stations is also shown on Figure 3.

2.3 Site Inspection

It is always good practice to make an inspection of the catchment to be modelled in order to appreciate the main catchment characteristics, the likely flood response and the validity of assumptions made in applying a hydrologic model to that catchment. Realistic adjustments and practical approximations can then be made during the modelling process to ensure that the results obtained are valid and that reasonable accuracy is achieved. The probable nature of flood flows for large events can be appreciated from a site inspection when overbank flow is likely to occur and wave speed may be dominated by flood plain roughness rather than by channel roughness.

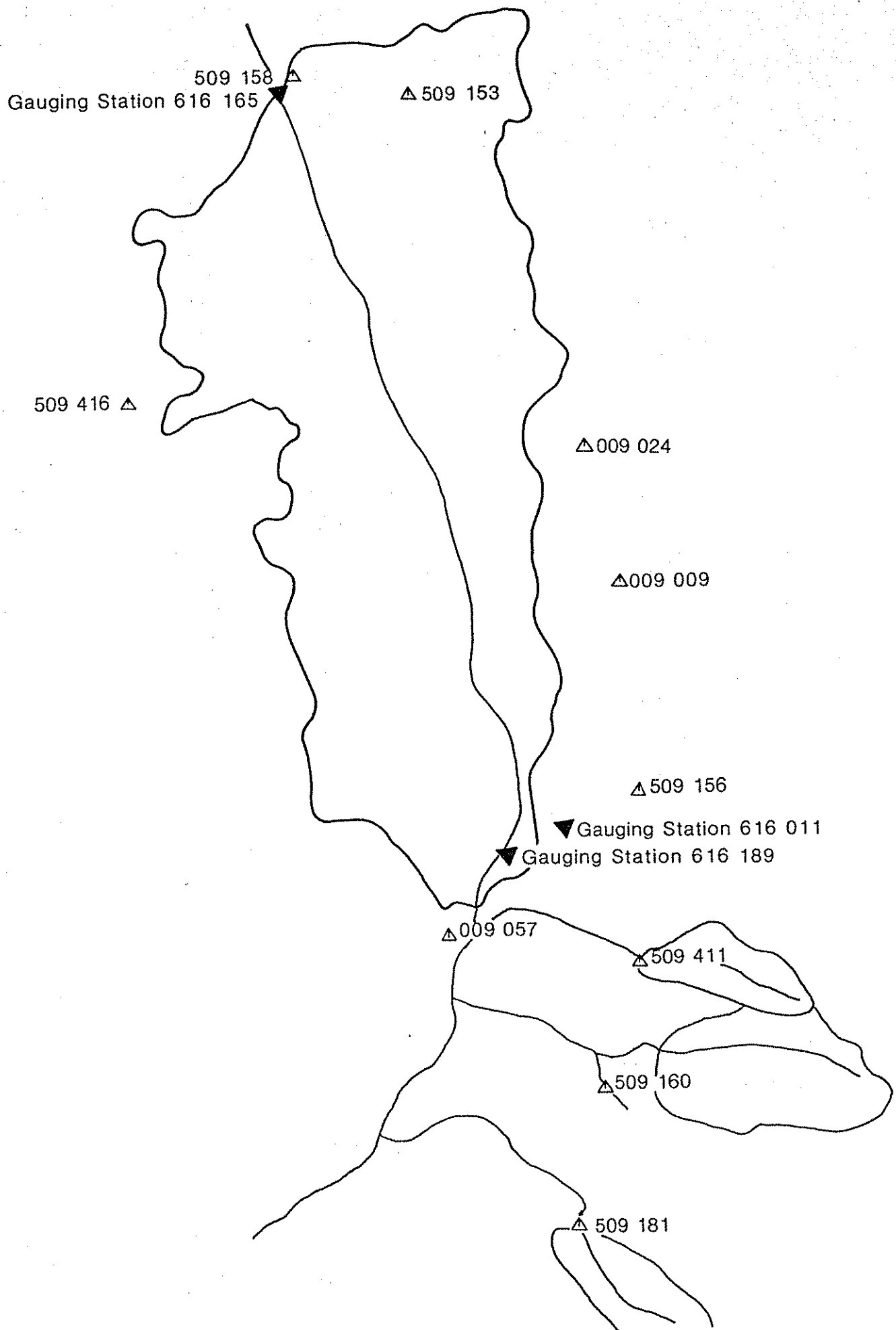
In the case of FLOUT the field inspection helped to identify areas of the catchment where channel characteristics needed to be measured for the derivation of model parameter values.

2.4 River Cross-Sections

Following the site inspection and preparation of a catchment sub-division map cross-sections were surveyed at a limited number of locations for the estimation of wave speed and attenuation parameters for the model FLOUT.

Because of time and cost constraints the number of cross sections was restricted and smoothing of the derived channel properties was required to achieve realistic model results.

The river cross-sections along the major channel through the Pinjarra Plain show a localised small main channel with extensive, flat and often swampy flood plains each side. Tributaries tend to be small and numerous with similarly small slopes apart from those draining the Dandaragan Plateau through the steeper parts of the Gingin and Darling scarps.



RAINFALL AND STREAM GAUGING STATIONS
FIGURE 3

3 UNIT HYDROGRAPH DERIVATION - FOR FLOUT

3.1 Introduction

Although there are a number of methods to derive a unit hydrograph, the method adopted in this study is the matrix inversion method which the Flood Studies Report(1975) found to give the most consistent results for a particular catchment. The method is also known as 'least squares', as the technique is to minimise the sum of squares of differences between ordinates of the observed and reconstituted hydrographs. The procedure is carried out using the spreadsheet software "Lotus 123 Release 2" which has matrix operation. Although a Fortran compiled program may be more efficient in its execution, the spreadsheet offers flexibility in data entry, manipulation and rapid graphics display of derived unit hydrographs.

One of the main limitations of the unit hydrograph concept is in the assumption of catchment linearity, i.e. that 20 mm of net rain produces double the peak flow rate obtained from 10mm of net rain.

Manning or other hydraulic formulae indicate that for cross sections with constant hydraulic resistance, velocity increases with discharge and the storage-discharge relation should approximate a power function. However for most natural streams the velocity of flow increases until the stage approaches the bankfull level or overbank flow begins. Beyond this the effects of the increasing roughness and reduced hydraulic radius may combine in such a way that the average velocity of flow may decrease slightly, or remain constant, indicating approximate conformity to the unit hydrograph theory (Draft AR&R,1987). Most of the calibration events for Ellen Brook are just inbank or slightly overbank. The majority of the subcatchments modelled have very flat and extensive flood plain areas and design floods are likely to be well overbank. It is therefore considered satisfactory to use the unit hydrograph concept without resorting to adjusting the unit hydrograph according to the size of the design storm.

3.2 Calibration Events

Eleven storm events with a single storm peak were selected for unit hydrograph analysis for Ellen Brook. Several other events were also analysed from four smaller catchments being; Lennards Brook, Jane Brook, Susannah Brook and Piesse Gully. Combining these data with those derived for the Avon River Flood Study (1985), a relationship between time to peak and catchment area was established.

As the data includes catchment areas slightly bigger in area than the sub areas of Ellen Brook, this relationship was used without too much extrapolation for the sub areas of Ellen Brook. The events analysed are listed in Table 1.

TABLE 1 - EVENTS FOR UNIT HYDROGRAPH DERIVATION

Date	Storm		CWI	API5	SMD	Baseflow		
	Runoff	Rainfall				Start	End	Average
	%	mm	mm	mm	mm	m3/s	m3/s	m3/s
ELLEN BROOK - 626 km ²								
13/7/85	3.61	40.04	123.1	1.96	3.7	0.400	1.470	0.935
18/8/85	7.04	36.82	153.5	0.17	-28.4	0.800	2.400	1.600
11/7/80	8.68	48.76	51.6	0.16	73.5	2.090	3.600	2.845
17/7/73	8.64	41.53	167.7	9.12	-33.6	1.370	3.400	2.385
1/8/82	9.74	31.62	112.7	0.57	12.8	1.030	1.640	1.335
13/9/84	10.36	61.10	138.7	1.79	-11.9	1.500	2.800	2.150
24/7/73	11.16	39.08	220.1	9.76	-85.4	2.180	4.090	3.135
6/8/82	11.81	34.71	138.3	6.22	-7.1	1.580	2.300	1.940
21/7/81	15.15	40.19	220.5	9.71	-85.8	1.730	5.770	3.750
9/8/81	18.70	28.35	296.5	8.97	-162.5	4.300	4.870	4.585
13/8/76	4.37	84.75	51.1	1.42	75.3	0.560	3.670	2.115
LENNARDS BROOK - 62.4 km ²								
1/8/82	1.09	29.62	112.7	0.57	12.8	0.240	0.290	0.265
6/8/82	1.68	33.30	138.3	6.22	-7.1	0.230	0.300	0.265
18/8/85	0.83	33.60	153.5	0.17	-28.4	0.220	0.250	0.235
13/7/85	0.86	33.75	123.1	1.96	3.7	0.200	0.230	0.215
JANE BROOK - 73 km ²								
13/9/84	10.99	53.22	138.7	1.79	-11.9	-	-	-
30/6/85	8.62	67.10	96.3	7.58	36.2	-	-	-
SUSANNAH BROOK - 24.8 km ²								
15/8/84	8.62	19.84	133.0	0.41	-7.6	-	-	-
19/8/84	5.81	9.29	142.5	4.92	-12.6	-	-	-
30/6/85	8.51	88.97	96.3	7.58	36.2	-	-	-
PIESSE GULLY - 55 km ²								
20/6/84	7.27	49.80	69.2	1.27	57.0	-	-	-
13/9/84	13.60	56.93	138.7	1.79	-11.9	-	-	-
5/8/85	4.34	27.00	233.0	14.73	-93.3	-	-	-

3.3 Baseflow Separation

Prior to derivation of the unit hydrograph the baseflow component has to be separated from the total hydrograph. There are several methods of baseflow separation however the one used in this study is based on fitting a baseflow curve using a cubic spline between the two tangents established at the points of start and finish of direct runoff.

The identification of the start and finish of direct runoff affects the slope of the tangents drawn and some care is required to establish these points. A plot of the hydrograph and its baseflow after the separation process helps to determine whether the separation is satisfactory. All flow below the separation line is then assumed to be baseflow and that above is assumed to be direct runoff.

3.4 Baseflow Simulation

The baseflow component in the sub areas of Ellen Brook particularly those in the Dandaragan Scarp can be a significant proportion of the total hydrograph. Although for the design of a medium sized event, the highest baseflow observed could be used, a regression analysis of the baseflow data from Ellen Brook was carried out. The event parameters used were CWI and P and the results of the analysis are shown in Table 2.

TABLE 2 - ELLEN BROOK BASEFLOW REGRESSION ANALYSIS

Regression Output:		
Dependent variable : BF _(EB)		
1st variable	:	P
2nd variable	:	CWI
Constant		-0.7232
Std Err of Y Est		0.8044
R Squared		0.5536
No. of Observations		11
Degrees of Freedom		8
X Coefficient(s)	0.0255	0.0133
Std Err of Coef.	0.0198	0.0043

Expressed as discharge per unit area the equation for Ellen Brook baseflows becomes ;

$$BF_{(EB)} = [0.0255 P + 0.0133 CWI - 0.723] / 626$$

An examination of the baseflow discharges at Lennards Brook corresponding to those events observed at Ellen Brook gauging station indicates that scaling by 0.08 gives reasonable baseflow prediction, i.e.

$$BF_{(LB)} = 0.08 [0.0255 P + 0.0133 CWI - 0.723] / 62.4$$

where BF_(EB) is Ellen Brook base flow per km² (m³/s)
and BF_(LB) is Lennards Brook base flow per km² (m³/s)

These relationships were used to simulate baseflow for the relevant sub-areas of the catchment in FLOUT design runs.

3.5 Rainfall Excess Model

In a storm event, the excess rainfall is defined as the rainfall that contributes directly to the flood hydrograph. The difference between the average rainfall for the catchment and the corresponding excess rainfall is termed the storm losses. There are a number of models of rainfall excess currently in use:

- i) constant loss rate, where the loss is assumed to be constant throughout the storm;

- ii) initial loss and continuing constant loss;
- iii) proportional loss, where the loss is assumed to be a constant fraction of the rainfall;
- iv) percentage loss varying according to catchment wetness index (CWI), as used in the FLOUT model.

The model used for net rain separation for unit hydrograph derivation is based on iv). It is a proportional loss type method which objectively distributes the losses during the storm according to the changing wetness of the catchment as indicated by CWI. In this model, loss rate could increase during dry periods within the storm or, in dry antecedent conditions, have higher initial loss values and slowly decay. The adoption of this model in unit hydrograph derivation maintains consistency with FLOUT which uses this rainfall excess model.

3.6 Antecedent Conditions

The use of the percentage based rainfall excess model requires the calculation of the catchment wetness index, CWI. A simple soil moisture accounting algorithm is used to compute the index CWI from the daily rainfall data. The formula computes the soil moisture deficit (SMD) by taking into account the loss by evapo-transpiration, the raising of the soil moisture by rainfall, the antecedent precipitation index taken over 5 days (API5) and assuming a root constant for the typical vegetation in the catchment. The wetness index is then determined by:-

$$CWI = K + API5 - SMD$$

where K is a constant introduced to ensure that in the majority of flood situations, CWI remains positive

SMD is the soil moisture deficit (mm)

API5 is the antecedent precipitation index based on the previous 5 days rainfall (mm)

In the algorithm, if the SMD value is less than zero, indicating saturation, SMD is set equal to zero. Similarly if SMD exceeds the root constant, SMD is set equal to the root constant. Initially a root constant of 150 mm was used. Most of the calibration events are winter events, and consequently the SMD values obtained are crowded in the lower end of the scale of SMD. Since SMD is affecting the value of CWI, which is one of the parameters used to determine the percentage runoff equation, the lack of spread of SMD data gave very poor explanation of percentage runoff. To increase the SMD range, the algorithm was modified such that SMD is not set equal to zero automatically when a value less than zero is found. This improved the percentage runoff relationship.

3.7 Deriving the Unit Hydrograph

The least squares procedure for deriving unit hydrograph can be achieved readily by a series of matrix operations solving the formula below:-

$$[u] = \{ [p^T] \cdot [p] \}^{-1} \cdot [p^T] \cdot [q]$$

where $[u]$ = unit hydrograph ordinates (column matrix)

$[p]$ = rainfall excess ordinates (rectangular matrix)

$[q]$ = surface runoff hydrograph ordinates (column matrix)

$[]^T$ = the transpose of a matrix

$\{ \}^{-1}$ = the inverse of a matrix

A PC spreadsheet (Lotus 123) was used to carry out the matrix operations to derive the unit hydrograph. The software was chosen due to its flexibility.

The time to peak of the unit hydrograph was expected to be 6 hours or greater for the sub-catchments considered. To provide good definition of the resulting unit hydrographs, a time step of 1 hour was chosen for the input of rainfall excess and the separated flow hydrograph. The unit hydrograph obtained is therefore described as the one hour unit hydrograph.

3.8 Averaging and Smoothing Unit Hydrographs

The raw unit hydrographs obtained are often affected by oscillations and although the dominant signal is usually clear, some form of smoothing is required. Smoothing was carried out by eye. The procedure was to first plot all the unsmoothed unit hydrographs in a single graph after aligning the peaks in time. Included in the graph was a calculated average to assist the eye. The resulting unit hydrograph was then adjusted so that the volume under the curve was equivalent to a runoff of 10 mm per 100 km² as required by FLOUT.

The derived smoothed and adjusted unit hydrographs for Ellen Brook and the four other nearby catchments are shown in Appendix C.

3.9 Synthetic Unit Hydrograph

Except for the unit hydrograph derived for Lennards Brook, the unit hydrographs obtained from the other gauged catchments in the region were not directly applicable to the sub catchments of Ellen Brook. This required a method of unit hydrograph synthesis for the sub catchments of Ellen Brook.

The procedure adopted was to analyse the unit hydrographs derived from Ellen Brook, Lennards Brook and other smaller gauged catchments nearby such as Jane Brook, Susannah Brook and Piesse Gully. Data from the Avon River Flood Study such as those from Julimar, Brockman and the two Mortlock Rivers were also included to increase the database.

The two unit hydrograph parameters used to develop a synthetic unit hydrograph for the sub catchments of Ellen Brook are Q_p , the peak flow in cumecs/100 km², and T_p , the time to peak. The data used and the result of the regression analysis are shown in Table 3. The peak of the synthetic unit hydrograph can be expressed in terms of T_p as:-

$$Q_p = 10^{(-0.022461 T_p)} \times 10^{1.4332}$$

Assuming a simple triangular shaped synthetic unit hydrograph, and a 10 mm runoff on a 100 km² catchment, the volume may be expressed as :

$$0.5 \times T_b \times Q_p \times 3600 = 10 \text{ mm} / 1000 \times 100 \text{ km}^2 \times 1000^2$$

Rearranging and substituting, we get

$$T_b = 20.49 \times 10^{0.022461 T_p}$$

TABLE 3 - REGRESSION OF Tp AND Log Qp

CATCHMENT	CATCHMENT AREA km ²	Tp hr	Qp m ³ /s	CALCULATED Qp m ³ /s
PIESSE	55	5.5	20.0	20.41
LENNARDS	64.2	6	18.0	19.88
JANE	73	7.5	25.0	18.40
JULIMAR	179	9	12.8	17.03
ELLEN	626	12	16.0	14.58
MORTLOCK NTH	6870	17.5	13.1	10.97
BROCKMAN	1514	18	9.1	10.69
MORTLOCK STH	9560	25	7.3	7.44

Regression output:				
Dependent variable : Log Qp				
1st variable : Tp				
Constant				1.4333
Std Err of Y Est				0.0885
R Squared				0.7849
No. of Observations				8
Degrees of Freedom				6
X Coefficient(s)			-0.0225	
Std Err of Coef.			0.0048	

The analysis shows that the synthetic unit hydrograph can be expressed by a single variable Tp. The next task was to derive Tp from catchment parameters. In the past, the majority of investigators have tended to use stream length and slope to determine the time delay parameter of the catchment. The formulae are often in the form $L/S^{1/2}$ (FSR Vol I, 1975) as a measure of travel time when compared to open channel flow formula. Tp has been shown to be very highly correlated to LAG, which is defined as the time from centroid of total rainfall to the centroid of the total flow hydrograph (FSR Vol I, 1975). In this study however, the aim is to relate Tp to catchment area. Published data from the Avon River Flood Study, 1985 were included in this study. Table 4 shows the data used and the results of the regression analysis.

TABLE 4 - REGRESSION OF Tp AND AREA

CATCHMENT	CATCHMENT AREA km ²	TIME TO PEAK Tp hr	REGRESSED TIME TO PEAK hr	log ₁₀ (AREA)
SUSANNAH	24.8	2	2.82	1.394
PIESSE	55	5.5	5.44	1.740
LENNARDS	64.2	6	5.95	1.808
JANE	73	7.5	6.37	1.863
JULIMAR	179	9	9.33	2.253
DALE	275	9	10.74	2.439
WOOROLOO	433	15	12.24	2.636
ELLEN	626	12	13.46	2.797
BROCKMAN	1514	18	16.37	3.180
MORTLOCK NTH	6870	17.5	21.35	3.837
MORTLOCK STH	9560	25	22.44	3.980
Regression Output:				
Dependent variable : PR				
1st variable : P				
2nd variable : CWI				
Constant -7.7638				
Std Err of Y Est 2.0784				
R Squared 0.9151				
No. of Observations 11				
Degrees of Freedom 9				
X Coefficient(s) 7.5873				
Std Err of Coef. 0.7703				

Although the Tp and AREA relate quite well, it does not imply that the application of the derived relationship to the Ellen Brook sub areas would be appropriate. This is due to considerable difference between the catchments analysed and some of the very flat sub areas of Ellen Brook. In fact calibration of the FLOUT model with observed events found that the Tp for the Lakes area and the Ellen valley are about double that derived from the regression equation. This behaviour is expected of the flat valley sections of Ellen Brook.

For future investigation, if it is anticipated that Tp could not be reliably estimated from analysis of gauged nearby catchments, the installation of a water level recorder in the early stages to obtain some measure of LAG may be worthwhile.

4 FLOOD FREQUENCY ANALYSIS

4.1 Observed Annual Flood Series

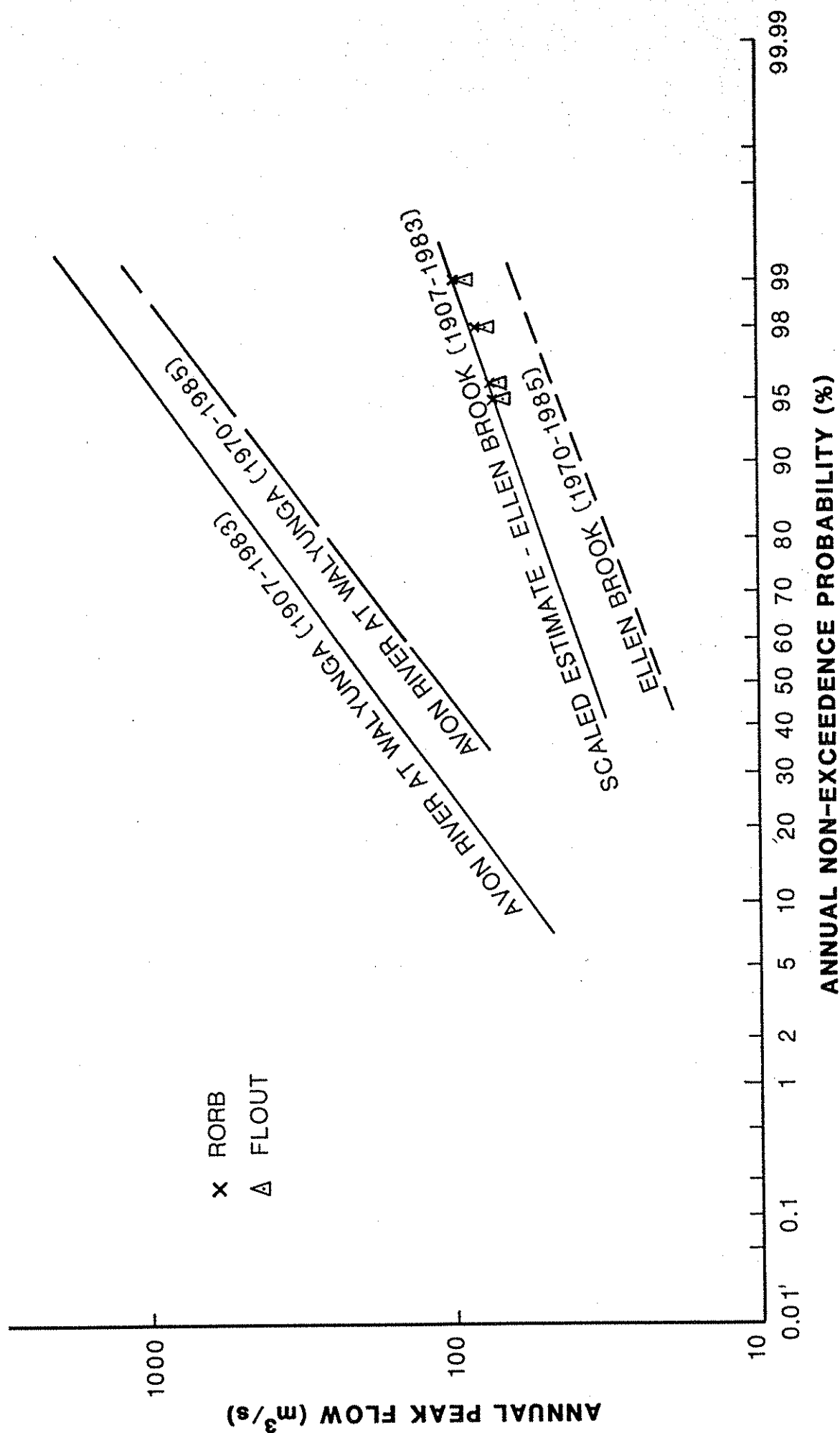
The observed annual flood series available at the Ellen Brook gauging station spans a period of only 16 years from 1972 to 1985. This was a period of generally lower rainfalls and smaller flood peaks throughout the South West of Western Australia, hence flood frequency analysis based on this period tends to under-estimate floods of a specified probability.

In this study reference was therefore made to a previous flood study for the adjacent Avon River (PWD, 1985) in which historic flood event modelling and daily catchment modelling combined with long term daily rainfalls provided good estimates of the 1% AEP flood. The daily catchment modelling provided a long term annual flood series from 1907 to 1985.

These data were re-analysed using only those years which correspond to the period of available data on Ellen Brook. The two flood frequency curves were then scaled at the 50 % and 1 % probabilities to give adjustment factors for application to the corresponding Ellen Brook flood frequency curve. The relevant flood frequency estimates given in Table 5 are shown in Figure 4.

TABLE 5 - ELLEN BROOK FLOOD FREQUENCY ANALYSIS

Log Normal Distribution				
River	AVON RIVER		ELLEN BROOK	
Gauging Station	Walyunga (G.S. 616 011)		Railway Parade (G.S. 616 189)	
Flood Probability	1%	50%	1%	50%
Short Term (1970 - 1985)	1087	112	62.0	20.5
Long Term (1907 - 1983)	1702	191	97.1*	35.0*
Scale Factor (long term/short term)	1.566	1.705	* Values scaled according to Scale Factors from Walyunga flood frequency analysis.	



ELLEN BROOK-ANNUAL FLOOD FREQUENCY ANALYSIS

FIGURE 4

5 PERCENTAGE RUNOFF ANALYSIS

5.1 Flood Event Parameters

In this study an attempt was made to derive a relationship for the percentage runoff using data from observed flood events. In this case the parameters CWI and total rainfall P were used. A series of daily rainfall and daily runoff was used to generate CWI values through the period of record at Ellen Brook gauging station and the values of CWI calculated for the day prior to the observed flood events were used in the analysis.

While the higher CWI values (indicating wetter antecedent catchment conditions) were generally associated with a higher percentage runoff the relationship was not strong. The equation derived was capable of explaining only 37% of the relationship.

When total storm rainfall P was included the regression analysis indicated an inverse relationship between percentage runoff and rainfall giving a similar correlation ($r^2 = 39\%$). It is recognised that percentage runoff need not necessarily correlate with total rainfall although runoff volume may do so.

An investigation of additional data and different parameters (eg rainfall intensity) for Ellen Brook and adjacent similar catchments could result in a better percentage runoff relationship, however such extensive additional work was outside the scope of this study.

5.2 Design Runoff Coefficient

In order to derive a runoff coefficient for the design case in this study a probabilistic approach was used with the model RORB and the derived flood frequency curve.

The estimated 1% AEP flood peak read from the scaled flood frequency curve, was reproduced with the RORB model using a design storm of critical duration, an initial loss of zero and a baseflow hydrograph equivalent to the largest observed baseflow. The runoff coefficient was varied until the required flood peak was reproduced, resulting in a value of 12.1 %. This value was used without adjustment for design floods of 1% to 4% AEP for both FLOUT and RORB.

6 ROUTING PARAMETERS - FOR FLOUT

6.1 Introduction

FLOUT uses a variable parameter Muskingum-Cunge (VPMC) method of routing the flood hydrograph from one reach to another. Details of the method are covered in FSR Vol 3, 1975, Price 1977. Two parameters, attenuation $\alpha(Q)$ and kinematic wave speed $c(Q)$ are required by the model. Both parameters should preferably be derived from records. Whereas $\alpha(Q)$ can be defined readily in terms of the river geometry from a contour map, the lack of data to define flood wave travel times along the reach can be a serious disadvantage. However, if suitable small interval contour maps are available, $c(Q)$ can be estimated from hydraulic assessment of discharge rating of cross sections drawn from such contour information.

6.2 Wave Speed Parameter

The wave speed, $c(Q)$ is defined as the average speed along a reach of the flood wave with peak discharge Q under the condition that there is no attenuation. This condition is equivalent to the requirement that $c(Q)$ is the speed derived for the equations for steady flow with discharge Q .

Where records are available, there are two cases to consider:

- i) continuous water level records are available at both the top and bottom of the sub-reach; or
- ii) travel times are available along a reach which contains the sub-reach being considered.

The parameter $c(Q)$ is then derived by extracting the travel times of the flood waves and accounting for any attenuation effects by using the equation below:

$$c(Q_a) = \frac{L}{T|_{Q=Q_a}} + \frac{Q^* d}{dQ} \frac{L}{T|_{Q=Q_a}}$$

where L/T is the observed wave speed, Q^* is the attenuation of the peak along the reach, $d/dQ (L/T)$ is the slope of the wave speed curve at $Q=Q_a$, and Q_a is the average Q at both ends of reach.

The method used to determine the wave speed $c(Q)$ for Ellen Brook is based on the Kleitz-Seddon Law:

$$c(Q) = dQ/dA$$

This method was used following the measurement of a number of cross-sections along the river. The approach is to derive the discharge relationship with cross sectional area using a backwater program and the cross-section data available. An estimate of the channel roughness is required to determine the water surface profile. The analysis is carried out for a range of flows from small inbank flows to an upper limit flood which is greater than the largest design flood demanded of the model.

From the results of the backwater analyses, curves of discharge Q , versus flow area, are plotted for each cross section. Depending on the flow interval used, the plot of Q versus A usually requires smoothing of the curves which can be achieved by taking the average of a data point and its two neighbouring points.

The parameter $c(Q)$ is then derived by computing the slope dQ/dA of the smoothed curve of Q versus A . The dQ/dA curve obtained although sometimes spikey in character will generally have the following features (Price 1977):

- i) c increases rapidly with discharge to a maximum value when the flow is about two thirds bankfull;
- ii) c then decreases to a minimum value for the flow above bank and when there is little flow along the flood plain;
- iii) c increases slowly as the discharge increases and the flow along the flood plain becomes more important.

The $c(Q)$ curve for a sub-reach is obtained by averaging the curves derived from a selected number of appropriate cross sections within the sub-reach.

6.3 Attenuation Parameter

The attenuation parameter $\alpha(Q)$, is derived from physical properties of the river channel and its flood plains. In the routing, the results of the FLOUT model are not as sensitive to errors in $\alpha(Q)$ as they are to errors in $c(Q)$. This is due to the degree of flood attenuation being proportional to α/c^3 so that it is more important to estimate c accurately.

An $\alpha(Q)$ for a sub-reach can be derived from the limits of flooding over the flood plain for a particular flood determined from a number of cross-section over the sub-reach by using the equation:

$$\alpha(Q) = 1/2 \left[\frac{1}{L} \sum_{m=1}^M \frac{P_m}{S_m^{1/3}} \right]^{-3} \sum_{m=1}^M \left[\frac{P_m^2}{L_m S_m^2} \right]$$

where P_m is the plan area (km^2) of the inundated flood plain and the channel in the m th sub-reach, and L_m and S_m are the corresponding length (km) and bottom slope (m/km) of the channel. Usually only a few points are adequate to defined the form of the curve for $\alpha(Q)$. The method of deriving $\alpha(Q)$ is detailed in Volume III of the Flood Studies Report (NERC, 1975).

The values of wave speed $c(Q)$ and attenuation parameter $\alpha(Q)$ used for the various routing reaches are shown highlighted in the typical FLOUT input file in Appendix B.1

7 DESIGN RAINFALLS

7.1 Method of Calculation

Design rainfalls were calculated using the draft version of the revised Australian Rainfall and Runoff (I.E.Aust., 1987). The method varies from that specified in the 1977 version. It provides for calculation of a full set of intensity-frequency duration (IFD) curves or intensities for a limited number of durations and frequencies for any specified location.

Temporal patterns were obtained from the Commonwealth Bureau of Meteorology's draft tables which will be included in the revised Australian Rainfall and Runoff, and a reduction factor for point to areal reduction was applied.

7.2 Results

Table 6 below lists the design rainfall hyetographs for a range of storm durations on Ellen Brook catchment for which the critical duration was found to be 48 hours. Table 7 sets out the 48 hour design storm hyetographs for the required range of probabilities.

TABLE 6 - ELLEN BROOK - DESIGN STORMS
ARI 100yrs (ref Draft ARR 1987)

36 HOUR DURATION

Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)
1	5.4	13	3.9	25	2.4
2	10.7	14	3.3	26	2.8
3	9.6	15	3.5	27	2.5
4	8.5	16	3.7	28	2.3
5	13.2	17	2.5	29	1.5
6	18.0	18	1.2	30	0.7
7	12.3	19	0.8	31	0.4
8	6.6	20	0.4	32	0.1
9	6.0	21	1.0	33	0.5
10	5.5	22	1.6	34	0.9
11	5.0	23	1.8	35	0.6
12	4.4	24	2.0	36	0.3

48 HOUR DURATION

Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)
1	9.3	13	4.1	25	0.9	37	1.0
2	18.5	14	3.8	26	0.5	38	0.3
3	14.7	15	3.3	27	1.9	39	1.4
4	10.8	16	2.9	28	3.4	40	2.5
5	9.5	17	1.8	29	2.4	41	1.4
6	8.2	18	0.8	30	1.4	42	0.2
7	7.3	19	0.9	31	1.8	43	0.2
8	6.4	20	1.0	32	2.2	44	0.1
9	5.8	21	1.5	33	1.4	45	0.1
10	5.3	22	2.0	34	0.6	46	0.2
11	4.9	23	1.6	35	1.1	47	0.1
12	4.5	24	1.3	36	1.6	48	0.0

TABLE 6 (Cont'd)

72 HOUR DURATION

Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)
1	3.1	13	4.7	25	2.6
2	6.2	14	4.4	26	2.2
3	9.4	15	4.1	27	1.8
4	12.5	16	3.8	28	1.4
5	11.1	17	3.5	29	1.5
6	9.7	18	3.1	30	1.7
7	8.3	19	2.8	31	1.9
8	6.9	20	2.5	32	2.1
9	6.4	21	2.6	33	1.7
10	6.0	22	2.7	34	1.4
11	5.5	23	2.9	35	1.0
12	5.0	24	3.0	36	0.7

Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)	Time Step (hr)	Rainfall (mm)
37	0.7	49	0.1	61	0.6
38	0.8	50	0.2	62	0.9
39	0.8	51	0.2	63	1.3
40	0.9	52	0.3	64	1.7
41	1.0	53	0.2	65	1.4
42	1.0	54	0.2	66	1.1
43	1.1	55	0.1	67	0.8
44	1.1	56	0.1	68	0.5
45	0.8	57	0.1	69	0.5
46	0.6	58	0.1	70	0.5
47	0.3	59	0.2	71	0.4
48	0.0	60	0.2	72	0.4

TABLE 7 - ELLEN BROOK DESIGN RAINFALLS
(Ref. Draft ARR - 1987)

time step (hr)	ARI 100 yrs			ARI 50 yrs			ARI 25 yrs		
	48 hr rainfalls			48 hr rainfalls			48 hr rainfalls		
	pattern	point	areal	pattern	point	areal	pattern	point	areal
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	11.8	9.9	9.3	11.8	8.4	7.9	11.8	7.6	7.1
2	23.6	19.7	18.5	23.6	16.8	15.8	23.6	15.1	14.2
3	18.7	15.6	14.7	18.7	13.3	12.5	18.7	12.0	11.2
4	13.8	11.5	10.8	13.8	9.8	9.2	13.8	8.8	8.3
5	12.2	10.2	9.6	12.2	8.7	8.2	12.2	7.8	7.3
6	10.5	8.8	8.2	10.5	7.5	7.0	10.5	6.7	6.3
7	9.3	7.8	7.3	9.3	6.6	6.2	9.3	6.0	5.6
8	8.1	6.8	6.4	8.1	5.8	5.4	8.1	5.2	4.9
9	7.5	6.3	5.9	7.5	5.3	5.0	7.5	4.8	4.5
10	6.8	5.7	5.3	6.8	4.8	4.5	6.8	4.4	4.1
11	6.3	5.3	4.9	6.3	4.5	4.2	6.3	4.0	3.8
12	5.7	4.8	4.5	5.7	4.1	3.8	5.7	3.6	3.4
13	5.3	4.4	4.2	5.3	3.8	3.5	5.3	3.4	3.2
14	4.8	4.0	3.8	4.8	3.4	3.2	4.8	3.1	2.9
15	4.3	3.6	3.4	4.3	3.1	2.9	4.3	2.8	2.6
16	3.7	3.1	2.9	3.7	2.6	2.5	3.7	2.4	2.2
17	2.4	2.0	1.9	2.4	1.7	1.6	2.4	1.5	1.4
18	1.0	0.8	0.8	1.0	0.7	0.7	1.0	0.6	0.6
19	1.2	1.0	0.9	1.2	0.9	0.8	1.2	0.8	0.7
20	1.3	1.1	1.0	1.3	0.9	0.9	1.3	0.8	0.8
21	1.9	1.6	1.5	1.9	1.4	1.3	1.9	1.2	1.1
22	2.5	2.1	2.0	2.5	1.8	1.7	2.5	1.6	1.5
23	2.1	1.8	1.6	2.1	1.5	1.4	2.1	1.3	1.3
24	1.6	1.3	1.3	1.6	1.1	1.1	1.6	1.0	1.0

TABLE 7 (Cont'd)

time step (hr)	ARI 100 yrs			ARI 50 yrs			ARI 25 yrs		
	48 hr rainfalls			48 hr rainfalls			48 hr rainfalls		
	pattern	point	areal	pattern	point	areal	pattern	point	areal
25	1.1	0.9	0.9	1.1	0.8	0.7	1.1	0.7	0.7
26	0.6	0.5	0.5	0.6	0.4	0.4	0.6	0.4	0.4
27	2.4	2.0	1.9	2.4	1.7	1.6	2.4	1.5	1.4
28	4.3	3.6	3.4	4.3	3.1	2.9	4.3	2.8	2.6
29	3.1	2.6	2.4	3.1	2.2	2.1	3.1	2.0	1.9
30	1.8	1.5	1.4	1.8	1.3	1.2	1.8	1.2	1.1
31	2.3	1.9	1.8	2.3	1.6	1.5	2.3	1.5	1.4
32	2.8	2.3	2.2	2.8	2.0	1.9	2.8	1.8	1.7
33	1.8	1.5	1.4	1.8	1.3	1.2	1.8	1.2	1.1
34	0.8	0.7	0.6	0.8	0.6	0.5	0.8	0.5	0.5
35	1.5	1.3	1.2	1.5	1.1	1.0	1.5	1.0	0.9
36	2.1	1.8	1.6	2.1	1.5	1.4	2.1	1.3	1.3
37	1.3	1.1	1.0	1.3	0.9	0.9	1.3	0.8	0.8
38	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.2
39	1.8	1.5	1.4	1.8	1.3	1.2	1.8	1.2	1.1
40	3.2	2.7	2.5	3.2	2.3	2.1	3.2	2.0	1.9
41	1.8	1.5	1.4	1.8	1.3	1.2	1.8	1.2	1.1
42	0.3	0.3	0.2	0.3	0.2	0.2	0.3	0.2	0.2
43	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1
44	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
45	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1
46	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1
47	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	total	167.0	157.5	total	142.3	134.2	total	128.0	120.7

8 CATCHMENT MODELLING - FLOUT

8.1 Introduction

The emphasis of the FLOUT model is on the simulation and prediction of unsteady discharges in the main streams of a river catchment. The magnitude of the flood discharges which the model can simulate with reasonably accuracy should be based on the flood events which are used to calibrate the routing parameters and the rainfall-runoff component incorporated in the model. Usually the flood events used are flood discharges that are largest recorded. Therefore use of the model to simulate very low flows or extreme events should be treated with caution. The accuracy of the routing component during low flow conditions may be suspect due to neglect of such processes as pool storages, channel flow interaction and the difficulty of prescribing kinematic wave speeds for low flow conditions without observed data.

Flood routing in FLOUT is based on the variable parameter Muskingum-Cunge (VPMC) method which is generally as accurate as the linear diffusion method (Price 1977). The VPMC method has one particular advantage over the diffusion methods, being able to include discrete tributaries along the reach which the diffusion method cannot include. However, the VPMC method should not be used where there is significant disturbance downstream such as is generated by a large weir or reservoir. FLOUT models these cases with separate reservoir routing subroutines.

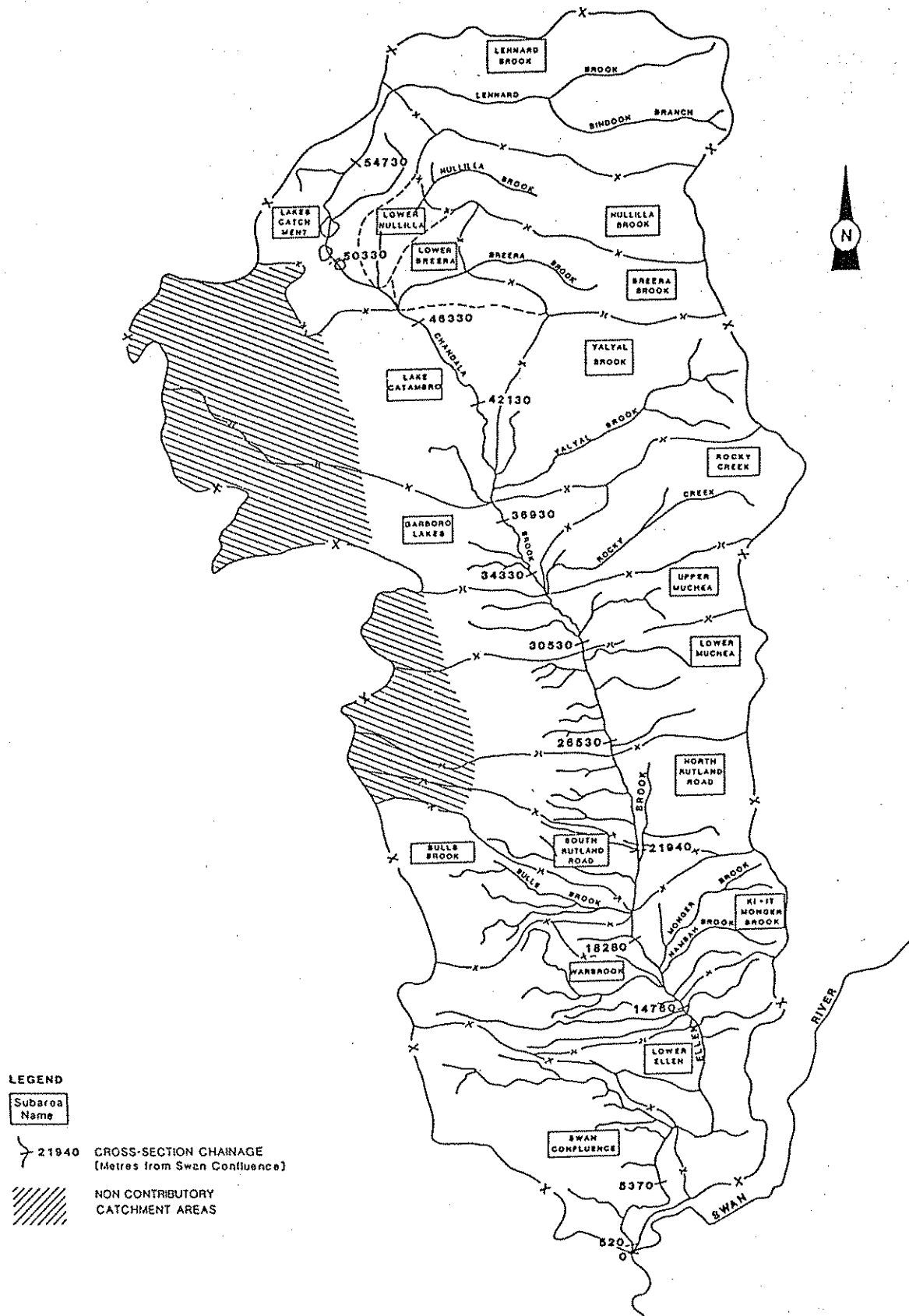
8.2 Catchment Subdivision

The river system to be modelled by FLOUT has to be described using the branch/channel notation devised originally by the UK TRRL 1976. The catchment to be modelled first has to be sub-divided into sub areas. It is usually a good practice to mark the main streams on a map of the catchment and to locate the major stream. Then the sub-catchments feeding into the major stream should be determined according the following criteria:

- i) whether the catchment to be modelled by unit hydrograph/losses model is less than 1000 km², or
- ii) there is a convenient gauging station, or
- iii) there is an important confluence of streams, or
- iv) at a point of interest where flood magnitude is required.

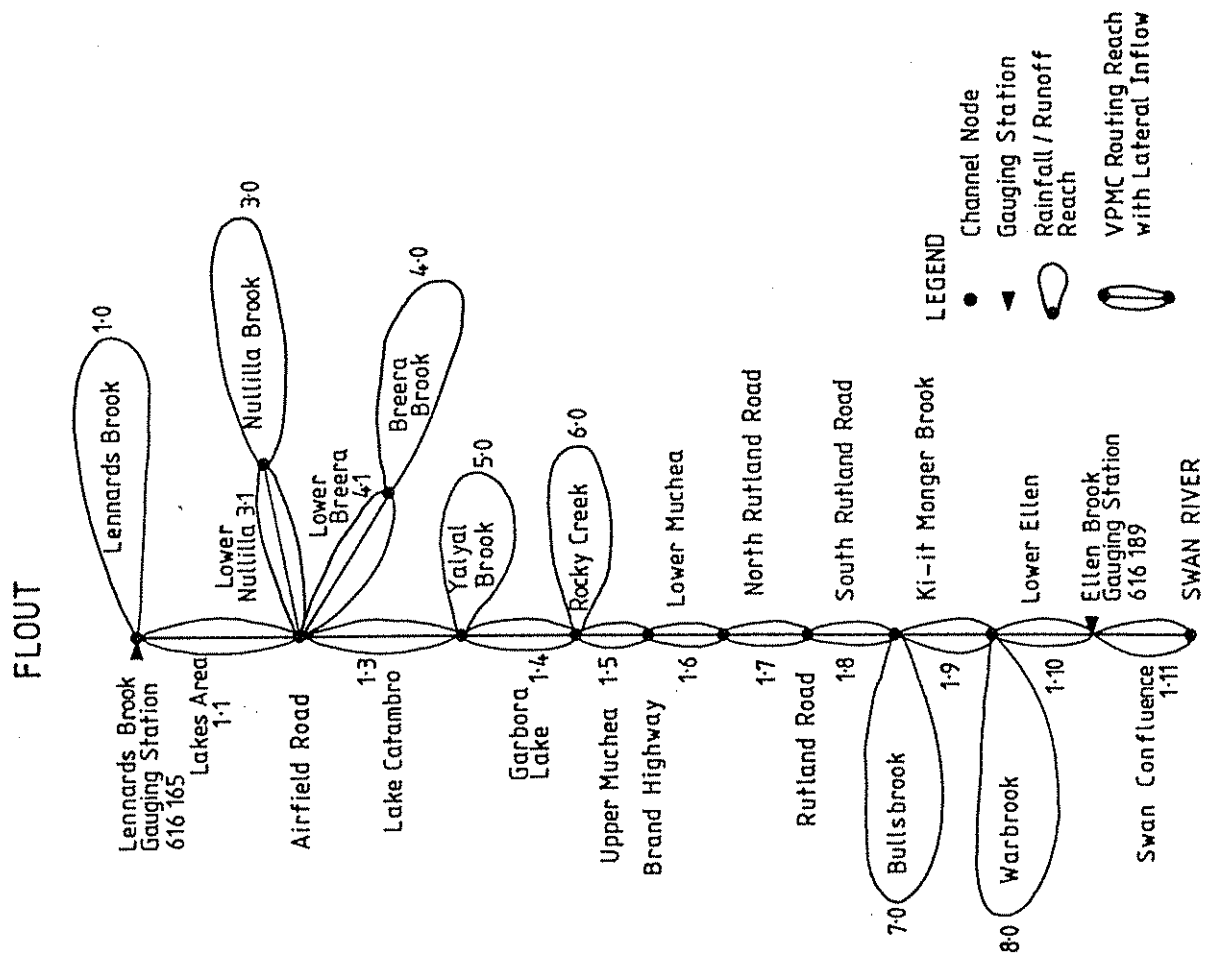
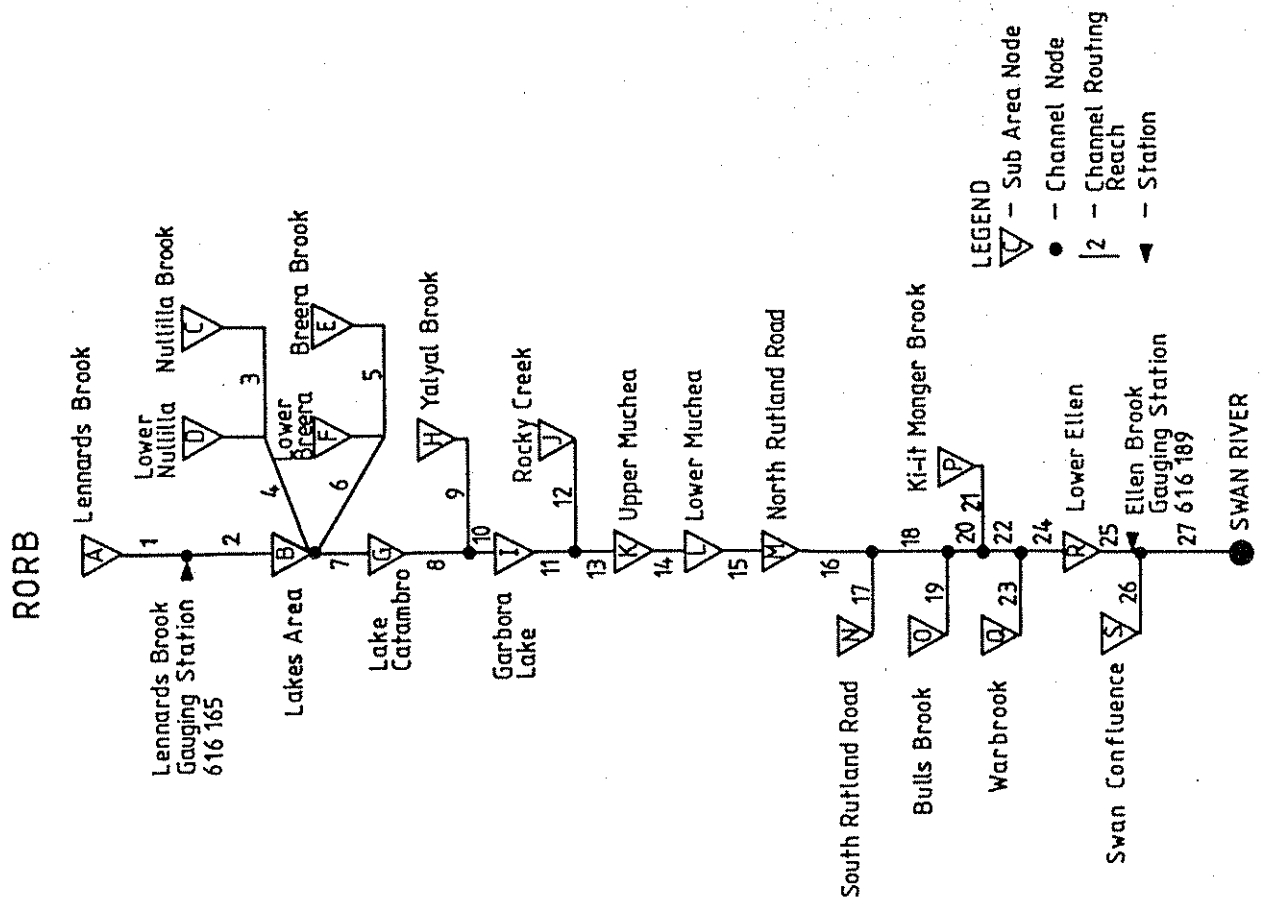
The subdivision of Ellen catchment has also been considered with regard to its suitability for both FLOUT and RORB models. The result of the subdivision of Ellen Brook is given in Figure 5.

The schematization of the catchment helps to show how the overall catchment is modelled. The catchment schematizations for FLOUT and RORB are shown in Figure 6.



**ELLEN BROOK FLOOD STUDY
CATCHMENT SUBDIVISION**

FIGURE 5



ELLEN BROOK
Model Schematization

For FLOUT, the catchment is set up to model the north eastern part (Dandaragan Scarp) with 5 rainfall-runoff sub catchments and the remaining mostly as VPMC reaches with lateral inflow derived from the unit hydrograph/losses model.

8.3 Model Calibration

The data file for FLOUT is built up to reflect the subdivision scheme for catchment. Data input includes derived wave speed and attenuation parameters, T_p s calculated from regression equation and appropriate flags for running the FLOUT program. Once the initial data set is created, it is then ready for calibration.

The calibration process consists of running the model using rainfall data from the observed events. The wave speed $c(Q)$, attenuation parameter $\alpha(Q)$ and the time to peak (T_p) are varied until the best set of corresponding flood peaks is reproduced.

This process, using the derived parameter values as the starting point, requires knowledge of the effects of each parameter on model output and an understanding of the hydraulics of river flow in channels. The adjustment of unit hydrograph T_p for the various sub-areas also requires a good understanding of the likely flood response from each sub-area.

It was found in this study that the model was robust with respect to variation of T_p but was more sensitive to variations in the wave speed / discharge relationship. The attenuation parameter $\alpha(Q)$ derived from assessments of flooded areas in each reach for a series of specified discharges was not changed during the calibration process.

8.4 Model Verification

One technique for model verification is to split the calibration data set, using one half for calibration and the other for verification. In this study however, because of the relatively small number of events it was decided to use all events for model calibration. Also because the areal distribution of rainfall was not well defined for most observed storms it was felt that using as many events as possible for calibration would tend to reduce bias and result in the best overall calibration.

The result of running all calibration events with the finally adopted parameter values is shown in Table 8.

TABLE 8 - FLOUT Runoff Routing Model Calibration

Event	Observed Flood Peak (m ³ /s)	Predicted Flood Peak (m ³ /s)	Error (%)
19 Jul 73	20.29	22.80	12.4
15 Aug 76	26.90	19.99	-25.7
12 Jul 80	19.20	18.88	-1.7
23 Jul 81	30.50	33.45	9.7
10 Aug 81	26.60	30.00	12.8
2 Aug 82	18.10	19.64	8.5
8 Aug 82	20.50	25.50	24.4
14 Sep 84	38.96	37.98	-2.5
14 Jul 85	11.30	11.57	2.4
20 Aug 85	12.80	13.04	1.9

9 CATCHMENT MODELLING - RORB

9.1 Introduction

The model RORB (Laurenson and Mein, 1983) is a well known general runoff and streamflow routing model for the computation of flood hydrographs from rainfall and other channel inputs. The model is areally distributed, non-linear, and applicable to both urban and rural catchments. It makes provision for temporal and areal variation of rainfall and losses and can model flows at any number of gauging stations. In addition to normal channel storage, specific modelling can be provided for retarding basins, storage reservoirs, lakes or large flood plain storages. Base flow and other channel inflow and outflow processes, both concentrated and distributed, can be modelled.

The catchment is divided into several sub-areas bounded by drainage divides. Rainfall on each sub-area is adjusted to allow for infiltration and other losses. A sub-area rainfall excess is assumed to enter the channel network at a point near the centroid of the sub-area. There it is added to any existing flow in the channel and the combined flow is routed through a storage by a linear or non-linear storage routing procedure based on continuity and a storage function

$S = kQ^m$
where S = storage
 Q = outflow discharge
 m = dimensionless exponent, a measure of
catchment non-linearity.
 k = a dimensional empirical coefficient,
a measure of catchment storage effects.

The model parameters k and m are fitted by calibration on observed flood events, then used for design with the required design rainfall excess to produce the corresponding design flood estimates.

9.2 Catchment Subdivision

The sub-division scheme adopted for the RORB model was formulated in parallel with that for FLOUT so that the results obtained from each model could be compared. This also simplified such tasks as the measurement of sub-area sizes and reach lengths.

The method of catchment sub-division is generally on the basis of the stream network and the drainage divides within the catchment. This is compatible with the sub-division scheme for FLOUT although the nomenclature for each system is different.

The sub-areas specified for the RORB model are shown in Figure 5 and the network is shown schematically in Figure 6 indicating the sub-area and reach naming system.

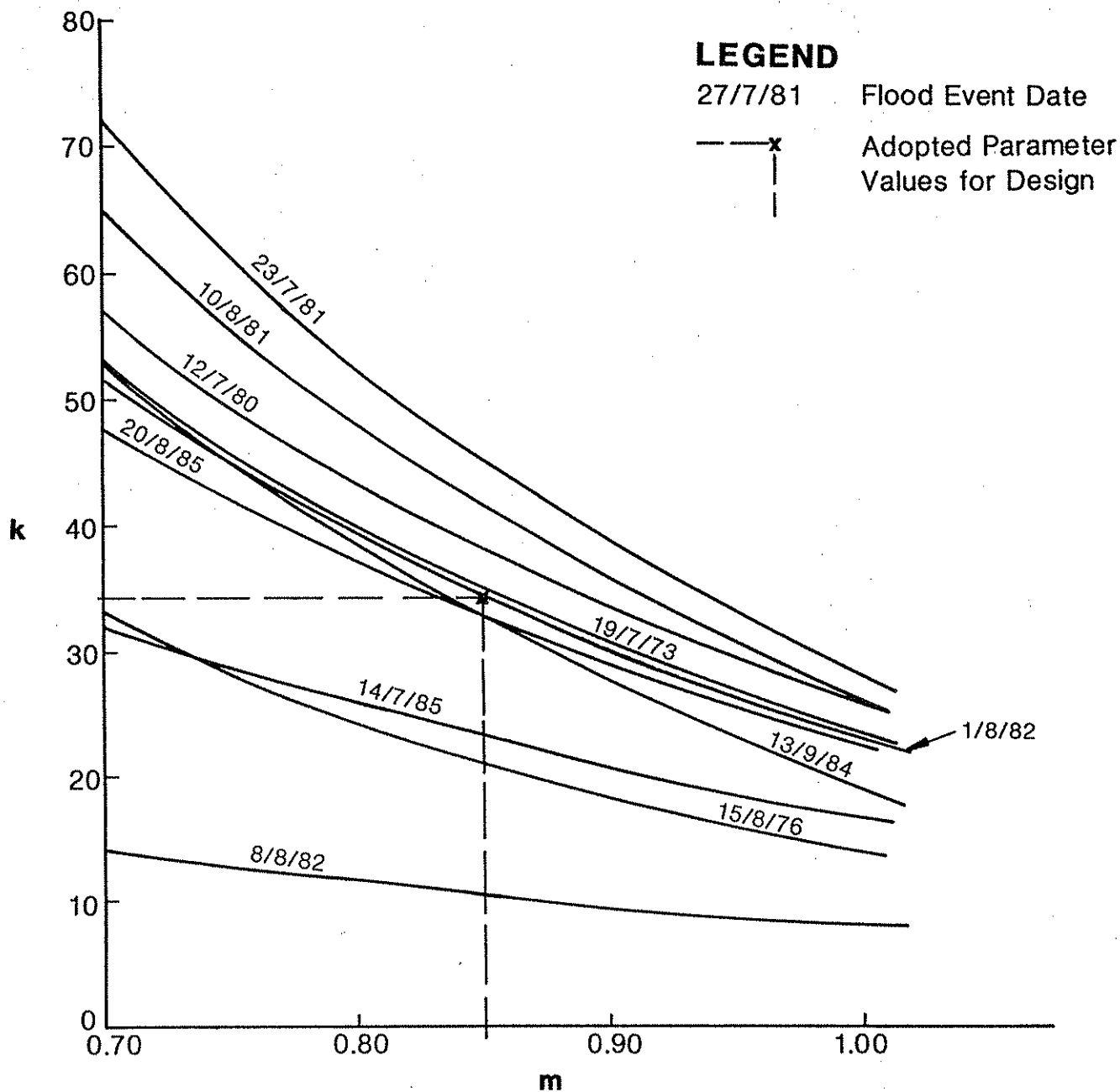
9.3 Model Calibration

The observed flood events shown in Table 1 were also used in the calibration of RORB. In this process eleven flood events were used with baseflow separation carried out as described in Chapter 3.3 prior to calibration. Both the direct runoff and baseflow hydrographs were used in the calibration with variations to initial loss until reasonable agreement with observed time to start of rise of the hydrograph was achieved. For this study the continuing losses during the storm were accounted for by a proportional loss model (ie losses are calculated as a fixed proportion of the rainfall in each time step to provide the correct volume of rainfall excess). The proportional loss model was used in this study since it has been found that it generally provides a better overall hydrograph fit on catchments in the south west of Western Australia than the constant continuing loss model used more extensively in the eastern States.

In this study a range of values of m were selected and k varied to reproduce the observed flood peak for each calibration flood. A parameter interaction diagram was then constructed to aid in the selection of the parameter values finally adopted for design (Figure 7). The values obtained during this process are shown in Table 9.

TABLE 9 - RORB MODEL CALIBRATION m and K VALUES

Calibration Events	"m" Values						
	0.70	0.75	0.80	0.85	0.90	0.95	1.00
	"k" Values						
1 Aug 82	51.5	45.1	39.3	34.3	30.1	25.1	23.0
20 Aug 85	47.0	42.4	37.4	33.0	29.0	25.4	22.5
13 Sep 84	55.0	45.3	38.7	32.3	27.4	22.9	19.0
14 Jul 85	32.0	28.7	26.0	23.1	20.7	18.5	16.5
8 Aug 82	14.0	12.7	11.7	10.5	9.7	8.9	8.0
23 Jul 81	72.0	61.4	52.5	45.1	38.9	33.1	28.0
10 Aug 81	64.8	55.8	47.9	41.5	35.9	30.7	26.0
19 Jul 73	53.0	45.4	40.0	34.8	30.6	26.6	23.4
12 Jul 80	56.9	49.5	43.3	38.0	33.5	29.5	25.6
15 Aug 76	33.0	28.2	24.3	21.0	18.2	15.6	13.8



ELLEN BROOK FLOOD STUDY
RORB - PARAMETER INTERACTION DIAGRAM

FIGURE 7

9.4 Model Verification

As with the model FLOUT, verification of the calibration of RORB was not rigorous. However the model was run for all observed events using the finally adopted model parameter values. Table 10 shows the results of these runs.

TABLE 10 - RORB MODEL CALIBRATION
HISTORICAL FLOOD PREDICTIONS

Adopted Model $m = 0.85$
Parameters $K = 34.3$

Event	Observed Flood Peak (m ³ /s)	Predicted Flood Peak (m ³ /s)	Error (%)
19 Jul 73	20.3	20.9	3.0
25 Jul 73	23.0	23.4	1.7
15 Aug 76	27.1	19.0	-29.9
12 Jul 80	19.2	20.3	5.7
23 Jul 81	30.5	34.5	13.1
10 Aug 81	26.6	29.8	12.0
2 Aug 82	18.1	18.1	0.0
8 Aug 82	20.5	12.3	-40.0
13 Sep 84	40.1	37.9	-5.5
14 Jul 85	11.3	7.8	-31.0
20 Aug 85	12.8	12.4	-3.1

It can be seen that the model is able to reproduce the observed flood peaks reasonably for most events in spite of the fact that rainfall distribution was not particularly well defined, being assumed to be uniformly distributed across the catchment.

The parameter value $k = 34.3$ adopted for design represents the median value from the calibration floods with an $m = 0.85$ being slightly above the value of 0.80 recommended by the authors of the model, however the plot of m vs k shown on Figure 7 indicates that a value closer to unity is a reasonable value to use. This is supported for relatively large floods by evidence presented by Bates and Pilgrim (1983) suggesting that catchment response tends to become linear (ie m approaches 1) as flood magnitude increases to large values.

The other critical factor in deriving design flood estimates is the runoff coefficient or the appropriate loss rate to use.

10 COMPARISON OF RORB AND FLOUT

10.1 Model Results

Design runs using RORB with various storm durations indicated that the critical duration was 48 hours for flows at the Ellen Brook gauging station near the Swan River confluence. Since this point is also near the area of particular concern for flood plain mapping a storm duration of 48 hours was adopted for all design flood estimates.

The design flood was also assumed to be a Winter event in this area of the State although it is recognised that an extreme flood or PMF may well result from a Summer PMP rather than a Winter storm. Antecedent conditions on the catchment were therefore assumed to be such that initial loss for the RORB model would be zero and the calibrated runoff coefficient of 12.1% was used.

The results of design runs from both models and the flood frequency analysis including peak flow discharges at various points of special interest on the catchment are shown in Table 11. More comprehensive model results for these design runs are shown in Appendix D.

TABLE 11 - DESIGN FLOOD ESTIMATES

PEAK FLOW SUMMARY from RORB AND FLOUT

Location	Average Recurrence Interval								
	100 yrs			50 yrs			25 yrs		
	RORB	FLOUT CWI=150	FLOUT CWI=250	RORB	FLOUT CWI=150	FLOUT CWI=250	RORB	FLOUT CWI=150	FLOUT CWI=250
Ellen Brook Rutland Rd	81	70	73	69	61	63	62	56	58
Bulls Bk @ Ellen Confluence	8.9	7.1	7.3	7.6	6.1	6.4	6.8	5.6	5.8
Ellen Bk Gauging Station	97 (97*)	91	96	83 (86*)	79	82	75 (75*)	72	74
Ellen Bk Swan R Confluence	99	100	104	88	86	89	76	78	82

* Flood Frequency estimates based on scaling from Avon River flood frequency curve.

It can be seen from Table 11 that the flood estimates are in good agreement. FLOUT generally gives slightly lower estimates than RORB except at the last reach to the Swan.

It can also be seen that the adoption of a high value for CWI in FLOUT (implying high antecedent wettness) does not cause a dramatic increase in flood peak. Overall percentage runoff was kept the same (12.1%) for both runoff routing models. The CWI value at the start of the event has some influence on the temporal distribution of direct runoff. The average value of 150 mm results in an "initial loss" effect at the start of the flood, however the overall direct runoff volume is determined by the specified percentage runoff. The resulting design hydrograph has a more gradual rise at the start which looks a little better than the sudden steep rise in the case of RORB where an initial loss of zero has been used.

A comparison of the 1%, 2% and 4% AEP flood hydrographs at the Ellen Brook gauging station are shown in Figure 8 to be in good agreement.

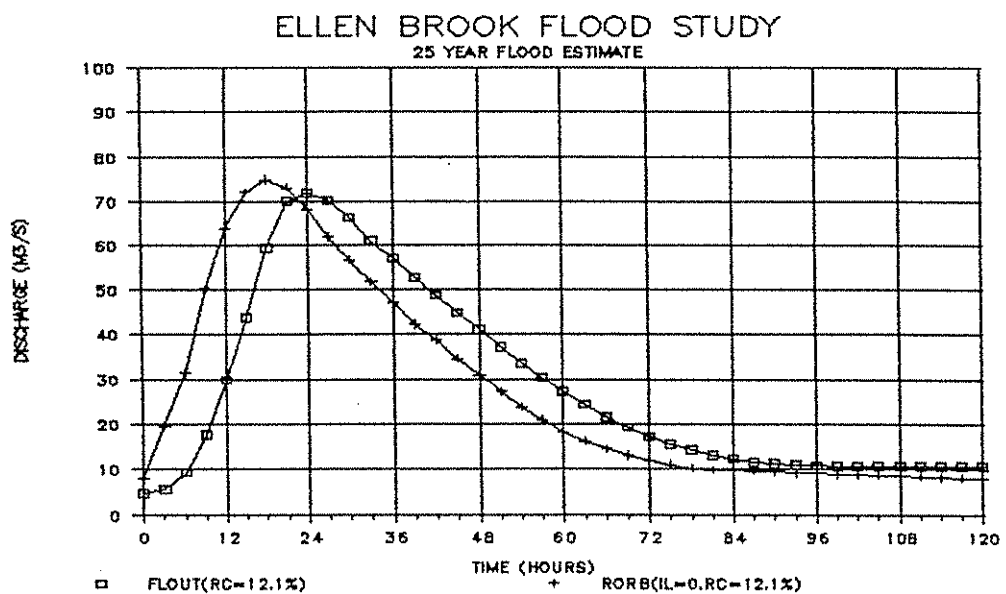
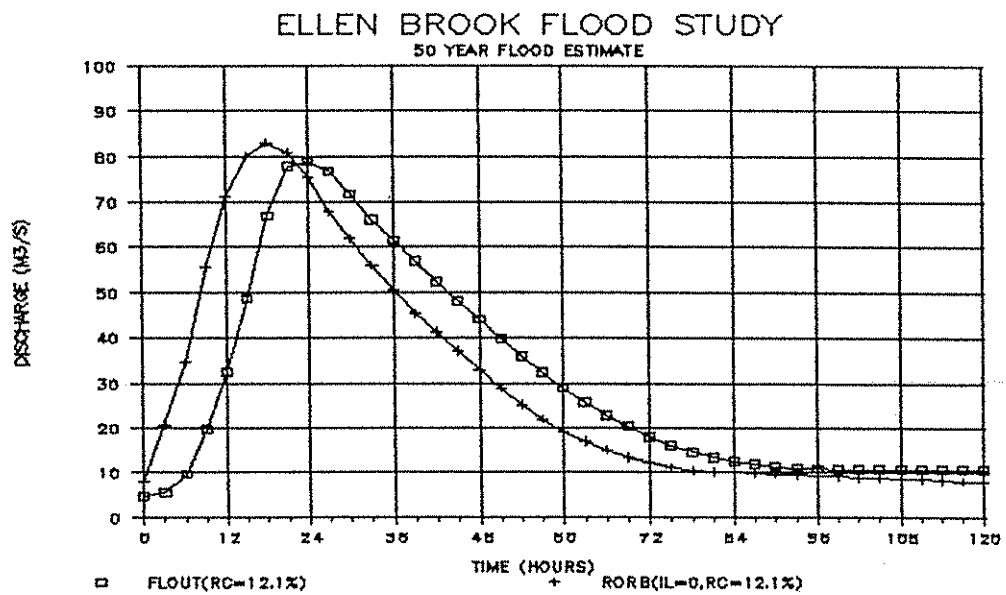
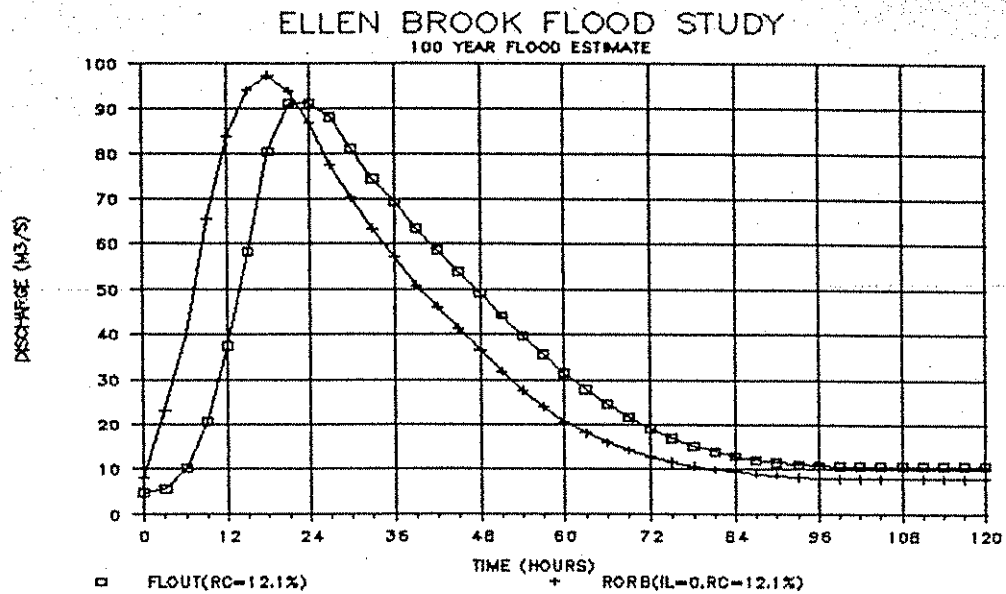
It should be noted that the design flood peak shown for Bulls Brook corresponds to a 48 hour duration design storm whereas the critical duration for that sub catchment in isolation would be much shorter. In terms of flood levels in Bulls Brook however, the flood level at its confluence with Ellen Brook will tend to be dominated by the flow in Ellen Brook. Design flows in the upper reaches of Bulls Brook would need to be evaluated for shorter duration storms as part of a more detailed study of that subarea.

10.2 Model Limitations

The principal limitation of the two runoff routing models is one common to any rainfall based method of flood estimation; that of what percentage runoff to apply in the design case. Adopting a median or average percentage runoff from observed flood events which are generally the largest available events that are suitable for calibration can result in bias towards wetter antecedent conditions. This could result in assumed losses being less than a true median value with consequent tendency to over estimate flood peaks in design.

A further limitation with runoff routing models applied to flood estimation in the South West of W.A. concerns model calibration where observed flood events have peak flow magnitudes only a small fraction of the design flood estimate. This means that the model is applied well beyond the calibration range in many cases with a corresponding reduction of confidence in the flood estimate. In these cases the application of several flood estimation methods is often carried out as a check.

In this study a flood frequency analysis has been used as a method of deriving an appropriate runoff coefficient for design. Being a more direct method, flood frequency analysis eliminates the need to consider catchment conditions and percentage runoff values since these are already implied in the flood estimate. The main limitation of this method is that only relatively short periods of record are available for rivers in the South West. In this study the flood frequency analysis based on only 16 years of streamflow record includes a ten year period of dry years and small floods. The adjustment made in this case to account for the low flow period relies on modelling of the Avon River with the development of a flood frequency curve based on long term



ELLEN BROOK
Design Hydrographs Comparisons

historical daily rainfalls and major historical flood events in that catchment. An adjustment based on scaling from a period common to both flood series was carried out as described in Chapter 5. Although a simple scaling of the flood frequency curve was used the results are regarded as reasonably reliable because the method is a direct flood estimation technique avoiding the problems of loss modelling, percentage runoff calculation etc.

10.3 Model Features

RORB is a widely used runoff routing model developed in Australia for flood estimation. It is relatively easy to apply, having only two parameters to fit ("m", defining the degree of non-linearity of flood response and "k", accounting for catchment storage-delay effects). It may be calibrated using observed flood event data or regionally derived values may be applied for some areas of Australia. Being a distributed model it can account for areal and temporal variations in model inputs and it can provide a full hydrograph output.

While the value of k can be calibrated for observed events and a median value selected for design, the parameter m is not so easily evaluated. It tends to be set at one value and remain unchanged. It does however, have a greater impact on model output than the k value so needs to be selected carefully. A value of $m = 0.8$ recommended by the authors of the model is probably conservative for the estimation of large floods and in this study the k vs m interaction diagram (Figure 7) indicates that a higher value is probably appropriate for this catchment. A value of 0.85 was therefore adopted, although that may also be fairly conservative. While the model has the facility to account for up to four different channel reach types governing the channel routing, its handling of these reaches with respect to storage delay effects in drains and piped systems is based on limited data.

FLOUT has been developed in the UK using data for British rivers. The version used for this study has been adapted for use on Australian catchments by Binnie & Partners Pty.Ltd.

In FLOUT the channel routing is governed by the wave speed and attenuation characteristics specified for each reach. The model can also account for overbank flow, distributed or concentrated inflows and outflows. While these features make it potentially more accurate for channel routing it requires the input of specific channel characteristics for each reach.

It was found in this study that the specification of overbank flow requires detailed data on the discharge coefficients which govern outflow from the channel during the flood rise and return flow to the channel during the recession. It also requires data on the level at which overbank flow (temporarily lost from the drainage network) commences and the level (lower) at which return flow begins to be added back into the drainage network.

In attempting to specify these parameter values it was found that

the resultant flood hydrograph could become unstable, developing severe oscillations when the channel discharge exceeded the overbank flow value specified for the reach. For the natural channels in this catchment, where flood flows tend to spread beyond the low flow channel, it was found that the model was more stable when a very large "overbank" flow is specified, (ie a value which is not exceeded during design flood runs). In this case flood water does not leave the drainage network but remains within the confines of what is effectively a large shallow dished channel. The wave speed and attenuation parameters then appear to handle flood flows satisfactorily.

The application of FLOUT requires the specification of more extensive input data than does RORB although it does have the potential to simulate more closely the flood routing response of individual channel reaches. Data preparation for FLOUT involves the calculation of wave speed and attenuation parameters for the channel routing component and the development of unit hydrographs for the generation of runoff from rainfall on each subarea (linear catchment response is therefore assumed.) This can involve surveying of river cross-sections, calculation of hydraulic properties and regression analyses for time to peak of unit hydrographs and percentage run-off relationships.

The model also uses a catchment wetness index (CWI) as the basis for the distribution of percentage runoff during the passage of the storm. Initial values for CWI are therefore required to represent antecedent catchment wetness conditions.

RORB has generally simpler input data requirements, yet it does have the flexibility to incorporate a more complex storage-discharge relationship for any routing reach if such an equation is known or can be derived. It can also handle variations in temporal and areal distribution of rainfall and provides for two commonly used loss models.

Although RORB can be used to simulate non-linear flood response by specifying $m < 1.0$, the calibration of the model is subject to interaction between its two parameters k and m . The basis of selection of a particular value for m (0.85 for this study) is not readily verifiable with currently available observed data in the south west of W.A. because of the lack of large flood events in the past. The degree of non-linearity is therefore assumed and the k value only is calibrated from observed flood events.

For the above reasons RORB is generally much quicker to set up and easier to use than FLOUT, however there is still a need for a full understanding of the assumptions made in RORB as with any other model.

The results from both models indicate good agreement with the more direct flood frequency approach which should yield a better flood estimate provided adequate length of recorded flood peaks is available.

Both runoff routing models used here have the advantage that they can provide a full hydrograph at any node point on the catchment whereas the flood frequency estimate provides only a peak flow at one location on the catchment (normally at a gauging station).

11 CONCLUSIONS

Design flood estimates have been prepared for Ellen Brook near Perth, Western Australia using two runoff routing models and a flood frequency method as part of a flood study for flood plain mapping in the lower reaches of the Ellen Brook catchment.

The study has shown that the models RORB and FLOUT can produce flood estimates close to those from a more direct flood frequency approach. Both FLOUT and RORB have the same limitations of any rainfall based flood estimation method, the major factor being selection of the appropriate runoff coefficient for flood estimates beyond the range of observed historical floods.

11.1 Modelling Using FLOUT

FLOUT is a distributed runoff routing model developed in the United Kingdom (Price, 1977), adapted and improved for Australian catchments by Binnie & Partners and applied to a number of hydrologic studies in Australia.

The program includes a number of routines for hydrologic and hydraulic calculations. One optional routine calculates runoff given rainfall using the unit hydrograph / losses model proposed in the UK Flood Studies Report (NERC, 1975).

Channel routing of flows uses the variable parameter Muskingum-Cunge (VPMC) method. The principal variables required for VPMC channel routing are the reach length, the wave speed and the attenuation parameter. The wave speed and attenuation parameters take account of the hydraulic characteristics of the river channel and its flood plain; the wave speed parameter describes the variation with discharge of the speed of travel of a flow wave in the river, while the attenuation parameter describes the variation with discharge of the attenuation of the peak due to temporary storage.

The program solves the river system working downstream. When a confluence is reached, the flows for the main channel are stored while calculation continues down the tributary back to the main channel. The main channel and tributary flows are added and calculation resumes down the river system.

The model is calibrated on a set of observed flood events varying the wave speed, attenuation and time to peak of the sub-area unitgraphs until the best overall set of corresponding flood peaks is reproduced. Design flood hydrographs are produced using the rainfalls for a series of storm durations to determine the critical duration. Percentage runoff for design is specified by the designer as with other rainfall based methods and is the most critical factor in the flood estimation process.

11.2 Modelling using RORB

The model RORB (Laurenson and Mein, 1983) is a well known general runoff and streamflow routing model for the computation of flood hydrographs from rainfall and other channel inputs. The model is areally distributed, non-linear, and applicable to both urban and rural catchments.

The catchment is divided into several sub-areas bounded by drainage divides. Rainfall on each sub-area is adjusted to allow for infiltration and other losses with sub-area rainfall excess assumed to enter the channel network at a point near the centroid of the sub-area. There it is added to any existing flow in the channel and the combined flow is routed through a storage by a linear or non-linear storage routing procedure based on continuity and a storage function :-

$$S = kQ^m$$

where S = storage

Q = outflow discharge

m = dimensionless exponent, a measure of catchment non-linearity.

k = a dimensional empirical coefficient, a measure of catchment storage effects.

The model parameters k and m are fitted by calibration on observed flood events.

In this study the catchment subdivision scheme for RORB was made the same as that for FLOUT and the same calibration floods were used for each model to aid in the comparison.

11.3 Comparison of Methodologies

The two runoff routing models use the same basic methodology of catchment sub-division, calibration on observed flood events and application of design rainfalls with an appropriate loss model to produce a design flood of the required probability.

The models differ in the amount of data required for the preparation of their input files and the ease of calibration. RORB requires a relatively small amount of data on catchment characteristics whereas FLOUT requires data on the wave speed and attenuation characteristics of each routing reach plus the development of unit hydrographs for each sub-area contributing direct runoff to the channel network. This can involve field work to measure river cross-sections and the derivation of relationships between catchment properties and flood response. These derivations normally involve regression analyses which are not always capable of fully explaining the relationships. Smoothing of data to obtain average values of parameters for each channel reach is normally required to achieve satisfactory model behaviour.

The approach to this study of using the pooled resources of two organisations has resulted in a valuable exchange of information and experience. It has indicated the potential for improved techniques of flood estimation combining the best elements of each model used in this study.

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APPENDICES

APPENDIX A.1 - ELLEN BROOK CATCHMENT SUB-DIVISION

NAME OF SUB- CATCHMENT	FLOUT REACH NUMBER	MODEL REACH TYPE	CATCHMENT AREA (km ²)	REACH LENGTH (km)	LOCATION OF D/S NODE	CHAINAGE OF D/S NODE (km)
Lennard Brook	1.0	Rainfall- Runoff (RF/RO)	60.0	-	Lennard Brook G.S.	48.2
Lakes Catchment No 1	1.1	VPMC reach with RF/RO lateral inflow	31.5	9.5	Near Bambun Rd.	38.7
Lakes Catchment No 2	1.2	VPMC reach with RF/RO lateral inflow	0.0	1.0	Airfield Rd. U/S of Nullilla and Breera conf	37.7
Nullilla Brook	3.0	RF/RO	31.2	-	Gnowlialup at Scarp	37.7
Lower Nullilla	3.1	VPMC reach with RF/RO lateral inflow	7.0	4.3	Airfield Rd U/S of Culvert	37.7
Breera Brook	4.0	RF/RO	23.7	-	Beyrangup at Scarp	37.7
Lower Breera	4.1	VPMC reach with RF/RO lateral inflow	11.6	3.0	Airfield Rd U/S of Culvert	37.7
Lake Catambro	1.3	VPMC reach with RF/RO lateral inflow	45.5	8.4	U/S of Chandala Bk./Yalyal Bk. confluence	29.3
Yalyal Brook	5.0	RF/RO	51.9	-	D/S of Chandala Bk./Yalyal Bk. confluence	29.3
Garbora Lakes	1.4	VPMC reach with RF/RO lateral inflow	27.1	4.8	U/S of Chandala Bk./Rocky Crk. confluence	24.5
Rocky Creek	6.0	RF/RO	35.3	-	D/S of Chandala Bk./Rocky Crk. confluence	24.5
Upper Muchea	1.5	VPMC reach with RF/RO lateral inflow	30.7	2.7	Brand Highway culvert	21.8

APPENDIX A.1 (Cont'd)

NAME OF SUB- CATCHMENT	FLOUT REACH NUMBER	MODEL TYPE	CATCHMENT AREA (km ²)	REACH LENGTH (km)	LOCATION OF D/S NODE	CHAINAGE OF D/S NODE (km)
Lower Muchea	1.6	VPNC reach with RF/RO lateral inflow	46	4.3	17.5 km U/S Ellen Bk G.S.	17.5
North Rutland Road	1.7	VPNC reach with RF/RO lateral inflow	34.1	3.7	Rutland Rd. Culvert	13.8
South Rutland Road	1.8	VPNC reach with RF/RO lateral inflow	17.4	2.8	U/S of Ellen Bk / Bullsbrook confluence	11.0
Bullsbrook	7.0	RF/RO	30.3	-	D/S of Ellen Bk / Bullsbrook confluence	11.0
Ki-it Monger Brk.	1.9	VPNC reach with RF/RO lateral inflow	26.3	4.5	@ 6.5 km Chainage	6.5
Warbrook	8.0	RF/RO	32.3	-	@ 6.5 km Chainage	6.5
Lower Ellen	1.10	VPNC reach with RF/RO lateral inflow	33.8	6.5	Ellen Brook Gauging Station	0.0
Swan Confluence	1.11	VPNC reach with RF/RO lateral inflow	50.5	7.2	Swan River/ Ellen Brook confluence	-7.2*

* indicates D/S of Ellen Bk. G.S.

APPENDIX A.2 - RORB CATCHMENT SUBDIVISION

RORB REACH	REACH	SUB-AREA	SUB-AREA	SUB-AREA	RORB REACH	REACH	SUB-AREA	SUB-AREA	SUB-AREA
NUMBER	LENGTH (km)	NODE	NAME	SIZE (km ²)	NUMBER	LENGTH (km)	NODE	NAME	SIZE (km ²)
1	6.5	A	Lennards Brook	60.0	12	6.1	L	Lower Muchea	46
2	4	B	Lakes Catchment	31.5	13	1.7	M	North Rutland Road	34.1
3	8	C	Nullilla Brook	31.2	14	3.2	N	South Rutland Road	17.4
4	4	D	Lower Nullilla	7.0	15	3.6	O	Bulls Brook	30.3
5	6.2	E	Breera Brook	23.7	16	3.6	P	Ki-it Monger Brook	26.3
6	2	F	Lower Breera	11.6	17	2.6	Q	Warbrook	32.3
7	4	G	Lake Catambro	45.5	18	1.0	R	Lower Ellen	33.8
8	4.3	H	Yalyal Brook	51.9	19	6.5	S	Swan Confluence	50.5
9	6	I	Garbora Lake	27.1	20	2.8			
10	2.2	J	Rocky Creek	35.3	21	2.7			
11	2.6	K	Upper Muchea	30.7	22	2.0			
					23	5.5			
					24	3.3			
					25	3.2			
					26	5.2			
					27	7.2			

APPENDIX B.1 TYPICAL FLOUT INPUT FILE

EVENT-SPECIFIC DATA SHOWN Underlined>.

ELLEN BROOK FLOOD STUDY - B & P and WAWA, CJUL731Z.PRN 12:47 PM 13-May-87

1,0 Lennards Bk,RR,@Lennard Bk GS

1	0	0	0	0	40		
0	0	0	2	1	1	0	
60	<u>0.0082385</u>	0					
[0.000	1.793	4.304	7.890	12.553	16.857	17.753	17.036]
[15.960	15.063	14.167	13.270	12.374	11.656	10.939	9.684] Unit hydrograph
[9.146	8.428	8.070	7.532	6.994	6.456	6.097	5.559] Ordinates
[5.200	4.663	4.304	3.945	3.587	3.228	2.869	2.511]
[2.331	1.973	1.614	1.255	0.538	0.179	0.000	0.000]

1,1 Lakes Catchment 1,VPMC,@u/s of 1.2

1	1	0	0	9500	-2		
0	2	0	0	0	1	0	
16	10	1	2				
[0.39	0.44	0.48	0.58	0.71	0.69	0.77	0.88] Wave Speed Parameter c(Q)
[1.02	1.07	1.1	1.18	1.23	1.31	1.42	1.6]
[2	1.4	1.2	1.12	1.05	1	0.98	0.9] Attenuation Parameter $\alpha(Q)$
[0.88	0.86	0.84	0.82	0.8	0.77	0.73	0.71]
40	32	40	60	1.8	0	60	9
31.5	<u>0.0102652</u>	0					

3,0 Nullilla Bk,RR,@Gnowlialup at Scarp

3	0	0	0	0	40		
0	0	0	2	1	1	0	
31.2	<u>0.0082385</u>	0					
0.000	1.793	4.304	7.890	12.553	16.857	17.753	17.036
15.960	15.063	14.167	13.270	12.374	11.656	10.939	9.684
9.146	8.428	8.070	7.532	6.994	6.456	6.097	5.559
5.200	4.663	4.304	3.945	3.587	3.228	2.869	2.511
2.331	1.973	1.614	1.255	0.538	0.179	0.000	0.000

3,1 Lower Nullilla,VPMC,@Airfield Rd u/s of culvert

3	1	0	0	4300	-2		
0	2	1	0	0	1	0	
16	10	1	2				
0.39	0.44	0.48	0.58	0.71	0.69	0.77	0.88
1.02	1.07	1.1	1.18	1.23	1.31	1.42	1.6
2	1.4	1.2	1.12	1.05	1	0.98	0.9
0.88	0.86	0.84	0.82	0.8	0.77	0.73	0.71
100	80	100	200	1.8	1.6	0	
7	<u>0.0082385</u>	0					

1,2 Lakes Catchment 2,VPMC,@Airfield Rd u/s Null/Breera conf

1	2	3	1	1000	0		
0	0	0	0	0	1	0	
16	10	1	2				
0.39	0.44	0.48	0.58	0.71	0.69	0.77	0.88
1.02	1.07	1.1	1.18	1.23	1.31	1.42	1.6
2	1.4	1.2	1.12	1.05	1	0.98	0.9
0.88	0.86	0.84	0.82	0.8	0.77	0.73	0.71
100	80	250	360	1.8	1.6	0	

APPENDIX B.1 (Cont'd)

4,0 Breera Bk,RR,@ Beyrangup at Scarp

4	0	0	0	0	40		
0	0	0	2	1	1	0	
23.7	0.0082385	0					
0.000	1.793	4.304	7.890	12.553	16.857	17.753	17.036
15.960	15.063	14.167	13.270	12.374	11.656	10.939	9.684
9.146	8.428	8.070	7.532	6.994	6.456	6.097	5.559
5.200	4.663	4.304	3.945	3.587	3.228	2.869	2.511
2.331	1.973	1.614	1.255	0.538	0.179	0.000	0.000

4,1 Lower Breera,VPMC,@ Airfield Rd u/s of culvert

4	1	0	0	3000	-2		
0	2	1	0	0	1	0	
16	10	1	2				
0.39	0.44	0.48	0.58	0.71	0.69	0.77	0.88
1.02	1.07	1.1	1.18	1.23	1.31	1.42	1.6
2	1.4	1.2	1.12	1.05	1	0.98	0.9
0.88	0.86	0.84	0.82	0.8	0.77	0.73	0.71
100	80	100	300	1.8	1.6	0	
11.6	0.0082385	0					

1,3 Lake Catambro,VPMC,@ u/s Chandala/Yalyal Bk conf

1	3	4	1	8400	-2		
0	2	1	0	0	1	0	
16	10	1	2.5				
0.49	0.52	0.5	0.51	0.51	0.53	0.6	0.64
0.67	0.72	0.77	0.8	0.89	0.95	1	1.15
4	3	2.4	1.87	1.5	1.32	1.25	1.2
1.15	1.1	1.05	1	0.95	0.92	0.9	0.87
200	160	200	1200	1.8	1.6	0	
45.5	0.0102652	0					

5,0 Yalyal Bk,RR,@ d/s of Chandala/Yalyal Bk conf

5	0	0	0	0	40		
0	0	0	2	1	1	0	
51.9	0.0082385	0					
0.000	1.793	4.304	7.890	12.553	16.857	17.753	17.036
15.960	15.063	14.167	13.270	12.374	11.656	10.939	9.684
9.146	8.428	8.070	7.532	6.994	6.456	6.097	5.559
5.200	4.663	4.304	3.945	3.587	3.228	2.869	2.511
2.331	1.973	1.614	1.255	0.538	0.179	0.000	0.000

1,4 Garbora Lakes,VPMC,@ u/s Chandala/Rocky Ck conf

1	4	5	0	4800	-2		
0	2	1	0	0	1	0	
16	10	1	2.5				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
30	17.5	5.4	3	2.2	1.9	1.7	1.58
1.5	1.35	1.28	1.2	1.15	1.1	1.06	1.01
200	180	320	570	1.8	1.6	0	0
27.1	0.0102652	0					

APPENDIX B.1 (Cont'd)

6,0 Rocky Ck,RR,@ d/s Chandala/Rocky Ck conf

6	0	0	0	0	40		
0	0	0	2	1	1	0	
35.3	0.0082385	0					
0.000	1.793	4.304	7.890	12.553	16.857	17.753	17.036
15.960	15.063	14.167	13.270	12.374	11.656	10.939	9.684
9.146	8.428	8.070	7.532	6.994	6.456	6.097	5.559
5.200	4.663	4.304	3.945	3.587	3.228	2.869	2.511
2.331	1.973	1.614	1.255	0.538	0.179	0.000	0.000

1,5 Upper Muchea,VPMC,@Brand Highway culvert

1	5	6	0	2700	-2		
0	2	1	0	0	1	0	
16	10	1	2.5				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
30	17.5	5.4	3	2.2	1.9	1.7	1.58
1.5	1.35	1.28	1.2	1.15	1.1	1.06	1.01
200	180	425	620	1.8	1.6	0	0

30.7 0.0102652

1,6 Lower Muchea,VPMC,@Chainage 17.5km

1	6	0	0	4300	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
30	17.5	5.4	3	2.2	1.9	1.7	1.58
1.5	1.35	1.28	1.2	1.15	1.1	1.06	1.01
200	160	300	525	1.8	1.6	0	0

46 0.0102652

1,7 Nth Rutland Rd,VPMC,@Rutland Rd culvert

1	7	0	0	3700	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
30	17.5	5.4	3	2.2	1.9	1.7	1.58
1.5	1.35	1.28	1.2	1.15	1.1	1.06	1.01
200	160	300	500	1.8	1.6	0	0

34.1 0.0102652

1,8 Sth Rutland Rd,VPMC,@u/s of Ellen Bk/Bulls Bk conf

1	8	0	0	2800	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
7	4.75	3.6	2.65	1.9	1.4	1.1	1
0.9	0.85	0.8	0.78	0.75	0.72	0.7	0.69
200	160	300	330	1.8	1.6	0	0

17.4 0.0102652

7,0 Bulls Bk,RR,@d/s of Ellen Bk/Bulls Bk conf

7	0	0	0	0	-2		
0	0	0	2	1	1	0	
30.3	0.0102652	0					

APPENDIX B.1 (Cont'd)

1,9 Ki-it Monger Bk, VPMC, @ 6.5 km chainage

1	9	7	0	4500	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
7	4.75	3.6	2.65	1.9	1.4	1.1	1
0.9	0.85	0.8	0.78	0.75	0.72	0.7	0.69
200	180	300	330	1.8	1.6	0	0
26.3	0.0102652	0					

8,0 Warbrook, RR, @ 6.5 km chainage

8	0	0	0	0	-2		
0	0	0	2	1	1	0	
32.3	0.0102652	0					

1,10 Lower Ellen, VPMC, @ Ellen Bk GS

1	10	8	0	6500	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.61	0.58	0.63	0.76	0.89	1.03	1.23	1.39
1.53	1.67	1.9	2.06	2.09	2.21	2.44	2.76
7	4.75	3.6	2.65	1.9	1.4	1.1	1
0.9	0.85	0.8	0.78	0.75	0.72	0.7	0.69
200	160	160	120	1.8	1.6	0	0
33.8	0.0102652	0					

1,11 Swan Conf catchment, VPMC, @ Swan/Ellen Bk conf

1	11	0	0	7200	-2		
0	2	1	0	0	1	0	
16	10	1	3				
0.2	0.6	0.8	0.7	0.8	1.0	1.15	1.3
1.45	1.5	1.55	1.6	1.6	1.6	1.6	1.6
45	25.5	6	4.25	4	3.85	3.75	3.7
3.65	3.6	3.55	3.5	3.45	3.4	3.36	3.31
250	200	20	145	1.8	1.6	0	0
50.5	0.0102652	0					

LAST REACH

CALIBRATION FLOOD - 19 JULY 1973

1600	17	7	1973	3	40	1	0
50							
0	0						
0.13	0	0.13	0.84	3.47	4.16	1.73	3.5
2.09	3.59	2.51	3.2	2.34	2.13	0.95	1.18
2.57	0.35	0.32	0.15	0.65	0.44	0.08	0.9
0.4	0.62	0.38	1.48	0.78	0	0.19	0.07
0	0.2	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0						

1,0 Lennards Bk, RR, @ Lennards Bk GS

1	0				0	0	T
-1	1	1		41.53	-1	1	1
168	90	0	5.73	1	8.6684324		

1,1 Lakes Catchment 1, VPMC, @ u/s of 1.2

1	1				0		
-1	1	1		41.53	-1	1	1
168	90	-2	9	1	8.6684324		
1	1				0	0	F

APPENDIX B.1 (Cont'd)

3,0 Nullilla Bk,RR,@Gnowlialup at Scarp

3	0			0	0	F
-1	1	1		41.53	-1	1
<u>168</u>	90	0	6	1	<u>8.6684324</u>	

3,1 Lower Nullilla,VPNC,@Airfield Rd u/s of culvert

3	1			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	4	1	<u>8.6684324</u>	
3	1			0	0	F

1,2 Lakes Catchment 2,VPNC,@Airfield Rd u/s Null/Breera conf

1	2			0	0	F
---	---	--	--	---	---	---

4,0 Breera Bk,RR,@ Beyrangup at Scarp

4	0			0	0	F
-1	1	1		41.53	-1	1
<u>168</u>	90	0	6	1	<u>8.6684324</u>	

4,1 Lower Breera,VPNC,@ Airfield Rd u/s of culvert

4	1			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	4	1	<u>8.6684324</u>	
4	1			0	0	F

1,3 Lake Catambro,VPNC,@ u/s Chandala/Yalyal Bk conf

1	3			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	9	1	<u>8.6684324</u>	
1	3			0	0	F

5,0 Yalyal Bk,RR,@ d/s of Chandala/Yalyal Bk conf

5	0			0	0	F
-1	1	1		41.53	-1	1
<u>168</u>	90	0	7	1	<u>8.6684324</u>	

1,4 Garbora Lakes,VPNC,@ u/s Chandala/Rocky Ck conf

1	4			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	8	1	<u>8.6684324</u>	
1	4			0	0	F

6,0 Rocky Ck,RR,@ d/s Chandala/Rocky Ck conf

6	0			0	0	F
-1	1	1		41.53	-1	1
<u>168</u>	90	0	7	1	<u>8.6684324</u>	

1,5 Upper Muchea,VPNC,@Brand Highway culvert

1	5			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	7	1	<u>8.6684324</u>	
1	5			0	0	F

1,6 Lower Muchea,VPNC,@Chainage 17.5km

1	6			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	7	1	<u>8.6684324</u>	
1	6			0	0	F

1,7 Nth Rutland Rd,VPNC,@Rutland Rd culvert

1	7			0		
-1	1	1		41.53	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	
1	7			0	0	F

APPENDIX B.1 (Cont'd)

1,8 Sth Rutland Rd, VPMC, @u/s of Ellen Bk/Bulls Bk conf

1	8			0		
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	
1	8			0		F

7,0 Bulls Bk, RR, @d/s of Ellen Bk/Bulls Bk conf

7	0			0		F
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	

1,9 Ki-it Monger Bk, VPMC, @ 6.5 km chainage

1	9			0		
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	
1	9			0		F

8,0 Warbrook, RR, @6.5 km chainage

8	0			0		F
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	

1,10 Lower Ellen, VPMC, @Ellen Bk GS

1	10			0		
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	5	1	<u>8.6684324</u>	
1	10			0		F

1,11 Swan Conf catchment, VPMC, @Swan/Ellen Bk conf

1	11			0		
-1	1	1		<u>41.53</u>	-1	1
<u>168</u>	90	-2	6	1	<u>8.6684324</u>	
1	11			0		F

LAST FLOWS

APPENDIX B.2 TYPICAL RORB INPUT FILE

EVENT-SPECIFIC DATA SHOWN Underlined>.

ELLEN BROOK - DESIGN RUN 100 YR 48 HR STORM (1987 ARR)

1, ALL REACHES ASSUMED TO BE NATURAL CHANNELS

9,0,25,1,0,-99, BASEFLOW AT ELLEN BROOK G.S.

1,6.5,-99, LENNARDS BROOK, REACH 1

7,

LENNARDS BK GS

5,6.0,-99, REACH 2

2,4.0,-99, 'LAKES' REACH

3, STORE H/G FROM LAKES AREA

1,8.0,-99, NULLILLA BRK , REACH 3

2,4.0,-99, LOWER NULLILLA , REACH 4

4, ADD IN U/S H/G

3, STORE H/G

1,6.2,-99, BREERA CRK, REACH 5

2,2.0,-99, LOWER BREERA, REACH 6

4, ADD IN U/S H/G

5,4.0,-99, ROUTE THRU REACH 7

2,4.3,-99, LAKE CATAMBRO, REACH 8

3, STORE H/G

1,6.0,-99, YALYAL BRK, REACH 9

4, ADD IN U/S H/G

5,2.2,-99, ROUTE THRU REACH 10

2,2.6,-99, GARBORA, REACH 11

3, STORE H/G

1,6.1,-99, ROCKY CRK, REACH 12

4, ADD IN U/S H/G

5,1.7,-99, ROUTE THRU REACH 13

2,3.2,-99, UPPER MUCHEA , REACH 14

2,3.6,-99, LOWER MUCHEA , REACH 15

2,3.6,-99, NORTH RUTLAND RD. REACH 16

7, PRINT DESIGN HYDROGRAPH

RUTLAND ROAD

3, STORE H/G

1,2.6,-99, SOUTH RUTLAND RD. REACH 17

4, ADD IN U/S H/G

5,1.0,-99, ROUTE THRU REACH 18

3, STORE H/G

1,6.5,-99, BULLS BROOK , REACH 19

7, PRINT DESIGN HYDROGRAPH

BULLSBROOK

4, ADD IN U/S H/G

7, PRINT DESIGN HYDROGRAPH

ELLEN BK D/S BULLSBK CONFL

5,2.8,-99, ROUTE THRU REACH 20

3, STORE H/G

1,2.7,-99, KI IT MONGER BK. REACH 21

4, ADD IN U/S H/G

5,2.0,-99, ROUTE THRU REACH 22

3, STORE H/G

1,5.5,-99, WARBROOK , REACH 23

4, ADD IN U/S H/G

5,3.3,-99, ROUTE THRU REACH 24

APPENDIX B.2 (Cont'd)

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2,3.2,-99, LOWER ELLEN REACH 25
7, PRINT DESIGN H/G
ELLEN BROOK G/S
3, STORE H/G
1,5.2,-99, SWAN CONFLUENCE REACH 26
4, ADD IN U/S H/G
5,7.2,-99, ROUTE THRU REACH 27 TO SWAN RIVER.
7, PRINT HYDROGRAPH
SWAN CONFLUENCE
0, END CONTROL VECTOR
C
C*****
C
C SUB AREA DATA
60.0 31.5 31.2 7.0 23.7
11.6 45.5 51.9 27.1 35.3
30.7 46.0 34.1 17.4 30.3
26.3 32.3 33.8 50.5, -99
0,-99, ASSUME NO IMPERVIOUS SUB-AREAS
DESIGN RUN (100YR/48HR)
DESIGN
C TIME INC 1 HRS,CALCS FOR 80 INCS,1 BURST,1PLUVIO,R/F UNIF
1,80,1,1,0,-99
C
C RAINFALL BURST FROM 0 TO 48 INCS
0,48
AR&R (1987) PLUVIO
9.3 18.5 14.7 10.8 9.5 8.2 7.3 6.4 5.8 5.3
4.9 4.5 4.1 3.8 3.3 2.9 1.8 0.8 0.9 1.0
1.5 2.0 1.6 1.3 0.9 0.5 1.9 3.4 2.4 1.4
1.8 2.2 1.4 0.6 1.1 1.6 1.0 0.3 1.4 2.5
1.4 0.2 0.2 0.1 0.1 0.2 0.1 0.0 -99
C
C BASEFLOW HYDROGRAPH @ ELLEN BK G/S
0,79, -99
BASEFLOW
8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00
8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00
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8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 8.00 -99

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APPENDIX C.1 - UNIT HYDROGRAPHS FOR FLOUT

ELLEN BROOK FLOOD STUDY

ADJUSTED AND SMOOTHED 1 HOUR UNIT HYDROGRAPHS

Ordinates expressed in m³/s/100km²

Ordinate No	Ellen Brook	Jane Brook	Lennards Brook	Piesse Gully	Susannah Brook
0	0.02	0.06	0.00	0.00	1.24
1	0.04	0.20	0.18	0.92	5.81
2	0.05	0.51	0.43	1.43	6.70
3	0.09	1.23	0.79	1.70	3.64
4	0.14	1.80	1.26	1.84	1.94
5	0.24	2.16	1.69	1.95	1.51
6	0.47	2.31	1.78	1.97	1.28
7	0.73	2.42	1.70	1.88	1.08
8	1.06	2.43	1.60	1.73	0.89
9	1.26	2.32	1.51	1.57	0.77
10	1.38	2.11	1.42	1.43	0.66
11	1.50	1.86	1.33	1.28	0.58
12	1.55	1.61	1.24	1.12	0.50
13	1.52	1.36	1.17	0.99	0.39
14	1.41	1.14	1.09	0.89	0.31
15	1.31	0.93	0.97	0.78	0.23
16	1.22	0.74	0.91	0.70	0.15
17	1.15	0.56	0.84	0.63	0.08
18	1.06	0.45	0.81	0.56	0.00
19	0.99	0.37	0.75	0.51	0.00
20	0.94	0.30	0.70	0.45	0.00
21	0.87	0.22	0.65	0.42	0.00
22	0.82	0.19	0.61	0.36	0.00
23	0.77	0.15	0.56	0.34	0.00
24	0.73	0.11	0.52	0.31	0.00
25	0.68	0.10	0.47	0.27	0.00
26	0.65	0.07	0.43	0.23	0.00
27	0.61	0.05	0.39	0.22	0.00
28	0.56	0.02	0.36	0.20	0.00
29	0.52	0.00	0.32	0.18	0.00
30	0.49	0.00	0.29	0.16	0.00
31	0.45	0.00	0.25	0.14	0.00
32	0.40	0.00	0.23	0.13	0.00
33	0.37	0.00	0.20	0.11	0.00
34	0.33	0.00	0.16	0.09	0.00
35	0.30	0.00	0.13	0.09	0.00
36	0.26	0.00	0.05	0.07	0.00
37	0.21	0.00	0.02	0.05	0.00
38	0.19	0.00	0.00	0.04	0.00
39	0.16	0.00	0.00	0.02	0.00
Runoff in mm	0.16	1.37	1.603	1.818	4.03

APPENDIX D.1 - FLOUT MODEL DESIGN RUNS

000000000 WATER AUTHORITY OF WESTERN AUSTRALIA 000000000

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Version 4.4

Last update 20Nov1986
 @copyright Binnie & Ptrs

CALCULATED ON 20/05/87 AT 15:00
 BY FLOUT4 VERSION 4 updated 20NOV86

RUN NUMBER : 1
 Design run for Average CWI - 100 YR / 48 HOUR DURATION

DATA FILE : d10048.inp
 ELLEN BROOK FLOOD STUDY - B & P and WAWA,D10048.INP 1130 Hrs 3 Apr-87
 RESULTS WRITTEN TO FILE : d100.out

Reach	IQL	CQINFL	IQT	DXL	AREA	Cwi	RAIN	STMFRQ	PR
Pluvio	NUH1	TP	Qcatch	Q u/s	Q d/s	COMMENTS			
1,0 Lennards Bk,RR,@Lennard Bk GS									
1- 0 0	1.00	2	0.	60.	150.	157.	.000	12.10	
1	40	6.	11.3	---	11.26	Rainfall runoff			
1,1 Lakes Catchment 1,VPNC,@u/s of 1.2									
1- 1 2	1.00	0	9500.	32.	150.	157.	.000	12.10	
1	-2	9.	6.9	11.26	17.42	VPNC/Lat infl from R/R			
3,0 Nullilla Bk,RR,@Gnowlialup at Scarp									
3- 0 0	1.00	2	0.	31.	150.	157.	.000	12.10	
1	40	6.	5.9	---	5.85	Rainfall runoff			
3,1 Lower Nullilla,VPNC,@Airfield Rd u/s									
3- 1 2	1.00	0	4300.	7.	150.	157.	.000	12.10	
1	-2	4.	1.6	5.85	7.37	VPNC/Lat infl from R/R			
1,2 Lakes Catchment 2,VPNC,@Airfield Rd									
1- 2 0	1.00	0	1000.	0.	150.	157.	.000	12.10	
1	0	4.	.0	24.18	24.13	VPNC/no lat inflow			

100 YR / 48 HOUR DURATION (Cont'd)

4,0 Breera Bk,RR,@ Beyrangup at Scarp										
4-	0	0	1.00	2	0.	24.	150.	157.	.000	12.10
	1			40	6.	4.4	---		4.45	Rainfall runoff
4,1 Lower Breera, VPMC,@ Airfield Rd u/s										
4-	1	2	1.00	0	3000.	12.	150.	157.	.000	12.10
	1			-2	4.	2.7	4.45		7.00	VPMC/Lat infl from R/R
1,3 Lake Catambro, VPMC,@ u/s Chandala/Yalyal Confluence										
1-	3	2	1.00	0	8400.	46.	150.	157.	.000	12.10
	1			-2	9.	10.0	30.40		38.89	VPMC/Lat infl from R/R
5,0 Yalyal Bk,RR,@ d/s of Chandala/Yalyal Bk Confluence										
5-	0	0	1.00	2	0.	52.	150.	157.	.000	12.10
	1			40	7.	9.7	---		9.74	Rainfall runoff
1,4 Garbora Lakes, VPMC,@ u/s Chandala/Rocky Ck Confluence										
1-	4	2	1.00	0	4800.	27.	150.	157.	.000	12.10
	1			-2	8.	6.0	46.70		51.40	VPMC/Lat infl from R/R
6,0 Rocky Ck,RR,@ d/s Chandala/Rocky Ck										
6-	0	0	1.00	2	0.	35.	150.	157.	.000	12.10
	1			40	7.	6.6	---		6.62	Rainfall runoff
1,5 Upper Muchea, VPMC,@ Brand Highway culvert										
1-	5	2	1.00	0	2700.	27.	150.	157.	.000	12.10
	1			-2	7.	6.2	56.71		61.36	VPMC/Lat infl from R/R
1,6 Lower Muchea, VPMC,@ Chainage 17.5km										
1-	6	2	1.00	0	4300.	27.	150.	157.	.000	12.10
	1			-2	7.	6.2	61.36		65.99	VPMC/Lat infl from R/R
1,7 Nth Rutland Rd, VPMC,@ Rutland Rd culvert										
1-	7	2	1.00	0	3700.	27.	150.	157.	.000	12.10
	1			-2	6.	6.3	65.99		70.38	VPMC/Lat infl from R/R
1,8 Sth Rutland Rd, VPMC,@ u/s of Ellen Bk										
1-	8	2	1.00	0	2800.	17.	150.	157.	.000	12.10
	1			-2	6.	4.1	70.38		73.29	VPMC/Lat infl from R/R
7,0 Bulls Bk,RR,@ d/s of Ellen Bk/Bulls B										
7-	0	0	1.00	2	0.	30.	150.	157.	.000	12.10
	1			-2	6.	7.1	---		7.07	Rainfall runoff
1,9 Ki-it Monger Bk, VPMC,@ 6.5 km chaina										
1-	9	2	1.00	0	4500.	26.	150.	157.	.000	12.10
	1			-2	6.	6.1	77.74		81.76	VPMC/Lat infl from R/R
8,0 Warbrook,RR,@ 6.5 km chainage										
8-	0	0	1.00	2	0.	32.	150.	157.	.000	12.10
	1			-2	6.	7.5	---		7.54	Rainfall runoff

100 YR / 48 HOUR DURATION (Cont'd)

1CALCULATED ON 20/05/87 AT 15:00

RUN NO 1

Design run for Average CWI

FLows FOR REACH 1.10 1,10 Lower Ellen, VPMC, @Ellen Bk GS
FOR DESIGN FLOOD - ARI 100 YRS, 48 HRS DRN

LATERAL INFLOW HAS LAG = .0 HR
TRIBUTARY HYDROGRAPH HAS LAG = .0 HR

TIME	UPSTREAM INPUT HYDROGRAPH (IN CUMEDS) AT 3.00 HOUR INTERVALS							
.0	4.7	6.8	13.9	25.5	40.8	60.9	79.1	85.7
24.0	86.5	82.1	75.1	69.5	63.8	58.5	53.5	48.9
48.0	44.2	39.6	35.5	31.3	27.5	24.1	21.1	18.5
72.0	16.3	14.5	13.1	12.1	11.4	10.8	10.4	10.2
96.0	10.1	10.0	9.9	9.9	9.9	9.9	9.9	9.9
120.0	9.9							

1,10 Lower Ellen, VPMC, @Ellen Bk GS

1-10	2	1.00	0	6500.	34.	150.	157.	.000	12.10
1		-2	5.	8.0	86.50	91.40	VPMC/Lat infl from R/R		

1,11 Swan Conf catchment, VPMC, @Swan/Ellen

1-11	2	1.00	0	7200.	51.	150.	157.	.000	12.10
1		-2	6.	11.8	91.40	100.43	VPMC/Lat infl from R/R		

TTTTTTTT	TT	TTTTTTTT	TT	TT	TTTTTTTTTTTT
TT	TT	TT	TT	TT	TT
TT	TT	TT	TT	TT	TT
TTTTTTTT	TT	TT	TT	TT	TT
TT	TT	TT	TT	TT	TT
TT	TT	TT	TT	TT	TT
TT	TTTTTTTT	TTTTTTTT	TTTTTTTT	TTTTTTTT	TT

Last update 20Nov1986
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DATA FILE : d5048.inp
ELLEN BROOK FLOOD STUDY - B & P and WAWA,D5048.INP 0900 Hrs 2 Apr-87
RESULTS WRITTEN TO FILE : d50.out

51

50 YR / 48 HOUR DURATION (Cont'd)

4,0 Breera Bk,RR,@ Beyrangup at Scarp

4- 0 0	1.00	2	0.	24.	150.	134.	.000	12.10
1	40	6.	3.9	---			3.86 Rainfall runoff	

4,1 Lower Breera,VPNC,@ Airfield Rd u/s

4- 1 2	1.00	0	3000.	12.	150.	134.	.000	12.10
1	-2	4.	2.3	3.86			6.09 VPMC/Lat infl from R/R	

1,3 Lake Catambro,VPNC,@ u/s Chandala/Ya

1- 3 2	1.00	0	8400.	46.	150.	134.	.000	12.10
1	-2	9.	8.7	26.40			33.79 VPMC/Lat infl from R/R	

5,0 Yalyal Bk,RR,@ d/s of Chandala/Yalya

5- 0 0	1.00	2	0.	52.	150.	134.	.000	12.10
1	40	7.	8.5	---			8.46 Rainfall runoff	

1,4 Garbora Lakes,VPNC,@ u/s Chandala/Ro

1- 4 2	1.00	0	4800.	27.	150.	134.	.000	12.10
1	-2	8.	5.2	40.59			44.69 VPMC/Lat infl from R/R	

6,0 Rocky Ck,RR,@ d/s Chandala/Rocky Ck

6- 0 0	1.00	2	0.	35.	150.	134.	.000	12.10
1	40	7.	5.8	---			5.75 Rainfall runoff	

1,5 Upper Muchea,VPNC,@Brand Highway cul

1- 5 2	1.00	0	2700.	27.	150.	134.	.000	12.10
1	-2	7.	5.4	49.32			53.37 VPMC/Lat infl from R/R	

1,6 Lower Muchea,VPNC,@Chainage 17.5km

1- 6 2	1.00	0	4300.	27.	150.	134.	.000	12.10
1	-2	7.	5.4	53.37			57.38 VPMC/Lat infl from R/R	

1,7 Nth Rutland Rd,VPNC,@Rutland Rd culv

1- 7 2	1.00	0	3700.	27.	150.	134.	.000	12.10
1	-2	6.	5.5	57.38			61.05 VPMC/Lat infl from R/R	

1,8 Sth Rutland Rd,VPNC,@u/s of Ellen Bk

1- 8 2	1.00	0	2800.	17.	150.	134.	.000	12.10
1	-2	6.	3.5	61.05			63.36 VPMC/Lat infl from R/R	

7,0 Bulls Bk,RR,@d/s of Ellen Bk/Bulls B

7- 0 0	1.00	2	0.	30.	150.	134.	.000	12.10
1	-2	6.	6.1	---			6.14 Rainfall runoff	

1,9 Ki-it Monger Bk,VPNC,@ 6.5 km chaina

1- 9 2	1.00	0	4500.	26.	150.	134.	.000	12.10
1	-2	6.	5.3	67.23			70.50 VPMC/Lat infl from R/R	

8,0 Warbrook,RR,@6.5 km chainage

8- 0 0	1.00	2	0.	32.	150.	134.	.000	12.10
1	-2	6.	6.5	---			6.54 Rainfall runoff	

50 YR / 48 HOUR DURATION (Cont'd)

1CALCULATED ON 20/05/87 AT 15:00

RUN NO 2

Design Run for 48 hr Storm

FLows FOR REACH 1.10 1,10 Lower Ellen, VPMC, @Ellen Bk GS

FOR DESIGN FLOOD - ARI 50 YRS, 48 HRS DRN

LATERAL INFLOW HAS LAG = .0 HR

TRIBUTARY HYDROGRAPH HAS LAG = .0 HR

TIME	UPSTREAM INPUT HYDROGRAPH (IN CUMEDS) AT 3.00 HOUR INTERVALS							
.0	4.7	6.6	12.9	23.0	35.5	51.4	66.9	73.5
24.0	74.6	71.8	66.2	61.4	56.6	52.0	47.6	43.7
48.0	39.6	35.6	32.1	28.5	25.2	22.2	19.5	17.3
72.0	15.4	13.8	12.7	11.8	11.1	10.7	10.4	10.2
96.0	10.0	9.9	9.9	9.9	9.9	9.9	9.9	9.9
120.0	9.9							

1,10 Lower Ellen, VPMC, @Ellen Bk GS

1-10	2	1.00	0	6500.	34.	150.	134.	.000	12.10
1		-2	5.	7.0	74.63	78.84	VPMC/Lat infl from R/R		

1,11 Swan Conf catchment, VPMC, @Swan/Elle

1-11	2	1.00	0	7200.	51.	150.	134.	.000	12.10
1		-2	6.	10.2	78.84	86.38	VPMC/Lat infl from R/R		


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Version 4.4

Last update 20Nov1986
 @copyright Binnie & Ptrs

RUN NUMBER : 3
Design Run with Average CWI - 25 YR / 48 HOUR DURATION

Reach	IQL	CGINFL	IQT	DXL	AREA	Cwi	RAIN	STMFRQ	PR
Pluvio	NUH1	TP	Qcatch	Q u/s	Q d/s	COMMENTS			
1,0 Lennards Bk,RR,@Lennard Bk GS									
1- 0	0	1.00	2	0.	60.	150.	121.	.000	12.10
1	40	6.	9.0	---	8.95	Rainfall runoff			
1,1 Lakes Catchment 1,VPMC,@u/s of 1.2									
1- 1	2	1.00	0	9500.	32.	150.	121.	.000	12.10
1	-2	9.	5.5	8.95	13.84	VPMC/Lat infl from R/R			
3,0 Nullilla Bk,RR,@Gnowialup at Scarp									
3- 0	0	1.00	2	0.	31.	150.	121.	.000	12.10
1	40	6.	4.7	---	4.65	Rainfall runoff			
3,1 Lower Nullilla,VPMC,@Airfield Rd u/s									
3- 1	2	1.00	0	4300.	7.	150.	121.	.000	12.10
1	-2	4.	1.3	4.65	5.85	VPMC/Lat infl from R/R			

25 YR / 48 HOUR DURATION (Cont'd)

1,2 Lakes Catchment 2, VPMC, @ Airfield Rd

1- 2	0	1.00	0	1000.	0.	150.	121.	.000	12.10
1			0	4.	.0	19.23			19.19 VPMC/no lat inflow

4,0 Breera Bk, RR, @ Beyrangup at Scarp

4- 0	0	1.00	2	0.	24.	150.	121.	.000	12.10
1			40	6.	3.5	---			3.54 Rainfall runoff

4,1 Lower Breera, VPMC, @ Airfield Rd u/s

4- 1	2	1.00	0	3000.	12.	150.	121.	.000	12.10
1			-2	4.	2.1	3.54			5.57 VPMC/Lat infl from R/R

1,3 Lake Catambro, VPMC, @ u/s Chandala/Ya

1- 3	2	1.00	0	8400.	46.	150.	121.	.000	12.10
1			-2	9.	8.0	24.16			30.94 VPMC/Lat infl from R/R

5,0 Yalyal Bk, RR, @ d/s of Chandala/Yalya

5- 0	0	1.00	2	0.	52.	150.	121.	.000	12.10
1			40	7.	7.7	---			7.74 Rainfall runoff

1,4 Garbora Lakes, VPMC, @ u/s Chandala/Ro

1- 4	2	1.00	0	4800.	27.	150.	121.	.000	12.10
1			-2	8.	4.8	37.16			40.94 VPMC/Lat infl from R/R

6,0 Rocky Ck, RR, @ d/s Chandala/Rocky Ck

6- 0	0	1.00	2	0.	35.	150.	121.	.000	12.10
1			40	7.	5.3	---			5.27 Rainfall runoff

1,5 Upper Muchea, VPMC, @ Brand Highway cul

1- 5	2	1.00	0	2700.	27.	150.	121.	.000	12.10
1			-2	7.	4.9	45.17			48.87 VPMC/Lat infl from R/R

1,6 Lower Muchea, VPMC, @ Chainage 17.5km

1- 6	2	1.00	0	4300.	27.	150.	121.	.000	12.10
1			-2	7.	4.9	48.87			52.54 VPMC/Lat infl from R/R

1,7 Nth Rutland Rd, VPMC, @ Rutland Rd culv

1- 7	2	1.00	0	3700.	27.	150.	121.	.000	12.10
1			-2	6.	5.0	52.54			55.78 VPMC/Lat infl from R/R

1,8 Sth Rutland Rd, VPMC, @ u/s of Ellen Bk

1- 8	2	1.00	0	2800.	17.	150.	121.	.000	12.10
1			-2	6.	3.2	55.78			57.76 VPMC/Lat infl from R/R

7,0 Bulls Bk, RR, @ d/s of Ellen Bk/Bulls B

7- 0	0	1.00	2	0.	30.	150.	121.	.000	12.10
1			-2	6.	5.6	---			5.62 Rainfall runoff

1,9 Ki-it Monger Bk, VPMC, @ 6.5 km chaina

1- 9	2	1.00	0	4500.	26.	150.	121.	.000	12.10
1			-2	6.	4.9	61.30			64.10 VPMC/Lat infl from R/R

8,0 Warbrook, RR, @ 6.5 km chainage

8- 0	0	1.00	2	0.	32.	150.	121.	.000	12.10
1			-2	6.	6.0	---			5.99 Rainfall runoff

25 YR / 48 HOUR DURATION (Cont'd)

1CALCULATED ON 20/05/87 AT 15:00

RUN NO 3

Design Run with Average CWI - 25 YR / 48 HOUR DURATION

FLWS FOR REACH 1.10 1,10 Lower Ellen,VPMC,@Ellen Bk GS
FOR DESIGN FLOOD - ARI 20 YRS,48 HRS DRN

LATERAL INFLOW HAS LAG = .0 HR

TRIBUTARY HYDROGRAPH HAS LAG = .0 HR

TIME	UPSTREAM INPUT HYDROGRAPH (IN CUMECs) AT 3.00 HOUR INTERVALS							
.0	4.7	6.5	12.3	21.5	32.6	46.3	60.1	66.8
24.0	67.9	65.9	61.1	56.7	52.4	48.1	44.1	40.5
48.0	36.8	33.1	29.9	26.8	23.8	20.9	18.5	16.5
72.0	14.8	13.4	12.4	11.6	11.0	10.6	10.3	10.1
96.0	10.0	9.9	9.9	9.9	9.9	9.9	9.9	9.9
120.0	9.9							

1,10 Lower Ellen,VPMC,@Ellen Bk GS

1-10	2	1.00	0	6500.	34.	150.	121.	.000	12.10
	1		-2	5.	6.4	67.88	71.85	VPMC/Lat infl from R/R	

1,11 Swan Conf catchment,VPMC,@Swan/Elle

1-11	2	1.00	0	7200.	51.	150.	121.	.000	12.10
	1		-2	6.	9.4	71.85	78.49	VPMC/Lat infl from R/R	

APPENDIX D.2 - RORB MODEL DESIGN RUNS

RORB VERSION 3.7 (23DEC85), COPYRIGHT MONASH UNIVERSITY

THIS COPY SUPPLIED TO :

--WATER AUTHORITY OF WESTERN AUSTRALIA (15 SEP 1986)

DATA FROM FILE :D10048B.DAT

OUTPUT TYPE 1

DATA CHECK COMPLETED

INPUT OF PARAMETERS:

ELLEN BROOK - DESIGN RUN 100 YR 48 HR STORM (1987 ARR)

DESIGN RUN (100YR/48HR)

TIME INCREMENT = 1.00 HOURS

LOSS MODEL 0 SELECTED

RUN 1

INITIAL LOSS = .0 MM

INPUT PERVIOUS AREA RUNOFF COEFF. COEFF=?

.12

ROUTING RESULTS:

ELLEN BROOK - DESIGN RUN 100 YR 48 HR STORM (1987 ARR)

DESIGN RUN (100YR/48HR)

DESIGN RUN NO. 1

PARAMETERS: KC= 34.30 M= .85

LOSS PARAMETERS:	INITIAL LOSS (MM)	RUNOFF COEFF.
	.0	.12

*** CALCULATED HYDROGRAPH, LENNARDS BK GS

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	17.80
TIME TO PEAK, H	6.0
VOLUME, M ³	1.29E+06
TIME TO CENTROID, H	19.2
LAG (C.M. TO C.M.), H	7.8
LAG TO PEAK, H	-5.3

100 YR 48 HR STORM (1987 ARR) (Cont'd)

*** CALCULATED HYDROGRAPH, RUTLAND ROAD

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	80.64
TIME TO PEAK, H	15.0
VOLUME, M ³	9.98E+06
TIME TO CENTROID, H	27.5
LAG (C.M. TO C.M.), H	16.2
LAG TO PEAK, H	3.7

*** CALCULATED HYDROGRAPH, BULLSBROOK

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	8.869
TIME TO PEAK, H	6.0
VOLUME, M ³	7.26E+05
TIME TO CENTROID, H	21.6
LAG (C.M. TO C.M.), H	10.3
LAG TO PEAK, H	-5.3

*** CALCULATED HYDROGRAPH, ELLEN BK D/S BULLSEK CONFL

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	88.73
TIME TO PEAK, H	15.0
VOLUME, M ³	1.11E+07
TIME TO CENTROID, H	27.2
LAG (C.M. TO C.M.), H	15.9
LAG TO PEAK, H	3.7

*** CALCULATED HYDROGRAPH, ELLEN BROOK G/S

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	97.34
TIME TO PEAK, H	18.0
VOLUME, M ³	1.32E+07
TIME TO CENTROID, H	30.1
LAG (C.M. TO C.M.), H	18.7
LAG TO PEAK, H	6.7

100 YR 48 HR STORM (1987 ARR) (Cont'd)

*** CALCULATED HYDROGRAPH, SWAN CONFLUENCE

	HYDROGRAPH CALC.
PEAK DISCHARGE, M ³ /S	99.49
TIME TO PEAK, H	20.0
VOLUME, M ³	1.41E+07
TIME TO CENTROID, H	31.9
LAG (C.M. TO C.M.), H	20.6
LAG TO PEAK, H	8.7

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THIS COPY SUPPLIED TO :

--WATER AUTHORITY OF WESTERN AUSTRALIA (15 SEP 1986)

DATA FROM FILE :D5048.DAT

OUTPUT TYPE 1

DATA CHECK COMPLETED

INPUT OF PARAMETERS:

ELLEN BROOK - DESIGN RUN 50 YR 48 HR STORM (1987 ARR)

DESIGN RUN (50YR/48HR)

TIME INCREMENT = 1.00 HOURS

LOSS MODEL 0 SELECTED

RUN 1

INITIAL LOSS = .0 MM

INPUT PERVIOUS AREA RUNOFF COEFF. COEFF=?

.12

ROUTING RESULTS:

ELLEN BROOK - DESIGN RUN 50 YR 48 HR STORM (1987 ARR)

DESIGN RUN (50YR/48HR)

DESIGN RUN NO. 1

PARAMETERS: KC= 34.30 M= .85

LOSS PARAMETERS: INITIAL LOSS (MM) RUNOFF COEFF.

.0

.12

*** CALCULATED HYDROGRAPH, LENNARDS BK GS

HYDROGRAPH

CALC.

PEAK DISCHARGE,M³/S 15.14

TIME TO PEAK,H 6.0

VOLUME,M³ 1.13E+06

TIME TO CENTROID,H 19.7

LAG (C.M. TO C.M.),H 8.3

LAG TO PEAK,H -5.4

*** CALCULATED HYDROGRAPH, RUTLAND ROAD

HYDROGRAPH

CALC.

PEAK DISCHARGE,M³/S 68.85

TIME TO PEAK,H 16.0

VOLUME,M³ 8.78E+06

TIME TO CENTROID,H 28.1

LAG (C.M. TO C.M.),H 16.7

LAG TO PEAK,H 4.6

50 YR 48 HR STORM (1987 ARR) - (Cont'd)

*** CALCULATED HYDROGRAPH, BULLSBROOK

HYDROGRAPH	
CALC.	
PEAK DISCHARGE, M ³ /S	7.580
TIME TO PEAK, H	6.0
VOLUME, M ³	6.43E+05
TIME TO CENTROID, H	22.3
LAG (C.M. TO C.M.), H	10.9
LAG TO PEAK, H	-5.4

*** CALCULATED HYDROGRAPH, ELLEN BK D/S BULLSBK CONFL

HYDROGRAPH	
CALC.	
PEAK DISCHARGE, M ³ /S	75.66
TIME TO PEAK, H	15.0
VOLUME, M ³	9.78E+06
TIME TO CENTROID, H	27.8
LAG (C.M. TO C.M.), H	16.4
LAG TO PEAK, H	3.6

*** CALCULATED HYDROGRAPH, ELLEN BROOK G/S

HYDROGRAPH	
CALC.	
PEAK DISCHARGE, M ³ /S	83.06
TIME TO PEAK, H	18.0
VOLUME, M ³	1.16E+07
TIME TO CENTROID, H	30.6
LAG (C.M. TO C.M.), H	19.2
LAG TO PEAK, H	6.6

*** CALCULATED HYDROGRAPH, SWAN CONFLUENCE

HYDROGRAPH	
CALC.	
PEAK DISCHARGE, M ³ /S	84.82
TIME TO PEAK, H	20.0
VOLUME, M ³	1.24E+07
TIME TO CENTROID, H	32.4
LAG (C.M. TO C.M.), H	21.1
LAG TO PEAK, H	8.6

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THIS COPY SUPPLIED TO :

--WATER AUTHORITY OF WESTERN AUSTRALIA (15 SEP 1986)

DATA FROM FILE :D2548.DAT

OUTPUT TYPE 1

DATA CHECK COMPLETED

INPUT OF PARAMETERS:

ELLEN BROOK - DESIGN RUN 25 YR 48 HR STORM (1987 ARR)

DESIGN RUN (25YR/48HR)

TIME INCREMENT = 1.00 HOURS

LOSS MODEL 0 SELECTED

RUN 1

INITIAL LOSS = .0 MM

INPUT PERVIOUS AREA RUNOFF COEFF. COEFF=?

.12

ROUTING RESULTS:

ELLEN BROOK - DESIGN RUN 25 YR 48 HR STORM (1987 ARR)

DESIGN RUN (25YR/48HR)

DESIGN RUN NO. 1

PARAMETERS: KC= 34.30 M= .85

LOSS PARAMETERS: INITIAL LOSS (MM) RUNOFF COEFF.

.0

.12

*** CALCULATED HYDROGRAPH, LENNARDS BK GS

HYDROGRAPH

CALC.

PEAK DISCHARGE, M³/S 13.54

TIME TO PEAK, H 6.0

VOLUME, M³ 1.03E+06

TIME TO CENTROID, H 20.0

LAG (C.M. TO C.M.), H 8.6

LAG TO PEAK, H -5.4

*** CALCULATED HYDROGRAPH, RUTLAND ROAD

HYDROGRAPH

CALC.

PEAK DISCHARGE, M³/S 62.07

TIME TO PEAK, H 16.0

VOLUME, M³ 8.08E+06

TIME TO CENTROID, H 28.5

LAG (C.M. TO C.M.), H 17.1

LAG TO PEAK, H 4.6

25 YR 48 HR STORM (1987 ARR) (Cont'd)

*** CALCULATED HYDROGRAPH, BULLSBROOK

	HYDROGRAPH
	CALC.
PEAK DISCHARGE, M ³ /S	6.807
TIME TO PEAK, H	6.0
VOLUME, M ³	5.94E+05
TIME TO CENTROID, H	22.8
LAG (C.M. TO C.M.), H	11.4
LAG TO PEAK, H	-5.4

*** CALCULATED HYDROGRAPH, ELLEN BK D/S BULLSBK CONFL

	HYDROGRAPH
	CALC.
PEAK DISCHARGE, M ³ /S	68.24
TIME TO PEAK, H	15.0
VOLUME, M ³	9.01E+06
TIME TO CENTROID, H	28.2
LAG (C.M. TO C.M.), H	16.8
LAG TO PEAK, H	3.6

*** CALCULATED HYDROGRAPH, ELLEN BROOK G/S

	HYDROGRAPH
	CALC.
PEAK DISCHARGE, M ³ /S	74.84
TIME TO PEAK, H	18.0
VOLUME, M ³	1.07E+07
TIME TO CENTROID, H	31.0
LAG (C.M. TO C.M.), H	19.6
LAG TO PEAK, H	6.6

*** CALCULATED HYDROGRAPH, SWAN CONFLUENCE

	HYDROGRAPH
	CALC.
PEAK DISCHARGE, M ³ /S	76.35
TIME TO PEAK, H	21.0
VOLUME, M ³	1.14E+07
TIME TO CENTROID, H	32.8
LAG (C.M. TO C.M.), H	21.4
LAG TO PEAK, H	9.6

APPENDIX 2

TEC and PEC Database Searches

FID	BDY_ID	OCC_UNIQUE	COM_ID	COM_NAME	CT_DESC	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	OCC_CONFID
0	0	3008	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	BAW9		500	Yes
1	0	2975	SCP22	Banksia ilicifolia woodlands	Priority 3	1	BIW9		500	Yes
2	0	3179	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	BAS25		500	Yes
3	0	3180	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	BAS26		500	Yes
4	237	167	SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	1	TWIN05		500	No
5	0	3168	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	TWIN07		500	No
6	0	3169	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	TWIN08		500	No
7	774	168	SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	1	TWIN10		500	No
8	0	3115	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3	1	SEW1		500	Yes
9	241	29	Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Critically Endangered	1	EG01		1500	No
10	0	3059	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE01		500	No
11	0	4979	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE02		500	No
12	0	3058	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE03		500	No
13	0	3057	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE08		500	No
14	0	4981	SCP18	Shrublands on calcareous silts of the Swan Coastal Plain	Vulnerable	1	ELE13		500	No
15	0	4983	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE22		500	No
16	0	4984	SCP22	Banksia ilicifolia woodlands	Priority 3	1	ELE23		500	No
17	0	3039	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE24		500	No
18	0	4988	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE25		500	No
19	0	4989	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE27		500	No
20	0	3063	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE28		500	No
21	0	4985	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE29		500	No
22	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN01		1000	No
23	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN02		1000	No
24	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN03		1000	No
25	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN04		1000	No
26	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN05		1000	No
27	1095	120	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN06		500	No
28	1096	1962	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN07		500	No
29	1097	1963	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN08		500	No
30	560	40	Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	1	VINESSE		1000	No
31	560	40	Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	1	VINESSW		1000	No
32	1098	1964	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN09		500	No
33	0	4428	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3	1	vines01		500	No

APPENDIX 3

Protected Matters Search Tool



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 24/01/13 16:56:34

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

[Coordinates](#)

[Buffer: 0.5Km](#)



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	17
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As [heritage values](#) of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	6
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	1
Regional Forest Agreements:	1
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [\[Resource Information \]](#)

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Claypans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [\[Resource Information \]](#)

Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
Insects		
Synemon gratiosa Graceful Sun Moth [66757]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Plants		

Name	Status	Type of Presence
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leaved Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat may occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat may occur within area
Grevillea curviloba subsp. curviloba Curved-leaf Grevillea [64908]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Thelymitra manginii K.Dixon & Batty ms. [67443]	Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area
Villarsia calthifolia Mountain Villarsia [10886]	Endangered	Species or species habitat may occur within area
Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		

Name	Threatened	Type of Presence
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species	[Resource Information]	
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves		[Resource Information]
Name		State
Ellen Brook		WA

Regional Forest Agreements		[Resource Information]
Note that all areas with completed RFAs have been included.		
Name		State
South West WA RFA		Western Australia

Invasive Species		[Resource Information]
Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.		
Name	Status	Type of Presence
Mammals		
Capra hircus		
Goat [2]		Species or species habitat likely to occur within area
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides		
Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica		
Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area

Name	Status	Type of Presence
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area

Coordinates

-31.740089 116.019495,-31.747856 116.024139,-31.763922 116.025358

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Department of Environment, Climate Change and Water, New South Wales](#)
- [-Department of Sustainability and Environment, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment and Natural Resources, South Australia](#)
- [-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts](#)
- [-Environmental and Resource Management, Queensland](#)
- [-Department of Environment and Conservation, Western Australia](#)
- [-Department of the Environment, Climate Change, Energy and Water](#)
- [-Birds Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-SA Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Atherton and Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [-State Forests of NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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[Department of Sustainability, Environment, Water, Population and Communities](#)

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APPENDIX 4

Conservation Codes

Western Australian and Commonwealth of Australia Conservation Codes

Flora

Definitions of the Conservation Codes for the Status of Flora under the Wildlife Conservation Act 1950 follow:

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa1 which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered

Considered to be facing an extremely high risk of extinction in the wild

EN: Endangered

Considered to be facing a very high risk of extinction in the wild

VU: Vulnerable

Considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Taxa that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Priority One: Poorly-known taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or

more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring

Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Vegetation

Definitions and criteria for presumed totally destroyed, critically endangered, endangered and vulnerable ecological communities are outlined below.

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence

of it is likely to recover its species composition and/or structure in the foreseeable future.

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤ 5 occurrences or a total area of $\leq 100\text{ha}$). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤ 10 occurrences or a total area of $\leq 200\text{ha}$). At least some occurrences are

not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Fauna

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, DEC also classifies fauna under five different Priority codes and rare and endangered fauna are classified under the Wildlife Conservation (Specially Protected Fauna) Notice 2006 into four schedules of taxa.

Schedule 1

Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2

Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3

Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.

Schedule 4

Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, the DEC also classifies fauna under five different priority codes:

Priority One: Taxa with few, poorly known populations on threatened lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Two: Taxa with few, poorly known populations on conservation lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Three: Taxa with several, poorly known populations, some on conservation lands

Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Four: Taxa in need of monitoring

Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Priority Five: Taxa in need of monitoring (conservation dependent)

Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Commonwealth of Australia Conservation Codes

The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* has the following nine conservation codes for Flora and Fauna.

Extinct

Taxa not definitely located in the wild during the past 50 years

Extinct in the Wild

Taxa known to survive only in captivity

Critically Endangered

Taxa facing an extremely high risk of extinction in the wild in the immediate future

Endangered

Taxa facing a very high risk of extinction in the wild in the near future

Vulnerable

Taxa facing a high risk of extinction in the wild in the medium-term

Near Threatened

Taxa that risk becoming Vulnerable in the wild

Conservation Dependent

Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known)

Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern

Taxa that are not considered Threatened

APPENDIX 5

DEC Threatened Flora Database Searches

OID_	POPID	NAMEID	TAXON	CONSSTAT US	WARANK	POPNUM BER	SUBPOPC ODE	POPSTAT US	VESTING	PURPOSE 1	PURPOSE 2	COUNTDATE
	89659	11336	Adenanthos cygnorum subsp. chamaephyton	3		19			LGA	VER		14/05/1999 0:00
	84938	1596	Caladenia huegelii	T	CR	25			PRI			15/10/1997 0:00
	84940	1596	Caladenia huegelii	T	CR	32		U	CC	CFF		29/09/2004 0:00
	84941	1596	Caladenia huegelii	T	CR	34		U	PRI			29/09/2004 0:00
	84942	1596	Caladenia huegelii	T	CR	35		U	CC	CFF		29/09/2004 0:00
	93193	16245	Cyathochaeta teretifolia	3		1			CC	CFF		3/11/1995 0:00
	93197	16245	Cyathochaeta teretifolia	3		13			CC	CFF		3/11/1995 0:00
	93992	17605	Eleocharis keigheryi	T	VU	1			CC	CFA		9/11/2007 0:00
	85477	1976	Grevillea christineae	T	EN	9			LGA	OTH		25/07/2007 0:00
	92200	14408	Grevillea curviloba subsp. curviloba	T	CR	2			CC	CFF		10/12/1998 0:00
	92201	14408	Grevillea curviloba subsp. curviloba	T	CR	3			CC	CFF		1/09/2004 0:00
	92202	14408	Grevillea curviloba subsp. curviloba	T	CR	4	A		CC	CFF		3/09/2004 0:00
	92204	14408	Grevillea curviloba subsp. curviloba	T	CR	4	B		CC	CFF		6/07/2012 0:00
	102716	14408	Grevillea curviloba subsp. curviloba	T	CR	10	A		CC	CFF	NRE	30/06/2009 0:00
	102717	14408	Grevillea curviloba subsp. curviloba	T	CR	10	B		PRI			30/06/2009 0:00
	92209	14409	Grevillea curviloba subsp. incurva	T	EN	17			CC	CFF		15/02/2000 0:00
	84894	1469	Haemodorum loratum	3		2			UNKNOWN			13/11/1981 0:00
	88387	6233	Hydrocotyle lemnoides	4		1			CC	CFA		2/11/1990 0:00
	96547	33638	Meionectes tenuifolia	3		4			PRI			3/11/1995 0:00
	84517	980	Schoenus capillifolius	3		3			CC	CFF		2/11/1990 0:00
	89291	7756	Stylidium longitubum	3		1			AGR	GVT		12/11/1989 0:00
	89302	7756	Stylidium longitubum	3		2			CC	CFA		28/12/1971 0:00
	89307	7756	Stylidium longitubum	3		3			CC	NRE		3/10/1988 0:00
	89308	7756	Stylidium longitubum	3		4			UNKNOWN			30/10/1992 0:00
	87125	4540	Tetratheca pilifera	3		15			CC	NPK		12/11/2003 0:00
	96349	32658	Trithuria occidentalis	T	CR	1			CC	NRE		27/10/1982 0:00

OID_	SHEET_NO	TAXON	CONS_CO DE	SITE	VEGETATION	LOCALITY	COLL_DATE
	PERTH 07132832	<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	3	Swale. Grey sand.	Low woodland. <i>Banksia attenuata</i> , <i>B. menziesii</i> , <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> .	Road verge on Jenkins Road opposite Lot 41, Bushplan Site 291	14 05 1999
	PERTH 256935	<i>Cyanicula ixioides</i> subsp. <i>ixioides</i>	4			Upper Swan	09 1913
	PERTH 06570240	<i>Cyathochaeta teretifolia</i>	3	Edge of seasonal wetland, gentle slope, north aspect, dark brown loam over red sand with limestone, well drained.	Associated species: <i>Eucalyptus calophylla</i> .	Cardinal Drive Bushland (Bush Forever Site 23) approx. 200 m N Bordeaux Road (adjacent to System 6 Update quadrat vines01) Ellenbrook Bushland	03 11 1995
	PERTH 02266865	<i>Eleocharis keigheryi</i>	T	Clay soil, under 6 inches water, dries in summer.		Ellen Brook Tortoise Reserve, 21 miles N of Perth,	19 10 1978
	PERTH 07782020	<i>Eleocharis keigheryi</i>	T	Seasonally inundated claypans with grey to brown clay.	Transitions from open clay pans comprised exclusively of of <i>E. keigheryi</i> to vegetated clay pans. <i>Melaleuca</i> spp., <i>Verticordia</i> sp. <i>Chorizandra enodis</i> , herbs, <i>Avena fatua</i> and <i>Briza maxima</i> .	Ellen Brook Nature Reserve, W side of the Great N Highway, Upper Swan	09 11 2007
	PERTH 07782047	<i>Eleocharis keigheryi</i>	T	Claypan with brown clay. Found in open water ponds.	<i>Chorizandra enodis</i> . Trees and shrubs 1-2 m.	Ellen Brook Nature Reserve, upper swan	12 10 2007
	PERTH 06512283	<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	3	Dampland; grey sand.	<i>Melaleuca</i> shrubland.	Wetland area to the N of quadrat Vines 01, W Vines residential area. Shire of Swan (Bush Forever Site 23)	03 11 1995
	PERTH 07708602	<i>Grevillea christineae</i>	T	Valley slope outcrop. Brown sand / loam / clay over granite boulder.	Scattered <i>Eucalyptus rudis</i> with <i>Grevillea</i> <i>enlicheriana</i> , <i>Calothamnus quadrifidus</i> , <i>Hakea</i> <i>erinacea</i> , <i>Labichea lanceolata</i> , <i>Darwinia citriodora</i> , <i>Petrophile biloba</i> , <i>Gastrolobium spinosum</i> , weeds.	Bells Rapid Park, Cathedral ave, Upper Swan. On the S side of the footbridge between the Swan River and the EW railway line	09 07 2007
	PERTH 06512836	<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	Edge of seasonal wetland, gentle slope, N aspect. Dark brown loam over red sand with limestone, well drained.	Associated species: <i>Eucalyptus calophylla</i> .	Cardinal Drive Bushland (Bush Forever Site 23). c. 200 m N Bordeaux Road (adjacent to System 6 Update quadrat vines 01) Ellenbrook Bushland	03 11 1995
	PERTH 05492963	<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	Flat, near shallow seasonal creekline. Grey sand.	Shrubland/Sedgeland. Characteristic species: <i>Hakea</i> <i>varia</i> .	Ellenbrook,	15 02 2000
	PERTH 1044567	<i>Haemodorum loratum</i>	3	Lateritic loam.	Wandoo woodland.	20 km ESE Muchea.	13 11 1981
	PERTH 1111167	<i>Halgania corymbosa</i>	3	Lateritic soil.		Susannah Brook, Millendon.	03 09 1980
	PERTH 06207154	<i>Hydatella dioica</i>	T	In water. Open muddy clay pan.		Ellen Brook Reserve, ca 15 km N Midland	14 10 1980
	PERTH 1048139	<i>Hydrocotyle lemnoides</i>	4	Growing in fresh water, stem rooted in clay.		15 km N of Midland on Great Northern Highway. Martyn Reserve	07 10 1976
	PERTH 1048104	<i>Hydrocotyle lemnoides</i>	4	Growing in fresh water, stem rooted in clay.		15 km N of Midland on Great Northern Highway, Martyn Reserve	07 10 1976
	PERTH 03401332	<i>Hydrocotyle lemnoides</i>	4			21 mile peg Reserve Great Northern Highway [10 km S of Bullsbrook East]	09 1963
	PERTH 1048112	<i>Hydrocotyle lemnoides</i>	4	Growing in shallow water over mud.		Short-necked Tortoise Reserve ca. 15 km N of Midland	13 09 1985

OID_	SHEET_NO	TAXON	CONS_CO DE	SITE	VEGETATION	LOCALITY	COLL_DATE
	PERTH 05991714	Persoonia sulcata	4	Laterite.	Eucalypt woodland with low shrubby understory.	Great Northern Highway, 102.6 km N of Perth GPO, 12.4 km N of turnoff to Toodyay,	18 12 1980
	PERTH 01278215	Schoenus capillifolius	3	Clay pan dry - some mud in deeper sections with live plants.		J. Martyn Reserve, 13 km N Midland	14 11 1980
	PERTH 02239108	Schoenus capillifolius	3	Winter wet claypan.	With Glossostigma sp., Hydatella sp. and Trithuria sp. surrounded by regenerating heath B of Melaleuca lateritica.	Ellen Brook Nature Reserve, Upper Swan	02 11 1990
	PERTH 07514271	Schoenus natans	4	Flooded claypan.	Melaleuca lateritia shrubland over Chorizandra enodis and aquatic herbs.	Ellenbrook Nature Reserve	07 10 2004
	PERTH 04097610	Schoenus sp. Bullsbrook (J.J. Alford 915)	2	Low lying flat, grey peaty sand over ? clay.	Herbs and low shrubs.	Twin Swamps Nature Reserve, 8 km S of Bullsbrook	31 10 1986
	PERTH 04750411	Schoenus sp. Waroona (G.J. Keighery 12235)	3	Winter wet flats, dark brown loam clay over clay.	Burnt low heath.	J & B Martyn Reserve, 13 km N of Midland	31 10 1988
	PERTH 03510042	Stylidium longitubum	3			Ellenbrook area, west of Vines golf course	30 10 1992
	PERTH 01643061	Stylidium longitubum	3	Grows in clayey sand, in small winter-wet depressions.	Under and around shrubs.	In a paddock on the W side of Railway Parade, 0.5 km N of Apple Road, Upper Swan	12 11 1989
	PERTH 01631098	Stylidium longitubum	3	Winter wet claypan.	Melaleuca lateritia shrubland; burnt.	J. & R. Martyn Reserve, 13 km N Midland	03 10 1988
	PERTH 08161119	Stylidium longitubum	3	Flat, clay pan. Moist grey clay.	Jacksonia, Acacia, Asteraceae, Villarsia, weeds.	Ellen Brook Nature Reserve, Great Northern Highway, West Swan	28 11 2008
	PERTH 06724884	Tetratheca pilifera	3	Towards top of hill on lower part of breakaway. Steep slope below, scarp. Outcropping laterite and smooth ?quartz pebbles over granite; grey clayey sand. Charcoal litter on surface.	Corymbia calophylla, Eucalyptus wandoo woodland with Xanthorrhoea preissii and low shrub understorey including Acacia pulchella, Macrozamia riedlei, Trymalium ledifolium, Hibbertia hypericoides, Dryandra nivea, Hakea sp.	Hillslope behind Ranger's residence, Walyunga National Park	12 11 2003
	PERTH 02472635	Trithuria occidentalis	T	In water, muddy open.		J.R. & B. Martyn Reserve, Ellen Brook, 13 km N Midland	27 10 1982
	PERTH 07855885	Trithuria occidentalis	T	Low-lying depression next to a low sand ridge covered by Petrophile sp. and Eucalyptus trees. Soil grey-brown clay, soft and damp to dry and hardening where higher.	Open shrubland of Melaleuca lateritia to 1.5 m tall with open ground between shrubs, colourful with flowering herbs including Villarsia capitata, Gratiola pubescens, Rhodanthe pyrethrum, Stylidium sp., Utricularia inaequalis, Aphelia drummondii, Lachnagr	Ellenbrook Nature Reserve (Reserve No A 27620), 15 km N of Midland	06 11 2007
	PERTH 02841886	Trithuria occidentalis	T	Slightly submerged clay pan, open.		Warbrook Siding, Upper Swan	18 10 1978
	PERTH 02841851	Trithuria occidentalis	T	Drying pools, muddy claypan.	Melaleuca laterite scrub.	J.R. and B. Martyn Reserve, Ellen Brook, 13 km N Midland	27 10 1982

Taxon	Status	Rank	IUCN Criteria	EPBC	DEC Region	DEC District	Distribution	Flowering Period	Recovery Plan
<i>Acacia anomala</i>	T	VU	C2a	VU	SWAN	PERTH HILLS, SWAN COASTAL	Darling Scarp, Bullsbrook, Muchea, Pickering Brook, Kalamunda, Bickley, Chittering	Aug, Sep	
<i>Chamaescilla gibsonii</i>	3				SWAN, SWST, WARR	SWAN COASTAL, BLACKWOOD, WELLINGTON, DOONELLY	Ellen Brook, Yule Brook, Mogumber, Muchea, Drakesbrook, Capel, Brunswick Jun, Quindinup		
<i>Cyathochaeta teretifolia</i>	3				SWAN, WARR	SWAN COASTAL, FRANKLAND	Whiteman Park, Lake Gnangara, Ellenbrook, Muchea, Denbarker, Yelverton, Wellard, Mundijong	Dec	
<i>Darwinia pimelioides</i>	4				SWAN	PERTH HILLS	John Forrest N.P., Walyunga, Darlington, Red Hill	Oct	
<i>Eleocharis keigheryi</i>	T	VU	B1	VU	MWST, SWAN, SWST, WHTB	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA, GREAT SOUTHERN, CENTRAL WHEATBELT	Kenwick, Lesueur, Cataby, Wannamal, Ellenbrook, Boyanup, Waterloo, Julimar, Lesueur, Bolgart, Beverley, Woodanilling	-	
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	3				SWAN	SWAN COASTAL	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-	
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	T	CR	B1ab(iii,v)+2ab(iii,v); C2a(iii,v)	EN	SWAN	PERTH HILLS	Bullsbrook		IRP
<i>Grevillea christineae</i>	T	EN	B1+2c	EN	MWST, SWAN, WHTB	PERTH HILLS, MOORA, CENTRAL WHEATBELT	Mortlock River, Goomalling, Watheroo, Upper Swan	Sep	
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	CR	B1ab(iii)+B2ab(iii)	EN	SWAN	PERTH HILLS, SWAN COASTAL	Bullsbrook, Muchea	Oct	IRP
<i>Guichenotia tuberculata</i>	3				MWST, SWAN	PERTH HILLS, MOORA	Mogumber, New Norcia, Gillingarra, Wannamal, Bullsbrook	Aug, Sep	
<i>Haemodorum loratum</i>	3				MWST, SWAN	PERTH HILLS, SWAN COASTAL, MOORA	Eneabba, Cockleshell Gully, Bullsbrook, Wattle Grove, Boonanaring, Mogumber	Sep-Nov	
<i>Meionectes tenuifolia</i>	3				MWST, SWAN, SWST	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA	Ruabon, Maddington, Harvey, Pinjarra, Upper Swan, Gingin, Cooljarloo, (Woorooloo, Midland, Byfields Mill), Mt Helena	Nov-Dec	
<i>Oxymyrrhine coronata</i>	4				SWAN	PERTH HILLS	Chittering, Bullsbrook, Avon Valley	Dec, Jan	
<i>Platysace ramosissima</i>	3				MWST, SWAN, SWST	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA	Yalgorup, Boonanarring, Gingin, Lancelin, Bullsbrook Nature Reserve		
<i>Schoenus capillifolius</i>	3				SWAN, SWST, WHTB	PERTH HILLS, SWAN COASTAL, WELLINGTON, GREAT SOUTHERN, CENTRAL WHEATBELT	Upper Swan, Kenwick, Waterloo, Beauford River, Beverley, Goomalling, Carousel Swamp, Pearce, Waroona, Karnup, Baldivis	Sep-Nov	
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Nov	
<i>Stenanthemum sublineare</i>	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Dec	
<i>Stylidium aceratum</i>	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Nov	
<i>Stylidium asteroideum</i>	3				SWAN, WHTB	PERTH HILLS, CENTRAL WHEATBELT	Clackline, Walyunga N.P., Mount Caroline N.R., Wandoo N.P., Wambyn N.R.	Sep-Oct	
<i>Stylidium longitubum</i>	3				SWAN, SWST, WHTB	SWAN COASTAL, BLACKWOOD, WELLINGTON, GREAT SOUTHERN	Upper Swan, Bullsbrook, Bunbury, Midland, Busselton, Arthur River, Jandakot, Mundijong, Karnup	Nov	
<i>Stylidium squamellosum</i>	2				SWAN, SWST	PERTH HILLS, BLACKWOOD	Bowelling, Muchea, Wonnerup Rd, Bullsbrook		
<i>Stylidium trudgenii</i>	3				SWAN, SWST	PERTH HILLS, BLACKWOOD, WELLINGTON	Ellenbrook, Scott River, Gingilup Swamp, Harvey	Oct, Nov	
<i>Tripterococcus paniculatus</i>	4				SWAN, SWST	SWAN COASTAL, BLACKWOOD	Cannington, Armadale, Leeming, Forrestfield, Upper Swan, Willetton, Forrestdale, Busselton	Nov	
<i>Trithuria occidentalis</i>	T	CR	B1ab(iii)+2ab(iii)	EN	SWAN	SWAN COASTAL	Ellenbrook N.R., (Midland)	Sep-Nov	
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	T	VU	B1ab(iii,v)+2ab(iii,v)	EN	SWAN	PERTH HILLS, SWAN COASTAL	Mundijong West Road, Bullsbrook NR	Nov	IRP

APPENDIX 6

Naturemap Database Search

NatureMap Species Report

Created By Jackalyn Hams on 24/01/2013

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 116°01' 27" E, 31°45' 03" S
Buffer 5km
Group By Conservation Status

Conservation Status	Species	Records
Rare or likely to become extinct	9	149
Protected under international agreement	2	4
Other specially protected fauna	1	1
Priority 2	1	1
Priority 3	10	26
Priority 4	4	8
Priority 5	2	38
Non-conservation taxon	557	1482
TOTAL	586	1709

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
Rare or likely to become extinct				
1.	1596 <i>Caladenia huegelii</i> (Grand Spider Orchid)		T	
2.	24734 <i>Calyptrorhynchus latirostris</i> (Carnaby's Cockatoo (short-billed black-cockatoo))		T	
3.	17605 <i>Eleocharis keigheryi</i>		T	
4.	1976 <i>Grevillea christineae</i>		T	
5.	14408 <i>Grevillea curviloba</i> subsp. <i>curviloba</i>		T	
6.	14409 <i>Grevillea curviloba</i> subsp. <i>incurva</i>		T	
7.	24168 <i>Macrotis lagotis</i> (Bilby)		T	
8.	25345 <i>Pseudemydura umbrina</i> (Western Swamp Turtle, tortoise)		T	
9.	32658 <i>Trithuria occidentalis</i> (Swan Hydatella)		T	
Protected under international agreement				
10.	24598 <i>Merops ornatus</i> (Rainbow Bee-eater)		IA	
11.	24843 <i>Plegadis falcinellus</i> (Glossy Ibis)		IA	
Other specially protected fauna				
12.	25240 <i>Morelia spilota</i> subsp. <i>imbricata</i> (Carpet Python)		S	
Priority 2				
13.	16279 <i>Schoenus</i> sp. <i>Bullsbrook</i> (J.J. Alford 915)		P2	Y
Priority 3				
14.	11336 <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>		P3	
15.	16245 <i>Cyathochaeta teretifolia</i>		P3	
16.	34027 <i>Galaxiella nigrostriata</i> (Black-stripe Minnow)		P3	
17.	1469 <i>Haemodorum loratum</i>		P3	
18.	6686 <i>Halgania corymbosa</i>		P3	
19.	33638 <i>Meionectes tenuifolia</i>		P3	
20.	25249 <i>Neelaps calonotos</i> (Black-striped Snake)		P3	
21.	980 <i>Schoenus capillifolius</i>		P3	
22.	17731 <i>Schoenus</i> sp. <i>Waroon</i> (G.J. Keighery 12235)		P3	
23.	7756 <i>Stylidium longitubum</i> (Jumping Jacks)		P3	
Priority 4				
24.	13826 <i>Cyanicula ixioides</i> subsp. <i>ixioides</i>		P4	
25.	6233 <i>Hydrocotyle lemnoides</i> (Aquatic Pennywort)		P4	
26.	2278 <i>Persoonia sulcata</i>		P4	
27.	1003 <i>Schoenus natans</i> (Floating Bog-rush)		P4	
Priority 5				
28.	24153 <i>Isodon obesulus</i> subsp. <i>fusciventer</i> (Quenda, Southern Brown Bandicoot)		P5	
29.	24131 <i>Macropus eugenii</i> subsp. <i>derbianus</i> (Tamar Wallaby (WA subsp))		P5	
Non-conservation taxon				

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
30.	15466	<i>Acacia applanata</i>			
31.	3254	<i>Acacia celastrifolia</i> (Glowing Wattle)			
32.	3324	<i>Acacia erinacea</i>			
33.	3454	<i>Acacia nervosa</i> (Rib Wattle)			
34.	15483	<i>Acacia pulchella</i> var. <i>pulchella</i>			
35.	3515	<i>Acacia restiacea</i>			
36.	3527	<i>Acacia saligna</i> (Orange Wattle)			
37.	30032	<i>Acacia saligna</i> subsp. <i>saligna</i>			
38.	24260	<i>Acanthiza apicalis</i> (Broad-tailed Thornbill)			
39.	24261	<i>Acanthiza chrysorrhoa</i> (Yellow-rumped Thornbill)			
40.	24262	<i>Acanthiza inornata</i> (Western Thornbill)			
41.	24560	<i>Acanthorhynchus superciliosus</i> (Western Spinebill)			
42.	1791	<i>Adenanthos obovatus</i> (Basket Flower)			
43.	184	<i>Aira caryophyllea</i> (Silvery Hairgrass)	Y		
44.	185	<i>Aira cupaniana</i> (Silvery Hairgrass)	Y		
45.	187	<i>Aira praecox</i> (Early Hairgrass)	Y		
46.	1056	<i>Alexgeorgea nitens</i>			
47.	1375	<i>Allium neapolitanum</i> (Naples Onion)	Y		
48.	1728	<i>Allocasuarina fraseriana</i> (Sheoak)			
49.	2652	<i>Alternanthera nodiflora</i> (Common Joyweed)			
50.	-14519	<i>Amblyomma triguttatum</i>			
51.	200	<i>Amphipogon turbinatus</i>			
52.	24312	<i>Anas gracilis</i> (Grey Teal)			
53.	24313	<i>Anas platyrhynchos</i> (Mallard)			
54.	24316	<i>Anas superciliosa</i> (Pacific Black Duck)			
55.	6300	<i>Andersonia aristata</i> (Rice Flower)			
56.	11470	<i>Anigozanthos bicolor</i> subsp. <i>bicolor</i>			
57.	6949	<i>Anthocercis littorea</i> (Yellow Tailflower)			
58.	24561	<i>Anthochaera carunculata</i> (Red Wattlebird)			
59.	24562	<i>Anthochaera lunulata</i> (Western Little Wattlebird)			
60.	12724	<i>Anthotium junciforme</i>			
61.	25670	<i>Anthus australis</i> (Australian Pipit)			
62.	1117	<i>Aphelia cyperoides</i>			
63.	1118	<i>Aphelia drummondii</i>			
64.	24990	<i>Aprasia pulchella</i>			
65.	24991	<i>Aprasia repens</i>			
66.	24285	<i>Aquila audax</i> (Wedge-tailed Eagle)			
67.	7838	<i>Arctotheca calendula</i> (Cape Weed)	Y		
68.	207	<i>Aristida contorta</i> (Bunched Kerosene Grass)			
69.	25566	<i>Artamus cinereus</i> (Black-faced Woodswallow)			
70.	24353	<i>Artamus cyanopterus</i> (Dusky Woodswallow)			
71.	6330	<i>Astroloma macrocalyx</i> (Swan Berry)			
72.	6334	<i>Astroloma pallidum</i> (Kick Bush)			
73.	6339	<i>Astroloma xerophyllum</i>			
74.	17233	<i>Austrostipa campylachne</i>			
75.	17240	<i>Austrostipa flavescens</i>			
76.	17244	<i>Austrostipa macalpinei</i>			
77.	17254	<i>Austrostipa tenuifolia</i>			
78.	233	<i>Avena barbata</i> (Bearded Oat)	Y		
79.	234	<i>Avena fatua</i> (Wild Oat)	Y		
80.	235	<i>Avena sativa</i> (Common Oat)	Y		
81.	24318	<i>Aythya australis</i> (Hardhead)			
82.	36441	<i>Babingtonia camphorosmae</i> (Camphor Myrtle)			
83.	32682	<i>Banksia armata</i> var. <i>armata</i>			
84.	1800	<i>Banksia attenuata</i> (Slender Banksia)			
85.	32576	<i>Banksia dallanneyi</i> (Couch Honeyeater)			
86.	32577	<i>Banksia dallanneyi</i> var. <i>mellicula</i>			
87.	32523	<i>Banksia fraseri</i> var. <i>fraseri</i>			
88.	1834	<i>Banksia menziesii</i> (Firewood Banksia)			
89.	1835	<i>Banksia micrantha</i>			
90.	32076	<i>Banksia sessilis</i> (Parrot Bush)			
91.	32080	<i>Banksia sessilis</i> var. <i>sessilis</i>			
92.	15037	<i>Bartsia trixago</i>	Y		
93.	740	<i>Baumea arthropphylla</i>			
94.	741	<i>Baumea articulata</i> (Jointed Rush)			
95.	743	<i>Baumea juncea</i> (Bare Twigrush)			
96.	3165	<i>Billardiera variifolia</i>			
97.	7856	<i>Blennospora drummondii</i>			
98.	17665	<i>Boronia purdieana</i> subsp. <i>purdieana</i>			
99.	1272	<i>Borya scirpoidea</i>			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
100.	1273	<i>Borya sphaerocephala</i> (Pincushions)			
101.	24251	<i>Bos taurus</i> (European Cattle)	Y		
102.	3710	<i>Bossiaea eriocarpa</i> (Common Brown Pea)			
103.	8661	<i>Brachypodium distachyon</i> (False Brome)	Y		
104.	7875	<i>Brachyscome glandulosa</i>			
105.	7878	<i>Brachyscome iberidifolia</i>			
106.	-19511	<i>Brachyuropis fasciolatus</i> subsp. <i>fasciolatus</i>			
107.	-19669	<i>Brachyuropis semifasciatus</i>			
108.	244	<i>Briza maxima</i> (Blowfly Grass)	Y		
109.	245	<i>Briza minor</i> (Shivery Grass)	Y		
110.	249	<i>Bromus diandrus</i> (Great Brome)	Y		
111.	250	<i>Bromus hordeaceus</i> (Soft Brome)	Y		
112.	253	<i>Bromus rubens</i> (Red Brome)	Y		
113.	1383	<i>Burchardia bairdiae</i>			
114.	12770	<i>Burchardia congesta</i>			
115.	1385	<i>Burchardia multiflora</i> (Dwarf Burchardia)			
116.	25716	<i>Cacatua sanguinea</i> (Little Corella)			
117.	24729	<i>Cacatua tenuirostris</i> (Eastern Long-billed Corella)	Y		
118.	1276	<i>Caesia micrantha</i> (Pale Grass-lily)			
119.	1592	<i>Caladenia flava</i> (Cowslip Orchid)			
120.	15348	<i>Caladenia flava</i> subsp. <i>flava</i>			
121.	15354	<i>Caladenia hirta</i> subsp. <i>hirta</i>			
122.	15380	<i>Caladenia splendens</i>			
123.	2856	<i>Calandrinia liniflora</i> (Parakeelya)			
124.	19309	<i>Calectasia narragara</i>			
125.	35816	<i>Calothamnus quadrifidus</i> subsp. <i>quadrifidus</i>			
126.	5439	<i>Calytrix angulata</i> (Yellow Starflower)			
127.	5461	<i>Calytrix glutinosa</i>			
128.	5481	<i>Calytrix sylvana</i>			
129.	-16582	<i>Carassius auratus</i>			
130.	2956	<i>Cassytha pomiformis</i> (Dodder Laurel)			
131.	1742	<i>Casuarina obesa</i> (Swamp Sheoak)			
132.	41567	<i>Cenchrus macrourus</i> (African Feather Grass)	Y		
133.	41568	<i>Cenchrus setaceus</i> (Fountain Grass)	Y		
134.	6539	<i>Centaureum erythraea</i> (Common Centaury)	Y		
135.	1120	<i>Centrolepis alepyroides</i>			
136.	1121	<i>Centrolepis aristata</i> (Pointed Centrolepis)			
137.	1125	<i>Centrolepis drummondiana</i>			
138.	1129	<i>Centrolepis glabra</i> (Smooth Centrolepis)			
139.	1132	<i>Centrolepis mutica</i>			
140.	-14766	<i>Cercophonius sulcatus</i>			
141.	11878	<i>Chamaescilla corymbosa</i> var. <i>paradoxa</i>			
142.	35598	<i>Chamaelaucium</i> sp. Winchester (C. Chapman s.n. PERTH 07879180)			
143.	3169	<i>Cheiranthra preissiana</i>			
144.	25337	<i>Chelodina oblonga</i> (Oblong Turtle)			
145.	24321	<i>Chenonetta jubata</i> (Australian Wood Duck)			
146.	2491	<i>Chenopodium macrospermum</i>	Y		
147.	33939	<i>Cherax cainii</i> (Marron)			
148.	763	<i>Chorizandra enodis</i> (Black Bristlerush)			
149.	6543	<i>Cicendia filiformis</i> (Slender Cicendia)	Y		
150.	25675	<i>Colluricincla harmonica</i> (Grey Shrike-thrush)			
151.	24399	<i>Columba livia</i> (Domestic Pigeon)	Y		
152.	40864	<i>Commersonia cygnorum</i>			
153.	1864	<i>Conospermum crassinervium</i> (Summer Smokebush)			
154.	6347	<i>Conostephium minus</i> (Pink-tipped Pearl flower)			
155.	6349	<i>Conostephium preissii</i>			
156.	11513	<i>Conostylis aculeata</i> subsp. <i>cygnorum</i>			
157.	1420	<i>Conostylis androstemma</i> (Trumpets)			
158.	1436	<i>Conostylis juncea</i>			
159.	11597	<i>Conostylis setigera</i> subsp. <i>setigera</i>			
160.	1455	<i>Conostylis setosa</i> (White Cottonhead)			
161.	25568	<i>Coracina novaehollandiae</i> (Black-faced Cuckoo-shrike)			
162.	2891	<i>Corrigiola litoralis</i> (Strapwort)	Y		
163.	25592	<i>Corvus coronoides</i> (Australian Raven)			
164.	17104	<i>Corymbia calophylla</i> (Marri)			
165.	7945	<i>Cotula coronopifolia</i> (Waterbuttons)	Y		
166.	7946	<i>Cotula cotuloides</i> (Smooth Cotula)			
167.	25595	<i>Cracticus tibicen</i> (Australian Magpie)			
168.	25596	<i>Cracticus torquatus</i> (Grey Butcherbird)			
169.	3137	<i>Crassula colorata</i> (Dense Stonecrop)			

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170.	3142	<i>Crassula natans</i>	Y		
171.	15706	<i>Crassula natans</i> var. <i>minus</i>	Y		
172.	24918	<i>Crenadactylus ocellatus</i> subsp. <i>ocellatus</i>			
173.	25398	<i>Crinia georgiana</i> (Quacking Frog)			
174.	25400	<i>Crinia insignifera</i> (Squelching Froglet)			
175.	13527	<i>Croninia kingiana</i>			
176.	13470	<i>Cryptandra arbutiflora</i> var. <i>arbutiflora</i>			
177.	9076	<i>Cryptandra myriantha</i>			
178.	30893	<i>Cryptoblepharus buchanani</i>			
179.	25039	<i>Ctenotus fallens</i>			
180.	25047	<i>Ctenotus impar</i>			
181.	15114	<i>Cyanicula gemmata</i>			
182.	768	<i>Cyathochaeta avenacea</i>			
183.	40661	<i>Cycnogeton lineare</i>			
184.	24322	<i>Cygnus atratus</i> (Black Swan)			
185.	283	<i>Cynodon dactylon</i> (Couch)	Y		
186.	794	<i>Cyperus gymnocaulos</i> (Spiny Flat-sedge)			
187.	806	<i>Cyperus polystachyos</i> (Bunchy Sedge)	Y		
188.	815	<i>Cyperus tenellus</i> (Tiny Flatsedge)	Y		
189.	-15906	<i>Cyprinus carpio</i>			
190.	17692	<i>Cytogonidium leptocarpoides</i>			
191.	30901	<i>Dacelo novaeguineae</i> (Laughing Kookaburra)	Y		
192.	7428	<i>Dampiera coronata</i> (Wedge-leaved Dampiera)			
193.	7451	<i>Dampiera lavandulacea</i>			
194.	7454	<i>Dampiera linearis</i> (Common Dampiera)			
195.	25673	<i>Daphoenositta chrysoptera</i> (Varied Sittella)			
196.	5508	<i>Darwinia citriodora</i> (Lemon-scented Darwinia)			
197.	1218	<i>Dasypogon bromeliifolius</i> (Pineapple Bush)			
198.	6218	<i>Daucus glochidiatus</i> (Australian Carrot)			
199.	3793	<i>Daviesia angulata</i>			
200.	3832	<i>Daviesia physodes</i>			
201.	17663	<i>Desmocladius asper</i>			
202.	17838	<i>Dielsia stenostachya</i>			
203.	17736	<i>Digitaria aequiglumis</i>	Y		
204.	311	<i>Digitaria ciliaris</i> (Summer Grass)	Y		
205.	320	<i>Digitaria sanguinalis</i> (Crab Grass)	Y		
206.	24929	<i>Diplodactylus granariensis</i> subsp. <i>granariensis</i>			
207.	4746	<i>Diplopeltis huegelii</i>			
208.	18541	<i>Diplopeltis huegelii</i> subsp. <i>huegelii</i>			
209.	18589	<i>Diplopeltis huegelii</i> subsp. <i>lehmannii</i>			
210.	3011	<i>Diplotaxis muralis</i> (Wall Rocket)	Y		
211.	7055	<i>Dischisma capitatum</i> (Woolly-headed Dischisma)	Y		
212.	7961	<i>Dittrichia graveolens</i> (Stinkwort)	Y		
213.	1634	<i>Diuris laxiflora</i> (Bee Orchid)			
214.	24470	<i>Dromaius novaehollandiae</i> (Emu)			
215.	3095	<i>Drosera erythrorhiza</i> (Red Ink Sundew)			
216.	13211	<i>Drosera erythrorhiza</i> subsp. <i>collina</i>			
217.	3097	<i>Drosera gigantea</i> (Giant Sundew)			
218.	15453	<i>Drosera gigantea</i> subsp. <i>gigantea</i>			
219.	3098	<i>Drosera glanduligera</i> (Pimpernel Sundew)			
220.	3101	<i>Drosera heterophylla</i> (Swamp Rainbow)			
221.	11853	<i>Drosera menziesii</i> subsp. <i>menziesii</i>			
222.	13216	<i>Drosera menziesii</i> subsp. <i>penicillaris</i>			
223.	3113	<i>Drosera neesii</i> (Jewel Rainbow)			
224.	3117	<i>Drosera paleacea</i> (Dwarf Sundew)			
225.	3123	<i>Drosera platystigma</i> (Black-eyed Sundew)			
226.	3124	<i>Drosera pulchella</i> (Pretty Sundew)			
227.	8911	<i>Drosera rosulata</i>			
228.	3131	<i>Drosera stolonifera</i> (Leafy Sundew)			
229.	347	<i>Ehrharta calycina</i> (Perennial Veldt Grass)	Y		
230.	349	<i>Ehrharta longiflora</i> (Annual Veldt Grass)	Y		
231.	24290	<i>Elanus caeruleus</i> subsp. <i>axillaris</i> (Australian Black-shouldered Kite)			
232.	822	<i>Eleocharis acuta</i> (Common Spikerush)			
233.	1644	<i>Elythranthera emarginata</i> (Pink Enamel Orchid)			
234.	2409	<i>Emex australis</i> (Doublegee)	Y		
235.	374	<i>Eragrostis cilianensis</i> (Stinkgrass)	Y		
236.	376	<i>Eragrostis curvula</i> (African Lovegrass)	Y		
237.	415	<i>Eriachne ovata</i>			
238.	1646	<i>Eriochilus dilatatus</i> (White Bunny Orchid)			
239.	4332	<i>Erodium botrys</i> (Long Storksbill)	Y		

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240.	4335	<i>Erodium cygnorum</i> (Blue Heronsbill)			
241.	6219	<i>Eryngium pinnatifidum</i> (Blue Devils)			
242.	5763	<i>Eucalyptus rudis</i> (Flooded Gum)			
243.	5767	<i>Eucalyptus salubris</i> (Gimlet)			
244.	12906	<i>Eucalyptus wandoo</i> subsp. <i>wandoo</i>			
245.	15137	<i>Euchiton sphaericus</i>			
246.	25622	<i>Falco cenchroides</i> (Australian Kestrel)			
247.	894	<i>Fimbristylis velata</i>			
248.	25727	<i>Fulica atra</i> (Eurasian Coot)			
249.	2969	<i>Fumaria capreolata</i> (Whiteflower Fumitory)	Y		
250.	32370	<i>Funaria hygrometrica</i>			
251.	907	<i>Gahnia trifida</i> (Coast Saw-sedge)			
252.	34028	<i>Galaxias occidentalis</i> (Western Minnow)			
253.	7323	<i>Galium murale</i> (Small Goosegrass)	Y		
254.	25729	<i>Gallinula tenebrosa</i> (Dusky Moorhen)			
255.	20483	<i>Gastrolobium linearifolium</i>			
256.	20512	<i>Gastrolobium praemorsum</i>			
257.	3924	<i>Gastrolobium spinosum</i> (Prickly Poison)			
258.	25530	<i>Gerygone fusca</i> (Western Gerygone)			
259.	1520	<i>Gladiolus caryophyllaceus</i> (Wild Gladiolus)	Y		
260.	2836	<i>Glinus oppositifolius</i>			
261.	7061	<i>Glossostigma drummondii</i> (Mudmat)			
262.	3951	<i>Gompholobium marginatum</i>			
263.	3957	<i>Gompholobium tomentosum</i> (Hairy Yellow Pea)			
264.	8614	<i>Goodenia claytoniacea</i>			
265.	12551	<i>Goodenia micrantha</i>			
266.	7538	<i>Goodenia pulchella</i>			
267.	24443	<i>Grallina cyanoleuca</i> (Magpie-lark)			
268.	14282	<i>Gratiola pubescens</i>			
269.	13450	<i>Grevillea manglesii</i> subsp. <i>manglesii</i>			
270.	2066	<i>Grevillea pilulifera</i> (Woolly-flowered Grevillea)			
271.	5014	<i>Guichenotia sarotes</i>			
272.	1465	<i>Haemodorum discolor</i>			
273.	1468	<i>Haemodorum laxum</i>			
274.	1472	<i>Haemodorum simplex</i>			
275.	2158	<i>Hakea erinacea</i> (Hedge-hog Hakea)			
276.	2166	<i>Hakea incrassata</i> (Marble Hakea)			
277.	2175	<i>Hakea lissocarpha</i> (Honey Bush)			
278.	2185	<i>Hakea myrtoides</i> (Myrtle Hakea)			
279.	2216	<i>Hakea varia</i> (Variable-leaved Hakea)			
280.	25409	<i>Heleioporus barycragus</i> (Hooting Frog)			
281.	25410	<i>Heleioporus eyrei</i> (Moaning Frog)			
282.	3016	<i>Heliophila pusilla</i>	Y		
283.	6838	<i>Hemiandra linearis</i> (Speckled Snakebush)			
284.	6839	<i>Hemiandra pungens</i> (Snakebush)			
285.	25119	<i>Hemiergis quadrilineata</i>			
286.	1526	<i>Hesperantha falcata</i>	Y		
287.	5112	<i>Hibbertia aurea</i>			
288.	5114	<i>Hibbertia commutata</i>			
289.	5118	<i>Hibbertia cunninghamii</i>			
290.	20051	<i>Hibbertia diamesogenos</i>			
291.	5135	<i>Hibbertia hypericoides</i> (Yellow Buttercups)			
292.	5162	<i>Hibbertia racemosa</i> (Stalked Guinea Flower)			
293.	20034	<i>Hibbertia</i> sp. <i>Gnangara</i> (J.R. Wheeler 2329)			
294.	5173	<i>Hibbertia subvaginata</i>			
295.	24491	<i>Hirundo neoxena</i> (Welcome Swallow)			
296.	445	<i>Holcus setiger</i> (Annual Fog)	Y		
297.	6222	<i>Homalosciadium homalocarpum</i>			
298.	17575	<i>Hordeum distichon</i>	Y		
299.	12741	<i>Hyalosperma cotula</i>			
300.	6223	<i>Hydrocotyle alata</i>			
301.	6226	<i>Hydrocotyle callicarpa</i> (Small Pennywort)			
302.	6229	<i>Hydrocotyle diantha</i>			
303.	5817	<i>Hypocalymma angustifolium</i> (White Myrtle)			
304.	35070	<i>Hypocalymma angustifolium</i> subsp. <i>Swan Coastal Plain</i> (G.J. Keighery 16777)			
305.	8086	<i>Hypochaeris glabra</i> (Smooth Catsear)	Y		
306.	1070	<i>Hypolaena exsulca</i>			
307.	1500	<i>Hypoxis glabella</i> (Tiny Star)			
308.	1503	<i>Hypoxis occidentalis</i>			
309.	11736	<i>Hypoxis occidentalis</i> var. <i>occidentalis</i>			

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310.	11	<i>Isoetes drummondii</i> (Quillwort)			
311.	910	<i>Isolepis cernua</i> (Nodding Club-rush)			
312.	14540	<i>Isolepis hystrix</i>	Y		
313.	917	<i>Isolepis marginata</i> (Coarse Club-rush)	Y		
314.	919	<i>Isolepis oldfieldiana</i>			
315.	921	<i>Isolepis producta</i>			
316.	924	<i>Isolepis stellata</i> (Star Club-rush)			
317.	2229	<i>Isopogon dubius</i> (Pincushion Coneflower)			
318.	7398	<i>Isotoma pusilla</i> (Small Isotome)			
319.	4012	<i>Jacksonia furcellata</i> (Grey Stinkwood)			
320.	4029	<i>Jacksonia sternbergiana</i> (Stinkwood)			
321.	1178	<i>Juncus bufonius</i> (Toad Rush)	Y		
322.	1180	<i>Juncus capitatus</i> (Capitate Rush)	Y		
323.	1188	<i>Juncus pallidus</i> (Pale Rush)			
324.	4044	<i>Kennedia prostrata</i> (Scarlet Runner)			
325.	4045	<i>Kennedia stirlingii</i> (Bushy Kennedia)			
326.	5835	<i>Kunzea micrantha</i>			
327.	17461	<i>Kunzea micrantha</i> subsp. <i>micrantha</i>			
328.	5841	<i>Kunzea recurva</i>			
329.	11289	<i>Labichea lanceolata</i> subsp. <i>lanceolata</i>			
330.	19955	<i>Lachnagrostis plebeia</i>			
331.	29046	<i>Lactuca serriola</i> forma <i>serriola</i>	Y		
332.	468	<i>Lamarckia aurea</i> (Goldentop)	Y		
333.	4052	<i>Latrobea tenella</i>			
334.	1303	<i>Laxmannia grandiflora</i>			
335.	1309	<i>Laxmannia squarrosa</i>			
336.	1051	<i>Lemna disperma</i> (Duckweed)			
337.	18074	<i>Lepidobolus preissianus</i> subsp. <i>preissianus</i>			
338.	925	<i>Lepidosperma angustatum</i>			
339.	930	<i>Lepidosperma costale</i>			
340.	936	<i>Lepidosperma leptostachyum</i>			
341.	937	<i>Lepidosperma longitudinale</i> (Pithy Sword-sedge)			
342.	940	<i>Lepidosperma pubisquameum</i>			
343.	1653	<i>Leporella fimbriata</i> (Hare Orchid)			
344.	5847	<i>Leptospermum erubescens</i> (Roadside Teatree)			
345.	1088	<i>Lepyrodia macra</i> (Large Scale Rush)			
346.	25128	<i>Lerista christinae</i>			
347.	25133	<i>Lerista elegans</i>			
348.	25165	<i>Lerista praepedita</i>			
349.	6439	<i>Leucopogon pulchellus</i> (Beard-heath)			
350.	40803	<i>Leucopogon squarrosus</i> subsp. <i>squarrosus</i>			
351.	6451	<i>Leucopogon tenuis</i>			
352.	7677	<i>Levenhookia stipitata</i> (Common Stylewort)			
353.	25005	<i>Lialis burtonis</i>			
354.	24581	<i>Lichenostomus virescens</i> (Singing Honeyeater)			
355.	25661	<i>Lichmera indistincta</i> (Brown Honeyeater)			
356.	4363	<i>Linum trigynum</i> (French Flax)	Y		
357.	36160	<i>Liparophyllum capitatum</i>			
358.	25378	<i>Litoria adelaidensis</i> (Slender Tree Frog)			
359.	25388	<i>Litoria moorei</i> (Motorbike Frog)			
360.	1223	<i>Lomandra caespitosa</i> (Tufted Mat Rush)			
361.	4059	<i>Lotus angustissimus</i> (Narrowleaf Trefoil)	Y		
362.	1092	<i>Loxocarya cinerea</i>			
363.	4065	<i>Lupinus angustifolius</i> (Narrowleaf Lupin)	Y		
364.	1097	<i>Lyginia barbata</i>			
365.	18049	<i>Lyginia imberbis</i>			
366.	36375	<i>Lysimachia arvensis</i> (Pimpernel)	Y		
367.	34736	<i>Lysinema pentapetalum</i>			
368.	25654	<i>Malurus splendens</i> (Splendid Fairy-wren)			
369.	17683	<i>Meeboldina cana</i>			
370.	17747	<i>Meeboldina decipiens</i>			
371.	34676	<i>Meionectes brownii</i> (Swamp Raspwort)			
372.	5926	<i>Melaleuca lateritia</i> (Robin Redbreast Bush)			
373.	5958	<i>Melaleuca radula</i> (Graceful Honeymyrtle)			
374.	5959	<i>Melaleuca raphiophylla</i> (Swamp Paperbark)			
375.	19365	<i>Melaleuca ryeae</i>			
376.	5978	<i>Melaleuca teretifolia</i> (Banbar)			
377.	5987	<i>Melaleuca viminea</i> (Mohan)			
378.	25663	<i>Melithreptus brevirostris</i> (Brown-headed Honeyeater)			
379.	25184	<i>Menetia greyii</i>			

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380.	25693	<i>Microeca fascians</i> (Jacky Winter)			
381.	485	<i>Microlaena stipoides</i> (Weeping Grass)			
382.	1657	<i>Microtis alba</i> (White Mignonette Orchid)			
383.	15419	<i>Microtis media</i> subsp. <i>media</i>			
384.	8105	<i>Millotia myosotidifolia</i>			
385.	4100	<i>Mirbelia spinosa</i>			
386.	7410	<i>Monopsis debilis</i>	Y		
387.	37440	<i>Monopsis debilis</i> var. <i>depressa</i>	Y		
388.	4666	<i>Monotaxis occidentalis</i>			
389.	19179	<i>Moraea flaccida</i> (One-leaf Cape Tulip)	Y		
390.	25191	<i>Morethia lineocellata</i>			
391.	2412	<i>Muehlenbeckia adpressa</i> (Climbing Lignum)			
392.	8114	<i>Myriocephalus appendiculatus</i> (White-tip Myriocephalus)			
393.	8117	<i>Myriocephalus helichrysoides</i>			
394.	14187	<i>Myriocephalus occidentalis</i>			
395.	6189	<i>Myriophyllum crispatum</i>			
396.	6192	<i>Myriophyllum drummondii</i>			
397.	25426	<i>Neobatrachus pelobatoides</i> (Humming Frog)			
398.	492	<i>Neurachne alopecuroides</i> (Foxtail Mulga Grass)			
399.	25252	<i>Notechis scutatus</i> (Tiger Snake)			
400.	2401	<i>Nuytsia floribunda</i> (Christmas Tree)			
401.	25564	<i>Nycticorax caledonicus</i> (Rufous Night Heron)			
402.	24407	<i>Ocyphaps lophotes</i> (Crested Pigeon)			
403.	-14595	<i>Oecobius navus</i>			
404.	8143	<i>Olearia paucidentata</i> (Autumn Scrub Daisy)			
405.	18255	<i>Opercularia vaginata</i> (Dog Weed)			
406.	36177	<i>Ornduffia albiflora</i>			
407.	7122	<i>Orobanche minor</i> (Lesser Broomrape)	Y		
408.	4355	<i>Oxalis perennans</i>			
409.	4356	<i>Oxalis pes-caprae</i> (Soursob)	Y		
410.	13135	<i>Ozothamnus ramosus</i>			
411.	25680	<i>Pachycephala rufiventris</i> (Rufous Whistler)			
412.	25253	<i>Parasuta gouldii</i>			
413.	25681	<i>Pardalotus punctatus</i> (Spotted Pardalote)			
414.	25682	<i>Pardalotus striatus</i> (Striated Pardalote)			
415.	7089	<i>Parentucellia latifolia</i> (Common Bartsia)	Y		
416.	7090	<i>Parentucellia viscosa</i> (Sticky Bartsia)	Y		
417.	519	<i>Paspalidium constrictum</i> (Knottybutt Grass)			
418.	1550	<i>Patersonia occidentalis</i> (Purple Flag)			
419.	6006	<i>Pericalymma ellipticum</i> (Swamp Teatree)			
420.	16478	<i>Pericalymma ellipticum</i> var. <i>floridum</i>			
421.	13911	<i>Persicaria decipiens</i>			
422.	24659	<i>Petroica goodenovii</i> (Red-capped Robin)			
423.	2284	<i>Petrophile biloba</i> (Granite Petrophile)			
424.	20391	<i>Petrophile juncifolia</i>			
425.	2299	<i>Petrophile linearis</i> (Pixie Mops)			
426.	2308	<i>Petrophile seminuda</i>			
427.	19825	<i>Petrorhagia dubia</i>	Y		
428.	24667	<i>Phalacrocorax sulcirostris</i> (Little Black Cormorant)			
429.	25699	<i>Phalacrocorax varius</i> (Pied Cormorant)			
430.	551	<i>Phalaris minor</i> (Lesser Canary Grass)	Y		
431.	24409	<i>Phaps chalcoptera</i> (Common Bronzewing)			
432.	1173	<i>Philydrella pygmaea</i> (Butterfly Flowers)			
433.	24596	<i>Phylidonyris novaehollandiae</i> (New Holland Honeyeater)			
434.	4675	<i>Phyllanthus calycinus</i> (False Boronia)			
435.		<i>Phytophthora cinnamomi</i>			
436.	78	<i>Piilularia novae-hollandiae</i> (Austral Pillwort)			
437.	11404	<i>Pimelea imbricata</i> var. <i>major</i>			
438.	11402	<i>Pimelea imbricata</i> var. <i>piligera</i>			
439.	12041	<i>Pimelea suaveolens</i> subsp. <i>suaveolens</i> (Tall Mulla Mulla)			
440.	25721	<i>Platycercus zonarius</i> (Australian Ringneck)			
441.	24750	<i>Platycercus zonarius</i> subsp. <i>semitorquatus</i> (Twenty-eight Parrot)			
442.	24751	<i>Platycercus zonarius</i> subsp. <i>zonarius</i>			
443.	25007	<i>Pletholax gracilis</i> subsp. <i>gracilis</i>			
444.	8175	<i>Podolepis gracilis</i> (Slender Podolepis)			
445.	8177	<i>Podolepis lessonii</i>			
446.	8183	<i>Podotheca chrysantha</i> (Yellow Podotheca)			
447.	8184	<i>Podotheca gnaphalioides</i> (Golden Long-heads)			
448.	24907	<i>Pogona minor</i> subsp. <i>minor</i>			
449.	24681	<i>Poliiocephalus poliiocephalus</i> (Hoary-headed Grebe)			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
450.	582	<i>Polypogon monspeliensis</i> (Annual Beardgrass)	Y		
451.	583	<i>Polypogon tenellus</i>			
452.	30854	<i>Polytelis anthopeplus</i> subsp. <i>westralis</i>			
453.	25731	<i>Porphyrio porphyrio</i> (Purple Swampphen)			
454.	1671	<i>Prasophyllum elatum</i> (Tall Leek Orchid)			
455.	1672	<i>Prasophyllum fimbria</i> (Fringed Leek Orchid)			
456.	25261	<i>Pseudechis australis</i> (Mulga Snake)			
457.	25259	<i>Pseudonaja affinis</i> subsp. <i>affinis</i> (Dugite)			
458.	25433	<i>Pseudophryne guentheri</i> (Crawling Toadlet)			
459.	11118	<i>Pterostylis pyramidalis</i> (Snail Orchid)			
460.	2716	<i>Ptilotus declinatus</i> (Curved Mulla Mulla)			
461.	2720	<i>Ptilotus esquamatus</i>			
462.	2742	<i>Ptilotus manglesii</i> (Pom Poms)			
463.	8195	<i>Quinetia urvillei</i>			
464.	25271	<i>Ramphotyphlops australis</i>			
465.	25288	<i>Ramphotyphlops waitii</i>			
466.	2932	<i>Ranunculus colonorum</i> (Common Buttercup)			
467.	2937	<i>Ranunculus sessiliflorus</i> (Smallflower Buttercup)			
468.	3061	<i>Raphanus raphanistrum</i> (Wild Radish)	Y		
469.	24245	<i>Rattus rattus</i> (Black Rat)	Y		
470.	6012	<i>Regelia ciliata</i>			
471.	25614	<i>Rhipidura leucophrys</i> (Willie Wagtail)			
472.	13312	<i>Rhodanthe pyrethrum</i>			
473.	1556	<i>Romulea rosea</i> (Guildford Grass)	Y		
474.	11544	<i>Romulea rosea</i> var. <i>australis</i> (Guildford Grass)	Y		
475.	14924	<i>Romulea rosea</i> var. <i>communis</i>	Y		
476.	2433	<i>Rumex crispus</i> (Curled Dock)	Y		
477.	40430	<i>Rytidosperma pilosum</i>			
478.	40427	<i>Rytidosperma setaceum</i>			
479.	6483	<i>Samolus junceus</i>			
480.	41660	<i>Schenkia australis</i>			
481.	968	<i>Schoenoplectus pungens</i> (Sharpleaf Rush)			
482.	975	<i>Schoenus bifidus</i>			
483.	984	<i>Schoenus curvifolius</i>			
484.	985	<i>Schoenus discifer</i>			
485.	994	<i>Schoenus humilis</i>			
486.	1006	<i>Schoenus odontocarpus</i>			
487.	17614	<i>Schoenus plumosus</i>			
488.	1011	<i>Schoenus rigens</i>			
489.	18164	<i>Schoenus</i> sp. <i>smooth culms</i> (K.R. Newbey 7823)			
490.	1017	<i>Schoenus subbulbosus</i>			
491.	1023	<i>Schoenus tenellus</i>			
492.	1026	<i>Schoenus unispiculatus</i>			
493.	17409	<i>Schoenus variicellae</i>			
494.	6033	<i>Scholtzia involucrata</i> (Spiked Scholtzia)			
495.	6	<i>Selaginella gracillima</i> (Tiny Clubmoss)			
496.	20663	<i>Senecio multicaulis</i> subsp. <i>multicaulis</i>			
497.	2909	<i>Silene gallica</i> (French Catchfly)	Y		
498.	15972	<i>Silene gallica</i> var. <i>gallica</i>	Y		
499.	11803	<i>Silene gallica</i> var. <i>quinquevulnera</i>	Y		
500.	8225	<i>Siloxerus humifusus</i> (Procumbent Siloxerus)			
501.	25266	<i>Simoselaps bertholdi</i> (Jan's Banded Snake)			
502.	30948	<i>Smicromis brevirostris</i> (Weebill)			
503.	6988	<i>Solanum americanum</i> (Glossy Nightshade)	Y		
504.	7022	<i>Solanum nigrum</i> (Black Berry Nightshade)	Y		
505.	8230	<i>Sonchus asper</i> (Rough Sowthistle)	Y		
506.	8231	<i>Sonchus oleraceus</i> (Common Sowthistle)	Y		
507.	1312	<i>Sowerbaea laxiflora</i> (Purple Tassels)			
508.	623	<i>Spartochloa scirpoidea</i>			
509.	6930	<i>Stachys arvensis</i> (Staggerweed)	Y		
510.	16197	<i>Stenanthemum emarginatum</i>			
511.	2316	<i>Stirlingia latifolia</i> (Blueboy)			
512.	25597	<i>Strepera versicolor</i> (Grey Currawong)			
513.	25589	<i>Streptopelia chinensis</i> (Spotted Turtle-Dove)	Y		
514.	25590	<i>Streptopelia senegalensis</i> (Laughing Turtle-Dove)	Y		
515.	24943	<i>Strophurus spinigerus</i> subsp. <i>inornatus</i>			
516.	24942	<i>Strophurus spinigerus</i> subsp. <i>spinigerus</i>			
517.	7693	<i>Stylidium brunonianum</i> (Pink Fountain Triggerplant)			
518.	7712	<i>Stylidium despectum</i> (Dwarf Triggerplant)			
519.	7713	<i>Stylidium dichotomum</i> (Pins-and-needles)			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
520.	7717	<i>Stylidium divaricatum</i> (Daddy-long-legs)			
521.	7719	<i>Stylidium ecome</i> (Foot Triggerplant)			
522.	25800	<i>Stylidium paludicola</i>			
523.	7773	<i>Stylidium petiolare</i> (Horn Triggerplant)			
524.	30274	<i>Stylidium purpureum</i> subsp. non stilted (J.A. Wege & F. Hort JAW 1384)			
525.	33106	<i>Stylidium recurvum</i>			
526.	7785	<i>Stylidium repens</i> (Matted Triggerplant)			
527.	25806	<i>Stylidium scarosum</i>			
528.	25830	<i>Stylidium</i> sp. Darling Range (H. Bowler 371)			
529.	3181	<i>Stylobasium australe</i>			
530.	2325	<i>Synaphea pinnata</i> (Helena Synaphea)			
531.	25705	<i>Tachybaptus novaehollandiae</i> (Australasian Grebe)			
532.	24331	<i>Tadorna tadornoides</i> (Australian Shelduck)			
533.	24167	<i>Tarsipes rostratus</i> (Honey Possum)			
534.	-13561	<i>Tasmanicosa leuckartii</i>			
535.	1701	<i>Thelymitra antennifera</i> (Vanilla Orchid)			
536.	673	<i>Themeda triandra</i>			
537.	24844	<i>Threskiornis molucca</i> (Australian White Ibis)			
538.	24845	<i>Threskiornis spinicollis</i> (Straw-necked Ibis)			
539.	1328	<i>Thysanotus dichotomus</i> (Branching Fringe Lily)			
540.	1343	<i>Thysanotus patersonii</i>			
541.	1357	<i>Thysanotus thyrsoides</i>			
542.	25203	<i>Tiliqua occipitalis</i> (Western Bluetongue)			
543.	25549	<i>Todiramphus sanctus</i> (Sacred Kingfisher)			
544.	6280	<i>Trachymene pilosa</i> (Native Parsnip)			
545.	1481	<i>Tribonanthes australis</i>			
546.	1483	<i>Tribonanthes longipetala</i>			
547.	4383	<i>Tribulus terrestris</i> (Caltrop)	Y		
548.	1361	<i>Tricoryne elatior</i> (Yellow Autumn Lily)			
549.	17763	<i>Trifolium campestre</i> var. <i>campestre</i> (Hop Clover)	Y		
550.	4295	<i>Trifolium dubium</i> (Suckling Clover)	Y		
551.	4313	<i>Trifolium subterraneum</i> (Subterranean Clover)	Y		
552.	19039	<i>Triglochin bulbosa</i>	Y		
553.	148	<i>Triglochin muelleri</i>			
554.	1139	<i>Trithuria bibracteata</i>			
555.	1141	<i>Trithuria submersa</i>			
556.	708	<i>Triticum aestivum</i> (Wheat)	Y		
557.	33418	<i>Trymalium odoratissimum</i> subsp. <i>odoratissimum</i>			
558.	24852	<i>Tyto alba</i> subsp. <i>delicatula</i> (Barn Owl)			
559.	8255	<i>Ursinia anthemoides</i> (Ursinia)	Y		
560.	38388	<i>Ursinia anthemoides</i> subsp. <i>anthemoides</i>	Y		
561.	7131	<i>Utricularia dichotoma</i> (Fairly Aprons)			
562.	7138	<i>Utricularia inaequalis</i>			
563.	7148	<i>Utricularia multifida</i>			
564.	7153	<i>Utricularia tenella</i>			
565.	7157	<i>Utricularia violacea</i> (Violet Bladderwort)			
566.	34772	<i>Vachellia karroo</i>	Y		
567.	25526	<i>Varanus tristis</i> (Racehorse Monitor)			
568.	8257	<i>Vellereophyton dealbatum</i> (White Cudweed)	Y		
569.	15431	<i>Verticordia acerosa</i> var. <i>acerosa</i>			
570.	6076	<i>Verticordia densiflora</i> (Compacted Featherflower)			
571.	15432	<i>Verticordia densiflora</i> var. <i>densiflora</i>			
572.	6088	<i>Verticordia huegelii</i> (Variegated Featherflower)			
573.	15434	<i>Verticordia insignis</i> subsp. <i>insignis</i>			
574.	4322	<i>Vicia sativa</i> (Common Vetch)	Y		
575.	4325	<i>Viminaria juncea</i> (Swishbush)			
576.	17042	<i>Vitis vinifera</i>	Y		
577.	722	<i>Vulpia bromoides</i> (Squirrel Tail Fescue)	Y		
578.	724	<i>Vulpia myuros</i> (Rat's Tail Fescue)	Y		
579.	1567	<i>Watsonia meriana</i> (Bulbil Watsonia)	Y		
580.	18118	<i>Watsonia meriana</i> var. <i>meriana</i>	Y		
581.	12072	<i>Wurmbea dioica</i> subsp. <i>alba</i>			
582.	1253	<i>Xanthorrhoea gracilis</i> (Graceful Grass Tree)			
583.	1256	<i>Xanthorrhoea preissii</i> (Grass tree)			
584.	6284	<i>Xanthosia candida</i>			
585.	6285	<i>Xanthosia ciliata</i>			
586.	25765	<i>Zosterops lateralis</i> (Grey-breasted White-eye)			

Conservation Codes

T - Rare or likely to become extinct

Name	ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
X - Presumed extinct					
IA - Protected under international agreement					
S - Other specially protected fauna					
1 - Priority 1					
2 - Priority 2					
3 - Priority 3					
4 - Priority 4					
5 - Priority 5					

¹ For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX 7

DEC Threatened Fauna Database Searches

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRAN K	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Calyptrorhynchus latirostris	TFAUNA	20100	24734	Psittacidae	Calyptrorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo)	Animalia	T	BIRD	Ellenbrook				ELLENBROOK
Calyptrorhynchus latirostris	BIRDATLAS2	5000733 794	24734	Psittacidae	Calyptrorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo)	Animalia	T	BIRD	Swan River, Walyunga NP	11	07	2003	UPPER SWAN
Calyptrorhynchus latirostris	TFAUNA	16765	24734	Psittacidae	Calyptrorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo)	Animalia	T	BIRD	Lexia Avenue, Upper Swan. Western side of Ellen Brook Nature Reserve	17	08	2009	UPPER SWAN
Macrotis lagotis	WAMSPECIMENS	M703 24168 //	24168	Thylacomyidae	Macrotis	lagotis			(Reid)	Bilby	Animalia	T	MAMMAL					UPPER SWAN
Pseudemydura umbrina	WAMSPECIMENS	R81206 25345 10/12/1980	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	LAID AT PERTH ZOO	10	12	1980	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95492 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95500 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R81203 25345 10/12/1980	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	EGG LAID AT PERTH ZOO	10	12	1980	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R114382 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK NATURE RESERVE				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95403 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLEN SWAMPS RESERVE				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95489 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95498 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R114380 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Hatched at Woodvale (Wildlife Reserve Centre), 25 November 1980. Died in captivity 8th July 1984.				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95495 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95493 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95491 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95487 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R81204 25345 05/12/1980	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	EGG LAID AT PERTH ZOO	05	12	1980	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95494 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95490 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R81205 25345 10/12/1980	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	EGG LAID AT PERTH ZOO	10	12	1980	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95502 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95497 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95496 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R114379 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Hatched 1983, Ellenbrook Nature Reserve.				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R95499 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	BRED IN CAPTIVITY AT PERTH ZOO				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R114378 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK NATURE RESERVE				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8848	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8836	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8841	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8859	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	4040	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Warbrook, crossing road in sub-swampy country between railway line and Great Northern Hwy.	01	07	1953	BULLSBROOK
Pseudemydura umbrina	TFAUNA	8835	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29347 25345 00/11/	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK OR WARBOOK RESERVE	11			BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29350 25345 11/08/1966	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	11	08	1966	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R21858 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	EX BULLSBROOK RESERVE				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29348 25345 00/00/1965	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE			1965	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29351 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	SEE REMARKS				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8838	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8846	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8857	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	TFAUNA	8844	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29344 25345 00/00/1967	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE			1967	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R21562 25345 00/08/1959	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK RD RESERVE, BULLSBROOK	08		1959	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R21560 25345 00/08/1959	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK RD RESERVE, BULLSBROOK	08		1959	BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R21859 25345 //	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	EX BULLSBROOK RESERVE				BULLSBROOK
Pseudemydura umbrina	WAMSPECIMENS	R29339 25345 27/01/1965	25345	Cheluidae	Pseudemydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK RESERVE	27	01	1965	BULLSBROOK

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRANR_K	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Pseudemadura umbrina	WAMSPECIMENS	R29346[25345]00/12/1966	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE		12	1966	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8830	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8837	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8833	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29320[25345]14/07/1965	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	14	07	1965	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29340[25345]02/06/1964	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WEST OF WARBROOK (TWIN SWAMPS) RESERVE	02	06	1964	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R11093[25345]00/00/1954	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK			1954	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29345[25345]02/09/1966	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	02	09	1966	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8856	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8852	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8834	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8864	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29349[25345]04/08/1966	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	04	08	1966	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8858	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8839	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8850	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8861	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8842	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29352[25345]00/10/1963	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK RESERVE	10		1963	BULLSBROOK
Pseudemadura umbrina	TFAUNA	11392	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Warbrook, between railway line and Great Northern Highway				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R13385[25345]00/10/1959	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK	10		1959	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8863	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8862	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8832	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8847	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8829	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8870	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Dam of NE-swamp at Twin Swamps NR				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8845	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R13386[25345]00/10/1959	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK	10		1959	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8854	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8851	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29366[25345]00/03/1967	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	03		1967	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R114381[25345]//	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve (ex.)				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R146998[25345]//	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	TWIN SWAMPS NATURE RESERVE				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R21559[25345]00/08/1959	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK RD RESERVE, BULLSBROOK	08		1959	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29342[25345]07/05/1964	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	07	05	1964	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R11092[25345]00/00/1954	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK			1954	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29338[25345]00/00/1967	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK RESERVE			1967	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8855	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8843	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8831	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29376[25345]14/10/1964	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	ELLENBROOK RESERVE	14	10	1964	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R29341[25345]00/00/1967	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE			1967	BULLSBROOK
Pseudemadura umbrina	TFAUNA	8840	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8853	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8849	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	TFAUNA	8860	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Twin Swamps Nature Reserve				BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R47843[25345]13/12/1974	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	TWIN SWAMPS WILDLIFE SANCTUARY	13	12	1974	BULLSBROOK
Pseudemadura umbrina	WAMSPECIMENS	R21561[25345]00/08/1959	25345	Cheilidae	Pseudemadura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK RD RESERVE, BULLSBROOK	08		1959	BULLSBROOK

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRANRAN K	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_COD E	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME	
Pseudeydura umbrina	WAMSPESICMENS	R29343 25345 07/05/1964	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE	07	05	1964	BULLSBROOK	
Pseudeydura umbrina	WAMSPESICMENS	R29337 25345 00/00/1967	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK (TWIN SWAMPS) RESERVE			1967	BULLSBROOK	
Pseudeydura umbrina	WAMSPESICMENS	R21563 25345 00/10/1959	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	WARBROOK RD RESERVE, BULLSBROOK		10	1959	BULLSBROOK	
Pseudeydura umbrina	WAMSPESICMENS	R12165 25345 00/00/1956	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	UPPER SWAN			1956	THE VINES	
Pseudeydura umbrina	WAMSPESICMENS	R39040 25345 00/09/1970	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	TWIN SWAMPS BULLSBROOK		09		1970	THE VINES
Pseudeydura umbrina	WAMSPESICMENS	R81201 25345 09/12/1980	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	TWIN SWAMPS NATURE RESERVE	09	12		1980	UPPER SWAN
Pseudeydura umbrina	TFAUNA	8811	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8793	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8807	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8805	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8800	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8823	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8822	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8816	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8814	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8818	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8799	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8817	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8795	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8828	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8820	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8802	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8819	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8789	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	4039	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Drain at side of a road in Upper Swan	30	08		1956	UPPER SWAN
Pseudeydura umbrina	TFAUNA	8796	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8794	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8797	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8821	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8787	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8827	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8788	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8804	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8810	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8798	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8806	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8809	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8825	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8808	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8790	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8815	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8826	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8791	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8812	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8803	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8801	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8869	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Midland Brick property, west of Ellen Brook NR. Near swamp gauge 3.					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8824	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN
Pseudeydura umbrina	TFAUNA	8792	25345	Chekildae	Pseudeydura	umbrina			Siebenrock	Western Swamp Turtle, tortoise	Animalia	T	REPTILE	Ellen Brook Nature Reserve					UPPER SWAN

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRAN K	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Morelia spilota subsp. imbricata	TFAUNA	12085	25240	Boidae	Morelia	spilota	subsp.	imbricata	(Smith)	Carpet Python	Animalia	5	REPTILE	Walunga National Park	24	10		WALYUNGA NATIONAL PARK
Merops ornatus	BIRDATLAS2	186794 329	24598	Meropidae	Merops	ornatus			Latham	Rainbow Bee-eater	Animalia	1A	BIRD	Bells Rapids, Walunga NP	07	02	2001	BRIGADOON
Merops ornatus	BIRDATLAS2	155804 329	24598	Meropidae	Merops	ornatus			Latham	Rainbow Bee-eater	Animalia	1A	BIRD	Swan River, Walunga NP	16	01	2000	UPPER SWAN
Merops ornatus	BIRDATLAS2	203047 329	24598	Meropidae	Merops	ornatus			Latham	Rainbow Bee-eater	Animalia	1A	BIRD	Ellenbrook Nature Reserve, Upper Swan	27	07	2001	UPPER SWAN
Plegadis falcinellus	BIRDATLAS2	157075 178	24843	Threskiornithidae	Plegadis	falcinellus			(Linnaeus)	Glossy Ibis	Animalia	1A	BIRD	Ellen Brook, Millhouse Road, Belhus				BELHUS
Galaxiella nigrostriata	TFAUNA	7288	34027	Galaxiidae	Galaxiella	nigrostriata				Black-stripe Minnow	Animalia	3	FISH	Nature Reserve 46919 South of Maralla Rd Ellenbrook.				ELLENBROOK
Neelaps calonotos	TFAUNA	14715	25249	Elapidae	Neelaps	calonotos			[A.M.C. DumDril, Bilbron & A. DumDril]	Black-striped Snake	Animalia	3	REPTILE	Ellenbrook	08	03	2000	ELLENBROOK
Neelaps calonotos	WAMSPICIMENS	R141144 25249 08/03/2000	25249	Elapidae	Neelaps	calonotos			[A.M.C. DumDril, Bilbron & A. DumDril]	Black-striped Snake	Animalia	3	REPTILE	ELLENBROOK				ELLENBROOK
Neelaps calonotos	TFAUNA	15120	25249	Elapidae	Neelaps	calonotos			[A.M.C. DumDril, Bilbron & A. DumDril]	Black-striped Snake	Animalia	3	REPTILE	Ellenbrook				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9185	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9185	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9189	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9200	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9204	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9208	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9197	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9194	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9206	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9198	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9182	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9184	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9207	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9190	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9193	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9202	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9192	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9205	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9212	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9188	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9196	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9211	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9201	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9209	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9186	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9181	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9183	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9191	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9210	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9199	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9195	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	9203	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Ellen Brook Reserve, Maralla Rd bushland				ELLENBROOK
Isodon obesulus subsp. fusciventer	TFAUNA	10408	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Walunga NP, north of Walunga Rd (Site J)				WALYUNGA NATIONAL PARK
Isodon obesulus subsp. fusciventer	FAUNASURVEY	342529	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	NorthWestWetland	05	09	2011	AVELEY
Isodon obesulus subsp. fusciventer	FAUNASURVEY	342539	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	NorthWestWetland	06	09	2011	AVELEY
Isodon obesulus subsp. fusciventer	TFAUNA	8157	24153	Peramelidae	Isodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Great Northern Hwy, beside Ellen Brook Nature Reserve	18	05	2004	UPPER SWAN
Macropus eugenii subsp. derbianus	TFAUNA	12558	24131	Macropodidae	Macropus	eugenii	subsp.	derbianus	(Gray)	Tammar Wallaby (WA subsp.)	Animalia	5	MAMMAL	Walunga National Park	24	01	2007	WALYUNGA NATIONAL PARK
Macropus eugenii subsp. derbianus	TFAUNA	12655	24131	Macropodidae	Macropus	eugenii	subsp.	derbianus	(Gray)	Tammar Wallaby (WA subsp.)	Animalia	5	MAMMAL	Walunga National Park				WALYUNGA NATIONAL PARK

APPENDIX 8

Aboriginal Heritage Inquiry System Reports



Search Criteria

1 sites in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6484678	406894
6487877	408152



Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

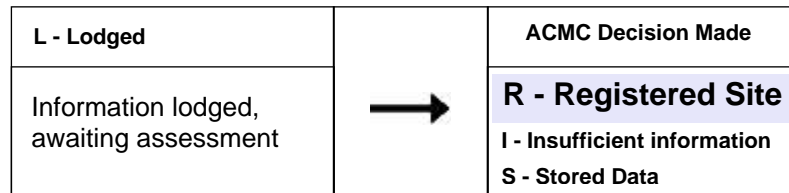
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Legend

Restriction	Access	Coordinate Accuracy
N No restriction	C Closed	Accuracy is shown as a code in brackets following the site coordinates.
M Male access only	O Open	[Reliable] The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.
F Female access	V Vulnerable	[Unreliable] The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status



Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting / Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

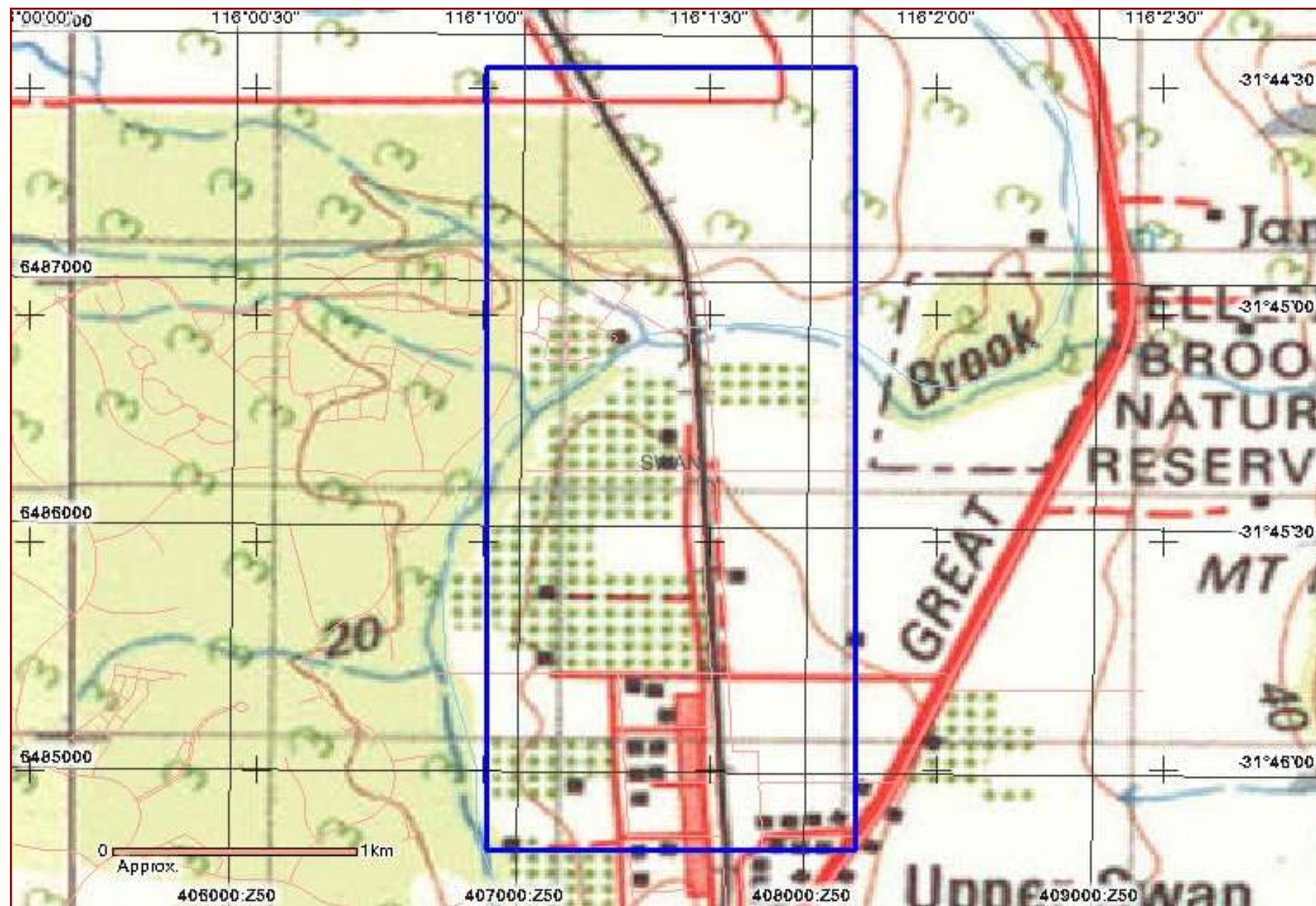
Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels



List of Registered Aboriginal Sites with Map

No results



Legend

Selected Heritage Sites

- Registered Sites
- Town
- Map Area
- Search Area

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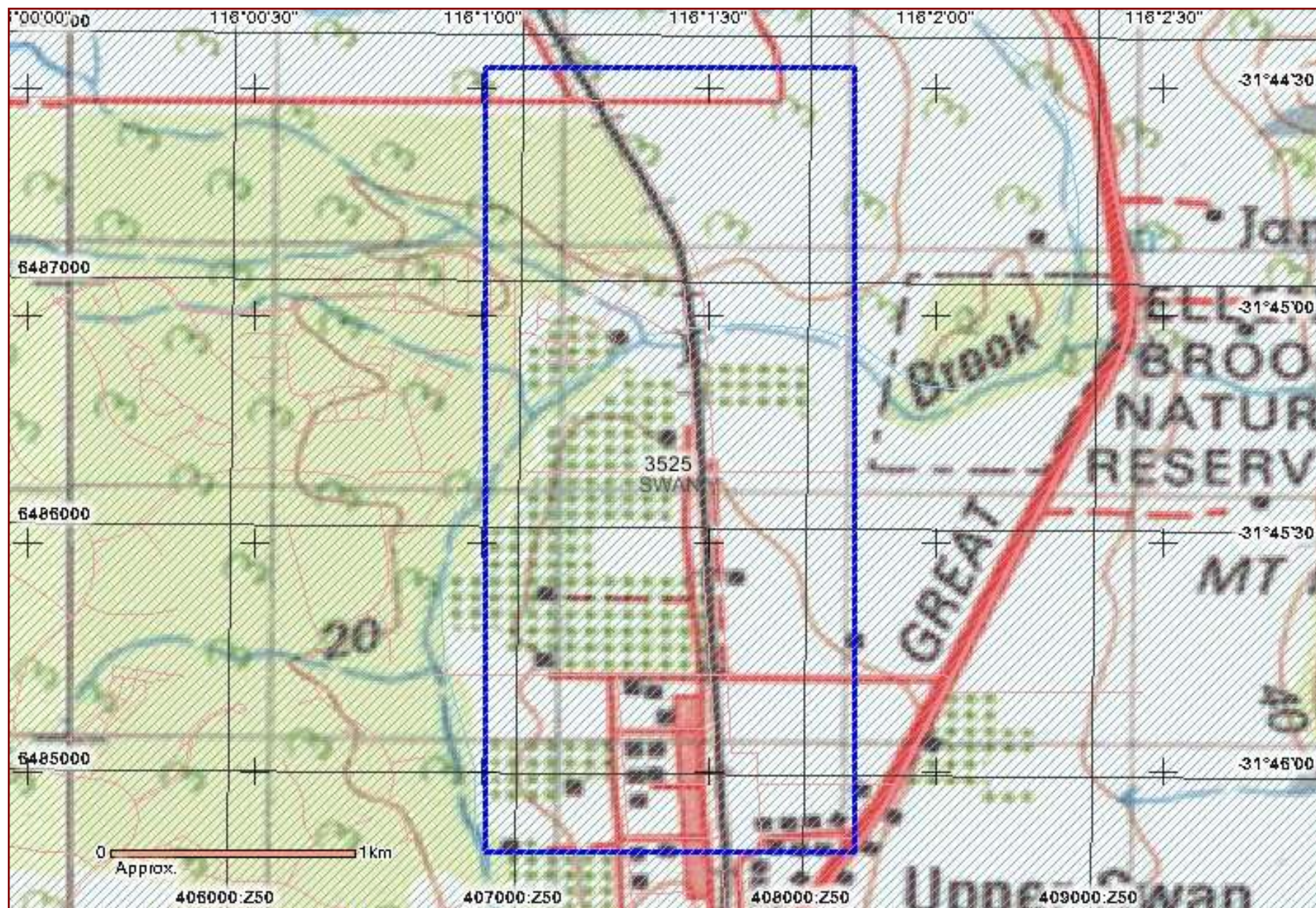
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List of 1 Other Heritage Places with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3525	I	C	N	Ellen Brook: Upper Swan	Mythological		*Registered Informant names available from DIA.	Not available for closed sites	S02516



Legend

Selected Heritage Sites

- Other Heritage Places
- Town
- Map Area
- Search Area

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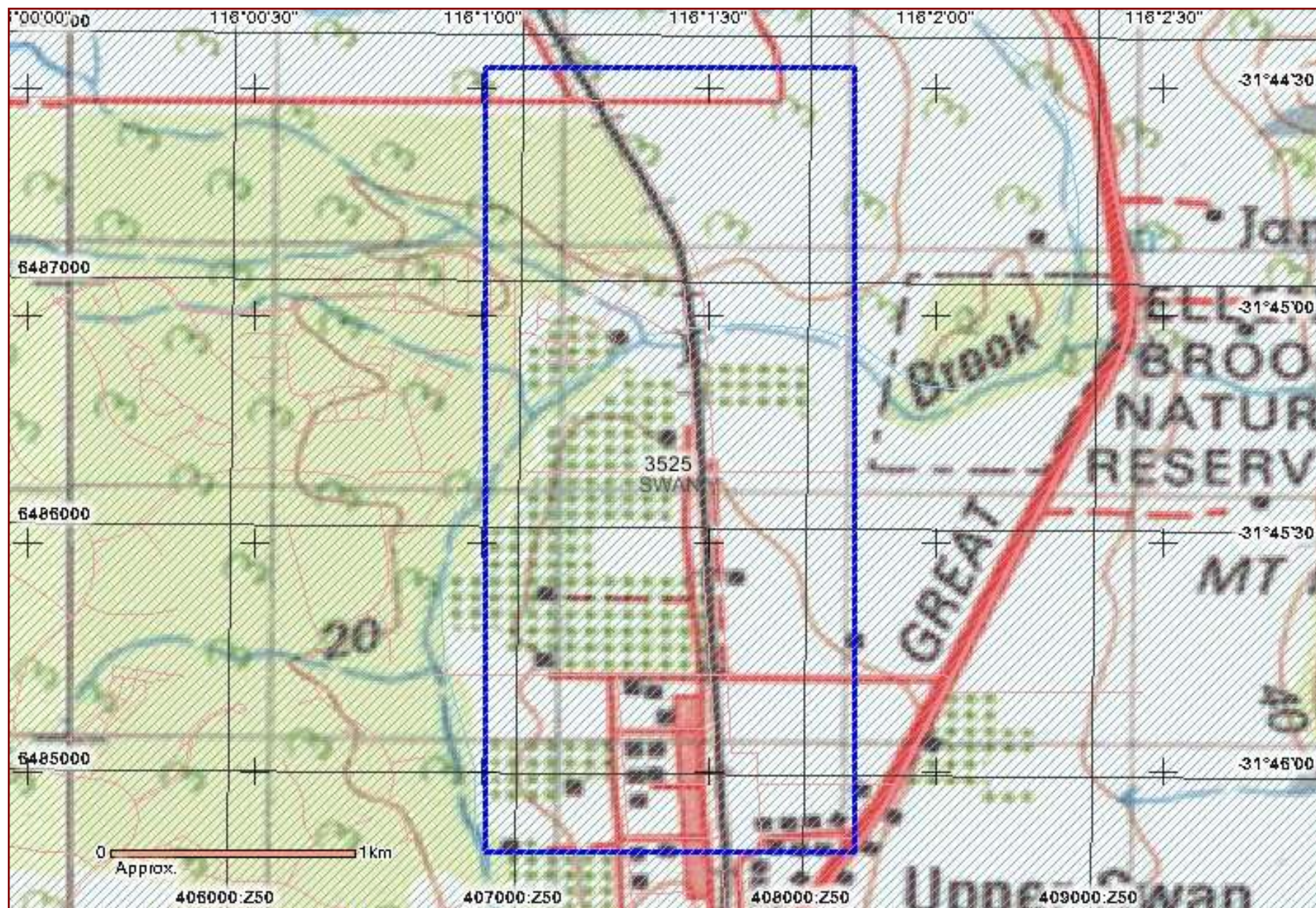
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Map Showing Registered Aboriginal Sites and Other Heritage Places



Legend

Selected Heritage Sites

- Registered Sites
- Other Heritage Places
- Town
- Map Area
- Search Area

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Search Criteria

12 surveys in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6484727	406894
6487876	408122

Disclaimer

Heritage Surveys have been mapped using information from the reports and / or other relevant data sources. Heritage Surveys consisting of small discrete areas may not be visible except at large scales. Reports shown may not be held at DIA. Please consult report holder for more information. Refer to www.dia.wa.gov.au/heritage for information on requesting reports held by DIA.

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Legend

Access

Some reports are restricted. The type of restriction is shown as a code in brackets following the catalogue number. No code indicates an unrestricted report.

[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending



Survey 3771

Project Gngangara Mound Groundwater, Metropolitan / Wheatbelt.
Start Date 17 Jun 2005
Proponents Department of Environment
Consultants Estill and Associates
Fisher Research Pty Ltd
Survey Types Ethnographic
Aboriginal People Consulted? Yes
Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
21909	HSR MW 2005 EST	Study of groundwater - related Aboriginal Cultural Values on the Gngangara Mound, Western Australia.	Bryn Coldrick Edward McDonald Linda Villiers Stuart Fisher Morgan Morris	Department of Indigenous Affairs

Survey 3016

Project Lot 4 Railway Parade, Upper Swan.
Start Date 11 Feb 2004
Proponents Western Retirement Village Management Pty Ltd
Consultants Australian Interaction Consultants
Survey Types Archaeological and Ethnographic
Aboriginal People Consulted? Yes



Survey 3016 (continued)

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
21071	HSR MW 2004 AUS	Archaeological and Ethnographic Consultation under the Aboriginal Heritage Act (1972) and European Heritage Assessment Under the Heritage Act 1990 of Lot 4 Railway Parade, Upper Swan, Western Australia Proposed for Residential Development	Donald Lantzke Irene Sauman Jeremy Mailing Ronald T. Parker Susan Parker	DIA

Survey 2662

Project Great Northern Highway, Lennard St. to Shire Boundary 6.34SLK - 33.52 SLK

Start Date 01 Aug 1997

Proponents Alan Tingay and Associates
Main Roads Western Australia

Consultants Collard & Collard Consultants
McDonald, Hales and Associates Pty Ltd

Survey Types Archaeological and Ethnographic

Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
20649	HSR MW 1998 MCD	Report of the Archaeological and Ethnographic Survey along Great Northern Highway Lennard St. to Shire Boundary 6.34 SLK-33.52SLK	E. McDonald Genevieve Clune Paul Raaff R. G. Locke	DIA



Survey 3737

Project Ballaruk, (Traditional Owners of Whadjuk territory) Site Recording Project
Start Date 01 Jan 1994
Proponents Heritage Council of Western Australia
Consultants Tamora Pty Ltd
Survey Types Ethnographic
Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
21817	HSR MW 1994 MAC	Ballaruk (traditional owners) Aboriginal site recording project	Barrie Machin	Department of Indigenous Affairs
21818	HSR MW 1995 MAC	Ballaruk (traditional owners of Whadjuk territorial boundaries the lands of the Ballaruk Peoples) Aboriginal site recording project : additional material	Barrie Machin	

Survey 2424

Project The Mews, Sanwa Vines Resort.
Start Date 01 Aug 1991
Proponents SANWA Vines Pty Ltd
Consultants McDonald, Hales and Associates Pty Ltd
Survey Types Archaeological and Ethnographic
Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
104388	HSR MW 1991 MCD [OWE]	A report of an archaeological and ethnographic survey for Aboriginal sites, The Mews, Sanwa Vines Resort	A. Murphy E. McDonald	DIA



Survey 2425

Project Ellenbrook Estate.
Start Date 01 Apr 1991
Proponents Department of Aboriginal Sites, Western Australian Museum
Consultants McDonald, Hales and Associates Pty Ltd
Survey Types Archaeological and Ethnographic
Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
102230	HSR MW 1991 MCD [OWE]	A summary of the research on Aboriginal sites on the Ellenbrook Estate and the Aboriginal consultative process	A. Murphy E. McDonald Jenny Smith	DIA

Survey 2368

Project Proposed Pipeline Crossing at Ellen Brook, Upper Swan.
Start Date 14 Apr 1989
Proponents McDonald, Hales and Associates Pty Ltd
Water Authority of Western Australia
Consultants University of Western Australia
Survey Types Archaeological
Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103370	HSR MW 1989 VET	Report of the archaeological survey of a proposed pipeline crossing at Ellen Brook, Upper Swan, Western Australia	Peter Veth	DIA



Survey 2305

Project Middle and Upper Swan Valley near Perth.

Start Date 01 Jan 1989

Proponents Australian National University

Consultants John Chappell

Survey Types Archaeological

Aboriginal People Consulted? No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
101808	HSR MW 1989 CHA	Late quaternary history of the middle and upper Swan Valley near Perth, Western Australia	John Chappell Gary Quartermaine S. Kee	DIA

Survey 2308

Project Upper Swan Bridge

Start Date 01 Jan 1987

Proponents Australian Heritage Commission

Consultants Department of Aboriginal Sites, Western Australian Museum

Survey Types Archaeological

Aboriginal People Consulted? Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103214	HSR MW 1988 WAL	Upper Swan Bridge S.0999 : Report of stabilization project	J. Wallam	DIA



Survey 2254

Project Wetland areas in the Perth metropolitan region.

Start Date 01 Jan 1986

Proponents N/A

Consultants University of Western Australia

Survey Types Archaeological

Aboriginal People Consulted? No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103891	HSR MW 1986 LEW	Aboriginal archaeological sites of the wetland areas in the Perth metropolitan region	Gareth Lewis	DIA

Survey 2229

Project Heritage Sites, Brigadoon Country Estate.

Start Date 01 Jan 1984

Proponents T.S Martin and Associates

Consultants K.-H. Wyrwoll

Survey Types Archaeological

Aboriginal People Consulted? No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103209	HSR MW 1984 WYR	Geomorphology and quaternary geology of the 'Brigadoon Country Estate' area	K.-H. Wyrwoll	DIA

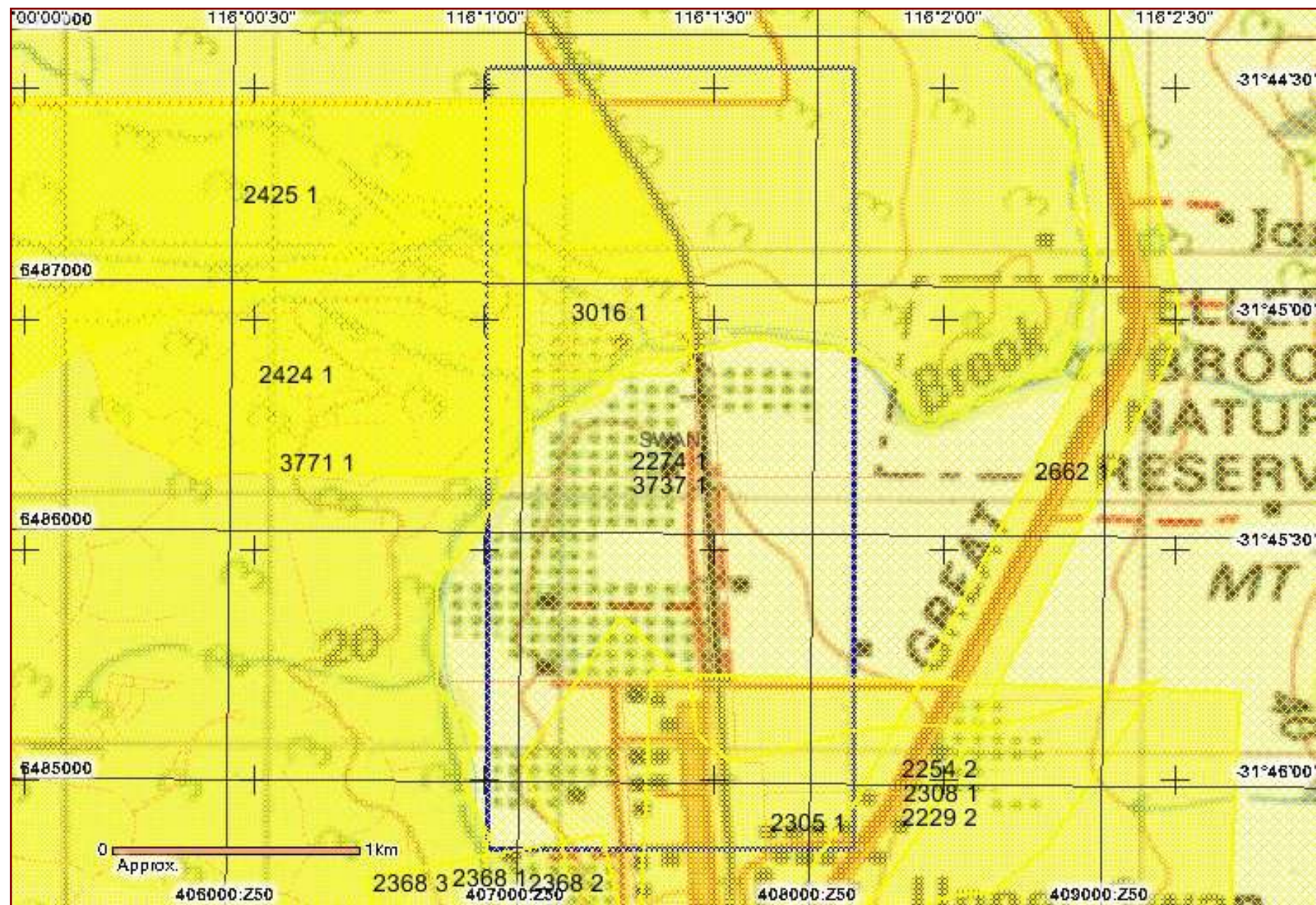


Survey 2274

Project The Perth Area.
Start Date 01 Apr 1970
Proponents University of Western Australia
Consultants University of Western Australia
Survey Types Archaeological and Archaeological and Ethnographic
Aboriginal People Consulted? No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103564	HSR MW 1972 UWA	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	University of Western Australia H. Polach	DIA
104023	Not in Catalogue	An Archaeological Survey Project. The Perth Arch. Area. Western Australia Report no.4 April 1971.	University of Western Australia H. Polach	DIA



Legend

Selected Heritage Surveys

- Heritage Survey
- Town
- Map Area
- Search Area

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APPENDIX C

FLORA AND VEGETATION SURVEY

PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

FLORA AND VEGETATION SURVEY

Prepared for: City of Swan
Report Date: 5 February 2014
Version: V1
Report No. 2014-137



pgv ENVIRONMENTAL

Contents

Contents	i
List of Attachments	ii
1. INTRODUCTION	1
1.1 Purpose.....	1
1.2 Scope of Works.....	1
2. EXISTING ENVIRONMENT	2
2.1 Land Use	2
2.2 Topography	2
2.3 Geology and Soils	2
2.4 Hydrology	2
2.5 Wetlands	2
3. FLORA AND VEGETATION	3
3.1 Methodology	3
3.2 Desktop Searches	3
3.3 Survey Conditions.....	6
3.4 Results	7
3.4.1 Flora.....	7
3.4.2 Vegetation	8
3.4.3 Vegetation Condition	11
3.4.4 Conservation Significance of Flora and Vegetation.....	11
4. CONCLUSIONS AND SUMMARY.....	13
5. REFERENCES	14

List of Attachments

Tables

Table 1:	List of Flora Species Identified from DPaW Database Searches within 5km of the site
Table 2:	Likelihood of Identified Significant Flora Species occurring on the Site
Table 3:	Threatened and Priority Ecological Communities Identified in Database Searches within 5km of the Site
Table 4:	Statement of Botanical Survey Conditions
Table 5:	Vegetation Condition Rating Scale

Plates

Plate 1:	Dense stands of Watsonia in the Apple Street road reserve
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Figures

Figure 1:	Site Location
Figure 2:	Vegetation Associations
Figure 3:	Vegetation Condition

Appendices

Appendix 1:	DPaW Flora Database Searches
Appendix 2:	NatureMap Report
Appendix 3:	Protected Matters Search Tool Report
Appendix 4:	Definitions of Conservation Codes
Appendix 5:	DPaW TEC and PEC Database Search
Appendix 6:	Species List
Appendix 7:	Releve Data

1. INTRODUCTION

1.1 Purpose

The City of Swan is proposing to upgrade the eastern road access to the expanding suburbs of The Vines, Ellenbrook and Aveley. The upgrade will require widening of Apple Street and Railway Parade within existing road reserves and the construction of a new traffic bridge over Ellen Brook.

The road widening will require clearing of native vegetation within existing road reserves. A level 1 flora and vegetation survey undertaken by PGV Environmental in 2013 as part of the Environmental Assessment of the road upgrade proposal (PGV Environmental, 2013) described the vegetation as mostly being in degraded condition due to an abundance of weeds. However, the survey identified the potential for conservation significant flora species or ecological communities to occur in the existing road reserve.

PGV Environmental was commissioned by the City of Swan to undertake a Level 2 Spring Flora and Vegetation Survey of the Apple Street and Railway Parade road reserves from the Great Northern Highway to Maralla Road (the site) (Figure 1).

1.2 Scope of Works

The Level 2 Spring Flora and Vegetation survey was undertaken in accordance with Guidance Statement 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004) and included the following:

- Desktop search and review of DPaW's Declared Rare and Priority Flora database and Threatened Ecological Communities database;
- Examination of recent aerial photography and contour maps to provisionally identify vegetation types and condition;
- Field survey in spring using quadrats or relevés to record native and introduced species as well as a thorough site walkover of any areas of native vegetation;
- Recording of any significant plant species using a hand-held GPS;
- Description and mapping of vegetation types and vegetation condition; and
- Compilation of a flora list.

The survey included the vegetated road reserve both sides of Apple Street and Railway Parade from the Great Northern Highway to Maralla Road, a distance of approximately 3.2km.

2. EXISTING ENVIRONMENT

2.1 Land Use

The site is all unused vegetated road reserve. An open drain occurs on both sides of Apple Street.

2.2 Topography

The site is flat except in the vicinity of Ellen Brook where it is very gently undulating north and south of the Brook. Elevations range from approximately 18 to 22m AHD (DoW, 2012). There is a small depression to the north of Ellen Brook with an elevation of approximately 15mAHD. The creek bed of Ellen Brook is at 12mAHD.

2.3 Geology and Soils

The site is located on the eastern side of the Swan Coastal Plain, predominately on the Pinjarra System. The Pinjarra system consists of poorly drained coastal plain with variable alluvial and aeolian soils.

The north of the site is mapped in the Yanga System which is described as poorly drained plain with pale sands and deep sandy duplex, wet, semi-wet and saline wet soils (Churchward and McArthur, 1978).

2.4 Hydrology

The depth to groundwater over the site varies with the topography from approximately 3.5m near the Ellen Brook to about 7m to the south and 4m in the north of the site (DoW, 2012b). Groundwater is at approximately 11.5 to 20mAHD.

Groundwater generally flows towards Ellen Brook (DoW, 2012b).

A section of Ellen Brook runs east to west through the middle portion of Railway Parade. Surface water in the vicinity of the Brook generally drains towards Ellen Brook. The southern part of the site contains heavy soils that collect surface water from road run-off. Open drains on Apple Street direct the water away from the site.

The northern end of Railway Parade north of Ellen Brook and associated wetlands is generally sandy and free-draining with run-off from the road soaking into the sands.

2.5 Wetlands

Three Resource Enhancement and Multiple Use Wetlands occur on the site.

A Multiple Use Palusplain (UFI 15282) occurs to the south of Ellen Brook. Immediately to the north of Ellen Brook is a Multiple Use Palusplain that extends north and is located on the site near Maralla Avenue (UFI 15732). A Palusplain is defined as a seasonally waterlogged flat (Semeniuk, 1987).

A Resource Enhancement Palusplain (UFI 15733) occurs to the north of Ellen Brook and adjacent to the western side of the rail reserve.

3. FLORA AND VEGETATION

3.1 Methodology

A flora and vegetation survey of the site was conducted by Dr Paul van der Moezel on 27 September 2013. The survey included sampling from 8 relevés. Relevés were used as the road reserves either side of the central road pavement were too narrow to survey using the more standard 10m x 10m quadrats. The relevés varied in size depending but were generally around 20m long and 5m wide. Site coverage was very high due to the ease of access through the open understorey and the narrow dimensions of the site.

3.2 Desktop Searches

A search of the Department of Parks and Wildlife's (DPaW's) Threatened Flora Database, the WA Herbarium database and the Declared Rare and Priority Flora Species List (Appendix 1) identified nine Threatened and 26 Priority plant species that have been located in the vicinity of the site (Table 1). The Naturemap database search had no additional species (DPaW, 2012a; Appendix 2)

The nine Threatened species under the *Wildlife Conservation Act 1950* are also listed under the EPBC Act. Nine additional Endangered species were identified by the EPBC Act Protected Matters Search Tool (SEWPaC, 2012a) (Appendix 3).

Table 1: List of Flora Species Identified from Database Searches within 5km of the Site.

Species	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
<i>Acacia anomala</i>	Grass Wattle, Chittering Grass Wattle	Threatened	Vulnerable
<i>Andersonia gracilis</i>	Slender Andersonia	Threatened	Endangered
<i>Caladenia huegelii</i>	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	Threatened	Endangered
<i>Centrolepis caespitosa</i>		Priority 4	Endangered
<i>Darwinia foetida</i>	Muchea Bell	Threatened	Critically Endangered
<i>Drakaea elastica</i>	Glossy-leaved Hammer-orchid	Threatened	Endangered
<i>Eleocharis keigheryi</i>	Keighery's Eleocharis	Threatened	Vulnerable
<i>Eucalyptus balanites</i>	Cadda Road Mallee	Threatened	Endangered
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	Split-leafed Grevillea	Threatened	Endangered
<i>Grevillea christineae</i>	Christine's Grevillea	Threatened	Endangered
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	Curved-leaf Grevillea	Threatened	Endangered
<i>Grevillea curviloba</i> subsp. <i>incurva</i>	Narrow curved-leaf Grevillea	Threatened	Endangered
<i>Lepidosperma rostratum</i>	Beaked Lepidosperma	Threatened	Endangered
<i>Thelymitra dedmaniarum</i> (<i>Thelymitra manginii</i>)	Cinnamon Sun Orchid	Threatened	Endangered
<i>Thelymitra stellata</i>	Star-sun Orchid	Threatened	Endangered
<i>Trithuria occidentalis</i> (<i>Hydatella dioica</i>)	Swan Hydatella	Threatened	Endangered

Species	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	Narrow-petalled Feather-flower	Threatened	Endangered
<i>Ornduffia calthifolia</i> (<i>Villarsia calthifolia</i>)	Mountain Villarsia	Threatened	Endangered
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)		Priority 2	
<i>Stenanthemum sublineare</i>		Priority 2	
<i>Stylidium aceratum</i>	Wongan Hills Triggerplant	Priority 2	
<i>Stylidium squamellosum</i>	Maze Triggerplant	Priority 2	
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	Woolly-bush	Priority 3	
<i>Chamaescilla gibsonii</i>	Blue Stars	Priority 3	
<i>Cyathochaeta teretifolia</i>		Priority 3	
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	Blue Devils	Priority 3	
<i>Guichenotia tuberculata</i>		Priority 3	
<i>Haemodorum loratum</i>		Priority 3	
<i>Halgania corymbosa</i>		Priority 3	
<i>Meionectes tenuifolia</i>		Priority 3	
<i>Platysace ramosissima</i>		Priority 3	
<i>Schoenus capillifolius</i>		Priority 3	
<i>Schoenus</i> sp. Waroona (G.J. Keighery 12235)		Priority 3	
<i>Stylidium asteroideum</i>	Star Triggerplant	Priority 3	
<i>Stylidium longitubum</i>	Jumping Jacks	Priority 3	
<i>Stylidium trudgenii</i>		Priority 3	
<i>Tetradlea pilifera</i>	Lilac Bells	Priority 3	
<i>Cyanicula ixioides</i> subsp. <i>ixioides</i>	Yellow China Orchid	Priority 4	
<i>Darwinia pimelioides</i>	Sunset Bell	Priority 4	
<i>Hydrocotyle lemnoides</i>	Aquatic Pennywort	Priority 4	
<i>Oxymyrrhine coronata</i>		Priority 4	
<i>Persoonia sulcata</i>	Snottygobble	Priority 4	
<i>Schoenus natans</i>	Floating Bog-rush	Priority 4	
<i>Tripterococcus paniculatus</i>		Priority 4	

A list of the definitions of the Conservation Codes is in Appendix 4.

The likelihood of each species occurring on the site is discussed in Table 2.

Table 2: Likelihood of Identified Significant Flora Species occurring on the Site

Species	Preferred Habitat*	Likelihood of presence on site
<i>Acacia anomala</i>	Lateritic soils. Slopes	Unlikely
<i>Andersonia gracilis</i>	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Possible
<i>Caladenia huegelii</i>	Grey or brown sand, clay loam	Unlikely
<i>Centolepis caespitosa</i>	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Possible
<i>Darwinia foetida</i>	Grey-white sand on swampy, seasonally wet sites and on winter-damp to wet clay	Unlikely

Species	Preferred Habitat*	Likelihood of presence on site
<i>Drakaea elastica</i>	White or grey sand. Low-lying situations adjoining winter-wet swamps	Possible
<i>Eleocharis keigheryi</i>	Clay, sandy loam. Emergent in freshwater: creeks, claypans	Possible
<i>Eucalyptus balanites</i>	Sandy soils with lateritic gravel.	Unlikely
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	Peaty sand, clay.	Possible
<i>Grevillea christineae</i>	Clay loam, sandy clay, often moist	Possible
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	Grey sand. Winter-wet heath	Possible
<i>Grevillea curviloba</i> subsp. <i>incurva</i>	Sand, sandy loam. Winter-wet heath	Possible
<i>Lepidosperma rostratum</i>	Peaty sand, clay	Possible
<i>Thelymitra dedmaniarum</i> (<i>Thelymitra manginii</i>)	Granite	Unlikely
<i>Thelymitra stellata</i>	Sand, gravel, lateritic loam	Unlikely
<i>Trithuria occidentalis</i> (<i>Hydatella dioica</i>)	Muddy (inundated) areas	Possible
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	Clay, sandy loam. Seasonally inundated swamps, road verges.	Possible
<i>Ornduffia calthifolia</i> (<i>Villarsia calthifolia</i>)	+ Restricted to the Porongurup Range where it is found in moist sheltered positions on the upper slopes of granite outcrops	Highly Unlikely
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)	Grey peaty sand. Low-lying flats	Possible
<i>Stenanthemum sublineare</i>	Littered white sand. Coastal plain	Possible
<i>Stylidium aceratum</i>	Sandy soils. Swamp heathland.	Possible
<i>Stylidium squamellosum</i>	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.	Unlikely
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	Grey sand, lateritic gravel	Unlikely
<i>Chamaescilla gibsonii</i>	Clay to sandy clay. Winter-wet flats, shallow water-filled claypans	Possible
<i>Cyathochaeta teretifolia</i>	Grey sand, sandy clay. Swamps, creek	Possible
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	Clay, sandy clay. Claypans, seasonally wet flats.	Possible
<i>Guichenotia tuberculata</i>	Sand clay over laterite, sand	Unlikely
<i>Haemodorum loratum</i>	Grey or yellow sand, gravel	Unlikely
<i>Halganina corymbosa</i>	Gravelly soils, soils over granite	Unlikely
<i>Meionectes tenuifolia</i>	Aquatic species	Possible
<i>Platysace ramosissima</i>	Sandy soils	Possible
<i>Schoenus capillifolius</i>	Brown mud. Claypans	Possible
<i>Schoenus</i> sp. Waroona (G.J. Keighery 12235)	Clay or sandy clay. Winter-wet flats.	Possible
<i>Stylidium asteroideum</i>	Gravelly soils	Unlikely
<i>Stylidium longitubum</i>	Sandy clay, clay. Seasonal wetlands.	Possible
<i>Stylidium trudgenii</i>	Grey sand, dark grey to black sandy peat. Margins of winter-wet swamps, depressions	Possible
<i>Tetratheca pilifera</i>	Gravelly soils	Unlikely
<i>Cyanicula ixioides</i> subsp. <i>ixioides</i>	Laterite, gravel	Unlikely

Species	Preferred Habitat*	Likelihood of presence on site
<i>Darwinia pimelioides</i>	Loam, sandy loam. Granite outcrops	Unlikely
<i>Hydrocotyle lemnoides</i>	Swamps	Possible
<i>Oxymyrrhine coronata</i>	Lateritic habitats on the Darling Range	Unlikely
<i>Persoonia sulcata</i>	Lateritic or granitic soils	Unlikely
<i>Schoenus natans</i>	Winter-wet depressions	Possible
<i>Tripterococcus paniculatus</i>	Grey, black or peaty sand. Winter-wet flats.	Possible

* sourced from Florabase (DPaW, 2014), DoE SPRAT Database (DoE, 2014), + Gilfillan and Barrett, 2004,

A search of DPaW's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted for the site (Appendix 5; 51-1012EC). There are no known occurrences of any TECs or PECs on the site. Six TECs and four PECs have been recorded in the vicinity of the site (Table 3). The EPBC Act Protected Matters Search Tool database search also identified two of the TECs as being present within the area (Appendix 3).

Table 3: Threatened and Priority Ecological Communities Identified in Database Searches within 5km of the Site

Community Identification	Community Name	Status under Wildlife Cons. Act	Status under EPBC Act
Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Critically Endangered	Endangered
SCP3c	<i>Eucalyptus calophylla</i> - <i>Xanthorrhoea preissii</i> woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	Endangered
SCP08	Herb rich shrublands in clay pans (Part of 'Claypans of the Swan Coastal Plain')	Vulnerable	Critically Endangered
SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	
SCP18	Shrublands on calcareous silts of the Swan Coastal Plain	Vulnerable	
SCP21c	Low lying <i>Banksia attenuata</i> woodlands or shrublands	Priority 3	
SCP22	<i>Banksia ilicifolia</i> woodlands	Priority 3	
SCP23b	Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands	Priority 3	
SCP25	Southern <i>Eucalyptus gomphocephala</i> - <i>Agonis flexuosa</i> woodlands	Priority 3	

Conservation Codes are outlined in Appendix 4

3.3 Survey Conditions

The conditions that the survey was undertaken in are presented in Table 4 in order to assess the adequacy of the survey. In summary, there were no constraints to the survey.

Table 4: Statement of Botanical Survey Conditions

ISSUE	CONSTRAINTS (YES/NO); SIGNIFICANT, MODERATE OR NEGLIGIBLE	COMMENT
Competency/experience of the consultant conducting the survey	No constraints	Dr Paul van der Moezel has extensive survey experience on the Swan Coastal Plain.
Proportion of the flora identified	No constraints	The timing of the survey in late September should have identified most of the native species on the site.
Sources of information (historic/recent or new data)	No constraints	The flora of the Swan Coastal Plain is relatively well documented.
Proportion of the task achieved and further work that may need to be undertaken	No constraints	No follow-up survey required.
Timing/weather/season/cycle	No constraints	Generally slightly below average rainfall in winter 2013 but above average spring rainfall in the Perth Metropolitan Region. Late September survey ideal for identifying rare orchids and maximising flowering of most species.
Intensity of survey (e.g. In retrospect was the intensity adequate)	No constraints	The small size and open understorey made access and coverage easy. Approximately 5 hours spent on the site.
Completeness (e.g. was relevant area fully surveyed)	No constraints	
Resources (e.g. degree of expertise available for plant identification)	No constraints	Experienced botanist undertook plant identifications mostly on site with some identification off-site using standard reference material
Remoteness and/or access problems	No constraints	Easily accessible site traversed entirely on foot.
Availability of contextual (e.g. bioregional) information for the study area.	No constraints	Hedde et al. (1980), Government of Western Australia (2000), Gibson et al. (1994).

Fungi and nonvascular flora (e.g. algae, mosses and liverworts) were not specifically surveyed for during the survey.

3.4 Results

3.4.1 Flora

A total of 95 species were recorded during the September 2013 flora survey (Appendix 6). This total consisted of 48 native species and 47 introduced species (49%). It is difficult to compare the total number of native species recorded within long, narrow road reserves with the results of other

surveys of blocks of vegetation in the vicinity of the site. However, the total of 48 native species over 3.2km of road reserves is considered to be very low compared to intact road reserve vegetation over this length.

None of the native species recorded is a Threatened (Declared Rare) or Priority flora species.

The 49% of introduced species recorded is a very high percentage and reflects the overall degraded condition of most the vegetation. A large number of introduced grass species was recorded with a total of 14 species. *Watsonia* (*Watsonia bulbifera*) was particularly dense in many places where the soils were heavy and waterlogged (Plate 1 and Releve 5 – Appendix 7).

Plate 1: Dense stands of *Watsonia* in Apple Street Road Reserve.



3.4.2 Vegetation

Vegetation Complexes

Vegetation Complexes are a broad level of vegetation description which is based on the underlying geomorphology and rainfall (Hedde *et al.*, 1980). The vegetation on the site is part of three vegetation complexes as follows:

Yanga Complex – This complex occurs in the northern portion of the site between Ellen Brook and associated wetlands and Maralla Road. The Yanga Complex is described as “Predominantly a closed scrub of *Melaleuca* spp. and low open forest of *C. obesa* on the flats subject to inundation. On drier sites the vegetation reflects the adjacent vegetation complexes of Bassendean and Coonambidgee”. The latter part of the description fits the vegetation in the drier northern section of the site.

Guildford Complex – This complex occurs around Ellen Brook and associated wetlands. The Guildford Complex is described as “A mixture of open forest to tall open forest of *E. calophylla*-*E. marginata* and woodland of *E. wandoo* (with rare occurrences of *E. lane-poolei*). Minor components include *E. rudis* – *M. raphiophylla*”.

Swan Complex – This complex occurs south of Ellen Brook to the Great Northern Highway. The Swan Complex is described as “Fringing woodland of *E. rudis* – *M. raphiophylla* with localised occurrence of low open forest of *C. obesa* and *M. cuticularis*”.

Vegetation Associations

Vegetation Associations are a finer level of vegetation mapping than the Vegetation Complex and are defined by the composition and structure of the dominant vegetation.

Most of the site was completely cleared of native vegetation and contained a variety of introduced weed species. In the areas which contained native vegetation seven vegetation associations were mapped (Figure 3) and are described below.

- **CcAs** *Corymbia calophylla* (Marri) Low Open Woodland over *Acacia saligna* Closed Heath over *Watsonia bulbillifera* Closed Herbland

This vegetation association occurred in a short stretch of the site near the southern part of Railway Parade. The Marri trees are sparse and relatively young, around 6-7m high. The understorey in places contains numerous *Acacia saligna* plants 1.5-2m high over dense stands of *Watsonia* (*Watsonia bulbillifera*). Releve 1 is representative of this vegetation association.

- **Cc** *Corymbia calophylla* (Marri) Low Woodland over *Watsonia bulbillifera* Closed Herbland

This vegetation association is similar to the CcAs but lacks any *Acacia saligna* and occurs at the top of the bank of Ellen Brook on the southern side only. A carpet of *Watsonia* covers the ground beneath scattered 8m high Marri trees. Releve 4 is representative of this vegetation association.

- **Js** *Jacksonia sternbergiana* Tall Open Shrubland over *Grevillea crithmifolia*/*Xanthorrhoea preissii* Open Shrubland over weeds

This vegetation association occurs in two locations on Railway Parade south of Ellen Brook. The *Jacksonia sternbergiana* shrubs are sparse, 5-10% cover, and around 3m high over a mixture of native shrubs including *Grevillea crithmifolia*, *Xanthorrhoea preissii* and *Hakea prostrata*. The understorey contains abundant weeds such as *Watsonia*, Veldtgrass (*Ehrharta longiflora*), Blowfly Grass (*Briza maxima*), and Lovegrass (*Eragrostis curvula*). Relevés 2 and 3 are representative of this vegetation association.

- **Er** *Eucalyptus rudis* (Flooded Gum) Low Woodland over *Watsonia bulbillifera* Closed Herbland

The northern and southern slopes of Ellen Brook contain *Eucalyptus rudis* (Flooded Gum) 8-10m high over dense weed understorey containing *Watsonia* and Veldtgrass. The association continues north of the Brook for a distance of around 80m. Releve 5 is representative of this vegetation association.

- **ErMr** *Eucalyptus rudis*/*Melaleuca raphiophylla* Low Open Woodland over weeds

This vegetation association occurs in two locations including the banks of Ellen Brook and within the Resource Enhancement wetland north of the Brook. *Eucalyptus rudis* trees are up to 10m high over scattered *Melaleuca raphiophylla* (Paperbark) trees 4m high. The understorey contains very few native species but an abundance of weeds including Watsonia, Fumitory (*Fumaria capreolata*), Arum Lily (*Zantedeschia aethiopica*), Kikuyu (*Cenchrus clandestinum*), Veldtgrass and Wild Oats (*Avena fatua*). Releve 6 is representative of this vegetation association

- **Ba** *Banksia attenuata* Low Open Woodland over weeds

The soil type changes north of the Resource Enhancement wetland to be more sandy and dry. A small section of *Banksia attenuata* Low Open Woodland occurs on the eastern side of the road reserve. The area was burnt recently but the main species regeneration were clearly introduced species such as Veldtgrass, Rose Pelargonium (*Pelargonium capitatum*), Capeweed (*Arctotheca calendula*), *Brassica tournefortii* and Ryegrass (*Lolium perenne*). Some native species were common in the understorey including *Podotheca angustifolia* and *Desmocaldus flexuosus*. Releve 7 is representative of this vegetation association.

- **Nf** *Nuytsia floribunda* (WA Christmas Tree) Low Open Woodland over mixed shrubs and herbs

This vegetation association occurs in the sandy soils north of Ellen Brook on the western side of Railway Parade. This association contained the largest number and density of native species in the understorey. However, the high number of weeds still resulted in an overall Good condition rating. The Christmas Trees were sparse and up to 4-5m high. Common native species in the understorey included *Hypolaena exsulca*, *Haemodorum laxum*, *Patersonia occidentalis*, *Podotheca angustifolia* and *Conostylis aculeata*. Releve 8 is representative of this vegetation association.

The Completely Degraded vegetation dominated by weeds contained a mix of introduced species with the most dominant being Watsonia (*Watsonia bulbillifera*), Tambookie Grass (*Hyparrhenia hirta*), Lovegrass (*Eragrostis curvula*), Veldtgrass (*Ehrharta longiflora* and *E. calycina*), Wild Oats (*Avena fatua*) and Arum lily (*Zantedeschia aethiopica*) in the wetland soils north of Ellen Brook.

Floristic Community Types

Floristic Community Types (FCT) are based on the whole floristic composition of the vegetation rather than being determined by soil type and geomorphology (Vegetation Complex) or the nature of the dominant species (Vegetation Association). The FCT level of vegetation is required to identify whether any of the vegetation on the site is a Threatened or Priority Ecological Community.

Analysis of releve or quadrat data to determine FCTs either by computer analysis or other tabular means such as the species-Community type table 12 in Gibson *et al.* (1994) requires vegetation to be in very good condition or better. Analysis using vegetation in Degraded or Good condition such as occurs on the site is not possible to accurately determine the FCT.

A large number of seasonal wetland and upland FCTs are known to occur in the Upper Swan area (Government of Western Australia, 2000). Therefore, it is difficult to determine what FCT the various vegetation associations on the site would have represented had they been in better condition.

3.4.3 Vegetation Condition

The vegetation condition over the site was assessed using the condition scale adopted in Bush Forever (Table 5). The vegetation condition over the site ranged from Completely Degraded for the areas cleared of native vegetation and those predominantly containing weeds in the understorey to Degraded for the areas containing some remnant native species in the southern road reserve (Figure 3). Only one small section of road reserve in the north of the site contained vegetation considered to be in Good condition. Good condition vegetation describes vegetation that has been significantly altered.

Table 5: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

3.4.4 Conservation Significance of Flora and Vegetation

Flora

None of the plant species recorded is a Threatened (Declared Rare) flora or listed as significant in Bush Forever.

Vegetation

The vegetation is part of the Yanga, Guildford and Swan vegetation complexes.

The State Government's Bush Forever process aimed to protect areas of regionally significant vegetation on the Swan Coastal Plain in the Perth Metropolitan Region. Bush Forever adopted one of the key commitments in the *Urban Bushland Strategy* (Government of Western Australia, 1995) which was to protect (rather than retain) at least 10% or 400ha, whichever is the largest, of each vegetation complex in at least five separate areas.

The percentage of each vegetation complex remaining in the System 6/Part System 1 part of the Swan Coastal Plain in 2002 (EPA, 2006) is listed below:

Yanga Complex - 18.7% remaining, 1% in secure reserves

Guildford Complex - 5% remaining, 0.1% in secure reserves

Swan Complex - 15.6% remaining, 0% in secure reserves

The Bush Forever process would have increased the percentage of each vegetation complex in secure reserves, however the percentages are still likely to be well under the 10% target. As a result, any vegetation from these vegetation complexes in good condition or better, and of a size that can be managed as a nature reserve would be a priority for protection. The vegetation on the site, however, is nearly all either Completely Degraded or Degraded and is not of sufficient quality to have conservation significance. The small area of Good quality vegetation in the northern part of the site is too small (about 200m long and 5m wide) and surrounded by cleared or poor quality vegetation to be of conservation value.

Ellen Brook has been identified as part of Bush Forever Site 300, Maralla Road Bushland, Ellenbrook/Upper Swan. Bush Forever site 300 is 641.5ha and links to Bush Forever sites 301 and 399. The part of Bush Forever Site 300 that is within the site has been identified as significant as it is vegetation associated with a creekline. The creekline vegetation provides the narrow link between the eastern side of Bush Forever site 300 and the Ellen Brook Nature Reserve (Bush Forever Site 3010) a short distance to the east. While the condition of the understorey along the banks of Ellen Brook is in poor condition, this could be rehabilitated over time to a better condition. The Flooded Gum and Paperbark trees along the creekline provide habitat for fauna along the creekline corridor.

The vegetation in the road reserve, together with the vegetation in the rail reserve to the east provides a tenuous north-south link between Twin Swamps Nature Reserve (Bush Forever Site 400) to the north and Ellen Brook and further south to the Swan River. However, the value of the native vegetation as a wildlife corridor is diminished significantly by the degraded nature of most of the vegetation in the road reserve.

4. CONCLUSIONS AND SUMMARY

The level 2 flora and vegetation survey of the Apple Street and Railway Parade road reserves between the Great Northern Highway and Maralla Road resulted in the following findings:

- A total of 95 plant species was recorded including 48 native and 47 introduced species. The high percentage of introduced species (49%) reflected the overall degraded nature of the vegetation;
- None of the species is a Threatened (Declared Rare) or Priority listed flora species or listed in Bush Forever as having conservation significance.
- Seven vegetation types were described and mapped for the site, none of which was particularly dominant. The vegetation types around Ellen Brook and south to the Great Northern Highway were all associated with heavy soils that are waterlogged in winter. The vegetation north of Ellen Brook and associated wetlands changed to low open woodlands of Banksia and WA Christmas Tree on dry sandy soils;
- The condition of the vegetation on the site was generally Completely Degraded to Degraded with only one small area of Good condition vegetation in the northern part of the site. The most dominant weed species were Watsonia (*Watsonia bulbifera*), Tambookie Grass (*Hyparrhenia hirta*), Lovegrass (*Eragrostis curvula*), Veldtgrass (*Ehrharta longiflora* and *E. calycina*), Wild Oats (*Avena fatua*) and Arum lily (*Zantedeschia aethiopica*) in the wetland soils north of Ellen Brook;
- The vegetation belongs to the Yanga, Guildford and Swan vegetation complexes which are all under-protected on the Swan Coastal Plain. However, the conservation significance of the native vegetation on the site as representative of these vegetation complexes is negligible due to the very poor condition of the vegetation;
- The vegetation is considered too degraded to assign a Floristic Community. Therefore the vegetation would not be considered a Threatened or Priority Ecological Community;
- The vegetation along Ellen Brook is part of Bush Forever site 300 and provides an ecological corridor between the balance of Bush Forever site to the west and the Ellen Brook Nature Reserve to the east. The vegetation in the road reserve is part of a tenuous north-south link, however the ecological value of the corridor is significantly diminished by the very poor condition of the vegetation.

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FIGURES



CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.

pgv

ENVIRONMENTAL

Drawn: P. van der Moezel

Date: 12 Mar 2014

Job: 10112

Rpt: 2014-137

Revision: A

City of Swan
ENVIRONMENTAL ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

SITE LOCATION AND TOPOGRAPHY

Figure 1



CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.

pgv

ENVIRONMENTAL

Drawn: P. van der Moezel

Date: 9 May 2014

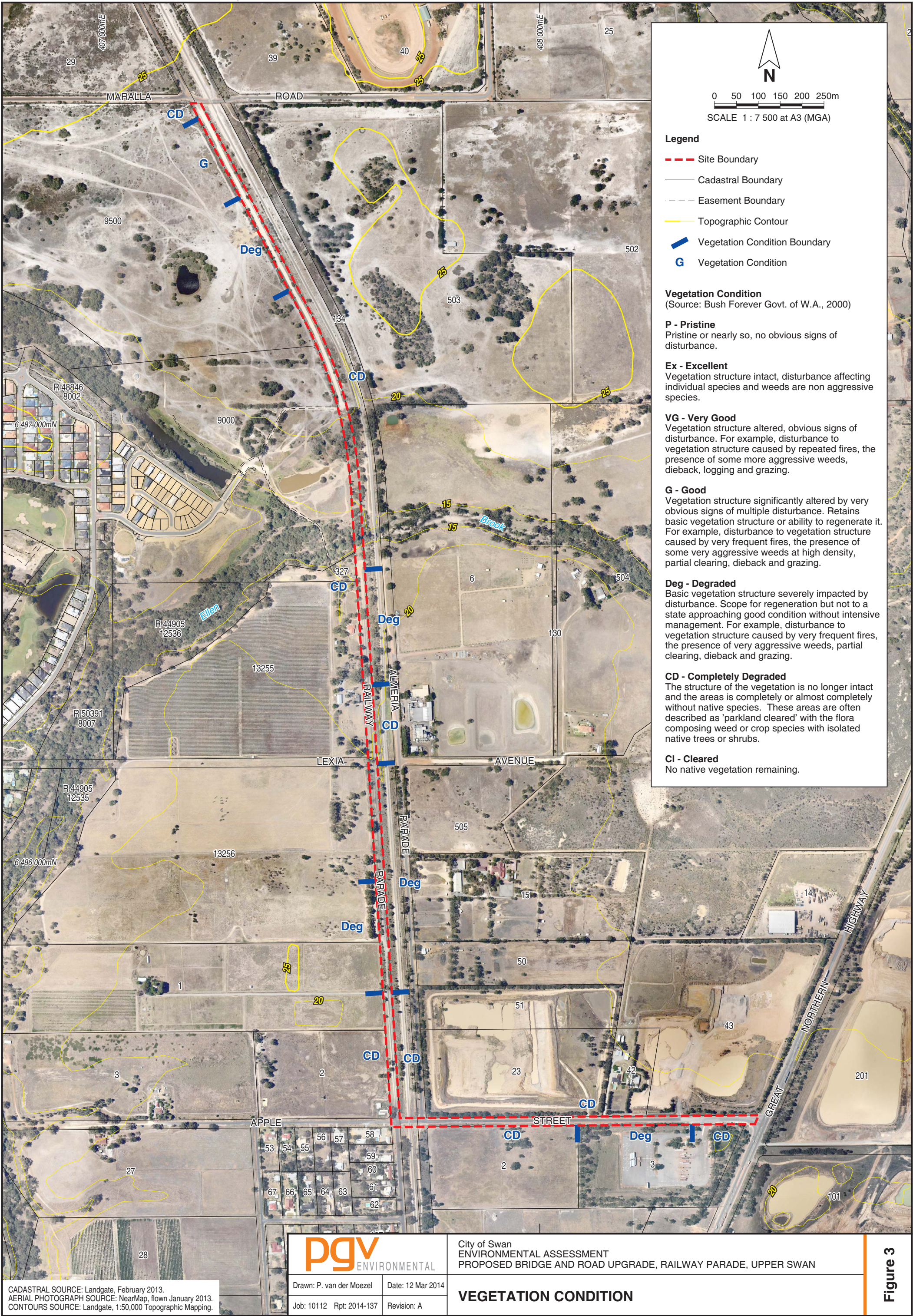
Job: 10112 Rpt: 2014-137

Revision: A

City of Swan
ENVIRONMENTAL ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

VEGETATION ASSOCIATIONS

Figure 2



CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.



Drawn: P. van der Moezel Date: 12 Mar 2014
Job: 10112 Rpt: 2014-137 Revision: A

City of Swan
ENVIRONMENTAL ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

VEGETATION CONDITION

APPENDIX 1

DPaW Flora Database Searches

Taxon	Status	Rank	IUCN Criteria	EPBC	DEC Region	DEC District	Distribution	Flowering Period	Recovery Plan
<i>Acacia anomala</i>	T	VU	C2a	VU	SWAN	PERTH HILLS, SWAN COASTAL	Darling Scarp, Bullsbrook, Muchea, Pickering Brook, Kalamunda, Bickley, Chittering	Aug, Sep	
<i>Chamaescilla gibsonii</i>	3				SWAN, SWST, WARR	SWAN COASTAL, BLACKWOOD, WELLINGTON, DOONELLY	Ellen Brook, Yule Brook, Mogumber, Muchea, Drakesbrook, Capel, Brunswick Jun, Quindinup		
<i>Cyathochaeta teretifolia</i>	3				SWAN, WARR	SWAN COASTAL, FRANKLAND	Whiteman Park, Lake Gnangara, Ellenbrook, Muchea, Denbarker, Yelverton, Wellard, Mundijong	Dec	
<i>Darwinia pimelioides</i>	4				SWAN	PERTH HILLS	John Forrest N.P., Walyunga, Darlington, Red Hill	Oct	
<i>Eleocharis keigheryi</i>	T	VU	B1	VU	MWST, SWAN, SWST, WHTB	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA, GREAT SOUTHERN, CENTRAL WHEATBELT	Kenwick, Lesueur, Cataby, Wannamal, Ellenbrook, Boyanup, Waterloo, Julimar, Lesueur, Bolgart, Beverley, Woodanilling	-	
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	3				SWAN	SWAN COASTAL	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-	
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	T	CR	B1ab(iii,v)+2ab(iii,v); C2a(iii,v)	EN	SWAN	PERTH HILLS	Bullsbrook		IRP
<i>Grevillea christineae</i>	T	EN	B1+2c	EN	MWST, SWAN, WHTB	PERTH HILLS, MOORA, CENTRAL WHEATBELT	Mortlock River, Goomalling, Watheroo, Upper Swan	Sep	
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	CR	B1ab(iii)+B2ab(iii)	EN	SWAN	PERTH HILLS, SWAN COASTAL	Bullsbrook, Muchea	Oct	IRP
<i>Guichenotia tuberculata</i>	3				MWST, SWAN	PERTH HILLS, MOORA	Mogumber, New Norcia, Gillingarra, Wannamal, Bullsbrook	Aug, Sep	
<i>Haemodorum loratum</i>	3				MWST, SWAN	PERTH HILLS, SWAN COASTAL, MOORA	Eneabba, Cockleshell Gully, Bullsbrook, Wattle Grove, Boonanaring, Mogumber	Sep-Nov	
<i>Meionectes tenuifolia</i>	3				MWST, SWAN, SWST	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA	Ruabon, Maddington, Harvey, Pinjarra, Upper Swan, Gingin, Cooljarloo, (Woorooloo, Midland, Byfields Mill), Mt Helena	Nov-Dec	
<i>Oxymyrrhine coronata</i>	4				SWAN	PERTH HILLS	Chittering, Bullsbrook, Avon Valley	Dec, Jan	
<i>Platysace ramosissima</i>	3				MWST, SWAN, SWST	PERTH HILLS, SWAN COASTAL, WELLINGTON, MOORA	Yalgorup, Boonanarring, Gingin, Lancelin, Bullsbrook Nature Reserve		
<i>Schoenus capillifolius</i>	3				SWAN, SWST, WHTB	PERTH HILLS, SWAN COASTAL, WELLINGTON, GREAT SOUTHERN, CENTRAL WHEATBELT	Upper Swan, Kenwick, Waterloo, Beauford River, Beverley, Goomalling, Carousel Swamp, Pearce, Waroona, Karnup, Baldivis	Sep-Nov	
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Nov	
<i>Stenanthemum sublineare</i>	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Dec	
<i>Stylidium aceratum</i>	2				SWAN	SWAN COASTAL	Bullsbrook	Oct-Nov	
<i>Stylidium asteroideum</i>	3				SWAN, WHTB	PERTH HILLS, CENTRAL WHEATBELT	Clackline, Walyunga N.P., Mount Caroline N.R., Wandoo N.P., Wambyn N.R.	Sep-Oct	
<i>Stylidium longitubum</i>	3				SWAN, SWST, WHTB	SWAN COASTAL, BLACKWOOD, WELLINGTON, GREAT SOUTHERN	Upper Swan, Bullsbrook, Bunbury, Midland, Busselton, Arthur River, Jandakot, Mundijong, Karnup	Nov	
<i>Stylidium squamellosum</i>	2				SWAN, SWST	PERTH HILLS, BLACKWOOD	Bowelling, Muchea, Wonnerup Rd, Bullsbrook		
<i>Stylidium trudgenii</i>	3				SWAN, SWST	PERTH HILLS, BLACKWOOD, WELLINGTON	Ellenbrook, Scott River, Gingilup Swamp, Harvey	Oct, Nov	
<i>Tripterococcus paniculatus</i>	4				SWAN, SWST	SWAN COASTAL, BLACKWOOD	Cannington, Armadale, Leeming, Forrestfield, Upper Swan, Willetton, Forrestdale, Busselton	Nov	
<i>Trithuria occidentalis</i>	T	CR	B1ab(iii)+2ab(iii)	EN	SWAN	SWAN COASTAL	Ellenbrook N.R., (Midland)	Sep-Nov	
<i>Verticordia plumosa</i> var. <i>pleiobotrya</i>	T	VU	B1ab(iii,v)+2ab(iii,v)	EN	SWAN	PERTH HILLS, SWAN COASTAL	Mundijong West Road, Bullsbrook NR	Nov	IRP

OID_	POPID	NAMEID	TAXON	CONSSTAT US	WARANK	POPNUM BER	SUBPOPC ODE	POPSTAT US	VESTING	PURPOSE 1	PURPOSE 2	COUNTDATE
	89659	11336	Adenanthos cygnorum subsp. chamaephyton	3		19			LGA	VER		14/05/1999 0:00
	84938	1596	Caladenia huegelii	T	CR	25			PRI			15/10/1997 0:00
	84940	1596	Caladenia huegelii	T	CR	32		U	CC	CFF		29/09/2004 0:00
	84941	1596	Caladenia huegelii	T	CR	34		U	PRI			29/09/2004 0:00
	84942	1596	Caladenia huegelii	T	CR	35		U	CC	CFF		29/09/2004 0:00
	93193	16245	Cyathochaeta teretifolia	3		1			CC	CFF		3/11/1995 0:00
	93197	16245	Cyathochaeta teretifolia	3		13			CC	CFF		3/11/1995 0:00
	93992	17605	Eleocharis keigheryi	T	VU	1			CC	CFA		9/11/2007 0:00
	85477	1976	Grevillea christineae	T	EN	9			LGA	OTH		25/07/2007 0:00
	92200	14408	Grevillea curviloba subsp. curviloba	T	CR	2			CC	CFF		10/12/1998 0:00
	92201	14408	Grevillea curviloba subsp. curviloba	T	CR	3			CC	CFF		1/09/2004 0:00
	92202	14408	Grevillea curviloba subsp. curviloba	T	CR	4	A		CC	CFF		3/09/2004 0:00
	92204	14408	Grevillea curviloba subsp. curviloba	T	CR	4	B		CC	CFF		6/07/2012 0:00
	102716	14408	Grevillea curviloba subsp. curviloba	T	CR	10	A		CC	CFF	NRE	30/06/2009 0:00
	102717	14408	Grevillea curviloba subsp. curviloba	T	CR	10	B		PRI			30/06/2009 0:00
	92209	14409	Grevillea curviloba subsp. incurva	T	EN	17			CC	CFF		15/02/2000 0:00
	84894	1469	Haemodorum loratum	3		2			UNKNOWN			13/11/1981 0:00
	88387	6233	Hydrocotyle lemnoides	4		1			CC	CFA		2/11/1990 0:00
	96547	33638	Meionectes tenuifolia	3		4			PRI			3/11/1995 0:00
	84517	980	Schoenus capillifolius	3		3			CC	CFF		2/11/1990 0:00
	89291	7756	Stylidium longitubum	3		1			AGR	GVT		12/11/1989 0:00
	89302	7756	Stylidium longitubum	3		2			CC	CFA		28/12/1971 0:00
	89307	7756	Stylidium longitubum	3		3			CC	NRE		3/10/1988 0:00
	89308	7756	Stylidium longitubum	3		4			UNKNOWN			30/10/1992 0:00
	87125	4540	Tetratheca pilifera	3		15			CC	NPK		12/11/2003 0:00
	96349	32658	Trithuria occidentalis	T	CR	1			CC	NRE		27/10/1982 0:00

OID_	SHEET_NO	TAXON	CONS_CO DE	SITE	VEGETATION	LOCALITY	COLL_DATE
	PERTH 07132832	<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	3	Swale. Grey sand.	Low woodland. <i>Banksia attenuata</i> , <i>B. menziesii</i> , <i>Eucalyptus marginata</i> subsp. <i>thalassica</i> .	Road verge on Jenkins Road opposite Lot 41, Bushplan Site 291	14 05 1999
	PERTH 256935	<i>Cyanicula ixioides</i> subsp. <i>ixioides</i>	4			Upper Swan	09 1913
	PERTH 06570240	<i>Cyathochaeta teretifolia</i>	3	Edge of seasonal wetland, gentle slope, north aspect, dark brown loam over red sand with limestone, well drained.	Associated species: <i>Eucalyptus calophylla</i> .	Cardinal Drive Bushland (Bush Forever Site 23) approx. 200 m N Bordeaux Road (adjacent to System 6 Update quadrat vines01) Ellenbrook Bushland	03 11 1995
	PERTH 02266865	<i>Eleocharis keigheryi</i>	T	Clay soil, under 6 inches water, dries in summer.		Ellen Brook Tortoise Reserve, 21 miles N of Perth,	19 10 1978
	PERTH 07782020	<i>Eleocharis keigheryi</i>	T	Seasonally inundated claypans with grey to brown clay.	Transitions from open clay pans comprised exclusively of of <i>E. keigheryi</i> to vegetated clay pans. <i>Melaleuca</i> spp., <i>Verticordia</i> sp. <i>Chorizandra enodis</i> , herbs, <i>Avena fatua</i> and <i>Briza maxima</i> .	Ellen Brook Nature Reserve, W side of the Great N Highway, Upper Swan	09 11 2007
	PERTH 07782047	<i>Eleocharis keigheryi</i>	T	Claypan with brown clay. Found in open water ponds.	<i>Chorizandra enodis</i> . Trees and shrubs 1-2 m.	Ellen Brook Nature Reserve, upper swan	12 10 2007
	PERTH 06512283	<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	3	Dampland; grey sand.	<i>Melaleuca</i> shrubland.	Wetland area to the N of quadrat Vines 01, W Vines residential area. Shire of Swan (Bush Forever Site 23)	03 11 1995
	PERTH 07708602	<i>Grevillea christineae</i>	T	Valley slope outcrop. Brown sand / loam / clay over granite boulder.	Scattered <i>Eucalyptus rudis</i> with <i>Grevillea</i> <i>enlicheriana</i> , <i>Calothamnus quadrifidus</i> , <i>Hakea</i> <i>erinacea</i> , <i>Labichea lanceolata</i> , <i>Darwinia citriodora</i> , <i>Petrophile biloba</i> , <i>Gastrolobium spinosum</i> , weeds.	Bells Rapid Park, Cathedral ave, Upper Swan. On the S side of the footbridge between the Swan River and the EW railway line	09 07 2007
	PERTH 06512836	<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	Edge of seasonal wetland, gentle slope, N aspect. Dark brown loam over red sand with limestone, well drained.	Associated species: <i>Eucalyptus calophylla</i> .	Cardinal Drive Bushland (Bush Forever Site 23). c. 200 m N Bordeaux Road (adjacent to System 6 Update quadrat vines 01) Ellenbrook Bushland	03 11 1995
	PERTH 05492963	<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	Flat, near shallow seasonal creekline. Grey sand.	Shrubland/Sedgeland. Characteristic species: <i>Hakea</i> <i>varia</i> .	Ellenbrook,	15 02 2000
	PERTH 1044567	<i>Haemodorum loratum</i>	3	Lateritic loam.	Wandoo woodland.	20 km ESE Muchea.	13 11 1981
	PERTH 1111167	<i>Halgania corymbosa</i>	3	Lateritic soil.		Susannah Brook, Millendon.	03 09 1980
	PERTH 06207154	<i>Hydatella dioica</i>	T	In water. Open muddy clay pan.		Ellen Brook Reserve, ca 15 km N Midland	14 10 1980
	PERTH 1048139	<i>Hydrocotyle lemnoides</i>	4	Growing in fresh water, stem rooted in clay.		15 km N of Midland on Great Northern Highway. Martyn Reserve	07 10 1976
	PERTH 1048104	<i>Hydrocotyle lemnoides</i>	4	Growing in fresh water, stem rooted in clay.		15 km N of Midland on Great Northern Highway, Martyn Reserve	07 10 1976
	PERTH 03401332	<i>Hydrocotyle lemnoides</i>	4			21 mile peg Reserve Great Northern Highway [10 km S of Bullsbrook East]	09 1963
	PERTH 1048112	<i>Hydrocotyle lemnoides</i>	4	Growing in shallow water over mud.		Short-necked Tortoise Reserve ca. 15 km N of Midland	13 09 1985

OID_	SHEET_NO	TAXON	CONS_CO DE	SITE	VEGETATION	LOCALITY	COLL_DATE
	PERTH 05991714	Persoonia sulcata	4	Laterite.	Eucalypt woodland with low shrubby understory.	Great Northern Highway, 102.6 km N of Perth GPO, 12.4 km N of turnoff to Toodyay,	18 12 1980
	PERTH 01278215	Schoenus capillifolius	3	Clay pan dry - some mud in deeper sections with live plants.		J. Martyn Reserve, 13 km N Midland	14 11 1980
	PERTH 02239108	Schoenus capillifolius	3	Winter wet claypan.	With Glossostigma sp., Hydatella sp. and Trithuria sp. surrounded by regenerating heath B of Melaleuca lateritica.	Ellen Brook Nature Reserve, Upper Swan	02 11 1990
	PERTH 07514271	Schoenus natans	4	Flooded claypan.	Melaleuca lateritia shrubland over Chorizandra enodis and aquatic herbs.	Ellenbrook Nature Reserve	07 10 2004
	PERTH 04097610	Schoenus sp. Bullsbrook (J.J. Alford 915)	2	Low lying flat, grey peaty sand over ? clay.	Herbs and low shrubs.	Twin Swamps Nature Reserve, 8 km S of Bullsbrook	31 10 1986
	PERTH 04750411	Schoenus sp. Waroona (G.J. Keighery 12235)	3	Winter wet flats, dark brown loam clay over clay.	Burnt low heath.	J & B Martyn Reserve, 13 km N of Midland	31 10 1988
	PERTH 03510042	Stylidium longitubum	3			Ellenbrook area, west of Vines golf course	30 10 1992
	PERTH 01643061	Stylidium longitubum	3	Grows in clayey sand, in small winter-wet depressions.	Under and around shrubs.	In a paddock on the W side of Railway Parade, 0.5 km N of Apple Road, Upper Swan	12 11 1989
	PERTH 01631098	Stylidium longitubum	3	Winter wet claypan.	Melaleuca lateritia shrubland; burnt.	J. & R. Martyn Reserve, 13 km N Midland	03 10 1988
	PERTH 08161119	Stylidium longitubum	3	Flat, clay pan. Moist grey clay.	Jacksonia, Acacia, Asteraceae, Villarsia, weeds.	Ellen Brook Nature Reserve, Great Northern Highway, West Swan	28 11 2008
	PERTH 06724884	Tetratheca pilifera	3	Towards top of hill on lower part of breakaway. Steep slope below, scarp. Outcropping laterite and smooth ?quartz pebbles over granite; grey clayey sand. Charcoal litter on surface.	Corymbia calophylla, Eucalyptus wandoo woodland with Xanthorrhoea preissii and low shrub understorey including Acacia pulchella, Macrozamia riedlei, Trymalium ledifolium, Hibbertia hypericoides, Dryandra nivea, Hakea sp.	Hillslope behind Ranger's residence, Walyunga National Park	12 11 2003
	PERTH 02472635	Trithuria occidentalis	T	In water, muddy open.		J.R. & B. Martyn Reserve, Ellen Brook, 13 km N Midland	27 10 1982
	PERTH 07855885	Trithuria occidentalis	T	Low-lying depression next to a low sand ridge covered by Petrophile sp. and Eucalyptus trees. Soil grey-brown clay, soft and damp to dry and hardening where higher.	Open shrubland of Melaleuca lateritia to 1.5 m tall with open ground between shrubs, colourful with flowering herbs including Villarsia capitata, Gratiola pubescens, Rhodanthe pyrethrum, Stylidium sp., Utricularia inaequalis, Aphelia drummondii, Lachnagr	Ellenbrook Nature Reserve (Reserve No A 27620), 15 km N of Midland	06 11 2007
	PERTH 02841886	Trithuria occidentalis	T	Slightly submerged clay pan, open.		Warbrook Siding, Upper Swan	18 10 1978
	PERTH 02841851	Trithuria occidentalis	T	Drying pools, muddy claypan.	Melaleuca laterite scrub.	J.R. and B. Martyn Reserve, Ellen Brook, 13 km N Midland	27 10 1982

APPENDIX 2

NatureMap Report

NatureMap Species Report

Created By Jackalyn Hams on 24/01/2013

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 116°01' 27" E, 31°45' 03" S
Buffer 5km
Group By Conservation Status

Conservation Status	Species	Records
Rare or likely to become extinct	9	149
Protected under international agreement	2	4
Other specially protected fauna	1	1
Priority 2	1	1
Priority 3	10	26
Priority 4	4	8
Priority 5	2	38
Non-conservation taxon	557	1482
TOTAL	586	1709

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
Rare or likely to become extinct				
1.	1596 <i>Caladenia huegelii</i> (Grand Spider Orchid)		T	
2.	24734 <i>Calyptrorhynchus latirostris</i> (Carnaby's Cockatoo (short-billed black-cockatoo))		T	
3.	17605 <i>Eleocharis keigheryi</i>		T	
4.	1976 <i>Grevillea christineae</i>		T	
5.	14408 <i>Grevillea curviloba</i> subsp. <i>curviloba</i>		T	
6.	14409 <i>Grevillea curviloba</i> subsp. <i>incurva</i>		T	
7.	24168 <i>Macrotis lagotis</i> (Bilby)		T	
8.	25345 <i>Pseudemys umbrina</i> (Western Swamp Turtle, tortoise)		T	
9.	32658 <i>Trithuria occidentalis</i> (Swan Hydatella)		T	
Protected under international agreement				
10.	24598 <i>Merops ornatus</i> (Rainbow Bee-eater)		IA	
11.	24843 <i>Plegadis falcinellus</i> (Glossy Ibis)		IA	
Other specially protected fauna				
12.	25240 <i>Morelia spilota</i> subsp. <i>imbricata</i> (Carpet Python)		S	
Priority 2				
13.	16279 <i>Schoenus</i> sp. <i>Bullsbrook</i> (J.J. Alford 915)		P2	Y
Priority 3				
14.	11336 <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>		P3	
15.	16245 <i>Cyathochaeta teretifolia</i>		P3	
16.	34027 <i>Galaxiella nigrostriata</i> (Black-stripe Minnow)		P3	
17.	1469 <i>Haemodorum loratum</i>		P3	
18.	6686 <i>Halgania corymbosa</i>		P3	
19.	33638 <i>Meionectes tenuifolia</i>		P3	
20.	25249 <i>Neelaps calonotos</i> (Black-striped Snake)		P3	
21.	980 <i>Schoenus capillifolius</i>		P3	
22.	17731 <i>Schoenus</i> sp. <i>Waroona</i> (G.J. Keighery 12235)		P3	
23.	7756 <i>Stylidium longitubum</i> (Jumping Jacks)		P3	
Priority 4				
24.	13826 <i>Cyanicula ixioides</i> subsp. <i>ixioides</i>		P4	
25.	6233 <i>Hydrocotyle lemnooides</i> (Aquatic Pennywort)		P4	
26.	2278 <i>Persoonia sulcata</i>		P4	
27.	1003 <i>Schoenus natans</i> (Floating Bog-rush)		P4	
Priority 5				
28.	24153 <i>Isodon obesulus</i> subsp. <i>fusciventer</i> (Quenda, Southern Brown Bandicoot)		P5	
29.	24131 <i>Macropus eugenii</i> subsp. <i>derbianus</i> (Tamar Wallaby (WA subsp))		P5	
Non-conservation taxon				

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
30.	15466	<i>Acacia applanata</i>			
31.	3254	<i>Acacia celastrifolia</i> (Glowing Wattle)			
32.	3324	<i>Acacia erinacea</i>			
33.	3454	<i>Acacia nervosa</i> (Rib Wattle)			
34.	15483	<i>Acacia pulchella</i> var. <i>pulchella</i>			
35.	3515	<i>Acacia restiacea</i>			
36.	3527	<i>Acacia saligna</i> (Orange Wattle)			
37.	30032	<i>Acacia saligna</i> subsp. <i>saligna</i>			
38.	24260	<i>Acanthiza apicalis</i> (Broad-tailed Thornbill)			
39.	24261	<i>Acanthiza chrysorrhoa</i> (Yellow-rumped Thornbill)			
40.	24262	<i>Acanthiza inornata</i> (Western Thornbill)			
41.	24560	<i>Acanthorhynchus superciliosus</i> (Western Spinebill)			
42.	1791	<i>Adenanthos obovatus</i> (Basket Flower)			
43.	184	<i>Aira caryophyllea</i> (Silvery Hairgrass)	Y		
44.	185	<i>Aira cupaniana</i> (Silvery Hairgrass)	Y		
45.	187	<i>Aira praecox</i> (Early Hairgrass)	Y		
46.	1056	<i>Alexgeorgea nitens</i>			
47.	1375	<i>Allium neapolitanum</i> (Naples Onion)	Y		
48.	1728	<i>Allocasuarina fraseriana</i> (Sheoak)			
49.	2652	<i>Alternanthera nodiflora</i> (Common Joyweed)			
50.	-14519	<i>Amblyomma triguttatum</i>			
51.	200	<i>Amphipogon turbinatus</i>			
52.	24312	<i>Anas gracilis</i> (Grey Teal)			
53.	24313	<i>Anas platyrhynchos</i> (Mallard)			
54.	24316	<i>Anas superciliosa</i> (Pacific Black Duck)			
55.	6300	<i>Andersonia aristata</i> (Rice Flower)			
56.	11470	<i>Anigozanthos bicolor</i> subsp. <i>bicolor</i>			
57.	6949	<i>Anthocercis littorea</i> (Yellow Tailflower)			
58.	24561	<i>Anthochaera carunculata</i> (Red Wattlebird)			
59.	24562	<i>Anthochaera lunulata</i> (Western Little Wattlebird)			
60.	12724	<i>Anthotium junciforme</i>			
61.	25670	<i>Anthus australis</i> (Australian Pipit)			
62.	1117	<i>Aphelia cyperoides</i>			
63.	1118	<i>Aphelia drummondii</i>			
64.	24990	<i>Aprasia pulchella</i>			
65.	24991	<i>Aprasia repens</i>			
66.	24285	<i>Aquila audax</i> (Wedge-tailed Eagle)			
67.	7838	<i>Arctotheca calendula</i> (Cape Weed)	Y		
68.	207	<i>Aristida contorta</i> (Bunched Kerosene Grass)			
69.	25566	<i>Artamus cinereus</i> (Black-faced Woodswallow)			
70.	24353	<i>Artamus cyanopterus</i> (Dusky Woodswallow)			
71.	6330	<i>Astroloma macrocalyx</i> (Swan Berry)			
72.	6334	<i>Astroloma pallidum</i> (Kick Bush)			
73.	6339	<i>Astroloma xerophyllum</i>			
74.	17233	<i>Austrostipa campylachne</i>			
75.	17240	<i>Austrostipa flavescens</i>			
76.	17244	<i>Austrostipa macalpinei</i>			
77.	17254	<i>Austrostipa tenuifolia</i>			
78.	233	<i>Avena barbata</i> (Bearded Oat)	Y		
79.	234	<i>Avena fatua</i> (Wild Oat)	Y		
80.	235	<i>Avena sativa</i> (Common Oat)	Y		
81.	24318	<i>Aythya australis</i> (Hardhead)			
82.	36441	<i>Babingtonia camphorosmae</i> (Camphor Myrtle)			
83.	32682	<i>Banksia armata</i> var. <i>armata</i>			
84.	1800	<i>Banksia attenuata</i> (Slender Banksia)			
85.	32576	<i>Banksia dallanneyi</i> (Couch Honeyeater)			
86.	32577	<i>Banksia dallanneyi</i> var. <i>mellicula</i>			
87.	32523	<i>Banksia fraseri</i> var. <i>fraseri</i>			
88.	1834	<i>Banksia menziesii</i> (Firewood Banksia)			
89.	1835	<i>Banksia micrantha</i>			
90.	32076	<i>Banksia sessilis</i> (Parrot Bush)			
91.	32080	<i>Banksia sessilis</i> var. <i>sessilis</i>			
92.	15037	<i>Bartsia trixago</i>	Y		
93.	740	<i>Baumea arthropphylla</i>			
94.	741	<i>Baumea articulata</i> (Jointed Rush)			
95.	743	<i>Baumea juncea</i> (Bare Twigrush)			
96.	3165	<i>Billardiera variifolia</i>			
97.	7856	<i>Blennospora drummondii</i>			
98.	17665	<i>Boronia purdieana</i> subsp. <i>purdieana</i>			
99.	1272	<i>Borya scirpoidea</i>			

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100.	1273	<i>Borya sphaerocephala</i> (Pincushions)			
101.	24251	<i>Bos taurus</i> (European Cattle)	Y		
102.	3710	<i>Bossiaea eriocarpa</i> (Common Brown Pea)			
103.	8661	<i>Brachypodium distachyon</i> (False Brome)	Y		
104.	7875	<i>Brachyscome glandulosa</i>			
105.	7878	<i>Brachyscome iberidifolia</i>			
106.	-19511	<i>Brachyurophus fasciolatus</i> subsp. <i>fasciolatus</i>			
107.	-19669	<i>Brachyurophus semifasciatus</i>			
108.	244	<i>Briza maxima</i> (Blowfly Grass)	Y		
109.	245	<i>Briza minor</i> (Shivery Grass)	Y		
110.	249	<i>Bromus diandrus</i> (Great Brome)	Y		
111.	250	<i>Bromus hordeaceus</i> (Soft Brome)	Y		
112.	253	<i>Bromus rubens</i> (Red Brome)	Y		
113.	1383	<i>Burchardia bairdiae</i>			
114.	12770	<i>Burchardia congesta</i>			
115.	1385	<i>Burchardia multiflora</i> (Dwarf Burchardia)			
116.	25716	<i>Cacatua sanguinea</i> (Little Corella)			
117.	24729	<i>Cacatua tenuirostris</i> (Eastern Long-billed Corella)	Y		
118.	1276	<i>Caesia micrantha</i> (Pale Grass-lily)			
119.	1592	<i>Caladenia flava</i> (Cowslip Orchid)			
120.	15348	<i>Caladenia flava</i> subsp. <i>flava</i>			
121.	15354	<i>Caladenia hirta</i> subsp. <i>hirta</i>			
122.	15380	<i>Caladenia splendens</i>			
123.	2856	<i>Calandrinia liniflora</i> (Parakeelya)			
124.	19309	<i>Calectasia narragara</i>			
125.	35816	<i>Calothamnus quadrifidus</i> subsp. <i>quadrifidus</i>			
126.	5439	<i>Calytrix angulata</i> (Yellow Starflower)			
127.	5461	<i>Calytrix glutinosa</i>			
128.	5481	<i>Calytrix sylvana</i>			
129.	-16582	<i>Carassius auratus</i>			
130.	2956	<i>Cassytha pomiformis</i> (Dodder Laurel)			
131.	1742	<i>Casuarina obesa</i> (Swamp Sheoak)			
132.	41567	<i>Cenchrus macrourus</i> (African Feather Grass)	Y		
133.	41568	<i>Cenchrus setaceus</i> (Fountain Grass)	Y		
134.	6539	<i>Centaureum erythraea</i> (Common Centaury)	Y		
135.	1120	<i>Centrolepis alepyroides</i>			
136.	1121	<i>Centrolepis aristata</i> (Pointed Centrolepis)			
137.	1125	<i>Centrolepis drummondiana</i>			
138.	1129	<i>Centrolepis glabra</i> (Smooth Centrolepis)			
139.	1132	<i>Centrolepis mutica</i>			
140.	-14766	<i>Cercophonius sulcatus</i>			
141.	11878	<i>Chamaescilla corymbosa</i> var. <i>paradoxa</i>			
142.	35598	<i>Chamaelaucium</i> sp. Winchester (C. Chapman s.n. PERTH 07879180)			
143.	3169	<i>Cheiranthra preissiana</i>			
144.	25337	<i>Chelodina oblonga</i> (Oblong Turtle)			
145.	24321	<i>Chenonetta jubata</i> (Australian Wood Duck)			
146.	2491	<i>Chenopodium macrospermum</i>	Y		
147.	33939	<i>Cherax cainii</i> (Marron)			
148.	763	<i>Chorizandra enodis</i> (Black Bristlerush)			
149.	6543	<i>Cicendia filiformis</i> (Slender Cicendia)	Y		
150.	25675	<i>Colluricincla harmonica</i> (Grey Shrike-thrush)			
151.	24399	<i>Columba livia</i> (Domestic Pigeon)	Y		
152.	40864	<i>Commersonia cygnorum</i>			
153.	1864	<i>Conospermum crassinervium</i> (Summer Smokebush)			
154.	6347	<i>Conostephium minus</i> (Pink-tipped Pearl flower)			
155.	6349	<i>Conostephium preissii</i>			
156.	11513	<i>Conostylis aculeata</i> subsp. <i>cygnorum</i>			
157.	1420	<i>Conostylis androstemma</i> (Trumpets)			
158.	1436	<i>Conostylis juncea</i>			
159.	11597	<i>Conostylis setigera</i> subsp. <i>setigera</i>			
160.	1455	<i>Conostylis setosa</i> (White Cottonhead)			
161.	25568	<i>Coracina novaehollandiae</i> (Black-faced Cuckoo-shrike)			
162.	2891	<i>Corrigiola litoralis</i> (Strapwort)	Y		
163.	25592	<i>Corvus coronoides</i> (Australian Raven)			
164.	17104	<i>Corymbia calophylla</i> (Marri)			
165.	7945	<i>Cotula coronopifolia</i> (Waterbuttons)	Y		
166.	7946	<i>Cotula cotuloides</i> (Smooth Cotula)			
167.	25595	<i>Cracticus tibicen</i> (Australian Magpie)			
168.	25596	<i>Cracticus torquatus</i> (Grey Butcherbird)			
169.	3137	<i>Crassula colorata</i> (Dense Stonecrop)			

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170.	3142	<i>Crassula natans</i>	Y		
171.	15706	<i>Crassula natans</i> var. <i>minus</i>	Y		
172.	24918	<i>Crenadactylus ocellatus</i> subsp. <i>ocellatus</i>			
173.	25398	<i>Crinia georgiana</i> (Quacking Frog)			
174.	25400	<i>Crinia insignifera</i> (Squelching Froglet)			
175.	13527	<i>Croninia kingiana</i>			
176.	13470	<i>Cryptandra arbutiflora</i> var. <i>arbutiflora</i>			
177.	9076	<i>Cryptandra myriantha</i>			
178.	30893	<i>Cryptoblepharus buehneri</i>			
179.	25039	<i>Ctenotus fallens</i>			
180.	25047	<i>Ctenotus impar</i>			
181.	15114	<i>Cyanicula gemmata</i>			
182.	768	<i>Cyathochaeta avenacea</i>			
183.	40661	<i>Cycnogeton lineare</i>			
184.	24322	<i>Cygnus atratus</i> (Black Swan)			
185.	283	<i>Cynodon dactylon</i> (Couch)	Y		
186.	794	<i>Cyperus gymnocaulos</i> (Spiny Flat-sedge)			
187.	806	<i>Cyperus polystachyos</i> (Bunchy Sedge)	Y		
188.	815	<i>Cyperus tenellus</i> (Tiny Flatsedge)	Y		
189.	-15906	<i>Cyprinus carpio</i>			
190.	17692	<i>Cytogonidium leptocarpoides</i>			
191.	30901	<i>Dacelo novaeguineae</i> (Laughing Kookaburra)	Y		
192.	7428	<i>Dampiera coronata</i> (Wedge-leaved Dampiera)			
193.	7451	<i>Dampiera lavandulacea</i>			
194.	7454	<i>Dampiera linearis</i> (Common Dampiera)			
195.	25673	<i>Daphoenositta chrysoptera</i> (Varied Sittella)			
196.	5508	<i>Darwinia citriodora</i> (Lemon-scented Darwinia)			
197.	1218	<i>Dasypogon bromeliifolius</i> (Pineapple Bush)			
198.	6218	<i>Daucus glochidiatus</i> (Australian Carrot)			
199.	3793	<i>Daviesia angulata</i>			
200.	3832	<i>Daviesia physodes</i>			
201.	17663	<i>Desmocladius asper</i>			
202.	17838	<i>Dielsia stenostachya</i>			
203.	17736	<i>Digitaria aequiglumis</i>	Y		
204.	311	<i>Digitaria ciliaris</i> (Summer Grass)	Y		
205.	320	<i>Digitaria sanguinalis</i> (Crab Grass)	Y		
206.	24929	<i>Dipodactylus granariensis</i> subsp. <i>granariensis</i>			
207.	4746	<i>Diplopeltis huegelii</i>			
208.	18541	<i>Diplopeltis huegelii</i> subsp. <i>huegelii</i>			
209.	18589	<i>Diplopeltis huegelii</i> subsp. <i>lehmannii</i>			
210.	3011	<i>Diplotaxis muralis</i> (Wall Rocket)	Y		
211.	7055	<i>Dischisma capitatum</i> (Woolly-headed Dischisma)	Y		
212.	7961	<i>Dittrichia graveolens</i> (Stinkwort)	Y		
213.	1634	<i>Diuris laxiflora</i> (Bee Orchid)			
214.	24470	<i>Dromaius novaehollandiae</i> (Emu)			
215.	3095	<i>Drosera erythrorhiza</i> (Red Ink Sundew)			
216.	13211	<i>Drosera erythrorhiza</i> subsp. <i>collina</i>			
217.	3097	<i>Drosera gigantea</i> (Giant Sundew)			
218.	15453	<i>Drosera gigantea</i> subsp. <i>gigantea</i>			
219.	3098	<i>Drosera glanduligera</i> (Pimpernel Sundew)			
220.	3101	<i>Drosera heterophylla</i> (Swamp Rainbow)			
221.	11853	<i>Drosera menziesii</i> subsp. <i>menziesii</i>			
222.	13216	<i>Drosera menziesii</i> subsp. <i>penicillaris</i>			
223.	3113	<i>Drosera neesii</i> (Jewel Rainbow)			
224.	3117	<i>Drosera paleacea</i> (Dwarf Sundew)			
225.	3123	<i>Drosera platystigma</i> (Black-eyed Sundew)			
226.	3124	<i>Drosera pulchella</i> (Pretty Sundew)			
227.	8911	<i>Drosera rosulata</i>			
228.	3131	<i>Drosera stolonifera</i> (Leafy Sundew)			
229.	347	<i>Ehrharta calycina</i> (Perennial Veldt Grass)	Y		
230.	349	<i>Ehrharta longiflora</i> (Annual Veldt Grass)	Y		
231.	24290	<i>Elanus caeruleus</i> subsp. <i>axillaris</i> (Australian Black-shouldered Kite)			
232.	822	<i>Eleocharis acuta</i> (Common Spikerush)			
233.	1644	<i>Elythranthera emarginata</i> (Pink Enamel Orchid)			
234.	2409	<i>Emex australis</i> (Doublegee)	Y		
235.	374	<i>Eragrostis cilianensis</i> (Stinkgrass)	Y		
236.	376	<i>Eragrostis curvula</i> (African Lovegrass)	Y		
237.	415	<i>Eriachne ovata</i>			
238.	1646	<i>Eriochilus dilatatus</i> (White Bunny Orchid)			
239.	4332	<i>Erodium botrys</i> (Long Storksbill)	Y		

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240.	4335	<i>Erodium cygnorum</i> (Blue Heronsbill)			
241.	6219	<i>Eryngium pinnatifidum</i> (Blue Devils)			
242.	5763	<i>Eucalyptus rudis</i> (Flooded Gum)			
243.	5767	<i>Eucalyptus salubris</i> (Gimlet)			
244.	12906	<i>Eucalyptus wandoo</i> subsp. <i>wandoo</i>			
245.	15137	<i>Euchiton sphaericus</i>			
246.	25622	<i>Falco cenchroides</i> (Australian Kestrel)			
247.	894	<i>Fimbristylis velata</i>			
248.	25727	<i>Fulica atra</i> (Eurasian Coot)			
249.	2969	<i>Fumaria capreolata</i> (Whiteflower Fumitory)	Y		
250.	32370	<i>Funaria hygrometrica</i>			
251.	907	<i>Gahnia trifida</i> (Coast Saw-sedge)			
252.	34028	<i>Galaxias occidentalis</i> (Western Minnow)			
253.	7323	<i>Galium murale</i> (Small Goosegrass)	Y		
254.	25729	<i>Gallinula tenebrosa</i> (Dusky Moorhen)			
255.	20483	<i>Gastrolobium linearifolium</i>			
256.	20512	<i>Gastrolobium praemorsum</i>			
257.	3924	<i>Gastrolobium spinosum</i> (Prickly Poison)			
258.	25530	<i>Gerygone fusca</i> (Western Gerygone)			
259.	1520	<i>Gladiolus caryophyllaceus</i> (Wild Gladiolus)	Y		
260.	2836	<i>Glinus oppositifolius</i>			
261.	7061	<i>Glossostigma drummondii</i> (Mudmat)			
262.	3951	<i>Gompholobium marginatum</i>			
263.	3957	<i>Gompholobium tomentosum</i> (Hairy Yellow Pea)			
264.	8614	<i>Goodenia claytoniacea</i>			
265.	12551	<i>Goodenia micrantha</i>			
266.	7538	<i>Goodenia pulchella</i>			
267.	24443	<i>Grallina cyanoleuca</i> (Magpie-lark)			
268.	14282	<i>Gratiola pubescens</i>			
269.	13450	<i>Grevillea manglesii</i> subsp. <i>manglesii</i>			
270.	2066	<i>Grevillea pilulifera</i> (Woolly-flowered Grevillea)			
271.	5014	<i>Guichenotia sarotes</i>			
272.	1465	<i>Haemodorum discolor</i>			
273.	1468	<i>Haemodorum laxum</i>			
274.	1472	<i>Haemodorum simplex</i>			
275.	2158	<i>Hakea erinacea</i> (Hedge-hog Hakea)			
276.	2166	<i>Hakea incrassata</i> (Marble Hakea)			
277.	2175	<i>Hakea lissocarpha</i> (Honey Bush)			
278.	2185	<i>Hakea myrtoides</i> (Myrtle Hakea)			
279.	2216	<i>Hakea varia</i> (Variable-leaved Hakea)			
280.	25409	<i>Heleioporus barycragus</i> (Hooting Frog)			
281.	25410	<i>Heleioporus eyrei</i> (Moaning Frog)			
282.	3016	<i>Heliophila pusilla</i>	Y		
283.	6838	<i>Hemiandra linearis</i> (Speckled Snakebush)			
284.	6839	<i>Hemiandra pungens</i> (Snakebush)			
285.	25119	<i>Hemiergis quadrilineata</i>			
286.	1526	<i>Hesperantha falcata</i>	Y		
287.	5112	<i>Hibbertia aurea</i>			
288.	5114	<i>Hibbertia commutata</i>			
289.	5118	<i>Hibbertia cunninghamii</i>			
290.	20051	<i>Hibbertia diamesogenos</i>			
291.	5135	<i>Hibbertia hypericoides</i> (Yellow Buttercups)			
292.	5162	<i>Hibbertia racemosa</i> (Stalked Guinea Flower)			
293.	20034	<i>Hibbertia</i> sp. <i>Gnangara</i> (J.R. Wheeler 2329)			
294.	5173	<i>Hibbertia subvaginata</i>			
295.	24491	<i>Hirundo neoxena</i> (Welcome Swallow)			
296.	445	<i>Holcus setiger</i> (Annual Fog)	Y		
297.	6222	<i>Homalosciadium homalocarpum</i>			
298.	17575	<i>Hordeum distichon</i>	Y		
299.	12741	<i>Hyalosperma cotula</i>			
300.	6223	<i>Hydrocotyle alata</i>			
301.	6226	<i>Hydrocotyle callicarpa</i> (Small Pennywort)			
302.	6229	<i>Hydrocotyle diantha</i>			
303.	5817	<i>Hypocalymma angustifolium</i> (White Myrtle)			
304.	35070	<i>Hypocalymma angustifolium</i> subsp. <i>Swan Coastal Plain</i> (G.J. Keighery 16777)			
305.	8086	<i>Hypochaeris glabra</i> (Smooth Catsear)	Y		
306.	1070	<i>Hypolaena exsulca</i>			
307.	1500	<i>Hypoxis glabella</i> (Tiny Star)			
308.	1503	<i>Hypoxis occidentalis</i>			
309.	11736	<i>Hypoxis occidentalis</i> var. <i>occidentalis</i>			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
310.	11	<i>Isoetes drummondii</i> (Quillwort)			
311.	910	<i>Isolepis cernua</i> (Nodding Club-rush)			
312.	14540	<i>Isolepis hystrix</i>	Y		
313.	917	<i>Isolepis marginata</i> (Coarse Club-rush)	Y		
314.	919	<i>Isolepis oldfieldiana</i>			
315.	921	<i>Isolepis producta</i>			
316.	924	<i>Isolepis stellata</i> (Star Club-rush)			
317.	2229	<i>Isopogon dubius</i> (Pincushion Coneflower)			
318.	7398	<i>Isotoma pusilla</i> (Small Isotome)			
319.	4012	<i>Jacksonia furcellata</i> (Grey Stinkwood)			
320.	4029	<i>Jacksonia sternbergiana</i> (Stinkwood)			
321.	1178	<i>Juncus bufonius</i> (Toad Rush)	Y		
322.	1180	<i>Juncus capitatus</i> (Capitate Rush)	Y		
323.	1188	<i>Juncus pallidus</i> (Pale Rush)			
324.	4044	<i>Kennedia prostrata</i> (Scarlet Runner)			
325.	4045	<i>Kennedia stirlingii</i> (Bushy Kennedia)			
326.	5835	<i>Kunzea micrantha</i>			
327.	17461	<i>Kunzea micrantha</i> subsp. <i>micrantha</i>			
328.	5841	<i>Kunzea recurva</i>			
329.	11289	<i>Labichea lanceolata</i> subsp. <i>lanceolata</i>			
330.	19955	<i>Lachnagrostis plebeia</i>			
331.	29046	<i>Lactuca serriola</i> forma <i>serriola</i>	Y		
332.	468	<i>Lamarckia aurea</i> (Goldentop)	Y		
333.	4052	<i>Latrobea tenella</i>			
334.	1303	<i>Laxmannia grandiflora</i>			
335.	1309	<i>Laxmannia squarrosa</i>			
336.	1051	<i>Lemna disperma</i> (Duckweed)			
337.	18074	<i>Lepidobolus preissianus</i> subsp. <i>preissianus</i>			
338.	925	<i>Lepidosperma angustatum</i>			
339.	930	<i>Lepidosperma costale</i>			
340.	936	<i>Lepidosperma leptostachyum</i>			
341.	937	<i>Lepidosperma longitudinale</i> (Pithy Sword-sedge)			
342.	940	<i>Lepidosperma pubisquameum</i>			
343.	1653	<i>Leporella fimbriata</i> (Hare Orchid)			
344.	5847	<i>Leptospermum erubescens</i> (Roadside Teatree)			
345.	1088	<i>Lepyrodia macra</i> (Large Scale Rush)			
346.	25128	<i>Lerista christinae</i>			
347.	25133	<i>Lerista elegans</i>			
348.	25165	<i>Lerista praepedita</i>			
349.	6439	<i>Leucopogon pulchellus</i> (Beard-heath)			
350.	40803	<i>Leucopogon squarrosus</i> subsp. <i>squarrosus</i>			
351.	6451	<i>Leucopogon tenuis</i>			
352.	7677	<i>Levenhookia stipitata</i> (Common Stylewort)			
353.	25005	<i>Lialis burtonis</i>			
354.	24581	<i>Lichenostomus virescens</i> (Singing Honeyeater)			
355.	25661	<i>Lichmera indistincta</i> (Brown Honeyeater)			
356.	4363	<i>Linum trigynum</i> (French Flax)	Y		
357.	36160	<i>Liparophyllum capitatum</i>			
358.	25378	<i>Litoria adelaidensis</i> (Slender Tree Frog)			
359.	25388	<i>Litoria moorei</i> (Motorbike Frog)			
360.	1223	<i>Lomandra caespitosa</i> (Tufted Mat Rush)			
361.	4059	<i>Lotus angustissimus</i> (Narrowleaf Trefoil)	Y		
362.	1092	<i>Loxocarya cinerea</i>			
363.	4065	<i>Lupinus angustifolius</i> (Narrowleaf Lupin)	Y		
364.	1097	<i>Lyginia barbata</i>			
365.	18049	<i>Lyginia imberbis</i>			
366.	36375	<i>Lysimachia arvensis</i> (Pimpernel)	Y		
367.	34736	<i>Lysinema pentapetalum</i>			
368.	25654	<i>Malurus splendens</i> (Splendid Fairy-wren)			
369.	17683	<i>Meeboldina cana</i>			
370.	17747	<i>Meeboldina decipiens</i>			
371.	34676	<i>Meionectes brownii</i> (Swamp Raspwort)			
372.	5926	<i>Melaleuca lateritia</i> (Robin Redbreast Bush)			
373.	5958	<i>Melaleuca radula</i> (Graceful Honeymyrtle)			
374.	5959	<i>Melaleuca raphiophylla</i> (Swamp Paperbark)			
375.	19365	<i>Melaleuca ryeae</i>			
376.	5978	<i>Melaleuca teretifolia</i> (Banbar)			
377.	5987	<i>Melaleuca viminea</i> (Mohan)			
378.	25663	<i>Melithreptus brevirostris</i> (Brown-headed Honeyeater)			
379.	25184	<i>Menetia greyii</i>			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
380.	25693	<i>Microeca fascians</i> (Jacky Winter)			
381.	485	<i>Microlaena stipoides</i> (Weeping Grass)			
382.	1657	<i>Microtis alba</i> (White Mignonette Orchid)			
383.	15419	<i>Microtis media</i> subsp. <i>media</i>			
384.	8105	<i>Millotia myosotidifolia</i>			
385.	4100	<i>Mirbelia spinosa</i>			
386.	7410	<i>Monopsis debilis</i>	Y		
387.	37440	<i>Monopsis debilis</i> var. <i>depressa</i>	Y		
388.	4666	<i>Monotaxis occidentalis</i>			
389.	19179	<i>Moraea flaccida</i> (One-leaf Cape Tulip)	Y		
390.	25191	<i>Morethia lineocellata</i>			
391.	2412	<i>Muehlenbeckia adpressa</i> (Climbing Lignum)			
392.	8114	<i>Myriocephalus appendiculatus</i> (White-tip Myriocephalus)			
393.	8117	<i>Myriocephalus helichrysoides</i>			
394.	14187	<i>Myriocephalus occidentalis</i>			
395.	6189	<i>Myriophyllum crispatum</i>			
396.	6192	<i>Myriophyllum drummondii</i>			
397.	25426	<i>Neobatrachus pelobatoides</i> (Humming Frog)			
398.	492	<i>Neurachne alopecuroides</i> (Foxtail Mulga Grass)			
399.	25252	<i>Notechis scutatus</i> (Tiger Snake)			
400.	2401	<i>Nuytsia floribunda</i> (Christmas Tree)			
401.	25564	<i>Nycticorax caledonicus</i> (Rufous Night Heron)			
402.	24407	<i>Ocyphaps lophotes</i> (Crested Pigeon)			
403.	-14595	<i>Oecobius navus</i>			
404.	8143	<i>Olearia paucidentata</i> (Autumn Scrub Daisy)			
405.	18255	<i>Opercularia vaginata</i> (Dog Weed)			
406.	36177	<i>Ornduffia albiflora</i>			
407.	7122	<i>Orobanche minor</i> (Lesser Broomrape)	Y		
408.	4355	<i>Oxalis perennans</i>			
409.	4356	<i>Oxalis pes-caprae</i> (Soursob)	Y		
410.	13135	<i>Ozothamnus ramosus</i>			
411.	25680	<i>Pachycephala rufiventris</i> (Rufous Whistler)			
412.	25253	<i>Parasuta gouldii</i>			
413.	25681	<i>Pardalotus punctatus</i> (Spotted Pardalote)			
414.	25682	<i>Pardalotus striatus</i> (Striated Pardalote)			
415.	7089	<i>Parentucellia latifolia</i> (Common Bartsia)	Y		
416.	7090	<i>Parentucellia viscosa</i> (Sticky Bartsia)	Y		
417.	519	<i>Paspalidium constrictum</i> (Knottybutt Grass)			
418.	1550	<i>Patersonia occidentalis</i> (Purple Flag)			
419.	6006	<i>Pericalymma ellipticum</i> (Swamp Teatree)			
420.	16478	<i>Pericalymma ellipticum</i> var. <i>floridum</i>			
421.	13911	<i>Persicaria decipiens</i>			
422.	24659	<i>Petroica goodenovii</i> (Red-capped Robin)			
423.	2284	<i>Petrophile biloba</i> (Granite Petrophile)			
424.	20391	<i>Petrophile juncifolia</i>			
425.	2299	<i>Petrophile linearis</i> (Pixie Mops)			
426.	2308	<i>Petrophile seminuda</i>			
427.	19825	<i>Petrorhagia dubia</i>	Y		
428.	24667	<i>Phalacrocorax sulcirostris</i> (Little Black Cormorant)			
429.	25699	<i>Phalacrocorax varius</i> (Pied Cormorant)			
430.	551	<i>Phalaris minor</i> (Lesser Canary Grass)	Y		
431.	24409	<i>Phaps chalcoptera</i> (Common Bronzewing)			
432.	1173	<i>Philydrella pygmaea</i> (Butterfly Flowers)			
433.	24596	<i>Phylidonyris novaehollandiae</i> (New Holland Honeyeater)			
434.	4675	<i>Phyllanthus calycinus</i> (False Boronia)			
435.		<i>Phytophthora cinnamomi</i>			
436.	78	<i>Piilularia novae-hollandiae</i> (Austral Pillwort)			
437.	11404	<i>Pimelea imbricata</i> var. <i>major</i>			
438.	11402	<i>Pimelea imbricata</i> var. <i>piligera</i>			
439.	12041	<i>Pimelea suaveolens</i> subsp. <i>suaveolens</i> (Tall Mulla Mulla)			
440.	25721	<i>Platycercus zonarius</i> (Australian Ringneck)			
441.	24750	<i>Platycercus zonarius</i> subsp. <i>semitorquatus</i> (Twenty-eight Parrot)			
442.	24751	<i>Platycercus zonarius</i> subsp. <i>zonarius</i>			
443.	25007	<i>Pletholax gracilis</i> subsp. <i>gracilis</i>			
444.	8175	<i>Podolepis gracilis</i> (Slender Podolepis)			
445.	8177	<i>Podolepis lessonii</i>			
446.	8183	<i>Podotheca chrysantha</i> (Yellow Podotheca)			
447.	8184	<i>Podotheca gnaphalioides</i> (Golden Long-heads)			
448.	24907	<i>Pogona minor</i> subsp. <i>minor</i>			
449.	24681	<i>Poliiocephalus poliiocephalus</i> (Hoary-headed Grebe)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
450.	582 <i>Polypogon monspeliensis</i> (Annual Beardgrass)	Y		
451.	583 <i>Polypogon tenellus</i>			
452.	30854 <i>Polytelis anthopeplus</i> subsp. <i>westralis</i>			
453.	25731 <i>Porphyrio porphyrio</i> (Purple Swampphen)			
454.	1671 <i>Prasophyllum elatum</i> (Tall Leek Orchid)			
455.	1672 <i>Prasophyllum fimbria</i> (Fringed Leek Orchid)			
456.	25261 <i>Pseudechis australis</i> (Mulga Snake)			
457.	25259 <i>Pseudonaja affinis</i> subsp. <i>affinis</i> (Dugite)			
458.	25433 <i>Pseudophryne guentheri</i> (Crawling Toadlet)			
459.	11118 <i>Pterostylis pyramidalis</i> (Snail Orchid)			
460.	2716 <i>Ptilotus declinatus</i> (Curved Mulla Mulla)			
461.	2720 <i>Ptilotus esquamatus</i>			
462.	2742 <i>Ptilotus manglesii</i> (Pom Poms)			
463.	8195 <i>Quinetia urvillei</i>			
464.	25271 <i>Ramphotyphlops australis</i>			
465.	25288 <i>Ramphotyphlops waitii</i>			
466.	2932 <i>Ranunculus colonorum</i> (Common Buttercup)			
467.	2937 <i>Ranunculus sessiliflorus</i> (Smallflower Buttercup)			
468.	3061 <i>Raphanus raphanistrum</i> (Wild Radish)	Y		
469.	24245 <i>Rattus rattus</i> (Black Rat)	Y		
470.	6012 <i>Regelia ciliata</i>			
471.	25614 <i>Rhipidura leucophrys</i> (Willie Wagtail)			
472.	13312 <i>Rhodanthe pyrethrum</i>			
473.	1556 <i>Romulea rosea</i> (Guildford Grass)	Y		
474.	11544 <i>Romulea rosea</i> var. <i>australis</i> (Guildford Grass)	Y		
475.	14924 <i>Romulea rosea</i> var. <i>communis</i>	Y		
476.	2433 <i>Rumex crispus</i> (Curled Dock)	Y		
477.	40430 <i>Rytidosperma pilosum</i>			
478.	40427 <i>Rytidosperma setaceum</i>			
479.	6483 <i>Samolus junceus</i>			
480.	41660 <i>Schenkia australis</i>			
481.	968 <i>Schoenoplectus pungens</i> (Sharpleaf Rush)			
482.	975 <i>Schoenus bifidus</i>			
483.	984 <i>Schoenus curvifolius</i>			
484.	985 <i>Schoenus discifer</i>			
485.	994 <i>Schoenus humilis</i>			
486.	1006 <i>Schoenus odontocarpus</i>			
487.	17614 <i>Schoenus plumosus</i>			
488.	1011 <i>Schoenus rigens</i>			
489.	18164 <i>Schoenus</i> sp. <i>smooth culms</i> (K.R. Newbey 7823)			
490.	1017 <i>Schoenus subbulbosus</i>			
491.	1023 <i>Schoenus tenellus</i>			
492.	1026 <i>Schoenus unispiculatus</i>			
493.	17409 <i>Schoenus variicellae</i>			
494.	6033 <i>Scholtzia involucrata</i> (Spiked Scholtzia)			
495.	6 <i>Selaginella gracillima</i> (Tiny Clubmoss)			
496.	20663 <i>Senecio multicaulis</i> subsp. <i>multicaulis</i>			
497.	2909 <i>Silene gallica</i> (French Catchfly)	Y		
498.	15972 <i>Silene gallica</i> var. <i>gallica</i>	Y		
499.	11803 <i>Silene gallica</i> var. <i>quinquevulnera</i>	Y		
500.	8225 <i>Siloxerus humifusus</i> (Procumbent Siloxerus)			
501.	25266 <i>Simoselaps bertholdi</i> (Jan's Banded Snake)			
502.	30948 <i>Smicromis brevirostris</i> (Weebill)			
503.	6988 <i>Solanum americanum</i> (Glossy Nightshade)	Y		
504.	7022 <i>Solanum nigrum</i> (Black Berry Nightshade)	Y		
505.	8230 <i>Sonchus asper</i> (Rough Sowthistle)	Y		
506.	8231 <i>Sonchus oleraceus</i> (Common Sowthistle)	Y		
507.	1312 <i>Sowerbaea laxiflora</i> (Purple Tassels)			
508.	623 <i>Spartochloa scirpoidea</i>			
509.	6930 <i>Stachys arvensis</i> (Staggerweed)	Y		
510.	16197 <i>Stenanthemum emarginatum</i>			
511.	2316 <i>Stirlingia latifolia</i> (Blueboy)			
512.	25597 <i>Strepera versicolor</i> (Grey Currawong)			
513.	25589 <i>Streptopelia chinensis</i> (Spotted Turtle-Dove)	Y		
514.	25590 <i>Streptopelia senegalensis</i> (Laughing Turtle-Dove)	Y		
515.	24943 <i>Strophurus spinigerus</i> subsp. <i>inornatus</i>			
516.	24942 <i>Strophurus spinigerus</i> subsp. <i>spinigerus</i>			
517.	7693 <i>Stylidium brunonianum</i> (Pink Fountain Triggerplant)			
518.	7712 <i>Stylidium despectum</i> (Dwarf Triggerplant)			
519.	7713 <i>Stylidium dichotomum</i> (Pins-and-needles)			

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
520.	7717	<i>Stylidium divaricatum</i> (Daddy-long-legs)			
521.	7719	<i>Stylidium ecome</i> (Foot Triggerplant)			
522.	25800	<i>Stylidium paludicola</i>			
523.	7773	<i>Stylidium petiolare</i> (Horn Triggerplant)			
524.	30274	<i>Stylidium purpureum</i> subsp. non stilted (J.A. Wege & F. Hort JAW 1384)			
525.	33106	<i>Stylidium recurvum</i>			
526.	7785	<i>Stylidium repens</i> (Matted Triggerplant)			
527.	25806	<i>Stylidium scarosum</i>			
528.	25830	<i>Stylidium</i> sp. Darling Range (H. Bowler 371)			
529.	3181	<i>Stylobasium australe</i>			
530.	2325	<i>Synaphea pinnata</i> (Helena Synaphea)			
531.	25705	<i>Tachybaptus novaehollandiae</i> (Australasian Grebe)			
532.	24331	<i>Tadorna tadornoides</i> (Australian Shelduck)			
533.	24167	<i>Tarsipes rostratus</i> (Honey Possum)			
534.	-13561	<i>Tasmanicosa leuckartii</i>			
535.	1701	<i>Thelymitra antennifera</i> (Vanilla Orchid)			
536.	673	<i>Themeda triandra</i>			
537.	24844	<i>Threskiornis molucca</i> (Australian White Ibis)			
538.	24845	<i>Threskiornis spinicollis</i> (Straw-necked Ibis)			
539.	1328	<i>Thysanotus dichotomus</i> (Branching Fringe Lily)			
540.	1343	<i>Thysanotus patersonii</i>			
541.	1357	<i>Thysanotus thyrsoides</i>			
542.	25203	<i>Tiliqua occipitalis</i> (Western Bluetongue)			
543.	25549	<i>Todiramphus sanctus</i> (Sacred Kingfisher)			
544.	6280	<i>Trachymene pilosa</i> (Native Parsnip)			
545.	1481	<i>Tribonanthes australis</i>			
546.	1483	<i>Tribonanthes longipetala</i>			
547.	4383	<i>Tribulus terrestris</i> (Caltrop)	Y		
548.	1361	<i>Tricoryne elatior</i> (Yellow Autumn Lily)			
549.	17763	<i>Trifolium campestre</i> var. <i>campestre</i> (Hop Clover)	Y		
550.	4295	<i>Trifolium dubium</i> (Suckling Clover)	Y		
551.	4313	<i>Trifolium subterraneum</i> (Subterranean Clover)	Y		
552.	19039	<i>Triglochin bulbosa</i>	Y		
553.	148	<i>Triglochin muelleri</i>			
554.	1139	<i>Trithuria bibracteata</i>			
555.	1141	<i>Trithuria submersa</i>			
556.	708	<i>Triticum aestivum</i> (Wheat)	Y		
557.	33418	<i>Trymalium odoratissimum</i> subsp. <i>odoratissimum</i>			
558.	24852	<i>Tyto alba</i> subsp. <i>delicatula</i> (Barn Owl)			
559.	8255	<i>Ursinia anthemoides</i> (Ursinia)	Y		
560.	38388	<i>Ursinia anthemoides</i> subsp. <i>anthemoides</i>	Y		
561.	7131	<i>Utricularia dichotoma</i> (Fairly Aprons)			
562.	7138	<i>Utricularia inaequalis</i>			
563.	7148	<i>Utricularia multifida</i>			
564.	7153	<i>Utricularia tenella</i>			
565.	7157	<i>Utricularia violacea</i> (Violet Bladderwort)			
566.	34772	<i>Vachellia karroo</i>	Y		
567.	25526	<i>Varanus tristis</i> (Racehorse Monitor)			
568.	8257	<i>Vellereophyton dealbatum</i> (White Cudweed)	Y		
569.	15431	<i>Verticordia acerosa</i> var. <i>acerosa</i>			
570.	6076	<i>Verticordia densiflora</i> (Compacted Featherflower)			
571.	15432	<i>Verticordia densiflora</i> var. <i>densiflora</i>			
572.	6088	<i>Verticordia huegelii</i> (Variegated Featherflower)			
573.	15434	<i>Verticordia insignis</i> subsp. <i>insignis</i>			
574.	4322	<i>Vicia sativa</i> (Common Vetch)	Y		
575.	4325	<i>Viminaria juncea</i> (Swishbush)			
576.	17042	<i>Vitis vinifera</i>	Y		
577.	722	<i>Vulpia bromoides</i> (Squirrel Tail Fescue)	Y		
578.	724	<i>Vulpia myuros</i> (Rat's Tail Fescue)	Y		
579.	1567	<i>Watsonia meriana</i> (Bulbil Watsonia)	Y		
580.	18118	<i>Watsonia meriana</i> var. <i>meriana</i>	Y		
581.	12072	<i>Wurmbea dioica</i> subsp. <i>alba</i>			
582.	1253	<i>Xanthorrhoea gracilis</i> (Graceful Grass Tree)			
583.	1256	<i>Xanthorrhoea preissii</i> (Grass tree)			
584.	6284	<i>Xanthosia candida</i>			
585.	6285	<i>Xanthosia ciliata</i>			
586.	25765	<i>Zosterops lateralis</i> (Grey-breasted White-eye)			

Conservation Codes

T - Rare or likely to become extinct

Name	ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
X - Presumed extinct					
IA - Protected under international agreement					
S - Other specially protected fauna					
1 - Priority 1					
2 - Priority 2					
3 - Priority 3					
4 - Priority 4					
5 - Priority 5					

¹ For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.



APPENDIX 3

Protected Matters Search Tool Report



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 24/01/13 16:56:34

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

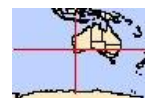
[Acknowledgements](#)



This map may contain data which are
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[Coordinates](#)

Buffer: 0.5Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	17
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As [heritage values](#) of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	6
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	1
Regional Forest Agreements:	1
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [\[Resource Information \]](#)

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Claypans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [\[Resource Information \]](#)

Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
Insects		
Synemon gratiosa Graceful Sun Moth [66757]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Plants		

Name	Status	Type of Presence
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leaved Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat may occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat may occur within area
Grevillea curviloba subsp. curviloba Curved-leaf Grevillea [64908]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Thelymitra manginii K.Dixon & Batty ms. [67443]	Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area
Villarsia calthifolia Mountain Villarsia [10886]	Endangered	Species or species habitat may occur within area
Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		

Name	Threatened	Type of Presence
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species	[Resource Information]	
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [\[Resource Information \]](#)

Name	State
Ellen Brook	WA

Regional Forest Agreements [\[Resource Information \]](#)

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [\[Resource Information \]](#)

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.

Name	Status	Type of Presence
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Mammals

[Capra hircus](#)

Goat [2]		Species or species habitat likely to occur within area
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[Felis catus](#)

Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
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[Oryctolagus cuniculus](#)

Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
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[Sus scrofa](#)

Pig [6]		Species or species habitat likely to occur within area
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[Vulpes vulpes](#)

Red Fox, Fox [18]		Species or species habitat likely to occur within area
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Plants

[Asparagus asparagoides](#)

Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
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[Brachiaria mutica](#)

Para Grass [5879]		Species or species habitat may occur within area
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[Cenchrus ciliaris](#)

Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
--	--	--

[Chrysanthemoides monilifera](#)

Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
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[Genista sp. X Genista monspessulana](#)

Broom [67538]		Species or species habitat may occur within area
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[Lantana camara](#)

Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
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[Lycium ferocissimum](#)

African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area
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Name	Status	Type of Presence
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area

Coordinates

-31.740089 116.019495,-31.747856 116.024139,-31.763922 116.025358

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [Department of Environment, Climate Change and Water, New South Wales](#)
- [Department of Sustainability and Environment, Victoria](#)
- [Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [Department of Environment and Natural Resources, South Australia](#)
- [Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts](#)
- [Environmental and Resource Management, Queensland](#)
- [Department of Environment and Conservation, Western Australia](#)
- [Department of the Environment, Climate Change, Energy and Water](#)
- [Birds Australia](#)
- [Australian Bird and Bat Banding Scheme](#)
- [Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [Museum Victoria](#)
- [Australian Museum](#)
- [SA Museum](#)
- [Queensland Museum](#)
- [Online Zoological Collections of Australian Museums](#)
- [Queensland Herbarium](#)
- [National Herbarium of NSW](#)
- [Royal Botanic Gardens and National Herbarium of Victoria](#)
- [Tasmanian Herbarium](#)
- [State Herbarium of South Australia](#)
- [Northern Territory Herbarium](#)
- [Western Australian Herbarium](#)
- [Australian National Herbarium, Atherton and Canberra](#)
- [University of New England](#)
- [Ocean Biogeographic Information System](#)
- [Australian Government, Department of Defence](#)
- [State Forests of NSW](#)
- [Geoscience Australia](#)
- [CSIRO](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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APPENDIX 4

Definitions of Conservation Codes

Western Australian and Commonwealth of Australia Conservation Codes

Flora

Definitions of the Conservation Codes for the Status of Flora under the Wildlife Conservation Act 1950 follow:

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa1 which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered

Considered to be facing an extremely high risk of extinction in the wild

EN: Endangered

Considered to be facing a very high risk of extinction in the wild

VU: Vulnerable

Considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Taxa that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Priority One: Poorly-known taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or

more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring

Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Vegetation

Definitions and criteria for presumed totally destroyed, critically endangered, endangered and vulnerable ecological communities are outlined below.

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence

of it is likely to recover its species composition and/or structure in the foreseeable future.

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤ 5 occurrences or a total area of $\leq 100\text{ha}$). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤ 10 occurrences or a total area of $\leq 200\text{ha}$). At least some occurrences are

not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Fauna

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, DEC also classifies fauna under five different Priority codes and rare and endangered fauna are classified under the Wildlife Conservation (Specially Protected Fauna) Notice 2006 into four schedules of taxa.

Schedule 1

Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2

Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3

Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.

Schedule 4

Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, the DEC also classifies fauna under five different priority codes:

Priority One: Taxa with few, poorly known populations on threatened lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Two: Taxa with few, poorly known populations on conservation lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Three: Taxa with several, poorly known populations, some on conservation lands

Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Four: Taxa in need of monitoring

Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Priority Five: Taxa in need of monitoring (conservation dependent)

Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Commonwealth of Australia Conservation Codes

The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* has the following nine conservation codes for Flora and Fauna.

Extinct

Taxa not definitely located in the wild during the past 50 years

Extinct in the Wild

Taxa known to survive only in captivity

Critically Endangered

Taxa facing an extremely high risk of extinction in the wild in the immediate future

Endangered

Taxa facing a very high risk of extinction in the wild in the near future

Vulnerable

Taxa facing a high risk of extinction in the wild in the medium-term

Near Threatened

Taxa that risk becoming Vulnerable in the wild

Conservation Dependent

Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known)

Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern

Taxa that are not considered Threatened

APPENDIX 5

DPaW TEC and PEC Database Search

FID	BDY_ID	OCC_UNIQUE	COM_ID	COM_NAME	CT_DESC	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	OCC_CONFID
0	0	3008	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	BAW9		500	Yes
1	0	2975	SCP22	Banksia ilicifolia woodlands	Priority 3	1	BIW9		500	Yes
2	0	3179	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	BAS25		500	Yes
3	0	3180	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	BAS26		500	Yes
4	237	167	SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	1	TWIN05		500	No
5	0	3168	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	TWIN07		500	No
6	0	3169	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	TWIN08		500	No
7	774	168	SCP15	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain	Vulnerable	1	TWIN10		500	No
8	0	3115	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3	1	SEW1		500	Yes
9	241	29	Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Critically Endangered	1	EG01		1500	No
10	0	3059	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE01		500	No
11	0	4979	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE02		500	No
12	0	3058	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE03		500	No
13	0	3057	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE08		500	No
14	0	4981	SCP18	Shrublands on calcareous silts of the Swan Coastal Plain	Vulnerable	1	ELE13		500	No
15	0	4983	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE22		500	No
16	0	4984	SCP22	Banksia ilicifolia woodlands	Priority 3	1	ELE23		500	No
17	0	3039	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE24		500	No
18	0	4988	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE25		500	No
19	0	4989	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE27		500	No
20	0	3063	SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	Priority 3	1	ELE28		500	No
21	0	4985	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	ELE29		500	No
22	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN01		1000	No
23	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN02		1000	No
24	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN03		1000	No
25	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN04		1000	No
26	1099	222	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	ELLEN05		1000	No
27	1095	120	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN06		500	No
28	1096	1962	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN07		500	No
29	1097	1963	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN08		500	No
30	560	40	Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	1	VINESSE		1000	No
31	560	40	Muchea Limestone	Shrublands and woodlands on Muchea Limestone	Endangered	1	VINESSW		1000	No
32	1098	1964	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	ELLEN09		500	No
33	0	4428	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3	1	vines01		500	No

APPENDIX 6

Species List

SPECIES LIST – Railway Parade Bridge

PTERIDOPHYTES

DENNSTAEDTIACEAE
Pteridium esculentum

GYMNOSPERMS

CYCADACEAE
Macrozamia fraseri

MONOCOTYLEDONS

ARACEAE
**Zantedeschia aethiopica*

ASPARAGACEAE
Sowerbaea laxiflora

COLCHICACEAE
Burchardia congesta

CYPERACEAE
Mesomelaena tetragona
Lepidosperma longitudinale

DASYPOGONACEAE
Dasypogon bromeliifolius

HAEMODORACEAE
Conostylis aculeata subsp. *aculeata*
Haemodorum laxum

HEMEROCALLIDACEAE
Tricoryne elatior

IRIDACEAE
**Gladiolus caryophyllaceus*
**Hesperantha falcata*
**Moraea flaccida*
Patersonia occidentalis
**Sparaxis pillansii*
**Watsonia bulbifera*

JUNCACEAE
Juncus pallidus

ORCHIDACEAE
Thelymitra spiralis

POACEAE
**Arundo donax*
**Avena fatua*
**Briza maxima*
**Briza minor*
**Ehrharta calycina*
**Ehrharta longiflora*
**Eragrostis curvula*
**Hordeum leporinum*
**Hyparrhenia hirta*
**Lolium perenne*
**Melinis repens*
**Pennisetum clandestinum*
**Pentaschistis airoides*
Neurachne alopecuroidea
Sporobolus virginicus
**Vulpia myuros*

RESTIONACEAE
Desmocladus flexuosus
Hypolaena exsulca

TYPHACEAE
**Typha orientalis*

XANTHORRHOEACEAE
Xanthorrhoea brunonis
Xanthorrhoea preissii

DICOTYLEDONS

AMARANTHACEAE
Ptilotus polystachyus

ASTERACEAE
**Arctotheca calendula*
**Hypochaeris glabra*
Podotheca angustifolia
**Sonchus oleraceus*
**Taraxacum officinale*

**Ursinia anthemoides*

CAMPANULACEAE

**Wahlenbergia capensis*

BORAGINACEAE

**Echium plantagineum*

BRASSICACEAE

**Brassica tournefortii*

CARYOPHYLLACEAE

**Petrorhagia dubia*

**Silene gallica* var. *gallica*

CRASSULACEAE

Crassula colorata

DILLENIACEAE

Hibbertia hypericoides

DROSERACEAE

Drosera glanduligera

Drosera menziesii subsp. *menziesii*

EUPHORBIACEAE

Phyllanthus calycinus

FABACEAE

**Acacia iteaphylla*

Acacia saligna

Bossiaea eriocarpa

Jacksonia furcellata

Jacksonia sternbergiana

Kennedia prostrata

**Ornithopus sativus*

**Lotus subbiflorus*

**Lupinus cosentinii*

**Trifolium campestre*

**Trifolium arvense* subsp. *arvense*

**Vicia sativa*

FUMARIACEAE

**Fumaria capreolata*

GERANIACEAE

**Erodium cicutarium*

**Pelargonium capitatum*

GOODENIACEAE

Dampiera trigona

LORANTHACEAE

Nuytsia floribunda

MYRTACEAE

Corymbia calophylla

Eucalyptus rudis

Hypocalymma angustifolium

Melaleuca raphiophylla

Melaleuca seriata

OROBANCHACEAE

**Orobanche minor*

**Parentucellia*

OXALIDACEAE

**Oxalis pes-caprae*

**Oxalis purpurea*

POLYGONACEAE

**Acetosella vulgaris*

PROTEACEAE

Adenanthos cygnorum subsp. *cygnorum*

Banksia attenuata

Banksia menziesii

Banksia littoralis

Banksia dallanneyi

Grevillea crithmifolia

Hakea prostrata

Petrophile linearis

RUBIACEAE

Opercularia vaginata

SOLANACEAE

**Solanum nigrum*

Solanum symonii

APPENDIX 7

Releve Data

Releve 1

407650 E 6485713 S

Vegetation: *Corymbia calophylla* Low Open Woodland over *Acacia saligna*
Closed Heath over *Watsonia bulbillifera* Closed Herbland

Condition: Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Corymbia calophylla</i>	6-7	
<i>Acacia saligna</i>	1.5-2	75
* <i>Watsonia bulbillifera</i>	0.5	90
<i>Xanthorrhoea preissii</i>		
<i>Jacksonia sternbergiana</i>		
<i>Hakea prostrata</i>		
<i>Hypocalymma angustifolium</i>		
* <i>Oxalis pes-caprae</i>		
* <i>Eragrostis curvula</i>		
* <i>Hyparrhenia hirta</i>		

* introduced species

Releve 2

407634 E 64856061 S

Vegetation: *Jacksonia sternbergiana*/*Grevillea crithmifolia* Tall Open Shrubland
over *Watsonia bulbillifera* Closed Herbland

Condition: Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Jacksonia sternbergiana</i>	3	5
<i>Grevillea crithmifolia</i>	1.3	30
<i>Watsonia bulbillifera</i>	0.4	90
<i>Xanthorrhoea preissii</i>		
<i>Hakea prostrata</i>		
* <i>Petrorhagia dubia</i>		
* <i>Hypochaeris glabra</i>		
* <i>Lotus subbiflorus</i>		
* <i>Melinis repens</i>		
* <i>Hesperantha falcata</i>		
* <i>Pentaschistis airoides</i>		
* <i>Sonchus oleraceus</i>		
* <i>Taraxacum officinale</i>		
* <i>Sparaxis pillansii</i>		
* <i>Briza maxima</i>		

* introduced species

Releve 3

407607 E 6486501 S

Vegetation: *Jacksonia sternbergiana* Tall Open Shrubland over *Xanthorrhoea preissii* Open Shrubland over weeds

Condition: Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Jacksonia sternbergiana</i>	3	10
<i>Xanthorrhoea preissii</i>	1	2
* <i>Briza maxima</i>		Very common
* <i>Ehrharta longiflora</i>		Very common
<i>Hakea prostrata</i>		
<i>Neurachne alopecuroidea</i>		
<i>Haemodorum laxum</i>		
* <i>Erodium cicutarium</i>		
* <i>Sparaxis pillansii</i>		
* <i>Watsonia bulbillifera</i>		
<i>Drosera glanduligera</i>		
* <i>Briza minor</i>		
* <i>Trifolium campestre</i>		
* <i>Eragrostis curvula</i>		
* <i>Oxalis purpurea</i>		

* introduced species

Releve 4

407594 E 6486693 S

Vegetation: *Corymbia calophylla* (Marri) Low Woodland over *Watsonia bulbillifera* Closed Herbland

Condition: Completely Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Corymbia calophylla</i>	8	10
* <i>Watsonia bulbillifera</i>	1	100
* <i>Eragrostis curvula</i>		
* <i>Avena fatua</i>		
* <i>Ehrharta longiflora</i>		

* introduced species

Releve 5

407593 E 6486727 S

Vegetation: *Eucalyptus rudis* Low Woodland over *Watsonia bulbillifera* Closed Herbland

Condition: Completely Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Eucalyptus rudis</i>	8-10	25
<i>Watsonia bulbillifera</i>	1	100
<i>Melaleuca raphiophylla</i>		
* <i>Ehrharta longiflora</i>		Very common
* <i>Fumaria capreolata</i>		
* <i>Vulpia myuros</i>		

* introduced species

Releve 6

407574 E 6486920 S

Vegetation: *Eucalyptus rudis*/*Melaleuca raphiophylla* Low Open Woodland over weeds

Condition: Completely Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Eucalyptus rudis</i>	8-10	25
<i>Melaleuca raphiophylla</i>	4	5
* <i>Fumaria capreolata</i>		Very common
* <i>Avena fatua</i>		Very common
* <i>Ehrharta longiflora</i>		Very common
* <i>Zantedeschia aethiopica</i>		Common
* <i>Watsonia bulbillifera</i>		Common
* <i>Lupinus cosentinii</i>		Common
* <i>Vulpia myuros</i>		
* <i>Typha orientalis</i>		
* <i>Sonchus oleraceus</i>		
* <i>Pennisetum clandestinum</i>		
<i>Acacia saligna</i>		
* <i>Conyza bonariensis</i>		
<i>Juncus pallidus</i>		
* <i>Solanum nigrum</i>		

* introduced species

Releve 7

407532 E 6487107 S

Vegetation: *Banksia attenuata* Low Open Woodland over weeds

Condition: Completely Degraded



SPECIES	HEIGHT (m)	COVER (%)
<i>Banksia attenuata</i>	4	20
* <i>Ehrharta longiflora</i>	1	
* <i>Pelargonium capitatum</i>		common
<i>Macrozamia fraseri</i>		
<i>Podotherca angustifolium</i>		
* <i>Brassica tournefortii</i>		
* <i>Lolium perenne</i>		
* <i>Arctotheca calendula</i>		
<i>Desmocladius flexuosus</i>		
* <i>Gladiolus caryophyllaceus</i>		
* <i>Ursinia anthemoides</i>		

* introduced species

Releve 8

407272 E 6487585 S

Vegetation: *Nuytsia floribunda* Low Open Woodland over mixed shrubs and herbs (recovering from fire)

Condition: Good



SPECIES	HEIGHT (m)	COVER (%)
<i>Nuytsia floribunda</i>	4-5	10
<i>Haemodorum laxum</i>		very common
<i>Desmocladius flexuosus</i>		common
<i>Hypolaena exsulca</i>		
* <i>Pelargonium capitatum</i>		
* <i>Ehrharta longiflora</i>		
* <i>Trifolium arvense</i> subsp. <i>arvense</i>		
<i>Patersonia occidentalis</i>		
<i>Conostylis aculeata</i>		
<i>Burchardia congesta</i>		
<i>Xanthorrhoea brunonis</i>		
<i>Bossiaea eriocarpa</i>		
* <i>Acetosella vulgaris</i>		
<i>Dasypogon bromeliifolius</i>		
* <i>Wahlenbergia capensis</i>		
* <i>Moraea flaccida</i>		
<i>Podotheca angustifolia</i>		
<i>Sowerbaea laxiflora</i>		
* <i>Brassica tournefortii</i>		
* <i>Orobanche minor</i>		
<i>Burchardia congesta</i>		

* introduced species

APPENDIX D

BLACK COCKATOO HABITAT ASSESSMENT

PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

BLACK COCKATOO HABITAT ASSESSMENT

Prepared for: City of Swan

Report Date: 5 February 2014

Version: 1

Report No. 2014-128



pgv ENVIRONMENTAL

CONTENTS

Contents	i
List of Attachments	iii
1 INTRODUCTION	1
1.1 Background.....	1
1.2 Scope of Works.....	1
2 BLACK COCKATOOS	2
2.1 Carnaby’s Black Cockatoo (<i>Calyptorhynchus latirostris</i>)	2
2.2 Forest Red-tailed Black Cockatoo (<i>Calyptorhynchus banksii naso</i>).....	2
2.3 Baudin’s Black Cockatoo (<i>Calyptorhynchus baudinii</i>).....	2
3 METHODOLOGY.....	3
4 BLACK COCKATOO HABITAT	4
4.1 Habitat definitions.....	4
4.2 Vegetation Descriptions	4
4.3 Foraging	6
4.4 Roosting.....	9
4.5 Breeding	10
4.6 Regional Context	10
4.6.1 Bush Forever Site 300.....	10
4.6.2 Bush Forever Site 301.....	10
4.6.3 Bush Forever Site 302.....	10
4.6.4 Bush Forever Site 400.....	10
4.6.5 Bush Forever Site 296.....	10
4.6.6 Bush Forever Site 412.....	11
4.6.7 Walyunga National Park	11
5 SIGNIFICANCE TEST	12
5.1 Significant Impact Guidelines 1.1	12
5.1.1 Forest Red-Tail Cockatoo.....	12
5.1.2 Carnaby’s Black Cockatoo.....	13
5.2 Black Cockatoo Referral Guidelines	15
5.2.1 Step 1: Black Cockatoo Habitat	15
5.2.2 Step 2: Level of Impact	15
5.2.3 Step 3: Mitigation	16

5.2.4	Step 4: Referral Advice	16
6	SUMMARY AND CONCLUSION	17
7	REFERENCES	18

LIST OF ATTACHMENTS

Tables

Table 1: Vegetation Condition Rating Scale

Table 2: Foraging Value Rating Matrix

Plates

Plate 1: Aerial Photography from January 2013 (Landgate, 2014)

Plate 2: Aerial Photography from November 2013 (Landgate, 2014)

Plate 3: *Acacia saligna* on Apple Street

Plate 4: *Xanthorrhoea preissii* on Apple Street

Plate 5: Marri (*Corymbia calophylla*) on Railway Parade

Plate 6: *Banksia attenuata* Woodland

Figures

Figure 1: Site Location

Figure 2: Vegetation and Significant Trees

Appendices

Appendix 1: Significant Tree Survey Results

1 INTRODUCTION

1.1 Background

The City of Swan is developing rapidly and as a result an alternative transport route west from new developments in The Vines, Ellenbrook and Aveley areas is becoming increasingly a priority. In creating a new route the City of Swan proposes to upgrade the road on Railway Parade from Apple Street to Maralla Road, construct a bridge on Railway Parade over the Ellen Brook in Upper Swan and upgrade Apple Street from Railway Parade to Great Northern Hwy (Figure 1).

The requirement for road upgrades and a bridge crossing over Ellen Brook has been identified by the WAPC in approving nearby subdivisions in The Vines area. The bridge and roadway on Railway Parade and Apple Street are to be two lanes and constructed to withstand loads in accordance with a Network 1 road.

The site extends from the Great Northern Highway to the south east, along Apple Street. The site then extends from the intersection of Apple Street and Railway Parade north along Railway Parade to Ellen Brook. At Ellen Brook the proposed bridge will cross over and then the road extends north through a wetland area and then to the intersection of Railway Parade and Maralla Road (Figure 2).

An Environmental Assessment undertaken for the area by PGV Environmental in 2013 identified three species of Black Cockatoo that could potentially be found on the site. The three species of Black Cockatoos are listed as Matters of National Environmental Significance under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

These are:

- Carnaby's Cockatoo (*Calyptorhynchus latirostris*) (Endangered);
- Forest Red-Tailed Black Cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable); and
- Baudin's Cockatoo (*Calyptorhynchus baudinii*) (Vulnerable).

1.2 Scope of Works

The Black Cockatoo Habitat Assessment has been prepared to:

- Describe the Black Cockatoo habitat on the site;
- Assess the impact of the proposed road and bridge construction on the Black Cockatoos;
- Ascertain whether referral of the proposed bridge and road construction is required under the EPBC Act; and
- Make recommendations on mitigating any impact on Black Cockatoo species.

2 BLACK COCKATOOS

2.1 Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia*, *Dryandra*, *Hakea*, *Eucalyptus*, *Grevillea*, *Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (DoE, 2013).

The site is within the modelled distribution for this species on the edge of the breeding and non-breeding ranges (SEWPaC, 2012a).

2.2 Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (SEWPaC, 2012a). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri and Jarrah (Johnstone and Kirkby, 2011).

The site is within the modelled distribution for this species (SEWPaC, 2012a).

2.3 Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species (Johnstone and Kirkby, 2011).

The site is outside of the modelled distribution for Baudin's Black Cockatoos and therefore habitat specific to this species has not been investigated further in this assessment (SEWPaC, 2012a ; Garnett *et al.*, 2011).

3 METHODOLOGY

The methodology to assess Black Cockatoo Habitat is contained in *EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus banksii naso* (SEWPaC, 2012b) and outlined in the SPRAT Database for each of the Black Cockatoo species for Black Cockatoo Habitat Assessments.

A site visit was undertaken by PGV Environmental on 27 September 2013. The site was traversed on foot and information on black cockatoo foraging, roosting and breeding habitat was assessed.

The extent, type and quality of the vegetation present, including the presence and extent of plants known to be used by Black Cockatoos was investigated for this assessment using the results of flora and vegetation studies undertaken concurrently on the site (PGV Environmental, 2014). The quality of the vegetation was ascertained in the context of foraging habitat for Black Cockatoos. During the site visit a search for feeding signs or feeding debris such as 'chewed' Banksia cones and Jarrah nuts was undertaken.

The site was also searched for evidence of roosting including areas of droppings, moulted feathers, feather down or clippings from branches under trees.

Breeding habitat is defined in the Referral Guidelines as trees of species known to support breeding within the range of the species which either have a suitable nest hollow OR are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most tree species, suitable DBH is 500 mm. The Significant Tree Survey component of this assessment was undertaken to identify trees within the site that have a DBH greater than 500mm. The location, species, tree trunk diameter at breast height (DBH) and any other important descriptive information about each tree located within the site was recorded.

4 BLACK COCKATOO HABITAT

4.1 Habitat definitions

‘Foraging habitat’ for Carnaby’s Black Cockatoos is determined from the plant species that are present on the site and evidence of feeding such as direct observation of birds or by chewed nuts and cones. ‘Roosting habitat’ is usually evident due to the presence of the cockatoos on the site in the evening and early morning and of scat under the roosting area. ‘Breeding habitat’ is defined as trees of species known to support breeding within the range of the species which either have a suitable nest hollow OR are greater than 500mm DBH.

4.2 Vegetation Descriptions

A Level 2 Flora and Vegetation Survey was undertaken on the site in 2013 (PGV Environmental, 2014). The vegetation types recorded on the site were:

- **CcAs** *Corymbia calophylla* (Marri) Low Open Woodland over *Acacia saligna* Closed Heath
- **Cc** *Corymbia calophylla* (Marri) Low Woodland over *Watsonia bulbillifera* Closed Herbland
- **Js** *Jacksonia sternbergiana* Tall Open Shrubland over *Grevillea*
- **Er** *Eucalyptus rudis* (Flooded Gum) Low Woodland over *Watsonia bulbillifera* Closed Herbland
- **ErMr** *Eucalyptus rudis*/*Melaleuca raphiophylla* Low Open Woodland over weeds
- **Ba** *Banksia attenuata* Low Open Woodland over weeds
- **Nf** *Nuytsia floribunda* (WA Christmas Tree) Low Open Woodland over mixed shrubs and herbs

The vegetation condition assessed by PGV Environmental (2013) according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000a) (Table 1).

Table 1: Vegetation Condition Rating Scale

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

Condition	Description
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

The road reserve along Apple Street was almost all Completely Degraded with the small area of *Acacia saligna* mapped as Degraded. The section of Railway Parade to the south of Ellen Brook was rated as Degraded. The vegetation on the banks of Ellen Brook were classified as Completely Degraded as was the vegetation on the wetland to the north of Ellen Brook, including the wetland. The *Banksia attenuata* woodland to the north of the wetland was classified as Completely Degraded and the area of *Nuytsia floribunda* Woodland near the intersection with Maralla Road was classified as Good.

The area to the north of Ellen Brook was burnt on 27 February 2013 which has impacted on the vegetation (Plate 1 and 2).

Plate 1: Aerial Photography from January 2013 (Landgate, 2014)



Plate 2: Aerial Photography from November 2013 (Landgate, 2014)



4.3 Foraging

The Level 2 Flora and Vegetation Survey (PGV Environmental, 2014) identified nine native species recorded on the site that are recognised as foraging habitat for Black Cockatoos (Valentine and Stock, 2008; Groom, 2010). These are:

- Orange Wattle (*Acacia saligna*);
- Harsh Hakea (*Hakea prostrata*);
- Marri (*Corymbia calophylla*);
- Candle Stick Banksia (*Banksia attenuata*);
- Firewood Banksia (*Banksia menziesii*);
- Swamp Banksia (*Banksia littoralis*);
- Couch Honey-pot (*Banksia dallanneyi*);
- Grass Tree (*Xanthorrhoea preissii*); and
- Grey Stinkwood (*Jacksonia furcellata*).

Four of the vegetation types have foraging species as one of the main components in the vegetation. There are small areas of native vegetation along Apple Street that is dominated by *Acacia saligna* and another small area containing *Xanthorrhoea preissii* and another with Marri (*Corymbia calophylla*) which is considered to be foraging habitat (Plate 3, 4 and 5).

Plate 3: *Acacia saligna* on Apple Street



Plate 4: *Xanthorrhoea preissii* on Apple Street



Plate 5: Marri (*Corymbia calophylla*) on Railway Parade



The *Banksia attenuata* woodland is fire impacted vegetation (Plate 6).

Plate 6: *Banksia attenuata* Woodland



The majority of the site is Completely Degraded and does not contain foraging habitat. The scattered Marris (*Corymbia calophylla*) and areas dominated by *Acacia saligna*, *Xanthorrhoea preissii* and *Banksia attenuata* covers a total area of 0.98ha.

There are no guidelines that specify what constitutes 'quality' foraging habitat apart from stating that it refers to the use of the habitat by Black Cockatoos rather than the overall quality of the vegetation which would normally be described using understorey as well as tree canopy. To rate the quality of the foraging habitat on the site the matrix prepared by PGV Environmental was used (Table 2).

Table 2: Foraging Value Rating Matrix

Vegetation Type	Vegetation Condition	Foraging Observed	Foraging Value
High Resource eg. Banksia woodland Marri Woodland mixed Jarrah/Banksia mixed Jarrah/Marri	VG-E	Y	Excellent
		N	Very Good
	G	Y	Very Good
		N	Good
	D-CD	Y	Good
		N	Good
Medium Resource eg. Jarrah woodland Parrot Bush Heath	VG-E	Y	Very Good
		N	Good
	G	Y	Good
		N	Poor
	D-CD	Y	Good
		N	Poor
Low Resource eg. Mixed Tuart/Jarrah Woodland Tuart woodland Flooded Gum woodland	VG-E	Y	Good
		N	Poor
	G	Y	Good
		N	Poor
	D-CD	Y	Good
		N	Poor

There was no evidence of foraging on the site. The *Acacia saligna* and *Xanthorrhoea preissii* vegetation is considered a Low Resource and were in Degraded condition. The foraging value of this vegetation is rated as Poor using the foraging value rating matrix as outlined in Table 2. The *Banksia* Woodland and Marri dominated vegetation is classified as a High Resource and is in Degraded condition. The foraging value of these vegetation types was classified as Good.

The total canopy cover of Poor foraging habitat on the site is approximately 0.89ha. The Good foraging habitat has a total canopy cover of approximately 0.09ha.

4.4 Roosting

There were some *Eucalyptus rudis* trees recorded immediately to the north of Ellen Brook which are listed as a roosting species for Black Cockatoos (Groom, 2011) but there was no evidence of roosting such as droppings, moulted feathers, feather down or clippings from branches under the trees. There was also no evidence of Black Cockatoos roosting in the Marri trees on the site.

The site does not contain a known roosting site (DoP, 2011). The closest known roosting site is located approximately 2.1km to the west of the northern part of the site in The Vines (DoP, 2011).

4.5 Breeding

Black cockatoos are known to breed in hollows of large eucalypts. The site is not known as a breeding site (DoP, 2011) and the nearest known breeding site for Carnaby's Black Cockatoos is approximately 12km to the north-east of the site on the Darling Scarp.

The site contains eight Marri (*Corymbia calophylla*) trees that are classified as potential breeding habitat (known species that can be breeding habitat with a DBH greater than 500mm). None of these trees contained hollows. The details of these trees are in Appendix 1 and are shown on Figure 2. No evidence of breeding was observed on-site by PGV Environmental in 2013.

4.6 Regional Context

There are six Bush Forever sites within 5km of the site and a National Park with a total area of almost 3,000ha. These are described below and five contain vegetation that would be considered to be habitat for Black Cockatoos.

4.6.1 Bush Forever Site 300

Bush Forever Site 300 (Maralla Road Bushland, Ellenbrook/Upper Swan) runs through the proposed road and bridge alignment and in this area is associated with Ellen Brook. The Bush Forever Site consists of 641.5ha and is mostly vegetation associated with wetlands. The uplands in the site are generally Banksia woodlands (Government of Western Australia, 2000).

4.6.2 Bush Forever Site 301

Bush Forever Site 301 (Ellenbrook Nature Reserve and Adjacent Bushland, Upper Swan) is 320m to the east of the site and is made up of 63.6ha of woodlands of *Corymbia calophylla* with scattered *Eucalyptus rudis* (Government of Western Australia, 2000).

4.6.3 Bush Forever Site 302

Bush Forever Site 302 (Swan River and Jane Brook, Ashfield to Upper Swan) is 227.3ha and is located approximately 1.8km to the south of the proposed road and bridge site. The site contains woodlands of *Eucalyptus rudis*, *Eucalyptus wandoo*, *Corymbia calophylla* and *Eucalyptus marginata* which are all habitat trees for Black Cockatoos (Government of Western Australia, 2000).

4.6.4 Bush Forever Site 400

Bush Forever Site 400 (Twins Swamps Nature Reserve and Adjacent Bushland, Bullsbrook) is located 1.7km to the north and is 170.7ha. The site has only had a limited survey but the upland vegetation mainly consists of woodland to open forest of *Banksia attenuata* and *Banksia menziesii* (Government of Western Australia, 2000).

4.6.5 Bush Forever Site 296

Bush Forever Site 296 (Ellen Brook, Upper Swan) is approximately 1.4km to the east. The Bush Forever Site is 44.1ha which has vegetation mapped as *mostly Melaleuca dominated* with *Eucalyptus*

rudis. This Bush forever site contains minimal habitat except roosting for Black Cockatoos (Government of Western Australia, 2000).

4.6.6 Bush Forever Site 412

Bush Forever Site 412 (Walyunga Road Bushland, Bullsbrook) consists of 44.5ha, Bush Forever Site 348 is located 2.7km to the east of the site. The vegetation in this Bush Forever site is described as *Eucalyptus marginata* woodland, *Eucalyptus wandoo* woodland with *Corymbia calophylla* Woodland and *Banksia sessilis* Open Shrubland (Government of Western Australia, 2000).

4.6.7 Walyunga National Park

Walyunga National Park is approximately 1,800ha in size and covers a large part of the Darling Scarp. This area typically provides habitat for Black Cockatoos.

5 SIGNIFICANCE TEST

5.1 Significant Impact Guidelines 1.1

The site contains 0.09ha of Good Foraging habitat and 0.89ha of Poor Foraging Habitat and eight potential breeding habitat trees. All of this habitat could potentially be cleared as a result of the road upgrade and bridge construction.

The significance of the impact, according to the Significant Impact Guidelines 1.1, depends on the sensitivity, value and quality of the environment and the intensity, duration, magnitude and geographic extent of the impacts. The significant impact criteria for listed flora and fauna species and ecological communities depend on the category of listing, eg. Endangered, Vulnerable or Migratory.

5.1.1 Forest Red-Tail Cockatoo

Assessment of the impact of clearing on Forest Red-tail Cockatoos against the criteria set out in these Guidelines for a significant impact on a Vulnerable species is made out below:

- *lead to a long-term decrease in the size of an important population of a species*

An important population is defined in the *Significant Impact Guidelines 1.1* as “a population that is necessary for a species’ long-term survival and recovery” and may be “key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species’ range”.

Forest Red-tail Cockatoos occur in the humid and sub-humid zones in south-west Western Australia extending from north of Gingin to east of Albany. They predominantly occur in forested areas but also occur on the Swan Coastal Plain. The site also has limited preferred foraging habitat for this species with a small number of Marri trees only. The small number of birds that would use the site for foraging is not considered to meet the criteria for an important population. Therefore, the proposed development of the site would not result in this outcome.

- *reduce the area of occupancy of an important population*

The small population that could use the site is not considered to meet the criteria for an important population. Therefore, the proposed development on the site would not result in this outcome.

- *fragment an existing important population into two or more populations*

The small population that could forage on the site is not considered to meet the criteria for an important population. Therefore, the proposed development on the site would not result in this outcome.

- *adversely affect habitat critical to the survival of a species*

Forest Red-tail Cockatoos do not breed on the site. The 0.98ha of Poor and Good foraging habitat are not considered to be critical to the survival of the species. Therefore, the proposed construction of the road and bridge on the site would not result in this outcome.

- *disrupt the breeding cycle of an important population*

Forest Red-tail Cockatoos do not breed on the site. It is considered that the proposed development on the site would not result in this outcome.

- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

There is quality foraging habitat to the north with six Bush Forever Sites and Walyunga National Park within a 5km radius of the site contain both foraging and potential breeding habitat. Therefore clearing the limited foraging habitat on the site would not cause the species to decline.

- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*

Clearing for the proposed road and bridge would not result in invasive species being introduced. Therefore, development on the site would not result in this outcome.

- *introduce disease that may cause the species to decline*

Clearing for the construction of the road and bridge with the implementation of appropriate hygiene standards during vegetation clearing, would not result in disease being introduced. Therefore, development on the site would not result in this outcome.

- *interfere substantially with the recovery of the species*

The population that would use the site, if any, is very small in comparison to the geographic distribution of the species, and is not an important population. Therefore any clearing of habitat on the site would not interfere substantially with the recovery of the species.

The conclusion in this assessment in accordance with the criteria set out in Significant Impact Guidelines 1.1 is that the construction of the road and bridge would not have a significant impact on Forest Red-tail Cockatoos.

5.1.2 Carnaby's Black Cockatoo

Assessment of the impact of clearing on Carnaby's Cockatoos against the criteria set out in these Guidelines for a significant impact on an Endangered species is below:

- *Lead to a long-term decrease in the size of a population*

The clearing of 0.89ha of Poor and 0.09ha of Good foraging habitat on the site is highly unlikely to impact on the whole population of Carnaby's Cockatoos such that it will lead to a long-term decrease in the size of the population. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Reduce the area of occupancy of the species*

There is 0.98ha of foraging habitat on the site but no evidence of recent foraging and no records or evidence of this species roosting or breeding on the site therefore the level of occupancy on the site

is considered to be very low. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Fragment an existing population into two or more populations*

Clearing of the site is unlikely to fragment the populations into sub-populations as the level of occupancy on the site is considered to be very low. Therefore, the clearing for the proposed construction of the bridge and road would not result in this outcome.

- *Adversely affect habitat critical to the survival of a species*

Carnaby's Cockatoos do not breed on the site. The 0.98ha of foraging habitat on the site is considered to be Poor to Good and there is almost 3,000ha of foraging habitat in six Bush Forever sites and Walyunga National Park within a 5km radius and therefore the habitat on the site is not critical to the survival of the species. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Disrupt the breeding cycle or a population*

Carnaby's Cockatoos do not breed on the site nor within close proximity. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

The site has limited quality foraging habitat and no records of this species roosting or breeding on the site therefore the level of occupancy on the site is considered to be very low such that clearing of vegetation would not cause the species to decline.

- *Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*

Clearing would not result in invasive species being introduced that would be harmful to Carnaby's Black Cockatoos. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Introduce disease that may cause the species to decline*

Clearing for the proposed development with the implementation of appropriate hygiene standards during vegetation clearing, would not result in disease being introduced. Therefore, the proposed construction of the bridge and road would not result in this outcome.

- *Interfere with the recovery of the species*

The population that would use the site is very small in comparison to the geographic distribution of the species, and is not an important population. Therefore any clearing of habitat on the site would not interfere with the recovery of the species

The conclusion in this assessment in accordance with the criteria set out in Significant Impact Guidelines 1.1 is that the proposed construction of the road and bridge would not have a significant impact on Carnaby's Cockatoos.

5.2 Black Cockatoo Referral Guidelines

The EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris* Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii* and Forest red-tailed black cockatoo (vulnerable) *Calyptorhynchus banksii naso* (SEWPaC, 2012b) (Black Cockatoo Guidelines) contain several steps to determine whether a referral is required or not. These steps are:

- The definition of habitat (breeding, roosting and foraging – Table 1);
- A description of the type of action that may have a high or low risk of being a significant impact and therefore require referral (Table 3);
- Formulation of a mitigation strategy to reduce the scale of impact; and
- A flowchart to assist in decision making on whether an action should be referred or not.

5.2.1 Step 1: Black Cockatoo Habitat

The first step is to determine whether the site contains habitat for any of the three listed Black Cockatoos. There is 0.89ha of Poor and 0.09ha of Good Quality foraging habitat. There is no recorded roosting or breeding on the site and limited potential breeding habitat (8 trees).

5.2.2 Step 2: Level of Impact

Foraging

According to Table 3 in the Black Cockatoo Referral Guidelines the clearing of more than 1ha of quality foraging habitat has a high risk of causing a significant impact. Degradation of more than 1ha of quality habitat by such things as altered hydrology or fire regimes has an uncertain risk. The significance of degradation depends on the type of degradation and the quality of the habitat.

The foraging habitat on the site consists of approximately 0.89ha of Poor and 0.09ha of Good foraging habitat, therefore in accordance with the guidelines, clearing is not likely to have a high risk of a significant impact.

Breeding

According to Table 3 in the Black Cockatoo Referral Guidelines the clearing of any known nesting tree has a high risk of being a significant impact. Any known nesting tree is defined in the Black Cockatoo Referral Guidelines as any existing tree in which breeding has been recorded or suspected. No known nesting trees occur on the site therefore there is no risk of a significant impact on a known nesting tree.

The Black Cockatoo Guidelines also consider that the clearing of any part or degradation of breeding habitat is likely to have a high risk of a significant impact. Breeding habitat is defined in Table 1 of the Black Cockatoo Guidelines as any patch of woodland or forest that contains live or dead trees of certain species with either a diameter at breast height greater than 500mm or the presence of

suitable nest hollows. Marri trees are considered potential breeding habitat in the Black Cockatoo Guidelines.

Importantly the Black Cockatoo Guidelines state that breeding habitat predominantly applies to those areas within the breeding range of the Black Cockatoo species as shown in the maps attached to the Guidelines. The site is identified on the maps as being on the edge of the breeding range of Carnaby's Black Cockatoo species.

According to the Black Cockatoo Guidelines, the definition of breeding habitat outside the known breeding range still applies *unless proven otherwise* (our italics). By definition, a tree can only be breeding habitat if it contains a hollow large enough for a Black Cockatoo to enter and form a nest. No trees on the site had hollows identified during habitat assessment. No evidence of breeding now or in the past has been observed in any of the hollows. Therefore these trees are highly unlikely to be breeding habitat. The risk of a significant impact is considered Low.

Roosting

The Black Cockatoo Referral Guidelines consider the clearing of a known roosting site as a high risk of being a significant impact. No roosting site is mapped on the site (DoP, 2011) and no evidence of roosting was observed during the survey. The closest mapped roosting site is approximately 2.1km away. The risk of a significant impact on a known roosting site is considered to be Low.

5.2.3 Step 3: Mitigation

The Black Cockatoo Guidelines allow the consideration of a mitigation strategy in the determination of the level of impact and requirement to refer. Application of best practice mitigation strategy may reduce the level of impact and therefore the risk of a significant impact. Mitigation strategies including avoiding impact, managing impact so that there is no net decline in habitat, and monitoring the effectiveness of mitigation.

Retention of native vegetation and trees within the road reserve including some of the potential breeding habitat trees will reduce any potential impact on Black Cockatoos.

5.2.4 Step 4: Referral Advice

Application of the Decision Making flowchart in Figure 1 of the Black Cockatoo Referral Guidelines is shown in sequence below as applied to the whole site.

- 1 Could the impacts of your action occur within the modelled distribution of the black cockatoos? – YES
- 2 Could the impacts of your action affect any black cockatoo habitat or individuals? - YES
- 3 Have you surveyed for black cockatoo habitat using the recommended methods? – YES
- 4 Could your action have an impact on black cockatoos or their habitat? – YES
- 5 Is your impact mitigation best practice so that it may reduce the significance of your impacts on black cockatoos? – YES (if required)
- 6 Could your action require a referral to the federal environment minister for significant impacts on black cockatoos? –LOW risk for foraging, breeding and roosting habitat.

RESULT – Referral Not Required.

6 SUMMARY AND CONCLUSION

The potential for Black Cockatoo species to occur on the site was investigated with Carnaby's Black Cockatoos and Forest Red-tailed Black Cockatoos considered likely to visit the site. Baudin's Black Cockatoos were not investigated as the site is outside of the modelled distribution of this species and it is highly unlikely to be present on the site.

The field survey of the site did not identify any evidence of foraging on the site. The breeding and potential breeding habitat was limited to eight Marri trees with a diameter at breast height greater than 500mm but no hollows have formed as yet. No evidence of breeding on the site has been recorded and there was no evidence that the site was used as roosting habitat.

The proposed construction of the road and bridge could, at worst case scenario remove approximately 0.09ha of Good Foraging habitat and 0.89ha of Poor Foraging Habitat, the loss of some potential roosting habitat and seven potential breeding habitat trees. The proposed construction of the road and bridge could retain some of the potential breeding habitat trees as well as some of the vegetation that is rated as Good quality foraging habitat on the site.

PGV Environmental considers the clearing for the proposed road and bridge construction would have a Low risk of a significant impact on Black Cockatoo species and in accordance with the referral guidelines, referral to the Department of the Environment under the EPBC Act is not required.

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FIGURES



CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.

pgv

ENVIRONMENTAL

Drawn: J. Hams

Date: 9 May 2014

Job: 10112

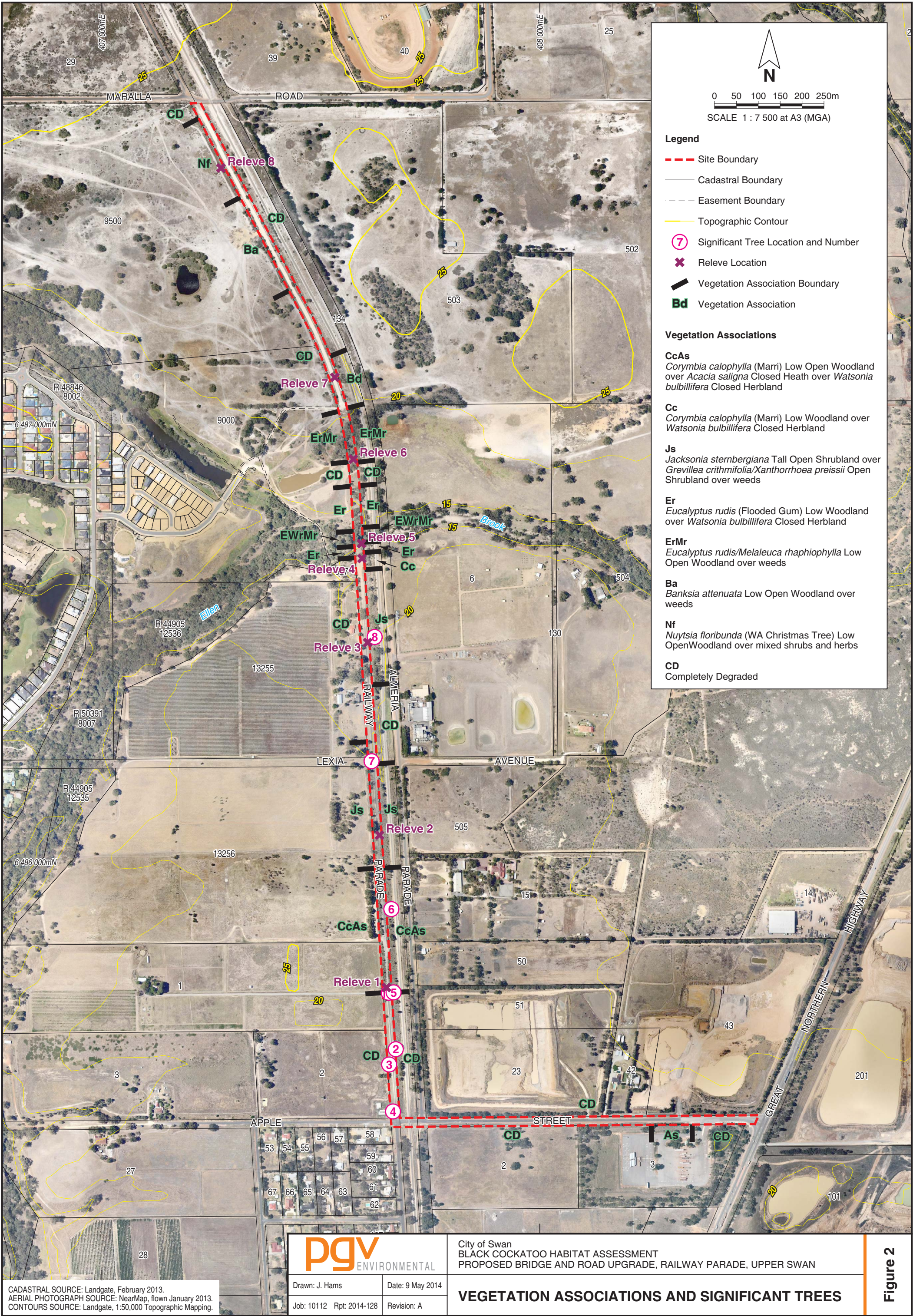
Rpt: 2014-128

Revision: A

City of Swan
BLACK COCKATOO HABITAT ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

SITE LOCATION AND TOPOGRAPHY

Figure 1



CADASTRAL SOURCE: Landgate, February 2013.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2013.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.

pgv ENVIRONMENTAL	
Drawn: J. Hams	Date: 9 May 2014
Job: 10112 Rpt: 2014-128	Revision: A

City of Swan
BLACK COCKATOO HABITAT ASSESSMENT
PROPOSED BRIDGE AND ROAD UPGRADE, RAILWAY PARADE, UPPER SWAN

VEGETATION ASSOCIATIONS AND SIGNIFICANT TREES

Figure 2

APPENDIX 1

Significant Tree Survey Results

Tree Number	Species	Easting MGA zn50	Northing MGA zn50	Photo Number	Height	Diameter	Second Branch	Notes (hollows, bees etc.)
1	Marri (<i>Corymbia calophylla</i>)	407655	6485701	6068	10	550		No Hollows, Good Condition
2	Marri (<i>Corymbia calophylla</i>)	407671	6485572	6069	9	700	30	No Hollows, Good Condition
3	Marri (<i>Corymbia calophylla</i>)	407656	6485537	6070	9	550		No Hollows, Good Condition
4	Marri (<i>Corymbia calophylla</i>)	407665	6485430	6071	8	700		No Hollows, Poor Condition
5	Marri (<i>Corymbia calophylla</i>)	407666	6485702	6073	10	500		No Hollows, Good Condition
6	Marri (<i>Corymbia calophylla</i>)	407661	6485892	6077	10	500		No Hollows, Good Condition
7	Marri (<i>Corymbia calophylla</i>)	407616	6486230	6080	8	5600		No Hollows, Good Condition
8	Marri (<i>Corymbia calophylla</i>)	407623	6486514	6083	8	700		No Hollows, Good Condition



Tree 1



Tree 2



Tree 3



Tree 4



Tree 5



Tree 6



Tree 7



Tree 8

APPENDIX E

DESKTOP REVIEW - REVIEW OF ABORIGINAL SITES



DESKTOP REPORT

REVIEW OF ABORIGINAL SITES RECORDED WITHIN THE VICINITY OF THE PROPOSED ELLEN BROOK BRIDGE, RAILWAY PARADE, UPPER SWAN

Prepared for

City of Swan

June 2012



Ownership of Information

This report has been prepared for submission to the City of Swan. Any cultural information contained within the report is the property of the people who provided the information. This report and the information it contains may not be copied in whole or part without written consent of the City of Swan and Big Island Research Pty Ltd. However, it is written for the purpose of assisting with the City of Swan with its Aboriginal heritage approvals processes and any copying associated with this purpose is permitted.

Geographic Co-ordinates

Geographic co-ordinates in this report were obtained using a hand-held Garmin Global Positioning System device accurate to within +/- 15 m. Geographic co-ordinates in this report are based on the GDA 94 coordinate system. All locations are in Zone 50J.

Maps

All maps in this report use data provided by Google Earth and City of Swan.

Report Authors

Written by Wendy Reynen BA (Hons), Kate Morse PhD

Disclaimer

Big Island is not responsible for omissions and inconsistencies that may result from information not available at the time this report was prepared.

Contents

Introduction	1
Archaeological Context.....	2
Previously Recorded Sites	3
DIA Site ID 3441 – Ellen Brook Scatter (Stored Data)	6
Assessment and Recommendations	6
DIA Site ID 3525 Ellen Brook Upper Swan (mythological site/ insufficient data)	7
Discussion and Recommendations	8
References.....	11

List of Maps

Map 1. City of Swan Proposed Ellen Brook Bridge with Listed DIA Sites	5
Map 2. DIA Site ID 3525 - showing extent of DIA site boundaries	7

List of Tables

Table 1. DIA listed sites located within 5 km of the proposed Bridge	3
Table 2. Centre Coordinate – DIA Site ID 3441 (GDA 94, Zone 50)	6

Introduction

This desktop report provides a brief review of Aboriginal heritage sites recorded to date within the vicinity of a proposed Bridge to be constructed by City of Swan and crossing Ellen Brook from Railway Parade, in Upper Swan, Perth.

The aim of the desktop was to:

- Identify the nature and extent of recorded sites in the immediate vicinity of the proposed Bridge
- Provide detailed maps showing the location of sites
- Review and clarify recommendations provided for sites

This review was requested by City of Swan Planning Engineer Anil Perera on 8th June 2012.

Archaeological Context

Available archaeological evidence confirms that Aboriginal people have inhabited the Swan Coastal Plain and the adjoining Darling Scarp for at least 40,000 years. The oldest known sites in the Perth metropolitan area are located on the Swan and Helena river systems on the Swan Coastal Plain, with the earliest evidence for occupation radiocarbon dated to 39,500BP +/- 2300 years BP at Upper Swan Bridge (Pearce and Barbetti 1981), and 27,000 years ago at Helena River, in Midland (Schwede 1983). Recent recalibration of the original 31,500 and 39,500 year BP dates provides an age for occupation of this site some 43,600 years before present (O'Connell and Allen 2012).

Numerous other sites in the metropolitan area have provided radiocarbon dates including 10,000 years ago at Minim Cove in Mosman Park (Clarke and Dortch 1977), 8,000 years ago at Walyunga (Pearce 1978), 4,500 years ago at Orchestra Shell Cave in Wanneroo (Hallam 1975) and 2,500 years ago at Brigadoon in Millendon (Schwede 1990). These sites confirm the human occupation of the Swan Coastal Plain and Darling Scarp over tens of thousands of years.

To date, more than 1,000 Aboriginal sites have been recorded in the greater Perth Metropolitan area, mostly as a result of development-driven consulting.

Archaeological sites range from large, complex artefact scatters with diverse stone assemblages including backed blades, grinding material and retouched artefacts to small discrete artefact scatters dominated by unretouched quartz flakes (Hallam 1987: 20). Despite massive disturbance from commercial and residential developments, surveys and excavations have established that subsurface archaeological material, including stone artefacts and human skeletal remains, is still found in the Perth Metropolitan area (Fisher *et al* 2002; Fisher *et al* 2000; Przywolnik and Harrison 2000).

Ethnographic and historical documents highlight the importance of water sources such as rivers, lakes and wetlands to Noongar land use patterns, ceremonial cycles and mythological tracks (Hallam 1975; Hammond 1933). Archaeological research has demonstrated that the lakes and wetlands of the coastal and riverine zones were more

intensively used than the Darling Scarp or the seaward margin of the coastal zone (Hallam 1987:23). The majority of archaeological sites are found in close proximity to water sources on the Swan Coastal Plain, with the largest sites located on elevated dunes and sand ridges near the Swan River and its tributaries, and other lakes and wetlands (Anderson 1984; Hallam 1975, 1987; Bowdler *et al* 1991; Strawbridge 1988). Lake, wetland and riverine areas typically contain a high number of large artefact scatters with diverse assemblages. Available evidence suggests a seasonal model of occupation in which *Noongar* groups focused on the resource rich areas of the Swan Coastal Plains during the summer months (November to March) and dispersed into smaller groups through the wider hinterland of the Darling Scarp during the winter and spring (April to October) (Anderson 1984: 36-38).

Previously Recorded Sites

A search of the DIA Heritage database identified nine registered sites and three other heritage places within 5 km of the centre point for the proposed Bridge (Table 1). Five of these sites have mythological or ceremonial components and five sites comprise stone artefact scatters. Many of these sites are located on the margins of rivers, lakes and wetlands.

Table 1. DIA listed sites located within 5 km of the proposed Bridge.

DIA Site ID	Site Name	Cultural Attribute
3441	Ellen Brook Scatter	Artefact Scatter
3525	Ellen Brook: Upper Swan	Mythological
3535	Ellen Brook Artefacts	Artefact Scatter
3536	Swan River	Mythological
3603	Ellen Brook: Bullsbrook	Artefact Scatter
3830	Buyat Cullung	Ceremonial, Mythological, Man-made structure
3831	Tjitti - Tjitti	Mythological
3881	Childrens Stone	Ceremonial, Mythological
3882	Millendon 12	Ceremonial, Mythological

DIA Site ID	Site Name	Cultural Attribute
3883	Millendon 11	Ceremonial, Mythological
4299	Upper Swan Bridge	Artefact Scatter
27868	Upper Swan Lot 39 Artefact Scatter	Artefact Scatter

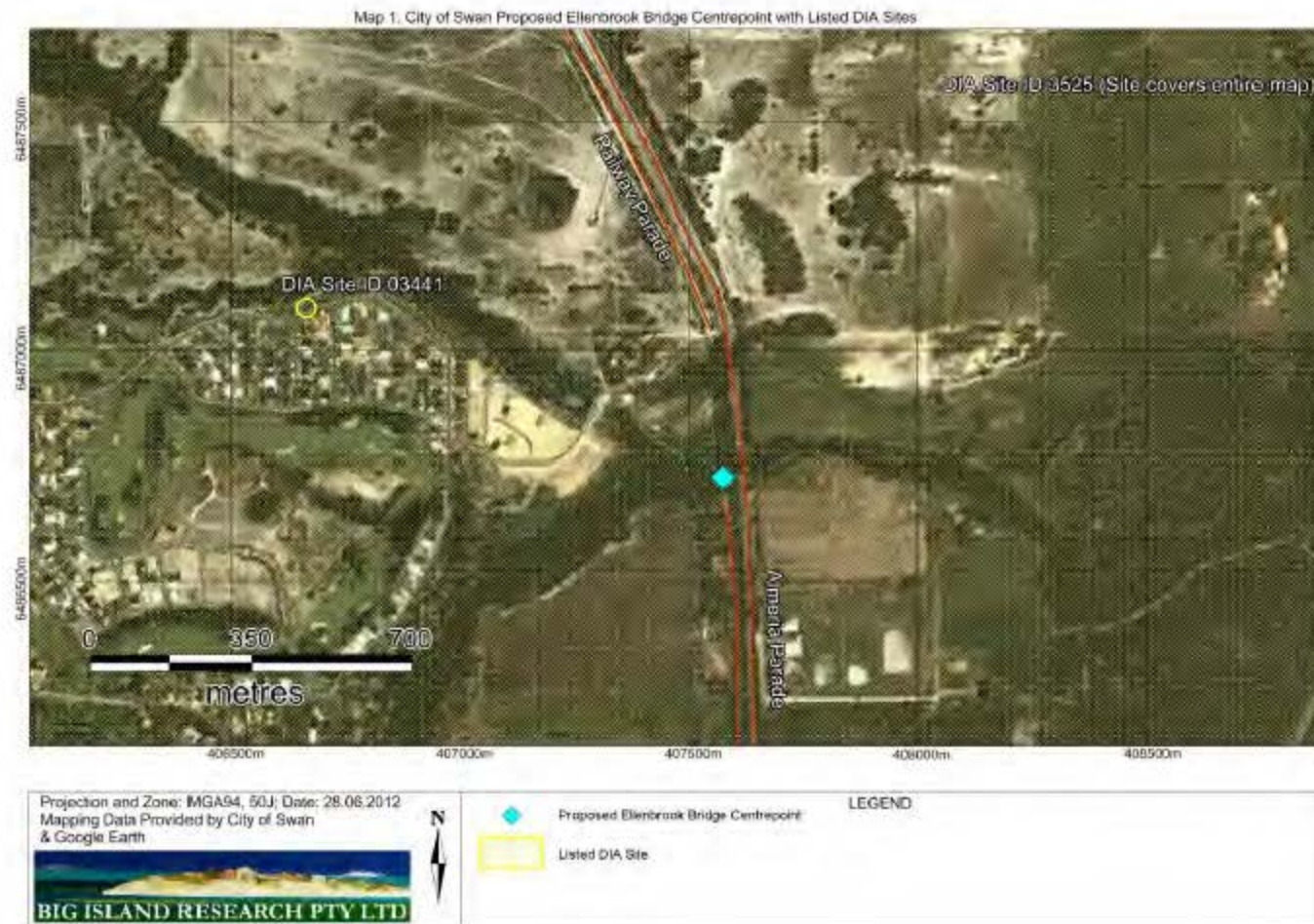
Only one site however is located within the proposed Ellenbrook Bridge crossing itself (Map 1). DIA Site ID 3525 Ellen Brook Upper Swan, is listed as a mythological site relating to Ellen Brook itself. The site file is closed to public access. The DIA register lists the site as containing “insufficient data”. This means that the site has been assessed by the Aboriginal Cultural Material Committee (ACMC) who have subsequently decided that the recording conducted has been inadequate and has not provided enough detail regarding the site’s location or characteristics.

The only other site located within 1 km of the proposed Bridge is DIA Site ID 3441 Ellen Brook Scatter, a small scatter of stone artefacts situated approximately 980 m northwest of the proposed Ellen Brook Bridge crossing (Map 1). A brief description of DIA Site ID 3441 is provided below.

DIA Site ID 3441 is listed as “stored data”. This means that this site has been assessed by the ACMC and it has been decided that it does not meet the definition of a site under Sections 5 and 39 of the Aboriginal Heritage Act 1972. It is, however, not explicit about the basis on which this site has been listed as “stored data”.

Map 1 below provides a visual representation of the proposed Bridge in relation to listed DIA sites.

Map 1. City of Swan Proposed Ellen Brook Bridge with Listed DIA Sites located on Railway Parade and Almeria Parade



DIA Site ID 3441 – Ellen Brook Scatter (Stored Data)

Table 2. Centre Coordinate – DIA Site ID 3441 (GDA 94, Zone 50)

mE	mN
406664	6487092

Site Description

DIA Site ID 3441 is a small artefact scatter located along a firebreak on the southern bank of a tributary of Ellen Brook, approximately 850 m west of Railway Parade and 1.5 km west of the Great Northern Hwy. The site extends over an area of 10 m x 5 m within the firebreak area. A total of 10 quartz 'pieces' and one mylonite 'chip' were recorded at the site.

Site Recording

DIA Site ID 3441 was recorded by McDonald in 1991 during the course of an ethnographic and archaeological survey for of the Mews development, Sanwa Vines Resort (McDonald 1991). The report rated the site as having low significance and little potential for future research.

Assessment and Recommendations

DIA Site ID 3441 has not been adequately recorded and the information provided in the site file is minimal. The site coordinates are unreliable.

Big Island recommends:

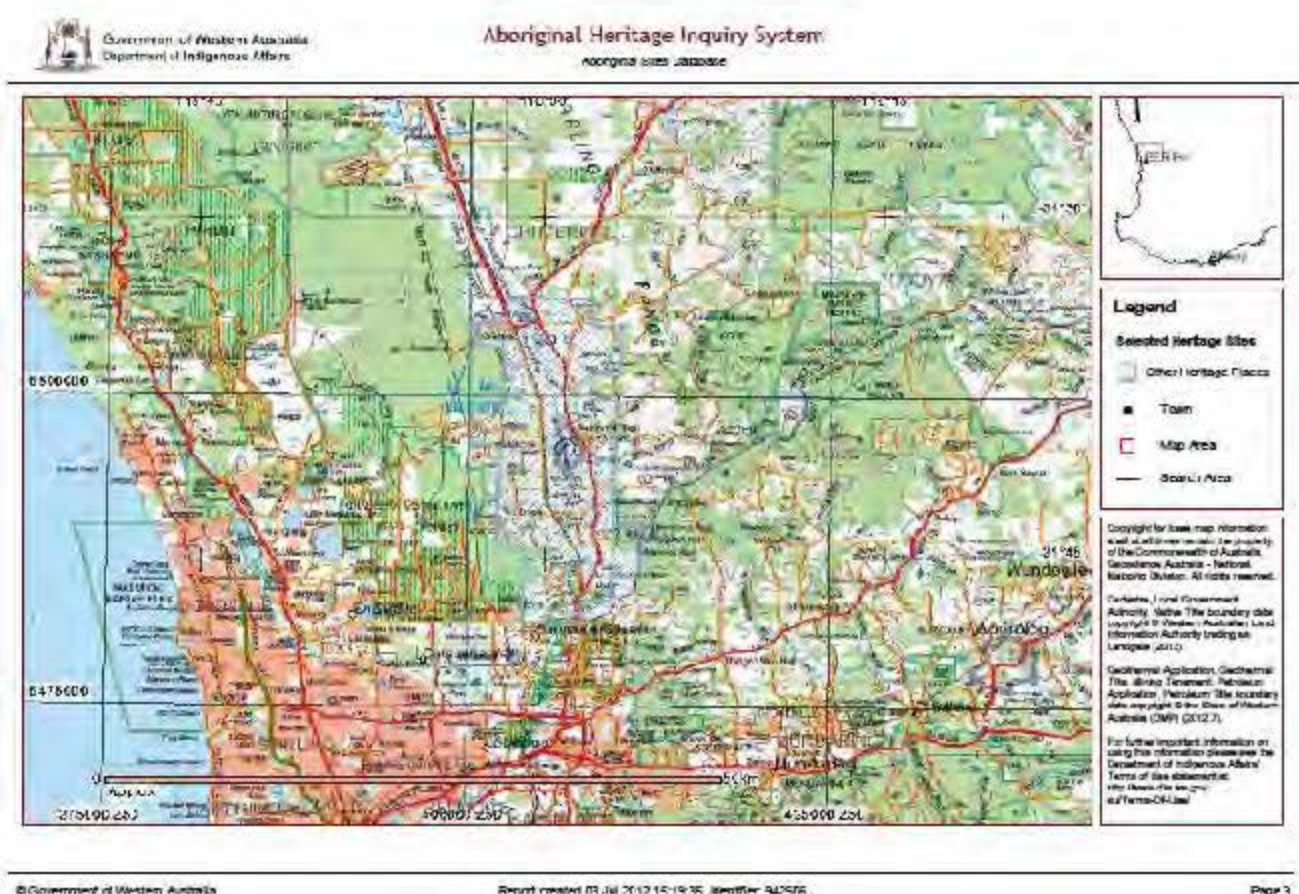
- Site recording to S.18 level will be required if ground disturbing activity is planned at this site location.

DIA Site ID 3525 Ellen Brook Upper Swan (mythological site/ insufficient data)

DIA Site file closed to public access. Permission from relevant Traditional Owners is required before closed site files can be accessed in the DIA.

This site relates to Ellen Brook itself and is currently categorized by DIA as an 'other heritage place', which means information about this place is not held on the DIA register (<http://www.dia.wa.gov.au/en/Site-Search/Aboriginal-Heritage-Inquiry-System/Improvements-to-the-Aboriginal-Heritage-Inquiry-System-AHIS/>). DIA Site ID 3525 is mapped (Map 2 below) as a polygon covering all of Ellen Brook.

Map 2. DIA Site ID 3525 - showing extent of DIA site boundaries



DIA advise (3 July 2012) that DIA Site ID 3525 Ellen Brook Upper Swan has previously been accepted as a registered site but an ACMC resolution in 2010 (2010/145) determined that there was insufficient information recorded for it to be retained as a site on the State Heritage Register. It has subsequently been classified as an 'other heritage place'. This means in effect, that DIA Site ID 3525 may be a site but there is currently insufficient specific information for it to be registered.

Discussion and Recommendations

Of particular relevance to the proposed Ellen Brook bridge crossing are the findings made at the Upper Swan Bridge archaeological site, DIA Site ID 4299 (Table 1). This site, located in alluvial and clay deposits on the Swan river terraces some 7 km from the proposed Ellen Brook Bridge crossing, is a dated archaeological deposit and, although questioned, is one of the oldest archaeological sites in Australia (Pearce and Barbetti 1981). Recent recalibration of the original 31,500 and 39,500 year BP dates provides an age for occupation of this site some 43,600 years before present (O'Connell and Allen 2012). Over 850 flaked stone artefacts as well as numerous charcoal fragments were recovered in mottled clays and sand some 70-90 cm below the surface.

Stratigraphy at the Upper Swan Bridge site was marked some 30 cm beneath the ground surface by a 25 cm thick lens of hard red-brown sandy clay that merged into sandy clay and then a dark yellow soil. Below this at a depth of some 80 cm below the surface, was a 10-15 cm thick layer of yellow clayey sand with small quartz and granite nodules. The underlying 10-15 cm comprised dull yellow clayey sand with small quartz and granite nodules merging into mottled grey clay. The deposit containing artefacts and charcoal was 70-90 cm below the original surface (Pearce and Barbetti 1981).

The proposed Ellen Brook Bridge crossing is located in a similar environmental context to that of DIA Site ID 4299 Upper Swan Bridge. The distinctive subsurface stratigraphy noted in the excavated trench at Upper Swan Bridge (Pearce and Barbetti

1981) provides a useful point of reference for any ground disturbance undertaken by City of Swan on the banks of Ellen Brook during construction of the proposed bridge. The possibility of a comparable deposit being present and visible in the creek banks prior to construction, or uncovered during construction works that disturb the banks of the Ellen Brook Bridge crossing should not be overlooked.

DIA 'other heritage place' Site ID 3525 Ellen Brook Upper Swan is also relevant to the proposed bridge crossing. As noted above, there is currently insufficient specific ethnographic information for it to be registered as a site. The site file is closed and it is not known at this point if this "other heritage place" covers the whole of Ellenbrook, as indicated on the DIA register (Map 2 above) and is relevant to the proposed bridge crossing, or relates to a different specific section of Ellenbrook. Consultation with appropriate Noongar Traditional Owners will be required to determine if sufficient specific ethnographic information is available to record this location such that it's status on the DIA register as an 'other heritage place' can be reassessed. Discussion with DIA staff indicated that this is a grey area but that reference to the new Due Diligence Guidelines (www.dia.wa.gov.au/en/Section-18-Applications/) may clarify this issue.

On the basis of the information presented in this report, Big Island Research Pty Ltd recommends that at the concept design stage for the Ellenbrook bridge, City of Swan should engage heritage consultants to:

- consult with appropriate *Noongar* Traditional Owners to identify if sufficient specific ethnographic information is available, and if so, to record the Ellen Brook 'other heritage place' DIA Site ID 3525 to s18 standard.
- Undertake an archaeological inspection of the proposed location of the Ellen Brook bridge crossing
- Depending on the outcome of this consultation, City of Swan may subsequently need to make an application to disturb under s18 or Regulation 10 of the Aboriginal Heritage Act (1972).

- Relevant Traditional Owners and an archaeological monitor are present during any ground disturbing work undertaken during construction of the proposed Ellen Brook Bridge.

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APPENDIX F

PRELIMINARY COST ESTIMATES

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Summary

Rates Current At July 2015

Location		Total Cost
A OPTION 1 - SINGLE SPAN BEAM		1,839,970.75
ESTIMATED NET COST		\$1,839,970.75
MARGINS & ADJUSTMENTS		
Preliminaries	19.0 %	\$350,000.00
Builders Margin	8.0 %	\$175,197.66
CONSTRUCTION COST SUB-TOTAL		\$2,365,168.41
Contingencies	15.0 %	\$354,775.27
Professional Fees		Excl.
Escalation		Excl.
GST		Excl.
ESTIMATED TOTAL COST		\$2,719,943.68

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

A OPTION 1 - SINGLE SPAN BEAM

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
801 EXCAVATION AND BACKFILL				
85 Clearing and grubbing	m ²	1,764.0	7.50	13,230.00
86 Topsoil removal (from site)	m ²	1,058.5	2.50	2,646.25
60 Embankment construction using selected fill, grading to slopes	m ³	1,582.7	25.00	39,567.50
55 Detailed excavation to abutment footing and wing wall	m ³	89.5	35.00	3,132.50
87 Foundation compaction	m ²	936.0	5.00	4,680.00
EXCAVATION AND BACKFILL				\$63,256.25
812 BORED CONCRETE PILES				
107 Piling - mobilisation	Item			30,000.00
28 Concrete bored piles 1000 diameter with reinforcement (200 kg/m ³) including site establishment, removal of excavated material, trimming tops of piles and testing	m	64.0	1,100.00	70,400.00
BORED CONCRETE PILES				\$100,400.00
820 CONCRETE FOR STRUCTURES				
2 Blinding generally - plain insitu N40	m ³	8.4	600.00	5,040.00
1 Approach slab - reinforced insitu concrete S40	m ³	32.5	450.00	14,625.00
3 Abutment wall and wing walls - reinforced insitu concrete S40	m ³	66.2	525.00	34,755.00
4 Abutment crosshead - reinforced insitu concrete S40	m ³	55.0	525.00	28,875.00
6 Deck slab and diaphragms - reinforced insitu concrete S40	m ³	139.3	450.00	62,685.00
7 Principal shared path topping - plain insitu N40	m ³	15.4	425.00	6,545.00
49 Access stair - reinforced insitu concrete S40	m ³	2.5	550.00	1,375.00
CONCRETE FOR STRUCTURES				\$153,900.00
821 FORMWORK				
14 Formwork - approach slab sides	m ²	19.0	200.00	3,800.00
15 Formwork - abutment wall and wing walls	m ²	368.4	250.00	92,100.00
16 Formwork - abutment crosshead	m ²	97.0	250.00	24,250.00
18 Formwork - sides of deck and upstand	m ²	44.4	200.00	8,880.00
19 Formwork - end diaphragm walls	m ²	41.0	250.00	10,250.00
20 Formwork - sides of PSP path	m ²	6.2	170.00	1,054.00
21 Formwork - Bondek to soffit of deck slab	m ²	398.0	160.00	63,680.00
50 Formwork - access stair	m ²	14.0	275.00	3,850.00
FORMWORK				\$207,864.00
822 STEEL REINFORCEMENT				
9 Steel bar reinforcement - approach slab (250kg/m ³)	t	8.125	3,000.00	24,375.00
10 Steel bar reinforcement - abutment wall and wing walls (270kg/m ³)	t	17.822	3,250.00	57,921.50
11 Steel bar reinforcement - abutment crosshead (270kg/m ³)	t	14.650	3,250.00	47,612.50
12 Steel bar reinforcement - deck slab and diaphragms (250kg/m ³)	t	34.751	3,000.00	104,253.00
51 Steel bar reinforcement - access stair (150kg/m ³)	t	0.340	3,500.00	1,190.00
13 Steel fabric reinforcement - shared path topping (allowance)	m ²	122.0	25.00	3,050.00
STEEL REINFORCEMENT				\$238,402.00

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

A OPTION 1 - SINGLE SPAN BEAM (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
828 PRECAST CONCRETE MEMBERS				
22 Supply - precast concrete Teeroff beams 30600 span x 1500 deep, delivered to site	No	4.0	90,000.00	360,000.00
23 Install - precast concrete Teeroff beams 30600 span x 1500 deep	No	4.0	23,000.00	92,000.00
43 Precast concrete S50 - parapet facing panels - approximate girth 1200 x 100 thick	m	81.3	350.00	28,455.00
PRECAST CONCRETE MEMBERS				\$480,455.00
603 SAFETY BARRIER SYSTEMS FOR STRUCTURES				
36 3 rail traffic barrier	m	81.3	725.00	58,942.50
SAFETY BARRIER SYSTEMS FOR STRUCTURES				\$58,942.50
833 BALUSTRADES AND HANDRAILS				
38 Galvanised and painted balustrade; approximately 1300 high	m	40.8	1,500.00	61,200.00
52 Galvanised steel balustrade (Monowills) to access stair/abutments	m	24.0	250.00	6,000.00
BALUSTRADES AND HANDRAILS				\$67,200.00
860 BRIDGE BEARINGS				
24 Bridge bearing including elastomeric bearing pad on concrete bearing plinth	No	8.0	2,500.00	20,000.00
BRIDGE BEARINGS				\$20,000.00
870 COMPRESSION JOINT SEAL				
83 Expansion joint with cover seal Granor AC-AR strip seal including concrete transition strip	m	26.0	950.00	24,700.00
COMPRESSION JOINT SEAL				\$24,700.00
875 WATERPROOF MEMBRANE				
84 Waterproof membrane to bridge deck	m²	385.0	65.00	25,025.00
WATERPROOF MEMBRANE				\$25,025.00
908 ANTI-GRAFFITI - BRIDGES AND STRUCTURES				
78 Anti graffiti coating to exposed surfaces	m²	315.1	15.00	4,726.50
ANTI-GRAFFITI - BRIDGES AND STRUCTURES				\$4,726.50
407 KERBING				
26 Precast concrete kerb	m	81.3	35.00	2,845.50
KERBING				\$2,845.50
890 MISCELLANEOUS				
64 75mm asphalt surfacing	m²	515.2	45.00	23,184.00
81 Single coat primerseal	m²	515.2	5.00	2,576.00
47 Concrete access path; 150 thick	m³	10.2	450.00	4,590.00
44 100 diameter pvc ducts fixed to soffit of deck	m	325.2	50.00	16,260.00
104 Light poles with light fitting - 12.5m high including wiring and connection	No	2.0	14,000.00	28,000.00
105 Signage - allowance	Item			5,000.00
106 Drainage - allowance	Item			30,000.00
MISCELLANEOUS				\$109,610.00

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

A OPTION 1 - SINGLE SPAN BEAM (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
406 ROCK PROTECTION				
46 Rip-rap rock protection to embankments (150-300mm rocks)	m ³	2,062.7	80.00	165,016.00
48 Rock protection, granite stone pitching 200 thick	m ²	336.0	125.00	42,000.00
45 Geotextile membrane, Bidim A44 or other equal	m ²	1,562.8	10.00	15,628.00
ROCK PROTECTION				\$222,644.00
900 METHOD RELATED ITEMS				
108 Waterway protection and barriers	Item			30,000.00
109 Pile access and mat	Item			30,000.00
METHOD RELATED ITEMS				\$60,000.00
OPTION 1 - SINGLE SPAN BEAM				\$1,839,970.75

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Summary

Rates Current At July 2015

Location		Total Cost
B OPTION 2 - THREE SPAN BEAM		3,031,718.50
ESTIMATED NET COST		\$3,031,718.50
MARGINS & ADJUSTMENTS		
Preliminaries	19.0 %	\$575,000.00
Builders Margin	8.0 %	\$288,537.48
CONSTRUCTION COST SUB-TOTAL		\$3,895,255.98
Contingencies	15.0 %	\$584,288.40
Professional Fees		Excl.
Escalation		Excl.
GST		Excl.
ESTIMATED TOTAL COST		\$4,479,544.38

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

B OPTION 2 - THREE SPAN BEAM

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
801 EXCAVATION AND BACKFILL				
85 Clearing and grubbing	m ²	2,730.0	7.50	20,475.00
86 Topsoil removal (from site)	m ²	1,638.2	2.50	4,095.50
60 Embankment construction using selected fill, grading to slopes	m ³	1,582.7	25.00	39,567.50
55 Detailed excavation to abutment footing and wing wall	m ³	89.5	35.00	3,132.50
87 Foundation compaction	m ²	1,128.0	5.00	5,640.00
EXCAVATION AND BACKFILL				\$72,910.50
812 BORED CONCRETE PILES				
107 Piling - mobilisation	Item			30,000.00
28 Concrete bored piles 1000 diameter with reinforcement (200 kg/m ³) including site establishment, removal of excavated material, trimming tops of piles and testing	m	168.0	1,100.00	184,800.00
92 Extra over 1000mm diameter bored piles for temporary formwork (smooth finish)	m	12.0	750.00	9,000.00
BORED CONCRETE PILES				\$223,800.00
820 CONCRETE FOR STRUCTURES				
2 Blinding generally - plain insitu N40	m ³	23.6	600.00	14,160.00
1 Approach slab - reinforced insitu concrete S40	m ³	32.5	450.00	14,625.00
3 Abutment wall and wing walls - reinforced insitu concrete S40	m ³	43.8	525.00	22,995.00
6 Deck slab and diaphragms - reinforced insitu concrete S40	m ³	229.7	450.00	103,365.00
7 Principal shared path topping - plain insitu N40	m ³	23.6	425.00	10,030.00
49 Access stair - reinforced insitu concrete S40	m ³	2.5	550.00	1,375.00
CONCRETE FOR STRUCTURES				\$166,550.00
821 FORMWORK				
14 Formwork - approach slab sides	m ²	19.0	200.00	3,800.00
15 Formwork - abutment wall and wing walls	m ²	339.6	250.00	84,900.00
18 Formwork - sides of deck and upstand	m ²	99.6	200.00	19,920.00
19 Formwork - end diaphragm walls	m ²	41.0	250.00	10,250.00
20 Formwork - sides of PSP path	m ²	7.8	170.00	1,326.00
21 Formwork - Bondek to soffit of deck slab	m ²	680.0	160.00	108,800.00
50 Formwork - access stair	m ²	14.0	275.00	3,850.00
FORMWORK				\$232,846.00
822 STEEL REINFORCEMENT				
9 Steel bar reinforcement - approach slab (250kg/m ³)	t	8.125	3,000.00	24,375.00
10 Steel bar reinforcement - abutment wall and wing walls (270kg/m ³)	t	11.768	3,250.00	38,246.00
12 Steel bar reinforcement - deck slab and diaphragms (250kg/m ³)	t	57.319	3,000.00	171,957.00
51 Steel bar reinforcement - access stair (150kg/m ³)	t	0.340	3,500.00	1,190.00
13 Steel fabric reinforcement - shared path topping (allowance)	m ²	187.0	25.00	4,675.00
STEEL REINFORCEMENT				\$240,443.00

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

B OPTION 2 - THREE SPAN BEAM (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
828 PRECAST CONCRETE MEMBERS				
65 Supply - precast concrete Teeroff beams 12400 span x 1200 deep, delivered to site	No	8.0	35,000.00	280,000.00
66 Install - precast concrete Teeroff beams 12400 span x 1200 deep	No	8.0	8,000.00	64,000.00
67 Supply - precast concrete Teeroff beams 26500 span x 1200 deep, delivered to site	No	4.0	81,000.00	324,000.00
68 Install - precast concrete Teeroff beams 26500 span x 1200 deep	No	4.0	21,000.00	84,000.00
43 Precast concrete S50 - parapet facing panels - approximate girth 1200 x 100 thick	m	124.7	350.00	43,645.00
79 Supply and install precast concrete abutment crosshead; 13000 long x 1500 wide x 1350 deep including restraint block (reinforcement 270kg/m ³)	No	2.0	135,000.00	270,000.00
80 Supply and install precast concrete pier crosshead, tapered ends; 13000 long x 1400 wide x 1300 deep including restraint block (reinforcement 270kg/m ³)	No	2.0	125,000.00	250,000.00
PRECAST CONCRETE MEMBERS				\$1,315,645.00
603 SAFETY BARRIER SYSTEMS FOR STRUCTURES				
36 3 rail traffic barrier	m	124.7	725.00	90,407.50
SAFETY BARRIER SYSTEMS FOR STRUCTURES				\$90,407.50
833 BALUSTRADES AND HANDRAILS				
38 Galvanised and painted balustrade; approximately 1300 high	m	62.5	1,500.00	93,750.00
52 Galvanised steel balustrade (Monowills) to access stair/abutments	m	24.0	250.00	6,000.00
BALUSTRADES AND HANDRAILS				\$99,750.00
860 BRIDGE BEARINGS				
24 Bridge bearing including elastomeric bearing pad on concrete bearing plinth	No	24.0	2,500.00	60,000.00
BRIDGE BEARINGS				\$60,000.00
870 COMPRESSION JOINT SEAL				
83 Expansion joint with cover seal Granor AC-AR strip seal including concrete transition strip	m	52.0	950.00	49,400.00
COMPRESSION JOINT SEAL				\$49,400.00
875 WATERPROOF MEMBRANE				
84 Waterproof membrane to bridge deck	m ²	680.0	65.00	44,200.00
WATERPROOF MEMBRANE				\$44,200.00
908 ANTI-GRAFFITI - BRIDGES AND STRUCTURES				
78 Anti graffiti coating to exposed surfaces	m ²	315.2	15.00	4,728.00
ANTI-GRAFFITI - BRIDGES AND STRUCTURES				\$4,728.00
407 KERBING				
26 Precast concrete kerb	m	124.7	35.00	4,364.50
KERBING				\$4,364.50

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

B OPTION 2 - THREE SPAN BEAM (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
890 MISCELLANEOUS				
64 75mm asphalt surfacing	m ²	810.2	45.00	36,459.00
81 Single coat primerseal	m ²	732.2	5.00	3,661.00
47 Concrete access path; 150 thick	m ³	10.3	450.00	4,635.00
44 100 diameter pvc ducts fixed to soffit of deck	m	498.8	50.00	24,940.00
104 Light poles with light fitting - 12.5m high including wiring and connection	No	2.0	14,000.00	28,000.00
105 Signage - allowance	Item			5,000.00
106 Drainage - allowance	Item			30,000.00
MISCELLANEOUS				\$132,695.00
406 ROCK PROTECTION				
46 Rip-rap rock protection to embankments (150-300mm rocks)	m ³	2,112.2	80.00	168,976.00
48 Rock protection, granite stone pitching 200 thick	m ²	312.0	125.00	39,000.00
45 Geotextile membrane, Bidim A44 or other equal	m ²	1,600.3	10.00	16,003.00
ROCK PROTECTION				\$223,979.00
900 METHOD RELATED ITEMS				
108 Waterway protection and barriers	Item			30,000.00
109 Pile access and mat	Item			40,000.00
METHOD RELATED ITEMS				\$70,000.00
OPTION 2 - THREE SPAN BEAM				\$3,031,718.50

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Summary

Rates Current At July 2015

Location		Total Cost
C OPTION 3 - PRECAST CONCRETE ARCH		4,454,345.75
ESTIMATED NET COST		\$4,454,345.75
MARGINS & ADJUSTMENTS		
Preliminaries	12.9 %	\$575,000.00
Builders Margin	8.0 %	\$402,347.66
CONSTRUCTION COST SUB-TOTAL		\$5,431,693.41
Contingencies	15.0 %	\$814,754.02
Professional Fees		Excl.
Escalation		Excl.
GST		Excl.
ESTIMATED TOTAL COST		\$6,246,447.43

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

C OPTION 3 - PRECAST CONCRETE ARCH

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
801 EXCAVATION AND BACKFILL				
85 Clearing and grubbing	m ²	4,900.0	7.50	36,750.00
86 Topsoil removal (from site)	m ²	3,675.3	2.50	9,188.25
5 Bulk excavation, remove from site (assumed unsuitable)	m ³	4,370.0	15.00	65,550.00
8 Backfill with imported fill (between retaining walls)	m ³	2,497.0	20.00	49,940.00
60 Embankment construction using selected fill, grading to slopes	m ³	553.6	25.00	13,840.00
88 Backfill with imported fill (zone around arch)	m ³	1,350.0	30.00	40,500.00
89 Detailed excavation to footings	m ³	410.0	90.00	36,900.00
87 Foundation compaction	m ²	750.0	5.00	3,750.00
EXCAVATION AND BACKFILL				\$256,418.25
820 CONCRETE FOR STRUCTURES				
2 Blinding generally - plain insitu N40	m ³	33.0	600.00	19,800.00
25 Arch footing - reinforced insitu concrete S40	m ³	151.0	450.00	67,950.00
29 Retaining wall footing - reinforced insitu concrete S40	m ³	256.0	450.00	115,200.00
39 Stitch between retaining wall footing to retaining wall - Insitu concrete S40	m ³	40.0	450.00	18,000.00
CONCRETE FOR STRUCTURES				\$220,950.00
821 FORMWORK				
27 Formwork - Arch Foundation	m ²	82.0	200.00	16,400.00
31 Formwork - Retaining wall footing	m ²	154.0	200.00	30,800.00
40 Formwork - Insitu concrete stitch	m ²	40.0	250.00	10,000.00
FORMWORK				\$57,200.00
822 STEEL REINFORCEMENT				
17 Steel bar reinforcement - arch foundations (200kg/m ³)	t	30.010	3,000.00	90,030.00
30 Steel bar reinforcement - Retaining wall footing (180kg/m ³)	t	46.080	3,000.00	138,240.00
STEEL REINFORCEMENT				\$228,270.00
828 PRECAST CONCRETE MEMBERS				
97 Supply and install precast concrete arch units (1.8m wide x half span of 21m)	No	14.0	31,000.00	434,000.00
98 Supply and install precast concrete spandrell wall panels including all reinforcement - large	No	4.0	44,000.00	176,000.00
99 Supply and install precast concrete spandrell wall panels including all reinforcement - small	No	4.0	34,000.00	136,000.00
100 Supply and install precast concrete retaining wall panels including all reinforcement	No	32.0	37,000.00	1,184,000.00
101 Supply and install precast concrete units (road parapet) including all reinforcement	No	25.0	12,000.00	300,000.00
102 Supply and install precast concrete units (PSP parapet) including all reinforcement	No	25.0	10,000.00	250,000.00
103 Supply and install precast concrete units (central barrier) including all reinforcement	No	25.0	10,000.00	250,000.00
90 Extra over precast retaining wall panels for textured finish (Rickli feature finish)	m ²	398.0	102.00	40,596.00

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

C OPTION 3 - PRECAST CONCRETE ARCH (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
91 Extra over precast spandrel panels for for textured finish (Rickli feature finish)	m ²	212.0	912.00	193,344.00
93 Extra over precast arch units for sandstone colour	m ³	134.0	174.00	23,316.00
94 Extra over precast spandrel panels for sandstone colour	m ³	53.0	174.00	9,222.00
95 Extra over precast retaining walls for sandstone colour	m ³	176.0	174.00	30,624.00
96 Extra over precast parapet units and central barrier footing units for sandstone colour	m ³	206.0	174.00	35,844.00
PRECAST CONCRETE MEMBERS				\$3,062,946.00
603 SAFETY BARRIER SYSTEMS FOR STRUCTURES				
36 3 rail traffic barrier	m	135.0	725.00	97,875.00
SAFETY BARRIER SYSTEMS FOR STRUCTURES				\$97,875.00
833 BALUSTRADES AND HANDRAILS				
38 Galvanised and painted balustrade; approximately 1300 high	m	67.7	1,500.00	101,550.00
BALUSTRADES AND HANDRAILS				\$101,550.00
875 WATERPROOF MEMBRANE				
74 Waterproof membrane to rear of retaining walls	m ²	399.0	35.00	13,965.00
75 Waterproof membrane to rear of spandrel walls	m ²	209.0	35.00	7,315.00
76 Waterproof membrane to concrete arches	m ²	362.0	35.00	12,670.00
WATERPROOF MEMBRANE				\$33,950.00
908 ANTI-GRAFFITI - BRIDGES AND STRUCTURES				
78 Anti graffiti coating to exposed surfaces	m ²	871.7	15.00	13,075.50
ANTI-GRAFFITI - BRIDGES AND STRUCTURES				\$13,075.50
407 KERBING				
26 Precast concrete kerb	m	135.0	35.00	4,725.00
KERBING				\$4,725.00
890 MISCELLANEOUS				
62 300mm drainage layer behind retaining walls	m ³	161.0	35.00	5,635.00
63 Crushed rock sub-base >250mm thick	m ³	494.0	75.00	37,050.00
64 75mm asphalt surfacing	m ²	553.6	45.00	24,912.00
69 Turnbuckle from spandrel wall to concrete arches - 32mm dia bar x 1000 long, 100 diameter PE sleeve	No	34.0	175.00	5,950.00
73 Expansion joints between precast concrete arches	m	185.0	100.00	18,500.00
77 100 diameter pvc ducts installed into sub base beneath PSP; 4 no. group	m	135.0	35.00	4,725.00
81 Single coat primerseal	m ²	553.6	5.00	2,768.00
82 Tack coat	m ²	554.0	1.00	554.00
47 Concrete access path; 150 thick	m ³	30.5	450.00	13,725.00
104 Light poles with light fitting - 12.5m high including wiring and connection	No	2.0	14,000.00	28,000.00
105 Signage - allowance	Item			5,000.00
106 Drainage - allowance	Item			30,000.00
MISCELLANEOUS				\$176,819.00

Railway Parade Bridge over Ellen Brook

Railway Parade Bridge - Option Estimates

Location Elements Item

C OPTION 3 - PRECAST CONCRETE ARCH (continued)

Rates Current At July 2015

Description	Unit	Qty	Rate	Total
406 ROCK PROTECTION				
46 Rip-rap rock protection to embankments (150-300mm rocks)	m³	1,540.1	80.00	123,208.00
48 Rock protection, granite stone pitching 200 thick	m²	250.0	125.00	31,250.00
45 Geotextile membrane, Bidim A44 or other equal	m²	1,610.9	10.00	16,109.00
ROCK PROTECTION				\$170,567.00
900 METHOD RELATED ITEMS				
108 Waterway protection and barriers	Item			30,000.00
METHOD RELATED ITEMS				\$30,000.00
OPTION 3 - PRECAST CONCRETE ARCH				\$4,454,345.75

APPENDIX G

APPROVALS AND CONSULTATIONS

Przemo Tomczyk

From: Rivers Planning <rivers.planning@dpaw.wa.gov.au>
Sent: Monday, 13 July 2015 12:14 PM
To: Przemo Tomczyk
Subject: FW: New Bridge Crossing in Upper Swan over Ellenbrook

*Cheers,
Mahtab*

From: Shedley, Erica
Sent: Friday, 3 July 2015 11:28 AM
To:
Subject: RE: New Bridge Crossing in Upper Swan over Ellenbrook

Hi Przemo,
I have looked at this proposed site in Ellen Brook and it is not within the Swan River Trust's Development Control Area. Therefore the development would not require a permit from the Swan River Trust.
Kind regards
Erica

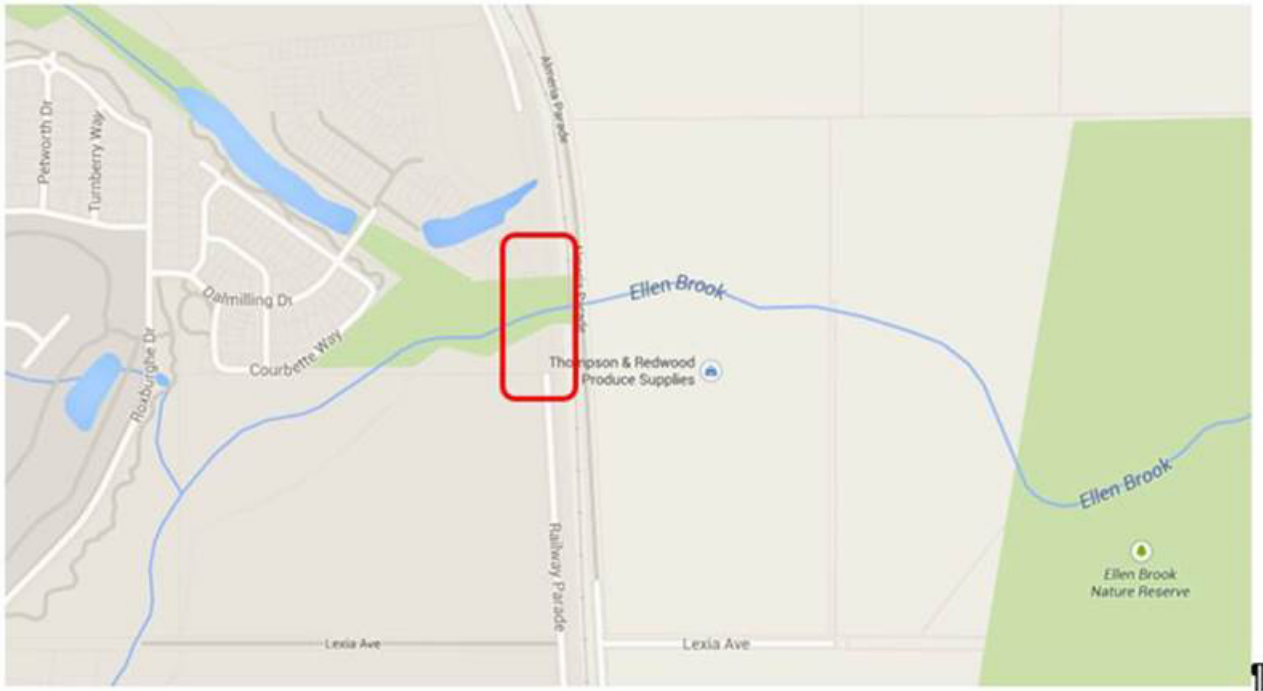
Dr Erica Shedley
Environmental Officer
Rivers and Estuaries Division
Department of Parks and Wildlife
Ph: 08 9278 0920 Mob: 0437 872 954
17 Dick Perry Avenue, Technology Park, Western Precinct, KENSINGTON WA 6151
Postal: Locked Bag 104, Bentley Delivery Centre WA 6983
Email: Erica.shedley@dpaw.wa.gov.au
Web: www.swanrivertrust.wa.gov.au or www.dpaw.wa.gov.au

From: D'Rozario, Mahtab
Sent: Friday, 3 July 2015 11:22 AM
To: Shedley, Erica
Subject: FW: New Bridge Crossing in Upper Swan over Ellenbrook

From: Przemo Tomczyk [<mailto:Przemo.Tomczyk@hyderconsulting.com>]
Sent: Tuesday, 23 June 2015 4:38 PM
To: Swan River Trust Planning
Cc: AA007882
Subject: New Bridge Crossing in Upper Swan over Ellenbrook

Hi there,

We are doing preliminary design works for City of Swan to provide a new crossing between the two banks of the Ellenbrook by extending the existing Railway Parade over the book. The snapshot below indicates the bridge location.



At this stage we are developing three options for the client to choose from and to progress in to a detailed design once the concept is chosen. The construction works will obviously involve excavations for foundations in the direct vicinity of the river channel, kind of through the banks and one option will require deepening of the channel by 400mm and a local widening downstream (~2.8m wide over a length of 26m) in order to ensure the afflux requirement is met.

I wanted to check with you whether there are any particular requirements we may need to consider / meet and whether there are not any particular obstructions from the Swan River Trust.

If you require any further information then please let me know and I will provide whatever I can.

Przemo Tomczyk

Team Leader - Structures

Direct: +61 (0) 8 9213 6722 | Mobile: +61 (0)468 939 000

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Hyder is a multinational design and engineering consultancy

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APPENDIX H

SAFETY IN DESIGN

H 1. INTRODUCTION

H1.1 General

Hyder provides this Design Safety Report to transfer information about design specific hazards that that may create risks, not only during initial construction, but to workers who may undertake maintenance or demolition work in the future.

Hyder considers the safe design of plant or structures begins at the pre-design or concept development phase when making decisions about:

- The design and its intended purpose
- Materials to be used
- Possible methods of construction, maintenance, operation and demolition
- What legislation, codes of practice and standards need to be complied with.

Hyder believes that addressing safety at the planning and design stages is more effective than making changes later when hazards become real risks in the workplace. This approach provides the following benefits:

- Prevention of injury and illness
- Improved useability of structures
- Improved productivity and reduced costs
- Better prediction and management of production and operational costs over the lifecycle of a structure
- Compliance with legislation
- Innovation, in that safe design can demand new thinking to resolve hazards in the construction phase and in end use.

H1.2 Scope of duty

H1.2.1 What is reasonably practical?

Reasonably practicable, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters including—

- (a) The likelihood of the hazard or the risk concerned occurring; and
- (b) The degree of harm that might result from the hazard or the risk; and
- (c) What the person concerned knows, or ought reasonably to know, about—
 - (i) The hazard or the risk; and
 - (ii) Ways of eliminating or minimising the risk
- (d) The availability and suitability of ways to eliminate or minimise the risk; and
- (e) After assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Model Work Health & Safety Act

H1.2.2 Primary duty of care

- (1) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of—
 - (a) Workers engaged, or caused to be engaged by the person; and
 - (b) Workers whose activities in carrying out work are influenced or directed by the person; while the workers are at work in the business or undertaking.
- (2) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.
- (3) Without limiting subsections (1) and (2), a person conducting a business or undertaking must ensure, so far as is reasonably practicable—
 - (a) The provision and maintenance of a work environment without risks to health and safety; and
 - (b) The provision and maintenance of safe plant and structures; and
 - (c) The provision and maintenance of safe systems of work; and
 - (d) The safe use, handling and storage of plant, structures and substances;
 - (e) The provision of adequate facilities for the welfare at work of workers in carrying out work for the business or undertaking, including ensuring access to those facilities; and
 - (f) The provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking; and
 - (g) That the health of workers and the conditions at the workplace are monitored for the purpose of preventing illness or injury of workers arising from the conduct of the business or undertaking.
- (4) If—
 - (a) A worker occupies accommodation that is owned by or under the management or control of the person conducting the business or undertaking; and
 - (b) The occupancy is necessary for the purposes of the worker's engagement because other accommodation is not reasonably available; the person conducting the business or undertaking must, so far as is reasonably practicable, maintain the premises so that the worker occupying the premises is not exposed to risks to health and safety.
- (5) A self-employed person must ensure, so far as is reasonably practicable, his or her own health and safety while at work.

Note—A self-employed person is also a person conducting a business or undertaking for the purposes of this section.

Model Work Health & Safety Act

H1.2.3 Duties of PCBU's that design plant, substances or structures

- (1) This section applies to a person (the designer) who conducts a business or undertaking that designs:
 - (a) Plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace, or
 - (b) A substance that is to be used, or could reasonably be expected to be used, at a workplace, or
 - (c) A structure that is to be used, or could reasonably be expected to be used, as, or at,

- a workplace.
- (2) The designer must ensure, so far as is reasonably practicable, that the plant, substance or structure is designed to be without risks to the health and safety of persons:
- (a) Who, at a workplace, use the plant, substance or structure for a purpose for which it was designed, or
 - (b) Who handle the substance at a workplace, or
 - (c) Who store the plant or substance at a workplace, or
 - (d) Who construct the structure at a workplace, or
 - (e) Who carry out any reasonably foreseeable activity at a workplace in relation to:
 - (i) The manufacture, assembly or use of the plant for a purpose for which it was designed, or the proper storage, decommissioning, dismantling or disposal of the plant, or
 - (ii) The manufacture or use of the substance for a purpose for which it was designed or the proper handling, storage or disposal of the substance, or
 - (iii) The manufacture, assembly or use of the structure for a purpose for which it was designed or the proper demolition or disposal of the structure, or
Example. Inspection, operation, cleaning, maintenance or repair of plant.
 - (f) Who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).
- (3) The designer must carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by subsection (2).
- (4) The designer must give adequate information to each person who is provided with the design for the purpose of giving effect to it concerning:
- (a) Each purpose for which the plant, substance or structure was designed, and
 - (b) The results of any calculations, analysis, testing or examination referred to in subsection (3), including, in relation to a substance, any hazardous properties of the substance identified by testing, and
 - (c) Any conditions necessary to ensure that the plant, substance or structure is without risks to health and safety when used for a purpose for which it was designed or when carrying out any activity referred to in subsection (2) (a)-(e).
 - (5) The designer, on request, must, so far as is reasonably practicable, give current relevant information on the matters referred to in subsection (4) to a person who carries out, or is to carry out, any of the activities referred to in subsection (2) (a)-(e).

Model Work Health & Safety Act

H1.3 Hazard identification and risk assessment

This report provides an overview of the risks in the key project phases as outlined below:

- 1** Pre Design Phase
- 2** Design Development Phase
- 3** Construction Phase
- 4** Post Construction Phase

Hyder use Hazard Identification and Risk Assessments (HIRA's) based on AS/NZS ISO 31000:2009 Risk management process as shown below in Figure 1.

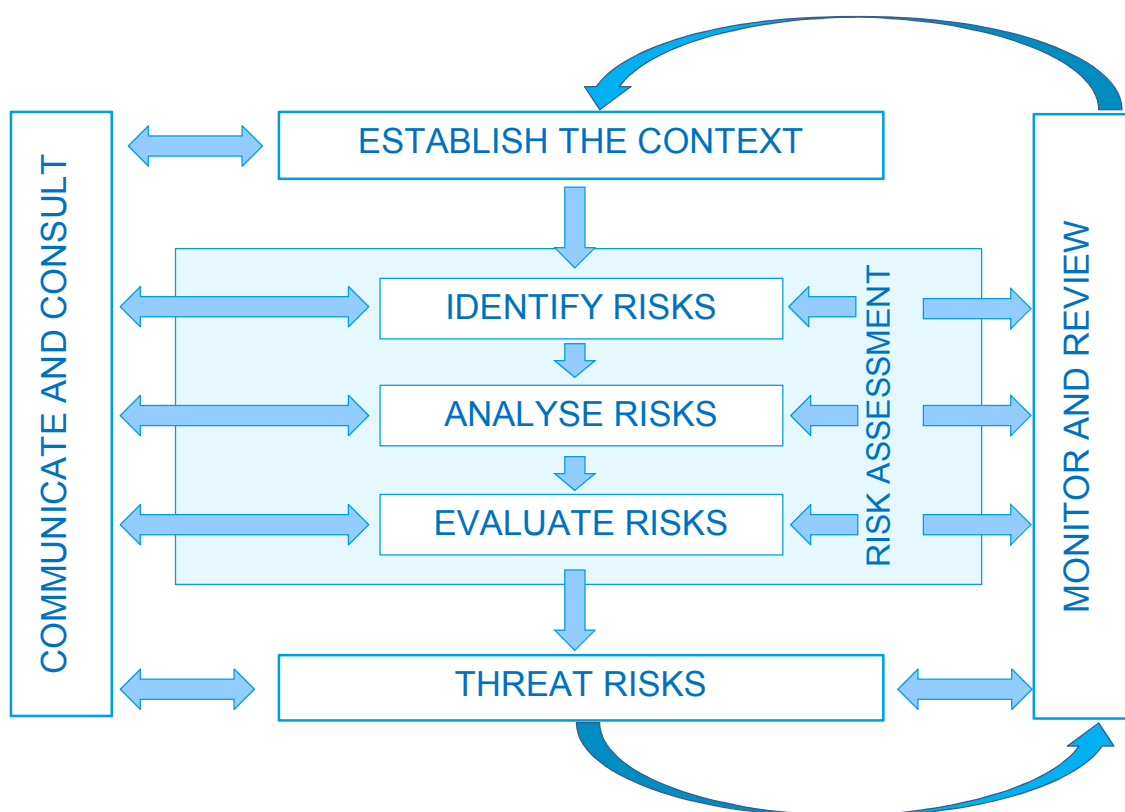


Figure 1 AS/NZS ISO 31000:2009—Risk management process

The purpose of a HIRA is to identify hazards, evaluate the risk of each hazard identified, and to implement control measures.

The risk rating approach in the HIRA process uses a matrix of likelihood and consequence to evaluate risk. Each is assigned a numerical value based on Table 1.1 and Table 1.2 as follows:

Table 1.1 Hazard Likelihood Rating

Likelihood	Score	Description— The event/impact:
ALMOST CERTAIN	5	is common and expected to occur in most circumstances
LIKELY	4	has happened before and will probably occur again
POSSIBLE	3	could occur at some time
UNLIKELY	2	is not likely to occur
RARE	1	may occur in exceptional circumstances

Table 1.2 Hazard Consequence Rating

Consequence	Score	Description
EXTREME	5	Major negative impact on key performance indicators. Large scale shareholder losses or damage to public image. Incident involving a fatality or permanent disability. An environmental impact that is likely to spread beyond the immediate site and will remain a serious problem over a prolonged period.
MAJOR	4	Large negative impact on key performance indicators. Extensive and severe risk of economic and financial loss. Major injury that would require a prolonged recovery or result in an incomplete recovery or a life threatening illness or disease. An environmental impact that is severe and likely to impact beyond the immediate site and remain a problem in the medium term
MODERATE	3	Significant negative impact on key performance indicators. Loss of production capability, medium financial loss. Broken bones or any injury that results in over three days lost work time. Onsite environmental impact that is localised and has short term effects.
MINOR	2	Minor negative impact on key performance indicators. Minor financial loss. Minor injuries that require first aid treatment. On-site release immediately contained resulting in only minor and transient environmental impact.
INSIGNIFICANT	1	Insignificant negative impact on key performance indicators. Minimal or no financial loss Minor cuts, bumps or bruises that don't require first aid. No appreciable environmental impact.

Table 1.3 Risk Assessment Matrix

CONSEQUENCE	5-Extreme	12	19	20	24	25
	4-Major	10	15	18	21	23
	3-Moderate	6	9	14	17	22
	2-Minor	3	5	8	13	16
	1-Insignificant	1	2	4	7	11
		1-Rare	2-Unlikely	3-Possible	4-Likely	5-Almost Certain
LIKELIHOOD						

A fatality is a clear category that is readily understood, the others are explained below:

- A major injury would require hospitalisation, an ambulance would be called, and there would be extensive bleeding or haemorrhaging or loss of limb. The injuries would be life

threatening and require a prolonged recovery period which might result in an incomplete recovery. A life-threatening illness or disease would also fall into this category.

- A significant injury would include broken bones, minor amputations—fingers, toes, etc., major cuts and bruises, or a significant illness or disease. A visit or short stay in hospital might be required.
- A first aid injury is one requiring some treatment from a trained person usually at the work place or nearby. Attendance at a hospital would normally not be required.
- A minor injury is one that does not require first aid, such as minor cuts or bruises, bumps, scrapes, etc.

The product of the likelihood and severity ratings produces the risk rating. The table below categorises risk ratings into general categories.

Table 1.4 Risk Rating Results

Key	Control Measures	Outcome
1-3 Low Level Risk	These risks are regarded as acceptable within normal business activities, are managed effectively by routine and standard procedures and can be excluded from further detailed consideration.	Continue with the work
4-12 Medium Level Risk	Staff can arrange their own risk assessments and control measures provided that they are competent to do so.	Competent staff can decide to proceed
13-19 High Level Risk	Discuss risks and proposed controls with your manager who will decide whether senior management attention and further evaluation is necessary. A risk action plan is normally needed which clearly allocates responsibilities and timetables for action	Manager can decide to proceed
20-25 Very High Level Risk	These risks will require close management attention at senior level, detailed evaluation and a formal risk action plan.	Only Directors/Officers can decide to proceed

H 2. DESIGN PHASE—HAZARD IDENTIFICATION

H2.1 Aim

To determine how the in-scope hazards identified during the Preliminary Hazard Identification phase will be eliminated or controlled through full risk management and implementation of recognised standard solutions.

Upon completion of design, the Client must undertake a review of the design solutions to ensure that the residual risks are understood.

H2.2 Design hazard identification

A Design Phase Hazard Identification and Risk Assessment was undertaken for these works. Recognised industry design solutions have been adopted where possible.

H2.3 Significant residual risks

The hazards identified in the Lifecycle Design Phase Hazard Identification and Risk Assessment in Section H7 which have a 'high' or 'very high risk rating', as defined by Table 1.4, are considered significant and must be brought to the attention of the contractor who is performing the works. All reasonably practical control measures must be implemented to further reduce the risk associated with the hazard.

Hazards with a 'medium' risk rating will also be highlighted to allow control measures to be put in place.

H 3. CONSTRUCTION PHASE— RISK MANAGEMENT

H3.1 Aim

The principal contractor must be provided with a copy of this Designer Safety Report to ensure familiarity with all the known risks identified by Hyder as likely to impact on the health and safety of workers during construction.

Hyder has taken into account the way in which construction activities are likely to be undertaken. As such, Hyder is required to ensure the same consideration is given to identifying 'design' hazards for the construction phase. Identified hazards have been eliminated or minimised through design, so far as is reasonably practicable.

H3.2 Construction risk management

The principal contractor, including their subcontractors, must undertake a Construction Risk Assessment and prepare documentation to manage risk in accordance with relevant legislation, standards and guidelines. When conducting the Construction Risk Assessment, the contractor, including subcontractors, must consider the Lifecycle Hazard Identification and Risk Assessment; see Section H7.

In particular, the contractor's system must demonstrate, as a minimum, compliance with the requirements of the Workplace Health and Safety Acts for the particular state; as specified in Section H6.

The contractor, including subcontractors, should also be familiar with the health and safety requirements of local government and service authorities to ensure its system complies with these documents and/or systems.

H 4. POST CONSTRUCTION—HAZARD IDENTIFICATION AND RISK ASSESSMENT

H4.1 Aim

Reviewing the final design solutions, clearly identifying hazards and analysing risks which could not be eliminated or reduced throughout the Design Phase is a proactive approach to the future management of the risks for the lifecycle of the structure.

The purpose of identifying and documenting these hazards and risks is to ensure Hyder meets its obligations as a designer to transfer risk information to the City of Swan or others who may be effected by the risks related to the design. This risk information must be passed onto the City of Swan's employees or the employees of the owners or lessees of the structure. This ensures the hazards and risks are appropriately managed so that ongoing workplaces are safe and without risk to health.

H4.2 Owner/operator risk management

Lifecycle Design Phase Hazard Identification and Risk Assessment has identified the hazards likely to present during the post-construction or operational phase of the structure. Only hazards that are 'in-scope' (i.e. can be affected, introduced or increased by the design of the structure) are considered.

H4.3 Post-construction hazard identification and risk assessment

The owner/operator of the structure should undertake its own hazard identification and risk assessment, in line with the intended use of the structure, to ensure that all hazards and risks have been identified using the Lifecycle Design Phase Hazard Identification and Risk Assessment.

Those risks identified by Hyder during the Design Phase, which could not be mitigated, should be incorporated into the owner/operator's Risk Register. Responsibility for the ongoing management of these risks and the mitigation rests with the owner/operator, in accordance Work Health and Safety legislation, as specified in Section 1 and other relevant legislation, standards and guidelines.

H 5. CONCLUSION

Throughout the Design Phase of the project, consideration has been given to workplace safety, not only during construction, but following the completion of works. Where reasonably practicable, identified hazards and risks have been eliminated, and/or reduced, from the design. Whilst every reasonable effort was made to remove identified hazards and risks, in accordance with the requirements of the Work Health and Safety legislation, not all hazards and risks have been eliminated.

It is imperative the client/owner of the final works independently assess any residual hazards and risks identified in this report, and incorporate these into their own Site Risk Register to ensure ongoing work health and safety obligations are met.

H 6. LEGISLATION, GUIDELINES AND STANDARDS

Legislation:

Commonwealth

[WORK HEALTH AND SAFETY ACT 2011](#)

[WORK HEALTH AND SAFETY REGULATIONS 2011](#)

Western Australia

[OCCUPATIONAL SAFETY AND HEALTH ACT 1984](#)

[OCCUPATIONAL SAFETY AND HEALTH REGULATIONS 1996](#)

Guidelines:

[Model Code of Practice Safe Design of Structures](#)

H 7. LIFECYCLE HAZARD IDENTIFICATION AND RISK ASSESSMENT

LIFECYCLE HAZARD IDENTIFICATION & RISK ASSESSMENT

Design statement	Project Code/Doc No: AA007882 / A5001-AA007882-AAR-00
This HIRA is to identify opportunities to improve design solutions to minimise or mitigate safety risks during construction and the buildings final intended use. Contractors are to provide their own HIRA and safety procedures to ensure optimum safety during construction phases. This Lifecycle HIRA is for Railway Parade Bridge Project	Project Name: Railway Parade Bridge
L = Likelihood C = Consequence RR = Risk Rating Likelihood and Consequence are evaluated on a 1 - 5 scale to yield a Risk Rating between 1 and 25	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
Lifecycle Risk—Construction			L	C	RR	
C1	Site location & site access – access by unauthorised personnel / local residents resulting in injuries or in extreme circumstances loss of life	The contractor to secure site access and to provide adequate danger signage.	3	4	18	
C2	Site clearance – risk of encounters with reptiles	The site staff to be made aware of risks and appropriate preventative measures.	3	3	14	
C3	Excavations – damage to underground services	No services were identified during the design phase, however contractor shall undertake dial-before-you-dig prior to works commencement.	2	3	9	
C4	Deep excavations – danger of falling in.	Excavations to be adequately fenced off.	1	4	10	
C5	Deep excavations – danger of collapse / disturbance of adjacent ground.	Adequate shoring of excavations / batter back the side slopes of excavations. Ensure plant is kept outside safe working zone for excavations.	2	5	19	
C6	Piling works – working near mobile plant and injury to operatives.	The contractor to use banks men and adopt safe working systems.	2	4	15	
C7	Piling works – potential of loss of stability of the pile rig due to the presence of soft soils.	The contractor to assess whether temporary foundations are required to address the construction loadings and soil conditions.	2	4	19	
C8	Piling works – risk of falling in to open pile shafts.	Pile shafts to be adequately temporarily protected against falling in until casting commences. No open shafts to be left over night.	1	5	12	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
C9	Working in the vicinity of operational railway – general.	Site activities requiring access to within the rail corridor shall be coordinated with rail authorities, rail operator. Railway / operator's representative to be present on site while incorporating safety measures. A detailed Works Method Statement shall be submitted to the client, rail operator and rail authorities for approval prior to work commencement. Temporary fencing to be provided along the rail corridor for the duration of construction works.	2	5	19	
C10	Working at heights – falling from heights, falling equipment and material.	The design utilizes precast bridge components to reduce the amount of works carried out at heights and to minimize the time required to complete construction activities when eliminating the risk was not practical. Approved access equipment, edge protection, scaffolding and fall-arrest systems to be used while working at heights.	3	4	18	
C11	Working near & over river – risk of falling into water	The contractor to keep on site adequate rescue equipment.	2	3	9	
C12	Working near & over river – risk of flooding resulting in injuries and loss of life	Water table level subjected to seasonal changes, contractor to monitor weather forecast and to suspend works and withdraw resources in instances of potential flooding.	1	5	12	
C13	Working near & over river – contamination of river water due to oil spillage	Construction equipment to be checked for oil leaks prior to its engagement on site. Spillage kits to be kept on site. Site crew to be familiar with the use of spillage kits and emergency procedures. The contractor to prepare and submit to the client and his environmental consultant a detailed Works Method Statement including an emergency response protocol for approval prior to works commencement.	3	2	8	
C14	Working near & over rivers – scouring of river banks and potential loss of stability of construction equipment	Water table level and velocity subjected to seasonal changes. The contractor to monitor weather forecast and to ensure slope stability assessment is undertaken for heavy equipment in the direct vicinity of river banks, which takes into account the water table changes.	1	4	10	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
C15	Working near & over rivers – risk of water contamination during concrete placement	Joints between the precast beams and formwork to be adequately sealed. Contractor to prepare and submit to the client and his environmental consultant a detailed Works Method Statement including an emergency response protocol for approval prior to works commencement.	3	2	8	
C16	Working in the river channel – risk of contamination during concrete placement	The contractor to consider suitable construction techniques with the emphasis on contamination avoidance. The contractor to prepare and submit to the City of Swan / representative a detailed Works Method Statement for approval prior to works commencement.	3	2	8	
C17	Working in Heritage Significance area – risk of overlooking and damaging artefacts	A representative of indigenous community to be present on site during site set-up, clearance and excavation works and to be accompanied by a heritage consultant. The contractor to brief site crew on what potential artefacts may look like.	3	3	14	
C18	Materials / bridge components delivery to site – loss of stability of delivery vehicles resulting in serious injuries or loss of life.	The contractor to investigate in detail access to site from the main road to address potential stability issues. Suitable access tracks to be provided by the contractor.	2	5	19	
C19	Lifting bridge components – crane stability during lifting, stability of lifted elements, injury to operatives working below and in the vicinity of the crane.	Soil conditions to be examined prior to crane setting – temporary foundations to be provided if necessary. Where the radius / height of operation infringes designated safety zones the crane shall be fitted with limiting devices otherwise alert devices to be installed. Surcharge from the crane on underground services and a potential damage to them to be considered. Elements to be securely stabilised until structural connections are made. A detailed Works Method Statement to be provided to the client / client's representative and services authorities for approval prior to works commencement.	2	5	19	
C20	Concreting works – stability and strength of formwork systems, stability and strength of temporary supports	The contractor to appoint an adequately qualified temporary works engineer to ensure strength and stability criteria are met in accordance with relevant Australian Standards.	1	5	12	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
C21	Concreting works – prolonged exposure to aggressive alkaline substance (concrete) / injury to operatives.	The contractor to provide adequate PPE and explain the risks to the site crew.	2	3	9	
C22	Concreting works – risk of river / soil contamination during the use of a concrete pump	The contractor / operator to check the equipment for a potential leakage prior to its use.	3	2	8	
C23	Concreting works – risk of river / soil contamination during cleaning of equipment	The contractor to establish an adequately protected washout area. The washout area to be checked for leakage prior to its use.	3	2	8	
C24	Formwork / Shuttering Operations – exposure to dust from cutting materials resulting in a long term health damage.	The contractor to provide adequate PPE and a safe working environment to all operatives.	3	2	8	
C25	Finishes – use of chemical substances	The contractor to possess adequate and up-to-date information (MSDS) regarding substances / chemicals used on the project and take relevant precautions. Staff working with the chemical to be made familiar with the safe methods of application and risks involved.	2	3	9	
C26	Storage of chemical substances – risk of inappropriate use by unauthorised personnel resulting in injuries / loss of life / contamination.	The contractor to provide an adequately secured storage facility.	2	5	19	
C27	Working near mobile plant – injury to operatives	The contractor to provide adequate safe working systems.	2	4	15	
C28	Exposure to noise – noise from plant, machinery and equipment causing long term hearing damage.	The contractor to provide ear protection adequate to the level of noise.	3	2	9	
C29	Backfilling operations – failure of embankments / falling from heights	A detailed Works Method Statement to be prepared by the contractor and submitted to the client / client's representative for approval prior to works commencements.	2	4	15	
Lifecycle Risk—Service			L	C	RR	
S1	Change in the nature of the area (densely populated) and accessibility to the railway embankment and the existing bridge by unauthorised personnel – risk of falling off the structure and accidents involving trains.	A wire-mesh fence to be provided along the rail corridor in the vicinity of the new crossing. Its length to be determined by a risk assessment.	2	5	19	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
S2	Access to bridge embankments / inspectable areas by unauthorised personnel / members of public – risk of falling off, slips and trips resulting in injuries or in extreme circumstances loss of life.	Steel trowel finish to be provided to the top surface of the inspection ledge and stairs or alternatively a thin epoxy based wearing course with grit finish to ensure the required skid resistance is provided. The access stairs and ledge to be equipped with monowills balustrade.	2	5	19	
S3	Access to the outer area of the deck behind the balustrade by members of the public – risk of falling off the structure resulting in serious injuries or loss of life.		1	5	12	
S4	Slips and trips while walking on the path – risk of minor to moderate injuries.	The top surface of the concrete screed to be provided with the Class U4 finish to ensure the required skid resistance is provided. Alternatively a thin epoxy based wearing course with a grit finish to be provided. Over the expansion joints recessed cover plates will be provided to main a smooth, free of trip hazards surface.	3	2	8	
S5	Falling off the bridge while cycling – risk of serious injuries or loss of life.	A standard MRWA 1,300mm tall PSP balustrade is provided along the shared path. It should be noted that a taller balustrade may be required when to protect users from a very severe hazard (e.g. high vertical drop to a body of rock or water) in accordance with Austroads Part 6A cl. 7.7.2 – this is yet to be assessed in collaboration with the City of Swan and adequately addressed during the detailed design stage.	1	5	12	
S6	An accidental impact with the balustrade and loss of stability while cycling over the bridge – risk of moderate injuries.	.	3	3	14	
S7	Risk of falling over the bridge barriers and onto the carriageway resulting in serious injuries or loss of life.	A standard MRWA three-rail regular containment barrier 1,300mm in height is provided between the carriageway and the PSP. The height may yet need to be assessed according to the risk profile – this is yet to be addressed during the detailed design stage in collaboration with the City of Swan.	1	5	12	
S8	Climbing piers by unauthorised personnel / members of the public – risk of falling down resulting in serious injuries of loss of life.	The top of the pier is located approximately 3.1m above the existing ground level. This is yet to be discussed with the City of Swan – localised lowering of the existing ground to increase the height to 4m would seem appropriate to defer people from climbing.	1	5	12	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
Lifecycle Risk—Maintenance and Inspections			L	C	RR	
M1	Accidents during inspection works – general	Access means have been provided as far as practicable – this include access stairs and ledge to the abutments. Steel trowel finish to be provided to the top surface of the inspection ledge and stairs or alternatively a thin epoxy based wearing course with grit finish to ensure the required skid resistance is provided. The access stairs and ledge to be equipped with monowills balustrade to prevent risk of falling down. Inaccessible areas requiring a close attention can be looked at with the use of binoculars otherwise approved scaffolding systems / access equipment to be used. Areas directly located over the brook shall be inspected with the use of mobile access equipment such as an EWP (elevated work platform) and the like. Portable access stairs may be used when trying to descent in areas not designed for access.	2	3	14	
M2	Accidents during inspection of pier bearings – risk of falling off resulting in serious injuries or loss of life.	Approved scaffolding systems / access equipment to be used. If mobile access equipment is to be used it shall only be operated by an appropriately trained and certified personnel. A detailed Works Method Statement to be prepared and submitted for approval to relevant authorities prior to undertaking the inspection. Stability of the equipment shall be considered. Items cast-in the body of piers to be investigated in collaboration with the City of Swan and MRWA in order to provide readily available means of connecting / hooking on to.	1	5	12	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
M3	Replacement of bearings and expansion joints – risk of injuries due to work in the vicinity of live traffic, stability of lifting equipment, working near and with mechanical equipment, limited accessibility,	Replacement of expansion joints will require traffic management or a temporary bridge closure. Replacement of bearings shall not be undertaken under live traffic, a temporary closure is required. At the pier both bridge decks shall be jacked up at the same time. A detailed Works Method Statement shall be prepared and submitted to the City of Swan / MRWA for approval prior to works commencement. Access to pier bearings to consider risks and mitigation measures as outlined in the item M2.	3	3	14	
M4	Replacement of damaged bridge furniture – risk of falling off the structure, working near life traffic.	Scaffolding / working platforms / fall-arrest systems to be utilised whilst replacing the balustrade and the edge barrier. A replacement of precast parapet panels with the use of lifting equipment / cranes to be undertaken by appropriately trained and certified staff. A replacement of barriers and precast parapet panels requires a suitable traffic management plan or a temporary closure. A detailed Works Method Statement shall be prepared and submitted to the City of Swan / MRWA for approval prior to works commencement.	1	4	10	
M5	Risk of falling down the embankment batters – risk of moderate injuries	The slope of embankment batter away from the bridge to be provided in 1:3. The steeper slopes in the vicinity of the structure are protected against scour and erosion eliminating the need to undertake the usual maintenance works. In instances when repairs to the embankment protection are required scaffolding / working platforms to be used to provide a safe working environment whilst working on a steep slope. Portable access stairs may be used to ensure a safe descent.	2	3	9	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
Lifecycle Risk—Decommissioning			L	C	RR	
D1	Impact on structural integrity – loss of stability / strength of bridge components.	A demolition sequence to be in the reverse order to the construction sequence. If an alternative sequence is considered the demolition contractor to engage a suitably qualified engineer to assess the impact and the suitability of the proposed methodology. A detailed Works Method statement shall be prepared and submitted to the City of Swan / MRWA for approval prior to works commencement.	2	5	19	
D2	Environmental impact – contamination of the river	A demolition methodology shall consider the specifics of the equipment proposed and its potential impact on the river ecosystem when oil leakage occurs. Also, the bridge components shall be disconnected and removed such that the amount of dust / particles of various construction materials falling in to the river is controlled and does not exceed allowable limits. A detailed Works Method Statement capturing the mitigation measures and controls shall be prepared and submitted to the City of Swan / MRWA for approval prior to works commencement.	2	3	9	
D3	Saw cutting / breaking – risk of exposure to dust and noise	The contractor to provide adequate PPE and a safe working environment to all operatives. A demolition methodology shall consider the overall level of noise and its impact on the nearby properties.	3	2	9	
D4	Movement of plants – risk of injuries / loss of life	The demolition contractor to provide adequate safe working systems.	2	4	15	
D5	Lifting bridge components – crane stability during lifting, stability of lifted elements, injury to operatives working below and in the vicinity of the crane.	Soil conditions to be examined prior to crane setting – temporary foundations to be provided if necessary. Where the radius / height of operation infringes designated safety zones the crane shall be fitted with limiting devices otherwise alert devices to be installed. Surcharge from the crane on underground services and a potential damage to them to be considered. Elements to be securely stabilised after their removal. A detailed Works Method Statement to be provided to the City of Swan / client's representative and services authorities for approval prior to works commencement.	2	5	19	

Ref	Design Risk	Design Input to eliminate/reduce Risk	Risk Rating L x C = RR			Information required by Risk Owner to manage Residual Risk
D6	Working at heights – falling from heights, falling equipment and material.	The design utilizes precast bridge components to reduce the amount of works carried out at heights and to minimize the time required to complete demolition activities when eliminating the risk was not practical. Approved access equipment, edge protection, scaffolding and fall-arrest systems to be used while working at heights.	3	4	18	
D7	Working near & over river – risk of falling into water	The contractor to keep on site adequate rescue equipment.	2	3	9	
D8	Working near & over river – risk of flooding resulting in injuries and loss of life	Water table level subjected to seasonal changes, contractor to monitor weather forecast and to suspend works and withdraw resources in instances of potential flooding.	1	5	12	
D9	Working near & over rivers – scouring of river banks and potential loss of stability of construction equipment	Water table level and velocity subjected to seasonal changes. The demolition contractor to monitor weather forecast and to ensure slope stability assessment is undertaken for heavy equipment in the direct vicinity of river banks. Stability assessment to take into account the water table changes.	1	4	10	

Authors	Date	Checked by	Date	Approved by	Date	Comments
Przemo Tomczyk	19/07/2015	David Teahan		Roger Chapman		

APPENDIX I

DIAL BEFORE YOU DIG

EXISTING GAS NETWORK

	High Pressure
	Fremantle High Pressure
	Polyethylene High Pressure
	City High Pressure
	Medium Pressure
	Albany Medium Pressure
	Medium Low Pressure
	Low Pressure
	Not Gassed
	Service Line
	High Pressure Service

PROPOSED GAS NETWORK

	Proposed Main
--	---------------

ABANDONED GAS NETWORK

	Abandoned Gas Main
	Abandoned Gas Main Sold
	Abandoned Valve
	Abandoned Fitting

DUCTS AND SLEEVES

	Duct
	Horizontal Boring
	Sleeve
	Road Crossing
	Concrete Slab

TOPOGRAPHY

	ATCO Easement
	Fence
	Building
	Kerb
	Water Boundary
	Contour Line
	Elevation Point

VALVES

	High Pressure
	High Pressure Service
	Main
	Service
	Isolation

GATE STATIONS AND REGULATOR SETS

	High Pressure
	Fremantle High Pressure
	Polyethylene High Pressure
	City High Pressure
	Medium Pressure
	Medium Low Pressure
	Gate Station
	L.P.G. Tank

FITTINGS

	Syphon
	Coupling
	Expansion Joint
	Main Cross
	Reducer
	Stopple
	Flange
	Change Node
	Thredolet
	Tapping Band
	Bend
	Elbow
	Monolithic Joint
	End Cap
	Tee
	Transition
	Three-Way Tee
	Short Stop
	Barrier
	Squeeze Off

PROTECTION DEVICES

	Test Point
	Potential Monitoring
	Odorant Test Point
	Earthing
	Pressure Monitoring Device
	Bond Wire
	Bond Junction
	Rectifier
	Insulation Joint
	Anode

DELIVERY POINTS

	Service Point
	Meter
	Interval Meter
	Meter Set

FEATURE POINTS

SC	Side Elevation
	Obstacle
	See Details
NC	Not Connected
SV	Gas Service
	Sign
OLS	Offline Service
	Linked Reference Document
PLS	Pre-Laid Service
PLSS	Pre-Laid Service Stairs
EoM B/L	End of Main Building Line
EoM CoD	End of Main on Direction Peg

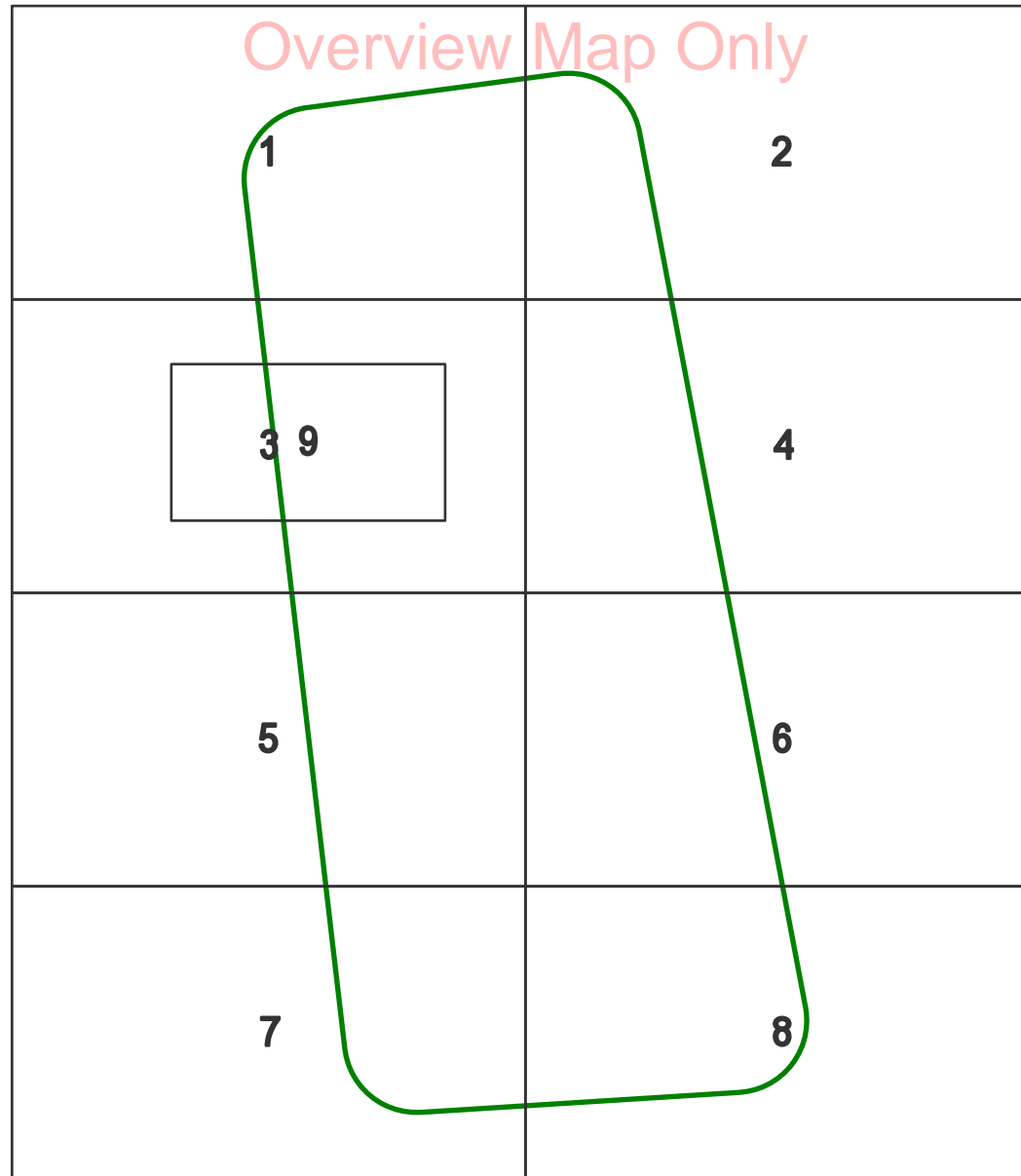
FEATURE LINES

	Miscellaneous Line
	Reference Line
	Gas Indicator Line
	Gas Pit

FEATURE POLYGONS

	Hard Digging		Proving Gas Location		Pressure Upgrade
	Licence Area		Not Gassed		
	Suburb		Local Government Authority		

WARNING - HIGH PRESSURE PIPELINE IN THE VICINITY.
No works within 15 metres of this asset are permitted without prior approval from ATCO Gas Australia PH 1300 926 755



Sequence No: 45276102

Map Tile:

Scale: 1:6150

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ACN 089 531 975

Job No: 9124734

Date: 2/05/2015

Location: Railway Parade, Upper Swan 6069

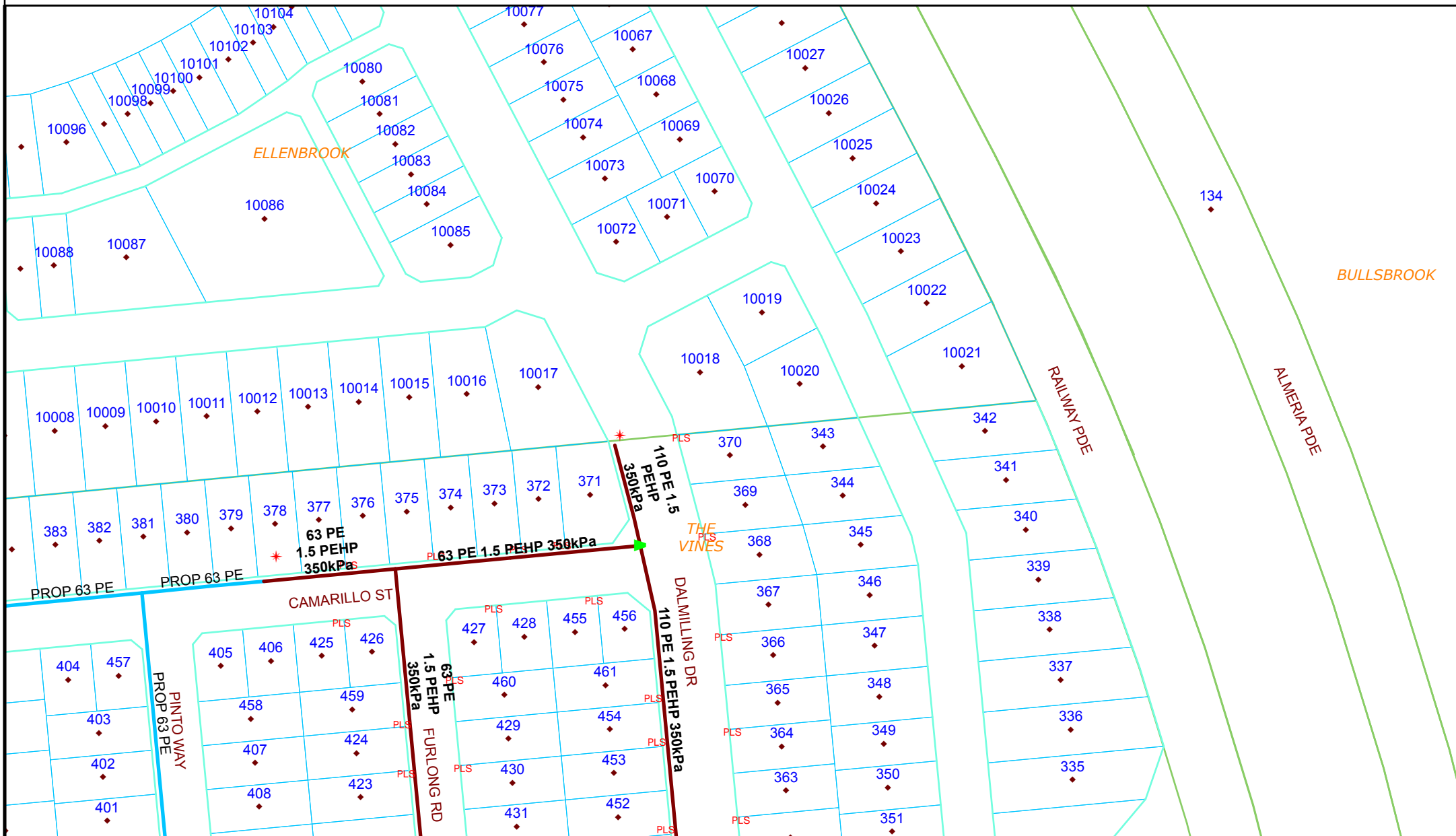


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BULLSBROOK

Sequence No: 45276102

Map Tile: 2

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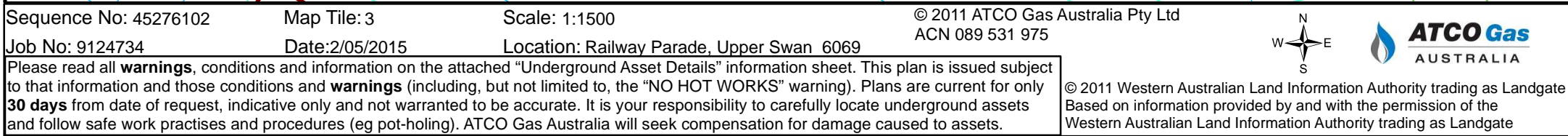
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ALMERIA PDE

UPPER
SWAN

Sequence No: 45276102

Map Tile: 4

Scale: 1:1500

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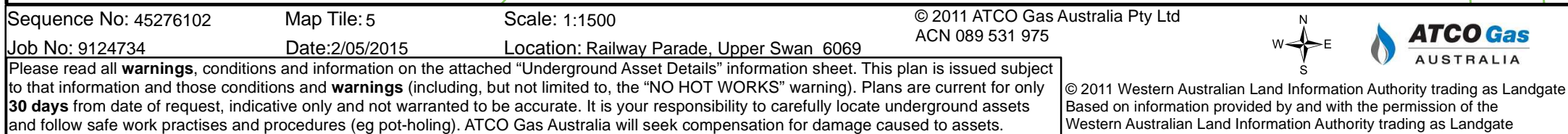
Location: Railway Parade, Upper Swan 6069



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ALMERIA PDE

UPPER
SWAN

6
♦
220

Sequence No: 45276102

Map Tile: 6

Scale: 1:1500

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Date: 2/05/2015

Location: Railway Parade, Upper Swan 6069



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THE
VINES

13255
♦

UPPER
SWAN

RAILWAY PDE

Sequence No: 45276102

Map Tile: 7

Scale: 1:1500

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Location: Railway Parade, Upper Swan 6069



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ALMERIA PDE

UPPER
SWAN

130

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Map Tile: 8

Scale: 1:1500

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Location: Railway Parade, Upper Swan 6069

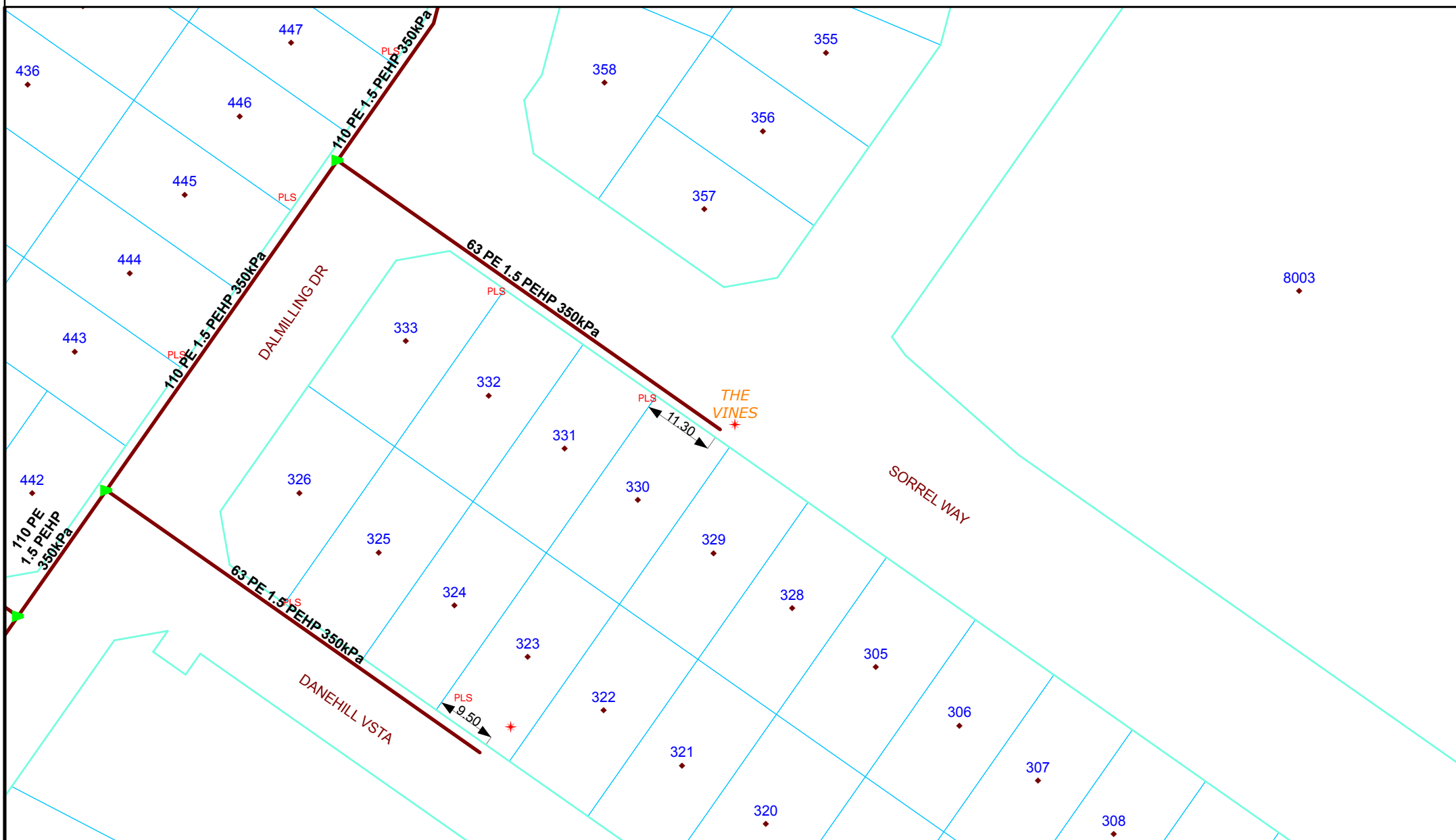


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Sequence No: 45276102

Map Tile: 9

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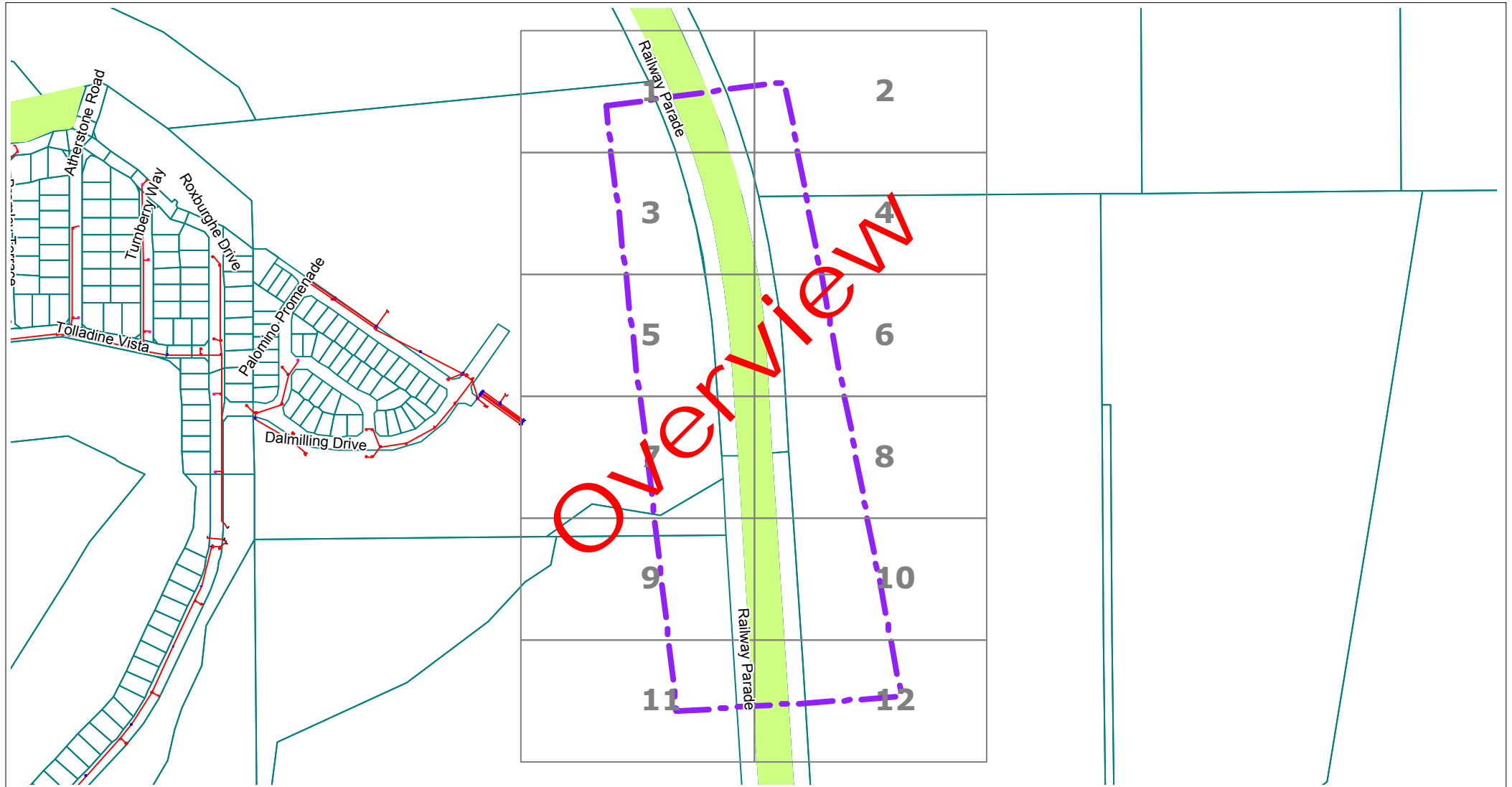


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City of Swan - NOASSETAFFECTED

Location: Address:Railway Parade, Upper Swan, WA, 6069



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Job Number: 9124734

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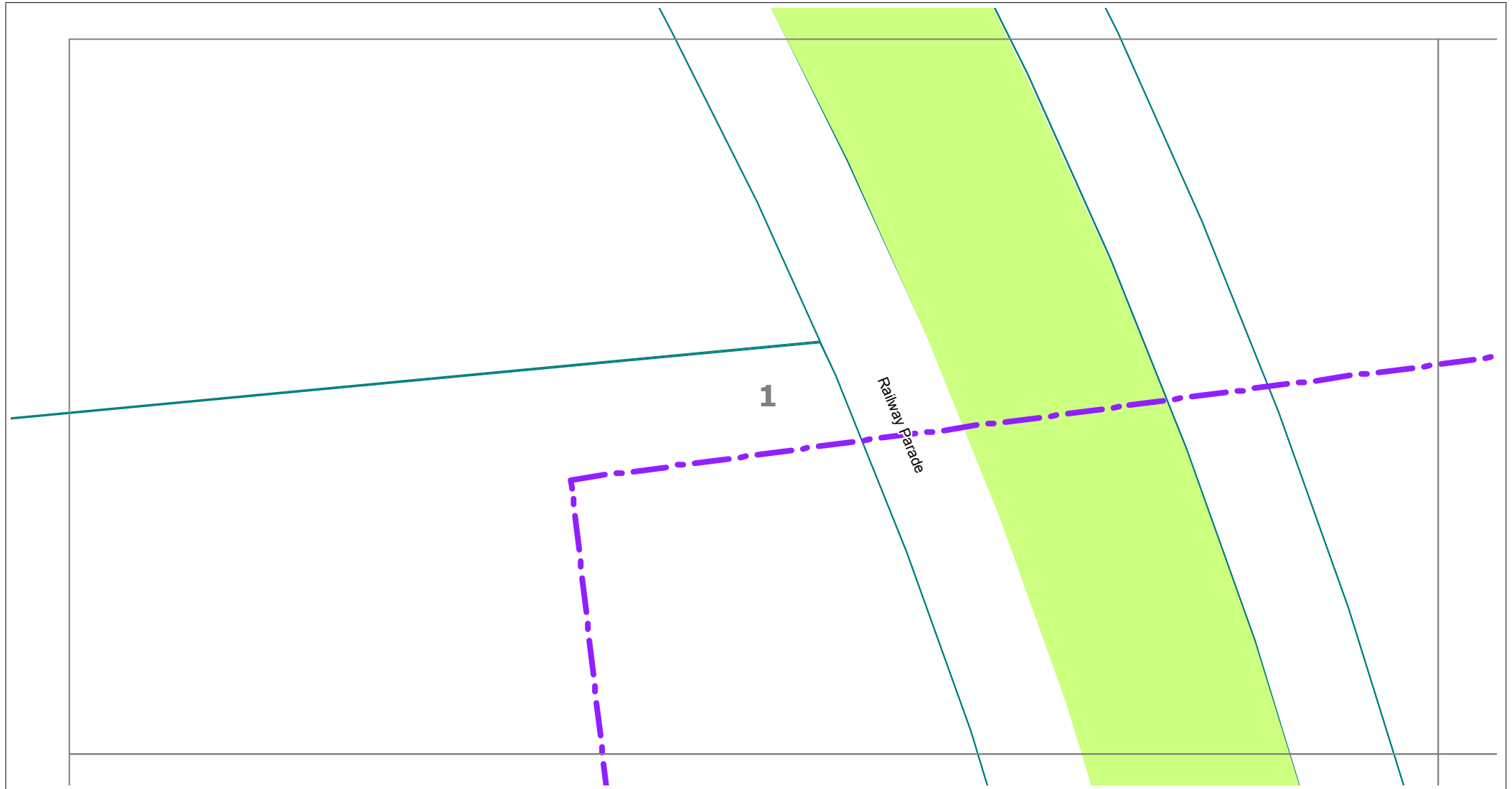
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- City Drainage Lines
- Subsoil Drainage
- Manholes - Gully's - Side Entry Pits
- Fibre Optic Pits
- Fibre Optic Cables
- Water Corp Main Drain
- Reticulation
- Additional Projects

City of Swan - NOASSETAFFECTED

Location: Address:Railway Parade, Upper Swan, WA, 6069



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City of Swan - NOASSETAFFECTED

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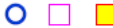





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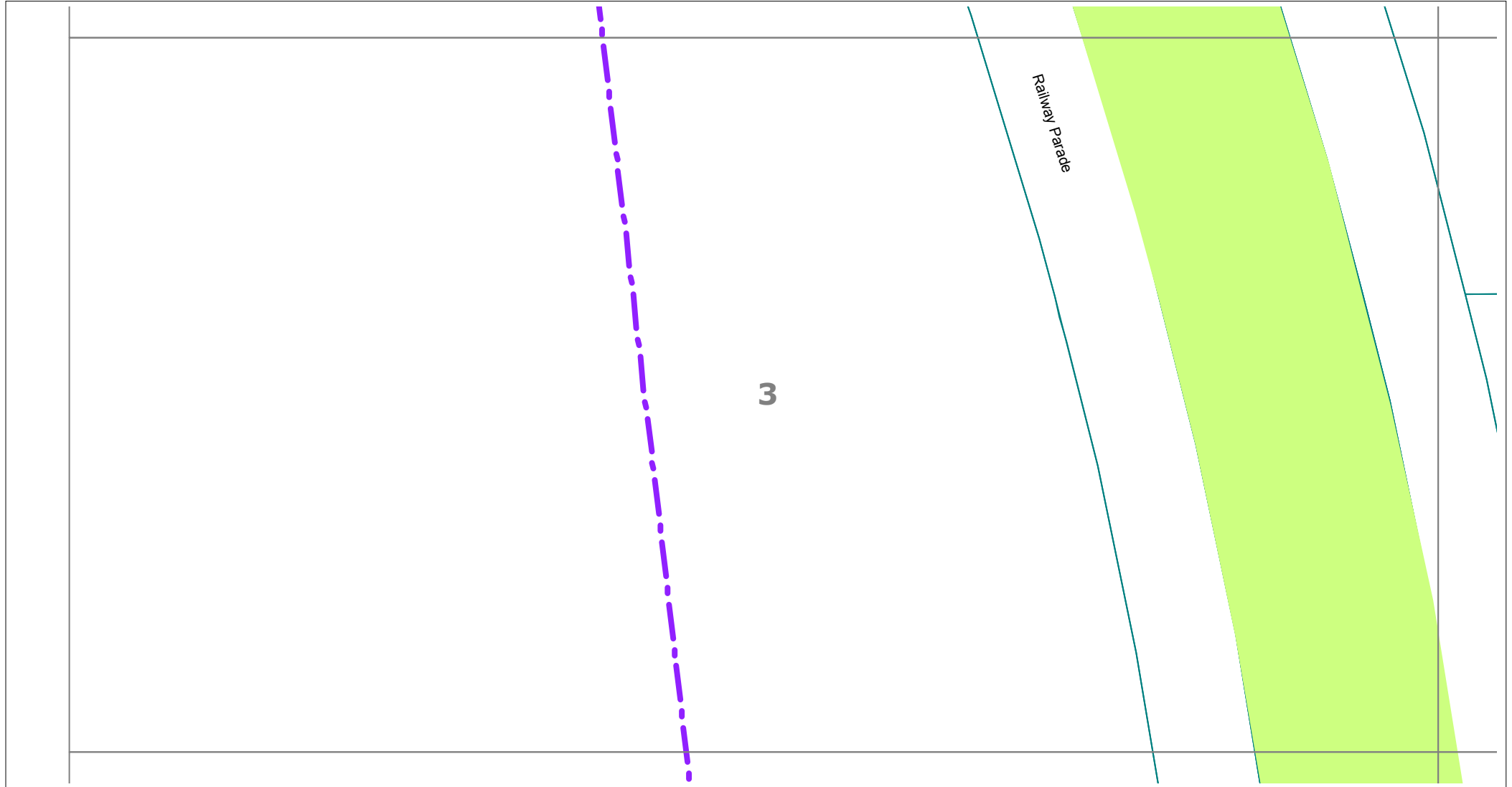
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City of Swan - NOASSETAFFECTED

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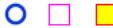




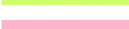
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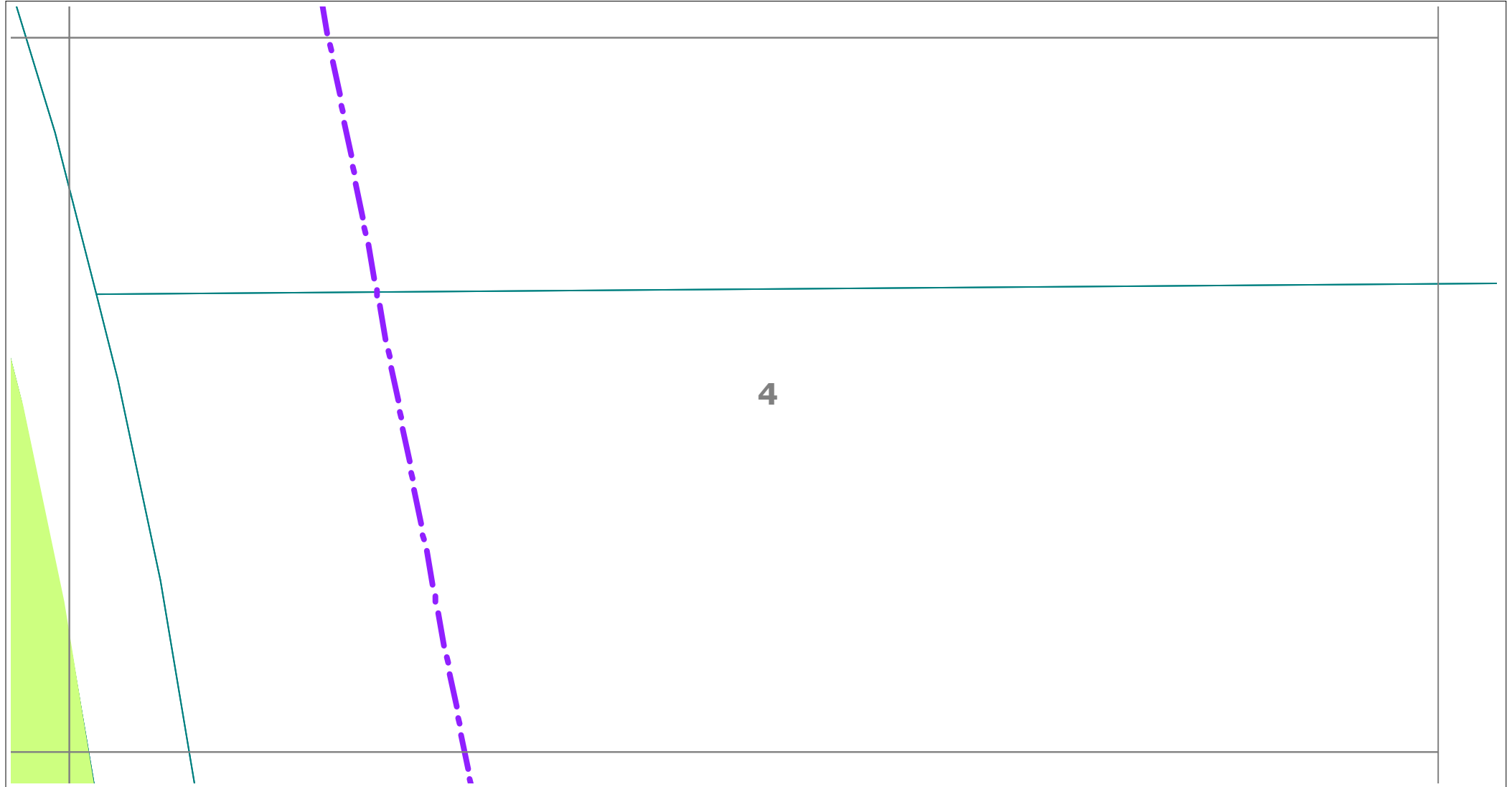
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City of Swan - NOASSETAFFECTED

Location: Address:Railway Parade, Upper Swan, WA, 6069












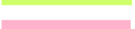
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Job Number: 9124734

Date Generated: 02/05/2015

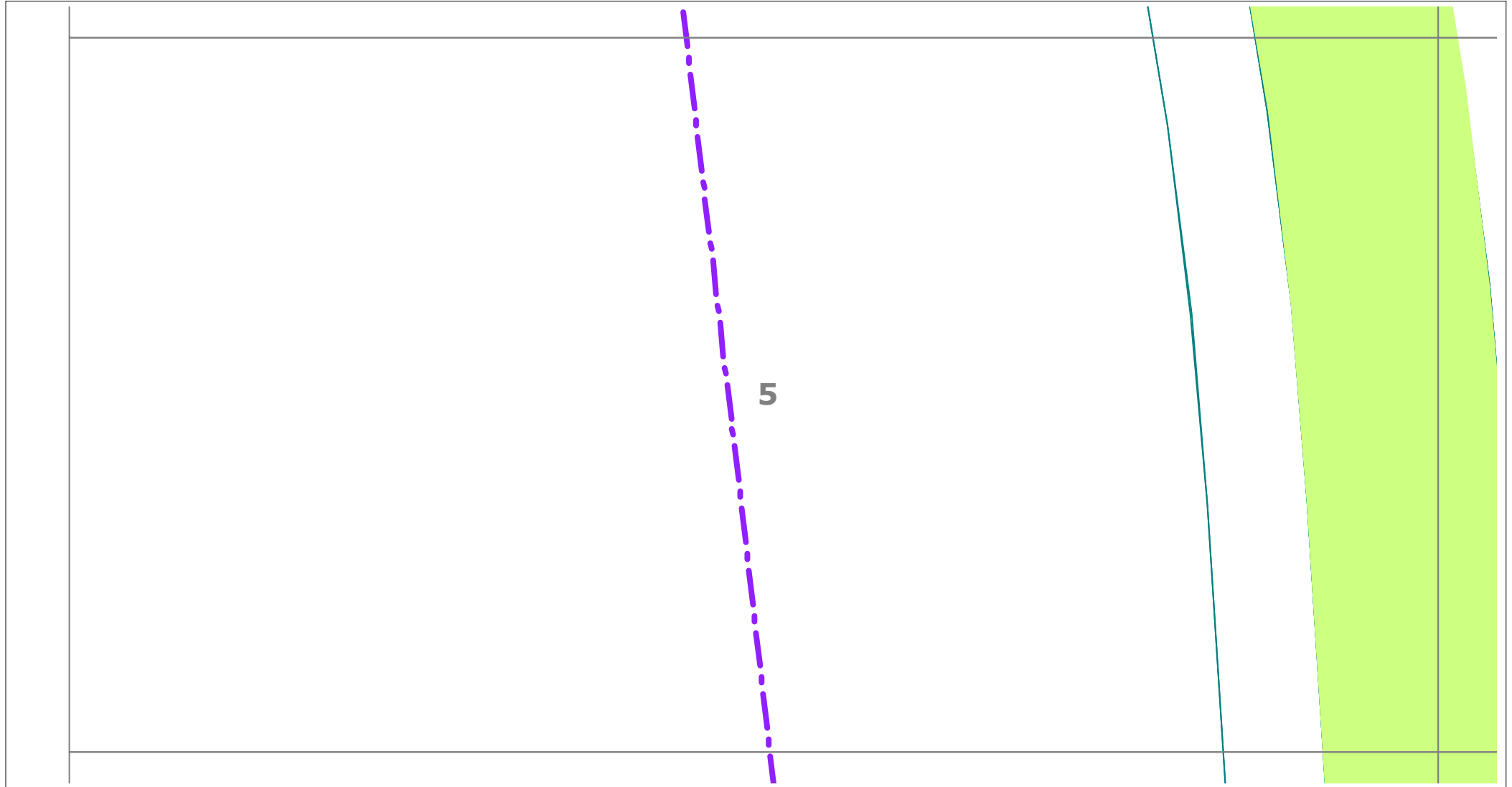
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-  City Drainage Lines
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-  Fibre Optic Pits
-  Fibre Optic Cables
-  Water Corp Main Drain
-  Reticulation
-  Additional Projects

City of Swan - NOASSETAFFECTED

Location: Address:Railway Parade, Upper Swan, WA, 6069










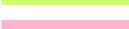
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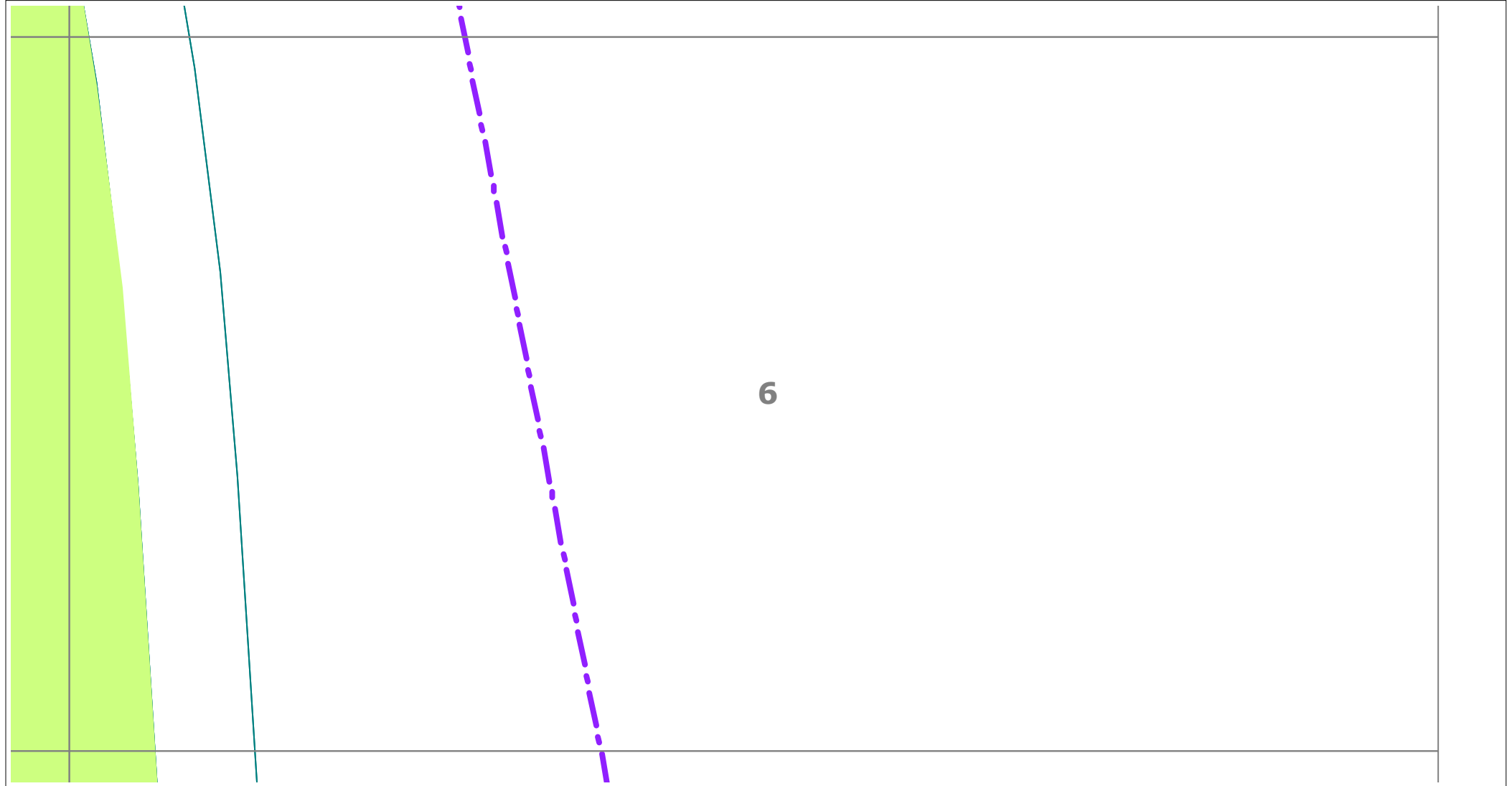
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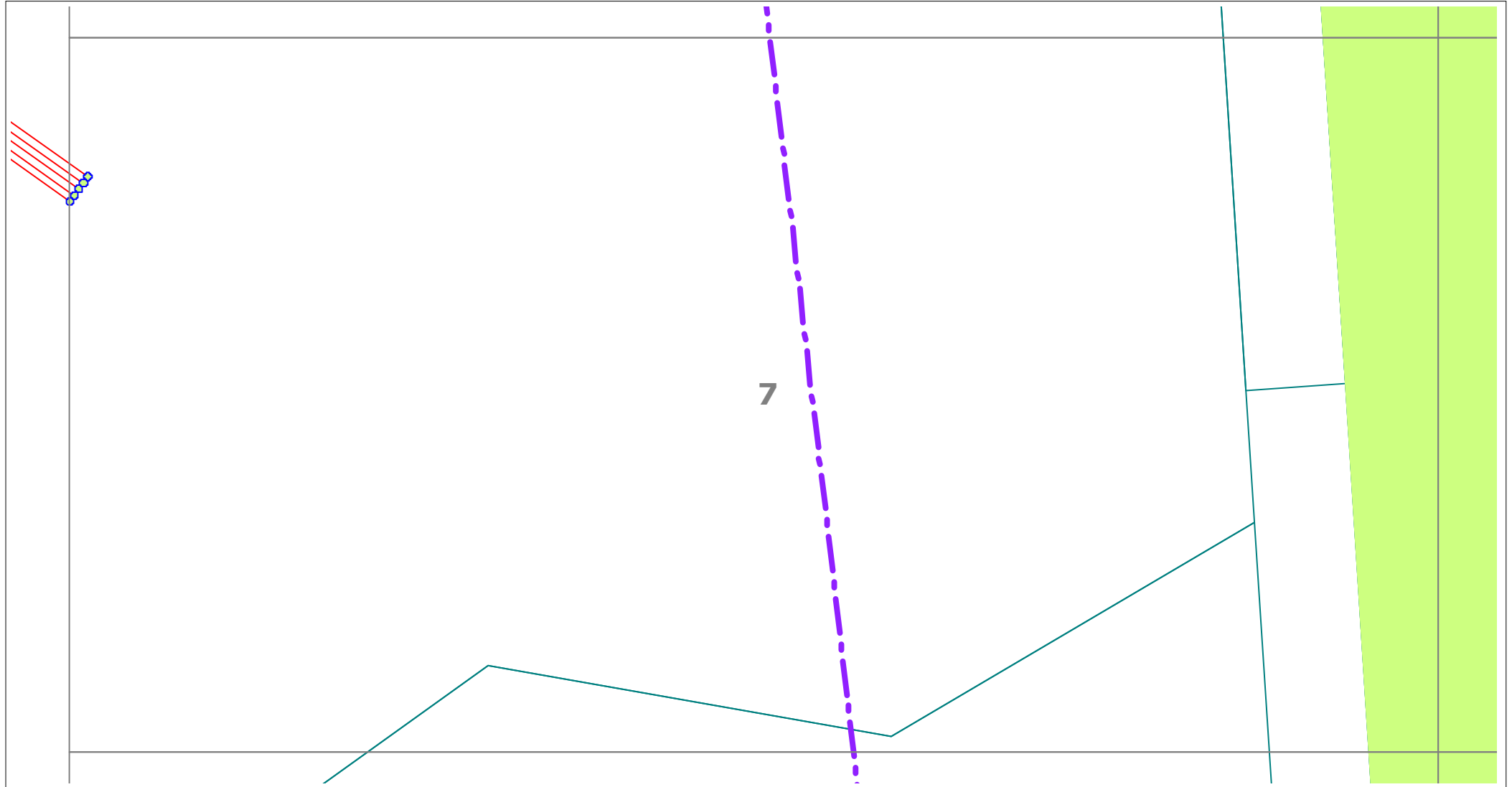
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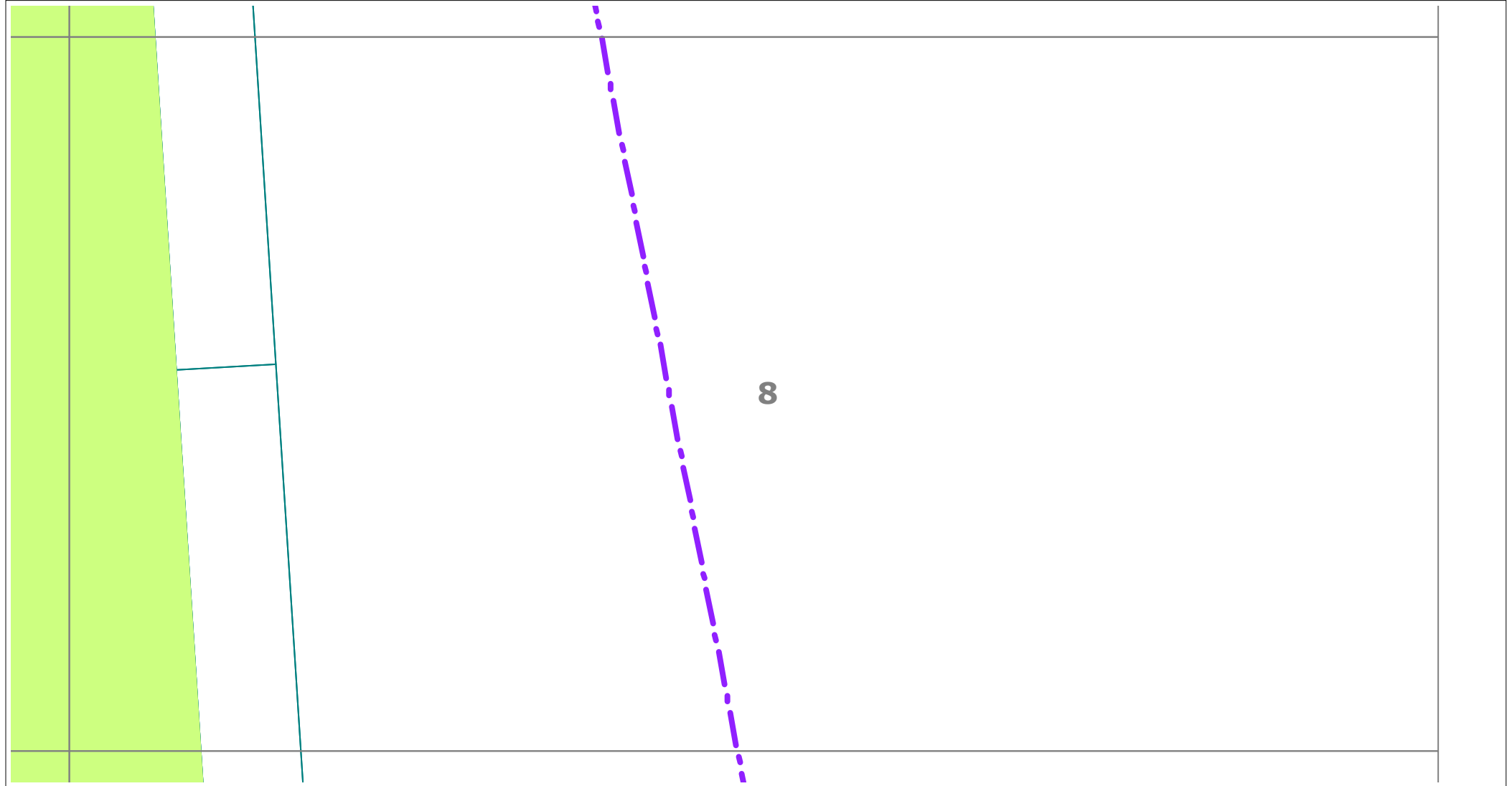
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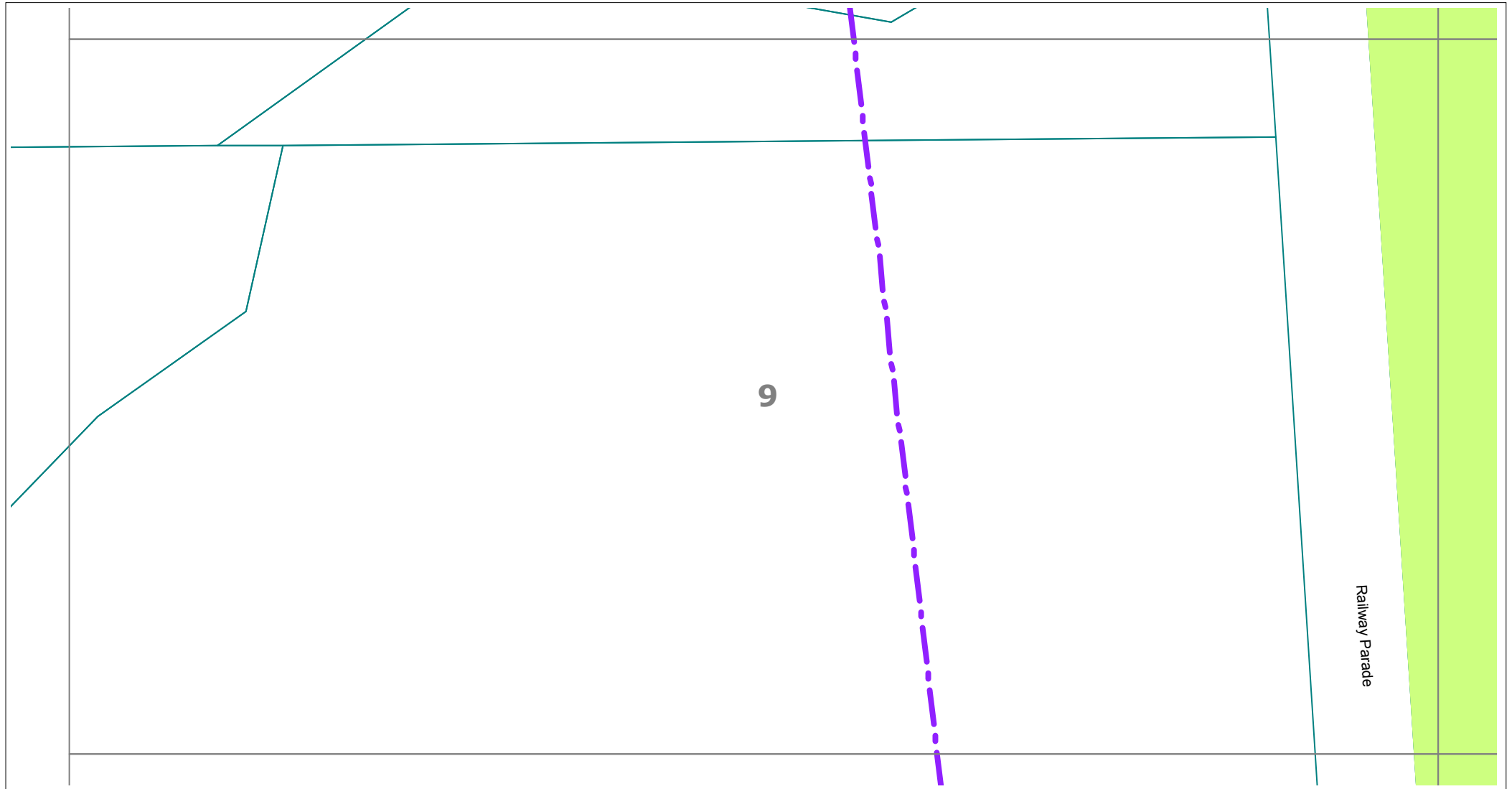
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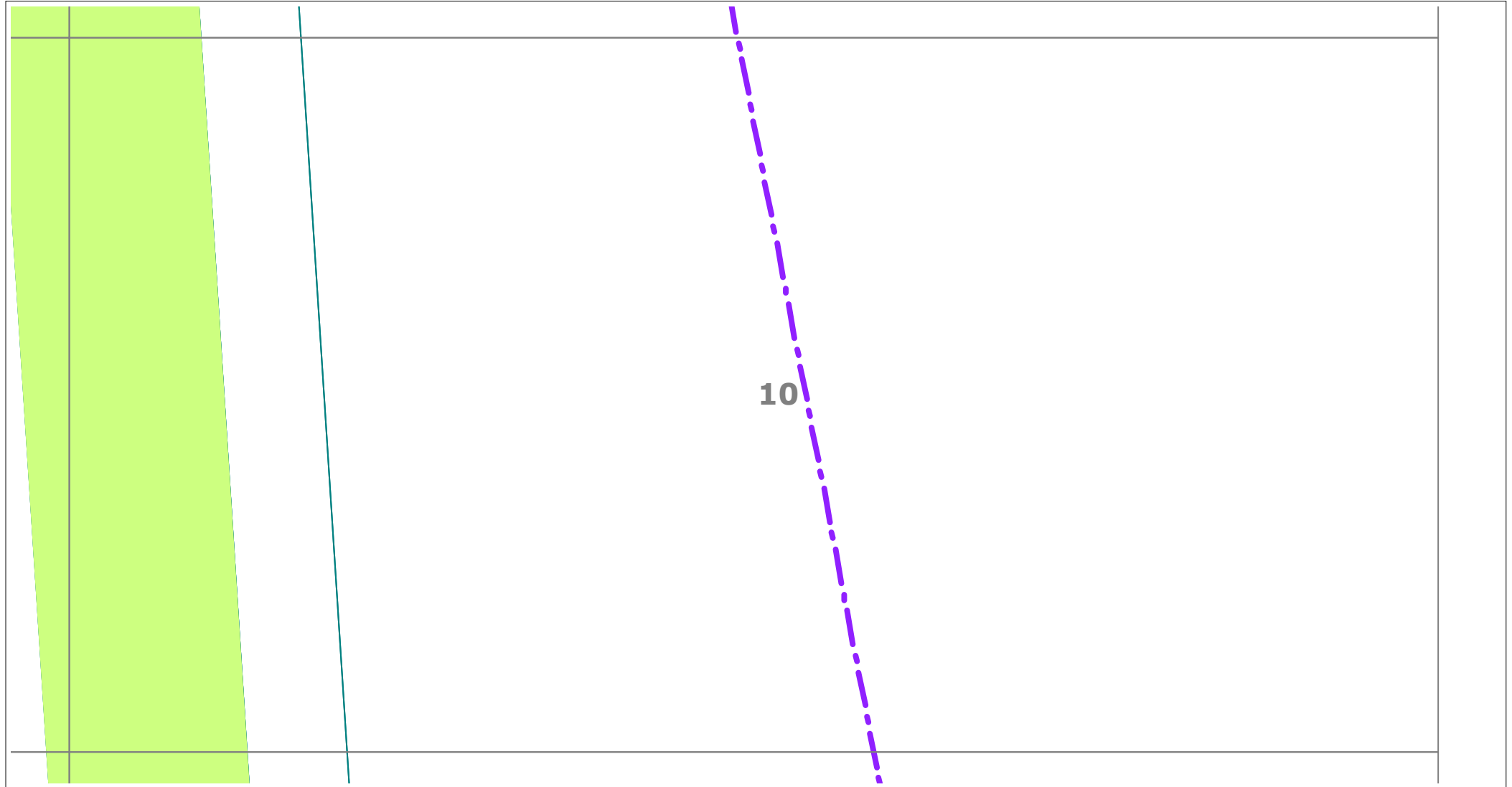
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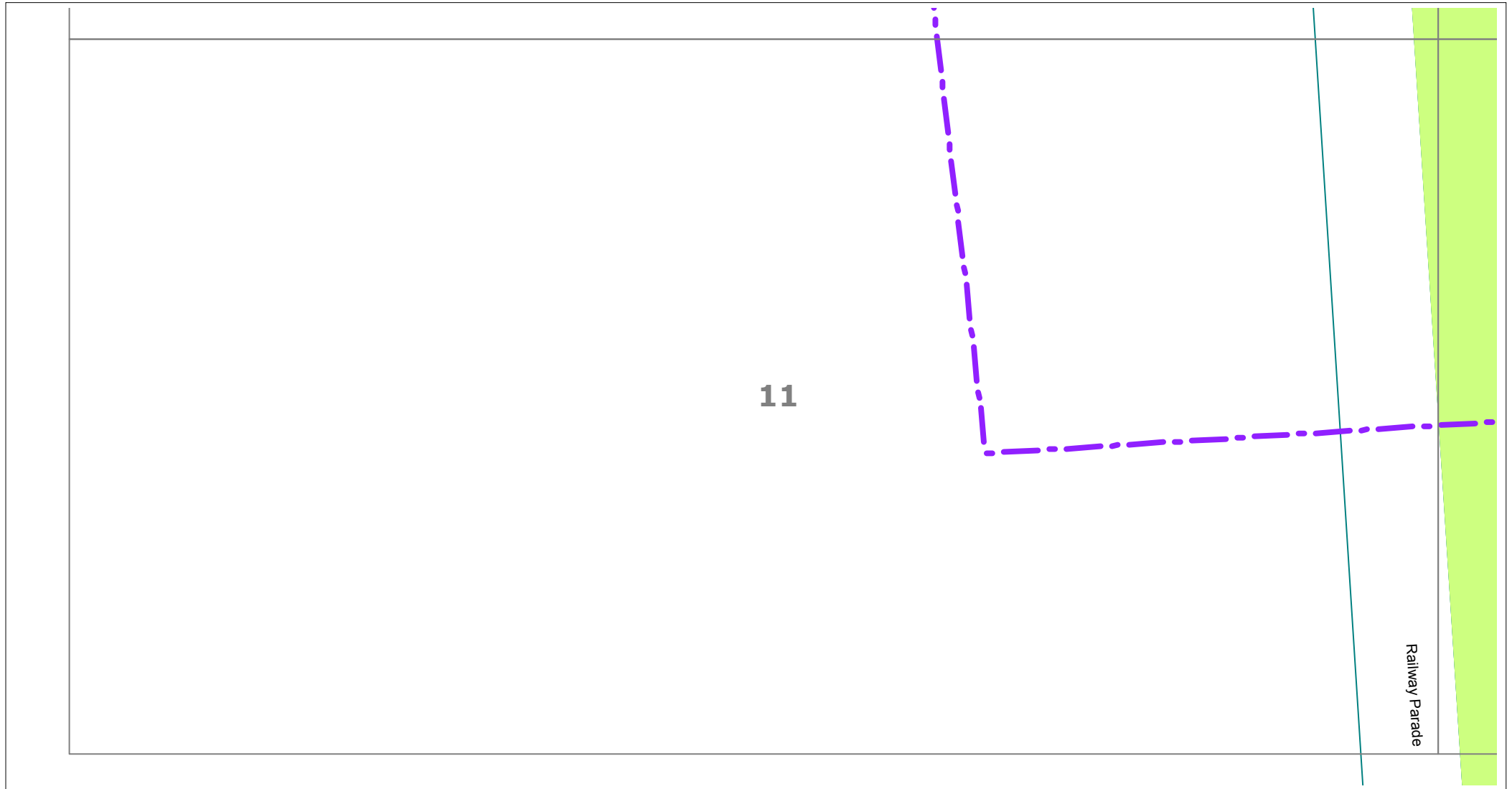
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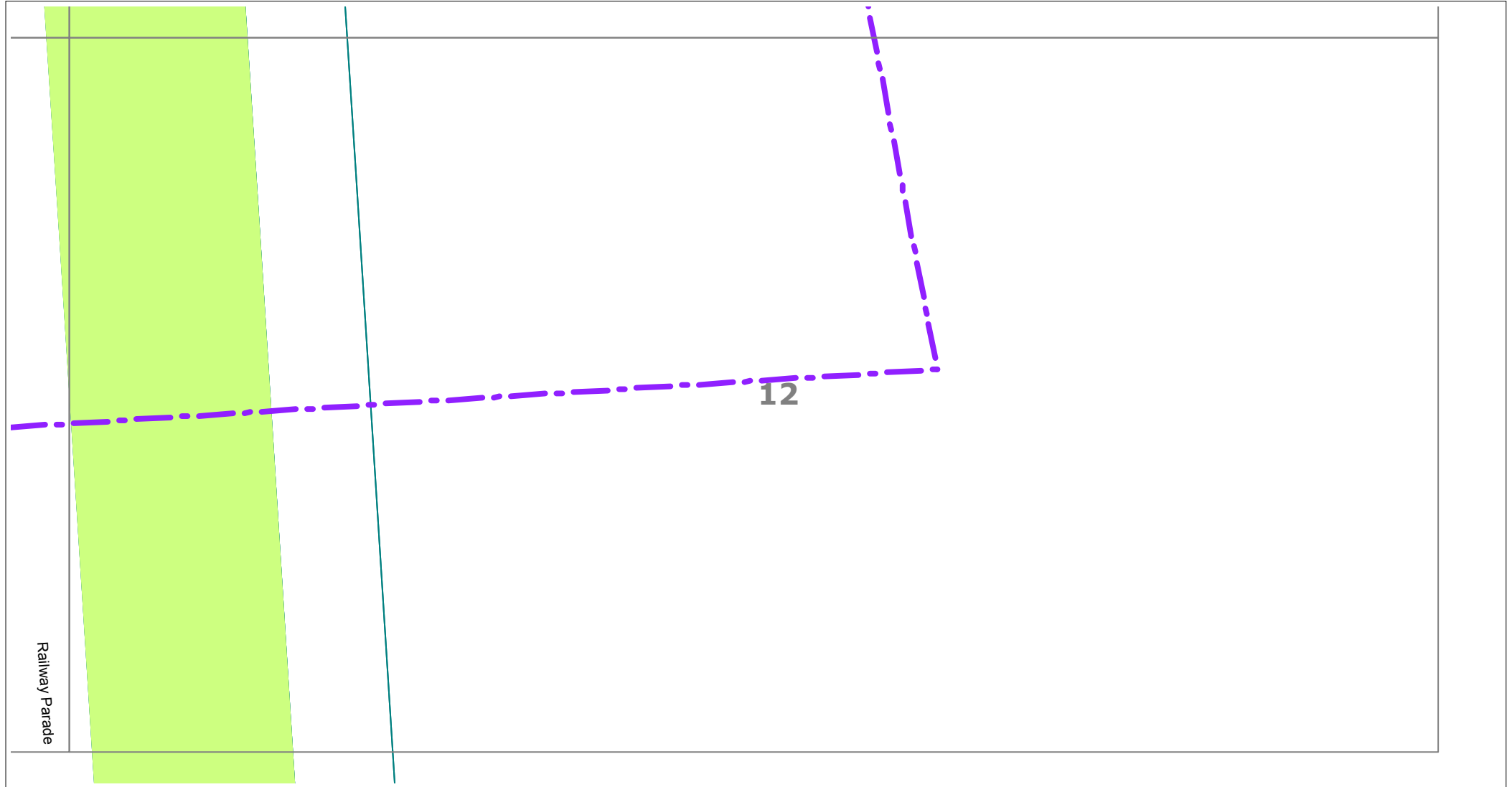
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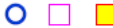




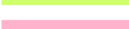
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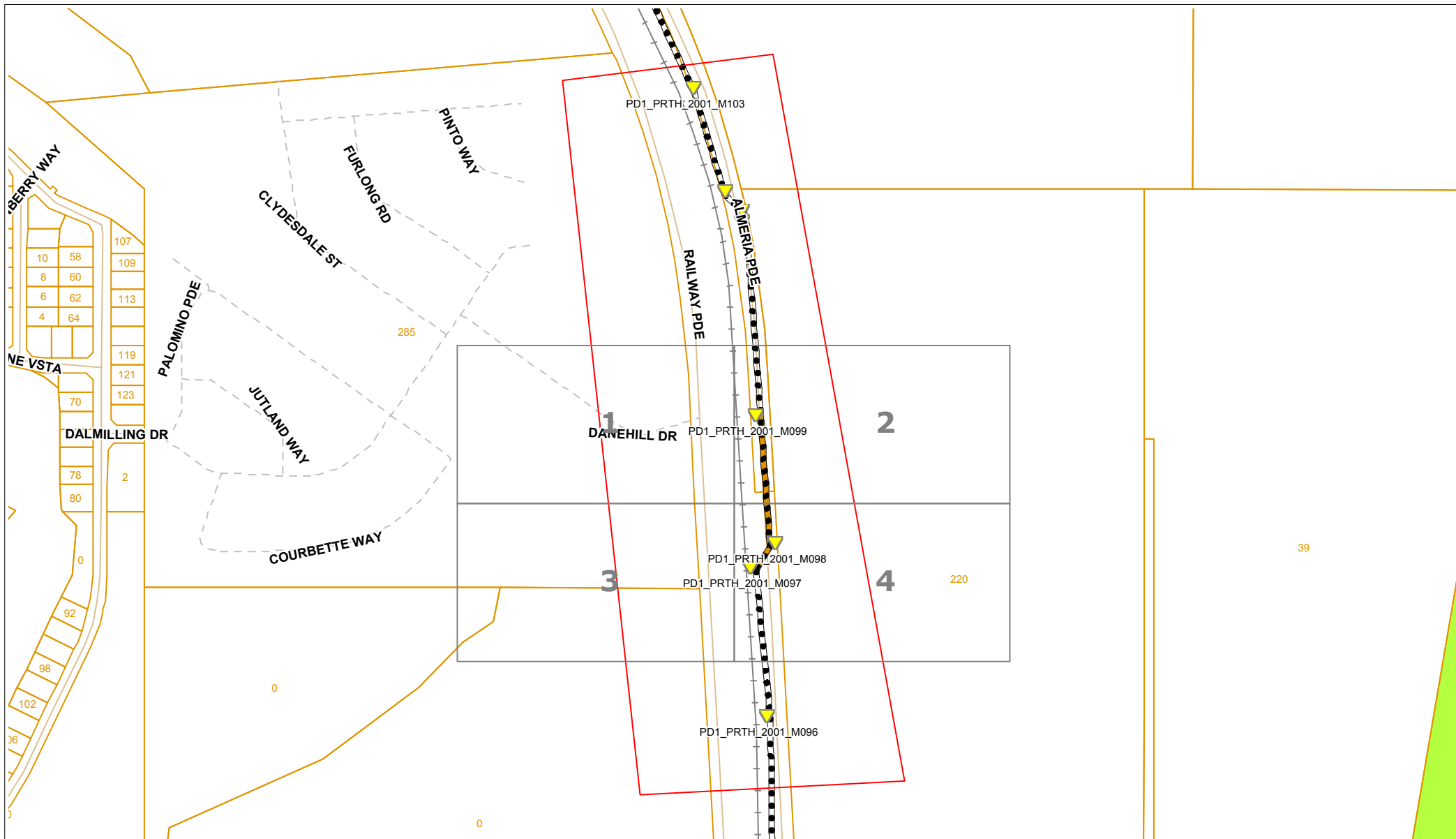
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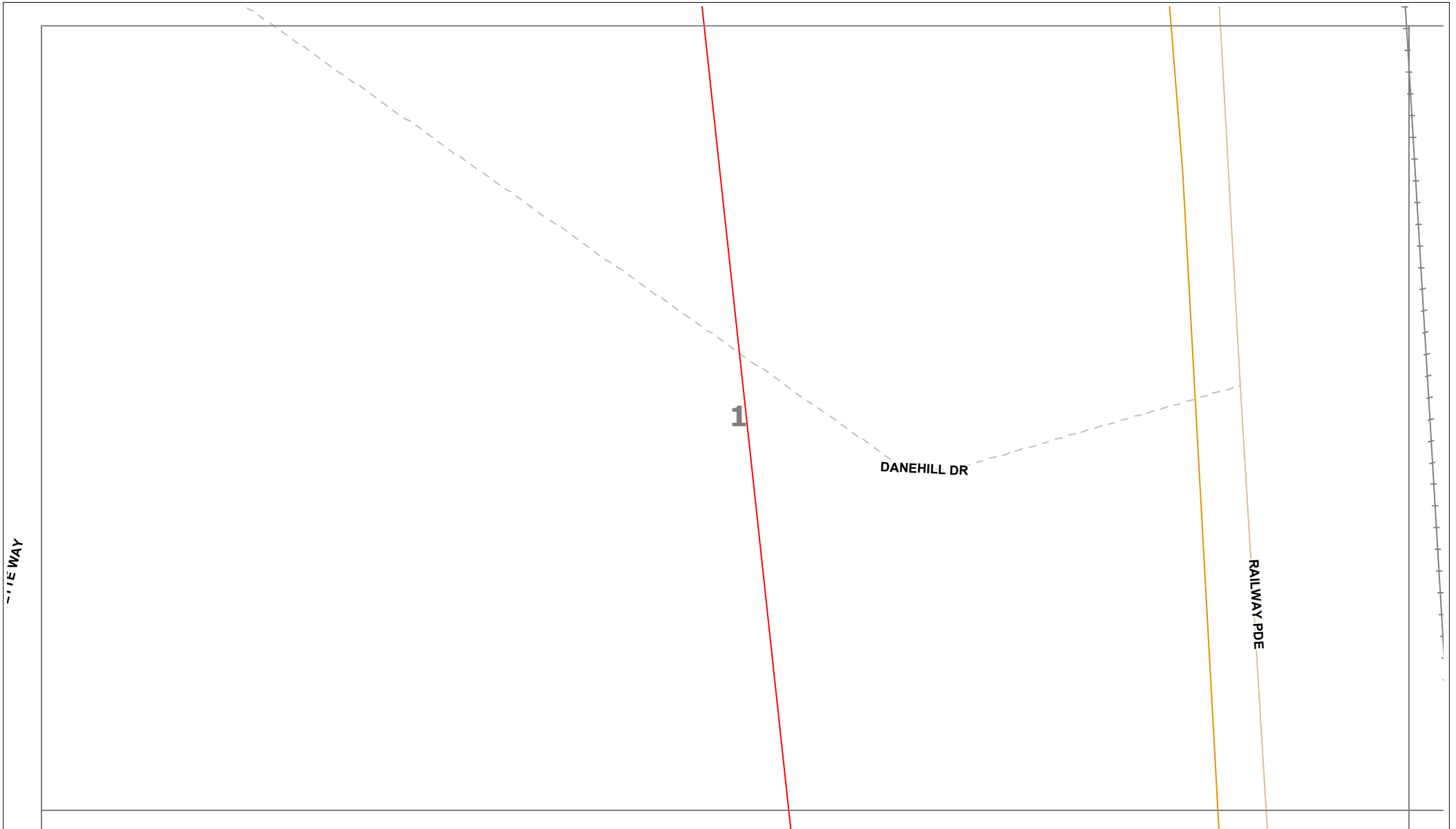
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LEGEND

Digsite	Assets
Point	Cable
Line	3rd Party Duct
Area	Marker Post



Sequence Number: 45276104

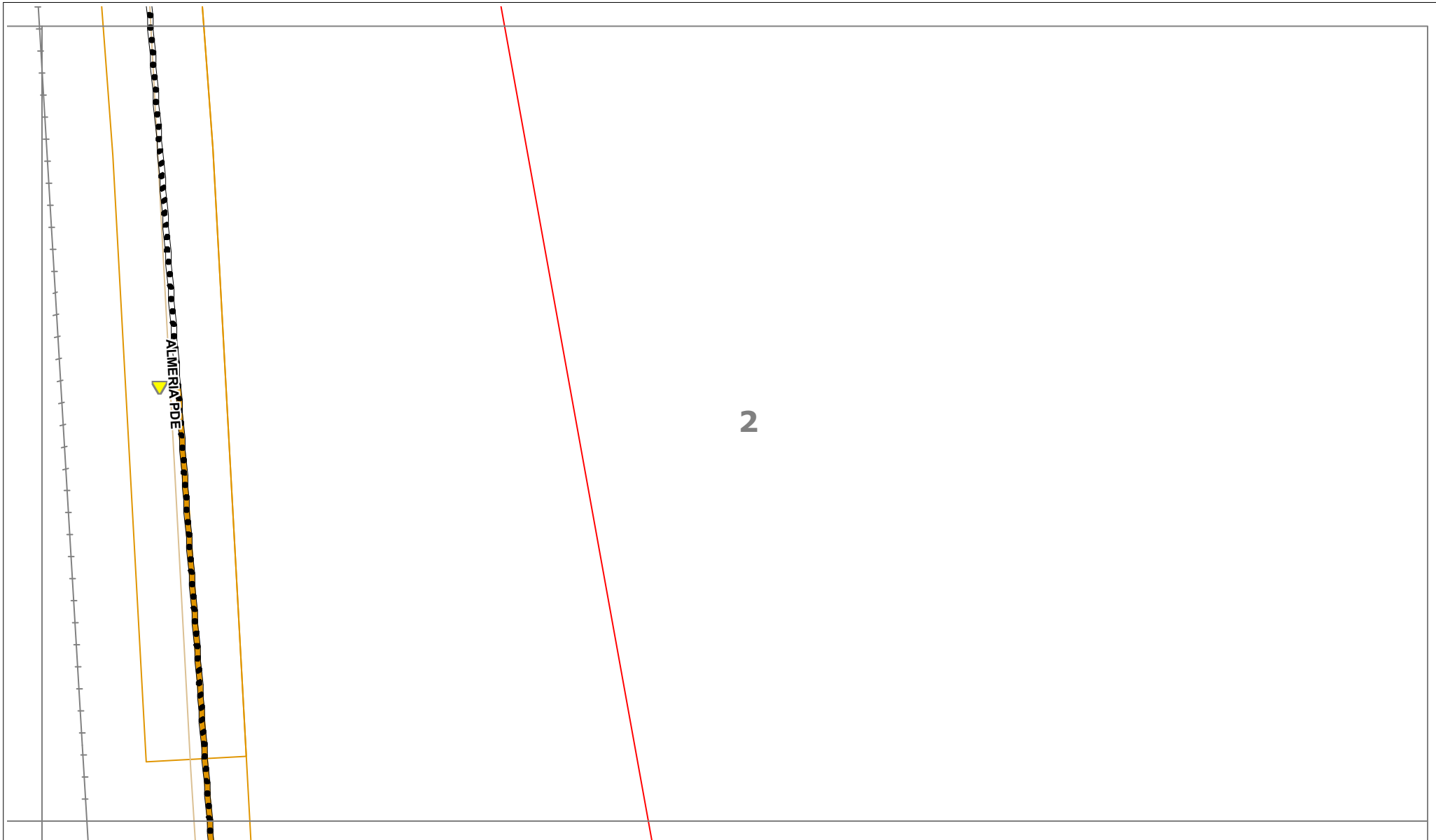
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LEGEND

Digsite		Assets	
	Point		Cable
	Line		3rd Party Duct
	Area		Marker Post



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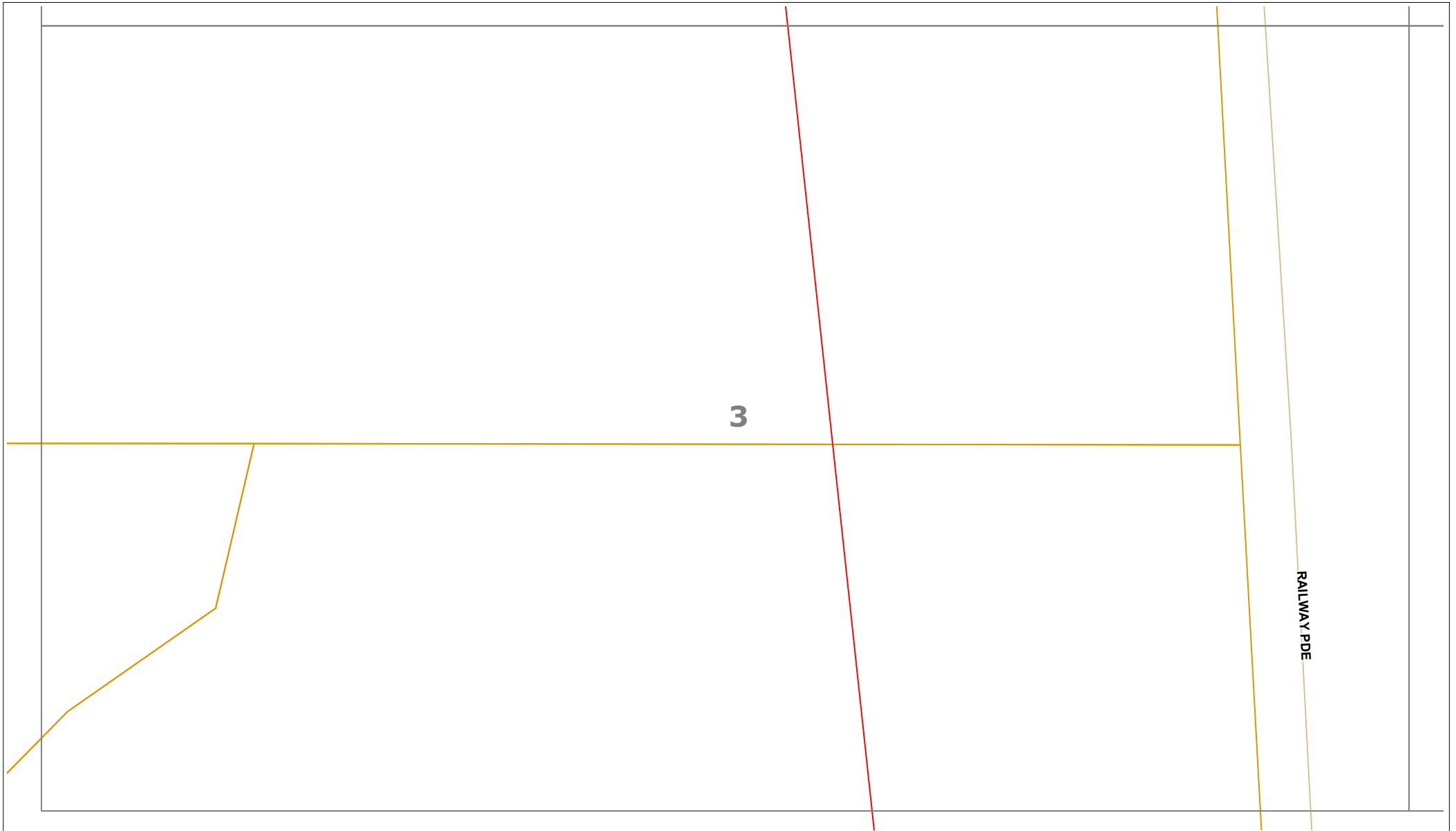
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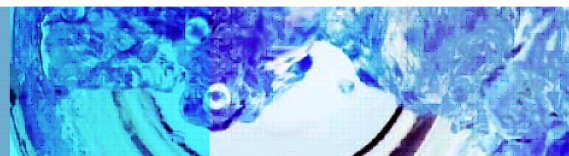


LEGEND

Digsite	Assets
Point	Cable
Line	3rd Party Duct
Area	Marker Post

Plan Legend (summary)



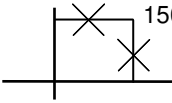
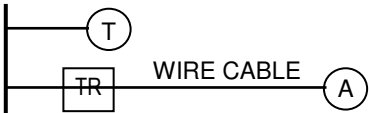
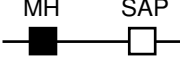
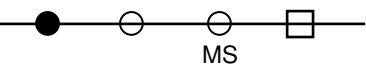
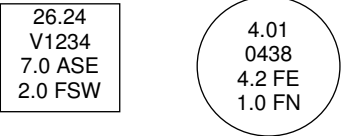

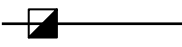
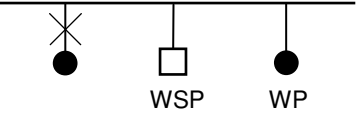
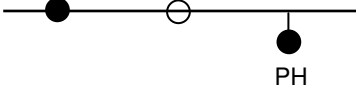
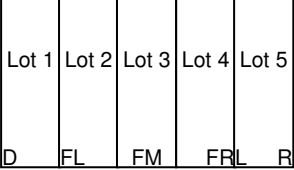

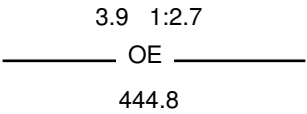
INFORMATION BROCHURE



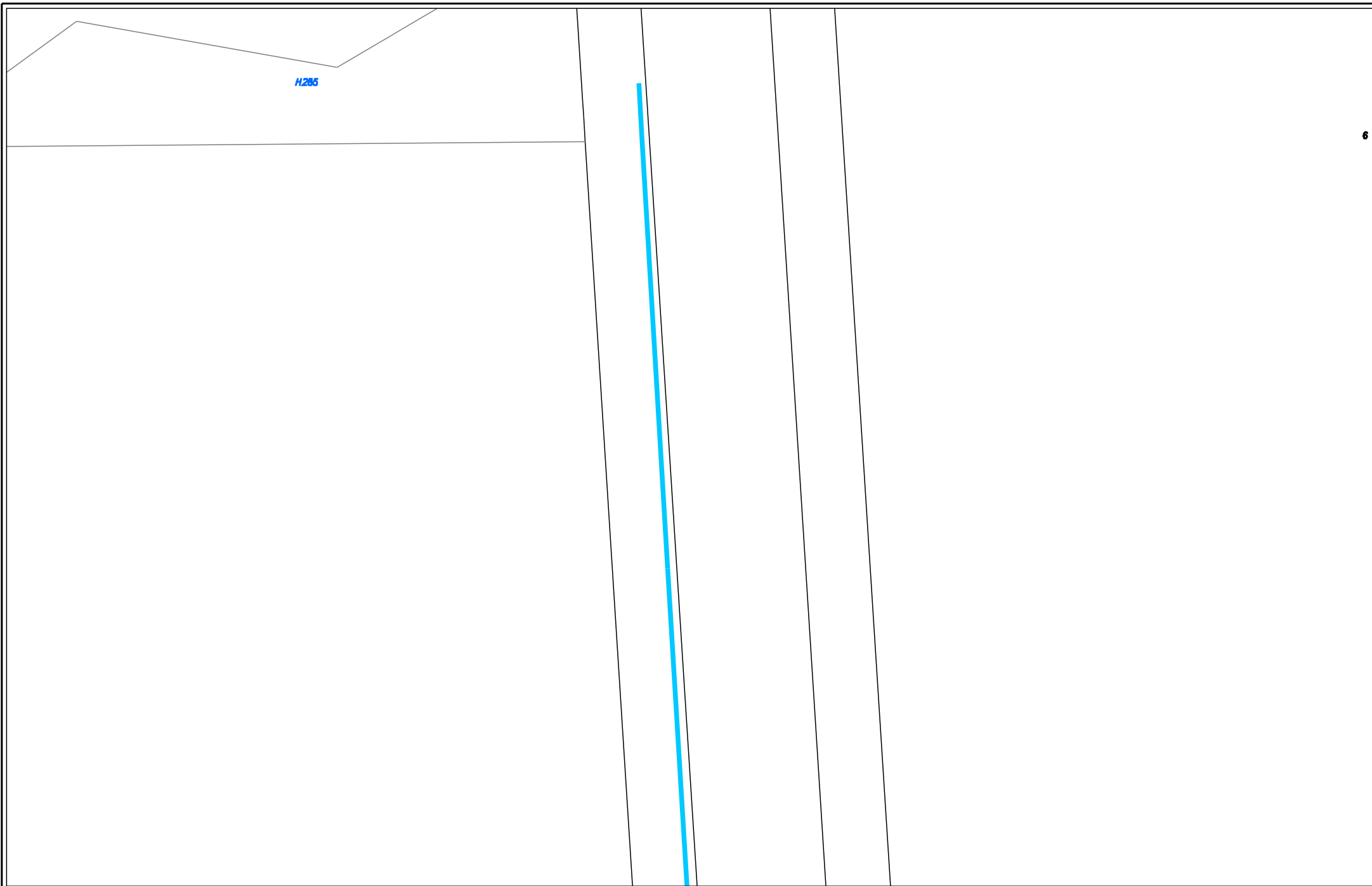
This legend is provided to [Dial Before You Dig](#) users to assist with interpreting Water Corporation plans. A more detailed colour version can be downloaded from www.watercorporation.com.au.

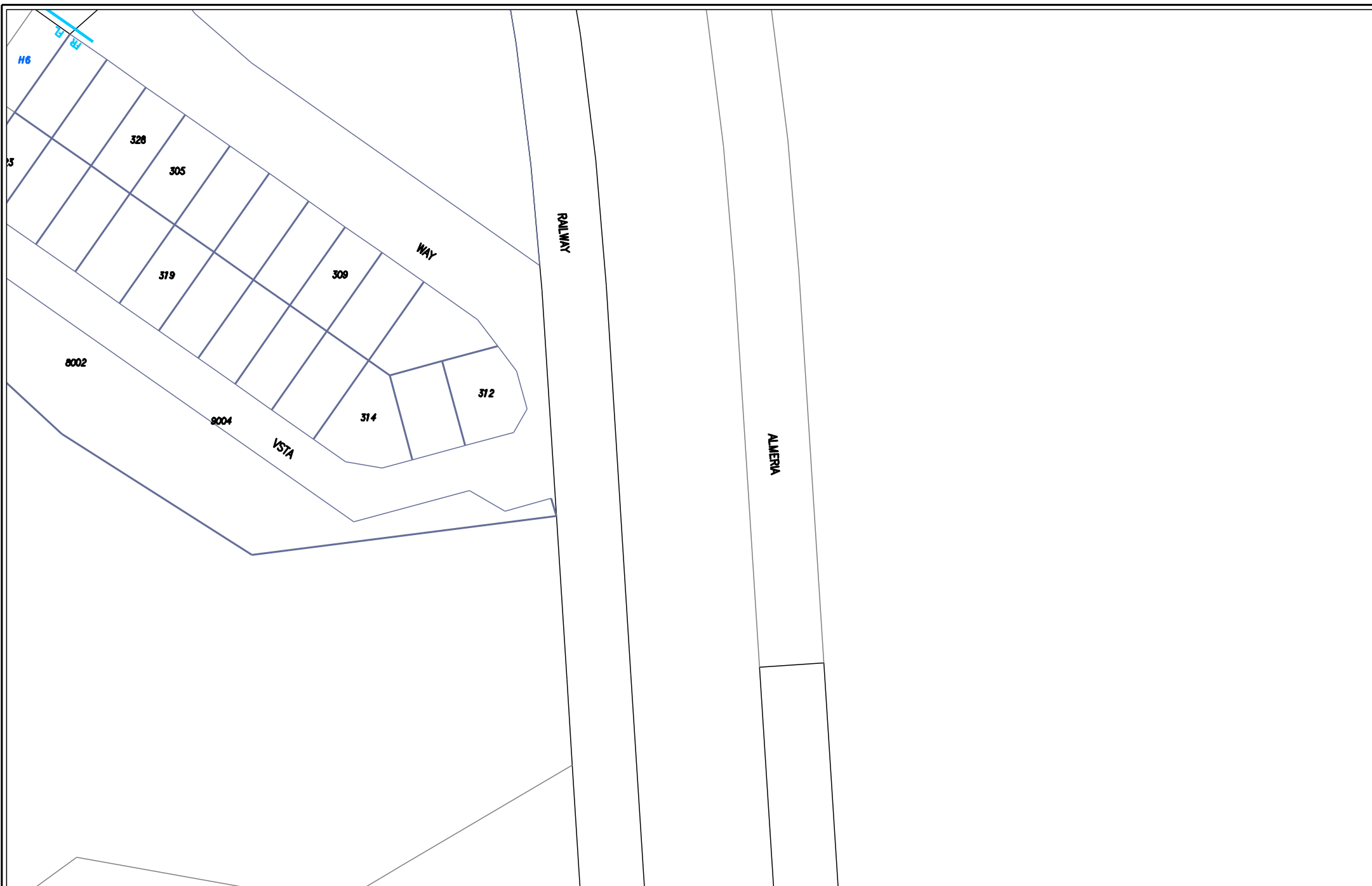
WARNING - Plans do not always show all pipes and associated equipment at a site or their accurate location. Pothole by hand to verify asset location before using powered machinery.

	<p>WATER, SEWERAGE AND DRAINAGE PIPELINES</p> <p>CRITICAL PIPELINE (thick line) EXTRA CAUTION REQUIRED A risk assessment may be required if working near this pipe. Refer to your Dial Before You Dig information or call 131375.</p> <p>Pipes are not always labelled on plans as shown here – assume all pipes are significant and pothole to prove location and depth.</p> <p>P.M. pressure main M.S. main sewer R rising main (i.e. drainage pressure main)</p> <p>Common material abbreviations: AC asbestos cement e.g. 100AC NOTE: AC is brittle and is easily damaged. CI cast iron GRP glass reinforced plastic P PVC - class follows pipe material (e.g. 100P-12) RC reinforced concrete S steel VC vitrified clay</p>
	<p>NON-STANDARD ALIGNMENT Pipes are not always located on standard alignments due to local conditions. (i.e. Other than 2.1 m for reticulation mains and 4.5 m for distribution mains.)</p>
	<p>OTHER PIPE SYMBOLS Other numbers or codes shown on pipes are not physical attributes. These are Water Corporation use only.</p>
	<p>CONCRETE ENCASEMENT, SLEEVING AND TUNNELS May be in different forms: steel, poured concrete, box sections, slabs.</p>
	<p>CHANGE INDICATOR ARROW Indicates a change in pipe type or size. e.g. 150mm diameter PVC to 150mm diameter asbestos cement (AC).</p>
	<p>PIPE OVERPASS The overpass symbol indicates the shallower of the two pipes.</p>
	<p>VALVES Many different valve types are in use. Valve may be in a pit or have a visible valve cover. There may be no surface indication.</p> <p>Valves may be shallower than the main or offset from it. e.g. A scour valve (SC) may have a pipe coming away from main pipeline on the opposite side to that indicated on the plan.</p>

 100P-DOMS  100S FS	FIRE SERVICES 100 mm polythene domestic (DOMS) service FS Fire service FHS Fire hydrant service Hydrant may be visible external to the building. Even if not visible a substantial fire service may still be present.						
 150S-5	PIPE BYPASS Bypass will not be on the same alignment as the main pipeline.						
	CATHODIC PROTECTION (CP) Buried CP equipment may be located some distance from the pipeline being protected interconnected by buried cable. All CP fittings may not be visible. A buried anode – various sizes and configurations TP test point - may be visible on a post or in-ground TR transformer rectifier						
	ACCESS TEE OR MANHOLE OR SERVICE ACCESS PIT NOTE: Opening any manhole or pit is dangerous and is prohibited. Below ground. May not be any visible signs at ground level or may be located in a pit.						
	WASTEWATER ACCESS CHAMBERS (MANHOLES) -- Manhole (shown not labelled) -- Tee or maintenance shaft (shown not labelled) MS maintenance shaft (labelled) WARNING: Opening any manhole or pit is dangerous and is prohibited.						
	WASTEWATER MANHOLE INFORMATION BOXES Square non-trafficable Do not drive vehicles over or place loads. Round trafficable In general if not located in the road treat as if non-trafficable.						
	HAZARDOUS MANHOLE Indicates a potential health hazard from risk of exposure to toxic waste. WARNING: Opening any manhole is dangerous and is prohibited.						
	FLOWMETER Various types of flow meters located in a pit. May be labelled with identifier. (e.g. 50 MFM, 50MM)						
	STANDPIPE, WATER SAMPLING POINT (WSP), WATER SUPPLY POINT (WP) May be located adjacent to mains. Usually there will be some visible indication.						
	<table border="0"> <tr> <td>Hydrant</td> <td>May not be visible.</td> </tr> <tr> <td>Hydrant Tee</td> <td>May not be visible.</td> </tr> <tr> <td>Pillar hydrant</td> <td>Visible</td> </tr> </table>	Hydrant	May not be visible.	Hydrant Tee	May not be visible.	Pillar hydrant	Visible
Hydrant	May not be visible.						
Hydrant Tee	May not be visible.						
Pillar hydrant	Visible						
	PRE-LAID SERVICES D Deferred FL Fully Prelaid Left FM Fully Prelaid Front Middle FR Fully Prelaid Right L Left R Right Code indicates on which side of a lot the water service is located: May be no visible indication at site.						
	SEWER OR DRAINAGE PUMP STATION Several pipes and a pressurised main will be in the vicinity.						
	OPEN CHANNEL OA Landscaped OE Normal Open Earth OF Open channel with flood levee OH Half Pipe OL Lined Channel OS Swale-Shallow Depression OW Natural Water Course Drainage structures, even if dry, must be kept clear of any obstruction such as sand stockpiles.						







Scale: 1:1500 Centre Point: 116.025°, -31.750°

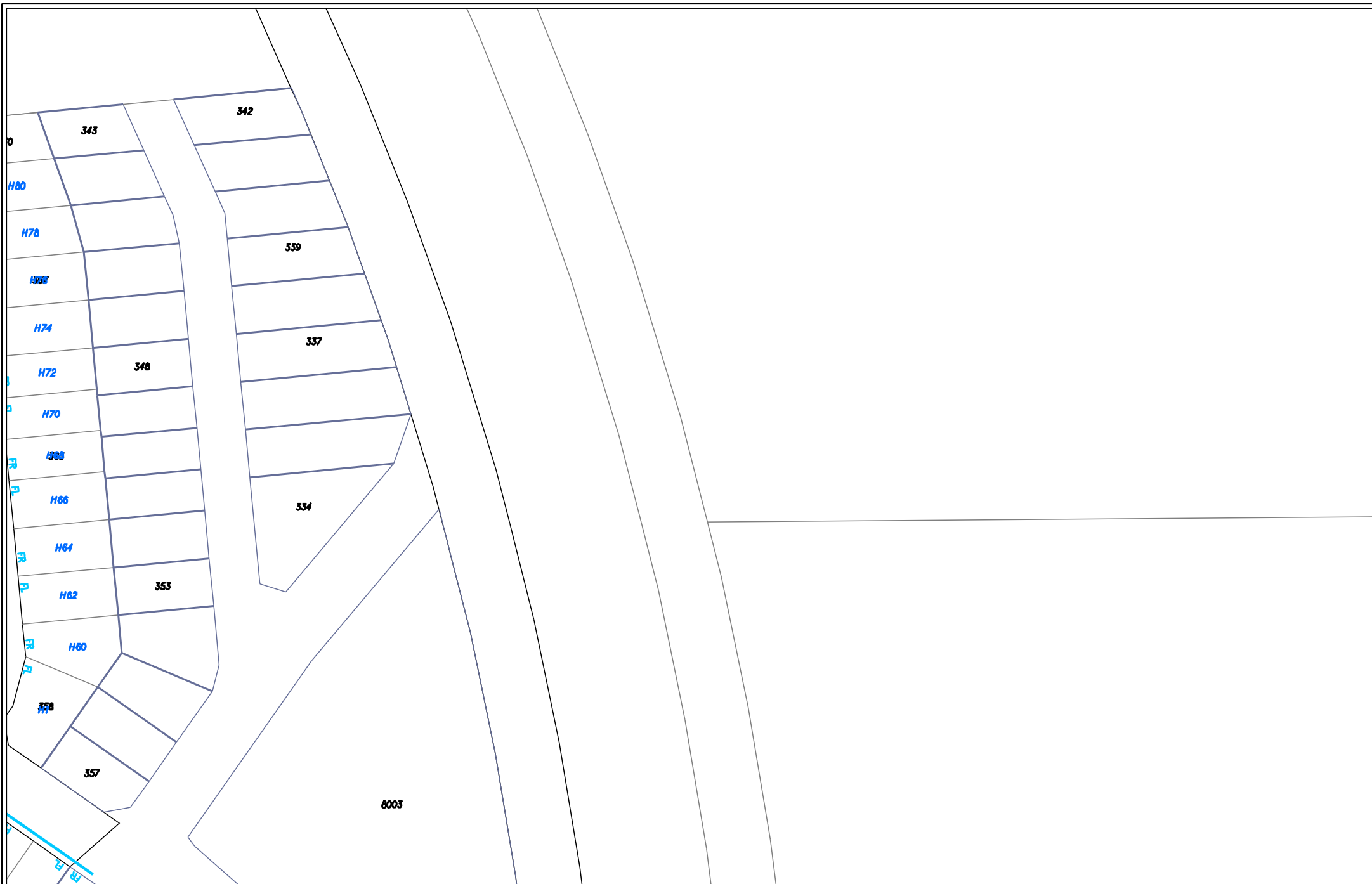
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Print Date: 02/05/2015 Page: 3 of 4



WARNING - CRITICAL PIPELINE
Refer to **Information Brochure Damage Prevention and Legend** for details

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Scale: 1:1500 Centre Point: 116.025°, -31.748°

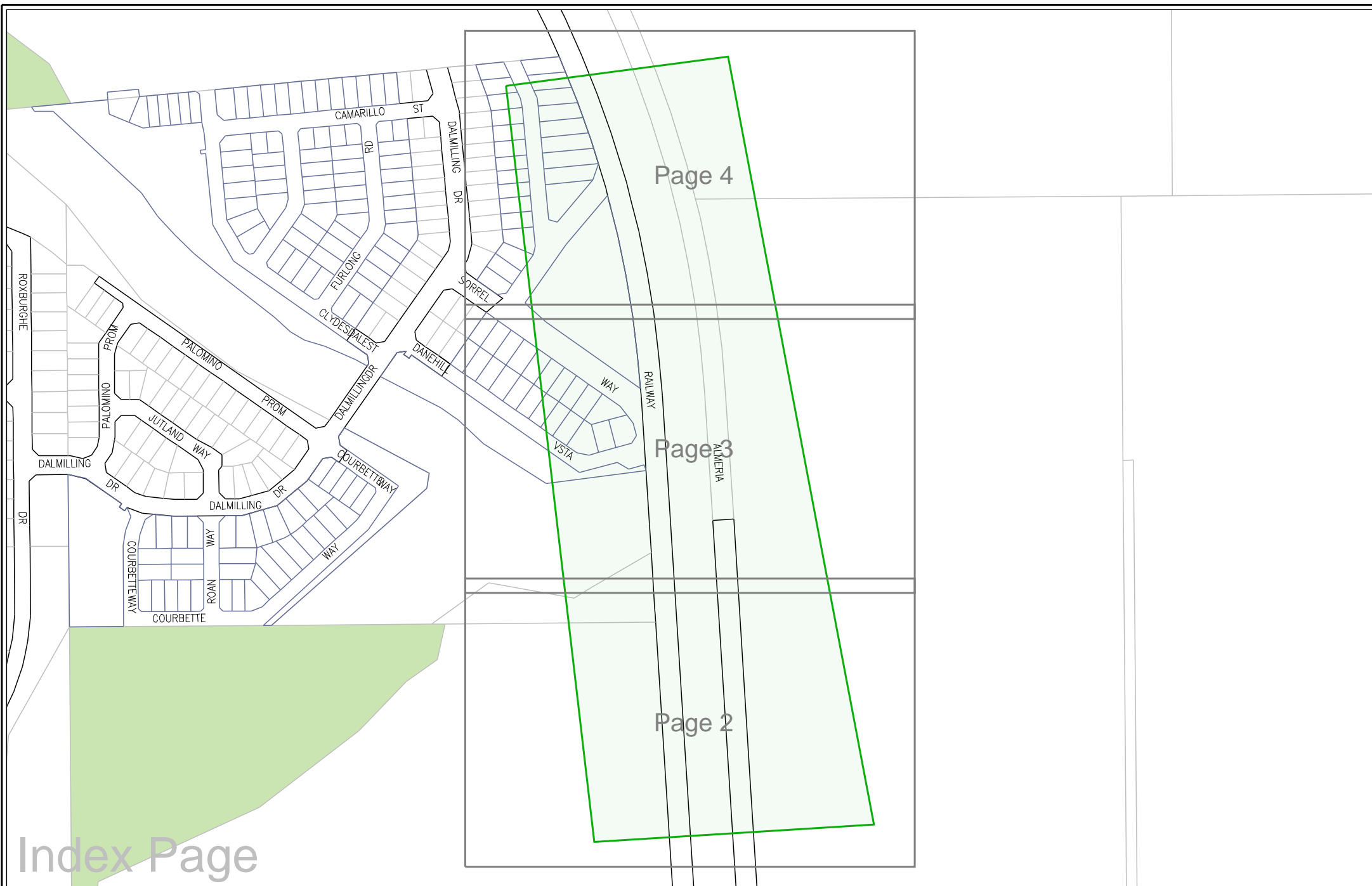
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Print Date: 02/05/2015 Page: 4 of 4



WARNING - CRITICAL PIPELINE
Refer to **Information Brochure Damage Prevention** and **Legend** for details

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H285

6



Scale: 1:1500 Centre Point: 116.025°, -31.753°

Sequence No: 45276103

Print Date: 02/05/2015 Page: 2 of 4



Sewer

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OVERVIEW ONLY



UNDERGROUND LEGEND

Structures

- | | |
|------------------|-----------------------|
| Pillar | UG Crossing * |
| Metal Pole | Ring Main Unit |
| Transformer Site | LV Distribution Frame |

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

**This map is INDICATIVE ONLY.
Hand exposure via pothole
method is MANDATORY.**

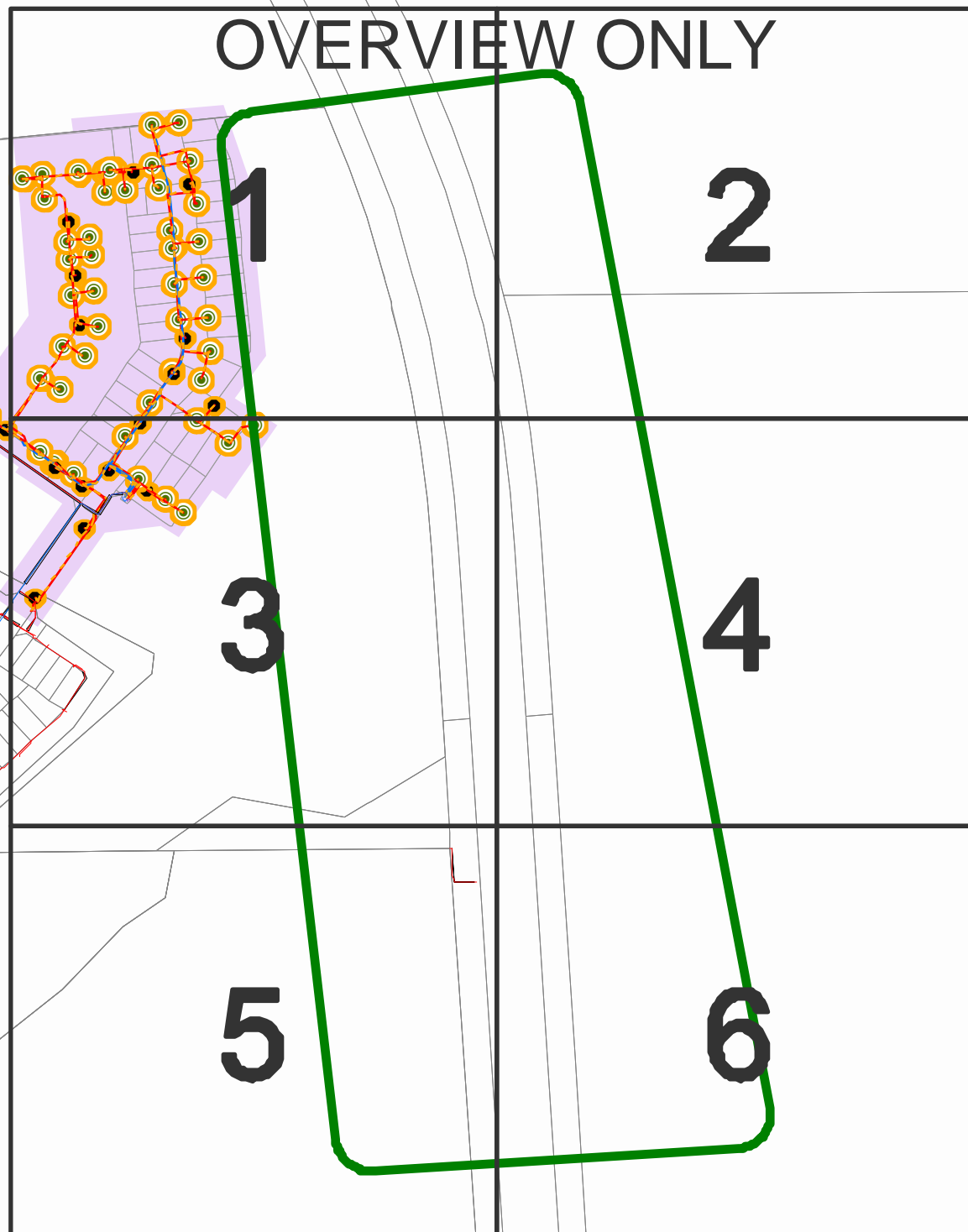
**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

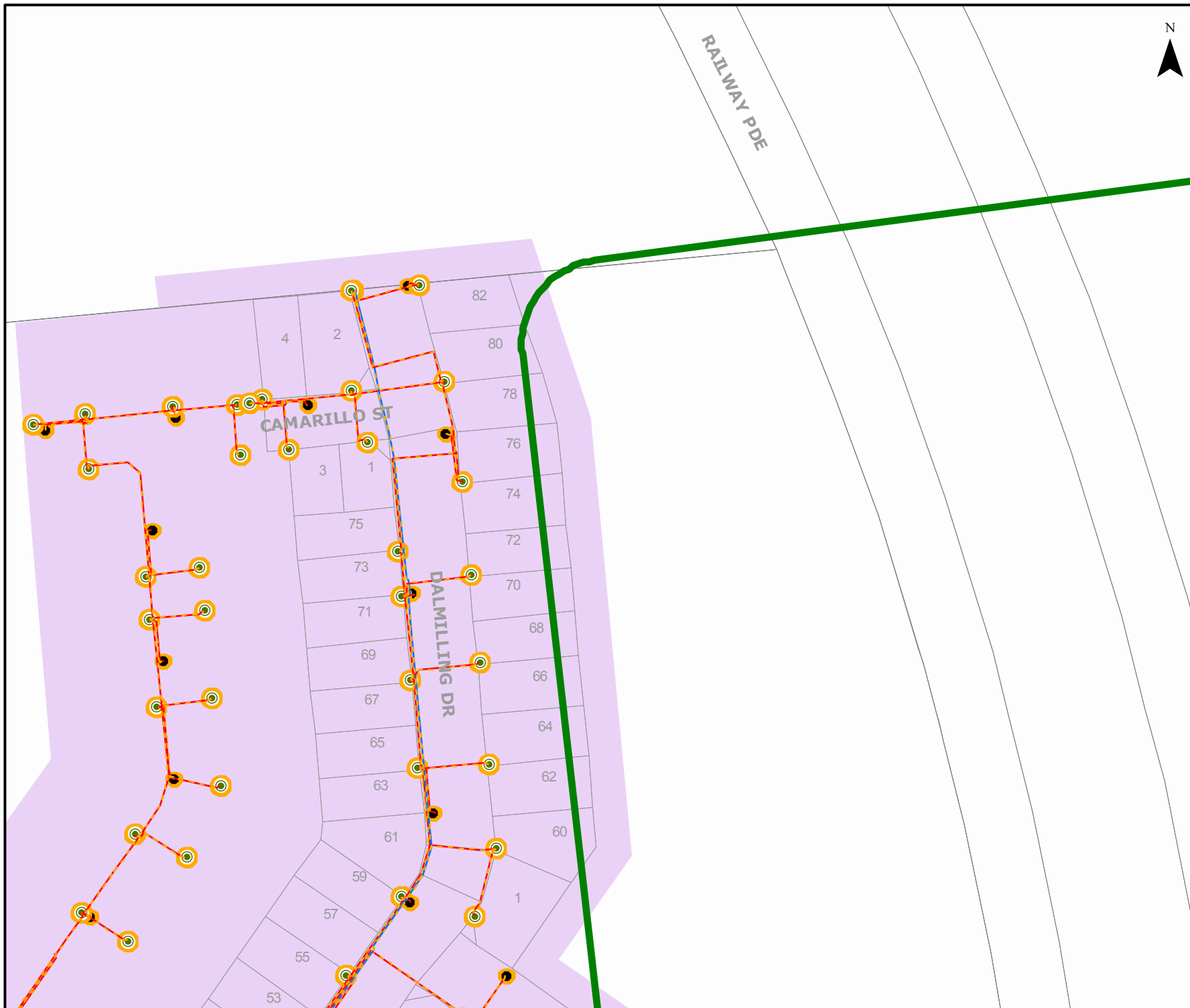
**Information valid for 30 days
from date of issue**

A4







Scale : 1:4612






**WARNING! Look out for
overhead power lines**















UNDERGROUND LEGEND

- Structures**
-  Pillar
 -  Metal Pole
 -  Transformer Site
 -  UG Crossing *
 -  Ring Main Unit
 -  LV Distribution Frame

- Distribution Cables**
-  High Voltage Cable (1kV - 33kV)
 -  Low Voltage Cable (< 1kV)
 -  Street Light Circuit (< 1kV)
 -  Street Light Pilot (< 1kV)
 -  Earth Wire

- Cable Pole Terminations**
-  HV Termination
 -  LV Termination

- Proposed Construction Assets**
-  Design Area *
 -  High Voltage Underground Cable
 -  Low Voltage Underground Cable
 -  Metal Pole
 -  Pillar
 -  Transformer site
 -  HV Termination
 -  LV Termination

- State Underground Power Project**
-  CURRENT Work Area *
 -  COMPLETED Area *

- Feature**
-  Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

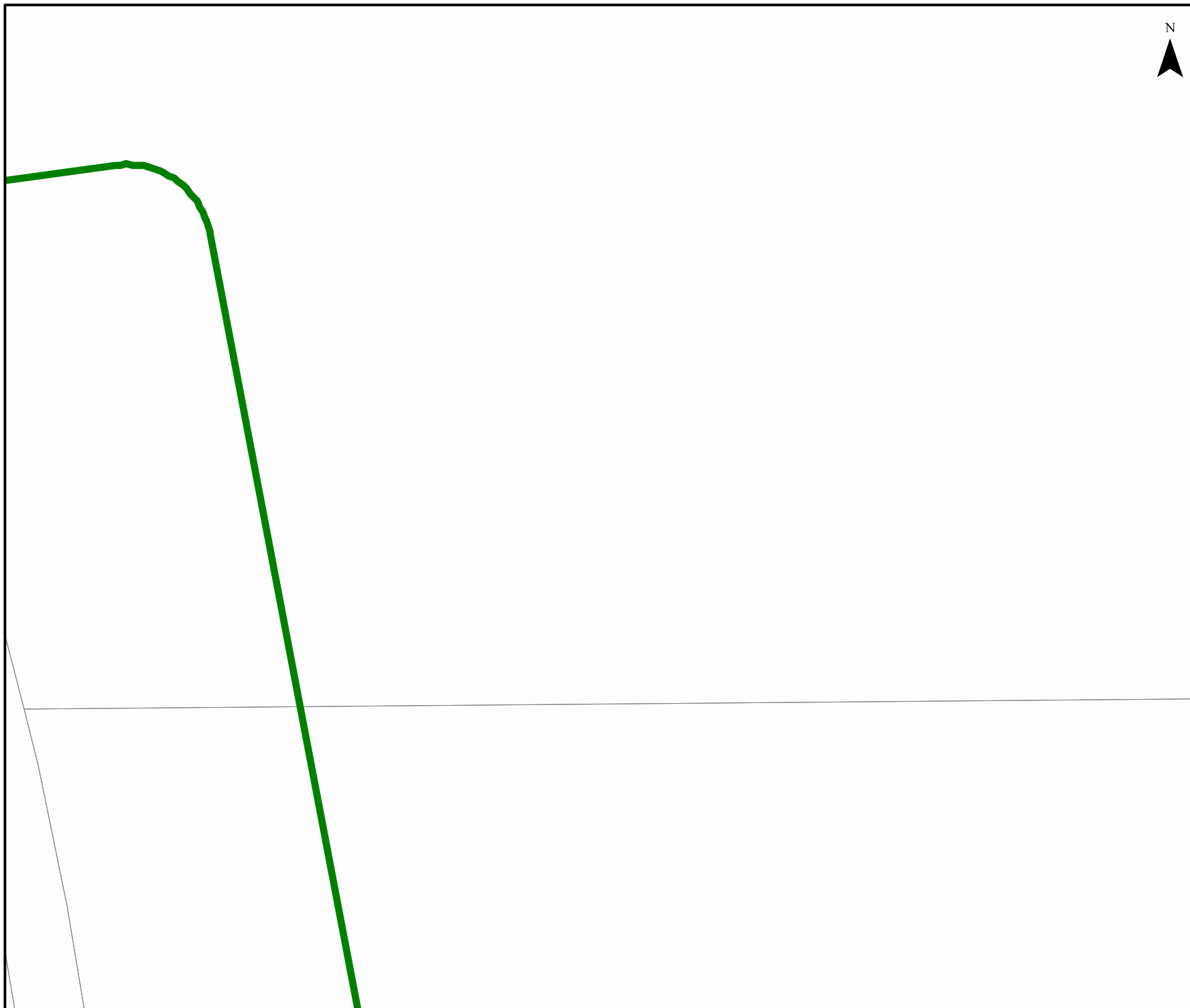
**This map is INDICATIVE ONLY.
Hand exposure via pothole method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

**Information valid for 30 days
from date of issue**

A4 Scale : 1:1500

**WARNING! Look out for
overhead power lines**



UNDERGROUND LEGEND

Structures	
Pillar	UG Crossing *
Metal Pole	Ring Main Unit
Transformer Site	LV Distribution Frame

Distribution Cables	
High Voltage Cable (1kV - 33kV)	
Low Voltage Cable (< 1kV)	
Street Light Circuit (< 1kV)	
Street Light Pilot (< 1kV)	
Earth Wire	

Cable Pole Terminations	
HV Termination	LV Termination

Proposed Construction Assets	
Design Area *	
High Voltage Underground Cable	
Low Voltage Underground Cable	
Metal Pole	HV Termination
Pillar	LV Termination
Transformer site	

State Underground Power Project	
CURRENT Work Area *	
COMPLETED Area *	

Feature	
Area of Interest	

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

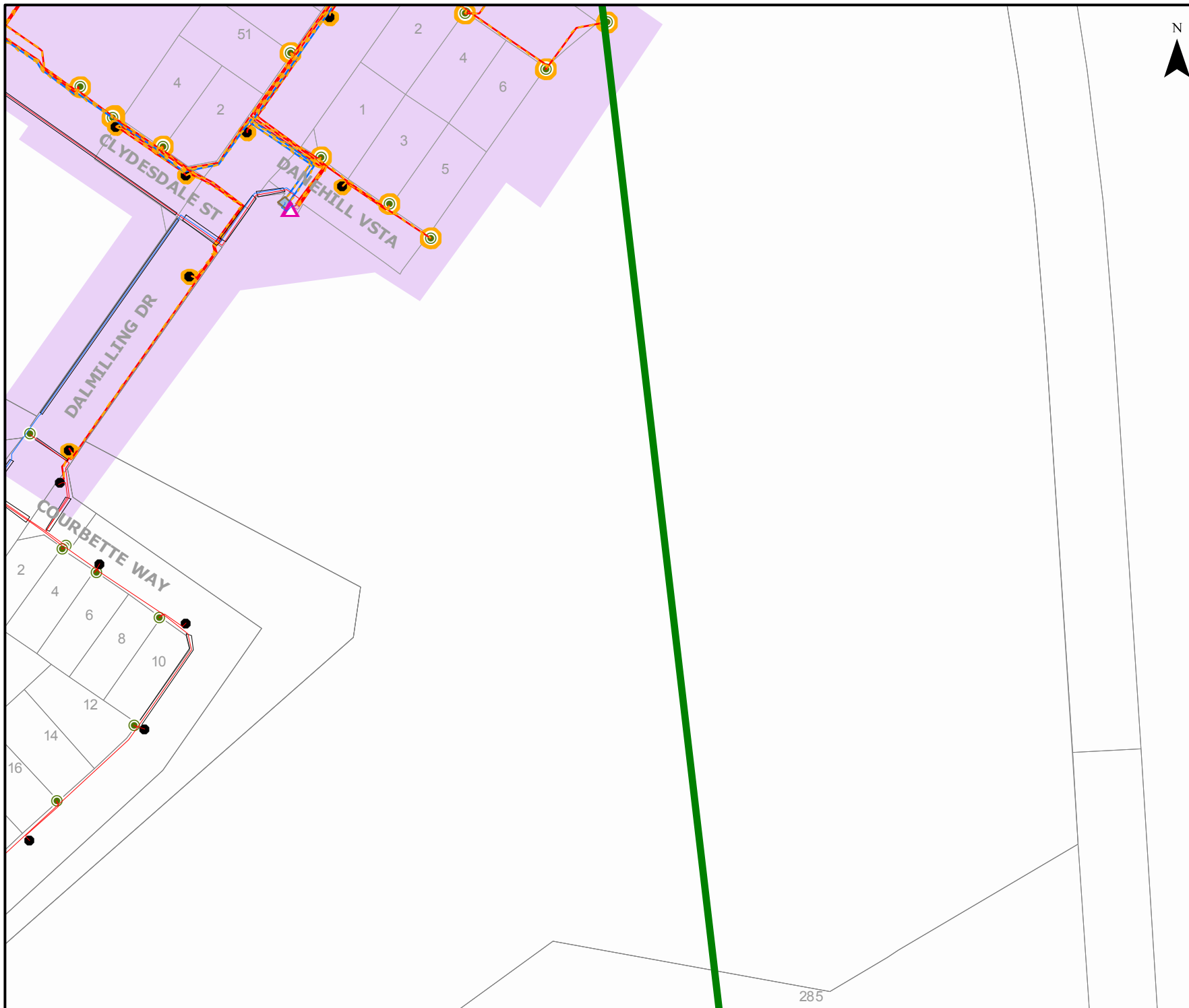
**This map is INDICATIVE ONLY.
Hand exposure via pothole method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

Information valid for 30 days from date of issue

A4	Scale : 1:1500
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WARNING! Look out for overhead power lines



UNDERGROUND LEGEND

Structures	
Pillar	UG Crossing *
Metal Pole	Ring Main Unit
Transformer Site	LV Distribution Frame

Distribution Cables	
High Voltage Cable (1kV - 33kV)	
Low Voltage Cable (< 1kV)	
Street Light Circuit (< 1kV)	
Street Light Pilot (< 1kV)	
Earth Wire	

Cable Pole Terminations	
HV Termination	LV Termination

Proposed Construction Assets	
Design Area *	
High Voltage Underground Cable	
Low Voltage Underground Cable	
Metal Pole	HV Termination
Pillar	LV Termination
Transformer site	

State Underground Power Project	
CURRENT Work Area *	
COMPLETED Area *	

Feature	
Area of Interest	

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

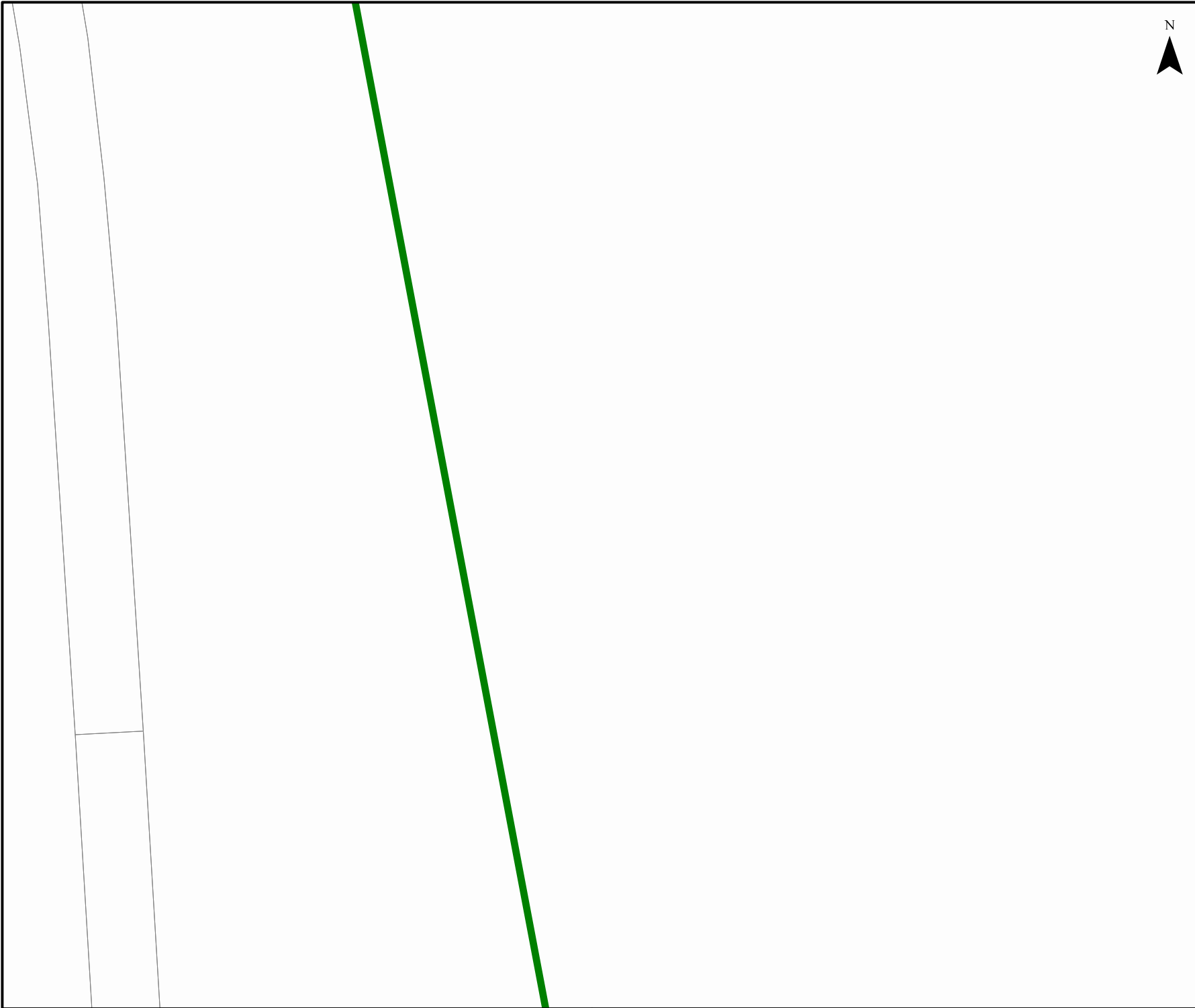
**This map is INDICATIVE ONLY.
Hand exposure via pothole method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

Information valid for 30 days from date of issue

A4	Scale : 1:1500
----	----------------

WARNING! Look out for overhead power lines



UNDERGROUND LEGEND

Structures	
Pillar	UG Crossing *
Metal Pole	Ring Main Unit
Transformer Site	LV Distribution Frame

Distribution Cables	
High Voltage Cable (1kV - 33kV)	
Low Voltage Cable (< 1kV)	
Street Light Circuit (< 1kV)	
Street Light Pilot (< 1kV)	
Earth Wire	

Cable Pole Terminations	
HV Termination	LV Termination

Proposed Construction Assets	
Design Area *	
High Voltage Underground Cable	
Low Voltage Underground Cable	
Metal Pole	HV Termination
Pillar	LV Termination
Transformer site	

State Underground Power Project	
CURRENT Work Area *	
COMPLETED Area *	

Feature	
Area of Interest	

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

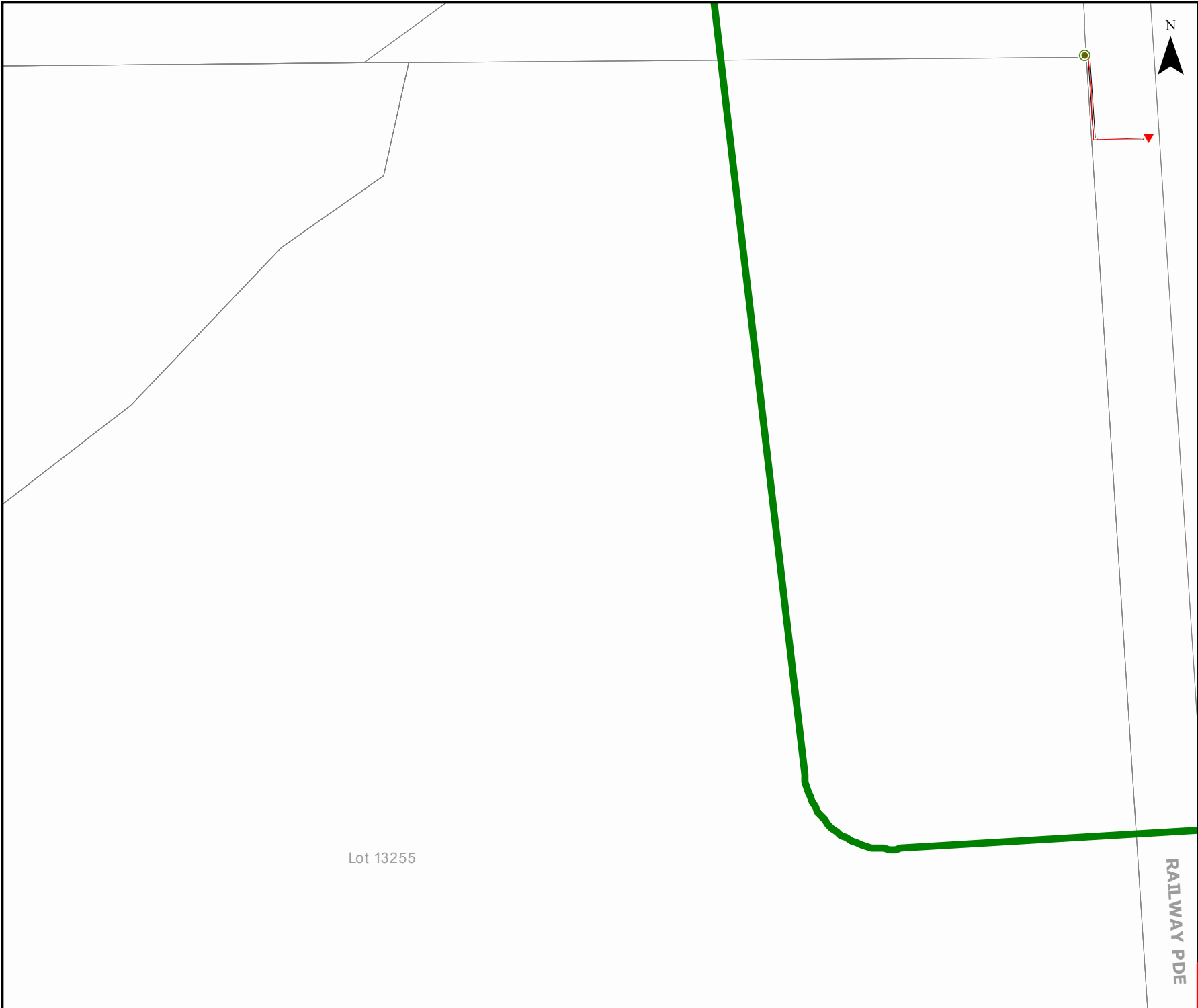
**This map is INDICATIVE ONLY.
Hand exposure via pothole
method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

**Information valid for 30 days
from date of issue**

A4 Scale : 1:1500

**WARNING! Look out for
overhead power lines**



UNDERGROUND LEGEND

Structures

- | | |
|------------------|-----------------------|
| Pillar | UG Crossing * |
| Metal Pole | Ring Main Unit |
| Transformer Site | LV Distribution Frame |

Distribution Cables

- | |
|---------------------------------|
| High Voltage Cable (1kV - 33kV) |
| Low Voltage Cable (< 1kV) |
| Street Light Circuit (< 1kV) |
| Street Light Pilot (< 1kV) |
| Earth Wire |

Cable Pole Terminations

- | | |
|----------------|----------------|
| HV Termination | LV Termination |
|----------------|----------------|

Proposed Construction Assets

- | | |
|-------------------------------|--------------------------------|
| Design Area * | High Voltage Underground Cable |
| Low Voltage Underground Cable | HV Termination |
| Metal Pole | LV Termination |
| Pillar | Transformer site |

State Underground Power Project

- | |
|---------------------|
| CURRENT Work Area * |
| COMPLETED Area * |

Feature

- | |
|------------------|
| Area of Interest |
|------------------|

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

**This map is INDICATIVE ONLY.
Hand exposure via pothole
method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

**Information valid for 30 days
from date of issue**

A4	Scale : 1:1500
----	----------------

**WARNING! Look out for
overhead power lines**



UNDERGROUND LEGEND

Structures

Pillar	UG Crossing *
Metal Pole	Ring Main Unit
Transformer Site	LV Distribution Frame









Distribution Cables

High Voltage Cable (1kV - 33kV)
Low Voltage Cable (< 1kV)
Street Light Circuit (< 1kV)
Street Light Pilot (< 1kV)
Earth Wire

Cable Pole Terminations

HV Termination	LV Termination
----------------	----------------

Proposed Construction Assets

	Design Area *
	High Voltage Underground Cable
	Low Voltage Underground Cable
	Metal Pole
	Pillar
	Transformer site
	HV Termination
	LV Termination

State Underground Power Project

CURRENT Work Area *
COMPLETED Area *

Feature

Area of Interest

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

**This map is INDICATIVE ONLY.
Hand exposure via pothole
method is MANDATORY.**

**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

**Information valid for 30 days
from date of issue**

A4 Scale : 1:1500

**WARNING! Look out for
overhead power lines**

ALMERIA PDE

OVERVIEW ONLY



OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

* Please refer to coversheet

**Privately owned cables NOT SHOWN
(including house services)**

This map is **INDICATIVE ONLY**.
Check that you have enough
clearance from the **DANGER ZONES**
near overhead powerlines.

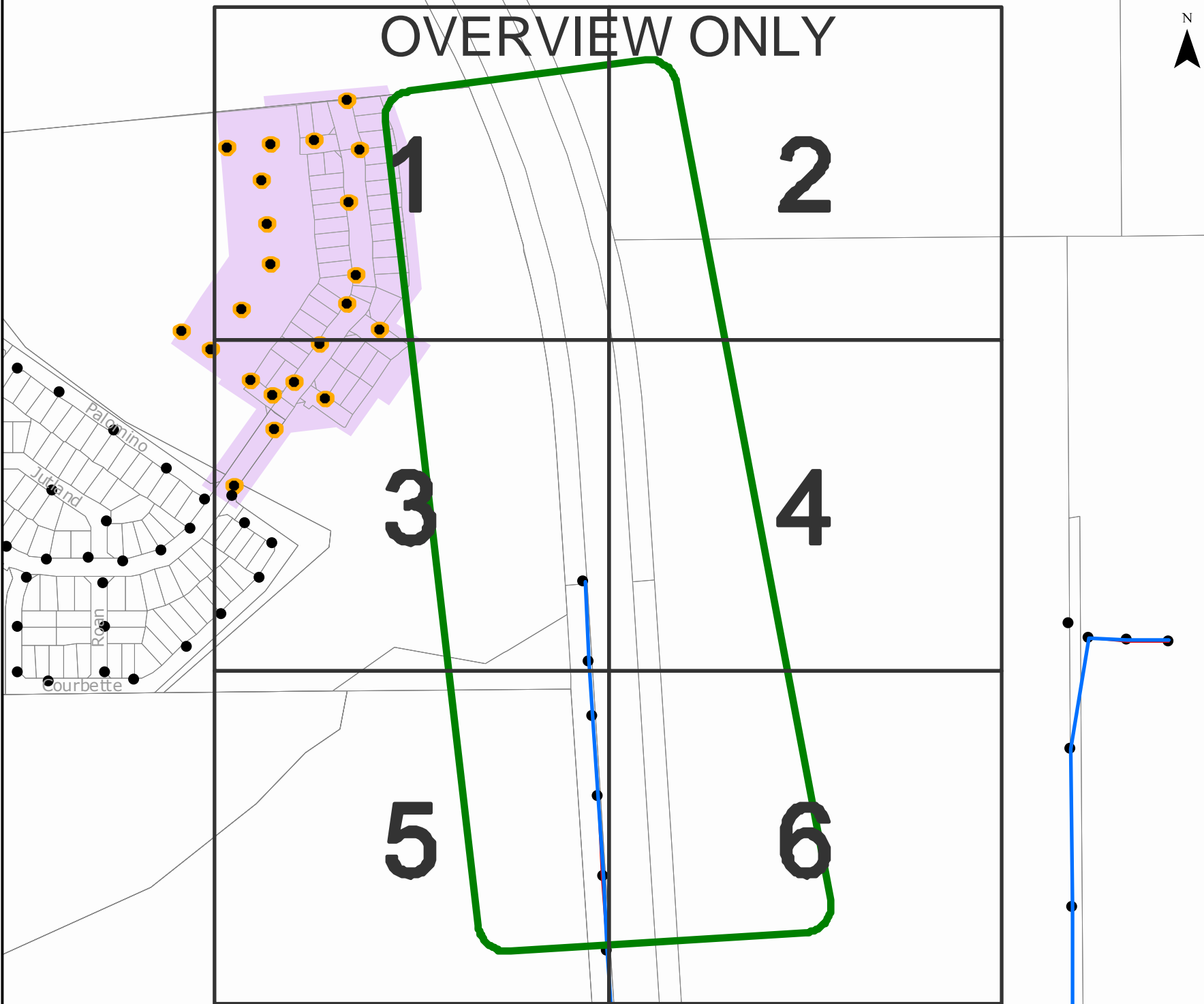
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Mon to Fri - 08:00 to 16:30

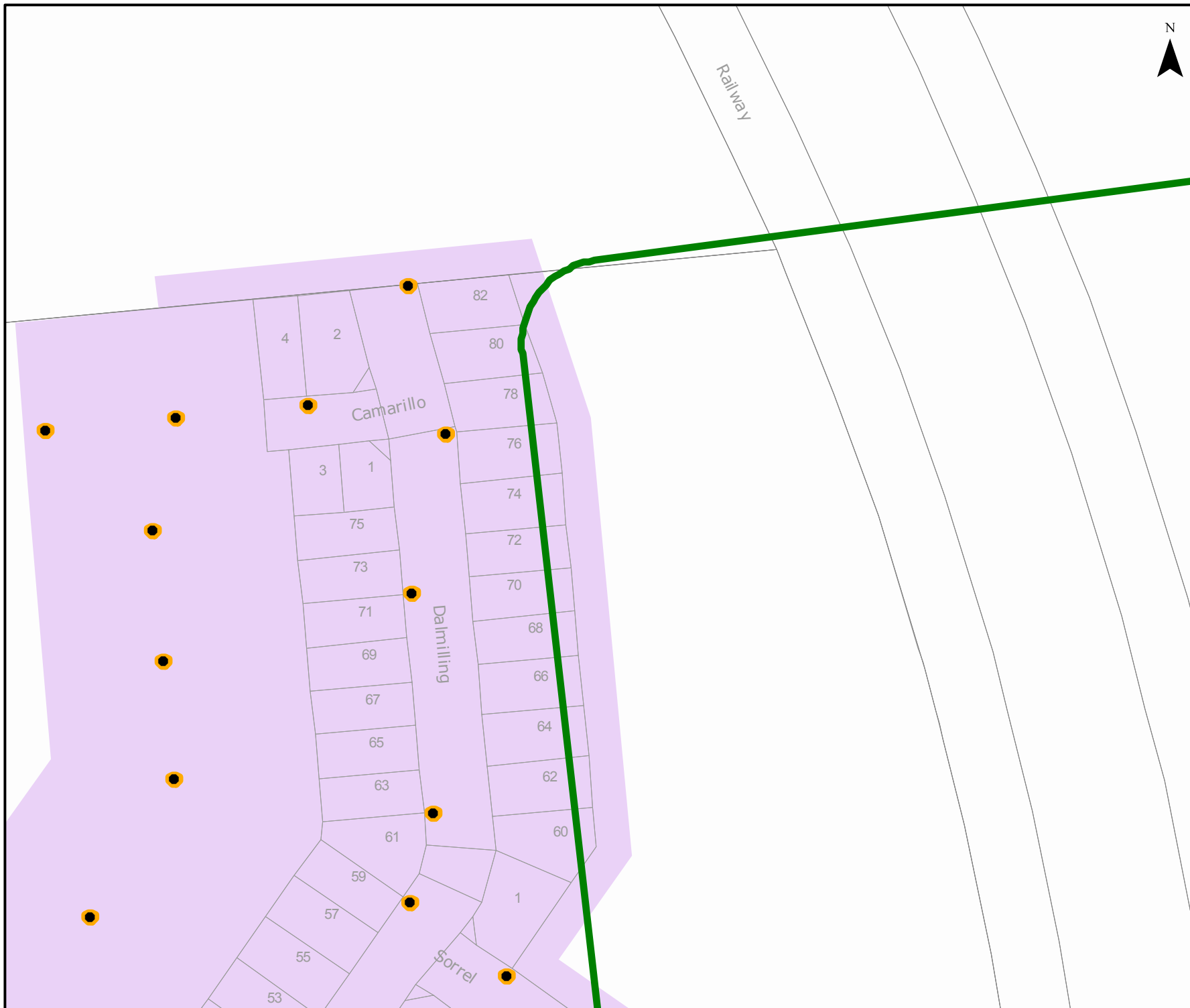
Information valid for 30 days
from date of issue

A4

Scale : 1:4612

**WARNING! Look out for
overhead power lines**





OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

* Please refer to coversheet

Privately owned cables NOT SHOWN (including house services)

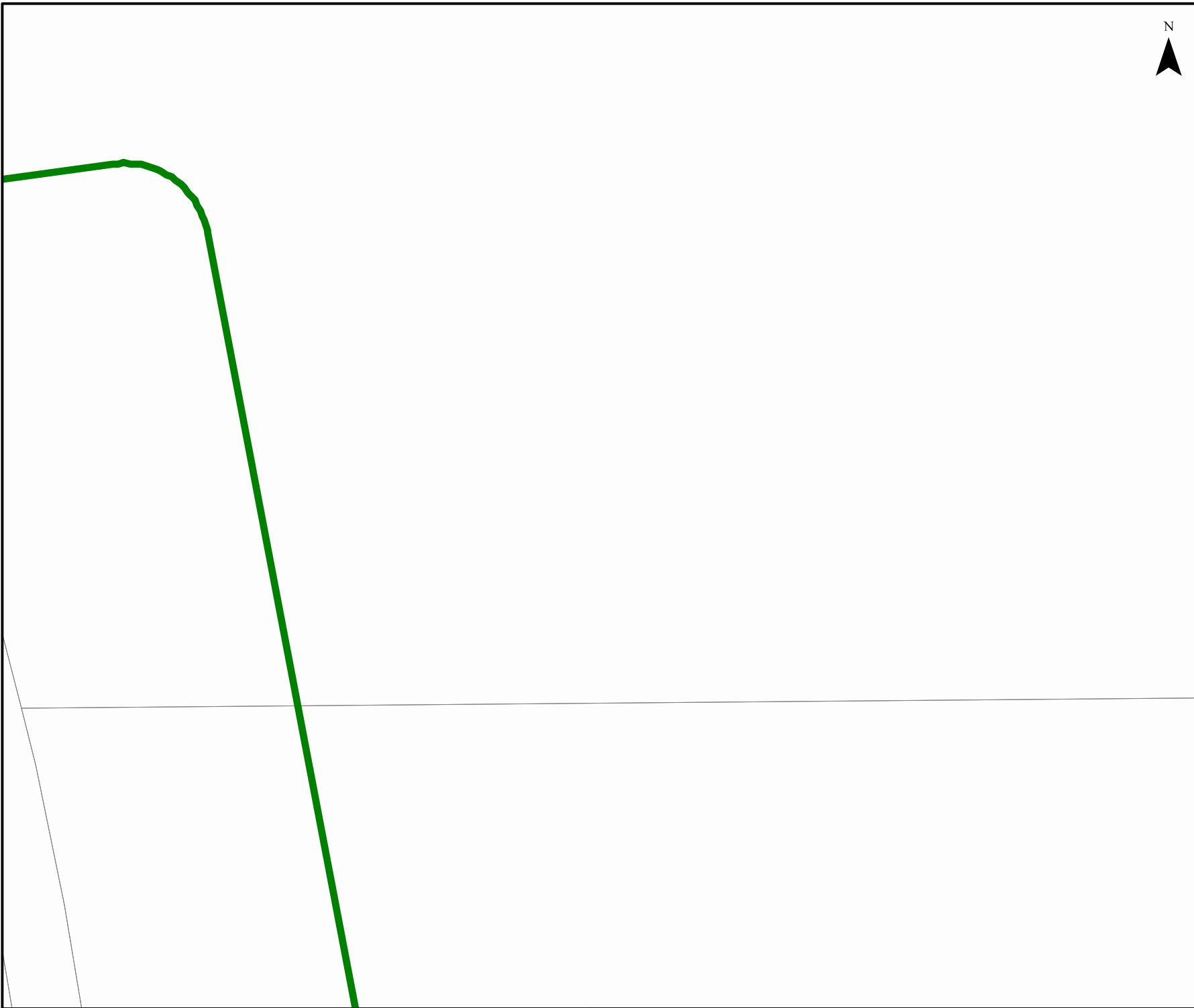
This map is **INDICATIVE ONLY**.
Check that you have enough clearance from the **DANGER ZONES** near overhead powerlines.

Telephone Support: 1 300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4 Scale : 1:1500

WARNING! Look out for overhead power lines



OVERHEAD LEGEND

Structures

- Power Pole ■ Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
— Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
— High Voltage Overhead Powerline
— Low Voltage Overhead Powerline
● Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- ▭ Area of Interest

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

**This map is INDICATIVE ONLY.
Check that you have enough
clearance from the DANGER ZONES
near overhead powerlines.**

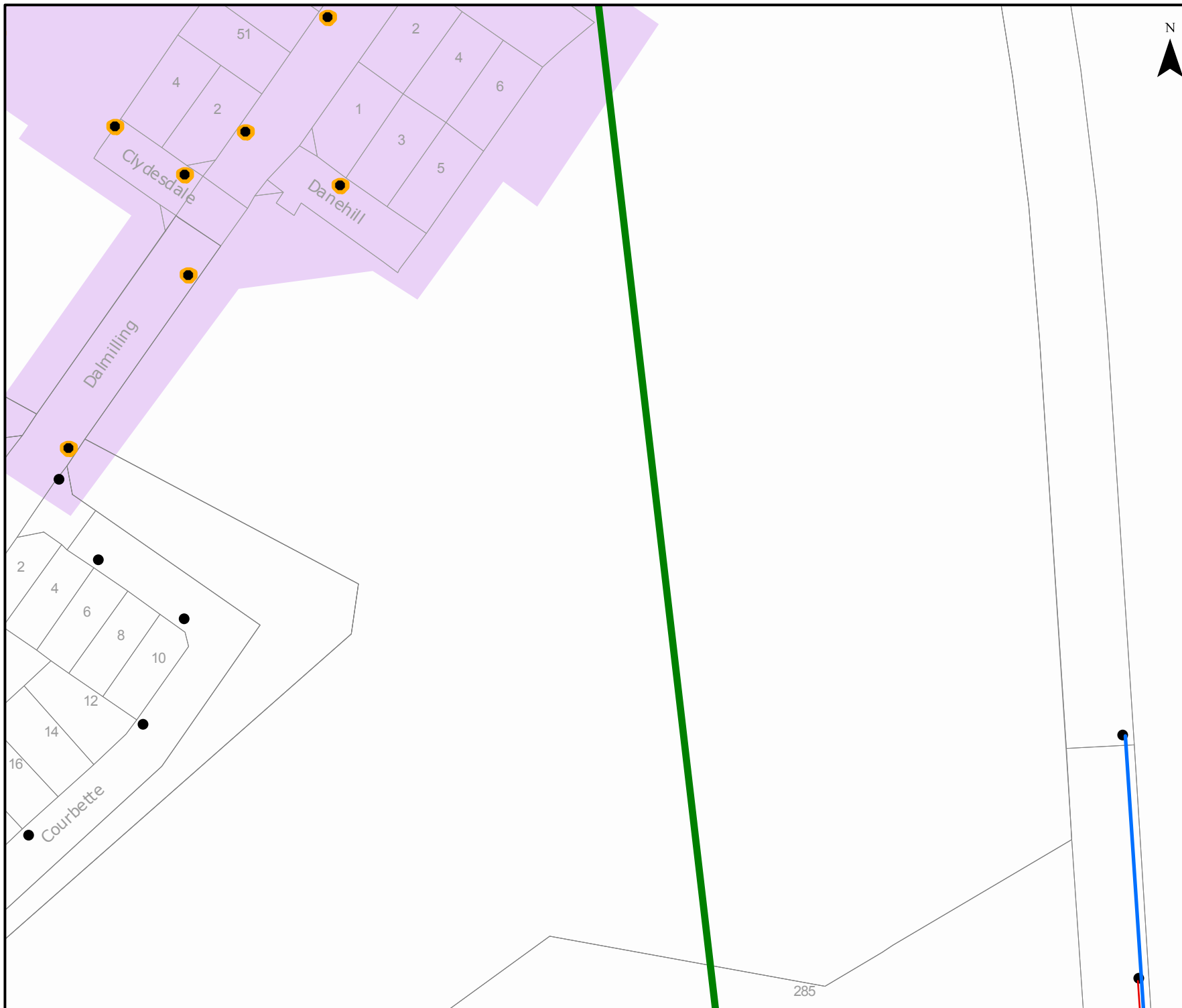
**Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30**

**Information valid for 30 days
from date of issue**

A4

Scale : 1:1500

**WARNING! Look out for
overhead power lines**



OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- ▭ Area of Interest

* Please refer to coversheet

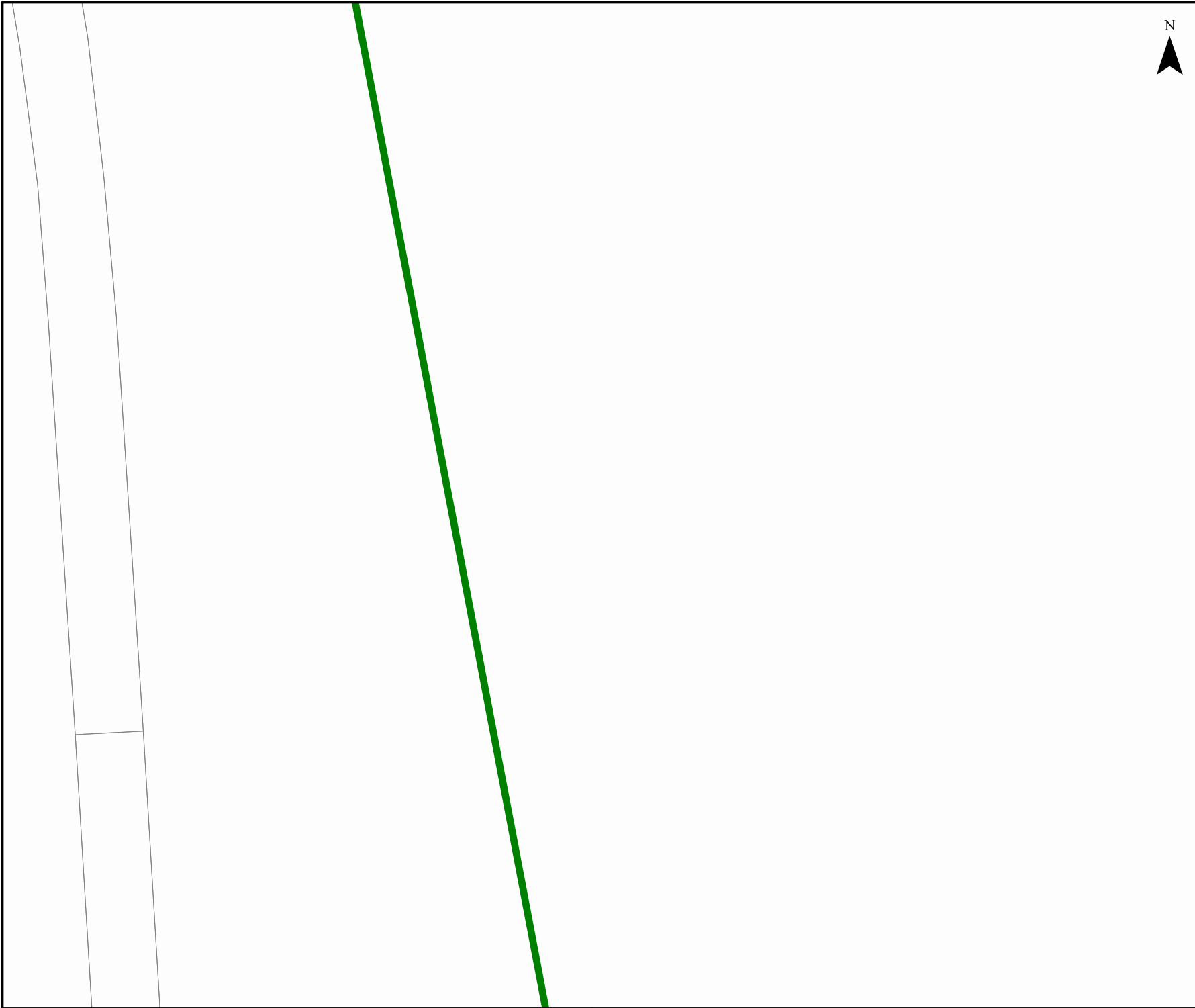
**Privately owned cables NOT SHOWN
(including house services)**

This map is **INDICATIVE ONLY**.
Check that you have enough
clearance from the **DANGER ZONES**
near overhead powerlines.
Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days
from date of issue

A4 | Scale : 1:1500

**WARNING! Look out for
overhead power lines**



OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

* Please refer to coversheet

Privately owned cables NOT SHOWN
(including house services)

This map is INDICATIVE ONLY.
Check that you have enough
clearance from the DANGER ZONES
near overhead powerlines.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days
from date of issue

A4 | Scale : 1:1500

WARNING! Look out for
overhead power lines












Lot 13255

Railway



OVERHEAD LEGEND

Structures	
● Power Pole	■ Transmission Poles
Transmission Overhead Powerline	
 Transmission (33kV - 330kV)	
Distribution Overhead Powerline	
 High Voltage (1kV - 33kV)	
 Low Voltage (< 1kV)	
Proposed Construction Assets	
 Design Area *	
 High Voltage Overhead Powerline	
 Low Voltage Overhead Powerline	
 Power Pole	
Communications Assets	
 Overhead Pilot Cable	
Feature	
 Area of Interest	

*** Please refer to coversheet**

**Privately owned cables NOT SHOWN
(including house services)**

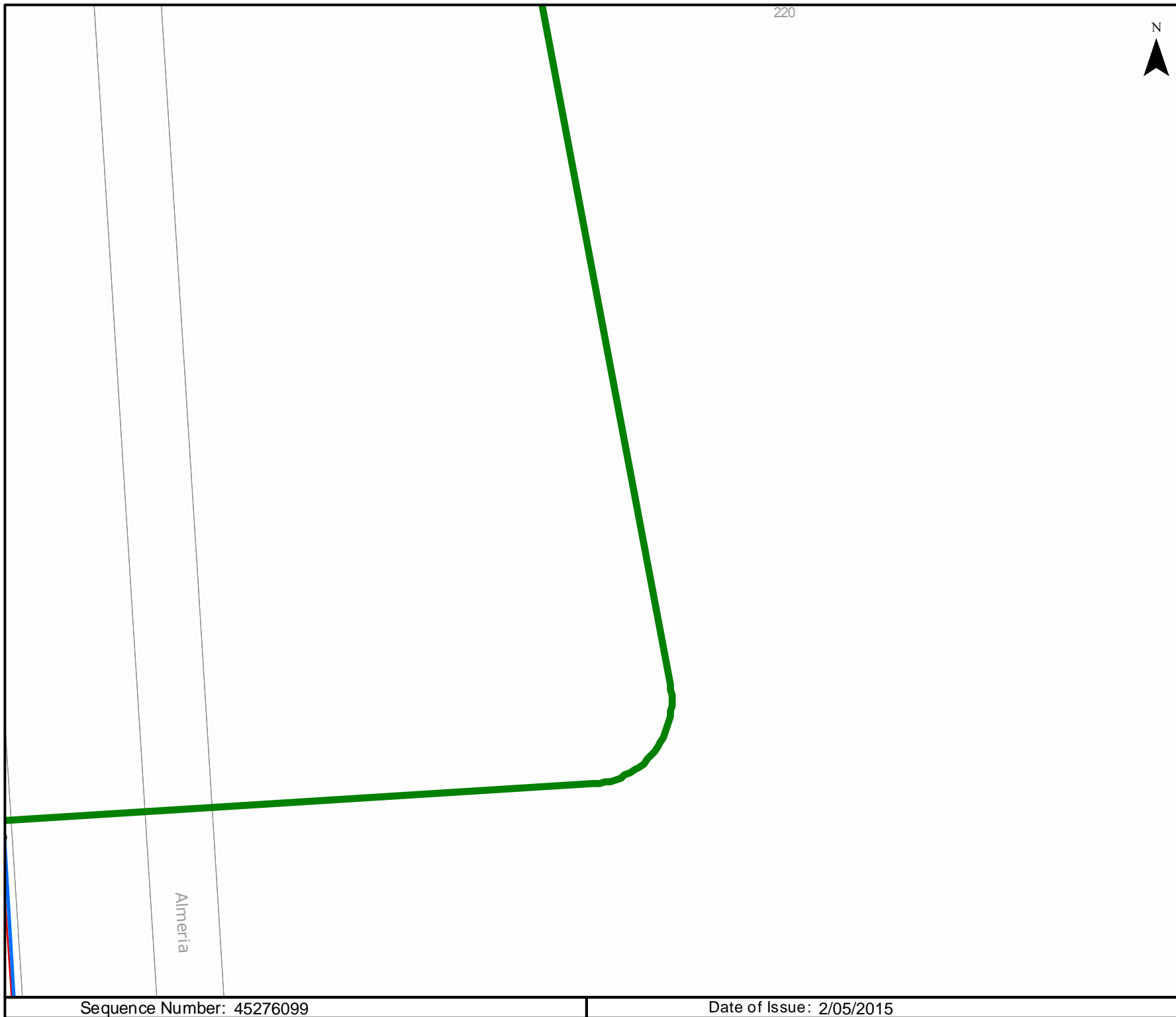
This map is INDICATIVE ONLY.
Check that you have enough
clearance from the DANGER ZONES
near overhead powerlines.


Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days
from date of issue

A4 | Scale : 1:1500

**WARNING! Look out for
overhead power lines**





OVERHEAD LEGEND

Structures

● Power Pole

■ Transmission Poles

Transmission Overhead Powerline

Transmission (33kV - 330kV)

Distribution Overhead Powerline

High Voltage (1kV - 33kV)

Low Voltage (< 1kV)

Proposed Construction Assets

Design Area *

High Voltage Overhead Powerline

Low Voltage Overhead Powerline

Power Pole

Communications Assets

Overhead Pilot Cable

Feature

Area of Interest

* Please refer to coversheet

Privately owned cables NOT SHOWN
(including house services)

This map is INDICATIVE ONLY.
Check that you have enough
clearance from the DANGER ZONES
near [overhead powerlines](#).
Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days
from date of issue

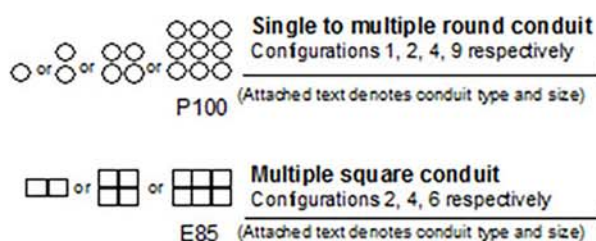
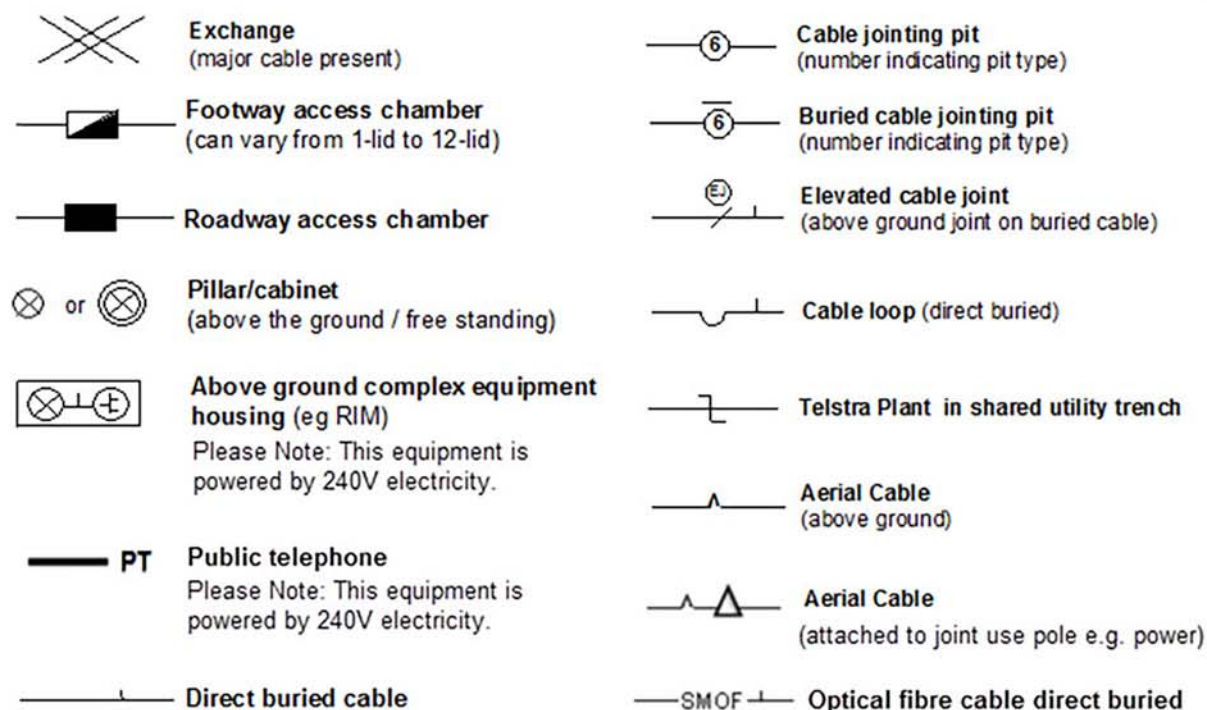
A4

Scale : 1:1500

WARNING! Look out for
overhead power lines



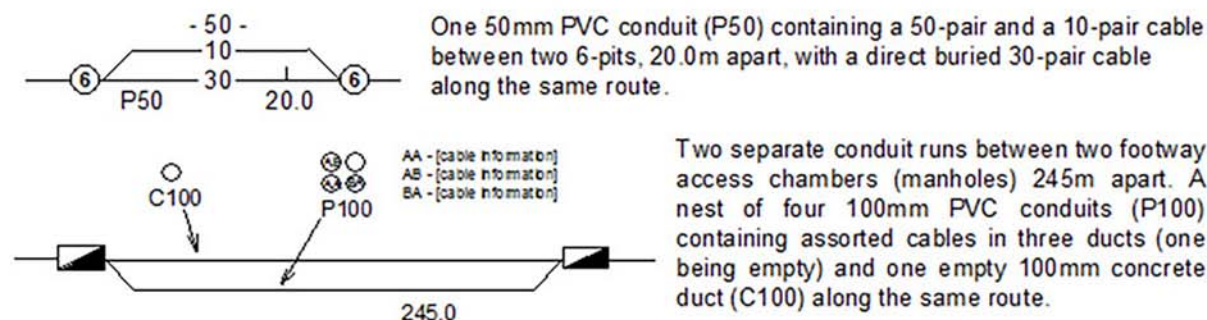
For more info contact a Telstra Accredited Locator or Telstra Plan Services 1800 653 935



Some examples of conduit type and size:
A - Asbestos cement, P - PVC / plastic, C - Concrete,
GI - Galvanised iron, E - Earthenware.
Conduit sizes *nominally* range from 20mm to 100mm.

P50	50mm PVC conduit
P100	100mm PVC conduit
A100	100mm asbestos cement conduit
E 85	85mm square earthenware conduit

Some examples of how to read Telstra plans:



WARNING: Telstra plans and location information conform to Quality Level 'D' of the Australian Standard AS 5488 - Classification of Subsurface Utility Information. As such, Telstra supplied location information is indicative only. Spatial accuracy is not applicable to Quality Level D. Refer to AS 5488 for further details. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy shown on the plans. FURTHER ON SITE INVESTIGATION IS REQUIRED TO VALIDATE THE EXACT LOCATION OF TELSTRA PLANT PRIOR TO COMMENCING CONSTRUCTION WORK. A plant location service is an essential part of the process to validate the exact location of Telstra assets and to ensure the asset is protected during construction works. The exact position of Telstra assets can only be validated by physically exposing it. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers.

L503
DP11365

P20 8.8
2/0.64 IB

2DEAD

L301
RESERVE

—10 PEHJ—



Sequence Number: 46887275

CAUTION: Fibre optic and/ or major network present in plot area. Please read the Duty of Care and contact Telstra Plan Services should you require any assistance.

TELSTRA CORPORATION LIMITED A.C.N. 051 775 556

Generated On 25/07/2015 20:39:23

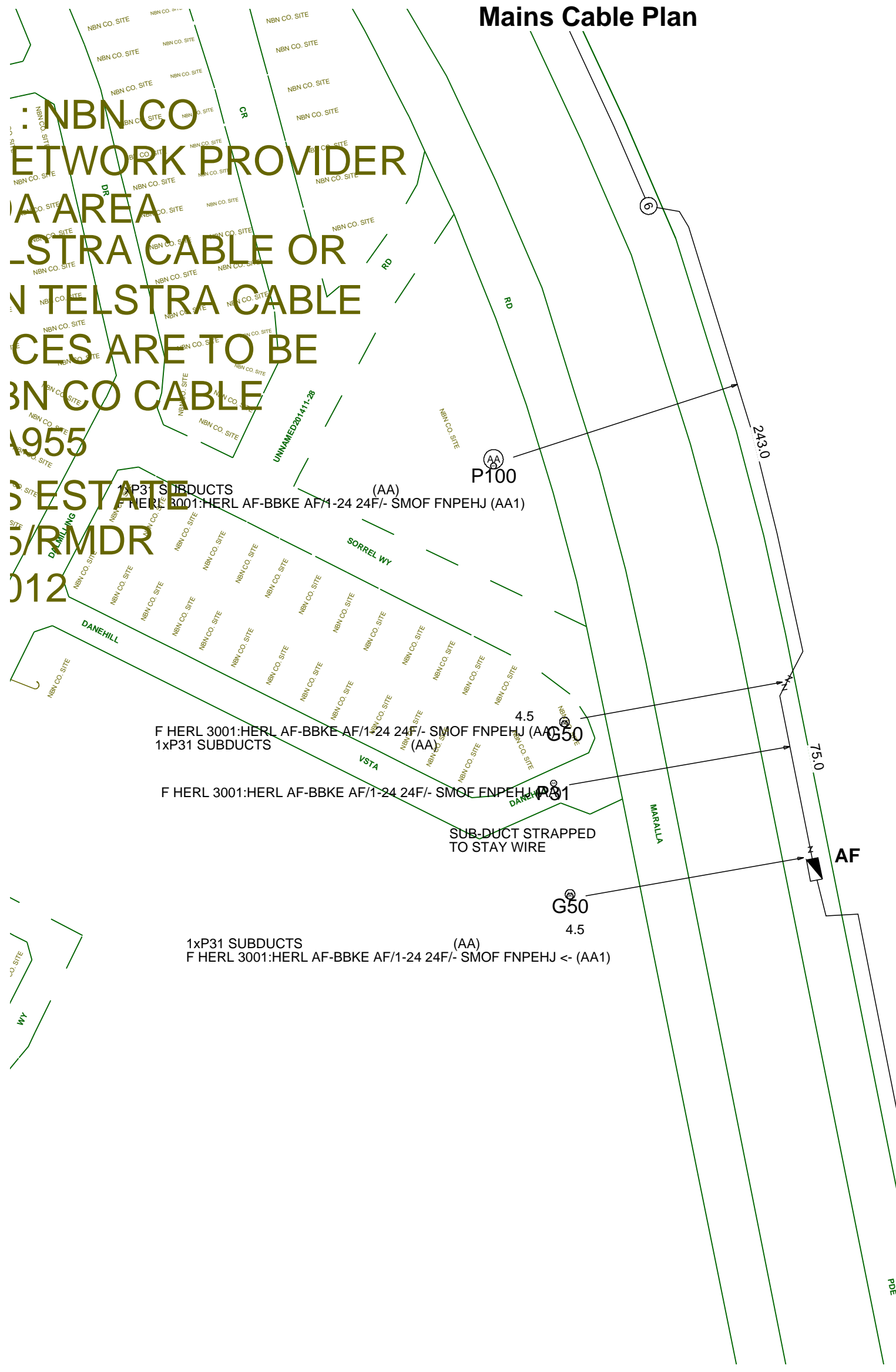
The above plan must be viewed in conjunction with the Mains Cable Plan on the following page

WARNING - Due to the nature of Telstra underground plant and the age of some cables and records, it is impossible to ascertain the precise location of all Telstra plant from Telstra's plans. The accuracy and/or completeness of the information supplied can not be guaranteed as property boundaries, depths and other natural landscape features may change over time, and accordingly the plans are indicative only. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy shown on the plans.

It is your responsibility to locate Telstra's underground plant by careful hand pot-holing prior to any excavation in the vicinity and to exercise due care during that excavation.

Please read and understand the information supplied in the duty of care statement attached with the Telstra plans. TELSTRA WILL SEEK COMPENSATION FOR LOSS CAUSED BY DAMAGE TO ITS PLANT.

Telstra plans and information supplied are valid for 60 days from the date of issue. If this timeframe has elapsed, please reapply for plans.



Sequence Number: 46887275

CAUTION: Fibre optic and/ or major network present in plot area. Please read the Duty of Care and contact Telstra Plan Services should you require any assistance.

WARNING - Due to the nature of Telstra underground plant and the age of some cables and records, it is impossible to ascertain the precise location of all Telstra plant from Telstra's plans. The accuracy and/or completeness of the information supplied can not be guaranteed as property boundaries, depths and other natural landscape features may change over time, and accordingly the plans are indicative only. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy shown on the plans.

It is your responsibility to locate Telstra's underground plant by careful hand pot-holing prior to any excavation in the vicinity and to exercise due care during that excavation.

Please read and understand the information supplied in the duty of care statement attached with the Telstra plans. TELSTRA WILL SEEK COMPENSATION FOR LOSS CAUSED BY DAMAGE TO ITS PLANT.

Telstra plans and information supplied are valid for 60 days from the date of issue. If this timeframe has elapsed, please reapply for plans.

APPENDIX J

PATTERN FINISH FOR THE PRECAST ARCH OPTION

2009 Catalogue

Supersedes our previous "2008 Catalogue" and now allows for 14 NEW extra pages and patterns

MOULDS FOR **ART** ON CONCRETE

By



Changing the face of concrete

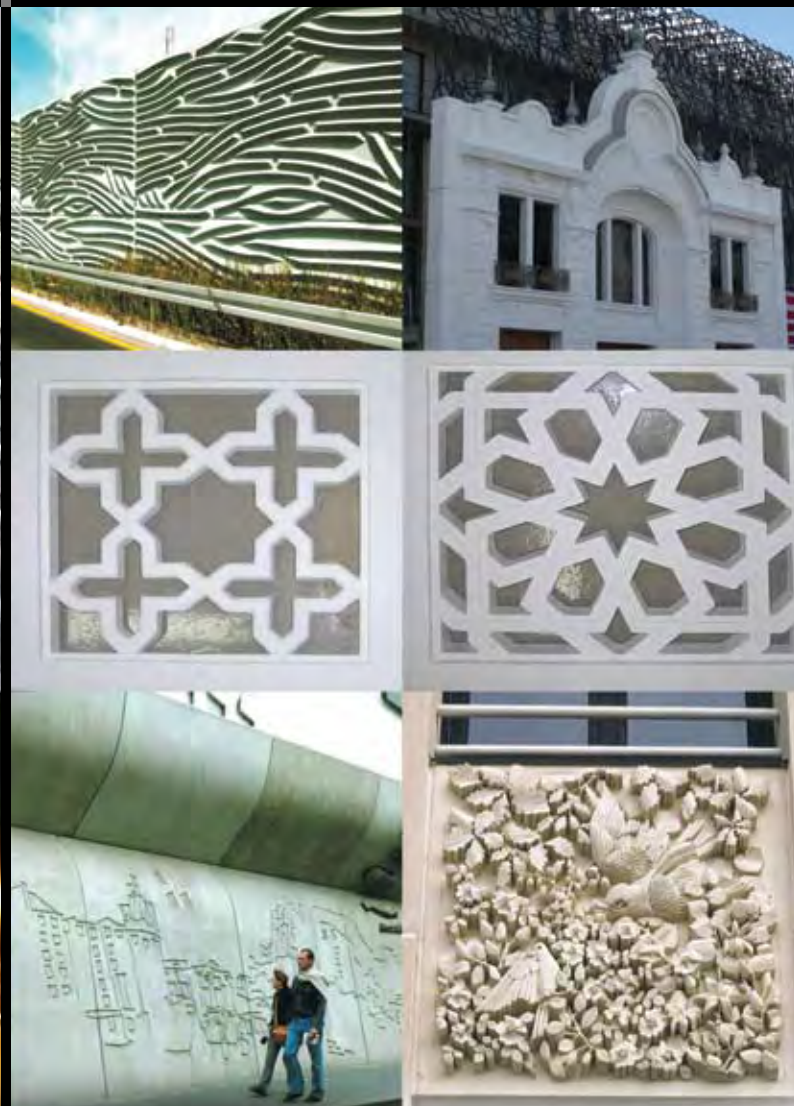
TICK	CIRCULATION

For extra copies:
please email:
reckli@optusnet.com.au
or fax: 03 8361 7186

Standard Patterns



Custom Patterns

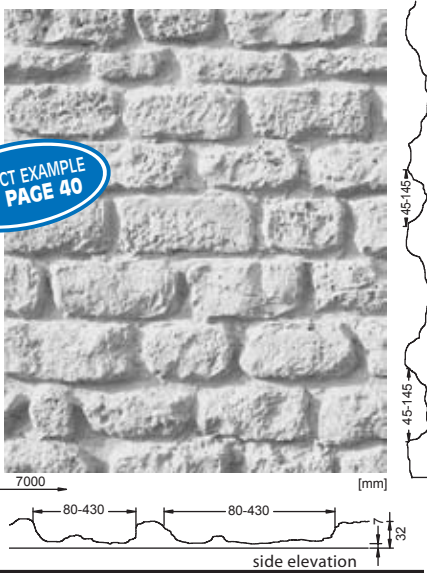


- ☒ Precast Elements
- ☒ Insitu-Cast Elements
- ☒ Stack/Site Cast Elements
- ☒ GRC - Glass Re-inforced Concrete
- ☒ Prestressed Elements

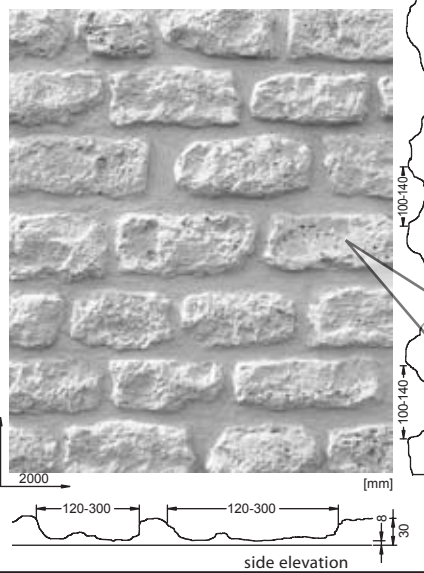
Brick and Masonry Patterns


Display Centre: Building 1, 123 Pipe Rd North Laverton Victoria 3026 Australia M: 0418 176 044 F: (+61 3) 8361 7186 E: reckli@optusnet.com.au ★

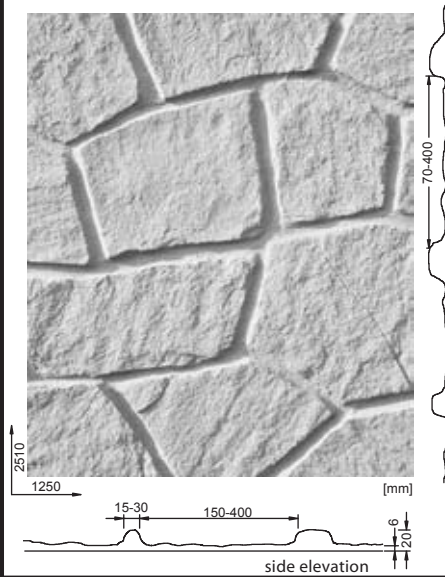
2/79 Mayenne

Web Link: www.reckli.de/2_79.htm


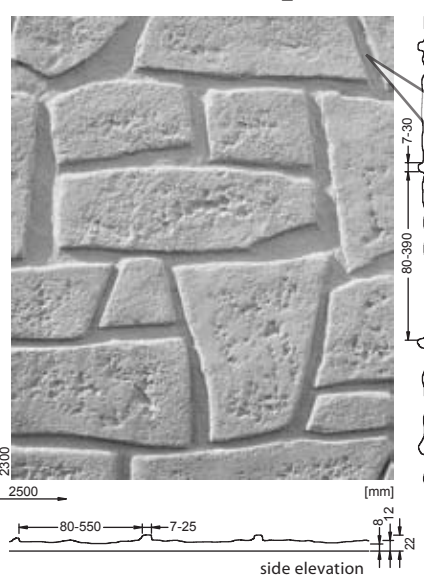
1/127 Shannon

Web Link: www.reckli.de/1_127.htm


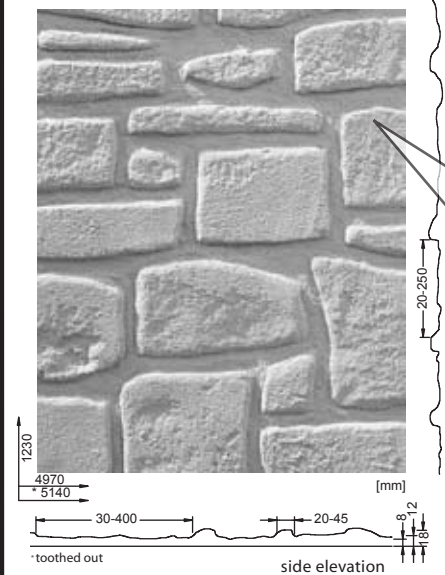
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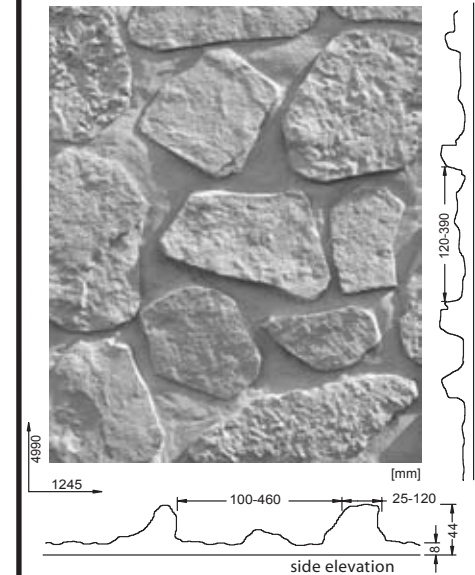
2/137 Bourgogne

Web Link: www.reckli.de/2_137.htm


2/135 Provence

Web Link: www.reckli.de/2_135.htm


2/374 La Reunion

Web Link: www.reckli.de/2_374.htm


RECKLI are suppliers of Rubber Moulds & Form-Liners for patterns on concrete panels & other concrete elements. RECKLI offers flexible & re-usable mould liners for architectural concrete/GRC units. RECKLI moulds will assist in increasing kerb appeal, enhancing architectural expression & integrate structures with their surroundings.

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Hong Kong

India

Iran

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New Zealand

Norway

Poland

Portugal

Russia

Saudi Arabia

Singapore

South Korea

Spain

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Thailand

Turkey

U.A.E

U.S.A

UK x2



Member



(Associate Member)

National Precast Concrete Association Australia

Noise Reduction Wall Formliner



From This...



...To This

Liquid rubber: For Make-your-own formliners and mould and pattern making as well as for the surfaces protection. The complex area of application goes from the preservation of monuments and restoration of valuable elements of buildings, as well to the mould making in the porcelain and ceramic industry.



Make Your Own Moulds
Balastrades Moulds



Changing the face of concrete

RECKLI Australia & New Zealand

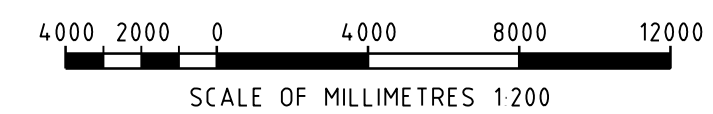
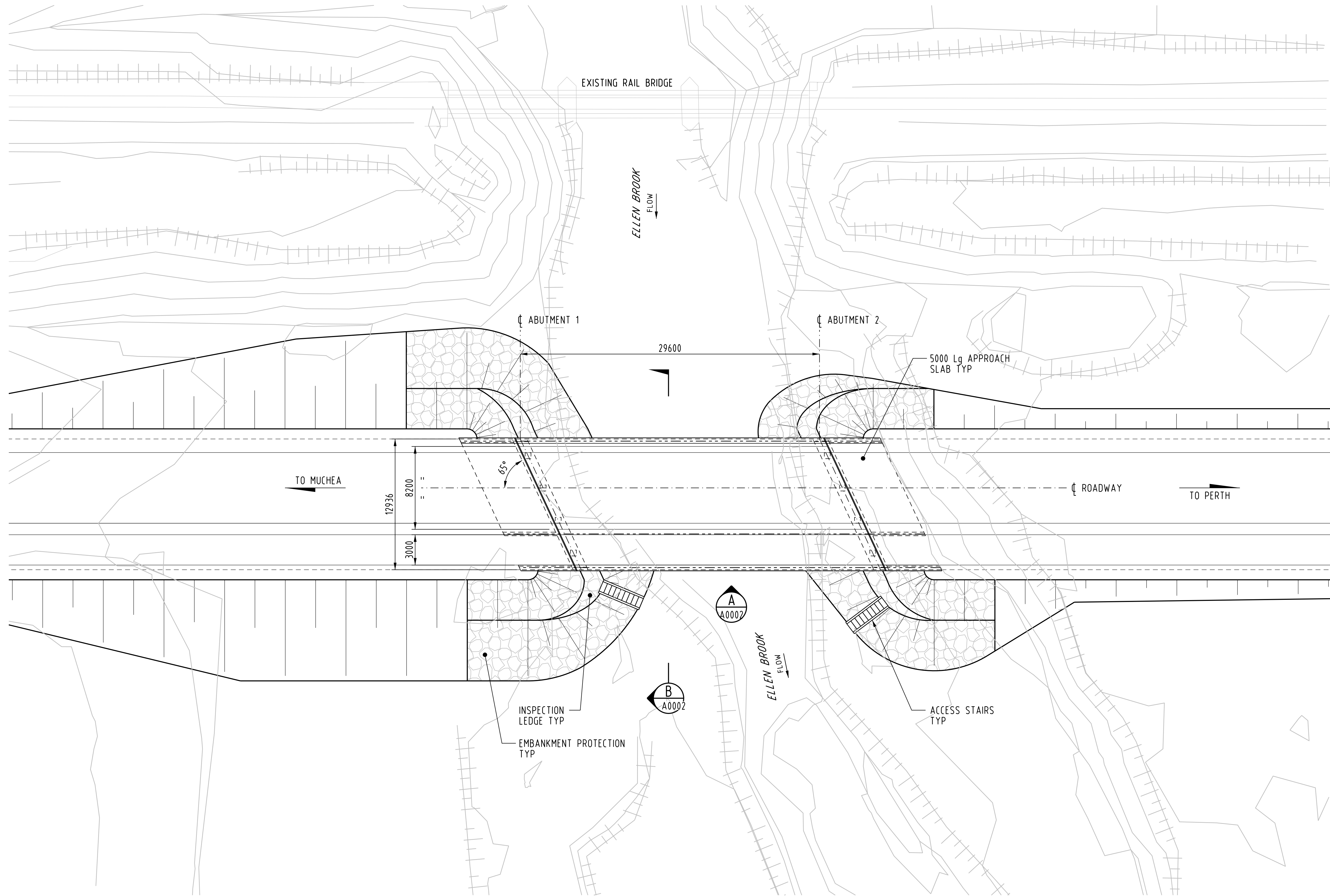
Display Centre: Building 1, 123 Pipe Rd North Laverton Victoria 3026 Australia

Postal Address: PO Box 120 Sunshine Victoria 3020 Australia Mobile: 0418 176 044

Fax: 03 8361 7186 Email: reckli@optusnet.com.au Web: www.reckli.com

APPENDIX K

PRELIMINARY DESIGN DRAWINGS



CONCEPT DRAWING
NOT TO BE USED
FOR CONSTRUCTION

AMENDMENTS

REV	DATE	BY	DESCRIPTION
A	25.07.15	TW	DRAFT ISSUE

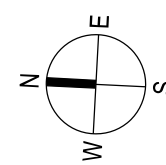


APPROVED

DESIGN CO-ORDINATOR DATE

DESIGNED: PT DRAWN: TW CHECKED: DT DATE: JULY 2015

SCALE: 200 (A1)
DATUM: A.H.D.



RAILWAY PARADE BRIDGE

OPTION 1 - SINGLE SPAN TEE-ROFF BEAM

GENERAL ARRANGEMENT PLAN

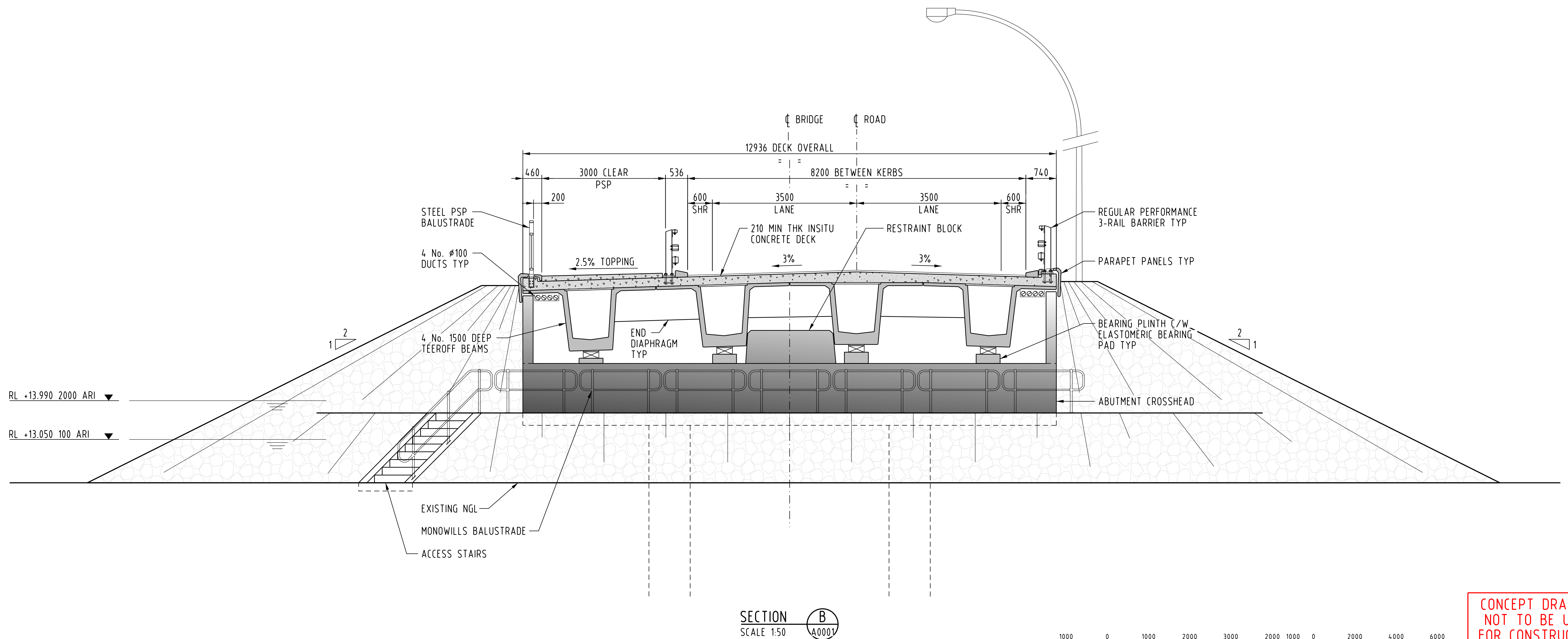
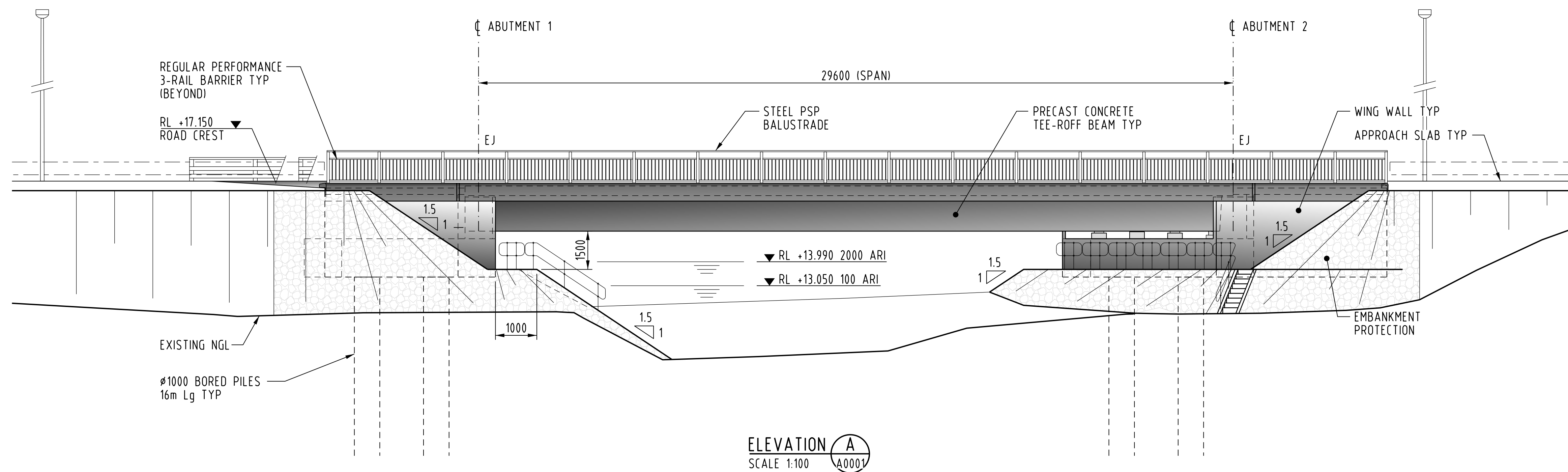


DRAWING No:
A0001-AA007882-AAD

REV No:
A

OPERATIONS

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CONCEPT DRAWING
NOT TO BE USED
FOR CONSTRUCTION

AMENDMENTS

REV	DATE	BY	DESCRIPTION
A	25.07.15	TW	DRAFT ISSUE



APPROVED

DESIGN CO-ORDINATOR DATE

DESIGNED: PT DRAWN: TW CHECKED: DT DATE: JULY 2015

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SCALE: NOTED (A1)
DATUM: A.H.D.

RAILWAY PARADE BRIDGE

OPTION 1 - SINGLE SPAN TEE-ROFF BEAM

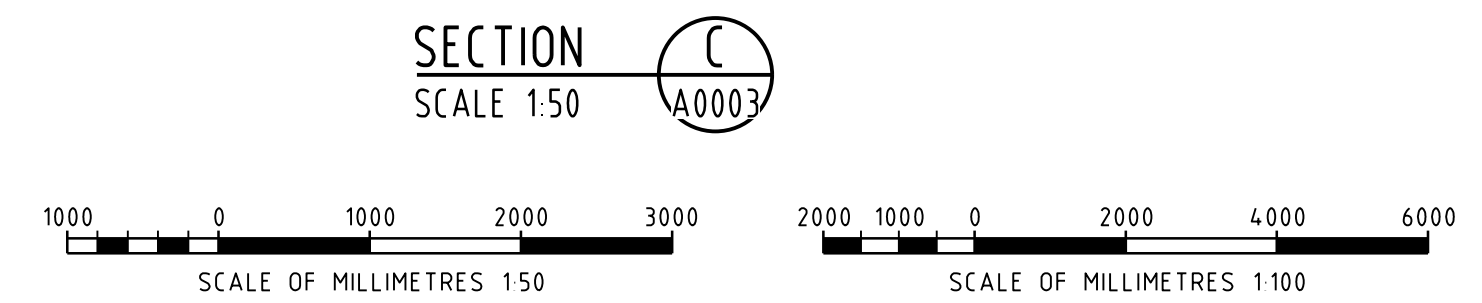
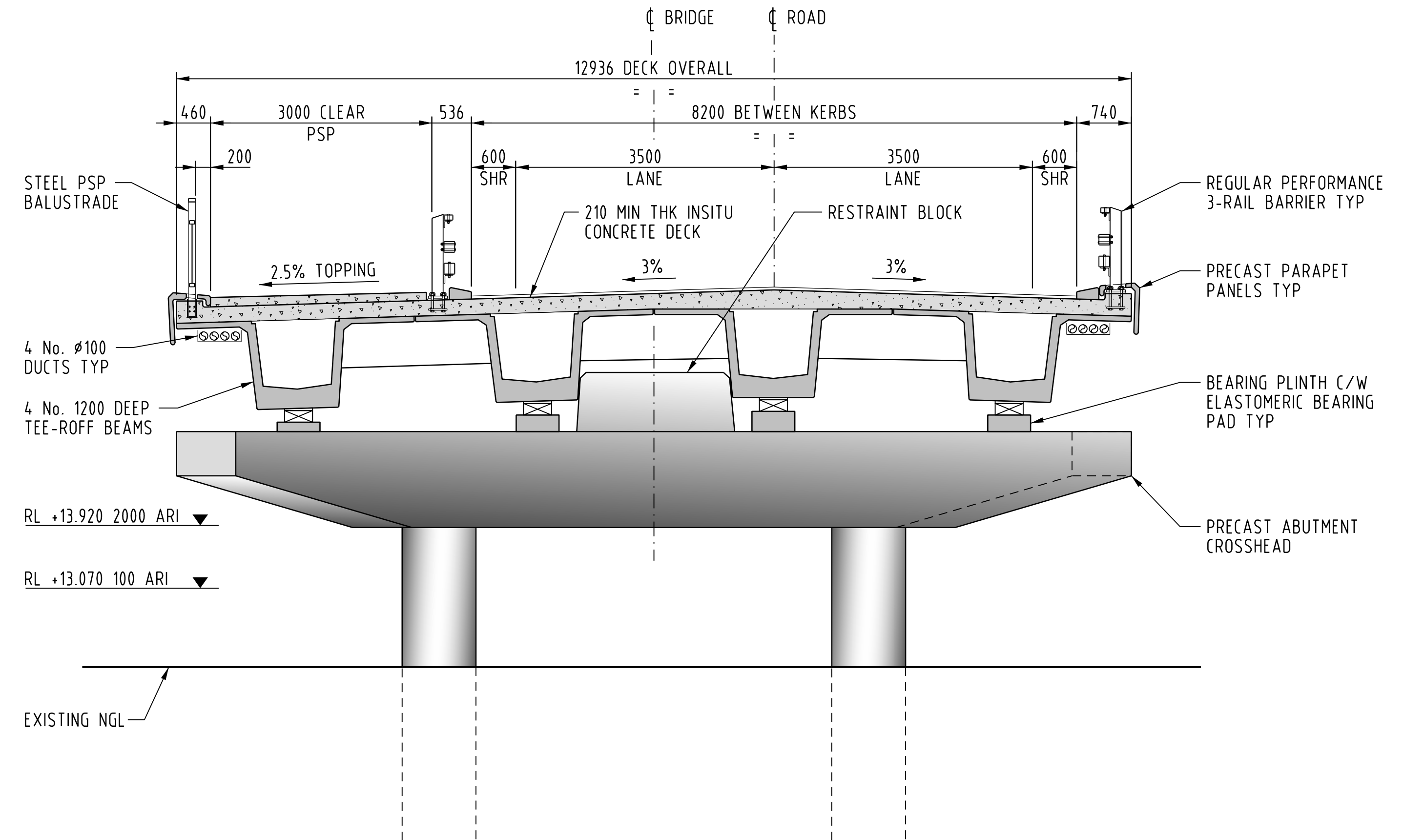
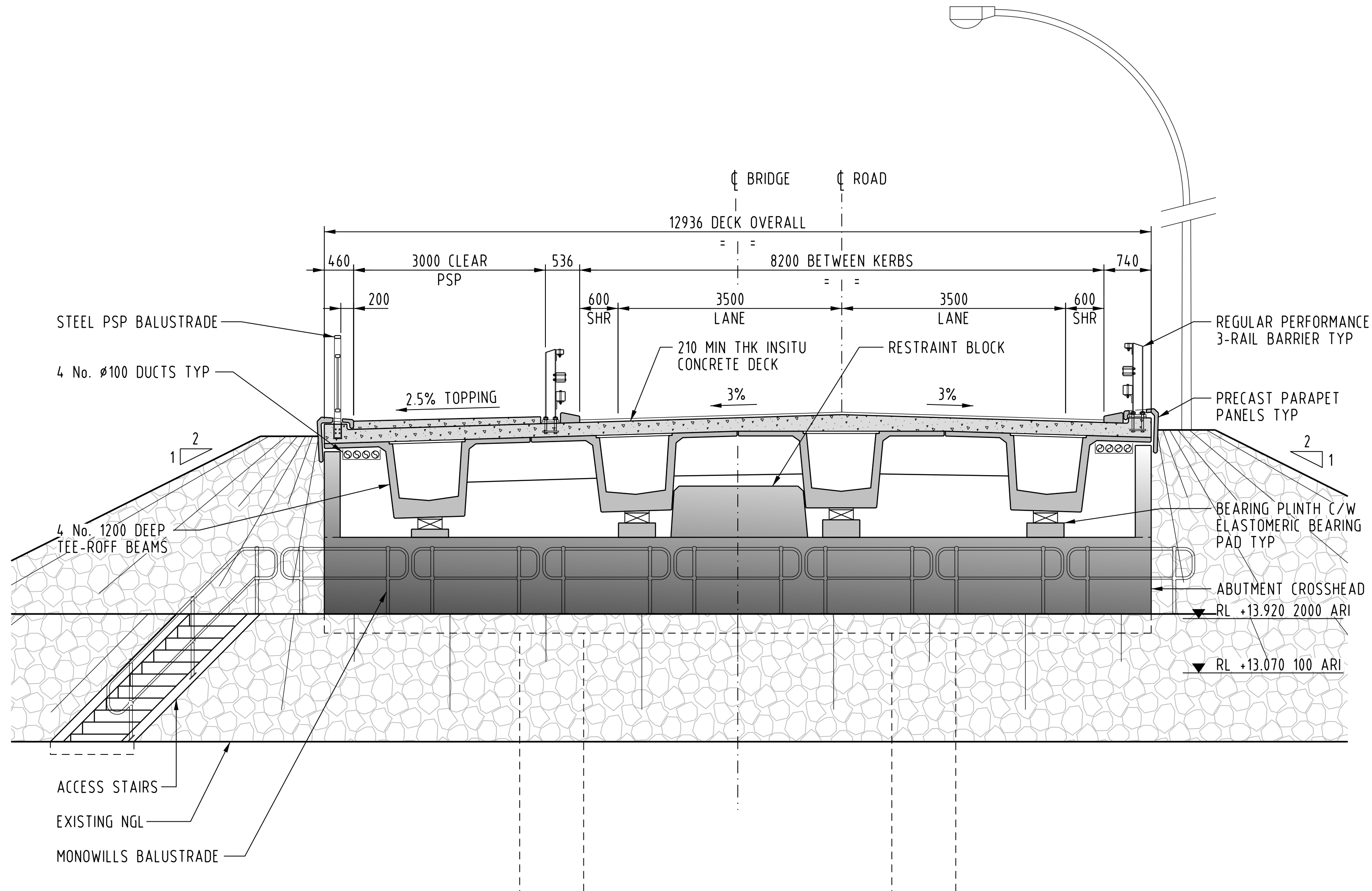
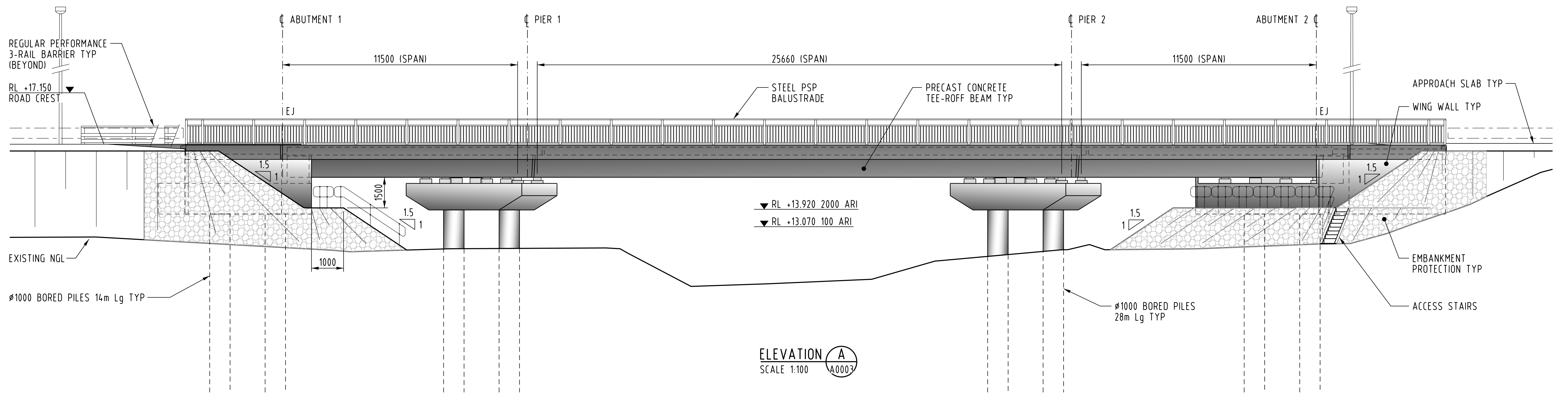
ELEVATION & SECTION



DRAWING No:
A0002-AA007882-AAD

REV No:
A

OPERATIONS



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AMENDMENTS

A 25.07.15 TW DRAFT ISSUE
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SCALE: NOTED (A1)
DATUM: A.H.D.

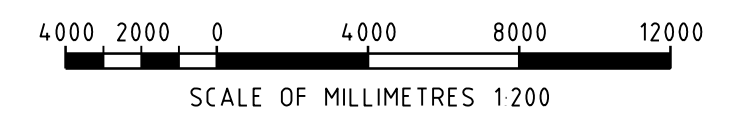
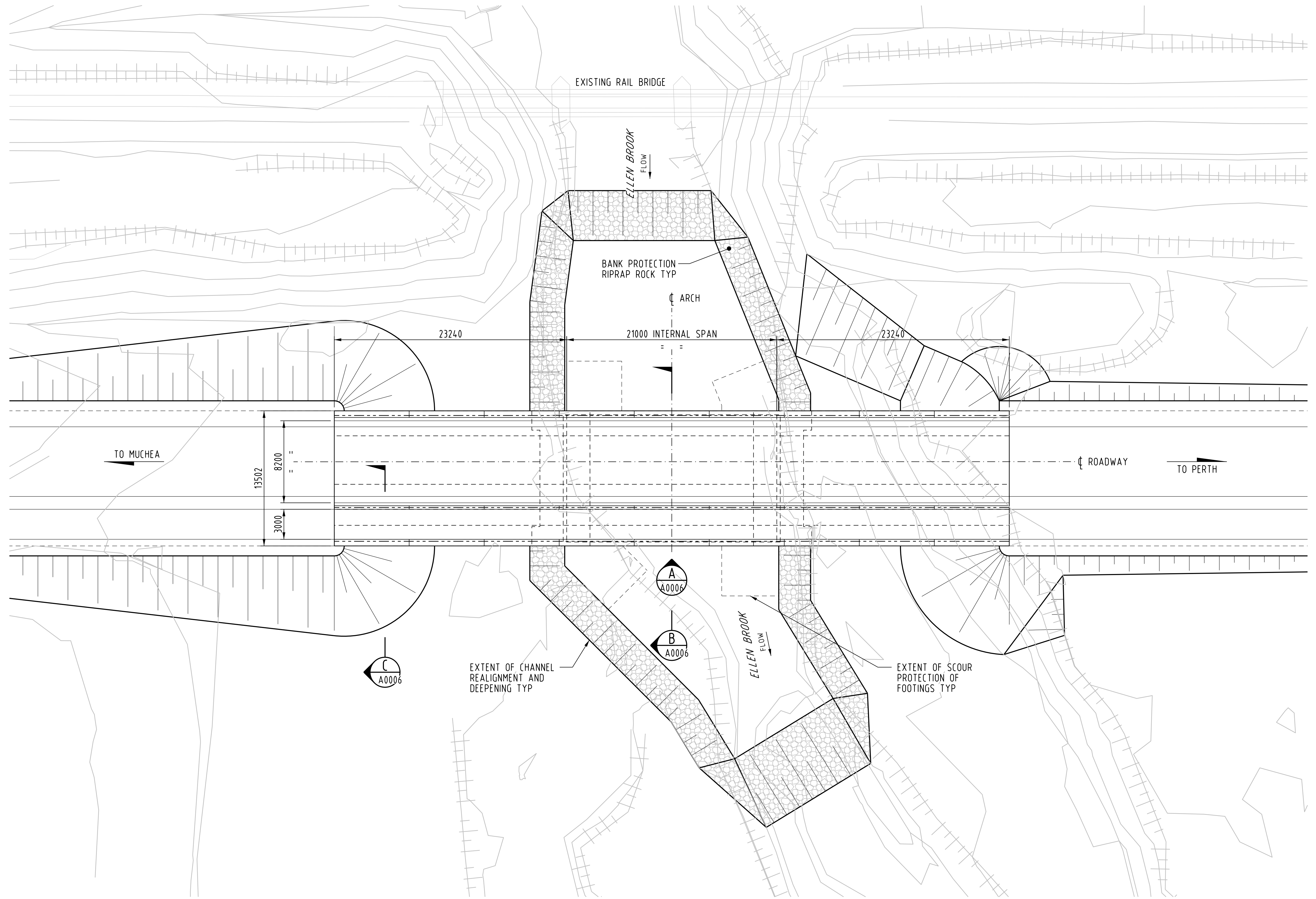
RAILWAY PARADE BRIDGE
OPTION 2 - THREE SPAN TEE-ROFF BEAM
ELEVATION & SECTION



DRAWING No:
A0004-AA007882-AAD

REV No:
A

OPERATIONS



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AMENDMENTS

REV	DATE	BY	DESCRIPTION
A	28.07.15	TW	ISSUE

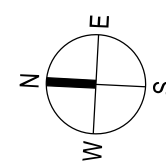


APPROVED

DESIGN CO-ORDINATOR DATE

DESIGNED: PT DRAWN: TW CHECKED: DT DATE: JULY 2015

SCALE: 1:200 (A1)
DATUM: A.H.D.



RAILWAY PARADE BRIDGE

OPTION 3 - PRECAST CONCRETE ARCH

GENERAL ARRANGEMENT PLAN

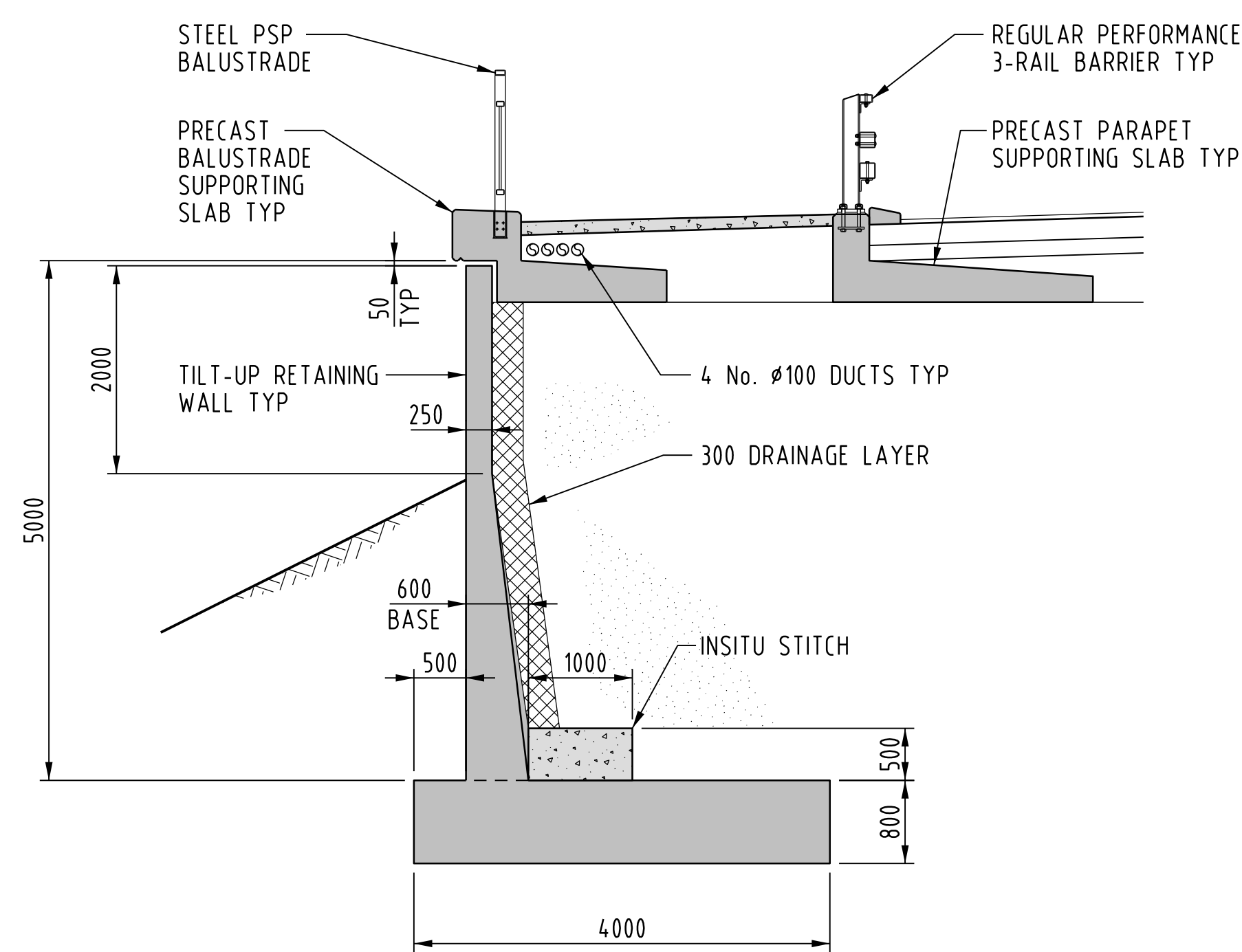
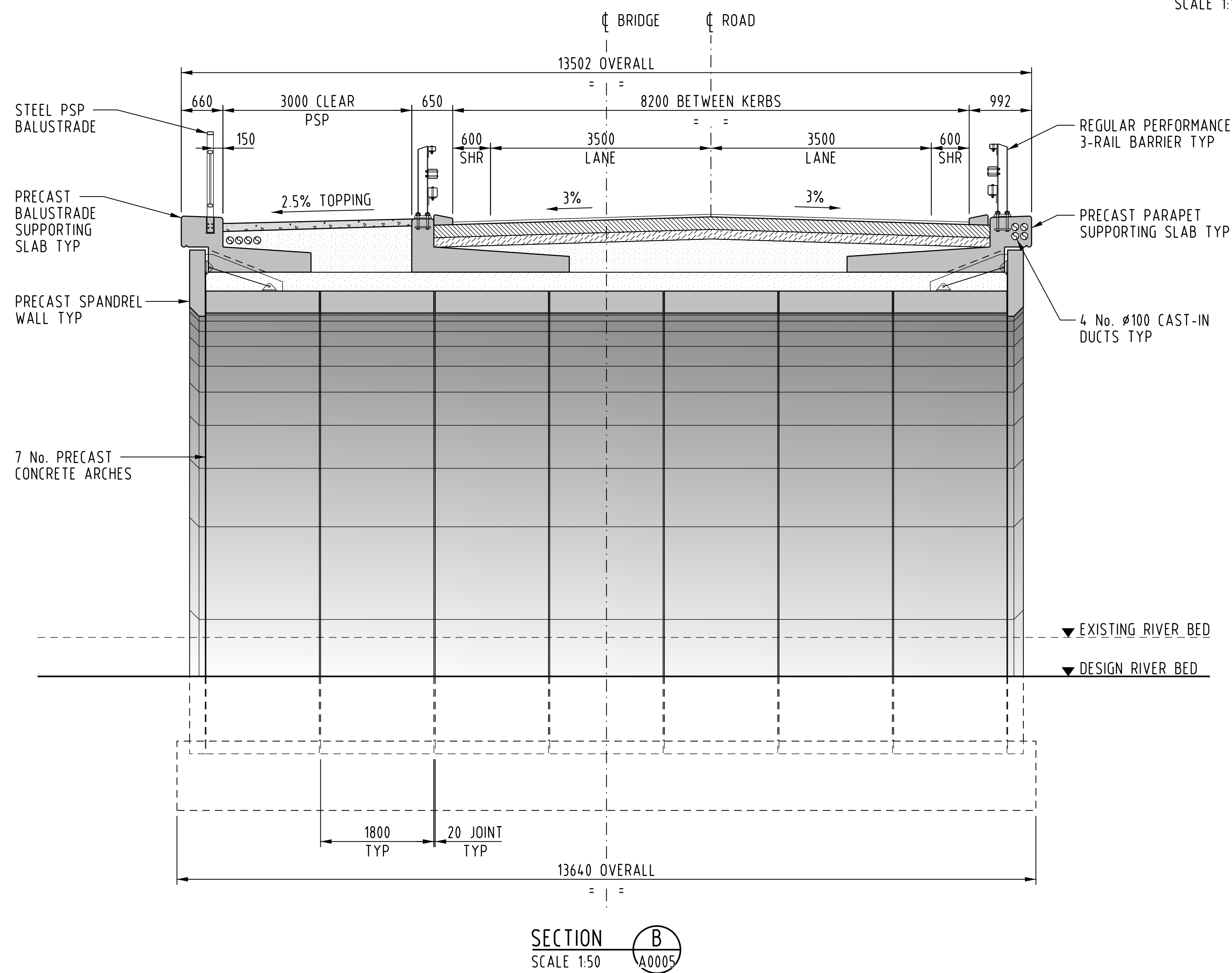
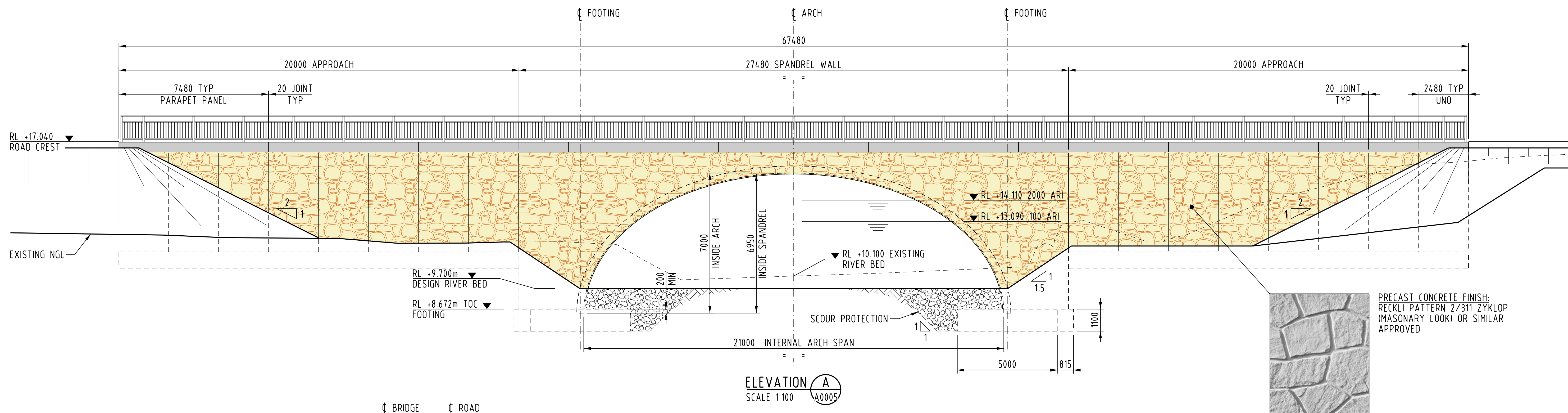


DRAWING No:
A0005-AA007882-AAD


REV No:
A

OPERATIONS

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CONCEPT DRAWING
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FOR CONSTRUCTION

AMENDMENTS		 Hyder An ARCADIS Company	APPROVED DESIGN CO-ORDINATOR DATE DESIGNED: PT DRAWN: TW CHECKED: DT DATE: JULY 2015	SCALE: 1:100 (A1) DATUM: A.H.D.	RAILWAY PARADE BRIDGE OPTION 3 - PRECAST CONCRETE ARCH ELEVATION & SECTIONS	DRAWING No: A0006-AA007882-AAD	REV No: A
	A 25.07.15 TW DRAFT ISSUE REV DATE BY DESCRIPTION						



OPERATIONS

APPENDIX L

PRELIMINARY LIGHTING DESIGN



SITE PLAN
SCALE 1:500 @ A1



WARNING

CONTRACTOR TO CONFIRM THE LOCATION OF ALL SERVICES PRIOR TO COMMENCEMENT OF WORKS.

WARNING

BEWARE OF UNDERGROUND SERVICES

The locations of underground services are approximate only and their exact position should be proven on site. No guarantee is given that all existing services are shown.

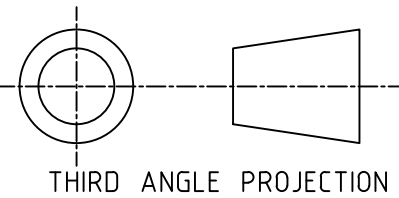
BEWARE OF OVERHEAD POWER LINES

Minimum clearances for Streetlight Pole/
Luminaire to Overhead Power Lines
Low Voltage - 1m
High Voltage - 3m
Extra High Voltage - 6m

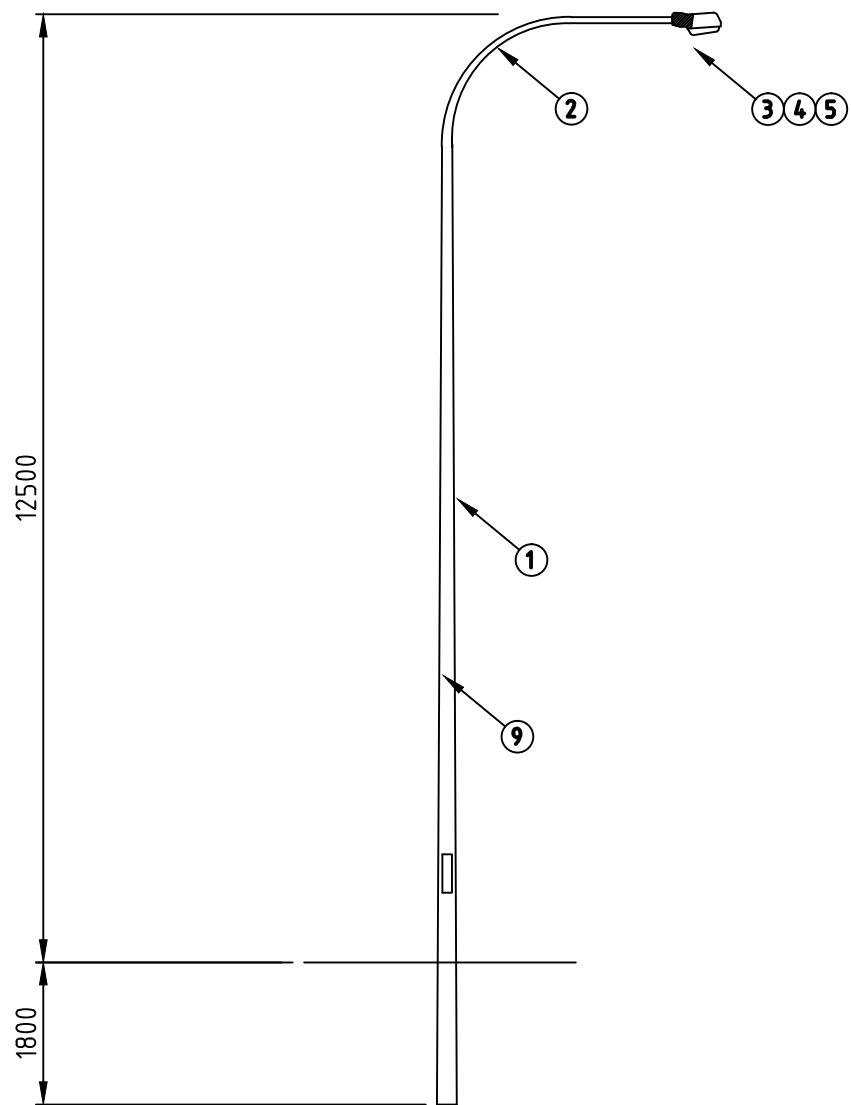
COMPLY WITH AS/NZS7000 CLEARANCES

0 5000 10000 20000 30000
Full Size 1:500 - Half Reduction 1:1000
SCALE (mm)

ALL DIMENSIONS ARE
IN MILLIMETRES
DRAWN IN ACCORDANCE
WITH AS1100-1992
DO NOT SCALE



THIRD ANGLE PROJECTION



12.5 METRE POLE WITH 3.0 METRE OUTREACH
(SCALE 1 : 100)

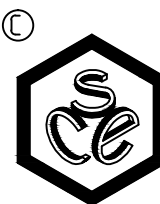
BILL OF MATERIALS

ITEM	STOCK NUMBER	DESCRIPTION	QTY
1.	CW0276	POLE 12.5m	1
2.	CW0278	SINGLE OUTREACH ARM - GALVANISED	1
3.	HL6146	LUMINAIRE - 250W HPS	1
4.	GL0755	LAMP 250W HPS	1
5.	HL5557	PE CELL	1
6.	GF1300	FUSE CARTRIDGE 10A	1
7.	H20128	SL FUSE BOX	1
8.	FL1408	COPPER CRIMP LUG	2
9.	EE1318	CABLE 2.5mm TWIN AND EARTH	1

PRELIMINARY DRAWING

A1

ISSUE	REVISION	DATE	CHECKED	ISSUE	REVISION	DATE	CHECKED
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SAGE
CONSULTING
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www.hyderconsulting.com

ELECTRICAL SERVICES

RAILWAY PARADE - ELLENBROOK W.A.

BRIDGE LIGHTING

SITE PLAN

DESIGNED C.L.	DRAWN A.G.R.	CHECKED M.D.S.
DATE 23/7/15	SCALE 1:500@A1	
PROJECT No. AS/NZS ISO 9001:2008 Certificate No. 9000 254		DRAWING No. 2431 E1
SHEET 1 OF 1		