Appendices

(Total No. of pages including blank pages = 546)

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Appendix 1

Submissions Summary

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Table A1-1
Submissions Summary – Objecting Submissions

Name	Submission ID	Location	Road Noise	Vehicle Dust	Traffic Levels	Groundwater	Sustainable Development	Biodiversity	Economic	Road Safety	Employment	Social	Community Consultation	Flooding	Water Quality	Rehabilitation	Environmental Management	Transport Route	Operating Hours
Section in Submissions Report where matters are addressed			4.2.15.1	4.2.15.2	4.2.15.4	4.2.6	4.2.13	4.2.2	4.2.3	4.2.15.6	4.2.3	4.2.12	4.2.12	4.2.5	4.2.16	4.2.10	4.2.4	4.2.15.5	4.2.7
Submitter Type: Public																			
John McInnes	SE-125841	Howlong			✓														
Name Withheld 2	SE-125844	Howlong			✓														
Penelope Pattinson	SE-125905	Howlong			✓	✓													
Olivia Noto	SE-125948	Howlong			✓		✓	✓	✓										
Name Withheld 4	SE-125966	Barnawartha								✓									
Debbie and Robert Travers	SE-126290	Howlong			✓	✓									✓				
Name Withheld 6	SE-126466	Not Provided		✓	✓			✓		✓									
Margaret O'Donnell	SE-126467	Howlong			✓						✓	✓	✓					✓	
Name Withheld 7	SE-126468	Howlong			✓	✓													
Name Withheld 8	SE-126471	Howlong		✓	✓					✓									
Name Withheld 11	SE-126524	Howlong		✓	✓			✓		✓									
Name Withheld 12	SE-126525	Howlong		✓	✓			✓		✓									
William Pressnell	SE-126527	Howlong	✓			✓				✓									
Name Withheld 13	SE-126530	Howlong	✓	✓	✓	✓						✓	✓						
Name Withheld 14	SE-126531	Howlong	✓		✓					✓									
Name Withheld 15	SE-126539	Howlong	✓	✓	✓					✓		✓		✓					
Name Withheld 16	SE-126543	Howlong	✓		✓	✓		✓		✓				✓					
Mark Smit	SE-126545	Howlong			✓				✓										
Narelle and Graham Ashford	SE-126555	Howlong	✓					✓		✓					✓	✓			
Helen Jones	SE-126556	Howlong			✓										✓		✓		
Name Withheld 17	SE-126557	Howlong	✓		✓					✓		✓						✓	
Name Withheld 18	SE-126566	Howlong	✓		✓	✓		✓	✓						✓			✓	
Leigh Ashford	SE-126602	Howlong	✓		✓					✓		✓							✓
Name Withheld 20	SE-126616	St Kilda East		✓		✓		✓				✓		✓		✓			
Judith Thomas	SE-126623	Howlong			✓								✓						

Note 1: Leigh Ashford submitted twice and Name Withheld 9 was resubmitted as Name Withheld 13. Duplicates have been removed.

Note 2: Margaret O'Donnell submission included a petition with 26 signatories.

Table A1-2
Submissions Summary – Commenting Submissions

Name	Submission ID	Location	Traffic Levels	Proximity	Groundwater	Road Condition	Transport Route	Biodiversity	Flood	Economic
Section in Submissions Report where matters are addressed			4.2.15	4.2.12	4.2.6	4.2.15	4.2.15.5	4.2.2	4.2.5	4.2.3
Submitter Type: Public										
Name Withheld 1	SE-125803	Howlong	✓	✓						
Name Withheld 10	SE-126512	Howlong	✓		✓	✓				
Kevin Donovan	SE-126526	Howlong	✓							
Stanley Smith	SE-126528	Howlong	✓			✓				
David Longley	SE-126533	Howlong	✓			✓				
Roger Hall	SE-126547	Browns Plains			✓		✓			
John Skinner	SE-126607	Howlong	✓			✓				
Name Withheld 19	SE-126618	Chiltern Valley	✓		✓			✓	✓	
Name Withheld 21	SE-126628	Howlong	✓			✓				✓

Table A1-3
Submissions Summary – Supporting Submissions

Name	Submission ID	Location	Employment	Resource Supply
Section in Submissions Report where matters are addressed			4.2.3	4.2.9
Submitter Type: Public				
Katrina Dutton	SE-125834	Corowa	✓	
Name Withheld 3	SE-125937	North Albury	✓	✓
Name Withheld 5	SE-125983	Blacksmiths		
Paul Gallagher	SE-126617	West Albury		✓
Submitter Type: Organisation				
Upton Engineering	SE-125926	Bundalong	✓	
Hanson Construction Materials Pty Ltd	SE-126605	Doncaster		✓
Barker Group NSW Pty Ltd	SE-126608	Albury	✓	✓
Fletcher Plumbing	SE-126636	Lavington	✓	✓

Appendix 2

Summary of Management and Mitigation Measures Proposed for the Project – February 2022

(Total No. of pages including blank pages = 8)

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Table A2-1
Proposed Environmental Management and Monitoring Measures

Action		Timing
1.	**Traffic and Transport**	
1.1	Upgrade the existing concrete bridge as recommended by SJ Street & Associates and Aussie Bridges.	Prior to the commencement of operations
1.2	Upgrade the intersection of the Quarry Access Road and the Riverina Highway to a Basic Auxiliary Left (BAL) and Basic Auxiliary Right in accordance with Austroads (2019) and as indicated in the conceptual design prepared by TTPP (2021) – see Appendix 3 of the Submissions Report.	
1.3	Prepare and implement a detailed Traffic Management Plan, incorporating a Driver's Code of Conduct, to safely manage any traffic impacts during all stages of the Project.	
1.4	Require all truck drivers travelling to and from the Quarry to sign a Driver's Code of Conduct that clearly outlines the Applicant's expectations of each driver whilst travelling to and from the Quarry on public roads.	
1.5	Construct a stopping point and one-way signage to direct traffic using the private bridge over the Black Swan Anabranch.	
1.6	Maintain the Quarry Access Road to ensure it is suitable for use and is not causing unnecessary impacts (noise and sediment generation).	Throughout the life of the Project
1.7	Request road registered heavy vehicles to follow a one-way route within the Quarry (generally anti-clockwise) to minimise conflict with other heavy vehicles.	
1.8	Encourage communication between Project-related heavy vehicle truck drivers and other heavy vehicle drivers on the public road network in the event of a traffic incident.	
1.9	Prioritise rapid response to traffic incidents.	
2.	**Groundwater**	
2.1	The Project would comply with the rules of any relevant water sharing plans	Throughout and following the life of the Project
2.2	Prepare and implement a Water Management Plan for the Project that incorporates groundwater management procedures including the following. i) Sediment and Erosion Control Plan ii) Site Water Balance iii) Monitoring and Reporting iv) Contingency Response Plan	Prior to the commencement of operations
2.3	Install groundwater monitoring bores as presented in a Water Management Plan and undertake aquifer testing during installation to gather site-specific data to inform future groundwater model calibration.	
2.4	Continue to utilise groundwater removed from extraction stages for irrigation of agricultural activities on the Property or neighbouring properties.	Throughout and following the life of the Project
2.5	Within one year of commencement re-calibrate the numerical groundwater modelling against monitored site data. Repeat this process every three years over the life of the Project.	Within one year of commencement and then every three years.

Table A2-1 (Cont'd)
Proposed Environmental Management and Monitoring Measures

Action		Timing
2.	**Groundwater**	
2.6	Implement a comprehensive monitoring program as described in the Water Management Plan that includes as a minimum: i) Groundwater monitoring in the vicinity of operating areas. ii) Water level monitoring in the Murray River in the vicinity of the Quarry Site. iii) Extraction area water level monitoring. iv) Metering of all water removed from extraction areas. v) Stability monitoring in the reclaimed 100m buffer to the Murray River until the Stage 1 water level is returned to natural levels.	Throughout the life of the Project
2.7	Establish protocols to reduce and manage water use and reduce potential impact on the highly connected groundwater - surface water system.	
2.8	Prepare a Closure Strategy that includes the following. i) A closure water licensing management strategy ii) Management strategies for wetlands in the final landform. iii) Strategies for final land use management including protocols to maintain water quality (where feasible) and contingencies relating to the removal of flood levees.	
2.9	Continue to balance water levels and irrigation demand in extraction stages as these are progressively developed.	
2.10	Compare groundwater monitoring results to trigger levels provided in the ANZ Guidelines (ANZG, 2018) and thresholds for further investigation, until sufficient data is available to indicate site-specific trigger values.	
2.11	Should monitoring indicate results have exceeded trigger levels, initiate contingency responses including: • an investigation of impacts to privately-owned water bores and groundwater availability; • provision of compensatory measures for the effected landowner including the supplementary water from on-site supply or remedial measures for bore operation; and • notification of impacts to the relevant Government authority and reporting on the incident.	
2.12	Any works within waterfront land would be designed, constructed and managed in accordance with the "Guidelines for Controlled Activities on Water Land (NRAR 2018).	
3.	**Surface Water**	
3.1	Construct a 2.7m high levee bank around the Quarry disturbance area to limit water ingress during periods of flooding.	Prior to the commencement of operations
3.2	Prepare and implement a Water Management Plan for the Project that incorporates surface water management procedures.	Prior to the commencement of operations
3.3	Ensure that no water collected within the Quarry Site is discharged to any nearby watercourse. All water would be used for processing, irrigation, on site dust suppression or would be stored and allowed to evaporate.	Throughout and following the life of the Project
3.4	Establish a surface water monitoring program that includes monitoring of water within extraction stages and the Murray River.	Monitoring every 6 months unless amended in a Water Management Plan

Table A2-1 (Cont'd)
Proposed Environmental Management and Monitoring Measures

Page 3 of 6

Action		Timing
4.	**Noise**	
4.1	Fit all mobile equipment with standard muffling apparatus.	Throughout the life of the Project
4.2	Use frequency modulated reversing alarms on all mobile equipment.	
4.3	Maintain internal roads to minimise body noise from empty trucks.	
4.4	Restrict noise-generating activities to the nominated hours of operation.	
4.5	Maintain vehicles according to manufacturer's specifications.	
4.6	Maintain dialogue with surrounding landowners to ensure any concerns over operational noise are addressed.	
4.7	Implementation of a complaints protocol to document complaints and to guide investigation and response procedures.	
4.8	Ensure that all activities are undertaken within the approved hours of operation.	
4.9	Refuse entry to poorly maintained vehicles, or those reported to generate excessive noise levels.	
4.10	Ensure all truck drivers comply with a Drivers Code of Conduct outlining procedures for reducing noise impacts when travelling to and from the Property and whilst on site.	
5.	**Air Quality**	
5.1	Check weather forecasts prior to undertaking material handling or processing and assess activities planned or during adverse weather conditions and modify as required.	Throughout the life of the Project
5.2	Use water carts or sprinklers to suppress dust from excavators, trucks and stockpiles to minimise wind erosion during periods with wind speeds in excess of 10m/s.	
5.3	Switch off engines of on-site vehicles and plant when not in use.	
5.4	Fit vehicles and plant with pollution reduction devices where practicable.	
5.5	Maintain vehicles according to manufacturer's specifications.	
5.6	Adjust or cease operations should excessive dust be generated.	
5.7	Keep the extent of exposed surfaces and stockpiles to a minimum.	
5.8	Cover or dampen exposed areas and stockpiles with water as far as is practicable if dust emissions are visible, or there is potential for dust emissions outside operating hours.	
5.9	Minimise dust generation by undertaking rehabilitation earthworks when topsoil and subsoil stockpiles are moist and/or wind speed is below 10m/s.	
5.10	Reduce drop heights from loading and handling equipment, where practical.	
5.11	Sweep/clean any hardstand areas, internal on-site or public roads, as required.	
5.12	Restrict vehicle traffic to designated routes.	
5.13	Enforce on-site speed limits.	
5.14	Cover all vehicle loads when travelling off-site.	

Table A2-1 (Cont'd)
Proposed Environmental Management and Monitoring Measures

Action		Timing
6.	**Land Resources**	
6.1	Clearly mark areas for stripping and stockpiling.	Throughout the life of the Project
6.2	Strip soil from all areas of disturbance and store in stockpiles no more than 2m high for future rehabilitation activities or transfer soil directly to areas to be revegetated.	
6.3	Refrain from stripping or placing soil during wet conditions as far as practicable.	
6.4	Implement erosion control measures (e.g. silt-stop fencing) at downslope locations if clearing during wet periods is unavoidable.	
6.5	Use water carts or sprinklers to suppress dust from excavators, trucks and stockpiles to minimise wind erosion during periods with wind speeds in excess of 10m/s.	
6.6	Mix gypsum and lime with soils prior to revegetation to improve soil quality, as required.	
6.7	Ensure that the soil stockpile surfaces have a surface that is as 'rough' as possible, in a micro-scale, to assist in surface water runoff control and seed retention and germination.	
6.8	Spread seed of a suitable cover crop on all soil stockpiles to facilitate revegetation.	
6.9	Signpost the soil stockpiles and limit operation of machinery on the stockpiles to minimise compaction and further degradation of soil structure.	
6.10	Rip or scarify all areas to be respread with topsoil to allow the respread material to be keyed into the underlying material.	
7.	**Biodiversity**	
7.1	Prepare and implement a Riparian and Wetland Management Plan to guide the integration of the created natural wetlands and natural wetlands and riparian areas in the vicinity of the disturbance area.	Prior to the completion of Stage 1
7.2	Reinstate a 100m buffer between extraction areas and the Murray River and rehabilitated the reinstate land.	During Stage 1 and Stage 2 of operations.
7.3	Avoid and minimise clearing impacts to native vegetation where possible.	Throughout and following the life of the Project
7.4	Ensure that any vehicle, equipment parking or stockpiling areas are identified and positioned to avoid areas containing high biodiversity value.	
7.5	Install signs including 'No Go Zone' or 'Environmental Protection Areas' on limits of clearing fencing.	
7.6	Identify excluded areas in site inductions.	
7.7	Implement a tree-clearing protocol for any large trees that are to be cleared.	
7.8	Include measures to mitigate indirect impacts to biodiversity from noise, vibration, waste, light and air pollution in the Biodiversity and Rehabilitation Management Plan.	
7.9	Rehabilitate Stage 1, 2, 3 and 4 extraction areas to form permanent wetlands and provide suitable habitat and foraging areas for aquatic species, birds and bats.	
7.10	Undertake revegetation activities using species representative of PCT 5 - River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina where appropriate and extend existing nesting and foraging habitat.	

Table A2-1 (Cont'd)
Proposed Environmental Management and Monitoring Measures

Action		Timing
8.	**Cultural Heritage**	
8.1	Fence off the Howlong 1 artefact scatter to avoid inadvertent disturbance.	Prior the commencement of operations
8.2	Prepared and implement an unexpected find protocol.	
8.3	Educate all relevant personnel, contractors and subcontractors regarding their legal obligations in relation to Aboriginal cultural heritage under the *National Parks and Wildlife Act 1974* through an on-site toolbox talk or induction.	
9.	**Visibility**	
9.1	Plant extensive areas of trees beside the levees surrounding the Quarry Site to provide additional tree screening.	Throughout and following the life of the Project
9.2	Paint infrastructure an appropriate colour to blend in with the surrounding.	Throughout the life of the Project
10.	**Public Safety Hazards**	
10.1	No diesel or other hydrocarbons / oils are to be stored within the Quarry Site	Throughout the life of the Project
10.2	All refuelling is to be undertaken using mobile fuel tanks brought to the Quarry Site.	
10.3	Refuelling would occur in a dedicated area with appropriate spill protections in place.	
10.4	Dispose any hydrocarbon waste using a licenced waste contractor and a licenced waste facility.	Throughout and following the life of the Project
10.5	Appropriately locate hydrocarbon spill kits to ensure spill response and clean up can be carried out immediately following the detection of any spills.	Throughout the life of the Project
10.6	Handle spills or leaks of other pollutants in accordance with the relevant Safety Data Sheet.	
11.	**Economic**	
11.1	Give preference when engaging new employees to candidates who live within the Federation LGA over candidates with equivalent experience and qualifications based elsewhere.	Throughout the life of the Project
11.2	Encourage and support participation of locally-based employees and contractors in appropriate training or education programs that would provide skills and qualifications that may be of use at the Quarry (and potentially elsewhere within the extractive, mining or related industries).	
11.3	Give preference, where practicable, to suppliers of equipment, services or consumables located within the Federation LGA.	

Table A2-1 (Cont'd)
Proposed Environmental Management and Monitoring Measures

<table>
<tr><th colspan="2">Action</th><th>Timing</th></tr>
<tr><td>12.</td><td colspan="2">Social</td></tr>
<tr><td>12.1</td><td>Establish and support a Community Consultative Committee with meetings to be held twice a year.</td><td>Prior to the commencement of operations and throughout the life of the Project</td></tr>
<tr><td>12.2</td><td>Develop a Community and Stakeholder Engagement Plan in consultation with the local community and describe ongoing consultation commitments.</td><td>Prior to the commencement of operations</td></tr>
<tr><td>12.3</td><td>Establish a complaints management protocol so that complaints are recorded, addressed by the appropriate person and feedback provided to the complainant in a timely manner.</td><td rowspan="2">Throughout the life of the Project</td></tr>
<tr><td>12.4</td><td>Review performance of the Community and Stakeholder Engagement Plan against the following criteria in the Annual Review.
• The number and nature of complaints received.
• The number of employees and, where appropriate, the number of employees living locally.
• Compliance with criteria relating to social amenity (noise, dust, transport).
• The number of traffic incidents or near misses.</td></tr>
</table>

Appendix 3

Intersection Design – Quarry Access Road / Riverina Highway – August 2021

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REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	PD	PD	24/08/21

ttpp
transport planning

PROJECT
HOWLONG SAND AND GRAVEL QUARRY

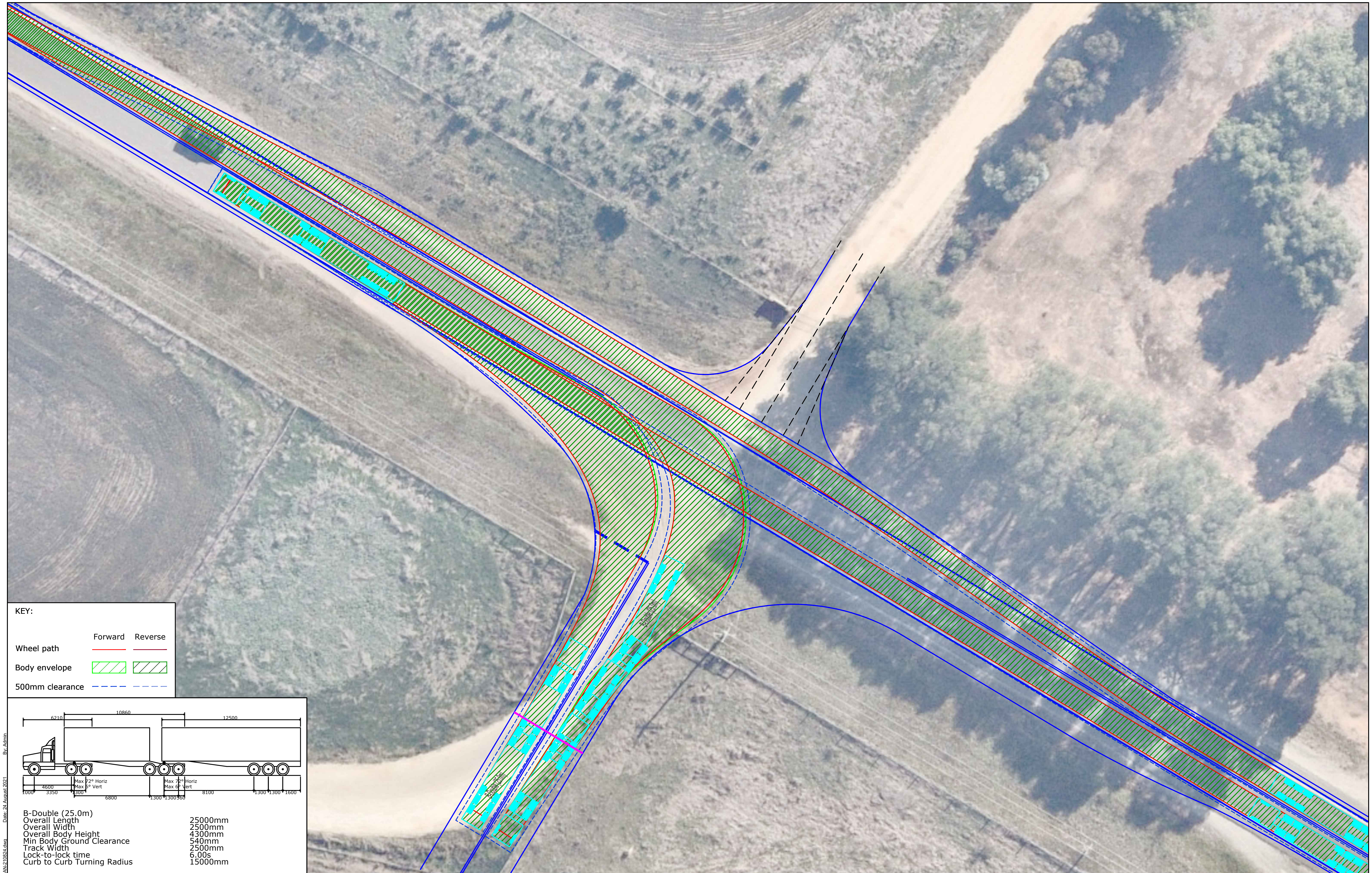
TITLE
CONCEPT PLAN

DWG No.
19339CAD004
FIGURE 1

DATE STAMP
24 AUGUST 2021

PROJECT No.	SCALE	REV.
19339	1:500 @A3	A

Filename: 19339CAD004-CONCEPT PLAN-210824.dwg Date: 24 August 2021 By: Admin



KEY:

	Forward	Reverse
Wheel path		
Body envelope		
500mm clearance		

B-Double (25.0m)

Overall Length	25000mm
Overall Width	2500mm
Overall Body Height	4300mm
Min Body Ground Clearance	540mm
Track Width	2500mm
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15000mm

REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	PD	PD	24/08/21

ttpp transport planning

PROJECT
HOWLONG SAND AND GRAVEL QUARRY

TITLE
SWEPT PATH ANALYSIS
25m B-DOUBLE

DWG No. 19339CAD004
FIGURE 2

DATE STAMP 24 AUGUST 2021

PROJECT No. 19339

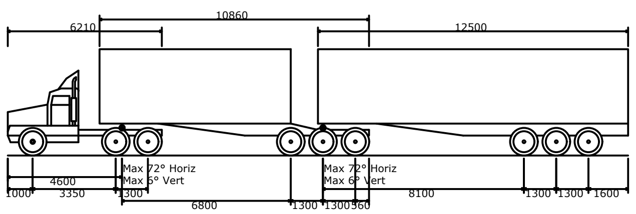
SCALE 1:400 @A3

REV. A

Filename: 19339CAD004-CONCEPT PLAN-210824.dwg Date: 24 August 2021 By: Admin

KEY:

	Forward	Reverse
Wheel path		
Body envelope		
500mm clearance		



B-Double (25.0m)

Overall Length	25000mm
Overall Width	2500mm
Overall Body Height	4300mm
Min Body Ground Clearance	540mm
Track Width	2500mm
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15000mm

REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	PD	PD	24/08/21

ttpp transport planning

PROJECT
HOWLONG SAND AND GRAVEL QUARRY

TITLE
SWEPT PATH ANALYSIS
25m B-DOUBLE

DWG No. 19339CAD004
FIGURE 3

DATE STAMP 24 AUGUST 2021

PROJECT No.	SCALE	REV.
19339	1:400 @A3	A

Filename: 19339CAD004-CONCEPT PLAN-210824.dwg Date: 24 August 2021 By: Admin

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Appendix 4

Transport for NSW – Correspondence Regarding Intersection Design – June 2021 to August 2021

(Total No. of pages including blank pages = 10)

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From: Cam O'Kane <Cam.O'kane@transport.nsw.gov.au>
Sent: Friday, 20 August 2021 11:27 AM
To: Nicholas Warren
Cc: Susan Appleyard; 'Greg Fraser'; 'Penny Dalton'; 'Joel Herbert'; Maurice Morgan; Development South West
Subject: 1019 - Howlong Sand and Gravel Quarry (SSD 8804)
Attachments: 02 Supporting Documentation - Strategic Design - TfNSW Intersection Desi..1.pdf; RE: 1019 - Howlong Sand and Gravel Quarry (SSD 8804) - Quarry Access Intersection Design; 1019 - Howlong Quarry - Traffic Volumes on the Riverina Highway; 19339-n01-210615-Howlong Quarry .pdf

Hi Nick,

We have revised the additional information provided as listed below:

1. Construction of a BAR/BAL intersection treatment for the intersection of the Riverina Highway & Quarry Access Road designed in accordance with the Austroads Guide to Road Design (attached – page 2) and agreed amendments in your email dated 18 June 2021 (also attached);
2. Swept paths as per the supporting documentation (pages 3 & 4 – first attachment);
3. The limitations on maximum hourly traffic – being a maximum hourly traffic of five laden loads (10 movements) across the entire day as per your email on 16 June 2021 (attached email and PDF);

We note that you are in the process of finalising a Submissions Report for DPIE.

Further to our previous correspondence, the additional information provided to date is considered to provide sufficient detail to allow for determination

For your reference, the following conditions will likely be recommended for inclusion on the consent documentation and to be complied with prior to operation of any consent for the expanded operations.

1. A maximum heavy vehicle volume of 5 vehicles entering the site (10 movements to/from the site) per hour. The quarry operator is to record and maintain a log of the extraction quantities and traffic movement in and out of the subject site. This log is to be kept on site and be available for inspection at the request of the consent authority.

2. As a minimum the intersection of the Riverina Highway and the proposed access road shall be constructed with a sealed Basic Right Turn (BAR) and Basic Left Turn (BAL) treatment in accordance with the Austroads Guide to Road Design for a B-Double route as amended by the supplements adopted by Transport for NSW. As a minimum the lanes on Riverina Highway shall be designed and constructed at 3.5 metres in width.

3. As a minimum the access driveway to the Riverina Highway shall be constructed as a 'Rural Property Access' type treatment in accordance with the Austroads Guide to Road Design with a minimum width of at least 6 metres to accommodate 2 way movement to the property boundary and be sealed for at least 30 metres from the edge of seal of the highway.

4. The access driveway and its intersection with the Riverina Highway shall be designed and constructed so that any vehicles entering or exiting the development site are not required to cross to the opposing travel lane of the Riverina Highway in order to perform the access or egress manoeuvre to/from the access driveway. Associated directional marking and signage is to be installed and maintained in accordance with Australian Standards.

1

5. Any entry gate to the subject site from the Riverina Highway shall be located at least 30m from the edge of seal of the carriageway or at the property boundary whichever is the greater. This is to allow for the standing of large vehicles when gates are to be opened.

6. The intersection of the proposed access road with the Riverina Highway shall be designed, constructed and maintained to prevent water from proceeding onto, or ponding within, the carriageway of the Riverina Highway. If a culvert is be installed and is to be located within the clear zone of the carriageway for the posted speed limit it is to be constructed with a traversable type headwall.

7. A management plan to provide measures to suppress dust generation from the development site and the access road shall be prepared and implemented to the satisfaction of Council and Transport for NSW.

8. Any damage or disturbance to the road reserve of the Riverina Highway is to be restored to match surrounding landform in accordance with Council requirements. All redundant driveways or gates to the Riverina Highway shall be removed and the road reserve is to be restored to match the surrounding roadside in accordance with Council requirements.

9. The Riverina Highway is part of the State Road network. For works on the State Road network the developer is required to enter into a Works Authorisation Deed (WAD) with Transport for NSW before finalising the design or undertaking any construction work within or connecting to the road reserve. The applicant is to contact the Team Leader, Development Services South on Ph. 02 6923 6611 for further detail.

10. Any works within the road reserve of the Riverina Highway requires concurrence from Transport for NSW under section 138 of the Roads Act 1993 prior to commencement of any such works. The developer is responsible for all public utility adjustment/relocation works, necessitated by the development and as required by the various public utility authorities and/or their agents.

11. No approval is granted for any signage on the development site that is visible from the Riverina Highway.

12. Any works associated with the development shall be at no cost to Transport for NSW.

Kind regards,

Cam O'Kane
Development Services Case Officer
South Region, Regional and Outer Metropolitan
Transport for NSW

0417 508 107
(02) 6923 6582
Level 3, 193-195 Morgan Street
Wagga Wagga NSW 2650

NSW GOVERNMENT | Transport for NSW

From: Nicholas Warren [mailto:nick@rwcorkery.com]
Sent: Wednesday, 18 August 2021 8:20 AM
To: Cam O'Kane <Cam.O'kane@transport.nsw.gov.au>
Cc: 'Greg Fraser' <Greg@fraserearthmoving.com.au>; 'Penny Dalton' <penny.dalton@ttpp.net.au>; 'Joel Herbert' <Joel.Herbert@planning.nsw.gov.au>; Maurice Morgan <Maurice.MORGAN@transport.nsw.gov.au>; Development South West <development.south.west@transport.nsw.gov.au>
Subject: RE: 1019 - Howlong Sand and Gravel Quarry (SSD 8804) - Quarry Access Intersection Design

2

Good morning Cam,

Thanks for your email and feedback. We will consider your comments and come back to you.

Can you advise if TfNSW has any further comments on the application at this time?

As we have discussed, we are in the process of preparing a Submissions Report to go to DPIE. That document will be finalised next week and we would like to have the opportunity to review any remaining comments from TfNSW so we may respond in that document.

I am seeking to understand if you have comments to come on any other aspects or if we can finalise a response to TfNSW on the basis of your email below.

I will give you a call later this morning to clarify.

Regards,
Nick

Nick Warren
Principal Environmental Consultant
B.Sc., M. Bus., M. Env.Sc.
Mobile: 0437 635 975
Email: nick@rwcorkery.com

R.W. CORKERY & CO. PTY. LIMITED
Geological and Environmental Consultants

Celebrating 40 years of success in 2020

From: Nicholas Warren <nick@rwcorkery.com>
Sent: Wednesday, 18 August 2021 2:28 PM
To: Cam O'Kane
Cc: 'Greg Fraser'; 'Penny Dalton'; 'Joel Herbert'; Development South West; Maurice Morgan
Subject: RE: 1019 - Howlong Sand and Gravel Quarry (SSD 8804) - Quarry Access Intersection Design

CAUTION: This email is sent from an external source. Do not click any links or open attachments unless you recognise the sender and know the content is safe.

Hi Cam,

Following the below email I have spoken to Fraser Earthmoving and TTPP and investigated the queries. I stress that we are keen to look at matters in the Submissions Report once and have outstanding matters resolved quickly.

Speed Limit Assumption
TTPP has confirmed that the 85th percentile speeds over the survey period were 101.0 km/h eastbound and 105.7 km/h westbound, and 103.1 km/h both directions combined. 100km/hr was assumed for the design. Therefore this is reasonable to consider the design speed limit assumption (100km/hr + 10% = 110km/hr). We have estimate that changing the design speed limit assumption adds the following to taper lengths for entering the Quarry.

- For the BAR, the 42m shown would need to increase to 46m
- For the BAL, the 28m shown would need to increase to 31m

We have not had time to update the design to reflect this but will present a conceptual design in the Submissions Report that includes the extended taper lengths.

Gate width
I understand that the 4m gate width in the design complies with Austroads "preferred option with indented access" for rural property access – where the driveway isn't used by articulated vehicles. However, I note that the property currently has a double gate that is 7m wide (two 12ft gates) further into the property. We are not likely to change this configuration in the final design.

We are therefore comfortable that the gate and width to the Riverina Highway would accommodate passing vehicles, if required. The updated design will reflect the current gate arrangements.

I trust the above resolves the below queries and I look forward to your final advice on the Project.

Regards,
Nick

Nick Warren
Principal Environmental Consultant
B.Sc., M. Bus., M. Env.Sc.
Mobile: 0437 635 975
Email: nick@rwcorkery.com

R.W. CORKERY & CO. PTY. LIMITED

1

Geological and Environmental Consultants

Celebrating 40 years of success in 2020

From: Cam O'Kane <Cam.O'kane@transport.nsw.gov.au>
Sent: Tuesday, 17 August 2021 5:09 PM
To: Nicholas Warren <nick@rwcorkery.com>; Development South West <development.south.west@transport.nsw.gov.au>
Cc: 'Greg Fraser' <Greg@fraserearthmoving.com.au>; 'Penny Dalton' <penny.dalton@ttpp.net.au>; 'Joel Herbert' <Joel.Herbert@planning.nsw.gov.au>
Subject: RE: 1019 - Howlong Sand and Gravel Quarry (SSD 8804) - Quarry Access Intersection Design

Hi Nick,

Thank you for your correspondence.

We have reviewed the concept plan and swept paths.

Overall, the Concept Plan reflects a BAR/BAL intersection treatment.

However, we make the following comments for your consideration:

1. It appears that the treatment has been calculated for the posted speed limit rather than the design speed as per AUSTROADS guidelines;
2. As a general comment, the northern gateway width is only 4 metres. Our preference would be designing the driveway to be a minimum width of 6 metres.

Regards,

Cam O'Kane
Development Services Case Officer
South Region, Regional and Outer Metropolitan
Transport for NSW

0417 508 107
(02) 6923 6582
Level 3, 193-195 Morgan Street
Wagga Wagga NSW 2650

NSW GOVERNMENT | Transport for NSW

From: Nicholas Warren [mailto:nick@rwcorkery.com]
Sent: Thursday, 29 July 2021 11:21 AM
To: Development South West <development.south.west@transport.nsw.gov.au>; Maurice Morgan <Maurice.MORGAN@transport.nsw.gov.au>
Cc: Cam O'Kane <Cam.O'kane@transport.nsw.gov.au>; 'Greg Fraser' <Greg@fraserearthmoving.com.au>; 'Penny Dalton' <penny.dalton@ttpp.net.au>; 'Joel Herbert' <Joel.Herbert@planning.nsw.gov.au>
Subject: 1019 - Howlong Sand and Gravel Quarry (SSD 8804) - Quarry Access Intersection Design

CAUTION: This email is sent from an external source. Do not click any links or open attachments unless you recognise the sender and know the content is safe.

2

Good morning Maurice,

Please see attached correspondence in relation to the Howlong Sand and Gravel Quarry.

Regards,
Nick

Nick Warren
Principal Environmental Consultant
B.Sc., M. Bus., M. Env.Sc.
Mobile: 0437 635 975
Email: nick@rwcorkery.com

R.W. CORKERY & CO. PTY. LIMITED
Geological and Environmental Consultants

Celebrating 40 years of success in 2020

Brooklyn	Orange	Brisbane
Level 1, 12 Dangar Road PO Box 239 BROOKLYN NSW 2083	62 Hill Street ORANGE NSW 2800	Level 54, 111 Eagle Street BRISBANE QLD 4000
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From:	Nicholas Warren <nick@rwcorkery.com>
Sent:	Wednesday, 16 June 2021 10:54 AM
To:	Maurice Morgan
Cc:	Development South West; Penny Dalton; Greg Fraser; Andrew McKimmie; Cam O'Kane
Subject:	1019 - Howlong Quarry - Traffic Volumes on the Riverina Highway
Attachments:	19339-n01-210615-Howlong Quarry .pdf

Hi Maurice,

I hope you enjoyed the long weekend and thanks for taking my call when on leave!

As we discussed, Fraser Earthmoving has looked closely at projected traffic levels and the upgrade requirements on the Riverina Highway that were discussed.

As mentioned in previous correspondence, the Company has committed to a BAR treatment for vehicles entering the Quarry from the direction of Howlong. It is not considered warranted for additional intersection works given the projected traffic on the highway and the level of traffic generated by the Quarry.

We however have noted your concerns about projected traffic in this location and the potential for visiting traffic in the afternoon.

To avoid further delays and to provide certainty, Fraser Earthmoving has committed to further limits on maximum hourly traffic, particularly in the afternoon.

We propose that maximum hourly traffic in the afternoon be limited to no more than five laden loads (10 movements) after 2pm. This would provide for the possibility that a light vehicle also needs to access the Quarry during that time. However, we stand by our assumption that this is not likely. We have provided an updated summary of the assessment of projected right turn movements from the Riverina Highway into the Quarry Access Road to support this (attached).

Further to this, we have provided a second option to reduce maximum hourly traffic to five laden loads (10 movements) across the entire day. While not our preference when considering operational efficiencies, this outcome is acceptable to Fraser Earthmoving if considered warranted.

We appreciate you taking the time to review this for the Project and look forward to your feedback on Friday.

Regards,
Nick

Nick Warren
Principal Environmental Consultant
B.Sc., M. Bus., M. Env.Sc.
Mobile: 0437 635 975
Email: nick@rwcorkery.com

Hour Starting	Major Road Traffic Volume Q_M Riverina Highway with 10 years of Growth	Minimum Right Turn Volume Q_R for CHR(S) Treatment[A]	Project Right Turn Volume Q_R at Maximum Production Rate	
			Option 1 Maximum[B]	Option 2 Maximum[B]
6:00am	165	35	8 (5 LV, 3 HV)	7 (5 LV, 2 HV)
7:00am	221	18	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
8:00am	292	10	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
9:00am	245	14	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
10:00am	240	15	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
11:00am	241	15	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
12:00pm	218	19	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
1:00pm	225	17	8 (2 LV, 6 HV)	7 (2 LV, 5 HV)
2:00pm	268	12	7 (2 LV, 5 HV)	7 (2 LV, 5 HV)
3:00pm	315	8	5 (5 HV)	5 (5 HV)
4:00pm	320	8	5 (5 HV)	5 (5 HV)
5:00pm	275	11	5 (5 HV)	5 (5 HV)
6:00pm	150	43	5 (5 HV)	5 (5 HV)
7:00pm	73	217	5 (5 HV)	5 (5 HV)
8:00pm	53	445	5 (5 HV)	5 (5 HV)
9:00pm	42	749	5 (5 HV)	5 (5 HV)

[A] *Arndt and Troutbeck (2006) as presented graphically in Figure 3.25a of Austroads (2020) Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management*
[B] *Hourly maximum may occur in any hour 7am to 10pm, but not in all hours (maximum 80 trucks per day [40 in, 40 out])*

Option 1 – maximum inbound truck movements reduces from 6 to 5 per hour after 2pm weekdays
Option 2 – maximum inbound truck movements reduces from 6 to 5 between 7am and 10pm weekdays

Appendix 5

Aboriginal Cultural Heritage Assessment prepared by Landskape Natural and Cultural Heritage Management – February 2021

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Howlong Sand and Gravel Expansion Project

Aboriginal Cultural Heritage Assessment

Report to Fraser Earthmoving Construction Pty Ltd

15 February 2021

Landskape

a division of ML Cupper Pty Ltd

ABN 48 107 932 918

PO Box 1068 Carlton 3053

e-mail: landskape@telstra.com

tel: 0408 006 690

Fraser Earthmoving Construction Pty Ltd

Howlong Sand and Gravel Expansion Project

Aboriginal Cultural Heritage Assessment

Local Government Area: Federation

Town: Howlong

Landskape

Natural and Cultural Heritage Management

a division of M.L. Cupper Pty Ltd

ABN: 48 107 932 918

Author: Dr Matt Cupper

Date: 15 February 2021

PO Box 1068
Carlton 3053
e-mail: landskape@telstra.com
tel: 0408 006 690

EXECUTIVE SUMMARY

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW. The Project would comprise an increase to the annual extraction rate to 330,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Fraser Earthmoving Construction Pty Ltd commissioned Landskape to complete an Aboriginal Cultural Heritage Assessment for the Howlong Sand and Gravel Expansion Project. This report presents an assessment of the potential Aboriginal cultural heritage related issues for the Howlong Sand and Gravel Expansion Project in accordance with the general requirements of the following guidelines and documents:

- *Aboriginal cultural heritage consultation requirements for proponents 2010 (Part 6 National Parks and Wildlife Act* 1974) (NSW Department of Environment, Climate Change and Water [DECCW] 2010a).
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b).
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (NSW Office of Environment and Heritage [OEH] 2011).
- The Australia International Council on Monuments and Sites (ICOMOS) *Burra Charter* (Australia ICOMOS 2013).
- NSW National Parks and Wildlife Service *Aboriginal Cultural Heritage: Standards and Guidelines Kit* (NSW National Parks and Wildlife Service 1997).
- *Ask First; A Guide to Respecting Indigenous Heritage Places and Values* (Australian Heritage Commission 2002).

The specific objectives of the cultural heritage assessment were to:

- Consult the local Aboriginal community (consultation with the Aboriginal community followed *Aboriginal cultural heritage community consultation requirements for proponents* [DECCW 2010a]), including in relation to cultural values of the Howlong Sand and Gravel Quarry Expansion Project.
- Conduct a desktop assessment to delineate areas of known and predicted cultural heritage potential within the Howlong Sand and Gravel Quarry Expansion Project area.
- Undertake an archaeological survey of known and predicted Aboriginal cultural heritage potential areas identified in the desktop assessment, with representatives of the local Aboriginal community.
- Record any Aboriginal cultural heritage sites within the Howlong Sand and Gravel Quarry Expansion Project area and assess their significance.
- Identify the nature and extent of any potential impacts of the Howlong Sand and Gravel Quarry Expansion Project on Aboriginal cultural heritage.
- Devise options in consultation with the community to avoid or mitigate potential impacts of the Project on Aboriginal cultural heritage sites and items.

Surface survey and subsurface archaeological testing did not identify any Aboriginal cultural heritage in the Project area.

Based on the results of this cultural heritage assessment and consultation with representatives of the registered Aboriginal stakeholders it is recommended that:

- the Howlong Sand and Gravel Quarry Expansion Project be allowed to proceed because the activity would not harm Aboriginal cultural heritage;
- if any previously unidentified Aboriginal cultural heritage places or items are encountered during the course of installation of the proposed Howlong Sand and Gravel Expansion Project all works likely to affect the material must cease immediately and the Environmental Line (tel: 131 555) consulted about an appropriate course of action prior to recommencement of work. It is an offence under the *National Parks and Wildlife Act* 1974 to disturb or destroy Aboriginal cultural heritage items without written consent of Heritage NSW; and,
- if human skeletal remains are encountered during the course of the proposed Howlong Sand and Gravel Quarry Expansion Project all work in that area must cease. Remains must not be handled or otherwise disturbed except to prevent further disturbance. If the remains are thought to be less than 100 years old the Police or the State Coroners Office (tel: 02 9552 4066) must be notified. If there is reason to suspect that the skeletal remains are more than 100 years old and Aboriginal, the proponent should contact the Environmental Line (tel: 131 555) for advice.

CONTENTS

Figures

Tables

Appendices

1 INTRODUCTION

1.1 THE PROPONENT

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figures 1 and 2).

1.2 THE PROJECT

Fraser Earthmoving Construction Pty Ltd is seeking development consent to increase the annual extraction rate of the Howlong Sand and Gravel Quarry to 330,000 tpa and expand into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

1.3 AIM AND OBJECTIVES OF THE ASSESSMENT

The objective of this assessment is to provide Fraser Earthmoving Construction Pty Ltd with an Aboriginal Cultural Heritage Assessment (ACHA) to support an application for development approval for the Howlong Sand and Gravel Expansion Project.

This investigation involves a description of the context of the Howlong Sand and Gravel Expansion Project area and surrounds, identification of Aboriginal cultural heritage sites, items and values within the Howlong Sand and Gravel Expansion Project area, an assessment of the potential impacts to Aboriginal cultural heritage as a result of construction of the planned expansion, and development of recommendations to minimise, manage and mitigate any potential impacts.

This assessment has been undertaken in accordance with the relevant requirements of the various advisory documents and guidelines. These guidelines and documents include:

- *Aboriginal cultural heritage consultation requirements for proponents 2010 (Part 6 National Parks and Wildlife Act* 1974) (Consultation Guidelines) (NSW Department of Environment, Climate Change and Water [DECCW] 2010a).
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b).
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (NSW Office of Environment and Heritage [OEH] 2011).
- The Australia International Council on Monuments and Sites (ICOMOS) Burra Charter (Australia ICOMOS 2013).
- *Aboriginal Cultural Heritage: Standards and Guidelines Kit* (NSW National Parks and Wildlife Service 1997).
- *Ask First; A Guide to Respecting Indigenous Heritage Places and Values* (Australian Heritage Commission 2002).

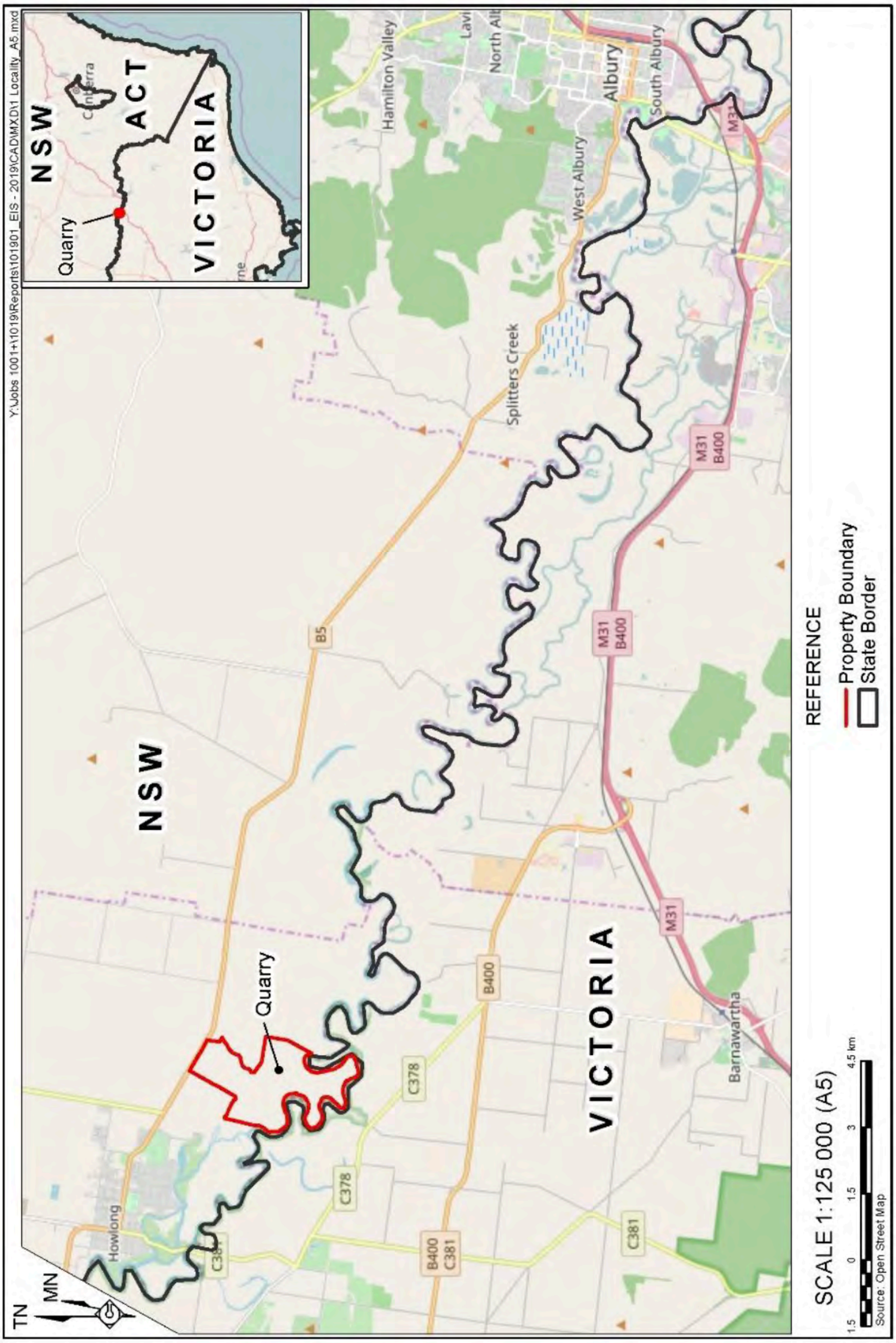

Figure 1. Location of the Howlong Sand and Gravel Expansion Project

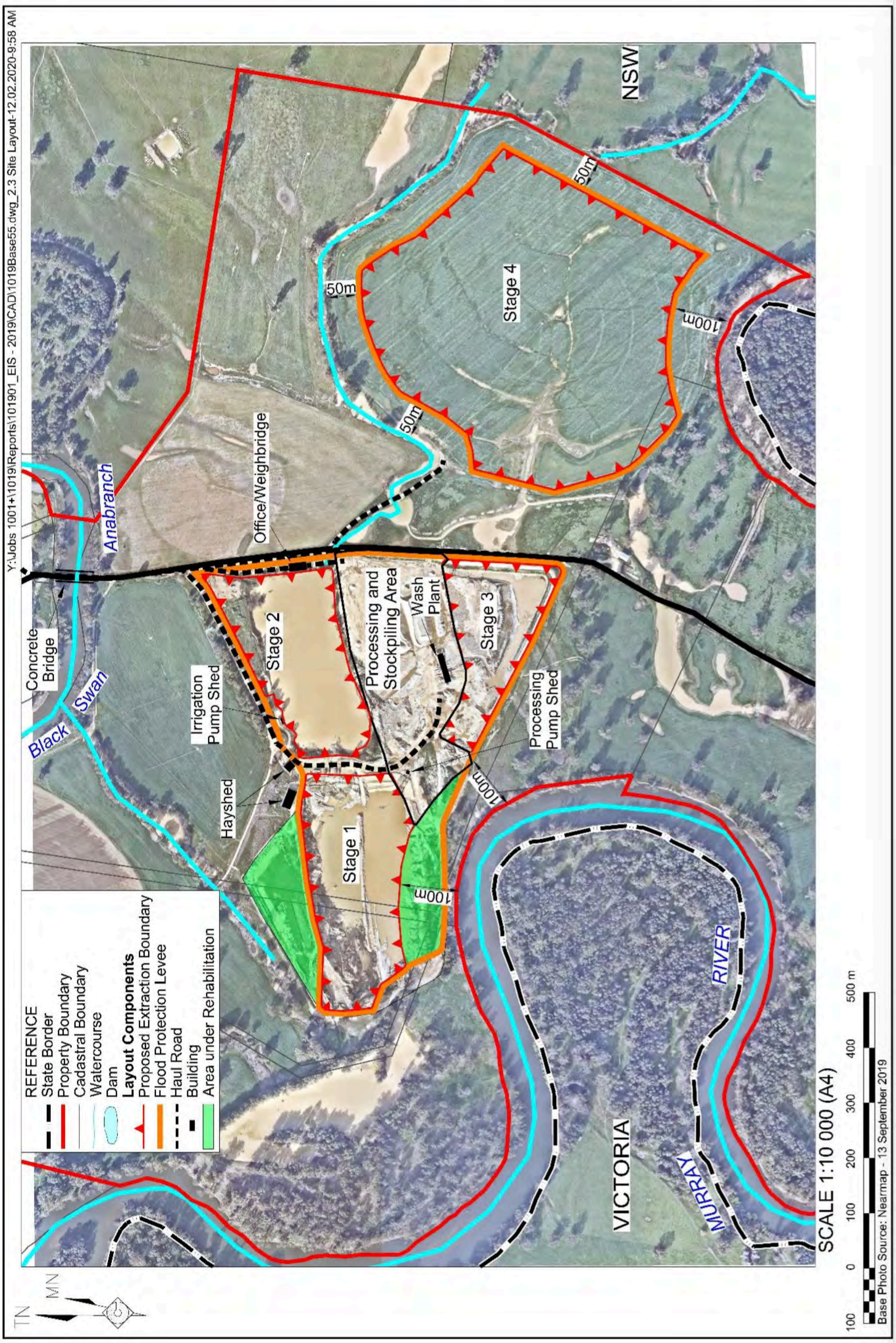

Figure 2. Proposed layout of the Howlong Sand and Gravel Expansion Project

1.4 STRUCTURE OF THIS REPORT

This ACHA has been prepared in consideration of the requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) and as such includes the following specific information:

Section 1: Outlines the Howlong Sand and Gravel Expansion Project and the objectives and structure of this report.

Section 2: Lists the investigators and contributors involved with this report.

Section 3: Provides a summary description of the development proposal.

Section 4: Details the consultation and partnership with Indigenous communities.

Section 5: Outlines the landscape context and includes descriptions of land use history, geology and vegetation within the Howlong Sand and Gravel Expansion Project area.

Section 6: Provides background information relevant to previous archaeological works including relevant ethno-history, the regional archaeological context and previous predictive models for the Howlong Sand and Gravel Expansion Project area.

Section 7: Describes predictions for the Howlong Sand and Gravel Expansion Project area and documents the archaeological survey and data collection, and includes information regarding the method of the survey and a description of the areas surveyed.

Section 8: Lists the results of the survey and provides a discussion and analysis of these results.

Section 9: Assesses the cultural heritage significance of the Howlong Sand and Gravel Expansion Project area.

Section 10: Assesses the impact of the Howlong Sand and Gravel Expansion Project on Aboriginal cultural heritage.

Section 11: Lists the management, mitigation measures and recommendations.

Section 12: Lists the references cited in this report.

A glossary of commonly used terms in the report is provided in Appendix 1.

1.5 BACKGROUND TO THIS ASSESSMENT

Advanced Environmental Systems Pty Ltd (2020) was initially commissioned to complete an ACHA for the Howlong Sand and Gravel Expansion Project. Although an archaeological field survey and involvement of members of the Aboriginal community was completed, this assessment was not wholly consistent with the relevant guidelines. As a result, Fraser Earthmoving Construction Pty Ltd elected to commission Landskape to complete a new assessment in order to remove any uncertainty concerning the potential for harm to Aboriginal cultural heritage as a result of the development of the Howlong Sand and Gravel Quarry.

2 INVESTIGATORS

Landskape was commissioned by Fraser Earthmoving Construction Pty Ltd in August 2020 to complete the ACHA for the Howlong Sand and Gravel Expansion Project and to prepare this report.

Dr Matt Cupper, a qualified archaeologist and geoscientist with 20 years' experience as a cultural heritage advisor, was Landskape's project archaeologist.

3 DESCRIPTION OF THE HOWLONG SAND AND GRAVEL EXPANSION PROJECT

Fraser Earthmoving Construction Pty Ltd has reviewed the Howlong Sand and Gravel Quarry to identify options to maximise capacity and to improve operational efficiency.

The review concluded the most preferred outcome was to increase the annual extraction rate of the Howlong Sand and Gravel Quarry to 330,000 tpa and expand into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity. Once wastage for processing activities is accounted for the annual production rate is expected to reach no more than 300,000 tpa.

The general arrangements of the Howlong Sand and Gravel Expansion Project are presented on Figure 2.

4 ABORIGINAL COMMUNITY CONSULTATION

4.1 INTRODUCTION

In accordance with the Consultation Guidelines (DECCW 2010a), this assessment has been prepared in consultation with the Aboriginal community.

The following sections describe involvement by the registered Aboriginal stakeholders and demonstrate that the input of the Aboriginal community has been considered when determining and assessing impacts, developing management measures, and making final recommendations relevant to Aboriginal cultural heritage within the Howlong Sand and Gravel Expansion Project area.

4.2 ABORIGINAL COMMUNITY PARTICIPATION

The registered Aboriginal stakeholders were consulted throughout the preparation of this assessment, including:

- review and comment on the Proposed Methodology;
- during the field survey with the representatives of the registered Aboriginal stakeholders;
- during the review period for the draft ACHA; and
- encouraged to provide feedback and input throughout the assessment process.

The following sections outline the process and outcomes of the community consultation undertaken during preparation of the assessment to ascertain and manage the Aboriginal cultural heritage values of the Howlong Sand and Gravel Expansion Project area.

4.2.1 Identification of Registered Aboriginal Stakeholders

The Albury and District Local Aboriginal Land Council has previously been identified as an Aboriginal stakeholder for the Howlong Sand and Gravel Expansion Project (Advanced Environmental Systems Pty Ltd 2020).

In accordance with Section 4.1.2 of the Consultation Guidelines (DECCW 2010a), notifications regarding the Howlong Sand and Gravel Expansion Project were sent on 17 June 2020 to the following organisations:

- Biodiversity and Conservation Division, Department of Planning, Industry and Environment;
- NSW Local Land Services;
- Federation Shire Council;
- National Native Title Tribunal (NNTT);
- Native Title Services Corporation Limited (NTSCORP);
- Albury and District Local Aboriginal Land Council (Albury LALC); and
- Office of the Registrar, *Aboriginal Land Rights Act 1983*.

Responses to the Howlong Sand and Gravel Expansion Project notifications were received from the following organisations:

- Biodiversity and Conservation Division, Department of Planning, Industry and Environment (23 June 2020);
- NNTT (18 June 2020);
- NTSCORP (17 June 2020); and,
- Federation Shire Council (23 June 2020)

As a result of the responses received, five individuals and organisations were identified as potential knowledge holders for the Howlong Sand and Gravel Expansion Project. A full record of all correspondence received from and sent to the Aboriginal community and the abovementioned organisations is presented in Appendices 2-4.

In accordance with Sections 4.1 and 4.2 of the Consultation Guidelines (DECCW 2010b), all individuals and organisations identified through the above correspondence were contacted in writing on 29 June 2020 and were invited to register an interest in the Howlong Sand and Gravel Expansion Project.

An advertisement inviting the registration of Aboriginal persons or groups who hold cultural knowledge relevant to, or who have a right or interest in, determining the cultural heritage significance of Aboriginal object(s) and/or place(s) in the Howlong Sand and Gravel Expansion Project area was published in the Border Mail newspaper on 30 June 2020.

The following Aboriginal organisations nominated as registered Aboriginal stakeholders for the Howlong Sand and Gravel Expansion Project:

- Bundyi Aboriginal Cultural Knowledge (3 July 2020); and
- Albury and District Local Aboriginal Land Council (19 April 2018).

A copy of the list of the registered Aboriginal stakeholders for the Howlong Sand and Gravel Expansion Project was provided to Heritage NSW and Albury LALC on 29 July 2020, in accordance with Section 4.1.6 of the Consultation Guidelines (DECCW 2010b).

4.2.2 Presentation of Information about the Proposed Howlong Sand and Gravel Expansion Project

Information regarding the Howlong Sand and Gravel Expansion Project was provided in writing to the registered Aboriginal stakeholders on 4 September 2020. The correspondence included a copy of the Proposed Methodology that was provided for review and comment.

Input was sought in regards to the following aspects:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Howlong Sand and Gravel Expansion Project area, or issues of cultural significance.
- Any restrictions or protocols considered necessary in relation to any information of sensitivity that may be provided.

- Any other factors considered to be relevant to the heritage assessment.

The period for commenting on the Proposed Methodology was open between 4 September 2020 and 2 October 2020.

The following registered Aboriginal stakeholders responded to the Proposed Methodology for the Howlong Sand and Gravel Expansion Project:

- Bundyi Aboriginal Cultural Knowledge (7 September 2020).

The registered Aboriginal stakeholders advised they required no changes to the Proposed Methodology.

4.2.3 Aboriginal Community Involvement during the Field Assessment

All registered Aboriginal stakeholders were invited to provide a representative for involvement in the field survey for the Howlong Sand and Gravel Expansion Project. The following registered Aboriginal stakeholders participated in the survey:

- Bundyi Aboriginal Cultural Knowledge (represented by Mr Mark Saddler); and,
- Albury and District Local Aboriginal Land Council (represented by Mr Andom Rendell).

The Aboriginal cultural heritage field survey was completed on 15 October 2020, with subsurface testing completed on 15 and 16 October 2020. Further details regarding the survey and survey coverage are provided in Section 7.

No comments on the Proposed Methodology were received so the survey was completed according to the strategy outlined in the Proposed Methodology and described in Section 7.

4.3 ABORIGINAL COMMUNITY INFORMATION ABOUT CULTURAL SIGNIFICANCE

As part of the review of the Proposed Methodology and during the field survey, the registered Aboriginal stakeholders were asked to contribute their knowledge on the Howlong Sand and Gravel Expansion Project area and surrounds. This information contributed to the assessment of the cultural heritage significance of the Howlong Sand and Gravel Expansion Project area and is discussed further in Section 9.

In particular, the representatives of the registered Aboriginal stakeholders identified River Red Gum trees on the property outside the Project area to be of cultural significance. The registered Aboriginal stakeholders requested that the proponent avoid harm to these features. The Project area is contained within existing protective barrier fences providing a buffer from inadvertent harm to any adjacent land. Additionally, a flood protection levee inside the perimeter of the Project area would serve as a bund to contain all activities.

4.4 REVIEW OF THE DRAFT ACHA

A draft of this report (i.e. the draft ACHA) was provided to all registered Aboriginal stakeholders for their review and comment on 5 January 2021, in accordance with Sections 4.3 and 4.4 of the Consultation Guidelines (DECCW 2010a). On 1 February 2021, Bundyi Aboriginal Cultural Knowledge representative Mr Mark Saddler advised he identified no required changes to the draft ACHA (Appendix 4). A finalised copy of the ACHA was provided to the registered Aboriginal stakeholders on 15 February 2021.

5 ENVIRONMENTAL CONTEXT

5.1 INTRODUCTION

The *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) requires a review of the environmental context to assist in the determination or prediction of the potential of a landscape to have accumulated or preserved Aboriginal cultural heritage items, the ways Aboriginal people may have used the landscape in the past, with regard to identifiable resources or focal points for activities, and the likely distribution of the material traces of Aboriginal land use based on these factors.

Detailing the landscape context is an integral procedure in modelling potential past Aboriginal land use practices and/or predicting site distribution patterns. The natural environment of an area influences the availability of local resources such as food and raw materials for artefacts, rock platforms for engravings and axe sharpening, and rock outcrops that may provide shelter. The landscape also provides the sediments that may bury objects and archaeological features, as well as the erosive processes that might expose or disperse them.

Geomorphic (land formative) processes may impact upon the type and frequency of archaeological remains. Past climate may also influence the location and types of resources available, which in turn shapes settlement and mobility patterns of past Aboriginal groups in the area. The location of different site-types (such as middens, stone artefact scatters, etc.) are strongly influenced by factors such as these along with a range of other associated features, which are specific to different land systems.

5.2 CLIMATE AND GEOLOGY

The Howlong Sand and Gravel Expansion Project area would be located on an alluvial terrace of the Murray River at Howlong in southern NSW. The Murray River is a regulated permanent stream course with associated lakes and wetland areas. This fluvio-lacustrine system lies within the Riverine Plain of the Murray Basin (Brown and Stephenson 1991). Climate is dry subhumid, receiving approximately 535 mm of rainfall per annum (Bureau of Meteorology 2020).

The surface geology of the region is mostly alluvial (river-lain) sediments, while underlying sequences within the basin were deposited by rivers over the past 60 million years (Brown and Stephenson 1991). The older surface sediments of the Riverine Plain comprise the older Shepparton Formation of the Wunghnu Group and the younger Coonambidgal Formation of the Wunghnu Group (Lawrence 1966, VandenBerg 1997, Cupper *et al*. 2003). These are channel and floodplain deposits of late Quaternary rivers. These alluvial sand, silt and clay sediments represent the last phases of the in-filling of the Murray Basin.

5.3 LANDFORMS AND VEGETATION

The Howlong Sand and Gravel Expansion Project area is located on a broad, scroll-patterned floodplain of the Murray River. Existing access from the Riverina Highway is from a high terrace (Shepparton Formation) onto the younger, inset floodplain (Coonambidgal Formation) of the Murray River. The landscape is flat and low-lying and comprises clayey silts of the Coonambidgal

Formation (Brown and Stephenson 1991). Prior to previous land clearing, this area would have supported a River Red Gum (*Eucalyptus camalulensis*) woodland with a grassy understorey. All of the original vegetation has been cleared by past development

European land use practices since the 1830s have significantly altered the hydrology and topography of the floodplain in the study area. The Black Swan Anabranch between the proposed quarry activities and uppermost terrace appears to have been dredged because it has a relatively straight planform (Figure 2). Billabongs have been excavated to trap silt and supply water for historic quarry operations.

Artificial levees have been constructed on the surface of the scroll bar topography to protect the quarry from flooding. A network of haul roads (including a bridge over Black Swan Anabranch) and farm roads has also been constructed. Where not subject to quarrying, the floodplain is under irrigated crop production or fallow.

Overall, the environment of the study area has been substantially modified by past European land use practices. Little of the original land surface remains. All of the original vegetation has been cleared during past agricultural activities and road and quarry construction. This disturbance includes the extensive removal of earth from existing quarry pits and laser levelling and deep-ripping of a centre pivot irrigated cropping paddock.

5.4 LAND-USE HISTORY

Explorers Alexander Hamilton Hume and William H. Hovell were the first Europeans to visit southern NSW, reaching the Murray River (which they named Hume River) near present day Albury on 16 November 1824 (Hovell and Hume 1837). Surveyor General of NSW, Major Thomas Livingston Mitchell, crossing the Murray River downstream of where Howlong is now located on 17 October 1836 (Mitchell 1839).

Within a couple of years of Mitchell’s expedition, the route along the Murray was used to drive cattle overland from the colony of NSW to Adelaide. Joseph Hawdon and Charles Bonney were the first of the so-called ‘overlanders’ (Kain 1991). Overlanders driving mobs of cattle to the colony of South Australia soon became a regular occurrence in the region.

Pastoralists brought sheep and cattle to the region soon after exploration of the Murray led to reports of land suitable for grazing. By the late 1830s much of the Upper Murray River frontage had been occupied by pastoral squatters. The initial squatter runs and later pastoral leases stretched from the main rivers into the riverine hinterlands.

The first run on the Upper Murray was William Wyse’s Mungabareena Run near where Albury is now located (Andrews 1920). Wyse ran 200 cattle and cleared land for wheat at Mungabareena. William’s brother James Wyse joined him in 1837 and later settled at Wyseworth Station west of Howlong, encompassing the present Project area (Burton 1973).

A policy of closer settlement was pursued during the second half of the nineteenth century with the passing of the 1861 and 1884 *Crown Lands Acts*. James Wyse forfeited part of the old pastoral holding Wyseworth, which was subdivided into smaller properties. A NSW Department of Lands (1892) cadastral map for the County of Hume Parish of Howlong shows freehold allotment 174, 310 acres in size, encompassing the study area. Wyse purchased this and many other freehold allotments.

Lot 174 Parish of Howlong, encompassing the study area, was cleared and planted to pasture. A 1948 aerial photograph shows the Project area cleared and occupied by number of open paddocks (Figure 3). The proposed Stages 1-3 areas for the Project have isolated paddock trees at this time, with the proposed Stage 4 area treeless.

Overall, the environments of the Howlong Sand and Gravel Expansion Project area have been extensively modified by past European land use practices (Figures 4-15). The entire area has been cleared for past agricultural activities and road and quarry construction. This disturbance includes the extensive removal of earth from existing quarry pits and laser levelling and deep-ripping of a centre pivot irrigated cropping paddock.

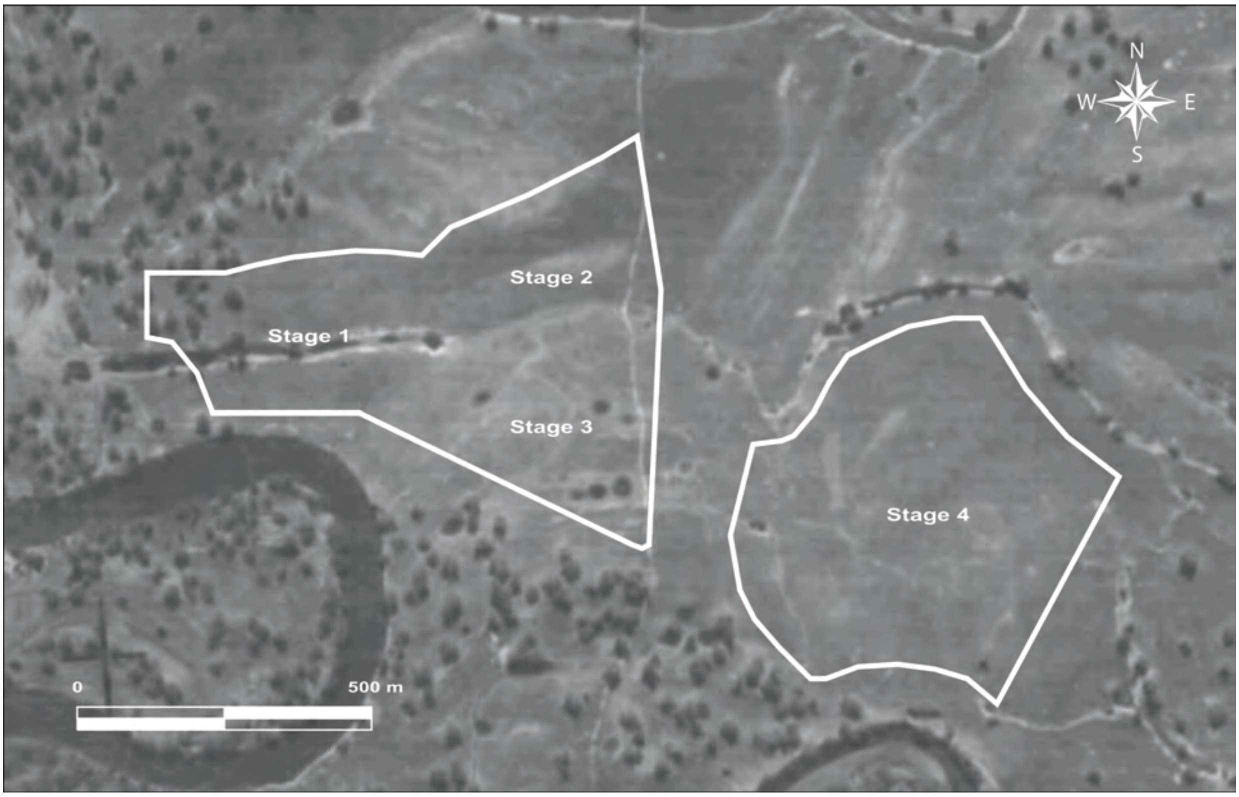

Figure 3. 1948 aerial photograph overlain with the Project area.

Figure 4. Stage 3 area of Howlong Sand and Gravel Quarry facing west.

Figure 5. Stage 3 area of Howlong Sand and Gravel Quarry facing west.

Figure 6. Stage 2 area of Howlong Sand and Gravel Quarry facing west.

Figure 7. Stage 1 area of Howlong Sand and Gravel Quarry facing west.

Figure 8. Stage 3 area of Howlong Sand and Gravel Quarry facing east.

Figure 9. Stage 3 area of Howlong Sand and Gravel Quarry facing east.

Figure 10. Stage 4 area of Howlong Sand and Gravel Quarry facing east.

Figure 11. Stage 4 area of Howlong Sand and Gravel Quarry facing east.

Figure 12. Stage 4 area of Howlong Sand and Gravel Quarry facing east.

Figure 13. Stage 4 area of Howlong Sand and Gravel Quarry facing east.

Figure 14. Stage 4 area of Howlong Sand and Gravel Quarry facing southwest.

Figure 15. Stage 4 area of Howlong Sand and Gravel Quarry facing east

6 ABORIGINAL CULTURAL HERITAGE CONTEXT

6.1 ETHNO-HISTORIC CONTEXT

Aboriginal people of the Jeithi language group appear to have occupied the eastern Riverine Plain at the time of first contact with Europeans (Curr 1886, Tindale 1974). The Jeithi are traditionally associated with the area north of the Murray River between Tocumwal and Howlong. It is thought Jeithi speakers were part of the larger Wiradjuri language group (Wafer and Lissarrague 2008). It is suggested that the name ‘Howlong’ was derived from the Wiradhuric word *oolong*, referring to place of brolgas (Reed 1969). The Wiradjuri are traditionally associated with the region encompassing the Macquarie, Lachlan and Murrumbidgee Rivers and bounded in the south by the Murray River (Sturt 1833, Hovell and Hume 1837, Mitchell 1839, Tindale 1974). However, when Chief Protector of Aborigines George Augustus Robinson visited Barnawartha Station immediately south of the Project area on 25 April 1840 he noted Wiradjuri speakers, suggesting Wiradjuri occupied both sides of the Murray, at least between Albury and Howlong.

There may have been around 60 different dialects of Wiradjuri, whose speakers shared similar material culture and social organization (White 1986, Howitt 1996). Perhaps the greatest regional variation was between speakers of the northern dialect (*Wirraaydhuurray*) and those of the south (speakers of the *Wirraayjuurray* dialect) (White 1986). For example, the practice of carving zigzag motifs into tree trunks appears to have been peculiar to the Wiradjuri of the Macquarie and Lachlan River valleys, but is absent from the Murrumbidgee and Murray (Etheridge 1918, Bell 1982). Such carved trees are thought to have perhaps marked ceremonial areas and burial grounds.

Chief Protector of Aborigines Robinson witnessed a major gathering of 250 people from a number of southern Wiradjuri clans occupying 50 ‘huts’ in Albury between 30 September and 5 October 1844. They held one of the largest corroborees he had ever seen.

The Wiradjuri were hunter-fisher-gatherers and appear to have had a semi-sedentary lifestyle. They caught fish including eels, freshwater crayfish, yabbies, tortoises and freshwater mussels in the Murray River and other streams and wetlands in the region (Sturt 1833, Mitchell 1839, Curr 1886, Beveridge 1889). Watercraft were manufactured from large slabs of bark cut from river red gum trees. Fish were caught using fishing lines and nets made from reed fibre.

Nets were also used to catch waterbirds, whose eggs were also collected. Some of the other animals that Aboriginal people of the Riverine Plain hunted include kangaroos, wallabies, emus, possums, echidnas, lizards, snakes and frogs (Curr 1886, Beveridge 1889, Bickford 1966, Burton 1973). In summer, some Wiradjuri journeyed southeast to the high plains of the Great Dividing Range, where bogong moths were collected in large quantities (Flood 1980). Plant foods included native millet, panic grass, pigface fruits, wild cherries, kangaroo apple, tubers, yams, roots and other grass grains (Curr 1886, Beveridge 1889, Gott 1983, Zola and Gott 1992).

The material record of this occupation is preserved in the archaeological sites of the Riverine Plain, most of which date to the period since the last Ice Age (after around 18,000 years ago). All that remains at many of these sites are flakes of stone debris from the making and resharpening of stone tools. These were made both at Aboriginal open habitation areas (campsites) or special activity areas such as stone knapping sites.

As well as being the sites of manufacture and maintenance of stone implements, open habitation areas usually contain evidence of domestic and other activities such as cooking and food preparation. Campfires or oven hearths are common, marked by heat retaining stones or hearthstones and charcoal. Organic remains consist of marsupial, rodent, bird, lizard, snake and fish bones, eggshell and freshwater mussel shell. Modified trees show where bark may have been removed by Aboriginal people to manufacture canoes, shelters and dishes.

6.2 TYPES OF ABORIGINAL CULTURAL HERITAGE SITES

Based on the results and analytical conclusions of previous archaeological records and surveys in similar landscape contexts on the Riverine Plain it is possible to predict the types and topographic contexts of Aboriginal cultural heritage sites in the Howlong area. The occurrence and survival of archaeological sites is, however, dependent on many factors including micro-topography and the degree of land surface disturbance.

The types of Aboriginal cultural heritage site previously recorded on the Riverine Plain are described in Sections 6.1.1-6.1.8.

6.2.1 Stone Artefact Scatters

Scatters of stone artefacts exposed at the ground surface are one of the most commonly occurring types of archaeological site in the region. The remains of fire hearths may also be associated with the artefacts. In rare instances, sites that were used over a long period of time may accumulate sediments and become stratified. That is, there may be several layers of occupation buried one on top of another.

Stone artefact scatters are almost invariably located near permanent or semi-permanent water sources. Local topography is also important in that open campsites tend to occur on level, well-drained ground elevated above the local water source. In the Riverina they are commonly located on river terraces and along creek-lines and also around the margins of lakes, swamps and claypans.

6.2.2 Hearths

Hearths consist of lumps of burnt clay or stone cobble hearthstones. Sometimes ash and charcoal are preserved. Other materials found in hearths include animal bone, freshwater mussel shell, emu eggshell and stone artefacts. Hearths probably represent the remains of cooking ovens, similar to those described in ethnographic accounts by Major Thomas Mitchell (1839) and Peter Beveridge (1889). These were lined with baked clay nodules and stone cobbles, possibly to retain heat. Hearths may be isolated or occur in clusters and may be associated with open camp sites or middens. They are often located on claypans, near soaks and on floodplain terraces of the Riverine Plain.

6.2.3 Freshwater Shell Middens

Shell middens are deposits of shell and other food remains accumulated by Aboriginal people as food refuse. In inland New South Wales these middens typically comprise shells of the freshwater lacustrine mussel *Velesunio ambiguus* or the freshwater riverine mussel *Alathyria jacksoni*. Freshwater middens are most frequently found as thin layers or small patches of shell and often contain stone or bone artefacts and evidence of cooking. Such sites are relatively common along the watercourses of the Riverine Plain and their associated lakes and other wetlands.

6.2.4 Earth Mounds

Earth mounds may have been used by Aboriginal people as cooking ovens or as campsites. They are common on the Riverine Plain (e.g. Klaver 1987). Originally they appear to have ranged from 3 to 35 metres in diameter and from 0.5 to 2 metres in height. Today, however, they may be difficult to recognize because of the effects of ploughing, grazing and burrowing rabbits. Earth oven material, stone artefacts, food refuse and the remains of hut foundations have been exposed in excavated earth mounds.

6.2.5 Quarry Sites

These are locations where Aboriginal people obtained raw material for their stone tools or ochre for their art and decoration. Materials commonly used for making flaked stone tools include chert, silcrete, quartz and quartzite. Stone sources are particularly scarce on the Riverine Plain, so most lithic material was probably sourced via trade links with people living in the adjacent foothills of the South West Slopes to the east.

6.2.6 Modified Trees

Slabs of bark were cut from trees by Aboriginal people and used for a variety of purposes including roofing shelters and constructing canoes, shields and containers. Scars also resulted from the cutting of toeholds for climbing trees to obtain honey or to capture animals such as possums. On the Riverine Plain River Red Gums and Box are the most commonly scarred species (Edwards 1972). The classification of scarred trees as natural, European or Aboriginal is often problematic. However, if the scar is Aboriginal the tree must now be more than ~150 years old.

6.2.7 Stone Arrangements, Ceremonial Rings and Ceremony and Dreaming Sites

Stone arrangements range from cairns or piles of rock to more elaborate arrangements such as stone circles or standing slabs of rock held upright by stones around the base. Some stone arrangements were used in ceremonial activities whilst others may represent sacred or totemic sites. Other features associated with the spiritual aspects of Aboriginal life are those now called ‘ceremony and dreaming’ sites. These can be either stone arrangements or natural features such as rock outcrops, waterholes or mountains, which may be associated with initiation ceremonies or the activities of ancestral creators.

6.2.8 Burials

Aboriginal burial grounds may consist of a single interment or a suite of burials. In the drier parts of the Riverine Plain burials tend to be in areas of sandy soil that were easy to dig and above floodwaters. Burials are frequently located in source-bordering sand dunes, sand ridges, lunettes and levees along watercourses (Bonhomme 1990, Hope 1993). Knowledge of Aboriginal burial grounds is best sought from local Aboriginal communities.

6.3 PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

Few detailed archaeological surveys have been undertaken in the vicinity of Howlong but an understanding of the past Aboriginal occupation of the Murray River valley in the wider region has begun to emerge from a number of studies. These include several systematic regional investigations, although most have been undertaken for infrastructure developments including electricity transmission lines, gas pipelines and roads.

Flood's (1980) regional investigation of the higher uplands to the east of the Project area suggested that there was little Aboriginal occupation of the region before 4000 years ago after which the region was occupied at low intensity. Flood (1981) found that lowland sites often either comprised large base camps, open occupation areas covering two or three square kilometres found on sand dunes and near lakes and rivers, or smaller camps distributed along river banks in a lineal pattern.

Flood (1980) noted typical landscape settings of Aboriginal campsites. All sites are within 1 km and most within 100 m of a river, creek, lake or spring. However, no sites are located right at the water's edge. All sites are located on well-drained ground with a reasonably good view of the approaches. When sites occur on the side of a mountain range or valley their aspect is usually east or north thus obtaining shelter from the prevailing westerly winds (Flood 1980).

Thompson’s (1996) broad scale study of northeast Victoria included a survey near Lake Moodemere downstream from Howlong and approximately 20 km southwest of the Project area. This study resulted in eight culturally modified trees being recorded near Lake Moodemere and Dugays Bridge (Thompson 1996). Other sites identified in the wider region included isolated artefacts and artefact scatters. In total, 45 culturally modified trees and 42 sites containing stone artefacts were recorded. Of these, 39 sites had less than six artefacts (Thompson 1996).

Bowdler (1976) investigated a burial site at ‘Roseleigh' some 8 km east of the Project area, which had been exposed by sand mining operations in a dune bordering the Murray River upstream from Howlong. The site comprised the remains of three individuals, which she reburied in the deposit. A low-density quartz artefact scatter was also recorded in the uppermost layers of the dune. Paton and Hughes (1984) re-examined the site locating a fourth individual eroding from a spoil heap and a number of quartz artefacts.

Stone and Paton (1994) assessed the Albury City Council’s sewage treatment site on the Murray River floodplain west of Albury. Five quartz artefact scatters and two isolated quartz artefacts were located on terrace edges, with the larger sites (n = 3) on the older terraces. The two smaller sites were located on younger Coonambidgal Formation scroll bar topography and the two isolated artefacts on the margins of the Cooks Lagoon palaeochannel.

Debney and Tulloch (2004) and Edwards and Bell (2013) completed surface and subsurface assessments of a freight centre at Barnawartha North (Victoria), approximately 8 km southeast of the Project area. Five stone artefact sites were encountered.

Of most relevance to the current assessment is Advanced Environmental Systems Pty Ltd’s (2020) due diligence assessment for the Project. One Aboriginal cultural heritage site (AHIMS site number 60-3-0134), a stone assemblage of eight quartz flakes, was identified during the assessment on a source bordering sand dune north of the Project area.

A number of archaeological investigations were completed for the East Australian Gas Pipeline and Murray Valley Towns Gas Supply projects over the late 1990s (e.g. Navin *et al*. 1995, Sciusco 1996, Navin and Officer 1996, Stone 1996a, b, Officer 1998, Officer and Navin 1998, Officer *et al.* 1998). These routes came close (within several kilometres of) the Project area. Numerous Aboriginal sites were located during these investigations, with site types including stone artefact scatters and isolated finds of stone artefacts and culturally modified trees.

Navin *et al.* (1995) surveyed the route proposed for the Wagga Wagga to Wodonga gas pipeline locating a total of eight Aboriginal sites. One of these sites was located on an elevated terrace overlooking the floodplain of the Murray River at Lesters Lagoon (NSW), about 1 km east of the Project area. This site comprised a low-density scatter of quartz flakes and flaked pieces on the northern bank of the lagoon. Two isolated finds were located nearby (Navin *et al.*1995).

Stone (1996a, 1996b) surveyed the routes proposed for gas pipelines across the Murray River at Corowa and Howlong and between Rutherglen and Koonoomoo in Victoria. The Howlong crossing was approximately 4 km southwest of the Project area. No Aboriginal cultural heritage sites were identified during these investigations (Stone 1996a, 1996b). Similarly, an archaeological assessment for an optic fibre cable route by Clark (1997) did not identify any sites along a linear study between Bundalong South and Norong (Victoria), about 30 km southwest of the present study area. Also in Victoria, Sciusco (1995) surveyed the proposed gas pipeline route between Chiltern and Rutherglen, locating one possible Aboriginal culturally modified tree about 30 km southwest of the Project area.

Several assessments have been completed for the Hume Freeway corridor south and east of the Project area. Upcher and Smith (1994) surveyed 120 km of the route of the freeway duplication, which traversed a 25 km corridor through Victoria south of Howlong and the remainder east in NSW through Albury, Tabletop and Mullengandra. Eight stone artefact scatters and three isolated finds of stone artefacts were recorded during the assessment (Upcher and Smith 1994). All were northeast of Albury.

Bell (2001) reexamined a proposed external highway bypass of Albury. Ten sites were encountered west and north of Dights Hill, approximately 13 km east of the Project area. These comprised eight stone artefact sites and two culturally modified trees.

Kelleher and Nightingale (2007) resurveyed the Tabletop to Mullengandra section the Hume Freeway duplication in 2007. They identified 20 additional archaeological sites, including 15 artefact scatter sites and five scarred trees. All of the sites previously identified by Upcher and Smith (1994) were near or part of the additional sites. Four culturally significant places were also identified during the assessment. These are known as Mullengandra Pathway Markers, Table Top Men's Ceremony Area, Mullengandra Women's Camp and Mullengandra Resource Area (Kelleher and Nightingale 2007). The Mullengandra Pathway Markers are landscape features, which delineate a ceremonial pathway associated with an ancestral spirit.

Quartz was the most common raw material for flaked stone artefacts, with chert, silcrete and quartzite also recorded (Kelleher and Nightingale 2007). The artefact scatter sites were mostly located on well-drained elevated areas associated with watercourses such as terraces above rivers or creek lines.

6.4 PREVIOUSLY RECORDED ABORIGINAL CULTURAL HERITAGE SITES NEAR THE PROJECT AREA

There are no previously recorded Aboriginal cultural heritage sites within the Howlong Sand and Gravel Expansion Project area registered on the Heritage NSW Aboriginal Heritage Information Management System (AHIMS) database (AHIMS search 550961, 19 November 2020). Appendix 5 contains the AHIMS search results.

The closest Aboriginal cultural heritage site to the Project area is a stone artefact scatter (AHIMS site number 60-3-0134) (Table 1). This feature was located on a source bordering sand dune south of Black Swan Anabranch during a due diligence assessment for the Project (Advanced Environmental Systems Pty Ltd 2020). A total of eight artefacts were recorded across the ~1400 m^2 surface of the dune. These cultural deposits are 350 m north of the Howlong Sand and Gravel Quarry Stage 4 area and outside the area of potential harm.

A further eight Aboriginal cultural heritage sites are located in NSW within 5 km of the Project area. These were identified by Navin *et al.* (1995) in a corridor proposed for the Wagga Wagga to Wodonga gas pipeline. The closest of these to the Project area is AHIMS site number 60-3-0048, 1 km east of the Project Stage 4 area. The site consists of eight quartz artefacts and a metasedimentary core recorded on the bank of a flood channel within scroll bar topography.

Table 1. Summary data of Aboriginal cultural heritage sites within 1 km of the Project area.

AHIMS Number	Name	GDA94 Zone 54 (mE)	GDA94 Zone 54 (mN)	Site size (m)	Land-form	Contents
60-3-0134	Howlong 1	470393	6015022	20 x 70	Sand dune	8 quartz artefacts
60-3-0048	WW2_ Morebringer 1	471540	6014320	100 x 15	Scroll bar	8 quartz artefacts, one metasediment artefact

Of the 108 registered Aboriginal cultural heritage sites in the broader region of NSW (within approximately 20 km of the Project area recorded on AHIMS, 66 % (n=71) are stone artefact sites, 29 % (n=31) are culturally modified trees, one (1 %) is a hearth site (with artefacts), one (1 %) is a burial (with artefacts), one (1 %) is a shell midden and three (3 %) are potential archaeological deposits (Table 2).

Table 2. Summary data of Aboriginal cultural heritage sites within approximately 20 km of the Project area.

Site Type	Number	Percentage
Stone artefact	71	66
Culturally modified tree	31	28
Potential archaeological deposit	3	3
Burial	1	1
Shell midden	1	1
Hearth	1	1
Total	**108**	**100**

7 CULTURAL HERITAGE FIELD INVESTIGATION

In accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in New South Wales* (OEH 2011) and *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b), an archaeological design and survey methodology was prepared as a key component of the cultural heritage field assessment. Details of the archaeological design and survey methodology are presented in the following sections.

7.1 OVERVIEW OF PREVIOUS ARCHAEOLOGICAL MODELS

An understanding of the Aboriginal archaeology of the Murray River valley of the Riverine Plain has begun to emerge from a number of studies including some undertaken in the Howlong area. These studies indicate the likely archaeological record of the Project area. Also relevant are localised studied by Navin *et al*. (1995) of Lesters Lagoon 1 km to the east and a due diligence assessment for the Howlong Sand and Gravel Expansion Project (Advanced Environmental Systems Pty Ltd 2020).

Craib's (1992) predictive model of the Murray River margins provides a detailed account of the different types of archaeological site present along the riverine corridors of southern New South Wales. This study established a model for predicting site occurrence and abundance based on five strata with differing hydrological, vegetative or topographical variables (see also Bonhomme Craib and Associates 1999).

Sites were relatively sparse in the *Open* stratum, which consisted of dunefields, sandplains and elevated clay plains. This land system contained stone artefact scatters, with modified trees on the clay plains. Sites were relatively sparse in the *Sand Hill* stratum of source-bordering sand dunes, but this stratum could be expected to contain burials in addition to stone artefact scatters and modified trees (Craib 1992, Bonhomme Craib and Associates 1999).

The margins and floodplains of the flowing rivers and creeks formed the *Riparian* stratum. This stratum could be expected to contain freshwater shell middens, modified trees and stone artefact scatters. The *Lacustrine* stratum comprised the margins of lakes, swamps and billabongs. Shell middens, modified trees, stone artefact scatters and burials are present in this stratum at a higher site density than in the riparian areas (Craib 1992, Bonhomme Craib and Associates 1999).

Modified trees were the most common site type on the *Box Plain* stratum. These areas could also be expected to contain shell middens and stone artefact scatters if they were adjacent to riparian or lacustrine environments (Craib 1992, Bonhomme Craib and Associates 1999).

7.2 CULTURAL HERITAGE SITE PREDICTIVE MODEL

Previous archaeological studies indicate that immediate floodplains of the Murray River have generally overall moderate density of Aboriginal cultural heritage sites, with most occupation sites concentrated along the riverbank and associated wetlands (the *Riparian* stratum of Craib [1992]). Sites further from the riverine corridors are invariably located at small ephemeral water sources such as swamps. The most frequently recorded Aboriginal sites are stone artefact scatters and trees scarred by Aboriginal people and hearths (AHIMS site database). Other Aboriginal cultural heritage site types previously identified in the Murray valley of the Riverine Plain are shell middens, burials, hearths and potential archaeological deposits (AHIMS site database).

Based on these observations of archaeological site types and their distribution and landscape setting, the following predictive model of site types and locations within the Howlong Sand and Gravel Expansion Project area was developed prior to the survey:

- **Stone artefact scatters**, **hearth** sites and **isolated finds of stone artefacts or hearthstones** have the potential to occur within the Project area. Open occupation sites are typically found within 500 metres of water sources, so such sites are most likely to be encountered on level ground adjacent to the Murray River and adjacent creeks, lagoons and billabongs.
- **Stone quarry** sites are unlikely to occur in the Project area, as no rock suitable for knapping outcrops at the study sites.
- **Scars made by Aboriginal people** may occur on the mature River Red Gum trees that grow adjacent to the Project area.
- **Shell middens** are possible, as they are usually found near permanent water sources, as are **burial** sites. **Shell middens** are most likely to be encountered within 100 m of the Murray River and adjacent water sources. Source-bordering dunes adjacent to waterways are the landforms most likely to contain human skeletal remains.
- Although **stone arrangements** have been recorded on the Riverine Plain, they are not common and were considered unlikely to be encountered in the Project area. Stone arrangements tend to occur on level ground, often on elevated landforms.

The potential for encountering Aboriginal cultural heritage in the Project area is mitigated to a large extent by the high degree of previous disturbance of the area. For example, the removal of the original vegetation during past land use means scarred trees will not be encountered. Similarly, extensive modification of the original land surface by ploughed cultivation, laser levelling and deep ripping during the past agricultural land use and deep excavation and hardstand and road construction associated with past sand and gravel quarrying could have destroyed or dispersed Aboriginal stone artefacts and discarded food remains including shell and bone and the remains of hearths and mounds, had they previously existed in these areas.

While predictive studies such as this can be expected to identify areas in which sites associated with economic or subsistence activities may be present, notably open habitation areas, other sites may fall outside such a predictive framework.

For example, places associated with spiritual aspects of traditional Aboriginal society such as ceremony and dreaming sites are often located at topographically distinct or unique features, which cannot be identified from an examination of maps or other records. For this reason, it was essential that local Aboriginal communities be consulted so that sites of significance to them can be identified.

7.3 FIELD METHODOLOGY

The archaeological field survey was based on the sampling strategy developed in accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011) and Requirement 5a of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) and outlined in Section 7.3.2.

The objective of the field survey was to identify sites of Aboriginal cultural significance within the Project area.

7.3.1 Personnel

The ground survey was completed on 15 October 2020, with subsurface testing completed on 15 and 16 October 2020. The participants of the field survey were project archaeologist Dr Matt Cupper of Landskape, together with the representatives from the registered Aboriginal stakeholders listed in Section 4.2.3 (Figures 16 and 17).

Figure 16. Survey team members inspecting the study area.

Figure 17. Survey team members inspecting the study area.

7.3.2 Ground Survey Methods

The Project area was inspected on foot by the project archaeologist and Aboriginal community representatives. The field team examined the ground surface for any archaeological traces such as stone artefacts, hearths, hearthstones, shells, bones and mounds. There were no mature trees in the Project area to inspect for scarring or carving by Aboriginal people.

Particular attention was paid to areas with high ground surface visibility such as along stock and vehicle tracks and in scalds, gullies and other eroded areas.

The team members walked abreast across the surveyed areas in a series of closely spaced transects. These were evenly distributed over the areas of proposed disturbance and approximately 20 metres apart. Due to the general openness of the landscape it was usually possible to identify likely site locations from at least 20 metres and deviate from the transects to make closer inspections.

Survey units and descriptions of the visibility conditions for each survey unit are provided in Table 3 and mapped in Figure 18.

Table 3. Visibility Conditions in the Project area.

Survey Unit	Landforms	Vegetation	Visibility	Exposures	Exposure	Survey Method
1	Alluvial Terrace	Laser-levelled paddocks	90 %	Grading, ploughing, tracks, scalds	90 %	Pedestrian
2	Alluvial Terrace	Cleared quarry	90 %	Excavation, grading, tracks, scalds	90 %	Pedestrian

% - percentage.

7.3.3 Subsurface Testing

The project archaeologist assisted by the representatives of the registered Aboriginal stakeholders completed hand test excavation at the Project area in accordance with proper archaeological practice, as required by the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011) and the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b).

Hand tools were used to excavate seven test excavation units 500 mm x 500 mm in size in a transect around the perimeter of the Stage 4 area (Figure 19).

All hand excavated material was removed in maximum 100 mm spits and sieved through a 5 mm diameter mesh screen.

Excavation continued into sterile, indurated and mottled silty clay deposits to a maximum 0.5 m depth.

Detailed notes were taken of the test excavation units including descriptions of the soil profile, sediments and any evidence of disturbance. Sediment colours were determined using a Munsell Color Chart and pH ascertained using a soil test kit. Photographs of the test excavation units were taken using a standard range pole.

Images of the test excavation units and representative stratigraphy are depicted in Figures 20-27.

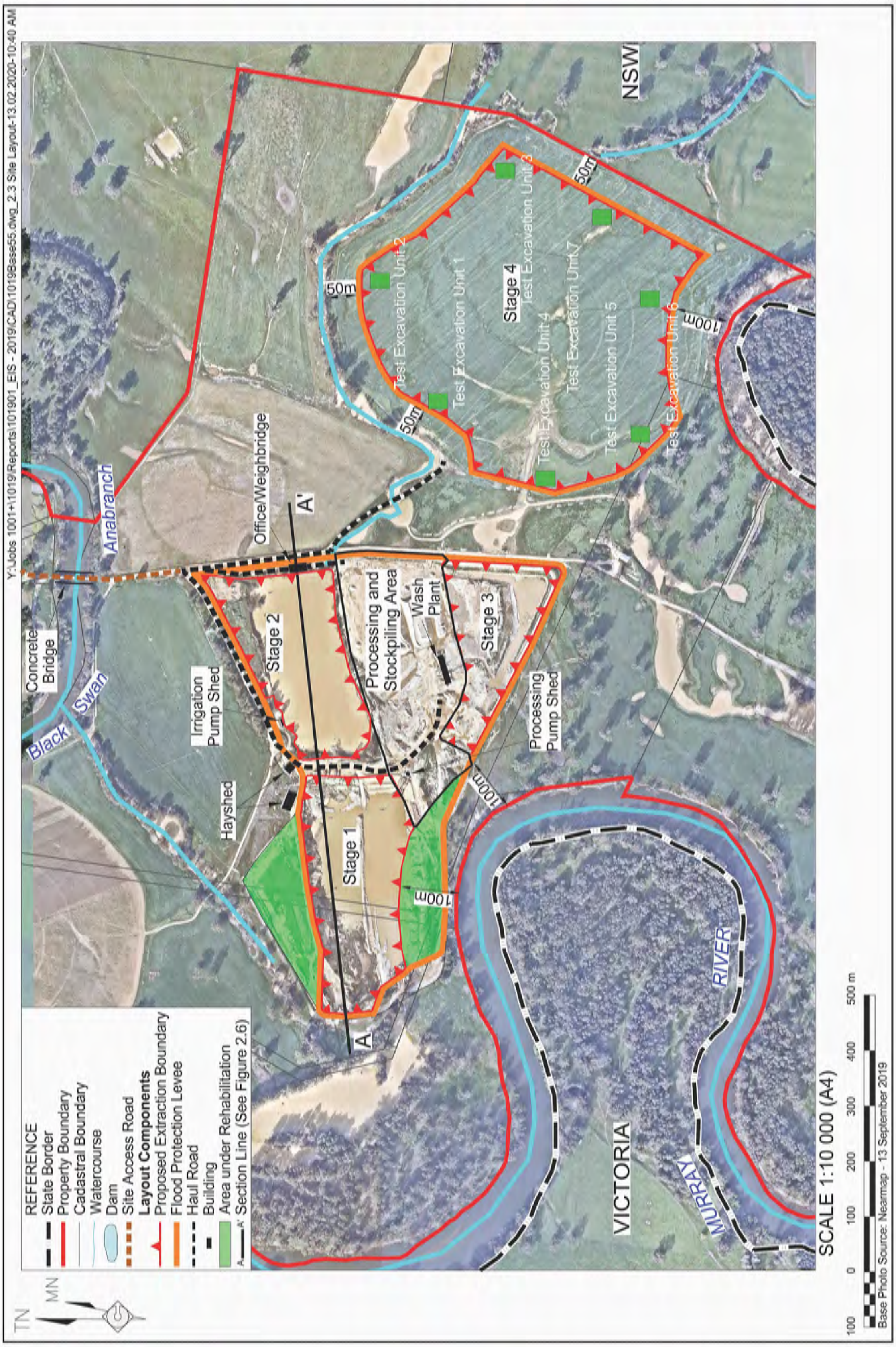

Figure 19. Locations of subsurface test excavation units at the Project area

Figure 20. Test excavation unit 1

Figure 21. Test excavation unit 2.

Figure 22. Test excavation unit 3.

Figure 23. Test excavation unit 4

Figure 24. Test excavation unit 5.

Figure 25. Test excavation unit 6.

Figure 26. Test excavation unit 7.

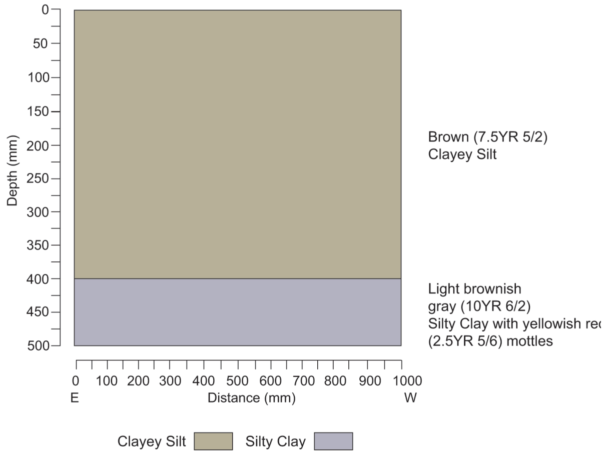

Figure 27. Example of stratigraphy at the Project area from test excavation unit 1

7.3.4 Mapping and Site Datum

The location and boundaries of the Project area were verified in the field by Fraser Earthmoving Construction Pty Ltd prior to the fieldwork commencing. The test excavation units were gridded by the archaeological field team using a tape measure. The precise locations of the excavation nodes were surveyed using a DGPS. These survey points were entered into a GIS and plotted to show the distribution of the test excavation units.

7.4 SURVEY COVERAGE DATA

7.4.1 Conditions of Visibility

Conditions of ground surface visibility affect how many sites are located. Visibility may also skew the results of a survey. If, for example, conditions of ground surface visibility vary dramatically between different environments, then this would be reflected in the numbers of sites reported for each area. The area with the best visibility may be reported as having the most sites (because they are visible on the ground) while another area with less visibility but perhaps more sites would be reported as having very little occupation. It is important therefore to consider the nature of ground surface visibility as part of any archaeological investigation.

The survey units and descriptions of the visibility conditions for the survey units are provided in Table 4 and mapped in Figure 28.

Conditions of ground surface visibility were typically around 90 % (Table 3). Grass and herbaceous plant growth was very low and the ground surface was exposed by cultivation, grading, earthworks and scalding and vehicular traffic (Figures 29 and 30).

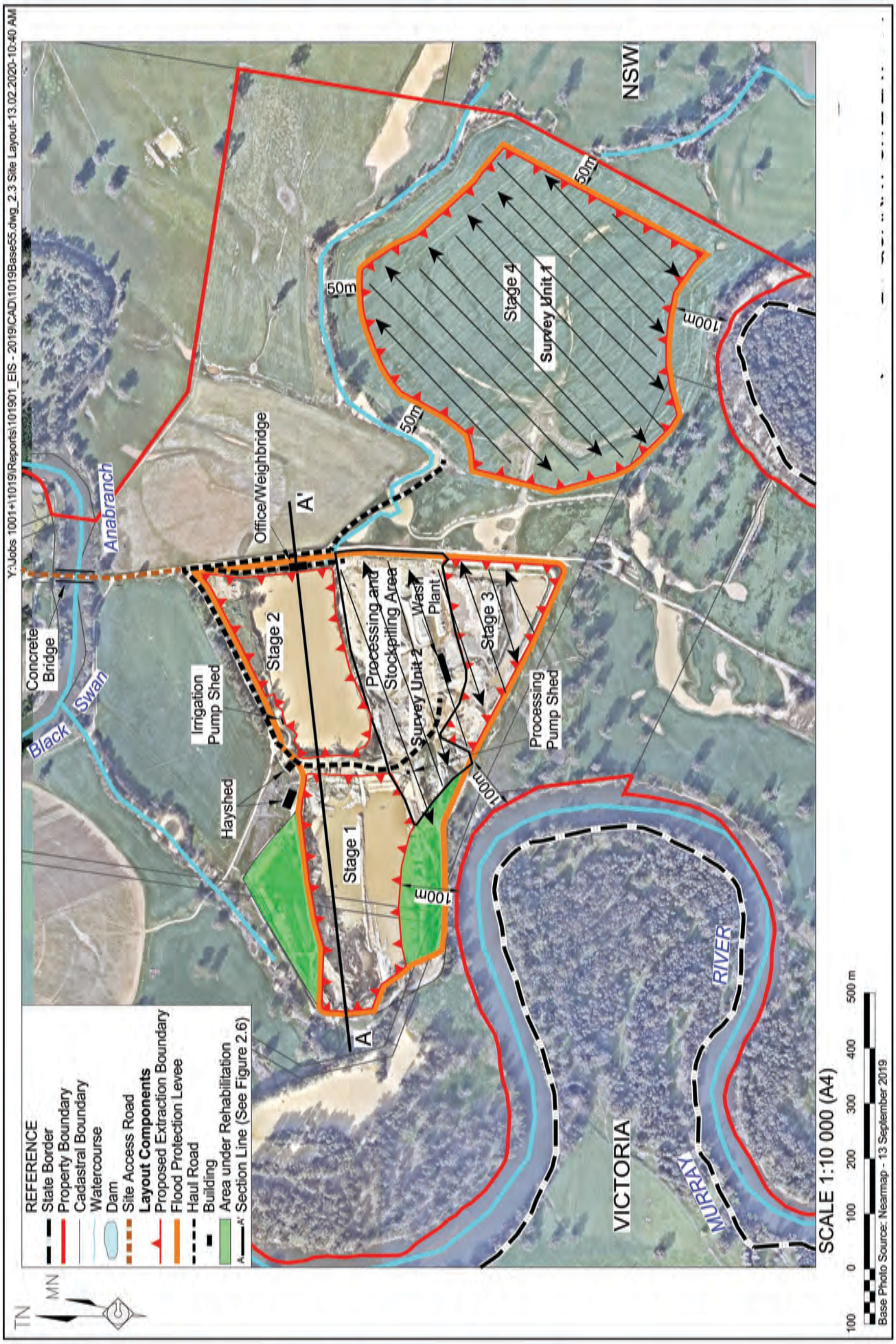

Figure 28. Survey units and survey transects at the Project area

Figure 29. Example of Surface Exposure in the Project area.

Figure 30. Example of Surface Exposure in the Project area.

7.4.2 Coverage Analysis

Coverage analysis is a useful measurement to allow cultural resource managers to assess surveys from adjacent areas and it also allows some meaningful calculation of the actual sample size surveyed. The *actual* or *effective* area surveyed by a study depends on the conditions of ground surface visibility. Conditions of surface visibility are affected by vegetation cover, geomorphic processes such as sedimentation and erosion rates and the abundance of natural rock that may obscure the remains of cultural activities.

All of the Project area was inspected on foot. The areas covered during the survey are outlined in Table 4 and Figures 28 and summarised by landform in Table 5. Survey coverage was high, given the intensive nature of the survey and the generally excellent conditions of visibility.

Table 4. Survey coverage of the Project area.

Survey Unit	Landform	Survey Unit Area (ha)	Visibility (%)	Exposure (%)	Effective Cover (ha)	Effective Cover (%)	Sites
1	Alluvial Terrace	25	90	90	9	29	-
2	Alluvial Terrace	29	80	80	3	7	-
Total		**54**			**12**	**22**	**-**

Table 5. Landform summary of sampled areas of the Project area.

Landform	Landform Area (ha)	Area Effectively Covered (ha)	Landform Effectively Surveyed (%)	Sites
Alluvial Terrace	54	12	22	-

8 RESULTS AND DISCUSSION

No Aboriginal cultural heritage sites were located in the Project area, despite the intensive nature of the survey, including subsurface test excavations. This negative result is despite the excellent conditions of surface visibility and high survey coverage. It is attributable to the past disturbance by quarrying and agriculture of the Project area, which is likely to removed Aboriginal cultural heritage sites, had they previously occurred.

Modified trees were not identified because all River Red Gum and Box, the most commonly scarred types of tree, have been previously cleared from the Project area. Nevertheless, the representatives of the registered Aboriginal stakeholders identified River Red Gum trees on the property to the south of the Stage 4 area and outside the Project area to be of cultural significance. The registered Aboriginal stakeholders requested that the proponent avoid harm to these features. The Project area is contained within existing protective barrier fences providing a buffer from inadvertent harm to any adjacent land. Additionally, a flood protection levee inside the perimeter of the Project area would serve as a bund to contain all activities.

Stone quarry sites are definitely not represented in the Project area as rock outcrop is lacking. Landforms such as lunettes or source-bordering sand dunes that might contain sensitive sub-surface archaeological material such as burials do not occur in the Project area. The sediments of the Project area had been well enough exposed by quarrying, pastoral and agricultural activities, vehicular traffic and wind and water erosion to determine that no archaeological material was present on the surface nor is likely to be buried beneath the soil.

9 ABORIGINAL CULTURAL HERITAGE VALUES

9.1 BACKGROUND

All Aboriginal objects are afforded protection under the NP&W Act, but decisions about appropriate management of individual cultural heritage items or sites are usually based on their assessed significance (archaeological and cultural) as well as the likely impact of the proposed development and the benefits of the development. The *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011) and *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b) requires significance assessment in accordance with the processes set out in the Burra Charter (Australia ICOMOS 1988, 1999, 2013).

The process of significance assessment has received considerable attention since the early 1980s and criteria for assessing these values have been developed and adapted to deal specifically with Aboriginal cultural heritage. The significance of Aboriginal archaeological sites such as those found during this study are usually assessed in terms of their importance to archaeologists (i.e. their scientific or research significance), their importance to contemporary Aboriginal people and their importance to the general public. Once the significance of a site has been assessed, it can be ranked against others and specific recommendations formulated. Criteria for assessing scientific significance are set out below.

Under the Burra Charter (Australia ICOMOS 1988, 1999, 2013), cultural significance means aesthetic, historic, scientific, or social value for past, present or future generations. Cultural significance is a concept that helps in estimating the value of places. The places that are likely to be of significance are those that help an understanding of the past, enrich the present, and may be of value to future generations. Cultural significance is embodied in the place itself, its "*fabric, setting, use, associations, meanings*, records, *related places* and *related objects*" (Australia ICOMOS 1999). The components of significance - aesthetic, historic, scientific, social and spiritual - are described below.

Aesthetic value includes aspects of sensory perception for which criteria can and should be stated. Such criteria may include consideration of the form, scale, colour, texture and material of the fabric, the smells and sounds associated with the place and its use (Australia ICOMOS 1988).

A place may have historic value because it has influenced, or has been influenced by, a historic figure, event, phase or activity. It may also have historic value as the site of an important event. For any given place, the significance will be greater where evidence of the association or event survives in-situ, or where the settings are substantially intact, than where it has been changed or evidence does not survive. However, some events or associations may be so important that the place retains significance regardless of subsequent treatment (Australia ICOMOS 1988).

The scientific or research value of a place will depend on the importance of the data involved, on its rarity, quality (integrity) or representativeness, and on the degree to which the place may contribute further substantial information (Australia ICOMOS 1988). Scientific or archaeological significance may be assessed by placing a site, feature or landscape in a broader regional context and by assessing its individual merits in the context of current archaeological discourse.

Social value is broadly defined as *the qualities for which a place has become a focus of spiritual, political, natural or other cultural sentimental to a majority or minority group* (Australia ICOMOS 1988: 30). Johnston (1994) explains *"Social value is about collective attachment to places that embody meaning important to a community, these places are usually community owned or publicly accessible or in some other way "appropriated" into people's daily lives. Such meanings are in addition to other values, such as the evidence of valued aspects of history or beauty, and these meanings may not be apparent in the fabric of the place, and may not be apparent to the disinterested observer"* (Johnston 1994: 10).

Although encompassed within the criterion of social value, the spiritual value of a place was added to The Burra Charter in 1999 (Australia ICOMOS 1999: 1). Spiritual value is predominantly used to assess places of cultural significance to Aboriginal Australians.

9.2 ABORIGINAL SOCIAL AND CULTURAL INFORMATION ABOUT THE PROJECT AREA

Aboriginal people of the Upper Murray region are generally concerned about any development that might impact upon Aboriginal cultural heritage and other values on land that is traditionally theirs. All land has high cultural significance for individual Aboriginal people and for the Aboriginal community collectively. It should also be noted that any development upon, or disturbance of land is contrary to principal Aboriginal beliefs regarding land, its values and its inherent cultural significance.

Aboriginal community representatives involved in this cultural heritage assessment were invited to provide specific information about the social and cultural values of the Project area.

The Wiradjuri Aboriginal community is particularly concerned about the preservation of Aboriginal cultural heritage sites. However, the RAPs involved in this assessment did not have any specific information pertaining to the Project area regarding Aboriginal cultural heritage. In particular, representatives of the Wiradjuri Aboriginal community involved in the field survey thought the Project area was unlikely to contain the physical remains of past Aboriginal occupation, due to past land disturbance by quarrying and agriculture.

The representatives of the registered Aboriginal stakeholders identified River Red Gum trees on the property to the south of the Stage 4 area and outside the Project area to be of cultural significance. The registered Aboriginal stakeholders requested that the proponent avoid harm to these features. The Project area is contained within existing protective barrier fences providing a buffer from inadvertent harm to any adjacent land. Additionally, a flood protection levee inside the perimeter of the Project area would serve as a bund to contain all activities.

10 IMPACT ASSESSMENT

In accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011), the principles of ecologically sustainable development were considered in assessing the likely harm of the Howlong Sand and Gravel Expansion Project to Aboriginal objects.

No Aboriginal cultural heritage was identified in the Project area, so no known Aboriginal cultural heritage sites, items or values would be potentially impacted by the Projectn. The potential for previously unidentified Aboriginal cultural heritage to occur in the Project area is however considered in Section 10.1.

10.1 POTENTIAL FOR PREVIOUSLY UNIDENTIFIED ABORIGINAL CULTURAL HERITAGE TO OCCUR IN THE PROJECT AREA

All of the Project area was inspected for cultural heritage sites during the field survey. There is a very low possibility that some archaeology was obscured by soil. Such previously unidentified features, should they occur, would probably be isolated finds or low-density concentrations of stone artefacts (based on the predictive model outlined in Section 7.2 and informed by the results of the current survey, summarised in Section 8).

Further sites of a type or significance not previously encountered at the Project area are improbable.

Past disturbance from pastoralism, agriculture and quarrying means that significant *in situ* subsurface cultural deposits are highly improbable.

The Project area does not contain culturally sensitive landforms such as lunettes or source-bordering sand dunes where subsurface Aboriginal cultural deposits (e.g. burials) have been recorded previously.

A strategy for managing any newly identified Aboriginal objects during the life of the Project is outlined in Section 11.

10.2 FLEXIBILITY OF THE DESIGN OF THE PROPOSAL

The location of the proposed works associated with the proposal are currently within their optimum design location, but minor variations are possible to avoid or minimize harm to Aboriginal cultural heritage.

10.3 POTENTIAL CUMULATIVE IMPACTS OF THE PROJECT

Given that no Aboriginal cultural heritage has been identified in the Project area, coupled with the very low potential for such heritage to occur, the Project would not increase cumulative impacts to Aboriginal cultural heritage in the region.

11 MANAGEMENT STRATEGIES FOR CULTURAL HERITAGE

This section presents proposed strategies for the management of Aboriginal cultural heritage values within the Howlong Sand and Gravel Expansion Project area that may be subject to impacts by the proposed works.

11.1 GENERAL RECOMMENDATIONS

11.1.1 Role of the Local Aboriginal Community

Fraser Earthmoving Construction Pty Ltd is committed to involving the local Aboriginal community as an integral participant in the management of Aboriginal cultural heritage values in the Howlong Sand and Gravel Expansion Project area. The strategies outlined in this report have incorporated the views of community representatives.

11.1.2 Site Management and Cultural Awareness Training

It is proposed to provide training to all on-site personnel regarding the cultural heritage management strategies relevant to their employment tasks.

11.2 MANAGEMENT OF CULTURAL HERITAGE IN PROXIMITY TO THE DISTURBANCE AREAS

Stone artefact site AHIMS site number 60-3-0134 350 m north of the Project area would not be harmed by the activity. Nevertheless, Fraser Earthmoving Construction Pty Ltd undertakes to erect a protective barrier fence around this feature to avoid any inadvertent future harm.

The representatives of the registered Aboriginal stakeholders also identified River Red Gum trees on the property to the south of the Stage 4 area and outside the Project area to be of cultural significance. The registered Aboriginal stakeholders requested that the proponent avoid harm to these features. The Project area is contained within existing protective barrier fences providing a buffer from inadvertent harm to any adjacent land. Additionally, a flood protection levee inside the perimeter of the Project area would serve as a bund to contain all activities.

11.3 SUMMARY RECOMMENDATIONS

Based on the results of this cultural heritage assessment and consultation with representatives of the registered Aboriginal stakeholders it is recommended that:

- the Howlong Sand and Gravel Quarry Expansion Project be allowed to proceed because the activity would not harm Aboriginal cultural heritage;
- if any previously unidentified Aboriginal cultural heritage places or items are encountered during the course of installation of the proposed Howlong Sand and Gravel Expansion Project all works likely to affect the material must cease immediately and the Environmental Line (tel: 131 555) consulted about an appropriate course of action prior to recommencement of work. It is an offence under the *National Parks and Wildlife Act* 1974 to disturb or destroy Aboriginal cultural heritage items without written consent of Heritage NSW; and,
- if human skeletal remains are encountered during the course of the proposed Howlong Sand

and Gravel Quarry Expansion Project all work in that area must cease. Remains must not be handled or otherwise disturbed except to prevent further disturbance. If the remains are thought to be less than 100 years old the Police or the State Coroners Office (tel: 02 9552 4066) must be notified. If there is reason to suspect that the skeletal remains are more than 100 years old and Aboriginal, the proponent should contact the Environmental Line (tel: 131 555) for advice.

12 REFERENCES

Advanced Environmental Systems Pty Ltd (2020). *Aboriginal and historical cultural heritage due diligence assessment for the Howlong Sand and Gravel Expansion Project*. Report to Fraser Earthmoving Construction Pty Ltd.

Andrews, A. (1920). *The First Settlement of the Upper Murray 1835 to 1845 with a short account of over two hundred runs 1835 to 1880*. D.S. Ford, Sydney.

Australia International Council on Monuments and Sites (ICOMOS) (2013). *Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (the Burra Charter)*. Revised edition. Australia ICOMOS, Canberra.

Australia International Council on Monuments and Sites (ICOMOS) (1999). *Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (the Burra Charter)*. Australia ICOMOS, Canberra.

Australia International Council on Monuments and Sites (ICOMOS) (1988). *Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (the Burra Charter)*. Australia ICOMOS, Canberra.

Australian Heritage Commission (2002). *Ask First; A Guide to Respecting Indigenous Heritage Places and Values*. Australian Heritage Commission, Canberra.

Bell, D. (1982). *Aboriginal carved trees in NSW.* Report to the National Parks and Wildlife Service, Sydney.

Bell, J. (2001). *An heritage study of the proposed Albury Wodonga external bypass route, NSW and Victoria*. Report to RTA NSW and VicRoads.

Beveridge, P. (1869). On Aboriginals ovens. *Journal of the Anthropological Society of London* **7**: 187-189.

Bickford, R.A. (1966). *The Traditional Economy of the Aborigines of the Murray Valley*. Unpublished BA (Honours) thesis. Dept of Anthropology, University of Sydney.

Bonhomme, T. (1990). *Aboriginal burials and sand mining on the Riverine Plain, NSW*. Report to the NSW National Parks and Wildlife Service.

Bonhomme Craib and Associates (1999). *Cultural Heritage Study for the Murray Darling Water Management Action Plan (MDWMAP)*. Report to MDWMAP.

Bowdler, S. (1983). *Aboriginal sites on the Crown-timber lands of New South Wales*. Report to the Forestry Commission of New South Wales.

Brown, C.M. and Stephenson, A.E. (1991). *Geology of the Murray Basin, Southeastern Australia*. (Bureau of Mineral Resources Bulletin 235).

Bureau of Meteorology (2020). *Climate statistics for Australian locations – Albury Airport*. (online: http://www.bom.gov.au/climate/averages/tables/cw_072146.shtml)

Burton, B. (1973). *Flow Gently Past: The Story of the Corowa District*. Corowa Shire Council, Corowa, NSW.

Clark, N. (1997). *Telstra Optic Fibre Cable Route Bundalong T.O. to Norong (15 km): An assessment of the potential impact on archaeological sites*. Report to Telstra.

Craib, J. (1992). *A Reconnaissance Survey of Aboriginal Archaeological Resources in the Wentworth-Gol Gol Area, Western NSW*. Report to NSW National Parks and Wildlife Service.

Curr, E. (1886). *The Australian Race: its origins, languages, customs, place of landing in Australia, and the routes by which it spread itself over that continent*. Government Printers, Melbourne

Debney, T. and Tulloch, J. (2004). *Archaeological Investigations for the Proposed LOGIC freight distribution centre, Barnawartha North, Victoria*. Report to Wodonga City Council.

Department of Environment, Climate Change and Water (DECCW) (2010a). *Aboriginal cultural heritage consultation requirements for proponents 2010 (Part 6 National Parks and Wildlife Act, 1974)*. NSW Department of Environment, Climate Change and Water, Sydney.

Department of Environment, Climate Change and Water (DECCW) (2010b). *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. NSW Department of Environment, Climate Change and Water, Sydney.

Edwards, A. and Bell,J. (2013). *Cultural Heritage Management Plan. Proposed industrial subdivision, Logic Centre, Murray Valley Highway, Barnawartha North*. Report to City of Wodonga.

Edwards, R., (1972). *Aboriginal Bark Canoes of the Murray Valley,* Rigby Limited, Adelaide.

Etheridge, R. (1918). The dendroglyphs or carved trees of New South Wales, *Geological Survey of New South Wales, Memoir, Ethnological Series,* III.

Flood, J. (1980). *The moth hunters: Aboriginal prehistory of the Australian Alps*. Australian Institute of Aboriginal Studies, Canberra.

Gott, B. (1983). Murnong – *Microseris scapigera*: a study of a staple food of Victorian Aborigines. *Australian Aboriginal Studies* **2**, 2-18.

Hope, J. (1993). *Aboriginal Burial Sites in the Murray-Darling Basin*. Report to the Murray-Darling Basin Commission.

Hope, J. (1993). *Aboriginal Burial Sites in the Murray-Darling Basin*. Report to the Murray-Darling Basin Commission.

Hovell, W.H. and Hume, H. (1837). *Journey of discovery to Port Phillip, New South Wales in 1824 and 1825 by W.H. Hovell and H. Hume*. (Compiler: Bland, W.). James Tegg, Sydney.

Howitt, A.W. (1996). *The Native Tribes of South-East Australia.* Aboriginal Studies Press.

Johnston, C (1994). What is Social Value: a discussion paper. *Australian Heritage Commission Technical Publications: Series Number 3*.

Kain, K.K. (1991). *The First Overlanders Hawdon and Bonney*. Gould Books, Adelaide.

Kelleher, M. and Nightingale, A. (2007). *Hume Highway Upgrade Table Top to Mullengandra Section: Aboriginal Cultural Heritage Assessment*. Prepared for the RTA Hume Highway Office.

Klaver, J. (1987). *Old Ovens Are Soon Hot*. Unpublished BA (Honours) thesis. Australian National University, Canberra.

Lawrence, C.R. (1966). Cainozoic stratigraphy and structure of the Mallee region, Victoria. *Proceedings of the Royal Society of Victoria* **79**, 517-553.

Marquis-Kyle, P. and Walker, M. (1992). *The Illustrated Burra Charter*. Australian ICOMOS, Sydney.

Mitchell, T.L. (1839). *Three Expeditions into the Interior of Eastern Australia*. (T. and W. Boone: London).

National Parks and Wildlife Service (1997). *Aboriginal Cultural Heritage: Standards and Guidelines Kit*. National Parks and Wildlife Service, Sydney.

Navin, K., Officer, K. and Tracey, M. (1995). *Preliminary Cultural Heritage Assessment Wodonga to Wagga Wagga Natural Gas Pipeline EIS*. Report to Sinclair Knight Merz.

Navin, K. and Officer, K. (1996). *Wodonga-Wagga Wagga Natural Gas Pipeline Further Archaeological Assessment*. Report to East Australian Pipeline Limited

Office of Environment and Heritage (2011). *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW.* Office of Environment and Heritage, Sydney.

Officer, K. (1998) *Wodonga To Wagga Wagga Natural Gas Pipeline Surface Collections of Artefacts*. Report to East Australian Pipeline Limited.

Officer, K. and Navin, K. (1998). *Wodonga To Wagga Wagga Natural Gas Pipeline Surface Surveys of Previously Restricted Areas*. Report to East Australian Pipeline Limited.

Officer, K., Navin, K, and Kamminga, J. (1998). *Wodonga - Wagga Wagga Natural Gas Pipeline Archaeological Subsurface Testing Program*. Report to East Australian Pipeline Limited.

Paton, R. and Hughes, P.J. (1984). *An Investigation of the Roseleigh Sand Dune, Albury NSW*. Report to the NSW National Parks and Wildlife Service.

Reed, A.W. (1969). *Place-names of New South Wales; their names and meanings*. A.H. and A.W. Reed, Sydney.

Sciusco L. (1995). *An archaeological survey of a Proposed Gas Pipeline Route Chiltern to Rutherglen Victoria*. Report to Gas and Fuel.

Stone, T. (1996a). *An Archaeological Survey of two Proposed Gas Main Crossings of the Murray River at Howlong and Corowa*. Report to Gas and Fuel.

Stone, T. (1996b). *An Archaeological Survey of the Proposed Gas Pipeline Route from Rutherglen to Koonoomoo, North East Victoria*. Report to Gas and Fuel.

Stone, T. and Paton, R. (1994). *An archaeological investigation of a proposed sewage treatment site and associated water reclamation areas near Albury, N.S.W*. A report to the Albury City Council.

Sturt, C.N. (1833). *Two Expeditions into the interior of Southern Australia during the years 1828, 1829, 1830 and 1831*. Smith Elder, London.

Tindale, N.B. (1974). *Aboriginal Tribes of Australia: their terrain, environmental controls, distribution, limits and proper names*. University of California, Berkeley, CA.

Thompson, C. (1996). *An archaeological Survey of North East Victoria*. Aboriginal Affairs Victoria, Melbourne.

VandenBerg, A.H.M. (1997). *Wangaratta and part of Jerilderie SJ 55-2 Edition 2, 1:250 000 Geological Map Series 1:250 000 geological map*. Geological Survey of Victoria.

Upcher, C. and Smith, L. (1994). *Archaeological Survey of the Proposed Albury Wodonga Bypass Routes, NSW and Victoria.* Report to Gutteridge Haskins and Davey.

Wafer, J., and Lissarrague, A. (2008). *A handbook of Aboriginal languages of New South Wales and the Australian Capital Territory*. Muurrbay Aboriginal Language and Culture Co-operative, Nambucca Heads, NSW.

White, I. (1986). *Dimensions of Wiradjuri: an ethnohistoric study*. B.Litt. thesis, Department Archaeology and Anthropology, ANU, Canberra.

Zola, N. and Gott, B. (1992). *Koorie Plants Koorie People: Traditional Aboriginal Food, Fibre and Healing Plants of Victoria*. Koorie Heritage Trust, Melbourne.

APPENDICES

Appendix 1. Glossary

Appendix 2. Consultation Log

Appendix 3. Correspondence to Aboriginal Community Stakeholders

Appendix 4. Correspondence from Aboriginal Community Stakeholders

Appendix 5. AHIMS Register Search

APPENDIX 1. GLOSSARY

Archaeological site - A place with evidence of past human activity. This evidence may include Aboriginal and/or historic artefacts, features, structures or organic traces.

Artefact scatter - A surface scatter of Aboriginal or historic cultural material. Scatters of stone artefacts are a common archaeological site type. These scatters may also contain charcoal, discarded animal bones, shell and ochre.

Assemblage - A collection of artefacts from a single archaeological site.

Burial site - A place with a concentration of human remains. Ochre, stone tools, charcoal and grave goods may be associated with burials. Most burial sites are found in sand dunes but dead trees, caves and rock shelters were also used.

Ceremonial ground - Place that may be associated with initiation ceremonies, meetings or sacred rituals. Stone arrangements may be present, including cairns, stone circles or standing slabs of rock.

Chert - A fine-grained opaline rock ranging in colour from white to black, but most often grey, brown, grayish brown and light green to rusty red.

Core - A piece of stone from which flakes have been removed. They usually have negative flake scares that have resulted from the removal of flakes.

Cultural material - Any material remains or objects resulting from human activity.

Debitage - Any waste material including flakes and cores produced during the manufacture of chipped stone tools.

Flake - A piece of stone detached from a core that typically displays a striking platform, bulb of percussion and flake scars on the ventral surface.

Flaked piece - Small fragments of stone resulting from the manufacture of stone tools. A striking platform or bulb of percussion may not be evident.

Ground surface visibility - The amount of bare ground exposed, usually expressed as a percentage.

Hearth - The remains of a campfire containing charcoal, discoloured soil, and possibly, hearthstones, heat retainers or the remains of animals or shellfish cooked and consumed at the campsite.

Hearthstone – Stone cobble placed in a campfire to retain heat for cooking. The types of stone used as hearthstones in western Victoria includes calcrete and sandstone.

Heat retainer - Nodule of baked clay, thought to have been placed in campfires to retain heat for cooking.

in situ - An artefact or other feature that has not been disturbed from its original position.

Mound - Raised areas of earth ranging from 3 to 35m in diameter and from 0.5m to 2m in height. Earth oven material, stone artefacts, food refuse and the remains of hut foundations have been recovered from excavated earth mounds in the central and western parts of Victoria.

Ochre - Soft varieties of the iron oxides goethite, limonite or haematite usually coloured red or yellow and used as pigment for painting.

Quarry - An outcrop of stone or ochre where Aboriginal people have extracted the raw material for use or trade. Stone quarries are identifiable by a dense scatter of broken stone and flakes or consist of pits or hollows where material has been dug out of the ground.

Quartz – A silica mineral resistant to weathering because of its hardness. It is commonplace in the landscape as a consequence.

Quartzite - A metamorphic rock formed by the re-crystallization of quartz.

Retouch - A stone artefact with fine, secondary flaking along one or more edges.

Scarred tree - A tree with a scar on its trunk caused by bark removal.

Shell midden - A surface scatter or heap of discarded shell often with charcoal, animal bones and stone artefacts. Middens may found near coastlines, rivers, creeks, swamps and ancient lakes.

Silcrete - A hard, fine-grained rock composed of silica cement.

Stone feature - Cairns, rock wells, grinding groves, stone structures, fish traps and stone arrangements are examples of stone features.

Stratified deposit - Material that has been laid down over time forming a sequence of events.

Survey - An inspection of land either by foot or vehicle for the purpose of identifying archaeological sites.

Transect - A predetermined area or a path that directs the course of a survey.

APPENDIX 2. CONSULTATION LOG

Date	Person Contacted	Organization Represented	Form of Contact	Contacted By	Organization Represented	Nature of consultation
17 June 2020	Registrar	Office of the Registrar, Aboriginal Land Rights Act 1983	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	-	National Native Title Tribunal	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	Frank Russo	NTS Corporation Limited	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	CEO	Federation Shire Council	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	-	Local Land Services	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	Sam Kirby	Albury and District Local Aboriginal Land Council	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	John Gilding	Department of Planning, Industry and Environment, Biodiversity and Conservation Division	Letter	Matt Cupper	Fraser Earthmoving Construction	Request for names of Aboriginal stakeholders that may have had an interest in registering in the consultation process for the Project.
17 June 2020	Matt Cupper	Fraser Earthmoving Construction	Email	George Tonna	NTS Corporation Limited	Response received from NTS Corporation Limited. Advised that it would forward notification to Albury and District Local Aboriginal Land Council and Brolga Family.

Date	Person Contacted	Organization Represented	Form of Contact	Contacted By	Organization Represented	Nature of consultation
23 June 2020	Matt Cupper	Fraser Earthmoving Construction	Email	Megan Leahy	Federation Shire Council	Response received from Federation Shire Council. Advised the names of all the Local Aboriginal Land Councils in the Wiradjuri region of the NSW Aboriginal Land Council.
23 June 2020	Matt Cupper	Fraser Earthmoving Construction	Email	Andrew Fisher	Department of Planning, Industry and Environment, Biodiversity and Conservation Division	Response received from Department of Planning, Industry and Environment, Biodiversity and Conservation Division. Advised the names of all the Aboriginal stakeholders in the Federation Shire Council LGA.
29 June 2020	CEO	Bangerang Aboriginal Corporation	Letter	Matt Cupper	Fraser Earthmoving Construction	Notification to register interest in the Project.
29 June 2020	Mark Saddler	Bundyi Aboriginal Cultural Knowledge	Letter	Matt Cupper	Fraser Earthmoving Construction	Notification to register interest in the Project.
29 June 2020	-	Yalmambirra	Letter	Matt Cupper	Fraser Earthmoving Construction	Notification to register interest in the Project.
29 June 2020	Liz Heta	-	Letter	Matt Cupper	Fraser Earthmoving Construction	Notification to register interest in the Project.
30 June 2020	-	General Public	Newspaper	Matt Cupper	Fraser Earthmoving Construction	Public Notice published in the Border Mail (Albury-Wodonga). Request for registrations of interest in the Project.
3 July 2020	Matt Cupper	Fraser Earthmoving Construction	Letter	Mark Saddler	Bundyi Aboriginal Cultural Knowledge	Registration of interest in the consultation process for the Project.
3 July 2020	Mark Saddler	Bundyi Aboriginal Cultural Knowledge	Letter	Matt Cupper	Fraser Earthmoving Construction	Acknowledgement of Bundyi Aboriginal Cultural Knowledge registration of interest in the consultation process for the Project.

Date	Person Contacted	Organization Represented	Form of Contact	Contacted By	Organization Represented	Nature of consultation
15 and 16 October 2020	Mark Saddler Andom Rendell	Bundyi Aboriginal Cultural Knowledge Albury and District Local Aboriginal Land Council	Field Survey	Matt Cupper	Fraser Earthmoving Construction	Representatives of registered Aboriginal stakeholders involved in cultural heritage field survey
5 January 2021	Mark Saddler Andom Rendell	Bundyi Aboriginal Cultural Knowledge Albury and District Local Aboriginal Land Council	Email	Matt Cupper	Fraser Earthmoving Construction	Draft Aboriginal cultural heritage assessment provided for input and comment
1 February 2021	Matt Cupper	Fraser Earthmoving Construction	Email	Mark Saddler	Bundyi Aboriginal Cultural Knowledge	Comments received to draft Aboriginal cultural heritage assessment
15 February 2021	Mark Saddler Andom Rendell	Bundyi Aboriginal Cultural Knowledge Albury and District Local Aboriginal Land Council	Email	Matt Cupper	Fraser Earthmoving Construction	Finalized Aboriginal cultural heritage assessment provided

APPENDIX 3. CORRESPONDENCE TO ABORIGINAL COMMUNITY STAKEHOLDERS

Landskape
Natural and Cultural Heritage Management
a division of M.L. Cupper Pty Ltd
ABN: 48 107 932 918

17 June 2020

Mr John Gilding
Archaeologist
South West Branch
Biodiversity and Conservation Division
Department of Planning, Industry and Environment
PO Box 1040
Albury 2640

Dear John,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1.1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could the Biodiversity and Conservation Division provide contact details of any known Aboriginal groups or individuals who may hold cultural knowledge relevant to the proposed project area, please?

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

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Figure 1.1
LOCALITY PLAN

17 June 2020

Sam Kirby
Chief Executive Officer
Albury and District Local Aboriginal Land Council
PO Box 22
Lavington 2640

Dear Sam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could Albury and District Local Aboriginal Land Council provide contact details of any known Aboriginal groups or individuals who may hold cultural knowledge relevant to the proposed project area, please?

Note Albury and District Local Aboriginal Land Council is **already registered** for the project.

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

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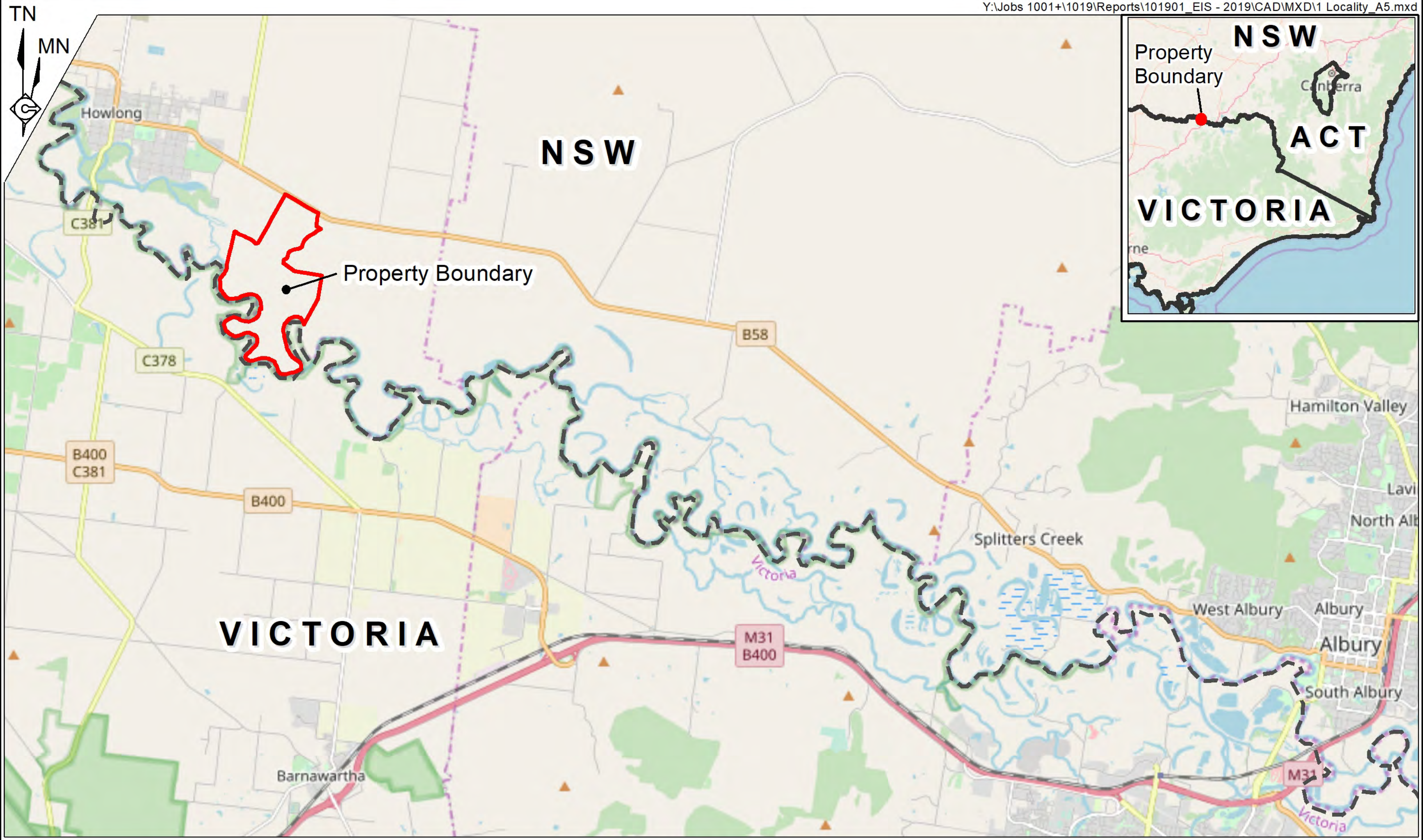

SCALE 1:125 000 (A5)

1.5 0 1.5 3 4.5 km

Source: Open Street Map

REFERENCE

Property Boundary

State Border

Figure 1.1
LOCALITY PLAN

17 June 2020

General Manager
Federation Council
100 Edward Street
Corowa 2646

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could you provide contact details of any known Aboriginal groups or individuals who may hold cultural knowledge relevant to the proposed project area, please?

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

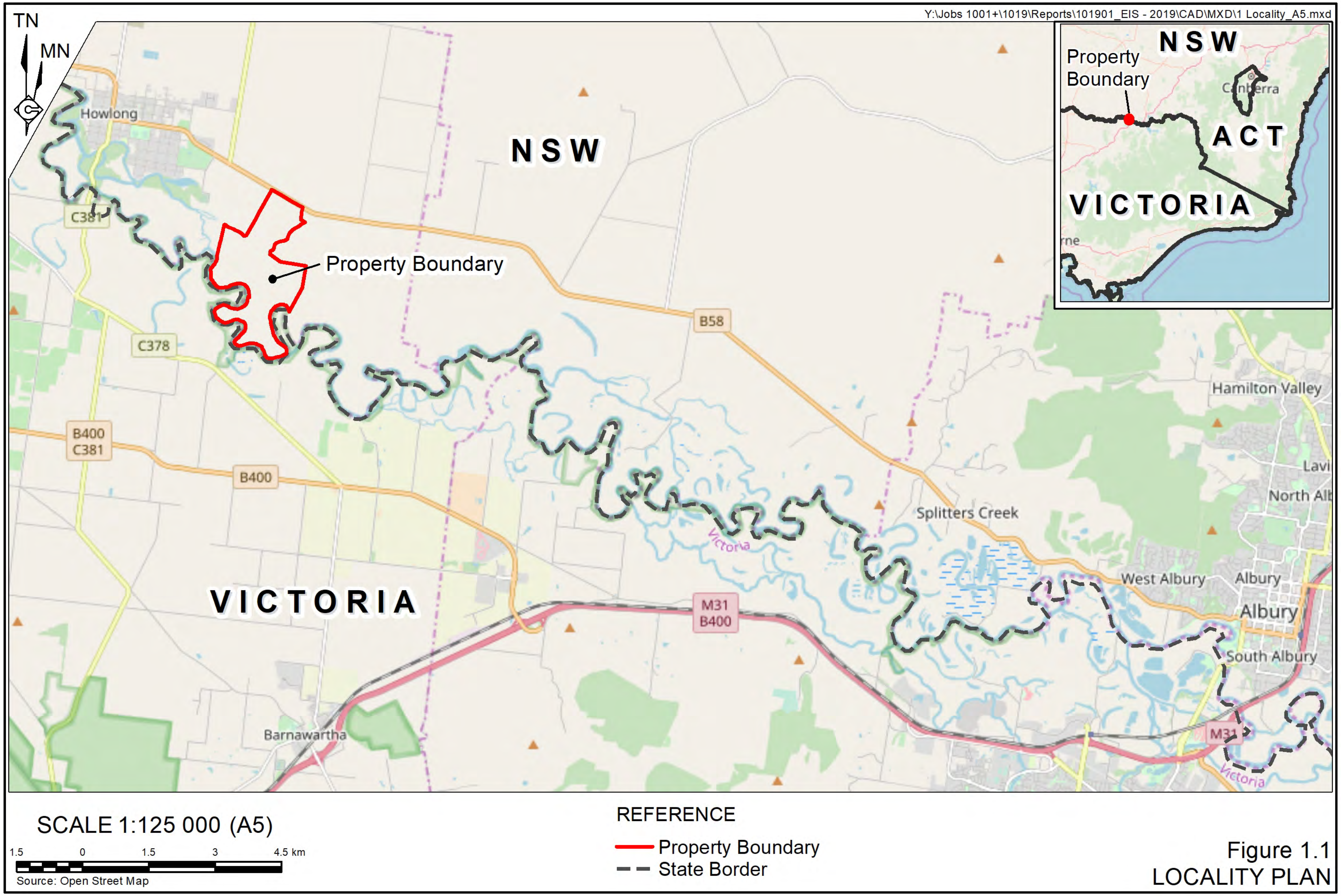

Figure 1.1
LOCALITY PLAN

17 June 2020

George Tonna
Notifications Officer
NTSCORP Ltd
PO Box 2105
Strawberry Hills NSW 2012

Dear George,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

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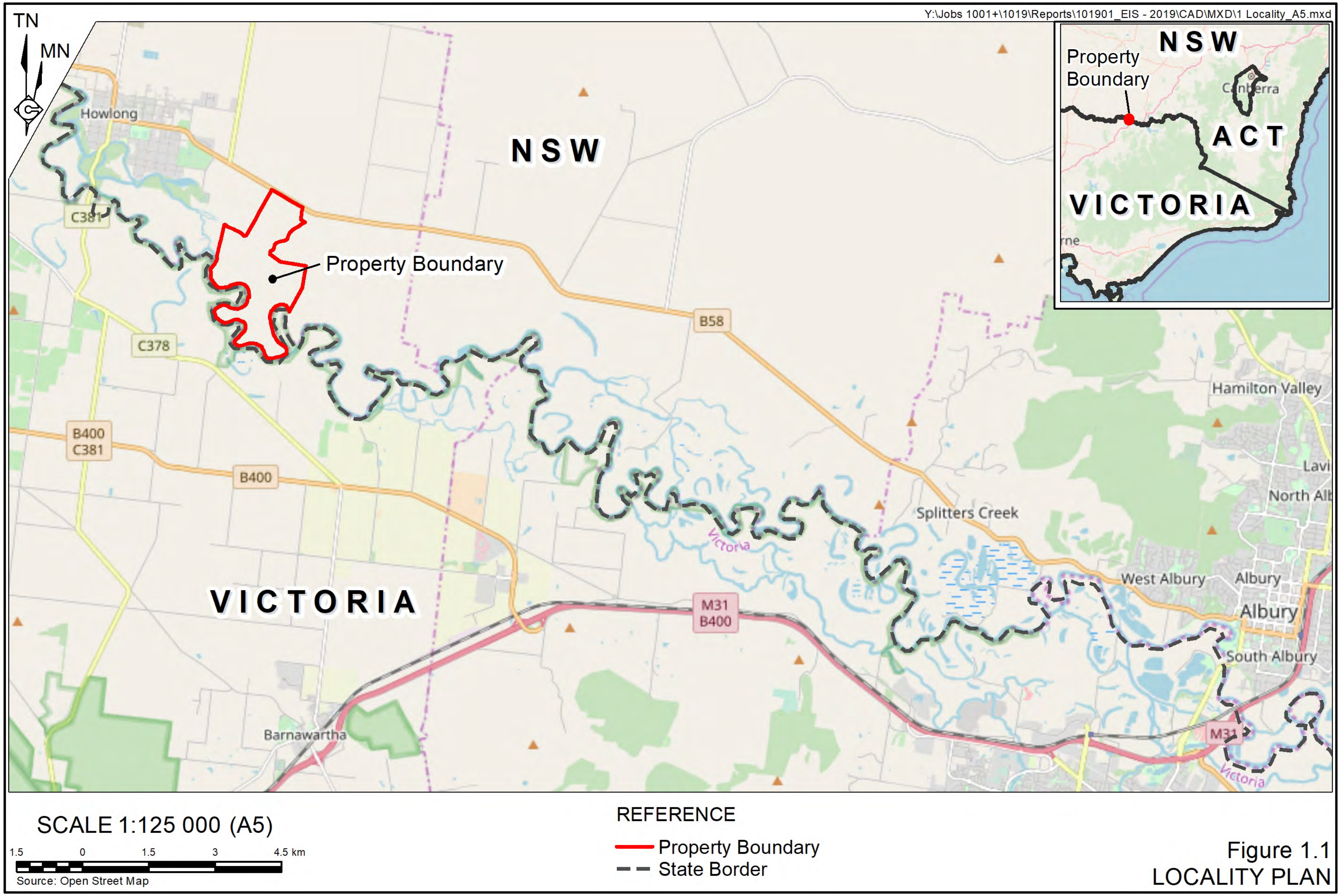

Figure 1.1
LOCALITY PLAN

17 June 2020

National Native Title Tribunal
GPO Box 9973
Perth WA 6848

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could the National Native Title Tribunal advise if there are any registered native title claimants, native title holders and registered Indigenous Land Use Agreements in the proposed project area, please?

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

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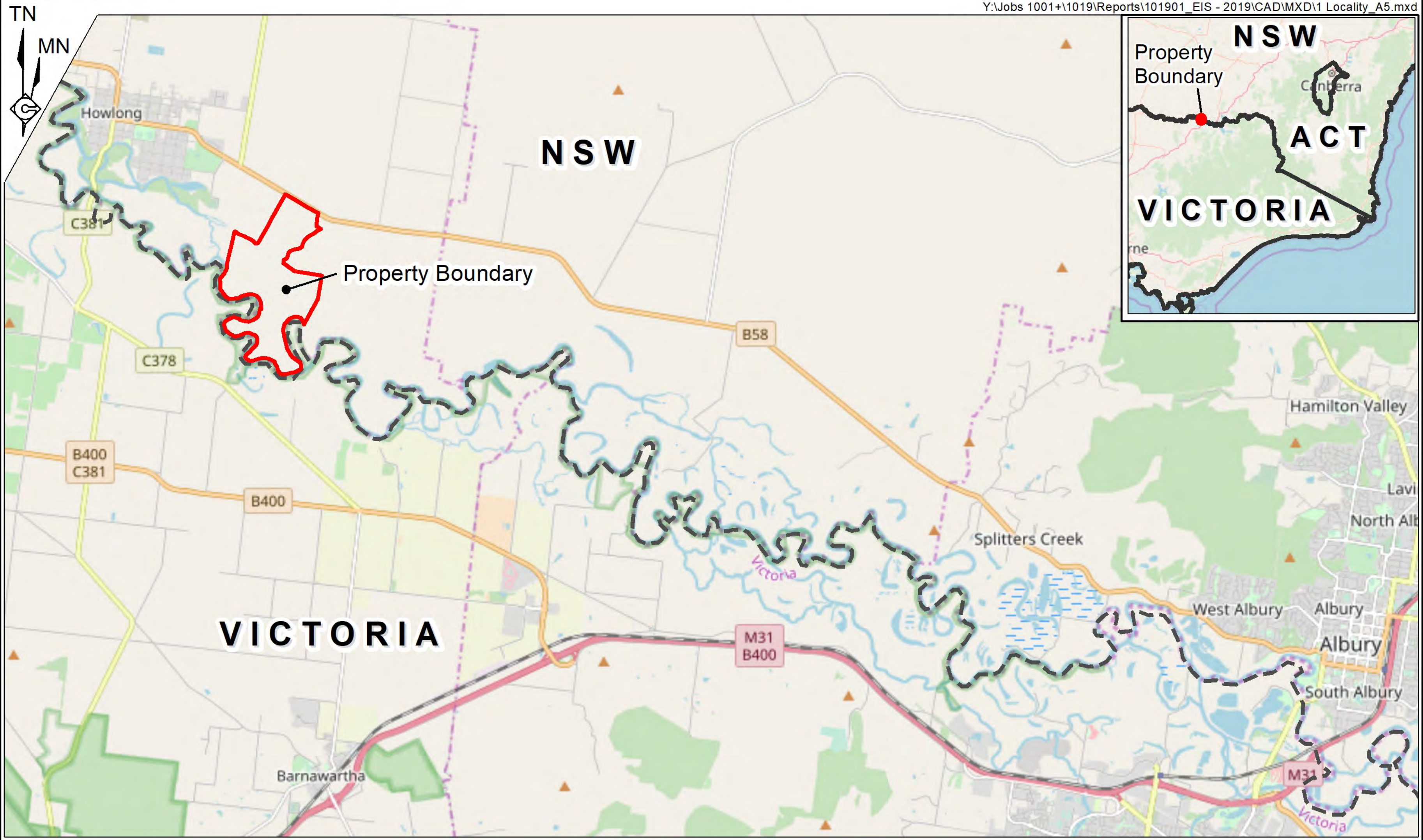

SCALE 1:125 000 (A5)

1.5 0 1.5 3 4.5 km

Source: Open Street Map

REFERENCE

Property Boundary

State Border

Figure 1.1
LOCALITY PLAN

17 June 2020

Murray Local Land Services
PO Box 797
Albury 2640

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

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Yours sincerely,

Dr Matt Cupper

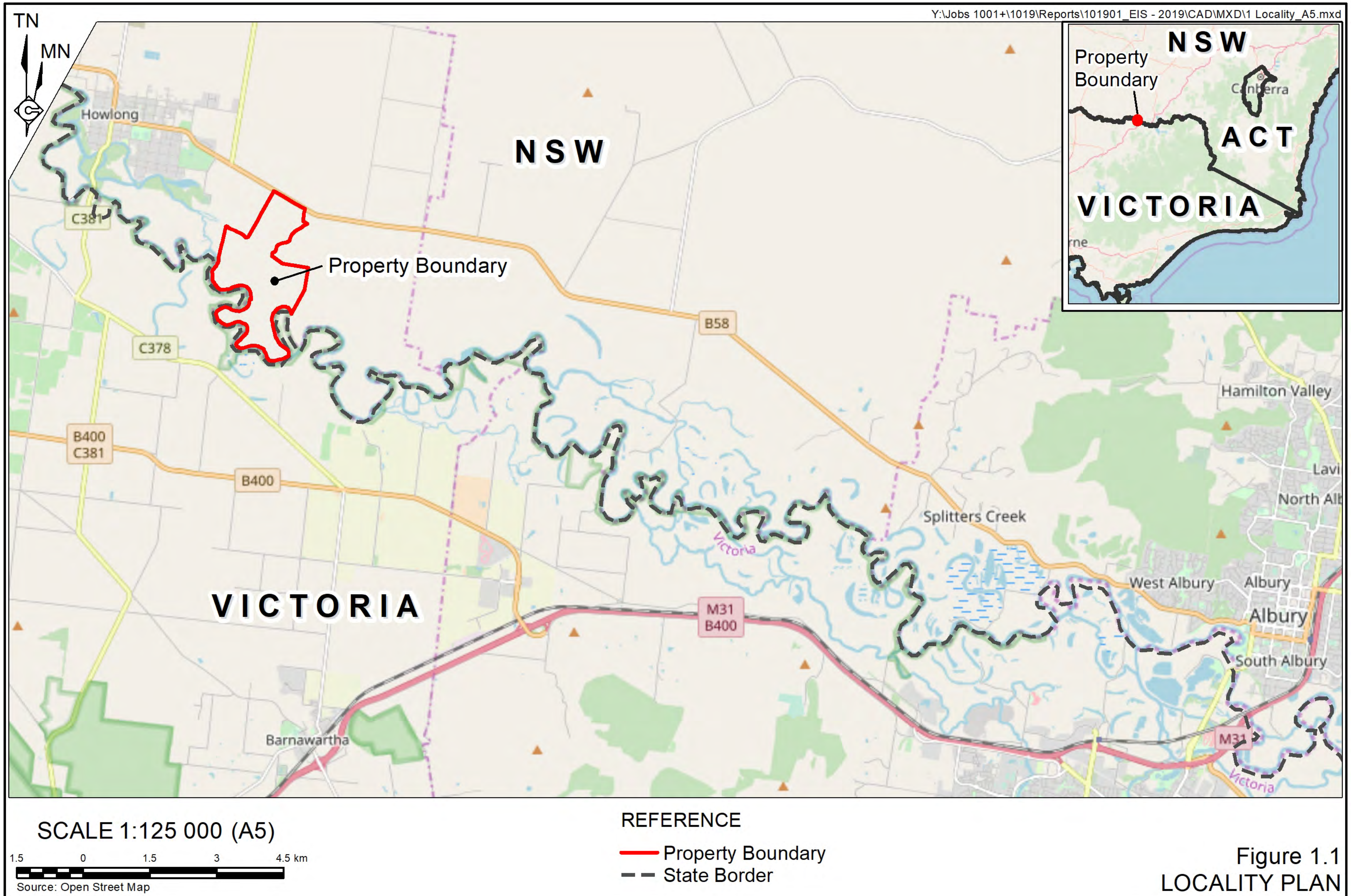

Figure 1.1
LOCALITY PLAN

Landskape
Natural and Cultural Heritage Management
a division of M.L. Cupper Pty Ltd
ABN: 48 107 932 918

17 June 2020

Office of the Registrar, NSW *Aboriginal Land Rights Act* 1983
NSW Department of Aboriginal Affairs
PO Box 112
Glebe NSW 2037

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could the Registrar, *NSW Aboriginal Land Rights Act* 1983 please advise if there are any Aboriginal owners in the proposed project area, please?

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

PO Box 1068 Carlton 3053
Tel: 0408 006 690 E-mail: landskape@telstra.com

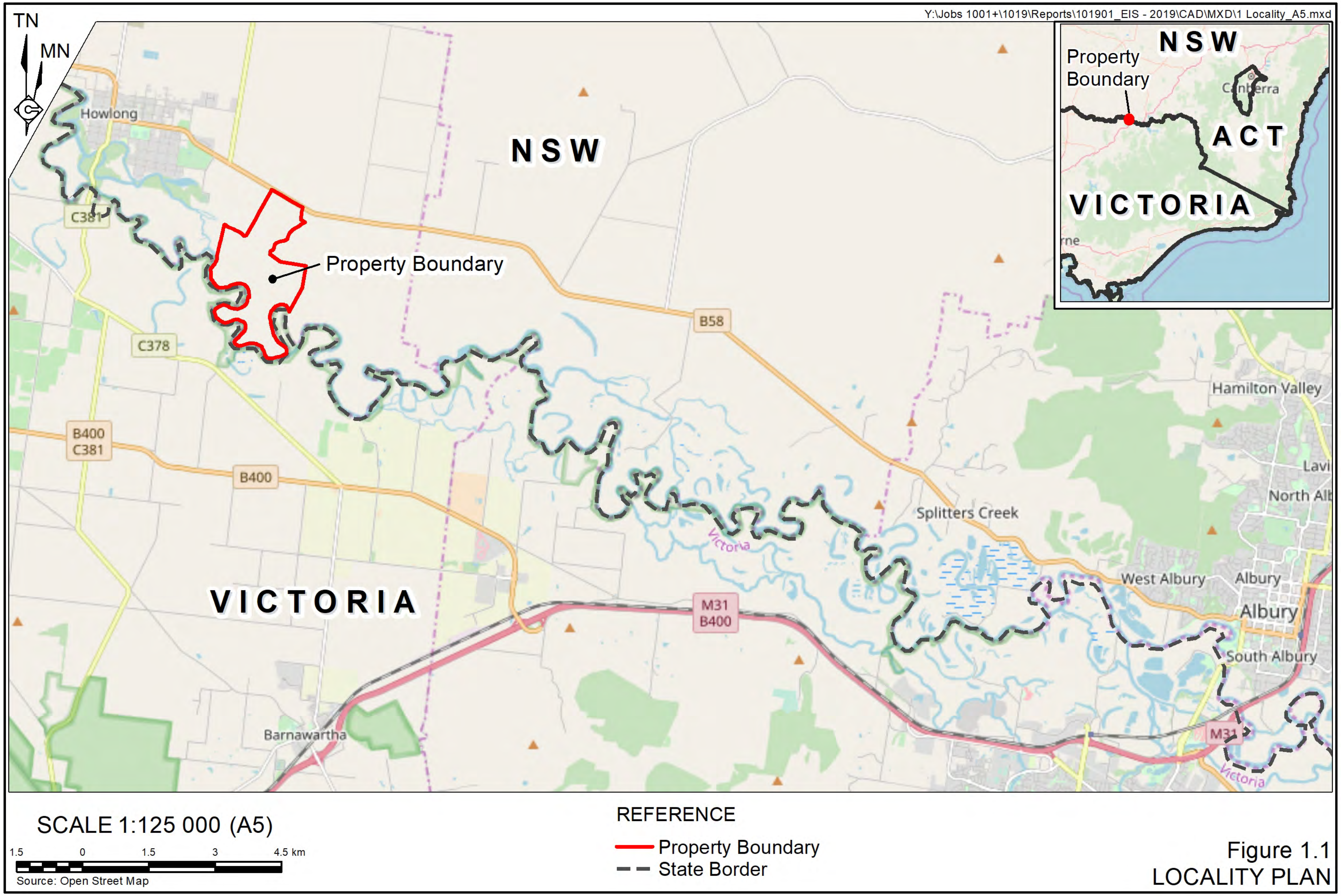

Figure 1.1
LOCALITY PLAN

29 June 2020

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Notification to Register Interest

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1.1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. The purpose of the consultation is to assist Fraser Earthmoving Construction Pty Ltd in the preparation of an application for an Aboriginal Heritage Impact Permit and to assist the Director General of the NSW Biodiversity and Conservation Division in his or her consideration and determination of the application.

Any persons or groups who would like to be consulted are invited to contact me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Closing date for registrations of interest is 5:00 pm Wed 15 Jul 2020.

Yours sincerely,

Dr Matt Cupper

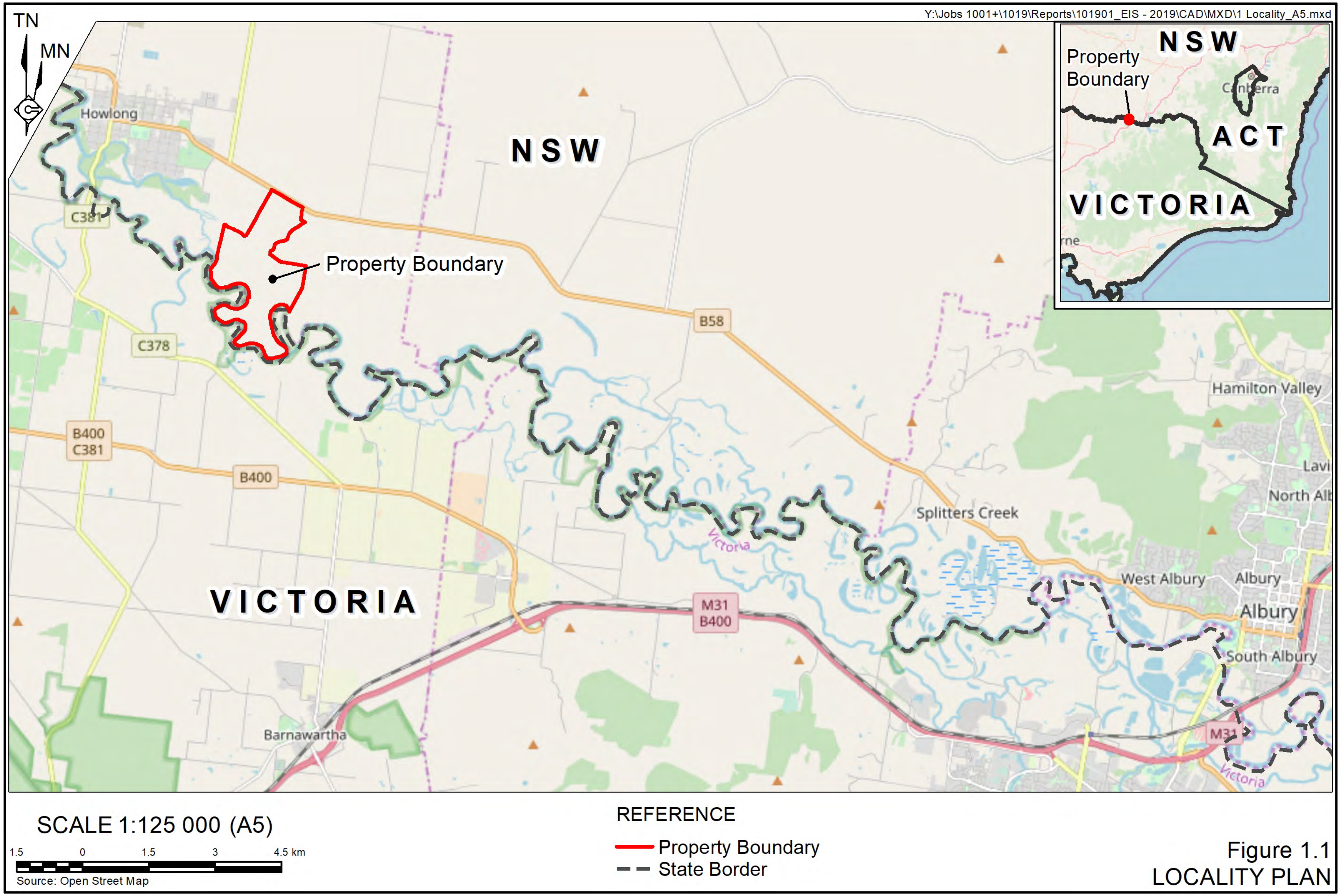

Figure 1.1
LOCALITY PLAN

Landskape
Natural and Cultural Heritage Management
a division of M.L. Cupper Pty Ltd
ABN: 48 107 932 918

17 June 2020

Office of the Registrar, NSW *Aboriginal Land Rights Act* 1983
NSW Department of Aboriginal Affairs
PO Box 112
Glebe NSW 2037

Dear Sir/Madam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

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Yours sincerely,

Dr Matt Cupper

PO Box 1068 Carlton 3053
Tel: 0408 006 690 E-mail: landskape@telstra.com

Landskape
Natural and Cultural Heritage Management
a division of M.L. Cupper Pty Ltd
ABN: 48 107 932 918

17 June 2020

Sam Kirby
Chief Executive Officer
Albury and District Local Aboriginal Land Council
PO Box 22
Lavington 2640

Dear Sam,

Re: Howlong Sand and Gravel Quarry – Aboriginal Stakeholder Identification

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could Albury and District Local Aboriginal Land Council provide contact details of any known Aboriginal groups or individuals who may hold cultural knowledge relevant to the proposed project area, please?

Note Albury and District Local Aboriginal Land Council is **already registered** for the project.

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Yours sincerely,

Dr Matt Cupper

Landskape
Natural and Cultural Heritage Management
a division of M.L. Cupper Pty Ltd
ABN: 48 107 932 918

17 June 2020

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Albury and District Local Aboriginal Land Council
PO Box 22
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Yours sincerely,

Dr Matt Cupper

HOWLONG SAND AND GRAVEL QUARRY EXPANSION PROJECT

PROPOSED METHODOLOGY
FOR THE
ABORIGINAL CULTURAL HERITAGE ASSESSMENT

4 September 2020

1 INTRODUCTION

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Fraser Earthmoving Construction Pty Ltd is seeking to engage with the Aboriginal community as part of the preparation for an Aboriginal Cultural Heritage Assessment (ACHA). Consultation with Aboriginal people and communities will be guided by the Heritage NSW's *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water [DECCW], 2010a).

Fraser Earthmoving Construction Pty Ltd has already completed an Aboriginal cultural heritage due diligence assessment with field survey for the Project (Advanced Environmental Systems Pty Ltd, 2020; attached as Appendix 1). This assessment, involving representatives of the Albury and District Local Aboriginal Land Council, did not encounter any Aboriginal cultural heritage sites in the Project area.

1.2 Structure of this Document

Sections 2 and 3 of this document outlines the Proposed Methodology for the cultural and archaeological assessment of Aboriginal objects, places and/or Aboriginal cultural heritage values within the Project area.

Section 4 outlines the sensitive cultural information management protocol and Section 5 provides further information on the preparation of the ACHA report. Relevant personnel and critical timeframes for the assessment are outlined in Sections 6 and 7, respectively.

2 PROPOSED ASSESSMENT METHODOLOGY

The Proposed Methodology for the cultural and archaeological assessment for the ACHA is as follows:

- Conduct a desktop assessment to delineate areas of known and predicted Aboriginal objects, places and/or Aboriginal cultural heritage values, including a detailed review of the previous assessments.
- Identify the Aboriginal cultural heritage values associated with the relevant area through consulting with Aboriginal people with cultural knowledge or responsibilities for Country in which the Project occurs, utilising written, oral research and field investigations.
- The conduct of a cultural and archaeological assessment with representatives of the local Aboriginal community, to identify Aboriginal objects, places and/or Aboriginal cultural heritage values. The field investigation would be carried out by the project archaeologist with the assistance of Aboriginal representatives.
- Record/document any Aboriginal objects, places and/or Aboriginal cultural heritage values within the relevant area and assessment of their significance with representatives of the Registered Aboriginal Parties (RAPs).
- In consultation with the RAPs, develop recommended management and mitigation measures for Aboriginal objects, places and/or Aboriginal cultural heritage values, including documentation (where relevant) of previous management and mitigation measures described for the approved CVO.
- Provide a consideration of the potential impacts of the Project on Aboriginal objects, places and/or Aboriginal cultural heritage values within the Project area.

- Describe and justify the outcomes and alternatives.
- Document the Aboriginal cultural heritage impact assessment and the recommendations to minimise potential impacts on Aboriginal cultural heritage.
- Provide a copy of the draft ACHA to the RAPs for their review and feedback.
- Documentation of feedback received as part of the cultural assessment from RAPs for presentation in the final ACHA report (subject to the sensitivity of the information provided).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW, 2010a), Fraser Earthmoving Construction Pty Ltd requests that RAPs provide, where relevant during the conduct of the ACHA, cultural information regarding:

- whether there are any Aboriginal sites/objects of cultural value to Aboriginal people in the relevant area or surrounds; and
- whether there are any places of cultural value to Aboriginal people in the relevant area or surrounds.

This may include places of social, spiritual and cultural value, historic places with cultural significance, and potential places/areas of historic, social, spiritual and/or cultural significance.

3 SUBSURFACE TESTING FOR ABORIGINAL CULTURAL HERITAGE

The methodology for subsurface testing using archaeological excavation at the Project Area is designed to provide information to make reasonable predictions about the presence of Aboriginal cultural heritage at the proposed disturbance areas, and assist in determining the nature, extent and significance of any Aboriginal cultural heritage that may be impacted by the Project. Subsurface testing will comply with Heritage NSW's *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (the *Code of Practice*; DECCW 2010b).

3.1. Objectives

Subsurface testing is required to determine the possible subsurface nature and extent of Aboriginal cultural heritage at the Project area.

3.2. Methodology

Subsurface testing will be supervised by a person appropriately qualified in archaeology and completed in accordance with proper archaeological practice and Requirement 16 "Test excavation that can be carried out in accordance with this Code" of the *Code of Practice* (DECCW 2010). Representatives of registered Aboriginal stakeholder organisations will be involved in the subsurface testing. Appropriate notifications will comply with Requirement 15 "Pre-conditions to carrying out test excavation" of the *Code of Practice* (DECCW 2010b).

Testing will comprise six test excavation units (see Figure 2 for locations). Test excavation units will be 0.5 m x 0.5 m in area. A spade may be used to excavate the topsoil and deposits where there is no cultural material, but as soon as artefacts are identified excavation will be by small hand tools (trowels, where possible). Excavation will be in stratigraphic layers and/or arbitrary levels (maximum of 50 mm spits for the first test unit at an area, and thereafter maximum of 100 mm spits if deemed appropriate) to 100 mm beneath of the base of the soil A horizon or to culturally "sterile" layers. Horizontal and vertical control will be maintained to constrain the three-dimensional context of any artefacts present. All excavated deposits will be sieved with a 5 mm screen.

The stratigraphy and any soil and *in situ* archaeological features will be recorded including by line drawings and photographs with a clear scale and photographic board. Documentation of soils will include texture, Munsell colour, pH and horizonation.

Locations of all test excavation units will be mapped using differential GPS.

3.3. Sampling Strategy

Six test excavation units will be excavated at the Stage 4 disturbance area at the Project Area.

Subsurface testing will cease in the unlikely event that human remains are encountered, in accordance with Requirement 17 “When to stop test excavations” of the *Code of Practice* (DECCW, 2010b).

3.4. Analysis

Any artefacts recovered would be labelled with a unique numeric identifier and separately bagged in a resealable plastic bag. Each bag would also be labelled with the same numeric identifier on an acid-free cardboard tag placed inside the bag. Bags would be collated by site and placed in labelled cardboard archival cartons, in which they were transferred an appropriate storage location[1].

Analysis of any recovered stone artefacts would follow Holdaway and Stern (2004) and be in accordance with Requirements 18 “Artefact recording” and 19 “Attribute recording” of the *Code of Practice* (DECCW, 2010). The attributes recorded to characterize the stone artefact assemblages will include raw material, manufacture type, amount of cortex, dimensions in three planes (length, width, thickness) and any other noteworthy features. Artefacts would be photographed with a scale in accordance with Requirement 20 “Photography and drawing” of the *Code of Practice* (DECCW, 2010b).

3.5. Documentation

Documentation of the subsurface testing will comply with Heritage NSW’s *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011) and the *Code of Practice* (DECCW, 2010b) and include:

- A description of the methodologies used;
- Mapping of all excavations;
- Diagrams of at least one test pit to scale and all test pits and shovel test pits yielding stone artefacts;
- All artefact data in tables and identify their spatial context;
- An analysis of the stratigraphy and the stratigraphic context of the archaeology;
- Predicted artefact extents and densities for the proposed disturbance areas based on recorded artefact densities and landforms identified; and,
- A discussion of past Aboriginal lifestyles and landscape utilisation in the light of these data.

[1] Fraser Earthmoving Construction Pty Ltd would apply to Heritage NSW for a Care Agreement for the appropriate storage and subsequent return of artefacts, in consultation with the registered Aboriginal stakeholders and in accordance with Requirement 26 “Stone artefact deposition and storage” of the *Code of Practice* (DECCW, 2010).

4 SENSITIVE CULTURAL INFORMATION – MANAGEMENT PROTOCOL

In the event that a RAP has sensitive or restricted public access information, it is proposed that Fraser Earthmoving Construction Pty Ltd would manage this information (if provided by the Aboriginal community) in accordance with a sensitive cultural information management protocol.

It is anticipated that the protocol would include making note of and managing the material in accordance with the following key limitations/requirements as advised by the relevant RAP at the time of the information being provided:

- any restrictions on access to the material;
- any restrictions on communication of the material;
- any restrictions on the location/storage of the material;
- any cultural recommendations on handling the material;
- any contextual information;
- any names and contact details of persons authorised by the relevant Aboriginal party to make decisions concerning the Aboriginal material and the degree of authorisation;
- any details of any consent given in accordance with customary law;
- the level of confidentiality to be accorded to the material; and
- any access and use by the RAP, of the cultural information in the material.

All RAPs should be aware of the mandatory requirement that all feedback provided must be documented in the final ACHA (DECCW, 2010a), including copies of any submissions received and the proponents response to the issues raised.

5 ABORIGINAL CULTURAL HERITAGE ASSESSMENT

Following consultation on the Proposed Methodology of the cultural and archaeological assessment, and undertaking any required field components, a draft ACHA report will be prepared. The draft ACHA will be provided to all RAPs for their review and comment, and will include:

- details of the Aboriginal objects, places and/or Aboriginal cultural heritage values within the Project area and how they will be impacted by the Project;
- details of the consultation undertaken and how comments received at various times were considered; and
- management and mitigation recommendations drawing on information provided by RAPs and the results of the cultural and archaeological assessments.

6 PERSONNEL

Project Archaeologist: Dr Matt Cupper would be the project archaeologist. Matt has a wide range of experience in cultural and natural heritage management and an academic background in archaeology, geology and botany, including a PhD in the palaeoecology and early Aboriginal occupation of the Darling River. His particular area of expertise is the interaction of Aboriginal people and arid ecosystems in the interior of Australia. As a consultant archaeologist he has been engaged in many management and research-oriented studies of the Murray Darling Basin for industry and government. These have included investigation of the cultural heritage of western and central NSW for mine developments (including the CVO), and archaeological surveys of water supply and irrigation infrastructure along the Lachlan, Macquarie, Murrumbidgee, Murray and Darling Rivers.

Aboriginal Field Representatives: It is anticiapted that Aboriginal field representatives would be engaged by Fraser Earthmoving Construction Pty Ltd for the duration of the cultural heritage field survey (although this number may be subject to change based on the extent of the area requiring survey or due to workplace health and safety constraints). Aboriginal field representatives (including community leaders and Elders attending community consultation meetings) would invoice and, where appropriate, negotiate with Fraser Earthmoving Construction Pty Ltd directly in relation to engagement for the field surveys. Aboriginal field personnel may be engaged on a rotational basis (e.g. a different team of representatives each day) as required.

7 CRITICAL TIMEFRAMES

Critical timeframes for the ACHA are outlined below:

1. Collation of cultural significant information – ongoing throughout process until the end of the draft ACHA review period.
2. Provision of comments on the Proposed Methodology to Fraser Earthmoving Construction Pty Ltd – to 2 October 2020.
3. Field survey – anticipated to occur in October 2020 (noting that survey dates will be confirmed with relevant representatives of the RAPs as required).
4. Provision of a draft ACHA (including proposed management and mitigation measures) to RAPs for review and comment – anticipated to occur in November 2020 (following field survey).
5. Provision of comments from RAPs on draft ACHA to Fraser Earthmoving Construction Pty Ltd – anticipated to occur in December 2020.
6. Finalise ACHA in consideration of comments received – December 2020.

8 REFERENCES

Advanced Environmental Systems Pty Ltd (2020). *Aboriginal and historic cultural heritage due diligence assessment for the Howlong Sand and Gravel Expansion Project*. Report to Fraser Earthmoving Construction Pty Ltd.

Department of Environment, Climate Change and Water (DECCW) (2010a) *Aboriginal cultural heritage consultation requirements for proponents 2010*.

Department of Environment, Climate Change and Water (DECCW) (2010b). *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. NSW Department of Environment, Climate Change and Water, Sydney.

Holdaway, S. and Stern, N. (2004). *A Record in Stone: The Study of Australia's Flaked Stone Artefacts*. Museum Victoria and AIATSIS.

Office of Environment and Heritage (OEH) (2011). *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. Office of Environment and Heritage, Sydney.

FIGURES

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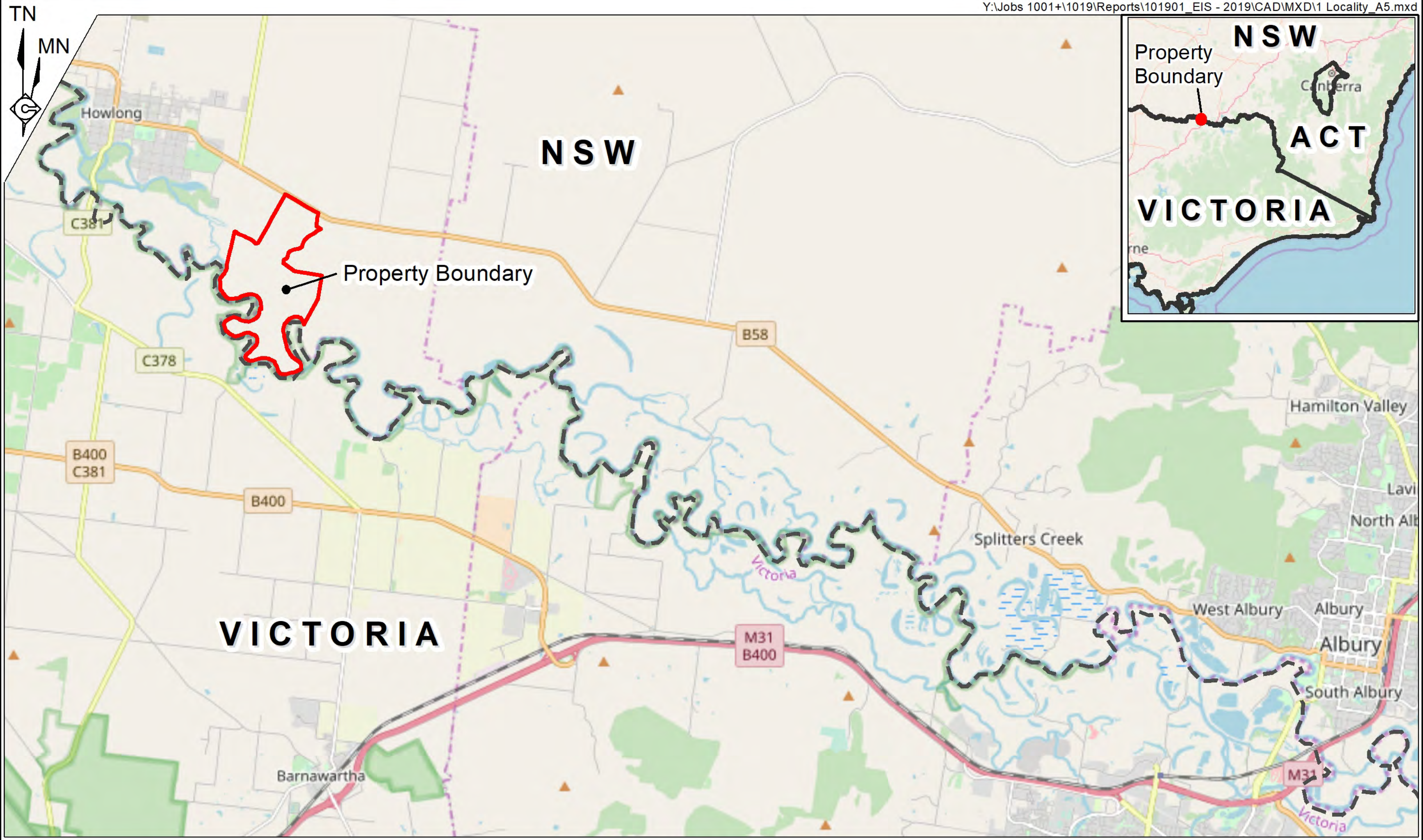


SCALE 1:125 000 (A5)

1.5 0 1.5 3 4.5 km

Source: Open Street Map

REFERENCE

Property Boundary

State Border

Figure 1.1
LOCALITY PLAN

Y:\Jobs 1001+\1019\Reports\101901_EIS - 2019\CAD\1019Base55.dwg_2.3 Site Layout-13.02.2020-10:40 AM

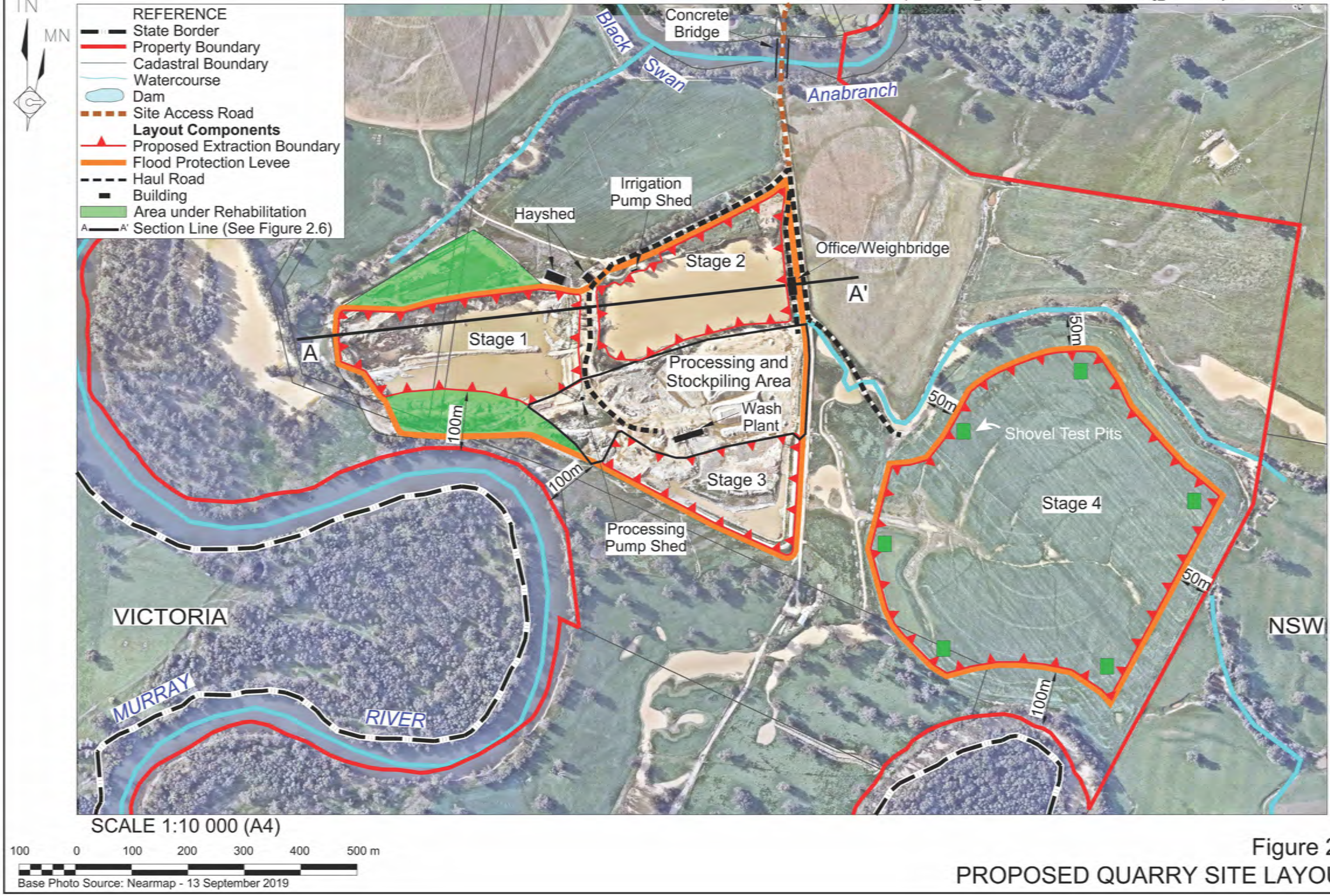


Figure 2
PROPOSED QUARRY SITE LAYOUT

APPENDIX 4. CORRESPONDENCE FROM ABORIGINAL COMMUNITY STAKEHOLDERS

From: **Mark Saddler** marksad@live.com.au
Subject: Howlong Sand and Gravel Quarry
Date: 3 July 2020 at 3:11 pm
To: landskape@telstra.com

MS

Yamma (hello) Matt,

This email is to advise you of my expression of interest for your approval of operation of the quarry.

Can you supply me the link or email to the Director Generals department as well please ?

I will also make my own contact with the relevant people to get more information regarding a proposed AHIP.

Can you also confirm receipt of this email please ?

Guwayu (Safe Travels)

Mark Saddler,
Cultural Awareness,
School & Tour Programs,
Bundyi Cultural Tours,
Web Page: www.bundyiculture.com.au
Facebook Page: https://www.facebook.com/WiradjuriMob/
You Tube Channel:
https://www.youtube.com/channel/UCqQObJ3e8u_WoV7N9xZ2JzA
Ph 0412 693 030

REGIONAL Tourism Awards

COUNTRY & OUTBACK AND RIVERINA MURRAY
GOLD 2019
Aboriginal & Torres Strait Islander Tourism

I respectfully acknowledge the traditional custodians of my land "The Wiradjuri people”

From: ROG South West Region Mailbox rog.southwest@environment.nsw.gov.au
Subject: DPIE BCD Response RE: Aboriginal community consultation Howlong Quarry
Date: 23 June 2020 at 4:18 pm
To: Matt Cupper landskape@telstra.com
Cc: John Gilding John.Gilding@environment.nsw.gov.au, Daniel Clegg Daniel.Clegg@environment.nsw.gov.au

---

Hi Matt,

Please find attached a list of Registered Aboriginal Parties for consultation on the proposed Howlong Sand and Gravel Quarry, Federation LGA.

Regards

Andrew Fisher
Senior Team Leader, Planning – South West

Biodiversity and Conservation I Department of Planning, Industry and Environment
T 02 6022 0623 I **M** 0427 562 844 I **E** andrew.fisher@environment.nsw.gov.au
PO Box 1040, 512 Dean St, Albury, NSW 2640
www.dpie.nsw.gov.au
Contact the South West Planning Team about biodiversity and Aboriginal cultural heritage planning and regulation matters by emailing rog.southwest@environment.nsw.gov.au.

From: Matt Cupper [mailto:landskape@telstra.com]
Sent: Wednesday, 17 June 2020 8:48 AM
To: John Gilding <John.Gilding@environment.nsw.gov.au>
Cc: Andrew Fisher <Andrew.Fisher@environment.nsw.gov.au>; Nicholas Warren <nick@rwcorkery.com>
Subject: Aboriginal community consultation Howlong Quarry

Dear John,

Trust all is well.

You may be aware I've been engaged to assist with the Aboriginal cultural heritage assessment for the proposed Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong.

I will discuss this assessment with you further shortly, but in the first instance, attached is a request for the identification of Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area.

Many thanks for your assistance and please feel free to contact me with any queries.

All the best,
Matt

Dr Matt Cupper
Principal
Landskape

Tel: 0408 006 690

DOC20-471162
Howlon...A.PDF

From: **George Tonna** gtonna@ntscorp.com.au
Subject: RE: Identification of Aboriginal stakeholders Howlong Sand Quarry
Date: 18 June 2020 at 3:00 pm
To: Matt Cupper landskape@telstra.com
Cc: Matilda Vaughan mvaughan@ntscorp.com.au

GT

Will send to Albury & District LALC AND Brolga Family

Ta

George Tonna | Notifications and Land Tenure Officer

t 61 2 9310 3188 | **f** 61 2 9310 4177
m
e gtonna@ntscorp.com.au | **w** www.ntscorp.com.au
Level 1, 44-70 Rosehill Street, Redfern, NSW 2016 Australia

ntscorp

NTSCORP proudly acknowledge that our office is situated on the country of the Gadigal People of the Dharug Nation. We also acknowledge and pay our respect to their Elders past and present.

NTSCORP is committed to supporting local Aboriginal businesses where possible through the purchase of goods and services.

From: Matt Cupper <landskape@telstra.com>
Sent: Wednesday, June 17, 2020 8:38 PM
To: George Tonna <gtonna@ntscorp.com.au>
Cc: Frank Russo <frusso@ntscorp.com.au>
Subject: Identification of Aboriginal stakeholders Howlong Sand Quarry

Dear George,

Fraser Earthmoving Construction Pty Ltd is planning to apply for an approval under Division 4.7 (State significant development) of Part 4 of the *Environmental Planning and Assessment Act 1979* for the continued operation of the Howlong Sand and Gravel Quarry, 4343 Riverina Highway, Howlong, NSW (see Figure 1, attached). The Project would comprise an increase to the annual production rate to 300,000 tpa and expansion into additional extraction areas as well as the ongoing processing, stockpiling and transportation at the increased production intensity.

Landskape on behalf of Fraser Earthmoving Construction Pty Ltd would like to consult with all Aboriginal people who hold cultural knowledge relevant to determining the significance of Aboriginal objects and places in the proposed project area. Could you provide contact details of any known Aboriginal groups or individuals who may hold cultural knowledge relevant to the proposed project area, please?

I would appreciate if you could provide any information regarding Aboriginal stakeholders by 1 Jul 2020 to me: Dr Matt Cupper, Landskape, PO Box 1068 Carlton 3053; e-mail: landskape@telstra.com; tel: 0408 006 690.

Many thanks,

Matt

Dr Matt Cupper
Principal
Landskape

Tel: 0408 006 690

Dr Matt Cupper
Principal
Landskape

Tel: 0408 006 690

From: **Mark Saddler** marksad@live.com.au
Subject: RE: Howlong Sand and Gravel Quarry
Date: 1 February 2021 at 10:41 am
To: Matt Cupper landskape@telstra.com

MS

Yamma Matt,

As long as you have protected the sites we looked from being damaged all is good.

Can you send me your final draft before you complete it please ?

Guwayu (Safe Travels)

Mark Saddler,
Cultural Awareness,
School & Tour Programs,
Bundyi Cultural Tours,
Web Page: www.bundyiculture.com.au
Facebook Page: https://www.facebook.com/WiradjuriMob/
You Tube Channel:
https://www.youtube.com/channel/UCqQObJ3e8u_WoV7N9xZ2JzA
Ph 0412 693 030

"I respectfully acknowledge the traditional custodians of my land, The Wiradjuri people"

"Always Was, Always Will Be"

REGIONAL Tourism Awards

COUNTRY & OUTBACK AND RIVERINA MURRAY
GOLD 2019
Aboriginal & Torres Strait Islander Tourism

From: Matt Cupper
Sent: Monday, 1 February 2021 8:45 AM
To: Mark Saddler
Subject: Re: Howlong Sand and Gravel Quarry

Dear Mark,

Trust you've had a great weekend. I saw you on the ABC news last week and hoping all is going well.

Just wondering if you have any text to incorporate into the draft report for Howlong, please?

Many thanks,
Matt

APPENDIX 5. AHIMS REGISTER SEARCH

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : Howlong

Client Service ID : 550961

LandSkape - Natural & Cultural Heritage Management

P O Box 246
Merbein Victoria 3505

Attention: Matt Cupper

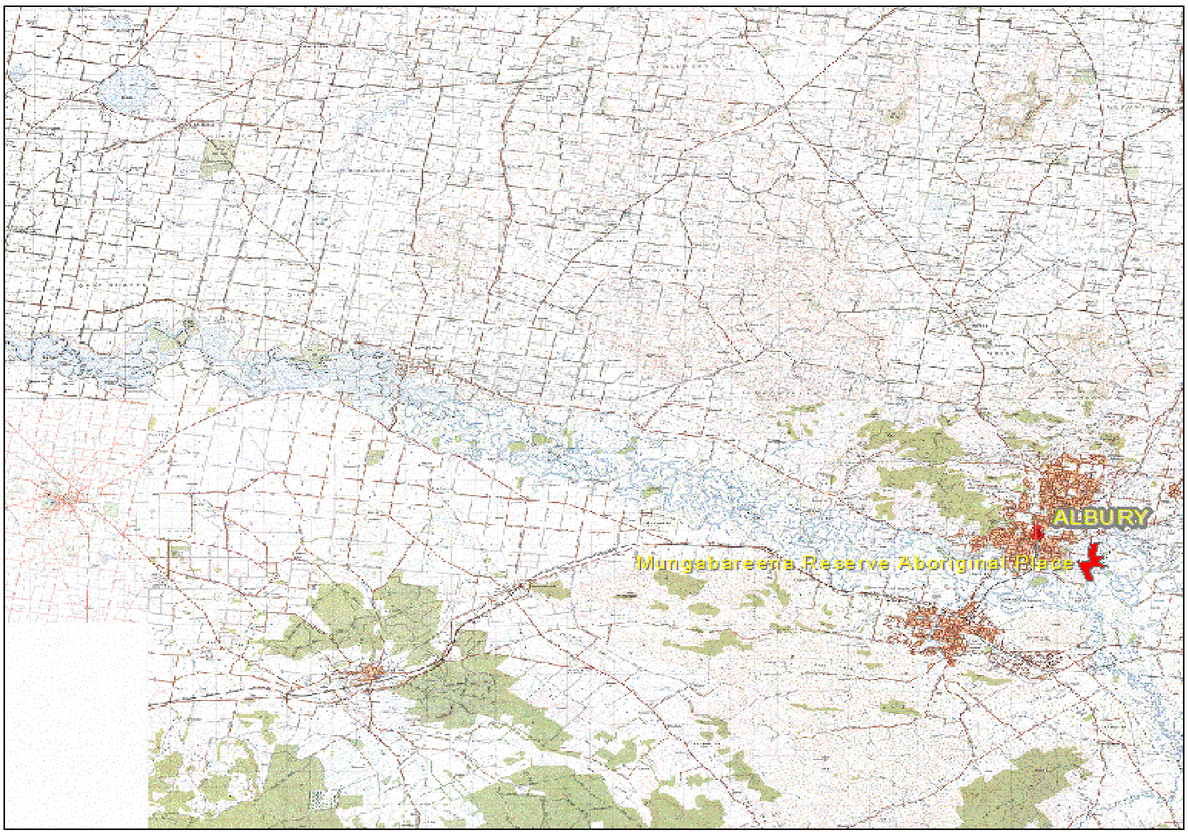
Email: landskape@telstra.com

Date: 19 November 2020

Dear Sir or Madam:

AHIMS Web Service search for the following area at Datum :GDA, Zone : 55, Eastings : 450000 - 498500, Northings : 6010000 - 6020000 with a Buffer of 1000 meters, conducted by Matt Cupper on 19 November 2020.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

108	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0054	Nine Mile Hill;Crown Land, South of Claremont;	AGD	55	498300	6017700	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	
	Contact	**Recorders**	Mr.Michael Mulvaney					**Permits**		
60-3-0065	Ring-a-Rah 1	AGD	55	483370	6009990	Open site	Valid	Hearth : 1, Artefact : -		98391
	Contact	**Recorders**	Joanne Bell					**Permits**	1417	
55-6-0041	ABP/NSW 5	AGD	55	492840	6020080	Open site	Valid	Artefact : 4		
	Contact	**Recorders**	Joanne Bell					**Permits**		
55-6-0042	ABP/NSW 6	AGD	55	492800	6020120	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Joanne Bell					**Permits**		
55-6-0043	ABP/NSW 4	AGD	55	485430	6016910	Open site	Valid	Artefact : 14		
	Contact	**Recorders**	Joanne Bell					**Permits**		
60-3-0066	ABP/NSW 2	AGD	55	483520	6013310	Open site	Valid	Artefact : 16		
	Contact	**Recorders**	Joanne Bell					**Permits**		
60-3-0067	ABP/NSW 3	AGD	55	483530	6013400	Open site	Valid	Artefact : 15		
	Contact	**Recorders**	Joanne Bell					**Permits**		
60-3-0068	ABP/NSW 1	AGD	55	482870	6009680	Open site	Valid	Artefact : 27		
	Contact	**Recorders**	Joanne Bell					**Permits**		
55-6-0081	Riverview IF 2	GDA	55	459201	6019284	Open site	Valid	Artefact : 1		100755
	Contact	**Recorders**	Total Earth Care Pty Ltd					**Permits**	2868	
61-3-0115	mod tree 1	AGD	55	499226	6009561	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders**	Mr.Graham Moore					**Permits**		
60-3-0100	mod tree 2	AGD	55	498839	6008999	Open site	Valid	Modified Tree (Carved or Scarred) : 1		102166
	Contact T Russell	**Recorders**	Mr.Graham Moore					**Permits**		
55-6-0066	mod tree 3	AGD	55	497824	6016639	Open site	Deleted	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders**	Mr.Graham Moore					**Permits**		
55-6-0067	mod tree 4	AGD	55	498375	6018203	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact T Russell	**Recorders**	Mr.Graham Moore					**Permits**		

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
55-6-0069	mod tree 6	AGD	55	499176	6020291	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders** Mr.Graham Moore						**Permits**		
55-6-0064	mungabareena-mm1	GDA	55	497447	6017227	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Sarah Colley	**Recorders** Biosis Pty Ltd - Sydney,Mr.Michael Mulvaney,Ms.Meaghan Aitchison,Ms.Meaghan A						**Permits**		
60-3-0101	CES2 (Albury)	GDA	55	493447	6012542	Open site	Valid	Artefact : -		100568,101135
	Contact Searle	**Recorders** Mr.Chris Price						**Permits**	2699	
60-3-0102	CES3 (Albury)	GDA	55	493396	6012228	Open site	Valid	Artefact : -		100568,101135
	Contact Searle	**Recorders** Mr.Chris Price						**Permits**	2699	
60-3-0103	CES4 (Albury)	GDA	55	493285	6012327	Open site	Valid	Artefact : -		100568,101135
	Contact Searle	**Recorders** Mr.Chris Price						**Permits**	2699	
55-6-0065	MUNGABARINA-MM3	AGD	55	499181	6020291	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Sarah Colley	**Recorders** Mr.Stephen Mark Free						**Permits**		
60-3-0099	Hume Golf Club	GDA	55	492295	6010334	Open site	Valid	Artefact : 5		100579,102080
	Contact Albury & District LALC	**Recorders** Mr.Graham Moore,Mr.Michael Mulvaney						**Permits**	2753,3242	
55-6-0073	Sargent Rd - mm7	GDA	55	498413	6020640	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders** Mr.Michael Mulvaney						**Permits**		
55-5-0054	Iona Mt	AGD	55	454521	6019040	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders** Mr.Dean Freeman						**Permits**		
60-3-0105	Negari Mt	AGD	55	471372	6013135	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders** Mr.Dean Freeman						**Permits**		
60-3-0113	AL01 (duplicate of 60-3-0108)	GDA	55	490588	6013318	Open site	Valid	Artefact : 1		101228
	Contact	**Recorders** Biosis Pty Ltd - Sydney,Mr.Dominic Brady						**Permits**		
60-3-0117	Black Spring Creek AS 1	GDA	55	491236	6010493	Open site	Valid	Artefact : 1		
	Contact	**Recorders** Ms.Ashley Edwards,Jo Bell Heritage Services Pty Ltd						**Permits**		

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0119	TH-15-AS1	GDA	55	496962	6009779	Open site	Valid	Artefact : -, Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Mr.Luke Wolfe					Permits	4113	
60-3-0118	Black Springs Creek AS 1	GDA	55	491236	6010493	Open site	Valid	Artefact : 1		
	Contact	Recorders	Ms.Ashley Edwards,Jo Bell Heritage Services Pty Ltd					Permits		
55-6-0198	Quat Quatta ST1	GDA	55	462052	6018367	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Ms.Amanda Lavender,Ms.Amanda Lavender,DPIE,DPIE					Permits		
55-6-0197	Quat Quatta M1	GDA	55	456424	6020823	Open site	Valid	Shell : -		
	Contact	Recorders	Ms.Amanda Lavender,DPIE					Permits		
60-3-0153	Nail Can Hill IF 2	GDA	55	490022	6009939	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Matthew Barber,NGH Heritage - Fyshwick					Permits		
60-3-0154	Nail Can Hill IF 1	GDA	55	488827	6014260	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Matthew Barber,NGH Heritage - Fyshwick					Permits		
60-3-0155	Nail Can Hill AFT 1	GDA	55	489516	6011670	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Matthew Barber,NGH Heritage - Fyshwick					Permits		
60-3-0146	Andersons Clay Mine IF1	GDA	55	495249	6013801	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Matthew Barber,NGH Heritage - Fyshwick					Permits		
60-3-0147	Trinity Artefact Scatter	GDA	55	498691	6012776	Open site	Valid	Artefact : -		
	Contact	Recorders	Biosis Pty Ltd - Sydney,Ms.Meaghan Aitchison					Permits		
55-6-0242	Ettamogah Rock Shelters	GDA	55	498531	6018323	Open site	Valid	Artefact : -, Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Ms.Ashley Edwards,Ms.Ashley Edwards,Biosis Pty Ltd - Albury - Ashley Edwards,Bi					Permits		
60-3-0057	BP6	AGD	55	483300	6013150	Open site	Valid	Artefact : -	Open Camp Site	100576
	Contact	Recorders	James Leslie Smith					Permits		
55-6-0008	Jindera;	AGD	55	494382	6019229	Open site	Valid	Artefact : -	Open Camp Site	54
	Contact	Recorders	ASRSYS					Permits		
55-6-0009	Jindera;	AGD	55	494848	6018412	Open site	Valid	Artefact : -	Open Camp Site	54
	Contact	Recorders	ASRSYS					Permits		
55-6-0019	WW16;Whittaker Lane;	AGD	55	472220	6017030	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	98638
	Contact	Recorders	Mr.Kelvin Officer					Permits		
55-6-0037	BP 5 (Howlong)	AGD	55	485650	6017300	Open site	Valid	Artefact : -	Open Camp Site	100576

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Laura-Jane Smith					Permits		
60-3-0040	Nursery Valley 3;	AGD	55	488200	6009200	Open site	Valid	Artefact : -	Open Camp Site	2808
	Contact	Recorders	Robert Paton					Permits		
60-3-0041	Nursery Valley 4;	AGD	55	488000	6009000	Open site	Valid	Artefact : -	Open Camp Site	2808
	Contact	Recorders	Robert Paton					Permits		
60-3-0048	WW2_Morebringer 1;	AGD	55	471420	6014140	Open site	Valid	Artefact : -	Open Camp Site	98639,98640
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
60-3-0049	WW1 Negari 1;	AGD	55	471490	6012800	Open site	Valid	Artefact : -	Open Camp Site	98639,98640
	Contact	Recorders	Mr.Kelvin Officer					Permits		
60-3-0050	WWIF2;	AGD	55	472120	6012950	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
60-3-0051	WWIF1	AGD	55	471880	6014750	Open site	Valid	Artefact : -	Isolated Find	
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
60-3-0052	WW4 Lesters lagoon 2;	AGD	55	472280	6014510	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	98639,98640
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
60-3-0053	WW3 Lesters Lagoon 1;	AGD	55	471750	6014800	Open site	Valid	Artefact : -	Open Camp Site	98637,98639,98640
	Contact	Recorders	Kerry Navin,Mr.Kelvin Officer					Permits		
60-3-0001	Thurgoona 1;	AGD	55	499056	6009132	Open site	Valid	Artefact : -	Open Camp Site	230,742,1463,102166
	Contact	Recorders	ASRSYS					Permits	1542	
60-3-0002	Thurgoona 2;	AGD	55	499054	6009315	Open site	Valid	Artefact : -	Open Camp Site	230,742,1463,102166
	Contact	Recorders	ASRSYS					Permits	1542	
60-3-0003	Thurgoona 3;	AGD	55	499316	6010506	Open site	Valid	Artefact : -	Open Camp Site	230,742,1463,102166
	Contact	Recorders	ASRSYS					Permits		
60-3-0004	Bungawannah Burial Ground;	AGD	55	477536	6013207	Open site	Valid	Burial : -, Artefact : -	Burial/s,Open Camp Site	1483
	Contact	Recorders	ASRSYS					Permits		
60-3-0005	One Tree Hill;TS7;	AGD	55	498711	6015983	Open site	Valid	Artefact : -	Open Camp Site	230
	Contact	Recorders	ASRSYS					Permits		
60-3-0006	One Tree Hill;Ettamogah Sanctuary;T/58;	AGD	55	498449	6014793	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	230
	Contact	Recorders	ASRSYS					Permits		

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0007	One Tree Hill;Ettamogah Sanctuary;T/59;	AGD	55	498449	6014793	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	230
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0008	One Tree Hill;Ettamogah Sanctuary;TS10;	AGD	55	498449	6014793	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	203,230
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0009	One Tree Hill;TS6;	AGD	55	498082	6014972	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	203,230
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0010	One Tree Hill;TS5;	AGD	55	498165	6015795	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	230
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0011	One Tree Hill;TS4;	AGD	55	494078	6013285	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	230
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0012	Dights Hill 1;	AGD	55	483038	6011435	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	276
	Contact	**Recorders**	ASRSYS					**Permits**		
55-6-0007	Jindera;	AGD	55	494382	6019229	Open site	Valid	Artefact : -	Open Camp Site	54
	Contact	**Recorders**	ASRSYS					**Permits**		
60-3-0070	AWH 1 PAD 10	GDA	55	499260	6016050	Open site	Valid	Artefact : 5		99657
	Contact Colin Clark	**Recorders**	Mr.Terence J. Kelly					**Permits**	2246,2334	
60-3-0108	AL01 (Albury)	GDA	55	490588	6013318	Open site	Partially Destroyed	Artefact : 1		101228,101697
	Contact	**Recorders**	Mr.Dominic Brady					**Permits**	3311,3312	
60-3-0106	CEST1 (Albury)	GDA	55	493449	6012436	Open site	Valid	Modified Tree (Carved or Scarred) : 1		101135
	Contact	**Recorders**	Mr.Chris Price					**Permits**		
60-3-0107	CES1 (Albury)	GDA	55	493488	6012557	Open site	Valid	Modified Tree (Carved or Scarred) : 1		101135
	Contact	**Recorders**	Mr.Chris Price					**Permits**		

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0092	Albury Wadonga Highway 4 and 5	AGD	55	498446	6013670	Open site	Valid	Artefact : -		
	Contact T Russell	Recorders	Parklands - Albury Wodonga					Permits		
55-6-0091	Sargent Rd 2	GDA	55	498377	6020714	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Office of Environment & Heritage					Permits		
60-3-0134	Howlong 1	GDA	55	470393	6015022	Open site	Valid	Artefact : -		
	Contact	Recorders	Ms.Jacqui Duncan,Tim Stone Pty. Ltd.					Permits		
55-6-0142	Jindera Scarred Tree	GDA	55	489213	6020956	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	Mr.Kyle Moffitt					Permits		
60-3-0136	Hume Country Estate 1	GDA	55	491060	6010660	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0137	Hume Country Estate 2	GDA	55	491726	6010240	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0138	Hume Country Estate 3	GDA	55	491595	6010340	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0139	Hume Country Estate 4	GDA	55	492028	6010270	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0140	Hume Country Estate 5	GDA	55	491368	6010730	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0141	Hume Country Estate 6	GDA	55	492018	6010540	Open site	Valid	Artefact : -		
	Contact	Recorders	Mr.Damian Wall					Permits		
60-3-0059	RING A RAH 1	AGD	55	483370	6009990	Open site	Valid	Artefact : -		
	Contact	Recorders	Joanne Bell,M Chamberlain					Permits		
60-3-0060	RING A RAH 2	AGD	55	483030	6009790	Open site	Valid	Artefact : -		
	Contact	Recorders	Joanne Bell,M Chamberlain					Permits		
60-3-0061	RING-A-RAH 3	AGD	55	482470	6009350	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Joanne Bell,M Chamberlain					Permits		
55-6-0039	scholz 1	AGD	55	487380	6017400	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Joanne Bell					Permits		

Report generated by AHIMS Web Service on 19/11/2020 for Matt Cupper for the following area at Datum :GDA, Zone : 55, Eastings : 450000 - 498500, Northings : 6010000 - 6020000 with a Buffer of 1000 meters. Additional Info : Identify previously recording Aboriginal cultural heritage sites in activity area. Number of Aboriginal sites and Aboriginal objects found is 108

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0062	MOORANGURY ROAD RESERVE	AGD	55	483260	6010840	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	**Recorders**	Joanne Bell,M Chamberlain					**Permits**		
60-3-0063	MOORANGURY 1	AGD	55	484980	6015510	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Joanne Bell,M Chamberlain					**Permits**	1417	
60-3-0064	RING-A-RAH 4	AGD	55	482450	6009300	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Joanne Bell,M Chamberlain					**Permits**		
60-3-0069	Little Billabong	AGD	55	498270	6013291	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	**Recorders**	Archaeological Risk Assessment Services (ARAS),Mr.Giles (dup ID#12832) Hamm					**Permits**		
60-3-0077	AWH 8 PAD 6	AGD	55	498375	6013678	Open site	Valid	Artefact : 15		
	Contact Searle	**Recorders**	Mr.Terence J. Kelly,Mr.Stephen Pollock					**Permits**	2334	
60-3-0078	AWH 9 PAD 7	AGD	55	498476	6013866	Closed site	Valid	Artefact : 26		
	Contact Searle	**Recorders**	Mr.Terence J. Kelly,Mr.Stephen Pollock					**Permits**	2334	
60-3-0079	AWH 10 PAD 8	AGD	55	498598	6014004	Open site	Valid	Artefact : 24		99657
	Contact Searle	**Recorders**	Mr.Terence J. Kelly,Mr.Stephen Pollock					**Permits**	2334	
60-3-0080	AWH 11 PAD 9	AGD	55	499036	6015329	Open site	Valid	Artefact : 23		99657
	Contact Searle	**Recorders**	Mr.Terence J. Kelly,Mr.Stephen Pollock					**Permits**	2334	
60-3-0093	Mitchell Park Scar Tree1	AGD	55	498521	6013801	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact T Russell	**Recorders**	Parklands - Albury Wodonga					**Permits**		
60-3-0076	AWH 7 PAD 4	AGD	55	497519	6011692	Open site	Valid	Artefact : 20		
	Contact	**Recorders**	Mr.Terence J. Kelly					**Permits**	2334	
60-3-0097	Centaur Rd	AGD	55	492413	6012374	Open site	Valid	Artefact : 150		100267
	Contact Searle	**Recorders**	Mr.Stephen Pollock					**Permits**	2585	
60-3-0098	Carsten St CEPAD1	GDA	55	493285	6012327	Open site	Valid	Potential Archaeological Deposit (PAD) : -		100568
	Contact	**Recorders**	Mr.Stephen Pollock					**Permits**	2600,2608,2699	
60-3-0094	12 mile MT	AGD	55	475828	6013479	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Sarah Colley	**Recorders**	Mr.Dean Freeman					**Permits**		

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0095	HV1	GDA	55	492413	6012190	Open site	Valid	Potential Archaeological Deposit (PAD) : -		
	Contact Searle	**Recorders**	Mr.Stephen Pollock					**Permits**	2512,2585	
60-3-0096	HV 1	AGD	55	492413	6012190	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Mr.Stephen Pollock					**Permits**		
60-3-0112	HEAS 1	GDA	55	492278	6010329	Open site	Valid	Artefact : 65		100579,102080
	Contact	**Recorders**	Mr.Stephen Pollock					**Permits**	2753,3242	
55-6-0103	Nexus AS1	GDA	55	497178	6016606	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Ashley Edwards					**Permits**	4118	
55-6-0104	Nexus AS2	GDA	55	497470	6016626	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Ashley Edwards					**Permits**	4118	
55-6-0105	Nexus AS3	GDA	55	497753	6016671	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Ashley Edwards					**Permits**	4118	
55-6-0106	Nexus AS4	GDA	55	497726	6016789	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Bridget Grinter					**Permits**	4118	
55-6-0107	Nexus AS5	GDA	55	497424	6016897	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Bridget Grinter					**Permits**	4118	
55-6-0108	Nexus AS6	GDA	55	497424	6017034	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Bridget Grinter					**Permits**	4118	
55-6-0109	Nexus AS7	GDA	55	497030	6017049	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Bridget Grinter					**Permits**	4118	
60-3-0121	Nexus AS8	GDA	55	497609	6015930	Open site	Destroyed	Artefact : 1		103840
	Contact	**Recorders**	Biosis Research (to be deleted),Ms.Bridget Grinter					**Permits**	4118	
60-3-0158	ROCKWOOD-LANE-AS1	GDA	55	497775	6015830	Open site	Valid	Artefact : 1, Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Biosis Pty Ltd - Albury - Ashley Edwards,Ms.Meaghan Aitchison					**Permits**		
60-3-0159	ROCKWOOD-LANE-AS2	GDA	55	497625	6015766	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Biosis Pty Ltd - Albury - Ashley Edwards,Ms.Meaghan Aitchison					**Permits**		
60-3-0160	ROCKWOOD-LANE-AS3	GDA	55	497537	6015586	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Biosis Pty Ltd - Albury - Ashley Edwards,Ms.Meaghan Aitchison					**Permits**		
60-3-0156	Hamilton Valley Artefact 2	GDA	55	489969	6013991	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Ms.Meaghan Aitchison,Jacobs Group (Australia) Pty Ltd - Wangaratta					**Permits**		

Report generated by AHIMS Web Service on 19/11/2020 for Matt Cupper for the following area at Datum :GDA, Zone : 55, Eastings : 450000 - 498500, Northings : 6010000 - 6020000 with a Buffer of 1000 meters. Additional Info : Identify previously recording Aboriginal cultural heritage sites in activity area. Number of Aboriginal sites and Aboriginal objects found is 108

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
60-3-0157	Hamilton Valley Artefact 1	GDA	55	490164	6013854	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Ms.Meaghan Aitchison,Jacobs Group (Australia) Pty Ltd - Wangaratta					**Permits**		

Appendix 6

Biodiversity Development Assessment Report prepared by EnviroKey – October 2021

(Total No. of pages including blank pages = 98)

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Biodiversity Development Assessment Report

Howlong Sand and Gravel Quarry Expansion

A report prepared for RW Corkery & Co Pty Limited on behalf of Fraser Earthmoving Construction

OCTOBER 2021

Report No. 20.BDAR-068

Citation

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EnviroKey	Project Title:	Proposed Howlong Sand and Gravel Quarry Expansion
Project Identifier :	20.BDAR-068	
Project Location:	\EnviroKey Public\Projects\RWC\Howlong	

Revision	Date	Prepared by (name)	Reviewed by (name)	Approved by (name)
Draft	09.08.2020	SS, AM, LS	LS	Steve Sass (CEnvP)
Final Draft	14.08.2020	SS	-	Steve Sass (CEnvP)
Final Draft v2	26.08.2020	SS	-	Steve Sass (CEnvP)
Final	27.10.2021	SS	-	Steve Sass (CEnvP)

Disclaimer

The scope of work for this report was defined by time and budgetary constraints and the availability of other reports and data.

EnviroKey accept no liability or responsibility for or in respect of any use of or reliance upon this report and its supporting material in whole or in part by any third party. Information in this report is not intended to be a substitute for site specific assessment or legal advice in relation to any matter.

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ABN 35150812570

Definitions & Acronyms used within this report

Activity	The nature of the proposed activity, as described in section 1.2
BAM	Biodiversity Assessment Methodology
BC Act	NSW Biodiversity Conservation Act 2016
BCD	Biodiversity Conservation Division
BC Reg	NSW Biodiversity Conservation Regulation 2017
BDAR	Biodiversity Development Assessment Report
BDAR footprint	The footprint of the proposed activity, that is the area of direct impact
BCF	Biodiversity Conservation Fund
BCT	Biodiversity Conservation Trust
DoEE	Department of the Environment & Energy
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
IBRA	Interim Bioregionalisation of Australia
LGA	Local Government Area
Likely	taken to be a real chance or possibility
Locality	means the area within a 5 km radius of the proposed activity
migratory species	a species specified in the schedules of the EPBC Act
PCT	Plant community type

Region means a biogeographical region that has been recognised and documented such as the Interim Biogeographical Regions of Australia (IBRA) (Thackway and Creswell, 1995). The study area is located within the Riverina Bioregion

Study area includes the Development footprint and any additional areas that are likely to be affected by the proposed activity, either directly or indirectly

Subject land the land containing the existing quarry operation

Subject site the area to be directly affected by the proposed activity. That is, the footprint of the proposed activity, also referred to as the BDAR footprint.

TEC threatened ecological community

threatened biota means those threatened species, endangered populations or endangered ecological communities considered known or likely to occur in the study area

threatened species a species specified in the schedules of the BC Act or the EPBC Act

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Figures, Maps & Tables

1 INTRODUCTION

EnviroKey was engaged by RW Corkery & Co Pty Limited (RWC) on behalf of Fraser Earthmoving Construction (FEC) (the "Applicant") to prepare a Biodiversity Development Assessment Report (BDAR) for the Howlong Sand and Gravel Quarry Expansion Project (now referred to as the "Project") located approximately 25 kilometres west of Albury and 3 kilometres east of Howlong, New South Wales (see **Map 1**). The Project is classified as a State Significant Development (SSD 8804) with approval required from the NSW Minister for Planning and Public spaces for a Development Consent under Division 4.7 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

This BDAR has been prepared by Mr Steven Sass, an Accredited Assessor (BAAS17047) under the NSW *Biodiversity Conservation Act 2016* (BC Act) and is consistent with the Biodiversity Assessment Methodology (BAM) (OEH, 2017a). Details of all personnel involved in the field surveys or the preparation of this BDAR are provided in **Appendix 1.**

1.1 PREVIOUS BDAR

A BDAR was previously prepared for the Project by Advanced Environmental Systems (AES, 2020). After comment was provided by Biodiversity Conservation Division (BCD) to the Department of Planning, Industry and Environment (DPIE) on the BDAR and subsequently given to RWC, **EnviroKey** was engaged to prepare this BDAR.

EnviroKey have used minimal information contained within the previously prepared BDAR. This is limited to threatened species sightings and the list of flora and fauna recorded within the Subject Land. BAM plot data prepared by AES (2020) has not been used for this BDAR with data collated by EnviroKey during a field survey on 6-7 July 2020. However, field survey outcomes may be considered alongside AES (2020) to provide a comprehensive overview of all biodiversity survey results within the project area.

1.2 PROPOSED ACTIVITY

The Project would comprise an increase of the annual production rate of the existing quarry operation to 300,000 tonnes per annum (tpa) based on extraction of 330,000tpa of raw materials, as well as an expansion into additional extraction areas. For the purpose of this report, the additional extraction areas are defined as the BDAR footprint.

1.3 SUBJECT LAND

The Subject Land is located about 3 kilometres east of Howlong (**Map 1**). For the purpose of this report, the Subject Land has been defined as the area owned by Nugania Pty Ltd and contains a larger area encompassing the BDAR footprint (i.e., the area of direct impact), and surrounding areas that may be subject to potential indirect impacts (**Map 2**).

The Subject Land is located within the Riverina Bioregion and Murray Plains IBRA subregion (Thackway and Creswell, 1995, NPWS, 2003), Federation local government area (LGA) and Murray Channels and Floodplains and Murray Scaled Plains Mitchell Landscapes (Mitchell, 2002).

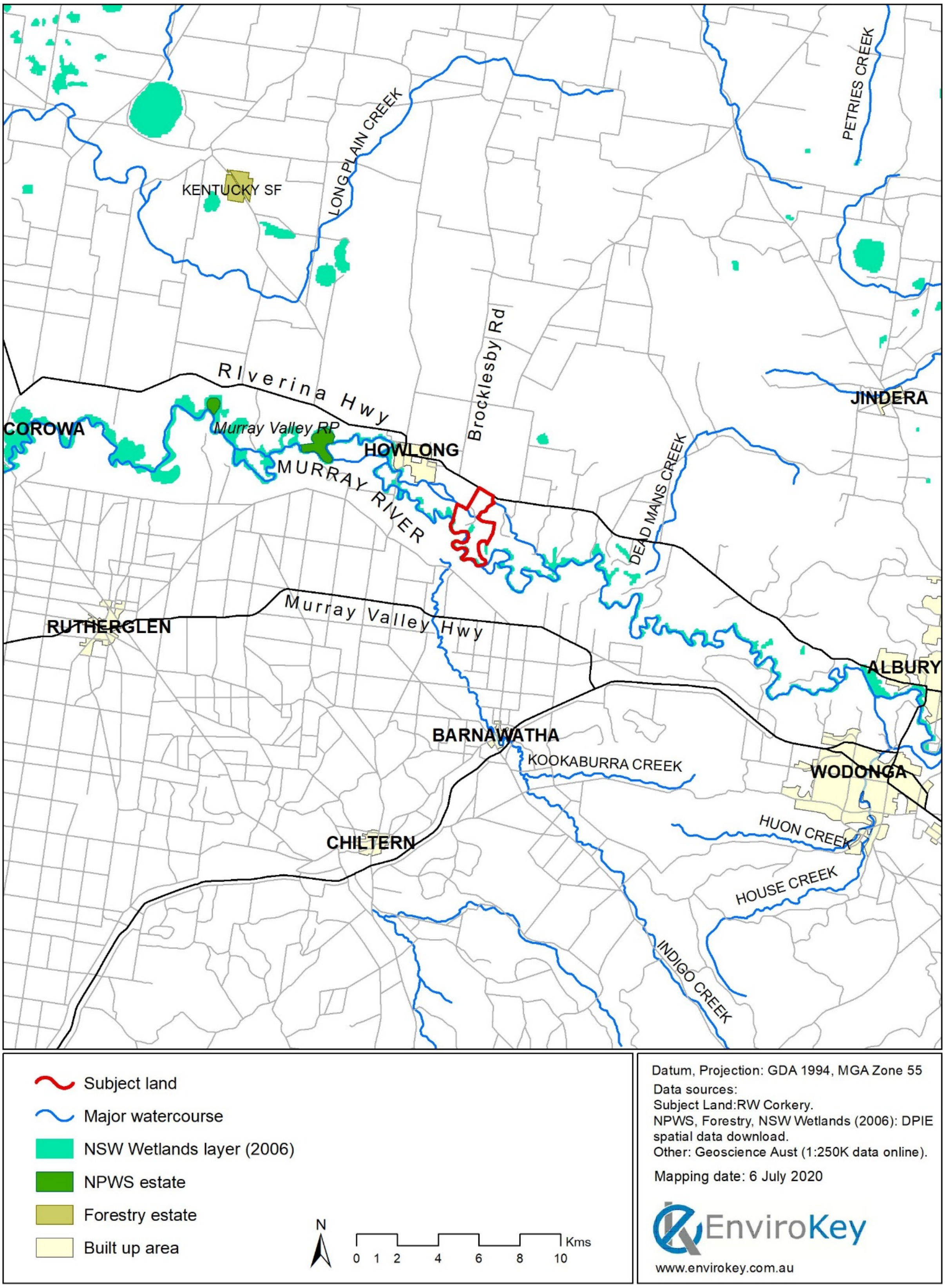
1.4 BIODIVERSITY OFFSET SCHEME

The *Biodiversity Conservation Regulation 2017* sets out thresholds for when the Biodiversity Offset Scheme (BOS) will be triggered. The threshold has three triggers:

1. Whether the amount of native vegetation being cleared exceeds a threshold based on minimum lot size associated with the property;
2. Whether the area cleared is mapped as ‘sensitive’ on the Biodiversity Values Map published by the NSW Office of Environment and Heritage; or
3. Whether a significant impact is likely according to a ‘test of significance’.

Based on the Biodiversity Offset Scheme Entry Threshold (BOSET) Map provided in **Appendix 2,** the proposed activity, it is unknown if the BDAR footprint exceeds the area clearing threshold. However, the SEARs confirm that a BDAR is required for the SSD application, as is required for all SSD projects.

On this basis, the BOS is triggered and a BDAR is the appropriate assessment pathway.



Map 1: Regional location of the study area.

2 LANDSCAPE CONTEXT

2.1 IDENTIFY LANDSCAPE FEATURES

In accordance with the BAM, a number of features are assessed within and surrounding the Subject Land. This section provides details relating to the IBRA region and subregion and NSW landscape region (Mitchell Landscapes) (**Map 2**). Other landscape features such as rivers, streams, estuaries and wetlands, habitat connectivity, karst areas or areas of outstanding biodiversity value are considered where appropriate.

2.1.1 IBRA bioregions and IBRA subregions

IBRA bioregions represent a landscape-based approach to the classification of land including geomorphology, landform, climate, lithology and characteristic flora and fauna. The proposed extraction area (BDAR footprint) is located entirely within the Riverina IBRA region and Murray Fans IBRA subregion (**Map 2**).

2.1.2 NSW landscape regions (Mitchell Landscapes)

The Subject land and BDAR footprint occur within two NSW Mitchell Landscapes; 'Murray Channels and Floodplains' and 'Murray Scalded Plains' (**Map 2**).

The Murray Channels and Floodplains Mitchell landscape comprises active channels and seasonally inundated floodplains of the Murray River and streams in Quaternary alluvium with associated billabongs, swamps, channels, levees and source bordering dunes with relief to only about 10 metres (Mitchell, 2002). This landscape generally consists of river red gum forests (*Eucalyptus camaldulensis*) with black box (*Eucalyptus largiflorens*) and river cooba (*Acacia stenophylla)*.

The Murray Scalded Plains landscape is characterised by quaternary alluvial plains with extensive scalding an artifact of relic floodplains, terraces or part of the Cadell tilt block. This landscape is generally cleared, cropped and grazed, and formerly open woodland and grasslands of white cypress pine (*Callitris glaucophylla*), grey box (*Eucalyptus microcarpa*) and myall (*Acacia pendula*) with annual grasses and herbs.

2.1.3 Other features

Wetlands

While the Subject Land does contain some wetlands as defined by DPIE desktop mapping (**Map 2**), these are located outside of the BDAR footprint, do not exist or both. For example, a wetland area is mapped between the smallest of the BDAR footprints and the Murray River. The large pit containing water, and the existing quarry operation, could not be considered natural wetlands as mapped on the DPIE State Wetlands layer (**Map 2**). Only one natural wetland is located within the direct vicinity of the BDAR footprint, which is an oxbow wetland.

Oxbow wetlands are a meander of the original river, in this case, the Murray River, that has become separated from the flow of water (Davies, 2000). One is located to the north of the eastern portion of the BDAR footprint (**Figure 1**). Over time, oxbow wetlands store excess water that might otherwise lead to flooding and provide floodplain connectivity. The oxbow wetland is likely to continue to receive water during major flood events and floodplain connectivity would remain.

Figure 1: Oxbow wetland within the Subject Land (just north of BDAR footprint)

The artificial waterbodies within the Subject Land could also be considered wetlands given the relatively permanent nature of these features. The large pit (adjacent to the BDAR footprint) that contains water is one of these features (**Figure 2**). Both the natural and artificial wetlands provide habitat for a range of species including waterbirds and frogs.

Figure 2: Example of artificial wetland within the Subject Land

Rivers and streams

The Murray River is located adjacent to the southern boundary of the Subject Land, and at its closest point, is about 30 metres from the river. Overall, the Murray River is 2,508 kilometres in length, making it Australia's longest river. It begins in the Australian Alps draining the western side of the Great Dividing Range. For most of its length, it forms the border between NSW and Victoria, flowing northwest into South Australia until it reaches the Southern Ocean at Lake Alexandrina.

The lower Murray River catchment is listed as aquatic endangered ecological community (DPI, 2007). The listing includes all native fish and aquatic invertebrates within all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River downstream of Hume Weir, the Murrumbidgee River downstream of Burrinjuck Dam, the Tumut River downstream of Blowering Dam and all their tributaries anabranches and effluents including Billabong Creek, Yanco Creek, Colombo Creek, and their tributaries, the Edward River and the Wakool River and their tributaries, anabranches and effluents, Frenchmans Creek, the Rufus River and Lake Victoria. Given this, the Black Swan Anabranch that flows roughly west to east within the Subject Land (about 210 metres north of the BDAR footprint) and the oxbow billabong (which is located adjacent to the BDAR footprint).

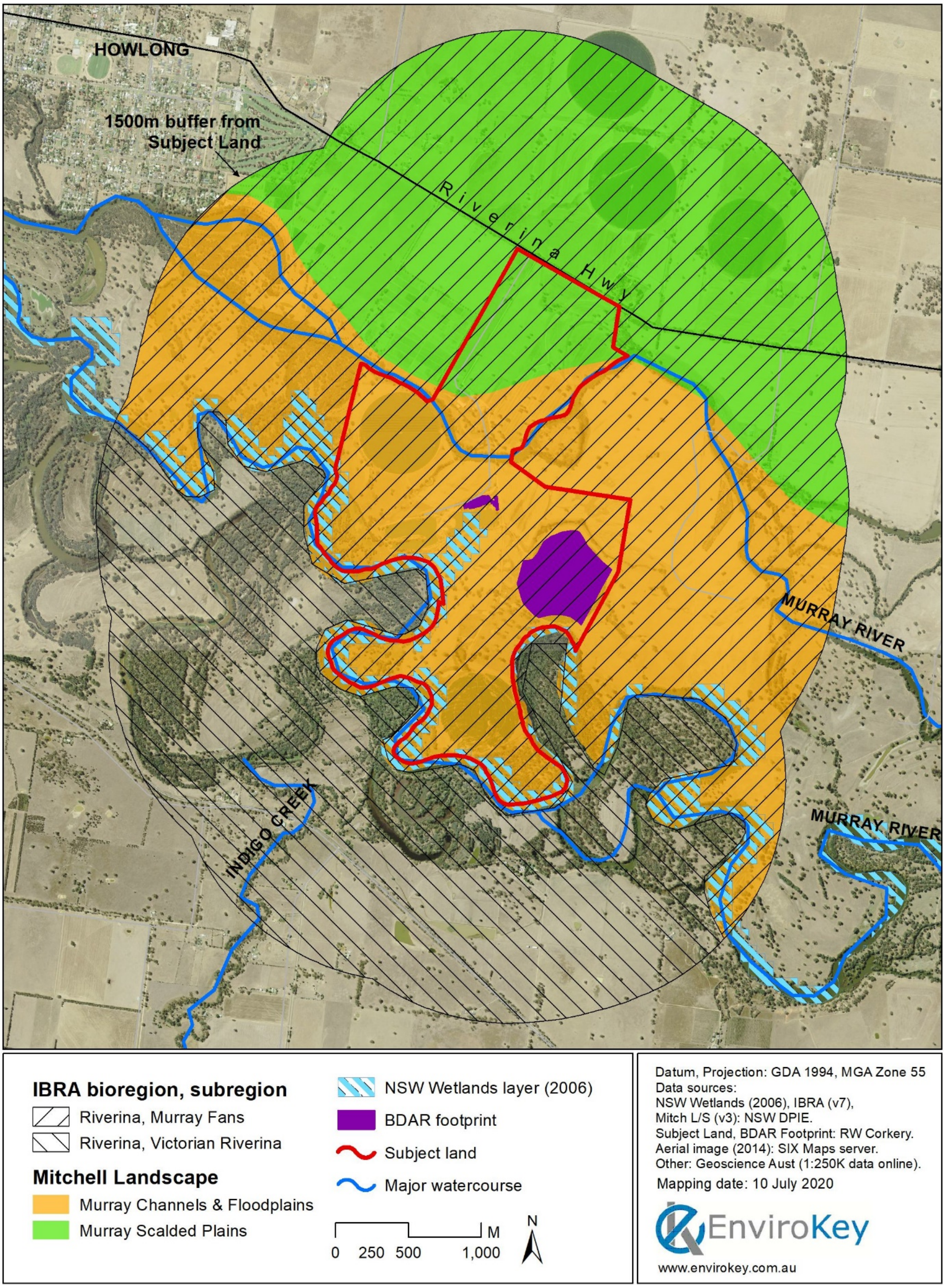
The Black Swan Anabranch and the Murray River have been recognised as having biodiversity values under the *Biodiversity Conservation Act 2016* and have been mapped under the Regulation as sensitive biodiversity areas (**Map 3**). The oxbow wetland is not mapped on the biodiversity values mapping.

Connectivity

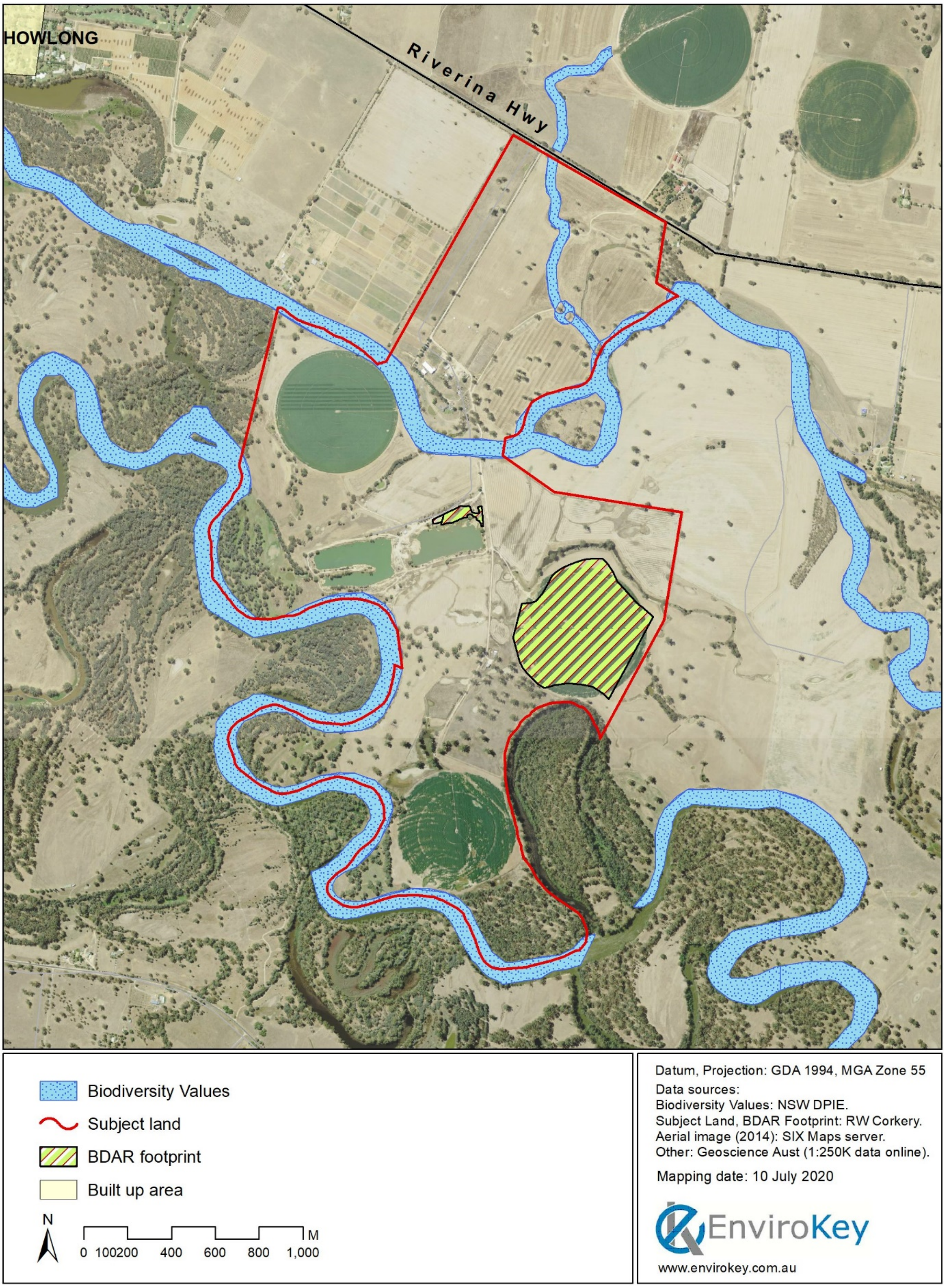
Given that the landscape has been substantially modified along this section of the Murray River floodplain, connectivity is essentially limited to the Murray River itself, and other vegetated connected features including Black Swan Anabranch. Both of these features are well clear of the BDAR footprint and identified on the existing biodiversity values mapping (**Map 3**).

Areas of outstanding biodiversity value

No area of outstanding biodiversity value as identified by the BC Act occurs within the Subject Land or within the Federation local government area.



Map 2: Landscape context of the BDAR footprint



Map 3: Location of areas mapped as having Biodiversity Values

2.2 DETERMINING SITE CONTEXT

2.2.1 *Assessing native vegetation cover*

To determine the site context, a review of native vegetation cover within a 1,500 metre buffer of the subject land was carried out using existing vegetation mapping datasets. Data from the State Vegetation Type Map: Riverina Region v1.2 (VIS_ID4469) was used to determine native vegetation cover in the NSW portion of the 1,500m buffer while data from the EVC mapping was used in the Victorian portion of the 1,500m buffer.

The total estimate of native vegetation within the NSW portion of the 1,500 metre buffer based on the State Vegetation Type Map: Riverina Region v1.2 (VIS_ID4469) is 454.42 hectares while the estimate from the EVC mapping for the NSW portion of the 1,500 metre buffer is 550.07 hectares. This gives a total of 1,004.49 hectares within the 1,500 metre buffer combined . Given that the total area of 1,500 metre buffer for the NSW and Victorian portions is 2,282.43 hectares, this equates to a native vegetation cover of 44% which was entered into the BAM calculator (BAMC) as 44%.

Table 1: Breakdown of vegetation communities from existing mapping within the 1,500 metre buffer of the Subject Land

Veg/PCT	EVC/PCT name	Total hectares (ha)	
		VIC	**NSW**
Victoria			
VRiv0055	Plains Grassy Woodland	65.29	0
VRiv0056	Floodplain Riparian Woodland	51.63	0
VRiv0068	Creekline Grassy Woodland	3.74	0
VRiv0081	Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	9.14	0
VRiv0168	Drainage-line Aggregate	23.55	0
VRiv0172	Floodplain Wetland Aggregate	14.66	0
VRiv0255	Riverine Grassy Woodland/Sedgy Riverine Forest/Wetland Formation Mosaic	7.48	0
VRiv0295	Riverine Grassy Woodland	146.92	0
VRiv0334	Billabong Wetland Aggregate	11.31	0
VRiv0803	Plains Woodland	22.2	0
VRiv0814	Riverine Swamp Forest	15.3	0
VRiv0815	Riverine Swampy Woodland	83.72	0
VRiv0816	Sedgy Riverine Forest	45.44	0
VRiv1035	Floodplain Riparian Woodland/Sedgy Riverine Forest Mosaic	49.69	0

Veg/PCT	EVC/PCT name	Total hectares (ha)	
		VIC	NSW
New South Wales			
165	Derived corkscrew grass grassland/forbland on sandplains and plains in the semi-arid (warm) climate zone	0	0.03
181	Common Reed - Bushy Groundsel aquatic tall reedland grassland wetland of inland river systems	0	1.18
182	Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses	0	1.32
237	Riverine Western Grey Box grassy woodland of the semi-arid (warm) climate zone	0	33.34
24	Canegrass swamp tall grassland wetland of drainage depressions; lakes and pans of the inland plains	0	6.63
277	Blakelys Red Gum - Yellow Box grassy tall woodland of the NSW South Western Slopes Bioregion	0	0.17
336	Rush - Sedge - Common Reed mainly lentic channel wetland of the Upper Murray and mid-Murrumbidgee River floodplains in the NSW South Western Slopes Bioregion	0	
5	River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	0	307.43
76	Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions	0	32.68
796	Derived grassland of the NSW South Western Slopes	0	71.63
	Cleared Land	376.86	941.22

2.2.2 Assessing patch size

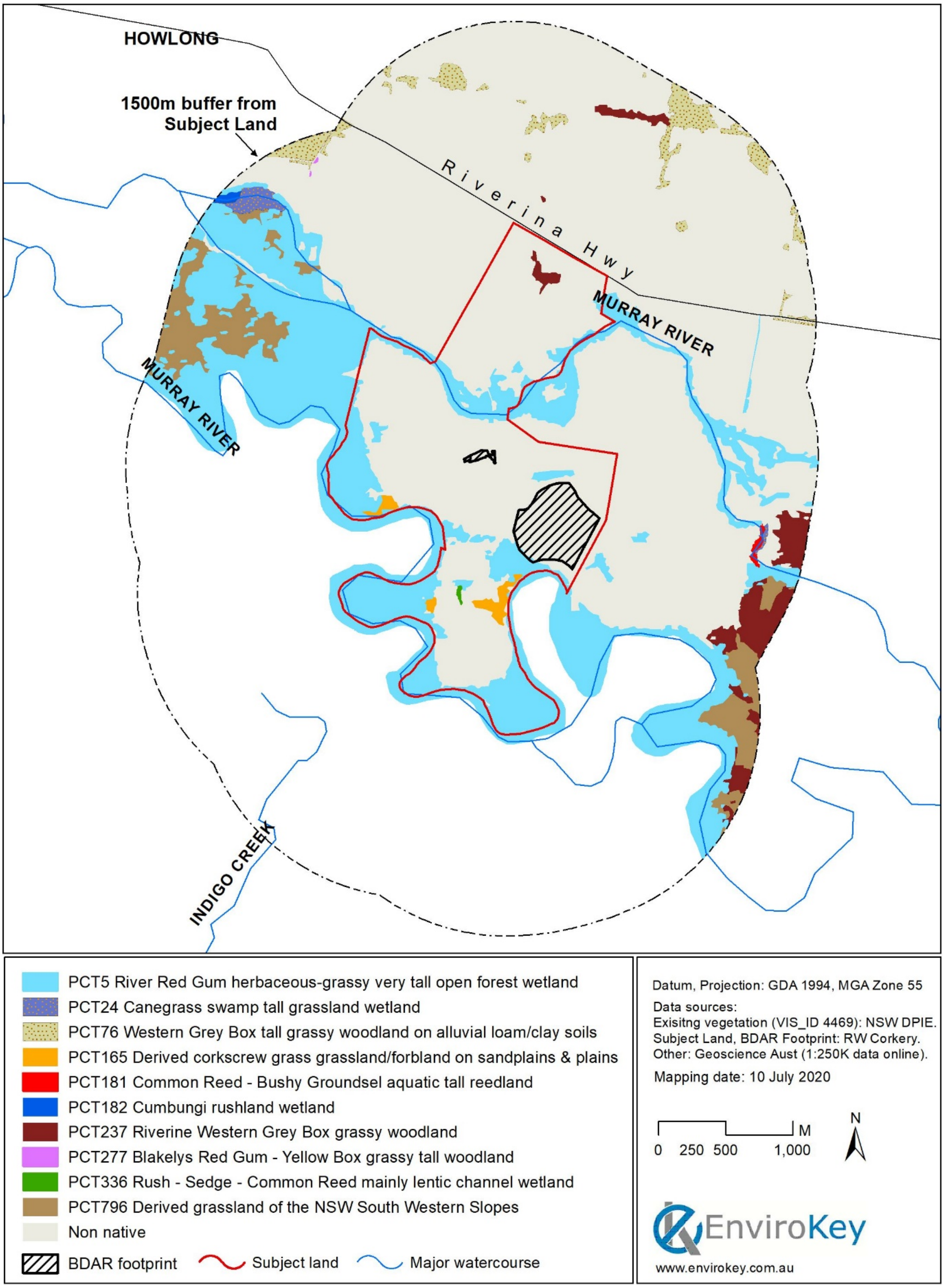
Patch size is defined by the BAM as '*an area of native vegetation that:*

- *Occurs on the development site or biodiversity stewardship site, and*
- *Includes native vegetation that has a gap of less than 100 metres from the next area of moderate to good condition native vegetation (or <30 metres for non-woody ecosystems).*

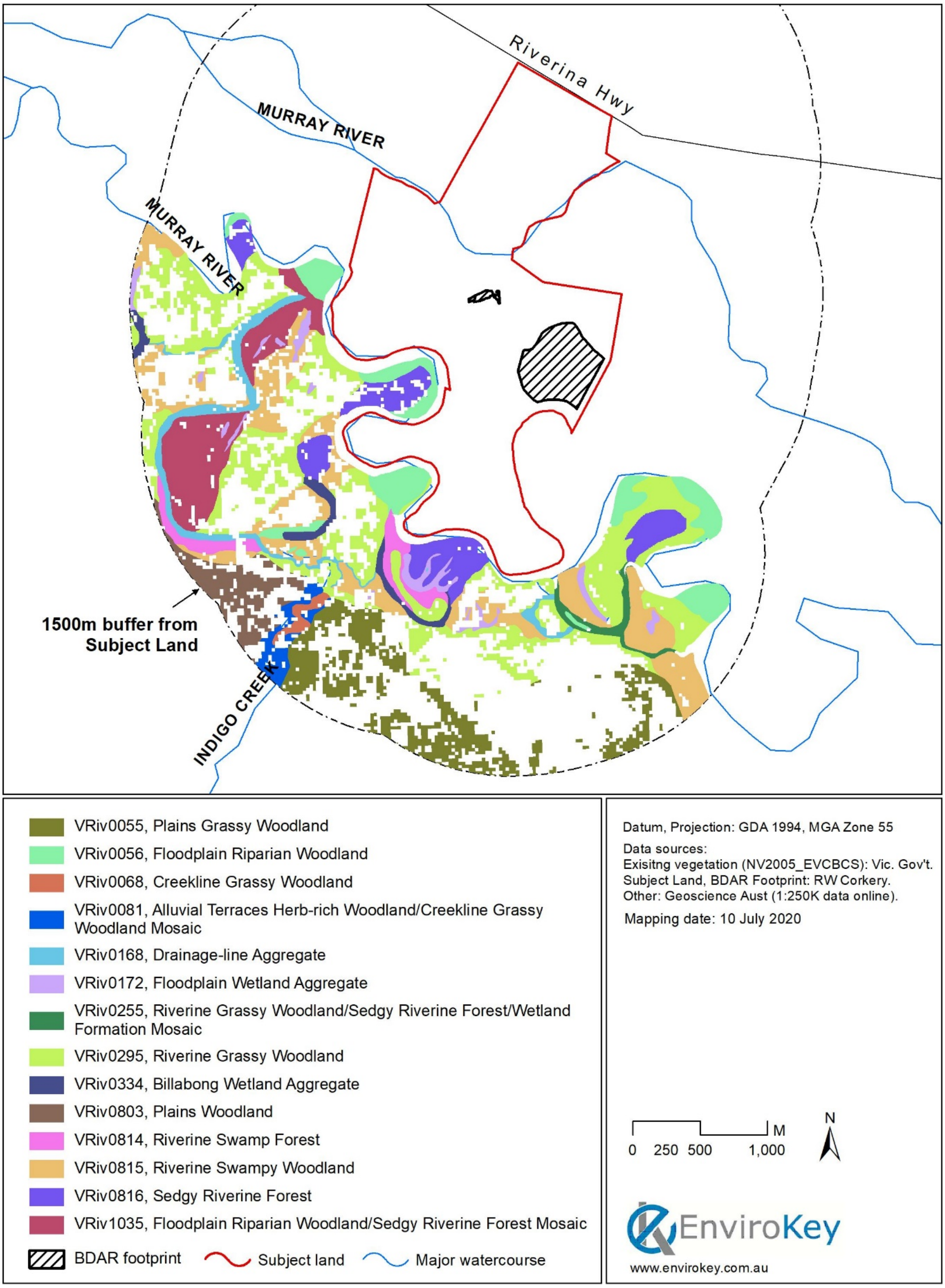
Patch size can extend onto adjoining land that is not part of the development site or biodiversity stewardship site'.

Patch size was calculated using the field validated vegetation types and air photo interpretation. Patch size is required to be assessed as one of four classes per vegetation zone mapped. These being <5 hectares, 5-24 hectares, 25-100 hectares or >100 hectares.

Based on these criteria, the BDAR footprint contains a single patch that joins both areas of mapped PCT 5 within the BDAR footprint and that extends slightly outside of the BDAR footprint. The total area of this patch is therefore 0.21 hectares which was then applied to the BAMC. This is not the BDAR footprint area, but rather the total area of the patch that impacts are proposed.



Map 4: Existing vegetation community data from the NSW State Vegetation Type Map: Riverina region covering the BDAR footprint, the subject land and 1,500 metre buffer



Map 5: Existing vegetation community data from the Victorian EVC mapping within the 1,500 metre buffer of the BDAR footprint.

3 NATIVE VEGETATION

3.1 PLANT COMMUNITY TYPES (PCTs) AND THREATENED ECOLOGICAL COMMUNITIES

3.1.1 Review of existing vegetation mapping

The Subject Land is within a single vegetation mapping dataset, this being the State Vegetation Type (SVT) Map: Riverina Region v1.2 (VIS_ ID4469). The dataset shows a total of 10 plant community types (PCT) within the Subject Land and within the 1,500 metre buffer of the Subject Land. Three of those were mapped within the Subject Land, but well clear of the BDAR footprint, so therefore, were not ground-truthed for the purpose of this BDAR.

From the SVT mapping, the PCT names and their extent within the BDAR footprint, within the Subject Land (but outside of the BDAR footprint) and within a 1,500 metre buffer of the Subject Land are provided in **Table 1**. This is also shown on **Map 5**. Non-native vegetation or cleared land is not included.

Table 2: Plant community types and their extent from the SVT Riverina Region v1.2 existing vegetation mapping within the BDAR footprint, the Subject land (outside of BDAR footprint) and within a 1,500 metre buffer of the Subject Land.

PCT No.	Plant community type (PCT)	BDAR footprint (ha)	Subject Land, outside of BDAR footprint (ha)	Total hectares within the 1500m buffer of Subject Land
5	River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	0.13	100.16	307.43
24	Canegrass swamp tall grassland wetland of drainage depressions; lakes and pans of the inland plains	0	0	6.63
76	Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions	0	0	32.68
165	Derived corkscrew grass grassland/forbland on sandplains and plains in the semi-arid (warm) climate zone	0	6.89	0.03
181	Common Reed - Bushy Groundsel aquatic tall reedland grassland wetland of inland river systems	0	0	1.18

PCT No.	Plant community type (PCT)	BDAR footprint (ha)	Subject Land, outside of BDAR footprint (ha)	Total hectares within the 1500m buffer of Subject Land
182	Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses	0	0	1.32
237	Riverine Western Grey Box grassy woodland of the semi-arid (warm) climate zone	0	2.29	33.34
277	Blakelys Red Gum - Yellow Box grassy tall woodland of the NSW South Western Slopes Bioregion	0	0	0.17
336	Rush - Sedge - Common Reed mainly lentic channel wetland of the Upper Murray and mid-Murrumbidgee River floodplains in the NSW South Western Slopes Bioregion	0	0.41	0
796	Derived grassland of the NSW South Western Slopes	0	0	71.63
	Cleared Land/non-native	27.34	287.68	941.22
	TOTAL	27.34	397.42	1,395.64

3.1.2 Species richness

A total of 63 flora species have been recorded when pooling the data of AES (2020) and the current field survey. This mostly comprised exotic flora species (44 species) which is not surprising given the existing use of the BDAR footprint for agricultural activity and as part of the overall quarry operation.

A full flora list is detailed in **Appendix 4**.

3.1.3 Plant community types

In addition to the previous field surveys completed by AES (2020), EnviroKey completed a field survey within the BDAR footprint, and in general across the Subject Land on 6-7 July 2020.

Field surveys were undertaken using the following methods:

- BAM plot/transects in accordance with the BAM
- Targeted threatened species surveys (Sloane's Froglet survey)
- Random meanders across the BDAR footprint.

While the majority of the BDAR was found to be dominated by Cleared Land comprising mostly non-native vegetation, one PCT was recorded within the BDAR footprint. This being:

- PCT 5 River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion (OEH, 2020b).

This PCT was allocated to the native vegetation given the presence of River Red Gum (*Eucalyptus camaldulensis*) and the location of the BDAR footprint on a floodplain adjacent to the Murray River. This section provides a summary of PCT 5.

PCT 5 River Red Gum herbaceous-grassy very tall open forest

PCT 5 is a River Red Gum (*Eucalyptus camaldulensis*) community that occurs on floodplains adjacent to inland river systems. The main characterising species was River Red Gum. Native ground cover species were few, however some of these included Silver Wattle (*Acacia dealbata*) and Common Couch (*Cynodon dactylon*). Those native species present are typically tolerant of disturbance in some form. Exotic flora dominated this PCT within the BDAR footprint which included various introduced grasses and forbs. Native plant species richness in PCT 5 was very low, ranging between one and six natives per 400sqm survey plot.

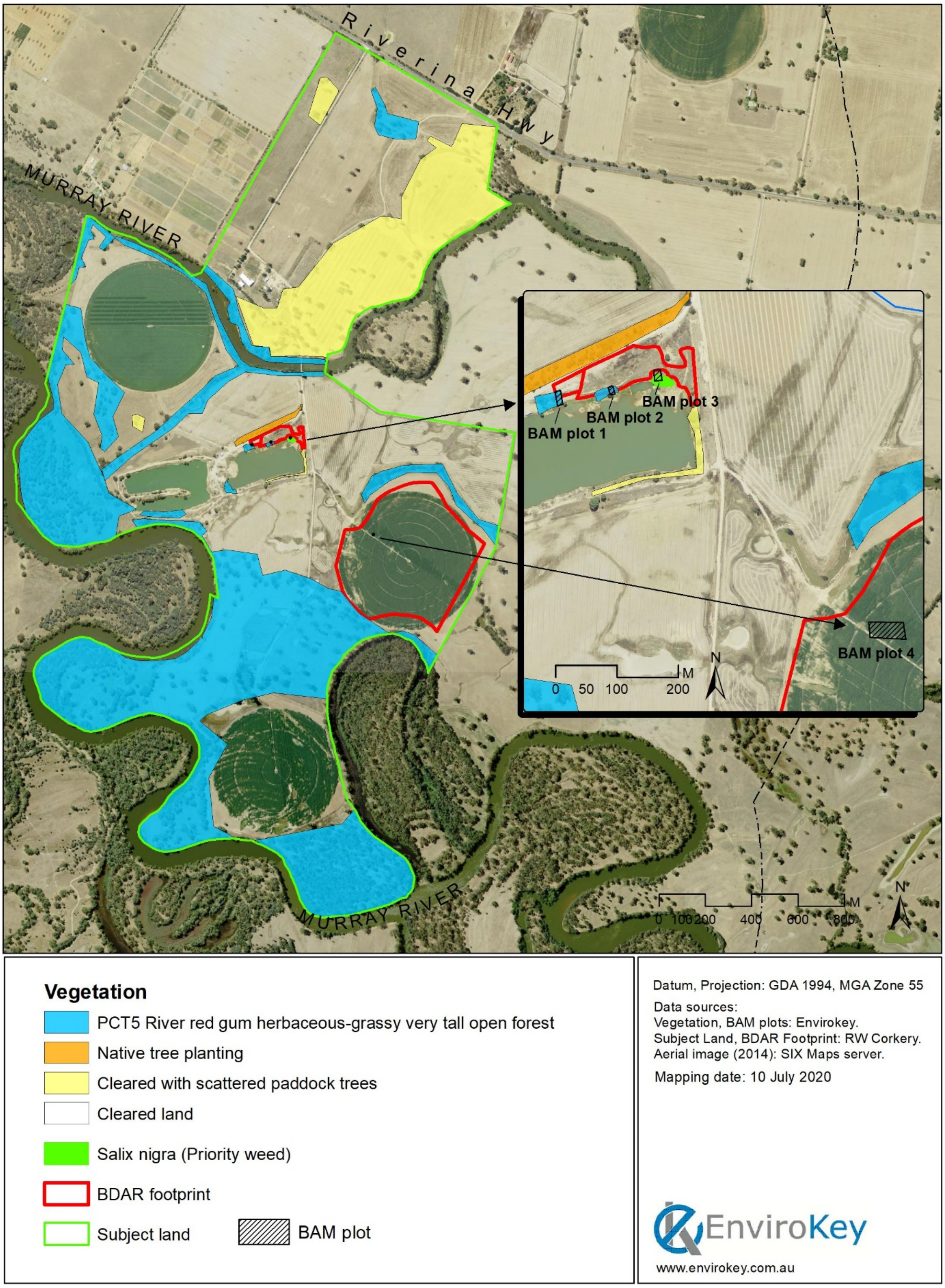
A summary of PCT 5 is detailed in **Table 3**, examples of the PCT provided in **Figure 3 & 4**, and the extent is mapped in **Map 6**.

Table 3: Summary of PCT 5 River Red Gum herbaceous-grassy very tall open forest

Vegetation Formation	Forested Wetland	
Vegetation Class	Inland Riverine Forest	
PCT code	5	
Extent within Subject land (and BDAR footprint)	124.327 ha (0.041 ha)	
BAM Plots within BDAR footprint	2 (BAM 1, BAM 2)	
BAM plots outside of BDAR footprint	Nil	
Condition	Low to moderate-good	
Conservation Status	NSW BC Act: Not listed	C'wealth EPBC Act: Not listed
Estimated % cleared (NSW)	40%	
Threatened plant species habitat	Given the dominance of exotic flora, no threatened species habitat is present.	

Figure 3: Example of PCT 5 River Red Gum herbaceous-grassy very tall open forest (BAM plot 2)

Figure 4: Example of PCT 5 River Red Gum herbaceous-grassy very tall open forest (BAM plot 1)



Map 6: Plant community types and BAM plots within the BDAR footprint and Subject Land

Table 4: Plant community types (and conservation status) within the BDAR footprint

Plant community type (PCT)	Vegetation Zones	Threatened ecological community	Area impacted (ha)	Local occurrence(ha)
River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion (PCT 5)	1	No, not listed under BC Act or EPBC Act	0.041	>500
Total Area Impacted (ha)		**Native Vegetation**	**0.041**	
		Cleared land/ Non-native Vegetation	**27.43**	

3.2 VEGETATION ZONES

3.2.1 Condition classes, subcategories and areas

The PCT identified within the BDAR footprint was classified into vegetation zones for the purpose of credit calculations. Given that the vegetation zones are almost adjacent and have the same use and disturbance, a single vegetation zone for the PCT was adopted for the purpose of the BAMC.

3.2.2 Vegetation integrity survey plots

A total of four vegetation integrity survey plots (BAM plots) have been completed within the BDAR footprint. Of these, a total of two BAM plots were completed within areas of native vegetation. The raw data sheets for all BAM plots are included in **Appendix 3**. The spatial location of the BAM plots are provided, as well as a general orientation of the plot in **Map 6**.

3.2.3 Current and future vegetation integrity scores

A vegetation integrity score (VIS) for each vegetation zone was calculated for the vegetation zone based on the BAM plot/transects completed.

The VIS (before development) for the vegetation zones was 22.2 (**Table 5**) confirming the low condition of the BDAR footprint. For this vegetation zone, the proposed activity would involve the complete removal of all vegetation within the development site. It is assumed that no ground cover would be retained so the score after development would be 0/100.

Table 5: Vegetation integrity scores for the vegetation zones, before and after development.

Veg/Mngt zone No.	Plant Community Type	Area impacted (ha)	VIS – before development	VIS – after development
1	PCT 5	0.041	22.2	0

4 THREATENED SPECIES

The BAM details the process for determining the habitat suitability for threatened species (section 6 of BAM). Under the BAM, threatened species are separated into two categories; ‘ecosystem’ and ‘species’ credit species. Those threatened species where the likelihood of occurrence of a species or components of the species’ habitat can be predicted by vegetation surrogates and landscape features, or for which a targeted survey has a low probability of detection, are identified as ‘ecosystem’ credit species. Targeted surveys are not required for ecosystem species and potential impacts to these species are assessed in conjunction with impacts to each PCT.

Threatened species where the likelihood of occurrence of a species or elements of suitable habitat for the species cannot be confidently predicted by landscape features or vegetation surrogates and can be reliably detected by survey are identified as ‘species’ credit species. A targeted survey or an expert report is required to confirm the presence or absence of these species on the subject land.

For some threatened species, they are identified as both ecosystem and species credit species, with different aspects of the habitat and life cycle representing different credit types. Commonly, threatened fauna species may have foraging habitat as an ecosystem credit, while their breeding habitat represents a species credit.

The following sections outline the process for determining the habitat suitability for threatened species within the subject site, and the results of targeted surveys for candidate threatened species.

4.1 IDENTIFY THREATENED SPECIES FOR ASSESSMENT

Threatened species that require assessment are initially identified based on a specific set of criteria. These being:

- The distribution of the species includes the IBRA subregion of the subject land
- Whether the subject land has geographic constraints for species distribution within the IBRA subregion
- The species is associated with the PCTs of the subject land
- Native vegetation cover within a 1,500 metre buffer of the subject land exceeds the minimum habitat required for the species
- Patch size exceeds the minimum required for the species
- The species is identified as an ecosystem or species credit species in the Threatened Biodiversity Data Collection.

Ecosystem Credit Species are defined by BAM as species for which the likelihood of occurrence or the presence of potential habitat can be predicted based on vegetation proxies and landscape features, or species for which targeted surveys have a low probability of detection (OEH, 2017b).

Species Credit Species are defined by BAM as species for which the likelihood of occurrence or the presence of potential habitat cannot be predicted based on vegetation proxies or landscape features and which can be reliably detected by targeted surveys.

Searches of relevant databases were completed to identify these species included:

- BCD Threatened Biodiversity profile search
- Protected Matters Search tool

The process for identifying threatened species which meet the criteria is determined by the BAM calculator (BAMC). The PCT identified within the subject land, patch size and native vegetation cover (as detailed within section 3 of this BDAR) were entered into the BAMC. This resulted in a preliminary list of threatened species.

4.1.1 Ecosystem credit species

The BAMC identified a range of ecosystem credit species predicted to occur within the BDAR footprint based on a number of variables including bioregion, landscape and PCT (**Table 6**). All ecosystem credit species generated by BAMC were retained within the predicted species report given the presence of PCT 5, albeit as a highly modified, very small patch.

Table 6: Ecosystem credit species predicted by the BAMC to occur within the BDAR footprint.

Common Name	Scientific Name	BC Act	EPBC Act
Australian Painted Snipe	*Rostratula australis*	E	E
Diamond Firetail	*Stagonopleura guttata*	V	-
Dusky Woodswallow	*Artamus cyanopterus*	V	-
Flame Robin	*Petroica phoenicea*	V	-
Freckled Duck	*Stictonetta naevosa*	V	-
Hooded Robin (south-eastern form)	*Melanodryas cucullata cucullata*	V	-
Koala	*Phascolarctos cinereus*	V	V
Little Lorikeet	*Glossopsitta pusilla*	V	-
Little Pied Bat	*Chalinolobus picatus*	V	-
Painted Honeyeater	*Grantiella picta*	V	V
Powerful Owl	*Ninox strenua*	V	-
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	V	-
Regent Honeyeater	*Anthochaera phrygia*	CE	CE

Common Name	Scientific Name	BC Act	EPBC Act
Scarlet Robin	*Petroica boodang*	V	-
Spotted Harrier	*Circus assimilis*	V	-
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E
Square-tailed Kite	*Lophoictinia isura*	V	-
Superb Parrot	*Polytelis swainsonii*	V	V
Swift Parrot	*Lathamus discolor*	E	CE
Turquoise Parrot	*Neophema pulchella*	V	-
Varied Sittella	*Daphoenositta chrysoptera*	V	-
White-bellied Sea-eagle (foraging)	*Haliaeetus leucogaster*	V	-
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V	-

*V = Vulnerable, E = Endangered, CE= Critically Endangered

4.1.2 Identify candidate species credit species for further assessment

As with ecosystem credit species, species credit species are predicted in the BAMC following an assessment of geographic and habitat features which include the IBRA subregion, PCT, patch size and native vegetation cover in the landscape context.

This section includes further assessment of species credit species to confirm if they will become candidate species for this BDAR. Section 6.4.1.17 of the BAM provides the opportunity to consider whether a predicted candidate species is unlikely to occur within the development site where habitat is substantially degraded to a point that they would be unlikely to utilise or where an expert report identifies that the species is unlikely to be present. A predicted candidate species credit species that is not considered to have suitable habitat present, does not require further assessment. However, the reasons for making these determinations must be documented.

To inform this assessment of how habitat degradation has impacted candidate threatened species, a search of the Atlas of NSW Wildlife (OEH, 2020a) was carried out for a 10 kilometre radius around the study area (**Maps 8-12**). Using these existing records, the likelihood of occurrence was assessed using the following methods:

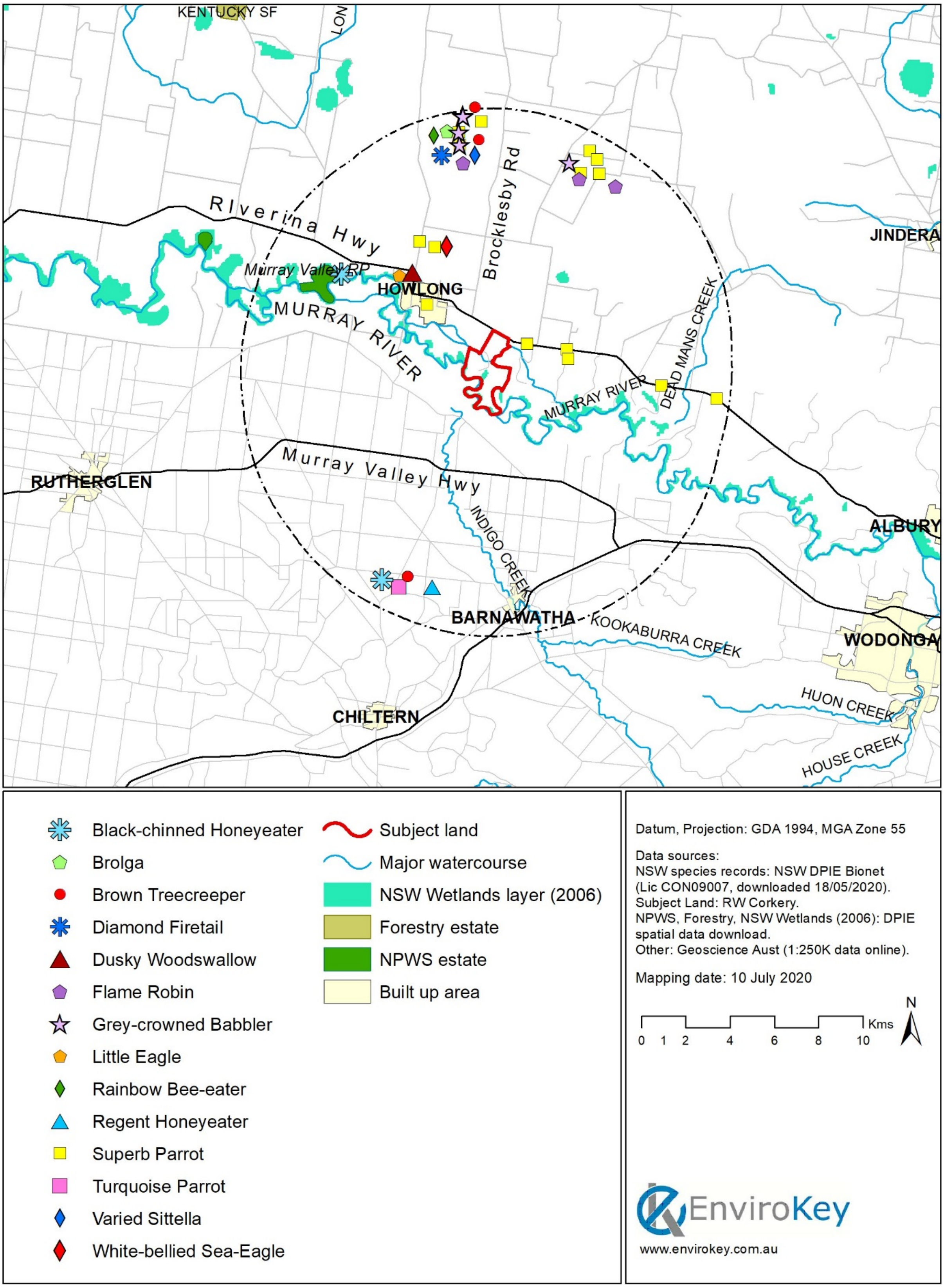
- Species occurrence within the study area and locality
- Condition and extent of available habitats
- Application of the knowledge and experience of the EnviroKey Principal Ecologist.

Table 7 outlines the predicted candidate species (from the BAMC) and provides a justification for the decision by EnviroKey to either maintain or discard each species as a candidate species based on the presence of suitable habitat within the study area.

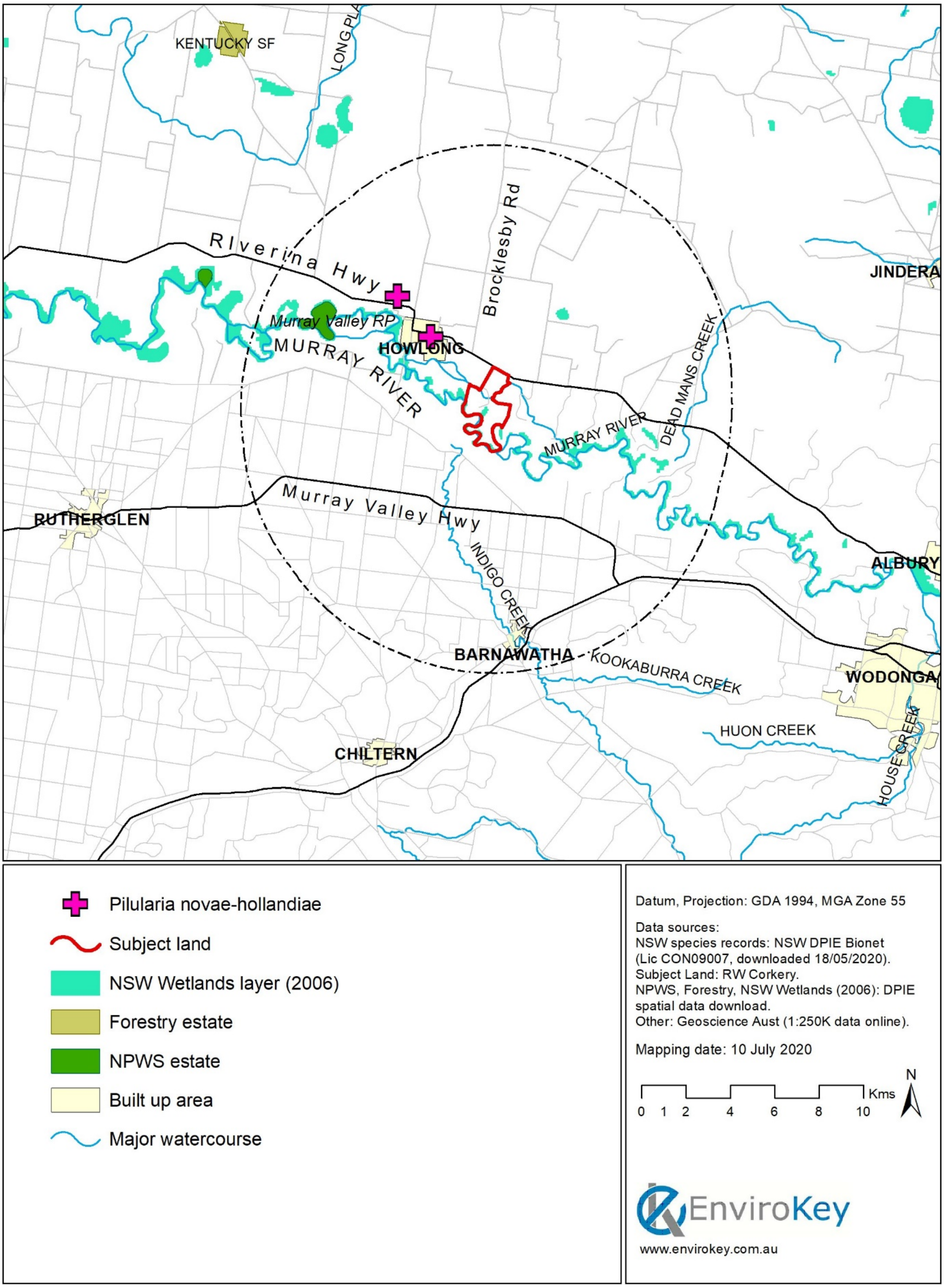
Table 7: Assessment of habitat constraints, geographic limitations and candidate species justification.

Common name	Habitat constraints / Geographic limitations	Candidate species justification
Sloane's Froglet	Semi-permanent/ephemeral wet areas containing relatively shallow sections with submergent and emergent vegetation, or within 500m of wet areas Within 500m of a water body	Retained due to records in locality, and potential habitat, although highly degraded, occurs in crop circle within BDAR footprint and adjacent.
Small Scurf-pea	-	BDAR footprint is highly degraded. Removed as a candidate species.
Swift Parrot	As per mapped areas	BDAR footprint is highly degraded. Species is vagrant. Removed as a candidate species.
Southern Myotis	Within 200m of riparian zone	BDAR footprint is highly degraded. Removed as a candidate species.
Squirrel Glider	-	BDAR footprint is highly degraded. Removed as a candidate species.
Brush-tailed Phascogale	-	BDAR footprint is highly degraded. Removed as a candidate species.
Koala	Areas identified via survey as important habitat	BDAR footprint is highly degraded. Removed as a candidate species.
Superb Parrot	Hollow-bearing trees Living or dead eucalypts with hollows >5cm Trees with >30cm DBH	No hollow-bearing trees. BDAR footprint is highly degraded. Removed as a candidate species.
Regent Honeyeater	As per mapped areas	BDAR footprint is highly degraded. Species is vagrant. Removed as a candidate species.
Bush Stone Curlew	Fallen/standing dead timber including logs	BDAR footprint is highly degraded. Removed as a candidate species.
Square-tailed Kite (breeding)	Nest trees	BDAR footprint is highly degraded. No nest tree apparent. Removed as a candidate species.
Powerful Owl (breeding)	Hollow-bearing trees Living or dead trees with hollows >20cm diameter	BDAR footprint is highly degraded. No hollow-bearing trees. Removed as a candidate species.

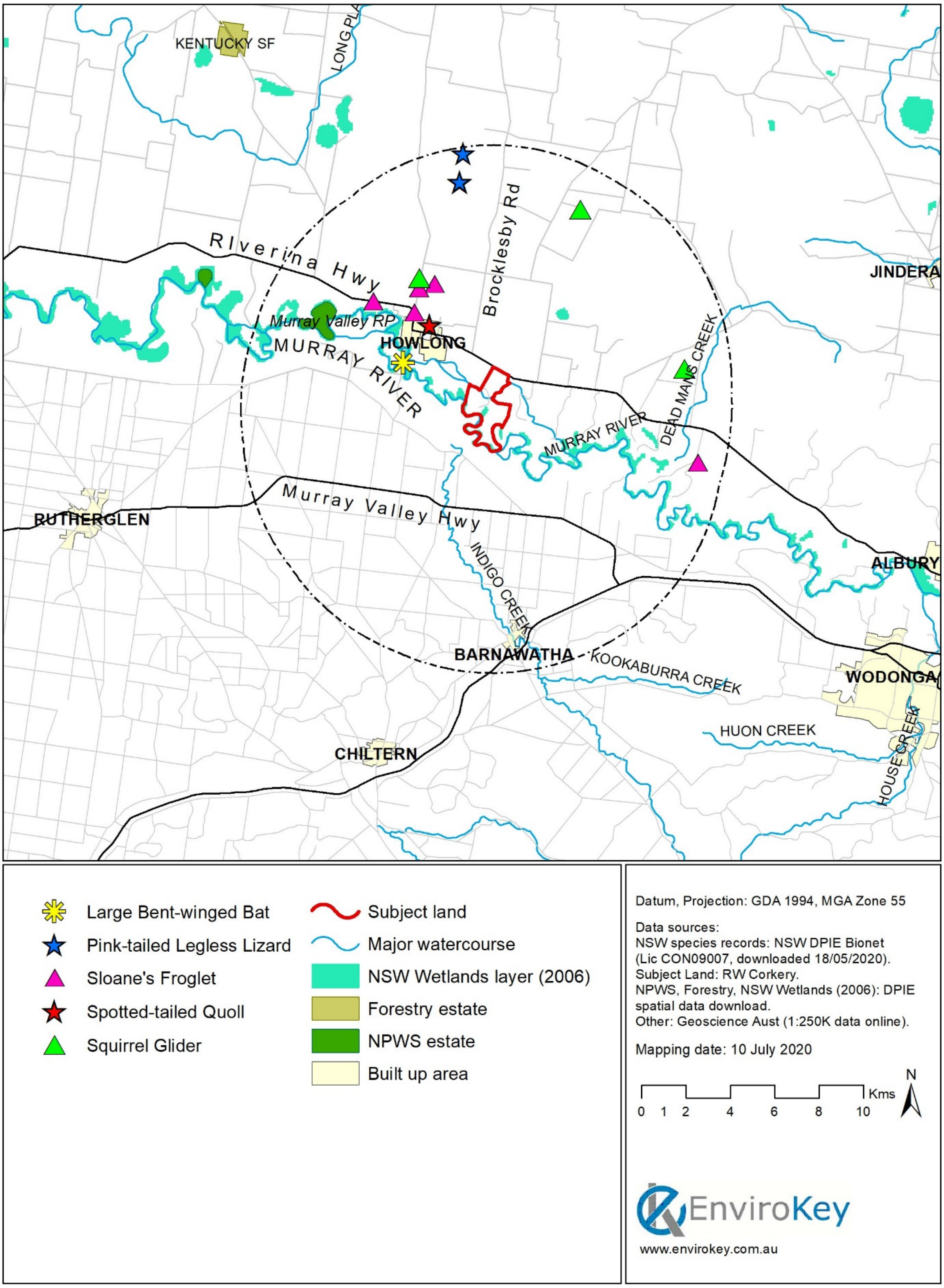
Common name	Habitat constraints / Geographic limitations	Candidate species justification
White-bellied Sea-eagle (breeding)	Living or dead trees within 1km of river, creek or wetland	Retained due to potential habitat features within BDAR footprint. Requires survey for breeding sites.
Little Eagle (breeding)	Nest trees are large old trees within vegetation	BDAR footprint is highly degraded and no suitable nesting sites. Removed as a candidate species.



Map 7: Previous records of threatened birds in the NSW portion of the locality



Map 8: Previous records of threatened flora in the NSW portion of the locality



Map 9: Previous records of other threatened species in the NSW portion of the locality

4.2 DETERMINE PRESENCE OR ABSENCE OF A CANDIDATE SPECIES CREDIT SPECIES

Confirmed candidate species were assessed consistent with steps 4-6 of section 6.4 of BAM.

This BDAR was led by Mr. Steve Sass (Principal Ecologist, B.App.Sci (Env.Sci) (Hons), GradCert.CaptVertMngt (CSU)) of EnviroKey. Mr Sass is also an accredited Biodiversity Assessor (BAAS17/047) under the NSW *Biodiversity Conservation Act 2016*. Field surveys were conducted by suitably qualified and experienced personnel. Details of all personnel and their role in the preparation of the BDAR are provided (see **Appendix 1**). Field surveys were conducted under the authority of a Scientific Licence issued by DPIE under the BC Act and an Animal Research Authority approved by, and in accordance with, the Animal Care and Ethics Committee (ACEC) of the Director-General of Department of Primary Industries.

In addition to the previous field surveys completed by AES (2020), EnviroKey completed a field survey within the BDAR footprint, and in general across the Subject Land on 6-7 July 2020.

4.2.1 Target field surveys – flora

No species credit species of candidate flora were retained within the BAMC. This is due to the highly degraded nature of the BDAR footprint. Given this, no target field surveys for candidate flora were carried out.

Regardless, AES (2020) did carry out some flora surveys (see Table 9 of AES (2020)). These were carried out in February 2018, February 2019, April 2018, July 2018 (two surveys), and no threatened flora, or any of the candidate flora species were recorded.

4.2.2 Target field surveys – fauna

In addition to the previous field surveys completed by AES (2020), EnviroKey completed a field survey within the BDAR footprint, and in general across the Subject Land on 6-7 July 2020. Fauna survey effort was focused on the basis of vegetation communities and potential habitat for candidate fauna within the BDAR footprint. The following provides a summary of the methodology applied to this BDAR by **EnviroKey**.

Diurnal bird surveys – White-bellied Sea-eagle

Surveys to determine the presence and usage of the BDAR footprint and surrounds by White-bellied Sea-eagle and other diurnal birds were conducted. A total of 10 diurnal bird surveys were guided by a standardised technique (Watson, 2003) and were conducted in either the early morning or late afternoon to coincide with peak bird activity. Observers actively searched for diurnal birds and identified species by sight and by vocalisation during each 20-minute bird survey. Specifically, visual searches of all trees were made of old or current White-bellied Sea-eagle nest sites. The locations of all diurnal bird surveys are provided on **Map 10**. Opportunistic data was also collected during the field surveys whenever traversing the Subject Land.

Frog surveys – Sloanes Froglet

Sloanes Froglet is a winter breeder becoming active in autumn and breeding through the winter months (Knight, 2015) coinciding with the peak time for detection given that males are calling. A combination of spot aural surveys (ie, listening for calling frogs and spotlight searching) and active transects were used to target Sloane's Froglet. Previous surveys by AES (2020) also targeted this species by using methods commensurate with detection and in a season suitable for detection (DECC, 2009, Anon, n.d).

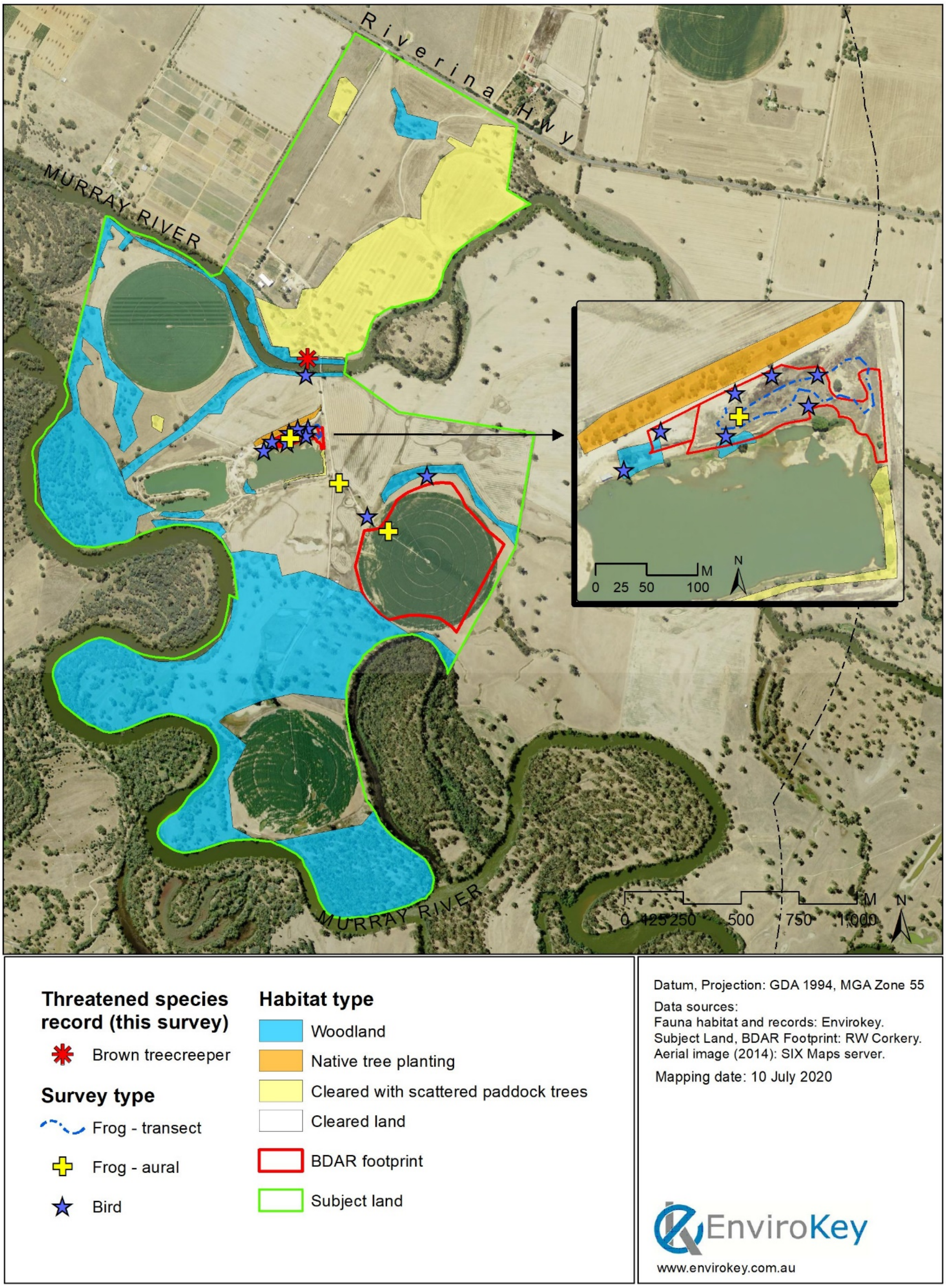
Surveys were carried out on the 6 and 7 July 2020, with each survey location (aural and transect) surveyed twice (over two nights). The aural surveys comprised a 10 minute listening period for calling frogs and then an active 20 minute search for any frogs. The spotlight transect survey involved walking a random transect for a period of about 1 person hour. All surveys were completed from dusk and within a couple of hours of sunset.

Additionally, as Sloanes Froglet often vocalises during daylight hours, all time spent within the BDAR footprint and the Subject Land, also effectively surveyed for calling Sloanes Froglet opportunistically.

A summary of the field survey effort for each fauna survey method is provided (**Table 8**). Fauna survey effort was guided by the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (working draft) (DEC, 2004) and species-specific guidelines taking into consideration the size of the BDAR footprint and the vegetation communities and fauna habitats present. The diverse range of survey methods used in this study and the survey effort conducted confirms that overall, this assessment is consistent with BCD/DPIE guidelines.

Table 8: Fauna survey type and effort by EnviroKey used for this BDAR.

Survey Type	Total Survey Effort
Diurnal Birds	10 locations for 20 minutes each. Total survey effort was 200 minutes
Frog surveys	Aural surveys at 3 locations for 2 nights at each location. This involved about 10 minutes of listening for calling frogs and then 20 minutes actively searching for frogs, each night. Transect survey at 1 location for 2 nights. This involved searching for active frogs and calling frogs using a suitable hand-held spotlight and head lamp. Transect survey was about 1 hour per night. Total survey effort was: Aural surveys – 180 minutes Transect survey – 2 hours
Opportunistic survey	At any time travelling between survey sites, or while in the BDAR footprint and Subject Land during the field survey (6-7 July 2020), any fauna species observed were recorded.



Map 10: Locations of fauna surveys within and adjacent to the BDAR footprint

4.3 THREATENED SPECIES RECORDED

Previous field survey by AES (2020) did not detect any threatened species within the Subject Land. **EnviroKey** recorded a single threatened species during the recent field survey. This being Brown Treecreeper, listed as vulnerable under the BC Act and is also listed as an ecosystem credit species under the BAM. Numerous individuals were observed and heard along the Black Swan Anabranch during our field survey and it is probable that at least one, but likely more, family groups occur along the Anabranch (**Map 10**, **Table 9**). It is also highly likely that this species also occurs in the extensive areas of River Red Gum Forest along the banks of the Murray River.

Brown Treecreeper was not predicted to occur within the BDAR footprint, which is likely due to site and landscape context. All records of Brown Treecreeper were well outside of the BDAR footprint and given the highly degraded nature of the BDAR footprint, they are unlikely to occur there. Given this, Brown Treecreeper was not added to the BAMC as a predicted ecosystem credit species.

Table 9: Threatened and migratory species recorded within the study area

Common name	Details	BC Act status	EPBC Act status	Ecosystem credit species	Species credit species
Brown Treecreeper	Several individuals were recorded along Black Swan Anabranch. These records and habitat are well outside of the BDAR footprint.	V	-	Yes	No

V= Vulnerable

4.4 FURTHER CONSIDERATION OF SPECIES-CREDIT SPECIES

4.4.1 White-bellied Sea-eagle

Field surveys by AES (2020) and **EnviroKey** have not detected White-bellied Sea-eagle within the Subject Land, or within the BDAR footprint, nor have any nest sites been identified. Two records are known from the within the locality with these being west and north of Howlong. It is likely that distribution of White-bellied Sea-eagle is largely confined to the Murray River and adjacent riparian vegetation, but they could also range across the floodplain landscape.

Searches of all suitable trees within and directly adjacent to the BDAR footprint confirmed that no nest sites are present.

Given these factors, species presence for White-bellied Sea-eagle within the BAMC was amended to “no (surveyed)” and therefore excluded from being a relevant Species Credit Species within the BAMC for this project as it relates to Breeding habitat only. Therefore, species polygons are not provided. On this basis, White-bellied Sea-eagle was retained as an ecosystem credit species within the BAMC.

4.4.2 Sloanes Froglet

Field surveys by AES (2020) and **EnviroKey** have not detected Sloanes Froglet within the BDAR footprint or the Subject Land. Surveys have targeted Sloanes Froglet by surveying in winter and spring by AES (2020) and in July by **EnviroKey**. Surveys of all potentially suitable habitat within and adjacent to the BDAR footprint have not identified species presence (**Figure 5-9**). Given these results, and in consideration that the survey effort and timing is regarded as suitable to detect this species, species presence for Sloanes Froglet within the BAMC was amended to “no (surveyed)” and therefore excluded from being a relevant Species Credit Species for this project. Therefore, species polygons are not provided.

Figure 5: Grassy habitat within the smallest BDAR footprint is dominated by exotic flora

Figure 6: Large shallow puddles were searched that occur adjacent to the largest BDAR footprint (the crop circle)

Figure 7: Small shallow puddles were searched within the largest BDAR footprint (the crop circle)

Figure 8: A number of small puddles occur within the largest BDAR footprint (the crop circle)

Figure 9: A small ephemeral wetland was searched that occurs adjacent to the largest BDAR footprint (the crop circle)

5 AVOIDING AND MINIMISING IMPACTS ON BIODIVERSITY VALUES

5.1 AVOIDING AND MINIMISING IMPACTS ON NATIVE VEGETATION AND HABITAT DURING PROJECT PLANNING

Across the Subject Land, existing agricultural activity and continuing quarry operations has already comprised the extent of native vegetation present. The current project design avoids larger areas of native vegetation that occur elsewhere on the Subject Land detailed on **Map 4** and **Map 6**. The BDAR footprint does not comprise an endangered or critically endangered ecological community.

5.2 AVOIDING AND MINIMISING PRESCRIBED BIODIVERSITY IMPACTS DURING PROJECT PLANNING

5.2.1 Impacts to threatened species or ecological communities associated within or non-native vegetation

The project, should it proceed, will have a minor impact on biodiversity within the BDAR footprint. The NSW biodiversity offsets policy for major projects in NSW commenced on 1 October 2014. The policy provides for the clarification, standardisation and improvement of biodiversity offsetting for major project approvals.

The policy applies to SSD and SSI projects, and as such, the Howlong Sand and Gravel Quarry Expansion would be considered under this policy.

The NSW biodiversity offset policy for major projects is underpinned by six principles. This section identifies how the BDAR meets those principles.

Principle 1: Before offsets are considered, impacts must first be avoided and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts.

FEC have made reasonable attempts to avoid impacts to biodiversity through designing the footprint of the project to avoid native vegetation where possible, and to within an area used historically and extensively for agriculture. Avoidance and minimisation measures are detailed in this BDAR.

Principle 2: Offset requirements should be based on a reliable and transparent assessment of losses and gains.

This BDAR has been prepared in accordance with the BAM using the BAMC. This assessment has been identified as the appropriate assessment pathway for the Project.

Principle 3: Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.

FEC are aware that a Biodiversity Offset Strategy (BOS) will be required, through either the development of a Biodiversity Stewardship Site/s, payment into the Biodiversity Conservation Fund (BCF) to the Biodiversity Conservation Trust (BCT) or by purchasing credits available on the open market (or a combination of all three). This will target any loss of biodiversity value. Any BOS would need to be approved by BCD and DPIE. It is likely that FEC would make a payment into the BCF.

Principle 4: Offsets must be additional to other legal requirements.

Biodiversity offsets are a legal requirement of projects assessed under the BAM.

Principle 5: Offsets must be enduring, enforceable and auditable.

It is expected that any biodiversity offsets established through the BOS would be enduring, enforceable and auditable. Should FEC make payment into the BCF to the BCT, the deliverables of the BCT would be enduring, enforceable and auditable.

Principle 6: Supplementary measures can be used in lieu of offsets.

While some mitigation measures are detailed within section 6 of this BDAR, the BOS identifies the measures required to offset the biodiversity impacts of the Project in consideration of the 'Fulfilling offset requirements' (flowchart – point 6) within the NSW biodiversity offset policy for major projects.

It is acknowledged that the BDAR footprint is dominated by cleared land, or non-native vegetation. The field surveys by both AES (2020) and **EnviroKey** have not identified any threatened species using these areas of non-native vegetation. Given this, areas of non-native vegetation within the BDAR footprint are considered to be of little importance to threatened biota.

Given this, no prescribed impacts relating to these factors, would occur.

5.2.2 Impacts to the connectivity of different habitat which facilitates the movement of threatened species

While the Subject Land is not recognised as a state, regional or local corridor for biodiversity, it is acknowledged that major river floodplains do provide some level of landscape connectivity to biodiversity and in particular threatened species. This may be relevant to the larger BDAR footprint (the crop circle) and the oxbow wetland.

The BDAR footprint would have a minor impact on some of this connectivity, however, the BDAR footprint would not block any passage of floodwaters to the Oxbow wetland. This would ensure that landscape connectivity would still be maintained and in the context of the locality, floodplain connectivity would continue across a large majority of the locality. Further, as detailed in section 2 of the EIS, reestablishment of riparian areas would be of benefit to connectivity. Given this, the proposed activity is unlikely to significantly impact connectivity.

5.2.3 Impacts to water quality, water bodies and hydrological processes that sustain threatened species or ecological communities

Both the Murray River and the Black Swan Anabranch are recognised as having biodiversity values under the *Biodiversity Conservation Act 2016* and have been mapped under the Regulation as sensitive biodiversity areas (**Map 3**). Water quality within these water bodies, while not tested by this study, is likely to be moderate to good. While the BDAR footprint would not impact directly on these features, it does have some potential (unmanaged) to affect water quality and hydrological processes in these areas. The quarry would involve maintenance of a levee bank, which would prevent flood water entering the extraction areas. In turn, this would prevent large sediment load from entering the river system in the event of floods (designed to manage a 1% AEP flood event).

With consideration of the BDAR footprint, it is unlikely that the project would increase existing processes that already occur as part of the approved quarry operation.

5.2.4 Impacts of wind turbine strikes on protected animals

This impact is not applicable to the current proposed activity.

5.2.5 Impacts of vehicle strikes on threatened species or on animals that are part of a TEC

Given the highly degraded nature of the Subject Land, it is unlikely that there is any potential for the proposed activity to increase the impact of vehicle strikes on threatened species.

6 ASSESSING AND OFFSETTING IMPACTS

6.1 ASSESSMENT OF IMPACTS

6.1.1 *Assessing direct impact to native vegetation and habitat, threatened ecological communities and threatened species habitat*

The proposed activity will impact on all native (and non-native) vegetation identified within the BDAR footprint. This equates to approximately 0.041 hectares of native vegetation. For the single vegetation zone and subsequent management zone, the future value of each attribute (composition, structure and function) and the vegetation integrity score would be zero. A further 27.43 hectares of Cleared Land (non-native vegetation) would also be a direct impact.

6.1.2 *Assessing indirect impact to native vegetation and habitat, threatened ecological communities and threatened species habitat*

It is difficult to quantify indirect impacts associated with many projects, but in this instance, these may include impacts such as weeds, accidental clearing, noise, and erosion and sediment control.

Given that the BDAR footprint (development site) is located mostly directly adjacent to existing quarry operations and agricultural activity, the potential for indirect impacts to occur is considered low. However, the largest BDAR footprint is located near to an oxbow wetland. On this basis, mitigation measures are proposed that limit the potential of indirect impacts to this area. Given this, it is unlikely that the proposed activity would have an adverse impact on adjacent areas of vegetation and habitat. It is also unlikely that the proposed activity would reduce the viability of any adjacent vegetation or habitat as a result from edge effects, noise, or dust.

6.2 ASSESSING PRESCRIBED BIODIVERSITY IMPACTS

The SEARs do not identify any particular prescribed biodiversity impacts for the proposed activity.

6.3 MITIGATING AND MANAGING IMPACTS ON BIODIVERSITY VALUES

EnviroKey have developed a range of measures to mitigate and manage impacts on biodiversity values commensurate to the level of impact proposed by this project (**Table 10**).

Table 10: Measures to mitigate and manage impacts on biodiversity values for the Howlng Sand and Gravel Quarry Expansion

Direct impact / prescribed impact	Mitigation measure	Timing
Clearing of native vegetation	• Avoid and minimise clearing impacts to native vegetation where possible • Ensure that any vehicle, equipment parking or stockpiling areas are identified and positioned to avoid areas containing high biodiversity value • Install signs including ‘No Go Zone’ or ‘Environmental Protection Areas’ on limit of clearing fencing • Identify these areas in site inductions • Development of a Rehabilitation Plan	Prior to and during vegetation clearing
Impacts to surface and groundwater quality due to sediment run-off or contamination	• Controls such as sediment fences, mulching or jute matting would be used where appropriate • Site vehicles will carry spill kits • An Erosion and Sediment Control Plan will be implemented • A Ground Water Management Plan will be implemented	During vegetation clearing, construction and operation
Indirect impacts		
Noise, vibration, lighting, waste and air pollution to adjacent habitats	• Any site-specific management plan should consider measures to mitigate impacts to biodiversity from noise, vibration, waste, light and air pollution	During construction and operation

6.4 ADAPTIVE MANAGEMENT FOR UNCERTAIN IMPACTS

Excluding the need for a site-specific management plan such as a Rehabilitation Plan, no additional adaptive management measures are proposed.

6.5 THRESHOLDS FOR THE ASSESSMENT AND OFFSETTING OF IMPACTS OF DEVELOPMENT

6.5.1 Serious and Irreversible impacts (SAII)

None of the candidate species credit species retained are identified as an SAII entity in the *Guidance to assist a decision-maker to determine a serious and irreversible impact* (DPIE, 2019). Given this, there would be no SAII as a result of the proposed activity.

6.5.2 Impacts that do require an offset

Impacts associated with any PCT generally require an offset under the BAM with the exception of any area mapped as non-native vegetation/cleared land including exotic grassland or planted non-indigenous vegetation. Section 10.3.1 of the BAM describes where impacts on native vegetation (ecosystem credits) require offsetting. For native vegetation, as the VIS is above 17 and is associated with threatened species habitat (as represented by ecosystem credits), biodiversity offsets are required.

7 FINAL CREDIT CALCULATIONS

7.1 CREDIT CALCULATIONS AND CLASSES

7.1.1 Ecosystem credits

A summary of the impacts on native vegetation and the required ecosystem credit is provided in **Table 11**.

Table 11: Summary of ecosystem credit requirements

Veg/Mngt zone No.	Plant Community Type	Condition	Area impacted	VIS – before development	VIS – after development	Credits required
1	PCT 5	Low-Moderate	0.041	22.2	0	1
Total number of ecosystem credits						1

The following like-for-like rules apply for the **credit class 5**:

- Like for like credit retirement options from Inland Riverine Forests. This includes PCT's: 2, 5, 7, 8, 9, 10, 11, 36, 78, 112, 233, 234, 249, 356 and 362
- In the following IBRA subregions: Murray Fans, Inland Slopes, Lower Slopes, Murrumbidgee, Robinvale Plains, and South Olary Plain, OR Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.
- Does need to contain hollow-bearing trees

The BAMC outputs including like-for-like credit report is provided in **Appendix 6**.

7.1.2 Species credits

No species credit species are relevant to the BDAR footprint (as outlined in section 4 of this BDAR).

7.2 CREDIT COSTS

Ecosystem credits are required for the proposed activity. The total cost of credits, should the BCT be used to offset the impacts of the development, are currently (09 August 2020) estimated to be $7,377.62 (excl. GST). Details are provided in **Table 12** and **Appendix 6.**

The Applicant may also wish to purchase credits available on the market, or may wish to pursue other offset sites as required.

Table 12: Credit requirements and estimated credit costs, as calculated on 9 August 2020.

Ecosystem credits				
Plant community type	**Risk premium**	**Administrative cost**	**No. of credits**	**Final credits price (excl. GST)**
PCT 5 River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains	19.12%	$239.69	1	$7,377.62
Ecosystem credits subtotal (excl. GST)				**$7,377.62**
Species credits				
No species credits are relevant				**n/a**
Species credits subtotal (excl. GST)				**$0.00**
Total price excluding GST				**$7,377.62**
Total price including GST				**$8,115.38**

8 REFERENCES

AES 2020. Biodiversity Development Assessment Report: Howlong Sand and Gravel Expansion Project (SSD 17_8804). *A report prepared by Advanced Environmental Systems Pty Ltd*.

ANON n.d. Brochure: Sloanes Champions: A brief guide to community surveying and monitoring of Sloanes Froglet (Crinia sloanei). *https://wtlandcare.org/wp-content/uploads/2018/06/Sloanes-Froglet-Monitoring-Guide-June-2018.pdf*.

DAVIES, P. E. 2000. Development of a national river bioassessment system (AusRivAS) in Australia. *In:* WRIGHT, J. F., SUTCLIFFE, D. W. & FURSE, M. T. (eds.) *Assessing the Biological Quality of Freshwaters: RIVPACS and other techniques.* Ambleside: Freshwater Biological Association.

DEC 2004. Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft). *NSW Department of Environment & Conservation, Hurstville, NSW.*

DECC 2009. Threatened species survey and assessment guidelines: field survey methods for fauna (Amphibians). *Department of Environment and Climate Change, Sydney, NSW*.

DPI 2007. Endangered ecological communties in NSW: Lower Murray River aquatic ecological community. *Department of Primary Industries,* Primefact 172.

DPIE 2019. Guidance to assist a decision-maker to determine a serious and irreversible impact. *https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/guidance-decision-makers-determine-serious-irreversible-impact-190511.pdf*.

KNIGHT, A. 2015. The case for Sloane's Froglet: Generating ecological knowledge with the intent to benefit biodiversity. *A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy, School of Environmental Sciences, Charles Sturt University*.

MITCHELL, P. B. 2002. Descriptions for NSW Mitchell Landscapes. *A report prepared for the NSW National Parks and Wildlife Service, Hurstville, NSW.*

NPWS 2003. The Bioregions of New South Wales: their biodiversity, conservation and history. *NSW National Parks and Wildlife Service, Hurstville*.

OEH 2017a. Biodiversity Assessment Method. *Office of Environment & Heritage for the NSW Government,* www.environment.nsw.gov.au/resources/bcact/biodiversity-assessment-method-170206.pdf.

OEH 2017b. Biodiversity Assessment Method. *Office of Environment & Heritage for the NSW Government*.

OEH. 2020a. *BioNET: The website for the Atlas of NSW Wildlife: A whole-of-government system for flora and fauna sightings information* [Online]. Available: www.bionet.nsw.gov.au [Accessed].

OEH 2020b. NSW Vegetation Information System: Classification. *http://www.environment.nsw.gov.au/NSWVCA20PRapp/default.aspx*.

THACKWAY, R. & CRESWELL, I. D. 1995. An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves. Version 4.0. *Australian Nature Conservation Agency, Canberra.*

WATSON, D. M. 2003. The 'standardized search' : An improved way to conduct bird surveys. *Austral Ecology,* 28**,** 515:525.

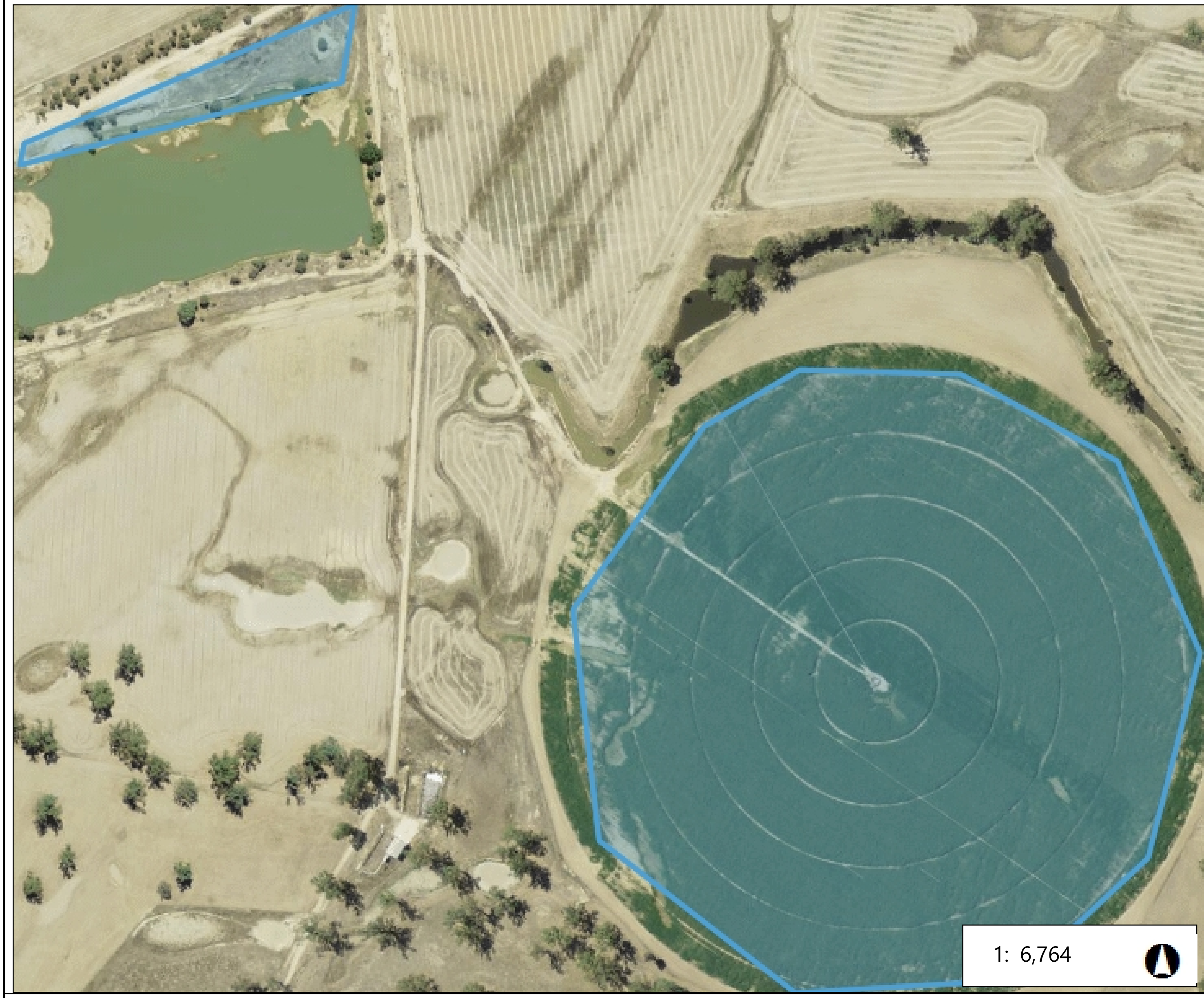
9 APPENDICES

APPENDIX 1 – QUALIFICATIONS AND EXPERIENCE OF PERSONNEL

Name and Qualifications	Experience
Steve Sass B.App.Sci (Env.Sci) (Hons), GradCert.CaptVertMngt (CSU) Director / Principal Ecologist NSW Biodiversity Accredited Assessor (BAAS17047) Certified Environmental Practitioner, EIANZ Member, Ecological Consultants Association of NSW	Steve is a highly experienced Ecologist having undertaken hundreds of terrestrial and aquatic ecological surveys and assessments across Australia since 1992. He has an in-depth working knowledge of environmental and biodiversity legislation across all states and territories which allows him to provide detailed and accurate assessments and formulate practical solutions to clients and specific projects on a case-by-case basis. He is a current NSW Biodiversity Accredited Assessor (BAAS17047) by the NSW Office of Environment and Heritage. Steve is a past Councillor of the Ecological Consultants Association of NSW. Steve was appointed 'Expert' status for a number of threatened species listed under the *Biodiversity Conservation Act 2016.* Previous and current research holds Steve in high regard within both the scientific and ecological consultants' community. To date, Steve has published, submitted or has in preparation, thirty-three manuscripts within peer-reviewed journals, many of which are related to threatened species survey, monitoring or management. Steve has extensive experience in NSW. Over the past 15 years, he has completed or provided specialist biodiversity advice to more than 1000 environmental assessments for projects such as residential and industrial developments, highway upgrades and telecommunications, water, sewerage, energy, mining and electricity network infrastructure projects. Steve was the senior author of this report and all BAM calculations.
Mark Harris B.App.Sci (Env Res Mgt) Senior Botanist / GIS Analyst	Mark is a highly experienced botanist having undertaken flora surveys across eastern and central Australia and he has more than 12 years' experience in Biodiversity Assessment and Planning. Mark completed the mapping and spatial analysis for this BDAR.
Alex Metcalfe Cert3. Capt.Animal.Management Ecology Assistant	Alex has worked as a field assistant with the NSW National Parks and Wildlife Service in Kosciuszko National Park for the past three years. Here, she was mainly involved with weed monitoring and threatened species surveys. In her short time at **EnviroKey**, Alex works under the direct supervision of the Principal Ecologist and Senior Ecologist, and provides valuable field assistance to the ecology team. For this project, Alex assisted with the field survey.
Linda Sass Assoc.Deg. Gn.St (Science), B.A, Dip. Ed (Sec) Director / Senior Ecologist Member, Ecological Consultants Association of NSW (ECA)	Linda is an experienced ecologist having conducted flora and fauna surveys across NSW over the past 12 years. Linda has extensive experience with the flora and fauna of southern, central and western NSW. In recent years, she has completed flora surveys for a proposed water pipeline in western NSW and a biodiversity study of an existing mining operation on the Cobar Peneplain. Linda conducted an internal review of this report.

APPENDIX 2 – BIODIVERSITY OFFSET SCHEME ENTRY LEVEL THRESHOLD TEST

Biodiversity Offset Scheme (BOS) Entry Threshold Map



343.6 0 171.79 343.6 Metres

WGS_1984_Web_Mercator_Auxiliary_Sphere

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

Legend

- Biodiversity Values that have been mapped for more than 90 days
- Biodiversity Values added within last 90 days

Notes

NSW GOVERNMENT

Biodiversity Values Map and Threshold Report

Results Summary

Date of Calculation	07/08/2020 3:08 PM		**BDAR Required***
Total Digitised Area	24.75	ha	
Minimum Lot Size Method	LEP		
Minimum Lot Size	400	ha	
Area Clearing Threshold	1	ha	
Area clearing trigger Area of native vegetation cleared	Unknown #		Unknown #
Biodiversity values map trigger Impact on biodiversity values map(not including values added within the last 90 days)?	no		no
Date of the 90 day Expiry	N/A		

*If BDAR required has:

- at least one 'Yes': you have exceeded the BOS threshold. You are now required to submit a Biodiversity Development Assessment Report with your development application. Go to https://customer.lmbc.nsw.gov.au/assessment/AccreditedAssessor to access a list of assessors who are accredited to apply the Biodiversity Assessment Method and write a Biodiversity Development Assessment Report
- 'No': you have not exceeded the BOS threshold. You may still require a permit from local council. Review the development control plan and consult with council. You may still be required to assess whether the development is '"likely to significantly affect threatened species' as determined under the test in s. 7.3 of the Biodiversity Conservation Act 2016. You may still be required to review the area where no vegetation mapping is available.

Where the area of impact occurs on land with no vegetation mapping available, the tool cannot determine the area of native vegetation cleared and if this exceeds the Area Threshold. You will need to work out the area of native vegetation cleared - refer to the BOSET user guide for how to do this.

On and after the 90 day expiry date a BDAR will be required.

Disclaimer

This results summary and map can be used as guidance material only. This results summary and map is not guaranteed to be free from error or omission. The State of NSW and Office of Environment and Heritage and its employees disclaim liability for any act done on the information in the results summary or map and any consequences of such acts or omissions. It remains the responsibility of the proponent to ensure that their development application complies will all aspects of the *Biodiversity Conservation Act 2016.*

The mapping provided in this tool has been done with the best available mapping and knowledge of species habitat requirements. This map is valid for a period of 30 days from the date of calculation (above).

Acknowledgement

I as the applicant for this development, submit that I have correctly depicted the area that will be impacted or likely to be impacted as a result of the proposed development.

Signature__________________________ Date: 07/08/2020 03:08 PM

APPENDIX 3 – BAM RAW FIELD DATA SHEETS

BAM Site – Field Survey Form

Site Sheet no:

		Survey Name	Plot Identifier	Recorders	
Date	7/7/2020	HOWLONG	BAM 1	SS	
Zone	Datum	IBRA region: RIVERINA.	Photo #		Zone ID
Easting	Northing	Dimensions: 50×20		Orientation of midline from the 0 m point.	

Vegetation Class	RIVERINE – FORESTED WETLAND ?		Confidence: H M L
Plant Community Type	PCT 5.	EEC: No	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m^2 plot)		Sum values
Count of Native Richness	Trees	1
	Shrubs	0
	Grasses etc.	3
	Forbs	0
	Ferns	0
	Other	1
Sum of Cover of native vascular plants by growth form group	Trees	5
	Shrubs	0
	Grasses etc.	20.
	Forbs	0
	Ferns	0
	Other	2.
High Threat Weed cover		6

BAM Attribute (20 x 50 m plot)		# Tree Stems Count		
dbh	Euc*	Non Euc	Hollows†	
large trees for Euc* & Non Euc 80 + cm	–	–	–	
50 – 79 cm	–	–	–	
30 – 49 cm	1	–	0	
20 – 29 cm	1	–	0	
10 – 19 cm	–	–	–	
5 – 9 cm	6	–	n/a	
< 5 cm			n/a	
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0			total 0.

Record number of living eucalypt* (Euc*) and living native non-eucalypt (Non Euc) stems separately

* Includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† Record total number of stems by size class with hollows (including dead stems/trees)

Counts must apply to each size class when the number of living tree stems within the size class is ≤ 10. Estimates can be used when the number of living tree stems within a class is > 10. Estimates should draw from the number series: 10, 20, 30 ... 100, 200, 300.

For a multi-stemmed tree, only the largest living stem is included in the count/estimate. For hollows count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	10	0	0	0	0	30	10	40	5	5	0	0	0	0	0	0	0	0	0	0
Average of the 5 subplots	.2					18					0					0.				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence
Clearing (inc. logging)	3		
Cultivation (inc. pasture)	0		
Soil erosion	3		
Firewood / CWD removal	0		
Grazing (identify native/stock)	0		
Fire damage	0		
Storm damage	0		
Weediness	3		
Other	0		

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 7/7/2020	HOWLONG	BAM 1	SS

GF Code	Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable	N, E or HTE	Cover	Abund	stratum	voucher
T	EUCALYPTUS CAMALDULENSIS.	N	5	8		
~~G~~	PASPALUM DILATATUM.	HTE.	5	500.		
/	TRAGOPOGAN PORRIFOLIUS. - OYSTER PLANT	E	2	1000		
/	HORDEUM LEPORINUM - BARLEY GRASS	E	10	500		
/	AVENA FATUA - WILD OATS.	E	20	1000		
G	AUSTRODANTHONIA ?CAESPITOSUM	N	5	1000		
G	AUSTROSTIPA SP.	N	5.	1000.		
/	HYPOCHAERIS RADICATA - FLAT WEED	E	2	50		
G	CYNODON DACTYLON - COMMON COUCH.	N	10	1000.		
O	JUNCUS USITATUS - COMMON RUSH.	N	2	50.		
/	CYPERUS ERAGROSTIS - UMBRELLA SEDGE.	HTE.	1	10.		
/	RUMEX CRISPUS - CURLED DOCK.	E	2	50.		
/	PHALARIS AQUATICA - PHALARIS	E.	20	500		
/	~~HA~~ VICIA HIRSUTA - HAIRY VETCH.	E	1	100.		
/	~~WHITE~~ POA ?ANNUA - WINTER GRASS	E	5	100.		
/	CENTAUREA SOLSTITIALIS - ST BARNABYS THISTLE	E	2	50.		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic **GF – circle code if 'top 3'.**

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

BAM Site – Field Survey Form

Site Sheet no:

		Survey Name	Plot Identifier		Recorders	
Date	7/7/2020.	HOWLONG.	BAM 2			
Zone	Datum	IBRA region	RIV.	Photo #	Zone ID	
Easting	Northing	Dimensions	50x20.		Orientation of midline from the 0 m point.	
Vegetation Class	FORESTED RIVERINE WETLAND				Confidence: H M L	
Plant Community Type	PCT5.			EEC: N	Confidence: H M L	

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	1
	Shrubs	0
	Grasses etc.	3
	Forbs	6
	Ferns	0
	Other	0
Sum of Cover of native vascular plants by growth form group	Trees	30.
	Shrubs	0.
	Grasses etc.	17.
	Forbs	0
	Ferns	0
	Other	0
High Threat Weed cover		2

BAM Attribute (20 x 50 m plot)		# Tree Stems Count	
dbh	Euc*	Non Euc	Hollows†
large trees for Euc* & Non Euc 80 + cm	0	0	0
50 – 79 cm	1	0	0
30 – 49 cm	0	0	0
20 – 29 cm	1	0	0
10 – 19 cm	7	0	0
5 – 9 cm	12	0	n/a
< 5 cm	0	0	n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0		total 0

Record number of living eucalypt* (Euc*) and living native non-eucalypt (Non Euc) stems separately

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† Record total number of stems by size class with hollows (including dead stems/trees)

Counts must apply to each size class when the number of living tree stems within the size class is ≤ 10. Estimates can be used when the number of living tree stems within a class is > 10. Estimates should draw from the number series: 10, 20, 30 ... 100, 200, 300

For a multi-stemmed tree, only the largest living stem is included in the count/estimate. For hollows count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	20	10	5	20	30	10	5	0	10	5	0	0	0	0	0	0	0	0	0	0
Average of the 5 subplots	17					6					0					0				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence
Clearing (inc. logging)	2		
Cultivation (inc. pasture)	0		
Soil erosion	3		
Firewood / CWD removal	3		
Grazing (identify native/stock)	2		
Fire damage	0		
Storm damage	0		
Weediness	2		
Other	0		

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 7/7/2020.	HOWLONG	BAM 2.	SS

GF Code	*Top 3 native species in each growth form group: Full species name mandatory* *All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
T	EUCALYPTUS CAMALDULENSIS. - RIVER RED GUM.	30 N	30	20		
G	ARISTIDA RAMOSA.	N	10	200.		
G	AUSTROSTIPA SP.	N	5	100.		
N	PHALARIS AQUATICA. PHALARIS	E	20	100		
/	PASPALUM DILATATUM. ~~COMMON~~ PASPALUM	HTE.	2	100.		
N	PASPALUM. DISTICHUM. - WATER COUCH	N.	2	100		
/	HORDEUM LEPORIUM - BARLEY GRASS	E	10	500		
/	CONYZA BONARIENSIS - FLEABANE.	E	1	5.		
/	PLANTAGO LANCEOLATA - PLANTAIN.	E	1	5.		
/	AVENA FATUA - WILD OATS	E	10	200		
/	MALVA SP. ?PARVIFLORA -	E.	2	2.		
/	SANGUISORBA MINOR - SALAD BURNETT	E	1	10.		

GF Code: see Growth Form definitions in Appendix 1 N: native, E: exotic, HTE: high threat exotic GF – circle code if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); **Note:** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

BAM Site – Field Survey Form					Site Sheet no:

		Survey Name	Plot Identifier	Recorders	
Date	7/7/2020.	HOWLONG	BAM 3.	SS	
Zone	Datum	IBRA region	RIVERIA.	Photo #	Zone ID
Easting	Northing	Dimensions	50×20.	Orientation of midline from the 0 m point.	
Vegetation Class					Confidence: H M L
Plant Community Type	CLEARED WITH JUST 1 E.CAMALDULENSIS.			EEC:	Confidence: H M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	2
	Shrubs	0
	Grasses etc.	0
	Forbs	0
	Ferns	0
	Other	0
Sum of Cover of native vascular plants by growth form group	Trees	21
	Shrubs	0
	Grasses etc.	0
	Forbs	0
	Ferns	0
	Other	0
High Threat Weed cover		30

BAM Attribute (20 x 50 m plot)	# Tree Stems Count		
dbh	Euc*	Non Euc	Hollows†
large trees for Euc* & Non Euc 80 + cm	0	0	0
50 – 79 cm	0	0	0
30 – 49 cm	1	1	0
20 – 29 cm	0	0	0
10 – 19 cm	0	3	0
5 – 9 cm	0	4	n/a
< 5 cm	0	0	n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0		total

Record number of living eucalypt* (Euc*) and living native non-eucalypt (Non Euc) stems separately

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† Record total number of stems by size class with hollows (including dead stems/trees)

Counts must apply to each size class when the number of living tree stems within the size class is ≤ 10. Estimates can be used when the number of living tree stems within a class is > 10. Estimates should draw from the number series 10, 20, 30 ..., 100, 200, 300.

For a multi-stemmed tree, only the largest living stem is included in the count/estimate. For hollows count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average of the 5 subplots	1					0					0					0.				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description.

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence
Clearing (inc. logging)	3		
Cultivation (inc. pasture)	3		
Soil erosion	2		
Firewood / CWD removal	3		
Grazing (identify native/stock)	3		
Fire damage	0		
Storm damage	0		
Weediness	3		
Other	0		

400 m² plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 7/7/2020.	HOWLONG	BAM 3	

GF Code	Top 3 native species in each growth form group: Full species name mandatory All other native and exotic species: Full species name where practicable	N, E or HTE	Cover	Abund	stratum	voucher
/	SALIX ?MATSUDANA – TORTURED WILLOW.	HTE	20	5.		
/	ECHIUM PLANTAGINEUM – PATTERSONS CURSE.	E	5	100.		
/	BROMUS ?DIANDRIS – GREAT BROOME.	HTE.	10	30		
/	PHALARIS AQUATICA – PHALARIS.	E	20	50		
T	ACACIA DEALBATA – SILVER WATTLE.	N	1	4.		
E	RUMEX CRISPUS – CURLED DOCK.	E	5	20.		
/	PANICUM ?COLORATUM. – PANICUM.	E	5	100		
/	POA ?ANNUA – WINTER GRASS	E	5	500.		
/	HORDEUM ?LEPORINUM – BARLEY GRASS	E	10	500.		
T	EUCALYPTUS CAMALDULENSIS – RIVER RED GUM.	N.	20	1		
/	VULPIA BROMOIDES – SILVER GRASS.	E	2	100.		
/	ARCTOTHECA CALENDULA – CAPEWEED	E	5	100.		

GF Code: see Growth Form definitions in Appendix 1 N: native, E: exotic, HTE: high threat exotic GF – circle code if 'top 3'.
Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); *Note: 0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

BAM Site – Field Survey Form

Site Sheet no:

Date	7/7/20.	**Survey Name** HOWLONG.	**Plot Identifier** BAM 4.	**Recorders** SS	
Zone	Datum	IBRA region	RIVERIA.	Photo #	Zone ID
Easting	Northing	Dimensions		Orientation of midline from the 0 m point.	
Vegetation Class	CLEARED.				Confidence: (H) M L
Plant Community Type	CLEARED		EEC: N.		Confidence: (H) M L

Record easting and northing from the plot marker. If applicable, orient picket so that perforated rib points along direction of midline.
Dimensions (Shape) of 0.04 ha base plot inside 0.1 ha FA plot should be identified, magnetic bearing taken along midline.

BAM Attribute (400 m² plot)		Sum values
Count of Native Richness	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
Sum of Cover of native vascular plants by growth form group	Trees	
	Shrubs	
	Grasses etc.	
	Forbs	
	Ferns	
	Other	
High Threat Weed cover		

BAM Attribute (20 x 50 m plot) dbh	# Tree Stems Count Euc*	Non Euc	Hollows†
large trees for Euc* & Non Euc 80 + cm	–	–	–
50 – 79 cm	–	–	–
30 – 49 cm	–	–	–
20 – 29 cm	–	–	–
10 – 19 cm	–	–	–
5 – 9 cm	–	–	n/a
< 5 cm	–	–	n/a
Length of logs (m) (≥10 cm diameter, >50 cm in length)	0		total

Record number of living eucalypt* (Euc*) and living native non-eucalypt (Non Euc) stems separately

* includes all species of *Eucalyptus*, *Corymbia*, *Angophora*, *Lophostemon* and *Syncarpia*

† Record total number of stems by size class with hollows (including dead stems/trees)

Counts must apply to each size class when the number of living tree stems within the size class is ≤ 10. Estimates can be used when the number of living tree stems within a class is > 10. Estimates should draw from the number series 10, 20, 30 ... 100, 200, 300

For a multi-stemmed tree, only the largest living stem is included in the count/estimate. For hollows count only the presence of a stem containing hollows, not the count of hollows in that stem. Only count as 1 stem per tree where tree is multi-stemmed. The hollow-bearing stem may be a dead stem.

BAM Attribute (1 x 1 m plots)	Litter cover (%)					Bare ground cover (%)					Cryptogam cover (%)					Rock cover (%)				
Subplot score (% in each)	0	0	0	0	0	10	8	15	20	10	0	0	0	0	0	0	0	0	0	0
Average of the 5 subplots	0					15.					0.					0.				

Litter cover is assessed as the average percentage ground cover of litter recorded from five 1 m x 1 m plots located on alternate sides and 5 m from the plot midline at the locations 5, 15, 25, 35, and 45 m along the midline. Litter cover includes leaves, seeds, twigs, branchlets and branches (less than 10 cm in diameter). Within these 1 m x 1 m plots assessors may also record the cover of rock, bare ground and cryptogam soil crusts. Collection of these data is optional - the data do not currently contribute to assessment scores, they hold potential value for future vegetation integrity assessment attributes and benchmarks, and for enhancing PCT description

Physiography + site features that may help in determining PCT and Management Zone (optional)

Morphological Type		Landform Element		Landform Pattern		Microrelief	
Lithology		Soil Surface Texture		Soil Colour		Soil Depth	
Slope		Aspect		Site Drainage		Distance to nearest water and type	

Plot Disturbance	Severity code	Age code	Observational evidence
Clearing (inc. logging)	3		
Cultivation (inc. pasture)	3		
Soil erosion	0		
Firewood / CWD removal	0		
Grazing (identify native/stock)	0		
Fire damage	0		
Storm damage	0		
Weediness	3		
Other	0.		

400 m^2 plot: Sheet _ of _	Survey Name	Plot Identifier	Recorders
Date 7/7/20.	HOWLONG	BAM 4.	SS

GF Code	*Top 3 native species in each growth form group: Full species name mandatory* *All other native and exotic species: Full species name where practicable*	N, E or HTE	Cover	Abund	stratum	voucher
/	POA ? ANNUA. — WINTER GRASS	E	20	10,000		
/	MOENCHIA ERECTA — COMMON CHICKWEED	E	1	5,000		
/	AVENA FATUA — OATS	E	60.	100,000		

GF Code: see Growth Form definitions in Appendix 1 **N:** native, **E:** exotic, **HTE:** high threat exotic GF – circle code if 'top 3'.

Cover: 0.1, 0.2, 0.3, ..., 1, 2, 3, ..., 10, 15, 20, 25, ...100% (foliage cover); ***Note:*** *0.1% cover represents an area of approximately 63 x 63 cm or a circle about 71 cm across, 0.5% cover represents an area of approximately 1.4 x 1.4 m, and 1% = 2.0 x 2.0 m, 5% = 4 x 5 m, 25% = 10 x 10 m*

APPENDIX 4 – FLORA RECORDED WITHIN THE STUDY AREA

P = Present

*= exotic species

Scientific Name	Common Name	AES (2020)	EK field survey
Acacia dealbata	Silver Wattle		P
**Acetosella vulgaris*	Sheep Sorrel	P	P
**Amaranthus viridis*	Green Amaranth	P	
**Arctotheca calendula*	Capeweed	P	P
Aristida ramosa	Purple Wiregrass	P	P
Austrodanthonia caespitosum	Ringed Wallaby Grass	P	P
Austrostipa spp.	Speargrass	P	P
Acaena sp.			P
**Avena fatua*	Wild Oats	P	P
**Bromus diandrus*	Great Brome	P	P
Callistemon sieberi	River bottlebrush	P	
**Centaurea solstilalis*	St Barnabys Thistle		P
Chloris truncata	Windmill Grass	P	P
**Conyza bonariensis*	Flaxleaf Fleabane	P	P
Cynodon dactylon	Common Couch	P	P
**Cyperus eragrostis*	Umbrella Sedge	P	P
**Dactylis glomerata*	Cocksfoot	P	
**Echium plantagineum*	Patterson's Curse	P	P
**Emilia sonchifolia*	Purple Sow Thistle		P
Enteropogon acicularis	Curly Windmill Grass	P	
Eucalyptus camaldulensis	River Red Gum	P	P
Fumaria muralis	Smoke weed	P	
**Hordeum leporinum*	Barley Grass	P	P
**Hypochaeris radicata*	Flat weed		P
**Hypericum perforatum*	St.Johns Wort		P
Juncus usitatus	Common Rush	P	P

Scientific Name	Common Name	AES (2020)	EK field survey
Juncus sp.			P
**Lactuca serriola*	Prickly Lettuce		P
Lepidium campestre	Pepperwort	P	
**Lolium multiflorum*	Italian Ryegrass	P	
**Lolium rigidum*	Wimmera Ryegrass	P	
**Malva neglecta*	Pink Mallow	P	
**Malva sp. ?parviflora*	Small-flowered Mallow		P
**Medicago polymorpha*	Burr Medic	P	
**Mentha arvensis?*	Wild mint	P	
**Moenchia erecta*	Common Chickweed		P
Panicium decompositum	Native millet	P	
**Panicum coloratum*	Blue Panicgrass	P	P
**Paspalum dilatatum*	Paspalum	P	P
Paspalum distichum	Water Couch	P	
**Phalaris aquatica*	Phalaris	P	P
**Plantago lanceolata*	Plantain		P
Poa? Annia	Winter Grass		P
**Polygonum aviculare*	Wireweed		P
**Polygonum erectum*	Wireweed	P	
**Romulea rosea var. australis*	Onion Grass	P	
**Rubus ulmifolius*	Blackberry	P	P
**Rumex crispus*	Curled Dock	P	P
**Salix ? matsudata*	Tortured Willow		P
**Sanguisorba minor*	Salad Burnett		P
**Silybum marianum*	Variegated Thistle		P
**Solanum nigrum*	Black-berry Nightshade		P
**Solanum pseudocapiscum*	Maideira Winter Cherry	P	
**Sonchus asper*	Prickly Sowthistle	P	
**Sonchus sp.*	A Sowthistle		P

Scientific Name	Common Name	AES (2020)	EK field survey
**Taraxacum officinale*	Dandelion	P	
**Tragopogan porritolius*	Oyster Plant		P
**Urtica dioica*	Stinging Nettle		P
**Verbena bonariensis*	Purpletop vervain	P	
**Vicia hirsuta*	Hairy vetch	P	P
Vulpia bromoides	Silver Grass		P
**Xanthium spinosum*	Bathurst Burr	P	

APPENDIX 5 – FAUNA RECORDED WITHIN THE STUDY AREA

P = Present

Scientific Name	Common Name	AES (2020)	EK field survey
Acrocephalus australis	Australian Reed Warbler		P
Anas gracilis	Grey Teal	P	
Anas superciliosa	Pacific Black Duck	P	P
Anthus novaeseelandiae	Australian Pipit	P	
Ardea modesta	Eastern Great Egret	P	
Ardea pacifica	White-necked Heron	P	P
Austronomus australis	White-striped Freetail-bat	P	
Cacatua galerita	Sulphur-crested Cockatoo	P	P
Cacatua sanguinea	Little Corella		P
**Cervus elephus*	Sambur Deer	P	P
Chalinolobus gouldii	Gould's Wattled Bat	P	
Chalinolobus morio	Chocolate Wattled Bat	P	
Chenonetta jubata	Australian Wood Duck	P	P
Climacteris picumnus	Brown Treecreeper		P
Colluricincla harmonica	Grey Shrike-thrush		P
Coracina novaehollandiae	Black-faced Cuckoo-shrike	P	
Corcorax melanorhamphos	White-winged Chough	P	P
Corvus coronoides	Australian Raven	P	P
Cracticus tibicen	Australian Magpie	P	P
Crinia parinsignifera	Eastern Sign-bearing Froglet	P	P
Crinia signifera	Common Eastern Froglet	P	
Dacelo nivaeguineae	Laughing Kookaburra		P
Egretta novaehollandiae	White-faced Heron	P	P
Elseyornis melanops	Black-fronted Dotterel		P
Eolophus roseicapillus	Galah	P	P
Falco berigora	Brown Falcon		P
Falco cenchroides	Nankeen Kestrel	P	
Grallina cyanoleuca	Magpie-lark		P
Haliastur sphenurus	Whistling Kite	P	P
Hirundo neoxena	Welcome Swallow	P	P

Scientific Name	**Common Name**	**AES (2020)**	**EK field survey**
Lichenostomus penicillatus	White-plumed Honeyeater		P
Limnodynastes dumerilii	Eastern Banjo Frog	P	
Limnodynastes peronii	Brown-striped Frog	P	
Limnodynastes tasmaniensis	Spotted Grass Frog	P	
Litoria ewingii	Southern Brown Tree Frog		P
Litoria verreauxii	Whistling Tree Frog	P	
Macropus giganteus	Eastern Grey Kangaroo	P	
Malurus cyaneus	Superb Fairy-wren		P
Manorina melanocephala	Noisy Miner	P	
Microcarbo melanoleucos	Little Pied Cormorant	P	P
Mormopterus (Ozimops) planiceps	Little Mastiff-bat	P	
Mormopterus (Ozimops) ridei	Eastern (Ride's) Free-tailed Bat	P	
Ninox novaeseelandiae	Southern Boobook	P	
Ocyphaps lophotes	Crested Pigeon	P	P
Pachcephala pectoralis	Golden Whistler		P
Pardalotus striatus	Striated Pardalote		P
Pelecanus conspicillatus	Australian Pelican	P	
Petrochelidon ariel	Fairy Martin	P	
Phalacrocorax sulcirostris	Little Black Cormorant	P	
Phalacrocorax varius	Pied Cormorant	P	
Platalea flavipes	Yellow-billed Spoonbill	P	
Platycercus elegans	Crimson Rosella (yellow form)		P
Platycercus eximius	Eastern Rosella		P
Psephotus haematonotus	Red-rumped Parrot		P
Pseudocheirus peregrinus	Common Ringtail Possum	P	
Pseudonaja textilis	Eastern Brown Snake	P	
Rhipidura leucophrys	Willie Wagtail	P	P
Sericornis frontalis	White-browed Scrubwren		P
Scotorepens balstoni	Inland Broadnosed Bat	P	
Scotorepens greyii	Little Broadnosed Bat	P	
Strepera graculina	Pied Currawong	P	P

Scientific Name	Common Name	AES (2020)	EK field survey
**Sturnus vulgaris*	Common Starling	P	P
Tachybaptus novaehollandiae	Australasian Grebe	P	
Tadorna tadornoides	Mountain Duck	P	
Threskiornis molucca	Australian White Ibis	P	
Todiramphus sanctus	Sacred Kingfisher	P	
Trichosurus vulpecula	Common Brushtail Possum	P	
Tyto javanica	Eastern Barn Owl	P	
Vanellus miles	Masked Lapwing		P
Vespadelus darlingtoni	Large Forest Bat	P	
Vespadelus vulturnus	Little Forest Bat	P	
**Vulpes vulpes*	Fox	P	

APPENDIX 6 – BAM CALCULATOR REPORTS

BAM Biodiversity Credit Report (Variations)

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020
Assessor Name	Assessor Number	BAM Data version *
Steven Sass	BAAS17047	29
Proponent Name(s)	Report Created	BAM Case Status
	09/08/2020	Open
Assessment Revision	Assessment Type	Date Finalised
0	Major Projects	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Potential Serious and Irreversible Impacts

Nil

Nil

Additional Information for Approval

PCTs With Customized Benchmarks

No Changes

Predicted Threatened Species Not On Site

No Changes

Ecosystem Credit Summary (Number and class of biodiversity credits to be retired)

Name of Plant Community Type/ID	Name of threatened ecological community	Area of impact	Number of credits to be retired
5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	Not a TEC	0.1	1.00

5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	**Like-for-like credit retirement options**			
	Class	Trading group	HBT	IBRA region
	Inland Riverine Forests This includes PCT's: 2, 5, 7, 8, 9, 10, 11, 36, 78, 112, 233, 234, 249, 356, 362	Inland Riverine Forests <50%	Yes	Murray Fans,Inland Slopes, Lower Slopes, Murrumbidgee, Robinvale Plains, South Olary Plain and Robinvale Plains. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.
	Variation options			
	Formation	Trading group	HBT	IBRA region

	Forested Wetlands	Tier 7 or higher	Yes (including artificial)	IBRA Region: Riverina, or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

Species Credit Summary

No Species Credit Data

BAM Biodiversity Credit Report (Like for like)

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020
Assessor Name	Assessor Number	BAM Data version *
Steven Sass	BAAS17047	29
Proponent Names	Report Created	BAM Case Status
	09/08/2020	Open
Assessment Revision	Assessment Type	Date Finalised
0	Major Projects	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Potential Serious and Irreversible Impacts

Nil

Nil

Additional Information for Approval

PCTs With Customized Benchmarks

No Changes

Predicted Threatened Species Not On Site

No Changes

Ecosystem Credit Summary (Number and class of biodiversity credits to be retired)

Name of Plant Community Type/ID	Name of threatened ecological community	Area of impact	Number of credits to be retired
5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	Not a TEC	0.1	1.00

5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	**Like-for-like credit retirement options**			
	Class	Trading group	HBT	IBRA region
	Inland Riverine Forests This includes PCT's: 2, 5, 7, 8, 9, 10, 11, 36, 78, 112, 233, 234, 249, 356, 362	Inland Riverine Forests <50%	Yes	Murray Fans, Inland Slopes, Lower Slopes, Murrumbidgee, Robinvale Plains, South Olary Plain and Robinvale Plains. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.

Species Credit Summary

No Species Credit Data

BAM Candidate Species Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Steven Sass	09/08/2020	29
Assessor Number	**Assessment Type**	**BAM Case Status**
BAAS17047	Major Projects	Open
	Assessment Revision	**Date Finalised**
	0	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

List of Species Requiring Survey

Name	Presence	Survey Months
Crinia sloanei Sloane's Froglet	No (surveyed) *Survey months are outside of the months specified in Bionet.	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Haliaeetus leucogaster White-bellied Sea-Eagle	No (surveyed) *Survey months are outside of the months specified in Bionet.	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

List of Species Not On Site

Name
Cullen parvum Small Scurf-pea
Lathamus discolor Swift Parrot
Myotis macropus Southern Myotis
Petaurus norfolcensis Squirrel Glider
Phascogale tapoatafa Brush-tailed Phascogale
Phascolarctos cinereus Koala
Polytelis swainsonii Superb Parrot

Anthochaera phrygia Regent Honeyeater	
Burhinus grallarius Bush Stone-curlew	
Lophoictinia isura Square-tailed Kite	
Ninox strenua Powerful Owl	
Hieraaetus morphnoides Little Eagle	

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020

Assessor Name	Report Created	BAM Data version *
Steven Sass	09/08/2020	29

Assessor Number	BAM Case Status	Date Finalised
BAAS17047	Open	To be finalised

Assessment Revision	Assessment Type
0	Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	Vegetation integrity loss / gain	Area (ha)	Constant	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Potential SAII	Ecosystem credits

River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.								
1	5_Mod-good	22.2	0.1	0.25	High Sensitivity to Potential Gain	1.50		1
							Subtotal	**1**
							Total	**1**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk weighting	Potential SAII	Species credits

Biodiversity payment summary report

Assessment Id	Payment data version	Assessment Revision	Report created
00021174/BAAS17047/20/00021175	68	0	09/08/2020

Assessor Name	Assessor Number	Proposal Name	BAM Case Status
Steven Sass	BAAS17047	Howlong Sand and Gravel Quarry Expansion	Open

Assessment Type	Date Finalised
Major Projects	To be finalised

PCT list

Price calculated	PCT common name	Credits
Yes	**5 -** River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	1

Species list

Price calculated	Species	Credits

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Biodiversity payment summary report

IBRA sub region	PCT common name	Threat status	Offset trading group	Risk premium	Administrative cost	Methodology adjustment factor	Price per credit	No. of ecosystem credits	Final credits price
Murray Fans	**5 -** River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	No	Inland Riverine Forests <50%	19.12%	$239.69	2.2502	$7,377.62	1	$7,377.62

Subtotal (excl. GST)	**$7,377.62**
GST	**$737.76**
Total ecosystem credits (incl. GST)	**$8,115.38**

Species credits for threatened species

Species profile ID	Species	Threat status	Price per credit	Risk premium	Administrative cost	No. of species credits	Final credits price

No species available

Grand total	**$8,115.38**

BAM Predicted Species Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020

Assessor Name	Report Created	BAM Data version *
Steven Sass	09/08/2020	29

Assessor Number	Assessment Type	BAM Case Status
BAAS17047	Major Projects	Open

Assessment Revision	Date Finalised
0	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Threatened species reliably predicted to utilise the site. No surveys are required for these species. Ecosystem credits apply to these species.

Common Name	Scientific Name	Vegetation Types(s)
Australian Painted Snipe	Rostratula australis	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Diamond Firetail	Stagonopleura guttata	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Dusky Woodswallow	Artamus cyanopterus cyanopterus	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Flame Robin	Petroica phoenicea	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Freckled Duck	Stictonetta naevosa	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.

Hooded Robin (south-eastern form)	Melanodryas cucullata cucullata	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Koala	Phascolarctos cinereus	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Little Eagle	Hieraaetus morphnoides	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Little Lorikeet	Glossopsitta pusilla	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Little Pied Bat	Chalinolobus picatus	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Painted Honeyeater	Grantiella picta	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Powerful Owl	Ninox strenua	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Purple-crowned Lorikeet	Glossopsitta porphyrocephala	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Regent Honeyeater	Anthochaera phrygia	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Scarlet Robin	Petroica boodang	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.

Spotted Harrier	Circus assimilis	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Spotted-tailed Quoll	Dasyurus maculatus	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Square-tailed Kite	Lophoictinia isura	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Superb Parrot	Polytelis swainsonii	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Swift Parrot	Lathamus discolor	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Turquoise Parrot	Neophema pulchella	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Varied Sittella	Daphoenositta chrysoptera	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
White-bellied Sea-Eagle	Haliaeetus leucogaster	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.
Yellow-bellied Sheathtail-bat	Saccolaimus flaviventris	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.

BAM Vegetation Zones Report

Proposal Details

Assessment Id	Assessment name	BAM data last updated *
00021174/BAAS17047/20/00021175	Howlong Sand and Gravel Quarry Expansion	18/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Steven Sass	09/08/2020	29
Assessor Number	**Assessment Type**	**BAM Case Status**
BAAS17047	Major Projects	Open
	Assessment Revision	**Date Finalised**
	0	To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Vegetation Zones

#	Name	PCT	Condition	Area	Minimum number of plots	Management zones
1	5_Mod-good	5-River Red Gum herbaceous-grassy very tall open forest wetland on inner floodplains in the lower slopes sub-region of the NSW South Western Slopes Bioregion and the eastern Riverina Bioregion.	Mod-good	0.05	1	

Appendix 7

Updated Groundwater Impact Assessment prepared by Water Technology – February 2022

(Total No. of pages including blank pages = 174)

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Groundwater Impact Assessment

Howlong Quarry Expansion

Fraser Earthmoving Construction

16 February 2022

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V2.0	Final	SLE	SLE	07/06/2018
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V6.0	Revision	RB	RB	14/08/2019
V7.0	Change in Operations	RB	RB	08/01/2020
V8.0	Change in Operations	RB	RB	06/02/2020
V9.0	Change in Operations	RB	RB	28/02/2020
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Project Details

Project Name	Howlong Quarry Expansion
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Document Number	P18189 R001 v12.0 Howlong Groundwater Assessment_Final_220216

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EXECUTIVE SUMMARY

The Howlong Sand Quarry Expansion Project aims to expand extraction operations and increase product despatch from the current rate of 30,000 tonnes per annum to 300,000 tonnes per annum. The quarry site accesses the Upper Murray Alluvium groundwater system within the Murray Alluvium Water Resource Plan Area, close to Howlong, between the Murray River and Black Swan Anabranch. Current operational practices utilise licensed groundwater allocations to provide water supply for quarry operations.

This report outlines Water Technology's investigations into hydrogeological processes at the materials extraction site. It identifies potential risks to the semi-regional groundwater system, and the impact of the proposed quarry expansion on the local groundwater system. The Upper Murray Alluvium groundwater system is unconfined to semi-confined with groundwater flow westwards, occurring primarily through unconsolidated alluvial sediments. Hydraulic conductivity and transmissivity are moderate to high and groundwater flow systems are typically local with short flow lengths defined by topographic catchments. Water quality within these systems is fresh to marginal. Water table depths are shallow to intermediate. Groundwater residence times are typically short to medium, with relatively quick responses to changes in land management. The Murray River and incident rainfall have been identified as major recharge sources for the aquifer while irrigation leakage was identified as a minor recharge source.

The regulated river level is the primary driver for shallow groundwater level variability near the proposed Sand Quarry Expansion project and the observed seasonal fluctuation of the River level is approximately 2.5 m. Groundwater hydrograph data indicates hydraulic connection between the river and the alluvial aquifer, for example when the River stage is at low flow the regional shallow groundwater levels near the River drop by a similar magnitude. Higher river levels are maintained during the irrigation season between approximately September and April.

The proposed Sand Quarry Expansion project aims to deepen the existing two pits and excavate two additional areas. The estimated surface area of the post-mining groundwater-filled pits will be around 41 Ha. The additional evaporative loss from the post-mining pit surface area would need to be accounted for under groundwater extraction licenses. During the development through Stages 1 to 4, it is estimated that groundwater pumping rates for pit dewatering would range from 0 ML/d to 4.6 ML/d. Groundwater pumping will require appropriate groundwater access licenses and management and water removed from active extraction areas would be used for on-site washing of materials, quarry activities and irrigation activities on the broader property. Water management within the excavated areas would be required to balance storages and to accommodate the anticipated volume of water removed from the active areas.

Drawdown as a result of pit dewatering and proposed irrigation supply has been assessed using a numerical groundwater flow model. The modelling shows that due to the bounding of the Murray River and Black Swan Anabranch the drawdown effects of the proposed staged development are largely constrained to a localised area between these water bodies. The limited extent of drawdown means that existing water supply works are not expected to be impacted. Drawdown in the order of 0.5 to 1.0 m is predicted to extend to the fringes of some GDEs. The impacted areas consist largely of the Plant Community Type 5: "River red gum herbaceous-grassy very tall open forest". Depending on the degree of reliance these vegetation communities have on the groundwater system, it is possible that some level of localised effect may be felt on GDEs directly adjacent the pits during operations. Post quarrying, the drawdown extent is significantly reduced and impacts to GDEs are expected to be minimal.

Impacts to the Murray River and downstream water users are not predicted to occur as the operation would be licenced and the worst-case dewatering scenario represents only 0.04% of the average daily flow of approximately 7,000 ML/d, as measured in 2019. Water quality in the river would be unchanged as the water levels in the extraction pits are modelled to be maintained at levels lower than the river water level thereby maintaining a flow gradient from the river to the pits.

The main long-term impact on the hydrogeological behaviour is anticipated to be an increase in the surface area of exposed water table due to an increase in the number of excavated pits. This will increase the rate of groundwater discharge from the Upper Murray Alluvium, which will need to be accounted for by corresponding licensed extraction of groundwater for irrigation purposes accounted for in water licencing held by the Applicant. The increased depth of excavation of the pits is assumed to fully penetrate the Shepparton Formation Aquifer. The pits are modelled to become evaporative sinks on the floodplain with localised groundwater flow paths reflecting this. It is possible that salinity increases in the pits of up to 10 mg/L per year may be observed depending on a range of factors including future climatic conditions, aquifer parameters, excavated pit dimensions and long-term management and use of the pits.

To validate the hydrogeological conceptual model and predicted impacts, it is recommended that groundwater and surface water monitoring (water level and quality) be undertaken to assess for actual groundwater impacts and that water use through-out the proposed operations are appropriately monitored to account for all water inputs and outputs.

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1 INTRODUCTION

This investigation concerns the proposed increase in extraction operations at the existing sand and gravel quarry at 4343 Riverina Highway, approximately 4 km south-east of Howlong in NSW (now referred to as the “Project”). The Project includes the planned expansion of the current quarry operation and increase to production from the current rate of 30,000 tonnes per annum (tpa) to 300,000 tpa. Increased production at the site is proposed to be a staged process as follows (refer to Figure 1-1 for locations):

- Stage 1 Western Existing Pit;
- Stage 2 Eastern Existing Pit;
- Stage 3 Processing Area and Future Pit; and
- Stage 4 Future Pit.

The Project site is within the Murray River floodplain and accesses the Upper Murray Alluvium groundwater system within the Murray Alluvium Water Resource Plan Area (WRPA). Thus, an understanding of hydrogeological processes that operate through this site is crucial for the successful extension and operation of the quarry. Water Technology was engaged to undertake a desktop groundwater assessment and numerical modelling to assess the potential impacts of the proposed quarry expansion.

This report outlines Water Technology’s investigations into hydrogeological processes at the materials extraction site. It identifies potential risks to the semi-regional groundwater system, and the impact of the proposed quarry expansion on the local groundwater system. A hydrogeological conceptual model of the Project area was developed for the site and was used to inform the development of a numerical groundwater flow model to quantify groundwater interactions during and after the increased extraction activities.

Fraser Earthmoving Construction currently operates the Howlong Sand and Gravel Quarry. The quarry has been in use for more than 60 years. Howlong Sand and Gravel Quarry, currently managed by Fraser Earthmoving Construction, is a relatively small operation supplying mainly to private projects and local farms.

Fraser Earthmoving Construction proposes to replace existing outdated equipment and refurbish infrastructure such as roads and bridges to allow for an increased annual extraction volume to service a wider market within the public sector. The proposal will set the annual maximum production limit at 300,000 tpa. The proposed project will provide an important construction resource to support the planned growth of the NSW Riverina region and beyond, providing increased employment to the area.

The proposed Project is a “State Significant Development” (SSD) as defined under the State Environmental Planning Policy (SEPP) (State and Regional Development) (SRD) 2011 and will require development consent under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

To date all old and out-dated equipment has been removed from the quarry area and has been replaced with a McCloskey Sandstorm 620 washing and screening system. A new access road has been constructed to avoid remnant vegetation and provide all weather access.

Figure 1-1 shows the site locality and proposed quarry expansion area and Figure 1-2 shows the topography, including the outline of the existing pits. The Murray River floodplain through Howlong is an anabranch system, with creeks leaving the Murray and flowing back in further downstream. There are many cut-off meanders and billabongs through the floodplain, formed from old river courses. Despite the complex topography of the river and anabranches, the floodplain is well defined, and in large floods is inundated to the floodplain margins. The quarry site is close to Howlong, between the Murray River and Black Swan Anabranch.

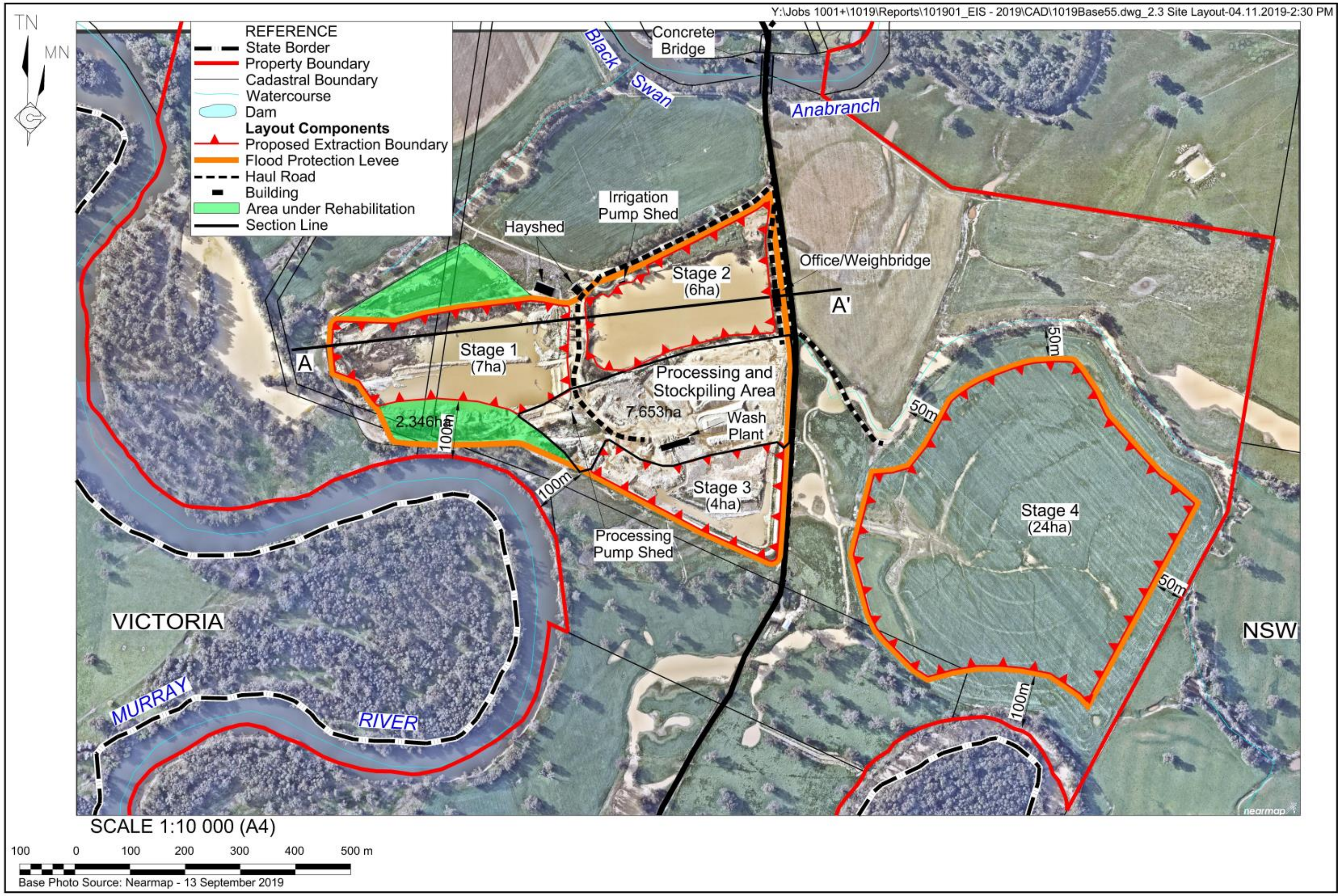

FIGURE 1-1 PROPOSED QUARRY EXPANSION AREA (RW CORKERY & CO, 2021)

FIGURE 1-2 FLOODPLAIN TOPOGRAPHY

2 REGULATORY FRAMEWORK

The groundwater impact assessment of the Project considers the following legislation, policy and guidelines relating to groundwater:

NSW Government:

- Legislation:
  - Water Management Act 2000; and
  - Protection of the Environment Operations Act 1997.
- Policy and Plans:
  - Groundwater Quality Protection Policy (1998);
  - Groundwater Dependent Ecosystems Policy (2002);
  - Aquifer Interference Policy (2012); and
  - Water Sharing Plans.

Sections below summarise the intent of the above legislation, policies and guidelines and how they apply to the Project.

2.1 Water Management Act 2000

The NSW Water Management Act 2000 (WM Act) manages NSW water resources via the regulation of access rights through water licensing and approvals. The WM Act is administered by the NSW Department of Planning, Industry - Water (DPIE – Water), the Natural Resources Access Regulator (NRAR) and WaterNSW via the following means:

- Water Access Licence (WAL): which allows the holder access to a maximum volume or share component that may be drawn from a particular water source. A WAL may also specify a category and the conditions under which water may be extracted from a particular water source;
- Water use approval: which authorises the particular use of water extracted under a WAL;
- Water work approval: which states the nature, type and location of infrastructure by which water may be extracted from a water source; and
- Activity approval: only relevant in certain circumstances (either for activities on waterfront land or where a proposed activity will interfere with an aquifer).

As the Project is considered a State Significant Development, under Section 4.4.1 of the EP&A Act it will not require a water use approval or a water work approval. However, Fraser Earthmoving Construction is required to hold WALs to account for the maximum annual inflows to open cut pits and an aquifer interference activity approval for extraction operations.

2.1.1 Water Sharing Plans

Under the WM Act, water sharing plans (WSP) have been developed for certain river and aquifer systems to regulate access rights in a manner that protects dependent ecosystems and basic landholder rights within water sources.

Due to areal and geological heterogeneity, the management of water resources under a WSP can be sub-divided to provide scope for further refinement in water resource allocation such as:

- Water sources which assign allocations in rivers, lakes, estuaries and other places where water occurs on or below the surface via long-term, average annual extraction limits (LTAAEL), available water determinations, access licence dealings and trading rules; and
- Water management zones and extraction management units which can provide for localised management of water sources via specific rules on trading and access licence dealings.

Details of the surface water and groundwater WSP in the vicinity of the Quarry, including the relevant sub-divisions (where applicable) and LTAEEL for each water source are presented in Table 2-1. The boundaries of the respective WSP and water sources are shown in Figure 2-1.

TABLE 2-1 DETAILS OF WATER SHARING PLANS IN THE VICINITY OF THE QUARRY

Water Sharing Plan	Water Source	Management Zone/Extraction Management Unit	Long Term Average Annual Extraction Limit (ML/year)[1]
Murray Alluvial Groundwater Sources Order, 2020	Upper Murray Groundwater	None	14 109
Murray Unregulated River Water Sources, 2011[2]	Majors	Unregulated Middle Murray	Not applicable

Notes: *1. Megalitres per year (ML/year)*

2. Plan was amended by the Murray Unregulated and Alluvial Water Sources Amendment Order 2020 to remove the Upper Murray Groundwater Source.

The WSP identified in Table 2-1 have been developed to align with the draft Murray Alluvium Water Resource Plan (NSW). Whilst this water resource plan remains under development, it has been prepared for the management and use of connected water resources to meet NSW's obligations under the Commonwealth's Murray-Darling Basin Plan (2012) (the "Basin Plan").

Murray Alluvial Groundwater Sources Order 2020

The target resource of the Quarry is situated within the shallow unconfined to semi-confined Shepparton Formation that overlies the deeper, semi-confined Lachlan Formation. The Shepparton Formation forms part of the groundwater system managed under the Murray Alluvial Groundwater Sources Order WSP (2020) (Murray Alluvial WSP). The Murray Alluvial WSP is sub-divided into four water sources with the groundwater resources of the Shepparton Formation being managed under the Upper Murray Groundwater Source (Upper Murray water source). The four water sources of the Murray Alluvial WSP align with those identified in Schedule 4 of the Basin Plan as being within the Murray Alluvium water resource plan area (GW8).

As shown in Table 2-1 the LTAEEL for the Upper Murray water source is 14,109 ML/year which aligns with the sustainable diversion limit (SDL) for this water source in the Basin Plan. The LTAAEL for the Upper Murray water source has been established with regards to acceptable impacts on the connected surface water resources and groundwater resources.

Murray Unregulated River Water Sources 2011

The Quarry is also situated within the boundaries of the *Murray Unregulated River Water Sources WSP* (2011) (Murray Unregulated WSP). The Murray Unregulated WSP was established to manage the naturally occurring surface water resources (Unregulated water source) of the Murray River.

As the LTAAEL for the Upper Murray water source has been established with regard to acceptable impacts on the connected surface water resources and the Quarry would not directly extract from this water source, the Murray Unregulated WSP has not been considered as part of this assessment.

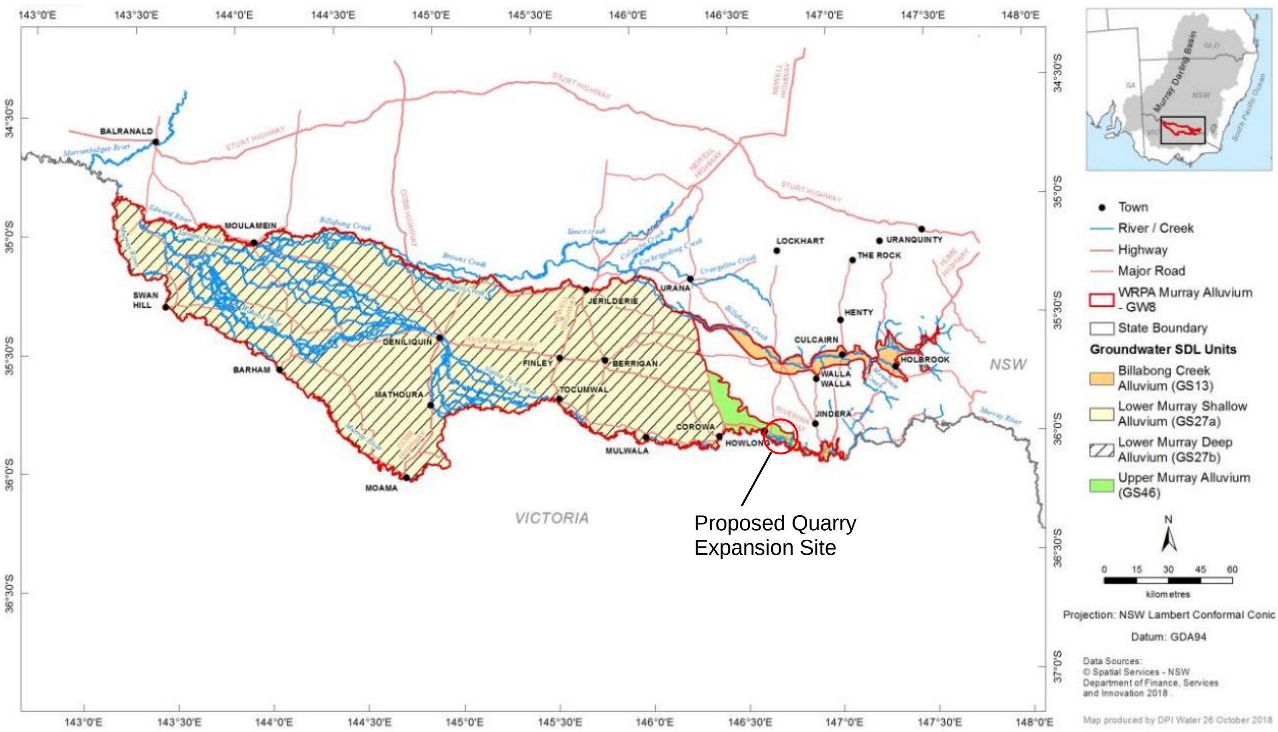

FIGURE 2-1 MURRAY ALLUVIUM WATER RESOURCE PLAN AREA

2.2 Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act 1997 (POEO Act) provides the framework for the regulation and reduction of pollution and waste in NSW. The POEO Act is administered by the NSW Environment Protection Authority (EPA), which issues environment protection licences (EPLs) for certain activities scheduled in the POEO Act, including those that may impact on groundwater quality.

The Quarry currently operates in accordance with EPL (254) permitting activities (crushing, grinding or separating and extractive) that are scheduled under the POEO Act. The POEO Act also requires immediate reporting of pollution incidents which cause or threaten to cause material harm to the environment.

2.3 State Groundwater Policy

2.3.1 Aquifer Interference Policy

Under the Aquifer Interference Policy (AIP), proponents of aquifer interference activities are required to provide predictions of the volume of water to be extracted from a water source(s) prior to Project approval. The proponent must subsequently hold sufficient WALs and share components to account for the extracted volume of water when that extraction occurs. During operations, these volumes must be measured and reported via annual returns or environmental management reports.

The AIP states that a WAL is required for the aquifer interference activity regardless of whether water is extracted directly for consumptive use or incidentally. In the case of the Quarry, extraction of groundwater will occur directly to facilitate extraction operations. Most of the groundwater extracted will then be utilised for either processing (washing) with the remainder used for irrigation.

The AIP also describes a series of acceptable thresholds for water level and quality changes that are known as “minimal impact considerations”. The minimal impact considerations depend upon whether the water source is classed as “highly productive” or “less productive” and whether the water source is alluvial or porous/fractured rock in nature.

A “highly productive” groundwater source is defined by the AIP as a groundwater source which has been declared in regulations and datasets, based on the following criteria:

a. has a Total Dissolved Solids (TDS) concentration less than 1,500 mg/L; and

b. contains water supply works that can yield water at a rate greater than 5 L/s.

Highly productive groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. “Less productive” groundwater sources are all other hydrogeological units that do not satisfy the “highly productive” criteria for yield and water quality.

The data reviewed for this assessment identifies that the groundwater system of the Quarry is classified as “highly productive” (TDS less than 1,500 mg/L and yield greater than 5 L/s – refer to discussion in Section 3.3).

Section 8 presents the Project impacts and compares these with the AIP minimal impact thresholds. Appendix C notes where information required to address the AIP is presented within this report.

2.3.2 NSW Groundwater Dependent Ecosystems Policy

This policy was developed to provide guidance on the protection and management of GDEs in NSW, principally through the development of environmental planning instruments such as WSPs. This policy also recognises the four Australian groundwater dependent ecosystem types (Hatton and Evans, 1998) that can be found in NSW, namely:

- Terrestrial vegetation;
- Base flows in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

The Murray Alluvium WSP has identified several High Priority GDEs in the Project area based on the High Ecological Value Aquatic Ecosystems (HEVAE) framework. The GDE HEVAE methods have direct alignment with Schedules 8 and 9 of the Basin Plan. In addition to the High Priority GDEs identified in the Murray Alluvium WSP, potential aquatic and terrestrial GDE layers from the Bureau of Meteorology GDE atlas have been accessed for the project and are illustrated along with the Murray Alluvium WSP GDEs in Figure 2-2. Terrestrial ecology surveys undertaken for the Project (Envirokey, 2020) identified that the species occurrence associated with the BoM terrestrial GDE was more limited than the BoM mapping. The aquatic GDEs mapped by the BoM are identified as potential wetlands.

Review of the Murray Alluvium WSP reveals there are no Ramsar, or Directory of Important Wetlands in Australia (DIWA) identified in the Project area.

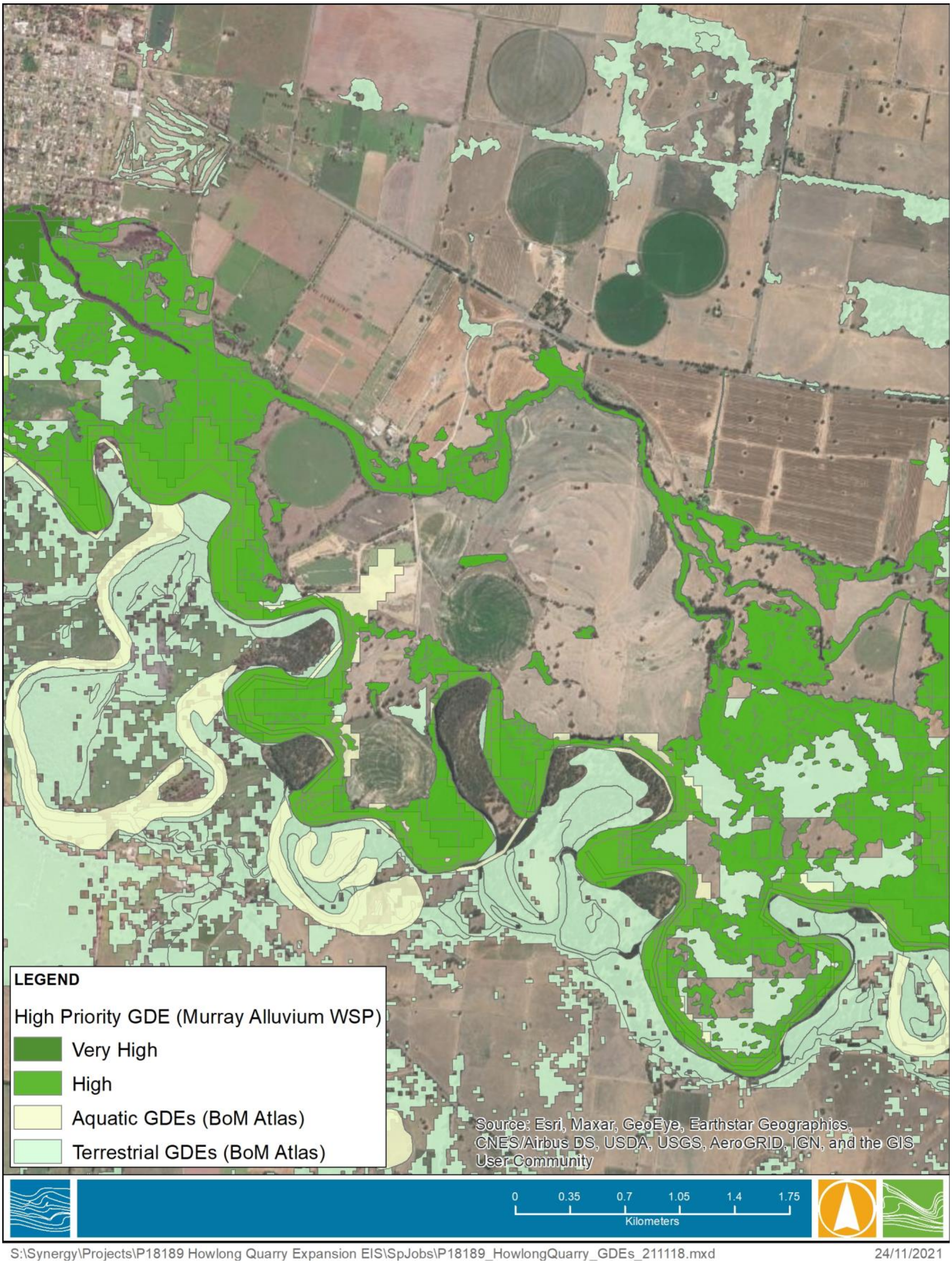

FIGURE 2-2 POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEMS

2.3.3 NSW Groundwater Quality Protection Policy

This policy is designed to protect groundwater resources against pollution to ensure their sustainability and ecosystem support functions are given consideration in resource management decision making. Like the Groundwater Dependent Ecosystems Policy, this policy identifies that its application would be via the development of environmental planning instruments such as WSP.

The key principles of this policy as they apply to the Project are as follows:

- Groundwater systems should be managed so that the most sensitive identified beneficial use (or environmental value) is maintained;
- Town water supplies should be afforded special protection against contamination;
- Groundwater pollution should be prevented so that future remediation is not required;
- For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the resource;
- A groundwater user shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation or receiving waters; and
- Groundwater dependent ecosystems will be afforded protection.

3 HYDROGEOLOGICAL SETTING

3.1 Overview

The following sections provide a regional and local overview of the hydrogeological setting relevant to the Project area. Further details regarding the hydrogeological conceptualisation of the site and translation of this conceptualisation into the numerical model are provided in Appendix A.

3.2 Murray Alluvium Hydrogeological Landscape

The Murray Alluvium hydrogeological landscape is described as a depositional environment characterised by alluvial floodplains with flood-runners, oxbows and levees (Muller et al., 2015). This landscape comprises unconsolidated Quaternary channel and floodplain sediments. Typically, these are sands, gravels and clays. Small patches of wind-blown sand occur locally as sandy rises. Topsoils in cleared areas are generally thinner and have less organic carbon than undisturbed areas. Stream-bank erosion and compaction due to vehicular traffic are the most common land degradation issues in this landscape.

Muller et al. (2015) summarises the aquifers within this landscape as unconfined to semi-confined with groundwater flow occurring primarily through unconsolidated alluvial sediments. Hydraulic conductivity and transmissivity are reported to be moderate to high. Groundwater recharge rates are estimated to be high. Groundwater systems are typically local with short flow paths and are loosely defined by topographic catchments. Water quality within these systems is reported to be fresh to marginal (Muller et al., 2015). Water table depths are shallow to intermediate. Localised perching of water tables occurs above clay lenses during wetter periods. Short to medium groundwater residence times are typical. These landscapes have a medium to fast response time to changes in land management (Muller et al., 2015).

TABLE 3-1 HYDROGEOLOGICAL PROPERTIES SUMMARY (AFTER MULLER ET AL., 2015)

Hydrogeologic Properties	Range
Aquifer Type	Unconfined to semi-confined; Perching above clay-rich layers
Hydraulic Conductivity	10^{-2} to >10 m/day
Aquifer Transmissivity	2 to >100 m^2/day
Specific Yield	5 to >15%
Hydraulic Gradient	<10%
Groundwater Salinity	EC <1 600 µS/cm
Depth to Water Table	<8 m

3.3 Upper Murray Alluvium Hydrogeological Landscape

The groundwater resources of the Upper Murray Alluvium have been described by Williams (1989) and Kulatunga (2009). The region of the proposed Howlong Sand Quarry Expansion is associated with Alluvium deposits up to 140 m thick and contains groundwater of low salinity. These Cainozoic sediments overlie the Palaeozoic metamorphics and granites and are deposited within a paleo-erosional valley incised into the basement rocks. The Cainozoic sedimentary sequence, from youngest to oldest comprises the Coonambidgal Formation, Shepparton Formation, Lachlan Formation and Olney Formation. Table 3-2 summarises each of these formations.

Groundwater salinity in the Upper Murray Alluvium is fresh and generally less than 800 µS/cm within five kilometres of the Murray River (NSW Department of Industries, 2019). The main productive aquifers are the sand and gravel deposits within the Lachlan formation. Bores in the deep aquifer system have yields up to 10 ML/day (up to 100 L/s). The shallow aquifers have lower yields compared to deeper aquifers and are the main source for stock and domestic supply (NSW Department of Industries, 2019).

TABLE 3-2 CAINOZOIC GEOLOGY AND HYDROGEOLOGY (AFTER WILLIAMS 1989 AND KULATUNGA 2009)

Geologic Formation	Age	Description	Hydrogeology
Coonambidgal Formation	Pleistocene to Recent	Sandy Silt to occasional Cobble, highly micaceous, fawn colour, can be discontinuous across the Flood Plain; upper boundary is a disconformity	Typically contains the water table, may exhibit perched aquifer characteristics; hydraulically connected to Shepparton Formation aquifer.
Shepparton Formation	Pliocene to Pleistocene	Clay to Gravel, fluviatile meandering stream deposits, Sands are quartzose, brown to yellow colour; Clays are located away from the main Murray alignment, are white, yellow, red-brown and grey; upper boundary is probably a disconformity	Shallow Aquifer; low to medium transmissivity (20 to 250 m^2/day); subject to evapotranspiration; estimated through-flow adjacent Quarry site at 1,160 m^3/day. Bore yields up to 3 ML/day. Typical target for Stock and Domestic users.
Lachlan Formation (equiv. to Calivil Fm.)	L Miocene to Pliocene	Clay/Sands/Gravel, poorly sorted, upward fining trends, grey colour, Sands and Gravels are predominantly sub-angular to rounded Quartz, upper boundary is probably a disconformity	Deeper Aquifer; high transmissivities (1 000 to 2,000 m^2/day); estimated through-flow adjacent Quarry site at 3,150 m^3/day. Bore yields up to 10 ML/day. Typical target for Irrigation
Olney Formation (Renmark Group)	L Eocene to E Miocene	Interbedded Sand/Clay, predominantly carbonaceous Clay, limited distribution, upper surface is erosional	Not targeted for groundwater in this area

Note: VAF – Victoria Aquifer Framework; Department of sustainability and Environment 2012

The Upper Murray Alluvium is considered as a single hydrogeological entity. That is, for management purposes, it is considered that the Shepparton and Lachlan Aquifers act as a single hydrogeological unit. The Murray River and rainfall have been identified as the major recharge sources for the aquifer system while irrigation infiltration was identified as a minor recharge source.

Kulatunga (2009) summarises the aspects of the groundwater balance as:

- Recharge via incident rainfall (3% of 650 mm annual average) estimated at 9,700 ML/a;
- Recharge from Murray River leakage (over 61 km reach) estimated at 33,600 ML/a;
- Annual groundwater recharge as determined by 2003/04 groundwater numerical model is 15,300 ML/a, under the current level of development; and
- Groundwater usage has been moderate in relation to full entitlement. The highest recorded usage was just over 16,000 ML in 2006/2007. Just over 12,000 ML was used in 2007/08.

The location of the proposed Howlong Sand Quarry Expansion is in an area where it is assumed the Upper Murray Alluvium aquifers transition from providing base flow to the surface river systems to receiving surface water from the losing surface river systems.

Regional groundwater flow is inferred to be from south-east to north-west, down topographic gradient of the river valley sediments in both the Shepparton and Lachlan aquifer systems as shown in Figure 3-1 and Figure 3-2 respectively.

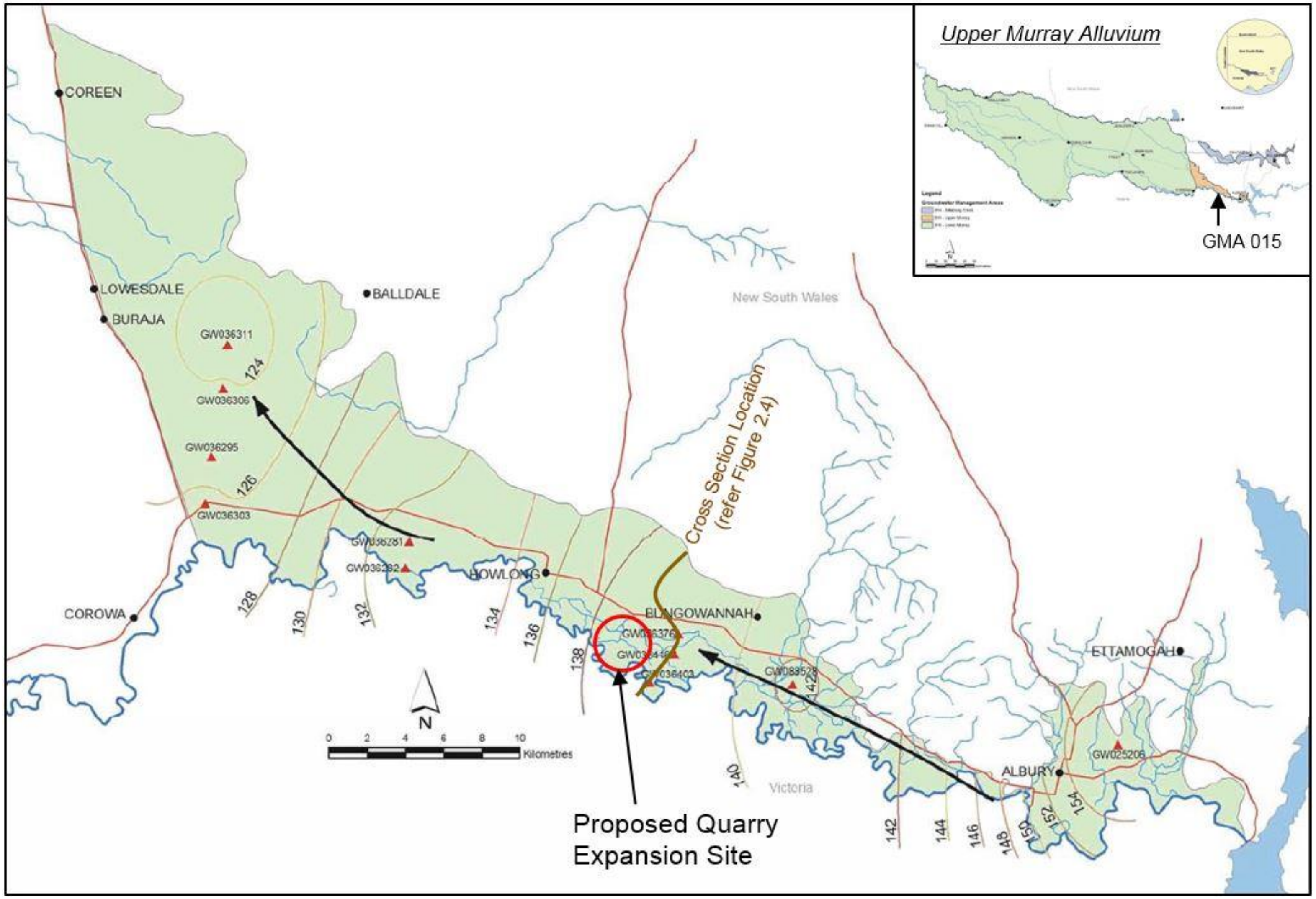

FIGURE 3-1 SHEPPARTON AQUIFER GROUNDWATER HEIGHT CONTOURS (AFTER KULATUNGA 2009)

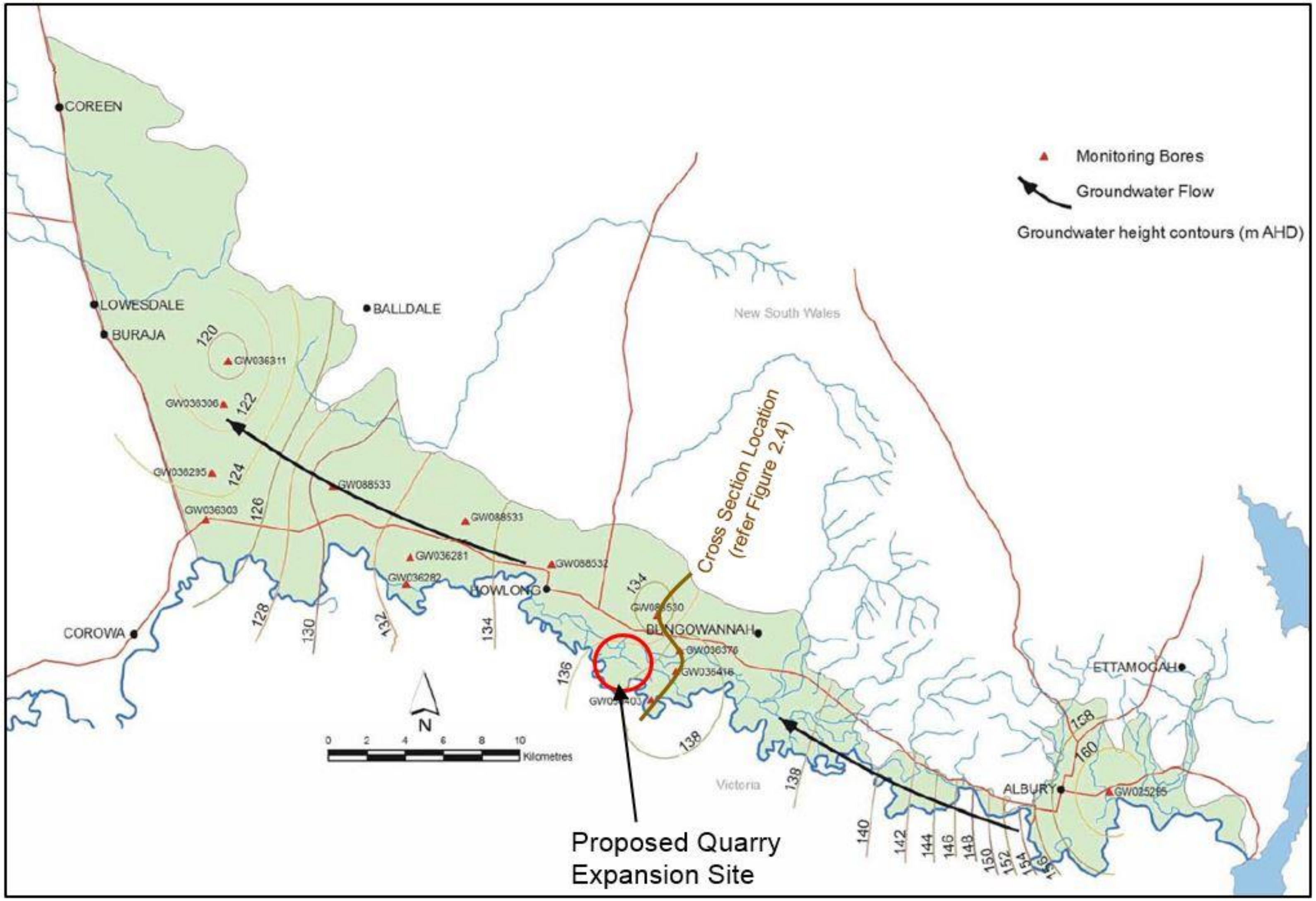

FIGURE 3-2 LACHLAN AQUIFER GROUNDWATER HEIGHT CONTOURS (AFTER KULATUNGA 2009)

3.4 Regional Hydrographs

An assessment of the monitored Murray River and groundwater level near the Project site is provided below. Existing groundwater monitoring bores relevant to this investigation are shown spatially in Figure 3-3 and in hydrogeological cross section in Figure 3-4.

The Albury (AWRC 409001) and Corowa (AWRC 409002) Murray River stage elevations and the NSW Office of Water groundwater monitoring bores GW036763, GW036403, GW036416, GW088530, GW088531 and GW030702 are analysed to show water level relationships and time series trends. Groundwater hydrographs for the Observation Bores are represented in Figure 3-5 and provided in detail in Figure 3-6.

The observed fluctuation of river level, due to regulation, ranges from around 2 m at Albury to around 3.5 m at Corowa. There is an observed relationship between seasonal flow within the Murray River and observed groundwater levels. Close to the river, as shown by groundwater levels in GW036403 located adjacent the Murray River the timing of the oscillation in observed groundwater levels coincides with river level oscillations. At groundwater monitoring sites distant from the river this seasonal relationship becomes less evident and groundwater levels appear more influenced by incident rainfall recharge and/or irrigation usage, particularly from the Lachlan Aquifer.

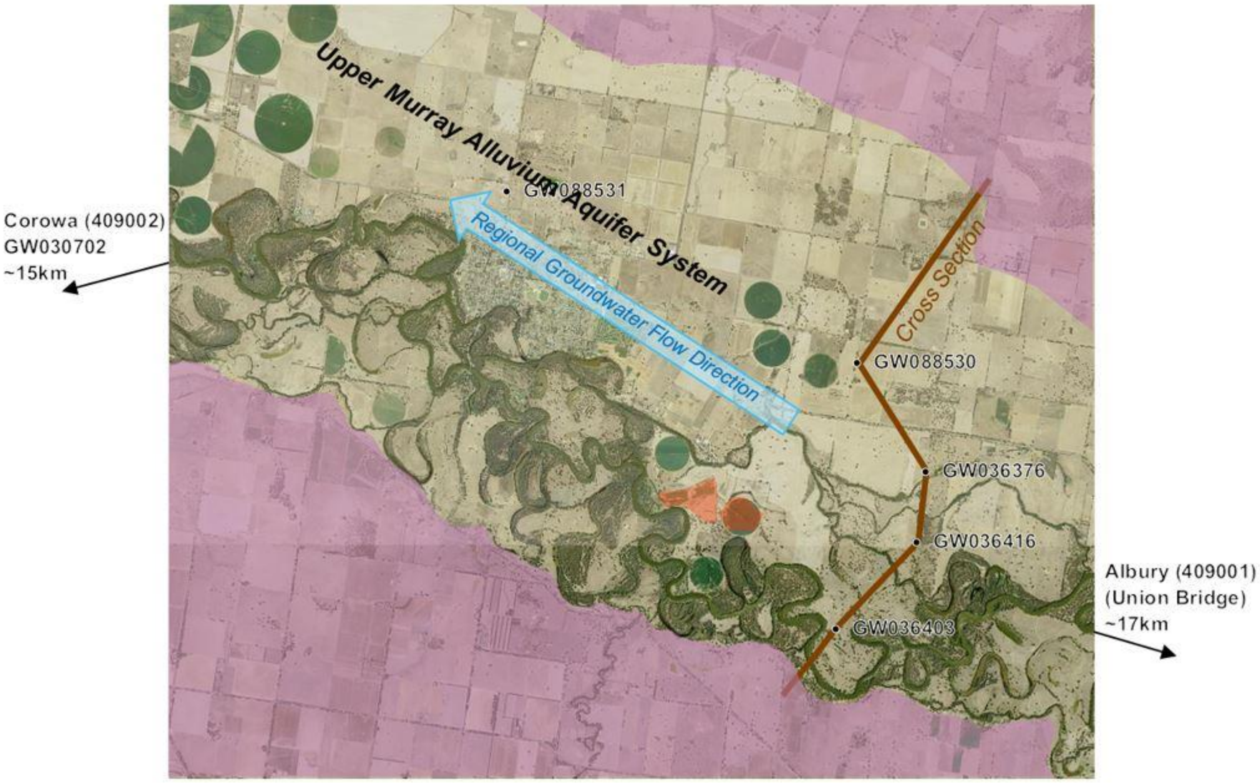

FIGURE 3-3 LOCATION OF RIVER AND GROUNDWATER MONITORING POINTS

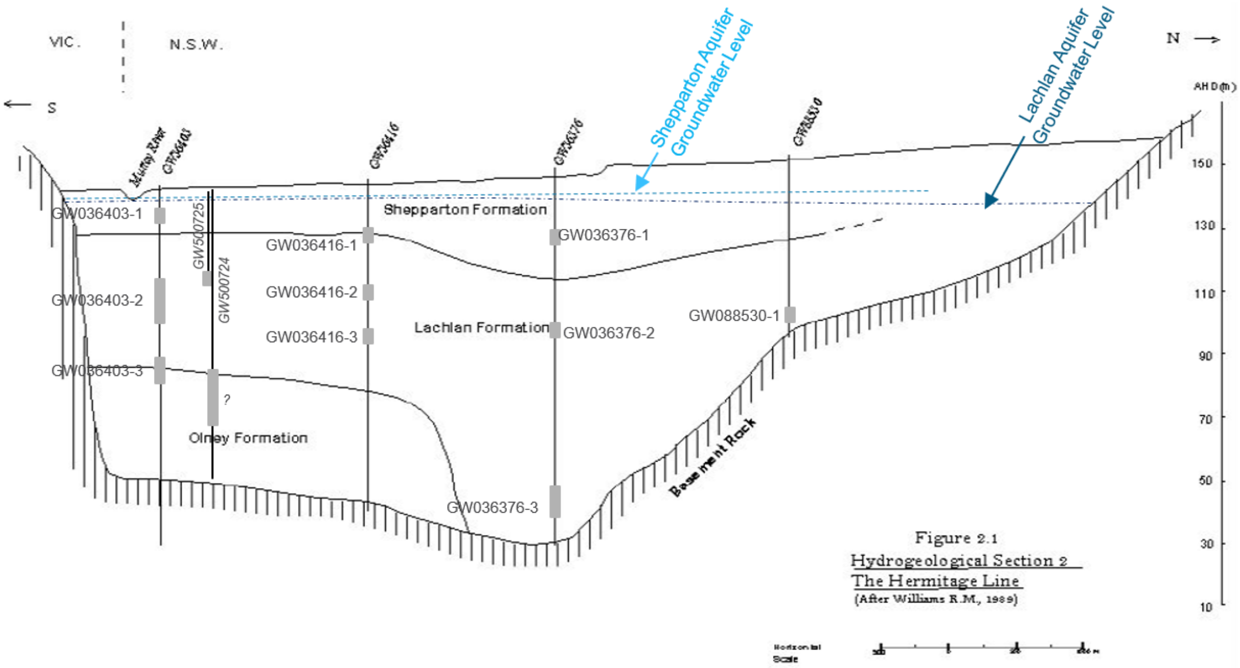

FIGURE 3-4 STYLISED CROSS SECTION ADJACENT THE PROPOSED QUARRY EXPANSION SITE (AFTER KULATUNGA 2009)

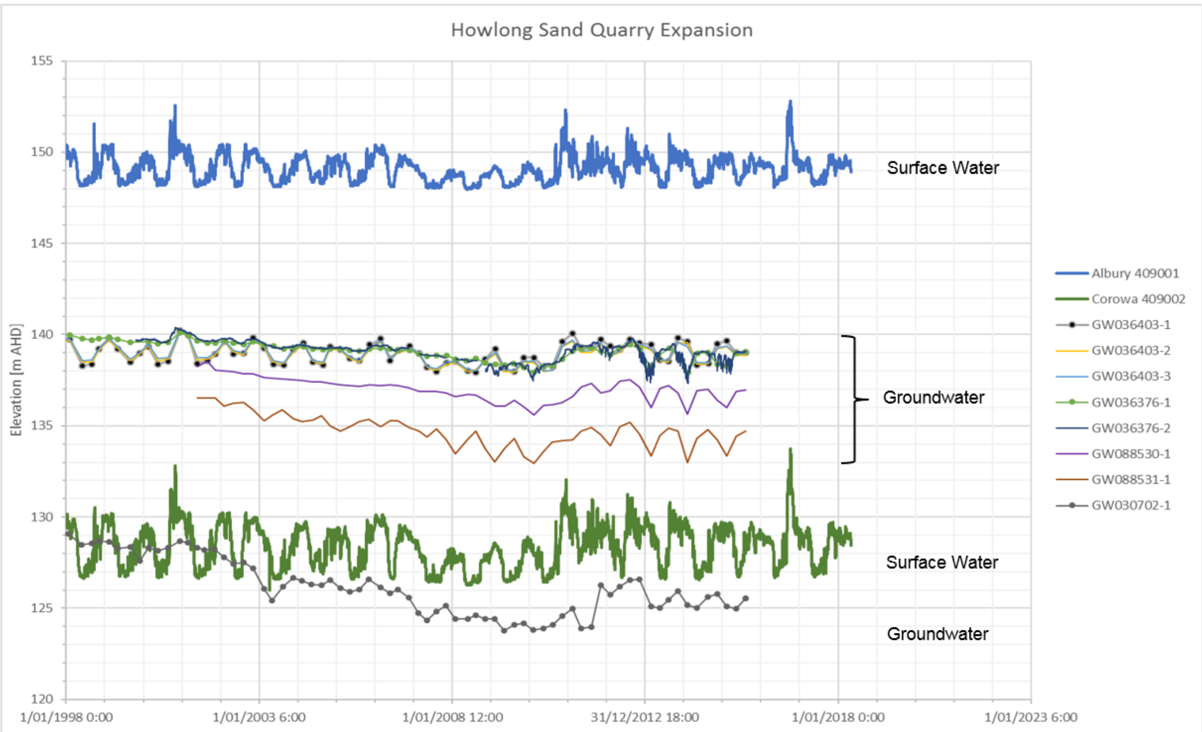

FIGURE 3-5 MURRAY RIVER AND UPPER MURRAY ALLUVIUM AQUIFER SYSTEMS WATER LEVEL COMPARISONS

Groundwater systems subject to local recharge often exhibit a relationship with local rainfall intensity patterns, specifically how actual rainfall varies against short, medium or long-term average rainfall. The analysis of how rainfall varies over time (called the 'cumulative deviation from the mean rainfall' or the 'mass balance') is shown for the rainfall record of Howlong Post Office[1] (refer Figure 3-6). The analysis trends horizontally during periods of average rainfall, trends downwards during periods of below average rainfall and upwards during periods of above average rainfall.

The comparison of this trend analysis with the groundwater level hydrographs indicates a relatively strong correlation at all sites with the exception of GW036403 (located close to the Murray River). This supports the assumption that the Murray River is in good hydraulic connection with the alluvial aquifer, and the adjacent groundwater levels are influenced by variations in river levels.

At each monitoring site where 'nested' piezometers are installed it appears that the Shepparton and Lachlan Aquifers are hydraulically connected as each piezometer trace tends to mirror those within the same 'nest'. Differences in groundwater level elevation within each 'nested' site indicates whether vertical groundwater flow potential is upwards or downwards between the Shepparton and Lachlan Aquifers (refer Figure 3-6 below).

Observation Bores at GW036403 indicate that historically (prior to approximately 2010, during times of low river flow the vertical groundwater flow direction potential between the Shepparton and Lachlan aquifers was upwards, whereas in recent times the vertical groundwater flow direction potential is generally downwards. Observation Bores at GW036416 (located north of the Black Swan Anabranch) indicate the vertical groundwater flow direction potential has remained upwards over time however the groundwater head pressure between monitoring depths, which drives vertical flow potential, has decreased. Observation bores at GW036376 (located further north just outside the high river flow inundation extent) indicate a similar reversal of vertical groundwater flow direction potential over time as GW036403. This impact of the development of groundwater extraction is more evident at this site. Also, the increased groundwater level variation within the Shepparton Aquifer at this site may indicate that this aquifer is utilised for groundwater extraction and/or is more responsive (connected) to the Lachlan Aquifer (and the groundwater extraction stresses imposed on that aquifer).

This reduction in upwards vertical groundwater flow potential may be an indicator that the impacts of the development of groundwater extraction of the Lachlan Aquifer is being felt at the location of these observation bores.

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[1] Howlong Post Office precipitation data taken from "RAINMAN and Streamflow" v4.3 DPI QLD, BoM, Ag WA, NSW Ag, DNRM QLD ICE Media

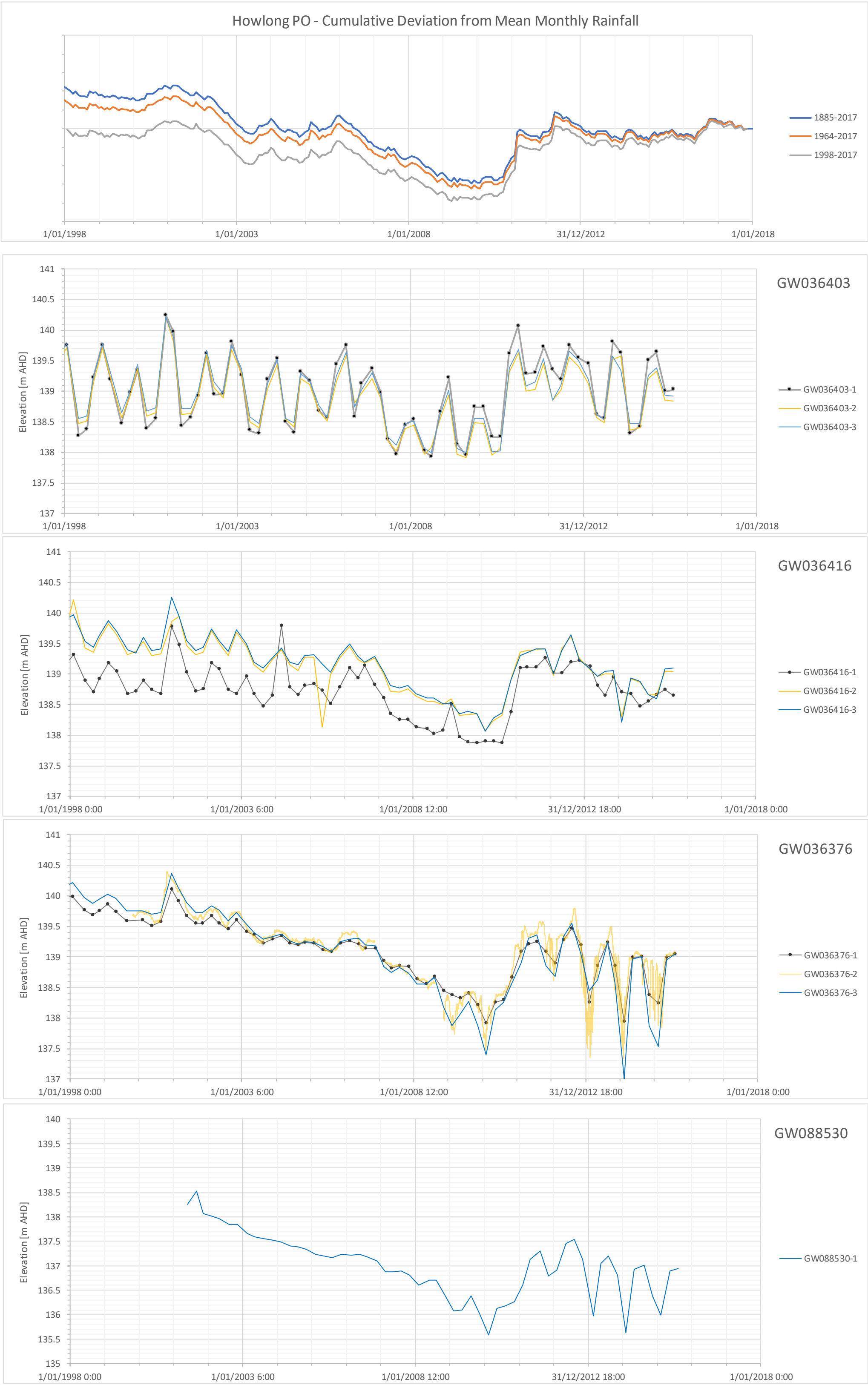


FIGURE 3-6 RAINFALL TRENDS AND GROUNDWATER HYDROGRAPHS FOR OBSERVATION BORES SHOWN IN FIGURE 3-3

4 SITE WATER BALANCE

4.1 Inflows

4.1.1 Regional Groundwater Inflow

Regional groundwater flow processes indicate that groundwater flows into the proposed Howlong Quarry Expansion site from the southeast. The proposed width of the pit excavation is approximated 10% of the established aquifer width and is planned to penetrate to near the base of the Shepparton Formation aquifer. This depth is approximately 25% of the full saturation depth of the combined Shepparton/Lachlan Formation aquifers and planned total excavation depth does not appear to penetrate the higher yielding Lachlan Formation aquifer.

4.1.2 Groundwater Inflow to Pits

Water taken during active pit dewatering is considered groundwater and is required to be taken under licence. As the working pit deepens there will be an increased rate of groundwater inflow into the pit during the operational phase. Site personnel provided data on pumping times and rates from the existing Stage 1 pit for the period 5 April to 5 July 2018 during which time the pit was intermittently dewatered for irrigation supply. The data indicated an average estimated inflow to the pit of 1.5 ML/d after dewatering occurs.

4.1.3 Rainfall

It is expected that given the sandy nature of the substrate that rainfall on disturbed land will infiltrate rather quickly and will not be available for collection and use (RW Corkery & Co, 2021). Therefore, it is assumed that rainfall would only be captured when it falls on ponded areas. Rainfall that would be available within ponded areas for each stage has been estimated by RW Corkery & Co (2021) and is summarised below:

- Stage 1 (rainfall captured within the existing Stage 2 pond) – 28.9ML/a.
- Stage 2 (rainfall captured within the Stage 1 pond) – 38.6ML/a.
- Stage 3 (rainfall captured within the Stage 1 and Stage 2 ponds) – 75.6ML/a.
- Stage 4 (rainfall captured within the Stage 1, Stage 2 and Stage 3 ponds) – 99.3ML/a.

Upon closure, it is estimated that approximately 240.3 ML would be captured from rainfall each year.

4.1.4 Licensed Water

The following water licences are associated with this operation:

- Water Access Licence (WAL) 29975 – 500 shares within the Upper Murray Groundwater Source of the Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011. Considering carryover entitlements, this licence provides access to the equivalent of 685ML of water per annum.
- WAL 29930 – 890 shares within the Upper Murray Groundwater Source of the Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011. Considering carryover entitlements, this licence provides access to the equivalent of 1,219ML of water per annum.
- WAL 29915 – 1,500 shares within the Upper Murray Groundwater Source of the Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011. Considering carryover entitlements, this licence provides access to the equivalent of 2,055ML of water per annum.
- WAL 29969 – 568 shares within the Upper Murray Groundwater Source of the Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011. Considering carryover entitlements, this licence provides access to the equivalent of 778ML of water per annum.

4.2 Throughflows

4.2.1 Quarry Operation

The current combined storage volume of the Stage 1 and Stage 2 pits is approximately 1,530 ML. This volume is stored as source water for washing and processing.

It is estimated that the total water demand for processing is up to 550 ML per annum (RW Corkery & Co, 2020). It is assumed that 95% of this water is returned to the extraction areas following use representing a loss of 80.5 ML. Water from processing is returned to the property balancing water storages.

4.3 Outflows

4.3.1 Regional Groundwater Outflow

Regional assessment of groundwater flow processes shown by the groundwater level contours (refer Figure 3-1 and Figure 3-2) suggest that the current quarry and irrigation operations have not invoked local groundwater level decline. It is proposed that groundwater from future pit dewatering will be used for the sand screening process, transferred to centre pivot irrigation or held in balancing storages.

4.3.2 Farm Water Usage

Currently there are 3 large pivots and 4 small pivots with plans for a fourth large pivot in the future.

It is proposed that removal of water from the extraction pits for irrigation would be an ongoing component of the water management system for the Quarry Operations. Historically, water for irrigation of the broader land holding has been pumped from the extraction pits. Groundwater inflows from dewatering of the existing pits has been used firstly for processing with return water or surplus water pumped to irrigation pivots.

4.3.3 Evaporation

Evaporative losses have been calculated based on review of historic evaporation data between 1971 and 2018 available from the SILO database. The annual average evaporation rate over that time has been used for calculation (1523.9 mm/yr) (RW Corkery & Co, 2021).

Based on the progressive extraction stages presented in Figure 1-1, it is estimated that the following evaporation would occur from ponded areas during each stage, when operational.

- Stage 1 (evaporation within the existing Stage 2 pond) – up to 20 ML/year.
- Stage 2 (evaporation within the Stage 1 pond) – up to 24 ML/year.
- Stage 3 (evaporation within the Stage 1 and Stage 2 ponds) – up to 44 ML/year.
- Stage 4 (evaporation within the Stage 1, Stage 2 and Stage 3 pond) – up to 58 ML/year.

Upon closure, a total of 139 ML is expected to be lost annually through evaporation from the combined pit lakes.

4.3.4 System Operation

When the Sandstorm 620 is in operation water is pumped from the designated water source using an electric pump mounted on a floating barge at a rate of up to 500 m^3/hr. This water is used for washing the aggregate and supplies the cyclones on the plant for washing the sand. Screen processing discharge water is returned to the designated holding pond to remove any heavy particles.

Water drawn from non-operational pits will continue to be used for irrigation in accordance with the current agreement with the landowner. Irrigation pumps currently supply the operating pivots with the pumping rate modified as needed to meet irrigation demand.

It is noted that the maximum rate of screening would not be required for all operating days. The Applicant estimates that approximately 100 days per year would be dedicated to screening operations with the timing for operations driven by demand and requirements for water management. For the purpose of assessment and in order to remain conservative, it has been assumed that operations are occurring over a full year (that is, dewatering is occurring year-round, and water is used for irrigation, regardless of the process water demand).

5 NUMERICAL GROUNDWATER MODEL

5.1 Overview

A numerical groundwater flow model was constructed based on the review of available hydrogeological, river and climate data using the United States Geological Survey (USGS) industry standard groundwater modelling code MODFLOW-2000 with the model constructed in the PMWIN platform (Chiang and Kinzelbach, 1998). The model conceptualisation, construction, calibration and predictive scenarios are documented in the groundwater modelling report completed by WatSec Environmental (2022) (Appendix A). The following discussion provide a high-level overview of the approach and key model outputs relevant to the groundwater impact assessment.

The model extent is shown on Figure 5-1 and includes the following key features:

- A length parallel to the river valley of 12 km and a width of 10 km.
- Model cells range from 100 m square to 50 m square in the vicinity of the quarry located in the middle of the model domain.
- Two layers representing the Shepparton Formation and the Lachlan Formation.
- River cells used to represent the main Murray River channel and the Black Swan Anabranch.
- Drain cells were used to represent the existing extraction voids with drain hydraulic conductance set at 1,000 m^2/d.
- Basement areas were set as inactive to represent the relatively impermeable basement geology.
- General head boundaries were assigned to the upstream (southeastern) and downstream (northwestern) edges of the model domain to establish and maintain the groundwater flow field across the model domain.
- Details of recharge (rainfall), evaporation and evapotranspiration were presented based on SILO data.

A parameter estimation program (PEST – Doherty, 2000) was used to run the calibration model and optimise model parameters. Suitable local monitoring bore data using the period from October 2012 to April 2018 were used for model calibration.

The reader is directed to Appendix A for further details regarding the model conceptualisation, construction, calibration, predictive scenarios and sensitivity analysis, The numerical groundwater flow model and report completed by WatSec Environmental (2022 Appendix A) has been independently peer reviewed and was found to be fit for purpose. The independent peer review completed by Hydrogeologoiust.com.au is provided in Appendix B.

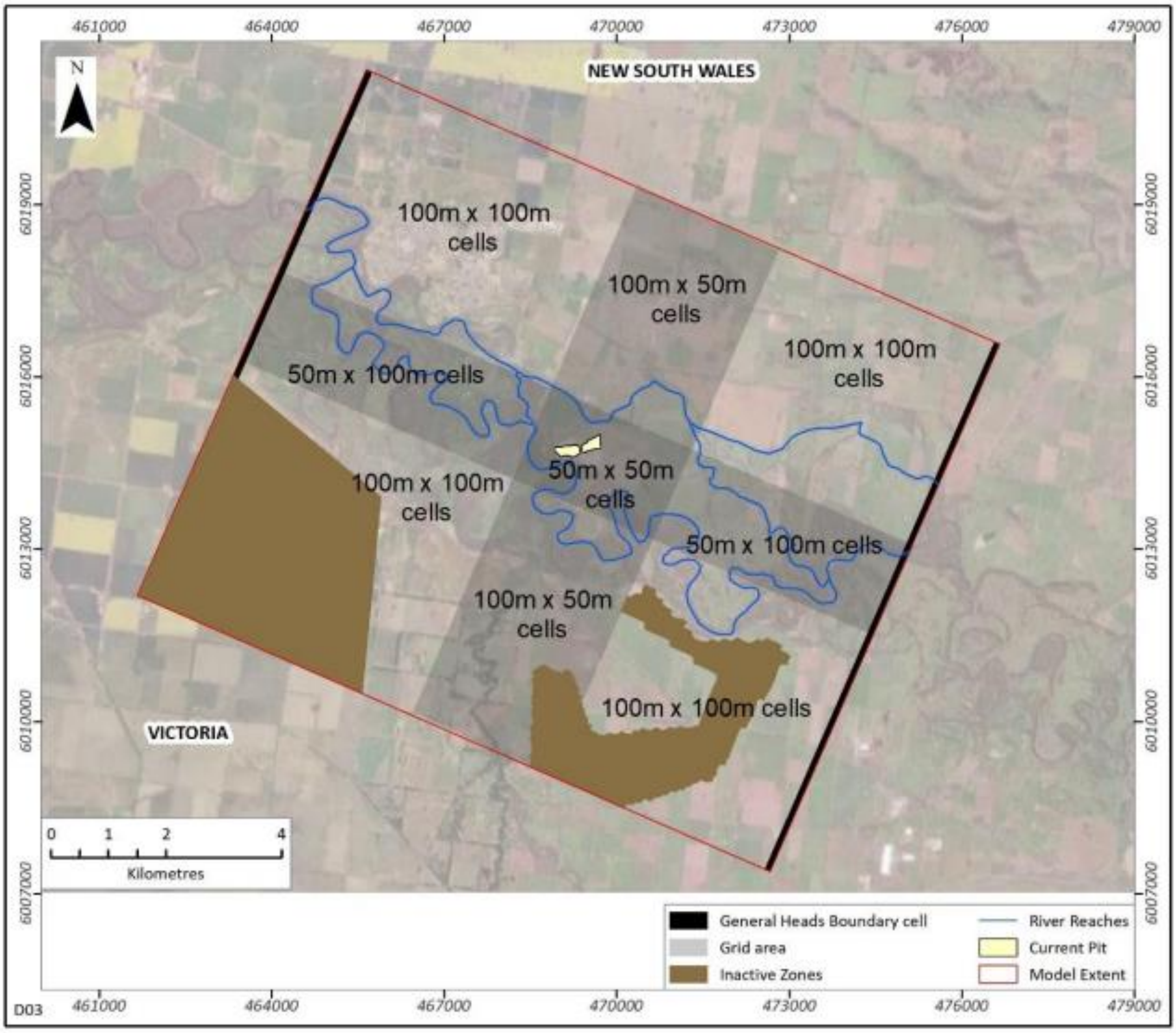


FIGURE 5-1 EXTENT OF NUMERICAL MODEL AND CELL DISCRETISATION (WATSEC ENVIRONMENTAL, 2022)

5.2 Modelled 2020 – 2050 Expansion Period

Based on the proposed quarrying schedule a model period of 2020 to 2050 was used to model the expansion of Pit 1 (2 years), then expansion of Pit 2 (2 years) followed by excavation of Pit 3 (3 years). Pit 4 was assumed to be developed over a period of 23 years, as 2 areas comprising 5 approximately north-south trending sub-pits (Stage 4a to e), which would be combined into 2 pit areas designated as Stage 4(ab) and Stage 4(cde) as shown on Figure 5-2. All pits were assumed to be excavated to a nominal elevation of 119 m AHD (base of Shepparton Formation) with pit water levels allowed to recover after completion of excavation. During the expansion period average river levels recorded for the 5-year model calibration period were adopted. The following model results were obtained for estimated pit groundwater inflows at final pit depths:

- Stage 1 expansion over 2 years – 1.9 ML/d.
- Stage 2 expansion over 2 years – 1.8 ML/d.
- Stage 3 excavation over 3 years – 1.7 ML/d.
- Stage 4(ab) excavation over 3 years – 3.3 ML/d.
- Stage 4(cde) excavation over 20 years - 4.6 ML/d.

The modelled groundwater drawdown impacts at the end of Stage 4(cde) are shown on Figure 5-3 for the Shepparton Formation (water table drawdown) and Figure 5-4 for the Lachlan Formation (potentiometric or pressure level reduction). The modelled aquifer drawdown and pressure reduction levels are relative to a modelled steady state baseline condition which assumes annual averages for hydraulic stresses and influences such as river level, irrigation extraction, drainage returns, stock and domestic extraction, recharge and evaporation. In all modelled scenarios the confined Lachlan Formation aquifer is not dewatered at any location i.e. the potentiometric level remains above the top of the aquifer.

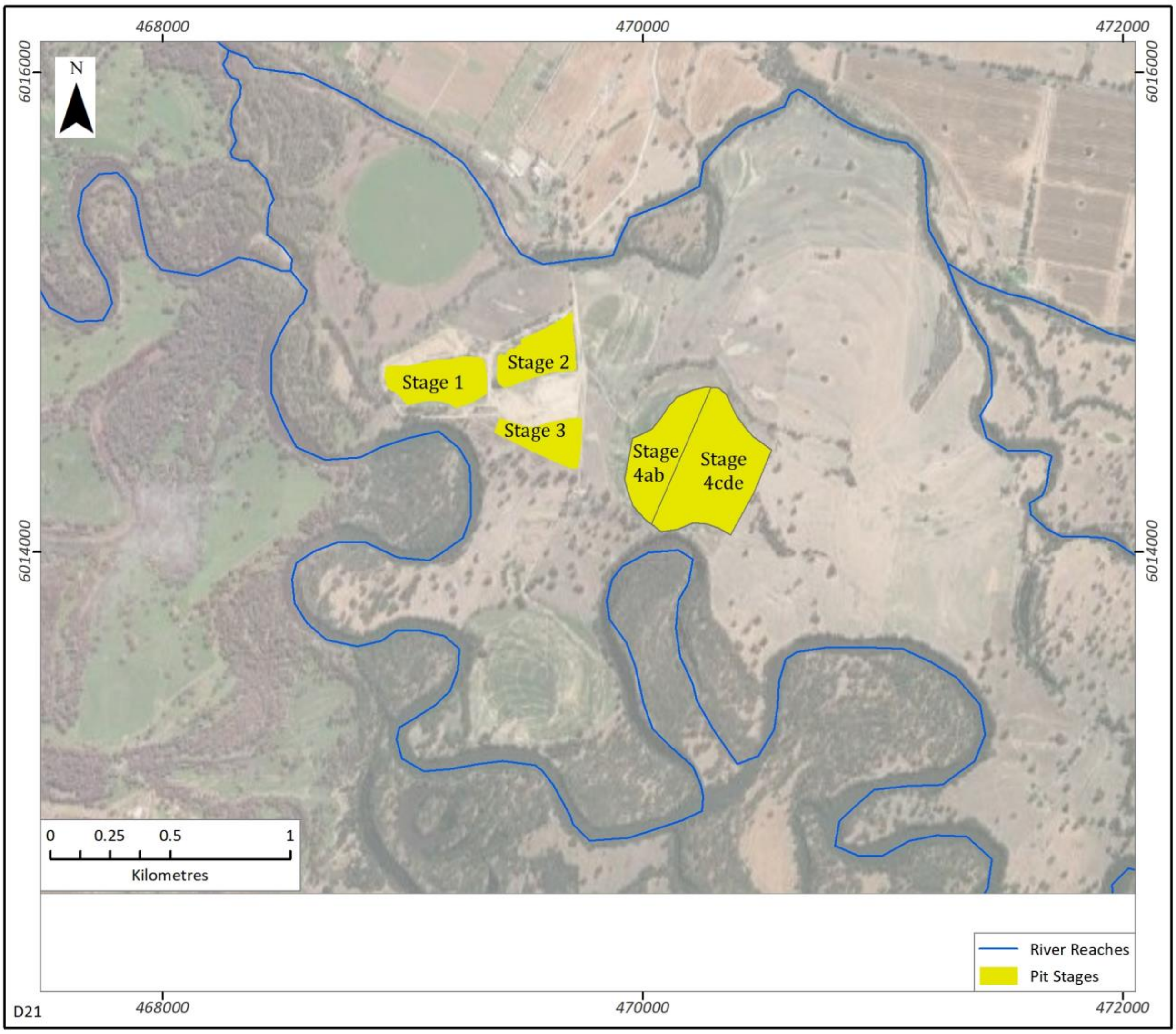


FIGURE 5-2 PROPOSED PIT EXPANSION EXTENTS (WATSEC ENVIRONMENTAL, 2022)

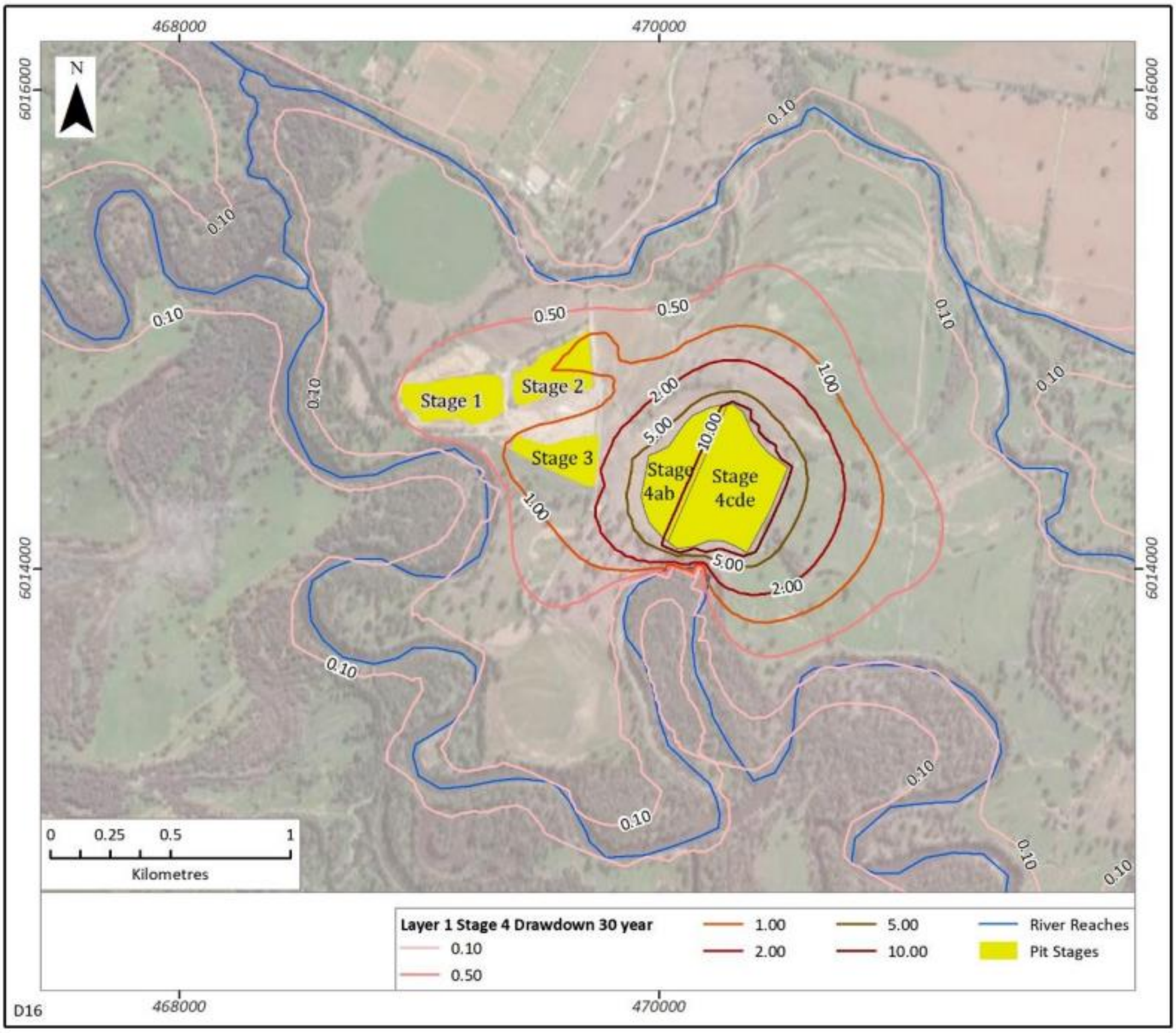


FIGURE 5-3 SHEPPARTON FORMATION DRAWDOWN AFTER STAGE 4(CDE) (WATSEC ENVIRONMENTAL, 2022)

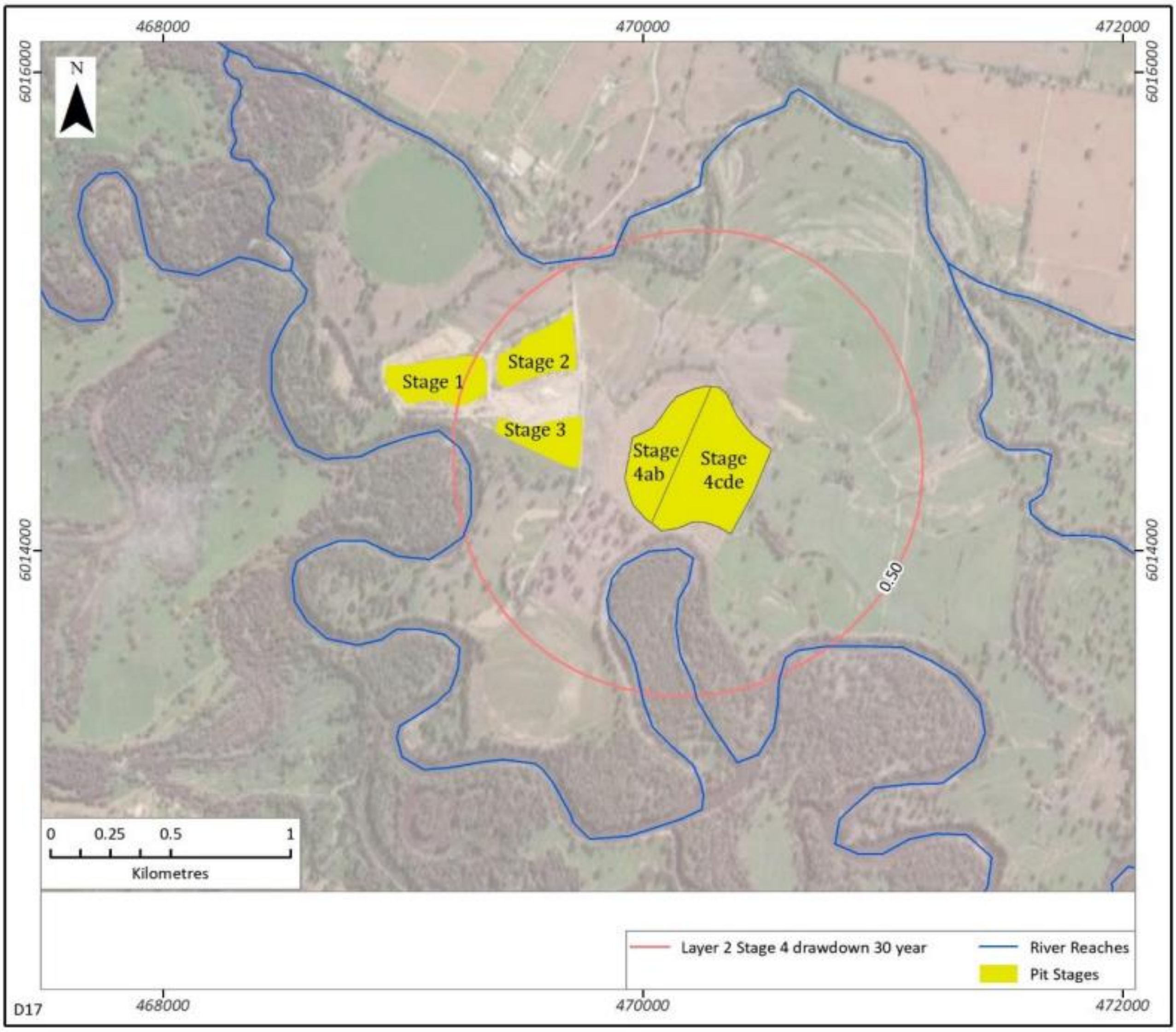


FIGURE 5-4 LACHLAN FORMATION POTENTIOMETRIC LEVEL REDUCTION AFTER STAGE 4(CDE) (WATSEC ENVIRONMENTAL, 2022)

5.3 Post Expansion Recovery Model

The MODFLOW groundwater model was extended to include a 50-year period following completion of the quarry expansion activities. During this period a nett negative recharge (discharge) was applied to each pit to integrate evaporative discharge (assuming a 60% pan factor) and rainfall recharge.

The pit areas were assigned a hydraulic conductivity of 1,000 m/d and specific yield of 1.0 to simulate open waterbodies. The 50-year post-expansion groundwater drawdown for the Shepparton Formation is shown in Figure 5-5 with the corresponding groundwater elevations shown in Figure 5-6. The excavated areas are modelled to stabilise with groundwater levels lower than background levels by around one metre, therefore establishing a groundwater discharge area under the influence of nett evaporation from the water bodies. Drawdown is highest around the Stage 4 pit which has the largest open area and hence evaporative loss.

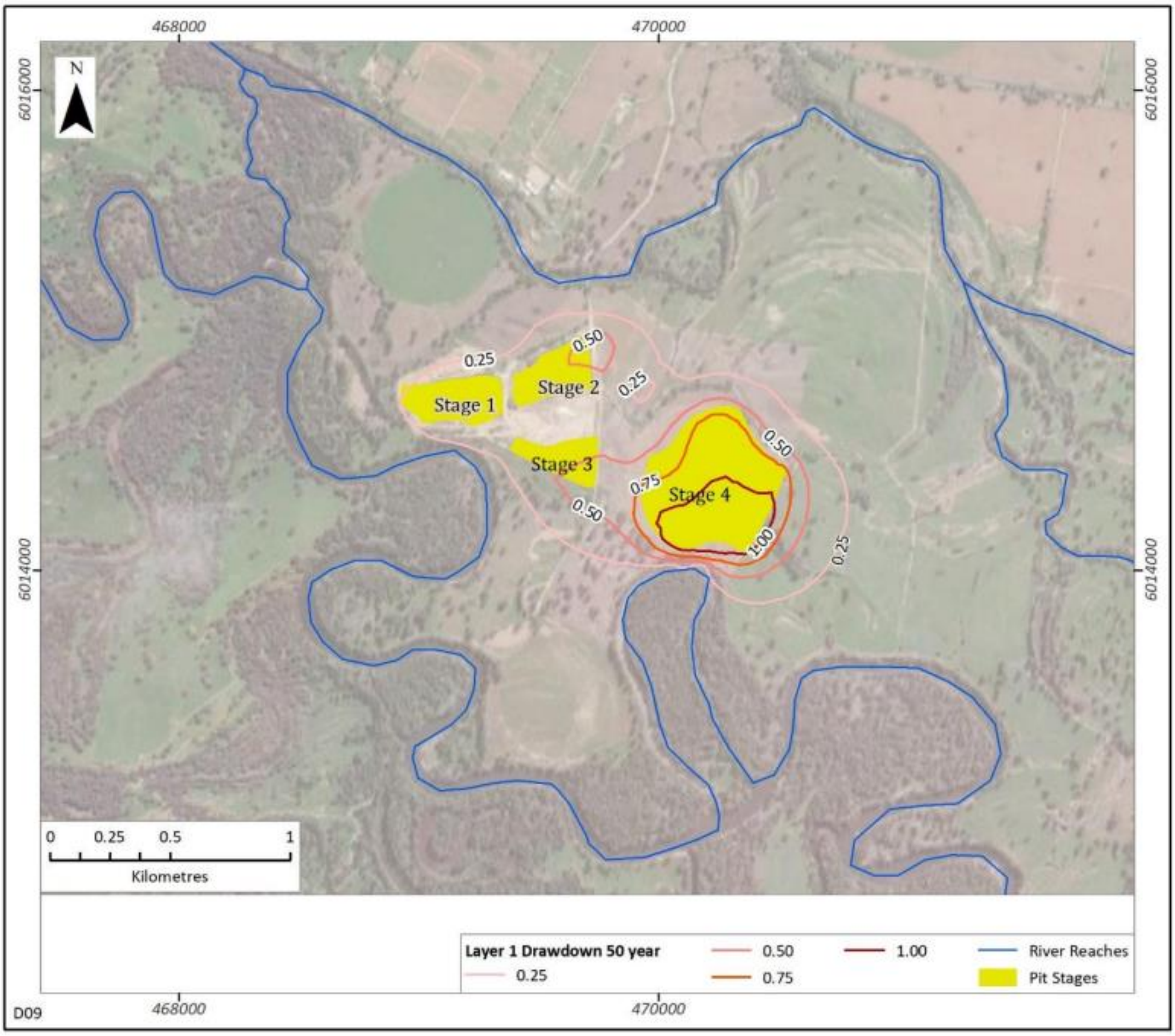


FIGURE 5-5 SHEPPARTON FORMATION POST-EXPANSION GROUNDWATER DRAWDOWN (WATSEC ENVIRONMENTAL, 2022)

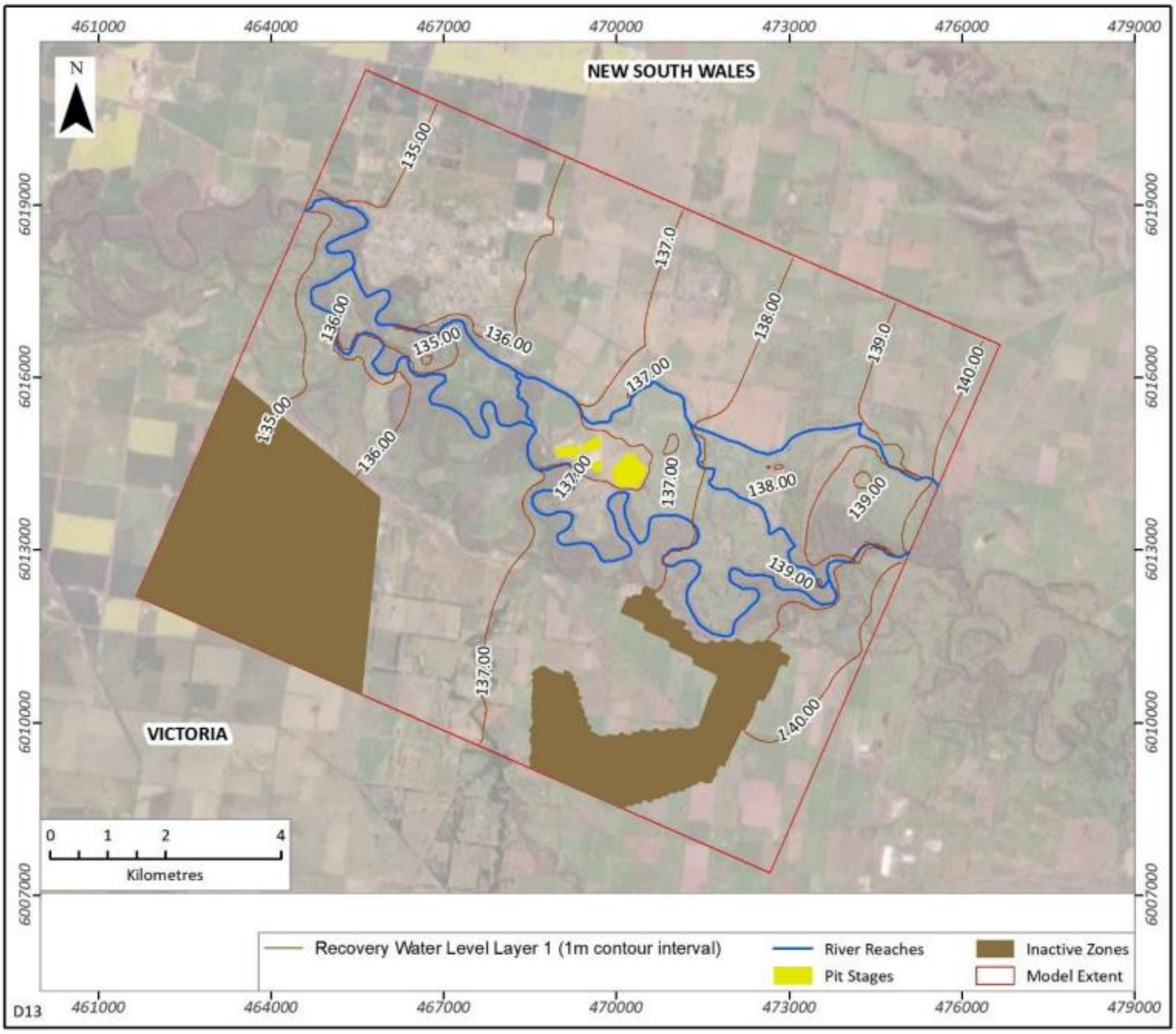


FIGURE 5-6 SHEPPARTON FORMATION POST-EXPANSION GROUNDWATER CONTOURS (WATSEC ENVIRONMENTAL, 2022)

The 50-year post-expansion groundwater contours in the vicinity of the site for the Lachlan Formation are shown below on Figure 5-7. The modelling shows that the long-term residual drawdown in layer 2 is less than 0.1 m across the site, and drawdown in this aquifer has therefore not been presented.

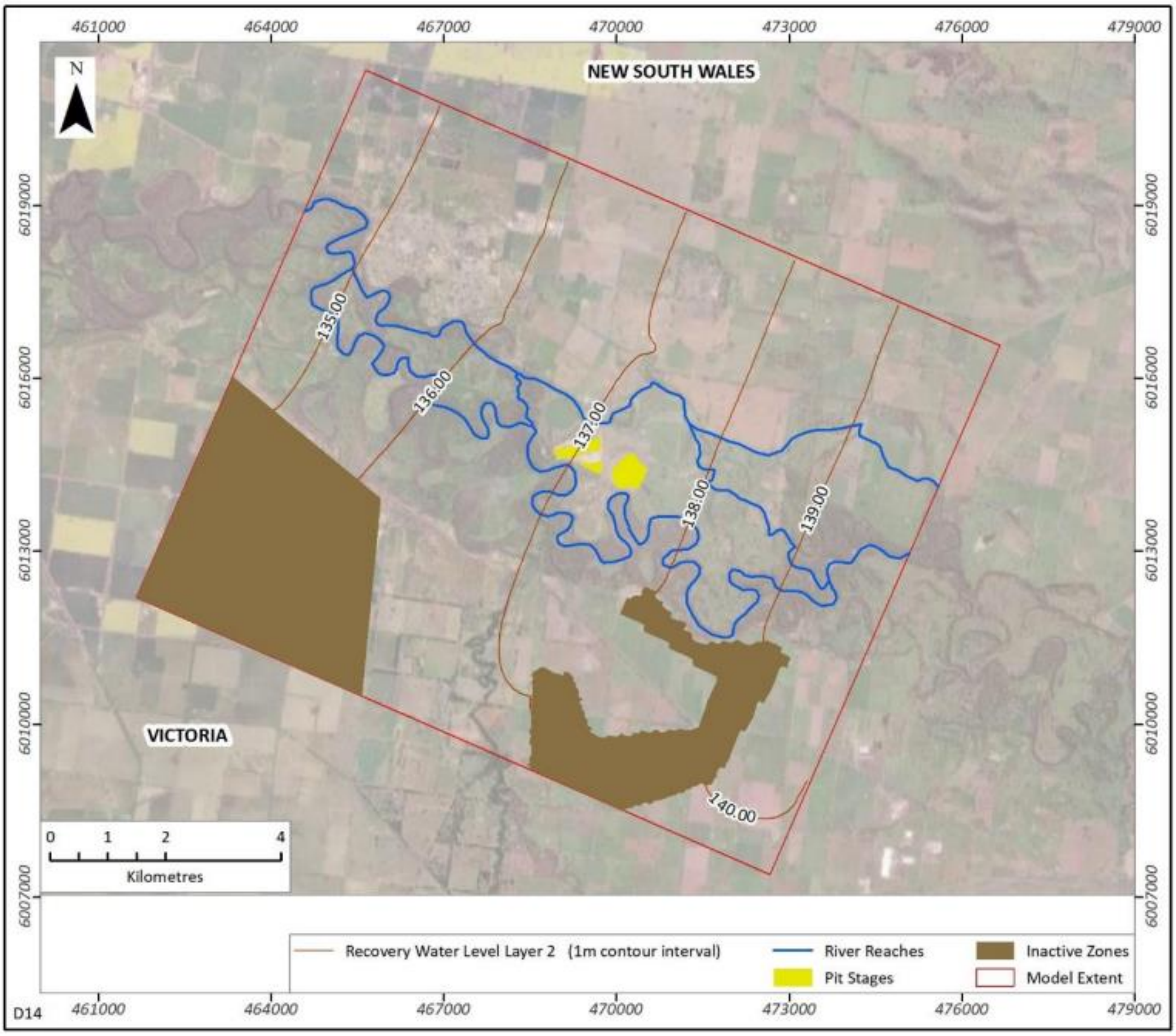


FIGURE 5-7 LACHLAN FORMATION POST-EXPANSION POTENTIOMETRIC CONTOURS

6 PIT WATER AND SALT BALANCES POST EXCAVATION

As each stage is completed the pit water levels will recover in response to groundwater and rainwater inflow and removal of water for irrigation or industrial use and evaporation. A spreadsheet model was used to model the long-term pit lake recovery levels and salinity with varying groundwater inflow rates depending on pit water level adopted from the MODFLOW model. The SILO 1971 – 2018 monthly average rainfall and evaporation data were used as inputs. Pit geometries were estimated based on a final excavation level of 119 m AHD, batter slopes of 2:1 (V:H) and surface areas as described in the staged development. The results of this modelling are shown on Figure 6-1, Figure 6-2, Figure 6-3 and Figure 6-4 and show that pit levels recover and stabilise within 6 to 8 years. With no additional extraction from the pits and for an assumed starting groundwater salinity of 450 mg/L, the spreadsheet modelling indicates the salinity of the pits may rise at a rate of approximately 10 mg/L per year due to evaporative concentration.

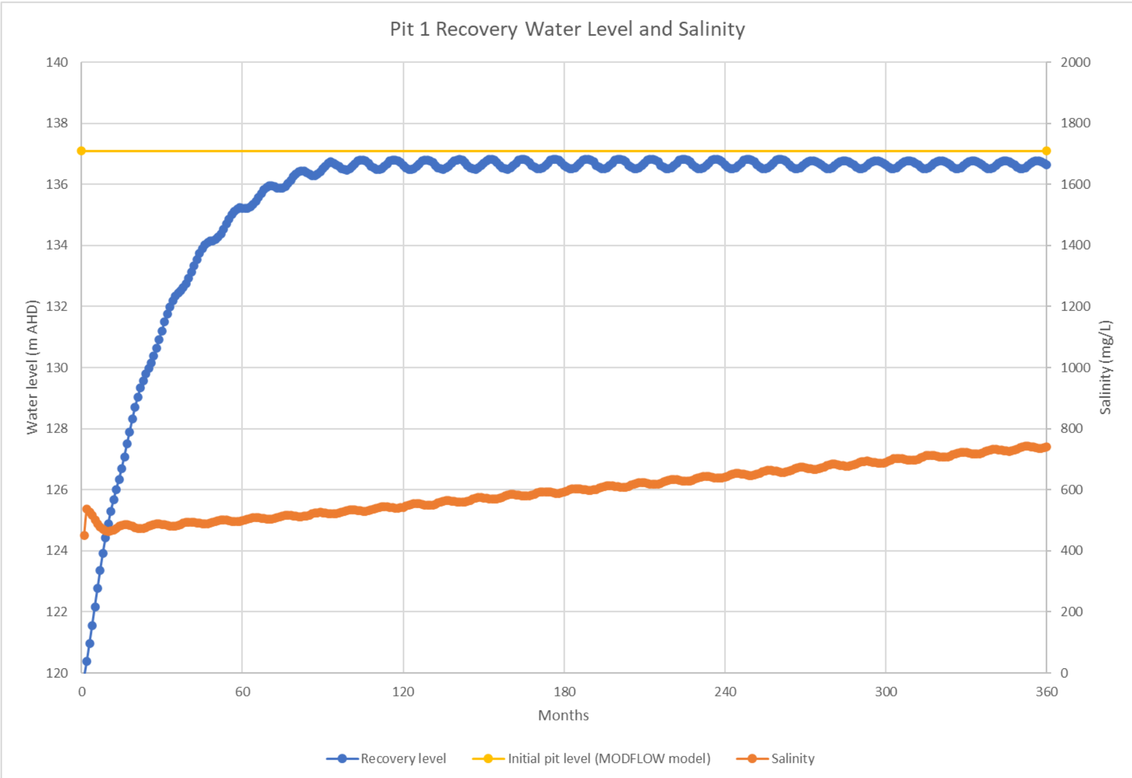


FIGURE 6-1 PIT 1 RECOVERY WATER LEVEL AND SALINITY

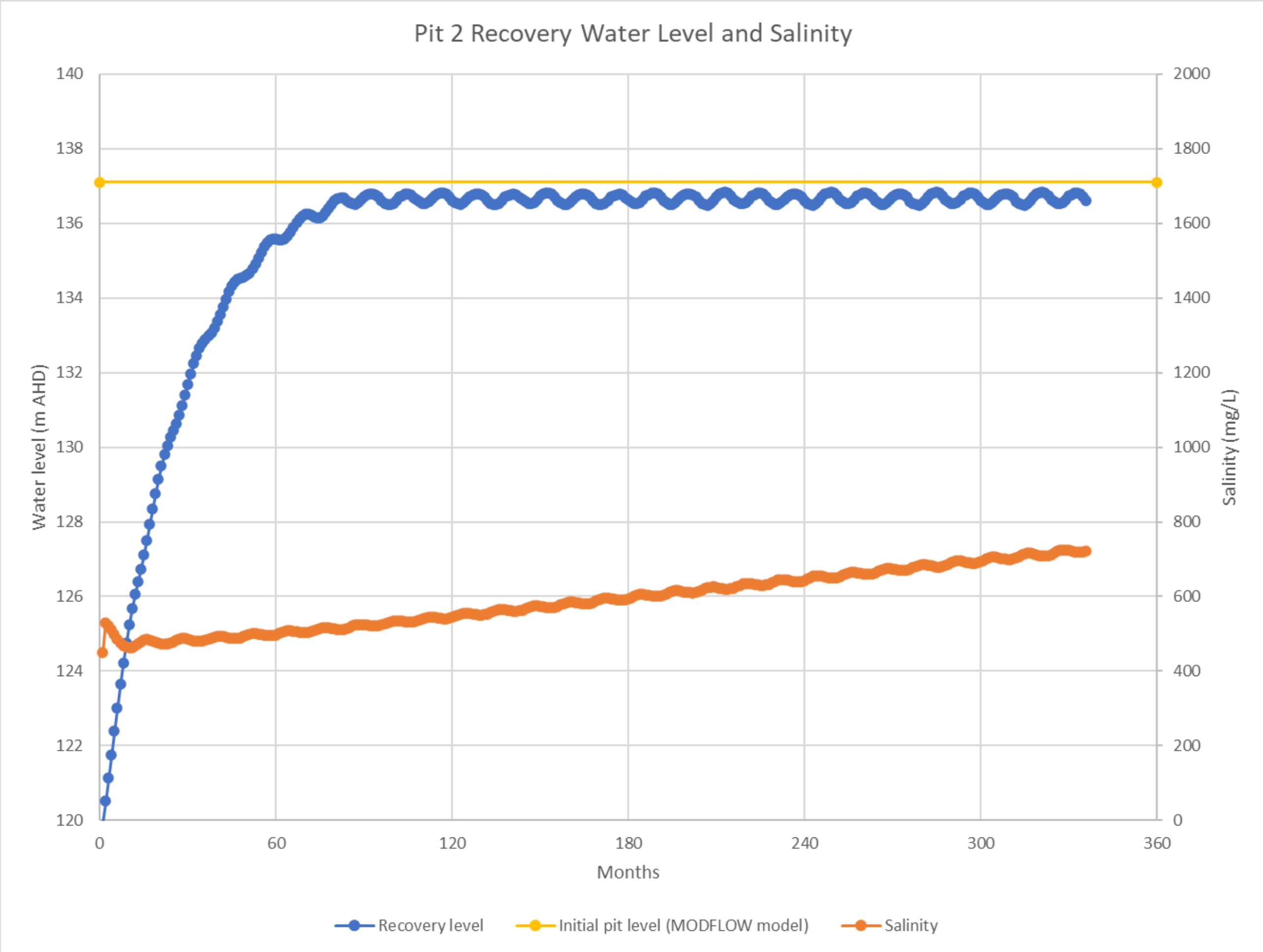


FIGURE 6-2 PIT 2 RECOVERY WATER LEVEL AND SALINITY

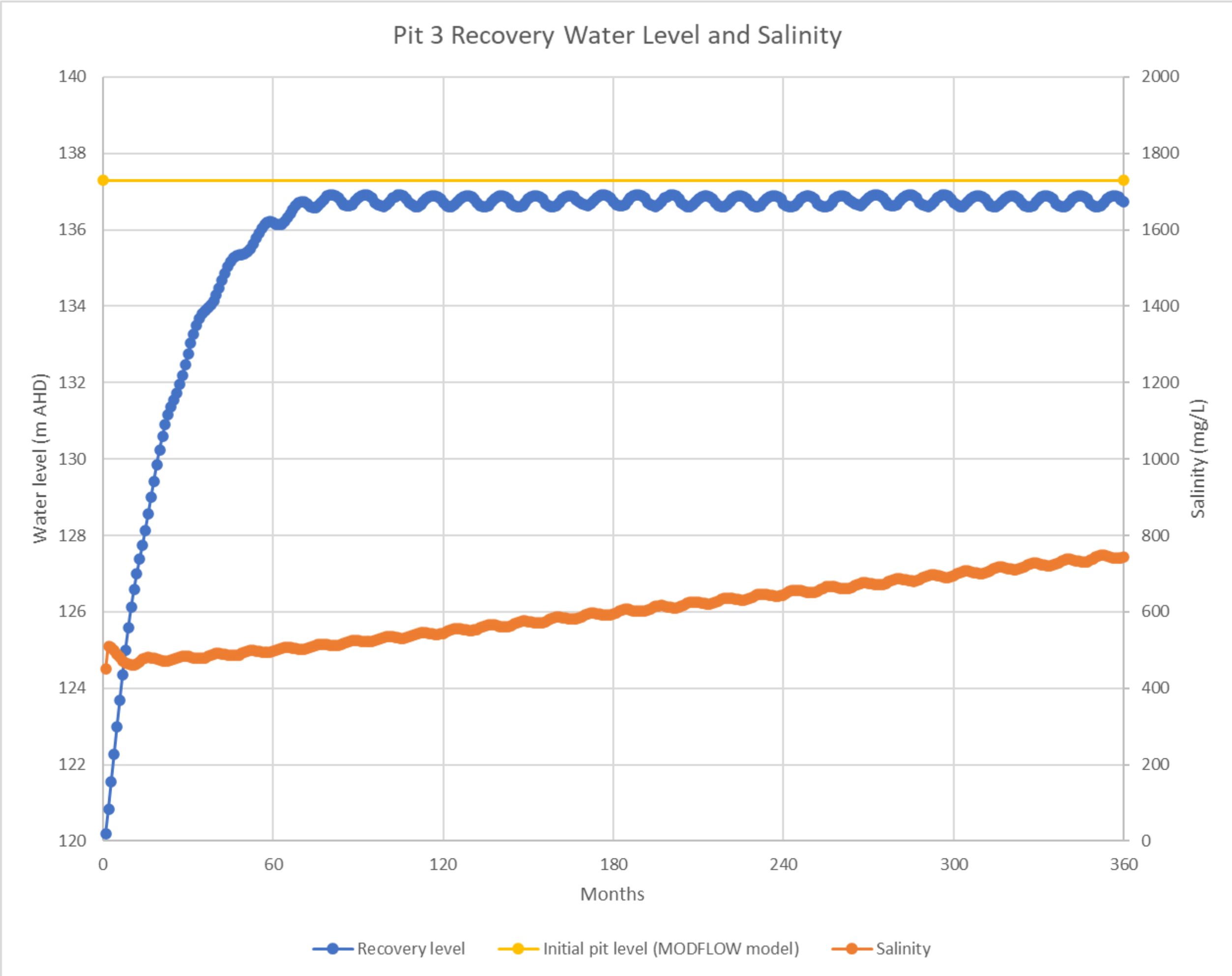


FIGURE 6-3 PIT 3 RECOVERY WATER LEVEL AND SALINITY

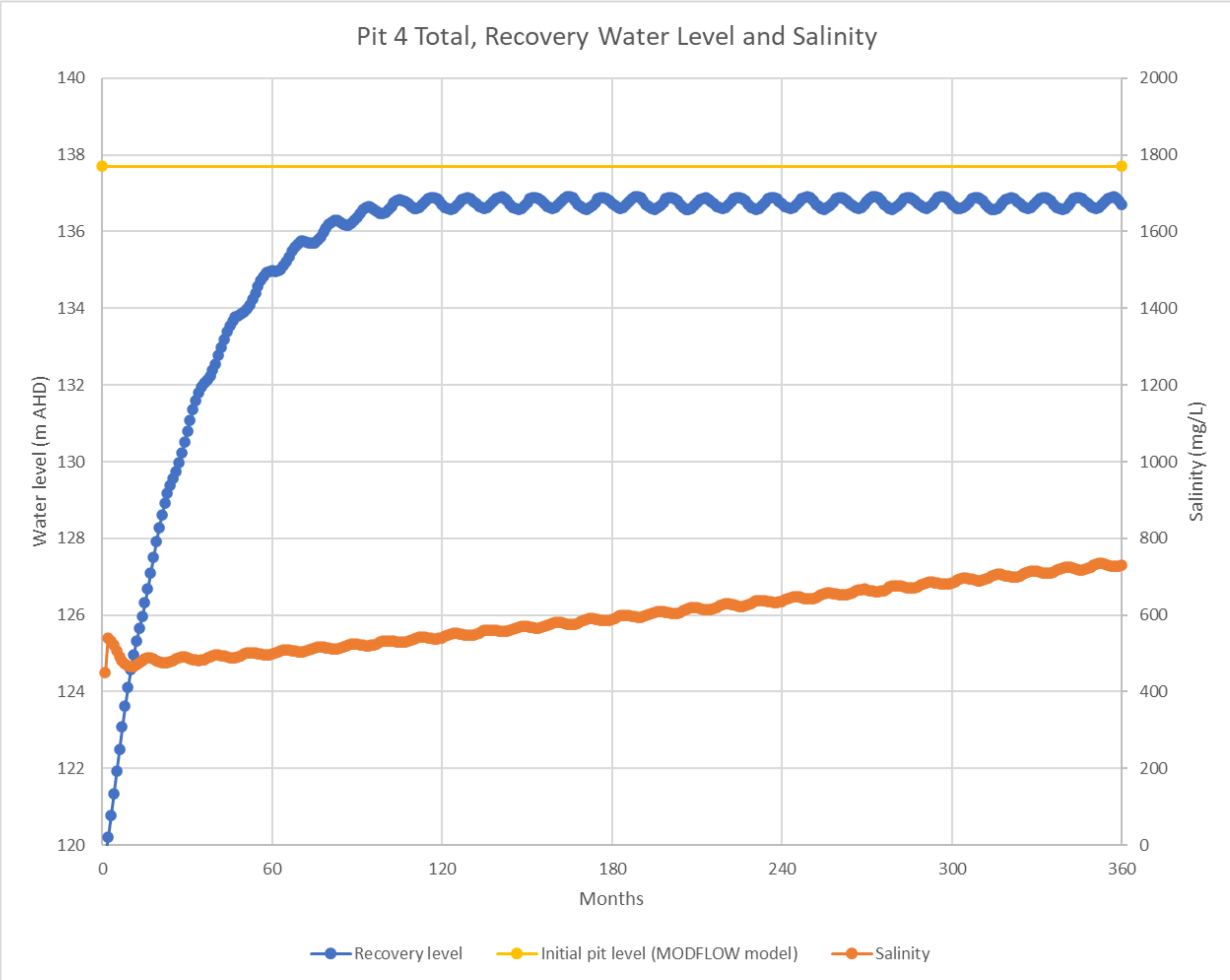


FIGURE 6-4 PIT 4 RECOVERY WATER LEVEL AND SALINITY

7 HYDROGEOLOGICAL IMPACT ASSESSMENT

7.1 Overview

The groundwater impact assessment of the Project has considered the legislation, policy and guidelines discussed in Section 2 of this report. Volumetric water requirements for the Project and associated impacts have been assessed using the numerical groundwater flow model presented in Appendix A and summarised in Section 5. The numerical groundwater flow model has been independently peer reviewed and was found to be fit for purpose (refer to Appendix B for peer review). The assessment approach has been aligned with the framework for assessing impacts as presented in the NSW AIP (refer to Appendix C for AIP self-assessment).

7.2 Accounting for the Take of Water

7.2.1 Project Water Requirements

Water is required to be extracted from the Upper Murray Alluvium to maintain dry working pits during the staged quarry development. Extracted groundwater will be used for processing with additional water used for irrigation on the broader land holding. In addition to groundwater extracted from the pits, losses will also occur from evaporation from non-worked pits, and this has been accounted for in the impact assessment. The assessment also suggests that the area of drawdown established by the staged pit dewatering will increase discharge from the Murray River to the Shepparton Formation aquifer and to a lesser extent reduce the discharge from the Shepparton Formation aquifer to the river. However, it is noted that the LTAAEL for the Upper Murray Alluvium water source has been established with regards to acceptable impacts on the connected surface water resources and groundwater resources. For this reason, a Murray Unregulated River Water Source licence is not considered necessary for the Project.

Annualised water licensing requirements for the proposed 30-year Project-life are presented in Table 7-1 along with the effects of the project on the Murray River / Shepparton Formation aquifer interaction (Appendix F of WatSec Environmental, 2022). The maximum predicted annual licensing requirement for the Project is 1,776 ML/a, which occurs in year 30. The Applicant holds Water Access Licences (29915 and 29975) with a combined total of 2,000 share components. As this equates to a minimum licensed volume of 2,000ML/a (1.0ML/share component), the Applicant holds sufficient water licensing to satisfy obligations under the Aquifer Interference Policy. However, it is proposed that the maximum predicted licensing requirement be confirmed with NSW regulatory agencies prior to year 10, following re-calibration of the groundwater model. This re-calibration would rely on the collection of additional site-specific data, furthering the Applicant's understanding of the interactions between the local groundwater system and surface water.

The post-quarry plan is to allow excavated pits to remain open to naturally fill with water and be rehabilitated as wetlands with the option to provide irrigation water supplies as previously described. An annual allocation of 139 ML/y would be needed to cover the on-going anticipated nett evaporation loss.

TABLE 7-1 EXPANSION STAGE WATER EXTRACTION BALANCES

Stage	Project Year	Total Extraction[1] (ML)	Total Effect on River / Aquifer Interaction (ML)
1	1	707	279
	2	653	312
2	3	691	311
	4	672	314
3	5	412	264
	6	731	337
	7	675	326
4(AB)	8	619	347
	9	1,087	492
	10	1,243	591
4(CDE)	11	85	326
	12	122	198
	13	312	192
	14	448	223
	15	574	271
	16	695	327
	17	811	388
	18	922	450
	19	1,030	513
	20	1,133	575
	21	1,232	636
	22	1,326	695
	23	1,415	751
	24	1,498	804
	25	1,574	854
	26	1,643	899
	27	1,702	939
	28	1,748	972
	29	1,776	994
	30	1,776	1,002

Notes: 1. Total extraction includes water extracted from pits and water lost through evaporation.

7.3 Addressing the Minimal Impact Considerations

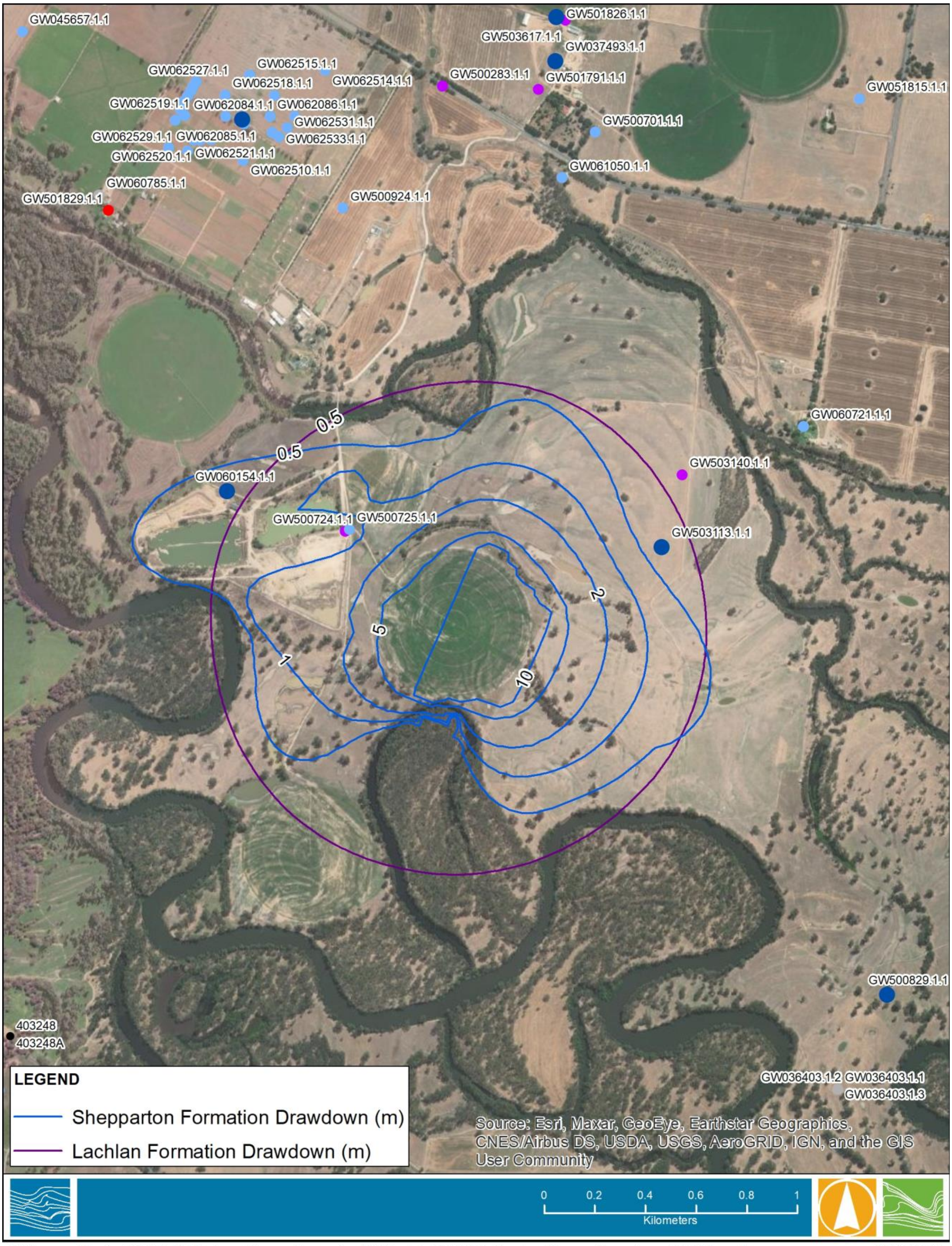
7.3.1 Water Supply Works

The location of existing groundwater wells is presented in Figure 7-1. Well locations were downloaded from the Australian Groundwater Explorer[2] and cross checked with information held within the NSW Groundwater online portal[3]. Three registered groundwater wells are located on the property (GW060154, GW500724 and GW500725 in Figure 7-1). It is understood that these wells are not used by the Applicant, as all water for quarry operations and irrigation is currently sourced from existing pits.

Assessment of the drawdown extent and magnitude against the location of other existing users (i.e. wells not located on the property) shows that drawdown is less than the 2-metre threshold as defined in the NSW Aquifer Interference Policy (2012) for all quarry development stages (i.e. Stage 1, 2, 3, 4(ab) and 4(cde)).

Drawdown of up to 0.5 m is predicted at wells GW503113 and GW503140 during Stage 4(cde) which represents the maximum extent of drawdown for each of the stages at these locations (Figure 7-1). Well GW503140 is listed as a monitoring well and its status is abandoned while well GW503113 is listed as an operational irrigation well. GW503113 is 54 m deep with a reported standing water level of 4 m and a yield of 30 L/s. Given the available drawdown in this well (around 50 m) and the high yield, the proposed operations are unlikely to have any noticeable impact on this well. Once pit dewatering ceases, the drawdown at this well is predicted to reduce to less than 0.5 m.

[2] http://www.bom.gov.au/water/groundwater/explorer/map.shtml
[3] https://realtimedata.waternsw.com.au/water.stm



S:\Synergy\Projects\P18189 Howlong Quarry Expansion EIS\SpJobs\P18189_HowlongQuarry_Drawdown_211118.mxd 18/11/2021

FIGURE 7-1 DRAWDOWN AT WATER SUPPLY WORKS STAGE 4(CDE)

7.3.2 Groundwater Dependent Ecosystems

The Murray Alluvium WSP identifies high priority GDEs in the Project area. In addition to the GDEs identified in the Murray Alluvium WSP, potential aquatic and terrestrial GDEs from the Bureau of Meteorology GDE atlas have been accessed for the Project area. These GDEs are presented spatially with the predicted drawdown contours in the Shepparton Formation for Stages 1, 2, 3 and 4(ab) in Figure 7-2 and Stage 4(cde) in Figure 7-3. Drawdown contours for the deeper Lachlan Formation have not been consider as ecosystems are assumed to be relying solely on the Shepparton Formation.

The modelling shows that due to the bounding of the Murray River and Black Swan Anabranch the drawdown effects in the Shepparton Formation are largely constrained to an area between these water bodies. During operations when dewatering is occurring, drawdown of up to 10 m is predicted at some GDEs located directly adjacent the pits (within 20 m). The drawdown is expected to be much less than this beneath other identified GDEs located away for the fringes of the pits as illustrated in Figure 7-2 and Figure 7-3. This is due to the steep hydraulic gradient which is predicted to develop between the operational pits and the river which acts as a recharge boundary for the Shepparton Formation.

Once dewatering ceases, groundwater levels are expected to rise, and the drawdown extent is significantly reduced when compared to the Stage 4(cde) drawdown contours (Figure 7-4). Drawdown is predicted to be less than 1 m when groundwater and pit lake levels have recovered. The impacted areas consist largely of the Plant Community Type (PCT) 5: *"River red gum herbaceous-grassy very tall open forest"* (refer Map 6 of EnviroKey, (2021)). Depending on the degree of reliance these vegetation communities have on the groundwater system, it is possible that some level of localised effect may be felt on GDEs directly adjacent the pits during the operational phase of the Project.

The Applicant would undertake a revegetation program outside of disturbed areas of the Quarry that may mitigate potential impacts to vegetation coverage within the 100m buffer area. This program would focus on riparian areas between the Quarry and the Murray River that have historically been cleared for agricultural use. These riparian areas generally correspond with the predicted drawdown and mapped High Priority GDEs. The objective of this program is to provide suitable buffers to the Murray River, enhance the biodiversity value of the land historically used for agriculture and improve connectivity in the local landscape.

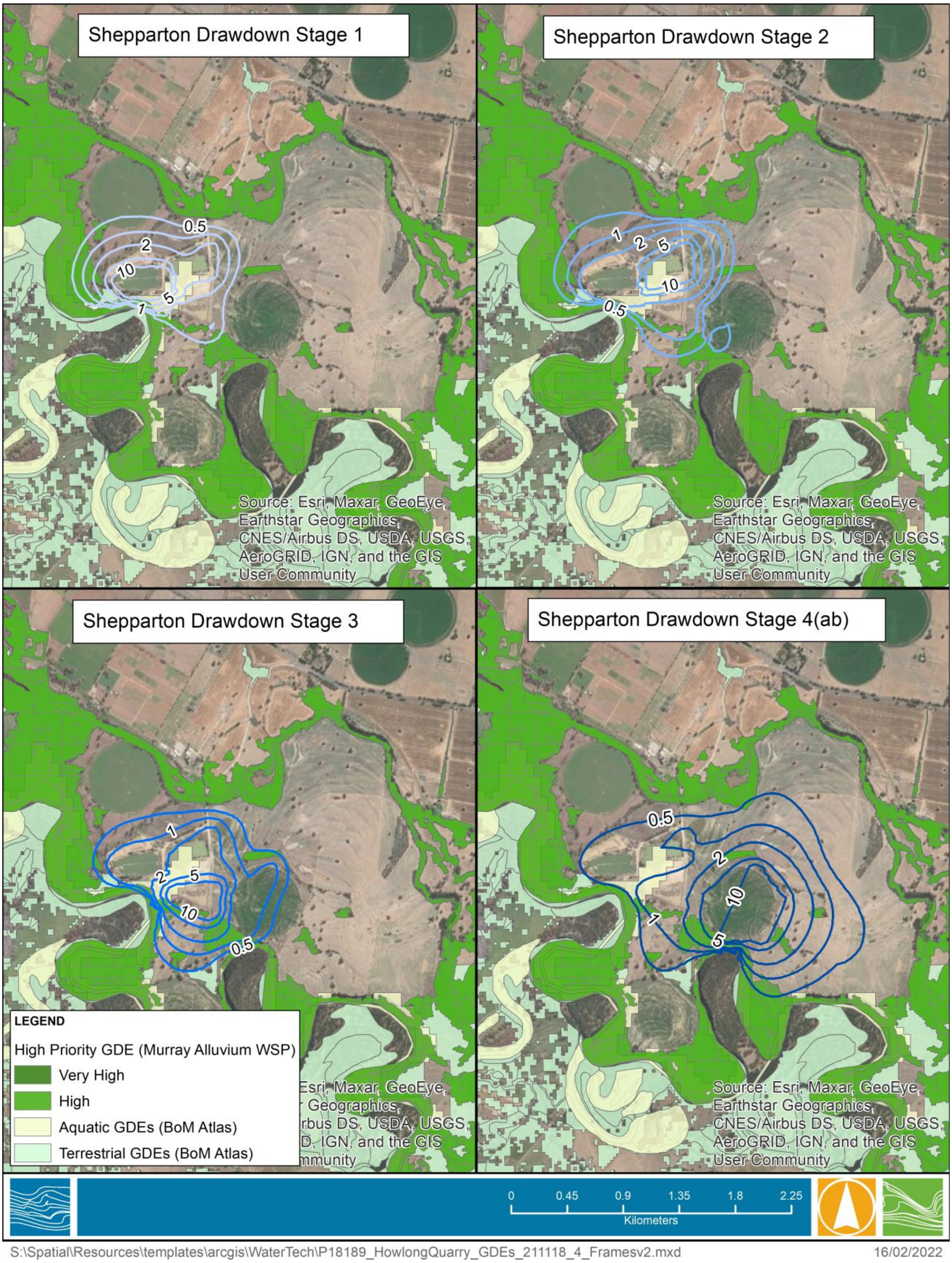


FIGURE 7-2 DRAWDOWN AT GDES AT THE END OF QUARRYING STAGE 1, 2, 3 AND 4(AB) IN THE SHEPPARTON FORMATION

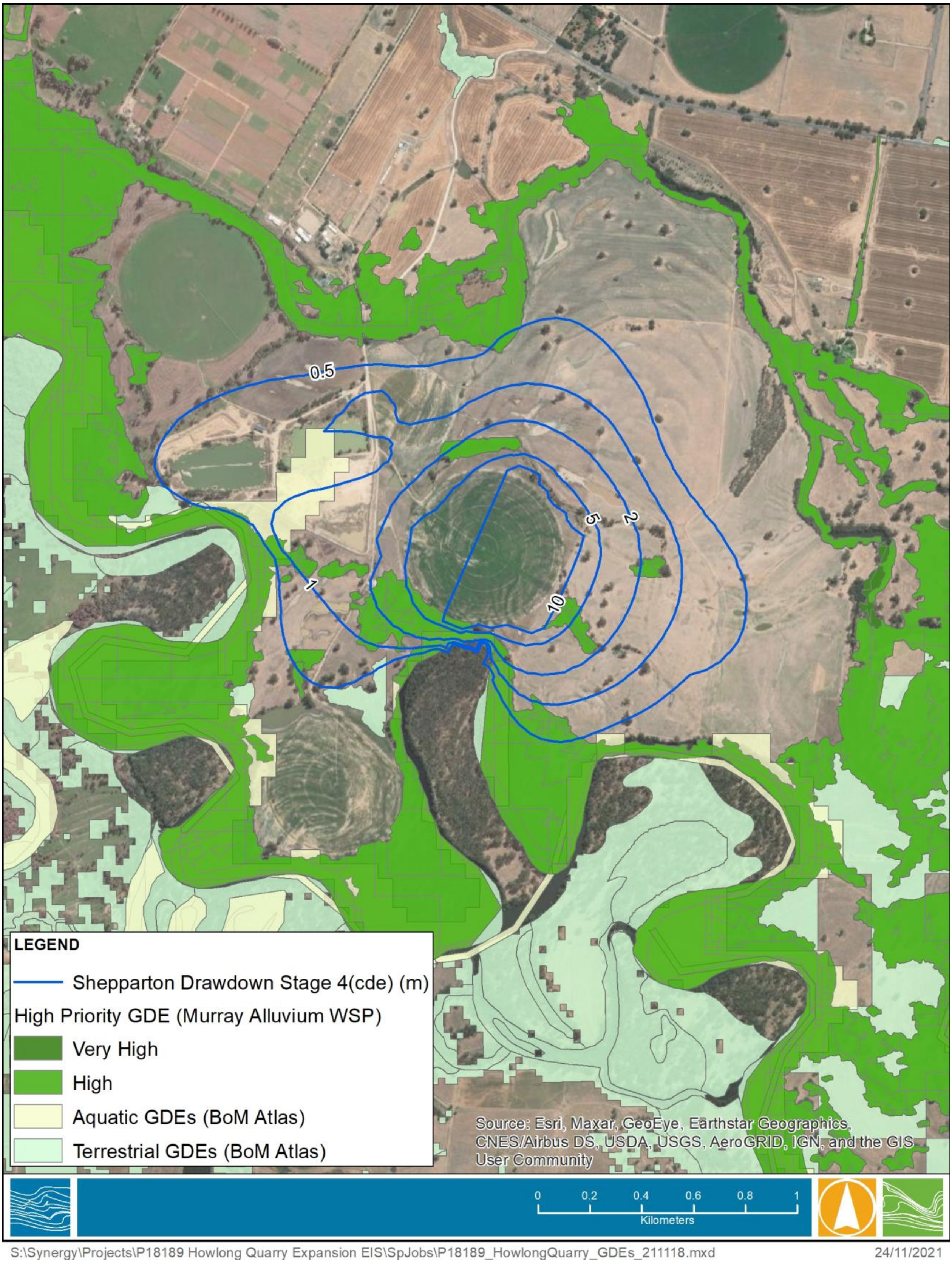


FIGURE 7-3 DRAWDOWN AT GDES AT THE END OF QUARRYING STAGE 4(CDE) IN THE SHEPPARTON FORMATION

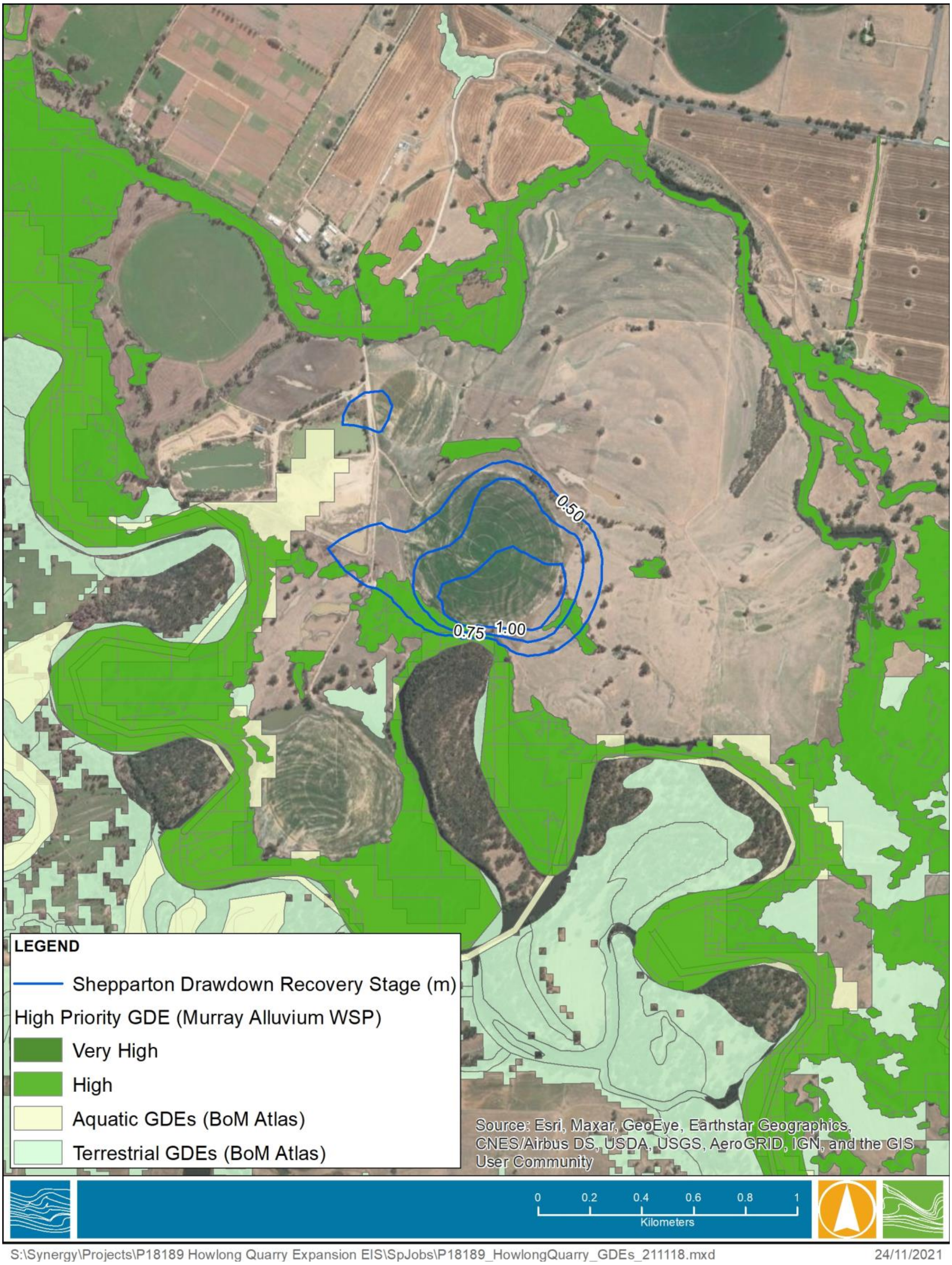


FIGURE 7-4 POST QUARRYING DRAWDOWN IN THE SHEPPARTON FORMATION

7.3.3 Potential Impacts on the Murray River

It is considered that the water quality and flow risks of pit excavations on the Murray River will be low because:

- The maximum modelled dewatering volume (Stage4(cde)) of 4.8 ML/d induces a combined increase in river leakage from the river to the aquifer and decrease in groundwater discharge from the aquifer to the river, of approximately 2.7 ML/d. This is 0.14% of the minimum (winter) daily river flow at Howlong of 2,000 ML/d based on 2019 data (which is representative of historical river flow), and 0.04% of the average daily flow for 2019 of approximately 7,000 ML/d.
- Based on the numerical groundwater modelling, the nett effects of evaporation will result in the pits establishing as evaporative sinks with levels being maintained below river level. In this scenario the flow gradient is from the Murray River to the pits (Figure 5-5) and hence water quality impacts on the Murray River are considered unlikely.

The Applicant has committed to reinstatement of a 100 m buffer between the river and extraction operations in Stage 1 against the southern edge, adjacent the edge nearest the Murray River (refer Figure 7-5). The area identified as “Area Under Rehabilitation” is the intended location of the landform rehabilitation. The rationale for this activity is to promote a vegetated buffer between the Stage 1 pit and the Murray River that enhances biodiversity, ensures stability and minimises erosion potential.

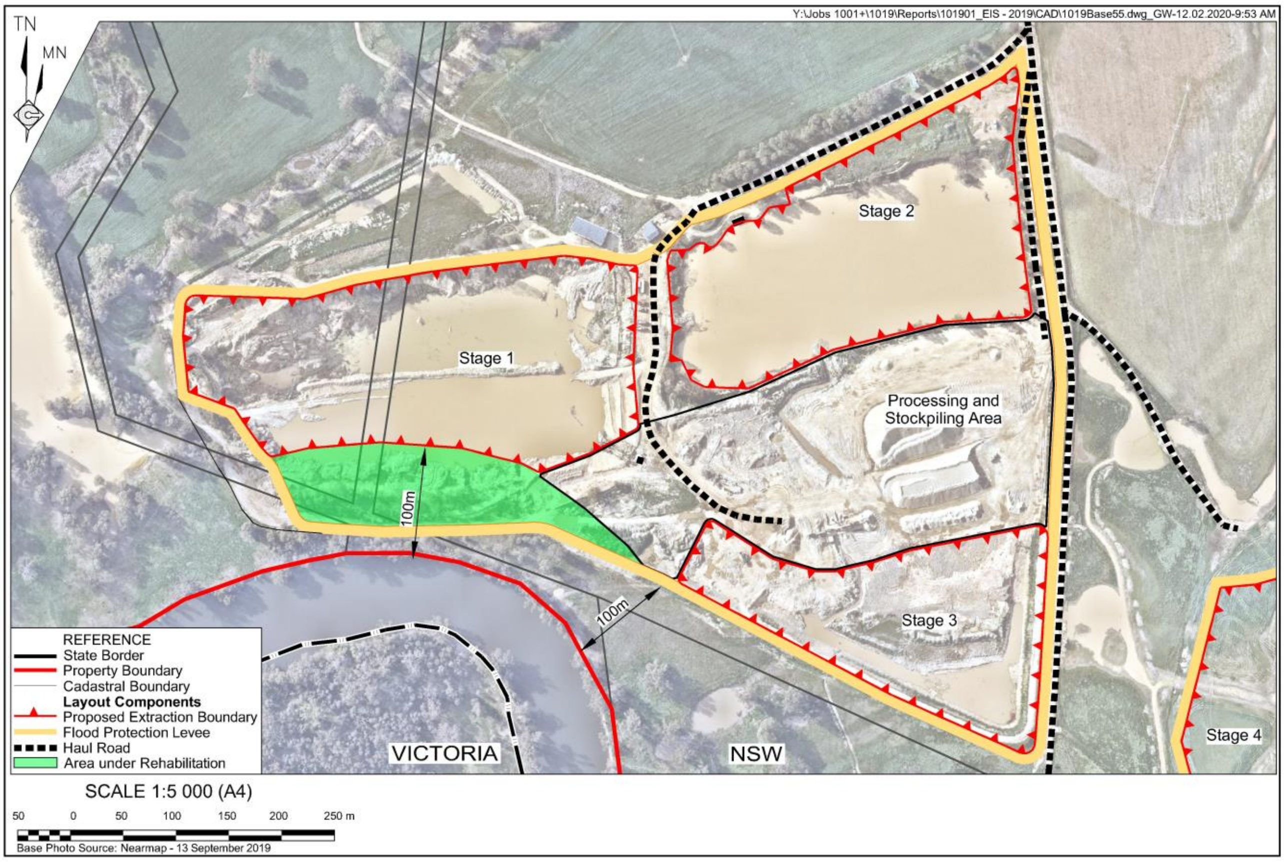


FIGURE 7-5 PROPOSED PIT 1 PARTIAL FILL OPTION

An engineered fill campaign would be initiated to ensure the stability of the rehabilitated area with the hydrogeological implications being influenced by the type of material placed, the dimensions of the fill zone and the compaction of the material. Therefore, the fill materials would be primarily the clay-based material removed from the Stage 1 and 2 pits. The proposed fill zone would subsequently be revegetated to establish

Red Gum Woodland and monitored against completion criteria established in an approved Rehabilitation Management Plan that would be prepared in consultation with the NSW BCD.

Given the minor spatial scale of the works when compared to extraction, any changes to hydraulic connectivity from material compaction would be unlikely to significantly alter groundwater flow patterns. While ponding of water around this landform may occur, this is likely to be minor. It is also noted that extraction within Stage 1 would occur over two years, after which time the extraction area would refill with groundwater providing additional stability.

7.3.4 Water Quality

The main long-term impact on the hydrogeological behaviour of the area is anticipated to be an increase in the surface area of exposed water table due to the excavated pits. There are currently two pits excavated covering an area of 13 hectares. This would increase to four pits covering a total area of around 42 hectares. This will generate groundwater discharge from the Upper Murray Alluvium (Shepparton Formation) to the excavated pit via evaporative loss from the pit lakes. If required, the increased discharge can be accounted for by a corresponding decrease in the licensed extraction of groundwater for irrigation purposes.

The pits would become evaporative sinks on the floodplain with localised groundwater flow being towards the pits. Hence, under normal conditions, no transmission of impacts to the local groundwater system are expected. The salinity of the pits is modelled to increase at approximately 10 mg/L/y from an assumed starting salinity of 450 mg/L. This estimate should be considered as indicative only as the actual long term salinity regime within the excavated pits will depend on a range of factors including climate, aquifer parameters, actual excavated pit dimensions and long-term pit management including whether they are used for irrigation supply.

7.3.5 Culturally Significant Sites

There are no known culturally significant sites within the study area.

8 GROUNDWATER MONITORING AND MANAGEMENT

To validate the assumptions used in this groundwater assessment and to provide the required data for model re-calibration it is recommended that groundwater and surface monitoring be undertaken, and that water use is appropriately monitored to account for all water consumed by the Project.

Model-recalibration is proposed following collection of one year of operational data. At this time, the project water requirements and drawdown impacts should be re-evaluated to support licensing arrangements beyond Project year 10 (Stage 4cde). Following the initial model update, it is proposed to update the model every three years to ensure that observed conditions are consistent with model predictions.

8.1 Groundwater Monitoring

Groundwater monitoring should be established around the working pits and at the upgradient and downgradient extremities of the proposed quarry expansion site. Suggested new groundwater monitoring sites are shown on Figure 8-1. Proposed sites have been located adjacent infrastructure (access roads, fences) for ease of access.

It is assumed that the observation bores adjacent the pits will be constructed to at least the anticipated maximum pit excavation depth to allow for an understanding of how the groundwater is behaving during the periods the pits are dewatered to their maximum depth. These bores should be screened over the full depth of sediment saturation (i.e. from above standing groundwater level to the base of the bore). This will ensure that if there is a need to sample for contamination then there is opportunity to take a sample from any depth of the saturated monitoring interval. Bores should be sealed to prevent surface water inflow during times of high river flow. This needs only to be done when flooding is expected, and the seal only needs to be in operation for the period of flooding.

Site Descriptions

Site 1. Located between the Murray River and the Stage 1 pit, to sample for water moving between the River and the pit and to validate the drawdown predictions.

Site 2 Located at the upgradient end of the property. This is to understand the quality of groundwater coming into the property.

Site 3 Located between Stages 1,2, 3 and 4 pits to assist in understanding what the hydraulic relationship is between Stage 3 (decommissioned and full of water) and Stage 4 (active sand extraction).

Site 4 Located down hydraulic gradient from Stages 1,2 and 3, to understand immediate impact to shallow groundwater from each pit stage activity.

Site 5 Located at the most down-hydraulic gradient point on the property and near a High Priority GDE (Murray Alluvium WSP).

A summary of existing bores located on or adjacent the quarry site is provided in Table 8-1 to ascertain if any of these wells can be utilised for groundwater monitoring purposes in additional to those presented above.

TABLE 8-1 EXISTING BORES ON AND ADJACENT TO THE SITE

Number	Purpose/ Status	Constructed	Cased to [m bGL]	Screened to [m bGL]	Target Aquifer
GW060154	Unspecified	1/1/1984	-	-	Shepparton
GW500724	Stock, Domestic	25/3/1998	-	-	Lachlan Aquifer
GW500725	Stock, Domestic	23/3/1998	25	27	Shepparton Aquifer
GW503113	Irrigation	1/6/2005	46	54	Lachlan Aquifer
GW503140	Test Bore, Abandoned	3/12/2001	0	N/A	-

Notes: (-) denotes to data

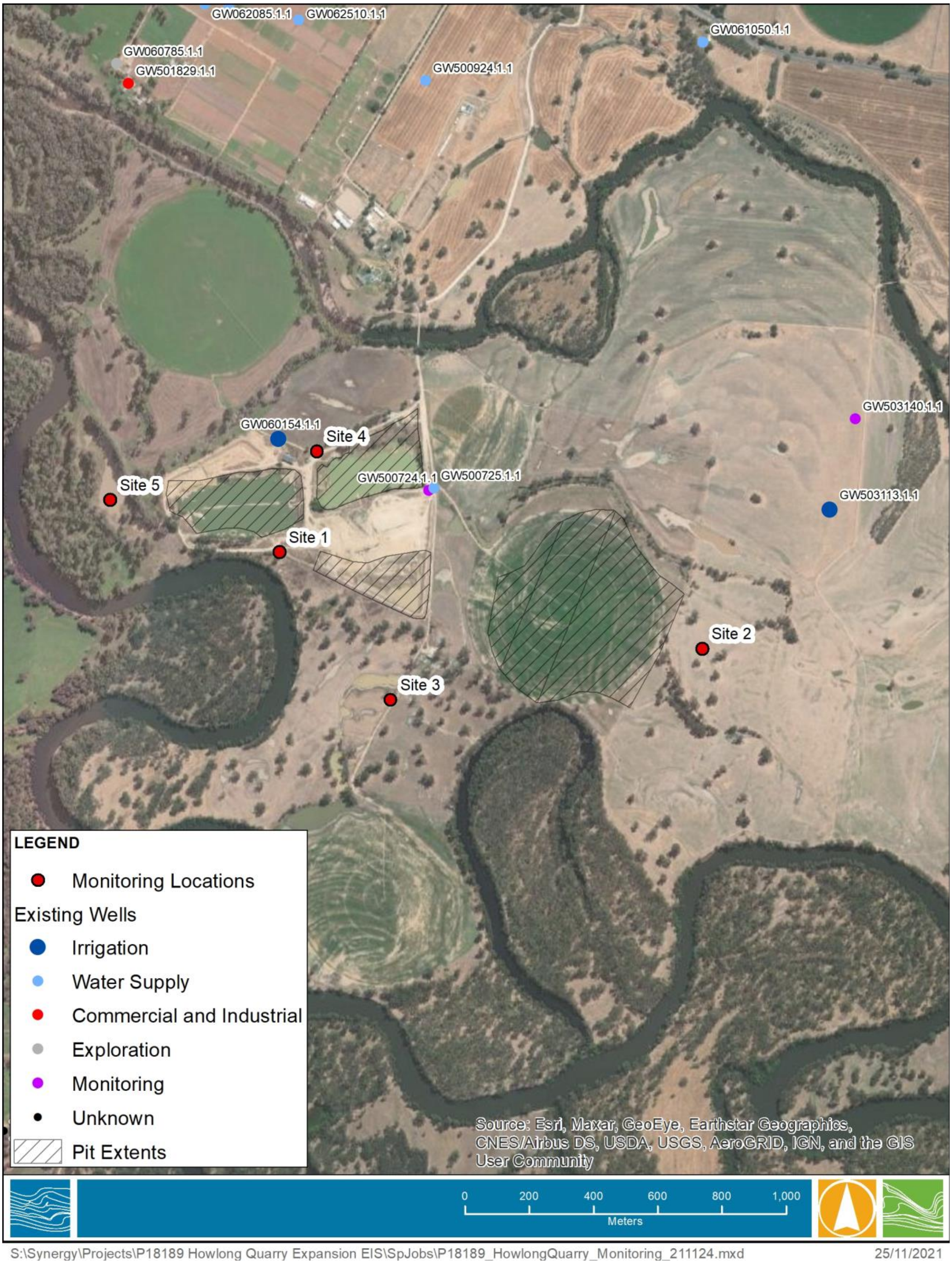


FIGURE 8-1 PROPOSED GROUNDWATER MONITORING SITES AND EXISTING BORES

Hydrogeological parameters to monitor in each of the proposed wells include:

- Depth to groundwater level (below surveyed reference point) monthly;
- Salinity of groundwater bi-annually;
- Water quality parameters annually to ascertain whether on-site activities have contaminated groundwater (EC, pH, TSS, TPH, Oil and Grease); and
- Murray River stage height adjacent the Stage 1 Pit, coincident with groundwater monitoring schedule.

The use of automated water level data loggers is also recommended in the wells closest to the worked pits and in the Murray River to better understand groundwater – surface water interactions at the site.

8.2 Water Balance Metering

As the dewatering of an actively excavated pit is considered the taking of groundwater (under licence), all water extracted from pits is required to be metered. It is also recommended that the volume of water used for processing and irrigation is metered so all water inputs and outputs can be accounted for. Meters should be read at least monthly, or as frequently as required to ensure water balance assumptions are maintained.

Monitoring and analysis of the water balance as the project progresses will enable confirmation of future extraction rates and calibration of the numerical groundwater flow model.

8.3 Pit Stage and Water Quality Monitoring

Monthly pit water level and bi-annual pit water quality monitoring should be undertaken in all open pits to provide data for model calibration and to assess the quality of groundwater seepage into the pits. Quality and level monitoring data from un-worked pits is also required to validate the post excavation water quality impact modelling.

9 SUMMARY

Numerical groundwater modelling analysis indicates that during Project Stages 1 to 4 the maximum predicted annual licensing requirement for the Project is 1,776 ML/a, which occurs in Project year 30. The Applicant holds Water Access Licences (29915 and 29975) with a combined total of 2,000 share components. As this equates to a minimum licensed volume of 2,000 ML/a (1.0 ML/share component), the Applicant holds sufficient water licensing to satisfy obligations under the Aquifer Interference Policy.

The modelling shows that due to the bounding of the Murray River and Black Swan Anabranch the drawdown effects of the proposed staged development are constrained to an area between these water bodies and to within less than 1 km along the floodplain from the quarrying operations. The limited extent of drawdown means that no existing water supply works (groundwater wells) are expected to be impacted.

Drawdown is predicted to extend to the fringes of some GDEs (Murray Alluvium WSP). At these locations, the expected drawdown may be up to 10 m where the identified GDEs are located directly adjacent the pits (within 20 m). Drawdown is expected to be much less than this within other identified GDE areas located closer to the river. The impacted areas consist largely of the Plant Community Type (PCT) 5: “River red gum herbaceous-grassy very tall open forest”. Depending on the degree of reliance these vegetation communities have on the groundwater system, it is possible that some level of localised effect may be felt on GDEs directly adjacent the pits during operations. Post quarrying, the drawdown extent is significantly reduced when compared to the Stage 4(cde) drawdown contours and impacts to GDEs are expected to be minimal.

It is likely that the pumped groundwater will require management in the form of on-site use for screening and other quarry activities, on-site balancing and appropriate levels of irrigation to accommodate the anticipated volumes. It is understood that by Stage 4 substantial revegetation and rehabilitation of land adjacent to the Quarry would be occurring or have been completed. Any surplus water would be irrigated over this land to support vegetation establishment.

The increased depth of excavation of the pits is assumed to fully penetrate the Shepparton Formation Aquifer. The pits are expected to become evaporative sinks on the floodplain with localised groundwater flow paths reflecting this. Due to the assumed post-quarrying extraction of water for irrigation, the salinity of the pits is modelled to increase by 10 mg/L/y from an assumed starting salinity of 450 mg/L. This estimate should be considered as indicative only as the actual long term salinity regime within the excavated pits will depend on a range of factors including climate, aquifer parameters, actual excavated pit dimensions and long-term pit management including whether they are used for irrigation supply.

The main long-term impact on the hydrogeological behaviour of the area is anticipated to be an increase in the surface area of exposed water table due to an increase in the number of excavation pits. This will likely increase the rate of groundwater discharge from the Upper Murray Alluvium and can be accounted for by a corresponding decrease in the licensed extraction of groundwater for irrigation purposes. Significant impacts to the Murray River and downstream water users are not predicted to occur as the maximum dewatering scenario for Stage 4(cde) induces a combined increase in discharge from the river to the aquifer and decrease in groundwater discharge from the aquifer to the river of 0.04% of the average daily river flow of approximately 7,000 ML/d measured in 2019. Water quality in the river would be unchanged as the modelling scenario shows water levels in the pits would be maintained at levels lower than the river water level thereby maintaining a flow gradient from the river to the pits.

To validate the predicted impacts in this groundwater assessment it is recommended that groundwater and surface water monitoring be undertaken to assess for actual groundwater impacts and that water use is appropriately monitored to account for all Project inputs and outputs. It is proposed that the numerical groundwater flow model is re-calibrated following collection of one year of operational data. At this time, the project water requirements and drawdown impacts should be re-evaluated to support licensing arrangements beyond Project year 10 (Stage 4cde).

10 REFERENCES

CAF Consulting (2017). *Howlong Sand Quarry Expansion – 4343 Riverina Highway, Howlong, Preliminary Environmental Assessment.* for Fraser Earthmoving Construction. Version C

Chiang, W. and Kinzelbach, W. (1998). *Processing Modflow. A Simulation System for Modeling Groundwater Flow and Pollution*.

EnviroKey (2020), Biodiversity Development Assessment Report for the Howlong Sand and Gravel Quarry Expansion, A report prepared for RW Corkery & Co Pty Limited on behalf of Fraser Earthmoving Construction

Gutteridge Haskins & Davey Pty. Ltd., Cameron McNamara Pty. Ltd. Laurie Montgomerie and Pettit Pty. Ltd. Murray (1986). *River Flood Plain Atlas*. Rural Water Commission of Victoria Water Resources Commission of New South Wales.

Harbaugh, A.W. and McDonald, M.G. (1996). *User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model*. USGS Open-File Report 96-485.

Kulatunga N., 2009, *Upper Murray Alluvium, Groundwater Management Area 015: Albury to Corowa, Groundwater Resources Status Report – 2008*. NSW Department of Water and Energy, Sydney

Muller, R., Nicholson, A., Wooldridge, A., Jenkins, B., Winkler, M., Cook, W., Grant, S. and Moore C.L. (2015). *Hydrogeological Landscapes for the Eastern Murray Catchment*. Office of Environment and Heritage, Sydney, NSW.

NSW Department of Primary Industries (2012). NSW Government policy for the licensing and assessment of aquifer interference activities

RW Corkery & Co. (2021). Howlong Sand and Gravel Expansion Project, Environmental Impact Statement, prepared for Fraser Earthmoving Construction Pty Ltd

Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011

Williams R.M. (1989). *Groundwater Resources of the Unconsolidated Sediments Associated with the Murray River Between Albany and Corowa, NSW*. Water Resources Commission Technical Services Report 89.001

APPENDIX A
NUMERICAL GROUNDWATER FLOW MODEL REPORT (WATSEC ENVIRONMENTAL, 2022)

WatSec Environmental

Howlong Quarry Expansion

Stage 2 Numerical Groundwater Impact Assessment Model

Final

PREPARED FOR:

Water Technology

February 2022

DOCUMENT RECORD	
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Client:	Water Technology
WSE Project No.:	P2101
Report Title:	Stage 2 Numerical Groundwater Impact Assessment Model
Report Ref.:	*P1201 Howlong Quarry Expansion Stage 2 Groundwater Model_v11_Final_220207*
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Issued To:	Water Technology (Rohan Baird), pdf via email RW Corkery & Co Pty Limited (Nicholas Warren, Paul Ryall), pdf via email
Issue Date:	7 February 2022

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1 Introduction

This report documents the Stage 2 numerical groundwater model constructed and run by WatSec Environmental for Water Technology to predict the potential groundwater impacts arising from the proposed expansion of the existing Howlong Sand and Gravel Quarry (the Project). The Project would comprise an increase to the annual production rate to 300 000 tonnes per annum (tpa) and expansion into additional extraction areas. The existing Howlong Sand and Gravel Quarry (the Quarry) is located on the Murray River floodplain, approximately 2.5km to the south-east of Howlong and approximately 25km west of Albury NSW. The Project would continue extraction of the sand and gravel resource using predominantly free dig techniques across four stages of development, commencing in the existing disturbed areas and progressively expanding to new areas in later stages, expanding production to 300 000tpa. Dredging may also be used in development of extraction stages. There would be no blasting for the development. The four stages of development would be as follows:

- Stage 1 - western existing pit, approximate area of 7 ha.
- Stage 2 - eastern existing pit, approximate area of 6 ha.
- Stage 3 - processing area and future pit, approximate area of 4 ha.
- Stage 4 - future pit, approximate area of 25 ha.

Further information relating to the Project, the approval process and the groundwater impact assessment are provided in Water Technology (2021). The study area and Stage 2 model extent are shown on Figure 1.

The Stage 2 model includes various updates of model architecture and water balance inputs when compared with the Stage 1 groundwater model which was developed to investigate the possible range of groundwater inflows to the proposed pits (WatSec Environmental, 2020).

2 Groundwater Model Objectives

The Stage 2 groundwater flow model has been constructed to suitably represent the local and regional groundwater system and to meet the following key objectives:

- Predict the average annual rates of groundwater pumping required to dewater each of the pits to the final pit depths and estimate the water licensing requirements of the Project.
- Predict the extent and magnitude of drawdown associated with dewatering the pits.
- Predict the effects of pit dewatering on groundwater levels at nearby ecological receptors and nearby groundwater users, the impacts of which are more fully addressed in Water Technology (2021).
- Predict the effects of the pit dewatering operations on average annual discharge of water from the Murray River into the alluvial aquifer.

- Estimate the long-term pit lake recovery levels following cessation of quarrying operations and provide data for estimating the possible long-term salinity within each pit lake.

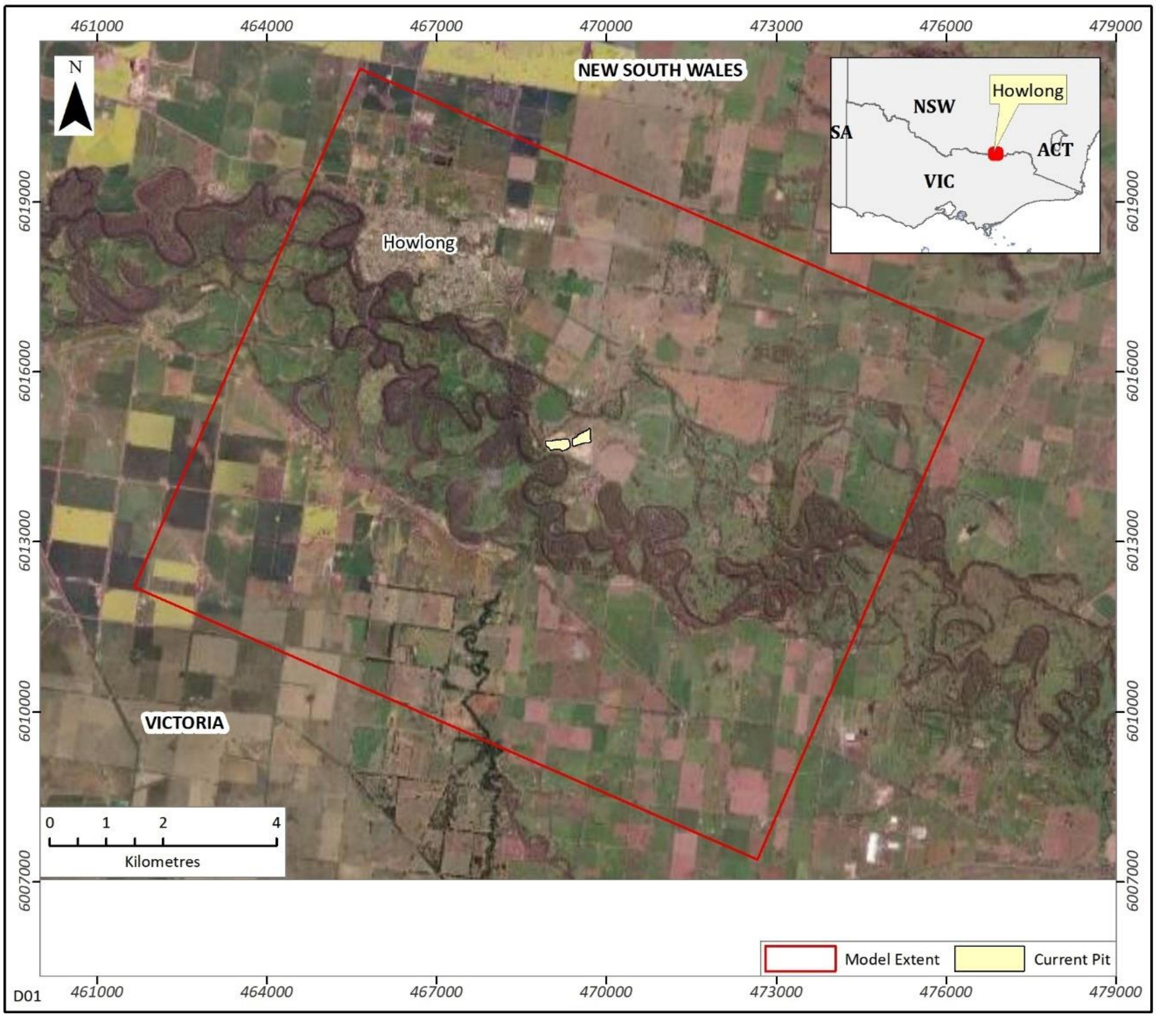


FIGURE 1: STUDY AREA AND STAGE 2 MODEL EXTENT

3 Hydrogeological Conceptualisation

3.1 Overview

This section contains information on the hydrogeology of the study area pertinent to the construction of the Stage 2 groundwater model. Additional contextual information on the regional hydrogeological setting and groundwater management within the area is presented in the Groundwater Impact Assessment (Water Technology, 2021).

The project area is located within the Upper Murray Alluvium Groundwater Source Management Area which comprises unconsolidated Cenozoic valley fill alluvial sediments comprising grey clay and fine sand to cobbles (Department of Industries, 2019). The water bearing sands and gravels are broadly divided into:

- A shallow unconfined / semi confined aquifer within the Shepparton Formation. The shallow aquifers have much lower yields compared to the deeper aquifers and are the main source for stock and domestic supply.
- The deeper semi confined aquifer within the Lachlan formation which contains productive sand and gravel aquifers which can provide bore yields of up to 10 ML/day.

The geological layering in the region of the Project is shown on The Hermitage cross section (Figure 2) developed by Williams (1989). The location of the Hermitage cross section is shown on Figure 9. A description of the key hydrogeological processes and data inputs relevant to the development of the model is provided in Sections 3.2 to 3.9.

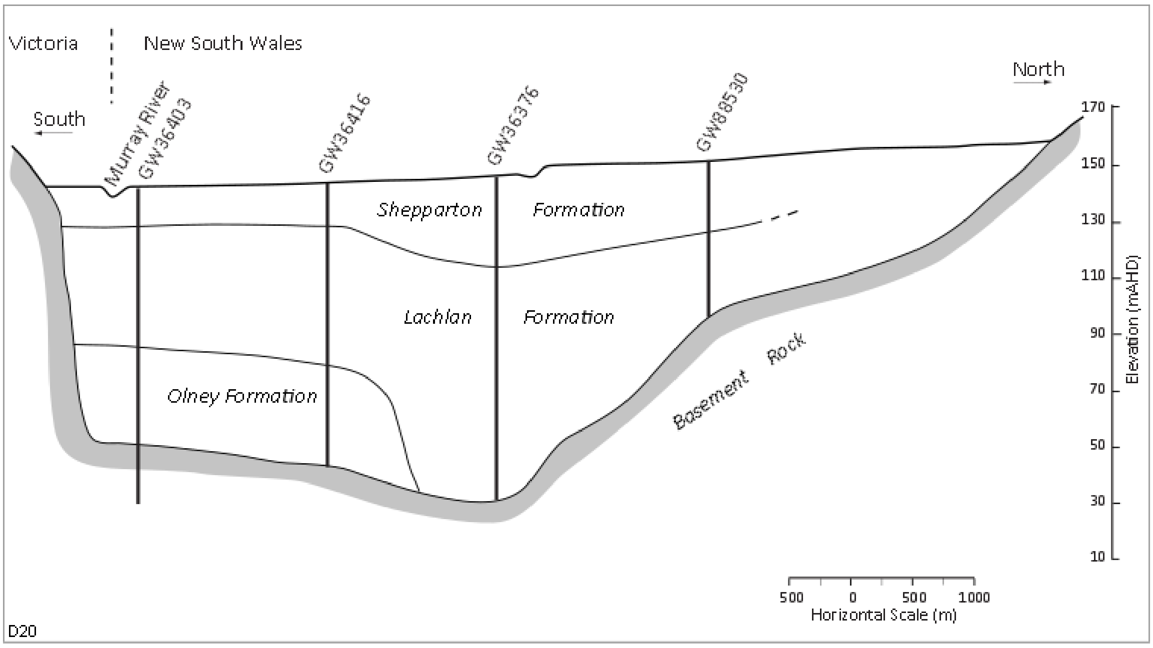


FIGURE 2: THE HERMITAGE CROSS SECTION (AFTER WILLIAMS, 1989)

Groundwater level records from monitoring bores indicate both the Shepparton Formation and Lachlan Formation show responses to river level variations, the magnitude of which varies according to proximity to the river or backwaters and location along the river length. Vertical head differences between the Shepparton Formation and Lachlan Formation are generally small (<0.5m) and are variable both across the study area and over time with variations in river level stage.

3.2 Hydrostratigraphic Units

3.2.1 Shepparton Formation

The Shepparton Formation is described in Williams (1989) and Kulatunga (2009) as a fluviatile meandering stream deposit consisting of clay, silt, sand and gravel. Sands are quartzose, brown to yellow colour while clays located away from the main Murray River alignment are white, yellow, red-brown and grey. Regional groundwater contours and flow directions for the Shepparton Formation are shown on Figure 3 (after Kulatunga, 2009). The general direction of groundwater flow is from southeast to northwest, consistent with the flow direction of the Murray River and its anabranches.

An average fine sand to coarse sand ratio of 84 : 16 was obtained from air core sample testing conducted as a part of resource definition works completed at the Howlong Quarry (AES Resource Assessment, Table 1). Based on the Stage1 pit dewatering trials in April 2018 (discussed further in Section 8), an estimate for hydraulic conductivity of 1 m/d was derived from calibration modelling, and this is within value ranges for a silty sand / clean sand (Freeze and Cherry, 1979). This corresponds to a transmissivity of approximately 20 - 30 m^2/d around the area of the proposed pit expansion area and is towards the lower end of the reported range of 20 to 250 m^2/d (Kulatunga, 2009 and Williams, 1989). A vertical hydraulic conductivity of 0.01 m/d was adopted based on the likely presence of silt and clay-rich layers or lenses within the sediment deposits which can potentially restrict the vertical flow of groundwater. A specific yield of 11% was derived from the calibration modelling, and this is consistent with ranges documented for sands (e.g. Johnson, 1992). The aquifer is reported to be unconfined to semi confined (Department of Industries, 2019).

No site aquifer testing data are available to provide more accurate estimates of hydraulic parameters for the Shepparton Formation.

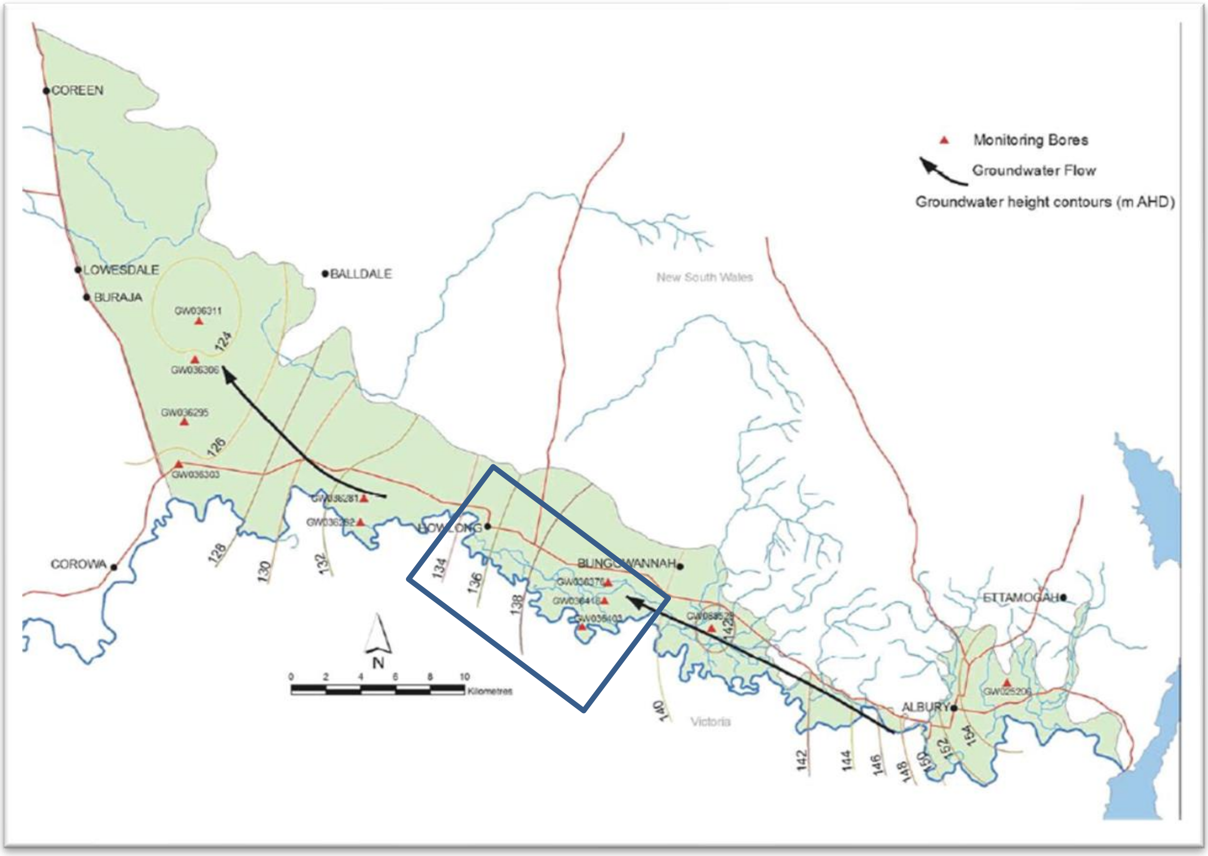


FIGURE 3: SHEPPPARTON FORMATION GROUNDWATER LEVELS AND FLOW DIRECTIONS (KULATUNGA, 2009)

(Approximate model extent shown as blue rectangle)

3.2.2 Lachlan Formation

The Lachlan Formation is described in Williams (1989) and Kulatunga (2009) as typically grey coloured clay, sands and gravel, poorly sorted and with upward fining trends. Sands and gravels are predominantly sub-angular to rounded quartz. The upper surface of the Lachlan Formation is probably a disconformity (Department of Industries, 2019). Regional groundwater contours and flow directions for the Lachlan Formation are shown on Figure 4. The general direction of groundwater flow is from southeast to northwest similar to the overlying Shepparton Formation.

A transmissivity of 2,356 m^2/d was derived from calibration modelling (discussed further in Section 8) and this is slightly above the upper end of the reported range of 1,000 to 2,000 m^2/d (Kulatunga, 2009 and Williams, 1989). The aquifer is reported to be semi confined (Department of Industries, 2019). An estimate for specific storage of 10^{-4}/m was adopted.

No site aquifer testing data are available to provide more accurate estimates of hydraulic parameters for the Lachlan Formation.

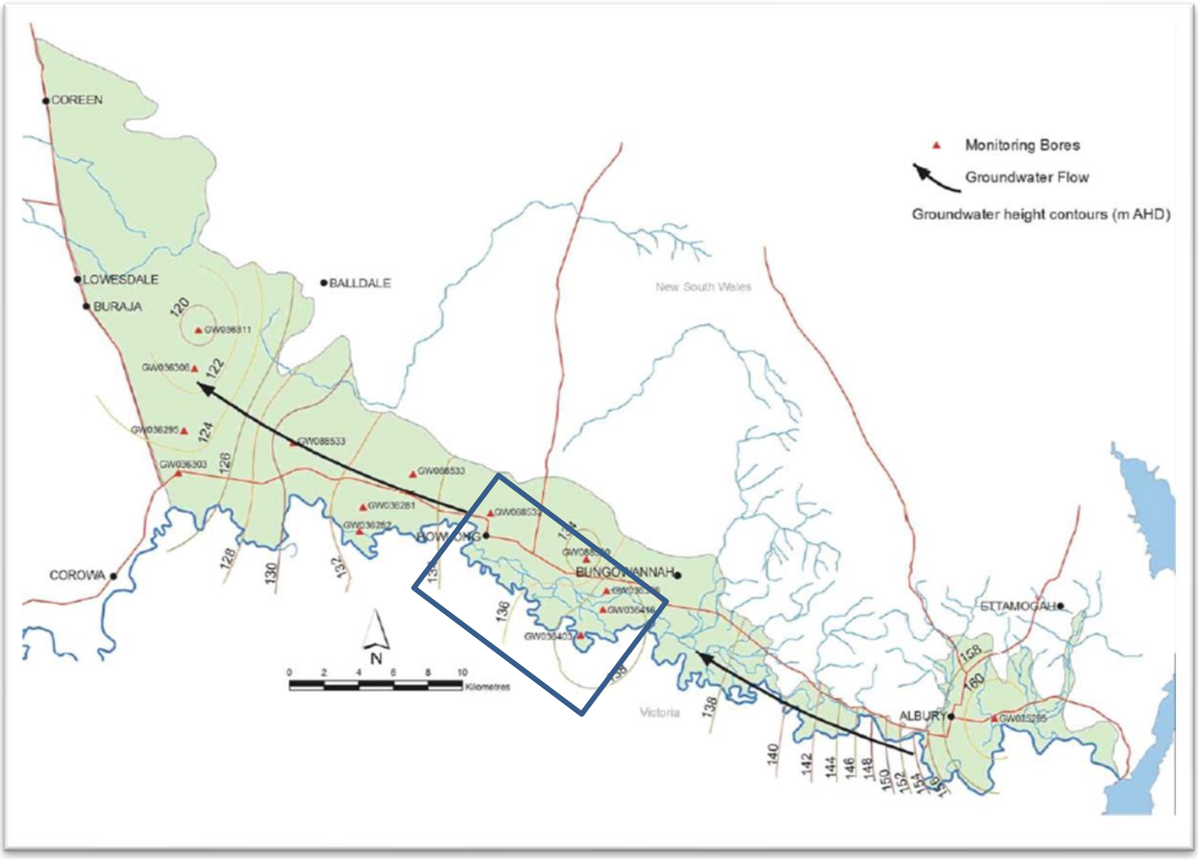


FIGURE 4: LACHLAN FORMATION GROUNDWATER LEVELS AND FLOW DIRECTIONS (KULATUNGA, 2009)

(Approximate model extent shown as blue rectangle)

3.2.3 Olney Formation

The Olney Formation shown below the Upper Murray Alluvium aquifer sediments on Figure 2 is reported to have a limited extent in the region and is mainly clayey (Kulatunga, 2009). Based on these characteristics it is likely that the Olney Formation is an aquitard of variable lateral and vertical extents, and as it underlies the Lachlan Formation it is considered unlikely that it would significantly influence the modelling results. The Olney Formation has therefore not been included in the model layering (similar to the Basement Rocks discussed below).

3.2.4 Basement Rocks

Basement rocks are described as undifferentiated pre-Cainozoic rocks on the *Wangaratta* hydrogeological map sheet (Hennessy et al, 1994) and are shown to outcrop in the south-west and south-east areas of the Stage 2 model domain (refer to hydrogeological map extract in Appendix A).

No basement outcrops are shown to the north of the river within the Stage 2 model domain on the *Jerilderie* hydrogeological map sheet (DWR, 1992).

The basement outcrops are classified on the Geoscience Australia interactive map web site as Ordovician to Silurian schist and phyllite of the Omeo Metamorphic Complex. These rock types are inferred to have very low hydraulic conductivity and storage properties and have been assigned as inactive within the model domain in both layers 1 and 2. An extract of the Geoscience Australia map is included in Appendix A.

3.3 SILO Climate Data

The SILO long-term average rainfall and evaporation data for Howlong are provided below in Table 1. These were adopted for the predictive stages of the modelling, with monthly recorded data used for the model calibration period (October 2012 to April 2018).

TABLE 1: AVERAGE MONTHLY RAINFALL AND EVAPORATION SILO DATA, 1971 TO 2018

Month	Rainfall (mm)	Evaporation (mm)
Jan	41	256
Feb	39	205
Mar	36	167
Apr	39	93
May	49	52
Jun	52	34
Jul	63	36
Aug	60	54
Sep	54	82
Oct	52	131
Nov	50	179
Dec	41	236
Total	**576**	**1,524**

3.4 Groundwater Recharge

Recharge in the area is reported in Kulatunga 2009 (based on Ross, 1999) as approximately 3% of rainfall, and this estimate was adopted for the Stage 2 numerical modelling.

3.5 Evapotranspiration

Evapotranspiration (ET) parameters were defined for input to the Stage 2 model as follows:

- An ET surface defined by the 1 sec DEM (Wilson et al, 2012).
- Maximum ET rates derived from the monthly SILO data for the model calibration stage, and annual averages for the model predictive stages.
- An assumed extinction depth of 3 m with the evapotranspiration flux linearly interpolated between the maximum evaporation rate at ground surface to zero at a depth of 3 m. This extinction depth is consistent with sandy clay or loam soils with a grass cover (Shah et. al., 2007).

3.6 Irrigation Extraction and Drainage Returns

The locations of irrigation extraction wells and estimated volumes are based on data provided in the Groundwater Resource Description for the Murray Alluvium Water Resource Plan (Department of Industries, 2019). The data, which is provided in Appendix B, represents the average usage distribution for licensed wells in this area. This data was used rather than allocation data from the NSW water register as it is considered to provide a more realistic estimate of actual usage. Extraction was assumed to be from the Lachlan Formation and was applied during the irrigation periods for the model calibration stage and as annual averages for the prediction and recovery stages. Licensed irrigation extraction was applied to the bores numbered 1 to 6 and shown on Figure 5 at the rates shown in Table 2 which are equivalent to the average of the range reported by Department of Industries (2019). It is acknowledged that the extraction locations and rates represent conditions at a point in time. This simplification is considered adequate in the absence of any other readily available licensed extraction data.

The assumed extraction from the stage 2 pit, referred to as location 7 in Table 2, was not explicitly modelled as extraction from the Shepparton Formation due to a lack of data on actual extraction rates and timing, and corresponding levels in the pit. This level of complexity between pit levels and pumped volumes was not attempted to be replicated in the stage 2 model.

Irrigation extraction data from the Victorian side of the river was not obtained as a part of this assessment.

Irrigation drainage return flows were applied during the irrigation season for the calibration model stage at the pivot locations adjacent the site shown on Figure 5. The drainage rates were applied during the irrigation season during the model calibration stage and was assumed to be 300 mm/a (this is equivalent to an average irrigation use as provided by RW Corkery and Co of 7.2 ML/d over the combined pivot area of 85 ha and at a 90% irrigation efficiency rate). The annual drainage rate of 300 mm/a was applied for the predictive model stages, except for the pivot area over the stage 4 pit area, which was excluded from the stage 4 dewatering period and post-expansion recovery period.

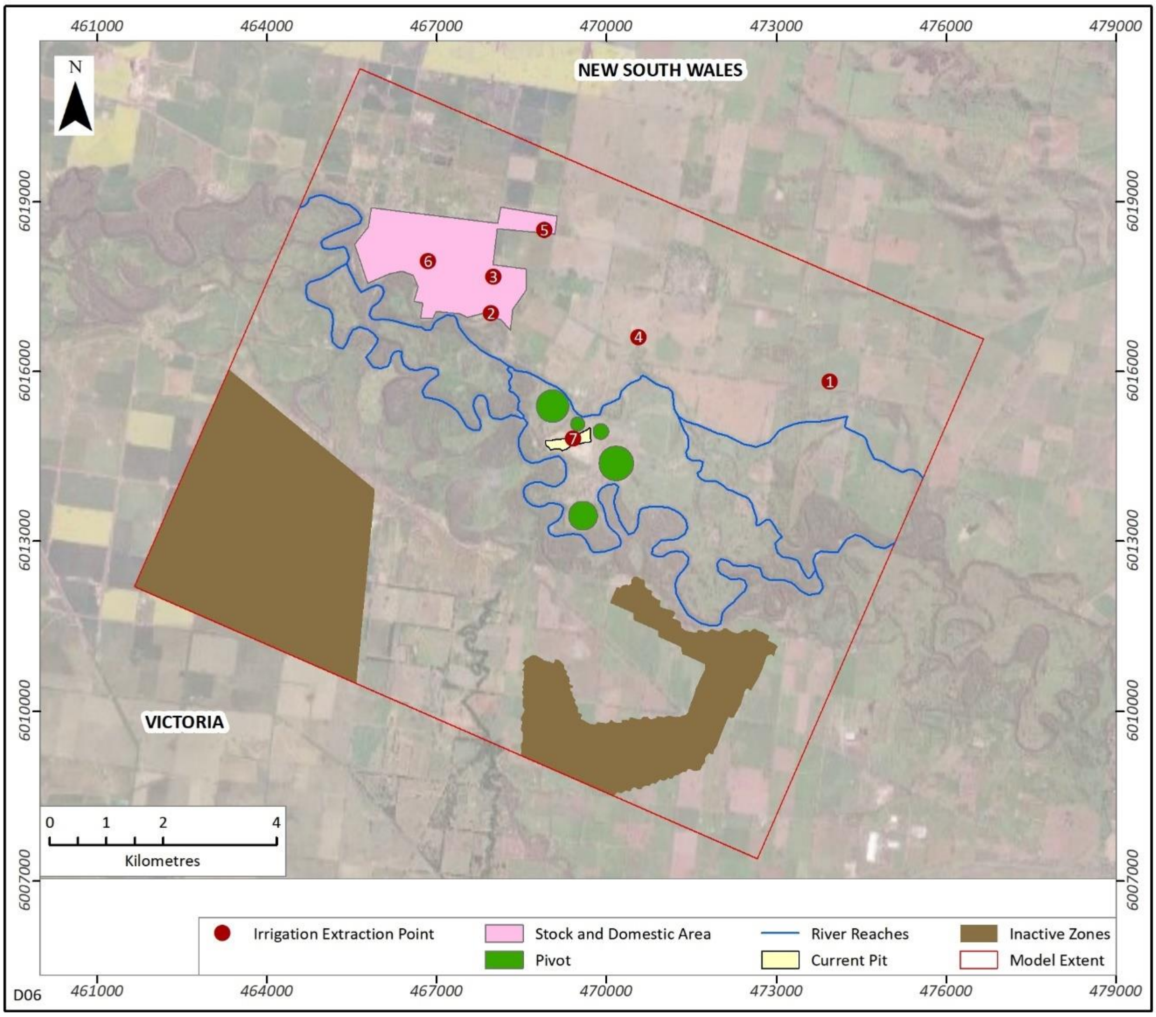


FIGURE 5: IRRIGATION EXTRACTION, CENTRE PIVOT RECHARGE AND STOCK AND DOMESTIC USE

TABLE 2: IRRIGATION EXTRACTION BORE RATES

Location	Easting	Northing	Usage Range (ML/a)	Possible Average Rate (ML/a)	Comment
1	473952	6015814	0-250	125	
2	467964	6017026	0-250	125	
3	468012	6017673	0-250	125	
4	470570	6016604	250-500	375	
5	468910	6018496	0-250	125	
6	466854	6017942	0-250	125	
7	469412	6014807	500-1000	750	Stage 2 pit

3.7 Stock and Domestic Use

It is estimated that many of the 400 or so bores in the NSW portion of the model domain are used for stock and domestic purposes and these are principally within or proximal to the Howlong township. It was considered that cross checking the NSW water register for individual licensing information on this large amount of bores was not warranted as many of the bores are likely used under basic landholder rights and will not have water access licenses attached to them.

As a simplification for modelling purposes the stock and domestic groundwater use from the town of Howlong and surrounds was estimated and extracted over the area shown in Figure 5. Extraction was assumed to be from the Shepparton Formation as aquifers in this formation provide water to the majority of stock and domestic bores in the management area (Kulatunga, 2009). Total stock and domestic extraction was assumed to be 400 bores x 250 kL per annum per bore which was applied as an annual negative recharge in the model. This approach was considered a suitable approximation for incorporating the effects of stock and domestic use into the model.

3.8 River-Aquifer Interactions

A regional mapping assessment of surface-groundwater connectivity for the Murray River and other major river catchments within the Murray-Darling Basin is reported in Parsons et al (2008). The connectivity mapping involved determining the direction and magnitude of groundwater flux to or from major rivers for most catchments within the project area, for a given point in time. This work found that the project area is located within an area where the interaction transitions from the Murray River being a gaining stream with low interaction to a reach where the interactions are seasonally varying, that is the Murray River can be either a losing or gaining stream depending on the regulated seasonal river level. Although very broad scale in nature and relating to a specific time, this basin wide assessment provides an indication of river-aquifer connectivity near the project area from which further detailed conceptualisations can be developed.

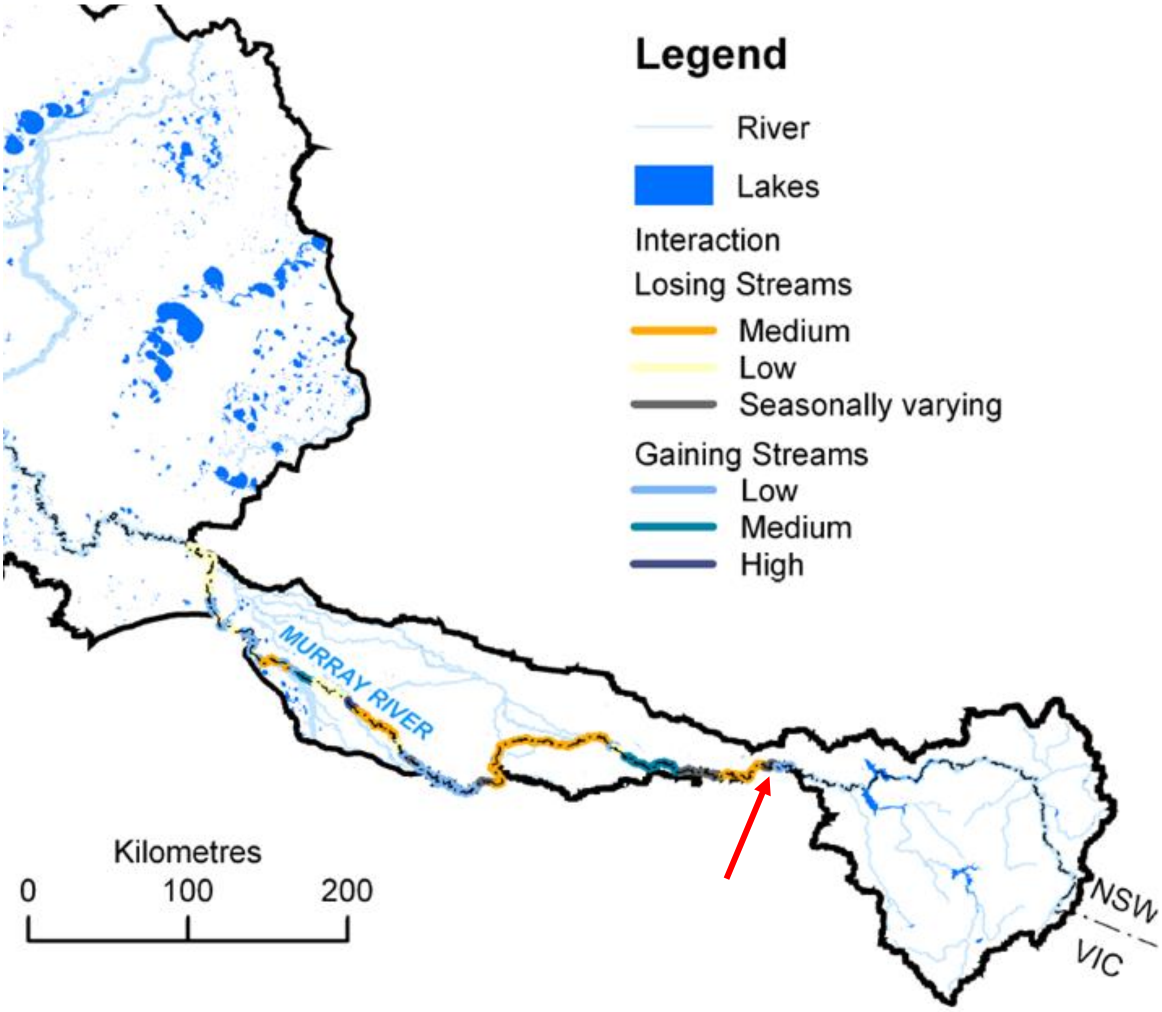


FIGURE 6: REGIONAL SURFACE-GROUNDWATER CONNECTIVITY MAP

(Approximate project area location indicated by red arrow).

An inspection of groundwater level data from monitoring bore records in the study area (Figure 9) and comparison with interpolated river levels (refer Section 7.5) adjacent these sites indicate the following:

- Upstream of the site the Murray River tends to be a gaining stream with records for monitoring bore GW36403 located near to the river indicating that groundwater levels are close to or slightly above river level during high river level periods and are significantly above river level during low river level periods. These interactions are unclear from monitoring bore records during flood events, but it is likely that the river recharges the aquifer during floods.

- Records for monitoring bore GW36416 indicate that at greater distances from the river the aquifer responses to river level changes are damped, and the interactions are seasonally variable with the river losing during high flow periods and gaining during low flow periods.
- Downstream of the site adjacent Howlong monitoring bore records indicate that the river-aquifer interactions are seasonally variable with the river losing during high flow periods and gaining during low flow periods.
- These observations are broadly consistent with the regional mapping assessment of Parsons et al (2008).

These interactions are discussed further for individual monitoring bores in Section 8.2.

3.9 Groundwater Dependent Ecosystems

The Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources (2011) states that at the time of publication, no high priority Groundwater Dependent Ecosystems (GDEs) have been identified in the area covered by the plan.

In the absence of any defined high priority groundwater dependent ecosystems, data from the Australian GDE Atlas (Bureau of Meteorology, 2019) has been assessed to identify potential GDE locations near the study site. The GDE atlas is based on broad scale analysis, existing data sets and remote sensing. GDEs are categorised as:

- Aquatic ecosystems that rely on the surface expression of groundwater; this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
- Terrestrial ecosystems that rely on the subsurface presence of groundwater; this includes all vegetation ecosystems.
- Subterranean ecosystems; this includes cave and aquifer ecosystems.

The locations of potential aquatic and terrestrial GDEs from the GDE Atlas are shown on Figure 7 and Figure 8. There are no subterranean ecosystems identified within the study extent.

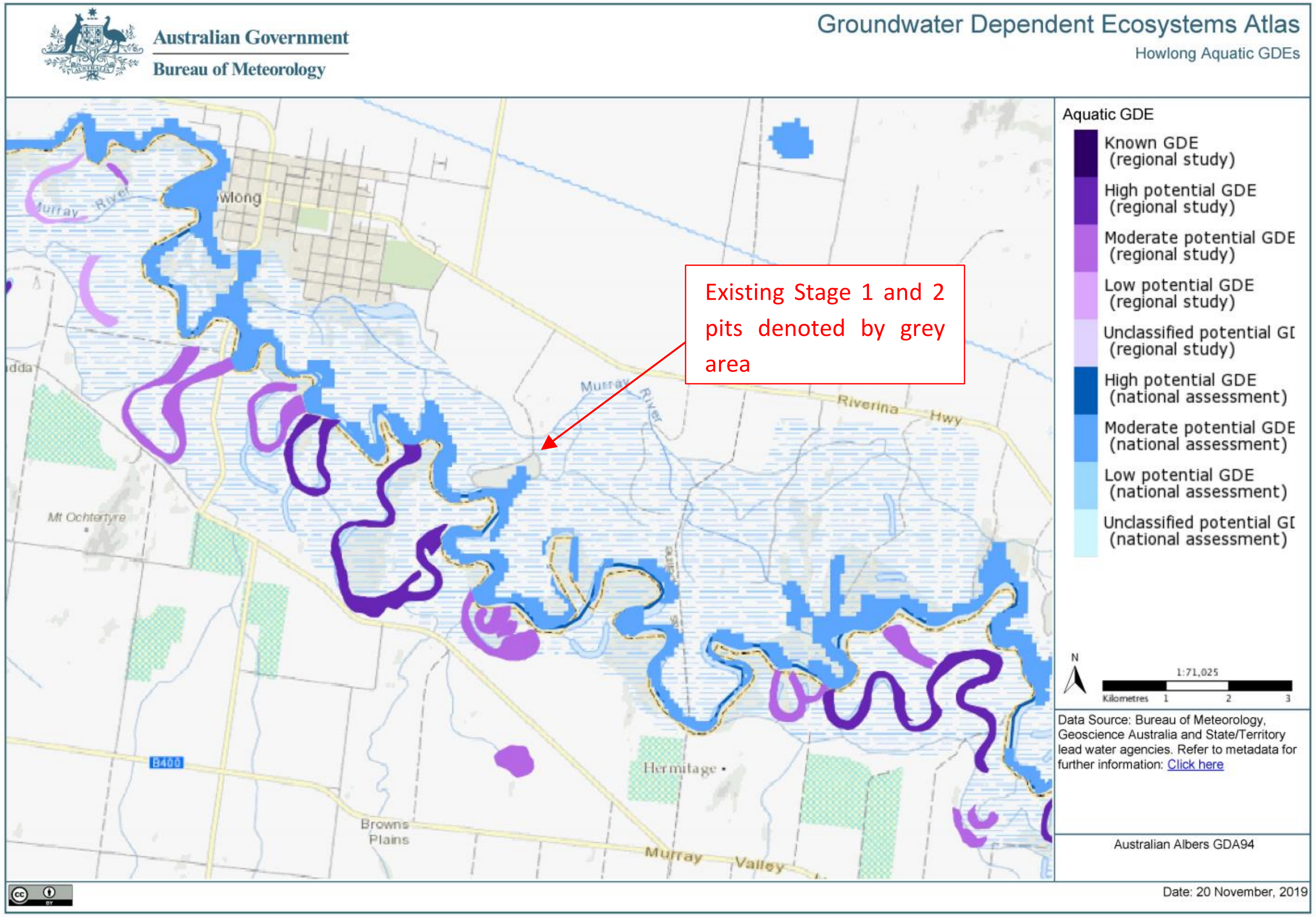


FIGURE 7: HOWLONG AQUATIC GDES

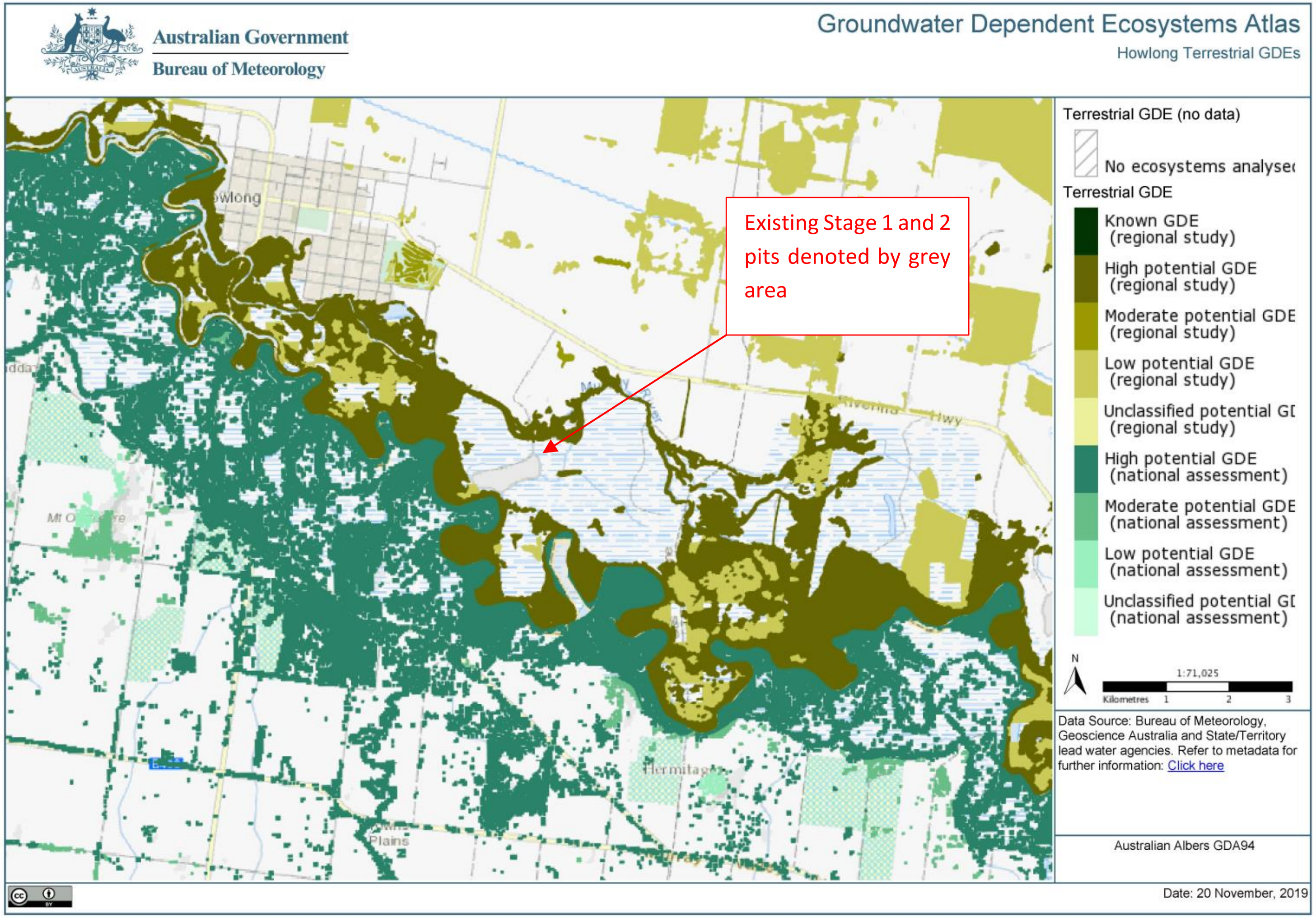


FIGURE 8: HOWLONG TERRESTRIAL GDES

4 Monitoring Bores and Groundwater Level Trends

The NSW and Victorian groundwater databases and the Australian Groundwater Explorer were searched to retrieve groundwater monitoring data for use in comparing modelled bore hydrographs to measured data for model calibration. Database search records are included in Appendix C.

Data from Water NSW and the Australian Groundwater Explorer provided information on monitoring bores within the model domain on the NSW side of the river within the model extent. The locations of these are shown on Figure 9 with available screen and aquifer monitored data provided in Table 3. The Visualising Victoria's Groundwater database indicates there are no previously or actively monitored groundwater bores within the model domain in Victoria.

A comparison of groundwater level hydrographs with river levels and the cumulative deviation from mean rainfall can be found in Water Technology (2021). Key findings from this assessment indicate that monitoring bores in both the Shepparton Formation and Lachlan Formation show responses to river level variations, the magnitude of which varies according to proximity to the river or backwaters. This indicates that the River Murray is in good hydraulic connection with the alluvial aquifer, and the adjacent groundwater levels are influenced by variations in river levels (Water Technology, 2021). A positive correlation between groundwater levels and the cumulative deviation from mean rainfall was also evident suggesting that groundwater levels are influenced by climatic conditions.

Vertical head differences between the Shepparton Formation and Lachlan Formation are generally small (<0.5m) and are variable both across the study and over time with variations in river level stage.

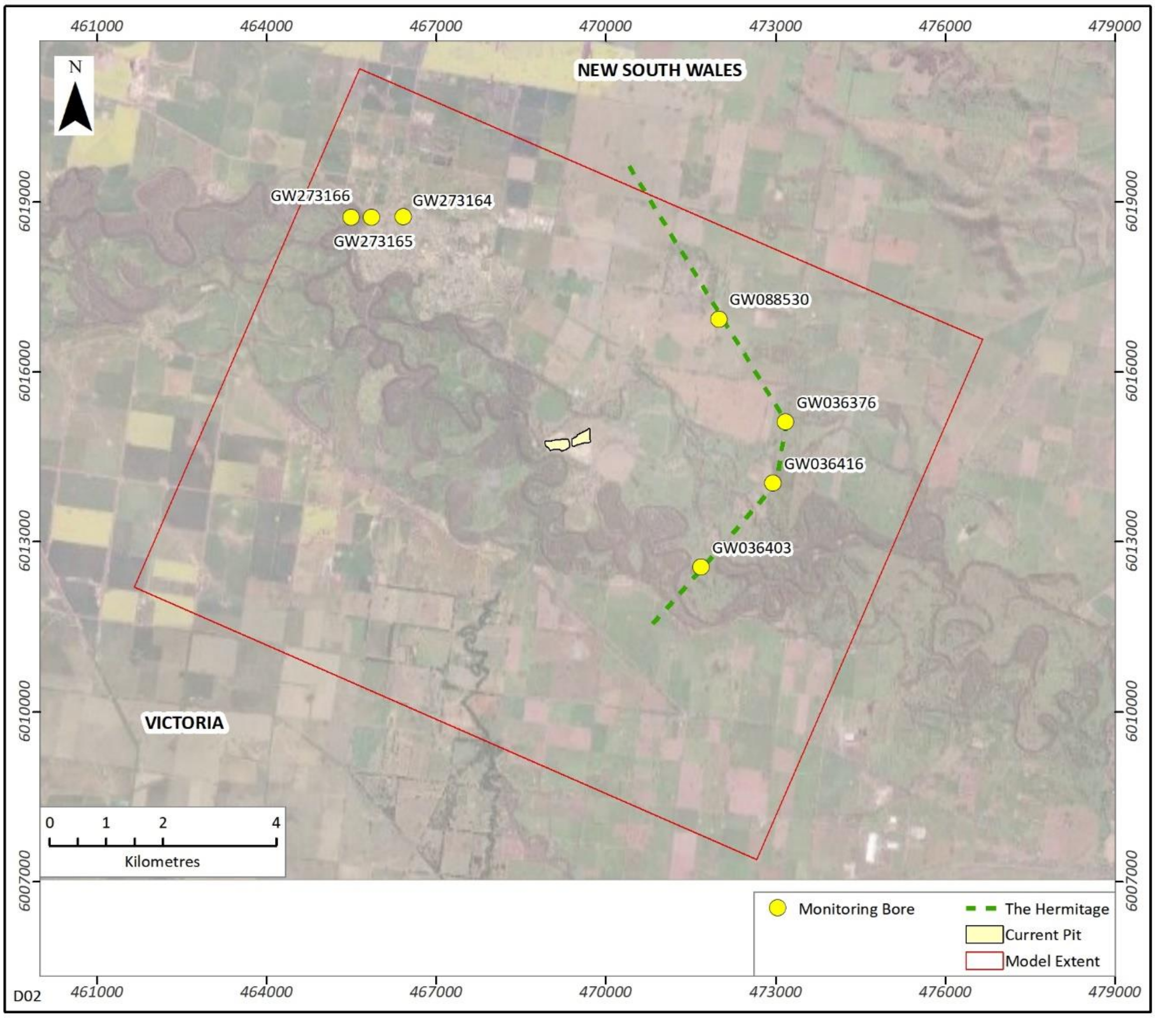


FIGURE 9: MONITORING BORE LOCATIONS AND THE HERMITAGE CROSS SECTION

TABLE 3: SUMMARY OF NSW MONITORING BORES

Bore	Slotted from (m)	Slotted to (m)	Aquifer unit [1]
GW36403-1	9	14	Shepparton Formation
GW36403-2	36	42	Lachlan Formation
GW36403-3	49	54	Lachlan Formation
GW36416-1	17	20	Shepparton Formation
GW36416-2	38	42	Lachlan Formation
GW36416-3	55.5	58.5	Lachlan Formation
GW36376-1	26	34	Lachlan Formation
GW36376-2	46	52	Lachlan Formation
GW36376-3	98	106	Lachlan Formation
GW88530-2	51	54	Lachlan Formation
GW273164-1	25	27	Shepparton Formation
GW273165-2	27	29	Lachlan Formation
GW273166-1	23	25	Lachlan Formation

(1) For the multi-bore completions along The Hermitage section drilling data indicates the monitoring pipes are completed within a single borehole. It is not clear if screened intervals were isolated by grout or bentonite. Bore hydrographs indicate all pipes are responding in similar ways.

5 Model Confidence Level Classification

The data described in the previous sections were collected and analysed to inform the hydrogeological conceptualisation and model development. The key data sets are summarised below in Table 4 and are given a confidence level classification using the descriptions provided in Table 2-1 of the Australian Groundwater Modelling Guidelines (Barnett et al, 2012) as a guide. An indication of the relative importance of the data set to model development and calibration is also provided in Table 4. Based on these data set characteristics it is considered that the overall model confidence level classification is Class 1 / Class 2. An important data gap is aquifer test data at or adjacent the site.

This class of model is consistent with the project model objectives of estimating:

- The average annual rates of groundwater pumping required to dewater each of the pits to the design pit depths.
- The extent and magnitude of drawdown associated with dewatering the pits.
- The effects of pit dewatering on groundwater levels at nearby ecological receptors and nearby groundwater users.
- The effects of the pit dewatering operations on average annual discharge of water from the Murray River into the alluvial aquifer.

- The long-term pit lake recovery levels following cessation of quarrying operations and provision of pit level / groundwater inflow data to inform the likely salinity effects within each pit lake.

TABLE 4: MODEL CONFIDENCE LEVEL CLASSIFICATION

Data	Summary Description	Confidence level classification	Relative importance
Hydrostratigraphic layering	Top of layer 1 based on 1 sec DEM, top of layer 2 based on interpolation of available borehole logs with reasonable spacing and density across the model domain, regional geological maps and cross sections used to assist in defining active extents. Base of layer 2 undefined due to lack of drillholes which have intersected basement.	2	High
River stage and flow	Flow and stage data available from the Howlong gauging station at the downstream end of the model domain, river stage interpolated across the model domain based on river distance and river flood curves	2	High
Irrigation extraction	Irrigation extraction bore locations and licensed use, but not metered actual use, available	1/2	Medium
Aquifer test data	Not available within the model domain	1	High
Time-series groundwater level monitoring	Geographically sparse data available across the model domain and none within 3 km of the site, suitable frequency and length of data	2	High
Climate including rainfall and evaporation	Detailed climate data available	3	High
Recharge	Regional estimates as % of rainfall	1	High

River-aquifer interactions	Some indications provided by good records of river flow / stage and groundwater monitoring data	2	High
Stock and domestic use	Gross usage inferred from bore numbers and assumed annual use	1	Low
Digital elevation model	1 sec DEM available	3	High
Site pit dewatering measurements	Broad monitoring of pumping rates required to maintain Stage 1 pit dewatered condition for a period of 2 months, no data on pit levels during pumping events	2	High

6 Model Code

The United States Geological Survey (USGS) industry standard groundwater modelling code MODFLOW-2000 model code was selected with the model constructed in the PMWIN platform (Chiang and Kinzelbach, 1998). The parameter estimation program PEST (Doherty,2000) was used for the model calibration stages to estimate key specified hydraulic parameters based on optimising the match between observed and modelled groundwater head data. The hydraulic parameters derived by the PEST calibration modelling were used in subsequent predictive modelling with MODFLOW-2000.

7 Model Design and Construction

7.1 Model Extent and Grid

The model domain extends for a length parallel to the Murray River floodplain of 12 km and a width of 10 km (Figure 10). The model domain was elongated in a north west to south east direction, approximately parallel to the interpreted regional groundwater flow directions as presented in the Groundwater Resources Status Report for the Upper Murray Alluvium (Kulatunga, 2009), and shown on Figure 3 and Figure 4. The area of the model domain was chosen to centre on the Quarry, to incorporate a significant extent of the river and floodplain and to provide sufficient distance from model boundaries to minimise potential boundary effects on model results.

Model grid cell sizes range from 100 m square to 50 m square in the vicinity of the Quarry located in the middle of the model domain. The model domain encompasses the floodplain of the Murray

River in NSW. In Victoria, the model domain encompasses areas of the Murray River floodplain, tributary streams and areas of basement rock as described in Section 3.2.4.

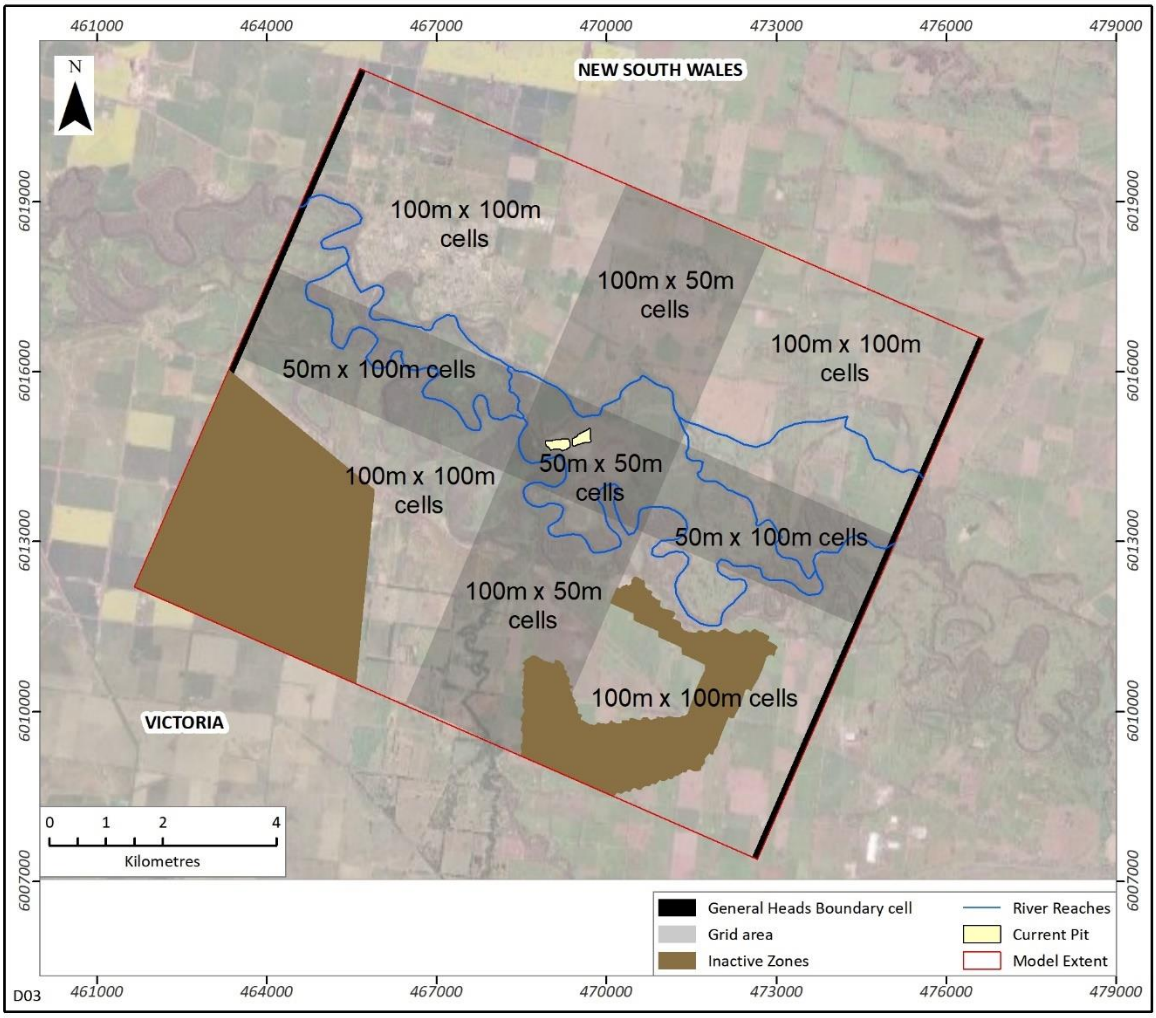


FIGURE 10: MODEL EXTENT AND GRID

7.2 Model Layers

7.2.1 Layer 1 (Shepparton Formation)

The Shepparton Formation extends across the whole model domain except where basement zones have been defined as inactive cells. The interpolated top of Layer 1 shown on Figure 11 was derived from the 1 sec DEM reported in Wilson et al (2011). The base of Layer 1 was generated using the field interpolator program within PMWIN using borehole data points with hydrostratigraphic information retrieved from the Bureau of Meteorology Groundwater Explorer database as shown on Figure 12.

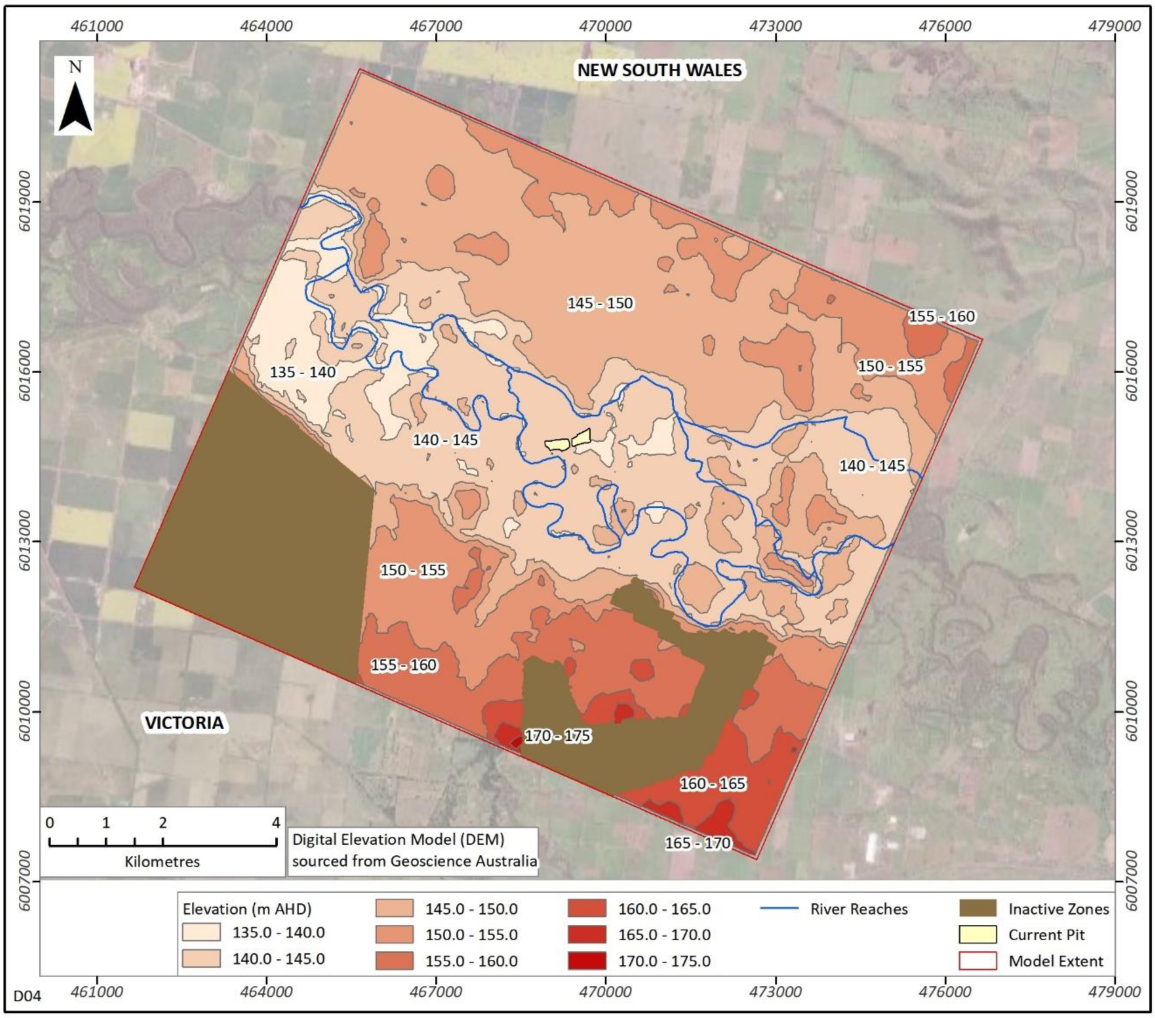


FIGURE 11: INTERPOLATED TOP OF LAYER 1 ELEVATION

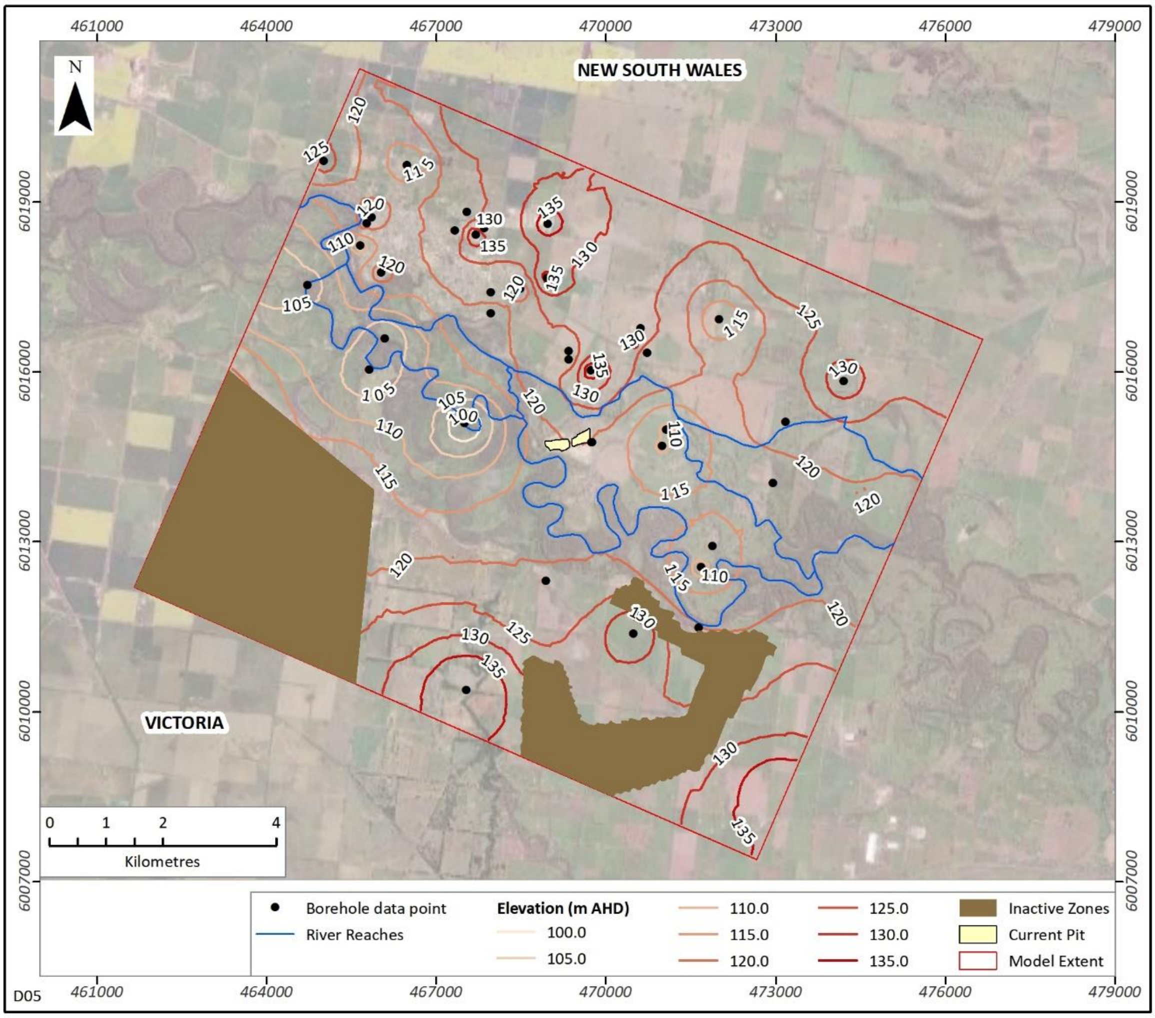


FIGURE 12: INTERPOLATED BOTTOM OF LAYER 1 ELEVATION

7.2.2 Layer 2 (Lachlan Formation)

The Lachlan Formation unit, model layer 2, extends across the whole model domain except where basement zones have been defined as inactive cells. The interpolated top of Layer 2 is shown on Figure 12 (bottom of Layer 1 elevation). The bottom elevation of the Lachlan Formation was not required to be defined as the unit was set to layer type confined for modelling purposes.

7.3 Inactive Basement Areas

As described in Section 3.2.4 areas of outcropping or very shallow basement were identified based on interpretation of regional geological maps and available borehole data and set as inactive zones within the model domain in layers 1 and 2.

7.4 Model Boundary Conditions

General Head Boundary (GHB) cells were assigned to the upstream (south eastern) and downstream (north western) edges of the model domain to establish and maintain the groundwater flow field across the model domain (Figure 10). GHB head values and distances were obtained from the regional groundwater contour maps and conductance values were estimated by the calibration period modelling (refer section 8). Parameters associated with the GHB's are summarised in Table 5 below.

TABLE 5: MODEL GHB PARAMETERS

	Layer 1		**Layer 2**	
GHB parameter	Upstream	Downstream	Upstream	Downstream
GHB head (m AHD)	141	133	140	133
GHB length (km)	3	3.5	10	3
Conductance (m^3/d)	19	0.12	10,000	78

No boundary conditions were assigned to the north-eastern and south-western edges of the model domain as these are approximately parallel to the interpreted groundwater flow directions.

7.5 Model River Cells

River cells were used in the groundwater model to simulate the main Murray River channel, the Black Swan Anabranch and other significant backwater reaches as shown on Figure 10. River cell stage heights were interpolated from synthesised upstream and downstream river hydrographs for the calibration period October 2012 to April 2018. These river hydrographs were based on:

- The Murray River level gauge at Howlong (Figure 13) obtained from the WaterNSW monitoring data website (gauge number 409037) which was used to synthesise the downstream river hydrograph. The site is located at Howlong adjacent the monitoring bore location GW273166 shown on Figure 9.
- Interpolation of the Murray River flood profile curves which indicated that the river hydrograph at the upstream edge of the model can be synthesised by adding 3.5 m to the downstream hydrograph at Howlong. Details of this interpolation are included in Appendix D.

Additional river cell parameters were set as follows:

- Elevation of the river bed was varied according to location and determined by assuming a constant river depth of 3 m.
- Width of river – 50 m to 100 m depending on location in the main river channel or backwater and as determined from inspection of Google Earth images.
- A thickness of river bed sediment of 1 m and hydraulic conductivity of 1 m/d.

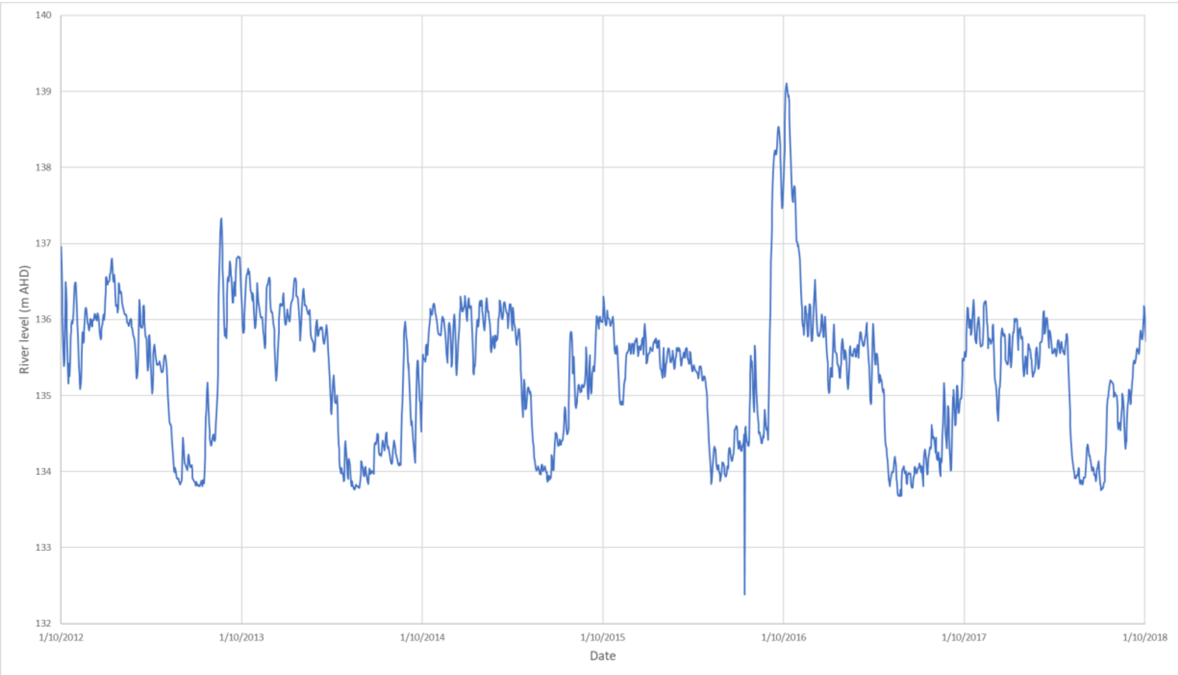


FIGURE 13: MURRAY RIVER STAGE HYDROGRAPH (HOWLONG GAUGE)

7.6 Model Time Discretisation

The model calibration period extends from October 2012 to April 2018 and was adopted as it is a significant time length which includes seasonal river level fluctuations as well as a significant flood event in 2016 and includes the dewatering period for the existing stage 1 pit in April 2018.

The initial heads for the transient calibration period were obtained with an initial steady state stress period. The model time discretisation is shown below in Table 6 and was based primarily on river stage variations with other seasonal inputs such as recharge, evaporation, irrigation extraction and irrigation drainage recharge modified according to each stress period length.

TABLE 6: MODEL TIME DISCRETISATION – CALIBRATION PERIOD

Model Stress Period	Date Range	Length (days)	Time Steps [(1)]	Steady state or Transient	Comment
1	-	1.15×10^{-5}-	1	Steady state	Provides initial starting heads for transient modelling
2	Oct ‘12 – Apr ‘13	212	7	Transient	Monitoring bore data used for calibration
3	May ’13 – Aug ‘13	123	4		
4	Sep ’13 – Mar ‘14	212	7		
5	Apr ’14 – Aug ‘14	153	5		Additional transient calibration periods for comparison to monitoring bore hydrographs
6	Sep ’14 – Mar ‘15	212	7		
7	Apr ’15 – Jun ‘15	91	3		
8	Jul ’15 – Apr ‘16	305	10		
9	May ’16 – Aug ‘16	123	4		
10	Sep ’16 – Oct ‘16	61	2		
11	Nov ’16 – Apr ‘17	181	6		
12	May ’17 – Sep ‘17	153	5		
13	Oct ’17 – Feb ‘18	151	5		
14	March ‘18	11	3		
15	March ‘18	10	3		
16	March ‘18	10	3		
17	April ‘18	30	3		Pit 1 dewatering trial

[(1)] All time step multipliers = 1

7.7 Existing Pits

The approximate extents of the current Stage 1 and Stage 2 pit areas are shown on Figure 5. There are no recorded data on pit water level fluctuations over the modelled period, but these are estimated at El 138 m AHD based on inspection of Google Earth imagery (January 2013 and 2014, October 2015 and 2016 and January 2017). During the calibration period, the existing Stage 1 and Stage 2 pits were represented by drain cells at this assumed long term average elevation of 138 m AHD. Drain hydraulic conductance was set at 1,000 m^2/d (determined by model test runs to be the value which results in modelled groundwater levels matching the drain level, that is the model pits are effectively free draining).

7.8 Recharge and Evaporation

An initial steady state period was used to generate starting heads using rainfall, and hence recharge, and evaporation from the October 2012 SILO climate data. Model recharge and evaporation were applied to the various stress periods according to the monthly records for the calibration period and adjusted for the length and timing of the stress periods. The resulting recharge and evaporation schedules are provided in Table 7.

TABLE 7: MODEL TIME PERIODS, RECHARGE AND EVAPORATION SCHEDULES

Model Stress Period	Months [1]	Model Time Steps	Model Days	Model Ev (m/d)	Model Recharge (m/d)
1	-	1	- (steady state)	$6x10^{-3}$	$2x10^{-5}$
2	Oct ‘12 – Apr ‘13	7	212	$6x10^{-3}$	$2x10^{-5}$
3	May ’13 – Aug ‘13	4	123	$1x10^{-3}$	$6x10^{-5}$
4	Sep ’13 – Mar ‘14	7	212	$6x10^{-3}$	$3x10^{-5}$
5	Apr ’14 – Aug ‘14	5	153	$2x10^{-3}$	$6x10^{-5}$
6	Sep ’14 – Mar ‘15	7	212	$6x10^{-3}$	$5x10^{-5}$
7	Apr ’15 – Jun ‘15	3	91	$2x10^{-3}$	$7x10^{-5}$
8	Jul ’15 – Apr ‘16	10	305	$5x10^{-3}$	$4x10^{-5}$
9	May ’16 – Aug ‘16	4	123	$2x10^{-3}$	$9x10^{-5}$
10	Sep ’16 – Oct ‘16	2	61	$3x10^{-3}$	$9x10^{-5}$
11	Nov ’16 – Apr ‘17	6	181	$6x10^{-3}$	$4x10^{-5}$
12	May ’17 – Sep ‘17	5	153	$2x10^{-3}$	$4x10^{-5}$
13	Oct ’17 – Feb ‘18	5	151	$6x10^{-3}$	$5x10^{-5}$
14	March ‘18	1	11	$5x10^{-3}$	$1x10^{-5}$
15	March ‘18	1	10	$6x10^{-3}$	$1x10^{-5}$
16	March ‘18	1	10	$6x10^{-3}$	$1x10^{-5}$
17	April ‘18	1	30	$4x10^{-3}$	$2x10^{-6}$

[1] The model stress period schedule was designed to match the river hydrograph (Figure 13), with modelled recharge and evaporation rates adjusted to reflect these time periods.

7.9 Monitoring Bores

Several of the monitoring bores in the model domain were not used for calibration due to uncertainty in interpreting their responses to river level fluctuations. The bores identified as reasonable to use for calibration are indicated in Table 8 below.

TABLE 8: MONITORING BORES USED FOR CALIBRATION

Monitoring Bore	Aquifer	Comment	Used for Calibration (Y/N)
GW36403-1	Shepparton Formation	OK	Y
GW36403-2	Lachlan Formation	OK	Y
GW36403-3	Lachlan Formation	Used above	N
GW36416-1	Shepparton Formation	OK	Y
GW36416-2	Lachlan Formation	OK	Y
GW36416-3	Lachlan Formation	Used above	N
GW36376-1	Lachlan Formation	Response opposite to river	N
GW36376-2	Lachlan Formation	Response opposite to river	N
GW36376-3	Lachlan Formation	Used above	N
GW88530-2	Lachlan Formation	Response opposite to river	N
GW273164-1	Shepparton Formation	OK	Y
GW273165-2	Lachlan Formation	OK	Y
GW273166-1	Lachlan Formation	OK	Y

8 Model Calibration and Sensitivity

8.1 Calibration Results

Calibration for the period October 2012 to April 2018 was carried out to confirm the viability of the model and adopted hydraulic parameters through:

- Producing starting groundwater flow fields that are considered plausible in the context of reported regional flow patterns.
- Comparing modelled versus measured monitoring bore data during the period October 2012 to January 2014. The monitoring bores used for comparison are identified in Table 8.
- Extending the transient calibration period to April 2018 to include part of monitored extraction from an approximately 12,500 m^2 section of the existing stage 1 pit to an

elevation of 121 m AHD. A photograph of the dewatered section of the pit during this trial is presented on Figure 14.

- Comparing modelled aquifer hydrographs with records from the nominated monitoring bores in the model domain for the whole calibration period.

FIGURE 14: EXISTING PIT 1 DEWATERED AREA

PEST was used to run the calibration model and optimise model parameters with the following results:

- The modelled starting flow fields shown on Figure 15 and Figure 16 are considered plausible when compared to the flow fields shown on Figures 3 and 4 from Kulatunga (2009).
- An SMSR of 5% between measured and modelled monitoring bore data as shown on Figure 17.
- An average modelled inflow to pit 1 during April 2018 of 1.6 ML/d compared to the estimated 1.5 ML/d.
- Modelled hydrographs for the whole calibration period correlate well with the measured data as shown on Figure 18 to Figure 22.

The hydraulic parameters varied by PEST are shown below in Table 9 with the optimised values. The adoption of model-derived hydraulic parameters is consistent with a Class 1 or 2 model confidence classification level; a Class 3 model would typically incorporate aquifer-testing data to measure key parameters.

TABLE 9: PEST PARAMETERS AND RESULTS

Layer	Parameter	Initial Value Estimate	PEST Optimised Result
Shepparton Formation	Specific yield	0.15 (1)	0.11
	Hydraulic conductivity (m/d)	2.0 (1)	1.0
	GHB upstream conductance (m^2/d)	1 (2)	19
	GHB downstream conductance (m^2/d)	0.5 (2)	0.12
Lachlan Formation	Transmissivity (m^2/d)	1,200 (1)	2,356
	GHB upstream conductance (m^2/d)	2,500 (2)	10,000
	GHB downstream conductance (m^2/d)	15 (2)	78

(1) From Stage 1 numerical model
(2) Initial estimates from analytical groundwater flow calculations and matching trial model runs

Water budget graphs for the model layers 1 and 2 are presented on Figure 23 and Figure 24. Model solver and convergence criteria are included in Appendix E.

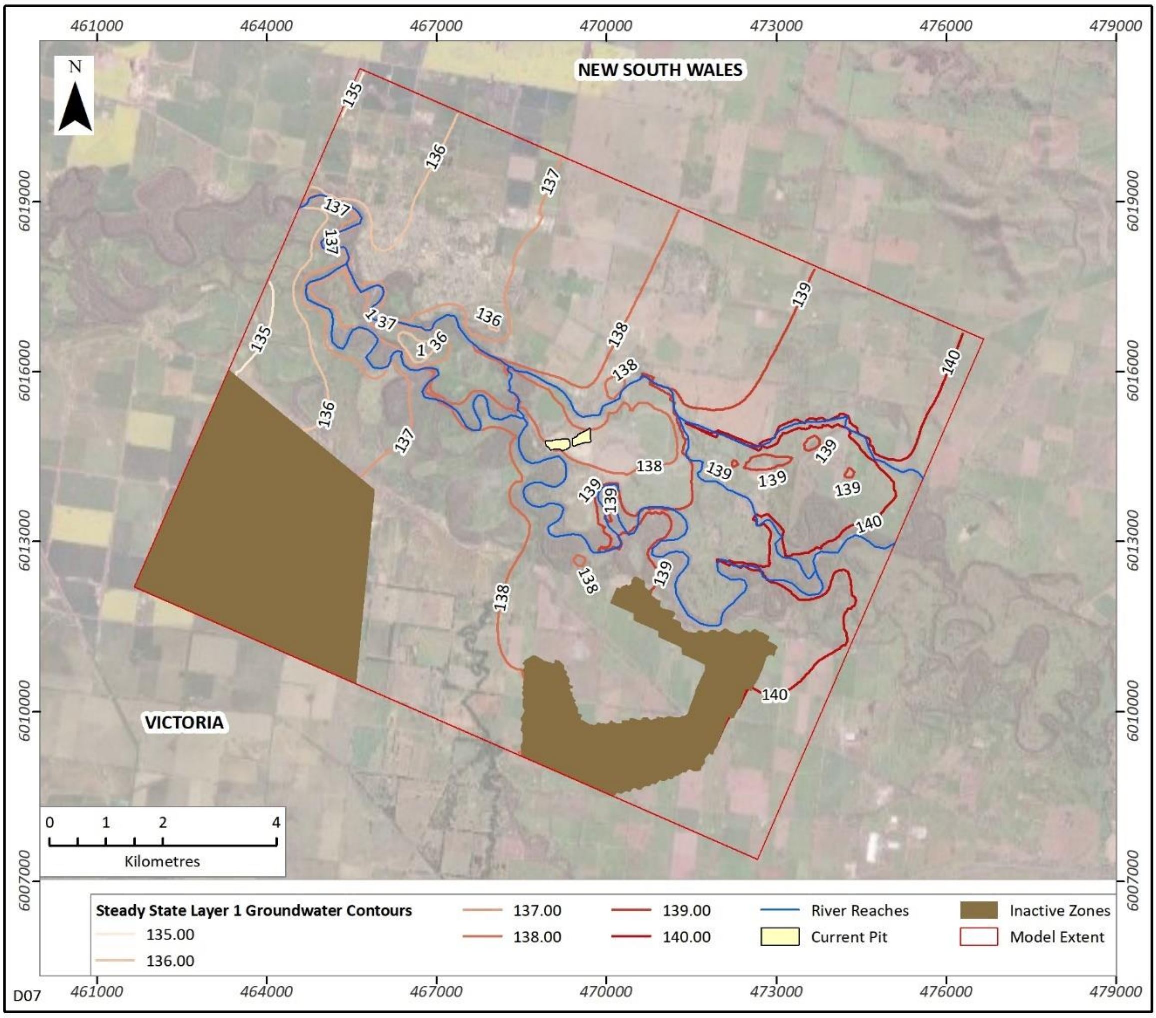


FIGURE 15: MODELLED STEADY STATE GROUNDWATER CONTOURS – SHEPPARTON FORMATION

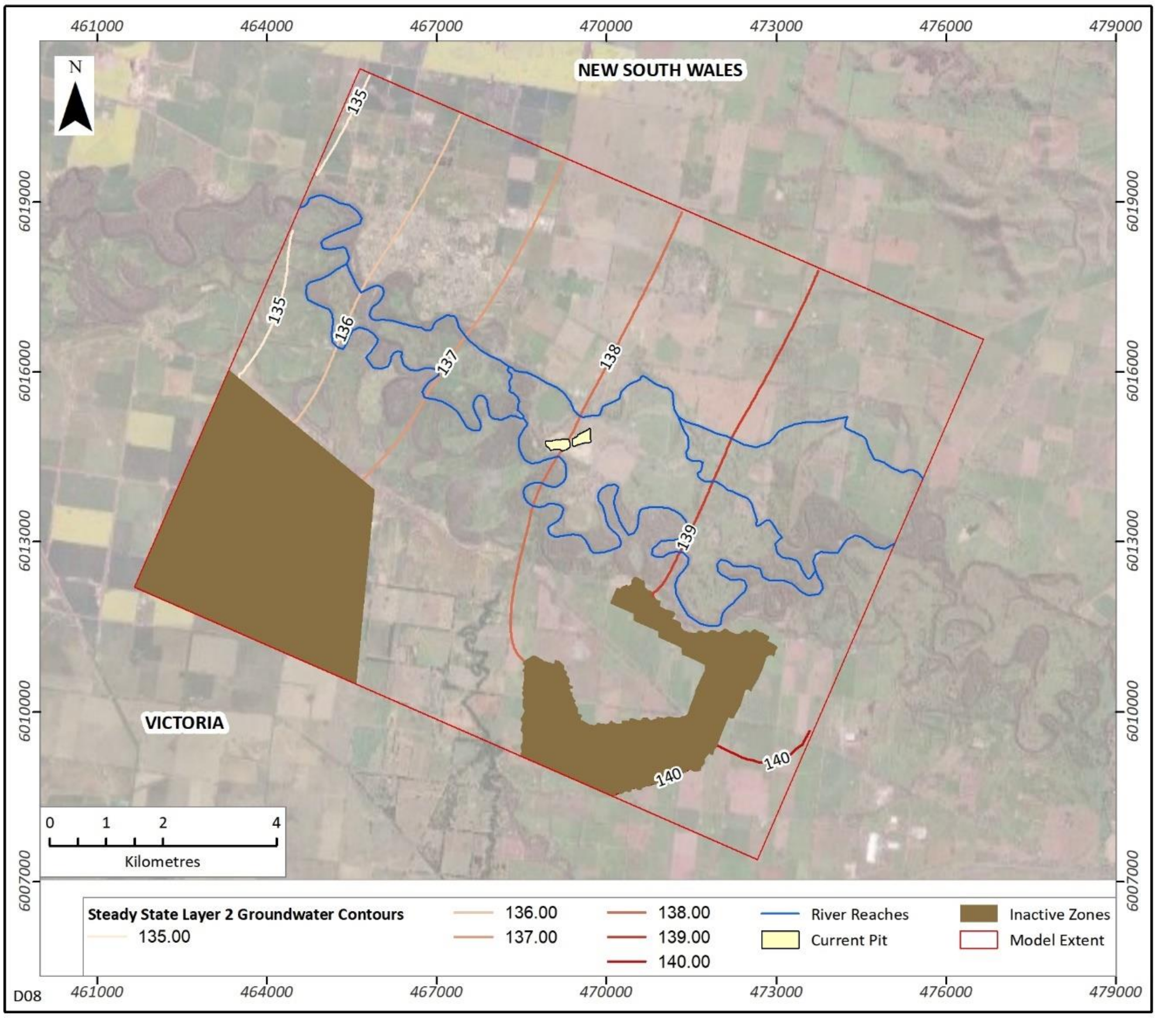


FIGURE 16: MODELLED STEADY STATE GROUNDWATER CONTOURS – LACHLAN FORMATION

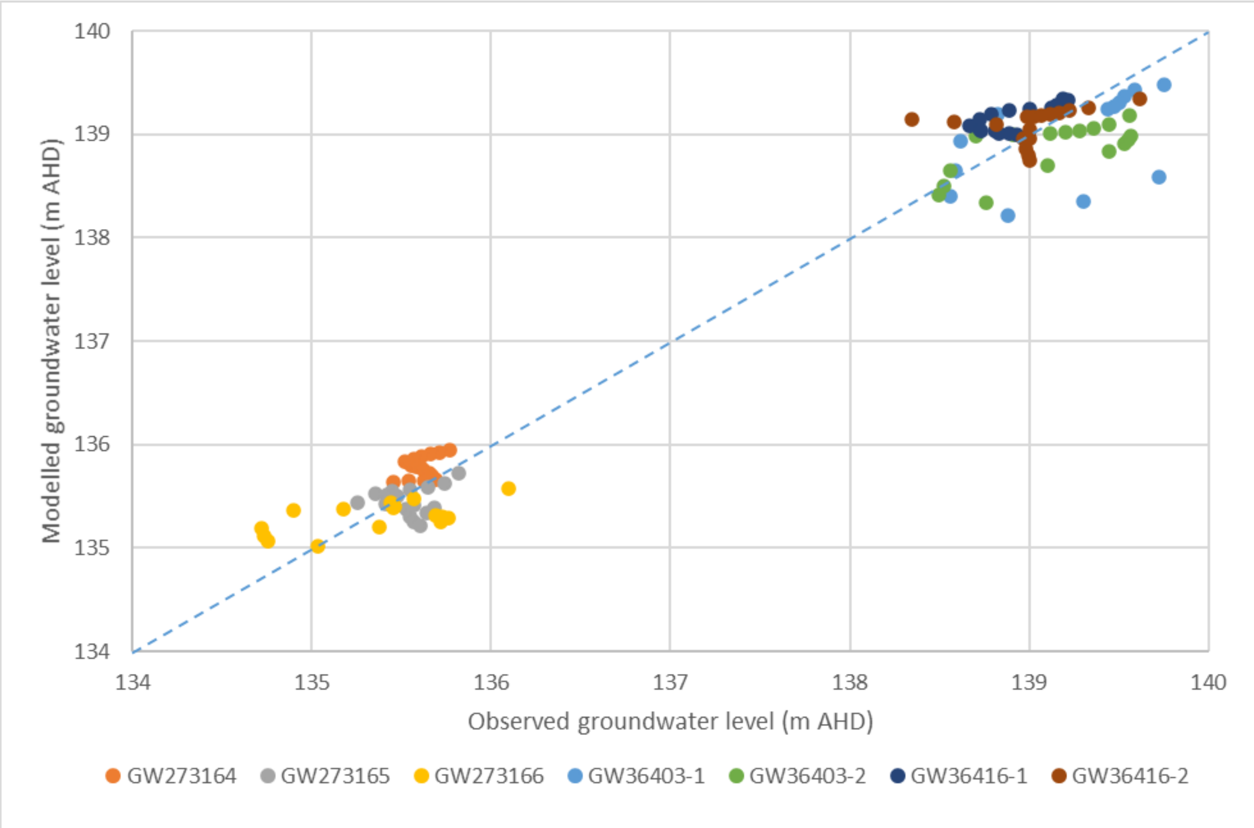


FIGURE 17: CALIBRATION PERIOD MODELLED VS MEASURED HEADS

The 1 : 1 blue dashed correlation line is shown on the above graph for comparative purposes.

TABLE 10: STATISTICAL ANALYSIS OF CALIBRATION HEAD DATA

Parameter		Value
Variance	Mean squared error	0.11
RMS	Root mean squared error	0.33
SRMS	Scaled root mean square error	6.5%
MSR	Mean sum of residuals	0.25
SMSR	Scaled mean sum of residuals	5.0%

8.2 Modelled vs Measured Monitoring Bore Hydrographs

GW36403

The 3 monitoring bore pipes at site GW36403 show very similar magnitudes and trends in response to changes in the interpolated river level (Figure 18). Pipe 1 is screened in the Shepparton Formation and pipes 2 and 3 in the Lachlan Formation, although it is unclear if the screened intervals are isolated by grout or bentonite. Measured levels indicate a general small downward head difference which is reduced during low river stages. Modelled water levels show similar patterns and magnitudes of response as the measured responses to river level variations.

GW36416

The 3 monitoring bore pipes at site GW36416 show similar magnitudes and trends in response to changes in the interpolated river level (Figure 19). Pipe 1 is screened in the Shepparton Formation and pipes 2 and 3 in the Lachlan Formation although it is unclear if the screened intervals are isolated by grout or bentonite. Measured groundwater levels indicate variable head differences depending on river stage, and this is also the case with the modelled levels. The modelled responses during the high river level in late 2016 are lower than observed.

GW273164

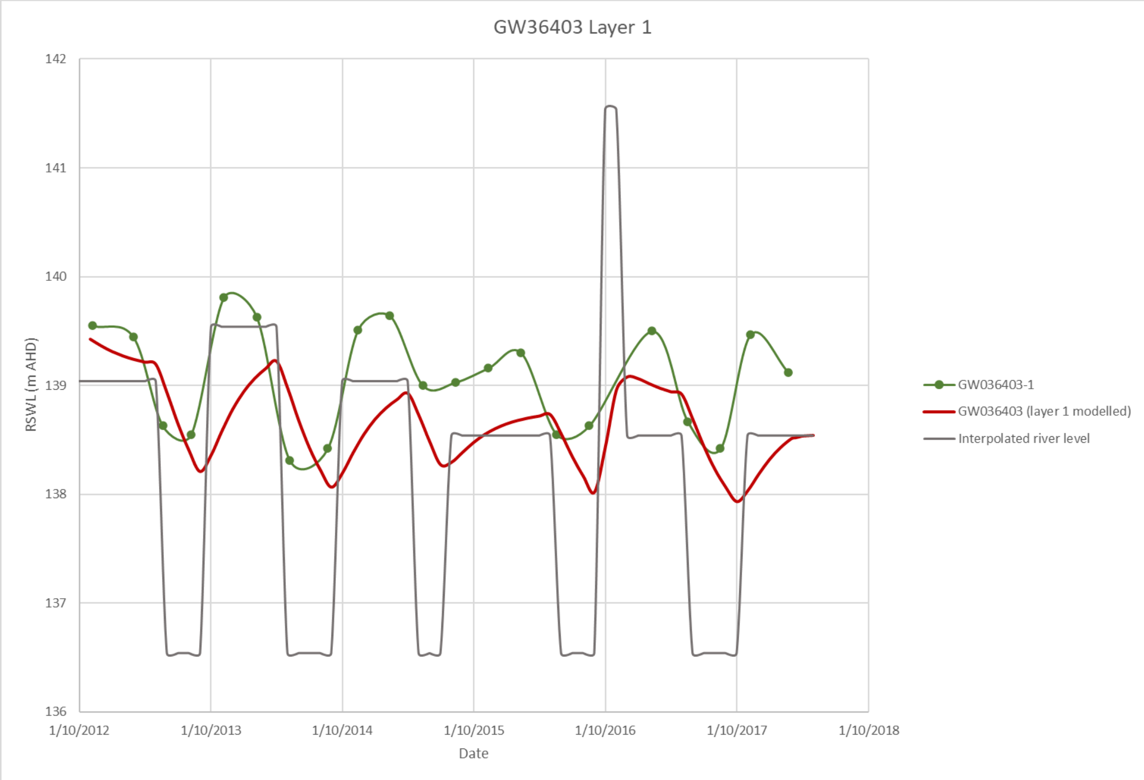
This bore is completed in the Shepparton Formation and there is a good correlation between measured and modelled groundwater levels (Figure 20).

GW273165

It is reported that this bore is completed in the Lachlan Formation and there is an overall good correlation between measured and monitored groundwater levels (Figure 21).

GW273166

This bore is reported to be screened from 23 to 25 m below ground level which is near the interpolated base of the Shepparton Formation shown on Figure 12 but it was drilled into the Lachlan Formation, and it is possible that this is affecting the measured groundwater levels. Modelled groundwater levels in the Lachlan Formation tend to provide a better match to measured heads apart from the high river event in 2016 (Figure 22).



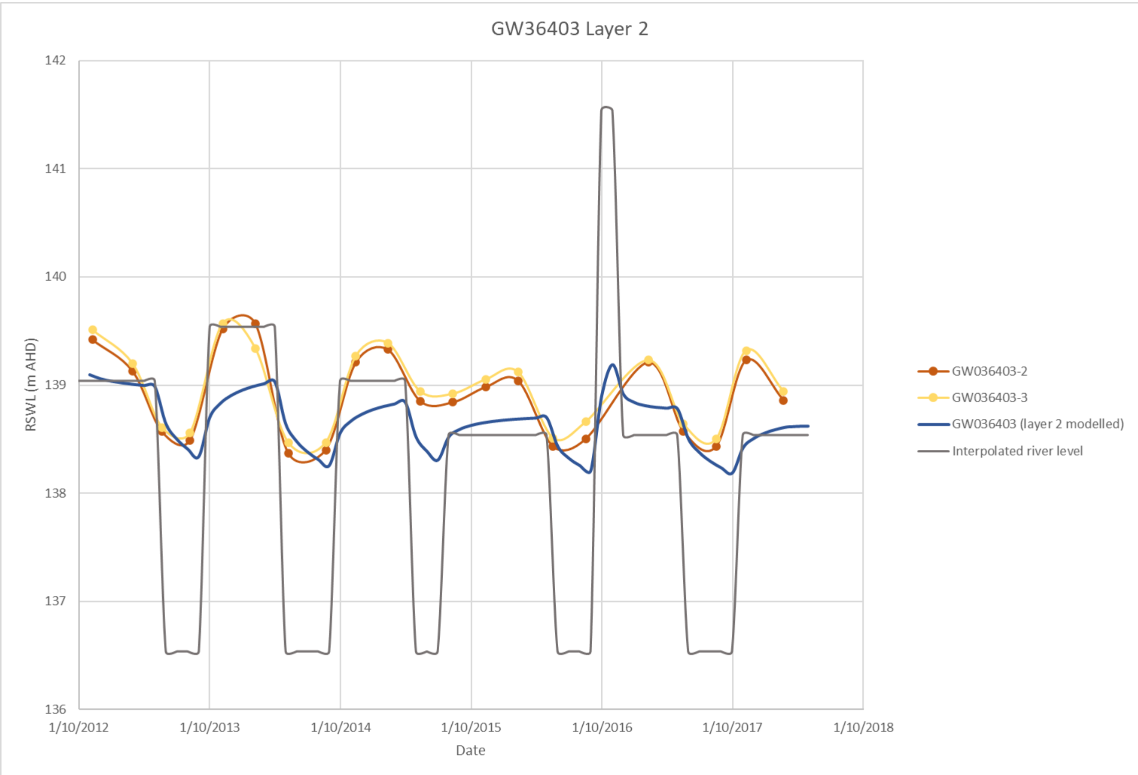
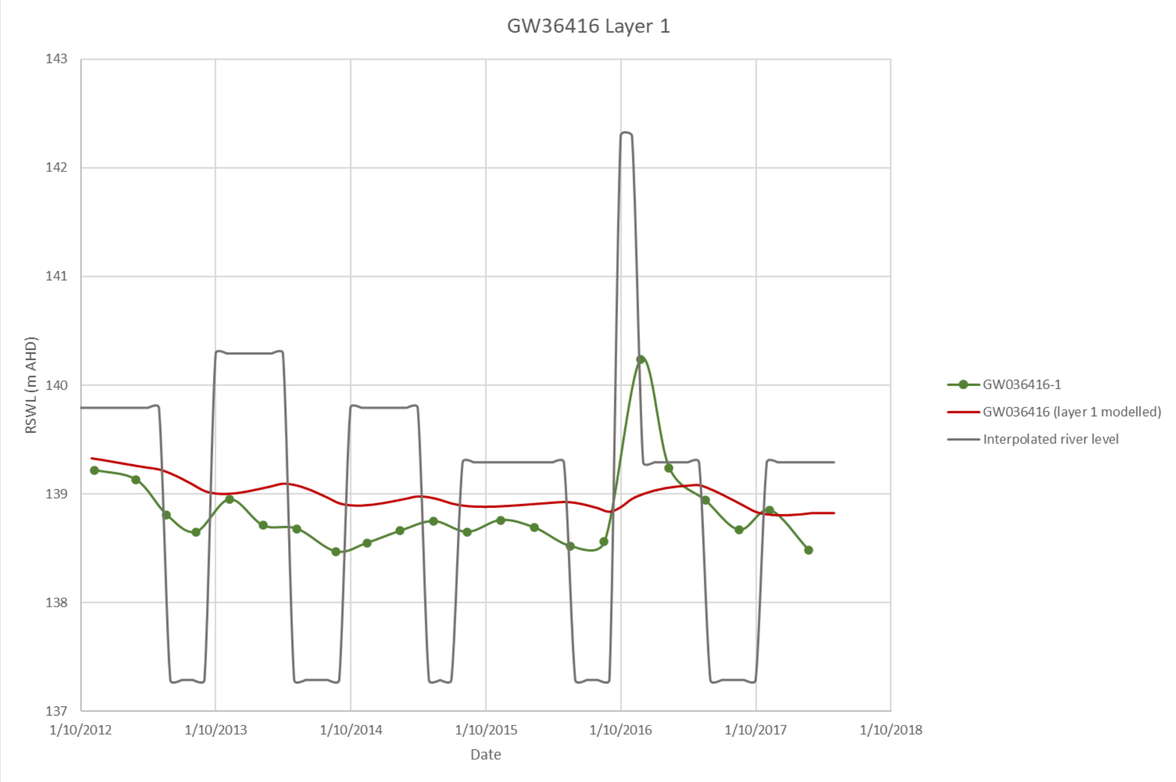


FIGURE 18: GW36403 MEASURED AND MODELLED HYDROGRAPHS



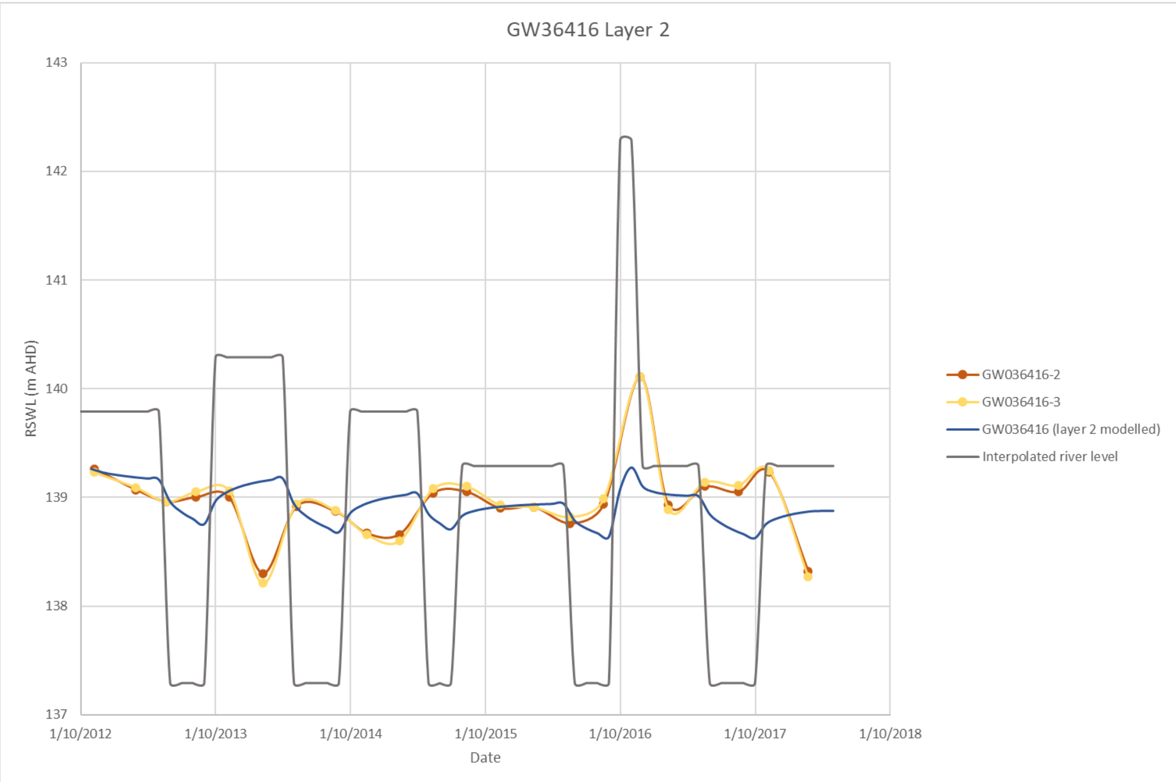


FIGURE 19: GW36416 MEASURED AND MODELLED HYDROGRAPHS

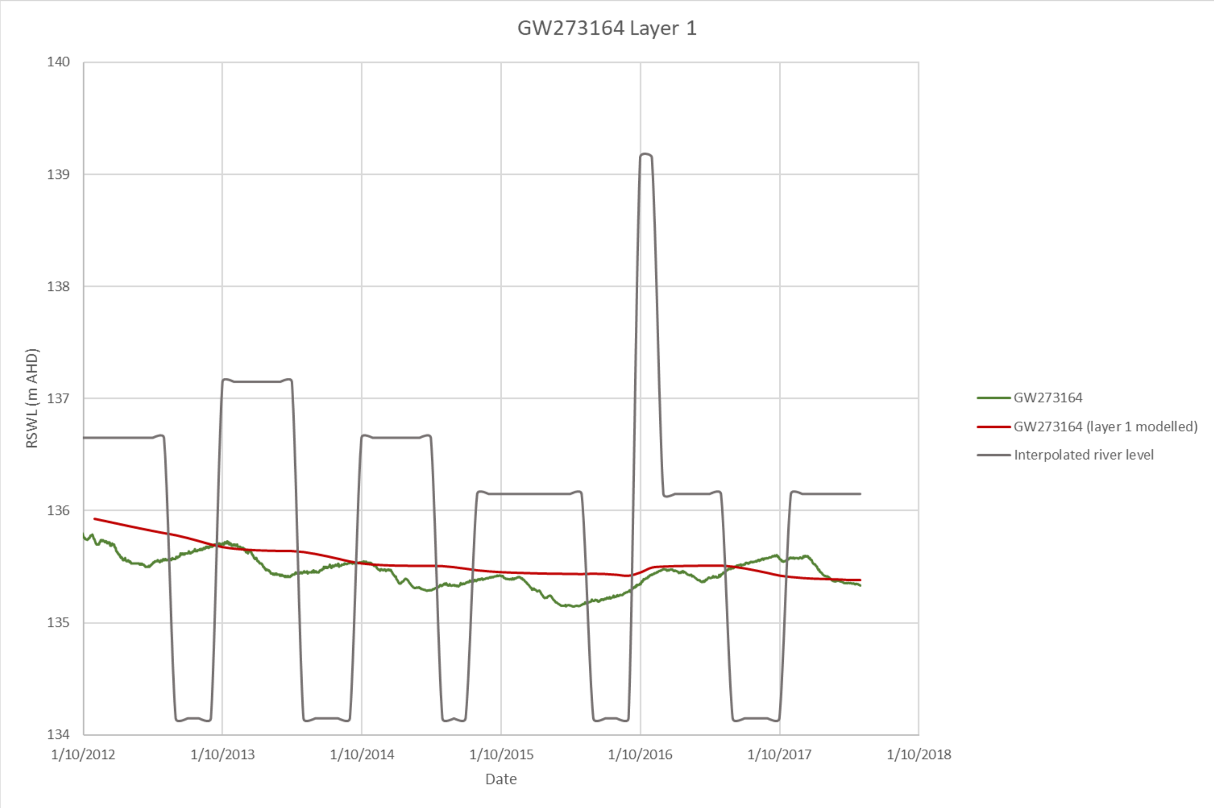


FIGURE 20: GW273164 MEASURED AND MODELLED HYDROGRAPHS

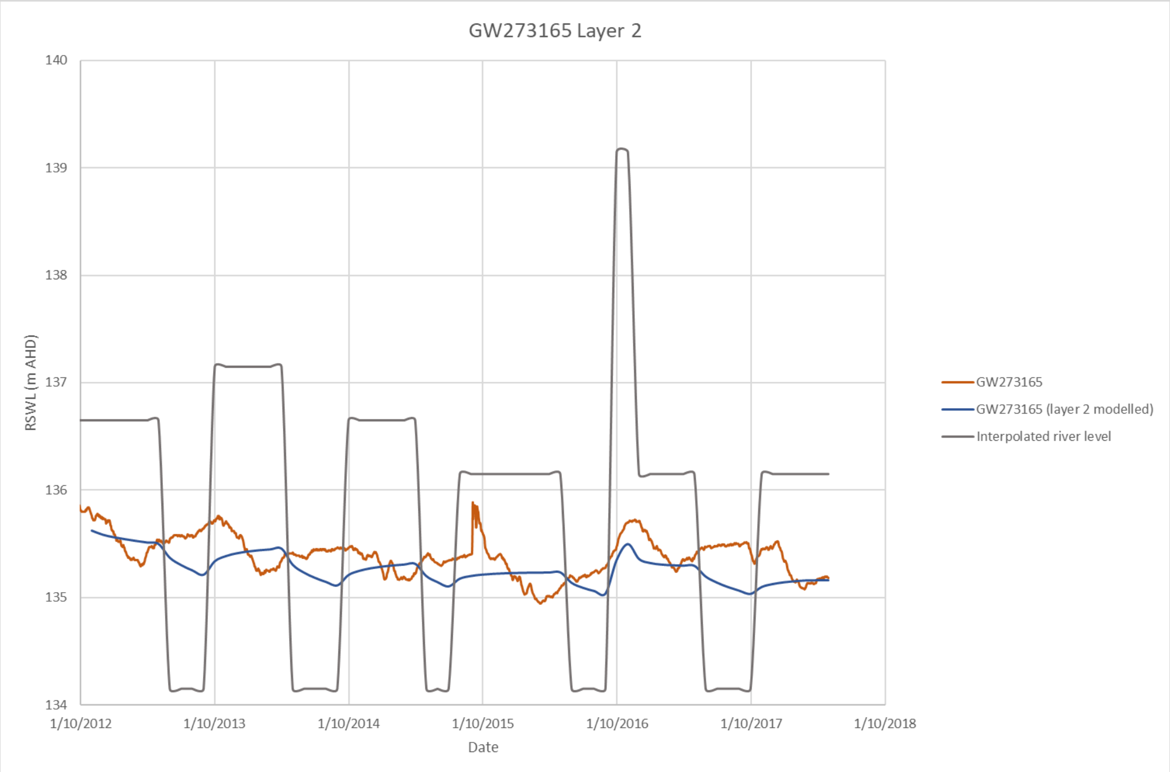


FIGURE 21: GW273165 MEASURED AND MODELLED HYDROGRAPHS

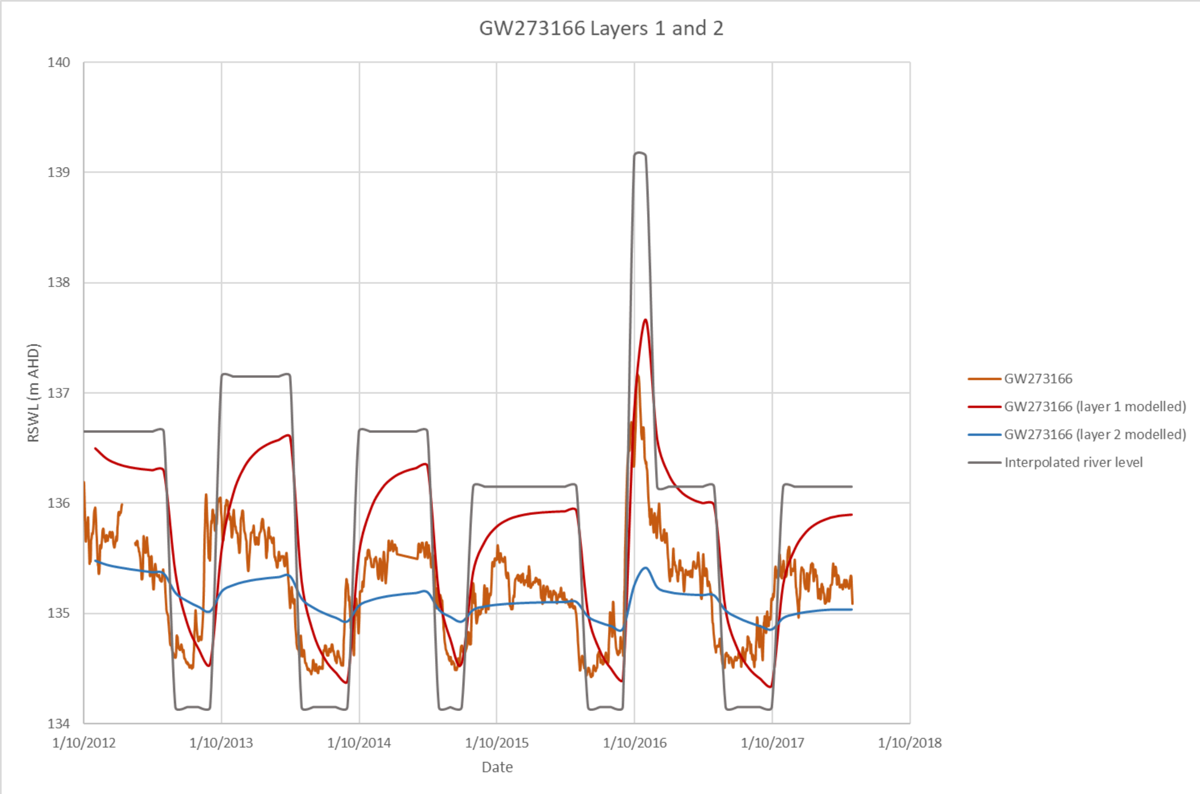


FIGURE 22: GW273166 MEASURED AND MODELLED HYDROGRAPHS

The overall modelled responses when compared to the observed monitoring data indicate similar trends in groundwater levels and responses to river level variations. It is also likely that irrigation extraction may be affecting some of the monitoring bores on the floodplain, at least to the south of the Quarry, and hence data from these monitoring locations were not used for model calibration purposes. It is also unclear whether multi-completed monitoring bores have been constructed to effectively isolate the monitored intervals. Given these uncertainties, and the lack of monitoring data at or adjacent the Quarry, the model results provide reasonable validation of the model construction and adopted hydraulic parameters. This is also supported by the modelled drain Stage 1 pit dewatering flows during April 2018 of 1.6 ML/d comparing very closely to the estimated measured groundwater inflows of 1.5 ML/d.

The model water budget rates (in m^3/d) for the transient calibration period are presented below on Figure 23 and Figure 24.

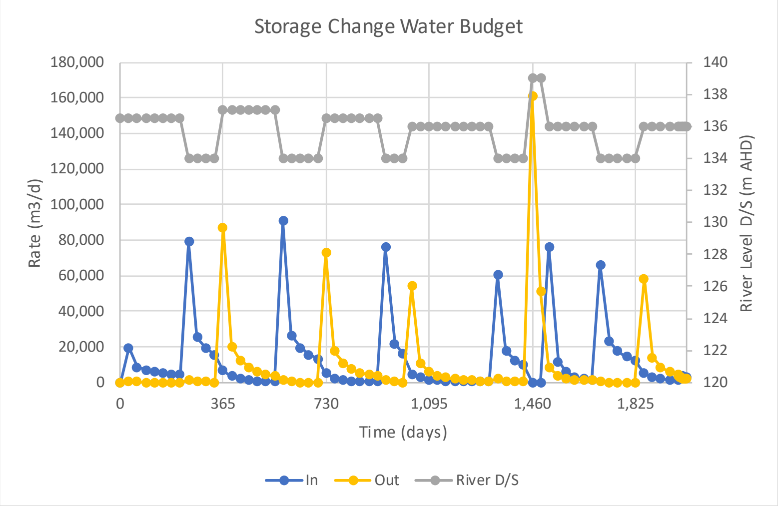
8.3 Sensitivity Analysis

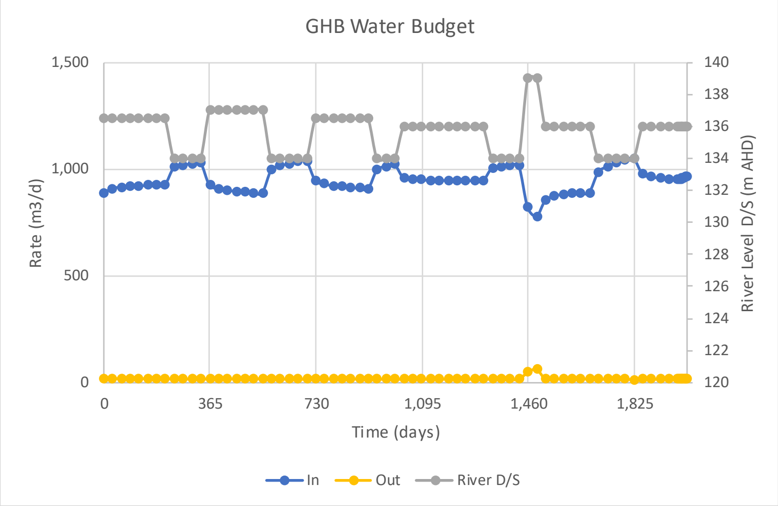
A range of model sensitivity cases were run for comparison with the adopted base case, in particular a comparison between the key calibration parameters of variance between measured and modelled heads and dewatering rates for the existing pit 1 during April 2018. The results of these sensitivity analysis runs are summarised in Table 11 below, and these results support the adoption of the base case for predictive modelling.

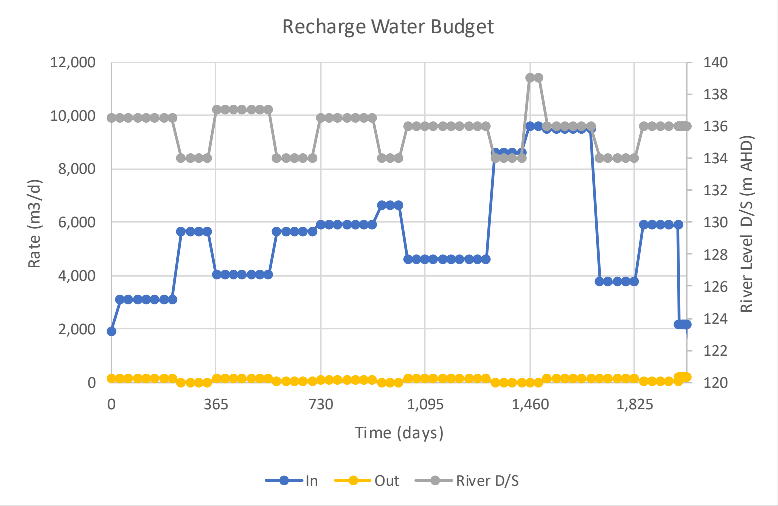
TABLE 11: SUMARY RESULTS OF SENSITIVITY RUNS

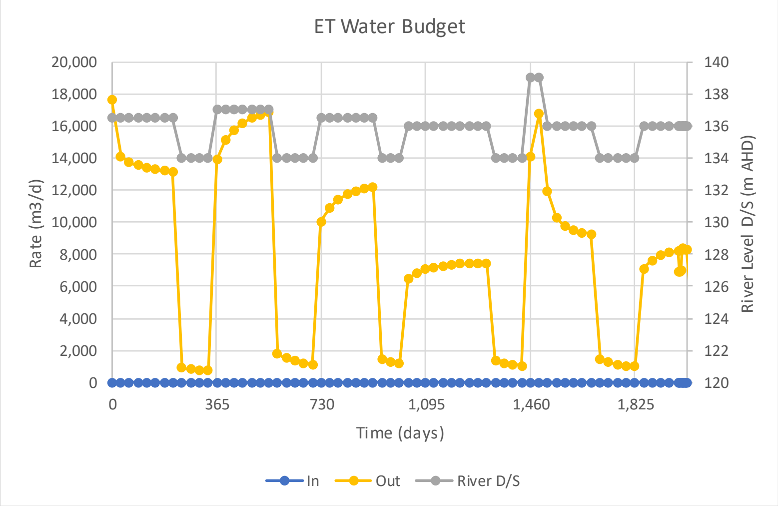
		Modelled pit 1 dewatering rates (m^3/d)				
	Variance	Model time step 1	Model time step 2	Model time step 3	Average (ML/d)	Comment
Base case	0.11	3,051	855	771	1.6	Adopted base case from PEST
River hydraulic conductance c = 500 m^2/d	0.11	3,122	860	773	1.6	Indicate low sensitivity to river conductance
River hydraulic conductance c = 50,000 m^2/d	0.11	3,123	860	773	1.6	
Layer 1 horizontal hydraulic conductivity and specific yield K1 = 1.5 m/d / Sy1 = 0.05	0.18	4,483	2,902	2,722	3.4	Heads and inflows less well correlated
Layer 1 horizontal hydraulic conductivity and specific yield	0.11	4,497	695	502	1.9	Inflows less well correlated

K1 = 0.5 m/d / Sy1 = 0.20						
Layer 1 vertical hydraulic conductivity Kv1 = 0.1 m/d	0.19	3,759	1,529	1,450	2.2	Heads and inflows less well correlated
Layer 1 vertical hydraulic conductivity Kv1 = 1 m/d	0.26	4,239	2,032	1,957	2.7	
Layer 2 transmissivity T2 = 1,000 m^2/d	0.13	3,120	860	772	1.6	Heads less well correlated
Recharge 6% of rain	0.11	3,172	875	786	1.6	Indicate low sensitivity to recharge over the range modelled
Recharge 1.5% of rain	0.11	3,095	853	766	1.6	


Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S

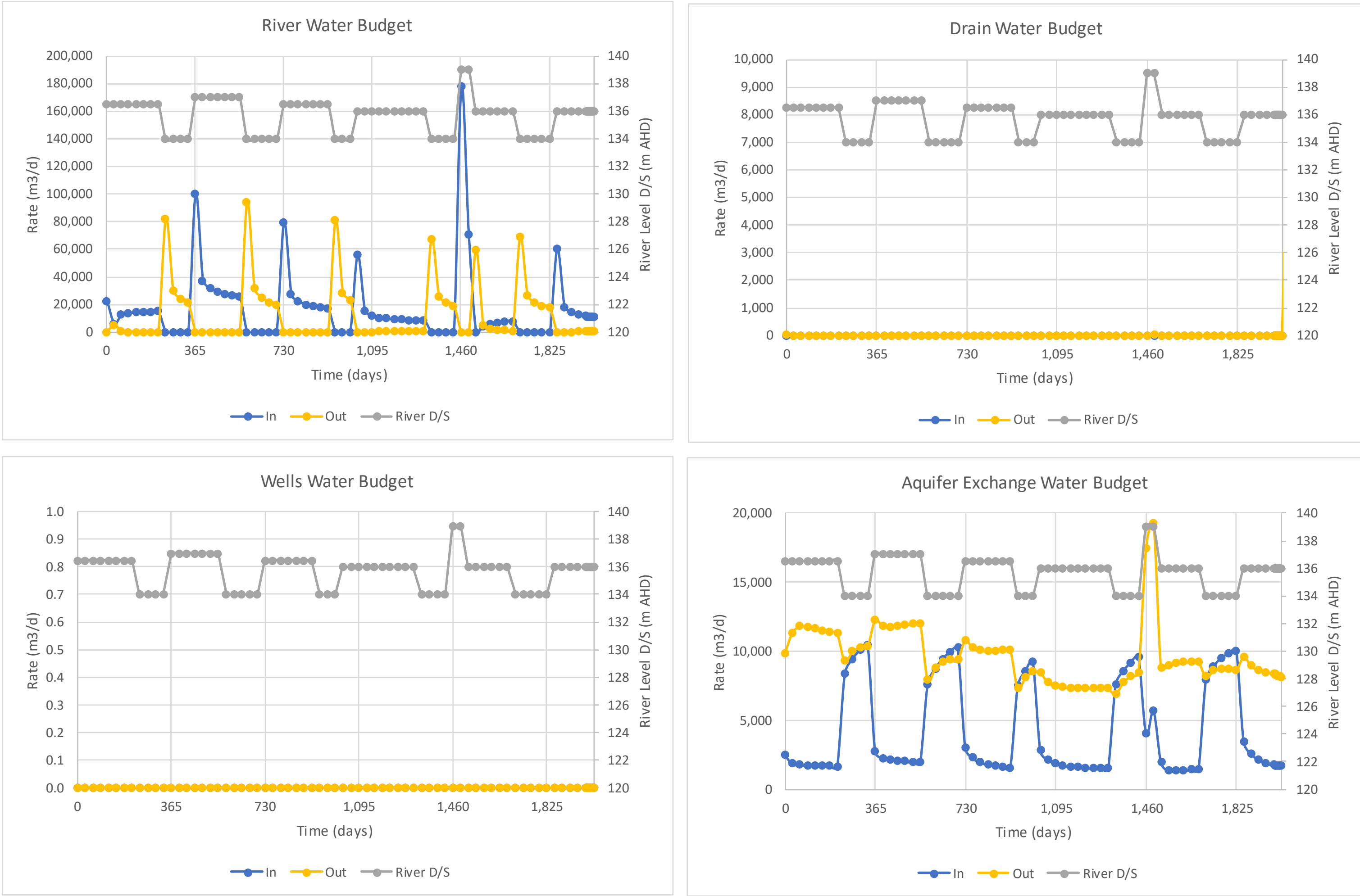
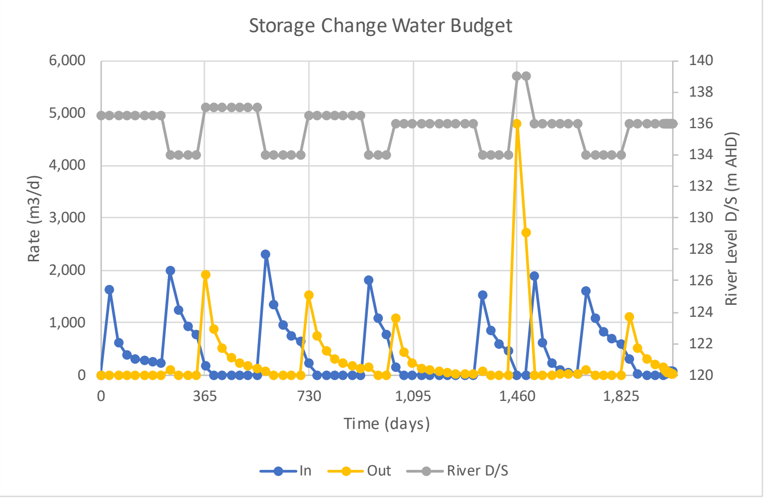
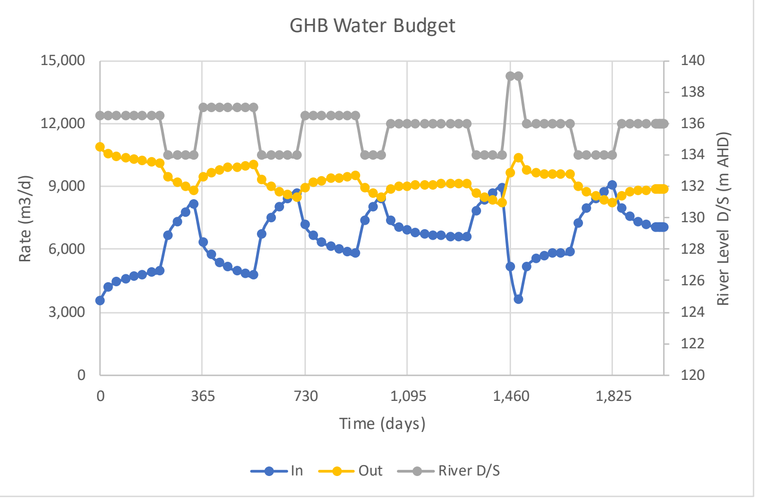
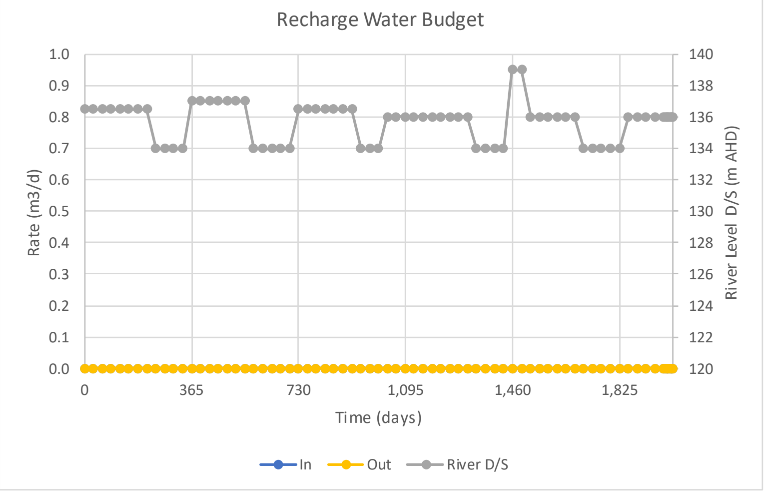
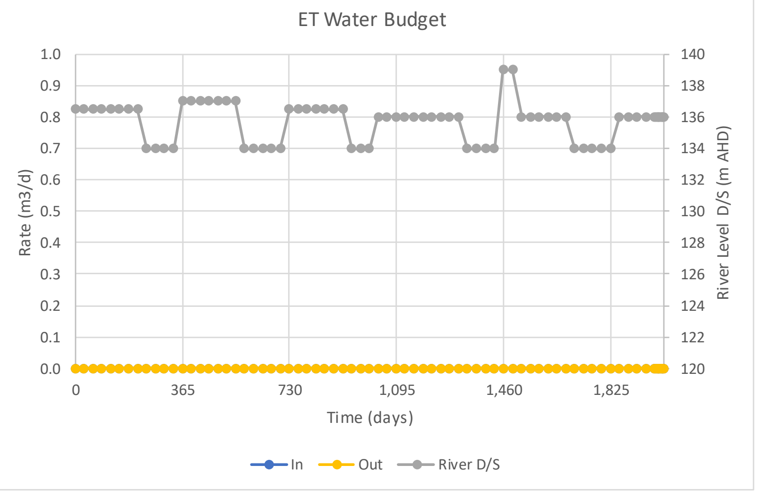


FIGURE 23: MODEL CALIBRATION PERIOD LAYER 1 WATER BUDGET


Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
0
365
730
1,095
1,460
1,825
0
1,000
2,000
3,000
4,000
5,000
6,000
120
122
124
126
128
130
132
134
136
138
140
In
Out
River D/S


GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
0
365
730
1,095
1,460
1,825
0
3,000
6,000
9,000
12,000
15,000
120
122
124
126
128
130
132
134
136
138
140
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
0
365
730
1,095
1,460
1,825
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
120
122
124
126
128
130
132
134
136
138
140
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
0
365
730
1,095
1,460
1,825
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
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124
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132
134
136
138
140
In
Out
River D/S

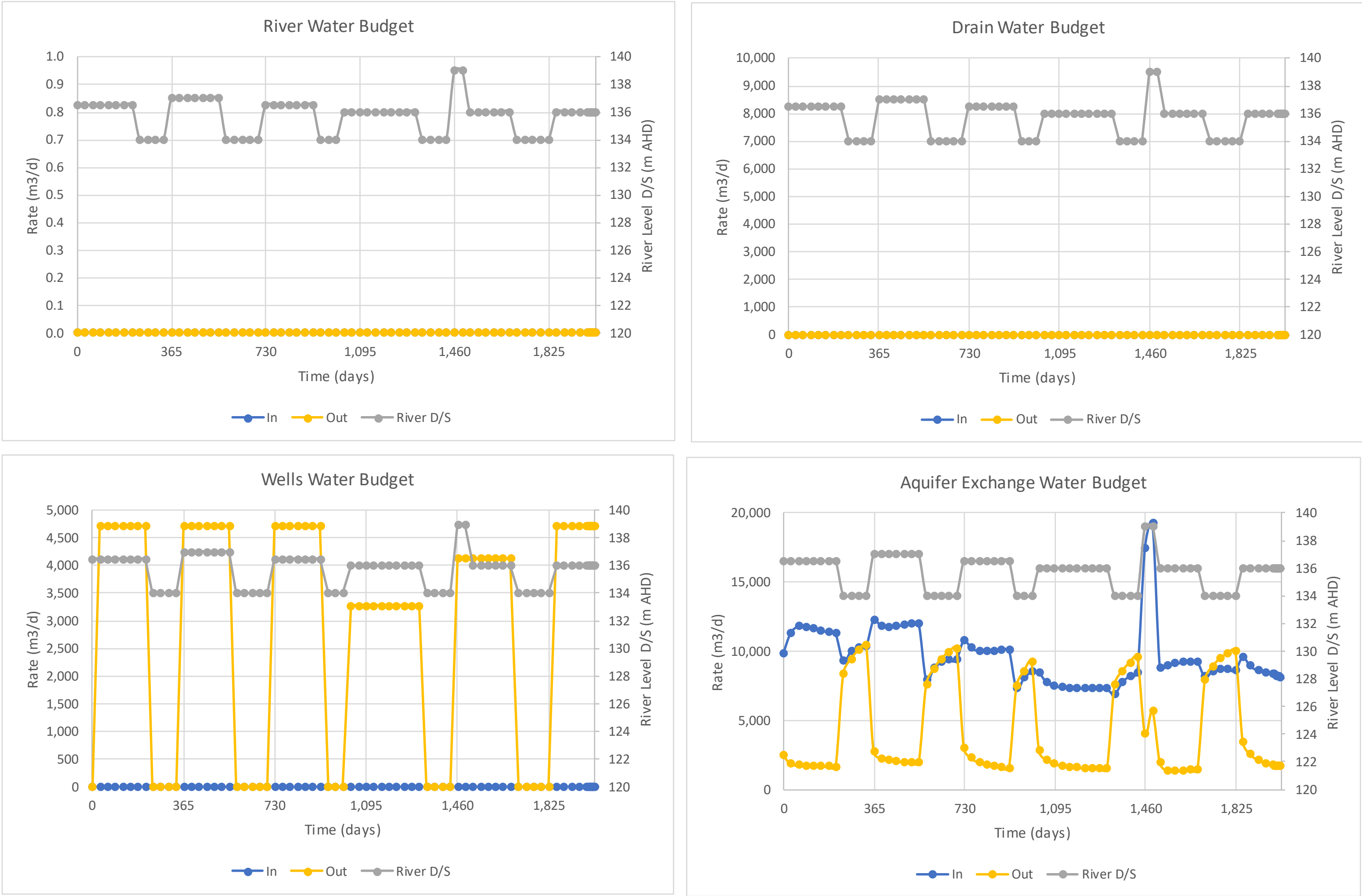


FIGURE 24: MODEL CALIBRATION PERIOD LAYER 2 WATER BUDGET

9 Predictive Modelling

The PEST parameter set obtained from the transient calibration modelling and shown in Table 9 was adopted for the predictive modelling which was undertaken as a pit expansion and dewatering stage and a separate recovery period model.

9.1 Pit Excavation and Dewatering

The groundwater model prediction runs for active pit excavation and dewatering were run in 5 stages consistent with the Project staging and dewatering model time discretisation as shown in Table 12. Information provided for the project indicates that the stage 4 pit will possibly be excavated as 2 areas comprising 5 approximately north-south trending sub-pits (a to e), which would be combined into 2 pit areas as shown on Figure 25, designated as stage 4(ab) and stage 4(cde). An initial steady state period was used to provide baseline groundwater levels and water balances for the model domain for comparison to the subsequent dewatering stages. This model stage used current estimated pit levels and average river levels derived from the Howlong gauge record shown on Figure 13.

TABLE 12: MODEL TIME DISCRETISATION – EXPANSION PERIOD

Model Stress Period	Length (years)	Time Steps (1)	Stage	Modelled elevation of pit base (m AHD)	Nominal Stage Area (ha)
1	0.1	1	Initial steady state period to provide average river condition starting heads	-	-
2	1	4	Stage 1 pit excavation	128 (2)	7
3	1	4		120 (3)	
4	1	4	Stage 2 pit excavation	128 (2)	6
5	1	4		121 (3)	
6	1	4	Stage 3 pit excavation	132	4
7	1	4		126	
8	1	4		119	
9	1	4	Stage 4(ab) sub-pits excavation	132	8
10	1	4		126	
11	1	4		119	
12 to 31	20 stress periods of 1 year length each	1 per stress period	Stage 4(cde) sub-pits excavation	119 with 1 m incremental steps over the 20 years	17

(1) All time step multipliers = 1.

(2) Higher than current pit base levels but adopted for modelling purposes as progressive dewatering still required.

(3) Final pit elevation assumed at highest elevation of base of layer 1 within pit area for modelling purposes.

The drain package was used to model the excavation of each individual Project stage with drain levels progressively deepened during each relevant model stress period. This approach provides estimates of annual dewatering volumes and these are shown in Table 13 below, together with estimated nett annual evaporative losses.

The modelled pit locations and maximum predicted drawdown contours in Layers 1 and 2 at the end of Stage 4 are shown below on Figure 25 and Figure 26. These were produced by using the predictive staged dewatering model with each of pit stages 1, 2, 3 and 4(ab) assigned as high K / high S_y (10^3 m/d / 1.0) zones. The drawdown patterns for Stage 4(cde) indicate the potential for pit slope instability where high gradients are established between the river and the pit. This is also the case for pit stages 3 and 4(ab). The modelled layer 2 drawdown is less than 1 m within the Stage 4 area.

Direct layer 1 drawdown due to pit excavation is constrained to the floodplain between the Murray River and anabranches with the river and anabranches acting as recharge boundaries. Pressure reduction in layer 2 is not constrained by river and extends in a roughly radial pattern away from the quarry site, this leads to the model producing small semi-regional drawdown effects in layer 1 across the river and away from the quarry site due to aquifer interactions.

Analysis of the model water budgets indicate that discharge from the Murray River to the Upper Murray Alluvium is increased on average by 594 m^3/d during Stages 1, 2 and 3, 917 m^3/d for Stage 4(ab) and 1,240 m^3/d for Stage 4(cde). The corresponding average reductions in discharge from the Upper Murray Alluvium to the Murray River are 234 m^3/d during Stages 1, 2 and 3, 353 m^3/d for Stage 4(ab) and 406 m^3/d for Stage 4(cde). When combined, these reduced rates of discharge result in a maximum daily loss of 2,746 m^3/d from the Murray River during the final year of the Stage 4(cde) expansion. Appendix F contains a tabulated sequence of model outputs (in units of m^3/d and ML/a), including modelled losses from the Murray River to the Upper Murray Alluvium as well as the modelled loss of recharge from the Upper Murray Alluvium to the Murray River.

Modelled water budgets for the Project dewatering periods are shown on Figure 27 and Figure 28. Model convergence criteria and solver settings are included in Appendix E.

TABLE 13: EXPANSION STAGE WATER EXTRACTION BALANCES

		Pit stage dewatering rate (ML/d)					Evaporative loss (ML/d)					Total (ML/d)	Total (ML/a)
Stage	**Year**	**1**	**2**	**3**	**4(ab)**	**4(cde)**	**1**	**2**	**3**	**4(ab)**	**4(cde)**		
1	**1**	1.94	-	-	-	-	-	-	-	-	-	1.94	707
	2	1.79	-	-	-	-	-	-	-	-	-	1.79	653
2	**3**	-	1.83	-	-	-	0.065	-	-	-	-	1.89	691
	4	-	1.78	-	-	-	0.065	-	-	-	-	1.84	672
3	**5**	-	-	1.01	-	-	0.065	0.056	-	-	-	1.13	412
	6	-	-	1.88	-	-	0.065	0.056	-	-	-	2.00	731
	7	-	-	1.73	-	-	0.065	0.056	-	-	-	1.85	675
4(ab)	**8**	-	-	-	1.54	-	0.065	0.056	0.037	-	-	1.70	619
	9	-	-	-	2.82	-	0.065	0.056	0.037	-	-	2.98	1,087
	10	-	-	-	3.25	-	0.065	0.056	0.037	-	-	3.40	1,243
4(cde)	**11**	-	-	-	-	0.00	0.065	0.056	0.037	0.074	-	0.23	85
	12	-	-	-	-	0.10	0.065	0.056	0.037	0.074	-	0.33	122

		Pit stage dewatering rate (ML/d)					Evaporative loss (ML/d)					Total (ML/d)	Total (ML/a)
	13	-	-	-	-	0.62	0.065	0.056	0.037	0.074	-	0.86	312
	14	-	-	-	-	1.00	0.065	0.056	0.037	0.074	-	1.23	448
	15	-	-	-	-	1.34	0.065	0.056	0.037	0.074	-	1.57	574
	16	-	-	-	-	1.67	0.065	0.056	0.037	0.074	-	1.90	695
	17	-	-	-	-	1.99	0.065	0.056	0.037	0.074	-	2.22	811
	18	-	-	-	-	2.30	0.065	0.056	0.037	0.074	-	2.53	922
	19	-	-	-	-	2.59	0.065	0.056	0.037	0.074	-	2.82	1,030
	20	-	-	-	-	2.87	0.065	0.056	0.037	0.074	-	3.11	1,133
	21	-	-	-	-	3.14	0.065	0.056	0.037	0.074	-	3.38	1,232
	22	-	-	-	-	3.40	0.065	0.056	0.037	0.074	-	3.63	1,326
	23	-	-	-	-	3.64	0.065	0.056	0.037	0.074	-	3.88	1,415
	24	-	-	-	-	3.87	0.065	0.056	0.037	0.074	-	4.10	1,498
	25	-	-	-	-	4.08	0.065	0.056	0.037	0.074	-	4.31	1,574
	26	-	-	-	-	4.27	0.065	0.056	0.037	0.074	-	4.50	1,643

		Pit stage dewatering rate (ML/d)					Evaporative loss (ML/d)					Total (ML/d)	Total (ML/a)
	27	-	-	-	-	4.43	0.065	0.056	0.037	0.074	-	4.66	1,702
	28	-	-	-	-	4.56	0.065	0.056	0.037	0.074	-	4.79	1,748
	29	-	-	-	-	4.63	0.065	0.056	0.037	0.074	-	4.87	1,776
	30	-	-	-	-	4.63	0.065	0.056	0.037	0.074	-	4.86	1,776

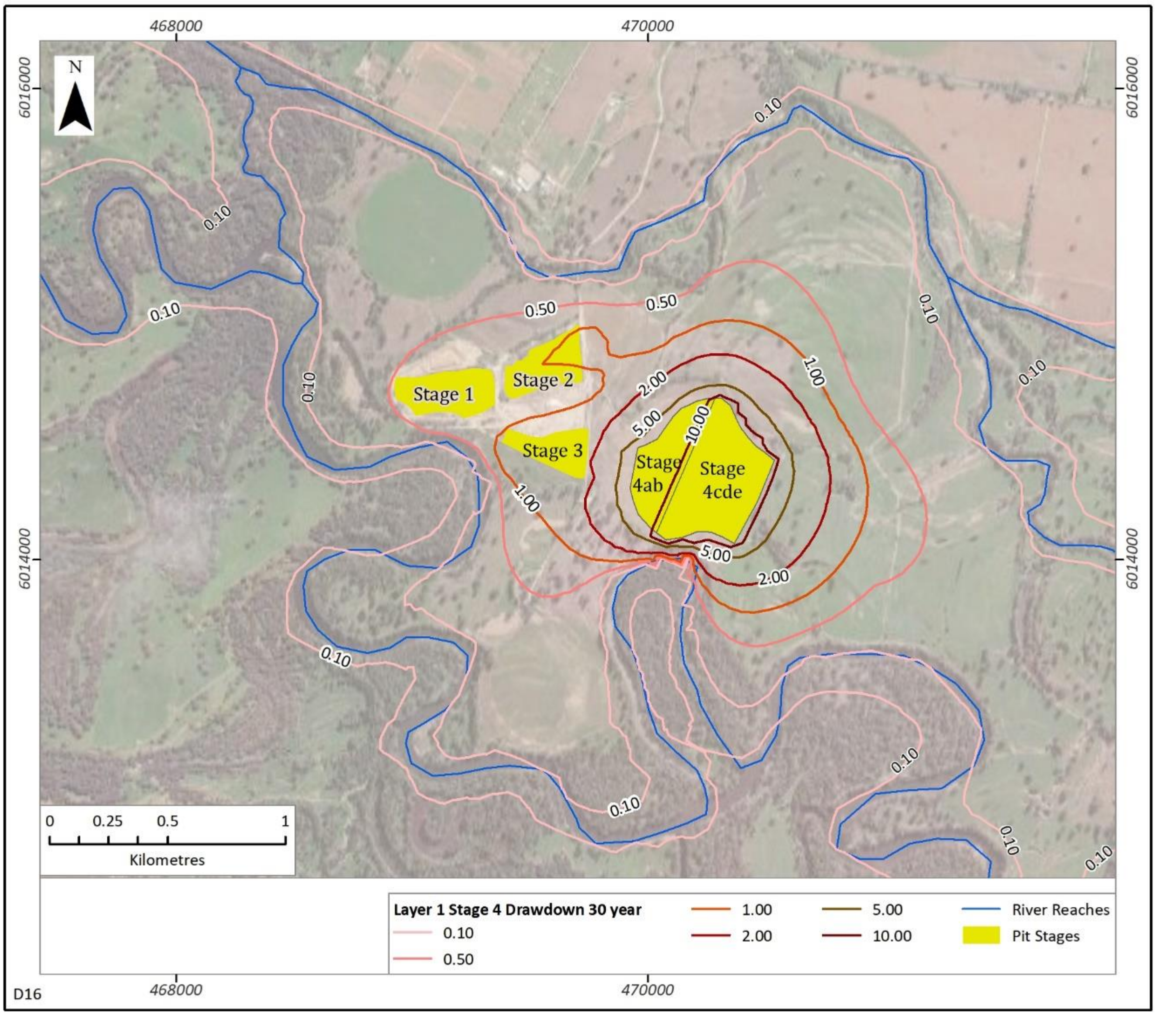


FIGURE 25: MODELLED LAYER 1 DRAWDOWN AFTER STAGE 4(CDE)

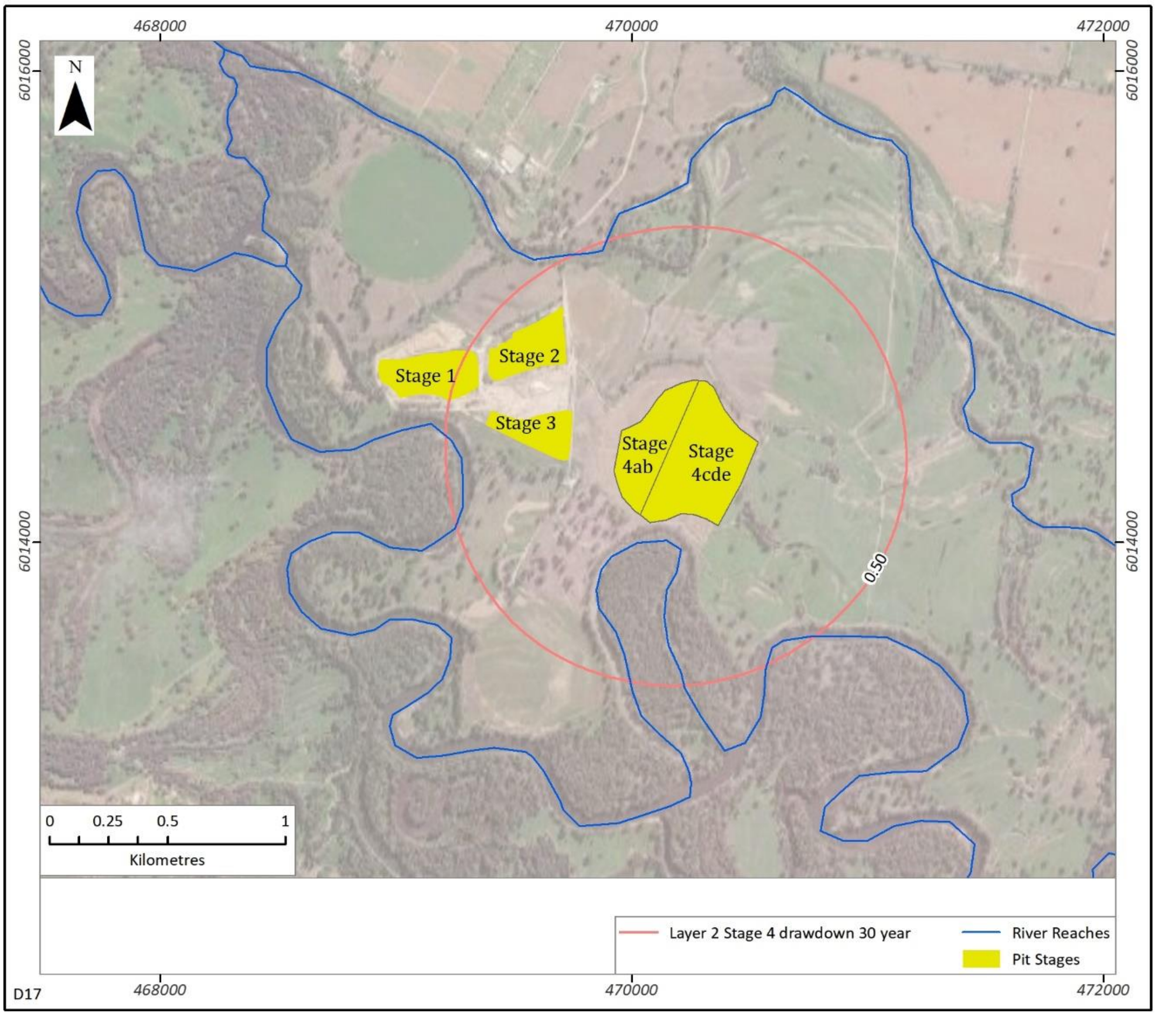
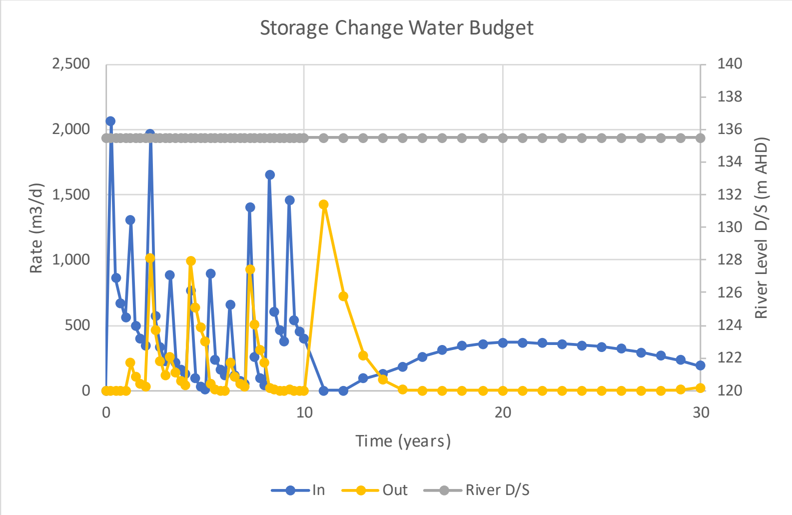
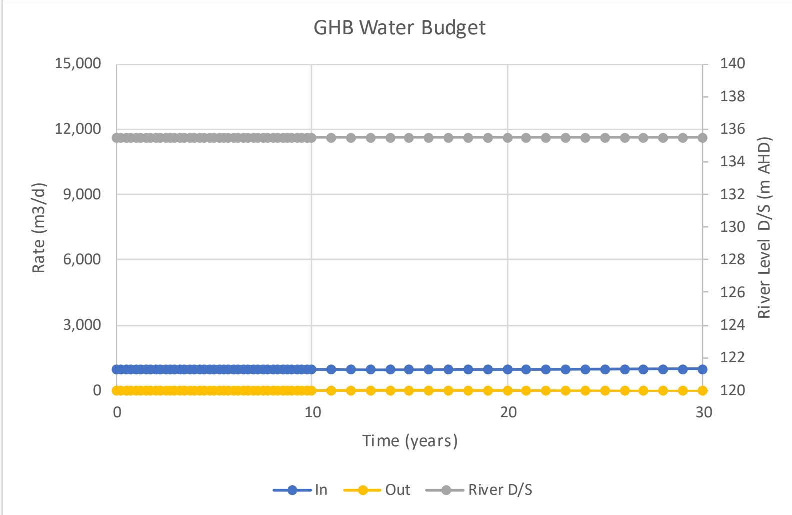
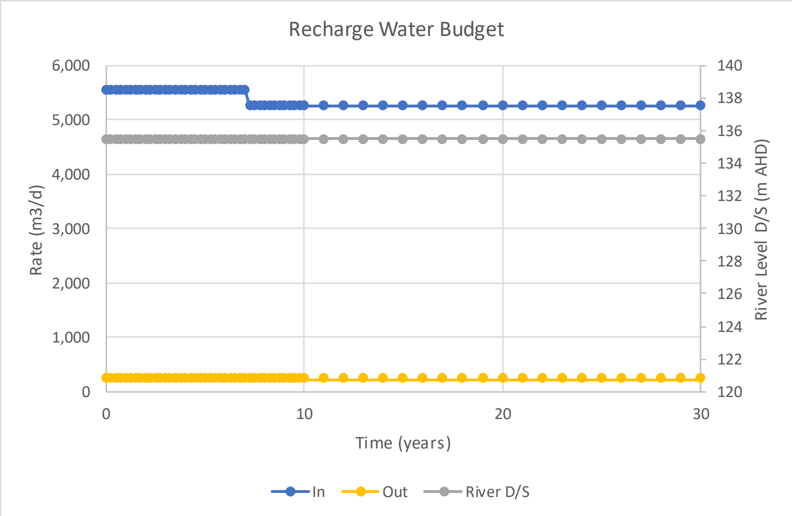
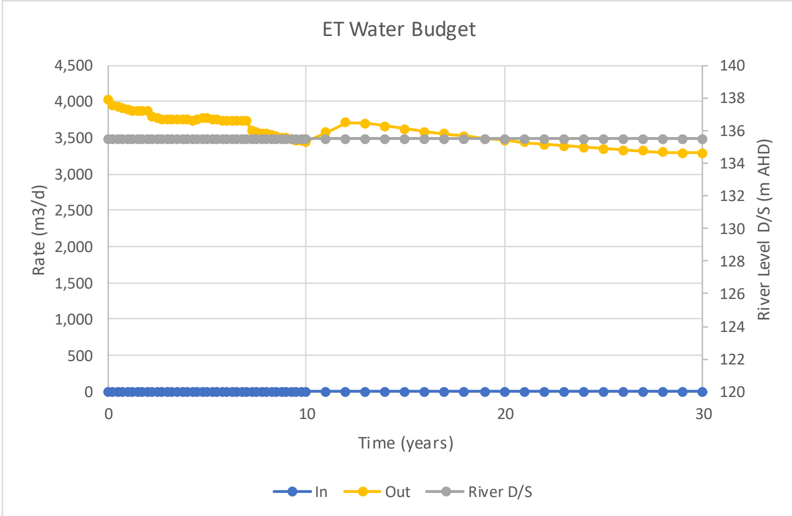


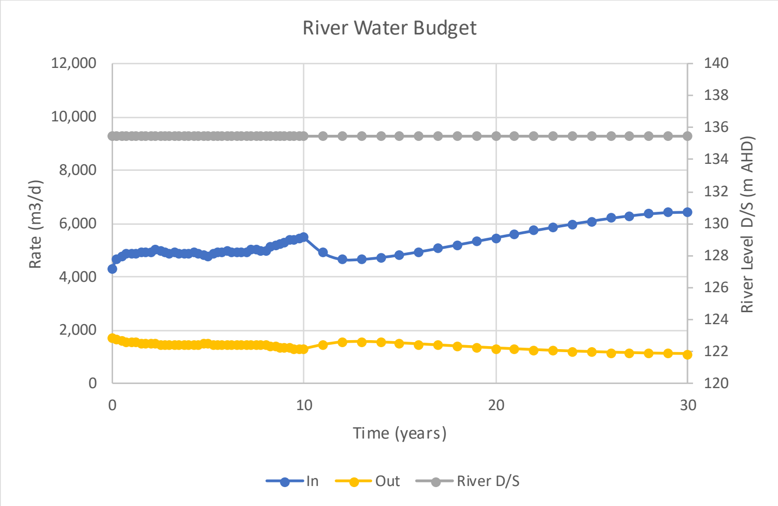
FIGURE 26: MODELLED LAYER 2 DRAWDOWN AFTER STAGE 4

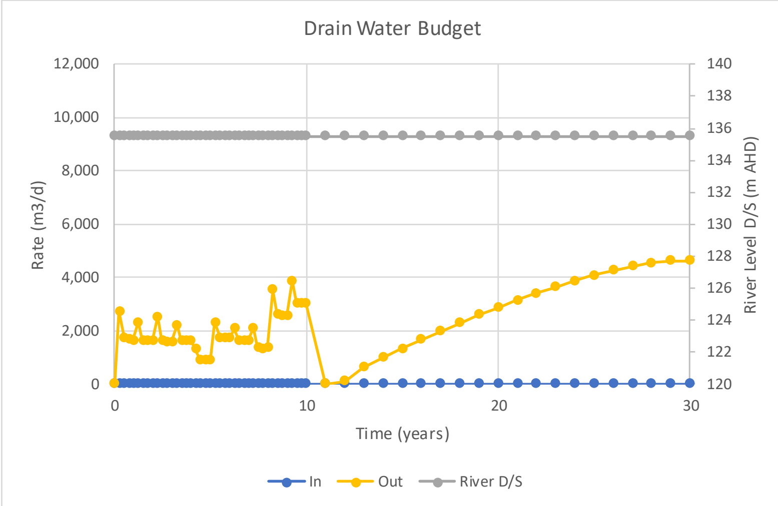

Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S

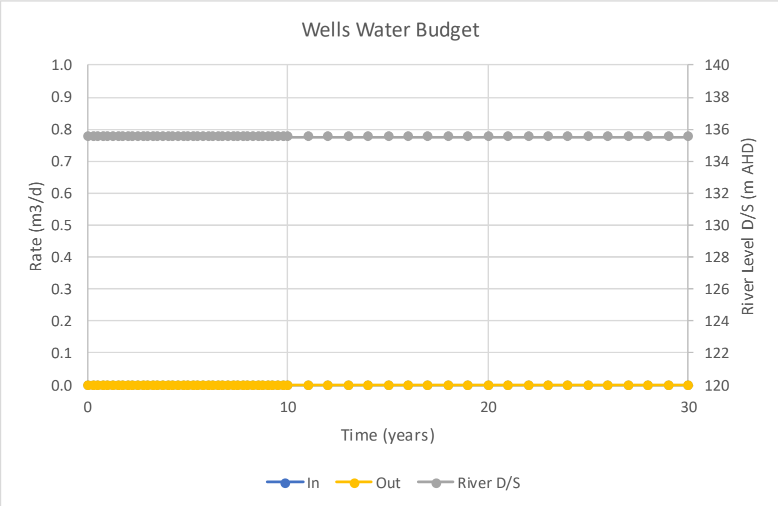

GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S







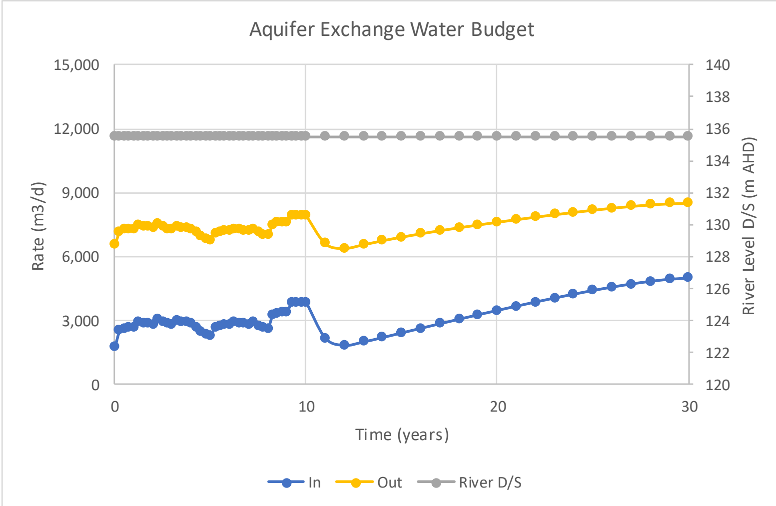
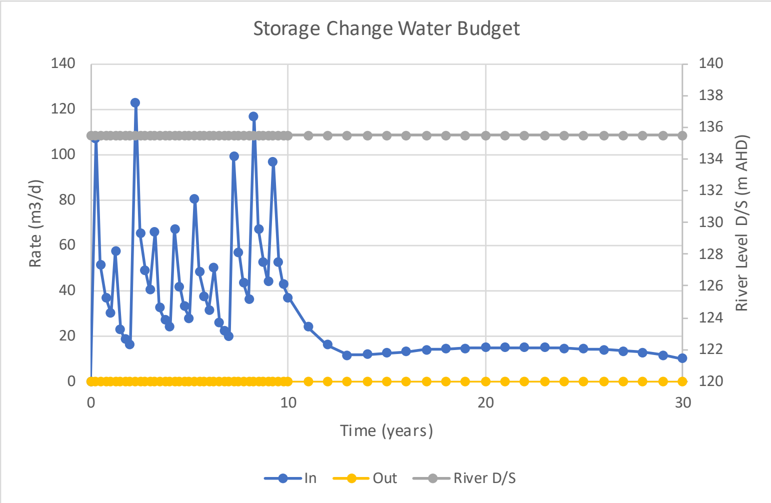
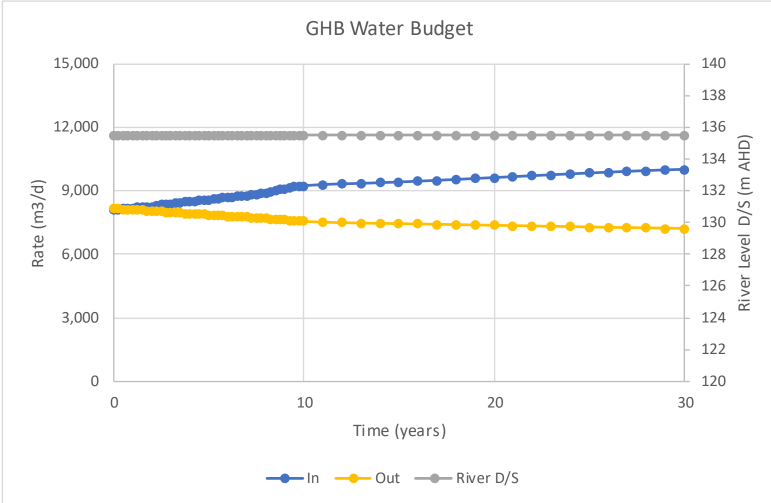
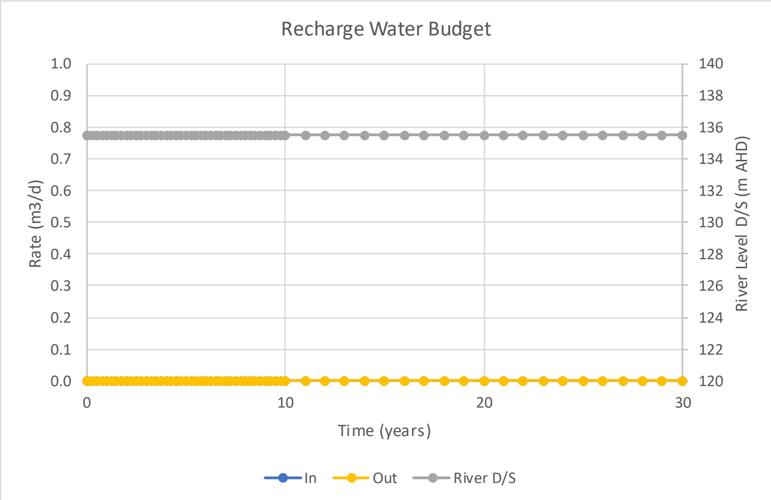
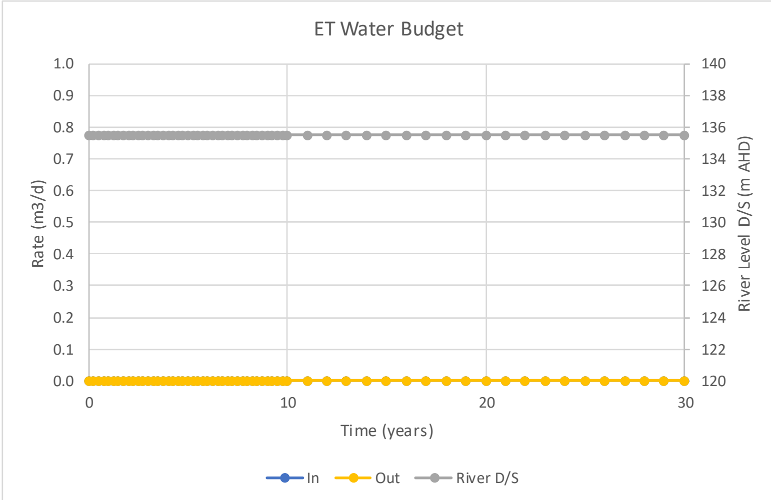


FIGURE 27: MODEL EXPANSION PERIOD LAYER 1 WATER BUDGET


Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S


GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (years)
In
Out
River D/S

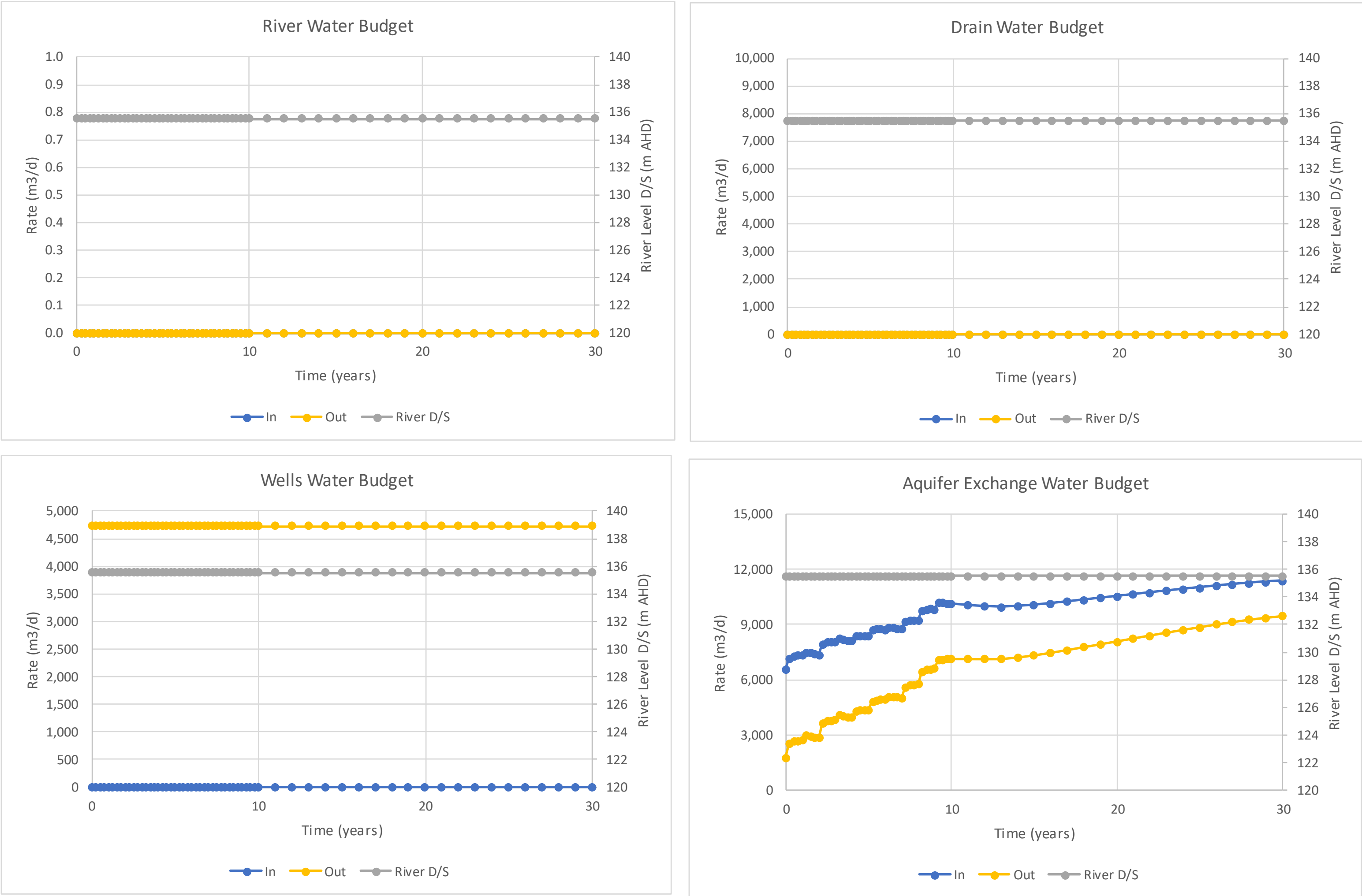


FIGURE 28: MODEL EXPANSION PERIOD LAYER 2 WATER BUDGET

9.2 Recovery Period

A 50 year recovery period was modelled as 1 Stress Period with 20 time steps and a time step multiplier of 1.3 during which time all pits were modelled as high K / high S_Y (10^3 m/d / 1.0) zones. A nett negative recharge was applied to each pit to integrate evaporative discharge (assuming a 60% pan factor) and rainfall recharge. These are detailed in Table 14 below. No irrigation extraction from the pits was considered.

TABLE 14: MODELLED RECOVERY PERIOD NETT DISCHARGE FROM PITS

Pit stage	Approximate Pit Area (ha)	Nett evaporative loss (m/d)	Evaporative loss (ML/d)	Evaporative loss (ML/a)
1	7	-0.0009	0.065	24
2	6	-0.0009	0.056	20
3	4	-0.0009	0.037	14
4(ab)	8	-0.0009	0.074	27
4(cde)	16	-0.0009	0.148	54
Totals	41		0.380	139

The modelled drawdown contours for Layer 1 at the end of the recovery period are shown below on Figure 29. These indicate that a long term area of drawdown up to 1 m due to evaporative discharge from the open pits is established in layer 1. The long term residual drawdowns in layer 2 are modelled to be less than 0.1 m across the site.

The model results also indicate that:

- The layer 1 groundwater contours and flow directions are locally modified by evaporative discharge from the pits but with generally throughflow conditions maintained (Figure 30).
- There are no modelled long term effects on layer 2 groundwater levels and flow directions (Figure 31).

Modelled water budgets for the Project and dewatering periods are shown on Figure 32 and Figure 33. Model convergence criteria and solver settings are included in Appendix E.

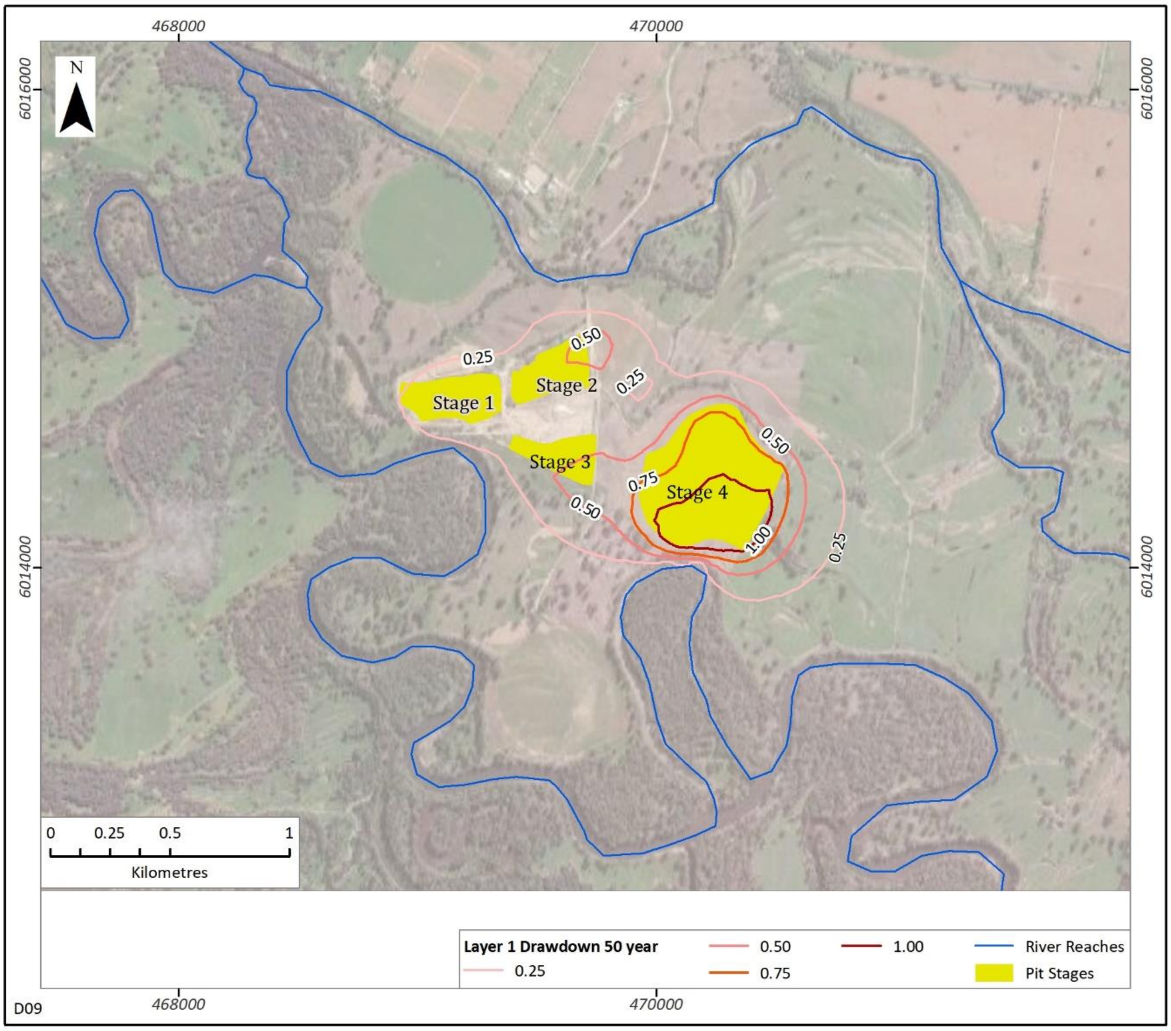


FIGURE 29: LAYER 1 RECOVERY DRAWDOWN

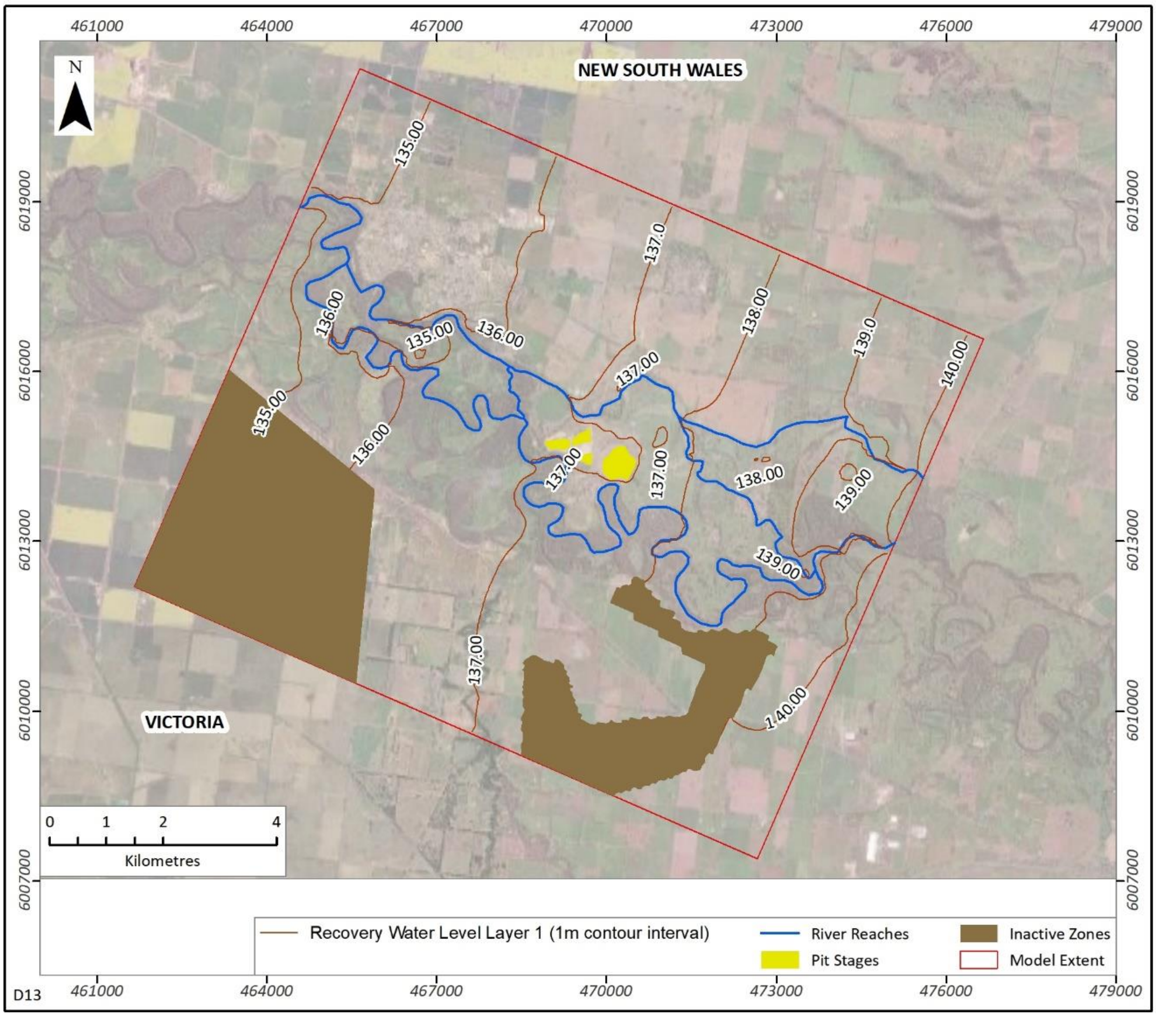


FIGURE 30: LAYER 1 RECOVERY GROUNDWATER CONTOURS – NO IRRIGATION

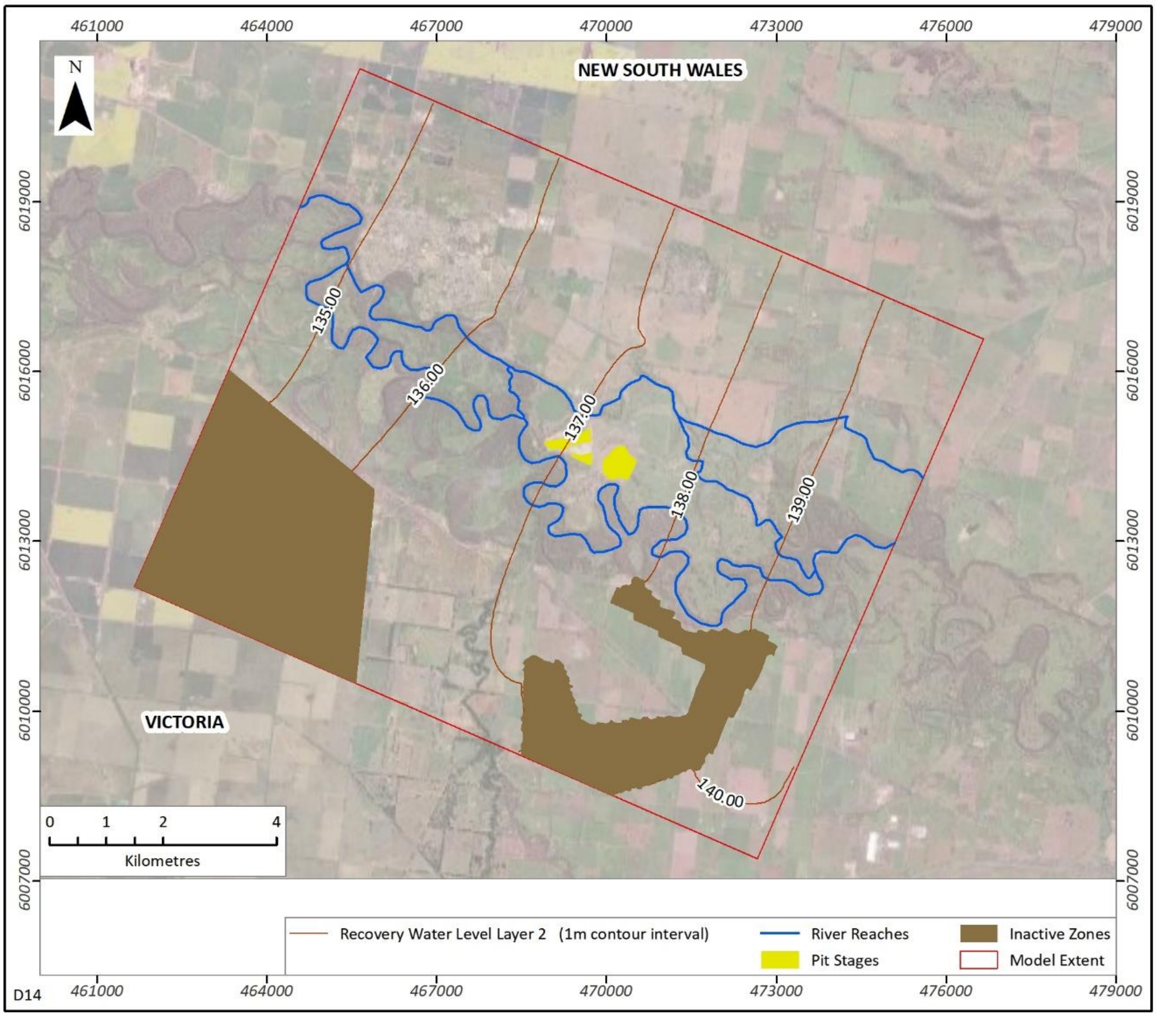
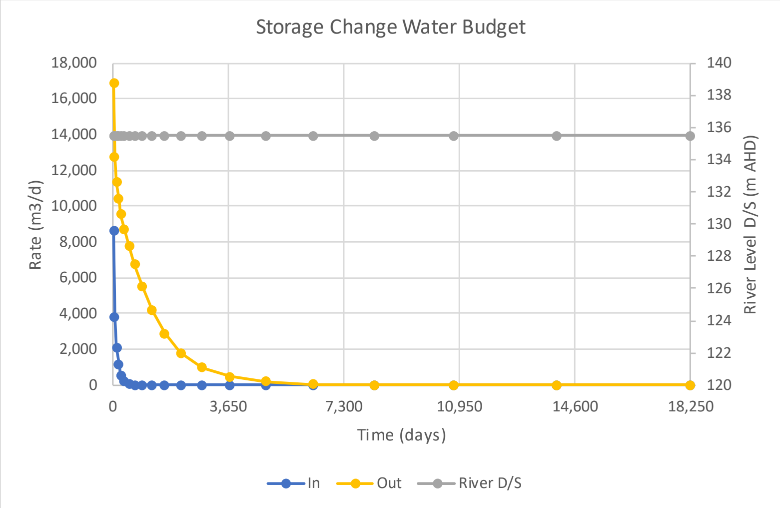
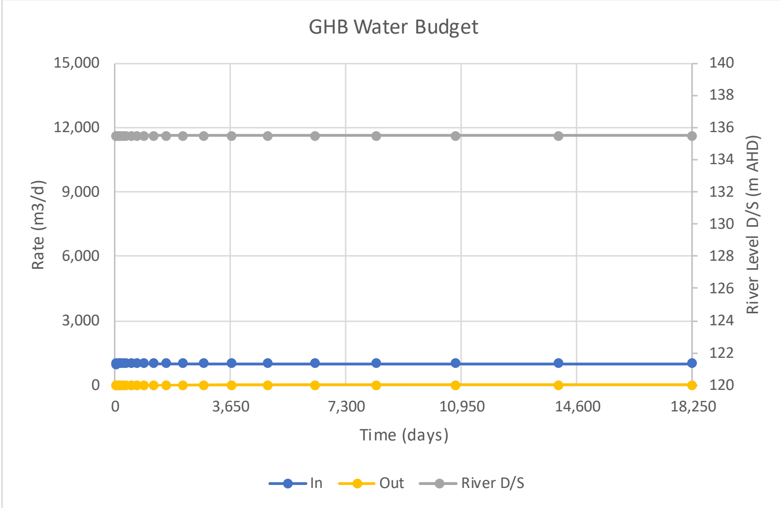
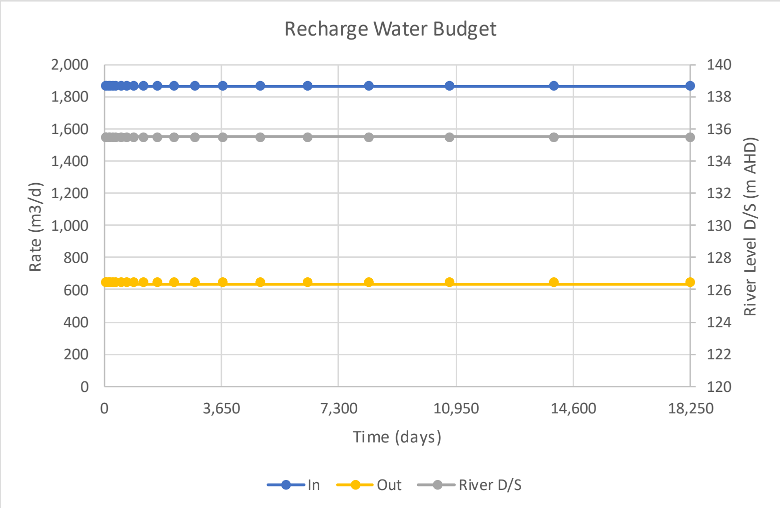
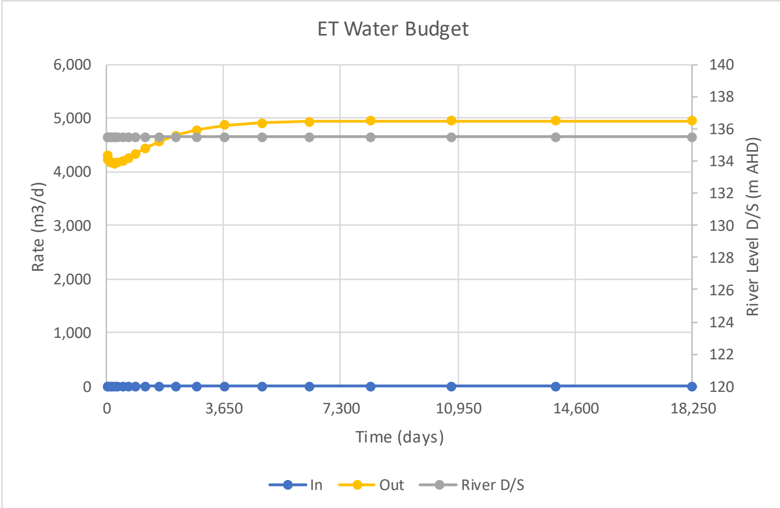


FIGURE 31: LAYER 2 RECOVERY GROUNDWATER CONTOURS – NO IRRIGATION


Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S

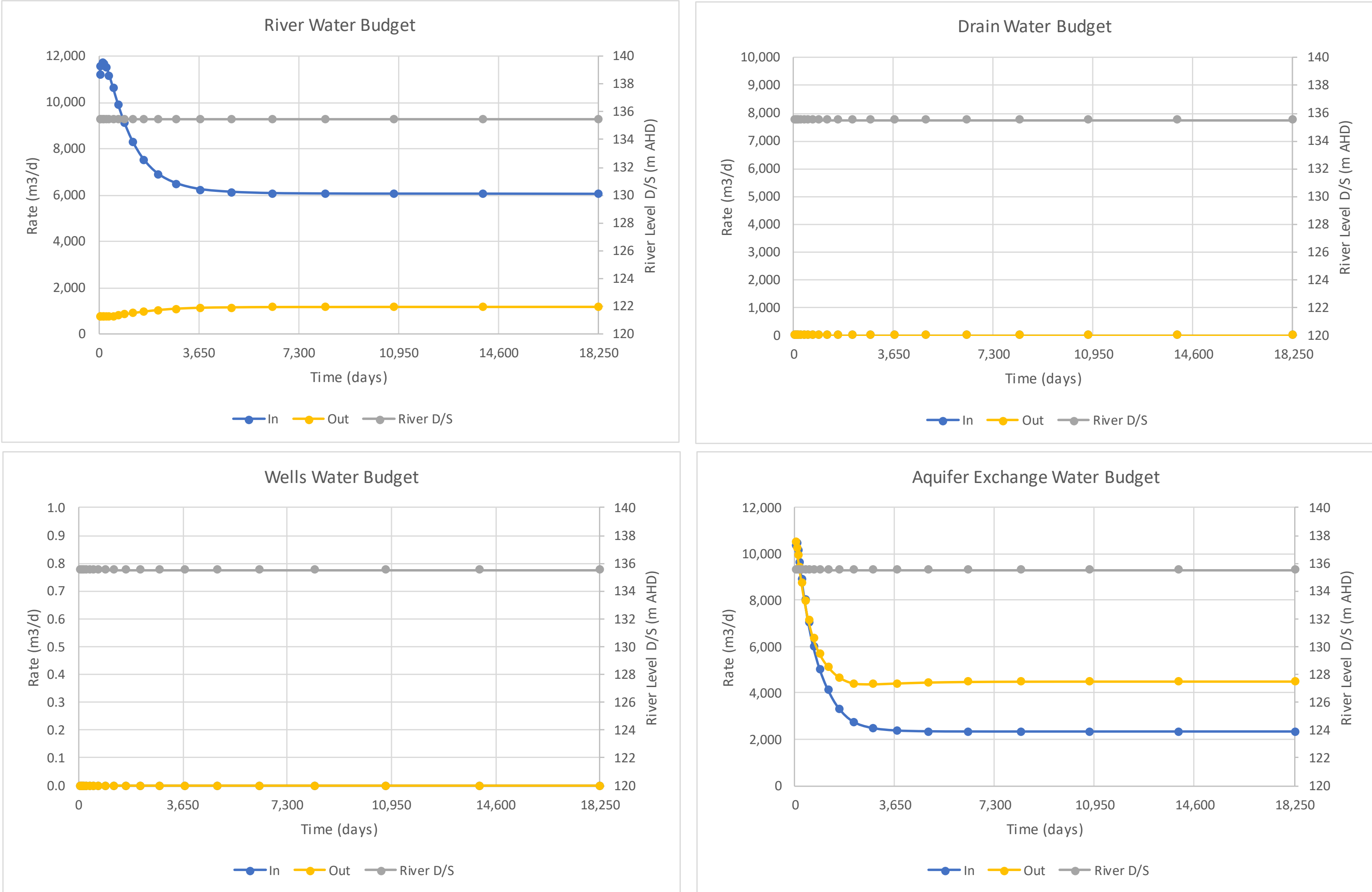
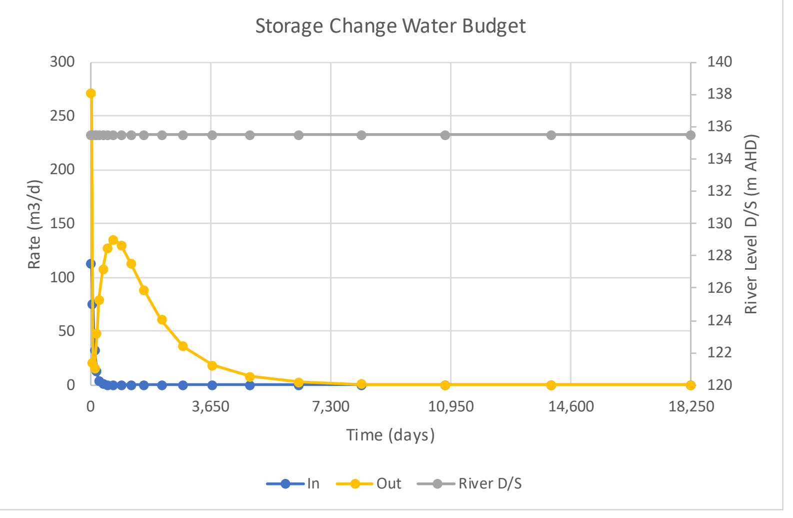
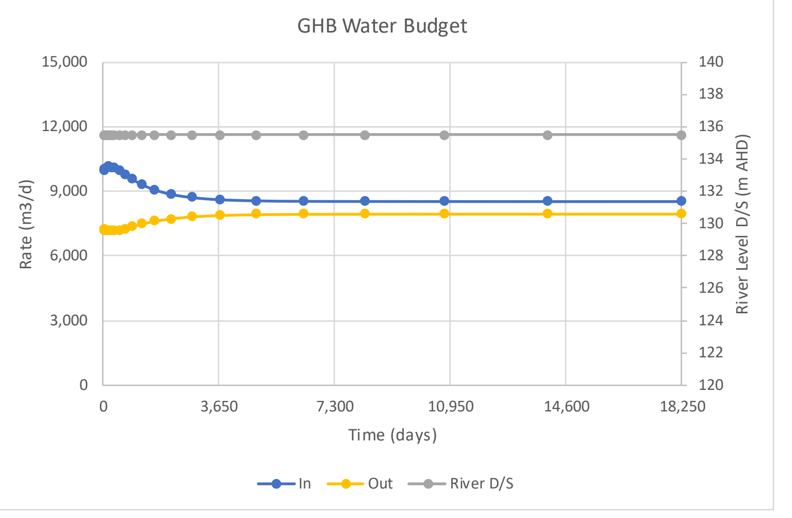
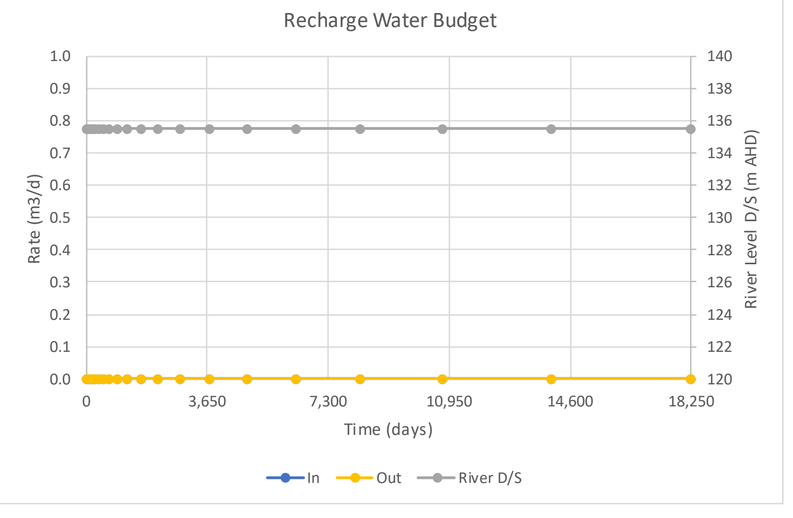
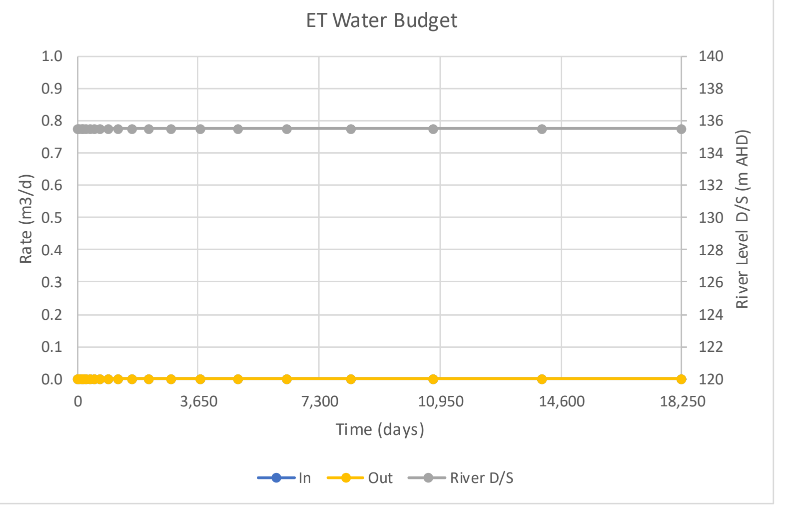


FIGURE 32: MODELLED LAYER 1 RECOVERY STAGE WATER BUDGETS


Storage Change Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


GHB Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


Recharge Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S


ET Water Budget
Rate (m3/d)
River Level D/S (m AHD)
Time (days)
In
Out
River D/S

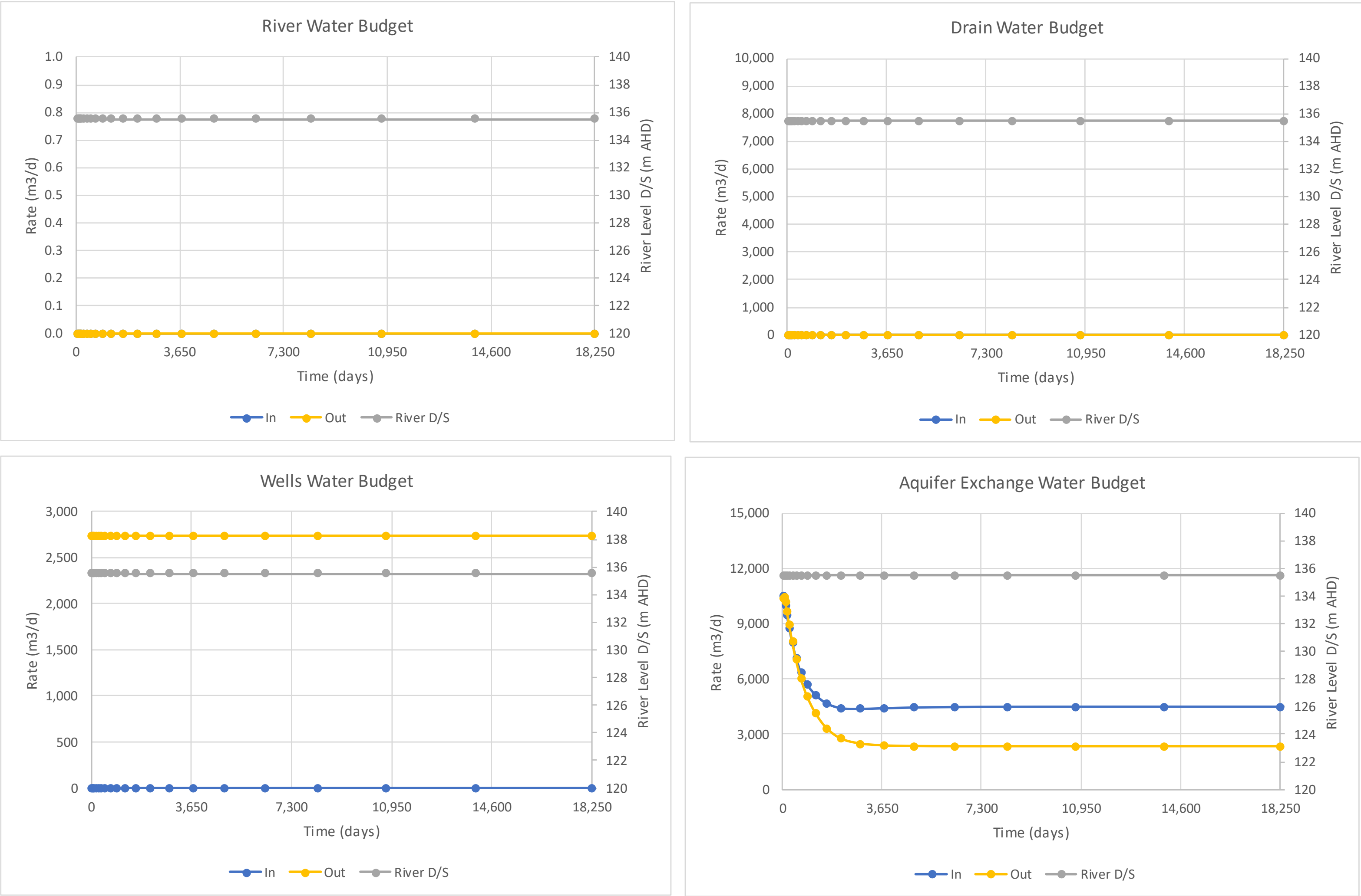


FIGURE 33: MODELLED LAYER 2 RECOVERY STAGE WATER BUDGETS

10 Model Uncertainty

The model runs undertaken during this Stage 2 modelling, and previously for the Stage 1 modelling, have multiple inputs with various degrees of uncertainty related to each. These have direct effects on the uncertainty associated with the results produced for the model objectives. Some of the key parameter data gaps which could be addressed include:

- Site monitoring bore time series groundwater level data.
- Site specific aquifer testing.
- Murray River level monitoring adjacent the site.
- Transient pit water level monitoring.
- Detailed monitoring and documentation of site water balance management.

An additional source of uncertainty is climatic variations into the future which could influence water releases from upstream storage and therefore river levels adjacent the Quarry and river-aquifer interactions. Regional groundwater recharge could also be affected. The predictive phase of the model has assumed values for average river levels and recharge rates which may be highly variable into the future.

The modelling indicates that the drawdown extents of 0.5 m or more at the end of the expansion stage are constrained to the floodplain between the Murray River and Black Swan Anabranch and are concentrated around the pit areas. The model provides an indication of the changes to river discharge to the aquifer due to the Project with sensitivity to riverbed conductance tested during model sensitivity analysis.

The aquifer parameters which are likely to influence regional impacts and near field fluxes are probably of most influence. In the absence of site-specific data, these parameters have been tested in the sensitivity work.

11 Model Capabilities and Limitations

The modelling methodology and model code used are considered appropriate for the level of detail required to achieve the stated model objectives and are compatible with the various data inputs, producing model outputs consistent with project requirements.

Model outcome uncertainty and data limitations are described previously in Section 8 and based on this the main focus of additional data collection would be on site specific time series groundwater and pit water level data, aquifer testing and detailed documentation of the site water balance management.

The stage 2 model is not considered suitable for detailed predictive assessments of small scale (<0.5m) drawdown estimates, seasonal or less-than-annual itemised groundwater budget accounting including river leakage due to dewatering operations, transient interactions between the various hydrogeological stresses on a less-than-annual scale or for detailed design of dewatering requirements.

12 Conclusions and Recommendations

The numerical groundwater model described in this report is consistent with the description of a Class 1 / Class 2 model as defined in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012). The model is considered suitable to achieve the stated modelling objectives of estimating:

- The average annual rates of groundwater pumping required to dewater each of the pits to the design pit depths.
- The extent and magnitude of drawdown associated with dewatering the pits.
- The effects of pit dewatering on groundwater levels at nearby ecological receptors and nearby groundwater users.
- The effects of the pit dewatering operations on the average annual discharge of water from the Murray River into the Shepparton Formation, within the assumptions made regarding future average river levels.
- The long-term pit lake recovery levels following cessation of quarrying operations and the provision of data to enable the likely long term salinity effects within each pit lake to be estimated.

This model class and suitability for purpose are supported by the following outcomes:

- An SMSR of 5% between measured and modelled monitoring bore data.
- The estimated groundwater inflow to Pit 1 of 1.5 ML/d is modelled as 1.6 ML/d which supports the adopted values for hydraulic conductivity (1 m/d) and specific yield (11%) for the Shepparton Formation as being reasonable.
- The observed groundwater level responses to river level in observed monitoring bore data are reasonably matched by the modelled responses where it is appropriate to make a direct comparison, for example where the measured groundwater levels are not affected by unidentified influences such as nearby irrigation extraction.
- The modelled trends and magnitudes of responses to river level changes provide further support that the adopted hydraulic parameter values for the Shepparton Formation, the Lachlan Formation and riverbed conductance are reasonable.
- A comprehensive set of sensitivity model runs were carried out and these further supported the adoption of the base case model hydraulic parameters.

The modelled dewatering requirements and evaporative losses for the various stages range from 85 ML/a to 1,776 ML/a over the 30 year simulation period. Analysis of the model water budgets indicate that discharge from the Murray River to the Upper Murray Alluvium is increased on average by 217 ML/a during Stages 1, 2 and 3, 335 ML/a for Stage 4(ab) and 453 ML/a for Stage 4(cde). The corresponding average reductions in discharge from the Upper Murray Alluvium to the Murray River are 85 ML/a during Stages 1, 2 and 3, 129 ML/a for Stage 4(ab) and 148 ML/a for Stage 4(cde). When combined, these reduced rates of discharge result in a maximum annual loss of 1,002 ML/a from the Murray River during the final year of the Stage 4(cde) expansion (refer Appendix F).

The modelled drawdown in excess of 0.5 m in the Shepparton Formation at the end of the 30 year expansion period is constrained to the floodplain area between the Murray River and the Black Swan anabranch. Pressure reduction in the Lachlan Formation is modelled to be less than 1 m within the Stage 4 area. In the longer term, and without significant extraction from the pits for purposes such as irrigation supply, pit water levels will recover to between 0.4 m and 0.9 m of pre-expansion groundwater levels with slight modifications to the flow field in the Shepparton Formation within the vicinity of the pits due to evaporative discharge. There are no significant modelled long-term effects on groundwater levels and flow directions in the Lachlan Formation. General throughflow conditions will be maintained throughout this section of the floodplain. Separate salt and water balance modelling of the pit lakes (Water Technology, 2021) indicate that for the no irrigation extraction scenario, evaporative discharge from the pits could create long term salinity increases within the lakes in the order of 10 mg/L per year. This estimate should be considered as indicative only as the actual long term salinity regime within the excavated pits will depend on a range of factors including climate, aquifer parameters, excavated pit dimensions and long-term pit management. An assessment of the impacts on existing groundwater users is discussed further in Water Technology (2021).

The modelling also indicates that areas of potential instability are established where the pits are excavated in close proximity to the Murray River due to steep hydraulic gradients induced by pit dewatering. These should be considered in the engineering design of the pit slopes and in the general excavation and dewatering activities associated with the Project.

It is recommended that a comprehensive site water management and monitoring plan be developed and implemented as soon as practicable. This should include the measurement of all aspects of site water management including groundwater and surface water.

13 References

Advanced Environmental Systems. *Appendix 8B. Resource Assessment Howlong Sand and Gravel*.

Australian Government Bureau of Meteorology, Groundwater Dependent Ecosystem Atlas. http://www.bom.gov.au/water/groundwater/gde/map.shtml, July 2019.

Barnett et al (2012). *Australian Groundwater modelling Guidelines*. Waterlines Report, National Water Commission, Canberra.

Chiang, W. and Kinzelbach, W. (1998). *Processing Modflow. A Simulation System for Modelling Groundwater Flow and Pollution*.

Department of Industries (2019). *Murray Alluvium Water Resource Plan. Groundwater Resource Description.* NSW Department of Industries, June 2019.

Department of Water Resources (1992). *Jerilderie Hydrogeological Map (1:250 000 scale).* Australian Geological Survey Organisation, Canberra, Australia.

Doherty, J. (2000). *PEST – Model-independent Parameter Estimation*. User's Manual. Watermark Computing, Australia.

Driscoll, F. (1986). *Groundwater and Wells.* Johnson Filtration Systems Inc.

Freeze, R. and Cherry, J. (1979). *Groundwater.* Prentice Hall, Inc.

Geoscience Australia (2020). *Australian and Region Surface Geology.* *http://maps.ga.gov.au/interactive-maps/#/theme/minerals/map/geology*. Australian Government.

Gutteridge Haskins & Davey Pty. Ltd., Cameron McNamara Pty. Ltd. Laurie Montgomerie and Pettit Pty. Ltd. Murray (1986). *River Flood Plain Atlas*. Rural Water Commission of Victoria Water Resources Commission of New South Wales.

Harbaugh, A.W. and McDonald, M.G. (1996). *User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model*. USGS Open-File Report 96-485.

Hennessy, J. et al (1994). *WANGARATTA Hydrogeological Map (1:250,000 scale).* Murray Basin Hydrogeological Map Series, Australian Geological Survey Organisation, Canberra.

Johnson, A. (1967). *Specific Yield – Compilation of Specific Yields for Various Materials.* US Geological Survey Water Supply Paper 1662-D.

Kulatunga N. (2009). *Upper Murray Alluvium, Groundwater Management Area 015: Albury to Corowa, Groundwater Resources Status Report – 2008*. NSW Department of Water and Energy, Sydney.

Parsons, S, Evans, R and Hoban, M (2008). *Surface–groundwater Connectivity Assessment*. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia.

Ross, J. (1999). *Sustainable Yield Estimates for High Risk Aquifers in NSW*. NSW Dept of Land & Water Conservation.

Shah, N., Nachabe, M. and Ross, M. (2007). *Extinction Depth and Evapotranspiration from Ground Water under Selected Land Covers.* GROUND WATER, Vol. 45, No. 3, pages 329–338. National Ground Water Association, May – June, 2007.

Water Sharing Plan for the Murray Unregulated and Alluvial Water Sources 2011.

Water Technology (2021). *Groundwater Assessment Howlong Quarry Expansion – Groundwater Assessment and Numerical Modelling*. Fraser Earthmoving Construction, In prep.

WatSec Environmental (2020). *Howlong Quarry Expansion. Documentation of Stage 1 Groundwater Model*. Draft prepared for Water Technology, September 2020.

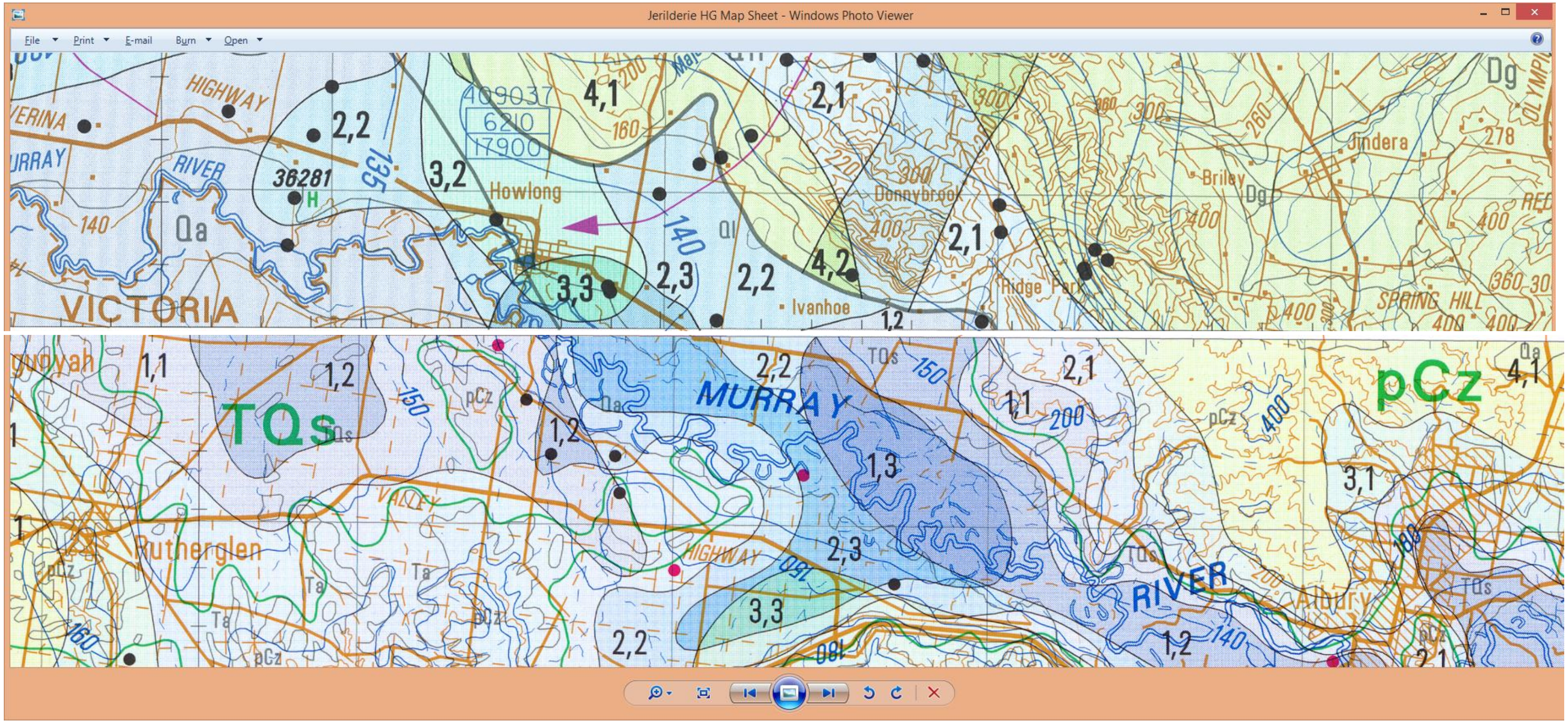
Williams R.M. (1989). *Groundwater Resources of the Unconsolidated Sediments Associated with the Murray River Between Albany and Corowa, NSW*. Water Resources Commission Technical Services Report 89.001.

Wilson, N., Tickle, P.K., Gallant, J., Dowling, T., Read, A. 2011. *1 second SRTM Derived Hydrological Digital Elevation Model (DEM-H) version 1.0.* Record 1.0.4. Geoscience Australia, Canberra.

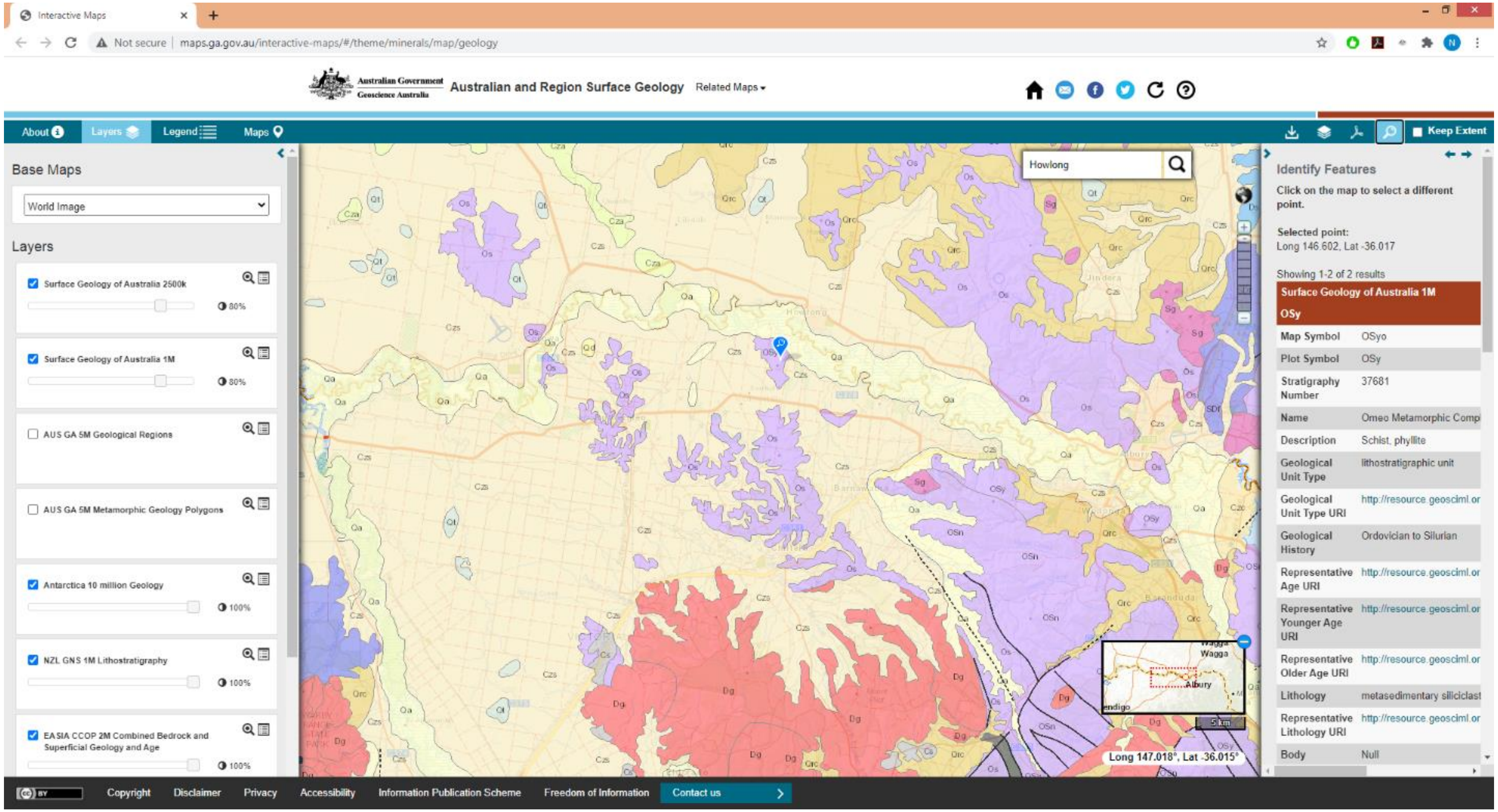
Appendix A

Hydrogeological and Geological Map Extracts

Extracts from Wangaratta and Jerilderie 1:250 000 Hydrogeological Maps

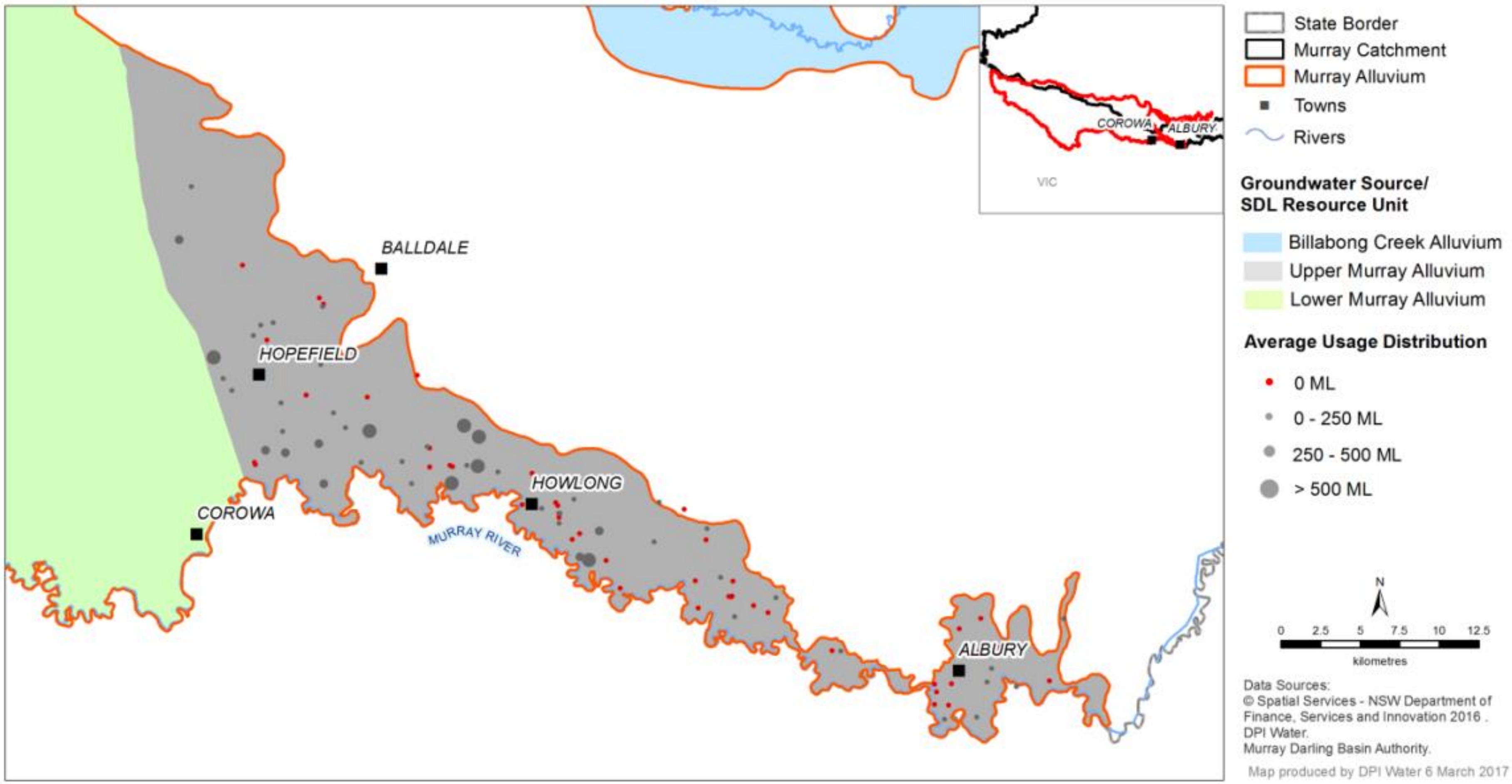


Extract from Geoscience Australia geological map



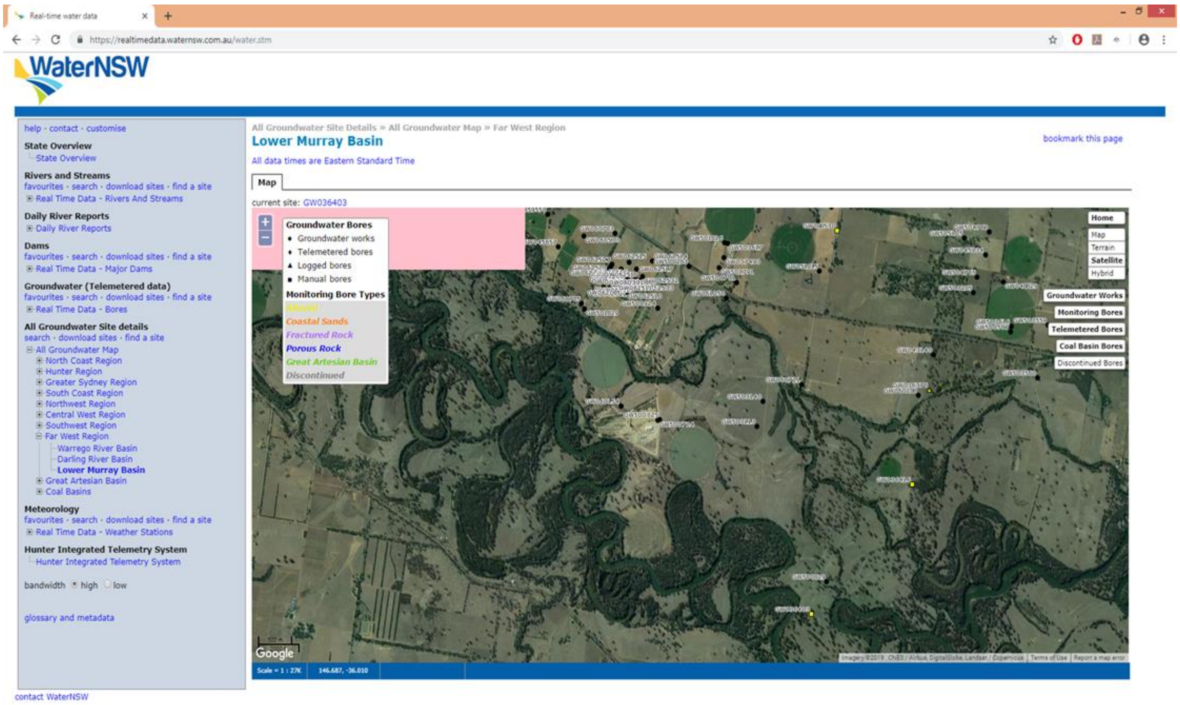
Appendix B

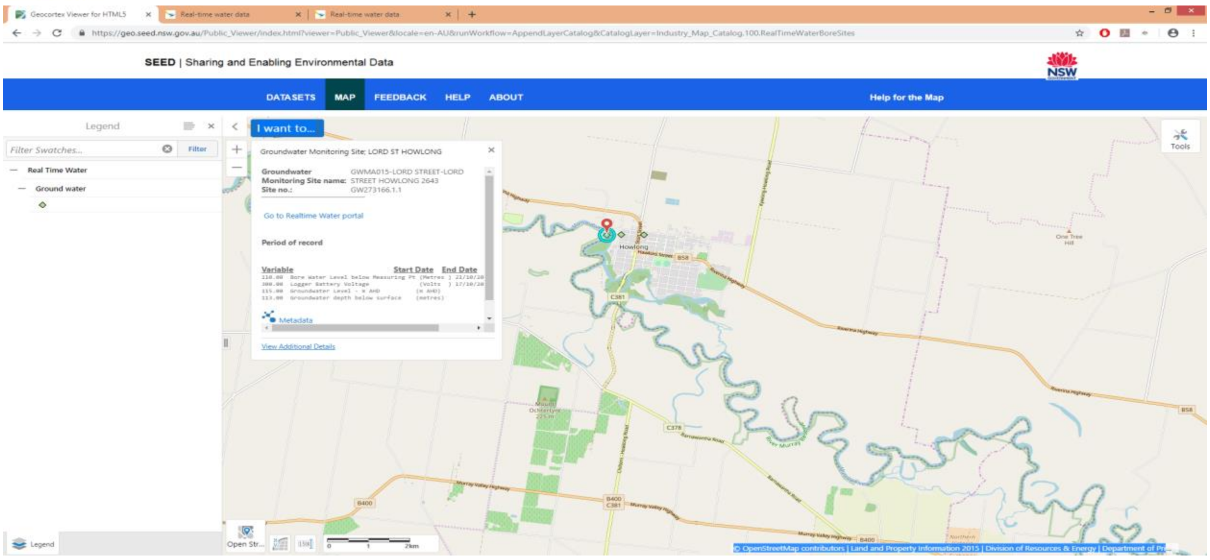
Irrigation Extraction Data

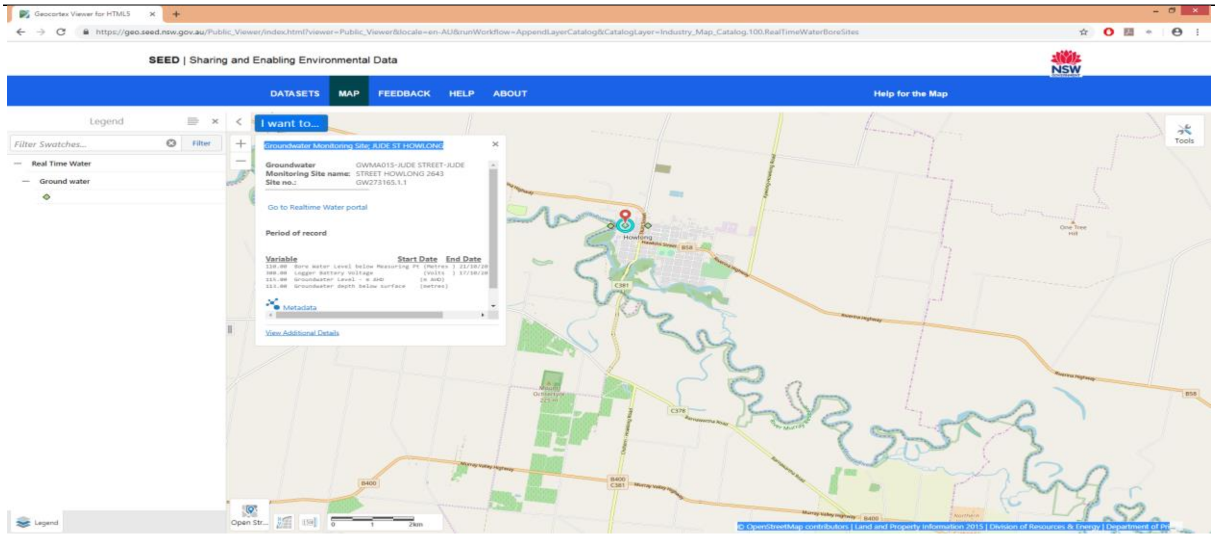

BALLDALE
HOPEFIELD
HOWLONG
COROWA
MURRAY RIVER
ALBURY
COROWA
ALBURY
VIC
State Border
Murray Catchment
Murray Alluvium
Towns
Rivers
Groundwater Source/
SDL Resource Unit
Billabong Creek Alluvium
Upper Murray Alluvium
Lower Murray Alluvium
Average Usage Distribution
0 ML
0 - 250 ML
250 - 500 ML
> 500 ML
N
0 2.5 5 7.5 10 12.5
kilometres
Data Sources:
© Spatial Services - NSW Department of Finance, Services and Innovation 2016 .
DPI Water.
Murray Darling Basin Authority.
Map produced by DPI Water 6 March 2017

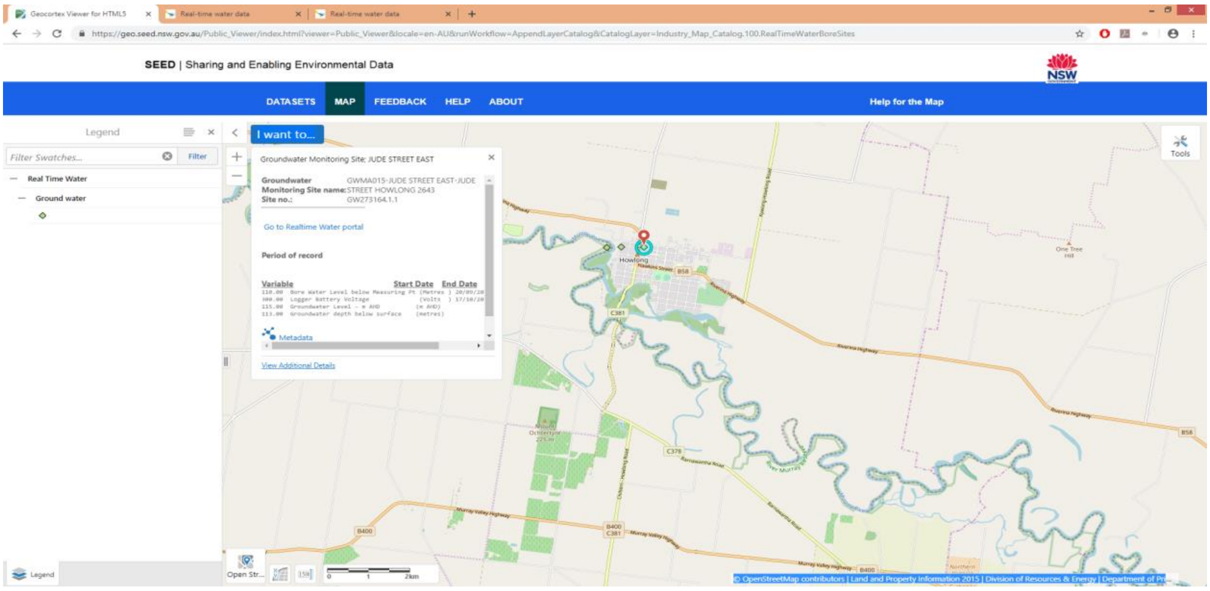
Appendix C

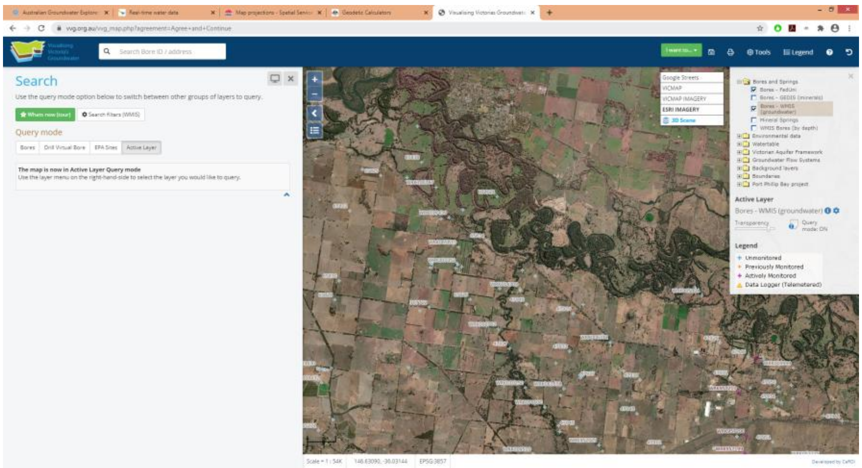
NSW and Victoria Monitoring Bore Database Search Records


WaterNSW
Lower Murray Basin
All data times are Eastern Standard Time
bookmark this page
State Overview
Rivers and Streams
Daily River Reports
Dams
Groundwater (Telemetered data)
All Groundwater Site details
Meteorology
Hunter Integrated Telemetry System
Groundwater Bores
Monitoring Bore Types
Coastal Sands
Fractured Rock
Porous Rock
Great Artesian Basin
Discontinued
Groundwater Works
Monitoring Bores
Telemetered Bores
Coal Basin Bores
Discontinued Bores
glossary and metadata
contact WaterNSW


SEED | Sharing and Enabling Environmental Data
DATASETS
MAP
FEEDBACK
HELP
ABOUT
Help for the Map
Legend
Real Time Water
Ground water
I want to...
Groundwater Monitoring Site: LORD ST HOWLONG
Go to Realtime Water portal
Period of record
Variable
Start Date
End Date
Metadata
View Additional Details
Howlong
NSW


SEED | Sharing and Enabling Environmental Data
DATASETS
MAP
FEEDBACK
HELP
ABOUT
Help for the Map
Legend
Real Time Water
Ground water
I want to...
Groundwater Monitoring Site: JUDE ST HOWLONG
Go to Realtime Water portal
Period of record
Variable
Start Date
End Date
Metadata
View Additional Details
Howlong
Tools

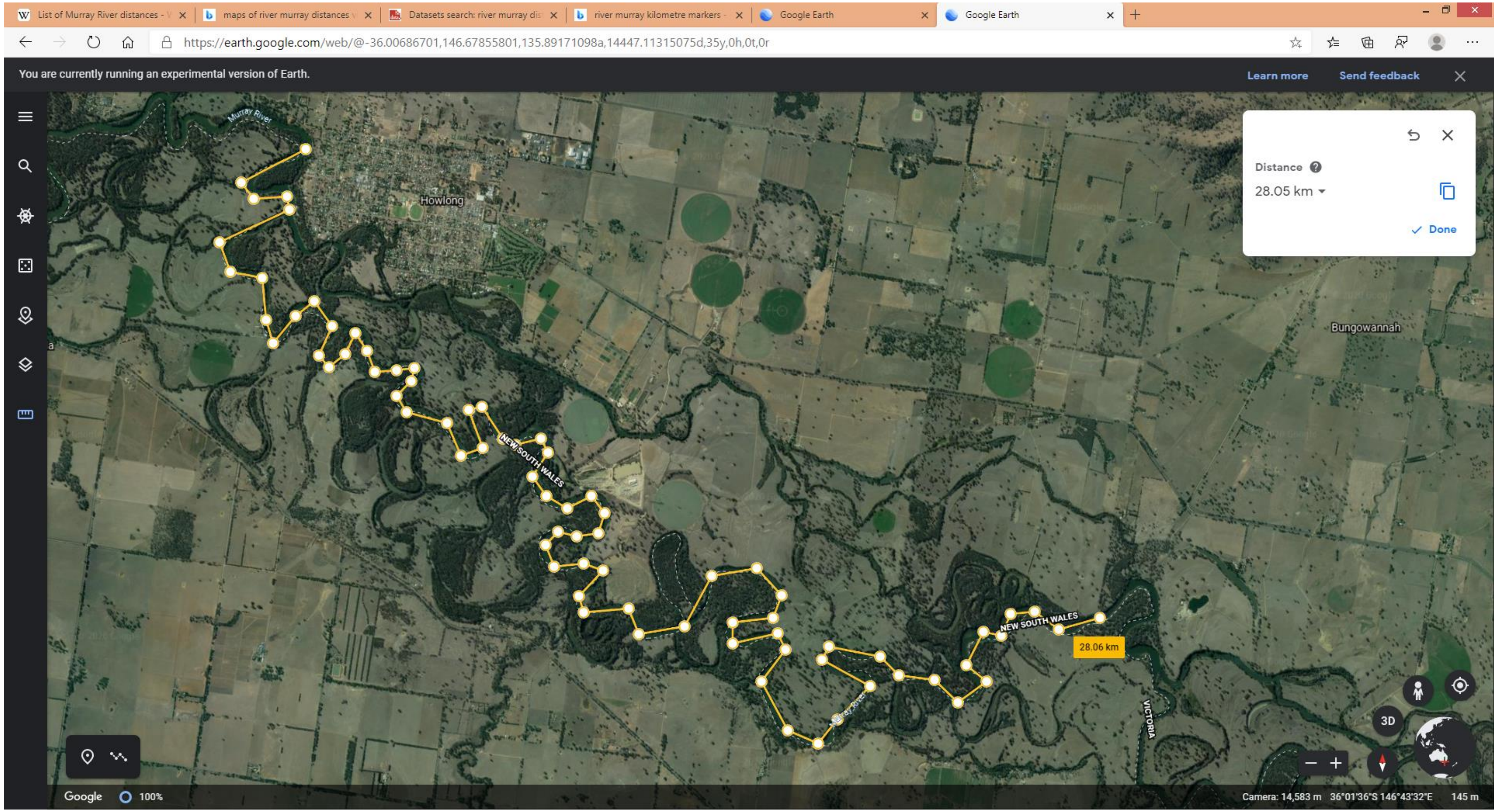

SEED | Sharing and Enabling Environmental Data
DATASETS
MAP
FEEDBACK
HELP
ABOUT
Help for the Map
Legend
Real Time Water
Ground water
I want to...
Groundwater Monitoring Site: JUDE STREET EAST
Go to Realtime Water portal
Period of record
Variable
Start Date
End Date
Metadata
View Additional Details
Howlong
Tools

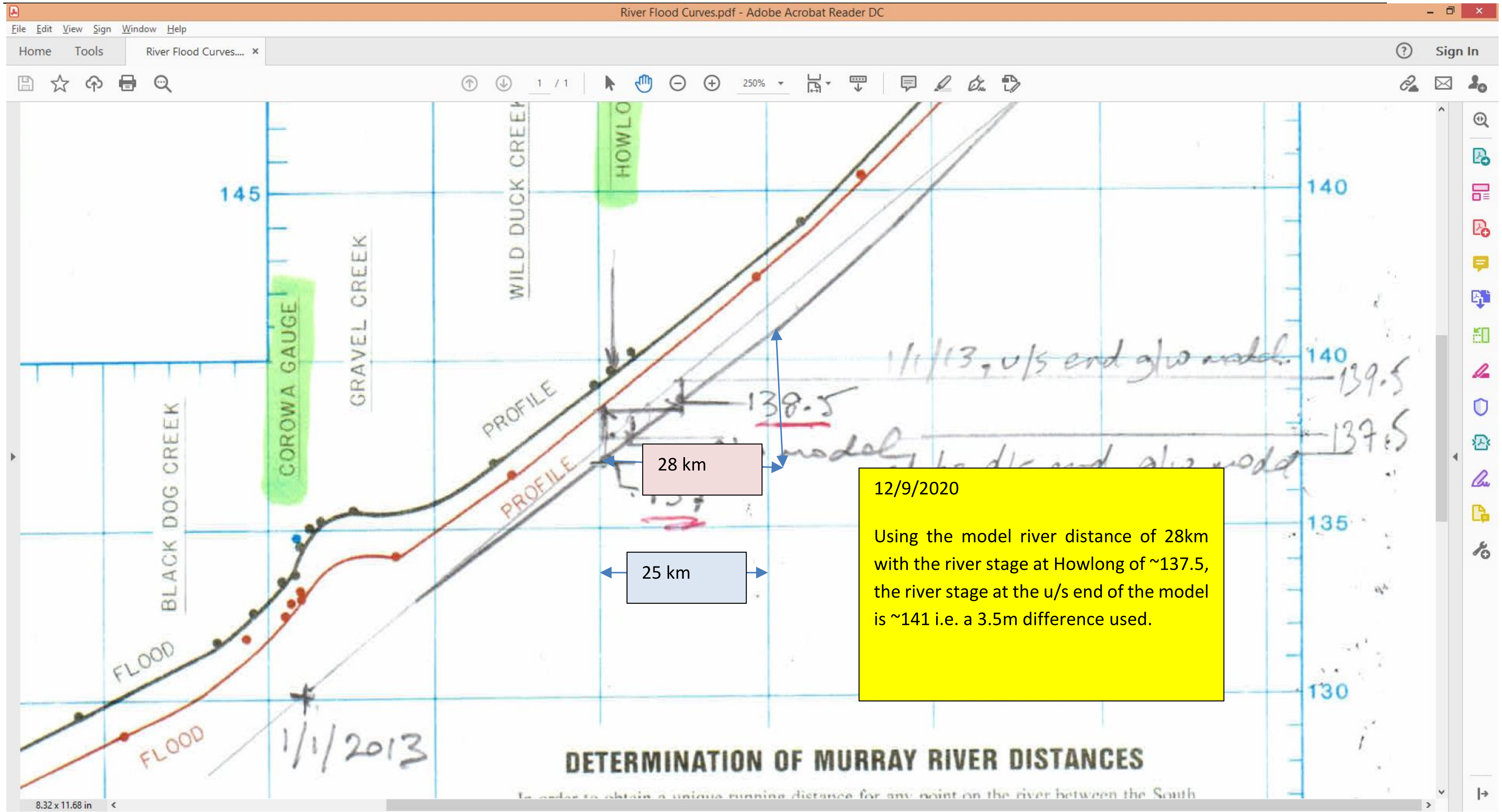

Search
Query mode
Active Layer
Legend

Appendix D

River Level Interpolation

Model river distance (Google Earth)

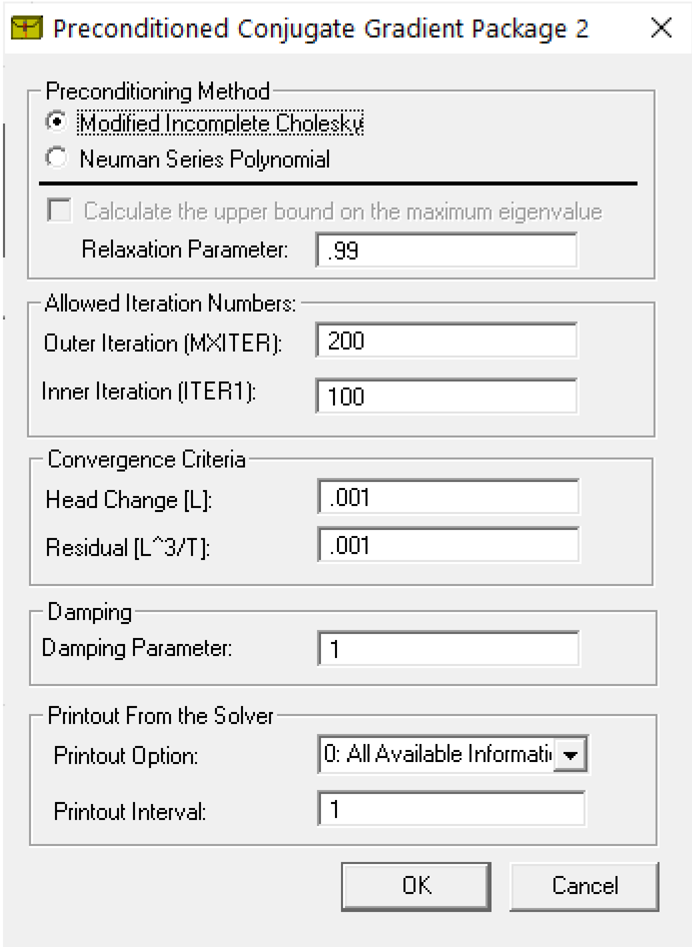



River Flood Curves.pdf - Adobe Acrobat Reader DC
BLACK DOG CREEK
COROWA GAUGE
GRAVEL CREEK
WILD DUCK CREEK
HOWLONG
145
140
140
135
130
FLOOD
FLOOD
PROFILE
PROFILE
138.5
139.5
137.5
1/1/2013
28 km
25 km
DETERMINATION OF MURRAY RIVER DISTANCES
12/9/2020
Using the model river distance of 28km with the river stage at Howlong of ~137.5, the river stage at the u/s end of the model is ~141 i.e. a 3.5m difference used.

Appendix E

Model Solver and Convergence Criteria

The PCG2 solver was adopted for all model runs with the convergence criteria as shown below.



Calibration Stage

The water balance discrepancy range was between -0.37% and 1% for 95% of the time steps, within the 1% target suggested in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012, Table 5-1). The remainder of time steps were between 1% and 2.23%.

Predictive Stage

The water balance discrepancy range of -0.04% to 0.00% is within the 1% target suggested in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012, Table 5-1).

Recovery Stage

The water balance discrepancy range of -0.08% to 0.01% is within the 1% target suggested in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012, Table 5-1).

Appendix F

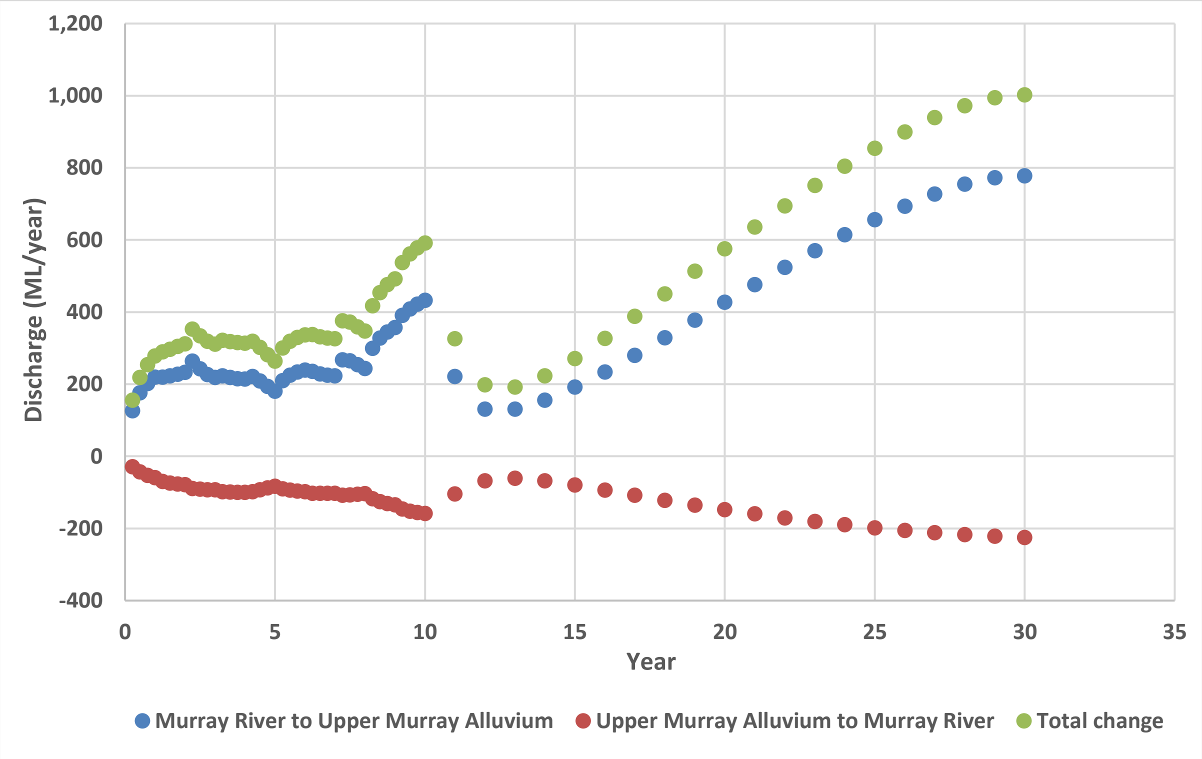
Modelled Surface Water – Groundwater Interactions

Table F1: Modelled Discharge Rates

Year	Month	Murray River to Upper Murray Alluvium (ML/a)	Upper Murray Alluvium to Murray River Change into River (ML/a)	Total Change	
				(m³/d)	(ML/a)
1	3	126	29	426	155
1	6	176	43	600	219
1	9	202	53	697	254
1	12	219	59	763	279
2	15	220	70	794	290
2	18	223	74	814	297
2	21	228	77	834	305
2	24	233	79	854	312
3	27	264	89	966	353
3	30	243	91	916	334
3	33	227	92	874	319
3	36	219	93	853	311
4	39	223	98	880	321
4	42	219	99	871	318
4	45	215	100	863	315
4	48	214	100	860	314
5	51	221	98	874	319
5	54	209	93	827	302
5	57	194	88	771	281
5	60	181	83	723	264
6	63	210	90	822	300
6	66	225	94	874	319
6	69	234	96	904	330
6	72	239	98	923	337
7	75	236	102	925	338
7	78	229	103	908	331
7	81	225	103	897	328
7	84	223	103	892	326
8	87	267	108	1,029	376
8	90	265	107	1,020	372
8	93	254	105	984	359
8	96	244	103	951	347
9	99	300	118	1,143	417
9	102	328	126	1,243	454
9	105	345	131	1,304	476
9	108	357	135	1,348	492
10	111	391	146	1,472	537
10	114	409	152	1,537	561
10	117	422	156	1,583	578
10	120	432	159	1,619	591
11	132	222	104	893	326
12	144	130	68	543	198
13	156	131	61	526	192
14	168	156	68	612	223
15	180	192	79	743	271
16	192	234	93	897	327
17	204	280	108	1,063	388
18	216	329	122	1,234	450
19	228	378	135	1,406	513
20	240	427	148	1,576	575
21	252	476	160	1,742	636
22	264	524	171	1,903	695

Year	Month	Murray River to Upper Murray Alluvium (ML/a)	Upper Murray Alluvium to Murray River Change into River (ML/a)	Total Change (m³/d)	Total Change (ML/a)
23	276	570	181	2,057	751
24	288	614	190	2,203	804
25	300	656	198	2,339	854
26	312	694	205	2,464	899
27	324	728	212	2,573	939
28	336	755	217	2,662	972
29	348	773	222	2,725	994
30	360	778	225	2,746	1,002

Figure F1: Modelled Discharge Rates



WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX B
INDEPENDENT PEER REVIEW OF GROUNDWATER MODELLING REPORT (HYDROGEOLOGIST.COM.AU, 2021)

hydrogeologist.com.au

REPORT ON

Howlong Quarry Expansion

Numerical Groundwater Impact Assessment Model

Third-Party Review

For: R.W. Corkery Pty Ltd

Project number: 4060
Date: 15/09/2021

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Howlong Quarry Expansion – Numerical Groundwater Impact Assessment Model

Third-Party Review

Prepared for

R.W. Corkery Pty Ltd

1. Introduction

A groundwater assessment has been developed to consider the impact of increased (staged) production at the Howlong Sand and Gravel Quarry (the Project) from 30,000 tpa to 300,000 tpa. The Project is located within the Murray River floodplain and accesses the Upper Murray Aquifer groundwater system. The proposed Project is a "State Significant Development" (SSD) as defined under the State Environmental Planning Policy (SEPP) (State and Regional Development) (SRD) 2011 and will require development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Groundwater impacts of the proposed quarry expansion have been assessed through a desktop assessment and numerical groundwater flow model. WatSec Environmental Pty Ltd (WatSec) were engaged by Water Technology Pty Ltd on behalf of Fraser Earthmoving Construction Pty Ltd (FEC) to develop the numerical model to support the groundwater impact assessment for the Project.

hydrogeologist.com.au was engaged by R.W Corkery & Co. Pty Ltd (RWC), on behalf of FEC, to undertake an independent, third-party peer review of the groundwater impact assessment numerical model. This report has been completed by **hydrogeologist.com.au** and provides a third-party review of the groundwater assessment.

1.1. Stakeholders

The stakeholders in the assessment include:

- Water Technology Pty Ltd / Watsec Environmental – consultants responsible for the groundwater assessment and numerical modelling;
- R.W Corkery & Co. – managers of the Project environmental approvals;
- Department of Planning, Industry and Environment – assessor of the Project in relation to groundwater issues; and
- Fraser Earthmoving Construction Pty Ltd – Project proponent.

1.2. Review objectives

The objective of the third-party review is to carry out a review and provide a peer review report suitable for use as a supporting document for the groundwater assessment in the public domain.

The review has been carried out in consideration of the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). The review against the modelling guidelines has not considered model or electronic files.

1.3. Review methodology

In September 2020, hydrogeologist.com.au carried out an initial review of the Stage 1 Numerical Groundwater Impact Assessment Model completed by WatSec and provided feedback to RWC. The initial review was carried out in consideration of the Australian Groundwater Modelling Guidelines (Barnett *et al*., 2012). The initial review documented several areas in the model report where additional information was required to fully assess the suitability of the model for impact assessment purposes. The Stage 2 Numerical Groundwater Impact Assessment Model has considered the feedback from the initial review, and it is on this Stage 2 report (the report) that the third-party review is based.

Section 9 of the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) includes a detailed checklist of eight elements that should be considered as part of a peer review process of a groundwater model. The third-party review has considered these elements in relation to the model purpose, objectives, and confidence level.

The third-party review needs to objectively define whether the numerical model is ‘fit for purpose’. The question as to whether a model is ‘fit for purpose’ should be considered in relation to the stated scope and objective of the study. It is also recognised that the effort put into numerical modelling is highly dependent on timing and budgetary constraints that are not known to the reviewer.

1.4. Qualifications

The review has been carried out by Daniel Barclay of hydrogeologist.com.au, a suitably qualified and experienced hydrogeologist with experience in numerical groundwater modelling. Daniel has over 24 years' experience as a hydrogeologist within the consulting, government and mining sectors, with hydrogeological exposure in Australia, Asia and North America. He has carried out numerous groundwater assessments in Queensland, New South Wales, Victoria, South Australia, Papua New Guinea and Laos. His experience includes:

- conceptualisation, design, supervision and monitoring of groundwater systems;
- groundwater supply operations;
- seepage investigations;
- hydrogeochemical assessments;
- conceptual modelling; and
- numerical modelling (FEFLOW, SEEP/W and MODFLOW).

2. Review findings

2.1. Hydrogeological conceptualisation

The hydrogeological conceptualisation is presented in Section 3 of the WatSec report. This section includes a clear summary of the two hydrostratigraphic units in the region and their hydraulic properties. As expected, there is an appropriate focus on surface water and groundwater interactions along the Murray River which is located immediately adjacent to the proposed quarrying activity.

The presented conceptual model is plausible and whilst it does not present a conceptual water balance, it identifies the water balance components responsible for bulk water movement into, though and out of the aquifers associated with the Project. There are certain aspects of the hydrogeological conceptualisation that could be improved through data collection and these are detailed below.

2.1.1. Data availability

Hydrological, hydrogeological and other data of relevance (e.g. climatic and irrigation) to the groundwater assessment are described in some detail in Section 3 and 4 of the WatSec report. Data and other limitations which have the potential to affect the modelling are discussed in Section 8 of the report.

Groundwater monitoring data was sourced from the relevant NSW and Victorian state data repositories. Several long-term groundwater monitoring bores records are available for the NSW portion of the model domain, however no records exist for the Victorian portion of the model domain. The NSW data is available for both the Shepparton Formation and the Lachlan Formation, with the nearest bores located approximately 3 km to 4 km from the Project area. This data has been used in the numerical model calibration. No site-specific monitoring bores have been installed in the Project area.

Hydraulic parameter data (i.e. hydraulic conductivity, specific yield and specific storage) has been used from regional groundwater studies as no site-specific is available. Whilst not ideal, the hydraulic parameters appear reasonable and have been applied in a bulk sense to the numerical model.

The assessment uses SILO rainfall and evaporation data (both averages and actual data) to inform the recharge and evapotranspiration inputs for the numerical modelling. This approach is valid and is consistent with numerous other impact assessments throughout Australia.

The extraction of groundwater for irrigation purposes has been represented in the model using NSW state data and is applied using average data. There are several simplifying assumptions around the use of this data including the estimated rates compared to allocations and the application of the extraction to the deeper, more permeable Lachlan Formation. These simplifying assumptions are considered appropriate given the scale and objectives of the numerical model.

Groundwater irrigation data and use from the Victorian side of the Murray River was not obtained for this assessment. This Victorian data is not considered essential for the impact assessment as the Murray River would act as a significant groundwater sink and source and would likely nullify any local drawdown that may occur to the south of the Murray River. In summary, the exclusion of the Victorian irrigation bores is considered to be a reasonable simplification and is unlikely to affect the ability of the model to predict project impacts.

However, comments within the report indicate that "irrigation extraction may be affecting some of the monitoring bores on the floodplain, at least to the south of the Quarry, and hence data from these monitoring locations were not used for model calibration purposes". In future, attempts should be made to quantify the location and rates of irrigation use on the Victorian side of the Murray River. This would potentially enable the inclusion of additional monitoring sites south of the Murray River and would improve the predictive capacity of the numerical model.

Irrigation returns were also applied in areas local to the Project, and the basis for this application and the rates provided appear plausible and reasonable. Stock and domestic use was also applied to the numerical model and several simplifying assumptions around the location and rates of use were defined. These assumptions appear plausible and reasonable in regard to the scale and objectives of the numerical model.

There are several data limitations with the potential to affect the current conceptualisation. These are recognised in the report and include:

- the lack of site-specific groundwater monitoring and hydraulic parameter data;
- lack of irrigation water use data from Victoria; and
- likely influence of irrigation to the south of the quarry on groundwater level data.

Additional data of this type would assist with the model calibration and quantifying the surface water groundwater interactions in the vicinity of the Murray River.

2.1.2. Hydrostratigraphic units

The conceptualisation outlined in the report is based upon a regional context of groundwater conditions in the Murray Darling Basin and applies these concepts to a local scale around the Project site. The conceptualisation refers to two main aquifer units, the shallower Shepparton Formation and the deeper Lachlan Formation. These units are incised into a relatively impermeable basement material, which is largely ignored for the purposes of this assessment.

The Shepparton Formation contains usable groundwater for stock and domestic use and is the aquifer that will be directly impacted (or quarried) by the Project. The Lachlan Formation is more permeable and provides irrigation supply within the region. The Lachlan Formation will not be directly impacted by the Project but may experience some localised drawdown.

2.1.3. Aquifer parameters

There is a lack of site-specific data to support the regional parameterisation that has been applied to the model domain. Whilst not ideal, the regional hydraulic parameters applied to the conceptualisation and numerical model appear reasonable and have been applied in a bulk sense to the model layers.

Typically in a model such as this, hydraulic parameters such as hydraulic conductivity, specific yield and specific storage would be applied in bulk (i.e. a single parameter per layer) to each model layer rather than having a complex zonation or cloud of values representing a range of hydraulic parameter values. The parameters would often be initially applied based on site-specific and regional data, then adjusted during the calibration process to achieve a level of fit with groundwater level and flow data. This parameterisation approach has been applied here and is assessed to be consistent with good modelling practice. Additional complexity, in this case spatial variability in modelled hydraulic parameters, should only be introduced where data is available to support this approach.

2.1.4. Surface water groundwater interactions

Groundwater level data in the region indicates a degree of hydraulic connection with the Murray River which varies spatially and vertically in the groundwater system. The Murray River is described as both a losing system and gaining system at various reaches within the model domain, indicating a dynamic interactive system between surface waters and groundwaters. The Murray River is a permanent river system and supports significant groundwater dependant ecosystems (both aquatic and terrestrial) adjacent to the Project.

Historical surface water data (levels and flows) is available for a gauging station at Howlong and an upstream flood profile is also available. This data has enabled a representation of the Murray River to be included in the model domain.

2.2. Review of numerical groundwater model report

The numerical model described in the WatSec report is based upon the conceptual model presented. The report is set out in a logical manner describing the model design and construction (Section 7), calibration and sensitivities (Section 8) and the model predictions (Section 9).

2.2.1. Model confidence level

The self-assessment completed by WatSec suggests that the model achieves a Class 1 / Class 2 confidence level. Table 4 of the report indicates that the availability of climate and the regional DEM data are assessed as achieving a Class 3 classification.

In general, we agree with the self-assessment provided by WatSec. In our opinion, the lack of site-specific data relating to groundwater levels, hydraulic parameters and local interaction with the Murray River bring some aspects of the numerical model back to a Class 1 confidence level. The Australian Groundwater Modelling Guidelines (Barnett et al. 2012) state that "if a model falls into a Class 1 classification for either the data, calibration or prediction sectors, it should be given a Class 1 model, irrespective of all other ratings". However, we do not agree with this statement and consider that a Class 1 / Class 2 classification rating is suitable. We believe that the key indicators of a Class 2 model (Barnett et al. 2012) are generally achieved by the model.

A Class 1 / Class 2 numerical groundwater model is considered appropriate to achieve the purpose and objectives of the Project.

2.2.2. Model structure

The use of MODFLOW 2000 within the PMWin graphical user interface is considered appropriate given the data availability, model objectives and purpose. Later variants of MODFLOW (e.g. USG or MODFLOW 6) are now more commonplace for larger impact assessment models however the underlying code (MODFLOW 2000) is robust and defendable for this purpose.

The model extent (i.e. 12 km by 10 km) is considered appropriate based on the likely extent of impacts. A 50 m by 50 m rectangular mesh has been employed in the Project area and is suitable given the scale and objectives of the numerical model.

2.2.3. Boundary conditions

General head boundaries (GHB) are applied to the upstream and downstream model boundaries to allow for regional groundwater inflow and outflow. The GHB parameters (head and conductance terms) are based upon regional groundwater levels and hydrogeological parameters. The GHB are a sufficient distance from the Project to not be influenced by drawdown from the quarry operations.

The Murray River (including the main channel, anabranches and backwater reaches) has been represented in the model using the MODFLOW river package (RIV) and assuming a river stage 3 m above the top of the modelled river bed. RIV cells parameterised in this way represent a general form of a constant head, where the volume of flow gained or lost by each RIV cell is calculated by the head difference between the RIV cell and the 'underlying' model layer and the RIV bed conductance.

The Project is located adjacent to the Murray River and the representation of the surface water system is a key element of the numerical model. The use of the RIV package to simulate the Murray River is appropriate in this instance. However, the RIV package has the ability to feed an infinite volume of water to the groundwater system which can potentially lead to an under-estimation of drawdown.

The parameters applied to the RIV package are based upon historical data at the Howlong gauge and the available flood profile curve. The conductance terms (i.e. width of the river, and thickness and hydraulic conductivity of the river bed sediments) are appropriate and provide a relatively high conductance value between the river bed and the underlying aquifer. This means that there is no major hydraulic restriction between the simulated river and the Layer 1 aquifer (Shepparton Formation). Any drawdown that propagates to the RIV cells from the Project would draw water in and this would be observed within the predicted water budgets.

The calibration phase of the numerical model demonstrates a losing system during wet season (flood) events and a gaining system during dry season (non-flood) periods. This model behaviour generally represents the conceptual understanding of the Murray River in this region.

2.2.4. Representation of quarries

Proposed quarrying is represented in the model using the MODFLOW drain package (DRN) which is appropriate for the likely extraction method within the active quarries. A high conductance term of 1000 m^2/day has been used to allow for free draining conditions.

2.2.5. Calibration approach

The calibration simulation comprises an initial steady state stress period followed by 16 transient timesteps representing the period 2012 to 2018. The steady state stress period results provide the initial conditions for the transient calibration. The transient calibration period (2012 to 2018) was chosen as it includes seasonal river level fluctuations, a flood event in 2016 and historical dewatering from the Stage 1 pit in April 2018.

The calibration period includes the simulation of historical quarrying and surface water groundwater interaction, which are key elements of the conceptualisation and understanding.

2.2.6. Model calibration

Calibration of the model was undertaken by varying model parameters relating to hydraulic conductivity, specific yield, and GHB properties (upstream and downstream conductance in Layers 1 and 2). A calibrated scaled RMS (SRMS) statistic of 6.5% is reported for the transient calibration. This suggests that model is able to replicate observed heads well.

The report states that the model was calibrated using the PEST suite of software. No further details on the precise PEST methodology adopted, or observation weightings, or parameter bounds are provided.

The calibration is presented as a scattergram of modelled vs measured heads, and as a series of hydrographs for the groundwater observation sites. The hydrographs appear to provide a good visual correlation between modelled and observed data with seasonal and longer-term trends represented by the model.

A map showing modelled head residuals would potentially be of benefit in understanding the spatial context of error within the model calibration.

The model calibration also describes that the average modelled inflow to Pit 1 during April 2018 was 1.6 ML/d compared to the estimated 1.5 ML/d. This flux calibration target is of significant benefit to the predictive capacity of the numerical model as it assists in reducing the non-uniqueness of the model and assists in the calibration of transient parameters such as specific yield.

The calibrated hydraulic parameters are summarised in Table 9 of the report. The calibrated values are considered plausible.

2.2.7. Modelled water balance

A modelled water budget for the transient calibration period is presented in Figure 23 and Figure 24 of the report for Layers 1 and 2 respectively. The dominant modelled output is reported to be from the RIV package with significant spikes representing the beginning and end of increased and decreased river levels (between 10,000 m^3/d to 160,000 m^3/d). This magnitude of flux generally appears to be consistent with gauged river data from upstream and downstream locations, however some comment in the report would be useful to understand the context of this flux.

Further large components of the water balance are derived from evapotranspiration, recharge and the GHB in Layer 2. Each component of the modelled water balance is influenced by varying degrees by the modelled river levels. The modelled water budget components appear reasonable and are consistent with the inputs described and the available data.

2.2.8. Predictions

The report does not specify if a null scenario has been used in the generation of the model drawdown predictions. The use of a null scenario would eliminate any influence of pre-existing stresses (such as irrigation pumping, stock and domestic pumping and irrigation return) from the drawdown predictions. The null scenario approach is consistent with guidance included in the Australian groundwater modelling guidelines as this approach can reduce uncertainty in the drawdown estimates and provides project only impacts to be presented.

The predicted dewatering rate and evaporative loss from the proposed quarries (Stages 1 through to 4[cde]) are presented in Table 13 of the report. The rates of dewatering are of a similar magnitude with the historical observed (and calibrated) dewatering rates and appear plausible. The rates and timing of the dewatering and evaporation are consistent with the project description and the size of the quarry pits.

The modelled drawdown in Layers 1 and 2 after Stage 4(cde) are shown in Figure 25 and Figure 26 of the report. Layer 1 presents the most drawdown with up to 10 m predicted within the Stage 4(cde) footprint. A fringe of 0.1 m drawdown is predicted around the Murray River (and anabranches) in Layer 1. This suggests a flux of water from the river to the groundwater system occurs in response to the Project. Several areas exist (in particular to the south of the Stage 4(cde) quarry) where the drawdown contours are compressed around the fringe of the river cells. The bulk of project induced river leakage would be occurring in this area. As discussed above, the use of a null scenario may reduce this predicted drawdown (and project induced leakage) as it would remove the influence of pre-existing or approved stressors such as irrigation.

The report states within the conclusions that “the model water budgets indicate that discharge from the Murray River to the Shepparton Formation is increased on average by 219 ML/a during Stages 1, 2 and 3, 329 ML/ for Stage 4(ab) and 438 ML/a for Stage 4(cde)”. However, examination of the water budgets presented in Figure 27 of the report would suggest that the net loss from the Murray River throughout the model domain is closer to 1,000 ML/a at the end of Stage 4(cde). The net loss from the Murray River should be calculated as the change in flux from the river minus the change in flux to the river. In this instance, the change in flux from the river increases and the change in flux to the river decreases. Figure 2-1 below provides a calculation of the net loss (shown as grey dots) from the Murray River over the entire model domain.

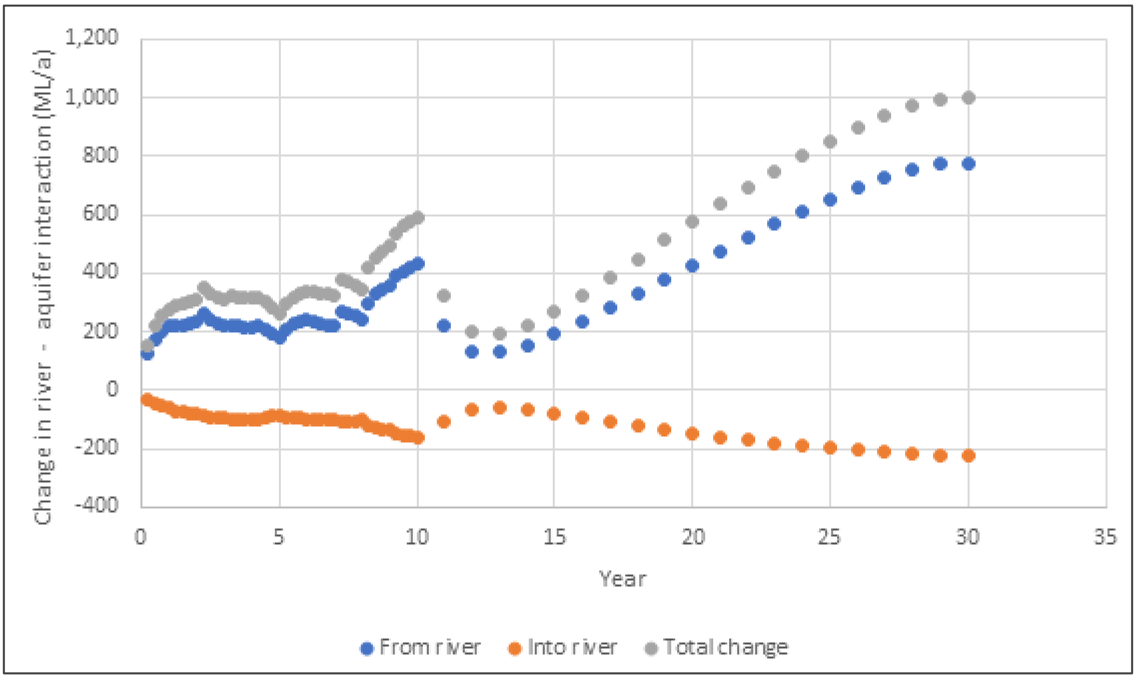

Figure 2-1 Expansion Period Impacts on River Aquifer Interaction

The recovery predictions presented in the report suggest a maximum residual drawdown of 1 m within the Stage 4 footprint. This residual drawdown is due to evaporative losses that would occur into perpetuity. The report describes a total evaporative loss of 139 ML/a from the quarry pits which is based upon an applied rate to the quarry footprints.

2.2.9. Uncertainty analysis

No uncertainty analysis has been carried out as part of the numerical modelling. Model uncertainty has been discussed in a qualitative sense and highlights some of the data gaps discussed earlier in this report. These data gaps include:

- site monitoring bore time series groundwater level data;
- site specific aquifer testing;
- Murray River level monitoring adjacent the Project;
- transient pit water level monitoring; and
- detailed monitoring and documentation of site water balance management.

For the purposes of this assessment, we would not recommend that uncertainty analysis be carried out until representative site-specific data is available. This site-specific data would enable a more robust calibration of the model (for both levels and fluxes) in the area of interest. In our opinion, only then would uncertainty analysis be of benefit to the model predictions.

2.2.10. Sensitivity analysis

Sensitivity analysis has been completed on the calibrated model outputs only. Nine scenarios were carried out including two scenarios of increased river conductance, an increase and decrease in recharge, an increase and decrease in Layer 1 Kx and Sy, an increase and decrease in Layer 1 Kv and a decrease in layer Kx. The sensitivities are presented in terms of the model calibration statistics (variance) and the predicted inflows to the Stage 1 pit.

Ideally the sensitivity outputs would be presented in relation to the key objectives of the model, namely the extent and magnitude of drawdown, the impact on the take of water from the Murray River and the residual drawdown following recovery. This would provide an understanding the of range of impacts in relation to the model objectives.

3. Conclusion

The groundwater modelling work described in the WatSec report has been carried out in a professional manner. The modelling work has generally been completed in line with the Guiding Principles outlined in the Australian Groundwater Modelling Guidelines (Barnett et al., 2012), and we have not identified any fundamental flaws in the work that are likely to significantly affect the model predictions.

We recognise that there are limitations with the existing model, however, we are of the opinion that the model is ‘fit for purpose’ given on the stated model purpose and objectives. We strongly recommend that a commitment is made to re-develop the project numerical model within one year of approval, with an update to be carried out every three years from the commencement of operations. The results of the proposed future modelling should be presented to the regulator for consideration. Based on the qualitative model uncertainty described by WatSec and the findings of this review, we recommend as a minimum that the following items below be addressed and included in the model re-development and subsequent updates:

- site monitoring bore time series groundwater level data;
- site specific aquifer testing;
- Murray River level monitoring adjacent to the Project;
- transient pit water level monitoring; and
- detailed monitoring and documentation of the site water balance management.

Table 3-1 below provides a high-level compliance checklist of the numerical model review, as suggested by the Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012).

Table 3-1 Numerical model review compliance checklist

Question	Rating
Are the model objectives and model confidence level classification clearly stated?	Yes
The model objectives and confidence level classification are clearly defined. Section 5 and Table 4 of the report provides further information on the classification characteristics. The model is self-assessed as a Class 1 / Class 2 classification and we agree with this classification.	
Are the objectives satisfied?	Yes
The model objectives are to predict the dewatering rates of the project, the magnitude and extent of drawdown associated with dewatering, the groundwater levels at receptors, the impacts and discharge from the Murray River and long term drawdown around the pits. We consider that the objectives has been satisfied.	
Is the conceptual model consistent with objectives and confidence level classification?	Yes
The conceptual model is presented clearly. Further improvements could be made to the local understanding through the installation of site-specific bores however these do not detract from the conceptual understanding presented.	

Question	Rating
Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes
The conceptual model is based upon regional data and the limitations with this data is acknowledged within the report.	
Does the model design conform to best practice?	Yes
The model is built using MODFLOW 2000 within PMWin. The model has been developed and completed in a manner consistent with its objectives, scope and classification level. The modelling process follows a standard workflow that is consistent with the model objectives and classification.	
Is the model calibration satisfactory?	Yes
The model was calibrated to transient conditions. The transient calibration SRMS is less than 10%. There are a limited number of calibration data points however given the Class 1 / Class 2 classification this is acceptable. The model has used both levels and fluxes as calibration targets.	
Are the calibrated parameter values and estimated fluxes plausible?	Yes
The calibrated parameter values are plausible and are generally consistent with regional data. The calibrated fluxes provide a reasonable match to observed dewatering rates. This general approach is considered acceptable.	
Do the model predictions conform to best practice?	No
The use of a null scenario model would enable project specific impacts to be presented and would improve the model predictions. There are discrepancies with the presented fluxes representing the project induced water take from the Murray River. These need to be clearly described and presented.	
Is the uncertainty associated with the predictions reported?	No
The model does not represent quantitative uncertainty yet only discusses qualitative uncertainty and data limitations. However, given the Class 1 / Class 2 classification this is considered acceptable.	
Is the model fit for purpose?	Yes
The Stage 2 numerical model is considered fit for purpose. However, it is recommended that additional data collection, model redevelopment and model updates are conditioned into the development consent.	

APPENDIX C
AQUIFER INTERFERENCE POLICY

Department of Primary Industries
Office of Water

AQUIFER INTERFERENCE ASSESSMENT FRAMEWORK

Assessing a proposal against the NSW Aquifer Interference Policy – step by step guide

Note for proponents

This is the basic framework which the NSW Office of Water uses to assess project proposals against the **NSW Aquifer Interference Policy (AIP).**

The NSW Aquifer Interference Policy can be downloaded from the NSW Office of Water website (www.water.nsw.gov.au under Water management > Law and policy > Key policies > Aquifer interference).

While you are not required to use this framework, you may find it a useful tool to aid the development of a proposal or an **Environmental Impact Statement (EIS)*.***

We suggest that you summarise your response to each AIP requirement in the tables following and provide a reference to the section of your EIS that addresses that particular requirement. Using this tool can help to ensure that all necessary factors are considered, and will help you understand the requirements of the AIP.

Table 1. Does the activity require detailed assessment under the AIP?

	Consideration	Response
1	Is the activity defined as an aquifer interference activity?	Yes
2	Is the activity a defined minimal impact aquifer interference activity according to section 3.3 of the AIP?	Yes

Note for proponents

Section 3.2 of the AIP defines the framework for assessing impacts. These are addressed here under the following headings:

1. Accounting for or preventing the take of water
2. Addressing the minimal impact considerations
3. Proposed remedial actions where impacts are greater than predicted.

1. Accounting for, or preventing the take of water

Where a proposed activity will take water, adequate arrangements must be in place to account for this water. It is the proponent's responsibility to ensure that the necessary licences are held. These requirements are detailed in Section 2 of the AIP, with the specific considerations in Section 2.1 addressed systematically below.

Where a proponent is unable to demonstrate that they will be able to meet the requirements for the licensing of the take of water, consideration should be given to modification of the proposal to prevent the take of water.

Table 2. Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Described the water source(s) the activity will take water from?	Refer Table 2-1.	
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	Refer Section 7.2.1 and Table 7-1.	
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?	Refer Section 7.2.1.	
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (refer to Table 3, below)	Yes	
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?	All water take would be apportioned as groundwater consistent with groundwater used for irrigation in the region. The connected surface water sources are acknowledged in the establishment of the LTAAEL for the Upper Murray Alluvium water source and therefore this approach is considered appropriate.	
6	Described how any licence exemptions might apply?	No exemptions apply.	
7	Described the characteristics of the water requirements?	Direct and incidental take for extraction area dewatering.	
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?	Refer Section 7.2.1. The Applicant currently holds sufficient entitlement to account for the maximum predicted inflows.	

<table>
<tr><th colspan="2">AIP requirement</th><th>Proponent response</th><th>NSW Office of Water comment</th></tr>
<tr><td>9</td><td>Considered the rules of the relevant water sharing plan and if it can meet these rules?</td><td>The project can meet the rules of the relevant WSPs.</td><td></td></tr>
<tr><td>10</td><td>Determined how it will obtain the required water?</td><td>Refer Section 7.2.1. The Applicant currently holds sufficient entitlement to account for the maximum predicted inflows.</td><td></td></tr>
<tr><td>11</td><td>Considered the effect that activation of existing entitlement may have on future available water determinations?</td><td>The activation of the entitlement would not impact future available water determinations as the majority of the water is currently taken for irrigation practices in conjunction with the existing operation.</td><td></td></tr>
<tr><td>12</td><td>Considered actions required both during and post-closure to minimize the risk of inflows to a mine void as a result of flooding?</td><td>A series of levees would be constructed to limit flooding impacts – see EIS Project Submissions Report (RWC, 2022).</td><td></td></tr>
<tr><td>13</td><td>Developed a strategy to account for any water taken beyond the life of the operation of the project?</td><td>Water take would be required in perpetuity to account for evaporation from pit lakes and to support irrigation. All water extracted will be in accordance with the Applicant's entitlements.</td><td></td></tr>
<tr><td colspan="4">Will uncertainty in the predicted inflows have a significant impact on the environment or other authorised water users?
No. Due to the bounding of the River Murray and Black Swan Anabranch the drawdown effects of the proposed staged development are constrained to an area between these water bodies and to within less than 1 km along the floodplain from the quarrying operations. The limited extent of drawdown means that existing users and groundwater dependent ecosystems are not expected to be adversely impacted. The areas impacted by drawdown currently comprise quarrying operations, irrigated floodplain and cleared floodplain areas.
If YES, items 14-16 must be addressed.</td></tr>
<tr><td>14</td><td>Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?</td><td>N/A</td><td></td></tr>
<tr><td>15</td><td>Quantified any other uncertainties in the groundwater or surface water impact modelling conducted for the activity?</td><td>N/A</td><td></td></tr>
<tr><td>16</td><td>Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the project, and how these requirements will be accounted for?</td><td>Refer Section 8.</td><td></td></tr>
</table>

Table 3. Determining water predictions in accordance with Section 3.2.3 (complete one row only – consider both during and following completion of activity)

	AIP requirement	Proponent response	NSW Office of Water comment
1	**For the Gateway process**, is the estimate based on a simple modelling platform, using suitable baseline data, that is, fit-for-purpose?	N/A	
2	**For State Significant Development or mining or coal seam gas production**, is the estimate based on a complex modelling platform that is: • Calibrated against suitable baseline data, and in the case of a **reliable water source,** over at least two years?	The MODFLOW groundwater model has used regional aquifer parameters and heads, observation bore data, river level fluctuations and existing pit inflow measurements as a guide to calibration. Refer to the Groundwater Assessment for the Howlong Quarry Expansion for further details (Water Technology, 2022).	
	• Consistent with the Australian Modelling Guidelines?	Yes.	
	• Independently reviewed, robust and reliable, and deemed fit-for-purpose?	The groundwater model has been independently peer reviewed by Hydrogeologoiust.com.au and was found to be fit for purpose. A copy of the peer review is appended to Water Technology (2022).	
3	In all other processes, estimate based on a desk-top analysis that is: • Developed using the available baseline data that has been collected at an appropriate frequency and scale; and • Fit-for-purpose?	N/A	

Other requirements to be reported on under Section 3.2.3

Table 4. Has the proponent provided details on:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Establishment of baseline groundwater conditions?	Yes, refer to Section 3 and Appendix A of Water Technology (2022).	
2	A strategy for complying with any water access rules?	The Project will operate within water access rules without need for a specific strategy.	
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	Refer Section 7.3.1	
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?	Refer Section 7.3.1	
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	Refer Section 7.3.2	
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	Refer Section 7.3.4	
7	Potential to cause or enhance hydraulic connection between aquifers?	Other than direct excavation of extraction areas, the Project would not cause or enhance hydraulic connection between aquifers.	
8	Potential for river bank instability, or high wall instability or failure to occur?	The Project would not undermine nor encroach upon the banks of the Murray River or the Black Swan Anabranch.	
9	Details of the method for disposing of extracted activities (for coal seam gas activities)?	N/A	

2. Addressing the minimal impact considerations

Note for proponents

Section 3.2.1 of the AIP describes how aquifer impact assessment should be undertaken.

1. Identify all water sources that will be impacted, referring to the water sources defined in the relevant water sharing plan(s). Assessment against the minimal impact considerations of the AIP should be undertaken for each ground water source.
2. Determine if each water source is defined as 'highly productive' or 'less productive'. If the water source is named in then it is defined as highly productive, all other water sources are defined as less productive.
3. With reference to pages 13-14 of the Aquifer Interference Policy, determine the sub-grouping of each water source (eg alluvial, porous rock, fractured rock, coastal sands).
4. Determine whether the predicted impacts fall within Level 1 or Level 2 of the minimal impact considerations defined in Table 1 of the AIP, for each water source, for each of water table, water pressure, and water quality attributes. The tables below may assist with the assessment. There is a separate table for each sub-grouping of water source – only use the tables that apply to the water source(s) you are assessing, and delete the others.
5. If unable to determine any of these impacts, identify what further information will be required to make this assessment.
6. Where the assessment determines that the impacts fall within the Level 1 impacts, the assessment should be 'Level 1 – Acceptable'
7. Where the assessment falls outside the Level 1 impacts, the assessment should be 'Level 2'. The assessment should further note the reasons the assessment is Level 2, and any additional requirements that are triggered by falling into Level 2.
8. If water table or water pressure assessment is not applicable due to the nature of the water source, the assessment should be recorded as 'N/A – reason for N/A'.

Table 5. Minimal impact considerations

Aquifer	**Alluvial aquifer**
Category	**Highly Productive**
Level 1 Minimal Impact Consideration	**Assessment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic post-water sharing plan variations, 40 metres from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan. **OR** A maximum of a 2 metre water table decline cumulatively at any water supply work.	Level 1 – Acceptable' Water level impacts are described in Section 7 of the Groundwater Assessment (Water Technology, 2022). The modelling shows that due to the bounding of the River Murray and Black Swan Anabranch the drawdown effects of the proposed staged development are largely constrained to an area between these water bodies and hence drawdown is constrained to a very localised area surrounding the pits. Declines in excess of 2 metres at water supply works are not predicted. There are no know culturally significant sites within the study area.
Water pressure A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 metre decline, at any water supply work. ~~**OR**, for the Lower Murrumbidgee Deep Groundwater Source:~~ ~~A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the top of the relevant aquifer to a maximum of a 3 metre decline, at any water supply work.~~	
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. No mining activity to be below the natural ground surface within 200 metres laterally from the top of high bank or 100 metres vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply.	Level 1 – Acceptable Evaporative concentration will raise the salinity of pit water over time. The salinity of the pits is maintained at between 500 mg/L and 600 mg/L for an assumed starting salinity of 450 mg/L. Historic operations have encroached within 30m of the high bank of the Murray River. A 100m buffer from the Murray River would be reinstated under the Proposal. Based on the numerical groundwater modelling, the nett effects of evaporation and irrigation extractions will result in the pit levels being maintained below river level and it is unlikely that water held in the extraction pits would flow to the Murray River (i.e. the flow gradient is from the river to the pits). Hence, water quality impacts on the River Murray are considered unlikely.

Aquifer	**Alluvial aquifer**
Category	**Highly Productive**

Level 1 Minimal Impact Consideration	**Assessment**
Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 metres laterally from the top of high bank and 100 metres vertically beneath a highly connected surface water source that is defined as a reliable water supply.	Level 1 – Acceptable as above.

3. Proposed remedial actions where impacts are greater than predicted.

Note for proponents

Point 3 of section 3.2 of the AIP provides a basic framework for considerations to consider when assessing a proponent's proposed remedial actions.

Table 6. Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Considered types, scale, and likelihood of unforeseen impacts *during operation*?	Yes – water management has been carefully planned to balance inflows with irrigation and other uses.	
2	Considered types, scale, and likelihood of unforeseen impacts *post closure*?	Yes – water management would be continued post-extraction with measures to account for passive management post-closure, if required.	
3	Proposed mitigation, prevention or avoidance strategies for each of these potential impacts?	Refer Section 8.	
4	Proposed remedial actions should the risk minimization strategies fail?	To be developed within Rehabilitation Management Plan.	
5	Considered what further mitigation, prevention, avoidance or remedial actions might be required?	To be developed within Rehabilitation Management Plan.	
6	Considered what conditions might be appropriate?	To be developed within Rehabilitation Management Plan.	

4. Other considerations

Note for proponents

These considerations are not included in the assessment framework outlined within the AIP, however are discussed elsewhere in the document and are useful considerations when assessing a proposal.

Table 7: Has the proponent:

	AIP requirement	Proponent response	NSW Office of Water comment
1	Addressed how it will measure and monitor volumetric take? (page 4 of the AIP)	Yes – See Section 8 of Water Technology (2022).	
2	Outlined a reporting framework for volumetric take? (page 4 of the AIP)	Yes – See Section 8 of Water Technology (2022). Reporting of water take would be presented in an Annual Review and at the end of each water year.	

More information

www.water.nsw.gov.au

Published by the NSW Department of Primary Industries.

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Appendix 8

Review of Flood Modelling Outcomes prepared by Water Technology – November 2021

(Total No. of pages including blank pages = 18)

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17 November 2021

Nick Warren
Principal Environmental Consultant
RW Corkery & Co
Via email nick@rwcorkery.com

Dear Nick,

Our ref: L01V02_HowlongQuarry_Response_to_BCD_Comments.docx

Howlong Quarry Expansion Flood Risk Assessment

This letter documents the response to the comments regarding the Howlong Quarry Expansion Flood Risk Assessment completed by Water Technology in December 2019.

The comments and recommended actions provided by the Federation Council and the Biodiversity and Conservation Division (BCD) from the Department of Planning, Industry and Environment are as follows:

- Details on the impact the proposed levee for stage 4 will have on the flood patterns on properties surrounding the site, vehicle access to the site and overland flows
- A more detailed and targeted impact assessment is required to effectively determine the level of flood impact on upstream properties, assets and infrastructure caused by the proposed levee development

This letter documents the response regarding the flood impact assessment on the Riverina Highway, the access to the site, neighbouring properties or other infrastructure on neighbouring properties.

Yours sincerely

Sebastien Barriere
Senior Engineer

Sebastien.barriere@watertech.com.au

WATER TECHNOLOGY PTY LTD

1 RIVERINA HIGHWAY

The modelling completed for the Howlong Quarry Flood Risk Assessment indicates the addition of a levee to prevent the expansion pits from flooding up to a 1% AEP flood event, could result in a minor increase in water levels up to 4 km upstream of the site. The current upstream model boundary and the Riverina Highway are shown in Figure 1-1. In a 1% AEP event, the increase in water levels at the upstream model boundary is around 3 cm. Due to the location of the upstream model boundary, the impact on floodwaters to the upstream at Riverina Highway cannot be visualised in the difference map.

The profiles of the 1% AEP water level from the stage 4 levee to the Riverina Highway and the changes between existing and developed conditions for all the modelled flood events are displayed in Figure 1-2. The maximum increase in water level varies from around 30 cm just upstream of the site for the 1% AEP event, gradually reducing to 3 cm 4.7 km east at the upstream model boundary. For the range of modelled flood events, in the vicinity of the quarry site the largest afflux is calculated for the 1% AEP event. Beyond 500m upstream, the afflux is largest for the 0.5% AEP event. For the latter, the afflux on the right bank of the Murray River, at the model boundary, is 4.5cm.

The Riverina Highway is more than 2 km further east from the upstream model boundary and the afflux caused by the levee will continue to reduce with the distance from the quarry site. Furthermore, the highway is located at elevations much higher than the 1% and 0.5% AEP flood levels therefore, it is not expected that the addition of these levees would have a detrimental impact on the flood levels along the Riverina Highway.

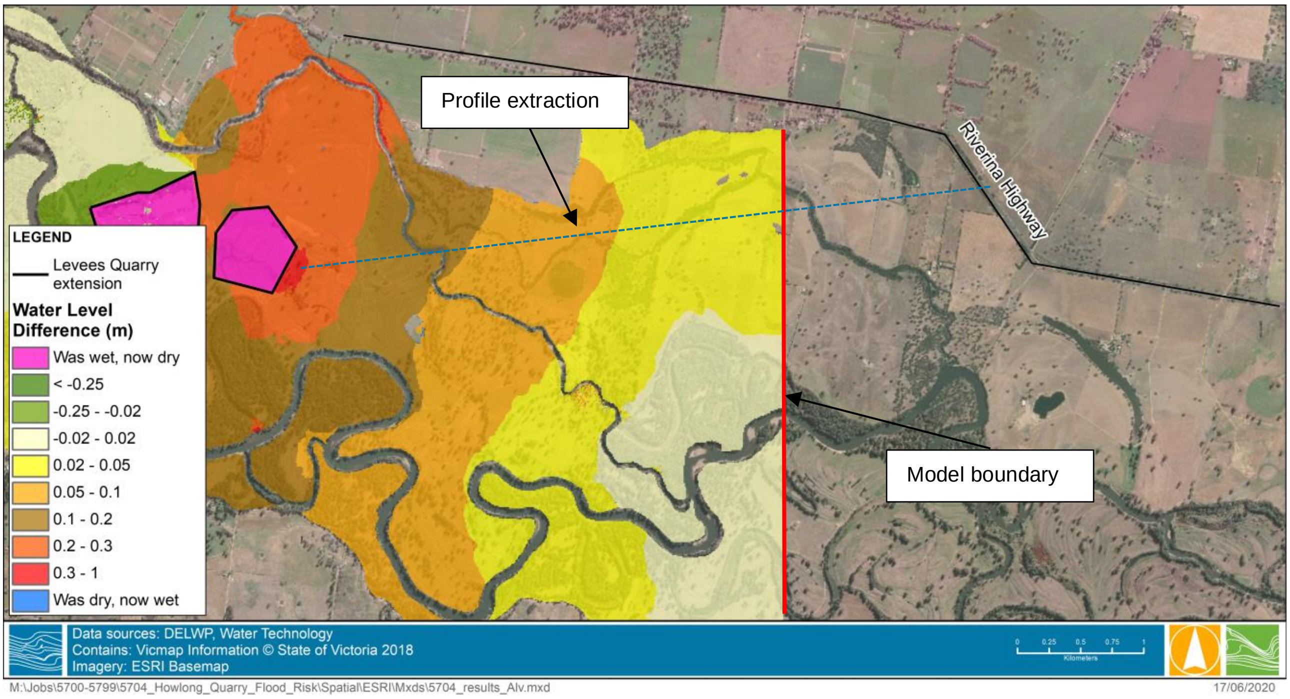

Figure 1-1 1% AEP flood difference map and upstream model boundary

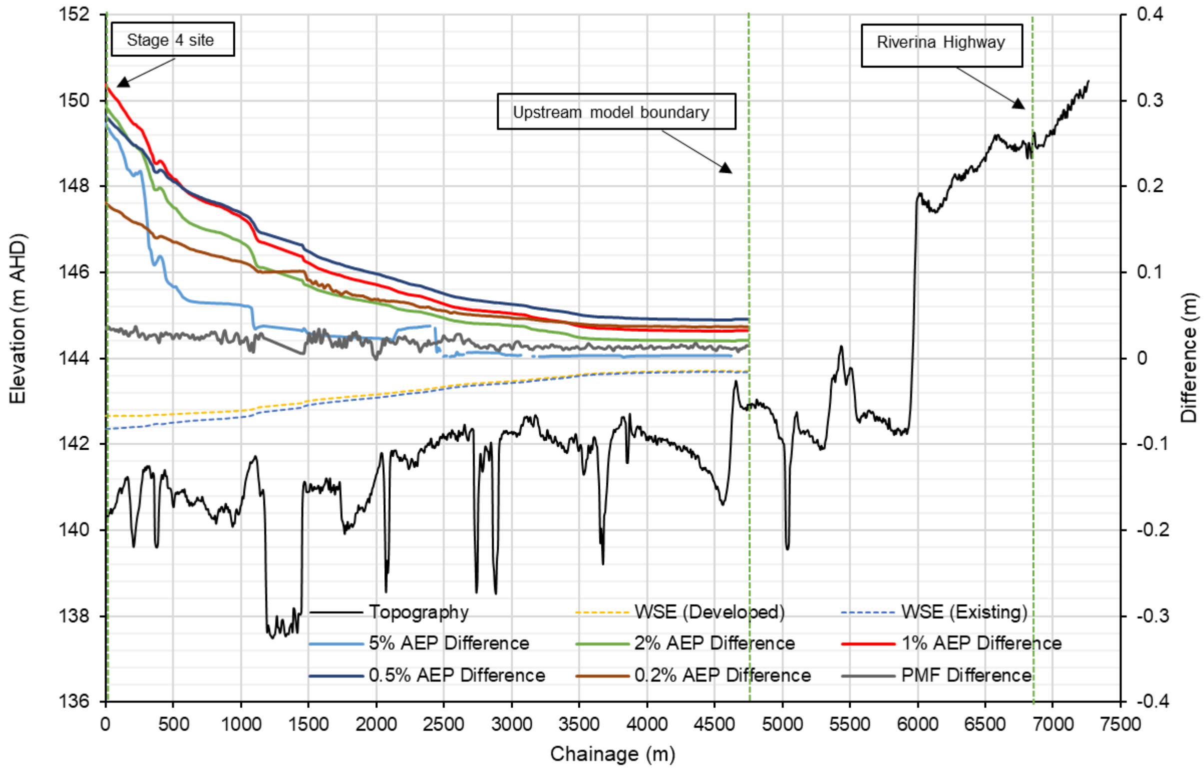

Figure 1-2 1% AEP water level profiles and water level changes for all design events from site to Riverina Highway

2 NEIGHBOURING PROPERTIES AND ROAD ACCESS

The modelling results have demonstrated that for none of the design events modelled, is there a noticeable increase in flood extent as a consequence of the new levees proposed for the quarry expansion. This is due to the confined nature of flooding within the floodplain.

The flood impact on neighbouring properties was investigated on the upstream and downstream of the site and they are shown in the 0.5% AEP flood event difference maps from Figure 2-1 to Figure 2-9. The 0.5% AEP event presents the biggest impacts on water level as shown in Figure 1-2.

For the properties upstream of the site, there is limited evidence showing the construction of levee would result in the increase in flood extents or cause inundation on these properties. Although it is noted that the flood extents are marginally increased along the fringe of the flood extent in some of these locations, the flood risk within the property boundaries is not increased.

For the properties downstream of the site, there are negligible differences in water levels and showing no extent changes. Figure 2-9 shows the difference map in the urban area within township of Howlong. There are no changes in flood extent and the changes in water levels are scattered with no impact on neighbouring residential houses.

In terms of the impact on road infrastructure and accessibility to the site, the majority of road assets within the flood extent for existing conditions are inundated with depths above 300 mm (water depths greater 300 mm are considered to prevent safe access or egress for people or small vehicles). Figure 2-10 shows the 5% AEP flood depth for existing conditions at the quarry site. Model results indicate the construction of levees would increase the flood levels over the access road from the Riverina Highway by about 100 mm. However, this road is already inundated with depths above 300 mm under existing conditions.

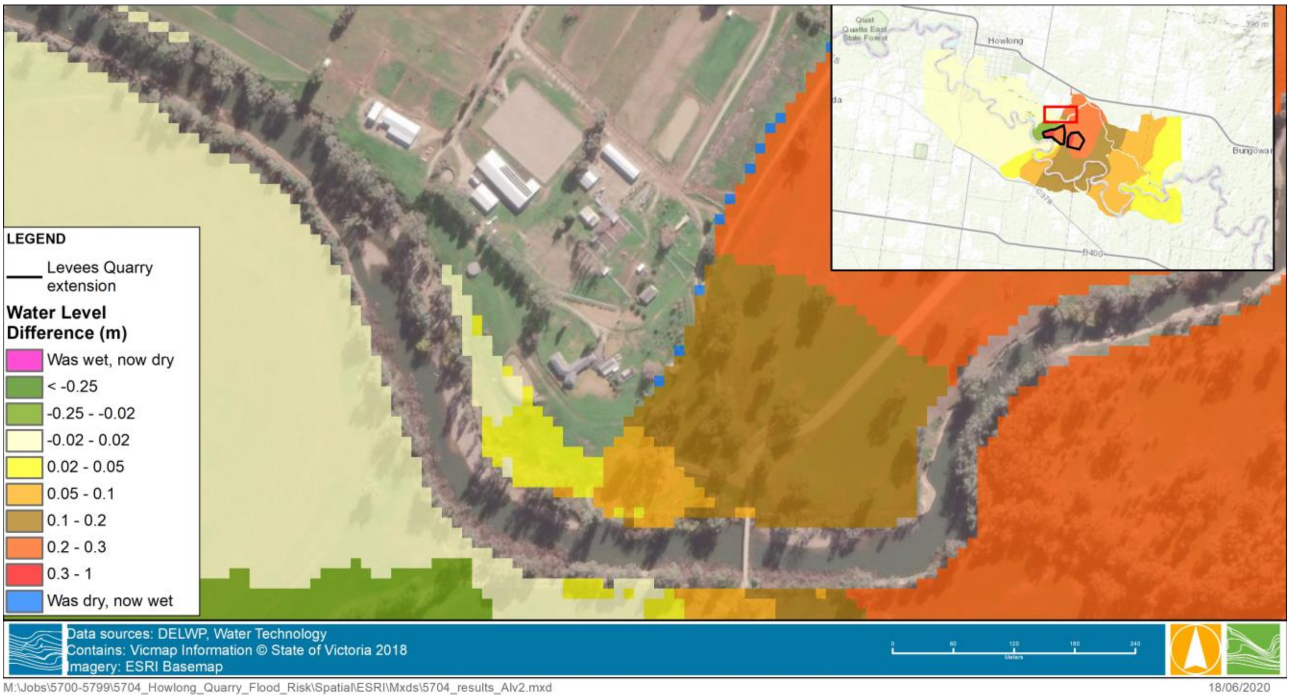

Figure 2-1 0.2% AEP difference map – 4343 Riverina Highway

Figure 2-2 0.2% AEP difference map – Camp Nelson Scout Camp

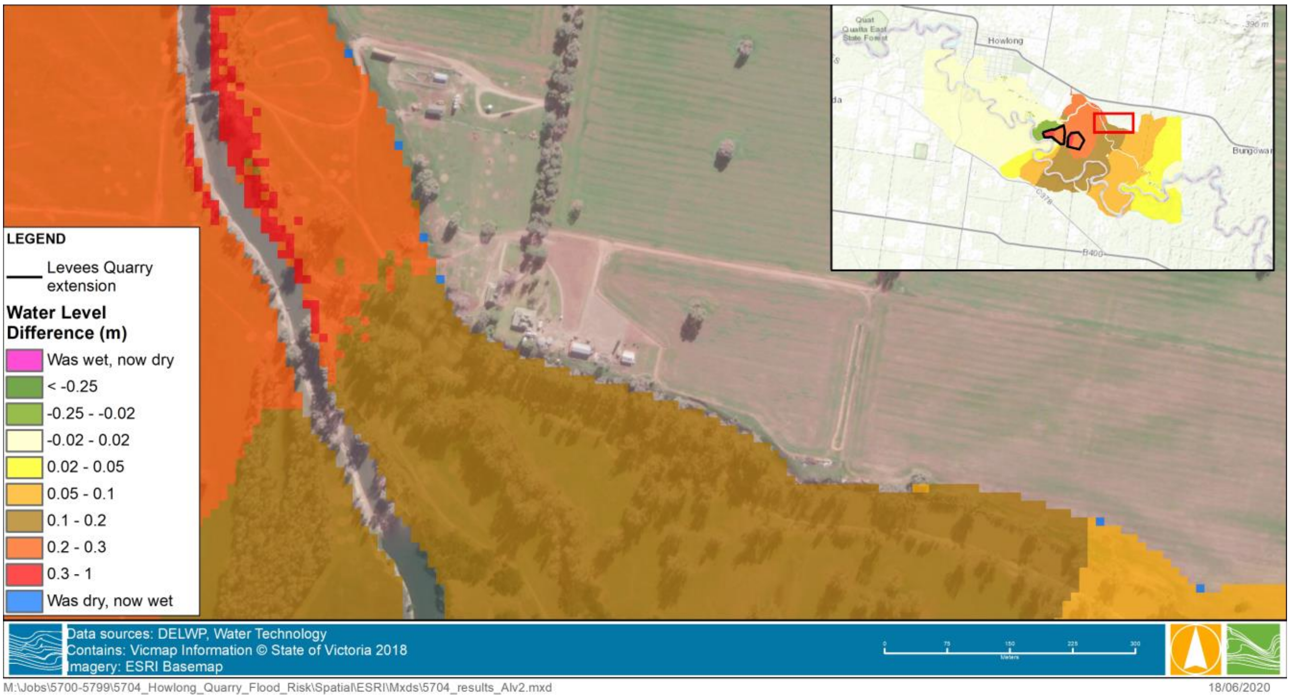

Figure 2-3 0.2% AEP difference map – unknown properties 1.2 km north east from the site

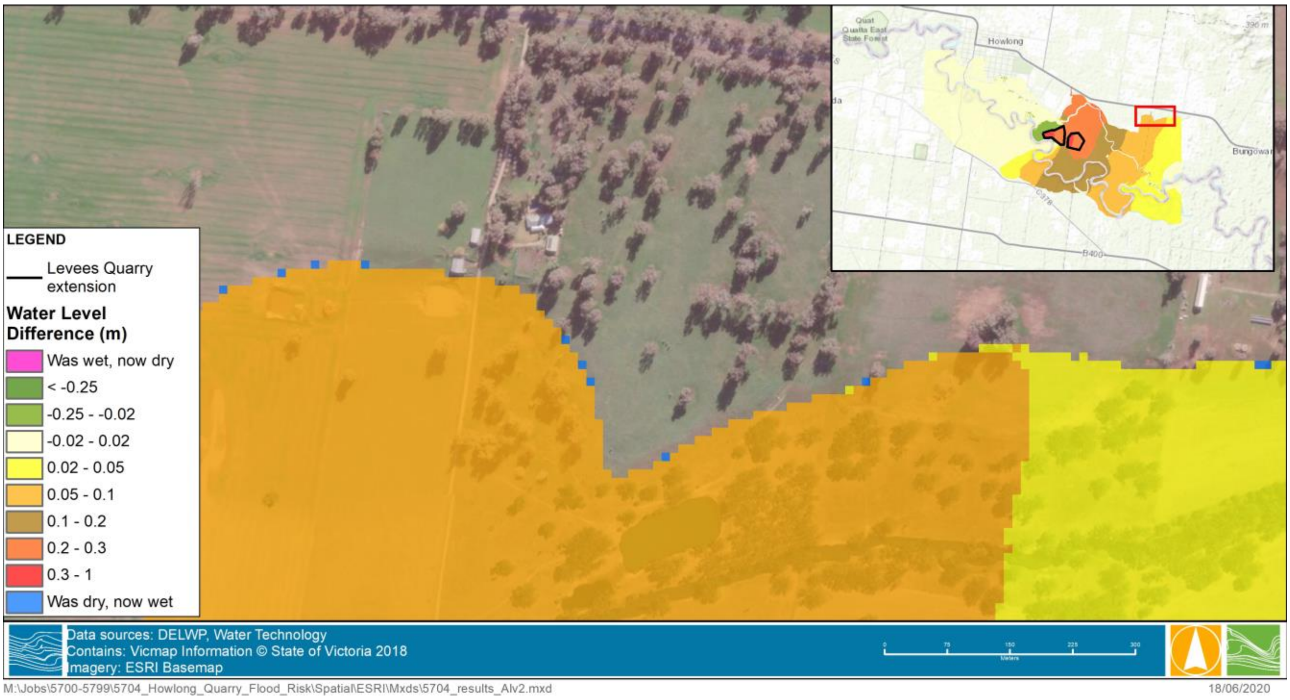

Figure 2-4 0.2% AEP difference map – 4007 Riverina Highway

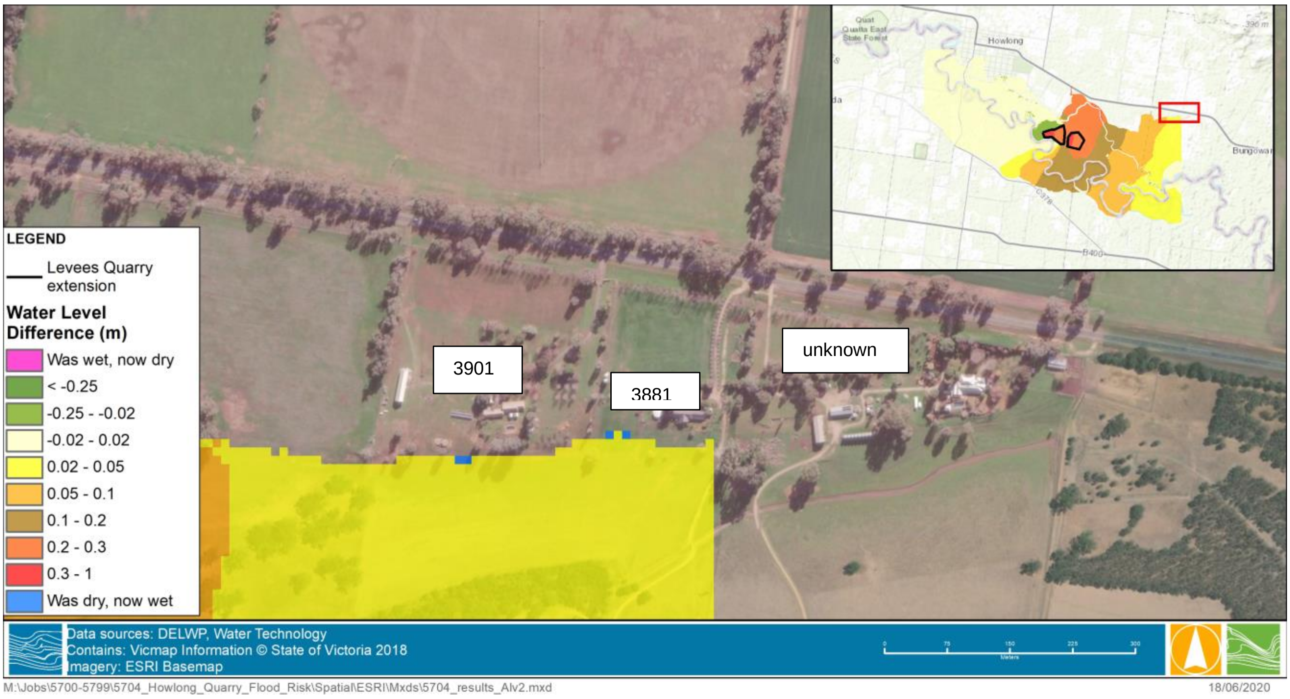

Figure 2-5 0.2% AEP difference map – properties 4 km north east from the site

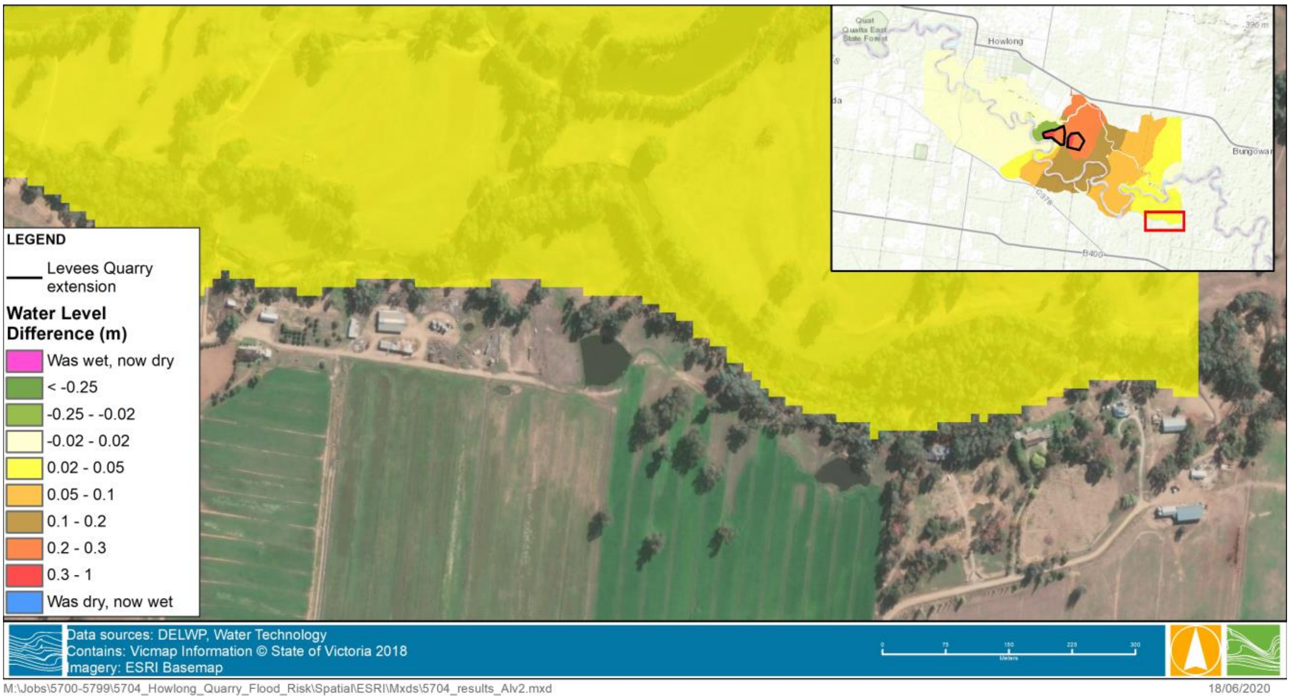

Figure 2-6 0.2% AEP difference map – unknown properties 4 km south east from the site

Figure 2-7 0.2% AEP difference map – unknown property on Stewarts Rd, 1.5 km south from the site

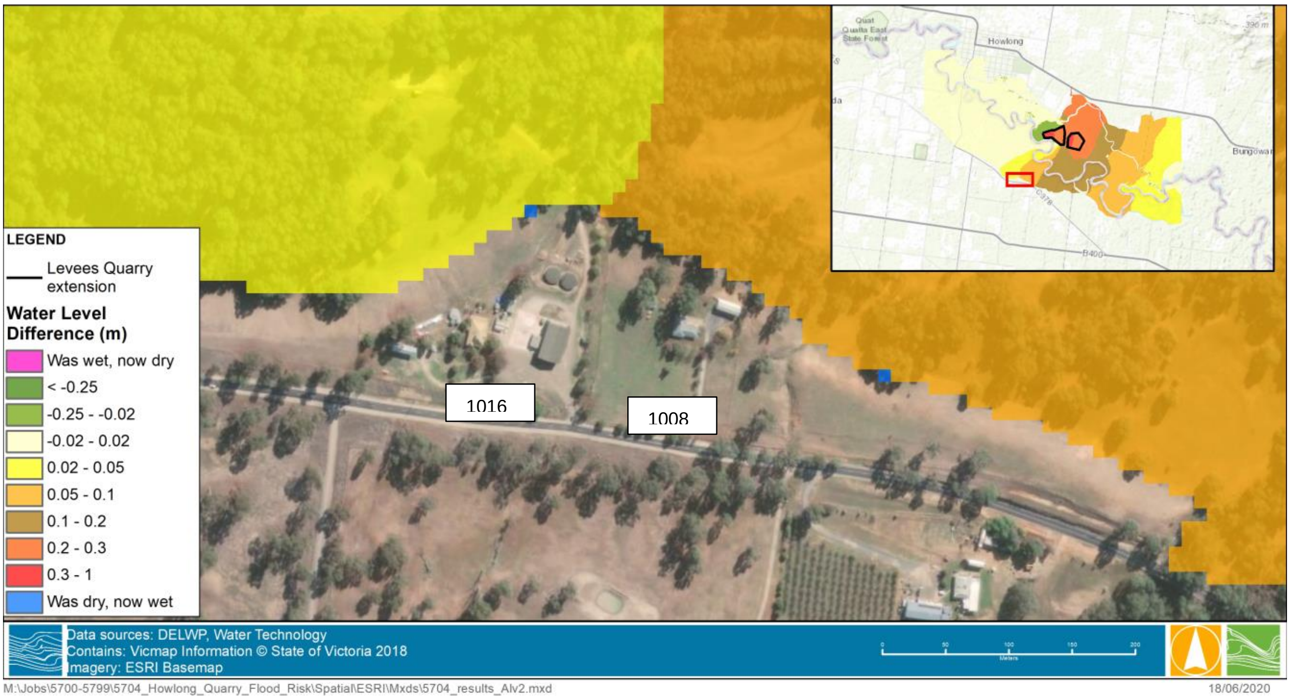

Figure 2-8 0.2% AEP difference map – properties 1008 and 1016 Barnawartha Rd

Figure 2-9 0.2% AEP difference map – township of Howlong

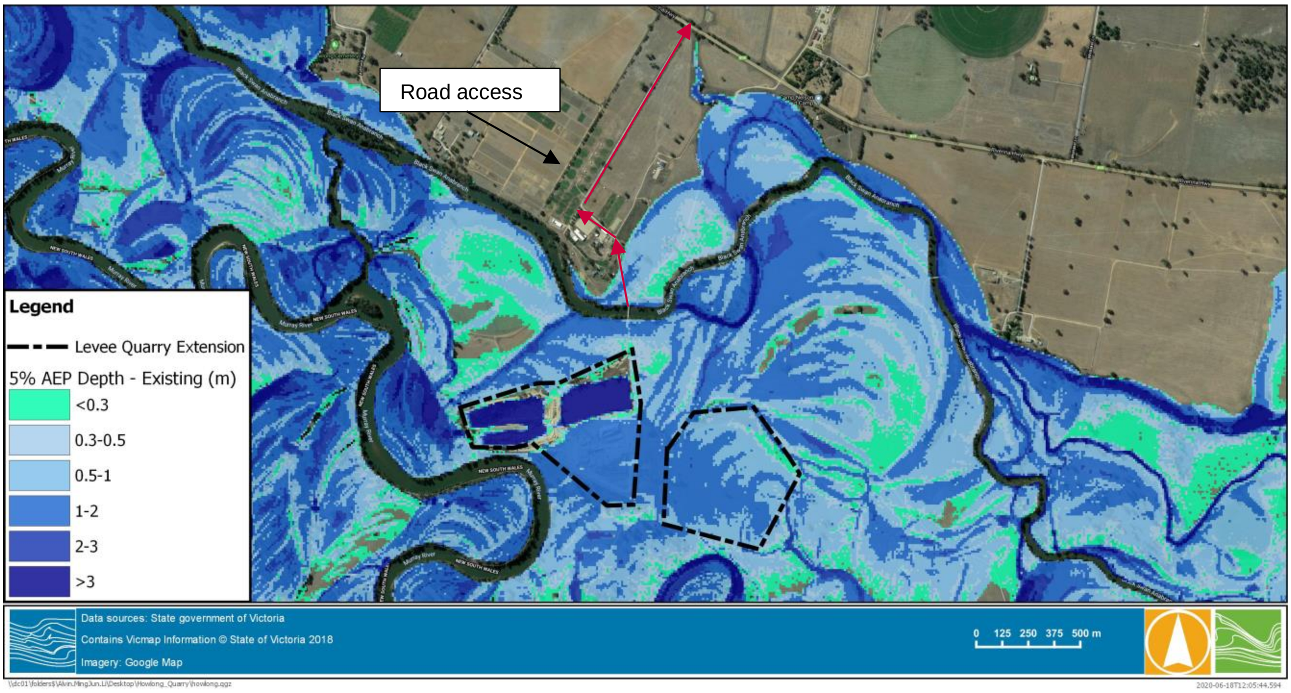

Figure 2-10 5% AEP flood depth at site

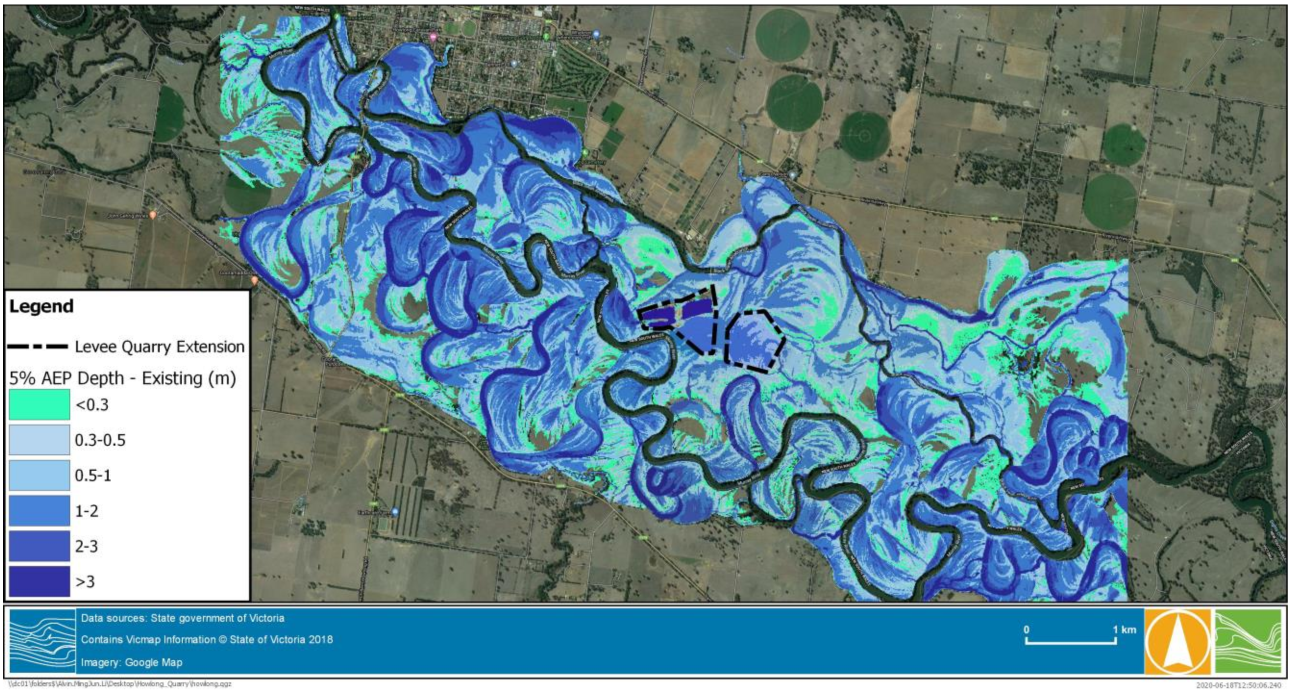

Figure 2-11 5% AEP flood depth

Further analysis on the impact of the quarry expansion on Flood hazard in the floodplain was undertaken. The most recent Australian Rainfall and Runoff Guidelines identify six hazard classifications based on hazard vulnerability curves. Hazard Classifications range from H1 to H6 based on a set of velocity and depth thresholds, as presented in Figure 12 below.

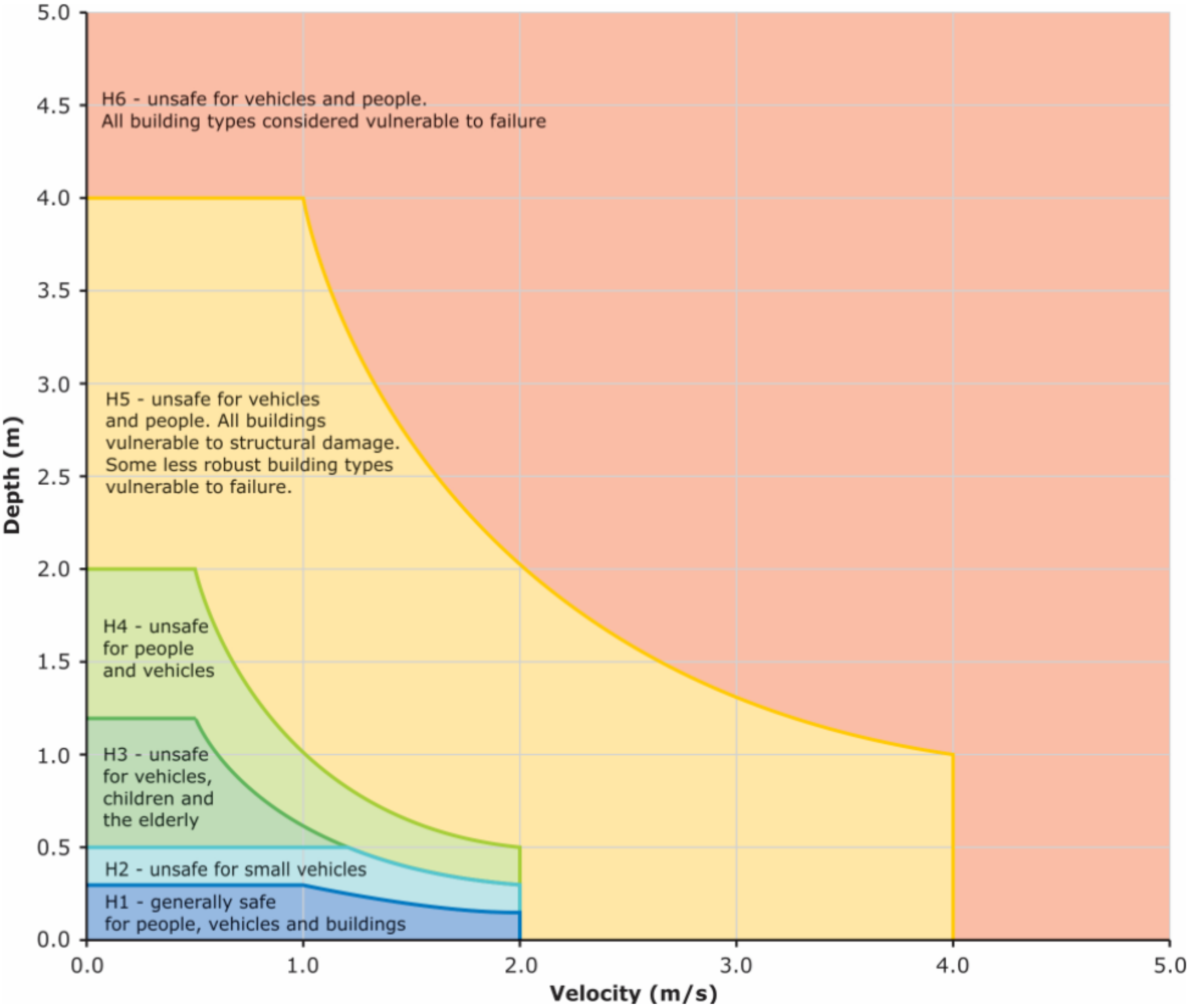

Figure 12 Combined Flood Hazard Curves (Smith et al., 2014) - **AR&R Book 6 Chapter 7.**

The hazard maps for existing and design conditions for the 1% AEP and 5% AEP flood events are presented in Figure 13 to Figure 16. The model outputs show that around the quarry site, the hazard is predominantly between H1 and H3 for the 5% AEP event, and between classes H3 and H5 for the 1% AEP event.

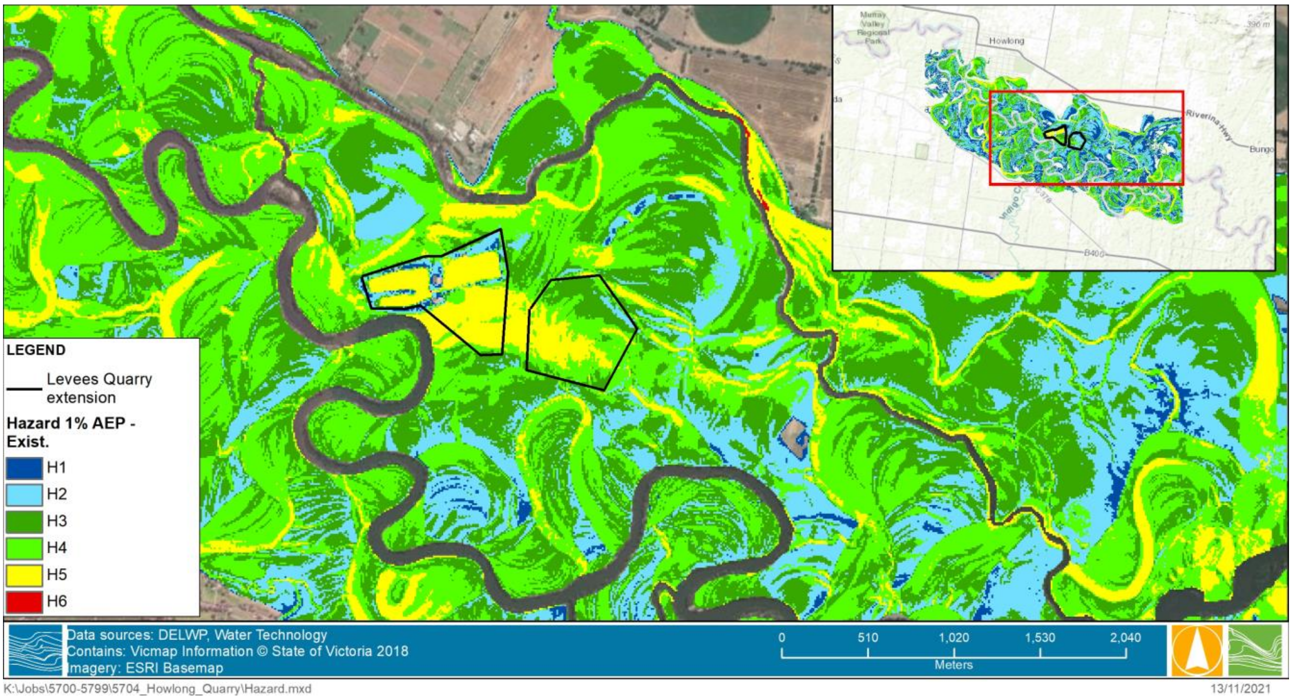

Figure 13 Hazard map – 1% AEP event - existing conditions

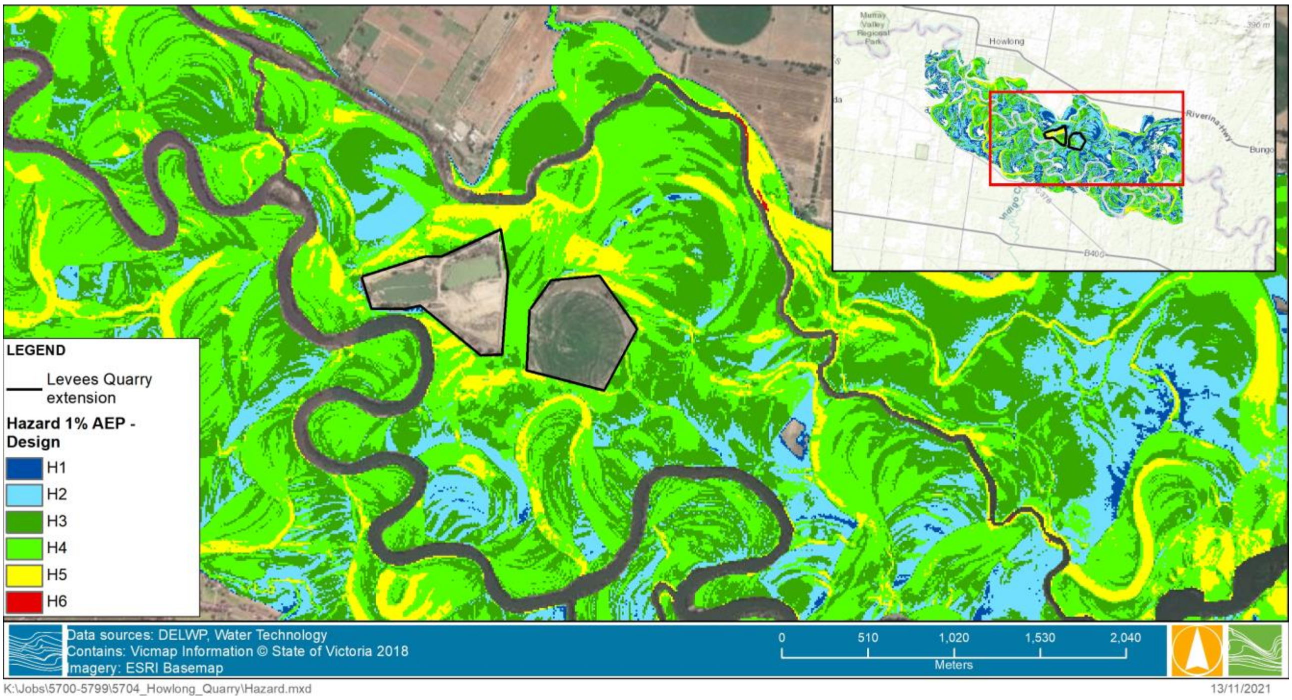

Figure 14 Hazard map – 1% AEP event - Design conditions

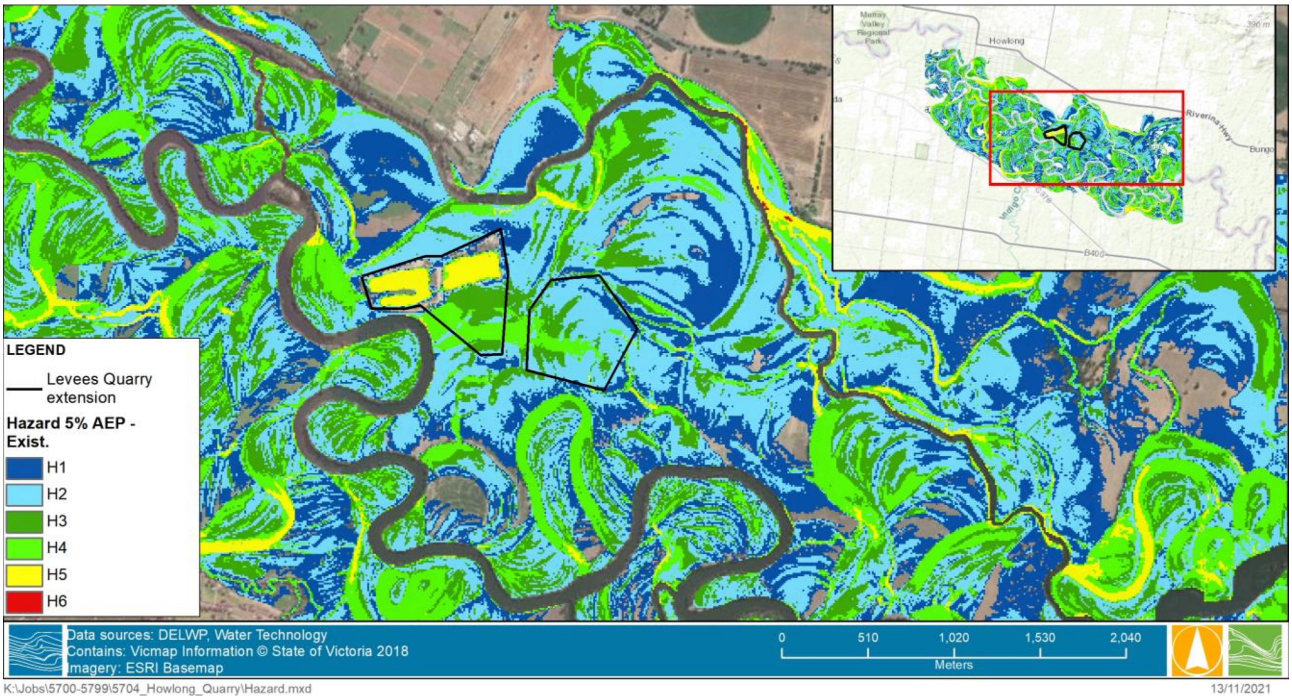

Figure 15 Hazard map – 5% AEP event - existing conditions

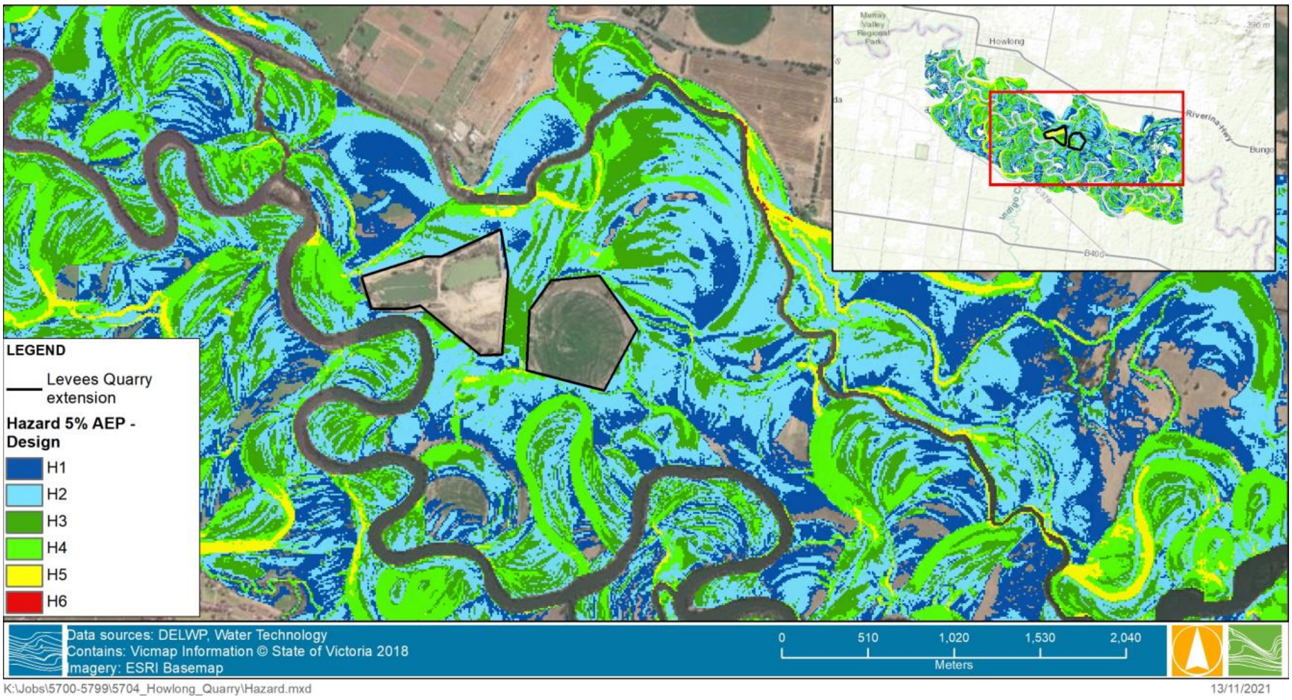

Figure 16 Hazard map – 5% AEP event - Design conditions

The change in hazard classification for the 5% and 1% AEP events is presented in Figure 17 and Figure 18 respectively. For the 5% AEP event there are localised areas within 1 km of the site where the hazard classes change between existing and proposed design conditions. For the most part, classes go from H1 to H2 or H2 to H3. Conversely, west of the added levels, hazard is reduced.

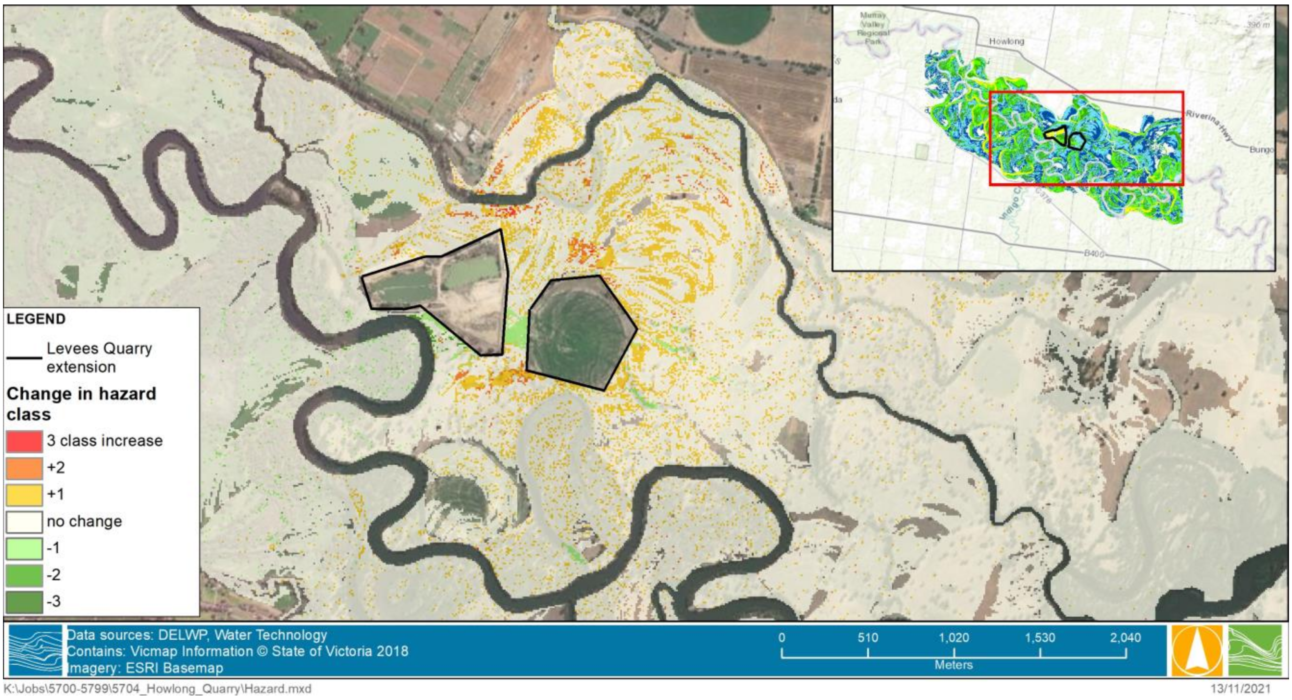

Figure 17 Change in flood hazard between existing and design – 5% AEP (warm colours indicate the flood hazard has increased, shades of green indicate the hazard is lowered under design conditions)

For the 1%AEP event, the area impacted by a change in hazard is similar to the 5% AEP event and is limited to a distance of 1 km from the site. The impacted areas are slightly greater to the north and south of the eastern pit. It should be noted that the reduced hazard is also more widespread than the 5% AEP event upstream and downstream of the levees. For this event, the change in hazard is generally H2 to H3 and H3 to H4. Close to the levees, there are areas where the hazard goes from H4 to H5.

Along the access track to the site, the hazard calculations indicate the road is unsafe for vehicles under both existing and design conditions. Therefore the proposed design does not adversely impact the access and egress to the site.

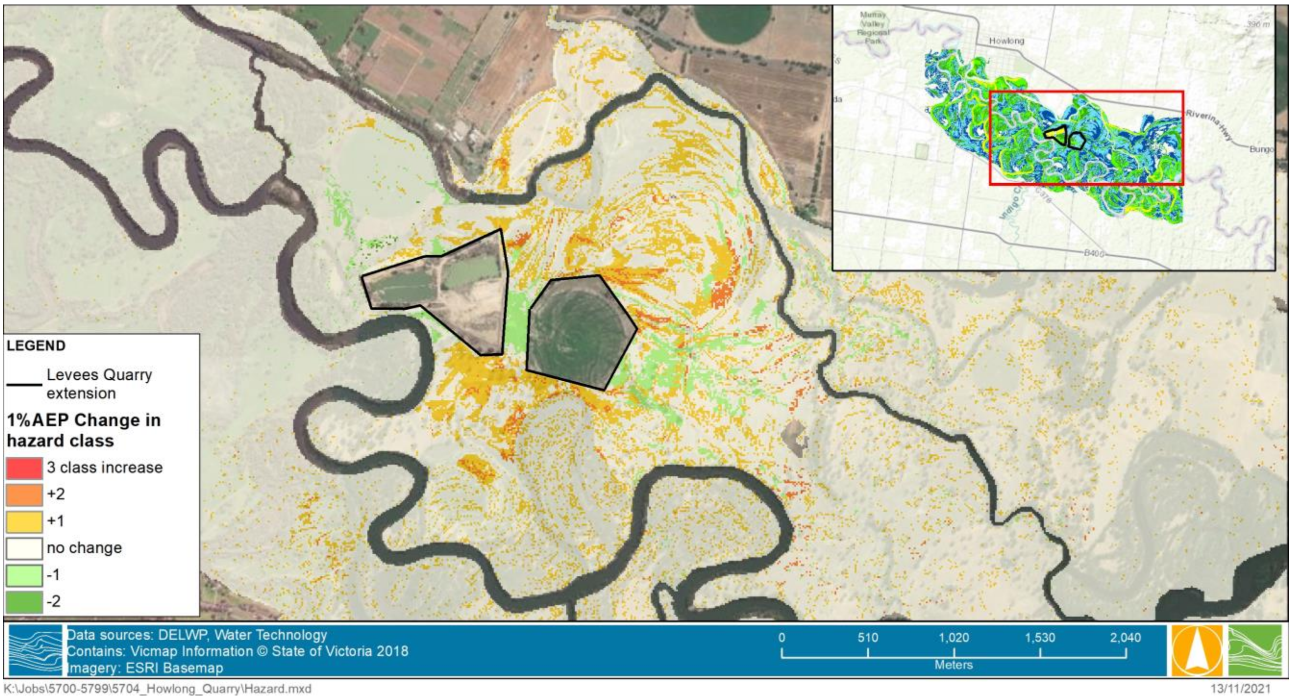

Figure 18 Change in flood hazard between existing and design – 1% AEP

3 CONCLUSION

A more detailed and targeted impact assessment on the Riverian Highway, access to the site and neighbouring properties was undertaken. Summary of findings are as follows:

- Due to the limit of the upstream model boundary, the modelling results do not show the impact of the quarry expansion on the Riverina Highway. However, there is no significant increase in flood extent upstream of the site and the afflux gradually reduces to 4.5 cm or less at the model boundary. The highway is on the edge of the floodplain a further 2.5 km upstream and sits well above the 0.5% AEP flood level, which presents the biggest afflux. It is unlikely the quarry expansion and associated levees would cause adverse impacts in terms of flood risk along the highway.
- The flood impact on neighbouring properties was investigated. The results showed that the construction of the levee would not cause adverse impacts to these properties.
- The flood impact on the access road from the Riverina Highway to the site was investigated. The modelling results show the road is overtopped on most of its length with depths above 300mm under existing conditions, for the 5% AEP flood event as shown in Figure 2-10. Hence, road immunity is not achieved under existing conditions for the 5% AEP flood event and above. Therefore, while the construction of the levee may locally cause an increase of water levels on the access road, given the current flood risk this will not have a detrimental impact on access and egress to the site during flood events.
- Along the access track to the site, the hazard calculations for the 5% and 1% AEP flood events indicate the road is unsafe for vehicles under both existing and design conditions. Therefore, the proposed design does not significantly alter the flood risk nor adversely impact the access and egress to the site.

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Appendix 9

Pit and Floodplain Stability Assessment prepared by Water Technology – December 2021

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Howlong Quarry Expansion Flood Risk Assessment

Pit and Floodplain Stability Assessment

RW Corkery and Co.

06 December 2021

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V02	Report	Michael Cheetham	Julian Martin	06/12/2021
V01	Report	Michael Cheetham	Julian Martin	22/10/2020

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Client Project Manager	Nicholas Warren
Water Technology Project Manager	Julian Martin
Water Technology Project Director	Michael Cheetham
Authors	Julian Martin
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CONTENTS

1 INTRODUCTION

1.1 Introduction

Water Technology has been commissioned by RW Corkery and Co. to undertake an investigation on floodplain and pit stability associated with the proposed Howlong Quarry expansion. The quarry is located on the NSW side of the Murray River floodplain, approximately 3.5km south-east of Howlong (Figure 1).

The existing quarry is sited adjacent to an outside bend of the Murray River, within a complex network of anabranches, which are located on both sides of the Murray River floodplain. The named anabranches include Chinamans, Chambers, Gulf, Parlour (referred to as Black Swan in previous reporting), Sawyers, Doolans and Punt Creeks.

The investigation has been initiated following comments from the Department of Planning, Industry and Environment Water Division that included a request for information relating to:

- The potential for increased erosion risk to the floodplain and/or the Murray River due to changes to flooding characteristics because of the proposed levees – this relates to absent comments on flow velocity or shear stress.
- Clarify the risk to floodplain and pit stability due to floodplain flows if the levees are removed to address water quality issues in the pits post closure.

1.2 Project Scope

With reference to the request for information from the Department of Planning, Industry and Environment Water Division, this investigation seeks to answer the following questions.

1. What are the floodplain erosion risks associated with the proposed levee arrangement surrounding the pit?
2. What are the risks to pit/floodplain/river stability should the levees need to be removed upon completion of the extraction activities (i.e., pit closure)?

In order to answer these questions, the following scope of works has been undertaken:

- A review of the existing floodplain expansion modelling scenarios undertaken by Water Technology in a previous scope of works.
- The preparation of a report (this report), which outlines:
  - The geomorphic and hydrologic behaviour and character within this section of the Murray River.
  - The general risks to floodplain/river stability associated with floodplain sediment extraction.
  - Specific comments regarding the erosion risks associated with the proposed levee arrangement surrounding the pit.
  - General guidance regarding risks and management options associated with the potential levee removal at pit closure.

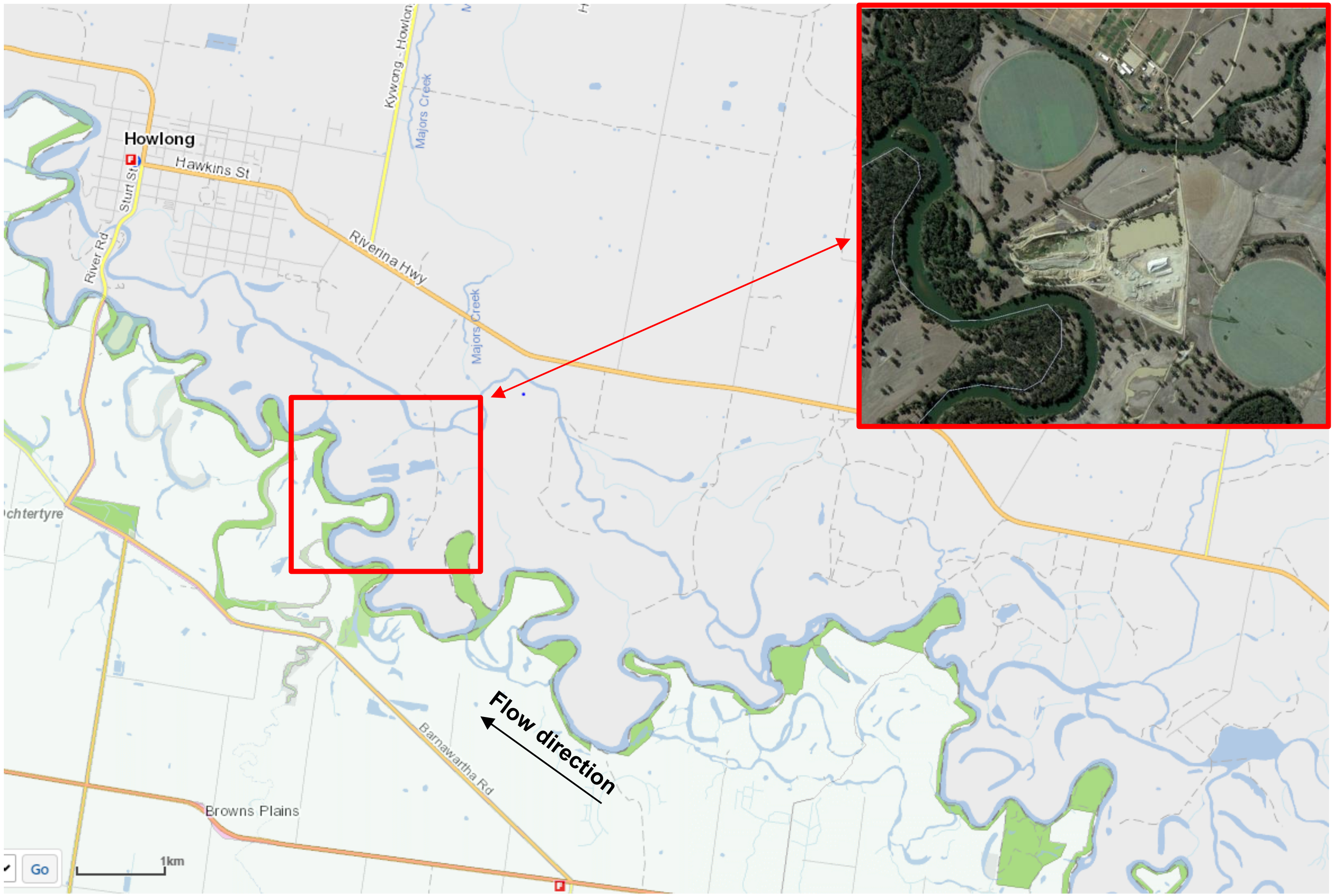

FIGURE 1 LOCALITY PLAN.

1.3 Quarry Expansion

The proposed quarry expansion arrangement is summarised in existing reports. In context of this current investigation, the proposed expansion involves multiple staged activities, including:

- The expansion of the existing extraction areas (Stage 1 and 2).
- The excavation of a new pit to the south-east of the existing pit (Stage 3 and 4).
- The construction of new levee banks that surround the pits. The proposed levee height is set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. It is understood that the levee is to be removed at the completion of the quarry operation.

It is also understood that as part of the expansion works, a 100m buffer will be established between the Murray River and the southern boundary of the levee attached to the Stage 1 – 3 pit.

The proposed expansion arrangement, reproduced from the Howlong Quarry Expansion Flood Risk Assessment (Water Technology, 2021) is provided in Figure 2.

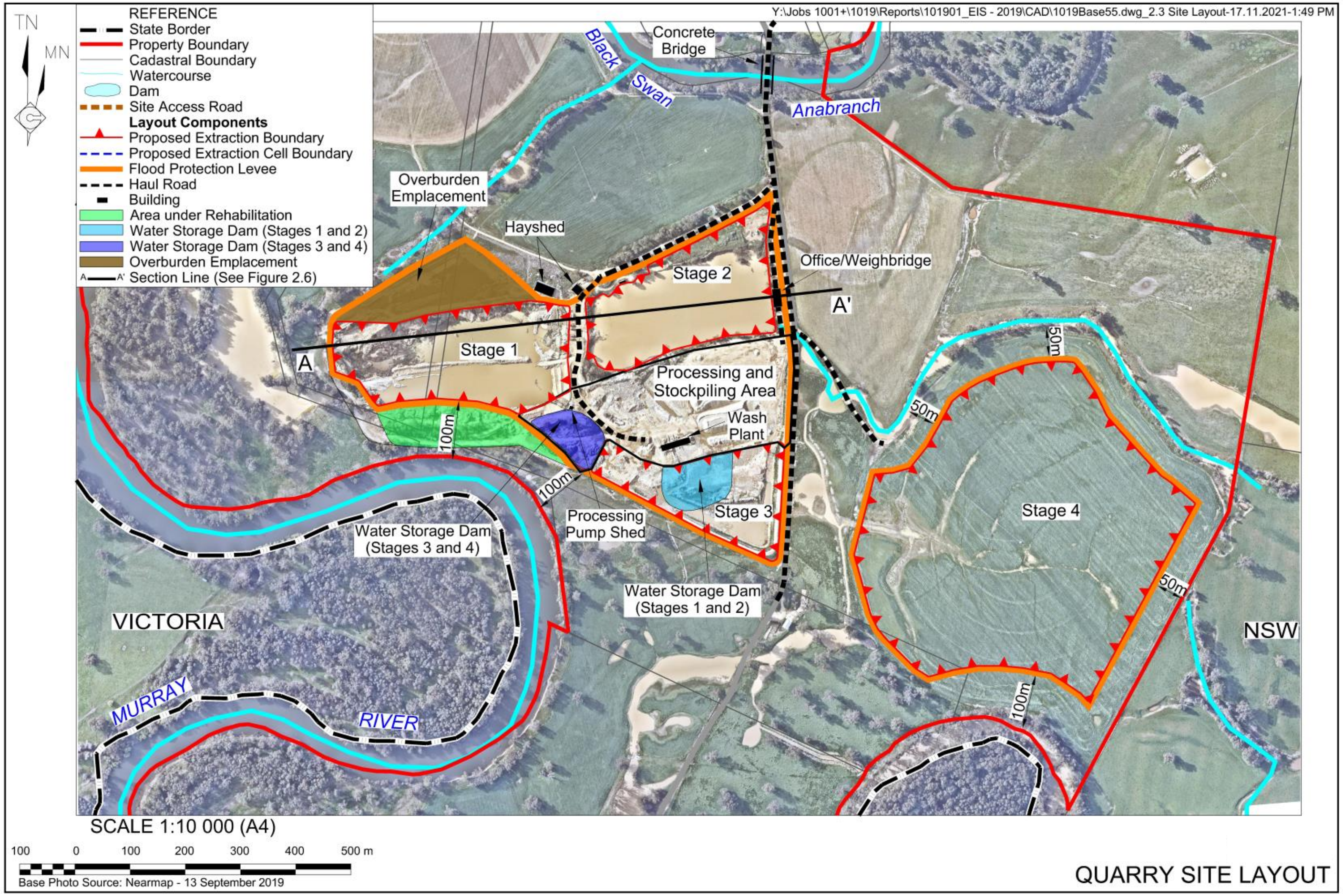

FIGURE 2 PROPOSED QUARRY EXTRACTION STAGES AND LEVEES AROUND THE EXTRACTION PITS (SHOWN IN ORANGE). IMAGE SUPPLIED BY R.W. CORKERY & CO. PTY LIMITED.

2 GEOMORPHIC SUMMARY

2.1 Overview

This brief geomorphic summary has been prepared to provide comment on the existing processes and features at the proposed extraction sites and to identify potential risks associated with the proposed extraction operation. The summary has been informed by a desktop review of available aerial photography and the hydraulic analysis outlined within this report. To assist the geomorphic discussion, a glossary of terms has been provided in Table 1.

TABLE 1 GLOSSARY OF GEOMORPHIC TERMS.

Term	Definition
Anabranch	A river channel which leaves the parent stream (i.e., the Murray River) and re-joins it further downstream.
Avulsion	The cutting of a new river channel (anabranch) through the floodplain. The avulsion may occur suddenly or over many years. The formation of an avulsion usually leads to the abandonment of the parent river channel due to the avulsion being a more hydraulically efficient flow path in comparison to the parent river channel.
Fluvial	Pertaining to or produced by a river.
Geomorphology	Relating to the structure, shape and development of landforms.
Knickpoint	A knickpoint is an erosional feature where there is a sharp change in the longitudinal channel bed slope. Knickpoints are mostly but not always vertical or near vertical features. Knickpoints migrate in an upstream direction. Knickpoints are also commonly known as erosion heads or head cuts.
Palaeochannel	An abandoned river channel.

2.2 Reach Overview

The Howlong Quarry is located within the Lake Hume to Lake Mulwala Reach of the River Murray system. This reach of the Murray River is defined as a laterally migrating, anabranching river. That is, the channel network has naturally evolved through the migration of meander bends and development of anabranches (Figure 3). Hence, erosion has and always will be a natural process within this reach.

The quarry is sited adjacent an outside bend of the Murray River, within a complex network of anabranches which are located on both sides of the Murray River floodplain (Figure 4). The named anabranches include Chinamans, Chambers, Gulf, Parlour (referred to as Black Swan Creek in previous reporting), Sawyers, Doolans and Punt Creeks.

Anthropogenic pressures are also interacting with natural processes to influence erosion rates on the Murray River. Erskine *et al.* (1993) investigated channel changes on the Lake Hume to Yarrawonga (Lake Mulwala) reach of the Murray River and proposed that the greatest influences on the physical form of the river were:

- River regulation.
- Floods (the frequency of which has been modified by the presence of Lake Hume).
- De-snagging.
- Changes in riparian vegetation.
- Boat waves.

Being located downstream of the Murray River's major water storage (Lake Hume), the reach is strongly influenced by a regulated flow regime. Current demands for water conveyance within this reach require sustained high flows for long periods of time during irrigation season (summer and autumn). The hydrologic effects of the current flow regime described by Erskine e.t al. (1993) include:

- Reversed seasonality of flow.
- Decreased duration of over bank flows and increased duration of in-channel flows.
- Reduced magnitude and frequency of floods.
- Slightly increased mean annual flow.

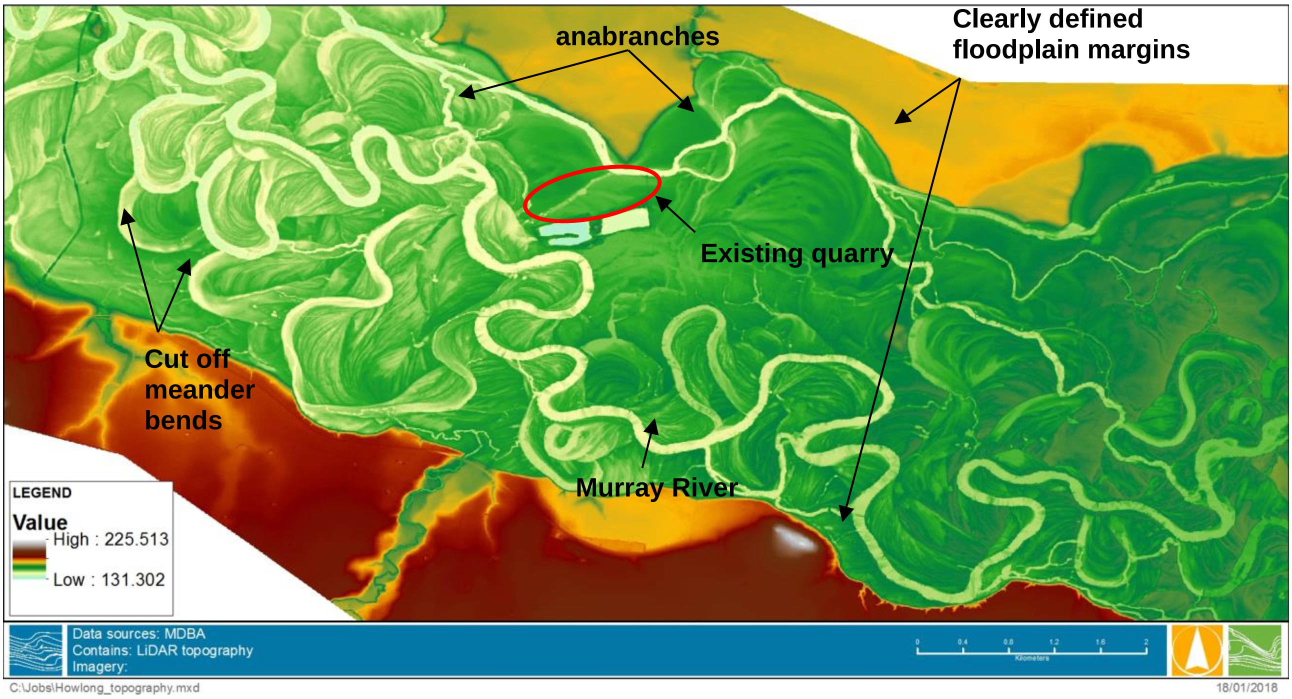

FIGURE 3 LIDAR IMAGE OF THE SUBJECT REACH SHOWING THE FLOODPLAIN TOPOGRAPHY, CHARACTERISTIC OF AN LATERALLY MIGRATING AND ANABRANCHING RIVER SYSTEM.

FIGURE 4 AERIAL IMAGE OF THE SUBJECT REACH SHOWING THE RELATIVE POSITION OF THE QUARRY TO THE SURROUNDING CHANNEL NETWORK. IMAGE REPRODUCED FROM WATER TECHNOLOGY (2018).

2.3 Geomorphic Processes

The dominant geomorphic processes occurring at the site, that have the potential to impact on stability of the levees, are that of anabranch development and bank erosion. These processes are outlined in the following sections.

2.3.1 Anabranch Development

The existing quarry is sited within a complex network of anabranches which are located on both sides of the Murray River floodplain. The development and evolution of anabranches involves the erosion and enlargement of a channel system until most, if not all of the flow has been captured from the parent channel. The rate of anabranch development, particularly within the subject reach is influenced by the complex interaction between several natural and anthropogenic influences. For instance, Parlour Creek and Common Creek (the anabranches in closest proximity to the quarry), form significantly straighter, steeper and hence shorter more hydraulically efficient sections of stream relative to the adjacent Murray River. As such, there is a risk that these anabranches will further develop and capture an increasing proportion of flow from the Murray River.

2.3.2 Bank Erosion

Bank erosion can occur in response to several different processes and can present in a variety of forms. In context of the subject reach, Erskine *et al.* presents evidence of both of channel (or lateral) migration as well as channel widening within the Lake Hume to Yarrawonga (Lake Mulwala) reach, which is relevant to both the Murray River and the associated anabranch network. The principal difference between the two processes being:

- Lateral migration is a natural geomorphic process and involves the movement of a meander bend in an outward and downstream direction that results in corresponding deposition on the opposite bank. Evidence of lateral migration can be found in the presence of point bars, scroll bars, floodplain ridges, cut-offs, counter point bars and concave benches on the floodplain.
- Channel widening is the erosion of a riverbank that is not restricted to outside bends, without corresponding deposition on the opposite bank. Channel widening is also a natural process but occurs discontinuously in a natural setting and is usually associated with bed deepening and/or river regulation.

3 POTENTIAL GEOMORPHIC RISKS

3.1 Overview

This summary has been prepared to provide comment on the existing processes and features in the vicinity of the existing quarry and to identify potential risks associated with the expanded extraction operation, including surrounding levees. The summary has been informed by a desktop review of available aerial photography and the hydraulic analysis previously prepared by Water Technology.

As identified through the completed hydraulic analysis (Water Technology, 2018), both the proposed extraction pits and surrounding floodplain surface are well connected to the Murray River during flood flows. Being situated on the floodplain, the physical risks associated with the pits can be broadly described as follows:

1. Bank erosion (principally lateral migration, outlined in Section 2.3.2).
2. Flow of water into and through the pit causing floodplain surface erosion or avulsion (Table 1).
3. Groundwater (geotechnical) instabilities (e.g., it is possible that the pit and river will be hydrologically connected through sub-surface flow. Prolonged sub-surface seepage can lead to piping failure of the pit walls). It is understood that the groundwater interaction between the river and proposed pits have been investigated as part of a separate investigation.

Further discussion relating to the risks of lateral migration and pit capture or avulsion are provided in the following sections.

3.2 Lateral Migration

As previously defined, lateral migration is a natural geomorphic process and involves the movement of a meander bend in an outward and downstream direction that results in corresponding deposition on the opposite bank. Evidence of lateral migration within the reach can be found in the presence of point bars, scroll bars, floodplain ridges, cut-offs, counter point bars and concave benches on the floodplain (Figure 3).

A review of available 2020 aerial photography (Google Earth imagery) indicates that the existing pit edge sits approximately 35m from an outside bend of the Murray River channel at its closest point. A vehicle track, situated south of the pit, is less than 20m from the same point of Murray River channel at its closest point. In context of the discussion outlined above, there is considerable risk that continued erosion through lateral migration processes will erode through the floodplain section currently separating the pit from the Murray River channel, leading to pit capture in the medium to long term. The rate of erosion cannot be easily quantified, however it should be noted that the development of the Parlour Creek – Common Creek anabranch network has the potential to influence rates of lateral migration on the adjacent section of the Murray River.

As presented in Figure 2, the proposed expanded operation will include establishment of a minimum 100m setback between the western pit (Stages 1, 2 and 3) and the river channel. The re-establishment of this buffer will reduce the risk of pit capture through lateral migration processes.

The proposed eastern pit (Stage 4) is situated in excess of 500m from both the Murray River and the Parlour Creek anabranch network. Hence, the physical risks associated with this pit and lateral migration processes can be broadly described as low.

FIGURE 5 2021 AERIAL IMAGE OF THE EXISTING PIT RELATIVE TO AN OUTSIDE BEND OF THE MURRAY RIVER. IMAGE SUPPLIED BY R.W. CORKERY & CO. PTY LIMITED.

3.3 Avulsion Risk

An avulsion is defined as a wholesale shift in channel position within the valley floor (floodplain), such that a new or secondary channel is created. In simple terms, the initiation of an avulsion is a two-step process involving diversion of water onto the floodplain and the cutting of a new channel through the floodplain (Judd 2005). Diversion of water onto the floodplain may occur through flooding or channel obstruction. Judd (2005) found that small to moderate floods are the most important events to the initiation of avulsion channels. An avulsion channel is typically more hydraulically efficient compared to the parent river channel (i.e., shorter and straighter). Hence, the formation of an avulsion often leads to the abandonment of the parent river channel.

Floodplain sediment extractions have the potential to contribute to the initiation and development of an avulsion during flood events. The general process of concern, that has the potential to increase the risk of an avulsion occurring at the site, involves floodwaters accessing the quarry pit, with the pit providing low flow resistance and a high cross-sectional area for the passage of flows. This in turn can lead to accelerated hydraulic conditions where flows enter the pit, which will likely lead to erosion. For an avulsion to occur at and surrounding the quarry, the development of floodplain flow paths surrounding the quarry would likely need to occur.

The potential for floodplain sediment extractions to contribute to or cause an avulsion is dependent upon multiple factors including:

- The position and shape of the extraction site relative to the parent river channel and other floodplain features including anabranches, palaeochannels, deferred tributary junctions, and flood flow re-entry points.
- The connectivity and interaction of the floodplain surface that the extraction site is situated in relative to the river channel and anabranch network.
- The hydraulics of flow.
- The composition and variability of floodplain sediments

Potential negative implications associated with an avulsion include:

- Increased slope and thus increased stream power.
- The capture of the parent river channel in favour of a new channel within the floodplain.
- The loss of private/public land and infrastructure.
- The liberation of a significant volume of sediment into downstream reaches.
- Potential bed degradation (incision) upstream of the avulsion.
- The potential loss of riparian vegetation.
- Reduction in water quality.
- Loss of in-stream habitat.

The entire Lake Hume to Lake Mulwala reach of the Murray River, including the section of the Murray River in the vicinity of the subject quarry is dynamic in terms of rapid channel planform change. This is evident through the presence of the complex anabranch network and meander cut-offs (Figure 3). Additionally, the existing hydraulic modelling (which modelled a series of flow scenarios including the 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF (Probably Maximum Flood) flows on the Murray River) indicates that the proposed extraction pits are situated on a floodplain surface that is well connected to the Murray River during flood flows.

An output of the hydraulic modelling scenario involving the final pit arrangement during a 20% AEP flow event is provided in Figure 6. The modelled flow scenario is inclusive of the proposed levees, which have the proposed levee height set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. Hence, the modelling demonstrates that flows do not enter either of the pits.

The modelling however does demonstrate the necessity to incorporate mitigation measures to address the risk of floodplain surface erosion. Specifically, the modelling demonstrates that in the absence of the levees there is a very high potential for erosion due to substantial velocities and shear stresses along specific concentrated floodplain flow paths (represented by the orange circles in Figure 6). In the absence of the levees, it is highly likely that erosion will initiate and occur along pit walls as the pit fills. This is due to supercritical flow as the water spilling out of the river enters the pit and flows down the pit walls. This type of erosion has the capacity to eat backwards through the floodplain (via a process referred to as knickpoint regression). Left unchecked this erosion has the potential to propagate across the floodplain over time, linking extraction pits with the river, each other, or adjacent topographic depressions (shown in Figure 6). In this instance, this type of erosion has the potential to link the western extraction pit (Stages 1, 2 and 3) with the Murray River and Parlour Creek, that has significant implications for anabranch development within this reach. Specifically, this type of erosion could increase the rate of abandonment of the Murray River channel in favour of Parlour Creek, through the extraction pit. For a period of time (likely decades or longer) the new channel course through the extraction pits would likely co-exist with the contemporary river/anabranch channels.

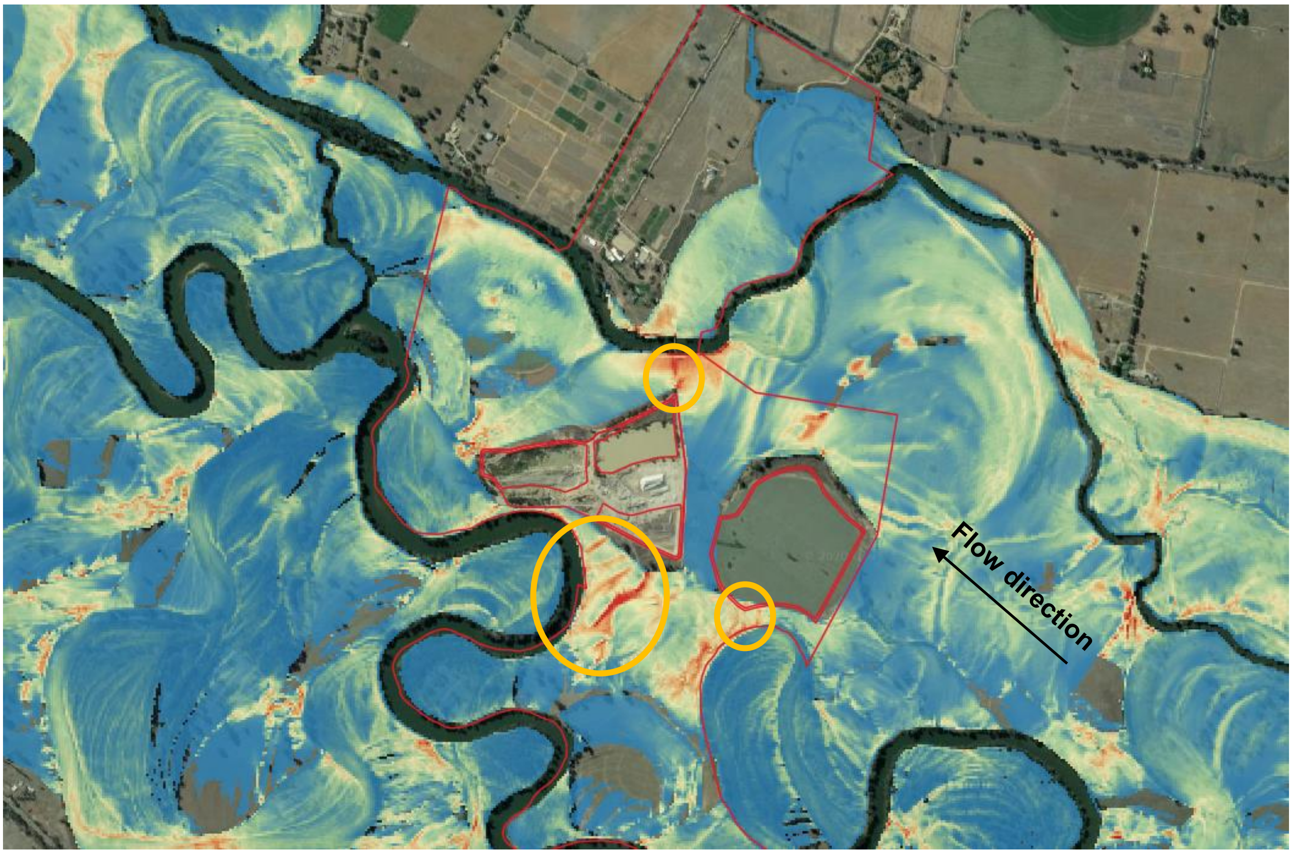

FIGURE 6 HYDRAULIC MODELLING OUTPUT INDICATING SHEAR STRESS ACROSS THE FLOODPLAIN DURING A 20% AEP FLOW EVENT FOR THE DEVELOPED CASE. THE KEY AREAS OF POTENTIAL EROSION ARE REPRESENTED BY THE ORANGE CIRCLES.

4 POTENTIAL MITIGATION MEASURES

Through this investigation a series of potential risks to floodplain stability have been identified. These specific risks include:

- Lateral migration of the Murray River channel into the floodplain section currently separating the pit from the Murray River channel, leading to pit capture in the medium to long term.
- Knickpoint progression across the floodplain surface (likely initiated if the levees are overtopped or removed upon completion of extraction activities) leading to the formation of an avulsion, potentially linking the western extraction pit (Stages 1, 2 and 3) with the Murray River and Parlour Creek, which may subsequently accelerate the capture of the Murray River into the Parlour Creek anabranch complex.

In any circumstance where fluvial erosion is to be mitigated, there are three potential mitigation measures. They are to **armour** the area being eroded, **increase the roughness** at and around the area being eroded, or **modify the flow conditions** affecting the area being eroded. Depending on the area, geomorphic context, hydrology, hydraulics, and sedimentology, one or a combination of these measures can be used. All mitigation measures should be accompanied by a suitable monitoring plan to ensure their effectiveness. The majority of erosion protection measures fail due to lack of maintenance.

This analysis has demonstrated the necessity to incorporate mitigation measures to address the risk of floodplain surface erosion. These mitigation options are briefly presented in the following paragraphs. Note that it is not within the scope of this investigation to develop specific design details associated with these measures.

Vegetated buffers are recommended at specific locations between the Murray River, Parlour Creek and the pits to minimise the potential for lateral migration and floodplain surface erosion. Specific areas where vegetated buffers are recommended shown in Figure 7 and include:

1. A minimum 100m buffer between the outside bend of the Murray River and the southern section of the levee attached to the western extraction pit (Stages 1, 2 and 3). It is understood that a 100m buffer is to be established in this area as part current expansion.
2. Adjacent the access track, linking the bridge over Parlour Creek and the north-eastern corner of the western extraction pit (Stages 1, 2 and 3).
3. Across the multiple concentrated floodplain flow paths linking the Murray River to the southern side of the western extraction pit (Stages 1, 2 and 3).
4. Across the concentrated floodplain flow paths linking the palaeochannel to the southern side of the eastern extraction pit (Stage 4).

As articulated in preceding sections, floodplain pits generally have high potential for erosion due to substantial velocities and shear stresses along their boundaries during fill. In this instance, knickpoint progression across the floodplain surface has the potential to initiate an avulsion. This risk will be effectively managed during the excavation phase through the construction of levees around each of the pits that are raised to the estimated 1% AEP (Annual Exceedance Probability) event. Key management implications of this arrangement relevant to this investigation include:

- That the levees will only mitigate this form of floodplain surface erosion up to the estimated 1% AEP event. That is, once the levees are overtopped, the integrity of the levees will be at risk due to overtopping. Failure of the levees will result in uncontrolled flows into the pits, erosion on the pit walls, and potentially, avulsion initiation.
- The integrity of the levees needs to be maintained during the life of the extraction.

With consideration of the preceding points, further investigation is required to determine a suitable mitigation arrangement to manage risks upon completion of the extraction activities (i.e., pit closure). Possible mitigation measures include:

- Maintaining a levee into perpetuity. Note that the Leading Practice Sustainable Development Program for the Mining Industry Mine Closure Report (DFATG, 2016) states that leading practice dictates that a post -closure design life of 1000 years be adopted as a definition of 'in perpetuity'. If this definition was adopted, it is likely that the levee height would need to be increased to account for the PMF flow event and require on-going monitoring and maintenance to ensure its integrity. This is considered practically difficult to achieve.
- Filling of the pits (with either water or fill material) to minimise bed shear stress and therefore the potential for erosion along the sides of the quarry as floodwaters enter the pits.
- Rock armouring of concentrated designed flow entry points. This option involves the placement of rock at the transition from the floodplain surface into the excavated pit at an appropriate batter slope at key locations. The feasibility of this option requires further analysis. Additionally, this option would require on-going monitoring and maintenance to ensure its integrity.
- Vegetated buffers. Vegetation is to be included as a component of any closure/rehabilitation plan.

FIGURE 7 KEY AREAS WHERE VEGETATED BUFFERS ARE RECOMMENDED.

5 PROPOSED QUARRY EXPANSION PLAN

5.1 Overview

With reference to the potential geomorphic risks and mitigation measures presented in this report, a proposed quarry expansion arrangement was supplied to Water Technology for review in November 2021 (reproduced in Figure 8). The proposed quarry expansion arrangement incorporates several mitigation measures summarised in the following points.

- The re-establishment of a **vegetated 100m buffer** between the outside bend of the Murray River and the southern section of the levee attached to the western extraction pit. The intent of this buffer is to mitigate bank erosion, principally lateral migration of the outside bend of the Murray River. This vegetated buffer will commence in Stage 1 of the proposed expansion plan.
- The construction of **new levee banks** that surround the pits. The proposed levee height is set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. It is understood that the levee is to be removed at the completion of the quarry operation. It is understood that levee removal is favoured in order to flush water from the pits during flood events in order to reduce salt concentrations within the pits over time.
- Established **vegetated buffers** across concentrated floodplain flow paths at risk of floodplain surface erosion identified through the hydraulic modelling summarised in Section 3.3 and Figure 6.

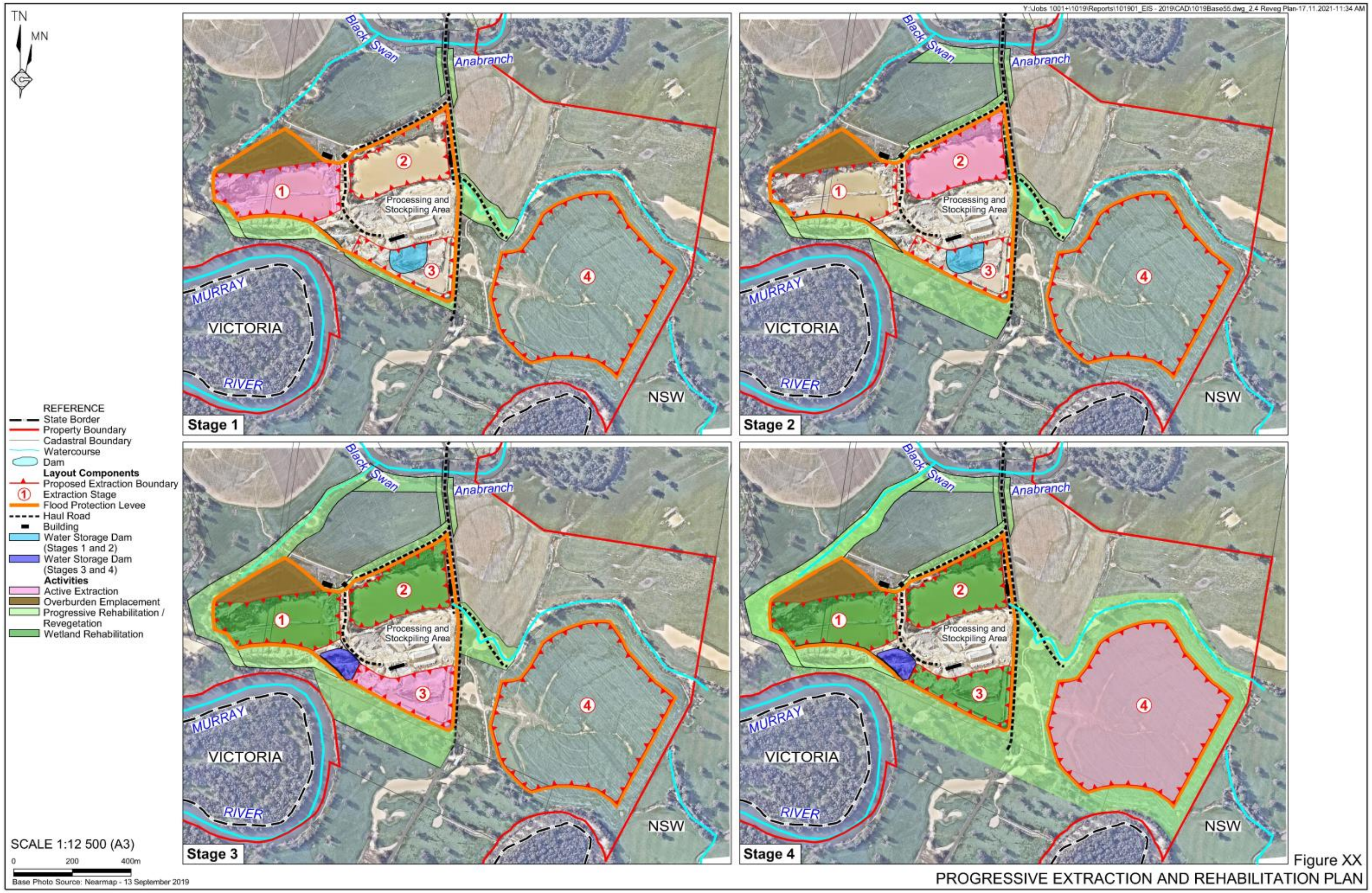

FIGURE 8 PROPOSED QUARRY EXTRACTION STAGES AND REVEGETATION ARRANGEMENT. IMAGE SUPPLIED BY R.W. CORKERY & CO. PTY LIMITED.

6 SUMMARY AND CONCLUSION

The proposed expansion involves multiple staged activities, including:

- The expansion of the existing extraction areas (Stage 1 and 2).
- The excavation of a new pit to the south-east of the existing pit (Stage 3 and 4).
- The construction of new levee banks that surround the pits. The proposed levee height is set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. It is understood that the levee is to be removed at the completion of the quarry operation.

The entire Lake Hume to Lake Mulwala reach of the Murray River, including the section of the Murray River in the vicinity of the subject quarry is dynamic in terms of rapid channel planform change. This is evident through the presence of the complex anabranch network and meander cut-offs. As identified through the completed hydraulic analysis (Water Technology, 2018), both the proposed extraction pits and surrounding floodplain surface are well connected to the Murray River during flood flows. Being situated on the floodplain, the physical risks associated with the pits can be broadly described as follows:

1. Bank erosion (principally lateral migration).
2. Flow of water into and through the pit causing floodplain surface erosion or avulsion.
3. Groundwater (geotechnical) instabilities (investigated as part of a separate assessment).

In general, these risks are applicable during both operation and post closure. In order to manage these risks, the proposed quarry expansion arrangement incorporates several mitigation measures to be undertaken during operation which are summarised in the following points.

- The re-establishment of a **vegetated 100m buffer** between the outside bend of the Murray River and the southern section of the levee attached to the western extraction pit. The intent of this buffer is to mitigate bank erosion, principally lateral migration of the outside bend of the Murray River. This vegetated buffer will commence in Stage 1 of the proposed expansion plan.
- The construction of **new levee banks** that surround the pits. The proposed levee height is set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. It is understood that the levee is to be removed at the completion of the quarry operation. It is understood that levee removal is favoured in order to flush water from the pits during flood events in order to reduce salt concentrations within the pits over time. Management implications associated with the proposed levees include:
  - The levees will mitigate flow of water into and through the pit causing floodplain surface erosion or avulsion:
    - Up to the estimated 1% AEP event. That is, once the levees are overtopped, the integrity of the levees will be at risk due to overtopping.
    - Whilst the levees remain, and their integrity is maintained. Failure or removal of the levees will result in uncontrolled flows into the pits, erosion on the pit walls, and potentially, avulsion initiation.
- Established **vegetated buffers** across concentrated floodplain flow paths at risk of floodplain surface erosion identified through the hydraulic modelling summarised in Section 3.3 and Figure 6.

A key risk associated with the proposed expansion and levee removal at the completion of the quarry operation is that of pit capture. It is recommended that closure planning include the identification of appropriate mitigation measures aimed at minimising erosion risks post closure. The closure plan should be developed utilizing an expert in fluvial geomorphic processes and waterway engineering. Specific considerations include:

- Maintaining water within the pits aimed at reducing the amount of time water flows over the pit walls.
- Rock armouring the pit walls at designated flood flow entry and exits points.
- Maintaining and expanding the proposed vegetated buffers across concentrated floodplain flow paths at risk of floodplain surface erosion. Specific areas where the existing vegetation buffer could be expanded during the quarry life to minimise the risk of erosion post closure are highlighted in Figure 9.

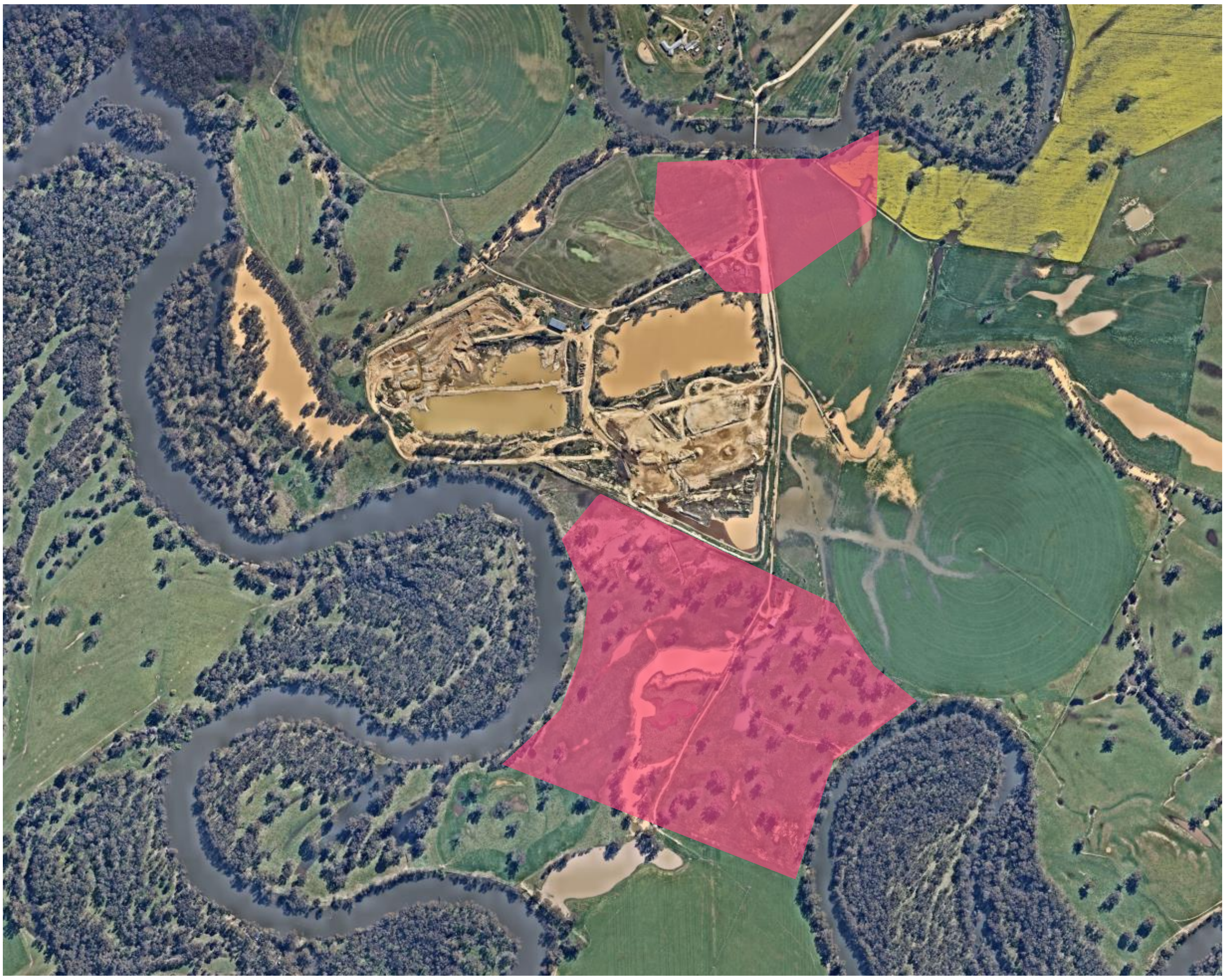

FIGURE 9 SPECIFIC AREAS WHERE IT IS RECOMMENDED TO EXPAND THE PROPOSED VEGETATION BUFFER TO MINIMISE FLOODPLAIN EROSION POTENTIAL (REPRESENTED BY THE PINK POLYGON).

7 REFERENCES

Department of Foreign Affairs and Trade (DFAT), 2016. Mine Closure. Leading Practice Sustainable Development Program for the Mining Industry. Canberra.

Erskine, WD, I D Rutherfurd, J Sherrard and J W Tilleard (1993). Investigation of River Channel Changes. River Murray and Anabranches Between Hume Dam and Lake Mulwala. Canberra, Ian Drummond and Associates for the Murray-Darling Basin Commission.

Water Technology (2018). Flood Risk Assessment. Howlong Quarry Expansion. Notting Hill. Water Technology for Advanced Environmental Systems.

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Appendix 10

Supplementary Noise Impact Assessment prepared by Octave Acoustics – July 2021

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Association of Australasian Acoustical Consultants

Consultant Advice Notice

8 July 2020

Client: RW Corkery & Co Pty Ltd

Attention: Nick Warren

email: nick@rwcorkery.com

4343 Riverina Highway, Howlong

Responses to EPA Request for Further Information

1 Introduction

Octave Acoustics was engaged by RW Corkery & Co Pty Ltd to undertake 3D computer modelling of noise impacts associated with the proposed ongoing and expanding operation of the alluvial sand and gravel quarry at 4343 Riverina Highway, Howlong.

The resulting assessment was documented in Octave Acoustics report *AA722ME-01E03 Technical Memorandum (r4)*. Key findings included that all items of plant operating on site, and vehicles utilising the access road as a result of the proposed expansion would generally result in noise levels at, or below the project noise trigger levels for the day and evening period.

On review of the Octave Report, the Environment Protection Authority (EPA) responded as follows:

> *Based on the information provided, we cannot adequately assess the potential noise impacts of the proposal. To fully assess these impacts, we require the following information.*
>
> *1. Assessing low frequency noise*
>
> *The derived project noise trigger levels have been adequately derived in accordance with the Noise Policy for Industry (NPfI). However, the predicted noise levels at the nearest residential receiver are equal to the trigger level for that receiver. In addition, the assessment of annoying characteristics is not considered adequate. The assessment of low frequency noise should include one-third octave or narrowband frequencies down to 10Hz. The assessment in Noise Modelling Assessment shows octave frequencies of 63Hz.*
>
> *We recommend that the proponent assess the annoying characteristics in accordance with Fact Sheet C of the NPfI (see Attachment B for further information) and apply a correction where applicable to the predicted noise level before comparison with the trigger level, and provide details of any further feasible and reasonable mitigation measures that are necessary to reduce the noise levels.*

2. *Provision of noise contour maps*

The Noise Modelling Assessment provides noise contour maps for Stage 2 of the proposal, however noise contour maps have not been provided for all the proposed stages of work.

We recommend that the proponent provide the noise contour maps for each stage of the work, not just for Stage 2.

3. *Assessment of noise impacts within Victoria*

The proposal is on the border of NSW and Victoria. The NPfI is a NSW policy and in the Noise Modelling Assessment it has been applied to the sensitive receivers on the NSW side of the border. The EPA note that there are sensitive receivers to the south of the premises, on the Victorian side of the border, who may be impacted by operations.

We recommend that the proponent considers assessing the potential noise impacts to those sensitive receivers to the south of the premises, on the Victorian side of the border.

Subsequent to receiving this response, RW Corkery & Co convened a video conference with Robin Brown of Octave Acoustics and Briohny Seaman and Truda King of the EPA. The key outcome of this meeting was agreement on the specific information required to address the EPA's request for further information. This document sets out the details of this specific information.

2 Modifying Factor Corrections

2.1 Assessing Low Frequency Noise

As requested by the EPA, Octave Acoustics has carried out an assessment of Low Frequency Noise (LFN) in accordance with Fact Sheet C of the Noise Policy for Industry. Where LFN is found to be present, an appropriate modifying factor correction is to be applied to the assessed noise levels from the quarry. Fact Sheet C has two requirements to determine the presence of LFN as follows:

1. A screening test to identify the potential for LFN by assessing whether there is a difference of 15dB or more between C and A-weighted noise, and where this is the case;
2. A detailed evaluation of the 1/3 octave frequencies between 10Hz and 160Hz with respect to the 'low frequency thresholds' set out in Table C2 of Fact Sheet C. Where noise levels are greater than the low frequency thresholds, a modifying factor correction shall be applied to the assessed noise level.

Octave Acoustics has used the CadnaA 3-D noise modelling package to assess quarry noise emissions down to the lowest octave band supported by the software (25Hz). A low frequency curve or 'tail' down to 10Hz was then developed in reference to (Parnell, 2015). Specifically, quarry plant was divided into two categories, 'LFN emitting' (ie. the wash plant) and 'other'. LFN was then assigned to each category of plant based on the LFN one-third octave spectra set out in Parnell, which are taken from measurement data. The resultant spectra and overall levels at the nearest noise sensitive receiver are attached in Appendix A.

Appendix A provides the data required for the 'C minus A' screening test, the result of which is 52-38 = 14dB. This result indicates that the subsequent detailed evaluation is not required and that no modifying factor correction is required. However in the interests of completeness, the second stage detailed evaluation was carried out. The results of this evaluation (presented in Table 1 below) show that in each low frequency third octave band, resultant quarry noise falls beneath the LF noise threshold. This outcome further substantiates that it is unnecessary to apply a modifying factor correction for LFN to the assessment results.

TABLE 1 – ASSESSMENT WITH RESPECT TO NPI LOW-FREQUENCY NOISE THRESHOLDS

	Third Octave Band Centre Frequency, Hz												
	10	13	16	20	25	32	40	50	63	80	100	125	160
LF noise at sensitive receiver	35	42	55	47	46	43	41	41	42	41	41	40	38
LF noise threshold	92	89	86	77	69	61	54	50	50	48	48	46	44

2.2 Tonality

Fact Sheet C of the NPI also sets out a test for tonal noise. If emissions from the quarry are found to be tonal, then a modifying factor correction should be added to the assessment result. Fact Sheet C states that a modifying factor correction should be added if the level of one third octave band exceeds the level of the adjacent bands on both sides by:

- 5dB or more if the centre frequency of the band containing the tone is in the range 500-10kHz.
- 8dB or more if the centre frequency of the band containing the tone is in the range 160-400Hz.
- 15dB or more if the centre frequency of the band containing the tone is in the range 25-125Hz.

Consideration of the Z-weighted third octave band results presented in Appendix A indicates that noise emission from the quarry should not attract a modifying factor correction for tonality.

3 Provision of Noise Contour Maps

It should be noted that noise impacts at the adjacent sensitive receivers do not vary significantly as the quarry progresses through the various stages. This is because noise at these receivers is dominated by vehicles using the quarry access road (rather than operations within the quarry pit).

Noise contour maps were provided for Stage 2 of the proposal only, as Stage 2 represents the worst-case scenario for emission of noise from the quarry. As referenced above, the variation of noise emissions with progressing stages will not be significant. If anything, noise impacts will reduce due to both increased quarry pit depth and increased distance from sensitive receivers.

Through the other quarry stages, there would be no material variation from the noise contours of Stage 2 proximate to the sensitive receivers.

4 Assessment of Noise Impacts within Victoria

The applicable criteria for the assessment of quarry noise in Victoria are prescribed by EPA Victoria publication 1411 *Noise from Industry in Regional Victoria* (NIRV). NIRV sets criteria based on land zoning classification of both the noise emitter and receiver. Figure 1 shows the zoning of the quarry and surrounds, including the location of noise sensitive receivers in Victoria. From Figure 1 it can be seen that the nearest receivers in Victoria are located on Farming zone (FZ), at a distance of over 1.5km from the quarry. The land on which the quarry operates is zoned Environmental Management (E3). The E3 classification does not exist in the Victorian scheme, however an equivalent may be FZ (as some quarries are located on FZ in Victoria). The resulting NIRV criteria at the noise sensitive receivers in Victoria would be as follows:

Day = 46dB(A)

Evening = 41dB(A)

Night = 36dB(A)

Results of noise modelling indicate that within Victoria, noise levels 1km from the quarry will be approximately 33dB(A). Noise levels at the nearest sensitive receivers in Victoria will be less than this as the closest is over 1.5km from the quarry. As such, this assessment indicates that noise from the quarry will comfortably comply with the applicable Victorian noise guideline (NIRV).

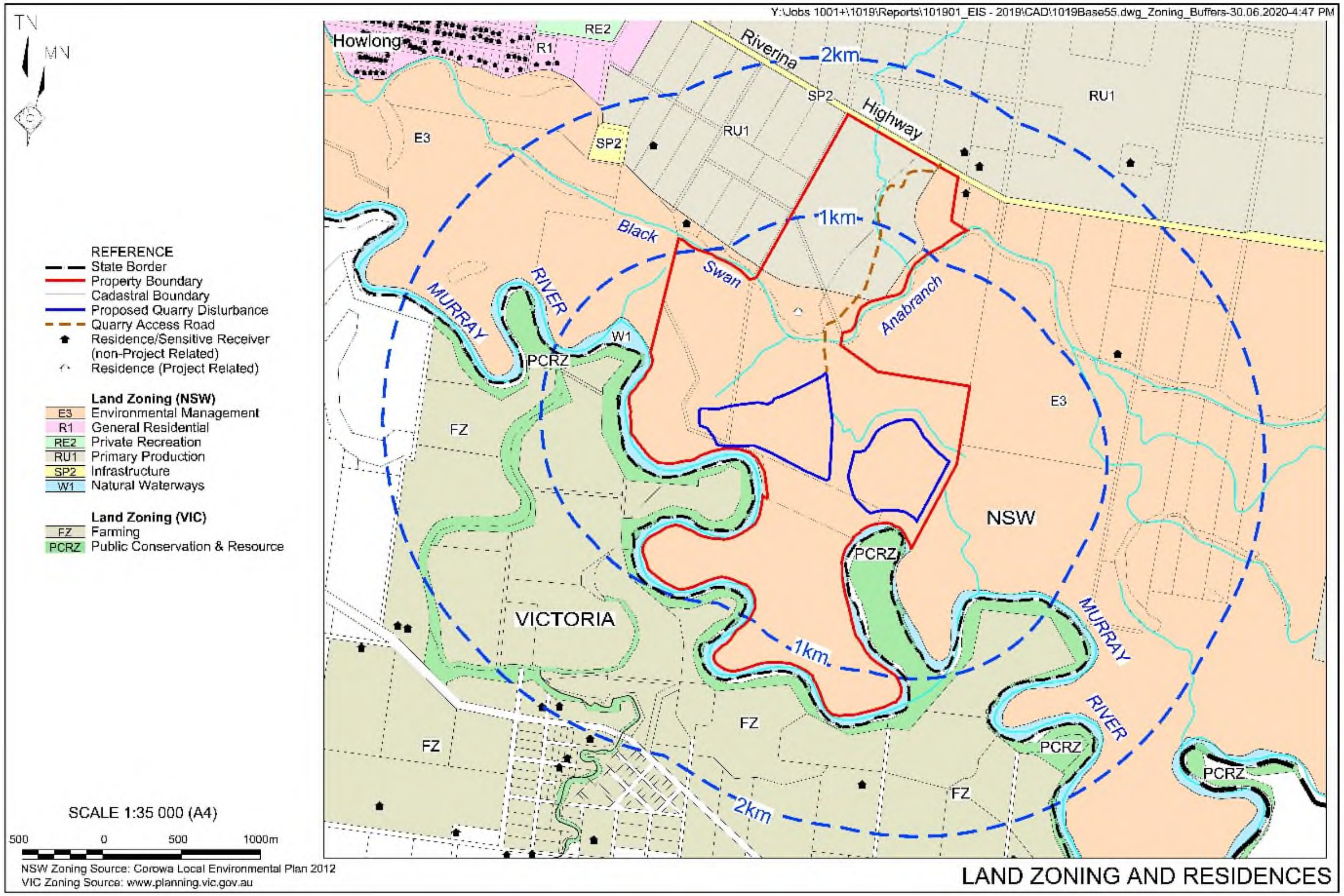

FIGURE 1 – INTERFACE WITH VICTORIA INCLUDING LAND ZONING CLASSIFICATION

5 References

Parnell, J. (2015). Acoustic Signature of Open Cut Coal Mines. *Australian Acoustical Society*, (p. 8). Hunter Valley.

Revision	Date	Comment	Author	Reviewer
0	08.07.2020	Issued to Client	RB	TE

Appendix A: LFN Spectra at the Nearest Noise Sensitive Receiver

	Octave Band Centre Frequency, Hz																											O
	10	**13**	**16**	**20**	**25**	**32**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**500**	**630**	**800**	**1k**	**1.25k**	**1.6k**	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	
dBZ	35	42	55	47	46	43	41	41	42	41	41	40	38	35	33	32	32	31	30	28	27	25	24	23	20	17	15	13	57
dBA	-35	-21	-2	-3	2	4	6	10	16	19	21	24	25	24	24	25	27	28	28	27	27	26	25	24	21	18	16	13	38
dBC	21	31	46	41	42	40	39	39	41	41	40	40	38	35	33	32	32	31	30	28	27	25	24	22	20	17	14	11	52

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Appendix 11

Driver's Code of Conduct – July 2020

(Total No. of pages including blank pages = 18)

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Drivers Code of Conduct
Howlong Sand and Gravel Quarry

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1. Contents

2. Revision History

Ver.	Date	Author	Comments	Authorised by	Next review date
1.0	27/07/2020	A. McKimmie	For Review	Greg Fraser	27/07/2021

3. General Requirements

Heavy vehicle drivers hauling from Howlong Sand and Gravel Quarry must:

- Have undertaken a site induction carried out by an approved member of the Quarry staff or suitably qualified person under the direction of the Quarry management;
- Complete the daily sign in and pre-start before entering the quarry;
- Hold a valid driver's licence for the class of vehicle that is operated;
- Operate the vehicle in a safe manner within and external to the Quarry site;
- Comply with the direction of authorised site personnel when within the site;'
- Comply with the Road Transport Act 2013 and its associated regulations in regard to drug use and alcohol consumption;
- Comply with all site rules/posted speed signs and give way to agriculture vehicles;
- Comply with the Australian Road Rules external to the site;
- Participate in regular toolbox meetings with appropriate supervisor/manager; and
- Sign the Drivers Code of Conduct on the first visit to site.

4. Transport Operating Hours

The Howlong Sand and Gravel Quarry has separate operating hours for Hanson and for ex-bin or other contracted vehicles.

For Hanson vehicles that are transporting material from the Quarry, the approved operating hours are as follows.

- Monday to Friday – 7:00am to 10:00pm
- Saturday – 7:00am to 12:00pm
- No transport operations on Sundays or public holidays.

As is current practice, vehicles may arrive at the Quarry from 6:30am. These hours are subject to customer demand and may be reduced during quiet periods.

Weighbridge operation for all other contractors is 7:00am to 4:00pm Monday to Friday only. No contracted trucks will be ticketed outside these hours.

5. Heavy Vehicle Speed

Increased speed means an increase in the risk of a crash and as well as an increase in severity if an accident occurs. A study undertaken for the Australian Transport Safety Bureau found that travelling 10 km/h faster than the average traffic speed can more than double the risk of involvement in a casualty accident (Kloeden, Ponte, & McLean, 2001).

There are two types of speeding:

- Where a heavy vehicle travels faster than the posted speed limit; and
- Where a driver travels within the speed limit but because of road conditions (e.g. fog or rain) this speed is inappropriate.

Drivers and truck operators are to be aware of the "Three Strikes Scheme" introduced by the Transport for NSW (TfNSW) which applies to all vehicles over 4.5 tonnes. When a heavy vehicle is detected travelling at 15 km/h or more over the posted or relevant heavy vehicle speed limit by a mobile Police unit or fixed speed camera, the TfNSW will record a strike against that vehicle. If three strikes are recorded within a three-year period, the TfNSW will act to suspend the registration of that vehicle (up to three months). More information is available from the TfNSW website.

The speed limits are:

- Quarry Driveway from Hwy to approx. 500mtrs from bridge – 40km/hr
- Below house pre bridge – 15km/hr
- Over bridge across river- 5km/hr (one truck on bridge at a time and will be monitored by speed camera)
- Across weighbridge- 5km/hr
- within the Quarry (plant/sales yard) – 15km/hr

Vehicle speed on public roads is enforced by the NSW Police Service. The speed limits which are accordingly signposted – are to be strictly maintained.

All vehicle drivers are to adhere to the posted speed limits on-site. Vehicle drivers who do not adhere will receive a strike against their name, following the; **Driver's Code of Conduct Disciplinary Action Register** (Section 11).

Drivers are to observe the posted speed limits, with speed adjusted to suit the road environment and prevailing weather conditions, to comply with the Australian Road Rules. The vehicle speed must be suitable to ensure the safe movements of the vehicle based on the vehicle configuration.

6. Heavy Vehicle Driver Fatigue

Fatigue is one of the biggest causes of crashes for heavy vehicle drivers. Fatigue can impact on driving ability, similar to the effect of drink-driving and result in slower reaction times, lack of concentration, reduced vigilance / poor judgement and nodding off. Symptoms of fatigue include:

- yawning,
- sore or heavy eyes,
- slower reaction times,
- daydreaming / not concentrating on driving
- driving speeds creeping
- impatience
- impaired driving performance
- stiffness and cramps
- loss of motivation

The Heavy Vehicle Driver Fatigue Reform was developed by the National Transport Commission (NTC) and approved by Ministers from all States and Territories in February 2007. These reforms have been carried over into the Heavy Vehicle National Law (HVNL) in February 2013. Fatigue legal obligations have four major sections under the HVNL:

- chain of responsibility
- work and rest hours
- work diaries
- fatigue management accreditation schemes – BFM and AFM

The heavy vehicle driver fatigue law commenced in NSW on 28 September 2008 and applies to trucks and truck combinations over 12 tonne Gross Vehicle Mass (GVM) (however there are Ministerial Exemption Notices that can apply).

The HVNL specifies that:

- a person must not drive a heavy vehicle on a road while impaired by fatigue
- managing driver fatigue is a shared responsibility by all parties in the chain parties must take all reasonable steps to ensure a person does not drive a heavy vehicle on a road while impaired by fatigue.

Under the law, industry has the choice of operating under three fatigue management schemes:

a) Standard Hours of Operation
b) Basic Fatigue Management (BFM)
c) Advanced Fatigue Management (AFM)

Heavy vehicle drivers should manage their fatigue by undertaking fatigue breaks at appropriate times as per the TfNSW guidelines. Fatigue breaks must be recorded by the heavy vehicle drivers and checked by management via their work diary to review if the correct procedure has been undertaken.

If a heavy vehicle driver has not confirmed within the rules, they will be placed on the **Driver's Code of Conduct Disciplinary Action Register** (Section 11).

All heavy vehicle drivers operating out of the Howlong Sand & Gravel Quarry are to be aware of their adopted Fatigue Management Scheme and operate within its requirements. By law, all drivers have a duty to not drive a fatigue-regulated heavy vehicle on a road while impaired by fatigue.

7. Heavy Vehicle Compression Braking

Compression braking by heavy vehicles is a source of irritation to the community and can generate numerous complaints from residents, especially at night when residents are sensitive to noise. There are instances compression braking is required for safety reasons, however when passing through or adjacent to residential areas, a reduction in the speed of the vehicle is recommended. This will always allow the avoidance of compression breaking .

All heavy vehicle drivers operating out of the Howlong Sand and Gravel Quarry are to minimise the use of compression brakes,(especially along Hawkins street Howlong) so as not to create excessive noise that could disturb residents, where possible. Compression braking within or adjacent to residential areas should only be used if required for safety reasons.

8. Heavy Vehicle Noise

All drivers are to be aware of vehicle noise generation, particularly when travelling through urban areas where there are residences adjacent to the road. Traffic noise is a particular concern for the community of Howlong and drivers should take all precautions to limit amenity-related impacts.

The principal controls for vehicle noise are the following.

- Maintaining vehicles to a suitable standard so that excessive noise is not being generated.
- Maintaining speeds consistent with the limits described in Section 5.
- Restricting operations to the approved operating hours described in Section 4.

9. Load Covering

Loose material on the road surface has the potential to cause road crashes and vehicle damage. Uncovered loads represent the greatest risk to loose material on the road and an increase in dust impacts on neighbouring residents along haul routes. To prevent these issues all heavy vehicles should be covered, whether loaded with material or not.

All trucks arriving at or departing from the Howlong Sand and Gravel Quarry whether loaded with material or not, are required to have an effective cover over their load for the duration of the trip. The load cover may be removed upon arrival at the delivery site.

All care is to be taken to ensure that all loose debris from the vehicle body and wheels are removed prior to leaving the site. Drivers must ensure that following tipping that the tailgate is locked before leaving the site.

Quarry Management is to monitor loose material on the side of the haulage route from Quarry operations and take appropriate action (removal or suppression) regularly.

10. Vehicle Departure and Arrival

Heavy vehicles travelling in close proximity on dual lane public roads can be of concern to light vehicle drivers as well as increasing noise through or adjacent to residential areas. To alleviate public concern and increase road safety, heavy vehicles leaving the Quarry should try to be separated by a minimum, 2-minute interval.

It is difficult to schedule arrivals to the Quarry (except at the commencement of work for the day) due to the different directions of approach from external jobs and the varying job completion times, however, when a driver becomes aware, through visual contact or two-way contact between trucks, that they will arrive at approximately the same time then they are to ensure that there is a suitable gap between vehicles.

To alleviate public concern and increase road safety, heavy vehicles leaving the Howlong Sand and Gravel Quarry should try to be separated by a minimum, 2-minute interval to minimise any impact on the Riverina Hwy.

11. Driving in Adverse Conditions

Howlong and surrounding areas are subject to occasion climatic events that may influence driving conditions. Road safety is the highest priority for Fraser Earthmoving Construction especially in the vicinity of Howlong. While it is responsibility of the driver to be aware of driving conditions and to modify driving to suit, the following is important to be aware of when transporting material from the Howlong Sand and Gravel Quarry.

1. Direct sunlight and glare – the Riverina Highway follows an east-west direction in the vicinity of the Quarry and during the early morning and late afternoon drivers may be subject to glare.

2. Fog – The local area is subject to fog during cooler periods of the year and drivers need to take due care during fog-affected mornings.

3. Heavy rainfall – Occasion storms and heavy showers may influence driving conditions. During these periods extra care should be taken to ensure visibility and safety is maintained.

4. Flood – The Howlong Sand and Gravel Quarry is located on the floodplain of the Murray River. During periods of sustained heavy rainfall flooding may occur. During these times access to the Quarry may be limited or totally restricted.

   Drivers are not to approach the Quarry if access requires driving through flooded areas of the locality and should make contact with Quarry management to establish access protocols during these periods.

It is expected that drivers will adjust their behaviour to suit local conditions and maintain safe driving practices at all times.

12. Safety Initiatives for Residential Areas and School Zones

All drivers are to show respect for our neighbours in the Howlong area. Care is to be taken around school bus stops in the morning (6:45am to 9:30am) and afternoon (2:45pm to 4:30pm) periods (see Figure 1). Drivers are to be mindful of children being dropped off and/or picked up in and around the Howlong areas during these hours. Drivers are to comply with 40km/h speed limit for traffic passing a school bus as well as within school zones.

All Drivers are to be reminded that Hawkins St Howlong is an 50km speed zone. Drivers are required to show consideration to all other people accessing the main street and shopping precinct by giving pedestrians and vehicles reversing a wide berth and be aware of the pedestrians' safety, road users' safety and their own safety at all times.

Drivers are to ensure that when passing pedestrians / cyclists a safe separation distance exists between trucks and pedestrian / cyclists as well as a reduction in speed if appropriate. In regard to cyclists, all drivers must abide by the Minimum Passing Distance Rule, whereby a minimum separation distance of 1 metre is required when the speed limit is 60 km/h or less, and a minimum separation distance of 1.5 metres is required when the speed limit is more than 60 km/h.

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13. Figure 1 and Figure 2 Truck Route and Hawkins Street, Howlong

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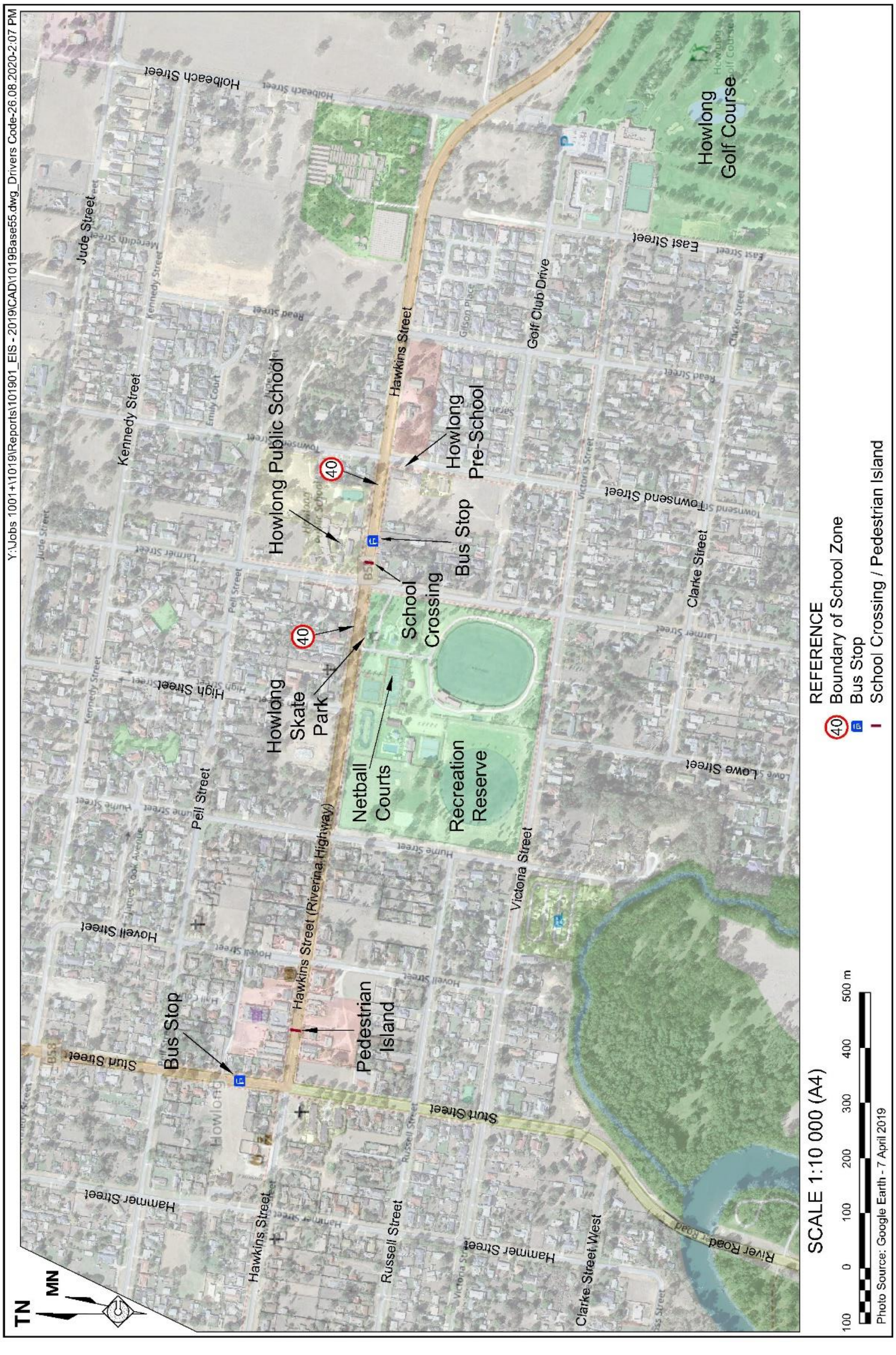

14. Primary Haulage Routes

The primary haulage routes are shown on **Figure 1**, with critical locations highlighted.

Heavy vehicle drivers are to carefully plan their routes so that State and regional roads are given priority for route selection. Local roads should only be used if there is no other option or in an emergency situation. To be considerate of our neighbours, short cuts and deviations should not be used when delivering Quarry products. Heavy vehicle drivers are to be aware of PBS weight restrictions and requirements when using roads and bridges.

15. Heavy Vehicle Breakdown and Incidents

In the case of a breakdown the vehicle must be towed to the nearest breakdown point as soon as possible. All breakdowns must be reported to the TfNSW TMC (Transport Management Centre) on 131 700 and the vehicle protected in accordance with the Heavy Vehicle Drivers handbook.

If there is a product spill while loading/unloading or en-route to and from the Quarry, the driver must:

a) Immediately warn persons in the area who may be at risk;
b) Inform their shift supervisor/owner. If the vehicle is owned or contracted by Hanson Construction Materials Pty Ltd, the Howlong Sand and Gravel Quarry Manager must be immediately informed so that emergency services can be contacted and a clean-up initiated;
c) All spills must be adequately cleaned up and waste disposed of in an acceptable and environmental manner;
d) Put out warning triangles where it is safe to do so;
e) Contact the NSW Police Service if on an external road. When within the Quarry the Quarry Manager is to be notified.

To ensure that traffic impacts are minimised in the event of an incident, rapid response from the haulage company is required. In order to ensure rapid response to incidents, drivers are encouraged to contact the TfNSW TMC on 131700, as soon as the stranded vehicle and load is safely secured.

16. Compliance Measures and Monitoring

The document is to be signed by individual drivers and a Hanson Construction Materials Pty Ltd authorised representative at the time when heavy vehicle haulage drivers attend their site induction or shortly thereafter.

To assist in the orderly resolution of complaints, Quarry management will keep a register itemising all reported incidents relating to complaints in regard to heavy vehicle driver conduct external to the Quarry site.

The incident register is to include (where possible):

a) Date of the complaint.
b) Time of the complaint.
c) Name of the complainant (if available).
d) How the complaint was received.
e) Detailed description of the complaint (including location, driver/heavy vehicle details).
f) What / when actions were taken to resolve the issue; and
g) The reply to the person / organisation that made the complaint.

Once the Quarry Manager is satisfied that the complaint is substantiated, an investigation of the location and causes of the complaint will be undertaken. Following investigation of the issue, the Quarry Manager will provide feedback to the complainant that details the investigations undertaken, the result of the investigation and measures implemented to ensure that operations remain compliant. A description of any follow-up investigations and the response provided to the complainant will also be recorded in the Complaints Register upon closure of the issue.

The incident register is to be made available, upon request, to an authorised State Government officer or Council officer.

In addition to the register, any breach of the Code of Conduct will result in the offending driver being placed on a Driver's Code of Conduct Disciplinary Action Register.

There are 3 stages to the process:

1st Stage – No driver will have their vehicle loaded prior to being inducted. During the induction process all drivers will be made aware of their responsibilities while they are in the control of haulage trucks operating from the Howlong Sand and Gravel Quarry.

During the induction process drivers will be required to sign documentation to demonstrate their understanding, these documents will include but not limited to;

- Quarry Induction,
- Driver's Code of Conduct,
- Quarry Safety Management Systems, and
- Driver's will be required to participate in Primary Risk assessments and activities.

2nd Stage – Driver will be warned for the breach, entered into the register, re-inducted and the company of the driver will be notified that a breach of the site rules has occurred by the offending driver. The result of this breach will result in disciplinary action that as a minimum will include being re-inducted but may involve being banned from site for a period determined by management.

3rd Stage – The driver will be banned from the Quarry Site entirely and the company of the driver will be notified of the ban period imposed on the driver. Where relevant, the incident and information will be provided to the local Howlong Police.

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17. Driver's Code of Conduct Disciplinary Action Register

Date of Complaint	Time	Complainant Name	How Complaint Received	Detailed description of the complaint	Action Taken	Complainant Notified of Action	IMS File Number

18. Emergency Contact Numbers

- TfNSW Transport Management Centre – 131 700
- Quarry Management – 0417 883 576
- Howlong Police – 02 6026 5507
- Howlong Medical – 02 6026 5307

19. Signature

I, the inductee, am aware of and agree to comply with the above mentioned statements and safety requirements.

Signed:	Authorisation by Quarry Manager or delegate Signed:
Name (Print):	Name (Print):
Date:	Date:

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Appendix 12

Road Transport Letter Report prepared by The Transport and Planning Partnership – September 2020

(Total No. of pages including blank pages = 28)

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ttpp transport planning

Our Ref: 19339

4 September 2020

Transport for New South Wales – South West Region
PO Box 484
WAGGA WAGGA NSW 2650

Attention: Mr Maurice Morgan – Manager, Land Use

Dear Maurice,

RE: SSD-8804 PROPOSED HOWLONG SAND AND GRAVEL QUARRY EXPANSION
4343 RIVERINA HIGHWAY HOWLONG

Following submission of the above application for expansion of the Howlong Quarry operations, Federation Council and Transport for New South Wales requested clarification and additional information regarding the proposal. The Transport Planning Partnership (TTPP) is pleased to provide the following clarifications and additional information in relation to traffic. This response should be read in conjunction with the original Road Transport Assessment (TTPP, 2020).

The Road Transport Assessment was undertaken on the basis that no Quarry trucks would enter or exit the Quarry Access Road to or from the east, due to heavy vehicle weight restrictions on Riverina Highway to the east. TTPP has now been advised that some empty trucks may be able to approach the Quarry from the east as the tare weight would allow their use of Riverina Highway east. The information which follows however assumes that all heavy vehicles enter and exit to and from the west, which represents the "worst case" in terms of the potential impact at any one location on the road network and for right turn entry to the Quarry Access Road. To the extent that empty trucks enter from the east, the impacts of the Project to the west of the Quarry Access Road will be reduced below those presented here and in the Road Transport Assessment.

Baseline Traffic Forecasts

Table 1 presents the average weekday hourly traffic volumes past the Quarry Access Road throughout the operational hours of the Project. The forecasts apply the growth rate to the total surveyed traffic, including that component of the traffic on Riverina Highway and Sturt Street which was being generated by the Quarry. That component would not be expected to materially alter under baseline conditions, hence the baseline forecasts are considered to slightly overestimate likely future conditions.

Table 1: Average Weekday Hourly Vehicles on Riverina Highway Past Quarry Access Road

Hour Starting	Surveyed			With 10 Years of Growth		
	Light	Heavy	Total	Light	Heavy	Total
6:00am[A]	136	14	150	150	15	165
7:00am	171	29	200	189	32	221
8:00am	238	26	264	263	29	292
9:00am	196	26	222	217	28	245
10:00am	193	24	217	213	27	240
11:00am	196	22	218	217	24	241
12:00pm	177	21	198	195	23	218
1:00pm	181	22	203	200	25	225
2:00pm	219	24	243	242	27	268
3:00pm	259	26	285	286	29	315
4:00pm	262	27	289	289	30	320
5:00pm	226	23	249	250	25	275
6:00pm	124	12	136	137	13	150
7:00pm	61	5	66	68	5	73
8:00pm	41	8	48	45	9	53
9:00pm	33	5	38	37	5	42

[A] *prior to operating hours, when employees may be expected to be arriving at the Quarry.*

Project Traffic Generation

We note that Council's request implies that Council understands that the Project will increase the workforce by 8 to 10 people, and increase heavy vehicle movements by 80 per day. For clarity, the future total workforce would be a total of 8 to 10 people, and the total heavy vehicle trips would be limited to a maximum of 80 per day, with an average 58 heavy vehicle trips per day at the maximum production rate. This compares with an existing total workforce of 8 people and average of 10 heavy vehicle trips per day.

The peak hourly forecasts presented in the Road Transport Assessment at the various locations refer to the hour during which the peak occurred at that specific location (refer to Table 3.4 of the report). There is not a consistent peak hour across all locations. This method ensures that the assessment addressed the possible peak conditions at each and every location, considering the potential for the Project's maximum of 12 truck trips per hour to occur during any operational hour. At maximum production, the Project may be expected to generate an average of fewer than eight truck trips per hour, however the assessment considers the maximum of 12 truck trips per hour.

To place the forecasts in context, the hourly peak of six laden truck departures (12 trips) per hour would generate 90 laden truck departures per day over the 15-hour haulage period, while a cap of 40 laden truck departures would be observed. The peak of six laden truck departures per hour could therefore occur for up to six hours per day, not 15 hours. It should therefore be understood that these forecast peak conditions are not anticipated to occur every hour of every day, and have been presented as a robust assessment of the potential impacts of the Project by considering the highest possible combination of Project and background traffic.

Forecast Traffic on Quarry Access Road

The future traffic volumes reported on the Quarry Access Road in Table 4.3 of the Road Transport Assessment included only the Quarry-generated traffic and so inadvertently excluded those vehicles which were using the access road during the surveys as part of agricultural activities. TTPP has been advised that these agricultural activities occur across the sites on both the southern and northern sides of Riverina Highway, with activity being “based” on the northern side. Farm employees arrive and depart each day via the Farm Access Road on the northern side of Riverina Highway, however during the day, they may travel across the highway via the Farm Access Road and Quarry Access Road, primarily in light vehicles, but also in heavy vehicles if those vehicles are needed on the southern site.

The traffic survey on the Quarry Access Road therefore captured both quarry-generated and farm-generated vehicle activity, however the traffic surveys are unable to distinguish which vehicles were associated with each activity. Access for agricultural activity is also available via a formal gate on the southern side of Riverina Highway approximately 500 metres west of the Quarry Access Road. The forecasts in Table 4.3 of the report represent conditions expected if the existing formal Farm Access to the west be used by the farm-generated traffic. As a worst case, the forecasts have been revised to assume that all farm-generated traffic would continue to use the Quarry Access Road in the future.

Table 2 summarises the peak volumes expected to be generated on the Quarry Access Road during the morning peak arrival of employees, during the daytime when haulage is at its peak and visitors to the Quarry would typically be expected, and during the afternoon and evening if haulage continues at its maximum, some employees depart, visitors are unlikely and farm activity is reduced.

Table 2: Hourly Vehicle Trips in/out of Quarry Access Road at Maximum Haulage

Vehicle	Right In	Left In	Right Out	Left Out	In from Farm	Out to Farm
Quarry Employee Arrival Period 6am to 7am						
Quarry Employees	5	5	0	0	0	0
Haulage Trucks	3[A]	0	0	0	0	0
Quarry Visitors	0	0	0	0	0	0
Farm Light Vehicles	0	0	0	0	5	5
Farm Heavy Vehicles	0	0	0	0	2	2
Total	**8**	**5**	**0**	**0**	**7**	**7**
Quarry Daytime Operations 7am to 3pm						
Quarry Employees	0	0	0	0	0	0
Haulage Trucks	6	0	0	6	0	0
Quarry Visitors	2	2	2	2	0	0
Farm Light Vehicles	0	0	0	0	5	5
Farm Heavy Vehicles	0	0	0	0	2	2
Total	**8**	**2**	**2**	**8**	**7**	**7**
Quarry Afternoon and Evening Operations 3pm to 10pm						
Quarry Employees	0	0	2	2	0	0
Haulage Trucks	6	0	0	6	0	0
Quarry Visitors	0	0	0	0	0	0
Farm Light Vehicles	0	0	0	0	1	1
Farm Heavy Vehicles	0	0	0	0	1	1
Total	**6**	**0**	**2**	**8**	**1**	**1**

[A] *Heavy vehicles may arrive from 6:30am.*

Table 2 indicates that at maximum haulage, the Project would be expected to generate up to:

- 8 vehicles (5 light and 3 heavy) on Riverina Highway west of the Quarry Access Road between 6am and 7am;
- 16 vehicles (4 light and 12 heavy) on Riverina Highway west of the Quarry Access Road in any hour between 7am and 3pm; and
- 14 vehicles (2 light and 12 heavy) on Riverina Highway west of the Quarry Access Road in in hour between 3pm and 10pm.

Saturday Mornings in Howlong

Council requested that consideration be given to the existing traffic movements in Hawkins Street around the Howlong business district on Saturday mornings. Due to the ongoing behavioural changes resulting from coronavirus restrictions, it is considered that any surveys undertaken at this time would not be indicative of "normal" traffic conditions. Nevertheless, the results of the previous surveys have been reviewed to consider Saturday morning conditions. The surveyed volumes are summarised in Table 3, which compares the surveyed

Saturday volumes with those at the same locations during the busiest hour on the average weekday.

Table 3: Surveyed Hourly Vehicles

Hour Starting	Riverina Highway West of Quarry Access Road			Sturt Street South of Riverina Highway		
	Light	Heavy	Total	Light	Heavy	Total
Saturday Morning						
6:00am	42	5	47	31	2	33
7:00am	65	8	73	56	11	67
8:00am	132	10	143	92	19	111
9:00am	161	16	177	154	21	175
10:00am	189	19	208	169	27	196
11:00am	212	11	223	168	22	190
Average Weekday Busiest Hour						
-	262	27	289	161	29	190

The surveyed volumes on Saturday morning are comparable to or lower than the hourly volumes surveyed on the average weekday, however the contribution of heavy vehicles is lower on the Saturday compared with weekdays. While the additional vehicle movements associated with the Howlong business district during normal conditions cannot be accurately deduced, it is reasonable to expect that those vehicles would primarily be light vehicles. During the Saturday morning period, the Project would contribute a maximum of 12 heavy vehicle movements (six in each direction) in any one hour on Hawkins Street through Howlong. As noted previously, this is a worst-case peak and would not occur every hour on a Saturday, nor on every Saturday through the year.

Drivers' Code of Conduct

As recommended in the Road Transport Assessment, the Project's heavy vehicle drivers would be subject to operational protocols which would include driver behaviour expectations at specific locations on the public road network. A Drivers' Code of Conduct has been prepared for the Project (refer to Attachment Two), which sets out requirements for the Project's heavy vehicles operating though Howlong and near pedestrians and cyclists. It also includes procedures for the management of complaints received regarding driver behaviour external to the site, and the disciplinary actions which will result from non-compliances with the Code.

The Drivers' Code of Conduct addresses the various aspects of driver behaviour requested by Council, and it is recommended that the operator consult with Council and TfNSW when reviews of the Code are undertaken.

Intersection Treatments

With respect to the intersection of the Quarry Access Road with Riverina Highway, the forecast Project traffic (Table 2) and passing traffic on Riverina Highway (Table 1) during the three periods of the day have been compared against the Austroads warrants for rural road intersection treatments. On this basis, as described in the Road Transport Assessment, BAL and BAR treatments in Riverina Highway would be required at the Quarry Access Road intersection. This comparison has not discounted the passing traffic on Riverina Highway for the existing traffic generated by the Quarry at the time of the surveys, hence slightly overestimates the forecast total traffic.

As noted above, the Road Transport Assessment was undertaken on the basis that no Quarry trucks would enter or exit the Quarry Access Road to or from the east, however it is now understood that some empty trucks may be able to approach the Quarry from the east. The main implication of this is on the concept layout of the upgrade to the intersection, which previously assumed that only light vehicles would turn left into the Quarry Access Road. Should some empty trucks turn left into the Quarry Access Road, the BAL treatment would need to allow for the swept path of the truck and trailer combinations.

A revised concept plan of the upgrade has therefore been prepared (attached), based on the requirements of the Austroads guidelines with regard to the BAL treatment on Riverina Highway.

With respect to the intersection of Hawkins Street, Riverina Highway and Sturt Street, the intersection is currently approved for use by 25/26m GML B-doubles with no restrictions. Concrete median islands are provided on all approaches, each of which has a pedestrian refuge with the exception of Hawkins Street, on which a separate pedestrian refuge with kerb extensions is provided approximately 50 m from the intersection. Upgrade of the intersection is not considered to be warranted to accommodate heavy vehicles or to accommodate pedestrians.

Quarry Access Road Width

The Road Transport Assessment indicates that the Quarry Access Road is generally 12 metres (m) wide. This refers to the road internal to the site, which varies along its length, which narrows to approximately 6 m wide on its approach to the intersection with Riverina Highway. The recommended upgrading of the intersection would be designed in accordance with Austroads guidelines, taking into consideration the swept paths of the trucks entering and exiting the Quarry Access Road. This would include widening of the Quarry Access Road at the intersection, as presented in the concept plan appended to the Road Transport Assessment and the revised concept plan attached.

We trust the above is to your satisfaction. Should you have any queries regarding the above or require further information, please do not hesitate to contact the undersigned on 8437 7800.

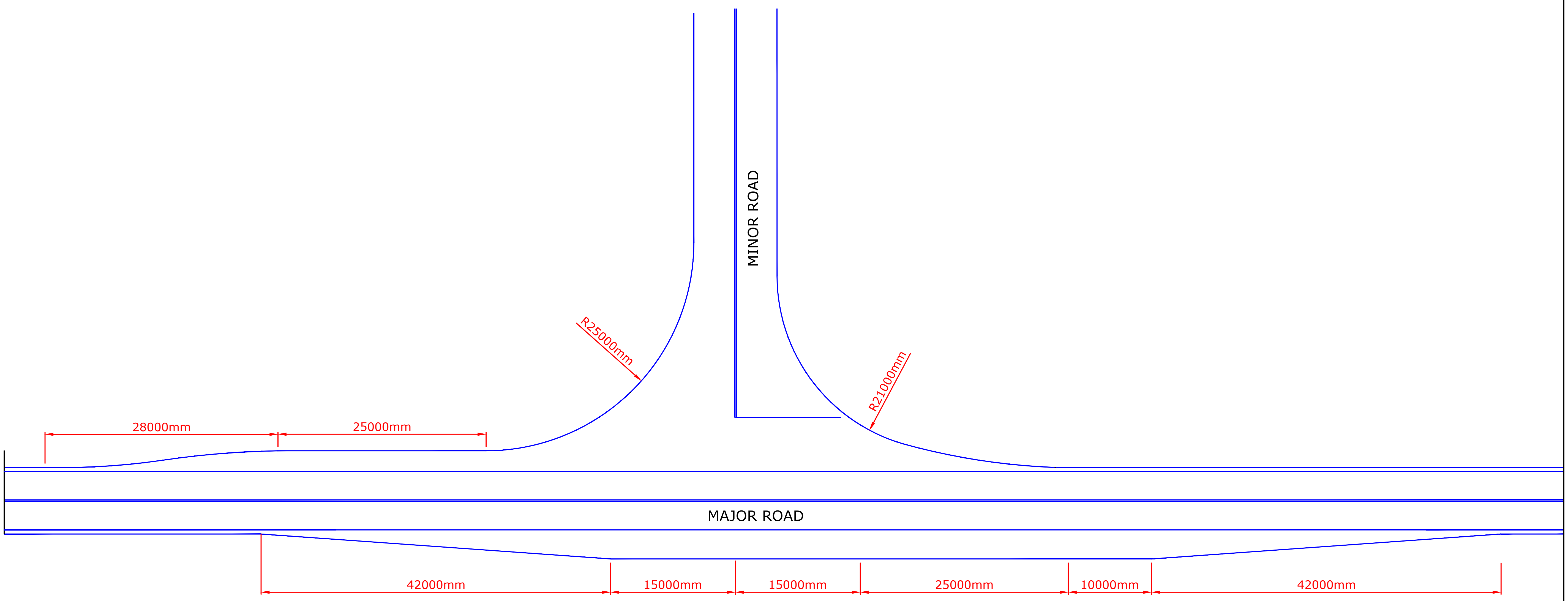
Yours sincerely,

PDalton

Penny Dalton
Associate Director

Attachment One

Revised Intersection Concept Plan



REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	PD	PD	30/06/20

ttpp transport planning

PROJECT

HOWLONG SAND AND GRAVEL QUARRY

TITLE

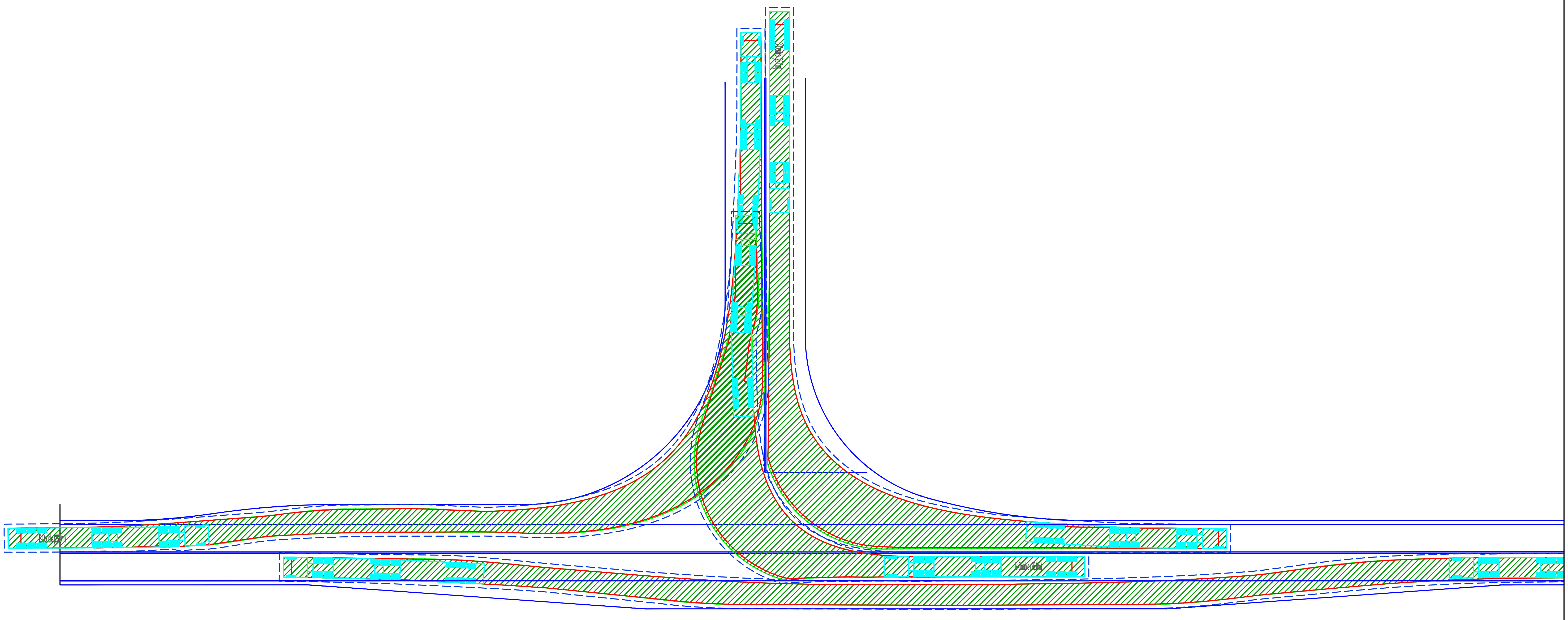
CONCEPT PLAN

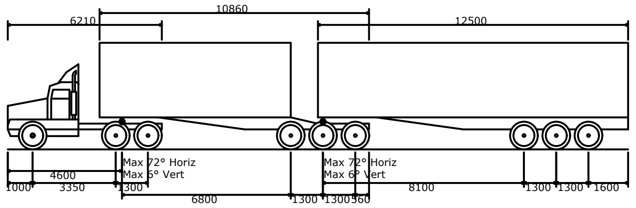
DWG No. 19339CAD002 FIGURE 1

DATE STAMP 30 JUNE 2020

PROJECT No.	SCALE	REV.
19339	1:500 @A3	A

Filename: 19339CAD002-CONCEPT PLAN-200630.dwg Date: 30 June 2020 By: Karl.magistrado





B-Double (25.0m)

Overall Length	25000mm
Overall Width	2500mm
Overall Body Height	4300mm
Min Body Ground Clearance	540mm
Track Width	2500mm
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15000mm

REV.	DESCRIPTION	DRAWN	CHECK	APP'D	DATE
A	ISSUE FOR DISCUSSION	KM	PD	PD	30/06/20

ttpp transport planning

PROJECT
HOWLONG SAND AND GRAVEL QUARRY

TITLE
SWEPT PATH ANALYSIS
25m B-DOUBLE

DWG No.	19339CAD002 FIGURE 2
DATE STAMP	30 JUNE 2020
PROJECT No.	19339
SCALE	1:500 @A3
REV.	A

Filename: 19339CAD002-CONCEPT PLAN-200630.dwg Date: 30 June 2020 By: Karl.magistrado

Attachment Two

Drivers' Code of Conduct

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Drivers Code of Conduct
Howlong Sand and Gravel Quarry

FRASER EARTHMOVING CONSTRUCTION

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1. Contents

2. Revision History

Ver.	Date	Author	Comments	Authorised by	Next review date
1.0	27/07/2020	A. McKimmie	For Review	Greg Fraser	27/07/2021

3. General Requirements

Heavy vehicle drivers hauling from Howlong Sand and Gravel Quarry must:

- Have undertaken a site induction carried out by an approved member of the Quarry staff or suitably qualified person under the direction of the Quarry management;
- Complete the daily sign in and pre-start before entering the quarry;
- Hold a valid driver's licence for the class of vehicle that is operated;
- Operate the vehicle in a safe manner within and external to the Quarry site;
- Comply with the direction of authorised site personnel when within the site;'
- Comply with the Road Transport Act 2013 and its associated regulations in regard to drug use and alcohol consumption;
- Comply with all site rules/posted speed signs and give way to agriculture vehicles;
- Comply with the Australian Road Rules external to the site;
- Participate in regular toolbox meetings with appropriate supervisor/manager; and
- Sign the Drivers Code of Conduct on the first visit to site.

4. Transport Operating Hours

The Howlong Sand and Gravel Quarry has separate operating hours for Hanson and for ex-bin or other contracted vehicles.

For Hanson vehicles that are transporting material from the Quarry, the approved operating hours are as follows.

- Monday to Friday – 7:00am to 10:00pm
- Saturday – 7:00am to 12:00pm
- No transport operations on Sundays or public holidays.

As is current practice, vehicles may arrive at the Quarry from 6:30am. These hours are subject to customer demand and may be reduced during quiet periods.

Weighbridge operation for all other contractors is 7:00am to 4:00pm Monday to Friday only. No contracted trucks will be ticketed outside these hours.

5. Heavy Vehicle Speed

Increased speed means an increase in the risk of a crash and as well as an increase in severity if an accident occurs. A study undertaken for the Australian Transport Safety Bureau found that travelling 10 km/h faster than the average traffic speed can more than double the risk of involvement in a casualty accident (Kloeden, Ponte, & McLean, 2001).

There are two types of speeding:

- Where a heavy vehicle travels faster than the posted speed limit; and
- Where a driver travels within the speed limit but because of road conditions (e.g. fog or rain) this speed is inappropriate.

Drivers and truck operators are to be aware of the "Three Strikes Scheme" introduced by the Transport for NSW (TfNSW) which applies to all vehicles over 4.5 tonnes. When a heavy vehicle is detected travelling at 15 km/h or more over the posted or relevant heavy vehicle speed limit by a mobile Police unit or fixed speed camera, the TfNSW will record a strike against that vehicle. If three strikes are recorded within a three-year period, the TfNSW will act to suspend the registration of that vehicle (up to three months). More information is available from the TfNSW website.

The speed limits are:

- Quarry Driveway from Hwy to approx. 500mtrs from bridge – 40km/hr
- Below house pre bridge – 15km/hr
- Over bridge across river- 5km/hr (one truck on bridge at a time and will be monitored by speed camera)
- Across weighbridge- 5km/hr
- within the Quarry (plant/sales yard) – 15km/hr

Vehicle speed on public roads is enforced by the NSW Police Service. The speed limits which are accordingly signposted – are to be strictly maintained.

All vehicle drivers are to adhere to the posted speed limits on-site. Vehicle drivers who do not adhere will receive a strike against their name, following the; **Driver's Code of Conduct Disciplinary Action Register** (Section 11).

Drivers are to observe the posted speed limits, with speed adjusted to suit the road environment and prevailing weather conditions, to comply with the Australian Road Rules. The vehicle speed must be suitable to ensure the safe movements of the vehicle based on the vehicle configuration.

6. Heavy Vehicle Driver Fatigue

Fatigue is one of the biggest causes of crashes for heavy vehicle drivers. Fatigue can impact on driving ability, similar to the effect of drink-driving and result in slower reaction times, lack of concentration, reduced vigilance / poor judgement and nodding off. Symptoms of fatigue include:

- yawning,
- sore or heavy eyes,
- slower reaction times,
- daydreaming / not concentrating on driving
- driving speeds creeping
- impatience
- impaired driving performance
- stiffness and cramps
- loss of motivation

The Heavy Vehicle Driver Fatigue Reform was developed by the National Transport Commission (NTC) and approved by Ministers from all States and Territories in February 2007. These reforms have been carried over into the Heavy Vehicle National Law (HVNL) in February 2013. Fatigue legal obligations have four major sections under the HVNL:

- chain of responsibility
- work and rest hours
- work diaries
- fatigue management accreditation schemes – BFM and AFM

The heavy vehicle driver fatigue law commenced in NSW on 28 September 2008 and applies to trucks and truck combinations over 12 tonne Gross Vehicle Mass (GVM) (however there are Ministerial Exemption Notices that can apply).

The HVNL specifies that:

- a person must not drive a heavy vehicle on a road while impaired by fatigue
- managing driver fatigue is a shared responsibility by all parties in the chain parties must take all reasonable steps to ensure a person does not drive a heavy vehicle on a road while impaired by fatigue.

Under the law, industry has the choice of operating under three fatigue management schemes:

a) Standard Hours of Operation
b) Basic Fatigue Management (BFM)
c) Advanced Fatigue Management (AFM)

Heavy vehicle drivers should manage their fatigue by undertaking fatigue breaks at appropriate times as per the TfNSW guidelines. Fatigue breaks must be recorded by the heavy vehicle drivers and checked by management via their work diary to review if the correct procedure has been undertaken.

If a heavy vehicle driver has not confirmed within the rules, they will be placed on the **Driver's Code of Conduct Disciplinary Action Register** (Section 11).

All heavy vehicle drivers operating out of the Howlong Sand & Gravel Quarry are to be aware of their adopted Fatigue Management Scheme and operate within its requirements. By law, all drivers have a duty to not drive a fatigue-regulated heavy vehicle on a road while impaired by fatigue.

7. Heavy Vehicle Compression Braking

Compression braking by heavy vehicles is a source of irritation to the community and can generate numerous complaints from residents, especially at night when residents are sensitive to noise. There are instances compression braking is required for safety reasons, however when passing through or adjacent to residential areas, a reduction in the speed of the vehicle is recommended. This will always allow the avoidance of compression breaking .

All heavy vehicle drivers operating out of the Howlong Sand and Gravel Quarry are to minimise the use of compression brakes,(especially along Hawkins street Howlong) so as not to create excessive noise that could disturb residents, where possible. Compression braking within or adjacent to residential areas should only be used if required for safety reasons.

8. Heavy Vehicle Noise

All drivers are to be aware of vehicle noise generation, particularly when travelling through urban areas where there are residences adjacent to the road. Traffic noise is a particular concern for the community of Howlong and drivers should take all precautions to limit amenity-related impacts.

The principal controls for vehicle noise are the following.

- Maintaining vehicles to a suitable standard so that excessive noise is not being generated.
- Maintaining speeds consistent with the limits described in Section 5.
- Restricting operations to the approved operating hours described in Section 4.

9. Load Covering

Loose material on the road surface has the potential to cause road crashes and vehicle damage. Uncovered loads represent the greatest risk to loose material on the road and an

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increase in dust impacts on neighbouring residents along haul routes. To prevent these issues all heavy vehicles should be covered, whether loaded with material or not.

All trucks arriving at or departing from the Howlong Sand and Gravel Quarry whether loaded with material or not, are required to have an effective cover over their load for the duration of the trip. The load cover may be removed upon arrival at the delivery site.

All care is to be taken to ensure that all loose debris from the vehicle body and wheels are removed prior to leaving the site. Drivers must ensure that following tipping that the tailgate is locked before leaving the site.

Quarry Management is to monitor loose material on the side of the haulage route from Quarry operations and take appropriate action (removal or suppression) regularly.

10. Vehicle Departure and Arrival

Heavy vehicles travelling in close proximity on dual lane public roads can be of concern to light vehicle drivers as well as increasing noise through or adjacent to residential areas. To alleviate public concern and increase road safety, heavy vehicles leaving the Quarry should try to be separated by a minimum, 2-minute interval.

It is difficult to schedule arrivals to the Quarry (except at the commencement of work for the day) due to the different directions of approach from external jobs and the varying job completion times, however, when a driver becomes aware, through visual contact or two-way contact between trucks, that they will arrive at approximately the same time then they are to ensure that there is a suitable gap between vehicles.

To alleviate public concern and increase road safety, heavy vehicles leaving the Howlong Sand and Gravel Quarry should try to be separated by a minimum, 2-minute interval to minimise any impact on the Riverina Hwy.

11. Driving in Adverse Conditions

Howlong and surrounding areas are subject to occasion climatic events that may influence driving conditions. Road safety is the highest priority for Fraser Earthmoving Construction especially in the vicinity of Howlong. While it is responsibility of the driver to be aware of driving conditions and to modify driving to suit, the following is important to be aware of when transporting material from the Howlong Sand and Gravel Quarry.

1. Direct sunlight and glare – the Riverina Highway follows an east-west direction in the vicinity of the Quarry and during the early morning and late afternoon drivers may be subject to glare.

2. Fog – The local area is subject to fog during cooler periods of the year and drivers need to take due care during fog-affected mornings.

3. Heavy rainfall – Occasion storms and heavy showers may influence driving conditions. During these periods extra care should be taken to ensure visibility and safety is maintained.

4. Flood – The Howlong Sand and Gravel Quarry is located on the floodplain of the Murray River. During periods of sustained heavy rainfall flooding may occur. During these times access to the Quarry may be limited or totally restricted.

   Drivers are not to approach the Quarry if access requires driving through flooded areas of the locality and should make contact with Quarry management to establish access protocols during these periods.

It is expected that drivers will adjust their behaviour to suit local conditions and maintain safe driving practices at all times.

12. Safety Initiatives for Residential Areas and School Zones

All drivers are to show respect for our neighbours in the Howlong area. Care is to be taken around school bus stops in the morning (6:45am to 9:30am) and afternoon (2:45pm to 4:30pm) periods (see Figure 1). Drivers are to be mindful of children being dropped off and/or picked up in and around the Howlong areas during these hours. Drivers are to comply with 40km/h speed limit for traffic passing a school bus as well as within school zones.

All Drivers are to be reminded that Hawkins St Howlong is an 50km speed zone. Drivers are required to show consideration to all other people accessing the main street and shopping precinct by giving pedestrians and vehicles reversing a wide berth and be aware of the pedestrians' safety, road users' safety and their own safety at all times.

Drivers are to ensure that when passing pedestrians / cyclists a safe separation distance exists between trucks and pedestrian / cyclists as well as a reduction in speed if appropriate. In regard to cyclists, all drivers must abide by the Minimum Passing Distance Rule, whereby a minimum separation distance of 1 metre is required when the speed limit is 60 km/h or less, and a minimum separation distance of 1.5 metres is required when the speed limit is more than 60 km/h.

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13. Figure 1 and Figure 2 Truck Route and Hawkins Street, Howlong

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14. Primary Haulage Routes

The primary haulage routes are shown on **Figure 1**, with critical locations highlighted.

Heavy vehicle drivers are to carefully plan their routes so that State and regional roads are given priority for route selection. Local roads should only be used if there is no other option or in an emergency situation. To be considerate of our neighbours, short cuts and deviations should not be used when delivering Quarry products. Heavy vehicle drivers are to be aware of PBS weight restrictions and requirements when using roads and bridges.

15. Heavy Vehicle Breakdown and Incidents

In the case of a breakdown the vehicle must be towed to the nearest breakdown point as soon as possible. All breakdowns must be reported to the TfNSW TMC (Transport Management Centre) on 131 700 and the vehicle protected in accordance with the Heavy Vehicle Drivers handbook.

If there is a product spill while loading/unloading or en-route to and from the Quarry, the driver must:

a) Immediately warn persons in the area who may be at risk;
b) Inform their shift supervisor/owner. If the vehicle is owned or contracted by Hanson Construction Materials Pty Ltd, the Howlong Sand and Gravel Quarry Manager must be immediately informed so that emergency services can be contacted and a clean-up initiated;
c) All spills must be adequately cleaned up and waste disposed of in an acceptable and environmental manner;
d) Put out warning triangles where it is safe to do so;
e) Contact the NSW Police Service if on an external road. When within the Quarry the Quarry Manager is to be notified.

To ensure that traffic impacts are minimised in the event of an incident, rapid response from the haulage company is required. In order to ensure rapid response to incidents, drivers are encouraged to contact the TfNSW TMC on 131700, as soon as the stranded vehicle and load is safely secured.

16. Compliance Measures and Monitoring

The document is to be signed by individual drivers and a Hanson Construction Materials Pty Ltd authorised representative at the time when heavy vehicle haulage drivers attend their site induction or shortly thereafter.

To assist in the orderly resolution of complaints, Quarry management will keep a register itemising all reported incidents relating to complaints in regard to heavy vehicle driver conduct external to the Quarry site.

The incident register is to include (where possible):

a) Date of the complaint.
b) Time of the complaint.
c) Name of the complainant (if available).
d) How the complaint was received.
e) Detailed description of the complaint (including location, driver/heavy vehicle details).
f) What / when actions were taken to resolve the issue; and
g) The reply to the person / organisation that made the complaint.

Once the Quarry Manager is satisfied that the complaint is substantiated, an investigation of the location and causes of the complaint will be undertaken. Following investigation of the issue, the Quarry Manager will provide feedback to the complainant that details the investigations undertaken, the result of the investigation and measures implemented to ensure that operations remain compliant. A description of any follow-up investigations and the response provided to the complainant will also be recorded in the Complaints Register upon closure of the issue.

The incident register is to be made available, upon request, to an authorised State Government officer or Council officer.

In addition to the register, any breach of the Code of Conduct will result in the offending driver being placed on a Driver's Code of Conduct Disciplinary Action Register.

There are 3 stages to the process:

1st Stage – No driver will have their vehicle loaded prior to being inducted. During the induction process all drivers will be made aware of their responsibilities while they are in the control of haulage trucks operating from the Howlong Sand and Gravel Quarry.

During the induction process drivers will be required to sign documentation to demonstrate their understanding, these documents will include but not limited to;

- Quarry Induction,
- Driver's Code of Conduct,
- Quarry Safety Management Systems, and
- Driver's will be required to participate in Primary Risk assessments and activities.

2nd Stage – Driver will be warned for the breach, entered into the register, re-inducted and the company of the driver will be notified that a breach of the site rules has occurred by the offending driver. The result of this breach will result in disciplinary action that as a minimum will include being re-inducted but may involve being banned from site for a period determined by management.

3rd Stage – The driver will be banned from the Quarry Site entirely and the company of the driver will be notified of the ban period imposed on the driver. Where relevant, the incident and information will be provided to the local Howlong Police.

17. Driver's Code of Conduct Disciplinary Action Register

Date of Complaint	Time	Complainant Name	How Complaint Received	Detailed description of the complaint	Action Taken	Complainant Notified of Action	IMS File Number

18. Emergency Contact Numbers

- TfNSW Transport Management Centre – 131 700
- Quarry Management – 0417 883 576
- Howlong Police – 02 6026 5507
- Howlong Medical – 02 6026 5307

19. Signature

I, the inductee, am aware of and agree to comply with the above mentioned statements and safety requirements.

Signed:	Authorisation by Quarry Manager or delegate Signed:
Name (Print):	Name (Print):
Date:	Date:

Appendix 13

Level Three Bridge Assessment prepared by Aussie Bridges Pty Ltd – September 2020

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FRASER EARTHMOVING CONSTRUCTION PTY LTD

LEVEL THREE BRIDGE ASSESSMENT REPORT FOR TARCOOLA BRIDGE LOCATED 4343 RIVERINA HIGHWAY, HOWLONG NSW OVER BLACK SWAN ANABRANCH

Our Reference: 20-0256
Date: Wednesday 2 September, 2020

TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND

Aussie Bridges Pty. Ltd. ('Aussie Bridges') was engaged by Fraser Earthmoving Construction Pty Ltd ('Fraser') to:

- Undertake a Level 3 bridge assessment incorporating:
  - Thorough site inspection / investigation to determine bridge condition and identify defects; and
  - Physical load testing, desk top analysis and provision of a Level 3 report.

Tarcoola Bridge ('the Bridge') which spans Black Swan Anabranch (off the Murray River), is privately owned and situated approximately 4.5 km SE of Howlong on a restricted access dirt road off the Riverina Highway. The main purpose of this Bridge is to provide access to a quarry operated by Fraser (refer below images) however, it also acts as a transit for wide loads particularly farm machinery.

BRIDGE LOCALITY: NEARMAP IMAGE 1 - 27 FEBRUARY 2020

BRIDGE LOCALITY: NEARMAP IMAGE 2 - 27 FEBRUARY 2020

The Bridge is a single lane continuous span steel-framed Bridge of six (6) spans with precast concrete deck units clipped to the girders.

Fraser advised that they were unable to provide original Bridge design drawings although the following report was made available for information:

- *"Tarcoola" Bridge Load Rating Assessment* dated 2 December 2017, prepared by S.J. Street & Associates prior to an inspection on 15 November 2017 ('SJS Report')

This report describes / details Aussie Bridges combined Level 2 inspection, Level 3 assessment (incorporating physical load testing and structural analysis), and the recommended Bridge load limit and repair options for Fraser consideration.

2. ASSESSMENT

2.1 Objectives

Bridge investigation / assessment objectives were:

- Inspect structure to determine its current condition;
- Identify specific defects / concerns;
- Ascertain the structure's present load carrying capacity; and
- Recommend required remedial work / repair.

2.2 Methodology

The inspection involved visual examination and measurement(s) of major Bridge components and elements to determine condition, and identify any defects requiring repair or alternative action. Physical load testing was also conducted.

An engineering desktop design / structural analysis was subsequently completed utilising load testing data and inspection details / information.

3. BRIDGE INVESTIGATION AND FINDINGS

Aussie Bridges Directors John Grewar and Ron Trimble traveled to the Bridge site on 25 July, 2020 and conducted a comprehensive investigation which included:

- Intensive inspection of the Bridge substructure and superstructure;
- Examination and measurement(s) of major structural components, noting damage and deterioration of Bridge elements;
- Conduct of physical structural load testing;
- Monitoring and recording physical load movement / deflections; and
- Taking appropriate digital records of the structure, individual Bridge elements / components and the physical load testing.

The 'Bridge and Major Culvert Level Two Inspection Report' which summarises Aussie Bridges L2 observations of the Bridge structure, approaches and in-vicinity environment is provided in Appendix 2.

3.1 Level 3 Investigation

Findings noted by Aussie Bridges during our L3 investigation are provided below:

- Vehicle wheel loads run close to straight along I-Beams, consequently deck itself is not under substantial load;
- Previous concrete deck unit repairs; and
- The slopes created between the deck and the lower level of the road approaches have the potential to increase horizontal impact loads on the Bridge.

Please refer Appendix 1 for relevant photos.

3.2 Load Testing

3.2.1 Methodology

For load testing purposes, Fraser provided a Hitachi AH400 articulated dump truck ('the truck') with the following approximate specifications:

- Gross vehicle mass – 29,850 kg;
  - Front axle – 14,650 kg;
  - Middle axle – 7,810 kg;
  - Rear axle – 7,390 kg;
- Overall length – 10,485 mm;
  - Front to middle axle – 4,470 mm;
  - Middle to rear axle – 1,950 mm;

- Overall width – 3,357 mm; and
- Wheelbase – 3,447 mm.

Please refer to Appendix 3 for vehicle specifications.

Load testing comprised:

- Visually inspecting, surveying and measuring the superstructure on the top side with no load at the abutments and quarter points along the structure itself for both the upstream and downstream sides;
- Monitoring truck entry to and whilst passing over the Bridge; and
- Parking the truck on the Bridge and measuring deflection(s) whilst load was applied to the structure.

The Bridge load testing / measuring was completed by Aussie Bridges Directors, John Grewar and Ron Trimble during the 25 July, 2020 inspection.

Please refer to 6.3.1 for load testing outcomes.

4. DESIGN CRITERIA

4.1 Black Swan Anabranch

Black Swan is a natural waterway, an anabranch of the Murray River whose nearest bank is located around 840 m SW of the Bridge site.

No current hydrological data was available for the site. As there were also no original design drawings for the Bridge it was not possible to determine the flood or other levels that may have been utilised during the design process.

4.2 Design Loading

In the absence of original engineering drawings, the original design load is another element that was unknown when Aussie Bridges undertook this assessment however, given the age of the Bridge it was likely a three-axle truck.

5. BRIDGE STRUCTURE - DESIGN

No information regarding when the Bridge was constructed / opened or who actually designed the structure was available.

Aussie Bridges determined / established the general arrangement of the structure and its design / components from measurements taken during the inspection and subsequent review of our digital records.

5.1 Substructure

Abutments

Each of the north / south abutments comprise:

- 2 No. of driven 420 mm diameter reinforced concrete piles. The different colours at the top of each pile indicate they were extended. Pile toe levels are not known;
- A 250 mm steel UC crosshead incorporating web stiffeners toward each end resting on a steel levelling plate / packer supports the I-Beams;
- Quasi fender wall consisting of what appears to be 2 No. of steel PFC channels at the north abutment and one (1) on the south abutment; and
- Embankment stabilisation comprising lengths of various steel sheeting including w beam guard rail driven into the ground, and a concrete wall.

Aussie Bridges did not see any evidence of sub-surface drainage ('SSD'). As the Bridge was essentially constructed for farm usage it is unlikely that SSD was incorporated in the design.

Intermediate Piers

- The first pier from the north abutment comprises 2 No. of piles;
- 3 No. of piles in the each of the 4 remaining piers; and
- 250 mm steel UC crossheads running parallel to each abutment crosshead span the piles and support the I-Beams. Steel packing plates have been placed between piles and crossheads.

5.2 Superstructure

The superstructure of the 6-span Bridge is tied vertically to the substructure and consists of:

- 2 No. of continuous longitudinal steel I-Beams
  - Size – 610 mm UB113 equivalent;
  - Grade 250 steel;
  - Installed at 2.70 m centres;
  - Joined / welded at distances varying between 1.5 m and 2.0 m from piers by:
    - Butt-welding an approximately 12.7 mm thick x 203 mm wide vertical plate (the same height as the beams) to the side of the beam with a single pass fillet and a 19.05 mm thick x 330 mm wide base plate welded in position with a three-pass fillet; and
  - Lateral restraint provided by 2 No. of right-angle steel lengths (placed diagonally) and welded between each I-Beam at mid-spans.

  The above referred I-Beams welding information was extracted from Appendix 1 of the SJS Report and its reasonableness confirmed on site during Aussie Bridges inspection.

- Spans as measured from the north end of the Bridge:
  - 10.60 m
  - 10.35 m
  - 10.00 m
  - 10.60 m
  - 10.53 m
  - 10.85 m

  These span lengths were extracted from the SJS Report and confirmed on site during Aussie Bridges inspection.

- Deck
  - Overall width - 4.2 m;
  - Width between kerbs - 3.9 m; and
  - 150 mm thick reinforced concrete deck units bolted to I-Beams by metal restraints.

5.2.1 Bridge Articulation

This Bridge which comprises continuous span steel girders does not provide articulation for the superstructure. The precast deck units are not continuous and situated / secured in position by locating clamps.

6. STRUCTURAL ANALYSIS

6.1 Modelling

The Bridge structure was modelled using Bentley's Microstran Advanced software package. The superstructure was modelled as a grillage of beam elements longitudinally and transversely. Soil-structure interaction of the abutment element of the substructure was represented by vertical springs to depict driven piles. This analysis methodology allows the Structural Engineer to determine the loads acting on each of the individual structural elements and the combined foundations and founding materials interaction.

For its structural analysis Aussie Bridges developed and utilised:

- An independent dual axle truck model with the following criteria:
  - A 16.5 t total load; with
  - Axles spaced at 1.25 m centres and wheel lines 2.0 m apart; and
- A similar model for a tri-axle group to a total of 22.5 t.

Both models were used to traverse the grillage of members to determine the most adverse effects and assist with determining the load rating factor (‘RF’).

Aussie Bridges have considered full permanent and imposed actions for the nominated traffic loads and utilised combination factors of 1.2 and 1.8 respectively.

6.2 Assumptions and Restrictions

Critical Assumption: Load sharing has not been assumed between deck units as the units are actually functioning independently of each other and do not act in composite action with the stringers.

Permanent and imposed actions have been applied symmetrically to the structure due to:

- The single lane nature of this Bridge; and
- Limited ability for lane departure.

The axle loads were determined by Aussie Bridges from vehicle geometry, maximum axle loads (VicRoads) and engineering experience.

6.3 Physical Load Testing

Approximate loads of 45 tonnes on the rear axles and 14 tonnes on the front axle created a gross load of 59 tonnes.

6.3.1 Testing Outcomes and Discussion

Surveyed physical load-testing deflection(s) and their 'immediately corresponding' contraflexure(s) in the subsequent span, measured from the south end of Bridge are provided in the table below:

Span No.	Midspan deflection	Subsequent span contraflexure	
		Span No.	Midspan contraflexure
1	-13.0 mm	2	+3.5 mm
2	-11.0 mm	3	+6.0 mm
3	-9.0 mm	4	+3.5 to +4.0 mm
4	-11.0 mm	5	+4.0 mm
5	-9.5 mm	6	+6.0 mm
6	-11.0 mm		

As indicated, all surveyed measures in this table were recorded midspan.

Whilst the maximum allowable deflection under the serviceability scenario (span / 600) utilising the nominated test vehicle is 16.6 mm, testing measured a maximum midspan deflection (sag) of 13 mm.

Serviceability Check: Following analysis of a known load versus the measured deflection it has been determined that the imperial section in grade 250 steel is more accurately represented by a 610 UB 125. Consequently, this representation has been utilised for Aussie Bridges final analysis work.

The deflection performance of the girder beam for an approximate 22.5 t load falls within the acceptable deflection criteria specified in *AS 5100:2017 Bridge Design* ('the Code'). The applied load is greater than twice that of a legal road-registerable axle group.

6.4 Analysis

Aussie Bridges analysed the capacity of individual Bridge element(s) using Tekla Tedds software.

Key Findings

Strength Check: Pursuant to the Code, the existing structure fails a pure strength check for SM1600 and HLP320 when analysed in Microstran and the results input to Tedds.

Utilising a group of point loads at midspan of the girder to represent a tri-axle combination, the main girder is only 3% overloaded in strength considering / applying a combination factor of 1.8 on a total 22.5 t group load. This represents a total factored load of 40.5 t which could not be loaded onto any normal axle group and is actually less than the load applied during Aussie Bridges load testing.

6.3 Analysis Summary and Conclusion

There is currently no load-limit on this Bridge consequently, considering its proximity to a quarry there is a high degree of certainty that the structure is regularly subjected to maximum 20 t loads on tri-axle groups.

As the bridge did not exhibit any signs of failure during physical load testing or our analysis of measured deflections it is the professional opinion of Aussie Bridges that this structure:

- Does not require any load restrictions; and
- Is more than suitable to receive any loading scenarios from legally loaded, road registered vehicles including any B-Double combination.

7. BRIDGE IMPROVEMENT / REPAIR AND MAINTENANCE

In addition to the suggested repairs / maintenance to address the defects / issues identified during our site inspection (refer 'Bridge and Major Culvert Level Two Inspection Report' included at Appendix 2), Aussie Bridges recommend the following L3 assessment actions:

1. Any sudden changes to the structure should be immediately referred to a competent suitably qualified bridge engineer;
2. Ensure scheduling and completion of 'minimum' annual Level 2 Bridge inspections to identify any significant changes in structural condition;
3. Limit vehicle speed to 5 kph. Consider installing cameras on the Bridge to monitor speed. This action would be more successful if there were consequences associated with non-compliance. Excessive speeds and their associated load increases have the potential to lessen the life of the structure and increase risks associated with structural compromise;
4. Provide suitable bollards on the approaches each side to control vehicle alignment across the bridge;
5. Plan for bridge replacement to AS5100 requirements within 5 years to allow for some residual life in the bridge for farm usage;
6. Develop a Bridge Management Plan incorporating:
   - The repairs / maintenance suggested in our 'Bridge and Major Culvert Level Two Inspection Report';
   - Routine maintenance scheduling and completion; and
   - Each of the ('accepted') recommended L3 actions numbered 1 to 5.

Please note that a failure to undertake routine maintenance will have a detrimental effect on both the life and safety of the structure.

If there are any queries regarding the content of this report please contact the undersigned by telephoning 03 5443 7793 or email admin@aussiebridges.com.au.

Kind Regards

John Grewar
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BE (Civil) Hons, MIE Aust. CPEng NER, Adv. Dip Engineering (Mech), MAGS, MACSEV, MASI

APPENDIX 1

North abutment: both piles have been extended (note different colour), levelling plate / packer at top of pile, web stiffener near each end of crosshead

North abutment: note ‘w-beam’ embankment stabilisation on LHS of image

North abutment: quasi fender wall assists in retaining soil on the embankment – refer above and below

South abutment: crosshead resting on steel plate / packer - refer above and below

South abutment: steel fender wall behind the crosshead and diagonal bracing

South abutment: accumulated dirt and rust on I-Beam

South abutment: crosshead supporting I-Beam (SE corner)

Diagonal bracing between I-Beams provide lateral support

Deck: previous deck unit repair

The truck utilized for load testing – refer above and below

Truck preparing to cross from south end of Bridge

APPENDIX 2

BRIDGE AND MAJOR CULVERT
LEVEL TWO INSPECTION REPORT

BRIDGE IDENTIFICATION / INSPECTION INFORMATION		
Structure ID: N/A	**Bridge Name:** Tarcoola Bridge **Road / Street:** Off 4343 Riverina Highway, Howlong NSW	**Waterway / Crossing Name:** Black Swan Anabranch
Inspectors: John Grewar and Ron Trimble	**Inspection Date(s):** 25 July 2020	**Location Details:** Latitude: -36.006956 Longitude: 146.663850

BRIDGE PROPERTIES / DIMENSIONS		
Description	**Item**	**Detail**
Continuous span steel-framed Bridge of six (6) spans with precast concrete deck.	Overall length	63.9 m
	Overall width	4.20 m

STRUCTURAL CONDITION		
Component / Element	**Condition / Defect(s)**	**Action(s)**
Substructure		
Abutments	No specific concerns	No action
Embankments	No stone beaching present	• Subsequent to removal of debris / vegetation (refer Aspect Maintenance below), lay rock / stone beaching along embankments to minimise erosion • Consider further bracing / supporting the existing steel / concrete stabilisation system
Piers and piles	Multiple timber piles from the old bridge remain in the waterway	Consider trimming back old timber piles to minimise waterway obstacles that can trap debris
Superstructure		
I-Beams and crossheads	Significant rust / corrosion on I-Beams, crossheads and bracing	• Abrasive sand blast all steelwork to Class 2.5 • Refer Aspect Maintenance below
Deck	• Misaligned deck unit • Wear along edges of concrete deck units have formed gaps / depressions along the joins • Non-active deck unit cracks • Metal fastenings securing deck units to I-Beams have loosened / moved	• Realign jutting deck unit • Upgrade fastenings securing deck units to I-Beams with hot dipped galvanised connections suitable for marine environment. Ensure all fastenings are well tightened
Scuppers	None present	Not applicable
Kerb	• Fully broken kerb and exposed reinforcement at SW corner • Cracking in kerb at SE corner	• Consider replacing broken / separated kerb at SW corner • Consider repairing kerb cracking at SE corner

Barrier / Guardrail	• Although guideposts were previously present on the Bridge, they have been removed at some point, most likely to allow wide vehicle / machinery transit • There are currently no guardrails / barriers on the bridge	Consider installation of low-profile barriers / guardrails to improve bridge safety but continue to allow wide load transit
Signage	• There is a 5 km p/h speed sign at the south end of the Bridge only • No bridge width markers	• Erect a 5 km p/h sign at the north end of the Bridge; • Install Bridge width markers on each side of both approaches • Consider installing appropriate single lane signage
Approaches	• A soft spot in the road at the left-hand side on the north approach • Road approaches are slightly lower where they meet the deck creating wear along the facing edges of the first concrete units	• Dig out / remove soil and other road material from the soft spot at the left-hand side of the north approach • Replace with suitable fill or road base • Fully compact replacement fill / base materials • Consider building up and levelling both road approaches to minimise vehicle impact on first concrete deck units
Aspect Maintenance		
Clean and Paint	Steel components / elements	Prepare all sandblasted steelwork and paint with an appropriate marine environment product, at minimum incorporating a double coat epoxy primer
Debris	• Branch segments hung up / jammed in superstructure • Old farm gates have been placed down north embankment creating an obstacle in the waterway and trapping debris • Substantial accumulation of debris, most of it vegetative, beneath and in the vicinity of the bridge	Remove: ◦ old branch segments from superstructure ◦ old farm gates from north embankment ◦ all debris beneath and in the vicinity of the bridge
Vegetation	Saplings from nearby trees and other vegetation growing beneath and in vicinity of bridge	Remove unnecessary vegetation from beneath and near the bridge

INSPECTION SUMMARY
Not applicable – refer L3 assessment

Looking south from north end of Bridge

North approach: obvious soft spot on LHS

SW corner: broken / separated kerb and exposed reinforcement – refer above and below

SW corner: broken kerb and exposed reinforcement viewed from beneath

I-Beam: fastening securing the deck unit to the I-Beam is loose, and has moved out of position. Also note the prevalence of rust / dirt

SE corner of bridge: cracked kerb. Old guide post was previously cut / removed

SE corner of bridge: crack in previous image extends down side of kerb. This damage was possibly caused by vehicle impact

Deck: depressions / gaps have formed between deck units – refer above and below

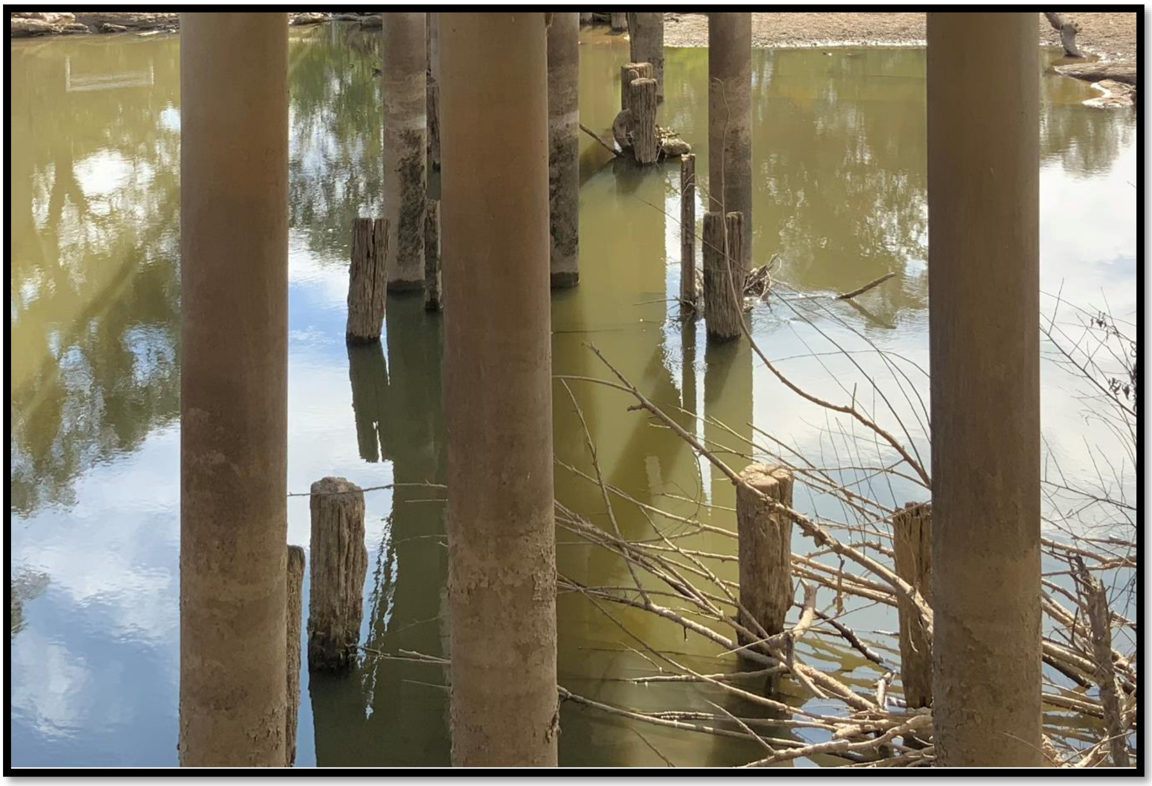
Deck: cracks visible in deck units are not active

Approach: depression / slope has formed in front of the first deck unit

Steel throughout Bridge structure is coated with rust and dirt / silt – refer above and below

Nth bank looking from east side of bridge: old farm gates, accumulated debris and a branch jammed in the superstructure – refer above and below

Saplings and rubbish beneath and in close proximity to the Bridge – refer above and below



Waterway: old timber piles act as obstacles to flow, adding to accumulation of debris

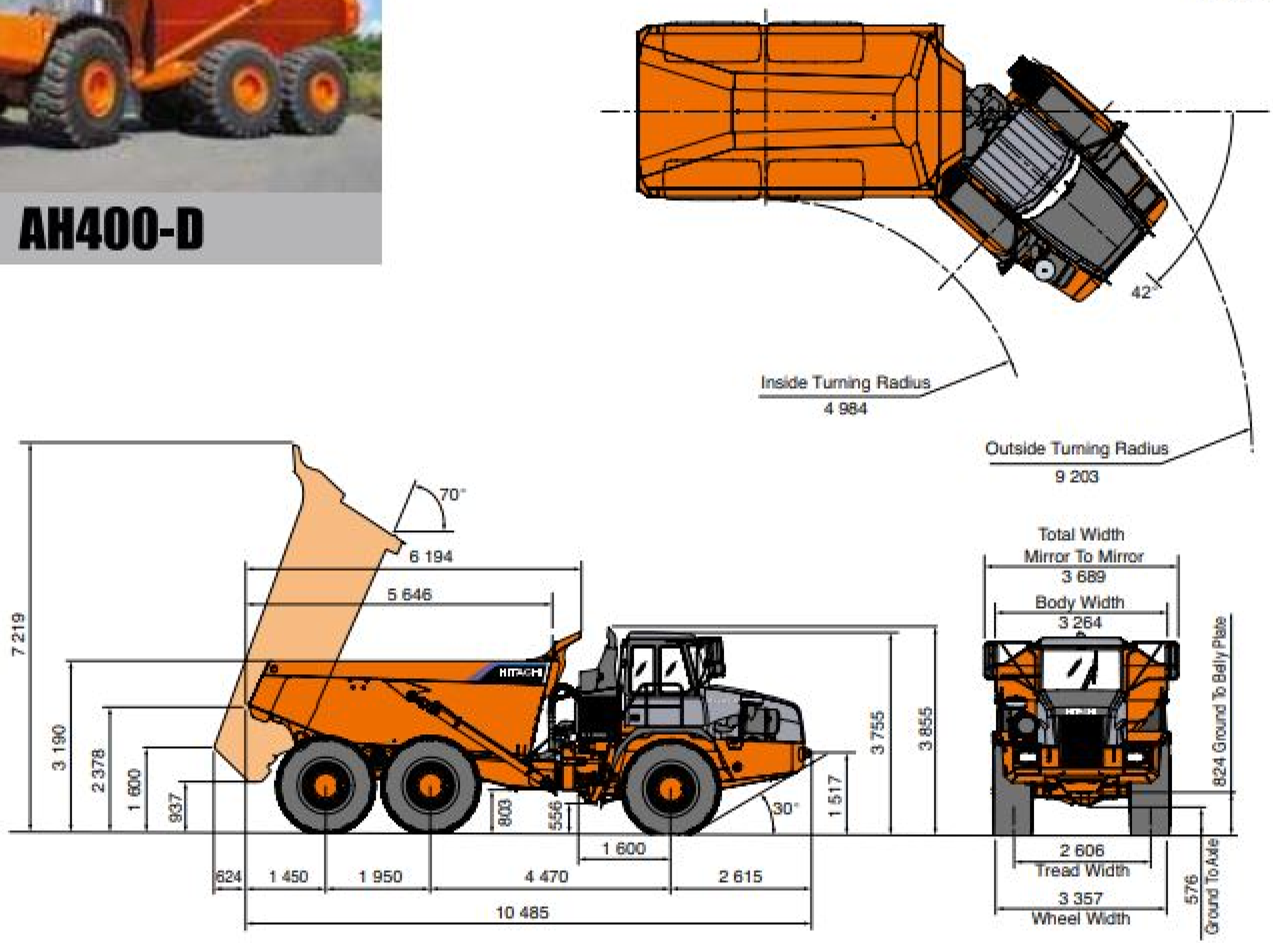
Speed limit sign on south approach

APPENDIX 3

AH400-D

DIMENSIONS

Unit : mm



SPECIFICATIONS

			AH400-D	AH350-D
RATED PAYLOAD			37 000 kg	32 500 kg
BODY CAPACITY: HEAPED			22.5 m^3	20.1 m^3
ENGINE NET POWER			308 kW (413 HP)	283 kW (380 HP)
BODY	Capacity:	Struck	16.9 m^3	15.2 m^3
		Heaped: SAE 2:1	22.5 m^3	20.1 m^3
	Rated Payload		37 000 kg	32 500 kg
	Lowering time		8 seconds	
	Raise time		13 seconds	
	Tipping angle		70 degrees	
OPERATING WEIGHTS	Unladen	Front	14 650 kg	14 120 kg
		Middle	7 810 kg	7 060 kg
		Rear	7 390 kg	7 050 kg
		Total	29 850 kg	28 230 kg
	Laden	Front	19 590 kg	18 350 kg
		Middle	23 840 kg	21 200 kg
		Rear	23 420 kg	21 180 kg
		Total	66 850 kg	60 730 kg
ENGINE	Model		MercedesBenz OM501LA	
	Configulation		V-6 with exhaust brake and Engine Valve Brake (EVB)	
	Emmision Certification		Meets Europe (EU) Stage IIIA ratings	
	Aspiration		Turbocharged and intercooled	
	Cooling system		Liquid cooled with single pass radiator as well as charge air cooler	
	Gross power (SAE J1995)		315 kW (422 HP) @1 800 min^{-1}(rpm)	290 kW (389 HP) @1 800 min^{-1}(rpm)
	Net Power		308 kW (413 HP) @1 800 min^{-1}(rpm)	283 kW (380 HP) @1 800 min^{-1}(rpm)
	Net torque		1 974 N-m @1 300 min^{-1}(rpm)	1 824 N-m @1 300 min^{-1}(rpm)
	Displacement		11.95 L	
	Fuel tank capacity		485 L	
ELECTRICAL SYSTEM	Voltage		24 V	
	Battery capacity		2 X 105 Ah	
	Alternator rating		28V 100A	
TRANSMISSION	Model		Allison HD4500R ORS with integral retarder	
	Layout		Engine mounted box with rear output	
	Gear layout		Constant meshing planetary gears, clutch operated	
	Clutch type		Hydraulically operated multiple disc	
	Control type		Electronic	
	Torque converter layout		Hydrodynamic, with lock-up in all gears	
	Vehicle speeds: km/h	1st	7.4	8.0
		2nd	15.7	17.0
		3rd	22.8	24.0
		4th	34.8	37.0
		5th	45.6	48.0
		6th	52.0	54.0
		Reverse	6.3	6.3
TRANSFER BOX	Model / type		VGR 17000 / Three in-line helical gears. 67/33 torque proportioning, pneumatically lockable on the move	
AXLES	Model		25T	
	Type		High strength steel fabricated with spiral bevel type gears on the Controlled Traction differential (CTD) and heavy duty outboard planetary gears.	
BRAKING SYSTEM	Service brake		Dual circuit, hydraulically actuated wet disc brakes on front and middle axles.	Dual circuit, hydraulically actuated dry disc brake calipers on all axles.
	Park & Emergency		Spring applied, air released driveline mounted disc	
	Auxiliary brake		Transmission retarder, automatic exhaust brake and Engine Valve Brake (EVB)	
WHEELS	Tire	Size	29.5R25	26.5R25
		Type	Radial Earthmover	
	Laden ground pressure at 15% sinkage of unloaded radius and specified weights		Middle: 158 kPa	Middle: 169 kPa
SUSPENSION	Front type		Semi-independent leading A-frame supported by nitrogen and oil filled struts.	
	Rear type		Pivoting walking beams, distributing equal load through laminated rubber suspension blocks. Each axle is coupled to the chassis by a Tri-Link system of three rubber-bushed links for ideal vertical movement and a transverse link for lateral restraint.	