Bringelly Brickworks and Quarry Expansion

ENVIRONMENTAL IMPACT STATEMENT

Volume 2

PREPARED FOR: Boral Bricks Pty Ltd
PREPARED BY: Hyder Consulting Pty Ltd

APPENDIX A

DIRECTOR GENERALôS ENVIRONMENTAL ASSESSMENT REQUIREMENTS (DGRS)

NSW GOVERNMENT | Planning & Infrastructure

Major Projects Assessment
Mining & Industry Projects
Contact: Caitlin Elliott
Phone: 02 9228 2055
Fax: 02 9228 6466
Email: caitlin.elliott@planning.nsw.gov.au

Our Ref: 233851

Ms Judy McKittrick
Boral Bricks
PO Box 42
WENTWORTHVILLE NSW 2145

Dear Ms McKittrick

State Significant Development - Director-General's Requirements
Bringelly Brickworks Project (SSD-5684)

I have attached a copy of the Director General's environmental assessment requirements (DGRs) for the preparation of an Environmental Impact Statement (EIS) for the Bringelly Brickworks Project.

These requirements are based on the information you have provided to date and have been prepared in consultation with relevant government agencies. I have attached a copy of their comments for your information (see Attachment 2).

Please note that the Department may alter these requirements at any time, and that you must consult further with the Department if you do not lodge a development application and EIS for the project within two years of the date of issue of these DGRs. The Department will review the EIS for the project carefully before putting it on public exhibition, and will require you to submit an amended EIS if it does not adequately address the DGRs.

Your project may require separate approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Department encourages you to confirm whether such an approval will be required as soon as possible. If an EPBC Act approval is required, I would appreciate it if you would advise the Department accordingly, as the Commonwealth approval process may be integrated into the NSW approval process, and supplementary DGRs may need to be issued.

I would appreciate it if you would contact the Department at least two weeks before you propose to submit the development application and EIS for your project. This will enable the Department to:

- confirm the applicable fee (see Division 1AA, Part 15 of the *Environmental Planning and Assessment Regulation 2000*); and
- determine the number of copies (hard-copy and CD-ROM) of the EIS required for review.

If you have any enquiries about these requirements, please contact Caitlin Elliott.

Yours sincerely

DKitto 24/12/12

David Kitto
Director
Mining & Industry Projects
as delegate of the Director-General

Director General's Environmental Assessment Requirements

Section 78A(8A) of the *Environmental Planning and Assessment Act 1979*

State Significant Development

Application Number	SSD 5684
Development	The Bringelly Brickworks Project, which includes: • expanding the extraction area from 17 hectares to 22 hectares; • increasing production to up to 263,000 tonnes of bricks per year for up to 30 years; • transporting the product from the brickworks via road; and • rehabilitating the site.
Location	60 Greendale Road, Bringelly, in the Camden LGA
Applicant	Boral Bricks (NSW) Pty Ltd
Date of Issue	24 December 2012
General Requirements	The Environmental Impact Statement (EIS) for the development must meet the form and content requirements in Clauses 6 and 7 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000.* In addition, the EIS must include a: • detailed description of the development, including: – need for the proposed development; – justification for the proposed quarry plan, including efficiency of resource recovery, mine safety, and environmental protection; – likely staging of the development - including construction, operational stage/s and rehabilitation; – plans of any proposed building works; • consideration of all relevant environmental planning instruments, including identification and justification of any inconsistencies with these instruments; • risk assessment of the potential environmental impacts of the development, identifying the key issues for further assessment; • detailed assessment of the key issues specified below, and any other significant issues identified in this risk assessment, which includes: – a description of the existing environment, using sufficient baseline data; – an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant guidelines, policies, plans and statutes; and – a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment; and • consolidated summary of all the proposed environmental management and monitoring measures, highlighting commitments included in the EIS. The EIS must be accompanied by a report from a qualified quantity surveyor providing: • a detailed calculation of the capital investment value (CIV) (as defined in clause 3 of the Environmental Planning and Assessment Regulation 2000) of the proposal, including details of all the assumptions and components from which the CIV calculation is derived; • a close estimate of the jobs that will be created by the development during the construction and operational phases of the development; and • certification that the information provided is accurate at the date of preparation.

Key issues	The EIS must address the following specific issues: • **Land Resources** ï including a detailed assessment of the potential impacts on: - soils and land capability (including salinisation and contamination); - landforms and topography, including cliffs, rock formations, steep slopes, etc; and - land use, including agricultural, forestry, conservation and recreational use; • **Noise** ï including a quantitative assessment of potential: - construction, operational and off-site transport noise impacts; - reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed; and - monitoring and management measures, in particular real-time, attended noise monitoring and predictive meteorological forecasting; • **Traffic & Transport** ï including: - accurate predictions of the road traffic generated by the construction and operation of the project; - an assessment of potential traffic impacts on the safety and efficiency of the road network; and - a detailed description of the measures that would be implemented to maintain and/or improve the capacity, efficiency and safety of the road networks in the surrounding area over the life of the project; • **Air Quality** ï including a quantitative assessment of potential: - construction and operational impacts, with a particular focus on processing and dust emissions, as well as diesel emissions; - reasonable and feasible mitigation measures to minimise processing, dust, diesel emissions, including evidence that there are no such measures available other than those proposed; and - monitoring and management measures, in particular real-time air quality monitoring; • **Water Resources** ï including: - detailed assessment of potential impacts on the quality and quantity of existing surface and ground water resources in accordance with the NSW *Aquifer Interference Policy*, including: o detailed modelling of potential groundwater impacts including identification of any highly productive groundwater (as defined by the *Aquifer Interference Policy*) or groundwater dependent ecosystems; o impacts on affected licensed water users and basic landholder rights; and o impacts on riparian, ecological, geomorphological and hydrological values of watercourses, including environmental flows; - a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures; - an assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives; - identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*; - demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP); - a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo; and - a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts; • **Biodiversity** ï including: - measures taken to avoid, reduce or mitigate impacts on biodiversity; - accurate estimates of proposed vegetation clearing;

- a detailed assessment of potential impacts of the development on:
  - terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems; and
  - regionally significant remnant vegetation, or vegetation corridors;
  - impacts on Existing Native Vegetation (ENV) identified under the Biodiversity Certification Order for the Sydney Region Growth Centres; and
- a comprehensive offset strategy to ensure the development maintains or improves the terrestrial and aquatic biodiversity values of the region in the medium to long term;

* **Heritage** ï including:
  - an Aboriginal cultural heritage assessment (including both cultural and archaeological significance) which must:
    - demonstrate effective consultation with Aboriginal communities in determining and assessing impacts, and developing and selecting mitigation options and measures;
    - outline any proposed impact mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures); and
  - a Historic heritage assessment (including archaeology) which must:
    - include a statement of heritage impact (including significance assessment) for any State significant or locally significant historic heritage items; and
    - outline any proposed mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures);
* **Waste** ï including:
  - accurate estimates of the quantity and nature of the potential waste streams of the development; and
  - a description of measures that would be implemented to minimise production of other waste, and ensure that that waste is appropriately managed;
* **Greenhouse Gases** ï including:
  - a quantitative assessment of potential Scope 1 and 2 greenhouse gas emissions;
  - a qualitative assessment of the potential impacts of these emissions on the environment; and
  - an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency;
* **Visual** ï including:
  - a detailed assessment of the:
    - changing landforms on the site during the various stages of the project; and
    - potential visual impacts of the project on private landowners in the surrounding area as well as key vantage points in the public domain, including lighting impacts; and
  - a detailed description of the measures that would be implemented to minimise the visual impacts of the project;
* **Hazards –** including bushfires;
* **Social & Economic** ï including an assessment of the:
  - potential direct and indirect economic benefits of the project for local and regional communities and the State;
  - potential impacts on local and regional communities, including:
    - increased demand for local and regional infrastructure and services (such as housing, childcare, health, education and emergency services); and
    - impacts on social amenity;
  - a detailed description of the measures that would be implemented to minimise the adverse social and economic impacts of the project, including any infrastructure improvements or contributions and/or voluntary planning agreement or similar mechanism; and
  - a detailed assessment of the costs and benefits of the development as

	a whole, and whether it would result in a net benefit for the NSW community; • **Rehabilitation** ï including the proposed rehabilitation strategy for the site, having regard to the key principles in the Strategic Framework for Mine Closure, including: - rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria; - nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies; and - the potential for integrating this strategy with any other rehabilitation and/or offset strategies in the region.
Plans and Documents	The EIS must include all relevant plans, architectural drawings, diagrams and relevant documentation required under Schedule 1 of the *Environmental Planning and Assessment Regulation 2000*. These documents should be included as part of the EIS rather than as separate documents.
Consultation	During the preparation of the EIS, you must consult with relevant local, State and Commonwealth Government authorities, service providers, community groups and affected landowners. In particular you must consult with the: • Commonwealth Department of Sustainability, Environment, Water, Population and Communities; • Office of Environment and Heritage (including the Heritage Branch); • Environment Protection Authority; • Division of Resources and Energy within the Department of Trade and Investment, Regional Infrastructure and Services; • Department of Primary Industries (including the NSW Office of Water, NSW Forestry, Agriculture and Fisheries sections, Catchments and Lands (Crown Lands Division)); • Transport for NSW (including the Centre for Transport Planning, Roads and Maritime Services); • Hawkesbury Nepean Catchment Management Authority; • Camden Council; and The EIS must describe the consultation process and the issues raised, and identify where the design of the development has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.
Further consultation after 2 years	If you do not lodge a DA and an EIS for the development within 2 years of the issue date of these DGRs, you must consult further with the Director-General in relation to the requirements for lodgement.
References	The assessment of the key issues listed above must take into account relevant guidelines, policies, and plans as identified. While not exhaustive, Attachment 1 contains a list of some of the guidelines, policies, and plans that may be relevant to the environmental assessment of this development.

ATTACHMENT 1
Technical and Policy Guidelines

The following guidelines may assist in the preparation of the Environmental Impact Statement. This list is not exhaustive and not all of these guidelines may be relevant to your proposal.

Many of these documents can be found on the following websites:
http://www.planning.nsw.gov.au
http://www.bookshop.nsw.gov.au
http://www.publications.gov.au

Policies, Guidelines & Plans

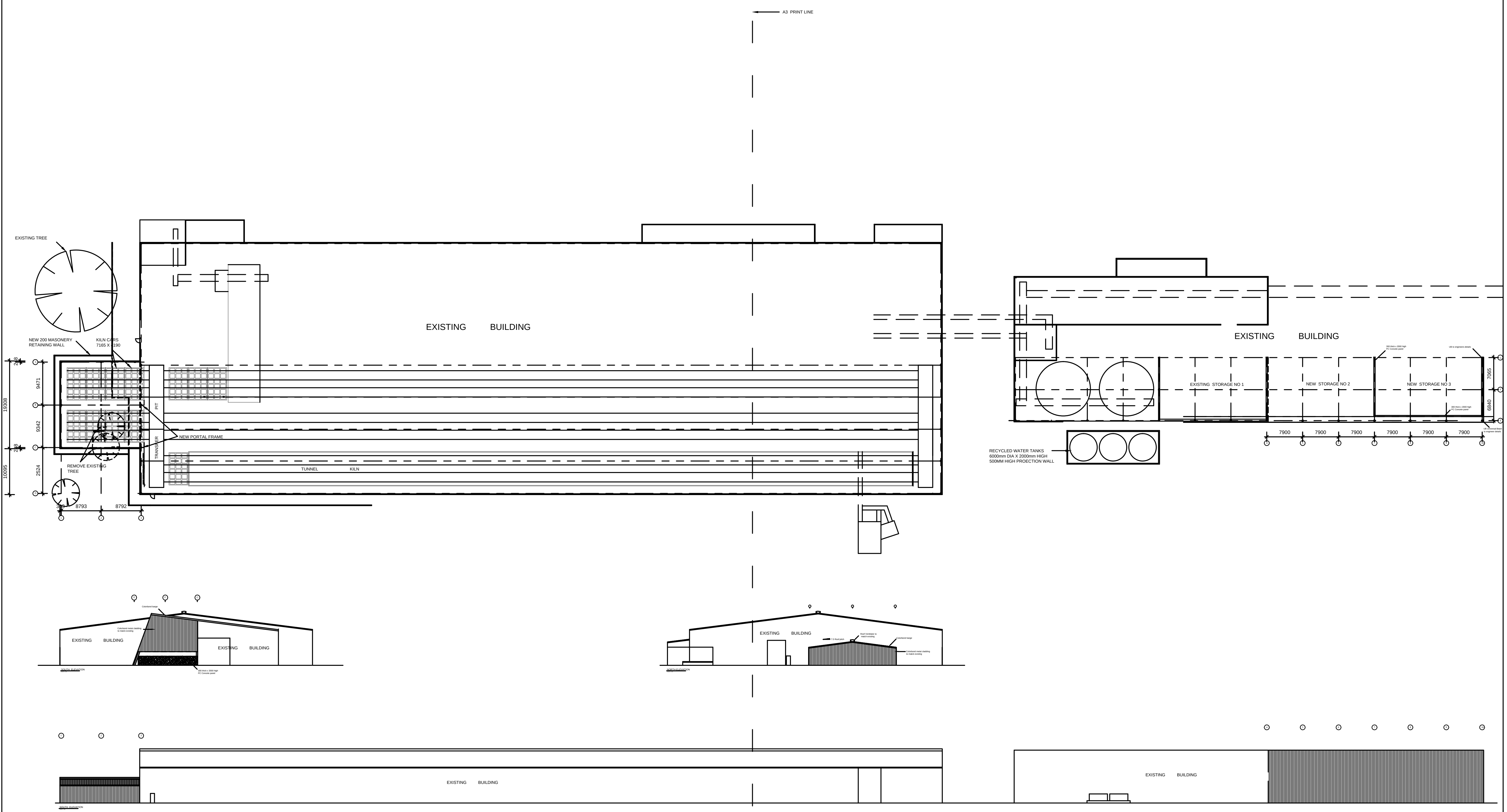
Risk Assessment	
	AS/NZS 4360:2004 Risk Management (Standards Australia)
	HB 203: 203:2006 Environmental Risk Management ï Principles & Process (Standards Australia)
Land Resources	
	Agricultural Impact Assessment Guidelines 2012 (DP&I)
	Agfact AC25: Agricultural Land Classification (NSW Agriculture)
	State Environmental Planning Policy No. 55 ï Remediation of Land
	Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC)
Biodiversity	
	Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna ï Amphibians (DECCW 2009)
	Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities ï Working Draft (DECC 2004)
	Threatened Species Assessment Guidelines: the Assessment of Significance (DECC 2007)
	Guidelines for Threatened Species Assessment (DoP 2005)
	BioBanking Assessment Methodology and Credit Calculator Operational Manual (DECCW 2008)
	NSW State Groundwater Dependent Ecosystem Policy (DLWC)
	Policy & Guidelines - Aquatic Habitat Management and Fish Conservation (NSW Fisheries)
	Policy & Guidelines - Fish Friendly Waterway Crossings (NSW Fisheries)
	State Environmental Planning Policy No. 44 ï Koala Habitat Protection
	State Environmental Planning Policy (Sydney Region Growth Centres) 2006
Water Resources	
Surface Water	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems ï Effluent Management (ARMCANZ/ANZECC)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems ï Use of Reclaimed Water (ARMCANZ/ANZECC)
	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC)
	State Water Management Outcomes Plan
	Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012
	Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2012
	NSW Government Water Quality and River Flow Objectives (DECC)
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)

	Managing Urban Stormwater: Soils & Construction (Landcom) and associated Volume 2E: Mines and Quarries.
	Managing Urban Stormwater: Treatment Techniques (DECC)
	Managing Urban Stormwater: Source Control (DECC)
	Floodplain Development Manual (DIPNR)
	Floodplain Risk Management Guideline (DECC)
	A Rehabilitation Manual for Australian Streams (LWRRDC and CRCCH)
	Technical Guidelines: Bunding & Spill Management (DECC)
	Environmental Guidelines: Use of Effluent by Irrigation (DECC)
Groundwater	NSW Aquifer Interference Policy (DPI, 2012)
	National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ/ANZECC)
	NSW State Groundwater Policy Framework Document (DLWC, 1997)
	NSW State Groundwater Quality Protection Policy (DLWC, 1998)
	NSW State Groundwater Quantity Management Policy (DLWC, 1998)
	Murray-Darling Basin Groundwater Quality. Sampling Guidelines. Technical Report No 3 (MDBC)
	Murray-Darling Basin Commission. Groundwater Flow Modelling Guideline (Aquaterra Consulting Pty Ltd)
	Guidelines for the Assessment & Management of Groundwater Contamination (DECC, 2007)
	Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012
	Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2012
Air Quality	
	Protection of the Environment Operations (Clean Air) Regulation 2002
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC)
	Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (DEC)
Noise & Blasting	
	NSW Industrial Noise Policy (DECC)
	Environmental Noise Management ï Assessing Vibration: a technical guide (DEC)
	NSW Road Noise Policy (DECCW)
	Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration (ANZECC)
Traffic & Transport	
	Guide to Traffic Generating Development (RTA)
	Road Design Guide (RTA)
Heritage	
Aboriginal	Draft Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation (DEC 2005)
	The Burra Charter (The Australia ICOMOS charter for places of cultural significance)
Historic	NSW Heritage Manual (NSW Heritage Office)
	The Burra Charter (The Australia ICOMOS charter for places of cultural significance)
Greenhouse Gases	
	National Greenhouse Accounts Factors (Australian Department of Climate Change (DCC))
	Guidelines for Energy Savings Action Plans (DEUS)
Waste	
	Waste Classification Guidelines (DECC)
Hazards	
	State Environmental Planning Policy No. 33 ï Hazardous and Offensive Development
	Hazardous and Offensive Development Application Guidelines - Applying SEPP 33
	Hazardous Industry Planning Advisory Paper No. 6 ï Guidelines for Hazard Analysis

Rehabilitation	
	Mine Rehabilitation ï Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth of Australia)
	Mine Closure and Completion ï Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth of Australia)
	Strategic Framework for Mine Closure (ANZMEC-MCA)
Socio-Economic	
	Draft Economic Evaluation in Environmental Impact Assessment (DoP)
	Techniques for Effective Social Impact Assessment: A Practical Guide (Office of Social Policy, NSW Government Social Policy Directorate)

APPENDIX B.1

PLANS SHOWING PROPOSED DEVELOPMENT



DRAFT PLAN NOT FOR CONSTURCTION

	AMENDMENTS	DATE
A	PRELIMINARY FIRST DRAFT	23.01.13
B	DELETE 1 TRACK OF KILN CARS	29.01.13
C	UPDATED PLANS	20.06.13

DJL ARCHITECTURAL DESIGN PTY LTD
155 Pitt Town Road
Kenthurst 2156
0417224342 96548660
djldmh@bigpond.com.au

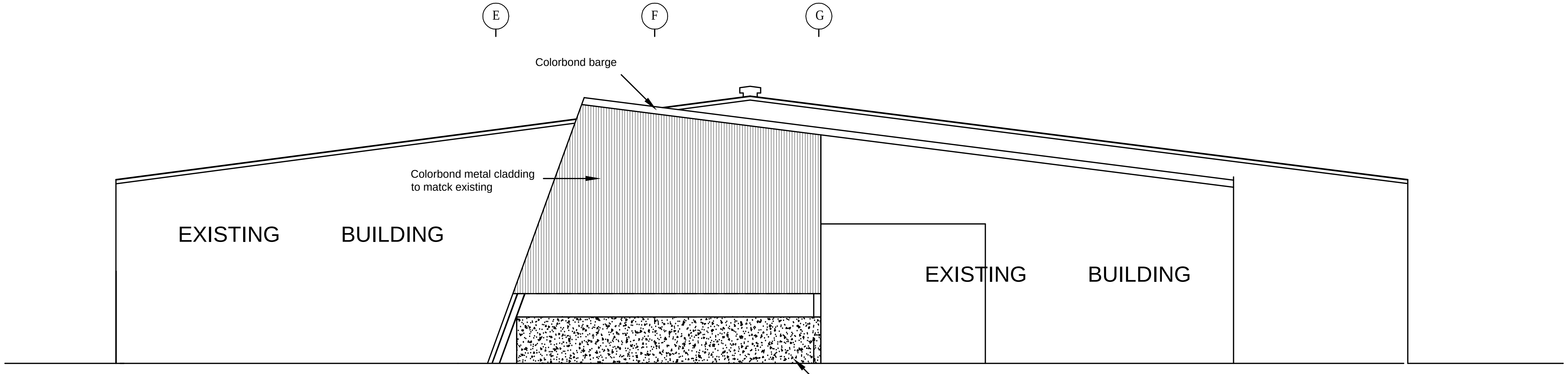
PROPOSED RESIDENCE FOR:
CLIENT: BORAL BRICKS

ADDRESS:
GREENDALE ROAD
BRINGELLY

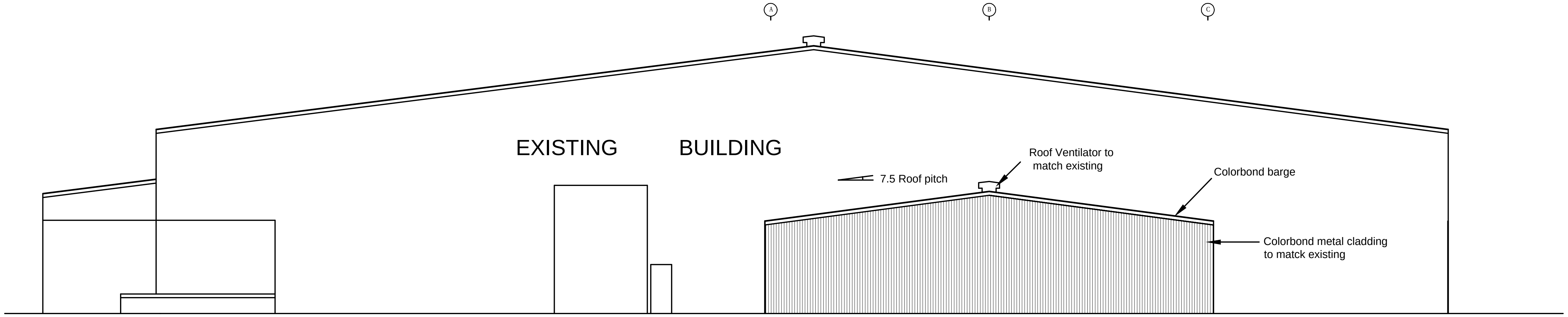
BUILDER
DESIGN NO:
FACADE:

JOB NO:	DATE: 23.01.13
DRAWN: DJL	CHECKED:
SCALE: 1 : 400	SHEET NO: 1 / 4

DO NOT SCALE THE DRAWING



SOUTH ELEVATION
SCALE 1 : 200



NORTH ELEVATION
SCALE 1 : 200

ELEVATIONS

DRAFT PLAN NOT FOR CONSTURCTION

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B	PROVIDE HEIGHTS	22.03.13
C	UPDATED PLANS	20.06.13

DJL ARCHITECTURAL DESIGN PTY LTD
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Kenthurst 2156
0417224342 96548660
djldmh@bigpond.com.au

PROPOSED RESIDENCE FOR:
CLIENT: BORAL BRICKS

ADDRESS:
GREENDALE ROAD
BRINGELLY

BUILDER
DESIGN NO:
FACADE:

JOB NO:	DATE: 23.01.13
DRAWN: DJL	CHECKED:
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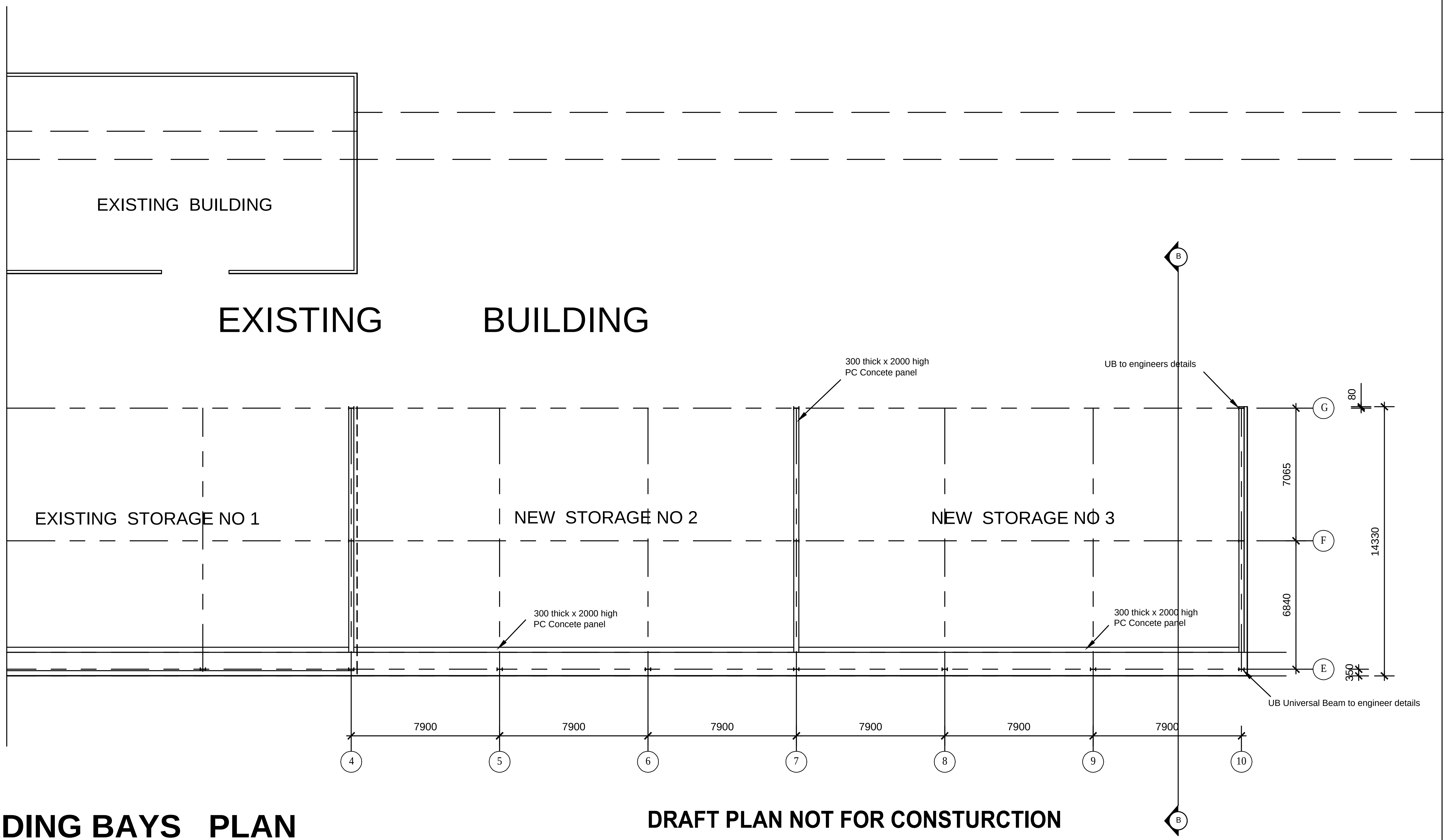

LOADING BAYS PLAN

DRAFT PLAN NOT FOR CONSTURCTION

ISSUE	AMENDMENTS	DATE
A	PRELIMINARY FIRST DRAFT	23.01.13
B	UPDATED PLANS	20.06.13

DJL ARCHITECTURAL DESIGN PTY LTD
155 Pitt Town Road
Kenthurst 2156
0417224342 96548660
djldmh@bigpond.com.au

PROPOSED RESIDENCE FOR:
CLIENT: BORAL BRICKS

ADDRESS:
GREENDALE ROAD
BRINGELLY

BUILDER
DESIGN NO:
FACADE:

JOB NO:	DATE: 23.01.13
DRAWN: DJL	CHECKED:
SCALE: 1 : 200	SHEET NO: 3 / 4

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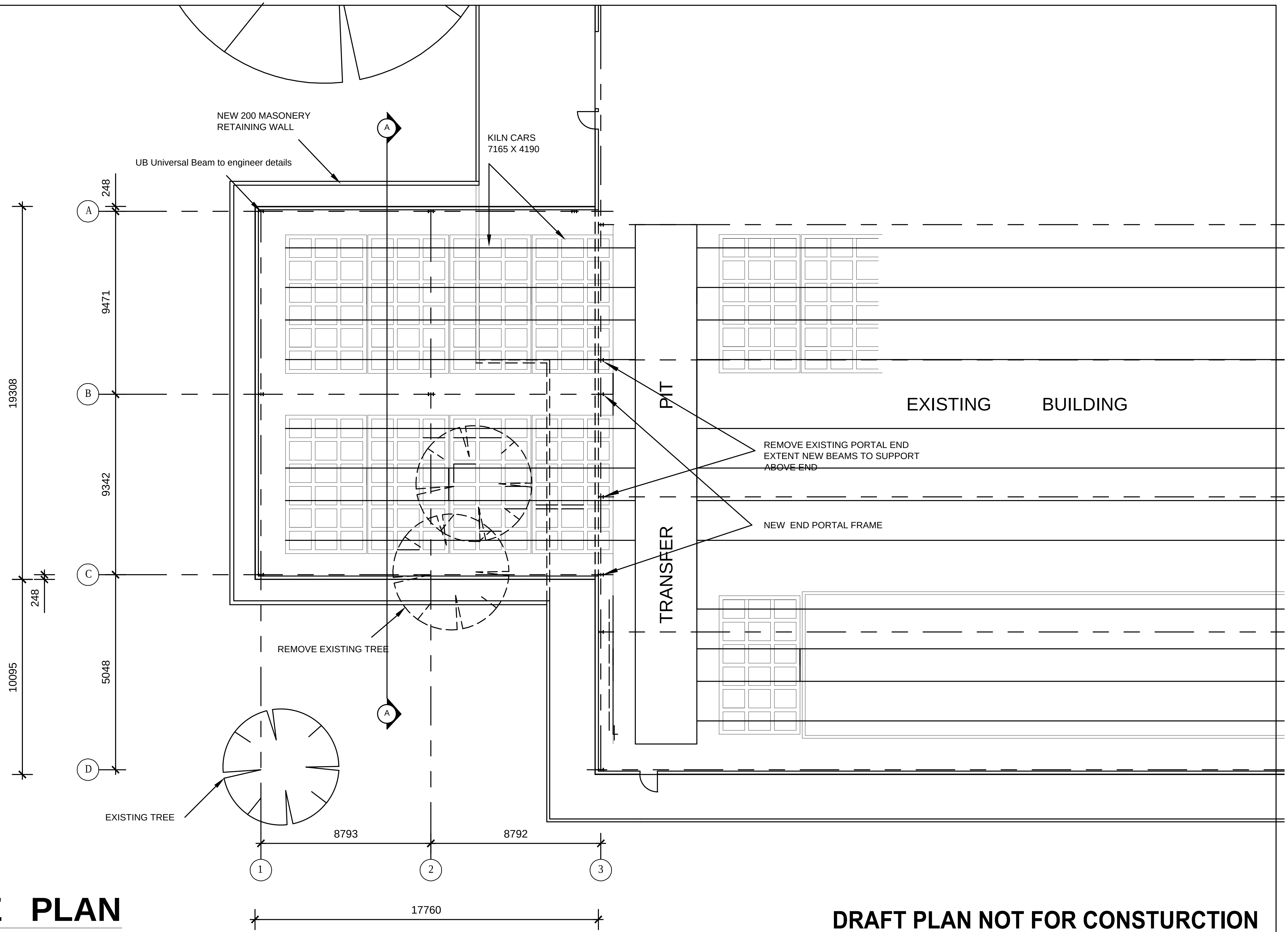

BRICK STORAGE PLAN

DRAFT PLAN NOT FOR CONSTURCTION

ISSUE	AMENDMENTS	DATE
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B	DELETE 1 TRACK OF KILN CARS	29.01.13
C	UPDATED PLANS	20.06.13

DJL ARCHITECTURAL DESIGN PTY LTD

155 Pitt Town Road
Kenthurst 2156
0417224342 96548660
djldmh@bigpond.com.au

PROPOSED RESIDENCE FOR:
CLIENT: BORAL BRICKS

ADDRESS:
GREENDALE ROAD
BRINGELLY

BUILDER
DESIGN NO:
FACADE:

JOB NO:	DATE: 23.01.13
DRAWN: DJL	CHECKED:
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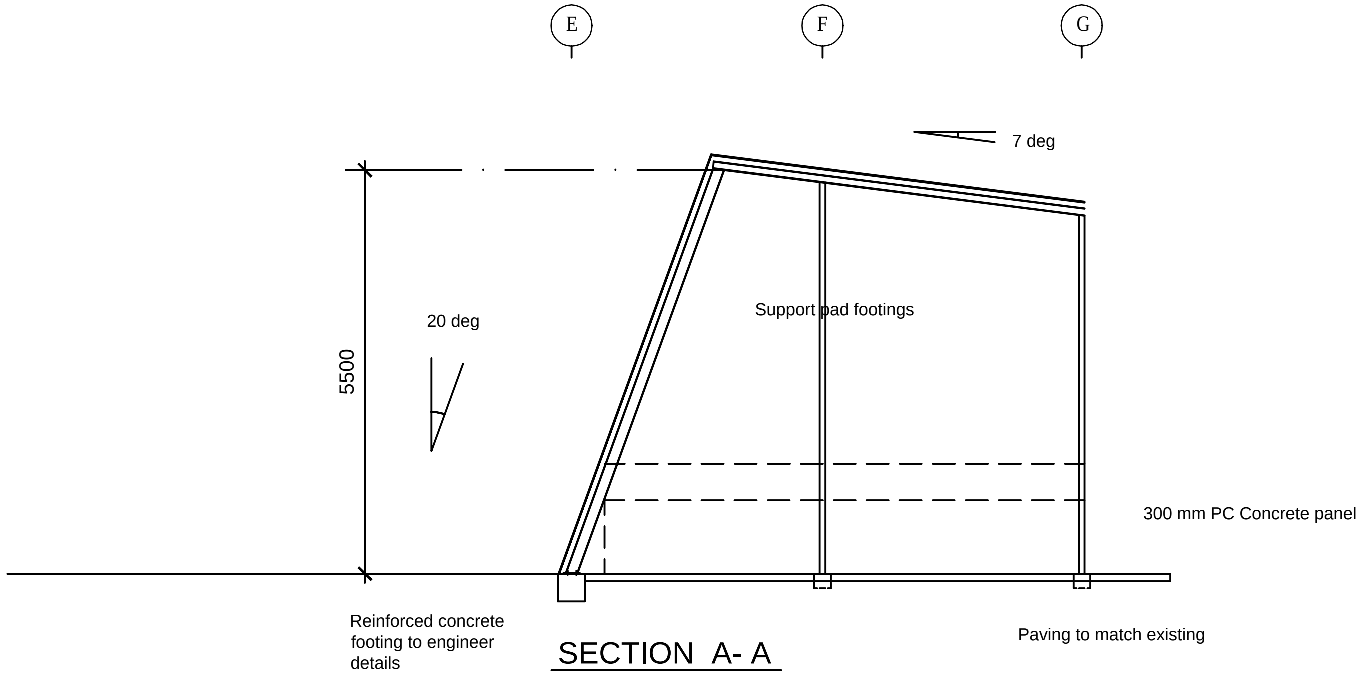
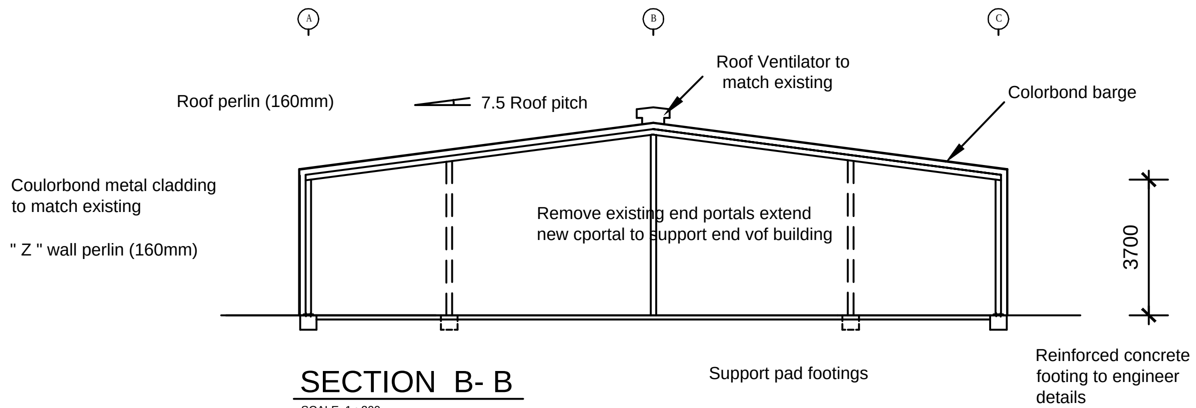


SECTION A- A
SCALE 1 : 200



SECTION B- B
SCALE 1 : 200

SECTIONS

DRAFT PLAN NOT FOR CONSTURCTION

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DJL ARCHITECTURAL DESIGN PTY LTD
155 Pitt Town Road
Kenthurst 2156
0417224342 96548660
djldmh@bigpond.com.au

PROPOSED RESIDENCE FOR:
CLIENT: BORAL BRICKS

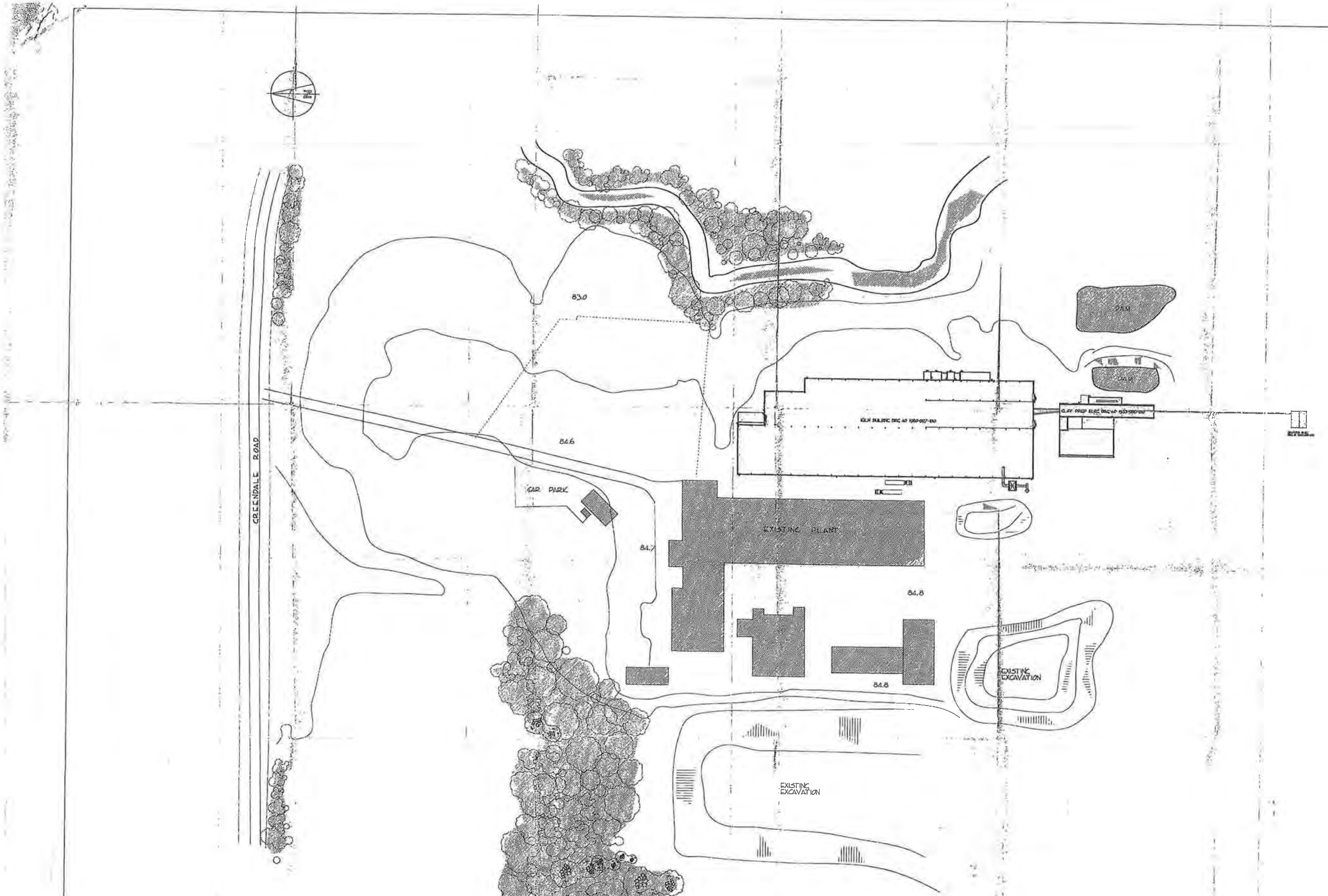
ADDRESS:
GREENDALE ROAD
BRINGELLY

BUILDER	
DESIGN NO:	
FACADE:	
JOB NO:	DATE: 23.01.13
DRAWN: DJL	CHECKED:
SCALE: 1 : 200	SHEET NO: 3 / 4

DO NOT SCALE THE DRAWING

APPENDIX B.2

PLANS SHOWING APPROVED DEVELOPMENT CURRENTLY ON THE SITE



APPROVED PLANS

Development consent no. 3069

Dated 13 / 9 / 91

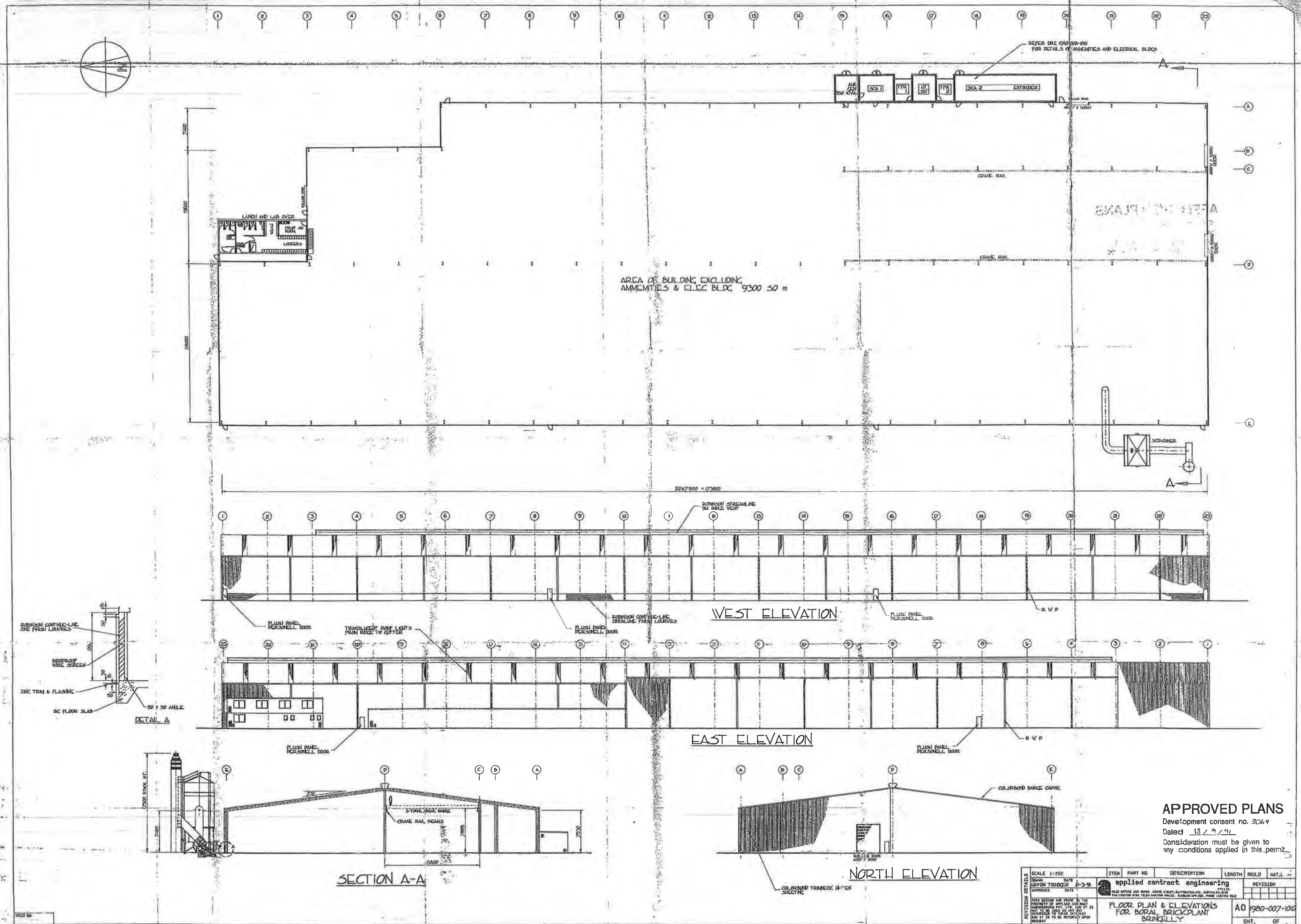
Consideration must be given to any conditions applied in this permit.

SITE PLAN
(EXISTING).

SCALE 1:750	ITEM	PART NO	DESCRIPTION	LENGTH	REQ,D	MAT.L
DRAWN DATE WAYNE TRUDGEN 8-7-91	applied contract engineering PTY.LTD.				REVISION	
APPROVED DATE					A B	
THIS DESIGN AND PRINT IS THE PROPERTY OF APPLIED CONTRACT ENGINEERING PTY. LTD. AND IT IS NOT TO BE USED IN ANY WAY INJURIOUS TO THEIR INTEREST AND IT IS TO BE RETURNED UPON REQUEST	SITE PLAN FOR BORAL BRICK BRINGELLY				A0	T1910-3M
					SHT.	OF

REVISION DETAILS

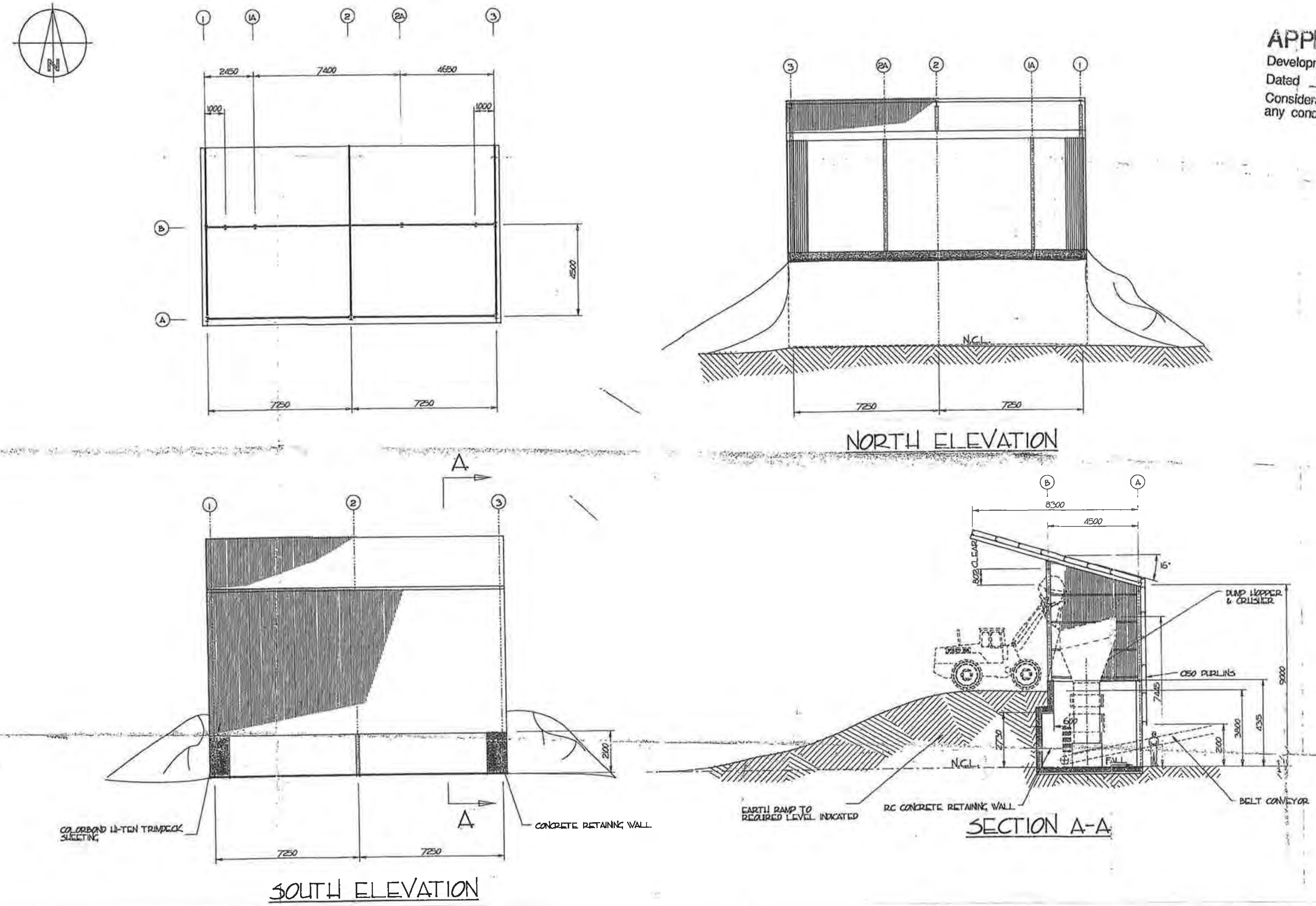
USED ON



APPROVED PLANS
Development consent no. 3069
Dated 13 / 9 / 91
Consideration must be given to any conditions applied in this permit

SCALE 1:200	ITEM	PART NO	DESCRIPTION	LENGTH	REQ.D	MAT.L
DRAWN LAYTON TRIDGELL DATE 21-3-91	applied contract engineering PTY.LTD.			REVISION		
APPROVED DATE						
THIS DESIGN AND PRINT IS THE PROPERTY OF APPLIED CONTRACT ENGINEERING PTY. LTD. AND IT IS NOT TO BE USED IN ANY WAY INJURIOUS TO THEIR INTEREST AND IT IS TO BE RETURNED UPON REQUEST	FLOOR PLAN & ELEVATIONS FOR BORAL BRICKPLANT BRINGELLY			A0	1980-007-1010	SHT. OF

REVISION DETAILS

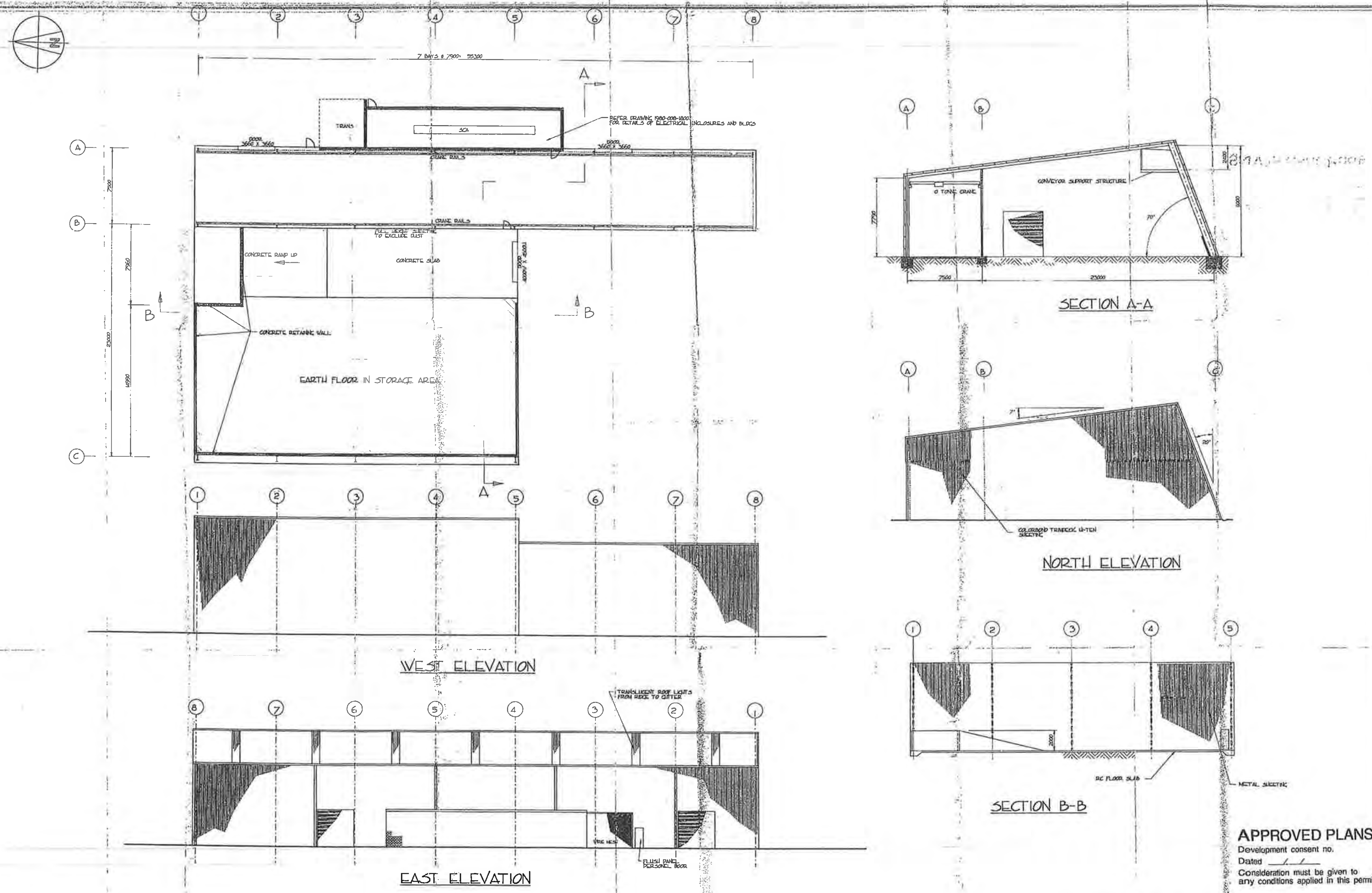


APPROVED PLANS
Development consent no. 3069
Dated 13 / 9 / 91
Consideration must be given to any conditions applied in this permit.

FLOOR PLANS & ELEVATIONS
CRUSHER BUILDING
(1980-005-1010)

REVISION DETAILS	SCALE 1:100	ITEM	PART NO	DESCRIPTION	LENGTH	REQ.D	MAT.L
REV A HEIGHT AND LENGTH INCREASED 6-5-91	DRAWN Haydn Trudgen DATE	applied contract engineering PTY.LTD.				REVISION	
	APPROVED DATE	HEAD OFFICE AND WORKS ,HOSIE STREET,BAYSWATER,VIC.,AUSTRALIA,3153 FAX:(03)729 8734 TELEX:AA31768 APPLIE. CABLES:APPLIED. PHONE (03)729 8555				A	
	THIS DESIGN AND PRINT IS THE PROPERTY OF APPLIED CONTRACT ENGINEERING PTY. LTD. AND IT IS NOT TO BE USED IN ANY WAY INJURIOUS TO THEIR INTEREST AND IT IS TO BE RETURNED UPON REQUEST	FLOOR PLAN AND ELEVATIONS FOR CRUSHER BUILDING BORAL BRINGELLY				A1 1980-005-1010	
						SHT.	OF

USED ON



APPROVED PLANS

Development consent no.

Dated __/__/__

Consideration must be given to any conditions applied in this permit.

SCALE 1:125	ITEM	PART NO	DESCRIPTION	LENGTH	REQ,D	MAT,L
DRAWN LLYON TRUDGEN DATE	applied contract engineering PTY LTD			REVISION		
APPROVED DATE						
THIS DESIGN AND PRINT IS THE PROPERTY OF APPLIED CONTRACT ENGINEERING PTY. LTD. AND IT IS NOT TO BE USED IN ANY WAY INJURIOUS TO THEIR INTEREST AND IT IS TO BE RETURNED UPON REQUEST	FLOOR PLAN & ELEVATIONS FOR CLAY PREPARATION BORAL; BRINGELLY			A0	1980-006-1010	SHT. OF

REVISION DETAILS

APPENDIX C

QUANTITY SURVEYOR REPORT

Trade Breakup By Head1

Job Name :	BRGLLY EXTRACTION3		**Job Description**
Client's Name:	Boral Bricks		Indicative estimate to increase clay extraction & factory building extension

Item No.	Item Description	Quantity	Unit	Rate	Mark Up %	Amount
Trade : 1	***ASSUMPTIONS***					
1	The ongoing clay extraction cost is not included as this is part of the raw material extraction to produce bricks and is not of capital nature.		note			
				Total by heading :		
			ASSUMPTIONS	**Total :**		
Trade : 2	***FACTORY BUILDING EXTENSION***					
1	Take down southern end of the existing external 40.0x12.0m high walls. Temporary supports until extension is built.	1.00	item	16,720.00		16,720.00
2	Take down northern end of the other building existing external 18.0x12.0m high walls. Temporary supports until extension is built.	1.00	item	11,480.00		11,480.00
3	40.0x40.0x12.0m high factory extension (large span, metal frame, metal cladding etc)	1,600.00	m2	1,100.00		1,760,000.00
4	18.0x18.0x4.0m high factory extension (large span, metal frame, metal cladding etc)	324.00	m2	900.00		291,600.00
				Total by heading :		**2,079,800.00**
			FACTORY BUILDING EXTENSION	**Total :**		**2,079,800.00**
Trade : 3	***CIVIL WORKS***					
	Site Preparation for Clay Extraction					
1	Dewatering from existing pond (allow 0.5m deep)	1,045.00	m3	1.00		1,045.00
2	Excavate silt & mud, cart and stockpiled onsite (allow 0.5m deep)	1,045.00	m3	6.50		6,792.50
3	Site clearance (trees, vegetation, debris mulch and stockpile on site) (Ash Turner suggested rate)	36,249.00	m2	2.00		72,498.00
4	Excavate topsoil 150mm for re-use over the earth bund	5,437.35	m3	10.00		54,373.50
5	Excavate overburden for material for use in the earth bund (Ash Turner suggested qty & rate)	24,911.00	m3	6.80		169,394.80
6	Spray grass seeds, plant trees & shrubs (tube stocks 1/m2)	51,771.00	m2	13.50		698,908.50
				Total by heading :		**1,003,012.30**
	Noise Amelioration					
7	Accoustic treatment along Eastern side of building	3,448.00	m2	87.00		299,976.00
8	Earth bund 4.5m high along Greendale Rd near the entry (reusing the topsoil) (AshTurner suggested qty & rate)	10,800.00	m3	6.80		73,440.00
9	Earth bund 4.5m high along northern section of quarry (Ash Turner suggested qty & rate)	19,548.00	m3	6.80		132,926.40

Trade Breakup By Head1

Job Name : BRGLLY EXTRACTION3

Client's Name: Boral Bricks

Job Description

Indicative estimate to increase clay extraction & factory building extension

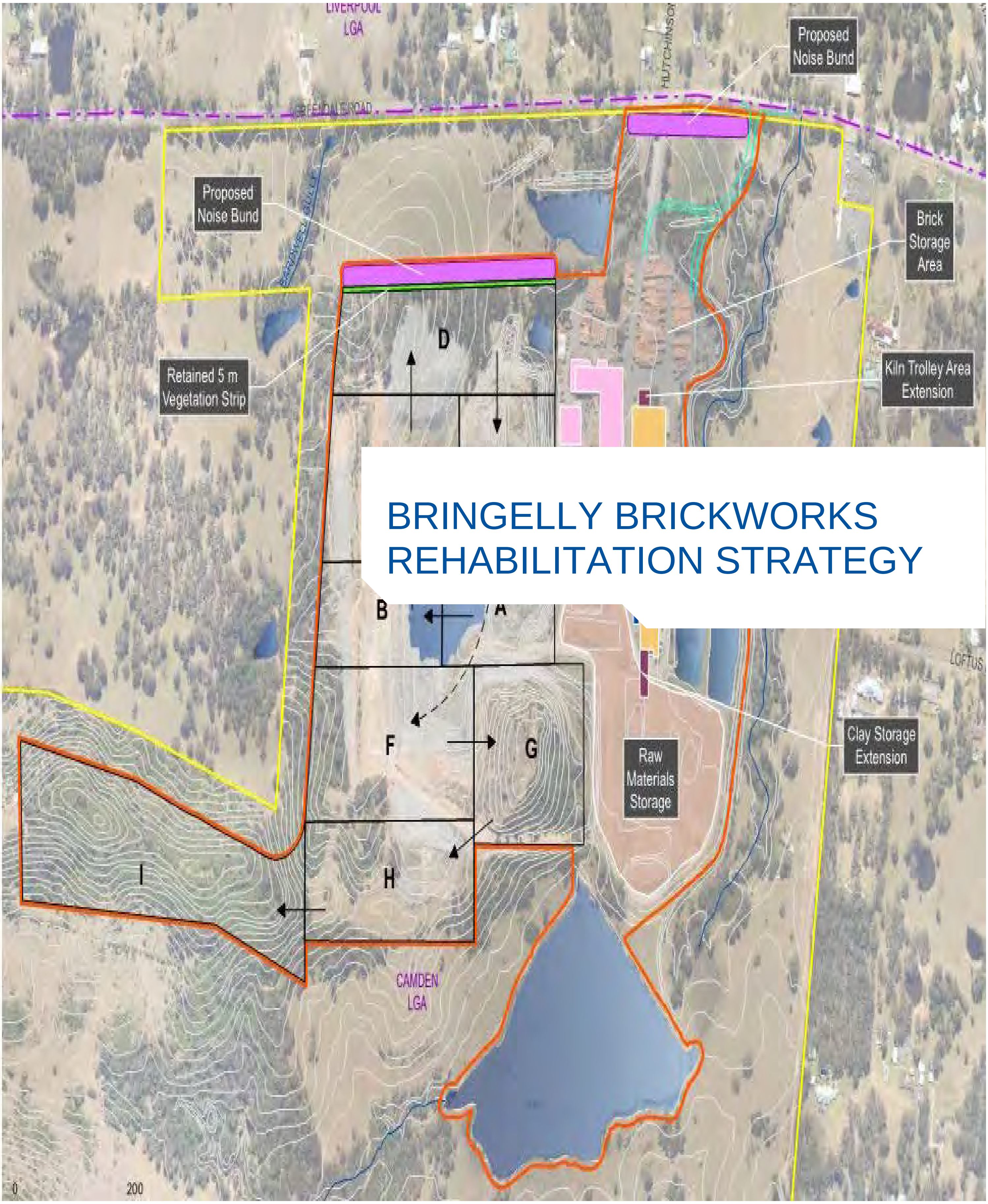
Item No.	Item Description	Quantity	Unit	Rate	Mark Up %	Amount
Trade :	**3** ***CIVIL WORKS***					*(Continued)*
10	Spray grass seeds, plant trees & shrubs (tube stocks 1/m2)	21,905.00	m2	13.50		295,717.50
				Total by heading :		**802,059.90**
	Access Road (380m long, 7.5m wide and 0.8m thick)					
11	Site clearance (trees, vegetation, debris mulch and stockpile on site) (Ash turner suggested rate)	6,653.00	m2	5.00		33,265.00
12	Bulldoze & grade road profile (to follow existing gradient) (Ash turner suggested rate)	2,850.00	m2	10.00		28,500.00
13	100mm Asphalt (Ash turner suggested qty, spec & rate)	2,850.00	m2	45.00		128,250.00
14	700mm Road base (Ash turner suggested qty, spec & rate)	2,850.00	m2	50.00		142,500.00
15	Kerb & gutter	50.00	m	57.00		2,850.00
16	Line markings, signs etc	1.00	item	2,000.00		2,000.00
				Total by heading :		**337,365.00**
	Fencing					
17	1.80m high mesh fencing	41.00	m	60.00		2,460.00
18	6.0m double gate	1.00	no	2,000.00		2,000.00
				Total by heading :		**4,460.00**
				CIVIL WORKS	**Total :**	**2,146,897.20**

Total of all trades: **4,226,697.20**

APPENDIX D

REHABILITATION STRATEGY

BRINGELLY BRICKWORKS REHABILITATION STRATEGY



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BORAL

BORAL BRINGELLY BRICKWORKS REHABILITATION STRATEGY

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Approver	Neville Hattingh	

Report No

Date 29 May 2013

CONTENTS

1 INTRODUCTION

Hyder Consulting has been commissioned by Boral to prepare a State Significant Development Environmental Impact Statement under Division 4.1 of the *Environmental Planning and Assessment Act 1979* for the Bringelly Brickworks site (the Project Site). To support the environmental assessment for proposed expansion of quarry and brickworks activities at the site Hyder have developed this rehabilitation plan to provide the framework for ongoing rehabilitation activities at the Project Site.

1.1 PURPOSE AND OBJECTIVES

The purpose of this rehabilitation strategy is to assist Boral to implement an integrated approach for quarry rehabilitation and to address the following Director General Requirements (DGRs) specific to rehabilitation. These include:

- Document the proposed rehabilitation strategy for the site, having regard to the key principles in the Strategic Framework for Mine Closure, including:
  - Rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria.
  - Nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies.
  - The potential for integrating this strategy with any other rehabilitation and/or offset strategies in the region.

The objectives of this rehabilitation strategy are to:

- Establish potential options for end use of the quarry area in accordance with compatible land use.
- Establish rehabilitation principles and criteria commensurate with future land use in accordance with regulations, policy and best practice guideline documentation.
- Establish rehabilitation processes for stockpiles, voids, water and vegetation management in accordance with proposed final land use.
- Document the alignment of this strategy with other relevant rehabilitation and offset strategies.
- Establish monitoring and maintenance procedures to facilitate assessment of performance against rehabilitation principles and criteria and to support ongoing adaptive management processes.

In summary this rehabilitation strategy provides guidance to support the development of a more detailed rehabilitation plan to inform rehabilitation management actions for the Bringelly Brickworks site.

1.2 SITE OVERVIEW AND PROPOSED ACTIVITIES

Site Overview

The Project Site is currently used for quarrying, brick production and associated activities. The brickworks and quarry is located on an approximately 385.55 hectare property owned by Boral Limited, which is located at 60 Greendale Road, within the Camden Local Government Area (Refer to Figure 1).

The brick making facility along with various administration buildings, a finished bricks storage yard, staff car park and internal road network is generally contained within the northern part of the Project Site (refer to Figure 1), and is set back approximately 200m from Greendale Road.

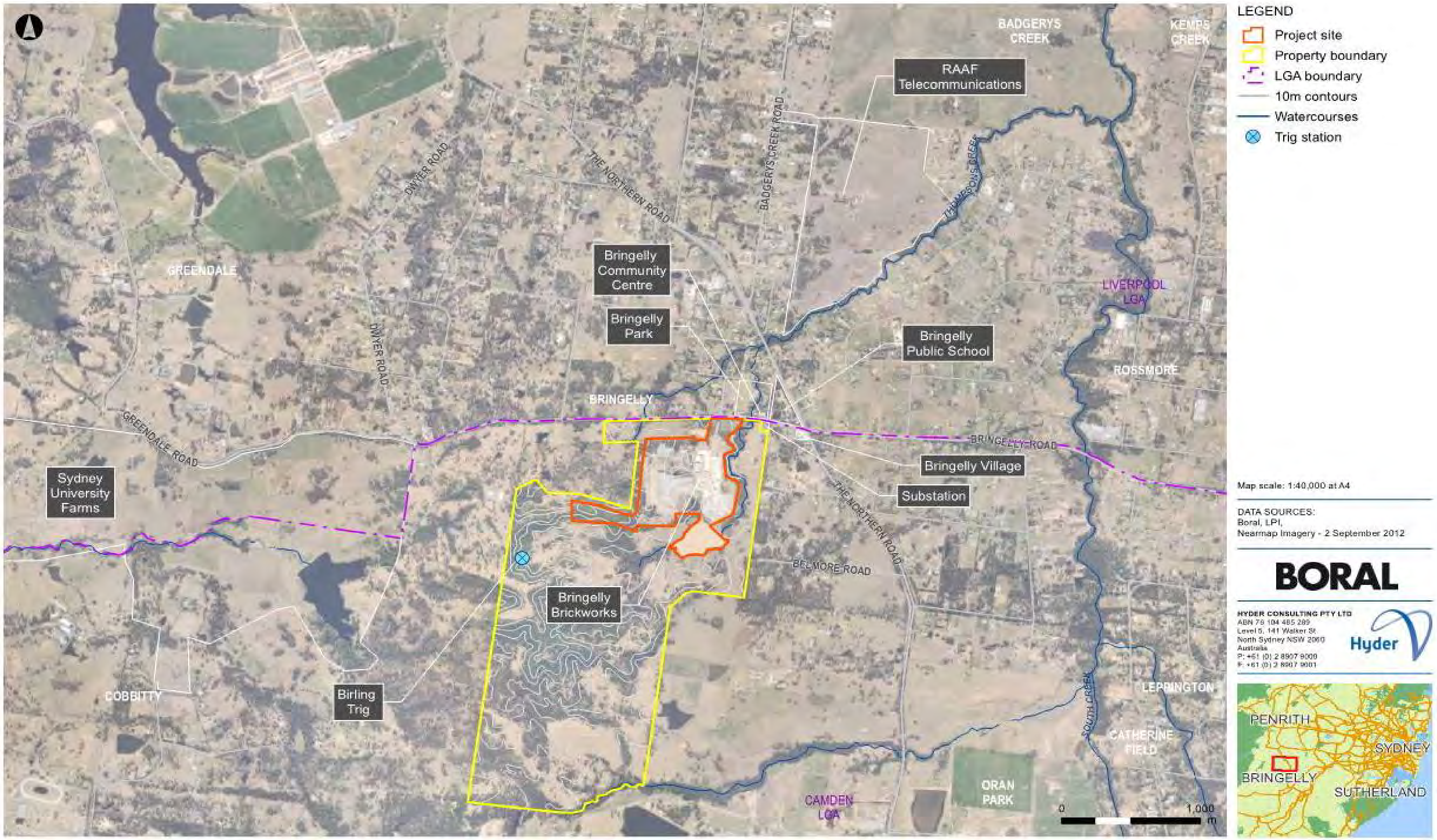

Figure 1: Location of Project Site

Existing quarrying activities have substantially altered the natural landform, with various voids and elevated stockpiles present in the active, north-western part of the Project Site. Other significant landforms on the site include the raw material stockpiles to the south of the brickworks, as well as unusable materials stockpiles along the western boundary of the site.

The underlying topography of the operational footprint on the Project Site is relatively flat, and the land slopes to the south toward Thompsons Creek.

The southern portion of the Project Site, adjacent to Thompsons Creek, is leased for the agistment of stock and grazing.

Thompsons Creek, which has a catchment area of approximately1.6km^2, has its source to the south-west of the Project Site and flows eastwards past the southern boundary of the quarry after which it turns northwards flowing along the eastern boundary of the brick making facility and carpark, passing under Greendale Road before it enters into South Creek approximately 4km further downstream, which in turn is a tributary of Hawkesbury River.

An earth bund has been constructed along the eastern side of the brick making facility which forms a dual purposed of attenuating production noise as well as providing immunity to the brickworks site from flooding of Thompsons Creek.

Proposed Activities

The current consent on the site permits quarry extraction of up to 200,000 tonnes per annum, and brick production of up to 160,000 tonnes per annum. Boral Bricks Pty Ltd is now seeking to increase brick production at their Bringelly brickworks.

Approval is therefore sought for the continuation of operations on the site involving the continued extraction of raw materials, but over a larger extraction area (quarry footprint), and continued brick making activities, but at a higher production rate. The proposed Project can be summarised as follows:

- Extraction of raw material from the site in the order of 200,000 tpa (no change to current extraction consent) as follows:
  - Continuation of extraction from the existing quarry area (current consent), to a maximum depth of 30 m.
  - Expansion of the quarrying operations over an additional 20.75 hectares (to a total of 30.65 hectares) with extraction to a maximum depth of 30m.
- Brick production in the order of 263, 500 tonnes of bricks per year (increase of 103,500 from current consent).
- Importation of raw materials required for brick making in the order of 96000tpa.
- Extension to the following existing buildings:
  - Clay preparation building.
  - Small area of the brick manufacturing plant near the exit to the kiln.
- Addition of two recycled water storage tanks.
- Upgrading of the existing bio-cycle sewage treatment plant.
- Construction of a new driveway to the east of the existing alignment.
- Construction of a 4.5 metre high noise bund along the northern boundary of the quarry operations (362 metres long x 3 metres flat top with a 21 metre wide base and 1:2 batter slopes).

- Construction of a 4.5m high noise bund along the northern Boral property boundary, from the position of the existing driveway to the proposed new driveway location (200m long x 3m flat top with a 21m wide base and 1:2 batter slopes).

The proposed quarrying area will expand northwards, southwards and south-westwards, covering a total surface area of 30.65 hectares to a maximum extraction depth of 30 metres. To facilitate the description of the quarrying activities, the proposed quarry area has been divided into nine cells, namely Cells A ï I (Refer to Figure 2 for proposed quarry layout).

BRINGELLY BRICKWORKS EIS

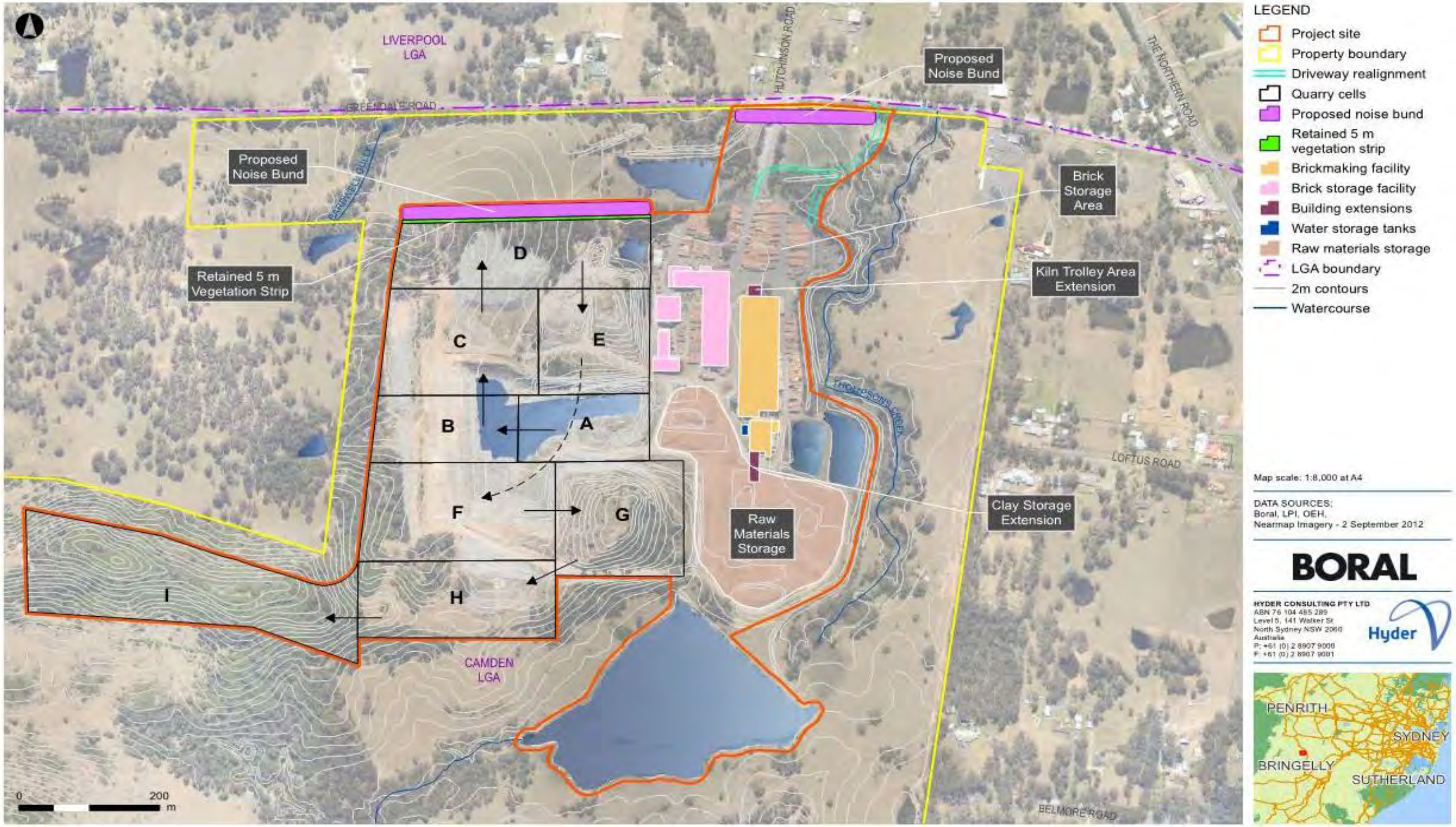

Figure 2: Proposed quarry layout

Quarrying extraction activities are expected to progress on the site according to the following plan:

- Continued extraction of Cells A, B & C (existing pits).
- Extraction of proposed Cells D, E, F, G, H & I.

Approval is being sought for continued extraction on the site, at a rate of 200,000 tpa, over the next 30 years. Quarrying activities would continue to be undertaken on a campaign basis. A campaign is a discrete quarrying event whereby material is extracted from the pits using bulk earthwork machinery, primarily excavators and is transported to stockpile areas by dump trucks where it is spread and shaped by dozers. The proposed campaigns are likely to be approximately two calendar months in duration (44 working days) and will be undertaken during standard working hours. Although the number of campaigns will be determined by the annual demand for bricks, up to three campaigns are proposed per annum, which would provide sufficient raw material for the manufacturing of 263,500 tonnes of bricks per annum.

In order to explain the staging of quarrying activities over its 30 year life, the total quarry area has been divided into nine cells (quarry areas), which are represented in Figure 3. Given that the extraction of material will be based on consumer demand, it is difficult to predict an exact duration of operations within each of these nine cells. However, the sequence of the material extractions is known, and there will be approximately three cells open at any one time so as to ensure that the different types of material resources can be accessed in different places and at different depths at any time during the operations. The only exception to this approach is Cell I, which covers a large enough area and has sufficient resource to allow for extraction of material at multiple depths at any one time during the life of this cell.

Each cell within the quarry will be progressively extracted on a campaign basis, starting with the active Cells A, B and C and continuing to D, E, F, G, H and finishing at Cell I (refer to Figure 5). For example, as Cell A ñbottoms outò(is exhausted/reaches 30m in depth), extraction will cease in Cell A and will commence in Cell D and therefore Cells B, C and D will be operational. As Cell B is exhausted, extraction will cease in Cell B and will commence in Cell E and therefore Cells C, D and E will be operational and so on.

Table 1 broadly summarises the three stages over the 30 year quarry life.

Table 1: Bringelly Brickworks proposed staging

Stage	Cells	Resource quantity
1	A, B, C	2,198,763 tonnes
2	D, E, F	2,273,969 tonnes
3	G, H, I	3,963,313 tonnes
	TOTAL	7,989,025 tonnes

The final quarry wall at the completion of each stage will have a benched form with a total of six benches, with each bench being 3m high and 1m wide. These benches will be rehabilitated and revegetated (refer to Section 6).

1.3 STRATEGY STRUCTURE

This rehabilitation strategy has been structured in accordance with the DGRs and includes the following sections:

- **Section 2**: Outlines the regulatory and policy framework as well as best practice guidelines that have informed the development of this rehabilitation strategy.
- **Section 3**: Describes the rehabilitation principles, objectives and performance criteria for the Project Site.
- **Section 4**: Describes the landform design and rehabilitation processes in accordance with principles and performance criteria.
- **Section 5**: Presents key rehabilitation processes and management activities that will provide the framework for more detailed rehabilitation planning.
- **Section 6**: Discusses the potential alignment of this rehabilitation strategy with other relevant strategies in the region.
- **Section 7**: Outlines monitoring and maintenance procedures to facilitate assessment of performance against rehabilitation principles and criteria and to support ongoing adaptive management processes.

2 REGULATORY AND POLICY FRAMEWORK AND BEST PRACTICE GUIDELINES

2.1 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

The project was declared a óstate significant developmentô under the provisions of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

This SSD is an application under Division 4.1 of the *Environmental Planning and Assessment Act 1979 (*E&A Act). Division 4.1 provides for development to be declared State Significant Development (SSD) either by a State Environmental Planning Policy (SEPP) or by order of the Minister. The Minister is generally the consent authority for SSD.

Under clause 8 of State and Regional Development SEPP, development is declared to be State Significant Development for the purposes of the EP&A Act if, among other provisions, the development is specified in Schedule 1 or 2 of the State environmental planning policy (State and Regional Development) 2011 (State and Regional Development SEPP).

On declaration of the project as SSD, DGRs were provided which included specific requirements for the development of rehabilitation strategy as part of the overall environmental impact assessment for the Proposal.

2.2 MINING ACT 1992

Following receipt of Project Approval, an application for a mining lease will be made in accordance with the *Mining Act 1992*. Clause 75V of the EP&A Act indicates that subject to the issue of Project Approval, a mining lease for the Project cannot be refused and must be substantially consistent with the terms of the Project Approval. Rehabilitation and environmental performance conditions are also attached to all authorities (exploration and mining) issued under the Mining Act 1992.

2.3 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The *Protection of the Environment Operations Act 1997 (*POEO Act) governs the pollution of waters, land and air in NSW in addition to environmental protection and waste management.

Environment protection licence (EPL) No. 1808 as issued under the POEO Act is currently held for the site. This EPL is currently being reviewed in accordance with the Project Approval and a variation to the current EPL may be made to reflect the future operations at the site.

2.4 STATE ENVIRONMENTAL PLANNING POLICY (SEPP) (MINING, PETROLEUM PRODUCTION AND EXTRACTIVE INDUSTRIES) 2007

Under the SEPP, development for the purposes of mining, on land that is the subject of a mining lease under the *Mining Act 1992*, is only permissible with development consent. The SEPP defines mining as including:

(a) the construction, operation and decommissioning of associated works, and

(b) the stockpiling, processing, treatment and transportation of materials extracted, and

(c) the rehabilitation of land affected by mining.

The application for a mining lease is currently being undertaken by Boral.

2.5 STATE ENVIRONMENTAL PLANNING POLICY (GROWTH CENTRES) 2006

The rehabilitation plans developed for the Project Site will align with the land use and development controls and objectives identified in the Growth Centres SEPP as they become defined for the surrounding area.

These considerations would include assessing implications of development controls and objectives for:

- Environment conservation and recreation zones.
- Flood prone and major creeks land.
- Vegetation.
- Cultural heritage landscape areas.

The rehabilitation plans would consider the implications for effecting rehabilitation on land within the zone defined for the site as well as any implication for other zones in immediate proximity to the Project Site.

2.6 ANZMEC STRATEGIC FRAMEWORK

The rehabilitation process requires the establishment of a performance framework in order to measure the success of the rehabilitation process and to facilitate a consistent approach. The ANZMEC (Australian and New Zealand Minerals and Energy Council) Strategic Framework (ANZMECC, 2000) provides a framework for rehabilitation and performance assessment for mining operations.

The performance framework should cover the following:

- Rehabilitation principles and objectives, including final land use.
- Decommissioning requirements.
- Community objectives and criteria.
- Consent criteria.
- Standards and issues related to whole-of-life considerations.
- Financial costing and provisioning.
- Legal requirements.
- Environmental and social management requirements.
- Safety considerations.

As the final end use is yet to be determined (see Section 4), this rehabilitation strategy will focus on documenting a strategic approach that meets the requirements of the DGRs documented in Section 1.1.

It is recommended that this strategy is reviewed every five years, accounting for the ANZMEC strategic framework and is regularly updated as more information becomes available.

3 REHABILITATION PRINCIPLES, OBJECTIVES AND CRITERIA

This section documents the rehabilitation principles, objectives and criteria that will guide and support rehabilitation activities at the Project Site.

3.1 REHABILITATION PRINCIPLES

This strategy has been developed in accordance with three key principles:

1. Least possible disturbance.
2. Erosion control and sediment management.
3. Progressive rehabilitation.

3.1.1 LEAST POSSIBLE DISTURBANCE

Quarrying activities will be staged to minimise the operational area exposed at any one time i.e. material will be extracted from each stage to a depth of 30m before moving to the next stage, rather than mining the entire proposed quarry area at the same time. This will assist in reducing the extent of potential for erosion as well as the extent of erosion and sediment control measures required.

Boral will restrict stockpiling of extracted raw material to the designated raw material stockpile area to the south of the brick making facility. As certain stages are completed (extracted to a depth of 30m), unusable material will be placed back in the quarry pits. Boral will clearly delineate the perimeter of each quarry stage and will ensure that all contractors responsible for undertaking quarrying campaigns are fully informed through inductions and ongoing training on the requirement to maintain extraction and associated stockpiling activities to within the delineated quarry stage and raw material stockpile areas.

3.1.2 EROSION CONTROL AND SEDIMENT MANAGEMENT

A strong emphasis will be placed on stormwater pollution prevention through landform stabilisation, stormwater runoff management and erosion control, rather than relying on the treatment of captured stormwater runoff only.

Establishing and maintaining groundcover through effective re-vegetation with appropriate, locally occurring species will be a critical focus of erosion and sediment control management. Other erosion and sediment control methods will also be applied such as silt fencing, bunding, diversion structure, catch drains and sedimentation basins. Runoff will be diverted around the quarry site wherever possible by the installation of clean water divergence structures. Stormwater runoff within the development footprint (quarry and brick making facility) will be managed by a robust stormwater management system that will be designed to reduce sediment loads and ensure release water to the downstream system that meets the EPL requirements.

3.1.3 PROGRESSIVE REHABILITATION

Progressive rehabilitation of the quarry will be undertaken by Boral. This has been found to reduce long-term rehabilitation liability and is usually more cost-effective than large scale rehabilitation following quarry closure.

Progressive rehabilitation of final benches in each quarry pit will be undertaken, where practical (refer to Section 5).

Key benefits associated with progressive rehabilitation include:

- Minimising areas of potential soil erosion, dust nuisance, water contamination and aesthetic impacts including off-site environmental effects.
- Reducing unnecessary handling of materials.
- Progressive re-use of topsoil to support rehabilitation activities.
- Practical trials of rehabilitation techniques that may require modification prior to widespread site application.

Central to this rehabilitation strategy is allowing for flexibility in end of life use of the quarry void. The key interim rehabilitation outcomes are to provide a safe and stable landform that will meet the end of mine life rehabilitation objectives and final closure criteria.

3.2 REHABILITATION OBJECTIVES

The objectives of this Rehabilitation Strategy are to:

- Provide a framework for site rehabilitation throughout the life of the project.
- Undertake rehabilitation activities to maintain safety and reduce hazards to persons or fauna.
- Ensure rehabilitation activities achieve a stable landform that is compatible with the surrounding land fabric. Land capability will be compatible with an agreed final land use and be consistent with land use planning requirements.
- Surface and groundwater leaving the site should not result in unacceptable water pollution off site.
- Ensure that this strategy is consistent with other rehabilitation and offset strategies in the region.

3.3 REHABILITATION CRITERIA

Rehabilitation targets and proposed completion criteria to meet the objectives identified in Section 3.2 are presented in Table 2. Performance indicators and criteria have been established with regard to the ANZMEC Strategic Framework (2000).

Table 2: Targets and completion criteria for the Project Site

Rehabilitation Aspect	Target	Performance Indicator	Completion Criteria
Safety	Significant hazards removed, controlled or contained.	Number of site hazards. Number of reported incidents on site.	No hazards or reported incidents on site for 12 months.
Landform stability	No significant erosion or loss of sediment from the site. No collapsing of quarry benches. No overland flows from off site into quarry.	Minimal visible rilling, slumping and other evidence of erosion. Minimal sediment deposition in drains and water retention basins. Stability of final quarry benches. No sign of slumping or collapse. Clean water divergence systems in place and not breached.	Stable landform, including quarry benches, erosion controls and drainage lines for 24 months. Compliance with EPL .
Water Quality	No polluted water leaving the site.	No polluted water leaving the site Any water leaving the site should as a minimum, meet the EPL criteria or negotiated criteria in collaboration with regulators.	Water quality consistently meets background or EPL criteria for 24 months for discharges to Thompsons Creek.
Land function	Land function commensurate with the surrounding land fabric or at least doesnô compromise the value of surroundings. Environmental assets on site are in good health.	Land capability aligned to proposed/potential future uses and/or does not prohibit future uses. Retained native vegetation on site is in Maintenance of environmental assets currently on or within proximity to the site.	Land left in a state that does not prohibit any of the identified potential end uses of the site.
Comparable to surrounding land fabric	Comparable to the future use of the surrounds.	Visual continuity of landscape. Consistent vegetation cover.	Visual continuity of landscape and connectivity with surrounding areas.

4 LAND USE AND LANDFORM DESIGN

4.1 FINAL LAND USE PLANNING

The site is located within the South-West Growth Centre and forms part of the Lowes Creek and Bringelly precincts. These precincts are designated for future residential uses under the Draft Sydney Metropolitan Plan Strategy (released for exhibition in March 2013), and the site occupied by the brickworks and extraction area is also earmarked for employment lands. It is anticipated that significant urban growth will occur in this area over the next 30 years.

The development proposal is seeking the expansion and continuation of both brickmaking and quarrying activities at the Project Site for a 30 year period. The proposed end of life land use for the Project Site is yet to be determined and may be influenced by a number of factors including future demand for bricks and surrounding land development progress.

4.2 FUTURE LAND USE OPTIONS

Although planning is currently being undertaken to anticipate the end land use for the Project Site as a component of the development of this rehabilitation strategy, it is impossible to predict accurately the likely future land use at the site, given substantial changes expected to occur in the region over the next 10 to 20 years. Future land use will need to consider the applicable planning policy framework as well as the surrounding land use and environmental and market conditions at the time.

There are a number of potential future land use options that are likely to be compatible with the Project Site when considering the existing environment and surrounding land use. Potential suitable future land uses at the Project Site include:

- Landfill.
- Employment uses ï such as industrial land uses or business parks.
- Residential uses ï as per the Growth Centres SEPP.
- Continued quarrying and brickworks activities.

The above-mentioned possible future land uses will require more detailed investigation closer to the end of life of the quarry.

4.3 FINAL LANDFORM

A conceptual final landform for the Project Site is shown in Figure 3. The conceptual final landform has been designed to allow for maximum flexibility in the future use of the Project Site.

The proposed final landform will consist of:

- One central water management storage area, following the completion of quarrying activities in Cell B.
- One void (quarry pit), comprised of Cells A, C, D, E, F, G, H.
- Brick making facility (roofed) and other associated hardstand areas including carpark, brick storage areas and internal roads.
- Rehabilitated non hardstand areas (areas not under roof or covered with asphalt and or buildings) including the old raw material stockpile area, noise bunds located directly to the east and north of the brick making facility and final stormwater management structures.

The retention of voids on the site will not sterilise or preclude land at the Project Site from being redeveloped for other purposes, in line with land use planning and policy at the time.

The final rehabilitation works would provide for a landform that may accommodate innovative building platforms within the voids for potential employment uses, as described in the Sydney Metropolitan Strategy 2006 or it would provide opportunities for the disposal of soils and rock from other major developments e.g. tunnel boring projects that generate excess spoil material, allowing the site to be returned to a similar landform as the surrounding area.

Future land use and development on the Project Site however, is still best determined closer to quarry closure when market conditions, surrounding land use and development and relevant policy can be assessed and considered to establish the most appropriate future use of the land. As such, final landform on the Project Site is conceptual only, and would be reviewed and further considered in the medium term.

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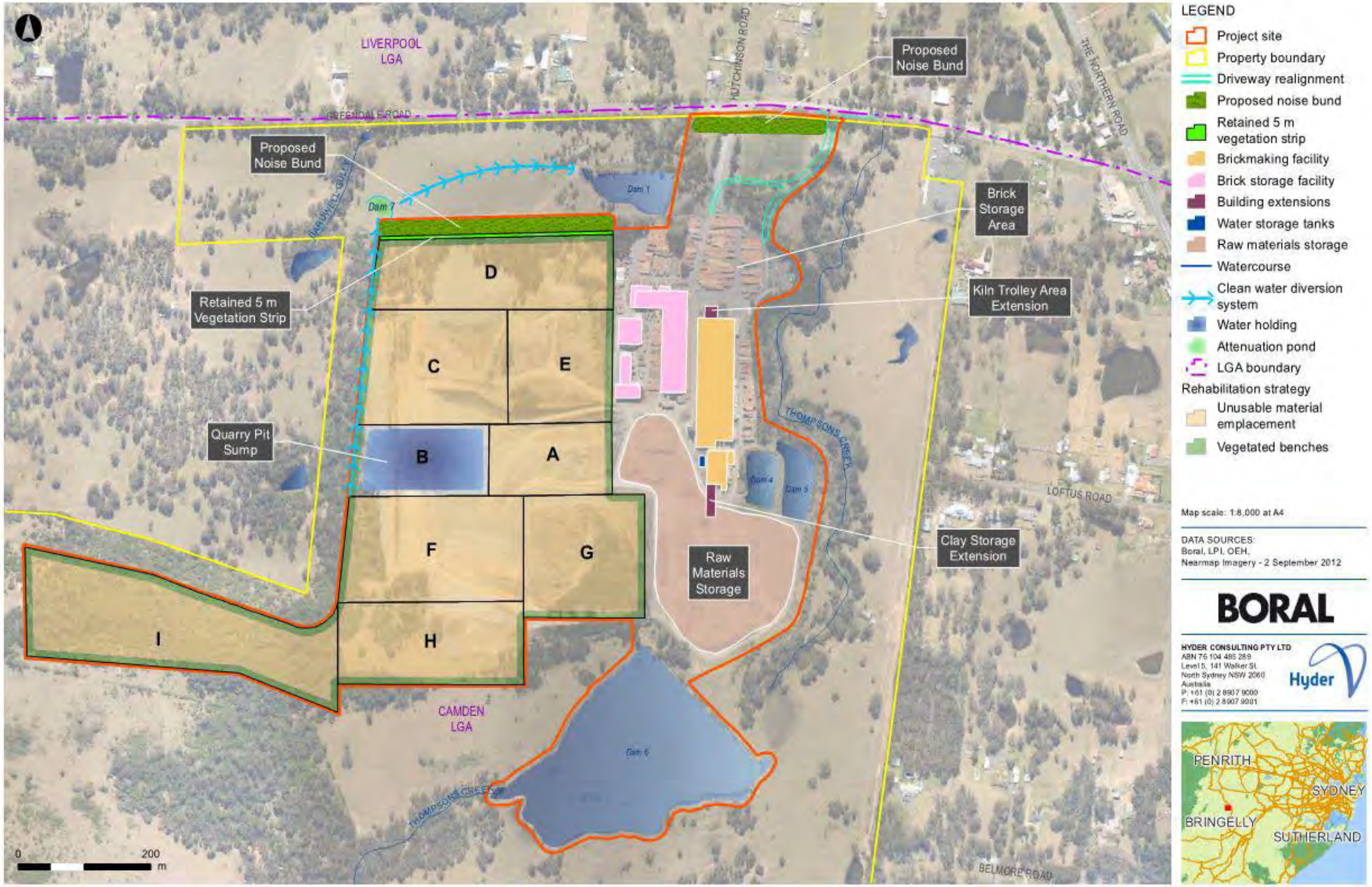

Figure 3: Conceptual final landform for 2043

5 REHABILITATION MANAGEMENT

5.1 QUARRY PIT MANAGEMENT AND REHABILITATION

Extraction of raw material from the quarry will be undertaken in 3 stages across nine cells (A ï I) as discussed in detail in Section 1.2. An open pit of approximately 30.65 ha in extent and approximately 30m deep will remain following cessation of quarry operations.

Overburden, interburden and all unusuable material from each subsequent stage will be placed in the preceeding void, facilitating sustainable re-use of unusable materials, minimising the disturbance footprint as additional undisturbed land is not required for the stockpiling of unusable material, and assisting with rehabilitation consistent with final land use. Cell B will become a central component for on-site water management following completion of quarrying within this cell. All other cells will remain as voids following completion of quarrying activities. The Project Site will remain fully fenced during extraction and following completion of quarrying, to achieve safety objectives documented within this Strategy. In addition to fencing, bunds will be established in appropriate positions to discourage access to the edge of the quarry pit.

A representative cross-section of a rehabilitated quarry pit showing potential rehabilitation techniques is presented in Figure 4. Under this scenario the quarry edge will be benched to create a stable landform. Benches will be topsoiled and revegetated with a mixture of locally occurring native trees and shrubs. A bund will be created on the outer edge of the quarry bench to act as a safety barrier and to ensure that the quarry voids are internally draining. The width and height of the benches will be determined closer to the time of rehabilitation in consultation with an appropriately qualified geotechnical engineer (the dimensions of the benches presented in Figure 4 are not correct for the Bringelly quarry final landform and are provided for representative purposes only).

An alternative rehabilitation scenario that Boral is currently considering will involve establishing a batter slope of approximately 1:2 or steeper, from the base of the final void to the surrounding land surface 30m above. The feasibility for contour ripping at intervals along the batter will be investigated, combined with placement of topsoil within the contour channels and revegetation with appropriate, locally occurring native trees and shrubs, to establish groundcover across the final batter slope. Under this scenario a bund will be established on the outer edge of the void to act as a safety barrier.

Note that the floor of the quarry pit will not be rehabilitated as this area may be periodically inundated, making establishment of vegetation difficult.

A description of proposed rehabilitation management and final landform for each cell is shown in Table 3.

Table 3: Proposed rehabilitation management and final landform

Cell	Rehabilitation/Management	Final Landform
A	Removal of existing unusable material stockpiles along western boundary of Cell B for use in construction of noise bunds along northern boundary of Cell D and along Greendale Road extending westwards of new site entrance. Pit to be used as the temporary quarry stormwater basin until Cell B is exhausted. Final quarry profile established with benched or batter slope with vegetation planting. Temporary stockpiling of unusable material extracted from Cell A (that is not required for the construction of noise bunds), on disturbed areas of Cells D and E. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell A will remain as a final void.
B	When Cell B bottoms out, regrading around pit to direct surface water drainage to Cell B which becomes the permanent quarry stormwater basin. Removal of remaining temporary unusable material stockpile (if any) on disturbed areas in Cells D and E and placement in Cell A. Placement of unusable material from Cell B in Cell A. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell B will be used as the quarry stormwater basin.
C	Placement of unusable material from Cell C in Cell A. When Cell C bottoms out, regrading base of Cell C to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell C will remain as a final void.
D	Noise bund will be built in one ñconstructionòactivity prior to the commencement of mining within Cell D (refer to Cell A above). Strip remaining topsoil and stockpile in appropriate disturbed area outside of active quarry and segregated from usable raw material stockpile area for use in rehabilitation activities, as required across the Project Site. Retain 5m strip of existing native vegetation (trees and understory) along northern boundary of Cell D. Remove any remaining usable raw material from stockpiles on Cell D to raw material stockpiles located south of brickworks prior to commencing excavation. Placement of unusable material from Cell D in Cells A and C. When Cell D bottoms out, regrading base of Cell D to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell D will remain as a final void.
E	Placement of unusable material from Cell E in Cells A, C and D. When Cell E bottoms out, regrading base of Cell E to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell E will remain as a final void

Cell	Rehabilitation/Management	Final Landform
F	Strip remaining topsoil and stockpile in appropriate disturbed area outside of active quarry and segregated from usable raw material stockpile area for use in rehabilitation activities, as required across the Project Site. Placement of unusable material from Cell F in Cells A, C, D and E. When Cell F bottoms out, regrading base of Cell E to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell F will remain as a final void
G	Strip remaining topsoil and stockpile in appropriate disturbed area outside of active quarry and segregated from usable raw material stockpile area for use in rehabilitation activities, as required across the Project Site. Placement of unusable material from Cell G in Cells A, C, D, E and F. When Cell G bottoms out, regrading base of Cell G to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell G will remain as a final void
H	Strip remaining topsoil and stockpile in appropriate disturbed area outside of active quarry and segregated from usable raw material stockpile area for use in rehabilitation activities, as required across the Project Site. Placement of unusable material from Cell H in Cells A, C, D, E, F and G. When Cell H bottoms out, regrading base of Cell H to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell H will remain as final void
I	Strip remaining topsoil and stockpile in appropriate disturbed area outside of active quarry and segregated from usable raw material stockpile area for use in rehabilitation activities, as required across the Project Site. Placement of unusable material from Cell I in Cells A, C, D, E, F, G and H. When Cell I bottoms out, regrading base of Cell I to direct surface water drainage to Cell B. Final quarry profile established with benched or batter slope with vegetation planting. Fencing and/or bunding at top of void, including installation of appropriate warning signs to mitigate potential safety risks to people.	Cell I will remain as a final void

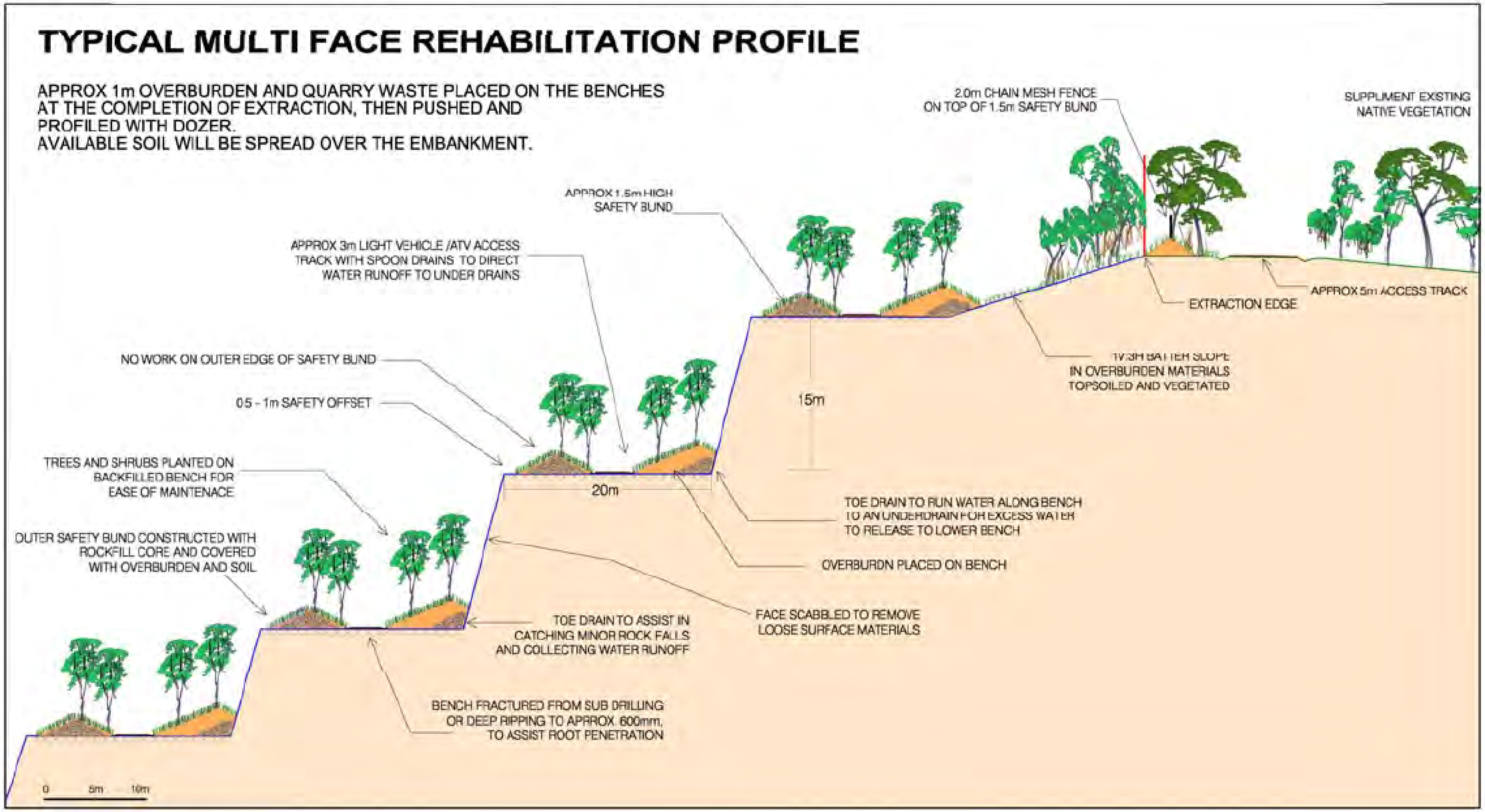

Figure 4: Representative cross-section of rehabilitated quarry benches (Umweldt 2011)

5.2 RAW MATERIAL STOCKPILE

The main raw material stockpile area is located south of the brick manufacturing plant. There is also a smaller temporary raw material stockpile located in Cell D that will be relocated to the main raw material stockpile when mining activities commence in Cell D. These stockpiles will be maintained as active areas throughout the life of the brickworks to provide the raw materials required in the brick manufacturing process.

The raw material stockpile area will be the final, non-built/non-hardstand area to be rehabilitated at the end of the quarry life. It is assumed that this area would be at or near ground level following quarry closure. Rehabilitation will involve ripping the compacted surface, placement and spreading of topsoil and establishing groundcover in the form of grass (to reduce dust generation) and providing flexibility for future land uses.

5.3 STOCKPILE MANAGEMENT

Stockpiles will be managed to allow rehabilitation of a stable landform as well as to ensure minimisation of double handling of materials. The majority of material in the unusable material stockpiles (W1 and W2) on the central western perimeter of the quarry will be used in construction of the two noise bunds located along the northern perimeter of Cell D and along Greendale road to the west of the new site access. Surplus material from all other unusable stockpile locations, including stockpiled material on Cell E will be emplaced in the quarry voids following the completion of quarrying of each cell.

5.4 TOPSOIL MANAGEMENT

Soil surveys will be undertaken prior to commencement of quarrying in new cells to determine the condition of topsoils. The texture, thickness and quality of available topsoil will be described and mapped to support ongoing rehabilitation activities on the Project Site.

Topsoil stockpiles will be kept to a minimum with the preference being the immediate use of stripped topsoil on the final benched or batter slope profiles of the exhausted cells. Where topsoil is required to be stockpiled for an extended duration, it will be stockpile in appropriate disturbed areas outside of the active quarry area and segregated from the usable raw material stockpile areas, for use in rehabilitation activities, as required across the Project Site. The height of the topsoil stockpiles will be limited to 2m and they will be revegetated with temporary ground cover species, mulching, chemical stabilisers or binders if they are to remain in place for more than 30 days. A minimum of 70 per cent cover is required for both mulch and vegetative covers. The duration for stockpiling should be the minimum practical, but ideally less than 12 months.

5.5 REVEGETATION (VEGETATION MANAGEMENT)

5.5.1 REVEGETATION

Rehabilitation plans will need to meet the following requirements for revegetation:

- Areas rehabilitated with native vegetation should be integrated with areas of undisturbed native vegetation, to provide connectivity and wildlife corridors.
- Native vegetation re-established at the site should be suitable for potential subsequent land use and as far as possible be compatible with the surrounding land fabric and land use requirements i.e. locally occurring, native plant species should be used in all revegetation.

- Consideration should be given when re-establishing native vegetation to accommodating threatened flora and fauna where appropriate.

Revegetation activities will generally be undertaken in Spring and Autumn, however, opportunistic revegetation may be undertaken if areas are ready for rehabilitation in Summer or Winter.

5.5.2 WEED CONTROL

Weed control will be in accordance with mitigation strategies documented in the biodiversity technical report. Weed management practices on disturbed sites generally involve the following:

- Management of weeds in and adjacent to cleared areas will occur in accordance with a Weed Management Plan. This plan will include details relating to the monitoring, management and where necessary eradication of weeds, disposal of green waste, and vehicle/plant weed wash down protocols if required.
- Equipment used for treating weed infestation will be cleaned prior to moving to a new area within the project site to minimise the likelihood of transferring any plant material and soil.
- Soil stripped and stockpiled from areas containing known weed infestations are to be stored separately and are not to be moved to areas free of weeds.
- Use of clean, certified fill only for any materials brought onto the site.
- Any vegetation removed from the site will be disposed of at an appropriately licensed waste facility where it cannot be reused locally.

The density of weeds on the site at the point of relinquishment should be no greater than the surrounding area.

5.6 WATER MANAGEMENT, INCLUDING DRAINAGE

The Project Site is located within close proximity to Thompsons Creek, forming part of the South Creek catchment. Any rehabilitation plan and associated activities must consider maintenance of flow regimes within these watercourses and include measures to maintain receiving water quality. Surface water management requires the separation of clean and dirty water on site and the passive treatment of water as it moves through the site prior to discharge.

Interim and final void landforms may be used to retain water on site for amenity, aesthetic purposes and for stormwater management or pollution control.

Rehabilitation plans must also identify measures to separate groundwater and surface water flows through the site and manage any ingress of groundwater into the operating and final landform.

5.7 SCHEDULE OF REHABILITATION ACTIONS

A preliminary rehabilitation schedule is presented in Table 4. The timeframe associated with each of these activities should be revised regularly and aligned to the proposed future use of the Project Site. Actions should be aligned to the rehabilitation objectives documented in Section 3.2 and meet the criteria presented in Section 3.3.

The proposed actions presented below will be revised in developing the rehabilitation plan.

Table 4: Preliminary rehabilitation action schedule

Proposed Actions	Timing
Commission a detailed topographical survey to provide a baseline (or update) for the rehabilitation process.	TBC
Further investigations - Commission a geotechnical investigation to advise on the final quarry profile parameters e.g. batter slope versus benches and associated dimensions/design. - Confirm drainage across and immediately surrounding the site. - Confirm receiving water quality criteria with NSW OEH/EPA. - Determine end of life land use.	
Earthworks - Stabilise voids and site slopes. - Undertake necessary cut/fill works to stabilise site and create the desired end landform. - Install additional water management structures as required.	
Revegetation - Spread clean topsoil and pasture seed on remaining exposed and stabilised areas. - Plantings (as required).	
Weed management.	
Installation of safety fencing and access points (e.g. fencing of final voids).	Ongoing through life of operation.
Preparation of survey plan and application for relinquishment.	TBD
Target date for rehabilitation and relinquishment of licence and lease.	TBC
Monitoring and review of rehabilitation performance and outcomes.	Ongoing through life of operation.

5.8 INTERIM REQUIREMENTS

The rehabilitation of the Project Site will require the confirmation of the desired and agreed end use of the site. The results of a risk analysis in conjunction with the desired end use will inform the specific rehabilitation needs for the site.

One of the key principles of rehabilitation is to enable all stakeholders to have their interests considered during the rehabilitation process. Consultation with stakeholders including OEH, DoPI and Camden Council should be undertaken every two years to inform stakeholders of current site status and progressive rehabilitation performance and to obtain stakeholder input into the rehabilitation of the site. At this time the rehabilitation strategy may be revised to include any alterations in the end use and to incorporate stakeholder input. Further, the security bond held for the site is also to be reviewed at this time and may also be amended to reflect rehabilitation performance.

It is recommended that a rehabilitation report be completed every five years in line with the review of the strategy and security bond to document and present progressive rehabilitation works that have been undertaken for the site. This report should present:

- Works undertaken in the preceding five years to obtain a stable landform in accordance with the POEO Act and Mining Act requirements.
- Present how these works align with the intended end outcome.
- Outline rehabilitation works that are planned for the following five years.

This five-yearly review should focus on progress towards achieving the end outcome of the Project Site. The rehabilitation of the site will consider the environmental assets on and in the vicinity of the Project Site.

6 ALIGNMENT WITH OTHER REHABILITATION,OFFSET STRATEGIES AND MANAGEMENT PLANS

This rehabilitation strategy will work in conjunction with other strategies applicable to the Project Site and across the region to progressively rehabilitate the site to a final end land use and ultimate relinquishment.

This strategy has directly built upon the rehabilitation principles and criteria adopted by Boral for their Badgerys Creek site. Although the attributes of this site have some distinct differences to the Bringelly site the regulatory context and framework for rehabilitation planning are aligned. This strategy is also consistent with the requirements of legislation and best practice guidelines applicable to rehabilitation outlined in Section 3 of this report.

The ecological assessment technical report (Appendix K of the EIS) provides a recommendation for a vegetation offset, located along the western boundary of the Project Site. This rehabilitation strategy recognises this offset area and will ensure that appropriate safeguards are in place to ensure nil disturbances to this area.

Mitigation strategies for stormwater management documented in the Surface Water Hydrology report (Appendix K of the EIS) including stormwater pollution prevention through landform stabilisation, stormwater runoff management and erosion and sediment control will be utilised to achieve the principles and objectives identified in Section 3. At the cessation of quarrying there will be no net discharges from the Project Site.

7 MONITORING AND MAINTENANCE

Monitoring of rehabilitation areas would be required to ensure that the rehabilitation and post-quarry land use objectives are being met, and that adverse changes are not occurring.

To monitor the progress of rehabilitation works towards the rehabilitation objectives of the Project Site, a monitoring program, as presented within Table 5, will be developed as part of rehabilitation management planning for the Project Site.

Table 5 Proposed monitoring program and recommended frequency

Rehabilitation Aspect	Monitoring Activity	Proposed Frequency
Safety	Visual inspection of site for hazards.	6 monthly
Landform Stability	Visual inspection of site for evidence of erosion, sedimentation and slumping and confirmation of performance of water management structures.	6 monthly
Water Quality	Hand held water quality testing by qualified professional in accordance with requirements of EPL and Pollution Reduction Program	Quarterly and immediately after significant events (event based)#
Land Function	Visual inspection of revegetation progress. Photographic record of progress.	6 monthly
Compatibility with surrounding land function	Visual inspection of revegetation progress. Photographic record of progress. Visual inspection of site to confirm if any spraying, seeding of planting program has taken. Photographic record of progress. Comparative assessments with adjoining land.	6 monthly Once ï 6 months after spraying.

8 REFERENCES

AECOM Australia (AECOM), (2010). *Environmental Assessment – Appendix D: Rehabilitation Plan.* AECOM Australia, NSW, May 2010.

ANZMECC and Minerals Council of Australia, (2000). *Strategic Framework for Mine Closure.*

Department of Industry, Tourism and Resources (DITR), (1996). *Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry*. Australian Government, Canberra, October 1996.

Department of Industry, Tourism and Resources (DITR), (2006). *Mine Closure and Completion: Leading Practice Sustainable Development Program for the Mining Industry*. Australian Government, Canberra, 2006.

NSW Department of Trade and Investment (DT&I). (2006). *EDG03 – Guidelines to the Mining, Rehabilitation and Environmental Management Process*. Accessed from: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/427021/EDG03-Mining,-Rehabilitation-and-Environmental-Management-Process-Guide.pdf Accessed on: 12/3/12

APPENDIX E

NOISE ASSESSMENT

ACOUSTICS AND AIR

BORAL BRICKWORKS, BRINGELLY

NOISE ASSESSMENT

REPORT NO. 12185-N
VERSION D

MAY 2013

PREPARED FOR

HYDER CONSULTING
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NORTH SYDNEY NSW 2060

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DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Final	3 May 2013	Brian Clarke	John Wassermann
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B	Final	23 May 2013	Brian Clarke	John Wassermann
C	Final	18 June 2013	Brian Clarke	John Wassermann
D	Final	24 July 2013	John Wassermann	Brian Clarke
D	Final	29 August 2013	John Wassermann	Brian Clarke

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GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

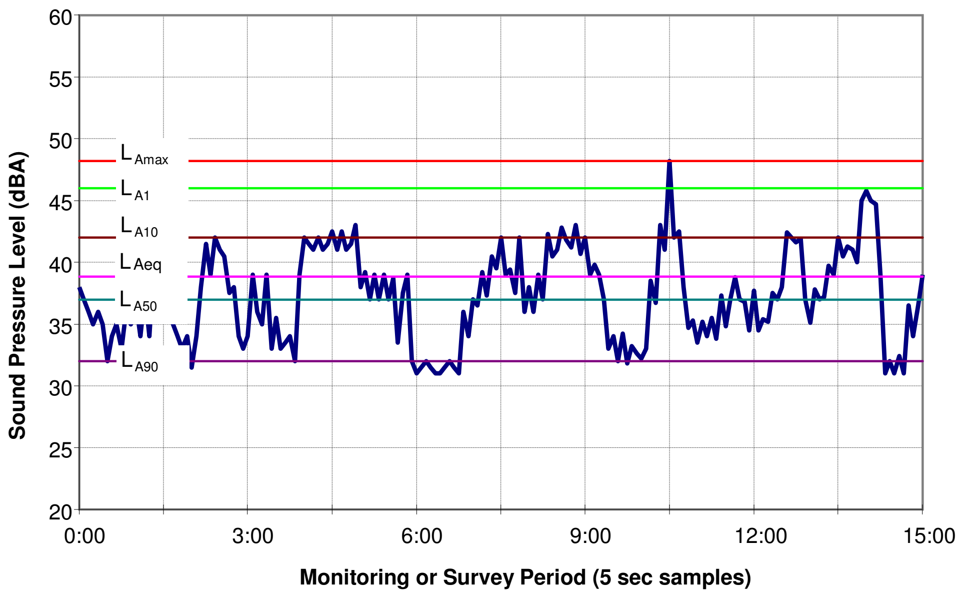
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

Wilkinson Murray Pty Limited has been engaged by Hyder Consulting Pty Ltd to provide a noise impact assessment of the proposed upgrade of production to the Boral Brickworks located at 60 Greendale Road Bringelly. This noise assessment relates to clay/shale extraction and manufacturing processes and includes noise associated with fixed and mobile mechanical plant and vehicle movements within the site.

The brickworks have been operating for over 20 years under existing approvals. As part of the proposed production upgrade, Boral Bricks proposes to update its noise management to be consistent with the NSW *Industrial Noise Policy.*

Construction and operation of the Project would result in an increase in the traffic volumes on public roads in the Project area. It is for this reason that a traffic noise assessment has been undertaken to determine potential noise impacts resulting from increased traffic flows on public roads in the area.

2 DESCRIPTION OF PLANT & ENVIRONS

The Boral Brickworks is located at 60 Greendale Road, Bringelly which is in south western Sydney approximately 55km from the coast.

The present operation, which produces bricks principally for the housing market, comprises of a gas-fired kiln and dryer housed in the largest of the existing buildings (See Figure 2-1) with exhaust stacks. Bricks are dried, fired and then removed by forklift to a holding yard. A clay shale quarry lies to the south and west of the Brickworks and material from this pit is extracted and used in the manufacture of the bricks.

The Bringelly facility is currently approved to produce 160,000 tonnes per annum. It is proposed to increase production to 263,500 tonnes per annum. The remaining activities at the site will generally be in accordance with the existing approval.

The quarrying operation which is currently 200ktpa remains unchanged. Supplementary material and off-site sources of clay, shale and non-clay materials (98,000 tonnes per annum,) are trucked to the site as required.

A comparison of the proposed upgrade with the approved operations is presented in **Table 2-1**.

Table 2-1 Comparison of Existing Facility and Proposed Upgraded Plant Facility

Project Aspect	Approved Development	Proposed Project
Quarrying Operations		
Quarry area	9.9 hectares	30.65 hectares
Quarry Production (i.e. extraction)		
Extraction volume	200,000 tonnes per annum	No change
Extraction rate	Two (2) extractive campaigns with 25 on-site days per year for each campaign	Three (3) extractive campaigns with 44 on-site days per year for each campaign
Extraction method	Dump trucks, dozer and excavator	No change
Material Handling and Stockpiling	Stockpiles contained south east of the brick making plant	No change
Manufacturing Process (i.e. brick making)		
Brick production rate	160,000 tonnes of bricks/annum	263,500 tonnes of bricks/annum
Clay preparation	3 storage bays	5 storage bays. Extension to clay preparation building (approx. 47.5m x 14m x 11.6m high)
Dehacking	Within existing building	14,000 bricks/hr. Extension of building for kiln car storage (approx.. 18m x 19.5m x 4m high)

No change is proposed to the existing and approved operational hours as presented in Table 2-2.

Table 2-3 Existing and proposed hours of operation

Existing Hours of Operation	Proposed Hours of Operation
Quarrying operations (incl. associated vehicle movements)	
6.00 am to 6.00 pm Monday to Friday	No change
6.00 am to 1.00 pm Saturdays	No change
No activity on Sundays or public holidays	No change
Processing / Manufacturing:	
Unlimited (subject to compliance with noise emission levels)	No change
Transport (truck movements and deliveries to and from the site)	
6.00 am to 6.00 pm Monday to Friday	No change
6.00 am to 1.00 pm Saturdays	No change
No trucks shall queue at the entrance to the site prior to 6.00 am	No change

There are currently 38 employees at the Bringelly Brickworks and up to ten contractors work for two to four months per annum on a campaign basis to complete the quarrying activities. The proposed workforce is forecast to increase by 34 staff, to a total of 72 employees. This increase is a result of the continued extraction and brick making at the Bringelly Brickworks and will likely consist of contractors, administrative staff and manufacturing and handling staff.

Two stockpile areas of raw material transported from the quarry are located to the south of the crusher building. Material from these stockpiles are crushed and conveyed to the main production plant.

Figure 2-1 Aerial Photograph of the Existing Site

The local terrain consists of gently undulating low hills with vegetation comprising scattered bushland with trees up to 10m high, interspersed with fields cleared for pasture. The land usage is a mixture of agricultural and residential. The Bringelly Public School and village is located approximately 500m to the northeast of the plant.

The land surrounding the quarry site is rural. There are a number of rural residential properties distributed around the area surrounding the subject site. There are 36 nearby residential receivers which have been identified and these are presented in **Table 2-1**. The closest residential receivers are presented in Figure 2-2.

Detailed Assessment has been conducted at the shaded receivers, being those which are closest to the Boral Site.

Table 2-1 Surrounding Residential Receivers

Receiver Number	Receiver Address
1	55 Loftus Road
2	54 Loftus Road
3	20 Greendale Road
4	9 Greendale Road
5	5 Greendale Road (Bringelly Community Centre)
6	46 Loftus Road
7	36 Loftus Road
8	47 Loftus Road
9	37 Loftus Road
10	27 Loftus Road
11	26 Loftus Road
12	15 Loftus Road
13	5 Loftus Road
14	23 Greendale Road
15	27 Greendale Road
16	29 Greendale Road
17	25 Greendale Road
18	31 Greendale Road
19	35 Greendale Road
20	170 Tyson Road
21	196 Greendale Road
22	46 Belmore Road
23	55 Belmore Road
24	63 Belmore Road
25	67 Belmore Road
26	73 Belmore Road
27	83-85 Belmore Road
28	76 Belmore Road
29	86 Belmore Road
30	87 Belmore Road
31	93 Belmore Road
32	95-97 Belmore Road
33	107 Belmore Road
34	96 Belmore Road
35	108 Belmore Road
36	1037 Northern Road
37	10 Greendale Road
38	Bringelly Public School

Figure 2-2 Site Location and Surrounding Residential and Sensitive Receivers

3 AMBIENT NOISE LEVELS

3.1 Unattended Noise Monitoring

To establish representative background noise levels at surrounding residences unattended noise monitoring was conducted in June and July 2012. The noise measurements were conducted at three locations around the site selected to be representative of identified residences surrounding the site, being.

- Noise Monitoring Location 1 9 Greendale Road;
- Noise Monitoring Location 2 26 Loftus Road; and
- Noise Monitoring Location 3 1037 Northern Road.

Monitoring at locations 1 and 2 was conducted between Friday, 8 June and Friday, 22 June 2012. Monitoring at location 3 was conducted between Saturday, 7 July and Sunday, 15 July 2012.

The noise monitoring equipment consisted of environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing statistical noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1}, L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary of Acoustic Terms for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle or impacts. The L_{A90} level is normally taken as the background noise level during the relevant period.

Detailed results for monitoring location are shown in graphical form in Appendix A. The graphs show measured values of L_{Aeq}, L_{A90}, L_{A10} and L_{A1} for each 15-minute monitoring period. Table 4-1 summarises the result of noise monitoring, for daytime, evening and night time periods as defined in the NSW EPA's *NSW Industrial Noise Policy* (INP). The summary values are:

- $L_{Aeq,Period}$ – the overall L_{Aeq} noise level measured over the assessment period; and
- RBL – Rating Background Level is a measure of typical background noise levels which are used in determining noise criteria.

In addition a shoulder period RBL for the period between 6 and 7 am was calculated to reflect the operational period of the last hour of the night period

Table 3-1 Summary of Measured Noise Levels

Location	RBL (dBA)				$L_{Aeq,Period}$ (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Shoulder Period 6 am - 7 am	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Shoulder Period 6 am - 7 am
1	41	40	37	42	57	49	46	53
2	41	41	38	45	51	50	48	53
3	39	43	38	42	49	48	45	45

It is noted the background (RBL) noise levels at the three measurement locations are typically consistent around the site.

3.2 Attended Noise Monitoring

To provide further perspective on the noise levels at various locations around the facility for daytime and night time periods, attended noise measurements where conducted on 22/6/12, 17/07/12, 18/07/12 and 4/9/12.

The purpose of the measurements was to measure noise emissions from the existing facility to be used in calibration of the noise model for the existing day and night time operations.

The location of the noise measurements are shown in Figure 3-1. During the day time measurements there was a moderate easterly wind. During the night time measurements there was no cloud cover or wind indicating likely temperature inversion conditions which are relatively common for this area in winter.

Figure 3-1 Attended Noise Measurement Locations

Based on the attended measurements the estimated plant noise contribution has been calculated. Table 3-2 presents these noise levels.

Table 3-2 Attended noise measurement results of site noise.

Measurement Location	Site Operations	Time	Measured Contribution from Site $L_{Aeq,15minutes}$	Remarks
6 – 46 Loftus Road	Production and Clay preparation plant operating.	15:00-15:15	33-35	Distant traffic 40dBA
34 / 35 Belmore Rd	Production and Clay preparation plant operating.	00:00-00:15	35	36dBA when environment quietest (Site audible)
6 – 46 Loftus Road	Production and Clay preparation plant operating (incl. Front end Loader).	00:45-1:00	42	43–45dBA when Front End Loader throttling
4 – 9 Greendale Road	Production and Clay preparation plant operating (incl. Front end Loader).	01:15-01:30	37	Production building noise 37–39dBA.
6 – 46 Loftus Road	Production and Clay preparation plant operating (incl. Front end Loader). Incl. quarry operations.	11:20-11:35	44	Dozer engine and ripping 44–46dBA. Truck dumping 48dBA, audible for 30-60 sec.

4 NOISE CRITERIA

4.1 Existing noise Limit Conditions

The Boral brickworks have been operating at the existing site for approximately 20 years. Both the Camden Council DA (DA3500/060/00) and the sites EPA Licence (Licence Number 1808) have prescribed two different noise limit conditions. A review of these noise limits indicates that they are not consistent with current NSW noise management policies.

Camden Council DA Noise Condition and EPA's Noise Licence Conditions are.

4.1.1 Camden Council DA – DA3500/060/00

The Camden Council DA (DA3500/060/00) state the following noise limit:

> *"The night time set maximum planning levels for noise emissions from the subject development shall be 32 dBA or such noise levels as determined by Council in accordance with Chapter 20 of the Environmental Noise Control Manual. In this regard material preparation and or manufacturing shall not be undertaken at night unless it can be demonstrated that this levels can be achieved."*

It is noted that this consent does not address day and evening noise limits. In addition the objectives stated in this condition are well below existing night - time background noise levels which is inconsistent with any current policy for noise emissions from an industrial facility.

4.1.2 EPA Licence Conditions – Licence Number 1808

The EPA Environmental Protection Licence (Licence Number 1808) state the following noise limits:

- *"Noise from mobile plant must not exceed an $L_{A10,\ 15min}$ noise emission criterion of 35 dBA at all times.*
- *Noise from the premises must not exceed an $L_{A10,\ 15min}$ noise emission criterion of 35 dBA at all times.*
- *Noise from the premises must be measured or computed at any point within 30 metres of the most affected residence to determine compliance with the above conditions. 5 dBA must be added if the noise is tonal or impulsive in character."*

In addition to using a noise descriptor that is no longer applied to noise licences by the EPA, the noise objectives contained in this condition are below existing ambient background levels.

4.1.3 Industrial Noise Policy

The current noise policy in NSW is the *Industrial Noise Policy (INP)*. The *INP* was released in 2000 and superseded the old EPA *Environmental Noise Control Manual (ENCM)*. The original environmental noise assessment for the Boral Brickworks was based on the *ENCM* and therefore, the noise conditions reflect the requirements of the older policy.

Some of the major changes between *INP* and the *ENMN* are:

- The relevant conditioning noise descriptor has been changed from the L_{A10} to L_{Aeq};
- The consideration of meteorological conditions that have the potential enhance (increase) noise levels at receivers are prescribed in the *INP*. The *ENCM* did not address this issue and was typically interpreted as requiring assessment for acoustically neutral conditions only.
- The *INP* presents revised noise modifying factors for tonality, low frequency noise intermittent noise and impulsive noise.

Therefore, as part of the proposed production upgrade, Boral Bricks propose to review its current noise envelop around the site and update its noise conditions to be consistent with the current relevant state noise policies and practices (i.e. *INP*).

The following section details the derivation of these conditions.

4.2 Industrial Noise Criteria (Continuous Noise)

The *NSW Industrial Noise Policy* (INP) recommends two criteria, "Intrusiveness" and "Amenity", both of which are relevant for the assessment of noise. In most situations, one of these is more stringent than the other and becomes the dominate noise criteria. The criteria are based on the L_{Aeq} descriptor, which is explained in the Glossary of Acoustic Terms.

For sources such as the fixed plant associated with the facilities, appropriate noise criteria are specified in the *INP*. The criterion depends on whether existing noise levels in an area are close to recommended amenity levels for different types of residential receiver areas (i.e. urban, rural, near existing roads).

In regions where existing noise levels are low, noise levels from the proposed operation are limited by the intrusiveness criterion. In general, the L_{Aeq} noise level from such sources should not exceed the RBL by more than 5dBA. This is assessed over a typical worst case 15-minute period.

Where noise levels from industrial sources are close to or above the acceptable levels then the amenity criterion, which incorporates a sliding scale to set limits, would apply. The sliding scale prevents the overall noise level exceeding the acceptable level due to the addition of a new noise source. Amenity criterion also needs to consider noise level from all industrial sources in the region, which includes the Bringelly facility. The intention is that the sum of all local noise sources remains within the acceptable levels for each time period.

The amenity criteria are determined by which particular characterisation surrounding residences become classified as. The potentially affected residences near the Bringelly facility are in an area which would be classified as "rural" and the relevant recommended "acceptable" amenity criteria for $L_{Aeq,period}$ are 50, 45 and 40dBA for daytime, evening and night time periods respectively. "Maximum" recommended levels are also part of the criteria and are all 5dBA higher than the "acceptable" levels.

Table 5-1 show the relevant noise industrial noise criteria for this project based on a rural area classification. Noise criteria for all receivers are based on the existing background measurement at Location 3 as these measurements are not be influenced by noise from the Brickworks site.

Table 4-1 Industrial Noise Intrusiveness and Amenity Criteria

Receiver Area	Time Period	RBL (dBA)	Intrusiveness Criterion $L_{Aeq,15min}$ (dBA)	Amenity Criterion $L_{Aeq,period}$ (dBA)
Boundary of nearest residential receivers	Daytime (7.00am–6.00pm)	39	44	50
	Evening (6.00pm–10.00pm)	43*	44	45
	Night Time (10.00pm–7.00am)	38	43	40
	Shoulder Period (6 am – 7am)	42	47	n/a

* The EPA recommend where the evening RBL is above the daytime RBL, the daytime RBL should be taken to develop the intrusive noise criteria.

For day and evening, the intrusive noise levels are below the amenity criteria. Therefore, the project specific noise levels for the day and evening are the intrusive noise criteria.

With regard to night time, the intrusive criterion is higher than the amenity criterion. From site noise measurements and as this site is the only industrial noise source around the area it was estimated that typically a minimum 3dB difference would exist between intrusive noise levels ($L_{Aeq,15minutes}$) and amenity noise levels ($L_{Aeq,period}$). Therefore if the intrusive noise criterion for night time is met this would mean that the amenity criterion is met. As such, the intrusive noise criterion for night time can be used as the night time project specific noise level.

In summary the controlling project specific noise level for the site would be:

- Daytime 44 dBA $L_{Aeq,15minutes}$
- Evening 44 dBA $L_{Aeq,15minutes}$
- Night Time 43 dBA $L_{Aeq,15minutes}$
- Shoulder Period 47 dBA $L_{Aeq,15minutes}$

4.3 Sleep Disturbance Noise Criteria

Intermittent noises due to activities such as reversing alarms during the night time period are not directly addressed by the *INP*.

In order to minimise the risk of sleep disturbance from the operations during night time operation, the EPA recommends that sleep disturbance is assessed as the emergence of the $L_{A1,1min}$ level above the $L_{A90,15min}$ level at the time. Appropriate screening criteria for sleep disturbance are determined to be an $L_{A1,1min}$ level 15dBA above the RBL for the night time period. Based on noise logging, a night period RBL of 38dBA has been established therefore giving sleep disturbance criteria of **53dBA** at nearby residences.

5 METEOROLOGY

At relatively large distances from a source the resultant noise levels from a noise source will be influenced by meteorological conditions, being:

- Wind; and
- Temperature gradients.

Winds and temperature gradients vary between hours of the day. Consequently, effects of these components need to be considered for day, evening and night time period.

When assessing potential noise impacts at the consent stage the *INP* requires that the effects of any weather conditions that are a feature of the area when the development operates need to be taken into consideration. The procedures described in the *INP* are directed toward finding a single set of meteorological conditions which represent general adverse conditions for noise propagation to be implemented in noise assessment.

5.1 Wind

Wind can increase noise at a receiver when it blows from the direction of the noise source. An increase in wind strength results in a corresponding increase in wind noise at the receiver which masks noise from the source under investigation.

The affectation of noise due to wind should be considered when wind is a feature of the area under consideration. The *INP* defines this as where wind blows at speeds up to 3 m/s for more than 30% of the time in any season.

Twelve month weather data for the year 2011 was obtained for the OEH meteorological station located at Bringelly. This data was analysed to determine the frequency of occurrence of seasonal winds up to speeds of 3m/s for the daytime, evening and night periods.

The data was analysed and it was determined that a 2.0 m/s SSW wind is applicable at this site for daytime periods (See Figure 5-1).

5.2 Temperature Inversion

Temperature inversions can increase noise levels at surrounding receivers by the reflection of sound waves from warmer upper layers of air. Temperature inversions occur predominantly at night. For a temperature inversion to be a significant characteristic of the area it needs to occur for approximately 30% of the total night-time period during a season, typically winter.

Pasquill-Gifford stability conditions indicate the potential for temperature inversions. There are six stability classes referred to as A to F. Stability class data was estimated from sigma theta data supplied with the meteorological data set. The frequencies of occurrence of stability class are shown in **Table 5-1**.

Table 5-1 Distribution of Atmospheric Stability Categories at the Bringelly Meteorological Station 2011

Stability	Percentage Occurrence
A	22.0
B	8.0
C	9.3
D	17.7
E	9.2
F	33.9

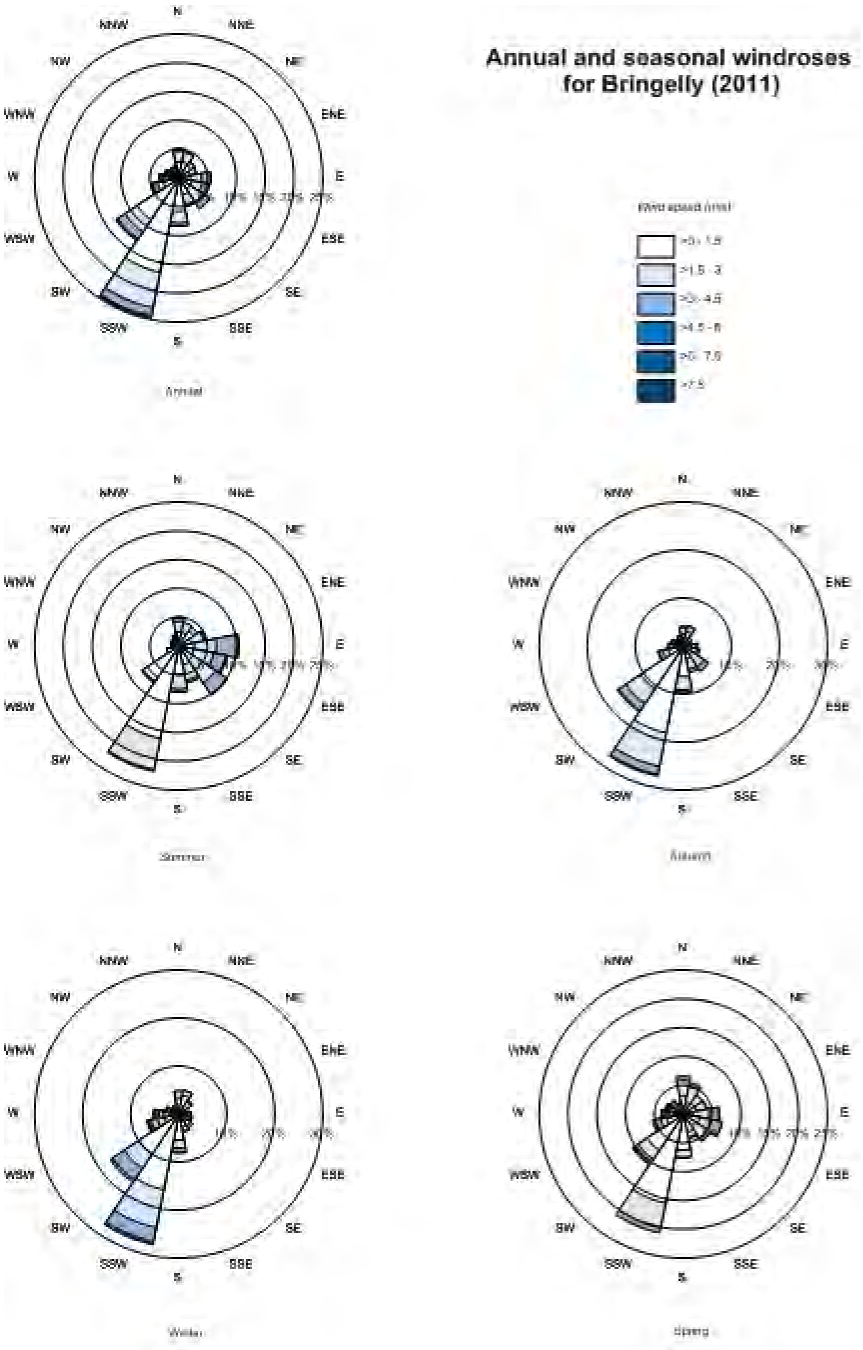
Stability Class A to D identifies typical lapse conditions. Stability Class F applies normally at night when winds are light and the sky is clear and indicates a temperature inversion. Class E describe intermediate conditions between those described above.

Based on the 12 month weather data for the year 2011, it was found that temperature inversion is a feature of this area. Therefore, assessment with respect to F class Pasquill stability (ie temperature inversion) has been adopted for the assessment of noise.

For noise modelling the following atmospheric conditions will be modelled:

Daytime calm conditions	Air temperature 20^0C, 70% relative humidity (RH), no wind, D class stability;
Daytime prevailing wind condition	Air temperature 20^0C, 70% relative humidity (RH), 2m/s wind from SSW, D class stability;
Evening calm conditions	Air temperature 5^0C, 70% R.H., no wind, D class stability; and
Evening temperature conditions	Air temperature 5^0C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)
Night time calm conditions	Air temperature 5^0C, 70% R.H., no wind, D class stability; and
Night time temperature conditions	Air temperature 5^0C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)
Shoulder period calm conditions	Air temperature 5^0C, 70% R.H., no wind, D class stability; and
Shoulder period temperature conditions	Air temperature 5^0C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)

Figure 5-1 Bringelly Windroses 2011



6 OPERATIONAL NOISE ASSESSMENT

6.1 Noise Modelling Methodology

Noise modelling was conducted for the proposed changes in the future operation. The existing facility has been previously modelled and validated in previous assessments of the site. This model has been modified to reflect the current proposal and then used for assessment purposes.

Site related noise emissions were modeled using CONCAWE noise model implemented in the "Cadna A" acoustic noise prediction software. Factors that are addressed in the modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- directivity;
- ground absorption; and.
- atmospheric absorption.

6.2 Operational Noise Sources

Noise levels associated with the plant were measured during a site visit on 22/06/12 and on the 4/9/12 for the quarrying operations. The Sound Power Level measurements of mobile plant such as forklifts and the front end loader were measured during typical operational movements at fixed distances.

Noise radiated from the crusher, grinder and main production buildings was based on internally measured noise levels and the attenuation through building enclosures (e.g. Spandek Steel sheeting). The internal noise level measured with the crusher building was between 90dBA (northern end of the building) and 100dBA (southern end of the building) as a reverberant noise level.

A similar method was used for the main production building using an average interior noise level. The internal noise level measured at the main production building was 79dBA as a reverberant noise level.

The Sound Power Level of the kiln exhaust stack was measured during an additional site visit on 2/8/12.

A summary of the calculated Sound Power Levels of the plant at the existing Bringelly plant are presented in Table 6-1.

Table 6-1 Sound Power Levels of Bringelly Plant

Item of Plant	Number of plant	Sound Power Level – dBA
	Brick Plant	
Production Building Roof	-	97
Production Building Walls	-	82 to 89
Box Feeder	-	94
Primary Crusher		94
Crusher Building Roof (East)	-	94
Crusher Building Roof (West)	-	79
Crusher Building Walls		73 to 95
Kiln Exhaust Fan	-	102
Kiln Exhaust Stack	-	78
10 Tonne Forklift	1	99
3.5 Tonne Forklift	4	99
Truck Engine	-	105 Engine 97 Exhaust
Front End Loader	1	106
	Extraction Pit*	
Grader	1	102
Dozer D8	1	111
Dozer Kamatzu 475	1	106
Excavator	1	102
Dump Truck (40t) – full	3	100
Dump Truck (40t) – empty		97

6.3 Processing / Manufacturing Noise Predictions

Noise predictions associated with normal operation of the Processing / Manufacturing facility has been conducted. The assessment has been conducted to determine noise emissions and control measures that are necessary to achieve compliance with noise criteria prior to assessment of extraction campaigns.

6.3.1 Processing / Manufacturing Noise Prediction Scenarios

Various noise modelling scenarios have been conducted representing future year round operations of the facility outside of campaigns.

The following modelling scenarios have been undertaken:

- Daytime – typical operations;
- Evening – typical operations;

- Night time – typical operations; and
- Shoulder period – typical operations

The time periods under consideration are a "worst case" 15 minute period for proposed hours of operation.

6.3.2 Operation Description

The current manufacturing process includes transporting the raw material from the stockpiling area by front end loader to the processing plant. The clay and shale blend are transported from the stockpiles by front end loader to the box feeder where it gets crushed by the primary crusher. This crushed material is transported by a fully enclosed rubber belt conveyor directly to the crusher building.

Within the crusher building the material is reduced to a stiff fine grain paste by passing it through roll mills and a mixer. This material is stockpiled undercover in the crusher building to eliminate moisture and form a 'dry grind'. The dry grind is subsequently loaded by front end loader into a pugmixer in the production building where water is added. The mix is then conveyed through a vacuum chamber, extruded and cut to size. The bricks are conveyed to the dryer and kiln where they undergo drying and firing. Firing takes approximately 2 days. The firing and drying is a 24-hour 7-day process.

The fired product is transported on the Kiln cars to an unloading machine, where the finished product is automatically transported from the kiln cars and primed into packs suitable for storage on site via a large forklift.

An additional 4 forklifts operate around the site moving brick pallets and load trucks for off site transport.

In relation to truck movements it is considered that the "worst case" operating scenario would be during the event when 4 truck movements overlap in the same 15-minute period. This assumption incorporates 4 trucks arriving one after another and subsequently leaving the site in a similar mode. The selection of 4 trucks is based on space constraints of the loading dock as this is the maximum that can be loaded simultaneously. This scenario will not change under future operations as the loading dock is not subject to any upgrade.

The time to enter and leave the loading bay is based on a 10 km/h speed limit over the respective distances. A B-Double model truck engine and exhaust have been taken into account and are time corrected according to the above assumption.

Table 6-3 describes the scenarios that have been modelled to represent future year round operations of the plant.

Table 6-3 Summary of Future Processing / Manufacturing Noise Scenarios

Site Activity	Typical Day	Typical Evening	Typical Night	Typical Shoulder period 6am to 7am
Transportation	✓ (4 truck 15-min period)	X	X	✓ (1 truck 15-min period)
Production Building	✓	✓	✓	✓
Box Feeder + Primary Crusher	✓	✓	✓	✓
Crusher Building	✓	✓	✓	✓
Kiln Exhaust Fan	✓	✓	✓	✓
Kiln Exhaust Stack	✓	✓	✓	✓
10 Tonne Forklift	✓	✓	✓	✓
3.5 Tonne Forklifts	✓	✓	✓	✓
Front End Loader	✓	✓	✓	✓

✓ Plant operating; and
X Plant not operating.

Noise predictions were conducted for the following meteorological conditions:

Daytime calm conditions — Air temperature 20^{0}C, 70% relative humidity (RH), no wind, D class stability;

Daytime prevailing wind condition — Air temperature 20^{0}C, 70% relative humidity (RH), 2m/s wind from SSW, D class stability;

Evening calm conditions — Air temperature 5^{0}C, 70% R.H., no wind, D class stability; and

Evening temperature conditions — Air temperature 5^{0}C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)

Night time calm conditions — Air temperature 5^{0}C, 70% R.H., no wind, D class stability; and

Night time temperature conditions — Air temperature 5^{0}C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)

Shoulder period calm conditions — Air temperature 5^{0}C, 70% R.H., no wind, D class stability; and

Shoulder period temperature conditions Air temperature 5^0C, 70% R.H., no wind, F class stability. (As the site is below the residential receivers no drainage wind is modelled)

The meteorological conditions which include wind and temperature inversions are the worst-case conditions required for assessment within the *INP*, and account for possible increases in noise emissions.

6.3.3 Noise Modelling Results

The noise levels for the various scenarios have been calculated using the CADNA modelling software and are summarised in Table 7-4. Noise levels for both calm and adverse meteorological conditions that increase the propagation of noise are presented. Exceedances of project specific criteria are presented in red.

Table 6-5 Predicted Noise Levels Untreated Plant $L_{eq, 15min}$

Receiver Number	Period	Day		Evening		Night 10pm-7am		Shoulder Period 6am-7am	
	Criterion	44		44		43		47	
	Receiver	Calm	SSW Wind	Calm	Temperature Inversion	Calm	Temperature Inversion	Calm	Temperature Inversion
1	55 Loftus Road	45	46	44	47	44	47	44	47
2	54 Loftus Road	44	46	43	46	43	46	43	46
3	20 Greendale Road	43	46	40	44	40	44	40	44
4	9 Greendale Road	48	50	43	45	43	45	43	45
5	5 Greendale Road* (Community Centre)	41	44	38	41	38	41	38	41
14	23 Greendale Road	53	54	48	48	48	48	48	48
15	27 Greendale Road	39	40	35	38	35	38	35	38
16	29 Greendale Road	37	39	35	38	35	38	35	38
17	25 Greendale Road	42	44	37	40	37	40	37	40
19	35 Greendale Road	30	30	29	33	29	33	29	33
20	170 Tyson Road	30	29	29	33	29	33	29	33
33	107 Belmore Road	37	34	36	40	36	40	36	40
35	108 Belmore Road	40	37	40	44	40	44	40	44

Red numbers indicate exceedance of *INP* noise criteria.
*A Noise objective of 50 dBA has been established for this receiver based on achieving an internal level of 40 dBA (windows open).

6.3.4 Discussion of Results

Generally all receivers that experience noise levels that exceed the site specific noise criteria can be separated into three noise exceedance categories, namely:

- 0-2dBA: minor exceedances; (Residence 3 and 35)
- 3-5dBA: marginal exceedances (Residences 1 and 2); and
- >5dBA: significant exceedances. (Residences 4 and 14)

The following observations are presented:

- For typical daytime, evening and night operations, residential receivers to the north near the entrance and to the east exceed the recommended noise criterion of 44dBA $L_{Aeq,15minutes}$.
- For typical shoulder period operations with extraction, residential receivers to the north near the entrance marginally exceed the recommended noise criterion of 47dBA $L_{Aeq,15minutes}$.

In cases where the criteria set out in Section 5 are exceeded, the *INP* sets out a range of responses, including:

- Application of "feasible and reasonable" mitigation measures to reduce noise levels;
- Negotiation with relevant government bodies and/or the affected community to determine reasonable levels based on the extent of any residual impacts and other factors such as social and economic benefits derived from the noise source; and
- In extreme cases, acquisition of affected properties. Recent Department of Planning and Infrastructure (DP&I) approaches for major projects suggest acquisition of properties where the operational noise level, under meteorological conditions as defined in Section 6, exceeds the RBL by more than 10dBA. None of the predicted noise levels in Table 6.5 exceed the criteria by more than 10dB(A) and therefore acquisition is not being considered for this proposal.

Based on the predicted exceedances of the noise criteria at receivers, the consideration of reasonable and feasible mitigations measures is considered appropriate.

6.3.5 Proposed Noise Mitigation Measures

Predicted potential noise exceedances at residences on Loftus Road and Greendale Road have prompted the application of additional noise mitigation in order to comply with applicable noise criteria.

The basic framework for mitigation was such that there is minimal or no disruption to the proposed operations of the plant. This means that the following components were constrained:

- Number of truck movements;
- Number of active plant; and
- Hours of operation.

The largest contributors to plant noise have been targeted to most efficiently mitigate the potential noise impacts on surrounding residences.

6.3.6 Greendale Road Residences

Predicted noise exceedances at residences on Greendale Road of up to 10 dBA are due to truck daytime movements on the site access road. Residences nearest the site access road are,

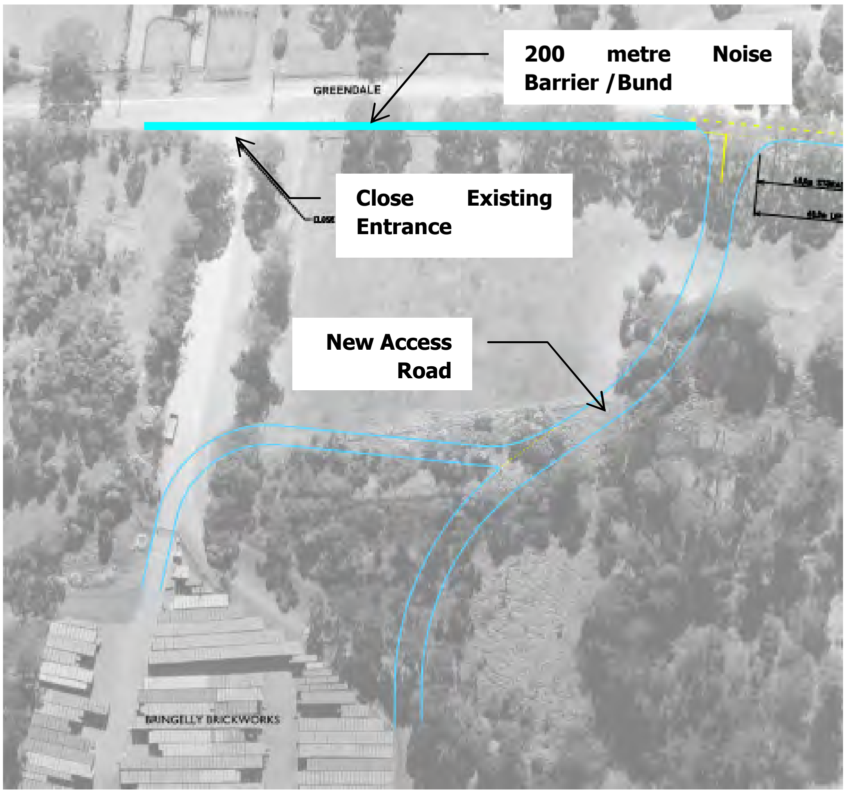
- 23 Greendale Road – 30 meters from site entrance
- 9 Greendale Road – 75 meters from site entrance

The following mitigation measures have been considered:

- modification of driveway location; and
- use of noise barriers.

The distance to the site entrance at 9 Greendale Road is notably larger than at 23 Greendale Road. The effect of moving the entrance eastwards and constructing a noise barrier along Greendale Road was modelled. Several iterations of barrier height and driveway trajectories were considered. The most effective and efficient method incorporates an arching driveway with a new site entrance 200 meters to the east in conjunction with a 4.5 metre high barrier/bund wall. The indicative location of the new drive way and the barrier is shown in Figure 6-1.

Figure 6-1 Modified Driveway Schematic



6.3.7 Loftus Road Residences

Residences located at the end of Loftus Road were predicted to potentially exceed noise criteria during daytime, evening and night periods by up to 4 dBA for the proposed operations. A review of individual noise contributions to these locations was assessed and the largest contributions to noise were determined to be:

- box feeder;
- primary crusher;
- crusher building; and
- front end loader.

Therefore it has been determined that treatment of the building housing of the box feeder and crusher buildings is required to ensure compliance with the *INP* criterion. Treatment of these buildings comprises of additional treatment to the inside of the walls and roofs. Suitable treatments are applying a flexible sound curtail to the inner surface of walls and ceilings:

Noise levels with the various barrier heights and locations were calculated in conjunction with building insulation. No combination was found that would meet the night time criterion prompting further mitigation, namely noise treatment of the Front End Loader.

It was determined that a reduction in the sound power level of the FEL to 102dBA in conjunction with building insulation would meet the night time criterion.

6.3.8 Summary of Recommended Noise Mitigation Measures

A summary of the "reasonable and feasible" noise mitigation measures required to achieve compliance with site specific *INP* noise criteria for brick production and product distribution is presented in Table 6-6.

Table 6-6 Summary of Proposed Noise Mitigation

#	Noise Mitigation
1	Acoustically Insulate Crusher and Box Feeder Buildings
2	Relocate driveway and install noise barrier/bund
3	Treat / Mitigate Front End Loader (Maximum sound power level of 102dBA)

The site has been modelled with the above recommendations and the results are summarised in Table 6-7.

A review of the results indicates that compliance with the established noise criteria under all conditions can be achieved with the implementation of the noise mitigation measures detailed above.

Table 6-7 Predicted Noise Levels for the Proposed Operations after Mitigation

Receiver Number	Period	Day		Evening		Night 10pm-7am		Shoulder Period 6am-7am	
	Criterion	44		44		43		47	
	Receiver	Calm	SSW Wind	Calm	Temperature Inversion	Calm	Temperature Inversion	Calm	Temperature Inversion
1	55 Loftus Road	41	41	39	43	39	43	39	43
2	54 Loftus Road	42	42	39	42	39	42	39	42
3	20 Greendale Road	43	44	37	40	37	40	37	40
4	9 Greendale Road	43	44	30	34	30	34	30	34
5	5 Greendale Road* (Community Centre)	47	49	33	36	33	36	33	36
14	23 Greendale Road	42	43	27	31	27	31	27	31
15	27 Greendale Road	38	39	30	34	30	34	30	34
16	29 Greendale Road	36	38	31	35	31	35	31	35
17	25 Greendale Road	40	41	31	34.	31	34.	31	34.
19	35 Greendale Road	28	27	25	30	25	30	25	30
20	170 Tyson Road	27	25	25	29	25	29	25	29
33	107 Belmore Road	33	29	32	35	32	35	32	35
35	108 Belmore Road	37	33	35	38	35	38	35	38

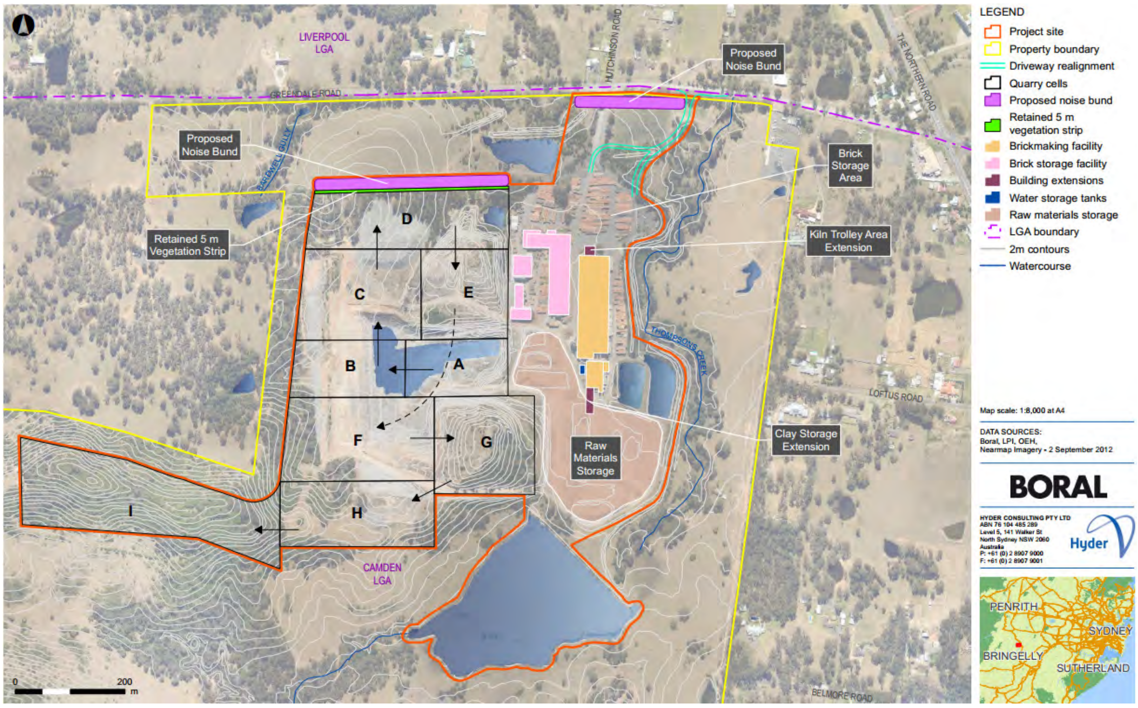
Red numbers indicate exceedance of *INP* noise criteria.

***A Noise objective of 50 dBA has been established for this receiver based on achieving an internal level of 40 dBA (windows open).**

6.4 Quarrying Noise Predictions

From time to time Quarrying campaigns are proposed in the Quarry area to the West of the production facility. Figure 6.3 shows the quarry area in cells from A to I

Figure 6-3 Proposed Quarry Extraction Area



The extraction process removes product material from the quarry in periods of up to 44 days known as Campaigns. Normal plant operations continue in addition to extra operations associated with the material extraction in the clay pit and stockpile area. The equipment used in the Campaign process consists of:

- A dozer and/or excavator are used for the extraction of product.
- A truck is used for transportation of product from the pit to the stockpile.
- A smaller dozer is used at times to level the stockpile.
- A water cart is available for operation during this period.

Each cell within the quarry will be progressively extracted on a campaign basis, starting with the active Cells A, B, C and part of F and continuing to D, E, F, G, H and finishing at Cell I (refer to Figure 6.3). For example, as Cell A "bottoms out" (is exhausted/reaches 30m in depth), extraction will cease in Cell A and will commence in Cell D and therefore Cells B, C and D will be operational. As Cell B is exhausted, extraction will cease in Cell B and will commence in Cell E and therefore Cells C, D and E will be operational and so on.

The Campaign scenarios have been defined, for noise assessment purposes, as follows in Table 6-8.

Table 6-8 Summary of Future Extraction Campaign Noise Stages

Stage	Cells
1	A, B, C
2	D, E, F
3	G, H, I

The noise modelling for each extraction stage has been modelled with the following equipment, operations and assumptions:

- Production, Forklifts and FEL being the normal operation of the production facility as detailed in Table 6.3;
- Transportation. (4 truck 15-min period);
- Dozer in Cell;
- Truck in Cell;
- Excavator in Cell;
- Truck Tipping in Stockpile Area;
- Trucks Operating between Cells and Stockpile Area;
- The Greendale Road barrier has been constructed;
- Dozer in Stockpile Area operating 50% of the time; and
- Quarrying of the hill in cell G would start from the western side so that the hill shields noise of the excavator and bulldozers from eastern residences.

The quarrying campaigns will occur during shoulder and day periods. Based on proceeding modelling it has been determined that the most stringent period is during the day period when site specific noise criteria for these two periods is the lowest. Therefore each campaign scenario has assessed under the following meteorological conditions:

Daytime calm conditions	Air temperature 20^{0}C, 70% relative humidity (RH), no wind, D class stability.
Daytime prevailing wind condition	Air temperature 20^{0}C, 70% relative humidity (RH), 2m/s wind from SSW, D class stability.

A reasonable and feasible review of noise bunds to mitigate quarrying noise has been investigated by Wilkinson Murray in conjunction with Boral. This review has confirmed a 4.5 metre high noise bund on the northern end of cell D. This will mitigate noise levels at receivers on the northern side of Greendale Road.

The 4.5 metre high noise bund on the northern end of cell D should be constructed prior to excavation commencing in cell D (See Figure 6-3).

Table 6-9 details predicted noise levels at residences during each of the scenarios.

Table 6-9 Predicted Noise Levels for the Proposed Quarrying Campaign Operations - dBA

Receiver Number	INP Noise criteria $L_{Aeq,15min}$	Quarrying Scenario	1		2		3 (Excavation in Cell I)		3 (Excavation in Cell G)	
		Cells	A,B and C		D,E and F		G,H and I		G,H and I	
		Receiver	Calm	SSW Wind	Calm	SSW Wind	Calm	SSW Wind	Calm	SSW Wind
1	44	55 Loftus Road	44	47	44	47	44	47	44	47
2		54 Loftus Road	44	46	44	46	44	46	44	47
3		20 Greendale Road	44	46	44	46	44	46	44	46
4		9 Greendale Road	44	46	44	46	44	46	44	45
5		5 Greendale Road* (Preschool)	46	49	46	49	46	49	46	49
14		23 Greendale Road	42	44	43	46	43	46	42	44
15		27 Greendale Road	38	40	42	45	42	45	39	42
16		29 Greendale Road	37	40	41	44	41	44	38	42
17		25 Greendale Road	40	42	42	45	42	45	40	43
19		35 Greendale Road	30	31	33	34	33	34	32	35
20		170 Tyson Road	36	35	37	35	37	35	37	35
33		107 Belmore Road	36	35	37	35	37	35	37	35
35		108 Belmore Road	42	39	42	39	42	39	42	40

Red numbers indicate exceedance of *INP* noise criteria of 44 dBA.
*A Noise objective of 50 dBA has been established for this receiver based on achieving an internal level of 40 dBA (windows open).

6.4.1 Discussion of Results

The predicted noise levels in Table 6-9 show compliance with the established noise objectives under calm conditions.

Under SSW wind conditions, exceedances of up to 3 dBA are predicted at residences to the east and north of the Boral Site.

Generally all receivers that experience noise levels that exceed the site specific noise criteria can be separated into three noise exceedance categories, namely:

- 0-2dBA: minor exceedances; (Residences 2, 3, 4, 14, 15 and 17)
- 3-5dBA: marginal exceedances (Residence 1); and
- >5dBA: significant exceedances. (No residences).

The raising of the noise bund along the eastern boundary of the raw material stockpile area along with some of the treatment of the dozer working the stockpile area was investigated. However these noise mitigation/attenuation measures did not result a significant noise reduction that would be considered reasonable and feasible.

In order to manage the possibility of noise exceedances Boral will develop and implement a noise management plan for the site. The noise management plan would initially undertake a noise audit during a quarrying campaign. This would include a thorough review of metrological conditions including SSW winds and validation of noise predictions thereby assisting in developing effective noise mitigation.

Figures 6-4 to 6-7 illustrate the noise predictions for each scenario.

Figure 6-4 Predicted Noise Levels for Stage 1 Campaign – Calm Meteorological Conditions (Mitigated), $L_{Aeq,15min}$

Figure 6-5 Predicted Noise Levels for Stage 2 Campaign – Calm Meteorological Conditions (Mitigated), $L_{Aeq,15min}$

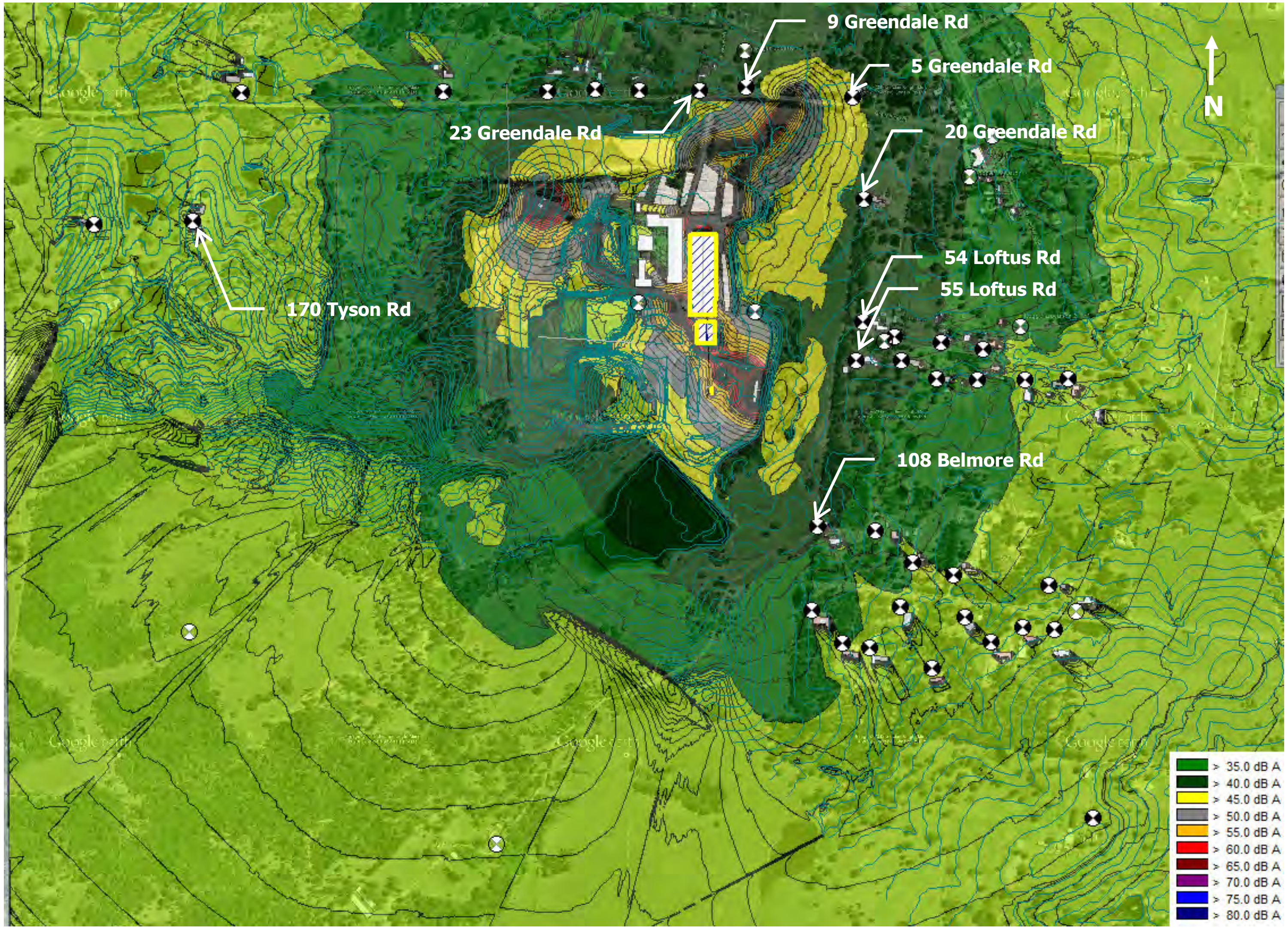


Figure 6-6 Predicted Noise Levels for Stage 3 Campaign Cell I Operations – Calm Meteorological Conditions (Mitigated), $L_{Aeq,15min}$

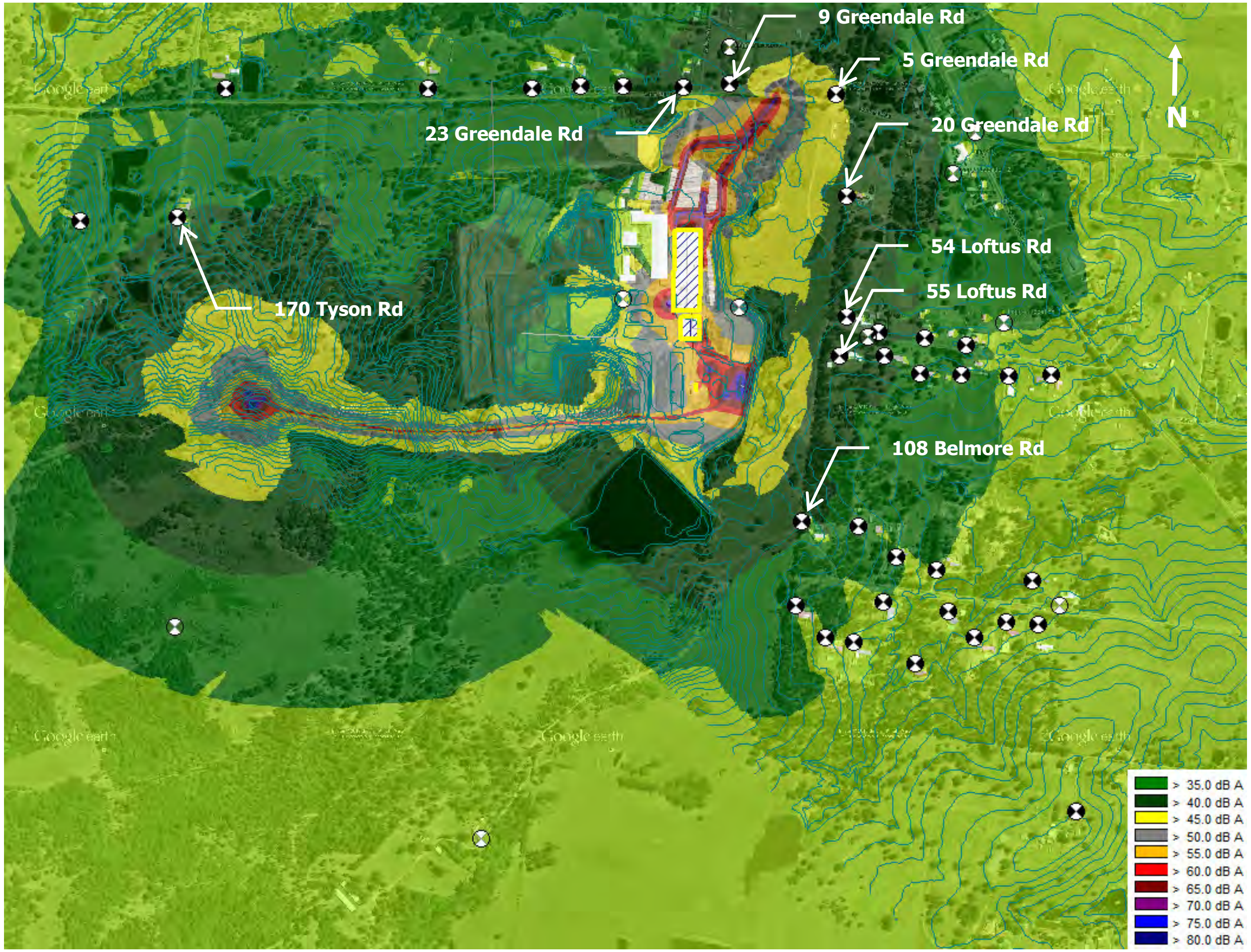


Figure 6-7 Predicted Noise Levels for Stage 3 Campaign Cell G Operations – Calm Meteorological Conditions (Mitigated), $L_{Aeq,15min}$

7 SLEEP DISTURBANCE ASSESSMENT

Reversing alarms and engine noise from Forklifts and the FEL are the likely activities that could cause maximum noise levels leading to potential sleep disturbance.

Table 7-1 details the maximum noise source levels for reversing alarms and engine noise.

Table 7-1 Typical Maximum Sound Power Levels – dBA

Noise Source	Sound Power Level
FEL engine	106
Forklift	99
Reversing alarm	105 – 115*

* The upper noise level is for a standard beeper reversing alarm. The lower noise level is for a broadband type reversing alarm.

Resultant noise levels at the closest residences have been predicted based on the operation of reversing alarms being the loudest noise source on site. Predicted noise levels are presented in Table 7-2.

Table 7-2 Predicted Maximum Noise Levels at Residences – dBA

	Receiver Location	Predicted L_{Amax} Noise Level (dBA)		Sleep Disturbance Screening Criterion (dBA)	Compliance with Screening Criterion
		Calm Conditions	Temperature Inversion		
1	55 Loftus Road	47	51	53	Yes
2	54 Loftus Road	47	51	53	Yes
3	23 Greendale Road	38	41	53	Yes
4	9 Greendale Road	40	43	53	Yes
6	46 Loftus Road	45	50	53	Yes

The predicted maximum noise levels for the night "worst case" standard beeper type reversing alarm will comply with sleep disturbance noise criteria. It should be noted that the FELs are currently fitted with a broadband alarm and the forklifts have standard beeper alarms.

Whilst compliance with criteria is indicated, it is recommended that forklifts fitted with standard beeper alarms be replaced with broadband alarms on decommissioning of the old plant equipment. This measure is recommended as best practice noise management.

8 CONSTRUCTION NOISE

8.1 Construction Noise Objectives

The NSW EPA released the "*Interim Construction Noise Guideline*" *(ICNG)* in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq,\ 15min}$ noise level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday, 7.00am to 6.00pm and Saturday, 8.00am to 1.00pm. Outside the standard hours, the criterion would be background + 5dBA. Table 8-1 details the *ICNG* noise goals.

Table 8-1 Construction Noise Goals at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences; 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

In addition, the following construction noise management levels $L_{Aeq,15\ min}$ are recommended for other receivers and areas.

- Active recreation areas (such as parks): external $L_{Aeq\ ,15\ min}$ 65dBA
- Industrial premises: external $L_{Aeq\ ,15\ min}$ 75dBA
- Offices, retail outlets: external $L_{Aeq,15\ min}$ 70dBA
- Classrooms at schools and other educational institutions internal $L_{Aeq\ ,15\ min}$ 45dBA

Based on the above, Table 8-2 presents the applicable noise management levels for construction activities at surrounding receivers.

Table 8-2 Site Specific Construction Noise Management Levels

Location	Construction Noise Management Level, $L_{Aeq,15min}$ – dBA			Maximum Construction Noise Level, $L_{Aeq,15min}$ – dBA
	Day	Evening	Night	
Residences	49	49**	43	75
All Commercial Properties	70			
Schools / Preschools	55*			
Parks / Outdoor Play Areas	65			

*The external noise goal of 55dBA is based on a 10 dB reduction through an open window.

** Based on Daytime RBL

8.2 Construction Equipment Noise Levels

It is proposed that the construction of the new access road, a noise bund along Greendale Road and the northern bund in cell G are to be conducted by Boral using existing plant on site supplemented by hire equipment where appropriate. Noise levels associated with construction equipment and associated maximum noise levels of the plant likely to be used during various stages of the construction works have been identified in Table 8-3. These noise levels have been measured at other similar construction sites by Wilkinson Murray.

Table 8-3 Typical Maximum Construction Sound Power Levels (SWL) of Plant

Equipment	**Sound Power Level – dBA**	Sound Pressure Level at 7m – dBA
Grader	102	77
Dozer D8	111	86
Dozer Kamatzu 475	106	81
Excavator	102	77
Dump Truck (40t) – full	100	75
Dump Truck (40t) – full	97	72
18-Tonne Rollers	108	83

The above noise levels have been utilised in predicting noise levels at nearby residences.

8.3 Construction Noise Scenarios

Following a review of the proposed construction, two "worst case" construction noise scenarios have been selected for noise modelling during the construction. These include all the following activities:

- Road realignment works and roadside noise bund construction, and
- Northern Bund construction.

The following sections describe the two assessment scenarios, together with indicative plant numbers.

8.3.1 Scenario A - Road realignment Works.

This scenario consists of daytime road works at the northern end of the site. Equipment site in this scenario is presented in Table 8-4.

Table 8-4 Road Diversion Construction Noise Scenario A Works

Equipment Likely to Operate Simultaneously
• Trucks x 2 -Load and travel along new road alignment.
• Excavator x1 - Loading dump trucks only.
• Rollers x1 - Once dump trucks are finished.
• Dozers x1 - Once dump trucks are finished.
• Grader x1 – working with roller.
• Water Truck x1 - One run per hour.
• Dozer working along the northern roadside bund.

8.3.2 Scenario B – Northern Bund Barrier Construction

This scenario consists of excavation and consolidation works in the new northern barrier / bund. Equipment included in this scenario is presented in Table 8-5.

Table 8-5 Construction Noise Scenario B Northern Bund

Equipment Likely to Operate Simultaneously
• Truck x 2 Pit, travel to bund, dump and return to pit. • Dozer x 1 - One in pit only. One on the bund. • Excavators x 1 - Pit only. • Water Cart x 1 Pit, travel to bund, dump and return to pit. Once per hour

8.4 Construction Noise Modelling

For noise modelling purposes this equipment was located randomly across the relevant sections of the proposed construction site representing typical locations during the relevant construction period. Although exact equipment locations will vary from day to day, this variation will not have a significant impact on noise levels at relevant receivers.

Site related noise emissions were modeled using the CONCAWE algorithms implemented in the "CadnaA" acoustic noise prediction software. Factors that are addressed in the modeling are:

- Equipment sound level emissions and location;
- Screening effects from buildings;
- Receiver locations;
- Ground topography;
- Noise attenuation due to geometric spreading;
- Ground absorption; and;
- Atmospheric absorption.

Computation of noise emission was carried out based on calm meteorological conditions which is consistent with normal practice for construction noise assessment.

Noise modelling has been conducted for each of the above scenarios based on the equipment, located across the construction site as follows:

Line Noise Source – Truck haulage or road routes are modelled as line noise sources.

Point Noise Sources – Individual equipment that is located in one place or which has particular characteristics (concrete pumps) are modelled as point sources.

The modelling assumes a "typical worst case" scenario whereby all the plant, is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site specific noise objectives.

Tables 8-7 and 8-8 present the results of the noise modelling.

Table 8-7 Predicted $L_{Aeq,15\ min}$ Construction Noise Levels at Residences due to Road Construction (Scenario A)– dBA

Location	Predicted Maximum L_{Aeq} Noise Level	EPA Noise Management Level
Northern Residences (Receiver 4)	66	49
Eastern Residences (Receiver 3)	51	49
Western Residences (Receiver 20)	33	49

A review of the results indicates compliance with normal EPA management levels at the residences with the exception of residences immediately to the north of the site. An exceedance of up to 17 dBA is predicted.

This exceedance is not a-typical by construction standards where residences are in close proximity to construction activities. It is noted that if the northern roadside bund is constructed prior to road works, the period of higher construction noise levels will be minimised. Therefore, where practicable, the northern bund should be constructed prior to the new access road.

In the case of construction scenario B the predicted construction noise levels are presented in Table 8-1

Table 8-8 Predicted $L_{Aeq,15\ min}$ Construction Noise Levels at Residences due to Northern Pit Bund (Scenario B)– dBA

Location	Predicted Maximum L_{Aeq} Noise Level	EPA Noise Management Level
Northern Residences (Receiver 16)	46	49
Eastern Residences (Receiver 3)	37	49
Western Residences (Receiver 20)	33	49

A review of the results indicates that compliance is indicated with normal EPA construction noise objectives at the residences for construction scenario B.

Figures 8-2 to 8-4 illustrate predicted noise levels during construction. It should be noted that residences are shown as circles in these diagrams.

Figure 8-2 Noise Contours for Construction Scenario A - Road Works

Figure 8-3 Noise Contours for Construction Scenario B – Northern Bund Works

8.5 Discussion of Construction Noise

In order to minimise and construction noise impacts, it is recommended that the following "best practice" construction noise mitigation measures are implemented:

- *Noise Sensitive Sites* – The quietest available plant and equipment that can economically undertake the work required should be selected. Mobile plant such as excavators, front-end loaders and other diesel equipment should be fitted with residential class mufflers and other silencing equipment, as applicable.

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service.

- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.

- *Site Noise Planning* – Where practical, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.

- *Community Liaison* – An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected appraised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with community groups, etc) of any anticipated changes in noise emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms. Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

- *Environmental Management Plan* – Management of noise should be included in the site Environmental Management Plan.

9 TRAFFIC NOISE

Construction and operation of the Project would result in an increase in the traffic volumes on public roads in the Project area. It is for this reason that a traffic noise assessment has been undertaken to determine potential noise impacts resulting from increased traffic flows on public roads in the area. The results of this traffic noise assessment are presented in the sub-sections below.

The construction works associated with the proposed increase in brick production will be limited to the construction of the new driveway and minor extensions to the brick making facility. It is anticipated that the construction of the new driveway will take around 8 weeks while the construction of the minor extensions to the brick making facility will take around 8 weeks. It is expected that the works will be undertaken concurrently and hence, a maximum of 8 weeks is assumed to be the total duration of the construction period.

During the proposed 8 week construction period it is predicted that up to 20 light vehicle and 8 heavy vehicles movements will occur per day. These numbers will not be acoustically significant at receivers on Greendale Road therefore the assessment of traffic noise has been focused on operation traffic noise impacts.

9.1 Traffic Noise Criteria

Criteria for assessment of road traffic noise are set out in the NSW Government's *NSW Road Noise Policy (RNP)*. Table 9-1 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use.

Table 9-1 Traffic Noise Criteria extracted from the NSW *RNP*

Road Category	Type of Project/Land Use	Assessment Criteria – dB(A)	
		Day (7.00am–10.00pm)	Night (10.00pm–7.00am)
Freeway / arterial / sub-arterial roads	1. Existing residences affected by noise from new freeway / arterial / sub-arterial road corridors	$L_{Aeq,15\,hr}$ 55 (external)	$L_{Aeq,9hr}$ 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway / arterial / sub-arterial roads 3. Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,15\,hr}$ 60 (external)	$L_{Aeq,9hr}$ 55 (external
Local roads	4. Existing residences affected by noise from new local road corridors 5. Existing residences affected by noise from redevelopment of existing local roads 6. Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1hr}$ 55 (external)	$L_{Aeq,1hr}$ 50 (external)

Where existing traffic noise levels are above the noise assessment criteria the RNP states the following regarding permissible increases in road traffic noise from a land use development:

> *"In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person."*

and

> *"For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'."*

Traffic noise levels are assessed separately for daytime and night time periods. Daytime is considered 7am to 10pm and night time is considered between 10pm and 7am.

The existing haulage route is along Greendale Road and then primarily along The Northern Road. The Northern Road is a main arterial road where additional project traffic would not be discernable. Greendale road is classified as a local road and as such the project traffic noise assessment will concentrate on this road. Due to the relocation of the entrance of the Brickworks the property at 10 Greendale Road will be the only potentially affected residential receiver.

In summary the traffic noise level criteria at the residential receiver on Greendale Road, based on the RNP are:

- $L_{Aeq,1hr}$ day 55dBA; and
- $L_{Aeq,1hr}$ night 50dBA.

Additionally the following noise criteria are applicable for other receivers along Greendale Road between the new entrance and the intersection with The Northern Road. Bringelly Public School and Bringelly Community Centre has been identified near the Project. The RNP recommends a maximum internal level of $L_{Aeq,\ 1hour}$ 40dBA for schools when in use. There are no specific criteria for community centres however the usage would be similar to a classroom as discussions and lectures could take place therefore it would seem appropriate that the same criteria be used as a school. Internal noise levels are generally 10dBA below external noise levels with windows open to a normal extent. The RNP would therefore imply a recommended external noise level criteria of L_{Aeq} 50dBA (no façade reflection) at the school and community centre.

9.2 Road Traffic Noise Impacts

A Traffic Impact Assessment for the Project has been prepared by Hyder Consulting. Results from that assessment have been used to estimate the potential for road traffic noise impacts.

As Greendale Road is considered a local road the noise assessment needs to be conducted for the period where the highest hourly traffic noise levels occur during day and night. The highest hourly traffic noise levels on Greendale Road would occur between 6am and 7am night-time and 8am and 9am daytime.

9.2.1 Existing Traffic Flows

A review of the traffic report prepared by Hyder indicates that existing traffic on Greendale Road is in the order of 1500 vehicles a day with 11.4 % being heavy vehicles.

Table 9-1 outlines the measured highest hourly traffic volumes on Greendale Road would occur between 6am and 7am night-time and 8am and 9am daytime.

Table 9-1 Existing Highest Hourly Daytime and Night time Traffic Volumes for Greendale Road

Road	ALL[2]	%HV[1]
8am - 9am daytime	172	17%
6am - 7am night-time	103	26%

Notes: 1 HV = Heavy Vehicles
2 5 day weekday average traffic volume

There would be a total of 176 truck movements daily (an increase of 98 heavy vehicle movements per day). Net increase for peak inbound and outbound is at it's maximum 10 additional movements during the day and 8 additional movements during 6am to 7am (night).

The noise generated by these truck movements along Greendale Road has been assessed with respect to the $L_{Aeq,1hr}$ hourly traffic noise level, using the Calculation of Road Traffic Noise (CORTN) traffic noise prediction technique.

Current and future peak hour traffic noise levels have been calculated at 10 Greendale Road, Bringelly Public School and Bringelly Community Centre and are presented in Table 9-2.

Table 9-2 Calculated Traffic Noise Levels along Greendale Road

Location	Daytime 8am to 9am		Night time 6am to 7am	
	Existing	Future	Existing	Future
	$L_{Aeq,1\ hr}$ (dBA)	$L_{Aeq,1\ hr}$ (dBA)	$L_{Aeq,1\ hr}$ (dBA)	$L_{Aeq,1\ hr}$ (dBA)
10 Greendale Rd	54.1	54.9	53	53.8
Bringelly Public School	57.5	58.3	Not operational during this time period.	
Bringelly Community Centre	56	56.9		

Peak hour day traffic noise levels of 54.1 dBA (existing) and 54.9 dBA (future) have been predicted at the facade of the most potentially affected residence, being 10 Greendale Road. It is noted that compliance with the RNP objective is indicated.

The existing traffic noise levels for Bringelly Public School, Bringelly Community Centre and 10 Greendale Road at night (6am to 7am), are above the RNP objective. Therefore, the RNP recommends that any increase in traffic noise levels, at residential and sensitive receivers, due to the proposed development should not exceed 2 dBA.

Review of Table 9-2 shows that increases in road traffic noise levels along the Greendale Road are less than 2 dBA and therefore comply with the relevant RNP criteria.

10 RECOMMENDATIONS AND CONCLUSION

A noise assessment has been conducted for the Boral Brickworks proposal.

Road traffic noise levels have been predicted and assessed in accordance the EPA's Road Noise Policy with compliance being shown.

The operational noise assessment of the Boral Brickworks is based on the EPA's Industrial Noise Policy.

In accordance with the procedures in the *INP*, "feasible and reasonable" noise control measures have been developed to ensure compliance with the appropriate noise criteria at surrounding residences. The following noise mitigation is recommended:

	Recommended Noise mitigation
	Production Facility
1	Acoustically Insulate Crusher and Box Feeder Buildings
2	Relocate driveway and install noise bund along Greendale Road
3	Treat / Mitigate Front End Loader (Maximum sound power level of 102dBA)
	Extraction Campaigns
4	Install a 4.5 metre noise bund on the northern end of cell D prior to the commencement of quarrying in this cell

With all the mitigation in place compliance with established site specific noise criteria is achieved for the proposed increase in production at the site when the production facility is in operation without campaigns.

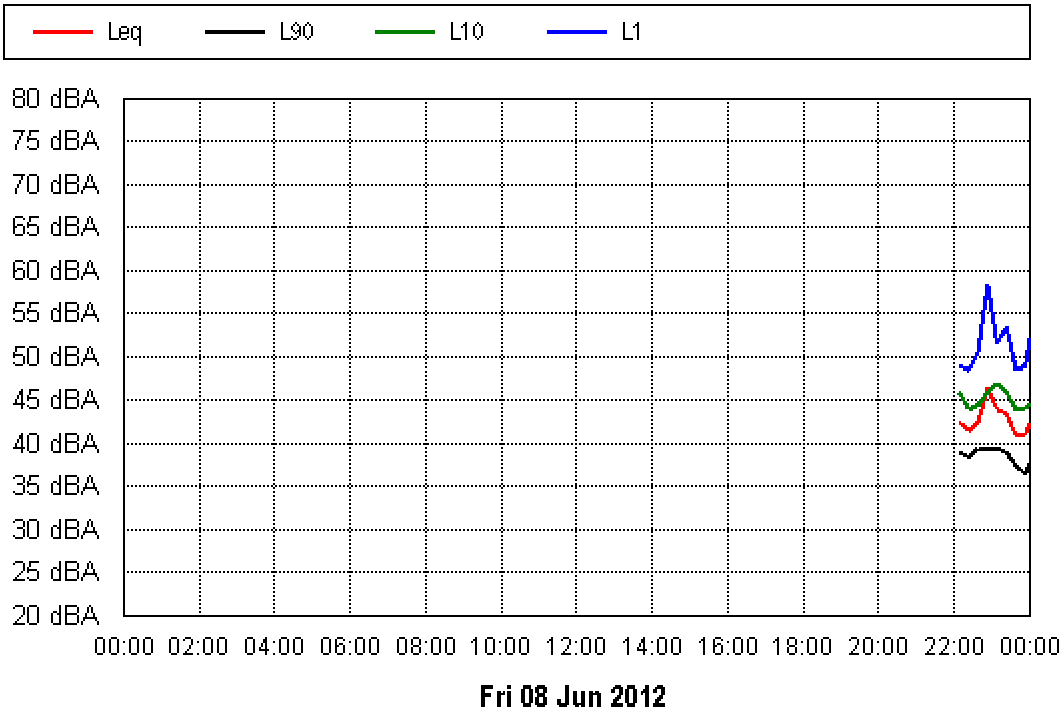
It is noted that a marginal exceedance of the intrusive noise criterion is still predicted at residential locations to the north and east of the site under adverse SSW wind conditions when production and extraction campaigns occur simultaneously. The exceedance is predicted to be no more than 3dB during SSW wind conditions. Typically a 2 to 3 dB exceedance is considered marginal and would not be distinguishable to the human ear. However, to minimise and manage noise levels during adverse wind conditions, a noise management plan will be developed.

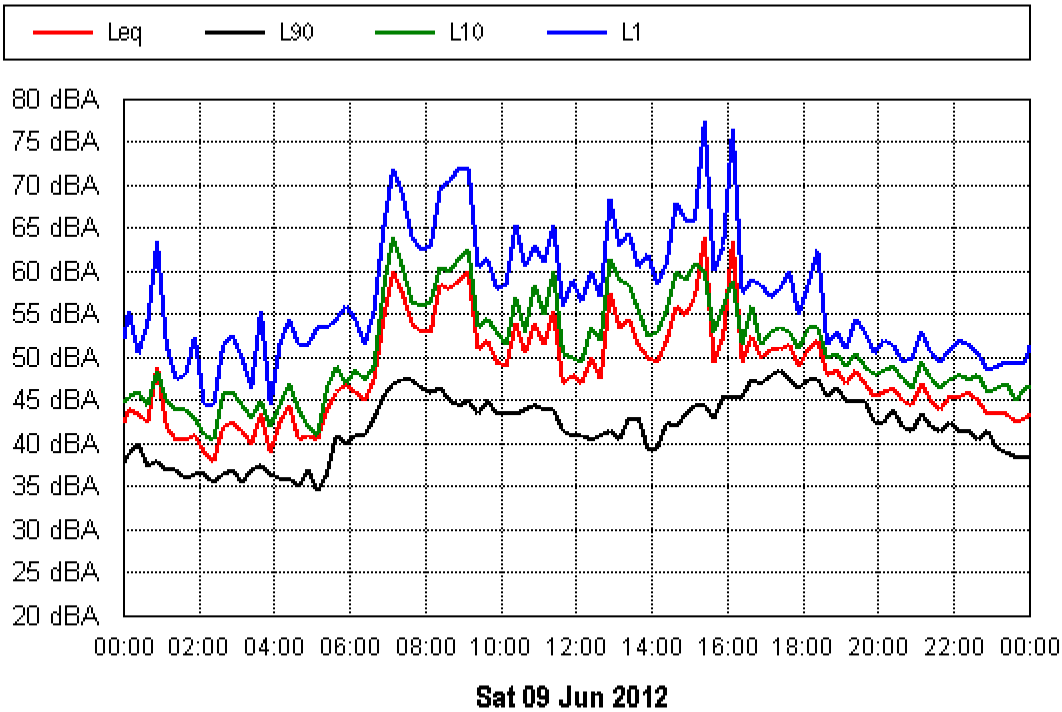
In the case of construction it has been determined that general compliance with noise management levels will be achieved at the majority of residences surrounding the site. The exception is residences to the north of the entrance when an exceedance of up to 17 dBA is predicted when the Boral driveway is relocated. The duration of construction noise exposure can be minimised if the proposed roadside bund is installed, up to the existing entrance prior to construction roadworks.

APPENDIX A

NOISE MEASUREMENT RESULTS

Project: 12185 - Boral Brickworks
Location: 9 Greendale Rd





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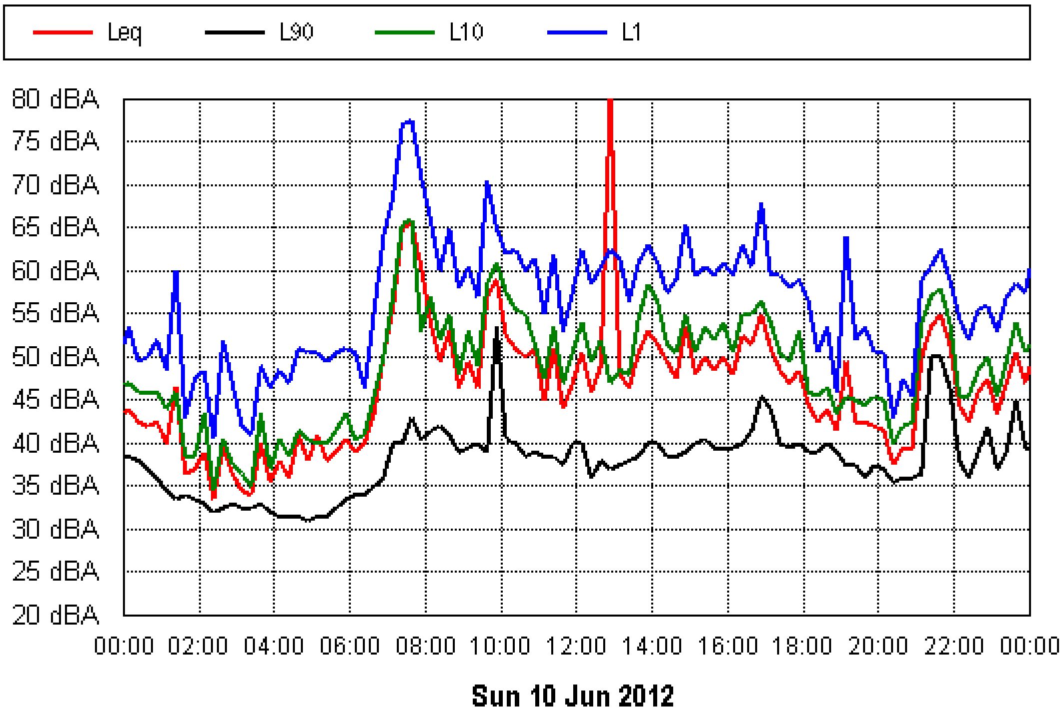
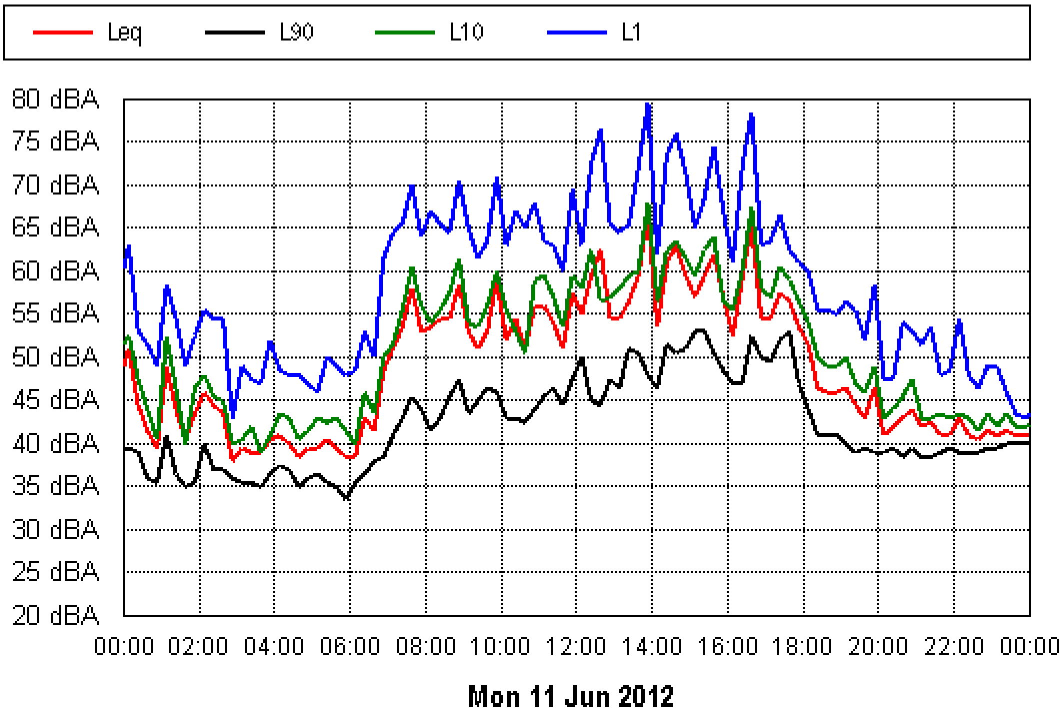
Location: 9 Greendale Rd





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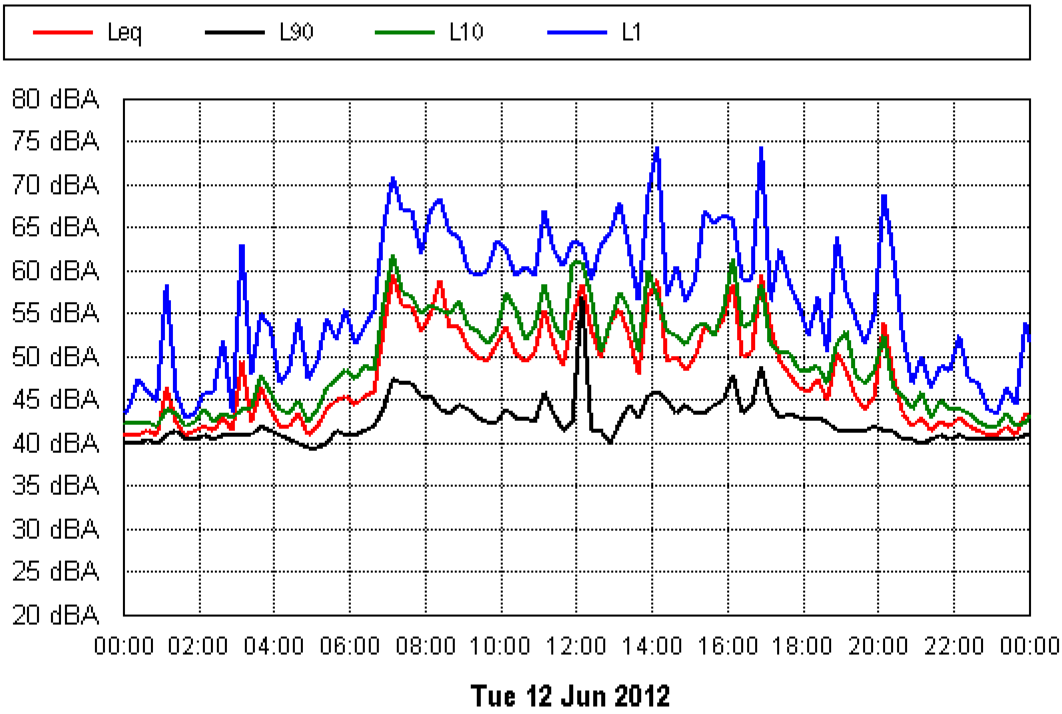
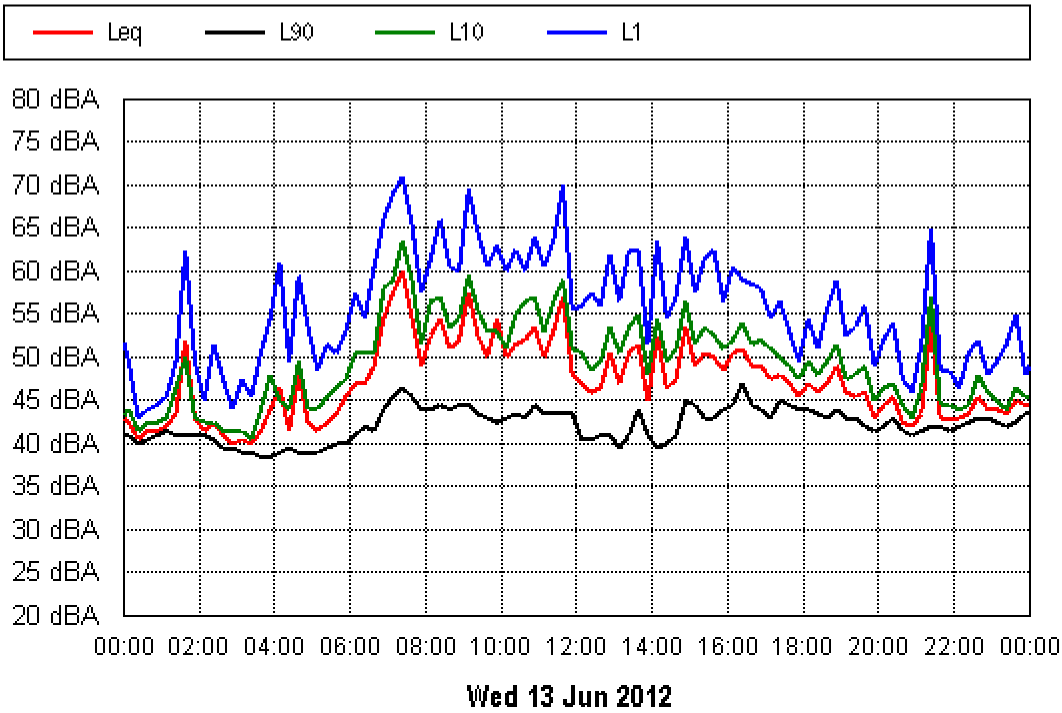
Location: 9 Greendale Rd





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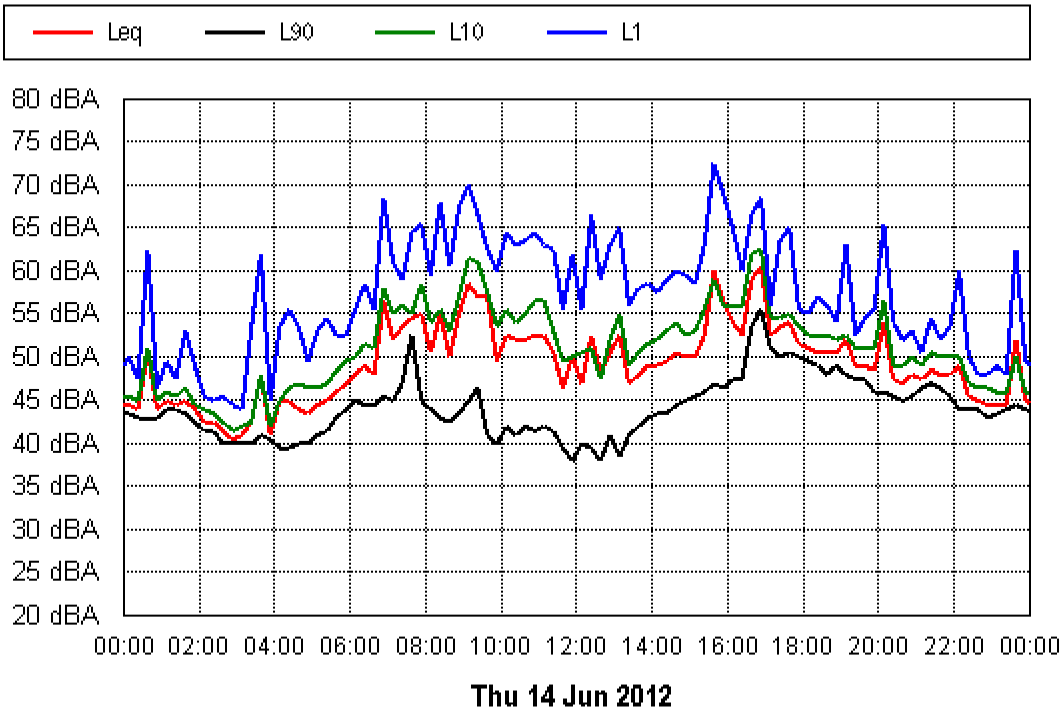
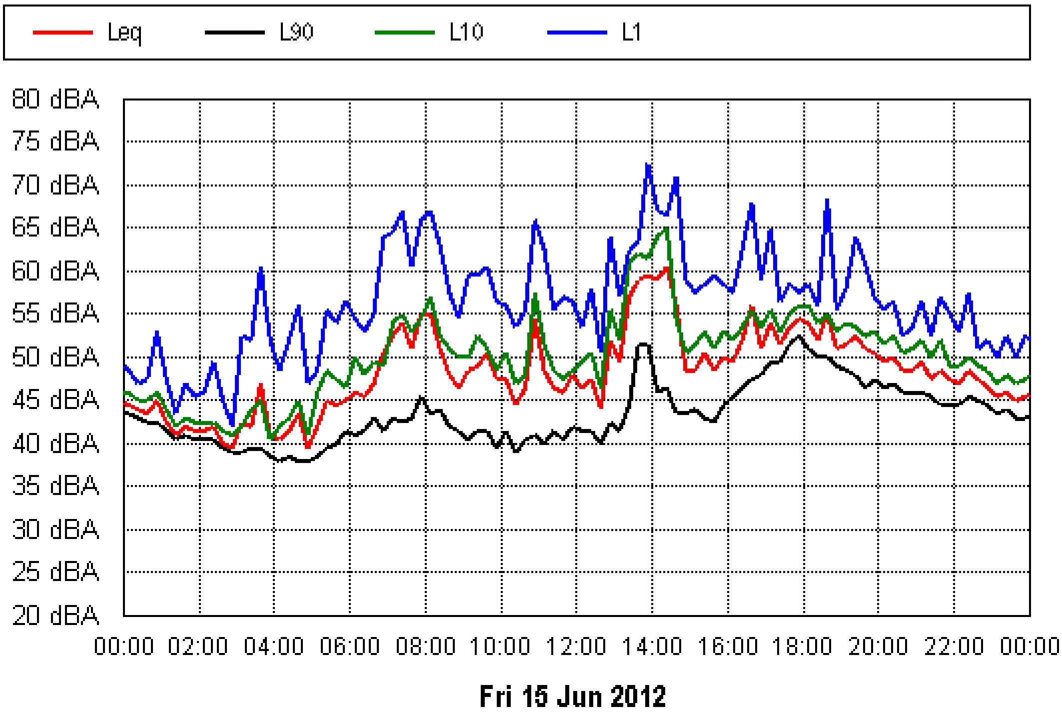
Location: 9 Greendale Rd





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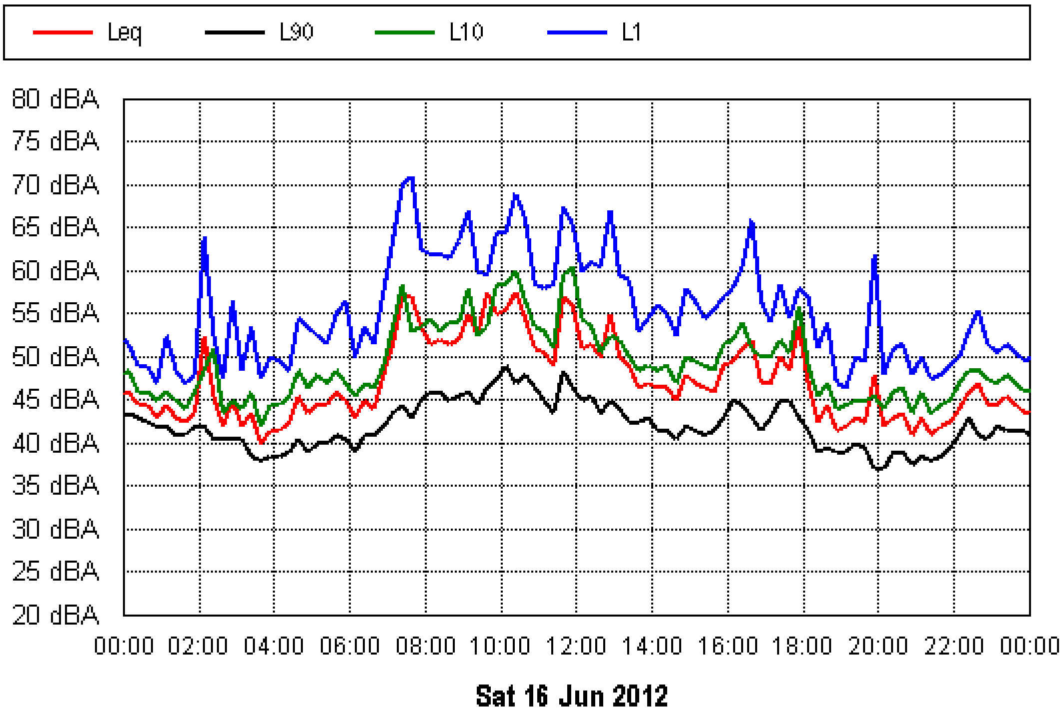
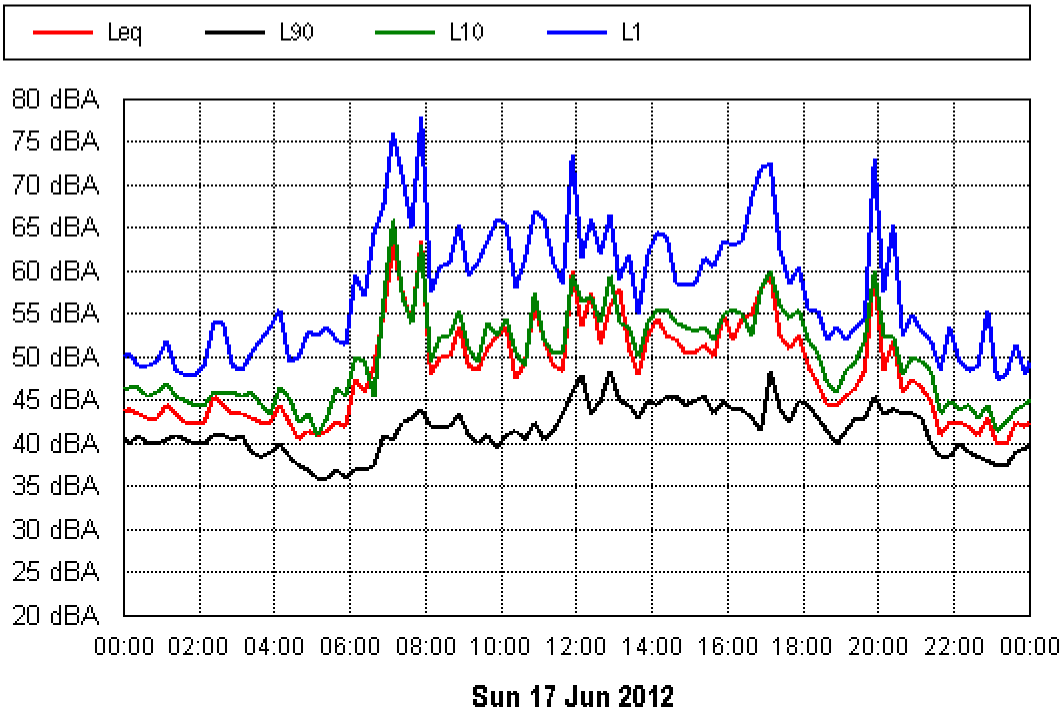
Location: 9 Greendale Rd





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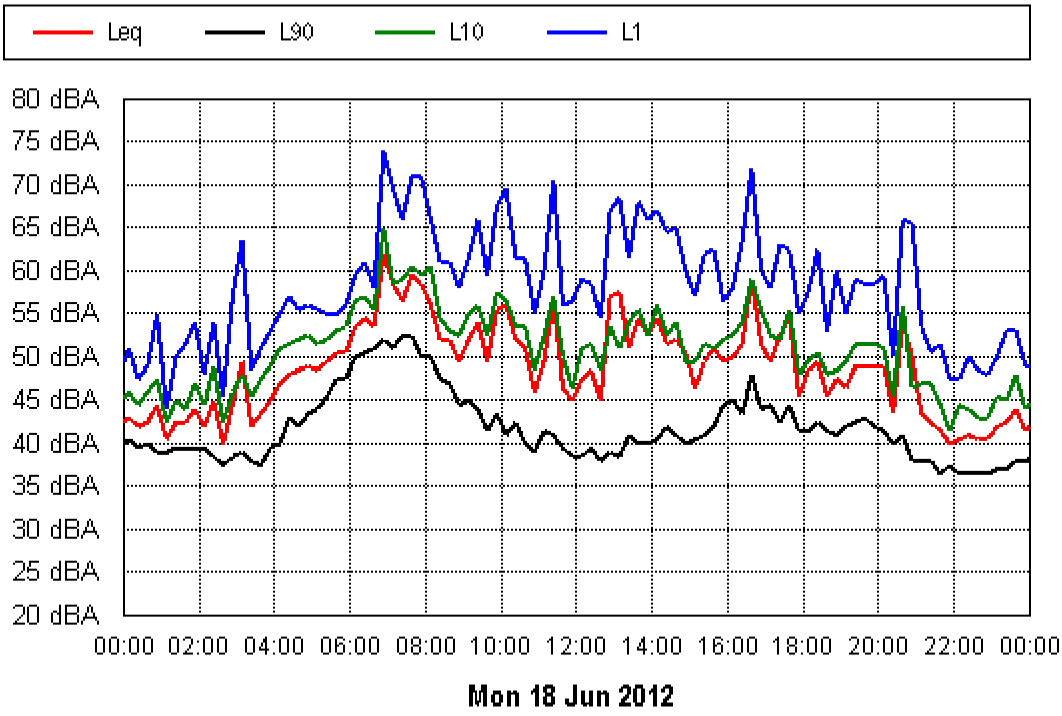
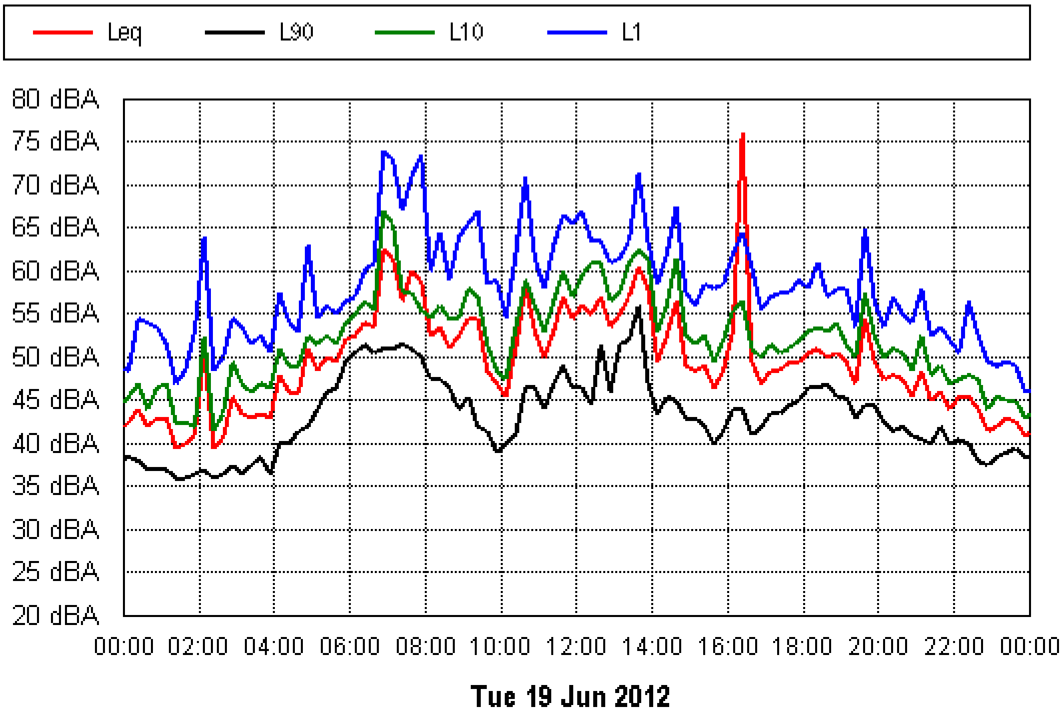
Location: 9 Greendale Rd





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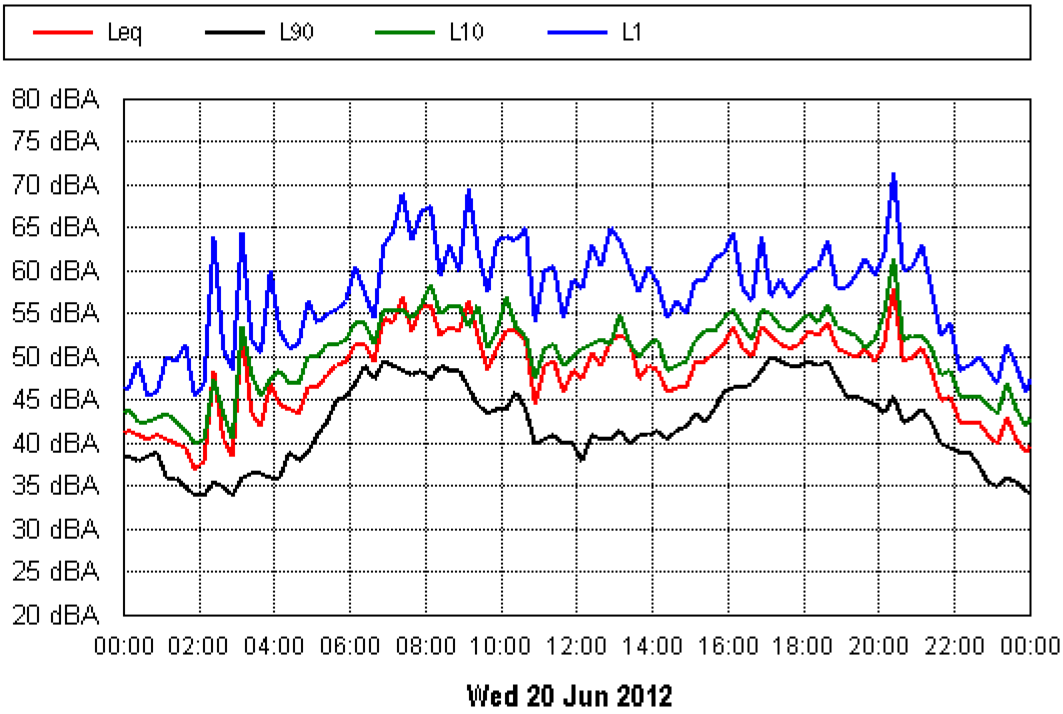
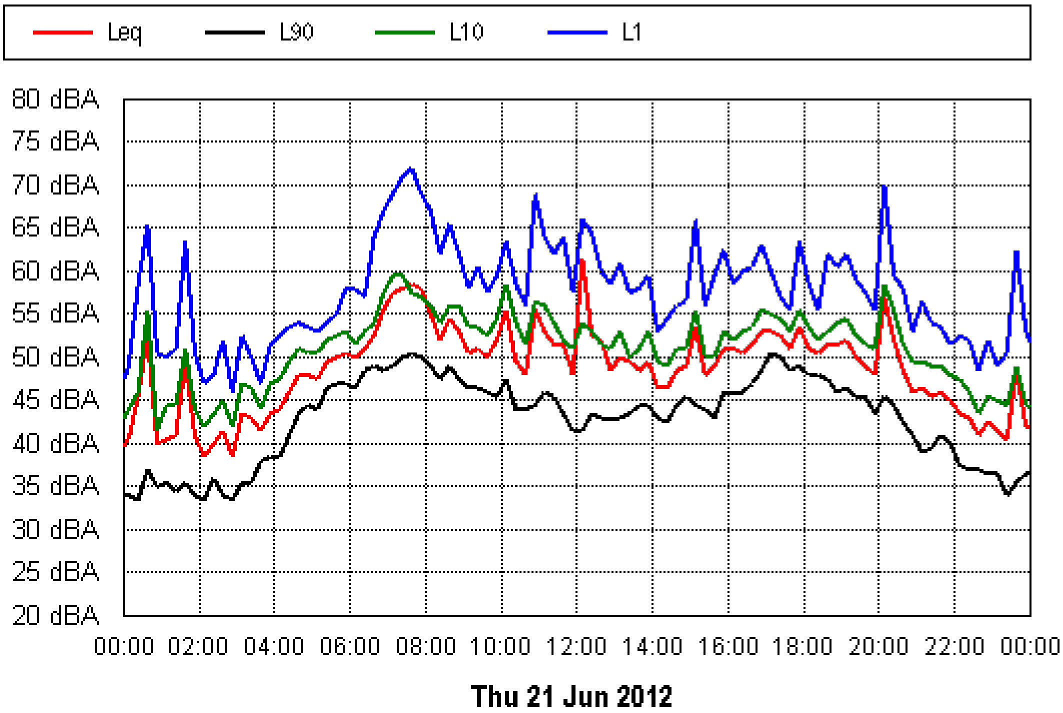
Location: 9 Greendale Rd





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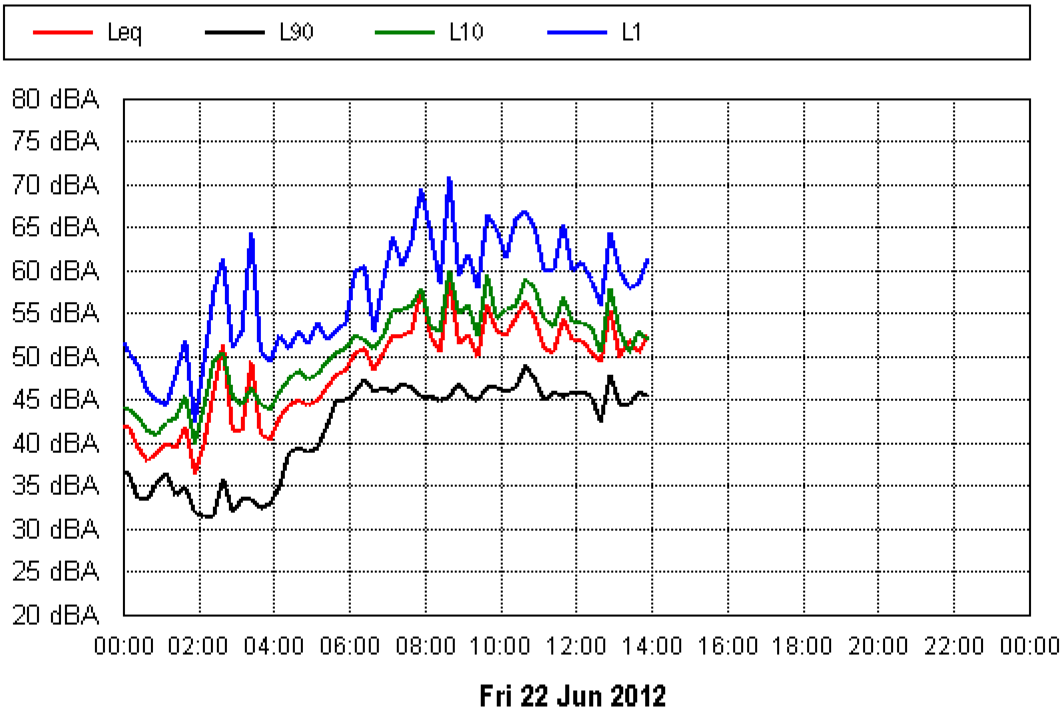

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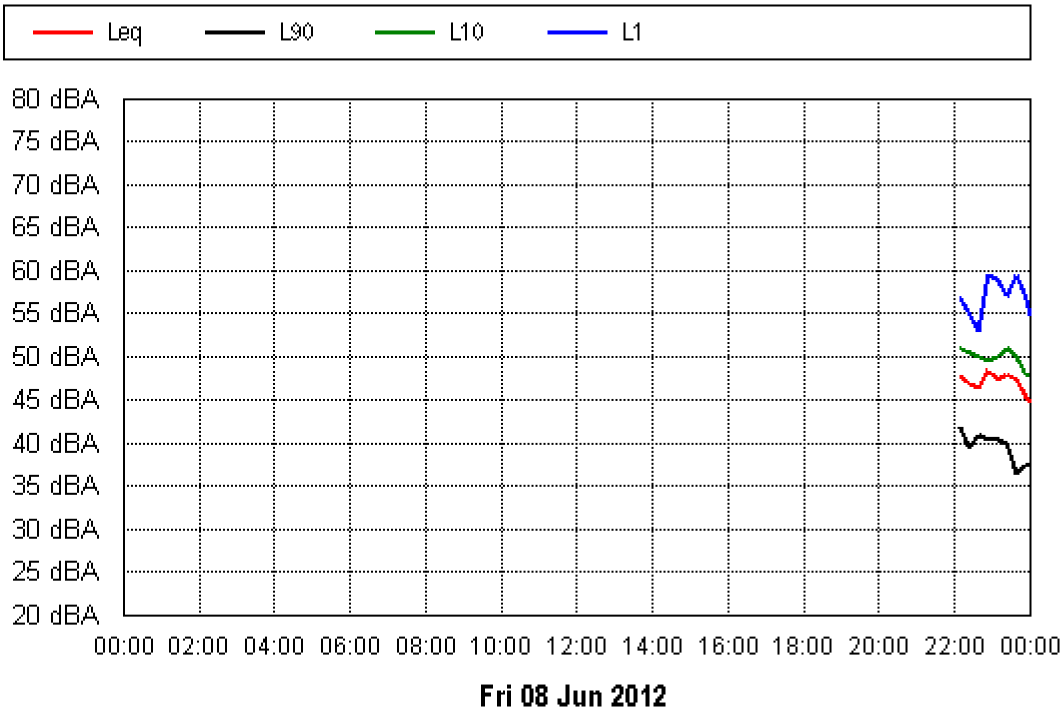

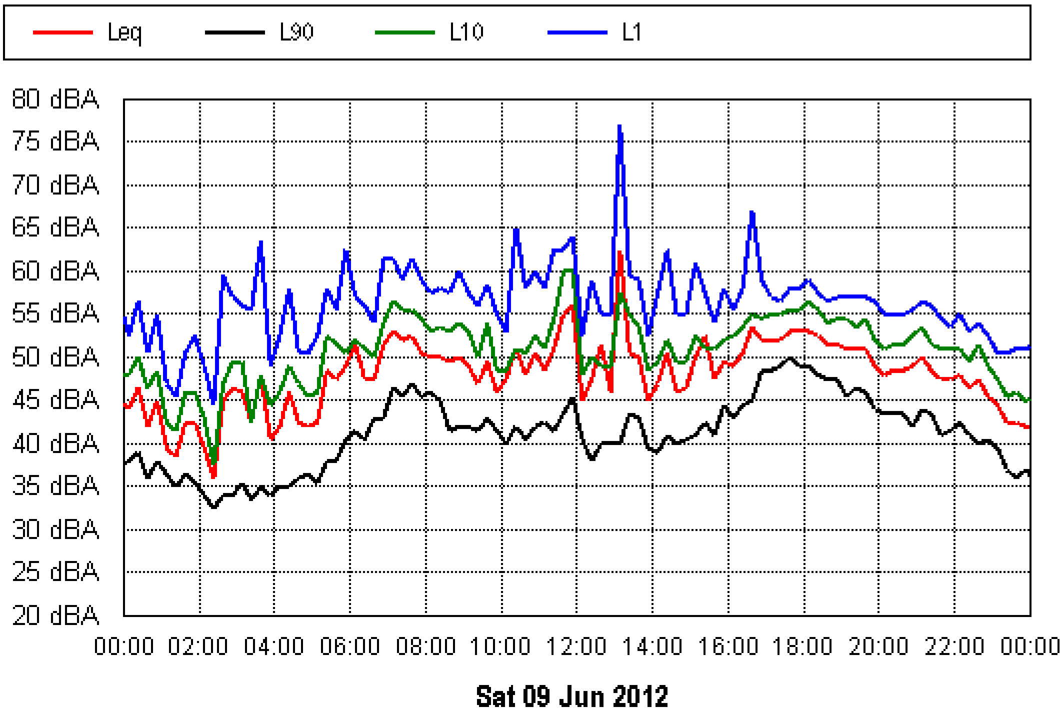

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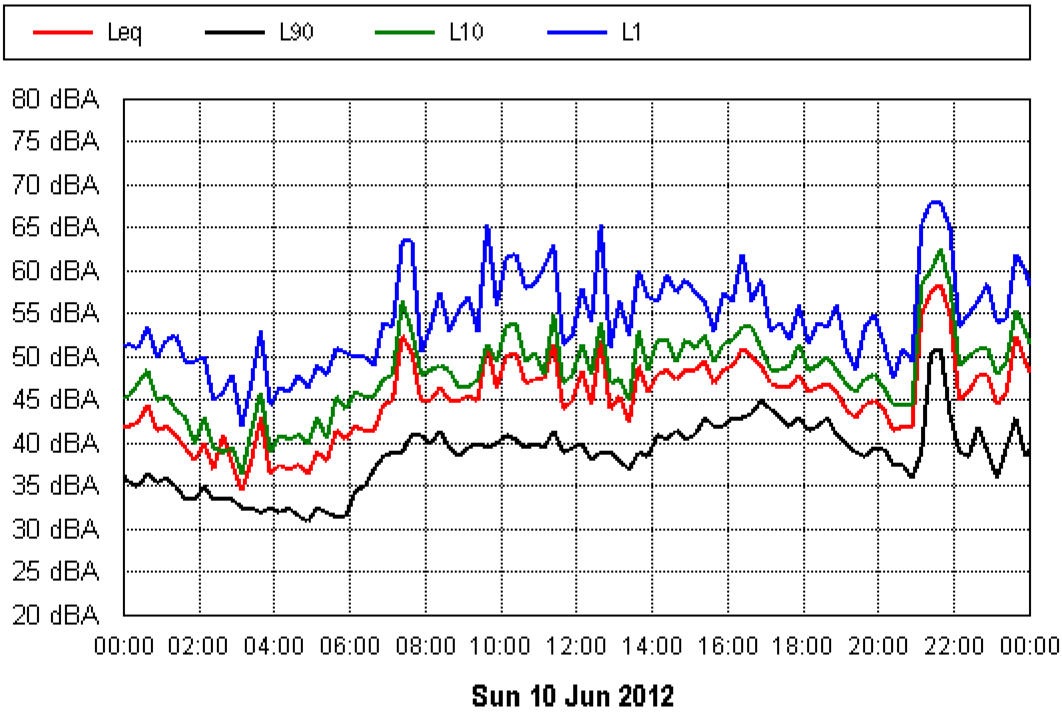

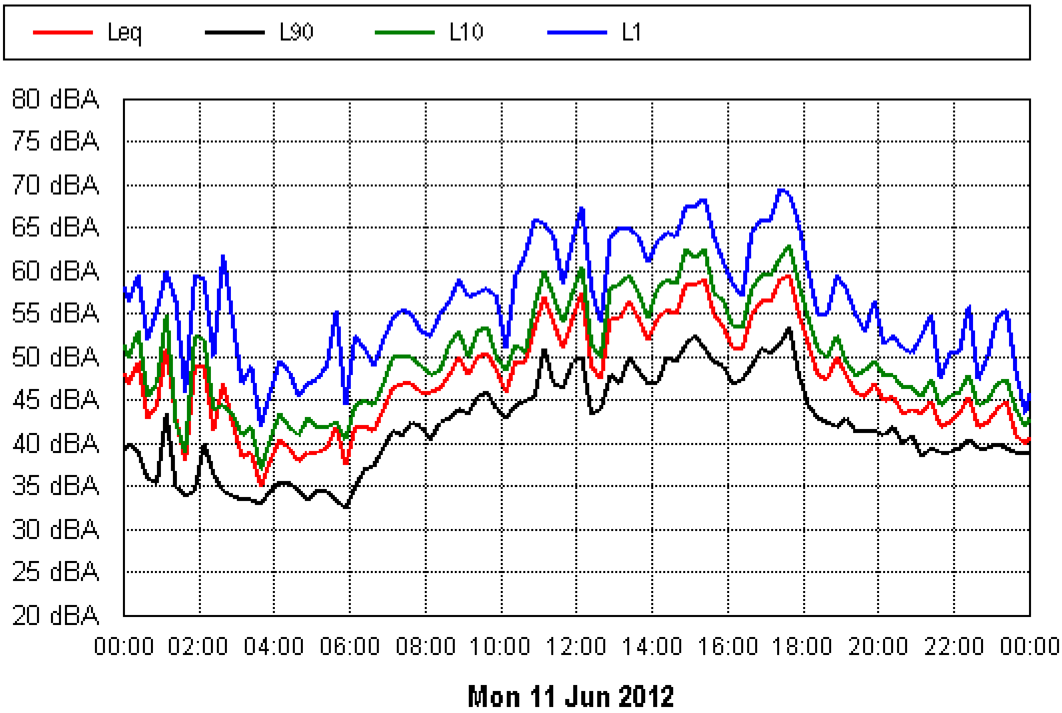

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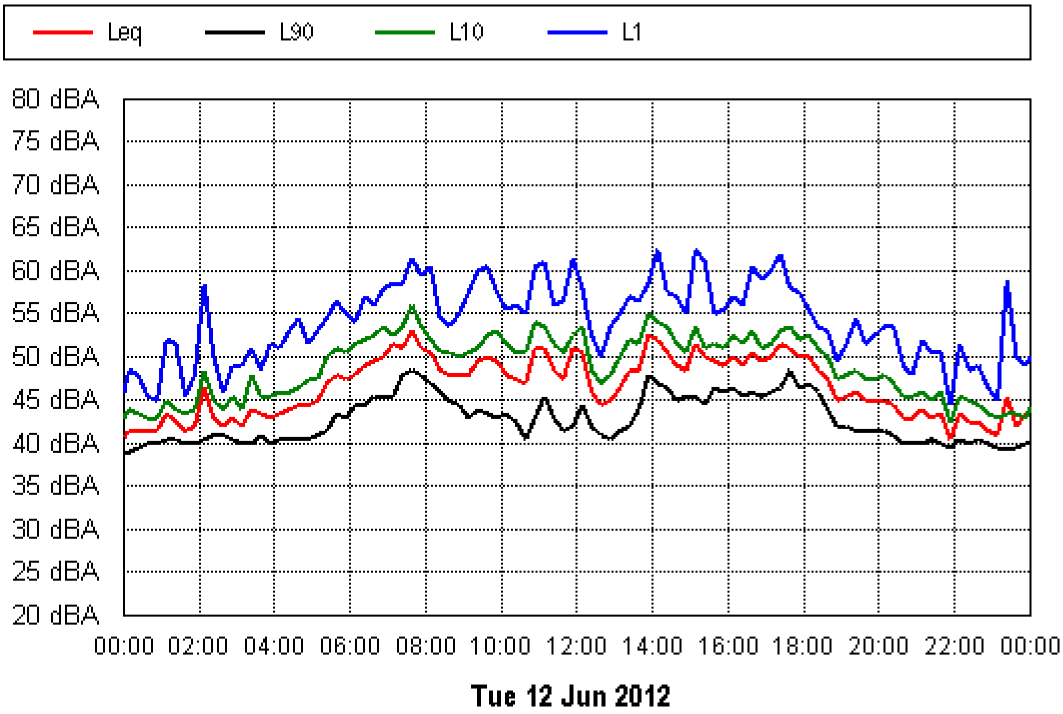

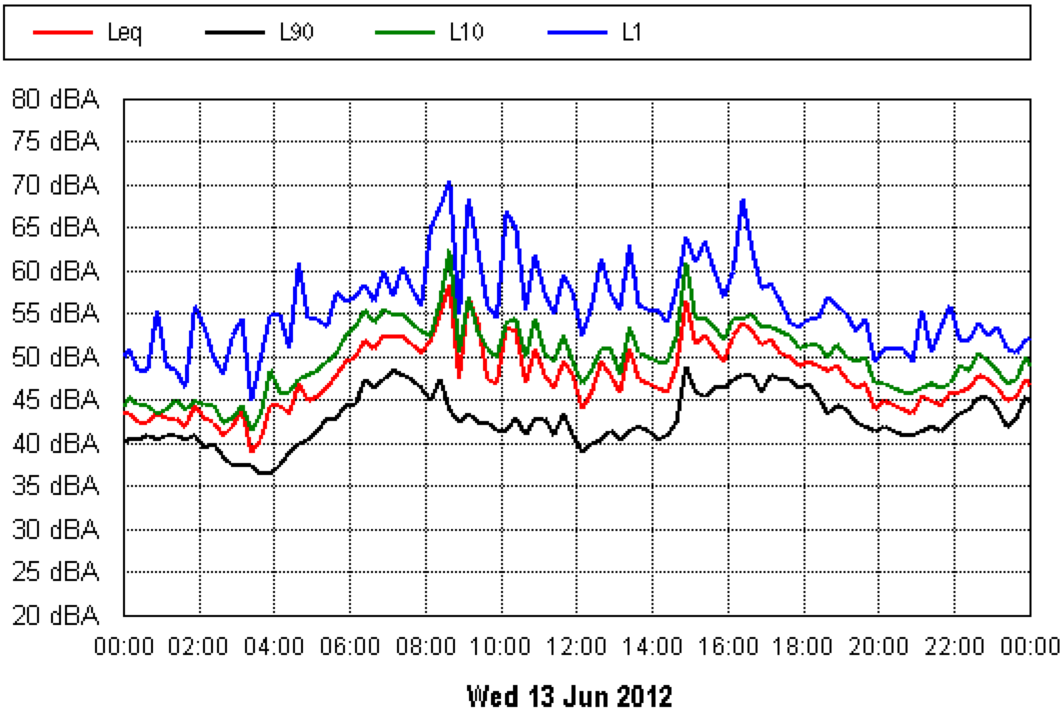

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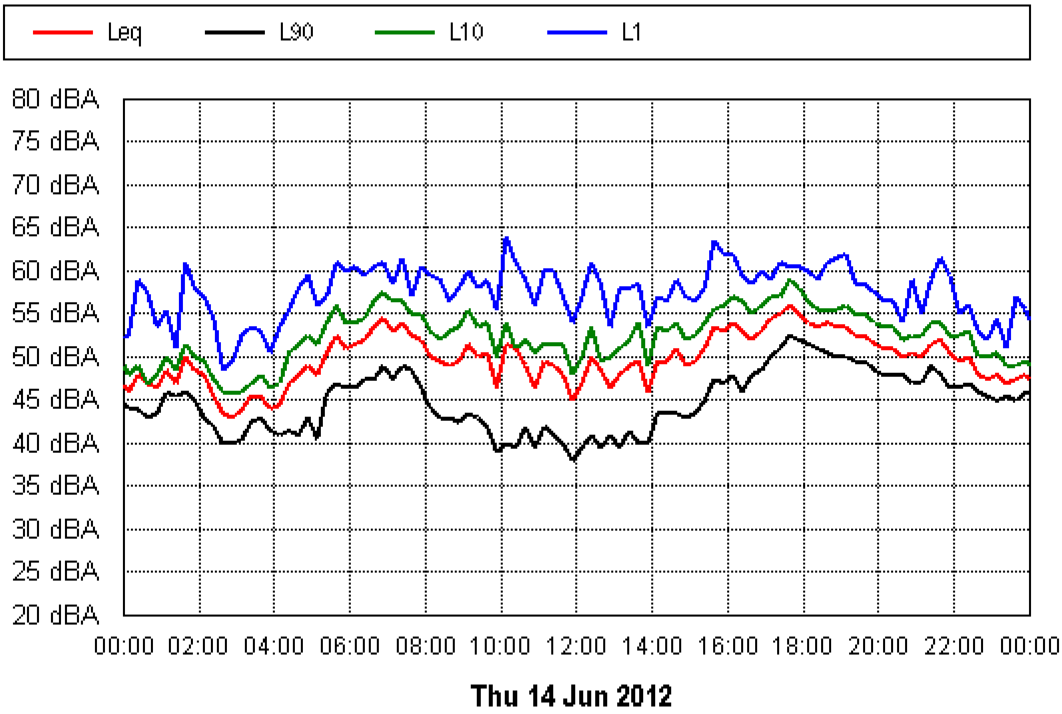

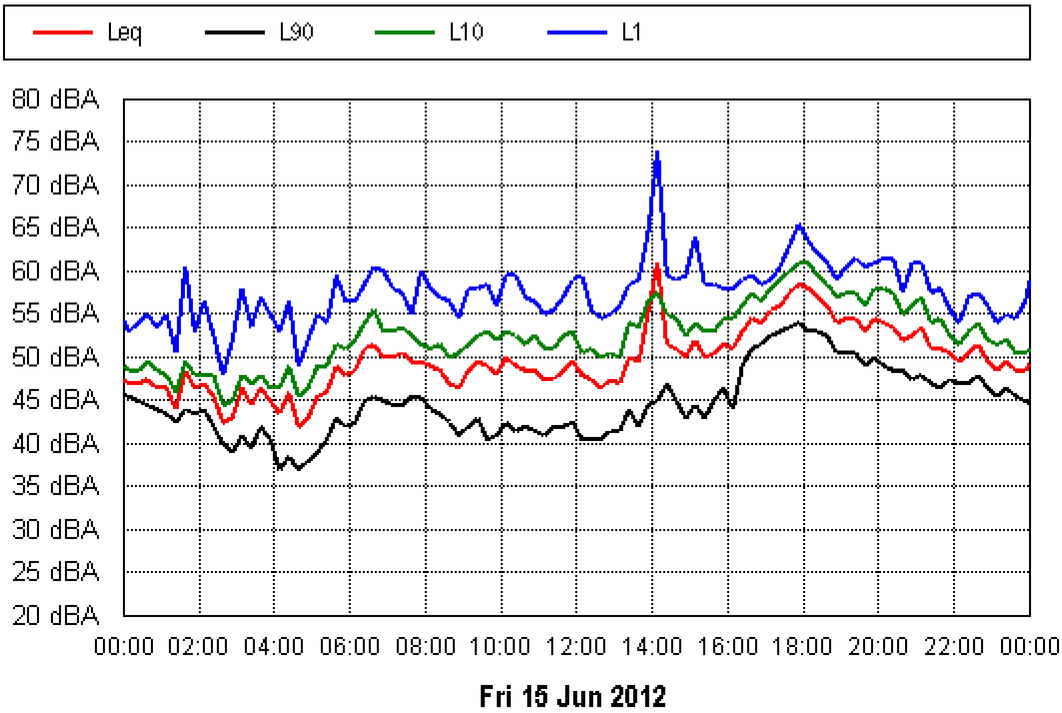

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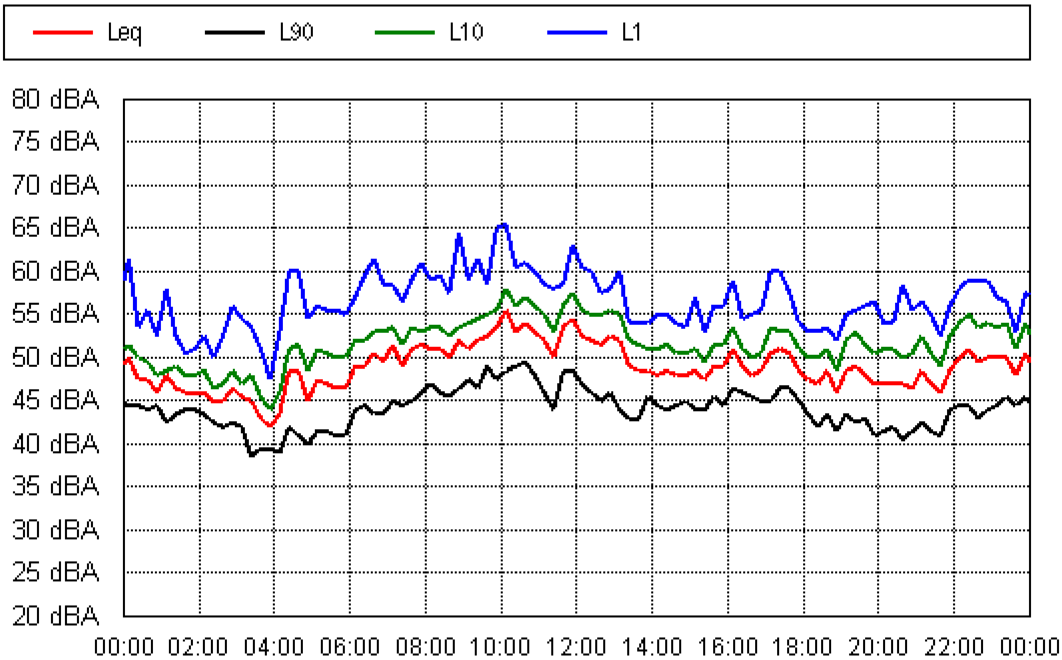

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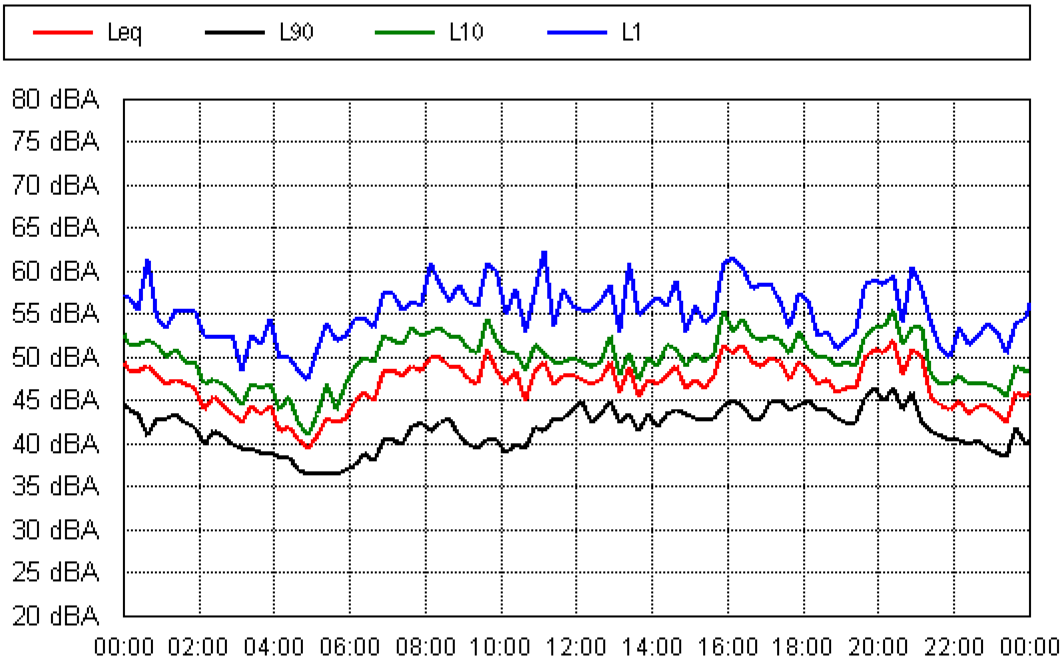

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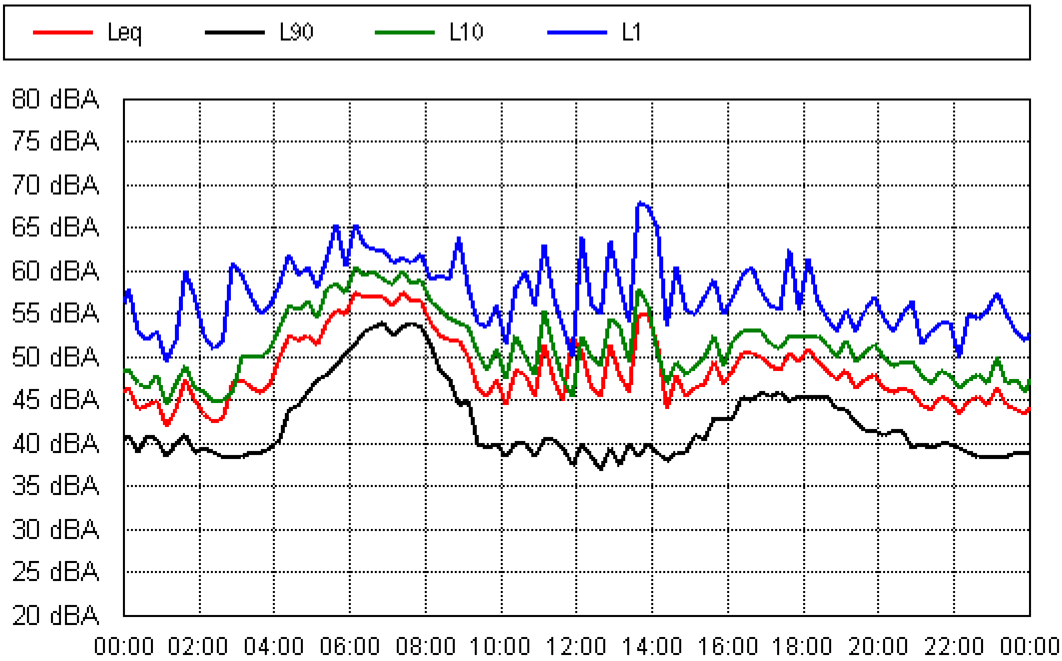

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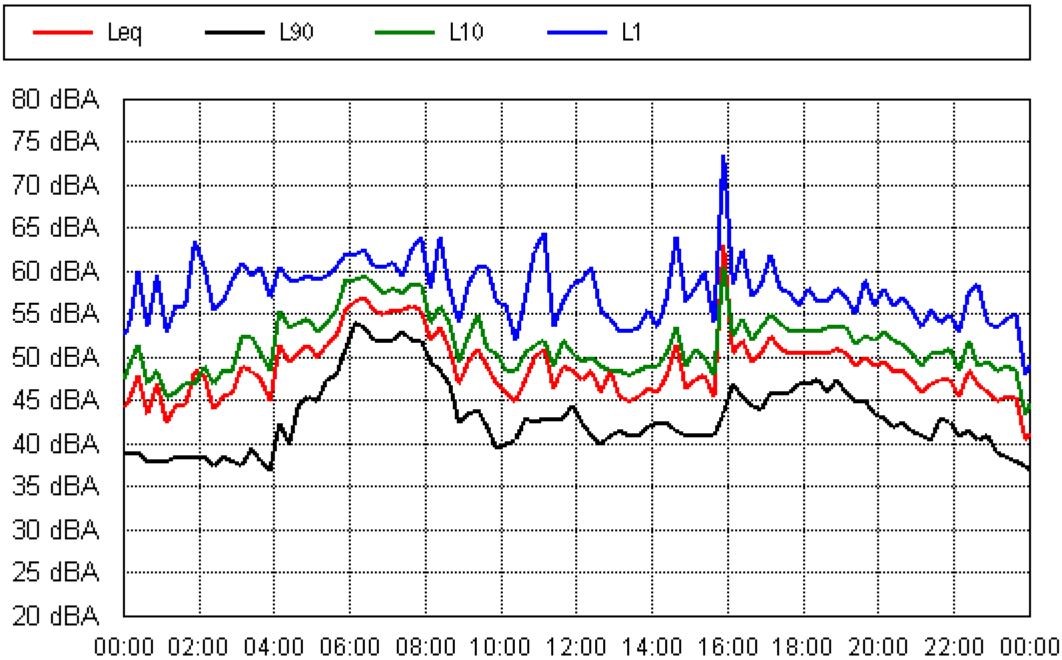

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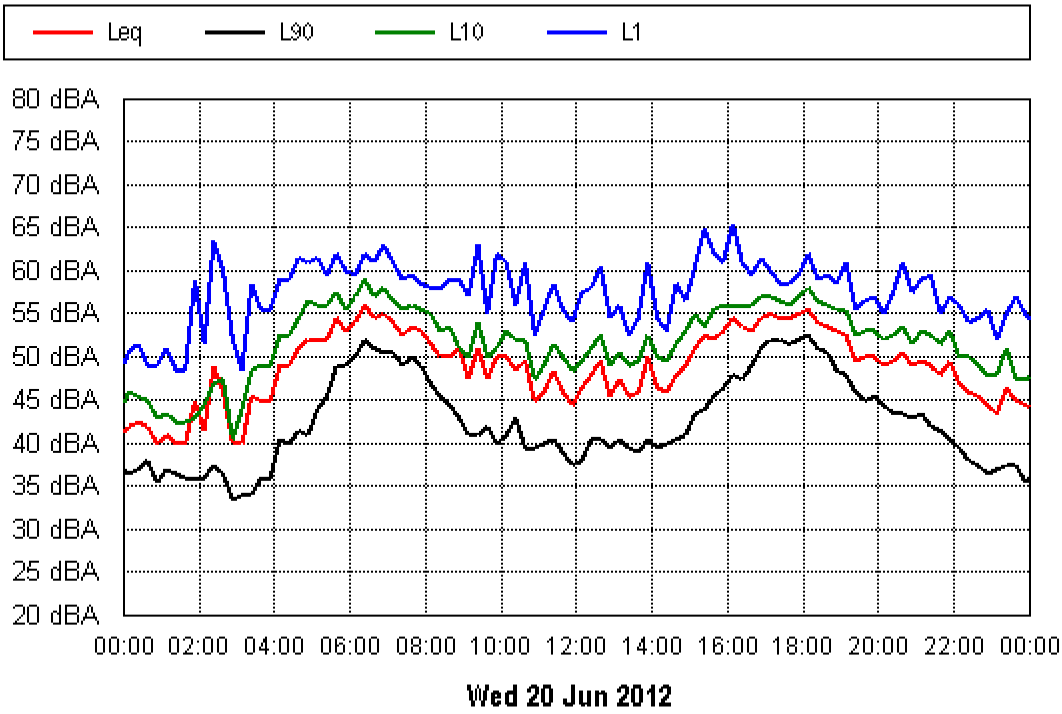

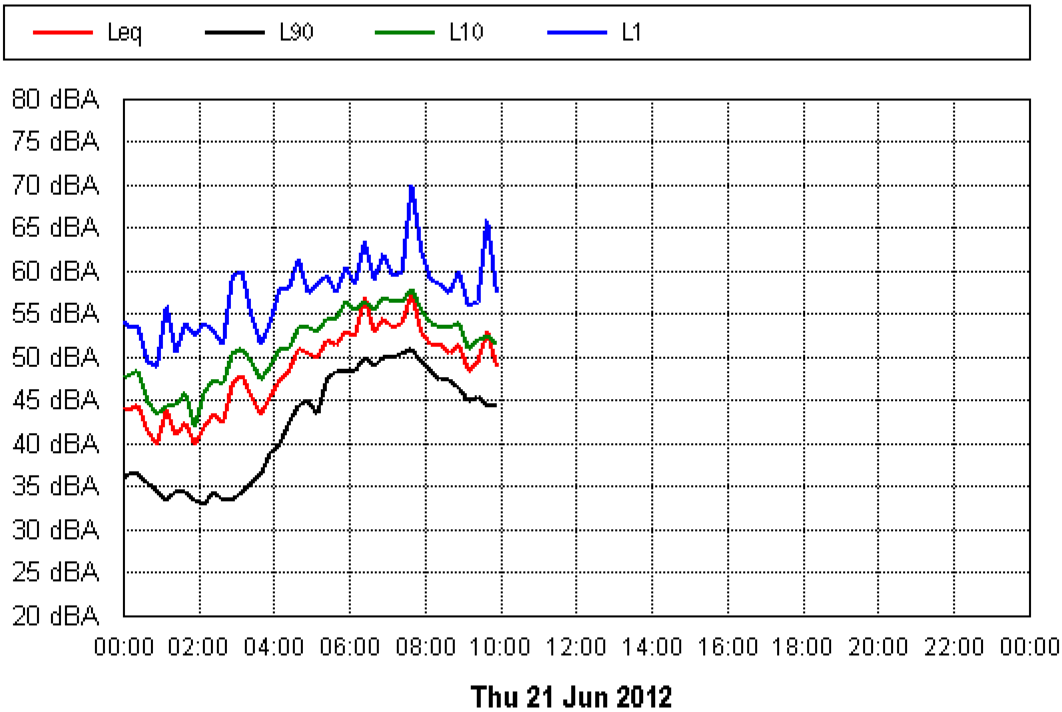

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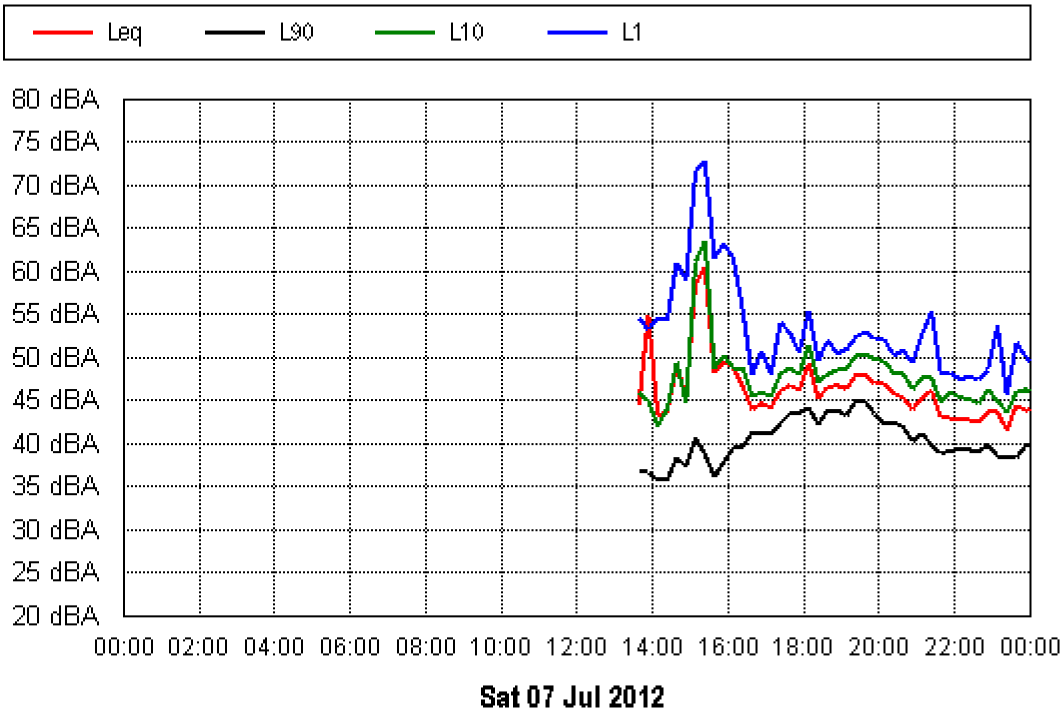
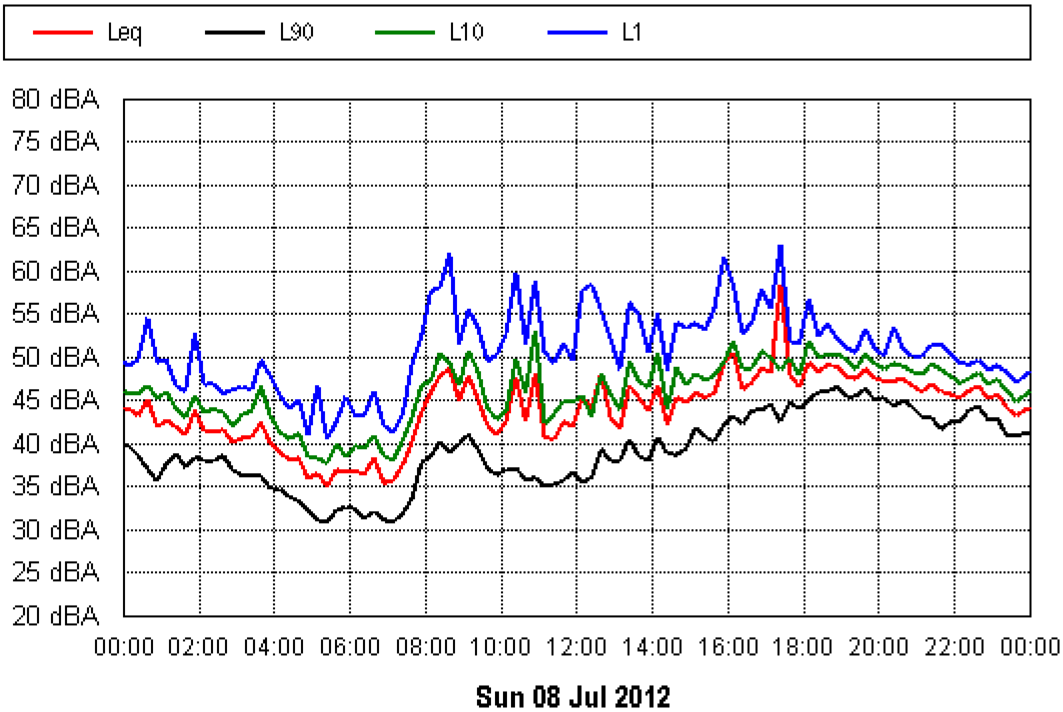
Location: 1037 Northern Road





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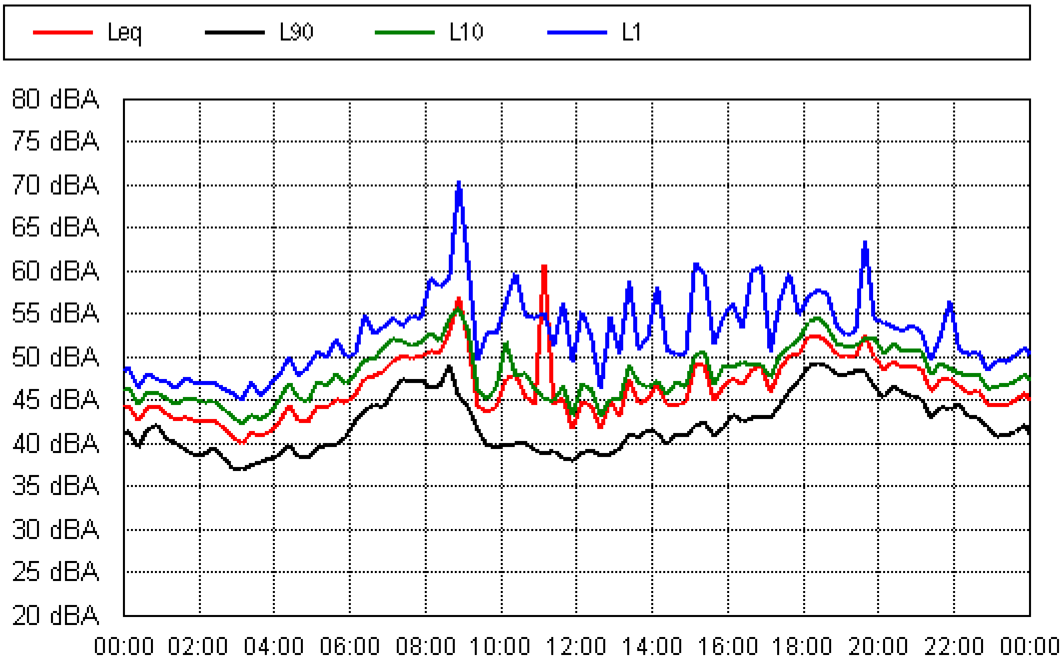
Location: 1037 Northern Road



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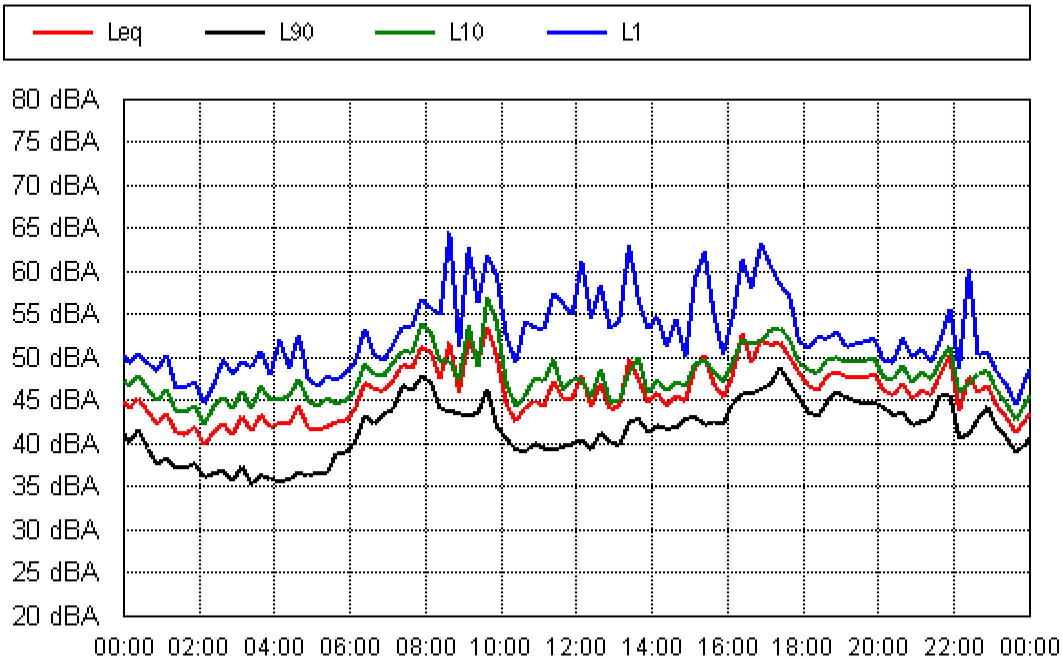

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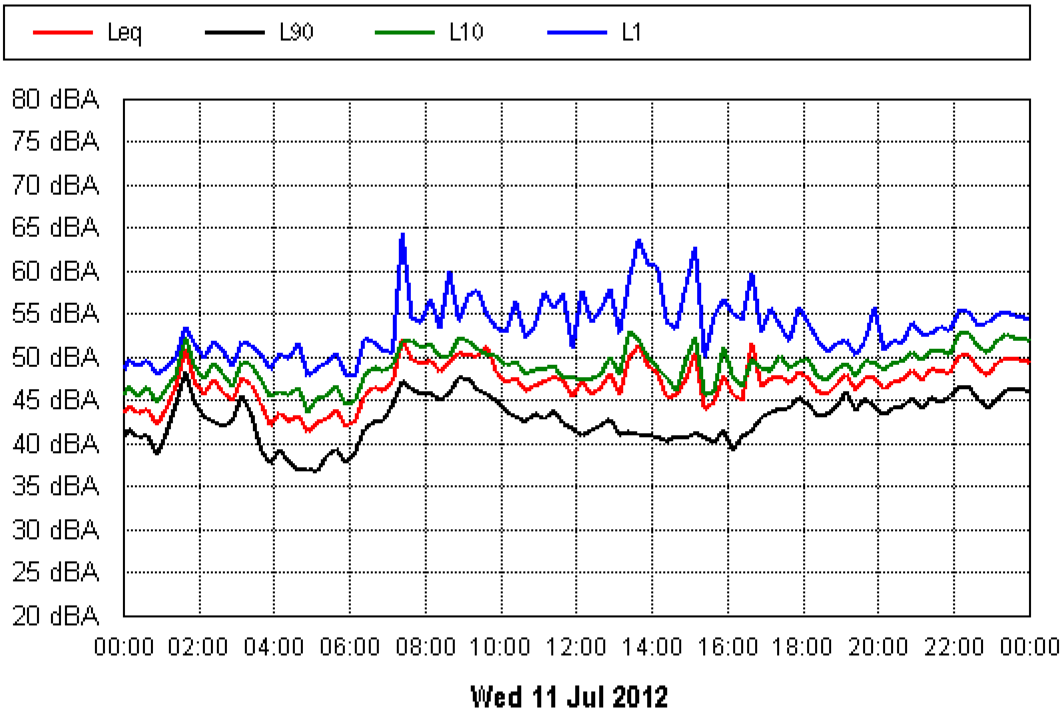

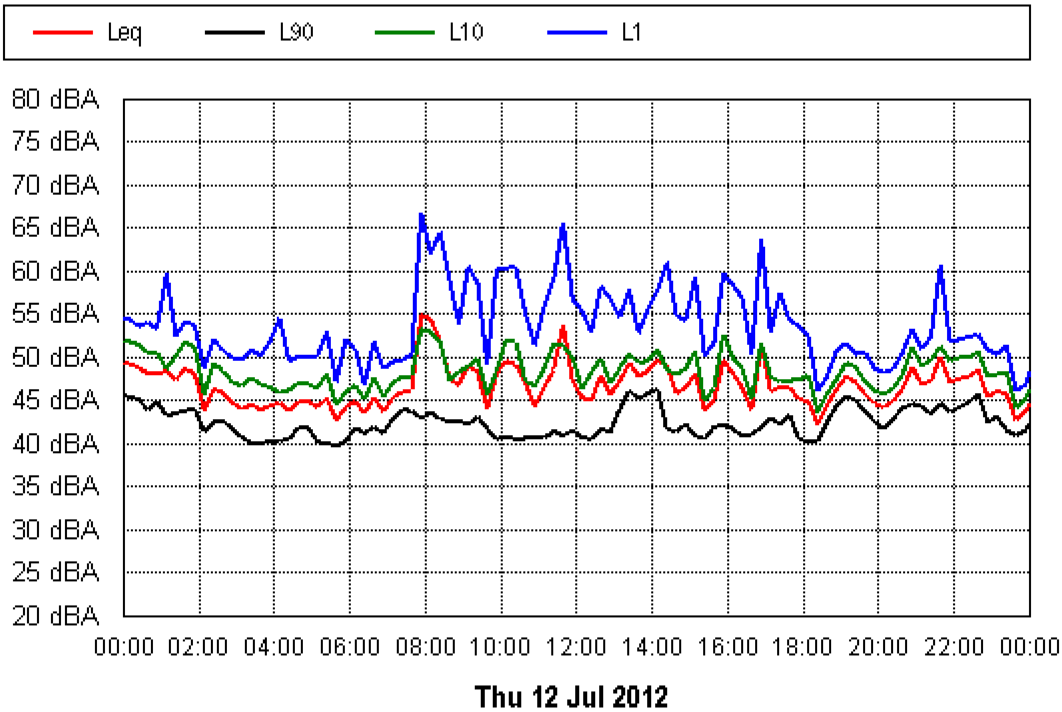

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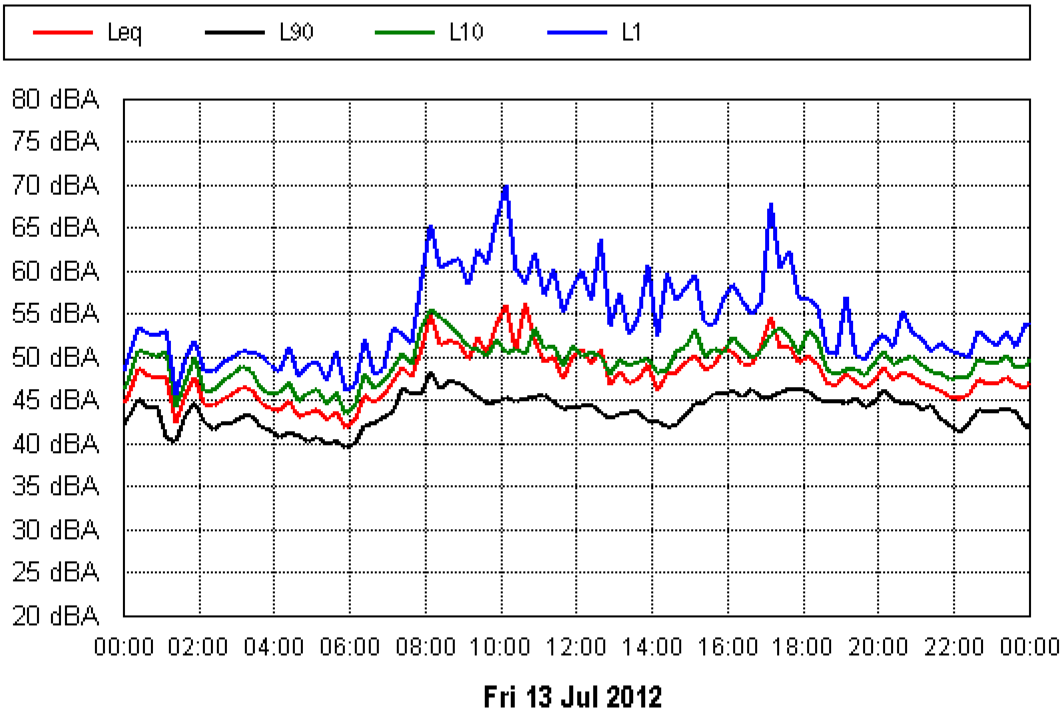
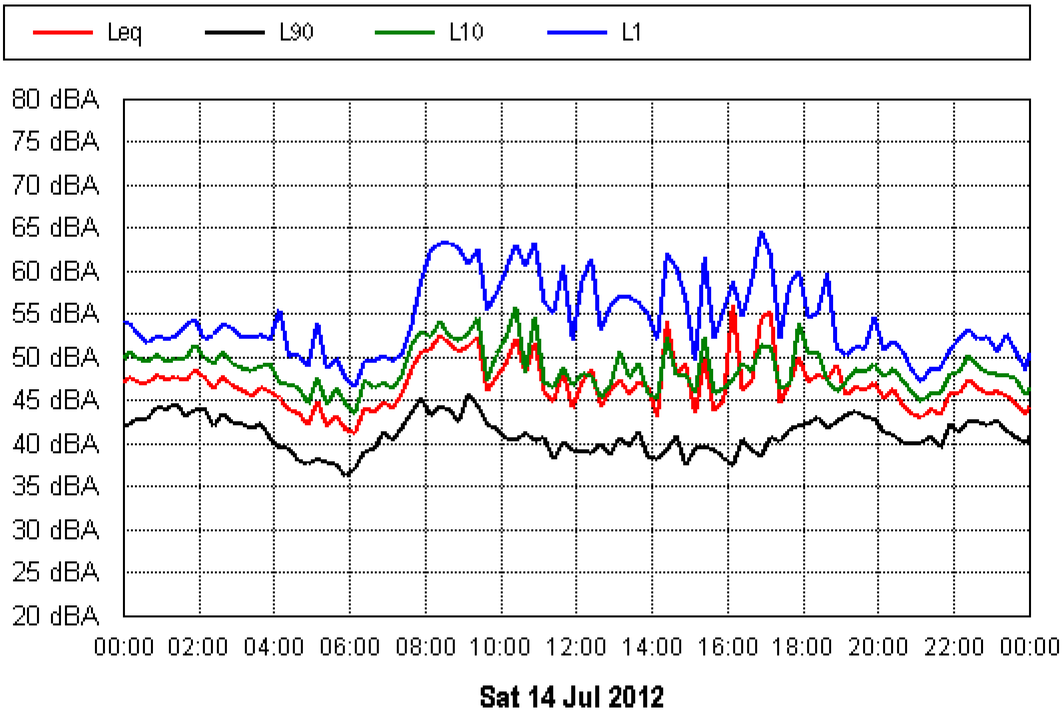
Location: 1037 Northern Road





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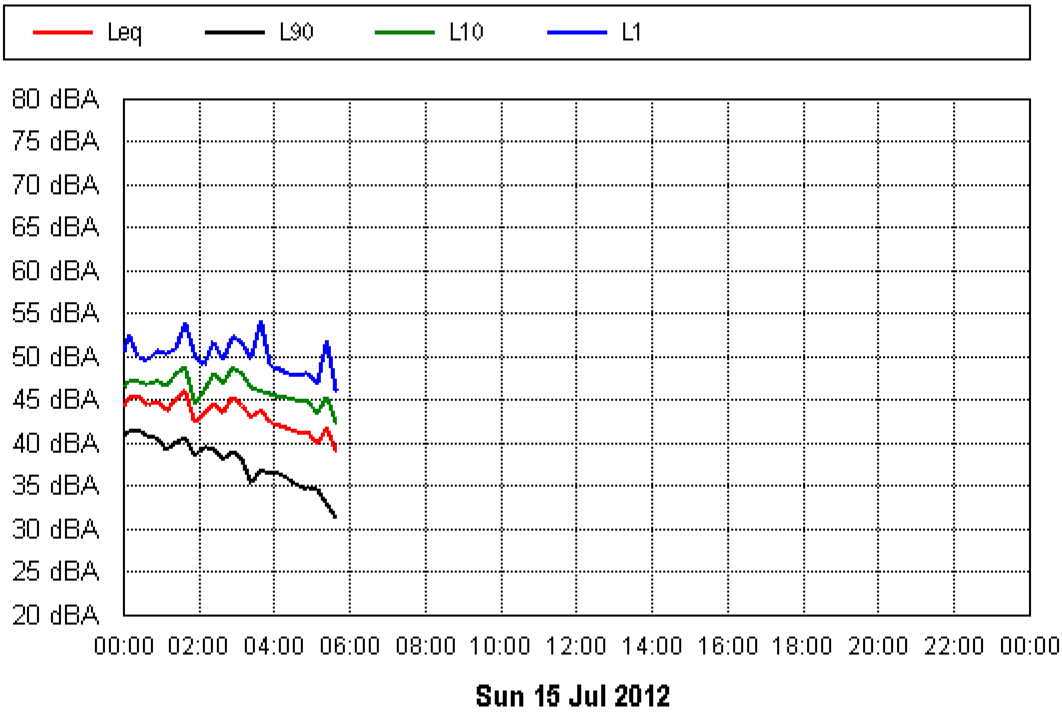

APPENDIX F

TRAFFIC IMPACT ASSESSMENT

BORAL BRINGELLY BRICKWORKS EXPANSION TRAFFIC IMPACT ASSESSMENT

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BORAL PROPERTY GROUPTY LTD

BORAL BRINGELLY BRICKWORKS EXPANSION

Traffic Impact Assessment

Author	S Manahan	
Checker	C Hutcheson	
Approver	B Searle	
Report No	F0004-AA005667-NSR-01.docx	
Date	24 June 2013	

This report has been prepared for Boral Property Group in accordance with the terms and conditions of appointment for Boral Bringelly Brickworks Expansion dated . Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

Hyder Consulting was commissioned by Boral Bricks (Boral) to undertake an Environmental Impact Assessment to support a State Significant Development (SSD) application for the proposed expansion of the Bringelly Brickworks site at 60 Greendale Road, Bringelly. The Site is located on the northern border of the Camden Council Local Government Area. It adjoins the southern boundary of Liverpool Council Local Government Area.

The Bringelly Brickworks Project Site comprises a clay preparation building, brick manufacturing plant, stockpiling areas, a product storage and delivery area, and a quarry extraction area. The brickworks site currently has development consent to operate with quarry extraction volumes of up to 200,000 tonnes per annum and brick production of 160,000 tonnes per annum. The existing development consent allows for 24 hour per day operation of the Brickworks. However, the current operating hours are 6:00 a.m. to 6:00 p.m.

1.2 LOCATION

The Boral property, on which the Bringelly Brickworks site is located, lies south of Greendale Road and covers an area of approximately 386 hectares. The surrounding area is predominantly agricultural land and fragmented rural residential, comprised of mostly one to two acre farm plots.

The location of the site is shown in Figure 1. It is within the South-West Growth Centre and forms part of the Lowes Creek and Bringelly precincts.

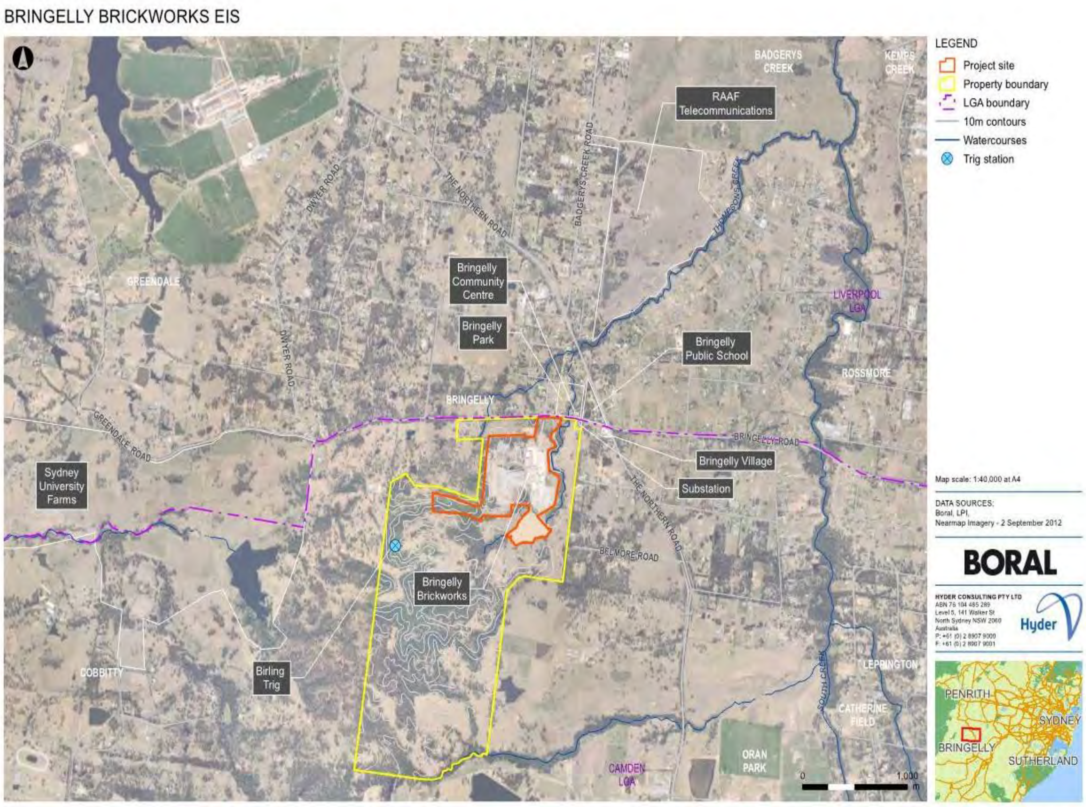

Figure 1 Site Location

1.3 ZONING

The Site is currently zoned RU1 Primary Production pursuant to Camden Council Local Environmental Plan 2010.

1.4 PROPOSED DEVELOPMENT

The current consent on the site permits quarry extraction of up to 200,000 tonnes per annum, and brick production of up to 160,000 tonnes per annum. In order to meet anticipated market demand following the mothballing of the Badgerys Creek brick making facility, Boral is now seeking to increase brick production at their Bringelly Brickworks to 263,500 tonnes per annum of bricks ï which represents an increase of 103,500 tonnes per annum. The increased brick production will require extraction of clay from a larger resource area totalling 30.65 ha.

A realignment of the access road from Greendale Road and minor extensions to the clay preparation building and brick manufacturing plant are also proposed.

1.5 PHASING AND TIMING

Market demands indicate a requirement for production to increase to 201,500 tonnes per annum by the second half of 2013, with further increase over the next 10 to 20 years to 263, 500 tonnes. The expanded quarry footprint is planned to provide enough resources to manufacture bricks at the proposed production rate for up to 30 years.

1.6 SCOPE OF THIS STUDY

This Traffic Impact Assessment report has been prepared to fulfil the Environmental Assessment Requirements issued by the Director General for development approval.

The Project DGRs for State Significant Development Bringelly Brickworks project (SSD-5684) were issued on 24 December 2012. The DGRs include the specific issues related to Traffic and Transport that will need to be addressed by the EIS with reference to:

- Guide to Traffic Generating Developments (RMS); and
- Road Design Guide (RMS).

The issues to be considered are outlined in Table 1.

Table 1 Director General Requirements

Issue Description	Relevant Section of Report
Accurate predictions of the road traffic generated by the construction and operation of the project	Section 4
An assessment of potential traffic impacts on the safety and efficiency of the road network	Section 5
A detailed description of the measures that would be implemented to maintain and/or improve the capacity, efficiency and safety of the road networks in the surrounding area over the life of the project	Section 6

1.7 REPORT FORMAT

The remainder of this report is set out as follows:

- Section 2 ï Description of Existing Transport Conditions;
- Section 3 ï Overview of the proposal for The Northern Road Upgrade;
- Section 4 ï Assessment of Traffic Generation and Distribution;
- Section 5 ï Assessment of Transport Implications; and,
- Section 6 ï Outline of Summary and Conclusion.

2 EXISTING TRANSPORT CONDITIONS

2.1 EXISTING ROAD NETWORK

2.1.1 THE NORTHERN ROAD

The Northern Road is an arterial road that links Narellan in the south with Richmond in the north, passing through Penrith LGA. It traverses predominantly rural areas, with the exception of stretches in Kingswood in Penrith LGA (Parker Street). For most of its length, The Northern Road is generally an undivided, two-lane road (both directions) with asphalt pavement.

Traffic counts conducted for the NSW Roads and Maritime Services (RMS)[1] indicate that The Northern Road at Greendale Road carries approximately 14,000 vehicles a day, of which 6% are heavy vehicles. Morning peak hour (7:00a.m. to 8:00a.m) flows are 689 vehicles while evening peak (4:00p.m. to 5:00p.m.) flows are 779 vehicles.

The speed limit on the Northern Road in the vicinity of Greendale Road is 80 km/hr.

Figure 2 The Northern Road, view looking north from the southwest corner of the intersection with Greendale Road

2.1.2 GREENDALE ROAD

Greendale Road is a two-way sealed road running westward from The Northern Road up to the Sydney University Farms where the alignment then shifts northward towards Wallacia in Penrith.

[1] Traffic and Transport Assessment, MR 154 The Northern Road Upgrade REF, SKM, August 2012

Bringelly Public School is located at the northwest corner of The Northern Road and Greendale Road intersection. There is a school zone on Greendale Road from the intersection with an associated 40 km/hr speed limit during the prescribed hours. Beyond the school zone, Greendale Road is signposted with a 60 km/hr speed limit up to 350 metres west of the brickworks access road where the speed limit increases to 80 km/h.

Figure 3 Greendale Road, view looking west from the southwest corner of the intersection with The Northern Road

Traffic surveys indicate that Greendale Road carries approximately 1,500 vehicles per day. The morning peak hour was recorded to take place between 8:00AM to 9:00AM with an average weekday volume of 103 vehicles per hour and the peak direction is eastbound. The evening peak was 4:00PM. to 6:00PM, with an average weekday volume of 130 vehicles per hour and the peak direction is westbound.

2.1.3 MEDWAY ROAD

Medway Road is a local road that provides access to some low density residential properties on the northern side of Greendale Road, directly opposite the access entrance to the Bringelly Brickworks Project Site. It is a two-way and signposted as a ñNo Through Roadò.

Figure 4 Medway Road, view looking north

2.2 EXISTING TRAFFIC FLOWS (PEAK HOUR VOLUMES)

Morning and evening peak hour traffic counts were conducted at the Greendale Road / The Northern Road / Bringelly Road intersection in June 2012. The morning and evening peak hour traffic flows (8:00 ï 9:00 AM and 4:00 ï 5:00 PM) are shown in Figure 5.

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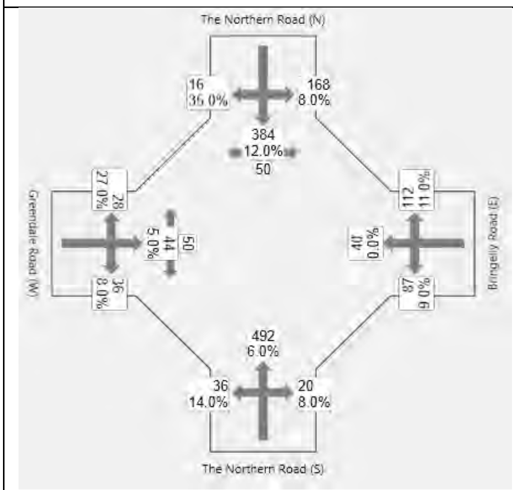
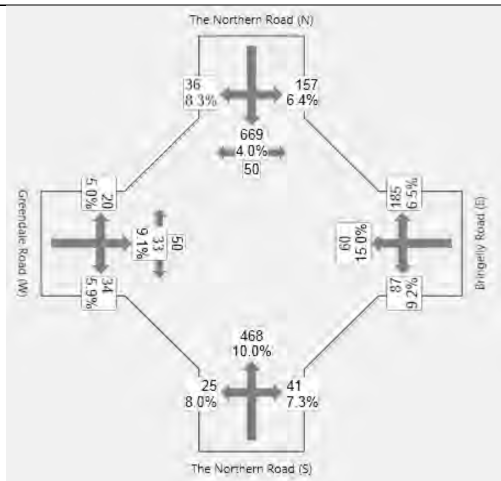
<tr><td>
</td><td>
</td></tr>
<tr><td>36 ï Total vehicles
14.0% - Percent heavy vehicles</td><td>36 ï Total vehicles
14.0% - Percent heavy vehicles</td></tr>
</table>

Figure 5 Existing Peak Hour Intersection Turning Volumes (2012)

2.3 EXISTING INTERSECTION PERFORMANCE

The performance of the existing road network is largely dependent on the operating performance of the key intersections which are critical capacity control points on the road network.

The criteria for evaluating the operational performance of intersections are provided by the *RMS Guide to Traffic Generating Developments, Version 2.2, October 2002*. The criterion is based on a qualitative measure (i.e. Level of Service), which is applied to each average delay band.

The óLevel of Serviceôis the standard used to measure the performance of the intersection operation. This is defined as the qualitative assessment of the quantitative effect of factors such as speed, traffic volume, geometric features, delays and freedom of movement.

Table 2 summarises intersection Level of Service criteria used to assess intersection performance.

Table 2 Level of Service Criteria for Intersection Performance

Level of Service	Average Delay per Vehicle (sec/veh)	Traffic Signals, Roundabout	Give Way & Stop Signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays & spare capacity	Acceptable delays & spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode	At capacity, requires other control mode
F	>70	Unsatisfactory with excessive queuing	Unsatisfactory with excessive queuing

SIDRA Intersection modelling was undertaken to assess the existing operational performance of the key access intersection at The Northern Road / Bringelly Road / Greendale Road. SIDRA predicts intersection performance for the following key parameters:

- Degree of saturation (DoS);
- Average delays to intersection;
- Level of service (LoS) determined from LoS criteria; and
- Queue length.

Table 3 below presents a summary of the results of the intersection analysis.

Table 3 The Northern Road/Greendale Road/Bringelly Road - Existing Intersection Performance (2013)

Time Period	Intersection Control	Average Delay [1] (sec/veh)	LoS [2]
Morning Peak Hour (8.00 to 9.00 AM)	Signals	20.9	B
Evening Peak Hour (4.00 to 5.00 PM)	Signals	27.2	B

Notes:

[1] The average delay for signalised intersection is taken over all movements.

[2] The level of service for signalised intersection is based on the average delay per vehicle for all movements during peak conditions.

From Table 3 it can be seen that the intersection of The Northern Road with Greendale Road and Bringelly Road currently operates satisfactorily with a Level of Service B

2.4 ROAD SEGMENT (MID-BLOCK) OPERATION

The capacity of the urban roads is generally determined by the capacity of the intersection. However an assessment of mid-block lane capacity is required to provide an indication of the ability of the approach roads to carry additional traffic for strategic planning purposes.

Greendale Road is a two-lane rural road based on the Austroads Road Classification hierarchy. The AUSTROADS *Guide to Traffic Engineering Practice - Part 2: Roadway Capacity* indicates that two-lane rural roads have a capacity of 2,800 passenger cars per hour total for both directions of flow, under ideal conditions where there are no restrictive roadway, terrain or traffic conditions. The current traffic volume along Greendale Road is around 1,500 vehicles per day (2 way).

Austroads defines level of service as a qualitative measure describing operational conditions within a traffic stream. The term Level of Service (LOS) and its characteristics for rural roads is defined in Table 4.

Table 4 Level of Service Criteria for Rural Road

LOS	Description	Rating
A	Free, restrictive flow	Very good
B	Mostly free flow, few disruptions	Very good
C	Stable flow	Good
D	Mostly stable flow, some delays	Acceptable
E	Congested flow, delays common	Bad
F	Forced flow	Bad

Source: Austroads Guide to Traffic Engineering Practice, Part 2

The volume and composition of traffic on a given road determines the level of interaction between vehicles and is measured as its LOS. LOS decreases with increasing traffic volumes. In a rural context LOS A, LOS B, LOS C are all considered satisfactory. LOS D can be satisfactory in some circumstances.

Table 5 provides the traffic flow limits for different levels of service, in terms of peak hour flows for one and two lanes of unidirectional travel. Level of Service is used as a performance standard to assess the effect of a development proposal on the traffic efficiency of the road network

Table 5 Maximum AADTs for Various Levels of Service on Two-Lane Two-Way Rural Roads on Level Terrain

% Peak Hour Flows (Design Hour Volume to AADT Ratio)	Level of Service				
	A	B	C	D	E
0.10	2,400	4,800	7,900	13,500	22,900
0.11	2,200	4,400	7,200	12,200	20,800
0.12	2,000	4,000	6,600	11,200	19,000
0.13	1,900	3,700	6,100	10,400	17,600
0.14	1,700	3,400	5,700	9,600	16,300
0.15	1,600	3,200	5,300	9,000	15,200

Source: AUSTROADS Guide to Traffic Engineering Practice, Part 2: Roadway Capacity, Table 3.9

The peak hour volumes along Greendale Road are 11.3% of the average daily traffic. With an AADT of 1,500 vehicles per day, the level of service is equivalent to LoS A and indicates that Greendale Road has spare capacity to accommodate additional traffic.

2.5 ADJACENT LAND USES

2.5.1 RESIDENTIAL USES IN FRONT OF EXISTING DRIVEWAY

There are rural residential land uses in the immediate vicinity of the existing access road to the Brickworks site. The dwellings are in close proximity to the site and may be impacted by noise attributed to truck movements to and from the access road.

2.5.2 BRINGELLY PUBLIC SCHOOL

Bringelly Public School is located at the northwest corner of The Northern Road and Greendale Road intersection. Drop off and pick up activities occur on both sides of Greendale road near the pedestrian entrance to the school grounds. The RMS has installed flashing lights on the school zone to reinforce the 40 km/hr speed limit during the prescribed hours. Camden Council has also recently installed a pedestrian refuge to facilitate safe pedestrian crossing on Greendale Road for school children and people accessing the school.

During the usual hours of drop off and pick-up, cars are parked on both sides of Greendale Road. Trucks travelling on Greendale Road during these hours need to cross over towards the centre to maintain adequate distance from the parked vehicles.

2.5.3 BRINGELLY RECREATION RESERVE

Bringelly Recreation Reserve is located off Greendale Road opposite the Boral site. It has facilities for football and netball. It is currently used by Bringelly Sports Club for training and weekend games. The Club has advised that games generally occur on Saturdays from 9.00 am to 12.00 noon. Parking is generally accommodated within the grounds of the reserve and does not typically extend to Greendale Road. An on-site inspection was conducted on Saturday 4 May 2013. No adverse conflicts were observed between the Boral operations and people accessing the sports field.

2.6 SITE ACCESSIBILITY

The main entry to the Project Site is currently provided at the intersection of Greendale and Medway roads. The access road is a two-way sealed road that leads to the main entrance of the Bringelly Brickworks.

2.7 PUBLIC TRANSPORT

There are currently no public transport services in the immediate vicinity of the site. The nearest service is a bus service that runs between Bringelly and Liverpool. Bus Route 856 is operated by Busabout. It links Bringelly with Liverpool via Prestons and Churchill Gardens. It runs along the Northern Road, Bringelly Road, Ingleburn Road, Camden Valley Way and The Hume Highway. Service frequency is limited to five bus trips per direction each weekday, four trips per direction on Saturdays and three trips per direction on Sundays and public holidays.

The closest bus stop for the direction towards Bringelly is located on the Northern Road at Bringelly Public School just north of the intersection of The Northern Road and Greendale Road. The closest bus stop for the direction towards Liverpool is located on Bringelly Road just east of the intersection with The Northern Road.

2.8 CYCLE AND PEDESTRIAN

There are no dedicated pedestrian and cycle facilities in the immediate vicinity of the site. There is a pedestrian footpath on the northern side of Greendale Road running west from The Northern Road for approximately 320 metres. In the vicinity of Greendale Road, The Northern Road has a pedestrian footpath on the western side.

2.9 ROAD SAFETY

The crash history[2] of the existing road network has been reviewed to accurately assess the existing conditions and safety of road in the vicinity of the Bringelly Brickworks site. The key findings from crash data from 2006 to 2010 are:

- One crash occurred in the immediate vicinity of the entrance to the site,
- Over the 5 year period a total of four crashes were recorded to have occurred in the vicinity of The Northern Road/ Bringelly Road/ Greendale Road intersection,
- With a total of 4 crashes over 5 years there has been 0 fatality.
- There were no accident clusters at the intersection for the 5 year period.

The crash data did not indicate significant safety issues over the 5 year period in the immediate vicinity of the site.

[2] GTA obtained vehicle crash data from RMS in the vicinity of the entrance to the Bringelly Brickworks site on Greendale Road and the intersection of the Northern Road/Bringelly Road/Greendale Road. Crash data for 100 metres on all approaches to these intersections was obtained.

3 THE NORTHERN ROAD UPGRADE

3.1 OVERVIEW

The future upgrade of the Northern Road is being proposed by the NSW Roads and Maritime Authority (RMS) in conjunction with the development of the South West Growth Centre. The upgrade covers 15 kilometres of The Northern Road between The Old Northern Road at Narellan and Mersey Road at Bringelly. It involves conversion from a two lane undivided road to a four lane divided road (twin carriageways separated by a wide central median) with an allowance for then developing a six-lane divided road. The length of The Northern Road covered by the upgrade includes thirteen major intersections including the intersection of The Northern Road with Greendale Road and Bringelly Road. The upgrade will be undertaken in stages as developments along The Northern Road are approved and precincts within the South West Growth Centre are developed.

The REF for the upgrade of the Northern Road states that "Greendale Road would be upgraded for a distance of 285 metres. A pick up/drop off bay would be provided for Bringelly Public School on Greendale Road, 165 metres from The Northern Road". This is shown as a u-turn around facility on the southern side of Greendale Road. It is understood that this proposal in the REF has not been confirmed and that Liverpool Council has questioned the suitability of its location. Regardless, the future provision of pedestrian and drop off / pick up facilities for the school does not influence the new access arrangements or the outcomes of this current application.

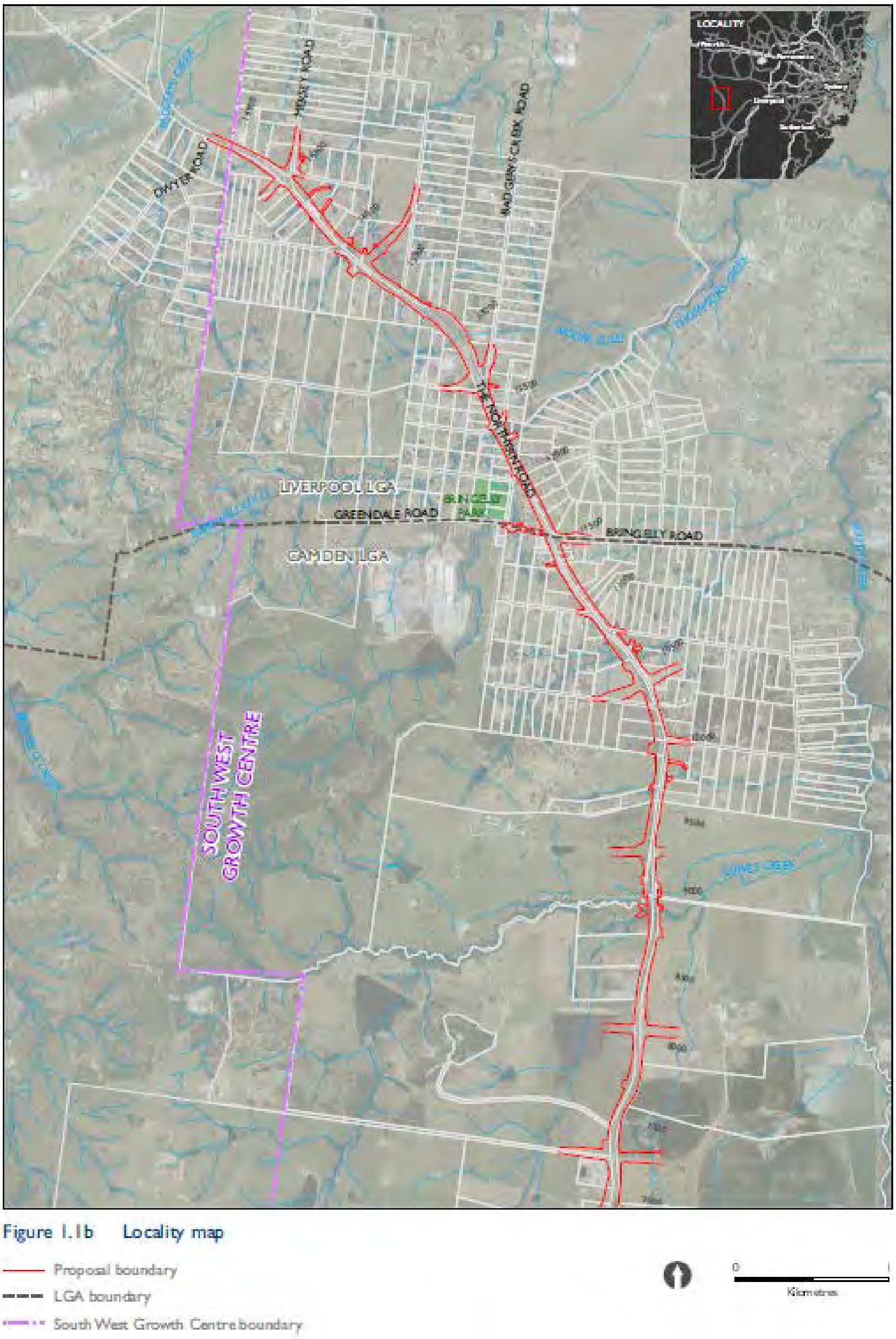


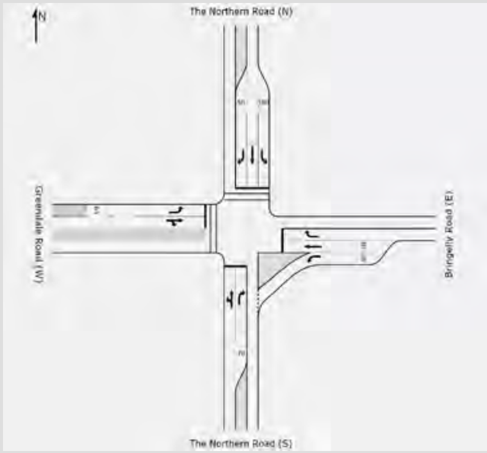
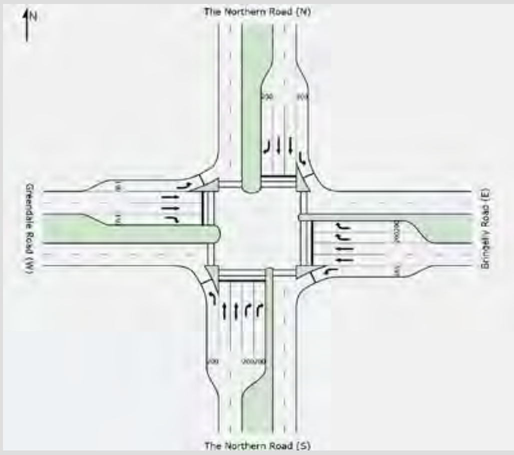
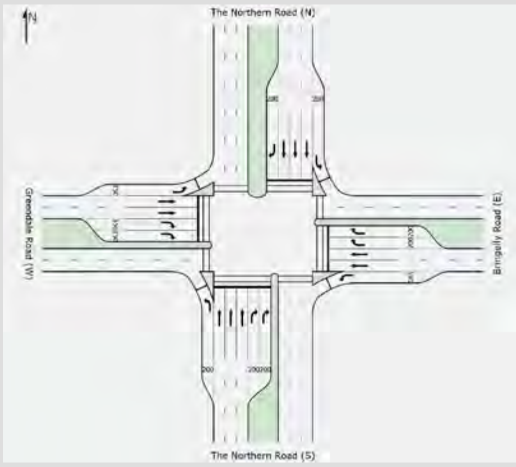
Figure 6 The Northern Road Upgrade

3.2 CONCEPT DESIGN AND STAGING

The Concept Design for The Northern Road includes an indicative staging of the upgrade as shown in Table 6. The staging of the concept design and the proposed intersection configurations for key intersections along the corridor is based on forecast traffic flows contained in the REF for The Northern Road Upgrade.

Although the timing of the upgrade will be determined by future land releases and the availability of funds, the proposal is expected to progress to detailed design stage following the exhibition of the Review of Environmental Factors and revised concept design in October 2012. The proposed intersection layouts for the Northern Road/Bringelly Road/Greendale Road for the design years 2016, 2026 and 2036 were modelled for the future scenario traffic assessment of the Bringelly Brickworks expansion proposal.

Table 6 The Northern Road Concept Design Stages

Design Year	Staged Works	Intersection Configuration for The Northern Road/Bringelly Road/Greendale Road
2016	<u>No change at Greendale Road</u> The corridor south of Bringelly Road to be progressively upgraded to a four lane divided carriageway configuration. However there will be no change in the vicinity of The Northern Road / Bringelly Road / Greendale Road intersection.	
2026	<u>Upgrade at Greendale Road</u> The section from Bringelly Road to Badgerys Creek Road to be progressively upgraded to a four lane divided carriageway configuration while the section from Badgerys Creek Road to Mersey Road intersections to remain in their existing lane configuration and intersection layouts	
2036	<u>Upgrade at Greendale Road</u> The sections of The Northern Road between Badgerys Creek Road and Mersey Road intersections to be upgraded to a four lane divided carriageway configuration. The remainder of the corridor south of Badgerys Creek Road to be progressively upgraded to a six lane divided carriageway configuration	

4 TRAFFIC GENERATION AND DISTRIBUTION

4.1 TRAFFIC GENERATION DURING OPERATION

Traffic generation for the Site is estimated on the basis of existing operations and the proposed expansion. The vehicle movements anticipated as a result of an increase in brick production to 263,500tpa, will consist of light vehicle (employee/staff travel) movements and truck movements.

4.1.1 STAFF / EMPLOYEE MOVEMENTS

Although the existing consent allows for 24-hour operations at the brickworks, the current brick production is undertaken from 6:00 a.m. to 5:00 p.m. The number of staff currently employed by the brickworks is 38. 24 of the employees work on a four day on/ four day off shift basis undertaking 11 hour shifts on any one day. Up to 26 employees are present on the site at any one time.

The proposed expansion will require the manufacturing and brick making process to operate on a 24-hour basis. An additional 34 employees will be required, bringing the total employee base to 72. 56 of the employees will work on the 12 hour four day on / four day off shift basis. Up to 44 employees will be present on the site at any one time.

Table 7 presents the existing and proposed staff numbers by type and shift.

Table 7 Existing Staffing and Staffing with Proposed Development

Unit	Shift	Existing Staff	Staff With Proposed Development	Work Hours
Production Wages/Salaries	Day Shift (Monday to Sunday) 4 days on/4 days off roster; 10 employees per roster	10	10	6:00 AM ï 6:00 PM
Production Wages/; Salaries	Night Shift (Monday to Sunday) 4 days on/4 days off; 10 employees per roster		10	6:00 PM ï 6:00 AM
Maintenance Wages	Day Shift (Monday to Sunday) 4 days on/4 days off; 2 employees per roster	2	2	6:00 AM ï 6:00 PM
Maintenance Wages	Night Shift (Monday to Sunday) 4 days on/4 days off; 2 employees per roster		2	6:00 PM ï 6:00 AM
Maintenance	Day Shift (Monday to Sunday) 4 days on/4 days off; 4 employees per roster		4	6:00 AM ï 6:00 PM

Unit	Shift	Existing Staff	Staff With Proposed Development	Work Hours
Maintenance Salaries	Monday ï Friday & Saturday	6	4	6:00 AM ï 6:00 PM
Management and Support Staff	Monday ï Friday & Saturday	6	4	6:00 AM ï 6:00 PM
Yard Wages / Salaries	Monday ï Friday & Saturday	2	5	6:00 AM ï 2:00 PM
Yard Wages	Monday ï Friday & Saturday		3	10:00 AM ï 6:00 PM
Total		38 staff (26 on-site at any one time)	72 staff (44 on-site at any one time)	

Given the above work hours, it is evident that staff arrivals and departures in the morning hours occur outside the morning peak hour traffic of the adjacent road network while staff arrivals and departures in the afternoon hours could coincide with the peak hour traffic on the local road network.

The proposed increase in brick production will involve:

- 29 employees arriving prior to the 6:00 AM start;
- 3 employees arriving prior to the 10:00 AM start;
- 32 employees departing after the 6:00 PM finish;
- 12 employees arriving prior to the 6:00 PM start; and
- 12 employees departing after the 6:00 AM finish.

In total, it is estimated that there would be a total of 32 staff finishing their shift at 6:00 PM and a total of 12 staff starting their shift at 6:00 PM. This translates to an additional 6 staff to the existing 26 staff finishing work at 6:00 PM and 12 staff arriving before the start of the 6:00 PM shift. This would total 18 additional staff movements during the 6:00 PM shift changeover.

For the purpose of assessing the impact on the adjacent road network, the worst case scenario has been considered, which would be the maximum staff movements likely to occur during the AM and PM peak hour. Considering the site is not easily accessible by public transport, it is assumed that all staff would drive a vehicle to work. Hence, the additional trip generation attributed to the expansion would potentially equate to 12 vehicle trips inbound and 6 vehicle trips outbound, totalling 18 vehicle trips.

4.1.2 TRUCK MOVEMENTS

The volume of trucks arriving at and departing from the site is attributed primarily to the delivery of raw materials/supplies and finished products. A small number of truck movements are attributed to heavy vehicles for maintenance.

For the current operations, a total of 450 truck movements (225 inbound/225 outbound) occur per week. With the proposed increase in brick production, it is estimated that a total of 1034 truck movements (517 truck movements inbound and 517 truck movements outbound) are expected to occur per week, as shown in Table 8. This equates to a net increase of 584 truck movements (292 inbound/292 outbound) per week.

Table 8 Truck and Commercial Vehicle Movements per Week

Item Transported	Inbound	Outbound	Type
Bricks truck (Production only)	234	234	Truck and trailer
Bricks truck (Stock transfer)	24	24	B Double
Bricks truck (Stock transfer)	41	41	Truck and trailer
Raw/Materials ï Clay/Shale	152	152	Truck and trailer
Materials ï Stockpiles	23	23	Truck and trailer
Materials - Additives	4	4	Semi trailer
Materials ï Consumables	1	1	Truck only
Materials ï Recycled Water	14	14	Semi-trailer
Equipment service	1	1	Light truck
Waste removal	4	4	Truck only
Supplies and counter	20	20	Light Truck
Total	517	517	

It is anticipated that haulage would occur between the following times:

- 6:00 AM to 6:00 PM Monday to Friday
- 6:00 AM to 1:00 PM Saturdays

Assuming truck movements to be spread over six days, the increased production at the brickworks will result in an average of approximately 98 additional truck movements per day. For the purpose of this assessment, a conservative factor of 20% is assumed on movements likely to occur during the AM or PM peak hour, resulting in a net increase of 20 truck movements (10 inbound/10 outbound).

4.1.3 TOTAL TRAFFIC GENERATION

For the proposed expansion works, the net increase in traffic generation is summarised in Table 9 .

Table 9 Total Net Increase in Traffic Generation

Vehicle Movements	Total Daily Movements	Net Increase due to proposed expansion	Estimated Net Increase for Peak Inbound	Estimated Net Increase for Peak Outbound
Light vehicle movements	88 movements	33 vpd	3 (AM) 12 (PM)	12 (AM) 6 (PM)
Heavy vehicle movements	176 movements	98 vpd	10	10

4.2 TRAFFIC DISTRIBUTION

In terms of directional split of traffic generated by the proposed development, the primary access route to the site is via The Northern Road/Bringelly Road/Greendale Road intersection. The 2013 distribution of light and heavy vehicles generated by the proposed development has been based on the present distribution of traffic flows observed at the intersection while the future (2016, 2026 and 2036) distribution for vehicles generated by the proposed development has been based on the projected traffic movement flows as presented in the modelling for The Northern Road in the REF for the Northern Road Upgrade.

Table 10 Traffic Distribution Parameters, Greendale Road (2013)

Directional Flow	Inbound to Greendale Road		Outbound from Greendale Road	
	LV	HV	LV	HV
The Northern Road North	39.1%	45.0%	26.0%	62.0%
Bringelly Road East	43.5%	0.0%	41.0%	15.0%
The Northern South	17.4%	55.0%	33.0%	23.0%

4.3 TRAFFIC GENERATION DURING CONSTRUCTION

The construction works associated with the proposed increase in brick production will be limited to the construction of the new driveway and minor extensions to the brick making facility. It is anticipated that the construction of the new driveway will take around 8 weeks while the construction of the minor extensions to the brick making facility will take around 8 weeks. It is expected that the works will be undertaken concurrently and hence, a maximum of 8 weeks is assumed to be the total duration of the construction period.

During construction for the expansion works, employee traffic will be associated with staff movements to the site and from the site. Staff would comprise project management, various trades, and general construction staff. Over the full construction period, the peak construction workforce is estimated to be some 10 employees over an 8 week period. Allowing for some ride sharing, counter balanced by moderate turnover of traffic throughout the day, some 20 daily trips, mostly by car and light vehicles are anticipated. At least half of the employee trips are anticipated during each of the morning and evening peak hours.

The proposed expansion works will also generate heavy vehicle traffic over the 8 week construction period. It is estimated that around 4 heavy vehicles a day would be used over this period resulting in 8 heavy vehicle movements per day (in + out).

4.4 CUMULATIVE TRAFFIC

Consultations with Councils was undertaken to seek information on other developments relevant to Greendale Road. Liverpool Council provided information on a proposal submitted in March 2013 for the construction of a 4,533 plot Muslim cemetery to be located on the northern side of Greendale Road further west of the Bringelly Brickworks site. The access road to the cemetery will be located some 400 metres west of the Bringelly site and on the northern side of Greendale Road. The Traffic Impact Assessment[3] reported that when all plots are fully sold out, the proposal is expected to attract a maximum of 30 vehicles per hour during the peak hour when at full capacity. The expected peak hour traffic generation can occur anytime between their operating hours of 9:00 AM ï 4:00 PM during a weekday and occasionally on weekends.

[3] Traffic Impact Assessment for Proposed Cemetery at 61 Greendale Road, Hemanote Consultants for Residential Logistics Pty Ltd., March 2013.

5 TRANSPORT IMPLICATIONS

5.1 ROADWAY CAPACITY

It is estimated that the proposed expansion will attract an additional 131 vehicle trips per day consisting of 33 light vehicles and 98 heavy vehicles. This would increase the average daily traffic on Greendale Road (both directions) to roughly 1,631 vehicles per day with 16.1% heavy vehicle composition.

The increase in traffic would change the Level of Service (LoS) for Greendale Road from LoS A (see Table 5) to LoS B. In a rural context, Los A and LoS B, are considered satisfactory.

5.2 FUTURE INTERSECTION PERFORMANCE

The increase in heavy vehicle traffic during peak periods will impact on the operating capacity of the key intersection along the surrounding road network. SIDRA analysis of the intersections was further carried out with projected traffic volumes to determine the impact on the operational performance of the intersection during the construction and normal operational phase.

The proposal anticipates production is likely to increase in the second half of 2013.

The analysis also considers the reported forecast traffic volumes at the intersection of The Northern Road/Bringelly Road/Greendale Road due to the potential growth of the South West region and as determined by the recent report on *The Northern Road Upgrade Review of Environmental Factors*.

A summary of the results is given in Table 11 and Table 12.

Table 11 AM Peak Intersection Performance, The Northern Road/Bringelly Road/Greendale Road, with Development

Year	Intersection Control	Average Delay (sec/veh)	LoS
2013 (Construction)	Signals	21.5	B
2013 (Operation)	Signals	21.2	B

Table 12 PM Peak Intersection Performance, The Northern Road/Bringelly Road/Greendale Road, with Development

Year	Intersection Control	Overall Average Delay (sec/veh)	Overall LoS
2013 (Construction)	Signals	27.36	B
2013	Signals	25.3	B

The results above indicate that the additional movements generated by the proposed expansion are minor and will not have a significant effect on the operation of the intersection of The

Northern Road/ Greendale Road/ Bringelly Road. The intersection is expected to operate at a similar level of services as under the existing traffic volumes.

5.3 SITE ACCESS

It is proposed that a new access, located 140m east of the existing access to Greendale Road, will be provided as part of the upgrade to replace the existing access. The proposed new access road is shown in Figure 7.

The new access road will accommodate a dedicated 60m left turn lane at the proposed vehicle access on the westbound lane of Greendale Road. An assessment of sight distance requirements for the proposed relocated site access has been undertaken with reference to the Austroads *Guide to Road Design, Part 3 – Geometric Design* (November 2009). For a 60kph zone, the required minimum sight distance is 91m and will potentially require the removal of trees and any associated vegetation on the southern side of Greendale Road, east of the proposed access location.

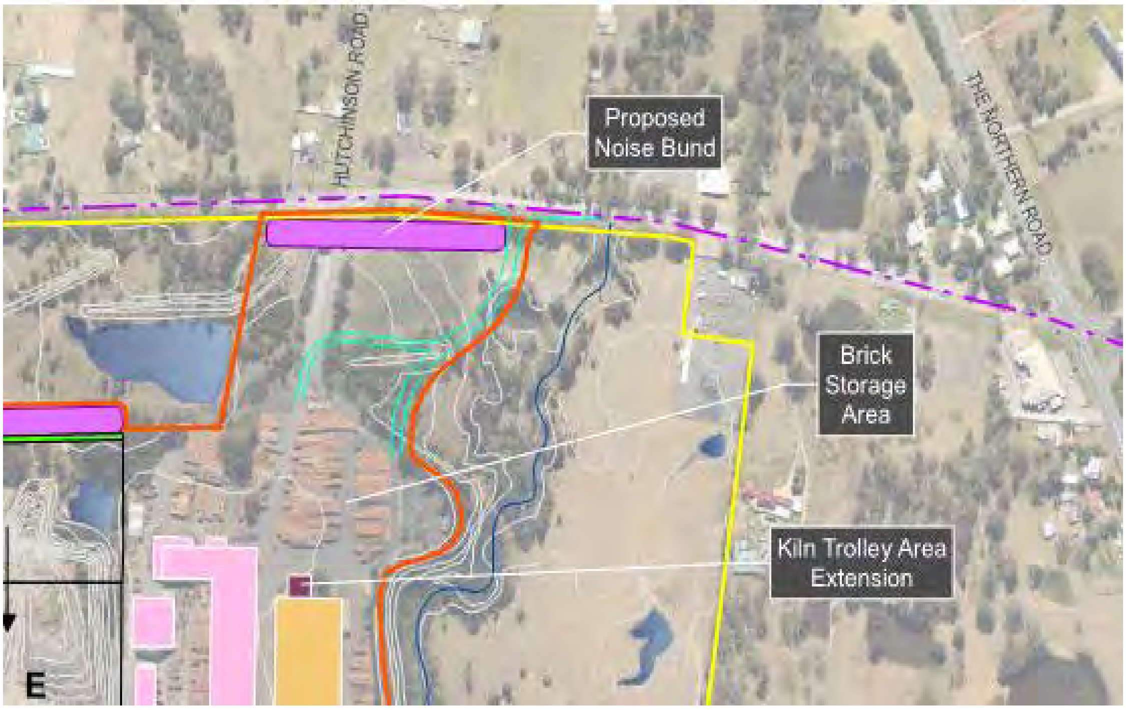


Figure 7 Proposed Access Road

5.4 ON-SITE PARKING

On-site car parking requirements for a development has been assessed in accordance with the RMS guidelines and Council's Development Control Plan (DCP).

The RMS's *Guide to Traffic Generating Developments* provides recommended minimum standards for specific land uses. There are no guidelines specific to the Boral Brickworks type of development and hence the most relevant development adopted from the RMS guide is for factories or warehouses. The basic requirement for factories and warehouses is "*that on-site parking must be provided for all vehicles used by employees*".

The car parking requirements for different land uses as set out in Camden Council's DCP 2011 Table B8 does not define specific requirements for the land use specific to the Boral Brickworks type of development. However, for land uses not specifically mentioned in Schedule B8, reference is made to other land uses defined in the Camden LEP 2010. The site is zoned 'RU1

Primary Production, which falls under the broad category of ôRural Zonesô in the Camden LEP The DCP 2011 states that the assessment for selected land uses categories defined in Camden LEP 2010 are to be assessed on merit taking into consideration the proposed land uses, staffing, servicing requirements and local requirement. Amongst the categories, ôRural Industryô appears to be the most applicable. Hence, it is appropriate that the car parking requirements for the site can be assessed based on employee parking requirements considering the location, work hours and the limitations on accessibility to public transport and active transport facilities.

5.4.1 STAFF PARKING

Parking requirements for staff are based on shift schedules. At its maximum capacity this operation will involve two, 12 hour shifts comprising of 72 employees. However, it is anticipated that a maximum of 44 employees are expected to be on site at any one time.

The peak demand for staff parking will occur in between shift changes, i.e. at 6:00 a.m. and 6:00 p.m. Using the conservative assumption of one car per employee, this peak demand for parking will be at around 6:00 pm when 32 staff will still be finishing their shift, and another 12 staff will have arrived to start their shift. On this basis, car parking requirements are estimated to be a minimum of 44 spaces.

In conclusion the proposed site layout currently provides 50 spaces which is sufficient to cater for the predicted staff parking requirements.

5.4.2 TRUCK PARKING

In addition, parking provisions for 10 semi-trailers and 8 light trucks will be available on-site. With a total of 1,034 truck movements a week or roughly 176 movements over a 12 hour (6:00 AM ï 6:00 PM) delivery period, it is estimated that there will be a need to accommodate at least 7 trucks every hour. The proposed parking provision of a total 18 spaces for truck parking allows a layover time of around two hours per truck. This is sufficient for accommodating the proposed truck parking requirements.

5.4.3 VISITOR PARKING

The total parking provision for light vehicles is 50 and, allowing for 44 staff spaces, leaves 6 spaces for visitors at any one time.

5.5 TRAFFIC MANAGEMENT DURING CONSTRUCTION OF NEW ACCESS ROAD

The Development Consent will need to include a requirement for a ñConstruction Traffic Management Planò to be submitted prior to commencement of Construction Works. The plan will be required to include arrangements for management of deliveries to the site.

Constructions activities at the new site entrance will need preparation of a Traffic Control Plan in accordance with RMS Guidelines which should be submitted to Camden Council for review.

6 SUMMARY AND CONCLUSIONS

The traffic assessment has examined a wide range of issues for the proposed Bringelly Brickworks expansion and has addressed the following key issues:

- Traffic impacts of road haulage during operations of the Bringelly Brickworks plant.
- Traffic impacts of road haulage during construction of the proposed new access road.
- An assessment of the existing and proposed traffic impacts.
- Mitigation measures to address any adverse impacts.

It is concluded that the proposed development will not have an adverse impact on either Greendale Road or the Greendale Road/ The Northern Road/ Bringelly Road intersection and no upgrades are required to accommodate the proposed development.

7 REFERENCE LIST

AUSTROADS 2009, *Guide to Road Design, Part 3 – Geometric Design*, Publication No. AGRD01/10, Austroads Ltd.

AUSTROADS 2009, *Guide to Traffic Management: Roadway Capacity,* Publication No. AGTM01/09, Austroads Ltd.

GTA 2012, Boral Brickworks Expansion, Greendale Road, Bringelly Traffic Impact Assessment, August 2012

Hyder Consulting 2013, *Boral Bringelly Brickworks Expansion Traffic Impact Assessment*, May 2013.

Roads and Maritime Services 2002, *Guide to Traffic Generating Developments*, Version 2.2, October 2002.

SKM 2012, *MR154 The Northern Road Upgrade – Appendix J Traffic and Transport Assessment Report* , Roads and Maritime Services, NSW

SKM 2012, *The Northern Road Upgrade Review of Environmental Factors*, Roads and Maritime Services, October 2012.

APPENDIX G

AIR QUALITY IMPACT ASSESSMENT

ACOUSTICS AND AIR

BORAL BRICKWORKS BRINGELLY

AIR QUALITY ASSESSMENT

REPORT NO. 12185-N
VERSION D

MAY 2013

PREPARED FOR

HYDER CONSULTING
LEVEL 5, 141 WALKER STREET
NORTH SYDNEY NSW 2060

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GLOSSARY OF TERMS

Air Pollutant – Any substance in air that could, in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne.

Air Pollution – The presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects.

Air Quality Standards – The level of pollutants prescribed by regulations that are not being exceeded during a given time in a defined area.

Air Toxics – Any air pollutant for which a national ambient air quality standard (NAAQS) does not exist (i.e. excluding ozone, carbon monoxide, PM-10, sulphur dioxide, nitrogen oxide) that may reasonably be anticipated to cause cancer; respiratory, cardiovascular, or developmental effects; reproductive dysfunctions, neurological disorders, heritable gene mutations, or other serious or irreversible chronic or acute health effects in humans.

Airborne Particulates – Total suspended particulate matter found in the atmosphere as solid particles or liquid droplets. Chemical composition of particulates varies widely, depending on location and time of year. Sources of airborne particulates include dust, emissions from industrial processes, combustion products from the burning of wood and coal, combustion products associated with motor vehicle or non-road engine exhausts, and reactions to gases in the atmosphere.

Area Source – Any source of air pollution that is released over a relatively small area, but which cannot be classified as a point source. Such sources may include vehicles and other small engines, small businesses and household activities, or biogenic sources, such as a forest that releases hydrocarbons, may be referred to as nonpoint source.

Carbon Monoxide (CO) – A colourless, odourless, poisonous gas, produced by incomplete burning of carbon-based fuels, including gasoline, oil and wood. Carbon monoxide is also produced from incomplete combustion of many natural and synthetic products. For instance, cigarette smoke contains carbon monoxide. When carbon monoxide gets into the body, the carbon monoxide combines with chemicals in the blood and prevents the blood from bringing oxygen to cells, tissues and organs. The body's parts need oxygen for energy, so high-level exposures to carbon monoxide can cause serious health effects, with death possible from massive exposures.

Concentration – The relative amount of a substance mixed with another substance. Examples are 5 ppm of carbon monoxide in air and 1 mg/l of iron in water.

Emission – Release of pollutants into the air from a source. We say sources emit pollutants.

Emission Factor – The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw materials.

Emission Inventory – A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community; used to establish emission standards.

Flow Rate – The rate, expressed in gallons -or litres-per-hour, at which a fluid escapes from a hole or fissure in a tank. Such measurements are also made of liquid waste, effluent, and surface water movement.

Fugitive Emissions – Emissions not caught by a capture system.

Hydrocarbons (HC) – Chemical compounds that consist entirely of carbon and hydrogen.

Hydrogen Sulphide (H_2S) – Gas emitted during organic decomposition. Also, a by-product of oil refining and burning. Smells like rotten eggs and, in heavy concentration, can kill or cause illness.

Inhalable Particles – All dust capable of entering the human respiratory tract.

Nitric Oxide (NO) – A gas formed by combustion under high temperature and high pressure in an internal combustion engine. NO is converted by sunlight and photochemical processes in ambient air to nitrogen oxide. NO is a precursor of ground-level ozone pollution, or smog.

Nitrogen Dioxide (NO_2) – The result of nitric oxide combining with oxygen in the atmosphere; major component of photochemical smog.

Nitrogen Oxides (NO_x) – A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal. Nitrogen oxides are smog formers, which react with volatile organic compounds to form smog. Nitrogen oxides are also major components of acid rain.

Mobile Sources – Moving objects that release pollution; mobile sources include cars, trucks, buses, planes, trains, motorcycles and gasoline-powered lawn mowers.

Particulates; Particulate Matter (PM-10) – A criteria air pollutant. Particulate matter includes dust, soot and other tiny bits of solid materials that are released into and move around in the air. Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, incineration of garbage, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining operations, agricultural burning (field and slash burning), and operation of fireplaces and woodstoves. Particulate pollution can cause eye, nose and throat irritation and other health problems.

Parts Per Billion (ppb)/Parts Per Million (ppm) – Units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

PM10/PM2.5 – PM10 is measure of particles in the atmosphere with a diameter of less than 10 or equal to a nominal 10 micrometers. PM2.5 is a measure of smaller particles in the air.

Point Source – A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Scrubber – An air pollution device that uses a spray of water or reactant or a dry process to trap pollutants in emissions.

Source – Any place or object from which pollutants are released.

Stack – A chimney, smokestack, or vertical pipe that discharges used air.

Stationary Source – A place or object from which pollutants are released and which does not move around. Stationary sources include power plants, gas stations, incinerators, houses etc.

Temperature Inversion – One of the weather conditions that are often associated with serious smog episodes in some portions of the country. In a temperature inversion, air does not rise because it is trapped near the ground by a layer of warmer air above it. Pollutants, especially smog and smog-forming chemicals, including volatile organic compounds, are trapped close to the ground. As people continue driving and sources other than motor vehicles continue to release smog-forming pollutants into the air, the smog level keeps getting worse.

1 INTRODUCTION

Wilkinson Murray Pty Limited has been engaged by Hyder Consulting Pty Ltd to provide an air quality assessment of the proposed upgrade of production to the Boral Brickworks located at 60 Greendale Road Bringelly. This air quality assessment relates to clay/shale extraction and manufacturing processes and includes air quality associated with fixed and mobile mechanical plant and vehicle movements within the site.

This report assesses air quality impacts arising from the emissions from a proposed upgrade of production to the Boral Brickworks located at Bringelly.

The evaluation of the impacts is based on the use of a computer-based dispersion model AUSPLUME to predict ground level concentrations of the flue gases hydrogen fluoride, hydrogen chloride, oxides of sulphur, nitrogen dioxide, carbon monoxide, VOCs and metals emitted from the stack associated with the kiln and dryers.

In addition, the report addresses the issue of dust generated by quarrying activities, the transport of raw material to stockpiles and subsequent processing.

The AUSPLUME dispersion model in conjunction with the meteorological data file provides predictions of ground level concentrations based on the emission estimates.

2 DESCRIPTION OF PLANT & ENVIRONS

The Boral Brickworks is located in Greendale Road, Bringelly which is in south western Sydney, approximately 55km from the coast.

The present operation, which produces bricks principally for the housing market, comprises of a gas-fired kiln and dryers housed in the largest of the existing buildings (see **Figure 2-1**) with exhaust stacks. Bricks are dried, fired and then removed by forklift to a holding yard. A clay shale quarry lies to the south and west of the Brickworks and material from this pit is extracted and used in the manufacture of the bricks.

The Bringelly facility is currently approved to produce 160,000 tonnes per annum. It is proposed to increase production to 263,500 tonnes of bricks per annum. As such the proposal requires the brickworks to be able to operate 24hours per day which is consistent with the current approval.

The quarrying operation which is currently approved to extract 200ktpa remains unchanged. Supplementary material and off-site sources of clay, shale and non-clay materials (96,000 tonnes per annum) are proposed to be trucked to the site as required.

A comparison of the proposed upgrade with the approved operations is presented in **Table 2-1**.

Table 2-1 Comparison of Existing Facility and Proposed Upgraded Plant Facility

Project Aspect	Approved Development	Proposed Project
Quarrying Operations		
Quarry area	9.9 hectares	30.65 hectares
Quarry Production (i.e. extraction)		
Extraction volume	200,000 tonnes per annum	No change
Extraction rate	Two (2) extractive campaigns with 25 on-site days per year for each campaign	Three (3) extractive campaigns with 44 on-site days per year for each campaign
Extraction method	Dump trucks, dozer and excavator	No change
Material Handling and Stockpiling	Stockpiles contained south east of the brick making plant	No change
Manufacturing Process (i.e. brick making)		
Brick production rate	160,000 tonnes of bricks/annum	263,500 tonnes of bricks/annum
Clay preparation	3 storage bays	5 storage bays. Extension to clay preparation building (approx. 47.5m x 14m x 11.6m high)
Dehacking	Within existing building	14,000 bricks/hr. Extension of building for kiln car storage (approx.. 18m x 19.5m x 4m high)

No change is proposed to the existing and approved operational hours as presented in Table 2-2.

Table 2-2 Existing and proposed hours of operation

Existing Hours of Operation	Proposed Hours of Operation
Quarrying operations (incl. associated vehicle movements)	
6.00 am to 6.00 pm Monday to Friday	No change
6.00 am to 1.00 pm Saturdays	No change
No activity on Sundays or public holidays	No change
Processing / Manufacturing:	
Unlimited (subject to compliance with noise emission levels)	No change
Transport (truck movements and deliveries to and from the site)	
6.00 am to 6.00 pm Monday to Friday	No change
6.00 am to 1.00 pm Saturdays	No change
No trucks shall queue at the entrance to the site prior to 6.00 am	No change

There are currently 38 employees at the Bringelly Brickworks and up to ten contractors work for two to four months per annum on a campaign basis to complete the quarrying activities. The proposed workforce is forecast to increase by 34 staff, to a total of 72 employees. This increase is a result of the continued extraction and brick making at the Bringelly Brickworks and will likely consist of contractors, administrative staff and manufacturing and handling staff.

Two stockpile areas of raw material transported from the quarry are located to the south of the crusher building. Material from these stockpiles are crushed and conveyed to the manufacturing plant.

Figure 2-1 Aerial Photograph of Existing Site

The local terrain consists of gently undulating low hills with vegetation comprising scattered bushland with trees up to 10m high, interspersed with fields cleared for pasture. The land usage is a mixture of agricultural and residential. The Bringelly Public School and village is located approximately 700m to the northeast of the plant.

The land surrounding the quarry site is rural. There are a number of rural residential properties distributed around the area surrounding the subject site. 36 nearby residential receivers have been identified and are presented in **Table 2-3.** The closest residential receivers are presented in **Figure 2-2**.

Table 2-3 Surrounding Residential Receivers

Receiver Number	Receiver Address
1	55 Loftus Road
2	54 Loftus Road
3	20 Greendale Road
4	9 Greendale Road
5	5 Greendale Road (Community Centre)
6	46 Loftus Road
7	36 Loftus Road
8	47 Loftus Road
9	37 Loftus Road
10	27 Loftus Road
11	26 Loftus Road
12	15 Loftus Road
13	5 Loftus Road
14	23 Greendale Road
15	27 Greendale Road
16	29 Greendale Road
17	25 Greendale Road
18	31 Greendale Road
19	35 Greendale Road
20	170 Tyson Road
21	196 Greendale Road
22	46 Belmore Road
23	55 Belmore Road
24	63 Belmore Road
25	67 Belmore Road
26	73 Belmore Road
27	83-85 Belmore Road
28	76 Belmore Road
29	86 Belmore Road
30	87 Belmore Road
31	93 Belmore Road
32	95-97 Belmore Road
33	107 Belmore Road
34	96 Belmore Road
35	108 Belmore Road
36	1037 Northern Road
37	10 Greendale Road

Detailed assessment has been conducted at the shaded receivers, being those which are closest to the Boral Site.

Figure 2-2 Site Location showing Residential Receivers and Dust Deposition Gauges

3 EMISSIONS

3.1 Stack Emissions

Firing of bricks in kilns leads to emissions of hydrogen fluoride, hydrogen chloride, oxides of nitrogen and sulphur, carbon monoxides, particulate matter, some VOC's and metals . The nitrogen oxides are a combustion product while the other emissions are mainly from the bricks. The sulphur content of natural gas is very low, so the sulphur oxides emissions would arise predominantly from the heating of the bricks.

The POEO Act of New South Wales and the site Environmental Protection Licence set maximum concentrations of impurities in the air at the point of emission from scheduled premises. These limits apply to residual gases, after the completion of the process and before they are mixed with clean air, smoke or other gases. Stack testing is conducted every year for the kiln and dryer. The standards set for the various emissions are summarised in **Table 3-1** and compared with the 2011 and 2012 measured stack concentrations from the proposed kiln and the dryer. This information was provided by Boral and stack testing conducted by EML Air Pty Ltd. It should be noted that the dryer has two stacks.

All of the stack concentrations are below the maximum levels set by the POEO Regulations 1999 for new installations and the site's Environmental Protection Licence.

It proposed to extend the kiln building by 20 metres to allow for an extra kiln car space. The kiln is not changing emission rates. However as the annual production rate of bricks is proposed to increase, it is likely the emissions from these sources would also increase. Therefore the existing emissions from the kiln and dryers have been prorated based on the production level increase in the assessment. For the modelling the average discharge between the 2011 and 2012 measurements have been used as the basis before prorating the emissions. Three Dryer building stacks are also located on the main building.

Emissions of other air toxics are also likely to arise from the kiln operations. VOC's and metals identified in the NPI document "Emissions Estimation Technique Manual for Bricks, Ceramics & Clay Product Manufacturing" (**NPI, 1998**) have also been applied to the modelling. Emissions of these substances have been estimated based on the tonnage of bricks produced annually.

The emission discharged used for the modelling for the kiln stack and the three dryer stacks, whose location is shown in **Figure 2-1,** are summarised in **Table 3-2**.

Table 3-1 Measured Stack Emissions Data

	Kiln		Dryer Stack 1		Dryer Stack 2		POEO Reg or Licence Limit $g.Nm^{-3}$ of dry air
Stack height (m)	17.5		13		13		
Stack diameter (m)	1.5		1.4		1.4		
Exist temperature (K)	436.5		319		308.5		
Exit velocity ($m.s^{-1}$)	13		5.6		6.55		
	Kiln $g.Nm^{-3}$ of dry air	Kiln g/s	Dryer Stack 1 $g.Nm^{-3}$ of dry air	Dryer Stack 1 g/s	Dryer Stack 2 $g.Nm^{-3}$ of dry air	Dryer Stack 2 g/s	
2011							
TSP	0.018	0.22	0.0016	0.011	0.0023	0.02	0.100
PM10	0.16	0.19	<0.0011	<0.0079	0.0012	0.011	-
Total fluoride	0.0011	0.13	0.000047	0.0003	0.000075	0.00068	0.05
HCl	0.031	0.37	0.000024	0.00015	<0.000034	<0.00031	0.1
NO2	0.054	0.65	<0.0041	0.029	<0.0041	<0.035	2.5
SO2	0.1	1.2	0.00058	0.004	0.00015	0.0013	-
SO3	0.00027	0.0033	0.0024	0.017	0.00011	0.00092	0.1
CO	0.064	0.78	<0.0025	0.017	0.0025	0.021	-
2012							
TSP	0.015	0.19	0.0017	0.013	0.0017	0.015	0.100
PM 10	0.012	0.15	0.0014	0.01	0.0015	0.013	-
Total fluoride	0.0088	0.11	0.000051	0.00038	0.000047	0.00041	0.05
HCl	0.028	0.34	0.000064	<0.00048	<0.000055	<0.00049	0.1
NO2	0.062	0.78	0.0041	0.03	0.0041	0.036	2.5
SO2	0.092	1.1	0.00029	0.0022	<0.000053	<0.00046	-
SO3	0.0054	0.068	0.0018	0.013	<0.000023	<0.0002	0.1
CO	0.1	1.3	0.0025	0.018	0.0025	0.022	-

Table 3-2 Stack Emissions Data Used for Modelling

Parameter	Kiln	Dryer 1 Stack 1	Dryer 1 Stack 2
Stack height (m)	17.5	13	13
Diameter (m)	1.5	1.4	1.4
Temperature (K)	436.5	319	308.5
Velocity (m/s)	13	5.6	6.55
Emissions			
TSP (g/s)	0.3383	0.0198	0.0289
PM_{10} (g/s)	0.2805	0.0148	0.0198
Total fluoride (g/s)	0.198	0.0006	0.0009
HCl (g/s)	0.5858	0.0005	0.0007
SO_3 (g/s)	0.0588	0.0012	0.014
SO_2 (g/s)	1.8975	0.0011	0.0158
NO_2 (g/s)	1.2540	0.0602	0.0734
CO (g/s)	1.8068	0.0652	0.0619
Acetone (g/s)	0.0071		
Benzene (g/s)	0.012		
Carbon disulphide (g/s)	0.00018		
Chlorine (g/s)	0.00543		
Chloroethane (g/s)	0.00196		
Ethylbenzene (g/s)	0.00018		
Xylene (g/s)	0.00052		
Phenol (g/s)	0.00036		
Styrene (g/s)	$8.355x10^{-5}$		
Tetrachloroethane (g/s)	$1.17\ x10^{-5}$		
Toluene (g/s)	0.00668		
Arsenic (g/s)	0.00013		
Beryllium (g/s)	$1.754x10^{-6}$		
Manganese (g/s)	0.0543		
Mercury (g/s)	$3.13x10^{-5}$		

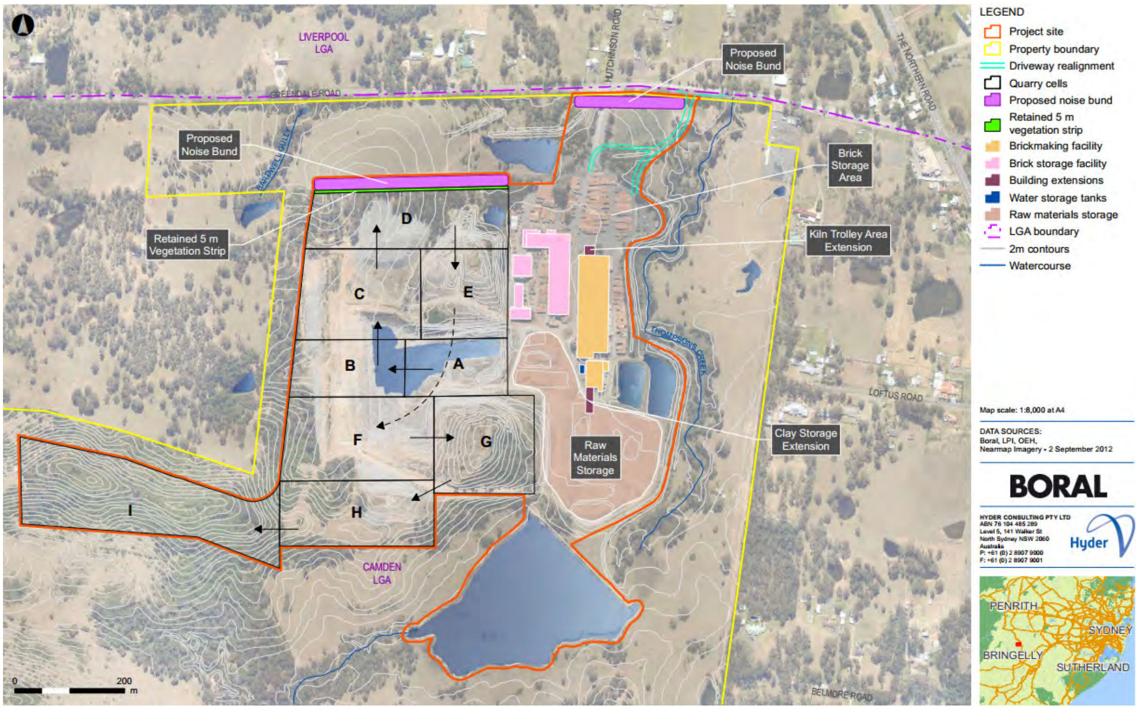
* Exponent to the power of 10.

3.2 Dust Emissions

Although some particulate matter will be emitted from the exhaust stack, most of the dust generated at the site will arise from the quarry operations, the transport of material to stockpiles and subsequent crushing and preparation for use in the manufacturing building.

Dust emissions have been estimated by analysing the Brickworks operations assuming that a total of 200,000 tonnes per year of material will be quarried. Three different stages have been assessed based on the locations of the quarrying activities (see **Figure 3-1**).

Figure 3-1 Proposed Quarry Extraction Area



The extraction process removes product material from the quarry in periods of up to 44 days to be known as campaigns. Normal plant operations continue in addition to extra operations associated with the material extraction in the clay pit and stockpile area. The equipment used in this process consists of:

- A dozer or excavator is used for the extraction of product.
- A truck is used for transportation of product from the pit to the stockpile.
- A smaller dozer is used at times to level the stockpile.
- A water cart is available for operation during this period.

The campaigns have been defined as follows:

Stages 1 Operation in Cells A, B and C;

Stages 2 Operation in Cells D, E, and F; and

Stages 3 Operation in Cells G, H and I.

Information about the dust-generating operations which take place at the site (that is, how much material is moved, how far it is moved and so on) has been used with emission factors developed both locally and by the US EPA to estimate the amount of dust produced from each operation. Estimated emission amounts for each activity are presented in **Table 3-3** . Details of the calculations are presented in Appendix A. The AUSPLUME dispersion model in conjunction with the meteorological data file provides predictions of ground level concentrations based on the emission estimates.

Table 3-3 Dust Emissions Inventories

Activity	TSP Emissions (kg/year)		
	Stage 1	**Stage 2**	**Stage 3**
Topsoil removal by scraper	1,160	1,160	1,160
Scraper travelling	1,496	1,496	1,496
Scraper unloading	800	800	800
Dozers ripping	1,463	1,463	1,463
Loading Clay/Shale in pit	21	21	21
Hauling Clay/Shale to stockpile	8,141	8,141	8,141
Unloading Clay/Shale at stockpile	21	21	21
Grading roads	492	492	492
Hauling material onsite (paved road)	4,394	4,394	4,394
Unloading material to stockpile	10	10	10
Loading box feeder (FEL)	31	31	31
Crushing	178	178	178
Plant feed conveyor	58	58	58
Wind erosion – Exposed area	337	469	544
Wind erosion – Stockpile area	238	238	238
Total	18,840	18,971	19,046

4 DISPERSION METEOROLOGY OF THE AREA

The dispersion models used to predict ground-level concentrations of gaseous emissions and dust deposition and concentration levels require data on wind speed, wind direction, temperature, mixed-layer height and atmospheric stability class. Typically, a year of such hourly data would be used. The data set used in this report was constructed from the EPA Meteorological station at Bringelly approximately 4km from the Boral Brick Facility measured in 2011.

This section provides a brief summary of the climatic data available.

4.1 Wind Speed & Direction

Seasonal wind roses for Bringelly for 2011 are shown in **Figure 4-1**. On an annual basis, winds are most dominant from the south-southwest, with a lesser frequency of winds from the southwest. In spring and summer, the wind distribution is similar to the annual distribution with a higher frequency of easterly winds occurring. During autumn and winter, winds from the south-southwest are most predominate. The annual average wind speed is 1.6m/s and the annual percentage of calms is 24.2%.

4.2 Atmospheric Stability

Stability class is used in dispersion models to determine the rate at which a pollutant plume grows by the process of turbulent mixing. Each stability class is associated with a different dispersion curve. These are used by the model to calculate the plume dimension and dust concentration at points downwind of the source. In AUSPLUME, the Paquill-Gifford curves were used to represent dispersion in the vertical and horizontal direction.

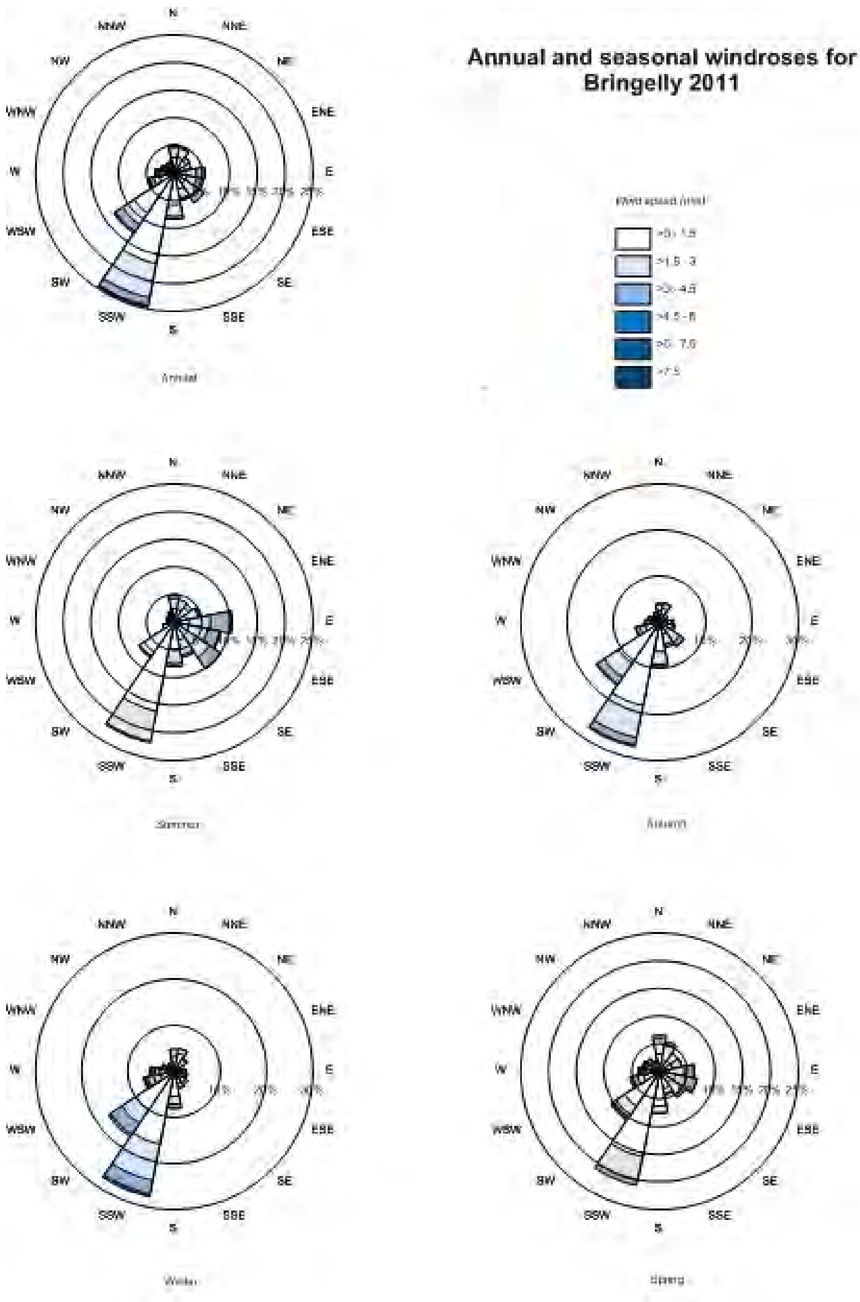
There are six stability classes referred to as A to F. Stability class data was estimated from sigma theta data supplied with the meteorological data set. The frequencies of occurrence of stability class are shown in **Table 4-1**.

Table 4-1 Distribution of Atmospheric Stability Categories at the Bringelly Meteorological Station 2011

Stability	Percentage Occurrence
A	22.0
B	8.0
C	9.3
D	17.7
E	9.2
F	33.9

Stability Class A applies under sunny conditions with light winds when dispersion of the plume is most rapid. Stability Class D applies under windy and/or overcast conditions when dispersion is moderately rapid and stability Class F applies normally at night or early mornings when winds are light and the sky is clear. Dispersion under Class F conditions is poor. Class B, C and E describe intermediate conditions between those described above.

Figure 4-1 Wind Roses Bringelly 2011



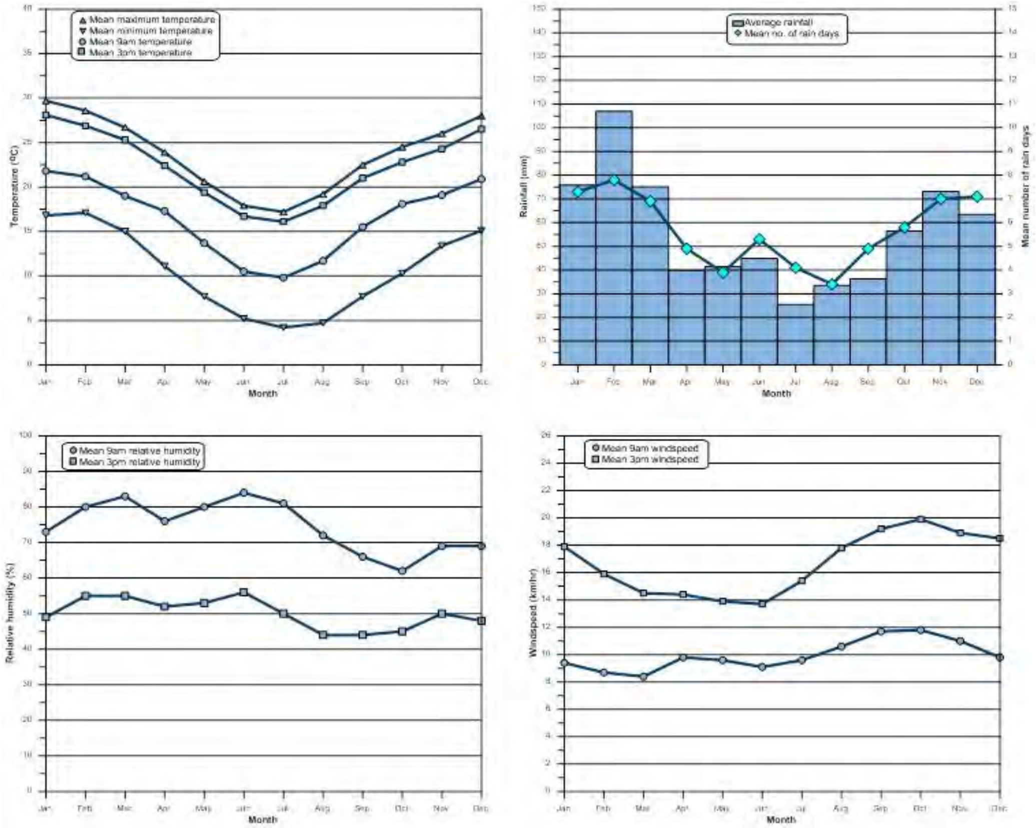
Long-term climate data collected at the nearest Bureau of Meteorology (BOM) station, Badgerys Creek AWS - Station Number 067108 located approximately 10 km north of the Project has been reviewed. This data is summarised in **Table 4-2** and **Figure 4-2** and assists in characterising the climatic conditions of the Project site. The climatic data indicate that on average, January is the hottest month of the year and July is the coldest month of the year with mean maximum and minimum temperatures of 29.7^{0}C and 4.2^{0}C. Rainfall data show that February is the wettest month of the year and July is the driest month of the year with average falls of 107.0mm and 25.5mm. Mean 9am humidity levels range from 62% in October to 84% in June. Mean 3pm humidity levels range from 44% in August and September to 56% in June. Mean 9am wind speeds range from 8.4km/h in March to 11.8km/h in October. Mean 3pm wind speeds range from 13.7km/h in June to 19.9km/h in October.

Table 4-2 Monthly Climate Statistics Summary – Badgerys Creek AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean max. temperature (ºC)	29.7	28.6	26.7	23.9	20.6	17.9	17.2	19.2	22.5	24.5	26.0	28.0
Mean min. temperature (ºC)	16.8	17.1	15.0	11.1	7.7	5.2	4.2	4.7	7.7	10.3	13.4	15.1
Rainfall												
Rainfall (mm)	75.8	107.0	75.2	39.9	41.4	44.9	25.5	33.5	36.2	56.4	73.1	63.5
Mean No. of rain days (≥1mm)	7.3	7.8	6.9	4.9	3.9	5.3	4.1	3.4	4.9	5.8	7.0	7.1
9am Conditions												
Mean temperature (ºC)	21.8	21.2	19.0	17.3	13.7	10.5	9.8	11.7	15.5	18.1	19.1	20.9
Mean relative humidity (%)	73	80	83	76	80	84	81	72	66	62	69	69
Mean wind speed (km/h)	9.4	8.7	8.4	9.8	9.6	9.1	9.6	10.6	11.7	11.8	11.0	9.8
3pm Conditions												
Mean temperature (ºC)	28.1	26.9	25.3	22.4	19.4	16.7	16.1	17.9	21.0	22.8	24.3	26.5
Mean relative humidity (%)	49	55	55	52	53	56	50	44	44	45	50	48
Mean wind speed (km/h)	17.9	15.9	14.5	14.4	13.9	13.7	15.4	17.8	19.2	19.9	18.9	18.5

Source: BoM, 2012

Figure 4-2 Monthly Climate Statistics Summary – Badgerys Creek AWS



5 EXISTING AIR QUALITY

Air quality standards and goals refer to pollutant levels which include the project and existing sources. To fully assess impacts against all the relevant air quality standards and goals, it is necessary to have information or estimates on existing pollutant concentrations in the area in which the project is likely to contribute to these levels.

Suitable site-specific air quality monitoring data are not available to quantify the existing ambient levels at the site. However, background ambient monitoring data obtained from the EPA Bringelly monitoring site that monitors various air pollutants (O_3, NO, NO_2, NOx, SO_2 and PM10) is considered suitable for the requirements of this assessment.

5.1 PM_{10} Concentrations

There has been no PM10 monitoring undertaken specifically for this Project, but there is data available from the EPA Bringelly monitoring station. The monthly average and maximum 24-hour average PM10 concentrations for 2011 at Bringelly are summarised in **Table 5-1**.

Table 5-1 The 2011 Monthly Average and Maximum 24-hour Average PM_{10} Concentrations EPA Monitoring Data for Bringelly ($\mu g/m^3$)

Month	Average	Maximum 24-hour
January	18.8	34.4
February	18.8	42.4
March	15.4	29.6
April	12.7	30.4
May	15.7	43.5
June	11.4	23.3
July	12.0	32.0
August	17.1	29.9
September	19.1	56.5
October	17.0	34.9
November	20.6	83.8
December	13.8	20.4
Annual	**16.0**	**-**

The monitoring data show the annual average PM10 concentrations at this monitoring site are below the 30µg/m^3 criterion. There were occasions in the year where the maximum measured 24-hour average concentration exceeded the NEPM goal of 50µg/m^3, most likely due to bush fire events or other localised sources.

5.2 TSP Concentrations and Dust Deposition

There are no readily available ambient TSP and deposited dust monitoring data for the Project. The EPA monitoring site does not measure these components; however estimates of the background levels for the site are required to assess the impacts per the criteria presented.

Estimates of the annual average background TSP concentrations can be determined from a relationship between measured PM10 concentrations. This relationship assumes that 40% of the TSP is PM10 and was established as part of a review of ambient monitoring data collected by co-located TSP and PM10 monitors operated for reasonably long periods of time in the Hunter Valley (NSW Minerals Council, 2000).

Applying this relationship with the annual average PM10 concentration of 16µg/m^3 from the Bringelly monitor estimates an annual average TSP concentration of the order of 40µg/m^3.

The site in question is located in a mixed residential and rural area. Site specific dust deposition monitoring occurred between March 2010 and July 2012 in the vicinity of the Brickworks at the four locations shown in **Figure 2-1** and the results are summarised in **Table 5-2**.

Table 5-2 Deposition Monitoring

Dust Gauge	Dust Fallout Rate g/m^2/month													
	Oct 2010	Nov 2010	Dec 2010	Jan 2011	Feb 2011	March 2011	April 2011	May 2011	June 2011	July 2011	March 2012	April 2012	Jan 2013	Mean
D1	-	-	2.89	2.35	2.01	-	2.17	-	0.52	3.55	-	0.88	0.73	1.9
D2	2.8	3.34	1.96	2.14	2.22	1.2	3.56	3.82	2.14	4.0	1.72	2.28	2.71	2.6
D3	2.13	-	1.33	1.64	2.19	0.68	1.85	1.56	1.05	1.87	0.68	1.23	1.9	1.6
D4	2.41	-	1.35	1.41	1.75	1.94	2.63	1.4	1.46	2.21	0.79	0.99	2.38	1.7

The values range from 0.52 to 4 g.m^{-2} month^{-1} which are fairly typical for this type of environment. The gauges with the highest readings (D1 and D2) are those closest to the Brickworks. They are also located downwind from the plant in the direction of the most prevailing winds as indicated in the Bringelly wind rose. The increased dust deposition levels recorded at these gauges are therefore likely to be, at least in part, due to dust emissions from the Brickworks. Sociological studies by Mitchell McCotter (1988) indicate that dust deposition levels would be allowed up to 4 g.m^{-2} .month^{-1} before a significant degradation in air quality had occurred.

Rather than using the dust deposition data measured and influenced by the Brickworks, annual average dust deposition levels have been estimated using a similar process to the method used to estimate TSP concentrations. This approach assumes that a TSP concentration of 90µg/m^3 will have an equivalent dust deposition value of 4g/m^2/month.

This relationship indicates a background annual average dust deposition of 1.9g/m^2/month for the area surrounding the Project.

5.3 NO_2

The monthly maximum 1-hour average NO_2 concentrations are presented in **Table 5-3**. The maximum concentration measured was 41µg/m^3 in 2011 which is significantly below the impact assessment criterion of 246µg/m^3. The annual average NO_2 concentration recorded at this site for 2011 was 23µg/m^3.

Table 5-3 EPA Monitoring Data for Bringelly NO_2 (µg/m^3)

Month	NO_2 Maximum Monthly 1-hour Average 2011
January	18.5
February	18.5
March	16.4
April	18.5
May	24.6
June	41.0
July	24.6
August	26.7
September	28.7
October	22.6
November	22.6
December	14.4

5.4 SO_2

The monthly maximum 1-hour average and 24-hour average SO_2 concentrations are presented in **Table 5-4**. The maximum 24-hour average concentration measured was 4.6µg/m^3 in 2010 which is significantly below the impact assessment criterion of 228µg/m^3. The annual average SO_2 concentration at this site for 2011 was 3.0µg/m^3.

Table 5-4 EPA monitoring data for Bringelly SO_2 (μg/m^3)

Month	SO_2 Maximum monthly 1-hour average 2011
January	4.6
February	2.8
March	2.8
April	2.8
May	2.6
June	1.1
July	1.7
August	2.8
September	4.3
October	4.3
November	4.0
December	2.3

There is currently no monitoring data available for other pollutants of relevance to this study, which include CO, HCL and HF. Given the semi-rural location of the project site, background concentrations of these pollutants are assumed to be negligible.

In view of the foregoing, the site-specific background air quality levels adopted for this assessment are:

- TSP 40.0 μg/m^3
- PM10 16.0 μg/m^3
- Dust Deposition 1.9 g/m^2/month
- NO_2 23 μg/m^3
- SO_2 3.0 μg/m^3

6 AIR QUALITY ASSESSMENT CRITERIA

Air quality criteria for possible pollutants are presented in the following sections.

6.1 Dust Concentration

The EPA Approved Methods specifies air quality assessment criteria for assessing impacts from dust generating activities (NSW EPA, 2005a).

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (see NEPC, 1998). However, the NSW EPA's criteria include averaging periods, which are not included in the Air-NEPMs and references to other measures of air quality, namely dust deposition and total suspended particulate matter (TSP).

Table 6-1 summarises the air quality goals for dust that are relevant to this study. The air quality goals relate to the total dust burden in the air and not just the dust from the project. Therefore, some consideration of background levels needs to be made when using these goals to assess impacts.

Table 6-1 Air Quality Assessment Criteria for Particulate Matter Concentrations

Pollutant standard	Goal	Averaging period	Agency
Total suspended particulate matter (TSP)	90 ·µg/m^3	Annual	NHMRC*
Particulate matter < 10 µm (PM10)	50 ·µg/m^3	24-hour maximum	NSW EPA
	30 ·µg/m^3	Annual mean	NSW EPA long-term reporting goal
	50 ·µg/m^3	(24-hour average, 5 exceedances permitted per year)	NEPM

*National Health and Medical Research Council

The PM10 particle size fraction is typically of the order of 50% of the TSP mass, the goal is consistent with an annual PM10 goal of approximately 45µg/m^3. Thus, the historical NHMRC goal may be regarded as not as stringent as the newer PM10 goal of 30 µg/m^3 expressed as an annual average.

6.2 Dust Deposition

The EPA has established air quality goals for dust deposition. These are based on an incremental approach in which acceptable increases in dust deposition depend on the background level up to a specified maximum. **Table 6-2** summarises the criteria.

Table 6-2 EPA Criteria for Allowable Dust Deposition

Pollutant	Averaging Period	Maximum Increase $g/m^2/month$	Maximum Total $g/m^2/month$
Dust Deposition	Annual	2	4

6.3 Other Air Pollutants

In addition to the assessment criteria for particulate matter, ground-level concentration (glc) criteria are specified by NSW EPA for other air pollutants (**NSW EPA, 2005**). The relevant pollutants are:

- Products of Combustion
  - Sulphur dioxide (SO_2);
  - Sulphuric Acid (SO_3)
  - Nitrogen dioxides (NO_2);
  - Hydrogen chloride (HCl);
  - Hydrogen fluoride (HF);
  - Carbon monoxide (CO);
  - VOCs including:
  - Acetone;
  - Benzene
  - Carbon disulphide
  - Chlorine
  - Chloroethane
  - Ethylbenzene
  - Xylene
  - Phenol
  - Styrene
  - Tetrachloroethane
  - Toluene
  - Arsenic
  - Beryllium
  - Manganese
  - Mercury

Table 6-3 shows the impact criteria applied in this assessment.

Table 6-3 Air Quality Assessment Criteria for Particulate Matter Concentrations

Pollutant Standard	Goal	Averaging Period	Agency
Sulphur dioxide (SO2)	712 µg/m³	10min	NHMRC (1996)
	570 µg/m³	1 hour	NEPC (1998)
	228 µg/m³	24 hour	NEPC (1998)
	60 µg/m³	Annual	NEPC (1998)
Sulphuric acid (SO3)	18µg/m³	1-hour	VIC EPA (2001)
Nitrogen dioxide (NO2)	246 µg/m³	1 hour	NEPC (1998)
	62 µg/m³	Annual	NEPC (1998)
Carbon monoxide (CO)	100 mg/m³	15min	WHO (2000)
	30 mg/m³	1 hour	WHO (2000)
	10 mg/m³	8 hour	NEPC (1998)
Hydrogen fluoride*	0.5µg/m³	90 days	ANZECC (1990)
	0.84µg/m³	30 days	ANZECC (1990)
	1.7µg/m³	7 days	ANZECC (1990)
	2.9µg/m³	24 hours	ANZECC (1990)
Hydrogen chloride (HCl)	140µg/m³	1-hour	VIC EPA (2001)
Acetone	22mg/m³	1-hour	VIC EPA (2001)
Benzene	0.029mg/m³	1-hour	VIC EPA (2001)
Carbon disulphide	0.07mg/m³	1-hour	VIC EPA (2001)
Chlorine	0.05mg/m³	1-hour	VIC EPA (2001)
Chloroethane	48mg/m³	1-hour	VIC EPA (2001)
Ethylbenzene	8mg/m³	1-hour	VIC EPA (2001)
Xylene	0.19mg/m³	1-hour	VIC EPA (2001)
Phenol	0.02mg/m³	1-hour	VIC EPA (2001)
Styrene	0.12mg/m³	1-hour	VIC EPA (2001)
Tetrachloroethane	1.0mg/m³	1-hour	VIC EPA (2001)
Toluene	0.36mg/m³	1-hour	VIC EPA (2001)
Arsenic	0.00009mg/m³	1-hour	VIC EPA (2001)
Beryllium	0.000004mg/m³	1-hour	VIC EPA (2001)
Manganese	0.018mg/m³	1-hour	VIC EPA (2001)
Mercury	0.0018mg/m³	1-hour	VIC EPA (2001)

* General land use.

7 AIR QUALITY IMPACT ASSESSMENT

The pollutant dispersion modeling utilises the AUSPLUME Gaussian Plume Dispersion Model software developed by EPA Victoria. AUSPLUME is the approved dispersion model for use in the majority of applications in NSW.

Default options specified in the Technical Users Manual (**EPA Victoria, 2000**) have been used, as per NSW EPA's, "*Approved Methods and Guidance for the Modeling and Assessment of Air Pollutants in New South Wales"*.

The AUSPLUME dispersion model in conjunction with the meteorological data file provides predictions of the ground level concentrations of PM10, TSP, dust deposition and stack pollutant levels based on the emission estimates. Sources were modelled as volume sources or point sources as applicable (**see Appendix B for sample of AUSPLUME output file**).

As a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions was not applied.

7.1 Dust

Table 7-1, **Table 7-2** and **Table 7-3** present the maximum predicted incremental ground-level concentrations at the nearby residences due to dust related emissions, including emissions from the stack for Stage 1, 2 and 3 respectively. All the predicted concentrations are significantly below the relevant impact assessment criteria.

Figure 7-1 to **Figure 7-4**, **Figure 7-8** to **Figure 7-11** and **Figure 7-15** to **Figure 7-18** present isopleths of the spatial distribution of predicted incremental impacts over the modelling domain for maximum 24-hour average PM10, annual average PM10, TSP and deposited dust levels for Stage 1, 2 and 3 respectively.

Figure 7-5 to **Figure 7-7**, **Figure 7-12** to **Figure 7-14** and **Figure 7-19** to **Figure 7-21** present isopleths of the spatial distribution of predicted total impacts over the modelling domain for annual average PM10, TSP and deposited dust levels for Stage 1, 2 and 3 respectively. The total impact is defined as the incremental impact combined with the ambient background levels as determined in **Section 5**.

Table 7-1, **Table 7-2** and **Table 7-3** present the dispersion modeling results at each of the discrete receptors shown in **Figure 2-1**.

Table 7-1 Predicted Ground-Level Particulate Matter Concentrations at Receptors – Stage 1

Receptor ID	Incremental				Cumulative (Total)		
	PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Incremental Criteria				Cumulative Criteria		
	-	-	-	2	30	90	4
1	13	0.9	1.1	0.6	17	41	2.4
2	13	0.9	1.2	0.6	17	41	2.4
3	12	1.2	1.5	0.5	17	42	2.3
4	11	2.1	2.6	0.7	18	43	2.5
5	11	1.4	1.7	0.5	17	42	2.3
14	13	2.0	2.5	0.8	18	42	2.6
16	18	1.7	2.1	0.8	18	42	2.6
17	14	2.1	2.6	0.9	18	43	2.7
19	5	0.4	0.5	0.2	16	40	2.0
20	5	0.4	0.5	0.2	16	41	2.0
33	9	0.3	0.4	0.1	16	40	1.9
35	8	0.4	0.6	0.2	16	41	2.0

Table 7-2 Predicted Ground-Level Particulate Matter Concentrations At Receptors – Stage 2

Receptor ID	Incremental				Cumulative (Total)		
	PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Incremental Criteria				Cumulative Criteria		
	-	-	-	2	30	90	4
1	15	0.9	1.2	0.6	17	41	2.4
2	14	0.9	1.2	0.6	17	41	2.4
3	12	1.3	1.5	0.6	17	42	2.4
4	12	2.3	2.8	0.9	18	43	2.7
5	10	1.5	1.8	0.5	17	42	2.3
14	17	2.3	2.9	1.1	18	43	2.9
16	18	2.0	2.8	1.3	18	43	3.1
17	25	2.7	3.6	1.5	19	44	3.3
19	4	0.4	0.5	0.2	16	40	2.0
20	4	0.4	0.5	0.2	16	40	2.0
33	10	0.3	0.4	0.1	16	40	1.9
35	8	0.4	0.6	0.3	16	41	2.1

Table 7-3 Predicted Ground-Level Particulate Matter Concentrations at Receptors – Stage 3

Receptor ID	Incremental				Cumulative (Total)		
	PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Incremental Criteria				Cumulative Criteria		
	-	-	-	2	30	90	4
1	17	0.9	1.1	0.6	17	41	2.4
2	18	0.9	1.1	0.6	17	41	2.4
3	14	1.2	1.5	0.5	17	41	2.3
4	12	1.8	2.2	0.6	18	42	2.4
5	10	1.4	1.7	0.5	17	42	2.3
14	9	1.4	1.8	0.6	17	42	2.4
16	6	1.0	1.2	0.4	17	41	2.2
17	9	1.2	1.5	0.5	17	41	2.3
19	3	0.4	0.5	0.2	16	41	2.0
20	5	0.5	0.7	0.3	16	41	2.1
33	7	0.3	0.4	0.2	16	40	2.0
35	11	0.5	0.6	0.3	16	41	2.1

Even with a large number of conservative assumptions applied, the predicted results show that minimal incremental impact from the operations would arise at nearby sensitive receptors. Therefore it is unlikely that the existing PM10, TSP or dust deposition levels at any sensitive receptor will be significantly changed.

The predicted cumulative results for PM10, TSP and dust deposition are below the criteria when compared with EPA guidelines (presented in **Table 6-1** and **Table 6-2**) at the discrete receptors.

The EPA contemporaneous assessment method was applied to examine the potential maximum total (cumulative) 24-hour average PM10 impacts for the Project. The assessment was undertaken is general accordance with the methods outlined in the Approved Methods for Modelling and Assessment of Air Pollutants in New South Wales (**NSW EPA, 2005**).

The analysis focuses on the sensitive receptor location immediately surrounding the Project, it is understood that if these receptors comply then consequently any more distant receptors would also comply.

Table 7-4 provides a summary of the findings from the contemporaneous assessment; detailed tables of the full assessment results are provided in **Appendix C**.

Table 7-4 Summary of EPA Contemporaneous Assessment

Receptor ID	Number of Days Above Criterion		
	Stage 1	Stage 2	Stage 3
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
14	0	0	0
16	0	0	0
17	0	0	0
19	0	0	0
20	0	0	0
33	0	0	0
35	0	0	0

The results in **Table 7-4** indicate that there are no exceedances of the total (cumulative) 24-hour average PM10 criterion of 50 µg/m^3 for Stages 1, 2 and 3. It should be noted that these dust generation levels are highly conservative as the effect of the precipitation rate (rainfall) in reducing dust emissions was not applied in the modelling of dust generation. Studies have shown that significant vegetation barriers can reduce dust emissions by up to 30 per cent (Warren 1973). Boral propose to retain a five metre strip of existing native Cumberland Plain Woodland along the northern boundary of quarry cell D, with the primary purpose of retaining a substantial, densely vegetated strip of vegetation to minimise dust deposition to the north of the quarry activities as the dominant wind at the site is from the SSW. In addition, two substantial 4.5 metre high noise bunds are proposed: one 200 metres in length and the other 362 metres long. These noise bunds will be revegetated with appropriate locally occurring native vegetation including trees and shrubs which, once established, will provide an even more robust vegetative buffer, further reducing dust emissions from the site and deposition impacts on neighbouring residential receivers to the north. The reduction from the vegetation buffers were not taken into account in the dust modelling.

Figure 7-1 Predicted Maximum 24-Hour Average PM_{10} Concentrations (µg/m^3) (Project Alone) – Stage 1 - (Criterion 50·µg/m^3)

Figure 7-2 Predicted Annual Average PM_{10} Concentrations (µg/m^3) (Project Alone) – Stage 1 – (Criterion 30 µg/m^3)

Figure 7-3 Predicted Annual Average TSP Concentrations (µg/m³) (Project Alone) – Stage 1 – (Criterion 90·µg/m³)

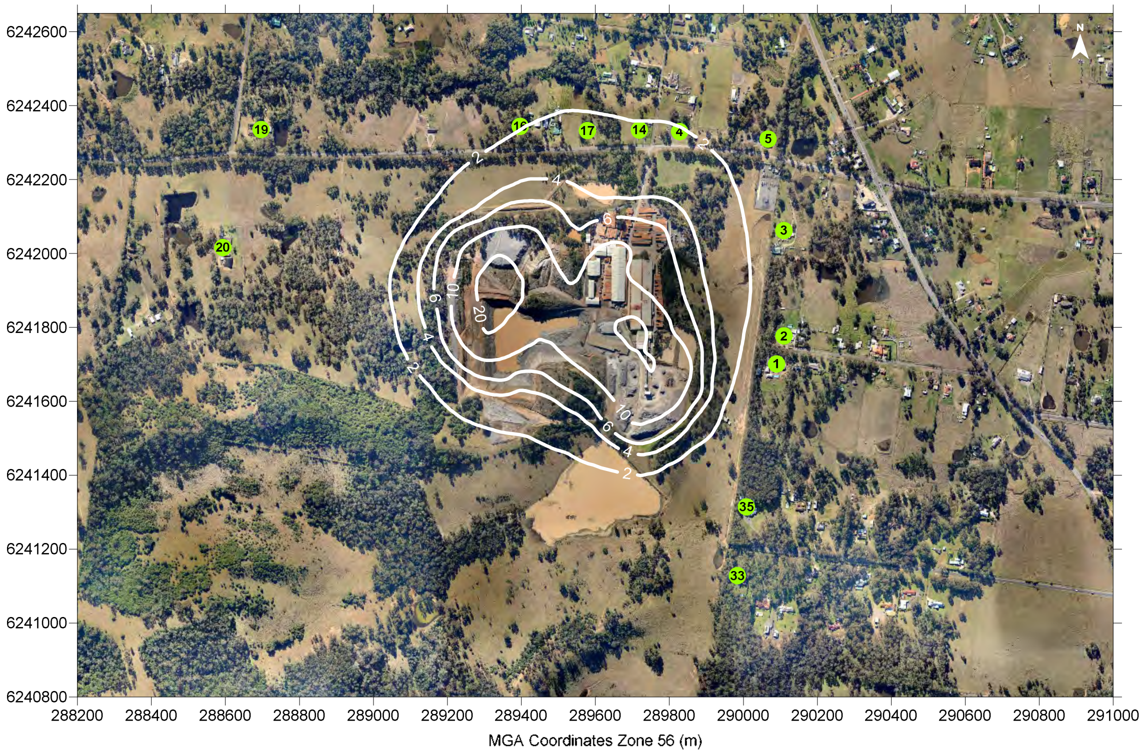


Figure 7-4 Predicted Annual Average Dust Deposition Levels (g/m²/Month) (Project Alone) – Stage 1 – (Criterion 4 g/m²/month)

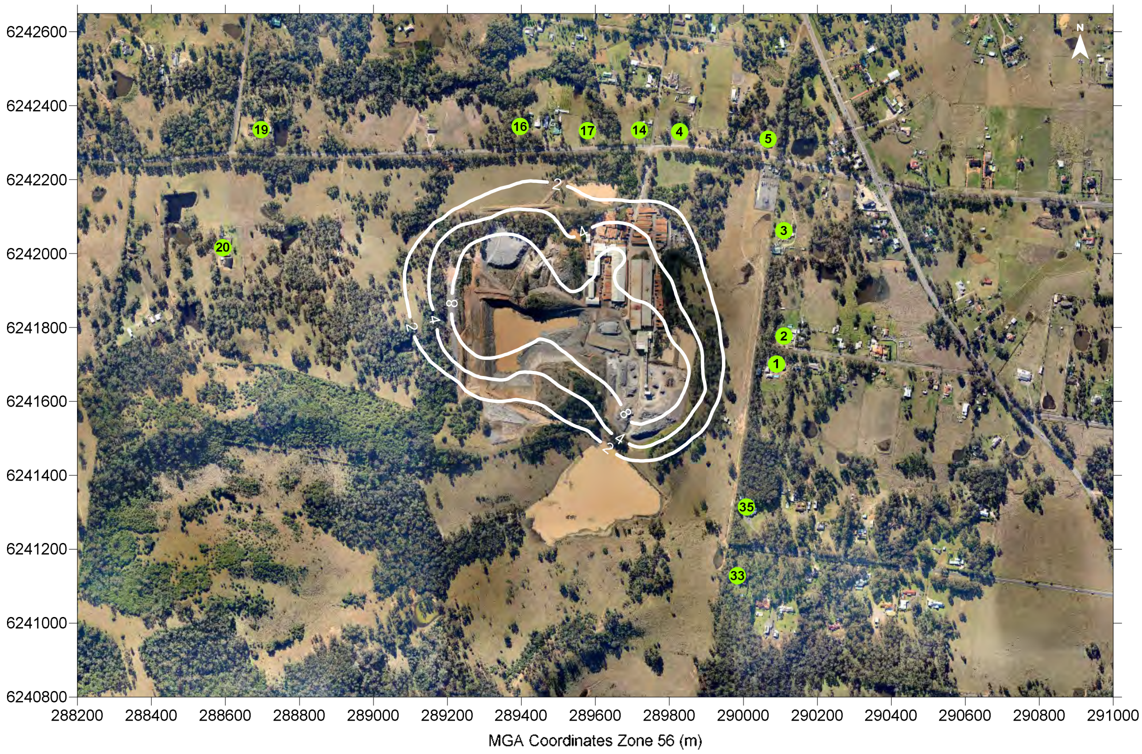


Figure 7-5 Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 1 - (Criterion 30 $\mu g/m^3$)

Figure 7-6 Predicted Annual Average TSP Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 1 - (Criterion 90 $\mu g/m^3$)

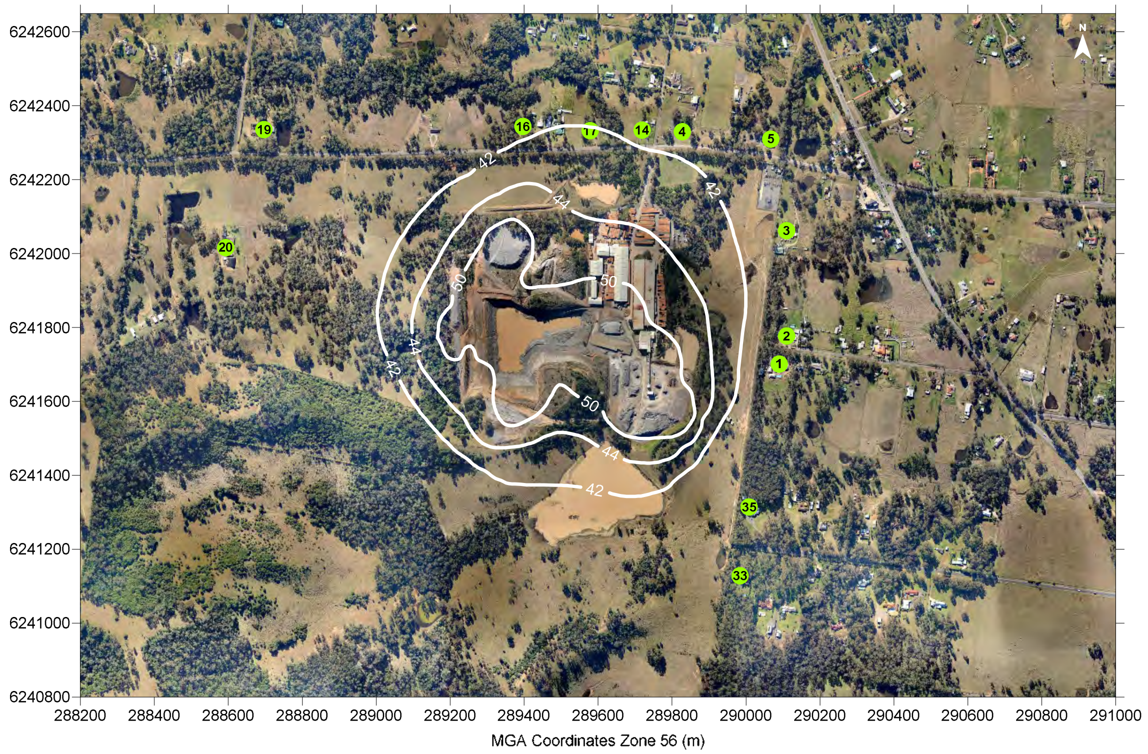


Figure 7-7 Predicted Annual Average Dust Deposition Levels (g/m^2/Month) (Project and Other Sources) – Stage 1 - (Criterion 4 g/m^2/month)

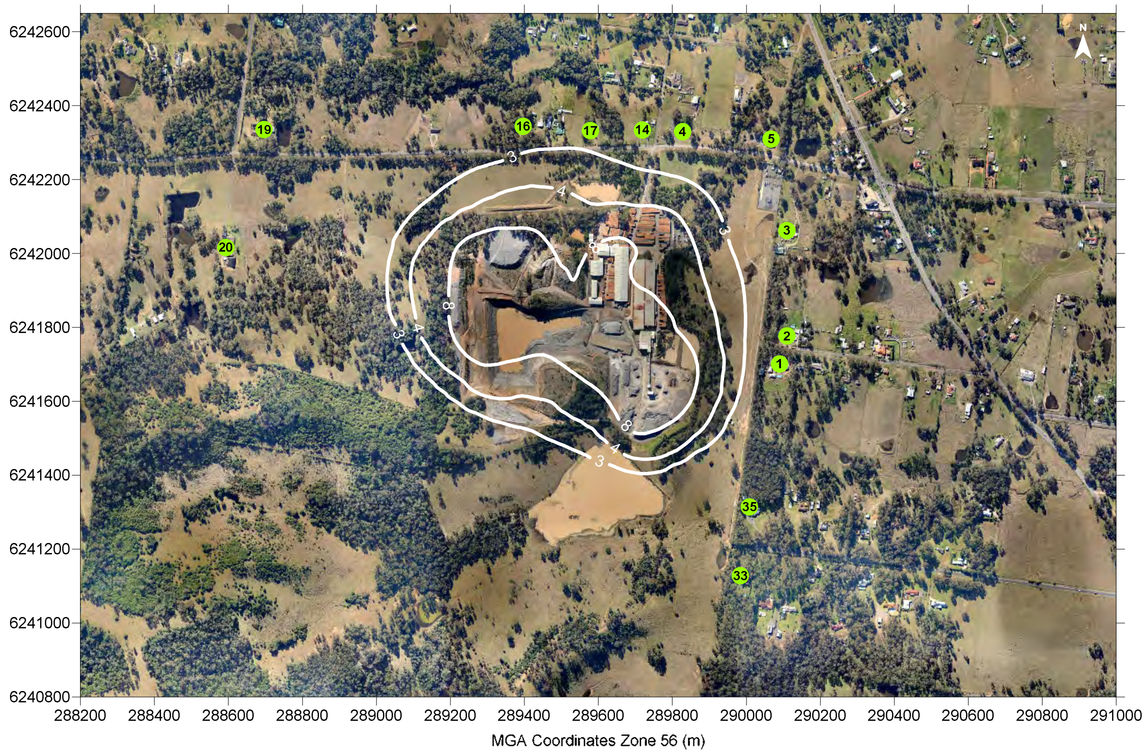


Figure 7-8 Predicted Maximum 24-Hour Average PM$_{10}$ Concentrations (µg/m^3) (Project Alone) – Stage 2 - (Criterion 50 µg/m^3)

Figure 7-9 Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) (Project Alone) – Stage 2 - (Criterion 30 $\mu g/m^3$)

Figure 7-10 Predicted Annual Average TSP Concentrations ($\mu g/m^3$) (Project Alone) – Stage 2 - (Criterion 90 $\mu g/m^3$)

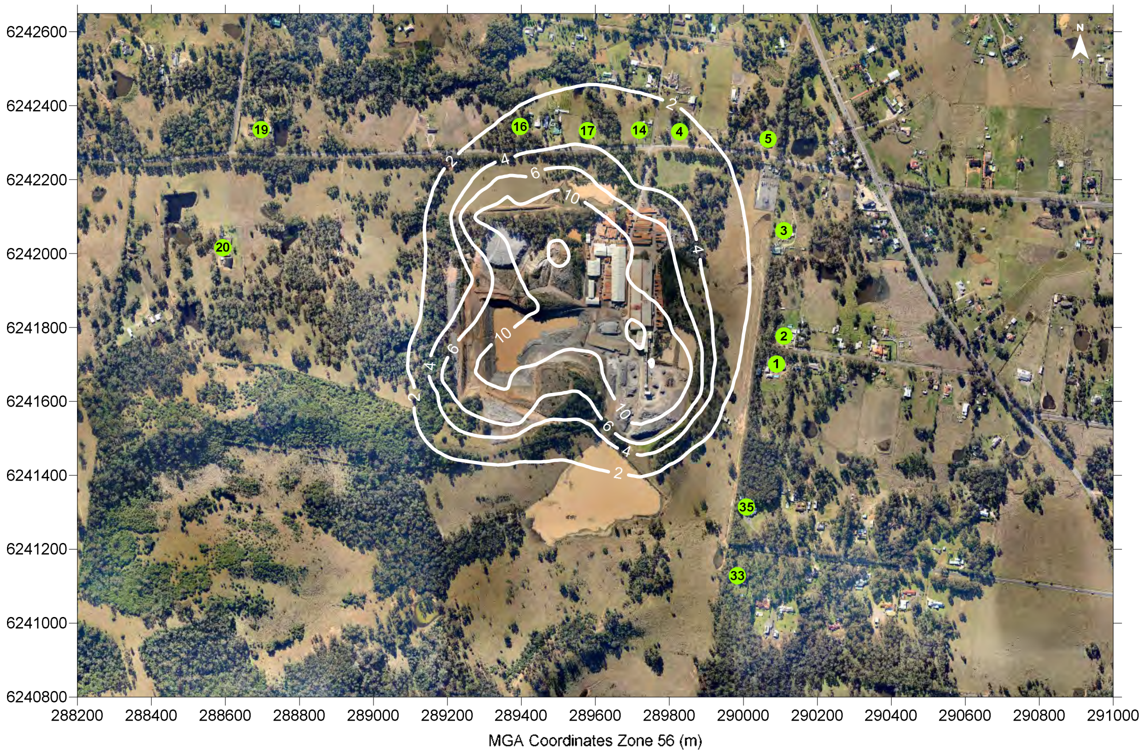


Figure 7-11 Predicted Annual Average Dust Deposition Levels (g/m^2/Month) (Project Alone) – Stage 2 - (Criterion 4 g/m^2/month)

Figure 7-12 Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 2 - (Criterion 30 $\mu g/m^3$)

Figure 7-13 Predicted Annual Average TSP Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 2 - (Criterion 90 $\mu g/m^3$)

Figure 7-14 Predicted Annual Average Dust Deposition Levels (g/m^2/Month) (Project and Other Sources) – Stage 2 - (Criterion 4 g/m^2/month)

Figure 7-15 Predicted Maximum 24-Hour Average PM_{10} Concentrations ($\mu g/m^3$) (Project Alone) – Stage 3 - (Criterion 50 $\mu g/m^3$)

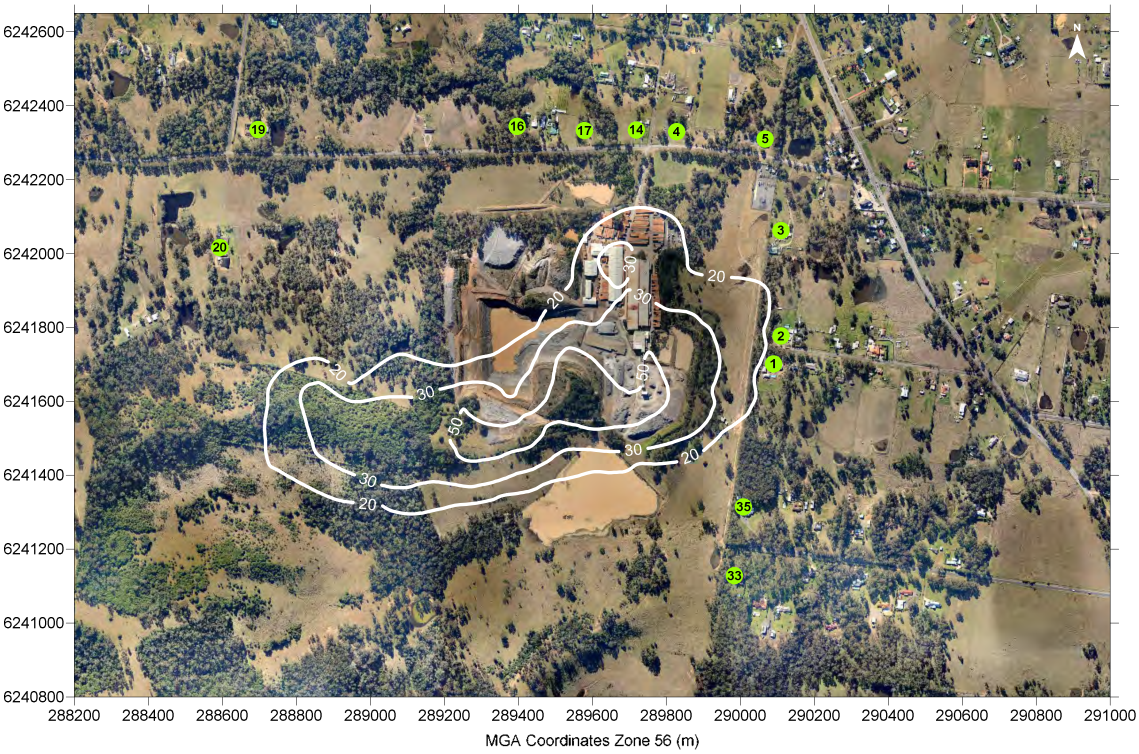


Figure 7-16 Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) (Project Alone) – Stage 3 - (Criterion 30 $\mu g/m^3$)

Figure 7-17 Predicted Annual Average TSP Concentrations (µg/m³) (Project Alone) – Stage 3 - (Criterion 90 µg/m³)

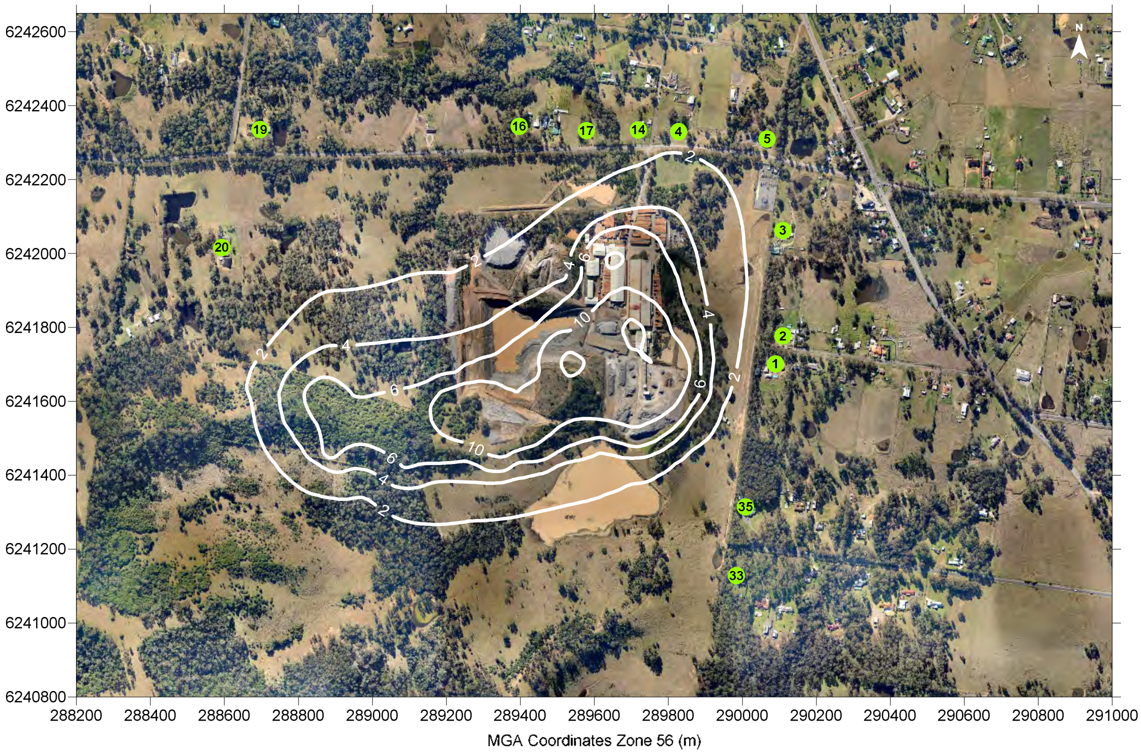


Figure 7-18 Predicted Annual Average Dust Deposition Levels (g/m²/Month) (Project Alone) – Stage 3 - (Criterion 4 g/m²/month)

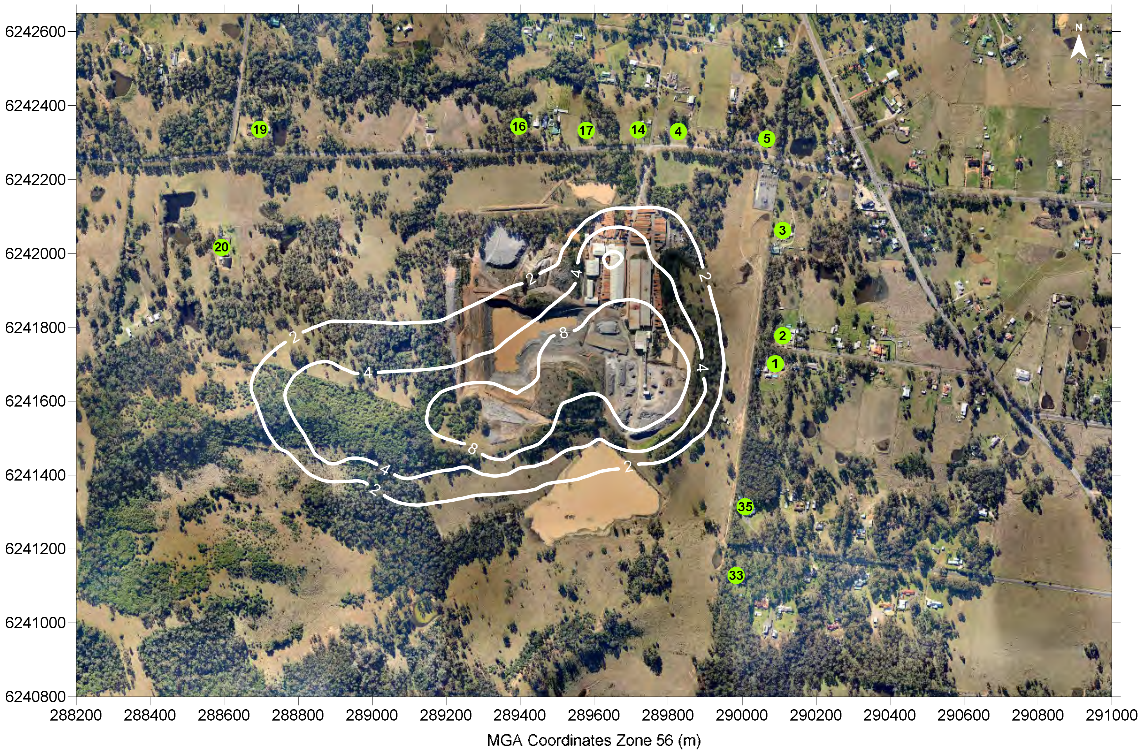


Figure 7-19 Predicted Annual Average PM_{10} Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 3 - (Criterion 30 $\mu g/m^3$)

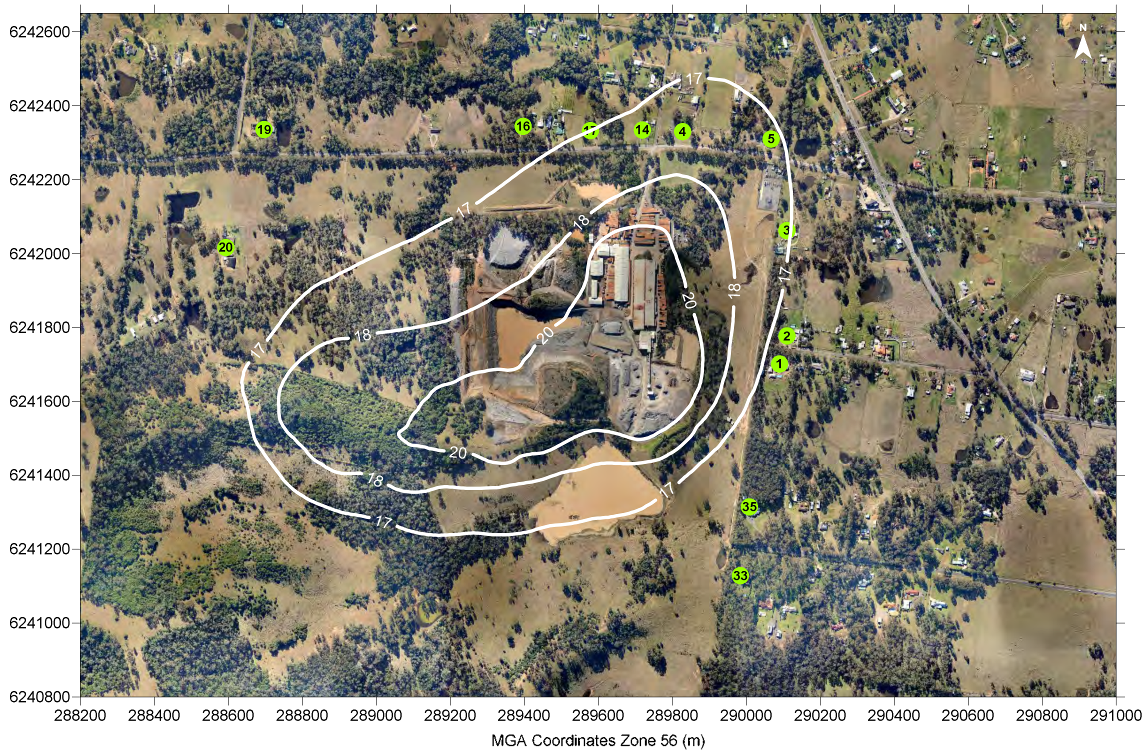


Figure 7-20 Predicted Annual Average TSP Concentrations ($\mu g/m^3$) (Project and Other Sources) – Stage 3 - (Criterion 90 $\mu g/m^3$)

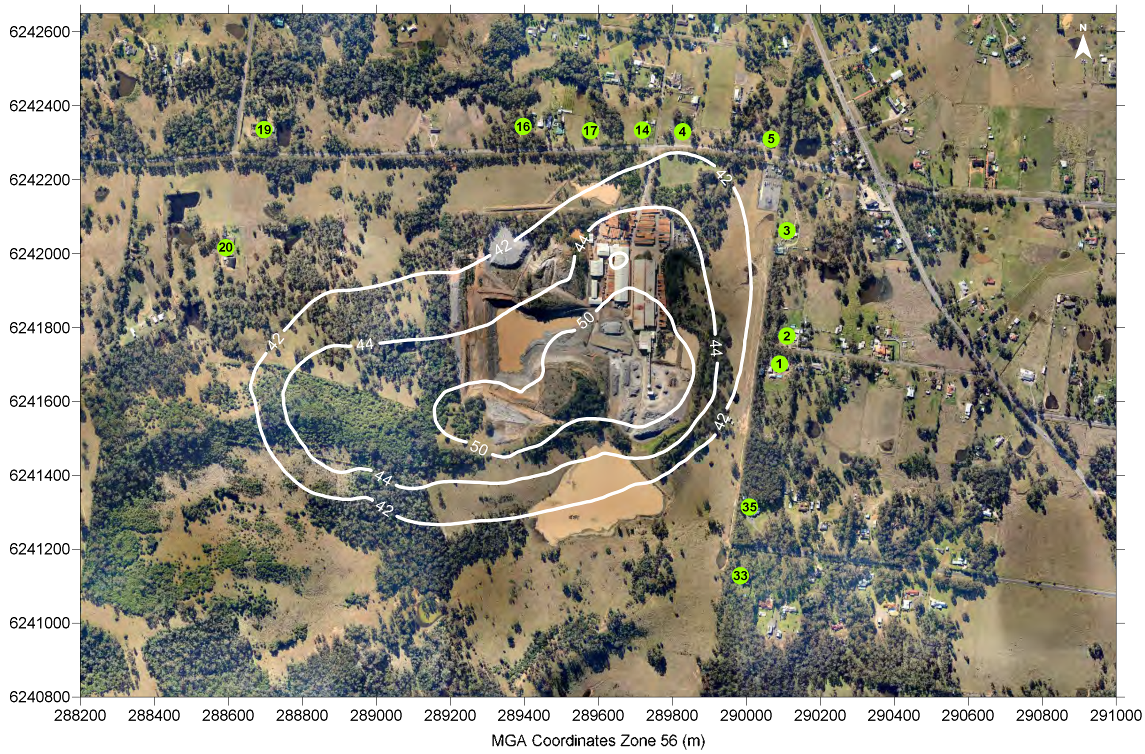
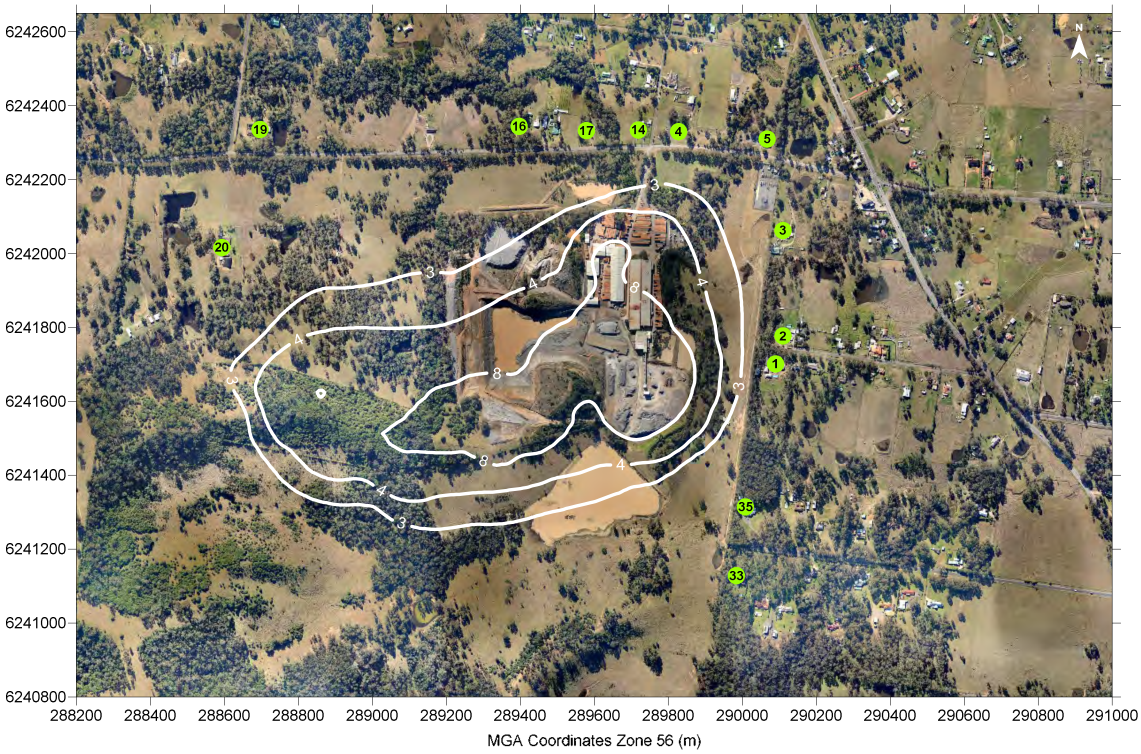


Figure 7-21 Predicted Annual Average Dust Deposition Levels (g/m^2/Month) (Project and Other Sources) – Stage 3 - (Criterion 4 g/m^2/month)



7.2 Other Air Pollutants

Figure 7-22 to **Figure 7-50** provide isopleths of the spatial distribution of predicted incremental impacts over the modelling domain for all stack pollutants assessed.

Table 7-5 presents the dispersion modelling results at each of the discrete receptors shown in **Figure 2-1**.

Table 7-5 Dispersion Modelling Results for Discrete Receptors (Other Air Pollutants)

Receptor ID	SO_2 (µg/m³)				NO_2 (µg/m³)		CO (µg/m³)			HF (µg/m³)			HCl (µg/m³)	SO3 (µg/m³)
	10-min	1-hr	24-hrs	Annual	1-hr	Annual	15-min	1-hr	8-hr	24-hrs	7-days	90-days	1-hr	1-hr
	Air Quality Impact Criteria													
	712	**570**	**228**	**60**	**246**	**62**	**$1x10^5$**	**$3x10^4$**	**$1x10^4$**	**2.9**	**1.7**	**0.5**	**140**	**18**
1	102.6	71.7	9.6	0.5	80.7	0.6	129.8	98.4	26.1	1.0	0.38	0.09	21.0	6.2
2	104.0	72.7	15.5	0.5	85.2	0.6	135.8	102.9	26.1	1.6	0.43	0.10	21.2	6.7
3	83.9	58.6	10.1	0.6	60.9	0.8	100.1	75.9	19.3	1.0	0.31	0.13	17.4	4.5
4	63.0	44.0	9.3	1.5	58.3	3.2	90.2	68.4	25.9	1.0	0.55	0.21	12.6	4.9
5	51.6	36.0	11.6	1.2	45.8	2.1	71.5	54.2	22.8	1.2	0.64	0.21	10.4	3.8
14	55.2	38.6	4.1	0.7	57.3	1.4	86.4	65.5	16.2	0.4	0.19	0.09	10.8	5.0
16	16.7	11.7	2.7	0.4	40.9	0.8	54.3	41.2	13.4	0.3	0.11	0.06	2.5	4.4
17	59.6	41.7	4.9	0.6	58.9	1.0	89.8	68.1	19.2	0.5	0.20	0.08	11.8	5.1
19	42.5	29.7	3.2	0.4	37.9	0.5	59.2	44.8	11.3	0.3	0.11	0.06	8.6	3.1
20	71.6	50.0	4.6	0.5	57.6	0.5	92.2	69.9	17.2	0.5	0.19	0.08	14.6	4.5
33	17.5	12.2	2.4	0.2	34.4	0.3	46.9	35.5	8.7	0.2	0.06	0.03	2.9	3.6
35	24.0	16.8	2.6	0.3	44.7	0.3	61.2	46.4	12.4	0.3	0.07	0.03	4.1	4.6

Table 7-6 Dispersion Modelling Results for Discrete Receptors (Other Air Pollutants)

Receptor ID	Acetone (µg/m^3) 1-hr	Benzene (µg/m^3) 1-hr	Carbon Disulphide (µg/m^3) 1-hr	Chlorine (µg/m^3) 1-hr	Chloroethane (µg/m^3) 1-hr	Ethylbenzene (µg/m^3) 1-hr	Xylene (µg/m^3) 1-hr	Phenol (µg/m^3) 1-hr	Styrene (µg/m^3) 1-hr	Tetra-chloroethane (µg/m^3) 1-hr	Toluene (µg/m^3) 1-hr	Arsenic (µg/m^3) 1-hr	Beryllium (µg/m^3) 1-hr	Manganese (µg/m^3) 1-hr	Mercury (µg/m^3) 1-hr
	Air Quality Impact Criteria														
	22000	**29**	**70**	**50**	**48000**	**8000**	**190**	**20**	**120**	**1000**	**360**	**0.09**	**0.004**	**18**	**1.8**
1	0.25	0.43	6.4x10^{-3}	0.19	0.07	6.5x10^{-3}	1.8x10^{-2}	1.3 x10^{-2}	3.0 x10^{-3}	4.1x10^{-4}	0.24	4.6x10^{-3}	6.2x10^{-5}	1.92	1.1x10^{-3}
2	0.25	0.43	6.4 x10^{-3}	0.19	0.07	6.5x10^{-3}	1.9x10^{-2}	1.3x10^{-2}	3.0 x10^{-3}	4.2x10^{-4}	0.24	4.6x10^{-3}	6.2 x10^{-5}	1.93	1.1x10^{-3}
3	0.21	0.35	5.3x10^{-3}	0.16	0.06	5.4 x10^{-3}	1.5 x10^{-2}	1.1x10^{-2}	2.4 x10^{-3}	3.4x10^{-4}	0.20	3.8x10^{-3}	5.1 x10^{-5}	1.59	9.2x10^{-4}
4	0.15	0.26	3.8x10^{-3}	0.11	0.04	3.9 x10^{-3}	1.1 x10^{-2}	7.6 x10^{-3}	1.8 x10^{-3}	2.5x10^{-4}	0.14	2.7x10^{-3}	3.7 x10^{-5}	1.14	6.6x10^{-4}
5	0.12	0.21	3.1x10^{-3}	0.09	0.03	3.2 x10^{-3}	9.1 x10^{-3}	6.2 x10^{-3}	1.5 x10^{-3}	2.0x10^{-4}	0.12	2.3x10^{-3}	3.1 x10^{-5}	0.94	5.4x10^{-4}
14	0.13	0.22	3.2x10^{-3}	0.10	0.04	3.3 x10^{-3}	9.4 x10^{-3}	6.5 x10^{-3}	1.5 x10^{-3}	2.1x10^{-4}	0.12	2.3x10^{-3}	3.2 x10^{-5}	0.98	5.6x10^{-4}
16	0.03	0.05	6.7x10^{-3}	0.02	0.01	6.9x10^{-4}	1.9 x10^{-3}	1.3 x10^{-3}	3.1x10^{-4}	4.4 x10^{-5}	0.02	4.8x10^{-4}	6.5 x10^{-6}	0.20	1.2x10^{-4}
17	0.14	0.24	3.5x10^{-3}	0.11	0.04	3.6 x10^{-3}	1.0 x10^{-2}	7.1 x10^{-3}	1.6 x10^{-3}	2.3x10^{-4}	0.13	2.5x10^{-3}	3.5 x10^{-5}	1.07	6.2x10^{-4}
19	0.10	0.17	2.6x10^{-3}	0.08	0.03	2.6 x10^{-3}	7.5 x10^{-3}	5.1 x10^{-3}	1.2 x10^{-3}	1.7x10^{-4}	0.10	1.9x10^{-3}	2.5 x10^{-5}	0.78	4.5x10^{-4}
20	0.17	0.30	4.4x10^{-3}	0.13	0.05	4.5 x10^{-3}	1.3 x10^{-2}	8.8 x10^{-3}	2.1 x10^{-3}	2.9 x10^{-4}	0.16	3.2x10^{-3}	4.3 x10^{-5}	1.33	7.7x10^{-4}
33	0.03	0.05	8.1x10^{-4}	0.02	0.01	8.3 x10^{-4}	2.4 x10^{-3}	1.6 x10^{-3}	3.8x10^{-4}	5.3x10^{-5}	0.03	5.9x10^{-4}	7.9 x10^{-6}	0.25	1.4x10^{-4}
35	0.05	0.08	1.1x10^{-3}	0.03	0.01	1.2 x10^{-3}	3.3 x10^{-3}	2.3 x10^{-3}	5.3x10^{-4}	7.5x10^{-5}	0.04	8.3x10^{-4}	1.1 x10^{-5}	0.35	2.0x10^{-4}

As discussed earlier, predicted ground-level concentrations of stack emissions were calculated using AUSPLUME. The modelling runs which were undertaken are as follows:

- Prediction of maximum sulphur dioxide and nitrogen dioxide ground-level concentrations for 1-hour and long-term averaging periods (see **Figures 7-22, 7-23, 7-24, 7-25, 7-26 and 7-27**);
- Prediction of maximum carbon monoxide ground-level concentrations for a 15-minute, 1 hour and 8 hour averaging periods (see **Figures 7-28, 7-29, and 7-30)**;
- Prediction of maximum ground-level concentrations of hydrogen fluoride for 24-hour, 7-day and 90-days averaging periods (**Figures 7-31, 7-32, and 7-33**); and
- Prediction of maximum ground-level concentrations of HCl for a 1 hour averaging period (see **Figure 7-34**);
- Prediction of maximum ground-level concentrations of SO3 from stack emissions for a 1 hour averaging period (see **Figure 7-35**).
- Prediction of maximum ground-level concentrations of Acetone from stack emissions for a 1 hour averaging period (see **Figure 7-36**).
- Prediction of maximum ground-level concentrations of Benzene from stack emissions for a 1 hour averaging period (see **Figure 7-37**).
- Prediction of maximum ground-level concentrations of Carbon disulphide from stack emissions for a 1 hour averaging period (see **Figure 7-38**).
- Prediction of maximum ground-level concentrations of Chlorine from stack emissions for a 1 hour averaging period (see **Figure 7-39**).
- Prediction of maximum ground-level concentrations of Chloroethane from stack emissions for a 1 hour averaging period (see **Figure 7-40**).
- Prediction of maximum ground-level concentrations of Ethylbenzene from stack emissions for a 1 hour averaging period (see **Figure 7-41**).
- Prediction of maximum ground-level concentrations of Xylene from stack emissions for a 1 hour averaging period (see **Figure 7-42**).
- Prediction of maximum ground-level concentrations of Phenol from stack emissions for a 1 hour averaging period (see **Figure 7-43**).
- Prediction of maximum ground-level concentrations of Styrene from stack emissions for a 1 hour averaging period (see **Figure 7-44**).
- Prediction of maximum ground-level concentrations of Tetrachloroethane from stack emissions for a 1 hour averaging period (see **Figure 7-45**).
- Prediction of maximum ground-level concentrations of Toluene from stack emissions for a 1 hour averaging period (see **Figure 7-46**).

- Prediction of maximum ground-level concentrations of Arsenic from stack emissions for a 1 hour averaging period (see **Figure 7-47**).
- Prediction of maximum ground-level concentrations of Beryllium from stack emissions for a 1 hour averaging period (see **Figure 7-48**).
- Prediction of maximum ground-level concentrations of Manganese from stack emissions for a 1 hour averaging period (see **Figure 7-49**).
- Prediction of maximum ground-level concentrations of Mercury from stack emissions for a 1 hour averaging period (see **Figure 7-50**).

The dispersion modelling results indicate that all sensitive receptors would be below the relevant criterion for all pollutants assessed.

Figure 7-22 Predicted 10-Minute Average SO_2 Concentrations (µg/m³) (Project Alone) – (Criterion 712 µg/m³)

Figure 7-23 Predicted 1-Hour Average SO_2 Concentrations (µg/m³) (Project Alone) - (Criterion 570 µg/m³)

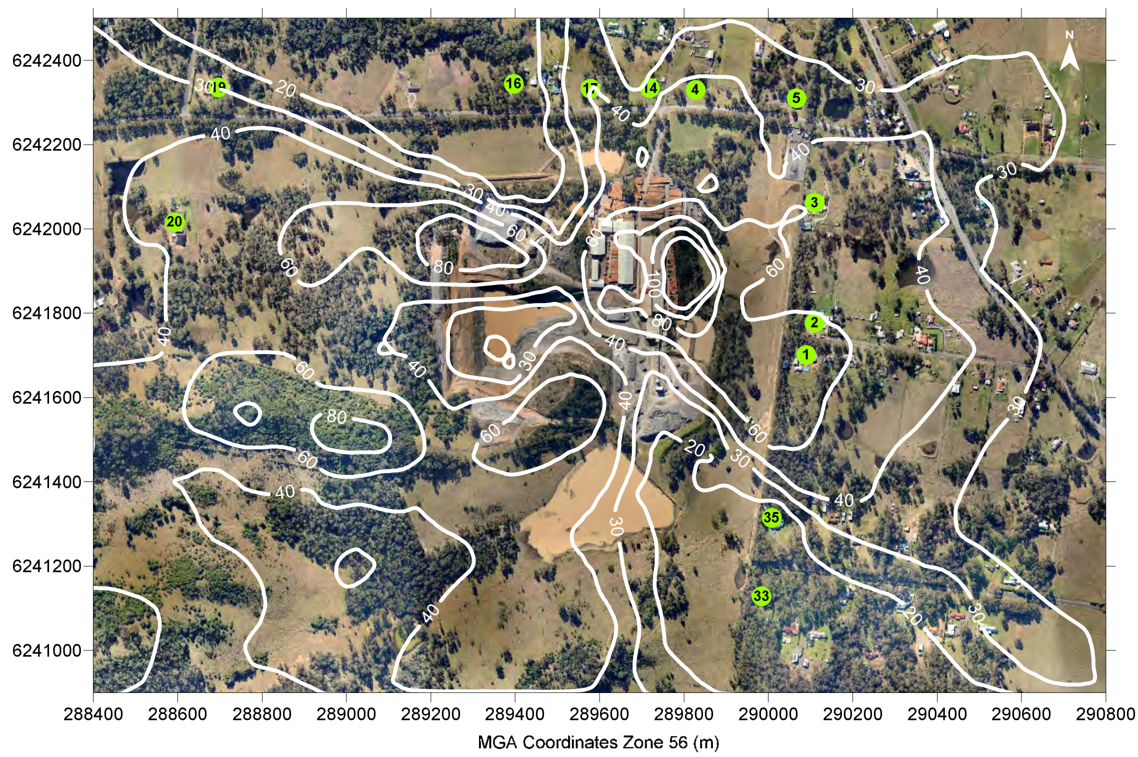


Figure 7-24 Predicted 24-Hour Average SO_2 Concentrations (µg/m³) (Project Alone) - (Criterion 228 µg/m³)

Figure 7-25 Predicted Annual Average SO_2 Concentrations (µg/m³) (Project Alone) - (Criterion 60 µg/m³)

Figure 7-26 Predicted 1-Hour Average NO_2 Concentrations (µg/m³) (Project Alone) - (Criterion 246 µg/m³)

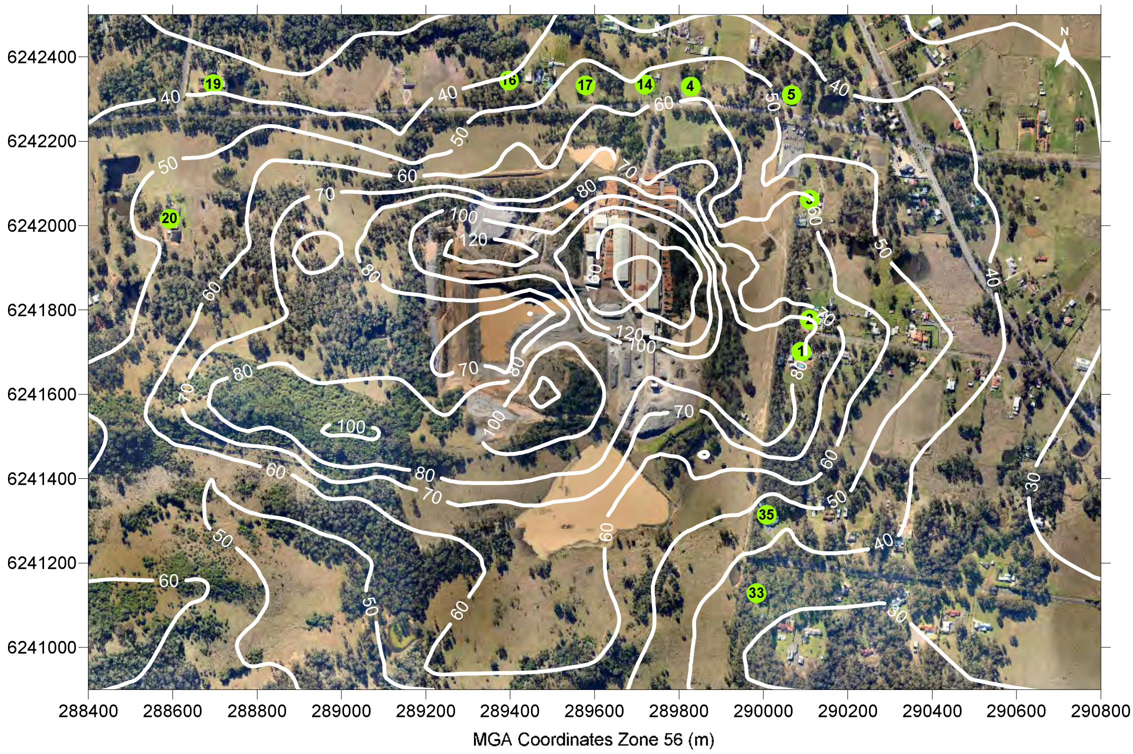


Figure 7-27 Predicted Annual Average NO_2 Concentrations (µg/m³) (Project Alone) - (Criterion 62 µg/m³)

Figure 7-28 Predicted 15-Minute Average CO Concentrations (µg/m³) (Project Alone) -(Criterion 1x10^5 µg/m³)

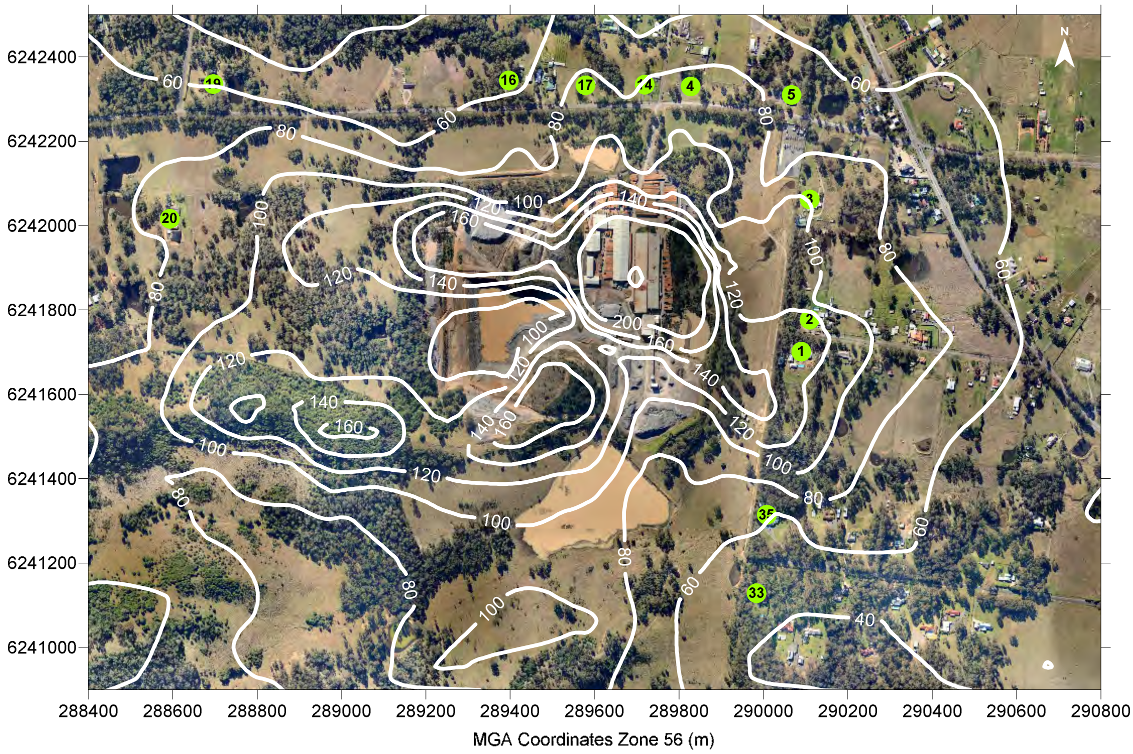


Figure 7-29 Predicted 1-Hour Average CO Concentrations (µg/m³) (Project Alone) -(Criterion 3x10^4 µg/m³)

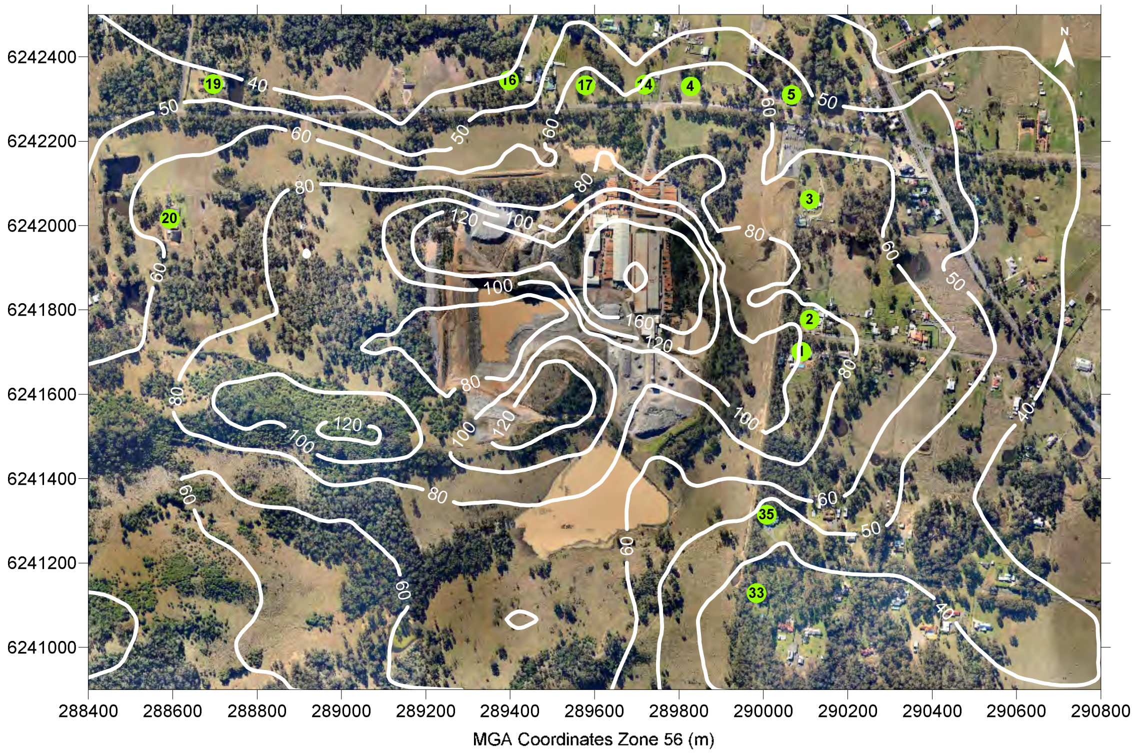


Figure 7-30 Predicted 8-Hour Average CO Concentrations (µg/m³) (Project Alone) - (Criterion 1x10^4 µg/m³)

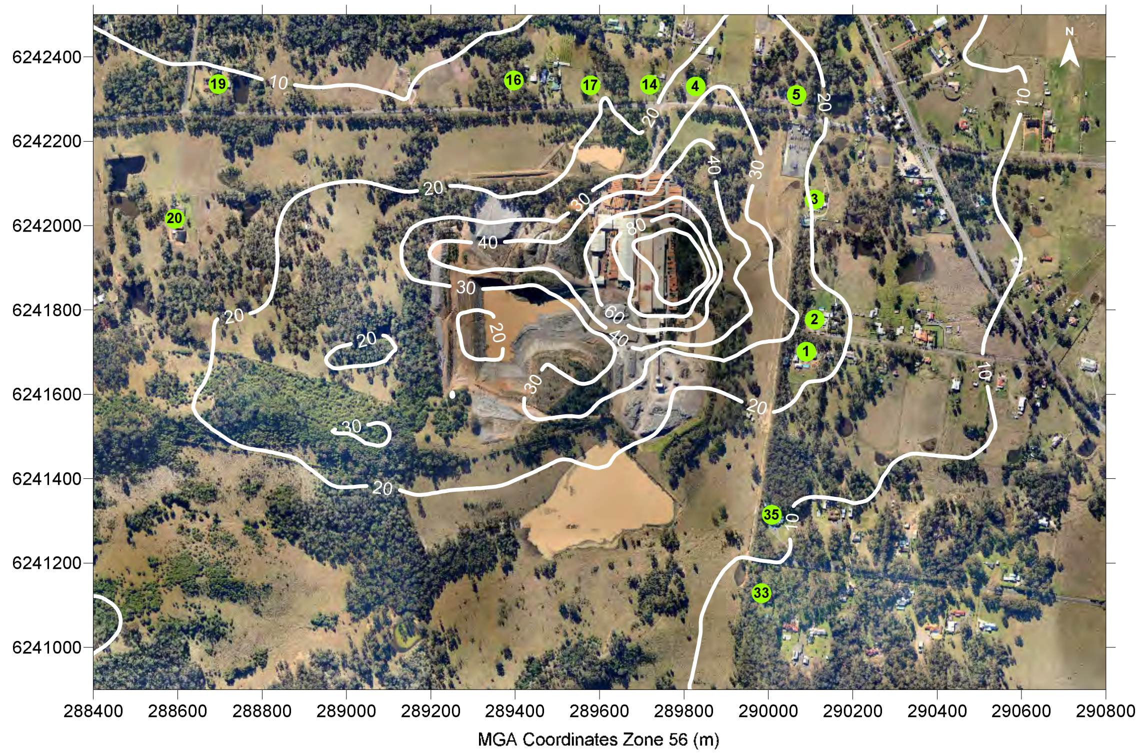


Figure 7-31 Predicted 24-Hour Average HF Concentrations (µg/m³) (Project Alone) - (Criterion 2.9 µg/m³)

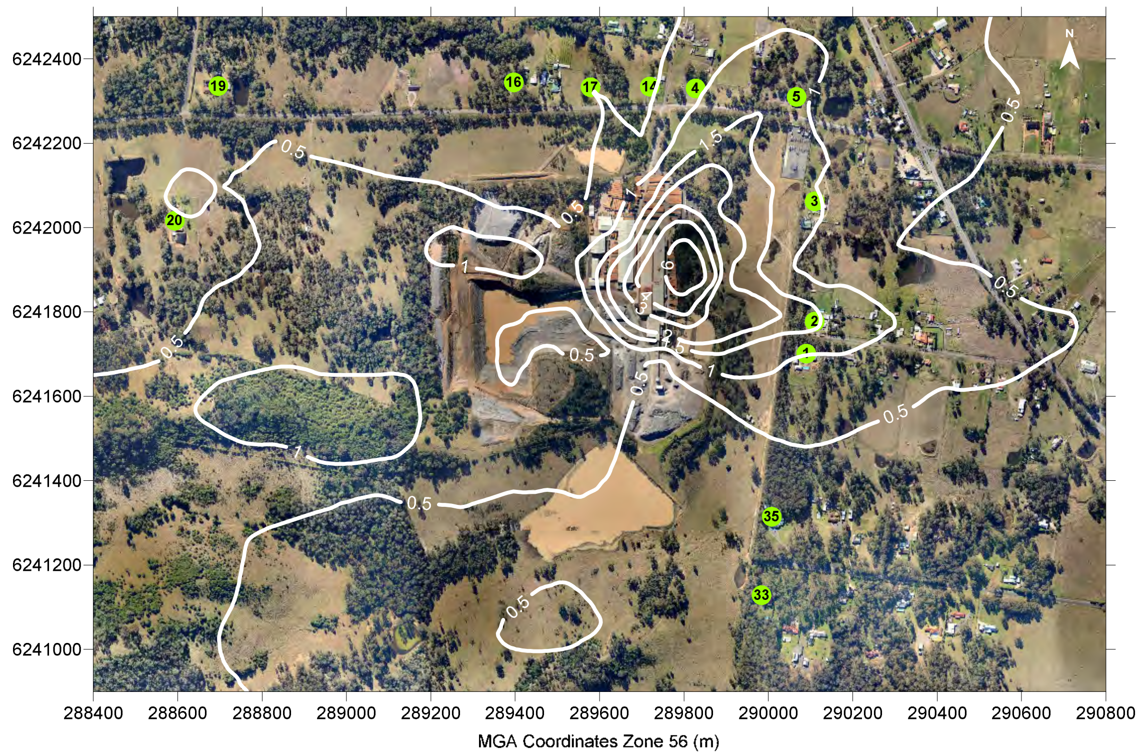


Figure 7-32 Predicted 7-day Average HF Concentrations (µg/m³) (Project Alone) - (Criterion 1.7 µg/m³)

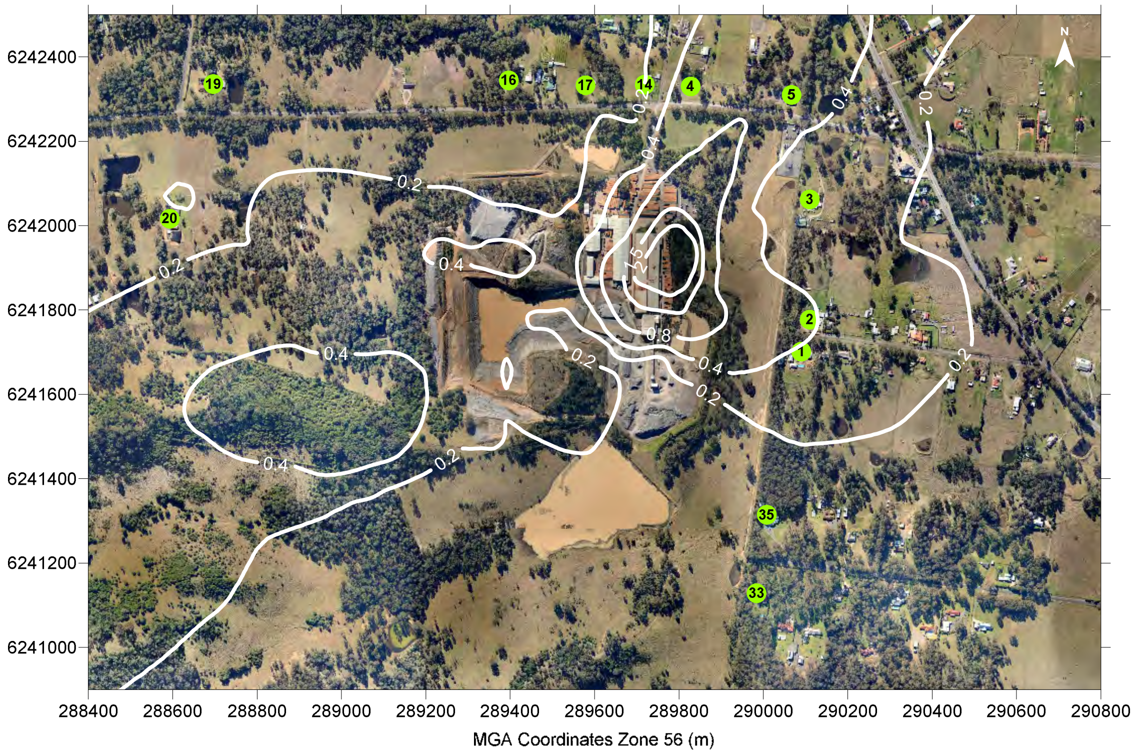


Figure 7-33 Predicted 90-Day Average HF Concentrations (µg/m³) (Project Alone) - (Criterion 0.5 µg/m³)

Figure 7-34 Predicted 1-Hour Average Hcl Concentrations (µg/m³) (Project Alone) - (Criterion 140 µg/m³)

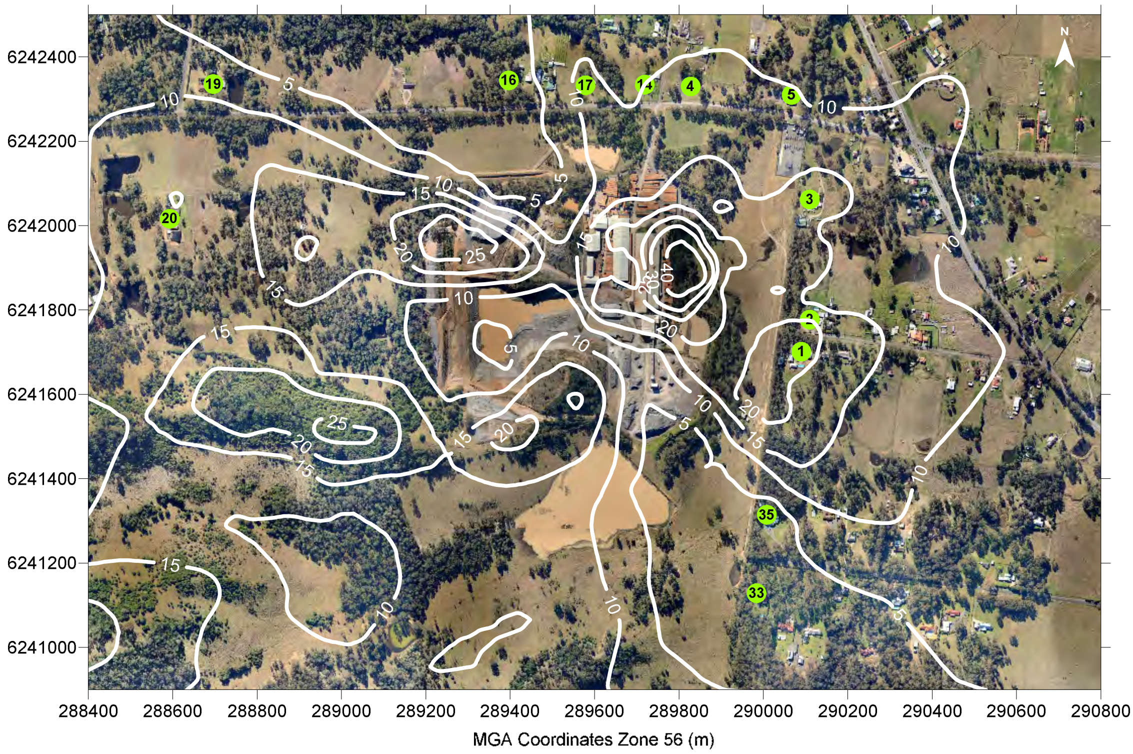


Figure 7-35 Predicted 1-Hour Average SO_3 Concentrations (µg/m³) (Project Alone) - (Criterion 18 µg/m³)

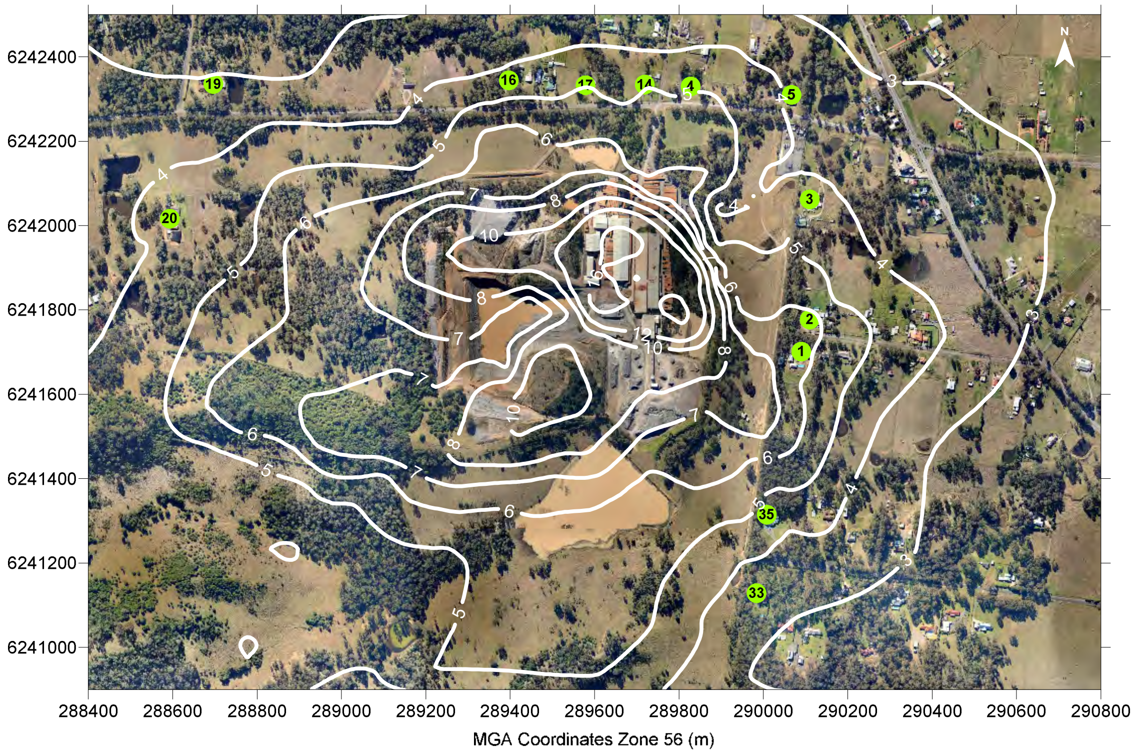


Figure 7-36 Predicted 1-Hour Average Acetone Concentrations (µg/m³) (Project Alone) - (Criterion 22000 µg/m³)

Figure 7-37 Predicted 1-Hour Average Benzene Concentrations (µg/m³) (Project Alone) - (Criterion 29 µg/m³)

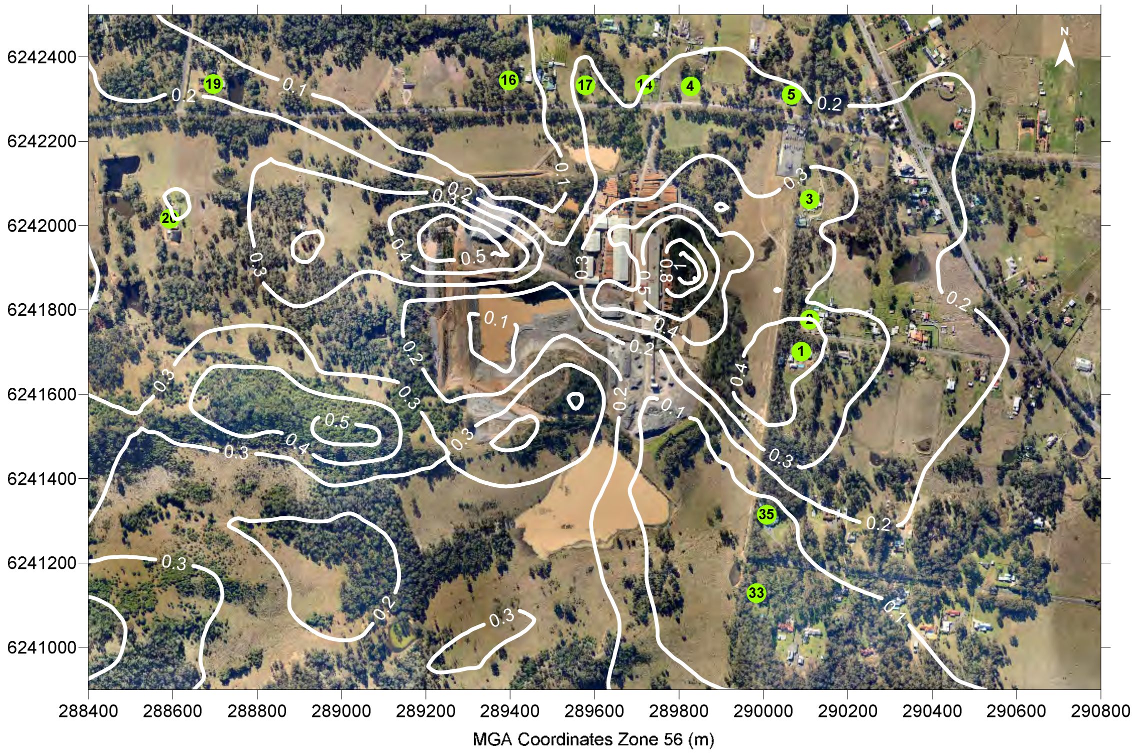


Figure 7-38 Predicted 1-Hour Average Carbon Disulphide Concentrations (µg/m³) (Project Alone) - (Criterion 70 µg/m³)

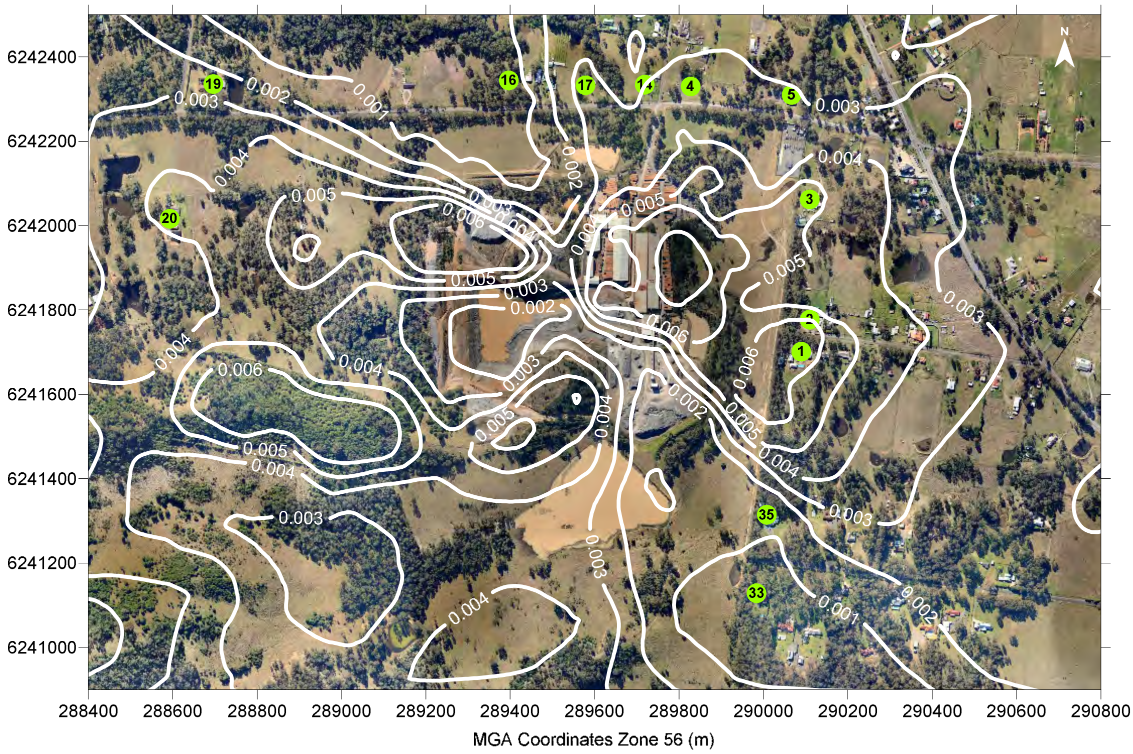


Figure 7-39 Predicted 1-Hour Average Chlorine Concentrations (µg/m³) (Project Alone) - (Criterion 50 µg/m³)

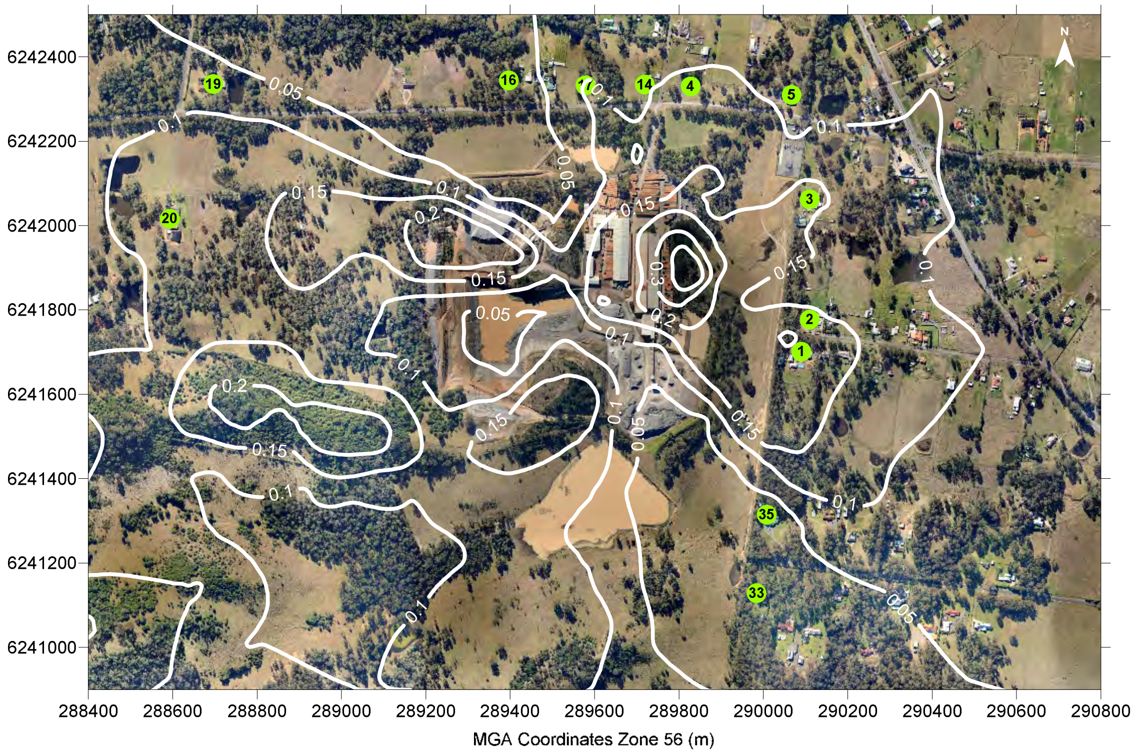


Figure 7-40 Predicted 1-Hour Average Chloroethane Concentrations (µg/m³) (Project Alone) - (Criterion 48000 µg/m³)

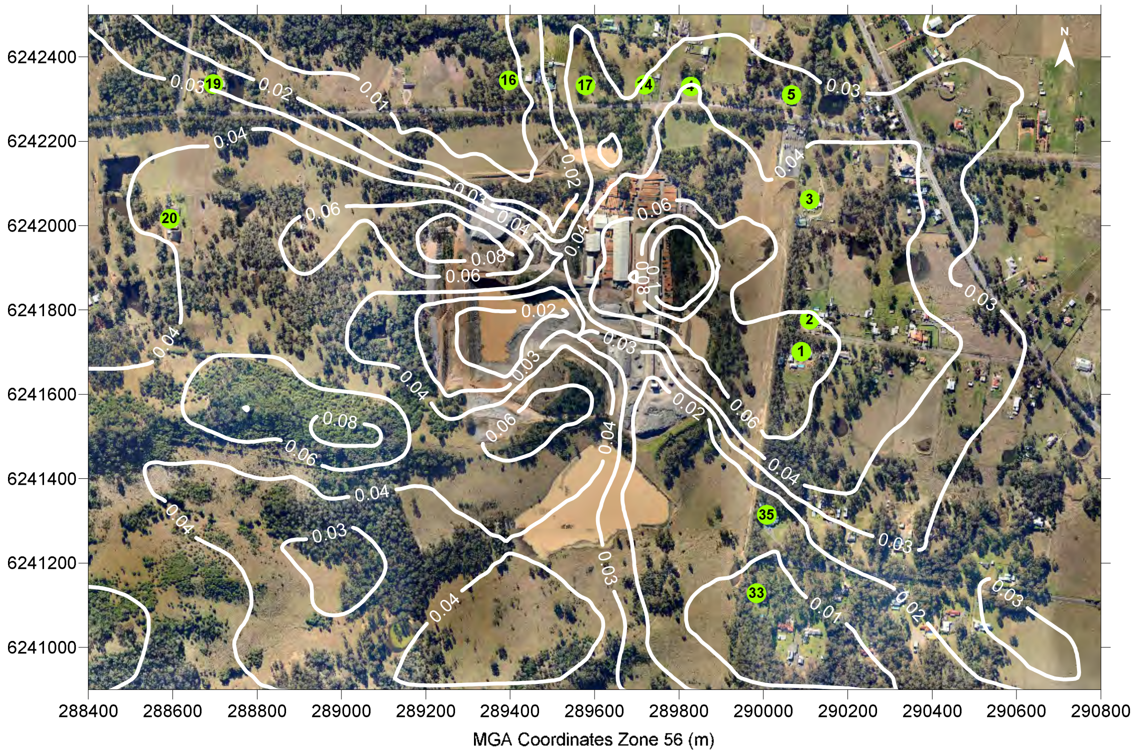


Figure 7-41 Predicted 1-Hour Average Ethylbenzene Concentrations (µg/m³) (Project Alone) - (Criterion 8000 µg/m³)

Figure 7-42 Predicted 1-Hour Average Xylene Concentrations (µg/m³) (Project Alone) - (Criterion 190 µg/m³)

Figure 7-43 Predicted 1-Hour Average Phenol Concentrations (µg/m³) (Project Alone) - (Criterion 20 µg/m³)

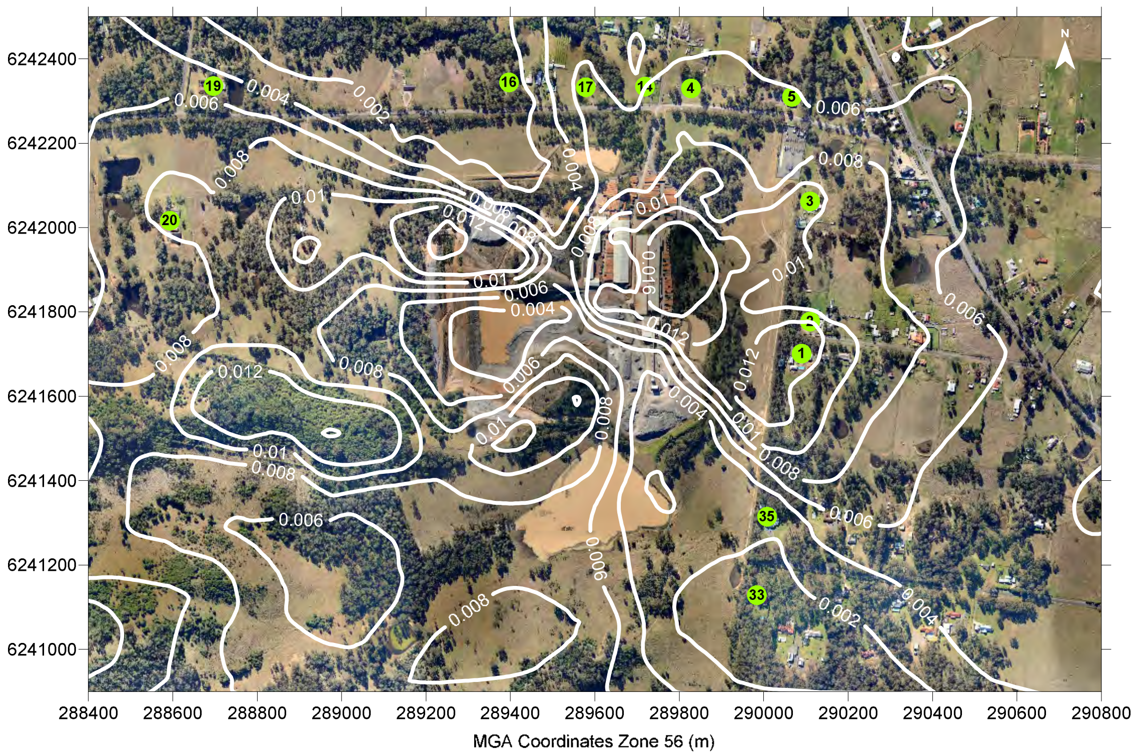


Figure 7-44 Predicted 1-Hour Average Styrene Concentrations (µg/m³) (Project Alone) - (Criterion 120 µg/m³)

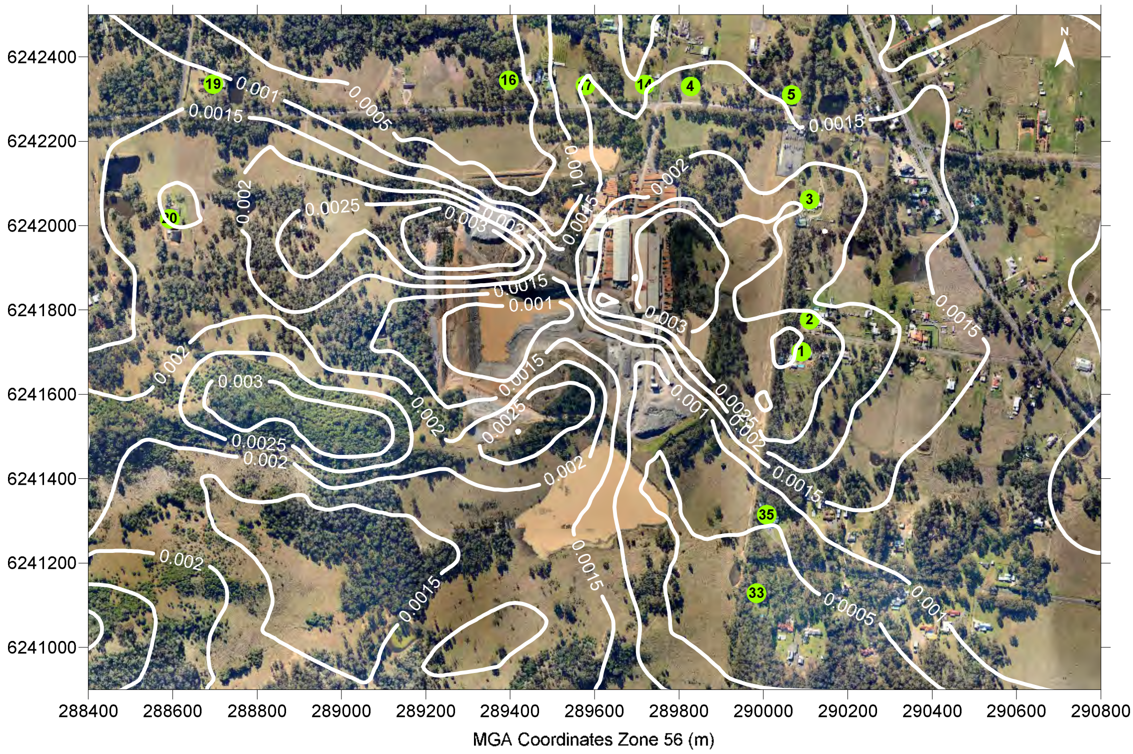


Figure 7-45 Predicted 1-Hour Average Tetrachloroethane Concentrations (µg/m³) (Project Alone) - (Criterion 1000 µg/m³)

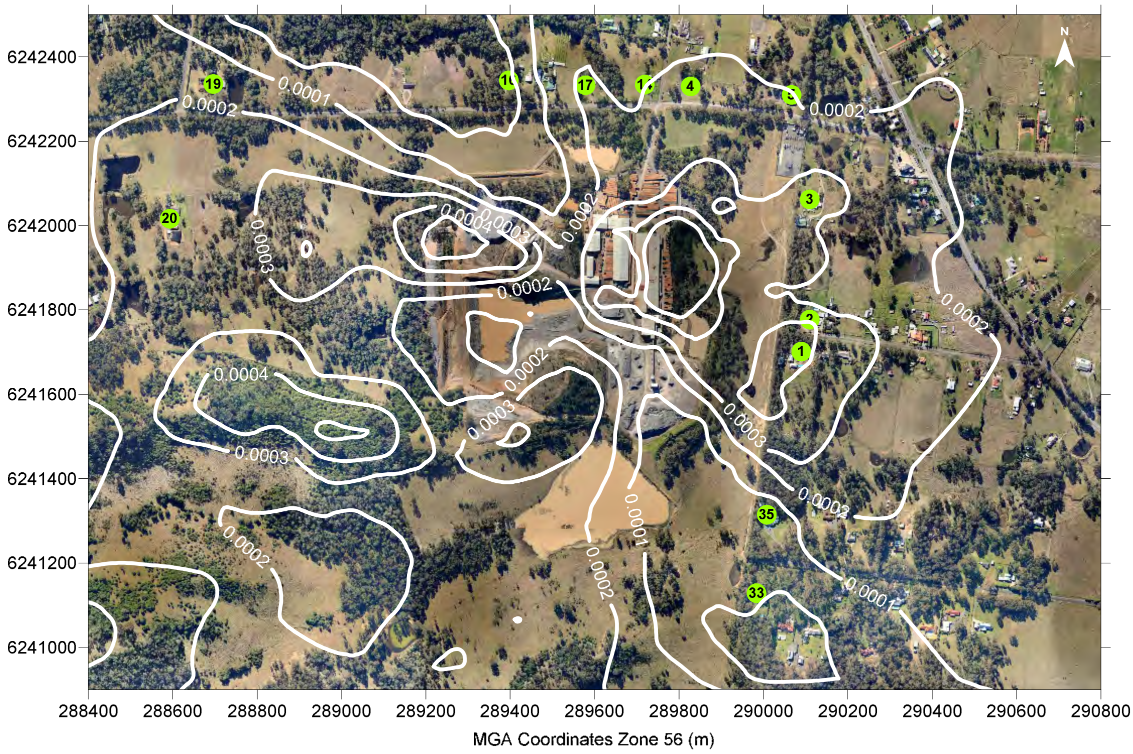


Figure 7-46 Predicted 1-Hour Average Toluene Concentrations (µg/m³) (Project Alone) - (Criterion 360 µg/m³)

Figure 7-47Predicted 1-Hour Average Arsenic Concentrations (µg/m³) (Project Alone) - (Criterion 0.09 µg/m³)

Figure 7-48 Predicted 1-Hour Average Beryllium Concentrations (µg/m³) (Project Alone) - (Criterion 0.004 µg/m³)

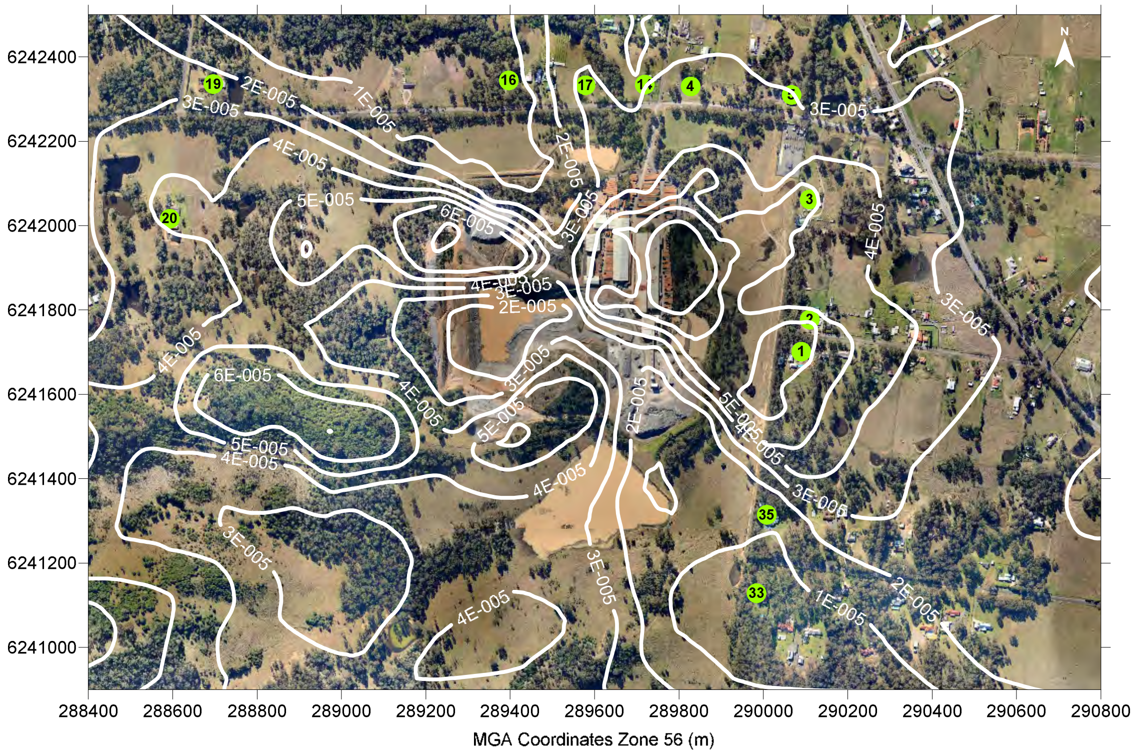


Figure 7-49 Predicted 1-Hour Average Manganese Concentrations (µg/m³) (Project Alone) - (Criterion 18 µg/m³)

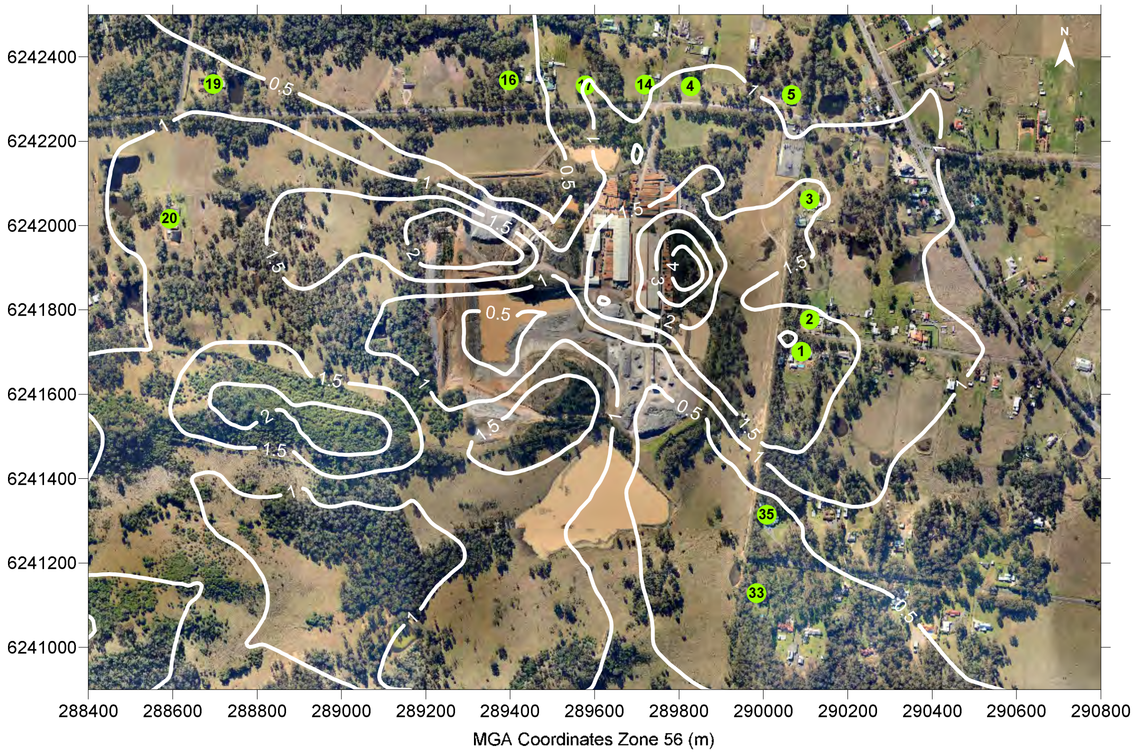
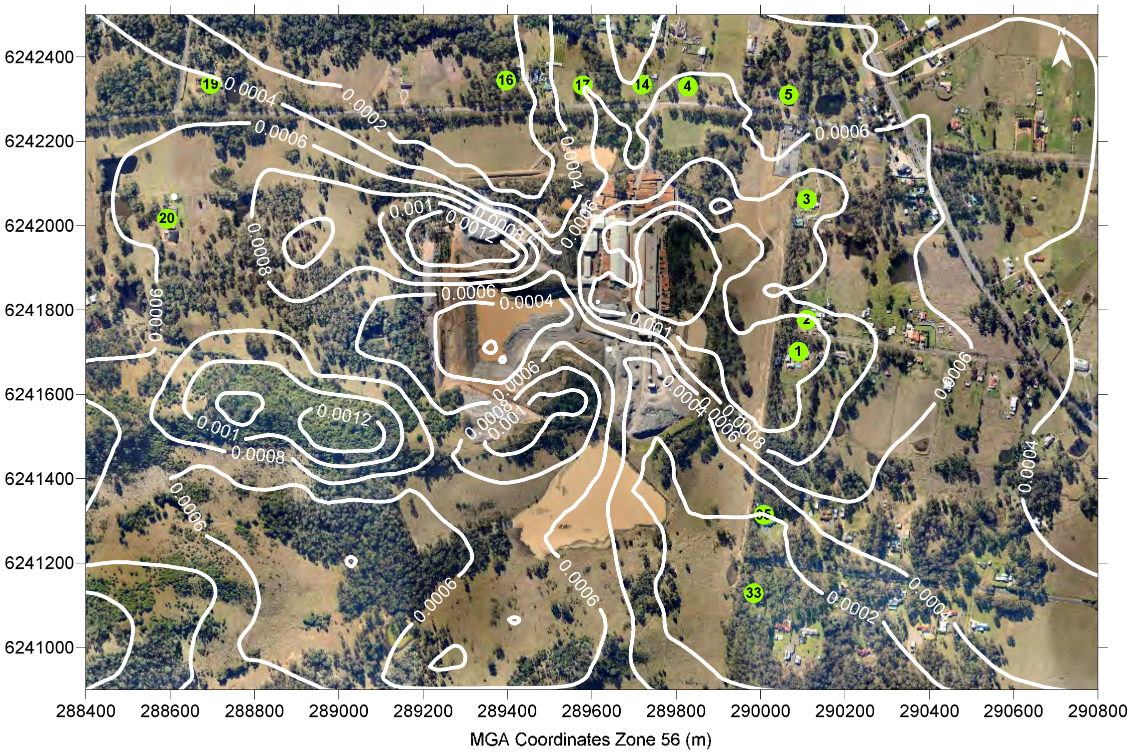


Figure 7-50 Predicted 1-Hour Average Mercury Concentrations (µg/m³) (Project Alone) - (Criterion 1.8 µg/m³)



8 MITIGATION MEASURES

8.1 Dust

The site activities will generate dust, therefore it is prudent to take reasonable and practicable measures to prevent or minimise dust emissions into the surrounding environment. The proponent will develop a dust emissions management and control procedure for managing the emissions from the operation that would supplement the measures described in this section.

The primary dust sources identified from the Project are:

- Wind-blown dust from stockpiles or exposed areas; and
- Dust generated by operational activities.

Table 8-1 summarises the following procedures proposed to minimise dust emissions from the primary dust sources.

Table 8-1 Dust Mitigation Measures

Source	Control Procedure
Exposed areas and quarry pit	• Restrict ground disturbance to the minimum area practically possible. Only commence quarrying in new areas when required clay reserves in active pits have been depleted. • Rehabilitate exhausted quarry pits as soon as practicable (refer to Rehabilitation strategy, • Use water sprays where practicable in exposed, non-vegetated areas to minimise dust lift-off.
Stockpiles	• Stockpiles are to be restricted to the designated raw material stockpile area to the south of the brick making facility. • Unusable material is to be used as backfill in exhausted quarry pits (refer to Rehabilitation strategy, • Temporary topsoil stockpiles are to be located in previously disturbed areas (devoid of vegetation) within the proposed quarry footprint. Topsoil stockpiles to remain in place for more than a month should be covered by establishing vegetative cover to minimise dust lift-off (refer to Rehabilitation strategy,
Hauling activities	• Watering of active haul roads and manoeuvring areas to minimise dust. • Limit vehicle speeds. • Covering loose, dust generating material loads, leaving the site.
All dust generating activities	• Retain a 5 m strip of mature woodland along the northern boundary of quarry Cell D. • Establish dense vegetation cover (mixture of locally occurring, native trees and shrubs on the two 4.5 m high noise bunds to be established along the northern boundary of quarry Cell D and to the east of the proposed new site access. • The above measures will act as significant vegetation buffers between the active quarry and sensitive receives to the north of Greendale Road, reducing fugitive dust emissions.

8.2 NO_x

A key air quality issue will in western Sydney is the generation of nitrogen oxides (NO_x) emissions.

This project has provided limited opportunity to reduce NOx emissions as the kiln is not being refurbished. Should the kiln be refurbished installation of best available control technology for the control of NO_x such as low NO_x burning technology and other efficient gas firing systems such as flameless regenerative thermal oxidation technology would be considered.

9 CONCLUSION

Wilkinson Murray has been commissioned to undertake an air quality impact assessment in relation to the proposed expansion of production for the Boral Brickworks at Bringelly.

Modeling of the following compounds has been undertaken using the AUSPLUME Gaussian Plume Dispersion Model software developed by the Victorian EPA:

- TSP;
- Dust deposition;
- PM10;
- NO_2;
- SO_2;
- HCL;
- HF;
- CO;
- VOC; and
- metals.

Air quality impacts from the facility having the potential to impact on nearby residential receivers has been assessed with respect to established air quality objectives and modelling potential impacts.

These predictions indicate that all air quality parameters attributable to the proposed operation will be within the air quality goals adopted for this project at all nearest sensitive receptors.

10 REFERENCES

Bureau of Meteorology (2012)
Climatic Averages Australia, Bureau of Meteorology website
[*http://www.bom.gov.au/climate/averages*]

EPA Victoria, 2000
"Ausplume Gaussian Plume Dispersion Model Technical User Manual"
Victorian EPA, December 1999

Mitchell McCotter (1988)
"Air Pollution from Surface Coal Mining: Community Perceptions Study"
NSW SPCC, NERDDC, June 1988

NPI (1998)
"Emissions Estimation Technique Manual for Bricks, Ceramics & Clay Product Manufacturing", National Pollutant Inventory, August 1998

NPI (2012)
"Emission Estimation Technique Manual for Mining, Version 3.1", National Pollutant Inventory, January 2012. ISBN: 0 642 54700 9

NSW EPA (2005)
"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", August 2005

NSW Minerals Council (2000)
"Technical Paper – Particulate Matter and Mining Interim Report"

NSW EPA (2011)
Environmental Issues Air, New South Wales Office of Environment and Heritage website
[*http://www.environment.nsw.gov.au*]

SPCC (1983)
"Air Pollution from Coal Mining and Related Developments", State Pollution Control Commission

US EPA (1985 and updates)
"Compilation of Air Pollutant Emission Factors", AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711. Note this reference is now a web-based document.

Warren, J. L. (1973)
"Green Space for Air Pollution Control". Technical Report N.50. School of Forest Resources, North Carolina State University, Rayleigh. July 1973

Appendix A – Emission Calculations

The production schedule and staging provided by the Proponent have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions and composition of the material being handled.

Emission factors and associated controls have been sourced from the US EPA AP42 Emission Factors (**US EPA, 1985 and Updates**), the National Pollutant Inventory document "*Emission Estimation Technique Manual for Mining, Version 3.1*" (**NPI, 2012**) and the State Pollution Control Commission document "*Air Pollution from Coal Mining and Related Developments*" (**SPCC, 1983**).

The emission factor equations used for each dust generating activity are outlined in **Table A-1** below. A detailed emission inventory for the modelled year is presented in **Table A-2**.

Table A-1 Emission Factor Equations

Activity	Emission Factor Equation	Variables	Control	Source
Scraper – topsoil removal	$EF = 0.0029\ kg/Mg$	-	-	US EPA, 1985
Scraper – travelling	$EF = 9.6 \times 10^{-6} \times s^{1.3} \times W^{2.4}\ kg/VKT$	S = silt content (%) W = vehicle mass (t)	50% - watering of travel route	NPI, 2012
Scraper – unloading	$EF = 0.02\ kg/Mg$	-	-	US EPA, 1985
Dozer – rip material	$EF = 2.6 \times s^{1.2}/M^{1.3}\ kg/hr$	S = silt content (%) M = moisture content (%)	-	US EPA, 1985
Loading / Unloading material	$EF = k \times 0.0016 \times \left(\left(U/2.2^{1.3}\right)/(M/2)^{1.4}\right)\ kg/tonne$	k_{TSP} = 0.74 U = wind speed (m/s) M = moisture content (%)	-	NPI, 2012
Hauling on unpaved roads	$EF = \left(\frac{0.4536}{1.6093} \times \left(\left(\frac{s}{12}\right)^{0.7} \times 4.9\right) \times \left(\frac{M \times 1.1023}{3}\right)^{0.45}\right)\ kg/VKT$	S = silt content (%) M = average vehicle gross mass (t)	75% - watering of travel route	US EPA, 1985
Grading roads	$EF = 0.0034 \times s^{2.5}\ kg/VKT$	s = speed of grader (km/hr)	-	US EPA, 1985
Crushing material	$EF = 0.0006\ kg/Mg$	-	-	US EPA, 1985
Conveyor	$EF = 0.4\ kg/ha\ /hour$	-	50% - enclosed	SPCC, 1983
Wind erosion	$EF = 1.9 \times \left(\frac{s}{1.5}\right) \times 365 \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right)\ kg/ha/year$	S = silt content (%) p = No. of days when rainfall >0.25mm f = % of time wind speed >5.4m/s	50% - watering of stockpiles 30% - wind breaks	NPI, 2012

Table A-2 Emissions Inventory – Stage 1

ACTIVITY	TSP emission (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control type	Units
TS - Topsoil Removal by Scraper	1,160	40,000	tonnes/year	0.029	kg/Mg												
TS - Scraper travelling	1,496	2,240	km	1.3	kg/vkt	39.94	tonnes (weight of scraper)	10	silt content %							50	% control
TS - Scraper unloading	800	40,000	tonnes/year	0.02	kg/Mg												
CL - Dozers ripping	1,463	600	hours/year	2.4386	kg/hr	10	% silt content	8.8	moisture content in %								
CL - Loading Clay/Shale in pit	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Hauling Clay/Shale to stockpile	8,141	200,000	tonnes/year	0.1628	kg/t	40	tonnes/load	1.4	km/return trip	4.7	kg/VKT	10	% silt conte	54	Ave GMV (tonnes)	75	% control
CL - Unloading Clay/Shale at stockpile	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Grading roads	492	1,600	km	0.6155	kg/VKT	8	speed of graders in km/h	200	hour of operation							50	% control
Hauling material onsite (paved road)	4,394	26,884	trip/year	0.33	kg/trip			0.6	km/return trip	0.5	kg/VKT	5	g/m2	40	Ave GMV (tonnes)	50	% control
Unloading material to stockpile	10	96,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Loading box feeder (FEL)	31	296,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Crushing	178	296,000	tonnes/year	0.0006	kg/Mg												
Plant feed conveyor	58	0.033	ha	0.4000	kg/ha/hour	8760	hours/year									50	% control
WE - Exposed area	337	8	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
WE - Stockpile area	238	5	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
Total TSP emissions (kg/yr)	**18,840**																

Table A-3 Emissions Inventory – Stage 2

ACTIVITY	TSP emission (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control type	Units
TS - Topsoil Removal by Scraper	1,160	40,000	tonnes/year	0.029	kg/Mg												
TS - Scraper travelling	1,496	2,240	km	1.3	kg/vkt	39.94	tonnes (weight of scraper)	10	silt content %							50	% control
TS - Scraper unloading	800	40,000	tonnes/year	0.02	kg/Mg												
CL - Dozers ripping	1,463	600	hours/year	2.4386	kg/hr	10	% silt content	8.8	moisture content in %								
CL - Loading Clay/Shale in pit	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Hauling Clay/Shale to stockpile	8,141	200,000	tonnes/year	0.1628	kg/t	40	tonnes/load	1.4	km/return trip	4.7	kg/VKT	10	% silt conte	54	Ave GMV (tonnes)	75	% control
CL - Unloading Clay/Shale at stockpile	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Grading roads	492	1,600	km	0.6155	kg/VKT	8	speed of graders in km/h	200	hour of operation							50	% control
Hauling material onsite (paved road)	4,394	26,884	trip/year	0.33	kg/trip			0.6	km/return trip	0.5	kg/VKT	5	g/m2	40	Ave GMV (tonnes)	50	% control
Unloading material to stockpile	10	96,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Loading box feeder (FEL)	31	296,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Crushing	178	296,000	tonnes/year	0.0006	kg/Mg												
Plant feed conveyor	58	0.033	ha	0.4000	kg/ha/hour	8760	hours/year									50	% control
WE - Exposed area	469	11	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
WE - Stockpile area	238	5	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
Total TSP emissions (kg/yr)	**18,971**																

Table A-4 Emissions Inventory – Stage 3

ACTIVITY	TSP emission (kg/year)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control type	Units
TS - Topsoil Removal by Scraper	1,160	40,000	tonnes/year	0.029	kg/Mg												
TS - Scraper travelling	1,496	2,240	km	1.3	kg/vkt	39.94	tonnes (weight of scraper)	10	silt content %							50	% control
TS - Scraper unloading	800	40,000	tonnes/year	0.02	kg/Mg												
CL - Dozers ripping	1,463	600	hours/year	2.4386	kg/hr	10	% silt content	8.8	moisture content in %								
CL - Loading Clay/Shale in pit	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Hauling Clay/Shale to stockpile	8,141	200,000	tonnes/year	0.1628	kg/t	40	tonnes/load	1.4	km/return trip	4.7	kg/VKT	10	% silt conte	54	Ave GMV (tonnes)	75	% control
CL - Unloading Clay/Shale at stockpile	21	200,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Grading roads	492	1,600	km	0.6155	kg/VKT	8	speed of graders in km/h	200	hour of operation							50	% control
Hauling material onsite (paved road)	4,394	26,884	trip/year	0.33	kg/trip			0.6	km/return trip	0.5	kg/VKT	5	g/m2	40	Ave GMV (tonnes)	50	% control
Unloading material to stockpile	10	96,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
CL - Loading box feeder (FEL)	31	296,000	tonnes/year	0.0001	kg/t	0.710	Ave(WS/2.2)^1.3 [m/s]	8.8	moisture content in %								
Crushing	178	296,000	tonnes/year	0.0006	kg/Mg												
Plant feed conveyor	58	0.033	ha	0.4000	kg/ha/hour	8760	hours/year									50	% control
WE - Exposed area	544	12	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
WE - Stockpile area	238	5	ha	292.2	kg/ha/year	10	silt content in %	68	(p)	0.75	(f)					85	% control
Total TSP emissions (kg/yr)	**19,046**																

Appendix B – Sample AUSPLUME File

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1                            _____________

                               Scenario 1

                             _____________

Concentration or deposition                         Concentration
Emission rate units                                 grams/second
Concentration units                                 microgram/m3
Units conversion factor                             1.00E+06
Constant background concentration                            0.00E+00
Terrain effects                                     Egan method
Plume depletion due to dry removal mechanisms included.
Smooth stability class changes?                     No
Other stability class adjustments ("urban modes")   None
Ignore building wake effects?                       Yes
Decay coefficient (unless overridden by met. file)  0.000
Anemometer height                                   10 m
Roughness height at the wind vane site              0.500 m

                   DISPERSION CURVES
Horizontal dispersion curves for sources <100m high  Pasquill-Gifford
Vertical  dispersion  curves for sources <100m high  Pasquill-Gifford
Horizontal dispersion curves for sources >100m high  Briggs Rural
Vertical  dispersion  curves for sources >100m high  Briggs Rural
Enhance horizontal plume spreads for buoyancy?       Yes
Enhance  vertical  plume spreads for buoyancy?       Yes
Adjust horizontal P-G formulae for roughness height? Yes
Adjust  vertical  P-G formulae for roughness height? Yes
Roughness height                                     0.400m
Adjustment for wind directional shear                None

                    PLUME RISE OPTIONS
Gradual plume rise?                                  Yes
Stack-tip downwash included?                         Yes
Building downwash algorithm:                        Schulman-Scire method.
Entrainment coeff. for neutral & stable lapse rates 0.60,0.60
Partial penetration of elevated inversions?          No
Disregard temp. gradients in the hourly met. file?   No

and in the absence of boundary-layer potential temperature gradients
given by the hourly met. file, a value from the following table
(in K/m) is used:

   Wind Speed                Stability Class
    Category       A      B      C      D      E      F
  _____________________________________________________
       1         0.000  0.000  0.000  0.000  0.020  0.035
       2         0.000  0.000  0.000  0.000  0.020  0.035
       3         0.000  0.000  0.000  0.000  0.020  0.035
       4         0.000  0.000  0.000  0.000  0.020  0.035
       5         0.000  0.000  0.000  0.000  0.020  0.035
       6         0.000  0.000  0.000  0.000  0.020  0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are:  1.54,  3.09,  5.14,  8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIMES
24 hours
 average over all hours
_____________________________________________________________________________
```

```
                         _________________

                             Scenario 1

                           SOURCE GROUPS

                         _________________

          Group No.     Members
          ____________________________________________________________
                1       1      2      3      4      5      6      7
                        8      9      10     11     12     13     14

                        15     16     17     18     19
                2       20     21     22     23     24     25     26
                        27     28     29     30     31     32     33

                        34     35     36     37     38
                3       39     40     41     42     43     44     45
                        46     47     48     49     50     51     52

                        53     54     55     56     57
 _________________________________________________________________________

1                      __________________________

                             Scenario 1

                       SOURCE CHARACTERISTICS

                       __________________________


                    VOLUME SOURCE: 1

   X(m)     Y(m)      Ground Elevation     Height   Hor. spread    Vert. spread
  289281  6241945           96m              2m         10m             2m

               (Constant) emission rate = 1.00E+00 grams/second

         Hourly multiplicative factors will be used with
         this emission factor.

                    Particle  Particle  Particle
                      Mass      Size    Density
                    fraction  (micron)  (g/cm3)
                   _____________________________
                      1.0000     1.0       2.50

etc
```

Appendix C – Contemporaneous PM_{10} assessment

Table C-1 Receptor 1 – PM_{10} 24-hour average (µg/m³) – Stage 1 - (Criterion 50 µg/m³)

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	1.4	44.9	27/08/2011	18.3	12.8	31.1
2/02/2011	42.4	0.2	42.6	20/04/2011	30.4	12.4	42.8
23/09/2011	39.4	0.4	39.7	10/08/2011	17.6	10.6	28.1
21/05/2011	37.8	0.0	37.9	13/07/2011	32.0	10.3	42.3
22/09/2011	36.2	1.8	38.1	3/07/2011	12.5	10.3	22.8
16/11/2011	34.9	0.8	35.7	29/07/2011	17.7	8.6	26.3
22/10/2011	34.9	0.3	35.2	8/11/2011	26.5	8.0	34.5
25/01/2011	34.4	0.3	34.7	18/07/2011	10.3	7.2	17.4
1/11/2011	33.5	0.7	34.2	15/08/2011	12.1	7.2	19.2
31/01/2011	32.4	0.2	32.5	31/07/2011	23.5	7.1	30.6

Table C-2 Receptor 2 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.9	44.4	27/08/2011	18.3	12.7	31.0
2/02/2011	42.4	0.2	42.6	31/07/2011	23.5	11.2	34.7
23/09/2011	39.4	0.3	39.7	20/04/2011	30.4	10.2	40.6
21/05/2011	37.8	0.0	37.9	29/07/2011	17.7	8.9	26.6
22/09/2011	36.2	1.6	37.8	3/07/2011	12.5	8.7	21.2
16/11/2011	34.9	1.0	35.9	10/08/2011	17.6	8.6	26.2
22/10/2011	34.9	0.2	35.1	18/07/2011	10.3	7.6	17.8
25/01/2011	34.4	0.6	34.9	13/07/2011	32.0	6.9	38.9
1/11/2011	33.5	1.3	34.8	31/08/2011	17.0	6.9	23.9
31/01/2011	32.4	0.1	32.5	15/08/2011	12.1	6.9	19.0

Table C-3 Receptor 3 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	31/07/2011	23.5	12.2	35.7
2/02/2011	42.4	1.4	43.8	20/04/2011	30.4	10.8	41.1
23/09/2011	39.4	0.6	39.9	10/04/2011	12.9	10.1	23.0
21/05/2011	37.8	0.1	38.0	29/07/2011	17.7	9.8	27.5
22/09/2011	36.2	0.3	36.5	9/08/2011	9.7	6.6	16.3
16/11/2011	34.9	3.1	38.0	25/08/2011	16.8	6.3	23.1
22/10/2011	34.9	0.2	35.1	19/04/2011	20.0	6.1	26.0
25/01/2011	34.4	1.0	35.4	14/08/2011	13.1	5.9	19.0
1/11/2011	33.5	2.2	35.7	1/04/2011	17.2	5.2	22.4
31/01/2011	32.4	1.3	33.7	27/08/2011	18.3	5.2	23.5

Table C-4 Receptor 4 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	2.2	45.7	30/07/2011	17.7	11.4	29.0
2/02/2011	42.4	0.1	42.5	25/08/2011	16.8	11.1	27.9
23/09/2011	39.4	0.5	39.8	10/04/2011	12.9	10.9	23.8
21/05/2011	37.8	4.7	42.5	11/08/2011	15.4	9.5	24.9
22/09/2011	36.2	0.3	36.5	22/04/2011	11.4	9.2	20.7
16/11/2011	34.9	4.5	39.5	9/08/2011	9.7	8.8	18.6
22/10/2011	34.9	0.2	35.0	1/08/2011	23.6	8.7	32.2
25/01/2011	34.4	0.7	35.1	28/04/2011	8.6	8.6	17.2
1/11/2011	33.5	3.0	36.5	4/07/2011	7.6	8.5	16.0
31/01/2011	32.4	0.0	32.4	16/08/2011	15.5	8.0	23.5

Table C-5 Receptor 5 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.4	43.9	31/07/2011	23.5	10.7	34.1
2/02/2011	42.4	0.2	42.7	10/04/2011	12.9	9.4	22.3
23/09/2011	39.4	0.8	40.1	25/08/2011	16.8	8.5	25.3
21/05/2011	37.8	0.4	38.3	9/08/2011	9.7	6.7	16.4
22/09/2011	36.2	0.3	36.5	1/04/2011	17.2	6.3	23.4
16/11/2011	34.9	4.0	38.9	28/04/2011	8.6	5.8	14.4
22/10/2011	34.9	0.1	35.0	11/08/2011	15.4	5.6	21.0
25/01/2011	34.4	0.8	35.1	7/11/2011	25.1	5.4	30.5
1/11/2011	33.5	2.5	36.0	8/04/2011	12.1	5.3	17.4
31/01/2011	32.4	0.5	32.8	11/04/2011	7.5	5.2	12.7

Table C-6 Receptor 14 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	25/08/2011	16.8	13.2	30.0
2/02/2011	42.4	0.0	42.4	28/04/2011	8.6	10.7	19.3
23/09/2011	39.4	0.2	39.5	2/07/2011	8.9	10.3	19.2
21/05/2011	37.8	2.9	40.8	10/04/2011	12.9	10.1	23.0
22/09/2011	36.2	0.2	36.5	8/04/2011	12.1	10.0	22.1
16/11/2011	34.9	5.0	39.9	1/04/2011	17.2	9.9	27.1
22/10/2011	34.9	0.1	35.0	4/08/2011	26.6	9.8	36.4
25/01/2011	34.4	0.6	34.9	11/08/2011	15.4	9.7	25.1
1/11/2011	33.5	2.8	36.3	22/04/2011	11.4	9.5	21.0
31/01/2011	32.4	0.0	32.4	9/08/2011	9.7	9.5	19.3

Table C-7 Receptor 16 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.5	16/07/2011	10.1	18.0	28.1
2/02/2011	42.4	0.2	42.6	22/04/2011	11.4	14.4	25.8
23/09/2011	39.4	0.5	39.8	30/07/2011	17.7	13.7	31.4
21/05/2011	37.8	0.2	38.0	2/07/2011	8.9	10.9	19.7
22/09/2011	36.2	0.1	36.3	13/08/2011	15.8	10.5	26.3
16/11/2011	34.9	2.1	37.0	2/04/2011	16.6	10.4	27.1
22/10/2011	34.9	0.9	35.8	31/03/2011	20.1	10.1	30.2
25/01/2011	34.4	0.4	34.8	1/08/2011	23.6	10.0	33.5
1/11/2011	33.5	1.0	34.5	25/07/2011	12.7	9.3	22.0
31/01/2011	32.4	0.1	32.5	4/07/2011	7.6	9.0	16.6

Table C-8 Receptor 17 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.0	43.5	25/08/2011	16.8	14.2	31.0
2/02/2011	42.4	0.0	42.5	28/04/2011	8.6	14.2	22.8
23/09/2011	39.4	0.2	39.6	30/07/2011	17.7	11.5	29.1
21/05/2011	37.8	2.0	39.9	11/04/2011	7.5	11.4	18.9
22/09/2011	36.2	0.2	36.4	26/07/2011	10.4	10.8	21.2
16/11/2011	34.9	9.2	44.1	2/07/2011	8.9	10.7	19.6
22/10/2011	34.9	1.6	36.5	30/08/2011	16.8	10.6	27.4
25/01/2011	34.4	0.6	34.9	16/07/2011	10.1	10.5	20.6
1/11/2011	33.5	1.7	35.2	4/07/2011	7.6	10.5	18.1
31/01/2011	32.4	0.0	32.4	23/04/2011	15.9	9.9	25.7

Table C-9 Receptor 19 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.3	43.8	17/08/2011	13.7	5.5	19.2
2/02/2011	42.4	0.3	42.7	6/08/2011	28.8	5.5	34.2
23/09/2011	39.4	0.1	39.4	14/04/2011	12.8	4.7	17.5
21/05/2011	37.8	0.1	37.9	7/08/2011	9.9	4.4	14.4
22/09/2011	36.2	0.1	36.3	2/08/2011	28.4	3.7	32.1
16/11/2011	34.9	0.4	35.3	10/03/2011	21.7	3.6	25.2
22/10/2011	34.9	0.3	35.2	24/11/2011	12.2	2.8	15.0
25/01/2011	34.4	0.2	34.5	17/11/2011	8.1	2.8	10.8
1/11/2011	33.5	0.4	33.9	3/11/2011	9.0	2.7	11.7
31/01/2011	32.4	0.3	32.7	16/07/2011	10.1	2.5	12.5

Table C-10 Receptor 20 – PM_{10} 24-hour average (µg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.6	19/04/2011	20.0	5.5	25.5
2/02/2011	42.4	0.4	42.8	6/07/2011	8.6	5.5	14.1
23/09/2011	39.4	0.3	39.6	15/04/2011	15.6	5.2	20.8
21/05/2011	37.8	0.1	37.9	29/08/2011	18.6	5.1	23.7
22/09/2011	36.2	0.2	36.4	21/04/2011	12.3	5.0	17.3
16/11/2011	34.9	0.1	35.0	21/03/2011	8.8	4.1	12.9
22/10/2011	34.9	0.4	35.2	3/08/2011	29.9	4.0	33.8
25/01/2011	34.4	0.2	34.5	12/07/2011	18.5	3.8	22.3
1/11/2011	33.5	0.7	34.2	3/11/2011	9.0	3.4	12.4
31/01/2011	32.4	0.3	32.7	20/11/2011	21.5	3.3	24.8

Table C-11 Receptor 33 – PM_{10} 24-hour average (μg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.6	24/07/2011	8.3	9.4	17.7
2/02/2011	42.4	0.0	42.4	13/07/2011	32.0	6.1	38.1
23/09/2011	39.4	0.1	39.5	14/11/2011	22.7	5.7	28.4
21/05/2011	37.8	0.0	37.9	1/03/2011	18.5	3.8	22.3
22/09/2011	36.2	0.0	36.3	25/04/2011	10.3	2.8	13.1
16/11/2011	34.9	0.0	35.0	26/04/2011	8.5	2.8	11.3
22/10/2011	34.9	0.2	35.0	26/12/2011	16.0	1.9	17.9
25/01/2011	34.4	0.0	34.4	28/07/2011	13.3	1.9	15.1
1/11/2011	33.5	0.1	33.6	7/08/2011	9.9	1.7	11.6
31/01/2011	32.4	0.2	32.6	8/07/2011	17.2	1.5	18.6

Table C-12 Receptor 35 – PM_{10} 24-hour average (μg/m³) – Stage 1

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	1/03/2011	18.5	8.7	27.2
2/02/2011	42.4	0.1	42.5	28/07/2011	13.3	8.0	21.3
23/09/2011	39.4	0.2	39.5	26/04/2011	8.5	7.6	16.1
21/05/2011	37.8	0.0	37.9	24/07/2011	8.3	7.0	15.3
22/09/2011	36.2	0.0	36.3	13/07/2011	32.0	5.9	37.9
16/11/2011	34.9	0.1	35.0	25/07/2011	12.7	5.8	18.5
22/10/2011	34.9	0.2	35.1	13/04/2011	11.7	5.6	17.2
25/01/2011	34.4	0.1	34.4	5/11/2011	19.1	5.4	24.4
1/11/2011	33.5	0.0	33.5	8/07/2011	17.2	4.4	21.6
31/01/2011	32.4	0.3	32.7	14/11/2011	22.7	4.1	26.8

Table C-13 Receptor 1 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	1.4	44.9	20/04/2011	30.4	14.8	45.1
2/02/2011	42.4	0.2	42.6	27/08/2011	18.3	12.4	30.6
23/09/2011	39.4	0.4	39.7	3/07/2011	12.5	9.6	22.1
21/05/2011	37.8	0.0	37.9	29/07/2011	17.7	9.3	27.0
22/09/2011	36.2	1.8	38.1	13/04/2011	11.7	9.2	20.9
16/11/2011	34.9	0.8	35.7	18/07/2011	10.3	7.8	18.0
22/10/2011	34.9	0.3	35.2	5/08/2011	26.0	7.3	33.3
25/01/2011	34.4	0.3	34.7	31/07/2011	23.5	7.2	30.6
1/11/2011	33.5	0.7	34.2	13/07/2011	32.0	7.1	39.1
31/01/2011	32.4	0.2	32.5	9/11/2011	17.9	6.9	24.8

Table C-2 Receptor 2 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.9	44.4	20/04/2011	30.4	13.7	44.1
2/02/2011	42.4	0.2	42.6	31/07/2011	23.5	11.5	35.0
23/09/2011	39.4	0.3	39.7	29/07/2011	17.7	10.2	28.0
21/05/2011	37.8	0.0	37.9	3/07/2011	12.5	9.5	22.0
22/09/2011	36.2	1.6	37.8	27/08/2011	18.3	8.6	26.9
16/11/2011	34.9	1.0	36.0	13/07/2011	32.0	7.6	39.6
22/10/2011	34.9	0.2	35.1	13/04/2011	11.7	6.8	18.5
25/01/2011	34.4	0.6	35.0	10/08/2011	17.6	6.8	24.3
1/11/2011	33.5	1.3	34.8	19/04/2011	20.0	6.0	25.9
31/01/2011	32.4	0.1	32.5	15/04/2011	15.6	5.7	21.3

Table C-3 Receptor 3 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	31/07/2011	23.5	12.1	35.5
2/02/2011	42.4	1.4	43.8	10/04/2011	12.9	9.5	22.4
23/09/2011	39.4	0.6	39.9	27/08/2011	18.3	7.8	26.1
21/05/2011	37.8	0.1	38.0	29/07/2011	17.7	7.7	25.4
22/09/2011	36.2	0.3	36.5	20/04/2011	30.4	7.5	37.9
16/11/2011	34.9	3.0	37.9	25/08/2011	16.8	6.3	23.1
22/10/2011	34.9	0.2	35.1	9/08/2011	9.7	6.2	16.0
25/01/2011	34.4	1.0	35.4	1/04/2011	17.2	5.2	22.4
1/11/2011	33.5	2.3	35.8	11/08/2011	15.4	4.8	20.2
31/01/2011	32.4	1.3	33.7	18/07/2011	10.3	4.7	15.0

Table C-4 Receptor 4 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	2.2	45.7	25/08/2011	16.8	12.3	29.1
2/02/2011	42.4	0.1	42.5	10/04/2011	12.9	12.1	25.0
23/09/2011	39.4	0.5	39.8	31/07/2011	23.5	10.8	34.3
21/05/2011	37.8	4.7	42.5	30/07/2011	17.7	10.4	28.0
22/09/2011	36.2	0.3	36.5	11/08/2011	15.4	10.1	25.5
16/11/2011	34.9	5.4	40.3	9/08/2011	9.7	9.9	19.6
22/10/2011	34.9	0.2	35.0	28/04/2011	8.6	9.3	17.9
25/01/2011	34.4	0.7	35.1	22/04/2011	11.4	9.2	20.7
1/11/2011	33.5	3.3	36.8	1/04/2011	17.2	8.5	25.7
31/01/2011	32.4	0.0	32.4	16/08/2011	15.5	8.4	23.9

Table C-5 Receptor 5 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.4	43.9	10/04/2011	12.9	10.3	23.1
2/02/2011	42.4	0.2	42.7	31/07/2011	23.5	9.6	33.0
23/09/2011	39.4	0.8	40.1	25/08/2011	16.8	8.5	25.3
21/05/2011	37.8	0.4	38.3	9/08/2011	9.7	6.8	16.5
22/09/2011	36.2	0.3	36.5	1/04/2011	17.2	6.2	23.4
16/11/2011	34.9	3.9	38.9	28/04/2011	8.6	5.7	14.3
22/10/2011	34.9	0.1	35.0	20/04/2011	30.4	5.6	35.9
25/01/2011	34.4	0.8	35.1	11/08/2011	15.4	5.4	20.8
1/11/2011	33.5	2.4	35.9	29/07/2011	17.7	5.2	23.0
31/01/2011	32.4	0.5	32.8	11/04/2011	7.5	5.1	12.6

Table C-6 Receptor 14 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	25/08/2011	16.8	16.7	33.5
2/02/2011	42.4	0.0	42.4	28/04/2011	8.6	13.9	22.5
23/09/2011	39.4	0.2	39.5	1/04/2011	17.2	12.8	30.0
21/05/2011	37.8	2.9	40.8	8/04/2011	12.1	11.9	24.0
22/09/2011	36.2	0.2	36.5	9/08/2011	9.7	11.5	21.2
16/11/2011	34.9	8.1	43.0	10/04/2011	12.9	11.2	24.0
22/10/2011	34.9	0.1	35.0	4/08/2011	26.6	10.8	37.4
25/01/2011	34.4	0.6	34.9	2/07/2011	8.9	10.8	19.6
1/11/2011	33.5	3.4	36.9	11/04/2011	7.5	10.7	18.2
31/01/2011	32.4	0.0	32.4	11/08/2011	15.4	10.4	25.8

Table C-7 Receptor 16 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.6	16/07/2011	10.1	18.2	28.3
2/02/2011	42.4	0.2	42.6	5/08/2011	26.0	15.2	41.2
23/09/2011	39.4	0.5	39.8	30/07/2011	17.7	12.9	30.5
21/05/2011	37.8	0.2	38.0	2/07/2011	8.9	12.3	21.2
22/09/2011	36.2	0.1	36.4	8/07/2011	17.2	12.3	29.4
16/11/2011	34.9	3.2	38.2	13/08/2011	15.8	12.0	27.8
22/10/2011	34.9	0.9	35.8	18/04/2011	12.9	12.0	24.9
25/01/2011	34.4	0.4	34.8	22/04/2011	11.4	11.5	22.9
1/11/2011	33.5	1.5	35.0	14/07/2011	13.9	10.1	24.0
31/01/2011	32.4	0.1	32.5	1/08/2011	23.6	9.9	33.5

Table C-8 Receptor 17 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.0	43.5	30/07/2011	17.7	25.4	43.0
2/02/2011	42.4	0.1	42.5	1/08/2011	23.6	19.7	43.2
23/09/2011	39.4	0.2	39.6	16/07/2011	10.1	19.4	29.5
21/05/2011	37.8	2.0	39.9	4/07/2011	7.6	18.2	25.7
22/09/2011	36.2	0.2	36.4	22/04/2011	11.4	17.7	29.2
16/11/2011	34.9	7.1	42.0	2/07/2011	8.9	15.0	23.9
22/10/2011	34.9	1.6	36.5	25/08/2011	16.8	15.0	31.8
25/01/2011	34.4	0.6	34.9	23/04/2011	15.9	14.6	30.4
1/11/2011	33.5	2.5	36.0	28/04/2011	8.6	14.4	23.0
31/01/2011	32.4	0.0	32.4	9/08/2011	9.7	13.7	23.4

Table C-9 Receptor 19 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.3	43.8	2/08/2011	28.4	4.5	32.9
2/02/2011	42.4	0.3	42.7	10/03/2011	21.7	3.9	25.6
23/09/2011	39.4	0.1	39.4	7/08/2011	9.9	3.8	13.7
21/05/2011	37.8	0.1	37.9	3/08/2011	29.9	3.7	33.6
22/09/2011	36.2	0.1	36.3	3/11/2011	9.0	3.6	12.6
16/11/2011	34.9	0.3	35.3	14/04/2011	12.8	3.6	16.4
22/10/2011	34.9	0.3	35.2	24/11/2011	12.2	3.4	15.6
25/01/2011	34.4	0.2	34.5	6/08/2011	28.8	3.1	31.9
1/11/2011	33.5	0.4	33.9	20/11/2011	21.5	2.9	24.4
31/01/2011	32.4	0.3	32.7	17/08/2011	13.7	2.5	16.2

Table C-10 Receptor 20 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.6	2/08/2011	28.4	4.3	32.7
2/02/2011	42.4	0.4	42.8	12/07/2011	18.5	3.4	21.9
23/09/2011	39.4	0.3	39.6	21/03/2011	8.8	3.2	11.9
21/05/2011	37.8	0.1	37.9	3/08/2011	29.9	3.1	33.0
22/09/2011	36.2	0.2	36.4	19/04/2011	20.0	3.0	23.0
16/11/2011	34.9	0.1	35.0	3/11/2011	9.0	2.9	11.8
22/10/2011	34.9	0.4	35.2	11/07/2011	14.1	2.8	16.9
25/01/2011	34.4	0.2	34.5	10/03/2011	21.7	2.7	24.4
1/11/2011	33.5	0.5	34.0	20/11/2011	21.5	2.7	24.2
31/01/2011	32.4	0.3	32.7	2/07/2011	8.9	2.7	11.5

Table C-11 Receptor 33 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.6	24/07/2011	8.3	9.6	18.0
2/02/2011	42.4	0.0	42.4	13/07/2011	32.0	6.3	38.3
23/09/2011	39.4	0.1	39.5	14/11/2011	22.7	6.3	29.0
21/05/2011	37.8	0.0	37.9	25/04/2011	10.3	3.0	13.3
22/09/2011	36.2	0.0	36.3	1/03/2011	18.5	2.6	21.1
16/11/2011	34.9	0.0	35.0	28/07/2011	13.3	2.2	15.5
22/10/2011	34.9	0.2	35.0	5/11/2011	19.1	2.2	21.3
25/01/2011	34.4	0.0	34.4	8/07/2011	17.2	2.2	19.4
1/11/2011	33.5	0.1	33.6	25/07/2011	12.7	1.9	14.6
31/01/2011	32.4	0.2	32.6	13/04/2011	11.7	1.9	13.6

Table C-12 Receptor 35 – PM_{10} 24-hour average (µg/m³) – Stage 2

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	24/07/2011	8.3	8.2	16.5
2/02/2011	42.4	0.1	42.5	13/07/2011	32.0	8.0	40.0
23/09/2011	39.4	0.2	39.5	1/03/2011	18.5	7.4	25.8
21/05/2011	37.8	0.0	37.9	26/04/2011	8.5	6.0	14.5
22/09/2011	36.2	0.0	36.3	5/08/2011	26.0	5.3	31.3
16/11/2011	34.9	0.1	35.0	28/07/2011	13.3	5.2	18.5
22/10/2011	34.9	0.2	35.1	14/11/2011	22.7	4.7	27.4
25/01/2011	34.4	0.1	34.4	13/04/2011	11.7	4.1	15.8
1/11/2011	33.5	0.0	33.5	25/07/2011	12.7	4.0	16.7
31/01/2011	32.4	0.3	32.7	5/11/2011	19.1	4.0	23.1

Table C-1 Receptor 1 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	1.4	44.8	20/04/2011	30.4	17.3	47.7
2/02/2011	42.4	0.2	42.6	29/07/2011	17.7	13.4	31.2
23/09/2011	39.4	0.3	39.7	27/08/2011	18.3	13.0	31.3
21/05/2011	37.8	0.0	37.9	15/04/2011	15.6	9.9	25.5
22/09/2011	36.2	1.8	38.0	9/04/2011	13.1	9.6	22.8
16/11/2011	34.9	1.1	36.0	19/04/2011	20.0	8.8	28.8
22/10/2011	34.9	0.3	35.2	3/07/2011	12.5	8.6	21.1
25/01/2011	34.4	0.3	34.7	31/07/2011	23.5	8.5	32.0
1/11/2011	33.5	0.7	34.2	13/04/2011	11.7	8.2	19.9
31/01/2011	32.4	0.2	32.5	18/07/2011	10.3	8.2	18.5

Table C-2 Receptor 2 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.9	44.4	20/04/2011	30.4	17.9	48.3
2/02/2011	42.4	0.2	42.6	31/07/2011	23.5	15.1	38.6
23/09/2011	39.4	0.3	39.7	29/07/2011	17.7	14.8	32.6
21/05/2011	37.8	0.0	37.9	19/04/2011	20.0	9.2	29.1
22/09/2011	36.2	1.6	37.8	14/08/2011	13.1	8.3	21.4
16/11/2011	34.9	1.0	36.0	15/04/2011	15.6	7.7	23.2
22/10/2011	34.9	0.2	35.1	10/04/2011	12.9	7.5	20.4
25/01/2011	34.4	0.6	35.0	3/07/2011	12.5	7.2	19.7
1/11/2011	33.5	1.3	34.8	27/08/2011	18.3	7.0	25.3
31/01/2011	32.4	0.1	32.5	9/04/2011	13.1	6.3	19.5

Table C-3 Receptor 3 – PM_{10} 24-hour average (µg/m³) - Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	31/07/2011	23.5	13.6	37.1
2/02/2011	42.4	1.4	43.8	10/04/2011	12.9	12.1	25.0
23/09/2011	39.4	0.6	39.9	11/08/2011	15.4	7.3	22.7
21/05/2011	37.8	0.1	38.0	25/08/2011	16.8	7.3	24.1
22/09/2011	36.2	0.3	36.5	27/03/2011	12.2	6.7	19.0
16/11/2011	34.9	3.0	37.9	13/03/2011	20.9	6.3	27.2
22/10/2011	34.9	0.2	35.1	9/08/2011	9.7	6.2	16.0
25/01/2011	34.4	1.0	35.4	1/04/2011	17.2	5.9	23.0
1/11/2011	33.5	2.3	35.8	29/07/2011	17.7	5.7	23.5
31/01/2011	32.4	1.3	33.7	7/11/2011	25.1	5.5	30.7

Table C-4 Receptor 4 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	2.2	45.7	30/07/2011	17.7	12.2	29.9
2/02/2011	42.4	0.1	42.5	1/08/2011	23.6	9.5	33.1
23/09/2011	39.4	0.5	39.8	4/07/2011	7.6	9.0	16.6
21/05/2011	37.8	4.7	42.5	22/04/2011	11.4	8.7	20.1
22/09/2011	36.2	0.3	36.5	25/08/2011	16.8	8.3	25.1
16/11/2011	34.9	5.4	40.3	28/04/2011	8.6	7.9	16.5
22/10/2011	34.9	0.2	35.0	23/04/2011	15.9	7.5	23.4
25/01/2011	34.4	0.7	35.1	16/07/2011	10.1	7.3	17.4
1/11/2011	33.5	3.3	36.8	26/07/2011	10.4	7.1	17.5
31/01/2011	32.4	0.0	32.4	9/08/2011	9.7	7.1	16.8

Table C-5 Receptor 5 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.4	43.9	25/08/2011	16.8	10.1	26.9
2/02/2011	42.4	0.2	42.7	1/04/2011	17.2	7.7	24.9
23/09/2011	39.4	0.8	40.1	10/04/2011	12.9	7.6	20.5
21/05/2011	37.8	0.4	38.3	28/04/2011	8.6	7.0	15.6
22/09/2011	36.2	0.3	36.5	8/04/2011	12.1	7.0	19.1
16/11/2011	34.9	3.9	38.9	9/08/2011	9.7	6.9	16.6
22/10/2011	34.9	0.1	35.0	11/04/2011	7.5	6.1	13.6
25/01/2011	34.4	0.8	35.1	28/03/2011	9.2	5.5	14.7
1/11/2011	33.5	2.4	35.9	26/07/2011	10.4	5.2	15.6
31/01/2011	32.4	0.5	32.8	16/08/2011	15.5	5.2	20.7

Table C-6 Receptor 14 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	16/07/2011	10.1	9.3	19.3
2/02/2011	42.4	0.0	42.4	22/04/2011	11.4	8.8	20.2
23/09/2011	39.4	0.2	39.5	30/07/2011	17.7	8.4	26.1
21/05/2011	37.8	2.9	40.8	31/03/2011	20.1	6.5	26.5
22/09/2011	36.2	0.2	36.5	11/08/2011	15.4	6.4	21.8
16/11/2011	34.9	8.1	43.0	28/04/2011	8.6	6.3	14.9
22/10/2011	34.9	0.1	35.0	1/08/2011	23.6	6.2	29.8
25/01/2011	34.4	0.6	34.9	4/07/2011	7.6	6.1	13.7
1/11/2011	33.5	3.4	36.9	2/07/2011	8.9	6.1	15.0
31/01/2011	32.4	0.0	32.4	25/07/2011	12.7	6.0	18.7

Table C-7 Receptor 16 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.5	16/07/2011	10.1	6.2	16.3
2/02/2011	42.4	0.2	42.6	5/08/2011	26.0	5.7	31.7
23/09/2011	39.4	0.5	39.8	8/07/2011	17.2	5.5	22.6
21/05/2011	37.8	0.2	38.0	18/04/2011	12.9	5.2	18.0
22/09/2011	36.2	0.1	36.4	2/07/2011	8.9	5.0	13.9
16/11/2011	34.9	3.2	38.2	13/08/2011	15.8	4.7	20.5
22/10/2011	34.9	0.9	35.8	28/04/2011	8.6	4.3	12.9
25/01/2011	34.4	0.4	34.8	30/07/2011	17.7	4.2	21.8
1/11/2011	33.5	1.5	35.0	3/08/2011	29.9	4.0	33.9
31/01/2011	32.4	0.1	32.5	2/08/2011	28.4	4.0	32.4

Table C-8 Receptor 17 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.0	43.5	16/07/2011	10.1	9.0	19.1
2/02/2011	42.4	0.1	42.5	2/07/2011	8.9	7.5	16.3
23/09/2011	39.4	0.2	39.6	5/08/2011	26.0	6.9	32.9
21/05/2011	37.8	2.0	39.9	4/08/2011	26.6	5.7	32.3
22/09/2011	36.2	0.2	36.4	12/04/2011	10.2	5.4	15.6
16/11/2011	34.9	7.1	42.0	28/04/2011	8.6	5.3	13.9
22/10/2011	34.9	1.6	36.5	22/04/2011	11.4	5.1	16.5
25/01/2011	34.4	0.6	34.9	30/07/2011	17.7	5.1	22.7
1/11/2011	33.5	2.5	36.0	30/04/2011	7.3	4.9	12.2
31/01/2011	32.4	0.0	32.4	14/07/2011	13.9	4.9	18.8

Table C-9 Receptor 19 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.3	43.8	16/07/2011	10.1	3.3	13.3
2/02/2011	42.4	0.3	42.7	5/08/2011	26.0	3.2	29.2
23/09/2011	39.4	0.1	39.4	18/04/2011	12.9	3.1	16.0
21/05/2011	37.8	0.1	37.9	8/07/2011	17.2	3.0	20.2
22/09/2011	36.2	0.1	36.3	2/08/2011	28.4	2.7	31.1
16/11/2011	34.9	0.3	35.3	13/08/2011	15.8	2.5	18.3
22/10/2011	34.9	0.3	35.2	3/08/2011	29.9	2.5	32.3
25/01/2011	34.4	0.2	34.5	17/08/2011	13.7	2.0	15.7
1/11/2011	33.5	0.4	33.9	19/04/2011	20.0	2.0	21.9
31/01/2011	32.4	0.3	32.7	20/03/2011	9.1	1.8	11.0

Table C-10 Receptor 20 – PM_{10} 24-hour average (µg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.1	43.6	2/08/2011	28.4	5.2	33.6
2/02/2011	42.4	0.4	42.8	3/08/2011	29.9	4.7	34.6
23/09/2011	39.4	0.3	39.6	8/07/2011	17.2	4.5	21.6
21/05/2011	37.8	0.1	37.9	6/07/2011	8.6	4.3	12.9
22/09/2011	36.2	0.2	36.4	18/04/2011	12.9	4.1	17.0
16/11/2011	34.9	0.1	35.0	21/03/2011	8.8	3.8	12.6
22/10/2011	34.9	0.4	35.2	13/08/2011	15.8	3.4	19.2
25/01/2011	34.4	0.2	34.5	28/07/2011	13.3	3.3	16.5
1/11/2011	33.5	0.5	34.0	15/04/2011	15.6	3.1	18.7
31/01/2011	32.4	0.3	32.7	10/03/2011	21.7	3.0	24.7

Table C-11 Receptor 33 – PM_{10} 24-hour average (μg/m³) - Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.6	24/07/2011	8.3	6.9	15.3
2/02/2011	42.4	0.0	42.4	13/07/2011	32.0	6.9	38.9
23/09/2011	39.4	0.1	39.5	5/08/2011	26.0	5.2	31.2
21/05/2011	37.8	0.0	37.9	14/11/2011	22.7	4.5	27.3
22/09/2011	36.2	0.0	36.3	20/04/2011	30.4	3.5	33.9
16/11/2011	34.9	0.0	35.0	5/11/2011	19.1	2.9	22.0
22/10/2011	34.9	0.2	35.0	19/08/2011	14.0	2.9	16.9
25/01/2011	34.4	0.0	34.4	13/04/2011	11.7	2.8	14.5
1/11/2011	33.5	0.1	33.6	1/03/2011	18.5	2.8	21.2
31/01/2011	32.4	0.2	32.6	25/07/2011	12.7	2.6	15.3

Table C-12 Receptor 35 – PM_{10} 24-hour average (μg/m³) – Stage 3

Date	Background	Predicted Increment	Total	Date	Background	Highest Predicted Increment	Total
20/05/2011	43.5	0.2	43.7	13/07/2011	32.0	10.9	42.9
2/02/2011	42.4	0.1	42.5	24/07/2011	8.3	6.3	14.6
23/09/2011	39.4	0.2	39.5	5/08/2011	26.0	6.0	32.0
21/05/2011	37.8	0.0	37.9	1/03/2011	18.5	5.4	23.9
22/09/2011	36.2	0.0	36.3	28/07/2011	13.3	4.9	18.2
16/11/2011	34.9	0.1	35.0	13/04/2011	11.7	4.8	16.5
22/10/2011	34.9	0.2	35.1	25/07/2011	12.7	4.6	17.2
25/01/2011	34.4	0.1	34.4	5/11/2011	19.1	4.5	23.5
1/11/2011	33.5	0.0	33.5	26/04/2011	8.5	4.4	13.0
31/01/2011	32.4	0.3	32.7	3/07/2011	12.5	4.2	16.7

APPENDIX H

GREENHOUSE GAS ASSESSMENT

BORAL BRINGELLY BRICKWORKS EXPANSION

Greenhouse Gas Assessment

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BORAL

BRINGELLY BRICKWORKS EXPANSION

Greenhouse Gas Assessment

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1 INTRODUCTION

Hyder Consulting has been commissioned by Boral to prepare a State Significant Development Environmental Impact Statement under Division 4.1 of the *Environmental Planning and Assessment Act 1979* for the Bringelly Brickworks site (the project site). To support the environmental assessment for proposed expansion of quarry and brickworks activities at the site Hyder have developed this greenhouse gas (GHG) assessment to address Director General Requirements and to provide a framework for management of GHG emissions at the project site.

1.1 Site location and context

The Boral Brickworks is located on part of Lot 11 in DP 1125892 (the project site), comprising area of approximately 385.55 hectares, is currently occupied by a clay shale quarry and brick manufacturing plant and is owned by Boral Bricks Pty Ltd. It is located within the Camden Local Government Area and is approximately 55 km southwest of the Sydney Central Business District. Refer to Figure 1 for the siteǆs regional context.

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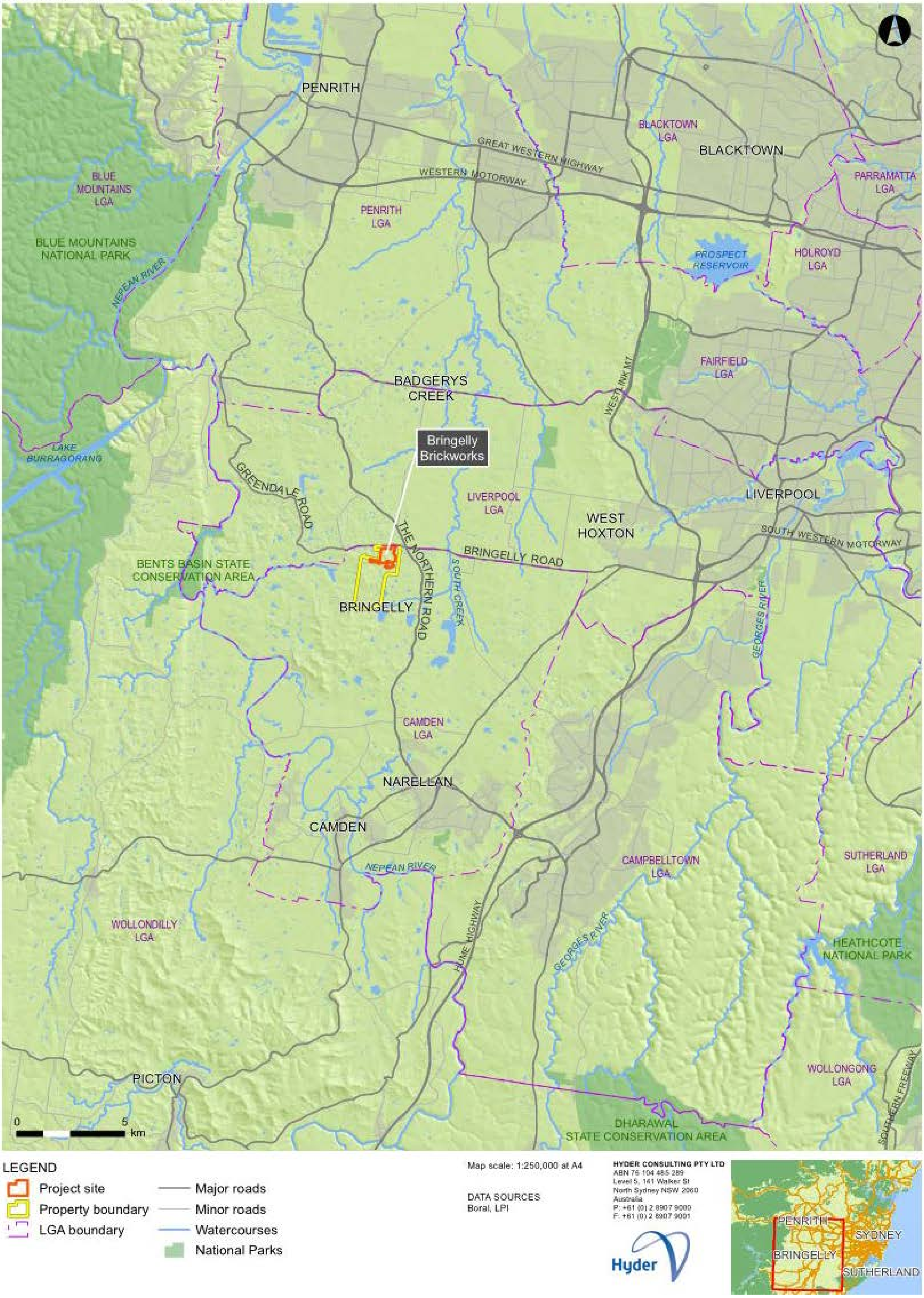

Figure 1 Regional Context Plan

1.2 Project site - existing environment

The project site is currently used for quarrying, brick production and associated activities. Existing features of the site include an active quarry pit, one large primary catchment basin in the existing quarry pit, two smaller sediment basins to the north-east of the existing quarry operations, two large sediment basins to the south-east of the brick manufacturing plant and one large dam to the south of the site located in Thompsons Creek.

The brick making facility along with various administration buildings, a finished bricks storage yard, staff car park and internal road network is generally contained within the northern part of the project site, and is set back approximately 200m from Greendale Road. The southern portion of the project site, adjacent to Thompsons Creek, is leased for the agistment of stock and grazing.

The underlying topography of the operational footprint on the project site is relatively flat, and the land slopes to the south toward Thompsons Creek. Existing quarrying activities in the northern portion of the site have substantially altered the natural landform, with various voids and elevated stockpiles present in the active, north-western part of the project site. Other significant landforms on the site include the raw material stockpiles to the south of the buildings and manufacturing plants, as well as unusable materials stockpiles along the western boundary of the site. Refer to Section 6.1 of this report for further information on existing project site layout.

1.3 PROPOSED PROJECT

The current consent permits quarry extraction of up to 200,000 tonnes per annum, and brick production of up to 160,000 tonnes per annum. Boral Bricks Pty Ltd seeks to increase brick production at their Bringelly brickworks to 263,500 tonnes per annum.

Approval is sought for the continuation of operations on the site involving the continued extraction of raw materials, over a larger extraction area (quarry footprint), and continued brick making activities, at a higher production rate. Key features of the project include:

- Extraction of raw material from the site in the order of 200,000 tpa (no change to current extraction consent) as follows:
  - Continuation of extraction from the existing quarry area (current consent), to a maximum depth of 30 m.
  - Expansion of the quarrying operations over an additional 20.75 hectares (to a total of 30.65 hectares) with extraction to a maximum depth of 30m.
- Brick production in the order of 263, 500 tonnes of bricks per year (increase of 103,500 from current consent).
- Importation of raw materials required for brick making in the order of 96,000 tpa.
- Extension to the following existing buildings:
  - Clay preparation building.
  - Small area of the brick manufacturing plant near the exit to the kiln.
- Addition of two recycled water storage tanks.
- Upgrading of the existing bio-cycle sewage treatment plant.
- Construction of a new driveway to the east of the existing alignment.

- Construction of a 4.5 metre high noise bund along the northern boundary of the quarry operations (362 metres long x 3 metres flat top with a 21 metre wide base and 1:2 batter slopes).
- Construction of a 4.5m high noise bund along the northern Boral property boundary, from the position of the existing driveway to the proposed new driveway location (200m long x 3m flat top with a 21m wide base and 1:2 batter slopes).

The proposed quarrying area will expand northwards, southwards and south-westwards, covering a total surface area of 30.65 hectares to a maximum extraction depth of 30 metres. To facilitate the description of the quarrying activities, the proposed quarry area has been divided into nine cells, namely Cells A ï I (Refer to Figure 2 for proposed quarry layout).

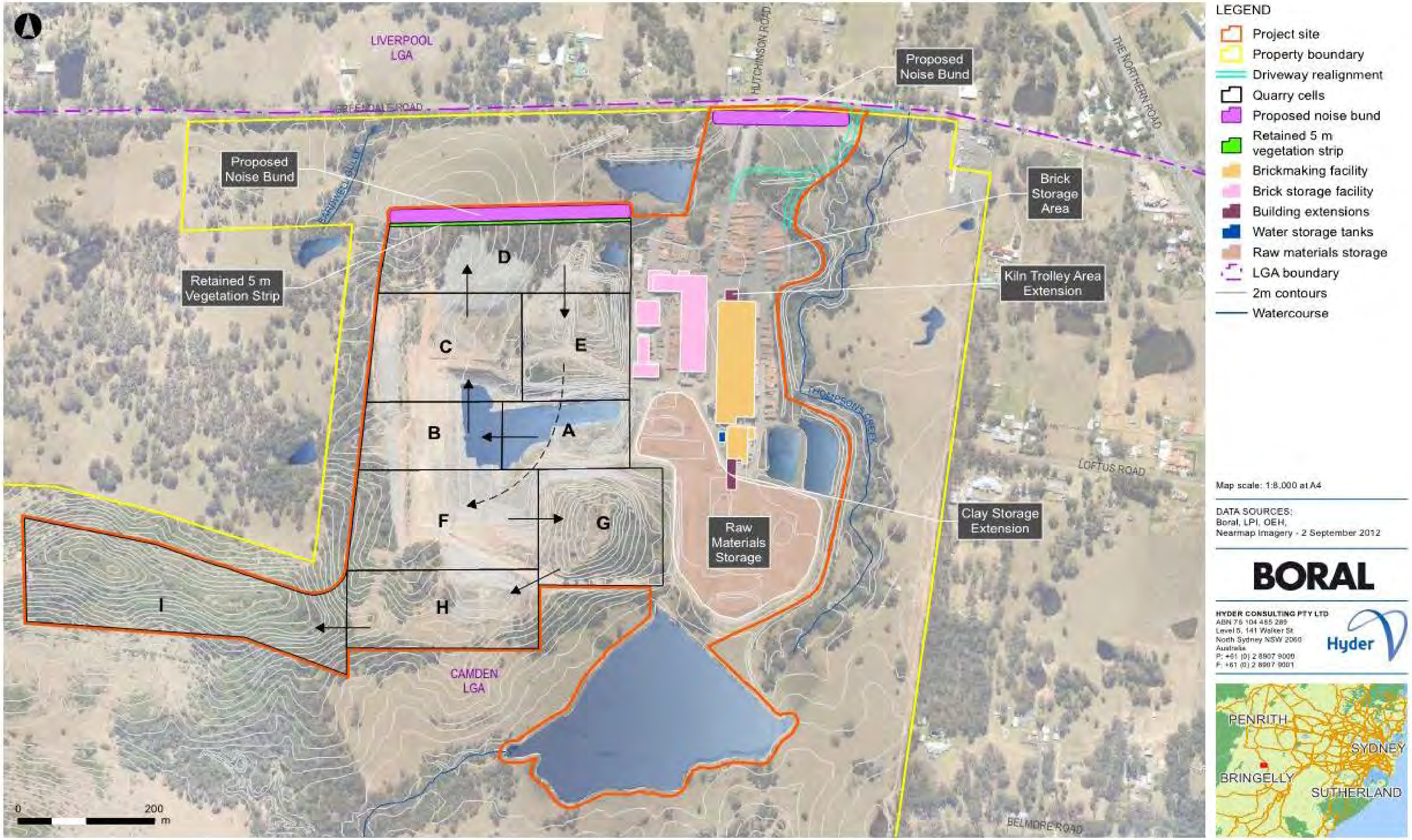

Figure 2: Proposed quarry layout

Quarrying extraction activities are expected to progress on the site according to the following plan:

- Continued extraction of Cells A, B & C (existing pits).
- Extraction of proposed Cells D, E, F, G, H & I.

Approval is being sought for continued extraction on the site, at a rate of 200,000 tpa, over the next 30 years. Quarrying activities would continue to be undertaken on a campaign basis. A campaign is a discrete quarrying event whereby material is extracted from the pits using bulk earthwork machinery, primarily excavators and is transported to stockpile areas by dump trucks where it is spread and shaped by dozers. The proposed campaigns are likely to be approximately two calendar months in duration (44 working days) and will be undertaken during standard working hours. Although the number of campaigns will be determined by the annual demand for bricks, up to three campaigns are proposed per annum, which would provide sufficient raw material for the manufacturing of 263,500 tonnes of bricks per annum.

In order to explain the staging of quarrying activities over its 30 year life, the total quarry area has been divided into nine cells (quarry areas), which are represented in Figure 2. Given that the extraction of material will be based on consumer demand, it is difficult to predict an exact duration of operations within each of these nine cells. However, the sequence of the material extractions is known, and there will be approximately three cells open at any one time so as to ensure that the different types of material resources can be accessed in different places and at different depths at any time during the operations. The only exception to this approach is Cell I, which covers a large enough area and has sufficient resource to allow for extraction of material at multiple depths at any one time during the life of this cell.

Each cell within the quarry will be progressively extracted on a campaign basis, starting with the active Cells A, B and C and continuing to D, E, F, G, H and finishing at Cell I (refer to Figure 5). For example, as Cell A ñbottoms outò (is exhausted/reaches 30m in depth), extraction will cease in Cell A and will commence in Cell D and therefore Cells B, C and D will be operational. As Cell B is exhausted, extraction will cease in Cell B and will commence in Cell E and therefore Cells C, D and E will be operational and so on.

Table 1 broadly summarises the three stages over the 30 year quarry life.

Table 1: Bringelly Brickworks proposed staging

Stage	Cells	Resource quantity
1	A, B, C	2,198,763 tonnes
2	D, E, F	2,273,969 tonnes
3	G, H, I	3,963,313 tonnes
	TOTAL	7,989,025 tonnes

1.4 CONTEXT OF GREENHOUSE GAS ASSESSMENT

In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report on climate change. It stated that warming of the climate system is unequivocal, as is evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. It also states that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas (GHG) concentrations (IPCC 2007).

In Australia and NSW, there are a number of policies, guidelines and regulations which have been developed to manage and reduce GHG emissions. These include the following:

- The Australian Government has committed to reduce its emissions between 5 and 25 per cent below 2000 levels by 2020. It has also committed to a long term emissions reduction target of 80 per cent below 2000 levels by 2050;
- The National Greenhouse and Energy Reporting (NGER) Act was introduced in 2007 and requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. For GHG emissions, thresholds are currently set at 25,000 tonnes carbon dioxide equivalent (tCO_2e) for a facility under a corporation and 50,000 tCO2e for a corporation as a whole for 2010-2011 (DCC 2008);
- The NSW Department of Infrastructure, Planning and Natural Resources ï Department of Energy, Utilities and Sustainability Guidelines for Energy and Greenhouse in EIA provides guidance on the consideration of energy and greenhouse issues when developing projects and when undertaking environmental impact assessment (EIA) under the Environmental Planning and Assessment Act 1979 (EP&A Act); and
- Australia introduced a price on carbon on 1 July 2012. A price on carbon is an incentive for those that will pay it to change the way they do business. It will encourage businesses to use or generate renewable energy, reduce energy consumption, implement technologies that will improve energy efficiency and/or invest in renewable energy, such as solar and wind.

In 2013, the Commonwealth Department of Climate Change and Energy Efficiency published its State and Territory Greenhouse Gas Inventories for 2010/11. This document provides an overview of the latest available estimates of GHG emissions for the Australian States and Territories based on a Kyoto accounting basis. Table 2 outlines the 2010/11 emissions estimates for Australia broken down by economic sector. It can be seen that emissions from metal ore and non-metallic mineral mining and quarrying makes up a relatively small proportion of overall emissions in Australia. However, emissions in this sector have also been growing at a relatively rapid pace since 1989/90. This assessment will estimate the CO_2 emissions associated with the construction and operation of the proposed Bringelly Brickworks quarry expansion and production increase and identify actions to manage and minimise these emissions where feasible.

Table 2: National emissions by economic sector in 2010/11 (DIICCSRTE 2013)

ANZSIC code	Industry Classification	Emissions (Mt CO_2-e)			Change in emissions (%)	
		1989/90	2009/10	2010/11	1989/90 ï 2010/11	2009/10-2010/11
Div A	**Agriculture, forestry and fishing**	**231.2**	**109.3**	**103.0**	**-55.5**	**-5.8**
Div B	**Mining**	**36.9**	**65.2**	**68.5**	**85.6**	**5.0**
06	Coal mining	20.2	33.0	34.7	71.6	4.9
07	Oil and gas extraction	12.8	25.0	25.7	101.5	2.9
08-10	Metal ore and non-metallic mineral mining and quarrying	3.9	7.2	8.1	106.0	12.9
Div C	**Manufacturing**	**67.1**	**71.9**	**71.6**	**6.7**	**-0.4**
11-12	Food, beverages, tobacco	4.8	4.6	4.7	-2.6	3.2

ANZSIC code	Industry Classification	Emissions (Mt CO_2-e)			Change in emissions (%)	
		1989/90	2009/10	2010/11	1989/90 ï 2010/11	2009/10-2010/11
13	Textiles, clothing, footwear and leather	0.6	0.4	0.4	-26.4	-0.3
14-16	Wood, paper and printing	2.0	2.3	2.1	6.2	-10.2
17-19	Petroleum, coal and chemical	15.2	18.9	19.1	25.6	1.0
20	Non-metallic mineral products	10.0	11.8	11.8	18.1	-0.1
21-22	Metal products	33.6	33.0	32.6	-3.0	-1.2
24	Machinery and equipment	0.8	0.7	0.7	-5.5	1.3
25	Other manufacturing	0.1	0.1	0.1	35.4	1.6
Div D	**Electricity, gas and water**	**136.1**	**209.0**	**204.6**	**50.4**	**-2.1**
Div E-H, J-Q	**Commercial services and construction**	**33.0**	**35.7**	**35.5**	**7.6**	**-0.6**
Div I	**Transport and storage**	**13.1**	**24.8**	**26.4**	**100.8**	**6.5**
	Residential	**40.7**	**52.5**	**53.2**	**30.7**	**1.3**
	Residential (non-transport)	8.1	10.7	11.0	35.9	3.21
	Residential (transport)	32.6	41.8	42.2	29.4	0.8

1.5 PURPOSE AND SCOPE

1.5.1 PURPOSE

The purpose of this GHG assessment is to assist Boral in undertaking an integrated approach to GHG management and to address the following Director General Requirements (DGRs) specific to greenhouse gases. These include:

- A quantitative assessment of potential Scope 1 and 2 GHG emissions
- A qualitative assessment for the potential impact of these emissions on the environment
- An assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency.

1.5.2 SCOPE OF WORKS

The scope of this GHG assessment is to undertake an assessment of projected GHG emissions from construction and operation of the Bringelly brickworks expansion project. The assessment will be used to identify actions for mitigating or reducing emissions, where possible. The scope of works for this assessment includes:

- Identify the main sources of emissions during construction and operational stages of the expansion;
- Scope and calculate the emissions from each source using factors and methods outlined in the *National Greenhouse Accounts (NGA) Factors*, published by the Australian Government Department of Climate Change and Energy Efficiency (2012), the GHG Protocol published by the World Business Council for Sustainable Development (2001) and the BPIC/ICIP Projectõs Methodology Guidelines for the Materials and Building Products Life Cycle Inventory Database;
- Investigate and recommend strategies for emissions mitigation to reduce GHG emissions associated with project development and operation.

Figure 3 illustrates the measurement boundaries and emissions sources investigated in this GHG assessment.

Site preparation
- Estimated decomposition of cleared vegetation
- Operation of mobile equipment
- Operation of stationary equipment
- Transport of fill to site
- Transport of materials to site
- Demolition of buildings on existing site

Construction phase
- Operation of mobile equipment
- Operation of stationary equipment
- Electricity use
- Transport of materials onto site

Operation
- Estimated electricity consumption
- Estimated natural gas consumption
- Estimated diesel consumption
- Estimated decomposition of cleared vegetation

Figure 3: GHG emissions boundary for construction of this project

The scoping processes used within this report for the operation of the facility are adapted from the ôThe Greenhouse Gas Protocolö (WBCSD 2001). Under this protocol, the projects direct and indirect emissions sources can be delineated into three ôscopesö (Scope 1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. This method of scoping helps to improve transparency, and assists in setting emissions reduction objectives.

The GHG protocol definitions for each scope are presented in Figure 4 and described in further detail below.

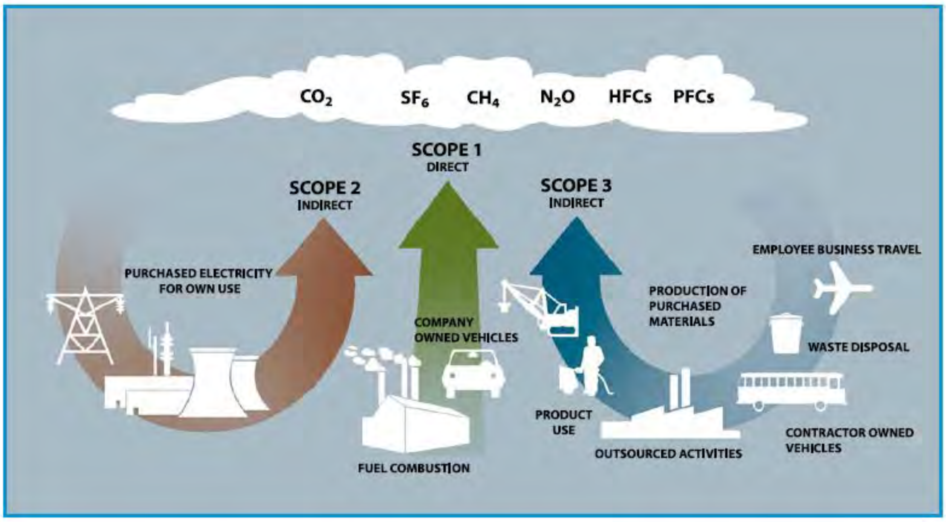

Figure 4: Overview of scopes and emission sources (Source: World Business Council for Sustainable Development, 2001)

GHG emissions scopes are summarised according to the following:

- **Scope 1 – Direct GHG emissions:** Scope 1 emissions are direct emissions that occur from sources on site. This would include emissions arising from the combustion of fuels in equipment on-site (e.g. boilers, furnaces, generators, vehicles, machinery, fugitive emissions etc).
- **Scope 2 – Electricity indirect GHG emissions:** Scope 2 emissions account for GHG emissions arising from the generation of purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated.
- **Scope 3 – Other indirect GHG emissions:** Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities on, but occur away from the development site and are not under Boral control.

This assessment has been undertaken using the best available current and historical data. Assumptions have been outlined, where appropriate to maintain transparency.

2 CONSTRUCTION BASED GHG INVENTORY

The construction phase of the project will include the transport of materials on and off the site, decomposition of vegetation waste and the use of machinery and vehicles for preparation of the site, civil works and construction of the structures. These activities require the use of fuels and electricity which will result in the release of associated GHG emissions.

Accurately quantifying these emissions at this stage requires a number of assumptions to be made including distances travelled and hours of use for vehicles and machinery. Other factors which will affect GHG emissions during the construction phase include construction methods, time table, materials sources and transport methods.

Emissions were calculated by estimating fuel use, electricity consumption and vegetation decomposition using available data. Emissions in tonnes CO_2 equivalent were calculated using factors and methods from the Australian Government *National Greenhouse Accounts Methods and Factors Workbook*. Specific assumptions were made with regard to fuel use, electricity consumption, construction schedules, material quantities, material transport and waste decomposition, outlined in detail in the following sections of this report. These assumptions are based on Hyder's experience in similar projects. General assumptions are provided in the report with specific calculations outlined in Appendix B.

2.1 SITE PREPARATION AND CONSTRUCTION OF NOISE BUNDS

The estimated emissions from site preparation and construction of noise bunds were approximately ***250.1 tCO_2e***. The breakdown of these emissions is detailed in the following sections. This includes emissions from the following construction activities:

- Vegetation clearing to prepare site for construction of buildings, noise bund and driveway (including emissions from transport and decomposition)
- Scraping and spreading of material for noise bunds

Estimated emissions from these activities are detailed in Table 3.

Table 3: Summary of GHG emissions from site preparation by construction activity

Construction activity	Emissions (tCO_2e)	Scope
Vegetation clearing to prepare site for construction of buildings, noise bund and driveway (including emissions from transport and decomposition)	74	1
Scraping and spreading of material for construction of noise bunds	176.1	1
TOTAL	**250.1**	

Assumptions used in calculating the above emissions are set out below:

- Site preparation and development of the noise bunds is expected to take approximately 1 month of continuous works;
- All machinery and vehicles were re-fuelled every 2 days on average;
- Cleared vegetation of grasslands due to site preparation and the construction of noise bunds was 0.7ha and assumed to be at 0.15m depth. Cleared vegetation of shrubs and trees was estimated to be 0.315 ha at an average height of 8m and 15% crown to trunk

ratio and 50% projected foliage cover. This was based on estimates from aerial photography and observations from site visits. This results in a volume of approximately 4,830m^3 of cleared vegetation equating to a mass of approximately 1159 tonnes (Tchobanoglous et al. 1993); and

- All cleared vegetation was composted on site.

The machinery and relative fuel capacity of the vehicles used during site preparation and construction of noise bunds are assumed to be as set out in the following tables:

Table 4: Specifications for machines/vehicles used during site preparation

Machine and model required	Capacity (m^3)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Scraper	N/A	170
Dozer	N/A	909
Grader	N/A	344
Compactor	N/A	672

The estimated program for the project site preparation along with estimated machine/vehicle days and associated fuel use are outlined in Table 5:

Table 5: Summary of assumptions for machinery use associated with noise bund

Construction activity*	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type	Scope 1 Emissions factor tCO_2-e/L	Scope 1 Estimated emissions (tCO_2-e)
Noise bund construction	156.6	65,484.3	Diesel	0.00269	176.1

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.2 CONSTRUCTION OF BUILDINGS AND DRIVEWAY

The estimated emissions from the construction of the new buildings and the driveway, located in the north eastern area of the project site were ***86 tCO_2e***. Note that the construction of buildings relates to extension of existing buildings, including the clay preparation building and a small area of the brick manufacturing plant near the exit to the kiln.

Table 6 outlines the breakdown of emissions from each stage of construction.

Table 6: Summary of GHG emissions from construction of buildings and driveway

Construction activity	Emissions (tCO_2e)	Scope
Construction of buildings		
Concrete transport fuel use	0.9	1
Concrete paving fuel use	16.1	1
Building construction fuel use	45.2	1
Steel transport fuel use	0.1	1
Subtotal	*62.3*	

Construction activity	Emissions (tCO_2e)	Scope
Construction of driveway		
Asphalt transport fuel use	1.4	1
Roadbase transport fuel use	6.2	1
Fuel use from asphalt paving	3.2	1
Fuel use from roadbase paving	12.9	1
Subtotal	*23.7*	
TOTAL	**86**	

Assumptions used in calculating the above emissions were determined from previous assessment experience and through consultation with Boral and are set out below:

- The nearest concrete provider is 10km from the site
- The nearest asphalt provider is 20km from the site
- The nearest steel provider is 10 km from the site
- The nearest roadbase provider is 13km from the site
- Construction activities associated with building construction were assumed to take approximately one month and included the following
  - Emissions associated with the transport and paving of concrete used in the extension to the brick manufacturing plant near the exit to the kiln
  - Steel up construction of the building extensions
  - Precast concrete panel construction
  - Fit out
- Structural steel use was estimated using typical warehouse construction use of $22kg/m^2$
- Asphalt and roadbase for the driveway with thicknesses of 0.1m and 0.7m respectively. The driveway will take approximately 1 month to construct
- All machinery and vehicles are re-fuelled every 2 days on average;

The machinery and relative fuel capacity of the vehicles used during construction of the new buildings and the driveway are assumed to be as set out in the following table:

Table 7: Specifications for machines/vehicles used during construction of buildings and driveway

Machine and model required	Capacity (m^3)	Fuel tank capacity (L)
20 tonne truck	12.5	410
Paver	N/A	250
8 Wheel agi	N/A	410
Crane	N/A	150
Cherry Picker	N/A	350

The estimated program for construction of the new buildings and driveway phase of the project along with estimated machine/vehicle days and associated fuel use are outlined in Table 8:

Table 8: Summary of assumptions for machinery use associated with earthworks, drainage and utilities installations

Construction activity*	Estimated works time (machine days)	Estimated fuel use (L)	Fuel type	Scope 1 Emissions factor tCO_2-e/L	Scope 1 Estimated emissions (tCO_2-e)
Construction of new buildings	193	23,151	Diesel	0.00269	62.7
Construction of Driveway	62	8,820	Diesel	0.00269	23.9

*Construction work days were assumed to be 8 hours a day and 6 days a week

2.3 SUMMARY OF CONSTRUCTION BASED GHG EMISSIONS

Figure 5 illustrates the breakdown of Scope 1 and 2 emissions from the project construction. Total estimated emissions for construction activities are ***336.2 t CO_{2-e}***. Construction of the noise bunds is estimated to be the most significant source of emissions during the construction phase, accounting for 176.2t CO_{2-e} (52%) of total emissions. Emissions from site preparation 74t CO_{2-e} (22%) and construction of the buildings 62.7t CO_{2-e} (19%) are also significant sources of construction emissions.

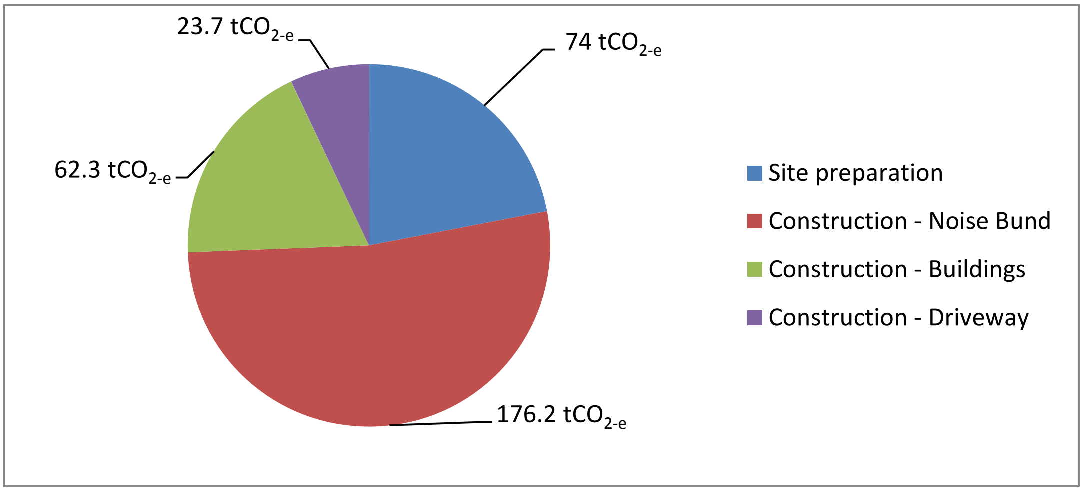

Figure 5: Emissions breakdown by construction activity

The *National Greenhouse Accounts Methods and Factors* workbook (DCCEE 2012) also provides guidance on estimating scope 3 emissions associated with fuel and electricity use. Scope 3 emissions are the indirect emissions associated with the extraction, processing and transport prior to the fuel or electricity being used on site.

The scope 1 and 3 emissions associated with all fuel use during construction are outlined in Table 9 below.

Table 9: Scope 1 and 3 emissions associated with fuel use in construction activities.

Construction activity	Estimated fuel use (L)	Fuel type	Scope 1 Emissions factor tCO_2-e/L	Scope 1 Estimated emissions (tCO_2-e)	Scope 3 Emissions factor tCO_2-e/L	Scope 3 Estimated emissions (tCO_2-e)
Construction of noise bunds	65,484	Diesel	0.00269	176.2	0.0002	13.1
Construction of new buildings	23,151	Diesel	0.00269	62.7	0.0002	4.6
Construction of Driveway	8,820	Diesel	0.00269	23.9	0.0002	1.8
Total (Fuel)	***97,455***			***262.8***		***19.5***

3 OPERATIONS BASED GHG INVENTORY

This section outlines the GHG emissions associated with the operation of the site following the proposed works. Emissions associated with operations due to the proposed expansion of the brickworks facility were calculated by extrapolating past emissions and production data from Boral's *National Greenhouse and Energy Reporting (NGER)* documentation. This section presents the findings of a quantitative assessment of potential scope 1, 2 and 3 emissions from the operation of the facility following the proposed expansion.

3.1 ON SITE OPERATIONS

Based on historical NGER data, the main emissions sources from operating the Bringelly Brickworks manufacturing plant are associated with use of natural gas, electricity and diesel fuel. These emissions sources are the result of the following activities within the facility:

- ***Mining and materials***: Boral's bricks are made from a blend of clay-shale, and other speciality elements. Shale is quarried on site and stockpiled for blending with the other materials which are externally sourced. Mining is conducted through extraction (digging) and no blasting is required within a clay-shale operation. It is assumed that diesel fuel is predominantly used to run the vehicles and machinery for this process.
- ***Crushing:*** The blended materials are crushed and water added to ensure a smooth consistency within the clay material used to make the bricks. The end material is stored (or 'soured') ahead of its use in the extrusion stage of production. It is assumed that diesel fuel is predominantly used to run the vehicles and machinery for this process.
- ***Extrusion:*** This part of the process sees the 'soured' base material physically transformed into bricks. Material is shaped, coloured with oxides and other compounds, and textured according to the type of product being made. It is assumed that electricity is predominantly used for this process.
- ***Racking:*** After the bricks have been created through extrusion, they must be dried for at least three days before being sent to the kilns for 'firing'. The drying process is referred to as 'racking'. There may be some diesel fuel used for transporting the bricks to the racks.
- ***Firing:*** Bricks are 'fired' in the on-site kilns through a process which lasts for three days and requires temperatures beyond 1000 degrees Celsius. As the site is allowed to manufacture 24 hours a day, the kiln is constantly running to ensure this process can be completed in a timely manner. It is assumed that natural gas is predominantly used for this process.
- ***Packaging, storage and distribution:*** After firing, bricks are placed into stacks and taken to the holding yard to await delivery to customers. Bricks from Bringelly are all transported off site by truck. It is assumed that diesel fuel is used for the transportation of bricks off site.

Table 10 below illustrates historical energy use and associated emissions (scope 1 and 3) onsite based on previous NGER reporting for the project site. It also includes projected emissions based on extrapolation of the proposed maximum production rate stated in Boral's development approval request.

Table 10: Historical and projected energy use and associated emissions from the Bringelly Brickworks facility.

A) Natural Gas

Period	Production (tonnes per annum)	Natural Gas Use (GJ)	Scope 1 Emissions factor $kgCO_2$-e/GJ	Scope 1 Estimated emissions (tCO_2-e)	Scope 3 Emissions factor $kgCO_2$-e/GJ	Scope 3 Estimated emissions (tCO_2-e)
FY 2008/09	94,291	157,644	51.2	8,071	14.2	2,239
FY 2009/10	134,489	257,910	51.2	13,205	14.2	3,662
FY2010/11	135,746	257,839	51.2	13,201	14.2	3,661
FY 2011/12	132,648	251,428	51.2	12,873	14.2	3,570
Historical Average	124,294	231,205	51.2	11,838	14.2	3,283
Proposed	*263,500*	*340,265*	*51.2*	*17,422*	*14.2*	*4,832*
Difference	*139,207*	*109,060*	*51.2*	*5,584*	*14.2*	*1,549*

B) Electricity

Period	Production (tonnes per annum)	Electricity Use (kWh)	Scope 2 Emissions factor $kgCO_2$-e/kWh*	Scope 2 Estimated emissions (tCO_2-e)	Scope 3 Emissions factor $kgCO_2$-e/kWh*	Scope 3 Estimated emissions (tCO_2-e)
FY 2008/09	94,291	5,312,405	0.89	4,728	0.18	956
FY 2009/10	134,489	7,941,122	0.89	7,068	0.18	1,429
FY2010/11	135,746	7,583,256	0.89	6,749	0.18	1,365
FY 2011/12	132,648	7,873,690	0.89	7,008	0.18	1,417
Historical Average	124,294	7,177,618	0.89	6,388	0.18	1,292
Proposed	*263,500*	*10,563,316*	*0.88**	*9,296*	*0.18*	*1,901*
Difference	*139,207*	*3,385,698*	*0.88*	*2,908*	*0.18*	*609*

*The emissions factor of electricity consumption in NSW was decreased in the 2012 NGA factors and methods workbook due to the increase in renewable energy used in the provision of electricity in the State.

C) Diesel Fuel

Period	Production (tonnes per annum)	Diesel Use (kL)	Scope 1 Emissions factor tCO_2-e/L	Scope 1 Estimated emissions (tCO_2-e)	Scope 3 Emissions factor tCO_2-e/L	Scope 3 Estimated emissions (tCO_2-e)
FY 2008/09	94,291	85	0.00269	229	0.0002	17
FY 2009/10	134,489	122	0.00269	328	0.0002	24
FY2010/11	135,746	123	0.00269	331	0.0002	25
FY 2011/12	132,648	129	0.00269	347	0.0002	26
Historical Average	124,294	115	0.00269	309	0.0002	23
Proposed	*263,500*	*169*	*0.00269*	*454*	*0.0002*	*34*
Difference	*139,207*	*54*	*0.00269*	*146*	*0.0002*	*11*

The above estimates assume the following:

- Emissions associated with brick production increases proportionally with increased production.
- No modifications were made to the brick manufacturing process to increase efficiency in brick production.

3.2 SUMMARY OF OPERATIONS BASED GHG EMISSIONS

Figure 6 illustrates the breakdown of Scope 1, 2 and 3 emissions by source from Bringelly Brickworks facility operations. Emissions from natural gas are estimated as the most significant source of GHG emissions, followed by electricity and diesel fuel respectively accounting for 66% 33% and 1% of total operations based GHG emissions.

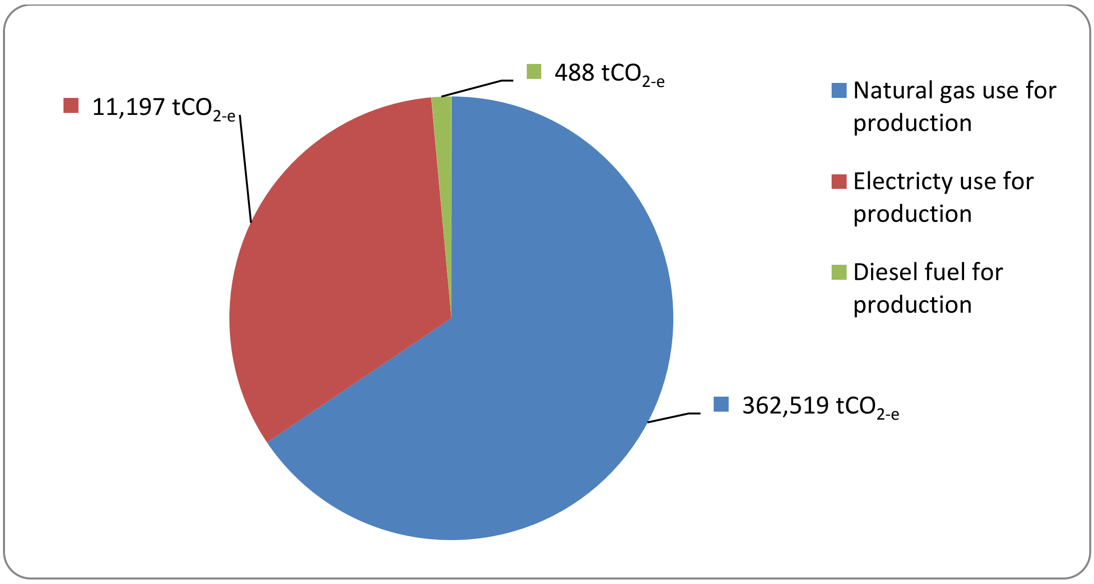

Figure 6 Operations based emissions breakdown by source

Table 11 below outlines the total operations based GHG emissions from Scope 1, 2 and 3 sources estimated for the Bringelly Brickworks site.

Table 11: Total GHG emissions by scope for the Bringelly Brickworks facility operations

Period	Production (tonnes per annum)	Scope 1 Estimated emissions (tCO_2-e)	Scope 2 Estimated emissions (tCO_2-e)	Scope 3 Emissions emissions tCO_2-e/L	Total Estimated emissions (tCO_2-e)
FY 2008/09	94,291	8,300	4,728	3,212	**16,240**
FY 2009/10	134,489	13,533	7,068	5,116	**25,717**
FY2010/11	135,746	13,532	6,749	5,051	**25,322**
FY 2011/12	132,648	13,220	7,008	5,013	**25,241**
Historical Average	124,294	12,146	6,388	4,598	**23,132**
Proposed	*263,500*	*17,876*	*9,296*	*6,767*	***33,939***
Difference	*139,207*	*5,729*	*2,908*	*2,169*	***10,806***

Total emissions from the proposed expansion operations are expected to increase by a total of ***10,806 tCO_2-e***. This overall increase is due to the escalation in production from the proposed expansion. It is expected that emissions per unit of production will not increase given the processes for brick manufacturing will remain the same. Import of raw material and export of product is expected to increase due to increased production and as such truck movements in and out of the facility are expected to increase. Emissions associated with transport of product and raw materials are expected to increase proportionally with increased production. The import and export of materials will be driven by market demand. Consequently, at the time of this study, there is insufficient information available in terms of sites providing raw materials and receiving product to quantify the emissions associated with raw material and product transport.

4 SUMMARY OF TOTAL GHG EMISSIONS ï CONSTRUCTION AND OPERATION

GHG emissions from the operational phase of the project are the largest contributor to emissions. Total emissions from construction are relatively low and only represent 1 per cent of total emissions for the project.

Emissions estimated from all sources are summarised in Table 12. The major source of emissions from the Bringelly Brickworks proposed expansion project are those associated with the combustion of natural gas in the production process (Scope 1 emissions), followed by electricity use (Scope 2 and 3 emissions) accounting for 66% and 33% respectively. Greenhouse gas emissions from natural gas combustion are lower than those associated with the combustion of other fossil fuels.

Table 12: Greenhouse gas emissions summary by source

Source	Activity	Scope 1 Estimated emissions (tCO_2-e)	Scope 2 Estimated emissions (tCO_2-e)	Scope 3 Estimated emissions (tCO_2-e)	Total tCO2-e
Site preparation	Vegetation clearing to prepare site for construction of buildings, noise bund and driveway (including emissions from transport and decomposition)	74.0	n/a	n/a	74.0
	Scraping and spreading of material for construction of noise bunds	176.1	n/a	n/a	176.1
Construction of buildings	Concrete transport fuel use	0.9	n/a	n/a	0.9
	Concrete paving fuel use	16.1	n/a	n/a	16.1
	Building construction fuel use	45.2	n/a	n/a	45.2
	Steel transport fuel use	0.1	n/a	n/a	0.1
Construction of driveway	Asphalt transport fuel use	1.4	n/a	n/a	1.4
	Roadbase transport fuel use	6.2	n/a	n/a	6.2
	Fuel use from asphalt paving	3.2	n/a	n/a	3.2
	Fuel use from roadbase paving	12.9	n/a	n/a	12.9
Total construction GHG emissions					**336.1**
Operations	Natural gas use for production	17,421.6	n/a	4,831.8	22,253.3
	Electricity use for production	n/a	9295.7	1901.4	11,197.1
	Diesel fuel for production	454.3	n/a	33.8	488.1
Total operations GHG emissions per annum					**33,938.5**

Source	Activity	Scope 1 Estimated emissions (tCO_2-e)	Scope 2 Estimated emissions (tCO_2-e)	Scope 3 Estimated emissions (tCO_2-e)	Total tCO2-e
Total GHG emissions from the project		***18,212***	***9,295.7***	***6,768***	***34,274.6***

Total emissions for the project were estimated to increase from 23,132 t CO_2-e to 34,274.6 tCO_2-e, or .03 Mt CO_2-e per year based upon the maximum level of production. Total annual potential emissions associated with the proposed project (.03 $MtCO_2$-e) represent approximately .37% of the total emissions from the mining non-energy sector in Australia (8.1 Mt CO_2-e) and .004% of total Australian emissions (756 Mt CO_2-e). Accordingly, the contribution of the proposed project to Australiaõs annual GHG emissions is not considered to be significant. Also the contribution of the project to global GHG emissions is a very small portion, given that Australia contributed approximately 1.5% of global GHG in 2005 (Commonwealth of Australia, 2011).

5 GHG EMISSIONS MANAGEMENT AND MITIGATION OPTIONS

The carbon management principles (shown in Figure 7) provide a robust framework for the management and reduction of GHG emissions.

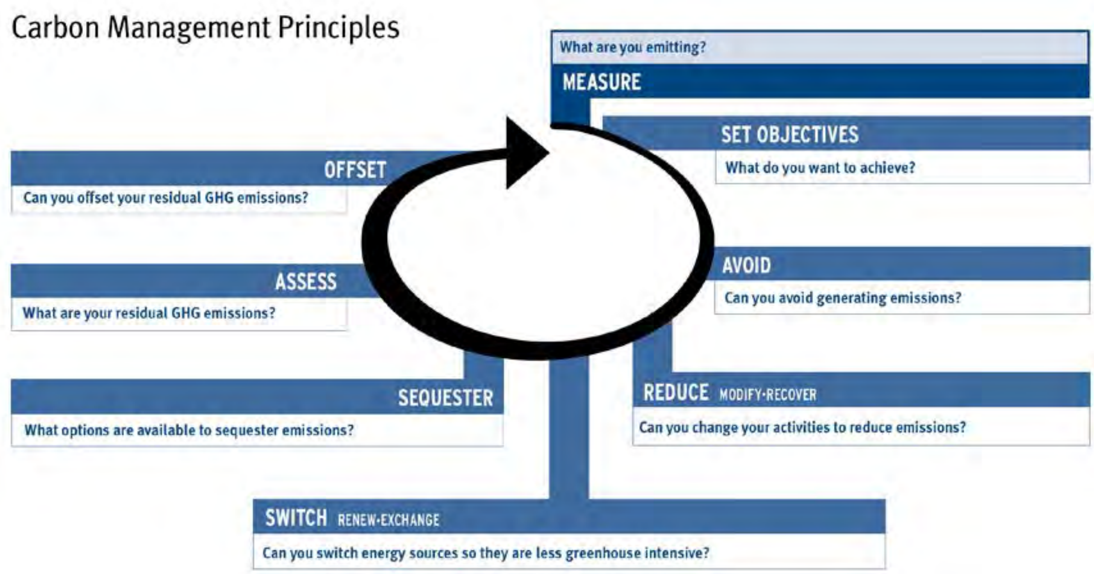

Figure 7: Carbon management principles for emissions reduction (Victorian EPA)

The earlier sections in this assessment represent the emissions measurement and setting objectives components of the carbon management principles. This section recommends actions to further reduce emissions throughout the project development. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles.

Management principle	Description
Avoid	Actions which avoid emissions, in the first instance, should be considered as a priority;
Reduce	Actions which result in a reduction of emissions should be considered next;
Switch	Actions which switch energy sources to reduce emissions should be the next considered;
Sequester	Actions which sequester GHG emissions do not reduce emissions but store them; and
Offset	Offsetting of emissions through the purchase of offsets. This should be considered as a last resort.

Regular monitoring of emissions is recommended throughout the project to assess the effectiveness of emissions mitigation actions.

The following actions are recommended for mitigation of GHG emissions during the construction and operation of the facility:

Table 13 Recommendations for mitigation of GHG emissions

Construction
When importing material, source from nearby construction sites wherever possible to reduce transport related emissions
Where possible, use locally sourced materials to reduce emissions associated with transport
Recycle/compost waste materials (e.g. use of reject bricks to support void rehabilitation) wherever possible
Plan construction works to avoid double handling of materials;
Develop construction/transport plans to minimise the use of fuel during each construction stage. For example throttling down and switching off construction equipment when not in use
Assess the fuel efficiency of the construction plant/equipment prior to selection, and where practical, use equipment with the highest fuel efficiency which use lower GHG intensive fuel (e.g. gas, ethanol)
Operation
Investigate the procurement of energy efficient equipment for the site (i.e. vehicles, forklifts, lighting etc);
Investigate route options and vehicle efficiencies for product export and materials import;
Investigate the feasibility of on-site renewable energy, such as photo-voltaics to reduce demand from the grid.
Regular maintenance of equipment to maintain optimum operations and fuel efficiency.

6 REFERENCES

Commonwealth of Australia (2011) Securing a Clean Energy Future ï The Australian Government Climate Change Plan, Canberra ACT.

DCC (2008) National Greenhouse and Energy Reporting Guidelines Commonwealth of Australia, Canberra ACT.

DCCEE (2012) National Greenhouse Accounts (NGA) Factors Commonwealth of Australia, Canberra ACT.

DIICCSRTE (2013) State and Territory Greenhouse Gas Inventories for 2008 Commonwealth of Australia, Canberra ACT.

IPCC, (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,

Tchobanoglous G., Theisen, H., and Vigil S. (1993) Integrated Solid Waste Management ï Engineering Principles and Management Issues McGraw-Hill, Inc.

World Business Council for Sustainable Development & Word Resources Institute (2001) The Greenhouse Gas Protocol ï A Corporate Accounting and Reporting Standard, Revised Edition.

APPENDIX I

SURFACE WATER MANAGEMENT REPORT

BORAL BRINGELLY BRICKWORKS SURFACE WATER MANAGEMENT REPORT

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BORAL BRICKS PTY LTD

BORAL

Surface Water Management Report

Author	Parham Ghasemzadeh
Checker	Sam Pollard
Approver	Brad Searle
Report No	F0005-AA005667-NSR-01
Date	3 July 2013

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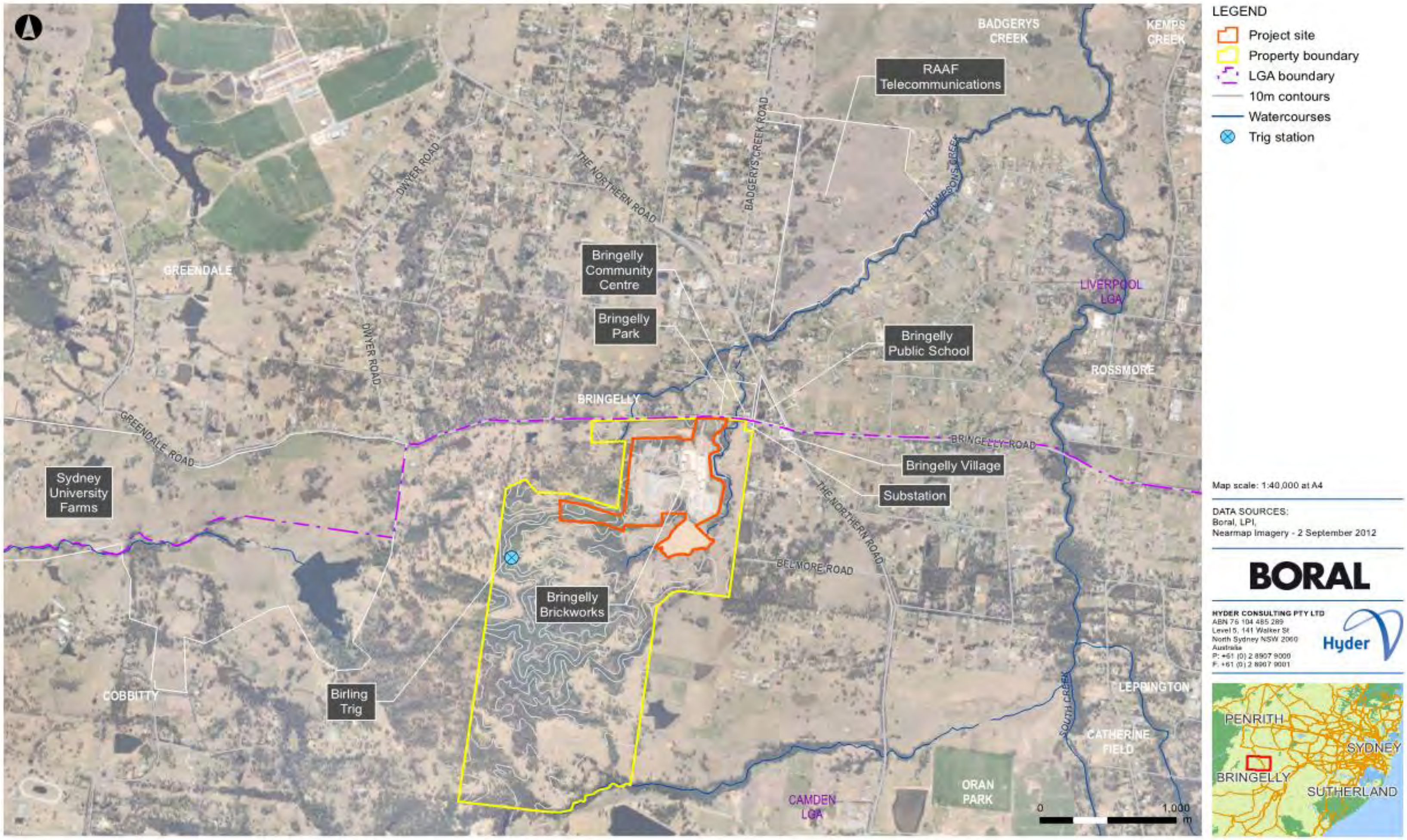

Figure 2.1 – Locality plan

2 SITE DESCRIPTION

The project site is currently used for quarrying, brick production and associated activities. The brickworks and quarry are located on an approximately 385.55 hectare property owned by Boral Limited, which is located at 60 Greendale Road, within the Camden local government area and is approximately 55 km southwest of the Sydney central business district (Refer to Figure 2.1).

The brick making facility along with various administration buildings, a finished bricks storage yard, staff car park and internal road network is generally contained within the northern part of the project site (refer to Figure 3.1), and is set back approximately 200m from Greendale Road.

Existing quarrying activities have substantially altered the natural landform, with various voids and elevated stockpiles present in the active, north-western part of the project site. Other significant landforms on the site include the raw material stockpiles to the south of the brickworks, as well as unusable materials stockpiles along the western boundary of the site.

The underlying topography of the operational footprint on the project site is relatively flat, and the land slopes to the south toward Thompsons Creek.

The southern portion of the project site, adjacent to Thompsons Creek, is leased for the agistment of stock and grazing.

Thompsons Creek, with a catchment area of approximately1.6km^2, has its source to the south-west of the project site. The creek flows eastwards past the southern boundary of the quarry, after which it turns northwards flowing along the eastern boundary of the brick making facility and carpark. It then passes under Greendale Road before joining South Creek approximately 4km further downstream. South Creek is a tributary of the Hawkesbury River.

A 6 metre high earth bund has been constructed along the eastern side of the brick making facility which has a dual purpose of attenuating production noise as well as providing flood immunity to the brickworks site from Thompsons Creek.

Based on the Upper South Creek Flood Study by Camden Council, the current developed site is outside of the 1% AEP flood extents. The proposed development is also situated outside the flood extent and therefore the current immunity will be maintained.

3 CURRENT CONDITION AND PROPOSED DEVELOPMENT

3.1 CURRENT STORMWATER MANAGEMENT PLAN

An existing SMP for Bringelly Brickworks and Quarry was prepared by ERM Australia Pty Ltd in October 2002. The SMP assessed the sites surface water characteristics which included:

- Stormwater runoff from the hard stand areas, capture, treatment and discharge.
- Sewerage treatment and on-site reuse
- Stormwater from disturbed areas capture, treatment and discharge.

The SMP also documented the EPA licence, (EPL) conditions and identified an ongoing plan to meet these conditions. At the time, the quarry was being developed in 4 stages over an area of approximately 9.9ha (refer to the approved quarry footprint in Figure 3.1).

3.1.1 EPA LICENCE (EPL) CONDITIONS

The current EPL conditions require the assessment and management of site runoff, storage and water quality including the development and implementation of a pollution reduction program. To meet these condition assessments the following will be required:

- An effluent management plan which confirms irrigation areas and that these areas have capacity to satisfy the effluents' nutrient and hydraulic loading applied to them without any detrimental effects (runoff, contamination etc) to the environment, or another solution to treatment and disposal of the sites treatment plan's effluent.
- Detailed plan for surface water management (capture and treatment),
- Mitigation of any proposed changes that may cause flooding off-site
- Inclusion of all surface water monitoring undertaken since the existing system was commissioned (1993).
- Plan and discussion around any changes needed to the existing SMP to meet the proposed extension.
- A preferred option to address the issue around tracking soil from the site onto Greendale road.
- A program for implementation of all proposed changes outlined in the updated SMP.

3.1.2 SUMMARY OF CURRENT OPERATION

Boral currently extract clay from a 9.9ha area under their 1991 development consent (refer to Figure 3.1). Quarrying has been undertaken to a depth of between 10m and 20m within the approved quarry footprint, with only limited extraction in the northern area of the project site undertaken to date.

The local catchments that currently contribute flows over the approved project site are shown in Figure 3.3. As per the EPL requirements the current SMP assessed the ability of the site's proposed pit dams and sedimentation ponds (dams) on the site to contain runoff from a 90th percentile, 5 day rainfall event. The operation of the existing stormwater management system is summarised below:

- Runoff from the roof of buildings on the site is collected to a dedicated drainage system and discharged to Thompsons Creek via Dam 1.
- Runoff from the car park and brick storage area drains to the effluent irrigation area.
- Runoff from the production area drains to Dam 2, which when full, overflows into Dam 1 which empties into Thompsons Creek; via a weir on the creek bank.
- Runoff from 27.1ha (of which 4.8ha is on neighbouring land to the west) of the catchment area to the west of the site drains towards and is largely captured within the existing quarry void.
- The overland flows that are captured within the quarry are pumped out before the commencement of each quarrying campaign. The clay material required for brick production is excavated in two campaigns per year and is stored in raw material stockpile areas to the south of the brick making facility.
- Overland flows collected in the quarry are pumped to Dam 4 for de-sedimentation. Flocculent is added to the water on route to Dam 4. Dam 4 overflows to Dam 5, whereby water is pumped to Dam 6 which is located in the headwaters of Thompsons Creek. Water then releases into Thompsons Creek over the Dam 6 causeway when the dam overflows, usually following heavy rainfall events. An EPL is currently in place for discharges/overflows from Dam 6 to Thompsons Creek.
- An existing bio-cycle treatment plant is situated on the site, but is no longer used for treatment, only for storage of the sewage within its holding tanks. Periodically (based on levels in the holding tanks) the sewerage is then pumped out by a tanker and transported to a local sewage treatment works. Currently no irrigation of effluent or discharge from the site takes place.

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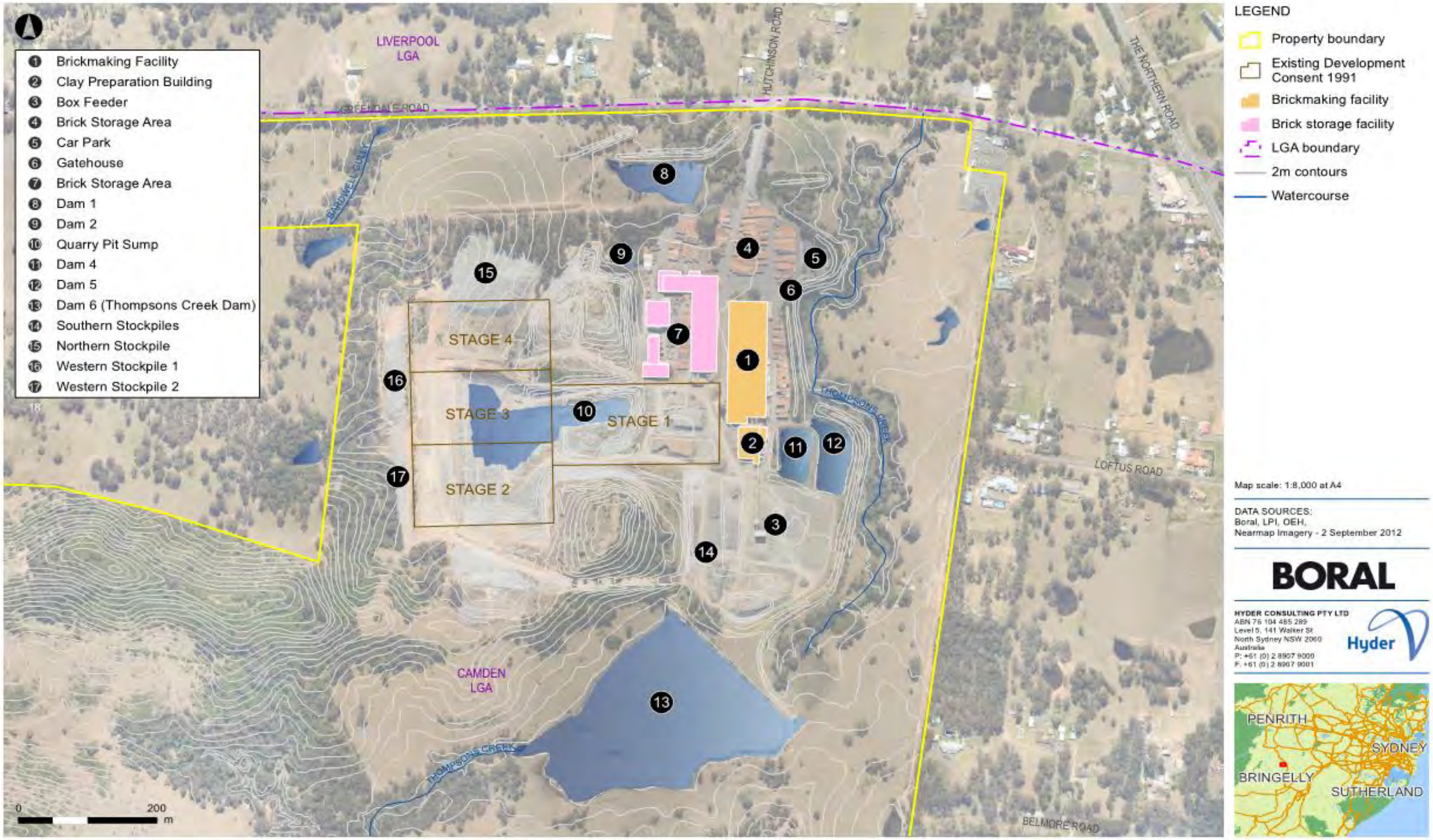

Figure 3.1: Existing site layout plan

3.2 PROPOSED DEVELOPMENT

Approval is sought for the continuation of operations on the site involving the continued extraction of raw materials, but over a larger extraction area (quarry footprint), and continued brick making activities, but at a higher production rate. Figure 3.2 shows the increased footprint.

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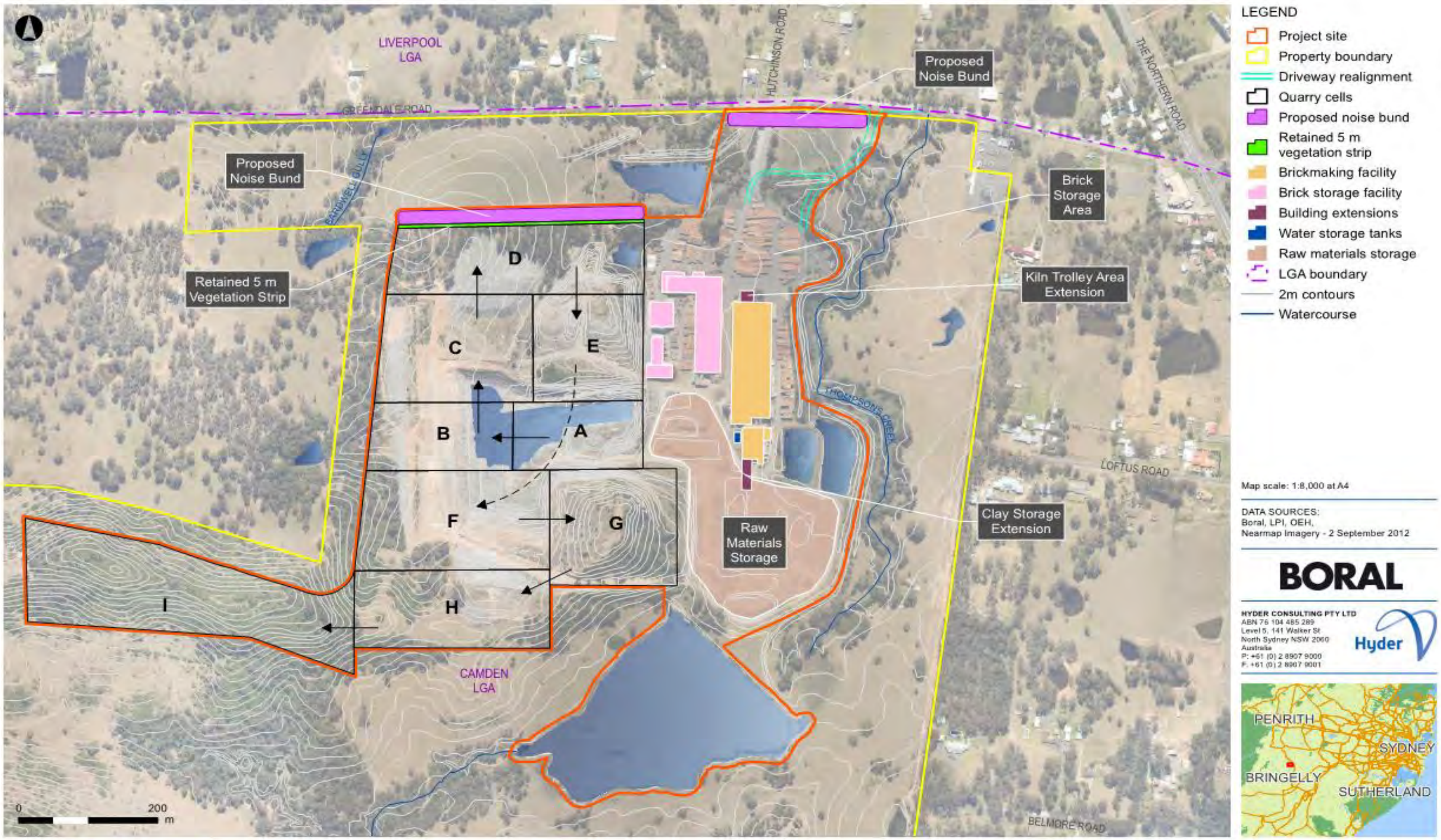

Figure 3.2: Proposed site layout plan

The proposed project can be summarised as follows:

- Extraction of raw material from the site in the order of 200,000 tpa (no change to current extraction consent) as follows:
  - Continuation of extraction from the existing quarry area (current consent), to a maximum depth of 30 m; and
  - Expansion of the quarrying operations over an additional 20.75 hectares (to a total of 30.65 hectares) with extraction to a maximum depth of 30m;
- Brick production in the order of 263,500 tonnes of bricks per year (increase of 103,500 from current consent);
- Construction of a 4.5m high noise bund along the northern boundary of the quarry operations (362m long x 3m flat top with a 21m wide base and 1:2 batter slopes);
- Importation of raw materials required for brick making in the order of 96000 tpa;
- Extension to the following existing buildings:
  - clay preparation building; and
  - small area of the brick manufacturing plant near the exit to the kiln
- Addition of two recycled water storage tanks;
- Construction of a new driveway to the east of the existing alignment; and
- Construction of a 4.5m high noise bund along the northern Boral property boundary, from the position of the existing driveway to the proposed new driveway location (200m long x 3m flat top with a 21m wide base and 1:2 batter slopes).

The proposed quarrying area will expand northwards, southwards and south-westwards, covering a total surface area of 30.65 hectares to a maximum extraction depth of 30 metres. To facilitate the description of the quarrying activities, the proposed quarry area has been divided into nine cells, namely Cells A – I, (Refer to Figure 3.2 for proposed quarry layout).

Quarrying extraction activities are expected to progress on the site according to the following plan:

- Continued extraction of Cells A, B & C (existing pits).
- Extraction of proposed Cells D, E, F, G, H & I.

Approval is being sought for continued extraction on the site, at a rate of 200,000 tpa, over the next 30 years. Quarrying activities would continue to be undertaken on a campaign basis. A campaign is a discrete quarrying event whereby material is extracted from the pits using bulk earthwork machinery (primarily excavators) and is transported to stockpile areas by dump trucks, where it is spread and shaped by dozers. The proposed campaigns are likely to be approximately two calendar months in duration (44 working days) and will be undertaken during standard working hours. Although the number of campaigns will be determined by the annual demand for bricks, up to three campaigns are proposed per annum, which would provide sufficient raw material for the manufacturing of 263,500 tonnes of bricks per annum.

In order to explain the staging of quarrying activities over its 30 year life, the total quarry area has been divided into nine cells (quarry areas), which are represented in Figure 3.2. Given that the extraction of material will be based on consumer demand, it is difficult to predict an exact duration of operations within each of these nine cells. However, the sequence of the material extractions is known, and there will be approximately three cells open at any one time so as to ensure that the different types of material resources can be accessed in different places and at different depths at any time during the operations. The only exception to this approach is Cell I, which covers a large enough area and has sufficient resource to allow for extraction of material at multiple depths at any one time during the life of this cell.

Each cell within the quarry will be progressively extracted on a campaign basis, starting with the active Cells A, B and C and continuing to D, E, F, G, H and finishing at Cell I. For example, as Cell A “bottoms out” (is exhausted/reaches 30m in depth), extraction will cease in Cell A and will commence in Cell D and therefore Cells B, C and D will be operational. As Cell B is exhausted, extraction will cease in Cell B and will commence in Cell E and therefore Cells C, D and E will be operational and so on.

Table 3-1 broadly summarises the stages over the 30 year quarry life.

Table 3-1 Bringelly Brickworks proposed staging

Stage	Cells	Resource quantity
1	A, B, C	2,198,763 tonnes
2	D, E, F	2,273,969 tonnes
3	G, H, I	3,963,313 tonnes
	TOTAL	7,989,025 tonnes

Upon cessation of quarrying in the nominated areas (cells), Boral will either infill each cell with excavated material or use them to facilitate temporary water storage capture. This will evolve in a way where the inter-burden, over-burden and all un-useable material from subsequent mined stages will be placed into the preceding exhausted cells from the previous stages (now a void). The final footprint will focus on cell B as being the central component of the sites water management, with the rest becoming rehabilitated voids.

Further information on the rehabilitation strategy can be found in Hyder’s rehabilitation strategy (Appendix B of the Bringelly Brickworks Expansion Project EIS (Hyder Consulting 2013).

3.3 PROPOSED CHANGES TO THE CATCHMENTS

Although the total catchment area of the site will remain almost the same, as the quarry expands laterally, the quarry catchment will increase, resulting in an evolving drainage pattern over the life of the quarry. These changes are evident when comparing the existing catchment scenario (Figure 3.3) and the expanded quarry scenario (Figure 3.4). Table 3.2 provides a summary of changes to catchments on the project site. Key terminology is outlined below.

- **The existing condition** - Defined by catchment sizes of all sections of the site as of 2013.
- **The developed “without diversion” condition –** Has a catchment size which is defined by a fully developed (all cells exhausted) site at the end of the quarry’s 30 year life. For the ‘’without diversion” condition, runoff from the 5.2ha off-site catchment area, located to the west of the site, discharges to the quarry. Runoff from undisturbed areas flows over the disturbed areas of the quarry, resulting in large volumes of sediment being deposited into the quarry area.
- **The developed “with diversion” condition** - Under this scenario flows from the off-site catchment from the western boundary are diverted into a temporary attenuation structure, Dam 7, which in turn will be diverted again into Dam 1. If Dam 7 is not diverted to Dam 1,

additional flow (compared to the existing condition) will result in Bardwell gully, causing potential flooding downstream. Diverting runoff to Dam 7 ensures that runoff over the disturbed areas of quarry is reduced, promoting segregation of clean and dirty water flows. This approach is consistent with best practice promoted by the planning and design strategies of the NSW guidelines “Managing Urban Stormwater - Soil and Construction, 1998.

The water balance modelling results for both potential development options (with and without diversion) are presented in Section 4 of the report.

The names given to each catchment area relate to the stormwater retention structure (Dam) in which stormwater runoff from that catchment area is captured.

Table 3.2: Catchment areas contributing to overland flows

Catchment	Existing Condition (ha)	Developed Condition “Without Diversion” (ha)	Developed Condition “With Diversion” (ha)
Dam 1	6.0	3.1	3.1
Dam 2	2.8	___	___
Quarry Pit	26.6	38.6	31.2
Dam 4	8.4	8.8	8.8
Dam 5	3.0	3.0	3.0
Dam 6	125.8	120.7	120.7
Dam 7	___	___	7.4
Total	**172.6**	**174.2**	**174.2**

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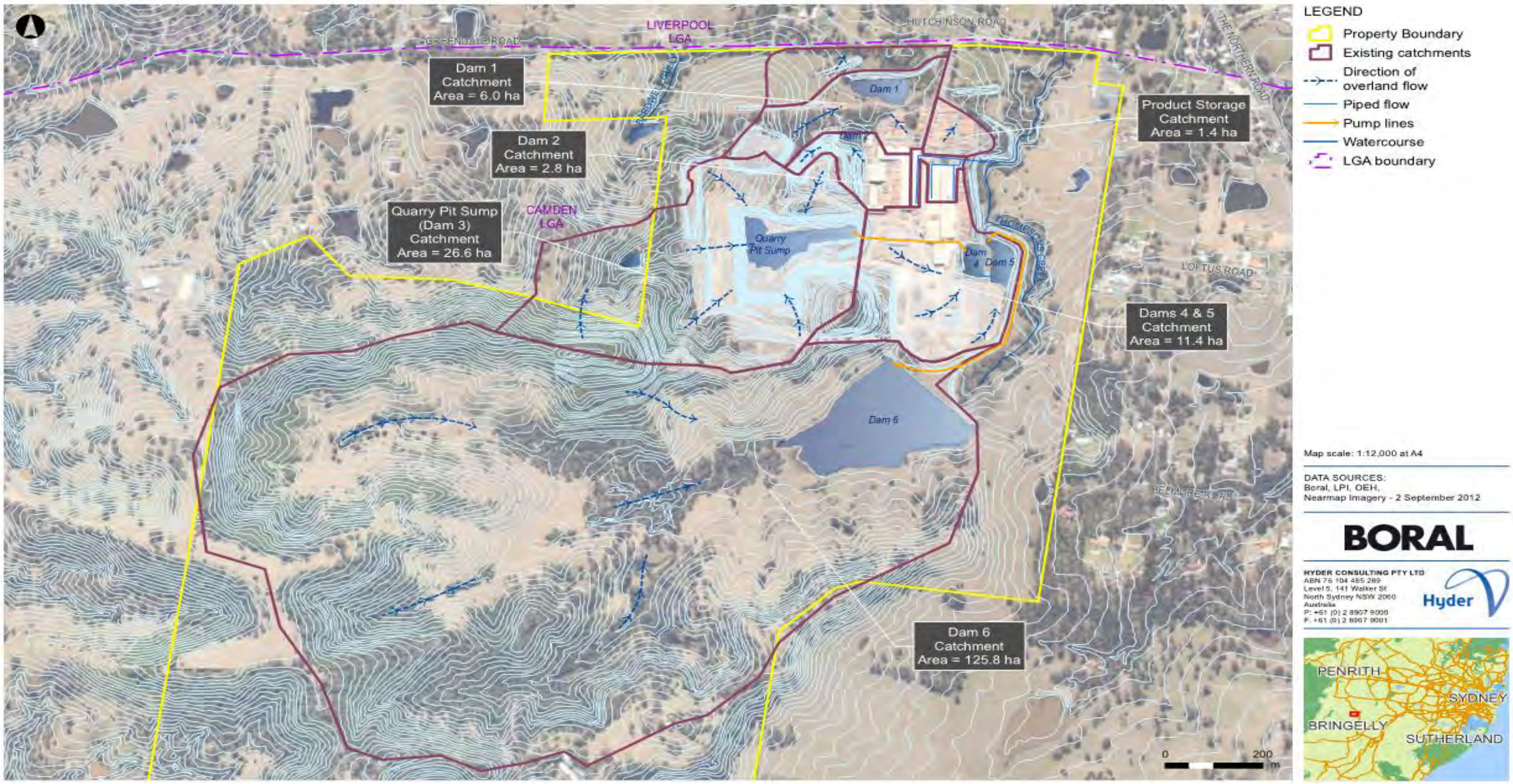


Figure 3.3 – Existing condition – catchments and active quarried area

BRINGELLY BRICKWORKS EIS

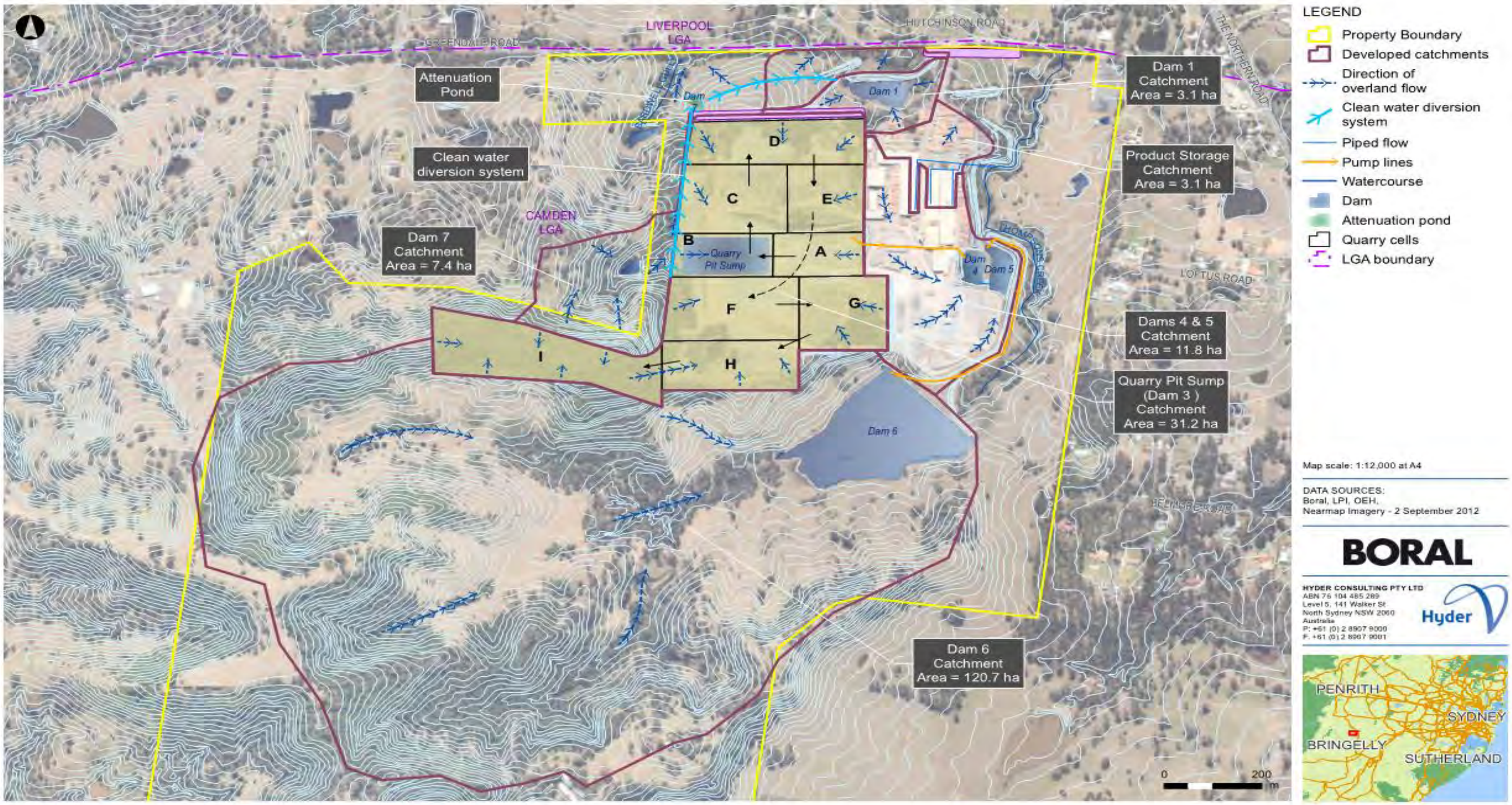


Figure 3.4 – Developed condition – catchments, flow paths and staged quarried area

4 WATER BALANCE MODELLING

4.1 APPROACH

The scenarios outlined in Section 3.3 were simulated via the development of a water balance model for the project site to understand the on-site water storage capacities for the quarry operations. The requirement for the site's dams and their operations is outlined in the NSW government's guideline 'Managing Urban Stormwater- Soil and Construction, 1998'.

Under directions of this guideline and EPL requirements a water balance model has been setup to investigate the following:

- Estimate the required capacity to contain runoff generated at each catchment during a 5 day 90th percentile rainfall event.
- Ensure that the discharge of water flowing from the disturbed part of the site is limited to 1 to 2 times during the year for a critical historical 10 year period.
- Demonstrate that the frequency and quantity of discharges for the developed condition is equal to or less than the existing conditions.

The following sections provide further details on the outcomes of water balance modelling for the project site.

4.2 MODELLING APPROACH

4.2.1 MODELLING SOFTWARE

A GoldSim modelling platform was utilised to develop the required daily time-step water balance model of the project site. This is seen as industry standard and the preferred model to use when developing stormwater management systems of large extractive industry projects. Examples include the Adani Coal Mine in the Galilee Basin QLD and APLNG's well fields in the Surat Basin QLD.

The model was developed spatially to represent all of the site's dams and catchment areas. Figures 4.1a and 4.1b provide an example of how the GoldSim modelling platform represents the quarry site.

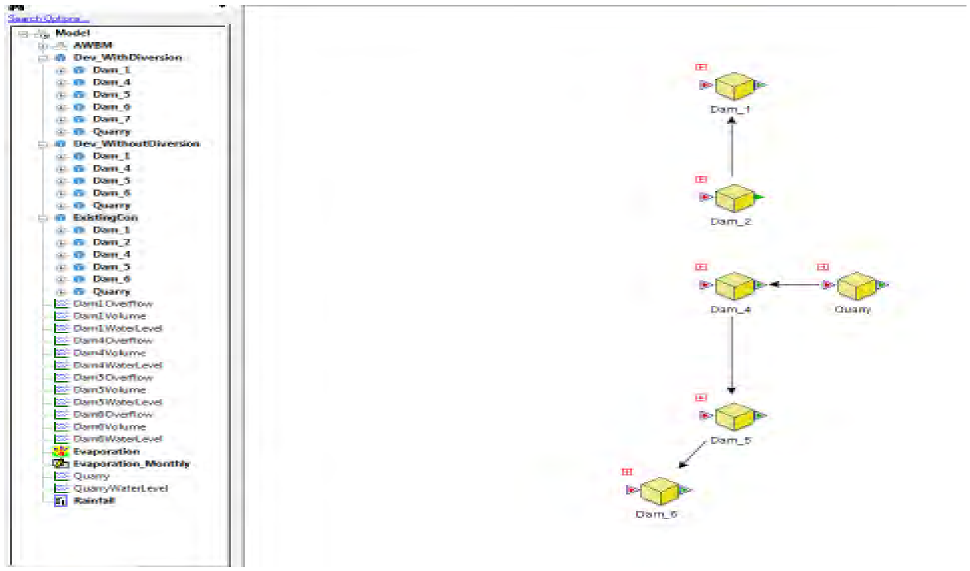


Figure 4.1a: GoldSim water balance - Existing Condition model structure

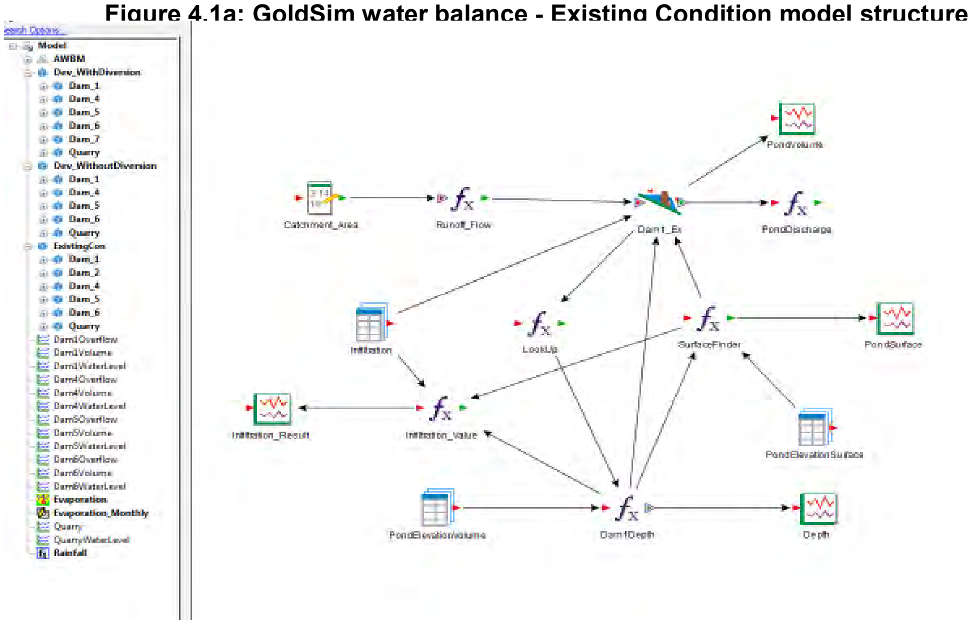


Figure 4.1b: GoldSim water balance - Existing Condition- Model Structure for Dam 1

The daily discharges to the site were quantified in GoldSim using the Australian Water Balance Method (AWBM) proposed by the Commonwealth Research Centre for Hydrology (CRC). The following values have been used in the AWBM based on the small size of the catchments and the soil conditions. Based on the ephemeral characteristic of the waterways at the site, it is assumed that the waterways contain no base flow prior to occurrence of rainfall events.

Avg Surface storage Cap.: 100mm

C1, C2, C3: 0.01X100, 0.33x100, 0.66x100

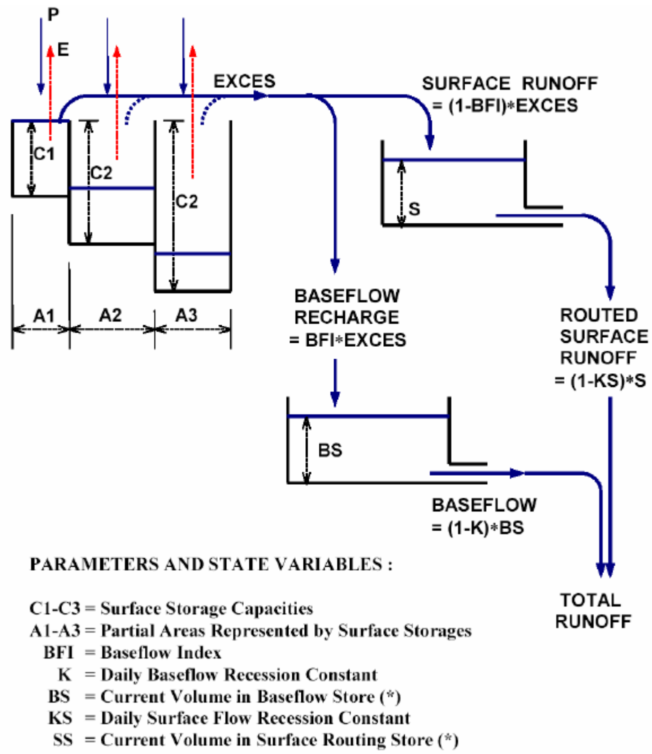
A1, A2, A3: 0.134, 0.433, 0.433

BFI: 0

K: 0.05

BS: 0.4

KS: 0.1



Source: Rainfall Runoff Library User's Guideline (CRC for Catchment Hydrology, 2004)

Figure 4.2: Schematic of AWBM used to assess rainfall runoff for the site.

4.2.2 MODELLING CONDITIONS/ASSUMPTIONS

Model Build

The following assumptions and inputs were applied during the development of the water balance model:

- The developed condition scenario is defined when the water storage area within the quarry is limited to cell 'B' (smallest storage) and once the quarry has been fully developed i.e. at the end of the 30 year quarry life when cells A – I have been fully extracted. This also reflects the worst case scenario where the minimum storage and maximum catchment area is reflected.
- A 90th percentile 5 day rainfall design storm event was applied to the model to ascertain the minimum storage requirements of each stormwater attenuation structure (dam), to capture runoff from the rainfall event, (refer to Table 4.3).
- To ensure a conservative and realistic assessment is being carried out, 20mm of rainfall will be applied prior to the 5 day 90 percentile rainfall event. This industry standard practice is followed to provide wetting of the catchment and allows the dams retain some water, as in practice the dams generally have carryover of water from previous flood events i.e. they are rarely dry.
- To understand how the system operates under both wet and dry conditions, both the existing and developed condition scenarios were modelled with application of a daily time step for a 10 year period, 1979 to 1989.
- Rainfall runoff was calculated using the AWBM model – refer to section 4.2.1 above for inputs used.

Rainfall and Evaporation Data

Daily rainfall data was sourced from the Bureau of Meteorology (BOM) Station at Prospect Reservoir (Station # 067019) and was applied to the model.

For the 5-day rainfall simulation, a 90th percentile daily rainfall of 22.6mm was calculated from the BOM data. The rainfall data was then transformed to runoff using the AWBM for estimation of the required on-site stormwater retention volumes.

The rainfall data recorded for a 10 year period between 1st of July 1979 to 30th of June 1989 was used for a long term simulation of the site water balance. This period was chosen as it contained the wettest and driest years in any consecutive 10 year period on record. It is also consistent with the approach taken for the SMP for Boral's Quarry and Brick Making Facility at Badgerys Creek, (AECOM, 2010), which is located nearby.

The average long term daily evaporation rates calculated at the Prospect Reservoir BOM Station has been used for water balance modelling. These values are shown in table 4.1.

Table 4.1: Average monthly evaporation (Prospect River BOM Station 067019)

Month	Daily Evaporation (mm/day)
January	5.5
February	4.8
March	3.9
April	3.0
May	2.0
June	1.6
July	1.7
August	2.6
September	3.6
October	4.4
November	4.9
December	5.7

Dam Volumes

Existing Condition

All on-site dams were modelled using their volume to depth and volume to surface ratios. The existing condition volumes for the on-site dams are shown in table 4.2. These volumes were sourced from the site's SMP report, completed by ERM, Oct 2002. The volumes were then verified using the available 1m contour lines from the 2011 survey of the site.

The dams are considered to be overtopping as soon as a ponded water volume reaches the maximum storage capacity. Water balance modelling results presented in section 4.3 show that the available on-site dams will adequately contain the runoff associated with existing site conditions for a 90th percentile 5 days rainfall event.

Developed Condition

The developed condition described here includes the proposed diversion initially discussed in section 3.3. As previously discussed, runoff from the western off-site catchment will be diverted to Dam 7 then diverted again to Dam 1.

For such a condition the storage volume of Dam 1 will not be enough to hold the runoff from the 5 day 90th percentile event without overflowing. Therefore additional flow retention capacity, such as increasing the size of Dam 1 or provision of an additional dam up-stream, would be required.

Based on the model's results there are two options providing increased flow retention capacity as follows:

1 Increase Dam 1 storage volume to $4000m^3$.

2 Create a new dam with a $1300m^3$ capacity upstream of Dam 1 (Dam 7).

Option 2 is the preferred option, as it negates the need to modify the capacity of an existing Dam (Dam 1). As discussed above in Section 3, Dam 7 overflows to Dam 1 and contributes to the overall flow retention capacity of the system. The construction of Dam 7 prevents the overflow of Dam 1 during a 5 day 90^{th} percentile event.

To prevent mixing of catchment waters of varying water quality, the flows from the un-disturbed catchment of Dam 7 should flow directly to Bardwell gully. This increase in flow to Bardwell Gully may; however, increase the potential for flooding downstream. Therefore, to mitigate this risk, the overflow from Dam 7 to Dam 1 will be managed via a constructed diversion.

Post-Operating Condition – Final Landform

The storage capacity of the quarry voids in its final landform will be five times more than the values specified in the "developed condition" column for the quarry in Table 4.2 below. Therefore, under post-operating conditions, pumping of water from the quarry pit to Dam 4 will not be required. In addition all runoff from the project site catchments will be effectively contained within the quarry water storage structures (voids) with no requirement for pumping.

During the operating period of the quarry, the ponding volume has been limited to one or two cells, dependent on the quarry's staged development. Based on this, the worst case scenario is shown in Table 4.2 for the developed condition which represents the ponding volume after completion of excavation works at Cell 'A' only.

Table 4.2: Volume of the dams in the Existing and Developed Condition

Ponding Structure	Volume (m^3) Existing Condition	Volume (m^3) Developed Condition
Dam 1	3,180	4,000
Dam 2	700	____*
Quarry Pit	346,100	381,500
Dam 4	3,350	3,350
Dam 5	3,020	3,020
Dam 6	50,000	50,000
Dam 7	_____	1300**

* Dam 2 will no longer exist after commencement of material extraction from cell 'D' and therefore all water from the existing Dam 2 catchment will flow into Dam 1.

** Proposed storage volume upstream of Dam1, located on the northern boundary of project site to hold the diverted runoff from western off-site catchment.

4.3 MODEL OUTPUTS

The outputs from the model are discussed in this section, with water management mitigation strategies discussed in Section 5 of this report. The modelling results discussed below are the outputs for the following simulation events:

- Five day 90th percentile rainfall event; and
- A historical 10 year rainfall simulation (1979-1989).

Each simulation was run for a number of scenarios which are given below:

- Existing conditions – as per the current site situation 2013.
- Developed 'without diversion' conditions – as per the proposed development
- Developed 'with diversion' conditions – as per the proposed development with a diversion for the site's western catchment into a new dam (Dam 7) upstream of Dam 1.

4.3.1 5 DAYS SIMULATION

Results Summary

As per the guideline "Managing Urban Stormwater - Soil and Construction, 1998", the on-site stormwater dams will contain all of the site's runoff triggered by a 5 day 90th percentile rainfall event. Table 4.3 provides a comparison between the ponded water volumes in each of the on-site dams during a 5 day 90^{th} percentile event and their volumetric capacities.

The discharge points from the site are Dams 1, 5 and 6. Based on the tabled results no overflow occurs for the developed condition which is consistent with the EPL and DGRs.

Table 4.3: Comparison between the ponded water volumes and the storage capacities during a 5 day 90th percentile event for the three simulated cases (existing, developed 'with diversion' and developed 'without diversion')

Dam	Existing		Developed Condition (With Diversion)		Developed Condition (Without Diversion – Selected option)		Comments
	Capacity (m^3)	Ponded Water (m^3)	Capacity (m^3)	Ponded Water (m^3)	Capacity (m^3)	Ponded Water (m^3)	
1	3180	1701	3180	1513	3180	842	No overflow in existing and developed condition
2	700	>700	____	____	____	____	Dam 2 overflows to Dam 1 Will be eliminated during excavation of Cell D
3 (Quarry Pit)	346,100	6610	381,500	8282	381,500	10247	No significant water ponding during a single event
4	3350	>3350	3350	>3350	3350	>3350	Dam 4 surcharges to Dam 5
5	3020	>3020	3020	803	3020	803	Under developed condition Dam 5 will contains the 5 day event
6	50000	35038	50000	32536	50000	32536	Dam 6 would contain flows from the 5 day event
7	____	____	1300	>1300	____	____	In with diversion alternative Dam 7 will be constructed and diverted to Dam 1

Dam 1 and Dam 7

The construction of Dam 7 allows for the ponded water volumes to fall below the volumes for the existing condition, as shown in Figure 4.3 below. The figure also shows that Dam 1 will have sufficient capacity to retain the runoff generated during the 90th percentile, 5 day rainfall event for the enlarged 10ha upstream catchment created by diversion of the site's western catchment to this dam.

Dam 7 should be constructed as a part of the western catchment flow diversion works, with a diversion between Dam 7 and Dam 1 also required.

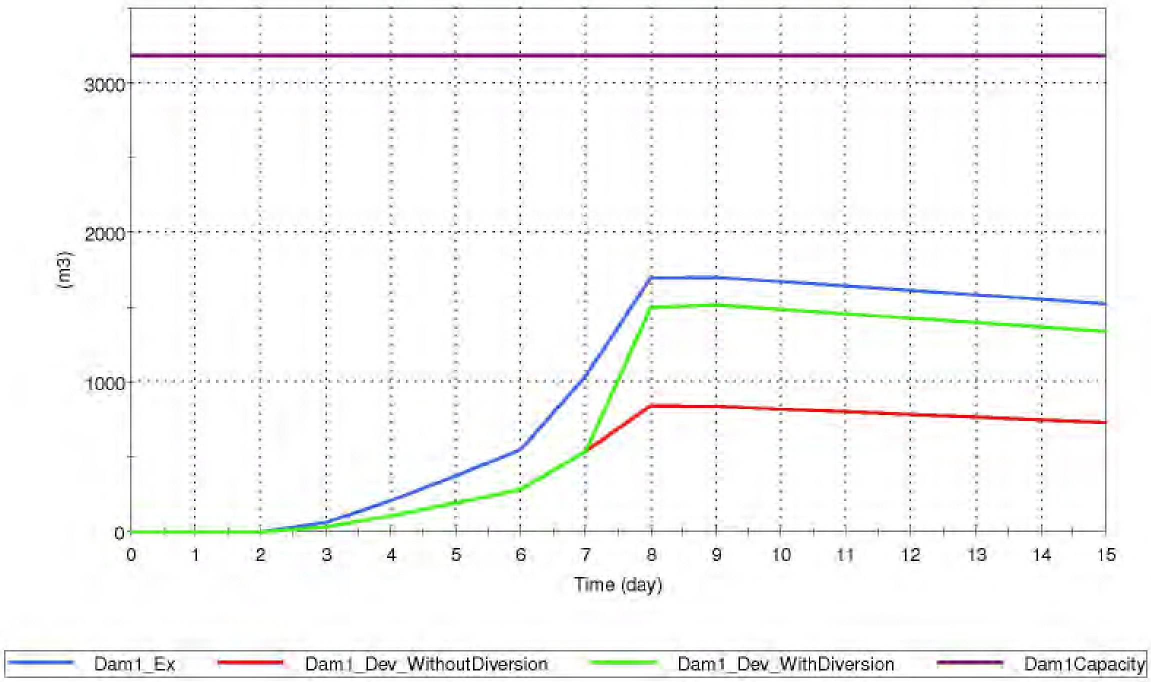


Figure 4.3: Storage Volume of Dam 1 during a 5 day 90th percentile rainfall event for the Existing and Developed conditions – Dam 1 Capacity – 3180m^3

Quarry Pit

Diversion of stormwater runoff from the western external catchment (‘with diversion’ condition) reduces the inflows into the quarry pit when compared to the ‘without diversion’ condition, as shown in Figure 4.4 below. The volume of the ponded water in the quarry for a 5 day 90th percentile rainfall event will reach a maximum of 8282m^3 for the ‘with diversion’ option, which is significantly lower than the full storage capacity of quarry pit in the quarry, (see Table 4.3 for volumes). This ability to retain large amounts of water will be used to control the discharge of water from the quarry pit to Thompsons Creek via Dams 4 and 5, as required and authorised under the existing EPL arrangement for the project site.

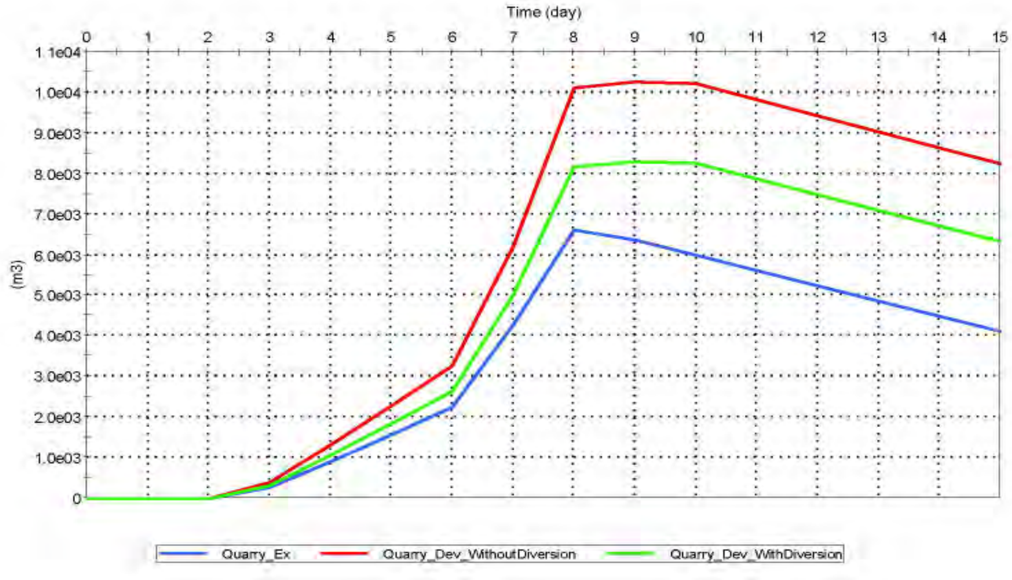


Figure 4.4: Quarry pit volume during a 5 day 90% event.
Quarry Pit Capacities - existing is 346,100m^3, developed is 381,500m^3

Dam 4 and Dam 5

Dam 4's overflow during a 5 day, 90 percentile event is captured and held by Dam 5. Figure 4.5 below illustrates that the period of time it takes for Dam 4 to overflow into Dam 5 is increased by 4 days for the 'with diversion' scenario.

Figure 4.6 illustrates Dam 5's ability to hold the 5 day, 90 percentile event's runoff for both the existing and 'with diversion condition. The time it takes for Dam 5 to overflow is again greatly increased for the 'with diversion' scenario, and in turn provides more control for regulated discharges from Dams 5 and 6.

The ponded water volumes and discharges for Dams 4 and 5 remain the same for both the 'with diversion' and 'without diversion' scenarios.

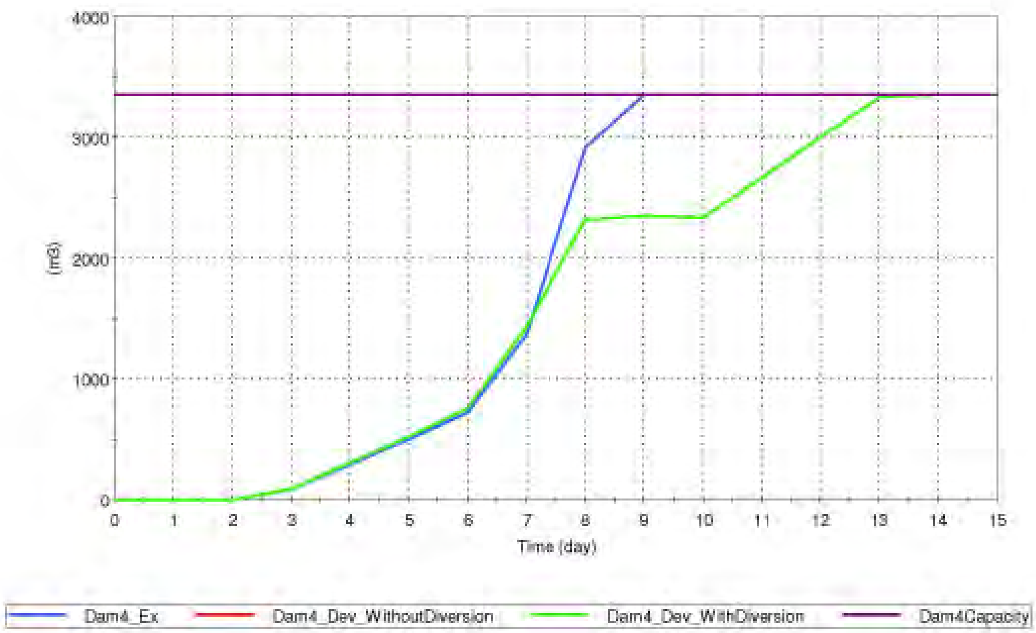


Figure 4.5: Dam 4 storage volume during a 5 day 90% event – Dam 4 storage capacity – 3350m^3

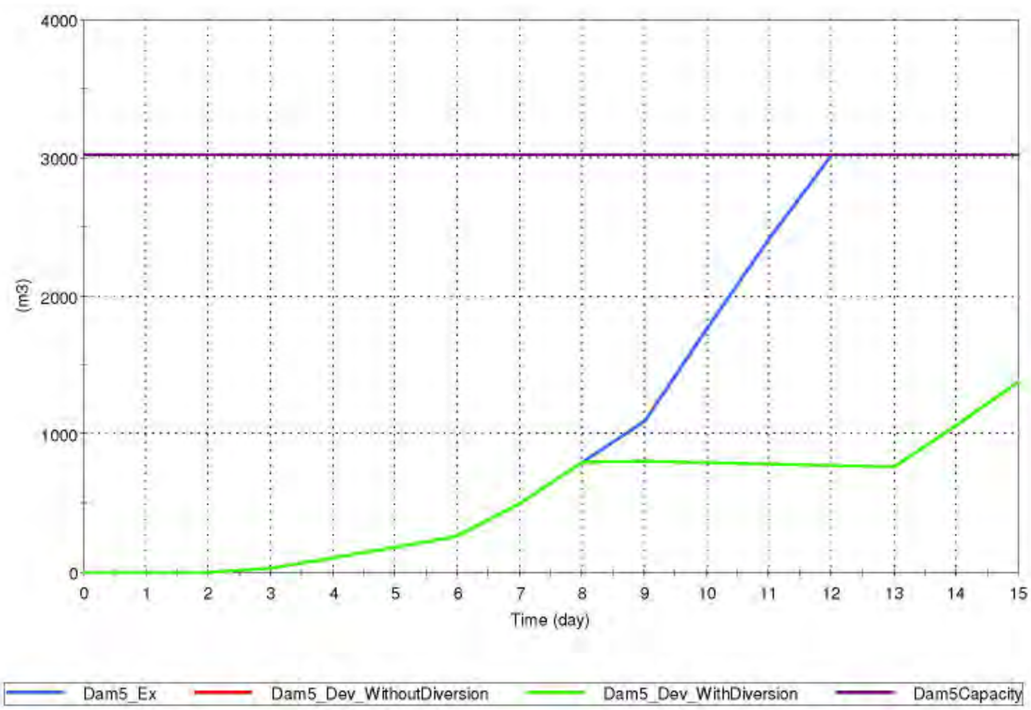


Figure 4.6: Dam 5 storage volume during a 5 day 90% event – Dam 5 storage capacity – 3020m^3

Dam 6

Expansion of the quarry to the final landform resulting in the exhaustion of all useable material in Cells A-I, will result in the reduction of Dam 6's catchment. Figure 4.7 below shows the effect of this change on operation of Dam 6.

The ponded water volumes and discharges for Dam 6 remain the same for both the 'with diversion' and 'without diversion' scenarios.

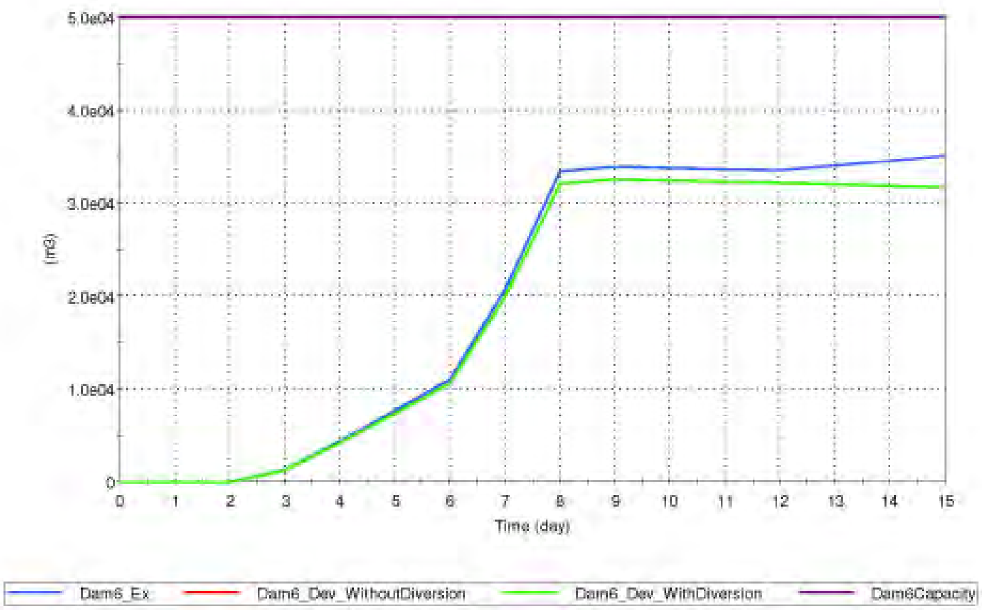


Figure 4.7: Dam 6 volume during a 5 day 90% event. Dam 6 storage capacity – 50000m^3

4.3.2 10 YEAR SIMULATION

Results Summary

For the given 10 year critical period (1979-1989) it was found that the developed 'with diversion' scenario performed similar to the existing condition with a similar number of discharges for the undisturbed areas (Dam 1) and no overflows from the quarry.

Dam 1

The variation of the water depth in Dam 1 during the critical 10 years of simulation is shown below in Figure 4.8.

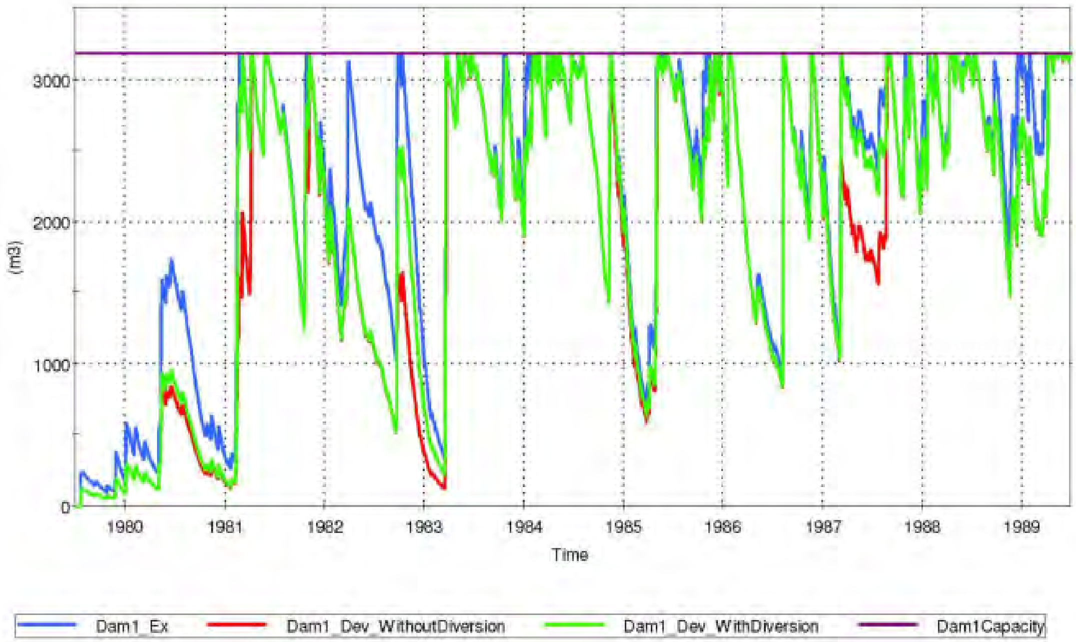


Figure 4.8: Dam 1 storage volume - critical 10 year period. Storage capacity 3180m^3

As shown above, Dam 1 overflows as soon as the storage volume reaches its maximum capacity of 3180m^3. It also shows that a range of overflows (2-8 per year) occur for Dam 1 into Thompsons Creek over the 10 year period. This frequency of overflows is deemed acceptable as the water quality in Dam 1 will be of a quality that will not adversely impact Thompsons Creek as follows:

- The inflow to the dam is sourced from undisturbed areas off and on the site.
- A grassed swale; which provides treatment of the runoff (sediment reduction, and nutrient loading) will be included in the bund which conveys flow from the western catchment to Dam 7 and ultimately Dam 1.
- The proposed Dam 7 will also provide additional de-sedimentation of the runoff via attenuation of the flows.

Figure 4.8 also shows that by the addition of Dam 7 as an attenuating storage, the stormwater management system, under the 'with diversion' scenario, will maintain the frequency of Dam 1 overtopping as per the existing condition.

Quarry Pit

Figure 4.9 shows the variation of the water level in quarry pit over the 10 year critical period based on a pumping strategy for both the existing and developed condition. The figure shows that during the entire 10 year period no overflow from quarry pit will occur. The water levels for the selected "with diversion" option are slightly higher than the existing condition.

The developed condition results are based on the worst case scenario with expansion of the quarry to all cells ('A' to 'I') and limiting the ponding area to a condition with very limited increase of storage capacity at the quarry pit i.e. cell A only.

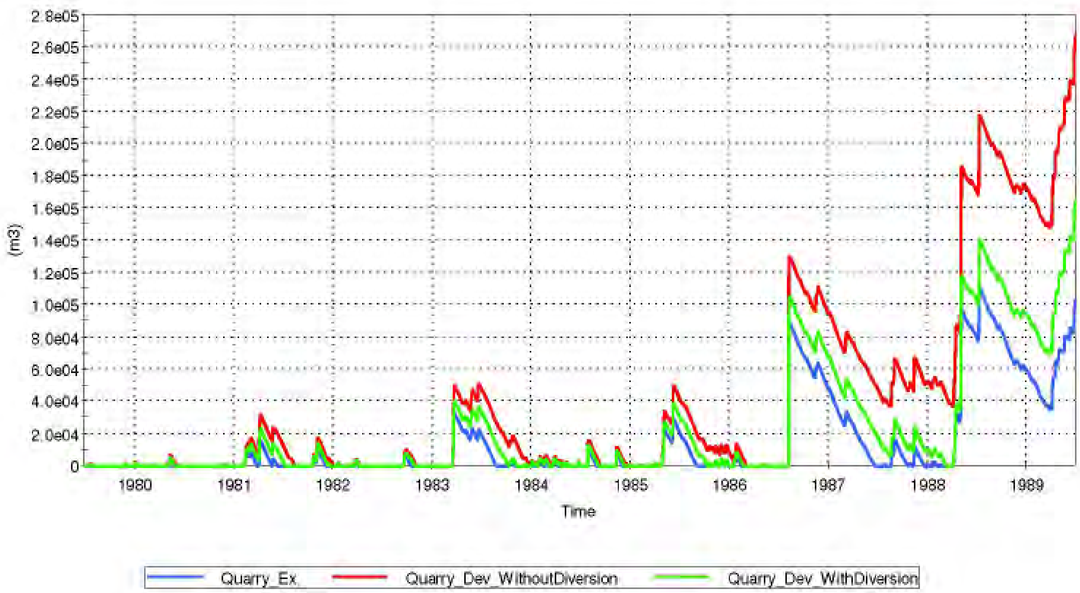


Figure 4.9: Quarry Pit Storage Volume during the selected 10 year period
Dam 3 storage capacities - existing is 346,100m^3, developed is 381,500m^3

5 PROPOSED STORMWATER MANAGEMENT STRATEGY

5.1 STRATEGY

5.1.1 SUMMARY

The proposed development will result in an increase of disturbed area and changes to the existing catchments. This will in turn cause higher volumes of runoff into the quarry pit. However, through expansion of the quarry, the utilisation of redundant voids will present opportunities for capture and retention of increased runoff volumes.

Two diversions are recommended. This first will be located along the western boundary of the project site's catchment area, and will divert flow into the proposed additional on-site storage (1300m^3 capacity). This additional storage, called Dam 7, will be located on the northern boundary of the project site. The second diversion will connect Dam 7 with Dam 1, which will prevent additional flow to Bardwell gully, preventing any new flooding to the area.

These changes and water quality treatment measures (such as swales, gross pollutant traps, sedimentation basins (dams) etc.) will be applied to ensure no adverse impacts will occur from the proposed development and therefore maintain conformance with current requirements established under the EPL.

The above mitigation measures for the impacts caused by the 'with diversion' scenario will require changes to the current surface water management plan. The proposed changes to surface water management for the project site are discussed below in Sections 5.2-5.6 and include three key components:

- stormwater runoff - clean water (roofs), dirty water (hard-standing and disturbed catchments);
- site sedimentation, and
- effluent from the site's wastewater treatment plant.

5.2 BUILDINGS AND HARD STANDING AREAS

Extensions to the brick manufacturing buildings have been proposed to provide more brick production capacity. These extensions will be constructed within the existing brick depot area, resulting in no increase to total on-site hard stand areas. As the surface areas have not changed, there will be no change in the overall runoff coefficient and therefore no increase in runoff for the site.

As per the existing SMP plan, runoff from the roofs will be collected via guttering and downpipes, which will then be carried via stormwater pipes and drains to the discharge point at Thompsons Creek. Runoff from the car park and storage area drains to the effluent irrigation area and Dam 4. The flow to the irrigation area is absorbed and settled in this area, with no off-site discharge. The other flows reach Dam 4 which are either re-used or discharged further to Dam 6. Based on the proposed increase to the roof area, runoff to the creek may increase slightly and the discharge to the effluent irrigation area may reduce at the same rate.

As a part of the proposed development, the existing drainage system of the site's internal roads, paved areas, car park and brick storage area will be inspected, and the water quality treatment measures discussed in the existing SMP adopted for the updated SMP. These treatment measures may include, but not be limited to, installation of trash collectors and oil traps as well as repair and maintenance of the open and closed drains including kerb and gutters and drain pipes.

5.3 UNDISTURBED AREAS OF THE SITE

5.3.1 DAM 2

Dam 2 is located inside cell 'D'. Consequently, with the commencement of the campaign that includes the excavation of this cell, Dam 2 will be removed. As such, part of the Dam 2 catchment located inside the quarry will discharge to the quarry pit. Part of Dam 2's catchment will be discharged directly to Dam 1, with the rest, including the manufacturing area, flowing to Dam 4, (see Figure 3.4).

For the developed condition, water quality treatment and control measures for Dams 4, 5 and 6 are recommended and will mitigate any adverse water quality impacts caused from the removal of Dam 2.

5.3.2 DAM 1 AND DAM 7

The proposed 'with diversion' scenario, as discussed in Section 3.3 will divert flows from the 7.4 ha catchment to the west of the site into Dam 1. This diversion will prevent flows from this undisturbed catchment to flow over the disturbed quarry area, and maintain better water quality. Due to the diversion, the capacity of Dam 1 will no longer be sufficient to contain the flows from the increased catchment. Therefore, as shown in Figure 3.4, Dam 7 (with the storage capacity of $1300m^3$) will be constructed at the outlet point of the diversion channel upstream of Dam 1. Hence, when full, Dam 7 will overflow via this diversion into Dam 1.

It is proposed that a water quality measure such as a grassed swale be constructed within the north-western area of the property as a part of the flow diversion. The proposed swale specification is given in Table 5.1 below. In addition, Dam 7 will serve as a sedimentation pond and as such no adverse impact to the quality of discharged water from Dam 1 to Thompsons Creek is anticipated.

Table 5.1: Proposed grass swale specifications for diversion of external catchment flows to Dam 1- developed "with diversion" condition.

Base Width	Top Width	Depth	Average Slope
1m	4m	0.5m	0.04

5.4 DISTURBED AREAS OF THE SITE

5.4.1 QUARRY

Runoff from the quarry and clay stockpile area will contain sediment and have a high level of salinity. As per the existing operation, this water will be retained in the quarry area and pumped to Dam 6 via Dams 4 and 5 for gradual mixing with Thompsons Creek flows. It is recommended that Dams 4 and 5 remain reasonably empty, relying on Dam 6's volume for dilution. This will provide a buffer for the next storm event which will be attenuated in the empty Dams 4 and 5.

As cell 'A' within the quarry is excavated to its final depth, the area will be dedicated to long term storage of captured flows. Therefore, as discussed in section 4 of the report, once cell 'A' is exhausted, the flow retention capacity at the quarry will be increased, enabling more control of the pumped discharge to Dam 6.

The water quality of the inflow and outflow to Dam 6 will be measured and compared based on a water sampling and monitoring program.

5.4.2 QUARRY EXPANSION REQUIREMENTS

The clay material required for brick production will be excavated during three distinct campaigns, lasting a total of 45 days per year, and will be stored in raw material stockpiling areas to the south of the crusher building.

The proposed quarry foot print will cover the current allocated areas for the overburden material stockpiling. Most of this material will be used for construction of the noise bund before the quarry is extended. With the commencement of material extraction at cells C, F and D which are the current overburden stockpiling locations, new areas may be allocated to provide the stockpiling requirements for the project site. It is a requirement that the stockpile areas remain inside the quarry catchment so the runoff over the stockpiled material discharges to the quarry pit.

Based on the current topography some parts of the proposed extended quarry will flow to discharge points other than quarry pit. For example, then southern part of cell 'I' flows to Dam 6 and the eastern part of cell 'G' flows to Dam 4. During excavation of raw materials from these stages, consideration should be given to the direction of overland flow from the excavated surface.

To ensure that this occurs for all instances during the current proposed life of the quarry, excavation of the cells should be started from the side closer to quarry pit and gradually proceed to the outer boundary of the quarry. The natural surface of the areas which are not sloping toward quarry pit should not be disturbed during the excavation of other parts of the quarry.

5.4.3 ONSITE WATER RE-USE

It is recommended that opportunities for water re-use from the quarry pit and Dams 4 and 5 be adopted to reduce flocculation volumes and discharges from the site to Dam 6 and ultimately Thompsons Creek. Water reuse opportunities may include activities such as dust suppression, irrigation of noise bunds and fire hazard reduction by prevention of dry grass build up. This will also reduce the amount of water reticulation usage on site, providing cost savings.

5.5 SITE SOIL LOSS AND SEDIMENTATION

The sediment inflow to the current and proposed dams was calculated using the NSW guideline 'Managing Urban Stormwater - Soils and Construction, 1998'. Based on section 5.4 of Volume 2A of the guideline, provision of a sedimentation basin is recommended for projects disturbing more than 2500m^2 of land.

All runoff from the excavated areas and stockpiling areas will flow into the quarry pit to settle before discharging to Thompsons Creek via Dams 4, 5 and 6. Therefore, there is no requirement for the development of any new sedimentation basins for the disturbed areas. As the total disturbed area for the proposed quarry footprint has increased, the sedimentation levels have been re-calculated.

The volume of eroded material from the quarry catchment can be calculated from Revised Universal Soil Loss Equation (RUSLE).

A= R.K.LS.P.C

In the above equation 'A' is the erodible soil per hectare per year with the required parameters, based on site conditions, defined as:

R= 2400 ***Rainfall erosivity factor***

K= 0.05 ***Soil erodibility factor***

LS= 3.1 ***Slope length. Gradient factor***

P= 1.3 ***erosion control practice factor***

C= 0.5 ***ground cover and management factor***

Based on this calculation, the estimated volume reduction to the sites quarry dam is 242 tonnes/ha/year. As quarrying operations progress through the life of the project, the size of the quarry dam will increase. While this increase in sedimentation will have a minimal impact on the overall water storage capacity, it has been included in the water balance model to ensure storage sizes have not been impacted.

Additionally, the trap efficiency of the quarry dam is directly dependent on the detention time for the captured runoff before it is pumped to Dam 4. It is anticipated that with a provision of a two day gap between the end of the each rainfall event and start of pumping, approximately 95% of the sediment will be retained in the quarry pond. To this end, the pump inlet hose should be permanently located at the deepest part of the quarry dam, with adequate distance from the base of the dam.

5.6 SEWAGE DISPOSAL

With an increase in the site's brick production rate, the number of the staff based at the project site will also increase from 38 to 72 people. Therefore, using an industry standard of 100L/person/day, the amount of sewerage produced will grow from 3,800 L/day to 7,200 L/day.

Based on this it is recommended that the sewage treatment plant be upgraded/replaced to accommodate the increased volume of effluent. Additionally, the current discharge licence for irrigation should be amended to allow for 7,200L/day and an irrigable area of 0.5ha.

6 CONCLUSIONS AND RECOMMENDATIONS

Boral Bricks Pty Ltd is proposing to expand their quarry and to increase brick production to 263,500 tpa at Bringelly, NSW. The current SMP was reviewed and a revised site water balance was developed to reflect potential modifications associated with the proposed project. A number of changes to the current stormwater management plan have been identified to ensure that the site's existing EPL conditions will be complied with as a result of this proposal. This report and its recommendations accompany the EIS for the project and should be considered along with the other technical reports, including the water monitoring program and groundwater assessment.

The outcomes of this stormwater management report are summarised below:

- Dam 2 will be removed and its catchment will be diverted to Dam 4 and quarry pit.
- Runoff from the external catchment to the west of the site will be diverted to Dam 1 via a new on-site storage pond called Dam 7. The required volume of Dam 7 is 1300m^3 and will result in the reduction of the runoff to the quarry area, further reducing the discharge volume of sediment laden saline water. A swale will be constructed along the quarry north-western area of the property at the western side of the site for flow diversion to Dam 1.
- The current drainage system of the site will need to be inspected during construction of the proposed building extensions, with water quality treatment devices such as oil traps and trash collectors added to the existing system.
- Increase the sewage treatment plant capacity (via upgrade or replacement) to 7,200L/d and increase the irrigable area from 0.25ha to 0.5ha area if on-site re-use is adopted.

Adoption of the above measures into the revised SMP will ensure that the project site meets all of the required existing EPL conditions.

7 REFERENCES

- AECOM (June 2011), 'Boral Badgerys Creek- Continued Operation of Quarry and Brick Making Facility'
- Australian Water Balance Model handbook, 2001, CRC for Hydrology
- Bureau of Meteorology, Gauging Station #067019
- Department of Environment & Climate Change NSW (January 2008), 'managing Urban Stormwater- Soils and Construction'
- Environmental Impact Statement (EIS) for the upgrading of the Bringelly Brick Quarry and manufacturing plant (1991)
- ERM (October 2002), 'Bringelly Brickworks and Quarry- Stormwater Management Plan'
- GoldSim User's Manual Version 10.5 2013
- Resources Planning Pty Ltd (August 1993), ' Stormwater Management Plan for Bringelly Brick'

APPENDIX J

GROUNDWATER ASSESSMENT

REPORT

Sept 2013

BORAL BRINGELLY BRICKWORKS EXPANSION PROJECT

Groundwater Impact Assessment

Submitted to:
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Boral Property Group
Lot 107, Clunies Ross Street
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Report Number. 137626001-005-R-Rev1

Distribution:

Boral Property Group: one electronic copy
Golder Associates: one copy (on file)

Golder Associates

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Company	Client Contact	Version	Date Issued	Method of Delivery
Boral Limited	Kate Jackson	RevA	03 July 2013	Via email
Boral Limited	Kate Jackson	Rev0	26 July 2013	Via email
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APPENDICES

1.0 INTRODUCTION

Golder Associates Pty Limited (Golder) was commissioned by Boral Limited (Boral) to carry out a groundwater impact assessment (GWIA) study for the proposed Boral Bringelly Brickworks expansion project in New South Wales (NSW) (the Project). The Boral Brickworks is located on Lot 11 in DP 1125892 comprising an area of approximately 386 hectares. The northern part of the property (the Project site) is currently occupied by a clay quarry and brick manufacturing plant and is owned by Boral Limited. The project site is approximately 56.75 hectares in area. It is located within the Camden Local Government Area and is approximately 55 kilometres southwest of the Sydney Central Business District, NSW. Figure 1 and Figure 2 show the regional context of the site and the Project site location, respectively. The quarry is currently only mined for approximately six to eight weeks of the year.

The proposed expansion project will involve the following:

1) An increase in production from 160,000 to 263,000 tonnes per annum of brick product

2) An increase in extraction area that will provide a resource of greater than five million tonnes and an operational increase in quarry production from 120,000 tonnes per annum to 200,000 tonnes per annum

3) Re-alignment of internal access road from Greendale Road

4) The installation and construction of acoustical mitigation measures

5) Building works to the Brick Manufacturing Plan.

The proposed quarry will extend northwards, southwards and south-westwards. Three, ten-year stages were planned over the 30-year quarry life. Extraction of raw material from the quarry will be undertaken in three stages across nine cells (from cell A to cell I) (refer to Figure 2). An open pit approximately 30.65 hectares in extent and approximately 30 m deep will remain following the cessation of quarry operations.

This groundwater impact assessment was prepared to meet the requirements of the Director General (DG) for the project Environmental Impact Statement (EIS) (refer to Table 1 for the DG requirements and the related sections of this GWIA report).

The objective of the groundwater impact assessment is to ascertain the potential impacts the proposed quarry extension would have on groundwater resources in the area as a result of the expansion and to recommend the management/mitigation measures.

This report considers the groundwater component of the Project only. Details related to proposed quarry activities and layout plan, stormwater management, heritage, waste, hazards and the rehabilitation plan are referred to in the main EIS report and the related EIS appendices.

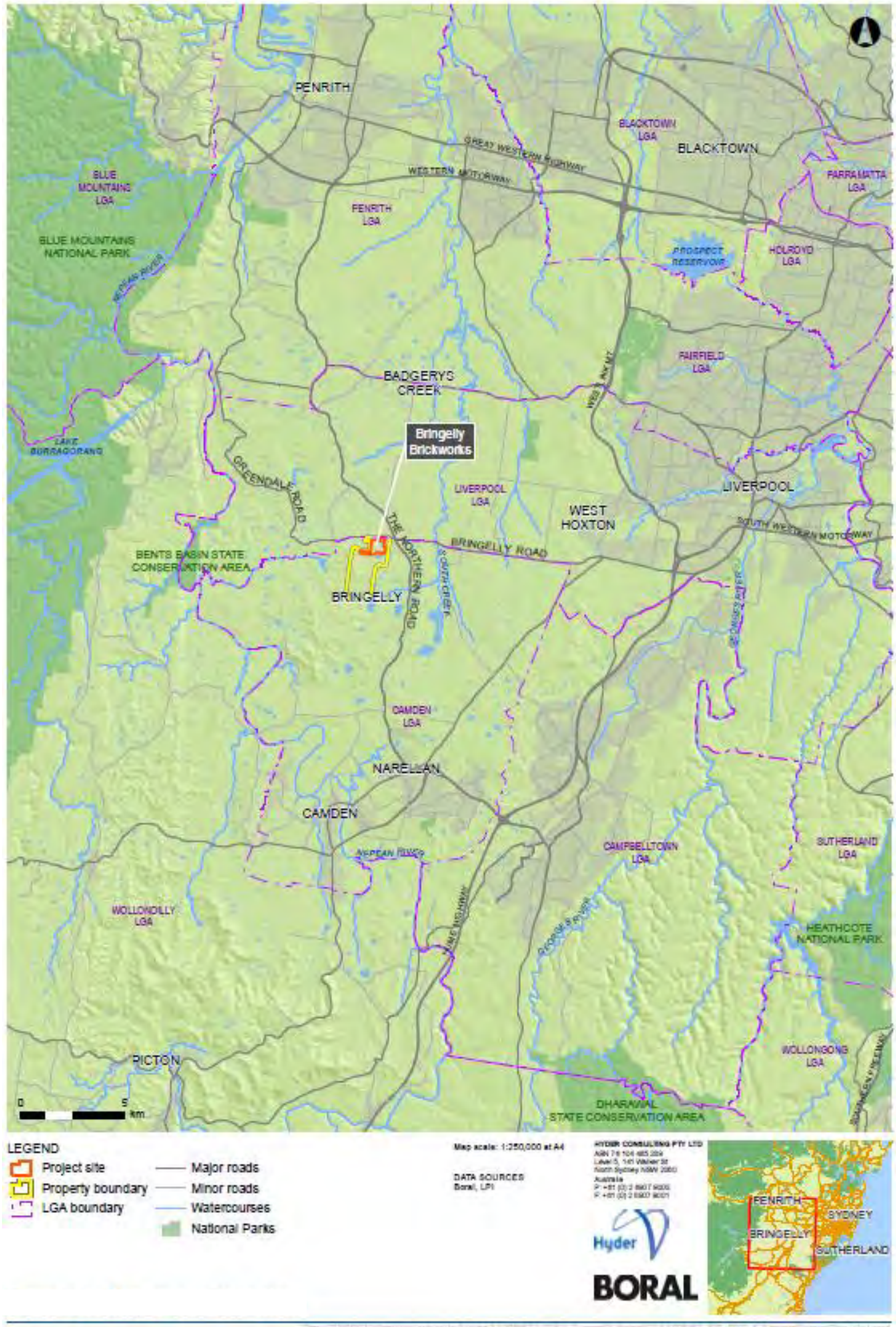
The GWIA is presented in the following format:

- Section 1.0 ï Introduction
- Section 2.0 ï Methodology
- Section 3.0 ï Legislative framework
- Section 4.0 ï Existing environment
- Section 5.0 ï Hydrogeological Modelling
- Section 6.0 ï Groundwater Impact Assessment including management/mitigation measures and recommendations
- Section 7.0 ï Licensing requirements

- Section 9.0 ï Limitations
- Section 10.0 ï References
- Section 11.0 ï Acronyms and glossary of terms used in the report

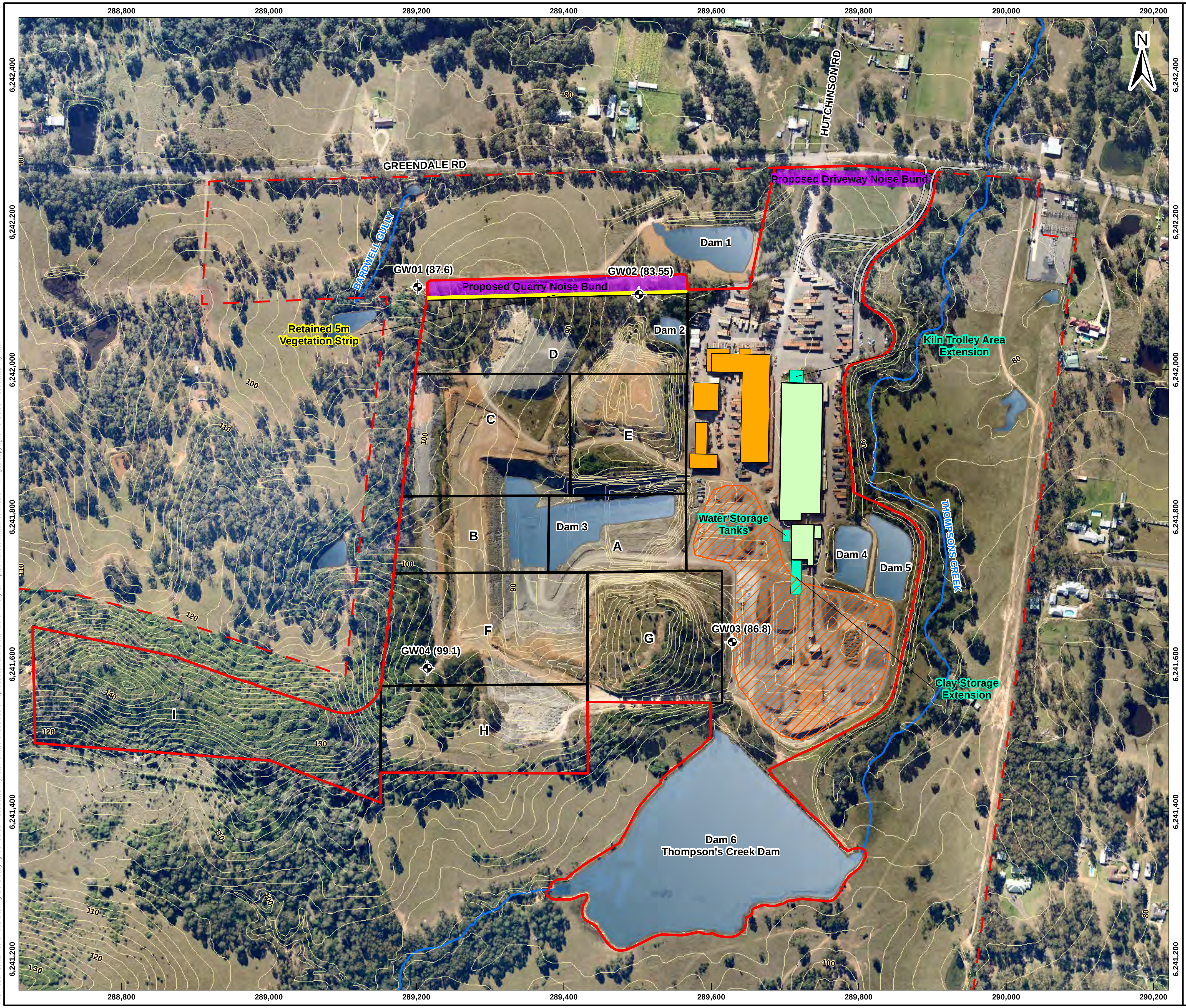
Supporting documents are included in the following appendices:

- Appendix A ï Risk Assessment Process and Results
- Appendix B ï Water Sharing Plan - Rules for the Sydney Basin Central Groundwater Source
- Appendix C ï Bore logs and monitoring bore construction details (GW01 to GW04)
- Appendix D ï Groundwater quality - Laboratory analysis results
- Appendix E ï Limitations



Source: Hyder Consulting EIS report (2013)

Figure 1: Regional context plan (not to scale)



BORAL BRINGELLY GROUNDWATER ASSESSMENT

BORAL LIMITED

SITE PLAN

LEGEND

- GW01 (87.6) Standpipe Piezometer (mAHD)
- Proposed Site Access
- Surface Elevation Contour - 2m Interval
- Watercourse
- Property Boundary (2/733115)
- Project Site
- Quarry Extraction Cell
- Raw Materials Storage
- Brick Making Facility
- Material Storage Facility
- Water Body

NOTES

1. Base data supplied by Boral Limited.
2. Imagery dated 18 May 2013.

COPYRIGHT

1. Imagery copyright Nearmap.
2. Inset Map Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

0 25 50 100 150 200 metres

SCALE (at A3) **1:5,000**

DATUM GDA 94, PROJECTION MGA Zone 56

PROJECT:	137626001
DATE:	30 AUG 2013
DRAWN:	SL
CHECKED:	DB

FIGURE 2

Golder Associates

Table 1: Director General Requirements

Groundwater-related Requirements		**Section of this GWIA report**
DGRs (9 January 2013)		
b) Description of the receiving groundwater	DGRs Attachment A Water Quality page 3	Section 4, Existing Environment
d) Describe the nature and degree of any likely impacts that the proposed project may have on the receiving environment. This should include a characterisation of potential water pollutants at the site and any associated mitigation and management measures	Attachment A Water Quality page 3	Section 6, Groundwater impact assessment
The environmental outcome for the project should ensure there is no pollution of waters (groundwater) except in accordance with an EPL	Attachment A Water Quality page 3	Section 6.4, Management and mitigation measures
Guidelines, policies, legislative framework	Attachment B ï Guidance Material	Section 3, Legislative framework
NSW Department of Primary Industries (21 December 2012)		
Assessment of potential impact to the water quality on Thompsons Creek	page 1, Comments by Fisheries NSW	Section 6, Groundwater impact assessment
An assessment of potential impacts of the proposal on watercourses, riparian areas, wetlands, groundwater and groundwater dependent ecosystems	page 2, Comments by NSW Office of Water	Section 6, Groundwater impact assessment
Adequate mitigating and monitoring requirements to address impacts	page 2, Comments by NSW Office of Water	Section 6.4, Management and mitigation measures
The EIS should take into account the objects and regulatory requirements of the Water Act 1912 and Water Management Act 2000, Water Sharing Plans, relevant Policies	Attachment A ï Detailed requirements by NSW Office of Water	Section 3, Legislative framework
Licensing Considerations	Attachment A ï Detailed requirements by NSW Office of Water	Section 7, Licensing Requirements

Groundwater-related Requirements		Section of this GWIA report
The EIS needs to provide adequate details to assess the potential impacts of the projects on all groundwater resources including: ■ the predicted highest groundwater table at the site ■ any works likely to intercept, connect with or infiltrate the groundwater sources ■ any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes ■ a description of the flow directions and rates and physical and chemical characteristics of the groundwater source ■ the predicted impacts of any final landform on the groundwater regime ■ the existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts ■ an assessment of the quality of the groundwater for the local groundwater catchment ■ an assessment of groundwater contamination ■ how the proposed development will not potentially diminish the current quality of groundwater, both in the short and long term ■ measures for preventing groundwater pollution so that remediation is not required ■ protective measures for any groundwater dependent ecosystems (GDEs) ■ results of any models or predictive tools used	Attachment A ï Detailed requirements by NSW Office of Water	Section 4, Existing environment Section 5, Groundwater modelling Section 6, Groundwater impact assessment
Where potential impacts are identified the assessment will need to identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependent groundwater environment or water users	Attachment A ï Detailed requirements by NSW Office of Water	Section 6, Groundwater impact assessment

2.0 METHODOLOGY

This section presents the methodology used in this study in relation to the legislative framework, data review, predictive groundwater modelling and groundwater impact assessment approach.

2.1 Legislative Framework

Legislation and regulation requires mining projects to manage the development activities in an environmentally sustainable manner. The key legislations and policies applicable to groundwater issues related to the Project are identified and summarised in this section.

- Identify whether the Project is located in a Groundwater Management Area or any other regulated water resource management areas
- Review legislations and policies that are related to the Project, with special consideration to:
  - the NSW Aquifer Interference Policy (2012)
  - identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000
  - an assessment of proposed water discharge quantity and quality against receiving water quality and flow.

2.2 Data review and collation

An understanding of the controlling factors for the behaviour of groundwater has been developed from a review of the Site Characteristics data. Data obtained from Boral and Hyder was supplemented by readily obtainable public data, literature review and previous studies, as summarised in Table 2. Climatic, geological, hydrogeological, environmental value, groundwater vulnerability, and existing registered groundwater user data were reviewed. The available hydrogeological information was collated and information in relation to aquifer properties (hydraulic conductivity), groundwater levels and groundwater quality are presented in this report. Golder has previously worked with Boral on a hydrogeological field program and a preliminary data review and assessment for the Boral Bringelly Brickworks Expansion Project

Table 2: List of data sighted

Data	Source	Notes
Bore names, locations, construction information and hydrogeological information	Golder Associates	Boral Bringelly Groundwater Assessment Factual Report (137626001-004-R-Rev0)
Bores names & locations, bore hydrogeological information	R W Corkery & Co Pty Ltd (1984); Resource Planning Pty Ltd (1993)	
Registered groundwater bore use, licensing	New South Wales Department of Primary Industries Office of Water website; New South Wales Natural Resource Atlas	http://realtimedata.water.nsw.gov.au/water.stm?ppbm=GROUND_WATER&gw&3&gwkm_url
Maps and images	Hyder Consulting; Resource Planning Pty Ltd (1993); Bing maps; New South Wales Natural Resource Atlas; NSW Government, Trade and Investment Resource and Energy,	Satellite images/aerial photos; Topography; Geological maps
Planning development	Hyder Consulting / Boral	
Regulatory / Licences	New South Wales Department of Primary Industries Office of Water; New South Wales Government, NSW Legislation	Legislative framework
Groundwater Dependent Ecosystems	Bureau of Meteorology	http://www.bom.gov.au/water/groundwater/gde

Data	Source	Notes
Groundwater vulnerability map	New South Wales Natural Resource Atlas	Groundwater vulnerability map
Water Sharing Plan	New South Wales Department of Primary Industries Office of Water	http://www.water.nsw.gov.au/Water-management/
Water quality data	Golder Associates	Boral Bringelly Groundwater Assessment Factual Report (137626001-004-R-Rev0)
Weather data	Bureau of Meteorology	http:// www.bom.gov.au/
Surface water, biodiversity, rehabilitation, hazard, waste	Hyder Consulting; Boral Limited	Technical sections of the Project EIS

2.3 Predictive groundwater modelling

Hydrogeological modelling of the Project area supports the understanding of potential impacts of the Project.

Following baseline data characterisation, various datasets (climatic, geological, and hydrogeological including groundwater levels and water quality, hydraulic parameters) were used in the development of a hydrogeological conceptual model to describe the controlling factors in groundwater flow and occurrence in the project area.

The conceptual model presents our interpretation of the hydrogeology of the project area including hydrostratigraphic units, aquifer connectivity, recharge and discharge, groundwater levels, hydraulic parameters and groundwater quality. The conceptual model forms a basis for the analytical groundwater model. Total groundwater inflows to the final quarry pit during the Project are estimated using analytical means. The anticipated groundwater flow to the quarry pit was estimated using AnAqSim [Analytic Aquifer Simulator] software, which allows for three-dimensional representation of the hydrogeological system. AnAqSim utilises the analytic element method (AEM), which superposes analytic solutions to yield a composite solution consisting of equations for head and discharge as functions of location and time.

2.4 Groundwater impact assessment methodology

The potential groundwater impacts and risks as a result of the Project are assessed using a risk-based framework. The risk-based approach allows the potential groundwater related risks associated with proposed mining activities to be considered and classified with respect to multiple evaluation criteria, such that the primary risk-driving activities are identified, prioritised and mitigated accordingly. The risk assessment process is summarised in Appendix A of this report.

The magnitude of an impact on groundwater resources was estimated considering the severity of the impact, the extent and duration of the impact. The categories of the sensitivity of the environmental values of groundwater resources were classified based on the groundwater quality and quantity, the size of aquifer, and the groundwater vulnerability. The significance of the groundwater impacts was assessed based on the magnitude of the impact and the sensitivity of resource/receptor. Impact Significance Assessment Results of the groundwater impact assessment were then used in the risk assessment. Descriptions for rating the sensitivity of the receptors and magnitude of impact on groundwater resources are presented in Appendix A.

The Groundwater Water Impact Assessment (GWIA) establishes a reasonable understanding of the groundwater system upon which to evaluate potential impacts from Project operations on groundwater resources within and around the Project site. Its purpose is also to identify the site environmental values and the necessary management/mitigation measures and groundwater monitoring strategy to manage impacts.

3.0 LEGISLATIVE FRAMEWORK

This section shows the water management areas, Water Sharing Plan, groundwater sources and water sources plan that are applicable to the Project and the legislation and policy that are relevant to the Project.

3.1 Groundwater Management Areas

Water management areas, Water Sharing Plan, groundwater sources and water sources plan that are applicable to the Project were identified based on the current information from NSW Department of Primary Industries Office of Water (website was accessed in June 2013).

The Project site is located within the ‘Hawkesbury Nepean Water Management Area’ (refer to Figure 3).

Source: http://www.water.nsw.gov.au/Water-management/Water-sharing-plans

Figure 3: Hawkesbury Nepean groundwater management area

The Water Sharing Plan for the *Greater Metropolitan Region Groundwater Sources* applies to the Project. The *Greater Metropolitan Region Groundwater Sources* plan was made on 2 March 2011 and commenced on 1 July 2011. This water sharing plan is due for extension/replacement in July 2021. Figure 4 shows the groundwater sources and management zones within the *Greater Metropolitan Region Groundwater Sources*.

The Project site is located within the ‘*Sydney Basin Central Groundwater Source*’. Appendix B shows a summary of the rules for the *Sydney Basin Central Groundwater Source* including the access rules, managing water allocation accounts, managing access licenses, rules for granting and amending water supply works approvals, rules for the use of water supply works approvals, limits to the availability of water and trading rules.

The Project site is located within the *Greater Metropolitan Region Unregulated River Water Sources Plan 2011* (refer to Section 7.6 Surface Water of the EIS for further information).

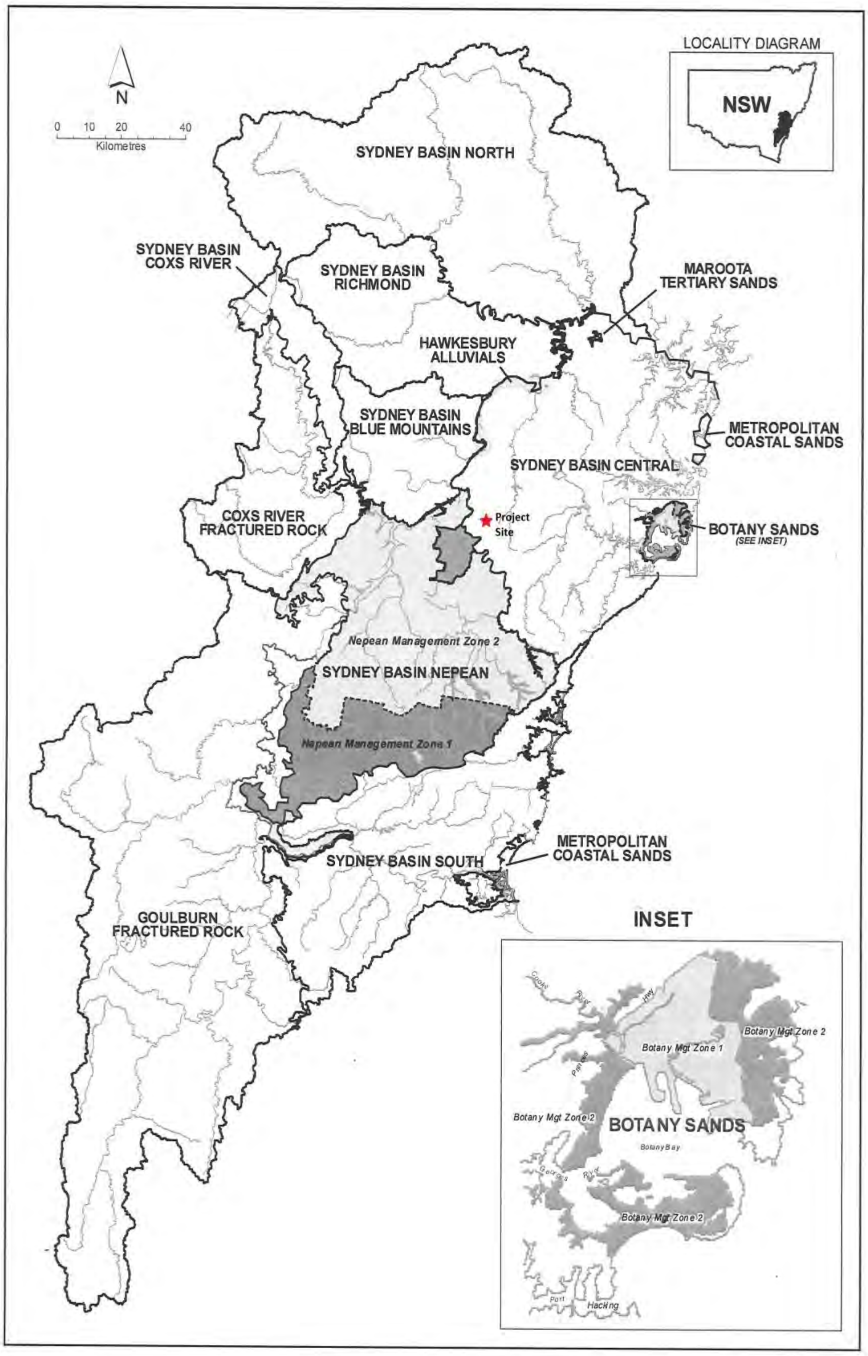


Figure 4: Groundwater sources and management zones within the Greater Metropolitan Region Groundwater Sources (NSW Office of Water, July 2011)

3.2 Legislative framework

The key legislations applicable to groundwater issues related to the Project are listed below.

- Commonwealth Water Legislation:
  - *Environment Protection and Biodiversity Conservation Act 1999;*

- Water Legislation in NSW:
  - *Water Management Act 200*0
  - *Water Act 1912*
  - *Environmental Planning and Assessment Act 1979* (EP&A Act)
- NSW State Groundwater Related Policies:
  - "NSW Groundwater Policy Framework Document – General"
  - "NSW Groundwater Quality Protection Policy", 1998
  - "NSW Groundwater Dependant Ecosystem Policy", 2002
  - 'Aquifer Interference Policy', 2012
- Water Licensing Requirements
- Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

Table 3: Legislation and policies applicable to the extraction and management of groundwater in the Project site

Legislation and Policy	Area of Application
Commonwealth Legislation *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*	Provides the regulatory framework for Matters of National Environmental Significance (MNES). Projects that have an impact on MNES require concurrent approval under the Commonwealth Environment Protection Biodiversity Conservation Act 1999 (EPBC Act). The ecological assessment for the Project includes an assessment of potential impacts on matters of national significance. This assessment concluded that the Project is not likely to have a significant impact on a MNES.
NSW *Environmental Planning and Assessment Act 1979*	The *Environmental Planning and Assessment Act 1979* (EP&A Act) regulates all development in NSW including the Project, which is to be assessed as a transitional Part 3A Project in accordance with the EP&A Act. DP&I issued DGRs for the Project on 21 December 2012.
NSW *Water Management Act 2000* – Project-related Water Sharing Plans (WSP)	*Water Management Act 2000* provisions for developing water sharing plans and licensing water extractions operate independently of the Basin Plan. The commenced WSP that is relevant to the Project is the *Greater Metropolitan Region Groundwater Sources 2011* and the *Greater Metropolitan Region Unregulated River Water Sources Plan* that commenced on 1 July 2011. Water supply for Project is covered under the applicable WSPs. The design and construction of the Bringelly quarry and brickmaking facility expansion will align with the objectives of the WMA and have consideration of the guidelines for controlled activities developed under the WMA to minimise impacts on water resources. Section 6 provides a detailed assessment of the potential impacts of the proposal on the local groundwater resources. The proposed expansion will not result in any significant impacts on downstream water users. Boral do not currently extract water from the Upper South Creek catchment and will not require a license to meet proposed water demands to support quarry expansion works. All current and on-site water demands will be met by a combination of potable water, on-site water and water imported from industrial recycling schemes; therefore, the proposed Project will operate in accordance with the requirements of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011.
NSW *Water Management Act 2000* - Water Access Licences (WALs)	The WMA 2000 establishes categories of water access licences (WALs). The category most relevant to the Project's activities is an aquifer WAL. Each year, "available water determinations" are made specifying the percentage of the "share component" that may be consumed for each licence category. These determinations will vary depending on environmental conditions such as recharge rates and changes in demands on water resources regulated by the WSP. The licensing regime under the WMA 2000 differs from the Water Act as licences are not tied to the land and water entitlements are therefore tradeable within a defined groundwater source.

Legislation and Policy	Area of Application
NSW *Water Act 1912*	The Water Act 1912 (Water Act) has a limited role in regulation of surface water and groundwater in NSW as it is currently being phased out and replaced by the WMA 2000. The Water Act applies only to water sources (rivers, lakes and groundwater aquifers) in NSW where a WSP (implemented in accordance with the WMA 2000) has not commenced. Water supply for the Study Area is covered under the relevant Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011; therefore, the Water Act 1912 does not apply to the Project.
NSW Groundwater Policy Framework Document ï General	The NSW State Groundwater Policy provides a direction on the ecologically sustainable management of NSW groundwater resources, including consideration of the beneficial use of aquifers for both now and in the future. In accordance with the NOW comments, an impact assessment of the Project activities upon adjacent licensed groundwater users, the riparian environment and groundwater-dependent ecosystems has been undertaken to meet the requirements of the NSW State Groundwater Policy in addition to the objects and principles of the Water Management Act 2000.
ôNSW Groundwater Quality Protection Policyö, 1998	The NSW Groundwater Quality Protection Policy (1998) is designed to protect groundwater resources against pollution. The groundwater quality observed within the Project site is saline and has been classified as unsuitable for potable use (either domestic, irrigation or for livestock watering) due to the elevated concentrations of sodium and chloride. There is the potential for spills and contamination by metals and hydrocarbons from the machinery, waste disposal, waste oil used in maintenance of equipments and fuel storage areas; however adequate bunding and immediate clean-up of spills which is standard practice and/or a legislated requirement at the Project site, should prevent contamination leakage to the groundwater system.
ôNSW Groundwater Dependent Ecosystems Policyö (2002)	The NSW Groundwater Dependent Ecosystems Policy (2002) provides guidance and how to protect and manage GDEs. The Groundwater Dependant Ecosystem Policy (2002) lists the following types of ecosystem in NSW: Terrestrial vegetation, Baseflow in streams (e.g. spring flow), Aquifer and cave ecosystems; and Wetlands. There is no ôhigh priorityö spring located within the Project site. It is inferred that baseflow occurs at South Creek which is located approximately 2.5 km to the east of the Project site.
ôNSW Aquifer Interference (AI) Policyö (2012)	The AI Policy applies to all aquifer interference activities including mining, extractive, coal seam gas, dewatering, water injection into aquifers and activities with the potential to impact groundwater quality or result in structural damage to an aquifer. The AI Policy provides definition of the groundwater impact assessments and management of groundwater associated with mining developments, and sets out a framework for assessing the impacts of aquifer interference activities on water resources.

4.0 EXISTING ENVIRONMENT

The development of the conceptual groundwater model and risk assessment requires an understanding of the Project site and the surrounding area. This section of the GWIA summarises information on topography, land use, drainage and surface water, climate, geology and hydrogeology within and in the vicinity of the Project site and provides our understanding of their importance to the dynamics of the groundwater system.

The site characterisation includes the assessment and summary of the following:

- Topography, surface water, climate and land use, and the relevance to this groundwater assessment
- The regional and local geology
- Regional hydrogeology
- Available results of local groundwater analysis (groundwater levels, hydraulic conductivities, groundwater quality)
- Environmental values.

4.1 Topography and land use

The Boral Bringelly site currently consists of a quarry, a brick manufacturing plant and various administrative and storage facilities. The surrounding topography varies from moderately undulated to hilly with a high density of low order streams to the southwest, to gently undulated with a lower density of streams to the east. The topography of the site is generally gently sloping to the south and east in the direction of Thompsons Creek.

The quarry area of the site has an elevated topography with the highest point towards the northwest corner at 113 m AHD. A constructed ridge runs along the western boundary north to south of the site which gently slopes downwards towards the east ï south east. The lowest point runs along the eastern side of the site and is characterised by Thompsons Creek.

The north-eastern area of the site is dominated by the brickworks, product stockyard, storage facilities and administration buildings. South of the brick manufacturing plant is a raw materials stockpile yard, adjacent to which lie settlement ponds Dams 4 and 5 (refer to Figure 2). The south-eastern area of the site next to Thompsons Creek is currently leased as farmland for livestock grazing.

The area surrounding the project site is predominantly used for agriculture to the west and south of the site with agricultural land with some rural residential development to the north and east. Significant land uses within close proximity of the project site include:

- Sydney University Farms Campus (5 km to the West)
- Bringelly Public School (c. 500 m to the East)
- Bringelly Retail Centre (c. 500 m to the Northeast)
- Bringelly Community Centre (c. 200 m to the East)
- Bringelly Park (c. 200 m to the Northeast)

In terms of future development, the site is located within the South West Growth Centre earmarked under the Draft Sydney Metropolitan Strategy for future residential development. The site itself has been identified as employment lands under the Greater Western Development Area.

4.2 Rainfall and evaporation

Climate affects groundwater occurrence and flow by influencing the intensity and distribution of rainfall and evaporation, both temporally and spatially. This influences the amount of water lost or gained to different parts of the water cycle by varying the amount going to surface runoff to rivers, infiltration to the ground, with parts lost by root uptake, as recharge to the water table or the portion lost to evaporation. An understanding of climatic effects is important to groundwater flow and occurrence.

Long-term climate data

The closest Bureau of Meteorology Station is Badgerys Creek (AWS – Station Number 067108, 33.90°S, 150.73°E), approximately four kilometres from the Project site. The historical climate data (1995-2013) indicate that on average, January is the hottest month of the year with a mean maximum temperature of 29.8°C and July is the coldest month of the year with a mean minimum temperature of 4.2°C. The historical climate data (1995-2013) indicate that on average, February is the wettest month of the year with a mean monthly total rainfall of 110 mm and July is the driest month of the year with a mean monthly total rainfall of 25.1 mm (refer to Table 4 and Figure 5). Total annual rainfall recorded at Badgerys Creek in 2012 was 903.4 mm. March was the highest rainfall month; with 198 mm recorded . August was the driest month, with 3.2 mm recorded.

The closest station with evaporation observations is at Prospect Reservoir (Station Number 067019, 33.82°S, 150.91°E), about 19 km to the northeast of Badgerys Creek station. Historical temperature and evaporation data (1965-2013) and rainfall data (1887-2013) at the Prospect Reservoir Station are shown in Table 4. The annual average evaporation recorded at Prospect Reservoir is 970 mm/year (refer to Figure 6).

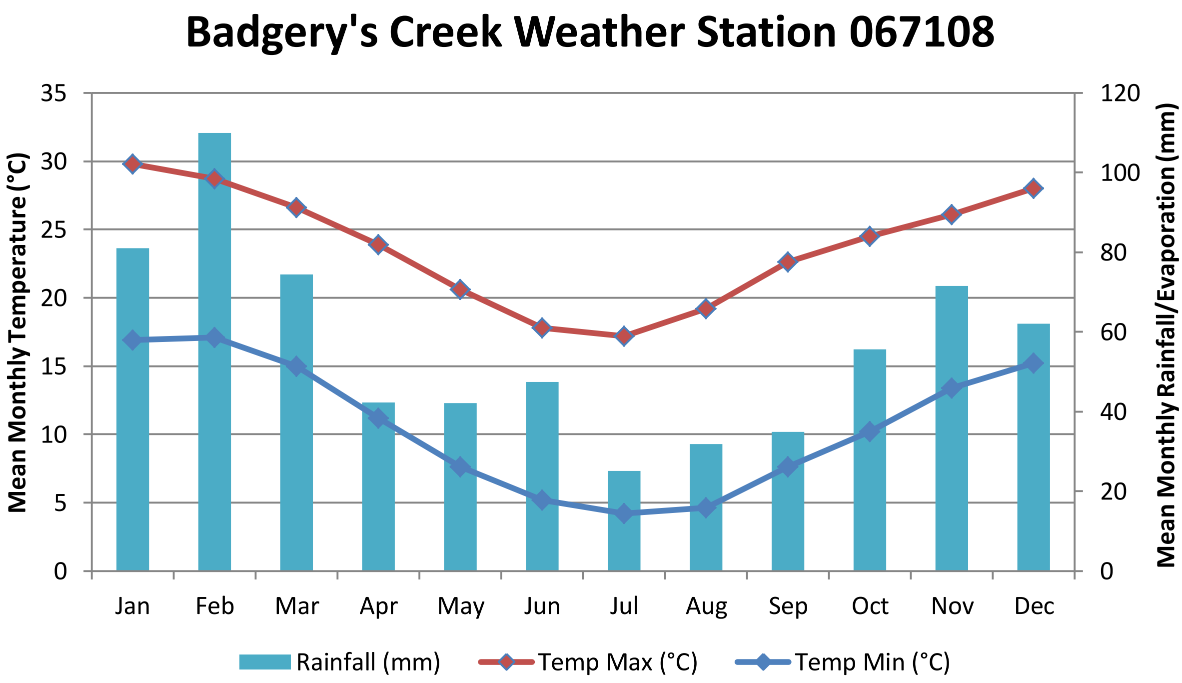
Table 4: Statistic climate data (temperature, rainfall and evaporation) for the Project site

Data	Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Monthly Max. Temp. (°C)	Badgerys Creek #067108	1995-2013	29.8	28.7	26.6	23.9	20.6	17.8	17.2	19.2	22.6	24.5	26.1	28	23.8
	Prospect Dam #067019	1965-2013	28.4	28	26.3	23.6	20.2	17.3	16.8	18.7	21.3	23.7	25.4	27.4	23.1
Mean Monthly Min. Temp. (°C)	Badgerys Creek #067108	1995-2013	16.9	17.1	15	11.2	7.6	5.2	4.2	4.6	7.6	10.2	13.4	15.2	10.7
	Prospect Dam #067019	1965-2013	17.7	17.8	16.1	13	9.9	7.4	6.1	6.8	9.4	12.1	14.3	16.3	12.2
Mean Monthly Rainfall (mm)	Badgerys Creek #067108	1995-2013	81	110	74.4	42.3	42.1	47.4	25.1	31.8	34.9	55.6	71.6	62	683
		2012	119.8	193.2	198	129.4	13	86.2	17.8	3.2	14.8	42.8	48.6	36.6	903.4
	Prospect Dam #067019	1887-2013	94.4	97.2	96.2	74.7	71.4	75.2	57	49.8	46.9	59.1	72.7	75.2	870.3
		2012	140.6	177.5	196.3	157.5	18.2	117.9	23	5.6	21	35.5	35.8	40.7	969.6
Mean Daily Evap. (mm)	Prospect Dam #067019	1965-2013	5.5	4.8	3.9	3	2	1.6	1.7	2.6	3.6	4.4	4.9	5.7	3.6
Extrapolated monthly mean Evap. (mm)	Prospect Dam #067019	1965-2013	170.5	135.6	120.9	90	62	48	52.7	80.6	108	136.4	147	176.7	170.5

Notes:

Temp.: Temperature

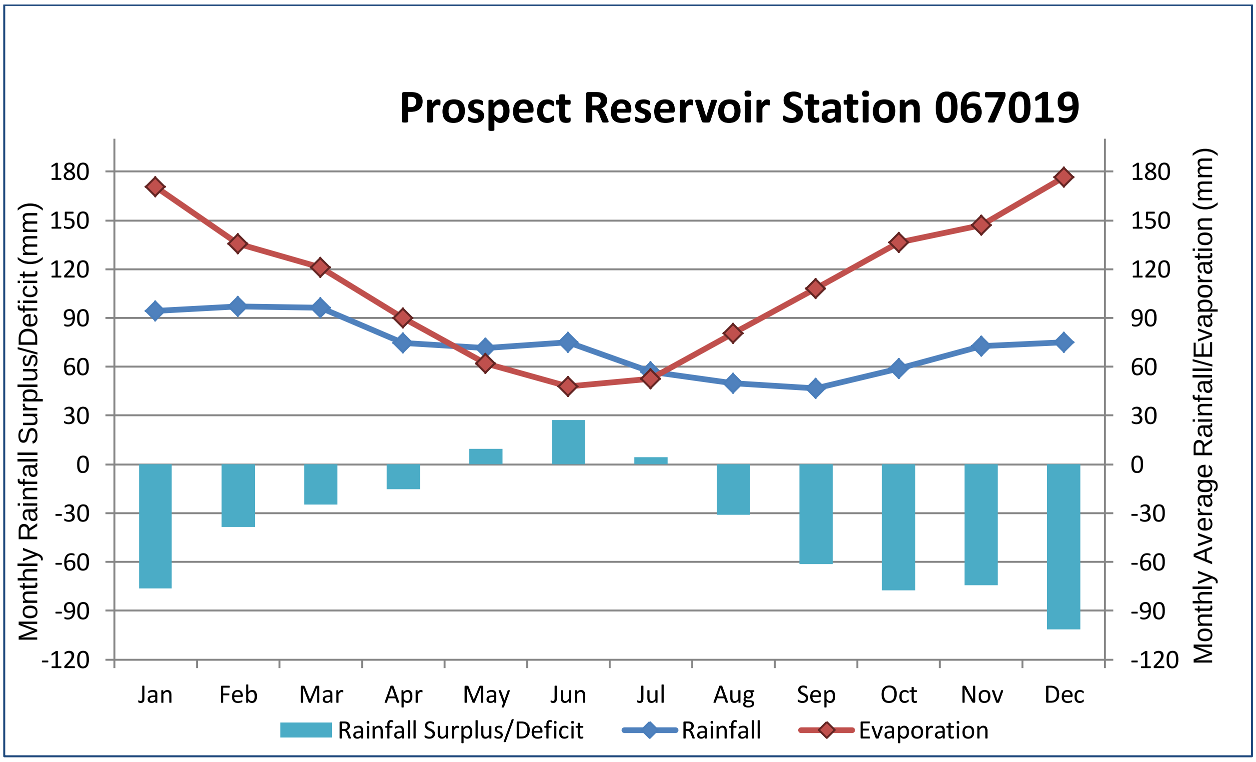
Evap.: Evaporation



Notes: (Data from Bureau of Meteorology website, accessed June 2013)

Figure 5: Historical climatic data (temperature and rainfall) at the weather station Badgery's Creek (Station No 067108)

Prospect Reservoir has maintained accurate pan evaporation records since 1909. Significant fluctuation has been observed over the past 100 years with a marked increase after 1970, followed by a gradual decrease from 1979, and returning to a marked increase in recent years (2004-2007). The average annual evaporation recorded at Prospect Reservoir Station is 970 mm/year (NSW Office of Water, 2013). Figure 6 show the monthly average rainfall (1887-2013) and monthly average evaporation (1965-2013). The rainfall surplus and rainfall deficit shown in this figure indicated that the rainfall deficit occurs most of the year due to the high evaporation.



Notes: The monthly average evaporation was interpolated from the daily average evaporation data.

Figure 6: Rainfall and evaporation (mm/year) data at Prospect Reservoir Station 067019

4.3 Drainage and surface water

4.3.1 Catchments

The Boral Bringelly site sits within the Hawkesbury-Nepean Catchment, the largest catchment area in the Sydney area at approximately 21,400 km^2. Included within this catchment is the South Creek sub-catchment (620 km^2) which includes Thompsons Creek, Lowes Creek, Rileys Creek, Kemps Creek and Bonds Creek. As a result of deforestation, increased urbanisation and agricultural activities the sub-catchment has an altered geomorphology and deteriorated water quality.

The project site is situated in the upper area of the South Creek sub-catchment with Thompsons Creek defining the eastern boundary of the site. The Upper South Creek Management Zone, defined in the Water Sharing Plan for the Greater Metropolitan Area Region Unregulated River Water Sources currently has 88 water licences attributed to it for a peak daily allowance of 43.85 ML/d, mainly for irrigation and watering of livestock.

4.3.2 Local surface water

Bardwell's Gully, a drainage channel on the site's northern boundary, flows north under Greendale Road and into Thompsons Creek. Local rural and residential drainage and run-off from Greendale Road lead to poor environmental conditions in this water body.

Thompsons Creek, running along the southern and eastern boundaries of the site, is classified as a second order ephemeral (intermittently flowing) stream, flowing north along the eastern boundary and eventually into South Creek. Boral's Dam 6, located at the south eastern area of the Project site and located within the headwaters of Thompsons Creek. Thompsons Creek is fed from rural, residential and urban drainage and demonstrates poor water quality.

4.3.3 Site water management

Available site information suggests the water table lies well below the base of Thompsons Creek and Bardwell's Gully and does not intersect these surface drainage lines. This suggests the groundwater does not provide baseflow to these creeks. Low permeability clay soils near the surface drainage lines impede rainfall infiltration and can cause perch water conditions or localised surface ponding after heavy rainfall events. The potential that groundwater is recharged by seepage of water in the creeks is therefore low.

The confluence of South Creek and Thompsons Creek is located 3.5 kilometres to the north east of the Project site (refer to Figure 1). South Creek is considered as one of the most degraded sub-catchments in the Sydney region. The catchment has been greatly altered through vegetation clearance and an increase in impervious areas through the urbanisation of the catchment. Creek water quality is impacted by both point and diffuse sources of pollution. It is inferred that there is a groundwater-surface water connectivity (i.e. baseflow condition) to South Creek. Increased salinity close to watercourses and drainage lines has been observed, probably reflecting discharge of deep groundwater from the Bringelly Shale.

The site water management system is intended to prevent uncontrolled discharges to the environment outside the site boundary. Roof runoff from the facility's buildings is collected and discharged directly into Thompsons Creek. The brickworks and car park surface runoff drains into Thompsons Creek, via a pit and drain located to the north of the car park. The temporary overburden stockpiles and brick storage area drains into Dam 1 and 2 to the north of the site where the water is allowed to settle. Dam 1, a licenced discharged point, is allowed to drain into Thompsons Creek after settlement has occurred. The Quarry pit sump (Dam 3) will be expanded as a result of quarry operations to ensure there is no increase in discharge frequency to Thompsons Creek.

Runoff from a catchment area of 26.6 hectares to the west of the Project site, of which 4.8 hectares is located within the existing quarry footprint, currently drains towards and is captured within the existing quarry. Dams 4 and 5, located to the east of the brickmaking facility adjacent to Thompsons Creek, accepts runoff from the raw material stockpile area, brickmaking operational areas and water collected from the quarry pit. Flocculants are added to the quarry pit water during the pumping process and settlement of suspended solids occurs in Dams 4 and 5. Water is then pumped into Dam 6, which is licensed for discharge of stormwater and pit water (EPL Ref 1808) and from there gets diluted further. Water discharges intermittently from Dam 6 to Thompsons Creek following heavy rainfall events (refer to Figure 2 for dam locations).

The site has a biological treatment facility for sewage waste, effluent from which is used to irrigate an area of open grassland on the northern boundary of the site. Boral's EPL allows 3,500 litres of the effluent to be spread per day on the grassland.

4.4 Geology

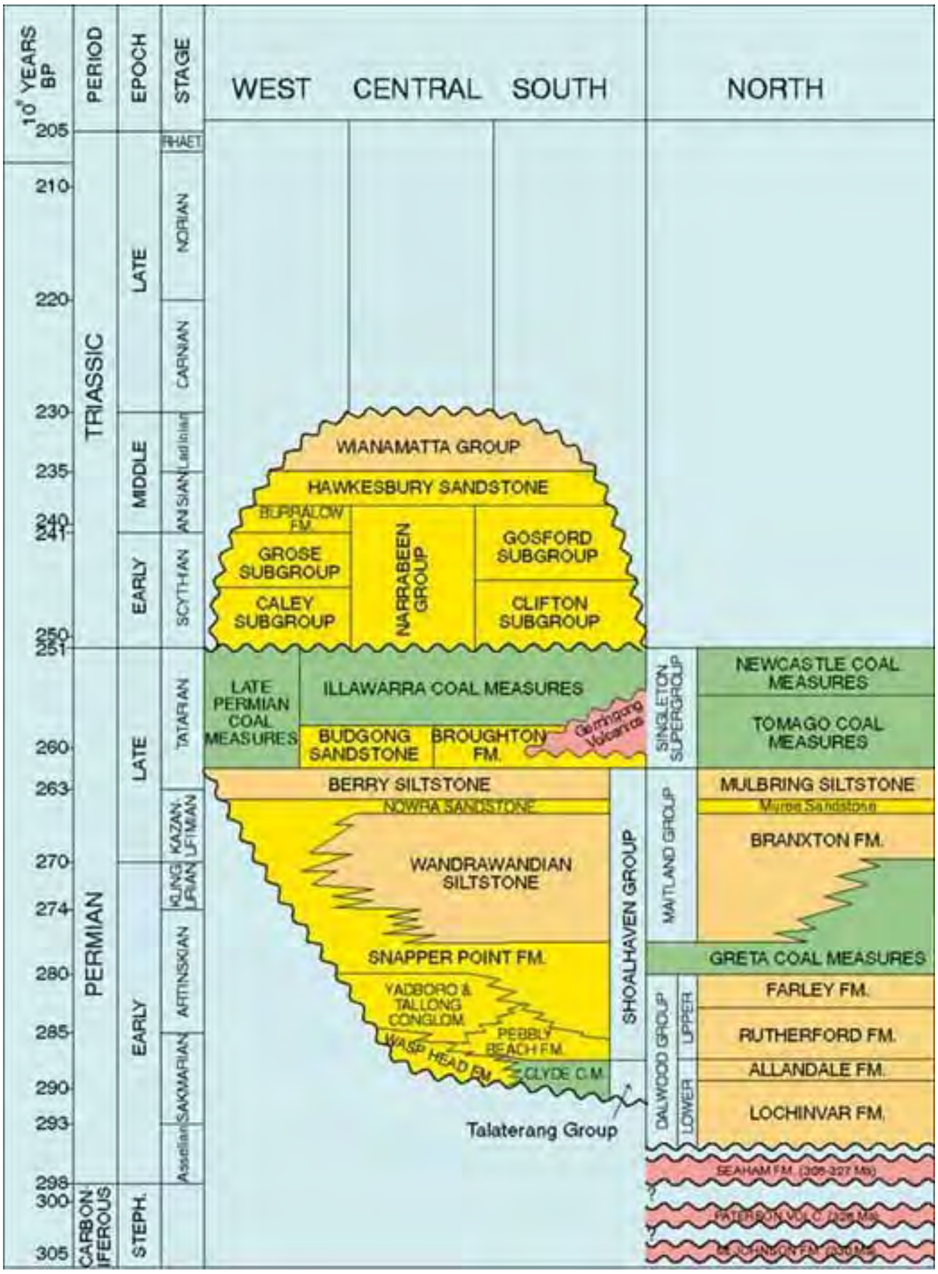
4.4.1 Regional geology

This section presents an overview of the regional and site geology.

The Bringelly Project site is located within a sequence of interbedded claystone, siltstone, laminate and sandstone known as the Middle Triassic Wianamatta Group, which crops out over a wide area to the west of Sydney. The group forms the upper most part of the Permo-Triassic sequence which comprises the Sydney Basin sediments and is divided into three formations:

- Bringelly Shale
- Minchinbury Sandstone
- Ashfield Shale

The upper unit is the Bringelly Shale, a formation dominated by claystone and siltstone with thin laminate horizons and minor sandstone. This is underlain by Minchinbury Sandstone, a three to six metres thick quartz lithic sandstone; followed by the Ashfield Shale which comprises sandstone-siltstone laminate and sideritic claystone. The Winiamatta Group is underlain by Hawkesbury Sandstone (refer to Figure 7).



Source: NSW Government, Trade and Investment Resource and Energy, Division of Resources and Energy website, http://www.resources.nsw.gov.au/geological/overview/regional/sedimentary-basins/sydbasin)

Figure 7: Sydney Basin Stratigraphy

4.4.2 Soils

The soil landscapes of the Penrith 1:100 000 sheet were mapped by Bannerman and Hazelton (1990). There are three different soil landscapes mapped within the area of the Project site:

- Residual soil landscape Blacktown (across the northeast of the Project site). This soil landscape is categorised by shallow to moderately deep, hard setting, mottled textured with red and brown podsolic on crests grading to yellow on lower slopes.
- Alluvial soil landscape South Creek (Along South Creek, Thompsons Creek and associated riparian corridor bordering the north-eastern extent of the project site). The South Creek soil landscape consists of layered alluvial soils, structured loams and structured plastic clays
- Erosional soil landscape Luddenham (Across most of the west and south of the Project site).

4.4.3 Site geology

During the site geological investigations in 1984, 14 diamond drill holes to the southwest of the existing pit were drilled by Corkery and Company Pty Ltd to provide information on the stratigraphy to a maximum depth of 37 metres below the ridges that dominate the project site (Corkery and Co Pty Ltd, 1984). In early 1989, five cored holes were drilled by Resource Planning in the eastern and southern parts of the project site. In late 1989, three cored holes to the west of the existing quarry were drilled to assess the westerly extent of the sandstone overburden and to identify the clay/shale reserve (Resource Planning Pty Ltd, 1993). In April 2013, seven cored holes were drilled to confirm clay/shale resource patterns and depth across the proposed quarry expansion area. Extensive deposits of “black”, “brown” and “red” clay were identified to the full drilling depth of 40 metres and are interspersed with sandstone rock lenses which vary in thickness between 0.5 metres and three metres (Hyder, 2013).

Geology in the region is comprised of a mix of Triassic and Quaternary age deposits. The Project site is underlain by the lower 75 metres to 150 metres of the Bringelly Shale which comprises claystone, siltstone, laminate and sandstone. The base of the sequence in this area is defined by the Cobbity Claystone, a thin (maximum six centimetres) persistent layer of weathered tuff. Alluvium (sands and gravels, fined-grained sand, silt and clay) derived from surrounding rocks are present along streams such as Thompsons Creek and Bardwell Gully.

The lithology observed during the drilling of four monitoring bores GW01 to GW04 in 2013 is summarised below (refer to Appendix C):

The first three metres of each of the holes for the monitoring bores were drilled by wash boring to penetrate the soil horizon. Soil encountered:

- Silty clay, high plasticity, pale brown trace organics (GW01)
- Sandy clay, medium plasticity, rounded sand particles, brown to dark brown (GW02)
- Clayey gravel, medium grained gravel, brown, medium plasticity clay with some sand (GW02)
- Silty clay, high plasticity, dark brown changing to pale grey, trace fine sand (GW03)
- Silty clay, high plasticity, brown (GW04)

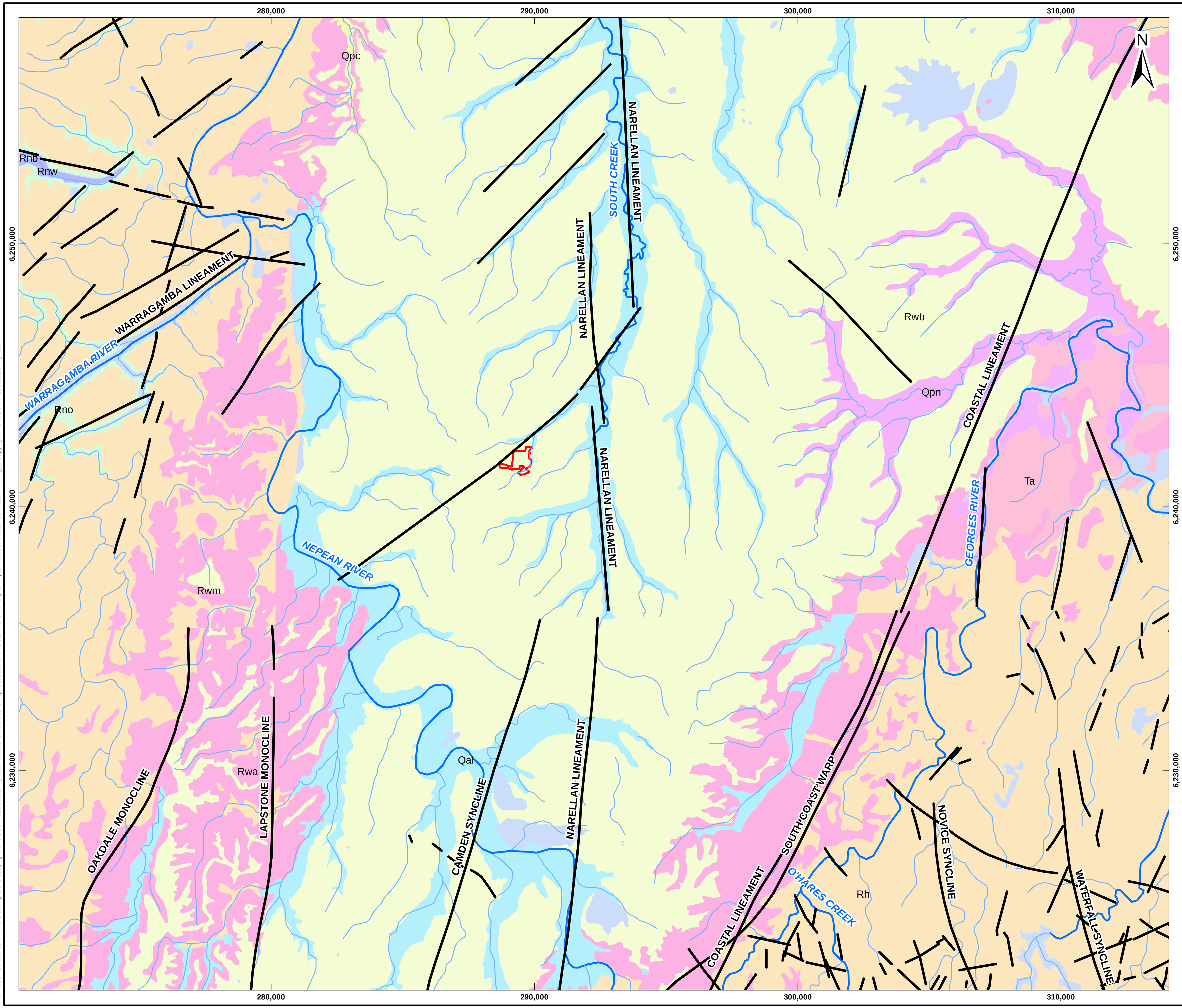
An initial layer of claystone was encountered for the first 0.5 metres of GW03, presumably originating from raw materials in the stockpile yard where the hole is located.

Four distinct rock types were encountered during the drilling of all four of the groundwater monitoring bores: claystone/mudstone, siltstone, sandstone and laminite.

- Claystone/mudstone encountered was typically fine grained, amorphous with a layered structure. Colouring varied from dark grey to black with strength tending to increase with depth.
- Siltstone was fine grained, layered in structure and varying from pale grey to dark grey in colour.
- Sandstone was pale grey in colour, medium grained and slightly weathered to fresh. The sandstone was found to generally demonstrate high strength, i.e. a 150 mm long piece of core could not be broken by hand but could be broken with under a single firm blow from the rock hammer.
- Laminite consisted of interbedded layers of mudstone, siltstone and sandstone. Typically of medium to high strength with its constituents consistent with those encountered throughout the boreholes.

The degree of weathering of the lithology tended to decrease with depth from highly weathered to moderately weathered to fresh. There were some incidents of weathering towards the bottom of GW01. The strength of the core recovered (determined from standard field tests) tended to increase with depth. Incidents of sandstone and laminites containing sandstone also tend to increase with depth in all of the boreholes.

Figure 8 shows the Triassic Bringelly Shale formation (R_{wb}) within the Project site and Quaternary alluvium (Q_{al}) along Thompsons Creek to the east of the site. Appendix C includes bore logs of monitoring bores GW01 to GW04 installed during this study.



BORAL BRINGELLY GROUNDWATER ASSESSMENT

BORAL LIMITED

GEOLOGY

LEGEND

- Geologic Structure
- Major Watercourse
- Minor Watercourse
- Project Site

Geologic Information

- Rwa - Ashfield Shale - Middle Triassic
- Rnw - Banks Wall Sandstone - Early Triassic
- Rwb - Bringelly Shale - Middle Triassic
- Rno - Burralow Formation - Middle Triassic
- Ta - Clayey quartzose sand and clay - Tertiary
- Qpc - Cranebrook Formation - Quarternary
- Qal - Fine-grained sand, silt and clay - Quarternary
- Rh - Hawkesbury Sandstone - Middle Triassic
- Qpn - Medium-grained sand, clay and silt - Quarternary
- Rwm - Minchinbury Sandstone - Middle Triassic
- Various

NOTES

1. Geology & Structures sourced from NSW Government, Resources and Energy.
2. Watercourses sourced from Geoscience Australia.

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0 0.5 1 2 3 4 5 km

SCALE (at A3) 1:140,000

DATUM GDA 94, PROJECTION MGA Zone 56

PROJECT:	137626001
DATE:	30 AUG 2013
DRAWN:	SL
CHECKED:	DB

FIGURE 8

Golder Associates

4.5 Hydrogeological setting

This section presents characteristics of hydrostratigraphic units within the Project site, the groundwater levels and groundwater quality that were observed during this study.

4.5.1 Hydrostratigraphic units

The hydrogeology of the Project site is mainly controlled by the geology. Hydrostratigraphy units within the Wianamatta Group comprise the Bringelly Shale, Minchinbury Sandstone and Ashfield Shale Units. The Bringelly Shale unit can be characterised as low permeable, majority of groundwater flow via fractures and bedding planes, and as a layered hydrostratigraphic units with limited inter-connection between layers.

The groundwater potentiometric surface generally follows topography. The regional groundwater system is recharged by rainfall recharge and discharge via evaporation, evapotranspiration and discharge to creeks to the east of the Project site and to the Hawkesbury-Nepean system to the north.

A weathered unit overlies the Bringelly Shale and perched shallow groundwater can occur within this layer at places. Exploration drilling indicated a shallow water at 3 mbgl at a bore located to the west of the existing pit (borehole BB10; 274030.56E, 242664.87N; Resource Planning, 1993).

Alluvial deposits occur around South Creek and Thompsons Creek (refer to Figure 8).

A summary of the hydrostratigraphy relevant to the Project is presented in Table 5. Section 4.5.2 presents information on hydraulic parameters of the strata.

Table 5: Characteristics of hydrostratigraphic units

Unit	Description	Groundwater Flow Characteristics	Location/ Depth (m)	Saturated Hydraulic Conductivity Range (m/s)
Quaternary deposits				
Blacktown residual soil	Shallow to moderately deep hardsetting mottled texture contrast soils; red brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines.	Residual soil across the northeast of the Project site. Low permeability Low flow	Few meter thick^	3×10^{-12} to 8×10^{-10} m/s(1)
South Creek (Alluvial) soil	Layered alluvial soils, structured loams and structured plastic clays. red and yellow podzolic soils are most common on terraces with small areas of structured grey clays, leached clay and yellow solodic soils.	Along South Creek, Thompsons Creek and associated riparian corridor bordering the north-eastern extent of the project site. Permeable / undersaturated silts and clays; Moderate flow, intergranular controlled	Often very deep layered sediments over bedrock or relict soils	3×10^{-10} to 6×10^{-6} m/s(1)
Luddenham (Erosional) soil	Shallow dark podzolic soils or massive earthy clays on crests; moderately deep red podzolic soils on upper slopes; moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines.	Across most of the west and south of the Project site. Low permeability; Low flow, partly intergranular- and partly fracture-controlled	Few meter thick^	No data
Middle Triassic Wianamatta Group				
Bringelly Shale	Clay zone Completely (highly) weathered shale and minor sandstone claystone and siltstone with thin laminate horizons and minor sandstone	Potential perched water occurs at the base of the weathering unit at places Hydraulic conductivity is largely controlled by the degree of fracturing	3.5 m thick	**2.5×10^{-10} to 2.6×10^{-7} m/s**(2) -- 1×10^{-7} to 6×10^{-7} m/s(3) --- 1×10^{-11} to 4×10^{-7} m/s(4)
Bringelly Shale	Partially-weathered shale and minor sandstone	Semi-consolidated Partially-weathered Fractured with clay in fractures at places Low permeability	4.1 m thick	
Bringelly Shale	Unweathered shale and siltstone with minor laminate and sandstone Sandstone rock lenses which vary in thickness between 0.5 metres and three metres were observed during the drilling program at the Project site	Unweathered hydrostratigraphy unit Confined aquifer Low permeability with zones of higher permeability (sandstone lens?) Brackish to saline water Majority of groundwater flow occurs via fractures and bedding planes	75 to 150 m	
Bringelly Shale	Cabbitty Claystone	A thin persistent layer of weathered tuff marked the base of Bringelly Shale	6 cm thick	
Minchinbury Sandstone	quartz lithic sandstone	Confined Aquifer Low to high permeability sandstone aquifer intergranular and fractured controlled	3 to 6 m thick	1×10^{-9} to 1×10^{-6} m/s(5)
Ashfield Shale	sandstone-siltstone laminate and sideritic claystone	Low permeability Low flow		1×10^{-12} to 1×10^{-10} m/s(4)
Middle Triassic Hawkesbury Sandstone				
Hawkesbury Sandstone	Quartzose sandstone with intervals of siltstone, sine sandstone laminate, siltstone horizons and claystone bands	Confined Aquifer Low to high permeability sandstone aquifer; high bore yield, intergranular and fractured controlled Low salinity water. Water quality improves with depth. Yields: <1 L/s to 50 L/s	120 to 230 m	1×10^{-9} to 2×10^{-5} m/s(6) -- 1×10^{-12} to 1×10^{-10} m/s(4)

Notes:

(1) literature data

(2) Estimated hydraulic conductivity value from results of hydraulic tests in Bringelly Shale (Mudstone, Siltstone, Claystone, Laminite and Sandstone strata) (Golder, 2013,falling head tests, April to May 2013).

(3) Golder (1979) results of field test (referenced in William 2005)

(4) Itakura (1999) results lab test for shale (referenced in William 2005)

(5) hydraulic conductivity for sandstone, Freeze and Cherry (1976)

(6) Pells Consulting(1993)

4.5.2 Bringelly Shale hydraulic conductivity

Hydraulic tests were carried out at monitoring bores within the Project site. Table 6 presents results of the tests at GW01, GW02 and GW03.

Table 6: Hydraulic conductivity of Bringelly Shale unit at the Project site

Bore ID	Test Date	Saturated Hydraulic Conductivity (m/s)	Saturated Hydraulic Conductivity (m/d)	Test Interval (m)	Weathering Degree	Formation Tested
GW01	24/4/2013	2.6×10^{-7}	2.3×10^{-2}	18 to 37	Moderately weathered (18-23 m), slightly weathered to fresh (23-37 m)	Mudstone, laminite (siltstone, mudstone, sandstone), siltstone, sandstone
GW02	24/4/2013	2.3×10^{-7}	2.0×10^{-2}	18 to 37	Slightly weathered to fresh	Laminite (siltstone, mudstone, sandstone), siltstone, sandstone, claystone
GW03	30/5/2013	1.9×10^{-9}	1.7×10^{-4}	27 to 37	Fresh	Laminite (siltstone, mudstone, sandstone), siltstone, claystone, sandstone
GW04	30/5/2013	2.55×10^{-10}	2.2×10^{-5}	21 to 39	Slightly weathered to fresh, Fresh	Mudstone, siltstone, laminite (siltstone, mudstone, sandstone), sandstone

Notes:

Hydraulic tests were conducted in April-May 2013 by Golder (Golder, 2013)

Results of hydraulic tests were analysed using the Hvorlev method

GW03: Logger installed 10 m below top of casing (mbTOC) and static water level is 35 mbTOC. Therefore initial aquifer recovery was not recorded. However, overall recovery of the aquifer is very slow and formation is very tight.

GW04: Bore is dry. Values for hydraulic conductivity for GW04 are intended for indicative purposes only

There is minimal laboratory data available for Sydney Basin shales; however, Golder Associates (1979) measured hydraulic conductivity values of the Bringelly shale in the field. Following 48 hours for bore saturation, the measured values ranged from 1×10^{-7} m/s to 6×10^{-7} m/s (Golder, 1979; referenced in William, 2005). The relatively high conductivity might have been attributed to the presence of more permeable rock units within Bringelly shale and / or to the structural disintegration due to post-saturation swelling (William, 2005).

Itakura (1999) performed tests on three types of specimens. He reported a decreased conductivity of Bringelly shale to be of the order of 10^{-11} m/s to 10^{-12} m/s.

- The test results on clayey shale specimens have shown that a rapid drop in the conductivity from 4.1×10^{-7} to 8.5×10^{-10} m/s and was also associated with a decrease in the void ratio from 0.16 to 0.11 respectively.
- Hydraulic conductivity value for reconstituted intact clay is decreased from 1.4×10^{-10} to 1.3×10^{-11} m/s with a decrease in void ratio from 0.66 to 0.46.
- A drop in void ratio was also observed as the hydraulic conductivity values of the sandy shale decreased from 4.1×10^{-9} m/ s to 8.4×10^{-10} m/s.

4.5.3 Groundwater levels

Groundwater level measurements are very limited at the Project site and there is no data to create a groundwater contour map. There are no registered groundwater bores within the Project site. Water was recorded at bore BB10 at 3 metres below ground surface (mbgs) and above the base of complete weathering layer (3.9 mbgs) (Resource Planning Pty Ltd, 1993).

Table 7 shows groundwater level measurements observed at four (4) monitoring bores GW01 to GW04 that were installed in April 2013 for this GWIA study (Golder, 2013, factual report).

The standing water levels (SWL) for the monitoring bores have been established based on water levels taken by Golder field staff on 30 May 2013 during the water quality sampling event at the end of the fieldwork program. Discounting GW04, the SWLs for GW01, GW02 and GW03 holes demonstrate the expected trend following the surface topography with the lowest water level in the south-eastern corner of the site towards Thompsons Creek. It is likely that a SWL has not established in GW04 at the latest monitoring event in May 2013. This may be due to very slow recovery as a result of the tight formation in the screened section of the monitoring bore. Groundwater levels varied from higher groundwater levels at the northern monitoring bores (76.96 mAHD at GW01 located in paddock just outside of the Project site boundary to the northwest; 73 mAHD at GW02 located adjacent to the paddock entrance gate at the northeast of the quarry) to the lower groundwater levels at the monitoring bores to the south of the Project site (55.16 mAHD) at GW03 located at the foot of hill to the west of the stockpile yard (refer to Table 7). The inferred local groundwater flow direction based groundwater level measurements at GW01, GW02 and GW03 is from the north toward the southeast.

Bore logs and construction details of these monitoring bores are included in Appendix C of this report.

Table 7: Groundwater level measurements

Bore ID	Coordinates		Surface Elevation (mAHD)	Top of Casing (maGL)	Drill Completion Date	Bore Depth (m)	SWL* (mTOC)	SWL* (mbgl)	SWL* mAHD
	Easting	Northing							
GW01	289202.0	6242112.1	87.6	0.56	12/04/2013	40	11.79	11.23	76.37
GW02	289502.1	6242101.8	83.55	0.62	15/04/2013	40	10.69	10.07	73.48
GW03	289628.5	6241630.2	86.8	0.6	6/04/2013	40	26.79	26.19	60.61
GW04	289214.9	6241594.5	99.1	0.6	9/04/2013	42	40.13	39.53	59.57

Notes:

Coordinates: Coordinates and ground elevations are from surveyors (Mepstead & Associates, 12 June 2013)

mAHD ï metres above Australian Height Datum

mbgs ï metres below ground surface

maGL ï metres above Ground Level

SWL ï Standing Water Level

*Groundwater level measurements on 30 May 2013 (Golder, 2013)

GW04 data: There is some uncertainty regarding the SWL for GW04. Initial groundwater levels measured by Golder field staff over the course of the fieldwork program suggest that the hole is dry or recovering extremely slowly. Groundwater quality sampling results for GW04 (refer to Table 7 above) also demonstrate elevated levels of hydrocarbons, which may indicate the presence of drilling fluids.

4.5.4 Groundwater quality

Groundwater sampling was carried out during the field investigations for this study (Golder, 2013b). Water samples were obtained from the four monitoring bores (GW01, GW02, GW03 and GW04) on 30 May 2013. Certificates of analysis and quality control provided by a NATA accredited laboratory are presented in Appendix D. Groundwater quality classification and water types, salinity and sodium hazard classes are discussed in Sections 4.5.4.1, 4.5.4.2, 4.5.4.3, respectively. Groundwater quality data was compared to the regulatory guidelines in order to assess their environmental values and vulnerability of groundwater resources.

Laboratory results of the water quality sampling program are summarised in Table 8 below. Table 8 shows laboratory water quality analysis and provides trigger values for stock water guidelines (ANZECC 2000) and toxicants in freshwater for the protection of 95% of species in the column óANZECC 2000 Freshwater 95%ô

The water quality data indicates levels of zinc from all water samples exceeding the *ANZECC 2000 Trigger Values for the Protection of Freshwater Aquatic Ecosystems (95% Level of Protection).*

Water quality for GW04 indicated elevated concentrations of semi-volatile Total Petroleum Hydrocarbons (refer to Appendix D) which may be evidence that the bore is producing very little water and that some residual polymers used during drilling may remain in the sump of the well. Data from GW04 water sample exhibits lower TDS, EC, Ca, Na concentrations comparing to water quality observed at other sites (GW01 to GW03). It is inferred that the water sample may have been mixed with drilling water and is not representative for the Bringelly Shale unit; therefore, this data was omitted from the data analysis and interpretation presented in Sections 4.5.4.1, 4.5.4.3 and Section 4.5.5.

Table 8: Groundwater quality laboratory analysis results

Analyte	**Unit**	**ANZECC 2000 Stock Water Guideline**	**ANZECC 2000 Freshwater 95%**	**GW01**	**GW02**	**GW02 Duplicate**	**GW03**	**GW04**
pH				8.49	8.04	8.02	7.62	8.04
Electrical Conductivity @ 25ÁC	ÕS/cm			15200	22000	22200	15200	2020
Total Dissolved Solids @180ÁC	mg/L	4000		8880	13600	13300	9220	2350
Redox Potential	mV			51	92.5	120	75.7	32
Dissolved Oxygen	mg/L			7.4	7.4	7.2	4.2	1.9
Turbidity	NTU			48.5	68.6	61.4	451	12400
Alkalinity								
Hydroxide Alkalinity as $CaCO_3$	mg/L			<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L			29	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L			219	393	388	274	327
Total Alkalinity as $CaCO_3$	mg/L			248	393	388	274	327
Dissolved Major Anions								
Chloride	mg/L			4740	7600	7620	4720	412
Sulfate as $SO4^{2-}$	mg/L	1000		6	<1	<1	10	31

Analyte	Unit	ANZECC 2000 Stock Water Guideline	ANZECC 2000 Freshwater 95%	GW01	GW02	GW02 Duplicate	GW03	GW04
Dissolved Major Cations								
Calcium	mg/L	1000		143	284	306	207	12
Magnesium	mg/L			138	238	255	77	2
Sodium	mg/L			2700	4680	4710	2850	433
Potassium	mg/L			57	54	57	57	9
Reactive Phosphorus as P	mg/L			0.02	0.04	0.04	0.04	<0.01
Nitrite as N	mg/L			<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L		0.7	0.01	0.01	<0.01	<0.01	<0.01
Nitrite and Nitrate as N (NOx)	mg/L			0.01	0.01	<0.01	<0.01	<0.01
Dissolved Metals								
Arsenic	mg/L	0.5	0.013	0.004	0.001	0.001	0.005	0.005
Cadmium	mg/L	0.01	0.0002	<0.0001	0.0001	<0.0001	<0.0001	0.0005
Chromium	mg/L	1	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	1	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.1	0.0034	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	0.002	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	1	0.011	0.001	0.001	<0.001	0.002	0.003
Zinc	mg/L	20	0.008	0.013	0.085	0.1	0.05	0.166
Ionic Balance								
Total Anions	meq/L		139	222	223	139	18.8	139
Total Cations	meq/L		137	239	242	142	19.8	137
Ionic Balance			0.52	3.56	4.26	1.15	2.62	0.52

Notes:

Water quality sampling date: 30 May 2013 (Golder, 2013)

4.5.4.1 *Groundwater quality classification*

The groundwater quality assessment included analysis of pH, total dissolved solids (TDS) and major ion chemistry.

Groundwater classification in terms of pH is presented in Table 9.

Table 9: Groundwater pH

Range	Description
pH < 5	Acid
pH 5 ï 7	Slightly Acid
pH 7	Neutral
pH 7 ï 9	Slightly Alkaline
pH >9	Alkaline

Source: Bates, 1973

Groundwater of the Bringelly Shale at the Project site can be classified as slightly alkaline (refer to Table 9) based on the pH data (7.62 to 8.49) observed at the site monitoring bores (GW01, GW02, GW03, Table 8).

TDS and EC are measures of the dissolved salt content. TDS is reported as a concentration (in mg/L) and is either measured by evaporating a known volume of water and weighing the residual solids. EC is a measure of the conductance of a liquid and is reported in micro-Siemens per centimetre (ÕS/cm) at 25ÁC.

A range of salinity classifications (based on TDS concentration) have been published in literature. Classifications are generally based on beneficial use applications (irrigation or livestock watering) and do not define the full range of TDS found in natural waters (e.g. seawater or brines). The water salinity classification adopted for this study is presented in Table 10, as adopted from Fetter (1994), with a further division of brackish water into slightly brackish and brackish (USDA, 2007).

Table 10: Groundwater classification based on TDS concentrations

Salinity Classes (modified from Fetter, 1994)	
Water type	**TDS (mg/L)**
Fresh	less than 1,000
Slightly brackish	1,000 to 3,000
Brackish	3,000 to 10,000
Saline	10,000 to 100,000
Brine	more than 100,000

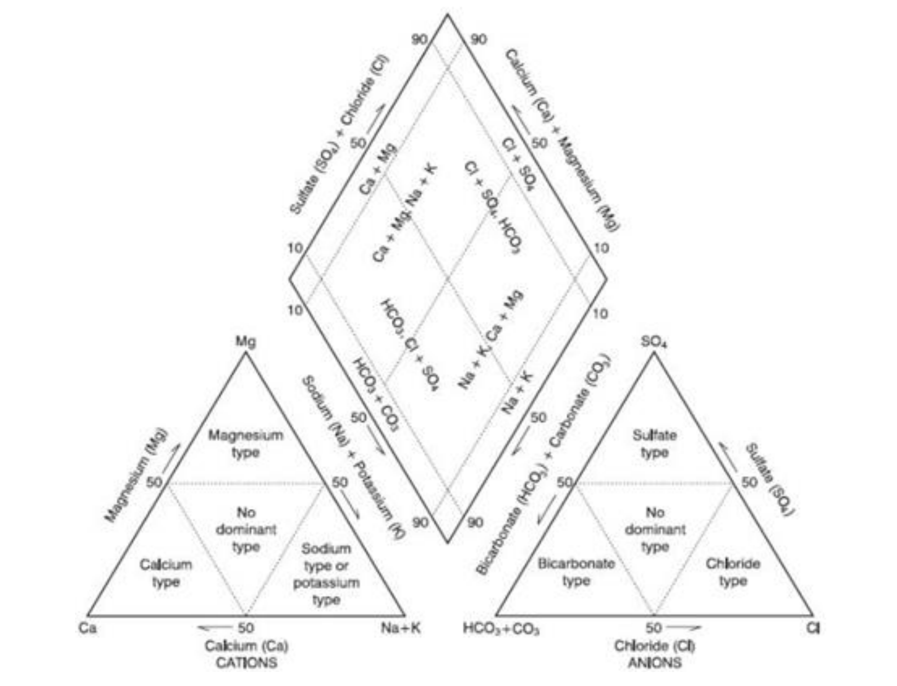
Groundwater of the Bringelly Shale at the Project site can be classified as ósalineô (refer to Table 10) based on TDS concentrations (8,880 to 13,600 mg/L) observed at the site monitoring bores (GW01, GW02, GW03, Table 8).

4.5.4.2 *Hydrochemical facies – Water types*

Cation and anion concentrations for each groundwater sample were converted to meq/L and plotted as percentages of their respective totals in two triangles of the Piper diagram (Figure 10). The cation and anion relative percentages in each triangle are then projected into a quadrilateral polygon that describes the water type. The Piper diagram therefore is a convenient tool to differentiate groundwater types based on the relative major ion composition.

Groundwater at the Project site (GW01, GW02, GW03) can be classified as sodium-chloride water type. Their hydrochemical facies are shown in the Piper diagram (Figure 10). GW04 water sample exhibits a different water type (sodium and no dominant anion water type) comparing to water quality observed at other sites (GW01 to GW03). It is inferred that the water sample may have been mixed with drilling water and is not representative for groundwater in the Bringelly Shale unit.

Classification of Hydrochemical Facies Using Piper Diagrams



Water types of groundwater samples from monitoring bores GW01 to GW04

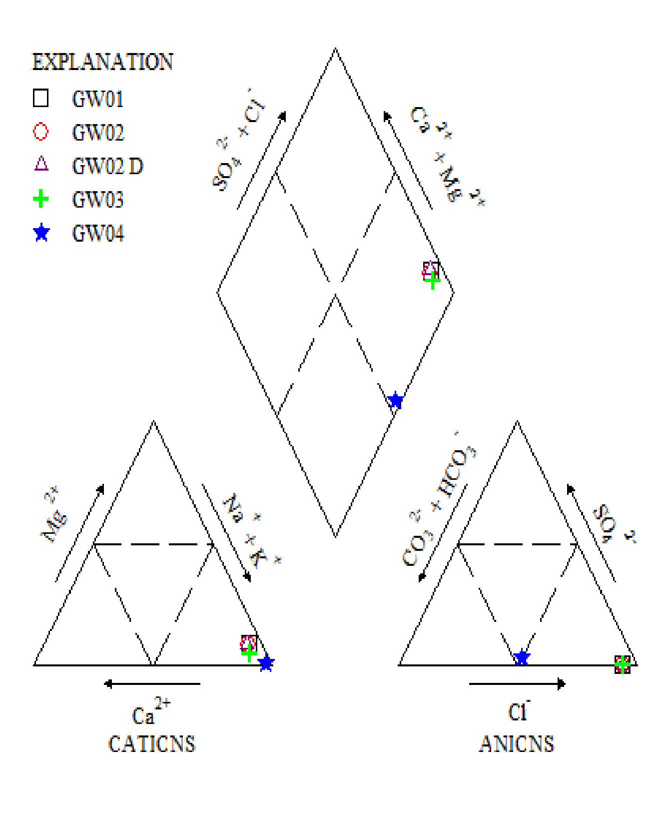


Figure 9: Water types of groundwater samples from monitoring bores GW01 to GW04

4.5.4.3 Salinity and sodium hazard classes

Agricultural use of groundwater includes irrigation and livestock watering. Irrigating with water that has a high content of dissolved salts and excess sodium can adversely impact the soil structure or adversely affect plant growth. This can depend on the amount of salt present in the water, the soil type being irrigated, the climate and the specific plant species and the growth stage.

The irrigation water quality classification system is based on two characteristics:

- salinity hazard; and
- sodium (alkali) hazard of the water.

The salinity and sodium hazard classes are presented in Table 11 and Table 12.

Table 11: Salinity Hazard Classes

Salinity Hazard Class	Electrical Conductivity (µS/cm)	Characteristics
C1 ï Low	0-250	Can be used for irrigation on most soil with minimal likelihood that soil salinity will develop
C2 ï Medium	251-750	Can be used for irrigation if a moderate amount of drainage occurs
C3 ï High	751-2250	Not suitable for use on soil with restricted drainage; some soils with adequate drainage may require special management control for salinity
C4 ï Very High	> 2250	Not suitable for irrigation under normal conditions

Source: Waterloo Hydrogeological Inc, 2003

The chemical analysis of groundwater samples at the Project site (refer to Table 8) indicates their Salinity Hazard Class is õVery Highö (GW01, GW02, GW03) based on the electrical conductivity classification shown in Table 11. The õVery Highö Salinity Hazard Class is not suitable for irrigation under normal conditions (refer to Table 11)

- GW01, GW02, GW03: Very High (EC = 15,200 to 22,200 ÕS/cm)

Table 12: Sodium Hazard Classes

Sodium Hazard Class	Sodium Adsorption Ratio (SAR)	Characteristics
S1 ï Low	0-10	Suitable for irrigation on most soil with minimal danger of harmful levels of exchangeable sodium
S2 ï Medium	10-18	Appreciable sodium hazard in fine textured soil having high cation exchange capacity
S3 ï High	18-26	Produces harmful levels of exchangeable sodium in most soils
S4 ï Very High	>26	Unsatisfactory for irrigation purposes

Source: Waterloo Hydrogeological Inc, 2003

The SAR indicates the tendency of sodium (Na) to replace calcium (Ca) and magnesium (Mg) in soil and is calculated as follows:

$$SAR = \frac{Na}{\sqrt{\frac{(Ca + Mg)}{2}}}$$

where*: Na: Sodium, Ca: Calcium, Mg: Magnesium; in meq/L.*

The chemical analysis of groundwater samples at the Project site (refer to Table 8) indicates their Sodium Hazard Class is ôVery Highô(GW01, GW02, GW03) based on the electrical conductivity classification shown in Table 12. The ñVery HighôSodium Hazard Class is unsatisfactory for irrigation purposes (refer to Table 12):

- GW01, GW02, GW03: Very High (SAR = 38 to 49)

4.5.5 Comparison of groundwater quality to regulatory guidelines

The Australian drinking water guidelines (ADWG, 2011) established drinking water criteria for public supplies of drinking water. The ADWG (2011) guidelines include the following:

- A health-related guideline value is the concentration that does not result in any significant risk to the health of the consumer over a lifetime of consumption; and
- An aesthetic guideline is the concentration associated with acceptability of water, based on appearance, taste and odour.

The assessment criteria for public supplies and domestic use are presented in Table 13. TDS, sodium and chloride of all analysed samples in this study exceed the drinking water standard. All of the analysed samples exceed the sodium drinking water standard.

Table 13: Comparison of groundwater quality to Australian drinking water criteria for the Project Area (ADWG, 2011)

Analyte	Drinking water standard (mg/L; except pH)	Number of groundwater samples exceeding standard***	Project site data ranges
pH	6.5 - 8.5	0% (0 out of 4 samples)	7.62 - 8.49
Chloride	250**	100% (4 out of 4 samples)	4720 - 7620
Sodium	180**	100% (4 out of 4 samples)	2700 - 4710
Sulphate	250**	0% (0 out of 4 samples)	<1 - 31
	500*	0% (0 out of 4 samples)	
TDS	< 600 ï good quality	100% (4 out of 4 samples)	8880 ï 13,600
	600-900 ï acceptable based on taste	100% (4 out of 4 samples)	
	900-1,200 ï poor quality	100% (4 out of 4 samples)	
	>1,200 ï excessive scaling, corrosion, unsatisfactory taste	100% (4 out of 4 samples)	
Fluoride	1.5*	NA	NA
Copper	1**	0% (0 out of 4 samples)	<0.001
	2*	0% (0 out of 4 samples)	
Iron	0.3	NA	NA
Manganese	0.1**	NA	NA
	0.5*	NA	
Zinc	3	0% (0 out of 4 samples)	0.013 ï 0.1
Nitrate	50*	0% (0 out of 4 samples)	<0.01 ï 0.01

* - health value

** aesthetic value

***TDS concentrations complying with standard

NA ï data not available

Total hardness is a commonly used measure to characterize the suitability of water for public-supply and domestic use. Total hardness can be characterised into four classes (Table 14, ADWG, 2011). Total hardness for samples within the Project site was calculated from the chemical composition and refers to the sum of calcium and magnesium (expressed in mg/L of $CaCO_3$). For the Project site groundwater samples, 100% represented ôhardôgroundwater and would have the potential to cause scaling.

Table 14: Groundwater Hardness

Total Hardness as CaCO3 (mg/L)	Hardness Classes	Number of groundwater samples exceeding standard***	Project site data ranges
<60	Soft, but possibly corrosive	0% (0 out of 4 samples)	-
60-200	Good quality (moderately hard)	0% (0 out of 4 samples)	-
200-500	Increasing scaling problem (hard)	100% (4 out of 4 samples)	248 - 393
>500	Severe scaling (very hard)	0% (0 out of 4 samples)	-

Groundwater suitability for livestock watering is assessed on the basis of TDS concentrations and the concentration of specific ions, particularly calcium and sulphate. The trigger values for both calcium and sulphate are 1,000 mg/L.

Recommended TDS concentrations in drinking water for livestock watering are summarised in Table 15. Groundwater observed at GW01 to GW03 range from slightly brackish to saline, with TDS concentrations ranging from 8,880 mg/L to 13,600 mg/L (GW02); therefore, no samples meet the criteria ñNo adverse effect on animalsò listed in the Table Tolerances of Livestock to TDS in drinking water (refer to Table 8).

Table 15: Tolerances of Livestock to TDS in Drinking Water (ANZECC & ARMCANZ, 2000)

Livestock	TDS (mg/L)		
	No adverse effect on animals	Stock should adapt without loss of production	Stock may tolerate these levels for short periods if introduced gradually
Beef cattle	< 4,000	4,000 ï 5,000	5,000 ï 10,000
Dairy cattle	< 2,500	2,500 ï 4,000	4,000 ï 7,000
Sheep	< 5,000	5,000 ï 10,000	10,000 ï 13,000
Horses	< 4,000	4,000 ï 6,000	6,000 ï 7,000
Pigs	< 4,000	4,000 ï 6,000	6,000 ï 8,000
Poultry	< 2,000	2,000 ï 3,000	3,000 ï 4,000

4.6 Environmental values

This section presents an overview of ecosystems, groundwater dependent environmental sensitive areas, groundwater ecosystems (stygofauna), dams, existing groundwater users, recreational, aesthetical, cultural and spiritual values, and an assessment of groundwater vulnerability.

4.6.1 Ecosystems

A comprehensive ecological assessment was completed by Hyder Consulting (refer to the main EIS report and its biodiversity appendix).

Seven vegetation communities were identified within the ecological study area including

- Native Vegetation
  - Moderate Condition Cumberland Plain Woodland
  - Poor Condition Cumberland Plain Woodland
  - Derived Grassland Cumberland Plain Woodland
  - Poor Condition Riparian Woodland
- Exotic vegetation:
  - Mixed Exotic/Planted Native
  - Olive Dominant Woodland

Most of the threatened plant species identified in the database searches were considered to have a low likelihood of occurring in the ecological study area, based on potential habitat and the proximity and number of records of these species in the locality. Native flora habitat in the ecological study area is poor, with stands of *Olea europaea subsp. cuspidata* shading out habitat across most of the ecological study area.

Three Threatened Ecological Communities (TECs) are likely to occur within 10 kilometres of the ecological study area (refer to Appendix K –Ecological Assessment– of the main EIS report for results of the EPBC Act Protected Matters Search). The TECs are:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
- Shale/Sandstone Transition Forest
- Western Sydney Dry Rainforest and Moist Shale Woodland on Shale.

4.6.2 Riparian and aquatic habitat

Four dams were recorded within the ecological study area that provide habitat for terrestrial fauna. Dams contained emergent vegetation and soft muddy substrates which would provide foraging and breeding habitat for frogs and wading birds.

Thompsons Creek dam (refer to Figure 2 for location of Dam 6) contained emergent vegetation which would provide nesting habitat and shelter for waterbirds. The dam is also a foraging resource for waterbirds. The dam and Thompsons Creek also provides a fresh water resource for most local fauna including exotic species. The southern section of Thompsons Creek became dry and void of aquatic vegetation as the creek progressed upstream from Thompsons Creek dam (Dam 6). The northern section of Thompsons Creek (downstream of the dam) contained emergent vegetation which would provide habitat for frogs and waterbirds.

4.6.3 Groundwater dependant environmental sensitive areas

GDEs can be defined as those ecosystems whose ecological processes and biodiversity are wholly or partially reliant on groundwater. Examples of GDEs include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps and near-shore marine ecosystems (NSW Office of Water). GDEs could include aquatic ecosystems in rivers and streams that receive groundwater baseflow. Baseflow typically accounts for a significant fraction of total flow volume in major rivers and streams. Baseflow can sustain stream flow volumes long after rainfall events, or throughout dry seasons, and is therefore critical to the maintenance of aquatic ecosystems in rivers and streams in many Australian environments. Baseflow can occur as springs discharging into a river or stream, or as diffuse influx of groundwater through banks and bed sediments.

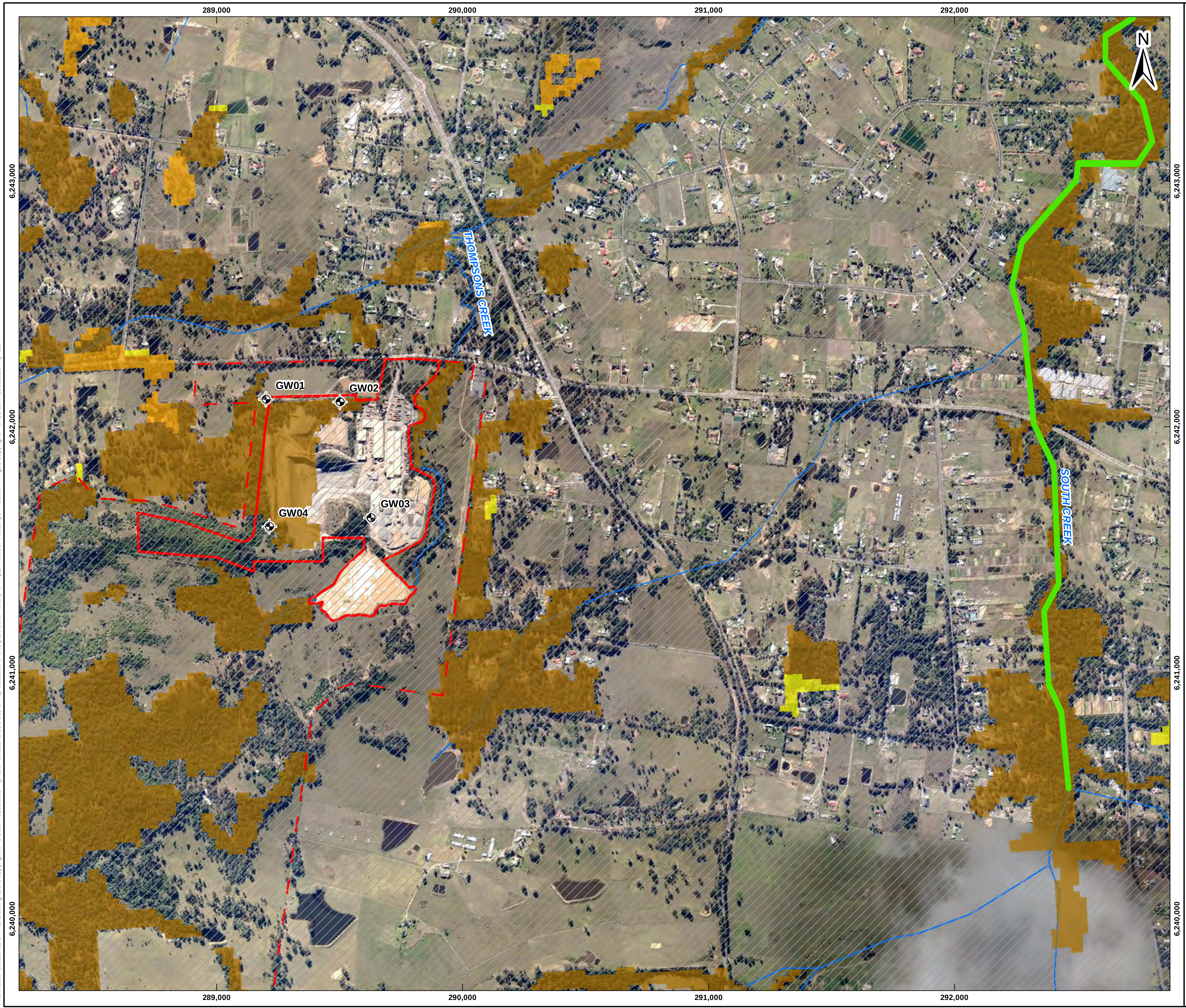
Results of the search for groundwater dependent ecosystems from the National Atlas of Groundwater Dependent Ecosystems (Australian Government, BOM, 2013) indicated the following GDEs (Category ôReliant on subsurface groundwater ï vegetationö):

- Cumberland Shale Hills Woodland
- Cumberland Shale Plains Woodland
- Cumberland River Flat Forest

Figure 10 shows zones of ôlowö, ômoderateö and ôhigh potential for groundwater interactionö GDE category ôReliant on subsurface groundwater (vegetation)) within and in the vicinity of the Project site. It is difficult to separate water dependant ecosystems from groundwater dependant ecosystems (NSW government, Sydney Catchment Authority, 2006).

South Creek is categorised as a GDE category ôReliant on surface expression of groundwater (rivers, springs, wetlands). No GDEs category ôSubterraneanö were identified within the Project site based on information from the National Atlas of GDEs.

The National Atlas of Groundwater Dependent Ecosystems presents the current knowledge of groundwater dependent ecosystems across Australia. It displays ecological and hydrogeological information on known groundwater dependent ecosystems and ecosystems that potentially use groundwater. It incorporates multiple lines of scientific evidence including previous fieldwork, literature and mapping, and combines nation-wide layers of satellite remote sensing data.



BORAL BRINGELLY GROUNDWATER ASSESSMENT

BORAL LIMITED

GROUNDWATER DEPENDANT ECOSYSTEMS

LEGEND

- Standpipe Piezometer
- Property Boundary (2/733115)
- Project Site
- Watercourse

GDE, Reliant on surface expression of groundwater (rivers, springs, wetlands)

- Identified in previous study: fieldwork
- Identified in previous study: desktop
- High potential for groundwater interaction
- Moderate potential for groundwater interaction
- Low potential for groundwater interaction

GDE, Reliant on subsurface groundwater (vegetation)

- Identified in previous study: fieldwork
- Identified in previous study: desktop
- High potential for groundwater interaction
- Moderate potential for groundwater interaction
- Low potential for groundwater interaction

GDE, Subterranean (Cave & Aquifers)

- Identified in previous study: fieldwork
- Identified in previous study: desktop
- No Ecosystem analysed

NOTES

1. Base data supplied by Boral Limited.
2. Imagery dated 18 May 2013.
3. GDE sourced from Australian Government, Bureau of Meteorology.

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0 50 100 200 300 400 500 metres

SCALE (at A3) 1:15,000

DATUM GDA 94, PROJECTION MGA Zone 56

PROJECT:	137626001
DATE:	30 AUG 2013
DRAWN:	SL
CHECKED:	DB

FIGURE 10

Golder Associates

4.6.4 Groundwater ecosystems – stygofauna

Groundwater fauna, or *stygofauna*, comprise the microscopic, aquatic animals that live in underground water. It is made up predominantly of many kinds of crustacean invertebrates but also includes worms, snails, insects and occasionally blind fish. Groundwater fauna contribute substantially to the biodiversity of Australia (Humpfreys, 2006). *Stygofauna* are known to exist in limestone, calcrete, and fractured rock aquifers, but appear most abundant in alluvial aquifers (Maria et al., 2012; Hancock and Boulton, 2008). Many *stygofauna* species are restricted to very small geographical areas; therefore, the new development that extends below the water table need to be considered carefully to avoid species extinction. The survey of *stygofauna* is currently not a compulsory feature of environmental impact assessment report in NSW.

Two new species of *Stygofauna* were reported in the shallow groundwater system at two sites (one perched zone at 2 m and a shallow sandstone zone at 25 m near Butler Swamp during the groundwater investigation at Upper Nepean Catchment (Kangaloon) about 65 km south of the Project site.

No GDEs category ©Subterraneanô were identified in previous study and no ecosystems of this category were analysed (refer to Section GDE and Figure 10). It is unknown whether *stygofauna* (groundwater fauna) are present in the groundwater systems in the Project site. The majority of groundwater has a high electrical conductivity and the occurrence of alluvial aquifers is limited in the Study Area; therefore, the likelihood of encountering *stygofauna* on the Project Site is considered to be low.

4.6.5 Existing groundwater users

The NSW Office of Water groundwater bore database and NSW Natural Resource Atlas were searched to identify the existing groundwater users within and in the vicinity of the Project site.

There are no registered groundwater bores within the Project site based on results of the groundwater bore search.

4.6.6 Local community recreational, aesthetical, cultural and spiritual values

The Aboriginal and Non-Indigenous Heritage study (refer to the main EIS and its appendix Heritage Study) indicated that four Aboriginal heritage sites were identified within the study area.

- Three sites (BB OS1, BB OS3 and BB OS4) were assessed as having low archaeological significance
- One site (BB OS2) was assessed as having moderate research potential as it has the potential to provide information about Aboriginal land use in the local area.
- No Non-Indigenous archaeological material or areas of archaeological potential were identified during the site survey carried out as part of this heritage assessment.

Other land uses within proximity to the Project site are as follows:

- Thompsons Creek is running along eastern side of the Project site. South Creek is downstream of Thompsons Creek
- Bringelly Reserve is located east of the Project site (~1.5 km)
- Bringelly Creek is situated west of the Project site (~2.5 km)
- Sydney University Farms campus is approximately five kilometres west of the site along Greendale Road, which is used for teaching and research.
- Bringelly Public School, which is approximately 500 metres to the east on the corner of The Northern Road and Greendale Road.
- Small retail shops approximately 500 metres to the east on the corner of The Northern Road and Greendale Road.

- Bringelly Community Centre, approximately 200 metres to the east, located at 5 Greendale Road.
- Bringelly Park (used by Bringelly Sports Club) borders the western boundary of the Bringelly Community Centre
- Bents Basin State Conservation Area, approximately 8 km to the west of the Project site.

4.6.7 Groundwater vulnerability

The Project site is located within the zones of ‘low’, ‘low moderate’ and ‘moderate’ groundwater vulnerability based on the NSW Atlas (accessed June 2013) (Figure 11). The zone along South Creek, which is located approximately 2.5 km to the east of the Project site, is rated as area of ‘high’ vulnerability rating. The vulnerability mapping shown in the NSW Atlas considered major geologic and hydrogeologic factors that affect and control groundwater movement and vulnerability including depth to water table, recharge, aquifer media, soil media, topography (slope), vadose zone media and hydraulic conductivity of aquifer.

As described in Section 4.5.4 of this report, the groundwater quality observed at bores installed in Bringelly Shale within the Project site is of poor quality and does not have high environmental values.

- The chemical analysis in Table 8 indicates groundwater classification ranging from slightly brackish to ‘saline’ based on TDS concentrations and ‘slightly alkaline’ based on the pH values.
- Agricultural use of groundwater includes irrigation and livestock watering. Irrigating with water that has a high content of dissolved salts and excess sodium can adversely impact the soil structure or adversely affect plant growth. This can depend on the amount of salt present in the water, the soil type being irrigated, the climate and the specific plant species and the growth stage.
  - Salinity Hazard Class is ‘Very High’ (GW01, GW02, GW03) based on the electrical conductivity classification.
  - Sodium Hazard Classes is ‘Very High’ (GW01, GW02, GW03) based on the Sodium Adsorption Ratio
- The criteria “no adverse effect on animals” based on the guidelines Tolerances of Livestock to TDS in drinking water (Table 15) was not met in all analysed water samples (GW01 to GW03).
- TDS, sodium and chloride of all analysed samples in this study exceed the Australian drinking water standard (ADWG, 2011). All of the analysed samples exceed the sodium drinking water standard and represent ‘hard’ groundwater which would have the potential to cause scaling.

The strata in the Project Site are considered to be poor water bearing units. The surficial silts and clays limit the potential for recharge by rainfall infiltration. As the Bringelly Shale hydrostratigraphic unit within and around the Project Area is very low yielding and of low quality, there is currently no groundwater bore within the Project site and the potential for development of this groundwater source is minimal. The majority of groundwater is ‘saline’ and has been classified as unsuitable for potable or agricultural use (either domestic, irrigation or for livestock watering) without treatment due to the elevated concentrations of sodium and chloride. Salinity observed from monitoring bores GW01 to GW03 varied from 8,880 mg/L to 13,600 mg/L (refer to Section 4.5.4). Results of hydraulic testing at GW01 to GW03 (refer to Section 4.5.2) indicated low hydraulic conductivity values ranging from 1.92×10^{-9} m/s to 2.6×10^{-7} m/s and bore yields from the Bringelly Shale are expected to be very low.

The criteria for “high productive” groundwater as defined in “NSW Aquifer Interference Policy” are total dissolved solids of less than 1,500 mg/L and water source that contains water supply works that can yield water at a rate greater than 5 L/sec. The groundwater in the Project Area is not considered to be “high productive” water source based on “NSW Aquifer Interference Policy” criteria.

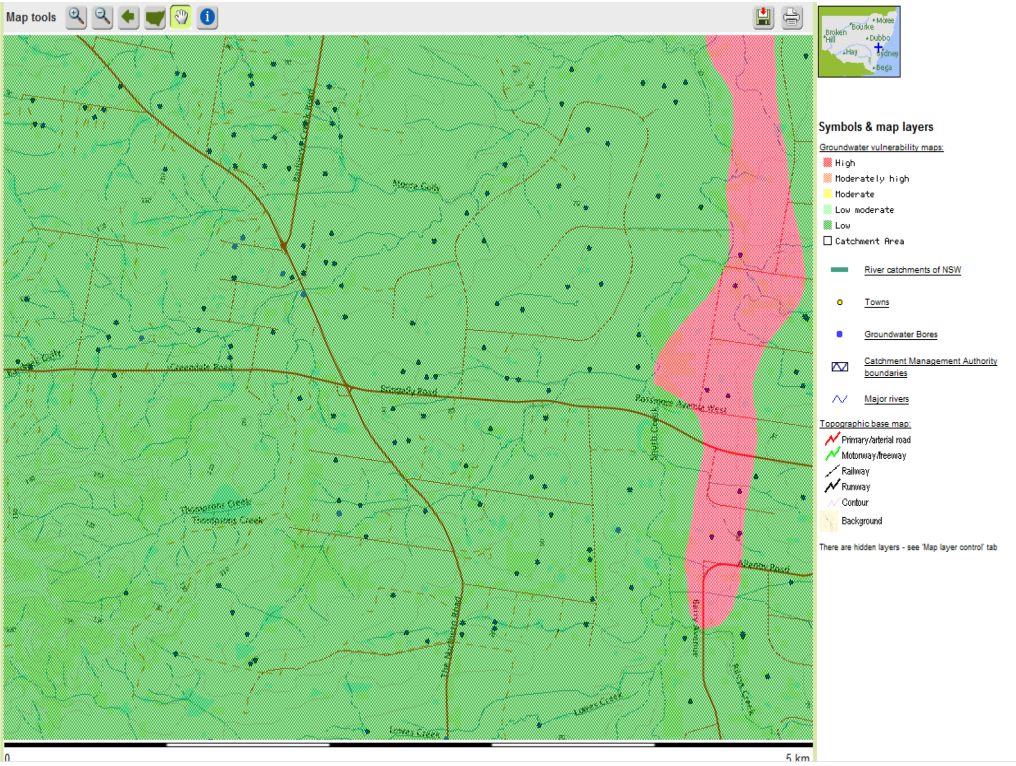


Figure 11: Groundwater vulnerability map (NSW Natural Resource Atlas, 2013)

5.0 HYDROGEOLOGICAL MODELLING

The process for assessing potential impacts of the Project on groundwater use hydrogeological modelling to simulate and predict changes in groundwater levels and flow. The first part of the process is to develop a Conceptual Groundwater Model. This is then translated into a groundwater flow model to assess potential impacts to groundwater levels and flows. The tool used for the impact analysis (given the relatively limited data available from the site) is an analytical element groundwater flow model.

In terms of the site location, it is noted that the following locations of concern are:

- GDEs (Category ‘Reliant on subsurface groundwater – vegetation’) (Cumberland Shale Hills Woodland, Cumberland Shale Plains Woodland, Cumberland River Flat Forest); GDE category ‘Reliant on surface expression of groundwater (South Creek) (refer to Section 4.6.3)
- Thompsons Creek is running along eastern side of the Project site. South Creek is downstream of Thompsons Creek

5.1 Conceptual groundwater model

A Conceptual Groundwater Model is a qualitative representation of the controlling factors influencing groundwater occurrence, distribution and flow. The controlling factors can be summarised as follows:

- Classification of the strata into either an aquifer, aquitard or aquiclude, their relative positions and how they interact;
- Groundwater – surface water interaction
- Local and regional geology

- Groundwater flow regime
- Impacts resulting from the existing and proposed activities influencing the geological and hydrogeological regimes.

A conceptual groundwater model was developed based on the understanding of the Site Characterisation, including previous groundwater testing and analysis, which is summarised in Section 4.0 of this report and data outlined in Table 2 of Section 2.2.

The conceptual model consists of layers of aquifer systems to represent the soil profile, the weathered Bringelly Shale, the fresh strata of the Wianamatta Group and the underlying Hawkesbury Sandstone. The conceptual model represents an area which is bounded by river boundaries (South Creek and Nepean River), that are assumed to reflect regional groundwater elevations to the east and west, and a distant assumed constant head boundary to the north to provide a south to north flow direction.

5.1.1 Hydrostratigraphy units and aquifers

The Bringelly Project site is located within a sequence of interbedded sedimentary units (claystone, siltstone, laminate and sandstone) known as the Middle Triassic Wianamatta Group. The group forms the upper most part of the Permo-Triassic sequence which comprises the Sydney Basin sediments and is divided into three formations (refer to Section 4.4). The upper unit is the Bringelly Shale, a formation dominated by claystone and siltstone with thin laminate horizons and minor sandstone. This is underlain by Minchinbury Sandstone, a three to six metres thick quartz lithic sandstone; followed by the Ashfield Shale which comprises sandstone-siltstone laminate and sideritic claystone. The Winiamatta Group is underlain by Hawkesbury Sandstone (refer to Figure 7).

The hydrogeology of the Project site is mainly controlled by the geology. Hydrostratigraphy units within the Wianamatta Group comprise the Bringelly Shale, Minchinbury Sandstone and Ashfield Shale Units (Table 16). The Bringelly Shale unit can be characterised as follows:

- Low permeability
- Majority of groundwater flow via fractures and bedding planes
- A layered aquifer system with limited inter-connection between layers
- The groundwater potentiometric surface generally follows topography.
- Site data indicated groundwater levels ranging from 59 mAHD to 76 mAHD.
- Groundwater is saline and is unsuitable for potable or agricultural use (either domestic, irrigation or for livestock watering) without treatment due to the elevated concentrations of sodium and chloride.

Lens of permeable sandstone have been observed within the Bringelly Shale unit (refer to Section 4.4.2 and APPENDIX C). A weathered unit overlies the Bringelly Shale and perched shallow groundwater can occur within this layer at places.

Ranges of aquifer parameters used in the conceptual model are based on the results of the hydraulic testing conducted for this study (Golder, 2013, factual report) and data from literature review. A summary of the hydrostratigraphic units relevant to the Project is presented in Table 5 (refer also to Section 4.5.1 and Section 4.5.2 for description of the hydrostratigraphic units and hydraulic conductivity data). Groundwater level and water quality data obtained for this study is shown in Section 4.5.3 and Section 4.5.4, respectively.

Table 16: Characteristic of hydrostratigraphic unit at Bringelly site

Hydrostratigraphic Units	Approximate Thickness (m)	Hydraulic Properties	Average Pre-mining Groundwater Level (mAHD)
Quaternary Alluvium and Surficial Deposits	0 to 5 m (approx.)	Aquifer (alluvium only)	Generally unsaturated
Blacktown residual soil	0 to 3 m (approx.)	Aquitard	Generally unsaturated
Bringelly Shale (completely weathered)	3.5 m	Aquitard	Generally unsaturated
Bringelly Shale (partially weathered)	4 m	Low permeability unit/Aquitard	55 to 77 mAHD
Bringelly Shale (unweathered)	75-150 m	Low permeability unit/Aquitard	55 to 77 mAHD
Bringelly Shale (Cabbitty Claystone)	0.06 m	Aquitard	No data
Minchinbury Sandstone	3-6 m	Confined aquifer	No data
Ashfield Shale	No data	Aquitard	No data
Hawkesbury Sandstone	120 to 230 m	Major confined aquifer	No data

Note that the base of the proposed quarry pit is around 60 m AHD, based on a maximum planned depth of 30 m (refer to Section 1) and a surface elevation of 90 m. At the groundwater levels observed at GW03 (60.6 mAHD) and GW04 (59.6 mAHD), there would be essentially no impact from deepening the quarry to 60 mAHD on the groundwater table as the quarry base would not incept groundwater. It is likely that a SWL has not yet been established in GW04 (SWL = 59 mAHD) at the latest monitoring event in May 2013 due to a very slow recovery as a result of the tight formation in the screened section of the monitoring bore.

For the basis of the impact assessment we have assumed the conservative position that groundwater occurs across the site at 76 mAHD across the site and that quarry deepening would proceed to 60 m AHD, 16 m below this groundwater level.

It is assumed that the water table lies within the unweathered Bringelly Shale. The deepening of the quarry to 60 mAHD will also occur wholly within this low permeability unit. Other units such as the Minchinbury and Hawkesbury Sandstones occur at greater depths and are separated from the Bringelly Shale by aquitards. With the overall low permeability of Bringelly Shale, plus the separation and lack of data on other units, only the Bringelly Shale is represented in the impact assessment modelling.

The combined low permeability nature of the unweathered Bringelly Shale and the aquitards that separate it from the regionally significant Hawkesbury Sandstone below makes it highly improbable that quarry deepening and its associated interception of the water will impact the Hawkesbury Sandstone, or other units underlying the Shale. Therefore in the groundwater flow model used for impact analysis only the Bringelly Shale unit is represented.

5.1.2 Aquifer recharge and discharge

The regional groundwater system is recharged by rainfall recharge and discharged via evaporation, evapotranspiration and by discharge to creeks and to the Hawkesbury-Nepean system to the north.

In the Project site, direct recharge from vertical percolation of rainfall infiltration occurs through the vadose zone. However, the rate of recharge is expected to be low because of the high evapotranspiration and evaporation. The low permeability silts and clay subsoil limits the potential for recharge by rainfall infiltration. Good outcrop is uncommon in Bringelly shale due to soil cover developed in situ as a result of the ongoing weathering of the parent rock (William, 2005).

NSW Office of Water estimated an average infiltration rate of 6% for the Sydney Basin based on rainfall recharge only (NOW, 2011, Water Sharing Plan Greater Metropolitan Region Groundwater Sources, Background Document, 2011). However, rainfall recharge can vary from 1% to 10% of rainfall for sedimentary and fractured rock strata (NSW Government, Sydney Catchment Authority, 2006)

The historical average annual rainfall ((1965-2013) observed at Badgery's Creek Station near the Project site is 683 mm/year (refer to Section 4.2). The low hydraulic conductivity of the Bringelly Shale may further limit the recharge to this geological unit, with rates of less than 1% of annual rainfall. The extensive distribution of surface water impoundments surrounding the project area indicates the low permeability of the surficial strata. The rainfall recharge rate over the wider area is estimated ranging 7 mm/yr to 41 mm/yr based on the infiltration rate of 1% and 6%, respectively.

In general, discharge within the Project site consists of evaporation and evapotranspiration.

5.1.3 Aquifer flow and connectivity

At the larger regional scale of the Sydney basin, the direction of groundwater flow is from outcrop areas and follows the formation dip (refer to Figure 12). Groundwater flow in the region is generally from south to the north; however, the flow direction can be influenced by the rivers/drainage system which acts as local discharge areas (Sydney Catchment Authority, 2006). The groundwater flow rate is dependent on the permeability and thickness of the aquifer, and the lateral hydraulic gradient for each unit.

In the relatively shallow formations, topography is the main control on groundwater levels. Available groundwater level measurements within the Project site are very limited (refer to Section 4.5.3). There are not sufficient groundwater level measurements to create a groundwater contour map for the Project site.

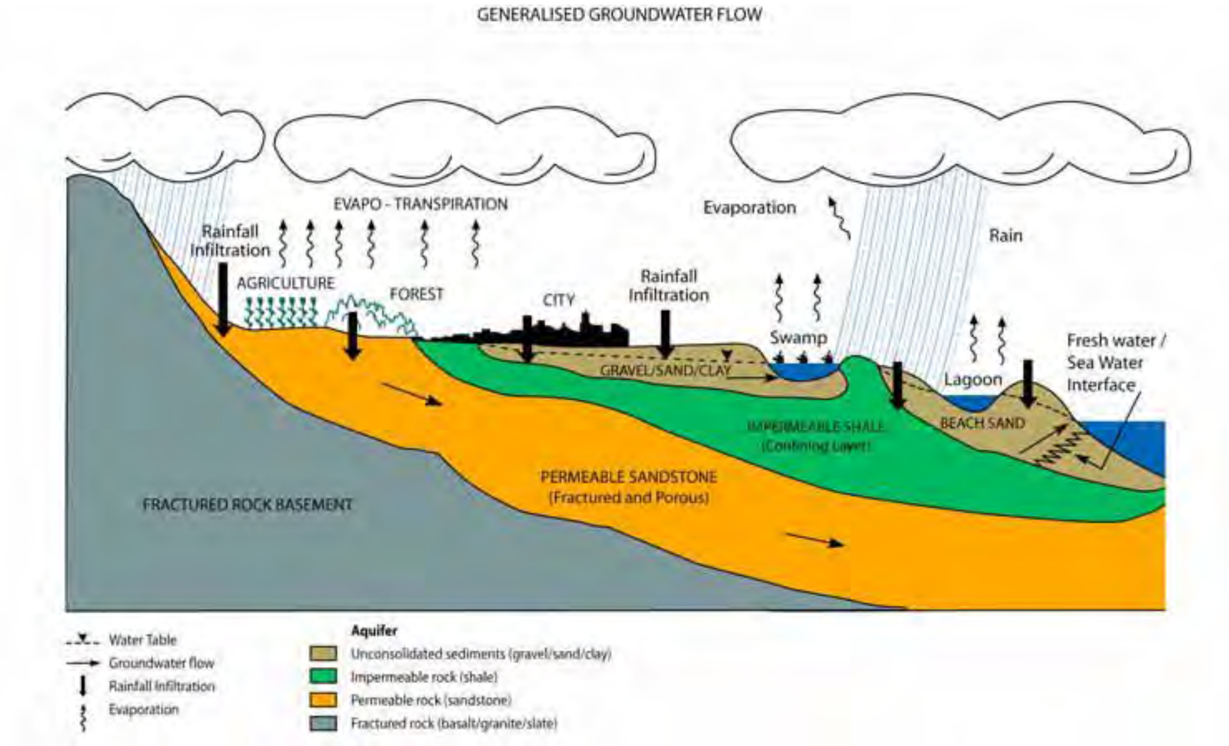
Vertical flow from or through one layer into another (upwards or downwards), sometimes referred to as "interaquifer" flows or vertical leakage, occurs naturally, to some level of magnitude, where there is a hydraulic connection between the aquifer and aquitards (i.e. in porous media systems, a component of vertical hydraulic conductivity, K_v, always exists) and a sufficient vertical hydraulic gradient exists. Such flows will be greatest where the vertical component of hydraulic conductivity, K_v, is large, (i.e. flow between two sandy aquifers) but least between aquitards of low K_v (i.e. flow through a mudstone, claystone or siltstone). For example, a mudstone or claystone band (aquitard) separating two aquifers would restrict (but not entirely eliminate) water flow from one aquifer layer to the other simply because its K_v is very low.

Inter-aquifer flow can also be enhanced when a structural overprint, say, where a secondary porosity comprising joints, fractures or faults cross-cuts the bedding within a sedimentary sequence so enhancing the vertical hydraulic conductivity. This typically occurs more readily at basin margins, where the rocks are folded and along fault lines, where the hydraulic conductivity has increased by brittle fracture of the rocks. In addition, inter-aquifer flow can be initiated or enhanced by groundwater abstraction which induces increased pressure gradients (hydraulic gradients) between the target abstraction aquifer and surrounding formations.

The vertical permeability of the Bringelly Shale is likely to be lower than the horizontal, signifying that groundwater flow will likely occur preferentially in a horizontal direction. The Cobbity Claystone is a thin persistent layer that marks the base of Bringelly Shale from the underlying Minchinbury Sandstone. Ashfield Shale can act as a confining layer, impeding water infiltration to the underlying Hawkesbury Sandstone aquifer.

Thompsons Creek is an ephemeral (intermittent flowing) stream (refer to Section 4.3). Available site information suggests the groundwater level lies well below the base of the Thompsons Creek and Bardwell's Gully and does not intersect these surface drainage lines. This suggests the groundwater is unlikely to provide baseflow to the creeks within the Project site.

Groundwater studies for the Upper Nepean Catchment area suggested that groundwater discharges from Hawkesbury Sandstone to incised creeks and rivers. There is a groundwater-surface water connectivity to the Nepean River and major tributaries where fractures occur and are open.



Source: (NSW Government, Sydney Catchment Authority, GW027-06-06VI, 2006)

Figure 12: Schematic of Sydney Basin Groundwater flow regime showing different rock types and groundwater systems across the Sydney Basin from west to east

5.2 Analytic element modelling

This section discusses the methodology and assumptions used to assess groundwater inflow to the quarry pit.

5.3 Assumptions

The following simplifications and assumptions have been necessary, primarily due to the limited hydrogeological information available for the Project site and surrounding area.

As the pit development will be undertaken progressively, for the purpose of the pit groundwater inflow/groundwater volumes estimate, the pit development has been simplified.

Assumptions regarding the model also include the following.

Analysis (Modelling) Assumptions:

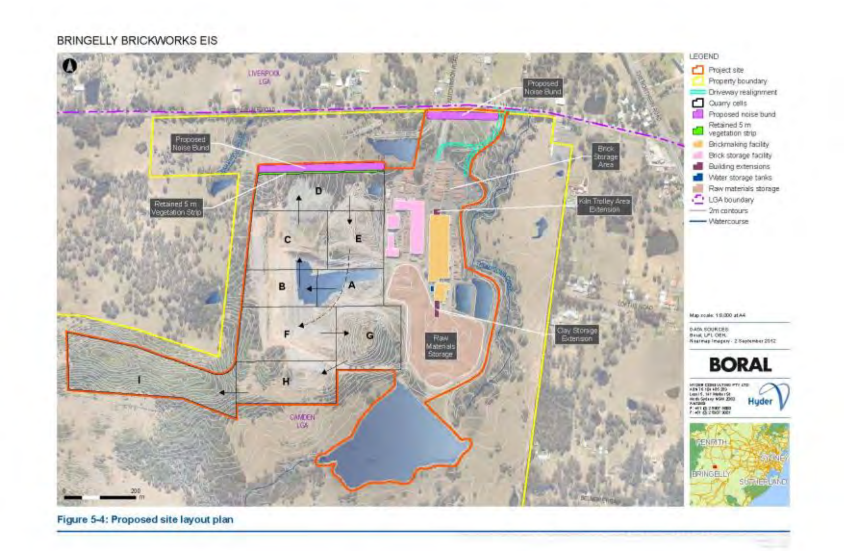
- Groundwater inflows to the pits were estimated for the final quarry pit depth with a level of 60 mAHD.
- The loss of groundwater due to evaporation is not represented in the model.
- Volume of water generated within the pit shell as a result of direct rainfall is not taken into account.
- Aquifer recharge is assumed to be constant throughout the model run and model domain, with the exception of direct precipitation into the pit.

Hydrogeological Assumptions:

- The represented strata is homogeneous, planar and horizontal throughout the model domain;
- A single layer of unweathered Bringelly Shale is represented. The rationale for this is based on the low permeability of the unit, that the groundwater level occurs approximately 25 m below surface and beneath the weathered shale and that there are aquitards separating the Shale from underlying sandstones;
- The layer is given hydraulic properties representative of the bulk behaviour of the strata. This is known as equivalent porous medium modelling. Golder considers this an appropriate approach for impact analysis and given available data;
- Groundwater flow is assumed to be intergranular flow only (porous media flow). No attempt has been made to model potential preferential flow in fractures, faults or other geological features;
- Inflow into the pit occurs through the saturated strata adjacent the pit wall and floor only. No unsaturated flow was accounted for in the model;
- The local surface water features, such as Thompsons Creek, in the vicinity of the project are ephemeral and located above the groundwater level. They are therefore excluded from the model;
- Nepean River and South Creek are perennial and are taken to be surface expressions of the groundwater table. These are represented as river boundary conditions within the model; and
- The maximum groundwater impact was assumed to occur at cessation of mining. No groundwater recovery or post-mining conditions were investigated in the model.

Quarry Plan Assumptions:

- The proposed site layout plan and resource extraction stage spatial and temporal staging was provided by Boral (Hyder Consulting EIS, 2013) (Figure 13)
- The base of open pit quarry excavation was assumed to be the level of dewatering across the mine pit
- An open pit approximately 30.65 hectares in extent will remain following the cessation of quarry operations
- Maximum excavation to 30 m below ground surface (approximate 60 mAHD)
- The properties of the strata do not alter as open pit excavation progresses (e.g. there is no material change in the hydraulic conductivity due to removal or backfilling of material)
- The maximum extent of groundwater impact was assumed to occur at the final stage of the quarry pit. No groundwater recovery or post-mining conditions were investigated in the model.



Source: Hyder Consulting EIS report (2013)

Figure 13: Site layout plan for the proposed Bringelly Project.

5.4 Analytical model set up

This section presents an overview of the selection of model software, model geometry and model hydraulic parameters.

5.4.1 Selection of model software

The groundwater inflow estimation was conducted using the analytical software AnAqSim (64-bit version 2013-1). AnAqSim is analytical software capable of superimposing multiple analytical calculations (using flow equation calculations) to yield a composite solution consisting of equations for head and discharge as a function of location and time. Whilst the analytical equations are written in two-dimensions, three-dimensional flow may be simulated using simple planar multiple levels. Note: AnAqSim is not a distributed numerical model that can permit widely varying boundaries and aquifer parameters, such as MODFLOW or FEFLOW. It has been selected for this project as it permits the rapid development of a modelled groundwater flow regime and impact analysis commensurate in detail to the degree of complexity of the hydrogeology, data availability and within the required timeframe.

5.4.2 Model geometry

The following sections discuss the model geometry in terms of domain, layers and hydraulic parameters.

5.4.2.1 Model domain

The model domain was constructed with a far field boundary located at approximately 10 - 15 km from the proposed pit shell.

5.4.2.2 Model layers

The base of the model is a no-flow boundary set an elevation of ~-20 mAHD. This permits representation of around 110 m of Bringelly Shale based on thickness estimates that vary between 75-150 m. Considering its thickness (75 to 150 m) and its hydrogeological properties (low hydraulic conductivity), the Bringelly Shale is the only layer represented in the model and its thickness is fixed at 120 m. This depth is considered to be sufficiently deep and does not affect model results.

The upper surface of the model is represented by the ground level (130 mAHD)

5.4.3 Model hydraulic parameters

The hydraulic parameters used in the model are vertical and horizontal hydraulic conductivity and storativity. Values used in the model were taken from site investigation data and published literature values (refer to Section 4.5). A summary of the final model input parameters in given in Table 17 for the predictive model.

5.4.3.1 Recharge

Historical average annual rainfall ((1965-2013) observed at Badgery's Creek Station near the Project site is 683 mm/year. As a starting point, it was assumed that approximately 2% of annual precipitation results in areal recharge to the model. This equates to a rate of 14 mm/year (14×10^{-3} m/year [3.8×10^{-5} m/day]) uniformly applied as a flux to the upper surface of the model.

This value was altered during model calibration.

5.4.3.2 Rivers and creeks

The observed groundwater levels (GW01 to GW03) within the Project site showed groundwater to be approximately 61 mAHD to 76 mAHD (or 26 to 11 mbgl) (refer to Section 4.5.3).

South Creek and Nepean River are represented as the eastern and western boundaries in the model with river stage (water) levels estimated from topography. They have been defined as river boundary conditions permitting either discharge of groundwater to the rivers, or infiltration of river water depending on the groundwater elevation.

5.4.3.3 No flow boundaries

The model is bounded by no flow boundaries at the sides of the model domain. These were located at a distance considered to have an acceptably small influence on the model result.

5.4.3.4 Constant head boundaries

The dewatering assumed at final quarry operation was delimited at the outer edge of the final stage of excavation by constant head boundaries. The value assigned to final stage of open pit excavation was 60 mAHD, assuming an approximate maximum depth of 30 m from existing topography of around 90 m AHD.

Table 17: Summary of Model Input Parameters

Representative Strata	Aquifer/ Aquitard	Initial Groundwater Level (mAHD)	Scenario A Low Hydraulic Conductivity (m/d)	Scenario B High Hydraulic Conductivity (m/d)	Specific Yield (dimensionless)	River conductance (m/d)
Bringelly Shale (unweathered)	Water bearing Unit/ Aquitard	76	1.7×10^{-4}	1×10^{-3}	1	0.05

5.5 Groundwater level calibration

With point and book values for aquifer parameters such as hydraulic conductivity and approximations of recharge, it was necessary to calibrate the model such that modelled groundwater levels broadly match those observed. Without calibration, modelled heads rise substantially above topography. Calibration was undertaken by varying:

- Hydraulic parameters of the strata (horizontal and vertical hydraulic conductivity): tested values from 8 Ĭ 10^{-5} m/d to 1 Ĭ 10^{-3} m/d.
- Areal recharge into the surface of the model: 0.08 mm/y (for Scenario A) and 14 mm/y (for Scenario B).
- Rivers conductance values: several different values have been tested. The final river conductance is set to 0.05 m/d.

The calibration fit (i.e. difference between modelled verses observed groundwater levels) was analysed using the groundwater head values from site. A groundwater contour map for the calibrated steady state model is shown in Figure 14 with calibration statistics in Table 18.

Table 18: Predictive Model Steady State verses Observed Pre-Mining Groundwater Levels

Modelled Groundwater Head (mAHD)	Observed Groundwater Head (mAHD)	Residual (m)
72	76	5

Note that the calibration of the groundwater flow model is non-unique. By varying both the recharge and hydraulic conductivity of the model by the same ratio, essentially the same groundwater flow field and calibration against site data can be obtained. This non-uniqueness of modelling solution is frequently encountered where no flow or other observation data is available. Non-uniqueness is dealt with by considering two sets of hydraulic conductivity and recharge values in the impact modelling.

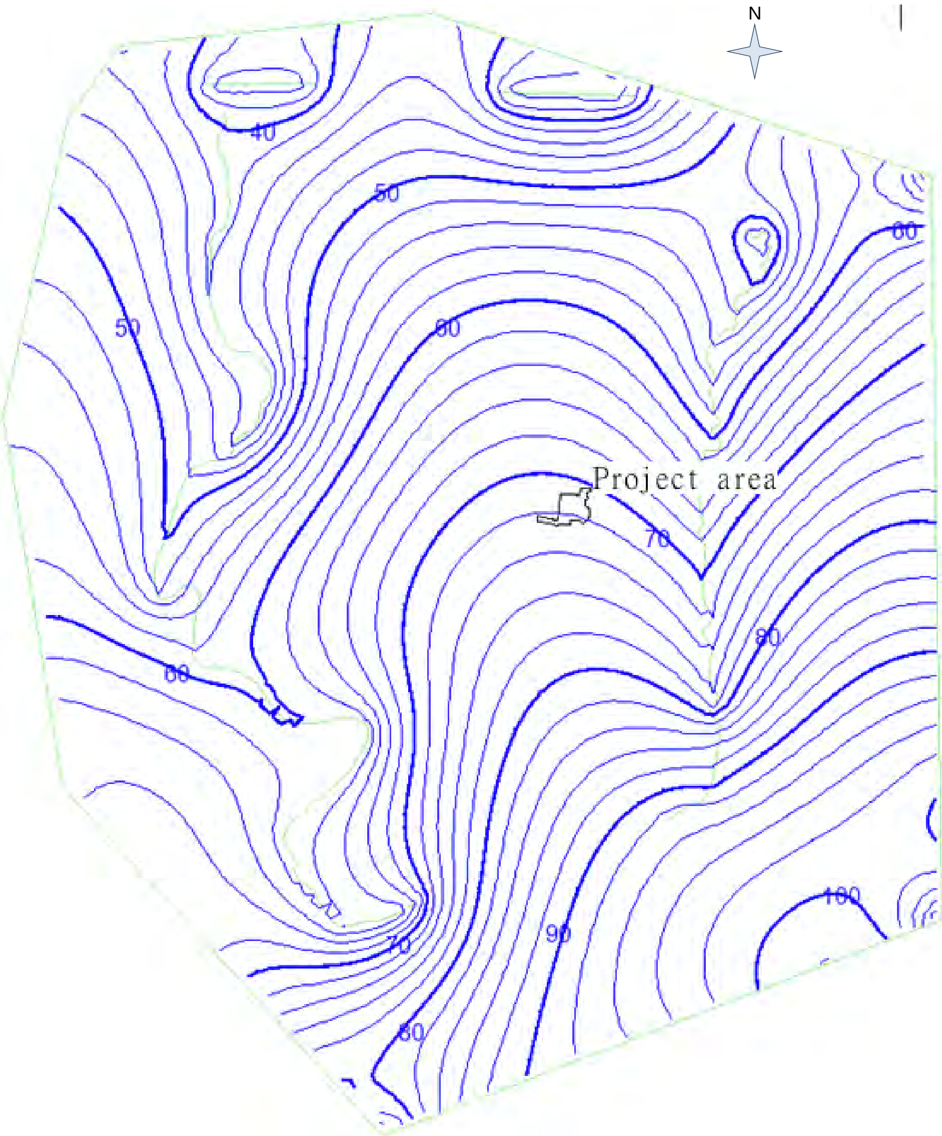


Figure 14: Predictive Model Steady State (Pre-Mining Groundwater Levels). The model domain is approximately 20 × 25 km.

5.6 Impact analysis

Due to the recognised non-unique nature of the calibrated model, two impact models (Scenario A and Scenario B) are run. This is essentially sensitivity analysis on model predictions; varying parameters within a credible range and observing the impact on predictions. The two impact models are:

- Scenario A: Low hydraulic conductivity, using a value of 1.7 Ĭ 10^{-4} m/d for the Bringelly Shale
- Scenario B: High hydraulic conductivity, using a value of 1 Ĭ 10^{-3} m/d for the Bringelly Shale

Note that for the two cases the recharge is varied in ratio with the hydraulic conductivity to yield essentially the same groundwater contours as shown in Figure 14

For the impact analysis a period of 10 years with the pit at the maximum depth of 30 m (60 m AHD) was modelled. In reality the pit will deepen over a number of years.

5.6.1 Groundwater drawdown and pit inflow

An estimation of the area of impact was undertaken on groundwater drawdown due to the pit dewatering at the final extent of the pit excavation. The area of impact was calculated as being the zone of groundwater drawdown of 5 m or greater (taken from initial pre-mining groundwater level) at cessation of mining.

The results are presented in Table 19 and can be summarised as follows (assumed to be at cessation of operation):

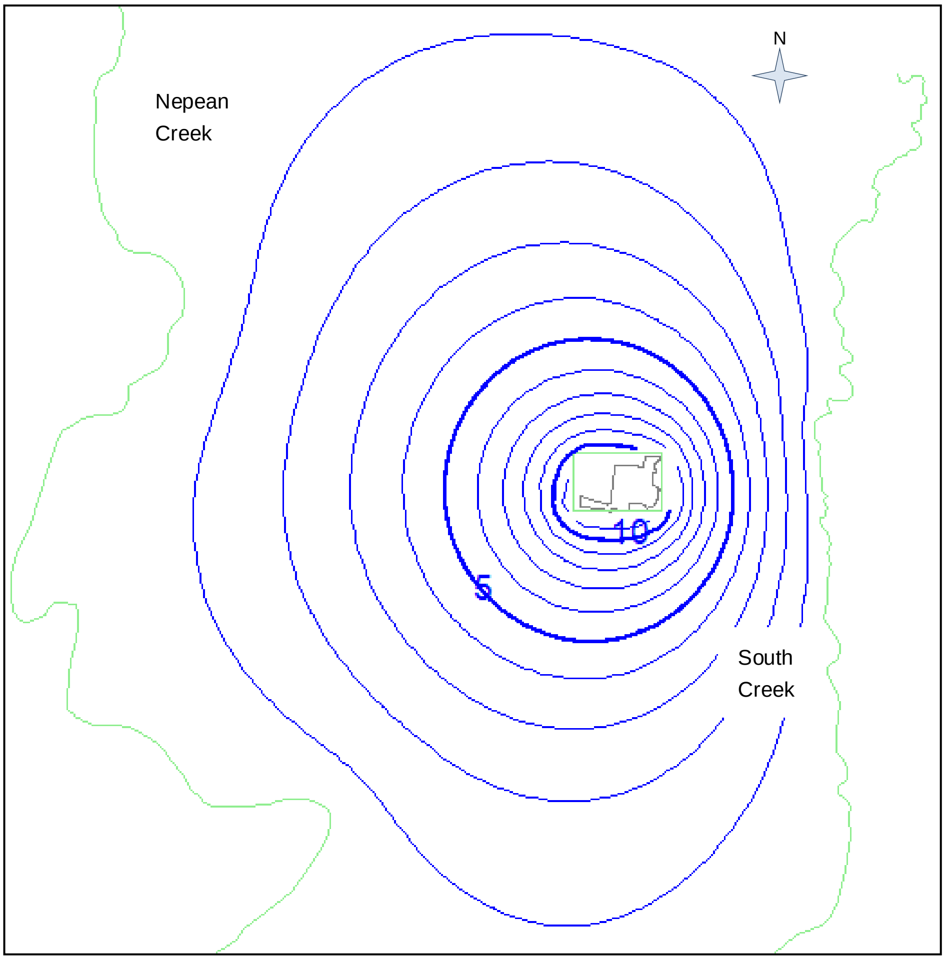
- Scenario A: Predictive modelled "*Low hydraulic conductivity*" zone of groundwater drawdown was calculated to be less than 1 m of drawdown. This drawdown level is too low to be displayed by the AnAqSim software. The calculated pit inflow was approximately 0.1 L/s.
- Scenario B: Predictive modelled "*High hydraulic conductivity*" zone of groundwater drawdown was calculated as being up to approximately 1.5 km from the pit shell. The calculated pit inflow is approximately 1.0 L/s.

Table 19: Modelling outcomes

Scenario	Characteristics	Max radius of influence (>5 m)	Modelled pit Inflow
Scenario A	Transient, Low hydraulic conductivity, Recharge rate = 0.08 mm/y	0 m	0.1 L/s
Scenario B	Transient, High hydraulic conductivity, Recharge rate = 14 mm/y	1.5 km	1.0 L/s

The low hydraulic conductivity / low recharge model (Scenario A) shows very small amounts of water flowing to the pit and essentially negligible impact on the groundwater level in the vicinity.

The high hydraulic conductivity / high recharge model (Scenario B) shown in Figure 15 has drawdown extending some kilometres from the pit. The area covered by a drawdown of 5 m or more is ellipsoid with a maximum extent some 2 km to the west of the pit.



Notes: The drawdown contours have an increment of 1 m. The green lines represent the Nepean River (West) and the South Creek (East). The green box represents the pit area.

Figure 15: Scenario B - High End of Predictive Model Zone of Long Term Affected Area *(10 years of operation).*

6.0 GROUNDWATER IMPACT ASSESSMENT

The groundwater impact assessment in this report focuses on the impact and risks arising from the continuation and expansion of the existing quarry (refer to the Project description in Section 1 of this report). The current Bringelly quarry operations already have existing environmental approvals.

The surface water resources, ecological values, biodiversity and their assessment are discussed in separate technical reports prepared for Boral (refer to the main EIS report and the related appendices; Hyder Consulting, 2013).

The impact assessment methodology is presented in Section 2.4 of this report. The assessment of groundwater vulnerability is discussed in Section 4.6.7.

The key impacts of the Project on the groundwater regime during quarry operations are described as follows:

6.1.1 Impact on groundwater levels and flow

The impact of the proposed Project on groundwater levels is expected to be localised, and limited mainly to the vicinity of the mine operations. There will be no impact to groundwater flow system when the excavation depth of the quarry pit extension is above the groundwater levels.

An analytical groundwater model was developed to assess potential changes to groundwater heads due to the proposed Project and total groundwater inflows to the final quarry pit. Groundwater withdrawn from open cut quarrying is predicted to have a localised impact surrounding the quarry operations. The low hydraulic conductivity of the water-bearing formations (Bringelly Shale) limits the areal extent of impact. The two predictive model runs show two extremes of the potential impact of pit deepening. The low hydraulic conductivity case (Scenario A) has minimal inflow and essentially no impact on groundwater levels. The high hydraulic conductivity case (Scenario B) permits the influence of the pit to extend beyond 2 km with an estimated inflow of 1 L/s after 10 years of maximum drawdown. Interpretation of the impact model results, combined with site information and the conceptual model suggests that the likely impact will lie between these results. With local surface water feature essentially isolated, above the groundwater table, any impacts from pit deepening are likely to be sufficiently small to be unnoticeable.

The total groundwater inflow to the final quarry pit during the Project was estimated using an analytical analysis methodology. The study indicated that the Project will generate low volumes of seepage from the Bringelly Shale. The modelled total groundwater inflow to the final quarry pit is estimated to range between 0.1 L/s and 1 L/s with a likely inflow of 0.1 L/s (Scenario A). The estimated inflow rates are based on conservative assumptions that the base of final open pit quarry (30 mbgl) is the level of dewatering across the mine pit and a groundwater level across the site is at 76 mAHD (the highest groundwater level observed in this study). Quarrying activities are proposed to be undertaken on a campaign basis with two months (44 working days) per campaign and up to three campaigns per year (refer to Section 1); therefore, the likely annual inflow is 1.5 ML/year (Scenario A) at the final stage of the pit excavation. If there is water ponding in the pit during the time quarrying ceases then groundwater may actually be recharged during this time and groundwater withdrawn during quarrying is recharged during the time the pit is allowed to fill. It is envisaged that the actual groundwater loss per year during the quarry expansion is less than the estimated annual inflows based on a conservative modelling approach.

The predictive modelling results indicated a negligible change in groundwater regional flow direction as a result of the Project activities. It is not envisaged that the groundwater seepage into the open cut quarry areas could potentially induce groundwater flow from neighbouring strata (from the underlying sandstone aquifers).

6.1.2 Potential impact on surface water systems

There is no measureable groundwater impact expected on the surface water system within and in the vicinity of the Project site as a result of the dewatering activities. The assessment of potential impact of released surface water from dams to Thompsons Creek is not included in this GWIA report (please refer to the Surface Water chapter of the EIS for information).

The surface water conceptualisation (refer to Section 4.3) was assessed as part of the EIS study. Thompsons Creek is fed from rural, residential and urban drainage and demonstrates poor water quality. Bardwell's Gully, a drainage channel on the site's northern boundary, flows north under Greendale Road and into Thompsons Creek.

The depth to groundwater level is generally observed at GW01 to GW03 in the Project site as being 10 mbgs to 26 mbgs. Available information suggests the water table lies well below the base of the Thompsons Creek and Barwell's Gully and does not intersect these surface drainage lines. This suggests the groundwater does not provide baseflow to the surface water within and in the vicinity of the Project site. It is envisaged that the pit dewatering will not have impact on Thompsons Creek and Barwell's Gully.

The groundwater vulnerability mapping indicated that South Creek is a GDE category "Reliant on surface expression of groundwater" (NSW Natural Resource Atlas, accessed June 2013) and the baseflow condition is expected for South Creek. Increased salinity close to watercourses and drainage lines has been observed, probably reflecting discharge of deep groundwater from the Bringelly Shale. Pressure reductions from open cut quarrying are predicted to have a localised impact surrounding the quarry operations (refer to Section 5). The modelled drawdown does not extend to the South Creek in Scenario A and is less than 0.2 m at South Creek in Scenario B; therefore, the impact on this receptor is considered to be low.

6.1.3 Impact on groundwater quality

There is the potential for spills and contamination by metals and hydrocarbons from the machinery, waste disposal, waste oil used in maintenance of equipment and fuel storage areas; however adequate bunding and immediate clean-up of spills which is standard practice and/or a legislated requirement at the Project site, should prevent contamination of shallow strata and subsequent leakage to the groundwater system.

6.1.4 Impacts on registered bores

There is no registered groundwater bore within the Project site (refer to Section 4.6.5). Based on the extent of the predicted drawdown in the Bringelly Shale formation associated with the Project, no private groundwater users have been identified as being affected or potentially affected by the Project.

6.1.5 Impact on groundwater dependent ecosystems

There are no identified "high priority" Groundwater Dependent Ecosystems (GDEs) within or surrounding the Project Area. Within the Project site, there are no river base flows, no karst or cave ecosystems, no known springs that are fed by groundwater around which groundwater dependent ecosystems have developed. No GDEs category "Subterranean" were identified within the Project site based on information from the Australian National Atlas of GDEs.

Results of the search for groundwater dependent ecosystems from the National Atlas of GDEs indicated the following GDEs Category "Reliant on subsurface groundwater – vegetation"

- Cumberland Shale Hills Woodland
- Cumberland Shale Plains Woodland
- Cumberland River Flat Forest

These woodlands are likely to be supported by localised perched water near the surface or rainfall. The likelihood of this receptor being impacted because of the loss of quantity of deeper groundwater in Bringelly Shale (10 to 26 mbgs) due to quarry operations is low as the drawdown caused by the Project is limited and that the slight lowering in groundwater table is not likely to stress the woodland. Where terrestrial ecosystems (vegetation) are rainfall dependant and not connected to the groundwater system, the quarrying and associated dewatering would have no impact on this receptor. The proposed quarry expansion has been designed to target the required resource, whilst avoiding significant vegetation, flood prone land, and environmentally sensitive areas such as creek lines, with a setback to Thompsons Creek proposed at a minimum of 40 metres.

It is envisaged that the baseflow in South Creek is not affected by the potential groundwater drawdown at the quarry pit extention (refer to Section 6.1.2); therefore, any GDE that may occur in the South Creek is not impacted by the proposed Project.

The ecological values and comprehensive biodiversity assessment are discussed in separate technical reports prepared for Boral (Hyder Consulting, 2013). Please refer to the Biodiversity study technical report for the extent of the vegetation communities and the discussion in relation to potential impact on the ecosystems and biodiversity.

6.1.6 Post-operation recovery of groundwater levels

During the post-operation stage, the groundwater will slowly enter the open pit and eventually an equilibrium water level will be reached over time. It is anticipated that the surface water runoff will fill the open pit at the cessation of operations and the pit water may represent a source of fresh water recharging the local groundwater if the pit water level is higher than the groundwater level. It is likely that no long term impact on post operation groundwater levels would be observed at any significant distance from the pit.

6.2 Results of risk analysis

The groundwater impact assessment described above indicates that the proposed Project does not pose a high risk to the groundwater regime for the following reasons:

- Interpretation of the impact model results, combined with site information of the local surface water feature essentially isolated above the groundwater level, any potential impacts from the quarry pit deepening and related drawdown are likely to be small to be unnoticeable.
- As the aquifers around the Project area are very low yielding and of low quality, there is currently no groundwater source development within the Project site. The potential for future development of these groundwater sources is minimal, therefore, the identified risks to the groundwater source are considered to be low. Based on the available information, there are no registered bores within the Project site. There are no registered bores located within the modelled zone of drawdown (one-meter drawdown).
- There are no high priority GDEs springs within the Project site. The quarry operation will therefore not be expected to impact on high priority GDE springs. The National GDE Atlas lists South Creek as a GDE (category ‘Reliant on surface expression of groundwater’). Groundwater withdrawal from open cut quarrying is predicted to have no impact to South Creek.

To address the potential groundwater impacts as a result of the Project activities, Boral will adopt a combination of preventative actions and management options to reduce the likelihood of adverse impacts occurring and to mitigate those risks. Management and mitigation measures are summarised in Table 19 and Section 6.3. Details of the groundwater impact assessment approach are included in Appendix A and Section 2.

Due to this low risk, limited monitoring of groundwater levels and quality will be required at the Project site. However, a monitoring program is required to confirm the conclusion reached that the risk to the groundwater regime is low. A monitoring program is therefore discussed in Section 7 as a result of this assessment.

A residual risk is the risk that remains after efforts have been made to manage and mitigate it as low as reasonably practicable. After a risk assessment, a residual risk is estimated based on the assumption that the management plan and mitigation measures are effective.

The findings of the risk assessment indicate that the risks associated with groundwater in the Study Area can be mitigated as described in the risk register (Appendix A). Residual risks are considered as ‘low’ in the risk analysis after efficient implementation of management and mitigation measures are implemented (refer to Section 6.3 and Appendix A).

6.3 Management and mitigation measures

Based on the results of this study, the following management measures are recommended:

- Boral will engage a regular (biannual) water quality sampling and groundwater level monitoring program in order to establish seasonal trend records of water quality and identify outliers in any key parameters.
  - Depth to groundwater will be measured and reported during each monitoring event. Field physico-chemical measurements of groundwater including EC, pH, temperature and dissolved oxygen should be collected during purging and sampling using a calibrated water quality meter. Groundwater samples should be collected and analysed at a NATA accredited laboratory for EC, pH, TDS, major cations (Na, K, Ca, Mg) and major anions (Cl, SO_4, alkalinity).
  - Trigger levels, regarding declines in groundwater levels and the degradation of groundwater quality, will be established to manage the potential impacts as part of the Project environmental management plan. Where monitoring results indicate levels in excess of the trigger values, an investigation appropriate for the situation will be conducted to assess the need to implement management/mitigation/remedial measures.

- The monitoring and exploration wells are designed, constructed and decommissioned to limit the risk of interaction between aquifers/saturated zones according to the Australian guidelines/standards.
- Fuel and chemical storages will be constructed and adequately bunded to the relevant Australian Standard. Accurate records of oil volumes, purchased, used, disposed, and recycled will be maintained. Spill containment procedures will be implemented to prevent migration and exposure of chemicals. Boral will ensure correct protocols regarding cleaning up of spills or leaks. Spill cleanup kits will be in accordance with Australian Standards (AS1940 and AS3780) and will be kept on site. Any significant leaks or spills of hazardous materials will be cleaned up according to appropriate emergency clean-up operations. Immediate clean-up of spills, which is standard practice and/or a legislated requirement at mine sites, will prevent contamination of shallow strata and subsequent leakage to the groundwater system.
- The proposed rehabilitation management and monitoring plans will be reviewed and altered as necessary.

7.0 LICENSING REQUIREMENTS

The *Water Management Act 2000* (WMA 2000) provides for four types of approvals: Water use approval, Water management work approval, Controlled activity approval and Aquifer interference activity approval. The Aquifer interference activity approval authorises the holder to conduct activities that affect an aquifer such as approval for activities that intersect groundwater, other than a water supply bore, for up to 10 years.

Aquifer interference licensing corresponds to the volume of water extracted from a water source as part of an aquifer interference activity. This includes induced leakage from an aquifer source to another as a result of groundwater extraction or any taking of water directly related to the activity being undertaken. The activity being undertaken requires aquifer interference approval.

The Aquifer Interference Policy requires new mining and petroleum exploration activities that take more than 3 ML/year from groundwater sources to hold a water access licence. As discussed in Section 6.1.1, the likely annual inflow is 1.5 ML/year based on results of a conservative modelling approach for Scenario A at the final stage of the pit excavation. If there is water ponding in the pit during the time quarrying ceases then the pit water may represent a source of water recharging the local groundwater if the water level is higher than the groundwater level. It is envisaged that the actual groundwater loss per year during the quarry expansion is less than the modelled annual inflows; therefore, a water access licence may not be required.

Water Sharing Plans (WSPs) are statutory instruments created under the WMA 2000 to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. WSPs also set the allocations for Water Access Licence (WAL) holders to draw water from particular sources within a WSP area, such as rivers, lakes and groundwater sources. In addition, WSPs set the water trading rules and procedures within the regulated water source, and the mechanisms for the controlled release of unassigned water (if any).

The WSP that is relevant to the Project is the *Greater Metropolitan Region Groundwater Sources* plan was made on 2 March 2011 and commenced on 1 July 2011 This water sharing plan is due for extension/replacement in July 2021. The Project site is located within the '*Sydney Basin Central Groundwater Source'*. New water access licences may be considered in this area if it is a local water utility, major water utility, domestic and stock and town water supply. Granting of water access licences may also be considered as part of a controlled allocation order made in relation to any unassigned water in this water source.

Boral does not currently extract water from the Upper South Creek catchment and will not require a license to meet proposed water demands to support quarry expansion works. All current and on-site water demands will be met by a combination of potable water, on-site water and water imported from industrial recycling schemes; therefore, the proposal will operate in accordance with the requirements of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011. Boral's Dam 6, located to the east and south of the brick manufacturing facility is allowed to discharge into Thompsons Creek under Boral's Environmental Protection Licence (EPL Ref 1808).

8.0 LIMITATIONS

Your attention is drawn to the document - "Limitations", which is included in Appendix E of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

9.0 REFERENCES

Australian and New Zealand Environment Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) 2000. Australian Water Quality Guidelines for Fresh and Marine Waters, Canberra.

Bates, R G., 1973. Determination of pH: theory and practice. Wiley, 1973

Bureau of Meteorology, 2013. Climatic Averages Australia, Bureau of Meteorology website [http://www.bom.gov.au/climate/averages]

Bureau of Meteorology, 2013. NSW Groundwater Dependent Ecosystems Atlas Map (http://www.bom.gov.au/water/groundwater/gde/)

Department of Infrastructure, Planning and Natural Resources (2003). Salinity Potential in Western Sydney. NSW Department of Infrastructure and Natural Resources (now OEH), March 2003.

Environmental Resources Management Australia, 2009. Light Horse Bussiness Center, Eastern Creek, Australia – Groundwater Assessment. Ref No 0071234RP01, August 2008

Fetter C W, 2001. Applied Hydrogeology. Fourth Edition. Prentice-Hall, Upper Saddle River, New Jersey, 598 p

Golder Associated Pty Ltd., 2013a. Site visit reports and recommendations for field program. Report No 137626001-001-R-RevA, prepared for Boral Pty Limited.

Golder Associated Pty Ltd., 2013a. Boral Bringelly Groundwater Assessment Factual Report. Report No 137626001-004-R-RevA, prepared for Boral Pty Limited.

Golder Associates (1979) Report to metropolitan waste disposal authority on preliminary site investigation for proposed extension to disposal area, Liquid Waste Disposal Site, Stage 8, Castlereagh NSW.

Mitchell, 2000. Salinity Hazard Mapping and Concept Modelling on the Cumberland Plain. Final Report, Ground Truth Consultants 2000.

National Health and Medical Research Council and Natural Resource Management Ministerial Council (NHMRC & NRMMC) 2004, Australian Drinking Water Guidelines ADWG 2004

New South Wales Government, NSW Legislation, 2011. Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (Current version for 1 October 2011 to date (accessed 13 June 2013)

NSW Government, Trade and Investment Resource and Energy, Division of Resources and Energy website, http://www.resources.nsw.gov.au/geological/overview/regional/sedimentary-basins/sydbasin, (accessed June 2013)

New South Wales Natural Resource Atlas, Groundwater Vulnerability Map (http://www.nratlas.nsw.gov.au/, accessed in June 2013)

New South Wales Department of Primary Industries, Office of Water, 2011. Greater Metropolitan Region Unregulated River Water Sources, Water Sharing Plan 2011.

New South Wales Department of Primary Industries, Office of Water, 2011. Greater Metropolitan Region Groundwater Sources, Water Sharing Plan Background document.

New South Wales Department of Primary Industries, Office of Water, 2011. Greater Metropolitan Region Groundwater Sources, Water Sharing Plan Guide.

New South Wales Department of Primary Industries, Office of Water, 2013. Real time data ï groundwater bores. Access May 2013 (http://realtimedata.water.nsw.gov.au/)

NSW Office of Water, 2013. Climate change and its impacts on water supply and demand in Sydney. http://www.waterforlife.nsw.gov.au/sites/default/files/publication-documents/climatechange_impact_watersupply_summary.pdf

Ian Grey Groundwater Consulting, 2009. Proposed Light Horse Landfill site, Eastern Creek. Detailed hydrogeological investigation and assessment. Ref No BJ07/Rp040 September 2009

Itakura, T. (1999) Transport of organic contaminants through natural clayey soils, PhD thesis, University of Sydney.

Pells Consulting, 2011. Report on the water levels of Thirlmere Lakes. Ref No. P053.L3, October 2011.

Resource Planning Pty Limited, 1991. Environmental Impact Statement for the upgrading of the Bringelly Brick and Paver Manufacturing Plant Greendale Road, Bringelly. Report prepared for Boral Bricks (NSW) Pty Ltd.

Resource Planning Pty Limited, 1993. Further evaluation ï Bringelly Clay/Shale Resources. Report prepared for Boral Bricks (NSW) Pty Limited.

R. W. Corkery & Co Pty Limited, 1984. Geological report on recent diamond drilling undertaken adjacent to the Bringelly Plant. Report prepared for Clark Brick Limited.

William E, 2005. Engineering Performance of Bringelly Shale, University of Sydney. Doctor of Philosophy thesis, 319 pp.

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APPENDIX A

Risk Assessment Process and Results

This appendix includes risk assessment objectives and process and the matrix of the impact significance that was applied to the risk assessment process.

1.1 Risk Assessment Objectives

In this section the potential impacts and risks to local and regional groundwater resources from the Project are assessed using a risk based framework. The risk-based approach allows the potential groundwater related risks associated with proposed mining activities to be considered and classified with respect to multiple evaluation criteria, such that the primary risk-driving activities are identified, prioritised and mitigated accordingly.

The process used to assess the risk of groundwater impacts is described. Potential groundwater impacts are discussed along with the results of the risk assessment. Measures to limit the risks, called risk mitigation measures, are discussed and the risk re-assessed to include the mitigation measures. There are two primary types of risk to be managed for this project:

- The impact of the activities on potential receptors; the potential receptors being:
  - Environmental values, as described in Section 4 of the main groundwater impact assessment report;
  - Surrounding aquifers; and
  - The local communities, recreational areas and activities, activities relying on groundwater and industrial groundwater users.
- The regulatory risks (adherence to applicable legislation)

1.2 Risk Assessment Process

A risk is defined by the Australia/New Zealand Standard for Risk Management (AS/NZSISO 31000:2009) as *the effect of uncertainty on objectives*. It is measured in terms of a combination of the consequences of an event, and the likelihood of an event occurring.

The potential impacts and risks to groundwater and environmental values associated with the Project activities were identified. The potential risks were assessed qualitatively and assigned a risk ranking according to the likelihood of the risk occurring, and the associated consequences, as discussed later in this section of the report.

Likelihood and consequence are defined as:

- The likelihood is the probability for an event to occur;
- The consequence is the effect that the event will have on different receptors or parameters. The consequence can be to human health and safety, to the natural environment and/or to the Projectœs reputation. Consequences can also be financial impacts.

The type of risk assessment carried out for this project is called a qualitative risk assessment because it uses qualitative descriptors to derive a risk rating. Some types of risk can also be assessed quantitatively, particularly financial risks. The matrix of descriptors used to assess the risk consequences is presented in Table A1. The table includes a description of the categories of consequences considered, and a description of the relative magnitude of the consequence for each category. The matrix used to evaluate the risk likelihood is presented in Table A2.

A risk category between one (low, tolerable) and four (critical, least tolerable), according to the matrix, is presented in Table A3. A risk issue assessed as Category 1 (low) is generally considered to be tolerable in its current state, without the need for mitigation actions to reduce the risk. Category 1 risks generally represent risk issues that are either very unlikely to occur, or that would result in a minor or negligible consequence if they do occur. Risk issues assessed as Category 2 to 4 (moderate to critical) may or may not be tolerable but generally require further evaluation of potential contingency actions or mitigation measures required. The risk matrix and risk rating definition are presented in Table A3.

Table A1: Risk Assessment Definitions – Consequences

Consequence Categories		Health and Safety	Natural Environment	Financial
Catastrophic	5	Fatality	Destruction of sensitive environmental features. Severe impact on ecosystem. Regulatory & high level Government intervention/action.	Financial loss in excess of $100 million
Major	4	Permanent disabling injury and/or long term off work	Long term impact of regional significance on sensitive environmental features. Regulatory intervention/action.	Financial loss from $50 to $100 million
Serious	3	Injury requiring medical treatment, time off work and rehabilitation	Short term impact on sensitive environmental features. Triggers regulatory investigation.	Financial loss from $5 to $50 million
Medium	2	Injury requiring medical treatment with no lost time	Impact on fauna, flora and/or habitat, but no negative effects on ecosystems. Requires immediate regulator notification.	Financial loss from $500,000 to $5 million
Minor	1	Minor injury - first aid treatment	Negligible impact on fauna, flora, habitat, aquatic ecosystems or water resources. Incident reporting according to routine protocols.	Financial loss from $0 to $500,000

Table A2: Risk Assessment Definitions - Likelihood

Likelihood Categories		Guidance	Supplementary Guidance
Almost Certain	**A**	Is expected to occur in most circumstances	Occurs daily/weekly
Likely	**B**	Could occur in most circumstances	Occurs monthly
Possible	**C**	Has occurred here or elsewhere	Occurs once a year
Unlikely	**D**	Hasn't occurred yet but could	Occurs once in 10 years
Rare	**E**	Very unlikely, may occur in exceptional circumstances	Occurs once in 100 years

Table A3: Risk Matrix and Risk Tolerance Definition

Likelihood	Consequence				
	1 - Minor	**2 - Medium**	**3 - Serious**	**4 - Major**	**5 - Catastrophic**
A - Almost Certain	Moderate	High	Critical	Critical	Critical
B - Likely	Moderate	High	High	Critical	Critical
C - Possible	Low	Moderate	High	Critical	Critical
D - Unlikely	Low	Low	Moderate	High	Critical
E - Rare	Low	Low	Moderate	High	High

Matrix of Significance of Groundwater Impact

This section presents the matrix of significance for groundwater impact assessment.

Impact Significance Assessment Descriptions of various categories for rating the sensitivity of groundwater resources and magnitude of impact on groundwater resources are presented in Table A4 and Table A5, respectively. The magnitude of an impact on groundwater resources was estimated considering the severity of the impact, extent and duration of the impact. The categories of the sensitivity of the environmental values of groundwater resources were classified based on the groundwater quality and quantity, the size of aquifer, and the groundwater vulnerability. The matrix of significance utilised for the groundwater impact assessment is shown in Table D6. The significance of the groundwater impacts was estimated based on the magnitude of the impact and the sensitivity of resource/receptor.

Table A4: Sensitivity of groundwater resources

Category	Description
High	■ The groundwater has good water quality and quantity. ■ National designated groundwater-dependent ecosystems. ■ Groundwater vulnerability rating: ñHighòor ñModerate to Highò
Moderate	■ Local groundwater supply of moderate water quality and quantity. Water quality is not suitable for human consumption but may be used for other consumptive use. ■ National designated groundwater-dependent ecosystems. ■ Groundwater vulnerability rating: ñModerateòor ñLow to Moderateò
Low	■ Local groundwater supply of limited water quantity, poor water quality unsuitable for general consumptive uses. ■ Groundwater vulnerability rating: ñLow to Moderateòor ñLowò

Table A5: Magnitude of impact on groundwater resources

Category	Description
High	■ Activity likely to have severe negative impact on groundwater resources and/or groundwater-dependent ecosystems. ■ Impact on district groundwater resources (groundwater quality, quantity, aquifer characteristics such as transmissivity, hydraulic conductivity, and storativity). ■ Recovery (if possible) is likely to take up to 25 years.
Moderate	■ Impact on groundwater resources and/or groundwater-dependent ecosystems will be detectable but not severe. ■ Generally occurring within 10 km of impact site. ■ Recovery is likely to take up to 7 years.
Low	■ Impact on groundwater resources and/or groundwater-dependent ecosystems may be detectable but is small and highly unlikely to have any significance. ■ Effects immediate surrounds of impact and extends for up to 2 km radius. ■ Recovery short term up to 3 years.

Table A6: Matrix of significance for groundwater impact assessment

	Sensitivity of Environmental Value		
Magnitude of Impact	**High**	**Moderate**	**Low**
High	**Major**	**High**	**Moderate**
Moderate	**High**	**Moderate**	**Low**
Low	**Moderate**	**Low**	**Negligible**

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			Groundwater Impact Assessment			Risk Assessment						
Risk Issue	Cause	Impact	Magnitude of Impact	Sensitivity of Receptors	Significance of Impact	Consequence	Likelihood	Risk Rating prior to Management and Mitigation measures	Site Specific Control Measures/Mitigation	Consequence (post management/ mitigation)	Likelihood (post management/ mitigation)	Site Specific Risk Rating inclusive of Mitigation and Controls
Leakage of introduced fluids during drilling or contaminated fluid. Leakage/spills of chemicals, hydrocarbons fuels, oils and petroleum products.	Poor design, Construction technique, Poor closure technique; Potential for spills and contamination by metals and hydrocarbons from workshop, waste disposal, machinery and fuel storage areas	Contamination, Non-compliance	Moderate	Low	Low	1	C	Low	Apply the minimum construction requirements for water bores in Australia (National Uniform Drillers Licensing Committee, NUDLC rev.3, 2012); check quality of data regularly, establish a complete operational protocol and data handling system; Fuel and chemical storages to be constructed and adequately bunded to the relevant Australian Standard. Immediate clean-up of spills which is standard practice and/or a legislated requirements at mine sites to prevent contamination of shallow strata and subsequent leakage to the groundwater system. Spill cleanup kits in accordance with Australian Standards (AS1940 and AS3780) will be kept on site.	2	D	Low
Degradation of groundwater quality	Potential contaminants entering the pit and the groundwater system	Change of water quality. Unavailable resource / reduced use of the water source.	High	Low	Moderate	2	C	Moderate	Use of resource is already minimal; Immediate clean-up of spills should prevent contamination entering the open pit water and subsequent leakage to the groundwater system. Revisit proposed rehabilitation management and monitoring plans and alter as necessary. The mobility of metals in the groundwater system within the Project site is envisaged to be limited due to the low hydraulic conductivity and the presence of clays, which has a high capacity for adsorption and/or exchange of metals in groundwater.	2	D	Low
Excessive groundwater drawdown	Dewatering of the quarry pit lowers the groundwater levels of the Bringelly Shale formation	Change of regional groundwater flow direction	Low	Low	Negligible	1	D	Low	Maintain monitoring and management of dewatering volumes at the quarry pit to meet the requirements of 'NSW Aquifer Interference Policy' (2012).	1	D	Low
Excessive groundwater drawdown	Dewatering of the quarry pit lowers the groundwater level of the Bringelly Shale formation and to the lesser extent, the perched water	Change of groundwater levels in the vicinity of the quarry operations.	Moderate	Low	Low	1	D	Low	The volume of water taken as a result of Project activities was modelled in the EIS study prior to project approval and will be measured and reported. Maintain monitoring and management of dewatering volumes at the quarry pit to meet the requirements of 'NSW Aquifer Interference Policy' (2012).	1	D	Low
		Degradation of the resource (limit supply) to other groundwater users / abstractors;	Low	Moderate	Low	1	D	Low	Groundwater in Bringelly Shale within the Project Area is a poor yielding resource. There are no registered groundwater users within the Project site . Maintain monitoring and management program.	1	E	Low
		Impact to nearby creeks or disconnection of ephemeral streams	Low	Moderate	Low	1	D	Low	Due to depth of encountered groundwater, Thompson Creek and Barwell Gully are not likely groundwater dependent. The groundwater level changes due to the Project do not impact South Creek.	1	D	Low
		Reduce availability of groundwater for GDEs (vegetation)	Moderate	Moderate	Moderate	2	D	Low	The likelihood of this receptor being impacted because of the loss of quantity of deeper groundwater in Bringelly Shale due to quarry operations is low as the root zones of the woodland would be significantly shallower than the expected level in the deeper groundwater system in Bringelly Shale unit (10 to 39 mbgs). Where terrestrial ecosystems (vegetation) are rainfall dependant and not connected to the groundwater system, the quarrying and associated dewatering would have no impact on this receptor. The proposed quarry expansion has been designed to target the required resource, whilst avoiding significant vegetation, flood prone land, and environmentally sensitive areas such as creek lines, with a setback to Thompsons Creek proposed at a minimum of 40 metres. Maintain effective monitoring and management programs.	1	D	Low
		Reduce availability of groundwater for surface water (South Creek)	Low	Moderate	Low	1	D	Low	There is no 'high priority' GDEs spring in the Project site; South Creek is located within the zone of modelled drawdown for the worst case scenario; Management strategy will be to monitor the changes in groundwater level and water quality using the water bore monitoring network. Trigger levels, regarding declines in groundwater levels and the degradation of groundwater quality will be established to manage the potential impacts. Where monitoring results indicate levels in excess of the trigger values, an investigation appropriate for the situation will be conducted to assess the need to implement additional monitoring and management/mitigation measures.	1	D	Low
Excessive groundwater drawdown	Groundwater withdrawn is non-conformance of the operating rules of the relevant Water Sharing Plan (WSP)	Non-conformance of the operating rules of the relevant legislations/policy	Moderate	Low	Low	2	D	Low	The volume of dewatering water taken as a result of quarry activities was modelled in this study prior to project approval and will be measured and reported. Maintain monitoring and management of d dewatering volumes at open pits to meet the requirements of 'NSW Aquifer Interference Policy' (2012).	1	D	Low
Post-operation groundwater levels	Recovery of groundwater levels is inconsistent with post-operation recovery plan	Change in equilibrium water table levels.	Moderate	Low	Low	1	C	Low	Revisit proposed rehabilitation management and monitoring plans and alter as necessary. Use of resource is already minimal	1	D	Low
	Potential contaminants entering the pit and the groundwater system	Change of water quality. Unavailable resource / reduced use of the water source.	High	Low	Moderate	2	C	Moderate	Use of resource is already minimal; Immediate clean-up of spills should prevent contamination entering the open pit water and subsequent leakage to the groundwater system. Revisit proposed rehabilitation management and monitoring plans and alter as necessary. The mobility of metals in the groundwater system within the Project site is envisaged to be limited due to the low hydraulic conductivity and the presence of clays, which has a high capacity for adsorption and/or exchange of metals in groundwater.	2	D	Low

APPENDIX B

Water Sharing Plan - Rules for the Sydney Basin Central Groundwater Source

Rules summary sheet for the Sydney Basin Central Groundwater Source

Water sharing plan	
Plan	Greater Metropolitan Region groundwater sources
Plan commencement date	1 July 2011
Term of the plan	10 years
Water sharing rules	These rules apply to groundwater that is contained within aquifers beneath the respective groundwater sources shown on the plan's map. The region is bounded by the Hawkesbury River catchment to the north and west and the Shoalhaven River catchment to the south and south west. The region also includes the groundwater of the Illawarra and metropolitan Sydney.

Rules Summary **The following rules are a guide only. For more information about your actual licence conditions, please contact licensing staff from the NSW Office of Water in Parramatta, phone (02) 8838 7531.**	
Access rules	
Rules for granting of access licences.	
Granting of access licences may be considered for the following:	• Local water utility, major water utility, domestic and stock, and town water supply *These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2004.* • Aquifer (Aboriginal cultural), up to 10ML/yr • Commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.
Rules for managing water allocation accounts	
Carryover	• Up to 10% entitlement allowed. *Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.*

Rules for managing access licences	
Managing surface and groundwater connectivity	• From year 7 of the plan, for areas adjoining unregulated water sources (i.e. rivers and creeks), **existing** works within 40 metres of the top of the high bank of a river or creek, **except existing** works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish: o the flow class of the river established under the water sharing plan for the corresponding unregulated water source, or o in the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river. • These distances and rules may be varied for an applicant if the work is drilled into the underlying parent material and the slotted intervals of the works commences deeper than 30 metres or no minimal impact on base flows in the stream can be demonstrated. • For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.
Rules for granting and amending water supply works approvals	
To minimise interference between neighbouring water supply works	No water supply works (bores) to be granted or amended within the following distances of existing bores: • 400m from an aquifer access licence bore on another landholding, or • 100m from a basic landholder rights bore on another landholding, or • 50m from a property boundary (unless written consent from neighbour), or • 1,000m from a local or major water utility bore, or • 200m from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water). *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
To protect bores located near contamination	No water supply works (bores) are to be granted or amended within: • 250m of contamination as identified within the plan, or • 250m to 500m of contamination as identified within the plan unless no drawdown of water will occur within 250m of the contamination source, • a distance greater than 500m of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
To protect water quality	To minimise the impact on water quality from saline interception in the shale aquifers overlying Sydney basin sandstone, the bore being used to take groundwater must be constructed with pressure cement to seal off the shale aquifer as specified by the Minister.

To protect bores located near sensitive environmental areas	No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan: • 100m for bores used solely for extracting basic landholder rights, or • 200m for bores used for all other access licences. The above distance restrictions for the location of works from high priority GDEs do not apply where the GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using an impermeable pressure cement plug from the surface of the land to a minimum depth of 30m. No water supply works (bores) to be granted or amended within the following distances from these identified features: • 500m of high priority karst environment GDEs, or • a distance greater than 500m of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or • 40m of a river or stream or lagoon (3rd order or above), • 40m of a 1st or 2nd order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30m (30m may be amended if demonstrate minimal impact on base flows in the stream), or • 100m from the top of an escarpment. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
To protect groundwater dependent culturally significant sites	No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan: • 100m for bores used for extracting for basic landholder rights, or • 200m for bores used for all other aquifer access licences *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
Rules for replacement groundwater works	A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister. A replacement bore must be located within: • 20 metres of the existing bore; or • If the existing bore is located within 40 metres of the high bank of a river the replacement bore must be located within: o 20 metres of the existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact Replacement works may be at a greater distance than 20 metres if the Minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem. The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110% of the existing work

Rules for the use of water supply works approvals	
To manage bores located near contaminated sites	The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
To manage the use of bores within restricted distances	The maximum amount of water that can be taken in any one year from an **existing** work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependant culturally significant sites is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
To manage the impacts of extraction	The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.
Limits to the availability of water	
Available Water Determinations (AWDs)	• 100% stock and domestic, local and major utilities and specific purpose access licences • 1ML/unit of share aquifer access licences *AWD for aquifer access licences may be reduced in response to a growth in use.*
Trading rules	
INTO groundwater source	Not permitted.
WITHIN groundwater source	Permitted subject to local impact assessment.
Conversion to another category of access licence	Not permitted.

More information about the macro planning process for the Greater Metropolitan Region groundwater sources is available at: www.water.nsw.gov.au.

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APPENDIX C

Bore logs and monitoring bore construction details (GW01 to GW04)

REPORT OF BOREHOLE: GW01

Golder Associates

SHEET: 1 OF 5

CLIENT: Boral	COORDS: 289202.00 m E 6242112.10 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 87.60 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 10/4/13
JOB NO: 137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 1/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB			0	87.60					Silty CLAY high plasticity, pale brown, trace organics, dry			
HQ3			3	3.00 84.60	3.00-3.50 m C 3.00-3.50 m				MUDSTONE / SILTSTONE fine grained, layered, pale grey with iron staining, low strength, highly weathered			
				3.50 84.10	3.50-5.00 m C 3.50-5.00 m				MUDSTONE fine grained, pale grey / dark grey and black with orange layers, low strength, highly weathered			
			5		5.00-6.50 m C 5.00-6.50 m							
				6.50 81.10	6.50-8.00 m C 6.50-8.00 m				SILTSTONE fine grained, pale grey, low strength, highly weathered, heavily fractured			
				6.90 80.70					SILTSTONE fine grained, layered, pale grey to dark grey wiht orange staining, low strength, highly weathered			
			8		8.00-9.50 m C 8.00-9.50 m							
			9	9.00 78.60					heavily fractured with clay in fractures			
					9.50-11.00 m C 9.50-10.00 m							
			10	10.00								

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

REPORT OF BOREHOLE: GW01

CLIENT:	Boral	COORDS:	289202.00 m E 6242112.10 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	87.60 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 10/4/13
JOB NO:	137626001	HOLE DEPTH:	40.00 m	CHECKED: SK	DATE: 1/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HQ3			10	77.60	9.50-11.00 m				MUDSTONE fine grained, layered, dark grey to black, low strength, moderately weathered			
			11		11.00-12.50 m C 11.00-12.50 m							
			12		12.50-14.00 m C 12.50-14.00 m							
			13	*12.90* 74.70					SANDSTONE medium grained, layered, pale grey, medium strength, moderately weathered			
				13.35 74.25					MUDSTONE fine grained, layered, dark grey, medium strength, moderately weathered, more fractures			
			14		14.00-15.50 m C 14.00-15.50 m							
			15		15.50-17.00 m C 15.50-17.00 m							
			16									
			17		17.00-18.00 m C 17.00-18.00 m							
			18		18.00-19.50 m C 18.00-19.50 m							
			19		19.50-20.00 m C 19.50-20.00 m							
			20	*20.00*								

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REPORT OF BOREHOLE: GW01

CLIENT: Boral
PROJECT: Bringelly Groundwater Assessment
LOCATION:
JOB NO: 137626001

COORDS: 289202.00 m E 6242112.10 m N MGA94 56
SURFACE RL: 87.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 40.00 m

DRILL RIG:
CONTRACTOR: Statewide Drilling
LOGGED: AB DATE: 10/4/13
CHECKED: SK DATE: 1/5/13

Drilling: METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HQ3			20	67.60	20.00-21.50 m C 20.00-21.50 m				MUDSTONE fine grained, layered, dark grey, medium strength, moderately weathered, more fractures			
			21	20.75 66.85					LAMINITE (sandstone, siltstone, mudstone), pale grey to black			
			22	21.35 66.25	21.50-23.00 m C 21.50-23.00 m				MUDSTONE fine grained, layered, medium strength, slightly weathered			
			23, 24	23.60 64.00	23.00-24.50 m C 23.00-24.50 m				LAMINITE (mudstone, sandstone and siltstone), fine to medium grained, pale grey, dark grey and black, medium to high strength, slightly weathered			
			25	25.00 62.60	24.50-26.00 m C 24.50-26.00 m				SILTSTONE fine grained, layered, pale grey, high strength, slightly weathered to fresh			
				25.85					MUDSTONE fine grained, layered, black, high strength, slightly weathered to fresh			
			26	26.00 61.60	26.00-27.50 m C 26.00-27.50 m				SILTSTONE fine grained, layered, pale grey, high strength, slightly weathered to fresh			
			27, 28	27.20 60.40	27.50-29.00 m C 27.50-29.00 m				MUDSTONE fine grained, layered			
			29	28.75 58.85	29.00-30.50 m				SANDSTONE medium grained, layered, pale grey, high strength, slightly weathered to fresh			
			30	29.35 58.25					LAMINITE (mudstone, siltstone, sandstone), fine to medium grained, layered, pale grey / dark grey and black, medium to high strength, slightly weathered to fresh			

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for hydrogeological purposes only, without attempt to assess geotechnical properties or possible contamination. Any reference to geotechnical properties or potential contamination are for information only and do not necessarily indicate the presence or absence of the properties stated.

Golder Associates

REPORT OF BOREHOLE: GW01

CLIENT:	Boral	COORDS: 289202.00 m E 6242112.10 m N MGA94 56	DRILL RIG:
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 87.60 m DATUM: AHD	CONTRACTOR: Statewide Drilling
LOCATION:		INCLINATION: -90°	LOGGED: AB DATE: 10/4/13
JOB NO:	137626001	HOLE DEPTH: 40.00 m	CHECKED: SK DATE: 1/5/13

Method: HQ3 (30.00–40.00 m)

DEPTH / RL	SAMPLE OR FIELD TEST	SOIL/ROCK MATERIAL DESCRIPTION	STRUCTURE AND ADDITIONAL OBSERVATIONS
30.00 – 30.25	29.00-30.50 m C 29.00-30.50 m C 29.00-30.50 m		
30.25 / 57.35	30.50-32.00 m C 30.50-32.00 m	MUDSTONE fine grained, layered, dark grey / black	
32.25 / 55.35		LAMINITE (sandstone, siltstone, mudstone), fine to medium grained, layered, pale grey / dark grey and black, high strength, slightly weathered to fresh	
33.50 / 54.10	33.50-35.00 m C 33.50-35.00 m	LAMINITE (mudstone, siltstone, minor sandstone), fine to medium grained, black / dark grey / dark brown and pale grey, high to very high strength, fresh	
35.00 / 52.60	35.00-36.50 m C 35.00-36.50 m	LAMINITE (sandstone, siltstone, mudstone), fine to medium grained, high to very high strength, fresh	
36.00 / 51.60		MUDSTONE (minor siltstone and sandstone), fine grained, amorphous, layered, very high strength, fresh	
36.50 / 51.10	36.50-38.00 m C 36.50-38.00 m	MUDSTONE fine grained, amorphous, black, medium to high strength, slightly weathered to fresh	
37.50 / 50.10		SILTSTONE fine grained, amorphous, dark grey, high strength, fresh	
37.90 – 38.00 / 49.60	38.00-39.50 m C 38.00-39.50 m	MUDSTONE fine grained, amorphous, black, high strength, slightly weathered to fresh	
		MUDSTONE fine grained, black, medium to high strength, slightly to extremely weathered	
38.86 / 48.75		SILTSTONE fine grained, amorphous, dark grey, highly weathered, fresh (layered)	
39.50 / 48.10	39.50-40.00 m C 39.50-40.00 m	MUDSTONE (minor siltstone), fine grained, amorphous, black / dark brown, highly weathered, fresh (layered)	
39.70 / 47.90			
39.95			

Depth scale (metres): 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Column headings: Drilling (METHOD, PENETRATION RESISTANCE, WATER, DEPTH (metres), DEPTH RL); Sampling (SAMPLE OR FIELD TEST, RECOVERED); Field Material Description (GRAPHIC LOG, USC SYMBOL, SOIL/ROCK MATERIAL DESCRIPTION, MOISTURE CONDITION, CONSISTENCY DENSITY, STRUCTURE AND ADDITIONAL OBSERVATIONS)

REPORT OF BOREHOLE: GW01

CLIENT:	Boral	COORDS: 289202.00 m E 6242112.10 m N MGA94 56		DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 87.60 m DATUM: AHD		CONTRACTOR: Statewide Drilling	
LOCATION:		INCLINATION: -90°		LOGGED: AB	DATE: 10/4/13
JOB NO:	137626001	HOLE DEPTH: 40.00 m		CHECKED: SK	DATE: 1/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			40						SANDSTONE (minor siltstone, mudstone), medium grained, amorphous, pale grey, highly weathered, fresh (layered)			
									MUDSTONE (minor siltstone), fine grained, amorphous, black / dark brown, highly weathered, fresh (layered)			
									END OF BOREHOLE @ 40.00 m Monitoring well installed			
			41									
			42									
			43									
			44									
			45									
			46									
			47									
			48									
			49									
			50									

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REPORT OF STANDPIPE INSTALLATION: GW01

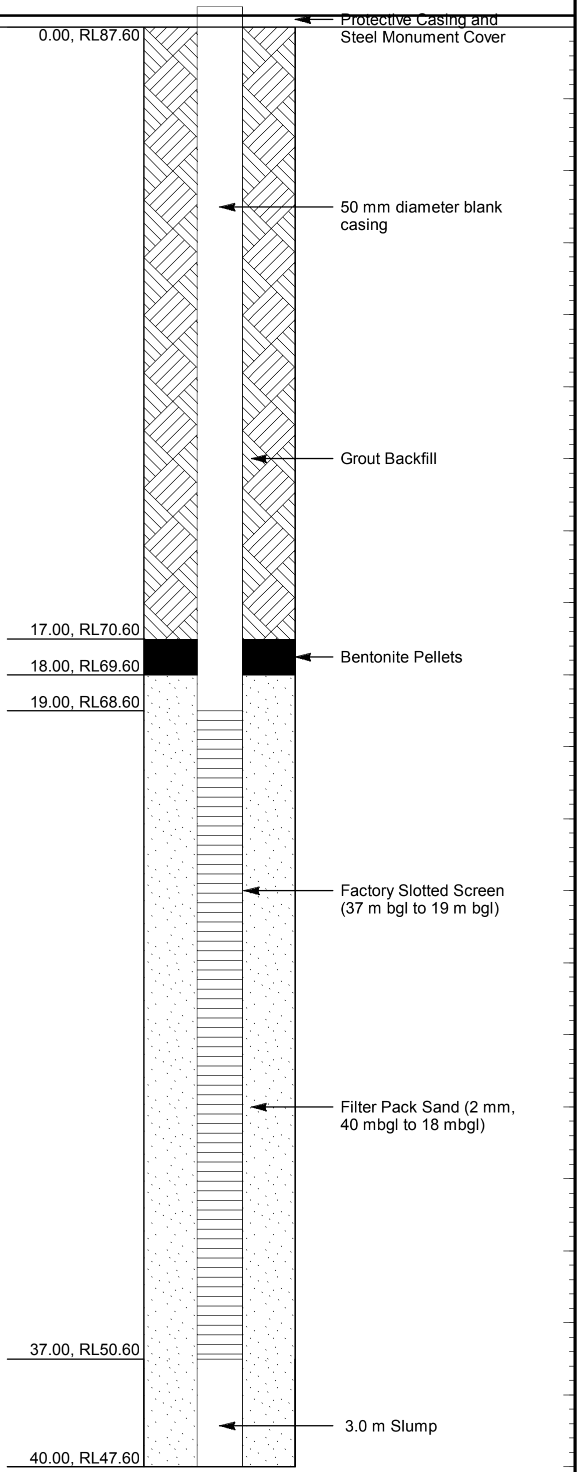
SHEET: 1 OF 1

CLIENT: Boral	COORDS: 289202.00 m E 6242112.10 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 87.60 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 10/4/13
JOB NO: 137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 1/5/13

Drilling | **Field Material Description** | **Instrumentation Details**

METHOD	DEPTH RL	SOIL/ROCK MATERIAL DESCRIPTION
WB		SILTY CLAY
HQ3	3.00	MUDSTONE / SILTSTONE
	3.50	MUDSTONE
	6.50	SILTSTONE
		SILTSTONE
	10.00	MUDSTONE
	12.90	SANDSTONE
	13.35	MUDSTONE
	20.00	MUDSTONE
	20.75	LAMINITE
	21.35	MUDSTONE
	23.60	LAMINITE
	25.00	SILTSTONE
	25.85	MUDSTONE
		SILTSTONE
	27.20	MUDSTONE
	28.75	SANDSTONE
	29.35	LAMINITE
	30.25	MUDSTONE
	32.25	LAMINITE
	33.50	LAMINITE
	35.00	LAMINITE
	36.00	MUDSTONE
	36.50	MUDSTONE
	37.50	SILTSTONE
	38.85	MUDSTONE
	39.50	MUDSTONE
		SILTSTONE
		MUDSTONE
		SANDSTONE
		MUDSTONE

END OF BOREHOLE @ 40.00 m
Monitoring well installed



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REPORT OF BOREHOLE: GW02

CLIENT:	Boral	COORDS: 289502.10 m E 6242101.80 m N MGA94 56		DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 83.55 m DATUM: AHD		CONTRACTOR: Statewide Drilling	
LOCATION:		INCLINATION: -90°		LOGGED: AB	DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH: 40.00 m		CHECKED: SK	DATE: 2/5/13

Drilling: METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX			0	83.55					Sandy CLAY rounded, medium plasticity, brown			
				3.60 79.95					Sandy CLAY rounded, medium plasticity, dark brown			
				3.80 79.75					Clayey GRAVEL medium grained, brown, medium plasticity, with some sand			
				4.50 79.05					Silty CLAY medium plasticity, pale grey, medium plasticity silt, trace sand			
				5.00 78.55					CLAYSTONE fine grained, amorphous / layered, grey with brown staining, very low strength, extremely weathered			Crushed zones (decomposed seams) at 5.4 m and 6.0 m; Vertical fracture with iron staining 6.9 m - 7.8 m
				6.50 77.05					LAMINITE (siltstone, claystone), fine grained, amorphous, layered, grey, medium strength, distinctly weathered			
				6.90 76.65					SANDSTONE (minor siltstone), fine to medium grained, pale grey with brown staining, amorphous, layered, distinctly weathered			
				8.00 75.55					SILTSTONE (minor claystone), fine grained amorphous, layered, grey with some brown staining, low strength, distinctly to slightly weathered			Decomposed seams at 8.03 m and 8.13 m (lenses)
			10									

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REPORT OF BOREHOLE: GW02

Golder Associates

SHEET: 2 OF 5

CLIENT:	Boral	COORDS: 289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:		
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 83.55 m DATUM: AHD	CONTRACTOR: Statewide Drilling		
LOCATION:		INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13	
JOB NO:	137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 2/5/13	

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX			10						SILTSTONE (minor claystone), fine grained amorphous, layered, grey with some brown staining, low strength, distinctly to slightly weathered			
			11									Decomposed seams at 11.5 m, 12.04 m, 12.08 m, 12.24 m and 12.3 m, occasional brown lenses
			12									Partially decomposed seam
			13									
			14	14.00 69.55					MUDSTONE fine grained, amorphous, layered, dark grey, very high strength, slightly weathered to fresh			Apparent porous / textured zone (no colour change)
			15									
			16									
			17									Possible core loss
			18									
			19	19.17 64.38					LAMINITE (mudstone, siltstone, sandstone), fine to medium grained, amorphous, layered, black / grey / pale grey, high strength, slilghtly weathered, bedded			Vertical fracture
			20									

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REPORT OF BOREHOLE: GW02

CLIENT:	Boral	COORDS: 289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 83.55 m DATUM: AHD	CONTRACTOR: Statewide Drilling
LOCATION:		INCLINATION: -90°	LOGGED: AB DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH: 40.00 m	CHECKED: SK DATE: 2/5/13

METHOD	DEPTH RL	SOIL/ROCK MATERIAL DESCRIPTION	STRUCTURE AND ADDITIONAL OBSERVATIONS
EX	20.18 / 63.37	SILTSTONE fine grained, amorphous, layered, grey, high strength, fresh, bedded	
	20.90 / 62.65	LAMINITE (mudstone, siltstone, sandstone), fine to medium grained, black / dark grey / pale grey, high strength, fresh, bedded	Intrusions, brown lenses
	21.75 / 61.80	SILTSTONE (minor mudstone), fine grained, grey / dark grey / black, high strength, fresh, bedded	Vertical black intrusion
	23.10 / 60.45	LAMINITE (sandstone, siltstone, minor mudstone), fine to medium grained, amorphous, layered, pale grey / grey / black, high strength, fresh, bedded	Brown layers to 26.25 m
	24.50 / 59.05	SANDSTONE (minor siltstone, mudstone), fine to medium grained, black, with some brown, high strength, slightly weathered to fresh, bedded	Brown lenses / staining 25.25 m - 25.5 m and 25.8 m - 26.0 m
	26.70 / 56.85	LAMINITE (siltstone, sandstone, mudstone), fine to medium grained, amorphous, layered, high strength, fresh, bedded	Some brown staining in core
	29.85 / 53.70		Vertical fractures and weathered at

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Golder Associates

REPORT OF BOREHOLE: GW02

CLIENT: Boral	COORDS: 289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 83.55 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13
JOB NO: 137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 2/5/13

Drilling: METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL
Sampling: SAMPLE OR FIELD TEST | RECOVERED
Field Material Description: GRAPHIC LOG | USC SYMBOL | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS

METHOD: EX

Depth scale (metres): 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

DEPTH	RL
30.40	53.15
32.07	51.48
32.49	
32.66	50.89
32.91	50.64
33.81	
33.94	49.61
34.35	49.20
34.60	48.95
35.00	48.55
36.40	
36.50	
36.64	46.91
36.94	46.61
38.00	45.55
38.86	
39.03	44.52
39.79	43.76

SOIL/ROCK MATERIAL DESCRIPTION

SANDSTONE
(minor siltstone and mudstone), fine to medium grained, amorphous, layered, pale grey / grey / black, high strength, slightly weathered to fresh

LAMINITE
(siltstone, sandstone, mudstone), fine to medium grained, amorphous, layered, grey / pale grey / black, high strength, slightly weathered to fresh, bedded

SILTSTONE
fine grained, amorphous, layered, grey, very high strength, fresh

CLAYSTONE
fine grained, amorphous, layered, black, very high strength, fresh

SILTSTONE
fine grained, amorphous, layered, black, very high strength, fresh

SANDSTONE
medium grained, amorphous, pale grey, high to very high strength, fresh

LAMINITE
(siltstone, sandstone, mudstone), fine to medium grained, amorphous, layered, pale brown / pale grey / black, high to very high strength, fresh, bedded

SILTSTONE
fine grained, amorphous, layered, grey, very high strength, fresh

CLAYSTONE
(minor siltstone), fine grained, amorphous, layered, black with grey, very high strength, fresh

SILTSTONE
fine grained, amorphous, layered, black with grey, very high strength, fresh

CLAYSTONE
(minor siltstone), fine grained, amorphous, layered, black with grey, very high strength, fresh

LAMINITE
(claystone, siltstone), fine grained, amorphous, layered, black / grey, very high strength, fresh

SANDSTONE
(minor siltstone, claystone), fine grained, amorphous, pale grey / pale brown / black, high strength, slightly weathered to fresh

SANDSTONE
(minor siltstone, claystone), fine grained, amorphous, pale grey / pale brown / black, high strength, slightly weathered to fresh

CLAYSTONE
(minor siltstone, grey), fine grained, amorphous, layered, black, fresh, bedded

LAMINITE
(sandstone, siltstone, claystone), fine tlo medium grained, amorphous, layered, pale grey / grey / brown / black, medium strength, slightly weathered, bedded

CLAYSTONE
fine grained, amorphous, layered, black, (minor siltstone, grey), high strength, fresh

LAMINITE
(sandstone, siltstone, claystone), fine grained, amorphous, layered, pale grey changing to dark grey, medium strength, fresh

CLAYSTONE
(minor siltstone) fine grained, amorphous, layered, black / grey, high strength, fresh, bedded

SANDSTONE

STRUCTURE AND ADDITIONAL OBSERVATIONS

29.84 m

Suspected joint at 30.16 m planar slickensided

Bands of sandstone at 30.66 m, 30.7 m and 30.9 m - 30.95 m

Joint / fracture at 32.19 m, no infill, planar, slickensided

Joint / fracture at 32.97 m, no infill, planar, slickensided

REPORT OF BOREHOLE: GW02

Golder Associates

SHEET: 5 OF 5

CLIENT:	Boral	COORDS:	289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	83.55 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH:	40.00 m	CHECKED: SK	DATE: 2/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			40						(minor siltstone, claystone), medium grained, pale grey / pale brown / black, medium strength, slightly weathered			
									END OF BOREHOLE @ 40.00 m Monitoring well installed			
			41									
			42									
			43									
			44									
			45									
			46									
			47									
			48									
			49									
			50									

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GAP gINT FN. F01a
RL3

REPORT OF STANDPIPE INSTALLATION: GW02

Golder Associates

SHEET: 1 OF 2

CLIENT:	Boral	COORDS:	289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	83.55 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH:	40.00 m	CHECKED: SK	DATE: 2/5/13

Drilling | **Field Material Description** | **Instrumentation Details**

METHOD: EX

WATER

DEPTH (metres): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42

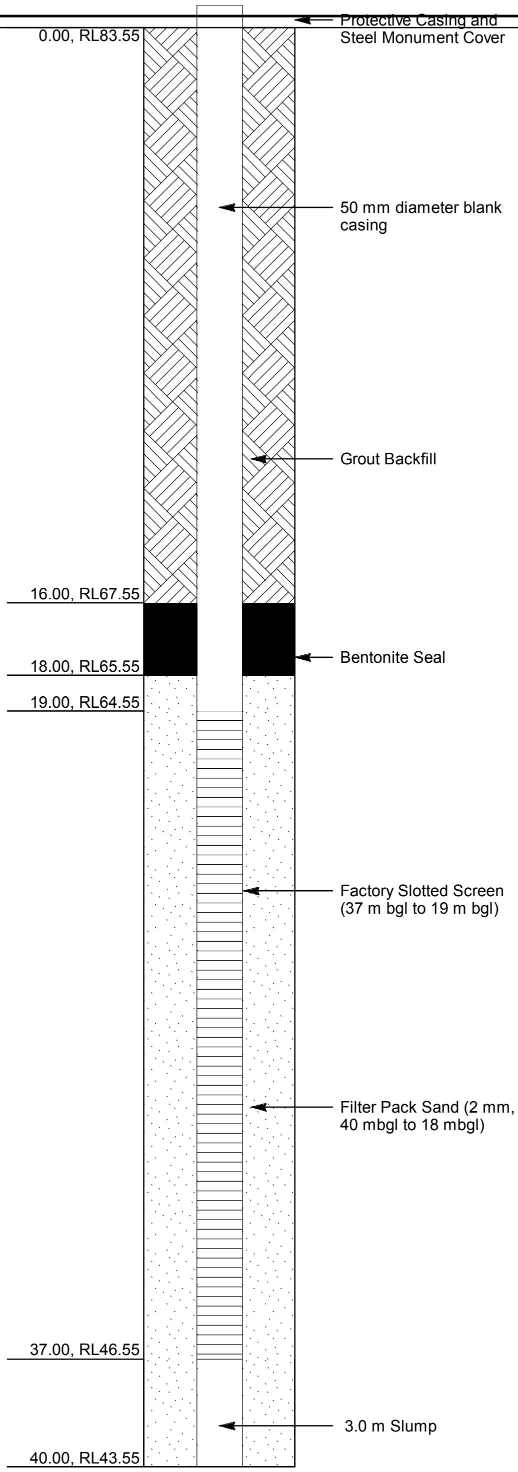
DEPTH RL: *3.60*, *4.50*, *5.00*, *6.50*, *8.00*, *14.00*, *19.17*, *20.18*, *20.90*, *21.75*, *23.10*, *24.50*, *26.70*, *29.80*, *30.40*, *32.07*, *32.49*, *33.81*, *36.40*, *38.00*, *38.86*, *39.79*

GRAPHIC LOG

SOIL/ROCK MATERIAL DESCRIPTION:

SANDY CLAY
SANDY CLAY
CLAYEY GRAVEL
SILTY CLAY
CLAYSTONE
LAMINITE
SANDSTONE
SILTSTONE
MUDSTONE
LAMINITE
SILTSTONE
LAMINITE
SILTSTONE
LAMINITE
SANDSTONE
LAMINITE
SANDSTONE
LAMINITE
SILTSTONE
CLAYSTONE
SILTSTONE
SANDSTONE
LAMINITE
SILTSTONE
CLAYSTONE
SILTSTONE
CLAYSTONE
LAMINITE
SANDSTONE
SANDSTONE
CLAYSTONE
LAMINITE

END OF BOREHOLE @ 40.00 m
Monitoring well installed



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REPORT OF STANDPIPE INSTALLATION: GW02

SHEET: 2 OF 2

CLIENT:	Boral	COORDS: 289502.10 m E 6242101.80 m N MGA94 56	DRILL RIG:		
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 83.55 m DATUM: AHD	CONTRACTOR: Statewide Drilling		
LOCATION:		INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13	
JOB NO:	137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 2/5/13	

Drilling				Field Material Description		Instrumentation Details
METHOD	WATER	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	END OF BOREHOLE @ 40.00 m Monitoring well installed
		42			CLAYSTONE	
					LAMINITE	
		44			CLAYSTONE	
					SANDSTONE	
		46				
		48				
		50				
		52				
		54				
		56				
		58				
		60				
		62				
		64				
		66				
		68				
		70				
		72				
		74				
		76				
		78				
		80				
		82				
		84				

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REPORT OF BOREHOLE: GW03

SHEET: 1 OF 4

CLIENT: Boral	COORDS: 289628.50 m E 6241630.20 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 86.80 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 3/4/13
JOB NO: 137626001	HOLE DEPTH: 40.00 m	CHECKED: SK	DATE: 3/5/13

DEPTH	RL	SOIL/ROCK MATERIAL DESCRIPTION
0	86.80	CLAYSTONE fine grained, laminated, black, very low strength, distinctly weathered
0.50	86.30	Silty CLAY high plasticity, dark brown, trace fine sand, dry
1.50	85.30	changing to pale grey
3.00	83.80	CLAYSTONE fine grained, laminated, dark brown, low to very low strength, highly weathered to extremely weathered
3.20		Sandy CLAY medium plasticity, dark brown, (highly weathered claystone)
	83.50	CLAYSTONE fine grained, laminated (with clay bands <1 mm), black, low to very low strength, distinctly weathered
4.60	82.20	fewer laminations, increased strength
5.00	81.80	fewer laminations
6.50	80.30	fine grained, laminated, black / dark grey, low to medium strength, slightly to distinctly weathered
8.00	78.80	fine grained, laminated, black / dark grey, low to medium strength, slightly to distinctly weathered, layered
8.70	78.10	SILTSTONE / SANDSTONE fine to medium grained, laminated, pale grey, medium strength, slightly weathered
9.40	77.40	LAMINITE
10.00		

Column headings: Drilling (METHOD, PENETRATION RESISTANCE, WATER, DEPTH (metres), DEPTH RL); Sampling (SAMPLE OR FIELD TEST, RECOVERED); Field Material Description (GRAPHIC LOG, USC SYMBOL, SOIL/ROCK MATERIAL DESCRIPTION, MOISTURE CONDITION, CONSISTENCY DENSITY, STRUCTURE AND ADDITIONAL OBSERVATIONS)

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GAP gINT FN. F01a RL3

REPORT OF BOREHOLE: GW03

SHEET: 2 OF 4

CLIENT:	Boral	COORDS:	289628.50 m E 6241630.20 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	86.80 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 3/4/13
JOB NO:	137626001	HOLE DEPTH:	40.00 m	CHECKED: SK	DATE: 3/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			10	76.80					CLAYSTONE fine grained, laminated, black, medium strength, slightly weathered			
			11	11.00 75.80					(shale), fine grained, laminated, black dark grey, medium strength			
			12	12.10 74.70					becoming more shale			
			13	13.00 73.80					becoming more shale			
			14	14.00 72.80					becoming more shale			
			15									
				15.50 71.30					fine grained, laminated, black / dark grey			
			16	16.00 70.80					becoming coarser sand, grey			
				16.90					with shale streak			
			17	17.00 69.80					with shale streak			
			18									
				18.75 68.05					SANDSTONE fine to medium grained, massive, pale grey, medium strength, slightly weathered			
			19									
				19.50 67.30					CLAYSTONE with shale streak			
			20	20.00								

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REPORT OF BOREHOLE: GW03

CLIENT: Boral
PROJECT: Bringelly Groundwater Assessment
LOCATION:
JOB NO: 137626001

COORDS: 289628.50 m E 6241630.20 m N MGA94 56
SURFACE RL: 86.80 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 40.00 m

DRILL RIG:
CONTRACTOR: Statewide Drilling
LOGGED: AB DATE: 3/4/13
CHECKED: SK DATE: 3/5/13

Drilling: METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	Sampling: SAMPLE OR FIELD TEST	RECOVERED	Field Material Description: GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			20	66.80					CLAYSTONE with shale streak, fine grained, black / dark grey, medium to high strength, slightly weathered to fresh			
			21									
			22	*21.90* 64.90					coarse with intrusions			
				22.40 64.40					? with siltstone			
			23	*23.00* 63.80					LAMINITE (siltstone, claystone), layered, black / dark grey, medium strength, slightly weathered			
			24									
			25									
				25.50 61.30					CLAYSTONE with chert			
			26	*26.00* 60.80					LAMINITE (claystone, siltstone, sandstone, minor bands), mostly fine grained, pale grey / dark grey and black, medium to high strength, slightly weathred to fresh			
			27									
			28									
			29									
			30	*30.00*								

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REPORT OF BOREHOLE: GW03

Golder Associates

CLIENT: Boral	COORDS: 289628.50 m E 6241630.20 m N MGA94 56	SHEET: 4 OF 4	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 86.80 m DATUM: AHD	DRILL RIG:	
LOCATION:	INCLINATION: -90°	CONTRACTOR: Statewide Drilling	
JOB NO: 137626001	HOLE DEPTH: 40.00 m	LOGGED: AB	DATE: 3/4/13
		CHECKED: SK	DATE: 3/5/13

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH / RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			30	56.80					LAMINITE (siltstone, sandstone, claystone), fine to medium grained, pale grey / dark grey and black, layered			
			31	30.90 / 55.90					SILTSTONE / CLAYSTONE fine grained, black			
				31.10 / 55.70					SANDSTONE coarse grained, massive, pale grey			
				31.70 / 55.10					CLAYSTONE / SILTSTONE layered			
			32	32.00 / 54.80					CLAYSTONE fine grained, black, layered, high strength, fresh			
				32.60					SILTSTONE with micro vesicles, pale grey, layered, high strength, fresh			
			33, 34	32.80 / 54.00					CLAYSTONE fine grained, black, layered, high strength, fresh			
			35	35.00 / 51.80					SILTSTONE			
				35.60 / 51.20					LAMINITE with sandstone (primary), and black mudstone			
			36	36.05 / 50.75					SANDSTONE medium, layered mudstone streaks, pale grey			
			37	36.50 / 50.30					SILTSTONE with streaks of mudstone, black, layered, high strength, fresh			
				37.30 / 49.50					SANDSTONE medium grained, layered, pale grey with black mudstone streaks, high strength, fresh			
			38	38.00 / 48.80					SILTSTONE medium grained, layered, pale grey with black mudstone streaks, high strength, fresh			
			39	38.80 / 48.00					SANDSTONE medium grained, layered, mudstone streaks, pale grey, high strength, fresh			
			40						END OF BOREHOLE @ 40.00 m Monitoring well installed			

REPORT OF STANDPIPE INSTALLATION: GW03

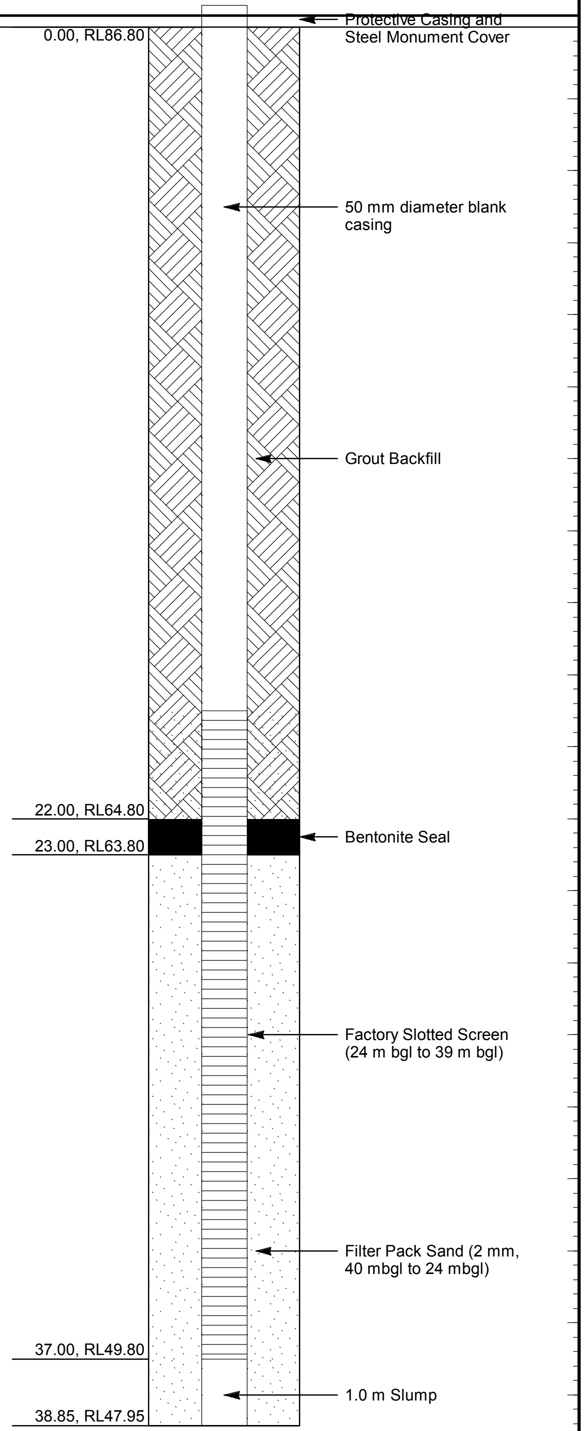
SHEET: 1 OF 1

CLIENT:	Boral	COORDS:	289628.50 m E 6241630.20 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	86.80 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 3/4/13
JOB NO:	137626001	HOLE DEPTH:	40.00 m	CHECKED: SK	DATE: 3/5/13

Drilling | **Field Material Description** | **Instrumentation Details**

METHOD	WATER	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION
		0	0.50		CLAYSTONE
					SILTY CLAY
		2	3.00		CLAYSTONE
		4			SANDY CLAY
					CLAYSTONE
		6			
		8	8.70		SILTSTONE / SANDSTONE
			9.40		LAMINITE
		10	10.00		CLAYSTONE
		12			
		14			
		16			
		18	18.75		SANDSTONE
			19.50		CLAYSTONE
		20	20.00		CLAYSTONE
		22	23.00		LAMINITE
		24	25.50		CLAYSTONE
		26	26.00		LAMINITE
		28			
		30	30.00		LAMINITE
			30.90		SILTSTONE / CLAYSTONE
			31.70		SANDSTONE
		32	32.60		CLAYSTONE / SILTSTONE
					CLAYSTONE
		34			SILTSTONE
			35.00		CLAYSTONE
			35.60		SILTSTONE
		36	36.05		LAMINITE
			36.50		SANDSTONE
			37.30		SILTSTONE
		38	38.00		SANDSTONE
			38.80		SILTSTONE
					SANDSTONE
		40	40.00		
		42			

END OF BOREHOLE @ 40.00 m
Monitoring well installed



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REPORT OF BOREHOLE: GW04

SHEET: 1 OF 5

CLIENT:	Boral	COORDS:	289214.90 m E 6241594.50 m N MGA94 56	DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL:	99.10 m DATUM: AHD	CONTRACTOR:	Statewide Drilling
LOCATION:		INCLINATION:	-90°	LOGGED: AB	DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH:	42.00 m	CHECKED: SK	DATE: 3/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0	99.10					Silty CLAY high plasticity, brown, dry			
			4	4.10 95.00					SILTSTONE fine grained, layered, pale grey, medium strength, distinctly weathered			
				4.30 94.80					becoming finer grained			
				4.50 94.60					SILTSTONE fine grained, layered, black with red layers, medium strength, distinctly weathered			
				5.40 93.70					MUDSTONE / SILTSTONE fine grained, layered, dark to pale grey, medium strength, distinctly weathered, fractures with iron staining			
				6.65 92.45					SILTSTONE fine grained, layered, pale grey, low strength, distinctly to highly weathered, fractures with iron staining			
			7	7.00 92.10					MUDSTONE fine grained, layered, dark grey, medium strength, slightly weathered			
			8	8.00 91.10					LAMINITE (siltstone, mudstone), fine grained, layered, medium strength, slightly weathered			
				9.50 89.60					SILTSTONE fine grained, layered, dark grey / black, medium to high strength, slightly weathered			
			10									

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REPORT OF BOREHOLE: GW04

CLIENT:	Boral	COORDS: 289214.90 m E 6241594.50 m N MGA94 56	DRILL RIG:		
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 99.10 m DATUM: AHD	CONTRACTOR: Statewide Drilling		
LOCATION:		INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13	
JOB NO:	137626001	HOLE DEPTH: 42.00 m	CHECKED: SK	DATE: 3/5/13	

DEPTH (metres)	DEPTH / RL	SOIL/ROCK MATERIAL DESCRIPTION	STRUCTURE AND ADDITIONAL OBSERVATIONS
10		SILTSTONE fine grained, layered, dark grey / black, medium to high strength, slightly weathered	
13	12.95 / 86.15	SANDSTONE medium grained, layered, pale grey, medium strength, slightly weathered, streaks of black siltstone	
14	13.90 / 85.20	SILTSTONE fine grained, layered, black, medium strength, slightly weathered	
	85.10	black / dark grey, medium strength, slightly weathered	
	14.40 / 84.70	SILTSTONE / MUDSTONE fine grained, layered, black, medium strength, slightly weathered to fresh, shale streaks	
16	16.00 / 83.10	fractures are planar and smooth along layer	
17	17.00	MUDSTONE fine grained, layered, black, medium strength, slightly weathered to fresh	
	17.15 / 81.95	SILTSTONE fine grained, layered, black / dark grey, medium strength, slightly weathered, planar fractures along layers	
	19.50	MUDSTONE fine grained, layered, black, high strength, slightly weathered to fresh, with more fractures	
20	19.65 / 79.45		

Column headings: Drilling (METHOD, PENETRATION RESISTANCE, WATER, DEPTH (metres), DEPTH RL); Sampling (SAMPLE OR FIELD TEST, RECOVERED); Field Material Description (GRAPHIC LOG, USC SYMBOL, SOIL/ROCK MATERIAL DESCRIPTION, MOISTURE CONDITION, CONSISTENCY DENSITY, STRUCTURE AND ADDITIONAL OBSERVATIONS)

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REPORT OF BOREHOLE: GW04

CLIENT:	Boral	COORDS: 289214.90 m E 6241594.50 m N MGA94 56	DRILL RIG:		
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 99.10 m DATUM: AHD	CONTRACTOR: Statewide Drilling		
LOCATION:		INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13	
JOB NO:	137626001	HOLE DEPTH: 42.00 m	CHECKED: SK	DATE: 3/5/13	

Depth (m)	RL	Graphic Log	Soil/Rock Material Description
20.00		Siltstone	SILTSTONE
20.50	78.60	Siltstone	becoming more coarse, slightly weathered
21.40	77.70	Mudstone	MUDSTONE fine grained, layered, black, high strength, minor shale intrusion (<1 mm lenses)
21.60	77.50	Siltstone	SILTSTONE fine grained, layered, dark grey, high strength, slightly weathered to fresh, with some minor shale intrusions (<1 mm lenses)
23.55	75.55	Mudstone	MUDSTONE fine grained, layered, black, high strength, with some minor shale intrusions and minor fractures
25.25	73.85	Mudstone	change to pale grey
26.00	73.10	Mudstone	becoming pale grey with shale intrusions (<1 mm)
27.25	71.85	Mudstone	becoming dark grey
27.50	71.60	Siltstone	SILTSTONE fine grained, layered, dark grey / black, high strength, slightly weathered to fresh
28.45	70.65	Siltstone	becoming coarse grained, with medium grained ? intrusion (10-20 mm), layered, dark grey / black, high strength, slightly weathered to fresh
29.00	70.10	Mudstone	MUDSTONE fine grained
29.35		Sandstone	SANDSTONE
29.53		Mudstone	MUDSTONE
	69.49	Sandstone	SANDSTONE
29.90	69.20	Laminite	LAMINITE

Columns: METHOD | PENETRATION RESISTANCE | WATER | DEPTH (metres) | DEPTH RL | SAMPLE OR FIELD TEST | RECOVERED | GRAPHIC LOG | USC SYMBOL | SOIL/ROCK MATERIAL DESCRIPTION | MOISTURE CONDITION | CONSISTENCY DENSITY | STRUCTURE AND ADDITIONAL OBSERVATIONS

REPORT OF BOREHOLE: GW04

CLIENT: Boral	COORDS: 289214.90 m E 6241594.50 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 99.10 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13
JOB NO: 137626001	HOLE DEPTH: 42.00 m	CHECKED: SK	DATE: 3/5/13

DEPTH	RL	SOIL/ROCK MATERIAL DESCRIPTION
30		successive layers of siltstone, mudstone, shale? (<1 mm)
		MUDSTONE with shale streaks and with sandstone streaks
30.50		SILTSTONE with shale streaks and intrusions
30.70	68.40	MUDSTONE with shale intrusion
31.10	68.00	LAMINITE predominantly siltstone with thin layer of sandstone
32.70	66.40	with sandstone layers (2-15 mm) increasing with depth
34.40	64.70	SILTSTONE
35.05	64.05	becoming coarse grained
36.28	62.82	LAMINATE (siltstone, shale, sandstone), sandstone layers increasing with depth
38.00	61.10	SANDSTONE medium grained, layered and cemented, pale grey
39.20	59.90	MUDSTONE fine to medium grained, layered and cemented, high strength, fresh
39.75	59.35	LAMINATE

Column headings: Drilling (METHOD, PENETRATION RESISTANCE, WATER, DEPTH (metres), DEPTH RL); Sampling (SAMPLE OR FIELD TEST, RECOVERED); Field Material Description (GRAPHIC LOG, USC SYMBOL, SOIL/ROCK MATERIAL DESCRIPTION, MOISTURE CONDITION, CONSISTENCY DENSITY, STRUCTURE AND ADDITIONAL OBSERVATIONS)

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REPORT OF BOREHOLE: GW04

Golder Associates

				SHEET: 5 OF 5	
CLIENT:	Boral	COORDS: 289214.90 m E 6241594.50 m N MGA94 56		DRILL RIG:	
PROJECT:	Bringelly Groundwater Assessment	SURFACE RL: 99.10 m DATUM: AHD		CONTRACTOR: Statewide Drilling	
LOCATION:		INCLINATION: -90°		LOGGED: AB	DATE: 16/4/13
JOB NO:	137626001	HOLE DEPTH: 42.00 m		CHECKED: SK	DATE: 3/5/13

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			40						LAMINATE			
			41									
			42	57.10					END OF BOREHOLE @ 42.00 m Monitoring well installed			
			43									
			44									
			45									
			46									
			47									
			48									
			49									
			50									

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REPORT OF STANDPIPE INSTALLATION: GW04

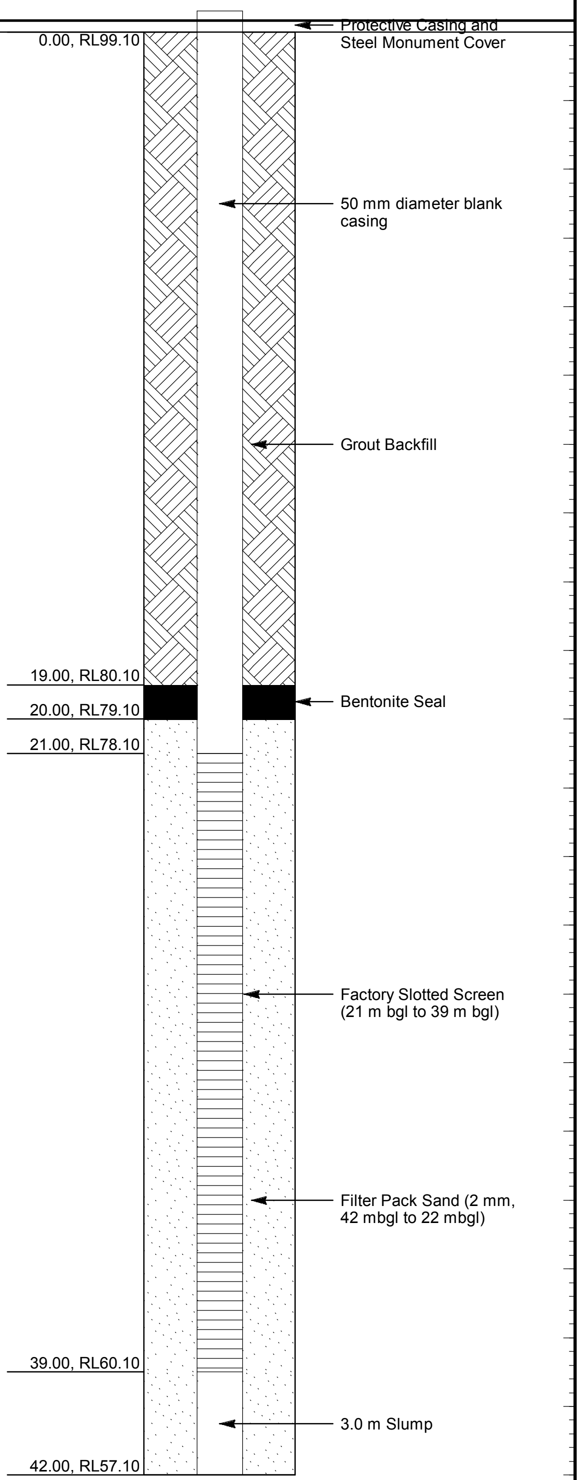
SHEET: 1 OF 1

CLIENT: Boral	COORDS: 289214.90 m E 6241594.50 m N MGA94 56	DRILL RIG:	
PROJECT: Bringelly Groundwater Assessment	SURFACE RL: 99.10 m DATUM: AHD	CONTRACTOR: Statewide Drilling	
LOCATION:	INCLINATION: -90°	LOGGED: AB	DATE: 16/4/13
JOB NO: 137626001	HOLE DEPTH: 42.00 m	CHECKED: SK	DATE: 3/5/13

Drilling | **Field Material Description** | **Instrumentation Details**

DEPTH RL	SOIL/ROCK MATERIAL DESCRIPTION
	SILTY CLAY
4.10	SILTSTONE
	SILTSTONE
5.40	MUDSTONE / SILTSTONE
6.65	SILTSTONE
	MUDSTONE
8.00	LAMINITE
9.50	SILTSTONE
12.95	SANDSTONE
13.90	SILTSTONE
	SILTSTONE / MUDSTONE
17.00	MUDSTONE
	SILTSTONE
19.50	MUDSTONE
	SILTSTONE
21.40	MUDSTONE
	SILTSTONE
23.55	MUDSTONE
27.50	SILTSTONE
29.00	MUDSTONE
	SANDSTONE
30.50	MUDSTONE
	SANDSTONE
	LAMINITE
	MUDSTONE
	SILTSTONE
	MUDSTONE
	LAMINITE
34.40	SILTSTONE
36.28	LAMINATE
38.00	SANDSTONE
39.20	MUDSTONE
39.75	LAMINATE
42.00 57.10	

END OF BOREHOLE @ 42.00 m
Monitoring well installed



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APPENDIX D

Groundwater quality - Laboratory analysis results

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **ES1312344**	Page	: 1 of 13
Client	: **GOLDER ASSOCIATES**	Laboratory	: Environmental Division Sydney
Contact	: MR SHAUN TROON	Contact	: Client Services
Address	: P O BOX 1734 MILTON QLD, AUSTRALIA 4064	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: stroon@golder.com.au	E-mail	: sydney@alsglobal.com
Telephone	: +61 07 3721 5400	Telephone	: +61-2-8784 8555
Facsimile	: +61 07 3721 5401	Facsimile	: +61-2-8784 8500
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 30-MAY-2013
Sampler	: ST	Issue Date	: 06-JUN-2013
Site	: ----		
		No. of samples received	: 6
Quote number	: SY/187/13	No. of samples analysed	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **TDS by method EA-015 may bias high for sample #1 due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.**

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Hoa Nguyen	Senior Inorganic Chemist	Sydney Inorganics
		Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
		Sydney Organics
Raymond Commodor	Instrument Chemist	Sydney Inorganics
Wisam Marassa	Inorganics Coordinator	Sydney Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-GW04	BORAL-GW02	BORAL-GW05	BORAL-GW03	BORAL-GW01
			Client sampling date / time	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10
Compound	CAS Number	LOR	Unit	ES1312344-001	ES1312344-002	ES1312344-003	ES1312344-004	ES1312344-005
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.04	8.04	6.33	7.62	8.49
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2020	22000	<1	15200	15200
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	2350	13600	----	9220	8880
Total Dissolved Solids @180°C	----	10	mg/L	----	----	<10	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	12400	68.6	<0.1	451	48.5
EA075: Redox Potential								
Redox Potential	----	0.1	mV	32.0	92.5	123	75.7	51.0
pH Redox	----	0.01	pH Unit	7.9	7.7	6.1	7.3	8.3
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	29
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	327	393	<1	274	219
Total Alkalinity as CaCO3	----	1	mg/L	327	393	<1	274	248
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	31	<1	<1	10	6
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	412	7600	<1	4720	4740
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	12	284	<1	207	143
Magnesium	7439-95-4	1	mg/L	2	238	<1	77	138
Sodium	7440-23-5	1	mg/L	433	4680	<1	2850	2700
Potassium	7440-09-7	1	mg/L	9	54	<1	57	57
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.005	0.001	<0.001	0.005	0.004
Cadmium	7440-43-9	0.0001	mg/L	0.0005	0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	0.003	0.001	<0.001	0.002	0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.166	0.085	<0.005	0.050	0.013

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

Compound	CAS Number	LOR	Unit	BORAL-GW04	BORAL-GW02	BORAL-GW05	BORAL-GW03	BORAL-GW01
			Client sampling date / time	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10
				ES1312344-001	ES1312344-002	ES1312344-003	ES1312344-004	ES1312344-005
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	**0.01**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	**0.01**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	**0.04**	<0.01	**0.04**	**0.02**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**18.8**	**222**	<0.01	**139**	**139**
Total Cations	----	0.01	meq/L	**19.8**	**239**	<0.01	**142**	**137**
Ionic Balance	----	0.01	%	**2.62**	**3.56**	----	**1.15**	**0.52**
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**1.9**	**7.4**	**9.6**	**4.2**	**7.4**
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	----	1	µg/L	<1	<1	<1	<1	<1
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	319-85-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	58-89-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	319-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	76-44-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	309-00-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	60-57-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	72-20-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)

			Client sample ID	BORAL-GW04	BORAL-GW02	BORAL-GW05	BORAL-GW03	BORAL-GW01
			Client sampling date / time	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10
Compound	CAS Number	LOR	Unit	ES1312344-001	ES1312344-002	ES1312344-003	ES1312344-004	ES1312344-005
EP068A: Organochlorine Pesticides (OC) - Continued								
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDT	50-29-3	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	72-43-5	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
^ Total Chlordane (sum)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of DDD + DDE + DDT	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Monocrotophos	6923-22-4	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Dimethoate	60-51-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Diazinon	333-41-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion-methyl	298-00-0	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Malathion	121-75-5	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenthion	55-38-9	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion	56-38-2	2.0	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Fenamiphos	22224-92-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Prothiofos	34643-46-4	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Ethion	563-12-2	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Carbophenothion	786-19-6	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Azinphos Methyl	86-50-0	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	**1.4**	**1.0**	<1.0	**1.0**	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-GW04	BORAL-GW02	BORAL-GW05	BORAL-GW03	BORAL-GW01
			Client sampling date / time	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10
Compound	CAS Number	LOR	Unit	ES1312344-001	ES1312344-002	ES1312344-003	ES1312344-004	ES1312344-005
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	**1.4**	**1.0**	<0.5	**1.0**	<0.5
^ Benzo(a)pyrene TEQ (WHO)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	**30**	<20
C10 - C14 Fraction	----	50	µg/L	**290**	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	**1120**	<100	<100	**100**	<100
C29 - C36 Fraction	----	50	µg/L	**260**	<50	<50	**100**	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	**1670**	<50	<50	**200**	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
C6 - C10 Fraction	----	20	µg/L	**20**	<20	<20	**30**	<20
^ C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	**500**	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	**1110**	<100	<100	**180**	<100
>C34 - C40 Fraction	----	100	µg/L	**110**	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	**1720**	<100	<100	**180**	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	**2**	<1	<1	**4**	<1
Toluene	108-88-3	2	µg/L	**4**	<2	<2	**13**	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	**4**	<2	<2	**2**	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-GW04	BORAL-GW02	BORAL-GW05	BORAL-GW03	BORAL-GW01
			Client sampling date / time	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10	30-MAY-2013 11:10
Compound	CAS Number	LOR	Unit	ES1312344-001	ES1312344-002	ES1312344-003	ES1312344-004	ES1312344-005
EP080: BTEXN - Continued								
^ Total Xylenes	1330-20-7	2	µg/L	**4**	<2	<2	**2**	<2
^ Sum of BTEX	----	1	µg/L	**10**	<1	<1	**19**	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	**77.0**	**103**	**94.0**	**101**	**115**
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	**74.4**	**99.8**	**92.8**	**98.2**	**116**
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	**71.6**	**83.1**	**84.2**	**81.6**	**86.4**
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	**25.4**	**32.1**	**20.6**	**31.7**	**29.3**
2-Chlorophenol-D4	93951-73-6	0.1	%	**49.0**	**64.2**	**46.5**	**64.2**	**58.8**
2.4.6-Tribromophenol	118-79-6	0.1	%	**65.4**	**54.0**	**39.1**	**74.4**	**62.1**
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	**56.8**	**77.6**	**52.8**	**73.7**	**72.2**
Anthracene-d10	1719-06-8	0.1	%	**65.9**	**83.8**	**71.3**	**82.2**	**83.5**
4-Terphenyl-d14	1718-51-0	0.1	%	**62.9**	**80.7**	**79.9**	**79.5**	**83.5**
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**83.6**	**86.3**	**85.5**	**79.0**	**85.7**
Toluene-D8	2037-26-5	0.1	%	**105**	**103**	**99.4**	**98.6**	**103**
4-Bromofluorobenzene	460-00-4	0.1	%	**101**	**99.7**	**96.1**	**94.6**	**93.4**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-DUP	----	----	----	----
			Client sampling date / time	30-MAY-2013 11:10	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1312344-006	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.02	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	22200	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	13300	----	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	61.4	----	----	----	----
EA075: Redox Potential								
Redox Potential	----	0.1	mV	120	----	----	----	----
pH Redox	----	0.01	pH Unit	7.8	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	388	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	388	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	7620	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	306	----	----	----	----
Magnesium	7439-95-4	1	mg/L	255	----	----	----	----
Sodium	7440-23-5	1	mg/L	4710	----	----	----	----
Potassium	7440-09-7	1	mg/L	57	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	0.100	----	----	----	----
EG035F: Dissolved Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-DUP	----	----	----	----
			Client sampling date / time	30-MAY-2013 11:10	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ES1312344-006**	**----**	**----**	**----**	**----**
EG035F: Dissolved Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.04**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**223**	----	----	----	----
Total Cations	----	0.01	meq/L	**242**	----	----	----	----
Ionic Balance	----	0.01	%	**4.26**	----	----	----	----
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**7.2**	----	----	----	----
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	----	1	µg/L	<1	----	----	----	----
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	----	----	----	----
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	----	----	----	----
beta-BHC	319-85-7	0.5	µg/L	<0.5	----	----	----	----
gamma-BHC	58-89-9	0.5	µg/L	<0.5	----	----	----	----
delta-BHC	319-86-8	0.5	µg/L	<0.5	----	----	----	----
Heptachlor	76-44-8	0.5	µg/L	<0.5	----	----	----	----
Aldrin	309-00-2	0.5	µg/L	<0.5	----	----	----	----
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	----	----	----	----
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	----	----	----	----
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	----	----	----	----
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	----	----	----	----
Dieldrin	60-57-1	0.5	µg/L	<0.5	----	----	----	----
4.4`-DDE	72-55-9	0.5	µg/L	<0.5	----	----	----	----
Endrin	72-20-8	0.5	µg/L	<0.5	----	----	----	----
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-DUP	----	----	----	----
			Client sampling date / time	30-MAY-2013 11:10	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1312344-006	----	----	----	----
EP068A: Organochlorine Pesticides (OC) - Continued								
4.4`-DDD	72-54-8	0.5	µg/L	<0.5	----	----	----	----
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	----	----	----	----
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	----	----	----	----
4.4`-DDT	50-29-3	2.0	µg/L	<2.0	----	----	----	----
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	----	----	----	----
Methoxychlor	72-43-5	2.0	µg/L	<2.0	----	----	----	----
^ **Total Chlordane (sum)**	----	0.5	µg/L	<0.5	----	----	----	----
^ **Sum of DDD + DDE + DDT**	----	0.5	µg/L	<0.5	----	----	----	----
^ **Sum of Aldrin + Dieldrin**	309-00-2/60-57-1	0.5	µg/L	<0.5	----	----	----	----
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.5	----	----	----	----
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.5	----	----	----	----
Monocrotophos	6923-22-4	2.0	µg/L	<2.0	----	----	----	----
Dimethoate	60-51-5	0.5	µg/L	<0.5	----	----	----	----
Diazinon	333-41-5	0.5	µg/L	<0.5	----	----	----	----
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.5	----	----	----	----
Parathion-methyl	298-00-0	2.0	µg/L	<2.0	----	----	----	----
Malathion	121-75-5	0.5	µg/L	<0.5	----	----	----	----
Fenthion	55-38-9	0.5	µg/L	<0.5	----	----	----	----
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.5	----	----	----	----
Parathion	56-38-2	2.0	µg/L	<2.0	----	----	----	----
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.5	----	----	----	----
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.5	----	----	----	----
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.5	----	----	----	----
Fenamiphos	22224-92-6	0.5	µg/L	<0.5	----	----	----	----
Prothiofos	34643-46-4	0.5	µg/L	<0.5	----	----	----	----
Ethion	563-12-2	0.5	µg/L	<0.5	----	----	----	----
Carbophenothion	786-19-6	0.5	µg/L	<0.5	----	----	----	----
Azinphos Methyl	86-50-0	0.5	µg/L	<0.5	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-DUP	----	----	----	----
			Client sampling date / time	30-MAY-2013 11:10	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1312344-006	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Phenanthrene	85-01-8	1.0	µg/L	<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	----	----	----	----
^ Benzo(a)pyrene TEQ (WHO)	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
C6 - C10 Fraction	----	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	BORAL-DUP	----	----	----	----
			Client sampling date / time	30-MAY-2013 11:10	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1312344-006	----	----	----	----
EP080: BTEXN - Continued								
^ Total Xylenes	1330-20-7	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	112	----	----	----	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	94.2	----	----	----	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	80.1	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	29.0	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%	58.2	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%	55.8	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	66.8	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%	79.2	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	79.2	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	82.2	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	102	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	88.7	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	24.8	143
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	30	120
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	26.8	129
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	44
2-Chlorophenol-D4	93951-73-6	15.9	102
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20.4	112
Anthracene-d10	1719-06-8	29.6	118
4-Terphenyl-d14	1718-51-0	21.5	126
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

ALS Group

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **ES1312344**	Page	: 1 of 10
Client	: GOLDER ASSOCIATES	Laboratory	: Environmental Division Sydney
Contact	: MR SHAUN TROON	Contact	: Client Services
Address	: P O BOX 1734 MILTON QLD, AUSTRALIA 4064	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: stroon@golder.com.au	E-mail	: sydney@alsglobal.com
Telephone	: +61 07 3721 5400	Telephone	: +61-2-8784 8555
Facsimile	: +61 07 3721 5401	Facsimile	: +61-2-8784 8500
Project	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 30-MAY-2013
Sampler	: ST	Issue Date	: 06-JUN-2013
Order number	: ----		
		No. of samples received	: 6
Quote number	: SY/187/13	No. of samples analysed	: 6

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER** — Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation Date extracted	Due for extraction	Evaluation	Analysis Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	---	30-MAY-2013	----	**30-MAY-2013**	30-MAY-2013	✓
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	---	27-JUN-2013	----	**30-MAY-2013**	27-JUN-2013	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural (EA015H) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	---	06-JUN-2013	----	**03-JUN-2013**	06-JUN-2013	✓
EA045: Turbidity							
Clear Plastic Bottle - Natural (EA045) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	----	----	----	**31-MAY-2013**	01-JUN-2013	✓
EA075: Redox Potential							
Clear Plastic Bottle - Natural (EA075) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	----	----	----	**30-MAY-2013**	30-MAY-2013	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) BORAL-GW04, BORAL-GW02, BORAL-GW05, BORAL-GW03, BORAL-GW01, BORAL-DUP	**30-MAY-2013**	---	13-JUN-2013	----	**30-MAY-2013**	13-JUN-2013	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	27-JUN-2013	----	**31-MAY-2013**	27-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
ED045G: Chloride Discrete analyser								
Clear Plastic Bottle - Natural (ED045G)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	27-JUN-2013	----	**31-MAY-2013**	27-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Natural (ED093F)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	06-JUN-2013	----	**31-MAY-2013**	06-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Natural (EG020A-F)								
BORAL-GW02,	BORAL-DUP	**30-MAY-2013**	---	26-NOV-2013	----	**01-JUN-2013**	26-NOV-2013	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F)								
BORAL-GW04,	BORAL-GW05,	**30-MAY-2013**	---	26-NOV-2013	----	**01-JUN-2013**	26-NOV-2013	✓
BORAL-GW03,	BORAL-GW01							
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Natural (EG035F)								
BORAL-GW02,	BORAL-DUP	**30-MAY-2013**	---	27-JUN-2013	----	**03-JUN-2013**	27-JUN-2013	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F)								
BORAL-GW04,	BORAL-GW05,	**30-MAY-2013**	---	27-JUN-2013	----	**03-JUN-2013**	27-JUN-2013	✓
BORAL-GW03,	BORAL-GW01							
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	01-JUN-2013	----	**31-MAY-2013**	01-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	27-JUN-2013	----	**31-MAY-2013**	27-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	---	01-JUN-2013	----	**31-MAY-2013**	01-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EP025: Oxygen - Dissolved (DO)								
Clear Plastic Bottle - Natural (EP025)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**----**	----	----	**30-MAY-2013**	30-MAY-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP066: Polychlorinated Biphenyls (PCB)								
Amber Glass Bottle - Unpreserved (EP066)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	06-JUN-2013	✓	**03-JUN-2013**	10-JUL-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP068A: Organochlorine Pesticides (OC)								
Amber Glass Bottle - Unpreserved (EP068)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	06-JUN-2013	✓	**03-JUN-2013**	10-JUL-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP068B: Organophosphorus Pesticides (OP)								
Amber Glass Bottle - Unpreserved (EP068)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	06-JUN-2013	✓	**03-JUN-2013**	10-JUL-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP080/071: Total Petroleum Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP071)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	06-JUN-2013	✓	**03-JUN-2013**	10-JUL-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM))								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	06-JUN-2013	✓	**03-JUN-2013**	10-JUL-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP080: BTEXN								
Amber VOC Vial - Sulfuric Acid (EP080)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	13-JUN-2013	✓	**31-MAY-2013**	13-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
Amber VOC Vial - Sulfuric Acid (EP080)								
BORAL-GW04,	BORAL-GW02,	**30-MAY-2013**	**31-MAY-2013**	13-JUN-2013	✓	**31-MAY-2013**	13-JUN-2013	✓
BORAL-GW05,	BORAL-GW03,							
BORAL-GW01,	BORAL-DUP							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	2	11	**18.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	4	25	**16.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Redox Potential	EA075	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	25	**8.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Pesticides by GCMS	EP068	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Polychlorinated Biphenyls (PCB)	EP066	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Redox Potential	EA075	3	6	**50.0**	**15.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / Analytical Methods	Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Evaluation	Quality Control Specification
Method Blanks (MB) - Continued							
Conductivity by PC Titrator	EA010-P	1	11	**9.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	25	**8.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Pesticides by GCMS	EP068	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Polychlorinated Biphenyls (PCB)	EP066	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	14	**7.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Turbidity	EA045	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	25	**8.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	APHA 21st ed. 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity by PC Titrator	EA010-P	WATER	APHA 21st ed., 2510 B This procedure determines conductivity by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Turbidity	EA045	WATER	APHA 21st ed., 2130 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Redox Potential	EA075	WATER	In House (Ion selective electrode)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Oxygen - Dissolved	EP025	WATER	APHA 21st ed., 4500-O G. Dissolved Oxygen Probe. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Polychlorinated Biphenyls (PCB)	EP066	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Pesticides by GCMS	EP068	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH - Semivolatile Fraction	EP071	WATER	USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Volatiles/BTEX	EP080	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Preparation Methods	Method	Matrix	Method Descriptions

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

APPENDIX E

Limitations

LIMITATIONS

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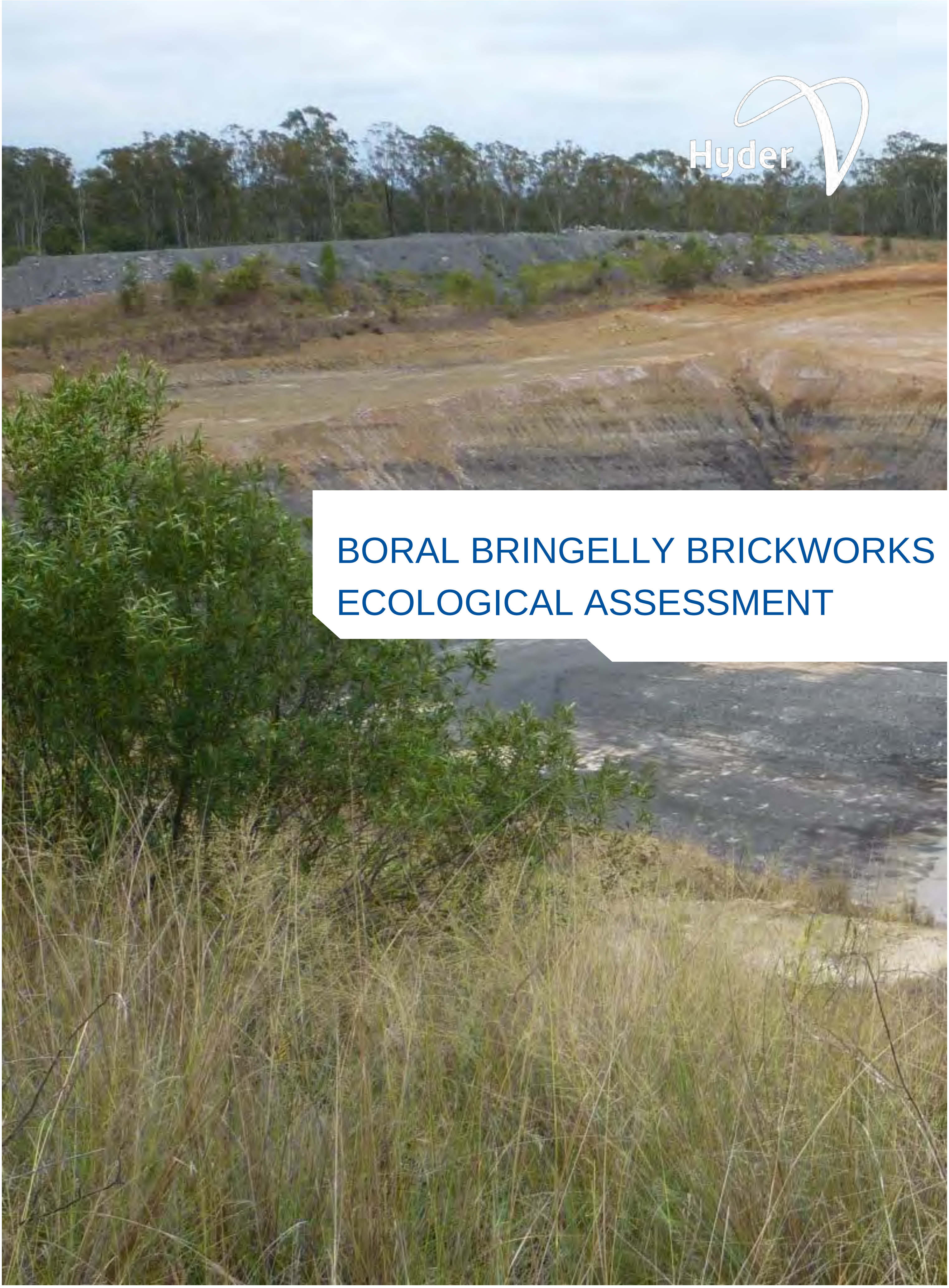
APPENDIX K

ECOLOGICAL ASSESSMENT



BORAL BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

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BORAL

BRINGELLY BRICKWORKS EXPANSION

Ecological Assessment

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Report No F0006-AA005667-NSR-01.docx

Date 3 September 2013

This report has been prepared for Boral in accordance with the terms and conditions of appointment for Bringelly Brickworks Expansion dated 7 January 2013. Hyder Consulting Pty Ltd (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

APPENDICES

1 EXECUTIVE SUMMARY

Boral proposes to expand their Brickworks facility at Bringelly, New South Wales to increase its production capacity. The increased brick production will require extraction of clay from a larger resource area (30.65 hectares) than permitted under the current consent for the site (9.9 hectares). The proposed Bringelly Brickworks expansion project is defined as a State Significant Development (SSD) under the *State Environmental Planning Policy (State and Regional Development) 2011*.

This Ecological Assessment has been prepared to inform the Environmental Impact Statement being prepared for assessment under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Study Area for this assessment comprises the Bringelly brickworks site and surrounding vegetation. The Study Area is within the South West Growth Centre as identified in the *State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP).

The majority of the proposed quarry expansion would be undertaken within certified areas under the biodiversity certification of the Growth Centres SEPP. Any developments or activities proposed to be undertaken within certified areas do not need to undertake assessment of impacts on threatened species, populations and ecological communities, or their habitats, listed under the *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as would normally be required by Part 4 or 5 of the EP&A Act.

The non-certified areas within the Study Area are subject to assessment of impacts on threatened species, populations and ecological communities, or their habitats, under the EP&A Act as well as the Relevant Biodiversity Measures (RBMs) of the Biodiversity Certification Order.

Terrestrial and aquatic flora and fauna surveys were undertaken in January 2013 and focused on vegetation within the quarry footprint that is not certified under the Growth Centres SEPP. The survey findings can be summarised as follows:

- The Critically Endangered Ecological Community (CEEC) Cumberland Plain Woodland (CPW), as defined under the TSC Act, occurred in the Study Area in moderate to poor condition and as derived grassland. Poor condition Riparian Woodland, which meets the criteria for the endangered ecological community River-flat Eucalypt Forest (RFEF) under the TSC Act, was recorded adjoining Thompsons Creek within certified areas.
- Other vegetation within the Study Area was dominated by exotic species, and included Olive dominant woodland, exotic grassland and mixed exotic/planted native vegetation.
- No threatened flora species or populations were found at the site or are considered likely to occur.
- Fauna habitat features included woodland with hollow-bearing trees, aquatic and riparian habitats and grassland habitats. Several threatened fauna species listed as Vulnerable under the TSC Act have the potential to utilise these habitats. These species include hollow-dependent species such as Little Lorikeet (*Glossopsitta pusilla*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Eastern Freetail-bat (*Mormopterus norfolkensis*), woodland birds and bats such as Varied Sittella (*Daphoenositta chrysoptera*), Little Eagle (*Hieraaetus morphnoides*), Scarlet Robin (*Petroica boodang*), Flame Robin (*Petroica phoenicea*), Southern Myotis (*Myotis macropus*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) and the Cumberland Plain Land Snail (*Meridolum corneovirens*), an invertebrate restricted to Cumberland Plain Woodland.

- Thompsons Creek borders the eastern quarry boundary. It is mapped as Key Fish Habitat by the Department of Primary Industries (DPI). The creek is unlikely to contain habitat for any threatened fish species listed under the FM Act or EPBC Act.

Impacts as a result of the proposal include the removal of 2.87 hectares of CPW from within non-certified areas and removal of 7.87 hectares fauna habitat for threatened species including the loss of at least 13 hollow-bearing trees. Impacts to threatened species and CPW CEEC were assessed as not significant.

The proposal will directly impact 1.16 hectares of Existing Native Vegetation (ENV), as defined by the Biodiversity Certification Order for the Growth Centres SEPP, within the non-certified area. The loss of this ENV would be offset through the retention of 1.93 hectares of native vegetation within certified areas in the north-west of the Project Site, comprising 1.12 hectares of Moderate Condition CPW and 0.81 hectares of Poor Condition CPW.

GLOSSARY AND ACRONYMS

BoM	Bureau of Meteorology
CEEC	Critically Endangered Ecological Community
CPW	Cumberland Plain Woodland
CWD	Coarse Woody Debris
dbh	Diameter at breast height (of tree trunks)
DEC	Former NSW Department of Conservation (now OEH)
DECC	Former NSW Department of Environment and Climate Change (now OEH)
DECCW	Former NSW Department of Environment, Climate Change and Water (now OEH)
DGRs	Director-Generalõs Requirements
DoP	Former Department of Planning (now DP&I)
DP&I	NSW Department of Planning and Infrastructure
DPI	NSW Department of Primary Industries
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ENV	Existing Native Vegetation
EP&A Act	*Environmental Planning & Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESD	Ecologically Sustainable Development
FM Act	*Fisheries Management Act 1994*
Growth Centres SEPP	*State Environmental Planning Policy (Sydney Region Growth Centres) 2006*
KTP	Key Threatening Process
LEP	Local Environmental Plan
LGA	Local Government Area
Matters of NES	Matters of National Environmental Significance
NPW Act	*National Parks and Wildlife Act 1974*
NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage

Project Site	Area comprising the active quarry operations and associated infrastructure as well as the proposed expansion area.
RBM	Relevant Biodiversity Measure
Relevant Biodiversity Measures	The provisions set out as conditions of biodiversity certification in relation to the Growth Centres SEPP.
SEPP	State Environmental Planning Policy
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Populations and Communities
SIS	Species Impact Statement
SSD	State Significant Development
Study Area	The Bringelly brickworks site and surrounding vegetation bounded by the northern and western boundary fencing, including Greendale Road, and Thompsons Creek to the south and east.
TEC	Threatened Ecological Community
TSC Act	*Threatened Species Conservation Act 1995*

2 INTRODUCTION

2.1 THE PROPOSAL

Boral's Bringelly Brickworks existing development consent, granted by Camden Council on the 13 September 1991, permits quarry production up to 200,000 tonnes per annum and brick production up to 160,000 tonnes per annum. A recent operational decision by Boral to defer its Badgerys Creek site has resulted in an immediate requirement to increase production capacity (beyond consented volumes) at Bringelly to meet anticipated demand.

Boral is now seeking to increase the Bringelly site's current authorised production capacity through expansion. Features of the proposed quarry expansion (the proposal) include:

- Extraction of raw material from the site in the order of 200,000 tonnes per annum (tpa) (no change to current extraction consent) from the following cell pits:
  - Continuation of extraction from Cell A, B, C & F (11.84 ha) and continued extraction in these pits to a depth of approximately 30 m.
  - Extraction from new Cells D, E, G, H & I (18.97 hectares) and extraction in these pits to a depth of approximately 30 m.
- Brick production in the order of 263, 500 tonnes of bricks per year (increase of 103,500 from current consent).
- Construction of a 4.5m high noise bund on the northern boundary of the quarry operations which has a 3m flat top (i.e. 21m wide base with 1:2 batters).
- Construction of a 4.5m high noise bund along the northern Boral property boundary, from the position of the existing driveway to the proposed new driveway location (200m long x 3m flat top with a 21m wide base and 1:2 batter slopes).
- Import of raw materials required for brick making in the order of 96,000 tpa.
- Extension to existing buildings: undercover storage extension to the clay preparation building, and kiln trolley area in the brick manufacturing plant.
- Addition of two recycled water storage tanks.
- Upgrading of the existing bio-cycle sewage treatment plant.
- Driveway realignment.
- Associated handling, packaging, storage and transport of bricks.
- Associated construction of stockpiles.
- Maintenance and rehabilitation works.

2.2 DIRECTOR-GENERAL'S REQUIREMENTS

The following general and key biodiversity issues were identified in the Director-General's Requirements (DGRs) for the Boral Bringelly proposal in Table 1.

Table 1: Director-General Requirements for the project

Director-General's Requirements	Agency	Where addressed
A description of the existing environment using sufficient baseline data;	NSW Planning and Infrastructure	Section 4
An assessment of the potential impact of all stages of the development , including cumulative impacts, taking into consideration relevant guidelines, policies, plans and statutes;	NSW Planning and Infrastructure	Section 5
A description of the measures that would be implemented avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment;	NSW Planning and Infrastructure	Section 7
Measures taken to avoid, reduce or mitigate impacts on biodiversity;	NSW Planning and Infrastructure	Section 7
Accurate estimates of proposed vegetation clearing;	NSW Planning and Infrastructure	Section 5.1
A detailed assessment of potential impacts of the development on:	NSW Planning and Infrastructure	
• Terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems;	NSW Planning and Infrastructure	Section 5
• Regionally significant remnant vegetation, or vegetation corridors;	NSW Planning and Infrastructure	Section 5
• Impacts on Existing Native Vegetation (ENV) identified under the Biodiversity Certification Order for the Sydney Region Growth Centres; and	NSW Planning and Infrastructure	Section 5
• A comprehensive offset strategy to ensure the development maintains or improves the terrestrial and aquatic biodiversity values of the region in the medium to long term.	NSW Planning and Infrastructure	Section 7.3
An assessment of the potential impact to water quality on Thompsons Creek. Fisheries NSW has mapped Thompsons Creek as key fish habitat and recommends the maintenance or improvement of water quality in this system as a result of the works.	DPI Fisheries NSW	Section 5
An assessment of potential impacts of the proposal on watercourses, riparian areas, wetlands, groundwater and groundwater dependent ecosystems.	NSW Office of Water	Section 5
Adequate mitigating and monitoring requirements to address impacts.	NSW Office of Water	Section 7.2
In accordance with Relevant Biodiversity Measure (RBM) 6, 2,000 hectares of existing native vegetation is required to be retained and protected. If any development within the Growth Centres impacts on this vegetation it must be offset in accordance with the RBMs to ensure the certification requirements are maintained. To address this requirement OEH recommends the works aim to avoid	Office of Environment and Heritage	ENV would be impacted. Offsets are addressed in Section 7.3 and Appendix 9

Director-General's Requirements	Agency	Where addressed
impacting existing native vegetation in the non-subject area.		
To address this OEH specifically requests that the EIS provide detailed maps that clearly identify the location of works in relation to the subject lands, the non-subject lands and any impacts on existing native vegetation.	Office of Environment and Heritage	Figure 1 and Figure 14
The EIS must clearly identify and quantify any impacts on existing native vegetation and outline offset arrangements in accordance with the relevant biodiversity measures. Offsets are to be secured prior to determination.	Office of Environment and Heritage	Section 5 and Section 7.3
Biodiversity impacts can be assessed using either the BioBanking Assessment Method (scenario 1) or a detailed biodiversity assessment (scenario 2). *Scenario 2 was selected. Requirements are as follows:*	Office of Environment and Heritage	
1. The EA should include a detailed biodiversity assessment, including assessment of impacts on threatened biodiversity, native vegetation and habitat. This assessment should address the matters included in the following sections.	Office of Environment and Heritage	Section 5
2. A field survey of the site should be conducted and documented in accordance with relevant guidelines, including: • *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians* (DECCW, 2009); • *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft* (DEC, 2004); and • Threatened species survey and assessment guidelines information on www.environment.nsw.gov.au/threatenedspecies/surveyassessmentgdlns.htm. • If a proposed survey method is likely to vary significantly from the above methods, the proponent should discuss the proposed method with OEH prior to undertaking the EA, to determine whether OEH considers that it is appropriate. Recent (less than five years old) surveys and assessments may be used. However, previous surveys should not be used if they have: ○ been undertaken in seasons, weather conditions or following extensive disturbance events when the subject species are unlikely to be detected or present; or ○ utilised methodologies, survey sampling intensities, timeframes or baits that are	Office of Environment and Heritage	Section 3.2, Appendices 6 and 7

Director-General's Requirements	Agency	Where addressed
not the most appropriate for detecting the target subject species, ○ unless these differences can be clearly demonstrated to have had an insignificant impact upon the outcomes of the surveys. If a previous survey is used, any additional species listed under the TSC Act since the previous survey took place, must be surveyed for. • Determining the list of potential threatened species for the site must be done in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft* (DEC, 2004) and the *Guidelines for Threatened Species Assessment* (Department of Planning, July 2005). The OEH Threatened Species website http://www.environment.nsw.gov.au/threatenedspecies/ and the Atlas of NSW Wildlife database must be the primary information sources for the list of threatened species present. The BioBanking Threatened Species Database, the Vegetation Types databases (available on OEH website at http://www.environment.nsw.gov.au/biobanking/biobankingtspd.htm and http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm, respectively) and other data sources (e.g. PlantNET, Online Zoological Collections of Australian Museums (http://www.ozcam.org/), previous or nearby surveys etc.) may also be used to compile the list.		
3. The EA should contain the following information as a minimum: • The requirements set out in the *Guidelines for Threatened Species Assessment* (Department of Planning, July 2005); • Description and geo-referenced mapping of Study Area (and spatial data files}, e.g. overlays on topographic maps, satellite images and /or aerial photos, including details of map datum, projection and zone, all survey locations, vegetation communities (including classification and methodology used to classify), key habitat features and reported locations of threatened species, populations and ecological communities present in the subject site and Study Area; • Description of survey methods used, including timing, location and weather conditions; • Details, including qualifications and experience of all staff undertaking the surveys, mapping and assessment of impacts as part of the EA;	Office of Environment and Heritage	Sections 3, 4, 5, 7 and Appendices 6 and 7

Director-General's Requirements	Agency	Where addressed
• Identification of national and State listed threatened biota known or likely to occur in the Study Area and their conservation status; • Description of the likely impacts of the proposal on biodiversity and wildlife corridors, including direct and indirect and construction and operation impacts. Wherever possible, quantify these impacts such as the amount of each vegetation community or species habitat to be cleared or impacted, or any fragmentation of a wildlife corridor; • Identification of the avoidance, mitigation and management measures that will be put in place as part of the proposal to avoid or minimise impacts, including details about alternative options considered and how long term management arrangements will be guaranteed; and • Description of the residual impacts of the proposal. If the proposal cannot adequately avoid or mitigate impacts on biodiversity, then a biodiversity offset package is expected (see the requirements for this at point 6 below).		
4. An assessment of the significance of direct and indirect impacts of the proposal must be undertaken for threatened biodiversity known or considered likely to occur in the Study Area based on the presence of suitable habitat. This assessment must take into account: • the factors identified in s.5A of the EP&A Act; and • the guidance provided by The Threatened Species Assessment Guideline - The Assessment of Significance (DECCW, 2007) which is available at: http://www.environment.nsw.gov.au/resources/threatenedspecies/tsaguide07393.pdf	Office of Environment and Heritage	Section 5 and Appendix 8
5. Where an offsets package is proposed by a proponent for impacts to biodiversity (and a BioBanking statement has not been sought) this package should: • Meet OEH's Principles for the use of biodiversity offsets in NSW, which are available at: www.environment.nsw.gov.au/biocertification/offsets.htm; • Identify the conservation mechanisms to be used to ensure the long term protection and management of the offset sites; and • Include an appropriate management plan (such as vegetation or habitat) that has been developed as a key amelioration measure to ensure any proposed compensatory offsets, retained habitat enhancement features within the development footprint and/or impact	Office of Environment and Heritage	Section 7.3

Director-General's Requirements	Agency	Where addressed
mitigation measures (including proposed rehabilitation and/or monitoring programs) are appropriately managed and funded.		
6. Where appropriate, likely impacts (both direct and indirect) on any adjoining and/or nearby OEH estate reserved under the *National Parks and Wildlife Act 1974* or any marine and estuarine protected areas under the *Fisheries Management Act 1994* or the *Marine Parks Act 1997* should be considered. Refer to the Guidelines for developments adjoining land and water managed by the Department of Environment, Climate Change and Water (DECC 2010).	Office of Environment and Heritage	Section 2.6
7. With regard to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the assessment should identify any relevant Matter of National Environmental Significance and whether the proposal has been referred to the Commonwealth or already determined to be a controlled action.	Office of Environment and Heritage	Section 5
8. In order to assess the project when the EA is on exhibition, OEH will require the applicant to provide copies of ESRI shapefiles (or similar GIS files) that delineate above ground infrastructure and clearing, as well as the proposed longwall panels layout. Other shapefiles that will be required are those showing all locations surveyed (include GPS track logs for random meander surveys), the locations of all threatened species found (with population sizes, etc, in the fields of the attribute tables) and mapping of vegetation communities carried out during the assessment.	Office of Environment and Heritage	Shapefiles will be provided to OEH on request
The EIS should provide an assessment of the consistency of the proposal with the relevant biodiversity measures contained within **[**the biodiversity certification conferred on the *State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP)].	Office of Environment and Heritage	Appendix 9

2.3 PURPOSE AND SCOPE

This Ecological Assessment has been prepared to inform the Environmental Impact Statement being prepared under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and addresses the biodiversity issues identified in the Director-Generalõs Requirements for the proposed Boral Brickworks expansion project (Table 1). The assessment has been prepared in accordance with *Draft Guidelines for Threatened Species Assessment* (DEC & DPI), *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC) and *Principles for the Use of Biodiversity Offsets in NSW* (DECCW).

2.4 OBJECTIVES

The key objectives of this Ecological Assessment are to:

- Describe the existing environment.
- Undertake targeted flora and fauna survey within the Study Area (in accordance *with Threatened Biodiversity and Assessment: Guidelines for Developments and Activities* (DECC 2004)).
- Identify any threatened terrestrial and aquatic (including groundwater dependent) species, populations or their habitats, Endangered Ecological Communities and/or critical habitat.
- Assess the potential impacts of the proposal, including direct, indirect and cumulative impacts.
- Describe measures to be implemented to avoid, minimise, manage, mitigate, offset and/or monitor the impacts of the proposal and any residual impacts.

2.5 STUDY AREA

The Study Area for this assessment comprises the Bringelly brickworks site and surrounding vegetation bounded by the northern and western boundary fencing, including Greendale Road and Thompsons Creek to the south and east.

The Study Area is located within the South West Growth Centre of the Sydney region as identified in the *State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP).

The Study Area for the current assessment covers a total area of approximately 96 hectares. The Project Site falls within the study area and comprises the active quarry operations and associated infrastructure as well as the proposed expansion area and covers an area approximately 56.75 hectares in size. The Study Area and Project Site are shown on Figure 1.

The Study Area is in the Camden Local Government Area (LGA).

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

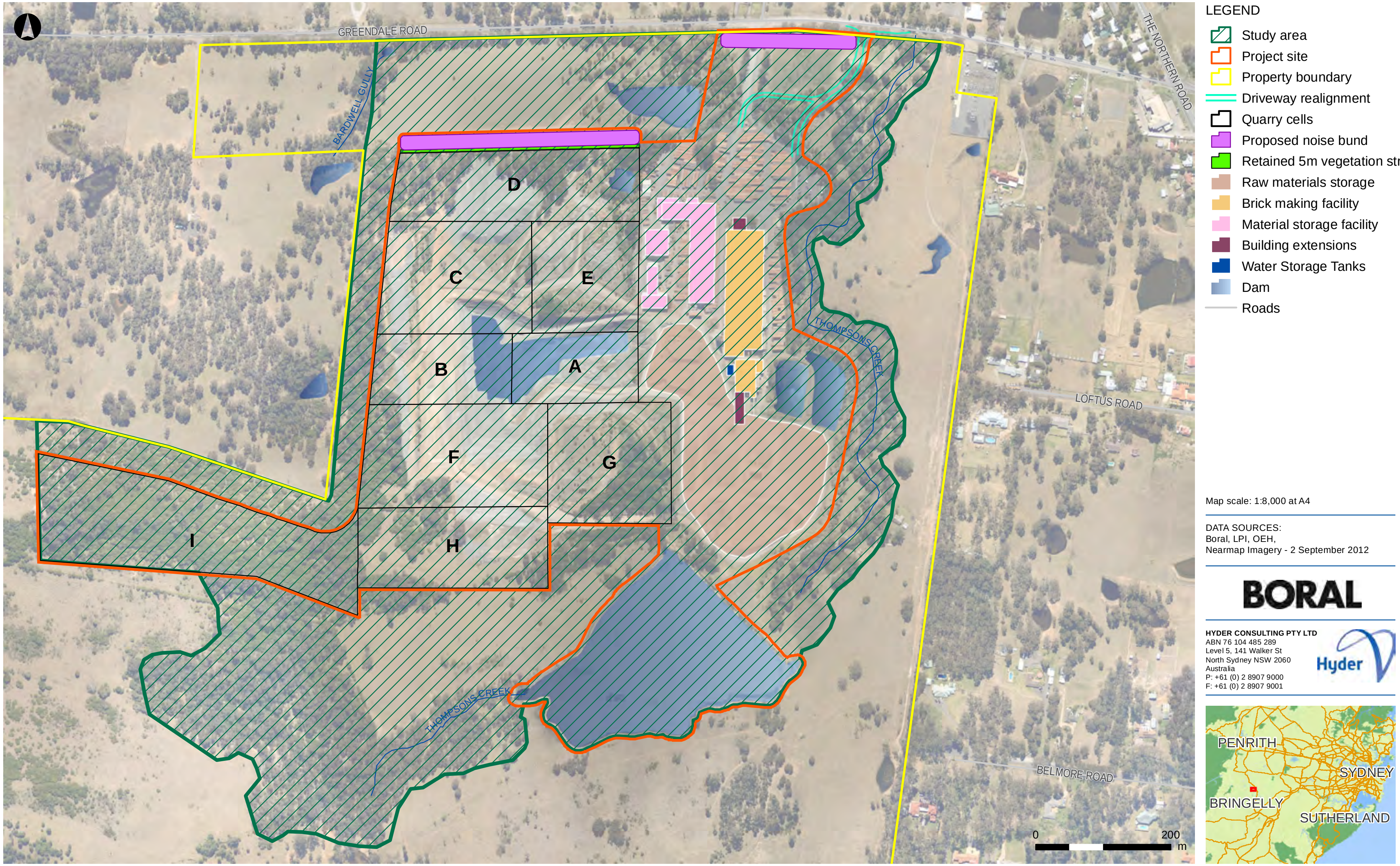

Figure 1: Study area

2.6 LEGISLATION AND POLICY

2.6.1 COMMONWEALTH *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999*

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, defined in the EPBC Act as matters of National Environmental Significance (NES). Matters of NES identified in the Act include:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (listed under the Ramsar Convention).
- Threatened species and communities.
- Migratory species protected under international agreements.
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- Nuclear actions (including uranium mines).

Under the EPBC Act, actions that have, or are likely to have, a significant impact on Matters of NES require approval from the Australian Government Minister for Sustainability, Environment, Water, Population and Communities (the Minister). The Minister holds responsibility for deciding whether assessment and approval is required under the EPBC Act.

2.6.2 NSW *ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979*

The *Environmental Planning and Assessment Act 1979* (EP&A Act) provides the framework for assessing developments in NSW. Under the EP&A Act, a project is classified as State Significant Development (SSD), pursuant to Part 4 Section 89C, if it is declared as SSD by a State Environmental Planning Policy (SEPP) or declared SSD by order of the Minister for Planning in the Government Gazette. The Bringelly Brickworks Expansion Project is classified as SSD, as it meets the requirements of Clause 7 (1)(b), Schedule 1 of *State Environmental Planning Policy (State and Regional Development) 2011*:

> *(1) Development for the purpose of extractive industry that:*
>
> > *(b) extracts from a total resource (the subject of the development application) of more than 5 million tonnes,*

The Minister is generally the consent authority for SSD in accordance with Part 4 of the EP&A Act.

In accordance with Section 5A (s.5A) of the EP&A Act seven factors ñmust be taken into accountò by a consent or determining authority in the administration of Sections 78A, 79C and 112 of the Act when considering an activity or development proposal. These seven factors comprise the Assessment of Significance, the aim of which is to determine ñwhether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitatsò, as listed under Schedules 1, 1A and 2 of the *Threatened Species Conservation Act 1995* and Schedules 4, 4A and 5 of the *Fisheries Management Act 1994*. If it is concluded that the proposal is likely to significantly impact any threatened species, populations or ecological communities, a Species Impact Statement (SIS) must be prepared.

2.6.3 NSW *THREATENED SPECIES CONSERVATION ACT 1995*

The NSW *Threatened Species Conservation Act 1995* (TSC Act) provides for the protection and management of threatened species, populations and ecological communities listed under schedules 1, 1A and 2 of the Act. The purpose of the TSC Act is to:

- Conserve biological diversity and promote ecologically sustainable development.
- Prevent the extinction and promote the recovery of threatened species, populations and ecological communities.
- Protect the critical habitat of those species, populations and ecological communities that are endangered.
- Eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities.
- Ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed.
- Encourage the conservation of threatened species, populations and ecological communities through co-operative management.

If a planned development or activity will have an impact on a threatened species, population or ecological community listed under the TSC Act, an Assessment of Significance under section 5A of the EP&A Act must be undertaken. If the impacts are likely to be significant, an SIS must be prepared and the Director-General of the Office of Environment and Heritage (OEH) must agree to the development approval.

Under Part 7AA of the TSC Act, the Minister may confer biodiversity certification on specified land. The effect of biodiversity certification on activities under Part 5 of the EP&A Act is that:

- an activity carried out or proposed to be carried out on biodiversity certified land is not likely to significantly affect any threatened species, population or ecological community listed under the TSC Act, or its habitat, and
- a determining authority under Part 5 of the Planning Act is not required under that Part to consider the effect on biodiversity values of an activity carried out on biodiversity certified land (despite section 111 of the EP&A Act).

The biodiversity certification order that applies to the Study Area is discussed further in Section 2.6.4 of this report.

2.6.4 *STATE ENVIRONMENTAL PLANNING POLICY (SYDNEY REGION GROWTH CENTRES) 2006* (GROWTH CENTRES SEPP)

The *State Environment Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP) aims to co-ordinate the release of land for residential, employment and other urban development in the North West and South West Growth Centres of the Sydney region. The Study Area is located within the South West Growth Centre.

On 11 December 2007 an order conferring biodiversity certification on the Sydney Growth Centres SEPP was made by the Minister for the Environment under section 126G of the TSC

Act. Under the terms of the Biodiversity Certification order (Appendix 1), any developments or activities proposed to be undertaken within certified areas do not need to undertake assessment of impacts on threatened species, populations and ecological communities, or their habitats, that would normally be required by Part 4 or 5 of the EP&A Act.

Therefore, further impact assessment for matters listed under the TSC Act or *Fisheries Management Act 1994* (FM Act) are not required for areas designated as ñcertifiedò.

Furthermore, listed threatened species and communities, and migratory species on the EPBC Act do not require assessment on certified land as discussed in Section 2.6.5.

The north-eastern 59 hectares of the Study Area, including the majority of the Project Site, has been mapped within the certified area on the map accompanying the Biodiversity Certification Order (Figure 2).The south-western 31 hectares of the Study Area is mapped within a non-certified area. The non-certified land that overlaps the Study Area extends further to the south and comprises approximately 249 hectares. The boundary between non-certified and certified areas in the Study Area is irregular. The non-certified area within the Study Area and to the south of the Study Area is also identified as ñtransitional landò on the South West Growth Centre Development Control Map ï sheet DVC_002 and is subject to development controls under clauses 20-23 of the Growth Centres SEPP. Clause 23 of the Growth Centres SEPP specifies that native vegetation on transitional land must not be cleared without approval under Part 3A of the EP&A Act (now repealed), or development consent, For the purposes of this clause, clearing native vegetation has the same meaning as it has in the Native Vegetation Act 2003, which is any indigenous species of trees, understorey plants, groundcover or wetland plants.

Development consent under clause 23 is not to be granted unless the consent authority is satisfied of the following in relation to the disturbance of bushland caused by the clearing of the vegetation:

(a) that there is no reasonable alternative available to the disturbance of the bushland,

(b) that as little bushland as possible will be disturbed,

(c) that the disturbance of the bushland will not increase salinity,

(d) that bushland disturbed for the purposes of construction will be re-instated where possible on completion of construction,

(e) that the loss of remnant bushland caused by the disturbance will be compensated by revegetation on or near the land to avoid any net loss of remnant bushland,

(f) that no more than 0.5 hectare of bushland will be cleared unless the clearing is essential for a previously permitted use of the land.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

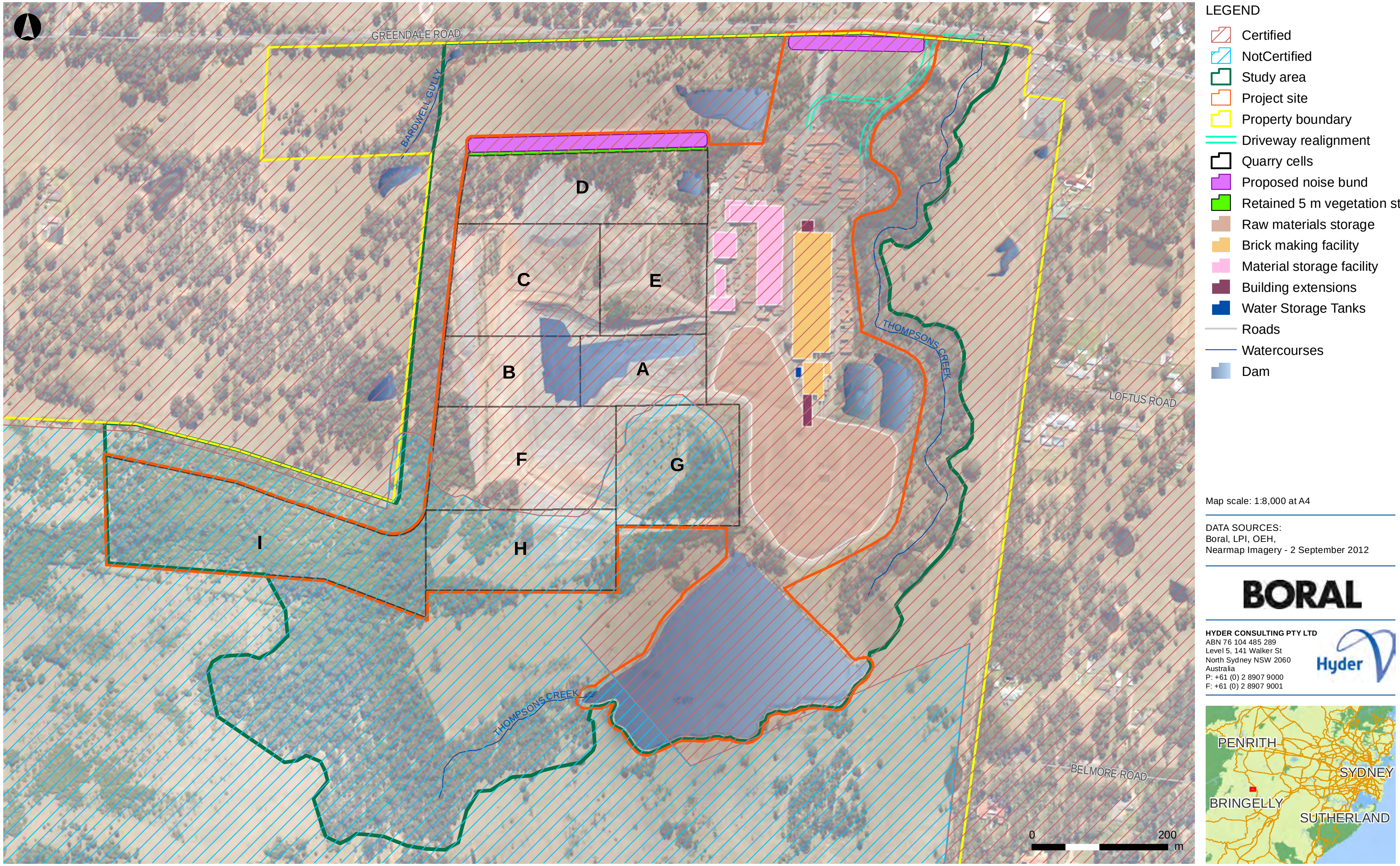

Figure 2: Biodiversity Certification within the study area

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2.6.5 COMMONWEALTH STRATEGIC ASSESSMENT

The NSW Department of Planning and Infrastructure (Office of Strategic Lands), in consultation with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC), undertook a Strategic Assessment under the EPBC Act of the Sydney Growth Centres (the program) (DECCW and DoP 2010).

The Strategic Assessment concluded that there were Matters of NES that were likely to be impacted through implementation of the program, but that the program addresses the potential impacts through a range of mechanisms including avoidance, mitigation and management, and offsets. The program was considered to meet the principles of ecologically sustainable development (ESD).

Following consideration of the program and the final Strategic Assessment report (DECCW and DoP 2010), the Commonwealth Minister endorsed the program document on 20 December 2011, with the inclusion of an addendum relating to further commitments and undertakings by the NSW government. The Commonwealth Minister subsequently approved all actions associated with the development of the Western Sydney Growth Centres as described in the Strategic Assessment Program Report on 28 February 2012. Actions approved under this decision would not require separate referral, assessment or approval under the EPBC Act in order to be taken. This applies to land that is certified under the Growth Centres SEPP.

2.6.6 NSW *FISHERIES MANAGEMENT ACT 1994*

The *Fisheries Management Act 1994* (FM Act) provides for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. The Act also covers the identification and management of key threatening processes which affect threatened species or could cause other species to become threatened.

If a planned development or activity is likely to have any impact on a threatened entity listed under the FM Act, an Assessment of Significance must be undertaken. If the impacts are likely to be significant, or if critical habitat is affected, an SIS must be prepared.

2.6.7 NSW *NOXIOUS WEEDS ACT* 1993

The Noxious Weeds Act 1993 provides for the identification and classification for noxious weeds in each New South Wales Local Government Area (LGA). The Act imposes obligations on occupiers of land to control noxious weeds declared for their LGA.

3 METHODOLOGY

3.1 DESKTOP RESEARCH

3.1.1 DATABASE INTERROGATION

Three database searches were undertaken to identify State and Commonwealth records of threatened entities and Commonwealth Matters of NES. Databases interrogated for this purpose were:

- The NSW Bionet Wildlife Atlas which is managed by the NSW Office of Environment and Heritage (OEH). A coordinate search using the centre point of the Study Area (33.94336, 150.72305) was undertaken to determine threatened species records listed under the TSC Act to within 10 kilometres of the Study Area.
- The Protected Matters Search Tool which is managed by SEWPaC. A coordinate search using the centre point of the Study Area (33.94336, 150.72305) was undertaken to determine threatened species, threatened ecological communities and migratory species listed under the EPBC Act known or likely to occur to within 10 kilometres of the Study Area.
- The Atlas of Living Australia, an Australian Government initiative that is a national database of Australiaộs flora and fauna. A coordinate search using the centre point of the Study Area (33.94336, 150.72305) was undertaken to determine threatened fish records listed under the FM Act or EPBC Act within 10 kilometres of the Study Area.

3.1.2 LITERATURE REVIEW

A review of relevant information was undertaken to provide an understanding of ecological values occurring or potentially occurring in the Study Area and wider region. Reports, vegetation maps, topographic maps, aerial photography and literature reviewed included, but were not limited to, the following:

- Soil Landscapes of the Penrith 1:100 000 Sheet (Bannerman & Hazelton 1990)
- Lot 2 DP 733115, Greendale Road, Bringelly Flora and Fauna Assessment for Boral (Cumberland Ecology 2007)
- Interpretation Guidelines for the Native Vegetation of the Cumberland Plain (NPWS 2002)
- Hawkesbury Nepean River Health Strategy Appendix 4.2: South Creek (Hawkesbury Nepean CMA 2007)

3.1.3 VEGETATION MAPPING

A number of large-scale vegetation mapping projects have been undertaken in the Sydney region. Those reviewed for this study are as follows:

- Native Vegetation of the Cumberland Plain (NPWS 2002)
- The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities (Tozer 2003)
- Changes in the distribution of Cumberland Plain Woodland (NSW Scientific Committee and Simpson 2008)

3.2 FIELD SURVEY

Terrestrial flora and fauna surveys of the Study Area were conducted by ecologists Jane Rodd and Kate Carroll on the 23rd and 31st January 2013. Jane and Kate have several years of experience as ecological consultants, both holding a Bachelor of Science in Ecology. The survey focused on vegetation within non-certified areas and the riparian corridor of Thompsons Creek. The Study Area is shown in Figure 1. Vegetation within certified areas was also included in the survey, though to a lesser detail as removal of this vegetation does not require assessment under the TSC Act or EPBC Act.

Weather on the first survey date was warm, overcast with high relative humidity and light south-south easterly winds. Weather on the second survey date was hot and sunny with high relative humidity and light easterly winds. Table 2 provides weather records from the Badgerys Creek weather station (station 067108) for the surveyed dates (BOM, 2013).

Table 2: Weather records from Badgerys Creek weather station for the survey dates

Date	Temperature		Rain	Maximum wind gust	
	Min °C	Max °C	mm	Direction	Speed (km/h)
23 January 2013	19.7	26.3	1.4	SSE	30
31 January 2013	19.2	33.0	0.4	E	31

3.2.1 FLORA

The plant taxonomy used in this report follows the system and nomenclature presented in the most recent edition of Flora of New South Wales (Harden 1990-1993, 2002). In this report plant species are referred to by both their scientific and common names (if applicable) when first mentioned. Subsequent references to these species cite the scientific name only.

Plant species and their habitat were surveyed by undertaking general habitat assessments, plot surveys and targeted searches. An inventory of plant species observed in the Study Area was compiled.

Random meander and targeted searches

The entire Study Area was traversed on foot and all species observed were recorded. Notes were made on the structure and condition of the vegetation in, and adjoining, the Study Area. Targeted searches for threatened plant species with potential habitat within the Study Area were undertaken during the random meanders.

Plot based survey (quadrats)

In order to comprehensively describe the structure and floristics of each sampled plant community, plot-based surveys were used. Plot-based surveys also provided a concentrated search area for the detection of inconspicuous plant species that may be present at a particular site. The structure and floristics of each plant community present in the Study Area were sampled using four 0.04 hectare quadrats. The quadrats were in the form of a 20 metre x 20 metre plot. The locations of the quadrats are shown on Figure 3.

The approximate projective foliage cover of every species identified in each quadrat was estimated and recorded as a percentage. Structural data including the height and projective foliage cover of each strata were recorded, as were the total length of fallen logs and number of trees with hollows within the quadrat.

Vegetation condition assessment

During the terrestrial flora survey the vegetation condition was assessed and rated according to the degree to which it resembled relatively natural, undisturbed vegetation. The condition assessment was based on visual assessment of the current habitat condition for each of the vegetation communities within the Study Area. Features examined to determine condition included: native species richness, native cover in each stratum, exotic cover, litter and bare ground cover, number of trees with hollows, woody debris, regeneration, diameter at breast height (dbh), canopy recruitment and tree health. These values were recorded quantitatively in transects/plots as well as qualitatively in general traverses across the Study Area.

The vegetation condition data obtained for each vegetation community in quadrats was compared with the Vegetation Type Benchmarks for the identified vegetation types (DECC 2008).

The condition of vegetation communities in the Study Area was assessed and mapped in accordance with three condition classes based on canopy cover, presence of structural vegetation layers and cover of exotic species. The criteria for the mapped condition classes are described in Table 3.

Table 3: Native vegetation condition classes

Condition class	Description
Good	Areas supporting >10% eucalypt cover. Native species are present and dominant in understorey.
Moderate	Areas supporting >10% eucalypt cover. Native species are present in understorey, however exotic species also occur and may be abundant in patches.
Poor	Areas supporting scattered eucalypt cover over cleared or exotic dominated ground cover.

3.2.2 FAUNA

The Study Area was traversed on foot and all species and evidence of fauna presence observed was recorded and habitat features assessed. An inventory of fauna species recorded in the Study Area was compiled.

Diurnal field surveys involved:

- Direct visual observations of animal activity.
- Aural recognition of bird and frog calls.
- Searches for indirect evidence of fauna (such as scats, nests, burrows, hollows, tracks, scratches and diggings).
- Fauna habitat assessment. Components of fauna habitat were assessed across the Study Area at varied locations according to habitat type. Locations are shown in Figure 3.
- Hollow-bearing tree inventory. Tree species, tree height, number and size of visible hollows were recorded. Trees without visible hollows but with the potential for hollows to occur were also recorded.

3.2.3 AQUATIC HABITAT

Aquatic assessments were undertaken at various locations along Thompsons Creek and at each of the dams within the Study Area, not in use for the quarry operations, including Thompsons Creek dam. A total of nine sites were surveyed. Survey locations are shown in Figure 3.

Aquatic assessments recorded the following:

- Channel features including channel width, substrate, water colour and turbidity.
- Instream habitat including rocks/pebbles, Coarse Woody Debris (CWD), aquatic vegetation.
- Riparian features including bank width and slope, riparian vegetation.

A visual assessment of any potential groundwater dependent ecosystems was also made across the site.

3.3 LIKELIHOOD OF OCCURRENCE OF THREATENED SPECIES

The database searches identified threatened flora and fauna species that have been recorded or that are likely to occur within 10 kilometres of the Study Area. The probability that each threatened species occurs within the Study Area was determined as being either Low, Moderate, High or Known, based on the criteria in Table 4.

Table 4: Likelihood of occurrence criteria for threatened species

Likelihood of occurrence	Criteria - one or more of the following conditions applies
Low	The species has not been recorded previously in the Study Area. The species has been recorded within 10km of the Study Area, though more than 20 years ago. The Study Area is beyond the current known geographic range. The species has specific habitat requirements that are not present in the Study Area. The species is considered extinct.
Moderate	The species has historically been recorded in the Study Area (>20 years ago) or more recently, within 10km of the Study Area. The species has specific habitat requirements that are present in the Study Area, but in a poor or modified condition. The species is unlikely to maintain a resident population in the Study Area, however may occasionally utilise resources within the Study Area.
High	The species has recently been recorded in the Study Area or nearby (i.e. within last 20 years). The species has specific habitat requirements that are present in the Study Area and are in good condition. The species is known or likely to maintain resident populations in proximity to the Study Area. The species is known or likely to regularly utilise resources in the Study Area.
Known	The species was recorded in the Study Area during the current survey.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

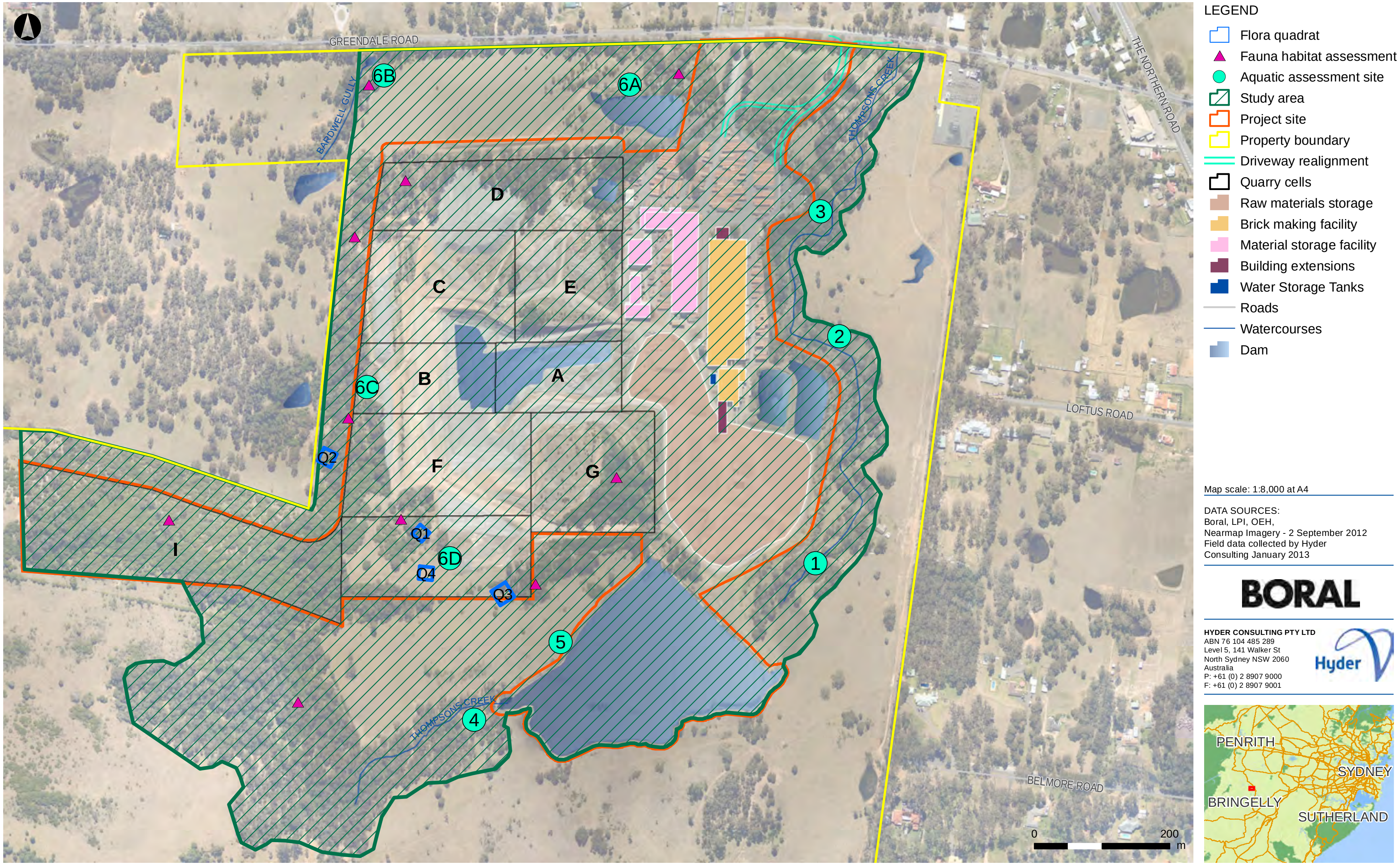

Figure 3: Ecological survey locations

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3.4 LIMITATIONS

The seasonal timing of the field investigation means that the full spectrum of flora and fauna species likely to occur on the Study Area may not be fully quantified or described in this report. Some plant species that occur in the local area, such as cryptic species, are annuals and are present only in the seed bank for much of the year. Other plant species are perennial but are inconspicuous or difficult to identify unless flowering.

Similarly, some fauna species that have been recorded in the local area occur on a seasonal or migratory basis, and may be absent from the locality for much for the year. Fauna behaviours may have also affected detectability; species that are easily disturbed or cryptic may not have been detected during surveys. It is possible that a number of flora and fauna species occurring in the Study Area were not detected during the current survey due to the above factors.

These potential limitations have been addressed by a thorough literature research and review and through identification of potential habitats for flora and fauna species and assessment of the potential for targeted species to occur on the site based on:

- Previous records.
- The type and condition of habitats present.
- The land use throughout the Study Area and surrounds.
- The landscape context.

The precautionary principle was applied where marginal habitat was identified or predicted to occur or where species are migratory or nomadic and were therefore likely to utilise habitat components at some stage during their life cycle.

4 RESULTS

4.1 ENVIRONMENTAL CONTEXT

4.1.1 GEOLOGY AND SOILS

The geology of the Penrith 1:100 000 sheet was mapped by Clark and Jones (1991). The majority of the Study Area was mapped as Wianamatta group Bringelly Shale which comprises shale, carbonaceous claystone, claystone, laminate, fine to medium grained lithic sandstone, rare coal and tuff (map unit Rwb). The riparian land of Thompsons Creek was mapped as Quaternary deposits of fine-grained sand, silt and clay (map unit Qal).

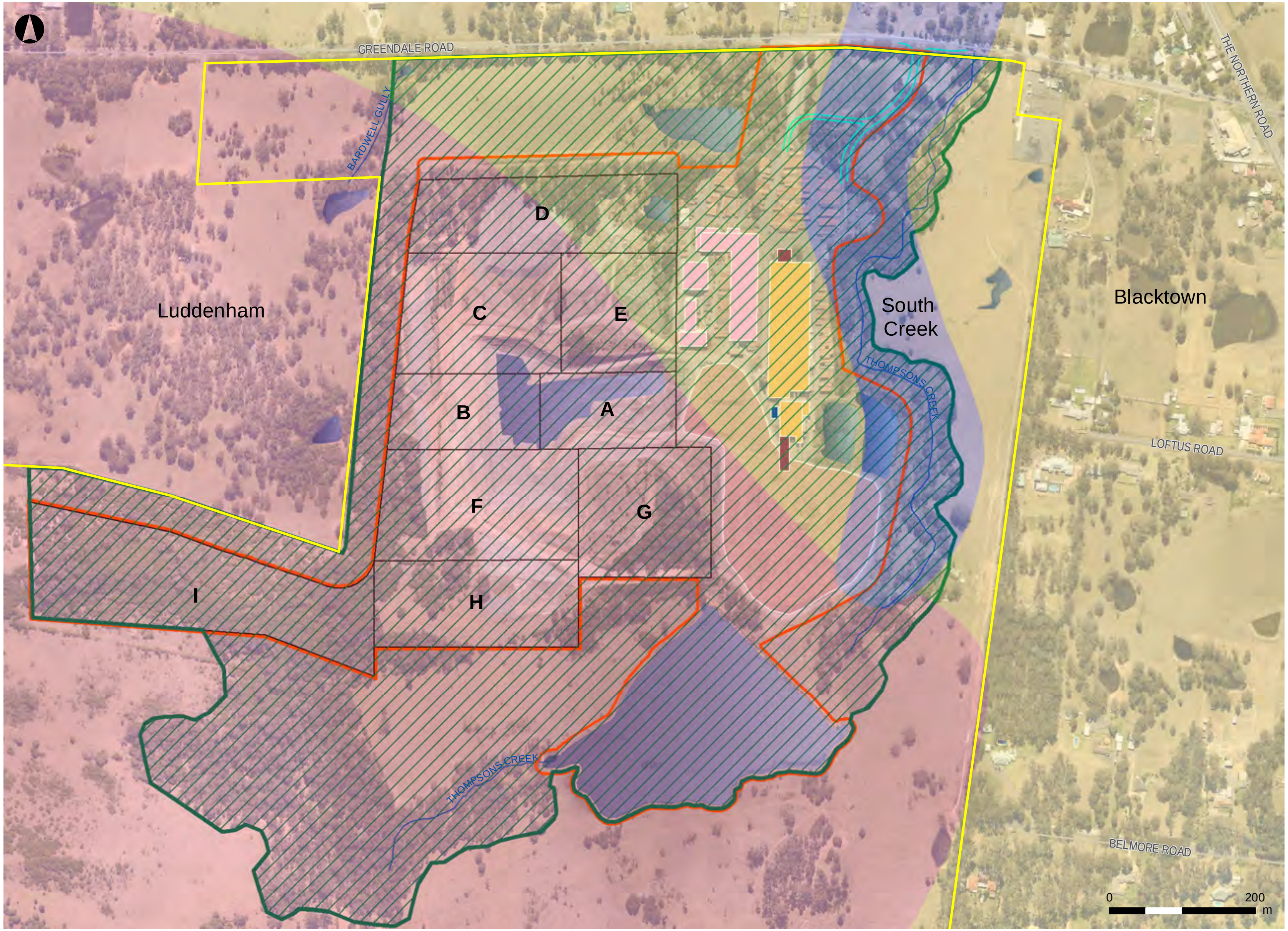
The soil landscapes of the Penrith 1:100 000 sheet were mapped by Bannerman and Hazelton (1990). There are three different soil landscapes mapped within the Study Area: the residual soil landscape Blacktown, the alluvial soil landscape South Creek, and the erosional soil landscape Luddenham.

The features and locations of each soil landscape are detailed in Table 5. Soil landscapes within the Study Area are mapped in Figure 4.

Table 5: Soil landscapes mapped in the Study Area (Bannerman and Hazelton, 1990)

Soil Landscape	Features (Bannerman and Hazelton 1990)	Location in Study Area
Blacktown (Residual)	Shallow to moderately deep hardsetting mottled texture contrast soils; red brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. Landscape is gently undulating rises on Wianamatta Group shales.	Across the northeast of the Study Area.
South Creek (Alluvial)	Often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays or structure loams in and immediately adjacent to drainage lines; red and yellow podzolic soils are most common on terraces with small areas of structured grey clays, leached clay and yellow solodic soils. Landscape comprises floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. Usually flat with incised channels and mainly cleared.	Along Thompsons Creek and associated riparian corridor bordering the north-eastern extent of the Study Area.
Luddenham (Erosional)	Shallow dark podzolic soils or massive earthy clays on crests; moderately deep red podzolic soils on upper slopes; moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines. Landscape is undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone.	Across most of the west and south of the Study Area.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT



LEGEND

Soil landscape

- Blacktown
- Luddenham
- South Creek
- Study area
- Project site
- Property boundary
- Driveway realignment
- Quarry cells
- Raw materials storage
- Brick making facility
- Material storage facility
- Building extensions
- Water Storage Tanks
- Roads
- Watercourses
- Dam

Map scale: 1:8,000 at A4

DATA SOURCES:
Boral, LPI, OEH,
Nearmap Imagery - 2 September 2012
Bannerman and Hazelton 1990

BORAL

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ABN 76 104 485 289
Level 5, 141 Walker St
North Sydney NSW 2060
Australia
P: +61 (0) 2 8907 9000
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Hyder

Figure 4: Soil landscapes of the study area (Bannerman and Hazelton 1990)

4.1.2 HYDROLOGY

The Study Area is located within the South Creek sub catchment of the Hawkesbury Nepean Catchment. It is managed by the Hawkesbury Nepean Catchment Management Authority (CMA). The South Creek sub catchment encompasses most of the Cumberland Plain, comprising meandering vertical river channels. Probably the most degraded sub catchment in the Hawkesbury-Nepean, the South Creek sub catchment is affected by sewage discharge, stormwater runoff from urban areas and agricultural runoff (Hawkesbury Nepean CMA, 2007).

Thompsons Creek is a tributary of South Creek. It is classified as a second order stream using the Strahler stream classification system (Strahler 1952). Thompsons Creek crosses the eastern and southern boundaries of the Study Area and also contains Thompsons Dam, directly south of the existing brickworks quarry. Thompsons Creek flows in a northerly direction across the Study Area.

Several dams are also located within the Study Area.

Hydrological features are mapped in Figure 5.

4.1.3 LAND USE

The Project Site is approximately 56.75 hectares in area and is occupied by a brick and clay manufacturing plant. It is located within the Camden Local Government Area and is approximately 55 km southwest of the Sydney Central Business District. Open woodland and cleared land surround the quarry operations. Since the site began brick production in 1968, the quarry area has undergone major expansions in the 1980s, 1990s and 2000s. Aerial photography over the past 25 years shows expansion mostly in the west of the site, resulting in clearing of woodland areas (as per development consent).

Land use in the locality is currently characterised by agricultural land and fragmented rural residential development. The Project Site is surrounded by mostly open woodland and cleared land which is predominately located to the southwest of the site. Rural residential development is located north-east of the site on the other side of Greendale Road, and toward the Northern Road to the east of the site.

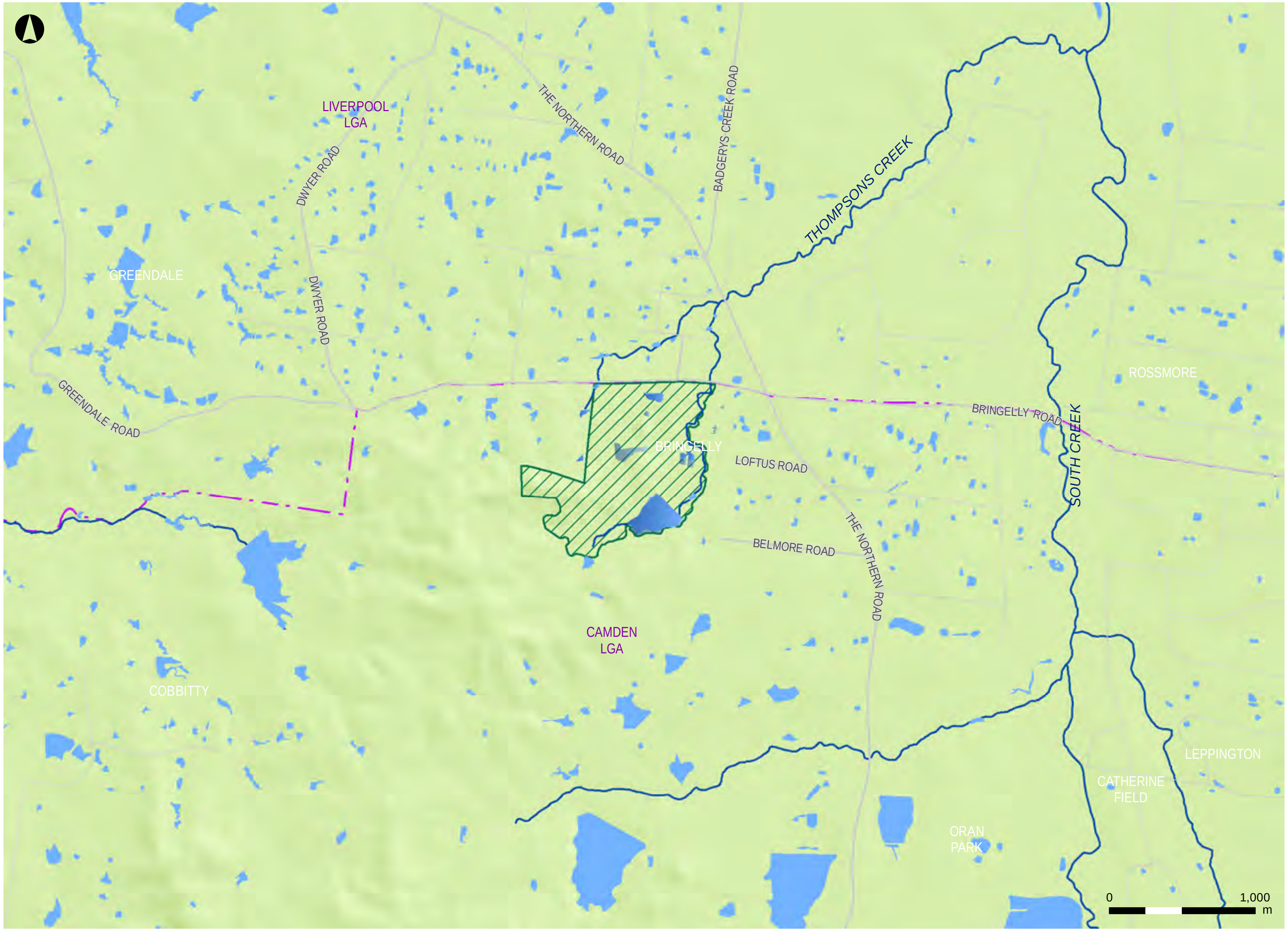
4.2 FLORA

4.2.1 LITERATURE REVIEW

An Environmental Impact Statement (EIS) was carried out for the upgrading of the Bringelly Brick and Paver Manufacturing Plant in 1991 (Resource Planning Pty Ltd 1991). According to Section 4.10 of the EIS (Vegetation and Fauna), a general field assessment of plant communities in the Study Area was undertaken. Much of the land was cleared at some time in the past, and has subsequently been infested with the weed species *Olea africana* (Olive) [now *O. europaea* subsp. *cuspidata*] and *Ligustrum sinense* (Privet). A stand of Eucalypt woodland remains along the drainage line and low ridge to the west of the existing plant and quarry; which has been partially cleared. The most common tree species on site are *Eucalyptus moluccana* (Grey Box), *E. acmenoides* and *E. tereticornis* (Forest Red Gum). The understorey is dominated by *Bursaria spinosa* (Blackthorn) and *Olea africana*, which the assessment states are "opportunistic species and are indicative of understorey disturbance".

Cumberland Ecology (2007) prepared a flora and fauna assessment for Lot 2 DP 733115, Greendale Road, Bringelly for Boral. The subject site for this assessment was 385 hectares in area and includes the current Study Area and areas to the south.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT



LEGEND

- Watercourses
- Lakes, dams
- Study area
- LGA boundary
- Roads

Map scale: 1:40,000 at A4

DATA SOURCES:
Boral, LPI, OEH,
Nearmap Imagery - 2 September 2012

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Hyder

Figure 5: Hydrological features of the study area and surrounds

Cumberland Ecology (2007) mapped the vegetation to the south and west of the existing quarry as Cumberland Plain Woodland, but state in descriptions of the vegetation that the introduced *Olea europaea* subsp. *africana* [now *O. europaea* subsp. *cuspidata*] dominates most of the forest and woodland on site, varying in cover from 10% to 95%. It was concluded that the majority of woodland and forest vegetation on the subject site was so degraded that it was no longer a viable EEC.

4.2.2 VEGETATION MAPPING

NPWS (2002)/Tozer (2003) mapped the native vegetation of the Cumberland Plain at a 1:16 000 scale, based on aerial photograph interpretation, mapped geological boundaries and field sampling. Mapping was updated in 2008. A total of 22 plant communities were defined using multi-variate analysis of quantitative field survey data. Each community was described using structural features, habitat characteristics and diagnostic species.

Three different plant communities were mapped in the Study Area (Figure 6); all correspond with threatened ecological communities listed under the TSC Act (Table 6).

Table 6: Vegetation communities mapped by NPWS (2002a)/Tozer (2003) and corresponding EECs

Vegetation map unit (NPWS 2002/Tozer 2003)	Corresponding TEC
Shale Hills Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion
Shale Plains Woodland	Cumberland Plain Woodland in the Sydney Basin Bioregion
Alluvial Woodland	River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

NPWS (2002) mapped the conservation significance of the vegetation in the Study Area as follows (Figure 7):

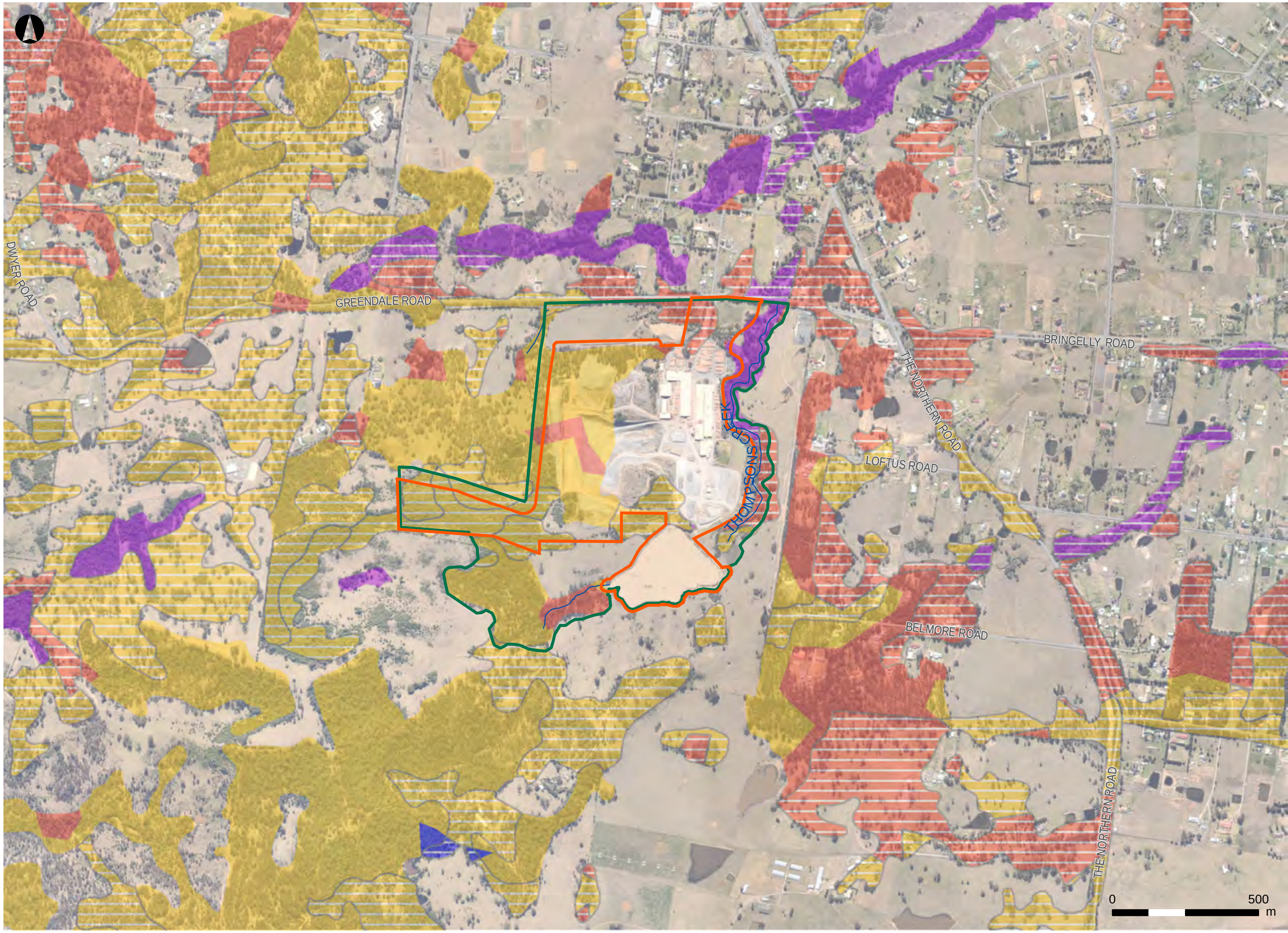
- Core habitat: Shale Hills Woodland and Shale Plains Woodland to the west and south of the existing quarry, and within the approved quarry area.
- Support to core habitat: Shale Hills Woodland, Shale Plains Woodland and Alluvial Woodland to the south-west, south, east and north of the existing quarry.

The Growth Centres Conservation Plan (ELA 2007) used endangered vegetation (areas mapped as TECs) as well as known distributions of threatened flora and fauna species as surrogates when determining biodiversity value.

Under the Growth Centres Biodiversity Certification, ENV is defined as areas of indigenous trees (including any sapling) that had 10 per cent or greater over-storey canopy cover present, were equal to or greater than 0.5 hectares in area, and were identified as ñvegetationò on maps 4 and 5 of the draft Growth Centres Conservation Plan (ELA 2007) at the time the biodiversity certification order took effect.

The areas of ENV mapped in the Study Area by ELA (2007) and referenced in the Biodiversity Certification Order are shown on Figure 8. The two small areas of ENV mapped along the northern edge of the non-certified area consists of the southern extent of a larger patch of ENV within certified areas, much of which has subsequently been cleared for stormwater mitigation.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT



LEGEND

Vegetation communities >10% canopy cover

- 9 - Shale Hills Woodland
- 10 - Shale Plains Woodland
- 11 - Alluvial Woodland
- 14 - Moist Shale Woodland

Vegetation communities <10% canopy cover

- 9 - Shale Hills Woodland
- 10 - Shale Plains Woodland
- 11 - Alluvial Woodland
- 14 - Moist Shale Woodland
- Project site
- Study area
- Roads
- Watercourses

Map scale: 1:20,000 at A4

DATA SOURCES:
Boral, LPI, OEH,
Nearmap Imagery - 2 September 2012
NSW Scientific Committee and
Simpson 2008

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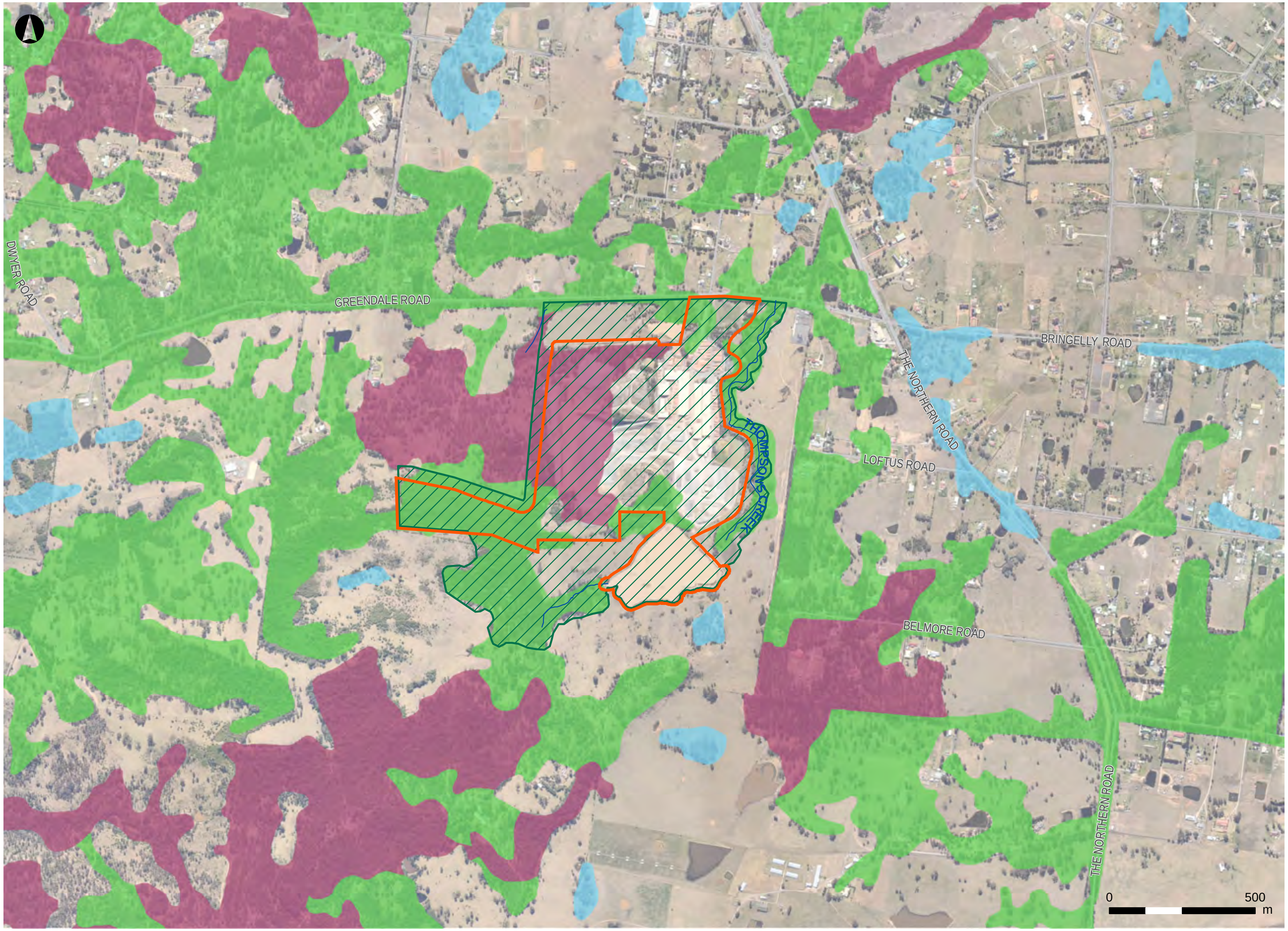
Figure 6: Native vegetation communities of the Cumberland Plain (NSW Scientific Committee and Simpson 2008)



LEGEND

Conservation significance assessment

- Core habitat
- Other remnant vegetation
- Support to core habitat
- Study area
- Project site
- Roads

Map scale: 1:20,000 at A4

DATA SOURCES:
Boral, LPI, OEH, NPWS 2002,
Nearmap Imagery - 2 September 2012

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Hyder

Figure 7: Conservation significance mapping of the Cumberland Plain (NPWS 2002)

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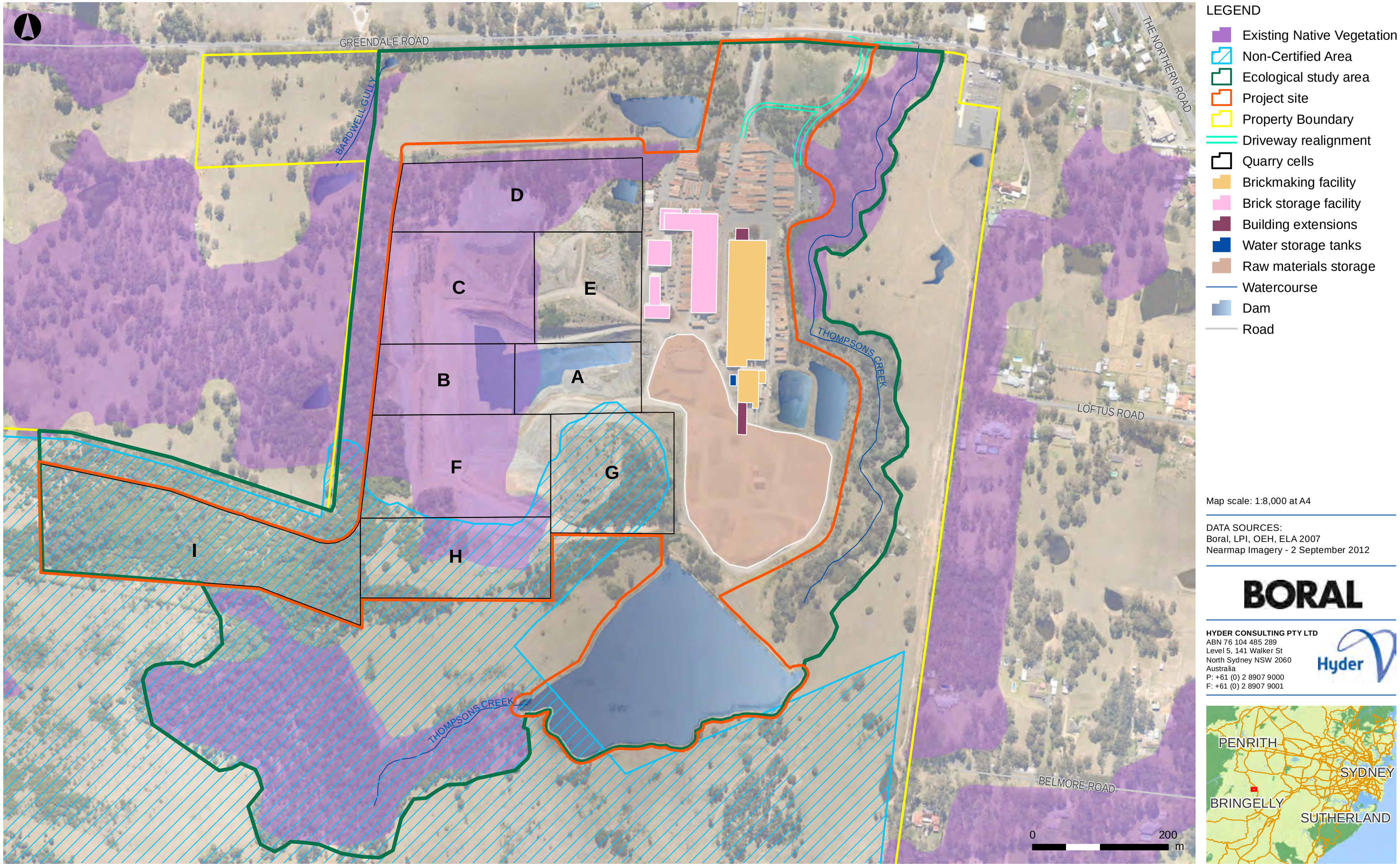

Figure 8: Existing Native Vegetation mapped within the study area

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Created by : KC
QA by : DD

4.2.3 DATABASE SEARCHES

Based on database and literature review, 20 plant species listed under the EPBC and/or TSC Acts are either recorded or have the potential to occur within 10 kilometres of the Study Area as shown in Table 7 and Figure 9.

Table 7: Threatened flora occurring within 10 kilometres of the Study Area

Scientific name	Common name	EPBC Act status	TSC Act status
Acacia pubescens	Downy Wattle	Vulnerable	Vulnerable
Allocasuarina glareicola	-	Endangered	Endangered
Cryptostylis hunteriana	Leafless Tongue-orchid	Vulnerable	Vulnerable
Cynanchum elegans	White-flowered Wax Plant	Endangered	Endangered
Dillwynia tenuifolia	-	Vulnerable	Vulnerable
Eucalyptus benthamii	Camden White Gum	Vulnerable	Vulnerable
Grevillea juniperina subsp. juniperina	Juniper-leaved Grevillea	-	Vulnerable
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	Vulnerable	Vulnerable
Lepidium hyssopifolium	Basalt Pepper-cress	Endangered	Endangered
Marsdenia viridiflora subsp. *viridiflora*	*Marsdenia viridiflora* R. Br. *subsp. viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith LGAs	-	Endangered population
Pelargonium sp. Striatellum (G.W. Carr 10345)	Omeo Storkôs-bill	Endangered	Endangered
Persoonia nutans	Nodding Geebung	Endangered	Endangered
Pimelea curviflora var. curviflora	-	Vulnerable	Vulnerable
Pimelea spicata	Spiked Rice-flower	Endangered	Endangered
Pomaderris brunnea	Rufous Pomaderris	Vulnerable	Vulnerable
Pterostylis saxicola	Sydney Plains Greenhood	Endangered	Endangered
Pultenaea parviflora	Sydney Bush-pea	Vulnerable	Endangered
Streblus pendulinus	Siahôs Backbone	Endangered	-
Syzygium paniculatum	Magenta Lilly Pilly	Vulnerable	Endangered
Thelymitra sp. Kangaloon	Kangaloon Sun-orchid	Critically Endangered	Critically Endangered

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

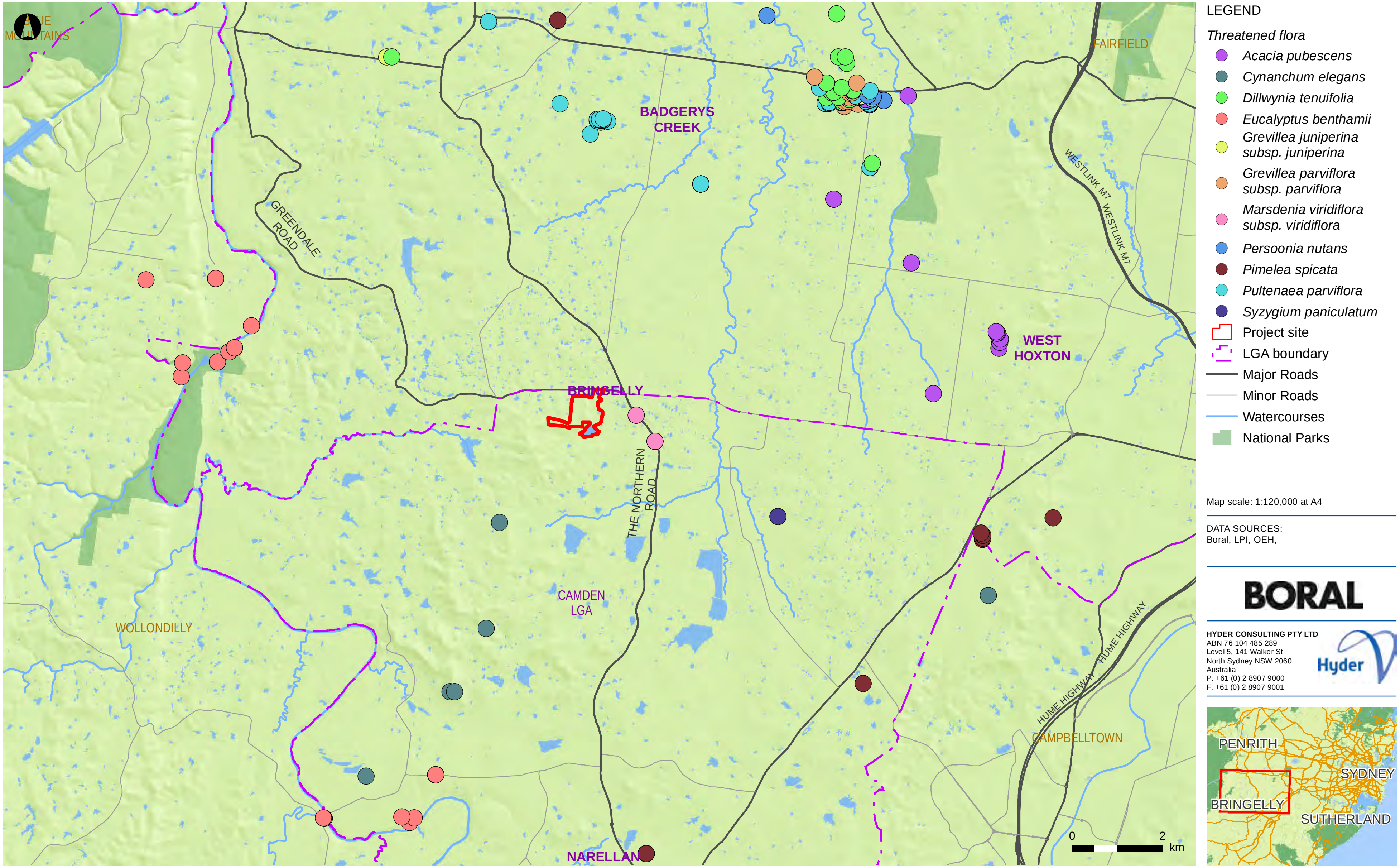

Figure 9: Threatened flora records within 10km of the study area (OEH 2013a)

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4.2.4 FIELD SURVEY

A total of 77 vascular plant species were recorded in the Study Area, comprising 54 local native species and 23 exotic species. A list of plant species recorded in the Study Area is provided in Appendix 3.

Vegetation communities

Ground truthing of the vegetation in the Study Area identified seven vegetation communities, including four communities with a canopy or ground layer dominated by native vegetation, and three communities dominated by exotic vegetation. The areas of each vegetation community within the study area are provided in Table 8 and the distribution of vegetation communities is shown on Figure 10.

Table 8: Vegetation communities identified in the Study Area

Vegetation community		Area in Study Area (ha)
Native vegetation	Moderate Condition CPW	15.12
	Poor Condition CPW	6.58
	Derived Grassland CPW	0.97
	Poor Condition Riparian Woodland	8.22
Exotic vegetation	Exotic Grassland	14.80
	Mixed Exotic/Planted Native	2.58
	Olive Dominant Woodland	9.02
Total		**57.30**

Native Vegetation Communities

Moderate Condition Cumberland Plain Woodland

Areas of Moderate Condition Cumberland Plain Woodland (CPW) had a canopy of regrowth *Eucalyptus moluccana* (Grey Box) and *E. tereticornis* (Forest Red Gum) to approximately 10 to 14 metres in height with an average diameter at breast height (dbh) of 20 to 30 cm. The understorey in these areas consisted of patchy cover of *Olea europaea* subsp. *cuspidata* (African Olive) with other native shrubs such as *Acacia implexa* (Hickory Wattle), *Bursaria spinosa* (Blackthorn) and *Melaleuca styphelioides* (Prickly Paperbark) occasionally present.

The ground layer varied from sparse native grasses and herbs with high leaf litter to dense native and exotic grasses including *Themeda australis* (Kangaroo Grass), *Aristida ramosa* (Wiregrass), *Austrostipa scabra* (Speargrass), *Microlaena stipoides* (Weeping Grass) and *Eragrostis curvula* (African Lovegrass). Good cryptogam cover was observed in some patches of these areas.

Understorey vegetation in the northwest section of Cell D was particularly weedy, containing exotic species such as *Eragrostis curvula*, *Bryophyllum delagoense* (Mother-of-millions) and *Chloris gayana* (Rhodes Grass). This area was not dominated by *Olea europaea* subsp. *cuspidata* in the understorey and therefore was not considered to constitute Poor Condition CPW.

Moderate condition CPW in non-certified areas in south-west of Study Area

Moderate condition CPW in certified areas in north-west of Study Area

Poor Condition Cumberland Plain Woodland

Poor Condition Cumberland Plain Woodland consisted of areas of remnant and regrowth *E. moluccana* and *E. tereticornis* over a dense midlayer of *Olea europaea* subsp. *cuspidata.* In most parts of this community, the *O. europaea* subsp. *cuspidata* is greater than 50% cover and ground layer vegetation is absent, supports *Olea* seedlings and leaf litter or has been reduced to very sparse cover of native and exotic grasses. These areas only very loosely meet the criteria for Cumberland Plain Woodland and are considered unlikely to be viable in the long term.

Poor condition CPW

Poor condition CPW south of quarry

Derived Grassland

South of the existing quarry, the stands of tree-dominated vegetation were interspersed with patches of grassland. The grasslands were dominated by native species such as *Themeda australis, Microlaena stipoides, Aristida ramosa* and *Chloris truncata* (Windmill Grass), with the cosmopolitan native pasture grass *Cynodon dactylon* (Couch) and exotic species such as *Eragrostis curvula, Chloris gayana* (Rhodes Grass) and *Briza subaristata* also present and dominant in patches. Areas of derived grassland are included in the definition of Cumberland Plain Woodland.

Derived grassland

Derived grassland

Poor Condition Riparian Woodland

Poor Condition Riparian Woodland occurred along Thompsons Creek to the east of the existing quarry. These areas supported scattered large trees of *Eucalyptus tereticornis* with an understorey of scattered *Olea europaea* subsp. *cuspidata* and *Bursaria spinosa* in the south and a denser midlayer of *Melaleuca styphelioides* and *Ligustrum sinense* (Small-leaved Privet) in the north. All areas of Degraded Riparian Woodland were in certified areas. This vegetation is in poor condition and loosely meets the criteria for the EEC River-flat Eucalypt Forest.

Exotic Vegetation Communities

Olive Dominant Woodland

Areas of Olive dominant woodland support a canopy of *Olea europaea* subsp. *cuspidata* with only occasional eucalypt occurrence. The ground layer is generally absent or supports *Olea* seedlings and leaf litter, although there are small patches of native and exotic grasses where there are canopy gaps. These areas are not considered to meet the criteria for Cumberland Plain Woodland.

Understorey beneath Olive dominant Woodland

Occasional grassland patches in Olive Dominant Woodland

The native vegetation communities identified in the Study Area are equivalent to the following Vegetation Types as defined in the NSW Vegetation Type Database (Table 9):

Table 9: Native Vegetation Types in the Study Area

Identified vegetation community	Equivalent Vegetation Type
Cumberland Plain Woodland	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin
Degraded Riparian Woodland	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin

Vegetation condition

A comparison of the quadrat data from the current survey with the benchmark values for the identified communities as defined in the OEH Vegetation Benchmarks Database found that both native species richness and structural attributes were well below benchmark condition for the equivalent vegetation type, Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin (Table 10). This is consistent with the historical and ongoing disturbance of the vegetation in the Study Area.

Table 10: Quadrat data compared with benchmark values for Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin

Benchmark Attribute	Benchmark Values	Recorded values for benchmark attributes			
		Q1	Q2	Q3	Q4
Native plant species richness	29	15	7	12	9
Native overstorey cover	21-26%	10%	10%	0	0
Native midstorey cover	26-31%	0	0	0	0
Native ground cover (grasses)	27-31%	30%	1%	30%	80%
Native ground cover (shrubs)	0-5%	0	0	0	0
Native ground cover (other)	15-19%	2%	1%	1%	2%
Number of trees with hollows	1	0	1	0	0
Total length of fallen logs (m)	5	10	10	0	0

Groundwater dependent ecosystems

Golder and Associates (2013) conducted a Groundwater Assessment for the proposal (Appendix J of the EIS). This assessment included an overview of groundwater dependent ecosystems (GDEs), which is summarised as follows. GDEs can be defined as those ecosystems whose ecological processes and biodiversity are wholly or partially reliant on groundwater. Examples of GDEs include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps and near-shore marine ecosystems (NSW Office of Water 2012).A search for GDEs from the National Atlas of GDEs indicates Cumberland Plain Woodland and River-flat Eucalypt Forest are reliant on subsurface groundwater. These woodlands are likely to be supported by water near the surface or rainfall.

The National GDE Atlas lists South Creek as a GDE category ōReliant on surface expression of groundwateró However, there are no identified high priority GDEs, subterranean GDEs, river base flows, karst or cave ecosystems, or known springs that are fed by groundwater in the Study Area and surrounds. More detailed information on the groundwater attributes of the Study Area is provided in the Golder and Associates (2013).

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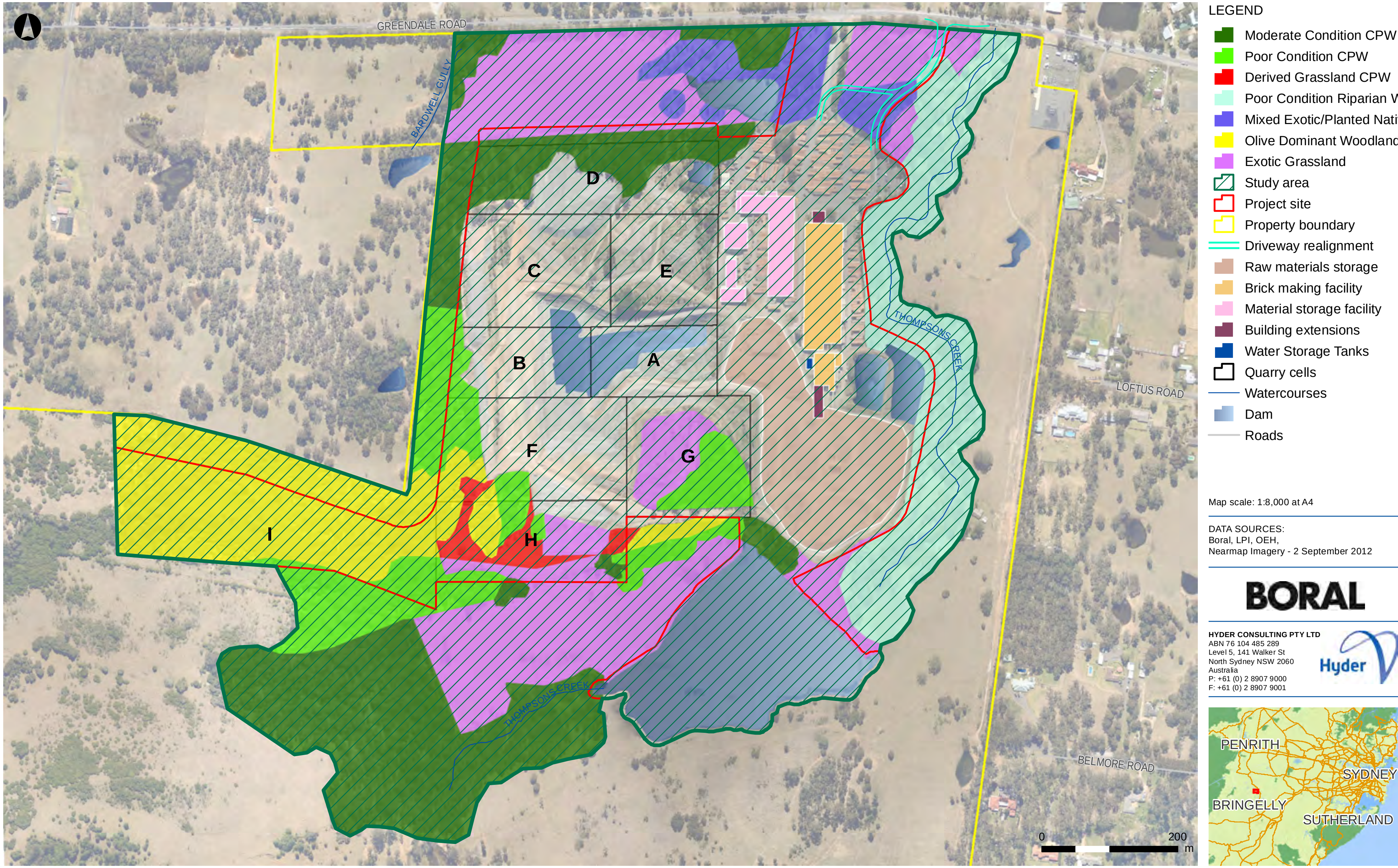

Figure 10: Vegetation communities of the study area

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QA by : DD

Weeds

Thirty two Weeds of National Significance (WoNS) have been identified in the Australian Weeds Strategy (Australian Weeds Committee 2012). The WoNS have been selected because of their invasiveness, impacts on primary production and the environment, potential for spread and socioeconomic impacts (Commonwealth of Australia 2012), The Australian Weeds Strategy provides a national framework to guide and complement state, territory, regional and local government strategies and industry initiatives. The legislation and administration of weed management is a State responsibility.

The NSW *Noxious Weeds Act* 1993 imposes obligations on occupiers of land to control noxious weeds declared for their area. The control requirements for the classes of noxious weeds recorded in the Study Area are presented in Table 11.

Table 11: Weed control classes and requirements

Control Class	Weed type	Control requirements
Class 4	Plants that pose a potentially serious threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area.	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.

Two of the 22 exotic species recorded in the Study Area, *Opuntia stricta* (Prickly Pear) *Senecio madagascariensis* (Fireweed) are listed as Weeds of National Significance (WoNS). *Opuntia stricta* and *Ligustrum sinense* (Small-leaved Privet) are listed as noxious weeds in the Camden Local government area (Table 12).

Table 12: Noxious weeds and WoNS recorded in the Study Area

Scientific name	Common name	Noxious weed control class	Weed of National Significance
Ligustrum sinense	Small-leaved Privet	4	-
Opuntia stricta	Prickly Pear	4	Yes
Senecio madagascariensis	Fireweed	-	Yes

4.2.5 SIGNIFICANT FLORA

Threatened ecological communities

The EPBC Act Protected Matters Search (Appendix 2) identified three Threatened Ecological Communities (TECs) as likely to occur within 10 kilometres of the Study Area:

- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.
- Shale/Sandstone Transition Forest.
- Western Sydney Dry Rainforest and Moist Shale Woodland on Shale.

Based on the review of soil, geology and vegetation mapping in the Study Area and the results of the field survey, Shale/Sandstone Transition Forest and Western Sydney Dry Rainforest and Moist Shale Woodland on Shale are unlikely to occur in the Study Area.

In order to qualify as the listed critically endangered ecological community Cumberland Plain Woodland under the EPBC Act, a patch must meet the following criteria as defined in the EPBC Act Policy Statement 3.3.1 (Commonwealth of Australia 2010):

- Native tree species present with a minimum projected foliage cover of 10 per cent.
- Patch 0.5 hectares or greater in size.
- Either:
  - Over 50 per cent of perennial understorey vegetative cover is made up of native species.
  - Patch greater than five hectares in size and has over 30 per cent native perennial understorey vegetative cover.
  - Patch contiguous with a native vegetation patch greater than five hectares in size and has over 30 per cent native perennial understorey vegetative cover.
  - Patch contains at least one tree per hectares that is large (>80 cm dbh) or has a hollow, and has over 30 per cent native perennial understorey vegetative cover.

Based on the above criteria, the larger area of Moderate Condition Cumberland Plain Woodland located to the south-west of the Study Area within the non-certified area fall within the definition of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest under the EPBC Act, as it is over 5 hectares in area, supports native tree species with a minimum projected foliage cover of 10 per cent, and has over 30 per cent native perennial understorey vegetative cover.

The more fragmented smaller patches of Moderate condition CPW in non-certified areas as well as all areas of Poor condition CPW and Derived Grassland CPW are not considered to fall within the EPBC Act definition of this community as they do not meet the above criteria.

Based on a search of the Bionet database, 13 TECs listed under the EPBC and/or TSC Acts are either recorded or have the potential to occur within 10 kilometres of the Study Area (Table 13).

Table 13: Threatened Ecological Communities (TECs) occurring within 10 kilometres of the Study Area

Name	EPBC Act status	TSC Act status
Agnes Banks Woodland in the Sydney Basin Bioregion		EEC
Blue Gum High Forest in the Sydney Basin Bioregion		CEEC
Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion		VEC
Castlereagh Swamp Woodland Community		EEC
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion		EEC
Cumberland Plain Woodland (Shale Woodlands and Shale-Gravel Transition Forest- EPBC Act listing)	CEEC	CEEC
Elderslie Banksia Scrub Forest		EEC
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		EEC

Name	EPBC Act status	TSC Act status
Shale gravel Transition Forest in the Sydney Basin Bioregion	CEEC	EEC
Shale/Sandstone Transition Forest		EEC
Southern Sydney sheltered forest on transitional sandstone soils in the Sydney Basin Bioregion		EEC
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		EEC
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	CEEC	EEC

CEEC = Critically Endangered Ecological Community, EEC = Endangered Ecological Community, VEC = Vulnerable Ecological Community.

Based on the vegetation mapping (NPWS 2002/Tozer 2003) of the Study Area and ground truthing during the field survey, two of the above threatened ecological communities occur in the Study Area:

- Cumberland Plain Woodland in the Sydney Basin Bioregion.
- River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

Cumberland Plain Woodland (CPW) includes the vegetation communities identified in the Study Area as listed in Table 14.

Table 14: Vegetation communities in the Study Area which meet the criteria for Cumberland Plain Woodland in the Sydney Basin Bioregion

Mapped vegetation community	Characteristics of mapped community	Consistency with the described TEC
Moderate Condition CPW	Regrowth eucalypts with patchy midstorey of *Olea europaea* subsp. *cuspidata* and occasional native shrubs. Groundlayer varies from sparse native grass, herb and litter to denser native and exotic grass dominance.	Meets structural, floristic and landscape criteria in Final Determination.
Poor Condition CPW	Remnant and regrowth eucalypts over a dense midlayer of *Olea europaea* subsp. *cuspidata.* Ground layer absent or reduced to sparse cover of native and exotic grasses.	Loosely meets the criteria in the Final Determination; definition as this community on a precautionary basis, although these stands are unlikely to be viable in the long term.
Derived Grassland CPW	Grassland dominated by native species with patches of exotic grass dominance. Trees and shrubs absent or reduced to isolated paddock trees.	Paragraph 2 of the Final Determination for Cumberland Plain Woodland states that areas of derived grassland are included in the community.

Areas of Olive Dominant Woodland are not considered to meet the criteria for Cumberland Plain Woodland as there are currently almost no characteristic CPW species in these areas and a very low likelihood that any natural regeneration can occur.

Existing Native Vegetation (ENV)

Under the relevant biodiversity measures (RBMs) of the Growth Centres Biodiversity Certification, clearing of any Existing Native Vegetation (ENV) in the non-certified areas must be offset elsewhere in the Growth Centres. ENV is defined as areas of indigenous trees (including any sapling) that had 10 per cent or greater over-storey canopy cover present, were equal to or greater than 0.5 hectares in area, and were identified as ñvegetationòon maps 4 and 5 of the draft Growth Centres Conservation Plan (ELA 2007) at the time the biodiversity certification order took effect.

The area of mapped ENV within non-certified areas in the Study Area is approximately 10.7 hectares, of which 1.17 hectares falls within the Project Site boundary. Of the 1.17 hectares of ENV, 1.16 hectares is located to the south of the existing quarry in Cell H and 0.01 hectares overlaps the western tip of Thompsons Creek dam.

The mapped ENV in the non-certified areas within the Study Area was validated using ground-truthed vegetation community data. The areas of validated ENV in the Study Area and Project Site are shown on Figure 8 and the vegetation communities mapped within areas of ENV in non-certified areas are provided in Table 15.

Table 15: Vegetation communities mapped within areas of ENV in non-certified areas

Vegetation Community	Areas mapped within ENV in non-certified areas in the Study Area	Areas mapped within ENV in non-certified areas in Project Site
Moderate Condition CPW	8.57 ha	0 ha
Poor Condition CPW	1.00 ha	0.26 ha
Derived Grassland CPW	0.1 ha	0.1 ha
Exotic Grassland	0.55 ha	0.39 ha
Olive Dominant Woodland	0.03 ha	0.03 ha
Total	**10.25 ha**	**0.78 ha**

Threatened Species

A habitat analysis was undertaken for threatened flora occurring within 10 kilometres of the Study Area to determine the likelihood of occurrence within the Study Area based on suitability of habitat observed during the field survey (Appendix 6). Species were assessed as having a Low, Moderate or High likelihood of occurrence in the Study Area, based on the criteria in Table 4. The comparative analysis was undertaken using database information for point locality records against habitat preferences identified by OEH (Threatened Species Profiles), Harden (1990-1993, 2002) and SEWPaC (Species Profile and Threats Database).

Most of the threatened plant species identified in the database searches were considered to have a low likelihood of occurring in the Study Area, based on potential habitat and the proximity and number of records of these species in the locality. Native flora habitat in the Study Area is poor, with stands of *Olea europaea* subsp. *cuspidata* shading out habitat in most parts of the Study Area.

4.3 FAUNA

4.3.1 DATABASE SEARCHES

Based on database and literature review, 46 animal species listed under the EPBC, TSC and/or FM Acts are either known or have the potential to occur within 10 kilometres of the Study Area (Table 16). TSC Act records occurring within 10 kilometres of the Study Area are shown in Figure 11.

Table 16: Threatened fauna occurring within 10 kilometres of the Study Area

Scientific name	Common name	Status under EPBC Act	Status under TSC Act	Status under FM Act
Anthochaera phrygia	Regent Honeyeater	Endangered, Migratory	Critically endangered	-
Apus pacificus	Fork-tailed Swift	Migratory		-
Ardea alba	Great Egret	Migratory		-
Ardea ibis	Cattle Egret	Migratory		-
Botaurus poiciloptilus	Australasian Bittern	Endangered	Endangered	-
Burhinus grallarius	Bush Stone-curlew	-	Endangered	-
Callocephalon fimbriatum	Gang-gang Cockatoo	-	Vulnerable	-
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Vulnerable	-
Chthonicola sagittata	Speckled Warbler	-	Vulnerable	-
Daphoenositta chrysoptera	Varied Sittella	-	Vulnerable	-
Dasyurus maculatus maculatus	Spotted-tailed Quoll	Endangered	Endangered	-
Ephippiorhynchus asiaticus	Black-necked Stork	-	Endangered	-
Erythrotriorchis radiatus	Red Goshawk	Vulnerable		-
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	Vulnerable	-
Gallinago hardwickii	Lathamõs Snipe	Migratory		
Glossopsitta pusilla	Little Lorikeet	-	Vulnerable	-
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory		-
Heleioporus australiacus	Giant Burrowing Frog	Vulnerable	Vulnerable	-
Hieraaetus morphnoides	Little Eagle	-	Vulnerable	-

Scientific name	Common name	Status under EPBC Act	Status under TSC Act	Status under FM Act
Hirundapus caudacutus	White-throated Needletail	Migratory		-
Hoplocephalus bungaroides	Broad-headed Snake	Vulnerable	Endangered	-
Lathamus discolour	Swift Parrot	Endangered	Endangered	-
Litoria aurea	Green and Golden Bell Frog	Vulnerable	Endangered	-
Litoria raniformis	Growling Grass Frog	Vulnerable	Endangered	-
Macquaria australasica	Macquarie Perch	Endangered	-	Endangered
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	-	Vulnerable	-
Meridolum corneovirens	Cumberland Plain Land Snail	-	Endangered	-
Merops ornatus	Rainbow Bee-eater	Migratory		-
Miniopterus schreibersii oceanensis	Eastern Bent-wing bat	-	Vulnerable	-
Monarcha melanopsis	Black-faced Monarch	Migratory		-
Mormopterus norfolkensis	Eastern Free-tail bat	-	Vulnerable	-
Myiagra cyanoleuca	Satin Flycatcher	Migratory		-
Myotis macropus	Southern Myotis	-	Vulnerable	-
Ninox strenua	Powerful Owl	-	Vulnerable	-
Oxyura australis	Blue-billed Duck	-	Vulnerable	
Petrogale penicillata	Brush-tailed Rock-wallaby	Vulnerable		-
Petroica boodang	Scarlet Robin	-	Vulnerable	-
Petroica phoenicea	Flame Robin	Marine	Vulnerable	-
Phascolarctos cinereus	Koala	Vulnerable (combined populations of QLD, NSW and the ACT)	Vulnerable	
Potorous tridactylus tridactylus	Long-nosed Potoroo (SE mainland)	Vulnerable		
Prototroctes maraena	Australian Grayling	Vulnerable		Protected
Pseudomys novaehollandiae	New Holland Mouse	Vulnerable		

Scientific name	Common name	Status under EPBC Act	Status under TSC Act	Status under FM Act
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Vulnerable	
Rhipidura rufifrons	Rufous Fantail	Migratory		
Rostratula australis	Australian Painted Snipe	Vulnerable, Migratory	Endangered	
Scoteanax rueppellii	Greater Broad-nosed Bat	-	Vulnerable	
Stagonopleura guttata	Diamond Firetail	-	Vulnerable	

4.3.2 FIELD SURVEY

Terrestrial Fauna Habitats

Three broad terrestrial fauna habitat types were identified in the Study Area; woodland, riparian and aquatic habitats and cleared/disturbed grassland (Figure 12).

Woodland

Woodland occurred across most of the Study Area, with the largest continuous patches occurring in the southern extent of the site on non-certified land. Woodland varied in condition as discussed in Section 4.2 from a moderate structure and diversity of flora species to poor quality woodland and woodland dominated by *O. europaea* subsp. *cuspidata*.

Hollow-bearing tree in Cell G

Woodland with *O. europaea* subsp. *cuspidata* in the Midstorey

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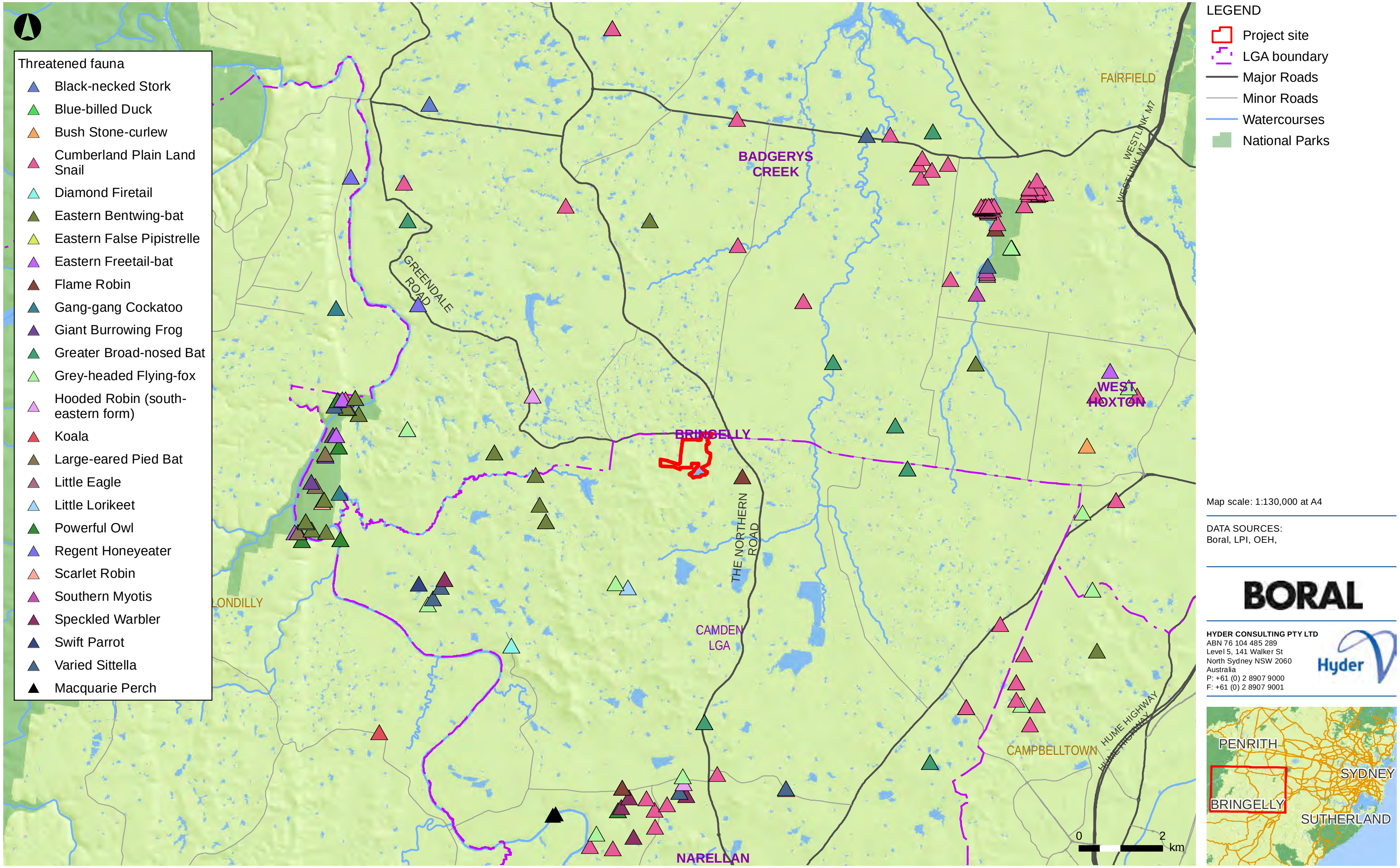

Figure 11: Threatened fauna records within 10km of the study area (OEH 2013a)

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Created by : KC
QA by : DD

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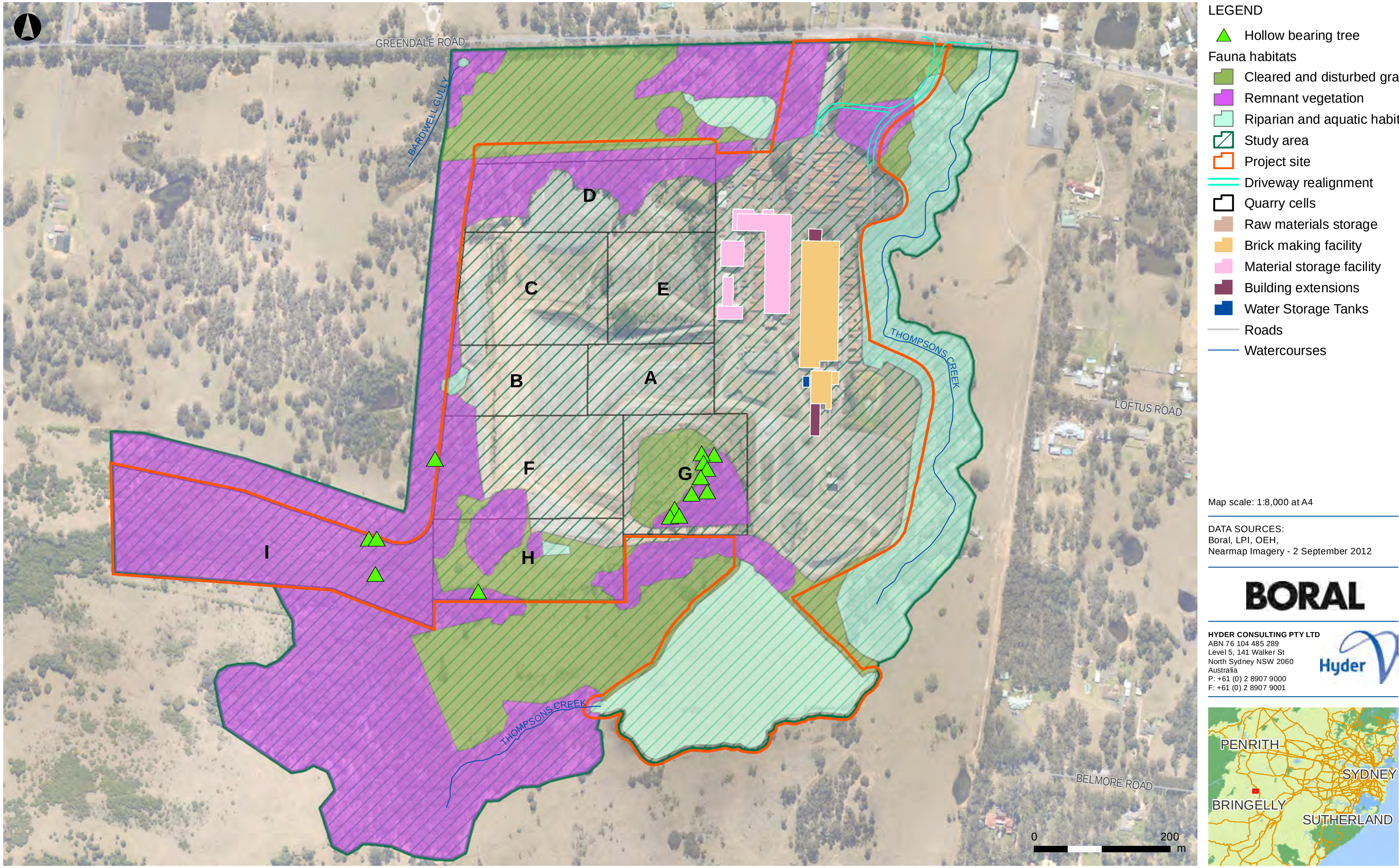

Figure 12: Terrestrial fauna habitat features

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Created by : KC
QA by : DD

Hollow-bearing trees were observed in woodland and were in highest concentration in Cell G at the southern boundary of the quarry operations (refer to photo above and Figure 12). A hollow-bearing tree register is provided in Appendix 5 and lists the details of each hollow-bearing tree identified including species, tree height, number of hollows visible and hollow sizes. Hollow-bearing tree locations were recorded if they occurred within the areas proposed for vegetation removal. Thirteen hollow-bearing trees were recorded. Potential hollow-bearing trees (with no visible hollows) are also included on the register. Hollow-bearing trees also occurred in the southern portion of woodland well outside of the Project Site. Remnant vegetation had old growth attributes and it is likely many mature eucalypts at the site could be hollow-forming in future decades. Hollow-bearing trees provide habitat for arboreal mammals such as possums, microchiropteran bats and woodland birds such as cockatoos, lorikeets, owls and treecreepers. A map showing the locations of hollow-bearing trees and potential hollow-bearing trees is provided in Figure 12.

Fallen timber and hollow logs were abundant in many areas of woodland, including those with high densities of *O. europaea* subsp. *cuspidata.* Other ground-layer resources included loose and embedded rocks, deep leaf litter, ant mounds and patches of native grasses. Ground-layer resources would provide shelter and foraging habitat for reptiles, birds, frogs and mammals.

Groundlayer resources within woodland including fallen timber and leaf litter

Ant mound within woodland habitat

Canopy resources found within woodland included foraging resources such as mistletoe, fruit and flowers and shelter in foliage and decorticating bark. Canopy species including *O. europaea* subsp. *cuspidata* and flowering eucalypts offer nesting and foraging opportunities for birds and arboreal mammals. Mistletoe was a prominent feature across most of the woodland, providing foraging opportunities for birds such as the Mistletoebird (*Dicaeum hirundinaceum*), honeyeaters and wattlebirds and mammals such as the Ringtail Possum (*Pseudochirus peregrinus*) and Brushtail Possum (*Trichosurus vulpecula*) (Bishop 2010). Decorticating bark on eucalypts offers potential roosting habitat for microchiropteran bat species.

Evidence of disturbance by feral herbivores was present in most of woodland habitats. Fallow Deer (*Dama dama*), Cow (*Bos sp*.), Rabbit (*Oryctolagus cuniculus*) and their scats were observed. Rabbit warrens were found in several locations, which could provide shelter for other fauna such as Short-beaked Echidnas (*Tachyglossus aculeatus*). Evidence of feral carnivores was also present. Fox (*Vulpes vulpes*), Dog (*Canus lupis familiaris*) and Cat (*Felis catus*) scats and/or sightings were recorded.

Riparian and aquatic habitat values for terrestrial fauna

Habitat values for terrestrial fauna in aquatic environments are described below. Details of riparian vegetation are provided for each aquatic survey location in Table 17.

Dams

Dam within the Study Area

Dam within the Study Area

Six dams were recorded within the Study Area that provide habitat for terrestrial fauna. Dams contained emergent vegetation and soft muddy substrates which would provide foraging and breeding habitat for frogs and wading birds. Frogs species including Green Reed Frog (*Litoria fallax*), Spotted Marsh Frog (*Limnodynastes tasmaniensis*) and Striped Marsh Frog (*Limnodynastes peronii*) were recorded in several dams. The dams also provide foraging opportunities for microchiropteran bats.

Thompsons Creek and associated dam

Emergent vegetation in Thompsons Creek north

Riparian vegetation of Thompsons Creek north

Thompsons Creek dam contained emergent vegetation which would provide nesting habitat and shelter for waterbirds such as Black Swan (*Cygnus atratus*) and Eurasian Coot (*Felica atra*) (refer to above photographs). Eurasian Coot nestlings were observed in the dam during the field survey. The dam is also a foraging resource for waterbirds such as Little Pied Cormorant (*Microcarbo melanoleucos*) and Australasian Darter (*Anhinga novaehollandiae*).The dam and Thompsons Creek also provides a fresh water resource for most local fauna including exotic species.

Black Swans in Thompsons Creek Dam

Emergent vegetation in Thompsons Creek dam.

The southern section of Thompsons Creek (upstream of Thompsons Creek dam) became dry and void of aquatic vegetation as the creek progressed upstream from the dam. Stagnant pools of water in this section of the creek would provide habitat for frogs. The northern section of Thompsons Creek (downstream of the dam) contained emergent vegetation which would provide habitat for frogs and waterbirds. Gully erosion was common along creek banks, particularly in the south and some vegetation overhangs the banks which could provide shelter for fauna.

Dry channel of Thompsons Creek south
showing riparian habitat

Riparian vegetation along the length of Thompsons Creek comprised scattered shrubs, denser where *O. europaea* was common, mature and immature eucalypts and paperbarks (refer to above photograph) which would offer some sheltering and foraging opportunities for terrestrial fauna that are found in riparian habitats such as microchiropteran bats and birds.

Cleared and Disturbed Grassland

Grassland at the site was mostly heavily grazed and disturbed by feral herbivores and farm animals (e.g. cattle). Rabbits (*Oryctolagus cuniculus*) and/or their scats and warrens were observed in every grassy habitat within the Study Area. Native grasses occurred in some areas of the site and would provide a food source for native birds and macropods and shelter for reptiles. Other fauna resources within grasslands included fallen timber, loose rock and ant mounds which would provide habitat and/or food for reptiles, birds and mammals. Grassland habitats in the Study Area are shown in the below photographs.

Grassland habitat

Grassland habitat in the south of the Study Area view south

Aquatic Fauna Habitats

Habitat assessments were undertaken at four locations along Thompsons Creek, Thompsons Creek dam, two dams outside of the site boundary and two dams within the site boundary. Table 17 provides a summary of aquatic habitat features at each assessment location. Aquatic habitat features are shown in Figure 13.

Thompsons Creek comprised intermittently wet channels and pools. The channel was narrow at times and undefined in some locations, particularly in the east. There was severe disturbance by cows trampling through the creekline on the east and severe bank erosion in the south west. Thompsons Creek is mapped as Key Fish Habitat by DPI and would be considered Class 3 fish habitat using the Fairfull and Witheridge (2003) fish habitat classification system. Class 3 fish habitat is characterised as follows: ñNamed or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.ò

Historical aerial imagery of the Study Area shows that dams have been established in the past few years which collect local runoff and water quality appears to be very low. There is no connectivity between them to any other waterbodies apart from the dam at Site 6C which is connected by a small creek to a dam in the adjacent property to the west. Formal aquatic assessments were not undertaken at other dams within the Project Site in use for quarry operations. Some emergent aquatic vegetation such as *Typha* sp. was observed in some of these dams. Aquatic vegetation would provide habitat for frogs, waterbirds and fish.

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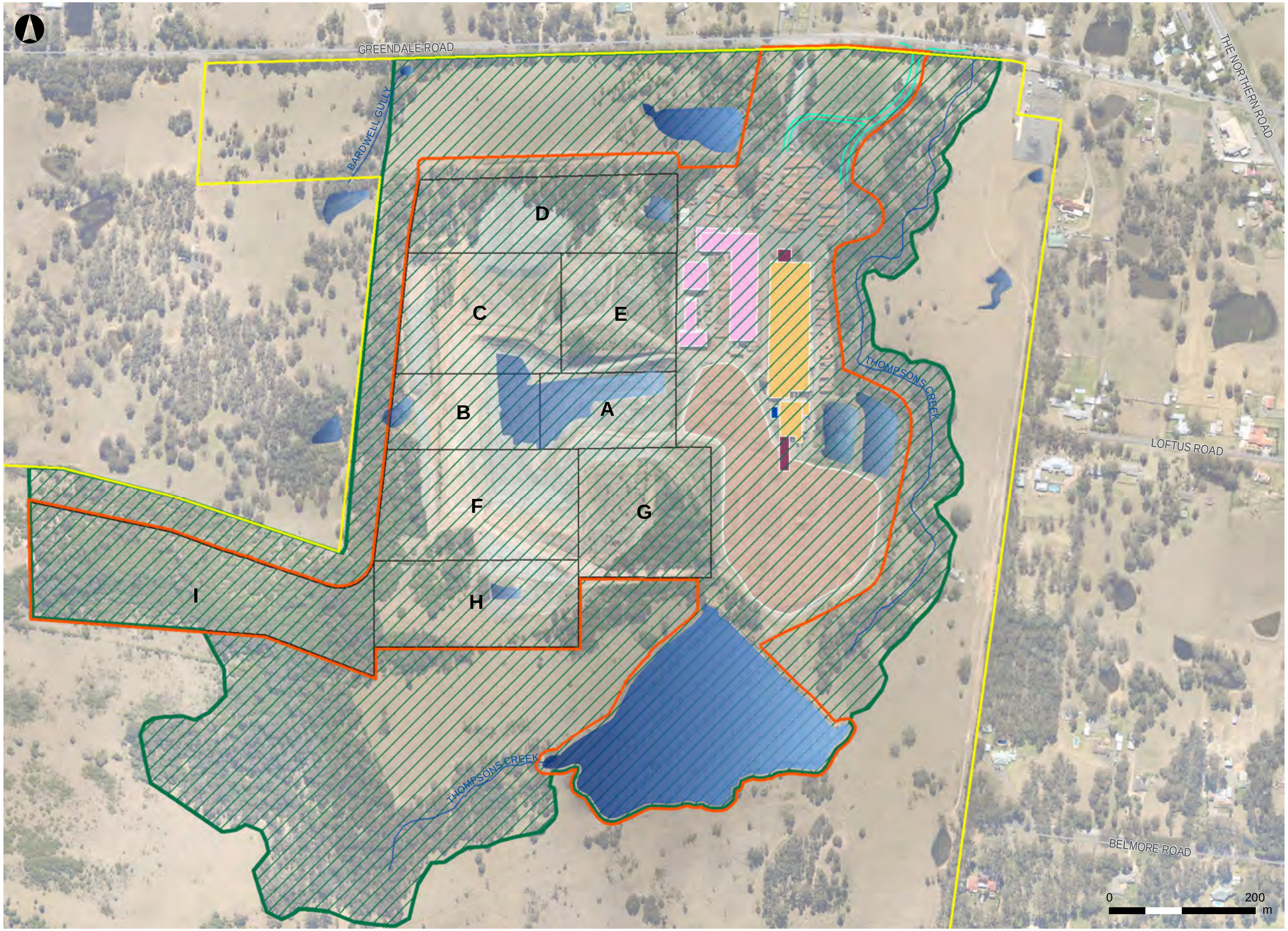

LEGEND

- Dam
- Watercourses
- Study area
- Project site
- Property boundary
- Driveway realignment
- Quarry cells
- Raw materials storage
- Brick making facility
- Material storage facility
- Building extensions
- Water Storage Tanks
- Roads

Map scale: 1:8,000 at A4

DATA SOURCES:
Boral, LPI, OEH,
Nearmap Imagery - 2 September 2012

BORAL

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Figure 13: Aquatic habitat features of the study area

Table 17: Aquatic habitat assessment

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
Thompsons Creek	Site 1	3	The drainage channel at this site was 1 metre wide on average and dry at the time of the site visit. It was undefined in some locations. It was highly modified with the most severe disturbance from trampling along the surveyed areas of Thompsons Creek. A lily pond was present downstream of the dam which would provide some habitat for frogs, fish and wading birds among dense instream vegetation (see photo). Large rock slabs and loose stones line the channel. Rocky features and coarse woody debris (CWD), found in occasional abundance in the channel would provide fish habitat in the event of flow. Riparian vegetation at this site comprised grasses, sedges (mostly *Juncus* sp.) and mature eucalypts (*E. tereticornis* dominant). Eucalypts were found in in low to moderate abundance. Channel banks were narrow with a moderate to low slope.	 Lily pond  Channel

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
	Site 2	3	The creek opened to a large pool at this site approximately 10 metres wide. The channel narrowed downstream of the pool to approximately 2 metres width. Upstream of the pool the channel was dry. Instream vegetation comprised dense sedges and grasses on a muddy substrate including *Paspalum distichum* and *Juncus* sp. in the pool and *Typha* sp. in the channel downstream of the pool. Standing dead trees were present in the channel. Water quality at this site appeared to be low. Water was stagnant, brown, with moderate turbidity and large amounts of algae. Instream vegetation would provide some habitat for hardy species of frogs and fish. Banks were approximately 1.5 metres wide up and downstream, steep in parts and grassy. Some minor bank erosion was evident. Riparian vegetation comprised trees and shrubs including *Melaleuca sp*. and *Eucalypts sp*.	 Large pool within Thompsons Creek (view downstream)
	Site 3	3	The channel was approximately 5 metres wide at this site with a muddy stream bed. Water quality at this site appeared to be low. Water was stagnant, with moderate turbidity and some algae. Instream vegetation was minimal with a stand of *Typha sp*. upstream. CWD also occurred. The site would provide some habitat for hardy species of frogs and fish. The creek bank at this site varied from steep and tall to narrow and wide. Banks were grassy in patches and, otherwise comprising bare soil and leaf litter among trees and shrubs. Some minor bank erosion was visible. Riparian vegetation including *Olea europaea subsp. cuspidata*, *Melaleuca sp*. and *Eucalypts sp*. occurred in high densities.	 Upstream channel

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
				 Downstream channel
	Site 4	3	The channel was approximately 1.5 metres wide at this site with a muddy/grassy stream bed splitting into two tributaries further upstream. Water levels were shallow with minimal flow and high turbidity. No instream vegetation was found with the exception of the grass in the stream bed. CWD in occasional abundance would provide fish habitat. Riparian vegetation at this site comprised grasses, sedges (mostly *Juncus* sp.), shrubs and mature and regenerating eucalypts. Channel banks were narrow with a low slope	 Downstream channel

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
				 Upstream channel
Thompsons Creek dam	Site 5	3	Patches of sedges are present in Thompsons Creek dam (see photo) which provide habitat for frogs and wading birds. Several species of wading birds were observed in the dam including juvenile Eurasian Coots wading in the sedges. Some woody debris was present on the dam banks, providing fish habitat when water levels are high. The dam had a soft muddy bottom which was subject to disturbance from trampling of cattle. The dam banks were largely grazed and with some sedges and the occasional eucalypt.	

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
Dams	Site 6		Six dams were observed during the site visit. These waterbodies provide habitat for terrestrial fauna as discussed above. Most of the dams contained instream vegetation such as *Typha* sp. and sedges on the dam banks. Though aquatic vegetation provides fish habitat, the dams are likely to have a low diversity and volume of fish species given the general lack of connectivity to streams or other waterways in the catchment and apparent low water quality observed; high turbidity, foul odour and/or rust-coloured algae occurred in dams.	 Site 6A - dam  Site 6B - dam

Aquatic feature	Assessment location	Fish Habitat Class	Habitat features	Photos
				 Site 6C- dam  Site 6D ï dam

Species recorded

A list of the fauna species and/or evidence of fauna species recorded during surveys is provided in Appendix 4. Forty-eight fauna species were observed during the two day survey. Birds were the most diverse assemblage, comprising 35 of the 48 species recorded. Two of the birds observed during the surveys were exotic. A diversity of woodland birds were observed in the Study Area such as Bell Miner (*Manorina melanophrys*), Grey Fantail (*Rhipidura albiscapa*) and Superb Fairy-wren (*Malurus cyaneus*) which were common across woodland habitats. Waterbirds such as Australasian Darter (*Anhinga novaehollandiae*), Black Swan (*Cygnus atratus*) and Little Pied Cormorant (*Microcarbo melanoleucos*) were observed at Thompsons Creek dam.

Three common frogs and two common reptiles were observed during the surveys, all were native. Frogs were found in dams and Thompsons Creek. Most areas of the site contained Macropod scats and a Common Wallaroo (*Macropus robustus*) was observed in a paddock adjacent to the site. A diverse range of exotic mammals was evidenced by scats, burrows and direct sightings across all habitats within the Study Area. Fox (*Vulpes vulpes*) scats were commonly found and a Cat (*Felis catus*) was observed. Cows (*Bos* sp.), Rabbits (*Oryctolagus cuniculus*) and Fallow Deer (*Dama dama*) were sighted and Rabbit scats and warrens were common in woodland and grassland habitats.

Habitat connectivity

The Study Area is located in a highly modified environment, in which large areas of native vegetation have been cleared for the quarry and urban and agricultural development in the surrounding lands. Patches of remnant vegetation are located in the southwest of the Study Area and along the riparian corridor of Thompsons Creek. Remnant vegetation in the Study Area has connectivity to larger areas of vegetation further southwest. This vegetation is fragmented and bordered by cleared agricultural land. It provides a corridor to the Nepean River and its tributaries which are of value to highly mobile native fauna occurring in the study such as microchiropteran bats, birds and mammals (e.g. macropods).

Patchy remnant vegetation occurs north of the Study Area set amongst low density residential housing. The Study Area has some connectivity to vegetation to the north, though some barriers to fauna movement are present including roads and cleared agricultural lands.

The riparian corridor of Thompsons Creek has some connectivity further downstream along Thompsons Creek and the riparian corridor of South Creek. The riparian corridor is very narrow throughout most of Thompsons Creek and is fragmented by local and main roads and residential development.

There is no clearly defined channel of Thompsons Creek upstream of the Study Area. Thompsons Creek dam poses a significant barrier to fish movement downstream of the site. Connectivity of fish habitat between South Creek and Thompsons Creek is highly influenced by the impacts on flow regimes from surrounding development.

At a regional scale, the native vegetation of the locality and the wider Cumberland Plain has been extensively cleared for agriculture, urban and industrial development since European settlement (DECCW 2010). The native vegetation that remains is significantly fragmented and continues to come under pressure from urban growth and development. The significance of remnant habitat has been mapped by NPWS (2002) and illustrates that core habitat in the Study Area is fragmented throughout the locality. In some case, patches of core habitat maintain connectivity with other patches of core habitat via supporting habitat. Supporting habitat includes cleared, disturbed and highly modified habitat that may not facilitate the movement of all fauna types.

4.3.3 SIGNIFICANT FAUNA

Probability of Occurrence of Threatened Fauna

The probability of each of the locally recorded threatened and migratory fauna species to occur within the Study Area was assessed using knowledge of each speciesô habitat and lifecycle requirements with regard to the habitat present within the Study Area (Appendix 7). Species were assessed as having a Low, Moderate or High likelihood of occurrence in the Study Area. The comparative analysis was undertaken using database information for point locality records (Figure 11) against habitat preferences identified by OEH (Threatened Species Profiles), and SEWPaC (Species Profile and Threats Database).

Several threatened fauna species identified in the database searches were considered to have a moderate to high likelihood of occurring in the Study Area, based on potential habitat and the proximity and number of records of these species in the locality. This included waterbirds that could occur in Thompsons Creek dam, woodland birds that could utilise woodland habitats and native grassland and microbats that could forage at waterbodies and within woodland and utilise hollow-bearing trees for roosting.

5 IMPACT ASSESSMENT

5.1 CONSTRUCTION PHASE

5.1.1 LIKELY IMPACTS

Likely impacts are those impacts that may arise as a result of unmitigated activities associated with the Bringelly Brickworks proposal.

Potential likely impacts associated with different aspects of the construction phase are outlined in further detail below.

Loss of native vegetation, including Endangered Ecological Communities

Clearing of native vegetation is required for the Proposal. The areas of each vegetation community that occurs within the Study Area are listed in Table 18 and mapped in Figure 14. The areas of each vegetation community to be cleared for the proposal in non-certified and certified areas are presented in Table 18 and mapped in Figure 14. The proportion of vegetation clearing for non-certified areas is greater than in certified areas, but the majority of this (7.94 hectares) is exotic dominated vegetation. A total of 2.87 hectares of native vegetation is to be removed from the non-certified areas, all of which meets the criteria for the TEC Cumberland Plain Woodland under the TSC Act.

Table 18: Native vegetation to be cleared within the Study Area

Vegetation Community		Area in Study Area (ha)	Area to be cleared (ha) within non-certified areas	Area to be cleared (ha) within certified areas
Native vegetation	Moderate Condition CPW	15.12	0.11	2.15
	Poor Condition CPW	6.58	1.88	1.05
	Derived Grassland CPW	0.97	0.88	0.06
	Poor Condition RFEF	8.22	0	0.04
Total native vegetation		**30.89**	**2.87**	**3.30**
Exotic vegetation	Mixed Exotic/Planted Native	2.58	0	0.23
	Olive Dominant Woodland	9.02	5.88	0.25
	Exotic Grassland	14.80	2.06	0.7
Total exotic vegetation		**26.40**	**7.94**	**1.18**
TOTAL all communities		**57.30**	**10.81**	**4.48**

Native vegetation clearing in the Study Area is also presented in Table 19 for key aspects of the Project Site.

Table 19: Native vegetation to be cleared within each area of the project

Vegetation Community	Cells									Drive way	Noise bunds
	A	B	C	D	E	F	G	H	I		
Moderate Condition CPW	0	0	0.01	1.78	0	0	0	0.11	0	0	0.35
Poor Condition CPW	0	0.25	0.02	0	0	0.65	0.94	0.49	0.58	0	0
Derived Grassland CPW	0	0	0	0	0	0.11	0	0.83	0	0	0
Poor Condition Riparian Woodland	0	0	0	0	0	0	0	0	0	0.04	0
Mixed Exotic/Planted Native	0	0	0	0	0	0	0	0	0	0.13	0.1
Olive Dominant Woodland	0	0	0	0	0	0.41	0	0.5	5.24	0	0
Exotic Grassland	0	0	0	0	0	0	1.07	0.99	0	0.06	0.64
Total within certified areas	**0**	**0.25**	**0.03**	**1.78**	**0**	**0.97**	**0.13**	**0.01**	**0**	**0.23**	**1.09**
Total within non-certified areas	**0**	**0**	**0**	**0**	**0**	**0.20**	**1.88**	**2.90**	**5.82**	**0**	**0**
TOTAL	**0**	**0.25**	**0.03**	**1.78**	**0**	**1.17**	**2.01**	**2.91**	**5.82**	**0.23**	**1.09**

Loss of Existing Native Vegetation

A total of 1.17 hectares of ENV is mapped within the Project Site, of which 1.16 hectares is located to the south of the existing quarry in Cell H and 0.01 hectares overlaps the western tip of Thompsons Creek dam.

Of the vegetation to be impacted within the non-certified areas, 1.16 hectares is mapped as Existing Native Vegetation (ENV). A portion of this ENV area (0.39 ha) was cleared prior to classification as ENV in order to carry out stormwater mitigation. The remaining 0.78 hectares of ENV currently supports vegetation cover, including 0.36 hectares mapped as native vegetation communities and 0.42 hectares mapped as exotic dominated vegetation.

The vegetation communities mapped within the area of ENV to be removed for the proposal are provided in Table 20 and shown on Figure 14. This area is located entirely within proposed cell H.

Table 20: Vegetation communities within areas of ENV in non-certified areas to be removed for the proposal

Vegetation category	Vegetation Community	Area mapped within ENV in non-certified areas
Native vegetation communities	Poor Condition CPW	0.26 ha
	Derived Grassland CPW	0.1 ha
Exotic dominated vegetation	Exotic Grassland	0.39 ha
	Olive Dominant Woodland	0.03 ha
Cleared land	N/A	0.39 ha
	Total	**1.16 ha**

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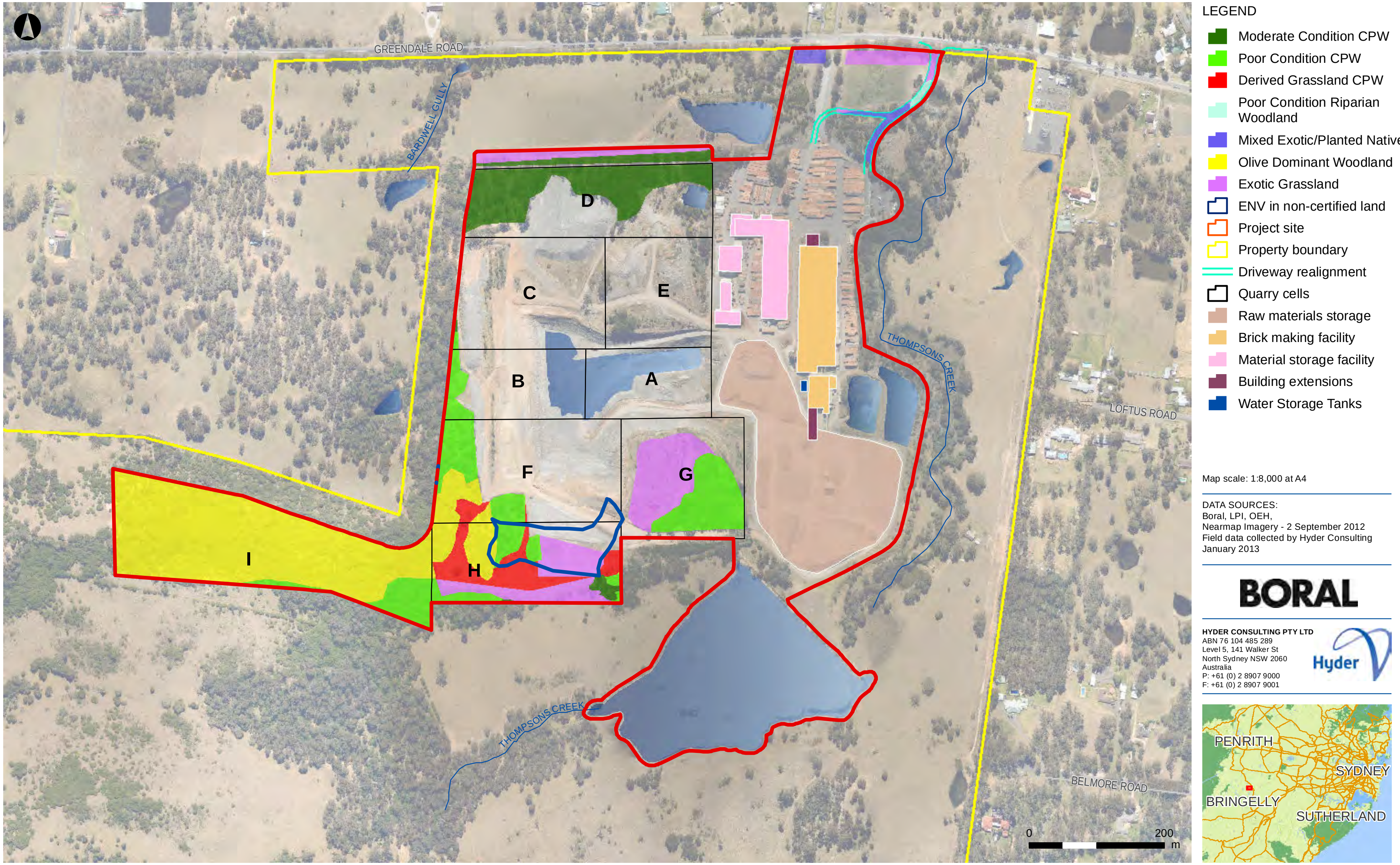

Map scale: 1:8,000 at A4

DATA SOURCES:
Boral, LPI, OEH,
Nearmap Imagery - 2 September 2012
Field data collected by Hyder Consulting January 2013

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Hyder

Figure 14: Vegetation removal proposed within the study area

Date: 29/08/2013 Path: \\HC-AUS-NS-FS-01\jobs\AA005667\L-GIS\A_Current\B_Maps\Specialist_Reports\Biodiversity\final\AA005667_F014_VegetationRemoval_r3v1.mxd
Created by : KC
QA by : DD

Impacts to groundwater-dependent ecosystems

Golder and Associates (2013) concluded that potential impacts to groundwater as a result of the proposal are expected to be localised and limited mainly to the vicinity of the mine operations. Changes to groundwater as a result of the proposal include a minor loss of deep groundwater resulting in limited drawdown and a slight lowering of the groundwater table. These changes are not likely to stress any GDEs in the study area and surrounds. Changes could potentially extend to South Creek, though any associated impacts would be minor. Impacts to groundwater and GDEs are discussed in further detail in Golder and Associates (2013) (Appendix J of the EIS).

Loss of fauna habitat, including that of threatened and migratory species

Clearing of native vegetation for the proposal will result in the removal of fauna habitat values (Figure 15). The areas of each fauna habitat type that occur within the Study Area, requiring removal, are listed in Table 21.

Table 21: Fauna habitat to be cleared within the Study Area

Fauna Habitat Type	Area in Study Area (ha)	Area to be cleared (ha) in non-certified areas	Area to be cleared (ha) in certified areas
Woodland	33.18	7.87	3.5
Cleared and disturbed grassland	15.7	2.87	0.76
Riparian and aquatic habitats (includes waterbodies)	15.00	0.07	0.13
TOTAL	**63.88**	**10.81**	**4.48**

The clearing of vegetation will result in the loss of specific fauna habitat components, including live trees, tree hollows, foraging resources (myrtaceous and flowering trees and shrubs, native grasses), groundlayer habitats such as fallen timber and well-developed leaf litter and riparian and aquatic and riparian habitats for terrestrial fauna such as frogs and waterbirds. A total of 15.29 hectares of habitat occurring within the Study Area requires removal, 10.81 hectares of which is non-certified. Habitat removal differs in area to the removal of vegetation calculated in Table 18 as it includes the loss of aquatic habitat. Resources requiring removal offer sheltering, foraging, nesting and roosting habitat to a variety of fauna occurring within the locality, including some threatened species.

Woodland habitats offer the greatest diversity of fauna habitat features for birds, reptile and mammal species. Clearing of 11.37 hectares of woodland vegetation, of which 7.87 hectares is not certified, will reduce the localised extent of habitat (and the foraging, roosting and breeding areas they provide) for some animals. Thirteen hollow-bearing trees and several potential hollow-bearing trees are likely to be removed for the proposal within non-certified land. The loss of hollow-bearing trees reduces available nesting and roosting habitat for hollow-dependent fauna such as birds and microchiropteran bats including the following threatened species: Little Lorikeet (*Glossopsitta pusilla*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*), Southern Myotis (*Myotis macropus*), Greater Broad-nosed Bat (*Scotenax rueppellii*) and Eastern Freetail-bat (*Mormopterus norfolkensis*).

A small amount of riparian vegetation along Thompsons Creek (0.05 hectares) and aquatic habitat within two small dams (0.15 hectares) would be impacted by the Proposal. The removal of riparian and aquatic habitats would reduce potential foraging resources for terrestrial fauna such as microchiropteran bats, mammals, birds and frogs within the locality. Breeding habitat in dams for common frogs and waterbirds could also be impacted, though impacts would be highly localised and over a small area. Furthermore, as the dams are very recent, their removal would not impact long-established breeding sites.

Threatened species with the potential to occur within certified lands in the Study Area do not require assessments of significance under the TSC Act or EPBC Act (e.g. Black-necked Stork, Great Egret, Eastern Bentwing-bat). However, the loss of fauna habitat within non-certified land could impact the following threatened species with the potential to occur at the site:

- Varied Sittella ï *Daphoenositta chrysoptera* (Vulnerable TSC Act)
- Eastern False Pipistrelle – *Falsistrellus tasmaniensis* (Vulnerable TSC Act)
- Little Lorikeet ï *Glossopsitta pusilla* (Vulnerable TSC Act)
- Little Eagle ï *Hieraaetus morphnoides* (Vulnerable TSC Act)
- Cumberland Plain Land Snail - *Meridolum corneovirens* (Vulnerable TSC Act)
- Eastern Freetail-bat - *Mormopterus norfolkensis* (Endangered TSC Act)
- Southern Myotis ï *Myotis macropus* (Vulnerable TSC Act)
- Scarlet Robin ï *Petroica boodang* (Vulnerable TSC Act)
- Flame Robin ï *Petroica phoenicea* (Vulnerable TSC Act)
- Greater Broad-nosed Bat ï *Scoteanax rueppellii* (Vulnerable TSC Act)

Seven-part tests were undertaken for each species with the potential to be impacted and are provided in Appendix 8. The seven-part tests found that the proposal would not significantly impact any of these species. No impacts to any threatened or migratory fauna listed on the EPBC Act are likely to occur within non-certified land.

Habitat fragmentation / loss of fauna habitat connectivity

The Study Area is located in a highly modified environment, in which large areas of native vegetation have been historically cleared for the quarry and urban and agricultural development in the surrounding lands. Habitat connectivity is currently restricted and additional removal of vegetation for the proposed quarry expansion would further fragment the landscape, reducing opportunities for fauna movements across the locality. Impacts to fauna habitat connectivity are likely to be minor in the broader landscape context. Connectivity of habitat within the Study Area and immediate surrounds would be compromised as a result of the Proposal. Retained vegetation along the western boundary of the site and Thompsons Creek riparian corridor would be largely disconnected due to the removal of vegetation in Cells G, H and I reducing the capacity of less mobile fauna to move within and between patches of remaining habitat. This is particularly relevant to locally occurring small, ground-dwelling fauna such as amphibians, reptiles and small ground-dwelling and arboreal mammals.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

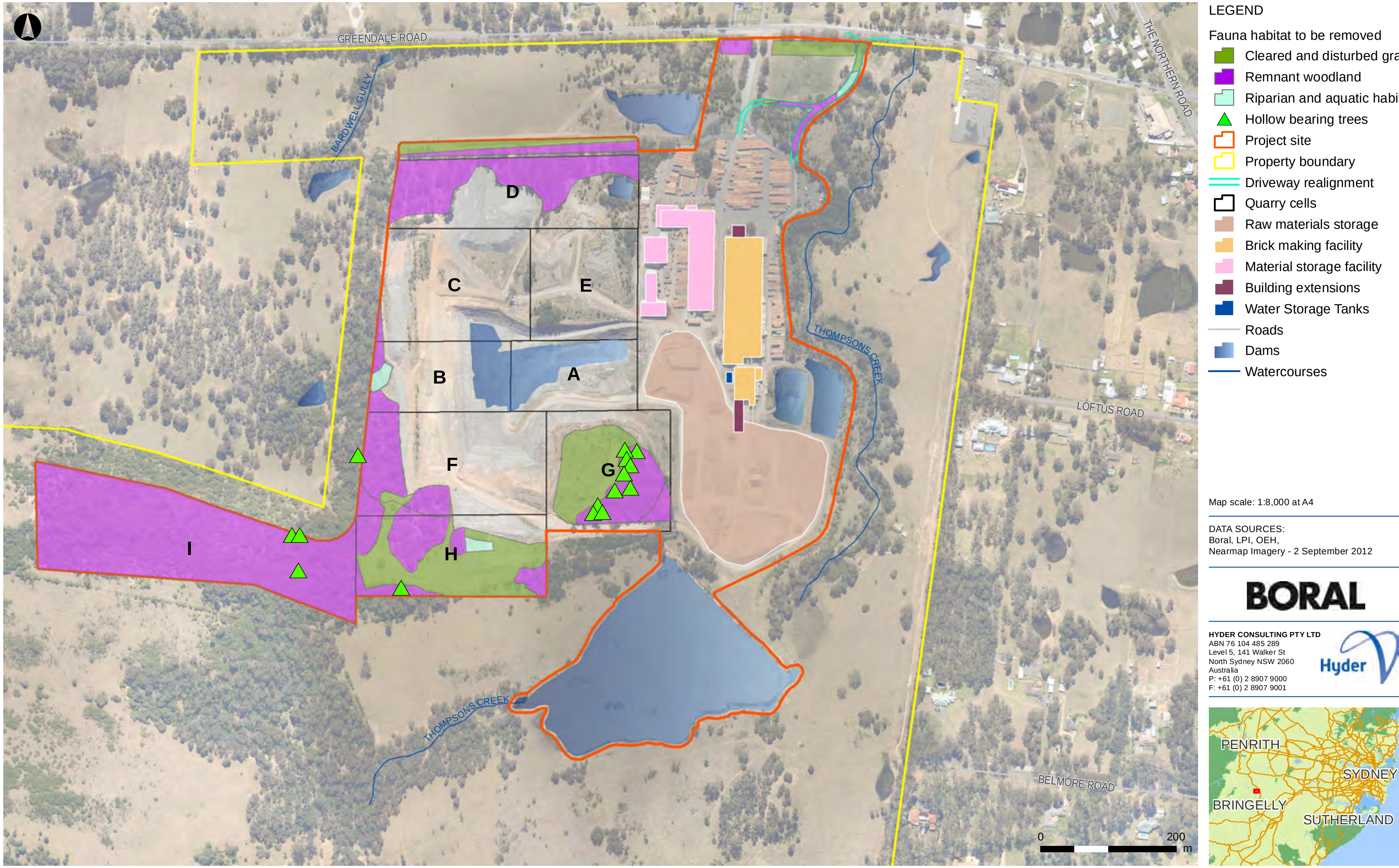


Figure 15: Fauna habitat proposed for removal within the study area

Alteration and degradation of aquatic habitats

The Proposal would require the removal of two small dams with low quality fish habitat (Figure 15). Removal of dams would impact at most, a small volume of fish of low species diversity. The removal of this habitat would not impact any threatened fish listed on the FM Act or EPBC Act. Direct impacts to terrestrial fauna such as frogs and waterbirds would occur from the loss of this habitat.

Construction activities in proximity to Thompsons Creek and Thompsons Creek dam could results in indirect impacts to aquatic habitat as a result of sediment-laden runoff and/or chemicals reaching the waterway and subsequent reduction in water quality. Construction activities occurring near Thompsons Creek include the construction of the new driveway in the northeastern corner of the Study Area and quarry expansion in Cells G, H and I. Quarry expansion would occur upslope of Thompsons Creek and Thompsons Creek dam, approximately 40 metres from the dam at the closest point and 180 metres from the creek at its closest point. The likelihood of impacts occurring as a result of expansion activities is moderate and would be further reduced provided erosion and sediment controls are implemented.

Construction of new driveway would be undertaken as close as 10 metres from Thompsons Creek. The mobilisation of sediments and pollutants has the potential to reduce the suitability of aquatic environments for some aquatic flora and fauna species due to a reduction in water quality. Stringent mitigation measures would be implemented to control runoff at the site and reduce the potential for chemical spills reaching the waterway.

Fauna mortality

Fauna injury or mortality is most likely to occur during vegetation clearing activities, but also may result from collisions with vehicles or plant, or accidental entrapment in plant, quarry pits or other earthworks.

The majority of fauna species recorded within the study were highly mobile bird species and mammals. These species are likely to be able to move away from vegetation clearing activities quite readily. Any fauna inhabiting the hollows in hollow-bearing trees may be injured during tree-felling. This could potentially include hollow-dependent birds and mammals and threatened microchiropteran bat species. Those animals that are unable to disperse away from areas under active clearing are also particularly susceptible to injury or death. This includes amphibians, reptiles and fish.

Edge effects and weed invasion

Fragmentation of vegetation will create new areas of edge habitat. This is most likely to occur in vegetation adjoining the proposed footprint in the non-certified area to the south of the site. Edge effects include alterations in humidity, light, moisture, wind, temperature and noise and soil profile conditions. These effects could impact on the adjoining native vegetation by affecting seed germination, flora and fauna species composition and weed establishment.

Increased movement of people, vehicles, machinery, vegetation waste and soil may facilitate the introduction of spread of weeds within the Study Area.

Alteration to air quality and noise levels

The construction phase of the proposal may impact upon the roosting, breeding and foraging activities of locally occurring fauna, as a result of increased exposure to light, noise, dust, vehicles and people. Air quality impacts and noise impacts have been considered in specialist reports prepared by Wilkinson Murray for the EIS.

5.2 OPERATIONAL PHASE

5.2.1 OPERATIONAL ACTIVITIES

Boralôs Bringelly Brickworks Quarry Expansion proposal will incorporate additional operational activities as follows:

- Extraction of material from new cells D, E, G, H and I
- Increase in brick production
- Increase in staff resulting in increased light vehicle traffic to and from the site
- Additional delivery of raw materials/supplies, consumables, maintenance and finished products resulting in increased heavy vehicle movements to and from the site and around the site
- Manufacturing activities in extended buildings
- Alteration of site access.

5.2.2 LIKELY IMPACTS

Likely impacts are those impacts that may arise as a result of unmitigated activities associated with the operation of the quarry expansion. Likely impacts include:

Fauna mortality

Fauna injury or mortality may result from collisions with vehicles or plant in operation within the site or as a result from increased traffic movements of light and heavy vehicles on local roads. They may also occur if fauna become trapped in quarry pits or other excavated areas.

Edge effects and weed invasion

Increased movement of people, vehicles, machinery, vegetation waste and soil may facilitate the introduction of spread of weeds within the Study Area.

Degradation of aquatic habitats

Oils, fuel, lubricants and other chemical substances will be required for the operation of vehicles, plant and machinery on the Bringelly Brickworks site. Accidental spills or leaks on the have the potential to result in contaminants reaching Thompsons Creek. Furthermore, excavation activities in quarry pits increases the risk of water quality impacts to Thompsons Creek as a result of sediment-laden runoff. Reduction in water quality could impact aquatic flora and fauna within the Study Area and further downstream of the Project Site.

Alteration to air quality and noise environments

Operation of the Bringelly Brickworks site will increase utilisation of the site by both people and vehicles from current levels and encroach further on nearby fauna habitats. This may impact on the roosting, breeding and foraging activities of locally occurring fauna, as a result of increased exposure to light, noise, dust, vehicles and people.

5.3 SUMMARY OF IMPACTS

The extent or scale of values likely to be affected as a result of the proposal is summarised in Table 22.

Table 22: Summary of ecological impacts

Likely Impact	Details	Extent/scale non-certified land	Extent/scale certified land
Loss of Endangered Ecological Communities	Cumberland Plain Woodland	2.87 hectares	3.26 hectares
Loss of native vegetation	Moderate Condition CPW	0.11 hectares	2.15 hectares
	Poor Condition CPW	1.88 hectares	1.05 hectares
	Derived Grassland CPW	0.88 hectares	0.06 hectares
	Poor Condition Riparian Woodland	0 hectares	0.04 hectares
Loss of exotic-dominated vegetation	Mixed Exotic/Planted Native	0 hectares	0.23 hectares
	Olive Dominant Woodland	5.88 hectares	0.25 hectares
	Exotic Grassland	2.06 hectares	0.7 hectares
Loss of fauna habitat	Woodland	7.87 hectares	3.5 hectares
		At least 13 hollow-bearing trees	
	Cleared and disturbed grassland	2.87 hectares	0.76 hectares
	Riparian and aquatic habitats (includes waterbodies)	0.07 hectares	0.13 hectares
Habitat fragmentation	May reduce the capacity of some less mobile fauna to move within and between patches of remaining habitat.	10.81 hectares of habitat to be removed in total	4.48 hectares of habitat to be removed in total
Fauna mortality	May result from collisions with vehicles or plant, or accidental entrapment in plant or pits.	Potential to occur across the entire site, though impacts are likely to be minor	Potential to occur across the entire site, though impacts are likely to be minor
Degradation of aquatic habitats	Caused by changes in runoff, potential pollution events and erosion may influence downstream habitats.	May vary depending on mitigation measures and site controls. Impacts are likely to extend	May vary depending on mitigation measures and site controls. Impacts are likely to

Likely Impact	Details	Extent/scale non-certified land	Extent/scale certified land
		beyond the local environment and influence downstream habitats.	extend beyond the local environment and influence downstream habitats.
Edge effects and weed invasion	Vehicles and plant may transport weed propagules into and across the Study Area. Creation of new edges will increase fragmentation and vulnerability of native vegetation to weed incursions	New edges where Project Site adjoins Moderate condition vegetation south of the Study Area are most susceptible.	
Alteration to air quality and noise environments	May impact upon the roosting, breeding and foraging activities of locally occurring fauna	Temporary and localised scale impacts during construction. Potential longer-term impacts during operation.	Temporary and localised scale impacts during construction. Potential longer-term impacts during operation.

5.4 CUMULATIVE IMPACTS

The Study Area is characterised by existing rural/residential and industrial development, regrowth or remnant bushland areas.

The proposal is located within the SWGC and there is extensive current and future development planned for this area. The biodiversity impacts from the development of the SWGC were considered and offset on a regional basis by the biodiversity certification of the Sydney Growth Centres SEPP. The biodiversity certification order also includes minimum offsetting requirements for any proposed clearing within the non-certified areas.

The impacts of the proposal on biodiversity values in certified areas have been previously assessed under the biodiversity certification of the Sydney Growth Centres SEPP and the Commonwealth Strategic Assessment.

The impacts of the proposal on biodiversity values in non-certified areas are minor, however would be offset according to the requirements in the biodiversity certification order.

5.5 KEY THREATENING PROCESSES

The Boral proposal is likely to result in the operation of one or more key threatening processes (KTPs) or the exacerbation of one or more KTPs currently in operation in the Study Area. KTPs listed under the TSC Act, FM Act and EPBC Act are provided in the following chapters.

5.5.1 *THREATENED SPECIES CONSERVATION ACT 1995*

Key threatening processes (KTPs) are processes that ῆthreaten or could threaten the survival or evolutionary development of species, populations or ecological communitiesὰ They are listed under Schedule 3 of the TSC Act and may adversely affect threatened species, populations or ecological communities or could cause species, populations or ecological communities that are not threatened to become threatened. The proposal may contribute to the following KTPs:

- Bushrock removal ï bushrock would be removed from woodland and grassland habitats as a result of the Proposal. Impacts would occur from the clearing of vegetation and excavation as a result of quarrying activities.
- Clearing of native vegetation ï approximately 6.07 hectares of native vegetation would be removed as a result of the Proposal
- Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*) ï evidence of the European rabbit was observed throughout the Study Area. Vegetation removal resulting in loss of fauna habitat and habitat fragmentation could increase competition between native fauna and the European rabbit for local resources
- Herbivory and environmental degradation caused by feral deer - evidence of the feral deer was observed throughout the Study Area. Vegetation removal resulting in loss of fauna habitat and habitat fragmentation could increase competition between native fauna and feral deer for local resources
- Invasion of native plant communities by exotic perennial grasses ï One grass identified as being of special concern, *Eragrostis curvula* (African lovegrass) occurs in the Study Area and was recorded in stands of Moderate condition CPW. The proposal may exacerbate this KTP by facilitating the spread of seeds or fragments of plant to areas where this weed is not present, via plant or contaminated topsoil.
- Invasion of native plant communities by African Olive *Olea europaea L. subsp. cuspidata* ï large stands of *Olea europaea* subsp. *cuspidata* were observed to have invaded native plant communities in the Study Area. The proposal may exacerbate this KTP by facilitating the spread of seeds or fragments of plant to areas where this weed is not present, via plant or contaminated topsoil. The proposal may also reduce the operation of this KTP in the Study Area through removal and management of Olives.
- Loss of hollow-bearing trees ï a minimum of 13 hollow-bearing trees would be removed as a result of the Proposal
- Predation by European red fox (*Vulpes vulpes*) ï native fauna displaced as a result of clearing activities may result in a short-term increase in predation opportunities for foxes
- Predation by feral cats (*Felis catus*) ï native fauna displaced as a result of clearing activities may result in a short-term increase in predation opportunities for feral cats
- Removal of dead wood and dead trees ï dead wood and a single dead tree would be removed as a result of the Proposal

5.5.2 *ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999*

The EPBC Act defines a key threatening process as one that ñthreatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.ò The proposal may contribute to the following key threatening processes:

- Competition and land degradation by rabbits ï evidence of the European rabbit was observed throughout the Study Area. Vegetation removal resulting in loss of fauna habitat and habitat fragmentation could increase competition between native fauna and the European rabbit for local resources
- Land clearance ï approximately 13.86 hectares of vegetation would be removed as a result of the Proposal

- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases ï construction and operational activities would result in an increase in greenhouse gas emissions
- Predation by European red fox ï native fauna displaced as a result of clearing activities may result in a short-term increase in predation opportunities for foxes
- Predation by feral cats ï native fauna displaced as a result of clearing activities may result in a short-term increase in predation opportunities for feral cats

5.5.3 *FISHERIES MANAGEMENT ACT* 1994

Under the FM Act key threatening processes are processes that, in the opinion of the Fisheries Scientific Committee, adversely affect threatened species populations or ecological communities, or could cause species, populations or ecological communities that are not threatened to become threatened. The proposal may contribute to the following Key Threatening Processes:

- Degradation of native riparian vegetation along New South Wales water courses ï removal of a small amount of riparian vegetation along Thompsons Creek could increase degradation within riparian vegetation of the creek to a minor degree as a result of weed spread

6 ASSESSMENTS OF SIGNIFICANCE

Assessments of Significance were undertaken for all relevant threatened species, populations and communities listed under the TSC Act that were recorded, or for which habitat occurs in the non-certified areas within the Study Area. Assessments of Significance were limited to consideration of impacts within the non-certified areas, and only considered the available habitat in surrounding non-certified areas. The assessments of significance are provided in Appendix 8.

No EPBC Act listed species or communities, or their habitat, were identified as likely to be impacted in the non-certified areas by the proposal

The threatened species and communities recorded or considered to have a high to moderate likelihood of occurrence in the non-certified areas are listed in Table 23.

Table 23: Threatened Species, Populations and Ecological Communities for which impact assessments have been undertaken

Threatened entity	EPBC Act Status[1]	TSC Act Status[2]	Likelihood of occurrence	Impacts within non-certified lands
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EPBC CPW)	CE		Known (outside of impact area)	None
Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW)		CE	Known	Loss of 2.87 ha including 0.11 ha Moderate condition CPW, 1.88 ha Poor condition CPW and 0.88 ha Derived Grassland CPW.
Cumberland Land Snail (*Meridolum corneovirens*)		E	Possible	Loss of 0.11 ha potential habitat (Moderate condition CPW)
Eastern Freetail-bat (*Mormopterus norfolkensis*)		V	Likely	At least 13 hollow-bearing trees (roosting habitat) and 7.87 hectares of woodland (foraging habitat)
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)		V	Possible	At least 13 hollow-bearing trees (roosting habitat) and 7.87 hectares of woodland (foraging habitat)
Greater Broad-nosed Bat (*Scoteanax rueppellii*)		V	Likely	At least 13 hollow-bearing trees (roosting habitat) and 7.87 hectares of woodland (foraging habitat)
Southern Myotis (*Myotis macropus*)		V	Likely	At least 13 hollow-bearing trees (roosting habitat) and 7.87 hectares of woodland (foraging habitat)

Threatened entity	EPBC Act Status[1]	TSC Act Status[2]	Likelihood of occurrence	Impacts within non-certified lands
Flame Robin (*Petroica phoenicea*)		V	Likely	0.11 hectares of moderate quality woodland and 0.88 hectares of native grassland (foraging and roosting habitat)
Little Eagle (*Hieraaetus morphnoides*)		V	Possible	1.96 hectares of moderate and poor quality woodland (foraging and nesting habitat)
Little Lorikeet (*Glossopsitta pusilla*)		V	Possible	At least 13 hollow-bearing trees (nesting habitat) and 0.11 hectares of moderate quality woodland (foraging habitat)
Scarlet Robin (*Petroica boodang*)		V	Possible	0.11 hectares of moderate quality woodland and 0.88 hectares of native grassland (foraging and roosting habitat)
Varied Sittella (*Daphoenositta chrysoptera*)		V	Possible	1.99 hectares of moderate and poor quality woodland (foraging and nesting habitat)

1. Conservation status under EPBC Act: CE = Critically Endangered
2. Conservation status under TSC Act: CE = Critically Endangered, E = Endangered, V = Vulnerable

The findings of the assessments of significance are summarised in Table 24. No threatened species, populations or communities were found to be subject to likely significant impacts as a result of the Proposal.

Table 24: Summary of Assessments of Significance

Threatened species, population or communities	Significance assessment questions[1]							Likely significant impact?
	a	b	c	d	e	f	g	
Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW)	X	X	N	N	X	N	Y	No
Cumberland Land Snail (*Meridolum corneovirens*)	N	X	X	N	X	N	Y	No
Eastern Freetail-bat (*Mormopterus norfolkensis*)	N	X	X	Y	X	X	Y	No
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	N	X	X	Y	X	X	Y	No
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	N	X	X	Y	X	X	Y	No

Threatened species, population or communities	Significance assessment questions[1]							Likely significant impact?
	a	b	c	d	e	f	g	
Southern Myotis (*Myotis macropus*)	N	X	X	Y	X	X	Y	No
Flame Robin (*Petroica phoenicea*)	N	X	X	N	X	X	Y	No
Little Eagle (*Hieraaetus morphnoides*)	N	X	X	N	X	X	Y	No
Little Lorikeet (*Glossopsitta pusilla*)	N	X	X	N	X	X	Y	No
Scarlet Robin (*Petroica boodang*)	N	X	X	N	X	X	Y	No
Varied Sittella (*Daphoenositta chrysoptera*)	N	X	X	N	X	X	Y	No

Notes: Y= Yes (negative impact), N= No (no or positive impact), X= not applicable, ?= unknown impact.

1. Significance Assessment Questions as set out in the Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979.
   a. in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
   b. in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
   c. in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
      (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
      (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,
   d. in relation to the habitat of a threatened species, population or ecological community:
      (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
      (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
      (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
   e. whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
   f. whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
   g. whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

7 MITIGATION MEASURES

The Part 3A Guidelines for Threatened Species Assessment (DEC & DPI 2005) require the description and justification of measures to mitigate adverse effects arising from development proposals. Primary consideration should be given to measures to avoid or minimise impacts; where avoidance and mitigation are not possible, offset strategies may be considered as a last resort. The steps in the avoid, mitigate and offset approach are as follows:

- Avoid areas of high biodiversity value wherever possible,
- Mitigate actions and safeguard values identified for retention by prescribing appropriate controls.
- Compensate for or offset the removal of biodiversity values.

7.1 AVOID IMPACTS

Impacts to ecological values at the site should be avoided where possible. Potential measures to avoid ecological impacts include:

- Reduction in the amount of clearing, in particular clearing of existing native vegetation and Cumberland Plain Woodland CEEC. The ENV in the west and to the south of the Study Area has been avoided when determining cell placement; the only area of ENV to be impacted is the 1.16 hectare patch to the south of the existing quarry (located largely in cell H), which is currently partially cleared.
- Avoiding removal of important fauna habitat features such as hollow bearing trees, dead trees and dead wood.
- Avoiding construction and operational activities with a high pollution risk in proximity to Thompsons Creek.

7.2 MITIGATE IMPACTS

Where impacts cannot be avoided, safeguards provided in Table 25 should be implemented to mitigate these impacts during construction.

Table 25: Mitigation measures for proposed actions

Activity	Impact	Mitigation Measure
General construction and operational activities	Flora and fauna impacts	A Flora and Fauna Management Plan (FFMP) would be prepared for the project site to manage impacts to flora and fauna as a result of the Proposal across the construction and operational stages. The FFMP would be appended to the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP).
Earthworks related to quarry pit establishment, noise bund and driveway construction	Sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitat	A Soil and Water Management Plan would be prepared to manage soil and water impacts across the site.
		Install appropriate drainage infrastructure (e.g. sediment basins, diversion drains), sediment and erosion controls prior to the commencement of construction.
		Clearing of vegetation would not be undertaken during rain events.
		Clearly identify sensitive areas and areas for construction and managing clearing such that clearing activities are constrained to these approved areas only.
		Locate stockpiles away from watercourses on flat land with appropriate erosion and sediment controls.
		Dust suppression activities would be undertaken where appropriate.
		Stabilisation of disturbed areas, including revegetation where appropriate, would be undertaken as soon as practicable after disturbance.
	Fauna injury/mortality	Undertake a pre-start check for sheltering native fauna in all infrastructure, plant and equipment.
	Weed establishment and invasion	A Weed Management Plan would be prepared to manage weed impacts across the site.
		Management of noxious weeds are to be undertaken in accordance with the *Noxious Weeds Act* 1993.
		Equipment used for treating weed infestation will be cleaned prior to moving to a new area within the Project Site to minimise the likelihood of transferring any plant material and soil
		Soil stripped and stockpiled from areas containing known weed infestations are to be stored separately and are not to be moved to areas free of weeds.

Activity	Impact	Mitigation Measure
	Topsoil removal and site rehabilitation	It is recommended that topsoil and plant material be salvaged from areas of Moderate Condition CPW to be cleared from the area to the north of the quarry, within certified areas, for re-use in rehabilitation works. It is preferable that cleared topsoil be re-used immediately, but it may be stored for later use if necessary.
		The noise bund should be spread with a 10-15 mm deep layer of topsoil and coarsely mulched native vegetation from cleared areas of Moderate Condition CPW. Additional planting of fast-growing local native shrubs such as *Acacia* spp and *Bursaria spinosa* may assist in slope stabilisation. The bund should be monitored during revegetation to ensure that *Olea europaea* subsp. *cuspidata* does not establish.
Vegetation clearance	Impacts to threatened hollow-dependent fauna (microbats and Little Lorikeet)	Clearing of hollow bearing trees would occur between March and May to avoid mortalities and impacts to breeding cycles of threatened fauna that are hollow-dependent, namely microbat breeding times (November - February) and hibernation period (June ï August) and the breeding season of Little Lorikeet (July - January).
		Implement a nest box program in woodland habitat in the Study Area with a naturally occurring low abundance of hollows to prevent impacts to hollow-dependent threatened species potentially occurring at the site.
	Loss of fauna habitat	Fauna microhabitat such as logs should be removed from areas to be cleared and relocated to suitable nearby bushland in the presence of an ecologist.
		Extent of clearing should be fenced with highly visible temporary fencing to ensure that clearing does not extend beyond the area necessary.
	Fauna injury/mortality	Undertake a two-stage approach to clearing: ▪ Remove non-hollow bearing trees at least 48 hours before hollow-bearing trees are removed. ▪ Hollow bearing trees are to be knocked to encourage fauna to evacuate the tree immediately prior to felling. ▪ A suitably qualified ecologist would be present for hollow-bearing tree removal. ▪ Felled trees would be left for a short period of time on the ground to give any fauna trapped in the trees an opportunity to escape. ▪ Felled hollow bearing trees would then be inspected by the ecologist.

Activity	Impact	Mitigation Measure
		Site inductions would include a briefing regarding the local fauna of the site and identification of protocols to be undertaken if fauna are encountered.
	Loss and degradation of native vegetation including Cumberland Plain Woodland CEEC	Clearance of native vegetation would be minimised as far as is practicable.
		The extent of vegetation clearing is to be clearly identified on construction plans
		Any additional construction areas, such as site offices, construction stockpile locations and machinery/equipment laydown areas are to be located within existing cleared or disturbed areas.
		Extent of clearing should be fenced with highly visible temporary fencing to ensure that clearing does not extend beyond the area necessary.
		Site rehabilitation will commence as soon as practicable. Management of land disturbed as a result of construction works will occur in accordance with the FFMP and Rehabilitation strategy.
		It is proposed to retain an approximately 5 metre wide strip of Moderate Condition CPW between the proposed noise bund and the extraction pit. This area includes mature trees with a predominantly native grass and shrub understorey.
Construction and operational activities in riparian areas/ in proximity to watercourses	Reduction in water quality as a result of chemical spills/plant leaks reaching Thompsons Creek	Emergency response protocols and procedures for implementation in the event of a contaminant spill or leak to be clearly articulated in the Environmental Management Plans.
		Spill kits would be readily available during construction activities to allow for timely response to uncontained spills. Site inductions would include a briefing on the use of spill kits and spill response.
		Refuelling would be undertaken at least 40 metres away from any waterbody.
		Chemicals and fuels would be stored in bunded containers in site buildings.
	Degradation of riparian zones	Minimise clearing and disturbance to the riparian zone where possible.
		Install appropriate drainage infrastructure, sediment and erosion controls prior to the commencement of construction.

Activity	Impact	Mitigation Measure
		Construction disturbance areas will be clearly demarcated to avoid accidental clearing or stockpiling in riparian vegetation.
Alteration to air quality and noise environments during construction and operation	Disruption of fauna foraging, nesting or roosting behaviours	Directional lighting will be used where lighting is required in construction areas.
		Frequent maintenance of construction machinery and plant will be undertaken to minimise unnecessary noise.
		Dust suppression activities would be undertaken where appropriate.
Operational activities	Fauna injury/ mortality	Speed limits will be developed in new site area so as to minimise the potential for fauna to be struck by a vehicle within the site.
		If any animal is injured, a local wildlife rescue agency (e.g. WIRES) and/or veterinary surgery would be contacted immediately. Any advice provided by the rescue agency/veterinary surgery for care of the animal would be followed until the animal can be cared for by a suitably qualified animal handler.
	Introduction of weed/pest species	Weed infestations that are identified during operation would be managed in accordance with the removal methods outlined in the Weed Management Plan.

7.3 OFFSET IMPACTS

The impacts on biodiversity, including ENV, within the certified areas are offset through the Sydney Growth Centres SEPP and do not require additional offsets.

The proposal will require the removal of a 1.16 hectare area mapped as ENV within the non-certified areas. Although not all of this area currently supports vegetation meeting the criteria for ENV, it is proposed to offset the entire 1.16 hectare mapped area.

In order to offset the loss of 1.16 hectares of ENV within the non-certified areas, it is proposed to conserve a 1.93 hectare strip of ENV in an offset area within the certified area in the north-west of the Study Area as shown in Figure 16. The proposed offset area contains 1.12 hectares of Moderate Condition CPW and 0.81 hectares of Poor Condition CPW.

The Moderate Condition CPW in the proposed offset area was identified as some of the better condition native vegetation in the Study Area. All vegetation in the proposed offset area was mapped as ENV in the Growth Centres Conservation Plan (ELA 2007), and meets the criteria for ENV as defined in the Biodiversity Certification Order.

The retention of this area would maintain the minimum area of ENV to be retained and protected in the Growth Centre as specified in relevant biodiversity measure (RBM) 6 of the Biodiversity Certification Order. An assessment of the consistency of the proposal with RBMs 6 to 13 of the Biodiversity Certification Order is provided in Appendix 9.

The proposed offsets have been determined with reference to the *Principles for the Use of Biodiversity Offsets in NSW* (OEH 2011a) (Table 26).

Table 26: OEH offsetting principles

OEH Offset Principles (OEH 2011a)	Consistency with proposal
1. Impacts must be avoided first by using prevention and mitigation measures.	Clearing of CPW in moderate condition has been minimised. The ENV in the west and to the south of the Study Area has been avoided when determining cell placement; the only area of ENV to be impacted is the 1.16 hectares to the south of the existing quarry, which is currently partially cleared.
2. All regulatory requirements must be met.	Offsets are proposed to address biodiversity impacts and satisfy the relevant biodiversity measures in the biodiversity certification order.
3. Offsets must never reward ongoing poor performance.	The proposed offset is located in some of the better condition CPW in the study area. Offset lands would not be deliberately degraded in order to increase the value from the offset.
4. Offsets will complement other government programs.	The proposed offset is aimed at satisfying the relevant biodiversity measures of the biodiversity certification order.
5. Offsets must be underpinned by sound ecological principles.	Offsets were determined following ecological field surveys which assessed the condition of vegetation communities across the site. The proposed offset, while fragmented from other areas of CPW, represents some of the better condition CPW in the Study Area.

OEH Offset Principles (OEH 2011a)	Consistency with proposal
6. Offsets should aim to result in a net improvement in biodiversity over time.	The offset will be managed in accordance with a flora and fauna management plan.
7. Offsets must be enduring ï they must offset the impact of the development for the period that the impact occurs.	Given that the proposed impact is permanent, the proposed offset area will also be secured in perpetuity through an appropriate legal instrument.
8. Offsets should be agreed prior to the impact occurring.	Offsets will be agreed prior to the commencement of construction work that would result in the clearing and/or disturbance of ENV in the non-certified areas.
9. Offsets must be quantifiable ï the impacts and benefits must be reliably estimated.	A quantitative assessment has been undertaken to determine the precise area that requires offsetting.
10. Offsets must be targeted.	The proposed offset represents a like-for-like or better conservation outcome, as it offsets a partially cleared area that includes Poor Condition CPW and Derived Grassland with a larger area of Moderate Condition CPW.
11. Offsets must be located appropriately.	The proposed offset is located within the Study Area, in proximity to the area of impact.
12. Offsets must be supplementary.	The proposed offset is within an area that is currently subject to biodiversity certification.
13. Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.	The proposed offset is suitable for ongoing management for conservation through an appropriate legal instrument.

Management of the proposed offset area would aim to maintain and enhance native vegetation values, and would be undertaken according to a Biodiversity Management Plan for the area. The Biodiversity Management Plan would be prepared in consultation with OEH and prior to vegetation clearing for the proposal, and would include details of management methods, fencing, timeframes, costs and monitoring.

BRINGELLY BRICKWORKS ECOLOGICAL ASSESSMENT

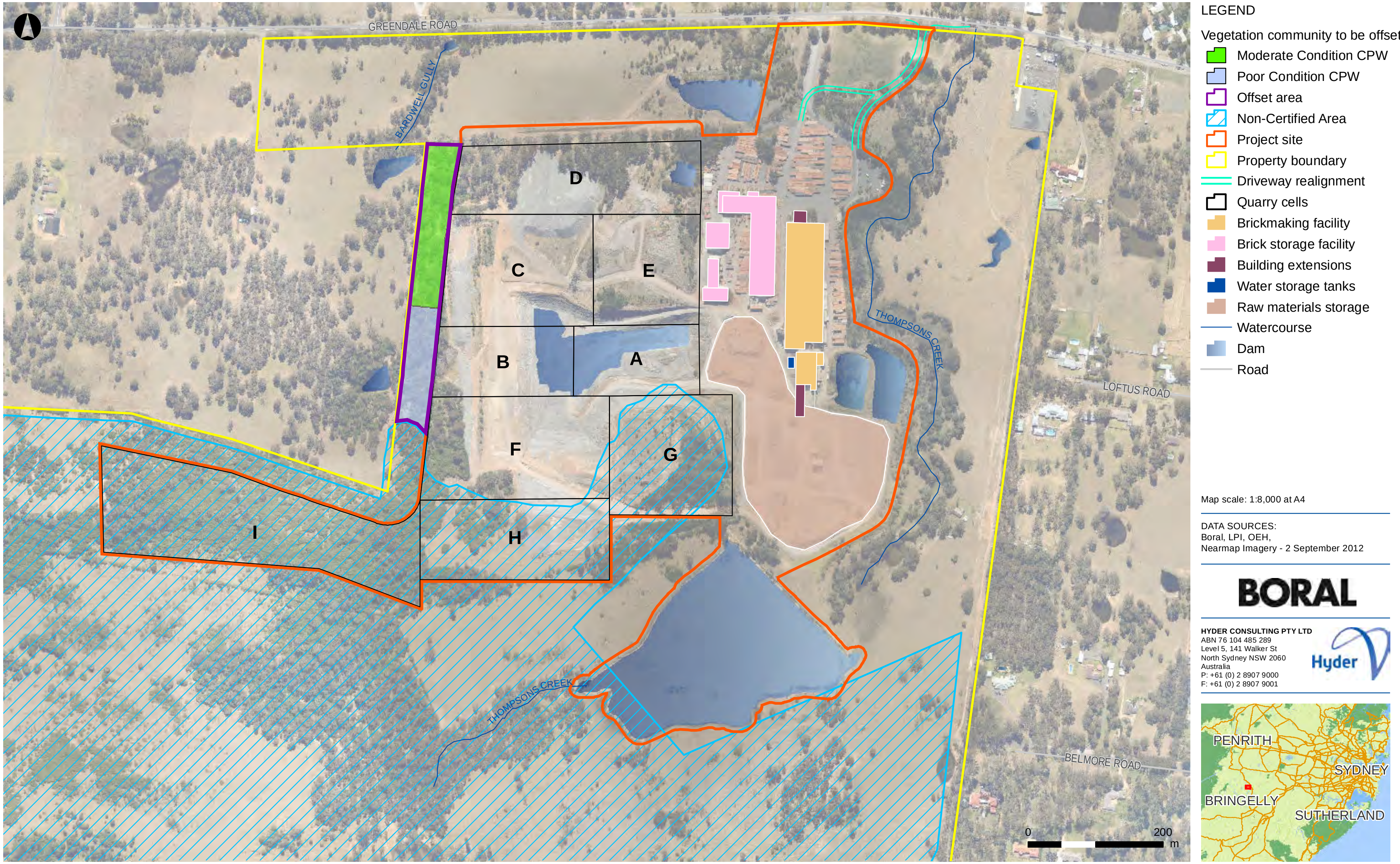


Figure 16: Proposed offset area

8 CONCLUSION

This Ecological Assessment was based on desktop research and field surveys undertaken in January 2013 for the expansion of Boral's Brickworks Quarry in Bringelly, NSW. Ecological features of the Study Area included woodland and grassland habitats, degraded riparian vegetation, aquatic habitats including several dams and Thompsons Creek.

No threatened flora or fauna listed under the EPBC Act or TSC Act were recorded in the Study Area. Several threatened fauna species listed as Vulnerable under the TSC Act have the potential to occur in the Study Area including Little Lorikeet, Eastern False Pipistrelle, Eastern Freetail-bat, Varied Sittella, Little Eagle, Scarlet Robin, Flame Robin, Southern Myotis, Greater Broad-nosed Bat and Cumberland Plain Land Snail. The proposal would impact 7.9 hectares of fauna habitat for threatened species including 13 hollow-bearing trees. Impacts to threatened fauna species are not deemed to be significant. To reduce potential impacts to hollow-dependent fauna, removal of hollow-bearing trees would be undertaken between March and May to avoid direct mortalities and breeding seasons.

The Critically Endangered Ecological Community Cumberland Plain Woodland (CPW), as defined by the TSC Act, was found in the Study Area. The proposal would have direct impacts on 2.87 hectares of CPW within the non-certified areas, comprising fragmented patches in Moderate and Poor Condition as well as Derived Grassland. An Assessment of Significance concluded that the proposal will not have significant impacts on this CEEC.

The vegetation to be impacted within non-certified areas includes 1.16 hectares mapped as ENV. The ENV to be removed would be offset through the retention and conservation of 1.12 hectares of Moderate Condition CPW and 0.81 hectares of Poor Condition CPW in a certified area in the north-west of the study area. The offsets have been determined with reference to RBMs 6 to 13 of the Biodiversity Certification Order for the Growth Centres SEPP as well as the *Principles for the Use of Biodiversity Offsets in NSW* (OEH 2011a).

It is unlikely that aquatic habitats would contain any threatened fish species listed under the FM Act or EPBC Act. Thompsons Creek, mapped as Key Fish Habitat by DPI, was assessed to be in a degraded condition. The proposal would not result in any direct impacts to the creek. Indirect impacts to the creek could occur as a result of runoff and spills during construction and operation of the quarry. Erosion and sediment control measures and spill management would be implemented to reduce the potential and severity of any impacts.

9 REFERENCES

Australian Weeds Committee (2012) *Weeds of National Significance 2012*. Department of Agriculture, Fisheries and Forestry, Canberra, ACT

Bannerman S.M. and Hazelton P.A. (1990) *Soil Landscapes of the Penrith 1:100,000 Map Sheet* (Soil Conservation Service NSW, Sydney).

Bishop, G.VC. (2010) *Briefing note on the importance of mistletoe and its effect of on regional biodiversity conservation – Lower North NRM Group*. Department of Environment and Heritage, South Australia.

BOM (2013) *Badgerys Creek NSW Weather Observations.* http://www.bom.gov.au/climate/dwo/201301/html/IDCJDW2005.201301.shtml Accessed 7 February 2013.

Churchill, S. (2008). *Australian Bats.* Reed New Holland, Sydney.

Clark, N. R. and Jones, D. C. (1990) *Geology of the Penrith 1:100 000 map sheet*. NSW Department of Mineral Resources.

Commonwealth of Australia (2012) *Weeds of National Significance* http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html Accessed 1 July 2013.

Cumberland Ecology (2007) *Lot 2 DP 733115, Greendale Road, Bringelly Flora and Fauna Assessment for Boral.*

DEC (2004a) *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities*. New South Wales Department of Environment and Conservation, Hurstville, NSW.

DEC (2004b) *Wildlife Corridors*. Department of Environment and Conservation (NSW), Coffs Harbour, NSW.

DEC & DPI (2005) *Draft Guidelines for Threatened Species Assessment.* Department of Environment and Conservation and Department of Primary Industries. Dated July 2005.

DEC (2005a) *Threatened Species Profile: Southern Myotis*. Department of Environment and Conservation (NSW), Hurstville.

DECC (2008) *NSW Vegetation Benchmarks Database.* Department of Environment and Climate Change, October 2008.

DECCW (2010) *Cumberland Plain Recovery Plan*. Department of Environment, Climate Change and Water NSW, Sydney.

ELA (2007) *Draft Growth Centres Conservation Plan*. Prepared for the Growth Centres Commission.

Fairfull, S. and Witheridge, G. (2003) *Why Do Fish Need To Cross The Road? Fish passage requirements or waterway crossings*. NSW Fisheries, Cronulla.

Golder and Associates (2013) *Boral Bringelly Brickworks Expansion Project: Groundwater Impact Assessment.* Prepared for Boral Property Group.

Goosem, M. W. (2005) *Wildlife Surveillance Assessment Compton Road Upgrade 2005: Review of Contemporary Remote and Direct Surveillance Options for Monitoring.* Report to the Brisbane

City Council. Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns. Unpublished report.

Growth Centres Commission (2007) *Growth Centres Conservation Plan: Exhibition Draft*. Growth Centres Commission, Parramatta, NSW.

Harden G. (1990-1993) *Flora of New South Wales Volumes 1-4.* University of New South Wales Press, Kensington.

Harden G. (2002) *Flora of New South Wales Volume 2 (Revised Edition).* University of New South Wales Press, Kensington.

Hawkesbury Nepean CMA (2007) *Hawkesbury Nepean River Health Strategy Appendix 4.2: South Creek.* Hawkesbury Nepean Catchment Management Authority.

Lovett, S. and Price, P. (2006) *Principles for Riparian Lands Management*. Land and Water Australia.

NPWS (2000*) Environmental Impact Assessment Guidelines: Cumberland Plain Large Land Snail*. National Parks and Wildlife Service, NSW

NPWS (2002) *Interpretation Guidelines for the Native Vegetation of the Cumberland Plain*. NSW National Parks and Wildlife Service.

Natural Resource Management Ministerial Council (NRMMC) (2010) *Australia's Biodiversity Conservation Strategy 2010-2030.* Australian Government, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

NSW Office of Water (2012) *Identification of high probability groundwater dependent ecosystems on the coastal plains of NSW and their ecological value.*

NSW Scientific Committee and Simpson, C.C. (2008) *Changes in the distribution of Cumberland Plain Woodland*.

OEH (2011a) *Principles for the use of biodiversity offsets in NSW*. NSW Office of Environment and Heritage www.environment.nsw.gov.au/biocertification/offsets.htm accessed 21 January 2013.

OEH (2011b) *NSW OEH interim policy on assessing and offsetting biodiversity impacts of Part 3A, State significant development (SSD) and State significant infrastructure (SSI) projects*, OEH June 2011.

OEH (2013a) *Bionet Atlas of NSW Wildlife.* Accessed 9 January 2013. http://www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

OEH (2013b) *Threatened species profiles.* http://www.environment.nsw.gov.au/threatenedspecies/ Accessed 8 May 2013.

Pizzey, G. and Knight, F. (2007) *The field guide to the birds of Australia - 8th Edition*. Harper Collins, Sydney.

Resource Planning Pty Limited (1991) *Environmental Impact Statement for the upgrading of the Bringelly Brick and Paver Manufacturing Plant Greendale Road, Bringelly*.

Schodde, R. & Tidemann, S.C. (Consultant eds.) (1986). *Reader's Digest Complete Book of Australian Birds*. Sydney: Reader's Digest Services.

Simpson K. and Day N. (1996) *The Claremont Field Guide to the Birds of Australia*. Penguin Books Australia.

Strahan R. (ed). (1995*) The Mammals of Australia*. Australian Museum/Reed Books, Chatswood.

Strahler, A.N. (1952) *Dynamics basis of geomorphology*. Geoscience Society of America Bulletin 63: 923-938.

Taylor, B. D., and R. Goldingay. (2009). *Can road crossing structures improve viability of an urban gliding mammal?* Ecology and Society 14(2):13

Tozer (2003) *The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities*. Cunninghamia 8(1): 1-75.

Triggs B. (1996). *Tracks, Scats and Other Traces: A Field Guide to Australian Mammals*. Oxford University Press, Melbourne.

van der Ree R., Grift E., Gulle N., Holland K., Mata C., Suarez F., (2007) *Overcoming the barrier effects of roads- how effective are mitigation measures? An International review of the use and effectiveness of underpasses and overpasses designed to increase the permeability of roads for wildlife.* UC Davis: Road Ecology Centre. [Online] URL: http://escholarship.org/uc/item/66j8095x

APPENDIX 1

BIODIVERSITY CERTIFICATION ORDER

<u>THREATENED SPECIES CONSERVATION ACT 1995</u>

Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006

I, Verity Firth, Minister Assisting the Minister for Climate Change, Environment and Water (Environment), do by this order confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006 (the SEPP) for the purposes of the *Threatened Species Conservation Act 1995* (the Act).

I am satisfied that the SEPP, and other relevant measures, will lead to the overall improvement or maintenance of biodiversity values.

Pursuant to section 126H of the Act, the biodiversity certification of the SEPP is subject to the conditions listed in Schedules 1, 2, 3 and 4 below. The conditions are necessary to ensure that the SEPP and other relevant measures will lead to the overall improvement or maintenance of biodiversity values, including the limiting of certification to specified lands, procedures for the allocation of conservation funding for offsets, and mechanisms for the on-going review of progress in delivering offsets.

This order is made under section 126G(1) of the Act.

This order is to take effect on and from the date of its publication in the Government Gazette.

Pursuant to section 126J of the Act, biodiversity certification of the SEPP shall remain in force from the date the biodiversity certification order takes effect until 30 June 2025.

VERITY FIRTH, M.P.
Minister Assisting the Minister for Climate Change,
Environment and Water (Environment)

Signed at Sydney, this 11th day of December 2007.

SCHEDULE 1 – CONDITIONS OF BIODIVERSITY CERTIFICATION

Definitions

In Schedules 1 to 4:

- ñActò means the *Threatened Species Conservation Act 1995*.

- ñbiodiversity certification mapsò means the maps marked ñNorth West Growth Centre ï Biodiversity Certificationò and ñSouth West Growth Centre ï Biodiversity Certificationò dated November 2007 and included in Schedule 2.

- ñbiodiversity valuesò has the same meaning as in the Act.

- ñcertified areaò means an area marked as a certified area on a biodiversity certification map.

- ñclearingò of existing native vegetation means any one or more of the following:

  (a) cutting down, felling, thinning, logging or removing existing native vegetation in whole or in part,
  (b) killing, destroying, poisoning, ringbarking, uprooting or burning existing native vegetation in whole or in part.

- ñconditions of biodiversity certificationò means Schedules 1 to 4.

- ñconservation agreementò means:

  (a) a conservation agreement under the *National Parks and Wildlife Act 1974*,
  (b) a biobanking agreement under Part 7A of the Act,
  (c) a planning agreement under the *Environmental Planning and Assessment Act 1979*, where the agreement provides for the conservation and/or enhancement of the biodiversity values of an area of land to which the agreement relates, or
  (c) a legally binding agreement that provides for the conservation and/or enhancement of the biodiversity values of an area of land.

- ñConservation Fundò means the Fund referred to in condition 21.

- ñconservation valueò includes, but is not limited to, vegetation type, condition and rarity.

- ñdraft Growth Centres Conservation Planò means the document titled ñGrowth Centres Conservation Plan Exhibition Draftò prepared by the GCC dated February 2007 and placed on public exhibition in February 2007.

- ñexisting native vegetationò means areas of indigenous trees (including any sapling) that:

  (a) had 10% or greater over-storey canopy cover present,
  (b) were equal to or greater than 0.5 ha in area, and
  (c) were identified as ñvegetationò on maps 4 and 5 of the draft Growth Centres Conservation Plan,

at the time the biodiversity certification order took effect, subject to condition 13.

- ñDECCò means the Director-General of the Department of Environment and Climate Change.

- ñfinancial yearò means the twelve month period from 1 July to 30 June.

- ñGCCò means the Growth Centres Commission constituted under the *Growth Centres (Development Corporations) Act 1974*.

- ñGrowth Centreò has the same meaning as in the SEPP.

- ñGrowth Centres Development Codeò means the document with that title produced by the GCC (dated October 2006) as updated and in force from time to time.

- ñMinisterò means the Minister administering the Act.

- ñMinister for Planningò means the Minister administering the *Environmental Planning and Assessment Act 1979*.

- ñnon-certified areaò means an area marked as a non-certified area on a biodiversity certification map.

- ñplan of managementò means:

  (a) a plan of management adopted under the *National Parks and Wildlife Act 1974* or *Local Government Act 1993,* or
  (b) a plan that provides for the management and protection of biodiversity values to the satisfaction of the DECC.

- ñprecinctò has the same meaning as ñgrowth centre precinctò in the SEPP.

- ñprecinct planò has the same meaning as in the Growth Centres Development Code.

- ñprotected area networkò means a system of lands especially dedicated to the protection and maintenance of biodiversity, and of natural and associated cultural resources, and managed through legal or other effective means.

- ñprotectionò or ñprotectedò in relation to land means land that is protected by a land use zoning under an environmental planning instrument or public ownership arrangements that provide for the protection of biodiversity values as a priority, or another arrangement that provides in-perpetuity security for biodiversity on the subject land.

- ñReport on Public Submissionsò means the document titled ñGrowth Centres Draft Conservation Plan - Report on Public Submissionsò prepared by the GCC and dated July 2007.

- ñSEPPò means *State Environmental Planning Policy (Sydney Region Growth Centres) 2006*.

- ñSpecial Infrastructure Contribution Practice Noteò means the document with that title prepared by the GCC (dated December 2006) as updated and in force from time to time.

- ñthreatened speciesò and ñthreatened species, populations and ecological communitiesò have the same meaning as in the Act.

<u>Explanatory notes</u>

A. Nothing in this biodiversity certification order:

   i. restricts any future decisions that may be made by the Minister under Part 7, Division 5 of the Act,

   ii. removes, alters or over-rides any requirement to obtain any necessary approvals under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

B. In accordance with section 126K of the Act, following any review of the SEPP under the *Environmental Planning and Assessment Act 1979* or any rezoning of land to which the SEPP applies, the Minister is to reassess the grant of biodiversity certification to determine whether it should be maintained or modified.

General

1. In the event of any inconsistency between the draft Growth Centres Conservation Plan, the Report on Public Submissions and the conditions of biodiversity certification, the conditions of biodiversity certification shall prevail.

2. This biodiversity certification order does not affect any consent or approval granted under Part 3A, Part 4 or Part 5 of the *Environmental Planning and Assessment Act 1979* before the order took effect, or any development or activity carried out in accordance with such a consent or approval.

3. The Minister, from time to time and as considered appropriate, may amend the conditions of biodiversity certification in accordance with the Act to address anomalies, errors, boundary revisions and/or to take into account new information, but only if the Minister is satisfied that any amendments will not detract from the ability of the SEPP, and other relevant measures, to lead to the overall improvement or maintenance of biodiversity values. Amendments may include, but are not limited to, boundary revisions to reflect updated flood mapping and the outcomes of the assessments completed under conditions 14, 17 and 18. The Minister may, but is not required to, provide for any such amendments to be exhibited for public comment.

4. Copies of all final reports, maps, reviews, plans and monitoring data referred to in the conditions of biodiversity certification must be held by the GCC and made publicly available, either on request and/or by a mechanism that is broadly publicly accessible. This does not apply to material that is commercially sensitive or contains sensitive information regarding the location of threatened species, populations or ecological communities or their habitat.

Areas subject to biodiversity certification

5. Pursuant to section 126H of the Act, the biodiversity certification of the SEPP is limited to the certified areas.

   Note: Pursuant to section 126I of the Act, developments or activities proposed to be undertaken within the certified areas do not need to undertake assessment of impacts on threatened species, populations and ecological communities, or their habitats, that would normally be required by Part 4 or 5 of the *Environmental Planning and Assessment Act 1979*.

Native vegetation to be retained within the Growth Centres

6. A minimum of 2,000 hectares of existing native vegetation must be retained and protected within the Growth Centres, either within the certified areas and/or the non-certified areas, subject to conditions 7 to 13 below.

- **Retention of existing native vegetation during precinct planning**

7. During the precinct planning process, the GCC may determine to make areas of existing native vegetation within the non-certified areas available for development if the clearance of such vegetation is considered necessary for either the provision of essential infrastructure and/or to meet the required Development Parameters specified in the Growth Centres Development Code.

8. In making a determination under condition 7, the GCC must demonstrate by way of information provided during the public exhibition of the precinct plan (where that exhibition occurs after this order takes effect) that the clearing of any existing native vegetation in the non-certified areas will be offset by:

    a. the protection of an equal or greater area of existing native vegetation elsewhere in the Growth Centres; and/or

    b. the revegetation and/or restoration of an area of land elsewhere in the Growth Centres, subject to satisfying the following,

        i. that the clearance of existing native vegetation in the non-certified areas will not affect the capacity to achieve overall improvement or maintenance of biodiversity values for threatened species, populations and ecological communities and their habitats,
        ii. the revegetated and/or restored areas will be protected,
        iii. the extent of revegetation and/or restoration compared to clearing of existing native vegetation must be undertaken at a ratio of at least 3:1 (to reflect the greater ecological risks relative to retaining existing native vegetation),
        iv. areas subject to revegetation and/or restoration must be of a suitable boundary configuration and design to support long-term management,
        v. revegetation and/or restoration of the proposed areas would not be undertaken under another scheme or regulatory requirement already in operation at the time that the clearing is approved (this includes but is not limited to any approvals, and associated conditions of such approvals, that may be required under the *Rivers and Foreshores Improvement Act 1948* and *Water Management Act 2000*),
        vi. revegetation and/or restoration will be undertaken by suitably qualified and experienced persons using indigenous plant stock, and
        vii. sufficient resources will be made available to undertake the revegetation and/or restoration and any necessary follow-up maintenance and monitoring for a minimum period of 5 years following the commencement of the revegetation and/or restoration.

9. Revegetation and/or restoration may be partly counted towards meeting the overall requirement to protect 2,000 hectares of existing vegetation required in condition 6. The amount that may be counted shall be calculated by dividing the total area of revegetation and/or restoration required under condition 8b(iii) by 3.

    <u>Note</u>: for example, if 9 hectares of revegetation is undertaken then 3 hectares may be counted.

- **Retention of existing native vegetation during development**

10. In the non-certified areas, proposals to clear existing native vegetation shall be subject to the relevant development controls in the SEPP and *Sydney Regional Environmental Plan No. 31 – Regional Parklands*, and the requirements of the *Environmental Planning and Assessment Act 1979*.

11. Where there are essential infrastructure proposals, including but not limited to proposals under Part 3A of the *Environmental Planning and Assessment Act 1979*, that involve clearing of existing native vegetation in the non-certified areas and that do not require development consent under the SEPP, such clearing must be offset by applying the same requirements specified in condition 8 above.

    In this case the offsets may be located outside of the Growth Centres (but within the Cumberland Plain of Western Sydney, as defined in condition 32) if the GCC is satisfied that there are no practicable offset options within the Growth Centres and all other requirements of condition 8 will be met. However, any offsets outside the Growth Centres cannot be counted towards meeting the requirements of condition 6.

- **Retention of existing native vegetation shown in areas marked with red hatching**

12. Notwithstanding any other conditions of biodiversity certification, in the lands marked by a red hatching on the biodiversity certification maps existing native vegetation must not be cleared unless it is in accordance with a plan of management or unless such clearance has been agreed to by the DECC.

- **Ground-truthing of existing native vegetation**

13. If new information becomes available after the biodiversity certification order took effect that demonstrates that the vegetation within an area does not otherwise meet the definition of existing native vegetation, then for the purposes of conditions 7 to 8 and condition 11 to 12 only the area of confirmed existing native vegetation shall be considered.

<u>Additional conservation actions within the Growth Centres ï native vegetation</u>

14. During or before the preparation of the relevant precinct plan(s) under the Growth Centres Development Code, a further detailed assessment must be undertaken of the areas adjoining or proximate to the Shanes Park Air Services Australia site marked in blue hatching on the biodiversity certification maps.

15. The assessment referred to in condition 14 must examine whether the areas meet the criteria specified in Schedule 3.

16. Based on the outcomes of the assessment the DECC shall provide advice to the Minister on whether the areas should be included within the certified areas or the non-certified areas shown on the biodiversity certification maps.

<u>Additional conservation actions within the Growth Centres ï plants</u>

17. During or before the preparation of the relevant precinct plan(s) under the Growth Centres Development Code relating to the areas referred to in the table below, the following actions must be undertaken:

Species	**Required action**
Acacia pubescens	<u>Potential populations at Cross Street, Kemps Creek and Thirty-second Avenue, Austral</u> ï as shown in black hatching on the biodiversity certification maps: • survey to confirm the presence of the species, and

	• if the species is present, provide for the protection of the area of suitable habitat for the species to the satisfaction of the DECC.
Pimelea spicata	Potential populations at Denham Court Road - as shown in black hatching on the biodiversity certification maps: • survey to confirm the presence of species, and • if the species is present, provide for the protection of the area of suitable habitat for the species to the satisfaction of the DECC.
Persoonia hirsuta	Potential populations at North Kellvville ï as shown in black hatching on the biodiversity certification maps: • survey to confirm the presence of the species, and • if the species is present, provide for the protection of the area of suitable habitat for the species to the satisfaction of the DECC.
Leucopogon fletcheri	Known population at North Kellyville - as shown in black hatching on the biodiversity certification maps: • survey to confirm the extent of the population, and • provide for the protection of the population to the satisfaction of the DECC.
Darwinia biflora *Hibbertia superans* *Epacris purpurascens var purpurascens* *Eucalyptus sp "Cattai"*	Known populations at North Kellyville - as shown in black hatching on the biodiversity certification maps: • survey to confirm the extent of the populations, and • provide for the protection of the populations to the satisfaction of the DECC.

Note: On completion of the above actions the Minister may decide that it is appropriate to amend the boundaries of the area subject to biodiversity certification, in accordance with condition 3.

Additional conservation actions within the Growth Centres ï animals

18. During or before the preparation of the relevant precinct plan(s) under the Growth Centres Development Code relating to the area referred to in the table below, the following actions must be undertaken:

Species	**Required action**
Green and Golden Bell Frog	Potential population at Riverstone - as shown in black hatching on the biodiversity certification maps: **Option 1** • survey to confirm the presence of the species, and • if the species is present, provide protection of the area of suitable habitat for the species to the satisfaction of the DECC. **Option 2** • if the species is present at Riverstone but cannot be adequately protected to the satisfaction of the DECC,

	then: (a) undertake targeted survey to confirm the presence of the species elsewhere in the Growth Centres, and (b) if the species is present elsewhere in the Growth Centres, provide for the protection of an area(s) of suitable habitat for the species to the satisfaction of the DECC.

Note: On completion of the above actions the Minister may decide that it is appropriate to amend the boundaries of the area subject to biodiversity certification, in accordance with condition 3.

Additional conservation actions within the Growth Centres ï development sites

19. Within twelve months of the biodiversity certification order taking effect, the GCC (in consultation with the DECC) must put in place procedures so that all future precinct plans (excluding any plans that were publicly exhibited before the biodiversity certification order took effect), where practicable, provide for the appropriate re-use of:

    a. native plants (including but not limited to seed collection) and the re-location of native animals from development sites, prior to development commencing; and

    b. top soil from development sites that contain known or potential native seed bank.

    For the purposes of condition 19a and 19b appropriate uses may include, but are not limited to, application in re-vegetation or restoration works and landscaping in the Growth Centres.

Conservation Fund

20. For the purposes of the conditions of biodiversity certification, references to dollar values are taken to be 2005/2006 values. All values shall be indexed in accordance with the ñland indexò to be published by the GCC, as detailed in the Special Infrastructure Contribution Practice Note.

21. Over the life of the development of the Growth Centres funding shall be provided to establish a Conservation Fund of at least $530 million to be used for biodiversity conservation and regional open space purposes. $397.5 million of the Conservation Fund is planned to be used to acquire lands and/or enter into conservation agreements over lands that are outside of the Growth Centres for the primary purpose of biodiversity conservation.

Timing and delivery of conservation funding

22. For that portion of the Conservation Fund that is to be used to fund the purchase and/or entering into conservation agreements over lands that are outside the Growth Centres, the following conditions apply:

    a. commencing in the 2008/2009 financial year, and continuing every financial year thereafter until the Conservation Fund is exhausted, the

GCC must work with DECC to arrange for the provision of an annual contribution to fund these actions outside the Growth Centres in accordance with an indicative ten-year timetable of payments to be submitted by the GCC for approval of the Minister within six months of the date of this certification order. Once approved, the indicative timetable shall be incorporated as Schedule 4 of the biodiversity certification order in accordance with condition 3;

b. the indicative ten-year timetable of payments is to be generally prepared by determining the proportion of total remaining lot production in the Growth Centres that is expected to occur within a given financial year and to then allocate for that financial year the same proportion of the remaining amount of the planned $397.5 million funding that has not been previously allocated;

c. to ensure adequate tracking of payments against the planned $397.5 million allocation, the GCC must ensure that the indicative ten-year payment timetable identifies the payments in both current and equivalent 2005/06 dollar values;

d. an updated indicative ten-year payment timetable (to provide details of the payments for the subsequent ten years) must be provided annually (by June of each financial year) by the GCC to the DECC;

e. the annual contributions must be used for the purposes detailed in conditions 23 and 24 below;

f. notwithstanding conditions 22a to 22e inclusive, if requested by the DECC the GCC must use its best endeavours to support the provision of additional funding contributions to accelerate land acquisition and/or conservation agreements over land outside the Growth Centres in any given financial year. The following conditions also apply,

   i. if an additional contribution is obtained in a given financial year, the GCC and DECC shall determine how subsequent annual contributions are to be reduced to account for the additional contributions in that financial year, and
   ii. if, despite best endeavours, an additional contribution is not obtained, the provisions of condition 27 will not be triggered with respect to this additional amount.

<u>Use of conservation funding</u>

23. As stated in condition 21, $397.5 million of the Conservation Fund is planned to be used by the DECC to arrange for the purchase and/or establishment of conservation agreements over lands <u>outside</u> the Growth Centres for the primary purpose of biodiversity conservation. This portion of the Conservation Fund must be allocated in accordance with the preferences for location and conservation values that are detailed in conditions 32, 33 and 34.

24. As part of the use of funds under condition 23, the DECC may arrange for allocation of a reasonable proportion towards the administration costs of purchasing land and/or entering into conservation agreements, and for the initial management costs of purchased land. However, from the commencement of the 2012/2013 financial year any such allocations must not exceed 5% of the annual

contribution from the Conservation Fund for the purchase and/or establishment of conservation agreements over lands <u>outside</u> the Growth Centres in any single financial year.

25. Funding that is planned to be allocated from the Conservation Fund <u>within</u> the Growth Centres shall be used to fund the purchase of lands as identified in the SEPP (as gazetted in July 2006), or the establishment of conservation agreements over an area or areas of land within the Growth Centres.

<u>Timing of expenditure</u>

26. The DECC must use its best endeavours to ensure that funds allocated within a financial year for the purchase and/or establishment of conservation agreements over lands <u>outside</u> the Growth Centres are allocated for those purposes as expeditiously as possible.

<u>Non-delivery of funding</u>

27. Despite the requirements of condition 22, if in any financial year (ñthe first financial yearò) the full annual contribution is not provided then:

    a. the Minister must consult with the Minister for Planning regarding the continued operation of section 126I of the Act in relation to the certified areas; and

    b. based on the outcomes of that consultation, if the Minister is satisfied that appropriate arrangements have been put in place to rectify the funding shortfall then section 126I shall continue to have effect for the certified areas; or

    c. the Minister shall determine whether to suspend or revoke the biodiversity certification order in accordance with the Act.

28. If no decision has been made in accordance with conditions 27b or 27c within six months of the end of the relevant financial year, then the provisions of section 126I of the Act are taken to no longer have effect in relation to the certified areas, until such time as the outstanding contribution is provided or the Minister is satisfied that appropriate arrangements have been put in place to rectify the funding shortfall. This condition does not affect any consent or approval granted under Part 3A, Part 4 or Part 5 of the *Environmental Planning and Assessment Act 1979* before the condition took effect, or any development or activity carried out in accordance with such a consent or approval.

    For the purposes of condition 27 and 28, ñrectifyò means amending the indicative timetable referred to in condition 22 to ensure that within four financial years of the first financial year the level of funding provided will be at least equal to the amount of funding that would otherwise have been provided by that time under the provisions of condition 22, or achievement of a comparable or better conservation outcome to the satisfaction of the Minister.

29. Conditions 27 and 28 do not have effect where the annual contribution required under condition 22 has not been provided because the balance of unspent funding being held in the Conservation Fund for the purchase and/or establishment of conservation agreements over lands <u>outside</u> the Growth Centres has reached a limit to be determined by the Minister.

Reporting

30. Commencing at the end of the 2008/2009 financial year, and at the end of every financial year thereafter until the Conservation Fund is exhausted, the GCC must provide the following information to the DECC within 2 months of the end of the relevant financial year:

    a. an estimate of the amount of existing native vegetation, specified by vegetation community type, that has been cleared within the Growth Centres. This may be based on, but is not limited to, the use of information on subdivision development approvals as a surrogate measurement for clearing, or some other basis agreed between the GCC and DECC.

31. Commencing at the end of the 2008/2009 financial year, and at the end of every financial year thereafter until the Conservation Fund is exhausted, the DECC must arrange for the publication of a report detailing the following matters:

    a. the information provided in condition 30;

    b. the amount of funding provided from the Conservation Fund in the financial year for the purchase and/or establishment of conservation agreements over lands outside the Growth Centres;

    c. the amount expended in the financial year, including the amount spent on land purchase, conservation agreements, administration and initial management costs for purchased land;

    d. a summary of the conservation outcomes achieved by that expenditure; and

    e. the predicted funding provision for the program for the next 10 years.

Location of expenditure of funds

32. The funding identified in condition 23 must be spent within the following locations in the order of preference identified below.

    First Preference: Priority areas within the Cumberland Plain

    a. First preference shall be allocated every financial year to the purchase of land and/or entering into conservation agreements over land that is:

        - identified as ñRegional Biodiversity Corridorsò and ñWestern Sydney Priority Areasò on the map labelled ñRegional Biodiversity Corridors and priority fauna habitatsò in the Hawkesbury Nepean Catchment Action Plan; AND

        - also occurs within the Cumberland Plain of Western Sydney; AND

        - generally meets the criteria specified in condition 33.

Where there is insufficient available land, or the cost-effectiveness of purchasing and/or entering into conservation agreements over lands in the above category is considered by the DECC to be too low, or the criteria in condition 33 cannot be met, then the funding may be allocated by DECC to be used on lands in accordance with condition 32b below.

<u>Second Preference: Priority areas within the Hawkesbury Nepean Catchment</u>

b. As second preference, funding shall be allocated every financial year to the purchase of land and/or entering into conservation agreements over land that is:

- identified as ñRegional Biodiversity Corridorsò and ñWestern Sydney Priority Areasò on the map labelled ñRegional Biodiversity Corridors and priority fauna habitatsò in the Hawkesbury Nepean Catchment Action Plan; AND

- is not identified in condition 32a; AND

- generally meets the criteria specified in condition 33.

Where there is insufficient available land, or the cost-effectiveness of purchasing and/or entering into conservation agreements over lands in the above category is considered by the DECC to be too low, or the criteria in condition 33 cannot be met, then the funding may be allocated by DECC to be used on lands in accordance with condition 32c below.

<u>Third Preference: Grassy Woodlands within the Hawkesbury Nepean Catchment</u>

c. As third preference, funding shall be allocated every financial year to the purchase of land and/or entering into conservation agreements over lands that:

- contain grassy woodlands within the Hawkesbury Nepean Catchment; AND

- are not identified in conditions 32a or 32b; AND

- generally meets the criteria specified in condition 33.

Where there is insufficient available land, or the cost-effectiveness of purchasing and/or entering into conservation agreements over lands in the above category is considered by the DECC to be too low, or the criteria in condition 33 cannot be met then the funding may be allocated by DECC to be used on lands in accordance with condition 32d below.

Fourth Preference: Grassy Woodlands within the Sydney Basin

d. As fourth preference, funding shall be allocated every financial year to the purchase of land and/or entering into conservation agreements over lands that satisfy the following criteria:

- land containing grassy woodlands within the Sydney Basin; AND
- that is not identified in conditions 32a, 32b or 32c; AND
- generally meets the criteria specified in condition 33.

Where there is insufficient available land, or the cost-effectiveness of purchasing and/or entering into conservation agreements over lands in the above category is considered too low, or the criteria in condition 33 cannot be met, then the funding may be allocated by DECC to be used on lands in accordance with condition 32e below.

Fifth Preference: other lands identified by the DECC

e. As fifth preference, funding shall be allocated every financial year to the purchase of land and/or entering into conservation agreements over land that is:

- within the Sydney Basin; AND
- is not identified in conditions 32a, 32b, 32c or 32d; AND
- generally meets the criteria specified in condition 33.

For the purposes of condition 32:

- ñcost-effectivenessò means a consideration of the conservation objectives that would be achieved by purchasing or entering into a conservation agreement for a parcel of land and the cost of the purchase and/or conservation agreement, relative to the cost of achieving the same or similar conservation objectives on other parcels of land within the Sydney Basin.
- “Cumberland Plain of Western Sydney” means the geographic area by that name as identified in National Parks and Wildlife Service (2000), *The native vegetation of the Cumberland Plain, Western Sydney – Technical Report*, NSW NPWS, Hurstville.
- ñgrassy woodlandsò mean the vegetation formation by that name as defined in Keith, D. (2004), *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*. NSW Department of Environment and Conservation. Hurstville, NSW.
- ñHawkesbury Nepean Catchmentò means the area of land described in the Hawkesbury Nepean Catchment Action Plan.
- ñHawkesbury Nepean Catchment Action Planò means the *Hawkesbury-Nepean Catchment Action Plan 2007-2016* published by the Hawkesbury-Nepean Catchment Management Authority (October 2006).

- ñSydney Basinò means the areas as defined by Environment Australia (2000), *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and development of Version 5.1 – Summary Report*. Department of Environment and Heritage, Canberra.

<u>Conservation values to be protected through the expenditure of funds</u>

33. Within each area specified in condition 32, the lands to be targeted for purchase and/or conservation agreement outside the Growth Centres shall be guided by consideration of the following criteria:

    - large remnants of intact native vegetation with the greatest potential for retaining biodiversity values over time;
    - vegetation communities that are under-represented in the protected area network;
    - areas of equivalent or better conservation value to that which are to be cleared within the Growth Centres;
    - areas that contain habitat for threatened species, including but not limited to species to be affected by development of the Growth Centres;
    - areas that have the highest cost effectiveness;
    - conservation reserve design principles, such as size, boundary configuration and landscape context;
    - previous land uses;
    - likely threats (such as existing or future adjoining land uses); and
    - availability (including the willingness of landowners to either sell land or place it under a conservation agreement). For the purpose of clarification, no land is intended to be compulsory acquired in order to meet any of the conditions of biodiversity certification.

    For the purposes of this condition, and the avoidance of doubt, the above attributes are to be considered and applied as a guide only.

34. The lands to be targeted for purchase and/or conservation agreement <u>outside</u> the Growth Centres must include a known population(s) or suitable habitat for the plant species *Cynanchum elegans*.

    <u>Note</u>: this action is required to ensure an appropriate improve or maintain outcome for this species, which occurs in the Growth Centres but is not currently protected by measures under the Growth Centres SEPP.

<u>Future precinct plans</u>

35. During the preparation of future precinct plans (excluding any precinct plans already publicly exhibited before this order took effect) the GCC must undertake and make publicly available an assessment of the consistency of the proposed precinct plan with the conditions of biodiversity certification. This may occur during or before any public exhibition of future draft precinct plans.

<u>Future threatened species listings or discoveries</u>

36. Where a preliminary determination is made under the Act to list a species, population or ecological community, and that species, population or ecological

community may or is known to occur within the Growth Centres, then the GCC must (as soon as practicable) provide advice to the DECC on whether:

a. the species, population or ecological community is known or likely to be present in the Growth Centres;
b. it was considered during the preparation of the draft Growth Centres Conservation Plan by the GCC; and
c. whether the SEPP, and related measures, provides adequate protection for the species, population or ecological community.

37. Based on the information provided in accordance with condition 36, and any other relevant matters, the DECC shall advise the Minister on whether to formally review, maintain, modify, suspend or revoke the biodiversity certification of the SEPP if the species, population or ecological community is listed under the Act.

Review

38. A review of the biodiversity certification of the SEPP must be undertaken by the DECC every four years after the biodiversity certification order takes effect (to be completed within two months of each four year anniversary). The timing of the review may be adjusted by DECC to coincide with any planned review of the operation of the Special Infrastructure Contribution within the Growth Centres.

39. The purpose of the review is to assess progress in achieving an overall improvement or maintenance of biodiversity values, including review of the arrangements for the provision of funds to the Conservation Fund and the allocation of those funds within and outside of the Growth Centres.

40. To assist in the review required under condition 38, the GCC must provide the following information to the DECC in a timely manner:

a. an estimate of the amount of existing native vegetation, specified by vegetation community type, that has been cleared within the Growth Centres, including maps of known locations, within the four year period (or adjusted period);

b. progress in achieving the requirements of condition 6, including the following,

i. the amount of existing native vegetation that has been retained and protected within planning precincts,

ii. the amount of revegetation and/or restoration that has occurred (or is planned to occur) within planning precincts,

iii. an indicative estimate of the amount of existing native vegetation, and the amount of revegetated and/or restored areas, planned to be protected in the remaining precincts within the Growth Centres that are yet to be released;

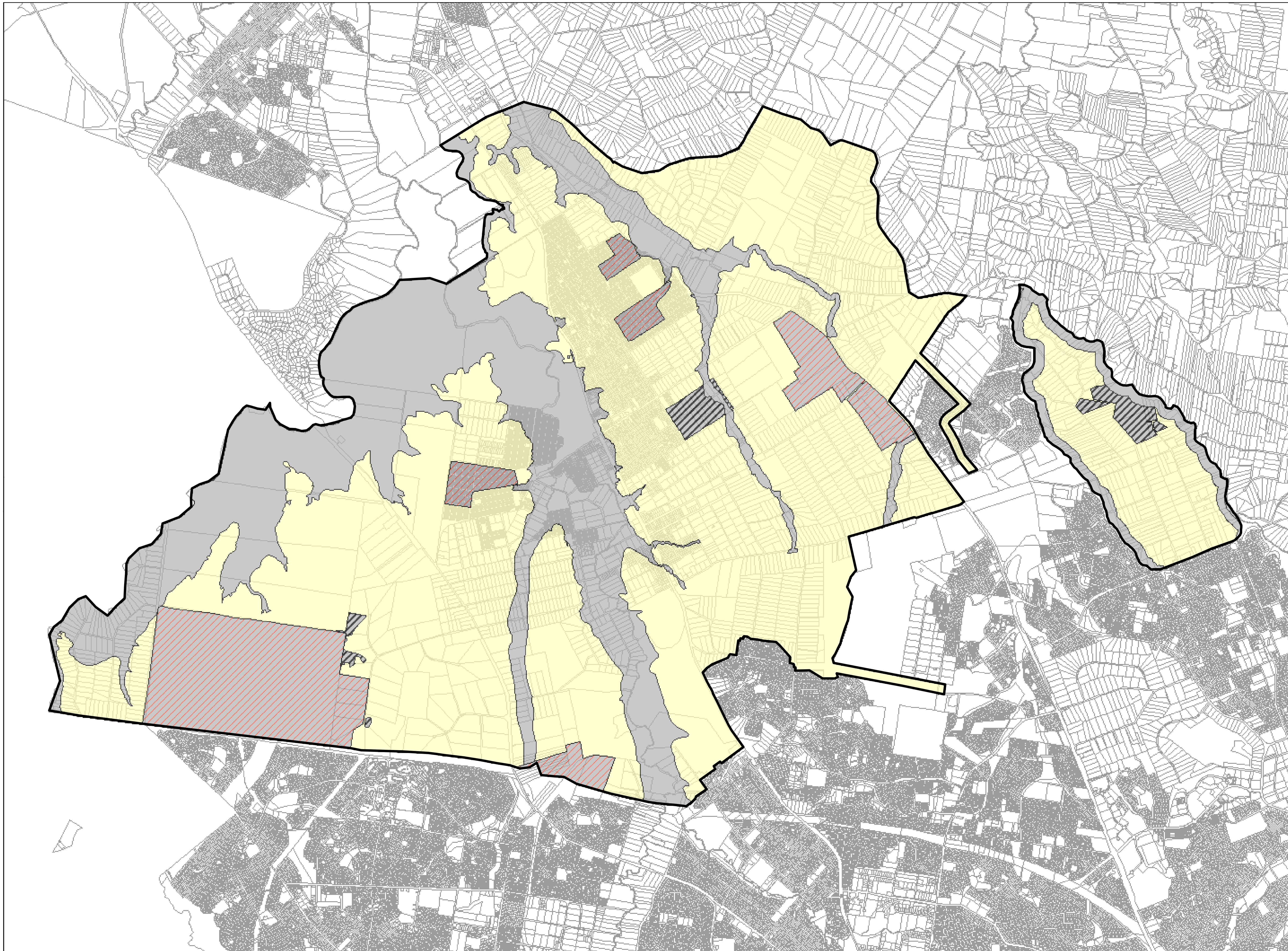
c. an overview of any amendments to the SEPP or related measures that have occurred within the four year period (or adjusted period);

d. any recommendations that would improve the operation of the conditions of biodiversity certification including, but not limited to, any modifications or revisions to the conditions themselves and the arrangements for management and allocation of funds from the Conservation Fund; and

e. any other information that is considered relevant by the DECC to assist in reviewing whether the SEPP, and any other relevant measures, will continue to lead to the overall improvement or maintenance of biodiversity values.

41. Based on the information provided under condition 40, and any other relevant matters, the DECC shall advise the Minister on whether biodiversity certification should be maintained, modified, suspended or revoked.

SCHEDULE 2 – BIODIVERSITY CERTIFICATION MAPS



Legend

- NW Growth Centre Boundary
- Certified Area
- Non Certified Area
- Non Certified Area
  Land subject to Condition 12 of the Biodiversity Certification Order.
- Non Certified Area
  Subject to further investigation in accordance with Conditions 14, 17 and 18 of the Biodiversity Certification Order.

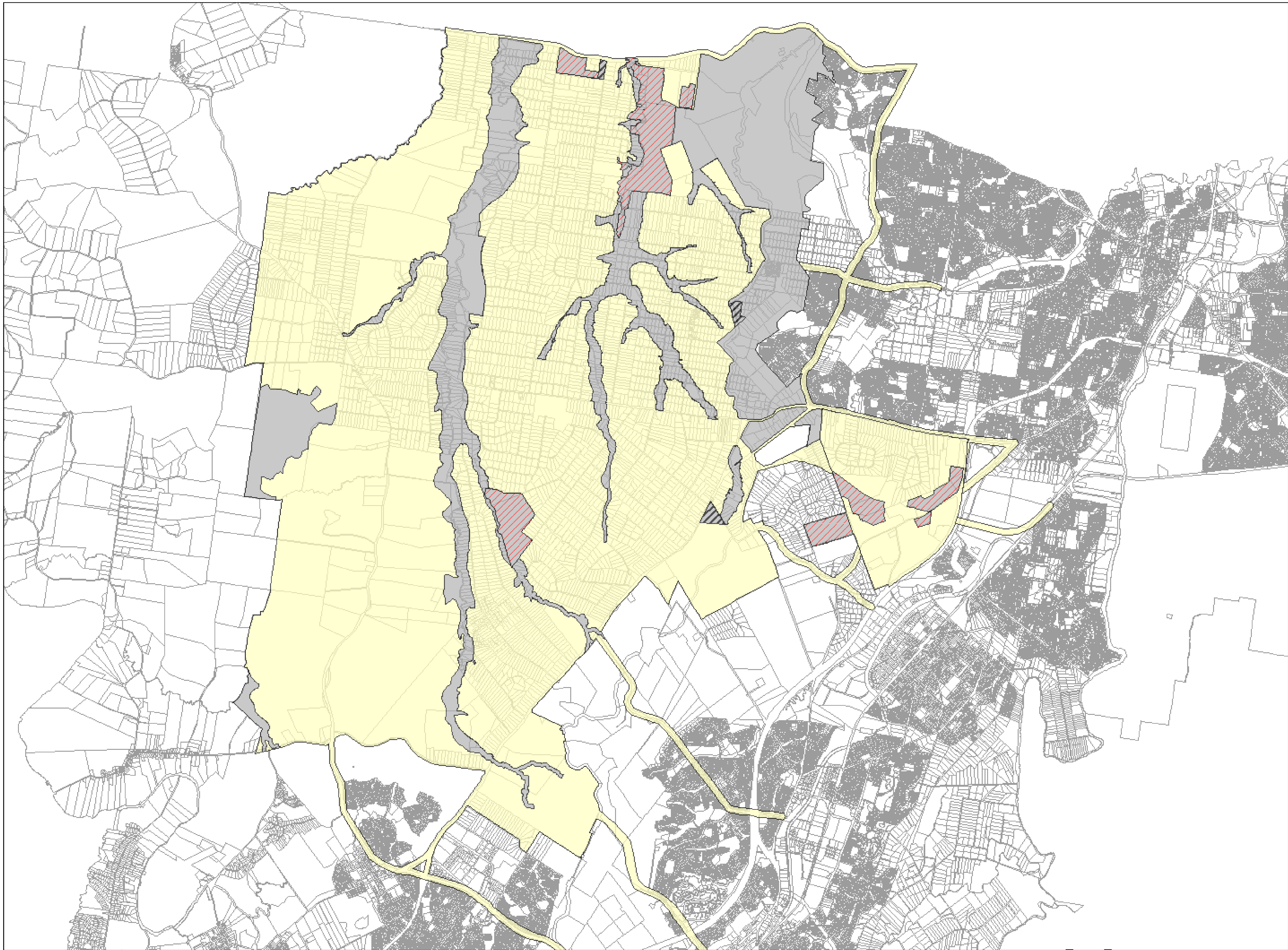
This is the Map referred to in the Biodiversity Certification Order.

November 2007

Disclaimer
The information contained on this map is, to the best of the Government's knowlwedge correct. However, no warranty or guarantee is provided by the Government and no liability is accepted for any loss or damage resulting from any person relying upon or using the information contained in the map.

North West Growth Centre - Biodiversity Certification

Y



Legend

SW Growth Centre Boundary

Certified Area

Non Certified Area

Non Certified Area
Land subject to Condition 12 of the Biodiversity Certification Order.

Non Certified Area
Subject to further investigation in accordance with Conditions 14, 17 and 18 of the Biodiversity Certification Order.

This is the Map referred to in the Biodiversity Certification Order.

November 2007

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South West Growth Centre - Biodiversity Certification

Y

SCHEDULE 3 – CRITERIA REFERRED TO IN CONDITION 15

The following are the criteria referred to in condition 15 of Schedule 1.

Whether the areas:

a. contain an endangered ecological community as listed under the Act;

b. are contiguous with the existing native vegetation on the Air Services Australia site;

c. are equal to or greater than 4 hectares;

d. have 10% or greater canopy cover;

e. have 30% or greater vegetation cover within,

   i. a 0.55 kilometre radius (for local connectivity), and
   ii. a 1.75 kilometre radius (for regional connectivity),

   as measured from the approximate centre point of each area;

f. have a perimeter to area ratio that is conducive to on-going conservation management; and

g. whether after applying a 50 metre disturbance buffer to the edge of each area (where that edge is likely to be made available for future urban development as identified in the SEPP), the overall size of the area then falls below 4 hectares.

SCHEDULE 4 – INDICATIVE TEN YEAR PAYMENT TIMETABLE

The following timetable is that referred to in condition 22 of Schedule 1.

Financial year	**Amount in current dollars ($ million)**	**Amount in 2005/06 dollars ($ million)**
2008/09	1.0	1.0
2009/10	3.0	3.0
2010/11	5.8	5.8
2011/12	8.8	8.8
2012/13	10.4	10.4
2013/14	12.1	12.1
2014/15	12.9	12.9
2015/16	14.1	14.1
2016/17	15.1	15.1
2017/18	15.8	15.8

APPENDIX 2

EPBC ACT PROTECTED MATTERS SEARCH RESULTS

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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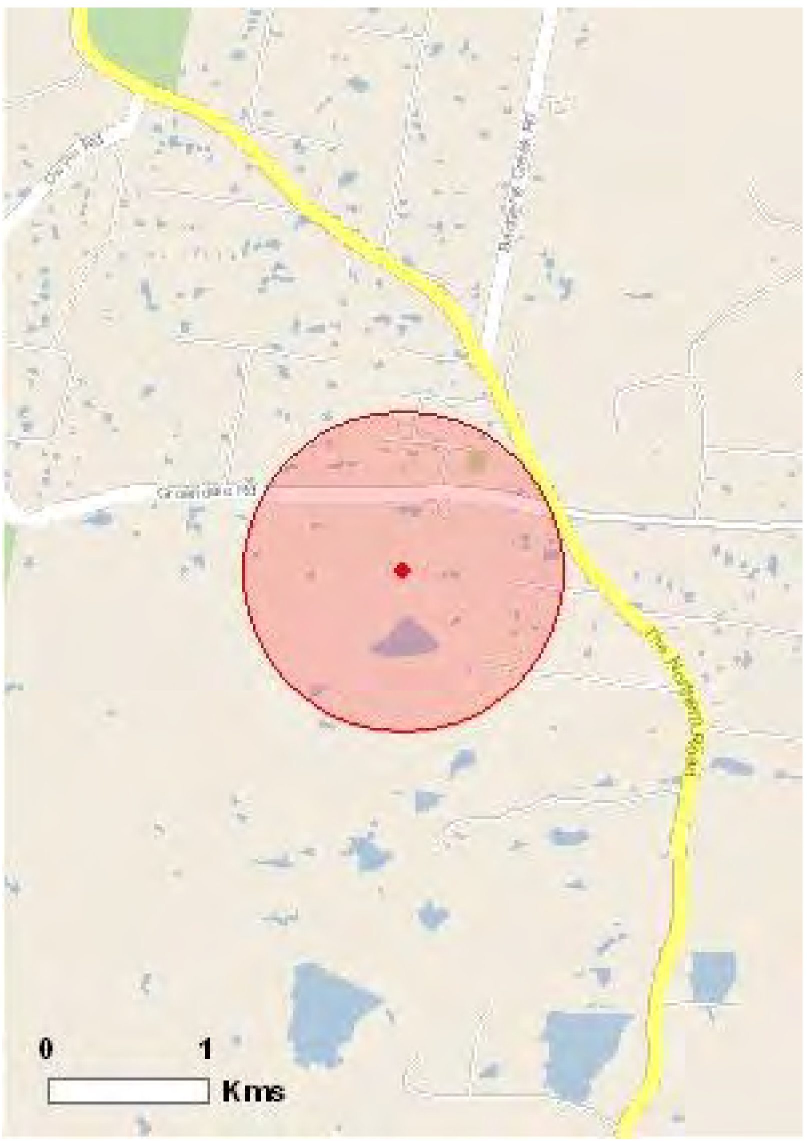
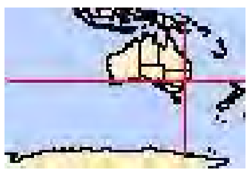


This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	23
Listed Migratory Species:	14

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	12
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	18
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Endangered	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area
Frogs		

Name	Status	Type of Presence
Heleioporus australiacus		
Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Petrogale penicillata		
Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae		
New Holland Mouse [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Allocasuarina glareicola		
[21932]	Endangered	Species or species habitat may occur within area
Cynanchum elegans		
White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Pimelea spicata		
[20834]	Endangered	Species or species habitat likely to occur within area
Pomaderris brunnea		
Rufous Pomaderris [16845]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis saxicola		
Sydney Plains Greenhood [64537]	Endangered	Species or species habitat may occur within area
Streblus pendulinus		
Siah's Backbone, Sia's Backbone, Isaac Wood [21618]	Endangered	Species or species habitat may occur within area
Reptiles		
Hoplocephalus bungaroides		
Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Xanthomyza phrygia Regent Honeyeater [430]	Endangered*	Species or species habitat likely to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur

Name	Threatened	Type of Presence
		within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat likely to occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides		
Alligator Weed [11620]		Species or species habitat likely to occur within area
Asparagus asparagoides		
Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area
Nassella neesiana		
Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Nassella trichotoma		
Serrated Tussock, Yass River Tussock, Yass Tussock, Nassella Tussock (NZ) [18884]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Ulex europaeus		
Gorse, Furze [7693]		Species or species habitat likely to occur within area

Coordinates

-33.94336 150.72305

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 3

FLORA SPECIES INVENTORY

Family		Botanical name	Common name	Q1	Q2	Q3	Q4
Ferns and allied plants							
Sinopteridaceae		*Cheilanthes sieberi*	Rock Fern	1			
Angiosperms - Dicotyledons							
Acanthaceae		*Brunoniella pumilio*	Dwarf Blue Trumpet	1			
Apocynaceae	*	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush			1	
Asteraceae	*	*Ageratina adenophora*	Crofton Weed				
	*	*Aster subulatus*	Wild Aster				
	*	*Cirsium vulgare*	Black Thistle, Spear Thistle			1	
	*	*Conyza sumatrensis*	Tall Fleabane				
	*	*Senecio madagascariensis*	Fireweed	1		1	1
Cactaceae	*	*Opuntia stricta*	Prickly Pear				
Casuarinaceae		*Casuarina glauca*	Swamp Oak				
Chenopodiaceae		*Einadia nutans subsp. linifolia*	Climbing Saltbush				
		Einadia trigonos	Fishweed				1
Clusiaceae		*Hypericum gramineum*	Small St Johns-wort			1	
Convolvulaceae		*Dichondra repens*	Kidney-weed	1	1	1	
Crassulaceae	*	*Bryophyllum delagoense*	Mother-of-millions				
Ericaceae Styphelioideae		*Leucopogon juniperinus*	Long-flowered Beard-heath				
Fabaceae Faboideae		*Desmodium varians*	Slender Tick-trefoil			1	1
		Dillwynia sp.	Eggs-and-bacon Pea				
		Glycine clandestina	Twining Glycine				
		Glycine tabacina					1
		Hardenbergia violacea	False Sarsaparilla				
Fabaceae Mimosoideae		*Acacia decurrens*	Black Wattle				
		Acacia falcata	Sickle Wattle				
		Acacia implexa	Hickory Wattle				
		Acacia trinervata	Three-veined Wattle				
Gentianaceae	*	*Centaurium tenuiflorum*	Centaury				
Lamiaceae		*Plectranthus parviflorus*					
Loranthaceae		*Amyema miquelii*	Box Mistletoe		1		
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne			1	1
Myoporaceae		*Eremophila debilis*	Winter Apple, Amulla				

Family		Botanical name	Common name	Q1	Q2	Q3	Q4
Myrtaceae		*Angophora subvelutina*	Broad-leaved Apple				
		Eucalyptus acmenoides	White Mahogany				
		Eucalyptus moluccana	Grey Box	8	10		
		Eucalyptus tereticornis	Forest Red Gum			1	
		Melaleuca styphelioides	Prickly Paperbark				
Oleaceae	*	*Ligustrum sinense*	Small-Leaved Privet				
	*	*Olea europaea subsp. cuspidata*	African Olive	50	50	1	
Oxalidaceae		*Oxalis exilis*	Creeping Oxalis				1
Phyllanthaceae		*Phyllanthus virgatus*					
Pittosporaceae		*Bursaria spinosa*	Blackthorn	1		1	
Plantaginaceae	*	*Plantago lanceolata*	Plantain, Ribwort			2	2
		Veronica plebeia	Creeping Speedwell				
Rubiaceae		*Asperula conferta*	Common Woodruff	1		1	
Solanaceae	*	*Solanum linnaeanum*	Apple of Sodom				
		Solanum prinophyllum	Forest Nightshade				
Verbenaceae	*	*Verbena bonariensis*	Purpletop				1
Angiosperms - Monocotyledons							
Cyperaceae		*Carex appressa*	Tall Sedge				
		Carex breviculmis		1			
		Cyperus gracilis	Slender Sedge	1			
		Scleria mackaviensis		2			
Juncaceae		*Juncus usitatus*	Common Rush				
Lomandraceae		*Lomandra filiformis subsp. filiformis*	Wattle Mat-rush		1		
		Lomandra sp.		1			
Poaceae		*Aristida ramosa*	Wiregrass	2	1	5	10
		Austrodanthonia sp.	Wallaby Grass				
		Austrostipa rudis				5	
	*	*Axonopus fissifolius*	Narrow-leaved Carpet Grass				
	*	*Briza subaristata*		1		5	2
	*	*Chloris gayana*	Rhodes Grass				1
		Chloris truncata	Windmill Grass	1			5
		Cymbopogon refractus	Barbed Wire Grass				
		Cynodon dactylon	Couch, Bermuda Grass			5	20

Family		Botanical name	Common name	Q1	Q2	Q3	Q4
		Dichelachne micrantha	Shorthair Plumegrass	2		5	
		Elymus scaber	Rough Wheatgrass				
		Entolasia stricta	Wiry Panic	1	1		
	*	*Eragrostis curvula*	African Lovegrass	1		20	5
		Lachnagrostis filiformis	Common Blown-grass				
		Microlaena stipoides	Weeping Grass				40
		Panicum simile	Two-colour Panic				
		Paspalidium distans					
	*	*Paspalum dilatatum*	Paspalum			20	20
	*	*Setaria parviflora*					
		Sporobolus sp.				1	
	*	*Stenotaphrum secundatum*	Buffalo Grass				
		Themeda australis	Kangaroo Grass	20	1	1	10
	*	*Vulpia bromoides*	Squirrel-tail Fescue				
Typhaceae		*Typha orientalis*	Broad-leaf Cumbungi				

APPENDIX 4

FAUNA SPECIES INVENTORY

General Status	
*	Exotic/introduced species
(?)	Uncertain identification
P	Protected
U	Unprotected

Conservation Status	
CE	Critically Endangered - listed under Schedule 1A of the TSC Act
E	Endangered - listed under Schedule 1 of the TSC Act
V	Vulnerable - listed under Schedule 2 of the TSC Act

Observation Type	
O	Visual observation
W	Aural (call recognition)
X	Scat

Status	Group	Scientific Name	Common Name	Obs Type
P	Amphibian	*Limnodynastes peronii*	Striped Marsh Frog	W
P	Amphibian	*Limnodynastes tasmaniensis*	Spotted Marsh Frog	W
P	Amphibian	*Litoria fallax*	Eastern Dwarf Tree Frog	W
P	Bird	*Acanthiza lineata*	Striated Thornbill	O
P	Bird	*Acanthiza pusilla*	Brown Thornbill	O
P	Bird	*Acanthiza reguloides*	Buff-rumped Thornbill	O
P	Bird	*Acanthorhynchus tenuirostris*	Eastern Spinebill	W
*	Bird	*Acridotheres tristis*	Common Myna	W
P	Bird	*Anas superciliosa*	Pacific Black Duck	O
P	Bird	*Anhinga novaehollandiae*	Australasian Darter	O
P	Bird	*Anthochaera carunculata*	Red Wattlebird	O
P	Bird	*Anthochaera chrysoptera*	Little Wattlebird	O
P	Bird	*Cacatua galerita*	Sulphur-crested Cockatoo	O
P	Bird	*Colluricincla harmonica*	Grey Shrike-thrush	O
P	Bird	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	O
P	Bird	*Corvus coronoides*	Australian Raven	W
P	Bird	*Cygnus atratus*	Black Swan	O
P	Bird	*Dacelo novaeguineae*	Laughing Kookaburra	W

P	Bird	*Dicaeum hirundinaceum*	Mistletoebird	O/W
P	Bird	*Elanus axillaris*	Black-shouldered Kite	O
P	Bird	*Eopsaltria australis*	Eastern Yellow Robin	O
P	Bird	*Fulica atra*	Eurasian Coot	O
P	Bird	*Grallina cyanoleuca*	Magpie Lark	W
P	Bird	*Hirundo neoxena*	Welcome Swallow	W
P	Bird	*Lichenostomus chrysops*	Yellow-faced Honeyeater	W
P	Bird	*Lichenostomus penicillatus*	White-plumed Honeyeater	O
P	Bird	*Malurus cyaneus*	Superb Fairy Wren	O/W
P	Bird	*Manorina melanocephala*	Noisy Miner	W
P	Bird	*Manorina melanophrys*	Bell Miner	W
P	Bird	*Meliphaga lewinii*	Lewin’s Honeyeater	W
P	Bird	*Microcarbo melanoleucos*	Little Pied Cormorant	O
P	Bird	*Neochmia temporalis*	Red-browed Finch	O/W
P	Bird	*Pachycephala rufiventris*	Rufous Whistler	O
P	Bird	*Platycercus eximius*	Eastern Rosella	O
*	Bird	*Pycnonotus jocosus*	Red-whiskered Bulbul	O
P	Bird	*Rhipidura albiscapa*	Grey Fantail	O/W
P	Bird	*Taeniopygia bichenovii*	Double-barred Finch	O
P	Bird	*Vanellus miles*	Masked Lapwing	O
*	Mammal	*Bos sp.*	Cow	O/X
*	Mammal	*Canis lupus familiaris*	Dog	X
*	Mammal	*Dama dama*	Fallow Deer	O/X
*	Mammal	*Felis catus*	Cat	O
P	Mammal	*Marcopus sp.*	Macropod	X
P	Mammal	*Macropus robustus*	Common Wallaroo	O
*	Mammal	*Oryctolagus cuniculus*	Rabbit	O/X
*	Mammal	*Vulpes vulpes*	Fox	X
P	Reptile	*Lampropholis sp.*	Skink	O
P	Reptile	*Pseudonaja textilis*	Eastern Brown Snake	O

APPENDIX 5

HOLLOW BEARING TREE REGISTER

HBT/Waypoint	Species	Approximate height (metres)	Number of hollows visible per size class (diameter)		
			Large (>20cm)	Med (10-20cm)	Small (<10cm)
14	*Eucalyptus moluccana*	15		3	
15	*E. moluccana*	14		2	
16	*E. moluccana*	12		3	1
17	Stump	3	1 trunk hollow		
18	*E. tereticornis*	12		1	
19	*E. moluccana*	10		3	
20	*E. moluccana*	10	1	2	
21	*E. moluccana*	9	1	2	3
21 +5m	*Eucalyptus sp.*	6	2	1	
26	Stag	7			2
412	*Eucalyptus sp.*	10	1		
413	*E. moluccana*	15	Potential HBT, no visible hollows		
421	*E. moluccana*	12	1 (trunk), 1	1	
422	*E. moluccana*	16		1	
423	*E. moluccana, E. tereticornis*	12 (average)	Cluster of potential hollow-forming trees		

APPENDIX 6

THREATENED FLORA SPECIES IN THE LOCALITY

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Acacia pubescens	Downy Wattle	Vulnerable	Vulnerable	Known from Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland. Occurs on alluviums, shales and at the intergrade between shales and sandstones.	16	Low. Closest record is 7 km to east, and the Study Area falls slightly outside the known range of the species. Marginal potential habitat in CPW in the Study Area.
Allocasuarina glareicola		Endangered	Endangered	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil. Found in open woodland with *Eucalyptus parramattensis, Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla* and *Melaleuca decora.*	0	Low. No records within 10 km of the Study Area. No potential habitat in the Study Area.
Cryptostylis hunteriana	Leafless Tongue-orchid	Vulnerable	Vulnerable	Known from a range of communities including swamp, heath and most typically woodland dominated by *Eucalyptus sclerophylla, E. sieberi, Corymbia gummifera* and *Allocasuarina littoralis.*	0	Low. No records within 10 km of the Study Area. Although habitat for this species is poorly defined, potential habitat is unlikely to occur in the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Cynanchum elegans	White-flowered Wax Plant	Endangered	Endangered	A climber restricted to the east coast of NSW, inland to Merriwa. Occurs on margins of dry rainforest, also littoral rainforest, open forest and woodland, and scrub.	7	Low. One record approximately 2 kilometres south of the Study Area. Habitat in the Study Area is likely to be too degraded for this species.
Dillwynia tenuifolia		Vulnerable	Vulnerable	The core distribution is on the Cumberland Plain from Windsor to Penrith east to Deans Park; in Liverpool LGA the species has been recorded from Voyager Point and Kemps Creek. May be locally abundant within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest; may also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland.	47	Low. The closest records to the Study Area are 8 kilometres to the north-east. No potential habitat in the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Eucalyptus benthamii	Camden White Gum	Vulnerable	Vulnerable	Occurs on the alluvial flats of the Nepean River and its tributaries. There are two major subpopulations: in the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. Several trees are scattered along the Nepean River around Camden and Cobbitty. At least five trees occur on the Nattai River in Nattai National Park. Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest.	26	Low. The closest records to the Study Area are 7.5 kilometres to the west on the Nepean River floodplain. No potential habitat in the Study Area.
Grevillea juniperina subsp. juniperina	Juniper-leaved Grevillea	Vulnerable		Broadly spreading to erect shrub endemic to Western Sydney. Associated canopy species include *Eucalyptus tereticornis, E. moluccana, E. crebra, E. fibrosa* and *E. eugenioides*. Known to occur in association with Cumberland Plain Woodland, Shale/Gravel Transition Forest, Castlereagh Woodland. Species tolerates moderate disturbance and is known from urbanised areas.	2	Low. The closest records to the Study Area are 8.5 kilometres to the north-east and north-west. Potential habitat in the Study Area is highly disturbed.
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	Vulnerable	Vulnerable	A low spreading to erect shrub occurring on sandy clay loam soils, often with lateritic ironstone gravels. Generally found on crests, upper slopes or flats. Distribution generally associated with Nepean and Georges Rivers. Small populations occur at Kemps Creek & Voyager Point.	12	Low. The closest records to the Study Area are 8.5 kilometres to the north-east. No potential habitat in the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Lepidium hyssopifolium	Basalt Pepper-cress	Endangered	Endangered	In NSW, there is a small population near Bathurst, two populations near Bungendore, and one near Crookwell. The species was also recorded near Armidale in 1945 and 1958.	0	Low. No records within 10 km of the Study Area. The Study Area is far outside of the typical range for this species – it is unclear why this species is in the search results. No suitable habitat exists within the Study Area.
Marsdenia viridiflora subsp. *viridiflora*		Endangered population		A climber with twining stems to 4 metres high that typically grows in vine thickets and open shale woodland. Occurs as very scattered plants with recent records from Prospect Reservoir, Cabramatta Creek, Smithfield and the former Australian Defence Industries site at St Marys.	4	Moderate. Recorded from remnant CPW adjoining Northern Road approximately 1 km east of the Study Area. Marginal potential habitat in stands of Moderate condition CPW in the Study Area.
Pelargonium sp. Striatellum (G.W. Carr 10345)	Omeo Stork's-bill	Endangered	Endangered	Associated with irregularly inundated or ephemeral lakes, in the transition zone between grasslands/pasture and wetland communities. Known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst.	0	Low No records within 10 km of the Study Area. The Study Area is far outside of the typical range for this species – it is unclear why this species is in the search results. No suitable habitat exists within the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Persoonia nutans	Nodding Geebung	Endangered	Endangered	An erect to spreading shrub restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south. Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	8	Low. The closest records to the Study Area are 8.5 kilometres to the north-east. No potential habitat within Study Area.
Pimelea curviflora var. curviflora	-	Vulnerable	Vulnerable	A small shrub confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta River and Port Jackson region. Distribution associated with shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands.	0	Low. No records within 10 km of the Study Area. No potential habitat within the Study Area.
Pimelea spicata	Spiked Rice Flower	Endangered	Endangered	A small spreading or erect shrub Cumberland Plain and coastal Illawarra. In western Sydney, occurs an undulating topography of substrates derived from Wianamatta Shale in associated with Cumberland Plain Woodland.	16	Low. The closest records to the Study Area are over 8 kilometres to the north and east. Potential habitat within the Study Area is likely to be too degraded for this species.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Pomaderris brunnea	Rufous Pomaderris	Vulnerable	Vulnerable	Found in a very limited area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area. Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines.	0	Low. No records within 10 km of the Study Area. No potential habitat within the Study Area.
Pterostylis saxicola	Sydney Plains Greenhood	Endangered	Endangered	A ground orchid known from few populations in western Sydney. Distribution restricted between Freemans Reach in the north and Picton in the south. Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines.	0	Low. No records within 10 km of the Study Area. No potential habitat within the Study Area.
Pultenaea parviflora	-	Endangered	Vulnerable	A small erect branching shrub endemic to the Cumberland Plain from Windsor to Penrith and east to Dean Park. Outlier populations are recorded from Kemps Creek and Wilberforce. Associated with scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays.	86	Low. The closest records to the Study Area are 5 kilometres to the north. No potential habitat within the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Streblus pendulinus	Siah's Backbone		Endangered	Occurs from Cape York Peninsula to Milton, south-east NSW, as well as Norfolk Island. The species grows in well developed rainforest, gallery forest and drier, more seasonal rainforest.	0	Low. No records within 10 km of the Study Area. The Study Area is far outside of the typical range for this species – it is unclear why this species is in the search results. No suitable habitat exists within the Study Area.
Syzygium paniculatum	Magenta Lilly Pilly	Endangered	Vulnerable	Natural occurrence is in littoral rainforest in scattered small populations along a narrow, linear coastal strip from Bulahdelah to Conjola State Forest.	1	Low. One record 4 kilometres east of the Study Area; likely to be a planted horticultural specimen. The Study Area is outside the natural range of this species, and any records in the locality are not of conservation significance.
Thelymitra sp. Kangaloon	Kangaloon Sun-orchid	Critically Endangered	Critically Endangered	Endemic to the Fitzroy Falls/Robertson/Kangaloon area. The species grows in seasonally swampy sedgeland on grey silty clay loam at 600–700 metres above sea level	0	Low. No records in the locality of the Study Area. No potential habitat within Study Area.

APPENDIX 7

THREATENED FAUNA SPECIES IN THE LOCALITY

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Anthochaera phrygia	Regent Honeyeater	Critically Endangered	Endangered	Distribution is extremely patchy; in NSW the species has been recorded from coastal areas to Narrabri with important breeding areas west of Armidale. Occurs in temperate eucalypt woodlands, most commonly box-ironbark associations and wet lowland coastal forests. Nests usually constructed in eucalypts, casuarinas or mistletoes. Forage for nectar and arthropods.	3	Low. Study Area does not support the diversity of vegetation this species requires.
Apus pacificus	Fork-tailed Swift		Migratory	The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. The Fork-tailed Swift does not breed in Australia.	0	Low. Species rarely settles and is usually found inland. Does not breed in Australia.
Ardea alba	Great Egret		Migratory	Occurs throughout Australia excluding arid areas. Inhabit lakes, swamps, dams and rivers and occasionally damp grasslands. Wades through shallows to hunt fish and invertebrates. Constructs a nest platform in a tree over water.	0	Moderate. Thompsons Creek dam offers potential foraging habitat. Thompsons Creek dam would not be impacted by the Proposal.
Adrea ibis	Cattle Egret		Migratory	Migrates south from Asia and northern Australia for the winter. Occurs in woodlands and wetlands, damp pasture and grassland around the northern, eastern and western Australian coasts where it forages for invertebrates. Commonly forage in proximity to grazing cattle. Nest in trees and shrubs along watercourses.	0	Moderate. Species occurs in woodlands, grassland and wetlands. Nesting could occur along Thompsons Creek.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Botaurus poiciloptilus	Australian Bittern	Endangered	Endangered	Widespread distribution but uncommon across south-eastern Australia. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spike rushes (*Eleoacharis* spp), where it forages at night for amphibians, invertebrates and crustaceans. Nests are built within densely vegetated wetlands on a platform of reeds.	0	Low. The Study Area does not support preferred habitat.
Burhinus grallarius	Bush Stone-Curlew	Endangered		Rare throughout south-eastern Australia where it inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Forages nocturnally for insects and small vertebrates. Nests in a shallow scrape on the ground.	1	Low. Woodland habitat within certified areas could provide suitable habitat however species has not been recorded in the area for more than 80 years.
Callocephalon fimbriatum	Gang-gang Cockatoo	Vulnerable		Found in the central NSW coast and tableland areas, including Canberra and the Hawkesbury/Nepean and Sydney Metro region. Usually frequents forested areas with old growth attributes required for nesting and roosting purposes. Also utilises less heavily timbered woodlands and urban fringe areas to forage, but appears to favour well-timbered country.	2	Low. Study Area supports marginal foraging habitat. Species prefers well-timbered country.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Vulnerable	Found mainly in areas with extensive cliffs and caves. It is generally rare with a very patchy distribution in NSW, with scattered records from the New England Tablelands and North-west Slopes. Roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (Hirundo ariel). Forage in low to mid-elevation dry open forest and woodland and well-timbered areas containing gullies close to roosting habitat, for small, flying insects. Most likely hibernates through coolest months.	5	Low. Study Area does not support preferred foraging habitat or a roost site.
Chthonicola sagittata	Speckled Warbler	Vulnerable		The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	8	Low. Species requires large, relatively undisturbed remnant vegetation.
Daphoenositta chrysoptera	Varied Sittella	Vulnerable		Widespread throughout mainland Australia, where it is found in eucalypt woodlands. Forages for insects in rough-bark eucalypts. Nests in a tree branch or fork.	15	Moderate. Moderate quality woodland within the Study Area provides potential habitat.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Dasyurus maculatus maculatus	Spot-tailed Quoll	Vulnerable	Endangered	Found along the escarpments, tablelands and coast of the eastern seaboard from the Bundaberg area in south-east Qld south through NSW to Victoria and Tasmania. Known from dry and moist eucalypt forests and rainforest. Species tends to move along drainage lines and make dens in fallen hollow logs or among large rocky outcrops. Usually nocturnal but are known to hunt and bask during the day. Hunts terrestrially and arboreally.	0	Low. Study Area does not support preferred habitat. No records within 10km of the Study Area.
Ephippiorhynchus asiaticus	Black-necked Stork	Endangered		Widespread in coastal and subcoastal northern and eastern Australia; in NSW, the species becomes increasingly uncommon south of the Northern Rivers region. Rarely occurs south of Sydney. Found in association with wetlands, swamps, billabongs, estuaries and surrounding vegetation. Forages in shallow still water, for small vertebrates and crustaceans. Nests in a tall live tree, including paddock trees and paperbarks.	1	Moderate. Study Area supports nesting and foraging habitat in certified lands (e.g. Thompsons Creek).
Erythrotriorchis radiatus	Red Goshawk	Critically Endangered	Vulnerable	Sparsely dispersed across coastal and sub-coastal Australia, from western Kimberley Division to north-eastern NSW and occasionally on continental islands. Found in coastal and sub-coastal areas in wooded and forested lands of tropical and warm-temperate Australia. Hunts for birds; mammals, reptiles and insects are rarely taken. Nests in large trees, frequently the tallest and most massive in a tall stand, typically within one km of permanent water.	0	Low. Study Area is outside of this species range.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Vulnerable		Occurs along the east coast of NSW, where it inhabits tall moist forests. Roosts in hollows of eucalypts, occasionally under loose bark on trees or in buildings. Hunts for flying insects above or below the tree canopy.	3	Moderate. Hollow-bearing trees at the site provide potential roosting habitat.
Gallinago hardwickii	Latham's Snipe		Migratory	Migrates to south-east Australia for the summer. Inhabits freshwater wetlands on or near the coast, generally among dense cover. Also known from short-grassed marshes and wet, treeless grasslands. Occasionally found in crops and pasture. An omnivorous species that forages in soft mudflats or shallow water. Roosts amongst low vegetation during the day.	0	Moderate. Species prefers wetland habitats with dense cover.
Glossopsitta pusilla	Little Lorikeet	Vulnerable		In NSW, the species occurs from the coast to the western slopes of the Great Dividing Range. Inhabits forests and woodlands, where it forages for nectar and pollen within the canopy stratum. Requires living, hollow-bearing eucalypts for nesting habitat.	1	Moderate. Study Area supports potential foraging and nesting habitat.
Haliaeetus leucogaster	White-bellied Sea Eagle		Migratory	Occurs throughout coastal Australia, along the coast, large lowland rivers and lakes. Occasionally found in association with inland lakes. Mainly hunts over water for aquatic animals; small terrestrial mammals and carrion may be taken from land. Typically nests in large trees to 30m, less often in smaller trees, on rocks or the ground.	0	Low. Study Area offers potential terrestrial and aquatic foraging habitat, however species has not been recorded within 10km of the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Heleioporus australiacus	Giant Burrowing Frog	Vulnerable	Vulnerable	Distribution largely restricted to sandstone geology of Sydney Basin, within heath, woodland and open dry sclerophyll forest. Moves to breeding habitat before or after heavy rain in autumn; typically soaks, pools in first or second order streams or hanging swamps. Outside of breeding period, inhabits burrows below soil surface or leaf litter, within 300m of breeding habitat. Generalist diet of invertebrates.	4	Low. Study Area does not support preferred habitat.
Hieraaetus morphnoides	Little Eagle	Vulnerable		Widespread throughout mainland Australia, often observed over woodland, forested land and open country. Appears to avoid rainforest and dense forest. Hunts for small terrestrial and arboreal mammals. Nests in a large living tree in open woodland or tree-lined watercourses.	4	Moderate. Tall trees within moderate quality woodland and riparian vegetation provides potential nesting habitat. Potential foraging habitat in riparian and woodland habitats.
Hirundapus caudacutus	White-throated Needletail		Migratory	Migrates from northern Asia to eastern Australia for the summer. In NSW, occurs from the coast to the western slopes of the Great Dividing Range. Species is almost exclusively aerial, most commonly recorded above open forest and rainforest. Rarely recorded flying over treeless areas. Forages aerially for insects. May roost aerially or in tree canopies or hollows in forests and woodland.	0	Low. Species may forage aerially above Study Area. Roosting habitat is present in the Study Area, however species has not been recorded within 10km of the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Hoplocephalus bungaroides	Broad-headed Snake	Endangered	Endangered	Distribution restricted to sandstone habitats within approximately 250 kilometres of Sydney. Requires rock crevices and flat sandstone rocks on exposed cliff edges for sheltering in cooler months, shelters in tree hollows near sandstone escarpments in summer. Forages for small reptiles, occasionally frogs and small mammals.	0	Low. Study Area does not support preferred habitat.
Lathamus discolor	Swift Parrot	Endangered	Endangered	Migrates from breeding grounds in Tasmania to the Australian mainland in winter. Preferred over-winter habitat is woodlands and riparian vegetation where there are winter flowering eucalypts such as the Swamp Mahogany, *Eucalyptus robusta* in coastal areas.	1	Low. Study Area supports foraging habitat, though low quality.
Litoria aurea	Green and Golden Bell Frog	Endangered	Vulnerable	Isolated, scattered populations throughout coastal NSW, several within the Sydney metropolitan area, Shoalhaven and mid-north coast. Breeding habitat comprises natural and constructed waterbodies including wetlands, stormwater detention basins, marshes, dams and streams-side, preferably those that are unshaded but with fringing vegetation. Forage for invertebrates within grassy habitats near breeding habitat. May shelter under vegetation, rocks and building materials such as fibro, sheet iron or bricks.	0	Low. Species has not been recorded historically within 10 km of the Study Area.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Litoria raniformis	Growling Grass Frog	Endangered	Vulnerable	Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat. During the breeding season animals are found floating amongst aquatic vegetation (especially cumbungi or Common Reeds) within or at the edge of slow-moving streams, marshes, lagoons, lakes, farm dams and rice crops. Outside the breeding season animals disperse away from the water and take shelter beneath ground debris such as fallen timber and bark, rocks, grass clumps and in deep soil cracks.	0	Low. No suitable habitat at the Study Area. Species has not been recorded within 10km of the Study Area historically.
Macquaria australasica	Macquarie Perch		Endangered	Found within the southern tributaries of the Murray Darling Basin (particularly the upstream reaches), Hawkesbury-Nepean and Shoalhaven river systems of NSW. Inhabits rivers and lakes. Feed on aquatic insects, crustaceans and molluscs. Breeds during spring and summer in shallow upland streams or flowing rivers. Requires riffle over cobble and gravel substrates in which to deposit eggs. Deep rock pools, overhanging vegetation and snags provide refuge habitat for the species.	0	Low. Thompsons Creek does not provide suitable habitat.

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Melanodryas cucullata cucullata	Hooded Robin	Vulnerable		Widespread throughout much of inland NSW, with the exception of the extreme north-west of the state. Typically inhabits structurally diverse open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas where it hunts for insects. Nests in tree fork or crevice, 1-5 m above the ground.	3	Low. Species inhabits structurally diverse woodland which does not occur in the Study Area.
Meridolum corneovirens	Cumberland Plain Land Snail	Endangered		Distribution restricted to Cumberland Plain Woodland in western Sydney, from Richmond in the north to Picton in the south. Found under leaf litter, bark, logs or loose soil at the base of trees, may bury deep into the soil to evade drought. Species is a fungus specialist.	67	Moderate. Moderate quality woodland within the Study Area supports potential habitat. Species has been recorded frequently in the area.
Merops ornatus	Rainbow Bee-eater		Migratory	Occurs throughout mainland Australia, excluding arid areas. Southern populations migrate north in winter. Found in open forest, woodland, shrubland and occasionally remnant vegetation within farmland, orchards and vineyards. Forages aerially for insects. Roosts in small shrubby trees. Constructs a tunnel in which to nest, in sandy bank or bare flat ground.	0	Moderate. Species may forage aerially above Study Area.
Miniopterus schreibersii oceanensis	Eastern Bentwing Bat	Vulnerable		Distributed throughout eastern and north-western Australia. In NSW, recorded from the coast to the western slopes of the Great Dividing Range. Occurring in forests and woodlands the species live in colonies and roost in caves, old mines and occasionally buildings. The species forages for insects above the tree canopy.	19	Moderate. Species could forage at the site along Thompsons Creek (certified land).

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Habitat	Number of records within 10 km of site	Likelihood of occurrence within the Study Area
Monarcha melanopsis	Black-faced Monarch		Migratory	Migrates to south-eastern coast of Australia from the north-eastern coast. Found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating. Forages on the wing or amongst vegetation for insects. Nests in small tree or shrub 3-6m above ground.	0	Low. Not recorded within 10km of the Study Area.
Mormopterus norfolkensis	Eastern Free-tail Bat	Vulnerable		Occurs along the east coast of NSW inland to the Great Dividing Range, where it is found in dry sclerophyll forest, woodland, swamp forest and mangrove forest. Roosts in trees hollows, occasionally under bark or in man-made structures. Forages for insects.	22	High. Hollow-bearing trees at the site provide potential roosting habitat.
Myiagra cyanoleuca	Satin Flycatcher		Migratory	Occurs along east coast of Australia, migrates north to Cape York Peninsula and Papua New Guinea in winter. Inhabits tall, wet eucalypts forests in gullies where it forages for insects. Nests in tree 3-25 m above ground.	0	Low. Study Area does not support preferred habitat.
Myotis macropus	Southern Myotis	Vulnerable		Distribution generally limited to within 100 kilometres of the coast. Forages over streams and pools for insects and small fish. Roosts communally in mine shafts, tree hollows, under bridges and storm water channels.	8	High. Hollow-bearing trees at the site provide potential roosting habitat.
Ninox strenua	Powerful Owl	Vulnerable		Widely distributed throughout NSW, from the coast inland to the tablelands. Inhabits woodland, open forest, tall wet forest and rainforest, where it hunts for arboreal mammals, occasionally birds. Roosts in dense vegetation, requires old, large hollow-bearing eucalypts for nesting habitat.	16	Low. Study Area does not support preferred nesting habitat (requires large hollows).

APPENDIX L

ABORIGINAL ARCHAEOLOGICAL ASSESSMENT

Boral Bringelly Brickworks

Aboriginal Archaeological Assessment

Report to Hyder Consulting

August 2013

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Executive Summary

Bringelly Brickworks is located at 60 Greendale Road, Bringelly (Lot 2 DP 733115), and currently operates within a 17 hectare development footprint comprising of a crushing and manufacturing plant, stockpiling areas, a product storage and delivery area and an active quarry. Boral is now seeking to increase brick production which will require extraction of clay from a larger resource area totalling 30.65 hectares.

The Minister for Planning and Infrastructure has identified this project as State Significant Development (SSD). Boral was issued with Director General's Requirements (DGRs) for the preparation of an Environmental Impact Statement (EIS), to be submitted to the Department of Planning and Infrastructure.

Hyder Consulting, on behalf of Boral, engaged Artefact to prepare an Aboriginal archaeological assessment. The aim of this assessment is to determine if any Aboriginal objects will be impacted by an expansion of the brickworks and to recommend if any additional management and mitigation measures are required.

In 1990 an archaeological survey was conducted for an earlier EIS within the study area. Four Aboriginal sites were recorded, all of which have since been destroyed by quarrying activities. In a survey conducted within the proposed impact area for this project an additional four Aboriginal sites were identified: BB OS1, BB OS2, BB OS3 and BB OS4. BB OS1 is located in the south eastern section of the study area in a disturbed context. It consists of one red silcrete proximal flake fragment and one red silcrete angular fragment. BB OS4 is located in the south western section of the study area in a disturbed context. It consists of a milky white quartz proximal flake fragment.

BB OS2 is located in the south western section of the study area and consists of a red silcrete medial flake fragment. An associated area of potential archaeological deposit (PAD) was identified due to the low level of disturbance and location on a slope between two crest landforms which would have been conducive to Aboriginal occupation. This site and associated PAD has been assessed as having a moderate research potential. Its archaeological significance cannot be accurately assessed until further archaeological investigations have been conducted.

BB OS3 was located immediately adjacent to the southern boundary of the study area (within 30 metres). This isolated artefact has been assessed to be of low archaeological significance as it is likely that it had been washed down from an above crest landform and was therefore found out of its original context.

The expansion of the brickworks will have a direct impact on Aboriginal sites located within the study area (BB OS1, BB OS2 and BB OS4). Due to the proposed expansion of quarrying activities, it will not be practicable to conserve sites BB OS1 and BB OS4. These sites have been assessed as demonstrating low archaeological significance, and no further archaeological investigations would be required prior to impacts.

To determine the extent and archaeological significance of BB OS2 and to inform further management and mitigation measures, it is recommended that test excavation is conducted in the associated area of potential.

As Aboriginal objects would be impacted by the proposal, comprehensive Aboriginal consultation in accordance with the DEC *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* 2005 would be undertaken. This consultation would be initiated prior to commencement of archaeological test excavations. The results of the community consultation and the test excavations would be included in an Aboriginal cultural heritage assessment report (CHAR) which would be provided to the Department of Planning and Infrastructure prior to approval of the EIS.

Following the submission of the EIS and approvals from the Director General, future management of Aboriginal heritage within the proposal area should be included in the construction environmental management plan (CEMP). Information that should be included within the CEMP would include procedures to follow if unexpected finds are located and the provision for a heritage induction.

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1.0 Introduction and Background

1.1 Introduction

Bringelly Brickworks is located at 60 Greendale Road, Bringelly (Lot 2 DP 733115), and currently operates within a 17 hectare development footprint comprising of a crushing and manufacturing plant, stockpiling areas, a product storage and delivery area and an active quarry which contains total resource yield of approximately 4.43 million tonnes at Bringelly.

The current consent on the site permits quarry extraction of up to 200,000 tonnes per annum, and brick production of up to 160,000 tonnes per annum. In order to meet anticipated market demand following the mothballing of the Badgerys Creek quarry and brick making facility, Boral is now seeking to increase brick production at their Bringelly brickworks to 263,500 tonnes per annum of bricks – which represents an increase of 103,500 tonnes per annum (or 40% brick production increase) (see Figure 1). Plant machinery required to process / manufacture bricks will continue to operate within the approved 24 hours per day operating hours. The increased brick production will require extraction of clay from a larger resource area totalling 30.65 hectares. The area of proposed impact is shown in Figure 2 as the 'project site', which is referred to throughout this report as the study area.

The Minister for Planning and Infrastructure has identified this project as State Significant Development (SSD). Boral was issued with Director General's Requirements (DGRs) for the preparation of an Environmental Impact Statement (EIS), to be submitted to the Department of Planning and Infrastructure. A study of Aboriginal heritage is one of these requirements.

Hyder Consulting, on behalf of Boral, engaged Artefact to prepare an Aboriginal archaeological assessment as a first stage of the Aboriginal heritage study. The aim of this assessment is to determine if any Aboriginal objects are likely to be impacted by an expansion of Boral's Bringelly plant and to recommend what management and mitigation measures are required.

1.2 Approvals process

This SSD is an application under Division 4.1 of the *Environmental Planning and Assessment Act 1979 (*EP&A Act). Division 4.1 provides for development to be declared SSD either by a State Environmental Planning Policy (SEPP) or by order of the Minister. The Minister is generally the consent authority for SSD. *State Environmental Planning Policy (State and Regional Development) 2011* ("State and Regional Development SEPP") declares development on certain types of land. Boral was issued with DGRs for the preparation of an EIS on 24 December 2012.

The sections of this report which address specific requirements of the DGRs are listed in Table 1.

Table 1: Director General's Requirements

Director-General's Requirements	Where addressed in this report
Demonstrate effective consultation with Aboriginal communities in determining and assessing impacts, and developing and selecting mitigation options and measures.	Sections 1.5, 10.0, 11.0.
Outline any proposed impact mitigation measures (including an evaluation of the effectiveness and reliability of the measures).	Section 11.0

1.3 Objectives of the assessment

This assessment complies with the Department of Planning and Infrastructure's *Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation* (2005) and is guided by the Office of Environment and Heritage (OEH) *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (2010). The objectives of this assessment are therefore, to:

- Describe the proposed development.
- Outline Aboriginal community involvement and consultation.
- Discuss the Aboriginal historical context of the subject land.
- Discuss the archaeological context of the subject land, which includes previous archaeological investigations in the local area.
- Discuss the landscape context of the subject land.
- Develop an archaeological predictive model.
- Describe and analyse Aboriginal sites located within the subject land.
- Develop a significance assessment for these sites and areas of Potential Archaeological Deposit (PAD) that addresses archaeological values.
- Impact assessment for Aboriginal sites and areas of PAD in the subject land.
- Recommend management and mitigation measures for Aboriginal sites and areas of PAD in light of the proposed development.

1.4 Investigator and contributions

Archaeologists Josh Symons and Georgia Wright conducted this investigation. Georgia Wright and Josh Symons prepared this report with management input from Principal Archaeologist Dr Sandra Wallace.

1.5 Aboriginal community involvement

Artefact was in contact with the Tharawal Local Aboriginal Land Council (TLALC) and Cubbitch Barta Native Title Claimants Aboriginal Corporation (CBNTCAC) throughout the assessment process. Representatives from both groups; Neale Sampson from TLALC, and Glenda Chalker and Toni Jae Whillock from CBNTCAC attended an archaeological survey of the study area. Comprehensive Aboriginal consultation was undertaken for this project and will be outlined in the Cultural Heritage Assessment Report (CHAR).

Figure 1: Proposed development plan (provided by Boral)

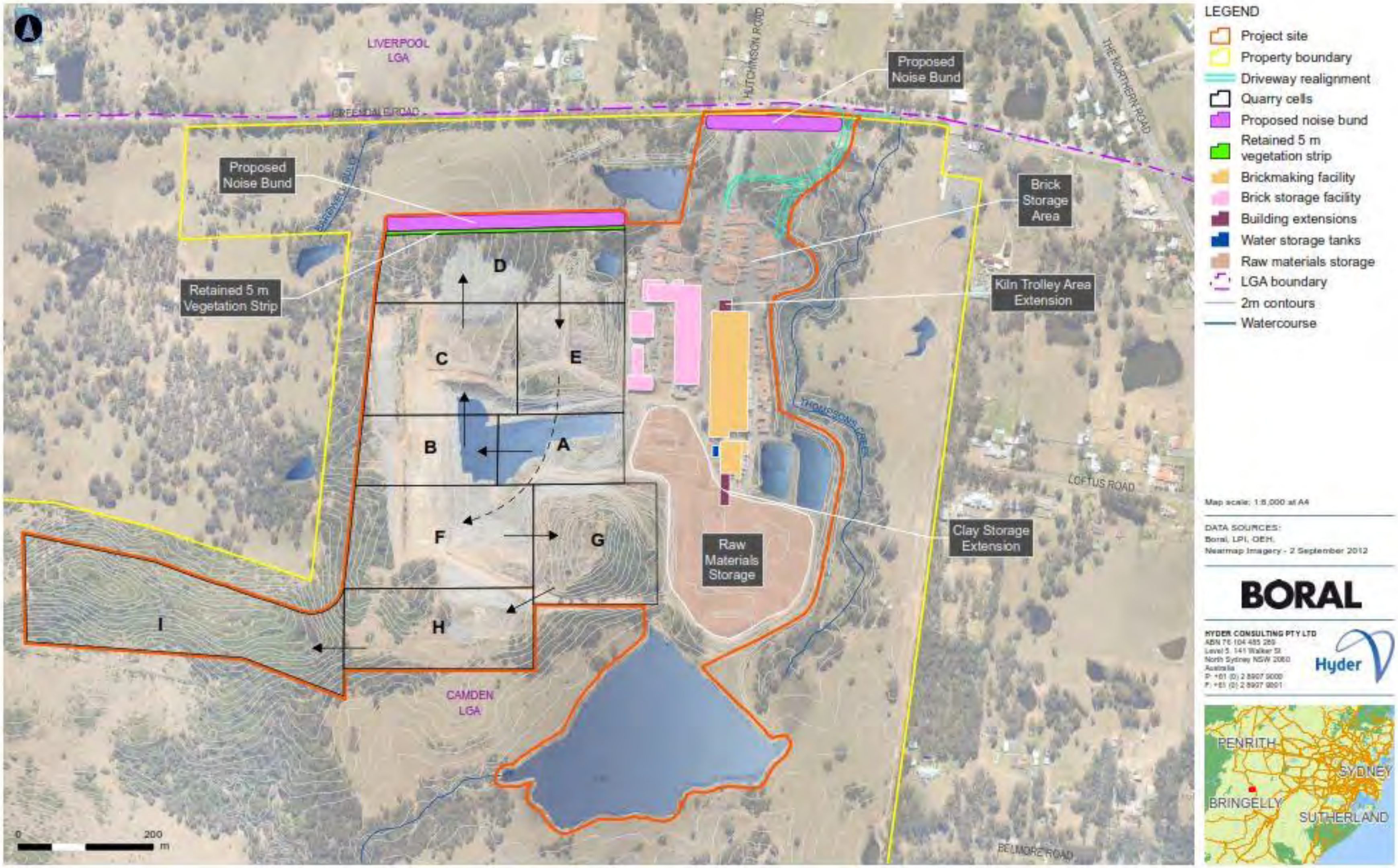
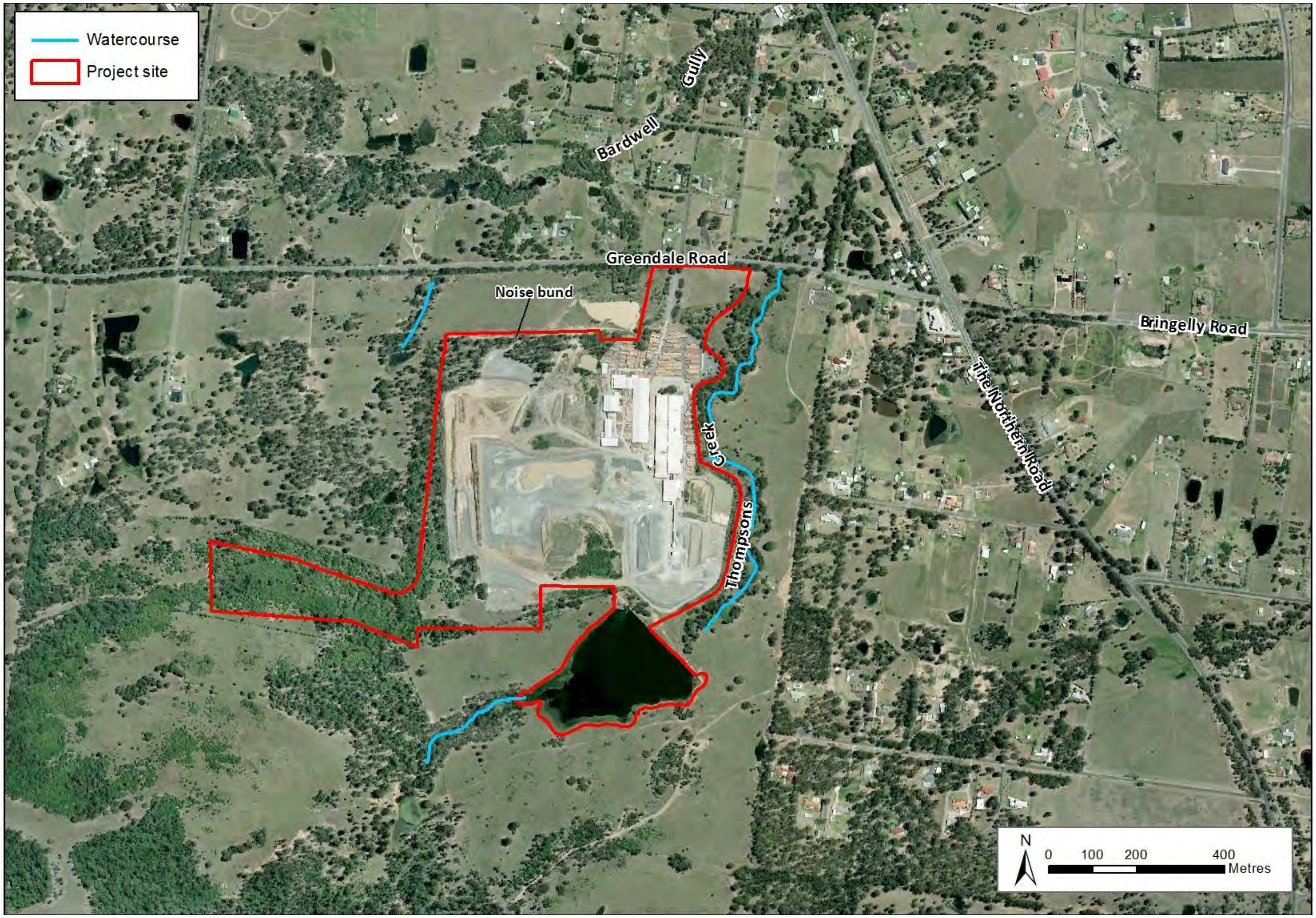


Figure 2: Study area in its locality (background aerial © Sinclair Knight Merz 2013 c/o Google)



2.0 Aboriginal Historical and Archaeological Context

2.1 Aboriginal material culture

The oldest securely dated site for Aboriginal occupation in the greater Sydney region is 14,700 years before present (yBP), which was recorded in a rock shelter at Shaw's Creek on the eastern margin of the Blue Mountains (Nanson et al 1987). Evidence of Aboriginal occupation has been found dated to 50-60,000 yBP at Lake Mungo in NSW, so it would be likely that Aboriginal people have lived in the Sydney region for even longer than indicated by the oldest recorded dates available at present. The archaeological material record provides evidence of this long occupation, but also provides evidence of a dynamic culture that has changed through time.

The existing archaeological record is limited to certain materials and objects that were able to withstand degradation and decay. As a result, the most common type of Aboriginal objects remaining in the archaeological record are stone artefacts. Archaeological analyses of these artefacts in their contexts have provided the basis for the interpretation of change in material culture over time. Technologies used for making tools changed, along with preference of raw material. Different types of tools appeared at certain times, for example ground stone hatchets are first observed in the archaeological record around 4,000 yBP in the Sydney region (Attenbrow 2010:102). It is argued that these changes in material culture were an indication of changes in social organisation and behaviour.

The Eastern Regional Sequence was first developed by McCarthy in 1948 to explain the typological differences he was seeing in stone tool technology in different stratigraphic levels during excavations such as Lapstone Creek near the foot of the Blue Mountains (McCarthy 1948). The sequence had three phases that corresponded to different technologies and tool types (the Capertian, Bondaian and Eloueran). The categories have been refined through the interpretation of further excavation data and radiocarbon dates (Hiscock & Attenbrow 2005, JMCHM 2005). It is now thought that prior to 8,500 yBP tool technology remained fairly static with a preference for silicified tuff, quartz and some unheated silcrete. Bipolar flaking was rare with unifacial flaking predominant. No backed artefacts have been found of this antiquity. After 8,500 yBP silcrete was more dominant as a raw material, and bifacial flaking became the most common technique for tool manufacture. From about 4,000 yBP to 1,000 yBP backed artefacts appear more frequently. Tool manufacture techniques become more complex and bipolar flaking increases (JMCHM 2006). It has been argued that from 1,400 to 1,000 years before contact there is evidence of a decline in tool manufacture. This reduction may be the result of decreased tool making, an increase in the use of organic materials, changes in the way tools were made, or changes in what types of tools were preferred (Attenbrow 2010:102). The reduction in evidence coincides with the reduction in frequency of backed blades as a percentage of the assemblage.

After European colonisation Aboriginal people of the Cumberland Plain often continued to manufacture tools, sometimes with new materials such as bottle glass or ceramics. There are a number of sites in Sydney where flaked glass has been recorded, for example at Prospect (Ngara Consulting 2003) and Oran Park (JMCHM 2007).

2.2 Aboriginal historical context

Aboriginal people traditionally lived in small family or clan groups that were associated with particular territories or places. The language group spoken in the Bringelly area is thought to have been Dharawal (Tindale 1974). The Dharawal language group is thought to have extended from the Shoalhaven River, north to Botany Bay and then inland to Camden. Some sources also describe the nearby Narellan area as being home to the Muringong people, speakers of the Darug language group (Mathews and Everitt 1900:265).

There is also some evidence that Aboriginal people around Bringelly spoke a distinctly separate language group and their tribal area was known as Cubbitch-Barta after its white pipe clay (Russell 1914). Government records from the 1830s and 1840s identify an Aboriginal group known as the Cobbiti Barta as associated with the Camden area (JMCHM 2007:21).

Historical records also show that Gandangara people came into the Bringelly area. It is not known whether these visitations represented recent displacement patterns as a result of European colonisation or were part of a longer term interaction with the Dharawal (Karskens 2010:496).

Laila Haglund has suggested that at contact the locality would have been near the border of the Dharawal, Darug and Gandangara territories and that the Narellan Valley may have been part of a ‘travel corridor’ facilitating movement between the northern Cumberland Plain and the Illawarra (JMCHM 2007:21 after Haglund 1989).

Historical observations suggest that Aboriginal people lived in the Bringelly area in relatively large numbers. Lieutenant Dawes observed that a number of bark huts, about seventy in all, located close to the river between the farms of Mr Wentworth and Mr Campbell at Narellan (Barton 1996).

British colonisation had a profound effect on the Aboriginal population of the Sydney region. In the early days of the colony Aboriginal people were disenfranchised from their land as the British claimed areas for settlement and agriculture. The colonists, often at the expense of the local Aboriginal groups, also claimed resources such as pasture, timber, fishing grounds and water sources.

It is thought that during the 1789 smallpox epidemic over half of the Aboriginal people of the Sydney region died. The disease would have spread southwest to the Bringelly area. This loss of life meant that some of the Aboriginal groups who lived away from the coastal settlement of Sydney may have disappeared entirely before Europeans could observe them, or record their clan names (Karskens 2010:452). This may have been the precursor to Watkin Tench's observation that he did not encounter Aboriginal people during his exploration of the Camden region during the first years of the colony (Tench 1793).

Some Aboriginal people of southwestern Sydney may have seen cattle before being first confronted by the colonists. Two bulls and four cows escaped from the Sydney colony in 1788 and were not recovered. In 1790 a group of cows were observed grazing near Camden in what became known as the 'Cowpastures'. The herd expanded and by 1801 were thought to number in the hundreds and efforts were made to recapture them (Turbet 2011: 88, Kayandel 2010:23).

In the early 1800s relationships between the Aboriginal people of the area and the European settlers were in general amicable. Grace Karskens notes several examples of close relationships between land owners and local Aboriginal people, including John Kennedy who gave the Dharawal protection on Teston Farm at Appin in later, not so peaceful, times (Karskens 2010).

Relations between Aboriginal people and colonists did not remain amicable. A sustained drought during 1814 and 1815, and continued disenfranchisement lead to tensions between farmers and Aboriginal people who remained to the southwest of Sydney. Aboriginal people were accused of stealing corn and potatoes and spearing cattle. A number of farmers were killed on their properties. In a dispatch Governor Macquarie wrote that 'The Native Blacks of this country…have lately broken out in open hostility against the British Settlers residing on the banks of the River Nepean near the Cow Pastures'. Aboriginal people were targeted and it was ordered that Aboriginal men be strung from trees when they were killed as an example (Turbet 2011:234).

In 1816 the tensions culminated in the Appin massacre when Aboriginal people where pursued by a detachment led by Captain James Wallis. Fourteen Aboriginal people of the Dharawal nation were shot or driven over a cliff to their deaths by the soldiers. The bodies of two of the Aboriginal men were strung up at the site (Turbet 2011).

Although the numbers of Aboriginal people in the Bringelly area decreased as settlers and farmers moved into the locality, communities remained living at Camden Park and along the Georges River near Liverpool.

2.3 Registered Aboriginal sites

An extensive search of the Aboriginal Heritage Information System (AHIMS) was conducted on 15 January 2013 to identify sites recorded in and around the study area. The coordinates used were:

GDA 94	MGA 56	288160 E	290680 E
		6240650 N	6242970 N
Buffer (meters)		50	
Number of sites recorded		8	
AHIMS Search ID		89488	

A total of eight Aboriginal sites were identified within the search area. All of these are open artefact sites and none are recorded within the study area. Site distribution across the landscape is shown in Figure 3.

The location of sites is considered to culturally sensitive information. It is advised that this information be removed from the report if it is to enter the public domain.

2.4 Site types

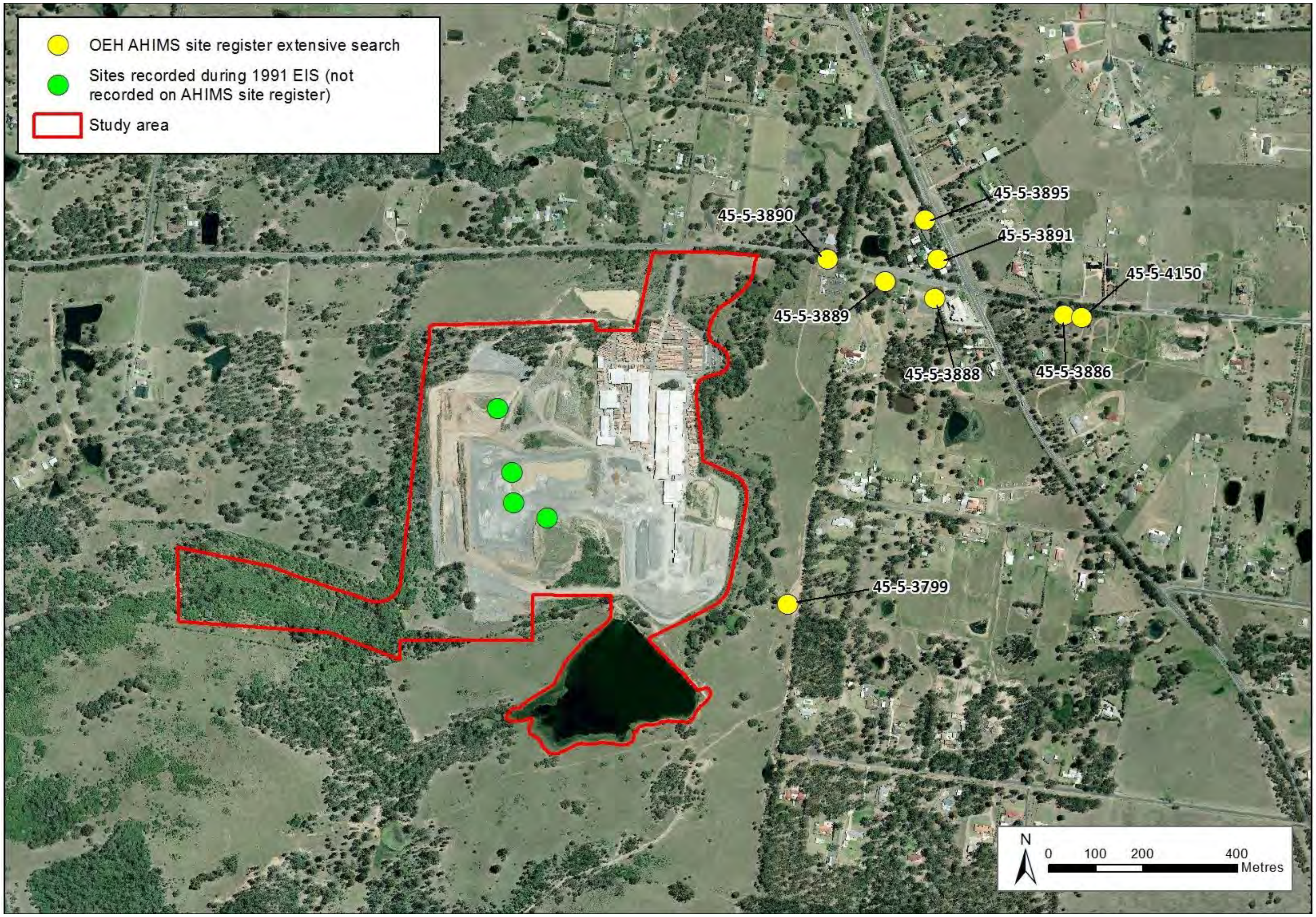
Material traces of Aboriginal occupation exist throughout the landscape and are known as Aboriginal sites. The primary site types that are found in the Sydney region are as follows.

- Stone Artefacts: Flaked and ground stone artefacts are the most common trace of Aboriginal occupation in the Sydney region. Aboriginal people used particular techniques to flake stone and these changed over time. The approximate age of a tool can often be diagnosed by the way that it was made. Stone artefacts are most often found in scatters that may indicate an Aboriginal campsite was once present. Stone artefacts may also be found as isolated finds. Stone tools in the Sydney region are most often made from raw materials known as silcrete, tuff and quartz. These are all easily flaked and form sharp edges, which can be used for cutting or barbing spears. It is possible that stone artefacts, either on the surface, or buried, exist within the study area.
- Rock shelters with deposit: Rock shelters were used by Aboriginal people for habitation, rest places and as art or ceremonial sites. Deposits can build up on the floor of these shelters over time and bury traces of Aboriginal occupation. If these deposits are not disturbed, rock shelters can provide an intact stratigraphy that can tell us about the way Aboriginal occupation changed through time. It is unlikely that rock shelters will be present within the study area due to an absence of sandstone.
- Shell middens: Shell middens are remains of campsites in which the primary traces are shell and/or bones of fish. Shell middens are often found close to rivers or streams and are either along banks or within enclosed shelters. The majority of shell middens in the Sydney region were destroyed when

they were mined for lime in the early days of the colony. It is unlikely that shell midden exists within the study area, as it is not close enough to a water body that supported shellfish.

- Rock engravings/rock art: Rock engravings are often found in Hawkesbury geologies on flat sandstone platforms. Shapes of animals, ancestor figures or other symbols were carved into the sandstone. Weathering has affected the visibility of many rock engravings. Other rock art of various forms has also been recorded in the Sydney basin. Stencils, charcoal drawings and paintings are examples of the techniques used by Aboriginal people. Rock art is relatively rare, but is more common on sandstone geologies than on the plains of western Sydney. It is unlikely that engravings exist in the study area due to the absence of sandstone.
- Axe grinding grooves: Axe grinding grooves are created when axe blanks (often basalt cobbles) are shaped by rubbing the stone across an abrasive rock such as sandstone, often using water. Sharpening axes and other tools also forms them. Axe grinding grooves are often found on the banks of streams or rock pools. It is unlikely that axe grinding grooves will be found within the study area, as they are most common on sandstone, and on the edge of permanent watercourses. It is unlikely that axe grinding grooves are present within the study area due an absence of suitable rock platforms.
- Scarred trees: Aboriginal people practiced tree marking or scarring for a variety of reasons. Large scars are often the result of a tree being debarked for a canoe blank and smaller scars may have been the result of making shields or coolamons (storage vessels). Tree marking may have been the result of ritual practices, or associated with burial. Scarred trees that remain today would be over 150 years old and the scar would retain certain characteristics that enable its identification as cultural. Scarred trees have been recorded in the local area and it is possible that old growth trees in the study area are marked.
- Post-contact sites: Sites where evidence of early interaction between Aboriginal people and Europeans are known as contact sites. Artefacts found at contact sites may include flaked glass or ceramic. It is possible that a contact site is located within the study area, as Aboriginal people are documented to have lived in a semi-traditional manner in the area into the 1800s. A significant contact site has been recorded at Denbigh, south of the study area (JMCHM 2007).
- Quarries: Quarries are areas where people procured resources for the manufacture of stone artefacts (Hiscock and Mitchell 1993). Raw materials often occurred in the form of cobbles. Cobbles were often reduced on site and made into smaller cores, which could be transported. Tool manufacture may also occur at quarry sites (JMCHM 2006). It is unlikely that a quarry site will be found in the study area.
- Potential Archaeological Deposit (PAD): Areas are classified as PADs if there is a likelihood of archaeological material existing below the ground surface or on the ground surface but obscured from view. An Aboriginal object does not need to be recorded for an area of PAD to be specified.

Figure 3: AHIMS map (background aerial © Sinclair Knight Merz 2013 c/o Google)



2.5 Previous archaeological investigations

A number of archaeological investigations have been undertaken in and around the study area. Of most relevance is a survey of Boral's Bringelly plant conducted in 1990 by Resource Planning. Other investigations include those associated with the Bringelly Road and Camden Valley Way Upgrades and the Oran Park and Turner Road Precincts in the South West Growth Centre of Camden.

Expansion of the Boral Brickworks at Bringelly (Resource Planning 1990)

Resource Planning conducted a survey of the Boral brickworks in 1990. Four open isolated artefact sites were identified (Figures 3 and 4). Two of these sites contained silcrete flakes, another contained a siltstone flake and the final site contained a silcrete core. All of these sites were located on the edge of woodland in an area that Resource Planning considered to be of low archaeological potential.

The four sites were not registered on the OEH AHIMS sites register by Resource Planning and have since been destroyed as a result of existing quarrying activities.

The Northern Road Power Line Route (JMCHM 2010)

Jo McDonald Cultural Heritage Management (JMCHM) conducted a survey of The Northern Road power line route, which ran between the Bringelly Zone Substation on Greendale Road and the Oran Park Zone Substation on The Northern Road. One open artefact scatter (TNR-1) was identified in a disturbed context. It contained three tuff flakes and ten tuff, four quartz and two silcrete fragments. TNR-1 is located approximately 400 metres north east of the study area. The site was assessed to be of low archaeological potential and significance. Areas of moderate archaeological potential were identified in areas where old growth Eucalypts trees were found including the east of the JMcDCHM study area, which runs parallel to Boral's plant. JMCHM recommended that impacts to these areas be minimised.

Bringelly Road Upgrade, Camden Valley Way to The Northern Road (Austral Archaeology 2010; KNC 2010)

Austral Archaeology completed an Aboriginal Archaeological Survey Report for the Bringelly Road Upgrade, which extended from Camden Valley Way, Leppington to The Northern Road, Bringelly. The study identified a total of 42 sites, one of which was associated with an area of PAD. Twenty six sites were open artefact scatters and 16 were isolated finds. A total of 138 artefacts of mostly silcrete, mudstone and chert were recorded. Flakes and flake fragments were the dominant artefact type, with a small number of cores and blades also identified. Several of these sites (BRP-S-01, BRP-S-02, BRP-S-03, BRP-S-04, BRP-S-08) are located approximately 500-600 metres east of the study area.

Kelleher Nightingale Consulting (KNC) later conducted an Aboriginal Cultural Heritage Assessment for the Bringelly Road Upgrade. KNC identified 44 sites similar to those identified above. Thirty nine of these sites were assessed to be of low or low to moderate archaeological significance. These sites had low artefact densities and were found in disturbed contexts. Five sites (BRP-S-10, BRP-PAD-01, BRP-S-24, BRP-S-25 and BRP-IF-16) were assessed to be of moderate archaeological significance, located in less disturbed contexts. Where harm to these sites could not be avoided, KNC recommended the sites be salvage excavated.

Oran Park and Turner Road Precincts in the South West Growth Centre (JMCHM 2007; ENSR 2009)

In 2007 JMCHM conducted a survey of the Oran Park and Turner Road Precincts. Forty four sites and four areas of PAD were identified in the Oran Park Precinct. Most sites were open artefact scatters or isolated finds. Scarred trees, contact period bottle glass artefacts and a basalt hatchet were also identified. Silcrete, quartz and tuff artefacts were recorded, most of which were flakes, flake fragments or cores. Four areas of PAD were identified for their low levels of disturbance, landform and proximity to a watercourse.

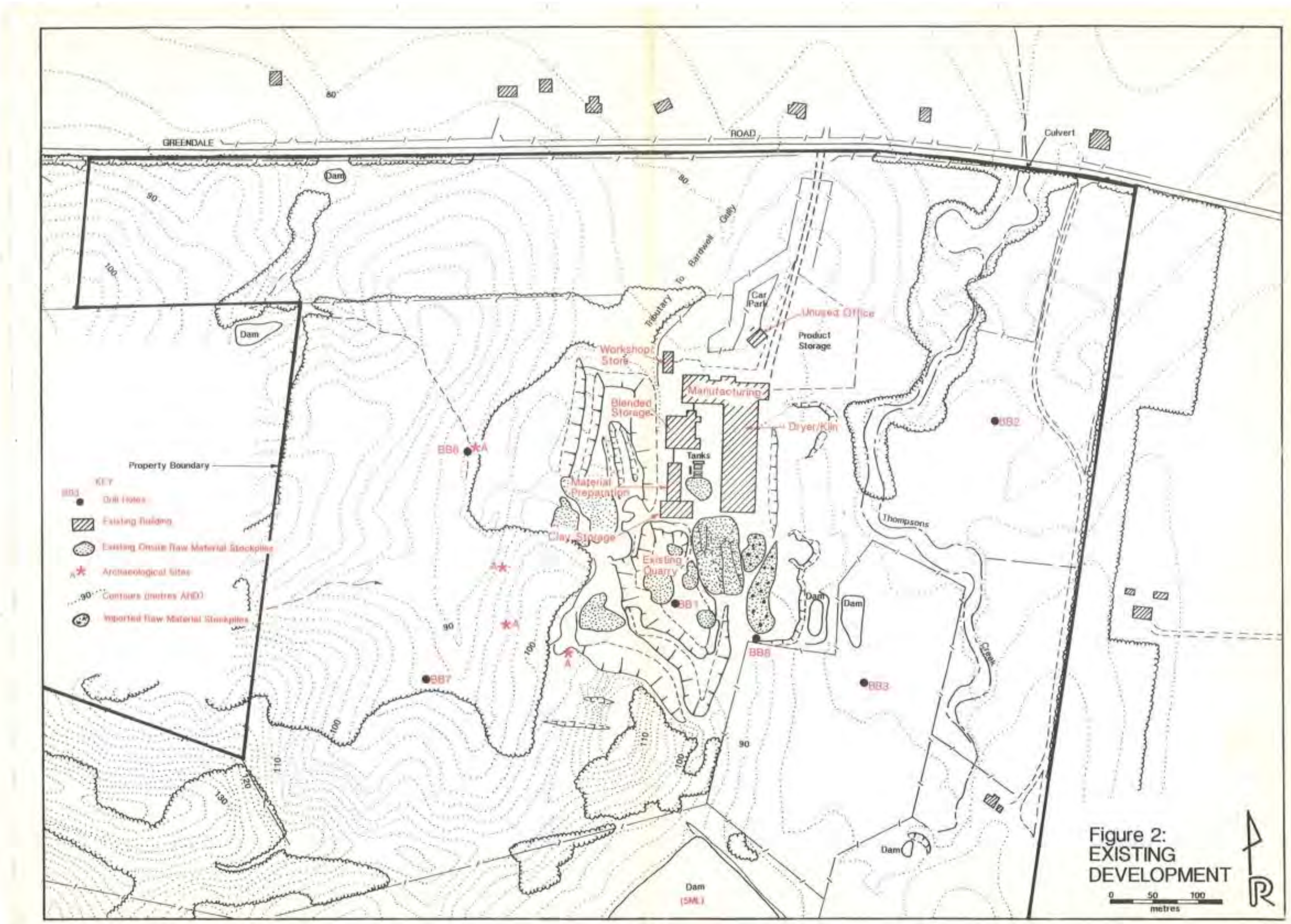
A first phase of test excavations in the Oran Park and Turner Road Precincts was later conducted by Archaeological Heritage Management Solutions (AHMS). A second phase of test excavations was undertaken by ENSR in 2008. A total of 4,780 artefacts were recovered from both phases of excavation. Over 70 per cent of these were made from silcrete, sourced from areas south and to the north. Other artefacts were made from mudstone, quartz, quartzite, chert, petrified wood, fine grained siliceous and igneous material. Cores, flakes and retouched flakes including backed artefacts and scraper tools. Flakes were the dominant artefact type with smaller quantities of cores and retouched flakes including backed artefacts and scraper tools. Artefacts were found in low densities and in elevated areas or vantage points in the landscape, a landform on which few sites in the Cumberland Plain had been recorded.

The Northern Road Upgrade, The Old Northern Road to Mersey Road (Artefact 2011)

In 2011 Artefact conducted a survey of the route of The Northern Road upgrade, which extended from The Old Northern Road, Narellan to Mersey Road, Bringelly, east of the current study area. A total of thirty two sites were identified. These included artefact scatters, isolated finds, areas of PAD and a scarred tree.

Seven of the recorded sites were assessed to be of moderate archaeological significance and one to be of high archaeological significance. It was recommended that a salvage excavation that covered an area representative of all sites of moderate archaeological significance to be impacted by The Northern Road Upgrade was conducted. It was also recommended that surface scatters and isolated finds were collected by the Aboriginal community under a Care and Control agreement that was to be negotiated with OEH. Impact to the site of high cultural significance, scared tree NRSTI, was avoided.

Figure 4: Previously recorded Aboriginal sites in the study area (Resource Planning 1990)



2.6 Predictive models

Beth White and Jo McDonald have recently contributed to the debate over site prediction on the Cumberland Plain in their discussion on the nature of Aboriginal site distribution as interpreted through lithic analysis of excavated sites in the Rouse Hill Development Area (RHDA) (White and McDonald 2010). This analysis brings together data from 631 dispersed 1m x 1m test squares from nineteen sample areas, which yielded 4,429 stone artefacts in total. The findings of this study generally support earlier models that predicted correlations between proximity to permanent water sources and site location, but also highlighted the relationship between topographical unit and Aboriginal occupation.

The major findings of the study were that artefact densities were most likely to be greatest on terraces and lower slopes within 100 metres of water. The stream order model was used to differentiate between artefact densities associated with intermittent streams as opposed to permanent water. It was found that artefacts were most likely within 50 to 100 metres of higher (fourth) order streams, within 50 metres of second order streams, and that artefact distribution around first order streams was not significantly affected by distance from the watercourse (White and McDonald 2010: 33). A number of variables relate to stream order across the Cumberland Plain, including fluctuations in rainfall during the Holocene and changes to sediment load since extensive land clearance following European colonisation. Stream order is calculated using information from the NSW Department of Planning and Infrastructure (DPI) Land and Property Information (LPI).

Overall landscapes associated with higher order streams (second order or greater) were found to have higher artefact densities, higher maximum densities, and more continuous distribution than lower order intermittent streams. The analysis also concluded that while there were statistically viable correlations that demonstrated a relationship between stream order, land form unit and artefact distribution across the RHDA, the entire area should be recognised as a cultural landscape with varied levels of artefact distribution (White and McDonald 2010: 37). This predictive model can be transferred to other areas of the Cumberland Plain.

The results of investigations at Oran Park and Turner Road Precincts in the South West Growth Centre however, do not correspond with that of the above. ENSR (2009: 50) instead stated “the evidence supports a more even spread of archaeological deposit comprising predominantly low density artefact distribution with occasional campsite concentrations in areas with good outlook over the main valley up to locations anywhere to several hundred meters away from the watercourses.”

Test excavations at the Oran Park and Turner Road Precincts in the South West Growth Centre identified artefacts in association with watercourses and/or in elevated areas or vantage points, a landform on which few sites in the Cumberland Plain had been recorded. The results from Oran Park and Turner

Road highlight the fact that landscape use is not intrinsically linked to stream flow and watercourse order, but that other variables including landform position were contributing factors in determining site locations.

3.0 Landscape Context

3.1 Landscape history

Around 20,000 years ago sea levels were at their lowest, with the coastline up to 20 kilometres further out than its present location. The coastal environment would have been a ‘broad undulating plain below the sandstone cliffs of the present coastline’ (Attenbrow 2010:38). It is therefore likely that many sites, and possibly with evidence of very early coastal occupation prior to twenty thousand years ago, are now submerged. The study area would have had similar landscape characteristics for at least the past seven thousand years, at which time the ocean stabilised to its present levels.

3.2 Landform

The study area is part of a prominent spur landform associated with a high point of 158 metres elevation at the Birling Triangulation Station approximately 750 metres southwest of the study area. The study area is situated on a series of moderate to steep hills that overlook the low lying floodplain of Thompsons Creek to the south and east, and the headwaters of Bardwell Gully to the north.

3.3 Hydrology

The study area is situated within the South Creek catchment area. Thompsons Creek, a second order stream, runs along the southern and eastern margins of the study area. A tributary of Bardwell Gully flows through the western side of the study area. A second order creek, Lowes Creek, is located over one kilometre south of the study area.

3.4 Geomorphology

The study area is underlain by Bringelly Shale, a Triassic Wianamatta Group geological unit. It consists of shale, carbonaceous claystone, claystone, laminate, fine to medium grained lithic sandstone, rare coal and tuff.

The northern and eastern sections of the study area are within the Blacktown soil landscape, which typically consists of a shallow duplex soil atop a clay base. The biomantle is characterised by a textured soil that is usually less than thirty centimetres deep. The southern section of the study area lies within the Luddenham soil landscape, an erosional and typically podsolic soil, also of moderate depth. The fluvial South Creek soil landscape, associated with Thompsons Creek, is also found in the study area (Clark and Jones 1991).

3.5 Natural resources

The study area would have once been covered by open Cumberland Plain Woodland, typical in areas underlain by the Wianamatta Group geological unit. Grey Box (*Eucalyptus moluccana*) and Forest Red Gum (*Eucalyptus tereticornis*) are among the species that would have grown there (Benson and Howell 1990).

Aboriginal people were highly mobile hunter-gatherers utilising different landform units and resource zones. Different resources may have been available seasonally, necessitating movement or trade (Attenbrow 2010: 78). Aboriginal people hunted kangaroo and wallaby and snared possums for food and skins. In marine or estuarine environments Aboriginal people caught fish and collected shellfish. There are many accounts by Europeans of Aboriginal people in canoes on rivers and the ocean, fishing and cooking the fish on small fires within the vessels (e.g. Collins 1798).

Plants were an important source of nutrition, common edible species being *Macrozamia*, a cycad palm with poisonous seeds that were detoxified and ground into a paste and *Xanthorrhoea*, or grass tree. The grass tree nectar was a high-energy food, the resin a strong hafting glue, and the flower spikes used for spear barbs. From observations by early European colonists, only about twenty species of plant are identified as being used for food or manufacture by Aboriginal people of the Sydney region (Attenbrow 2010:41). It is likely this is only a fraction of what was actually used.

There are no suitable stone sources for large scale artefact manufacture within the study area. Small silcrete and tuff gravels have been recorded at the confluence of South Creek and Badgerys Creek, about ten kilometres north of the study area. It is likely that silcrete was brought from the St Mary's Formation, approximately 18 kilometres north of the study area (ENSR 2009: 64). A grey white silcrete, comparable to that recorded south of Camden at Marulan has also been recorded in the area (JMCHM 2007:17). Resources therefore, appear to have been brought from both the north and south of Camden.

3.6 Land use history

Prior to the establishment of Boral's brick making plant, which has operated since 1968, the land had been cleared and used for agricultural purpose. A sheep grazing property existed in the northern section of the study area and fodder crops were cultivated on the flats of Thompsons Creek.

The land on which the brick making plant now stands has been extensively quarried. The movement of heavy vehicles on and around the plant has also caused a considerable amount of disturbance to the land. Areas of woodland remain in the southern sections of the study area.

4.0 Predictions

4.1 Aboriginal land use

The exact nature of Aboriginal land use patterns in the vicinity of the study area before colonisation is unknown. Assumptions about land use patterns are made on the basis of archaeological data, observations made by Europeans after settlement in the area and knowledge of available natural resources.

As Aboriginal people were mobile hunter-gatherers, is likely that they moved across the landscape between resources. It is also likely that movement was related to socio/cultural factors such as gatherings and ceremonial obligations. Campsites would have provided temporary residences such as the bark structures noted by Tench. It is difficult to ascertain whether a campsite existed at a given location, but correlations between stone artefact density and campsites are often assumed. While it is likely that knapping would have occurred at a campsite, it is also likely that knapping would have occurred during movement across the landscape, as tools were prepared or repaired during hunting and gathering activities.

Test excavations at the Oran Park and Turner Road Precincts identified artefacts in elevated areas or vantage points. ENSR (2009) suggested that camp sites at vantage points were a deliberate defensive measure taken so that the group would have an upper hand should conflict arise between other language groups in the area.

4.2 Predictive model

As noted above, the results of investigations at Oran Park and Turner Road Precincts in the South West Growth Centre do not correspond with the predictive model of White and McDonald (2010). This investigation will test the relevance of the results of both of the above in the study area.

This predictive model comprises a series of statements about the nature and distribution of evidence of Aboriginal land use that is expected in the study area. These statements are based on the information gathered regarding;

- Landscape context and landform units.
- Ethno historical evidence of Aboriginal land use.
- Distribution of natural resources.
- Results of previous archaeological work in the vicinity of the study area.
- Predictive modelling proposed in previous investigations.

Predictive statements are as follows:

- Open sites or isolated finds are the most likely Aboriginal site type that would be identified within the study area. Previous investigations in the local area found lithics to be the most common site type.
- Scarred trees may be identified in the study area. Scarred trees are known to exist within the Camden area. Where old growth woodland remains there is a possibility that scarred trees will be identified.
- Artefact densities are likely to be low with isolated areas of higher density.
- Given their dominance in assemblages in other investigations in the area, silcrete, tuff and quartz will be the main raw material identified in the study area.
- *In situ* artefacts would be located in areas of least ground disturbance.
- Visibility is likely to be low, obstructed by leaf litter and grass cover.
- Sites on the ground surface will be most obvious in exposed areas where vegetation has been cleared, on tracks and/or on fence lines.
- Sites are likely to be found on crest and slope landforms within 300 metres of a permanent watercourse and/or on vantage points. Sites are also likely to be spread across the landscape.

5.0 Field Methods

5.1 Site definition

An Aboriginal site is generally defined as an Aboriginal object or place. An Aboriginal object is the material evidence of Aboriginal land use, such as stone tools, scarred trees or rock art. Some sites, or Aboriginal places can also be intangible and although they might not be visible, these places have cultural significance to Aboriginal people.

OEH guidelines state in regard to site definition that one or more of the following criteria must be used when recording material traces of Aboriginal land use:

- The spatial extent of the visible objects, or direct evidence of their location.
- Obvious physical boundaries where present, e.g. mound site and middens (if visibility is good), a ceremonial ground.
- Identification by the Aboriginal community on the basis of cultural information.

For the purposes of this study an Aboriginal site was defined by recording the spatial extent of visible traces or the direct evidence of their location.

PADs are areas where sub-surface stone artefacts and/or other cultural materials are likely to occur (OEH 2010:38). These areas may be associated with recorded sites but are often greater in extent taking in areas around the visible artefacts where there is a potential for further buried artefacts to exist. PADs may also be present where no visible artefacts are located. This may be the case when there is no ground surface visibility, but the area is seen to have a high likelihood of containing artefacts.

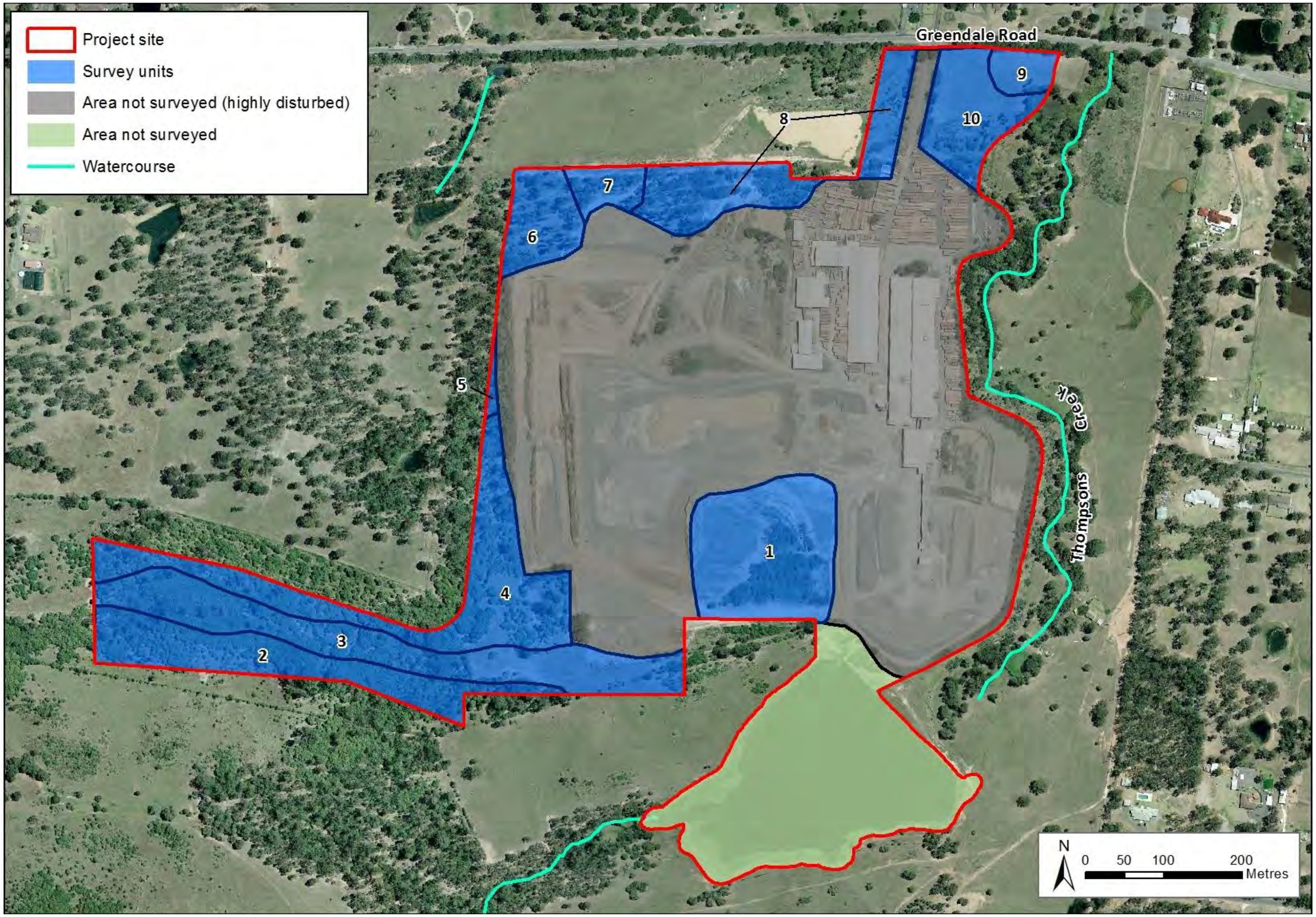
5.2 Survey methodology

An archaeological survey of the study area was conducted over two days. Land within the central and eastern portions of the study area has been extracted as part of the existing quarry activities and was not surveyed. The areas around the extraction, shown in Figure 5 were the focus of this investigation. The survey area was divided into ten survey units according to their landform. The large dam at the southeastern end of the study area was not surveyed but is disturbed with the construction of a large dam (see Figure 5).

The survey was undertaken in accordance with the DEC *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (2005) and was informed by the Code of *Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (OEH 2010). All survey units were covered on foot. All exposed areas within survey units were examined for stone artefacts or other traces of Aboriginal occupation. Old growth trees were examined for signs of cultural scarring or marking. A handheld Global Positioning System (GPS) was used to track the path of the surveyors and a map was carried by all members of the survey team.

A photographic record was kept of all sections of the study area. Photographs were taken to represent the landform unit, vegetation communities, objects of interest and levels of disturbance. Scales were used for photographs where appropriate.

Figure 5: Survey area map (background aerial © Sinclair Knight Merz 2013 c/o Google)



6.0 Results

6.1 Effective survey coverage

The survey area included areas around the extraction, shown in Figure 5. Three landform units were identified in the survey area: crest, slope and flat. Table 3 gives a more detailed breakdown of the landforms covered.

Visibility across the survey area was low due to dense vegetation, leaf litter and/or grass coverage. Exposed areas were associated with natural erosion or disturbance, such as in the eastern section of the survey area where the land had been cleared and stripped of its top soil. Other exposures were associated with vehicle or walking tracks or where fences had been erected. Table 2 takes into consideration visibility and exposure levels to determine the effective survey coverage.

Table 2: Effective survey coverage

Survey unit	Landform	Survey unit area (m2)	Visibility (%)	Exposure (%)	Effective coverage area (m2)	Effective coverage (%)
1	Crest	30,754	20	40	2,460	8
2	Slope	24,727	5	2	25	0.1
3	Crest	35,335	5	2	36	0.1
4	Slope	35,518	2	2	14	0.04
5	Crest	988	5	2	1	0.1
6	Slope	10,622	10	5	53	0.5
7	Crest	5,062	5	5	13	0.25
8	Slope	21,179	10	5	106	0.5
9	Flat	4,379	5	5	11	0.25
10	Slope	15,068	10	10	151	1

Table 3: Landform survey coverage

Landform	Landform area (m2)	Area effectively surveyed (m2)	% of landform effectively surveyed	Number of sites	Number of artefacts or features
Slope	107,114	349	0.3	2	BB OS3 contained 1 artefact; BB OS4 contained 1 artefact
Crest	72,139	2,510	3.5	2	BB OS1 contained 2 artefacts; BB OS2 contained 1 artefact
Flat	4,379	11	0.3	0	n/a

6.2 Survey observations

Survey Unit 1

Survey Unit 1 comprised a crest landform unit in the south eastern section of the study area. The survey unit was highly disturbed as a result of land clearing, soil stripping and introduced materials. In the western section of the survey unit a large exposure has been created where the top soil has been stripped (Plate 1). Site BB OS1 was located within this disturbed context. The eastern section of the survey unit is covered in dense regrowth and remnant old growth Eucalypts.

Survey Unit 2

Survey Unit 2 comprised a slope landform in the southern section of the study area where there has been less ground disturbance. The area is covered in dense vegetation, which consists of recent native regrowth and African Olive weed. Visibility across most of the survey unit was low due to dense leaf litter. Site BB OS3 was located on an exposure in the southern section of the survey unit, where visibility was higher.

Survey Unit 3

Survey Unit 3 comprised a crest landform in the southern section of the study area with a ground low - moderate disturbance level. As seen in Plate 2 a cleared track runs parallel to a fence line in the eastern section of the survey unit, where visibility is high. Site BB OS2 and an associated area of PAD were identified on the track (see Section 6.5 and 7.2). The remainder of the survey unit is covered in dense native regrowth and African Olive weed.

Survey Unit 4

Survey Unit 4 comprised a slope landform in the south western section of the study area (Plate 3). The survey unit is covered in dense regrowth and African Olive weed and the ground surface is obscured by leaf litter. Site BB OS4 was identified amongst the leaf litter on a steep slope in the southern section of the survey unit. The eastern portion of the survey unit has been affected by stockpiling and heavy vehicle movement.

Survey Unit 5

Survey Unit 5 comprised a small portion of crest landform on the western side of the study area. The entire survey unit was on the margin of an area of stockpiling and heavy vehicle movement located immediately to the east. Visibility across the survey unit was low due to vegetation cover (Plate 4).

Survey Unit 6

Survey Unit 6 comprised a slope landform in the north western section of the study area. The survey unit is highly disturbed. A track has been cut diagonally through the southern section of the survey unit and some introduced materials were visible in some portions of the survey unit.

Survey Unit 7

Survey Unit 7 comprised a crest landform in the northern section of the study area. A large bund has been formed across the southern margin of the survey unit, approximately two metres high and 200 metres long. A track runs in between the fence and mound where visibility is relatively high. Visibility across much of the survey unit is poor due to leaf litter.

Survey Unit 8

Survey Unit 8 comprised a slope landform in the northern section of the study area. The eastern strip of the survey unit is covered in thick grass, while the southern section is covered in dense regrowth and African Olive weed. Portions of the survey unit are highly disturbed from dam construction in the eastern strip of the survey unit and stockpiling materials along the southern margin. A track also runs through the middle of the southern section of the survey unit.

Survey Unit 9

Survey Unit 9 comprised a flat landform in the eastern section of the study area, adjacent to Greendale Road. The area appears to have been recently modified as the landform is not consistent with its surroundings. As seen in Plate 6 visibility across the survey unit is low due to grass and vegetation cover.

Survey Unit 10

Survey Unit 10 comprised a slope landform adjacent to Survey Unit 9 and backs onto road access to Boral's current car park. A large portion of the survey unit is covered by grass, whilst the southern portion is covered by dense vegetation and as a result visibility is low.

Plate 1: Survey Unit 1, facing east.

Plate 2: Survey Unit 3, facing east.

Plate 3: View NE across Survey Unit 4.

Plate 4: View NW from stockpiling area towards Survey Unit 5.

Plate 5: View of Survey Units 7 and 8, facing north.

Plate 6: Survey Unit 9, facing west.

6.3 Summary of results

Four sites were identified during the survey, three of which are located within the study area (Table 4 and Figure 6). One site, BB OS3, was located immediately outside the southern boundary of the study area (within 30 metres). Visibility across the survey area was low, obscured by leaf litter and grass cover. Exposed areas were associated with disturbance, where vegetation had been cleared, tracks had been cut or fences had been erected.

Table 4: Summary of survey findings

Site Name	AHIMS site register ID	Feature(s)	Survey Unit	Landform	Coordinates GDA94 MGA 56
BB OS1	45-5-4285	Artefact scatter	1	Crest	289525E 6241628N
BB OS2	45-5-4286	Isolated artefact	3	Crest/ Slope	289211E 6241486N
BB OS3	45-5-4287	Isolated artefact	-	Slope	288952E 6241444N
BB OS4	45-5-4288	Isolated artefact	4	Slope	288703E 6241630N

6.4 Previously recorded Aboriginal sites

In 1990 four isolated artefact sites were recorded within the study area. Three of these have since been destroyed as a result of Boral's mining operations. The fourth site, located on the outskirts of Boral's current mine, was visited on the survey (Plates 7 and 8). The site has been destroyed by quarry extraction activities.

Plate 7: Site identified by Resource Planning in 1990; facing north.

Plate 8: Site identified by Resource Planning in 1990, facing south.

6.5 Newly recorded Aboriginal sites

BB OS1 (Boral Brickworks Open Site 1)

Landform: Crest
Coordinates: 289525E 6241628N
Site type: Artefact scatter
Site Length: 20 metres
Site Width: 5 metres

BB OS1 is a scatter of two artefacts, spread out on an exposure that measures 20 metres in length and five metres in width, a total area of 100 square metres (Plates 9 and 10). Both artefacts were made of red silcrete. The characteristics of each are outlined in Table 5.

BB OS1 was identified in Survey Unit 1. Survey Unit 1 has been heavily disturbed. The exposure on which the artefact was located was created by the clearing of vegetation on the site and the stripping of topsoil.

Plate 9: Artefacts identified at BB OS1

Plate 10: BB OSI facing west

Table 5: BB OS1 artefact characteristics

Raw Material	Colour	Fragment	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Red	Proximal flake fragment	12	12	6
Silcrete	Red	Angular fragment with 15% cortex	38	19	12

BB OS2 (Boral Brickworks Open Site 2)

Landform:	Crest/ Slope
Coordinates:	289211E 6241486N
Site type:	Isolated artefact and area of PAD
Site Length:	150 metres
Site Width:	65 metres

BB OS2 is an isolated artefact and area of PAD (Plates 11 and 12). The artefact was located on a slope landform, in between two crest landforms, one to the east and one to the west. The artefact's characteristics are outlined in Table 6. An associated area of PAD that covers the slope and crest landform(s), shown in Figure 6, has been identified. The area of PAD was generally delineated by the 110 metre contour. The artefact was found on an exposure approximately 20 metres in length and three metres in width, a total area of 60 square metres. The exposure runs parallel to a fence line and is surrounded on its south and west by dense vegetation. At the time of survey, visibility was 50 per cent.

Table 6: BB OS2 artefact characteristics

Raw Material	Colour	Fragment	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Red	Medial Flake Fragment	26	16	6

Plate 11: BB OS2 facing east

Plate 12: Artefact at BB OS2

Figure 6: Survey results (background aerial © Sinclair Knight Merz 2013 c/o Google)

BB OS3 (Boral Brickworks Open Site 3)

Landform: Slope

Coordinates: 288952E 6241444N

Site type: Isolated artefact

Site Length: 20 metres

Site Width: 40 metres

BB OS3 is an isolated artefact located on a heavily deflated exposure that measures 20 metres east-west and forty metres north-south (Plates 13 and 14). It is likely that the artefact which was found on a slope was washed down from the crest above. The characteristics of the artefact are outlined in Table 7.

At the time of survey visibility on the exposure was 50 per cent. Vegetation had been cleared and some top soil removed. The exposure is surrounded by dense vegetation, where visibility of the ground surface was five per cent.

Table 7: BB OS3 artefact characteristics

Raw Material	Colour	Fragment	Length (mm)	Width (mm)	Thickness (mm)
Silcrete	Pink	Proximal Flake Fragment	19	14	4

Plate 13: Artefact at BB OS3

Plate 14: BB OS3, facing south

BB OS4 (Boral Brickworks Open Site 4)

Landform:	Slope
Coordinates:	288703E 6241630N
Site type:	Isolated artefact
Site Length:	1 metre
Site Width:	1 metre

BB OS4 is an isolated artefact which was located on a steep, heavily eroded slope. It is likely that the artefact had been washed down from the crest above (Plate 15). The characteristics of the artefact are outlined in Table 8.

Visibility at BB OS4 was five per cent at the time of survey. The ground surface was obscured by dense leaf litter and vegetation (Plate 16).

Table 8: BB OS4 artefact characteristics

Raw Material	Colour	Fragment	Length (mm)	Width (mm)	Thickness (mm)
Quartz	Milky White	Proximal Flake Fragment	21	19	8

Plate 15: Artefact identified at BB OS4

Plate 16: BB OS4, facing north

7.0 Analysis and Discussion

7.1 Disturbance

Overall, there is a high level of disturbance across the study area. The land in the centre of the study area has been extracted as part of Boral's mining operation and the old growth woodland that once covered the study area has been cleared. Most of the areas that were surveyed are now covered in recent regrowth and African Olive weed.

Survey Unit 1 is particularly disturbed. The western section has been cleared, the top soils stripped back and some portions covered by introduced materials. On the inside edge of the western length of the survey area the sides of an adjacent built up track has collapsed inwards. In disturbed areas such as at site BB OS1 artefacts unlikely to be in their original context and the archaeological potential of the area is low. In areas where there has been less ground disturbance, such as where BB OS2 and associated area of PAD were identified, it is likely that there has been less sub-surface disturbance.

Significant disturbance to sub-surface deposit, such as fence posts and erosions scours, was isolated to particular areas within BB OS2. Sub-surface impact from vegetation clearance, pastoral and agricultural activities is unlikely to have had a significant impact on sub-surface archaeological deposit. The majority of archaeological excavations conducted in the Cumberland Plain occur across pastoral / agricultural land, where ploughing and vegetation clearance have occurred. In many cases a mixture of natural bioturbation and historical farming activities has affected the vertical distribution of sub-surface assemblages, with the horizontal movement of artefacts less affected.

7.2 Discussion

In 1990 four isolated artefact sites were recorded within the study area, all of which have since been destroyed or impacted. Four new Aboriginal sites were identified during the current investigation, three of which are located within the study area. An artefact scatter, BB OS1, was located in a disturbed context in the south eastern section of the study area. An isolated find and area of PAD, BB OS2, was identified in the southern section of the study area. BB OS2 is located on a landform conducive to Aboriginal occupation and in an area where there is a low level of disturbance. BB OS4 is an isolated find in a disturbed context in the south western section of the study area.

BB OS3 was located south of the southern boundary of the study area. It consists of a pink silcrete proximal flake fragment. It is possible that this artefact, found on a slope, was washed down from an above crest. BB OS3 is located in an area that has a low level of disturbance.

BB OS2 and associated PAD

Site BB OS2 and associated PAD was located across a unique well-defined crest landform between the catchments of Bardwell Gully to the north and Thompsons Creek to the south. The northern side of the crest landform formed part of the headwaters of Bardwell Gully, whilst the southern slope overlooked the Thompsons Creek valley, a third order watercourse.

Previous archaeological investigations in the region have highlighted the role of different landform contexts in overall landscape use. From investigations at Oran Park, ENSR/AECOM (2009: 65-66) suggest that Aboriginal artefact clusters were likely to occur in a continuous low density scatter up to 300 metres from major watercourses and 120 metres from second order streams. Landscape characteristics, including reliable water and good outlook over surrounding valleys were also noted as important determining factors.

Sub-surface excavation conducted in the region has demonstrated variable artefact density on raised crest locations. Areas of high density signifying areas where activities took place, interspersed with low artefact densities where single and/or brief events occurred. Mean artefact density from sub-surface excavation in similar landform contexts varies between 1.1 and 5.9 artefacts per square metre (Artefact Heritage 2013). The higher artefact densities retrieved from similar settings follows ENSR/AEOMS's (2009: 65-66) assertion that landscape context and reliable water were important factors in the distribution of archaeological material across the landscape. The location of site BB OS2 would have provided a significant outlook over the Thompsons Creek valley to the south (see Plate 17) and the Bardwell Gully catchment to the north. Additionally, the site was located within 300 metres of Thompsons Creek, and the crest location of BB OS2 may have formed an access way from those catchment areas to the higher ridge landform located immediately to the west (see Plate 18). Further archaeological investigation of artefact density in relation to key landform features, such as the BB OS2 crest landform setting, would add further information to archaeological site modelling in the southern portion of the Cumberland Plain.

Plate 17: View southeast from BB OS2 across the Thompsons Creek valley.

Plate 18: View west over BB OS2

8.0 Legislative Context

This study has been undertaken in the context of several items of legislation that relate to Aboriginal heritage and its protection in NSW.

National Parks and Wildlife Act (1974)

The *National Parks & Wildlife Act 1974*, administered by the OEH provides statutory protection for all Aboriginal 'objects' (consisting of any material evidence of the Aboriginal occupation of NSW) under Section 90 of the Act, and for 'Aboriginal Places' (areas of cultural significance to the Aboriginal community) under Section 84.

The protection provided to Aboriginal objects applies irrespective of the level of their significance or issues of land tenure. However, areas are only gazetted as Aboriginal Places if the Minister is satisfied that sufficient evidence exists to demonstrate that the location was and/or is, of special significance to Aboriginal culture.

As this project is being assessed under Part 5.1 of the EP&A Act 1979 permits issued under the NPW Act 1974 are not required.

Aboriginal Land Rights Act (1983)

The *Aboriginal Land Rights Act 1983* is administered by the NSW Department of Human Services - Aboriginal Affairs. This Act established Aboriginal Land Councils (at State and Local levels). These bodies have a statutory obligation under the Act to; (a) take action to protect the culture and heritage of Aboriginal persons in the council's area, subject to any other law, and (b) promote awareness in the community of the culture and heritage of Aboriginal persons in the council's area.

The study area was located within the boundaries of the TLALC.

Native Title Act (1994)

The *Native Title Act 1994* was introduced to work in conjunction with the Commonwealth Native Title Act. Native Title claims, registers and Indigenous Land Use Agreements are administered under the Act.

No active Native Title claims occur within the study area.

The Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process. The EP&A Act requires that environmental impacts are considered prior to land development.

The proposal will be assessed under Part 5.1 of the EP&A Act, which establishes an assessment and approval regime for State Significant Development (SSD). Part 5.1 applies to development that is declared to be SSD by a State Environmental Planning Policy (SEPP). Section 115ZG of the EP&A Act specifies that approvals or permits under section 90 of the NPW Act 1974 are not required for approved SSD. However, approval from the Minister of Planning and Infrastructure is required and an EIS must be submitted. The EIS must address the impact of the proposal on Aboriginal sites and Aboriginal places, through the framework of existing heritage legislation including the NPW Act 1974 and the 2005 DEC (now OEH) draft Aboriginal cultural heritage impact assessment guidelines and the 2004 DEC interim Aboriginal community consultation guidelines.

9.0 Significance Assessment

9.1 Assessment criteria

Archaeological significance refers to the archaeological or scientific importance of a landscape or area. This is characterised by using archaeological criteria such as archaeological research potential, representativeness and rarity of the archaeological resource and potential for educational values. These are outlined below:

- Research potential: does the evidence suggest any potential to contribute to an understanding of the area and/or region and/or state's natural and cultural history?
- Representativeness: how much variability (outside and/or inside the subject area) exists, what is already conserved, how much connectivity is there?
- Rarity: is the subject area important in demonstrating a distinctive way of life, custom, process, land-use, function or design no longer practised? Is it in danger of being lost or of exceptional interest?
- Education potential: does the subject area contain teaching sites or sites that might have teaching potential?

Any received comments on the values to the Aboriginal community associated with the identified sites will be attached as an Appendix to the final report.

9.2 Archaeological significance assessment

BB OS1

BB OS1 has been assessed to be of low archaeological significance. It is located in an area that has a high level of disturbance and is unlikely to be in its original context. It has a low research and educational potential and low representative and rarity value.

BB OS2

BB OS2 is an isolated artefact and associated area of PAD. This site has been assessed to have moderate research potential as it has the potential to provide information about Aboriginal land use in the local area. The artefact and associated area of PAD was located in an area of relatively low disturbance in a crest landform context. The archaeological significance of the PAD cannot be accurately assessed until further archaeological investigations have been conducted.

BB OS3

BB OS3 is an isolated artefact and has been assessed to be of low archaeological significance. The site is located on a steep slope landform and it is likely that it has been washed downslope and is out of its original context. This site has a low research and educational potential and low representative and rarity value.

BB OS4

BB OS4 is an isolated artefact that has been assessed to be of low archaeological significance. The site is located on a steep slope landform and it is likely that the artefact has been washed down from a crest above. The artefact has therefore, been found out of its original context. The site has a low research and educational potential and low representative and rarity value.

Table 9: Summary of significance values.

Site name	Research Potential	Scientific / Archaeological Value	Representative Value	Rarity Value	Overall Significance
BB OS1	Low	Low	Low	Low	Low
BB OS2 and PAD	Moderate	Unknown	Unknown	Unknown	Unknown
BB OS3	Low	Low	Low	Low	Low
BB OS4	Low	Low	Low	Low	Low

10.0 Impact Assessment

The expansion of Boral's Bringelly plant will have a direct impact on the three Aboriginal sites located within the study area, BB OS1, BB OS2 and BB OS4 (Table 10)

BB OS3 was located outside the study area and will not be directly impacted by proposed expansion works. Due to the close proximity of site BB OS3 to the study area boundaries (within 30 metres), it is possible that activities within the quarry boundaries may have an indirect impact on the site, including increased erosion and movement of heavy machinery.

Table 10: Impact assessment

Name	Type of harm	Degree of ham	Consequence of harm
BB OS1	Direct	Total	Total loss of value
BB OS 2	Direct	Total	Total loss of value
BB OS3	None	None	None
BBOS4	Direct	Total	Total loss of value

11.0 Management and Mitigation Measures

11.1 Guiding principles

The overall guiding principle for cultural heritage management is that where possible Aboriginal sites should be conserved. If conservation is not practicable, measures should be taken to mitigate against impacts to Aboriginal sites.

The nature of the mitigation measures recommended is based on the assessed significance of the site or sites. The final recommendations would also be informed by cultural significance, which will be discussed by the Aboriginal community in their responses during the next stage of consultation.

11.2 Mitigation measures

BB OS1 and BB OS4 have been assessed to be of low archaeological significance. No further archaeological investigations are necessary if the sites are to be impacted.

BB OS2 and associated area of PAD have been assessed to be of moderate research potential. As the site falls within the proposed quarry footprint and will be destroyed during quarrying activities, further archaeological investigations should be conducted in order to determine the full extent of the site and to accurately assess its significance. These investigations should include an archaeological test excavation of the area of potential. The results of the test excavation would guide recommendations on management and mitigation measures.

BB OS3 is located immediately outside the southern boundary of the study area and would not be directly impacted by the proposal. Due to the close proximity of the site to the study area, measures should be put in place to ensure that the site is not inadvertently impacted. Inadvertent impacts could include increased erosion and movement of heavy machinery. Management measures to avoid inadvertent impact could include marking a five metre perimeter around the site with hi-visibility temporary fencing should quarrying activities take place in the vicinity of the site location. Additionally, consideration should be given to erosion and spoil movement or stockpiling in the vicinity of the site to avoid inadvertent impact.

As Aboriginal objects would be impacted by the proposal, comprehensive Aboriginal consultation in accordance with the DEC *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* 2005 would be undertaken. This consultation would be initiated prior to commencement of archaeological test excavations. The results of the community consultation and the test excavations would be included in an Aboriginal cultural heritage assessment report (CHAR) which would be provided to the Department of Planning and Infrastructure prior to approval of the EIS.

11.3 Management measures

Following the submission of the EIS and approvals from the Director General, future management of Aboriginal heritage within the proposal area should be included in the construction environmental management plan (CEMP). Information that should be included within the CEMP should include procedures of unexpected finds and Aboriginal heritage requirements of induction for all workers.

Unexpected finds

The CEMP should include a procedure for unexpected finds. If unexpected finds are encountered during works, all work should cease in the vicinity of the finds and a qualified archaeologist should be contacted to undertake a site inspection and determine whether or not the find is an Aboriginal object. If the find is assessed to be an Aboriginal object, the archaeologist must record it and submit a site card to the OEH AHIMS site register. The archaeologist must also assess the potential for further archaeological material in the surrounding area and provide recommendations regarding the need for further investigation, approvals and stakeholder consultation.

Works may only recommence in the vicinity of the find once all requirements for further investigation, approvals, recording and consultation have been fulfilled.

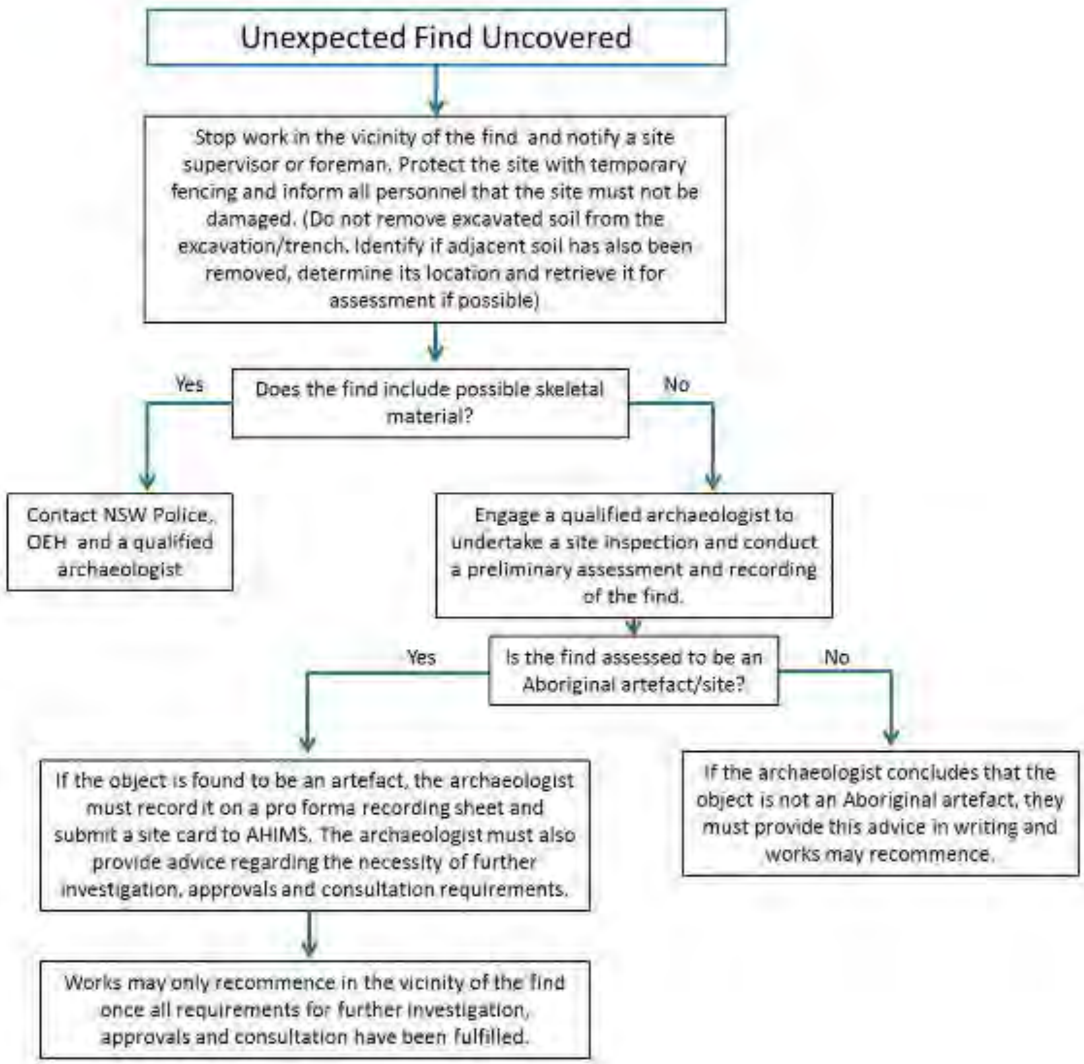
If suspected human skeletal remains are uncovered during works, all works must cease in the area. The NSW Police should be notified to provide details of the remains and their location. No recommencement of works in the vicinity of the skeletal remains can recommence until investigations by NSW Police have concluded. A flowchart outlining the unexpected finds procedure is included as Figure 7.

Heritage induction

All employees, subcontractors and agents undertaking construction activities at the site should attend a heritage induction to ensure they understand and are aware of the nature of possible Aboriginal heritage finds, including burials. The induction could be included as part of the general site induction for all workers.

The induction would include a brief introduction to the legal obligations relating to Aboriginal heritage, and provide pictures of the most likely Aboriginal objects to occur within the study area. This would include pictures of different types of stone artefacts, reflecting the main raw materials and colour variations that occur within the region. The induction should also include information on the unexpected finds procedure, including the necessity to stop work immediately and notify a site supervisor or foreman.

Figure 7: Unexpected finds procedure



12.0 Recommendations

The following recommendations were based on consideration of:

- Statutory requirements under the EP&A Act 1979.
- The requirements of the DGRs.
- The results of the background research, site survey and assessment.
- The likely impacts of the proposed development.
- The interests of Aboriginal stakeholders.

It was found that:

- Newly recorded sites BB OS1 and BB OS4 are located within the study area and have been assessed to be of low archaeological significance. The expansion of the brickworks will have a direct impact on these sites.
- Newly recorded site BB OS2 is located within the study area. BB OS2 is an isolated artefact with an associated area of PAD. Its significance cannot be accurately assessed until the results of further archaeological investigations are known. The expansion of the quarry will have a direct impact on the site.
- Newly recorded site BBOS 3 is located immediately outside the southern boundary of the study area. It has been assessed to be of low archaeological significance. The expansion of the quarry will not have a direct impact on the site.

It is therefore recommended that:

- Due to the proposed expansion of the quarry, conservation of BB OS1 and BB OS4 is not practicable. No further archaeological investigation of sites BB OS1 and BB OS4 is necessary as they are of low archaeological significance.
- Test excavation should be conducted at BB OS2 to determine its extent and archaeological significance and to inform further management or mitigation measures. A research design for test excavation would be developed in consultation with the registered Aboriginal stakeholders.
- During construction, management measures should be put in place to avoid inadvertent impact to BB OS3, located immediately outside the southern boundary of the study area.
- As Aboriginal objects would be impacted by the proposal comprehensive Aboriginal community consultation in accordance with the *Interim Community Consultation Requirements for Applicants* (2004) will be required. A registered stakeholder list would be compiled prior to any further archaeological work commencing.

- A CHAR would be prepared outlining the results of the Aboriginal consultation, test excavations and detailing proposed impacts to the significance of Aboriginal heritage values of all identified Aboriginal sites within the study area. This report would be provided to the Department of Planning and Infrastructure prior to approval of the EIS.
- Following the submission of the EIS and the appropriate approvals, Aboriginal heritage management and mitigation measures should be included in the CEMP. Details within the CEMP should include an unexpected finds procedure that details what steps should be taken if such material is identified, and the requirement of an Aboriginal heritage component to the induction for all workers.

13.0 References

Artefact Heritage, 2013. *Menangle Park Horse Stable Complex: Draft Archaeological Test Excavation Results*. Report to Cardno.

Attenbrow, V. 2010 *Sydney's Aboriginal Past: Investigating the Archaeological and Historical Records* University of New South Wales Press Ltd, Sydney.

Austral Archaeology Pty Ltd (Austral) 2010. MR 647 Bringelly Road Upgrade Aboriginal Archaeological Survey, Camden Valley Way, Leppington to the Northern Road, Bringelly. Report to the Roads and Traffic Authority of NSW (Draft report, August 2010).

Barton, H. 1996 *Camden Bush Corridor Management Plan, Archaeological Study*. Report prepared by Jo McDonald Cultural Heritage Management for EDAW.

Benson, D. and Howell, J. 1990 . *Taken for granted: the bushland of Sydney and its suburbs.* Sydney, Kangaroo Press (in assoc) with the Royal Botanic Garden.

Clark, N.R. & Jones, D.C. (eds). 1991. Penrith 1:100,00 Geological Sheet 9030 (New South Wales Geological Survey, Sydney).

Department of Environment, Climate Change & Water [now OEH] 2010 *Aboriginal cultural heritage consultation requirements for proponents 2010*.

Department of Environment, Climate Change & Water [now OEH] 2010 *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*.

Department of Planning and Infrastructure 2005 *Guidelines for Aboriginal Cultural Heritage Assessment and Community Consultation*

ENSR/AECOM 2009. *Report on Phase 2 Archaeological Excavations Oran Park Precinct & Turner Road Precinct South West Sydney*. Report to Landcom.

Hiscock, P. and Attenbrow, V. 2005. Australia's Eastern Regional Sequence Revisited: Technology and Change at Capertee 3. *Oxford: BAR Monograph Series 1397* Archaeopress.

Hiscock, P. and Mitchell, S. 1993. Stone artefact quarries and reduction sites in Australia: towards a type profile *Australian Heritage Commission Technical Publications Series No.4,* Australian Government Publishing Service, Canberra.

JMCHM 2005. *Archaeological salvage excavation of site CG1 (NPWS #45-5-2648), at the corner of Charles and George Streets, Parramatta, NSW.* Report for Meriton Apartments Pty Ltd.

JMCHM 2006. *Archaeological Salvage Excavation of the Colebee Release Area, Schofields, NSW, Volume 1.* Report prepared for Medallist Golf Holdings Pty Ltd.

JMCHM 2007. *Archaeological investigation of the Oran Park Precinct in the South West Growth Centre, Camden, NSW.* Report to APP.

JMCHM 2010. *Indigenous Archaeological Investigation of the proposed Power Line Route along The Northern Road from Bringelly Zone Substation, NSW*. Report to Integral Energy.

Karskens, G. 2010 *The Colony: A History of Early Sydney.* Allen and Unwin, Sydney.

Kayandel Archaeological Services 2010. *Aboriginal Archaeological Heritage Assessment of Stages 1 & 3 Watermain, Spring Farm.* Report to Lean and Hayward.

KNC 2008 *Oran Park and Turner Road Precincts: Aboriginal Heritage Investigation for Proposed Infrastructure Service Routes and Site Options.* Report to Landcom.

KNC 2010 *Bringelly Road upgrade: Camden Valley Way to The Northern Road Aboriginal cultural heritage Cultural Heritage Assessment Report* Prepared for the Roads and Traffic Authority.

Matthews R.H. and Everitt M.M. 1900 The organisation, language and initiation ceremonies of the Aborigines of the south-east coast of N.S. Wales. *Journal and Proceedings of the Royal Society of NSW. 34:262-81.*

McCarthy, F. D., Brammell, E., and Noone, H. V. V. 1948. The stone implements of Australia. *Memoirs of the Australian Museum* 9, 1-94

Nanson, G.C., Young, R.W., & Stockton, E.D. 1987. Chronology and palaeoenvironment of the Cranebrook Terrace (near Sydney) containing artefacts more than 40,000 years old. *Archaeology in Oceania*, 22 (2): 72-78.

Ngara Consulting Pty Ltd *2003b Archaeological Assessment of Aboriginal Heritage: Reservoir Entry Lands: Prospect.* Report to Conybeare Morrison.

Tench, W. 1789, 1793. *Sydney's first four years: being a reprint of A narrative of the expedition to Botany Bay and A complete account of the settlement at Port Jackson.* Reprinted in 1961. (Angus and Robertson in association with RAHS).

Turbet, P. 2010 *The First Frontier: The Occupation of the Sydney Region: 1788 to 1816*. Rosenberg Press.

White, E. and J. McDonald. 2010 Lithic Artefact Distribution in the Rouse Hill Development Area, Cumberland Plain, New South Wales. *Australian Archaeology* 70:29-38.

APPENDIX M

NON-INDIGENOUS HERITAGE ASSESSMENT

artefact
...discover

30 Aug 2013

Ursula O'Donnell
Environmental Consultant
Hyder Consulting Pty Ltd
Via email: Ursula.Odonnell@hyderconsulting.com

Dear Ursula,

Re: Boral Bringelly Brickworks Preliminary Non-Indigenous Heritage Assessment

The Boral Bringelly plant brickworks is located at 60 Greendale Road, Lot 2 DP 733115 in the Camden Local Government Area (LGA). A decline in demand has led to the closure of Badgerys Creek operations and has left Bringelly as Boral's only manufacturing plant in Sydney. The consolidation of their operations will necessitate an increase in production at the Bringelly plant, which will require an amendment of an approval granted by Camden Council on 13 September 1991 for the operation of the plant (DA91/1194).

Boral has been issued with Director General's Requirements (DGRs) for the preparation of an Environmental Impact Statement (EIS), to be submitted to the Department of Planning and Infrastructure. In order to fulfill the requirements of the DGRs, Hyder Consulting, on behalf of Boral, engaged Artefact to prepare this Non-Indigenous Heritage Assessment for the proposal to be included in the EIS.

Site location and context

The Boral Brickworks is located on part of Lot 11 in DP 1125892 (the Project Site), comprising an area of approximately 385.55 hectares, and is currently occupied by a clay quarry and brick manufacturing plant and is owned by Boral Limited (Figure 1). It is located within the Camden Local Government Area and is approximately 55 km southwest of the Sydney Central Business District.

The proposal

The Project Site is currently used for quarrying, brick production and associated activities. Existing features of the site include an active quarry pit, one large primary catchment basin in the existing quarry pit, two smaller sediment basins to the north-east of the existing quarry operations, two large sediment basins to the south-east of the brick manufacturing plant and one large dam to the south of the site located in Thompsons Creek.

The brick making facility along with various administration buildings, a finished bricks storage yard, staff car park and internal road network is generally contained within the northern part of the Project Site, and is set back approximately 200 m from Greendale Road. The southern portion of the Project Site, adjacent to Thompsons Creek, is leased for the agistment of stock and grazing.

Approval is sought for the continuation of operations on the site involving the continued extraction of raw materials, but over a larger extraction area (quarry footprint), and continued brick making activities, but at a higher production rate. The proposed Project can be summarised as follows:

- Extraction of raw material from the site in the order of 200,000 tpa (no change to current extraction consent) as follows:
  - Continuation of extraction from the existing quarry area (current consent), to a maximum depth of 30 m; and
  - Expansion of the quarrying operations over an additional 20.75 hectares (to a total of 30.65 hectares) with extraction to a maximum depth of 30 m;
- Brick production in the order of 263, 000 tonnes of bricks per year (increase of 103,500 from current consent);
- Construction of a 5m high noise bund along the northern boundary of the quarry operations;
- Importation of raw materials required for brick making in the order of 64,000 tpa;
- Extension to the following existing buildings:
  - clay preparation building; and
  - small area of the brick manufacturing plant near the exit to the kiln
- Addition of two recycled water storage tanks;
- Construction of a new driveway to the east of the existing alignment;
- Construction of a 4.5 m high noise bund along the northern Boral property boundary, from the position of the existing driveway to the proposed new driveway location (200 m long x 3 m flat top with a 21 m wide base and 1:2 batter slopes).

Figure 2 shows the proposed site layout.

Figure 1: Study area in its locality (background aerial © Sinclair Knight Merz 2013 c/o Google)

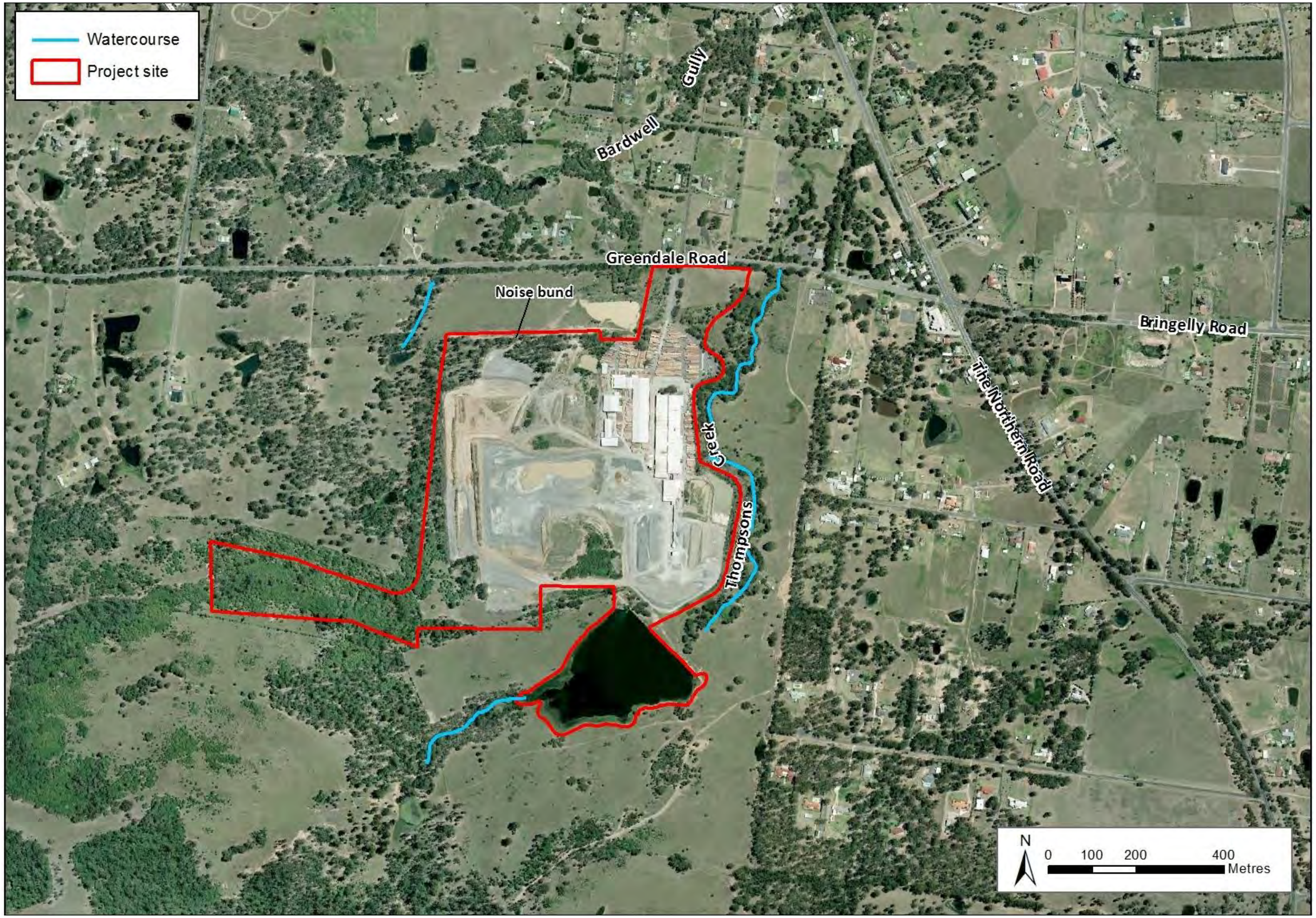
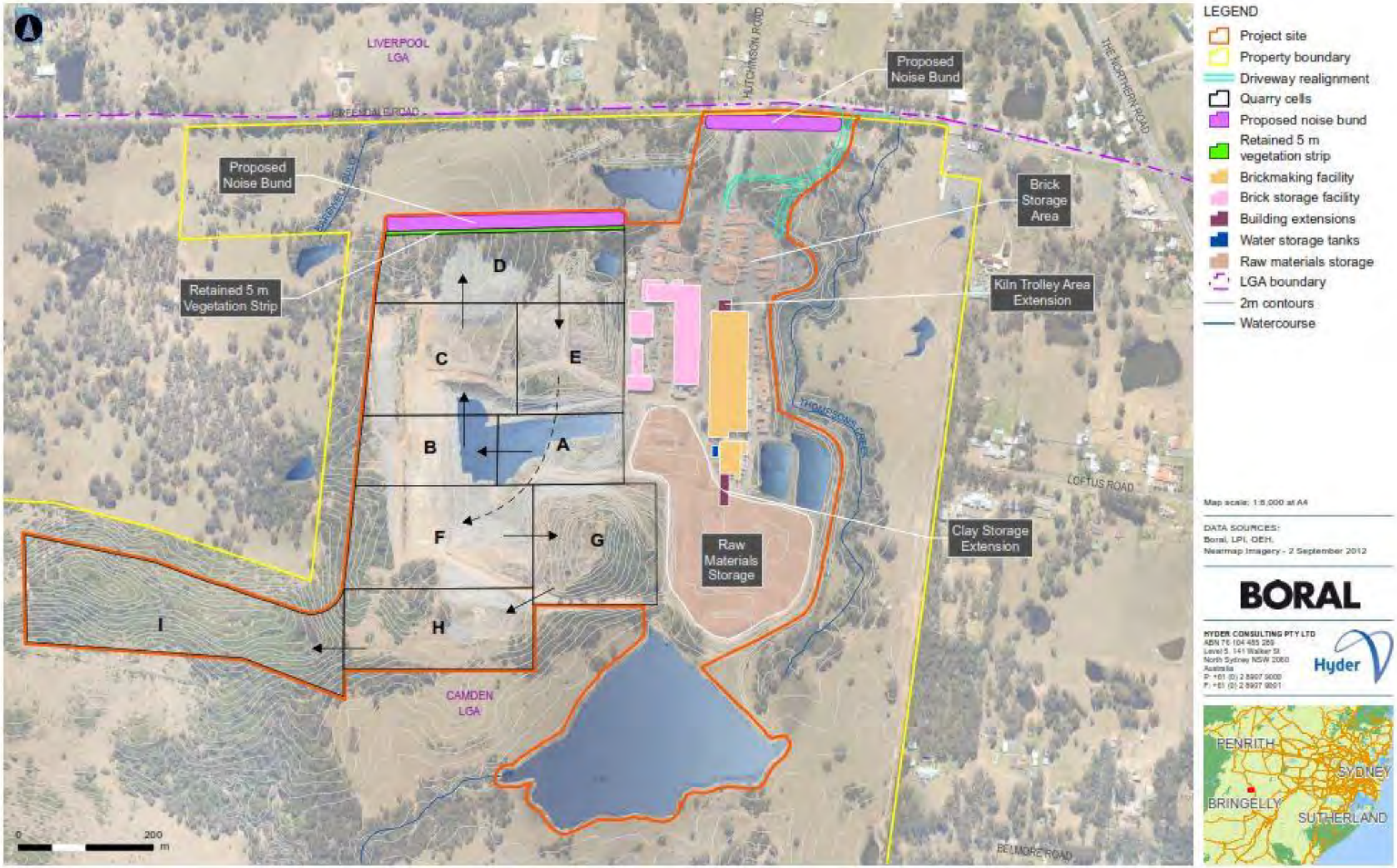


Figure 2: Proposed site layout plan (provided by Boral)



Legislative context

There are several items of State legislation that are relevant to the current study. A summary of these Acts and the implications for the proposed development follow.

The Heritage Act 1977

The *NSW Heritage Act 1977* (the Heritage Act) is the primary item of State legislation affording protection to items of environmental heritage (natural and cultural) in New South Wales. Under the Heritage Act, 'items of environmental heritage' include places, buildings, works, relics, moveable objects and precincts identified as significant based on historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic values. State significant items are listed on the NSW State Heritage Register (SHR) and are given automatic protection under the Heritage Act against any activities that may damage an item or affect its heritage significance. The Heritage Act also protects 'relics', which can include archaeological material, features and deposits.

The Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process. The EP&A Act requires that environmental impacts are considered prior to land development; this includes impacts on cultural heritage items and places as well as archaeological sites and deposits. The EP&A Act also requires that Local Governments prepare planning instruments (such as Local Environmental Plans [LEPs] and Development Control Plans [DCPs]) in accordance with the Act to provide guidance on the level of environmental assessment required. The current study area falls within the boundaries of the Camden LGA, and is subject to the Camden LEP 2011. It is also located immediately south of the Liverpool LGA and therefore the Liverpool LEP 2008 is also relevant.

The proposal will be assessed as a State Significance Development (SSD) under Part 4 of the EP&A Act. Part 4, Division 4.1 establishes an assessment and approval regime for SSD and specifies that approvals or permits under Part 4 or Section 139 of the Heritage Act are not required for approved SSD. However, approval from the Minister of Planning and Infrastructure is required and an EIS must be submitted. The EIS must address the impact of the proposal on heritage items, through the framework of existing heritage legislation including the Heritage Act, and the local LEPs and DCPs.

Register listings

Statutory registers provide legal protection for heritage items. In NSW the Heritage Act and the EP&A Act give legal protection. The State Heritage Register, the s170 registers, and heritage schedules of LEPs are statutory listings. Places on the World Heritage List and the National Heritage List are protected under the *Environment Protection and Biodiversity Conservation Act 1999*.

State Heritage Register

The SHR is a list of places and objects of particular importance to the people of NSW and is administered by the Heritage Branch of the Office of Environment and Heritage (OEH). To be listed, an item must be deemed to be of heritage significance for the whole of NSW.

No SHR items are located in the vicinity of the study area.

Section 170 Registers

Section 170 (s170) Registers are created by government bodies and are registers of all heritage listed items that are owned, occupied or managed by those bodies.

The Bringelly Public School Group, including the entire school property, is listed on the s170 Register of the Department of Education and Communities.

Camden LEP 2010

The LEP includes a schedule of local heritage items and zoning maps that show the curtilages of heritage items within the LGA.

Maryland estate, located around two kilometres to the south of the project area, is listed on the Camden LEP (item number I1).

Liverpool LEP 2008

The LEP includes a schedule of local heritage items and zoning maps that show the curtilages of heritage items within the LGA.

The Bringelly Public School Group, including the entire school property, is listed on the Liverpool LEP (item number 7).

Historical context

General

Exploration to the west of Sydney Cove began soon after first settlement, as it was found that the sandstone soils of coastal Sydney were unsuited for cultivation. The Cumberland Plain, with its rich alluvial soils, offered better conditions for farming and land was cleared there as early as the 1790s. Settlement at first focused on the well-watered areas around the Hawkesbury and Georges Rivers, but soon began to spread further west and south.

As favourable land was discovered, the successive governors of the colony issued land grants as a way to encourage settlers to become self-sufficient and to produce food for the colony at large. Large areas of land were initially granted to the retired officers of the NSW corps, and by 1800 to members of the colony's elite. Within four years of first settlement, land grants were becoming a source of increasing wealth and status for many colonists.

Access to the land beyond the Nepean River was restricted in order to preserve the wild cattle herd of the Cowpastures and most Crown grants in the region were not made until after 1810, when Lachlan Macquarie was appointed Governor (Atkinson 1988:11). Several large grants were made in the Bringelly area after 1815.

The development of the village of Bringelly was slow. A post office was opened in 1857, but the town was not officially named until 1863, when the post office was named Bringelly Post Office (Liverpool City Council n. d.). A public school was opened in 1878 on the intersection between Bringelly Road and The Northern Road, with an initial attendance of 20 children, which grew to 50 in the early 1890s as settlement in the area increased. During the twentieth century, further community services were established around the post office. In 1914, an agency of the Commonwealth Bank opened, and by 1925 a grocery business was being conducted in conjunction with the post office. In the 1960s, the post office was moved into the new complex of shops built on the corner of The Northern Road and Greendale Road (Austral Archaeology 2011:98). The population of Bringelly increased rapidly in the late 1950s, with the school's enrolment growing by 20 between 1957 and 1960 (Bringelly Public School 1978:8-9).

<u>The study area</u>

The study area is located on land that was originally owned by Robert Lowe. In 1812, Lowe was granted 1000 acres in the District of Cooke, named Birling after his wife's home in England (Figure 3). This original grant was located to the south of the study area, which was part of 500 acres acquired by Lowe at a later date. Lowe and his family arrived in New South Wales as free settlers in 1812. In 1815 he was made a magistrate for the Bringelly and Cooke districts, and for the County of Cumberland in 1820 (Parsons 1967). The first house at Birling is thought to have been built in 1812, before being destroyed by fire and replaced with a second timber homestead (Liverpool City Council n.d). The Birling homestead was located on the original 1000 acre grant.

The 500 acre parcel of land and part of the original 1000 acre grant were combined to form a farm named Newstead, which was occupied by Robert Lowe's son, Joseph, from c. 1850 until his death in 1892 (*Australian Town and Country Journal* 23 July 1892). Joseph Lowe ran cattle on the property (*Sydney Morning Herald* 19 Oct 1855:6). A homestead named Newstead is still present around 700 metres to the south of the current study area (Figure 4), and it is likely that the original homestead was situated in the same location.

In 1911, the land within the study area was sold to Fitzwilliam Wentworth, along with the remainder of the original Birling grant and Portion 45 of the Parish of Bringelly. Members of the Wentworth family had already been granted a number of large properties in the surrounding area. Fitzwilliam mortgaged the property to the Bank of NSW, and the property passed on to William Charles Wentworth in 1916, following Fitzwilliam's death (Old Title Record Vol. 2196 Fol. 114).

In 1918, the property was sold to Thomas Charles Barker, a grazier who already owned the large estate of Maryland to the south of Lowes Creek. In 1939, the property was purchased by James Dunlop McLeod, a woolbroker of Sydney. In 1948, McLeod sold the property to William Hartland Cullen, who produced wool at the property, which was still known as Newstead (*The Biz* 25 January 1951:2) (Old Title Record Vol. 2196 Fol. 114). Cullen was the son of the former Chief Justice, Sir William Cullen, and his wife was the State and then Federal President of the Country Women's Association between 1953 and 1958.

In 1949, while in Cullen's ownership, the land on which the study area is located was proclaimed a bird and animal sanctuary. This suggests that that portion of the Newstead property was not used for farming at that time.

The property was sold to Cecil George Holdaway and his wife, Honor May Holdaway in 1958 (Old Title Record Vol. 2196 Fol. 114). The brickworks began operation on the site in 1968.

Figure 3: Parish map showing original land grants to Robert Lowe

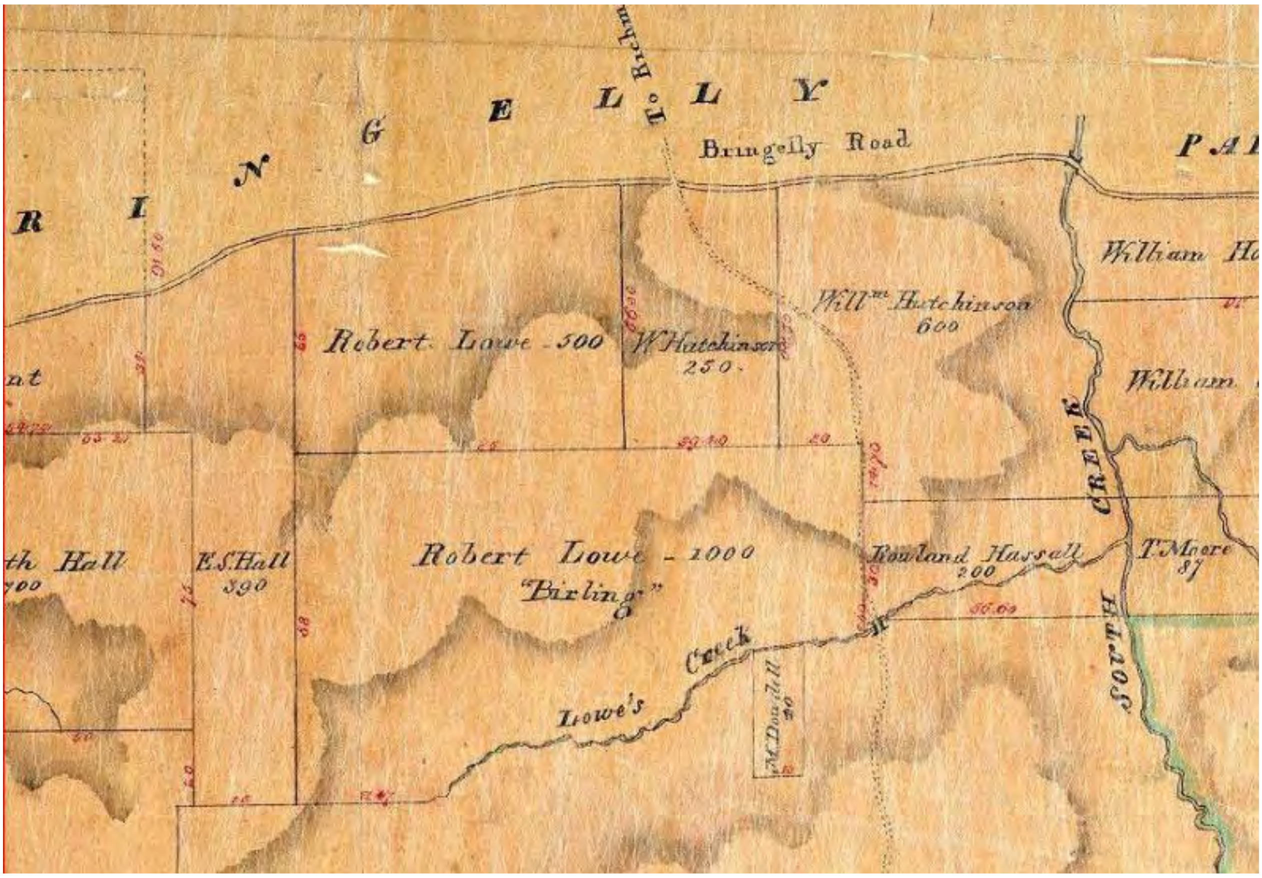
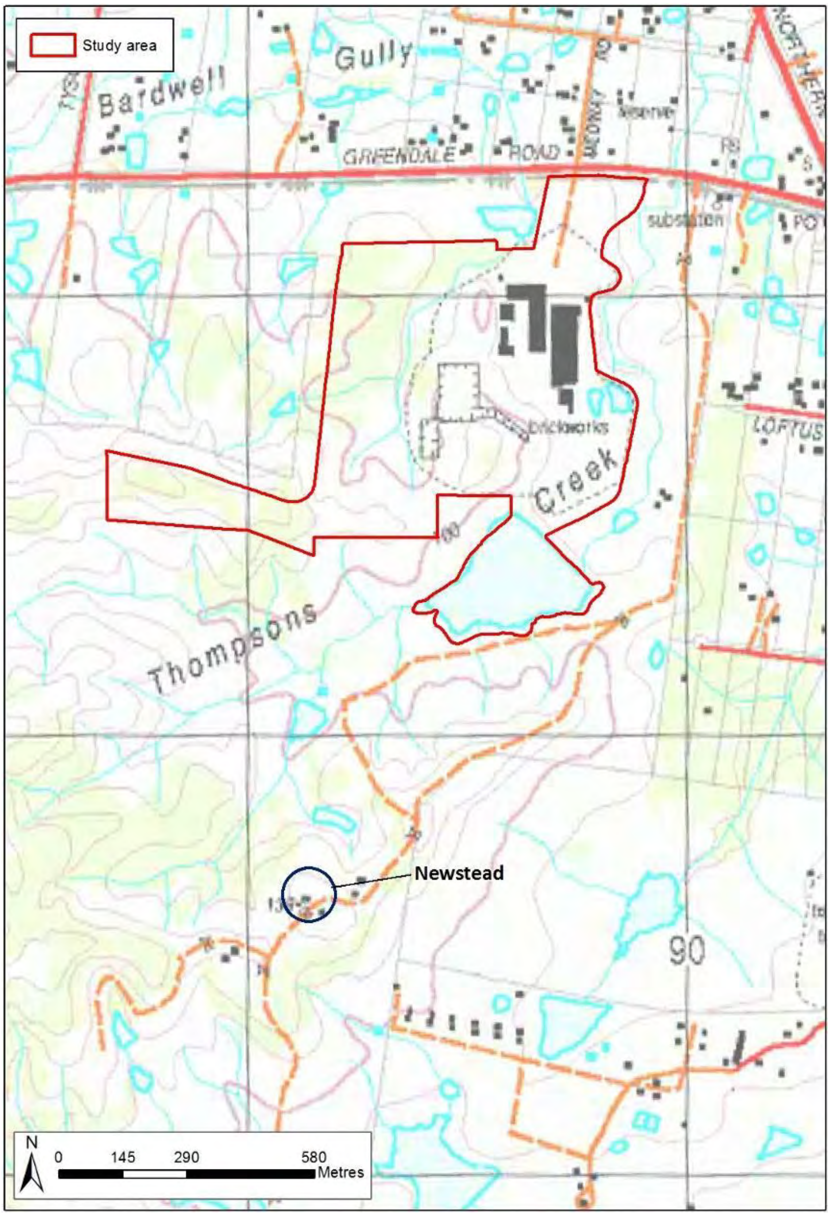


Figure 4: Newstead (circled) in relation to the study area (outlined in red) (base map © NSW LPI 2013)



Heritage listed items

Maryland

<u>History</u>

In 1816, 3000 acres at Bringelly were granted to John Dickson, a Scottish engineer. According to the deed, this property was to be called Dixon's Farm, however parish maps record its name as Nonorrah (AMAC 2008a:53).

In 1833, Dickson returned to England while on bail under suspicion of forgery. His mill was advertised for sale that year, and his agent began to sell off his pastoral property, which by this time also included nearby Orielton. Thomas Barker, Dickson's former apprentice and the husband of his niece, was managing Nonorrah and Orielton by the mid-1830s, though there is some confusion about when he took formal ownership of the property (AMAC 2008a:53). According to Broadbent there is an unsubstantiated tradition that the land was given to Barker and his wife as a wedding gift, however more recent research appears to indicate that Barker purchased the homestead in 1854 (Broadbent 1982:337). The present house at Maryland was probably constructed by Barker in the late 1830s or 1840s, though it has been suggested that it replaced an earlier house built by Dickson in the early 1820s (Broadbent 1982:340).

After T.C. Barker's death in 1940, Maryland was sold to Mr and Mrs N. A. Thompson, who left the estate to their daughters, Annette and Elizabeth (Broadbent 1982: 340). The Thompson daughters used the property for grazing, ran a dairy, and raised cattle to compete in agricultural shows. Elizabeth died in 2006 and Annette in 2009 (SMH July 17 2009).

<u>Description</u>

The current entrance to the Maryland property is located on the western side of The Northern Road, about four kilometres south of Bringelly Road. The driveway is around 1.5 km long and leads to the main homestead complex which is situated on a knoll and has views to the north over Lowes Creek and toward The Northern Road in the east. Outbuildings and remnant plantings are scattered along the main ridgeline and slopes, but the major plantings occur around the homestead, loop road and eastern slopes.

The outbuildings located on the hilltop include a stone cottage, former winery, stone store, and gatekeeper's cottage. Further down the slope and to the north is a second group of outbuildings with a stone barn, stables, various sheds, and a worker's cottage. Between these and the main homestead complex are some modern buildings.

The main homestead complex is surrounded by mature trees and shrubs.

<u>Heritage significance</u>

The statement of significance included in the State Heritage Inventory entry for the item is as follows:

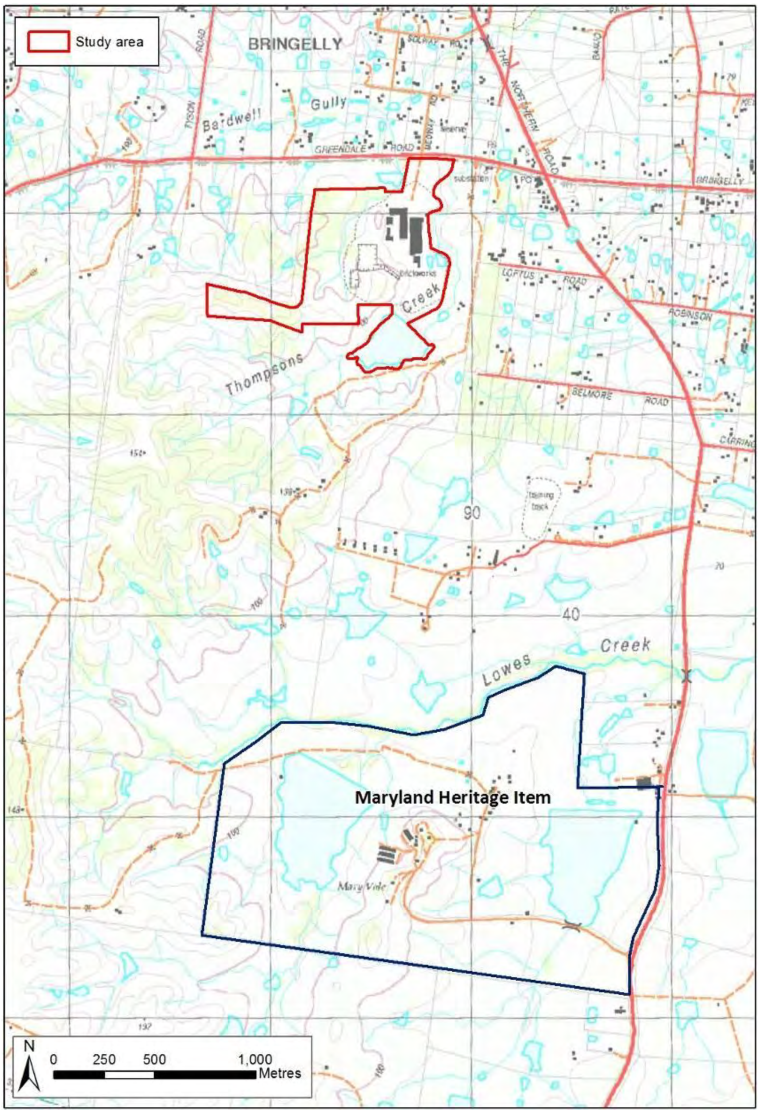
> *"Maryland is an outstanding complex of early homestead and farm buildings, especially significant for its completeness as a group, its excellent state of preservation, and the integration of the buildings, garden and magnificent setting. Includes many early buildings in good repair as well as buildings of special architectural interest. The winery and store may be the oldest winery buildings in Australia. Property has been in continuous occupation by only two families for over 130 years. Long associations with the surrounding district. The Main Building is an important historic grouping, set in magnificent garden and landscape and retaining most original fabric. The outbuildings form a substantial group which are of state significance because they are an important historic grouping and some of the earliest on the buildings on site. They illustrate the*

diversity of functions associated with early agricultural activity in this area. All are virtually intact." [1]

Statement of heritage impact

The northern boundary of Maryland is approximately 1.8 kilometres from the study area (Figure 5). As there are such tall and thick plantings around the main homestead complex on the top of the hill, there would be no clear views toward the project area. Even if glimpses were available toward the study area, the proposed expansion of works would not significantly alter the appearance of the Boral Brickworks site from such a distance and would have a negligible impact on views from Maryland.

Figure 5: Maryland heritage item in relation to the study area (base map © NSW LPI 2013)



Required actions

No actions are required.

[1] http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=1280029

Bringelly Public School

History

The school was established in 1878 to replace an earlier and dilapidated school at Cabramatta. Initially the school property consisted of 10 acres of land, a farmhouse, and a detached slab kitchen, sold to the Council of Education by George Stanfield (SRNSW [5/15090.1] 'Letter from George Stanfield to Council of Education, 16th Aug 1877'). Formerly functioning as the local post office, the house was built of brick and was converted into a combined classroom with attached accommodation for a teacher (SRNSW [5/15090.1] Memo to District Inspector, 28th June 1889). In 1894, a new teacher's residence was built, and the old residence/classroom was converted entirely into a classroom. By 1897, the classroom building was in poor repair and it was replaced by a new building, which is still standing (Bringelly Public School 1978:9).

The school included an area for a garden in the corner of the grounds near the intersection of the roads, as well as grazing land for the pupils' horses. The children maintained the garden and Adams (1978:24) refers to finding old bricks, foundation material, clinkers, and cinders while digging in the garden during his attendance at the school in around 1915. It is thought that the clinkers were associated with the blacksmith's forge once located on the south-western corner of the Greendale/The Northern Road intersection, while the structural material is likely to have been the remains of the original classroom building formerly owned by George Stanfield (Austral Archaeology 2011:95).

The initial attendance of the school was 20 children, which grew to 50 in the early 1890s as settlement in the area increased (Bringelly Public School 1978:8-9).

Description

Both the teacher's residence and the school building constructed in 1897 are still present at the site. The teacher's residence is a single storey building, oriented to the east, with a verandah on the eastern side. It had been in use as the administration centre for the school but was recently vacated due to safety concerns over large cracks in the walls (Office of Environment and Heritage n. d. "Bringelly Public School Group, Residence"). The schoolroom is also a single storey building, oriented to the east. It is currently used as a classroom, while the in-filled verandah on the northern side is used by the Bringelly Baby Clinic and the Hoxton Park Community Health Centre (Office of Environment and Heritage n. d. "Bringelly Public School Group, Primary School"). Both buildings front The Northern Road.

The item is located to the north-east of the current study area, around 350 metres from the proposed area of works.

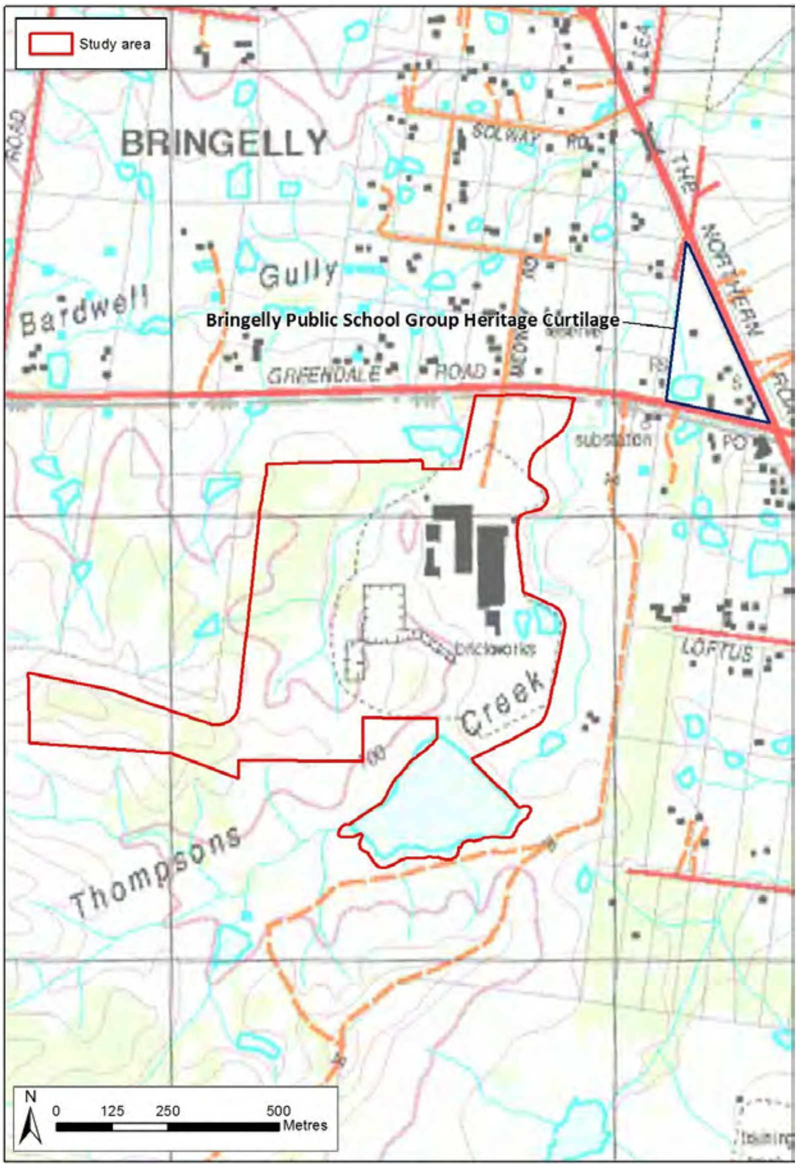
Heritage significance

The Bringelly Public School Group is significant at a local level as a site which demonstrates the history of settlement and education in the area. The classroom building is representative of educational buildings from the late nineteenth and early twentieth century, while the teacher's residence is representative of the design of teachers' residences commonly built in association with rural schools at this time.

Statement of heritage impact

Although the item is located close to the northeast corner of the brickworks property, it is located around 800 meters from the land which is proposed to be added to the area of works (Figure 6). There are no views toward the brickworks from the school and the proposal would have no physical or visual impacts on the heritage significance of the Bringelly Public School Group.

Figure 6: Bringelly Public School Group in relation to the study area (base map © NSW LPI 2013)



Required actions

No actions are required.

Unlisted items of potential heritage value

Bringelly Road/Greendale Road Rural Cultural Landscape

Bringelly Road/Greendale Road, with its associated rural cultural landscape is listed as a potential heritage item in the Camden DCP 2011. The Bringelly Road/Greendale Road cultural landscape possesses local historical and aesthetic significance as a rural landscape that has remained relatively intact since early settlement and that maintains a clear visual link to the local area's agricultural history. The DCP controls state that "development should optimise the preservation and interpretation of the identified significant Cultural and Visual Landscapes" (B3.1.5).

Statement of heritage impact

The proposed works would include the construction of a 200 m long by 4.5 m high noise bund running along the northern boundary of the property (Figure 7). While the bund would be planted with locally occurring native species in order to blend into the surrounding landscape, its height and proximity to the road boundary would have some impact on views from Greendale Road and would alter the setting of the rural cultural landscape.

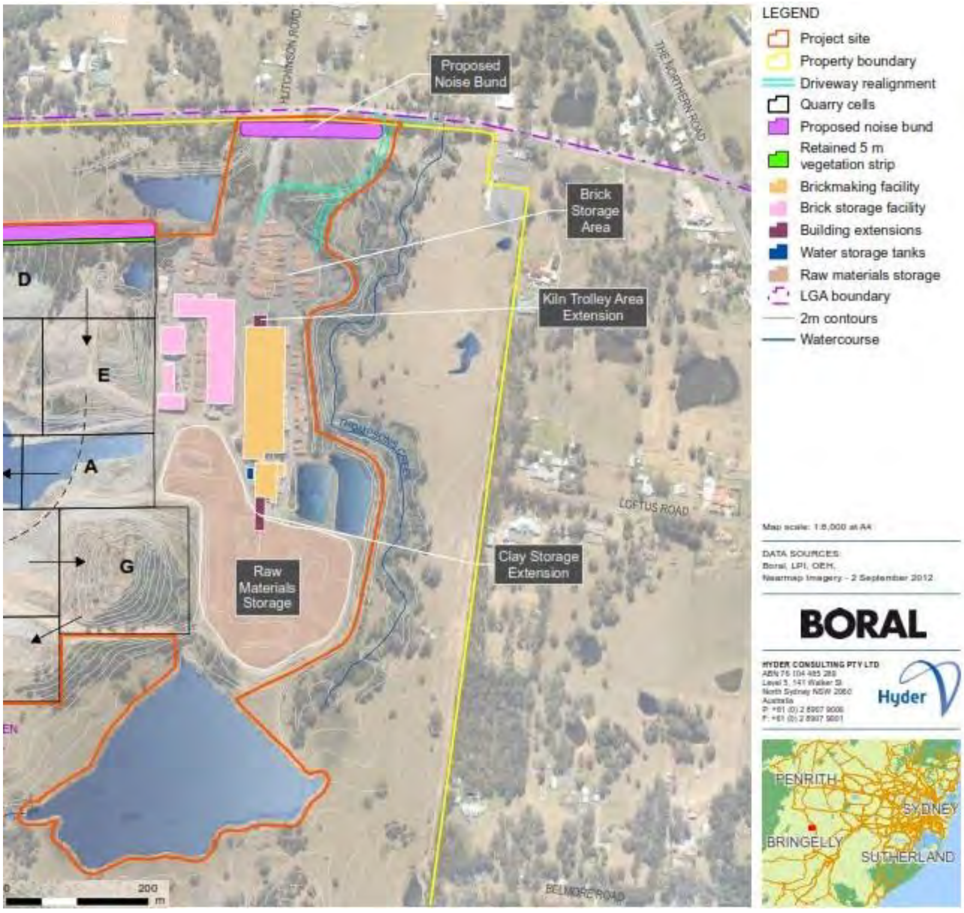
During the initial assessment of non-Indigenous Heritage values, it was suggested that the proposed noise bund along part of the northern boundary of the site, be moved at least 20 metres further back from Greendale Road in order to minimise visual impacts to the Bringelly Road/Greendale Road Cultural Landscape. In an effort to ensure that the cultural landscape values were not compromised, Wilkinson Murray (appointed noise consultants) modelled the noise levels from delivery truck movements, at nearby residential receivers to the north of Greendale Road, with the noise bund set back from Greendale Road. The results of the noise modelling revealed that the positioning the noise bund back from Greendale Road would result in higher noise levels at the nearby residential receivers than if the noise bund was located immediately south of Greendale Road. As such, it is recommended that the most appropriate approach to managing both noise and visual impacts on the landscape along the Greendale Road frontage would be to retain the noise bund in the proposed location and to revegetate the noise bund with appropriate, locally occurring native trees and shrubs, which will soften the built form of the noise bund and will assist in blending it into the local landscape.

A small access road is proposed in the northeastern section of the study area. The road would join Greendale Road with the brickworks loading area. This road would be visible from Greendale Road and would involve the removal of a small number of trees along the side of Greendale Road, however, the presence of the access road would not have a significant impact on views from the road or the heritage value of the Bringelly Road/Greendale Road cultural landscape.

Required actions

Revegetate the noise bund with appropriate, locally occurring native trees and shrubs.

Figure 7: Detail of proposed site layout plan showing bund and access road near Greendale Road (provided by Boral)



Assessment of archaeological potential

Archaeological potential is defined as the potential of a site to contain archaeological relics, as classified under the Heritage Act. Archaeological potential is assessed by identifying former land uses and associated features through historical research, and evaluating whether subsequent activity may have involved the removal or disturbance of evidence for these former land uses.

It is unlikely that significant non-Indigenous archaeological material exists within the study area. The study area was part of a large grazing property from the early 19th century. This property was named Newstead and was occupied by Joseph Lowe and his family from c. 1850. However, the main farmstead complex for this property is likely to have been situated in the same location as the present-day Newstead buildings. An aerial photograph of the property dating to 1947 does not show any structures within or near the study area. The only visible feature in this photograph is a dam located within the proposed area of works (Figure 8). The photograph shows that the majority of the property was cleared, with some minor tracks winding through it. There are no signs of cultivation, and this is consistent with its use for grazing.

In 1949, when the property was occupied by William Hartland Cullen, who ran sheep on the land, the portion of the property that includes the study area was proclaimed to be a bird and animal sanctuary.

This suggests that the study area was not used for farming (or at least not intensive grazing) at that time.

It is unlikely that any significant former features would have been located within the study area. Former features so far from the main farmstead are likely to have been limited to fence lines and small ephemeral structures such as shelters for livestock. Such features would be unlikely to leave intact archaeological evidence, and such evidence would be difficult to identify and date through visual inspection if it did survive.

No non-Indigenous archaeological material or areas of archaeological potential were identified during the site survey carried out as part of this heritage assessment. If any surviving archaeological material is present within the study area, it would be expected to be of low research potential as it is likely to be limited in nature and unlikely to provide useful new information that could answer relevant research questions regarding the history of the site or local area.

Figure 8: 1947 aerial photograph showing the study area outlined in red. Possible dam location circled yellow.

Recommendations

Based on the findings of this assessment it is recommended the proposed noise bund should be revegetated with appropriate, locally occurring native trees and shrubs in order to minimise impacts on the Bringelly Road/Greendale Road Rural Cultural Landscape. There are no further constraints on the proposal with regard to non-Indigenous heritage.

If unexpected archaeological finds are encountered during works, all works in the immediate vicinity of the identified material must stop, the Heritage Branch must be notified and an archaeologist must be contacted to assess the significance of the material and recommend whether further action is required. A procedure for unexpected non-Indigenous archaeological finds should be included in the Construction Environmental Management Plan for the project, and in the heritage induction given to workers.

If you have any questions regarding non-Indigenous heritage or archaeological potential, or require further information, do not hesitate to contact me at any stage of your project and I would be happy to advise.

Regards,

Dr Sandra Wallace

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References

Adams, D. (1978) “When The Old Schoolhouse Was New”, in Bringelly Public School (1978) *Bringelly Public School 100 years…of public school education 1878-1978,* pp. 23-27.

Atkinson, A. (1988) *Camden: Farm and village life in early New South Wales* (Oxford University Press: Melbourne).

AMAC (2008) *Preliminary non-aboriginal heritage assessment, The Northern Road Upgrade, Camden NSW, Vol 1: Report*, report for the Roads and Traffic Authority of NSW.

Austral Archaeology Pty Ltd (2011) *MR 647 Bringelly Road Upgrade, Camden Valley Way, Leppington to The Northern Road, Bringelly: Heritage Assessment and Statement of Heritage Impact.* Report to RTA.

Bringelly Public School (1978) *Bringelly Public School: 100 years of public school education.*

Broadbent, James (1982) “Maryland, New South Wales”, in *Historic Homesteads, Australian Council of National Trusts – Heritage Reprints,* Canberra, 1982, reprinted 1993, pp. 336-343.

Liverpool City Council (n. d.) *History of our suburbs: Bringelly*

Office of Environment and Heritage (n. d.) “Bringelly Public School Group, Primary School” State Heritage Inventory Listing. Online edition, accessed 5/7/11 <http://www.heritage.nsw.gov.au/07_subnav_04_2.cfm?itemid=1970066>

Office of Environment and Heritage (n. d.) “Bringelly Public School Group, Residence” State Heritage Inventory Listing. Online edition, accessed 5/7/11 http://www.heritage.nsw.gov.au/07_subnav_04_2.cfm?itemid=1970455

Parsons, V. (1967) “Lowe, Robert (1783-1832)” *Australian Dictionary of Biography.* Online edition, accessed 27/6/11.