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Dixon Sand (Penrith) Pty Ltd

HAERSES ROAD QUARRY EXTRACTION AREA MODIFICATION

Environmental Assessment

FINAL

September 2016

Dixon Sand (Penrith) Pty Ltd

HAERSES ROAD QUARRY EXTRACTION AREA MODIFICATION

Environmental Assessment

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Dixon Sand

Project Director:	John Merrell
Project Manager:	Lachlan Sweeney
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Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

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Executive Summary

Background

Dixon Sand (Penrith) Pty Limited (Dixon Sand) operates the Haerses Road Quarry located on Haerses Road at Maroota, NSW. Haerses Road Quarry was granted development consent (DA 165-7-2005) by the Minister for Planning in 2006. The development consent provides for the extraction of 250,000 tonnes per annum (tpa) for a period of 25 years. The Quarry extracts sand from the Tertiary Maroota Sand deposit.

Due to the recent increases in demand for medium to coarse grain sands and specialist sands in the Sydney market, Dixon Sand is seeking to modify the development consent for the Haerses Road Quarry to increase the extraction area to target a friable sandstone resource and to extend the life of the quarry. The friable sandstone resource will expand the suite of sand products provided by Hearses Road Quarry, assisting to meet this market demand.

Approval for the proposed changes (the Modification) is being sought by Dixon Sand under Section 75W of the *Environmental Planning and Assessment Act 1979*.

The Modification

The Modification involves increasing the extraction area to quarry a friable sandstone resource in addition to the tertiary sand deposit as well as including provision of additional plant and equipment at the site to provide for the processing of the friable sandstone and tertiary material. The key components of the Modification include:

- new 30 year quarry life from 2016 to 2046 based on the extent of the available resource
- increasing the extraction area by approximately 19 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039 (refer to **Figure 1.3**). The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader
- addition of mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening using the existing dry screening plant
- addition of a mobile wet plant to wash the crushed friable sandstone and tertiary material to remove clay fines from the sand product. This will allow processing at the Hearses Road site as opposed to necessarily having to transport it to the Dixon Sand's Old Northern Road Quarry for processing

- importation of up to 100,000 tpa of clean recycled Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM). The VENM and ENM would be reprocessed by blending with product from either the Haerses Road Quarry or Old Northern Road Quarry prior to sale . VENM or ENM would also be used to achieve the final landform where there is a shortfall in overburden or fines from the washing process

- utilise the existing approved traffic movements between Old Northern Road and Hearses Road quarries to allow for blending of speciality sands, including VENM and ENM. No new traffic movements would be generated by the proposed modification and there would be negligible change to traffic generation between quarries as a result of the Modification

- use of mobile washing and processing plant on site, utilising water from existing water licence provisions

- installation of additional detention basins and associated water management infrastructure

- establishment of site office, workshop and weighbridge

- progressive rehabilitation of the proposed additional extraction area.

Need and Benefit of the Modification

The modified quarry would provide a long-term, high quality supply of construction materials into the Sydney local and regional markets. This supply is needed to replace supply from existing quarries that are nearing the end of their resources and will contribute to the security and economic viability of the Sydney construction industry along with supply to other key sand markets.

The Modification would result in a decrease in the number of truck movements through the township of Maroota and past Maroota Public School. The Modification would also increase employment at the site with up to eight full time jobs required.

There is no proposal to increase currently approved production rates and associated traffic movements to and from site, reducing the potential for changes in impacts from those currently approved.

Broad Overview of Environment Impacts

This Environmental Assessment (EA) includes a detailed assessment of the potential environmental and social impacts of the Modification and identifies the management and mitigation measures that will be implemented as part of the Modification. A brief summary of the key findings of the assessment process is provided in **Table 1**.

Table 1 Summary of the Key Environmental Impact Assessment Findings

Environmental issues	Overview of Potential Impacts
Groundwater	Groundwater monitoring data was used to establish groundwater elevations for the Maroota Tertiary Sands Groundwater Source (MTSGS) and the Sydney Central Basin Groundwater Source (SCBGS). The highest recorded water level measured in each bore was used to develop a maximum potential extraction depth. The maximum extraction depth represents an elevation of two metres above the wet weather groundwater level sources. The Modification has been designed to avoid impacts on groundwater by not impacting on the MTSGS and by staying a minimum of two metres above the wet weather groundwater level of the SCBGS. The Groundwater Assessment found that: • the proposed extraction area remains entirely in the unsaturated zone and will not result in capture of groundwater • the MTSGS and SCBGS will not be intercepted during quarrying operations • there will be no interference with neighbouring bores • no groundwater supply works are being carried out as part of the Modification.
Surface Water	To manage potential water quality impacts on downstream watercourses and users throughout the life of the quarry, it is proposed to maintain the approved water management system for the quarry and install additional sediment basins and associated drains to manage dirty water from the proposed new extraction area. The Modification is predicted to have negligible potential impacts on water quality on downstream watercourses due to the proposed proper design, installation and maintenance of water management infrastructure in accordance with Landcom's *Managing Urban Stormwater Soils and Construction Volume 1 and Volume 2e – Mines and Quarries* (the Blue Book) (2004). Water balance modelling indicates that the Modification will not result in any water discharges from site during an average rainfall year. This is consistent with existing quarry operations where no water discharges have occurred from the operations. The water management system catchment area for Haerses Road Quarry would increase to 0.9 per cent of the total catchment area of Little Cattai Creek (as compared to 0.7 per cent for the existing operations), as such it is considered that the Modification will have negligible impact on annual flow volumes or flooding in Little Cattai Creek.

Environmental issues	Overview of Potential Impacts
Noise	Noise modelling was carried out for representative worst case scenarios. Noise levels during early near surface level extraction in Cells 1 and 3 were predicted to marginally exceed the consent noise limits by 1 dB(A) at two receiver locations to the west of the proposed extraction area. Similar noise levels are expected in Cell 2. This minor degree of exceedance would barely be perceptible. Similar noise levels are expected during clearing and pre-stripping operations. In Cell 4 and Cell 5, noise levels during at surface and early near surface level extraction (and later stages of pre-stripping when carried out behind the bund wall) are predicted to marginally exceed the noise limits by up to 2 dB(A) at the nearest receivers. Reasonable and feasible mitigation measures have been incorporated into the design of the Modification. Noise levels will progressively reduce as the extraction pit depth is increased. Road traffic noise levels are predicted to comply with the nominated Road Noise Policy noise criteria during both day and night periods.
Air quality	Dust emissions during operation of the modified quarry have been estimated based on activities and equipment that would be operating at the site. The results for the incremental increases from the Modification on an annual and worst case operational basis, when added to the background concentrations are below the respective EPA criteria for all of the potential pollutants (PM10, PM2.5, total suspended particulates and dust deposition). The results for the cumulative assessment indicate that there is potential for a maximum of four additional exceedances of the cumulative 24-hour PM_{10} impact assessment criteria of 50 µg/m^3 per year for the most affected receiver. If the worst day operations happened to coincide with already elevated background concentrations, the relevant criteria may be exceeded. However this outcome is considered unlikely to occur. For the cumulative 24-Hour PM2.5 the result indicate that the Modification would be unlikely to result in any days over the impact assessment criteria of 25 µg/m^3, and that the Modification would have a very minimal impact on current $PM_{2.5}$ concentrations.

Environmental issues	Overview of Potential Impacts
Ecology	A detailed Biodiversity Assessment Report (BAR) was prepared to assess the potential ecological impacts of the Modification using the Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (FBA). The proposed extraction area supports 0.08 hectares of Coastal Upland Swamp(s) which is listed under the *Threatened Species conservation Act 1995* (TSC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Modification has been designed to avoid a larger area of this community that occurs to the north of the Modification disturbance area. Threatened species that were identified within the modification disturbance area are: • *Darwinia biflora* • *Grevillea parviflora* subsp. *supplicans* • *Tetratheca glandulosa* • Dural woodland snail (*Pommerhelix duralensis*) • Eastern pygmy-possum (*Cercartetus nanus*) • large-eared pied bat (*Chalinolobus dwyeri*) • little bentwing-bat (*Miniopterus australis*). The BioBanking Credit Calculator (Major Project Assessment Type) was used to determine the credits required for the Modification. In summary, the Modification requires 962 ecosystem credits and 2581 Species credits. Dixon Sand is committed to delivering a Biodiversity Offset Strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Modification. Firstly, Dixon Sand has sought to design the Modification to avoid and minimise ecological impacts in the project planning stage and a range of impact mitigation strategies have been included in the Modification to mitigate the impact on biodiversity values. Fulfilling offset requirements under the FBA will be undertaken using one or a combination of the following offset strategies: • on-site in-perpetuity conservation of applicable credits • offsetting through a site secured by a BioBanking Agreement • potentially securing required credits through the open credit market, off site, if required • if suitable offsets are unavailable, contributing money to supplementary measures in accordance with relevant conservation or recovery actions will be investigated. It is currently proposed that the biodiversity offset strategy will consist of the following: • establishment of proponent-managed offset sites at Haerses Road and Porters Road • purchase of credits from the Biodiversity Credits Register for the residual credits that need to be retired.

Environmental issues	Overview of Potential Impacts
Traffic and transport	The Modification would not change the total traffic movements for the quarry. The ability to transport a greater proportion of product, potentially all product, direct to market would result in a decrease in truck numbers on Old Northern Road passing Maroota Public School and the township of Maroota. The key intersections potentially affected by the Modification are the T intersection of Haerses Road with Wisemans Ferry Road and Wisemans Ferry Road with Old Northern Road. Observations on site show that both of these intersections operate very well with no delays for the majority of traffic movements. Traffic turning into or out of the side road typically did not need to stop and the only delay was that associated with manoeuvring through the intersection. A Sidra intersection analysis has been completed at the intersection of Old Northern Road and Wisemans Ferry Road and the analysis confirms that the intersection operates very well with negligible delays and congestion. All movements have Level of Service A and the delays are less than 7 seconds for all movements. It is considered that the intersection of Haerses Road and Wisemans Ferry Road would operate to a similar level of service and delays. With no increase to the truck numbers at this location the intersection will continue to operate at this level of service.
Visual amenity	Based on topography only (i.e. no allowance for screening vegetation) an assessment of the visual catchment indicates that the additional extraction area would be visible for a small number of residences to the west of the site located on the southern side of Wisemans Ferry Road. Taking into account screening vegetation it is likely that only those residences with an existing view of the approved Stage 5 quarry operations at Haerses Road Quarry would also have views, or partial views, of the additional extraction area. As the additional extraction area is down slope of the currently operational Stage 5 this would generally appear as a continuation of the existing operational area with very similar visual characteristics. Similarly, based on topography only (i.e. no allowance for screening vegetation) there is the potential that some residences to the east of the site may have views to the proposed processing area. This would represent a fairly minor change to the existing situation where the mobile screening plant may be located within any part of the active stages of the approved operations and would also be potentially visible. The weighbridge and car parking area (12 spaces) would be adjacent to Haerses Road and be of minor visual impact and will not be visually inconsistent with the existing built elements in this area.
Aboriginal heritage	An Aboriginal Cultural Heritage and Archaeological Assessment (ACHAA) has been undertaken for the Modification in compliance with the Office of Environment and Heritage (OEH) *Aboriginal Cultural Heritage Consultation Requirements (ACHCRs) for Proponents* (2010). No Aboriginal artefacts were identified during the survey of the Modification disturbance area that was undertaken with four Aboriginal party representatives. No areas of Potential Archaeological Deposit (PAD) were identified during the survey. The proposed extraction area is considered to have low archaeological potential based on a number of factors including: the landforms are not suitable for camping, soils are skeletal and unlikely to retain archaeological deposit; and water sources in the immediate vicinity of the proposed extraction area are ephemeral at best and would not support prolonged occupation.

Further details of the predicted environmental and social impacts of the Modification are provided in the main text of this EA and associated technical reports. The EA includes commitments by Dixon Sand to the implementation of management, mitigation and offset measures to minimise the predicted impacts of the Modification.

Conclusion

The Modification has been assessed against the principles of ecologically sustainable development (ESD) as required by the NSW *Environmental Planning and Assessment Act 1979*. This assessment has indicated that the Modification is consistent with the principles of ESD.

On considering the balance of the potential impacts of the Modification on the environment and community, and the benefits of and the need for the proposed changes, it would be reasonable to consider that with the implementation of the management, mitigation and offset measures proposed by Dixon Sand the benefits of the Modification outweigh the impacts.

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1.0 Introduction

Dixon Sand (Penrith) Pty Limited (Dixon Sand) operates the Haerses Road Quarry located on Haerses Road at Maroota, NSW (refer to **Figure 1.1**). Haerses Road Quarry was granted development consent (DA 165-7-2005) under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) by the Minister for Planning on 14 February 2006. The development consent provides for the extraction of 250,000 tonnes per annum (tpa) for a period of 25 years. The Quarry extracts sand from the Tertiary Maroota Sand deposit.

Due to the recent increase in demand for medium to coarse grain sands and specialist sands in the Sydney market, Dixon Sand is seeking to modify the development consent for the Haerses Road Quarry to increase the extraction area to target a friable sandstone resource. The friable sandstone resource will expand the suite of sand products provided by Hearses Road Quarry, assisting to meet this market demand. Dixon Sand also propose some other changes to the approved quarry operations as discussed in **Section 1.1**.

Dixon Sand has consulted with the Department of Planning and Environment (DP&E) in regard to the proposed modification and is seeking approval to modify the development consent under Section 75W of the EP&A Act, to provide for the proposed changes. This Environmental Assessment (EA) has been prepared by Umwelt (Australia) Pty Limited (Umwelt) on behalf of Dixon Sand to assess the potential environmental and social impacts associated with the proposed modification. The EA will be a supporting document to the modification application lodged with DP&E.

1.1 Overview of the Proposed Modification

Dixon Sand has been operating the Haerses Road Quarry (the site) since consent was granted in 2006 (refer to **Figure 1.2**). The resource contains a Tertiary deposit of fluvial and eluvial sediments that are suited for use as concrete and specialty sands (ERM, 2005).

The development consent currently allows for extraction of 7 million tonnes from the site over 25 years at a rate of 250,000 tonnes per annum (tpa). The consent allows for hauling of 190,000 tpa of screened sand to the processing facility at Dixon Sand's Old Northern Road Quarry located approximately two kilometres to the north, and hauling of 60,000 tpa of screened sand direct to local and regional markets.

The proposed modification involves increasing the extraction area to quarry a friable sandstone resource in addition to the tertiary sand deposit as well as including provision of additional plant and equipment at the site to provide for the processing of the friable sandstone and tertiary material. The key components of the proposed modification (the Modification) include:

- new 30 year quarry life from 2016 to 2046 based on the extent of the available resource
- increasing the extraction area by approximately 19 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039 (refer to **Figure 1.3**). The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader
- addition of mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening using the existing dry screening plant
- addition of a mobile wet plant to wash the crushed friable sandstone and tertiary material to remove clay fines from the sand product. This will allow processing at the Hearses Road site as opposed to necessarily having to transport it to the Dixon Sand's Old Northern Road Quarry for processing

- importation of up to 100,000 tpa of clean recycled Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM). The VENM and ENM would be reprocessed by blending with product from either the Haerses Road Quarry or Old Northern Road Quarry prior to sale. VENM or ENM would also be used to achieve the final landform where there is a shortfall in overburden or fines from the washing process

- utilise the existing approved traffic movements between Old Northern Road and Hearses Road quarries to allow for blending of speciality sands, including VENM and ENM. No new traffic movements would be generated by the proposed modification and there would be negligible change to traffic generation between quarries as a result of the modification

- use of mobile washing and processing plant on site, utilising water from existing water licence provisions

- installation of additional detention basins and associated water management infrastructure

- establishment of site office, workshop and weighbridge

- progressive rehabilitation of the proposed additional extraction area.

Haerses Road Quarry operates 7am to 6pm, Monday to Saturday, with vehicle access to and from the site and loading activities permitted from 6am. There is no change proposed to the operating hours as part of the Modification.

The modification would not change the annual production volume of the quarry and would require no increase in total truck movements. A community benefit of the Modification is that it would result in a reduction in the number of truck movements past the township of Maroota and Maroota Public School. Dixon Sand has a good environmental and community record over the 10 years of operation of its two Maroota quarries. An existing Community Consultative Committee is in operation for its two quarries and Dixon Sand is committed to working with the community representatives to achieve the best possible workable outcomes.

1.2 Site Context

1.2.1 Environmental Setting and Land Use

Quarry operations at the site commenced in 2006 with Stage 1 of the five approved stages (refer to **Figure 1.4**). The Stage 1 area contains fine sands which are suitable for blending with other coursers grains extracted from the site. As such, Stage 1 will remain open throughout the life of the quarry or until the resource in this area is completed. Currently, Stages 1 and 2 are open with Stage 1 approximately 60% complete and Stage 2 approximately 30% complete.

Prior to the commencement of quarrying activities, the site was used for orchards and growing horticultural crops with parts of the site consisting of native vegetation. There were previously five dwellings located along Haerses Road. There are now three dwellings along the northern part of Haerses Road as well as one former dwelling house which is now used as the Dixon Sand Haerses Road Quarry site office. These land uses currently continue within the site in addition to the quarrying operations.

The friable sandstone resource proposed to be extracted covers the portion of the site to the west and south of the approved extraction area, as shown in **Figure 1.3**. This area currently consist of dense native vegetation, some cleared land and a dam currently used as part of the site's water management system.



Image Source: Google Earth (2014)

0 0.5 1.0 2.0km

1:50 000

Legend

Haerses Road Quarry Site

FIGURE 1.1

Locality Map

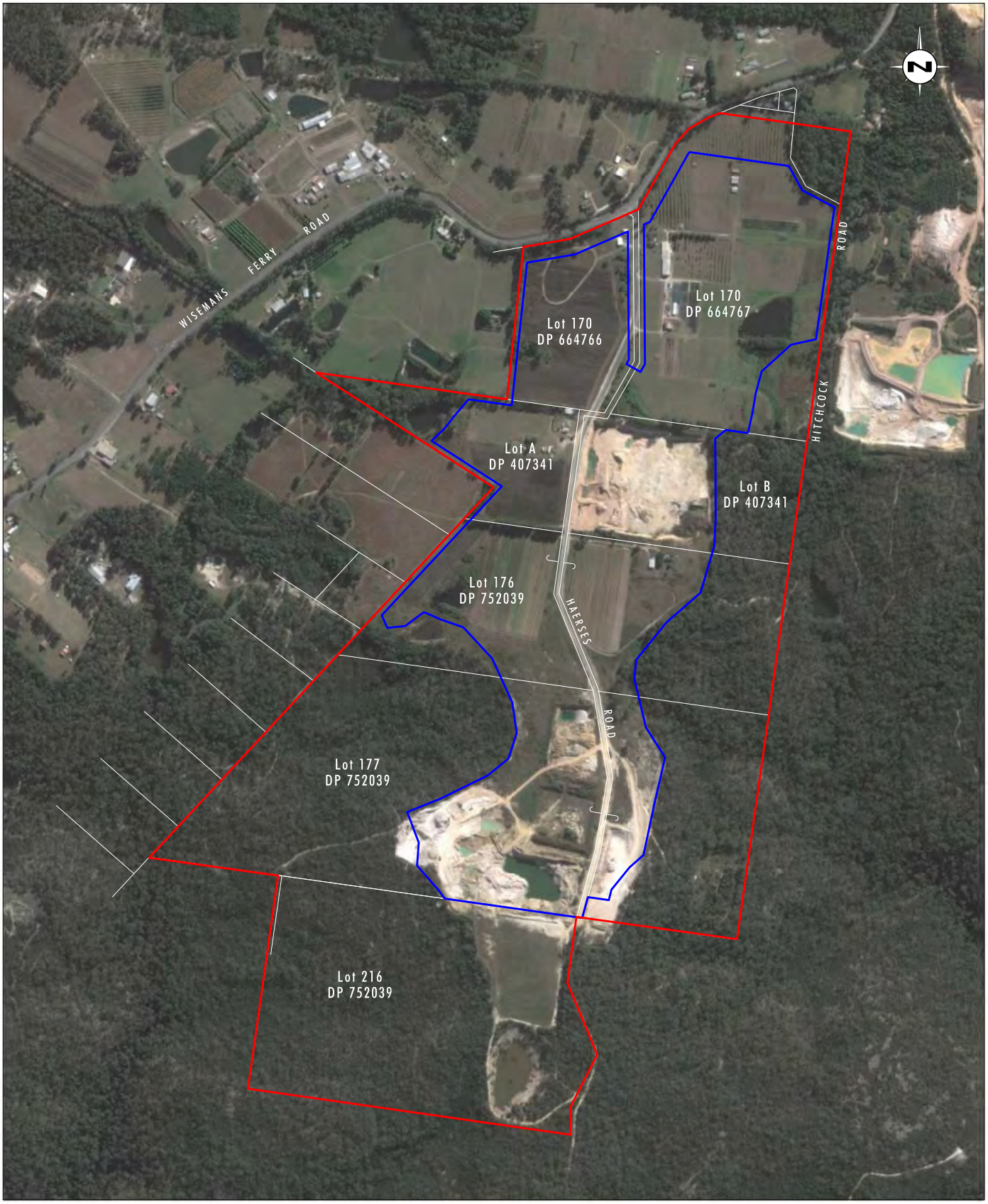


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area

FIGURE 1.2

Haerses Road Quarry Site

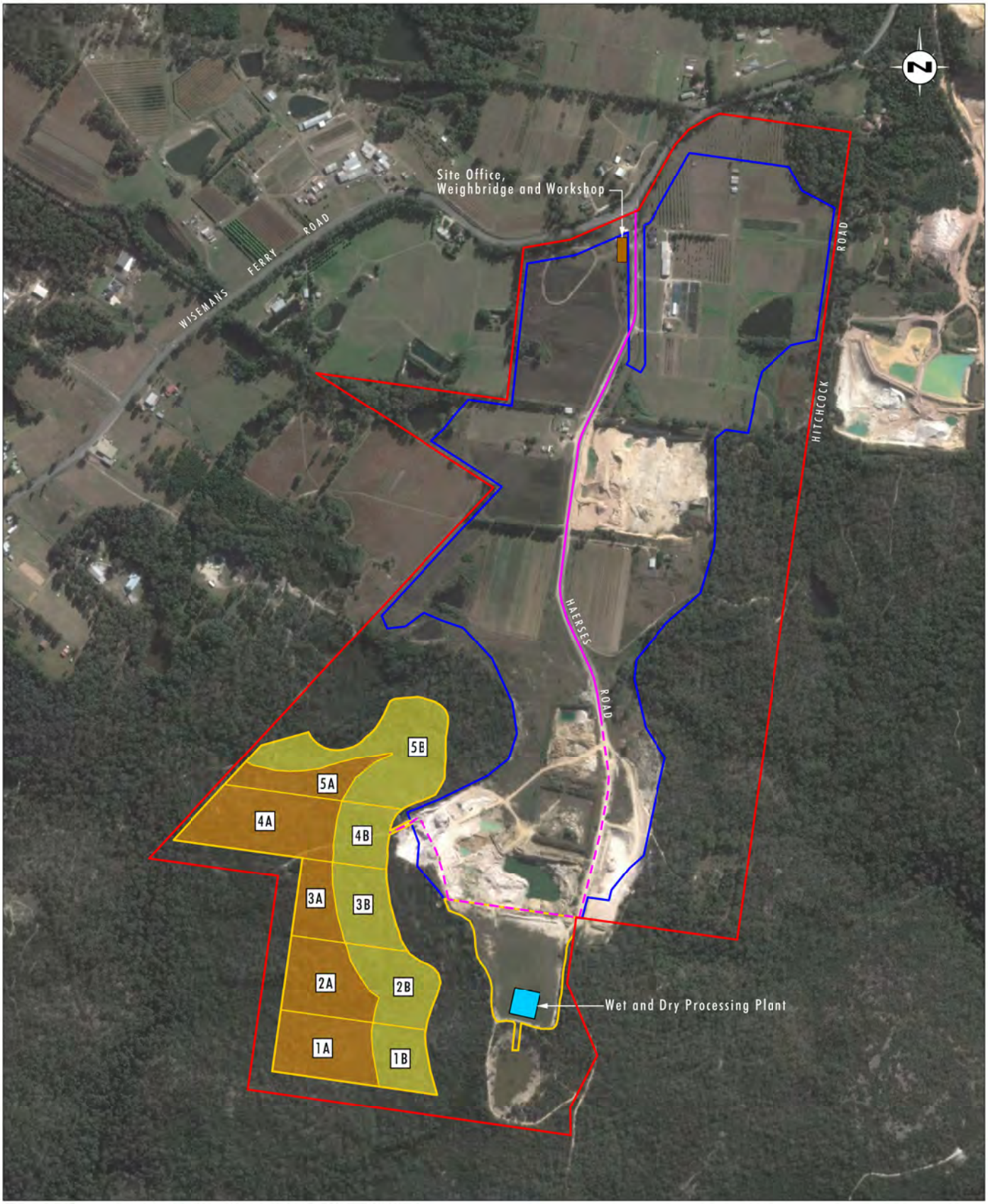


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Proposed Extraction Area A
- Proposed Extraction Area B
- [1] Extraction Cell Number
- Site Office, Weighbridge and Workshop
- Wet Processing Plant
- Indicative Unsealed Haul Road
- Sealed Haul Road

FIGURE 1.3

Proposed Modification

File Name (A4): R05/3479_058.dgn
20160922 10.28

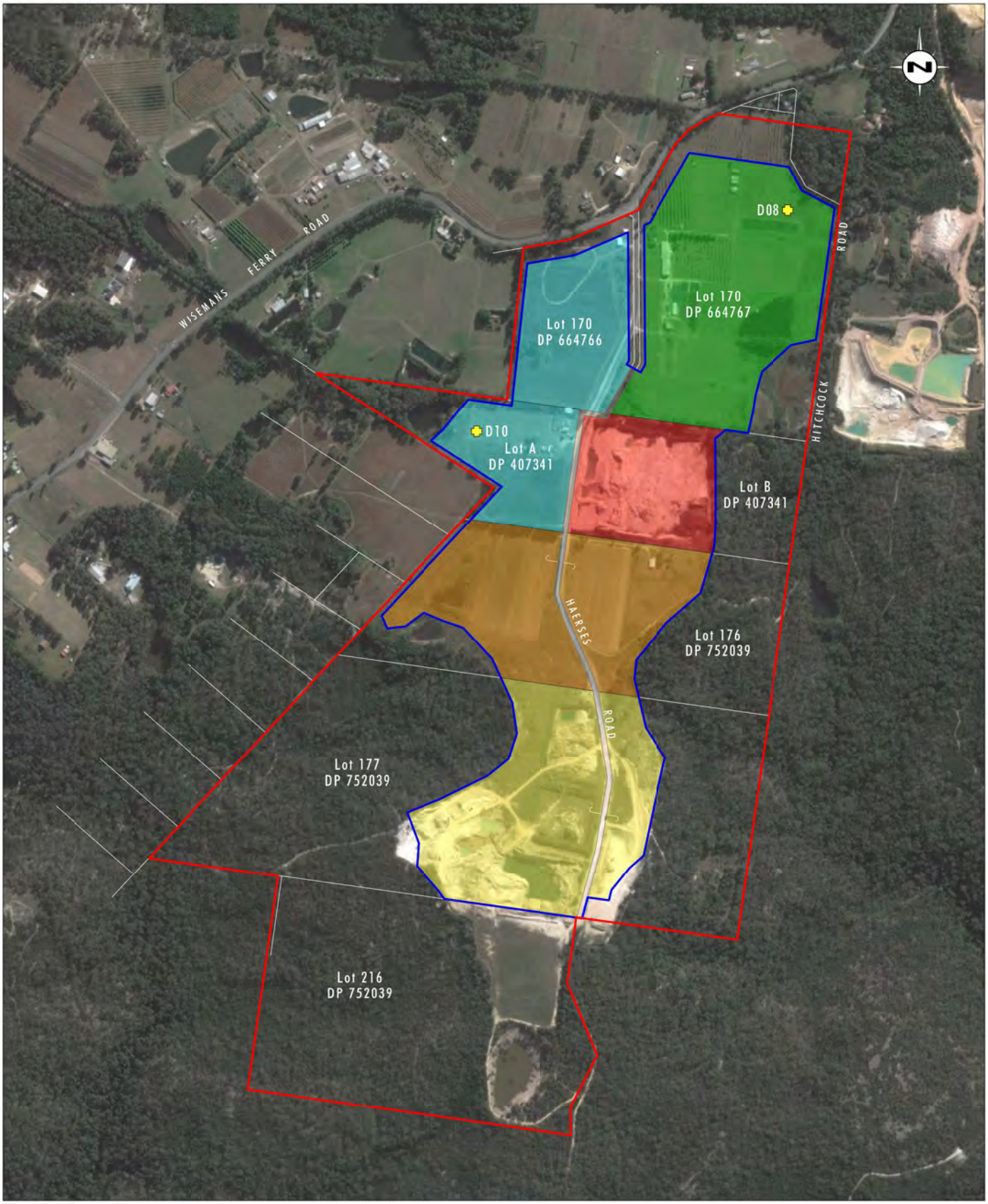


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Stages
- Proposed Extraction Area Stage 1
- Proposed Extraction Area Stage 2
- Proposed Extraction Area Stage 3
- Proposed Extraction Area Stage 4
- Proposed Extraction Area Stage 5
- Static Dust Gauge

FIGURE 1.4

Haerses Road Quarry
Approved Stages

File Name (A4): R05/3479_063.dgn
20160922 10.30

There are two key aquifers of relevance to the Modification: the Maroota Tertiary Sands Groundwater Source (MTSGS) with occurs in the tertiary sand deposit; and the Sydney Central Basin Groundwater Source (SCBGS) which occurs in the Hawkesbury Sandstone. The wet weather elevation of the SCBGS (and extraction depth) is lower than the wet weather elevation of the MTSGS, which is perched some 40 metres above the regional aquifer of the SBCGS.

The predominant land uses within the vicinity of the site are rural residential properties along Wisemans Ferry Road and Old Northern Road with bushland associated with the Deerubbin Local Aboriginal Land Council (LALC) property to the south and east of the site.

The site is located on the south western outskirts of the rural community of Maroota, which supports a small rural residential population of 291 people (Census, 2011). The Maroota Public School is located approximately 1.6 kilometres to the north of the site. Other small rural communities located in the region include South Maroota, which is located approximately 4 kilometres south west of the site and Wisemans Ferry, which is located approximately 9 kilometres north of the site.

Haerses Road Quarry is a substantial distance from any major residential areas. The closest being Windsor located approximately 21 kilometres to the south west, Rouse Hill located approximately 24 kilometres to the south south-west and Hornsby located approximately 27 kilometres to the south east.

The land uses in the local area include fruit orchards, market gardens, quarries, grazing of livestock and rural residential properties. The surrounding region is a significant area for quarrying, with at least five sand/sandstone quarries located within the local area. Specifically, the site is located in proximity to the following sand/sandstone quarries:

- Maroota Sandstone Quarry Australia – located approximately 5.4 kilometres to the west of the site
- P.F. Formation, Pits 3 and 5 – located approximately 4.0 kilometres to the north of the site
- P.F. Formation, Old Telegraph Road Sand Extraction – located 2.5 kilometres to the north east of the site
- Dixon Sand, Old Northern Road Quarry – located approximately 2.0 kilometres to the north of the site
- Hodgson Quarries and Plant, Roberts Road Quarry – located approximately 1.0 kilometres to the east north-east of the site
- P.F. Formation, Hitchcock Road Sand Extraction – located adjacent to the northern part of the site on the eastern side.

The site is located within the catchment of Little Cattai Creek with surface runoff from the Modification area draining to the west to a tributary of Little Cattai Creek. To the south of the site Little Cattai Creek flows in a southerly then westerly direction before joining the Hawkesbury River approximately 11 kilometres to the south west of the site.

The topography of the Hearses Road Quarry site consists of a north/south aligned ridge on which Haerses Road is located with the land sloping away to the east and west (refer **Figure 1.5**). Within the site Haerses Road is at an elevation of approximately 190 metres sloping away to the west to the lowest point within the site of approximately 110 metres.

1.2.1 Existing Conservation and Management Areas

As part of the conditions of consent for the modified Old Northern Road Quarry, Dixon Sand identified a biodiversity offset area within the south eastern portion of the Haerses Road Quarry site. The biodiversity offset area, shown in **Figure 1.6**, has been approved by OEH and is 8.7 hectares in size. The Modification will not encroach on this area.

1.3 Land Ownership

Dixon Sand owns all of the land within the Haerses Road Quarry site, being Lot 170 DP 664766, Lot 170 DP 664767, Lots A and B DP 407341, and Lots 176, 177 and 216 DP 752039. The Modification area is entirely contained within the existing site owned by Dixon Sand. The Modification would not require any works outside of the existing site boundary.

The land immediately surrounding the site generally consists of privately owned rural residential lots, with other quarrying operations to the north, east and west and the Deerubbin LALC property (formally the Maroota State Forest) to the south and west.

1.4 Project Team

This EA was prepared by Umwelt on behalf of Dixon Sand. Studies contributing to and included in the EA were undertaken by a number of technical specialists, including:

- Aboriginal Cultural Heritage Assessment – Umwelt
- Air Quality Assessment – Pacific Environment
- Ecological Impact Assessment – Umwelt
- Groundwater Assessment – Australian Groundwater Technologies
- Traffic Impact Assessment – SECA Solutions.

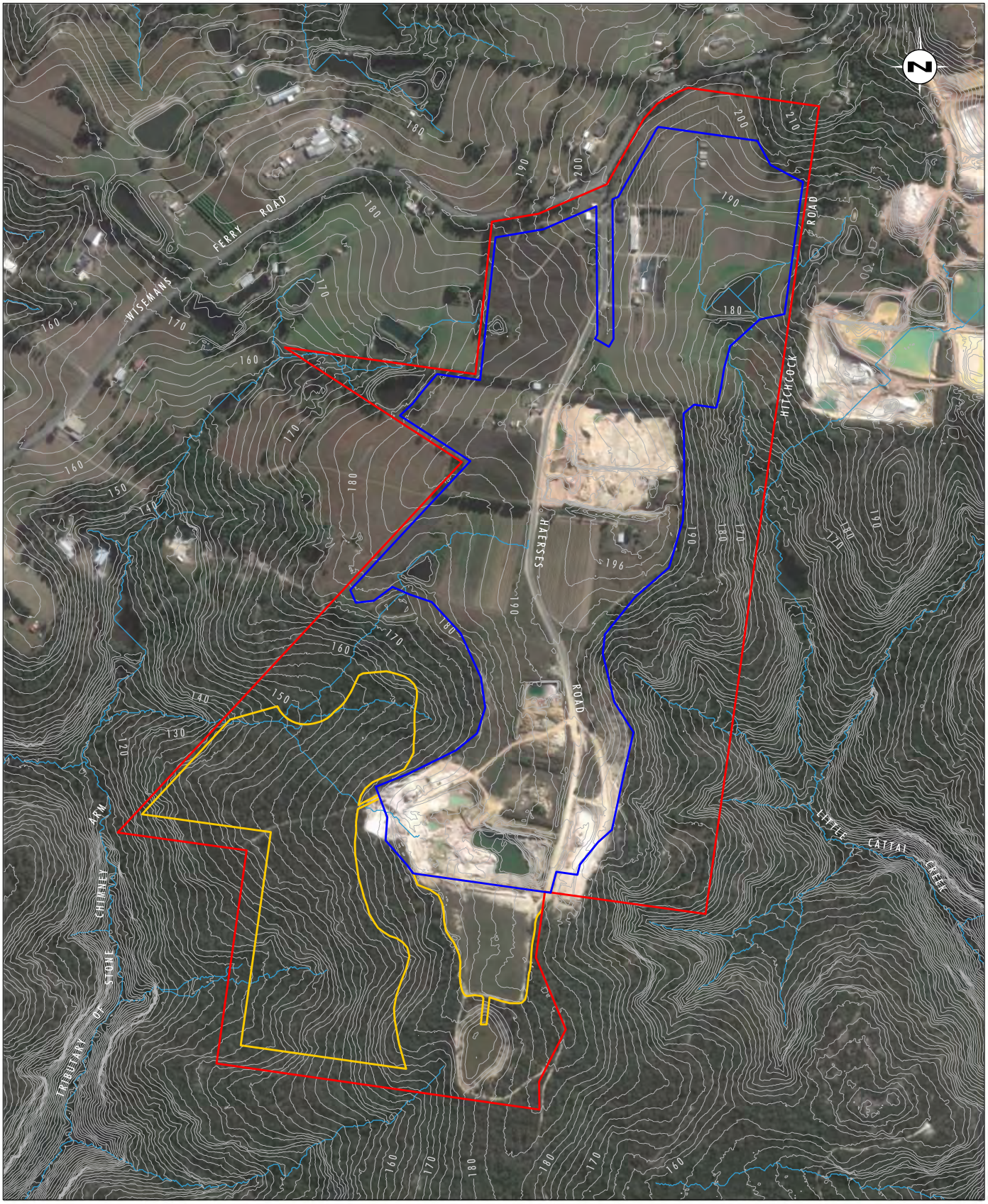


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)
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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Drainage Line

FIGURE 1.5

Haerses Road Quarry
Topography and Drainage Lines

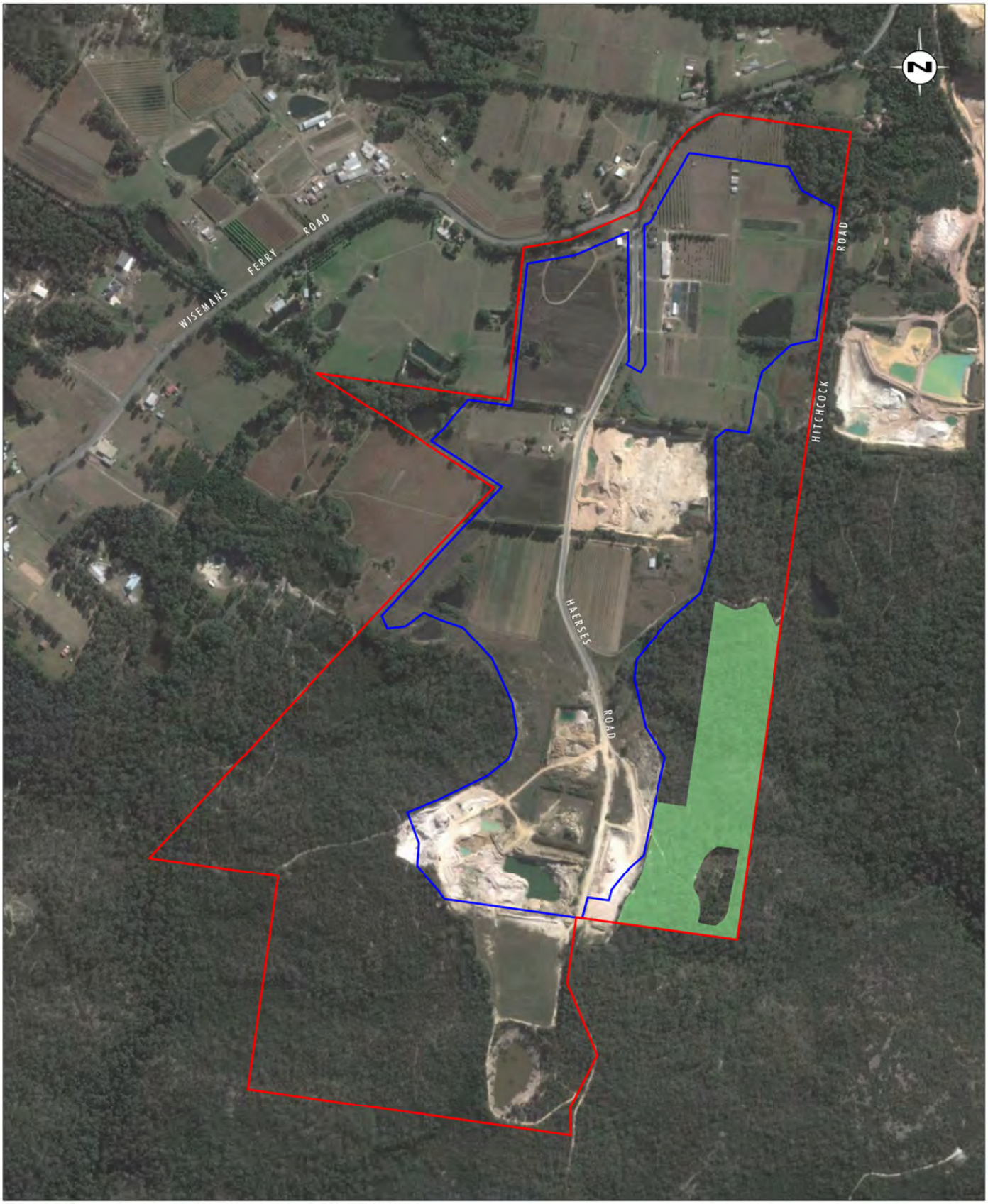


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Biodiversity Offset Area for Old Northern Road Quarry

FIGURE 1.6

Biodiversity Offset Area

1.5 Environmental Assessment Structure

The EA has been prepared in accordance with the EP&A Act and the *Environmental Planning and Assessment Regulation 2000* (refer to the EA Statement of Authorship in **Appendix 1**). An overview of the structure of this EA is provided below.

The Executive Summary provides a brief overview of the Modification and the major outcomes of the EA.

Section 1.0 introduces the Modification, outlines the background, provides a summary of the key details of the Modification, and outlines the EA project team and the EA structure.

Section 2.0 contains a description of the existing and approved site operations, including current consents and other statutory approvals.

Section 3.0 provides a detailed description of the Modification, as well as alternatives considered in the design of the Modification.

Section 4.0 outlines the planning and approvals context for the Modification, including the applicability of Commonwealth and State legislation.

Section 5.0 describes the stakeholder consultation and details the environmental and community issues identified as part of this process for consideration in the EA.

Section 6.0 identifies the key environmental and community issues and provides analysis and assessment of these issues relevant to the Modification, including the project specific and cumulative impacts.

Section 7.0 sets out a summary of the environmental management measures (including monitoring) proposed to be adopted throughout the life of the Modification in order to mitigate potential impacts.

Section 8.0 summarises the key conclusions arising from the detailed environmental assessment, discusses the justification for the Modification and sets out how it is consistent with the principles of ecologically sustainable development.

Section 9.0 lists references cited in the EA.

2.0 Existing Operations

2.1 Existing Approvals

In July 2005, Dixon Sand lodged a development application and accompanying Environmental Impact Statement (EIS) (ERM, 2005) with the then Department of Infrastructure, Planning and Natural Resources (DIPNR) (now DP&E) for determination by the Minister for Planning. The project was classed as a State Significant Development. Development Consent was granted for the project on 14 February 2006 approving the sand quarry to operate at up to 250,000 tpa over an operational period of 25 years (until 14 February 2031).

Since the original approval, there have been no modifications to this consent.

Dixon Sands also hold several other environmental and operational approvals which apply to Haerses Road Quarry. These are outlined in **Table 2.1**.

Table 2.1 Legislation and Policies Relevant to the Quarry

Planning Provisions	Comments	Approval Details
Protection of the Environment Operations Act 1997	Dixon Sand holds an Environment Protection Licence (EPL) for the existing operations.	EPL No. 12513
Roads Act 1993	Dixon Sand obtained agreement from The Hills Shire Council for upgrade works to Haerses Road which were required prior to commencing operations at the quarry.	Section 138 of Roads Act

2.2 Approved Operations at Haerses Road Quarry

The development consent provides for the operation of a sand quarry with total extraction of 7 million tonnes from the site over 25 years at a rate of 250,000 tonnes per annum (tpa).

Key components of the approved operations include:

- undertaking extraction in five stages, with each stage being progressively extracted and rehabilitated with the exception being Stage 1, which is the first stage and will remain operational for the life of the quarry
- progressively extracting and reinstating Haerses Road, which runs through the site, so that access is maintained during the life of the quarry
- removing coarse rejects on site using a mobile screen
- hauling of 190,000 tpa of screened sand to Dixon Sand's nearby Old Northern Road Quarry
- hauling of 60,000 tpa of screened sand direct to local and regional markets

- using facilities and land at the Old Northern Road Quarry for sand processing and tailings disposal
- rehabilitating the site to class 4 agricultural land.

The approved operation hours for all quarry activities is Monday to Saturday 7am to 6pm. Vehicle access to the site and sand loading into vehicles is also permitted 6am to 7am Monday to Saturday. There is no work at any time on Sundays or public holidays.

The quarry currently employs four full time staff.

The approved extraction area is shown in **Figure 1.2**. The quarrying process used at Haerses Road Quarry consists of several principal stages as follows:

- clearing and topsoil stripping (stockpiling or using vegetation for rehabilitation as required)
- overburden removal and emplacement
- quarrying using front end loader and dozer to load material to either truck or mobile screen
- processing the extracted sand through a mobile screen to remove oversize material
- transport of material to Old Northern Road Quarry for processing or direct to market
- progressive rehabilitation of the quarry pit and other areas affected by quarrying operations.

2.3 Existing Environmental Management System

Haerses Road Quarry has an established environmental management system (EMS) which comprises of an Environmental Management Strategy, a range of environmental management plans (EMPs) and an environmental monitoring program. The Strategy provides the strategic context for the environmental management of the quarry, while the EMPs provide detail on the management of key environmental issues. The EMS and EMPs have been developed in accordance with the conditions of the Hearses Road development consent.

As the Modification would be a continuation of the existing Haerses Road Quarry operations, ongoing implementation of the Haerses Road Quarry EMS would be the most efficient and effective way of managing site operations. The existing EMS will therefore be updated to reflect the changes associated with the Modification and implemented for the ongoing operations, pending approval of the Modification.

The key existing EMPs for Haerses Road Quarry that will assist in the management of operations undertaken as part of the Modification include:

- Noise Management Plan – provides a framework for the management of noise including procedures, monitoring and reporting requirements
- Air Quality Management Plan – provides a framework for the management and monitoring of dust, particulate matter and total suspended particulates including procedures and reporting requirements
- Groundwater Management Plan – provides a framework for the management of groundwater including depth of extraction, groundwater quality monitoring and reporting requirements

- Site Water Management Plan – provides an overarching framework for the management of water on site, including surface water management and monitoring and erosion and sediment controls

- Rehabilitation and Landscape Management Plan – outlines the approach to quarry rehabilitation and describes in detail the rehabilitation processes and the approach to managing the ecological and landscape values of the site.

Details of how these plans will be updated and applied to the Modification, are discussed in the relevant environmental assessment section of this report (refer to **Section 6.0**).

3.0 Description of the Proposed Modification

3.1 Need for the Modification

As a result of the recent increase in demand for medium to coarse grain sands and specialist sands in the Sydney market, Dixon Sand is seeking to modify the existing Haerses Road Quarry development consent to increase the extraction area and to increase the volume of sand sold direct to market from the site. There is no proposal to increase currently approved production rates and associated traffic movements to and from site.

The modified quarry would provide a long-term, high quality supply of construction materials into the Sydney local and regional markets. This supply is needed to replace supply from existing quarries that are nearing the end of their resources and will contribute to the security and economic viability of the Sydney construction industry along with supply to other key sand markets.

3.2 Key Features of the Modification

The Modification involves extracting friable sandstone in addition the currently approved extraction of the tertiary sand deposit and increased on site processing capacity. Other key elements of the proposed modifications include:

- new 30 year quarry life from 2016 to 2046 based on the extent of available resource
- increasing the extraction area by approximately 19 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039 (refer to **Figure 1.3**). The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader
- addition of mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening using the existing dry screening plant
- addition of a mobile wet plant to wash the crushed friable sandstone and tertiary material to remove clay fines from the sand product. This will allow processing at the Hearses Road site as opposed to necessarily having to transport it to the Dixon Sand's Old Northern Road Quarry for processing
- importation of up to 100,000 tpa of clean recycled Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM). The VENM and ENM would be reprocessed by blending with product from either the Haerses Road Quarry or Old Northern Road Quarry prior to sale. VENM or ENM would also be used to achieve the final landform where there is a shortfall in overburden or fines from the washing process
- utilise the existing approved traffic movements between Old Northern Road and Hearses Road quarries to allow for blending of speciality sands, including VENM and ENM. No new traffic movements would be generated by the proposed modification and there would be negligible change to traffic generation between quarries as a result of the modification
- use of mobile washing and processing plant on site, utilising water from existing water licence provisions
- installation of additional detention basins and associated water management infrastructure

- establishment of site office, workshop and weighbridge
- progressive rehabilitation of the proposed additional extraction area.

Table 3.1 provides a comparison between the approved quarry and the Modification. The Modification disturbance area is shown in **Figure 1.3** and consists of the proposed extraction area and the cleared area incorporating the wet and dry processing area which includes temporary stockpiling and truck turning areas.

Table 3.1 Comparison of the Currently Approved Haerses Road Quarry and the Modification

Quarry Components	Currently Approved	Proposed Modifications
Quarry life	Quarry operations to cease 14 February 2031	Additional fifteen years. Quarry operations to cease 2046
Limit on production	250,000 tpa	No change
Maximum transport of product	To Old Northern Road Quarry	
	190,000 tpa	No change
	Direct to market	
	60,000 tpa	Increase flexibility to allow all of the 250,000 tpa to be delivered direct to market
Truck movements	28 truck movements into Haerses Road per day (10 movements allowed between 6am and 7am). 28 truck movements out of Haerses Road per day (0 – 7 left hand turns, 21 – 28 right hand turns).	No change to inbound movements. Flexibility for up to 28 left hand turns out of Haerses Road (product direct to market).
Total disturbance footprint	As shown on **Figure 1.2** (approximately 52 hectares)	As shown on **Figure 1.3** No change to approved tertiary sand extraction area. Increase of extraction area of 19 hectares to extract friable sandstone deposit within 5 cells to be opened and rehabilitated progressively. An additional 3.5 hectare cleared area will be used as the wet and dry processing area including temporary stockpiling and truck turning areas.
Overburden	Used for acoustic barriers or stockpiled and used to fill voids	No change.
Importation of material	Not included in approved operations	Receival of up to 100,000 tpa of clean recycled sands (VENM, ENM) for reprocessing and sale using existing truck movements

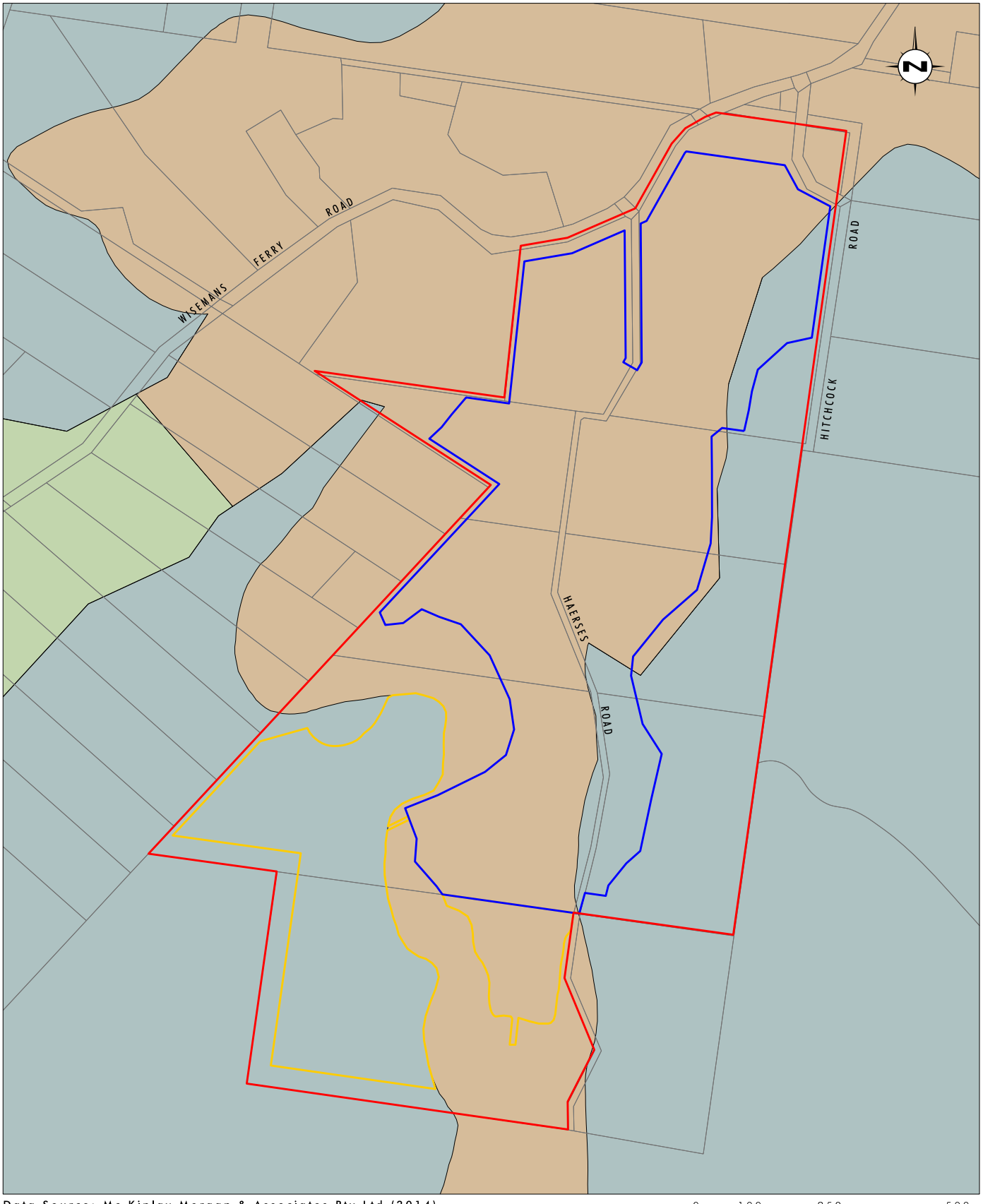
Quarry Components	Currently Approved	Proposed Modifications
Infrastructure	Haerses Road is key haul road with existing dams used for water supply	No change to haul road and water supply. The existing house immediately to the south east of the intersection of Haerses Road and Wisemans Ferry Road to be converted to site office. Ancillary to this, construction of site workshop, weighbridge and gravel car parking area (8 staff plus 4 visitor spaces). See Table 3.2 for more detail.
Equipment	Front end loader (1), 40 tonne Excavator, 30 tonne trucks (2), water cart (1), mobile dry screen, dozer (periodically), grader (irregularly), service vehicle (irregularly)	Additional mobile jaw and rotary crushers and wet processing plant
Hours of operation	Monday to Saturday 7am to 6pm. Vehicle access and sand loading 6am to 7am Monday to Saturday. No work on Sundays and public holidays	No change
Employment	Equivalent to two people full time	Up to eight people full time

3.3 Geology and Target Resource Description

Haerses Road Quarry currently quarries a tertiary deposit of fluvial and eluvial sediments that produce sand products that are suited for use as concrete and specialty sands. This sand deposit occurs along a ridgeline which broadly follows the alignment of Haerses Road (refer to **Figure 3.1**). The sand deposit sits on top of Hawkesbury Sandstone which was deposited in the Triassic and is a massive, homogeneous quartz arenite with a fine to coarse matrix (Bureau of Mineral Resources, 1961). As shown on **Figure 3.1**, the Hawkesbury Sandstone also surrounds the tertiary sand deposit on the site.

The Hawkesbury Sandstone is the target resource of a number of the local sandstone quarries including Dixon Sand's Old Northern Road Quarry and is the target of the additional quarrying area sought as part of the Modification. This deposit is well understood in the Maroota area and produces a range of suitable sand and sandstone products.

Based on an extraction area two metres above the wet weather groundwater level there is approximately 15 million tonnes of friable sandstone within the proposed 19 hectare extraction area. This comprises approximately nine million tonnes within Extraction Area A and six million tonnes within Extraction Area B (the 100 metre buffer zone of the MTSGS).



Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014), Mineral Resources NSW, December 2003

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Tertiary (Sand, silt, clay & gravel)
- Bringelly Shale, Minchinbury Sandstone, Ashfield Shale
- Hawksbury Sandstone

FIGURE 3.1

Geology

File Name (A4): R05/3479_057.dgn
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3.3.1 Groundwater Resources and Wet Weather Groundwater Elevation

A key driver for the design of the additional extraction area was avoidance of impacts on groundwater. There are two key aquifers of relevance to the Modification: the Maroota Tertiary Sands Groundwater Source (MTSGS) with occurs in the tertiary sand deposit; and the Sydney Central Basin Groundwater Source (SCBGS) which occurs in the Hawkesbury Sandstone.

Groundwater monitoring data was used to establish groundwater elevations for the MTSGS, using data since 2005, and for the SCBGS using data since 2011. The highest recorded water level measured in each bore from the monitoring network was used to determine the maximum extraction depth. The maximum extraction depth is set at an elevation of two metres above the wet weather groundwater level.

The wet weather elevation of the SCBGS (and extraction depth) is lower than the wet weather elevation of the MTSGS, which is perched some 40 metres above the regional aquifer of the SBCGS. The potential for groundwater seepages from the MTSGS to the proposed extraction cells in the Hawkesbury Sandstone will be managed by the adoption of a 100 metre buffer from the western boundary of the MTSGS. No extraction would be undertaken within the 100 metre buffer of the MTSGS until two additional monitoring bores within the western margin of the MTSGS have been established and monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS. The decision to commence quarrying in this area will be undertaken in consultation with DPI Water and with the approval of DPE. The proposed buffer zone is shown on **Figure 6.1** and on a cross section of the site (**Figure 6.2**). The buffer zone consists of the low permeability Hawkesbury sandstone.

The maximum extraction depth within the friable sandstone resource of the proposed extraction area, based on the wet weather elevation of the borehole network of the site is between 118.15 and 133.5 metres Australian Height Datum (mAHD) from east to west respectively.

3.4 Conceptual Quarry Design

The Modification does not involve any changes to the approved extraction area or process for the tertiary sand deposit approved to be quarried at Hearses Road Quarry. The proposed additional extraction area will be quarried concurrently with the existing tertiary deposit, however, as the same plant and equipment would be used for both the existing approved extraction area and the proposed extraction area, extraction operations would only ever occur within either the existing approved extraction area or within the proposed extraction area, never both at the same time. For this reason the maximum production from Hearses Road Quarry is proposed to remain at the currently approved 250,000 tpa.

As discussed in **Section 3.3.1**, avoidance of impacts on groundwater was a key design criteria for the Modification and the initial extent of the conceptual quarry pit design was modified in response to groundwater investigations and information from Department of Primary Industries (DPI) Water clarifying the extent of the MTSGS. The eastern extent of the proposed modification extraction area was reduced to avoid the underlying MTSGS. Following ecological investigations, the proposed extraction area was further revised to avoid impact on an endangered ecological community, including provision of a buffer area.

The proposed additional extraction area is approximately 19 hectares in size, inclusive of the 100 metre buffer to the MTSGS, and would be extracted progressively in five cells (**Figure 1.3**) from south to north. Initially the 'A' portion of each cell which is outside of the 100 metre buffer of the MTSGS would be fully extracted and then extraction of the 'B' portion of the cell would only commence if groundwater monitoring results indicate this could be undertaken with no impact to the MTSGS. The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader. The dozer would be used to rip the friable sandstone, a process which is not currently required within the existing Tertiary sand deposit at the site.

Cell 1 would be extracted with material hauled to the wet and dry processing plant location. Upon completion of Cell 1, the pit excavation would be used as a silt/sediment storage dam. This would occur within the first five years of operation of the Modification, subject to resource demand. The wet and dry processing plant would be installed within the existing cleared area to the east of the proposed extraction pit (refer to **Figure 1.3**).

The wet and dry processing plant would be located at the furthest point practicable from sensitive receivers while being in proximity to the existing dam for water supply. The wet processing plant would be operated once the silt/tailings emplacement area within Cell 1 is installed to provide for emplacement of fines generated by the washing process. Tailings from the wet processing plant would be emplaced in cells in the extracted area and progressively dried and rehabilitated to achieve the final landform in the extracted cells.

Extraction would continue in a similar fashion in a south to north direction for the remainder of the cells. Extraction in Cell 2 would commenced following completion of extraction in Cell 1. The final landform levels for Cell 1 would be achieved using tailings from the wet processing plant from the extraction of Cells 1 and 2 as required. The silt pond in Cell 1 would be capped and rehabilitated using stockpiled overburden and topsoil.

Once the final landform levels are established in Cell 1, vegetation from Cell 3 would be translocated to Cell 1 to achieve final rehabilitation. Extraction in Cell 4 would not commence until rehabilitation in Cell 1 was complete. This process would continue so that cells are progressively rehabilitated south to north in sequential stages.

3.5 Site Infrastructure

The proposed changes to the approved quarry infrastructure include some additional plant and equipment and converting an existing dwelling into a site office with associated weighbridge and workshop. Through the quarry concept design process the opportunity was identified to incorporate additional plant and equipment to reduce the need for double handling of product when material is transported from Haerses Road Quarry to Old Northern Road Quarry for processing prior to transport to market. Currently much of the sand extracted from the site is taken by truck to the Old Northern Road Quarry for processing resulting in numerous truck movements between the two quarries (passing the Maroota town and Maroota Public School) and double handling of materials. The addition of processing plant at Hearses Road Quarry will allow for a greater proportion (and potentially all) product to be delivered direct to market to significantly reduce truck movements through Maroota and Maroota Public School and provide for significant operational efficiencies, whilst not changing the total number of truck movements from the site.

The proposed changes to the site infrastructure are identified in **Table 3.2**. As the Modification is implemented, some further minor refinements of the layout of the indicative site infrastructure may occur as part of the engineering design and construction process, however, these minor refinements will not result in changes to the components, overall location or impacts of the site infrastructure. Further detail on the key changes proposed is provided in **Sections 3.4.1** to **3.4.5**.

Table 3.2 Proposed Modifications to Haerses Road Quarry Site Infrastructure

Project component	Details of Modification
Site Access	No change
Unsealed haul roads	Additional haul roads will be constructed as required from the five extraction cells to Haerses Road. **Figure 1.3** shows the indicative alignment of the haul roads.
Mobile screen	Currently used on site as part of approved operations. To be used at the wet and dry processing plant area (refer **Figure 1.3**).
Additional plant and equipment	• Mobile jaw crusher to break up hard patches of sandstone rock fragments into sand (on an intermittent basis where required) • Mobile rotary crusher to break up hard patches of sandstone rock fragments into sand (on an intermittent basis where required) • Basic wet processing plant consisting of cyclone tanks and pumps. The mobile crushers will typically be located adjacent to the wet processing area. The wet processing plant will be located in cleared area to the east of the proposed extraction area (**Figure 1.3**).
Water management system	Three additional sediment basins and associated drains.
Site office	An existing dwelling on Haerses road is currently used as the Haerses Road site office. The existing dwelling within the northern part of the site, located immediately to the south west of the intersection of Haerses Road and Wisemans Ferry Road, will be converted to a site office with amenities for workers. This dwelling currently has electrical and sewerage connection.
Workshop	A new workshop will be constructed adjacent to the site office (current dwelling) to allow equipment maintenance to be undertaken on site.
Weighbridge	A weighbridge will be constructed adjacent to the site office and workshop.

3.5.1 Unsealed Haul Roads

The haul roads required to transport material from the five cells of the proposed extraction area to the wet processing plant or onto Haerses Road would be constructed as needed as extraction progresses from Cell 1 through to Cell 5. The haul roads would be unsealed, two way gravel roads incorporating drainage design to ensure runoff is directed to controlled areas. The haul roads would be managed for dust suppression using the water cart on an as needs basis.

3.5.2 Mobile Screen

The existing mobile screen that operates within the approved extraction area would also be utilised for material from the proposed extraction area. The screen will be moved between the approved extraction area and the wet and dry processing plant location shown in **Figure 1.3** as required.

3.5.3 Additional Plant and Equipment

The friable sandstone resource within the proposed extraction area may require crushing prior to screening which necessitates the addition of both jaw and rotary crushers. The crushers will be located at the wet and dry processing plant location (refer **Figure 1.3**) with material to be hauled from the pit to the processing area for crushing, screening and washing.

3.5.4 Water Management System

The proposed approach to the water management system for the Modification is consistent with the current water management strategies and will utilise the majority of the infrastructure of the existing water management system with the addition of three new sediment basins and associated drains as required.

As part of the Modification, the following improvements to the water management system are proposed:

- three additional sediment basins located in the south west, west and north west corners of the proposed extraction area to manage dirty water runoff from the stages of the Modification as extraction progresses
- additional dirty water drains at the boundaries of the extraction areas to assist in directing dirty water to the appropriate sediment basins during all phases of the extraction process
- additional clean water drains to intercept runoff from the upslope catchment and convey runoff around the disturbed areas.

The proposed drains and sediment basins will assist in managing upslope runoff from the clean catchment areas upslope of the existing water management system. The additional quarry pit will incorporate a sump so that dirty water can be collected and recycled.

3.5.5 Site Office, Workshop and Weighbridge

A site office, workshop and weighbridge are proposed in the northern part of the site immediately adjacent to Haerses Road (refer **Figure 1.3**). The Modification would allow greater processing of product within the Haerses Road site and a larger proportion of product to be sold direct to market from the site. To facilitate this, a site office with amenities for staff is required. Currently any maintenance of plant and equipment is undertaken at the Old Northern Road Quarry site. The proposed workshop will allow maintenance to be undertaken at the Haerses Road site without the requirement of transporting plant or equipment to the Old Northern Road Quarry site. The workshop would be approximately 20 metres by 24 metres and constructed of Colourbond material.

The Modification would allow increased movement of product direct from the site to market. Currently product going from the Haerses Road site direct to market is weighed via a weight cell fitted to the front end loader. With the potential for a substantially greater volume of product going directly from the Haerses Road site as a result of the Modification, a weighbridge provides a far more efficient method of determining the amount of product leaving the site.

3.6 Transport of Product

The proposed Modification does not seek to alter the overall number of truck movements in and out of the Haerses Road Quarry site, but rather may alter the potential truck movement patterns in and out of the site. The proposed Modification involves the following:

- Maximum of 250,000 tpa exiting the site (no change to current consent)
- Up to a maximum of 250,000 tpa direct to market (increase from current consent of 60,000 tpa)
- Up to a maximum of 190,000 tpa to exit site to Old Northern Road site (no change to current consent)
- Up to 100,000 tpa of VENM / ENM to site for processing.

The 100,000 tonnes of VENM / ENM will be transported to the site in trucks that are currently entering the site empty to pick up a load for removal of product to either the Old Northern Road Quarry or to market.

The modification does not seek to alter the overall number of truck movements in and out of the site (28 per day), but rather seeks to alter the potential truck movement patterns which currently restrict trucks to a maximum of 7 trucks movements to the south-west (left out of Haerses Road) per day and increase this to a maximum of 28 per day. If the 28 truck movements per day turn left out of the site, there will be no trucks turning right out of the site, which is currently restricted to 28 per day maximum.

3.7 Quarry Rehabilitation and Final Landform

In accordance with Condition 22 of Schedule 3 of the Haerses Road Quarry development consent, a detailed Rehabilitation and Landscape Management Plan has been prepared for the quarry. This plan provides a detailed description of the planned approach to rehabilitation of the quarry, focusing on the rehabilitation of the approved extraction area. Aspects of the Modification that will require a revision of the rehabilitation strategy outlined in the Rehabilitation and Landscape Management Plan include the additional extraction area, the wet and dry processing area, new water management features and the overall increase to the disturbance footprint.

A key aim of the rehabilitation strategy is to provide for progressive rehabilitation of disturbed areas once activities in these areas are complete. The Rehabilitation and Landscape Management Plan provides a detailed description of the strategies that will be used to rehabilitate the areas disturbed by quarrying operations. These strategies will be applied to the modified aspects of the projects outlined above including:

- clearing and rehabilitation - cleared vegetation and topsoil from one strip would be transferred directly for use in the rehabilitation of a previously extracted strip
- topsoil management - the top 100 to 300 millimetres of soil will be stripped immediately prior to extraction and applied directly over areas to be rehabilitated. In the event that a rehabilitation area is not ready for topsoil spreading, the topsoil will be stockpiled temporarily (typically less than 12 months) away from drainage lines
- revegetation techniques and species – the approved extraction area will generally be rehabilitated to agricultural land using a pasture mix. The additional extraction area will be rehabilitated to native vegetation using local native species
- drainage lines - stands of native vegetation will be progressively re-established within the drainage lines to stabilise soil and slow runoff into dams and waterways.

The Rehabilitation and Landscape Management Plan includes a conceptual final rehabilitation plan for the quarry. A revised conceptual final rehabilitation plan for the proposed modifications to the approved quarry is included as **Figure 6.21**.

Should the proposed modification be approved, the Rehabilitation and Landscape Management Plan will be updated to incorporate the proposed modifications.

3.8 Alternatives and Justification

3.8.1 Alternatives

Initially the proposed Modification incorporated an extraction area larger than the currently proposed 19 hectares. The proposed extraction area was refined based on groundwater investigations to ensure avoidance of impacts on the MTSGS and SCBGS. The size of the proposed extraction area was further refined to assist in reducing impacts to threatened species and ecological communities within the site and to allow for the incorporation of an on-site offset area for the protection of the Coastal Upland Swamp endangered ecological community (refer to **Section 6.7.2**).

The other key alternative that requires consideration in regard to the proposed Modification is the 'do nothing' alternative, that is, proceeding with the quarry as currently approved and not proceeding with the proposed Modification. This alternative is not considered desirable as this would result in a high quality resource of medium to coarse grain sands and specialist sands located near to Sydney not being available for the Sydney market which has recently seen an increase in demand for these products. It would also result in the underutilisation of a site already subject to quarrying.

It is acknowledged that the quarry could continue without the proposed changes, however, the changes provide benefits to the Sydney region construction sand market and they can be undertaken without resulting in significant environmental impacts on the community as identified in this environmental assessment. In these circumstances, it is considered that the 'do nothing' alternative is not an appropriate alternative.

3.8.2 Justification for the Proposed Modification

The quarry will provide a long-term, high quality supply of construction sand into the Sydney region market. This supply is needed to meet the increased demand within Sydney and will contribute to the security of supply to the Sydney region sand market. There is a shortage of sand in the Sydney market due to the recent closure of sand quarries such as Penrith Lakes as well as other quarries such as Kurnell not being extended. Part of the shortfall can be sourced from regional quarries around Newcastle and the Southern Highlands however these locations have associated increased transport distances and associated haulage costs and road safety issues. The extension of the quarrying area and life of operation of the Haerses Road quarry would provide a local resource close to the Sydney metropolitan market and transport links. A high level resource assessment estimates that within the 19 hectare expansion area there is approximately 15 million tonne of friable sandstone.

The Haerses Road Quarry will also provide direct employment for the equivalent of 8 full time people with flow on indirect benefits within the local community.

The proposed Modifications to the quarry will not change any of the benefits of the quarry as identified in the EIS (ERM, 2005) and as demonstrated in this EA, will not result in significant environmental impact on the community.

4.0 Planning Considerations

The following section identifies relevant State and Commonwealth legislation and discusses the application of these planning provisions to the Modification.

4.1 Commonwealth Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the primary environmental and planning regulatory instrument relevant to the Modification at a Commonwealth level. The operation of the EPBC Act and its application to the Modification is discussed in **Section 4.1.1** below.

The *Native Title Act 1993* is administered by the National Native Title Tribunal. The Tribunal is responsible for maintaining a register of native title claimants and bodies to whom native title rights have been granted. The *Native Title Act 1993* prescribes that native title can be extinguished under certain circumstances, including the granting of freehold land.

The *Native Title Act 1993* is not directly relevant to the approval process for the Modification as the additional area consists entirely of freehold land.

4.1.1 Environmental Protection and Biodiversity Conservation Act 1999

Under the EPBC Act, approval by the Commonwealth Minister for the Environment is required for any action that may have a significant impact on matters of national environmental significance. These matters are:

- World Heritage properties
- National Heritage Places
- Wetlands of international importance (Ramsar wetlands)
- migratory species, threatened species, critical habitats or ecological communities listed in the EPBC Act
- Commonwealth land, marine areas or reserves
- nuclear actions
- a water resource in relation to coal seam gas development and large coal mining development.

The existing operations are not subject to an EPBC approval.

The Modification does not interact with any Commonwealth land, Commonwealth marine areas, the Great Barrier Reef Marine Park and is not a nuclear action, coal seam gas development or large coal mining development. The remaining potentially relevant matters have been considered in regard to the Modification.

Those aspects of the Modification requiring consideration under the EPBC Act were referred to the Commonwealth Department of the Environment (DoE) in November 2015 to determine whether or not it was a controlled action, thereby requiring approval of the Commonwealth Minister for the Environment. On 28 January 2016, the Modification was determined to be a Controlled Action requiring approval under the EPBC Act from the Commonwealth Minister for the Environment due to its potential impact on listed threatened species and communities, including:

- *Darwinia biflora*
- Coastal Upland Swamp in the Sydney Basin Bioregion.

A copy of the determination of the Modification as a Controlled Action is provided in **Appendix 2**. The assessment path for the Project is under the bilateral agreement between the Commonwealth and NSW Governments.

4.2 State Legislation

4.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act is administered by DP&E and by local government and is the primary legislation governing environmental planning and assessment for NSW. DP&E is responsible for State Significant Development which includes Haerses Road Quarry and is therefore the responsible agency for the Modification.

The objectives of the EP&A Act relevant to the Modification encourage:

- the proper management, development and conservation of natural and artificial resources
- the promotion and co-ordination of the orderly and economic use and development of land
- the protection of the environment
- ecologically sustainable development.

DA 165-7-2006-5 was granted under Part 4 of the EP&A Act in February 2006 and classified as State Significant Development. As the original consent was deemed a State Significant Development and granted under Part 4 of the EP&A Act during the transitional Part 3A arrangements, section 75W of the EP&A Act is available to modify DA 165-7-2006-5, as discussed below.

It is proposed to modify the existing development consent under the transitional arrangements applying with respect to Section 75W of the EP&A Act, which was repealed on 1 October 2011. Clause 8J(8) of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) prescribes how, in certain circumstances, a development consent can be modified under Section 75W of the EP&A Act. Clause 8J(8) relevantly provides:

> (8) For the purposes only of modification, the following development consents are taken to be approvals under Part 3A of the Act and section 75W of the Act applies to any modification of such a consent:
>
> (c) a development consent granted by the Minister under Part 4 of the Act (relating to State Significant Development) before 1 August 2005 or under clause 89 of Schedule 6 to the Act,
>
> ...
>
> The development consent, if so modified, does not become an approval under Part 3A of the Act.

The existing Haerses Road Quarry was granted under Part 4 of the EP&A Act in February 2006 and was subject to the savings and transitional provisions contained in clause 89 of Schedule 6 of the EP&A Act.

Part 3A of the EP&A Act has been repealed, however, Schedule 6A, Clause 12 of the EP&A Act provides for the continued operation of Section 75W in relation to the modification of the development consents referred to in Clause 8J(8) of the EP&A Regulation. Schedule 6A, Clause 12 of the EP&A Act states:

> **12 Continuing application of Part 3A to modifications of certain development consents**
>
> Section 75W of Part 3A continues to apply to modifications of the development consents referred to in clause 8J (8) of the Environmental Planning and Assessment Regulation 2000, and so applies whether an application for modification is made before or after the commencement of this clause.

Section 75W is therefore considered the appropriate approval pathway for the Modification. The Minister for Planning is the consent authority for the Modification. This approval pathway was confirmed by DP&E in an email to Umwelt dated 25 August 2016.

4.2.1.1 Permissibility

The local environmental planning instrument relevant to the Modification is *The Hills Local Environment Plan 2012* (LEP). The LEP applies to The Hills local government area (LGA).

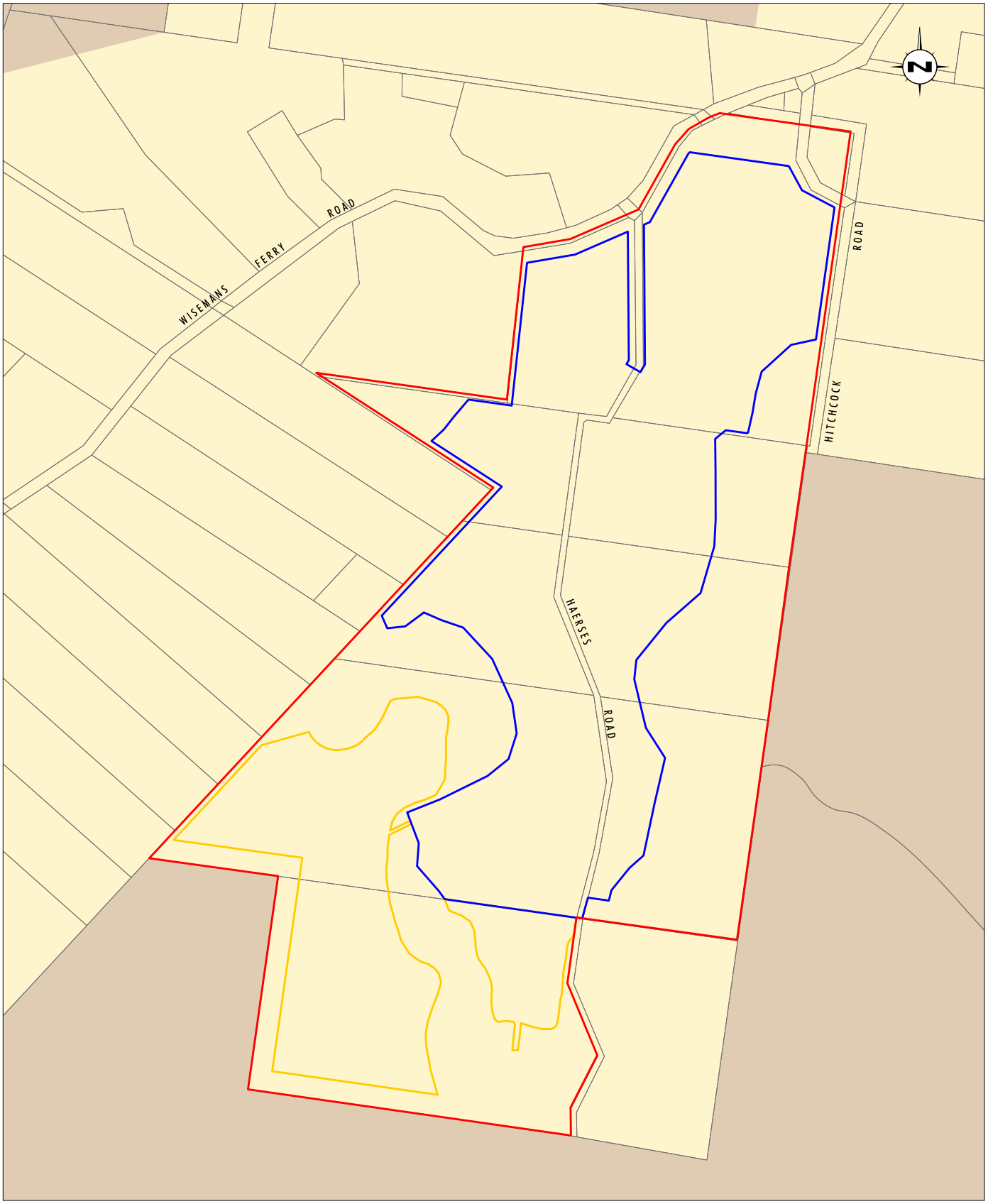
The entire site is zoned RU1 Primary Production (**Figure 4.1**). The objectives of the RU1 zone is:

- to encourage sustainable primary industry production by maintaining and enhancing the natural resource base
- to encourage diversity in primary industry enterprises and systems appropriate for the area
- to minimise the fragmentation and alienation of resource lands
- to minimise conflict between land uses within this zone and land uses within adjoining zones
- to facilitate the economic extraction of materials from land and the subsequent rehabilitation of that land.

Extractive industries are permissible with development consent within land zoned RU1. As the development is permissible with consent, the Minister (or delegate) can approve the carrying out of the Modification.

4.2.2 Summary of Other State Legislation

A summary of the other State Acts potentially applicable to the Modification is included in **Table 4.1**, along with an indication of which additional approvals will be required.



Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014), Mineral Resources NSW, December 2003

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- RU1 - Primary Production
- RU2 Rural Landscape

FIGURE 4.1

Zoning

Table 4.1 Summary of Other Potentially Relevant State Legislation

Act	Comments	Approval Required
Protection of the Environment Operations Act 1997	Dixon Sands holds an Environment Protection Licence (EPL No. 12513) for the Haerses Road Quarry. Should the Modification be approved, the EPL will need to be modified to accommodate the proposed changes.	Yes
National Parks & Wildlife Act 1974	Aboriginal Heritage Impact Permits (AHIPs) are required under s87 and s90 of the *National Parks & Wildlife Act 1974* for Aboriginal sites proposed to be impacted by development. The site does not contain any identified Aboriginal archaeological sites and therefore there is currently no requirement to obtain specific approvals relating to Aboriginal cultural heritage.	No
Water Act 1912	This Act has been repealed by the *Water Management Act 2000*; however, some of the licensing provisions remain in force where the water source is not covered by a water sharing plan. The Haerses Road Quarry is within an area covered by a water sharing plan.	No
Water Management Act 2000	The site falls within the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* which commenced on 1 July 2011. As such, surface water within the catchment is managed under the *Water Management Act 2000*. All water extractions from water sources (surface and groundwater) regulated by a Water Sharing Plan will require licensing under the *Water Management Act 2000* where they are in addition to extractions permitted under harvestable rights. Dixon Sand currently holds two water licences for the purpose of irrigation for the Haerses Road site. As identified in **Section 6.4** of this report the water balance indicates that external water supply is unlikely to be required, however, if in the such as supply is required, application would be made to convert the licence to the applicable use (as required). A controlled activity approval is required to authorise its holder to carry out a controlled activity in, on or under waterfront land.	Yes

Act	Comments	Approval Required
	Waterfront land is defined as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark. There are two first order creek lines which run through the Modification Area and which will be quarried through, therefore a controlled activity approval will be required for the Modification.	
Threatened Species Conservation Act 1995	A licence under this Act is not required for any activity undertaken in accordance with a development consent granted under the EP&A Act and therefore no approvals are required.	No
Heritage Act 1912	No heritage sites will be affected and no s140 or s60 excavation permits are required under this Act for works associated with the Modification.	No
Roads Act 1993	The *Roads Act 1993* determines the rights of the public and adjacent land owners to use public roads, and establishes procedures for the opening and closing of public roads. Under the Act applications are required to be made for the closure of roads and for works in road reserves. No road closures or road works are proposed as part of the Modification.	No
Crown Lands Act 1989	The Crown Lands Act provides for the administration and management of Crown land in the eastern and central divisions of NSW. Crown land may not be occupied, used, sold, leased, dedicated, reserved or otherwise dealt with unless authorised by this Act or the *Crown Land (Continued Tenures) Act 1989*. As noted above, no road closures or road works are proposed as part of the Modification and no areas of Crown land would be affected.	No
Native Vegetation Act 2003	The provisions of this Act do not apply to any activity undertaken in accordance with a development application granted for designated development under the EP&A Act and therefore do not apply to the Modification.	No

Act	Comments	Approval Required
Environmentally Hazardous Chemicals Act 1985	Under the *Environmentally Hazardous Chemicals Act 1985* a licence is required for any storage, transport or use of prescribed chemicals. Dixon Sand does not propose to store, transport or use any chemicals currently subject to a Chemical Control Order (CCO) under this Act. Should such chemicals be required during the life of the Haerses Road Quarry operations, Dixon Sand will manage the chemicals in accordance with the relevant CCO, including obtaining any appropriate licences.	No

4.3 State Environmental Planning Policies

State Environmental Planning Policies (SEPPs) are environmental planning instruments created by the State government. The SEPPs that are potentially relevant to the Modification are discussed in the following section.

4.3.1 State Environmental Planning Polices (State and Regional Development) 2011

The State and Regional Development SEPP commenced on 1 October 2011, on the date Part 3A of the EP&A Act was repealed. The SEPP identifies development that is State Significant Development. Haerses Road Quarry, if a new proposed development, would be of a class of development listed as State Significant Development under the SEPP. As discussed in **Section 4.2.1**, as the original consent was deemed a State Significant Development and granted under Part 4 of the EP&A Act subject to the savings and transitional provisions contained in clause 89 of Schedule 6 of the EP&A Act, Section 75W of the EP&A Act is the appropriate approach to modify the existing consent.

4.3.2 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Extractive Industries SEPP)

The Extractive Industries SEPP regulates the permissibility and assessment requirements for mining, petroleum production and extractive industries and related development. The SEPP outlines where various extractive industry activities are permissible both with and without development consent. The SEPP also defines mining, petroleum production and extractive industries developments that are prohibited, exempt or complying developments.

Part 3 of the Extractive Industries SEPP requires specific matters to be considered in relation to development applications. These requirements are set out below:

Clause 12, extracted below, requires the consent authority to consider the compatibility of proposed developments with existing land uses in the area.

12 Compatibility of proposed mine, petroleum production or extractive industry with other land uses

Before determining an application for consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must:

(a) consider:

(i) the existing uses and approved uses of land in the vicinity of the development, and

(ii) whether or not the development is likely to have a significant impact on the uses that, in the opinion of the consent authority having regard to land use trends, are likely to be the preferred uses of land in the vicinity of the development, and

(iii) any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses, and

(b) evaluate and compare the respective public benefits of the development and the land uses referred to in paragraph (a) (i) and (ii), and

(c) evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a) (iii).

The Modification is a continuation of an existing approved operation which has been coexisting with neighbouring land uses for approximately 10 years. The key operational areas of the quarry have substantial buffer distances to sensitive surrounding land uses and the Modification, as designed, is considered to be broadly compatible with surrounding land uses. The compatibility of the Modification with surrounding land uses is considered in more detail in **Section 6.0**.

Clause 13 of the Extractive Industries SEPP requires the consent authority to consider the potential impact of proposed developments in the vicinity of an existing extractive industry operation or potential resources.

Surrounding land uses include agriculture, extractive industries and the rural residential areas of Maroota. Agricultural activities include orchards, market gardens and grazing, and are mostly restricted to the Maroota Ridge (ERM, 2005). Sand extraction has been a significant land use in the Maroota area since the 1980s. There are a number of sand quarries to the north and east of the site.

Given the distances between these extractive operations and Haerses Road Quarry, and the fact that Haerses Road Quarry is a currently approved operation, the Modification will not adversely impact upon or constrain these operations or their resources.

The Modification will not adversely impact on any known minerals or petroleum resources.

Environmental Management

Clause 14 of the Extractive Industries SEPP requires the consent authority to consider the impact of a proposed extractive industry project on natural resources and whether specific environmental management conditions should be imposed on the development if approved. The Modification's potential impact on natural resources, including those specifically referred to in Clause 14(1), (i.e. significant surface and groundwater resources; threatened species/biodiversity; greenhouse gas emissions) is addressed in detail in **Section 6.0**. Specific commitments regarding the management of potential environmental impacts are contained in **Section 7.0**, building on the controls in place for the existing Haerses Road Quarry via the development consent and management plans prepared in accordance with the consent.

Resource Recovery

Clause 15 of the Extractive Industries SEPP requires the consent authority to have regard to the efficiency of a proposed extractive industry development in terms of its ability to optimise extraction of the target resources. The Modification has been developed to facilitate the efficient recovery of extractive resources from within the proposed extraction area. This is discussed in more detail in **Section 3.0**.

Transport

Clause 16 of the Extractive Industries SEPP requires the consent authority to consider whether or not the proposed extractive industry development under consideration should be subject to conditions restricting the use of public roads for product transport or other related traffic. As detailed in **Section 3.0**, no new traffic movements would be generated by the Modification and there would be negligible change to traffic generation as a result of the proposed Modification.

Rehabilitation

Clause 17 of the Extractive Industries SEPP requires a authority determining a development application for a proposed extractive industry development to have regard to whether or not to impose specific conditions regarding the rehabilitation of land affected by the development. The areas disturbed by quarrying activity will be progressively rehabilitated as the Modification progresses. The approach to rehabilitation is dealt with in more detail in **Section 6.14**.

4.3.3 State Environmental Planning Policy 33 – Hazardous and Offensive Development

SEPP No. 33 – Hazardous and Offensive Development requires the consent authority to consider whether an industrial proposal is a potentially hazardous industry or a potentially offensive industry. The aim of this policy is to link the permissibility of a proposal to its safety and pollution control performance. The assessment process establishes whether the proposal is potentially hazardous or offensive and if this is not the case, SEPP 33 is not applicable.

The existing operations were determined, as part of the original approval process to not be a hazardous or offensive development. The proposed Modification will not result in any changes to the existing Haerses Road Quarry operations which would alter this classification. No further consideration of SEPP No. 33 is required.

4.3.4 State Environmental Planning Policy 44 – Koala Habitat Protection

SEPP No. 44 – Koala Habitat Protection applies to the extent that a consent authority is restricted from granting development consent for proposals on land identified as core koala habitat, without the preparation of a plan of management. There is no core koala habitat within the site therefore the further provisions of the SEPP do not apply.

4.3.5 State Environmental Planning Policy 55 – Remediation of Land

SEPP No. 55 – Remediation of Land aims to provide a state wide planning approach to the remediation of contaminated land, and to reduce the risk of harm to human health and the environment, by consideration of contaminated land as part of the planning process. Under the SEPP, a consent authority must not consent to the carrying out of development on land unless it has considered potential contamination issues.

There are no known areas of contaminated land within the site including no known contaminated areas associated with the existing operations. Therefore, SEPP 55 does not place any constraints on the Modification.

4.3.6 Sydney Regional Environmental Plan No 9—Extractive Industry (No 2—1995)

Sydney Regional Environmental Planning Policy No. 9 - Extractive industries (SREP 9) aims to:

- facilitate the development of extractive resources in proximity to the population of the Sydney Metropolitan Area by identifying land which contains extractive material of regional significance, and
- permit, with the consent of the council, development for the purpose of extractive industries on land described in Schedule 1 or 2, and
- ensure consideration is given to the impact of encroaching development on the ability of extractive industries to realise their full potential, and
- promote the carrying out of development for the purpose of extractive industries in an environmentally acceptable manner, and
- prohibit development for the purpose of extractive industry on the land described in Schedule 3 in the Macdonald, Colo, Hawkesbury and Nepean Rivers, being land which is environmentally sensitive.

Haerses Road Quarry is located within the land identified in Schedule 2 of SREP 9. As such, development for the purposes of extractive industries is to be permitted with council consent taking into account relevant environmental issues. However, as identified in **Section 4.2.1** the Minister for Planning is the consent authority for the Modification.

5.0 Stakeholder Consultation

Consultation for this proposed modification has been undertaken to inform stakeholders about the Modification, to obtain their views and identify any issues of concern to be investigated and addressed.

5.1 Authority Consultation

In regard to the proposed Modification, Dixon Sand and Umwelt met with DP&E in August 2015. At this meeting, Dixon Sand and Umwelt presented an overview of the status of the quarry development, the proposed modifications, planned approval pathway and approach to the environmental assessment.

Following this meeting a Background Scoping Document was prepared which accompanied the modification application. The Background Scoping Document detailed the proposed modifications and the approach to environmental impact assessment. Following DP&E review of the Background Scoping Document, Dixon Sand was advised that the Secretary's Environmental Assessment Requirements would not be issued for the Modification and that the assessment should proceed as detailed in the Background Scoping Document.

A teleconference with the Commonwealth DoE was held on 18 November 2015 to discuss the Modification and in particular the potential impact on Commonwealth listed threatened species and communities. Following this meeting a referral was prepared identifying the Modification as a controlled action. In February 2016 DoE confirmed that the Modification was a controlled action and that the Modification would be assessed in accordance with the Bilateral agreement under section 45 of the EPBC Act, specifically as a state significant development under Part 4 of the EP&A Act.

On 18 April a teleconference was held between OEH, DP&E, Dixon Sand and Umwelt. The purpose of the teleconference was to provide OEH with background to the Modification and the assessment and findings of the ecological investigations that had been undertaken at that time and the proposed approach to offsetting. Specifically, the assessment approach for the threatened plant *Darwinia biflora* was discussed in relation to the recent changes to OEH policy which allow certain species to be assessed on an area basis rather than on number of individuals basis.

Consultation was also undertaken with representatives of the local Aboriginal community as part of the Aboriginal archaeological and cultural heritage assessment process. Details of this consultation are presented in **Section 6.10**.

Dixon Sand sought a meeting with Department of Primary Industry Water (DPI Water) to discuss the groundwater assessment findings, however due to the timeframe for availability of DPI Water staff a meeting was unable to be held in a suitable timeframe to assist in the preparation of this report.

5.2 Community Consultation

Dixon Sand is committed to being a part of the Maroota community and has continued to consult with the local community regarding the Haerses Road and Old Northern Road quarries since 1991. Dixon Sand facilitate a bi-annual Community Consultation Committee for the Old Northern Road and Haerses Road quarries. The committee discusses environmental and community issues in relation to the quarries and the local area and include representatives from the local community, Maroota Public School, The Hills Council, DP&E, a bush regeneration group, the consultants that undertake the environmental monitoring and Dixon Sand management.

The key mechanism used for community involvement in relation to the proposed Modification was the distribution of a community consultation flyer to the Maroota community and surrounds. The community consultation flyer, attached as **Appendix 2**, provided details of the proposed modifications, the reasons for them and the environmental assessment process to be undertaken. The flyer also contained contact details so that members of the community could raise issues or request further information about the Modification.

Approximately 130 copies of the flyer were distributed in the immediate local area in April 2016. Copies were left in the letterbox of residences along Days Road, Wisemans Ferry Road, Haerses Road, Hitchcock Road and Old Northern Road. A copy of the flyer was sent to Maroota Public School.

At the time of preparing this report one response to the information flyer had been received. The respondent identified the following issues:

- Current and projected traffic numbers and routes
- Use of compression braking
- Potential impacts from dust generation and proposed mitigation measures
- Request for electronic copies of assessment documents.

A Dixon Sand representative has spoken with the respondent to organise a time to meet to discuss the Modification and the identified issues of concern. Dixon Sand have made several follow up attempts to organise a suitable time to meet, however, at the time of preparing this report the meeting has not yet taken place.

6.0 Environmental Assessment

6.1 Identification of Key Environmental and Community Issues

The key environment and community issues that need to be assessed in this EA have been identified through consideration of:

- the existing approved operations and description of the Modification (refer to **Sections 2.0** and **3.0**)
- the findings of the original 2006 EIS (ERM, 2006) and the background scoping document (Umwelt, 2015) prepared for this Modification
- the planning and environmental context for the locality (refer to **Sections 1.3**, **4.0** and **6.0**)
- the environmental risk analysis of potential environmental impacts associated with the Modification (refer to **Section 6.1.1**)
- feedback from the community and government agencies on the issues that they felt are relevant to the Modification and Haerses Road Quarry more generally (refer to **Section 5.2** and **Section 6.11**)
- the findings of baseline studies completed as part of preparation of the EA and the issues that were identified as requiring further assessment.

The issues identified as being relevant to the Modification are assessed in detail in the following sections.

6.1.1 Preliminary Environmental Risk Analysis

A preliminary environmental risk analysis was undertaken for the Modification to identify, from a technical perspective, the key environmental and community issues that are relevant to the Modification and the level of assessment of these issues that is required as part of the EA process.

The method used for the environmental risk analysis encompassed the following key steps:

- identify each element of the Modification
- identify the environmental and community aspects and potential impacts/risks associated with each element of the Modification in the context of the existing approved operations (that is, whether or not there is a change to the impacts approved as part of the existing approvals for the quarry)
- assess the potential scope of the impact/risk to determine the key issues requiring further assessment and the level of assessment required.

The outcomes of the preliminary environmental risk analysis are detailed in **Table 6.1**.

Table 6.1 Potential Environmental and Community Impacts Associated with the Modification

Environmental Aspect	Preliminary Environmental Assessment	Further Assessment Required?
Land use	The Modification would result in an area of existing bushland within the site being cleared for the proposed extraction area. This change from bushland to active quarry is in keeping with the approved land use of the site.	Yes, refer to **Section 6.2** for further detail.
Soils and agriculture	The Modification would result in an increase to the extraction area of approximately 19 ha with associated disturbance to topsoils. Soil erosion issues are addressed as part of the surface water assessment. Within the local area agricultural pursuits are generally restricted to the flat ridgetop land with side slopes and gullies generally consisting of areas of native vegetation. The existing horticultural pursuits undertaken on parts of the Haerses Road Quarry site all occur on the flat ridge top land that runs north-south through the site. The proposed extraction area is located on the side slope and is approximately 19 hectares in area and is not particularly suited for agricultural pursuits. The use of this land for extractive industry purposes is an appropriate and beneficial use of this land. It is considered that the potential impact on agriculture from the Modification is negligible.	No
Public Infrastructure	The modification would not result in any changes to public infrastructure. Haerses Road will be progressively reinstated after quarrying the resource beneath it in accordance with the existing approval. The modification does not require any change to public infrastructure.	No
Traffic	There will be no changes to the maximum production limit of the quarry, or the methods or volumes of transportation of quarry products from the site. The Modification seeks approval for a change in the distribution of traffic leaving the site, with the opportunity to transport a greater proportion of product direct to market from Haerses Road Quarry. This will divert truck movements away from the Maroota locality and reduce truck movements past the Maroota Public School.	Yes, refer to **Section 6.8** for further detail.

Environmental Aspect	Preliminary Environmental Assessment	Further Assessment Required?
Groundwater	The location and maximum depth of the quarry pit have been determined through groundwater investigations so that there will be no impact to the Maroota Tertiary Sands Groundwater Source or the Greater Sydney Basin Groundwater Source.	Yes, refer to **Section 6.3** for further detail.
Surface Water	Effective management of water as part of the quarry operations is a key consideration for Haerses Road Quarry. An assessment of the water requirements and potential surface water impacts of the Modification is required.	Yes, refer to **Section 6.4** for further detail.
Noise	Operation of the Modification has the potential to result in changes to noise emissions and a detailed noise assessment is required.	Yes, refer to **Section 6.5** for further detail.
Air quality	Operation of the Modification has the potential to change the impacts of the Haerses Road Quarry on local air quality and a detailed assessment is required to confirm any potential impacts.	Yes, refer to **Section 6.6** for further detail.
Ecology	The Modification disturbance area consists predominantly of native vegetation and therefore an assessment of the ecological impacts of the Modification is required.	Yes, refer to **Section 6.7** for further detail.
Visual	The Modification will result in an additional extraction area with quarrying activities, overburden emplacement areas and noise bunds which has the potential to change the current visibility of the quarry. A visual impact assessment is therefore required for the Modification.	Yes, refer to **Section 6.9** for further detail.
Aboriginal Heritage	Due to the extent of known Aboriginal sites and cultural heritage values in proximity to the Maroota area, a detailed assessment of potential impacts from the Modification is required.	Yes, refer to **Section 6.10** for further detail.
Historic Heritage	The Modification will result in an additional disturbance footprint of approximately 22.5 hectares, however there will be no impact on listed heritage sites as none were recorded within the Modification area or immediate vicinity. Further detail on the heritage searches is provided in **Section 6.11**.	No. Further information is provided in **Section 6.11**.
Socio-economic	The socio-economic impacts of the quarry will remain substantially unchanged, however, as the amenity aspects of the quarry have potential to change, the socio-economic impacts have been reassessed.	Yes, refer to **Section 6.12** for further detail.

Environmental Aspect	Preliminary Environmental Assessment	Further Assessment Required?
Greenhouse Gas and energy	The Modifications has potential to change the energy use and greenhouse gas emissions of the Quarry. Further discussion regarding this issue is provided in **Section 6.8**.	Yes, refer to **Section 6.13** for further detail.
Hazards	As discussed in **Section 4.3.3**, the approved quarry was determined as part of the original environmental assessment and approval process to not be a hazardous or offensive development. The nature and components of the quarry are not proposed to change as a result of the Modification. Furthermore there would be no change to the inventory or storage of hazardous materials. Diesel fuel and motor oil lubricants may be stored in the maintenance workshop. These chemicals are not classed as hazardous and would be stored in accordance with the relevant Australian Standard.	No
Contaminated land	The original 2006 EIS identified that due to the past land uses on the site it is unlikely to be affected by significant contamination issues. Several items that may have resulted in localised contamination (car bodies, petrol drums and white goods) were removed from Stage 1 of the approved extraction area prior to the commencement of quarrying operations. The Modification extraction area consists entirely of bushland that has been inspected as part of the current investigations. There are no visible signs of any contamination within the Modification extraction area or the processing area. A July 2016 search of the OEH contaminated land database identified that there are no registered contaminated sites in the Maroota area.	No
Rehabilitation and Final Landform	The overall approach to rehabilitation of Haerses Road Quarry will remain unchanged, however, due to the additional quarrying location, overburden emplacement and the refilling of the proposed extraction area there will be some change to the final landform of the site. An updated rehabilitation and closure strategy is therefore required for the Modification.	Yes, refer to **Section 6.14** for further detail.

A detailed assessment of each of the environmental and community aspects identified in the environmental risk analysis as requiring further assessment for the Modification is provided in **Sections 6.2** to **6.14**.

6.2 Land Use

6.2.1 Existing Land Use

The existing land uses of the Haerses Road Quarry site are quarrying, horticulture, some former residential dwellings (owned by Dixon Sand and one of which is used as the site office) and bushland. As part of the approved quarry operations the areas that are occupied by non-quarrying land uses will be progressively converted to quarrying operations as the quarry progresses.

The predominant land uses within the immediate vicinity of the site are rural residential properties along Wisemans Ferry Road and bushland associated with the Deerubbin Local Aboriginal Land Council (LALC) property to the south and west of the site. The land uses in the local area include fruit orchards, market gardens, quarries, grazing of livestock and rural residential properties. The surrounding region is a significant area for quarrying, with at least five sand/sandstone quarries located within the local area.

6.2.2 Impacts to Land Use

The Modification would result in an area of land approximately 19 hectares in size being converted from native vegetation to a quarry extraction area over the life of the quarry. This represents a relatively small area of native vegetation in a local and regional context, with large tracts of native vegetation surrounding the Haerses Road site.

The Modification is not predicted to result in any adverse impacts on the surrounding land uses. The direct impacts of the Modification will be limited to the Haerses Road site and assessment of amenity issues such as noise, air quality and visual have identified that the quarry operations will not result in significant impacts on surrounding land uses.

Haerses Road Quarry is a substantial distance from any major residential areas. The closest being Windsor located approximately 21 kilometres to the south west, Rouse Hill located approximately 24 kilometres to the south south-west and Hornsby located approximately 27 kilometres to the south east. There would be no impact to major residential areas as a result of the Modification.

6.3 Groundwater

The potential for the proposed quarry operations to interact with local groundwater resources was a key consideration for the design of the Modification, with some important groundwater resources existing in the Maroota area. To avoid impacts on groundwater, the proposed extraction area has been designed to remain two metres above the wet weather groundwater level. A detailed assessment of the local groundwater environment has been undertaken to inform the design of the quarry and to avoid groundwater impacts.

The detailed Groundwater Assessment for the Modification was completed by Australian Groundwater Technologies (AGT) and is included in **Appendix 3**. A summary of the key findings of the assessment is included in the following sections.

6.3.1 Existing Groundwater Environment

There are two aquifers in the Maroota area that required consideration as part of the Groundwater Assessment, being:

- the Maroota Tertiary Sands Groundwater Source (MTSGS). The MTSGS occurs in the Maroota Sands deposit and in the upper part of the Hawkesbury Sandstone (eluvial sands)

- the Hawkesbury Sandstone, a regional fractured rock aquifer. The Hawkesbury Sandstone forms part of the Sydney Central Basin Groundwater Source (SCBGS).

Both of these aquifers occur at the Haerses Road Quarry site. The MTSGS occurs along the central portion of the site, to the east of and upslope of the proposed extraction area for the Modification (refer to **Figure 6.1**). The SCBGS occurs within the Hawkesbury Sandstone deposit that is the target of the proposed extraction area for the Modification. However, the aquifer is below the proposed extraction area which will remain a minimum of two metres above the SCBGS wet weather groundwater level.

The MTSGS is recharged by direct rainfall infiltration and is subject to seasonal rainfall variations and longer term climatic cycles. At the Haerses Road site, water bore drilling has identified the MTSGS comprises of thin layers of gravel, thick sequences of clay, and interbedded clays and sands. These profiles are typical of palaeochannel sequences and represent the meandering nature of old river systems (Woodward and Clyde, 1999).

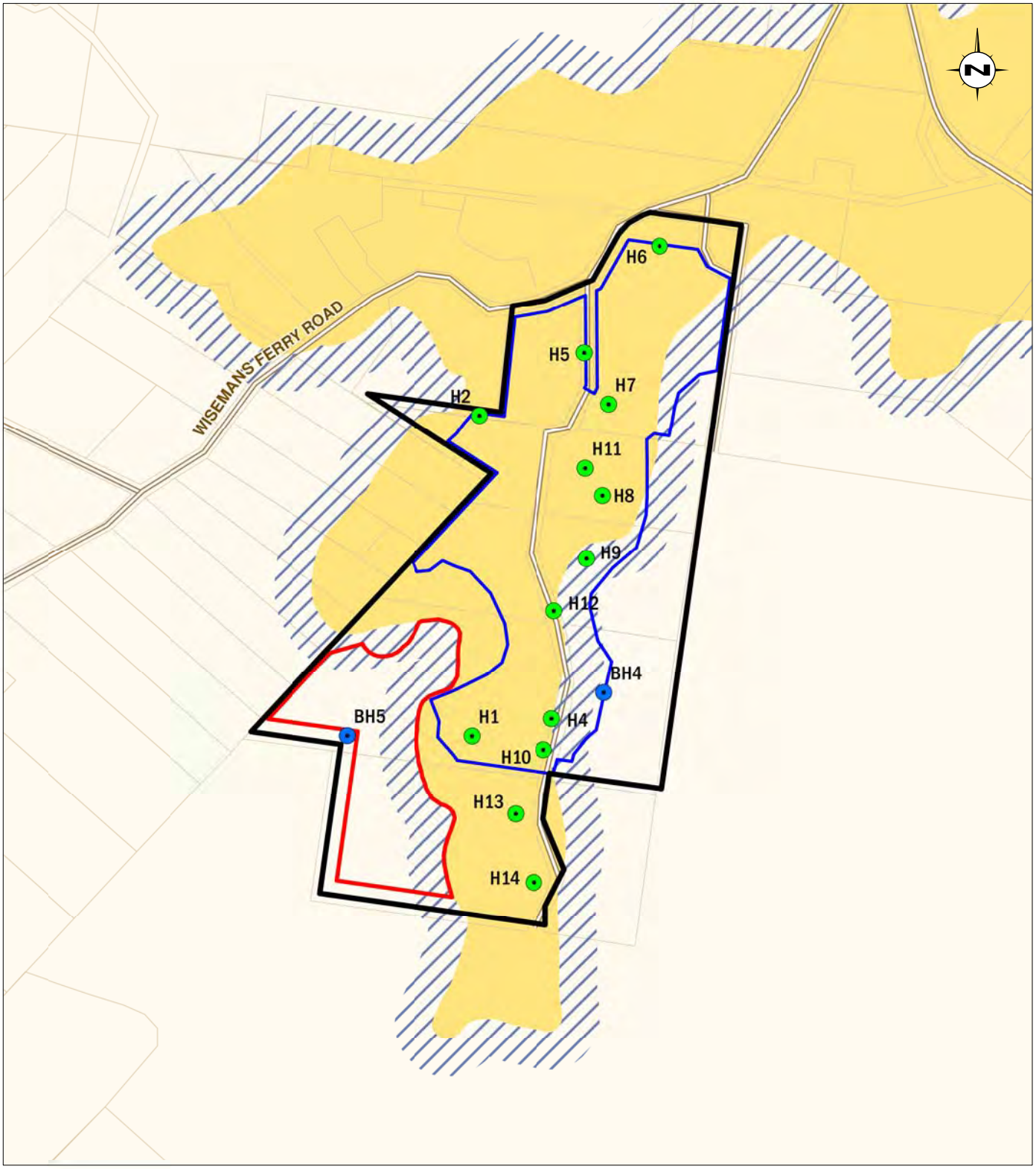
In the weathered profile of the Hawkesbury Sandstone small aquifer zones have developed in the eluvial sand (such as the deposit which is the quarry resource for the approved Haerses Road Quarry), which comprises the leached and weathered profile of the Hawkesbury Sandstone. These zones often form perched aquifer systems above the deeper regional water level of the Hawkesbury Sandstone. In the majority of cases, these perched aquifer systems have limited resource value because, like the Maroota Sand, they have small aerial extent and storage. They act as temporary storage of groundwater prior to leakage to underlying aquifers.

The Hawkesbury Sandstone is generally an impermeable rock and although the rock has very little primary permeability, fracturing and jointing, where open and interconnected, provides secondary permeability and storativity.

Groundwater Levels

The water level of the MTSGS has been monitored and recorded at the Haerses Road Quarry since 2005 while the regional water table of the SCBGS has been monitored and recorded since 2011 (refer **Figure 6.1**).

Within the proposed extraction area the SCBGS wet weather level varies from 146 mAHD in the east to 115 mAHD in the west, therefore the maximum quarry floor level has been set at 148 mAHD in the east and 117 mAHD in the west which is 2 metres above the wet weather level. A summary of the monitoring bores which includes their maximum and average water levels is presented in **Appendix 3**.



Legend

- SCBGS Monitoring Bores
- MTSGS Monitoring Bores
- Site Boundary
- Current Extraction Area
- Proposed Extraction Area
- Maroota Tertiary Sands
- 100 m buffer around Maroota Tertiary Sands
- Cadastral boundary
- Roads

FIGURE 6.1

Location of the Maroota Tertiary Sands

Image Source: Australian Groundwater Technologies (2016)

Groundwater Quality

In accordance with the current development consent conditions for Haerses Road Quarry, groundwater samples have been collected from each bore for analysis of the following parameters:

- Electrical Conductivity (EC)
- pH
- Totals Suspended Solids (TSS)
- turbidity.

A summary of the natural variation of groundwater quality is provided in **Appendix 3** and summarised below:

- groundwater salinity of the shallow and deep aquifers is very low, ranging from 51 to 435 µS/cm
- pH ranges from 4.1 to 6.6, with deeper bores revealing higher average pH values (5.5) in comparison to the shallower bores (4.6)
- groundwater turbidity and TSS was generally higher in the shallow bores than in the deeper bores.

As the groundwater salinity is less than 1,500 mg/L, the source is classified as a highly productive groundwater source under the criteria of the NSW Aquifer Interference Policy (AIP).

Groundwater Users

There are a total of 40 existing bores within 2.5 km of the site, 28 of which target the deep SCBGS with the remaining 12 targeting the shallow MTSGS. A summary of existing bores in the area is provided in **Appendix 3**.

At the closest point there is one bore that targets the SCBGS (GW109927 – status unknown) located approximately 500 metres west of the proposed extraction area. It was drilled to a depth of 162 m and has a groundwater level of 74 mBGL. The nearest MTSGS bore (GW108385) is located approximately 150 metres southeast of the proposed extraction area and is drilled to a depth of 13 metres.

Coastal Upland Swamp Community

There are two occurrences of a coastal upland swamp community in or in the vicinity of the Modification disturbance area. A small area of coastal upland swamp community is within the proposed extraction area, while a much larger area of coastal upland swamp community was identified to the north of the proposed extraction area and to the west of the current approved extraction area (refer **Figure 6.17**). A drainage line runs east to west through this area of swamp. The drainage line is an ephemeral stream that only exists for a short period of time after rainfall events and is fed by an upstream dam.

The geomorphic development of the coastal upland swamps is driven by positive feedbacks that operate when there is significant excess of precipitation over evaporation. This, along with high run-on from catchments and low rates of percolation and run-off, promotes soil water logging. Drainage of the swamps is mainly via lateral seepage through the sediments with some possible very slow vertical percolation into the underlying poorly permeable bedrock. The coastal upland swamp community is not a groundwater dependant ecosystem.

A 50 metre buffer zone has been designed into the quarry around the swamp where extraction will be excluded. The purpose of the buffer zone is to protect and manage this community providing a barrier to direct disturbance.

6.3.2 Groundwater Impact Assessment

As discussed above, the Modification has been designed to avoid impacts on groundwater by not impacting on the MTSGS (and incorporating a buffer from the edge of the aquifer to provide certainty) and by staying a minimum of two metres above the wet weather groundwater level of the SCBGS. To achieve this outcome, the Groundwater Assessment defined the extent of the aquifers within the local area through updating the conceptual groundwater model for the site, utilising additional drilling data and groundwater level monitoring data obtained since the development consent was granted. The assessment also included a review of groundwater levels to determine the extraction depth limit for the new extraction area which overlays the SCBGS.

Groundwater monitoring data has been used to establish groundwater elevations for the MTSGS since 2005 and the SCBGS since 2011. The highest recorded water level measured in each bore was used to develop a maximum potential extraction depth map. The maximum extraction depth contours represent an elevation of two metres above the wet weather groundwater level sources. As discussed above, the proposed extraction area occurs within the Hawkesbury Sandstone above the level occupied by the MTSGS. The maintenance of the minimum two metre buffer above the wet weather groundwater level will avoid impacts on the MTSGS.

The wet weather elevation of the SCBGS (and extraction depth) is lower than the wet weather elevation of the MTSGS, which as discussed in **Section 6.3.1** and indicated on **Figure 6.2**, is perched approximately 40 metres above the regional aquifer of the SCBGS. Groundwater seepages from the MTSGS will be prevented by the creation of a 100 metre buffer from the western boundary of the MTSGS. No extraction would be undertaken within the 100 metre buffer of the MTSGS until two additional monitoring bores within the western margin of the MTSGS have been established and monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS. The decision to commence quarrying in this area will be undertaken in consultation with DPI Water and with the approval of DPE.

The Groundwater Assessment found that:

- the proposed extraction area remains entirely in the unsaturated zone and will not result in capture of groundwater
- the MTSGS and SCBGS will not be intercepted during quarrying operations
- there will be no interference with neighbouring bores
- no groundwater supply works are being carried out as part of the Modification.

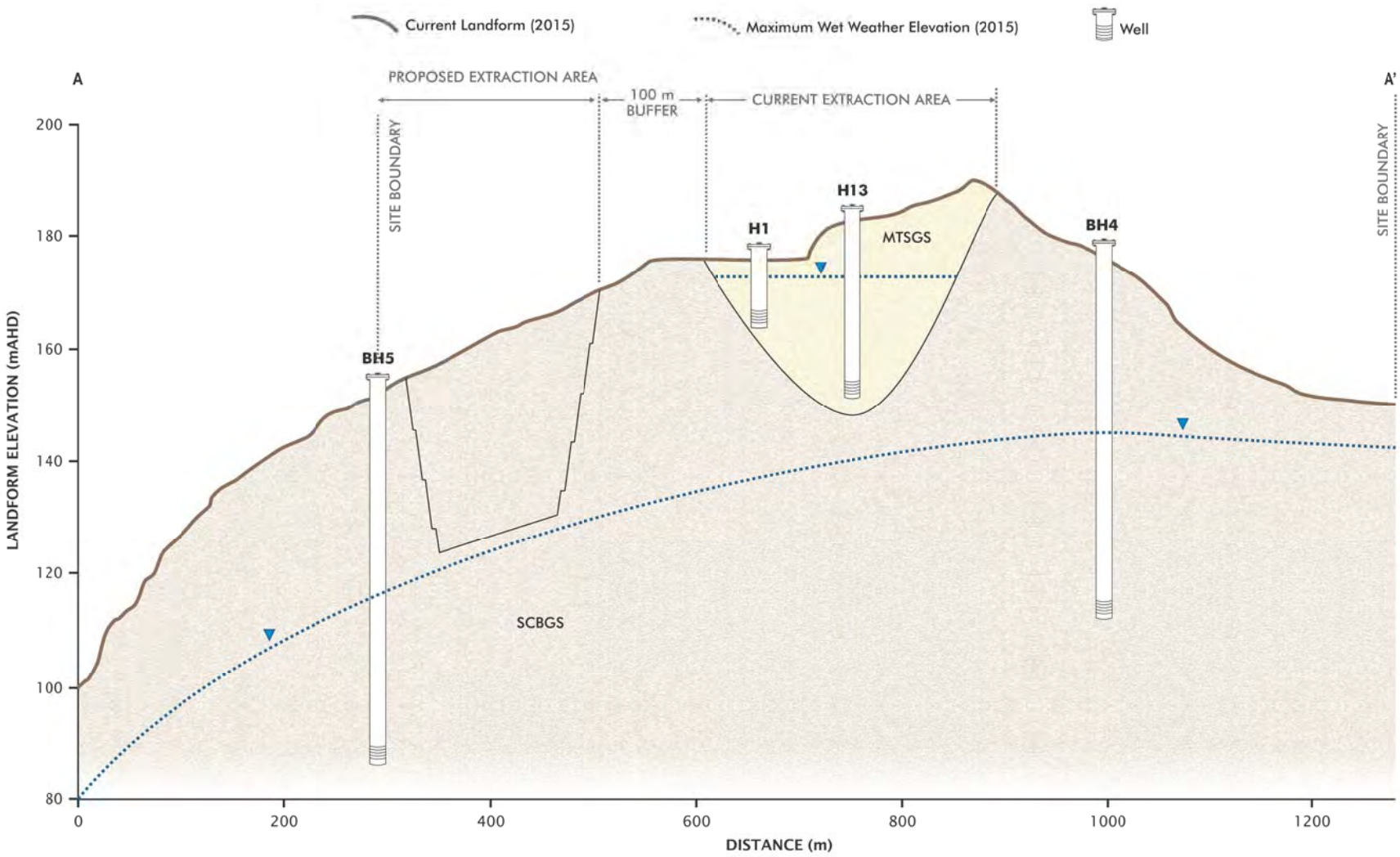


FIGURE 6.2

Wet Weather Elevation of Groundwater Sources

Image Source: Australian Groundwater Technologies (2016)

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6.3.3 Assessment against the NSW Aquifer Interference Policy and Water Sharing Plan

Since the development consent for Haerses Road Quarry was granted, policy changes have seen the introduction of the Greater Metropolitan Region Groundwater Sources Water Sharing Plan (WSP) (2011) and Aquifer Interference Policy (AIP) (2012). The Modification requires consideration against both of these policies.

NSW Aquifer Interference Policy

The AIP describes the requirements for a proponent when designing a project, completing an environmental assessment, how the NSW Government will assess and regulate aquifer interference activities and describes minimal impact considerations (or minimal harm criteria) for water pressure, water table and water quality.

As the proposed extraction area has been designed to avoid impacts on groundwater, the groundwater assessment found that the Modification is not predicted to have adverse effects on the water table, water pressure or water quality within or surrounding the site. As such, the Modification is considered to meet the minimal impact considerations under the AIP and therefore the groundwater impacts of the Modification are considered acceptable under the AIP.

Further details of the assessment against the AIP minimal harm criteria are contained in **Appendix 3**.

Greater Metropolitan Region Groundwater Sources Water Sharing Plan

The MTSGS and the SCBGS are the gazetted groundwater resources within the vicinity of the proposed extraction area for the Modification. As discussed above, the MTSGS occurs to the east of the proposed extraction area and a 100 metre buffer has been incorporated into the design of the quarry to avoid impact. No extraction would be undertaken within the 100 metre buffer of the MTSGS until two additional monitoring bores within the western margin of the MTSGS have been established and monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS. The SCBGS underlies the proposed extraction area with the extraction depth limited to avoid impacts on this aquifer.

The Groundwater Assessment found that the Modification will not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.

6.3.4 Groundwater Licensing

As outlined in **Section 6.3.2**, the groundwater assessment indicates that there will be no interception of groundwater as a result of the Modification. As a result, no groundwater licences will be required for the Modification.

6.3.5 Mitigation, Monitoring and Management Measures

A groundwater monitoring program for the Haerses Road site has been ongoing since 2005. The groundwater monitoring network has included 15 monitoring bore locations, of which six have been decommissioned or replaced (refer to **Figure 6.1**). The existing groundwater monitoring program has been designed to detect changes in groundwater levels, groundwater quality, or to indicate an abnormal condition in response to quarrying. Key aspects of the groundwater monitoring program include:

- water quality sampling from groundwater across the site on a biannual basis

- monitoring and assessment of any groundwater inflows and quality to the existing quarry pit, in the unlikely event that groundwater inflows occur (noting that the existing pit has been designed to stay two metres above the wet weather groundwater level of the MTSGS)

- monitoring groundwater levels in the MTSGS and SCBGS.

Monitoring will be continued for the life of the Haerses Road Quarry operations to continue to refine the mapping of the extent of the MTSGS and the wet weather groundwater level in both the MTSGS and the SCBGS to allow appropriate buffers to be maintained throughout the life of the quarry. The monitoring will also serve to detect any unpredicted groundwater level or quality impacts. No extraction would be undertaken within the 100 metre buffer of the MTSGS until two additional monitoring bores within the western margin of the MTSGS have been established (refer to **Figure 6.1**) and monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS. The decision to commence quarrying in this area will be undertaken in consultation with DPI Water and with the approval of DPE..

The strategy for groundwater management at the site is to prevent groundwater inflows to the quarry, and preservation of pre-quarrying groundwater quality. For the proposed extraction area, the strategy involves maintaining the depth of mining to an elevation which is at least two metres above the 'wet weather' groundwater elevation for the SCBGS and creation of a 100 m buffer zone from the western edge of the MTSGS within which no extraction would be undertaken until monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS.

The Groundwater Assessment has identified mitigation measures for each potential impact including unpredicted impacts. The proposed groundwater monitoring program therefore specifically deals with:

- a mechanism for ensuring the operations are compliant with the rules of the WSP and AIP (DPI, 2012)

- unforeseen impacts on groundwater levels on neighbouring properties and on any users of groundwater that target the MTSGS or SCBGS

- unforeseen impacts on groundwater quality

- ongoing monitoring of local and regional groundwater levels and quality during the quarry operations and on a reduced basis for at least five years post quarrying to confirm that the quarry avoids impacts on groundwater.

A Trigger Action Response Plan (TARP) for groundwater will be developed as part of the ongoing groundwater monitoring program to focus upon appropriate trigger and response actions for the management or mitigation of any unpredicted impacts that occur. The monitoring program that is in place will be used to establish the triggers, which will be designed to identify any potential impacts and trigger an appropriate response. Further details on the proposed groundwater TARP are provided in **Appendix 3**.

6.4 Surface Water

There is the potential for the Modification to change impacts on surface water due to the additional quarry footprint, construction of new haul roads and change in water usage. This section provides an assessment of the potential surface water impacts including a site water balance.

6.4.1 Surface Water Context

All current and approved operations at Haerses Road Quarry are located within the catchment area of Little Cattai Creek (refer to **Figure 6.3**) which discharges to the Hawkesbury River approximately 12 kilometres south west of the site. The Little Cattai Creek catchment covers an area of 9,980 hectares with the Haerses Road Quarry site comprising 128 hectares or 1% of this catchment area.

Dixon Sand currently manages surface water at the site in accordance with the *Haerses Road Sand Quarry Site Water Management Plan* (SWMP) (ERM, 2006). The approved quarry water management system (WMS) covers the existing operations encompassing an area of approximately 68 hectares. This area includes existing dams within the site which capture runoff from undeveloped portions of the site. The quarry WMS is proposed to increase by approximately 25 hectares with the addition of the new extraction area and wet and dry processing plant area. This would take the total area covered by the quarry WMS to approximately 93 ha. The existing WMS is described in **Section 6.4.3.1** and the proposed WMS is described in Section **6.4.3.2**.

The Haerses Road Quarry site is underlain by two separate soil landscapes – the Maroota (ma) and Gymean (gy) soil landscapes as per mapping undertaken by McInnes (1997). Both soil landscapes have a high to extreme erosion hazard under concentrated flows and are also highly permeable. Therefore, particular care must be taken with erosion and sediment control measures to prevent erosion of soils and off site sediment transport. This risk has been considered in the design of the WMS for the Modification.

6.4.1.1 Downstream Users

The site is located within the Little Cattai Creek Catchment which ultimately drains to the Hawkesbury River approximately 12 kilometres to the south west of the site. Water use within the catchment is regulated under the *Water Sharing Plan (WSP) for the Greater Metropolitan Region Unregulated River Water Sources* which commenced on 1 July 2011.

The WSP covers an area of approximately 32,500 square kilometres, from Shoalhaven Heads in the south, Broken Bay in the north, Lithgow to the west and Goulburn to the south west. The WSP encompasses 87 management zones that are grouped into six water sources. The site falls within the catchments for the Hawkesbury and Lower Nepean Rivers and specifically within the Upper Hawkesbury River Management Zone (Cattai Creek to Colo River).

Surrounding and downstream land uses include agriculture, extractive industries, forestry and the residential areas of Maroota. Agricultural activities include orchards, market gardens and grazing and are mostly restricted to the Maroota Ridge. The Maroota State Forest adjoins the eastern and southern boundaries of the site. The Broadwater Swamp is approximately eight kilometres downstream of the site, connecting Little Cattai Creek to the Hawkesbury River.

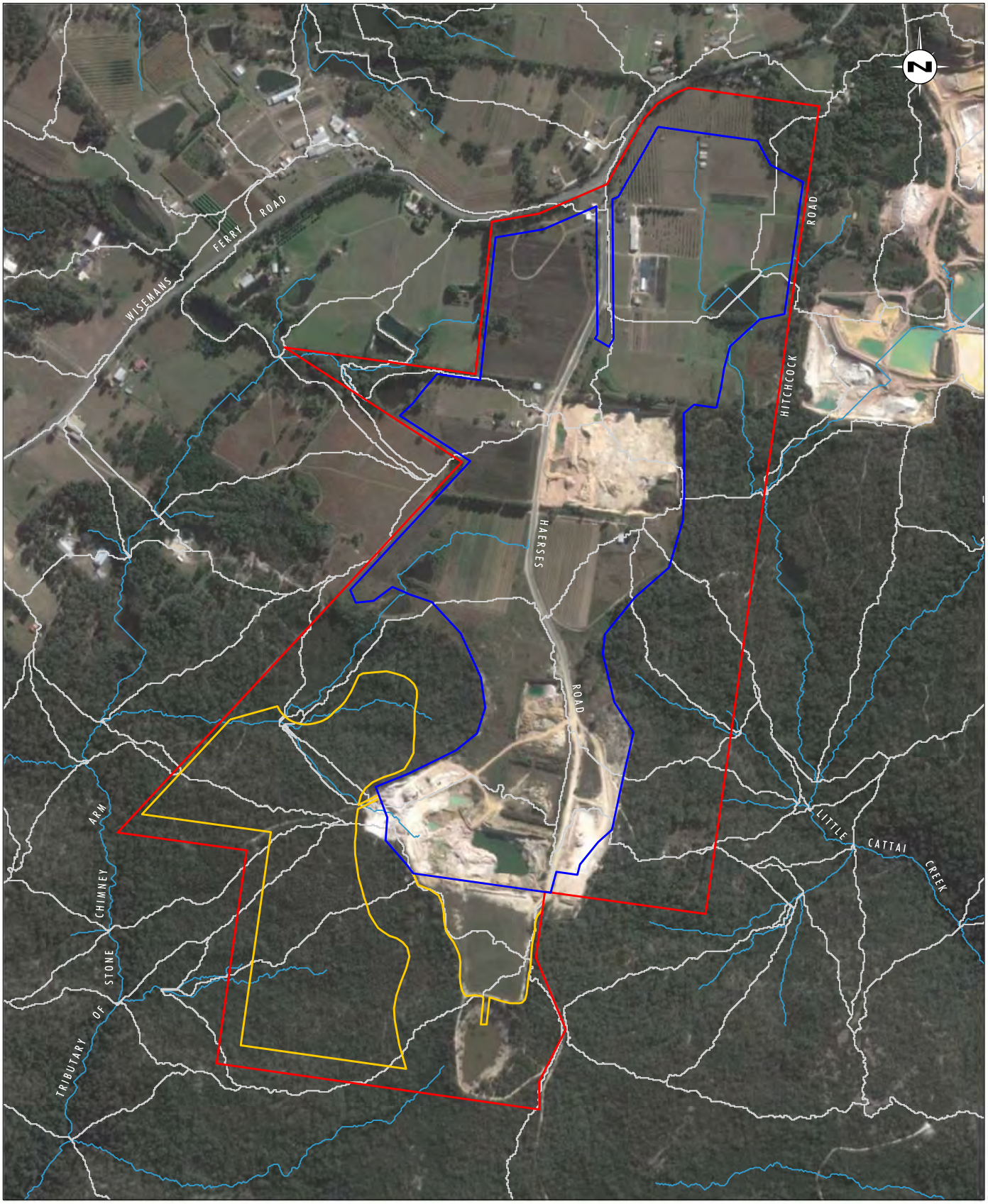


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Catchment Boundary
- Drainage Line

FIGURE 6.3

Haerses Road Querry
Catchments and Drainage Lines

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6.4.2 Potential Surface Water Impacts

The Modification has the potential to result in the following impacts on the management of surface water resources:

- changes to surface water flows due to the addition of new WMS controls including clean and dirty water controls (refer **Section 6.4.3.2**) and the capture of water within the quarry WMS
- changes to the amount of water captured by and used at the quarry (that is, the site water balance, refer **Section 6.4.4**)
- changes to impacts on downstream surface water systems (refer to **Section 6.4.5**).

These potential impacts are assessed in the following sections.

6.4.3 Water Management System

6.4.3.1 Existing Water Management System

The principal objectives of the existing water management strategy at Haerses Road Quarry are:

- maintenance of a two (2) metre extraction buffer to the groundwater table (wet weather high level)
- minimisation of the area of soil disturbed and exposed to erosion
- control of water flow through the site (i.e. separating 'clean' and 'dirty' water and directing sediment laden water to sediment basins)
- containment of dirty water on site to prevent off site discharges
- rehabilitation of disturbed areas quickly to limit erosion potential
- maintenance of soil and water management measures throughout the life of the quarry.

The key components of the existing WMS for Stages 1 and 2 that are currently operational at the Haerses Road Quarry are shown on **Figure 6.4**.

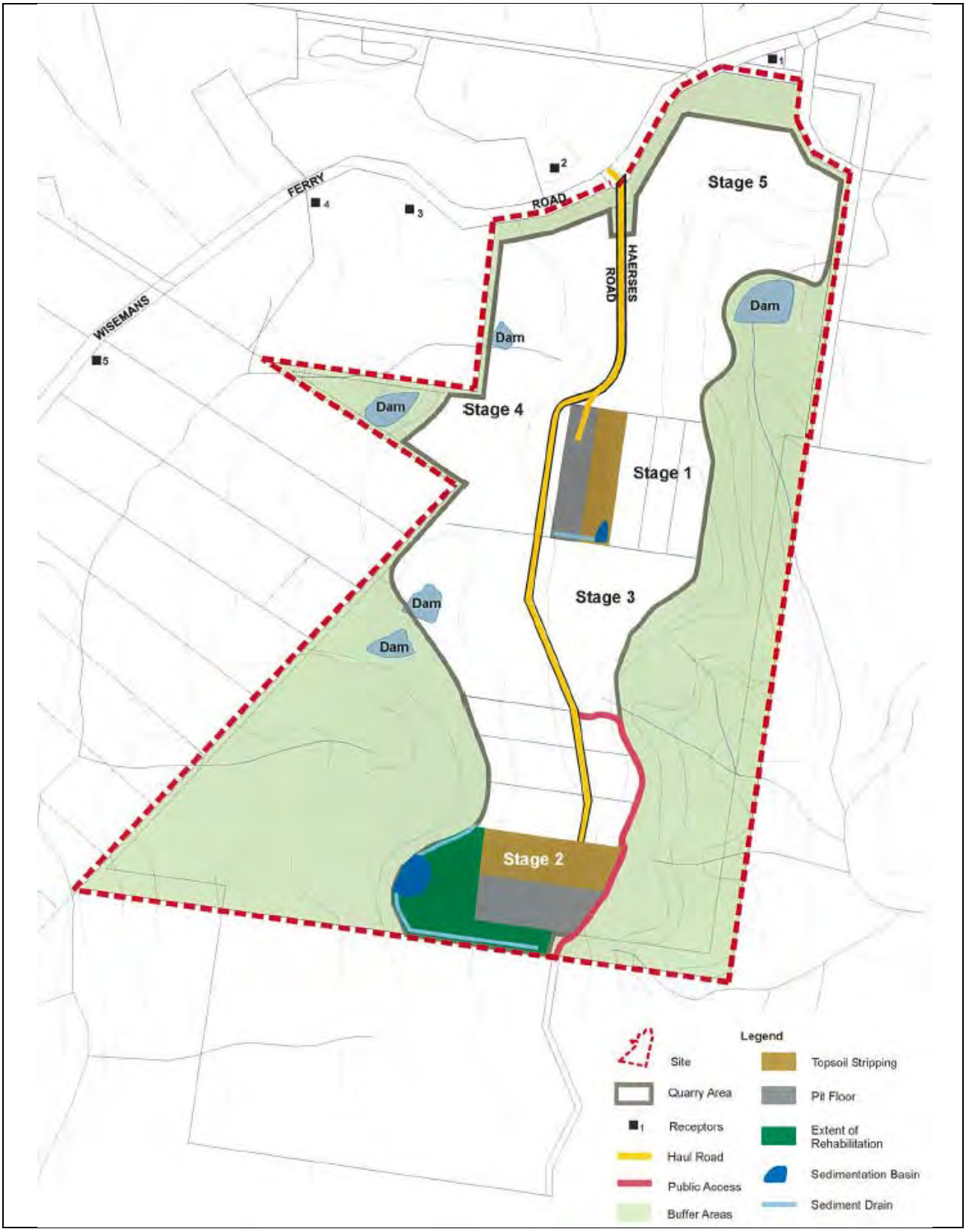


Figure 6.4 Existing Water Management System and Proposed Quarry Plan for Stages 1 & 2

Source: Figure 2.3a Dixon Sand EIS – Haerses Road, Maroota NSW (ERM, 2005)

Historically, Dixon Sand has not needed to manage and release water captured from upslope catchment areas. This is attributable to the highly permeable sandy soils on the site, where water runoff is only generated in significant quantities during very heavy rainfall events. Presently, clean water is diverted around the extraction areas using earth banks constructed in accordance with Landcom's *Managing Urban Stormwater Soils and Construction Volume 1 and Volume 2e – Mines and Quarries* (the Blue Book) (2004). The location of these earth banks is moved as the quarry progresses so that no clean water flows enter the extraction area.

All stormwater within the quarry pit is contained and directed to sediment basins within, or adjacent to, the quarry floor. The quarry floor is generally graded so that all stormwater drains to the nearest sediment basin, where catch drains within the quarry floor collect and control stormwater flows. The high permeability of the quarry floor maintains current infiltration and groundwater recharge rates, and also ensures that the depth and duration of surface water ponding with the quarry is minimal.

The WMS also involves maintaining sediment basins within rehabilitated areas until such time that sufficient vegetative cover is established and the soil surface is stabilised.

6.4.3.2 Proposed Water Management System

The proposed WMS for the Modification will build on the existing WMS for Haerses Road Quarry and will focus on:

- diversion of clean water around the proposed disturbance area for the Modification
- capture, treatment and reuse of dirty (sediment laden) water from within the disturbance area
- avoiding the need for discharge of dirty water from the quarry operations.

The existing WMS will be expanded to cater for the Modification including the addition of three new sediment basins and associated drains. Operation of the existing WMS will remain unchanged as a result of the addition of the new sediment basins and associated drains.

As part of the Modification, the following additions to the WMS are proposed:

- a large in-pit sump to capture and store water from the proposed extraction area as during most stages of extraction the quarry floor will be below ground level and will not be able to drain to existing surface water catchments.
- three additional sediment basins located in the south west, west and north west corners of the extraction area to manage dirty water runoff from each of the cells as extraction progresses
- additional dirty water drains at the boundaries of the extraction cells to assist in directing dirty water to the appropriate sediment basins during all phases of the extraction process
- additional clean water drains to intercept runoff from the upslope catchment and convey runoff around the disturbed areas.

The proposed extensions to the WMS for the Modification, including proposed drains and sediment basins are shown on **Figures 6.5** to **6.10**. The area of the catchments within the extended WMS for the quarry are displayed in **Table 6.2**.

The conceptual locations of the three additional sediment basins are shown on **Figure 6.10**, however detailed design work on the placement and design of these sediment basins will be undertaken as part of the implementation of the Modification. All controls will be designed as per the Blue Book. The stage at which each of the proposed conceptual sediment basins is required to be installed is listed in **Table 6.2**. Sediment basins will be required to be maintained until appropriate levels of rehabilitation are achieved across the contributing catchment.

Runoff from the proposed new wet and dry processing area to the east of the proposed new extraction area will be diverted into an existing sediment basin located to the south through the use of dirty water drains.

The new quarry haul roads will be constructed and managed in accordance with the SWMP. Mitre drains will be constructed at regular intervals (typically no greater than 50 metres) to shed water from the shoulders of haul roads and from table drains to nearby sediment basins. This will also reduce runoff velocity and therefore erosion of haul road drains and shoulders.

Clean water run-on into the proposed new extraction area and new processing plant area will be prevented through the use of clean water drains located upslope of the extraction areas and processing plant area. Conceptual locations for the clean water drains are shown for each stage of extraction on **Figures 6.5** to **6.10**. Clean water drains will be installed along the contour to allow fall of water along the drains to a designated outlet point stabilised with a level spreader (or similar). This will prevent the capture of clean water from upslope catchments and reduce the amount of water to be managed as part of the quarry WMS.

All new WMS infrastructure will be managed in accordance with the controls listed in the SWMP. The SWMP will be updated to incorporate the new infrastructure. No off-site discharge of “dirty water” is proposed from the extraction or processing areas.

Conceptual sizing of all sediment basins related to the proposed extraction area and new processing plant is provided in **Table 6.2**. These sizes are based on conceptual quarry plans and will be reviewed and revised as necessary prior to construction as part of the detailed design of the quarry.

Table 6.2 Conceptual sediment basin sizing for proposed additional extraction and processing areas

Dam Name	Installed in stage	Maximum Catchment Area (ha)	Encompassing extraction stages	Provisional Sediment Basin Volume (ML)
Basin 1	1	9.5	1-3	0.8
Basin 2	4	3.8	4	0.3
Basin 3	5	6.6	4-5	0.6
Basin 4*	1	8.3	Wet and dry processing plant area	0.7

* Note: This basin is existing on-site. Dixon Sand estimate the capacity of this basin is greater than 10 ML which is in excess of the required provisional basin volume.

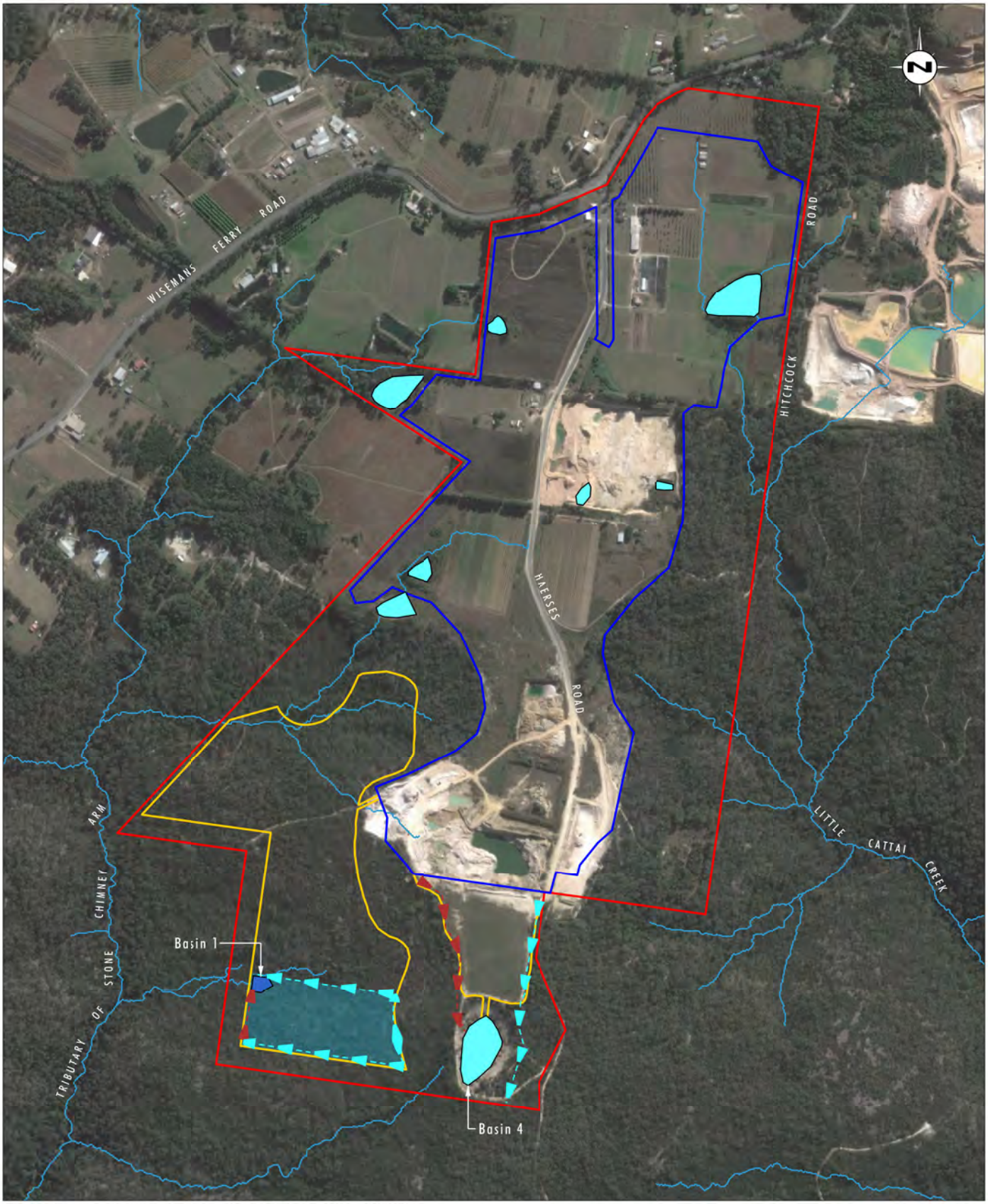


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Cell 1 WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.5

Cell 1 Water Management System

File Name (A4): R05/3479_049.dgn
20160922 10.21

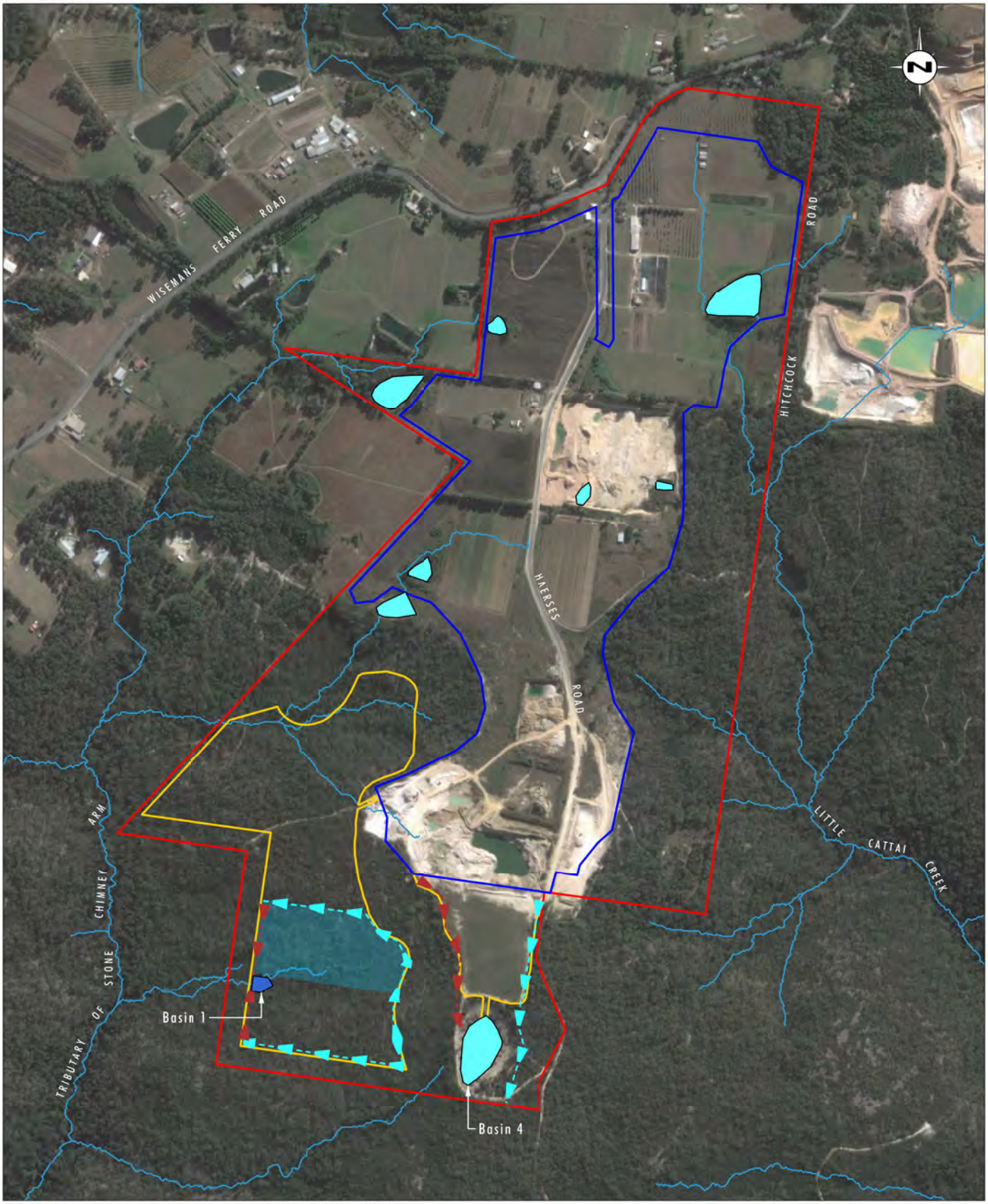


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Cell 2 WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.6

Cell 2 Water Management System

File Name (A4): R05/3479_050.dgn
20160922 10.22

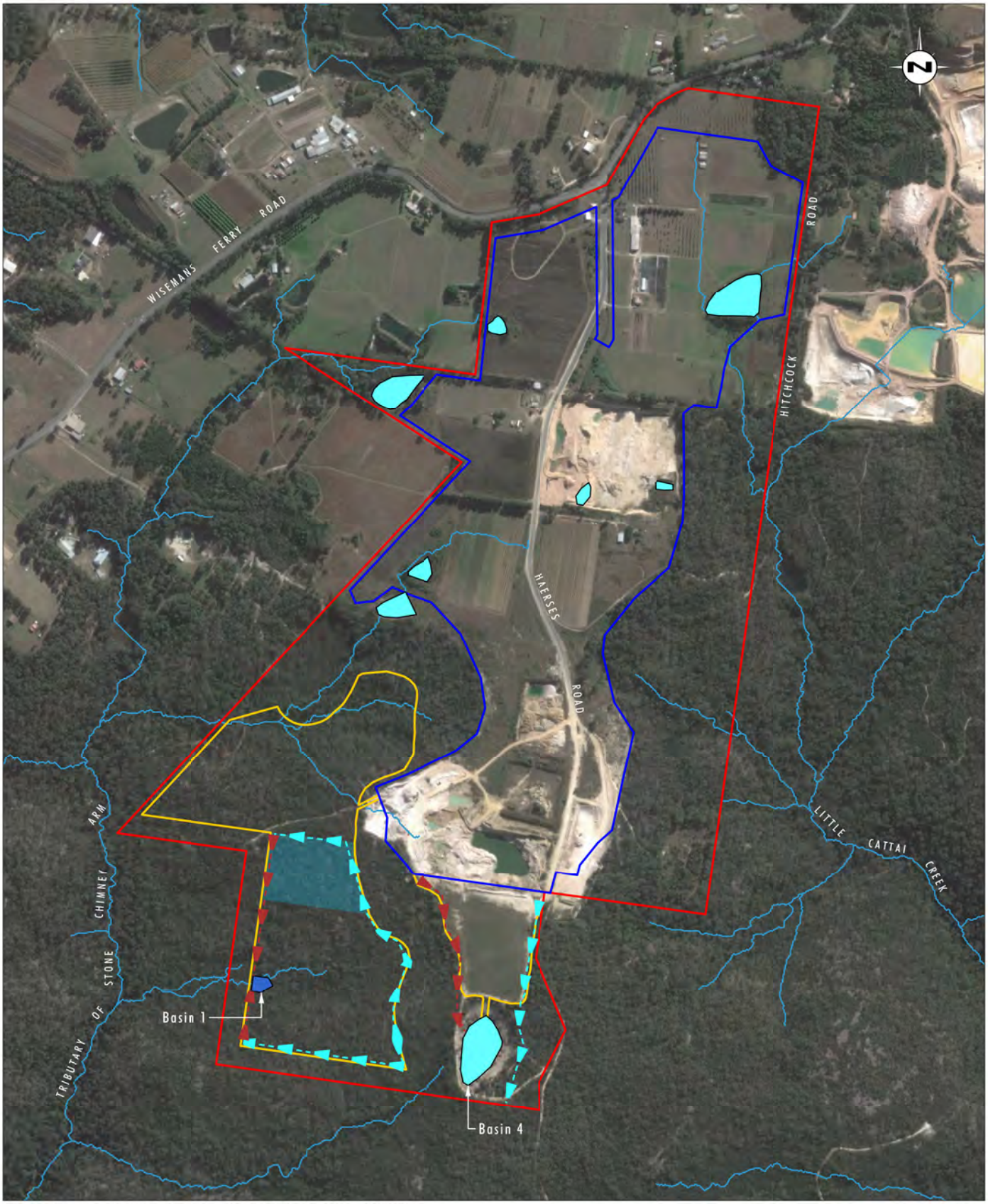


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Cell 3 WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.7

Cell 3 Water Management System

File Name (A4): R05/3479_051.dgn
20160922 10.23

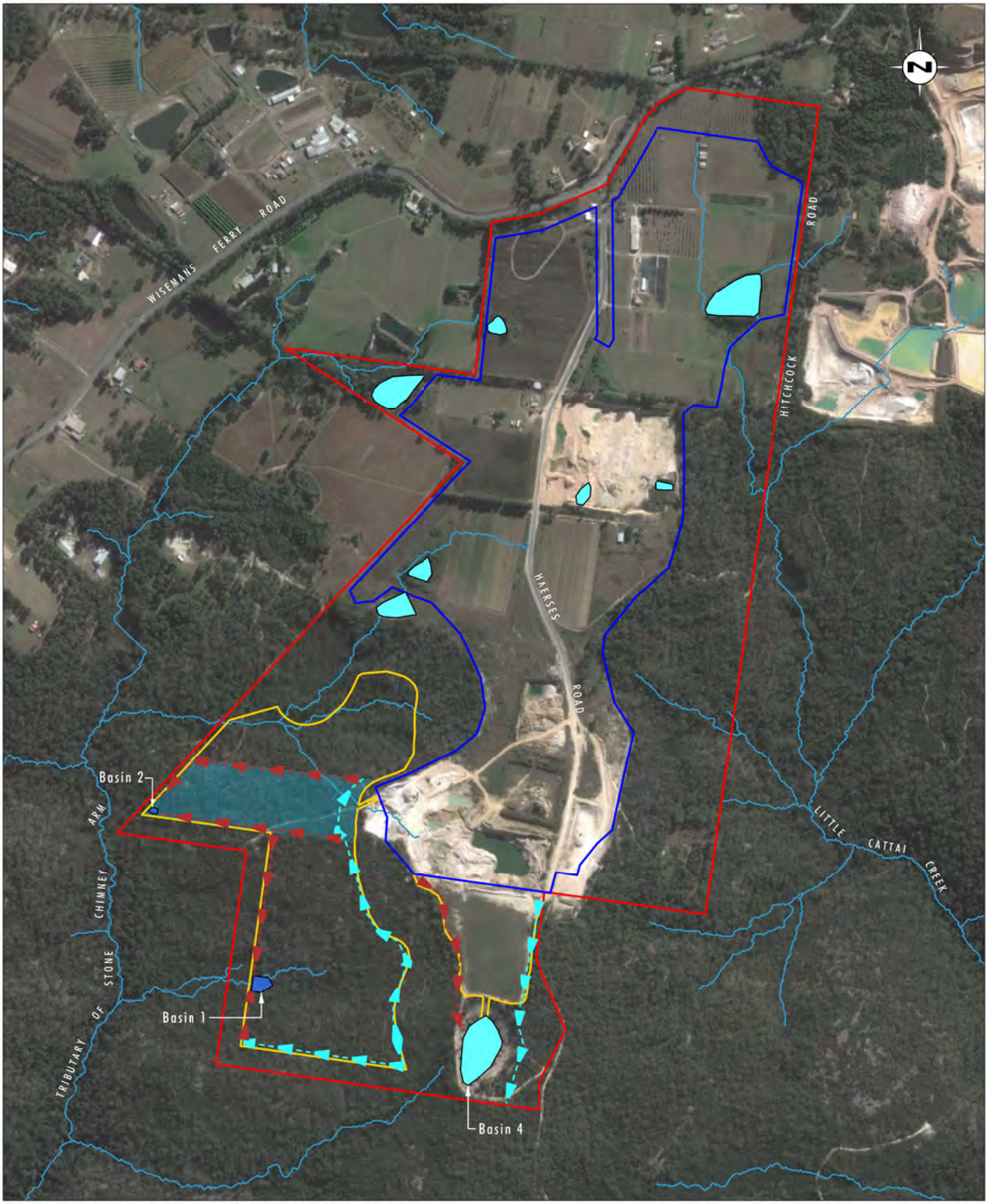


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Cell 4 WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.8

Cell 4 Water Management System

File Name (A4): R05/3479_052.dgn
20160922 10.24

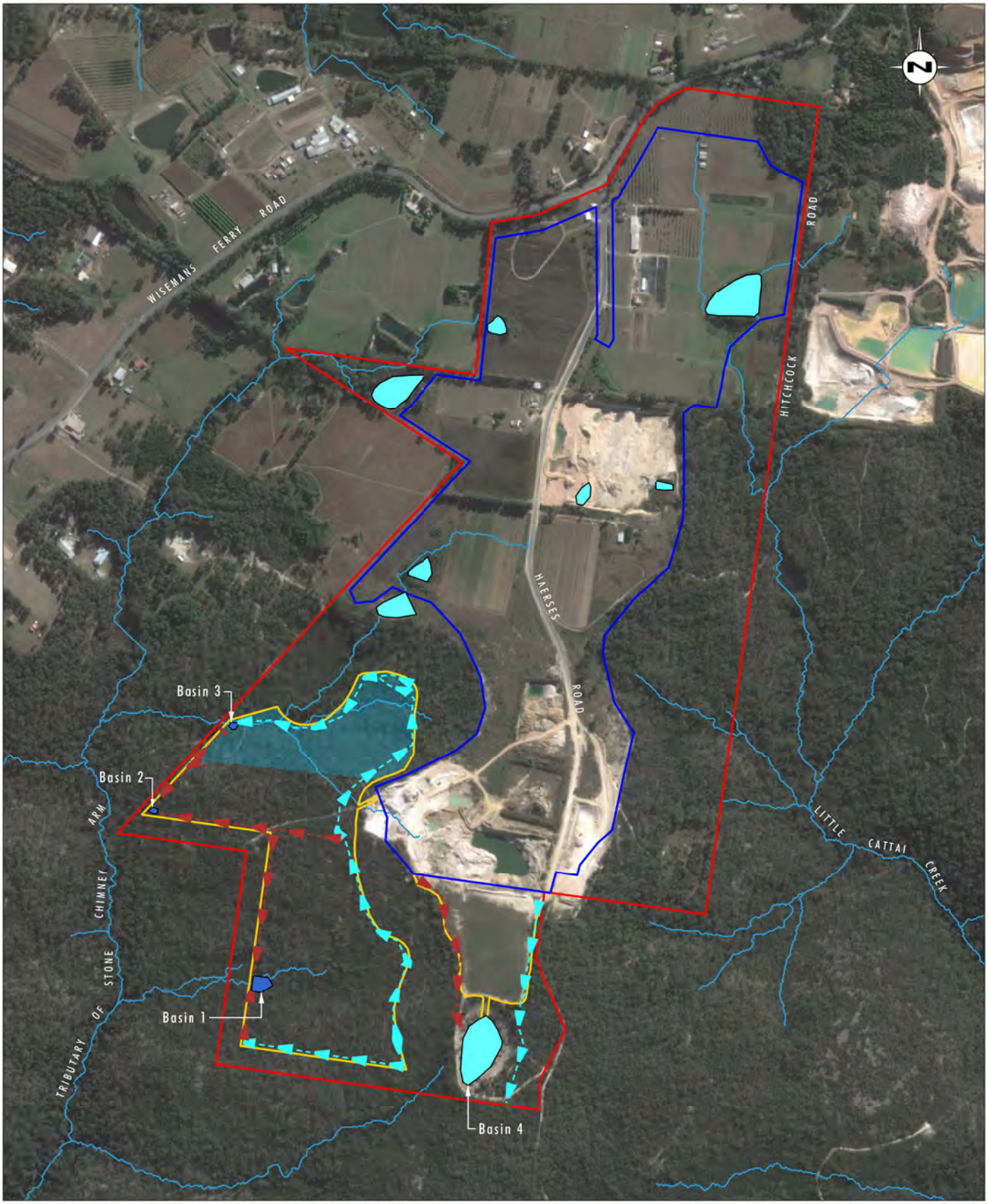


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Cell 5 WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.9

Cell 5 Water Management System

File Name (A4): R05/3479_053.dgn
20160922 10.25

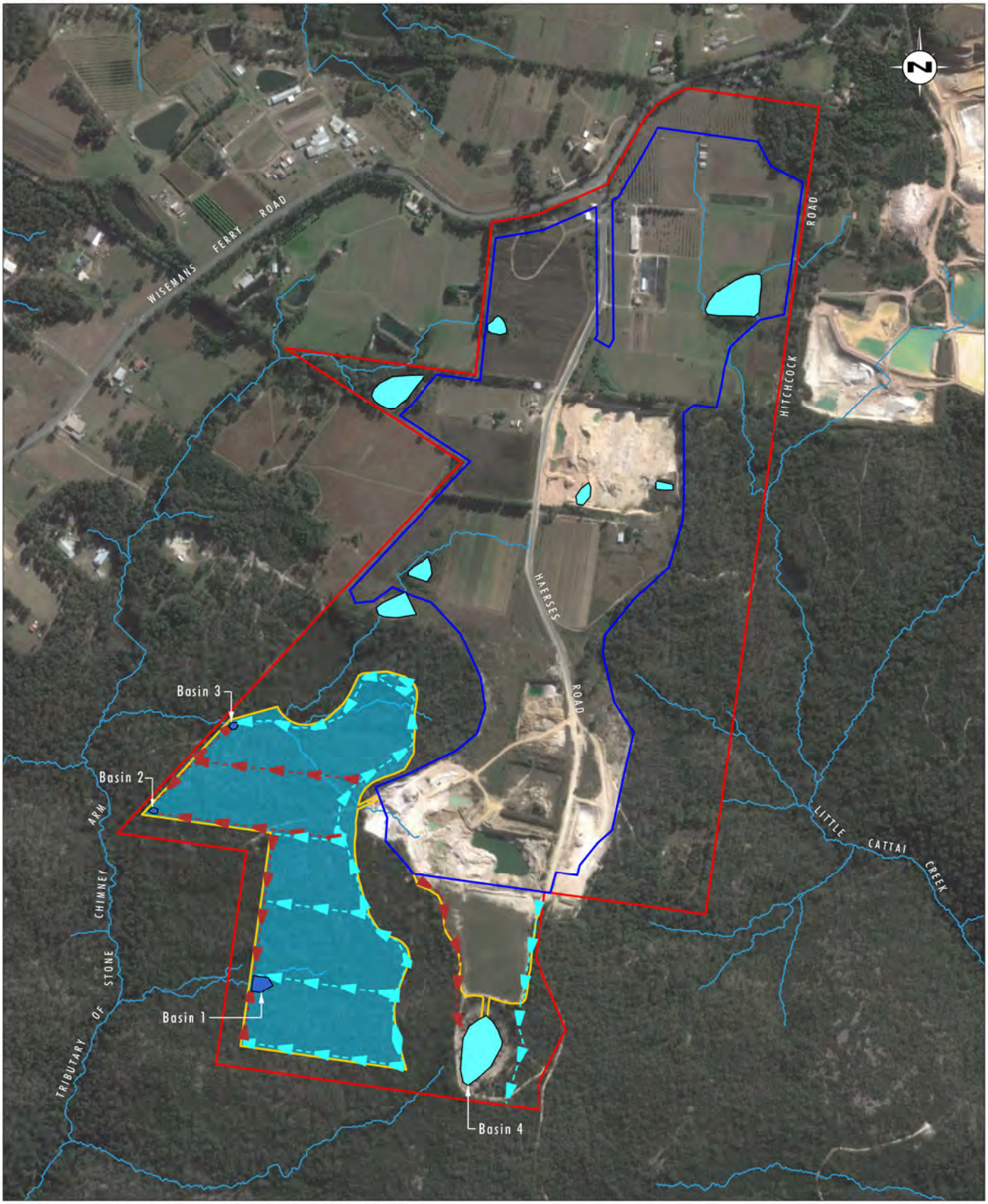


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Final WMS
- Existing WMS Drainage Pond
- Basin
- Clean Drain
- Dirty Drain
- Drainage Line

FIGURE 6.10

Final Water Management System

File Name (A4): R05/3479_054.dgn
20160922 10.26

The provisional basin volumes were calculated in accordance with the Blue Book (Volume 2) and the Dixon Sand EPL No. 12513 design requirements. Design parameters are included in **Table 6.3**.

Table 6.3 Sediment Basin Design Parameters[1]

Parameter	Value	Units
$R_{90\%ile,\ 5\text{-}day}$ design rainfall depth[2]	39.7	mm
Soil hydrologic group	A	-
'C_v', volumetric runoff coefficient	0.15	-
Sediment zone sizing factor	50	%
Basin Type	Type F	-

1. Source: Landcom, 2004
2. 5-day, 90th percentile design rainfall depth for Richmond

Dirty water within the proposed new sections of the WMS will continue to be reused on site for dust suppression and processing.

6.4.4 Water Balance

The Modification will result in changes to the water balance for the quarry due to increased surface water capture with the increased footprint and increased water usage due to factors including increased haul road length and water demand for the proposed wet plant and associated crushing infrastructure. The following section provides an updated water balance for the quarry including the Modification.

6.4.4.1 Overview

Inflows to the quarry water balance include site rainfall runoff captured in the WMS.

The current water demands at the quarry are primarily water for dust suppression, while future water demands will primarily be for the wet processing plant. The watercart utilises water from the nearest dam containing water for the purposes of suppressing dust on unsealed haul roads.

The site has access to fresh water for potable uses.

6.4.4.2 Water Sources

For water balance considerations it is important to have data that contains the long term climate records for a site (i.e. typically greater than 100 years). There are numerous BoM stations located in the region surrounding Haerses Road Quarry that record daily rainfall. Long term daily rainfall data is available for Old Telegraph Rd, Maroota (Station 067014) located approximately 2 kilometres north east of Haerses Road Quarry with daily rainfall records from 1925 to date. Although the data available is missing some periods of data (i.e. 1954 to 1965), and has patchy data during some periods (i.e. 1986 to 2013), a comparison of long term climate records indicates that the available good quality data captures the long term rainfall variation (i.e. long term wet and dry periods).

The daily rainfall data for the above BoM station is summarised in **Table 6.4**.

Table 6.4 Yearly Rainfall

Percentile	Yearly Rainfall (mm)
10th percentile	584.2
50th percentile	841.8
90th percentile	1161.3

In the region surrounding Haerses Road Quarry, there is only one Bureau of Meteorology (BoM) station, the University of Western Sydney (UWS) Hawkesbury Campus (Station 067021), which currently records daily evaporation data. The UWS BoM Station is located approximately 26 kilometres south west of Haerses Road Quarry and has daily evaporation records from 1973 to date.

Annual pan evaporation has been recorded at the UWS Hawkesbury Campus (Station 067021) for the years 1973 to 2016. Analysis of the historical record shows an expected trend of evaporation increasing during the summer months and decreasing during the winter months. Average daily evaporation data for each month of the year is shown in **Table 6.5**.

Table 6.5 Average Daily Pan Evaporations

Month	Average Daily Pan Evaporation (mm/day)
January	5.9
February	4.9
March	4.0
April	3.0
May	2.1
June	1.7
July	1.8
August	2.7
September	3.8
October	4.7
November	5.0
December	5.6

6.4.4.3 Water Demands

Current water use at Haerses Road Quarry is estimated at approximately 14 ML per year (primarily for dust suppression) and is predicted to be approximately 26 ML per year for future predicted use at maximum production levels (mainly for product washing and processing and dust suppression). Water used in the wet

processing plant will be recirculated through a water storage dam for reuse in the plant. A breakdown of the current and predicted site water demands is included in **Table 6.6**.

Table 6.6 Annual Quarry Water Demands (ML per year) at Maximum Production Levels

Use	Existing (ML/yr)	Predicted (ML/yr)
Product washing and processing	-	8
Dust Suppression	16 (10th percentile (dry) rainfall year) 14 (50th percentile (average) rainfall year) 13 (90th percentile (wet) rainfall year)	21 (10th percentile (dry) rainfall year) 18 (50th percentile (average) rainfall year) 17 (90th percentile (wet) rainfall year)
Total	**14**	**26**

The general assumptions for **Table 6.6** above are as follows:

- For future operations, moisture content of the sand product before and after washing and processing will increase from 3.5% to 6.5% respectively. Based on 250,000 tonnes of product washed and processed on an annual basis, there will be approximately 8 ML of water added to the product per annum

- Dust suppression increases from existing to modified operations due to the increase in haul road area (approximately 1 km of haul roads for existing operations and approximately 1.3 km of haul roads for modified operations).

6.4.4.4 Site Water Balance

The water balance for the existing operations was determined based on historical rainfall and evaporation data (refer to **Section 6.3.4.2**). The existing water balance indicates that the quarry typically has a net water surplus in the order of 39 ML per year for the 50th percentile rainfall condition (refer to **Table 6.7**). The net water surplus is predicted to increase slightly to 41 ML per year with the Modification (refer to **Table 6.8**).

Table 6.7 Water Balance (ML per year)

Rainfall Condition	Existing (ML/yr)	Predicted (ML/yr)
10th percentile (dry)	-14.6	-24.1
50th percentile (average)	3.9	-2.9
90th percentile (wet)	24.3	20.6

Table 6.8 Water Balance (Average Year Results) (ML per year)

Rainfall Condition	Existing (ML/yr)	Predicted (ML/yr)
Inflows		
Rainfall/runoff	23.5	29.3
Rain on dams	18.4	19.4
Total Inflow	**41.9**	**48.7**
Demands/Losses		
Evaporation	24.0	25.2
Dust suppression	14.0	18.2
Product washing and processing	-	8.0
Total Demands/Losses	**38.0**	**51.5**
Water Balance	**3.9**	**-2.9**

The general assumptions for **Table 6.8** above are as follows:

- Rainfall runoff per hectare has been calculated based on a reduced average regional runoff rate due to seepage losses through the highly permeable sandy soils on site. The average regional runoff is 0.8 ML/ha/year for the area (determined using the NSW Department of Primary Industries Office of Water Maximum harvestable right calculator) and the runoff rate used in the water balance was 0.32 ML/ha/year (40% of the average regional runoff rate published by DPI Water for farm dam calculations). This runoff rate was determined through review of site conditions and based on the current neutral water balance for the operations.

- Dust suppression has been calculated based on usage at similar sized quarries, ranging from 0.0013 ML/m^2 for a 90th percentile rainfall year to 0.0016 ML/m^2 for a 10th percentile rainfall year.

The water balance indicates that the current quarry WMS manages approximately 41.9 ML/year of rainfall/runoff from disturbed areas (average year). As the quarry extends from the current WMS area to the proposed WMS area, the quarry WMS will capture approximately 48.7 ML/year of rainfall/runoff from disturbed areas (average year).

The water balance indicates that water demands for the approved and modified quarry operations can be met by capture of runoff from disturbed areas within the quarry WMS. Modelling indicates that the site, on average, has a close to neutral water balance.

Management of Upslope Catchment Runoff Volumes

Water balance modelling indicates that, on average, 48.7 ML of runoff will flow into the WMS from upslope (disturbed) catchment areas annually and the quarry will operate with an approximately neutral water balance for an average year. This is comparable to current approved operations with an approximate neutral water balance for an average year. During dry years the quarry will adjust production to reduce operational water demands and ensure dust suppression demands are met, or import water to the site to meet operational needs.

Historically, Dixon Sand has not needed to manage and discharge any water that is captured from upslope catchment areas. This is attributable to the highly permeable sandy soils on the site, as described in **Section 1.3.1**, where water runoff is generally only generated in significant quantities during very heavy rainfall events. As a result, the surplus water as calculated in **Tables 6.7** and **6.8** is considered to be a conservative estimate, and it is not expected Dixon Sand will need to discharge excess water as per current operations.

Dixon Sand has access to existing water bores on its local land holding and should a period of water deficit occur, these bores could be used (in accordance with appropriate licences) to provide water to the quarry operations during dry periods.

6.4.5 Surface Water Impact Assessment

To manage potential water quality impacts on downstream watercourses and users throughout the life of the quarry, it is proposed to maintain the approved WMS for the quarry and install three additional sediment basins and associated drains to manage dirty water from the proposed new extraction area and the new wet and dry processing plant area. The Modification is predicted to have negligible potential impacts on water quality on downstream watercourses due to the proposed proper design, installation and maintenance of water management infrastructure is completed in accordance with the Blue Book (refer to **Section 6.4.3.2**).

Water balance modelling indicates that the Project will not result in any water discharges from site during an average rainfall year. This is consistent with existing quarry operations where no water discharges have occurred from the operations. It is therefore considered unlikely that the proposed Modification will have any impacts on downstream flooding due to water discharge.

The WMS catchment area for Hearses Road Quarry is proposed to increase to 0.9 per cent of the total catchment area of Little Cattai Creek (as compared to 0.7 per cent for the existing operations), as such it is considered that the Modification will have negligible impact on annual downstream flow volumes and downstream water users or flooding in Little Cattai Creek.

6.4.6 Mitigation, Monitoring and Management Measures

Construction Phase

During the construction of infrastructure for the Modification all works and associated erosion and sediment controls will be inspected monthly and maintained as required to ensure that all required controls are in place and effective. In addition, all erosion and sediment controls will be designed, constructed and managed in accordance with the Blue Book Volumes 1 and 2.

Following the completion of construction works, the work areas will be inspected monthly and after any rainfall events generating runoff until revegetation and stabilisation of drainage structures are complete.

Operation Phase

During the operational phase of the Modification, inspections of the water management controls will be undertaken on a monthly basis and after storm events (i.e. greater than 50 mm rainfall in 24 hours).

The walls of all water management dams will be inspected biannually (every two years) for their structural integrity and for any maintenance requirements. The walls of the water management dams will be grassed and kept free of any trees and shrubs.

Decommissioning

As part of the decommissioning of the quarry, the water management dams will either remain in use as farm dams or will be removed and the disturbed areas rehabilitated. If the dams are to be retained, the capacity of the dams will be reviewed and the size/volume modified, if required to suit future land uses and licensing provisions (see below). Once each stage has been appropriately revegetated the proposed drainage systems will be blended in with the surrounding topography and any remaining disturbed areas will be suitably rehabilitated to ensure no runoff of dirty water. Local erosion and sediment controls (i.e. sediment fences) will be left in place until any remaining small disturbed areas achieve an appropriate level of ground cover. All buildings/workshops and associated hardstand and sealed areas will be removed and revegetated.

Surface Water Monitoring

Currently no surface water quality monitoring program is in place for the existing operations at Haerses Road Quarry. Due to the lack of water discharges, it is recommended that visual inspections of water quality be undertaken after storm events and a comment on visual water quality be included on any erosion and sediment control inspections that are undertaken. Monthly surface water monitoring of the in-pit sump is proposed to provide for ongoing monitoring of site water quality, noting that off-site discharge of water from the quarry pit is not proposed.

Water Balance

Dixon Sand proposes to monitor the site water balance through monthly monitoring of site water usage and changes in dam water volumes, to determine an annual site water balance.

Licensing Requirements

The site falls within the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* which commenced on 1 July 2011. As such, surface water within the catchment is managed under the *Water Management Act 2000*. The WMS captures water for pollution control purposes, with this water reused for construction and processing purposes. Dixon Sand does not hold any water licences under the *Water Management Act 2000* for Haerses Road Quarry.

There are several new dams proposed as part of the Modification. These dams are to be sediment dams for the primary use of pollution control. The proposed locations of these dams all fall within 1st order stream catchments. The water captured in the sediment dams will either be used for dust suppression or within the processing plant on site. As such, these dams are exempt from licensing.

Dixon Sand will continue to source water for quarry operations from within the WMS boundary and harvestable rights provisions from upslope catchment areas.

Under the *Water Management Act 2000* a controlled activity approval is required to authorise its holder to carry out a specific controlled activity at a specified location in, on or under waterfront land. Waterfront land is defined as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark. There are two first order stream lines which run through the Modification area and which will be quarried through, therefore a controlled activity approval will be required for the Modification.

6.5 Noise Assessment

A Noise Impact Assessment (NIA) has been undertaken for the Modification in accordance with the *NSW Industrial Noise Policy* (INP) (EPA 2000) and supporting application notes to the INP (EPA 2013), and with the *NSW Road Noise Policy* (DECCW 2011). The assessment considered potential noise impacts from the construction and operational phases of the Modification as well as traffic noise impacts associated with quarry related traffic travelling on public roads.

6.5.1 Existing Noise Environment

The site is located within a rural environment with typically low background noise levels. Existing noise sources include local road traffic, agricultural activities and industrial contributions from surrounding quarries.

Background noise levels surrounding Haerses Road Quarry were established by ambient noise monitoring as part of the 2005 EIS. The adopted rating background level (RBL) for receivers R1 to R4 in the 2005 EIS was 34 dB(A). A conservative RBL of 30 dB(A) has been adopted for the remaining sensitive receivers surrounding the site, representing the lowest assessable RBL under the INP. As these background noise levels existed prior to Haerses Road Quarry they are considered appropriate to use for this assessment.

6.5.2 Potentially Most Affected Noise Sensitive Receptors

A number of privately owned dwellings are located near the site. **Figure 6.11** shows the closest privately owned noise-sensitive receptors. Locations R1 to R5 were assessed as part of the original 2005 EIS. Locations R6 to R11 are additional locations identified as potentially most affected by the Modification. These dwellings are in general located on higher land, with the proposed additional extraction area located on the western side of the quarry, on sloping land facing the dwellings on the opposite side of a small valley.

Residences to the east of Hitchcock Road are associated with the PF Graham (No 2) Pty Ltd sand quarry and are covered by an agreement with Dixon Sand to waiver any potential noise impacts from the proposed development. Also, Location R2 has signed a private agreement with Dixon Sand under which the consent noise conditions do not apply.

6.5.3 Project Noise Criteria

6.5.3.1 Conditions of Approval and EPA Licence Conditions

Conditions of Approval

The noise assessment contained within the original EIS for Haerses Road Quarry assessed noise from operations within the site in accordance with the INP. The consent contains a number of conditions specifically related to noise levels at the nearby receptors.

The key consent conditions relating to noise, including specific noise limits, are as follows:

[1]**NOISE**

Note: The Applicant is required to obtain a licence for the development under the Protection of the Environment Operations Act 1997.

Noise Impact Assessment Criteria

5. The Applicant shall ensure that the noise generated by the development does not exceed the noise impact assessment criteria in Table 1.

Table 1: Noise impact assessment criteria dB(A)

Day	Shoulder (6am to 7am)		Land
$L_{Aeq(15\ minute)}$	$L_{Aeq(15\ minute)}$	$L_{A(max)}$	
37	37	45	1. F & J Roberts and J & D Young
40	40		2. E. Ramm
38	38		3. M. Ramm
37	37		4. B Ramm
35	35		All other residences on privately owned land

Monitoring

10. Prior to carrying out any development, the Applicant shall prepare (and following approval implement) a Noise Monitoring Program for the development, in consultation with the DEC, and to the satisfaction of the Director-General. This program must include a combination of attended and unattended noise monitoring and a noise monitoring protocol for evaluating compliance with the noise impact assessment criteria in this consent.

EPA Licence Conditions

EPL 12513 includes limits on the noise generated from the quarry. These limits, outlined in Condition L6.1 are the same as the consent noise limits above.

6.5.3.2 Project Adopted Operational Site Noise Criteria

As an existing operation looking to modify its consent, the Modification at Haerses Road is assessable under Section 10 of the INP. The approach being adopted in this assessment for the purpose of the Modification is to seek to achieve compliance with the current consent noise limits based on the implementation of reasonable and feasible measures, as appropriate.

Accordingly, the noise criteria for operational noise emanating from the site adopted for the Modification (and based on existing consent noise limits) are set out in **Table 6.9**.

Table 6.9 Modification Operational Site Noise Criteria

Receiver	Day	Shoulder Period (6am to 7am)	
	L_{Aeq} , 15 minute	L_{Aeq} , 15 minute	$L_{A\ max}$
R1	37	37	45
R3	38	38	

Receiver	Day LAeq , 15 minute	Shoulder Period (6am to 7am)	
		LAeq , 15 minute	LA max
R4	37	37	
All other receivers without private agreement	35	35	

Note: R2 is subject to a private agreement relating to noise, therefore is not considered a sensitive receiver for the purpose of this NIA.

6.5.3.3 Road Traffic Noise Criteria

The Department of Environment, Climate Change and Water (DECCW) (now EPA) NSW Road Noise Policy (RNP) (DECCW 2011) sets out criteria for road traffic noise through the provision of a framework that addresses traffic noise issues associated with new developments, new or upgraded road developments or planned building developments.

Direct access to and from the site is via Wisemans Ferry Road, which intersects with Old Northern Road to the west.

Table 6.10 outlines the road traffic noise criteria that would be applicable on Wisemans Ferry Road and Old Northern Road. Under the road category definitions provided in Table 2 of the RNP, these roads are considered to fall under the functional road category of arterial/sub-arterial roads.

Table 6.10 Road Traffic Noise Criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment Criteria, dB(A)	
		Day (7.00 am – 10.00 pm)	Night (10.00 pm – 7.00 am)
Freeway/arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	LAeq, 15 hour 60 (external)	LAeq, 9 hour 55 (external)

Where the prevailing noise levels are already higher than the criteria, Section 3.4 of the RNP notes that when assessing noise impacts and the effectiveness of 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.

Furthermore, specifically relevant to traffic generated by new land use developments, Section 3.4.1 of the RNP states that for existing residences and other sensitive land uses affected by additional traffic on existing roads, any increase in the total noise level should be limited to 2dB above that of the corresponding level without the project. This is applicable when the noise criteria are exceeded in any time period.



Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 250 500 750m
1:15 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Noise Receiver Location
- Noise Receiver with Private Agreement

FIGURE 6.11

Haerses Road Quarry Noise Receiver Location

File Name (A4): R05/3479_071.dgn
20160922 10.49

6.5.3.4 Construction Noise Criteria

The EPA recognises that construction activities could potentially generate higher noise levels than those of typical industrial operations. The Department of Environment and Climate Change (DECC) (now EPA) Interim Construction Noise Guideline (ICNG) (DECC 2009) provides noise management criteria for construction activities. The criteria presented in **Table 6.11**, are intended to guide the need for and the selection of feasible and reasonable work practices to minimise construction noise impacts.

Table 6.11 Construction Noise Management Levels at Residences, dB(A)

Construction Time	Management Level, $L_{Aeq,15\ minute}$
Recommended standard hours Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise Affected: Rating Background Noise Level + 10 dB
	Highly Noise Affected: 75 dB(A)
Outside recommended standard hours	Noise Affected: Rating Background Noise Level + 5 dB

Based on the above and the adopted RBLs of 34 dB(A) for Locations R1 to R4 in the 2005 EIS (established from ambient noise monitoring) and a conservatively assumed RBL of 30 dB(A) (i.e this is conservative as it represents the minimum recommended RBL based on EPA procedures) at other locations (i.e Locations R5 and above), the corresponding Modification construction Noise Management Levels are outlined in **Table 6.12**.

Table 6.12 Construction Noise Criteria, dB(A)

Receiver Description	Management Level, $L_{Aeq,15\ minute}$	
	Standard hours (based on day-time RBL)	**Outside Standard Hours** (based on night-time RBL)
Locations R1 to R4	44	39
Locations R5 and above	40	35

Note: R2 is subject to a private agreement relating to noise, therefore is not considered a sensitive receiver for the purpose of this NIA.

The construction noise management levels for the non-sensitive receivers such as other industrial operations is 75 dB(A).

6.5.4 Modelling of Site Noise

6.5.4.1 Modelling Software

Computer noise modelling was undertaken based on the CONCAWE (Conservation of Clean Air and Water in Europe) industrial noise algorithm as implemented in the CadnaA environmental noise software package. CONCAWE is an internationally recognised algorithm used in the prediction of environmental noise from industrial complexes. The software utilises terrain data, source and receptor locations and heights, source sound power levels and input meteorological conditions to predict noise levels. The software accounts for ground effect, source sound power levels, geometric spreading, air absorption, acoustic shielding from topography and barriers as well as meteorological enhancement in its predictions.

6.5.4.2 Noise Modelling Parameters and Scenarios

Meteorological factors such as source to receptor winds and temperature inversions can enhance the propagation of noise. The INP requires noise modelling to include prevailing noise enhancing meteorological conditions which are considered to be a feature of the area. In terms of wind, a prevailing wind direction (i.e. up to 3 m/s) is defined to be that which occurs from a given direction for 30% of the time or more in any daytime, evening or night time period, in any single season. Similarly, temperature inversions are considered to be a feature of an area if they occur for 30% or more of the night time period in the winter months, where operations occur during the night time period.

An analysis of hourly samples of wind data collected for contiguous years between January 2002 and January 2005 at the Bureau of Meteorology Richmond (RAAF Base) weather station was undertaken as part of the noise study for the 2005 EIS. No prevailing wind directions were identified as a feature of the area within the operating hours. Furthermore, as part of the air quality study for this proposed Modification, analysis of recent wind data collected in the local area at Maroota Public School was also undertaken. Winds were found to be typically light, with a relatively high percentage of calm periods. A similar pattern of wind directions was found when compared with data from the Bureau of Meteorology in Richmond, with a worst-case easterly wind occurring for approximately 14% of the time during summer. This is a relatively low degree of occurrence and it is therefore concluded that assessment under prevailing source to receiver winds is not applicable under the INP. Accordingly, consistent with the approach of the approved 2005 EIS, noise modelling was carried out for still, isothermal (i.e calm) conditions (Pasquill Stability Class D, 20^{o}C and 70% humidity).

LIDAR derived topography data was utilised within the modelling.

Plant and equipment currently used on site is as follows:

- 1 x Komatsu 375A dozer
- 1 x Caterpillar 972G front end loader
- 2 x 30 tonne dump trucks
- 1 x water cart
- 1 x Caterpillar 12G grader (irregularly)
- 1 x service vehicle (irregularly)
- 1 x mobile dry screening plant.

In addition to the above plant and equipment currently used on site, as part of the Modification, two mobile crushers (one rotary and one jaw crusher) would be required to pre-process material prior to screening and one new wet processing plant would be installed at the southern extent of the site.

The sound power levels utilised in the noise modelling are presented in **Table 6.13** and are generally based on information contained within the Umwelt database with reference to the UK Government's Department of Environment, Food and Rural Affairs construction noise database and Umwelt's experience of similar operations and equipment and previous projects.

Table 6.13 Noise Source Sound Power Levels, dB(A)

Noise Source	Sound Power Levels
30t Dump Truck	112
Dozer	109
Product Trucks	108
Water Cart	112
Grader	106
Front End Loader	108
Wet Processing Plant	96
Crushers (jaw and rotary) and Screen Unit	116
Product Truck Idling	98
Dump Truck Idling	102

Note: Wet Processing Plant source height is 4m above local ground level. Source height of all other sources is 2m above local ground level.

6.5.4.3 Incorporated Noise Mitigation Measures

The INP requires the implementation of reasonable and feasible noise mitigation measures to meet and minimise any exceedances of noise criteria. This approach was utilised to establish noise mitigation measures incorporated in the modelling. An iterative process of noise modelling, optimisation and refinement was used to investigate and optimise possible options.

The original requirement was for the crushers and screen to be operated within the extraction areas. This resulted in relatively high noise levels in the two northern extraction cells (Cell 4 and 5), requiring high and impracticable bund heights in the order of 9m running north to south along the cell width to be constructed every 100m from the western boundary to the eastern boundary. This is because of the interaction of the relatively high noise levels generated by the crushers and screen, dwellings located on relatively high land opposite the site and the downward slope of the land from east to west on site providing minimal topographic screening. In light of this, the following alternative feasible and practicable option has been adopted and incorporated in the noise modelling, consistent with the reasonable and feasible methodology recommended under the INP:

- construct a minimum 7 metre high bund (or combined bund / noise fence) along the western boundary of Cell 4, with a minimum 80 metre return along the northern boundary of the cell prior to early extraction works in Cell 4
- construct a minimum 7 metre high bund (or combined bund / noise fence) set back a minimum of 50 metres from the western boundary of Cell 5 prior to early extraction works in Cell 5.
- either one of dozer or front end loader (not both) to operate in Cell 4 and Cell 5 during early extraction, clearing or construction of bund walls, to minimise noise
- during early extraction works (at or near surface level) in Cell 4 and Cell 5, product to be stockpiled and hauled away separately so that extraction does not occur simultaneously with haulage.

6.5.4.4 Predicted Noise Levels

Daytime Operations

The additional extraction area is located on terrain that slopes downwards from east to west. This drop-of continues progressively further west of the site boundary before rising again. The potentially most affected receivers are generally located on higher ground to the west of the proposed extraction area.

Table 6.14 presents predicted indicative typical worst case noise levels with the incorporated noise control measures outlined in **Section 6.5.4.3**. No modification factors are deemed necessary with reference to INP procedures.

Table 6.14 Predicted $LA_{eq,15minute}$ Daytime Noise Levels, dB(A)

Location	Criteria LA_{eq} , 15 minute	Cell 4, Early Extraction [1]	Cell 5, Early Extraction [1]	Cell 1, Clearing, Pre-stripping and Early Extraction [1, 2]	Cell 3, Clearing, Pre-stripping and Early Extraction [1, 2]	Cell 4, Bund Construction [1]
R1	37	41	31	31	31	31
R2[3]	40	43	43	43	43	43
R3	38	34	34	34	34	34
R4	37	35	34	34	35	35

Location	Criteria LA_{eq} , 15 minute	Cell 4, Early Extraction [1]	Cell 5, Early Extraction [1]	Cell 1, Clearing, Pre-stripping and Early Extraction [1, 2]	Cell 3, Clearing, Pre-stripping and Early Extraction [1, 2]	Cell 4, Bund Construction[1]
R5	35	35	34	34	35	35
R6		36	37	32	33	40
R7		34	36	34	36	34
R8		36	36	36	36	36
R9		35	35	35	35	35
R10		33	33	33	33	34
R11		33	32	32	33	33

1 - Product truck movement on Haerses Road modelled for all scenarios.
2 - Dump truck haulage to the Wet Processing Area modelled
3 - Location R2 is covered by a private agreement with Dixon Sand under which the consent noise conditions do not apply, however it has been included in the table for completeness

Noise modelling was carried out for the representative worst case scenarios, as shown in **Figure 6.12**. The plant and equipment were moved about the extraction areas in an iterative process to identify the locations that would represent typical worst case conditions. This is not necessarily when plant is at the westernmost point (i.e. closest to the site boundary and dwellings) due to the interaction of distance, some acoustic shielding from local topography in areas, elevation of source and receivers and the acoustic shadow zone of the earth bund walls. Moving point sources were used to represent dump (haul) truck movements (8 trips per hour) along the haul road to/from the relevant extraction cells to the wet processing area and product trucks accessing the wet processing area on site via Haerses Road (a conservative 20 movements per hour).

As can be seen from the results presented in **Error! Reference source not found.14**, other than Location R2 which is covered by a private agreement with Dixon Sand under which the consent noise conditions do not apply, noise levels during early near surface level extraction in Cells 1 and 3 are predicted to marginally exceed the consent noise limits by 1 dB(A) at locations R7 and R8. Similar noise levels are expected in Cell 2. This minor degree of exceedance would barely be perceptible. Similar noise levels can be expected during clearing and pre-stripping operations.

In Cell 4 and Cell 5, noise levels during at surface and early near surface level extraction (and later stages of pre-stripping when carried out behind the bund wall) are predicted to marginally exceed the noise limits by up to 2 dB(A) at the nearest receivers.

During the clearing and stripping operations in Cells 4 and 5, both of which are relatively short term operations which would be conducted on a campaign basis, noise levels of 40 dB(A) are expected at the worst affected location nearest to the site.

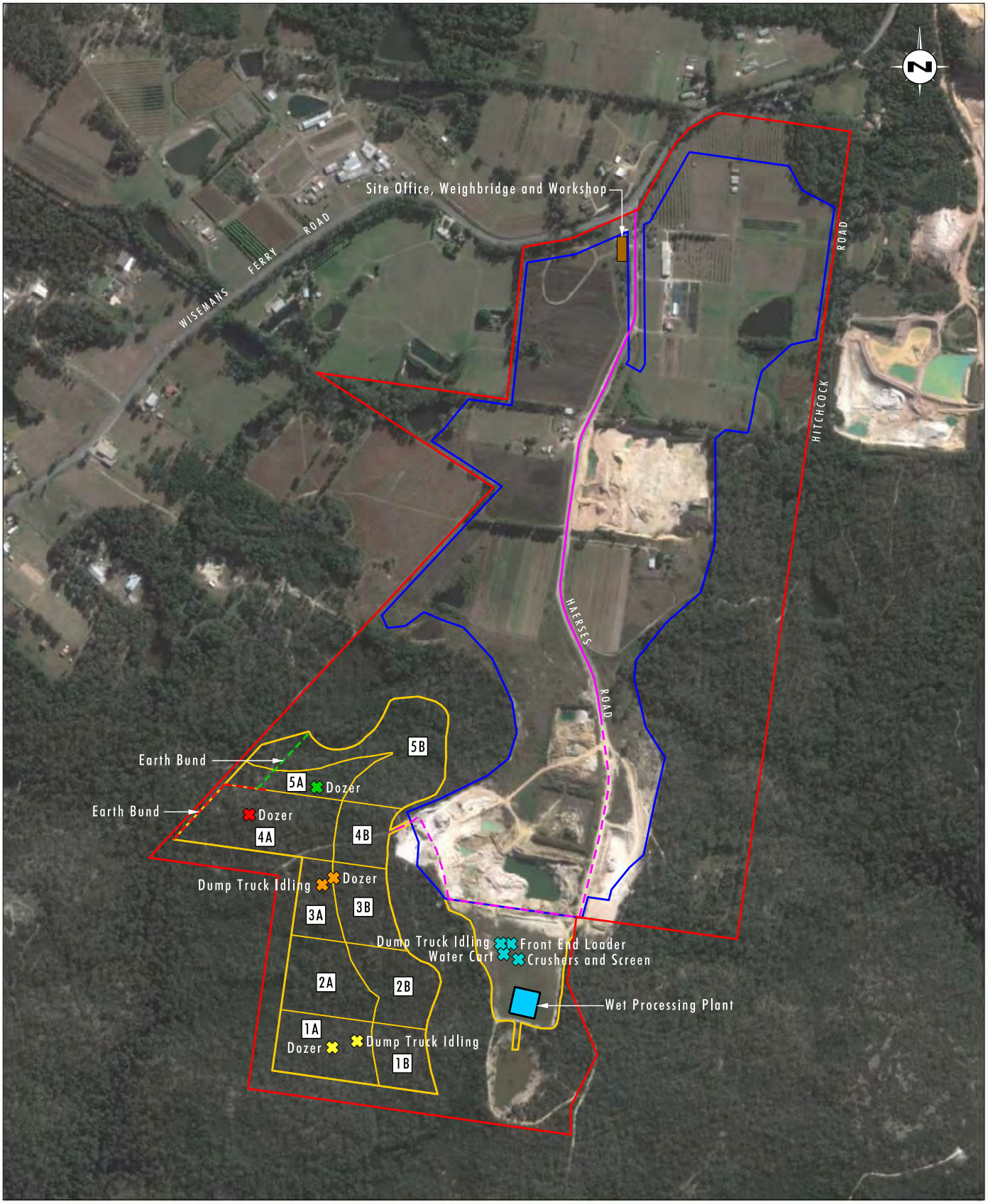


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- 1 Extraction Cell Number
- Site Office, Weighbridge and Workshop
- Wet Processing Plant
- Indicative Unsealed Haul Road
- Sealed Haul Road
- Cell 4 Earth Bund
- Cell 5 Earth Bund

Source Locations:

- Early Extraction Cell 1
- Early Extraction Cell 3
- Early Extraction Cell 4
- Early Extraction Cell 5
- Other Sources

FIGURE 6.12

Source Locations

File Name (A4): R05/3479_072.dgn
20160922 10.34

Discussion of Daytime Noise Levels

Locations directly affected by changes due to the Modification (i.e. by noise from works in the additional extraction area and wet and dry processing area) are isolated to Locations south of R5, closest to these work areas.

In relation to early extraction noise when plant is near surface level, marginal exceedances of 1 dB(A) to 2 dB(A) would be barely perceptible and considered acceptable particularly given that reasonable and feasible mitigation measures have already been implemented. Furthermore, noise levels will progressively reduce as the extraction pit depth is increased and the dozer (or front end loader) will be more effectively shielded by the working face of the pit, which would potentially be well over 10m during later stages of extraction.

It is noted that the INP (refer Section 11.1.3) considers that a development will be deemed to be in non-compliance with a noise consent or licence condition if the monitored noise level is more than 2 dB above the statutory noise limit specified in the consent or licence condition. Should greater exceedances be experienced, further noise management and mitigation measures would be investigated. Some examples of measures that can potentially be investigated in this event include temporarily shutting down some equipment/operations and construction of intermediate bund walls within the extraction cells. Other potential measures that may assist are outlined in **Section 6.5.7.**

During clearing, pre-stripping and construction of the earth bund in Cell 4 and Cell 5, noise levels of up to 40 dB(A) may be expected. These activities are a necessary part of the operation and are unavoidable. Furthermore, construction of the bund walls are required to mitigate noise levels from the longer term extraction phase. However, these activities would be of relatively short-term duration and would be carried out on a campaign basis in a similar manner as is being undertaken for other stages of the approved development at present. It is expected that the duration for clearing and construction of the bund within a cell would typically be in the order of four weeks. Although construction noise criteria would typically not be applicable in this situation given that the activity is not a clearly defined activity that would be carried out at the start of the project but one that would be carried out at various stages throughout the project, it is of note that the noise levels are expected to comply with the construction noise criteria at the nearest dwellings. In view of the relatively short duration of land clearing, early pre-stripping and bund construction works, it is recommended that best management practices be adopted to minimise noise impacts where possible.

Measures that will be implemented during this phase of works include:

- consultation with the nearest residents prior to work commencement advising them of the potential for elevated noise levels during surface works and bund construction, the timing of works, duration and taking into consideration times that might be of least disturbance to them

- provision of a site contact and telephone number to raise any concerns during the works.

Loading and Transportation during Morning Shoulder Period

Error! Reference source not found.15 shows the predicted noise level in the morning shoulder period between 6am and 7am during loading activities in the wet processing area at the closest and potentially most affected residential receivers (this being a new activity proposed as part of the Modification). The noise modelling includes product trucks accessing the wet processing area and the front end loader loading operations in the wet processing area.

Table 6.15 Predicted $LA_{eq,15minute}$ Noise Levels during the Morning Shoulder Period, dB(A)

Location	$LA_{eq,15minute}$ Noise Level	LA_{max} Noise Level*
R1	30	23/23/21
R2	43	27/27/26
R3	33	27/27/26
R4	32	33/33/32
R5	<30	34/34/33
R6	<30	32/32/30
R7	<30	34/34/33
R8	<30	36/35/34
R9	<30	34/34/33
R10	<30	32/32/30

*L_{max} noise levels associated with Truck/FEL/Reversing Alarm. L_{max} sources located in the Wet Processing Area

As demonstrated by **Table 6.15**, predicted noise levels from operations attributable to this Modification during the morning shoulder period are well within the stipulated consent and EPL limits as a result of the lower intensity of operations during the morning period and relatively large setback distances to the potentially most affected receivers.

6.5.5 Road Traffic Noise

As discussed in the Traffic Impact Assessment prepared by SECAsolution (refer to **Appendix 4**), the current consent does not seek to alter the overall number of truck movements in and out of the site (28 per day), but rather seeks to alter the potential truck movement patterns which currently restrict trucks to a maximum of 7 truck movements to the south-west per day and increase this up to a maximum of 28 per day corresponding to the currently approved maximum number of trucks entering the site. Furthermore, in the morning period between 6am to 7am, the current consent restricts traffic entering the site to 10 trucks, which will not change. Based on the 7 truck restriction to the south-west, this conservatively implies up to 17 movements to/from the south-west during the 6am to 7am period. Under this modification proposal, in a worst case scenario, this could potentially increase by up to 3 additional movements to 20 movements, relative to the current situation of up to 17 movements.

The area adjacent to the site and further west of the site is typically rural, with dwellings on large blocks of land and generally well set back from the road. However there are some dwellings at closer proximity to the road, in the order of 20m.

Based on peak hour traffic surveys, the Traffic Impact Assessment estimated the daily traffic flow on Wisemans Ferry Road to the west of the site at approximately 1,800 vehicles per day. Furthermore, with guidance from the project traffic consultant, an estimated traffic split of 90% during the 15 hour daytime period and a heavy vehicle content of 10% of the current traffic volume at a traffic speed of 80 km/h (based on the posted speed) is assumed. During the night-time period (which includes the 6am to 7am period), a 5% heavy vehicle content is assumed. **Table 6.16** shows the calculated facade road traffic noise levels

based on UK Department of Transport's Calculation of Road Traffic Noise (CoRTN) 1988 road traffic noise algorithms. It has also been conservatively assumed, for a worst case analysis, that the maximum possible upper limit of 20 project related truck movements per day would occur along Wisemans Ferry Road between 6am and 7am (i.e. three more than could occur currently) and up to 56 truck movements could potentially occur over the rest of the day. This is a worst case analysis as in reality, a proportion of traffic can reasonably be expected to travel to the north, as is now the case with the majority of traffic under the current consent.

Table 6.16 Predicted Road Traffic Noise Levels, dB(A)

Distance from Road, m	Day (7am to 10pm)		Night (10pm to 7am)	
	Current Noise Level	Noise Level with Modification	Current Noise Level	Noise Level with Modification
20	58	59	50	52
30	56	56	48	50
Criteria	**60**		**55**	

Note: CoRTN noise levels incorporating local Australian adjustment of -3 dB(A) for L_{A10} to L_{Aeq} and -1.7 Australian Road Research Board (ARRB) adjustment for local conditions.

As shown in **Table 6.16**, road traffic noise levels are predicted to comply with the nominated RNP noise criteria during both day and night periods with even lower noise levels at greater offset distances typical of a rural environment.

6.5.6 Construction Noise

A weighbridge, office and maintenance shed are proposed to be constructed on site as part of the Modification. The nearest private dwellings are located approximately 70m to the north and over 300m to the east (R1) and west (R2) along Wisemans Ferry Road. Of these, the dwelling to the north (R2) is covered by a private agreement related to noise associated with the development. In any case, noise associated with these construction works is anticipated to be of relatively low intensity particularly in comparison with the ongoing sand extraction and transportation activities on site. For example, relatively few construction-related delivery trucks (compared to up to 56 operational truck movements per day) would potentially be used to transport raw materials to site and a mobile crane may be used to assist in the construction. Noise levels from these and associated activities are expected to easily comply with the construction noise criteria.

6.5.7 Noise Management

The measures outlined in **Section 6.5.4.3** will be incorporated into the Modification in order to minimise noise from the quarry.

Haerses Road Quarry currently has an Environmental Management Program which outlines the noise monitoring requirements. The Environmental Management Plan will be modified to incorporate additional noise monitoring at the potentially most affected locations near the south-western end of the site, such as Location R6 and R8, when extraction operations are being conducted in the additional extraction area.

Further to the above, a Noise Management Protocol will be prepared and implemented prior to commencing campaign works such as clearing of the extraction cells, early pre-stripping works and construction of the noise bunds. Measures to be included in the Protocol are:

- consultation with the nearest residents prior to work commencement advising them of the potential for elevated noise levels, the timing of works, duration and taking into consideration times that might be of least disturbance to them

- provision of a contact and telephone number to raise any concerns during the works.

There are a number of additional noise control measures or operational procedures available for consideration on an as-needed basis to assist in managing noise emissions on site. The implementation of these measures or operating procedures may depend on operational and meteorological conditions. Additional noise management measures that will be considered include:

- utilising stockpiles located between near surface loading activities in the extraction cells and nearest receivers (in particular R6 and R8), where this is possible

- in the wet processing plant area, locate stockpiles along the western boundary of the area to shield loading/unloading activities. In particular, locating stockpiles as close as possible to the crushers and screen, between these plant items and the nearest receivers (in particular R6 and R8) would be beneficial, if possible

- construction of the earth bund walls in Cell 4 and Cell 5 as early as possible following clearing and early pre-stripping so that subsequent pre-stripping works at the western end of the extraction cells will benefit from the acoustic shielding provided by the bund walls

- when excavating within the extraction pits, where and when possible, excavation should be such that the western excavation face is the working face. This maximises acoustic shielding

- where noise from the dry and wet plant is found to be directional, orientate the plant so that the quieter direction is towards the closest and most affected receptors (e.g. R6 and R8), where this is feasible

- switch engines on mobile plant off when stationary rather than on idle

- make operators of mobile plant aware of measures to minimise impacts on sensitive recievers, particularly during operations in Cells 4 and 5, and provide adequate training so that quiet operating procedures can be implemented, where feasible and reasonable .

6.6 Air Quality

A detailed Air Quality Assessment has been prepared for the Modification by Pacific Environment Limited in general accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods) (NSW DEC, 2005). The Air Quality Assessment is provided in **Appendix 5** with the results summarised in this section of the EA.

6.6.1 Existing Air Quality Environment

The quarry is located in an area that is primarily rural, although significant sand extraction activity is also taking place in the area both by Dixon Sand and other companies. The closest sensitive receptor locations are presented in **Figure 6.13**. These residential receivers (some of which are owned by Dixon Sand and PF Formation, as indicated) represent assessment locations in close proximity to the Modification.

Air quality standards and goals refer to pollutant levels which include the contribution from proposed projects as well as other sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which a project is likely to contribute to these levels. Dixon Sand measures particulate matter at Maroota Public School approximately 2 kilometres north of the Haerses Road Quarry, and dust deposition on site at the Haerses Road Quarry. There are also several other dust deposition monitoring locations in the local area associated with other quarries.

For the purposes of assessing potential air quality impacts, the following existing air quality levels are assumed based on review of monitoring data for assessment against the long-term criteria:

- annual average PM_{10} concentrations of 13 µg/m^3
- annual average $PM_{2.5}$ concentrations of 6.2 µg/m^3
- annual average TSP concentrations of 32.5 µg/m^3
- annual average dust deposition of 2.1 g/m^2/month.

Wind speed and direction data collected from Maroota Public School show predominant winds are from the north, east and south-west quadrants and are generally light with an average wind speed of 1.2 m/s. There is also a relatively high percentage of calms (wind speeds below 0.5 m/s) at 16.5%. Wind data from 2015 has been found to be generally representative of the larger data set in terms of average wind speed, percentage of calms and directional patterns and has therefore been selected to represent the meteorology of the Modification area in the air quality assessment.

6.6.2 Air Quality Criteria

The air quality assessment criteria adopted for the Modification are consistent with those recommended by the EPA and specified in the Approved Methods (NSW DEC, 2005). These criteria are health-based (i.e. they are set at levels to protect against health effects) and for PM_{10} are consistent with the now superseded *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (NEPC, 1998a). However, the Approved Methods include other measures of air quality, namely dust deposition and TSP which are not stated in the Ambient Air-NEPM.

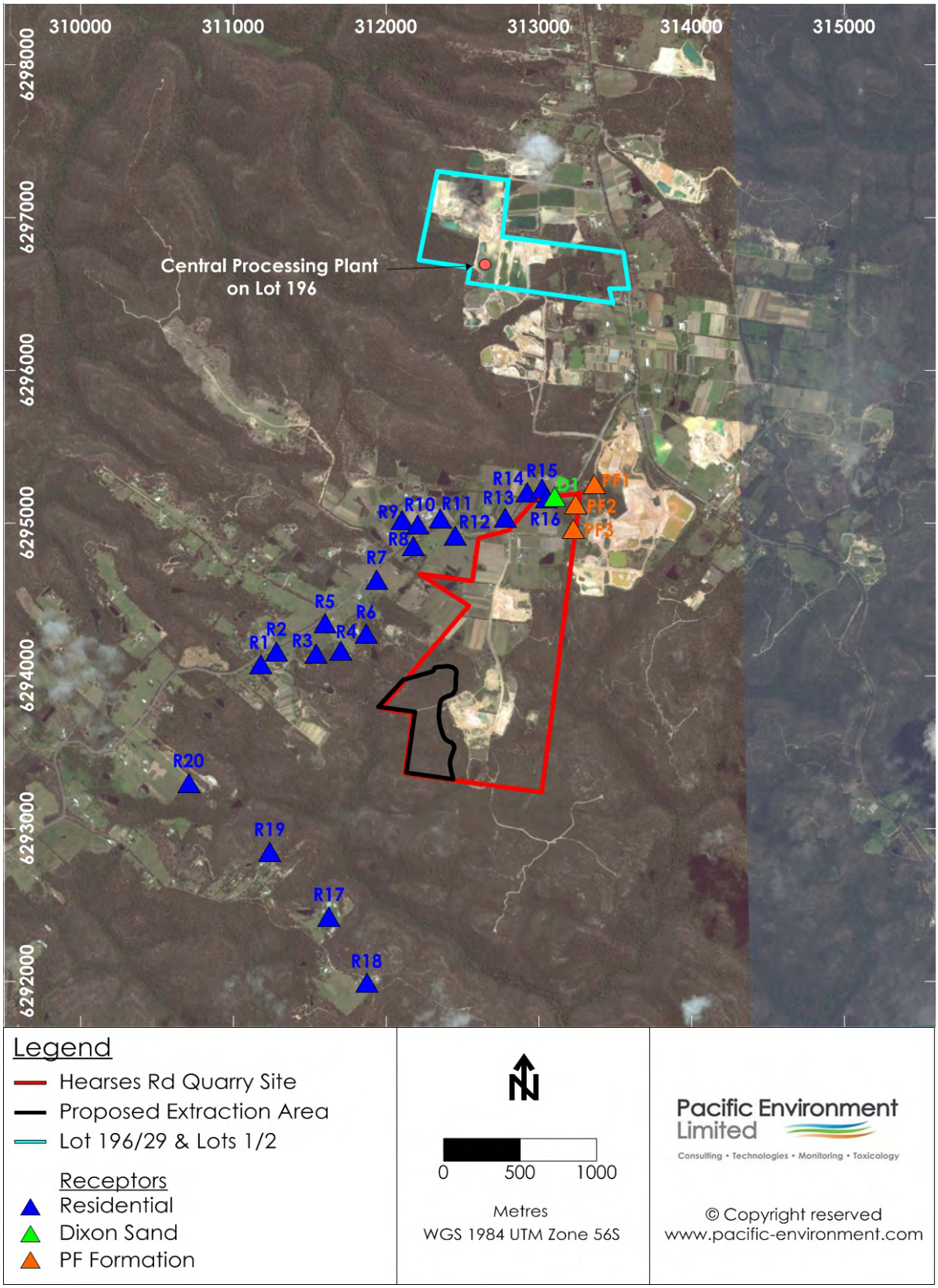


Figure 6.13 Location of Air Quality Assessment Sensitive Receptors

Source: Figure 3.1 Dixon Sand Haerses Road Modification – Air Quality Assessment (Pacific Environment, 2016)

The NEPC released an amended Ambient Air NEPM in January 2016 (NEPC, 2016) that takes into account the latest scientific evidence about the health impacts of particles. The amendment changed the 'advisory reporting standards' status for annual average and 24-hour average $PM_{2.5}$ (particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less) to 'standards'. The 2016 NEPM for $PM_{2.5}$ standards have been used in this report for comparison against dispersion modelling results.

Air quality standards for relevant pollutants are included in **Table 6.17**. It is important to note that the criteria are applied to the cumulative impacts due to the Modification and other sources.

Table 6.17 NSW EPA Air Quality Standards for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 µg/m^3	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 µg/m^3	24-Hour	NSW DEC (2005) (assessment criteria)
	30 µg/m^3	Annual	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	25 µg/m^3	24-Hour	NEPC (2016)
	8 µg/m^3	Annual	NEPC (2016)

Notes: µg/m3 – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust deposition can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts. **Table 6.18** shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition are set to protect against nuisance impacts (NSW DEC, 2005).

Table 6.18 EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Crystalline Silica

Dust generated from the Modification may contain silica dust. Long-term exposure to high levels of respirable crystalline silica (RCS) in the work place may result in silicosis, a serious lung disease. The World Health Organization's *Concise International Chemical Assessment Document on Crystalline Silica, Quartz* (CICAD, 2000) states that "there are no known adverse health effects associated with the non-occupational exposure to quartz". In addition, an Australian Government Senate Committee (2005) report identified that there are no reports in the international literature of individuals developing silicosis as a result of exposure to non-occupational levels (i.e. levels outside the work place) of silica dust, and an expert appearing before the committee confirmed the potential for such an occurrence as being very remote.

A literature review on the potential impacts to health from exposure to crustal material in Port Hedland, WA, states "exposure to airborne quartz carries the risk of silicosis, but only with prolonged exposure to concentrations greater than 200 µg/m^3" (Department of Health, 2007). As detailed in **Section 6.6.4** the maximum cumulative annual average PM_{10} concentrations (of which RCS would be a small fraction) at the most affected residence is predicted to be 14.7 µg/m^3 (of which 13 µg/m^3 is due to existing background levels), significantly below levels that may be of concern. For this reason, RCS has not been considered further in this assessment.

6.6.3 Assessment Methodology

The overall approach to the assessment generally follows the Approved Methods (NSW DEC, 2005) using the Level 2 assessment methodology.

Modelling System

AERMOD was chosen as the most suitable model due to the source types, location of nearest receivers and the nature of the local topography as well as being an accepted model of the NSW EPA.

Operational Scenarios

Generally dry and wet processing will occur at the processing area shown on **Figure 1.3**, however dry processing (screening and crushing) could potentially occur within the extraction pits once the pit is deep enough to provide sufficient acoustic screening. Both scenarios have been assessed:

- Scenario 1 – dry and wet processing at the processing location
- Scenario 2 – dry processing in pit, wet processing at processing location.

6.6.4 Air Quality Impact Assessment

Air quality standards and goals include the pollutants from all sources, inclusive of those expected as a result of the Modification. This assessment includes data gathered on existing dust concentration and deposition levels in the area in which the Modification is likely to contribute. Dust emissions during operation of the modified quarry have been estimated based on activities and equipment that would be operating at the site. The full emissions inventories for general operations, worst case operations and source locations are presented in **Appendix 5** along with a summary of the predicted pollutant concentrations at each of the assessment locations and contour plots showing the full suite of modelling results.

For all of the potential pollutants the results indicate that the incremental increases from the Modification on an annual and worst case operational basis, when added to the background concentrations outlined in **Section 6.6.1**, are below the respective EPA criteria for particulate matter and dust deposition. Note that the results for Scenario 2 are comparable to Scenario 1 in each case and therefore Scenario 1 is discussed specifically below.

Incremental Impact Assessment

The predicted particulate matter concentrations and dust deposition levels due to emission from the Modification alone are summarised as follows:

- **PM_{10}** - There are no privately owned receptors that are predicted to experience ground level concentrations (glcs) of PM_{10} above the assessment criteria, due to emissions from the Modification

only. The highest predicted glcs occur at R1, where the predicted incremental 24-hour PM_{10} concentration is 30.8 µg/m^3. The predicted annual average PM_{10} concentration at this receptor is 1.3 µg/m^3. Contour plots for PM_{10} annual and 24 hour worst case day operations are shown in **Figures 6.14** and **6.15** respectively.

- **$PM_{2.5}$** - There are no exceedances of the relevant 24-hour and annual average criteria predicted beyond the site boundaries. There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Modification only. The highest predicted glc occurs at the R6, where the predicted incremental 24-hour $PM_{2.5}$ concentration is 5.7 µg/m^3 and the predicted annual average $PM_{2.5}$ concentration is 0.4 µg/m^3.

- **TSP** - There are no privately owned receptors that are predicted to experience glcs of TSP above the assessment criteria, due to emissions from the Modification only. The highest predicted glc occurs at R4, where the predicted incremental annual average TSP concentration is 1.5 µg/m^3.

- **Dust deposition** - There are no privately owned receivers that are predicted to experience glcs of dust deposition above the assessment criteria, due to emissions from the Modification only. The highest predicted glc occurs at receptors 1, 3 and 13. At these locations, the predicted incremental annual average dust deposition concentration is 0.04 g/m^2/month.

Cumulative Impact Assessment

In order to assess the cumulative impacts of the Modification on local air quality, predicted 24-hour average PM_{10} and $PM_{2.5}$ concentrations for the Modification alone were added to existing 24-hour average background data from Maroota Public School (for PM_{10}) and NSW EPA stations at Wyong and Richmond (for $PM_{2.5}$). The assessment was conservatively completed for the worst case day operations at the four most impacted receivers as a result of the Modification (R1, R2, R6, and R18).

24-Hour Average PM_{10}

The results indicate that for the four receptors assessed, there is potential for a maximum of four additional exceedances of the cumulative 24-hour PM_{10} impact assessment criteria of 50 µg/m^3 per year for the most affected receiver (R1). However the percentage of time when the incremental concentration at R1 is over 2 µg/m^3 is less than 1% of the modelled period, highlighting the relatively minor impact of the Modification on the existing background particulate matter in the area. Therefore it is considered that only under worst case meteorological conditions combined with high background concentrations of particulate matter will an exceedance of the criteria potentially occur.

For PM_{10}, if the worst day operations happened to coincide with already elevated background concentrations, the relevant criteria may be exceeded. However this outcome is considered unlikely to occur and with the current Dixon Sand EPL requirement to modify/cease operations if rolling 24-hour averages exceed 42 µg/m^3, this will minimise the potential for this to occur even further.

24-Hour Average $PM_{2.5}$

The result indicate that the Modification would be unlikely to result in any days over the impact assessment criteria of 25 µg/m^3, and that the Modification would have a very minimal impact on current $PM_{2.5}$ concentrations. It is noted that R18 has been predicted to have one exceedance over the 2015 period, however this correlates with the highest background concentration and incremental increase, and hence the air quality impact is considered minor.

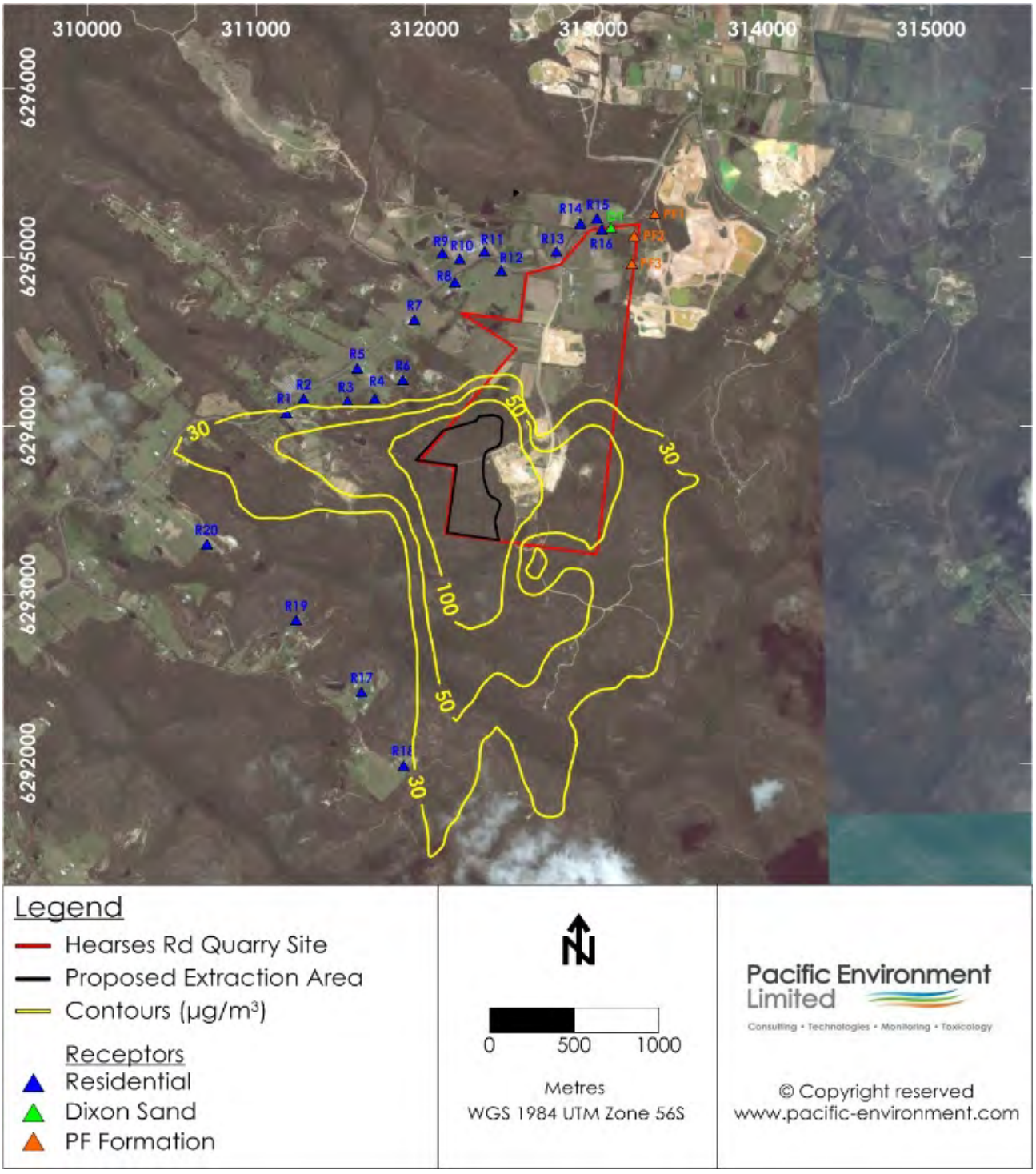


Figure 6.14 Annual Operations Maximum 24-Hour PM10 Concentration

Source: Figure 7.1 Dixon Sand Haerses Road Modification – Air Quality Assessment (Pacific Environment, 2016)

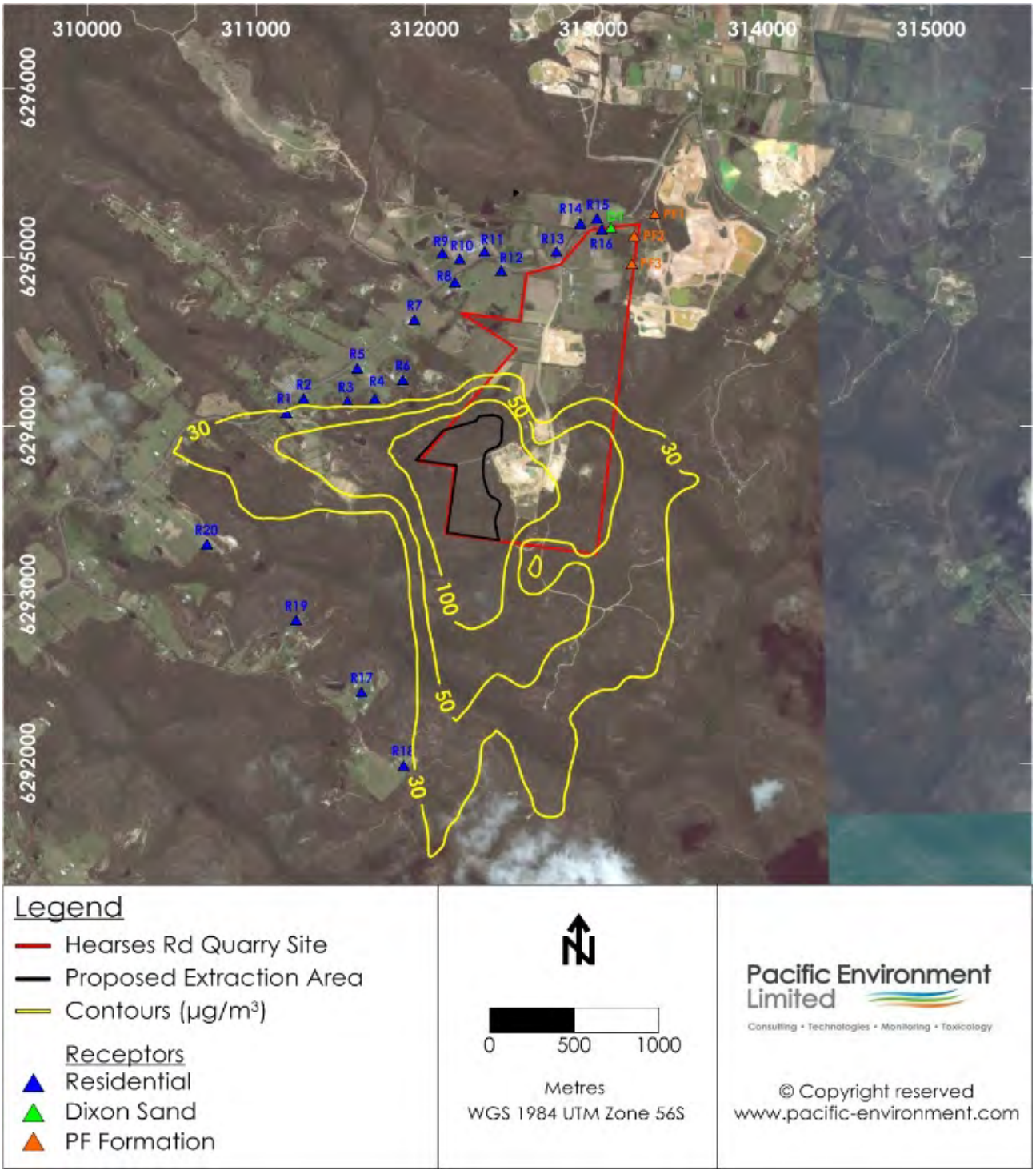


Figure 6.15 Worst Case Day Operations Maximum 24-Hour PM10 Concentration

Source: Figure 7.1 Dixon Sand Haerses Road Modification – Air Quality Assessment (Pacific Environment, 2016)

6.6.5 Mitigation and Management Measures

The following air quality management measures will continue to be implemented at the site as part of the Modification:

- use of a water cart to control emissions from haul roads (unsealed)
- enforcement of speed limits onsite
- progressive rehabilitation of exposed areas
- minimising drop height of material during truck loading and unloading where possible
- management of dust generating activities during unfavourable meteorological conditions.

6.7 Ecology

A detailed Biodiversity Assessment Report (BAR) has been prepared to assess the potential ecological impacts of the Modification using the Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (FBA). The FBA was released in October 2014 and specifies the required approach for ecological assessments for major projects in NSW. The FBA process is a credit driven system where calculators provided by the NSW government are input with ecological data about the site to generate 'impact credits'. The project is then required of offset these credits through a biodiversity offset strategy. The BAR report is provided in **Appendix 6** with a summary included in this section.

Following the FBA methodology, the BioBanking Credit Calculator (BBCC) Version 4.1 (Major Project Assessment Type) was applied following extensive literature reviews, the identification of relevant landscape features and detailed flora and fauna field surveys, in accordance with the BioBanking Assessment Methodology (BBAM) (DECC, 2008a).

6.7.1 Environmental Setting

The proposed extraction area lies in the Sydney Basin bioregion, at the top of the local catchment of Little Cattai Creek, and drains towards the west. The Modification area encompasses an area of approximately 44 hectares of which some small areas (approximately 4 ha) in the south have been disturbed by existing quarrying activities. The majority of the Modification area remains intact native woodland and forest vegetation. The woodland and forest areas of the Modification area is on the edge of a very large connected area of woodland and forest that extends eastwards towards the coast including Yengo National Park, Wollemi National Park and the Blue Mountains National Park in the west. This remnant of connected woodland and forest vegetation is among the largest remnants of woodland and forest along the east coast of NSW.

6.7.2 Avoidance Measures

Dixon Sand commissioned initial ecological field surveys within a broader biodiversity study area which included the Modification disturbance area and surrounding land to inform its design process for the Modification. Through this process, different quarry boundaries were considered and Dixon Sand sought to minimise the biodiversity impacts associated with the Modification whilst providing an economic resource. Key factors in selecting the final design of the Modification included the likely impacts on significant ecological features, including threatened species, threatened ecological communities (TEC) and/or their habitats.

Key ecological constraints that have been considered by Dixon Sand during the design phase of the Modification include the location and extent of the Coastal Upland Swamp(s) in the Sydney Basin Bioregion Endangered Ecological Community (EEC) (referred to as Coastal Upland Swamp TEC) and the population of threatened flora species *Darwinia biflora* that was identified in the Modification area.

Dixon Sand reduced the extent of the proposed extraction area from that initially proposed and thus minimised the impacts to *Darwinia biflora*. Additionally, only a very small portion of Coastal Upland Swamp TEC is now being impacted by the Modification. The final proposed extraction area boundary also includes a 50 metre buffer around the Coastal Upland Swamp TEC that will be retained.

6.7.3 Assessment Methodology

The threatened species and ecological communities known or likely to occur within the Modification area were identified by a systematic approach comprising appropriate database searches, a review of recent literature and targeted field surveys.

Database searches were undertaken to develop a list of TECs and threatened flora and fauna species that have previously been recorded, or are predicted to occur within 10 kilometres of the boundary of the Modification area. The information obtained was used to inform survey design, and was also used to assist in the assessment of potentially occurring threatened and migratory species and endangered populations. Relevant databases included:

- EPBC Protected Matters Search Tool
- OEH Atlas of NSW Wildlife.

A preliminary assessment using the BioBanking Credit Calculator was undertaken to provide a list of species credit species that might require targeted survey and the suitable survey periods for each species. The results of the database searches, literature review and preliminary assessment using the BioBanking Credit Calculator were used to design the survey requirements for species credit species so that adequate surveys were undertaken.

The vegetation of the Modification area was surveyed over two periods. The first was during spring, from 25 to 27 November, 2014 and the second was in summer, from 14 to 17 December, 2015. The additional targeted species survey undertaken in December 2015 focussed primarily on threatened flora species.

Fauna surveys across the proposed extraction area were undertaken from 25 to 27 November 2014 as well as on 16 December 2015. Fauna survey methods included a range of survey techniques including targeted searches, hair funnel trapping, call playback, anabat echolocation, spotlighting, remote detection camera surveys and meandering transects. Further detail on survey methods are provided in **Appendix 6**.

Following completion of the field survey, the BioBanking Credit Calculator (BBCC) Version 4.1 (Major Project Assessment Type) was applied in accordance with FBA methodology (OEH 2014) to calculate the credit requirements for the Modification.

6.7.4 Key Values of the Modification Disturbance Area

6.7.4.1 Landscape Features

Landscape features that were considered in the connectivity value scores in the FBA assessment for the Modification area are outlined in **Table 6.19** below.

Table 6.19 Landscape Features in the Modification Area

Landscape Features	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Yengo – Hawkesbury/Nepean
Mitchell Landscape	Hornsby Plateau
Rivers, Streams, Estuaries	1st order streams from Stone Chimney Arm Creek
Wetlands	None identified
Native Vegetation	82.19 hectares in the inner assessment circle 745.59 hectares in the outer assessment circle
State or Regional Biodiversity Links	None identified

No state or regional significant biodiversity links were identified within a plan approved by the Chief Executive of OEH in the Yengo – Hawkesbury/Nepean area. Although a number of first order streams of tributaries of Stone Chimney Arm Creek run through the site, these are not defined as state or regional significant biodiversity links under the FBA (OEH 2014).

6.7.4.2 Native Vegetation

Surveys of the Modification area identified four Biometric Vegetation Types (BVTs) (excluding exotic pastures) being:

- HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion
- HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
- HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion
- HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion.

The BVTs were categorised into four vegetation condition zones (refer to **Figure 6.16**).

One TEC, listed under the TSC and EPBC Act, was recorded in the proposed extraction area (refer to **Figure 6.17**) being the Coastal Upland Swamp(s) in the Sydney Basin Bioregion Endangered Ecological Community (EEC). Coastal Upland Swamp in the Sydney Basin Bioregion is listed as an EEC under the TSC Act. The proposed extraction area supports 0.08 hectares of Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC within HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition). A larger area of this community occurs outside the Modification disturbance area, with the Modification being designed to avoid impact on this area.

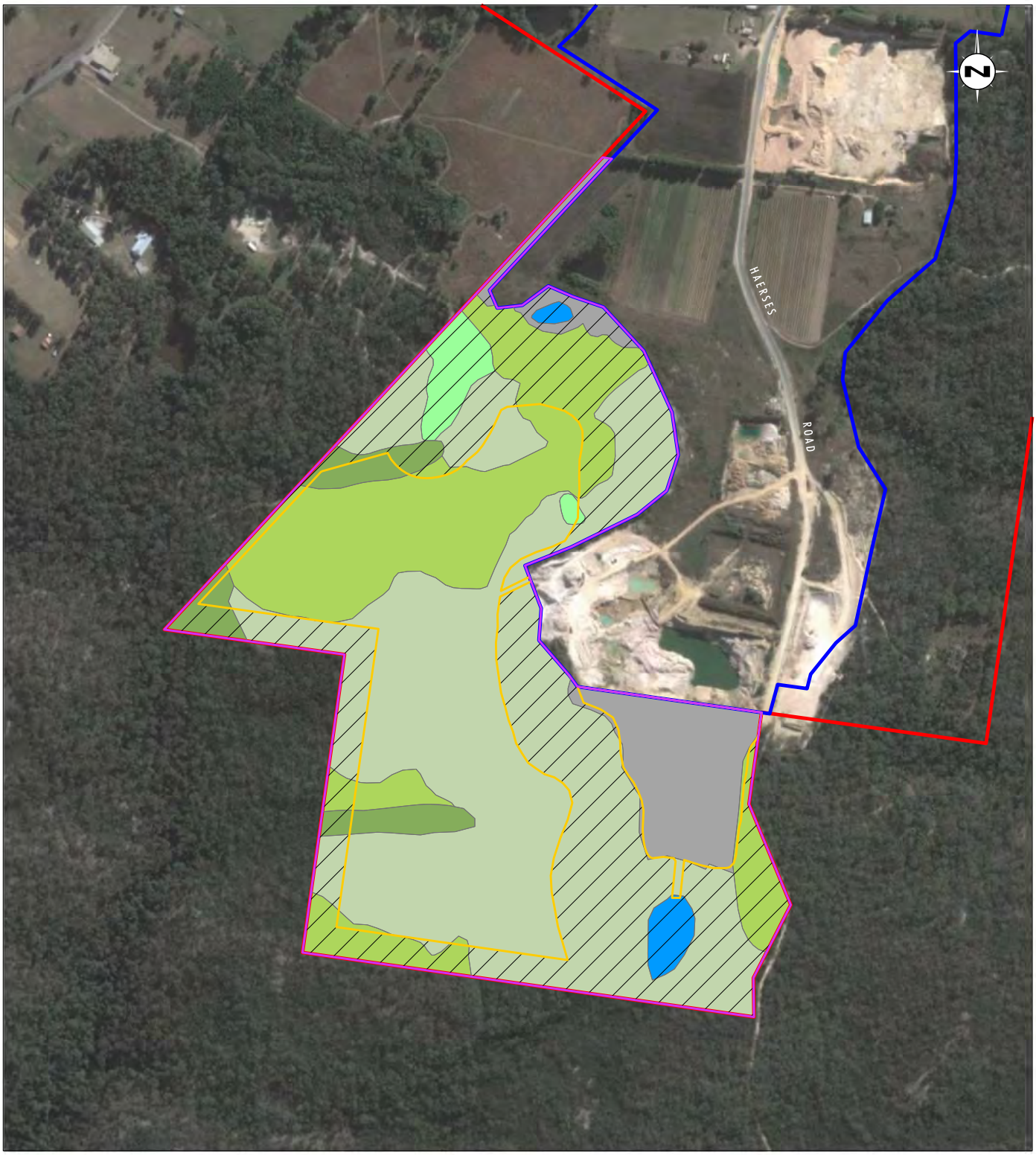


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 200 400m
1:7500

Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Ecology Study Area
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition
- Cleared
- Dam
- Area Mapped Outside The Development Site (not impacted)

FIGURE 6.16

Biometric Vegetation Types

File Name (A4): R05/3479_065.dgn
20160922 10.39

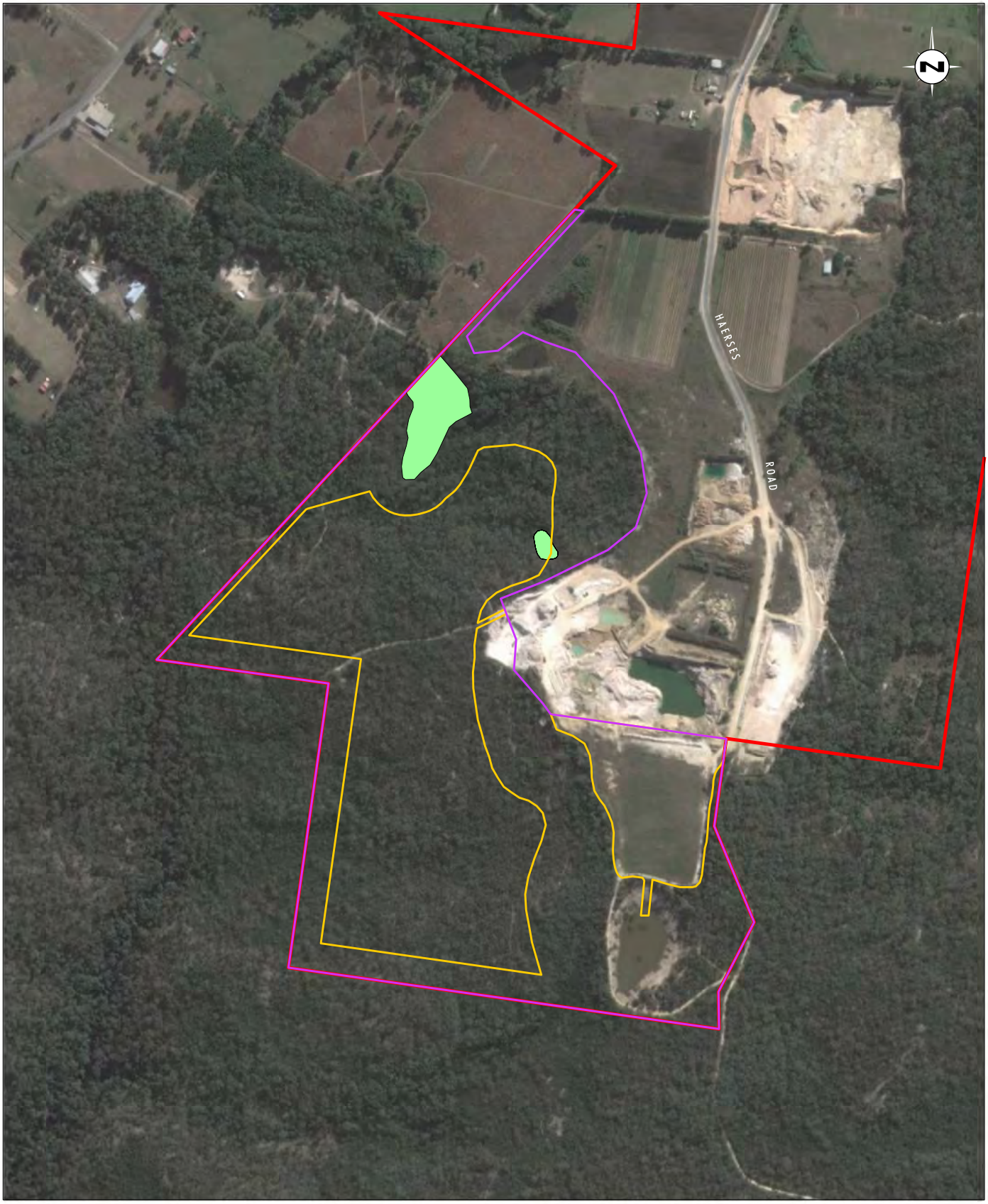


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 200 400m
1:7500

Legend

- Haerses Road Quarry Site
- Modification Disturbance Area
- Ecology Study Area
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition (Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act)

FIGURE 6.17

Threatened Ecological Communities

File Name (A4): R05/3479_067.dgn
20160922 10.36

6.7.4.3 Threatened Flora Species

The FBA methodology categorises fauna species as either ecosystem-credit species or species-credit species. These are defined as:

- Ecosystem-credit species – species that can be reliably predicted to occur in Plant Community Types (PCTs) and have a high likelihood of occurring on the site. Therefore, targeted surveys for ecosystem-credit species are not required.

- Species-credit Species – species that cannot be reliably predicted based on a PCT, distribution or habitat criteria. These species require targeted survey effort to determine their presence or otherwise on the site.

All non-threatened species and some threatened species are ecosystem species and do not therefore require further detailed assessment under the methodology. The remaining threatened species are species-credit species and require further assessment and the calculation of impact species-credits under the FBA methodology.

Five species-credit species were recorded in the Modification disturbance area during the surveys undertaken for this assessment (refer to **Figure 6.18**). These were:

- *Darwinia biflora*

- *Grevillea parviflora* subsp. *supplicans*

- *Tetratheca glandulosa*

- Dural woodland snail (*Pommerhelix duralensis*)

- Eastern pygmy-possum (*Cercartetus nanus*).

Another species-credit species, *Hibbertia superans*, was also recorded during these surveys outside the Modification disturbance area. A discussion on these records is provided below and a full species list from the surveys is included in **Appendix 6**.

6.7.4.4 Threatened Fauna Species

One ecosystem credit species, large-eared pied bat (*Chalinolobus dwyeri*), was recorded in the proposed extraction area during the surveys undertaken. One other ecosystem credit species, little bentwing-bat (*Miniopterus australis*), was recorded within the ecology study area (refer to **Figure 6.19**).

A range of other threatened species were predicted to occur by the BioBanking Credit Calculator (Major Project Assessment Type). These are discussed in detail in **Appendix 6**.

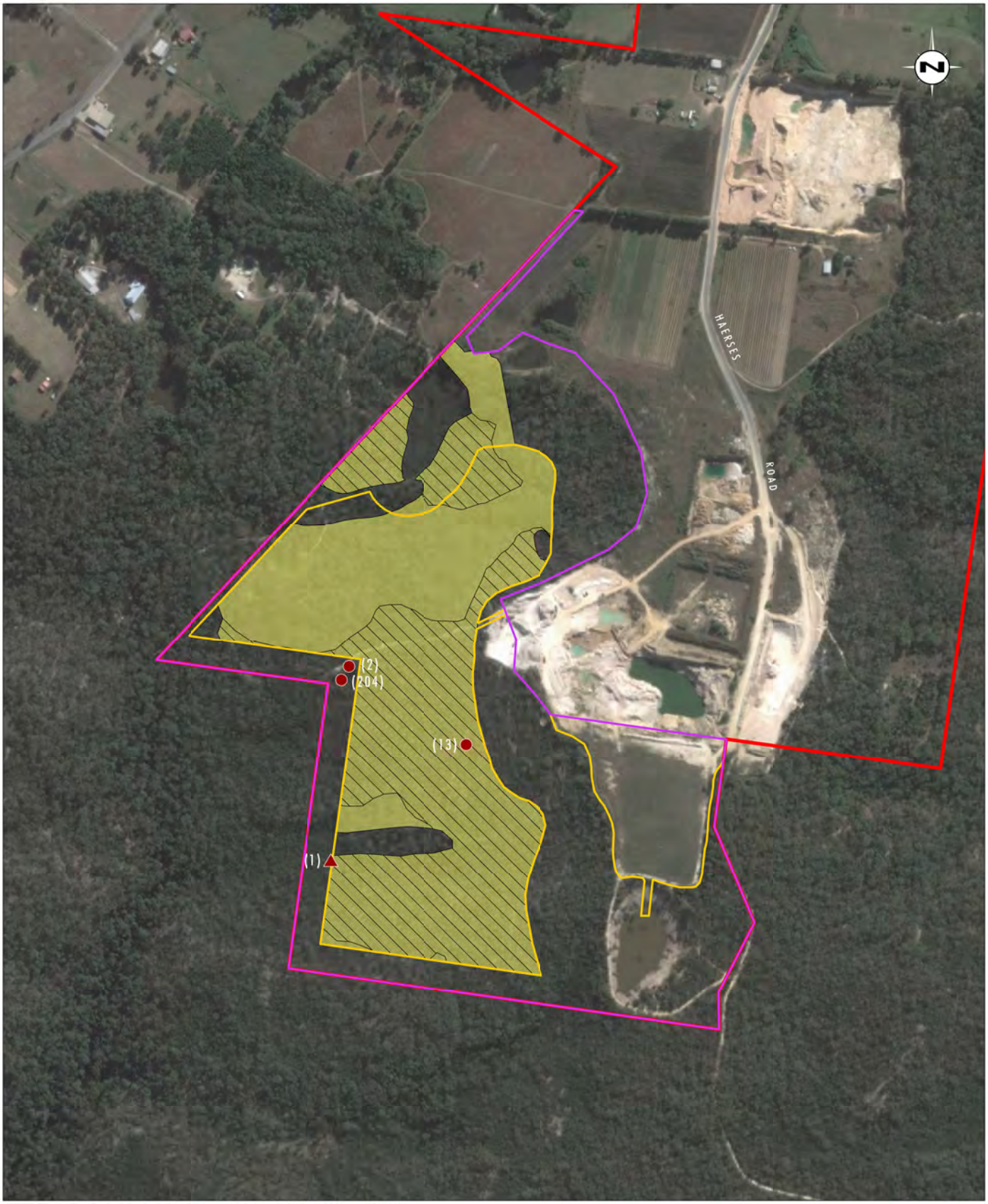


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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1:7500

Legend

- Haerses Road Quarry Site
- Modification Disturbance Area
- Ecology Study Area
- Darwinia biflora, Tetratheca glandulosa and Dural woodland snail
- Eastern pygmy-possum
- *Grevillea parviflora* subsp. *supplicans*
- *Hibbertia superans*

FIGURE 6.18

Species-credit Species

File Name (A4): R05/3479_068.dgn
20160922 10.35

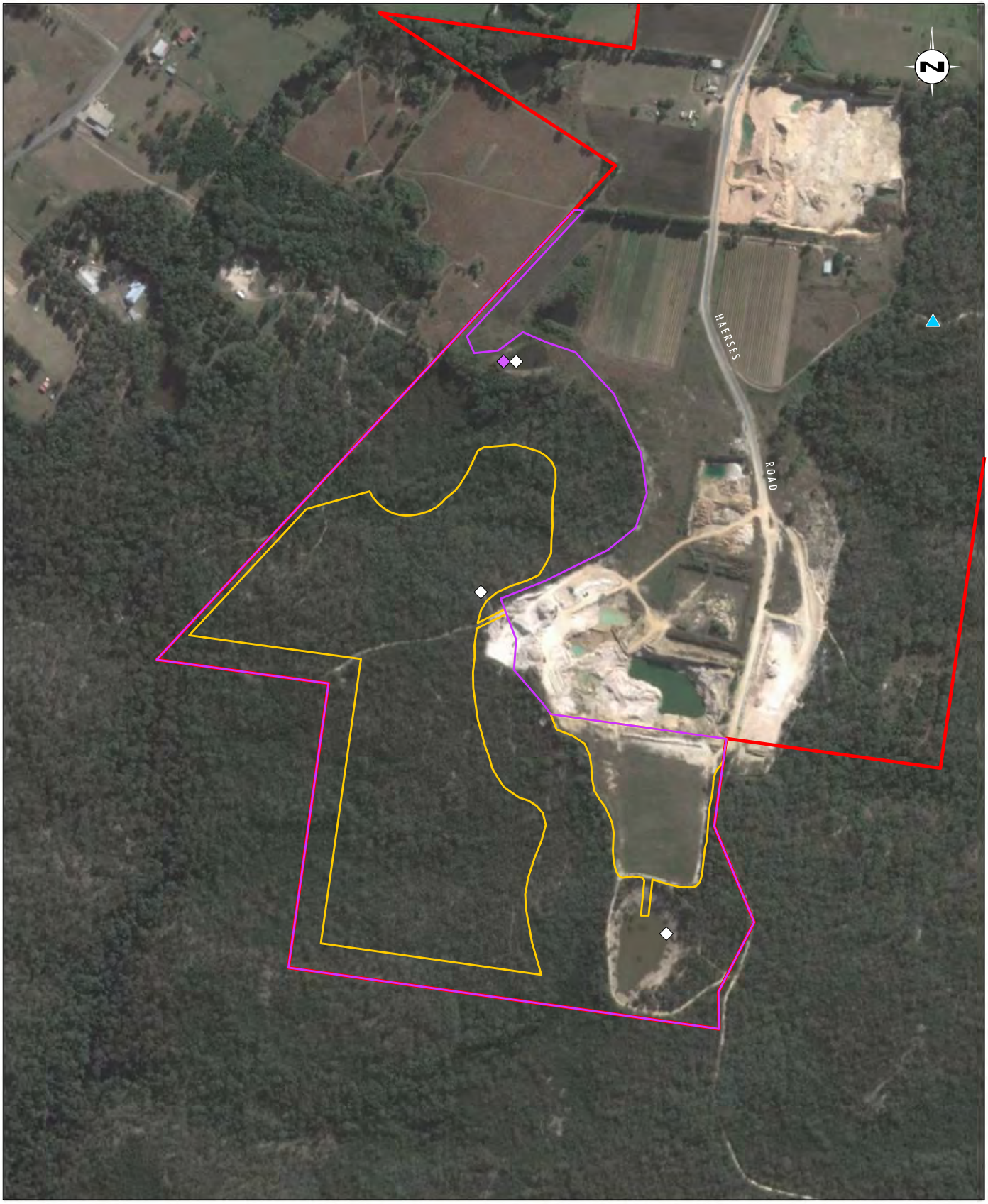


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Modification Disturbance Area
- Ecology Study Area
- Glossy Black-cockatoo (2 recorded)
- Little Bentwing-Bat
- Large-Eared Pied-Bat

FIGURE 6.19

Ecosystem-credit Species

File Name (A4): R05/3479_066.dgn
20160922 10.38

6.7.5 Impact Assessment

6.7.5.1 Direct Impacts

The Modification will result in a range of direct impacts on biodiversity values within the Modification disturbance area. Direct impact includes loss of native vegetation and fauna habitats as a result of direct clearance works and construction of the quarry.

Table 6.20 below outlines these impacts as they were entered into the BioBanking Credit Calculator (Major Project Assessment Type). **Table 6.20** also outlines the ecosystem credits required to offset those impacts. A full Credit Calculator report is included in **Appendix 6**.

Table 6.20 Biometric Vegetation Types Requiring Offset and the Ecosystem Credits Required

Biometric Vegetation Types	Area to be Impacted (ha)	Ecosystem Credit Requirements
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	0.08	3
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	6.67	377
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	11.15	538
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	0.99	44

Table 6.21 below outlines the species-credit species to be impacted as a result of the Modification and the species credits required to offset those impacts. A full Credit Calculator report is included in **Appendix 7**.

Table 6.21 Species-credit Species Requiring Offset and the Species Credits Required

Common Name	Species Name	Species Credits Required
Darwinia biflora	*Darwinia biflora*	360
eastern pygmy-possum	*Cercartetus nanus*	223
Grevillea parviflora subsp. *Supplicans*	*Grevillea parviflora* subsp. *supplicans*	338
Dural woodland snail [1]	*Pommerhelix duralensis*	1,372
Tetratheca glandulosa	*Tetratheca glandulosa*	288

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the dural woodland snail of 7.7.

In summary, the Modification requires 962 ecosystem credits and 2581 Species credits.

6.7.5.2 Indirect Impacts

The Modification is not expected to result in any substantial indirect impacts on the biodiversity values of surrounding lands during the construction or operational phases of the Modification.

Revision to the boundary of the proposed extraction area was made to provide a minimum 50 metre buffer around the Coastal Upland Swamp(s) EEC occurring outside the Modification disturbance area.

Construction and operational noise and dust impacts have the potential to adversely impact native species. Potential impacts include:

- dust covering vegetation thereby reducing vegetation health and growth
- noise disturbing the roosting and foraging behaviour of fauna species
- noise reducing the occupancy of areas of suitable habitat.

The design of the Modification will include inherent measures to minimise the potential for adverse noise and dust impacts. These include:

- the use of physical barriers adjacent to operational quarry areas, where practical, such as earthen bunds and noise walls
- dust suppression on haul roads and other operational areas to reduce vehicle generated dust emissions
- the minimisation of vegetation clearance to that required for operational purposes
- progressive rehabilitation and stabilisation of disturbed land
- equipment maintenance to minimise noise generation.

There is also the potential for weed species to be inadvertently brought into the site with imported materials, or to invade through removal of native vegetation. Mitigation measures will be implemented to minimise the potential for weed encroachment into native vegetation areas around the proposed extraction area (refer to **Appendix 6**).

6.7.6 Mitigation Measures

Dixon Sand has committed to the implementation of a comprehensive strategy to mitigate the impacts of the Modification on biodiversity during the operational and construction phases of the Modification. This includes specific measures to minimise the potential impacts on the biodiversity of the Modification area and the locality. General mitigation measures will include:

- ongoing weed management
- ongoing sediment and erosion controls
- a tree felling procedure will be implemented to minimise the potential for impacts on native fauna species (focusing on threatened species) as a result of the clearing of hollow-bearing trees

- employee education and training including inductions for staff, contractors and visitors to the site, to inform personnel of the biodiversity issues present at the site and their role and responsibilities in relation to the protection and/or minimisation of impacts to biodiversity

- areas of biodiversity value outside the proposed extraction area will be fenced or signposted, where appropriate, to prevent the unnecessary disturbance

- traffic control measures/speed limits/signage will be utilised on haul roads and access roads to minimise fauna injury/road kills.

Further details of the proposed management and mitigation measures are outlined in **Appendix 6**.

6.7.7 Biodiversity Offset Strategy

Dixon Sand is committed to delivering a Biodiversity Offset Strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Modification under the NSW *Biodiversity Offsets Policy for Major Projects* (OEH 2014). Firstly, Dixon Sand has sought to design the Modification to avoid and minimise ecological impacts in the project planning stage and a range of impact mitigation strategies have been included in the Modification to mitigate the impact on biodiversity values.

Fulfilling offset requirements under the FBA will be undertaken using one or a combination of the following offset strategies:

- on-site in-perpetuity conservation of applicable credits

- offsetting through a site secured by a BioBanking Agreement

- potentially securing required credits through the open credit market, off site, if required

- if suitable offsets are unavailable, contributing money to supplementary measures in accordance with relevant conservation or recovery actions will be investigated.

It is currently proposed that the biodiversity offset strategy will consist of the following:

- establishment of proponent-managed offset sites, including the following sites (refer to **Figure 6.20**):

    - Haerses Road Offset Site

    - Porters Road Offset Site

- purchase of credits from the Biodiversity Credits Register for the residual credits that need to be retired.

Table 6.22 below provides a summary of the credits generated from the proponent-managed offset sites proposed by Dixon Sand.



Image Source: Google Earth (2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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1:100 000

Legend

- Haerses Road Quarry Site
- Haerses Road Offset Site
- Porters Road Offset Site

FIGURE 6.20

Proposed Offset Sites

Table 6.22 Summary of Key Potential Offsetting Outcomes

Name	Credits Required	Haerses Road Offset Site Credits Generated	Porters Road Offset Site Estimated Credits	Overall Status
Ecosystem Credits				
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	3	11	0	+8
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	377	6	86	-285
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	538	17	104	-417
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	44	4	327	+287
Total	**962**	**38**	**517**	**-407**
Species Credits Required and Generated				
Darwinia biflora	360	14	142	-204
eastern pygmy-possum (*Cercartetus nanus*)	223	11	0	-212
Grevillea parviflora subsp. *supplicans*	338	0	0	-338
Dural woodland snail (*Pommerhelix duralensis*)[1]	1,372	16	0	-1,356
Tetratheca glandulosa	288	14	142	-132
Total	**2,581**	**55**	**284**	**-2,242**
Species Credits Generated				
Epacris purpurascens subsp. *purpurascens*	0	0	142	+142
Hibbertia superans	0	0	142	+142
Bynoe's Wattle (*Acacia bynoeana*)	0	0	142	+142
Lasiopetalum joyceae	0	0	64	+64

Dixon Sand will investigate, in consultation with OEH, the potential use of the Offsets Fund (when available) in addition to the proposed offset sites to address the residual credit requirements for the Modification.

With a number of ecosystem and species credits that remain in deficit after considering those generated at two offset sites and those that are available for purchase on the Biodiversity Credits Register, Dixon Sand has listed credits sought after on the Credits Wanted Register.

6.8 Traffic and Transport

A Traffic Impact Assessment has been prepared for the Modification by SECAsolution and is summarised in this section of the EA. The full report is presented in **Appendix 4**.

6.8.1 Existing Traffic and Access Arrangements

The main road through the locality is Old Northern Road, which runs in a north south direction to the west of Haerses Road Quarry. It provides an important road link through the locality, providing a connection for a number of rural suburbs between Wisemans Ferry to the north and Baulkham Hills and the greater area of Sydney to the south. Wisemans Ferry Road connects with Old Northern Road to the east of the quarry. Wisemans Ferry Road provides a sealed width in the order of 6m operating under a speed limit of 80 km/h and provides a route through to Cattai and the north-west sector of Sydney.

Haerses Road Quarry is located on Haerses Road, off Wisemans Ferry Road, to the west of the intersection with Old Northern Road. Vehicle access to the quarry is via Haerses Road. The intersection of Haerses Road and Wisemans Ferry Road was upgraded as required by the consent conditions for the quarry. There are four dwelling houses owned by Dixon Sand located off Haerses Road. One house is currently used as the Haerses Road Quarry site office with the three other houses rented.

The current approval allows for 28 inbound truck movements and 28 outbound truck movements per day. The inbound truck movements must be right hand turns from Wisemans Ferry Road with up to 10 movements permitted between 6am and 7am. The outbound truck movements can consist of up to 7 left hand turns onto Wisemans Ferry Road heading direct to market and between 21 and 28 right hand turns onto Wisemans Ferry Road heading to the Old Northern Road Quarry for processing. Truck movements to the Old Northern Road Quarry pass through the township of Maroota and Maroota Public School.

Car parking within the quarry currently consists of informal parking on the lawn associated with the site office (former dwelling house) opposite Stage 1 of the approved operations.

6.8.2 Proposed Traffic and Access Arrangements

The site access to Haerses Road Quarry will remain unchanged. There will also be no change to the total number of truck movements which will remain as 28 inbound movements and 28 outbound movements. To allow the flexibility to transport up to 250,000 tpa of product direct to market, it is proposed to allow the 28 outbound truck movements to be either left or right hand turns depending on the market destination. It is anticipated that truck movements from the quarry onto Wisemans Ferry Road would be approximately 50% left hand turns and 50% right hand turns. It is also proposed to allow inbound truck movements to be either left hand or right hand turns from Wisemans Ferry Road depending on the origin of trucks returning to the quarry to pick up a load.

The Modification also seeks to allow the import of VENM and ENM to Haerses Road Quarry for processing and then sale. The laden inbound truck movements transporting VENM or ENM to site would replace a normally empty inbound truck movement and would count against the total allowable 28 inbound truck movements. Similarly, outbound movements of the reprocessed material would count against the

allowable 28 outbound truck movements. As such, no additional truck movements would be required for the processing and sale of VENM and ENM.

Currently the amount of material leaving the Haerses Road site is calculated via weight scales fitted to the front end loader when loading trucks. With the potential increase from 60,000 tpa to 250,000 tpa exported directly to market a more efficient method is required. A weighbridge is therefore proposed to be constructed at the northern end of Haerses Road adjacent to the workshop and site office (refer **Figure 1.3**).

6.8.3 Impacts of the Proposed Changes

The Modification would not change the total traffic movements for the quarry. The ability to transport a greater proportion of product, potentially all product, direct to market would result in a decrease in truck numbers on Old Northern Road passing Maroota Public School and the township of Maroota.

The key intersections potentially affected by the Modification are the T intersection of Haerses Road with Wisemans Ferry Road and Wisemans Ferry Road with Old Northern Road. Observations on site show that both of these intersections operate very well with no delays for the majority of traffic movements. Traffic turning into or out of the side road typically did not need to stop and the only delay was that associated with manoeuvring through the intersection.

A Sidra intersection analysis has been completed at the intersection of Old Northern Road and Wisemans Ferry Road and the analysis confirms that the intersection operates very well with negligible delays and congestion. All movements have Level of Service A and the delays are less than 7 seconds for all movements. It is considered that the intersection of Haerses Road and Wisemans Ferry Road would operate to a similar level of service and delays. With no increase to the truck numbers at this location the intersection will continue to operate at this level of service.

There would be no change to access to Haerses Road Quarry and hence the Traffic Impact Assessment found that there is no requirement for road or upgrade works to the Haerses Road and Wisemans Ferry Road intersection.

There are no bus stops, public transport routes, cycling or pedestrian facilities that would be impacted by the Modification.

The Haerses Road operation hours would not change as a result of the Modification.

6.9 Visual Amenity

6.9.1 Existing Visual Environment

Haerses Road Quarry is located on a north-south aligned ridge. The viewing catchment of the site is generally bounded by Wisemans Ferry Road which follows the ridge line to the north and south west of the site and Old Northern Road which follows the ridgeline to the east. To the south of the site is an extensive area of unoccupied bushland. Stages 1 and 2 (refer to **Figure 1.4**) of the approved quarry stages are currently in operation at the site.

There are potential public viewing points to the site from various points in the surrounding landscape including:

- some residences to the north east, east and north west on Wisemans Ferry Road and Hitchcock Road have middle distance views of the site

- motorists on Wisemans Ferry Road have intermittent views of the site between existing dwellings and roadside vegetation.

The approved quarry operations are closer and more visible from the majority of potential viewing locations compared to the elements of the Modification that would be visible. As part of the existing consent Dixon Sand is required to plant screen trees along the northern boundary of the site.

6.9.2 Visual Assessment

The aspects of the Modification that have the potential to alter existing visual amenity of the quarry are the additional extraction area, the plant at the processing area and the weigh bridge, parking area and maintenance shed at the northern end of the site.

Based on topography only (i.e. no allowance for screening vegetation) an assessment of the visual catchment indicates that the additional extraction area would be visible for a small number of residences to the west of the site located on the southern side of Wisemans Ferry Road. Taking into account screening vegetation it is likely that only those residences with an existing view of Stage 5 would also have views, or partial views, of the additional extraction area. As the additional extraction area is down slope of the currently operational Stage 5 this would generally appear as a continuation of the existing operational area with very similar visual characteristics. It would, however, be closer to these residences being approximately 440 metres distant at the closest point compared to the existing 660 metres for the approved quarry. Seven metre high noise bunds will be constructed on the western side of Cell 4 and Cell 5 of the additional extraction area, however due to the 30 metre increase in height from the western to the eastern side of the extraction area, these bunds will not fully screen the extraction pit. No dwellings to the east of the site would view the additional extraction area due to its topographical position.

Similarly, based on topography only (i.e. no allowance for screening vegetation) there is the potential that some residences to the east of the site may have views to the proposed processing area. This would represent a fairly minor change to the existing situation where the mobile screening plant may be located within any part of the active stages of the approved operations. The Modification would result in additional plant on site being the wet processing plant and crushers which will be located in the processing area. Views to this equipment would generally be shielded by stockpiled quarry material. Furthermore, it is likely that intervening vegetation will screen the majority of these potential views.

The proposed maintenance shed, parking area and weighbridge will be located in the northern part of the site to the south of the existing dwelling, on the eastern side of Haerses Road (refer **Figure 6.20**). The existing dwelling will be converted to become the site office and would not result in any change in visual character. The maintenance shed would be 20 metres by 24 metres with a peaked roof at approximately 8 metres high, with an awning on one side and constructed of Colourbond material in a green or brown colour. This structure would be similar in appearance to numerous other existing sheds in the local area and is not considered likely to adversely affect the existing visual character.

The weighbridge and car parking area (12 spaces) would be adjacent to Haerses Road and be of minor visual impact and will not be visually inconsistent with the existing built elements in this area.

In summary, the visual characteristics of the Haerses Road Quarry site would change very little as a result of the Modification, with the changes being consistent with the existing visual environment of both the quarry and the surrounding areas.

6.10 Aboriginal Cultural Heritage

An Aboriginal Cultural Heritage and Archaeological Assessment (ACHAA) has been undertaken for the Modification in compliance with the Department of Environment, Climate Change and Water (DECCW, now Office of Environment and Heritage (OEH)) *Aboriginal Cultural Heritage Consultation Requirements (ACHCRs) for Proponents* (2010). The ACHAA is presented in **Appendix 7** with a summary of the key findings included in this section.

6.10.1 Consultation Process

Following the notification process, the organisations that registered an interest in consultation for the Modification were:

- Deerubbin Local Aboriginal Land Council (DLALC)
- Darug Land Observations (DLO)
- Tocomwall
- Kawul Cultural Services
- Darug Aboriginal Cultural Heritage Assessments (DACHA).

A Native Title Search from the National Native Title Tribunal indicated that there were no registered Native Title applications in the search area, which covered the Haerses Road Quarry site.

Registered Aboriginal Parties were encouraged to provide comments on the Aboriginal cultural values and significance of the Modification disturbance area and on a draft of the ACHAA for inclusion in this final ACHAA. A full consultation log and consultation records are provided in **Appendix 7**.

6.10.2 Aboriginal Social, Cultural and Archaeological Context

Haerses Road Quarry is located in the traditional lands of the Darug people who were known to have laws that promoted sustainable hunting and gathering that ensured that all members of the clan were fed (Kohen 1993). Men would hunt possums, goannas and wallabies whereas the women would fish and also gather tubers, fruits and other sources of food (Turbin 1989). The Darug people were also known to use the ridgelines and creeklines to travel across their lands due to the predominantly steep and rugged terrain and based on economic behaviour it is likely that inland Aboriginal groups had little contact with those located on the coast. Early observations by soldiers noted that there were differences in tribal groups in addition to economic and social divisions (McDonald 2008).

A search of the OEH Aboriginal Heritage Information Management System (AHIMS) was undertaken on 5 January 2016 which identified 64 Aboriginal sites within 10 kilometres of the Haerses Road Quarry. Of these sites, five are located within two kilometres of the quarry and one is located 650 metres to the east of the quarry. These sites are predominantly grinding grooves and engraving sites with very few artefacts recorded in the area. Previous investigations have indicated that artefact scatters are likely to be present in low densities on ridgeways and travelways.

6.10.3 Survey Methodology

The survey of the extraction area was undertaken on 8 December 2015 by a field team of two Umwelt archaeologists and four Aboriginal party representatives from: Darug Land Observations; Deerubbin Local Aboriginal Land Council; Kawul Culture Services; and Tocomwall.

Based on the outcomes of the predictive archaeological model for the site, the survey strategy covered 100% of the spur crests and creek lines in addition to an adequate sample of the spur slopes. A small track was identified during the survey and this was followed as it was assessed to be the most likely area to have exposures that may have visible artefacts. Survey transects were 50-100 metres wide and conducted with the assistance of Aboriginal party participants with one archaeologist forming the centreline.

The survey methodology used complies with the requirements of OEH's *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010) and Aboriginal participants had the opportunity during the survey to discuss any potential impacts of the Modification on Aboriginal cultural heritage sites and values.

6.10.4 Results

No Aboriginal artefacts were identified during the survey of the Modification disturbance area. Outcrops of sandstone were observed on the slopes within the proposed extraction area and were inspected for grinding grooves, engravings and other evidence of Aboriginal people using the landscape. The sandstone was highly weathered and no remains of Aboriginal use were identified.

The soil was observed to be sandy and skeletal. No areas of Potential Archaeological Deposit (PAD) were identified during the survey. The proposed extraction area is considered to have low archaeological potential based on a number of factors including: the landforms are not suitable for camping, soils are skeletal and unlikely to retain archaeological deposit; and water sources in the immediate vicinity of the proposed extraction area are ephemeral at best and would not support prolonged occupation. On this basis it is assessed that while Aboriginal people may have used the proposed extraction area and the site more broadly in a transitional fashion, this is unlikely to have resulted in the formation of archaeological deposits.

6.10.5 Archaeological Significance

The criteria applied to the assessment of archaeological significance are listed in **Appendix 7**. As no Aboriginal sites were identified in the survey area, the assessment of archaeological significance is applied to the landscape within the survey area as per **Table 6.23**.

Table 6.23 Assessment of Archaeological Significance

Landform within the survey area	Rarity Value	Representative Value	Research Potential	Educational Potential	Integrity	Overall Archaeological Significance
Creek Line	Low	Low	Low	Low	Low	Low
Spur Crest	Low	Low	Low	Low	Low	Low
Slope	Low	Low	Low	Low	Low	Low

6.10.6 Aboriginal Cultural Significance of the Landscape

As Aboriginal cultural significance relates to the values of a site, place or landscape to Aboriginal people, it must be determined by Aboriginal people. The registered Aboriginal parties participating in the assessment therefore have the right and obligation for assessing the significance of their cultural heritage. In assessing this significance a range of factors may be considered and this can extend beyond the physical presence of a site and its contents. Archaeological material, cultural knowledge, natural resources and landscape may all be considered.

Aboriginal parties on site during the survey noted that the area was rich with Aboriginal resources and the poor visibility limited the observation of any surface artefacts.

6.10.7 Management Measures

The recommendations presented below were discussed with the registered Aboriginal party representatives participating in the survey of the site. The registered Aboriginal party representatives indicated that the recommendations were suitable provided that there was clarity about the nature and extent of works and that consideration was given to any future works.

The following recommendations have been developed from information detailed in the ACHAA and current cultural heritage legislation:

- Dixon Sand should ensure that its employees and contractors are aware that it is an offence under Section 86 of *the National Parks and wildlife Act 1974* (NPW Act) to harm or desecrate an Aboriginal object unless that harm or desecration is the subject of an Aboriginal Heritage Impact Permit (AHIP) or other approval

- the Modification area does not contain any identified Aboriginal archaeological sites and therefore there is currently no requirement to obtain specific approvals relating to Aboriginal cultural heritage. However, in the unlikely event that previously unrecorded artefactual material is exposed during ground disturbance works, work must cease in the vicinity of the artefactual material and the registered Aboriginal parties contacted and the artefactual material managed in accordance with a methodology to be prepared in consultation with the registered Aboriginal parties and OEH, if required

- in the unlikely event that suspected human skeletal material is identified within the Modification disturbance area, all works in the immediate vicinity of the suspected human skeletal material will cease and the skeletal material will be inspected to determine if it is human (including assessment by a forensic specialist if required). If the skeletal material is human, the NSW Police and OEH will be contacted. No excavation will proceed until an appropriate course of action has been determined in consultation with NSW Police, OEH and the Aboriginal parties.

6.11 Historic Heritage

No listed heritage items were identified within the Haerses Road Quarry site or the immediate surrounds in the original 2005 EIS. A review of relevant heritage databases was undertaken for the Modification in July 2016, including:

- NSW State Heritage Register (SHR)

- State Heritage Inventory

- Australian Heritage Database (including Commonwealth and National Heritage lists and the Register of the National Estate (RNE))

- The Hills Local Environment Plan (LEP) 2012.

There were no known statutory heritage listings or potential archaeological sites within or in the immediate vicinity of the quarry. The archaeological site survey discussed in Section 6.10 did not identify any potential historic heritage sites.

No impacts on historic heritage are predicted as a result of the Modification.

6.12 Socio – economic

The consideration of socio-economic issues is a critical component of the NSW environmental assessment process, considering the potential impacts (both positive and negative) on the community both in terms of environmental impacts (e.g. dust, noise, visual as assessed in preceeding sections) and other social impacts, in addition to the consideration of economic benefits.

As part of the assessing socio-economic impacts, an understanding is required of the local community. **Section 6.12.1** provides a summary of key demographic data related to residents of Maroota as sourced from the 2011 ABS Census, while **Section 6.12.2** provides an overview of the issues raised by the community through the consultation process undertaken for the Modification.

6.12.1 Demographic and Economic Profile of Maroota

Analysis of key demographic data from the 2011 Census found that:

- The population of Maroota was 291, with a median age of 40.

- The average number of children per family was 1.9, and 47.3% of families in Maroota were couple families with children.

- Residents of Maroota have slightly higher levels of post-secondary education than the state average (40% compared to 37% for NSW).

- Volunteering levels were comparable to the state average (16.5% compared to 16.9% for NSW), and cultural diversity was lower than the state average with only 13.3% born overseas (31.4% for NSW).

- Mobility levels (as evidenced through usual place of residence five years ago) were lower than the NSW average (21.8% compared to 39.2%), suggesting a limited population movement in the area (ABS, 2011).

Analysis of key economic data from the 2011 Census found that:

- The largest industry of employment was mushroom and vegetable growing (7.1%), and the most common occupation was in management (21.3%).

- The unemployment rate is considerably lower than the NSW average at 3.4% (compared to 5.9% for NSW).

- The median weekly household income was $1,487, which is higher than the state average of $1,237.

- In terms of home ownership, 32.7% owned their house outright, and 36.7% held a mortgage. The median mortgage repayment was $1,600 and the median rent was $250 (ABS, 2011).

6.12.2 Community Issues Analysis

Residents were offered the opportunity to voice concerns or seek information related to the Modification through a newsletter that was provided to 130 households within proximity to Haerses Road Quarry and to the Maroota Public School. The newsletter provided information about the Modification, with email and telephone details provided for a representative from Dixon Sand. One resident responded to the newsletter by email, and voiced concerns about increased traffic and health concerns related to dust, as the resident's family members have asthma. This resident requested further information related to these matters, including:

- current and projected traffic and traffic routes associated with the modification, particularly related to trucks
- strategies to minimise the use of compression braking, such as signage
- dust mitigation strategies, which were of particular concern as the modified extraction area would be close to the resident's property
- an update regarding the status of the modification, and request for electronic copies of the EA and other relevant documents.

A Dixon Sand representative has spoken with the respondent to organise a time to meet to discuss the Modification and the identified issues of concern. Dixon Sand have made several follow up attempts to organise a suitable time to meet, however, at the time of preparing this report the meeting has not yet taken place.

A Community Consultative Committee for the Dixon Sand's quarry operations exists, and has 14 members comprised of Government representatives and local community resident and groups, including a representative from Maroota Public School. A review of the last two years of CCC minutes was undertaken finding that there were limited issues raised related to the quarry operations, and none related to the Haerses Road Quarry site. The CCC will continue to be a forum for residents to provide feedback about operations.

6.12.3 Assessment

In terms of the impact of the Modification to residents and local community, it is unlikely that the broader community will be greatly impacted by the Modification above and beyond current levels, given that change to current operations is not likely to greatly change the offsite impacts of the quarry operations from that which is currently approved. In addition, the change of traffic flow from Haerses Road Quarry with an increase in the number of trucks heading direct to market, will result in a reduction in trucks from Haerses Road Quarry travelling through the township of Maroota and past Maroota Public School.

In terms of the specific economic impact of the Modification, four staff are currently employed at the operations and there are plans to increase to eight staff, pending approval of the Modification. The additional employment of four full time staff at the Haerses Road Quarry has the potential to have a minor positive impact for local businesses through incidental spending in the local area.

The broader economic impact of the Modification will be the provision of high quality sand materials for the Sydney and regional markets which will largely be used in the construction of new homes.

The issues of concern raised through the consultation process, and other potential local amenity issues, have been assessed in detail in the noise, air quality and traffic sections of this report. Management and mitigation measures identified for these issues will assist to realise the benefits of the quarry while minimising these impacts on the local community.

6.13 Greenhouse Gas and Energy Assessment

This section presents the results of a greenhouse gas and energy assessment (GHGEA) for the Modification. From a greenhouse gas and energy perspective, the Modification will increase on-site energy consumption, shift the distribution of Scope 3 greenhouse gas emissions and increase total greenhouse gas emissions over the life of the quarry.

6.13.1 Methodology

The GHGEA framework is based on the methodologies and emission factors contained in the *National Greenhouse Accounts (NGA) Factors 2015* (DOE, 2015). The assessment framework also incorporates the principles of *The Greenhouse Gas Protocol 2004* (WRI/WBCSD, 2004) (The GHG Protocol).

The GHG Protocol provides an internationally accepted approach to greenhouse gas accounting. It provides guidance on setting reporting boundaries, defining emission sources and dealing with issues such as data quality and materiality. The GHG Protocol defines three 'Scopes' of emissions for greenhouse gas accounting and reporting purposes. These scopes are briefly outlined below.

Scope 1 emissions are direct emissions which occur from sources owned or controlled by the proponent, over which they have a high level of control (such as fuel use).

Scope 2 emissions are those generated from purchased electricity consumed by the proponent, which can be easily measured and can be influenced through energy efficiency measures. Scope 2 emissions physically occur at the facility where electricity is generated (i.e. the power station).

Scope 3 emissions are indirect emissions that are a consequence of the activities of the proponent, but occur at sources owned or controlled by another reporting entity (e.g. outsourced services). Scope 3 emissions can include emissions generated upstream of the facility by providers of energy, materials and transport. Scope 3 emissions can also include emissions generated downstream of the facility by providers of product transport.

All emissions were calculated based on the methodologies and emission factors provided by the National Greenhouse Accounts (NGA) Factors 2015 (DOE, 2015).

6.13.2 Assessment Boundaries and Assumptions

The following GHGEA is limited to quantifying the greenhouse gas emissions associated with on-site energy use. The assessment does not quantify the greenhouse gas emissions associated with product use, product transport or land use change (clearing vegetation, developing biodiversity offsets and revegetation). As the Modification will not result in any changes to total annual production, no significant changes in annual greenhouse gas emissions associated with product transport are envisaged.

The greenhouse gas and energy use assessment is based on the following assumptions:

- electricity use will increase 25%, from 36 GJ to 45 GJ due to the operation of a new weighbridge and upgraded site facilities

- diesel use associated with quarrying materials will not change, and average 100 kL (3,860 GJ) per annum over the life of the quarry
- product material will be processed on-site using mobile plant, instead of being processed at the Old Northern Road Quarry
- the on-site processing plant will consume up to 157 kL (6,060 GJ) of diesel per annum
- the Modification will allow additional annual energy consumption between 2017 and 2031
- the Modification will allow the quarry to operate for an additional fifteen years.

6.13.3 Energy Consumption

Annual Energy Consumption

Table 6.24 includes a summary of the direct annual energy use impacts of the Modification. **Table 6.24** demonstrates that the Modification may increase the annual demand for energy by approximately 6,000 GJ.

Table 6.24 The impact of the Modification on annual energy consumption

Activity	Approved Project (GJ)	Modification (GJ)	Energy Use Change (GJ)
Electricity use	36	45	9
Diesel use – quarrying	3,860	3,860	0
Diesel use – processing	0	6,060	6,060
Total			**6,069**

Total Energy Consumption

The Modification allows total energy consumption to increase over the life of the quarry, through the addition of new processing equipment, and extending operations by fifteen years. **Table 6.25** demonstrates that the Modification may increase demand for energy by approximately 241,000 GJ.

Table 6.25 The impact of the Modification on total energy consumption

	Electricity use (GJ)	Diesel use (GJ)	Total (GJ)
Annual increase over the Approved Project 2017-2030	135	90,903	91,038
Additional 5 years of operation	675	148,803	149,478
Total	**810**	**239,706**	**240,516**

6.13.4 Greenhouse Gas Emissions

The Modification will allow the generation of both direct and indirect greenhouse gas emissions. **Table 6.26** summarises the additional greenhouse gas emissions that may be associated with the Modification.

Table 6.26 The impact of the Modification on total greenhouse gas emissions

Scope	Fuel use	Energy Use (GJ)	Emission Factor[1] (Kg CO2-e / GJ)	GHG Emissions (t CO2-e)
1	Diesel use	239,706	70.2	16,827
2	Electricity use	810	233	189
3	Indirect emissions associated with purchased diesel	239,706	3.6	863
3	Indirect emissions associated with purchased electricity	810	34	28
Total				**17,907**

6.13.5 Impact Assessment

The greenhouse gas emissions generated by the Modification have the potential to impact the environment and the greenhouse gas reduction objectives of national and international governing bodies.

Table 6.26 demonstrates that the Modification may allow up to 17,000 t CO_2-e Scope 1 emissions over the life of the quarry. **Table 6.26** also demonstrates that the energy use associated with the Modification will generate up to 200 t CO_2-e of Scope 2 emissions and approximately 900 t CO_2-e of Scope 3 emissions associated with purchased diesel and electricity. All Scope 2 and 3 emissions are attributable to, and may be reported by, third party entities not directly related to the Modification.

Over the life of the quarry, the annual Scope 1 emissions attributable to the Modification may average 570 t CO2-e per annum. Given the scale of the Scope 1 emissions, the Modification is unlikely to make a significant impact on atmospheric concentrations of greenhouse gas emissions or on Australia's ability to meet its emission targets.

6.13.6 Assessment of Mitigation Measures

Approximately 99 per cent of the Modification's Scope 1 and 2 emissions relate to on-site diesel use. Improving the diesel use efficiency associated with plant and equipment will provide the greatest reduction in greenhouse gas emissions. Dixon Sand will review opportunities for diesel use efficiency when purchasing or replacing equipment at the quarry and will appropriate maintain all equipment to provide for efficient operations.

[1] National Greenhouse Accounts factors. Department of the Environment 2015.

6.14 Quarry Rehabilitation

Dixon Sand is committed to the effective rehabilitation and closure of its quarry sites. This is achieved through progressive rehabilitation and managing quarry operations to work towards the eventual final rehabilitation and closure of the site.

In accordance with Condition 22 of Schedule 3 of the Consent, a Rehabilitation and Landscape Management Plan has been prepared for the approved project. This plan provides a detailed description of the planned approach to rehabilitation of the Quarry, including the rehabilitation of the quarry pit. The key aspects of the Modification which have the potential to revise the rehabilitation strategy outlined in the Rehabilitation and Landscape Management Plan are the additional extraction area and the site office and maintenance shed location. No changes are proposed to rehabilitation completion criteria or final land use, except that the additional quarry area will be returned to native vegetation.

The Rehabilitation and Landscape Management Plan prepared for the Quarry and approved by DPE provides a detailed description of the strategies that will be used to rehabilitate the areas disturbed by quarrying operations. The Plan will be updated for the Modification to incorporate the rehabilitation of the proposed extraction area.

Dixon Sand proposes to progressively rehabilitate the additional extraction area by refilling and contouring the extraction area by emplacement of fines from the wash plant combined with unsuitable material from the quarrying process and VENM and ENM to achieve a landform generally consistent with the surrounding topography and pre-quarrying landform.

As part of the detailed quarry planning process, a detailed Quarry Closure Plan will be developed approximately three years prior to cessation of quarrying activities. The Quarry Closure Plan will describe in detail the proposed operational and progressive rehabilitation procedures for the remainder of the quarry life and subsequent to the quarry closure.

6.14.1 Closure and Rehabilitation Objectives

Rehabilitation of the quarry extraction area will be undertaken in accordance with the relevant key principles of the Strategic Framework for Mine Closure (Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia 2000) and encompasses the following objectives:

- provide a safe and stable landform compatible with the intended final land use
- comply with relevant regulatory requirements
- reduce the need for long term monitoring and maintenance by achieving effective rehabilitation
- complete the closure, decommissioning and rehabilitation works as quickly and cost effectively as possible whilst achieving primary objectives
- provide a sustainable plant cover through rehabilitation of disturbed areas
- ensure that the design periods and factors for safety for all site works take into account extreme events and other natural processes such as erosion.

6.14.2 Preliminary Closure and Rehabilitation Criteria

Completion criteria will be utilised to demonstrate achievement of rehabilitation objectives/performance standards. The preliminary closure and rehabilitation completion criteria for the Modification are outlined in **Table 6.27**. These will be subject to ongoing refinement over the life of the quarry and will be incorporated into the updated Rehabilitation and Landscape Management Plan.

Table 6.27 Preliminary Closure and Rehabilitation Completion Criteria

Aspect	Preliminary Completion Criteria
Decommissioning	All infrastructure which does not have a potential future use associated with the post-quarrying land use will be removed, unless such removal has a greater environmental impact than rehabilitating the area with the infrastructure remaining in place.
	Removal of all services which do not have a potential future use associated with the post-quarrying land use (power, water, communications).
Landform	No significant erosion is present that would constitute a safety hazard or compromise the capability of supporting the final land use.
	Contour banks are stable and there is no evidence of overtopping or significant scouring as a result of runoff.
	Surface is free of any hazardous materials.
Soil	Topsoil or a suitable alternative has been spread uniformly over the rehabilitation surface.
Water	Runoff water quality from the site does not pose a threat to downstream water quality.
Vegetation	There is no significant weed infestation.
	Native vegetation areas have established within the rehabilitated proposed extraction area.
	Trees planted as part of rehabilitation have reached maturity, maturity being defined as when trees are capable of producing fruits and flowers.
Bushfire Hazard	Appropriate bushfire hazard controls have been implemented.

The preliminary closure criteria will be reviewed and revised throughout the Project life and used as the basis for further refinement following the commencement of rehabilitation activities; consideration of the results of rehabilitation monitoring programs; and consideration of any stakeholder feedback.

6.14.3 Proposed Final Landform

The proposed final landform for the quarry involves re-filling and contouring the extraction area to achieve a landform consistent with the surrounding topography and pre-quarrying landform. The conceptual final landform for the quarry is shown in **Figure 6.21**. Further details on the rehabilitation methodology to achieve the landform design are outlined below.

Quarry Extraction Area

Rehabilitation of the quarry pit will be commenced progressively following completion of each stage of extraction. As described in **Section 3.0**, the final landform levels for Cell 1 would be achieved using tailings from the wet processing plant from the extraction of Cells 1 and 2 as required. The silt pond in Cell 1 would be capped and rehabilitated using stockpiled overburden and topsoil.

Once the final landform levels are established in Cell 1, vegetation from Cell 3 would be translocated to Cell 1 to achieve final rehabilitation. Extraction in Cell 4 would not commence until rehabilitation in Cell 1 was complete. This process would continue so that cells are progressively rehabilitated south to north in sequential stages.

Where sufficient material from the quarrying process (e.g. tailings or other unsuitable material) is unavailable, VENM or ENM (or equivalent classification) may be imported to the site to contribute to backfilling of the quarry void. The extraction area will be re-filled and contoured to achieve a landform consistent with the surrounding topography and pre-quarrying landform. Permanent dams will be established in the lower reaches of the extraction area to provide for sediment control during the vegetation establishment phase and will likely be retained in the final landform.

Surface Infrastructure

During the decommissioning process, the processing plant and quarrying infrastructure not required to support the post-quarrying land use will be removed. Where required, the areas occupied by these facilities would be re-profiled, deep ripped, topsoiled and revegetated with pasture grass species. Infrastructure with the potential to support the post quarry land use may be retained following consultation and agreement with the relevant landowners.

6.14.4 Rehabilitation Strategy

As discussed in **Section 6.16.4**, rehabilitation will be completed progressively as part of the ongoing development of the quarry. The proposed extraction area will be returned to native vegetation, primarily using topsoil and cleared vegetation from each progressive extraction area to re-spread over rehabilitated areas. This will be supplemented by planting of native species as required.

Further details on the approach to rehabilitation will be included in the updated Rehabilitation and Landscape Management Plan.



FIGURE 6.21

Proposed Final Landform

0 100 250 500m
1:10 000

Image Source: ERM (2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

File Name (A4): R05/3479_054.dgn
20160914 15.07

6.14.5 Rehabilitation Monitoring and Maintenance

A rehabilitation monitoring program will be implemented to include the aspects outlined below.

Rehabilitation Monitoring

Annual inspections of rehabilitated areas will be undertaken over the life of the Project to assess soil conditions and erosion, drainage and sediment control structures, runoff water quality, revegetation germination success, plant health and weed infestation. Where necessary, remediation measures will be implemented and rehabilitation procedures will be amended accordingly with the aim of continually improving rehabilitation standards.

The objective of this monitoring is to evaluate the progress of rehabilitation towards fulfilling long term land use objectives and criteria. The monitoring program will be continued until it can be demonstrated that rehabilitation has satisfied the rehabilitation and closure criteria. Information from this monitoring program will also be used to refine rehabilitation and closure criteria as required.

Rehabilitation Care and Maintenance

Dependent upon the outcomes of the rehabilitation monitoring as outlined above, the scope of the rehabilitation care and maintenance may include the following:

- weed and feral animal control
- erosion and sediment control works
- re-seeding of rehabilitation areas that may have failed
- maintenance fertilising
- repair of fence lines, access tracks and other general related land management activities.

7.0 Summary of Environmental Management Measures

Dixon Sand has an existing Environmental Management Strategy and associated management plans and systems which guide environmental management at the Haerses Road Quarry. These plans will be revised and updated as part of the implementation of the Modification. A summary of the key management and mitigation measures proposed to be implemented as part of the Modification Project is provided below, focussing on the additional controls to be implemented as part of the Modification.

7.1 Update of Management Plans and Programs

- Within 12 months of the granting of approval for the modification, or as otherwise agreed with DP&E, Dixon Sand will update all of the environmental management plans and programs required by the development consent.

7.1.1 Groundwater

- Monitoring will be continued for the life of the Haerses Road quarry operations to continue to refine the mapping of the extent of the MTSGS and the wet weather groundwater level in both the MTSGS and the SCBGS to allow appropriate buffers to be maintained throughout the life of the quarry.

- No extraction would be undertaken within the 100 metre buffer of the MTSGS until two additional monitoring bores within the western margin of the MTSGS have been established and monitoring shows that quarrying can be undertaken in this area without impacting on the MTSGS. The decision to commence quarrying in this area will be undertaken in consultation with DPI Water and with the approval of DPE.

- The depth of quarrying will maintain an elevation which is at least two metres above the 'wet weather' groundwater elevation for the SCBGS.

- A TARP for groundwater will be developed as part of the ongoing groundwater monitoring program to focus upon appropriate trigger and response actions for the management or mitigation of any unpredicted impacts that occur. The monitoring program that is in place will be used to establish the triggers, which will be designed to identify any potential impacts and trigger an appropriate response.

7.1.2 Surface Water

- During the construction of infrastructure for the Modification all works and associated erosion and sediment controls will be inspected monthly and maintained as required to ensure that all required controls are in place and effective.

- All erosion and sediment controls will be designed, constructed and managed in accordance with the Blue Book Volumes 1 and 2.

- Following the completion of construction works, the work areas will be inspected monthly and after any rainfall events generating runoff until revegetation and stabilisation of drainage structures are complete.

- During the operational phase of the Modification, inspections of the water management controls will be undertaken on a monthly basis and after storm events (i.e. greater than 50 mm rainfall in 24 hours).

- The walls of all water management dams will be inspected biennially (every two years) for their structural integrity and for any maintenance requirements. The walls of the water management dams will be grassed and kept free of any trees and shrubs.

- Visual inspections of water quality will be undertaken after storm events and a comment on visual water quality will be included on any erosion and sediment control inspections that are undertaken.

- Monthly surface water monitoring of the in-pit sump is proposed to provide for ongoing monitoring of site water quality.

- Dixon Sand will monitor the site water balance through monthly monitoring of site water usage and changes in dam water volumes, to determine an annual site water balance.

7.1.3 Noise

- The existing noise monitoring program will be modified to incorporate additional noise monitoring at the potentially most affected locations near the south-western end of the site, such as Location R6 and R8, when extraction operations are being conducted in the additional extraction area.

- A Noise Management Protocol will be prepared and implemented prior to commencing campaign works such as clearing of the extraction cells, early pre-stripping works and construction of the noise bunds. Measures to be included in the Protocol are:

    - consultation with the nearest residents prior to work commencement advising them of the potential for elevated noise levels, the timing of works, duration and taking into consideration times that might be of least disturbance to them

    - provision of a contact and telephone number to raise any concerns during the works.

- The following noise controls (or alternative achieving the same outcome) will be incorporated into the design of the Modification:

    - locate the crushers and screen within the wet processing plant area, where the distance between the plant and nearest dwellings is maximised

    - construct a minimum 7 metre bund (or combined bund / noise fence) along the western boundary of Cell 4, with a minimum 80 metre return along the northern boundary of the cell prior to early extraction works in Cell 4

    - construct a minimum 7 metre bund (or combined bund / noise fence) set back a minimum of 50 metre from the western boundary of Cell 5 prior to early extraction works in Cell 5. Due to conditions of the local topography, location of the bund at the western boundary would require a significantly higher bund for little benefit

    - either one of dozer or front end loader (not both) to operate in Cell 4 and Cell 5 during early extraction, clearing or construction of bund walls, to minimise noise

    - during early extraction works (at or near surface level) in Cell 4 and Cell 5, product to be stockpiled and hauled away separately so that extraction does not occur simultaneously with haulage.

- There are a number of additional noise control measures or operational procedures available for consideration on an as-needed basis to assist in managing noise emissions on site. The implementation of these measures or operating procedures may depend on operational and meteorological conditions. Additional noise management measures that will be considered include:

    - utilising stockpiles located between near surface loading activities in the extraction cells and nearest receivers (in particular R6 and R8), where this is possible

    - in the wet processing plant area, locate stockpiles along the western boundary of the area to shield loading/unloading activities. In particular, locating stockpiles as close as possible to the crushers and screen, between these plant items and the nearest receivers (in particular R6 and R8) would be beneficial, if possible

    - construction of the earth bund walls in Cell 4 and Cell 5 as early as possible following clearing and early pre-stripping so that subsequent pre-stripping works at the western end of the extraction cells will benefit from the acoustic shielding provided by the bund walls

    - when excavating within the extraction pits, where and when possible, excavation should be such that the western excavation face is the working face. This maximises acoustic shielding

    - where noise from the dry and wet plant is found to be directional, orientate the plant so that the quieter direction is towards the closest and most affected receptors (e.g. R6 and R8), where this is feasible

    - switch engines on mobile plant off when stationary rather than on idle

    - make operators of mobile plant aware of measures to minimise impacts on sensitive recievers particularly during operations in Cells 4 and 5, and provide adequate training so that quiet operating procedures can be implemented, where feasible and reasonable.

7.1.4 Air Quality

- The following air quality management measures will continue to be implemented at the site as part of the Modification:

    - Use of a water cart to control emissions from haul roads (unsealed).

    - Enforcement of speed limits onsite.

    - Progressive rehabilitation of exposed areas.

    - Minimising drop height of material during truck loading and unloading where possible.

    - Management of dust generating activities during unfavourable meteorological conditions.

7.1.5 Ecology

- Dixon Sand will implement the following measures to minimise the potential impacts on the biodiversity of the Modification area and the locality:
    - ongoing weed management
    - ongoing sediment and erosion controls
    - a tree felling procedure will be implemented to minimise the potential for impacts on native fauna species (focusing on threatened species) as a result of the clearing of hollow-bearing trees
    - employee education and training including inductions for staff, contractors and visitors to the site, to inform personnel of the biodiversity issues present at the site and their role and responsibilities in relation to the protection and/or minimisation of impacts to biodiversity
    - areas of biodiversity value outside the proposed extraction area will be fenced or signposted, where appropriate, to prevent the unnecessary disturbance
    - traffic control measures/speed limits/signage will be utilised on haul roads and access roads to minimise fauna injury/road kills.
- Dixon Sands will retire biodiversity credits as outlined in **Section 6.7** prior to the disturbance of native vegetation in the Modification area. The credits may be retired progressively based on the staging of native vegetation disturbance in line with the progressive development of the quarry. Dixon Sands will retire credits for the first stage by 12 months post the date of approval of the Modification. The area of progressive disturbance and associated credits retired will be reported annually, along with an indication of when the next stage of disturbance requiring further credits will occur. Credit retirement will be undertaken in accordance with the Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (OEH September 2014).

7.1.6 Aboriginal Heritage

- Dixon Sand will ensure that its employees and contractors are aware that it is an offence under Section 86 of *the National Parks and wildlife Act 1974* (NPW Act) to harm or desecrate an Aboriginal object unless that harm or desecration is the subject of an Aboriginal Heritage Impact Permit (AHIP) or other approval.
- The Modification area does not contain any identified Aboriginal archaeological sites, however, in the unlikely event that previously unrecorded artefactual material is exposed during ground disturbance works within the extraction area, work will cease in the vicinity of the artefactual material and the registered Aboriginal parties contacted and the artefactual material managed in accordance with a methodology to be prepared in consultation with the registered Aboriginal parties and OEH, if required.
- In the unlikely event that suspected human skeletal material is identified, all works in the immediate vicinity of the suspected human skeletal material will cease and the skeletal material will be inspected to determine if it is human (including assessment by a forensic specialist if required). If the skeletal material is human, the NSW Police and OEH will be contacted. No excavation will proceed until an appropriate course of action has been determined in consultation with NSW Police, OEH and the Aboriginal parties.

7.1.7 Social

- Dixon Sand will maintain the CCC and will regularly report to the CCC the progress of the Haerses Road Quarry and associated environmental management measures.

7.1.8 Greenhouse Gas and Energy Assessment

- Dixon Sand will review opportunities for diesel use efficiency when purchasing or replacing equipment at the quarry and will appropriate maintain all equipment to provide for efficient operations.

7.1.9 Rehabilitation

- The Rehabilitation and Landscape Management Plan will be updated for the Modification to incorporate the rehabilitation of the proposed extraction area.

- As part of the detailed quarry planning process, a detailed Quarry Closure Plan will be developed approximately three years prior to cessation of quarrying activities. The Quarry Closure Plan will describe in detail the proposed operational and progressive rehabilitation procedures for the remainder of the quarry life and subsequent to the quarry closure.

- Rehabilitation monitoring and maintenance will be undertaken as outlined in **Section 6.14.5**.

8.0 Conclusion and Ecologically Sustainable Development

8.1 Ecologically Sustainable Development

The EP&A Act aims to encourage ecologically sustainable development (ESD) within NSW. As outlined in **Section 4.0**, the Modification requires approval under Section 75W of the EP&A Act. As such, the consent authority needs to be satisfied that the quarry is consistent with the principles of ESD. This section provides an assessment of the Modification in relation to the principles of ESD.

To justify the Modification with regard to the ESD principles, the benefits of the quarry in an environmental and socio-economic context, with the Modification, should outweigh any negative impacts. The ESD principles encompass the following:

- the precautionary principle
- inter-generational equity
- conservation of biological diversity
- valuation and pricing of resources.

Essentially, ESD requires that current and future generations should live in an environment that is of the same or improved quality than the one that is inherited.

8.1.1 The Precautionary Principle

The EP&A Regulation defines the precautionary principle as:

> *Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*
>
> *In the application of the precautionary principle, public and private decisions should be guided by:*
>
> *(i) Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
>
> *(ii) an assessment of the risk-weighted consequences of various options.*

In order to achieve a level of scientific certainty in relation to potential impacts associated with the Modification, this EA has undertaken an extensive evaluation of all the key components. Detailed assessment of all key issues and necessary management procedures has been conducted and is comprehensively documented in this EA.

The assessment process has involved a detailed study of the existing environment and the use of engineering and scientific modelling and study to assess and determine potential impacts as a result of the Modification. To this end, there has been careful evaluation to avoid, where possible, irreversible damage to the environment.

The decision making process for the design, impact assessment and development of management processes has been transparent in the following respects:

- relevant government authorities and community representatives were consulted during EA preparation (refer to **Section 5.0**). This enabled comment and discussion regarding potential environmental impacts and proposed environmental management procedures.

- the approved quarry incorporates environmental management plans, procedures and environmental monitoring, that will be revised in regard to the Modification. In addition, the management controls that will be implemented by Dixon Sand as part of the implementation of the quarry have been clearly specified in **Section 7.0** and the development consent for the approved Haerses Road Quarry.

- this EA has been undertaken on the basis of the best available scientific information about the Modification area. Where uncertainty in the data used in the assessment has been identified, a conservative worst case analysis has been undertaken and contingency measures have been identified to manage that uncertainty

8.1.2 Intergenerational Equity

The EP&A Regulation defines intergenerational equity as:

> *Intergenerational equity namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.*

Intergenerational equity refers to equality between generations. It requires that the needs and requirements of today's generations do not compromise the needs and requirements of future generations in terms of health, bio-diversity and productivity.

The modified quarry would provide a long-term, high quality supply of sand and sandstone products into the Sydney, local and regional markets. This supply will assist to meet the current and growing demand for high quality sand products. As part of quarrying operations a comprehensive rehabilitation strategy has been developed, including an approved Rehabilitation and Landscape Management Plan. The Rehabilitation and Landscape Management Plan provides a description of the strategies that will be used to rehabilitate the areas disturbed from quarrying operations and will be updated as part of the implementation of the Modification.

As detailed in **Section 6.0**, the proposed modifications can be undertaken without having a significant impact on the local environment or community. The environmental management measures discussed in **Sections 6.0** and **7.0** have been developed to minimise the impact of the Modification on the environment and community to the extent reasonably practicable.

The management of environmental issues as outlined in this EA will assist to maintain the health, diversity and productivity of the environment for future generations whilst also realising the benefits of the quarrying operations.

8.1.3 Conservation and Biological Diversity

The conservation of biological diversity refers to the maintenance of species richness, ecosystem diversity and health and the links and processes between them. All environmental components, ecosystems and habitat values potentially affected by the Modification are described in this EA. Potential impacts are also outlined and measures to offset the impacts of the Modification developed in accordance with NSW government policy.

Dixon Sand undertook initial ecological field surveys to inform its design process for the proposed extraction area. Through this process, various extraction area boundaries were considered as Dixon Sand sought to minimise the biodiversity impacts associated with the Modification whilst providing an economic resource. Key factors in selecting the location of the extraction area boundary included the likely impacts on significant ecological features, including threatened species, threatened ecological communities and/or their habitats. Key ecological constraints that were considered by Dixon Sand during the design phase of the proposed extraction area include the location and extent of the Coastal Upland Swamp TEC and the population of the threatened flora species *Darwinia biflora*.

For the ecological impacts that cannot be avoided, Dixon Sand is committed to delivering a Biodiversity Offset Strategy that appropriately compensates for the loss of ecological values as a result of the Modification under the NSW *Biodiversity Offsets Policy for Major Projects* (OEH 2014).

In addition, the approved Rehabilitation and Landscape Management Plan for the quarry will ensure that native vegetation will be established in the rehabilitated extraction area which will assist in improving the ecological values of the site in the medium to long term.

8.1.4 Valuation and Pricing Resources

The goal of improved valuation of natural capital has been included in Agenda 21 of Australia's Intergovernmental Agreement on the Environment. The principle of improved valuation and pricing refers to the need to determine proper values of services provided by the natural environment. The objective is to apply economic terms and values to the elements of the natural environment. This is a difficult task largely due to the intangible comparisons that need to be drawn in order to apply the values.

The Modification optimises the valuation and pricing of the sand and sandstone resource with minimal impact by:

- ensuring a high quality resource of sand and sandstone products is available in close proximity to the Sydney, local and regional markets
- maximising the efficient extraction of the sandstone resource through detailed design and planning.

Feasibility considerations during the design process for the Modification have included the costs of integration of effective management measures to minimise potential environmental and social impacts.

8.2 Conclusion

Dixon Sand is seeking to modify the existing Haerses Road Quarry development consent to increase the extraction area and to increase the volume of sand and sandstone products sold direct to market from the site. The proposed changes would allow Dixon Sand to contribute to meeting the recent increase in demand for medium to coarse grain sands and specialist sands in the Sydney market. The modified quarry would provide a long-term, high quality supply of construction materials at very close proximity to the local Sydney and regional markets, contributing to the security and economic viability of the Sydney construction industry along with supply to other key sand markets.

This EA has identified that the proposed modifications would generally result in impacts similar to those of the currently approved operations. Impacts to biodiversity would be managed through the establishment of on-site and off-site biodiversity offset areas and other measures in accordance with current NSW government policy. The EA has identified the required management and mitigation measures to be implemented as part of the Modification, building on the measures provided in the existing consent conditions.

On considering the balance of the potential impacts of the Modification to the approved quarry on the environment and community, and the benefits of the proposed changes, it would be reasonable to conclude that the benefits of the proposed modifications outweigh the impacts.

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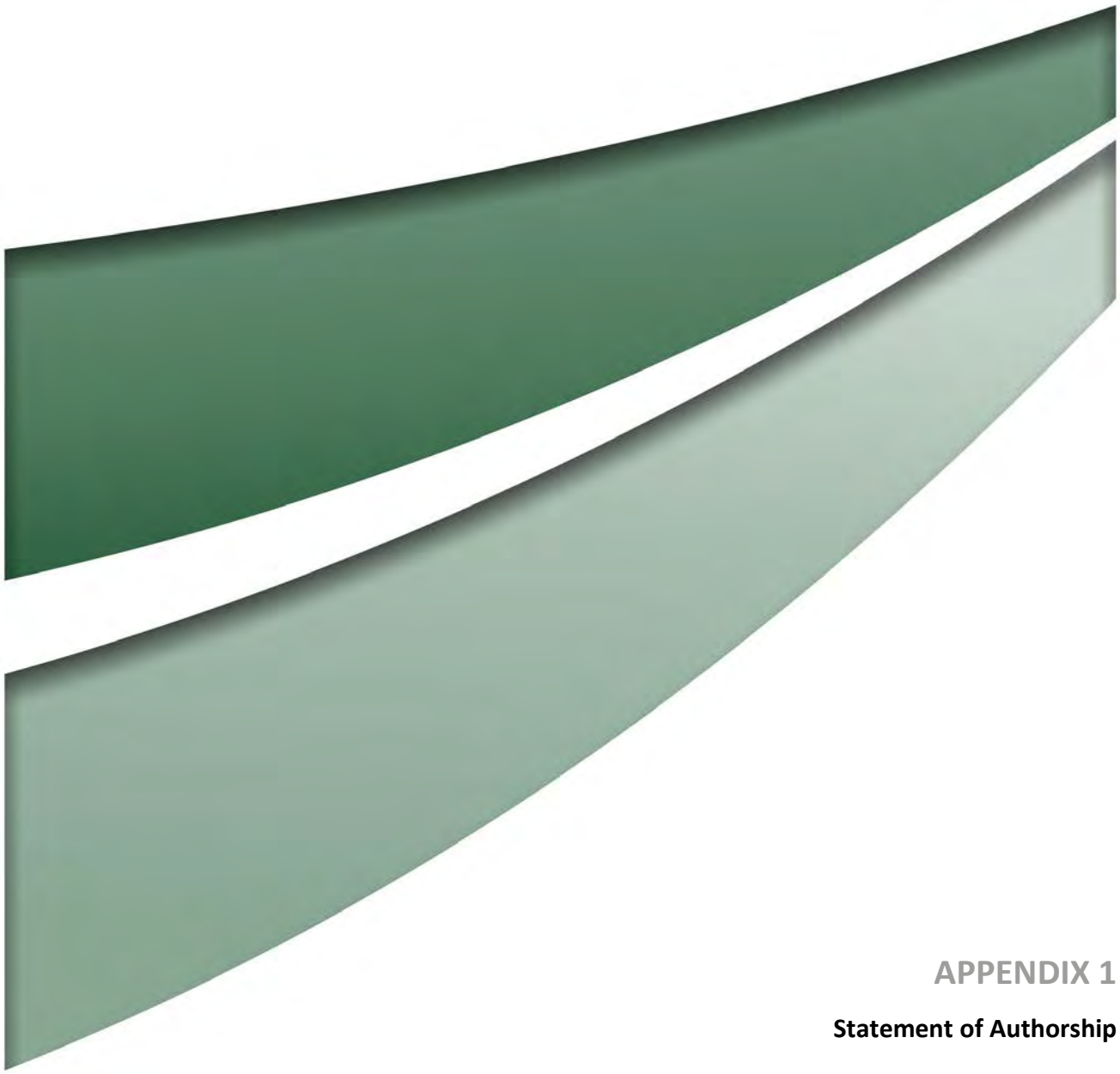
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APPENDIX 1

Statement of Authorship

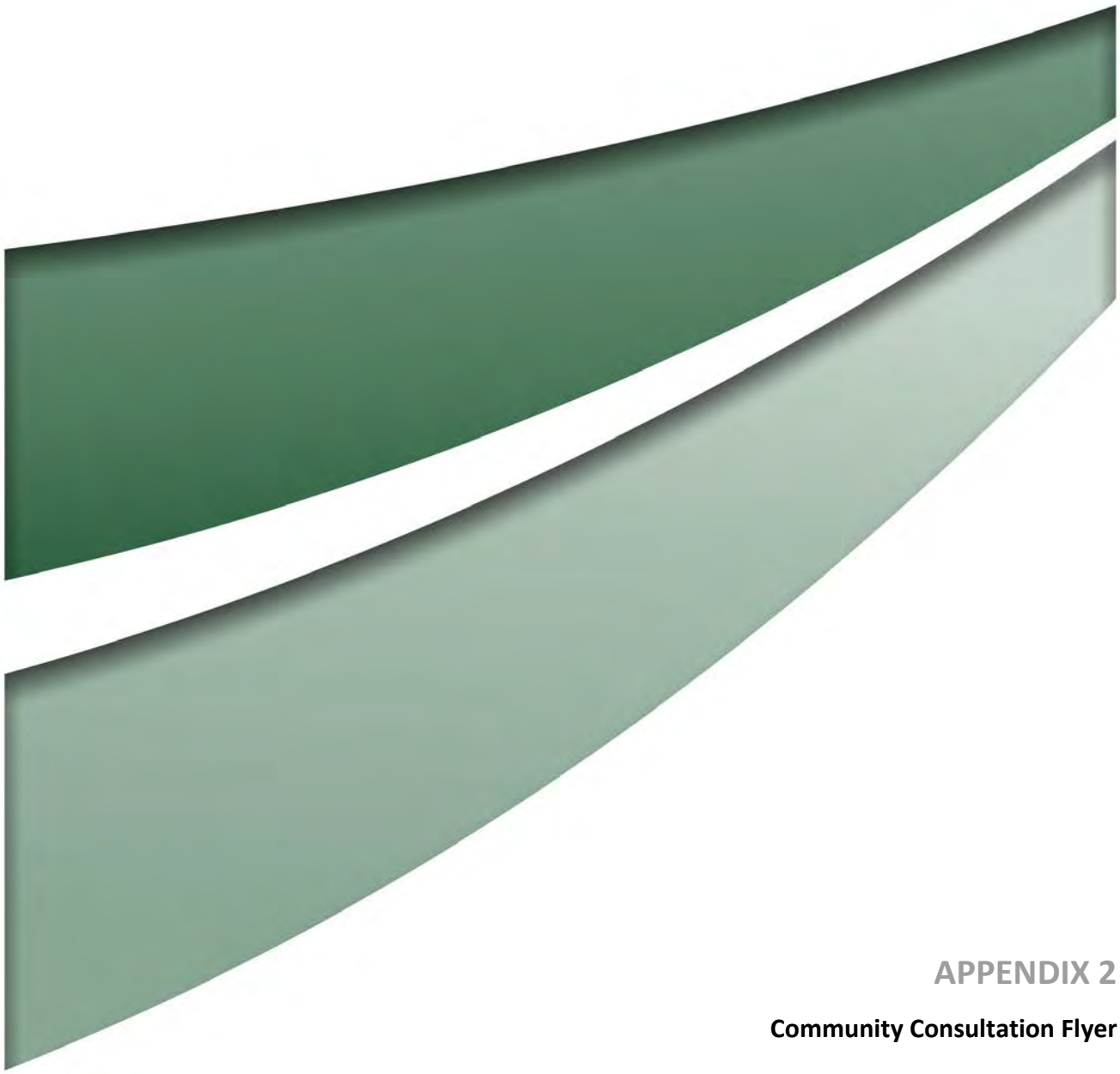
Statement of Authorship

EA prepared by	
Name:	John Merrell, Group Manager Environment & Community NSW
Qualifications:	B. Env. Sc
Address:	Umwelt (Australia) Pty Limited 75 York Street Teralba NSW 2284
In respect of:	Haerses Road Quarry Extraction Area Modification
Applicant Name:	Dixon Sand
Applicant Address:	4610 Old Northern Road Maroota, NSW 2756
Land to be developed:	See **Appendix 1** of the accompanying Environmental Assessment (EA) for the Schedule of Lands.
Proposed Development:	Lynwood Quarry Extraction Area Modification as described in the accompanying Environmental Assessment.
Environmental Assessment	An EA is attached.
Certification	I certify that I have prepared the contents of this environmental assessment and to the best of my knowledge: • it is in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*, and • it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.
Signature:	
Name:	John Merrell
Date:	22 September 2016

Project Team

Umwelt (Australia) Pty Limited – EA Preparation	
John Merrell, Group Manager, Environment & Community - NSW B Env Sc	Project Director
Lachlan Sweeney, Senior Environmental Scientist - B Sc, (Hons)	Project Manager
Travis Peake, Practice Leader Ecology – B Nat Res (Hons)	Ecological Assessment
Bill Wallach, Senior Ecologist – B Sc (Hons)	Ecological Assessment
Susan Shield, Manager Water Resources Engineering/Associate B E (Hons), M E (Water),	Surface Water Assessment and Water Balance Assessment
Melissa Harrow, Senior Environmental Engineer -B Env Eng (Hons)	Surface Water Assessment, and Water Balance Assessment
Tim Procter, Manager Engineering Services/Associate B Eng (Chem) (Hons)	Noise Impact Assessment
Glenn Homes, Principal Acoustician - BE (Hons) Mech (Sydney University) MIEAust CPEng	Noise Impact Assessment
Nicola Roche, Manager Cultural Heritage – B A (Hons) Anthropology	Aboriginal Cultural Heritage and Archaeological Assessment
Alison Lamond, Archaeologist –B Sc (Geology & Geophysics) B A (Hons) Archaeology	Aboriginal Cultural Heritage and Archaeological Assessment and Historic Heritage
Malcolm Sedgwick, Principal Energy & Greenhouse Specialist B Sc	Greenhouse Gas and Energy Assessment
Kristine Bencke, Senior Social Consultant – B A Social Science	Social Impact Assessment
Michael Ong, Senior Draftsperson Rebecca Abbott, Drafting Supervisor – Major Projects	Drafting, Graphic Design Drafting, Graphic Design
Joelle Brockman, Project Administrator Diploma of Business Management	Report Formatting and Document Control

Other Specialist Investigations	
Pacific Environment Operations Pty Ltd Judith Cox Angelo Ruggos	Air Quality Impact Assessment
Australian Groundwater Technologies Jason van den Akker	Groundwater Assessment
SECA Solution Sean Morgan	Traffic Impact Assessment



APPENDIX 2

Community Consultation Flyer

Dixon Sand (Penrith) Pty Ltd

Dixon Sand
HAERSES ROAD QUARRY

APRIL 2016

Dixon Sand currently operate the Haerses Road quarry, extracting tertiary Maroota sand in accordance with their existing development consent. Dixon Sand has identified the opportunity to extract an adjacent area of friable sandstone from within the quarry, and are seeking approval for the extraction and rehabilitation of this area. The proposed extraction area is within the Sydney Regional Environmental Plan No. 9 - Extractive Industry (No 2 - 1995) precinct. **Figure 1** shows the existing approved extraction area and the proposed additional extraction area.

It is not proposed to increase the volume of material extracted from the site per year, hence truck movements to and from the site would not increase from what is currently approved.

Dixon Sand will prepare an application, including an environmental assessment, to be lodged with the NSW Department of Planning and Environment (DP&E) seeking approval for the additional extraction. The environmental assessment which is being prepared by Umwelt (Australia) Pty Limited (Umwelt) will address the following issues: traffic, noise, air quality, ground and surface water, ecology, Aboriginal heritage and socio-economic aspects.

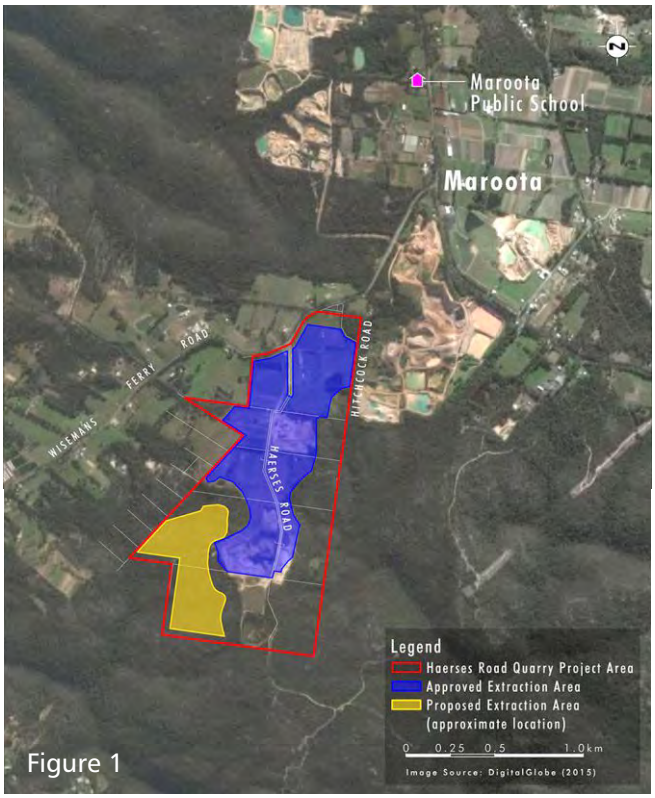


Figure 1

PROJECT TIMING ▼

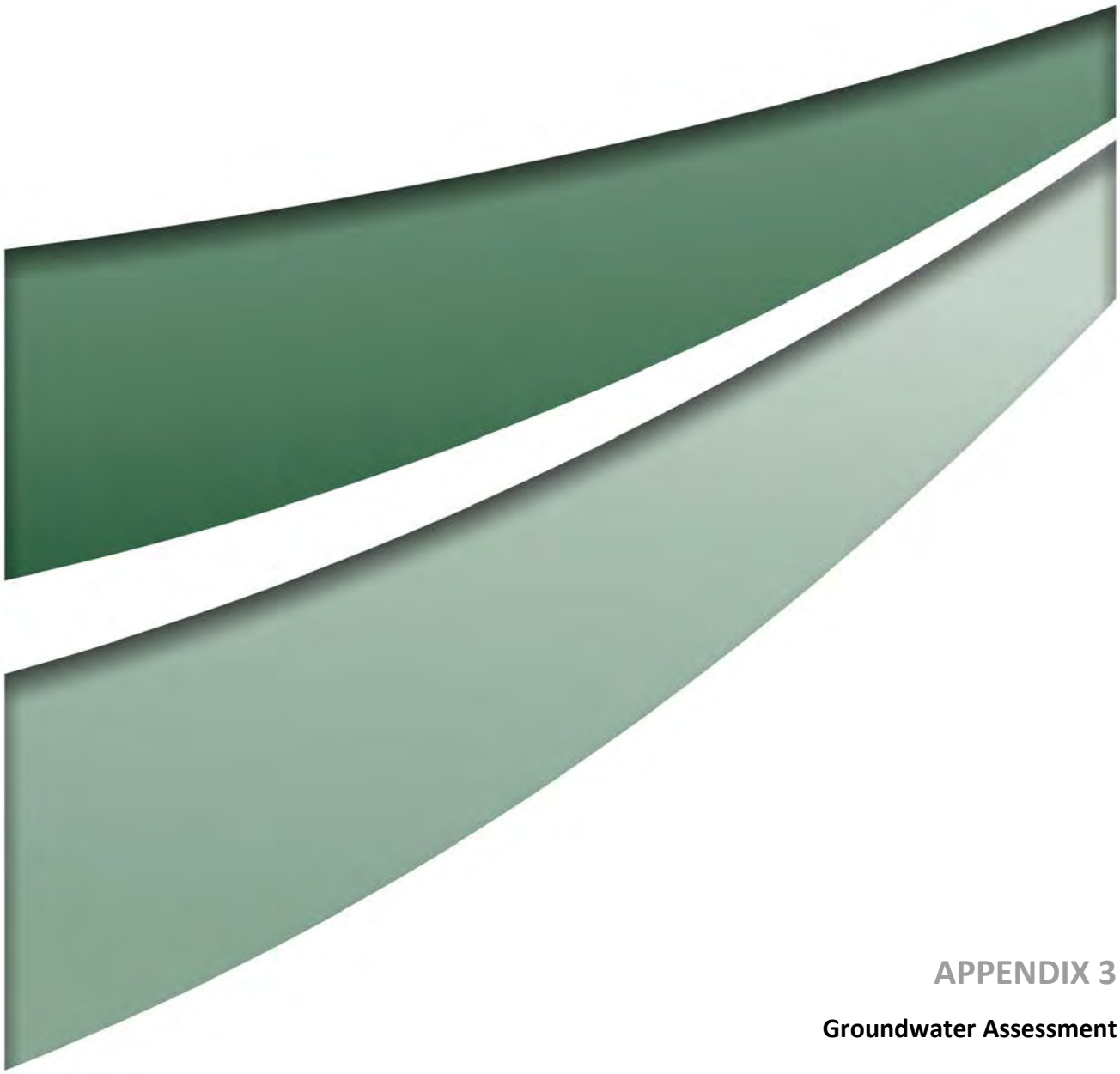
	Conceptual Quarry Plan	August 2015
	Lodgement of Background Scoping Document	October 2015
WE ARE HERE	Preparation of Environmental Studies	November 2015 - Mid 2016
	Finalise EA for submission and public exhibition	Mid 2016
	Response to submissions	Mid - Late 2016
	Assessment and Determination	Late 2016

It is anticipated that the application will be lodged with DP&E in mid 2016. Updates on progress of the application will be available via the 'Keeping Informed' tab on the Dixon Sand website:

www.dixonsand.com.au

For further information or to raise any concerns you have in relation to the proposal you can contact **David Dixon** from Dixon Sand on **0414 330 490** or via email at **david@dixonsand.com.au**.

umwelt



APPENDIX 3

Groundwater Assessment

Haerses Road Quarry Groundwater Assessment

Prepared for Dixon Sands (Penrith) Pty Ltd

AGT Report no: 1390-14-DAY
September 2016







Australian Groundwater Technologies

"making water work"

Document Control

Document Title

Haerses Road Quarry Groundwater Assessment

Report no

1390-14-DAY

Prepared for

Dixon Sands (Penrith) Pty Ltd

Author	Date
Jason van den Akker and Ryan Kluske	17/5/2016
Reviewed by	**Date**
Peter Dundon	26/7/2016
Approved by	**Date**
Jason van den Akker	28/9/2016

Revision history

Revision No.	Date Issued	Reason/Comments
1	1/8/2016	Final
2	28/9/2016	Revised Final

Distribution

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1	Dixon Sands

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Statement of Limitations

The services performed by AGT have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. This report is solely for the use of Dixon Sands (Penrith) Pty Ltd and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided or conditions encountered at the site during the investigation. AGT has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. AGT assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to AGT was false.

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
GPO Box 2645, ADELAIDE SA 5001
PH: (08) 8212 5622
FAX: (08) 8231 5399
www.agwt.com.au

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1 Introduction

1.1 Background

Dixon Sand (Penrith) Pty Ltd owns and operates a sand quarry off Haerses Road, Maroota, NSW. The quarry operates under an existing consent (DA 165-7-2006-5), which allows for the extraction of sand to a depth of 2 m above the wet weather groundwater elevation of the Maroota Tertiary Sands Groundwater Source (MTSGS). This depth was determined by the original Environmental Impact Statement (EIS) (ERM 2005).

Dixon Sands are seeking to modify the existing consent to allow the extraction of friable sandstone to the west of the current extraction area (within Lots 176/177/216). The proposed expansion falls outside the MTSGS and is situated above the Sydney Central Basin Groundwater Source (SCBGS)

The current area of extraction approved under the existing consent (DA 165-7-2006-5), and the proposed area of extraction being sought under this modification are presented on Figure 1.

The maximum depth of extraction in the area is constrained by the elevation of the *'wet weather groundwater elevation'* of the groundwater sources that underlie the site. These have been identified as the:

- MTSGS which comprises the Maroota Tertiary Sands unit and any weathered sandstone. This underlies the approved extraction area of the current consent.
- SCBGS which comprises the deeper Hawkesbury Sandstone Aquifer and underlies the proposed modification to the west of the current extraction area.

Defining the wet weather groundwater levels of each groundwater source utilised the sites existing groundwater monitoring network (Figure 1). For example, the depth of extraction in the approved extraction area was defined by the groundwater elevation of the existing H series observation bores (H2–14) that target the MTSGS. Whereas, the depth of extraction within the SCBGS (i.e. in the proposed extension area) was defined by the groundwater levels measured in the BH series observation bores (BH4 and BH5).

Since the original consent, policy changes have seen the introduction of the Greater Metropolitan Region Groundwater Sources Water Sharing Plan (WSP) (2011) and Aquifer Interference Policy (AIP) (2012). As part of the modification, the New South Wales Department of Primary Industries (DPI) requires evidence that the proposed modifications comply with the above mentioned plans. For this reason, AGT has assessed the modification against rules and criteria outlined in the WSP and AIP.

1.2 Objectives

The objectives of this assessment were to:

- Update the conceptual groundwater model, utilising additional drilling data and groundwater level monitoring data obtained since the original consent.
- Update the original groundwater assessment, including review of groundwater levels to determine the extraction depth limit for the new extraction area which overlays the SBCGS.
- Assess the quarry modifications against the Greater Metropolitan Region Water Sharing Plan (GMRWSP) and the Aquifer Interference Policy (AIP).
- Outline a strategy for groundwater monitoring and management that will ensure the modification will comply with the WSP and AIP.

1.3 Scope of Works

The scope of work is covered in the following sections and includes:

Section 2

- A description of the proposed modification (extension area).

Section 3

- Review previous groundwater EIS studies, drilling investigations and groundwater monitoring data and outline the new knowledge relevant to the proposed modification.

Section 4

- A description of the existing environment including groundwater levels and groundwater quality.

Section 5

- A description of the existing groundwater users including private bores and groundwater dependant ecosystems.
- A description of groundwater impacts to the groundwater sources and existing users from the proposed modification and
- Demonstration how the modification will comply with the AIP and WSP (see Section 9).

Section 6

- Confirmation of the wet weather groundwater elevation for the SCBGS and MTSGS, which was used to inform the maximum extraction depth of the proposed modification.

Section 7

- Outline groundwater monitoring and management which covers existing and proposed groundwater monitoring activities, presentation of baseline data for all aquifers since the original EIS,
- If required, outline of management and mitigation measures to protect groundwater quality and levels.

Section 8

- A description of the measures that would be implemented to avoid, minimise, (and if necessary), offset the potential impacts of the proposed modification, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment.

Section 9

- An assessment of potential impacts on the quality and quantity of groundwater resources in accordance with the AIP. The AIP came into effect in September 2012 and the modification has been assessed against the rules of this policy in terms of the impacts of the modification on the groundwater systems.
- An assessment of the modification against the rules and criteria of the Greater Metropolitan Region Groundwater Sources WSP.

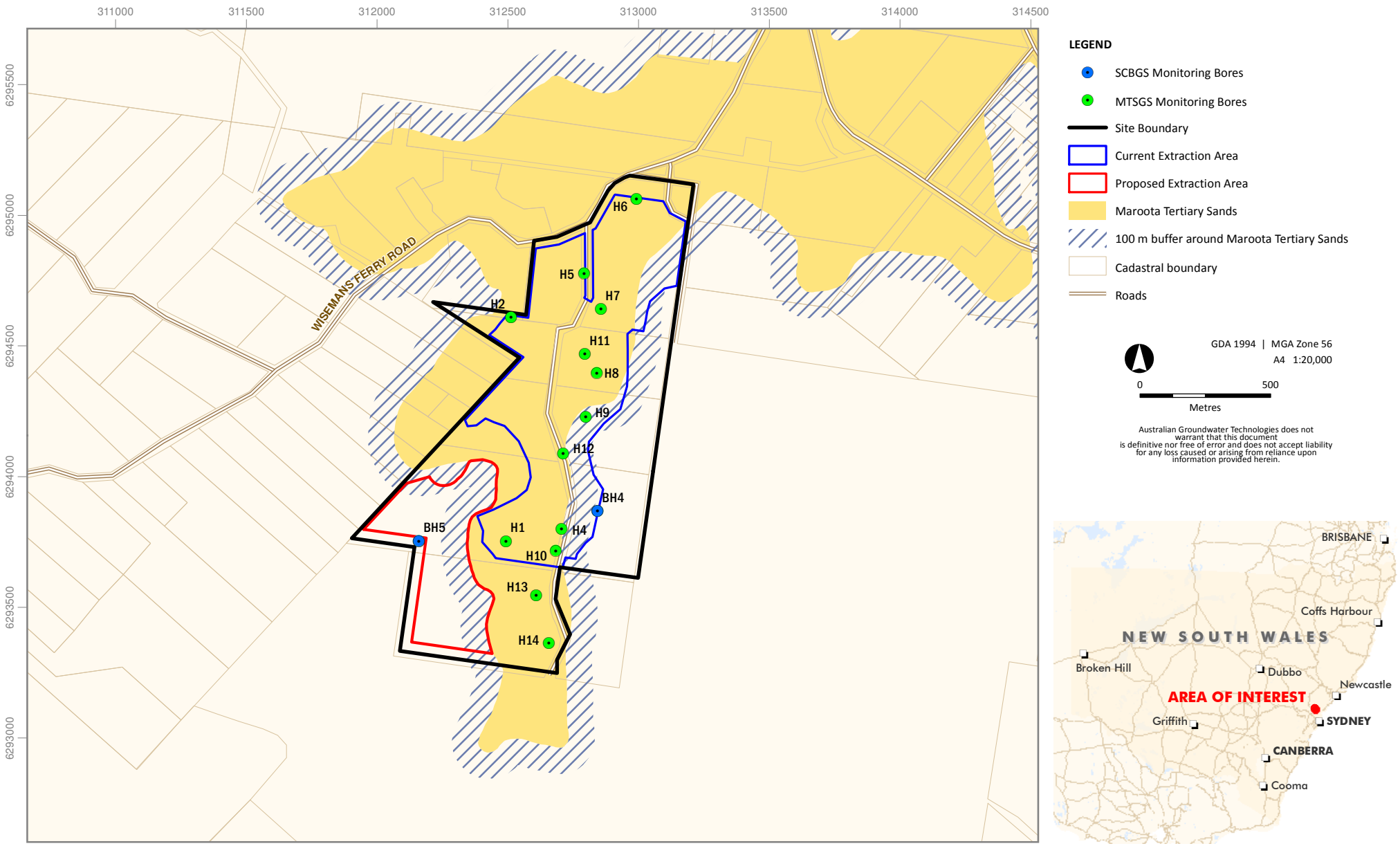


Figure 1 | Current and proposed extraction areas including groundwater sources

July, 2016 | P:\(DAY)_Dixon_Sands\Project\1390-14-DAY_Hearses Rd EA\GIS\Maps\1390-DAY current & proposed extraction areas.mxd

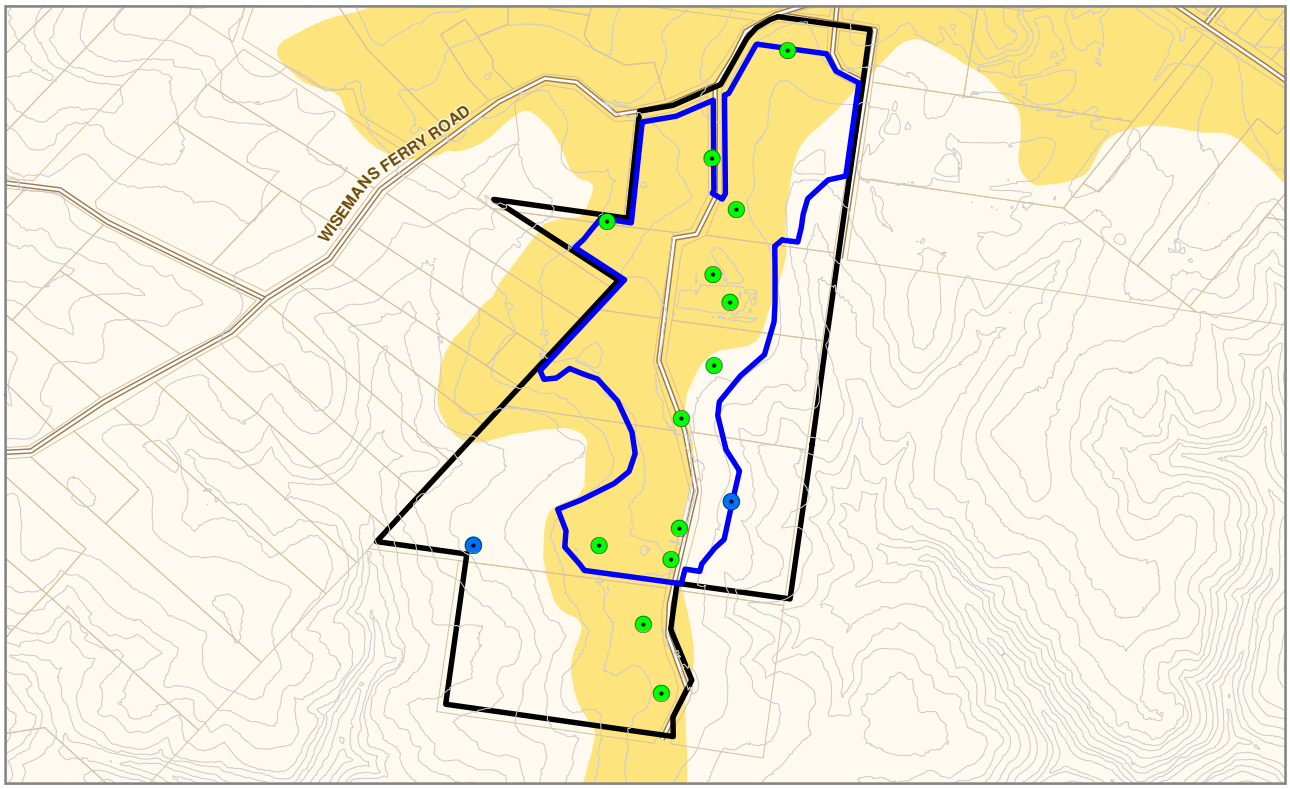
2 Proposed Expansion

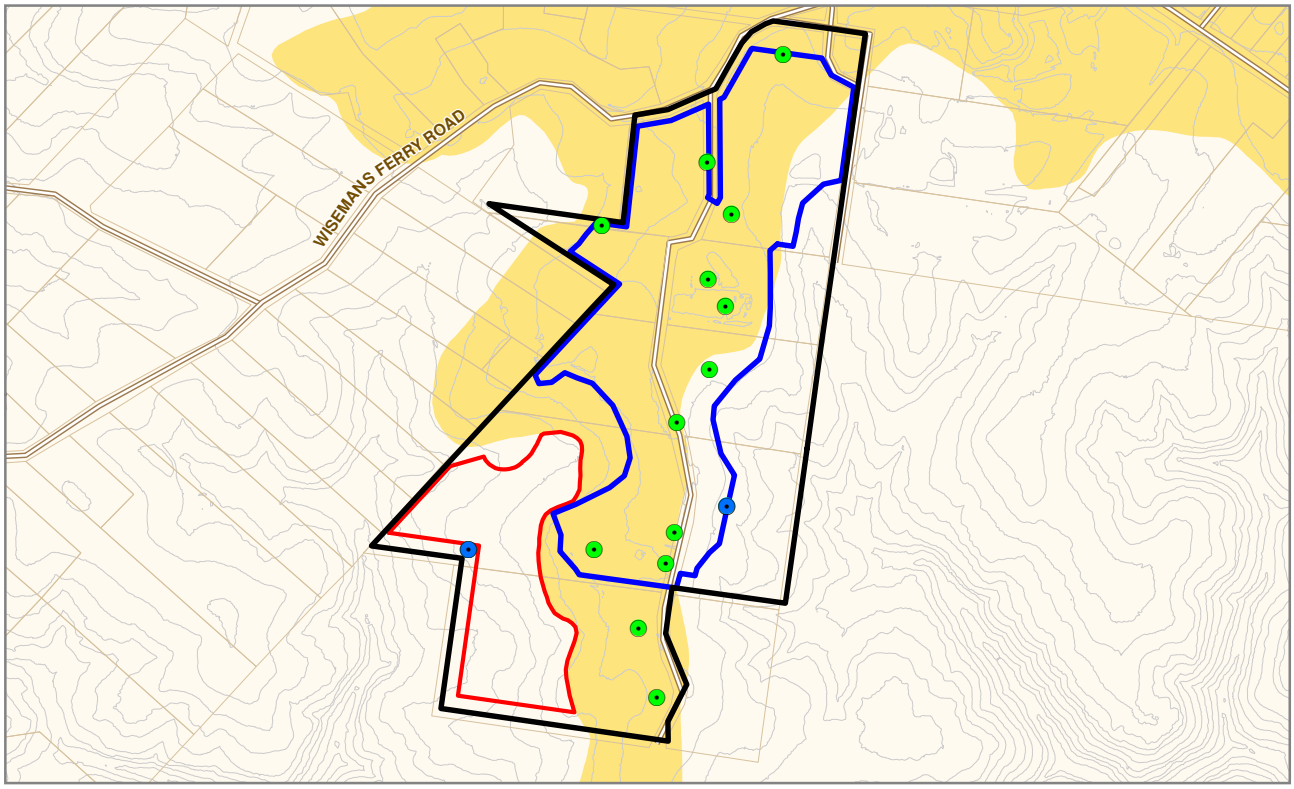
2.1 Current Quarry Operations

The extent of the current extraction area is presented in Figure 2. The MTSGS is the commodity being extracted. The depth of the current quarrying operations is restricted to 2 metres above the maximum wet weather water table of the MTSGS.

2.2 Proposed Quarry Expansion

The extent of the proposed extraction area, including all necessary buffer zones, is presented in Figure 2. The SCBGS is the proposed commodity to be extracted. The depth of the proposed quarrying operations is restricted to 2 metres above the maximum wet weather water table of the SCBGS.





LEGEND

- Site Boundary
- Current Extraction Area
- Proposed Extraction Area
- Contours (10 m interval)
- Maroota Tertiary Sands
- SCBGS Monitoring Bores
- MTSGS Monitoring Bores

GDA 1994 | MGA Zone 56
A4 1:20,000

0 500
Metres

Australian Groundwater Technologies AGT

Figure 2 | Current and proposed quarry operations including ground elevation contours

July, 2016 | P:\(DAY)_Dixon_Sands\Project\1390-14-DAY_Hearses Rd EA\GIS\Maps\1390-DAY current&proposed operations-elevation contours.mxd

3 Previous Work

3.1 Overview

In the Maroota area there have been numerous groundwater assessments completed. The most relevant for this assessment include the Haerses Road EIS (ERM, 2005), Haerses Road Sand Quarry Environmental Monitoring Plan (EMP) (ERM, 2006) and the Groundwater Assessment for Dixon Sand Operations, Lot 1 and 2 DP547255 (RPS Aquaterra, 2012), which is located to the north of the Haerses Road Quarry.

3.2 Original EIS Assessment

In 2005, Environmental Resources Management (ERM) conducted an environmental impact assessment to support quarry extraction to 2 m above the 'wet weather' groundwater elevation for the MTSGS. The study concluded that the 'wet weather' groundwater elevation ranged between 171.5 to 185.7 mAHD, allowing quarrying to a maximum depth of between 173.5 and 187.7 mAHD (ERM 2005).

The assessment considered potential impacts including:

- reduced groundwater availability to users from water table lowering.
- groundwater contamination
- a reduction in groundwater quality to streams.

The following outlines the findings of the 2005 EIS. In addition, a provisional assessment has been conducted to highlight changes to the assessment for the proposed modification. This is discussed further in Section 8 (assessment against principles in the AIP and WSP).

3.2.1 Reduced groundwater availability to users / water table lowering

The original assessment concluded that because quarrying is restricted to two metres above the wet weather groundwater level, the groundwater surface will not be exposed at any time during quarrying. As such, a lowering of the groundwater levels as a result of evaporation losses is unlikely to occur.

In addition, rapid groundwater infiltration to the shallow aquifer occurs through the site's highly permeable soils, such that the quarrying of sand will not significantly increase the rate of recharge nor accelerate groundwater mounding through vertical infiltration.

3.2.2 Aquifer contamination

The original EIS identified the potential for aquifer contamination from fuel spillages principally from the operation of heavy machinery during quarry excavation. ERM (2005) assessed the risks from this activity as low provided adequate management strategies were in place i.e. appropriate fuel storages and implementation of a site management plan.

3.2.3 A reduction in groundwater quality to streams

Stripping of vegetation and topsoil for quarrying would typically cause recharge waters to be less acidic because of removal of humic material. The quarry area has been previously used for agriculture and the organic level of the soil has been altered. Therefore, the proposed quarry is unlikely to change the pH of the downstream environment.

3.3 Original Environmental Monitoring Plan

The existing groundwater monitoring network was established in 2005 and focused on monitoring the MTSGS via the H series monitoring bores (H1 to H10) (these were referred to a MW series in ERM 2006). The wet weather groundwater levels established during the EMP for the MTSGS are provided in Table 1. Further detail about the baseline monitoring data is provided in Section 4 of this report.

Table 1: Summary of the wet weather groundwater levels established during the EMP (Source: EMP 2006)

Monitoring Bore	Wet Weather Groundwater Level (mAHD)
H1	171.68
H2	178.75
H5	177.12
H6	180.68
H7	177.80
H8	184.69
H9	186.49
H10	175.72

3.4 SCBGS Drilling 2011

In 2011, two deeper monitoring bores (BH4 and BH5) were drilled to the east and west of the MTSGS and target the deeper SBCGS (Figure 1). The objective of these bores was to establish the wet weather elevation of the SBCGS to support this modification. The drilling logs for BH4 and BH5 are provided in Appendix A.

4 Hydrogeological Setting

4.1 Hydrogeology

The aquifers identified across the Maroota area incorporate the following Groundwater Sources:

- The Maroota Sands that together with the upper part of the Hawkesbury Sandstone (eluvial sands) constitute the regional water table aquifer. This unit forms the MTSGS.
- The Hawkesbury Sandstone, a regional fractured rock aquifer. The Hawkesbury Sandstone forms part of the SBCGS. The unit is competent (lithified) with secondary fracturing the predominant mechanism for groundwater flow.

The MTSGS is recharged by direct rainfall infiltration and is subject to seasonal rainfall variations and longer term climatic cycles. At the project site, water bore drilling has identified the MTSGS comprises of thin layers of gravel, thick sequences of clay, and interbedded clays and sands. These profiles are typical of palaeochannel sequences and represent the meandering nature of old river systems (Woodward and Clyde, 1999).

In the Weathered Profile of the Underlying Hawkesbury Sandstone small aquifer zones have developed in the eluvial sand, which comprises the leached and weathered profile of the Hawkesbury Sandstone. These zones often form perched aquifer systems above the deeper regional water level of the Hawkesbury Sandstone. In the majority of cases, these perched aquifer systems have limited resource value because, like the Maroota Sand, they have small aerial extent and storage. They act as temporary storage of groundwater prior to leakage to underlying aquifers.

The Hawkesbury Sandstone is generally an impermeable rock, due to the fine grained clayey matrix (largely kaolinite and illite) and large degree of grain cementation resulting from the development of secondary minerals in the interstitial spaces, such as secondary silica and siderite (iron carbonate). Although the rock has very little primary permeability, fracturing and jointing, where open and interconnected, provides secondary permeability and storativity.

In 2011, two monitoring bores were drilled to investigate the groundwater conditions to a depth of 65 m below ground level (bgl). Within the proposed extraction area on the western side of the MTSGS BH5 revealed hard sandstone from ground surface to the bottom of hole. Over the period of monitoring (2011-2016), groundwater elevations have ranged from 114.25 to 116.15 mAHD. On the eastern side of the MTSGS BH4 revealed sandstone to 10 m bgl, followed by unsaturated sands, clays and silts to 16 m bgl followed by hard sandstone of the SBCGS. The groundwater level in this bore was measured at 145.38 to 147.07 mAHD. The large difference in water level between these two bores is a reflection of the large difference in topographic elevation.

4.2 Groundwater Levels

4.2.1 Maroota Tertiary Sands Groundwater Source

The water level of the MTSGS has been monitored and recorded at the Haerses Road Quarry since 2005. Originally eight monitoring bores were used to monitor the water levels (see Table 1), however ongoing quarry operations have resulted in a number of the original bores being removed and new bores installed. The monitoring bores currently in operation are presented in Table 2 along with their maximum and average water levels recorded since monitoring began. The hydrographs for these bores are presented in Figure 3, and a groundwater contour map of the highest recorded groundwater elevation is presented in Figure 4. The cumulative deviation from mean monthly rainfall (Figure 3) demonstrates a strong relationship between rainfall and groundwater level within the MTSGS.

Table 2: Summary of monitoring bores targeting the MTSGS – Haerses Road Quarry

Bore ID	Maximum SWL (mAHD)	Maximum SWL Date	Average SWL (mAHD)
*H1	174.4	March 2005	172.15
H2	180.10	October 2013	178.46
*H4	188.95	December 2006	184.32
*H5	177.27	May 2005	177.13
H6	184.23	February 2016	182.39
H7	181.90	February 2016	179.69
*H8	187.37	June 2008	185.19
H9	187.99	May 2012	186.47
*H10	176.66	July 2007	176.09
*H11	186.01	November 2010	185.02
H12	183.50	April 2015	181.42
H13	173.00	May 2012	171.71
H14	176.50	February 2016	174.47

*Decommissioned/replaced

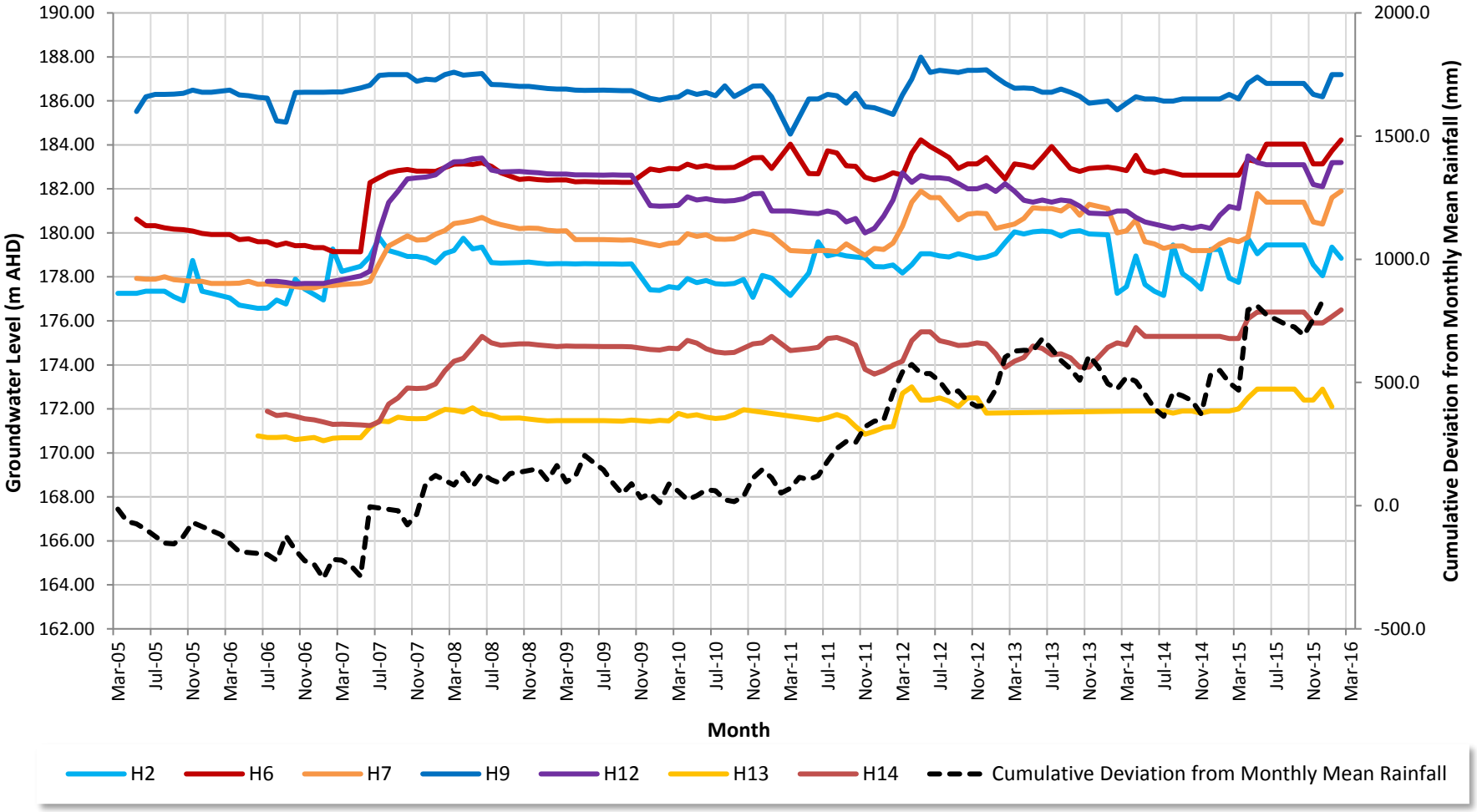
4.2.2 Sydney Central Basin Groundwater Source

The regional water table of the SCBGS has been monitored and recorded at the Haerses Road Quarry since 2011 via monitoring bores BH4 and BH5. A summary of the monitoring bores which includes their maximum and average water levels is presented in Table 3. The hydrographs for these bores are presented in Figure 5.

Table 3: Summary of monitoring bores targeting the SCBGS at the Haerses Road Quarry

Bore ID	Maximum SWL (mAHD)	Maximum SWL Date	Average SWL (mAHD)
BH4	147.07	March 2014	146.45
BH5	116.15	Jan 2016	114.81

Figure 3: Haerses Road long-term groundwater levels for the MTSGS H Series bores including the cumulative deviation from mean monthly rainfall



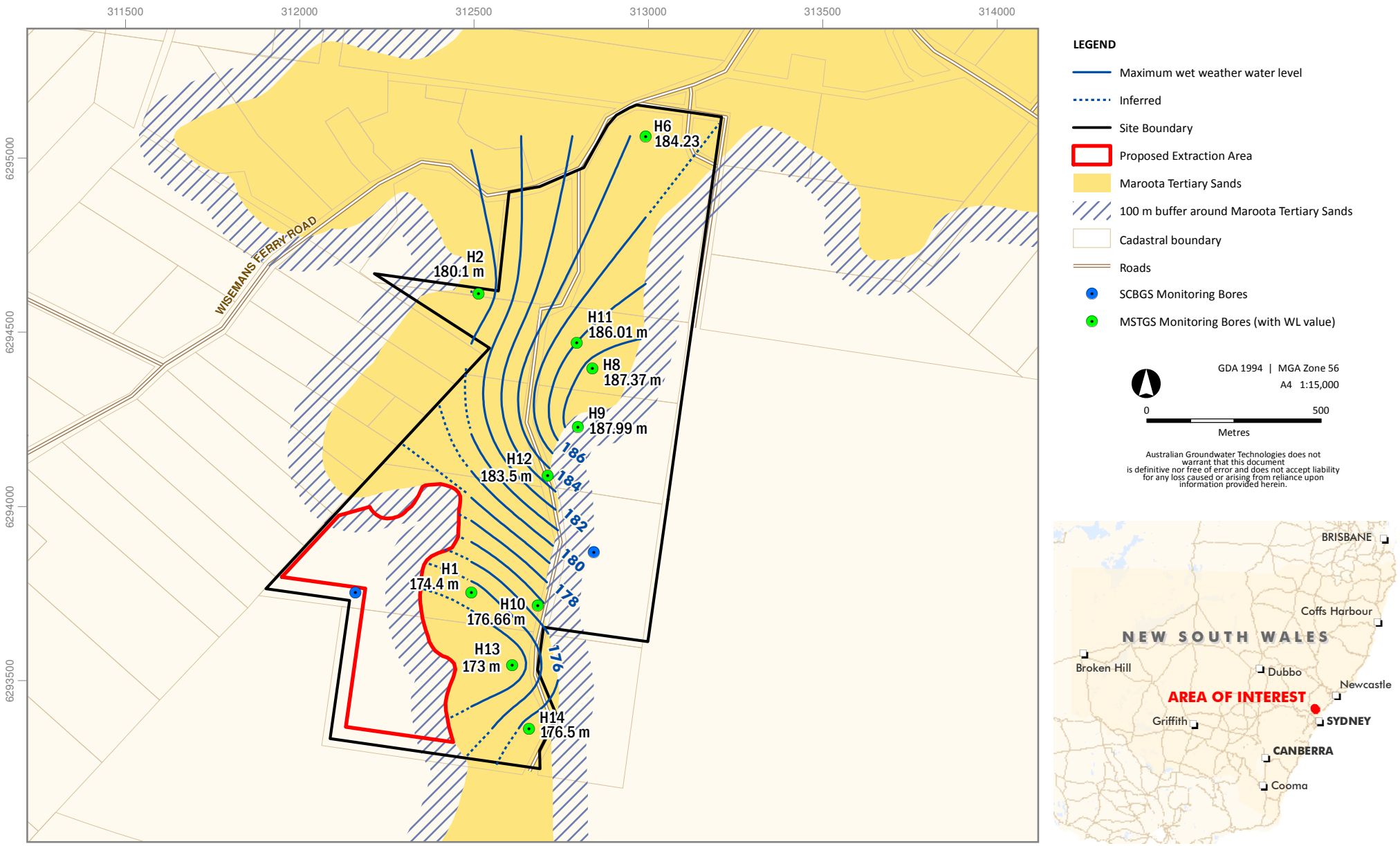
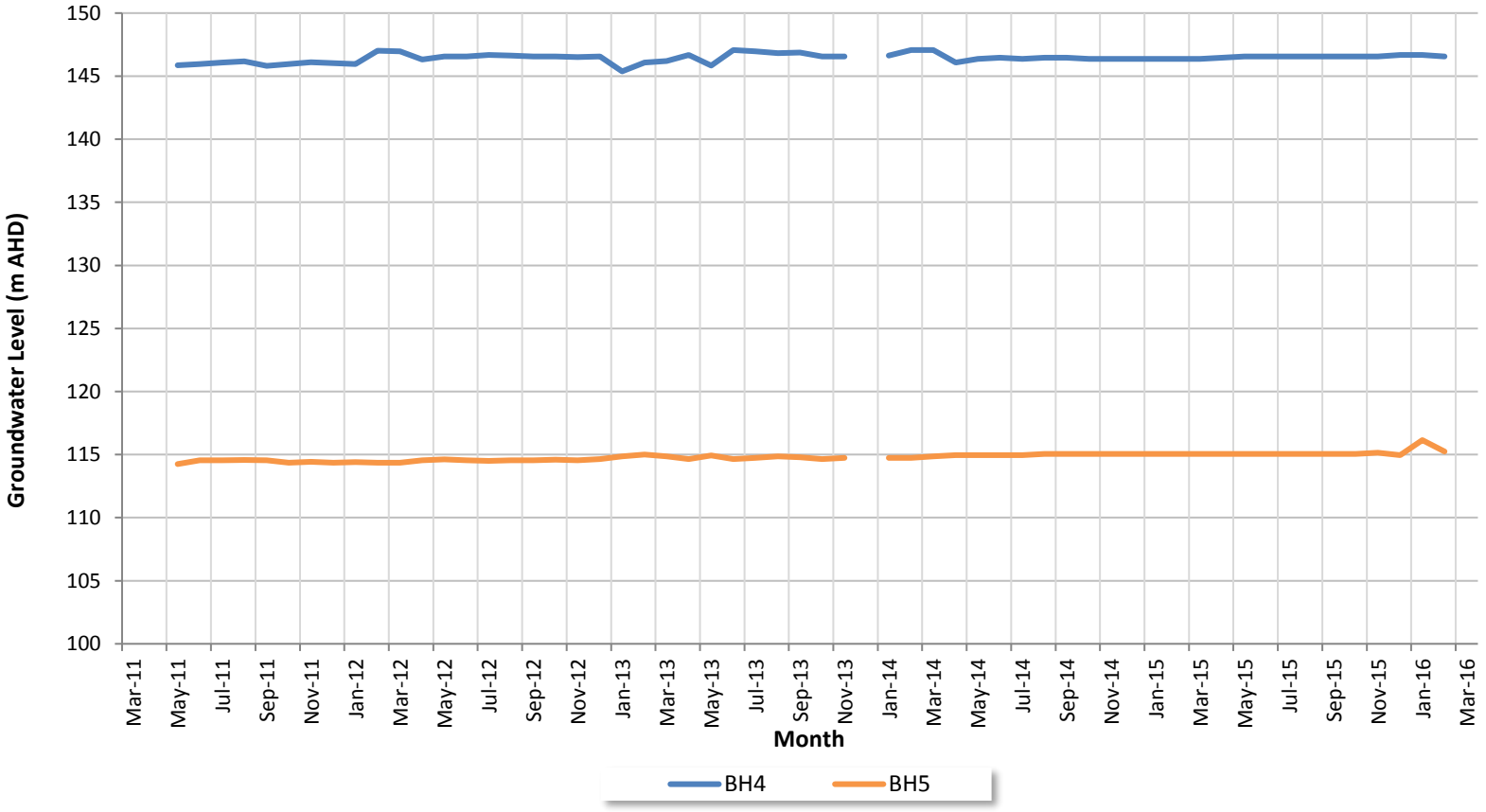


Figure 4 | Maximum wet weather water level contour map for the MTSGS

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Figure 5: Haerses Road long term groundwater levels for the SCBGS BH Series bores



4.3 Water Quality

In accordance with the current development consent conditions, groundwater samples have been collected from each bore for analysis of the following parameters: Electrical Conductivity (EC), pH, Totals Suspended Solids (TSS) and Turbidity. A summary of the natural variation of groundwater quality is provided in Table 4 and summarises below.

- Groundwater salinity of the shallow and deep aquifers is very low, ranging from 51 to 435 µS/cm (~32 to 278 mg/L).
- pH ranges from 4.1 to 6.6, with deeper bores revealing higher average pH values (5.5) in comparison to the shallower bores (4.6).
- Groundwater turbidity and TSS was generally higher in the shallow bores than in the deeper bores.

As the groundwater salinity is <1,500 mg/L, the source is classified as a highly productive groundwater source under the criteria of the AIP.

Table 4: Water Quality for all bores on site

Bore	H2	H6	H7	H9	H12	H13	H14	BH4	BH5
Electrical Conductivity (µS/cm)									
Nov 10	64	187	426	152	207				
Jul 11	65	182	435	128	207	88	69	136	270
Jan 12	274	261	262	301	286			198	270
Jun 12	55	189	268	125	174	97	90	120	252
Dec 12	235	238	234	233	228	232	224	143	144
Jun 13	52	204	51	51	174	202	103	141	148
Feb 14	174	207	335	185	184		188	257	134
Jun 14	120	182	379	127	137	95		188	141
Dec 14	52	169	274	125	128	93		182	129
Jun 15	57	134	155	124	269	117	114	119	126
Dec 15	74	199	213	138	214			201	133
pH									
Nov 10	4.7	4.3	4.2	4.5	4.8				
Jul 11	4.3	4.4	4.4	4.8	4.8	4.6	4.9	5.6	4.9
Jan 12	4.6	4.2	4.1	4.4	4.7			5.3	4.6
Jun 12	4.9	4.4	4.4	5.1	5.8	4.7	4.9	5.7	4.7
Dec 12	4.7	4.6	4.9	4.7	4.6	4.5	4.5	4.6	4.6
Jun 13	4.6	5.9	4.6	4.6	4.7	4.7	4.8	6.6	6.3
Feb 14	4.3	4.4	4.4	5	4.9		4.9	5.3	6.2
Jun 14	4.4	4.4	4.3	4.7	4.8	4.6		6.1	6.4
Dec 14	4.2	4.1	4.1	4.6	4.2	4.4		4.8	5.3
Jun 15	4.7	4.3	4.4	4.6	4.8	4.6	5.2	5.7	6.2
Dec 15	4.6	4.4	4.4	5.3	4.7	6.8		5.6	5.8
Turbidity (NTU)									
Feb 14	55	1200	260	230	75		490	4	13
Jun 14	1400	840	720	160	8.5	400		17	27
Dec 14	60	7	75	27	2	24		9	15
Jun 15	45	15	24	36	26	810	50	9	29
Dec 15	100	290	32	25	4.3	75		7	17
TSS (mg/L)									
Feb 14	59	1580	288	266	91		583	18	7
Jun 14	1530	948	820	204	10	405		12	22
Dec 14	53	7	78	37	3	31		12	16
Jun 15	40	15	31	38	21	838	20	8	13
Dec 15	246	501	57	50	4	76		8	17

5 Groundwater Users

5.1 Existing Groundwater Users

There are a total of 40 existing bores within 2.5 km of the Haerses Road, 28 of which target the deep SCBGS with the remaining 12 targeting the shallow MTSGS. A summary of existing bores in the area is provided in Appendix B with their locations presented in Figure 6.

At the closest point there is one bore that targets the SCBGS (GW109927 – status unknown) located ~500 m west of the proposed quarry. It was drilled to a depth of 162 m and has a groundwater level of 74 mBGL. The nearest MTSGS bore (GW108385) is located ~150 m southeast of the proposed quarry and is drilled to a depth of 13 m.

5.2 Coastal Upland Swamp

There is a coastal upland swamp that has been identified to the north of the proposed extraction area and west of the current approved extraction area (map provided in Appendix C) by Umwelt (Umwelt, 2016). There is also a drainage feature that runs east to west through the swamp. The drainage feature is an ephemeral stream that only exists for a short period of time after rainfall events and is fed by an upstream dam.

The geomorphic development of the coastal upland swamps is driven by positive feedbacks that operate when there is significant excess of precipitation over evaporation. This, along with high run-on from catchments and low rates of percolation and run-off, promotes soil water logging. Drainage of the swamps is mainly via lateral seepage through the sediments with some possible very slow vertical percolation into the underlying poorly permeable bedrock. Channels, if present, are discontinuous and usually are very shallow and linking a series of deep pools at the downstream end of large valley-floor swamps (EPBC Act 1999).

It is proposed that a 60 m buffer zone be put in place around the swamp where extraction will not occur. The purpose of the buffer zone is to help protect and manage the national ecological community. The buffer zone is intended to act as a barrier to further direct disturbance. For instance, a buffer zone may help to protect the ecological community from altered water flows, pollution and other threats (EPBC Act 1999).

There is an additional much smaller area of Coastal Upland Swamp on the eastern edge of the proposed extraction area. This area of Coastal Upland Swamp would be impacted by extraction within the 100 metre buffer of the MTSGS if this was approved by the NSW Department of Environment and Planning (DPE) following the monitoring process.

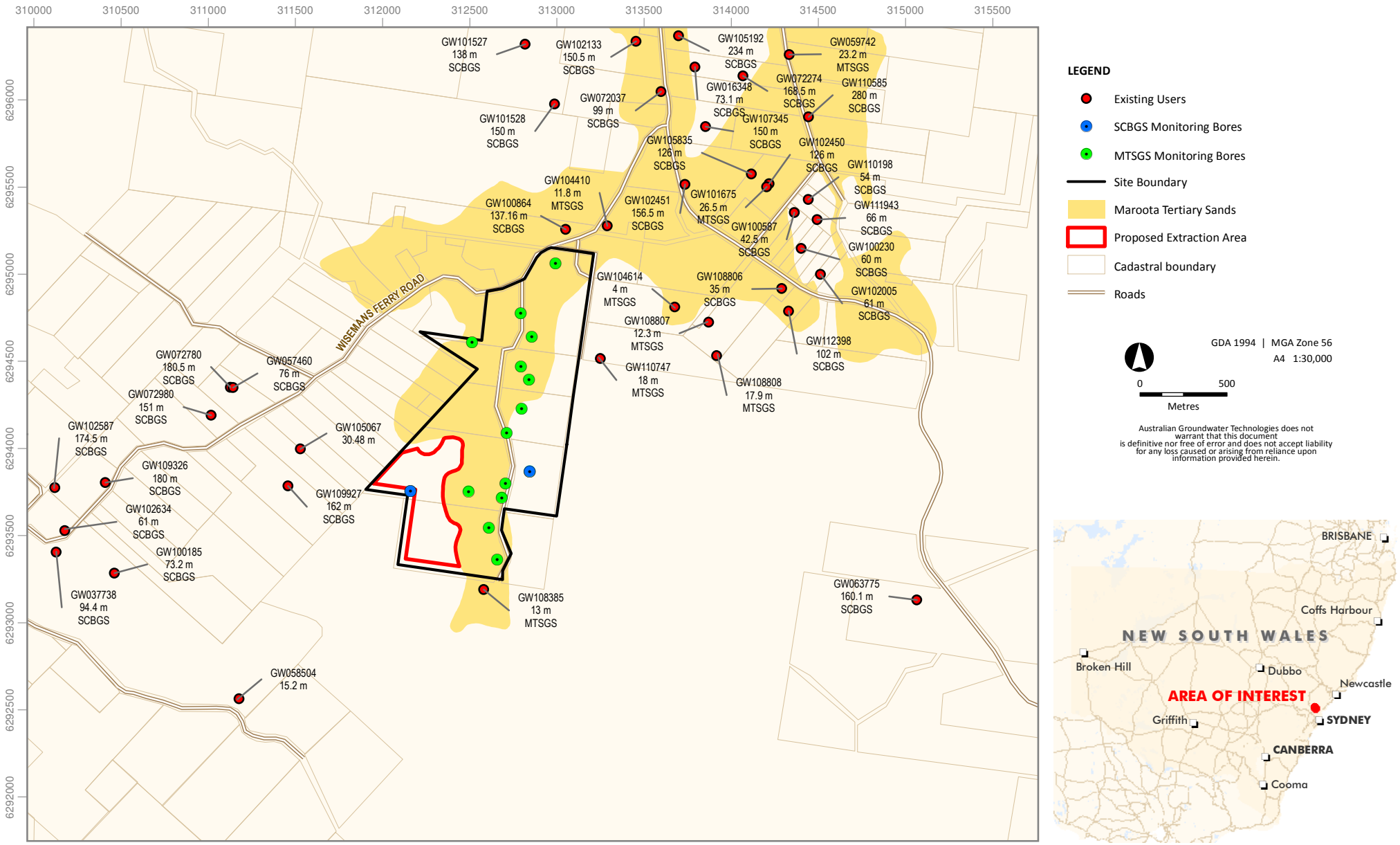


Figure 6 | Existing groundwater users including the H and BH well series

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6 Quarry Extension: Wet Weather Groundwater Elevation

6.1 Wet Weather Groundwater Elevation

Groundwater monitoring data has been used to establish groundwater elevations for the MTSGS (since 2005) and the SBSGS (since 2011).

The highest recorded water level measured in each bore was used to develop a maximum extraction depth map (Figure 7). The maximum extraction depth contours represent an elevation of 2 m above the wet weather groundwater level sources.

The wet weather elevation of the SBCGS (and extraction depth) is lower than the wet weather elevation of the MTSGS, which is perched some 40 m above the regional aquifer of the SBCGS. Groundwater seepages from the MTSGS will be prevented by the creation of a 100 m buffer from the western boundary of the MTSGS. The proposed buffer zone is shown on Figure 7 and on the cross section of the site (Figure 8).

The buffer zone occupies the low permeability Hawkesbury sandstone. Groundwater monitoring of the MTSGS, including two proposed addition bore locations (Figure 9), would be ongoing during extraction operations outside of the buffer zone to determine any potential changes or impacts to the MTSGS. No extraction would be undertaken within the buffer zone until groundwater monitoring results show that quarrying can be undertaken in this area without impacting on the MTSGS. The decision to commence quarrying in this area will be undertaken in consultation with DPI Water and with the approval of the DPE. Any extraction that occurs within this buffer zone should remain at least 2 m above the shallow water table of the H series bores which target the MTSGS. The maximum extraction depth within the buffer zone, based on the contours produced on Figure 7 is 176 to 180 mAHD.

The maximum extraction depth within the proposed extraction area, based on the wet weather elevation of BH4 and BH5 is between 118.15 and 133.5 mAHD (as shown in Figure 8).

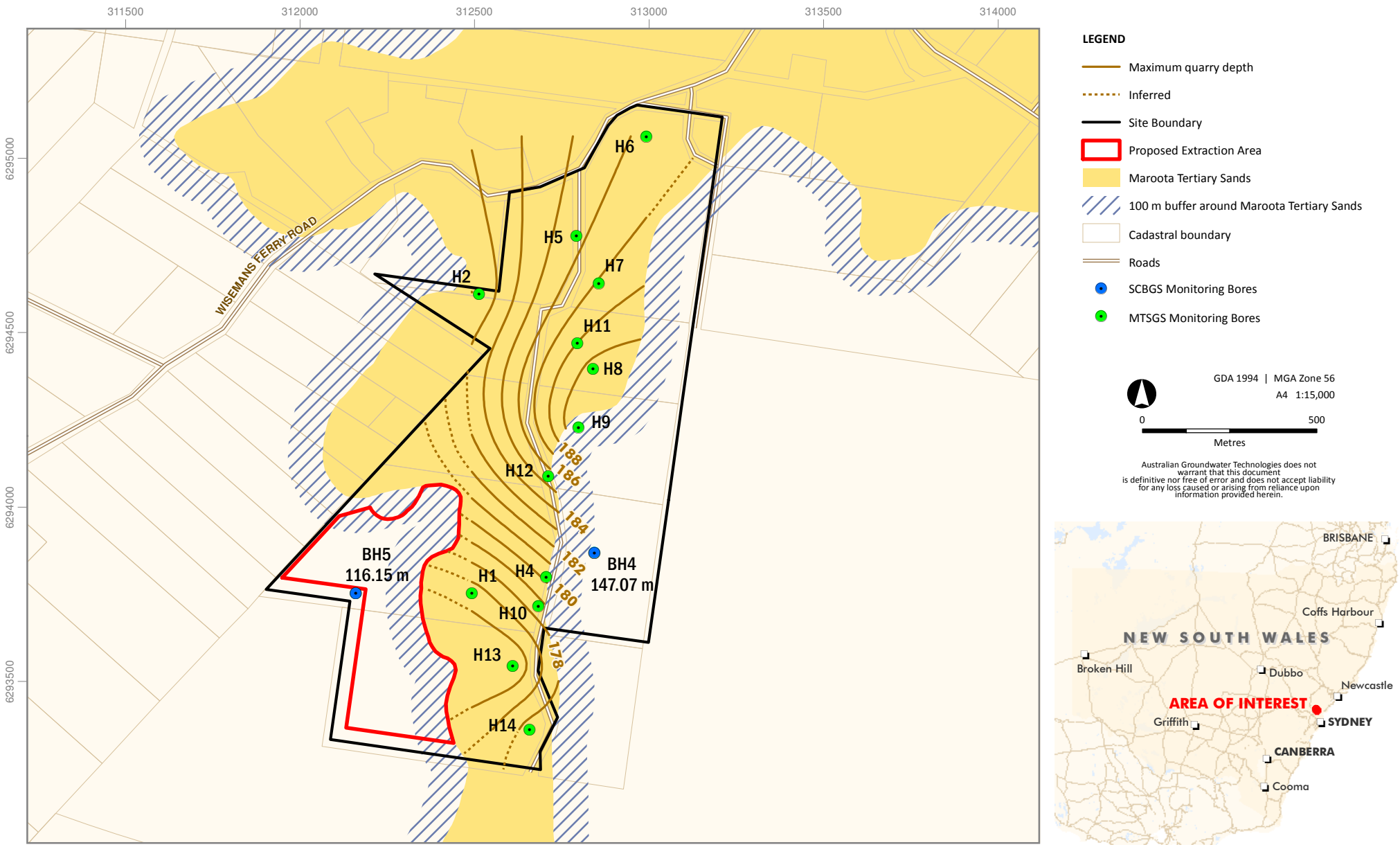


Figure 7 | Maximum quarry depth for the MTSGS based on the wet weather water level *(2 m above wet weather water table)*

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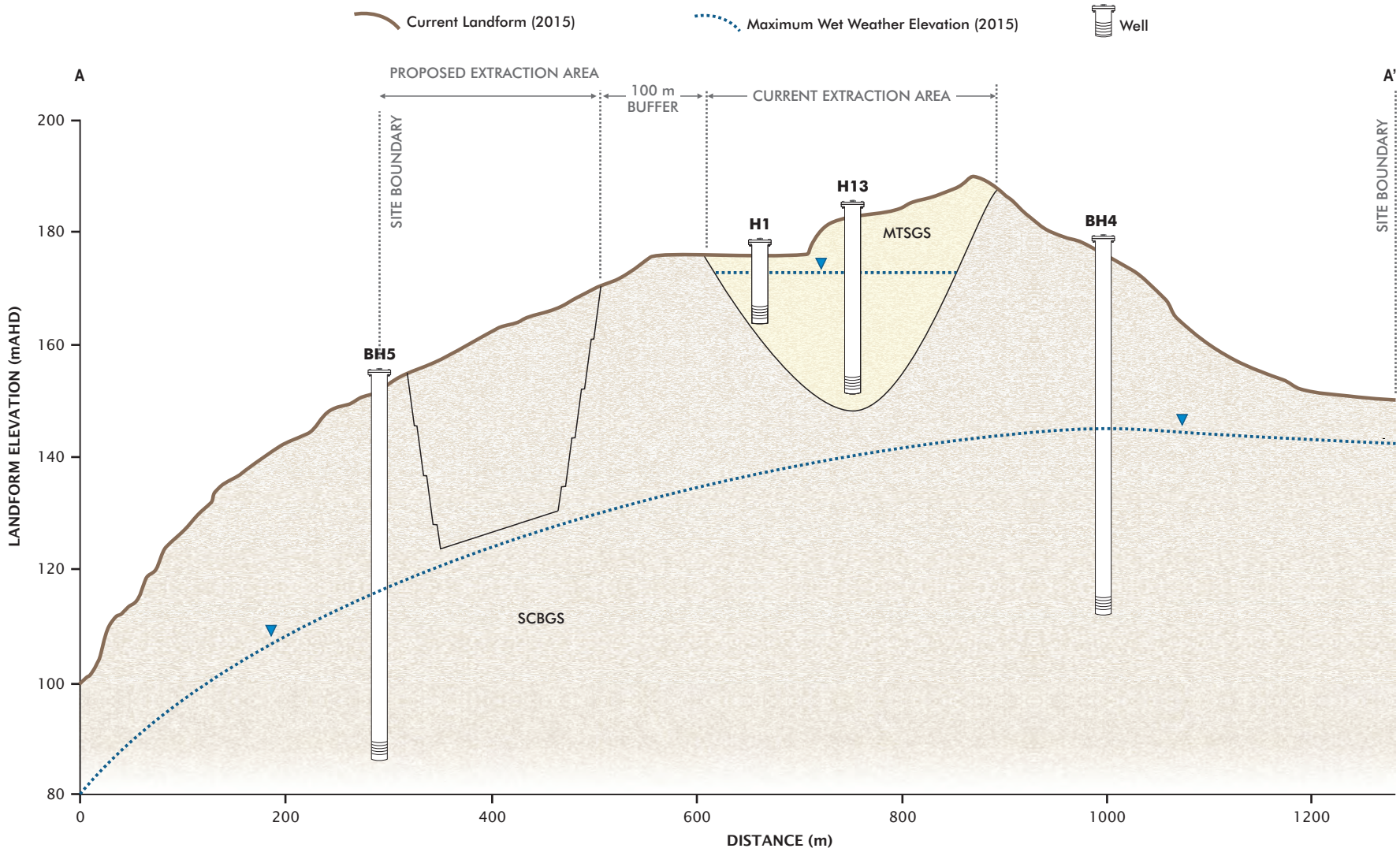


Figure 8 | Cross Section between BH4 and BH5

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7 Groundwater Monitoring and Management

7.1 Existing Groundwater Monitoring Program

The locations of the groundwater monitoring bores at Haerses Road are presented in Figure 6 and are summarised in Table 2.

A baseline groundwater monitoring programme for the Haerses Road site has been active since 2005 and is ongoing. The monitoring network was expanded in 2011 with the installation of the deeper BH monitoring bore series that target the SBCGS. The Haerses Road monitoring network includes nine monitoring bores (see Sections 3 and 4).

7.2 Proposed Groundwater Monitoring Program

Although quarrying at Haerses Road Quarry will not exceed 2 m above the wet weather groundwater level of the SBCGS or the MTSGS, monitoring will be continued for the life of the project to detect any unforeseen groundwater level or quality impacts, including any impacts to existing groundwater users.

Prior to any extraction within the 100 metre buffer zone of the MTSGS, groundwater monitoring results during the period of extraction immediately adjacent to the buffer zone would be reviewed and discussed with DPI Water to identify any potential changes or impacts. Extraction within the 100 metre buffer zone would not proceed until DPE provide approval to do so.

Monitoring of the existing network should continue, however two additional monitoring bores are recommended on the western margin of the MTSGS. The bores will be used to detect any unforeseen groundwater responses over the life of the quarrying. The proposed locations for the new monitoring bores are shown on Figure 9.

The proposed monitoring program for an approved operation is summarised in Table 5, and has been designed to detect changes in groundwater levels, groundwater quality, or to indicate an abnormal condition in response to quarrying. Key aspects include:

- Water quality sampling from groundwater across the project area on a biannual basis.
- Monitoring and assessment of groundwater inflows and quality to the open cut quarry operations, in the unlikely event that groundwater inflows occur.
- Monitoring groundwater levels in the MTSGS and SBCGS.

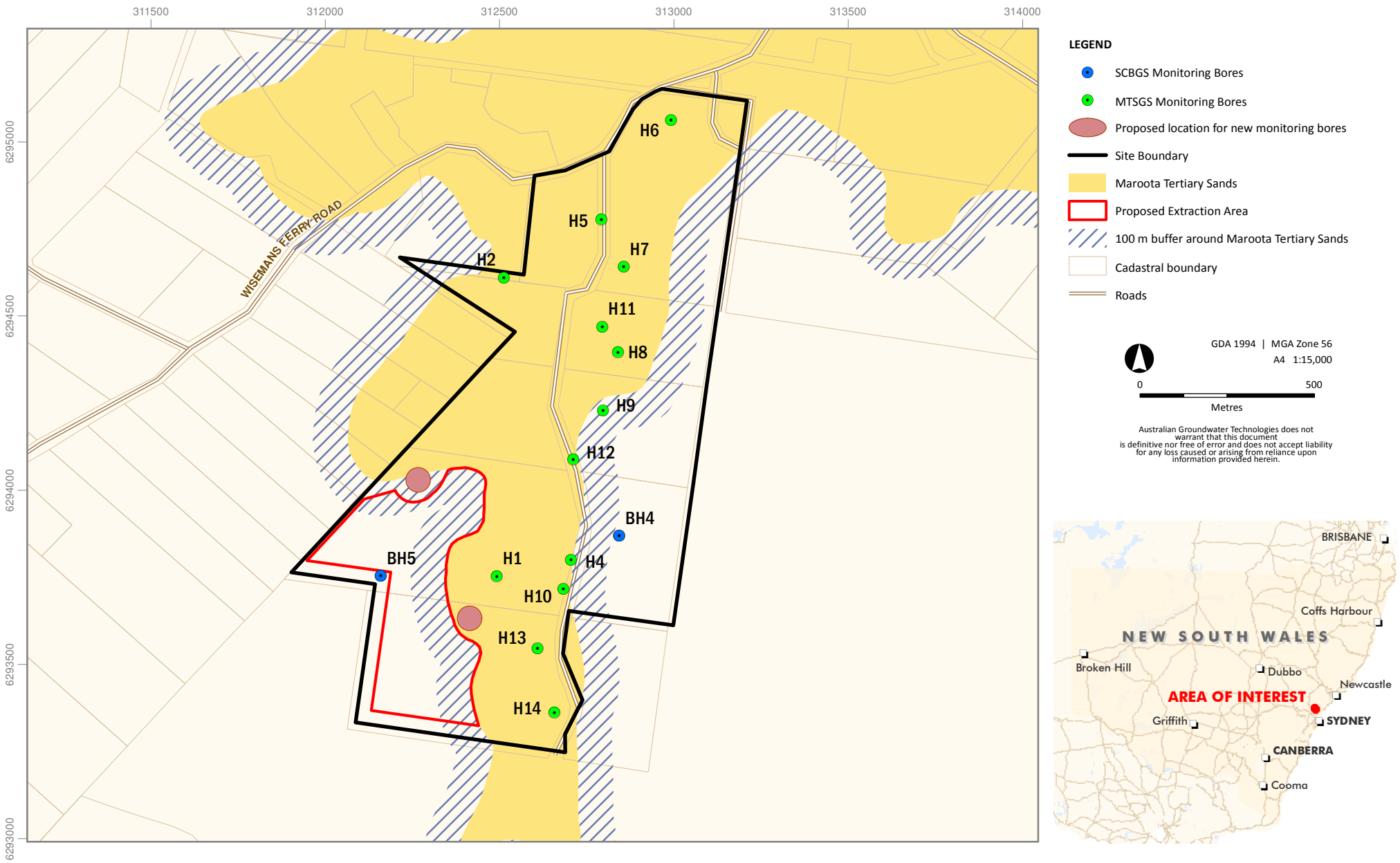


Figure 9 | Current monitoring network including proposed locations for new monitoring bores

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Table 5: Proposed groundwater monitoring program

Pre-quarrying	Purpose	Weekly	Monthly	Bi-annual
MTSGS – H2,6,7,9,12,14 SCBGS – BH4,5	To obtain baseline, pre-quarrying conditions for the two aquifers		Water level	
	Provide the foundation for establishing trigger values for investigation			Field Parameters EC, TSS, pH, Turbidity
	Obtain natural variation of regional groundwater level, such that depth of quarrying can be determined		Water level	
During quarrying				
MTSGS – H2,6,7,9,12,14 SCBGS – BH4,5	Ensure quarrying is maintained 2 m above the groundwater levels of the MTSGS and SBCGS		Water level	
	Monitor any unforeseen water quality impacts, ensuring that there is no change in overall beneficial use category >40 m from site			Field Parameters EC, TSS, pH, Turbidity
	Monitor unforeseen regional impacts, ensure there are no WL/WQ impacts to neighbouring private bores		Water level	Field Parameters EC, TSS, pH, Turbidity
	Ongoing compliance with the WSP and AIP	No pit seepages are expected, but undertake volumetric measurements in the unlikely event that measurable seepages occur	No pit seepages are expected, but sample for water quality in the unlikely event that measurable seepages occur	
Post quarrying				
MTSGS – H2,6,7,9,12,14 SCBGS – BH4,5	Monitoring of post-quarrying water level and quality impacts and ensuring ongoing compliance with the WSP and AIP			Water level & Field Parameters

8 Management of Groundwater Impacts

8.1 Groundwater Management Strategy

The strategy for groundwater management is to prevent groundwater inflows from the MTSGS and SBCGS to the quarry, and preservation of pre-quarrying groundwater quality. It involves maintaining the depth of quarrying to an elevation which is at least 2 m above the 'wet weather' groundwater elevation and creation of a 100 m buffer zone as discussed in Section 6.

Groundwater components assessed to be at risk have been previously assessed by ERM (2005) and summarised in Section 3.2 of this report. Mitigation measures have been proposed for each potential impact including predicted and unpredicted impacts. As such the groundwater monitoring program specifically deals with:

- A mechanism for ensuring the project is compliant with the rules of the WSP and AIP (DPI, 2012).
- Unforeseen impacts on groundwater levels on neighbouring properties and on any users of groundwater that target the MTSGS or SBCGS.
- Unforeseen impacts on groundwater quality (including impacts from chemical storage areas).
- Periodic monitoring for local and regional impacts of the quarry on groundwater levels and quality during the project and on a reduced basis for at least five years post quarrying.

Information gained from the monitoring program has been used to determine a maximum pit extraction depth of between 118.15 and 133.5 mAHD outside of the 100 m buffer zone and to a depth of 176 to 180 mAHD inside the buffer zone. This will ensure the pit floor remains at least 2 m above the 'wet weather' groundwater level, thereby mitigating any drawdown impact to the SBCGS and MTSGS.

Ongoing groundwater monitoring serves to notify changes to the groundwater, quality or unforeseen discharges into the pit. Monitoring is necessary to indicate that abnormal conditions relating to quarrying have developed, as well as compliance with the rules of the WSP and AIP.

A Trigger Action Response Plan (TARP) for groundwater will be developed to focus upon appropriate trigger and response actions for the management or mitigation of impacts. The baseline monitoring program that is in place will be used to establish the triggers, which will consider the level of impact and trigger an appropriate response. The fundamental means of determining the magnitude of any impact and the need for further monitoring and / or remedial actions is based upon the impact assessment criteria detailed in Table 6. The responses (actions) documented in the Table are proposed to ensure the timely and adequate management of impacts outside of the established trigger levels.

Table 6: Trigger Action and Response Plan

Impact	Observation	Strategy for Mitigation	Monitoring	Monitoring Action	Response
Groundwater level	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the water sharing plan.	Baseline GWL data has been used to ensure depth of quarrying remains above the MTSGS and SCBGS. Regular review of monitoring data to ensure quarrying is maintained above the elevation of the regional water table. For quarrying of the SBCGS, a 100 m buffer zone has been proposed along the western margin of the MTSGS to ensure the perched aquifer is not impacted.	**MTSGS:** H series bores **SBCGS** BH series bores **Buffer Zone:** New monitoring bores to be installed within buffer zone (see Figure 9)	**Water level**: If water level monitoring indicates increasing trends or confirmed pit inflows, increase monitoring frequency to weekly to establish trend.	Investigate potential contributing factors: -Confirm trends or anomalies by repeating water level or quality sampling as required -Compare exceedance with climatic conditions -Engage a hydrogeologist to undertake a preliminary investigation and report on any identified changes. Where investigations determine that impacts are the result of Quarry operations or may potentially impact on adjacent bores or surface water users implement Section 8.2 of this report, which may include: Modify mine plan or
Groundwater quality	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	Ensure all spillages are contained, diversion of dirty water into settling ponds, maintenance of machinery to be undertaken in work shop areas. Water quality monitoring of the pit will be undertaken as a first line of defence to detect & control the risk of groundwater contamination.	In-pit surface expressions	**Water Quality**: Repeat sampling of bore and in pit water to confirm contamination event.	
Groundwater users	Reported decrease in yield or GWL outside of climatic variations. Reported decrease in water quality parameter outside of baseline variation.	Baseline GWL data has been used to ensure depth of quarrying remains above the MTSGS and SCBGS. Regular review of monitoring data to ensure quarrying is maintained above the elevation of the regional water table.		**Water level**: Increase monitoring frequency to weekly to establish trend.	

Pit inflows	Observed seepages from pit wall	Any groundwater inflows should be metered in isolation of any other inputs such as rainfall runoff. Regular review of monitoring data to ensure quarrying is maintained above the elevation of the SCBGS. Monitoring of water quality in pit will be undertaken as a first line of defence to control the risk of groundwater contamination. **Buffer zone monitoring** If any seepage of groundwater is observed from the buffer area into the pit and that water is sufficient to measure, Dixon Sands will measure and record the volume of water pumped from the pit using a flow meter on the pump to show how much water is removed.		**Water level**: Increase monitoring of bores to weekly to establish trend. **Water quality:** obtain comprehensive analysis from pit seepages. **Volume:** weekly record of pit seepages.	obtain groundwater licence to offset impact.

8.2 Quarry Responsible Impacts Procedure

Where investigations detailed in the TARP determine that groundwater impacts are the result of quarry operations or the quarry may potentially impact on adjacent bores, the following procedure will be conducted:

- Inform landholders adjacent to streams and / or private bore owners, and the NSW Office of Water of preliminary investigation outcomes as appropriate.
- Undertake a detailed investigation and assess possible mitigation measures in consultation with the landowner and the NSW Office of Water.
- If deemed necessary prepare and implement a site mitigation/action plan to the satisfaction of the Department of Primary Industries (DPI), in consultation with the landowner and the NSW Office of Water.
- Conduct a review of results from the follow up investigation.

Further, the responses referred to above include, but are not limited to:

- Results of preliminary investigation reported within one week of completion.
- Commence preparation of detailed investigation including assessment of possible mitigation measures immediately.
- Commence preparation of mitigation / action within one week of the need being identified.

8.3 Notification of Significant Impact

Where a significant, confirmed impact to the environment or private landowner has occurred according to the TARPs, relevant agencies will be contacted immediately.

9 Assessment against the AIP and WSP

9.1 Aquifer Interference Policy (2012)

As detailed in this report, the depth of the development will not extend to the depth of the groundwater level for the SCBGS. For this reason, aquifer interference will not occur and the project is compliant with the rules of the AIP. For clarity however, all of the rules and requirements stipulated in the AIP have been summarised in Table 7. with reasons why rules are satisfied. Table 8 provides additional data to support the assessment of “minimal impact” as stipulated in the AIP (see page 26 of AIP, 2012).

Table 7: Minimal impact considerations for aquifer interference activities

	Highly Productive Groundwater Sources					
	Water Table	**Summary of impact and monitoring**	**Water Pressure**	**Summary of impact and monitoring**	**Water Quality**	**Summary of impact and monitoring**
1. Alluvial Water Sources	1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work. 2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (c) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work, then make good provisions should apply.	**Mitigation Measure:** Quarrying will be maintained 2 m above the wet weather regional groundwater level for the two aquifers. There will be no groundwater extraction or pit inflows during or post quarrying activities from the regional water table. This will mitigate any drawdown impact to high priority GDE's or culturally significant assets. **Monitoring**: Groundwater monitoring will be conducted onsite via the monitoring bore network. These bores will monitor groundwater level trends and detect any unforeseen impacts including detection of impacts > 40 m from the site.	1. A cumulative pressure head decline of not more than 40% of the "post water sharing plan" pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work. 2. If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	**Mitigation Measure:** Quarrying will be maintained 2 m above the wet weather regional groundwater level for the two aquifers. For this reason, this principle is not applicable. **Monitoring**: Deep monitoring bores are already on site that monitor the SCBGS. These bores will be monitored and maintained during quarry operations to detect any unforeseen groundwater impacts. This will be in addition to the shallow monitoring bore that targets the MTSGS.	1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. 2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	**Mitigation Measure:** Quarrying will be maintained 2 m above the wet weather regional groundwater level for the two aquifers. There are no water quality impacts as a result of the project. There are no GDE or Water supply works identified in the greater area that could be impacted. **Monitoring**: Suitably constructed monitoring bores will be maintained on to detect any unforeseen groundwater quality impacts.

Table 8: Summary of AIP requirements

Requirement	Summary of compliance	Reference of compliance
Establishment of baseline groundwater conditions including groundwater depth, quality and flow based on sampling of all existing bores in the area potentially affected by the activity, any existing monitoring bores and any new monitoring bores that may be required under an authorisation issued under the *Mining Act 1992* or the *Petroleum (Onshore) Act 1991*.	Baseline groundwater and quality data has been captured since 2005 for shallow and deep bores, over a range of climatic variations.	Section 4 of this report; (ERM 2005)
A strategy for complying with any water access rules applying to relevant categories of water access licences, as specified in relevant water sharing plans. For example, returning water of an acceptable quality to the affected water source during periods when flows are at levels below which water users are not permitted to pump.	Project is in accordance with the rules of the WSP, in particular meets the criteria stipulated for both the MTSGS and The Sydney Basin Central Groundwater Source.	Section 4 and 9 of this report.
Details of potential water level, quality or pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right. Consideration will need to be given to any relevant distance restriction requirements that may be specified in any relevant water sharing plan or any remediation measures to address these impacts.	No impact to existing users as the MTSGS will not be intercepted as part of quarrying activities nor will the Sydney Basin Central Groundwater Source.	Section 4 and 9 of this report.
Details of potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources.	No impact to existing users as the MTSGS will not be intercepted as part of quarrying activities nor will the Sydney Basin Central Groundwater Source.	Section 4 and 9 of this report.
Details of potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems.	Groundwater will not be intercepted as part of quarrying operations, and for this reason impacts to GDE's are will not occur.	ERM 2005
Details of potential for increased saline or contaminated water inflows to aquifers and highly connected river systems.	Mitigation measures for contamination are in place.	Section 8-9, Table 6 of this report
Details of the potential to cause or enhance hydraulic connection between aquifers.	Quarrying will be above the MSTGS, therefore there is no opportunity for hydraulic connection to the underlying Sydney Basin Central Groundwater Source.	Section 4 of this report
Details of the potential for river bank instability, or high wall instability or failure to occur.	Quarrying will not be carried out near any significant river or drainage line.	ERM 2005
Details of the method for disposing of extracted water (in the case of coal seam gas activities).	N/A	N/A

9.2 Compliance with Water Sharing Plan

The MTSGS and the SBCGS are the gazetted groundwater resources underlying the development area. Geological mapping conducted by the Geological Survey of NSW (Etheridge, 1980 as cited in Woodward-Clyde, 1999) confirms that the proposed development is encapsulated by outcropping Maroota Sands and Hawkesbury Sandstone (see Figure 1). For this reason, rules in the WSP have been considered for the MTSGS and the SCBGS and are detailed in Tables 9 and 10 respectively.

Table 9: Summary spreadsheet of WSP rules and compliance for the MTSGS

Access Rules	Relevance for this Development	Reason why rule is not applicable
Granting of access licenses may be considered for a listed number of activities	Not applicable	- The proposed work modifications do not seek an access license because the regional Maroota Sands aquifer will not be intercepted. Excavations from quarrying will extend to a maximum depth of 189.99 mAHD, 2 m above the approved 'wet weather' groundwater elevation (187.99 mAHD) and a buffer zone will be put in place between the modification and MTSGS to prevent seepage losses.
Rules for managing water allocation accounts		
Carryover	Not applicable	- No access license is being sought therefore amendments to license conditions are not required, - The Maroota Tertiary Sands Groundwater Source will not be intercepted during site operations.
Rules for Managing Access Licenses		
Managing surface and groundwater connectivity	Not applicable	- The existing pit is >40 m from the high bank of any named river or creek. - The nearest groundwater seepage points are over 1 km to the south-west and north-east of the quarry site.
Rules for granting or amending water supply works approvals		
To minimise interference with neighbouring water supply networks	Not applicable	The regional Maroota Sands aquifer will not be intercepted and therefore interference with neighbouring bores cannot occur.
To protect bores located near contamination	Not applicable	- No access licence is being sought, - The development does not intercept or abstract groundwater and therefore will not impact hydraulic gradients, or facilitate the mobilization of any contamination in the vicinity, - The development remains entirely in the unsaturated zone, - No areas of contamination have been identified within 500 m of the proposed operation
To protect water quality	Not applicable	- The pit floor will be at least 2 m above the wet weather water level of the MTSGS and therefore does not intercept groundwater, - The development remains in the unsaturated zone and therefore cannot initiate saline intrusion to the aquifer.

Access Rules	Relevance for this Development	Reason why rule is not applicable
To protect bores located near sensitive environmental areas	Not applicable	- No groundwater supply works are being carried out as part of the development, - No interception of the groundwater source will take place. Groundwater will not be intercepted or taken during quarrying either through pumping or inflows from open voids, - The development remains entirely above the 'wet weather' groundwater elevation and will not impact on any discharges to / from sensitive environmental areas.
To protect groundwater dependent culturally significant sites	Not applicable	- No groundwater supply works are being carried out as part of the development, - No interception of the groundwater source will take place. Groundwater will not be intercepted or taken during quarrying either through pumping or inflows from open voids, - The development remains entirely above the 'wet weather' groundwater elevation and will not impact on any discharges to / from sensitive environmental areas.
Rules for replacement groundwater supply works	Not applicable	- Groundwater replacement works are not being conducted. The proposed work modifications relate specifically to the quarry plan, extraction methods and the estimated mine life.
Rules for the use of water supply works approvals		
To manage bores located near contaminated sites	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose. - No contaminated site exists within 500 m of the proposed operation
To manage the use of bores within restricted distances	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.
To manage the impacts of extraction	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.
Limits to the availability of water		
Available water determinations (AWD's)	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.

Table 10: Summary spreadsheet of WSP rules and compliance for the SCBGS

Access Rules	Relevance for this Development	Reason why rule is not applicable
Granting of access licenses may be considered for a listed number of activities	Not applicable	- The proposed work modifications do not seek an access license because the SCBGS aquifer will not be intercepted. Excavations from quarrying will extend to a maximum depth of 2 m above the approved 'wet weather' groundwater elevation.
Rules for managing water allocation accounts		
Carryover	Not applicable	- No access license is being sought therefore amendments to license conditions are not required, - The Sydney Central Basin Groundwater Source will not be intercepted during site operations.
Rules for Managing Access Licenses		
Managing surface and groundwater connectivity	Not applicable	- The existing pit is >40 m from the high bank of any named river or creek. - The nearest groundwater seepage points are over 1 km to the south-west and north-east of the quarry site.
Rules for granting or amending water supply works approvals		
To minimise interference with neighbouring water supply networks	Not applicable	The SCBGS aquifer will not be intercepted and therefore interference with neighbouring bores cannot occur.
To protect bores located near contamination	Not applicable	- No access licence is being sought, - The development does not intercept or abstract groundwater and therefore will not impact hydraulic gradients, or facilitate the mobilization of any contamination in the vicinity, - The development remains entirely in the unsaturated zone, - No areas of contamination have been identified within 500 m of the proposed operation.
To protect water quality	Not applicable	- The pit floor will be at least 2 m above the wet weather water level of the SCBGS and therefore does not intercept groundwater. - The development remains in the unsaturated zone and therefore cannot initiate saline intrusion to the aquifer.

Access Rules	Relevance for this Development	Reason why rule is not applicable
To protect bores located near sensitive environmental areas	Not applicable	- No groundwater supply works are being carried out as part of the development, - No interception of the groundwater source will take place. Groundwater will not be intercepted or taken during quarrying either through pumping or inflows from open voids, - The development remains entirely above the 'wet weather' groundwater elevation and will not impact on any discharges to / from sensitive environmental areas.
To protect groundwater dependent culturally significant sites	Not applicable	- No groundwater supply works are being carried out as part of the development, - No interception of the groundwater source will take place. Groundwater will not be intercepted or taken during quarrying either through pumping or inflows from open voids, - The development remains entirely above the 'wet weather' groundwater elevation and will not impact on any discharges to / from sensitive environmental areas.
Rules for replacement groundwater supply works	Not applicable	- Groundwater replacement works are not being conducted. The proposed work modifications relate specifically to the quarry plan, extraction methods and the estimated mine life.
Rules for the use of water supply works approvals		
To manage bores located near contaminated sites	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose, - No contaminated site exists within 500 m of the proposed operation.
To manage the use of bores within restricted distances	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.
To manage the impacts of extraction	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.
Limits to the availability of water		
Available water determinations (AWD's)	Not applicable	- The proposed work modification does not involve groundwater extraction or interception of gazetted groundwater sources for any purpose.

10 References

DPI, 2012. NSW Aquifer Interference Policy: NSW Government policy for the licensing and assessment of aquifer interference activities. September 2012. ISBN 978 1 74256 338 1

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B). Conservation Advice (including listing advice) for Coastal Upland Swamps in the Sydney Basin Bioregion

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Etheridge, L.H., 1980. *Geological Investigation and Resource Assessment of the Maroota Tertiary Alluvial Deposit*. Geological Survey of New South Wales, Department of Mineral Resources. Report GS1980/201

NSW Office of Water, 2011. Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources

RPS Aquaterra, 2012. *Groundwater Assessment for Dixon Sand Operations, Lot 1 and 2 DP547255 Maroota NSW*. August 2012, Report S95/021D

Umwelt, 2016. Haerses Road Quarry Modification – Biodiversity Assessment Report

Woodward-Clyde, 1999. *Lots 1 and 2, DP228308, Lot 2, DP312327, Maroota, Development Application. Groundwater Impact Assessment*

Appendix A – Bore logs

RPS Aquaterra
Suit 902, Level 9, North Tower
1-5 Railway Street, Chatswood
NSW, 2067
Australia
Tel: (+61) (02) 9412 4630
Fax: (+61) (02) 9412 4805

COMPOSITE WELL LOG

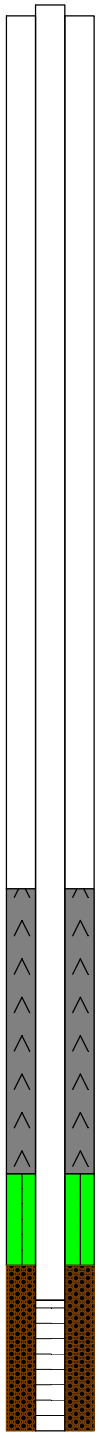
Well No: BH4

Client: Dixon Sand (Penrith) Pty Ltd **Project:** S95

Commenced:	**Method:** Rotary Air	**Area:** Maroota
Completed: 01/11/2010	**Fluid:**	**East:** 312843.05
Drilled: Terratest	**Bit Record:**	**North:** 6293869.05
Logged By:		**Collar (RL):** 177.07

Static Water Level: 30.51 **Date:** 15/11/2010

Depth (mbgl)	Bit Log	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Sand		Topsoil: Top Soil Sand			
	Sandstone/Siltstone		Sandstone: Red sandstone, hard			
			Sand and Silt: Fine sandstone/siltstone white			
	Clay		Clay: Clay band, moist			
10	Silty Sandstone		Sand and Silt: fine sandstone/siltstone white/red			
			Clay: Clay band			
			Silty Sand: Fine silty sandstone white			
	Sandstone		Sandstone: Sandstone yellow			
			Sandstone: Sandstone white (18.4 to 18.6 m hard)			
20			Sandstone: Sandstone some clay			
	Cl		Sandstone: Sandstone gray			
	Sandstone		Sandstone: Clayey sandstone gray (22 to 25 m approx. water 40 l/m)			
			Sandstone: Sandstone gray			
30			Sandstone: Sandstone gray brown, ironstone gravels			
	Sand		Sandstone: Sandstone/Shale, some ironstone			
	Sandstone		Sandstone: Sandstone, some gravels			
			Sandstone: Sandstone yellow			
40			Sandstone: Sandstone, some shale and ironstone gravels			
			Sandstone: Sandstone brown, some ironstone			
			Sandstone: Sandstone gray			
50			Sandstone: Sandstone, some shale			
			Sandstone: Sandstone, gray			
	Sand		Sandstone: Sandstone/Shale			
60	Sandstone		Sandstone: Sandstone, some clay			
			Sandstone: Sandstone gray. Water 58.3 l/m			
70						



Blank PVC (0 to 40.1m)

Grout (40.1m to 53.2m)

Bentonite (53.2m to 57.4m)

Gravel Pack (57.4m to 65m)

Screen (59m to 65m (EOH))

RPS Aquaterra
Suit 902, Level 9, North Tower
1-5 Railway Street, Chatswood
NSW, 2067
Australia
Tel: (+61) (02) 9412 4630
Fax: (+61) (02) 9412 4805

COMPOSITE WELL LOG

Well No: BH5

Client: Dixon Sand (Penrith) Pty Ltd **Project:** S95

Commenced:	**Method:** Rotary Air	**Area:** Maroota
Completed: 03/11/2010	**Fluid:**	**East:** 312159.4
Drilled: Terratest	**Bit Record:**	**North:** 6293753.96
Logged By:		**Collar (RL):** 152.75

Static Water Level: 37.78 **Date:** 15/11/2010

Depth (mbgl)	Bit Log	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Sandstone		Topsoil: Top soil sand			
			Sandstone: Sandstone white			
			Sandstone: Sandstone red			
			Sandstone: Sandstone white, 6.2 m small clay band			
			Sandstone: Sandstone orange			
10			Sandstone: Fine sandstone white			
			Sandstone: Sandstone orange			
			Sandstone: Fine sandstone white			
	Silt/Sandstone		Silty Sand: Silty fine sandstone, 15.9 m clay band, moist.			
20	Sandstone		Sandstone: fine sandstone gray			Blank PVC (0 to 40m)
			Ironstone: Ironstone, hard			
			Sandstone: Silty sandstone gray, fine			
30			Sandstone: Sandstone brown			
			Sandstone: Sandstone gray			
			Sandstone: Sandstone yellow			
40	Sandstone		Sandstone: Sandstone brown, ironstone gravels. 42.8 m water 10 l/m			
			Sandstone: Sandstone brown			
			Sandstone: Sandstone brown, ironstone layers			Grout (40m to 52.5m)
50						
	Sandstone		Sandstone: Sandstone/Shale			Bentonite (52.5m to 57.7m)
	Shale		Shale: Shale			
	Sandstone		Shale: Shale, some iron stone gravels			Gravel Pack (57.7m to 65m)
60			Sandstone: Sandstone/Shale, some Ironstone. 58.7 m water 6 l/m			
	Sandstone		Sandstone: Sandstone gray			Screen (59m to 65m (EOH))
70						

Appendix B – Private Bores

Bore ID	Easting	Northing	Depth (m)	SWL (mBGL)	Water Level Date	Targeted Aquifer	Aquifer Code
GW072980	311016	6294189	151 m			Hawkesbury Sandstone	SCBGS
GW072780	311127	6294350	180.5 m			Hawkesbury Sandstone	SCBGS
GW057460	311142	6294348	76 m			Hawkesbury Sandstone	SCBGS
GW105067	311528	6293997	30.48 m	26.212	1/01/1984	Perched	PRCH
GW109927	311457	6293784	162 m	74	16/12/2008	Hawkesbury Sandstone	SCBGS
GW108385	312580	6293190	13 m			Maroota Sands	MTSGS
GW108384	312543	6293400	19 m			Maroota Sands	MTSGS
GW108383	312613	6293885	17 m			Maroota Sands	MTSGS
GW106934	312503	6293888	15.8 m			Maroota Sands	MTSGS
GW108382	312586	6294155	14 m			Maroota Sands	MTSGS
GW109635	312838	6294207	15.7 m			Maroota Sands	MTSGS
GW108386	312681	6294291	17 m			Maroota Sands	MTSGS
GW106936	312894	6294451	15.6 m			Maroota Sands	MTSGS
GW110747	313250	6294515	18 m	4.1	14/04/2009	Maroota Sands	MTSGS
GW106937	312896	6294658	15.3 m			Maroota Sands	MTSGS
GW106938	312899	6294752	15.3 m			Maroota Sands	MTSGS
GW100649	313211	6924830	22.8 m			Maroota Sands	MTSGS
GW104614	313676	6294811	4 m			Maroota Sands	MTSGS
GW108807	313871	6294723	12.3 m			Maroota Sands	MTSGS
GW108808	313916	6294531	17.9 m			Maroota Sands	MTSGS
GW112398	314329	6294786	102 m			Hawkesbury Sandstone	SCBGS
GW108806	314290	6294918	35 m			Hawkesbury Sandstone	SCBGS
GW102005	314512	6294999	61 m	18	31/03/1998	Hawkesbury Sandstone	SCBGS

Bore ID	Easting	Northing	Depth (m)	SWL (mBGL)	Water Level Date	Targeted Aquifer	Aquifer Code
GW100230	314402	6295147	60 m	29	18/06/1993	Hawkesbury Sandstone	SCBGS
GW111943	314493	6295313	66 m	30	4/12/2012	Hawkesbury Sandstone	SCBGS
GW100587	314362	6295353	42.5 m	14	24/11/1992	Hawkesbury Sandstone	SCBGS
GW110198	314442	6295428	54 m	28	3/07/2009	Hawkesbury Sandstone	SCBGS
GW105835	314116	6295574	126 m	17.2	6/07/1999	Hawkesbury Sandstone	SCBGS
GW102450	314218	6295518	126 m			Hawkesbury Sandstone	SCBGS
GW101675	314203	6295500	26.5 m			Maroota Sands	MTSGS
GW102451	313735	6295514	156.5 m			Hawkesbury Sandstone	SCBGS
GW104410	313289	6295277	11.8 m	10.57	6/03/1998	Maroota Sands	MTSGS
GW100864	313050	6295256	137.16 m			Hawkesbury Sandstone	SCBGS
GW063775	315065	6293130	160.1 m			Hawkesbury Sandstone	SCBGS
GW109326	310409	6293804	180 m	82	11/09/2008	Hawkesbury Sandstone	SCBGS
GW102587	310120	6293774	174.5 m			Hawkesbury Sandstone	SCBGS
GW102634	310177	6293528	61 m			Hawkesbury Sandstone	SCBGS
GW037738	310127	6293404	94.4 m			Hawkesbury Sandstone	SCBGS
GW100185	310462	6293284	73.2 m			Hawkesbury Sandstone	SCBGS
GW058504	311177	6292562	15.2 m			Perched	PRCH
GW107345	313853	6295846	150 m	55	24/08/2004	Hawkesbury Sandstone	SCBGS
GW110585	314443	6295902	280 m	74	15/09/2005	Hawkesbury Sandstone	SCBGS
GW072274	314067	6296137	168.5 m			Hawkesbury Sandstone	SCBGS
GW059742	314333	6296259	23.2 m			Maroota Sands	MTSGS
GW103148	314520	6296617	60 m	11	23/03/2000	Hawkesbury Sandstone	SCBGS
GW053898	314327	6296567	31 m			Maroota Sands	MTSGS
GW104460	314078	6296500	96 m			Hawkesbury Sandstone	SCBGS
GW105192	313698	6296366	234 m	46	27/03/2003	Hawkesbury Sandstone	SCBGS

Bore ID	Easting	Northing	Depth (m)	SWL (mBGL)	Water Level Date	Targeted Aquifer	Aquifer Code
GW016348	313792	6296187	73.1 m			Hawkesbury Sandstone	SCBGS
GW072037	313598	6296047	99 m			Hawkesbury Sandstone	SCBGS
GW101528	312987	6295975	150 m	20.58	4/03/1998	Hawkesbury Sandstone	SCBGS
GW102133	313454	6296335	150.5 m	77	11/03/1999	Hawkesbury Sandstone	SCBGS
GW108133	313484	6296427	150.6 m	58	9/04/2004	Hawkesbury Sandstone	SCBGS
GW034628	313477	6296458	91.4 m			Hawkesbury Sandstone	SCBGS
GW048741	313603	6296615	30 m			Perched	PRCH
GW101527	312818	6296319	138 m	35.36	6/03/1998	Hawkesbury Sandstone	SCBGS
GW105046	313074	6296497	25 m	5	1/01/2002	Maroota Sands	MTSGS
GW103993	313159	6296827	30 m	18	1/11/1998	Maroota Sands	MTSGS
GW103992	312937	6296628	25 m	17	1/11/1998	Maroota Sands	MTSGS

Appendix C – Upland Swamp

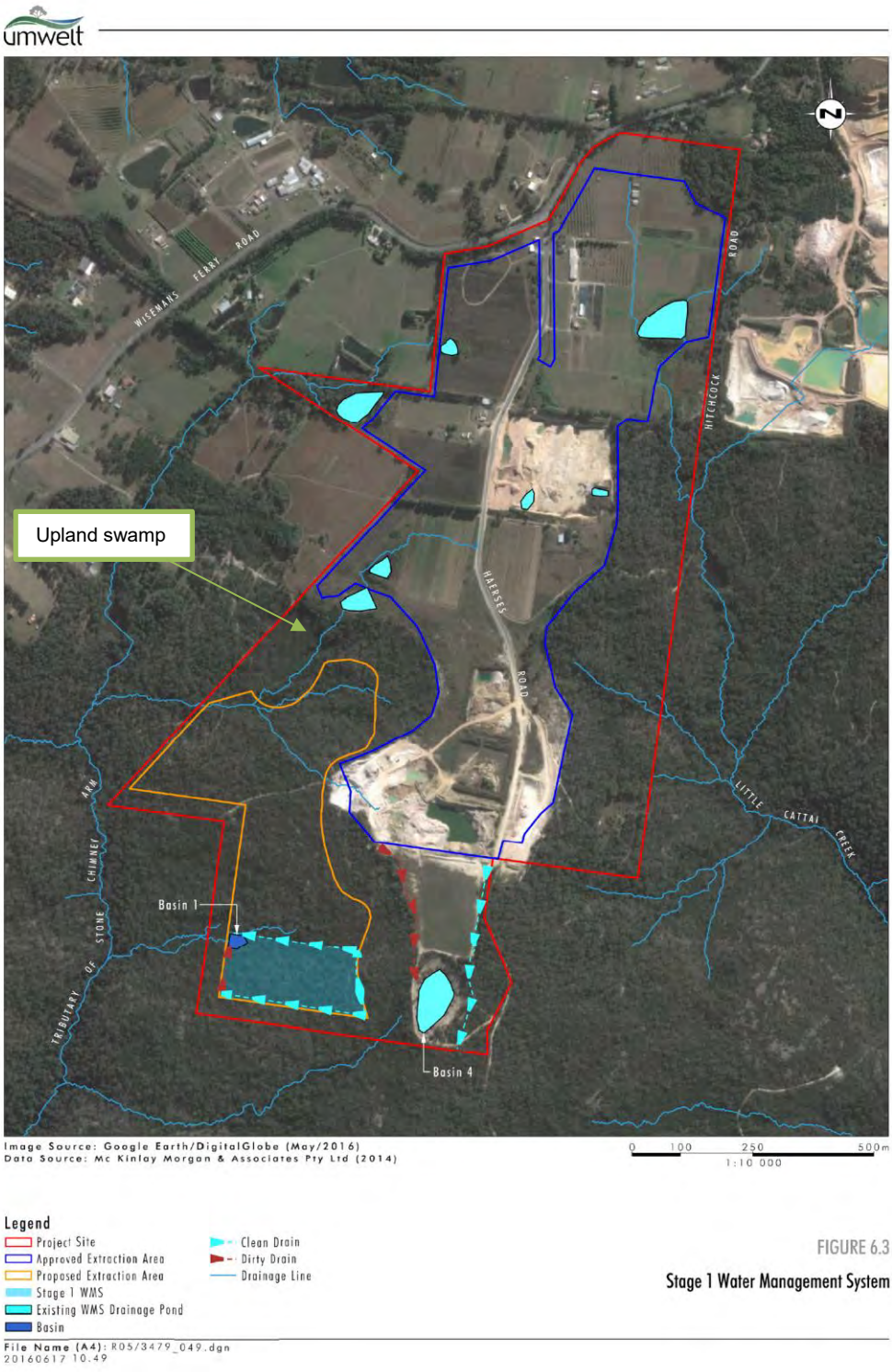
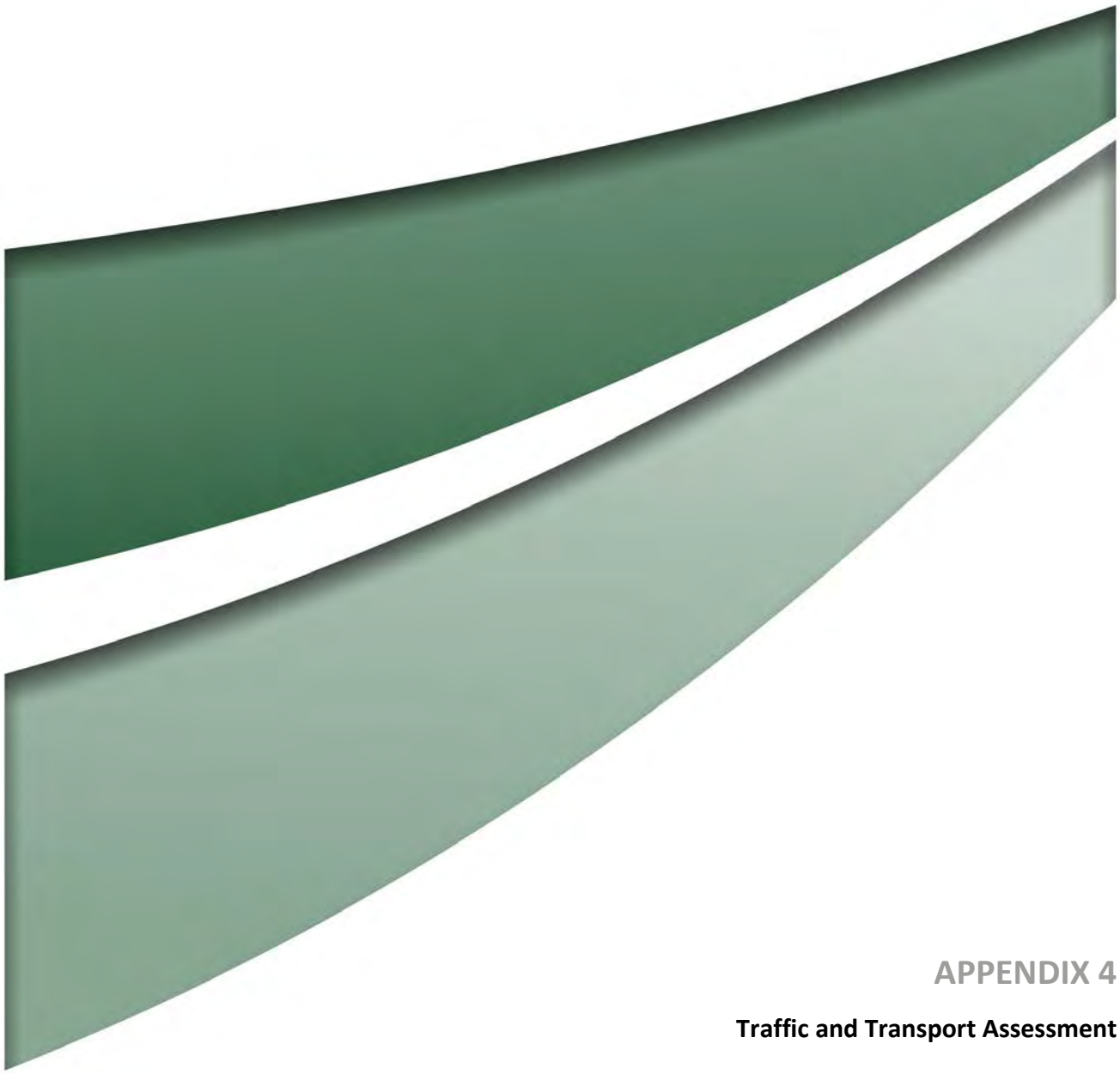


FIGURE 6.3

Stage 1 Water Management System



APPENDIX 4

Traffic and Transport Assessment

SECA solution
ACN: 164611652
Suite 10, 265 King Street
Newcastle NSW 2300
Ph: (02) 4925 7795
admin@secasolution.com.au

21 September 2016

P0300 Dixon Quarry

Umwelt (Australia) Pty Limited
75 York Street
Teralba, NSW 2284

Attn: Lachlan Sweeney

Dear Lachlan,

Proposed additional extraction area, Dixon Sand Quarry, Haerses Road, Maroota, NSW
Traffic Impact Assessment

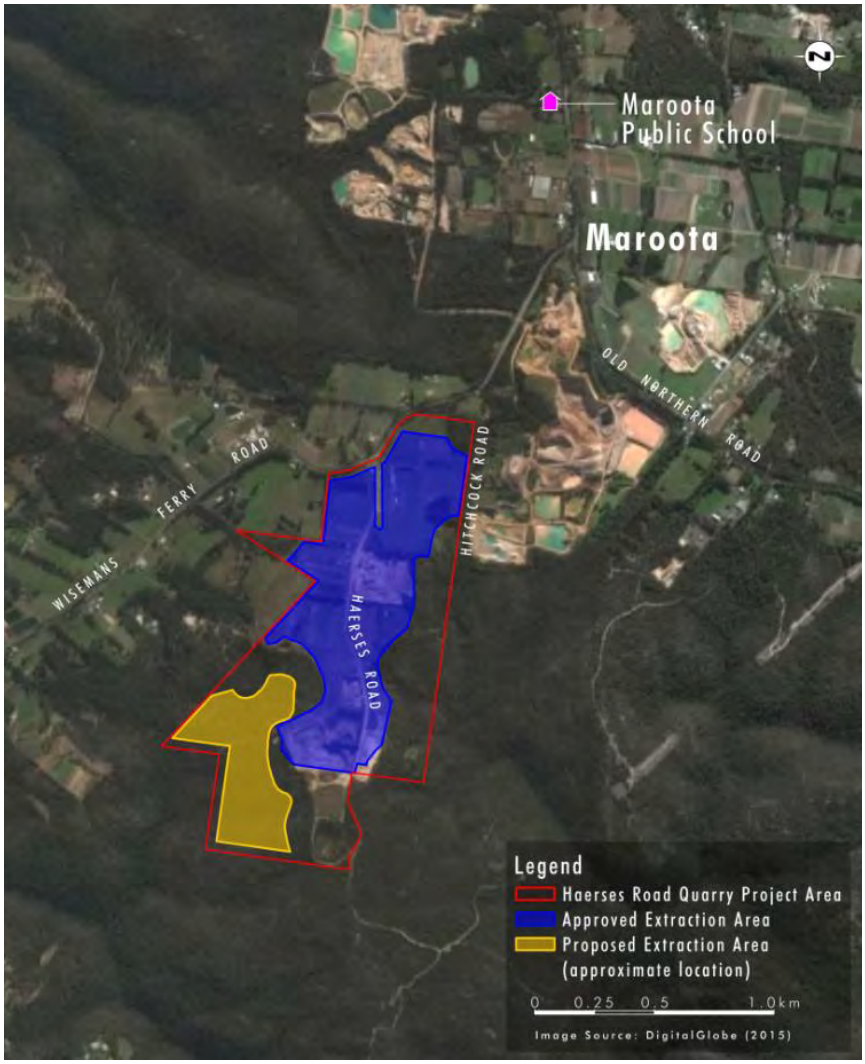
Further to our recent discussions, we have completed our site investigation of the proposed additional extraction area of the Dixon Sand quarry at Haerses Road, Maroota. We have reviewed the access location and have reviewed the project description. The subject site is located within the general locality of Maroota with the key access route being south along the Old Northern Road towards Sydney.

This traffic impact assessment has been prepared in accordance with the Austroads Guidelines and Section 2.3 of the RMS Guide to Traffic Generating Developments. Section 2.3 of the RMS Guide to Traffic Generating Developments provides a structure for reporting, covering the key issues to be addressed in determining the impact of traffic associated with a development. The Guide indicates that using this format and checklist will ensure that the most significant matters associated with a Development Application are considered by the road authority, be they the RMS or Council.

The report has also taken into consideration The Hills Hornsby Development Control Plan 2013 which makes reference to the Sydney Regional Environmental Plan No 9--Extractive Industry (No 2--1995) - Reg 1.

Quality Traffic Advice

The location of the site is shown below.



The items identified in Section 2.3 of the RMS Guide to Traffic Generating Developments are addressed below.

Item	Response
Existing Situation	
2.1.1 Site Location and Access	The quarry is located on Haerses Road, off Wisemans Ferry Road, to the west of the intersection with Old Northern Road. The current vehicle access is via Haerses Road which will continue to be used for the proposed expansion on the project site
2.2.1 Road Hierarchy	The main road through the locality is Old Northern Road, which runs in a north south direction to the west of the subject site. It provides an important road link through the locality, providing a connection for a number of rural suburbs between Wisemans Ferry to the north and Baulkham Hills and the greater area of Sydney to the south. In the locality of the subject site it generally provides a single lane of travel in each direction with additional turn lanes at key locations to maintain capacity. It operates under the posted speed limit of 80 km/h in the vicinity of the site and the intersection with Wisemans Ferry Road. There are no footpaths

Item	Response
	along the road in the location of the site with minimal sealed shoulders, reflective of the rural setting in this locality. Wisemans Ferry Road connects with Old Northern Road to the east of the site. Wisemans Ferry Road provides a sealed width in the order of 6m operating effectively under a speed limit of 80 km/h with a varying width sealed shoulder with a minimal verge bounded by small trees and shrubs. The road provides a route through to Richmond and the north-west sector of Sydney.
2.2.2 Roadworks	No road works are occurring within the general locality of the subject site. Given the reasonably low traffic flows in this area it can be seen that other than road maintenance there is no requirement for any major road upgrades in this location.
2.2.3 Traffic Management Works	None currently noted.
2.2.4 Pedestrian and Cycling Facilities	No pedestrian or cyclists facilities provided. Cyclists are able to use the road as required and there is generally very limited demand for pedestrian movements in this rural location due to the lack of local shops, schools etc.
2.2.5 Public Transport	There are no bus stops in the locality. It is noted that there are a number of school bus runs in this location and that buses pick up and drop off at informal locations along Old Northern Road adjacent to side roads and / or residents as required.
2.3 Traffic Flows	
2.3.1 Daily Traffic Flows	Daily traffic flows in the vicinity of the site are reasonably low, reflective of the rural location. As part of the project work, Seca Solution completed a traffic survey on Old Northern Road to the north of Maroota during the AM and PM peak periods during a typical working day (23rd November 2015). These counts shows that during the AM peak the 2-way flow was 146 vehicles per hour and 144vph in the PM peak. Based on the peak hour flow typically representing 10% of the daily flows, the daily traffic flows on this section of Old Northern Road could be in the order of 1,500 vehicles per day. Traffic surveys were also completed by Seca Solution on 4th December 2014 at the intersection of Old Northern Road and Wisemans Ferry Road, between 2.30PM and 5.00PM to determine the current traffic flows during the peak period associated with the Maroota Public School to the north of this location. These flows show that the two-way traffic flow on Old Northern Road to the north of Wisemans Ferry Road was 216 vehicles, indicating that daily traffic movements could be in the order of 2,100 vehicles per day, slightly higher than the surveys further north on Old Northern Road near Laughtondale Gully Road. Traffic flows on Wisemans Ferry Road, in the location of the site, were in the order of 176 vehicles during the afternoon peak period. This would indicate daily flows in the order of 1,800 per day.

Item	Response
2.3.2 Daily Traffic Flow Distribution	The peak hour traffic flows along Old Northern Road show a slight bias in traffic movements southbound in the AM peak, reflective of education and work opportunities to the south of the locality. In the PM peak the flows are reasonably evenly balanced. Daily traffic flows are expected to be equally balanced between northbound and southbound.
2.3.3 Vehicle Speeds	No speed surveys were completed as part of the study work. However, it is considered that the majority of drivers drive at the posted speed limit, due to the road alignment in the general locality of the site along Wisemans Ferry Road.
2.3.4 Existing Site Flows	The site is currently used for sand extraction with the current consent allowing for a maximum of 28 truck movements per day onto Hearses Road, with a limit of 10 trucks between 6-7 AM.
2.3.5 Heavy Vehicle Flows	There are a number of heavy vehicle movements in the locality, associated with the various quarries in the area as well as rural use demands. The vast majority of the heavy vehicle demands associated with the quarries are to the south of the locality, to the Greater Sydney area with very few heavy vehicles continuing north to Wisemans Ferry and beyond. A number of trucks were observed during the survey periods, associated with quarry activities and typical are truck and dog combinations.
2.3.6 Current Road Network Operation	The road network in the vicinity of the subject site currently operates very well with limited delays and congestion.
2.4 Traffic Safety and Accident History	The local road network in the general vicinity of the subject site is well laid out and caters safely for the overall traffic flows in the general vicinity of the subject site. Crash Data provided by the RMS for the past five years show that there have been no accidents recorded at the intersection of Haerses Road and Wisemans Ferry Road, Maroota. For the same period there has been only two crashes recorded at the intersection of Wisemans Ferry Road and Old Northern Road. One in 2010 and one in 2011. Neither involved a heavy vehicle. Overall it is considered that road safety in the locality of the subject site is good and that the limited number of heavy vehicles in the locality do not create any significant safety concerns.
2.5 Parking Supply and Demand	
2.5.1 On-street Parking Provision	There are no designated parking areas within the general locality of the site with parking demands catered for within the individual lots. Parking is permitted along the side of the roads if required on the verges, although observations on site show that there is little demand for road side parking in this area.
2.5.3 Parking Demand and Utilisation	There has been no demand for parking noted within the vicinity of the site.
2.5.4 Set down or pick up areas	There are no designated set down areas in the immediate locality of the subject site.
2.6 Public Transport	
2.6.1 Rail Station Locations	The location is not served by trains.

Item	Response
2.6.2 Bus Stops and Associated Facilities	There are no regular bus services to this location. There are a number of school bus runs that operate along Old Northern Road providing a service primarily for school students.
2.6.3 Pedestrians	There are no pedestrian footpaths within the vicinity reflecting the limited demand and rural setting.
2.7 Other Proposed Developments	No other significant developments noted in the immediate locality of the subject site. A new quarry has been approved on Laughtondale Gully Road to the north of the subject site.
Proposed Development	
3.1 The Development	Dixon Sand (Penrith) Pty Ltd (Dixon Sand) is seeking a modification to the existing development consent to expand the extraction area of the Hearses Road Quarry. The proposed modification does not seek to alter the overall number of truck movements in and out of the project site, but rather seeks to alter the potential truck movement patterns in and out of the project site. The proposed modification involves the following: - Maximum of 250,000 tonnes per annum exiting the site (NO change to current consent) - Maximum of 250,000 tonnes per annum direct to market (increase from current consent of 60,000 tonnes per annum) - Maximum of 190,000 tonnes per annum exit site to Old Northern Road site (NO change to current movements through township of Maroota) - Up to 100,000 tonnes per annum of VENM / ENM to / from site for processing. The 100,000 tonnes of VENM / ENM will be transported to the site in trucks that are currently entering the site empty to pick up a load for removal of product to either the associated Old Northern Road Quarry or to market. The consent does not seek to alter the overall number of truck movements in and out of the site (28 per day), but rather seeks to alter the potential truck movement patterns which currently restrict trucks to a maximum of 7 trucks movements to the south-west per day and increase this to a maximum of 28 per day. If the 28 truck movements per day turn left out of the site, there will be no trucks turning right out of the site, which is currently restricted to 28 per day maximum.
3.1.1 Nature of Development	Sand extraction quarry
3.1.2 Access and Circulation Requirements	Access will be provided via the existing access along Hearses Road which then connects with Wisemans Ferry Road. The layout of the site and the operations allows for all vehicles to enter and exit the site in a forward direction. There is no change to the current access arrangements for the project.
3.2 Access	The access to the site will be via the existing access on Hearses Road. Hearses Road connects with Wisemans Ferry Road via a simple Give Way control, with Hearses Road being located on the

Item	Response
	outside of the slight curve in this location which allows for good visibility for vehicles entering and exiting Hearses Road. This access currently caters for all turning movements associated with the current operations on the site, which allow for trucks and light vehicles to enter and exit Hearses Road from the east and west on Wisemans Ferry Road.
3.2.1 Driveway Location	The driveway access to the site is located at the end of Hearses Road and effectively operates as the terminus of Hearses Road.
3.2.2 Sight Distances	The intersection of Hearses Road and Wisemans Ferry Road is a simple T intersection, with Wisemans Ferry Road being the priority road. There is a short length of sheltered right turn lane that allows for the vehicles turning right off Wisemans Ferry Road into Hearses Road. The sight distances at this location are restricted, due to curvature of the roads and the road side vegetation. For the posted speed limit of 80 km/h, the required safe intersection sight distance is 160 metres, whilst the stopping sight distance requirement is 100 metres. The sight distance available in both directions is approximately 140 metres, which equates to a design speed of 70 km/h. The alignment of the road in the locality of the intersection with Hearses Road does not encourage speeding with vehicles typically travelling at lower than the posted speed limit. The sight distance available exceeds the requirements under Approach Sight Distance requirement of 100 metres under Austroads requirements. Approach Sight Distance allows an approaching driver to appreciate the intersection geometry and pavement markings in order to negotiate the intersection or stop (if necessary). Whilst the safe intersection sight distance is short be 20m this existing access appears to operate in a safe manner with vehicles able to observe the intersection and adjust speeds accordingly. Based upon observations on site and a review of the current operations on site, it is considered that the intersection of Hearses Road and Wisemans Ferry Road can continue to operate to an acceptable standard for the proposed modification of the quarry. It is noted that the proposed modification will not increase the current number of truck movements using this intersection associated with the quarry.
3.2.3 Service Vehicle Access	The site will require limited servicing and the service vehicles will typically be required for maintenance of construction vehicles on site, tyre changes, etc. These vehicles will typically be a small rigid truck or smaller. The number of service vehicles is not expected to alter with the proposed modification.
3.2.4 Queuing at entrance to site	No vehicle queues expected at site entry / exit point due to the low overall flows from the site as well as low flows on Wisemans Ferry Road. Observations on site during a typical morning and afternoon peak period showed that the current intersection of Hearses Road and

Item	Response
	Wisemans Ferry Road operates very well, with no delays or congestion noted. The vast majority of turn movements in and out of Hearses Road occurred with no delays other than the geometric delay created by the intersection, with the through movement on Wisemans Ferry Road being low and accordingly leaving large gaps in the traffic movements. This pattern also occurs at the intersection of Wisemans Ferry Road and Old Northern Road, with no delays for the vast majority of drivers other than those associated with negotiating the intersection.
3.2.5 Comparison with existing site access	Existing site access is via Hearses Road and there will be no change to this access required or proposed.
3.2.6 Access to Public Transport	There is very limited access to public transport in this area and it is considered that employees associated with the project will not rely on public transport to access the site.
3.3 Circulation	
3.3.1 Pattern of circulation	All vehicles can enter and exit the site in a forward direction and circulate around the site as required.
3.3.2 Road width	The existing internal roads allow for two-way traffic movements as required and given the very low traffic movements associated the development the existing internal road does not create any issues.
3.3.3 Internal Bus Movements	No internal bus movement will be required for this modifcation.
3.3.4 Service Area Layout	No specific service area layout required. A maintenance shed is provided on site to allow for vehicle maintenance as required.
3.4 Parking	
3.4.1 Proposed Supply	A gravel car parking providing 12 spaces (8 staff and 4 visitor) will be located adjacent to Haerses Road at the weighbridge. There will be no trucks parked on the site overnight.
3.4.2 Authority Parking	No specific parking rate provided for the development land use under The Hills Development Control Plan. Similarly, the RMS Guide to Traffic Generating Developments makes no recommendations for parking for extractive industries. Thus the parking is to be provided based upon the actual demand of the end user.
3.4.3 Parking Layout	No formal parking bays to be provided. Parking will occur adjacent to the weighbridge and/or maintenance shed.
3.4.4 Parking Demand	Normal parking demands can be accommodated within the site.
3.4.5 Service Vehicle Parking	Service vehicles can be accommodated within the site as required.
3.4.6 Pedestrian and Bicycle Facilities	It is considered that there will be no demand for pedestrian or cycle access given the remote location of the site and as such, no formal facilities will be provided.
Traffic Assessment	
4.1 Traffic Generation	There are no standard traffic generation rates provided by the RTA Guide to Traffic Generating Development for this type of development and as such the generation should be based upon the future operational characteristics of the site.

Item	Response
	The modification will allow for the continual extraction of up to 250,000 tonnes of material per annum from the site. This means that the current limit of truck movements in and out of the site will remain at the current levels i.e. 28 per day. Currently a maximum of 190,000 tonnes is extracted from the site and proceeds north on Old Northern Road to the other facilities operated by Dixon Sands. This will not change under the proposed modification. Currently, a maximum of 60,000 tonnes per annum (out of the total of 250,000 tonnes per annum) is extracted from the site and dispatched directly to the market. The modification seeks to increase this to a maximum of 250,000 tonnes per annum direct to market. If the full quantity of 250,000 tonnes per annum is extracted and delivered direct to market, then there will be no material moved to the site on Old Northern Road to the north of Maroota. The proposal will also allow for the import of VENM and ENM material, up to 100,000 tonnes per annum. This will utilise empty trucks travelling to the site, which will then carry the outbound material from the site. Currently these inbound trucks do not carry a load. This ensures that the modification will continue to operate under the current limit of 28 trucks per day (inbound and outbound) The hours of operation for the quarry will be Monday to Saturday 7am to 6pm. The modification will result in a maximum of 28 truck movements per day (no change) and a limit of 10 trucks per hour between 6-7 AM.
4.1.1 Other Developments	No other significant developments are noted within the locality of the site. A quarry has been approved on Laughtondale Gully Road to the north of the subject site. This will generate traffic movements along Old Northern Road, once it becomes fully operational.
4.1.3 Daily and Seasonal Factors	Operational traffic associated with the quarry is in response to market demands. There will be a significant daily variation in traffic movements as a consequence of this. At times there may be no demand and as such there will be no activity in and out of the quarry.
4.1.4 Pedestrian Movements	No pedestrian movements are expected to and from the site. All internal pedestrian movements will be covered by WH&S guidelines.
4.2 Traffic Distribution and Assignments	The traffic movements will allow for access in both directions along Wisemans Ferry Road dependent upon the market demands. Current traffic movements are limited to a maximum of 7 trucks to the west of Hearses Road with the balance, up to 28 trucks per day, to the east on Hearses Road. The modification allows for the maximum of 28 trucks per day to remain, but allowance for up to 28 trucks to use either Wisemans Ferry Road to the east or west of Hearses Road.

Item	Response
4.2.1 Origin / destinations assignment	100% of trucks will enter and exit via Hearses Road only. Up to 28 trucks per day will travel along Wisemans Ferry Road with no restriction on how many of these travel to the west or to the east. Those travelling east will then access the broader network along Old Northern Road (north or south dependent upon if outbound material to market or transport to other Dixon Sands site to north of Maroota).
4.3 Impact on Road Safety	It is considered that the project will have a minimal impact upon road safety in the general locality of the subject site. The modification does not allow for any increase in the number of truck movements, just a re-allocation of truck movements onto the road network and allowing empty trucks to carry inbound material. The road network in the locality of the subject site operates well with minimal delays. The rural nature of the locality does not encourage high traffic speeds and the road alignment of Wisemans Ferry Road and Old Northern Road both allow for safe traffic movements. There are already a number of quarry related truck movements in the area which generate heavy vehicle movements and these overall movements will not increase due to the modification. The modification will not increase the number of truck movements passing through the township of Maroota and past Maroota Pubic School in this location and therefore will not have an impact on safety at this location.
4.4 Impact of Generated Traffic	
4.4.1 Impact on Daily Traffic Flows	It is considered that the traffic movements generated by the modification will have a minimal impact on the daily traffic movements in the immediate locality of the subject site. The development will not generate any additional traffic movements but allows for a different distribution of traffic which is only low. The development will continue to generate 28 truck movements per day (inbound and outbound). Current daily flows on Old Northern Road, based upon the peak hour surveys completed by Seca Solution, are in the order of 1,500 vehicles per day well within acceptable limits for the local roads in this location. The trucks are currently using this road and as such there is no impact. For the alternative access route, with the market demand requiring all 28 trucks to head to market via Wiseman Ferry Road to the south-west of the site, the current daily traffic flows are in the order of 2,100 in the vicinity of the site. It is considered that the additional 28 truck movements per day in both directions would have a negligible impact upon the operation of this road in this location. It is noted that the current consent permits up to 7 trucks per day via this route and so the proposal is to increase this by 21 trucks per day per direction maximum.

Item	Response
4.4.2 Peak Hour Impacts on Intersections	The key intersections identified as being potentially affected by the modification is the T intersection of Hearses Road with Wisemans Ferry Road and Wisemans Ferry Road with Old Northern Road. Observations on site show that both of these intersections operate very well with no delays for the majority of traffic movements. Traffic turning into or out of the side road typically did not need to stop and the only delay was that associated with manoeuvring through the intersection. A Sidra intersection analysis has been completed at the intersection of Old Northern Road and Wisemans Ferry Road and the analysis confirms that the intersection operates very well with negligible delays and congestion. Levels of service for all movements are A and the delays are less than 7 seconds for all movements. It is considered that the intersection of Hearses Road and Wisemans Ferry Road would operate to a similar level of service and delays. With no increase to the truck numbers at this location the intersection will continue to operate at this level of service. Traffic flows are lower than at the intersection of Old Northern Road and Wisemans Ferry Road and observations on site show that this intersection currently operates with negligible delays for all traffic movements.
4.4.3 Impact of Construction Traffic	All construction work will be contained within the site so minimal impact upon external road network. The majority of the equipment is located on the site and will be able to continue to be used and as such there will be little if any additional construction traffic movements.
4.4.4 Other Developments	No other significant developments occurring in the immediate locality of the subject site.
4.5 Public Transport	
4.5.1 Options for improving services	No requirements to improve services.
4.5.2 Pedestrian Access to Bus Stops	None required
4.6 Recommended Works	
4.6.1 Improvements to Access and Circulation	No improvements for access to the internal road network is proposed. The internal roads allow for safe and efficient movement of vehicles and will not allow for general public access.
4.6.2 Improvements to External Road Network	None required as the development will not increase the traffic demands associated with the site.
4.6.3 Improvements to Pedestrian Facilities	No upgrades required.
4.6.4 Effect of Recommended Works on Adjacent Developments	No impact as no external works recommended.
4.6.5 Effect of Recommended Works on Public Transport Services	Nil
4.6.6 Provision of LATM Measures	None required

Item	Response
4.6.7 Funding	No external road upgrades required.



Photo 1 – View north along Old Northern Road showing typical alignment and approach to Wisemans Ferry Road



Photo 2 – View to left for drivers exiting Wisemans Ferry Road onto Old Northern Road



Photo 3 – View to right for drivers exiting Wisemans Ferry Road onto Old Northern Road

Conclusion

From the site work completed and the review of the proposed modification, it is considered that the proposed quarry expansion will have a minimal impact upon the overall road network within the general vicinity of the site.

The site access can continue to operate in a safe manner and allows for vehicles to enter and exit the site in a safe manner, via the intersection of Hearses Road and Wisemans Ferry Road. This intersection currently allows for safe turning movements and provides adequate sight lines to maintain road safety.

The modification will maintain the daily truck movements associated with the quarry at 28 per day via Hearses Road however allows for a different distribution direct to the market, with up to 28 trucks per day travelling east or west along Wisemans Ferry Road, dependent upon the market demands. The current consent permits up to 28 truck movements per day on Old Northern Road heading south so there is no change created by the modification. If the market demand is for 28 truckloads per day to head south-west then this will potentially increase the truck movements on Wisemans Ferry Road to the south-west of the site from the current consent of 7 per day each way to 28 per day each way. This will have a minimal impact upon the operation of Wisemans Ferry Road. There will be no increase to the number of trucks heading north via Maroota carrying product between the project site and the other Dixon Sands site north of Maroota and the delivery of product direct to market has the potential to actually reduce these movements. The import of VENM or ENM product, utilising empty trucks inbound to the quarry, will not impact on the number of movements but rather utilise existing trucks on the road network.

It is therefore concluded that the development should be approved on traffic and access grounds.



Sean Morgan

Director

Attachment A - Site Plan Location and Plan



SECAsolution

Attachment B - Accident Data

Summary Crash Report

Transport for NSW — Centre for Road Safety

# Crash Type		
Car Crash	1	50.0%
Light Truck Crash	0	0.0%
Rigid Truck Crash	0	0.0%
Articulated Truck Crash	0	0.0%
'Heavy Truck Crash	(0)	(0.0%)
Bus Crash	0	0.0%
"Heavy Vehicle Crash	(0)	(0.0%)
Emergency Vehicle Crash	0	0.0%
Motorcycle Crash	1	50.0%
Pedal Cycle Crash	0	0.0%
Pedestrian Crash	0	0.0%

' Rigid or Artic. Truck " Heavy Truck or Heavy Bus
These categories are NOT mutually exclusive

Location Type		
*Intersection	1	50.0%
Non intersection	1	50.0%

* Up to 10 metres from an intersection

Collision Type		
Single Vehicle	1	50.0%
Multi Vehicle	1	50.0%

Road Classification		
Freeway/Motorway	0	0.0%
State Highway	0	0.0%
Other Classified Road	2	100.0%
Unclassified Road	0	0.0%

Contributing Factors		
Speeding	0	0.0%
Fatigue	0	0.0%

Weather		
Fine	1	50.0%
Rain	1	50.0%
Overcast	0	0.0%
Fog or mist	0	0.0%
Other	0	0.0%

Road Surface Condition		
Wet	1	50.0%
Dry	1	50.0%
Snow or ice	0	0.0%

Natural Lighting		
Dawn	0	0.0%
Daylight	2	**********
Dusk	0	0.0%
Darkness	0	0.0%

Crash Movement		
Intersection, adjacent approaches	0	0.0%
Head-on (not overtaking)	0	0.0%
Opposing vehicles; turning	0	0.0%
U-turn	0	0.0%
Rear-end	1	50.0%
Lane change	0	0.0%
Parallel lanes; turning	0	0.0%
Vehicle leaving driveway	0	0.0%
Overtaking; same direction	0	0.0%
Hit parked vehicle	0	0.0%
Hit railway train	0	0.0%
Hit pedestrian	0	0.0%
Permanent obstruction on road	0	0.0%
Hit animal	0	0.0%
Off road, on straight	0	0.0%
Off road on straight, hit object	0	0.0%
Out of control on straight	1	50.0%
Off road, on curve	0	0.0%
Off road on curve, hit object	0	0.0%
Out of control on curve	0	0.0%
Other crash type	0	0.0%

Speed Limit					
40 km/h or less	0	0.0%	80 km/h zone	1	50.0%
50 km/h zone	0	0.0%	90 km/h zone	0	0.0%
60 km/h zone	0	0.0%	100 km/h zone	0	0.0%
70 km/h zone	1	50.0%	110 km/h zone	0	0.0%

~ 07:30-09:30 or 14:30-17:00 on school days	~ 40km/h or less		~ School Travel Time Involvement	
	0	0.0%	0	0.0%

Day of the Week												
Monday	0	0.0%	Wednesday	0	0.0%	Friday	0	0.0%	Sunday	0	0.0%	WEEKEND	2 **********
Tuesday	0	0.0%	Thursday	0	0.0%	Saturday	2 **********		WEEKDAY	0	0.0%		

#Holiday Periods																
New Year	0	0.0%	Easter	0	0.0%	Queen's BD	0	0.0%	Christmas	0	0.0%	Easter SH	1	50.0%	Sept./Oct. SH	0	0.0%
Aust. Day	0	0.0%	Anzac Day	0	0.0%	Labour Day	0	0.0%	January SH	0	0.0%	June/July SH	0	0.0%	December SH	0	0.0%

CRASHES	2	
Fatal	0	0.0%
Serious inj.	0	0.0%
Moderate inj.	1	50.0%
Minor/Other inj.	1	50.0%
Uncategorised inj.	0	0.0%
Non-casualty	0	0.0%

Self Reported Crash	0	0%

Time Group		% of Day	
00:01 - 02:59	0	0.0%	12.5%
03:00 - 04:59	0	0.0%	8.3%
05:00 - 05:59	0	0.0%	4.2%
06:00 - 06:59	0	0.0%	4.2%
07:00 - 07:59	0	0.0%	4.2%
08:00 - 08:59	0	0.0%	4.2%
09:00 - 09:59	0	0.0%	4.2%
10:00 - 10:59	0	0.0%	4.2%
11:00 - 11:59	0	0.0%	4.2%
12:00 - 12:59	1	50.0%	4.2%
13:00 - 13:59	0	0.0%	4.2%
14:00 - 14:59	1	50.0%	4.2%
15:00 - 15:59	0	0.0%	4.2%
16:00 - 16:59	0	0.0%	4.2%
17:00 - 17:59	0	0.0%	4.2%
18:00 - 18:59	0	0.0%	4.2%
19:00 - 19:59	0	0.0%	4.2%
20:00 - 21:59	0	0.0%	8.3%
22:00 - 24:00	0	0.0%	8.3%

Street Lighting Off/Nil		% of Dark
0	of 0	in Dark 0.0%

CASUALTIES	2	
Killed	0	0.0%
Seriously inj.	0	0.0%
Moderately inj.	1	50.0%
Minor/Other inj.	1	50.0%
Uncategorised inj.	0	0.0%
^ Unrestrained	0	0.0%

^ Belt fitted but not worn, No restraint fitted to position OR No helmet worn

Crashes		Casualties
1	2011	1
1	2010	1

McLean Periods		% Week	
A	0	0.0%	17.9%
B	0	0.0%	7.1%
C	0	0.0%	17.9%
D	2	100.0%	3.5%
E	0	0.0%	3.6%
F	0	0.0%	10.7%
G	0	0.0%	7.1%
H	0	0.0%	7.1%
I	0	0.0%	12.5%
J	0	0.0%	10.7%

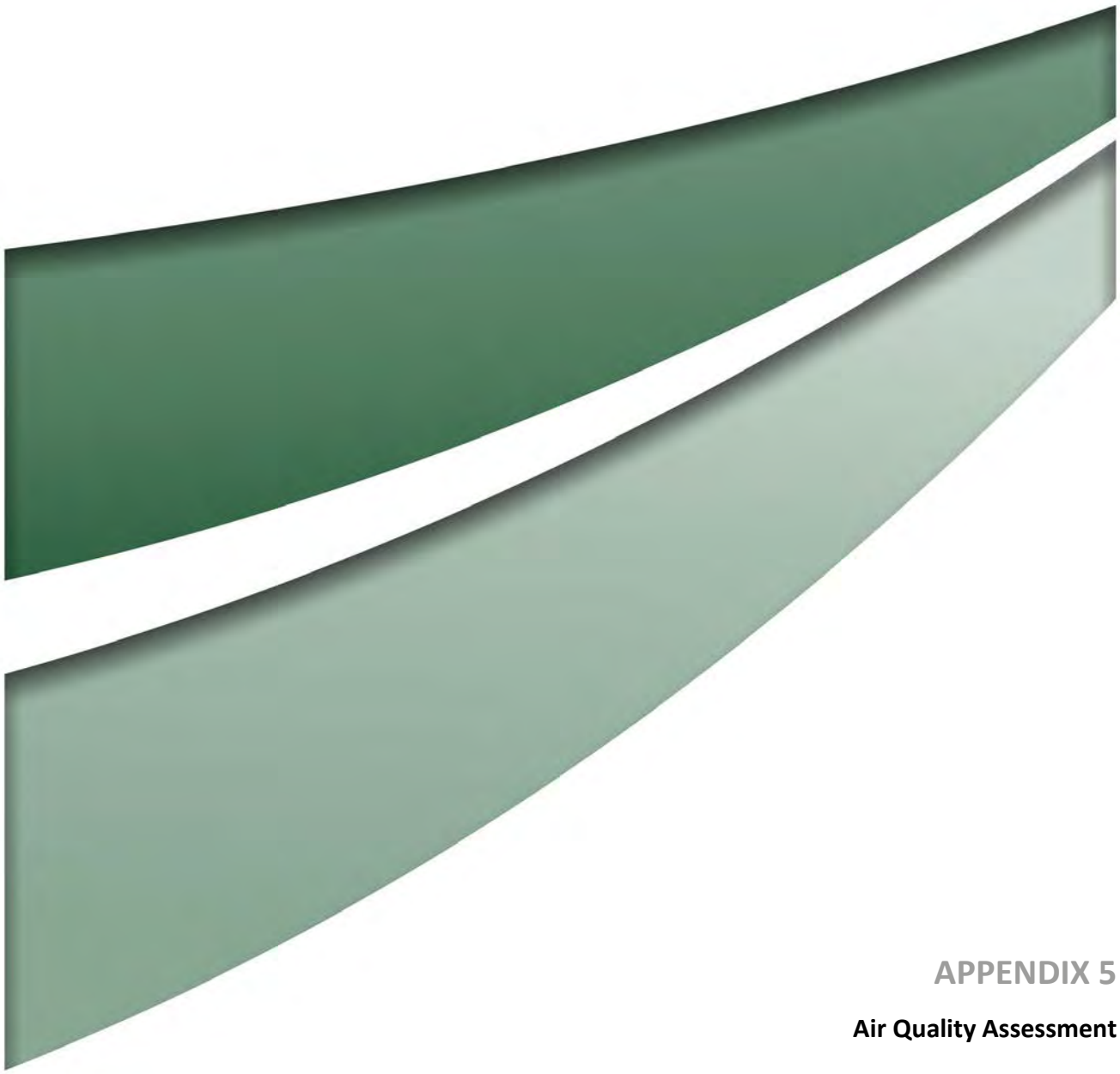
Crashid dataset 6820 - Reported crashes within 20m of intersection - Wisemans Ferry Rd & Old Northern Rd - 1 July 2010 to 30 June 2015

Note: Crash self reporting, including self reported injuries began Oct 2014. Trends from 2014 are expected to vary from previous yrs. More unknowns are expected in self reported data. Reporting yrs 1996-2004 and 2014 onwards contain uncategorised inj crashes.

Percentages are percentages of all crashes. Unknown values for each category are not shown on this report.

Rep ID: REG01 **Office:** Sydney **User ID:** nafiza

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APPENDIX 5

Air Quality Assessment

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology



Report

DIXON SAND HAERSES ROAD QUARRY MODIFICATION – AIR QUALITY ASSESSMENT

DIXON SAND QUARRY C/O UMWELT

Job ID. 21153B

13 September 2016

PROJECT NAME:	Dixon Sand Haerses Road Quarry Modification – Air Quality Assessment
JOB ID:	21153B
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D1	31.05.16	Angelo Rouggos	Judith Cox
D2	06.06.16	Angelo Rouggos	Judith Cox
D3	06.06.16	Angelo Rouggos	Judith Cox
R1	13.09.16	Angelo Rouggos	Judith Cox

Pacific Environment Operations Pty Ltd: ABN 86 127 101 642

BRISBANE
Level 19, 240 Queen St, Brisbane Qld 4000
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

ADELAIDE
35 Edward Street, Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

MELBOURNE
Level 17, 31 Queen Street Mel 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

SYDNEY
Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

PERTH
Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

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EXECUTIVE SUMMARY

Pacific Environment has prepared this air quality assessment on behalf of Dixon Sand Pty Ltd (the Proponent). It assesses the air quality impacts associated with the proposed additional extraction area and other changes to the current operations at the Haerses Road site (the Modification).

The assessment was prepared in general accordance with the NSW EPA "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (*Approved Methods*) (NSW DEC, 2005).

The surrounding land use is primarily rural, although there is significant sand extraction activity in the area, both by Dixon Sand and other companies.

AERMOD was chosen as the most suitable model due to the source types, location of nearest receivers and nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes and is now commonly applied to assessments of this nature in NSW.

The operational stage has been modelled for average annual production. A worst case 24-hour operational scenario has also been modelled accounting for maximum daily throughput. Two scenarios were assessed to account for dry processing activities that could occur in different locations on site.

The results of the modelling indicate that the predicted incremental PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest sensitive receivers all comply with the impact assessment criteria.

A cumulative assessment, incorporating existing background levels, indicates that the Modification may result in some additional exceedances of relevant impact assessment criteria at the closest sensitive receptors, if the worst day operations happened to coincide with already elevated background concentrations. However this outcome is considered unlikely to occur and the current requirements to modify/cease operations if rolling 24-hour averages exceed 42 $\mu g/m^3$ will minimise the potential for this to occur even further.

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1 INTRODUCTION

Dixon Sand (Penrith) Pty Limited (Dixon Sand) operates the Haerses Road Quarry located on Haerses Road at Maroota, NSW. Dixon Sand extracts Tertiary Maroota Sand from the Haerses Road Quarry from Lot 170 DP 664767, Lots A and B DP 407341, and Lots 176 and 177 DP 752039 in accordance with development consent DA 165-7-2005.

Pacific Environment has prepared this air quality assessment for Dixon Sand (the Proponent) to assess the air quality impacts associated with the proposed additional extraction area and other changes to the existing sand quarrying activities at the Haerses Road Quarry. The additional extraction area relates to a friable sandstone resource to the west of the existing tertiary sand resource (the Modification).

The assessment has been prepared in general accordance with the NSW EPA "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", hereafter referred to as the *Approved Methods* (NSW DEC, 2005).

2 PROJECT DESCRIPTION

The Proponent has been operating the Haerses Road Quarry since consent was granted in 2006. The resource contains a Tertiary deposit of eluvial sediments that are suited for use as concrete and specialty sands.

DA 165-7-2006-5 currently allows a total extraction of 7 million tonnes from the site over 25 years at a rate of 250,000 tonnes per annum (tpa). The consent allows for hauling of 190,000 tpa of screened sand to the processing facility at Dixon Sand's Old Northern Road Quarry located approximately two kilometers to the north, and hauling of 60,000 tpa of screened sand direct to local and regional markets.

The proposed modification to DA 165-7-2006-5, being sought for the Haerses Road Quarry involves increasing the extraction area as well as including a provision for mobile plant and equipment to be utilised on the site to avoid double handling and double processing of the product. The proposed modifications are:

- Increasing the extraction area by approximately 19 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039. The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader. The existing dozer would be used to rip the friable sandstone on site which wasn't required for tertiary sand deposit in the original consent. The existing dry screening plant would utilise mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening;
- Utilise existing traffic movements between Old Northern Road and Hearses Road Quarries to allow for blending of speciality sands, including importation of up to 100,000 tpa of clean recycled sands (Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM)) from approved sites. No new traffic movements would be generated by the proposal and there would be negligible change to traffic generation between quarries as a result of the proposed modification;
- Use of mobile washing and processing plant on site, utilising water from existing water licence provisions;
- Installation of detention basins; and
- Establishment of site office, workshop and weighbridge.

An Air Quality Assessment has been prepared as part of the modification application for the proposed expansion of the quarry, in accordance with Section 75W of the *Environmental Planning and Assessment Act 1979*.

3 LOCAL SETTING

The land use in the area surrounding the proposed development is primarily rural, although there is significant sand extraction activity in the area, both by Dixon Sand and other companies.

The closest discrete receptor locations are presented in Table 3.1. These residential receivers (some of which are owned by Dixon Sand and PF Formation, as stated) represent assessment locations in close proximity to the Modification (see Figure 3.1).

Table 3.1: Receptor Locations

Receptor ID	Type	Easting (m)	Northing (m)	Height ASL (m)
R1	Residential	312924	6295200	195
R2	Residential	312780	6295033	193
R3	Residential	312454	6294919	179
R4	Residential	312177	6294850	176
R5	Residential	311939	6294631	162
R6	Residential	311871	6294275	156
R7	Residential	311600	6294343	161
R8	Residential	311702	6294162	153
R9	Residential	311543	6294146	147
R10	Residential	311283	6294161	153
R11	Residential	311179	6294076	155
R12	Residential	313049	6295163	196
R13	Residential	313018	6295228	198
R14	Residential	312353	6295030	184
R15	Residential	312207	6294990	183
R16	Residential	312103	6295021	178
R17	Residential	310707	6293300	145
R18	Residential	311239	6292850	134
R19	Residential	311627	6292424	132
R20	Residential	311873	6291990	149
D1	Owned by Dixon Sand	313103	6295173	196
PF1	Owned by PF Formation	313362	6295255	205
PF2	Owned by PF Formation	313242	6295125	198
PF3	Owned by PF Formation	313228	6294961	189

Dixon Sand's central processing plant at the Old Northern Road site, the Haerses Road site and sensitive receptors are shown in Figure 3.1.

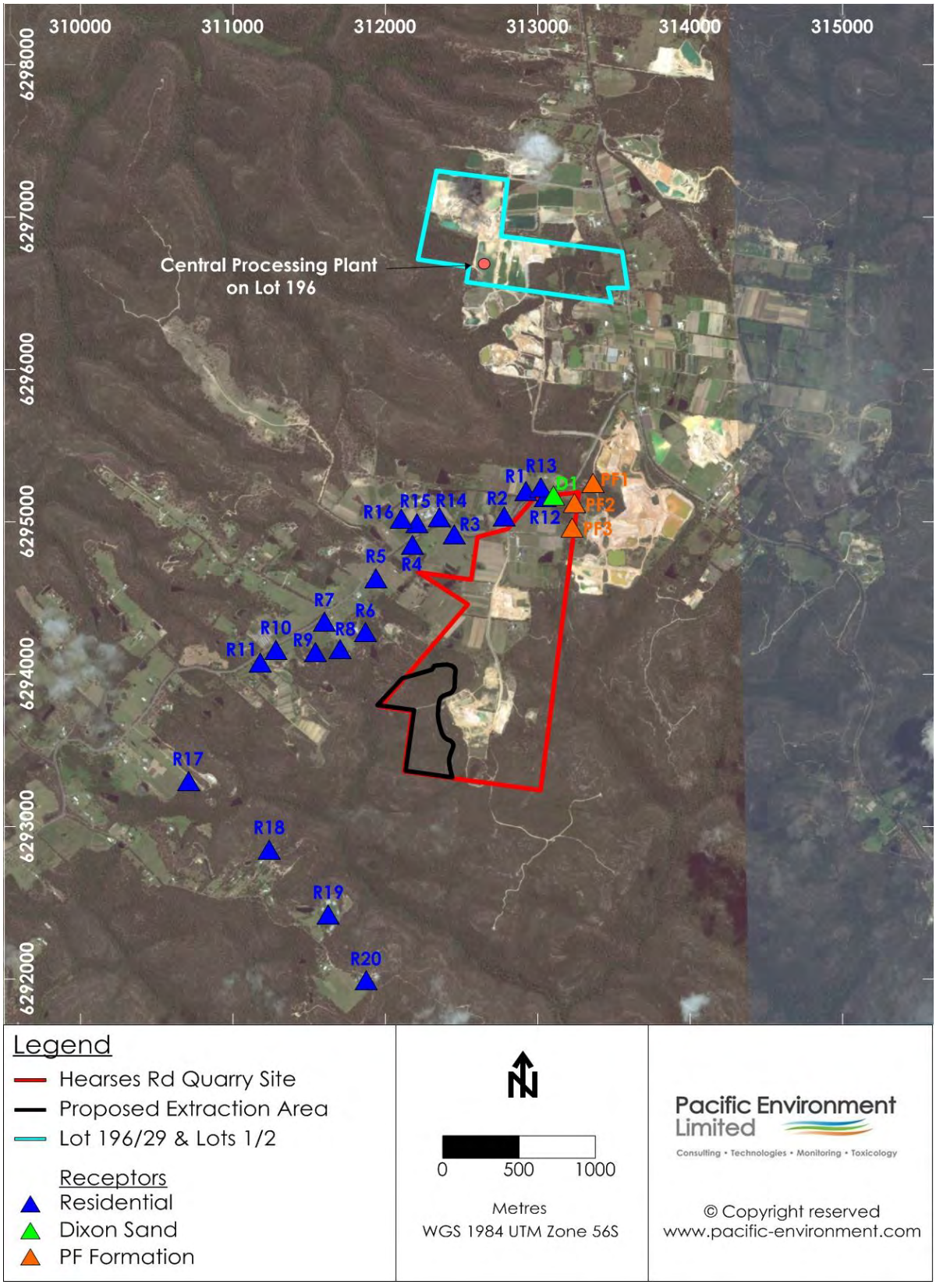


Figure 3.1: Location of the Haerses Road Quarry and Sensitive Receptors

4 AIR QUALITY CRITERIA

The potential emissions to air from the Modification are summarised as follows:

- Modification activities described in Section 2 have the potential to generate fugitive dust emissions, particularly from sand extraction, hauling and site rehabilitation.
- Combustion of diesel in quarrying equipment will result in emissions of fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. This assessment focuses on the key pollutants of fine PM.

It is noted that emissions of PM from diesel exhaust are considered to be accounted for in the emission factors for fugitive PM for relevant sources (i.e. dozers).

4.1 Impact Assessment Criteria

The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from air pollution (NSW DEC, 2005). These criteria are health-based (i.e. they are set at levels to protect against health effects) and for PM_{10} are consistent with the now superseded National Environment Protection Measure for Ambient Air Quality (referred to as the Ambient Air-NEPM) (NEPC, 1998a). However, the Approved Methods include other measures of air quality, namely dust deposition and TSP which are not stated in the Ambient Air-NEPM.

In January 2016, the NEPC released an amended Ambient Air-NEPM (NEPC, 2016) to take into account the latest scientific evidence about the health impacts of particles. The amendment changed the 'advisory reporting standards' status for annual average and 24-hour average $PM_{2.5}$ (particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less) to 'standards', but in absence of any other relevant standard/goal, the 2016 NEPM for $PM_{2.5}$ standards have been used in this report for comparison against dispersion modelling results.

Table 4.1 presents the air quality goals for pollutants that are relevant to this study. It is important to note that the criteria are applied to the cumulative impacts due to the Modification and other sources.

Table 4.1: NSW EPA Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 µg/m³	24-Hour	NSW DEC (2005) (assessment criteria)
	30 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	25 µg/m³	24-Hour	NEPC (2016)
	8 µg/m³	Annual	NEPC (2016)
Nitrogen Dioxide	246 µg/m³	1-Hour	NSW DEC (2005) (assessment criteria)
	62 µg/m³	Annual	NSW DEC (2005) (assessment criteria)

Notes: µg/m³ – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust deposition can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 4.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance impacts (NSW DEC, 2005).

Table 4.2: EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

4.2 Crystalline Silica

Whilst dust generated from the Modification may contain silica dust, and long term inhalation of silica dust may lead to the formation of scar tissue in the lungs, which can result in silicosis, a serious lung disease, silicosis is a work place issue associated with long-term exposure to high levels of respirable crystalline silica (RCS).

The World Health Organization's Concise International Chemical Assessment Document on Crystalline Silica, Quartz (CICAD, 2000) states that "*there are no known adverse health effects associated with the non-occupational exposure to quartz*". In addition, an Australian Government Senate Committee (2005) report identified that there are no reports in the international literature of individuals developing silicosis as a result of exposure to non-occupational levels (i.e. levels outside the work place) of silica dust, and an expert appearing before the committee confirmed the potential for such an occurrence as being very remote.

A literature review on the potential impacts to health from exposure to crustal material in Port Hedland, WA, states "exposure to airborne quartz carries the risk of silicosis, but only with prolonged exposure to concentrations greater than 200 µg/m^3" (Department of Health, 2007). As detailed in Section 7 the maximum cumulative annual average PM_{10} concentrations (of which RCS would be a small fraction) at the most affected residence is predicted to be 14.7 µg/m^3 (of which 13 µg/m^3 is due to existing background levels), significantly below levels that may be of concern. For this reason, RCS has not been considered further in this assessment.

5 EXISTING ENVIRONMENT

5.1 Local Climatic Conditions

Table 5.1 presents the temperature, humidity and rainfall data for the Bureau of Meteorology site located at Peats Ridge (Site number 061351), approximately 28 km northeast of the site. Humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Peats Ridge station are 21.8°C and 11.3 °C respectively. On average, January is the hottest month, with an average maximum temperature of 27.0°C. July is the coldest month, with average minimum temperature of 6.1°C. The annual average relative humidity reading collected at 9am from the Peats Ridge station is 75% and at 3pm the annual average is 62%. The months with the highest relative humidity on average are February and March with 9am averages of 82% and the month with the lowest relative humidity is September with a 3pm average of 54%.

Rainfall data collected at the Peats Ridge station shows that February is the wettest month, with an average rainfall of 154.3 mm over an average of 14.1 rain days. The average annual rainfall is 1248.6 mm with an average of 137 rain days per year.

Table 5.1: Climate Averages for the Peats Ridge Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	21.1	20.5	19.0	17.2	14.1	11.3	10.5	12.1	15.2	17.6	18.4	20.2	16.4
Humidity	78.0	82.0	82.0	78.0	79.0	78.0	75.0	69.0	65.0	65.0	72.0	74.0	75.0
3pm Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	25.3	24.8	23.1	20.4	17.5	15.0	14.4	16.3	18.7	20.8	22.1	24.1	20.2
Humidity	64.0	66.0	66.0	66.0	67.0	66.0	60.0	55.0	54.0	58.0	61.0	63.0	62.0
Daily Maximum Temperature (ºC)													
Mean	27.0	26.4	24.6	22.0	19.1	16.4	15.8	17.7	20.5	22.8	24.1	25.8	21.8
Daily Minimum Temperature (º C)													
Mean	16.3	16.4	14.6	12.0	9.5	7.2	6.1	6.6	8.7	10.9	13.0	14.8	11.3
Rainfall (mm)													
Mean	113.3	154.3	135.9	123.0	89.7	99.5	62.7	74.0	69.1	85.3	100.7	92.4	1248.6
Rain days (Number)													
Mean	13.8	14.1	14.1	11.3	11.4	10.5	9.7	8.4	8.3	10.6	12.4	12.7	137.3

Source: BOM (2016) Climate averages for Station: 061351; Commenced: 1981 – Last Record 2015; Latitude: 33.31°S; Longitude: 151.24 °E

5.2 Local Meteorology

5.2.1 Wind Speed and Direction

Air quality impacts are influenced by meteorological conditions, primarily in the form of gradient wind flow regimes, and by local conditions that are generally driven by topographical features and interactions with coastal influences, such as the sea breeze. Wind speed, wind direction, temperature and relative humidity all affect the potential dispersion and transport of plumes and are basic input retirements for dispersion modelling.

Wind speed and direction data have been collected locally at the Maroota Public School, approximately 3 km north of the Haerses Road site. The annual and seasonal 2015 wind roses for the weather station are presented in Figure 5.1 (right side). The wind speeds recorded at the site are very light with an average wind speed for the period of 1.2 m/s. The percentage of calms (wind speeds below 0.5 m/s) for the station are relatively high at 16.5%.

The predominant winds are from the north, east and southwest quadrants on an annual basis. Summer and spring winds are predominantly from the east and south-south-west while for the other seasons the winds are primarily from the north and west.

Given the lack of cloud data available from the closest BoM weather station at Richmond RAAF, data was produced using The Air Pollution Model (TAPM), through an integration of the onsite wind speed and direction available. This data, along with the other appropriate meteorological parameters were used in the modelling.

5.2.2 Suitability of Meteorology

The suitability of the meteorology for the project area has been completed through a comparison to previously recorded data from the weather station at the Maroota Public School and the BoM Richmond RAAF AWS.

Shown in Appendix C are windroses for the Maroota Public School (period April 2013 – March 2014 and April 2014 – March 2015). It is apparent that the seasonal wind directions vary between the windroses presented for the respective periods. Further, the measured wind speeds and hence percentage of calms varies greatly. It was detailed to Pacific Environment that the logger recording the data in the weather station had been changed during the years presented. However no additional information was provided on this matter and hence the meteorological data collected for these periods was not considered suitable for modelling.

The appropriateness of the 2015 data is highlighted through a comparison to the BoM Richmond RAAF AWS in Figure 5.1. It must be noted that this site is a significant distance from Richmond RAFF (26 km) and is subject to a flatter terrain, however as shown the wind directions and percentage of calms is highly comparable.

In summary, based upon the data avaliable and discrepancies outlined from previous years, the wind data collected at Maroota Public School for 2015 were found to be generally representative of the larger data set in terms of average wind speed, percentage of calms and directional patterns. Therefore it was selected to represent the meteorology at the project area in the air quality assessment.

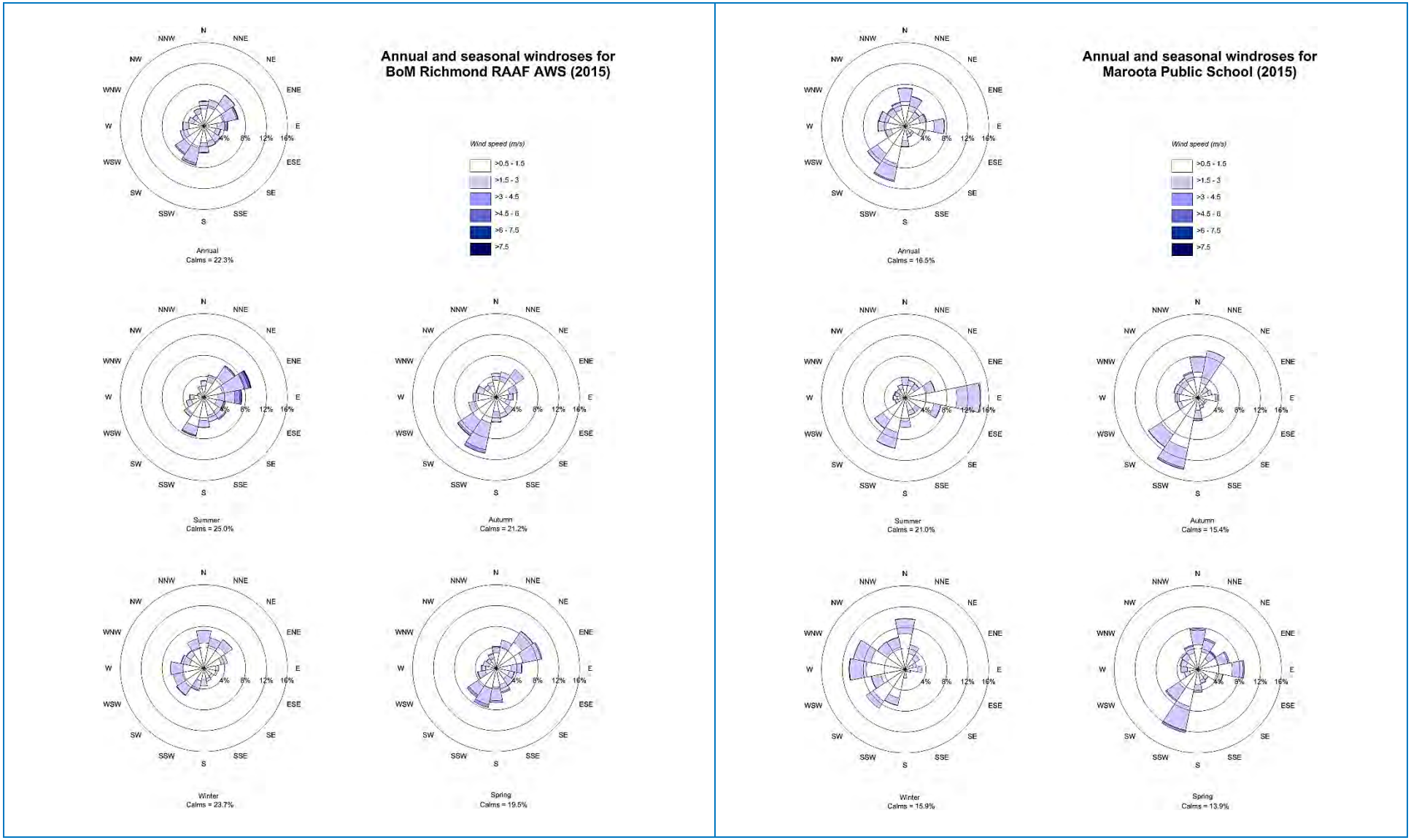


Figure 5.1: Windroses for 2015 (Left: BoM Richmond RAAF AWS, Right: Maroota Public School)

5.2.3 Atmospheric Stability

An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface, and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The stability of the atmosphere plays a large role in determining the dispersion of a plume and it is important to have it correctly represented in dispersion models. Current air quality dispersion models (such as AERMOD and CALPUFF) use the Monin-Obukhov Similarity Theory (MOST) to characterise turbulence and other processes in the PBL. One of the measures of the PBL is the Monin-Obukhov length (L), which approximates the height at which turbulence is generated equally by thermal and mechanical effects (Seinfeld and Pandis 2006). It is a measure of the relative importance of mechanical and thermal forcing on atmospheric turbulence.

Because values of L diverge to + and - infinity as stability approaches neutral from the stable and unstable sides, respectively, it is often more convenient to use the inverse of L (i.e., 1/L) when describing stability.

Figure 5.2 shows the hourly averaged 1/L for the site computed from all data in the AERMET surface file. Based on Table 5.2 this plot indicates that the PBL is stable overnight and becomes unstable as radiation from the sun heats the surface layer of the atmosphere and drives convection. The changes from positive to negative occur at the shifts between day and night. This indicates that the diurnal patterns of stability are realistic.

Table 5.2: Inverse of the Monin-Obukhov length L with respect to atmospheric stability

1/L	Atmospheric Stability
Negative	Unstable
Zero	Neutral
Positive	Stable

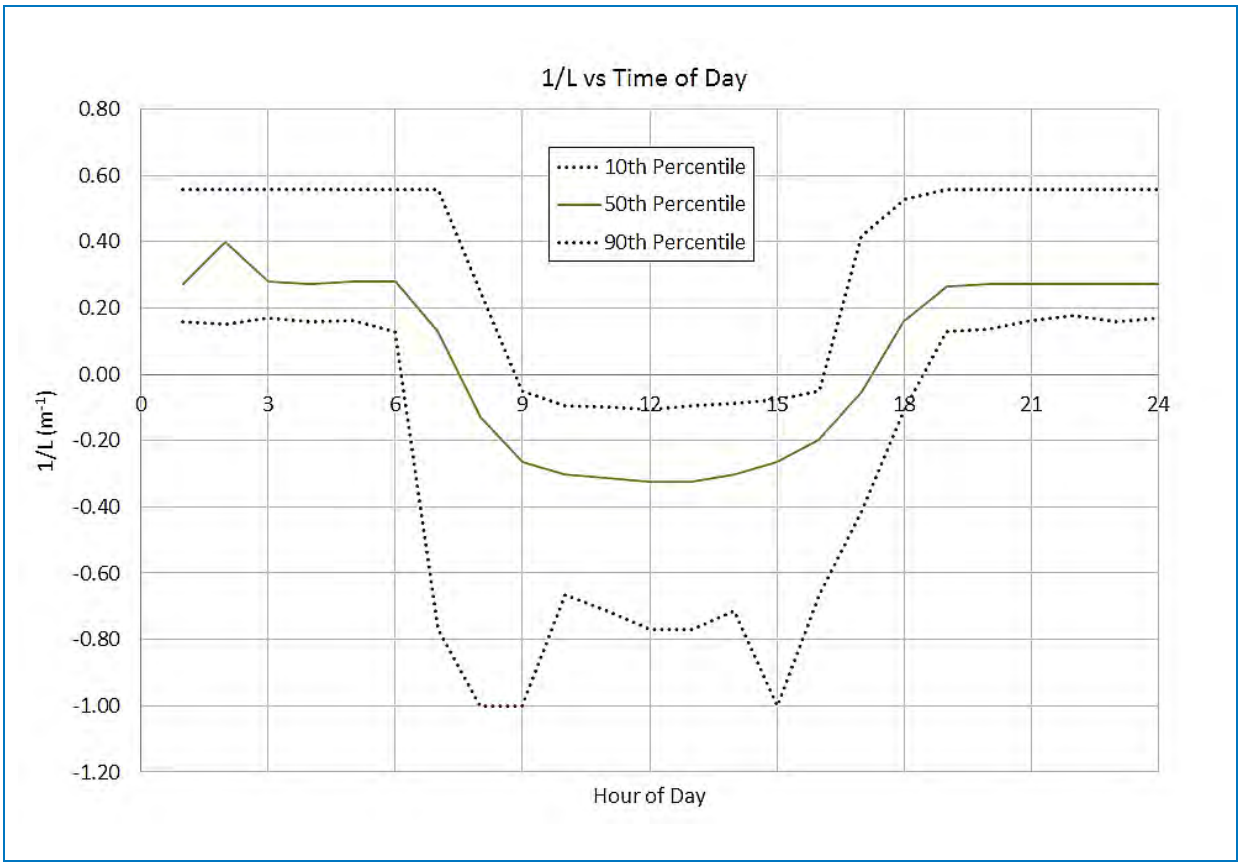


Figure 5.2: Annual statistics of 1/L by hour of the day

Figure 5.3 shows the variations in stability over the year by hour of the day, with reference to the widely known Pasquill-Gifford classes of stability. The relationship between L and stability classes is based on values derived by Golder (1972) set out in NSW DEC (2005). Note that the reference to stability categories here is only for convenience in describing stability. The model uses calculated values of L across a continuum.

Figure 5.3 shows that stable and very stable conditions occur for about 60% of the time, which is typical for inland locations that regularly experience temperature inversions at night. Atmospheric instability increases during the day and reaches a peak around noon as solar-driven convective energy peaks. A stable atmosphere is prevalent during the night. These profiles indicate that pollutant dispersion is most effective during the daytime and least effective at night.

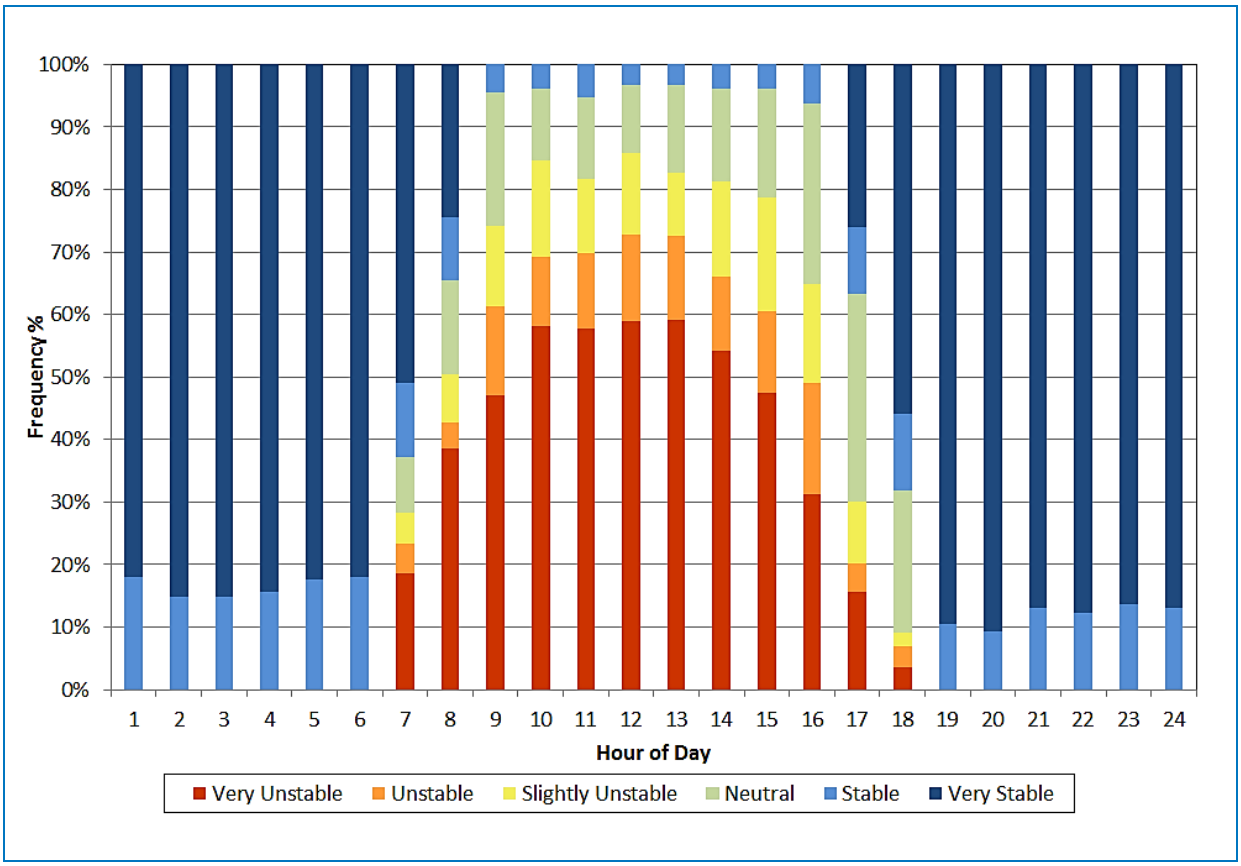


Figure 5.3: Annual distribution of stability type by hour of the day

5.3 Existing Air Quality

Air quality standards and goals refer to pollutant levels which include the contribution from proposed projects as well as other sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which the project is likely to contribute to these levels.

5.3.1 PM Concentrations

As part of Dixon Sand Environment Protection License (EPL) No 12513, they are required to measure PM_{10} at Maroota Public School. Figure 5.4 shows the PM_{10} concentrations measured by a Tapered Element Oscillating Microbalance (TEOM) at Maroota Public School, the annual and 24-hour average assessment criterion (see Section 4.1).

Also shown is the Dixon Sand "investigation limit' stated in EPL 12513 that states:

- if any rolling 24-hour average PM_{10} result measured is found to be greater than 42 µg/m^3 and the prevailing wind at the site is between 180º and 240º, Dixon Sand must immediately implement a series of dust mitigation measures.

The 24-hour average PM_{10} concentrations have exceeded the assessment criteria on seven occasions during the period from March 2013 to Dec 2015. Six of the seven exceedances all occurred between September and December 2013. There was widespread and severe bushfire activity across eastern NSW during this period which saw 19 areas declared as natural disaster areas (BoM, 2013) and will have contributed significantly to measured dust levels at that time.

Further, the exceedance in May 2015 was correlated to a dust storm event from fires at nearby residents (Dixon, 2015). The annual average for the modelling period and that used to represent background PM_{10} for the cumulative assessment is 13 µg/m^3.

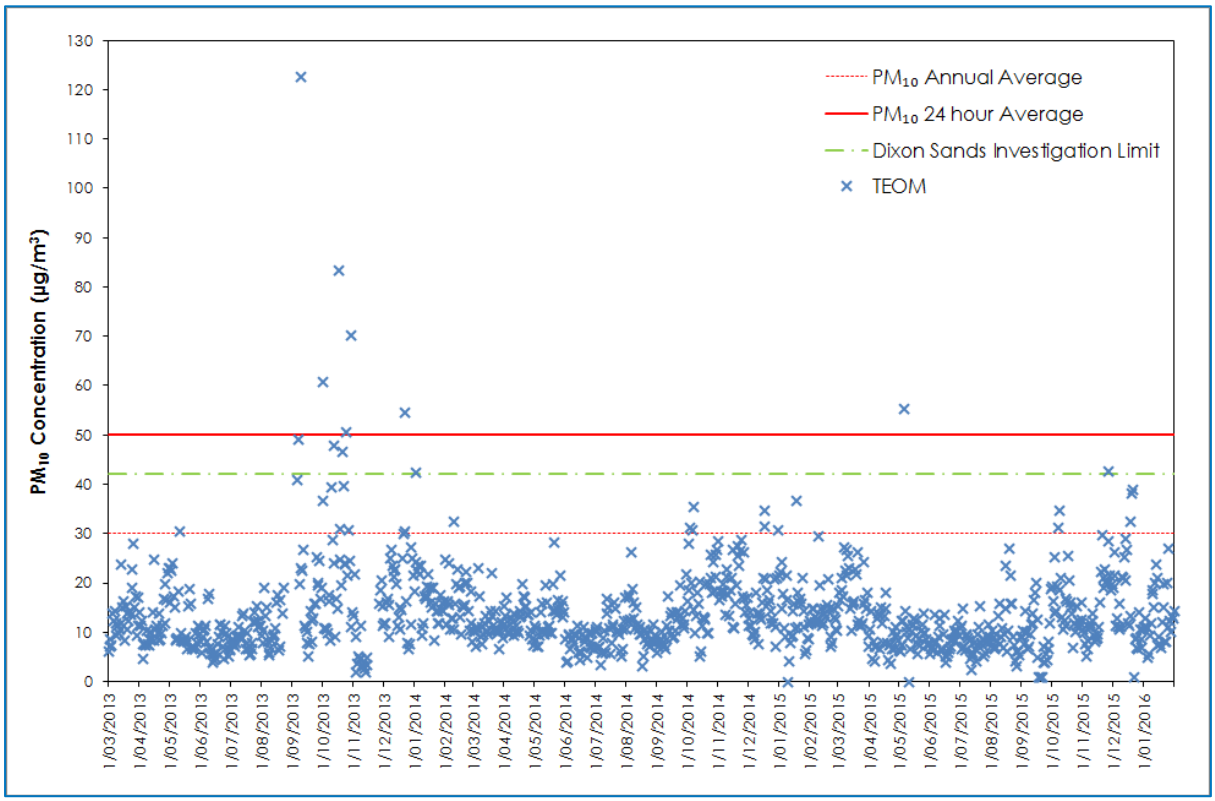


Figure 5.4: Measured PM_{10} for Maroota Public School TEOM

There are no $PM_{2.5}$ measurements near the site and the closest EPA sites are at Vineyard, Richmond and Wyong. Table 5.3 presents the annual averages of both the PM_{10} and $PM_{2.5}$ concentrations measured at these sites.

The average PM_{10} concentrations recorded across all three sites is 16 µg/m³ and the average $PM_{2.5}$ concentration is 6.2 µg/m³. Given that the surrounding EPA sites PM_{10} concentrations are a similar level to the TEOM at Maroota, a PM_{10} background level of 13 µg/m³ has been adopted for cumulative assessment. The average of the two EPA sites $PM_{2.5}$ of 6.2 µg/m³ will be adopted for the cumulative $PM_{2.5}$ assessment.

Table 5.3: PM_{10} and $PM_{2.5}$ Concentrations at EPA Monitoring Sites

Site	2010	2011	2012	2013	2014	2015	2016[1]
PM_{10}							
Wyong	-	-	21.8	16.6	15.1	14.9	18.5
Richmond	13.1	13.2	15.1	17.3	15.4	12.8	16.8
Vineyard	14.5	14.0	14.4	16.1	16.3	15.9	18.8
$PM_{2.5}$							
Wyong			7.3	6.7	5.5	5.2	5.6
Richmond	4.2	4.7	5.3	8.3	6.7	7.7	7.0

[1] Data presented for January – 15 March 2016

5.3.2 TSP Concentrations

There are no measurements of TSP available for the site. Estimates of annual average TSP concentrations can be made from the PM_{10} measurements by assuming that 40% of the TSP is PM_{10}. This relationship was obtained from data collected by co-located TSP and PM_{10} monitors operated for long periods of time in the Hunter Valley (NSW Minerals Council, 2000). Although this ratio is based on Hunter Valley data, in the absence of site specific data this provides an indicative estimate of the ambient TSP. Use of this relationship on the adopted PM_{10} annual average of 13 µg/m³ gives an existing annual average TSP concentration of approximately 32.5 µg/m³.

5.3.3 Dust Deposition

Table 5.1 shows annual average insoluble solids deposition rates from Dixon Sand's dust deposition gauge (Haerses Road Quarry) (Dixon Sand, 2015). PF Formation operates sand quarries in close proximity to the proposed Haerses Road site, and the four dust deposition gauges (Maroota Public School, Hitchcock Rd and Jurd's House) have been included to provide a more thorough data set (PF Formation, 2015). The locations of the dust deposition gauges is presented in Figure 5.5.

An annual average dust deposition level above 4 g/m²/month indicates a level of air quality unsuitable for residential purposes. Levels measured are affected by dust from other sand extraction activities in the area as well as other sources of dust such as agricultural activities normally expected in rural areas.

Using a conservative estimate, the background dust deposition level for the modelling year of 2.1 g/m²/month was determined using the average of all four sites presented in Table 5.1.

Table 5.1: Annual Average Dust Deposition Data (g/m²/month)

Year	Haerses Road Quarry	Maroota Public School	Hitchcock Rd	Jurd's House
2015	1.2[1]	2.4	2.6	2.2

[1] August and September results excluded from the annual average as the results for these months were outliers in the data. It is stated in the EPL reports that Dixon Quarry did not operate for the majority of these monitoring periods. It is suggested that the high result could be attributed to agricultural burn offs, grass slashing by the resident and/or clean up in the vicinity of the static dust gauge.

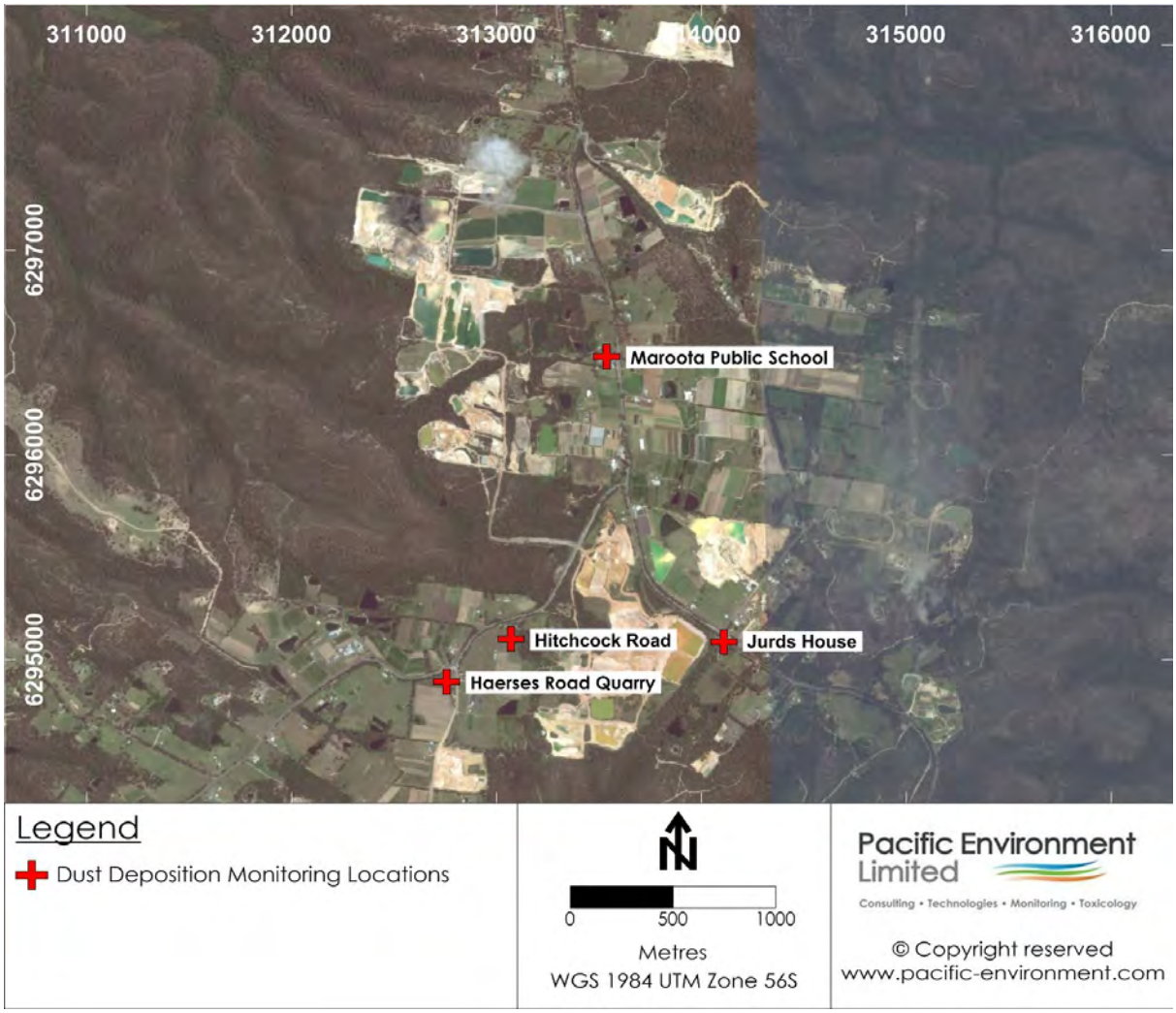


Figure 5.5: Dust Deposition Monitoring Locations

5.3.4 Background Values

In summary, for the purposes of assessing potential air quality impacts, the following existing air quality levels are assumed for assessment against the long-term criteria. PM_{10} is also assessed against a short-term (24-hour) criterion which is assessed separately in Section 4.

- Annual average PM_{10} concentration of 13 µg/m^3.
- Annual average $PM_{2.5}$ concentration of 6.2 µg/m^3.
- Annual average TSP concentration of 32.5 µg/m^3.
- Annual average dust deposition of 2.1 g/m^2/month.

6 EMISSIONS TO AIR

6.1 Modelling Approach

The overall approach to the assessment generally follows the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005) using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of air dispersion models should be completed. They include guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from projects.

6.1.1 Modelling System

AERMOD was chosen as the most suitable model due to the source types, location of nearest receivers and nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes and it is an accepted model of the NSW EPA. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it provides more realistic results. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications is based on ISC, which has now been replaced by AERMOD.

A significant feature of AERMOD is the Pasquill-Gifford stability based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data.

Terrain data was sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (3 arc-second (~90m) resolution) and processed within AERMAP to create the necessary input files.

AERMET requires surface and upper air meteorological data as input. Surface data was sourced from the Maroota Public School weather station and cloud data from TAPM. Appropriate values for three surface characteristics are required for AERMET as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Bowen ratio, which is an indicator of surface moisture.
- Albedo, which is an indicator of reflectivity of the surface.

Values of surface roughness, Bowen ratio and albedo were determined based on a review of aerial photography for a radius of 3 km centred on the quarry site. Default values for cultivated land was chosen for the entire area.

The configuration of the model and the inputs used are explained below. A summary of all the AERMOD inputs is provided in Appendix A.

6.2 Operational Scenarios

Plant at the Haerses Road site is mobile and would operate either within the existing approved extraction area or within the proposed additional extraction area. Plant and activities would not occur within both areas of the site at the same time.

There is potential for dry processing operations (screening and crushing) to occur in the extraction pits themselves, before the material is hauled to the wet processing area and then to either the central processing plant at the Old Northern Road site or directly to market. Although the scenario where dry processing will occur directly prior to wet processing is expected to be the predominant use at the quarry, it was considered suitable to assess both.

The operational scenarios are presented in Table 6.1.

Table 6.1: Operational Scenarios

Description	Scenario
Dry processing outside extraction cells	1
Dry processing inside extraction cells	2

6.3 Emissions Summary

Dust emissions during operation of the modified quarry have been estimated based on activities and equipment that would be operating at the site, as follows:

- Dozer/excavator/loader clearing vegetation/topsoil;
- Dozer/loader for overburden shaping;
- Excavator/loader for excavation of raw material;
- Front End Loader stockpiling raw material;
- Front End Loader loading road trucks in extraction cells;
- Hauling on unsealed roads from extraction cells to sealed road ;
- Hauling product on sealed access road to processing plant and/or to market;
- Dry processing (crushing/screening); and
- Wind erosion from active extraction cells, areas yet to be rehabilitated and active stockpiles.

The estimated dust emissions for annual average production are presented in Table 6.2 and worst case maximum daily production in Table 6.3. Note that the emission estimations presented are for Scenario 1. However the total emissions are comparable between the scenarios, with only the order of activities varying, therefore it was not considered necessary to present both in this section.

The full emissions inventories for general operations, worst case operations and source locations are presented in Appendix B.

The maximum daily production scenario (worst case) is modelled based on maximum product transport of 850 tonnes per day. The maximum daily emissions are applied for each day of the modelled year so that a full range of meteorological conditions can be tested for this scenario to determine the worst-case 24-hour concentrations. This does not represent a realistic estimate of annual dust emissions, although they could potentially reach these emission levels on a daily basis.

Most activities and emissions (with the exception of wind erosion) are assumed to occur between 7am and 6pm, modelled as seven days per week to be conservative[a]. Hauling also occurs between the

[a] Note, the site will only operate six days a week, but the dispersion modelling has conservatively it will operate seven days a week

hours of 7am and 6pm and wind erosion is assumed to occur 24 hours per day. TSP, PM_{10} and $PM_{2.5}$ emission rates were calculated using emission factors derived from US EPA (1995) (see Appendix B).

Table 6.2: Estimated Dust Emissions for Scenario 1 – Annual Average

ACTIVITY	TSP (kg/y)	PM10 (kg/y)	PM2.5 (kg/y)
Dozer stripping topsoil (from pit 5)	9,312	2,271	978
FEL Loading sand to trucks (from pit 5)	53	25	4
Hauling from pit 5 to Processing Area (unsealed)	7,423	2,004	200
FEL Unloading sand to stockpile	53	25	4
FEL Loading sand from stockpile	53	25	4
FEL Unloading sand to Dry Processing	53	25	4
Crusher (uncontrolled)	4,875	1,875	146
Transfer (Crusher to Screen) [conveyor transfer point]	53	25	4
Screen (uncontrolled)	3,125	1,075	94
Transfer (Screen to Wet Processing) [conveyor transfer point]	53	25	4
Wet Processing (no expected emissions)	0	0	0
FEL Loading sand from Product Stockpile to haul trucks	15	7	1
Hauling out of Site (unsealed)	7,204	1,945	194
Hauling out of Site (sealed)	1,630	313	76
Wind Erosion - Extraction Area (pit 3)	2,628	1,314	197
Wind Erosion - (pit 4)	4,380	2,190	329
Wind Erosion - (pit 5)	4,468	2,234	335
Wind Erosion - Extraction Stockpile	123	61	9
Wind Erosion - Pre Processing Stockpile	123	61	9
Wind Erosion - Product Stockpile	123	61	9
TOTAL EMISSIONS	45,743	15,561	2,600

Table 6.3: Estimated Annual Dust Emissions for Scenario 1 Based on Maximum Daily Production Scenario (Worst Case)

ACTIVITY	TSP (kg/y)	PM10 (kg/y)	PM2.5 (kg/y)
Dozer stripping topsoil (from pit 5)	9,312	2,271	978
FEL Loading sand to trucks (from pit 5)	65	31	5
Hauling from pit 5 to Processing Area (unsealed)	9,212	2,487	249
FEL Unloading sand to stockpile	65	31	5
FEL Loading sand from stockpile	65	31	5
FEL Unloading sand to Dry Processing	65	31	5
Crusher (uncontrolled)	6,050	2,327	181
Transfer (Crusher to Screen) [conveyor transfer point]	65	31	5
Screen (uncontrolled)	3,878	1,334	116
Transfer (Screen to Wet Processing) [conveyor transfer point]	65	31	5
Wet Processing (no expected emissions)	0	0	0
FEL Loading sand from Product Stockpile to haul trucks	18	9	1
Hauling out of Site (unsealed)	8,940	2,413	241
Hauling out of Site (sealed)	2,023	388	94
Wind Erosion - Extraction Area (pit 3)	2,628	1,314	197
Wind Erosion - (pit 4)	4,380	2,190	329
Wind Erosion - (pit 5)	4,468	2,234	335
Wind Erosion - Extraction Stockpile	123	61	9
Wind Erosion - Pre Processing Stockpile	123	61	9
Wind Erosion - Product Stockpile	123	61	9
TOTAL EMISSIONS	51,669	17,337	2,777

6.4 Proposed Dust Control Measures

The Modification will employ a number of best practice mitigation measures on-site to ensure that dust impacts are minimised.

Measures to be employed for the Modification include:

- Use of a water cart to control emissions from haul roads (unsealed).
- Enforcement of speed limits onsite.
- Progressive rehabilitation of exposed areas.
- Minimising drop height of material during truck loading and unloading where possible.
- Management of dust generating activities during unfavourable meteorological conditions.

7 OPERATIONAL PHASE IMPACT ASSESSMENT

The modelling predictions for the Modification are presented in the sections below. The contour plots are indicative of the concentrations that could potentially be reached under the new conditions modelled. It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths, it is necessary to make interpolations, and as a result the isopleths will not always match exactly with predicted impacts at any specific location.

A summary of the predicted pollutant concentrations at each of the assessment locations is presented in Table 7.1 through Table 7.4. The results indicate that the incremental increases from the Modification on an annual and worst case operational basis, when added to the background concentrations outlined in Section 5.3, are below the respective EPA criteria for particulate matter and dust deposition.

The cumulative 24-hour average concentrations are discussed further in Section 7.2.

Table 7.1: Predicted incremental and cumulative ground level concentrations for Scenario 1 (Annual Operations)

ID	PM_{10}				$PM_{2.5}$				TSP		Dust Deposition	
	24 hour		Annual		24 hour		Annual		Annual		Annual	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
Units	$\mu g/m^3$										$g/m^2/month$	
Impact Assessment Criteria	N/A	50	N/A	30	N/A	25	N/A	8	N/A	90	2	4
R1	9.2	22.2	0.2	13.2	1.3	7.5	0.1	6.3	0.5	33	0.02	2.12
R2	6.8	19.8	0.4	13.4	1.1	7.3	0.1	6.3	1.3	33.8	0.04	2.14
R3	7.1	20.1	0.4	13.4	1.4	7.6	0.1	6.3	0.5	33	0.02	2.12
R4	4.2	17.2	0.3	13.3	1.2	7.4	0.1	6.3	0.4	32.9	0.01	2.11
R5	8.3	21.3	0.7	13.7	4.1	10.3	0.2	6.4	0.6	33.1	0.01	2.11
R6	25.7	38.7	1.4	14.4	5.7	11.9	0.4	6.6	1.4	33.9	0.04	2.14
R7	5.6	18.6	0.6	13.6	2.2	8.4	0.2	6.4	0.6	33.1	0.02	2.12
R8	18.7	31.7	1.3	14.3	3.5	9.7	0.4	6.6	1.5	34	0.05	2.15
R9	24.6	37.6	1.3	14.3	4.2	10.4	0.4	6.6	1.4	33.9	0.04	2.14
R10	25.8	38.8	1	14	4.5	10.7	0.3	6.5	1	33.5	0.03	2.13
R11	30.8	43.8	1.3	14.3	5.4	11.6	0.4	6.6	1.3	33.8	0.04	2.14
R12	10.5	23.5	0.2	13.2	1.6	7.8	0.1	6.3	0.6	33.1	0.02	2.12
R13	10.1	23.1	0.2	13.2	1.5	7.7	0	6.2	0.5	33	0.02	2.12
R14	5.1	18.1	0.2	13.2	1.1	7.3	0.1	6.3	0.4	32.9	0.01	2.11
R15	10.1	23.1	0.2	13.2	1.5	7.7	0	6.2	0.5	33	0.02	2.12
R16	2.8	15.8	0.2	13.2	0.8	7	0.1	6.3	0.3	32.8	0.01	2.11
R17	21.8	34.8	0.7	13.7	3.8	10	0.2	6.4	0.5	33	0.01	2.11
R18	6.9	19.9	0.4	13.4	2.1	8.3	0.1	6.3	0.3	32.8	0.01	2.11
R19	9.1	22.1	0.3	13.3	1.7	7.9	0.1	6.3	0.3	32.8	0.01	2.11
R20	22.1	35.1	0.3	13.3	5.4	11.6	0.1	6.3	0.3	32.8	0.01	2.11
D1	8.7	21.7	0.2	13.2	1.4	7.6	0	6.2	0.5	33	0.02	2.12
PF1	4	17	0.1	13.1	0.6	6.8	0	6.2	0.4	32.9	0.01	2.11
PF2	4.5	17.5	0.2	13.2	0.7	6.9	0	6.2	0.5	33	0.02	2.12
PF3	6.2	19.2	0.4	13.4	1	7.2	0.1	6.3	0.7	33.2	0.02	2.12

Table 7.2: Predicted incremental and cumulative ground level concentrations for Scenario 1 (Worst Case Day Operations)

ID	PM_{10}				$PM_{2.5}$				TSP		Dust Deposition	
	24 hour		Annual		24 hour		Annual		Annual		Annual	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
Units	$\mu g/m^3$										$g/m^2/month$	
Impact Assessment Criteria	N/A	50	N/A	30	N/A	25	N/A	8	N/A	90	2	4
R1	9.8	22.8	0.3	13.3	1.4	7.6	0.1	6.3	0.6	33.1	0.02	2.12
R2	7	20	0.5	13.5	1.2	7.4	0.1	6.3	1.5	34	0.04	2.14
R3	7.2	20.2	0.4	13.4	1.6	7.8	0.1	6.3	0.6	33.1	0.02	2.12
R4	4.8	17.8	0.3	13.3	1.3	7.5	0.1	6.3	0.5	33	0.01	2.11
R5	9.7	22.7	0.7	13.7	4.4	10.6	0.2	6.4	0.6	33.1	0.02	2.12
R6	26.4	39.4	1.5	14.5	6.2	12.4	0.4	6.6	1.5	34	0.04	2.14
R7	6.7	19.7	0.6	13.6	2.3	8.5	0.2	6.4	0.7	33.2	0.02	2.12
R8	18.8	31.8	1.4	14.4	3.5	9.7	0.4	6.6	1.6	34.1	0.05	2.15
R9	24.6	37.6	1.4	14.4	4.3	10.5	0.4	6.6	1.5	34	0.04	2.14
R10	25.8	38.8	1.1	14.1	4.5	10.7	0.3	6.5	1.1	33.6	0.03	2.13
R11	30.8	43.8	1.4	14.4	5.4	11.6	0.4	6.6	1.4	33.9	0.04	2.14
R12	10.6	23.6	0.3	13.3	1.6	7.8	0.1	6.3	0.7	33.2	0.02	2.12
R13	10.4	23.4	0.3	13.3	1.6	7.8	0.1	6.3	0.6	33.1	0.02	2.12
R14	5.7	18.7	0.3	13.3	1.3	7.5	0.1	6.3	0.4	32.9	0.01	2.11
R15	10.4	23.4	0.3	13.3	1.6	7.8	0.1	6.3	0.6	33.1	0.02	2.12
R16	3.4	16.4	0.2	13.2	1	7.2	0.1	6.3	0.3	32.8	0.01	2.11
R17	21.9	34.9	0.7	13.7	3.8	10	0.2	6.4	0.6	33.1	0.01	2.11
R18	7.7	20.7	0.4	13.4	2.3	8.5	0.1	6.3	0.3	32.8	0.01	2.11
R19	9.3	22.3	0.4	13.4	1.7	7.9	0.1	6.3	0.4	32.9	0.01	2.11
R20	22.1	35.1	0.3	13.3	5.4	11.6	0.1	6.3	0.3	32.8	0.01	2.11
D1	8.7	21.7	0.2	13.2	1.4	7.6	0.1	6.3	0.6	33.1	0.02	2.12
PF1	4	17	0.2	13.2	0.6	6.8	0	6.2	0.4	32.9	0.01	2.11
PF2	4.6	17.6	0.2	13.2	0.7	6.9	0	6.2	0.5	33	0.02	2.12
PF3	6.2	19.2	0.4	13.4	1.2	7.4	0.1	6.3	0.8	33.3	0.02	2.12

Table 7.3: Predicted incremental and cumulative ground level concentrations for Scenario 2 (Annual Operations)

ID	PM_{10}				$PM_{2.5}$				TSP		Dust Deposition	
	24 hour		Annual		24 hour		Annual		Annual		Annual	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
Units	$\mu g/m^3$										$g/m^2/month$	
Impact Assessment Criteria	N/A	50	N/A	30	N/A	25	N/A	8	N/A	90	2	4
R1	7.9	20.9	0.2	13.2	1.2	7.4	0.1	6.3	0.6	33.1	0.02	2.12
R2	6.5	19.5	0.4	13.4	1	7.2	0.1	6.3	1.3	33.8	0.04	2.14
R3	7.1	20.1	0.3	13.3	1.3	7.5	0.1	6.3	0.6	33.1	0.02	2.12
R4	3.9	16.9	0.3	13.3	1.2	7.4	0.1	6.3	0.4	32.9	0.01	2.11
R5	7.2	20.2	0.7	13.7	3.5	9.7	0.2	6.4	0.7	33.2	0.02	2.12
R6	27.4	40.4	2	15	6.1	12.3	0.5	6.7	1.8	34.3	0.05	2.15
R7	6.1	19.1	0.6	13.6	2.5	8.7	0.2	6.4	0.7	33.2	0.02	2.12
R8	18.9	31.9	1.6	14.6	4	10.2	0.4	6.6	2	34.5	0.06	2.16
R9	24.7	37.7	1.6	14.6	5	11.2	0.4	6.6	1.8	34.3	0.05	2.15
R10	25.8	38.8	1.2	14.2	4.5	10.7	0.3	6.5	1.2	33.7	0.04	2.14
R11	30.9	43.9	1.5	14.5	5.4	11.6	0.4	6.6	1.5	34	0.04	2.14
R12	10.5	23.5	0.3	13.3	1.6	7.8	0.1	6.3	0.6	33.1	0.02	2.12
R13	9.7	22.7	0.3	13.3	1.5	7.7	0.1	6.3	0.6	33.1	0.02	2.12
R14	5.1	18.1	0.2	13.2	1	7.2	0.1	6.3	0.4	32.9	0.01	2.11
R15	9.7	22.7	0.3	13.3	1.5	7.7	0.1	6.3	0.6	33.1	0.02	2.12
R16	2.7	15.7	0.2	13.2	0.7	6.9	0	6.2	0.3	32.8	0.01	2.11
R17	21.8	34.8	0.7	13.7	3.8	10	0.2	6.4	0.5	33	0.01	2.11
R18	6	19	0.4	13.4	1.8	8	0.1	6.3	0.3	32.8	0.01	2.11
R19	8.9	21.9	0.3	13.3	1.6	7.8	0.1	6.3	0.3	32.8	0.01	2.11
R20	22.1	35.1	0.3	13.3	5.4	11.6	0.1	6.3	0.3	32.8	0.01	2.11
D1	8.8	21.8	0.2	13.2	1.4	7.6	0	6.2	0.6	33.1	0.02	2.12
PF1	4.1	17.1	0.1	13.1	0.6	6.8	0	6.2	0.4	32.9	0.01	2.11
PF2	4.6	17.6	0.2	13.2	0.7	6.9	0	6.2	0.5	33	0.02	2.12
PF3	6.3	19.3	0.3	13.3	1	7.2	0.1	6.3	0.7	33.2	0.02	2.12

Table 7.4: Predicted incremental and cumulative ground level concentrations for Scenario 2 (Worst Case Day Operations)

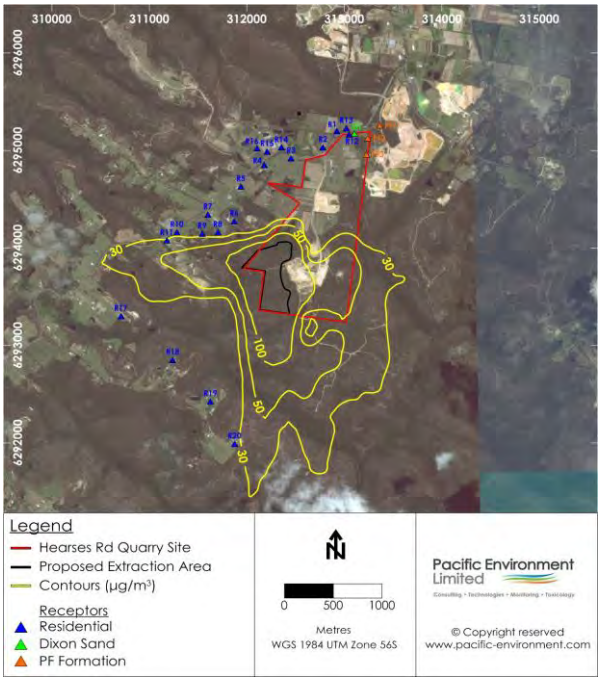
ID	PM_{10}				$PM_{2.5}$				TSP		Dust Deposition	
	24 hour		Annual		24 hour		Annual		Annual		Annual	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
Units	$\mu g/m^3$										$g/m^2/month$	
Impact Assessment Criteria	N/A	50	N/A	30	N/A	25	N/A	8	N/A	90	2	4
R1	8.2	21.2	0.3	13.3	1.2	7.4	0.1	6.3	0.7	33.2	0.02	2.12
R2	6.7	19.7	0.5	13.5	1.1	7.3	0.1	6.3	1.6	34.1	0.05	2.15
R3	7.2	20.2	0.4	13.4	1.3	7.5	0.1	6.3	0.7	33.2	0.02	2.12
R4	4.4	17.4	0.3	13.3	1.2	7.4	0.1	6.3	0.5	33	0.01	2.11
R5	8.1	21.1	0.8	13.8	3.6	9.8	0.2	6.4	0.8	33.3	0.02	2.12
R6	28.5	41.5	2.2	15.2	6.6	12.8	0.5	6.7	1.9	34.4	0.05	2.15
R7	7.3	20.3	0.7	13.7	2.6	8.8	0.2	6.4	0.8	33.3	0.02	2.12
R8	18.9	31.9	1.8	14.8	4.1	10.3	0.4	6.6	2.2	34.7	0.06	2.16
R9	24.8	37.8	1.8	14.8	5.2	11.4	0.4	6.6	2	34.5	0.06	2.16
R10	25.9	38.9	1.3	14.3	4.7	10.9	0.3	6.5	1.4	33.9	0.04	2.14
R11	30.9	43.9	1.7	14.7	5.4	11.6	0.4	6.6	1.6	34.1	0.04	2.14
R12	10.6	23.6	0.3	13.3	1.6	7.8	0.1	6.3	0.7	33.2	0.02	2.12
R13	10	23	0.3	13.3	1.5	7.7	0.1	6.3	0.7	33.2	0.02	2.12
R14	5.2	18.2	0.2	13.2	1	7.2	0.1	6.3	0.4	32.9	0.01	2.11
R15	10	23	0.3	13.3	1.5	7.7	0.1	6.3	0.7	33.2	0.02	2.12
R16	3.1	16.1	0.2	13.2	0.8	7	0.1	6.3	0.3	32.8	0.01	2.11
R17	21.9	34.9	0.7	13.7	3.8	10	0.2	6.4	0.6	33.1	0.01	2.11
R18	6.2	19.2	0.4	13.4	1.9	8.1	0.1	6.3	0.4	32.9	0.01	2.11
R19	9.1	22.1	0.4	13.4	1.7	7.9	0.1	6.3	0.4	32.9	0.01	2.11
R20	22.1	35.1	0.4	13.4	5.4	11.6	0.1	6.3	0.3	32.8	0.01	2.11
D1	8.8	21.8	0.3	13.3	1.4	7.6	0.1	6.3	0.7	33.2	0.02	2.12
PF1	4.1	17.1	0.2	13.2	0.6	6.8	0	6.2	0.4	32.9	0.01	2.11
PF2	4.7	17.7	0.2	13.2	0.7	6.9	0	6.2	0.6	33.1	0.02	2.12
PF3	6.4	19.4	0.4	13.4	1	7.2	0.1	6.3	0.8	33.3	0.02	2.12

7.1 Incremental Impact Assessment

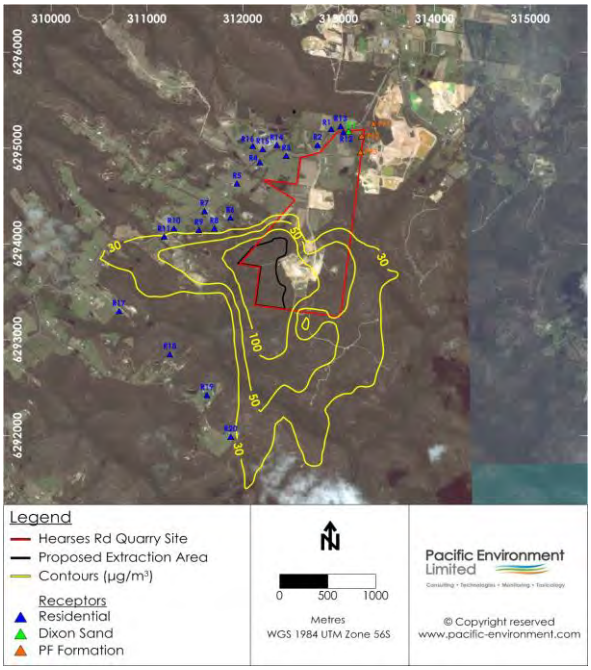
7.1.1 Ground Level PM_{10} Concentrations

Contour plots for the predicted (glcs) of PM_{10} are presented in Figure 7.1 and Figure 7.2. Predicted 24-hour and annual average PM_{10} are presented for the annual and worst case day operations. Note that the resultant contours for Scenario 2 are comparable to Scenario 1 and therefore they are not presented.

There are no privately owned receptors that are predicted to experience glcs of PM_{10} above the assessment criteria, due to emissions from the Modification only. The highest predicted glcs occur at receptor 11 (R11). At this location, the predicted incremental 24-hour PM_{10} concentration is 30.8 $\mu g/m^3$. The predicted annual average PM_{10} concentration at this receptor is 1.3 $\mu g/m^3$.

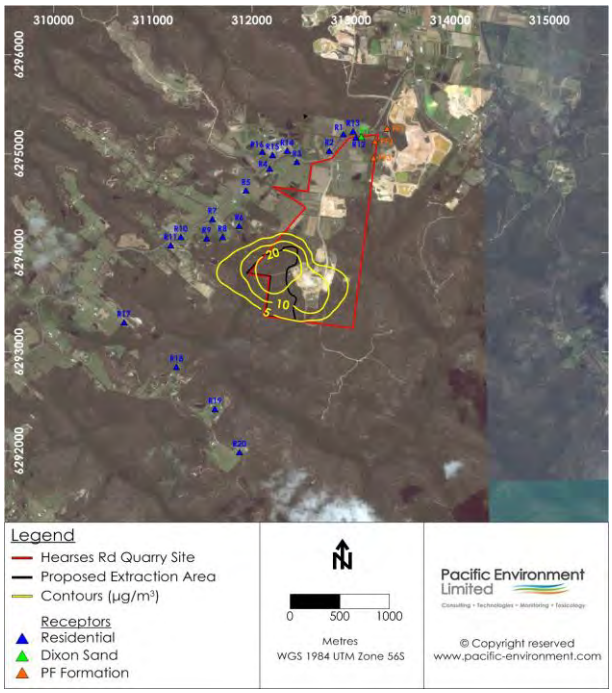


Annual Operations

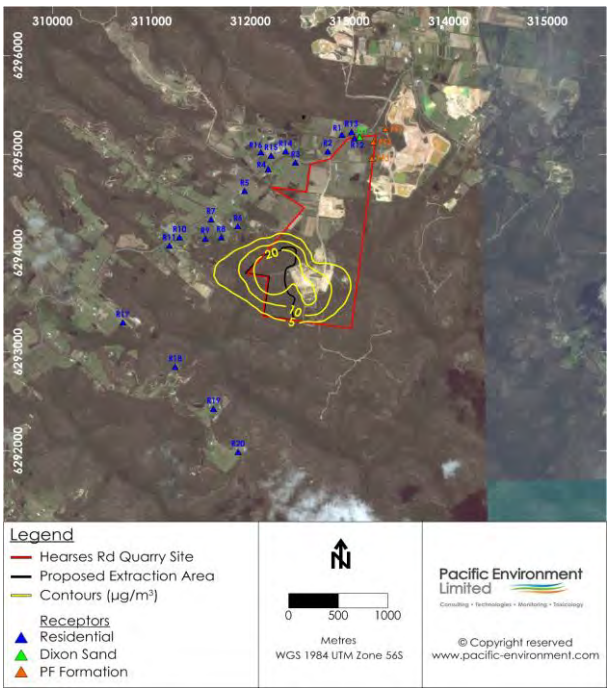


Worst Case Day Operations

Figure 7.1: **Maximum 24-Hour PM_{10} Concentration – Scenario 1**



Annual Operations



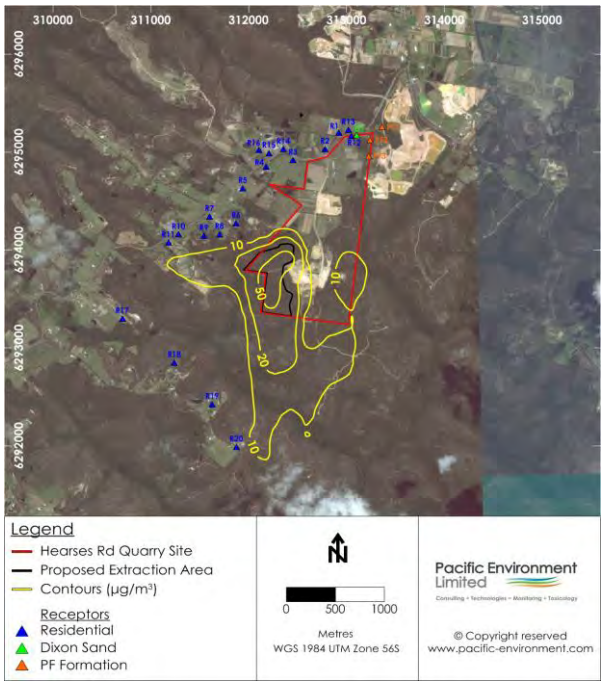
Worst Case Day Operations

Figure 7.2: **Incremental Annual Average PM_{10} Concentration – Scenario 1**

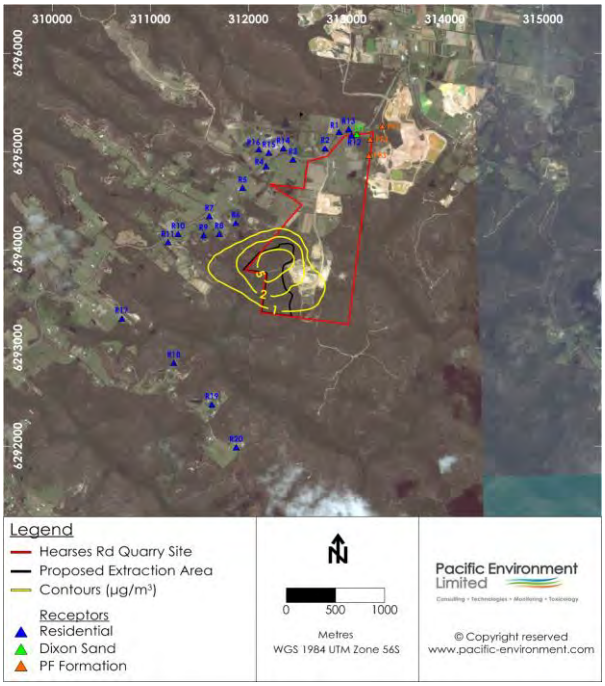
7.1.2 Ground Level $PM_{2.5}$ Concentrations

Contour plots for the predicted glcs of $PM_{2.5}$ are presented in Figure 7.3 and Figure 7.4. There are no exceedances of the relevant 24-hour and annual average criteria beyond the site boundaries. There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Modification only.

The highest predicted glc occurs at the receptor 6 (R6). At this location, the predicted incremental 24-hour $PM_{2.5}$ concentration is 5.7 µg/m³ and the predicted annual average $PM_{2.5}$ concentration is 0.4 µg/m³.

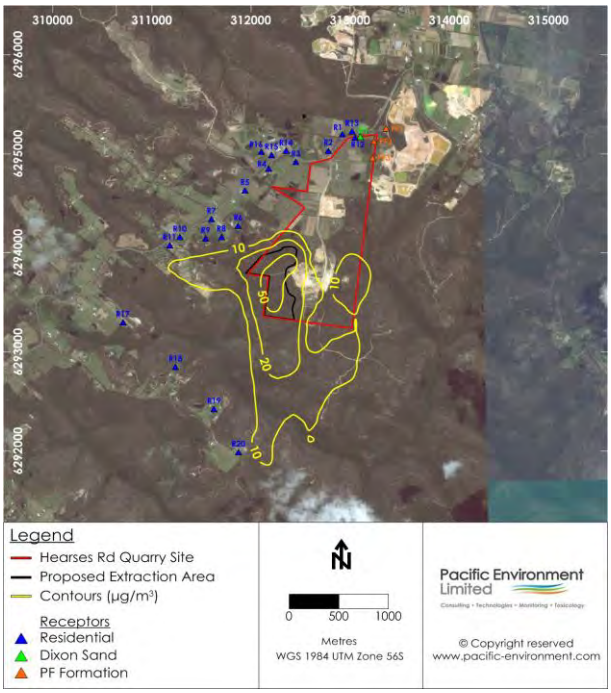


Annual Operations

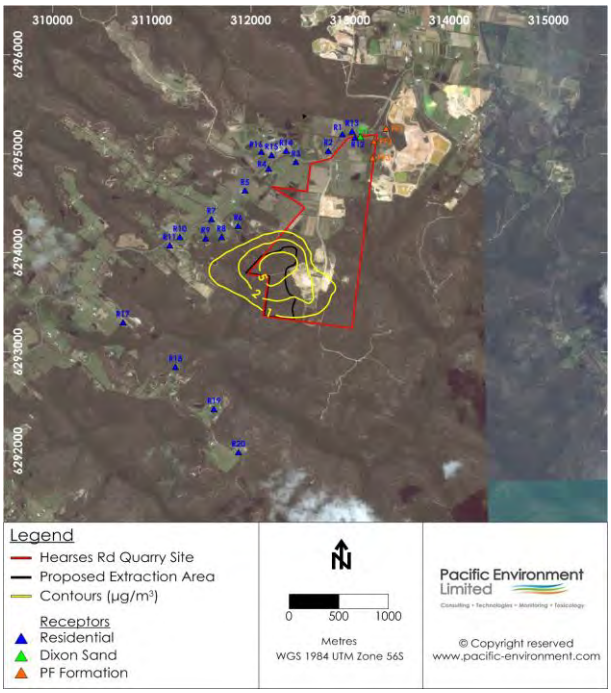


Worst Case Day Operations

Figure 7.3: **Maximum 24-Hour $PM_{2.5}$ Concentration – Scenario 1**



Annual Operations



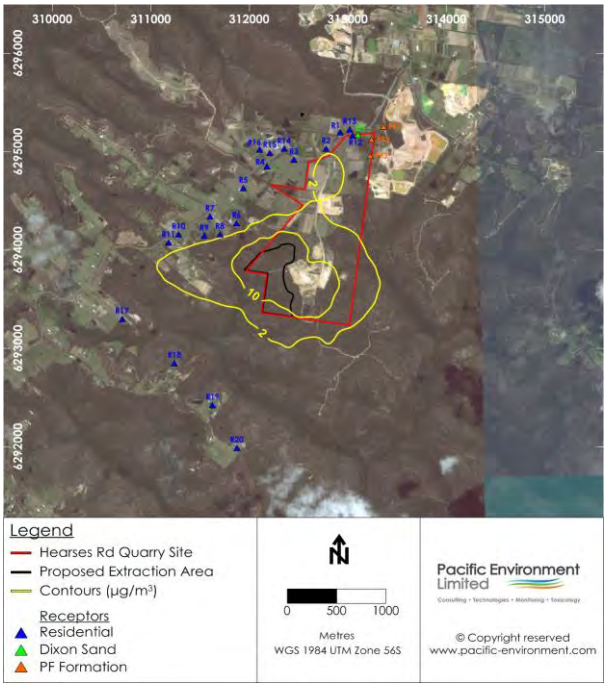
Worst Case Day Operations

Figure 7.4: **Incremental Annual Average $PM_{2.5}$ Concentration – Scenario 1**

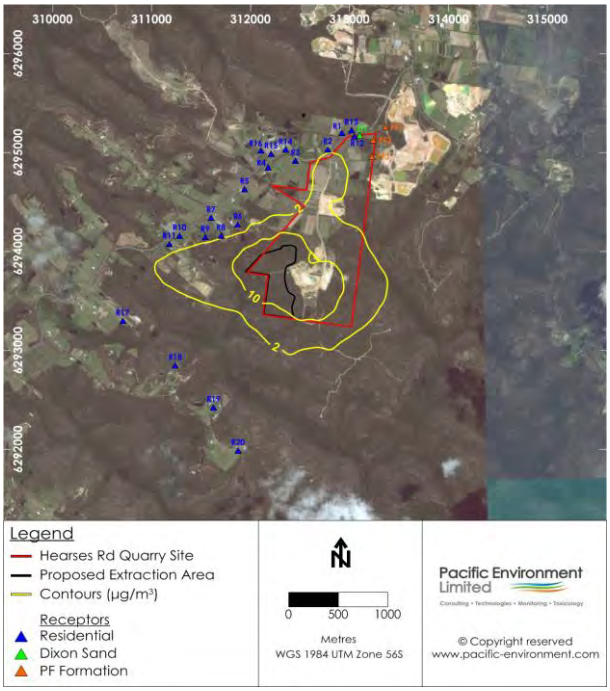
7.1.3 Ground Level TSP Concentrations

Contour plots for the predicted glcs of TSP are presented in Figure 7.5. There are no privately owned receptors that are predicted to experience glcs of TSP above the assessment criteria, due to emissions from the Modification only.

The highest predicted glc occurs at receptor 8 (R8). At this location, the predicted incremental annual average TSP concentration at this residence is 1.5 µg/m³.



Annual Operations



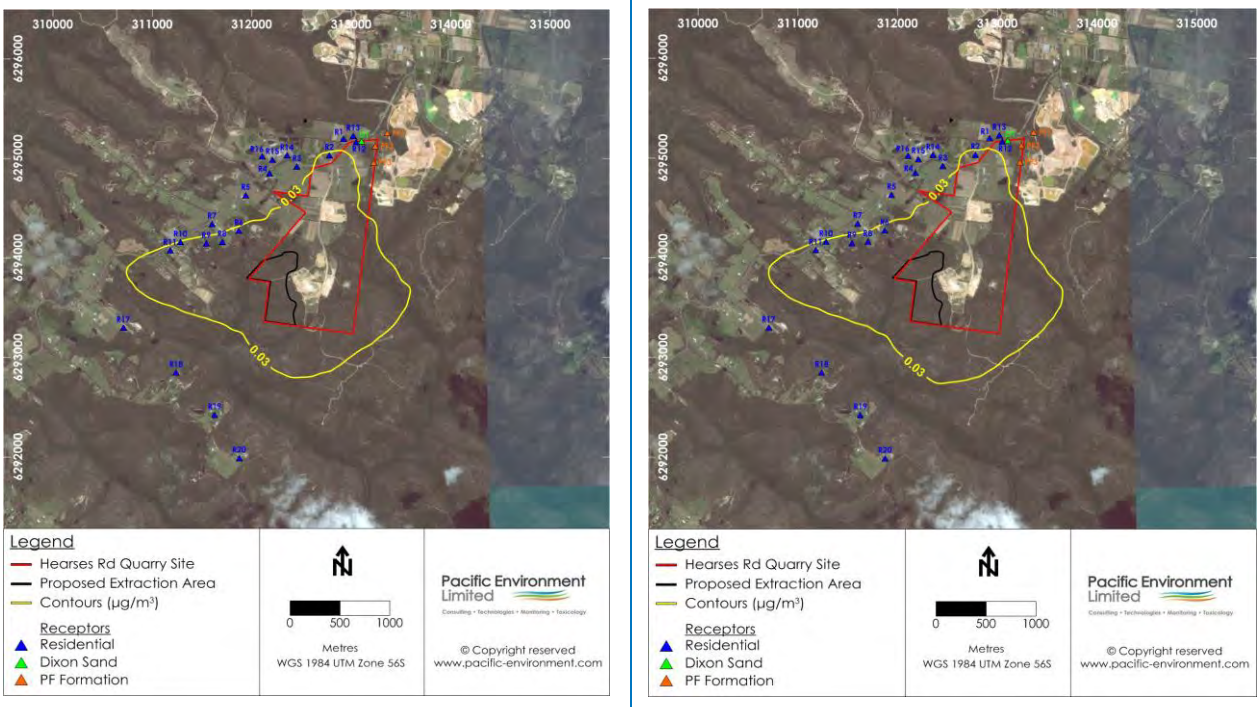
Worst Case Day Operations

Figure 7.5: **Incremental Annual Average TSP Concentration – Scenario 1**

7.1.4 Ground Level Dust Deposition Concentrations

Contour plots for the predicted glcs of dust deposition are presented in Figure 7.6. There are no privately owned receivers that are predicted to experience glcs of dust deposition above the assessment criteria, due to emissions from the Modification only.

The highest predicted glc occurs at receptor 8. At these locations, the predicted incremental annual average dust deposition concentrations is 0.05 g/m^2/month.



Annual Operations | Worst Case Day Operations

Figure 7.6: **Incremental Annual Average Dust Deposition Concentration – Scenario 1**

7.2 Cumulative Impact Assessment

For 24-hour average concentrations, the cumulative concentrations are assumed to be the sum of the 24-hour average Maroota Public School data for PM_{10} and NSW EPA Wyong and Richmond data for $PM_{2.5}$, with the modelled contribution due to the Modification.

The assessment has been conservatively completed for the worst case day operations at the four most impacted receivers as a result of the Modification (R6, R10, R11 and, and R20).

For background annual average concentrations, the assumptions detailed in Section 5.3 have been applied.

7.2.1 24-Hour average PM_{10}

The cumulative assessments of PM_{10} concentrations at the most impacted receptors are shown in Figure 7.7. The plots show the cumulative 24-hour average PM_{10} concentration compared with the assumed background over the 2015 period.

The results indicate that for all four receptors assessed there is potential for maximum of four additional exceedance of the cumulative 24-hour PM_{10} impact assessment criteria of 50 µg/m³.

R1 is the most impacted, with the Modification predicted to result in an additional four exceedances. However the percentage of time when the incremental concentration at R11 is over 2 µg/m³ is less than 1% of the modelled period, highlighting the relative minor impact of the Modification on the existing background particulate matter in the area. Therefore it is considered that only under worst case meteorological conditions combined with high background concentrations of particulate matter will an exceedance of the criteria potentially occur.

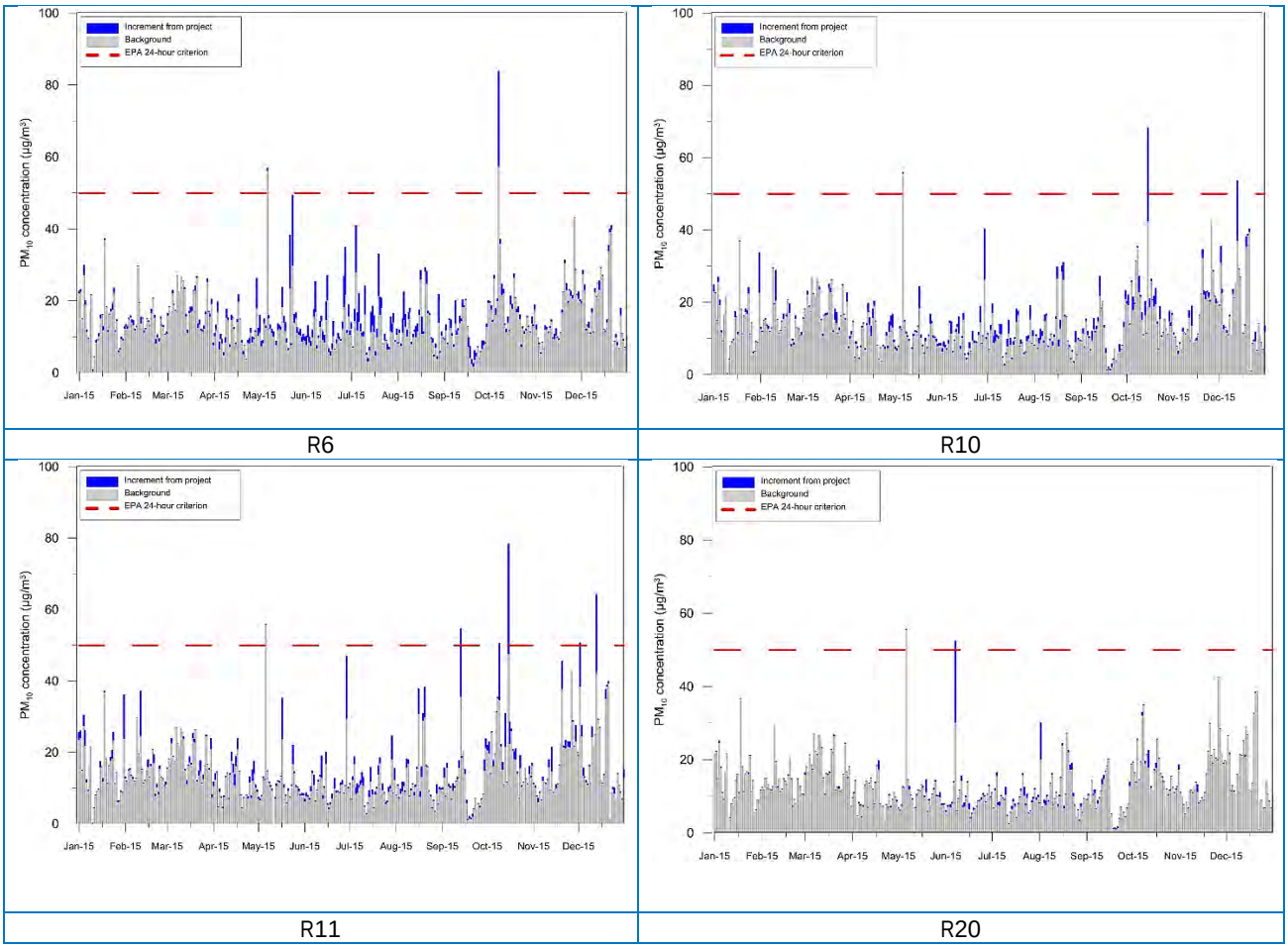


Figure 7.7: PM_{10} **Concentration time-series – Scenario 1 (Worst Day Operations)**

7.2.2 24-Hour average $PM_{2.5}$

The cumulative assessments of $PM_{2.5}$ concentrations at the most impacted receptors are shown in Figure 7.8. The plots show the cumulative 24-hour average $PM_{2.5}$ concentration compared with the assumed background over the 2015 period.

It is clear from these plots that the addition of the Modification would be unlikely to result in any days over the impact assessment criteria at the 25 µg/m³ level, and that the Modification has a very minimal impact on current $PM_{2.5}$ concentrations. It is noted that receptor 18 has been predicted to have one exceedance over the 2015 period, however this correlates with the highest background concentration and incremental increase, and hence the air quality impact is considered minor.

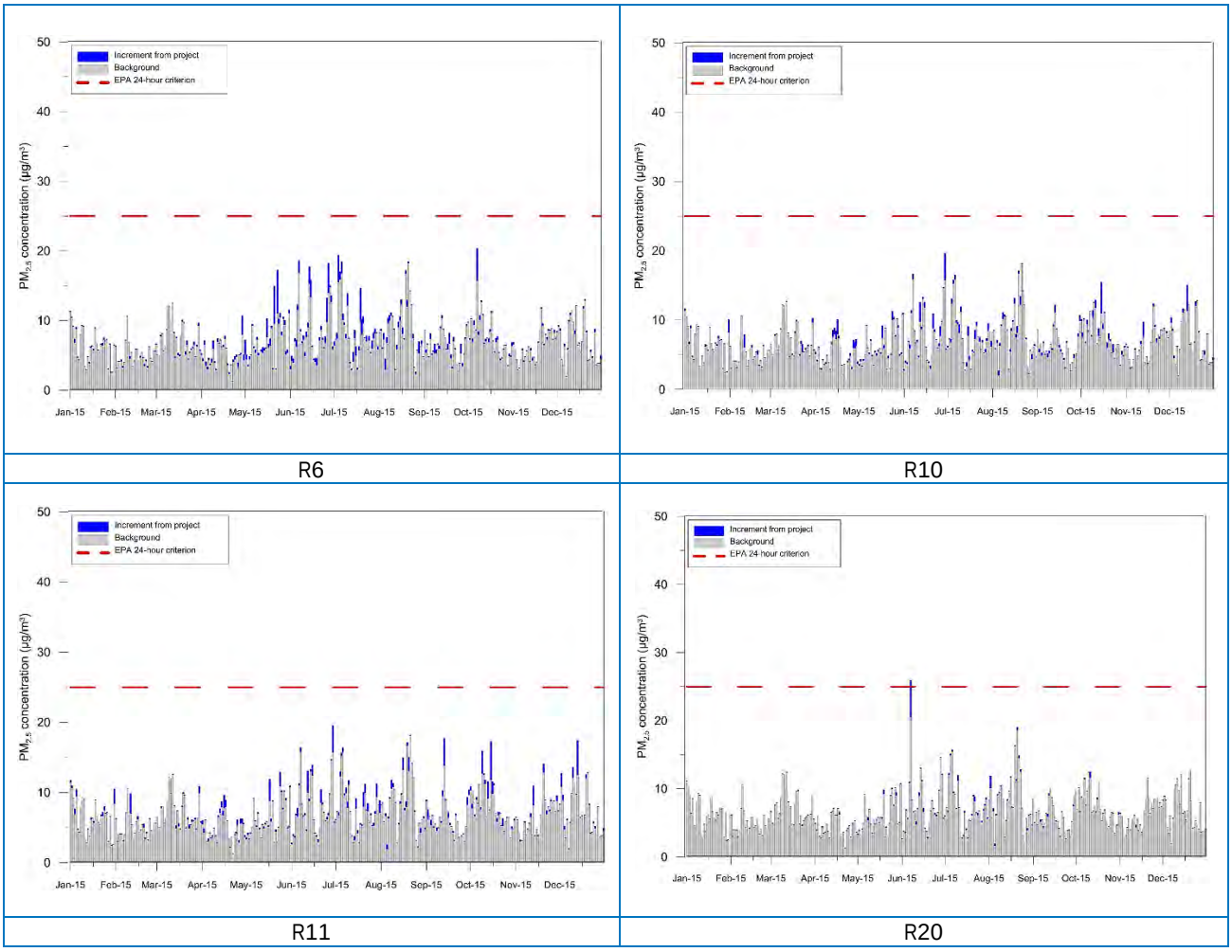


Figure 7.8: $PM_{2.5}$ **Concentration time-series – Scenario 1 (Worst Day Operations)**

8 CONCLUSION

Pacific Environment has completed an air quality assessment for Dixon Sand for the proposed Modification of the existing sand quarry at the Haerses Road site in Maroota NSW.

The operational stage has been modelled for average annual production. A worst case 24-hour operational scenario has also been modelled accounting for maximum daily throughput. Two scenarios were assessed to account for dry processing activities that could occur in different locations on site.

The results of the modelling indicate that the predicted incremental PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest sensitive receivers all comply with the impact assessment criteria.

A cumulative assessment, incorporating existing background levels, indicates that the Modification may result in some additional exceedances of relevant impact assessment criteria at the closest sensitive receptors, if the worst day operations happened to coincide with already elevated background concentrations. However this outcome is considered unlikely to occur and the current requirements to modify/cease operations if rolling 24-hour averages exceed 42 $\mu g/m^3$ will minimise the potential for this to occur even further.

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Appendix A MODEL SET UP

Table B.1: AERMOD setup Options used

AERMOD				
Meteorology				
Meteorological data for Surface Files –(Samson file)	Maroota Public School - Meteorological Station • Air temperature • Relative Humidity • Wind speed • Wind direction • Station Pressure • Precipitation TAPM centred over Maroota Public School • Cloud cover • Cloud height			
Land Use	Cultivated land (Albedo – 0.28, Bowen ratio- 0.75 and Surface roughness – 0.0725)			
AERMET PFL	Upper Air estimator			
Year of analysis	January 2015 - December 2015			
Model Set up				
Centre of domain (lat, long)	-33°28.16' S, 150°59.35' E			
Centre of domain (easting, northing)	313500, 6294672			
MGA coordinate zone	56 S			
Grid domain size	5km x 5km			
Grid spacing	200m			
South west corner of gridded receiver domain (m)	308800, 6290300			
Number of grid points	40 x 40			
Terrain data	SRTM3 at 90m resolution			
Rural Mode	Selected			
Particle parameters				
Particle type	TSP	PM_{10}	$PM_{2.5}$	Dust deposition
Particle Method	Method 1	Method 1	Method 1	Selected
Particle diameter (microns)	17	5	1	17
Mass Fraction	1	1	1	1
Particle Density	N/A	N/A	N/A	2.5
Dry depletion	Selected	Selected	Selected	Selected
Output Options				
Highest values				

Appendix B EMISSION ESTIMATES

B.1 EMISSION ESTIMATES

Silt and moisture content

Silt and moisture content values for in quarry activities are based on measured values provided by Dixon Sand operations.

	Silt content (%)	Moisture content (%)
Topsoil	13	4
Product	13	10
Hauling - unsealed	6.4	N/A

Loading / transfer material dumping

Each tonne of material loaded will generate a quantity of particulate matter that will depend on the wind speed and the moisture content according to the US EPA emission factor equation (US EPA, 1985 and updates) shown below:

$$E\ (kg/t) = k\ \times 0.0016\ \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\right)$$

Where:

K = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$

U – wind speed (m/s)

M – moisture content (%)

The moisture content of the raw material is assumed to be 4%, the processed material is assumed to be 10% and the wind speed is taken from the wind speed data from Maroota Public School Meteorological monitor.

Hauling material on unsealed surfaces

The emission estimate of wheel generated dust associated with hauling at the quarry (i.e. for hauling of material during construction is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (US EPA, 1985 and updates) shown below:

$$E_{TSP}\ (kg/VKT) = 0.2819 \times 4.9 \times [\ (s/12)\text{^}0.7 \times ((W \times 1.1023)/3)\text{^}0.45]$$

$$E_{PM_{10}}\ (kg/VKT) = 0.2819 \times 1.5 \times [\ (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$

$$E_{PM_{2.5}}\ (kg/VKT) = 0.2819 \times 0.15 \times [\ (s/12)\text{^}0.9 \times ((W \times 1.1023)/3)\text{^}0.45]$$

Where:

s = silt content of road surface

W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 6.4%.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip.

Client supplied	Vehicle type	Unloaded (tare) weight	Loaded (GVM) including load	Capacity (tonnes)
Onsite	Dump Truck	23	51	28
Onsite	Product Truck	15	45	30

Hauling material on sealed surfaces

The emission estimate of wheel generated dust associated with hauling from the site towards the processing plant is based the US EPA AP42 emission equation for paved roads at (US EPA, 1985 and updates) shown below:

$$E_{TSP}\ (kg/VKT) = k \times [\ (sL)\text{^}0.91 \times (W)\text{^}1.02]$$

Where:

k = 3.23 for TSP, 0.62 for PM_{10} and 0.15 for $PM_{2.5}$ in g/VKT

sL = road surface silt loading

W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 0.4g/m^2.

Dozers

Emissions from dozers have been calculated using the US EPA emission factor equation (US EPA, 1985 and updates).

$$E_{TSP}(kg/hr) = 2.6\ \times \frac{s^{1.2}}{M^{1.3}}$$

$$E_{PM_{10}}(kg/hr) =\ 0.3375 \times \frac{s^{1.5}}{M^{1.4}}$$

$$E_{PM_{2.5}}(kg/hr) =\ 0.105 \times E_{TSP}$$

Where:

s = silt content (assumed to be 13%)

M = moisture content (assumed to be 4% for topsoil and 10% for sand product).

Wind Erosion

The emission factor used for wind erosion has been taken as 0.1 kg/ha for TSP and 0.05 kg/ha for PM_{10} and 0.075 kg/ha for $PM_{2.5}$ US EPA (1985 and updates).

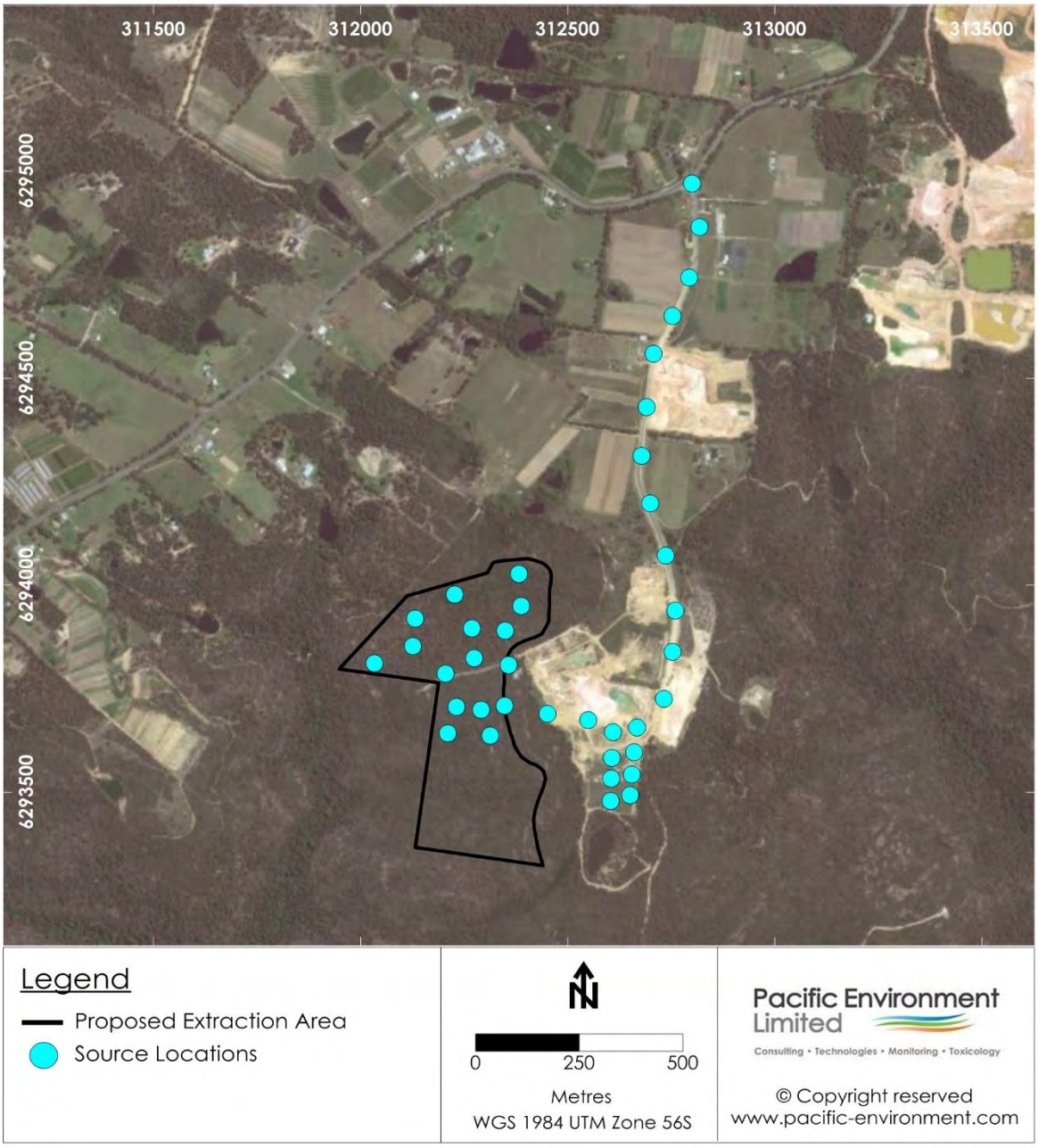


Figure B.1: Source Locations

General Operations - TSP

ACTIVITY	TSP (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	9,312	1,000	h/y	9.3	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	53	250000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	7,423	250000	t/y	0.119	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	3.33	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	53	250,000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	53	250,000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	53	250,000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (uncontrolled)	4,875	250,000	t/y	0.0195	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	53	250,000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (uncontrolled)	3,125	250,000	t/y	0.0125	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	53	250,000	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	15	250,000	t/y	0.00006	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	7,204	250,000	t/y	0.115	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	3.14	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	1,630	250,000	t/y	0.007	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.08	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	2,628	3.0	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	4,380	5.0	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	4,468	5.1	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	45,743																	

General Operations – PM_{10}

ACTIVITY	PM10 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	2,271	1,000	h/y	2.3	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	25	250000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	2,004	250000	t/y	0.032	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	0.90	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	25	250,000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	25	250,000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	25	250,000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (uncontrolled)	1,875	250,000	t/y	0.0075	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	25	250,000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (uncontrolled)	1,075	250,000	t/y	0.0043	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	25	250,000	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	7	250,000	t/y	0.00003	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	1,945	250,000	t/y	0.031	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	0.85	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	313	250,000	t/y	0.001	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.01	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	1,314	3.0	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	2,190	5.0	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	2,234	5.1	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	15,561																	

General Operations - $PM_{2.5}$

ACTIVITY	PM2.5 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	978	1,000	h/y	0.98	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	4	250000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	200	250000	t/y	0.003	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	0.09	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	4	250,000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	4	250,000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	4	250,000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (controlled)	146	250,000	t/y	0.00059	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	4	250,000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (controlled)	94	250,000	t/y	0.00038	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	4	250,000	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	1	250,000	t/y	0.000004	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	194	250,000	t/y	0.003	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	0.08	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	76	250,000	t/y	0.000	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.00	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	197	3.0	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	329	5.0	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	335	5.1	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	2,600																	

Worst Case Operations - TSP

ACTIVITY	TSP (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	9,312	1,000	h/y	9.3	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	65	310250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	9,212	310250	t/y	0.119	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	3.33	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	65	310,250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	65	310,250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	65	310,250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (uncontrolled)	6,050	310,250	t/y	0.0195	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	65	310,250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (uncontrolled)	3,878	310,250	t/y	0.0125	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	65	310,250	t/y	0.00021	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	18	310,250	t/y	0.00006	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	8,940	310,250	t/y	0.115	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	3.14	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	2,023	310,250	t/y	0.007	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.08	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	2,628	3.0	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	4,380	5.0	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	4,468	5.1	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	123	0.14	ha	0.1	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	51,669																	

Worst Case Operations - PM_{10}

ACTIVITY	PM10 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	2,271	1,000	h/y	2.3	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	31	310250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	2,487	310250	t/y	0.032	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	0.90	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	31	310,250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	31	310,250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	31	310,250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (uncontrolled)	2,327	310,250	t/y	0.0075	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	31	310,250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (uncontrolled)	1,334	310,250	t/y	0.0043	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	31	310,250	t/y	0.00010	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	9	310,250	t/y	0.00003	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	2,413	310,250	t/y	0.031	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	0.85	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	388	310,250	t/y	0.001	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.01	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	1,314	3.0	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	2,190	5.0	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	2,234	5.1	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	61	0.14	ha	0.05	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	17,337																	

Worst Case Operations - $PM_{2.5}$

ACTIVITY	PM2.5 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable	Units	Variable 3	Units	Variable 3	Units	Variable 4	Units	Control	Units	Type
Extraction Area																		
Dozer stripping topsoil (from pit 5)	978	1,000	h/y	0.98	kg/h	13	silt content in %	4	moisture content (%)									1
FEL Loading sand to trucks (from pit 5)	5	310250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Hauling from pit 5 to Processing Area (unsealed)	249	310250	t/y	0.003	kg/t	28	t/load	51	Vehicle gross mass (t)	1	km/return trip	0.09	kg/VKT	6.4	% silt content	75	% control	1
Processing Area																		
FEL Unloading sand to stockpile	5	310,250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Loading sand from stockpile	5	310,250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
FEL Unloading sand to Dry Processing	5	310,250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Crusher (controlled)	181	310,250	t/y	0.00059	kg/t													1
Transfer (Crusher to Screen) [conveyor transfer point]	5	310,250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Screen (controlled)	116	310,250	t/y	0.00038	kg/t													1
Transfer (Screen to Wet Processing) [conveyor transfer point]	5	310,250	t/y	0.000015	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	4	moisture content (%)									2
Wet Processing (no expected emissions)	-																	1
FEL Loading sand from Product Stockpile to haul trucks	1	310,250	t/y	0.000004	kg/t	0.47	average of (wind speed/2.2)^1.3 in m/s	10	moisture content (%)									2
Hauling out of Site (unsealed)	241	310,250	t/y	0.003	kg/t	30	t/load	45	Vehicle gross mass (t)	1.1	km/return trip	0.08	kg/VKT	6.4	% silt content	75	% control	1
Hauling out of Site (sealed)	94	310,250	t/y	0.000	kg/t	30	t/load	45	Vehicle gross mass (t)	2.6	km/return trip	0.00	kg/VKT	0.4	g/m2 silt loading	0	% control	1
Wind Erosion																		
WE - Extraction Area (pit 3)	197	3.0	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - (pit 4)	329	5.0	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - (pit 5)	335	5.1	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Extraction Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Pre Processing Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
WE - Product Stockpile	9	0.14	ha	0.0075	kg/ha/h	8,760	h									0	% control	3
TOTAL EMISSIONS	2,777																	

Appendix C MAROOTA PUBLIC SCHOOL WINDROSES

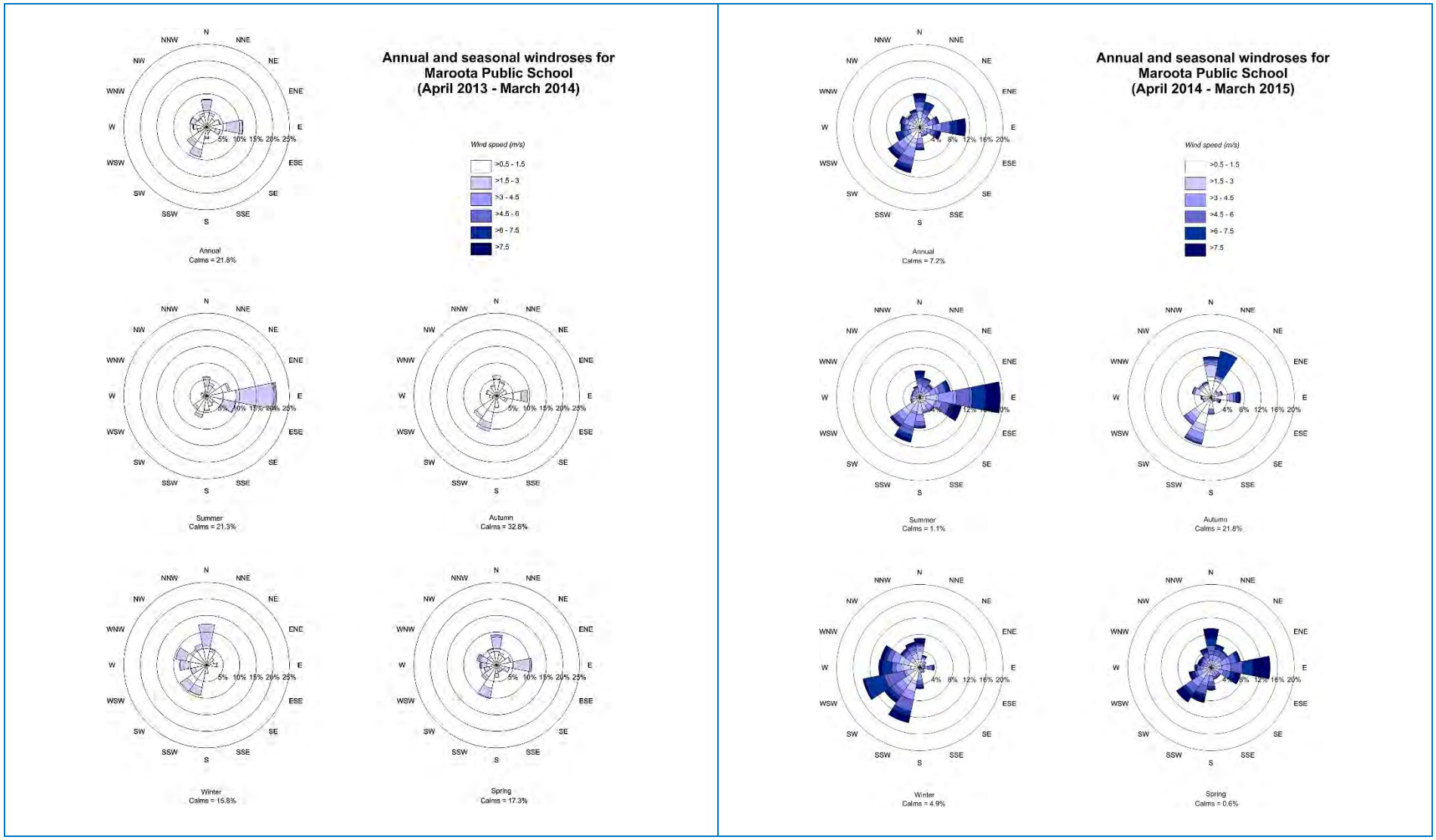
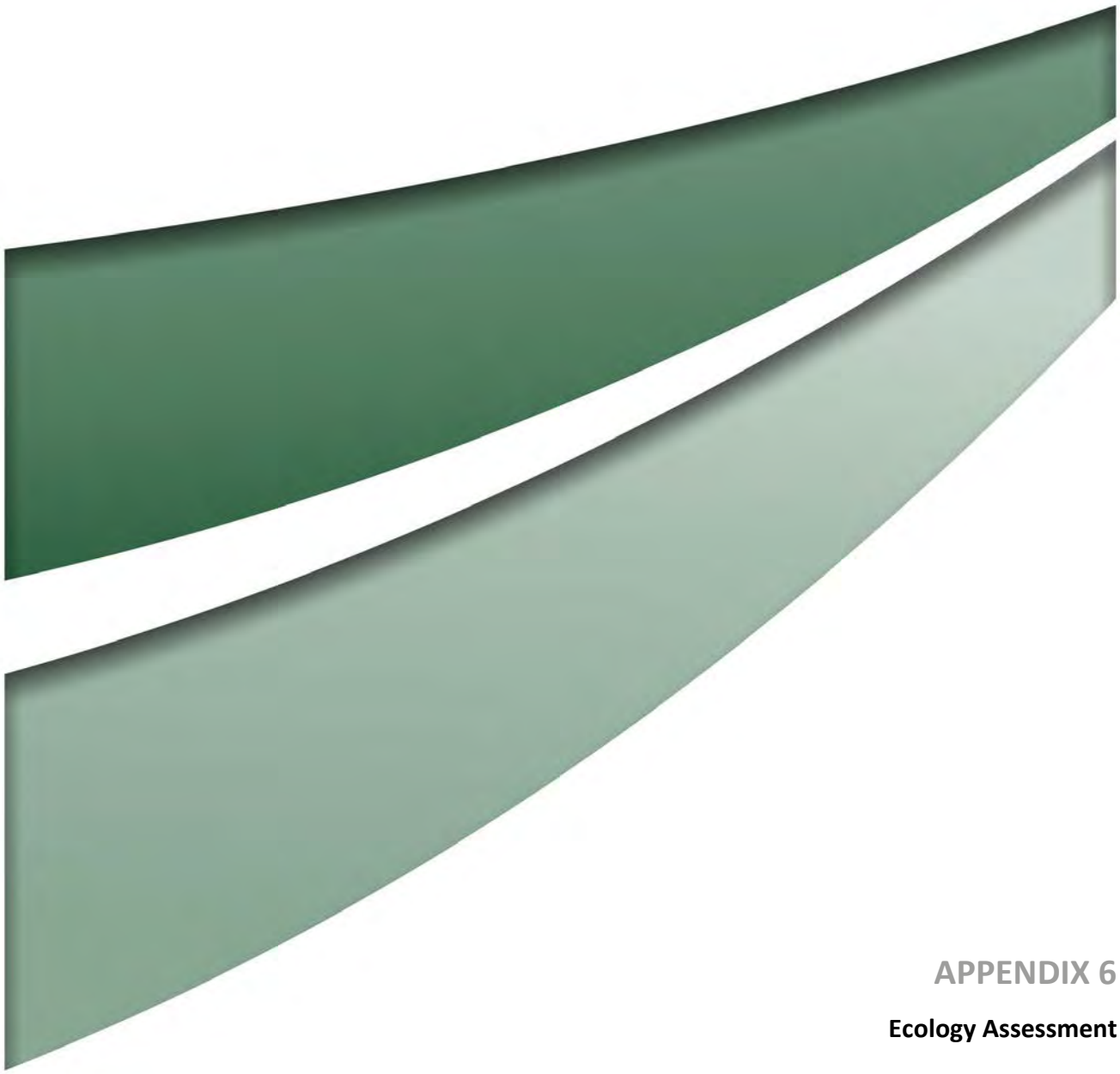


Figure C.1: Wind roses for Maroota Public School – (Left: April 2013 – March 2014, Right: April 2014 – March 2015)



APPENDIX 6

Ecology Assessment

umwelt

Inspired people | Dedicated team
Quality outcomes



Dixon Sand (Penrith) Pty Ltd

HAERSES ROAD QUARRY EXTRACTION AREA MODIFICATION PROJECT

Biodiversity Assessment Report

FINAL

September 2016

Dixon Sand (Penrith) Pty Ltd

HAERSES ROAD QUARRY EXTRACTION AREA MODIFICATION PROJECT

Biodiversity Assessment Report

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Dixon Sand

Project Director:	John Merrell
Project Manager:	Lachlan Sweeney
Technical Director:	Travis Peake
Technical Manager:	Bill Wallach
Report No.	3479/R04
Date:	September 2016

umwelt

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

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Executive Summary

Umwelt (Australia) Pty Limited (Umwelt) has prepared this Biodiversity Assessment Report (BAR) on behalf of Dixon Sand to assess the potential ecological impacts of the proposed Modification Project at Haerses Road Quarry. Additionally, Umwelt assessed the potential credits generated at an offset site adjoining the northern boundary of the Development Site. Both assessments were undertaken using the *Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (FBA)*.

The BioBanking Credit Calculator (BBCC) Version 4.1 (Major Project Assessment Type) was applied following extensive literature reviews, the identification of relevant landscape features and detailed flora and fauna field surveys undertaken in November 2014 and December 2015 of the Development Site, in accordance with FBA methodology (OEH 2014).

Following the application of appropriate avoidance and mitigation measures, the FBA identified the following biodiversity features and subsequent credits required for offsetting as a result of the Modification Project:

- 3 ecosystem credits for Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (HN560)
- 337 ecosystem credits for Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (HN566)
- 538 ecosystem credits for Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (HN582)
- 44 ecosystem credits for Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (HN586)
- 360 species credits for *Darwinia biflora*
- 223 species credits for eastern pygmy-possum (*Cercartetus nanus*)
- 338 species credits for *Grevillea parviflora* subsp. *supplicans*
- 1372 species credits for Dural woodland snail (*Pommerhelix duralensis*) and
- 288 species credits for *Tetratheca glandulosa*.

Additionally, the following biodiversity features and subsequent credits would be generated as a result of securing the Haerses Road Offset Site:

- 11 ecosystem credits for Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (HN560)
- 6 ecosystem credits for Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (HN566)
- 17 ecosystem credits for Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (HN582)
- 4 ecosystem credits for Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (HN586)
- 14 species credits for *Darwinia biflora*
- 11 species credits for eastern pygmy-possum (*Cercartetus nanus*)
- 16 species credits for Dural woodland snail (*Pommerhelix duralensis*) and
- 14 species credits for *Tetratheca glandulosa*.

Glossary

Approved Extraction Area	Area as approved under DA 165-7-2005 as shown on **Figure 1.2**.
BAR	Biodiversity Assessment Report
BBAM	BioBanking Assessment Methodology
BBCC	BioBanking Credit Calculator
BVT	Biometric Vegetation Type
CEEC	Critically Endangered Ecological Community
CMA	Catchment Management Authority
DECC	NSW Department of Environment and Climate Change (now OEH)
Development Site	The area within the Modification Area that relates to Development Footprint as referred to in the FBA Methodology (OEH 2014).
DoE	Commonwealth Department of the Environment
Ecosystem credit	A measurement of the value of EECs, CEECs and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at an offset site.
EEC	Endangered Ecological Community
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994* (NSW)
GIS	Geographic Information System
IBRA	Interim Biogeographic Regionalisation for Australia (Version 7)
LGA	Local Government Area
LPI	Land and Property Information
MGA	Map Grid of Australia
MNES	Matters of National Environmental Significance
Modification Area	The term used in this report for the Development Site as referred to in the FBA Methodology (OEH 2014)
Modification Project	The subject of this Biodiversity Assessment Report, the Proposed Extraction Area Modification, which includes the proposed development of an additional quarry resource to the west of the currently approved quarry area and associated components.
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
PCT	Plant Community Type
PMST	Protected Matters Search Tool
SAT	Spot Assessment Technique

Species credit	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Species Profile Database.
TEC	Threatened Ecological Community
tpa	Tonnes Per Annum
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
TSPD	Threatened Species Profile Database
VIS	Vegetation Information System

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1.0 Introduction

1.1 Background

Dixon Sand (Penrith) Pty Limited (Dixon Sand) operate the Haerses Road Quarry located on Haerses Road Maroota, NSW. Haerses Road Quarry extracts Tertiary Maroota Sand from Lot 170 DP 664767, Lots A and B DP 407341, and Lots 176 and 177 DP 752039 (the site) in accordance with development consent DA 165-7-2005.

Dixon Sand was granted development consent for the State Significant Development DA 165-7-2005 under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) by the Minister for Planning on 14 February 2006. The development consent provides for the operation of a sand quarry on Haerses Road at Maroota with a total extraction of 7 million tonnes from the site over 25 years at a rate of 250,000 tonnes per annum (tpa). The consent allows for hauling of 190,000 tpa of screened sand to the processing facility at Dixon Sand's nearby Old Northern Road quarry and hauling of 60,000 tpa of screened sand direct to local and regional markets.

Due to the recent increase in demand for medium to coarse grain sands and specialist sands in the Sydney market, Dixon Sand is seeking a modification to DA 165-7-2006-5 for the Haerses Road quarry to increase the extraction area and to increase the volume of sand sold direct to market from the site. There is no proposal to increase total annual production or the currently approved traffic movements to and from site.

The planning approach for the modification is to modify the existing consent under Section 75W of the EP&A Act. Umwelt (Australia) Pty Limited (Umwelt) has prepared this Biodiversity Assessment Report (BAR) on behalf of Dixon Sand to assess the potential ecological impacts of the proposed modification at the Haerses Road Quarry using the *Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014).

1.1.1 Proposed Modification

The proposed modification to DA 165-7-2006-5, being sought for the Haerses Road Quarry involves increasing the extraction area as well as including a provision for mobile plant and equipment to be utilised on the site to avoid double handling and double processing of the product. The proposed modifications are:

- Increasing the extraction area by approximately 19 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039 (refer to **Figure 1.1**). The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader. The existing dozer would be used to rip the friable sandstone on site which wasn't required for tertiary sand deposit in the original consent. The existing dry screening plant would utilise mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening

- Utilise existing traffic movements between Old Northern Rd and Haerses Rd Quarries to allow for blending of speciality sands, including importation of up to 100,000 tpa of clean recycled sands (Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM)) from approved sites. No new traffic movements would be generated by the proposal

- Use of mobile washing and processing plant on site

- Installation of detention basins and water management infrastructure

- Establishment of site office, workshop and weighbridge.

The modification does not affect any currently approved activities within the Haerses Road Quarry.

1.2 Development Site Information

For the purposes of this Biodiversity Assessment Report (BAR), the various parts of the quarry have been defined to facilitate the understanding of the existing approved components of the site and the proposed modification.

The total area of land comprising the Haerses Road Quarry is referred to as the Project Site (refer **Figure 1.2**). The existing approved activities occur within the Approved Extraction Area. The portion of the site covered by the modification is the Modification Area which includes the Development Site which comprises the area of land to be impacted by the proposed modification that is outside of the existing approved disturbance area at Haerses Road Quarry. It consists of the proposed extraction area and the proposed processing area.

1.2.1 Location

Haerses Road Quarry is a sand quarry operated by Dixon Sand, located in the Maroota area, approximately 40 kilometres north of Parramatta, NSW (refer to **Figure 1.1**). The Modification Area is located within the Sydney Basin IBRA bioregion and the Yengo IBRA subregion. Refer to **Figures 1.2** to **1.4** for the location of the Development Site and other relevant landscape features that pertain to the FBA assessment.

Table 1.1 Development Site Location in the Landscape

Haerses Road Quarry Modification Area	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Yengo
Major Catchment Area	Hawkesbury/Nepean
Mitchell Landscape	Maroota Sands (majority)
LGA	The Hills
Address	Haerses Road, Maroota, NSW, 2756

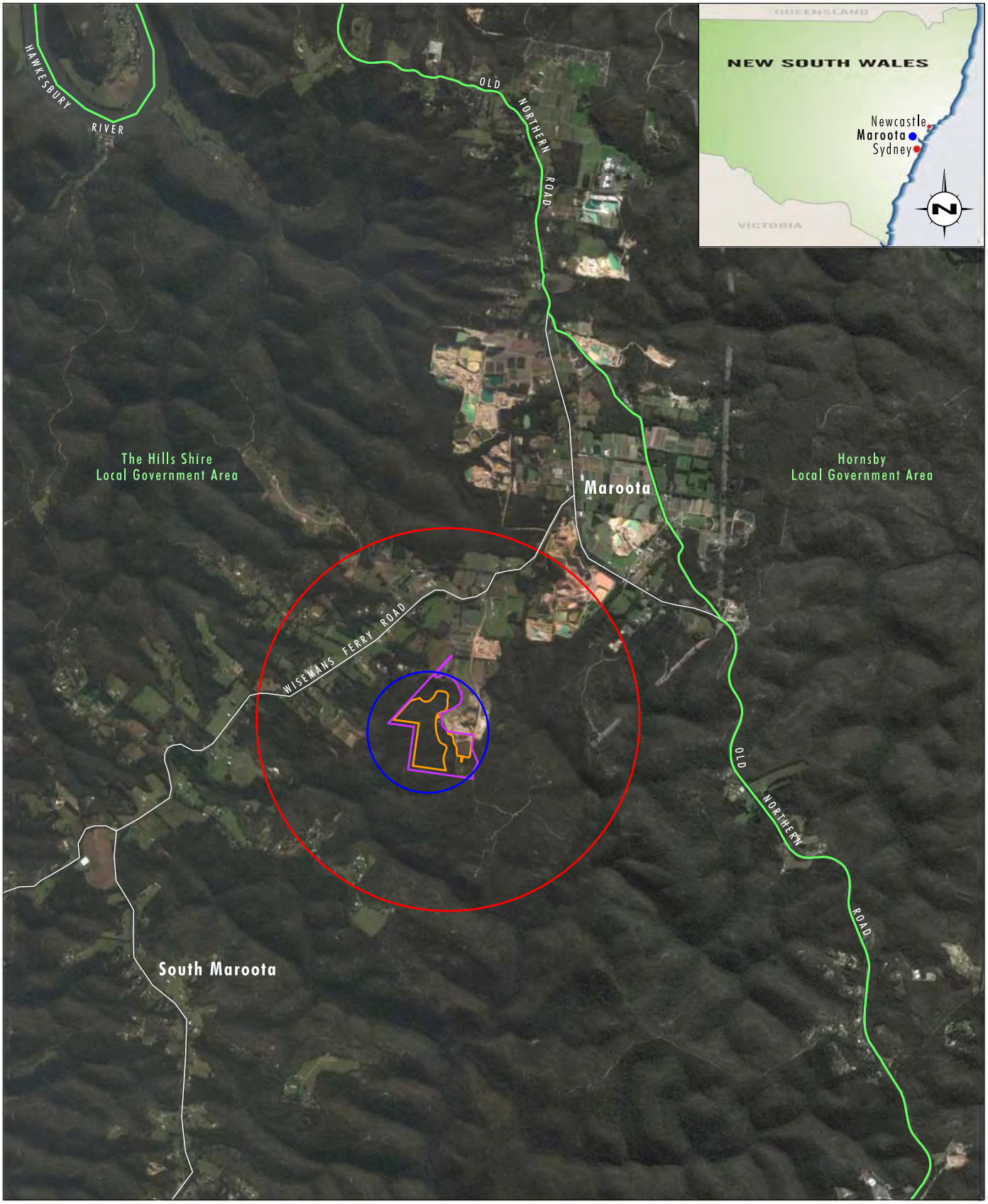


Image Source: Google Earth (2014)
Data Source: LPI (2015)

0 0.5 1.0 2.0km
1:50 000

Legend

- Development Site
- Modification Area
- Local Government Area Boundary
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle

FIGURE 1.1

Locality Map

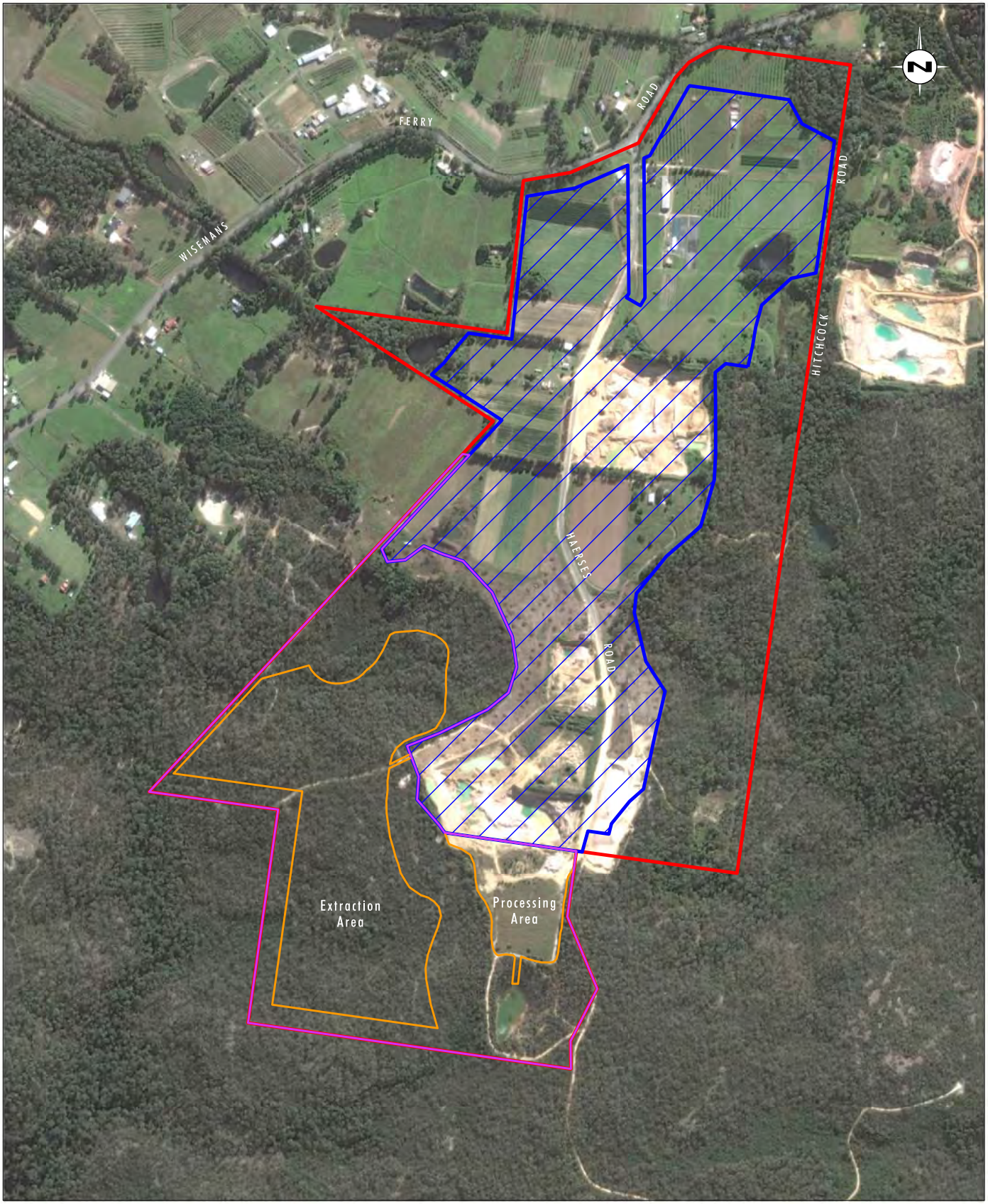


Image Source: Google Earth (2014)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

0 100 250 500m
1:10 000

Legend

- Project Site
- Approved Extraction Area
- Development Site (22.4 Hectares)
- Modification Area (44 Hectares)

FIGURE 1.2

Proposed Extraction Area Modification Project

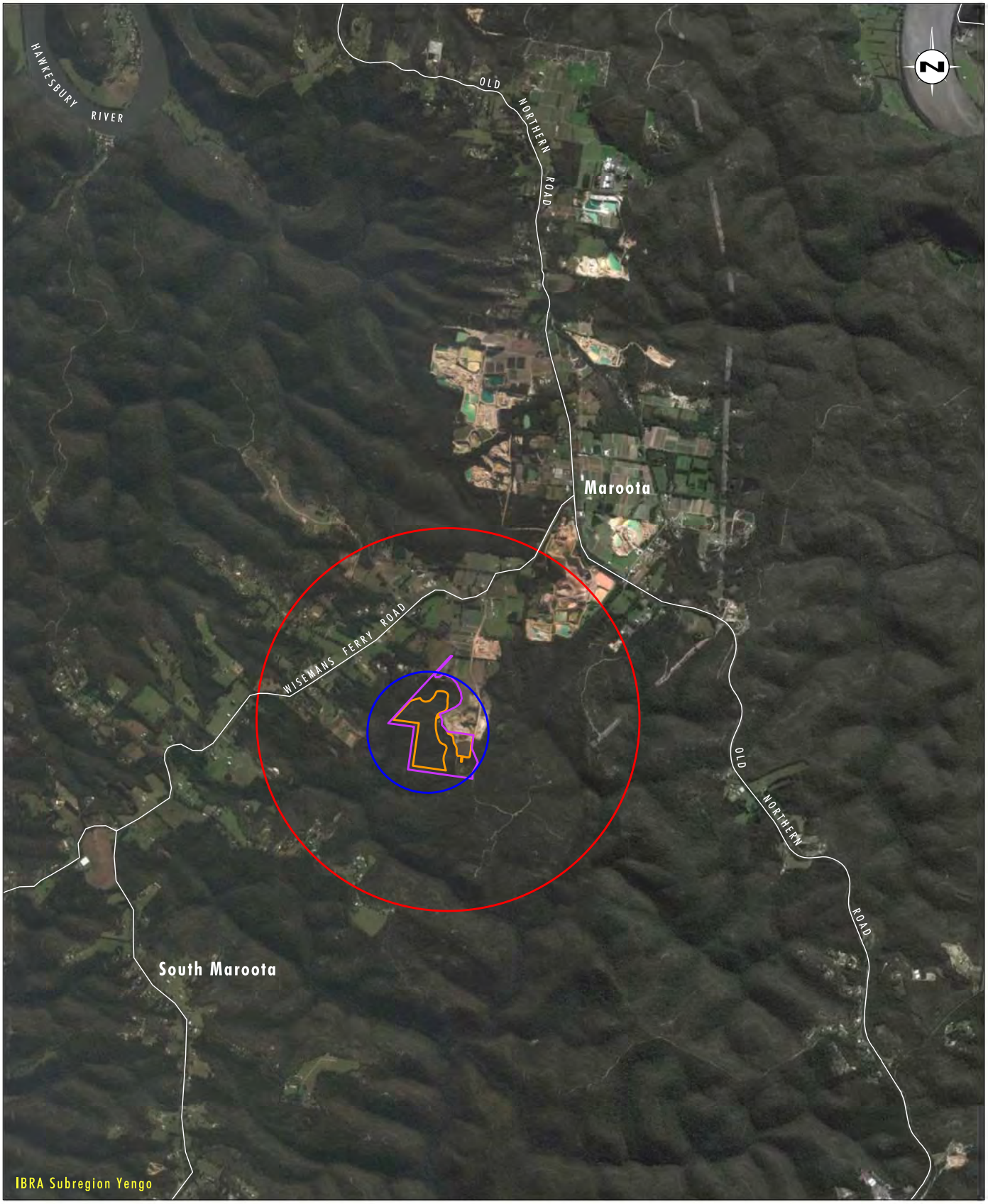


Image Source: Google Earth (2014)
Data Source: IBRA V7 - Australian Government Department of the Environment (2012)

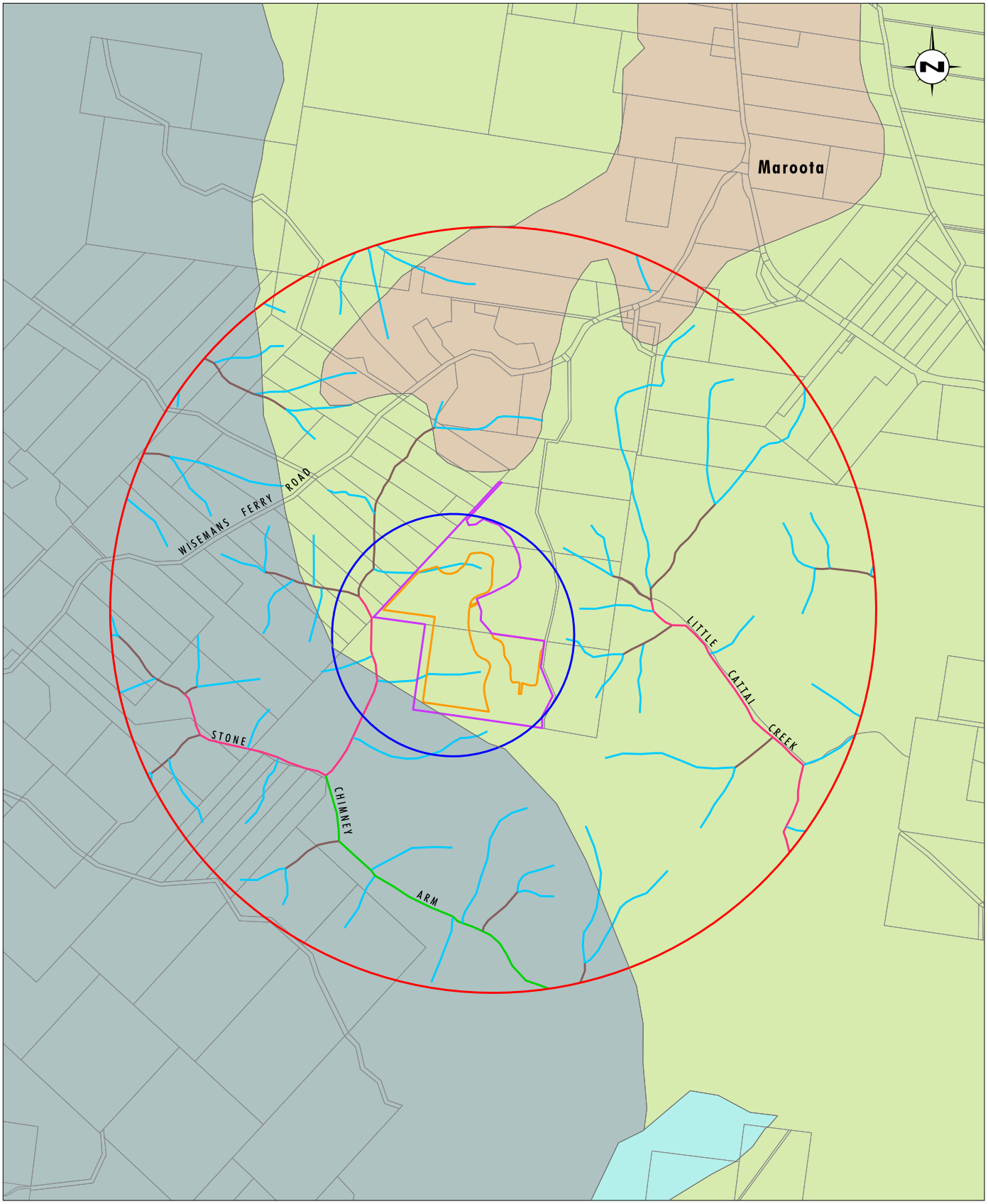
0 0.5 1.0 2.0km
1:50 000

Legend

- Development Site
- Modification Area
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle

FIGURE 1.3

Location Map - IBRA V7 Regions



Data Source: DECC (2008),LPI (2011)

0 0.5 1.0 1.25km

1:25 000

Legend

- Development Site
- Modification Area
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream

Mitchell Landscapes:

- Blaxlands Ridge
- Hornsby Plateau
- Maroota Sands
- Sydney Basin Diatremes

FIGURE 1.4

Location Map - Landscape Features

File Name (A4): R04/3479_029.dgn
20160920 11.11

1.2.2 Size

The Modification Area covers approximately 44 hectares.

The Development Site comprises approximately 22.4 hectares.

1.2.3 Topography and Natural Features

The Modification Area lies in the Sydney Basin bioregion, at the top of the local catchment, and drains towards the west. The gradient decreases from approximately 190 ASL in the east to approximately 130 metres ASL in the west representing a gradient change of approximately 1 metre in every 10 metres. There is negligible gradient change from north to south. The topography is consistent with that of the Yengo subregion, characterised by steep slopes forming narrow valleys with low cliff lines on Narrabeen sandstone and a structurally controlled drainage pattern (Morgan, 2001).

The Modification Area drains to the Hawkesbury River, approximately 12 km south west, via the first order drainage line into the upper reaches of Stone Chimney Arm (creek), a tributary of Little Cattai Creek and the Broadwater Swamp. The Broadwater Swamp is approximately eight kilometres downstream of the site, connecting Little Cattai Creek to the Hawkesbury River. The local catchment of which the site is a part is shown has an area of approximately 9980 hectares (ERM, 2006).

The Modification Area encompasses an area of approximately 44 hectares of which some small areas (~4 ha) in the south have been disturbed by existing quarrying activities. The majority of the Modification Area remains intact native woodland and forest vegetation. The woodland and forest areas of the Modification Area form part of a very large connected area of woodland and forest that extends eastwards towards the coast from Yengo National Park, Wollemi National Park and the Blue Mountains National Park in the west. The Modification Area is part of a remnant of connected woodland and forest vegetation that is among the largest remnants of woodland and forest along the east coast of NSW. The presence of such a large connected remnant that dominates the landscape is considered an outstanding natural feature.

1.3 Key Resources, Policies and Documents

The following key resources, policies and documents were used to prepare the Biodiversity Assessment Report for the Modification Project:

- Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (OEH September 2014)
- BioBanking Assessment Methodology 2008 (DECC July 2008)
- BioBanking Assessment Methodology 2014 (OEH September 2014)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities –Working Draft (DEC 2004)
- BioBanking Credit Calculator (Major Project Assessment Type) Version 4.1, accessed in April-May 2016
- Vegetation Information System (VIS) Classification Database (OEH 2015), accessed in August 2015
- OEH Atlas of NSW Wildlife database and mapping tool (OEH 2015), accessed in March 2016
- Department of the Environment (DoE) Protected Matters Database (DoE 2015), accessed in March 2016

1.4 Report Preparation

This Biodiversity Assessment Report (BAR) was prepared by Bill Wallach (Senior Ecologist) and Travis Peake (Practice Leader Ecology). Both Bill Wallach and Travis Peake (Practice Leader Ecology) are accredited BioBanking and BioCertification Assessors.

2.0 Methods – Modification Area

2.1 Description

The threatened species and ecological communities known or likely to occur within the Modification Area were identified by a systematic approach comprising appropriate database searches, a review of recent literature, and targeted field surveys.

2.2 Database Searches

Database searches were undertaken to develop a list of Threatened Ecological Communities (TECs) and threatened flora and fauna species that have previously been recorded, or are predicted to occur within 10 kilometres of the boundary of the Modification Area. The information obtained was used to inform survey design, and was also used to assist in the assessment of potentially occurring threatened and migratory species and endangered populations. Relevant documents included:

- EPBC Protected Matters Search Tool (30/03/16)
- NSW Office of Environment and Heritage (OEH) Atlas of NSW Wildlife (30/03/16).

Marine species such as albatrosses, petrels, turtles and whales were excluded from the database search results due to an absence of marine habitats in the Modification Area.

A preliminary assessment using the BioBanking Credit Calculator was undertaken, which provided a list of species credit species that might require survey and the suitable survey periods for each species. The results of the database searches, literature review and preliminary assessment using the BioBanking Credit Calculator were used to design the survey requirements for species credit species to ensure that adequate surveys were undertaken.

The Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC 2004) was considered when undertaking the threatened species surveys in the Development Site.

2.3 Systematic Quadrat Surveys

Systematic vegetation quadrats were undertaken across two field surveys, the first in November 2014 and the second in December 2015. Detailed information on the timing of these two surveys is provided below in **Section 2.8**.

Systematic vegetation quadrat sites were selected by considering a vast array of attributes that were likely to influence or determine the type of vegetation communities present in the Modification Area. This stratification was done intuitively, based on existing topographic, soil, vegetation and geological mapping. Other factors considered included the spatial coverage of sites across the Modification Area, as well as the topographic position and aspect.

Each vegetation quadrat comprised 20 metres by 20 metres (400 m^2); a standard size used widely for systematic flora surveys throughout NSW and is recognised by OEH and the Royal Botanic Gardens Sydney. Each quadrat was searched between 45 to 60 minutes for all vascular flora species present. Two ecologists conducted surveys at each quadrat sampled. The highest effort was spent examining the groundcover

vegetation, as this stratum supported the majority of species at most sites. Furthermore, effort was also made to search the canopy and trunks of trees for mistletoes, vines and epiphytes.

Information on the structural characteristics of the vegetation in each quadrat was also recorded, and included the height range, canopy cover of each stratum and the dominant species in each stratum. Any species observed outside the quadrat but within the vegetation community being sampled were recorded. Such species were noted as being present but were not assigned cover-abundance values. Flora species cover-abundance data were recorded on a proforma.

2.3.1 Plot/Transect Selection and Stratification of the Development Site

Designing an appropriate survey requires consideration of both survey methods and effort. Reference was made to the VIS Classification Database to identify Plant Community Types (PCTs), as well as reviews of other regional and local vegetation mapping and reporting (refer to **Section 3.2.1**) when designing the field survey. The Development Site PCTs were further stratified into Vegetation Zones (condition states) following the initial field survey of the site to determine the appropriate number of transect/plots required in accordance with the FBA methodology (OEH 2014) as outlined in **Table 2.1**. Broad condition states include vegetation in 'Moderate/Good' condition.

Table 2.1 Minimum Number of Plots/Transects Required per Zone Area (OEH 2014)

Vegetation Zone Area (ha)	Minimum Number of Plot/Transect
0-4	1 transect/plot per 2 ha (or part thereof) or 1 transect/plot if vegetation is in low condition
>4-20	3 transects/plots or 2 transects/plots if vegetation is in low condition
>20-50	4 transects/plots or 3 transects/plots if vegetation is in low condition
>50-100	5 transects/plots or 3 transects/plots if vegetation is in low condition
>100-250	6 transects/plots or 4 transects/plots if vegetation is in low condition
>250-1000	7 transects/plots or 5 transects/plots if vegetation is in low condition (More transects/plots may be needed if the condition of the vegetation is variable across the zone)
>1000	8 transects/plots or 5 transects/plots if vegetation is in low condition or in a homogenous landscape in the Western Division (More transects/plots may be needed if the condition of the vegetation is variable across the zone)

Table 2.2 below outlines the adequacy of the plot-based flora survey with respect to the BioBanking Methodology (OEH 2014) pertinent to the Development Site. All Vegetation Zones identified also occur outside the Development Site, but within the Modification Area and were sampled during the surveys undertaken for this assessment as the boundary of the Development Site was refined.

Table 2.2 Adequacy of Vegetation Survey in the Development Site

Vegetation Zone	BVT and Condition Class (does not include cleared areas)	Area in the Development Site (ha[1])	No. Plots and Transects Sampled (No. Required in parentheses)		
			Plot	Transect	Rapid Sampling
1	HN560_Moderate/Good	0.08^	1 (1)	1 (1)	1
2	HN566_Moderate/Good	6.76^	3 (3)	3 (3)	1
3	HN582_Moderate/Good	11.46^	3 (3)	3 (3)	4
4	HN586_Moderate/Good	1.20^	1 (1)	1 (1)	4
Total		**19.50**	**8 (8)**	**8 (8)**	**10***

[1] All areas are approximate areas despite being shown at two decimal places. Areas are approximate as vegetation type boundaries are based on a combination of field survey and desktop assessment. Additionally, precise boundaries between communities can be difficult or impossible to determine in the field due to the overlap of species in common occurring among vegetation types.

^ These vegetation zones also occur in the wider Modification Area and were sampled during the two field surveys undertaken for this assessment prior to the refinement of the Development Site. Consequently, all eight plots/transects were completed within the Modification Area but not exclusively within the Development Site.

* Three additional Rapid Sampling points were completed but occurred in cleared land and therefore is not identified in this table.

2.3.2 Plot/Transect Data Collected

At each plot/transect data was recorded according to Appendix 2 of the BioBanking Assessment Methodology (BBAM) and Credit Calculator Operational Manual (DECC 2014). This involved setting out 20 x 50 metre and 20 x 20 metre plots and a 50 metre transect. The location of each quadrat was recorded using a hand-held GPS with accuracy of ± 5 metres. The Map Grid of Australia (MGA) coordinate system was used. The location of the 8 plots/transects undertaken within the Modification Area is shown on **Figure 2.1**.

At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Searches of each 20 x 20 metre plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to search the tree canopy and tree trunks for mistletoes, vines and epiphytes.

Species within the plot were also assigned a cover-abundance value to reflect their relative cover and abundance in the plot. Species located outside the plot (recorded to assist in vegetation community identifications and mapping) were marked as present but were not assigned a cover-abundance value. A modified Braun-Blanquet 6-point scale was used to estimate cover-abundances of all plant species within each quadrat (Braun-Blanquet 1927), with selected modifications sourced from Poore (1955) and Austin *et al*. (2000). **Table 2.3** shows the cover-abundance categories used. Voucher specimens were collected of species that could not be identified in the field for later identification. The following specimens were sent to NSW Royal Botanic Gardens and formally identified:

- crimson bottlebrush (*Callistemon citrinus*)

- *Darwinia biflora*
- *Darwinia fascicularis*
- *Grevillea parviflora* supbsp. *supplicans*
- *Hibbertia superans*
- peach blossom tea-tree (*Leptospermum squarrosum*) and
- *Tetratheca glandulosa*.

Table 2.3 Modified Bran-Blanquet Crown Cover-Abundance Scale

Class	Cover-abundance^	Notes
1	Few individuals (less than 5% cover)	Herbs, sedges and grasses: <5 individuals Shrubs and small trees: <5 individuals
2	Many individuals (less than 5% cover)	Herbs, sedges and grasses: 5 or more individuals Shrubs and small trees: 5 or more individuals Medium-large overhanging tree
3	5 – less than 20% cover	Applies to all species.
4	20 – less than 50% cover	
5	50 – less than 75% cover	
6	75 – 100% cover	

Note: at the time of survey, the updated BioBanking and FBA Methodology (OEH 2014) had not been released including the new requirements for abundance ratings and therefore the modified Braun-Blanquet 6-point scale was used for Cover-Abundance measures. Modified Braun-Blanquet scale (Poore 1955; Austin *et al*, 2000).

At each standard flora quadrat, 10 points along a 50 metre transect were assessed for:

- percentage native overstorey cover, and
- percentage native mid-storey cover.

In addition, 50 points along a 50 metre transect were assessed for:

- percentage native groundcover (grass)
- percentage native groundcover (shrubs)
- percentage native ground cover (other), and
- percentage exotic plant cover.

Additional details were also recorded in each quadrat, including soil texture, drainage and depth; site disturbances; physiography (position in the landscape); and vegetation structure (strata percentage covers, heights and dominant species). Photographic records were also taken at each site.

2.4 Semi-quantitative Rapid Sampling

A total of 13 semi quantitative rapid assessments plots were completed in the Modification Area (consisting of 10 within the development site and three outside) to collect information about the vegetation. Assessment areas were not fixed area-based, but were generally confined to an area similar to that of a 10 x 10 metre quadrat. Rapid assessments were used to document the characteristics of vegetation over large areas.

Rapid vegetation assessment points were located within distinct vegetation community units (rather than within ecotones) to allow data collection for each community without confounding effects from adjacent communities. Dominant, common and some uncommon plant taxa were recorded within each rapid vegetation assessment points, along with cover abundance scores as per **Table 2.3**. The vegetation structure at each rapid vegetation assessment point was documented, including each stratum's height, percent foliage cover and dominant species. Rapid assessment plots were later transferred into a geographical information system (GIS) to aid vegetation community mapping and description. **Figure 2.1** shows the location of the 13 rapid assessment plots completed across the Modification Area.

2.5 Plant Identification and Nomenclature Standards

All vascular plants recorded or collected within plots and quadrats were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002) and Jacobs *et al.* (2008). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2016), the online plants name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name. Where the identity of a specimen was unknown or uncertain, it was lodged with the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney.

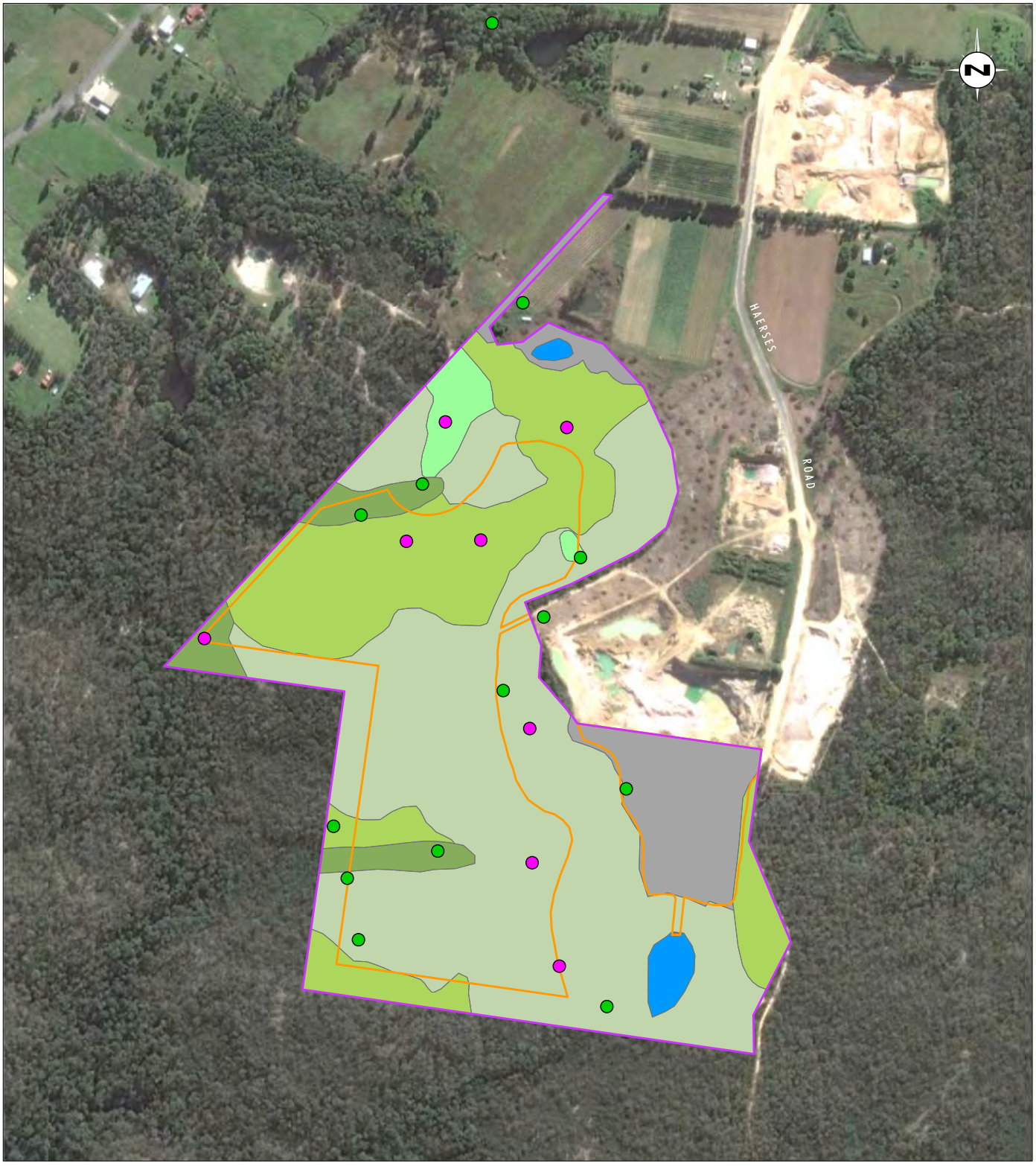


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Cleared
- Dam
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition
- Flora Plot/Transects
- Semi-quantitative Rapid Sampling Plot

FIGURE 2.1

Flora Survey Locations

2.6 Targeted Threatened Ecological Community Investigations

Vegetation communities identified in the Modification Area were compared to TECs listed under the Commonwealth EPBC Act and NSW TSC Act and an assessment of similarity with the NSW Scientific Committee Final Determinations and the Commonwealth Threatened Species Scientific Committee Listing and Conservation Advice.

Six TECs were identified as potentially occurring in the Modification Area. The six listed communities are:

- Coastal Upland Swamps in the Sydney Basin Bioregion (EEC – TSC Act and EEEC – EPBC ACT)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EEC – EPBC Act)
- Shale/Sandstone Transition Forest (CEEC – TSC Act)
- Subtropical and Temperate Coastal Saltmarsh (VEC – EPBC Act)
- Turpentine-Ironbark Forest in the Sydney Basin Bioregion and (EEC – TSC Act and CEEC – EPBC Act)
- Western Sydney Dry Rainforest and Moist Woodland on Shale (CEEC – EPBC Act).

2.7 Targeted *Darwinia biflora* Survey

Given the potential for large numbers of *Darwinia biflora* present in the Modification Area, it was impractical to count and mark each individual plant. Instead, the numbers of *D. biflora* were counted within standard 10 x 10 metre or 20 x 20 metre plots (depending on density) during the initial survey in November 2014. This species was recorded in the Sandstone Heath (Heath/Woodland Complex) and Sandstone Ridgetop Woodland.

Further targeted survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot.

Due to the sporadic nature in which the species occurs in the Modification Area, the impacts to *D. biflora* were assessed by area of habitat rather than the number of individuals. Typically, impacts to flora species should be assessed based on the number of individuals as indicated in Section 10.4.4.2 of the FBA methodology (OEH, 2014). However in the case of sporadically occurring plant species like *D. biflora* it is permitted to assessed the impacts by area of habitat. The NSW Guide to Surveying Threatened Plants (OEH, 2016b) states that impacts to a threatened species can be assessed as area of habitat as long as the surveyor considers the history of land use and/or disturbance and previous surveys of the species at the site. This approach was discussed with OEH during the course of the project. The survey effort undertaken by Umwelt in the Modification Area identified that the population of *D. biflora* could not be accurately measured due to the sporadic nature in which it occurs.

2.8 Flora Survey Timing and Effort

The vegetation of the Modification Area was surveyed in two events. The first was during spring, from 25 to 27 November, 2014 and the second was in summer, from 14 to 17 December, 2015. All surveys were completed by two Ecologists. A total of 14 person-days, six initially and eight later, were completed to sample the vegetation communities and flora species within the Modification Area.

The following survey effort was completed across the Modification Area (refer to **Figure 2.1**):

- Eight 400 m^2 flora plots and
- Thirteen semi-qualitative rapid assessment plots.

2.9 Fauna Survey Timing and Effort

Fauna surveys across the Modification Area were undertaken from 25 to 27 November 2014 as well as on 16 December 2015. Fauna survey effort was designed in consideration of the following survey guidelines:

- Department of Environment, Water, Heritage and the Arts (DEWHA) (2010a). Survey Guidelines for Australia's Threatened Birds
- DEWHA (2010b). Survey Guidelines for Australia's Threatened Frogs
- DEWHA (2011a). Survey Guidelines for Australia's Threatened Reptiles and
- DEWHA (2011b). Survey Guidelines for Australia's Threatened Mammals.

2.10 Trapping and Remote Surveys

Terrestrial Hair Funnels

Terrestrial Faunatech hair funnels were baited with a rolled oats and peanut butter mixture. All terrestrial hair funnels were positioned amongst habitat features such as logs, fallen bark, rocks and ground cover. Three lines of 20 hair funnels were left in position from 25 November 2014 to 23 December 2014 (refer to **Figure 2.2**). All hair samples collected were identified by Barbara Triggs (a recognised expert in the field of hair and scat identification).

Remote Cameras

During November and December 2014, remote camera surveys were conducted to target terrestrial mammal species at 10 locations across the Modification Area. At each site, a Bushnell Trophy Cam HD remote camera was mounted approximately 1 metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey. Cameras were set to take three photos in quick succession when movement was detected. Remote cameras were set at each site for 28 days resulting in a total of 280 camera day/nights of survey. The locations of the remote cameras are displayed on **Figure 2.2**.

Micro-bat Echolocation Recordings

Echolocation calls emitted by micro-bats were detected using an Anabat II Bat Detector. Echolocation calls were recorded using an Anabat CF storage ZCAIM or an Anabat SD2 unit. The combination of detector and recording device is hereafter collectively referred to as the 'Anabat echolocation recorder'. The Anabat echolocation recorders were positioned at an approximate 30 degree angle and 1 metre above the ground

in waterproof housing. While micro-bat activity is likely to be reduced during rain, calls were still able to be collected during dry parts of the night (particularly nights with brief thunderstorms).

Anabat echolocation recorders were positioned within the vicinity of potential micro-bat flyways. The recorders were automated and programmed to start recording one hour before dusk and to stop recording one hour after sunrise the following morning. Recordings were collected over two to four nights at each Anabat echolocation recording location.

All micro-bat species were identified by Anna McConville of Echo Ecology Pty Limited (a recognised expert in the identification of micro-bat calls). The location of Anabat surveys are shown on **Figure 2.2**. Micro-bat echolocation recordings were undertaken at three locations.

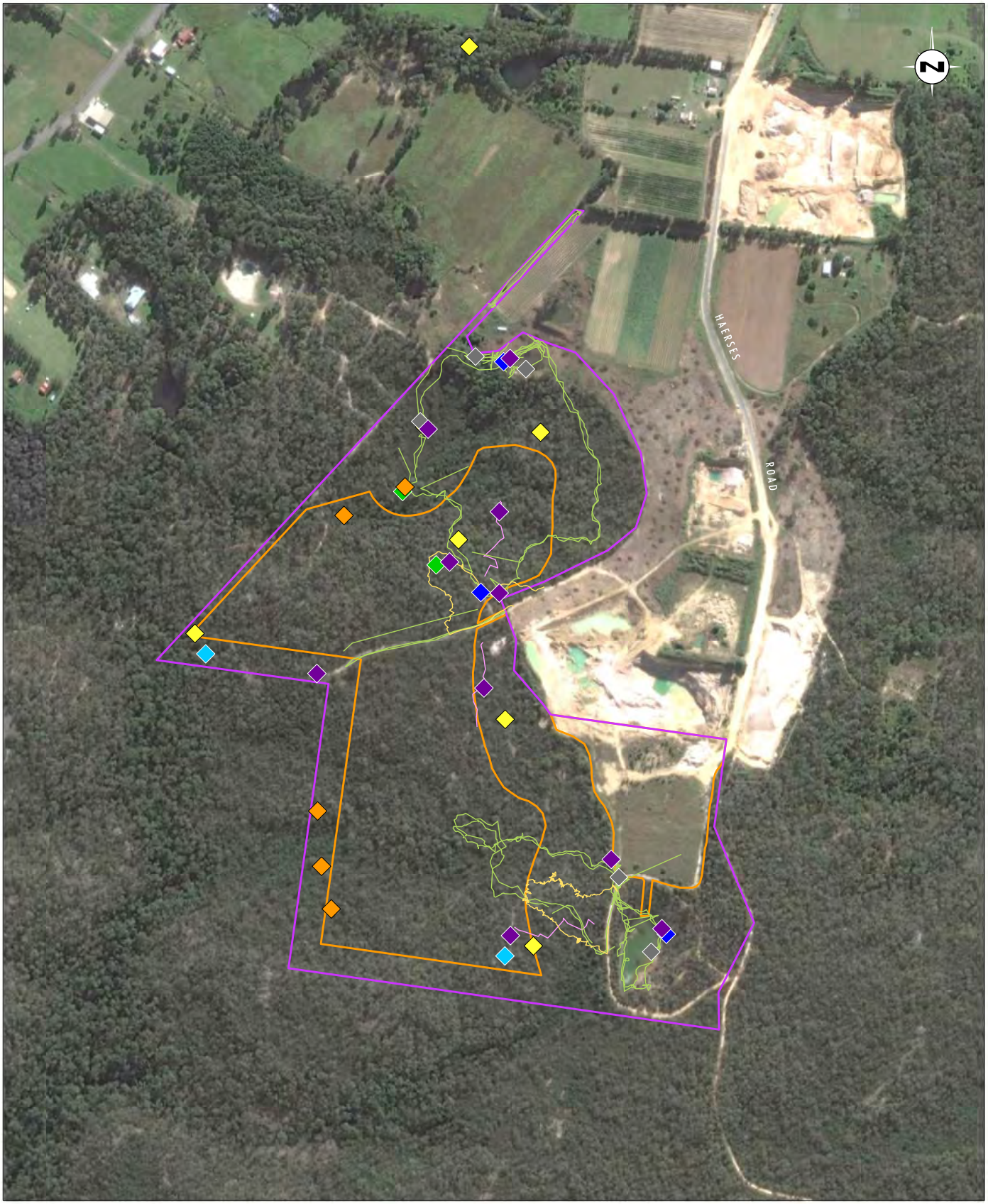


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Dural woodland snail search
- Spotlighting Search
- Terrestrial Hair Funnel Line
- Anabat
- Bird Search
- Habitat Assessments and SAT Test
- Nocturnal Call Playback
- Remote Camera
- Reptile Search
- SAT Test

FIGURE 2.2

Fauna Survey Locations

File Name (A4): R04/3479_031.dgn
20160920 11.14

2.11 Area-based Searches

Spotlighting Searches

Spotlighting searches were undertaken both on foot and from a moving vehicle (refer to **Figure 2.2**). Walking spotlighting searches were undertaken by two observers for a period of one hour (total of two person hours) on each occasion. Vehicle spotlighting searches were undertaken by the passenger(s) from a slow moving vehicle along vehicle tracks between trapping sites. Both walking and vehicle spotlighting searches were conducted using 30 watt Lightforce spotlights.

Reptile and Amphibian Searches

Diurnal searches targeting the Broad-headed snake, *Hoplocephalus bungaroides*, and Rosenberg's goanna, *Varanus rosenbergi*, were undertaken during the warmest parts of the day. Diurnal searches were undertaken by a single person for half an hour on two separate days (refer to **Figure 2.2**). Nocturnal searches targeted the red-crowned toadlet, *Pseudophryne australis*, and giant burrowing frog, *Heleioporus australiacus*. Nocturnal reptile and amphibian searches were undertaken by two people for one hour on two occasions using Petzl headlamps and/or 30 watt Lightforce spotlights. Diurnal and nocturnal searches were undertaken by two ecologists for a period of at least 30 minutes during each search.

Habitat features investigated during reptile and amphibian searches included water bodies, emergent vegetation, wet soak areas, logs, rocks, loose bark on tree trunks, exposed bedrock, leaf litter, and open grassland areas. Amphibians not identifiable from their calls were captured for visual identification. All amphibians were handled according to the hygiene protocol for the control of disease in frogs (Wellington and Haering 2001). Non-venomous snake species and small lizards were captured for identification where necessary.

Bird Searches

Bird searches were undertaken at the trap and hair funnel sites (refer to **Figure 2.2**) at various times of the day, primarily during early to mid morning and mid to late afternoon. Bird searches were undertaken for one person hour (by one or two observers) at two locations. Opportunistic observations were recorded during all other aspects of the field surveys, particularly while checking traps and when travelling between survey sites. Bird species were identified by characteristic calls and by observation using 10 x 24 binoculars.

Dural Woodland Snail Searches

Targeted spotlighting searches for the Dural woodland snail (*Pommerhelix duralensis*) were completed on 16 December 2016 by two observers. These searches were completed on foot at two separate locations within the Development Area (refer to **Figure 2.2**) for a period of 40 and 70 minutes (total of 1.3 and 2.3 person hours). Walking spotlighting searches were conducted using Petzl headlamps and/or 30 watt Lightforce spotlights. Photographs and specimen measurements of the recorded Dural woodland snail were sent to the Australian Museum for identification.

Signs of Presence Searches

Searches for indirect evidence of animal presence were conducted opportunistically during all survey activities, particularly during habitat searches and reptile and amphibian searches. Due to the opportunistic nature of signs of presence surveys, the level of survey effort was not recorded. Evidence of presence included scats, feathers, nests, burrows, bones, tufts of hair and scratch marks on trees. All hair, scat and bone samples were identified by Barbara Triggs.

Habitat Assessments

Seven habitat assessments were undertaken across the range of habitat types present in the Modification Area (refer to **Figure 2.2)**. The assessment targeted potential habitat and resources for fauna species, particularly threatened fauna species. Records of a number of habitat features were made at each site, including:

- Evidence of disturbance such as fire, weeds, feral animals, dumping, erosion and logging
- Presence of stumps and stags
- Presence of fallen timber/logs
- Presence of dieback and/or insect attack
- Mistletoe presence
- Presence of perch sites, fallen and loose bark
- Vegetation strata and composition
- Tree size class (trunk diameter), and age (old growth, mature, regenerating, saplings)
- Presence of other specific feed tree species (such as for cockatoos and honeyeaters) and
- Collection of detailed hollow data, including tree species and height, hollow size, orientation, position, and height of hollow).

Habitat features such as tree hollows and fallen logs were inspected for any evidence of fauna occupation such as scratches on the trunks of trees, chewed entrances to hollows, scratching or diggings near logs and scats at the base of trees or near logs.

Nocturnal Call Playback

Nocturnal call playback sessions were undertaken at five sites within the first 4 hours after dusk. Calls were broadcast using a 10 watt directional loud hailer. Call playback sessions commenced and ended with a quiet listening period of approximately two minutes. Each species' call was played for a minimum of four minutes followed by a listening period of two minutes before the beginning of the next species' call. Mammal calls were played before bird calls to prevent the calls of predators (such as owls) decreasing the likelihood of prey species (such as gliders) responding to call playback. Call playback sessions included the calls of the following species:

- Giant burrowing frog (*Heleioporus australiacus*)
- Red-crowned toadlet (*Pseudophryne australis*)
- Squirrel glider (*Petaurus norfolcensis*)
- Koala (*Phascolarctos cinereus*)
- Masked owl (*Tyto novaehollandiae*)
- Sooty owl (*Tyto tenebricosa*)

- Barking owl (*Ninox connivens*) and
- Powerful owl (*Ninox strenua*).

Fauna Survey Effort Summary

Table 2.4 summarises the trapping and remote camera survey effort undertaken across the Modification Area during spring 2014.

Table 2.4 Summary of Fauna Trapping and Remote Survey Effort

Trapping Method	Number of trap nights – Spring 2014
Terrestrial hair funnel	1680
Anabat echolocation (entire nights)	6
Remote cameras	280

Note: One trap night equals one trap/camera/detector set for one night.

Table 2.5 summarises the area search effort undertaken across the Modification Area during spring 2014.

Table 2.5 Summary of Fauna Area Search Effort

Survey Method	Spring 2014	Summer 2015
Bird surveys (person hours)	2	-
Koala SAT survey points	12	-
Diurnal reptile and amphibian surveys (person hours)	1	-
Nocturnal reptile and amphibian surveys (person hours)	4	-
Walking spotlight	4	-
Dural woodland snail spotlight (person hours)	-	7.2
Driving spotlight	Undertaken opportunistically, kilometres not recorded	-
Nocturnal call playback	5	-

2.12 Threatened Species

2.12.1 Species-credit Flora Surveys

Species-credit flora surveys were undertaken over 7 days and 2 survey periods:

- 25 to 27 November 2014
- 14 to 17 December 2015.

The November 2014 field survey was undertaken at a time which was suitable for detection of most targeted species. An additional targeted species survey was undertaken in December 2015 to focus primarily on threatened flora species as the earlier survey was combined with fauna survey efforts. It should be noted that all threatened flora species are species-credit species under the BioBanking Assessment Methodology (OEH 2014).

A preliminary list of species-credit flora species with potential to occur in the Development Site was generated during the literature review, completion of database searches and preliminary assessment using the BioBanking Credit Calculator. The preliminary list of potentially occurring species credit species was reviewed to remove species that are not known to occur in the local area or species for which there was a lack of suitable habitat in the Development Site. **Table 2.6** identifies the species-credit flora species that were identified through the BioBanking Credit Calculator, we have amended the table to identify those species that have potential to occur in the Development Site and required targeted and seasonal surveys, as well as those that do not.

Table 2.6 Species-credit Flora Species Requiring Targeted Survey

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Potential to Occur					
Acacia gordonii	*Acacia gordonii*	E	E	All Year	BBCC
Ancistrachne maidenii	*Ancistrachne maidenii*	V	-	December – February	BBCC
Asterolasia elegans	*Asterolasia elegans*	E	E	All Year	BBCC
brown Pomaderris	*Pomaderris brunnea*	E	V	All Year	BBCC
Bynoes wattle	*Acacia bynoeana*	E	V	September – March	BBCC
clandulla geebung	P*ersoonia marginata*	V	V	All Year	BBCC
Darwinia biflora	*Darwinia biflora*	V	V	September – February	BBCC

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Darwinia fascicularis subsp. *oligantha* population, Baulkham Hills and Hornsby Local Government Areas	*Darwinia fascicularis* subsp. *oligantha* - endangered population	EP	-	All year	BBCC
Darwinia peduncularis	*Darwinia peduncularis*	V	-	All Year	BBCC
Grevillea parviflora subsp. *supplicans*	*Grevillea parviflora* subsp. *supplicans*	E	-	All year	BBCC
hairy geebung	*Persoonia hirsuta*	E	E	December – May	BBCC
Hibbertia superans	*Hibbertia superans*	E	-	July – December	BBCC
Kunzea rupestris	*Kunzea rupestris*	V	V	All Year	BBCC
Leucopogon fletcheri subsp. *fletcheri*	*Leucopogon fletcheri* subsp. *fletcheri*	E	-	All Year	BBCC
Micromyrtus blakelyi	*Micromyrtus blakelyi*	V	V	All Year	BBCC
Olearia cordata	*Olearia cordata*	V	V	All Year	BBCC
Pimelea curviflora subsp. *curviflora*	*Pimelea curviflora* subsp. *curviflora*	V	V	All Year	BBCC
spreading guinea flower	*Hibbertia procumbens*	E	-	December - March	BBCC
Tetratheca glandulosa	*Tetratheca glandulosa*	V	-	July – November	BBCC
Zieria involucrata	*Zieria involucrata*	E	-	All Year	BBCC

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Unlikely to Occur					
downy wattle	*Acacia pubescens*	V	V	All Year	BBCC
Epacris purpurascens subsp. *purpurascens*	*Epacris purpurascens* subsp. *purpurascens*	V	-	All Year	BBCC
Eucalyptus sp. Cattai	*Eucalyptus* sp. Cattai	CE	-	All Year	BBCC
groves paperbark	*Melaleuca groveana*	V	-	All Year	BBCC
Gyrostemon thesioides	*Gyrostemon thesioides*	E	-	All Year	BBCC
Hibbertia puberula	*Hibbertia puberula*	E	-	September – February	BBCC
Leptospermum deanei	*Leptospermum deanei*	V	V	All Year	BBCC
netted bottle brush	*Callistemon linearifolius*	V	-	September – March	BBCC
Pultenaea parviflora	*Pultenaea parviflora*	E	V	All Year	BBCC
singleton mint bush	*Prostanthera cineolifera*	V	V	All Year	BBCC
Velleia perfoliata	*Velleia perfoliata*	V	V	September - November	BBCC

^ Months that surveys are required according to the Threatened Species Profile Database for the Hawkesbury Nepean CMA.

Throughout flora surveys of the Development Site, targeted searches were carried out for threatened flora species that are known to occur in the vicinity of the Development Site or were considered likely to occur based on the species' known distribution and the presence of suitable habitat. Searches for these species were undertaken in suitable habitat along numerous walking meandering transects and within the plot and transect surveys.

Further survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot. The methodology is described in full for the targeted *Darwinia biflora* survey above in **Section 2.7.**

The seasonal requirements of all species-credit flora species with potential to occur within the Development Site were met between the combination of the November 2014 and December 2015 survey periods.

2.12.2 Species-credit Fauna Surveys

Species-credit fauna surveys were undertaken over **6** days and **two** survey periods:

- 25 to 27 November 2014
- 14 to 17 December 2015.

A preliminary list of species-credit fauna species with potential to occur in the Development Site was generated during the literature review, completion of database searches and preliminary assessment using the BioBanking Credit Calculator (BBCC). The preliminary list of potentially occurring species-credit fauna species was reviewed to remove species that are not known to occur in the local area or species for which there was a lack of suitable habitat in the Development Site. **Table 2.7** identifies the species-credit fauna species that were identified through the BioBanking Credit Calculator. The table has been amended to identify those species that have potential to occur in the Development Site and required targeted and seasonal surveys, as well as those that do not.

Table 2.7 Species-credit Fauna Species Requiring Targeted Survey

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Potential to Occur					
brush-tailed phascogale	*Phascogale tapoatafa*	V	-	All Year	
eastern pygmy-possum	*Cercartetus nanus*	V	-	Not specified	BBCC

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	EP	-	All Year	BBCC
giant burrowing frog	*Heleioporus australiacus*	V	V	September - May	BBCC
koala	*Phascolarctos cinereus*	V	V	All Year	BBCC
red-crowned toadlet	*Pseudophryne australis*	V	-	All Year	BBCC
regent honeyeater	*Anthochaera phrygia*	CE	CE	All Year	BBCC
Rosenbergs goanna	*Varanus rosenbergi*	V	-	November – February	BBCC
squirrel glider	*Petaurus norfolcensis*	V	-	All Year	BBCC
Unlikely to Occur					
giant barred frog	*Mixophyes iteratus*	E	E	October – April	BBCC

^ Months that surveys are required according to the Threatened Species Profile Database for the Hawkesbury Nepean CMA.

Targeted surveys were undertaken for the species listed in **Table 2.7** that included a range of survey techniques including targeted searches, hair funnel trapping, call playback, anabat echolocation, spotlighting and remote detection camera surveys. Throughout surveys of the Development Site, opportunistic surveys for these species were undertaken in suitable habitat along numerous walking meandering transects. The seasonal requirements of all species-credit fauna species with potential to occur within the Development Site were met between the combination of the November 2014 and December 2015 survey periods. The details of these surveys are discussed in the sections below and specific survey locations are shown on **Figure 2.2.**

2.12.2.1 Regent Honeyeater Surveys

Diurnal bird surveys, each of one person-hour, were undertaken in two locations within the Development Site in November 2014. Bird surveys were undertaken at various times of the day, primarily in early to mid morning and mid to late afternoon. Each survey consisted of a slow walking transect within a Development Site. The bird surveys targeted areas of flowering eucalypt woodlands containing other nectarivorous species such as lorikeets and honeyeaters.

Bird species were identified from characteristic calls and by observation using binoculars with magnification up to 10 x. Opportunistic observations were recorded during all other aspects of the field survey.

2.12.2.2 Eastern Pygmy Possum and Squirrel Glider Surveys

Eastern pygmy possum and squirrel glider were targeted by conducting spotlighting and remote camera surveys. Additionally, nocturnal call playback surveys were undertaken for squirrel glider.

Nocturnal spotlighting surveys, each of two person-hours repeated over two nights, were undertaken in three locations within the Development Site. Spotlighting was conducted on foot using 30 watt Lightforce hand-held spotlights and head torches. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk. In addition, spotlighting was undertaken from a slow-moving vehicle along vehicle tracks and while travelling between trapping locations at night.

Bushnell Trophy Cam HDs (remote cameras) were mounted approximately one metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey to increase the likelihood of detecting the eastern pygmy possum. The cameras were set to take three photos in quick succession when movement was detected. The remote cameras were programmed to record movement on an ongoing basis until removed from the site. The cameras were installed for 28 nights in 10 locations, totalling 280 nights of remote camera survey.

Nocturnal call-playback sessions targeting squirrel glider were undertaken at four locations within the Development Site. An additional location was surveyed immediately north of the Development Site for context. Call-playback sessions commenced with a quiet listening period of approximately five minutes. The squirrel glider call was played on a 15 watt directional loud hailer for a minimum of 4 minutes followed by a listening period of 2 minutes.

2.12.2.3 Koala Surveys

Koalas were targeted by conducting nocturnal call playback and walking and driving spotlighting surveys.

Nocturnal spotlighting surveys, each of one person-hour repeated over two nights, were undertaken in three locations within the Modification Area. Walking spotlighting searches were conducted by two observers for a period of one hour (total of two person hours) on each occasion. Vehicle spotlighting searches were undertaken by the passenger(s) from a slow moving vehicle along vehicle tracks between trapping sites. Both walking and vehicle spotlighting searches used a 30 watt Lightforce hand-held spotlight and head torch for detecting fauna. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk.

Nocturnal call-playback sessions targeting koala were undertaken at four locations within the Development Site. An additional location was surveyed immediately north of the Development Site for context. Call-playback sessions commenced with a quiet listening period of approximately five minutes. The koala call was played on a 15 watt directional loud hailer for a minimum of 4 minutes followed by a listening period of 2 minutes.

Searches for signs of the presence of koalas were undertaken at 12 locations across the Modification Area in using the Spot Assessment Technique (SAT). Searches were conducted on and around the base of 10 – 30 trees at every survey site. The searches focussed on signs of presence including scats at the base of trees and characteristic scratches on tree trunks.

2.12.2.4 Amphibian Surveys

The BioBanking Calculator predicted the occurrence of red-crowned toadlet (*Pseudophryne australis*) and giant burrowing frog (*Heleioporus australiacus*) due to the geographic habitat feature of land within 100 metres of a waterbody and land within 40 metres of woodland within the Hawkesbury/Nepean catchment area, respectively. Despite these habitat features being present at the site in the form of woodland and two dams, no permanent streams with substantial fringing vegetation occur in the Development Site.

Despite this, diurnal herpetological searches were undertaken in 2 locations across the Development Site. During the search likely micro-habitats were examined including around waterbodies, beneath rocks and logs, in tree bark and in ground litter. Each survey consisted of approximately one person hour of survey, totalling 1 hour of diurnal herpetological surveys.

Nocturnal spotlighting surveys, each of two person-hours repeated over two nights, were also undertaken in three locations within the Modification Area. Spotlighting was conducted on foot using 30 watt Lightforce hand-held spotlights and head torch. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk and targeted relevant habitat features such as water bodies, emergent vegetation, wet soak areas and riparian zones.

2.12.2.5 Micro-bat Habitat Surveys

The presence of threatened micro-bat species was also surveyed using Anabat SD1 recorders at two locations within the Development Site. At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flight paths or over waterbodies to increase the likelihood of detecting micro-bat species. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise.

Recordings of bat calls were analysed by Anna McConville of Echo Ecology Pty Limited (a recognised expert in the identification of micro-bat calls). The echolocation calls of species were identified to one of three levels of confidence:

- confident
- probable, and
- possible.

3.0 Results – Development Site

3.1 Landscape Value

3.1.1 Landscape Features

The outer assessment circle contains some prominent landscape features including sections of 4th order streams, Stone Chimney Arm Creek and Little Cattai Creek. The outer assessment circle also covers multiple Mitchell landscapes and an extensive area of native vegetation predominantly in the east, south and west of the circle. These landscape features are shown in **Figures 1.3** and **1.4**.

Landscape features that were considered in the connectivity value scores for the Development Site are outlined in **Table 3.1** below.

Table 3.1 Landscape Features in the Development Site

Landscape Features	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Yengo – Hawkesbury/Nepean
Mitchell Landscape	Hornsby Plateau
Rivers, Streams, Estuaries	1st order streams from Stone Chimney Arm Creek
Wetlands	None identified
Native Vegetation	82.19 hectares in the inner assessment circle 745.59 hectares in the outer assessment circle
State or Regional Biodiversity Links	None identified

3.1.2 Landscape Value Scores

3.1.2.1 Percent Native Vegetation Cover

Table 3.2 details the percent native vegetation cover before and after the proposed disturbance in the Development Site and the native vegetation per cent class entered into the BioBanking Calculator as per Table 9 of Appendix 4 of the FBA (OEH 2014).

Table 3.2 Native Vegetation Cover in Assessment Circles

Assessment Circle	Before Development			After Development		
	Area of Native Vegetation (ha)	Native Vegetation Cover (%)	Native Vegetation Percent Class	Area of Native Vegetation (ha)	Native Vegetation Cover (%)	Native Vegetation Percent Class
Outer (1,000 ha)	745.59	74.6	71-75	725.65	72.6	71-75
Inner (100 ha)	82.19	82.2	81-85	62.69	62.7	61-65

3.1.2.2 Connectivity Value

No state or regional significant biodiversity links were identified within a plan approved by the Chief Executive of OEH in the Yengo – Hawkesbury/Nepean. Although a number of first order streams of tributaries of Stone Chimney Arm Creek run through the Development Site, these are not defined as state or regional significant biodiversity links under the FBA (OEH 2014) (refer to **Figure 3.1**).

Connecting links using moderate to good condition native vegetation were found on the site to occur in all woodland communities in the Development Site. The entire Development Site comprises remnant native vegetation and thus the current narrowest point of these links is estimated to be approximately greater than 500 metres wide (refer to **Figure 3.1**). After the development of the Modification Project, this link would remain, not in the Development Site but surrounding it. Therefore it is considered that the connectivity width class after the development of the Modification Project would be greater than 500 metres wide (refer to **Table 3.3**).

Woody PCTs within the outer assessment circle were assumed to be in good condition for overstorey foliage cover and midstorey foliage cover. This assumption was based on the location of the Development Site, abundance of adjacent remnant vegetation and quality of the vegetation within the Development Site. The overstorey per cent foliage cover in the woody vegetation in the outer assessment circle was assumed, on the whole, to be within benchmark. The midstorey per cent foliage cover in the woody vegetation in the outer assessment circle was assumed, on the whole, to be within benchmark. These are likely to remain the same after the Modification Project.

Details of the connectivity value scores entered into the BioBanking Credit Calculator are shown in **Table 3.3** below.

Table 3.3 Connectivity Value Scores

Attribute	Before Development	After Development
Connectivity Width Class	>500m	>500m
Connectivity Overstorey Condition	PFC at benchmark	PFC at benchmark
Connectivity Midstorey Condition	PFC at benchmark	PFC at benchmark

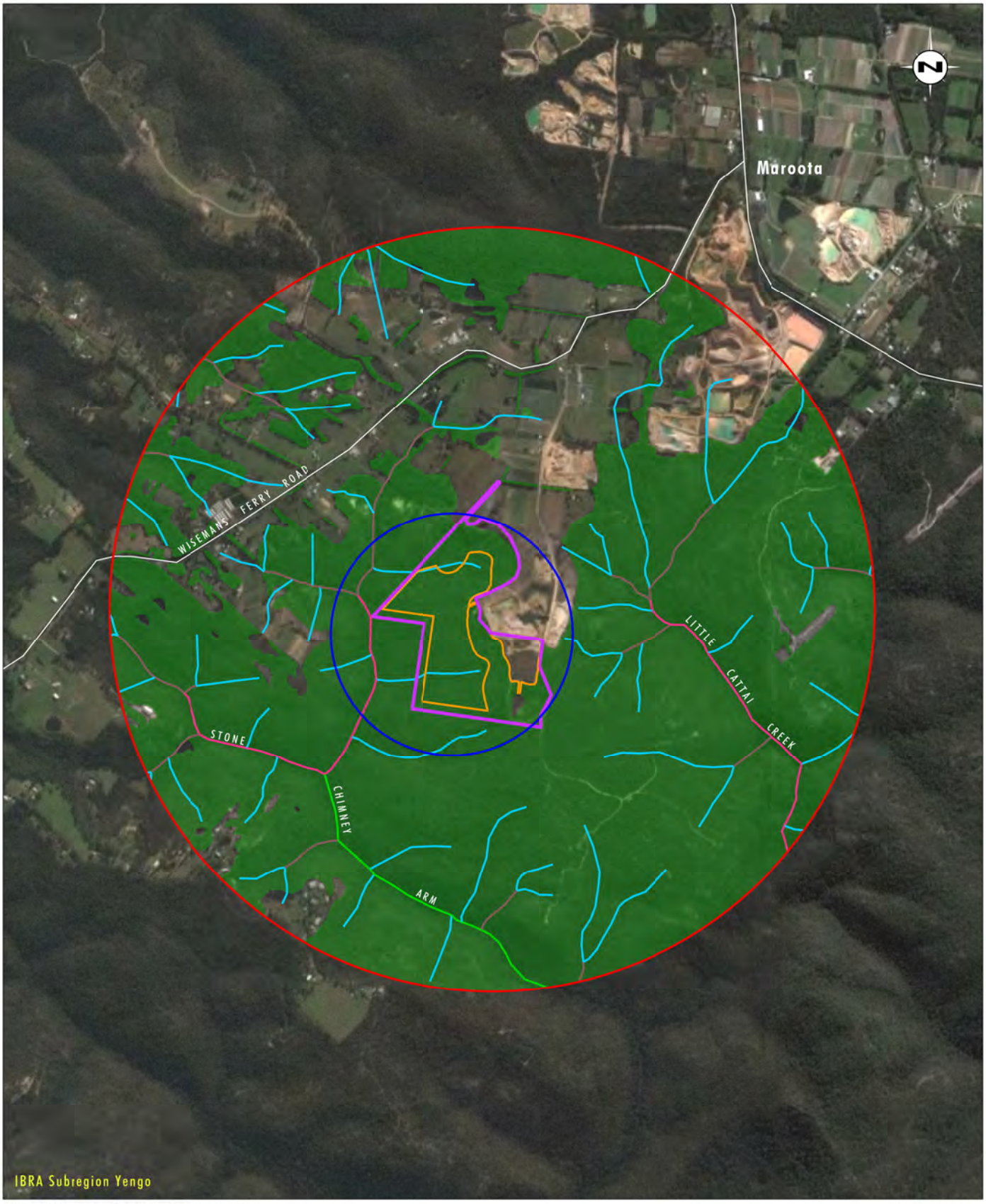


Image Source: Google Earth (2014)
Data Source: LPI (2011)

0 0.5 1.0 1.25km
1:25 000

Legend

- Development Site
- Modification Area
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle
- Native Vegetation
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream

FIGURE 3.1

Connectivity Value

File Name (A4): R04/3479_032.dgn
20160920 11.15

3.1.2.3 Patch Size

Table 3.4 below details the parameters that determined the Patch Size score as per Table 15 of Appendix 4 of the FBA (OEH 2014).

Table 3.4 Patch Size Score Parameters

Mitchell Landscape	Hornsby Plateau
Percent Native Vegetation Cleared	14%
Patch Size Class	1001 hectares
Patch Size Score	**12**

3.1.2.4 Landscape Value Score

The landscape value score for the Development Site is 13.20.

3.2 Native Vegetation within the Development Site

3.2.1 Biometric Vegetation Types and Vegetation Zones

Surveys of the Development Site identified four Biometric Vegetation Types (BVTs) (excluding exotic pastures) being:

- HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion
- HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
- HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion and
- HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion.

These BVTs were aligned with types described as part of the NSW Biometric vegetation types database (OEH 2014b), the Sydney Basin Vegetation Inventory (Tozer *et al.* 2010) and the Baulkham Hills Vegetation Mapping. The BVTs were then categorised into four vegetation condition zones (refer to **Figure 3.2**). The composition of these vegetation zones are outlined in **Tables 3.5** to **3.8** below.

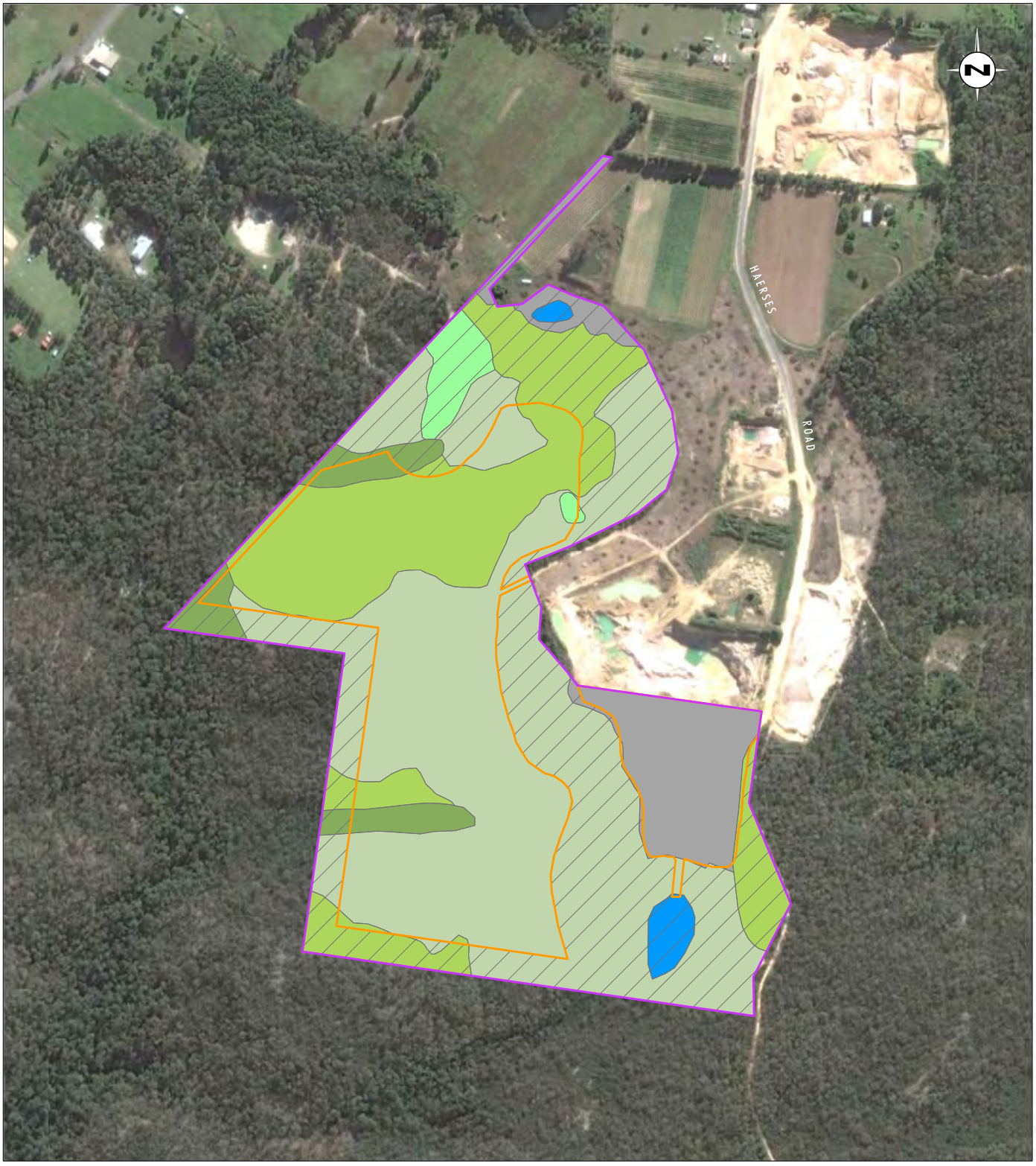


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Area Mapped Outside The Development Site
- Modification Area
- Cleared
- Dam
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition

FIGURE 3.2

Vegetation Zones in the Development Site

Table 3.5 Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN560
PCT ID	978
Vegetation Formation	Freshwater Wetlands
Vegetation Class	Coastal Heath Swamps
Hectares in Modification Area	1.03
Hectares in Development Site	0.08
Tozer *et al.* (2010) Equivalent	FrW p129: Coastal Upland Swamp
AES Environmental Consultancy (2001) Equivalent	N/A
Plots/Transects Undertaken	One (P04)
Floristic Description	This vegetation zone occurs at two locations where ground water seeps to the surface. This vegetation zone is characterised by a mid-dense shrub layer dominated by dwarf apple (*Angophora hispida*), prickly tea-tree (*Leptospermum juniperinum*), heath-leaved banksia (*Banksia ericifolia*), fern-leaved banksia (*Banksia oblongifolia*), *Leucopogon esquamatus*, crimson bottlebrush (*Callistemon citrinus*) and heath myrtle (*Baeckea imbricata*). The dense ground layer is dominated by zig-zag bog rush (*Schoenus brevifolius*), *Ptilothrix deusta*, *Leptocarpus tenax*, spreading rope-rush (*Empodisma minus*), *Drosera spatulata* and pouched coral fern (*Gleichenia dicarpa*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	*Coastal Upland Swamp in the Sydney Basin Bioregion EEC*
EPBC Status	*Coastal Upland Swamps in the Sydney Basin Bioregion EEC*

Feature	Description
Photo	

Table 3.6 Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN566
PCT ID	1083
Vegetation Formation	Dry Sclerophyll Forests (Shrubby sub-formation)
Vegetation Class	Sydney Coastal Dry Sclerophyll Forests
Hectares in Modification Area	11.46
Hectares in Development Site	6.67
Tozer *et al.* (2010) Equivalent	DSF p131 Coastal Sandstone Ridgetop Woodland
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Ridgetop Woodland
Plots/Transects Undertaken	Three (SR1, P01 and P06)

Feature	Description
Floristic Description	This vegetation zone supports a sparse canopy dominated by yellow bloodwood (*Corymbia* eximia), red bloodwood (*Corymbia gummifera*), narrow-leaved stringybark (*Eucalyptus sparsifolia*) and grey gum (*Eucalyptus punctata*). A dense shrub layer is present and comprises flakey-barked tea-tree (*Leptospermum trinervium*), mountain devil (*Lambertia formosa*), needlebush (*Hakea sericea*), heath-leaved banksia (*Banksia ericifolia*), *Darwinia biflora* and conesticks (*Petrophile pulchella*). The ground layer generally comprises lesser flannel flower (*Actinotus minor*), wiry panic (*Entolasia stricta*), *Lepyrodia scariosa*, *Austrostipa pubescens* and oat speargrass (*Anisopogon avenaceus*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.
Photo	

Table 3.7 Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN582
PCT ID	1134
Vegetation Formation	Heathlands
Vegetation Class	Sydney Coastal Heaths
Hectares in Modification Area	24.49
Hectares in Development Site	11.14

Feature	Description
Tozer *et al.* (2010) Equivalent	Coastal Sandstone Plateau Heath
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Heath
Plots/Transects Undertaken	Three (SH1, P02 and P03)
Floristic Description	This vegetation zone is dominated by a dense cover of shrubs, with emergent eucalyptus scattered throughout and forming an open woodland community in some areas. Emergent eucalypts include scribbly gum (*Eucalyptus haemastoma*), red bloodwood (*Corymbia gummifera*) and scaly bark (*Eucalyptus squamosa*). Common shrubs include flakey-barked tea-tree (*Leptospermum trinervium*), dwarf apple (*Angophora hispida*), heath-leaved banksia (*Banksia ericifolia*), mountain devil (*Lambertia formosa*), *Darwinia biflora*, grey spider flower (*Grevillea buxifolia*) and conesticks (*Petrophile pulchella*). The ground layer generally comprises grasstree (*Xanthorrhoea* sp.), lesser flannel flower (*Actinotus minor*), heath bog-rush (*Schoenus ericetorum*), wiry panic (*Entolasia stricta*) and *Ptilothrix deusta*. Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.
Photo	

Table 3.8 Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN586
PCT ID	1181
Vegetation Formation	Dry Sclerophyll Forests (Shrubby sub-formation)
Vegetation Class	Sydney Coastal Dry Sclerophyll Forests
Hectares in Modification Area	1.91
Hectares in Development Site	0.99
Tozer *et al.* (2010) Equivalent	DSF p142 Coastal Sandstone Gully Forest
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Gully Forest
Plots/Transects Undertaken	One (P05)
Floristic Description	This vegetation zone supports a sparse to mid-dense canopy dominated by smooth-barked apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), grey gum (*Eucalyptus punctata*), yellow bloodwood (*Corymbia eximia*), and old-man banksia (*Banksia serrata*), with occurrences of red bloodwood (*Corymbia gummifera*), turpentine (*Syncarpia glomulifera* subsp. *glomulifera*) and red mahogany (*Eucalyptus resinifera* subsp. *resinifera*). A mid-dense shrub layer is present and comprises flakey-barked tea tree (*Leptospermum trinervium*), white wattle (*Acacia linifolia*), tantoon (*Leptospermum polygalifolium*), heath-leaved banksia (*Banksia ericifolia*), spiny bossiaea (*Bossiaea obcordata*), hairpin banksia (*Banksia minor*), and *Dillwynia retorta*. The ground layer generally comprises lesser flannel flower (*Actinotus minor*), spiny-headed mat-rush (*Lomandra longifolia*), wiry panic (*Entolasia stricta*), *Lepyrodia scariosa*, *Gahnia* sp. and common bracken (*Pteridium esculentum*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.

Feature	Description
Photo	

3.2.2 Current Site Value

Table 3.9 below details the current site value scores for each of the vegetation zones in the Development Site. The raw site condition attribute data for each of the vegetation zones is provided in **Appendix B**.

Table 3.9 Vegetation Zone Site Value Scores

Vegetation Zone No.	Vegetation Zone	Current Site Value Score (out of 100)
1	HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion	56.52
2	HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion	81.77
3	HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion	69.10
4	HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion	63.77

3.2.3 Threatened Ecological Communities

One TEC, listed under the TSC or EPBC Act, was recorded in the Development Site (**Figure 3.3**) being:

- *Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC* under the TSC Act (refer to **Sections 3.2.3.1)** and EPBC Act (refer to **Sections 3.2.3.2)**.

Analysis of consistency to the scientific determinations for each TEC was undertaken, with consideration of the advice provided by the NSW Scientific Committee and/or the Commonwealth Threatened Species Scientific Committee guidelines for interpreting listings for species, populations and ecological communities under the TSC Act and EPBC Act, respectively.

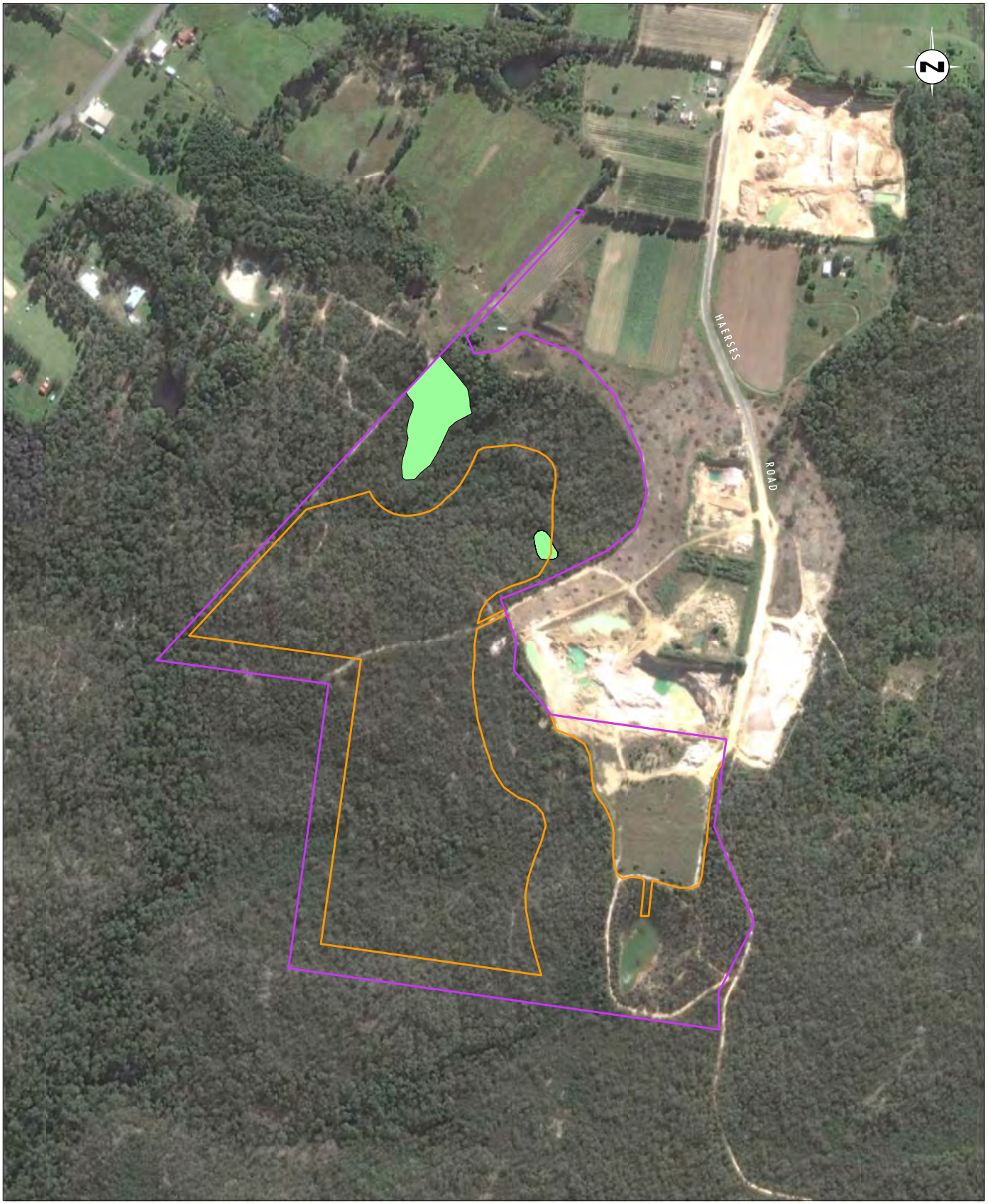


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition (Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act)

FIGURE 3.3

Threatened Ecological Communities within the Development Site

3.2.3.1 *Coastal Upland Swamp in the Sydney Basin Bioregion* EEC under the TSC Act

Coastal Upland Swamp in the Sydney Basin Bioregion is listed as an endangered ecological community under the TSC Act. The community is known to occur on periodically waterlogged soils on Hawkesbury sandstone plateaus, where the mean annual rainfall generally exceeds 950 millimetres. The community is often associated with acid soils ranging from yellow or grey mineral sandy loams that have a shallow organic horizon to highly organic spongy black peats with pallid subsoils, as described in the Final Determination (NSW Scientific Committee 2012).

The vegetation of this community varies from tall scrub, open heath to sedgelands and is usually dominated by sclerophyll shrubs and/or sedges. This EEC is generally treeless however scattered trees may occur.

The Development Site supports a total of 0.08 hectares of Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act within HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition) (**Figure 3.3**). A comprehensive analysis of this vegetation community was undertaken to determine if it conformed to the Final Determination for this community (NSW Scientific Committee 2012).

Constituent Species

The species recorded within Coastal Upland Swamp EEC in the Development Site comprises an assemblage of species consistent with the Final Determination under the Act (NSW Scientific Committee 2012).

This includes a ground layer dominated by zig-zag bog-rush (*Schoenus brevifolius*) and *leptocarpus tenax* below an upper stratum of peach blossom tea-tree (*Leptospermum squarrosum*) and heath-leaved Banksia (*Banksia ericifolia*).

Assemblage of Species

The NSW Scientific Committee (2012) lists 71 species as characterising the assemblage of species for the *Coastal Upland Swamp* EEC. As part of ecological investigations for the Project, one systematic 20 metre x 20 metre quadrat was sampled in *Coastal Upland Swamp* EEC due to the small area present in the Development Site.

A total of 21 species were recorded in the Coastal Upland Swamp EEC quadrat, of these 13 (62 per cent) of the species listed in the Final Determination were present within this community.

Particular Area

In relation to the particular area of the *Coastal Upland Swamp* EEC, the NSW Scientific Committee (2012) states that the community occurs within the Sydney Basin Bioregion on Hawkesbury sandstone plateaus.

The Development Site is located in the Sydney Basin Bioregion on a Hawkesbury sandstone plateau.

Supplementary Descriptors

In relation to supplementary descriptors, the NSW Scientific Committee (2012) includes the following key information pertaining to the *Coastal Upland Swamp* EEC:

- generally has a mean annual rainfall exceeding 950 millimetres
- soils that are acidic and vary from yellow or grey mineral sandy loams with a shallow organic horizon to highly organic spongy black peats with pallid subsoils and

- the vegetation of this community varies from tall scrub, open heath to sedgelands and is usually dominated by sclerophyll shrubs and/or sedges. This EEC is generally treeless however scattered trees may occur.

Of the above supplementary descriptors, the *Coastal Upland Swamp* EEC present in the Development Site occurs on waterlogged soils and comprises dark brown peaty soils above sands, a relatively fertile soil in comparison to adjacent remnant vegetation. The mean annual rainfall for the local area is 919 millimetres, but of the last seven years (2009 – 2015) five have exceeded the required mean annual rainfall of 950 millimetres. The vegetation is dominated by multiple shrubs and sedges, and trees are absent.

3.2.3.2 *Coastal Upland Swamps in the Sydney Basin Bioregion* EEC under the EPBC Act

Coastal Upland Swamps in the Sydney Basin Bioregion is listed as an endangered ecological community under the EPBC Act. This community includes a range of vegetation and fauna associated with periodically waterlogged soils on Hawkesbury sandstone plateaus (TSSC 2014). The listing describes a community that includes open graminoid heath, sedgeland and tall scrub.

The Development Site supports a total of 0.08 hectares of Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act within HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition) (**Figure 3.3**). A comprehensive analysis of this vegetation community was undertaken to determine if it conformed to the Conservation Advice (including Listing Advice) provided by the Department of the Environment under the EPBC Act (TSSC 2014).

Particular Area

The Coastal Upland Swamps in the Sydney Basin Bioregion EEC under the EPBC Act is endemic to NSW and occurs in the eastern part of the Sydney Basin IBRA bioregion (TSSC 2014).

The Development Site is within the Sydney Basin Bioregion.

Additional Criteria

The Conservation Advice (including Listing Advice) for the EEC identifies that it occurs primarily on permeable sandstone plateaux in the low relief headwater valleys with abundant seepage moisture (TSSC 2014). Soils are described to vary from yellow or grey sandy loams with a shallow organic horizon to highly organic spongy black peats (TSSC 2014). Additionally, the EEC swamps predominantly occur at elevations between 200 – 450 metres above sea level, but are also known to occur as low as 20 metres and up to 600 metres above sea level.

The swamp vegetation identified at the Development Site occurs on waterlogged soils and comprise dark brown peaty soils above sands. Specifically, a high degree of seepage moisture was recorded during the field survey. Additionally the development site occurs at approximately 160 metres above sea level.

Vegetative Criteria

A description of the vegetation composition for the EEC is provided in the Conservation Advice (including Listing Advice). It describes a variable mosaic of vegetation that are characterised by soil conditions, size, recent rainfall, fire regimes and disturbance history (TSSC 2014). The EEC is essentially treeless, however trees may be present as scattered individuals or isolated clumps. The advice also provides a list of indicative list of vascular plant species characteristic of the EEC, a list that comprises 73 flora species. However the advice also notes that the total number of vascular plants within the community is likely to exceed 200 species.

As part of ecological investigations for the Project, one systematic 20 metre x 20 metre quadrat was sampled in *Coastal Upland Swamp* EEC due to the small area present in the Development Site.

A total of 21 species were recorded in the Coastal Upland Swamp EEC quadrat, of these 13 (18 per cent) of the species listed in the Conservation Advice (including Listing Advice) were present within this community.

HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition) within the Development Site is deemed to meet the criteria discussed above. It therefore conforms to the Coastal Upland Swamps in the Sydney Basin Bioregion endangered ecological community under the EPBC Act.

3.3 Threatened Species within the Development Site

3.3.1 Ecosystem-credit Species

3.3.1.1 Predicted Species

Table 3.10 below outlines the predicted ecosystem-credit species predicted to occur by the BioBanking Calculator and whether they are considered to occur on site.

Table 3.10 Predicted Ecosystem-credit Species

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
eastern false pipistrelle *Falsistrellus tasmaniensis*	V	-	2.2	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 7 km north west of the site from 2014 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
eastern freetail-bat *Mormopterus norfolkensis*	V	-	2.2	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 5 km south east of the site from 2008 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
eastern grass owl *Tyto longimembris*	V	-	1.3	Yes	Species has not been recorded in the Development Site. There are no known records of this species within 10 kilometres of the Development Site (OEH 2015).
gang-gang cockatoo *Callocephalon fimbriatum*	V	-	2.0	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 2 km south of the site from 2009 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
glossy black-cockatoo *Calyptorhynchus lathami*	V	-	1.8	Yes	Species was not recorded in the Development Site but it was recorded nearby along the eastern boundary of the Project Area during the surveys undertaken for this assessment (refer to **Figure 3.4** and **Section 3.3.1.2**). The Development Site contains foraging habitat for the species.
greater broad-nosed bat *Scoteanax rueppellii*	V	-	2.2	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 5 km south of the site from 2006 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
little eagle *Hieraaetus morphnoides*	V	-	1.4	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 4 km north west of the site from 1994 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
little lorikeet *Glossopsitta pusilla*	V	-	1.8	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 5 km east of the site from 2009 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
New Holland mouse *Pseudomys novaehollandiae*	-	V	2.6	Yes	Species has not been recorded in the Development Site. There are no known records of this species within 10 km of the Development Site (OEH 2015).
scarlet robin *Petroica boodang*	V	-	1.3	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 5 km south of the site from 1975 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
spotted-tailed quoll *Dasyurus maculatus*	V	E	2.6	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 6 km north west of the site from 1979 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
square-tailed kite *Lophoictinia isura*	V	-	1.4	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 9 km south west of the site from 2006 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
swift parrot *Lathamus discolor*	E	E	1.3	Yes	Species has not been recorded in the Development Site. There are no known records of this species within 10 km of the Development Site (OEH 2015).
varied sittella *Daphoenositta chrysoptera*	V	-	1.3	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 3 km south west of the site from 1996 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
yellow-bellied glider *Petaurus australis*	V	-	2.3	Yes	Species has not been recorded in the Development Site. There are several records within approximately 3 km of the site (OEH 2015). The Development Site may contain marginal foraging habitat for the species.
yellow-bellied sheathtail-bat *Saccolaimus flaviventris*	V	-	2.2	Yes	Species has not been recorded in the Development Site. The closest record occurs approximately 9 km south west of the site from 2013 (OEH 2015). The Development Site may contain marginal foraging habitat for the species.

^ As entered into the 'Site Survey Details' tab in the BBCC.

3.3.1.2 Survey Results

One ecosystem credit species, large-eared pied bat (*Chalinolobus dwyeri*), was recorded in the Development Site during the surveys undertaken. One other ecosystem credit species, little bentwing-bat (*Miniopterus australis*), was recorded within the Modification Area (refer to **Figure 3.4**). The Glossy Black-cockatoo was recorded to the east of the Modification area.

A discussion on these records is provided below and a full fauna species list from the surveys undertaken by Umwelt in 2014 and 2015 is included in **Appendix C**.

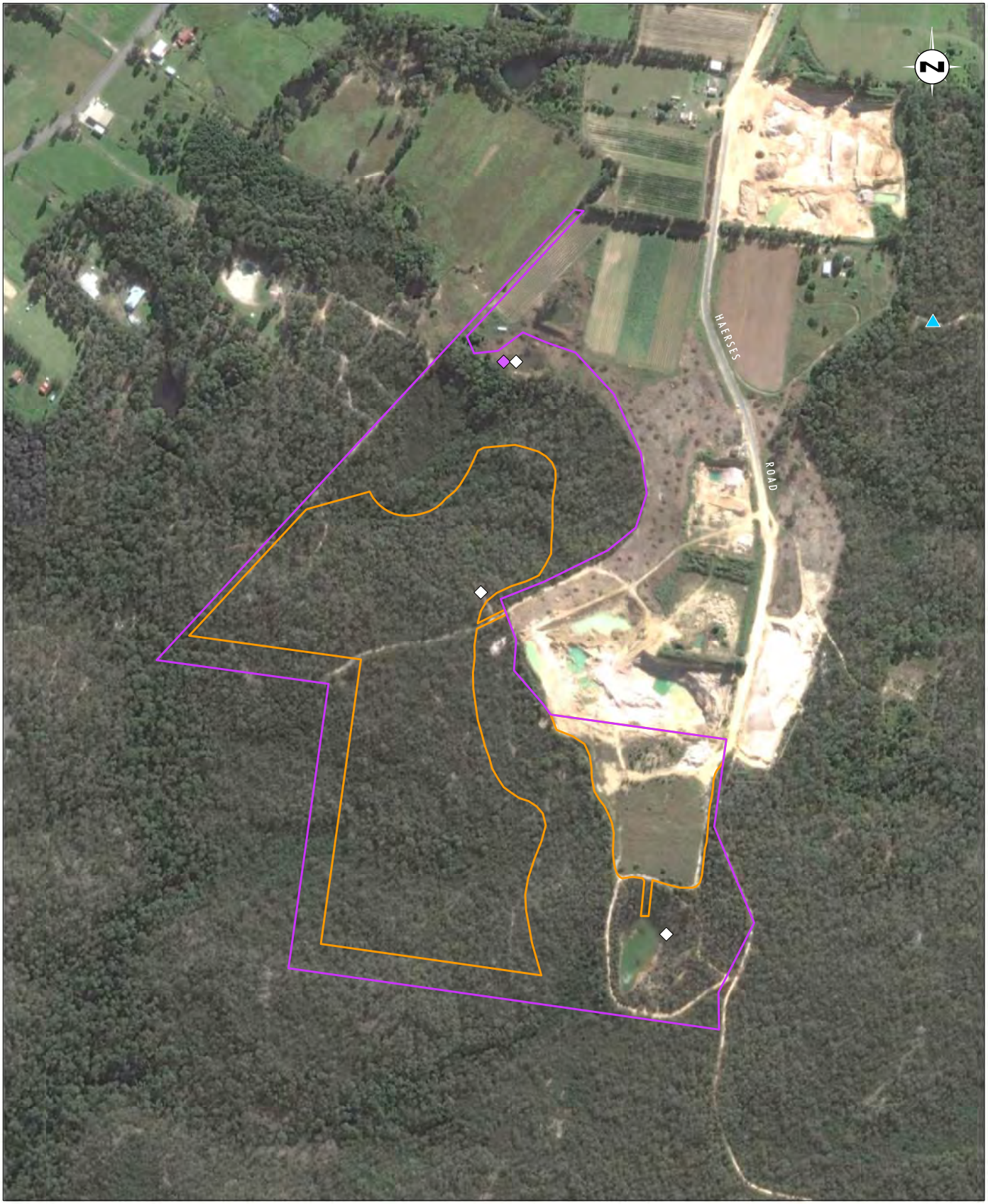


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Glossy Black-cockatoo (2 recorded)
- Little Bentwing-Bat
- Large-Eared Pied-Bat

FIGURE 3.4

Ecosystem-credit Species Recorded in the Development Site

Large-eared Pied Bat – *Chalinolobus dwyeri*

The large-eared pied-bat is listed as vulnerable under the TSC Act and EPBC Act. The species is found in areas with extensive cliffs and caves from Rockhampton, Queensland to Bungonia in New South Wales.

Large-eared pied-bat was not recorded in the Development Site, but rather in the north of the Development Site. It was recorded through use of bat echolocation recordings using an Anabat II Bat Detector. These recordings were then professionally identified by Anna McConville of Echo Ecology Pty Limited.

The Development Site does not contain any roosting habitat for the species but is considered to comprise marginal foraging habitat for this species as part of a wider foraging range in the locality.

Little Bentwing-bat – Miniopterus australis

The little bentwing-bat is listed as vulnerable under the TSC Act. The species is occurs along the eastern coast and ranges of Australia, extending from Cape York, Queensland to Wollongong, New South Wales.

This species was recorded in the Development Site.. It was recorded through use of bat echolocation recordings using an Anabat II Bat Detector. These recordings were then professionally identified by Anna McConville of Echo Ecology Pty Limited.

The Development Site does not contain any roosting habitat for the species but is considered to comprise marginal foraging habitat for this species as part of a wider foraging range in the locality.

3.3.2 Species-credit Species

3.3.2.1 Geographic and Habitat Features

Seven geographic and habitat features (refer to **Table 3.11**) were chosen in the BioBanking Credit Calculator as having broad features that match site habitats at the Development Site. Other geographic and habitat features were considered as not having broad features that match the Development Site habitats and were therefore not relevant to the Development Site and were filtered out of the subsequent steps of the assessment.

Table 3.11 Geographic and Habitat Features in the Development Site

Geographic/Habitat Feature	Relevant Species-credit Species
Land within 250 metres of termite mounds or rock outcrops	Rosenbergs goanna (*Varanus rosenbergi*)
Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 metres of, ephemeral or intermittent drainage lines	red-crowned toadlet (*Pseudophryne australis*)
Land within 40 metres of heath, woodland or forest	giant burrowing frog (*Heleioporus australiacus*)
Ridgetops	*Hibbertia superans*
Sandstone rock outcrops	*Kunzea rupestris*

Geographic/Habitat Feature	Relevant Species-credit Species
Land within Maroota area of Baulkham Hills and Hornsby LGAs in Yengo CMA subregion	*Darwinia fascicularis* subsp. *oligantha* population, Baulkham Hills and Hornsby Local Government Areas (*Darwinia fascicularis* subsp. *oligantha* - endangered population)
Land below 1000 metres in altitude and within 40 m of rainforest or eucalypt forest with deep leaf litter	giant barred frog (*Mixophyes iterates*)

3.3.2.2 Predicted Species

Table 3.12 below outlines the predicted species-credit species predicted to occur by the BioBanking Credit Calculator (Major Project Assessment Type) and whether they are considered to occur on the Development Site.

Table 3.12 Predicted Species-credit Species

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Acacia gordonii	E	E	2.6	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Ancistrachne maidenii	V	-	2.2	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Asterolasia elegans	E	E	1.8	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
brown Pomaderris *Pomaderris brunnea*	E	V	1.5	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
brush-tailed phascogale *Phascogale tapoatafa*	V	-	2.0	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted remote camera surveys being done for this species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Bynoes wattle *Acacia bynoeana*	E	V	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Clandulla geebung P*ersoonia marginata*	V	V	1.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Darwinia biflora	V	V	2.0	Yes	A population of this species was recorded throughout the Modification Area, including the Development Site during the original survey in 2014. The second field survey in December 2015 was designed to further detail the population of this species within these areas. The surveys suggested the total size of the population could not be determined due to the sporadic habit of the species. For this reason the impacts to this species within the Development Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.
Darwinia fascicularis subsp. *oligantha* endangered population, Baulkham Hills and Hornsby Local Government Areas	EP	-	1.4	No	A potential specimen of this species was collected during the November 2014 survey. This specimen was sent to the National Herbarium of New South Wales at the Royal Botanic Garden Sydney (RBGS) for formal identification. The RBGS was unable to identify the specimen as being *Darwinia fascicularis* subsp. o*ligantha*, therefore this endangered population was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys. The identification letter from RBGS is attached as **Appendix E**.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Darwinia peduncularis	V	-	1.8	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Deanes paperbark *Melaleuca deanei*	V	V	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
downy wattle *Acacia pubescens*	V	V	1.9	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
eastern pygmy-possum *Cercartetus nanus*	V	-	2.0	Yes	This species was recorded at two locations within the Modification Area through a targeted remote camera survey for the species. Both locations of this species occur outside the boundary of the Development Site but impacts have been assumed due to the consistency in habitat and proximity of the records to the Development Site.
Epacris purpurascens subsp. *purpurascens*	V	-	1.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Eucalyptus sp. Cattai	CE	-	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	E	-	2.0	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
giant barred frog *Mixophyes iteratus*	E	E	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
giant burrowing frog *Heleioporus australiacus*	V	V	1.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted call playback and spotlighting surveys being done for this species.
Grevillea parviflora subsp. *supplicans*	E	-	2.6	Yes	This species was recorded within the Development Site and the Modification Area. A total of 13 plants occur within the Development Site while 206 individuals were recorded outside the disturbance boundary in the Modification Area.
Groves paperbark *Melaleuca groveana*	V	-	1.4	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Gyrostemon thesioides	E	-	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
hairy geebung *Persoonia hirsuta*	E	E	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Hibbertia puberula	E	-	4.0	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Hibbertia superans	E	-	2.6	No	This species was recorded at one location within the Modification Area and is outside the western boundary of the Development Site. It has been determined that this

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
					species will not be impacted by the Development Site under the strict assumption that no works will extend beyond the development site boundary.
koala *Phascolarctos cinereus*	V	V	2.6	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Kunzea rupestris	V	V	2.6	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Leptospermum deanei	V	V	1.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Leucopogon fletcheri subsp. *fletcheri*	E	-	1.6	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Micromyrtus blakelyi	V	V	2.6	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Dural woodland snail [1] *Pommerhelix duralensis*	-	E	7.7	Yes.	Targeted spotlight surveys undertaken in December 2015 recorded one individual of this species. It was recorded outside the Development Site in the Modification Area. Impacts to this species were considered due to the consistency in suitable habitat within the Development Site.
netted bottle brush *Callistemon linearifolius*	V	-	1.4	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Olearia cordata	V	V	1.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Pimelea curviflora subsp. *curviflora*	V	V	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Pultenaea parviflora	E	V	1.5	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
red-crowned toadlet *Pseudophryne australis*	V	-	1.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted call playback and spotlighting surveys being done for this species.
regent honeyeater *Anthochaera phrygia*	CE	CE	7.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Rosenbergs goanna *Varanus rosenbergi*	V	-	3.3	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Singleton mint bush *Prostanthera cineolifera*	V	V	1.4	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
spreading guinea flower *Hibbertia procumbens*	E	-	1.8	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
squirrel glider *Petaurus norfolcensis*	V	-	2.2	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Tetratheca glandulosa	V	-	1.6	Yes	This species was recorded within the Development Site and the Modification Area. The impacts to this species were applied on a habitat basis due to the cryptic nature of this species. For this reason the impacts to this species within the Development Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.
Velleia perfoliata	V	V	1.7	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.
Zieria involucrata	E	-	1.5	No	This species was not recorded within the Development Site or the larger Modification Area during either of the two extensive field surveys.

^ As entered into the 'Threatened Species Survey Results' tab in the BBCC.

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

3.3.2.3 Survey Results

Five species-credit species were recorded in the Development Site during the surveys undertaken for this assessment (refer to **Figure 3.5**). These were:

- *Darwinia biflora*,
- Eastern pygmy-possum (*Cercartetus nanus*),
- *Grevillea parviflora* subsp. *supplicans*,
- Dural woodland snail (*Pommerhelix duralensis*), and
- *Tetratheca glandulosa*.

Another species-credit species, *Hibbertia superans*, was also recorded during these surveys outside the Development Site. A discussion on these records is provided below and a full species list from the surveys is included in **Appendix C**.

Darwinia biflora

Darwinia biflora is listed as vulnerable under the TSC and EPBC Acts. It is an erect to spreading shrub recorded in Ku-ring-gai, Hornsby, Baulkham Hills and Ryde local government areas. It occurs on the edges of weathered shale-capped ridges at the integration with Hawkesbury Sandstone.

A population of this species was recorded throughout the Modification Area, including the Development Site during the original survey in 2014. Further survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot.

Eastern pygmy-possum – *Cercartetus nanus*

The eastern pygmy-possum is listed as vulnerable under the TSC Act. The species occurs in south-eastern Australia, from southern Queensland, predominantly along the New South Wales coastline around to eastern South Australia and also Tasmania.

Eastern pygmy-possum was recorded at two locations within the Modification Area during the initial field survey in November 2014. Both records occur outside the Development Site boundary. These records were made through targeted remote camera surveys. Bushnell Trophy Cam HDs (remote cameras) were mounted approximately one metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey to increase the likelihood of detecting the eastern pygmy possum. The cameras were set to take three photos in quick succession when movement was detected. The remote cameras were programmed to record movement on an ongoing basis until removed from the site. The cameras were installed for 28 nights in 10 locations, totalling 280 nights of remote camera survey.

Grevillea parviflora* subsp. *supplicans

Grevillea parviflora subsp. *supplicans* is listed as endangered under the TSC Act. This species is a low shrub less than 1 metre tall and has characteristic arching branches. *Grevillea parviflora* subsp. *Supplicans* has a very restricted known distribution that is confined to the north west of Sydney in the Arcadia, Maroota and Marramarra Creek area.

Grevillea parviflora subsp. *supplicans* was recorded in two areas within the Modification Area, one of which occurs in the Development Site and one outside the western boundary. A total of 219 individuals of this species were recorded within the Modification Area, 13 of which occur in the Development Site. An additional 7 plants were recorded on the eastern boundary of the larger Project Area to the east of the Modification Boundary.

Dural woodland snail – *Pommerhelix duralensis*

Dural woodland snail is listed as endangered under the EPBC Act. This species is a medium sized snail with dark brown to black semi-translucent, almost spherical shaped shell. It is a shale-influenced habitat specialist that occurs in low densities along the western and north west fringes of the Cumberland IBRA subregion on shale-sandstone transitional landscapes.

Targeted spotlighting searches for the Dural woodland snail (*Pommerhelix duralensis*) were completed on the December 2015 survey. Walking spotlighting searches were conducted at two separate locations within the Development Site. One specimen of the Dural woodland snail was located just outside the eastern boundary of the Development Site, but within the Modification Area.

Tetratheca glandulosa

Tetratheca glandulosa is listed as vulnerable under the TSC Act. A small, spreading shrub that produces stems often becoming entwined among other plants within the ground stratum. The species is associated with shale-sandstone transition habitat.

Similarly to *Darwinia biflora* the impacts to this species were applied on a habitat basis due to the cryptic nature of this species. For this reason the impacts to this species within the Development Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.

3.3.2.4 Species Habitat Polygons

Species habitat polygons have been prepared for all the species that are being assessed based on area of occupancy that were recorded and assumed present at the site as per **Table 3.14** above. The species polygons were prepared:

- using satellite imagery dated 2009 (LPI 2014)
- using the unit of measurement identified for those species in the Threatened Species Profile Database
- including the location of the species or areas likely occupied by the species
- containing the specific habitat feature associated with the species at the Development Site, and
- using GPS to confirm the location of the species polygon on the best available aerial image of the Development Site.

Species polygons are shown on **Figure 3.5**. Additionally, threatened species records for *Grevillea parviflora* subsp. *supplicans* are also shown in **Figure 3.5**.

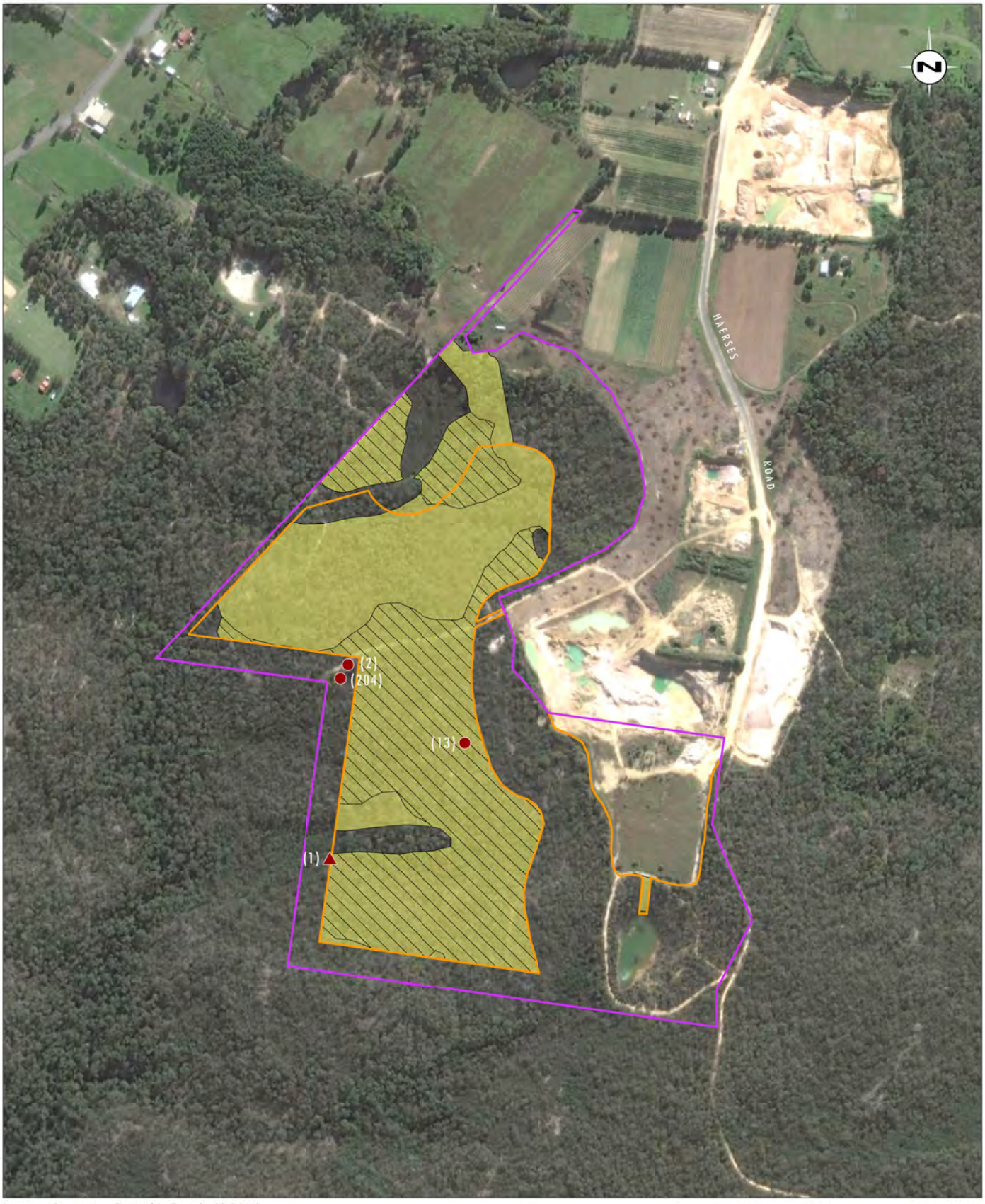


Image Source: Google Earth (2014)

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1:7500

Legend

- Development Site
- Modification Area
- Darwinia biflora, Tetratheca glandulosa and Dural woodland snail
- Eastern pygmy-possum
- *Grevillea parviflora* subsp. *supplicans*
- *Hibbertia superans*

FIGURE 3.5

Species-credit Polygons

File Name (A4): R04/3479_036.dgn
20160920 11.49

4.0 Avoidance and Minimisation Measures

4.1 Site Selection and Planning Phase Avoidance

4.1.1 Site Selection

Dixon Sand undertook initial ecological field surveys within the Modification Area to inform its design process for the proposed Development Site. Through this process, different quarry boundaries were considered and Dixon Sand has sought to minimise the biodiversity impacts associated with the project whilst providing an economic resource. Key factors in selecting the location of the quarry included the likely impacts on significant ecological features, including threatened species, TECs and/or their habitats.

Ecological field surveys were undertaken in November 2014 and December 2015 within the Modification Area that encompasses the Development Site. The boundary of the Development Site has undergone several revisions based on the extent of sandstone material as well as the location of key ecological and groundwater features. In particular, the latest revision to the boundary of the Development Site was made to provide a minimum 50 metre buffer around the Coastal Upland Swamp(s) EEC listed under TSC and EPBC Acts that occurs in the proposed onsite offset area that occurs north of the Development Site.

4.1.2 Planning Phase

Once the quarry expansion location was selected, Dixon Sand then assessed the preliminary opportunities and constraints in relation to ecological values within the proposed extraction and original offset areas at Haerses Road, Maroota (Cumberland 2014). The project has undergone a range of variations to the design of the proposed quarry to get to what is now the Development Site. Additionally, the location of onsite offsets has also undergone similar changes. Key ecological constraints that have been considered by Dixon Sand during the design phase of the Development Site are the location and extent of the Upland Coastal Swamp TEC and the population of threatened flora species *Darwinia biflora*. Dixon Sand engaged Umwelt to undertake significant survey effort for *Darwinia biflora* to try and identify key locations of the species within the Modification Area and areas where the species did not occur that could ultimately facilitate the design of the Development Site to minimise or avoid impacts to the species. Unfortunately surveys identified that the species occurs throughout much of the Modification Area and that impacts to the species could not be avoided completely.

Project planning also focussed on seeking to use areas of non-native vegetation where practicable and the proposed processing and plant area was located in an area of cleared land, reducing the impacts of the proposed development on native vegetation and fauna habitat.

Dixon Sand have limited the extent of the Development Site and thus minimised the impacts to *Darwinia biflora*. Additionally, only a very small portion of Coastal Upland Swamp TEC is now being impacted by the proposed development. The latest revision of the Development Site boundary included incorporating a 50 metre buffer around the Coastal Upland Swamp TEC that occurs within the onsite offset site.

Figure 4.1 shows the final Development Site in relation to the BVTs mapped within the Development Site and the areas of avoidance.

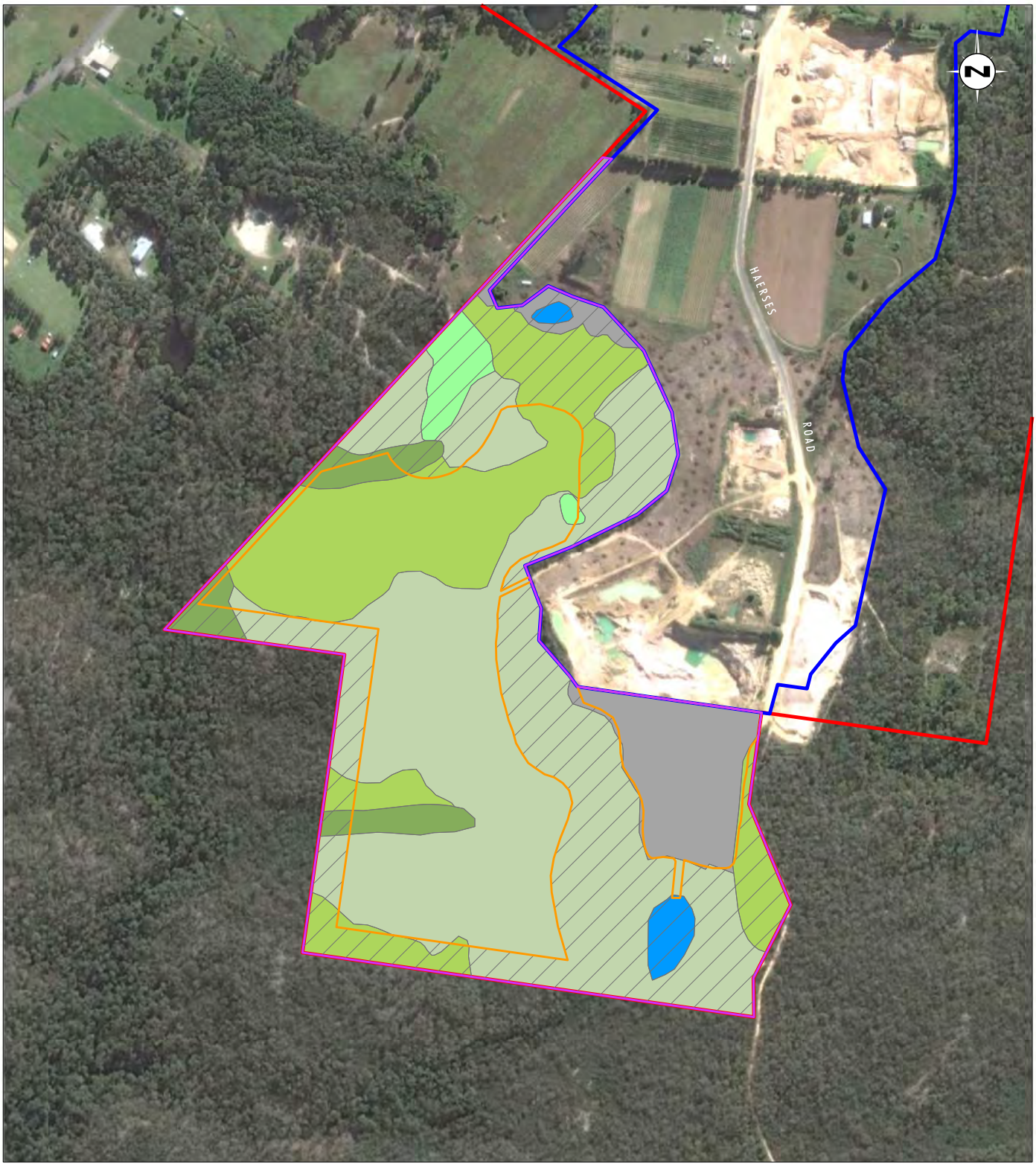


Image Source: Google Earth (2014)

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1:7500

Legend

- Project Site
- Approved Extraction Area
- Development Site
- Modification Area
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition
- Cleared
- Dam
- Area Mapped Outside The Development Site (not impacted)

FIGURE 4.1

Final Development Footprint

File Name (A4): R04/3479_037.dgn
20160920 11.25

Table 4.1 Vegetation Community and Habitat Avoidance

Vegetation Community	Area in the Modification Area (ha)	Area to be Impacted in the Development Site (ha)	Area to be Retained (Avoided) in the Modification Area (ha)
Moderate Quality Woodlands			
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	1.03	0.08	0.95
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	11.46	6.67	4.79
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	24.49	11.15	13.34
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	1.91	0.99	0.92
Total	**38.89**	**18.89**	**20.00**
Cleared			
Cleared	4.23	3.46	4.23
Dam			
Dam	0.63	0.00	0.63
All Vegetation			
Total	43.75	22.35	24.86

4.2 Construction (Site Clearance) Phase

Dixon Sand has committed to the design and implementation of a comprehensive strategy to mitigate adverse impacts during the construction phase of the Modification Project. This includes specific measures to manage potential impacts on fauna species in the Development Site during vegetation clearing and construction of the quarry.

Dixon Sand has an existing ecological management regime in place for Haerses Road quarry, including management plans approved under both NSW and Commonwealth approvals. This existing management regime will be updated and applied to the Modification Project as part of the implementation of the project. Further discussion of the proposed management and mitigation measures to be implemented is included in the following sections.

Additionally, two threatened flora species were recorded just outside of the western boundary of the Development Site, namely *Grevillea parviflora* subsp. *supplicans* and *Hibbertia superans*. *Grevillea parviflora* subsp. *supplicans* also occurs in the Development Site at another location and impacts to this species have only been calculated based on the records within the boundary, of which there were 13 plants. The plants of *Grevillea parviflora* subsp. *Supplicans* and *Hibbertia superans* outside of the Development Site have not been entered into the calculator under the strict assumption that no construction works will occur up to the exact boundary to ensure that there will be no indirect impacts to them. Such an assumption will need to be incorporated into the existing ecological management regime.

4.2.1 Management of Arboreal Species and Habitat

A tree felling procedure will be implemented to minimise the potential for impacts on native fauna species (focusing on threatened species) as a result of the clearing of hollow-bearing trees. The tree felling procedure is designed to minimise impacts to hollow-dependent fauna, particularly the threatened eastern pygmy possum and hollow-dependent micro-bats.

4.2.1.1 Pre-clearance Surveys

Pre-clearance surveys will be required within areas of woody native vegetation (including scattered trees within grassland) that are to be cleared. Pre-clearance surveys will be undertaken by suitably qualified and experienced person and involve the following:

- the demarcation of areas approved for clearing to reduce risk of accidental clearing
- habitat resources and habitat trees should be identified and marked (Note: habitat trees are those containing hollows, cracks or fissures and spouts, active nests, dreys or other signs of recent fauna usage. Other habitat features to be identified include fallen timber/hollow logs, burrows and boulder piles)
- the potential presence of threatened flora and fauna species, endangered populations and TECs should be identified
- the identification of species or habitat features that are suitable for translocation or salvage
- the presence of weed species and vertebrate pest species should be assessed, if relevant, and
- disturbance activities should be targeted for specific times of the year to minimise impacts to target species usage of habitat features for breeding and roosting, where practicable.

4.2.1.2 Tree-felling Supervision

Tree clearing will be completed as close to the completion of pre-clearance surveys as practicable to limit the potential for new issues to arise (such as new active nests being built). Tree felling supervision will be undertaken by an appropriately qualified and experienced person after pre-clearance surveys have identified potential threatened species habitat. The supervising person will be licensed by the relevant field survey and ethics authorities to allow for capture, housing, transport and possibly ethical euthanizing of injured fauna. The tree-felling procedure will include the following:

- Prior to clearing identified habitat trees, the felling of non-habitat trees will be completed as close to the felling of habitat trees as possible, with all surrounding habitat trees to be vigorously shaken with heavy machinery.

- On the day of habitat tree felling, the following is to be undertaken:
    - all habitat trees will be subject to a visual inspection to survey for threatened species
    - trees previously identified as containing fauna will be shaken and then felled, providing no threatened species are identified
    - all reasonable attempts will be made to reduce the impact of felling on all fauna species. This may include delaying felling trees with fauna present or felling in sections to reduce potential for injury
    - the lowering of hollow-bearing trees will be done as gently as possible with heavy machinery
    - if a threatened species is identified in a habitat tree on the day of felling, the supervising person is to advise the most appropriate method to minimise potential harm. This may include leaving the tree overnight, further shaking to encourage the animal to vacate the tree, gradual removal of branches to discourage ongoing use, soft-felling of the tree with the animal in the tree, or measures to capture and relocate the animal to secure habitats
    - uninjured animals should be released on the day of capture into nearby suitable secure habitat and should not be held for extended periods of time, and
    - injured animals will be taken to the nearest veterinary clinic or wildlife carer as soon as possible for assessment and treatment. If required, the supervising person may ethically euthanize fauna
- Following felling, habitat trees will be inspected for remaining or injured fauna species and to ensure that no hollows are blocked against the ground. This may require the tree to be rolled to ensure adequate access
- All felled habitat trees should remain in place for a least one night to allow any fauna still present to move on
- Habitat features identified for translocation or salvage operations should be extracted and stored appropriately, and
- Detailed records should be maintained regarding the type and number of habitat features cleared, the type and number of fauna encountered and their fate. This will assist in informing mitigation programs such as nest boxes and habitat augmentation programs.

4.2.2 Weed Control

Weed species could be inadvertently brought into the Modification Area with imported materials, or could invade naturally through removal of native vegetation. The increased presence of weed species within the Development Site has the potential to decrease the value of extant vegetation to native species, particularly threatened species that will remain in the Modification Area.

The following management measures will be undertaken to minimise the potential impacts and spread of weeds during the modification to the Development Site:

- Any vehicles or equipment being brought onto the Dixon Sand site to be involved in ground disturbance activities and/or travelling around the site must be inspected and cleaned prior to commencing work to limit the spread of seeds and plant material between sites.

- The limits of ground disturbance will be clearly demarcated and no unnecessary disturbance will be undertaken outside of these areas.

- Regular inspections will be undertaken in the Development Site to monitor the spread of weed species.

- Training of environmental personnel on the identification of target weed species.

Any outbreak of noxious weeds will be controlled and eradicated as required under the *Noxious Weeds Act 1993*, and as required by the Local Land Services and other relevant authorities. Weed control and eradication techniques may include:

- spraying with herbicides

- physical removal e.g. chipping, or

- minimisation of area available for weed infestation, through prompt revegetation of bare areas.

4.2.3 Sediment and Erosion Control

Surface water management procedures currently used within the existing Haerses Road are proposed for the Modification Project. This will involve ensuring the direction of clean water flows around the quarry site where practicable and the containment of dirty water within the quarry water management system for treatment.

Erosion and sediment control will be undertaken in accordance with the *Haerses Road Sand Quarry Site Water Management Plan (WMP)* (ERM, 2006b), which will be updated as part of the implementation of the Modification Project. The WMP provides a framework for the management of erosion and sedimentation at Haerses Road Quarry.

As part of construction works, the specific inspection, maintenance and revegetation requirements for each works area will be determined and implemented. These control measures will be in accordance with relevant guidelines for erosion and sediment control, including the relevant volumes of the Blue Book, including:

- Landcom (2004) Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.

- Department of Environment and Climate Change (DECC) (2008) Managing Urban Stormwater – Soils and Construction, 2C – Unsealed Roads.

- Department of Environment and Climate Change (DECC) (2008) Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

4.2.4 General Mitigation Measures

A range of general mitigation measures will be employed across the site during the construction phase to minimise impacts to biodiversity values, including:

- Employee education and training including inductions for staff, contractors and visitors to the site will be conducted to inform personnel of the biodiversity issues present at the site and so they know their role and responsibilities in relation to the protection and/or minimisation of impacts to native biodiversity.

- Areas of biodiversity value outside the Development Site will be fenced or signposted, where appropriate, to prevent the unnecessary disturbance during the construction phase.

- Traffic control measures/speed limits/signage will be enforced on haul roads and access roads to minimise fauna injury/road kills, as much as possible.

4.3 Operational Phase

Dixon Sand has committed to the implementation of a comprehensive strategy to mitigate the adverse impacts during the operational phase of the Modification Project. This includes specific measures to minimise the potential impacts on the biodiversity of the Development Site and the locality. As discussed in **Section 4.2**, an existing ecological management regime is in place for the Haerses Road Quarry and it will be updated and implemented for the Modification Project.

4.3.1 Ongoing Weed Management

Dixon Sand will refer to the existing Environmental Management Plan to incorporate details of the design and implementation of a robust weed management program for the Development Site.

Regular inspections of the Development Site will be undertaken for weed infestations and to assess the need for control measures. Areas not impacted by quarrying activities will be subject to six monthly weed assessments, to be undertaken by the Environmental Officer. These inspections will identify any weed infestations, the need for any control measures and the effectiveness of past weed control activities. Rehabilitated areas will also be regularly inspected to reduce the potential for weed infestations in these areas.

As outlined in **Section 4.2.2**, any outbreak of noxious weeds will be controlled and eradicated as required under the *Noxious Weeds Act 1993*, and as required by the Local Land Services and other relevant authorities. Noxious and other undesirable weed species within the Development Site will be controlled to an acceptable level, and where possible eliminated. Weed control and eradication techniques may include:

- spraying with herbicides

- physical removal e.g. chipping, or

- minimisation of area available for weed infestation, through prompt revegetation of bare areas.

4.3.2 Ongoing Sediment and Erosion Control

During the operational phase, additional water management system components will be constructed as work progresses. The operational phase will involve the ongoing management of the water management system, and be consistent with the relevant requirements of:

- Landcom (2004) Managing Urban Stormwater – *Soils and Construction, Volume 1, 4th Edition,* and

- Department of Environment and Climate Change (DECC) (2008) Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

Specific erosion and sediment control measures proposed to be implemented for the Modification Project will also include those measures outlined the existing Environmental Management Plan.

4.3.3 General Mitigation Measures

The general mitigation measures outlined in **Section 4.2.4**, are also applicable during the operational phase of the Modification Project.

4.4 Direct Impacts

The construction and operation of the Modification Project will result in a range of direct impacts on biodiversity values within the Disturbance Site. Direct impact includes loss of native vegetation and fauna habitats as a result of direct clearance works and construction of the quarry.

Table 4.2 below outlines these impacts as they were entered into the BioBanking Credit Calculator (Major Project Assessment Type). Avoidance and mitigation measures associated with minimising the impacts of these direct impacts are discussed in **Sections 4.1**, **4.2** and **4.3** above.

Table 4.2 Direct Impacts of the Modification Project

Ecological Feature	Area within the Development Site Impact (ha)
Biometric Vegetation Types	
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	0.08
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	6.67
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	11.15
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	0.99

4.5 Indirect Impacts

The Modification Project is not expected to result in any substantial indirect impacts on the biodiversity values of surrounding lands during the construction or operational phases of the Modification Project.

The latest revision to the boundary of the Development Site was made to provide a minimum 50 metre buffer around the Coastal Upland Swamp(s) EEC listed under TSC and EPBC Acts that occurs in the proposed onsite offset area that occurs north of the Development Site. The EEC Final Determination under the TSC Act (NSW Scientific Committee 2012) and Listing Advice under the EPBC Act (TSSC 2014) do not provide a recommended buffer zone around areas of the EEC to ensure that indirect impacts to the community are avoided. We have recommended the minimum buffer of 50 metres around areas of vegetation identified as conforming with the EEC. The vegetation in the buffer zone however is not part of the EEC and not formally protected under either of the TSC or EPBC Acts.

4.5.1 Noise and Dust Impacts

Construction and operational noise and dust impacts have the potential to adversely impact native species. Potential impacts include:

- dust covering vegetation thereby reducing vegetation health and growth
- noise disturbing the roosting and foraging behaviour of fauna species, and
- noise reducing the occupancy of areas of suitable habitat.

The design of the Modification Project will include inherent measures to minimise the potential for adverse noise and dust impacts. These include:

- the use of physical barriers adjacent to operational quarry areas, where practical such as earthen bunds and noise walls
- dust suppression on haul roads and other operational areas to reduce vehicle generated dust emissions
- the minimisation of vegetation clearance where it is not required
- progressive rehabilitation and stabilisation of disturbed land
- equipment maintenance to minimise noise generation.

Further details of the noise controls that will be implemented as part of the Modification Project are outlined in the Environmental Assessment report.

4.5.2 Weed and Feral Animal Encroachment

Weed species could be inadvertently brought into the Modification Area with imported materials, or could invade naturally through removal of native vegetation. The presence of weed species within the Modification Area has the potential to decrease the value of extant vegetation to native species, particularly threatened species. Mitigation measures outlined in **Sections 4.2.2** and **4.3.2** will minimise the potential for weed encroachment into surrounding areas around the Development Site.

5.0 Impact Assessment

5.1 Impacts Not Requiring Further Assessment

Impacts not requiring further assessment under the FBA include areas of land without native vegetation. Areas of cleared land and bodies of water were identified within the Modification Area, but not within the Development Site. Therefore, all the vegetation in the Development Site is involved in the further assessment under the FBA.

5.2 Impacts Not Requiring Offset

Impacts on native vegetation not requiring offsets under the FBA include native vegetation that has a site value score of less than 17, including native vegetation that is an endangered or critically endangered ecological community, and/or vegetation that is associated with threatened species habitat (as represented by ecosystem credits).

Impacts on species and populations not requiring offsets under the FBA include threatened species habitat associated with a PCT that has a site value score of less than 17 or species or populations that are not threatened and do not form part of a EEC or CEEC.

A range of non-threatened flora and fauna species were recorded within the Development Site during the surveys undertaken for this assessment. These species do not require offsets under the FBA. Additionally, as no BVTs within the Development Site have a site value score of less than 17 and are predicted to be habitat for threatened ecosystem species, all will require offsetting as discussed in **Section 5.3**.

5.3 BVTs and Threatened Species Requiring Offset

A range of BVTs, ecosystem-credit species and species-credit species were found to require offsetting as discussed in the sections below.

5.3.1 Ecosystem Credits

Table 5.1 outlines the ecosystem-credit species requiring offset as a result of the Modification Project. The highest threatened species offset multiplier will determine the credit requirements for the BVTs these species are predicted to occur in.

Table 5.1 Ecosystem-credit species requiring offset as a result of the Modification Project

Common Name	Species Name	Threatened Species Offset Multiplier
eastern false pipistrelle	*Falsistrellus tasmaniensis*	2.2
eastern freetail-bat	*Mormopterus norfolkensis*	2.2
eastern grass owl	*Tyto longimembris*	1.3
gang-gang cockatoo	*Callocephalon fimbriatum*	2.0

Common Name	Species Name	Threatened Species Offset Multiplier
glossy black-cockatoo	*Calyptorhynchus lathami*	1.8
greater broad-nosed bat	*Scoteanax rueppellii*	2.2
little eagle	*Hieraaetus morphnoides*	1.4
little lorikeet	*Glossopsitta pusilla*	1.8
New Holland mouse	*Pseudomys novaehollandiae*	2.6
scarlet robin	*Petroica boodang*	1.3
spotted-tailed quoll	*Dasyurus maculatus*	2.6
square-tailed kite	*Lophoictinia isura*	1.4
swift parrot	*Lathamus discolor*	1.3
varied sittella	*Daphoenositta chrysoptera*	1.3
yellow-bellied glider	*Petaurus australis*	2.3
yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*	2.2

Table 5.2 below outlines the BVTs to be impacted as a result of the Modification Project and the ecosystem credits required to offset those impacts. A full Credit Calculator report is included in **Appendix D**.

Table 5.2 Biometric Vegetation Types Requiring Offset and the Ecosystem Credits Required

Biometric Vegetation Type	Vegetation Zone	Area to be Impacted (ha)	Loss in Landscape Value	Current Site Value Score	Future Site Value Score	Threatened Species Offset Multiplier	Ecosystem Credits Required
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	1	0.08	13.20	56.52	0.00	2.6	3
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	2	6.67	13.20	81.77	0.00	2.6	377
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	3	11.15	13.20	69.10	0.00	2.6	538
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	4	0.99	13.20	63.77	0.00	2.6	44

5.3.2 Species Credits

Table 5.3 below outlines the species-credit species to be impacted as a result of the Modification Project and the species credits required to offset those impacts. A full Credit Calculator report is included in **Appendix D**.

Table 5.3 Species-credit Species Requiring Offset and the Species Credits Required

Common Name	Species Name	Threatened Species Offset Multiplier	Species Credits Required
Darwinia biflora	*Darwinia biflora*	2.0	360
eastern pygmy-possum	*Cercartetus nanus*	2.0	223
Grevillea parviflora subsp. *supplicans*	*Grevillea parviflora* subsp. *Supplicans*	2.6	338
Dural woodland snail [1]	*Pommerhelix duralensis*	7.7	1,372
Tetratheca glandulosa	*Tetratheca glandulosa*	1.6	288

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

5.4 Impacts that Require Further Consideration

Under the FBA, certain impacts on biodiversity values may require further consideration by the consent authority. These are impacts that are considered to be complicated or severe and include:

- impacts on landscape features, being:
    - impacts that will reduce the width of vegetation in the riparian buffer zone bordering significant streams and rivers, important wetlands or estuarine areas, or
    - impacts that will prevent species movement along corridors that have been identified as providing significant biodiversity linkages across the state, and
- impacts on native vegetation that are likely to cause the extinction of an EEC/CEEC from an IBRA subregion or significantly reduce its viability, and
- impacts on critical habitat or on threatened species or populations that are likely to cause the extinction of a species or population from an IBRA subregion or significantly reduce its viability.

The Modification Project will not have an impact on any biodiversity features that would result in one or more of the above severe impacts. Therefore there are no impacts that require further consideration by the consent authority.

5.5 Impacts on Aquatic Species

No *Fisheries Management Act 1994* (FM Act) listed threatened aquatic flora or fauna species has been recorded within the Development Site. The Development Site contains minimal aquatic habitats being two small dams occurring in the western and southern portions of the Development Site.

5.6 Seven Part Tests of Significance

Threatened species impact assessment is an integral part of environmental impact assessment. The objective of s. 5A of the EP&A Act, the *assessment of significance*, is to improve the standard of consideration afforded to threatened species, populations and ecological communities, and their habitats through the planning and assessment process, and to ensure that the consideration is transparent.

Although it is understood that the preparation of a BioBanking Assessment under the FBA supersedes the requirement to prepare Seven Part Tests, DPE has previously advised that some consideration of s. 5A is required. The preparation of a BAR under the FBA addresses the components of the Seven Part Tests by use of the BBCC. A summary of the requirements of the Seven Part Tests of Significance and where they are addressed in the FBA Assessment is outlined in **Table 5.4** below.

Table 5.4 Seven Part Tests of Significance and the FBA

Seven Part Test of Significance	Where Addressed in the FBA Process
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;	Threatened species (ecosystem-credit and species-credit) are predicted in the BBCC by the landscape features of the Development Site (native vegetation cover, IBRA regions, patch sizes, condition and plant community types) and assessed by the impact on these features. Impacts requiring further consideration (Section 9.2 of the FBA (OEH 2014) identify impacts on critically endangered threatened species, impacts that may cause the extinction of a species in a IBRA subregion and impacts that significantly reduce the viability of a species.

Seven Part Test of Significance	Where Addressed in the FBA Process
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	Endangered populations are predicted in the BBCC by the landscape features of the Development Site (native vegetation cover, IBRA regions, patch sizes, condition and plant community types) and assessed by the impact on these features. Impacts requiring further consideration (Section 9.2 of the FBA (OEH 2014) identify impacts that may cause the extinction of an endangered population in a IBRA subregion and impacts that significantly reduce the viability of a population.
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; and 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;	Endangered ecological communities are predicted in the BBCC by the plant community types and biometric community types identified from the field surveys and entered into the BBCC. Impacts requiring further consideration (Section 9.2 of the FBA (OEH 2014) are identified as impacts on any critically endangered or endangered ecological community that may cause the extinction of the EEC/CEEC in a IBRA subregion or significantly reduce the viability of an EEC/CEEC.

Seven Part Test of Significance	Where Addressed in the FBA Process
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; 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;	Habitat loss is assessed in the BBCC via the 'Site Values' tab and the loss in site value score entered for each vegetation zone. Fragmentation of habitat is addressed as part of the 'Landscape Value' score including consideration of features before and after the development including per cent native vegetation cover, connectivity value and vegetation condition. The per cent cleared scores for the dominant Mitchell Landscape is also calculated in the 'Landscape Value' score. Important habitat features are identified through determining geographic and habitat features relevant for particular species-credit species and the assessment of landscape features (such as riparian buffers, important wetlands and state or regionally significant biodiversity links). The extent of habitat loss is ultimately determined by the measure of ecosystem credits and species credits calculated in the BBCC.
e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);	Critical habitat is addressed under impacts that require further consideration by the consent authority (refer to Section 9.2 of the FBA (OEH 2014)).

Seven Part Test of Significance	Where Addressed in the FBA Process
f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan; and	Recovery plans are not directly addressed in the FBA. National recovery plans have been prepared for large-eared pied bat (*Chalinolobus dwyeri*) (DERM 2011). It is likely that the Modification Project would be inconsistent with any recovery plans prepared for the threatened species impacted by the Project as it relates to impacts on habitat for the species. However the Modification Project will not impede the implementation of these recovery plans. If supplementary offsetting measures are used (as per Appendix B of the NSW Biodiversity Offset Policy for Major Projects) to offset species or communities impacted by projects, reference can be made to the key objectives and actions in the relevant recovery plans.
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.	Key threatening processes are not directly assessed under the FBA. In the case of the Modification Project, the Project may contribute to the following key threatening processes: • Aggressive exclusion of birds by noisy miners (*Manorina melanocephala*); • Clearing of native vegetation; • Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*); • Competition and land degradation by unmanaged goats (*Capra hircus*); • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants; • Predation by the European red fox (*Vulpes vulpes*); and • Predation by feral cats.

5.7 Impacts on Matters of National Environmental Significance

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on matters of national environmental significance (MNES). These matters are:

- listed threatened species and communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- World Heritage properties
- National Heritage places
- nuclear actions, and
- a water resource, in relation to coal seam gas development and large coal mining development.

A Referral to the Commonwealth Environment Minister was submitted in November 2015. Confirmation from the Department of Environment was received in February 2016 that the proposed modification is a 'Controlled Action' due to likely significant impacts on listed threatened species and communities.

6.0 Offsetting Requirements

6.1 Biodiversity Credit Report

A full Credit Calculator report is included in **Appendix E**.

Table 6.1 below provides a summary of the ecosystem and species credits that require offsetting as a result of this Modification.

Table 6.1 Ecosystem and Species Credits Generated at the Development Site

Name	Credits Required
Ecosystem Credits	
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	3
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	377
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	538
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	44
Total	**962**
Species Credits	
Darwinia biflora	360
eastern pygmy-possum (*Cercartetus nanus*)	223
Grevillea parviflora subsp. *supplicans*	338
Dural woodland snail (*Pommerhelix duralensis*)[1]	1,372
Tetratheca glandulosa	288
Total	**2581**

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

6.1.1 Offsetting Options for Ecosystem Credits

Ecosystem credits for any of the PCTs in the Development Site can be located in any IBRA subregion that adjoins the IBRA subregion in which the Modification Project occurs. The Modification Project occurs in the Yengo – Hawkesbury/Nepean IBRA subregion and therefore, ecosystem credits can be sourced from the following IBRA subregions:

Sydney Basin Bioregion

- Cumberland
- Hunter
- Kerrabee
- Pittwater
- Wollemi
- Wyong or
- Yengo – Hawkesbury/Nepean.

Through finalising the FBA calculator a full Credit Calculator report is produced and within this report a list of offset options for each of the vegetation zones impacted on within the Development Site is provided. A copy of the full Credit Calculator report is provided in **Appendix D**. A summary of suitable offsetting PCTs for each of the vegetation zones being impacted within the Development Site are provided below.

6.1.1.1 HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion

The following PCTs could be used to offset HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion under the FBA:

- HN560 Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion
- HN563 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion or
- HN633 Baeckea linifolia - Grevillea acanthifolia subsp. acanthifolia shrub/sedge swamp on sandstone, Sydney Basin Bioregion.

6.1.1.2 HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion

The following PCTs could be used to offset HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion under the FBA:

- HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
- HN587 Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion

- HN567 Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion
- HN586 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- HN642 Spotted Gum - Grey Ironbark open forest in the Pittwater area, Sydney Basin Bioregion or
- HN644 Sydney Peppermint - White Stringybark - Smooth-barked Apple forest on shale outcrops, Sydney Basin Bioregion.

6.1.1.3 HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion

The following PCTs could be used to offset HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion under the FBA:

- HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion or
- HN580 Sandstone cliff soak moist shrubland of the Sydney Basin Bioregion.

6.1.1.4 HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion

The following PCTs could be used to offset HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion under the FBA:

- HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion
- HN587 Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion
- HN566 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion
- HN567 Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion
- HN642 Spotted Gum - Grey Ironbark open forest in the Pittwater area, Sydney Basin Bioregion or
- HN644 Sydney Peppermint - White Stringybark - Smooth-barked Apple forest on shale outcrops, Sydney Basin Bioregion.

6.1.1.5 Offsetting Options for Species Credits

A required species credit must be offset with a species credit created for the same species, determined in accordance with the BBAM. Under the FBA and strictly in accordance with the rules set out in Section 10.5.7 of the FBA methodology (OEH 2014), the consent authority may also approve:

a) a variation of the offset rules for matching species credits by allowing a different species to that impacted by the proposed development to be used to meet the offset requirement, or

b) a supplementary measure to be proposed as an offset for the species impacted by the development.

6.2 Haerses Road Offset Site

Dixon Sand is committed to delivering a Biodiversity Offset Strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Modification Project under the NSW *Biodiversity Offsets Policy for Major Projects* (OEH 2014). Firstly, Dixon Sand has, where possible, altered the Modification Project to substantially avoid and minimise ecological impacts in the project planning stage, and a range of impact mitigation strategies have been included in the Modification Project to mitigate the impact on ecological values (refer to **Section 4.0**) prior to the consideration of offsetting requirements.

The NSW *Biodiversity Offset Policy for Major Projects* commenced on 1 October 2014. Fulfilling offset requirements under the Policy will be undertaken using one or a combination of the following offset strategies:

- On-site in-perpetuity conservation of applicable credits.
- Offsetting through a site secured by a BioBanking Agreement.
- Potentially securing required credits through the open credit market, off site, if required.
- If suitable offsets are unavailable, contributing money to supplementary measures in accordance with relevant conservation or recovery actions will be investigated.

The following sections present an offset site for the Modification Project that is part of the larger Project Site, hereafter this site will be referred to as the Haerses Road Offset Site.

6.2.1 Location

Table 6.2 below provides a summary of the Haerses Road Offset Site and **Figure 6.1** shows the location of the Offset Site in relation to the Development Site.

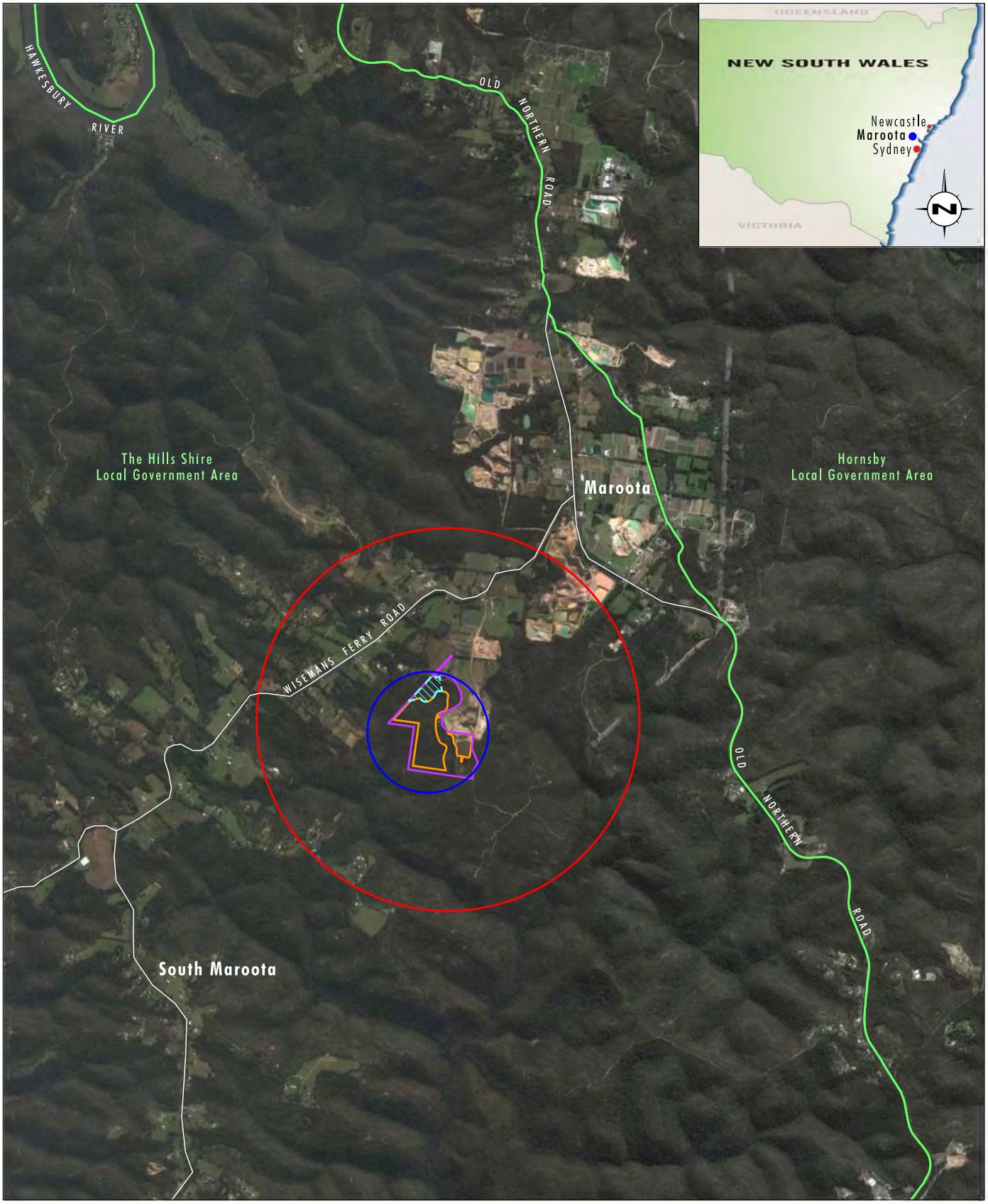


Image Source: Google Earth (2014)
Data Source: LPI (2015)

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1:50 000

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Local Government Area Boundary
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle

FIGURE 6.1

Proposed Haerses Road Offset Site

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Haerses Road Offset Site adjoins the Development Site to the north, as part of the Modification Project. It occurs on land owned by Dixon Sand, located in the Maroota area, approximately 40 kilometres north of Parramatta, NSW (refer to **Figure 6.1**). Haerses Road Offset Site is located within the Sydney Basin IBRA bioregion and the Yengo IBRA subregion. Refer to **Figure 6.2** and **Figure 6.3** for the location of the offset site and other relevant landscape features.

Table 6.2 Offset Site Location in the Landscape

Haerses Road Offset Site	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Yengo
Major Catchment Area	Hawkesbury/Nepean
Mitchell Landscape	Hornsby Plateau
LGA	The Hills
Address	Haerses Road, Maroota, NSW, 2756

6.2.2 Size

The Haerses Road Offset Site covers approximately 4 hectares.

6.2.3 Topography and Natural Features

The Haerses Road Offset Site lies in the Sydney Basin bioregion, at the top of the local catchment, and drains towards the west. The gradient decreases from approximately 180 ASL in the north to approximately 150 metres ASL in the south west.

Haerses Road Offset Site drains to the Hawkesbury River, approximately 12 km south west, via the first order drainage line into the upper reaches of Stone Chimney Arm (creek), a tributary of Little Cattai Creek and the Broadwater Swamp. The Broadwater Swamp is approximately eight kilometres downstream of the site, connecting Little Cattai Creek to the Hawkesbury River. The local catchment of which the site is a part is shown has an area of approximately 9980 hectares (ERM, 2006).

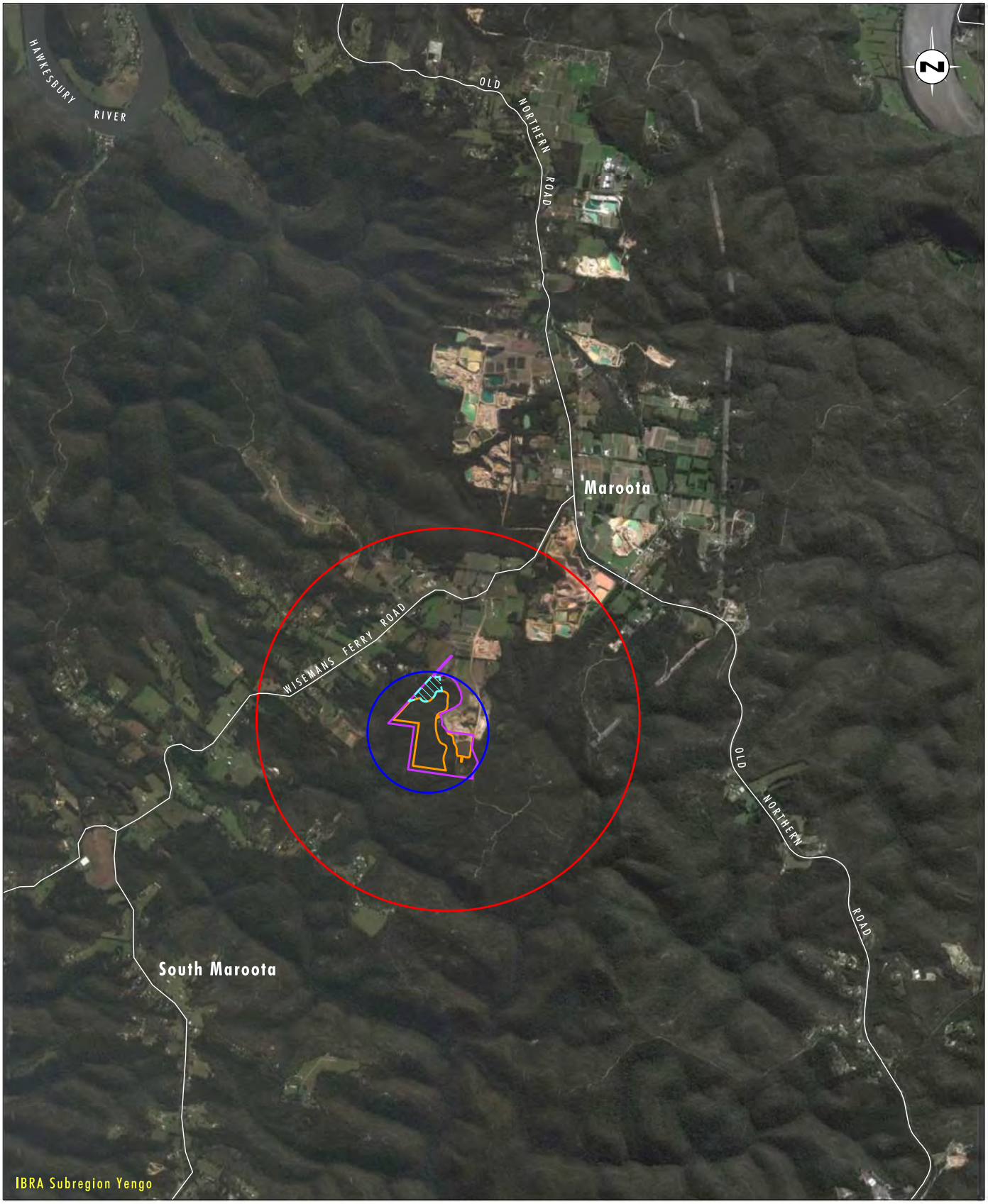


Image Source: Google Earth (2014)
Data Source: IBRA V7 - Australian Government Department of the Environment (2012)

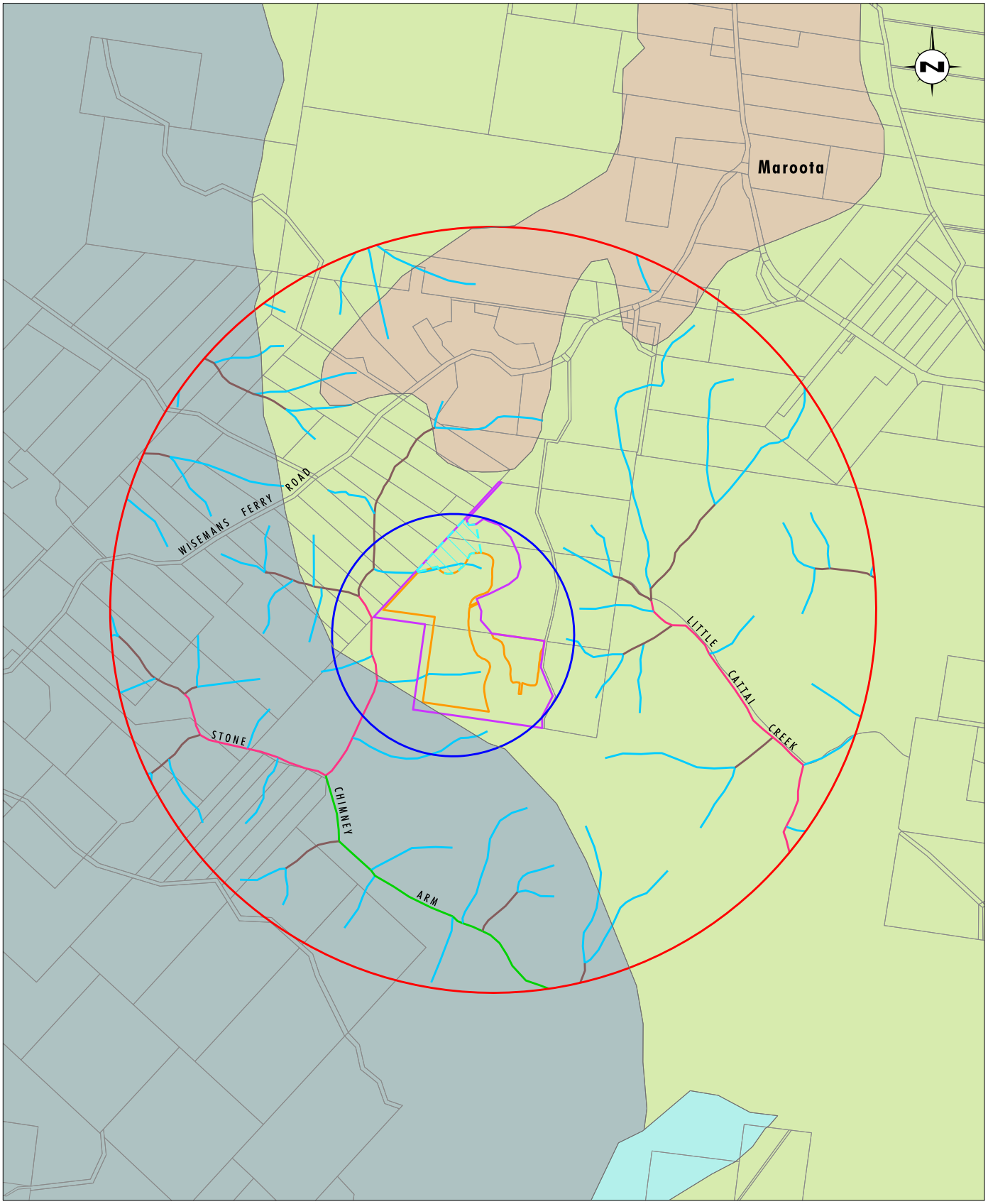
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1:50 000

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle

FIGURE 6.2

Haerses Road Offset Site
Location Map - IBRA V7 Regions



Data Source: DECC (2008),LPI (2011)
Note: Site lies within the IBRA Subregion Yengo

0 0.5 1.0 1.25km
1:25 000

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream

Mitchell Landscapes:

- Blaxlands Ridge
- Hornsby Plateau
- Maroota Sands
- Sydney Basin Diatremes

FIGURE 6.3

Haerses Road Offset Site
Location Map - Landscape Features

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6.2.4 Key Resources, Policies and Documents

The following key resources, policies and documents were used to prepare the Biodiversity Assessment Report for the Haerses Road Offset Site:

- Framework for Biodiversity Assessment – NSW Biodiversity Offsets Policy for Major Projects (OEH September 2014)
- BioBanking Assessment Methodology 2008 (DECC July 2008)
- BioBanking Assessment Methodology 2014 (OEH September 2014)
- Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities –Working Draft (DEC 2004)
- BioBanking Credit Calculator (Major Project Assessment Type) Version 4.1, accessed in April 2016
- Vegetation Information System (VIS) Classification Database (OEH 2015), accessed in August 2015
- OEH Atlas of NSW Wildlife database and mapping tool (OEH 2015), accessed in March 2016
- Department of the Environment (DoE) Protected Matters Database (DoE 2015), accessed in March 2016.

6.3 Methods – Haerses Road Offset Site

The threatened species and ecological communities known or likely to occur within the Haerses Road Offset Site were identified by a systematic approach comprising appropriate database searches, a review of recent literature, and targeted field surveys.

6.3.1 Database Searches

Database searches were undertaken to develop a list of Threatened Ecological Communities (TECs) and threatened flora and fauna species that have previously been recorded, or are predicted to occur within 10 kilometres of the boundary of the Haerses Road Offset Site. The information obtained was used to inform survey design, and was also used to assist in the assessment of potentially occurring threatened and migratory species and endangered populations. Relevant documents included:

- EPBC Protected Matters Search Tool (30/03/16)
- NSW Office of Environment and Heritage (OEH) Atlas of NSW Wildlife (30/03/16).

As the Haerses Road Offset Site adjoins the northern boundary of the Development Site, assessed under the FBA process and reported above, the same database searches were used for the Haerses Road Offset Site assessment.

Marine species such as albatrosses, petrels, turtles and whales were excluded from the database search results due to an absence of marine habitats in the Haerses Road Offset Site.

A preliminary assessment using the BioBanking Credit Calculator was undertaken, which provided a list of species credit species that might require survey and the suitable survey periods for each species. The results of the database searches, literature review and preliminary assessment using the BioBanking Credit

Calculator were used to design the survey requirements for species credit species to ensure that adequate surveys were undertaken.

The Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC 2004) was considered when undertaking the threatened species surveys in the Development Site.

6.3.2 Systematic Quadrat Surveys

Systematic vegetation quadrats were undertaken within the Modification Area, which encompasses the Haerses Road Offset Site, across two field surveys, the first in November 2014 and the second in December 2015. Detailed information on the timing of these two surveys is provided below in **Section 2.8**.

Systematic vegetation quadrat sites were selected by considering a vast array of attributes that were likely to influence or determine the type of vegetation communities present in the Modification Area. This stratification was done intuitively, based on existing topographic, soil, vegetation and geological mapping. Other factors considered included the spatial coverage of sites across the Modification Area, as well as the topographic position and aspect. Field surveys were undertaken prior to Umwelt being aware of the location of the Haerses Road Offset Site, which resulted in the field survey effort being spread across the Modification Area rather than specifically within the Haerses Road Offset Site.

Each vegetation quadrat comprised 20 metres by 20 metres (400 m^2); a standard size used widely for systematic flora surveys throughout NSW and is recognised by OEH and the Royal Botanic Gardens Sydney. Each quadrat was searched between 45 to 60 minutes for all vascular flora species present. Two ecologists conducted surveys at each quadrat sampled. The highest effort was spent examining the groundcover vegetation, as this stratum supported the majority of species at most sites. Furthermore, effort was also made to search the canopy and trunks of trees for mistletoes, vines and epiphytes.

Information on the structural characteristics of the vegetation in each quadrat was also recorded, and included the height range, canopy cover of each stratum and the dominant species in each stratum. Any species observed outside the quadrat but within the vegetation community being sampled were recorded. Such species were noted as being present but were not assigned cover-abundance values. Flora species cover-abundance data were recorded on a proforma.

6.3.2.1 Plot/Transect Selection and Stratification of the Development Site

Designing an appropriate survey requires consideration of both survey methods and effort. Reference was made to the VIS Classification Database to identify Plant Community Types (PCTs), as well as reviews of other regional and local vegetation mapping and reporting (refer to **Section 7.2.1**) when designing the field survey. The Development Site PCTs were further stratified into Vegetation Zones (condition states) following the initial field survey of the site to determine the appropriate number of transect/plots required in accordance with the FBA methodology (OEH 2014) as outlined in **Table 6.3**. Broad condition states include vegetation in 'Moderate/Good' condition.

Table 6.3 Minimum Number of Plots/Transects Required per Zone Area (OEH 2014)

Vegetation Zone Area (ha)	Minimum Number of Plot/Transect
0-4	1 transect/plot per 2 ha (or part thereof) or 1 transect/plot if vegetation is in low condition
>4-20	3 transects/plots or 2 transects/plots if vegetation is in low condition
>20-50	4 transects/plots or 3 transects/plots if vegetation is in low condition
>50-100	5 transects/plots or 3 transects/plots if vegetation is in low condition
>100-250	6 transects/plots or 4 transects/plots if vegetation is in low condition
>250-1000	7 transects/plots or 5 transects/plots if vegetation is in low condition (More transects/plots may be needed if the condition of the vegetation is variable across the zone)
>1000	8 transects/plots or 5 transects/plots if vegetation is in low condition or in a homogenous landscape in the Western Division (More transects/plots may be needed if the condition of the vegetation is variable across the zone)

Table 6.4 below outlines the adequacy of the plot-based flora survey with respect to the BioBanking Methodology (OEH 2014) pertinent to the Haerses Road Offset Site. Vegetation Zones were identified within the Modification Area prior to Umwelt being aware of the location of the Haerses Road Offset Site, which resulted in the field survey effort being spread across the Modification Area rather than specifically within the Haerses Road Offset Site.

Table 6.4 Adequacy of Vegetation Survey in the Haerses Road Offset Site

Vegetation Zone	BVT and Condition Class	Area in the Haerses Road Offset Site (ha[1])	No. Plots and Transects Sampled (No. Required in parentheses)		
			Plot	Transect	Rapid Sampling
1	HN560_Moderate/Good	0.93^	1 (1)	1 (1)	1
2	HN566_Moderate/Good	0.78^	3 (1)	3 (1)	1
3	HN582_Moderate/Good	1.52^	3 (1)	3 (1)	4
4	HN586_Moderate/Good	0.36^	1 (1)	1 (1)	4
Total		**3.59**	**8 (4)**	**8 (4)**	**10***

[1] All areas are approximate areas despite being shown at two decimal places. Areas are approximate as vegetation type boundaries are based on a combination of field survey and desktop assessment. Additionally, precise boundaries between communities can be difficult or impossible to determine in the field due to the overlap of species in common occurring among vegetation types.

^ These vegetation zones also occur in the wider Modification Area and were sampled during the two field surveys undertaken for this assessment prior to the allocation of the Haerses Road Offset Site. Consequently, all eight plots/transects were completed within the Modification Area but not exclusively within the Haerses Road Offset Site.

* Three additional Rapid Sampling points were completed but occurred in cleared land and therefore is not identified in this table.

6.3.2.2 Plot/Transect Data Collected

At each plot/transect data was recorded according to Appendix 2 of the BioBanking Assessment Methodology (BBAM) and Credit Calculator Operational Manual (DECC 2014). This involved setting out 20 x 50 metre and 20 x 20 metre plots and a 50 metre transect. The location of each quadrat was recorded using a hand-held GPS with accuracy of ± 5 metres. The Map Grid of Australia (MGA) coordinate system was used. The location of the 8 plots/transects undertaken within the Modification Area. Of the 8 plots/transects completed within the Modification Area only one occurs in the Haerses Road Offset Site as shown in **Figure 6.4**.

At each plot/transect, roughly 45 to 60 minutes was spent searching for all vascular flora species present within the 20 x 20 metre plot. Searches of each 20 x 20 metre plot were generally undertaken through parallel transects from one side of the plot to another. Most effort was spent on examining the groundcover, which usually supported well over half of the species present, however the composition of the shrub, mid-storey, canopy and emergent layers were also thoroughly examined. Effort was made to search the tree canopy and tree trunks for mistletoes, vines and epiphytes.

Species within the plot were also assigned a cover-abundance value to reflect their relative cover and abundance in the plot. Species located outside the plot (recorded to assist in vegetation community identifications and mapping) were marked as present but were not assigned a cover-abundance value. A modified Braun-Blanquet 6-point scale was used to estimate cover-abundances of all plant species within each quadrat (Braun-Blanquet 1927), with selected modifications sourced from Poore (1955) and Austin *et al*. (2000). **Table 6.5** shows the cover-abundance categories used. Voucher specimens were collected of species that could not be identified in the field for later identification. The following specimens were sent to NSW Royal Botanic Gardens and formally identified:

- crimson bottlebrush (*Callistemon citrinus*)
- *Darwinia biflora*
- *Darwinia fascicularis*
- *Grevillea parviflora* supbsp. *supplicans*
- *Hibbertia superans*
- peach blossom tea-tree (*Leptospermum squarrosum*) and
- *Tetratheca glandulosa*.

Table 6.5 Modified Bran-Blanquet Crown Cover-Abundance Scale

Class	Cover-abundance^	Notes
1	Few individuals (less than 5% cover)	Herbs, sedges and grasses: <5 individuals Shrubs and small trees: <5 individuals
2	Many individuals (less than 5% cover)	Herbs, sedges and grasses: 5 or more individuals Shrubs and small trees: 5 or more individuals Medium-large overhanging tree
3	5 – less than 20% cover	Applies to all species.
4	20 – less than 50% cover	
5	50 – less than 75% cover	
6	75 – 100% cover	

Note: at the time of survey, the updated BioBanking and FBA Methodology (OEH 2014) had not been released including the new requirements for abundance ratings and therefore the modified Braun-Blanquet 6-point scale was used for Cover-Abundance measures. Modified Braun-Blanquet scale (Poore 1955; Austin *et al*, 2000).

At each standard flora quadrat, 10 points along a 50 metre transect were assessed for:

- percentage native overstorey cover, and
- percentage native mid-storey cover.

In addition, 50 points along a 50 metre transect were assessed for:

- percentage native groundcover (grass)
- percentage native groundcover (shrubs)
- percentage native ground cover (other), and
- percentage exotic plant cover.

Additional details were also recorded in each quadrat, including soil texture, drainage and depth; site disturbances; physiography (position in the landscape); and vegetation structure (strata percentage covers, heights and dominant species). Photographic records were also taken at each site.

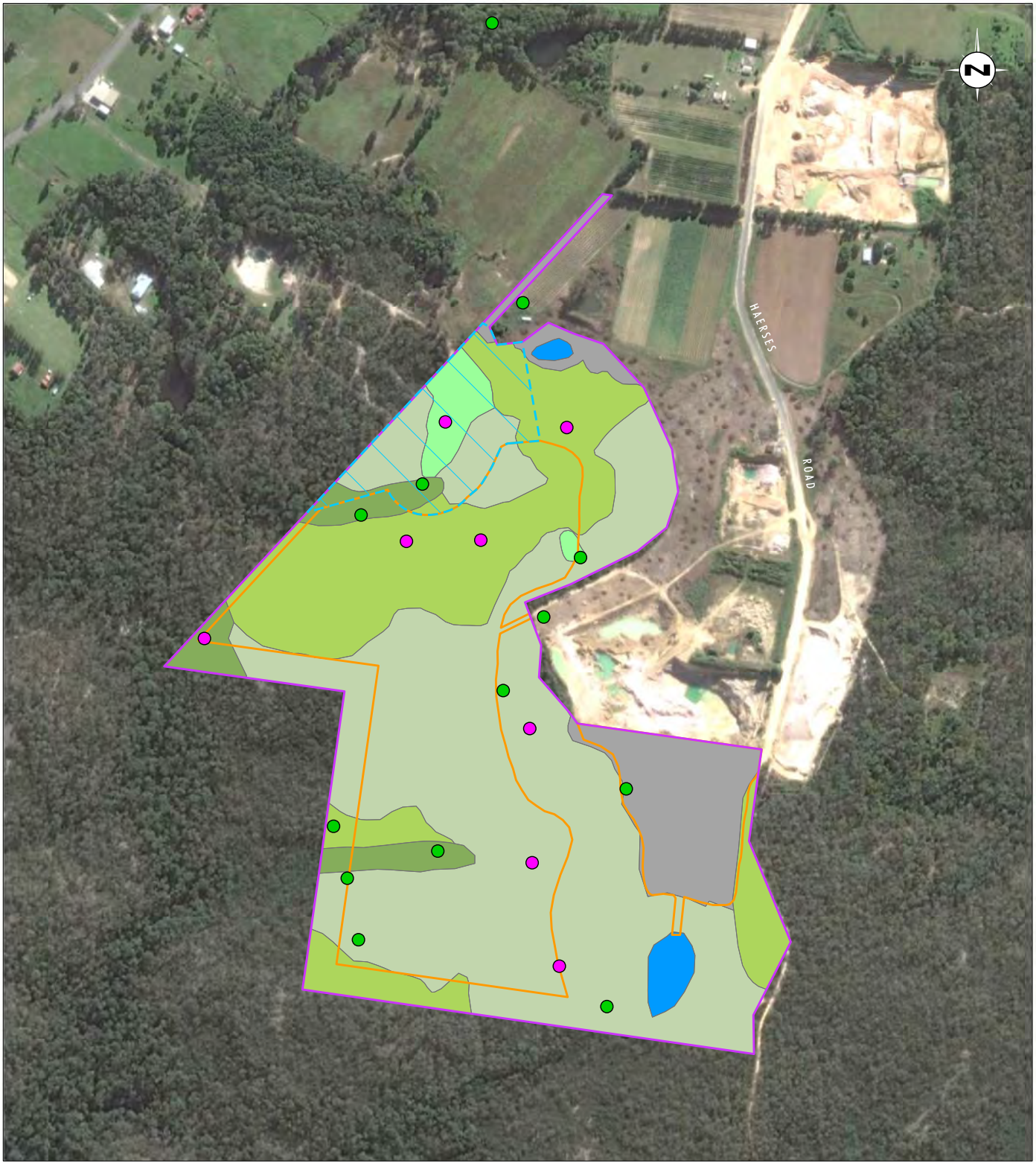


Image Source: Google Earth (2014)

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Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition
- Cleared
- Dam
- Flora Plot/Transects
- Semi-quantitative Rapid Sampling Plot

FIGURE 6.4

Flora Survey Locations

6.3.3 Semi-quantitative Rapid Sampling

A total of 13 semi quantitative rapid assessments plots were completed in the Modification Area to collect information about the vegetation, of which only one occurs within the Haerses Road Offset Site. Assessment areas were not fixed area-based, but were generally confined to an area similar to that of a 10 x 10 metre quadrat. Rapid assessments were used to document the characteristics of vegetation over large areas.

Rapid vegetation assessment points were located within distinct vegetation community units (rather than within ecotones) to allow data collection for each community without confounding effects from adjacent communities. Dominant, common and some uncommon plant taxa were recorded within each rapid vegetation assessment points, along with cover abundance scores as per **Table 6.5**. The vegetation structure at each rapid vegetation assessment point was documented, including each stratum's height, percent foliage cover and dominant species. Rapid assessment plots were later transferred into a geographical information system (GIS) to aid vegetation community mapping and description. **Figure 6.4** shows the location of the 13 rapid assessment plots completed across the Modification Area.

6.3.4 Plant Identification and Nomenclature Standards

All vascular plants recorded or collected within plots and quadrats were identified using keys and nomenclature in Harden (1992, 1993, 2000 & 2002) and Jacobs *et al.* (2008). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from *PlantNET* (Botanic Gardens Trust 2015), the online plants name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name. Where the identity of a specimen was unknown or uncertain, it was lodged with the National Herbarium of New South Wales at the Royal Botanic Gardens Sydney.

6.3.5 Targeted Threatened Ecological Community Investigations

Vegetation communities identified in the Haerses Road Offset Site were compared to TECs listed under the Commonwealth EPBC Act and NSW TSC Act and an assessment of similarity with the NSW Scientific Committee Final Determinations and the Commonwealth Threatened Species Scientific Committee Listing and Conservation Advice.

Six TECs were identified as potentially occurring in the Haerses Road Offset Site. The six listed communities are:

- Coastal Upland Swamps in the Sydney Basin Bioregion
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
- Shale/Sandstone Transition Forest
- Subtropical and Temperate Coastal Saltmarsh
- Turpentine-Ironbark Forest in the Sydney Basin Bioregion and
- Western Sydney Dry Rainforest and Moist Woodland on Shale.

6.3.6 Targeted *Darwinia biflora* Survey

The initial field survey determined that it was impractical to count and mark each individual plant of *Darwinia biflora* in the Modification Area given the potential for large numbers. Instead, the numbers of *D. biflora* were counted within standard 10 x 10 metre or 20 x 20 metre plots (depending on density) during the initial survey in November 2014. This species was recorded in the Sandstone Heath (Heath/Woodland Complex) and Sandstone Ridgetop Woodland.

Further survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, none of the stratified plots targeting *Darwinia biflora* were completed within the area that has now been identified as the Haerses Road Offset Site.

Due to the sporadic nature in which the species occurs in the Modification Area, the impacts to *D. biflora* was assessed by area of habitat rather than the number of individuals. Typically, impacts to flora species should be assessed based on the number of individuals as indicated in Section 10.4.4.2 of the FBA methodology (OEH, 2014). However in the case of sporadically occurring plant species like *D. biflora* it is permitted to assessed the impacts by area of habitat. The NSW Guide to Surveying Threatened Plants (OEH, 2016b) states that impacts to a threatened species can be assessed as area of habitat as long as the surveyor considers the history of land use and/or disturbance and previous surveys of the species at the site. The survey effort undertaken by Umwelt in the Modification Area identified that the population of *D. biflora* could not be accurately measured due to the sporadic nature in which it occurs.

6.3.7 Flora Survey Timing and Effort

The vegetation of the Modification Area was surveyed in two events. The first during spring, from 25 to 27 November 2014 and the second in summer, from 14 to 17 December 2015. All surveys were completed by two Ecologists. A total of 14 person-days, six initially and eight later, were completed to sample the vegetation communities and flora species within the Modification Area.

The following survey effort was completed across the Modification Area and Haerses Road Offset Site (refer to **Figure 6.4**):

- Eight 400 m^2 flora plots, one of which occurs in Haerses Road Offset Site
- Thirteen semi-qualitative rapid assessment plots, one of which occurs in Haerses Road Offset Site.

6.3.8 Fauna Survey Timing and Effort

Fauna surveys across the Modification Area were undertaken from 25 to 27 November, 2014 as well as on 16 December, 2015. Fauna survey effort was designed in consideration of the following survey guidelines:

- Department of Environment, Water, Heritage and the Arts (DEWHA) (2010a). Survey Guidelines for Australia's Threatened Birds

- DEWHA (2010b). Survey Guidelines for Australia's Threatened Frogs
- DEWHA (2011a). Survey Guidelines for Australia's Threatened Reptiles
- DEWHA (2011b). Survey Guidelines for Australia's Threatened Mammals.

6.3.9 Trapping and Remote Surveys

Terrestrial Hair Funnels

Terrestrial Faunatech hair funnels were baited with a rolled oats and peanut butter mixture. All terrestrial hair funnels were positioned amongst habitat features such as logs, fallen bark, rocks and ground cover. Three lines of 20 hair funnels were left in position from 25 November 2014 to 23 December 2014 (refer to **Figure 6.5**). All hair samples collected were identified by Barbara Triggs (a recognised expert in the field of hair and scat identification).

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, no hair funnels were located within the area that has now been identified as the Haerses Road Offset Site.

Remote Cameras

During November and December 2014, remote camera surveys were conducted to target terrestrial mammal species at 10 locations across the Modification Area. At each site, a Bushnell Trophy Cam HD remote camera was mounted approximately 1 metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey. Cameras were set to take three photos in quick succession when movement was detected. Remote cameras were set at each site for 28 days resulting in a total of 280 camera day/nights of survey. The locations of the remote cameras are displayed on **Figure 6.5**.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, only one remote camera was located within the area that has now been identified as the Haerses Road Offset Site.

Micro-bat Echolocation Recordings

Echolocation calls emitted by micro-bats were detected using an Anabat II Bat Detector. Echolocation calls were recorded using an Anabat CF storage ZCAIM or an Anabat SD2 unit. The combination of detector and recording device is hereafter collectively referred to as the 'Anabat echolocation recorder'. The Anabat echolocation recorders were positioned at an approximate 30 degree angle and 1 metre above the ground in waterproof housing. While micro-bat activity is likely to be reduced during rain, calls were still able to be collected during dry parts of the night (particularly nights with brief thunderstorms).

Anabat echolocation recorders were positioned within the vicinity of potential micro-bat flyways. The recorders were automated and programmed to start recording one hour before dusk and to stop recording one hour after sunrise the following morning. Recordings were collected over two to four nights at each Anabat echolocation recording location.

All micro-bat species were identified by Anna McConville of Echo Ecology Pty Limited (a recognised expert in the identification of micro-bat calls). The location of Anabat surveys are shown on **Figure 6.5**. Micro-bat echolocation recordings were undertaken at three locations.

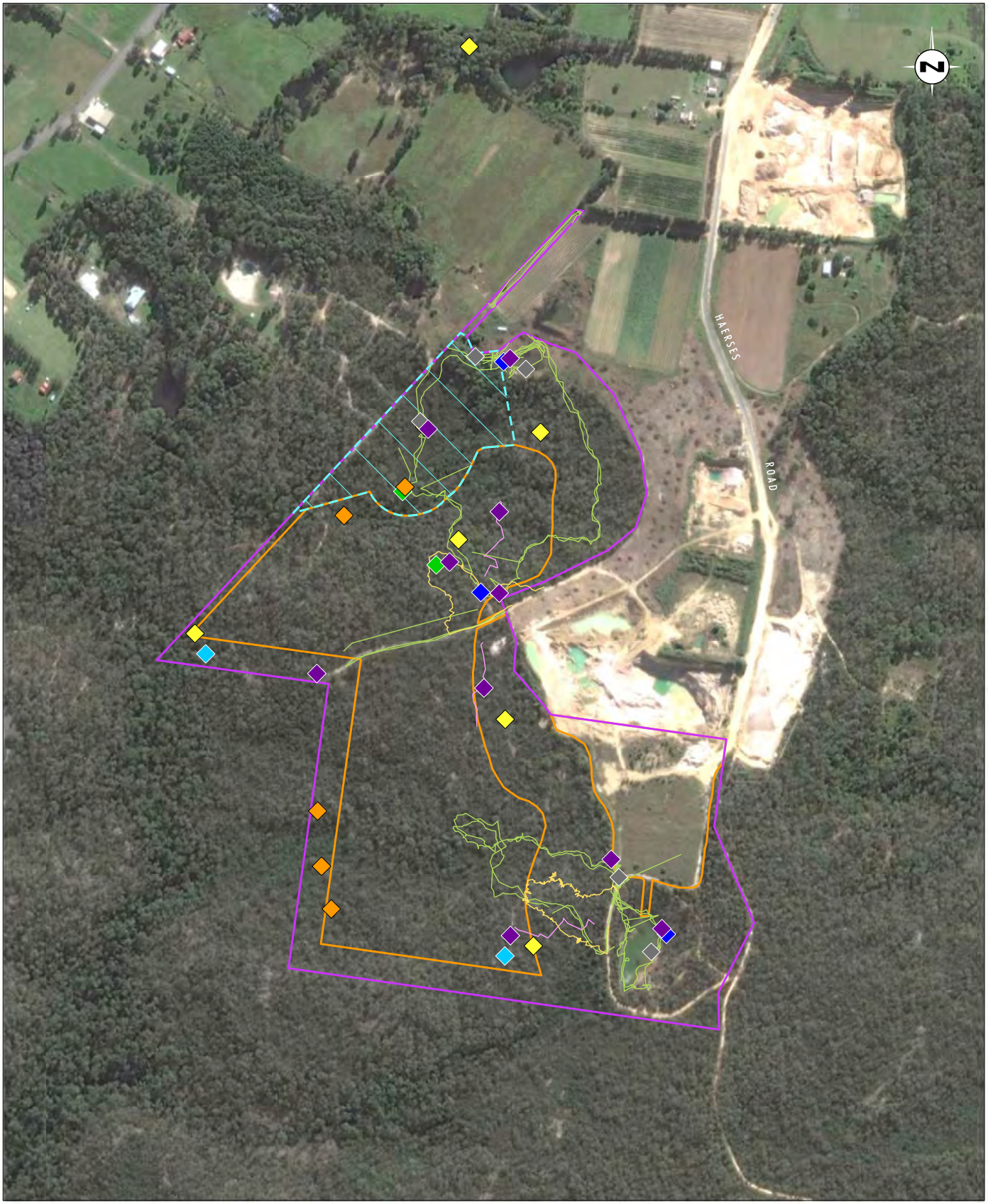


Image Source: Google Earth (2014)

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Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Dural woodland snail search
- Spotlighting Search
- Terrestrial Hair Funnel Line
- Anabat
- Bird Search
- Habitat Assessments and SAT Test
- Nocturnal Call Playback
- Remote Camera
- Reptile Search
- SAT Test

FIGURE 6.5

Fauna Survey Locations

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At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, no Anabat units were located within the area that has now been identified as the Haerses Road Offset Site. One unit was however located on the north eastern boundary.

6.3.10 Area-based searches

Spotlighting Searches

Spotlighting searches were undertaken both on foot and from a moving vehicle (refer to **Figure 6.5**). Walking spotlighting searches were undertaken by two observers for a period of one hour (total of two person hours) on each occasion. Vehicle spotlighting searches were undertaken by the passenger(s) from a slow moving vehicle along vehicle tracks between trapping sites. Both walking and vehicle spotlighting searches were conducted using 30 watt Lightforce spotlights.

Reptile and Amphibian Searches

Diurnal searches targeting the Broad-headed snake, *Hoplocephalus bungaroides*, and Rosenberg's goanna, *Varanus rosenbergi*, were undertaken during the warmest parts of the day. Diurnal searches were undertaken by a single person for half an hour on two separate days (refer to **Figure 6.5**). Nocturnal searches targeted the red-crowned toadlet, *Pseudophryne australis*, and giant burrowing frog, *Heleioporus australiacus*. Nocturnal reptile and amphibian searches were undertaken by two people for one hour on two occasions using Petzl headlamps and/or 30 watt Lightforce spotlights. Diurnal and nocturnal searches were undertaken by two ecologists for a period of at least 30 minutes during each search.

Habitat features investigated during reptile and amphibian searches included water bodies, emergent vegetation, wet soak areas, logs, rocks, loose bark on tree trunks, exposed bedrock, leaf litter, and open grassland areas. Amphibians not identifiable from their calls were captured for visual identification. All amphibians were handled according to the hygiene protocol for the control of disease in frogs (Wellington and Haering 2001). Non-venomous snake species and small lizards were captured for identification where necessary.

Bird Searches

Bird searches were undertaken at the trap and hair funnel sites (refer to **Figure 6.5**) at various times of the day, primarily during early to mid morning and mid to late afternoon. Bird searches were undertaken for one person hour (by one or two observers) at two locations. Opportunistic observations were recorded during all other aspects of the field surveys, particularly while checking traps and when travelling between survey sites. Bird species were identified by characteristic calls and by observation using 10 x 24 binoculars.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, only one bird survey was located within the area that has now been identified as the Haerses Road Offset Site.

Dural Woodland Snail Searches

Targeted spotlighting searches for the Dural woodland snail (*Pommerhelix duralensis*) were completed on 16 December 2016 by two observers. These searches were completed on foot at two separate locations within the Development Site (refer to **Figure 6.5**) for a period of 40 and 70 minutes (total of 1.3 and 2.3 person hours). Walking spotlighting searches were conducted using Petzl headlamps and/or 30 watt Lightforce spotlights. Photographs and specimen measurements of the recorded Dural woodland snail were sent to the Australian Museum for identification.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, no Dural woodland snail searches were located within the area that has now been identified as the Haerses Road Offset Site.

Signs of Presence Searches

Searches for indirect evidence of animal presence were conducted opportunistically during all survey activities, particularly during habitat searches and reptile and amphibian searches. Due to the opportunistic nature of signs of presence surveys, the level of survey effort was not recorded. Evidence of presence included scats, feathers, nests, burrows, bones, tufts of hair and scratch marks on trees. All hair, scat and bone samples were identified by Barbara Triggs.

Habitat Assessments

Seven habitat assessments were undertaken across the range of habitat types present in the Modification Area (refer to **Figure 6.5**). The assessment targeted potential habitat and resources for fauna species, particularly threatened fauna species.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, only one habitat assessment was located within the area that has now been identified as the Haerses Road Offset Site.

Records of a number of habitat features were made at each site, including:

- Evidence of disturbance such as fire, weeds, feral animals, dumping, erosion and logging
- Presence of stumps and stags
- Presence of fallen timber/logs
- Presence of dieback and/or insect attack
- Mistletoe presence
- Presence of perch sites, fallen and loose bark
- Vegetation strata and composition
- Tree size class (trunk diameter), and age (old growth, mature, regenerating, saplings)
- Presence of other specific feed tree species (such as for cockatoos and honeyeaters) and
- Collection of detailed hollow data, including tree species and height, hollow size, orientation, position, and height of hollow).

Habitat features such as tree hollows and fallen logs were inspected for any evidence of fauna occupation such as scratches on the trunks of trees, chewed entrances to hollows, scratching or diggings near logs and scats at the base of trees or near logs.

Nocturnal Call Playback

Nocturnal call playback sessions were undertaken at five sites within the first 4 hours after dusk. Calls were broadcast using a 10 watt directional loud hailer. Call playback sessions commenced and ended with a quiet listening period of approximately two minutes. Each species' call was played for a minimum of four minutes followed by a listening period of two minutes before the beginning of the next species' call. Mammal calls were played before bird calls to prevent the calls of predators (such as owls) decreasing the likelihood of prey species (such as gliders) responding to call playback. Call playback sessions included the calls of the following species:

- Giant burrowing frog (*Heleioporus australiacus*)
- Red-crowned toadlet (*Pseudophryne australis*)
- Squirrel glider (*Petaurus norfolcensis*)
- Koala (*Phascolarctos cinereus*)
- Masked owl (*Tyto novaehollandiae*)
- Sooty owl (*Tyto tenebricosa*)
- Barking owl (*Ninnox connivens*) and
- Powerful owl (*Ninnox strenua*).

Fauna Survey Effort Summary

Table 6.6 summarises the trapping and remote camera survey effort undertaken across the Modification Area during spring 2014.

Table 6.6 Summary of Fauna Trapping and Remote Survey Effort

Trapping Method	Number of trap nights – Spring 2014
Terrestrial hair funnel	1680
Anabat echolocation (entire nights)	6
Remote cameras	280

Note: One trap night equals one trap/camera/detector set for one night.

Table 6.7 summarises the area search effort undertaken across the Modification Area during spring 2014.

Table 6.7 Summary of Fauna Area Search Effort

Survey Method	Spring 2014	Summer 2015
Bird surveys (person hours)	2	-
Koala SAT	12	-
Diurnal reptile and amphibian surveys (person hours)	1	-
Nocturnal reptile and amphibian surveys (person hours)	4	-
Walking spotlight	4	-
Dural woodland snail spotlight (person hours)	-	7.2
Driving spotlight	Undertaken opportunistically, kilometres not recorded	-
Nocturnal call playback	5	-

6.4 Threatened Species

6.4.1 Species-credit Flora Surveys

Species-credit flora surveys were undertaken over 7 days and 2 survey periods:

- 25 to 27 November 2014 and
- 14 to 17 December 2015.

The November 2014 field survey was undertaken at a time which was suitable for detection of most targeted species. An additional targeted species survey was undertaken in December 2015 to focus primarily on threatened flora species as the earlier survey was combined with fauna survey efforts. It should be noted that all threatened flora species are species-credit species under the BioBanking Assessment Methodology (OEH 2014).

A preliminary list of species-credit flora species with potential to occur in the Haerses Road Offset Site was generated during the literature review, completion of database searches and preliminary assessment using the BioBanking Credit Calculator. The preliminary list of potentially occurring species credit species was reviewed to remove species that are not known to occur in the local area or species for which there was a lack of suitable habitat in the Haerses Road Offset Site. **Table 6.8** identifies the species-credit flora species that were identified through the BioBanking Credit Calculator, we have amended the table to identify those species that have potential to occur in the Development Site and required targeted and seasonal surveys, as well as those that do not.

Table 6.8 Species-credit Flora Species Requiring Targeted Survey

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Potential to Occur					
Acacia gordonii	*Acacia gordonii*	E	E	All Year	BBCC
Ancistrachne maidenii	*Ancistrachne maidenii*	V	-	December – February	BBCC
Asterolasia elegans	*Asterolasia elegans*	E	E	All Year	BBCC
brown Pomaderris	*Pomaderris brunnea*	E	V	All Year	BBCC
Bynoes wattle	*Acacia bynoeana*	E	V	September – March	BBCC
clandulla geebung	P*ersoonia marginata*	V	V	All Year	BBCC
Darwinia biflora	*Darwinia biflora*	V	V	September – February	BBCC
Darwinia fascicularis subsp. *oligantha* population, Baulkham Hills and Hornsby Local Government Areas	*Darwinia fascicularis* subsp. *oligantha* - endangered population	EP	-	All year	BBCC
Darwinia peduncularis	*Darwinia peduncularis*	V	-	All Year	BBCC
Grevillea parviflora subsp*. supplicans*	*Grevillea parviflora* subsp*. supplicans*	E	-	All year	BBCC
hairy geebung	*Persoonia hirsuta*	E	E	December – May	BBCC
Hibbertia superans	*Hibbertia superans*	E	-	July – December	BBCC
Kunzea rupestris	*Kunzea rupestris*	V	V	All Year	BBCC

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Leucopogon fletcheri subsp. *fletcheri*	*Leucopogon fletcheri* subsp. *fletcheri*	E	-	All Year	BBCC
Micromyrtus blakelyi	*Micromyrtus blakelyi*	V	V	All Year	BBCC
Olearia cordata	*Olearia cordata*	V	V	All Year	BBCC
Pimelea curviflora subsp. *curviflora*	*Pimelea curviflora* subsp. *curviflora*	V	V	All Year	BBCC
spreading guinea flower	*Hibbertia procumbens*	E	-	December - March	BBCC
Tetratheca glandulosa	*Tetratheca glandulosa*	V	-	July – November	BBCC
Zieria involucrata	*Zieria involucrata*	E	-	All Year	BBCC
Unlikely to Occur					
downy wattle	*Acacia pubescens*	V	V	All Year	BBCC
Epacris purpurascens subsp. *purpurascens*	*Epacris purpurascens* subsp. *purpurascens*	V	-	All Year	BBCC
Eucalyptus sp. Cattai	*Eucalyptus* sp. Cattai	CE	-	All Year	BBCC
groves paperbark	*Melaleuca groveana*	V	-	All Year	BBCC
Gyrostemon thesioides	*Gyrostemon thesioides*	E	-	All Year	BBCC
Hibbertia puberula	*Hibbertia puberula*	E	-	September – February	BBCC
Leptospermum deanei	*Leptospermum deanei*	V	V	All Year	BBCC
netted bottle brush	*Callistemon linearifolius*	V	-	September – March	BBCC
Pultenaea parviflora	*Pultenaea parviflora*	E	V	All Year	BBCC

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
singleton mint bush	*Prostanthera cineolifera*	V	V	All Year	BBCC
Velleia perfoliata	*Velleia perfoliata*	V	V	September - November	BBCC

^ Months that surveys are required according to the Threatened Species Profile Database for the Hawkesbury Nepean CMA.

Throughout flora surveys of the Haerses Road Offset Site, targeted searches were carried out for threatened flora species that are known to occur in the vicinity of the Haerses Road Offset Site or were considered likely to occur based on the species' known distribution and the presence of suitable habitat. Searches for these species were undertaken in suitable habitat along numerous walking meandering transects and within the plot and transect surveys.

Further survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, none of the stratified plots targeting *Darwinia biflora* were completed within the area that has now been identified as the Haerses Road Offset Site.

The seasonal requirements of all species-credit flora species with potential to occur within the Haerses Road Offset Site were met between the combination of the November 2014 and December 2015 survey periods.

6.4.2 Species-credit Fauna Surveys

Species-credit fauna surveys were undertaken over 6 days and two survey periods:

- 25 to 27 November 2014
- 14 to 17 December 2015.

A preliminary list of species-credit fauna species with potential to occur in the Haerses Road Offset Site was generated during the literature review, completion of database searches and preliminary assessment using the BioBanking Credit Calculator (BBCC). The preliminary list of potentially occurring species-credit fauna species was reviewed to remove species that are not known to occur in the local area or species for which there was a lack of suitable habitat in the Haerses Road Offset Site. **Table 6.9** identifies the species-credit fauna species that were identified through the BioBanking Credit Calculator, we have amended the table to identify those species that have potential to occur in the Haerses Road Offset Site and required targeted and seasonal surveys, as well as those that do not.

Table 6.9 Species-credit Fauna Species Requiring Targeted Survey

Common Name	Scientific Name	TSC Status	EPBC Status	Required Survey Period^	Source
Potential to Occur					
brush-tailed phascogale	*Phascogale tapoatafa*	V	-	All Year	
eastern pygmy-possum	*Cercartetus nanus*	V	-	Not specified	BBCC
Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	EP	-	All Year	BBCC
giant burrowing frog	*Heleioporus australiacus*	V	V	September - May	BBCC
koala	*Phascolarctos cinereus*	V	V	All Year	BBCC
red-crowned toadlet	*Pseudophryne australis*	V	-	All Year	BBCC
regent honeyeater	*Anthochaera phrygia*	E	CE	All Year	BBCC
Rosenbergs Goanna	*Varanus rosenbergi*	V	-	November – February	BBCC
squirrel glider	*Petaurus norfolcensis*	V	-	All Year	BBCC
Unlikely to Occur					
giant barred frog	*Mixophyes iteratus*	E	E	October – April	BBCC

^ Months that surveys are required according to the Threatened Species Profile Database for the Hawkesbury Nepean CMA.

Targeted surveys were undertaken for the species listed in **Table 6.9** that included a range of survey techniques including targeted searches, hair funnel trapping, call playback, anabat echolocation, spotlighting and remote detection camera surveys. Throughout surveys of the Modification Area, opportunistic surveys for these species were undertaken in suitable habitat along numerous walking meandering transects. The seasonal requirements of all species-credit flora species with potential to occur within the Modification Area were met between the combination of the November 2014 and December 2015 survey periods. The details of these surveys are discussed in the sections below and specific survey locations are shown on **Figure 6.5.**

6.4.2.1 Regent Honeyeater Surveys

Diurnal bird surveys, each of one person-hour, were undertaken in two locations within the Haerses Road Offset Site in November 2014. Bird surveys were undertaken at various times of the day, primarily in early to mid morning and mid to late afternoon. Each survey consisted of a slow walking transect within a Haerses Road Offset Site. The bird surveys targeted areas of flowering eucalypt woodlands containing other nectarivorous species such as lorikeets and honeyeaters.

Bird species were identified from characteristic calls and by observation using binoculars with magnification up to 10 x. Opportunistic observations were recorded during all other aspects of the field survey.

6.4.2.2 Eastern Pygmy Possum and Squirrel Glider Surveys

Eastern pygmy possum and squirrel glider were targeted by conducting spotlighting and remote camera surveys. Additionally, nocturnal call playback surveys were undertaken for squirrel glider.

Nocturnal spotlighting surveys, each of two person-hours repeated over two nights, were undertaken in three locations within the Modification Area, of which one occurs within the Haerses Road Offset Site. Spotlighting was conducted on foot using 30 watt Lightforce hand-held spotlights and head torches. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk. In addition, spotlighting was undertaken from a slow-moving vehicle along vehicle tracks and while travelling between trapping locations at night.

Bushnell Trophy Cam HDs (remote cameras) were mounted approximately one metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey to increase the likelihood of detecting the eastern pygmy possum. The cameras were set to take three photos in quick succession when movement was detected. The remote cameras were programmed to record movement on an ongoing basis until removed from the site. The cameras were installed for 28 nights in 10 locations, totalling 280 nights of remote camera survey. Of the ten cameras used within the Modification Area, one was located within the Haerses Road Offset Site.

Nocturnal call-playback sessions targeting squirrel glider were undertaken at four locations within the Modification Area, one of which occurs within the Haerses Road Offset Site. An additional location was surveyed immediately north of the Development Site for context. Call-playback sessions commenced with a quiet listening period of approximately five minutes. The squirrel glider call was played on a 15 watt directional loud hailer for a minimum of 4 minutes followed by a listening period of 2 minutes.

6.4.2.3 Koala Surveys

Koalas were targeted by conducting nocturnal call playback and walking and driving spotlighting surveys.

Nocturnal spotlighting surveys, each of one person-hour repeated over two nights, were undertaken in three locations within the Modification Area, of which one occurs in the Haerses Road Offset Site. Walking spotlighting searches were conducted by two observers for a period of one hour (total of two person hours)

on each occasion. Vehicle spotlighting searches were undertaken by the passenger(s) from a slow moving vehicle along vehicle tracks between trapping sites. Both walking and vehicle spotlighting searches used a 30 watt Lightforce hand-held spotlight and head torch for detecting fauna. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk.

Nocturnal call-playback sessions targeting koala were undertaken at four locations within the Modification Area of which one occurs in the Haerses Road Offset Site. An additional location was surveyed immediately north of the Development Site for context. Call-playback sessions commenced with a quiet listening period of approximately five minutes. The koala call was played on a 15 watt directional loud hailer for a minimum of 4 minutes followed by a listening period of 2 minutes.

Searches for signs of the presence of koalas were undertaken at 12 locations across the Modification Area in using the Spot Assessment Technique (SAT). Searches were conducted on and around the base of 10 – 30 trees at every survey site. The searches focussed on signs of presence including scats at the base of trees and characteristic scratches on tree trunks.

6.4.2.4 Amphibian Surveys

The BioBanking Calculator predicted the occurrence of red-crowned toadlet (*Pseudophryne australis*) and giant burrowing frog (*Heleioporus australiacus*) due to the geographic habitat feature of land within 100 metres of a waterbody and land within 40 metres of woodland within the Hawkesbury/Nepean catchment area, respectively. Despite these habitat features being present at the site in the form of woodland and two dams, no permanent streams with substantial fringing vegetation occur in the Development Site.

Despite this, diurnal herpetological searches were undertaken in 2 locations across the Modification Area. During the search likely micro-habitats were examined including around waterbodies, beneath rocks and logs, in tree bark and in ground litter. Each survey consisted of approximately one person hour of survey, totalling 1 hour of diurnal herpetological surveys. At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, no herpetological search was completed within the area that has now been identified as the Haerses Road Offset Site.

Nocturnal spotlighting surveys, each of two person-hours repeated over two nights, were also undertaken in three locations within the Referral Area, of which was located within Haerses Road Offset Site. Spotlighting was conducted on foot using 30 watt Lightforce hand-held spotlights and head torch. Spotlighting was undertaken generally between 8.00 pm and 12.00 am, commencing one hour after dusk and targeted relevant habitat features such as water bodies, emergent vegetation, wet soak areas and riparian zones.

6.4.2.5 Micro-bat Habitat Surveys

The presence of threatened micro-bat species was also surveyed using Anabat SD1 recorders at two locations within the Referral Area of which one occurs on the north eastern boundary of the Haerses Road Offset Site. At each site, the Anabat was positioned at an approximate 30 degree angle one metre above the ground in waterproof housing. Each detector was positioned towards potential micro-bat flight paths or over waterbodies to increase the likelihood of detecting micro-bat species. The Anabat detector was programmed to start recording from one hour before sunset to one hour after sunrise.

Recordings of bat calls were analysed by Anna McConville of Echo Ecology Pty Limited (a recognised expert in the identification of micro-bat calls). The echolocation calls of species were identified to one of three levels of confidence:

- confident
- probable, and
- possible.

7.0 Results - Haerses Road Offset Site

7.1 Landscape Value

7.1.1 Landscape Features

The outer assessment circle contains some prominent landscape features including sections of 4th order streams, Stone Chimney Arm Creek and Little Cattai Creek. The outer assessment circle also covers multiple Mitchell landscapes and an extensive area of native vegetation predominantly in the east, south and west of the circle. These landscape features are shown in **Figures 6.2** and **6.3**.

Landscape features that were considered in the connectivity value scores for the Haerses Road Offset Site are outlined in **Table 7.1** below.

Table 7.1 Landscape Features in the Haerses Road Offset Site

Landscape Features	
IBRA Bioregion	Sydney Basin
IBRA Subregion	Yengo – Hawkesbury/Nepean
Mitchell Landscape	Hornsby Plateau
Rivers, Streams, Estuaries	1st order streams from Stone Chimney Arm Creek
Wetlands	None identified
Native Vegetation	43.67 hectares in the inner assessment circle 726.69 hectares in the outer assessment circle
State or Regional Biodiversity Links	None identified

7.1.2 Landscape Value Scores

7.1.2.1 Percent Native Vegetation Cover

Table 7.2 details the percent native vegetation cover before and after the BioBanking Offset Agreement in the Haerses Road Offset Site and the native vegetation per cent class entered into the BioBanking Calculator as per Table 9 of Appendix 4 of the FBA (OEH 2014).

Table 7.2 Native Vegetation Cover in Assessment Circles

Assessment Circle	Before BioBanking Offset Agreement			After BioBanking Offset Agreement		
	Area of Native Vegetation (ha)	Native Vegetation Cover (%)	Native Vegetation Percent Class	Area of Native Vegetation (ha)	Native Vegetation Cover (%)	Native Vegetation Percent Class
Outer (1,000 ha)	726.69	72.66	71-75	726.69	72.66	71-75
Inner (100 ha)	43.67	43.67	41-45	43.67	43.67	41-45

7.1.2.2 Connectivity Value

No state or regional significant biodiversity links were identified within a plan approved by the Chief Executive of OEH in the Yengo – Hawkesbury/Nepean. Although a number of first order streams of tributaries of Stone Chimney Arm Creek run through the Haerses Road Offset Site, these are not defined as state or regional significant biodiversity links under the FBA (OEH 2014) (refer to **Figure 7.1**).

Connecting links using moderate to good condition native vegetation were found on the site to occur in all woodland communities in the Haerses Road Offset Site. The entire Haerses Road Offset Site comprises remnant native vegetation and thus the current narrowest point of these links is estimated to be approximately greater than 500 metres wide (refer to **Figure 7.1**). This link will remain with the BioBanking Offset Agreement in place. Therefore it is considered that the connectivity width class after the BioBanking Offset Agreement is finalised on Haerses Road Offset Site would be greater than 500 metres wide (refer to **Table 7.3**).

Woody PCTs within the outer assessment circle were assumed to be in good condition for overstorey foliage cover and midstorey foliage cover. This assumption was based on the location of the Haerses Road Offset Site, abundance of adjacent remnant vegetation and quality of the vegetation within the Haerses Road Offset Site. The overstorey per cent foliage cover in the woody vegetation in the outer assessment circle was assumed, on the whole, to be within benchmark. The midstorey per cent foliage cover in the woody vegetation in the outer assessment circle was assumed, on the whole, to be within benchmark. These are likely to remain the same after the BioBanking Offset Agreement.

Details of the connectivity value scores entered into the BioBanking Credit Calculator are shown in **Table 7.3** below.

Table 7.3 Connectivity Value Scores

Attribute	Before BioBanking Offset Agreement	After BioBanking Offset Agreement
Connectivity Width Class	>500m	>500m
Connectivity Overstorey Condition	PFC at benchmark	PFC at benchmark
Connectivity Midstorey Condition	PFC at benchmark	PFC at benchmark

7.1.2.3 Patch Size

Table 7.4 below details the parameters that determined the Patch Size score as per Table 15 of Appendix 4 of the FBA (OEH 2014).

Table 7.4 Patch Size Score Parameters

Mitchell Landscape	Hornsby Plateau
Percent Native Vegetation Cleared	14%
Patch Size Class	1001 hectares
Patch Size Score	**12**

7.1.2.4 Landscape Value Score

The landscape value score for the Haerses Road Offset Site is **12.0**.

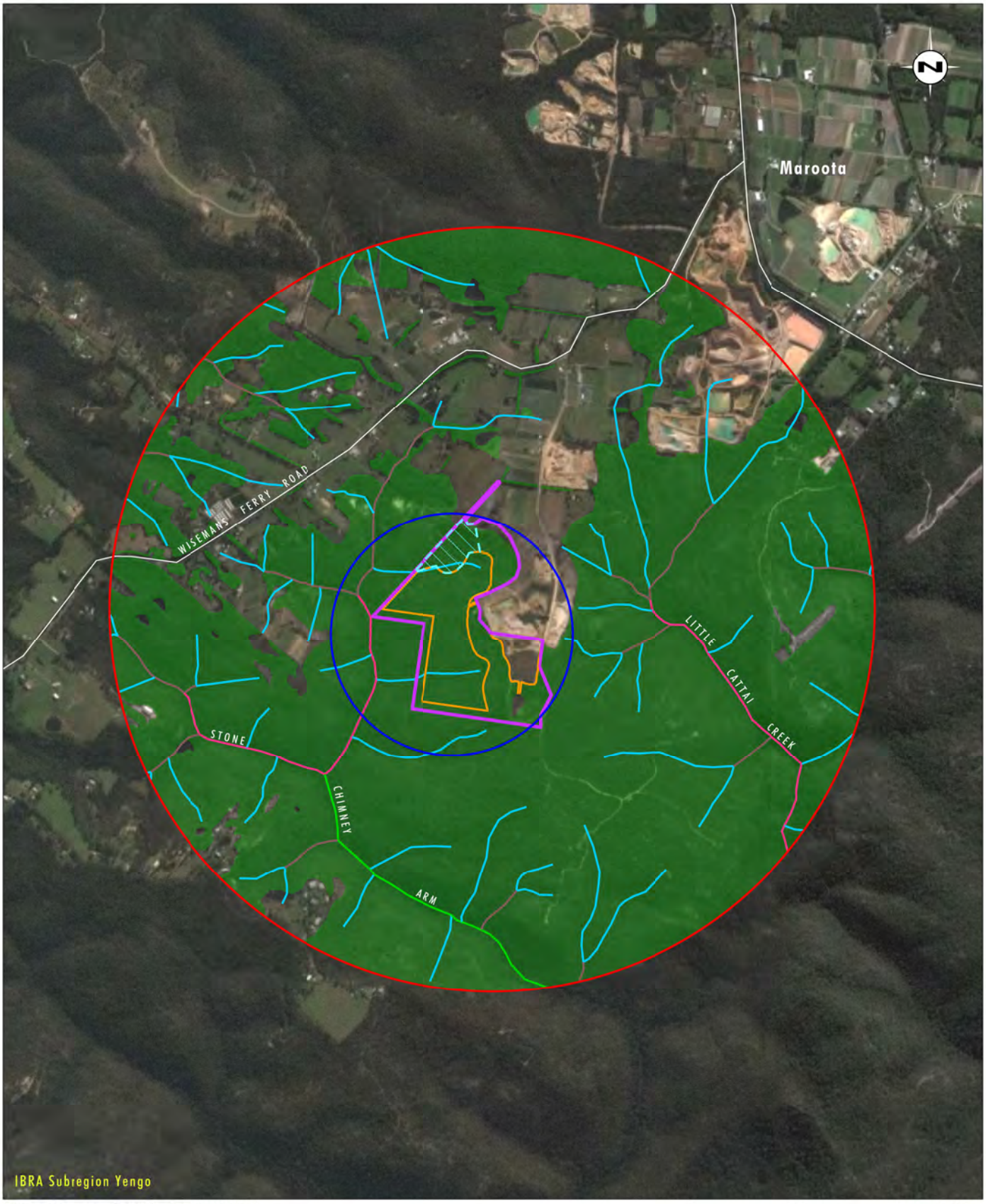


Image Source: Google Earth (2014)
Data Source: LPI (2011)

0 0.5 1.0 1.25km
1:25 000

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- 1000 Ha Assessment Circle
- 100 Ha Assessment Circle
- Native Vegetation
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th Order Stream

FIGURE 7.1

Haerses Road Offset Site Connectivity Value

File Name (A4): R04/3479_043.dgn
20160920 11.40

7.2 Native Vegetation within the Haerses Road Offset Site

7.2.1 Biometric Vegetation Types and Vegetation Zones

Surveys of the Haerses Road Offset Site identified four Biometric Vegetation Types (BVTs) (excluding cleared areas and dams) being:

- HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion
- HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
- HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion and
- HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion.

These BVTs were aligned with types described as part of the NSW Biometric vegetation types database (OEH 2014b), the Sydney Basin Vegetation Inventory (Tozer *et al.* 2010) and the Baulkham Hills Vegetation Mapping. The BVTs were then categorised into four vegetation condition zones (refer to **Figure 7.2**). The composition of these vegetation zones are outlined in **Tables 7.5** to **7.8** below.

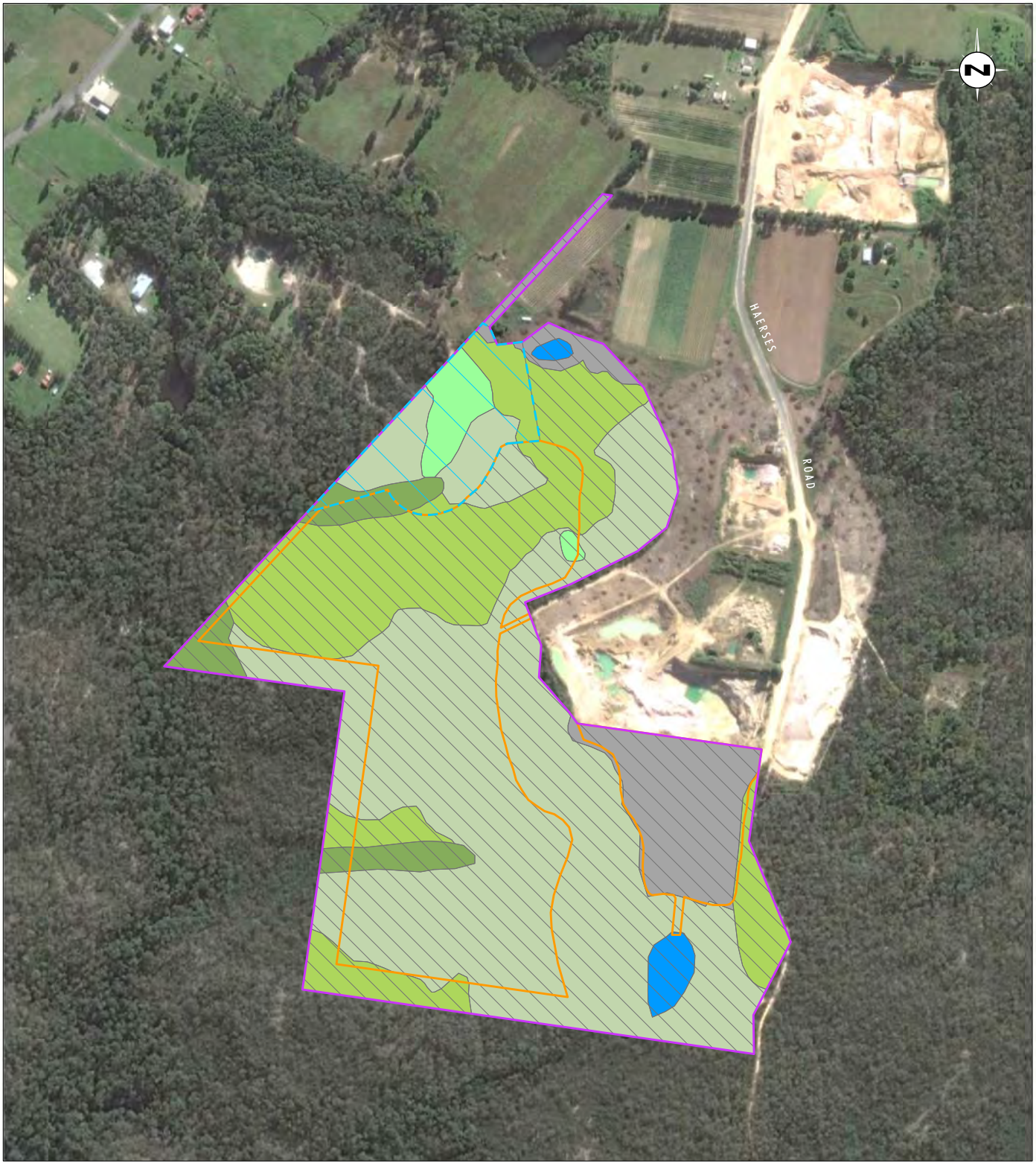


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Area Mapped Outside Haerses Road Onsite Offset Site
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition
- Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition
- Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition
- Cleared
- Dam

FIGURE 7.2

Vegetation Zones in Haerses Road Offset Site

File Name (A4): R04/3479_044.dgn
20160920 11.42

Table 7.5 Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN560
PCT ID	978
Vegetation Formation	Freshwater Wetlands
Vegetation Class	Coastal Heath Swamps
Hectares in Modification Area	1.03
Hectares in Haerses Road Offset Site	0.93
Tozer *et al.* (2010) Equivalent	FrW p129: Coastal Upland Swamp
AES Environmental Consultancy (2001) Equivalent	
Plots/Transects Undertaken	One (P04)
Floristic Description	This vegetation zone occurs at two locations where ground water seeps to the surface. This vegetation zone is characterised by a mid-dense shrub layer dominated by dwarf apple (*Angophora hispida*), prickly tea-tree (*Leptospermum juniperinum*), heath-leaved banksia (*Banksia ericifolia*), fern-leaved banksia (*Banksia oblongifolia*), *Leucopogon esquamatus*, crimson bottlebrush (*Callistemon citrinus*) and heath myrtle (*Baeckea imbricata*). The dense ground layer is dominated by zig-zag bog rush (*Schoenus brevifolius*), *Ptilothrix deusta*, *Leptocarpus tenax*, spreading rope-rush (*Empodisma minus*), *Drosera spatulata* and pouched coral fern (*Gleichenia dicarpa*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	*Coastal Upland Swamp in the Sydney Basin Bioregion EEC*
EPBC Status	*Coastal Upland Swamps in the Sydney Basin Bioregion EEC*

Feature	Description
Photo	

Table 7.6 Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN566
PCT ID	1083
Vegetation Formation	Dry Sclerophyll Forests (Shrubby sub-formation)
Vegetation Class	Sydney Coastal Dry Sclerophyll Forests
Hectares in Modification Area	11.46
Hectares in Haerses Road Offset Site	0.78
Tozer *et al.* (2010) Equivalent	DSF p131 Coastal Sandstone Ridgetop Woodland
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Ridgetop Woodland
Plots/Transects Undertaken	Three (SR1, P01 and P06)

Feature	Description
Floristic Description	This vegetation zone supports a sparse canopy dominated by yellow bloodwood (*Corymbia* eximia), red bloodwood (*Corymbia gummifera*), narrow-leaved stringybark (*Eucalyptus sparsifolia*) and grey gum (*Eucalyptus punctata*). A dense shrub layer is present and comprises flakey-barked tea-tree (*Leptospermum trinervium*), mountain devil (*Lambertia formosa*), needlebush (*Hakea sericea*), heath-leaved banksia (*Banksia ericifolia*), *Darwinia biflora* and conesticks (*Petrophile pulchella*). The ground layer generally comprises lesser flannel flower (*Actinotus minor*), wiry panic (*Entolasia stricta*), *Lepyrodia scariosa*, *Austrostipa pubescens* and oat speargrass (*Anisopogon avenaceus*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.
Photo	

Table 7.7 Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN582
PCT ID	1134
Vegetation Formation	Heathlands
Vegetation Class	Sydney Coastal Heaths
Hectares in Modification Area	24.49
Hectares in Haerses Road Offset Site	1.52

Feature	Description
Tozer *et al.* (2010) Equivalent	Coastal Sandstone Plateau Heath
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Heath
Plots/Transects Undertaken	Three (SH1, P02 and P03)
Floristic Description	This vegetation zone is dominated by a dense cover of shrubs, with emergent eucalyptus scattered throughout and forming an open woodland community in some areas. Emergent eucalypts include scribbly gum (*Eucalyptus haemastoma*), red bloodwood (*Corymbia gummifera*) and scaly bark (*Eucalyptus squamosa*). Common shrubs include flakey-barked tea-tree (*Leptospermum trinervium*), dwarf apple (*Angophora hispida*), heath-leaved banksia (*Banksia ericifolia*), mountain devil (*Lambertia formosa*), *Darwinia biflora*, grey spider flower (*Grevillea buxifolia*) and conesticks (*Petrophile pulchella*). The ground layer generally comprises grasstree (*Xanthorrhoea* sp.), lesser flannel flower (*Actinotus minor*), heath bog-rush (*Schoenus ericetorum*), wiry panic (*Entolasia stricta*) and *Ptilothrix deusta*. Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.
Photo	

Table 7.8 Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition

Feature	Description
Name	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion
Condition	Moderate to Good
BVT ID	HN586
PCT ID	1181
Vegetation Formation	Dry Sclerophyll Forests (Shrubby sub-formation)
Vegetation Class	Sydney Coastal Dry Sclerophyll Forests
Hectares in Modification Area	1.91
Hectares in Haerses Road Offset Site	0.36
Tozer *et al.* (2010) Equivalent	DSF p142 Coastal Sandstone Gully Forest
AES Environmental Consultancy (2001) Equivalent	Sydney Sandstone Gully Forest
Plots/Transects Undertaken	One (P05)
Floristic Description	This vegetation zone supports a sparse to mid-dense canopy dominated by smooth-barked apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), grey gum (*Eucalyptus punctata*), yellow bloodwood (*Corymbia eximia*), and old-man banksia (*Banksia serrata*), with occurrences of red bloodwood (*Corymbia gummifera*), turpentine (*Syncarpia glomulifera* subsp. *glomulifera*) and red mahogany (*Eucalyptus resinifera* subsp. *resinifera*). A mid-dense shrub layer is present and comprises flakey-barked tea tree (*Leptospermum trinervium*), white wattle (*Acacia linifolia*), tantoon (*Leptospermum polygalifolium*), heath-leaved banksia (*Banksia ericifolia*), spiny bossiaea (*Bossiaea obcordata*), hairpin banksia (*Banksia minor*), and *Dillwynia retorta*. The ground layer generally comprises lesser flannel flower (*Actinotus minor*), spiny-headed mat-rush (*Lomandra longifolia*), wiry panic (*Entolasia stricta*), *Lepyrodia scariosa*, *Gahnia* sp. And common bracken (*Pteridium esculentum*). Flora species recorded in this zone are included in **Appendix A**.
TSC Status	None.
EPBC Status	None.

Feature	Description
Photo	

7.2.2 Current Site Value

Table 7.9 below details the current site value scores for each of the vegetation zones in the Haerses Road Offset Site. The table displays the change in site value scores that is expected to occur following the BioBanking Offset Agreement being secured on the Haerses Road Offset Site. The raw site condition attribute data for each of the vegetation zones is provided in **Appendix B**.

Table 7.9 Vegetation Zone Site Value Scores

Vegetation Zone No.	Vegetation Zone	Current Site Value Score (out of 100)	Site Value following BioBanking Offset Agreement (out of 100)
1	HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion	56.52	81.88
2	HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion	81.77	87.50
3	HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion	69.10	88.72
4	HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion	63.77	78.74

7.2.3 Threatened Ecological Communities

One TEC, listed under the TSC or EPBC Act, was recorded in the Haerses Road Offset Site being:

- *Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC* under the TSC Act (refer to **Section 7.2.3.1**) and EPBC Act (refer to **Section 7.2.3.2**).

Analysis of consistency to the scientific determinations for each TEC was undertaken, with consideration of the advice provided by the NSW Scientific Committee and/or the Commonwealth Threatened Species Scientific Committee guidelines for interpreting listings for species, populations and ecological communities under the TSC Act and EPBC Act, respectively.

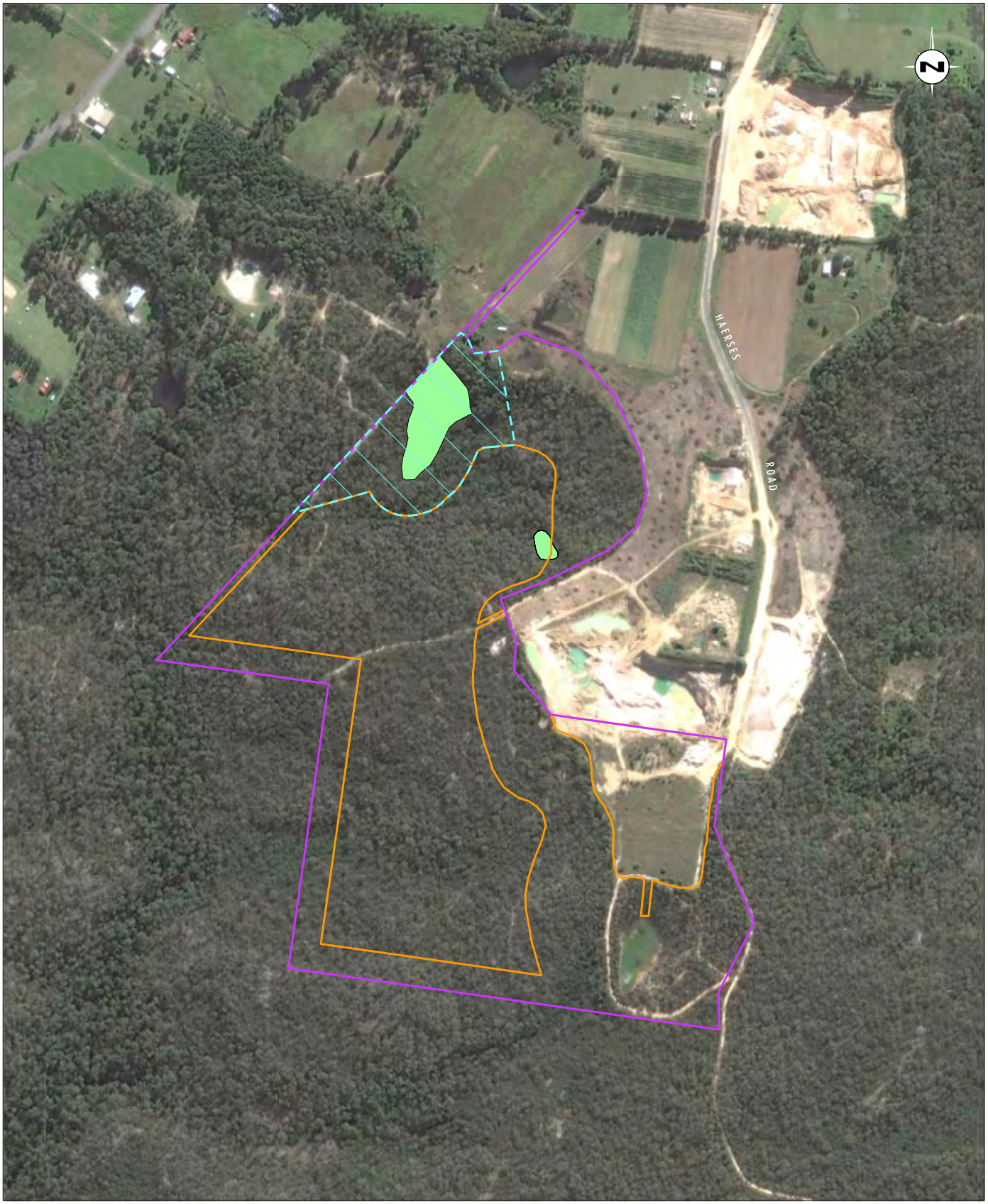


Image Source: Google Earth (2014)

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Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition (Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act)

FIGURE 7.3

Threatened Ecological Communities within Haerses Road Offset Site

7.2.3.1 *Coastal Upland Swamp in the Sydney Basin Bioregion* EEC under the TSC Act

Coastal Upland Swamp in the Sydney Basin Bioregion is listed as an endangered ecological community under the TSC Act. The community is known to occur on periodically waterlogged soils on Hawkesbury sandstone plateaus, where the mean annual rainfall generally exceeds 950 millimetres. The community is often associated with acid soils ranging from yellow or grey mineral sandy loams that have a shallow organic horizon to highly organic spongy black peats with pallid subsoils, as described in the Final Determination (NSW Scientific Committee 2012).

The vegetation of this community varies from tall scrub, open heath to sedgelands and is usually dominated by sclerophyll shrubs and/or sedges. This EEC is generally treeless however scattered trees may occur.

The Haerses Road Offset Site supports a total of 0.93 hectares of Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act within HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition). A comprehensive analysis of this vegetation community was undertaken to determine if it conformed to the Final Determination for this community (NSW Scientific Committee 2012).

Constituent Species

The species recorded within Coastal Upland Swamp EEC in the Haerses Road Offset Site comprises an assemblage of species consistent with the Final Determination under the Act (NSW Scientific Committee 2012).

This includes a ground layer dominated by zig-zag bog-rush (*Schoenus brevifolius*) and *leptocarpus tenax* below an upper stratum of peach blossom tea-tree (*Leptospermum squarrosum*) and heath-leaved Banksia (*Banksia ericifolia*).

Assemblage of Species

The NSW Scientific Committee (2012) lists 71 species as characterising the assemblage of species for the *Coastal Upland Swamp* EEC. As part of ecological investigations for the Project, one systematic 20 metre x 20 metre quadrat was sampled in *Coastal Upland Swamp* EEC due to the small area present in the Haerses Road Offset Site.

A total of 21 species were recorded in the Coastal Upland Swamp EEC quadrat, of these 13 (62 per cent) of the species listed in the Final Determination were present within this community.

Particular Area

In relation to the particular area of the *Coastal Upland Swamp* EEC, the NSW Scientific Committee (2012) states that the community occurs within the Sydney Basin Bioregion on Hawkesbury sandstone plateaus.

The Haerses Road Offset Site is located in the Sydney Basin Bioregion on a Hawkesbury sandstone plateau.

Supplementary Descriptors

In relation to supplementary descriptors, the NSW Scientific Committee (2012) includes the following key information pertaining to the *Coastal Upland Swamp* EEC:

- generally has a mean annual rainfall exceeding 950 millimetres

- soils that are acidic and vary from yellow or grey mineral sandy loams with a shallow organic horizon to highly organic spongy black peats with pallid subsoils and

- the vegetation of this community varies from tall scrub, open heath to sedgelands and is usually dominated by sclerophyll shrubs and/or sedges. This EEC is generally treeless however scattered trees may occur.

Of the above supplementary descriptors, the *Coastal Upland Swamp* EEC present in the Haerses Road Offset Site occurs on waterlogged soils and comprise dark brown peaty soils above sands. The mean annual rainfall for the local area is 919 millimetres, but of the last seven years (2009 – 2015) five have exceeded the required mean annual rainfall of 950 millimetres. The vegetation is dominated by multiple shrubs and sedges, and trees are absent.

7.2.3.2 *Coastal Upland Swamps in the Sydney Basin Bioregion* EEC under the EPBC Act

Coastal Upland Swamps in the Sydney Basin Bioregion is listed as an endangered ecological community under the EPBC Act. This community includes a range of vegetation and fauna associated with periodically waterlogged soils on Hawkesbury sandstone plateaus (TSSC 2014). The listing describes a community that includes open graminoid heath, sedgeland and tall scrub.

The Haerses Road Offset Site supports a total of 0.93 hectares of Coastal Upland Swamp(s) in the Sydney Basin Bioregion EEC under the TSC Act and EPBC Act within HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition). A comprehensive analysis of this vegetation community was undertaken to determine if it conformed to the Conservation Advice (including Listing Advice) provided by the Department of the Environment under the EPBC Act (TSSC 2014).

Particular Area

The Coastal Upland Swamps in the Sydney Basin Bioregion EEC under the EPBC Act is endemic to NSW and occurs in the eastern part of the Sydney Basin IBRA bioregion (TSSC 2014).

The Haerses Road Offset Site is within the Sydney Basin Bioregion.

Additional Criteria

The Conservation Advice (including Listing Advice) for the EEC identifies that it occurs primarily on permeable sandstone plateaux in the low relief headwater valleys with abundant seepage moisture (TSSC 2014). Soils are described to vary from yellow or grey sandy loams with a shallow organic horizon to highly organic spongy black peats (TSSC 2014). Additionally, the EEC swamps predominantly occur at elevations between 200 – 450 metres above sea level, but are also known to occur as low as 20 metres and up to 600 metres above sea level.

The swamp vegetation identified at the Haerses Road Offset Site occurs on waterlogged soils and comprise dark brown peaty soils above sands. Specifically, a high degree of seepage moisture was recorded during the field survey. Additionally the development site occurs at approximately 160 metres above sea level.

Vegetative Criteria

A description of the vegetation composition for the EEC is provided in the Conservation Advice (including Listing Advice). It describes a variable mosaic of vegetation that are characterised by soil conditions, size, recent rainfall, fire regimes and disturbance history (TSSC 2014). The EEC is essentially treeless, however trees may be present as scattered individuals or isolated clumps. The advice also provides a list of indicative list of vascular plant species characteristic of the EEC, a list that comprises 73 flora species. However the

advice also notes that the total number of vascular plants within the community is likely to exceed 200 species.

As part of ecological investigations for the Project, one systematic 20 metre x 20 metre quadrat was sampled in *Coastal Upland Swamp* EEC due to the small area present in the Haerses Road Offset Site.

A total of 21 species were recorded in the Coastal Upland Swamp EEC quadrat, of these 13 (18 per cent) of the species listed in the Conservation Advice (including Listing Advice) were present within this community.

HN560 - Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good Condition) within the Haerses Road Offset Site is deemed to meet the criteria discussed above. It therefore conforms with the Coastal Upland Swamps in the Sydney Basin Bioregion endangered ecological community under the EPBC Act.

7.3 Threatened Species within the Haerses Road Offset Site

7.3.1 Ecosystem-credit Species

7.3.1.1 Predicted Species

Table 7.10 below outlines the predicted ecosystem-credit species predicted to occur by the BioBanking Calculator and whether they are considered to occur on site.

Table 7.10 Predicted Ecosystem-credit Species

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
eastern false pipistrelle *Falsistrellus tasmaniensis*	V	-	2.2	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 7 km north west of the site from 2014 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
eastern freetail-bat *Mormopterus norfolkensis*	V	-	2.2	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 5 km south east of the site from 2008 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
eastern grass owl *Tyto longimembris*	V	-	1.3	Yes	Species has not been recorded in the Haerses Road Offset Site. There are no known records of this species within 10 km of the Haerses Road Offset Site (OEH 2015).
gang-gang cockatoo *Callocephalon fimbriatum*	V	-	2.0	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 2 km south of the site from 2009 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
glossy black-cockatoo *Calyptorhynchus lathami*	V	-	1.8	Yes	Species was not recorded in the Haerses Road Offset Site but it was recorded nearby along the eastern boundary of the Project Area during the surveys undertaken for this assessment (refer to **Figure 3.4** and **Section 3.3.1.2**). The Haerses Road Offset Site contains foraging habitat for the species.
greater broad-nosed bat *Scoteanax rueppellii*	V	-	2.2	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 5 km south of the site from 2006 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
little eagle *Hieraaetus morphnoides*	V	-	1.4	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 4 km north west of the site from 1994 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
little lorikeet *Glossopsitta pusilla*	V	-	1.8	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 5 km east of the site from 2009 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
New Holland mouse *Pseudomys novaehollandiae*	-	V	2.6	Yes	Species has not been recorded in the Haerses Road Offset Site. There are no known records of this species within 10 km of the Haerses Road Offset Site (OEH 2015).
scarlet robin *Petroica boodang*	V	-	1.3	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 5 km south of the site from 1975 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
spotted-tailed quoll *Dasyurus maculatus*	V	E	2.6	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 6 km north west of the site from 1979 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
square-tailed kite *Lophoictinia isura*	V	-	1.4	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 9 km south west of the site from 2006 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
swift parrot *Lathamus discolor*	E	E	1.3	Yes	Species has not been recorded in the Haerses Road Offset Site. There are no known records of this species within 10 km of the Haerses Road Offset Site (OEH 2015).
varied sittella *Daphoenositta chrysoptera*	V	-	1.3	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 3 km south west of the site from 1996 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	On Site?^	Justification
yellow-bellied glider *Petaurus australis*	V	-	2.3	Yes	Species has not been recorded in the Haerses Road Offset Site. There are several records within approximately 3 km of the site (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.
yellow-bellied sheathtail-bat *Saccolaimus flaviventris*	V	-	2.2	Yes	Species has not been recorded in the Haerses Road Offset Site. The closest record occurs approximately 9 km south west of the site from 2013 (OEH 2015). The Haerses Road Offset Site may contain marginal foraging habitat for the species.

^ As entered into the 'Site Survey Details' tab in the BBCC.

7.3.1.2 Survey Results

Two ecosystem credit species were recorded in the Haerses Road Offset Site during the surveys undertaken for this assessment, these included:

- large-eared pied bat (*Chalinolobus dwyeri*); and
- little bentwing-bat (*Miniopterus australis*).

A discussion on these records is provided below and a full fauna species list from the surveys undertaken by Umwelt in 2014 and 2015 is included in **Appendix C**.

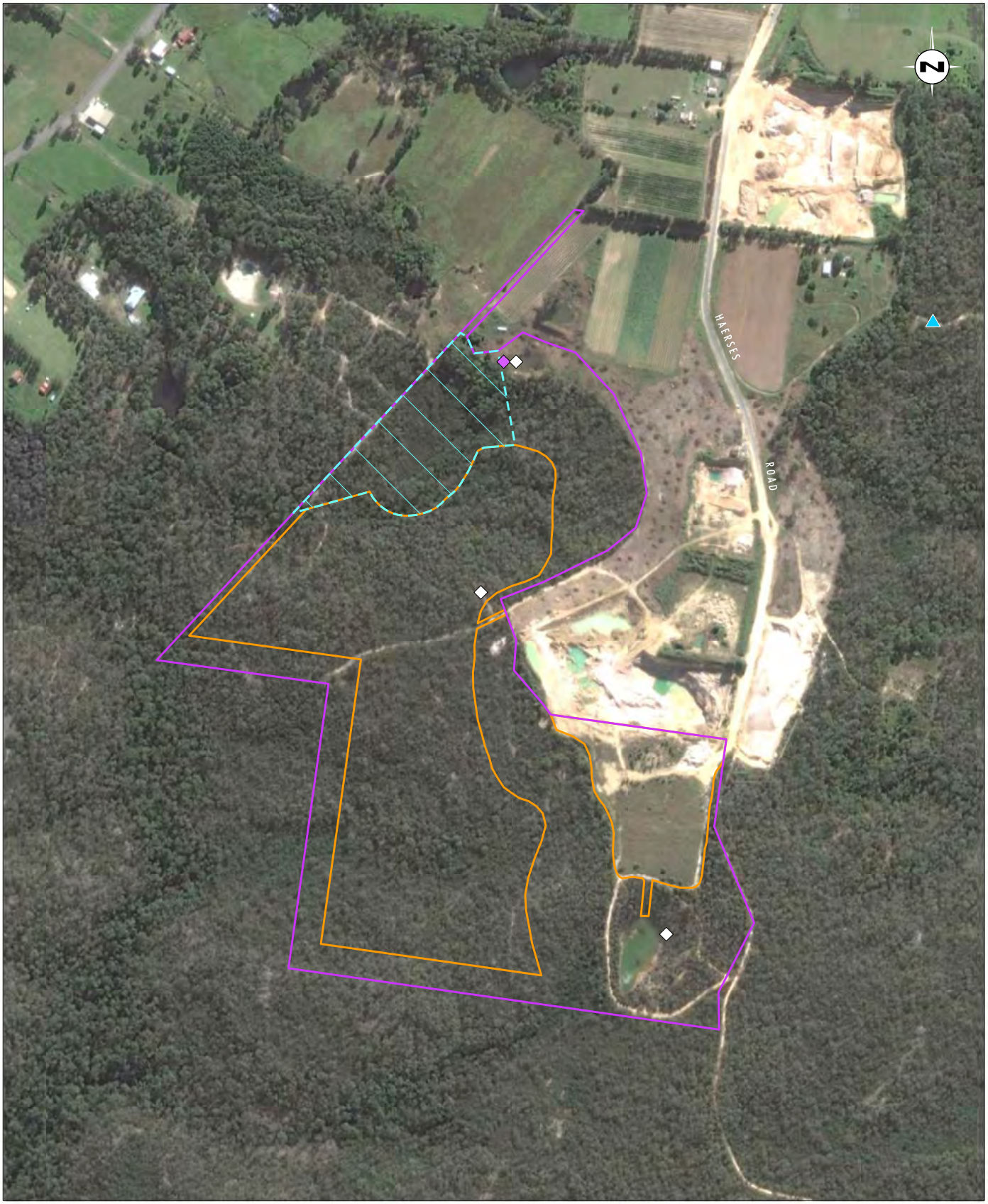


Image Source: Google Earth (2014)

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Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Glossy Black-cockatoo (2 recorded)
- Little Bentwing-Bat
- Large-Eared Pied-Bat

FIGURE 7.4

Ecosystem-credit Species Recorded in Haerses Road Offset Site

File Name (A4): R04/3479_046.dgn
20160920 11.44

Large-eared Pied Bat – *Chalinolobus dwyeri*

The large-eared pied-bat is listed as vulnerable under the TSC Act and EPBC Act. The species is found in areas with extensive cliffs and caves from Rockhampton, Queensland to Bungonia in New South Wales.

Large-eared pied-bat was recorded in the Haerses Road Offset Site. It was recorded through use of bat echolocation recordings using an Anabat II Bat Detector. These recordings were then professionally identified by Anna McConville of Echo Ecology Pty Limited.

The Haerses Road Offset Site does not contain any roosting habitat for the species but is considered to comprise marginal foraging habitat for this species as part of a wider foraging range in the locality.

Little Bentwing-bat – Miniopterus australis

The little bentwing-bat is listed as vulnerable under the TSC Act. The species is occurs along the eastern coast and ranges of Australia, extending from Cape York, Queensland to Wollongong, New South Wales.

This species was recorded in the Haerses Road Offset Site. It was recorded through use of bat echolocation recordings using an Anabat II Bat Detector. These recordings were then professionally identified by Anna McConville of Echo Ecology Pty Limited.

The Haerses Road Offset Site does not contain any roosting habitat for the species but is considered to comprise marginal foraging habitat for this species as part of a wider foraging range in the locality.

7.3.2 Species-credit Species

7.3.2.1 Geographic and Habitat Features

Seven geographic and habitat features (refer to **Table 7.11**) were chosen in the BioBanking Credit Calculator as having broad features that match site habitats at the Haerses Road Offset Site. Other geographic and habitat features were considered as not having broad features that match the Haerses Road Offset Site habitats and were therefore not relevant to the Haerses Road Offset Site and were filtered out of the subsequent steps of the assessment.

Table 7.11 Geographic and Habitat Features in the Haerses Road Offset Site

Geographic/Habitat Feature	Relevant Species-credit Species
Land within 250 metres of termite mounds or rock outcrops	rosenbergs goanna (*Varanus rosenbergi*)
Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 metres of, ephemeral or intermittent drainage lines	red-crowned toadlet (*Pseudophryne australis*)
Land within 40 metres of heath, woodland or forest	giant burrowing frog (*Heleioporus australiacus*)
Ridgetops	*Hibbertia superans*
Sandstone rock outcrops	*Kunzea rupestris*

Geographic/Habitat Feature	Relevant Species-credit Species
Land within Maroota area of Baulkham Hills and Hornsby LGAs in Yengo CMA subregion	*Darwinia fascicularis* subsp. *oligantha* population, Baulkham Hills and Hornsby Local Government Areas (*Darwinia fascicularis* subsp. *oligantha* - endangered population)
Land below 1000 metres in altitude and within 40 m of rainforest or eucalypt forest with deep leaf litter	giant barred frog (*Mixophyes iterates*)

7.3.2.2 Predicted Species

Table 7.12 below outlines the predicted species-credit species predicted to occur by the BioBanking Credit Calculator (Major Project Assessment Type) and whether they are considered to occur on Haerses Road Offset Site.

Table 7.12 Predicted Species-credit Species

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Acacia gordonii	E	E	2.6	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Ancistrachne maidenii	V	-	2.2	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Asterolasia elegans	E	E	1.8	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
brown Pomaderris *Pomaderris brunnea*	E	V	1.5	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
brush-tailed phascogale *Phascogale tapoatafa*	V	-	2.0	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted remote camera surveys being done for this species.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
bynoes wattle *Acacia bynoeana*	E	V	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
clandulla geebung P*ersoonia marginata*	V	V	1.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Darwinia biflora	V	V	2.0	Yes	A population of this species was recorded throughout the Modification Area during the original survey in 2014. The second field survey in December 2015 was designed to further detail the population of this species within these areas. The surveys suggested the total size of the population could not be determined due to the sporadic habit of the species. For this reason the population of this species within the Development Site and population within the Haerses Road Offset Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.
Darwinia fascicularis subsp. *oligantha* endangered population, Baulkham Hills and Hornsby Local Government Areas	EP	-	1.4	No	A potential specimen of this species was collected during the November 2014 survey. This specimen was sent to the National Herbarium of New South Wales at the Royal Botanic Garden Sydney (RBGS) for formal identification. The RBGS was unable to identify the specimen as being *Darwinia fascicularis* subsp. o*ligantha*, therefore this endangered population was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys. The identification letter from RBGS is attached as **Appendix E**.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Darwinia peduncularis	V	-	1.8	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
deanes paperbark *Melaleuca deanei*	V	V	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
downy wattle *Acacia pubescens*	V	V	1.9	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
eastern pygmy-possum *Cercartetus nanus*	V	-	2.0	Yes	This species was recorded at two locations within the Modification Area. Both locations of this species occur outside the boundary of the Haerses Road Offset Site, but the species was assumed to be present based on the consistency in habitat and proximity of the records to the Haerses Road Offset Site.
Epacris purpurascens subsp. *purpurascens*	V	-	1.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Eucalyptus sp. Cattai	CE	-	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	E	-	2.0	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
giant barred frog *Mixophyes iteratus*	E	E	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
giant burrowing frog *Heleioporus australiacus*	V	V	1.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted call playback and spotlighting surveys being done for this species.
Grevillea parviflora subsp. *supplicans*	E	-	2.6	Yes	This species was recorded within Modification Area, but not specifically in the Haerses Road Offset Site. A total of 219 plants occur within the Modification Area. The species was not to be present in the Haerses Road Offset Site.
groves paperbark *Melaleuca groveana*	V	-	1.4	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Gyrostemon thesioides	E	-	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
hairy geebung *Persoonia hirsuta*	E	E	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Hibbertia puberula	E	-	4.0	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Hibbertia superans	E	-	2.6	No	This species was recorded at one location within the Modification Area. It has been determined that this species does not occur within the Haerses Road Offset Site.
koala *Phascolarctos cinereus*	V	V	2.6	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Kunzea rupestris	V	V	2.6	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Leptospermum deanei	V	V	1.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Leucopogon fletcheri subsp. *fletcheri*	E	-	1.6	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Micromyrtus blakelyi	V	V	2.6	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Dural woodland snail [1] *Pommerhelix duralensis*	-	E	7.7	Yes.	Targeted spotlight surveys undertaken in December 2015 recorded one individual of this species in the Modification Area but not within the Haerses Road Offset Site. The species was assumed to be present based on the consistency in habitat and proximity of the records to the Haerses Road Offset Site.
netted bottle brush *Callistemon linearifolius*	V	-	1.4	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Olearia cordata	V	V	1.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Pimelea curviflora subsp. *curviflora*	V	V	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
Pultenaea parviflora	E	V	1.5	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
red-crowned toadlet *Pseudophryne australis*	V	-	1.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys. That is despite targeted call playback and spotlighting surveys being done for this species.
regent honeyeater *Anthochaera phrygia*	E	CE	7.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
rosenbergs goanna *Varanus rosenbergi*	V	-	3.3	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
singleton mint bush *Prostanthera cineolifera*	V	V	1.4	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
spreading guinea flower *Hibbertia procumbens*	E	-	1.8	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Squirrel Glider *Petaurus norfolcensis*	V	-	2.2	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Tetratheca glandulosa	V	-	1.6	Yes	This species was recorded within the Haerses Road Offset Site and the Modification Area. The population of this species was applied on a habitat basis due to the cryptic nature of this species. For this reason the population of this species within the Development Site and population within the

Species Name	TSC Status	EPBC Status	Threatened Species Offset Multiplier	Impacted by the Modification Project?^	Justification
					Haerses Road Offset Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.
Velleia perfoliata	V	V	1.7	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.
Zieria involucrata	E	-	1.5	No	This species was not recorded within the Haerses Road Offset Site or the larger Modification Area during either of the two extensive field surveys.

^ As entered into the 'Threatened Species Survey Results' tab in the BBCC.

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

7.3.2.3 Survey Results

One species-credit species was recorded in the Haerses Road Offset Site during the surveys undertaken for this assessment (refer to **Figure 7.5**), that being *Tetratheca glandulosa*. An additional three species-credit species were considered to be present within the Haerses Road Offset Site due to the population size within the Development Site, consistency of vegetation and suitable habitat present within the Haerses Road Offset Site. The three species were:

- *Darwinia biflora*
- Eastern pygmy-possum (*Cercartetus nanus*)
- Dural woodland snail (*Pommerhelix duralensis*).

Darwinia biflora

Darwinia biflora is listed as vulnerable under the TSC and EPBC Acts. It is an erect to spreading shrub recorded in Ku-ring-gai, Hornsby, Baulkham Hills and Ryde local government areas. It occurs on the edges of weathered shale-capped ridges at the integration with Hawkesbury Sandstone.

A population of this species was recorded throughout the Modification Area during the original survey in 2014. Further survey effort was undertaken for *Darwinia biflora* in the December 2015 survey. This involved a randomised sampling of 10 x 10 metre plots within suitable habitat for the species within the Development Site. The location of plots were randomised using a stratified grid network and between 30 minutes and 60 minutes was spent counting every individual within the plot. The time spent was dependent on how many individuals of the species were present. As the plot locations were randomly stratified, *Darwinia biflora* did not necessarily occur in every plot.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, none of the stratified plots targeting *Darwinia biflora* were completed within the area that has now been identified as the Haerses Road Offset Site.

Eastern pygmy-possum – *Cercartetus nanus*

The eastern pygmy-possum is listed as vulnerable under the TSC Act. The species occurs in south-eastern Australia, from southern Queensland, predominantly along the New South Wales coastline around to eastern South Australia and also Tasmania.

Eastern pygmy-possum was recorded at two locations within the Modification Area during the initial field survey in November 2014. Both records occur outside the Haerses Road Offset Site boundary. The records were made through targeted remote camera surveys. Bushnell Trophy Cam HDs (remote cameras) were mounted approximately one metre above the ground on a tree trunk and positioned towards a bait station containing oats and honey to increase the likelihood of detecting the eastern pygmy possum. The cameras were set to take three photos in quick succession when movement was detected. The remote cameras were programmed to record movement on an ongoing basis until removed from the site. The cameras were installed for 28 nights in 10 locations, totalling 280 nights of remote camera survey.

Because of the consistency of vegetation and suitable habitat present within the Haerses Road Offset Site the population of this species within the Haerses Road Offset Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.

Dural woodland snail – *Pommerhelix duralensis*

Dural woodland snail is listed as endangered under the EPBC Act. This species is a medium sized snail with dark brown to black semi-translucent, almost spherical shaped shell. It is a shale-influenced habitat specialist that occurs in low densities along the western and north west fringes of the Cumberland IBRA subregion on shale-sandstone transitional landscapes.

Targeted spotlighting searches for the Dural woodland snail (*Pommerhelix duralensis*) were completed on the December 2015 survey. Walking spotlighting searches were conducted at two separate locations within the Modification Area. One specimen of the Dural woodland snail was located within the Modification Area.

At the time of the original survey in November 2014 and additional survey in December 2015 the location and/or extent of the Haerses Road Offset Site was not known. As a result, none of the spotlighting searches targeting Dural woodland snail (*Pommerhelix duralensis*) were completed within the area that has now been identified as the Haerses Road Offset Site. Because of the consistency of vegetation and suitable habitat present within the Haerses Road Offset Site the population of this species within the Haerses Road Offset Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.

Tetratheca glandulosa

Tetratheca glandulosa is listed as vulnerable under the TSC Act. A small, spreading shrub that produces stems often becoming entwined among other plants within the ground stratum. The species is associated with shale-sandstone transition habitat.

Tetratheca glandulosa was recorded at one location within the Haerses Road Offset Site with a total of 11 plants being recorded. The species was also widely recorded throughout the Modification Area. Because of the consistency of vegetation and suitable habitat present within the Haerses Road Offset Site the population of this species within the Haerses Road Offset Site has been calculated based on suitable habitat as is permitted within the FBA 2014 methodology.

7.3.2.4 Species Habitat Polygons

Species habitat polygons have been prepared for all the species recorded and assumed present at the site as per **Table 7.12** above. The species polygons were prepared:

- using satellite imagery dated 2009 (LPI 2014)
- using the unit of measurement identified for those species in the Threatened Species Profile Database
- including the location of the species or areas likely occupied by the species
- containing the specific habitat feature associated with the species at the Haerses Road Offset Site, and
- using GPS to confirm the location of the species polygon on the best available aerial image of the Haerses Road Offset Site.

Species polygons are shown on **Figure 7.5**.

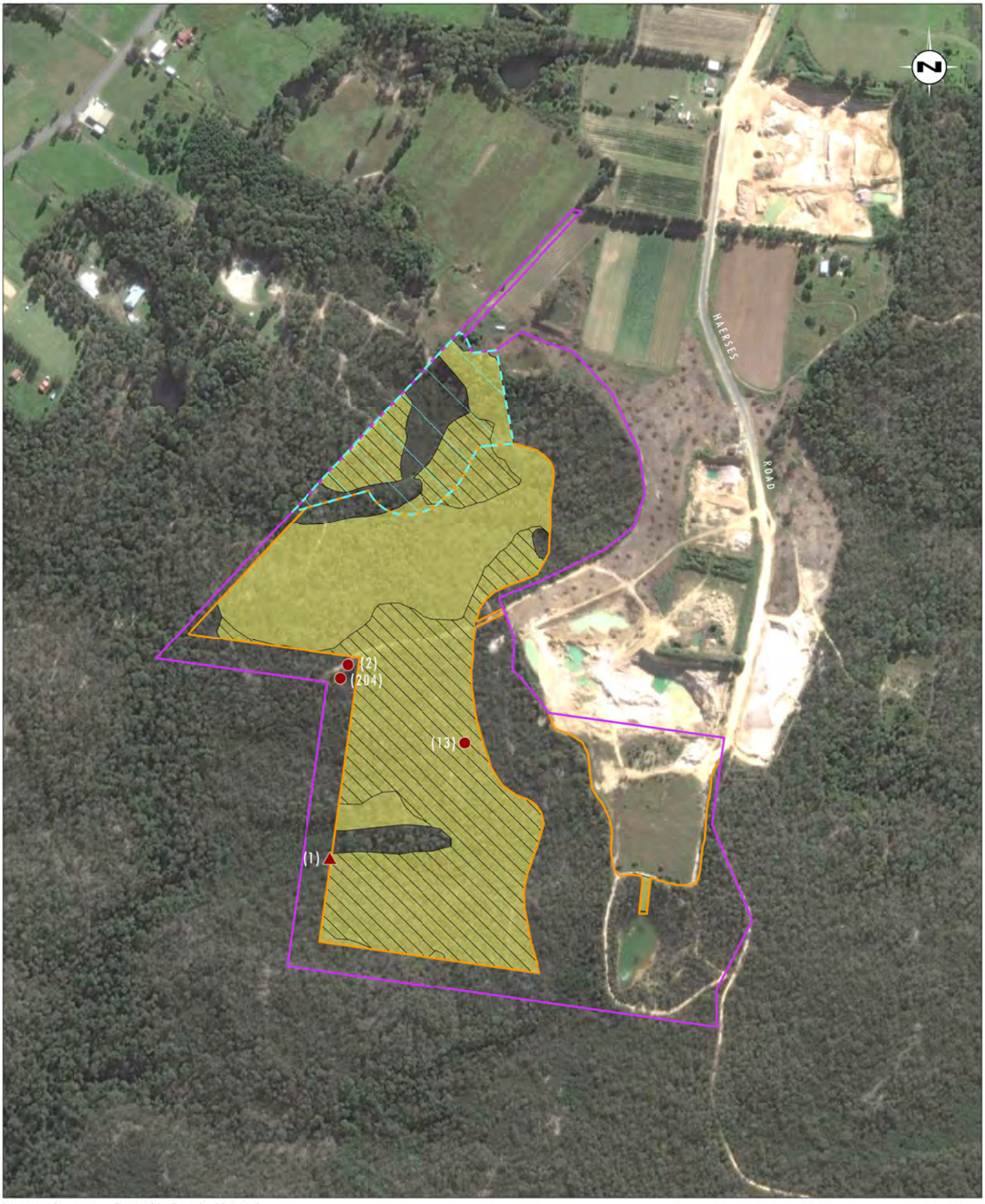


Image Source: Google Earth (2014)

0 100 200 400m
1:7500

Legend

- Development Site
- Modification Area
- Haerses Road Offset Site
- Darwinia biflora, Tetratheca glandulosa and Dural woodland snail
- Eastern pygmy-possum
- *Grevillea parviflora* subsp. *supplicans*
- *Hibbertia superans*

FIGURE 7.5

Species-credit Polygons at Haerses Road Offset Site

File Name (A4): R04/3479_047.dgn
20160920 11.51

7.4 BVTs and Threatened Species Credits

A range of BVTs, ecosystem-credit species and species-credit species were found to occur at the Haerses Road Offset Site as discussed in the sections below.

7.4.1 Ecosystem Credits

Table 7.13 outlines the ecosystem-credit species predicted as being present at the Haerses Road Offset Site.

Table 7.13 Ecosystem-credit species present at Haerses Road Offset Site

Common Name	Species Name	Threatened Species Offset Multiplier
eastern false pipistrelle	*Falsistrellus tasmaniensis*	2.2
eastern freetail-bat	*Mormopterus norfolkensis*	2.2
eastern grass owl	*Tyto longimembris*	1.3
gang-gang cockatoo	*Callocephalon fimbriatum*	2.0
glossy black-cockatoo	*Calyptorhynchus lathami*	1.8
greater broad-nosed bat	*Scoteanax rueppellii*	2.2
little eagle	*Hieraaetus morphnoides*	1.4
little lorikeet	*Glossopsitta pusilla*	1.8
New Holland mouse	*Pseudomys novaehollandiae*	2.6
scarlet robin	*Petroica boodang*	1.3
spotted-tailed quoll	*Dasyurus maculatus*	2.6
square-tailed kite	*Lophoictinia isura*	1.4
swift parrot	*Lathamus discolor*	1.3
varied sittella	*Daphoenositta chrysoptera*	1.3
yellow-bellied glider	*Petaurus australis*	2.3
yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*	2.2

Table 7.14 below outlines the BVTs within the Haerses Road Offset Site and the ecosystem credits generated to offset those credits required by the Modification Project on the Development Site. A full Credit Calculator report is included in **Appendix D**.

Table 7.14 Biometric Vegetation Types Generated within the Haerses Road Offset Site

Biometric Vegetation Type	Vegetation Zone	Area to be Impacted (ha)	Landscape Value Score	Current Site Value Score	Future Site Value Score	Averted Loss in Site Value	Ecosystem Credits Generated
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	1	0.93	12.00	56.52	81.88	9.42	11
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	2	0.78	12.00	81.77	87.50	15.10	6
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	3	1.52	12.00	69.10	88.72	13.02	17
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	4	0.36	12.00	63.77	78.74	12.08	4

7.4.2 Species Credits

Table 7.15 below outlines the species-credit species generated within the Haerses Road Offset Site. A full Credit Calculator report is included in **Appendix D**.

Table 7.15 Species-credit Species Generated within the Haerses Road Offset Site

Common Name	Species Name	Threatened Species Offset Multiplier	Species Credits Generated
Darwinia biflora	*Darwinia biflora*	2.0	14
eastern pygmy-possum	*Cercartetus nanus*	2.0	11
Dural woodland snail [1]	*Pommerhelix duralensis*	7.7	16
Tetratheca glandulosa	*Tetratheca glandulosa*	1.6	14

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

8.0 Offsetting Comparison

8.1 Biodiversity Credit Report

A full Credit Calculator report for the Haerses Road Offset Site is included in **Appendix D**.

Table 8.1 below provides a summary of the ecosystem and species credits that require offsetting as a result of this Modification Project and those that are generated within the Haerses Road Offset Site.

Table 8.1 Ecosystem and Species Credits Required by the Modification Project and those generated at the Haerses Road Offset Site

Name	Credits Required	Credits Generated	Overall Status
Ecosystem Credits			
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	3	11	+8
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	377	6	-371
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	538	17	-521
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	44	4	-40
Total	**962**	**38**	**-924**
Species Credits			
Darwinia biflora	360	14	-346
eastern pygmy-possum (*Cercartetus nanus*)	223	11	-212
Grevillea parviflora subsp. *supplicans*	338	-	-338
Dural woodland snail (*Pommerhelix duralensis*)[1]	1,372	16	-1,356
Tetratheca glandulosa	288	14	-274
Total	**2,581**	**55**	**-2,526**

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

8.2 Additional Offsetting Options

As identified above in **Table 8.1** there are a number of ecosystem and species credit deficits between the number of credits that require offsetting as a result of the Modification Project and those that are generated at the Haerses Road Offset Site. Fulfilling offset requirements, including credit shortfalls will be undertaken using one or a combination of the following offset strategies:

- securing required credits through the open credit market, off site
- offsetting through a land-based offset site secured by a BioBanking Agreement
- if suitable offsets are unavailable, contributing funds to supplementary measures in accordance with relevant conservation or recovery actions relevant to the species, and
- contributing to the Offsets Fund.

The sections below discuss additional offsetting options that are being considered by Dixon Sand.

8.2.1 Porters Road Offset Site

An additional offset site (Porters Road Offset Site) is currently being considered by Dixon Sand that is offsite compared to the location of the Modification Project (**Figure 8.1**). The site is approximately 53 hectares in size and is in the preliminary stages of consideration and subsequently no detailed surveys have been undertaken. A preliminary assessment has been completed on the Porters Road Offset Site by South East Environmental (2016). The assessment was designed around determining suitability of the site for *Darwinia biflora* through the identification of individuals or habitat.

The surveys undertaken by South East Environmental identified six threatened flora species confidently within the site, including *Darwinia biflora*. The additional five species are listed below:

- Bynoe's wattle (*Acacia bynoeana*)
- *Epacris purpurascens* subsp. *purpurascens*
- *Hibbertia superans*
- *Lasiopetalum joyceae*
- *Tetratheca glandulosa*.

The preliminary field survey also confirmed the presence of three vegetation communities that had been identified through regional mapping by Tozer *et al*. (2003) (**Figure 8.2)**.

The results of the preliminary assessment were entered into the BioBanking Credit Calculator to provide insight as to the suitability of Porters Road Offset Site for the Modification Project. **Table 8.2** below provides the preliminary credit summary of Porters Road Offset Site, and an updated potential overall credit summary. As no detailed surveys have been completed on the Porters Road Offset Site, there is currently no transect/plot data for the site. For the purposes of entering data in to the BioBanking Credit Calculator, data was extrapolated (duplicated) from the plot/transect undertaken in the same vegetation type in the Modification Area.



Image Source: Google Earth (2016)

0 1.0 2.5 5.0km
1:100 000

Legend

- Modification Area
- Porters Road Offset Site

FIGURE 8.1

Porters Road Offset Site
Site Location

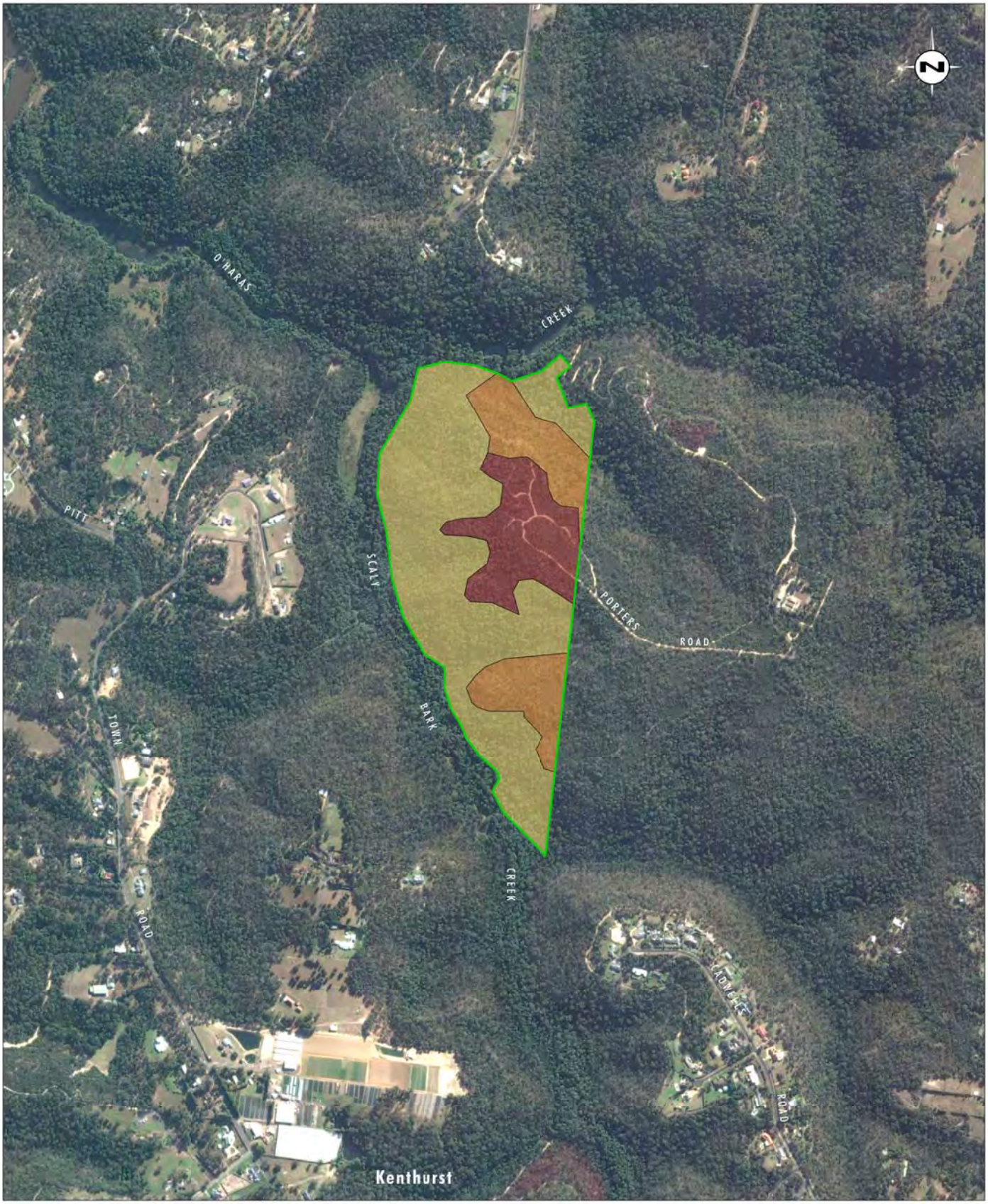


Image Source: Google Earth - DigitalGlobe (July 2016)

0 250 500 750m
1:15 000

Legend

- Porters Road Offset Site
- HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion
- HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion
- HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion

FIGURE 8.2

Vegetation Communites at the Porters Road Offset Site

File Name (A4): R04/3479_062.dgn
20160712 14.35

Table 8.2 Ecosystem and Species Credits Required by the Modification Project, those generated at the Haerses Road Offset Site and those estimated at the Porters Road Offset Site

Name	Credits Required	Haerses Road Offset Site Credits Generated	Porters Road Offset Site Estimated Credits	Overall Status
Ecosystem Credits				
HN560 Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	3	11	0	+8
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	377	6	86	-285
HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good)	538	17	104	-417
HN586 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion (Moderate/Good)	44	4	327	+287
Total	**962**	**38**	**517**	**-407**
Species Credits Required and Generated				
Darwinia biflora	360	14	142	-204
eastern pygmy-possum (*Cercartetus nanus*)	223	11	0	-212
Grevillea parviflora subsp. *supplicans*	338	0	0	-338
Dural woodland snail (*Pommerhelix duralensis*)[1]	1,372	16	0	-1,356
Tetratheca glandulosa	288	14	142	-132
Total	**2,581**	**55**	**284**	**-2,242**
Species Credits Generated				
Epacris purpurascens subsp. *purpurascens*	0	0	142	+142
Hibbertia superans	0	0	142	+142
Bynoe's wattle (*Acacia bynoeana*)	0	0	142	+142
Lasiopetalum joyceae	0	0	64	+64

[1] This species was not able to be added to the list of threatened species within the BBCC. Instead Mitchells rainforest snail (*Thersites mitchellae*) was entered into the BBCC as it has the same Threatened Species Offset Multiplier as the Dural woodland snail of 7.7.

8.2.2 Biodiversity Credits Register

Dixon Sand may consider purchasing ecosystem and species credits to offset those required as part of the Modification Project and that remain in deficit despite those generated at the Haerses Road Offset Site and those that could be generated at the Porters Road Offset Site. The Biodiversity Credits Register provides a means for developers seeking credits to search and purchase such credits as required. The Biodiversity Credit Register is an online resource that has been established in accordance with the TSC Act 1995.

Umwelt accessed the Biodiversity Credit Register in June 2016 (OEH 2016a). **Table 8.3** below provides a summary of ecosystem credits and **Table 8.4** provides a summary of species credits that are currently listed on the Biodiversity Credit Register for those credits with an overall credit status that is currently in deficit. No additional credits are required for those credits that are in a surplus.

Table 8.3 Ecosystem Credits listed on the Biodiversity Credit Register

Name	Overall Credit Status	IBRA sub-region		Potential Overall Status
		Yengo	Wollemi	
HN566 Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion (Moderate/Good)	-285	105	42	-138

There were no credits for HN582 Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion (Moderate/Good) listed on the Biodiversity Credit Register. Additionally, there are no credits listed for HN580 Sandstone cliff soak moist shrubland of the Sydney Basin Bioregion which was identified in **Section 6.2.1.3** as a suitable offsetting replacement.

Table 8.4 Species Credits listed on the Biodiversity Credit Register

Name	Overall Credit Status	Credits Listed on the Register	Potential Overall Status
Darwinia biflora	-204	7,072	+6,868
eastern pygmy-possum (*Cercartetus nanus*)	-212	0	-212
Grevillea parviflora subsp. *supplicans*	-338	0	-338
Dural woodland snail (*Pommerhelix duralensis*)[1]	-1,356	0	-1,356
Tetratheca glandulosa	-132	882	+750

As previously mentioned, the Dural woodland Snail could not be entered into the BioBanking calculator. A replacement species in Mitchells rainforest snail (*Thersites mitchellae*) was entered in its absence. Additionally, this species could not be searched on the Biodiversity Credits Register for available credits. Further, detailed discussion with regulators will be required to determine an appropriate offset strategy for the impacts of the Modification Project on Dural woodland snail (*Pommerhelix duralensis*).

8.2.3 Credits Wanted Register

The Credits Wanted Register is an online tool for proponents who are seeking biodiversity credits, allowing them to search for ecosystem and species credits which they require but also list those credits with their contact details. This allows people with excess credits to make direct contact with people that are seeking such credits.

With a number of ecosystem and species credits that remain in deficit after considering those generated at two offset sites and those that are available for purchase on the Biodiversity Credits Register, Dixon Sand have listed credits sought after on Credits Wanted Register. Should any person, company or organisation have one or a number of credits required by the Modification Project they will be able to contact Umwelt on behalf of Dixon Sand to discuss the potential selling of credits.

Umwelt listed credits on the Credits Wanted Register on behalf of Dixon Sand on 7 April 2016.

9.0 Conclusion

Dixon Sand is committed to delivering a Biodiversity Offset Strategy that appropriately compensates for the unavoidable loss of ecological values as a result of the Modification Project under the NSW *Biodiversity Offsets Policy for Major Projects* (OEH 2014).

As previously mentioned, fulfilling offset requirements under the NSW *Biodiversity Offset Policy for Major Projects* will be undertaken using one or a combination of the following offset strategies:

- On-site in-perpetuity conservation of applicable credits.
- Offsetting through a site secured by a BioBanking Agreement.
- Securing required credits through the open credit market, off site.
- If suitable offsets are unavailable, contributing money to supplementary measures in accordance with relevant conservation or recovery actions will be investigated.
- Contributing to the Offsets Fund.

Dixon Sand will investigate, in consultation with OEH, the application of the Offsets Fund (when available) and the monetary contribution required addition to the proposed offset sites through the use of a BioBanking Agreement.

10.0 References

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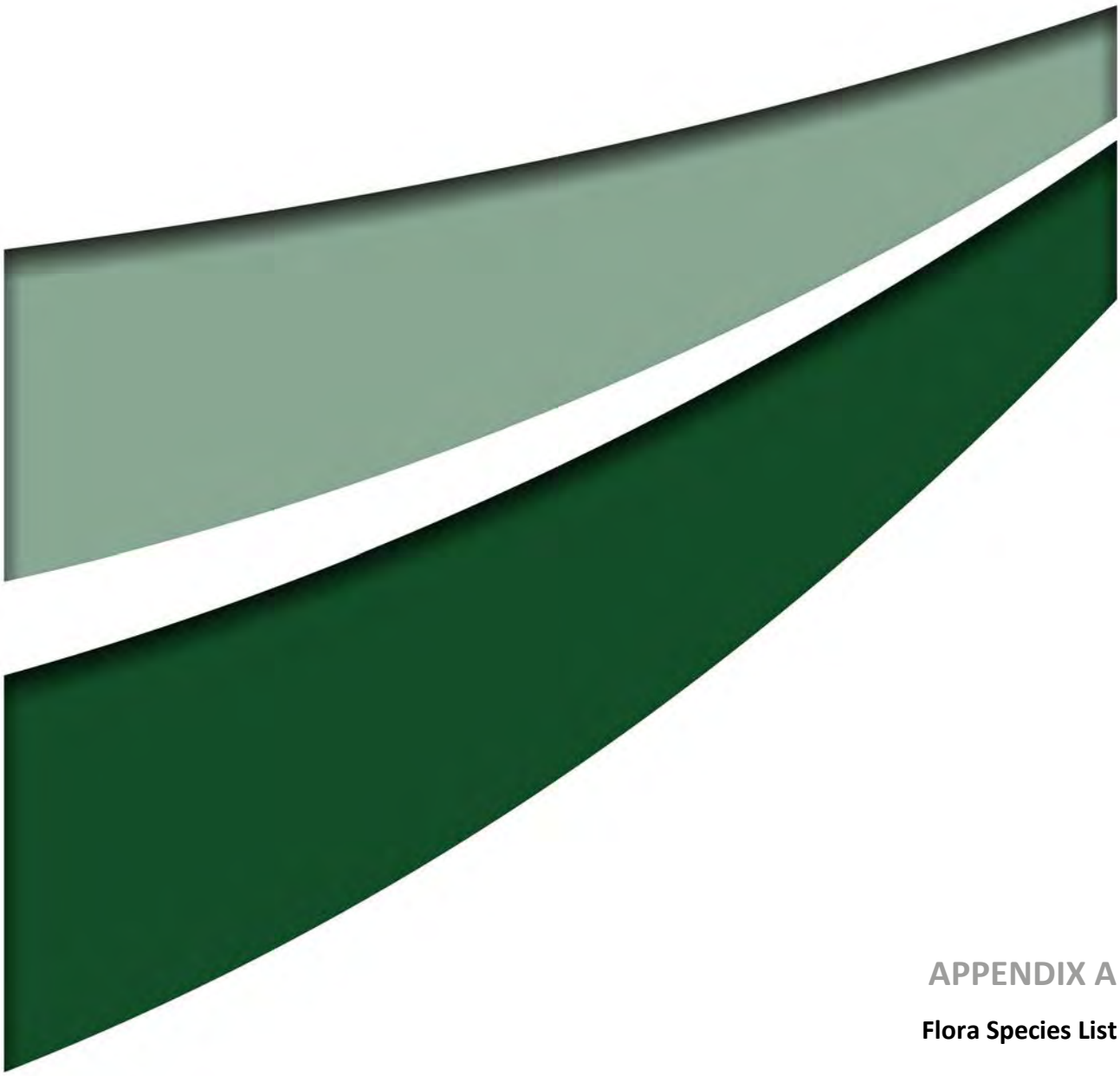
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APPENDIX A

Flora Species List

Appendix A - Flora Species List

The following list was developed from surveys of the Modification Site by Umwelt in November 2014 and December 2015. It includes all species of vascular plants observed during these surveys. It is acknowledged that the list may not be completely comprehensive, as not all species are readily detected at any one time of the year. Many species flower only during restricted periods of the year, and some flower only once in several years. In the absence of flowering material, many of these species cannot be identified, or even detected.

Names of classes and families follow a modified Cronquist (1981) System.

Any species that could not be identified to the lowest taxonomic level are denoted in the following manner:

sp.	specimens that are identified to genus level only.

The following abbreviations or symbols are used in the list:

asterisk (*)	denotes species non-native species;
subsp.	subspecies;
var.	variety; and
+	denotes species recorded outside the plot/transect but in the same vegetation community.

All vascular plants recorded or collected were identified using keys and nomenclature in Harden (1992, 1993, 2000 and 2002) and Wheeler *et al.* (2002). Where known, changes to nomenclature and classification have been incorporated into the results, as derived from PlantNET (Botanic Gardens Trust 2016), the on-line plant name database maintained by the National Herbarium of New South Wales.

Common names used follow Harden (1992, 1993, 2000 & 2002) where available, and draw on other sources such as local names where these references do not provide a common name.

The score below each species is an estimated cover-abundance score allocated using a modified Braun-Blanquet 6-point scale (Braun-Blanquet 1927), with selected modifications sourced from Poore (1955) and Austin *et al*. (2000). A full definition of this methodology and scoring system is provided in **Section 2.3** of the main report.

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Filicopsida (Ferns)											
Adiantaceae	*Adiantum aethiopicum*	common maidenhair								3	
Aspleniaceae	*Asplenium flabellifolium*	necklace fern		1				2			
Dennstaedtiaceae	*Pteridium esculentum*	bracken						2			
Gleicheniaceae	*Gleichenia dicarpa*	pouched coral fern					1				
Lindsaeaceae	*Lindsaea microphylla*	lacy wedge fern				2					
Schizaeaceae	*Schizaea bifida*	forked comb fern	1					+			
Schizaeaceae	*Schizaea* spp.			+							
Magnoliopsida (Flowering Plants) - Liliidae (Monocots)											
Anthericaceae	*Caesia parviflora* var. *parviflora*		1	1							
Anthericaceae	*Thysanotus tuberosus*	common fringe-lily		1					1	2	1
Colchicaceae	*Burchardia umbellata*	milkmaids					1	1			
Cyperaceae	*Caustis pentandra*	thick twist rush			1					4	
Cyperaceae	*Caustis recurvata*				1			1			
Cyperaceae	*Cyathochaeta diandra*		1								
Cyperaceae	*Eleocharis sphacelata*	tall spike rush	1								
Cyperaceae	*Gahnia sieberiana*	red-fruit saw-sedge						3			
Cyperaceae	*Lepidosperma gunnii*					2		1	1		
Cyperaceae	*Lepidosperma* spp.				1						
Cyperaceae	*Ptilothrix deusta*					3			3		
Cyperaceae	*Schoenus brevifolius*						3				
Cyperaceae	*Schoenus ericetorum*			1	2			1	1		
Haemodoraceae	*Haemodorum planifolium*					1					
Lomandraceae	*Lomandra cylindrica*			1							
Lomandraceae	*Lomandra glauca*	pale mat-rush				2			2		
Lomandraceae	*Lomandra longifolia*	spiny-headed mat-rush		1				2	2		3

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Lomandraceae	*Lomandra multiflora* subsp. *multiflora*	many-flowered mat-rush							1		
Lomandraceae	*Lomandra obliqua*			3	2				2	2	3
Lomandraceae	*Lomandra* spp.	mat-rush								3	
Orchidaceae	*Cryptostylis erecta*	tartan tongue orchid	1								
Orchidaceae	*Cryptostylis subulata*	large tongue orchid	1			1				2	
Orchidaceae	*Cymbidium suave*	snake orchid	1								
Orchidaceae	*Dipodium punctatum*		1								
Orchidaceae	*Dipodium variegatum*		1								
Orchidaceae	*Prasophyllum flavum*	yellow leek orchid	1								
Orchidaceae	*Thelymitra* spp.		1								
Phormiaceae	*Dianella prunina*			1	1			2			
Poaceae	*Anisopogon avenaceus*	oat speargrass						1			
Poaceae	*Aristida calycina* var. *calycina*									3	
Poaceae	*Austrostipa pubescens*							2			3
Poaceae	*Cynodon dactylon*	common couch	1								
Poaceae	*Entolasia stricta*	wiry panic		2	2	2		3			
Poaceae	**Eragrostis curvula*	African lovegrass	1								
Poaceae	*Paspalidium distans*			+							4
Poaceae	**Paspalum dilatatum*	paspalum	1								
Poaceae	*Themeda australis*	kangaroo grass	1						2		
Restionaceae	*Empodisma minus*						3				
Restionaceae	*Leptocarpus tenax*						3				
Restionaceae	*Lepyrodia scariosa*			2	1	3		3			
Restionaceae	*Lepyrodia* spp.									1	
Smilacaceae	*Smilax glyciphylla*	sweet sarsparilla		1				1			
Xanthorrhoeaceae	*Xanthorrhoea* spp.			2		2			2		

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Magnoliopsida (Flowering Plants) - Magnoliidae (Dicots)											
Apiaceae	*Actinotus helianthi*	flannel flower	1								
Apiaceae	*Actinotus minor*	lesser flannel flower					1	2	2	3	
Apiaceae	*Platysace ericoides*								1		1
Apiaceae	*Platysace linearifolia*			2	2			2		2	
Apiaceae	*Xanthosia pilosa*							1			
Apiaceae	*Xanthosia* spp.			2							
Apiaceae	*Xanthosia tridentata*	rock xanthosia		2							
Araliaceae	*Astrotricha obovata*							+			
Asteraceae	**Hypochaeris radicata*	catsear	1								
Campanulaceae	*Wahlenbergia gracilis*	sprawling bluebell	1								
Caryophyllaceae	**Polycarpon tetraphyllum*	four-leaved allseed		1					1		
Casuarinaceae	*Allocasuarina distyla*					1					
Cunoniaceae	*Ceratopetalum gummiferum*	Christmas bush		1				1			
Dilleniaceae	*Hibbertia empetrifolia* subsp. *empetrifolia*			2				1	+		
Dilleniaceae	*Hibbertia fasciculata*					1					
Dilleniaceae	*Hibbertia* spp.									1	
Droseraceae	*Drosera peltata*	a sundew								1	
Droseraceae	*Drosera spatulata*						2				
Elaeocarpaceae	*Elaeocarpus reticulatus*	blueberry ash						1			
Elaeocarpaceae	*Tetratheca glandulosa*			1					1		
Ericaceae	*Epacris microphylla*	coral heath								3	
Ericaceae	*Epacris pulchella*	Wallum heath		2		2		2			
Ericaceae	*Leucopogon attenuatus*	a beard-heath			1	2					
Ericaceae	*Leucopogon ericoides*	pink beard-heath		1							
Ericaceae	*Leucopogon esquamatus*						2				

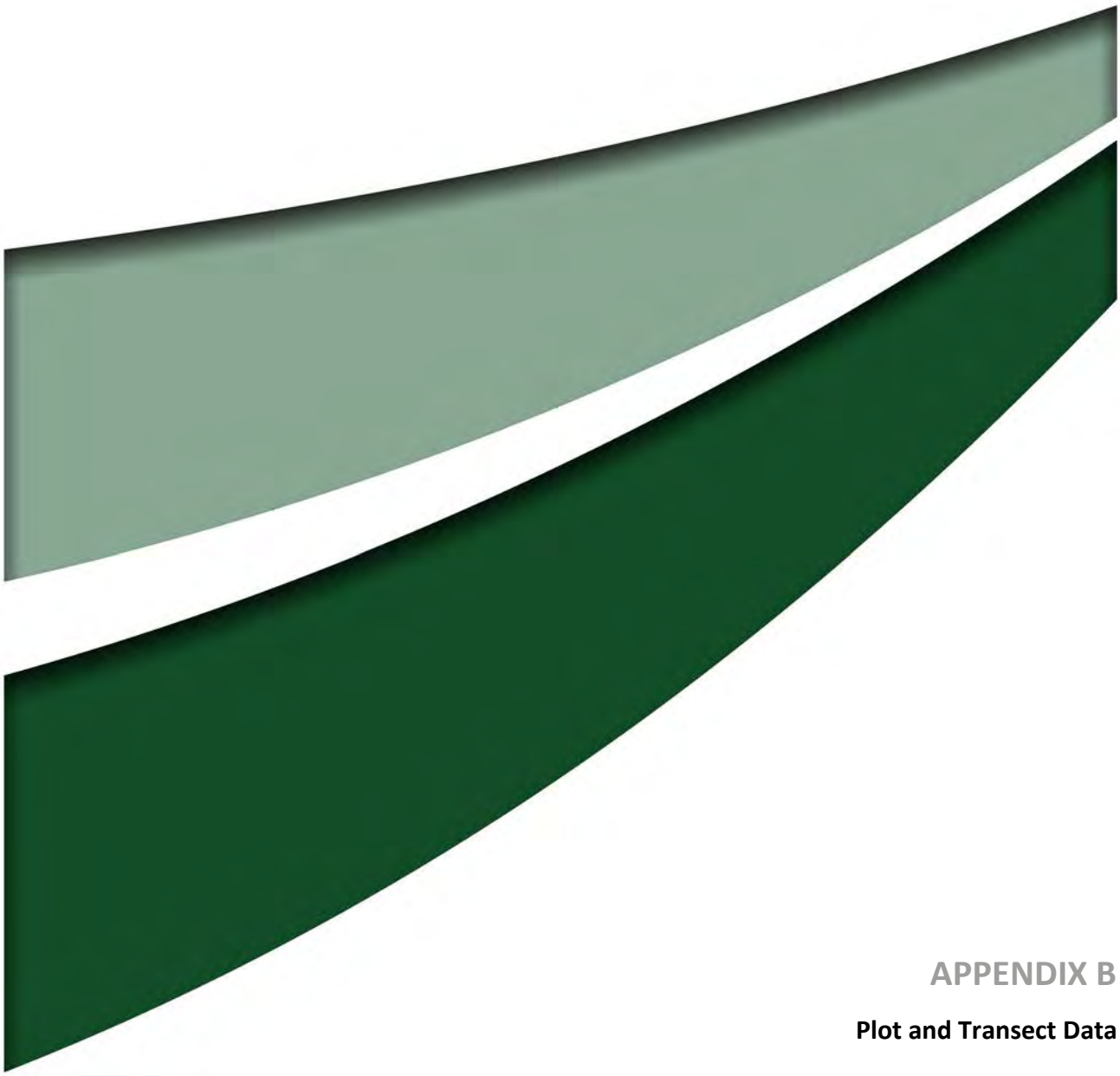
Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Ericaceae	*Leucopogon microphyllus*		1			2					
Ericaceae	*Lissanthe strigosa*	peach heath								3	
Ericaceae	*Melichrus procumbens*	jam tarts							1		
Ericaceae	*Monotoca scoparia*				1			1			
Ericaceae	*Woollsia pungens*		1		1	1					
Euphorbiaceae	*Amperea xiphoclada* var. *xiphoclada*							+			
Fabaceae (Faboideae)	*Aotus ericoides*			2							
Fabaceae (Faboideae)	*Bossiaea ensata*	sword bossiaea			2	2					
Fabaceae (Faboideae)	*Bossiaea heterophylla*	variable bossiaea			2			1			
Fabaceae (Faboideae)	*Bossiaea lenticularis*							3	1		3
Fabaceae (Faboideae)	*Bossiaea obcordata*	spiny bossiaea		3							
Fabaceae (Faboideae)	*Bossiaea scolopendria*							2		2	
Fabaceae (Faboideae)	*Bossiaea* spp.										1
Fabaceae (Faboideae)	*Dillwynia retorta*				1				1	2	
Fabaceae (Faboideae)	*Gompholobium glabratum*	dainty wedge pea			1						
Fabaceae (Faboideae)	*Gompholobium grandiflorum*	large wedge pea						1	1		
Fabaceae (Faboideae)	*Hovea linearis*								1		
Fabaceae (Faboideae)	*Hovea purpurea*				+						
Fabaceae (Faboideae)	*Mirbelia rubiifolia*	heathy mirbelia		2				2			
Fabaceae (Faboideae)	*Phyllota grandiflora*	heath phyllota				2					
Fabaceae (Faboideae)	*Phyllota phylicoides*	heath phyllota			3						
Fabaceae (Faboideae)	*Pultenaea retusa*						1				
Fabaceae (Faboideae)	*Pultenaea* spp.							1	1		
Fabaceae (Faboideae)	*Pultenaea tuberculata*				1						
Fabaceae (Mimosoideae)	*Acacia echinula*	hedgehog wattle				1					
Fabaceae (Mimosoideae)	*Acacia elongata*	swamp wattle					1				

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Fabaceae (Mimosoideae)	*Acacia linearifolia*	narrow-leaved wattle							2		
Fabaceae (Mimosoideae)	*Acacia linifolia*	white wattle		1							3
Fabaceae (Mimosoideae)	*Acacia longifolia*									1	
Fabaceae (Mimosoideae)	*Acacia suaveolens*	sweet wattle		1		2		2	1		1
Fabaceae (Mimosoideae)	*Acacia ulicifolia*	prickly moses						1			
Gentianaceae	**Centaurium* spp.		1								
Goodeniaceae	*Dampiera stricta*			1	1	1	1	1	1		
Goodeniaceae	*Goodenia bellidifolia*					1					
Goodeniaceae	*Goodenia bellidifolia* subsp. *bellidifolia*									2	
Goodeniaceae	*Goodenia* spp.		1								
Goodeniaceae	*Scaevola ramosissima*	purple fan-flower	1					1	1	1	2
Haloragaceae	*Gonocarpus tetragynus*	poverty raspwort							1		1
Lamiaceae	*Hemigenia purpurea*					1					
Lauraceae	*Cassytha glabella*			2	2	2			2	2	1
Lauraceae	*Cassytha pubescens*	downy dodder-laurel						2			1
Loranthaceae	*Amyema* spp.	mistletoe		+							
Myrtaceae	*Angophora costata*	Sydney red gum						3			
Myrtaceae	*Angophora hispida*	dwarf apple		1	1				1	3	
Myrtaceae	*Baeckea diosmifolia*	fringed baeckea	1	2	1			2		1	2
Myrtaceae	*Baeckea imbricata*						1				
Myrtaceae	*Callistemon citrinus*	crimson bottlebrush					2	1			
Myrtaceae	*Callistemon linearis*	narrow-leaved bottlebrush		1							
Myrtaceae	*Calytrix tetragona*	common fringe-myrtle			2						
Myrtaceae	*Corymbia eximia*	yellow bloodwood		3							
Myrtaceae	*Corymbia gummifera*	red bloodwood				+		1	3		3
Myrtaceae	*Darwinia biflora*			3	1	3			1	2	

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Myrtaceae	*Darwinia fascicularis*			+							3
Myrtaceae	*Eucalyptus haemastoma*	broad-leaved scribbly gum								3	
Myrtaceae	*Eucalyptus piperita*	Sydney peppermint						3			
Myrtaceae	*Eucalyptus punctata*	grey gum						3	3		3
Myrtaceae	*Eucalyptus sparsifolia*	narrow-leaved stringybark		3	+				3		3
Myrtaceae	*Eucalyptus squamosa*	scaly bark									3
Myrtaceae	*Kunzea ambigua*	tick bush			2	2					
Myrtaceae	*Leptospermum parvifolium*			3							
Myrtaceae	*Leptospermum polygalifolium*			3		2	2	1		3	
Myrtaceae	*Leptospermum squarrosum*						4			2	
Myrtaceae	*Leptospermum trinervium*	slender tea-tree						3			
Myrtaceae	*Syncarpia glomulifera*	turpentine		2				3			
Olacaceae	*Olax stricta*				1						
Phyllanthaceae	*Phyllanthus hirtellus*	thyme spurge							2		
Pittosporaceae	*Billardiera scandens*	hairy apple berry		2					1		1
Polygalaceae	*Comesperma defoliatum*						+				
Proteaceae	*Banksia aemula*	Wallum banksia	1								
Proteaceae	*Banksia ericifolia*	heath-leaved banksia		2		4				5	
Proteaceae	*Banksia marginata*	silver banksia								3	
Proteaceae	*Banksia oblongifolia*	fern-leaved banksia		1	1	2					
Proteaceae	*Banksia serrata*	old-man banksia	1					3			
Proteaceae	*Banksia spinulosa*	hairpin banksia		2				1	1		
Proteaceae	*Grevillea buxifolia*	grey spider flower	1	2	2				1		1
Proteaceae	*Grevillea mucronulata*			1				1	2		
Proteaceae	*Grevillea parviflora* subsp. *supplicans*		1								
Proteaceae	*Grevillea speciosa*	red spider flower	1		2			1		1	

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Proteaceae	*Grevillea* spp.						1		+		
Proteaceae	*Hakea dactyloides*	finger hakea		2	1	2					
Proteaceae	*Hakea gibbosa*				2	2			2		
Proteaceae	*Hakea sericea*	needlebush		2							
Proteaceae	*Hakea* spp.			1							
Proteaceae	*Isopogon anemonifolius*	broad-leaf drumsticks			1	1				2	
Proteaceae	*Isopogon anethifolius*	narrow-leaf drumsticks									3
Proteaceae	*Lambertia formosa*	mountain devil		2		2		1	2		1
Proteaceae	*Lomatia silaifolia*	crinkle bush						1	1		1
Proteaceae	*Persoonia lanceolata*	lance leaf geebung		1		+					
Proteaceae	*Persoonia levis*	broad-leaved geebung		1	1			1	1		1
Proteaceae	*Petrophile pulchella*	conesticks		3	2	2		1	3		1
Rubiaceae	*Pomax umbellata*	pomax		2							
Rutaceae	*Boronia ledifolia*	Sydney boronia		+	1			1	1		
Rutaceae	*Boronia pinnata*					1		2			
Rutaceae	*Boronia* spp.					1				2	
Rutaceae	*Nematolepis squamea* subsp. *squamea*	satinwood			2						
Rutaceae	*Philotheca salsolifolia*					2					
Santalaceae	*Exocarpos cupressiformis*	cherry ballart									3
Stackhousiaceae	*Stackhousia nuda*						2				
Stackhousiaceae	*Stackhousia viminea*	slender stackhousia								2	
Sterculiaceae	*Lasiopetalum parviflorum*			1							
Stylidiaceae	*Stylidium graminifolium*	grass triggerplant						+			
Thymelaeaceae	*Pimelea glauca*	smooth rice-flower	1								
Thymelaeaceae	*Pimelea linifolia*	slender rice flower			1						
Thymelaeaceae	*Pimelea linifolia* subsp. *linifolia*							1			

Family	Scientific Name	Common Name	Ops	P01	P02	P03	P04	P05	P06	SH1	SR1
Thymelaeaceae	*Pimelea* spp.					1					
Violaceae	*Hybanthus monopetalus*	slender violet-bush				1				1	
Violaceae	*Viola* spp.										2



APPENDIX B

Plot and Transect Data

Appendix B - Plot and Transect Data

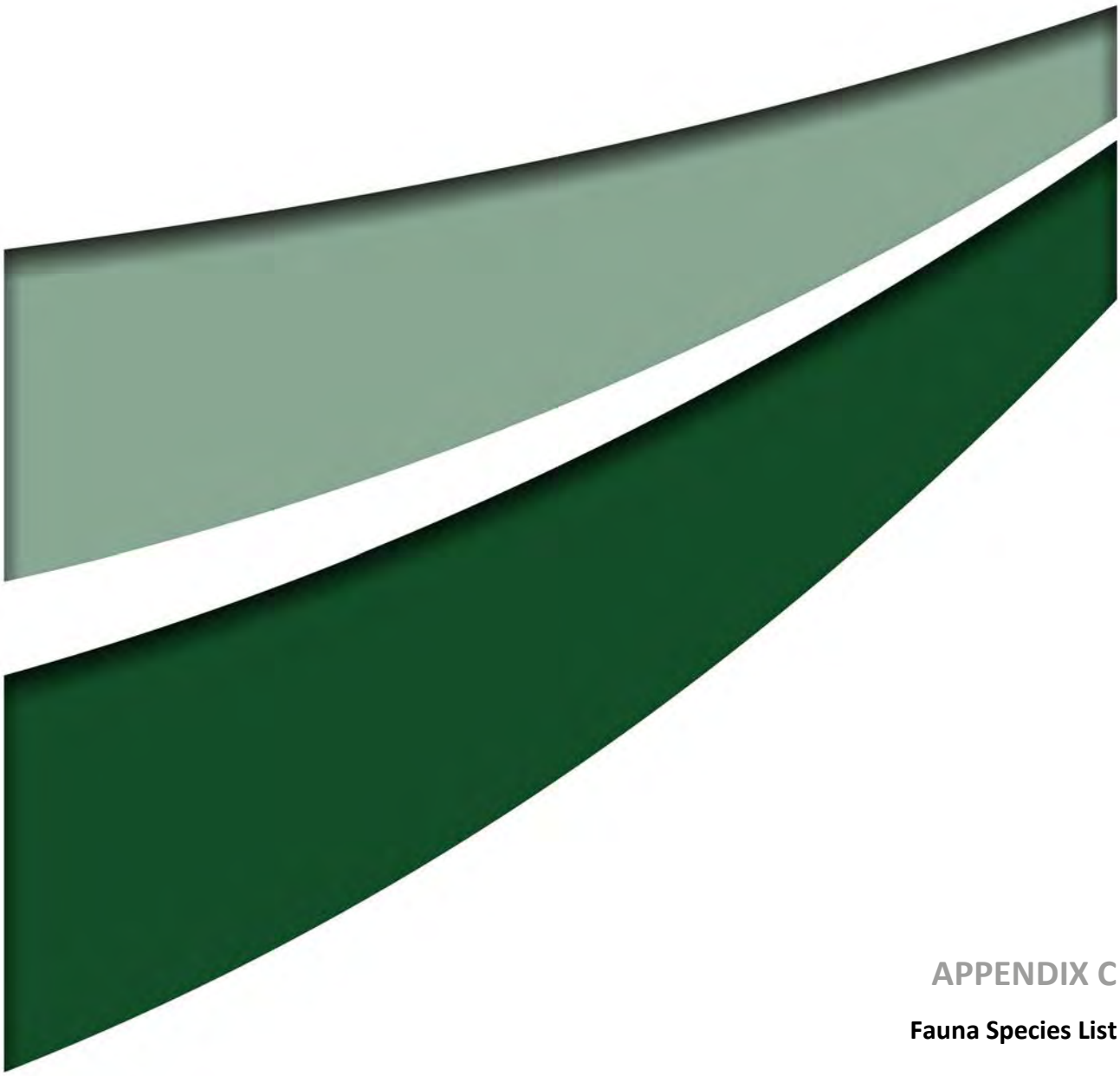
The following plot and transect data was collected from surveys of the Development Site. It includes the ten site attributes that are recorded in each Biometric plot and transect as per Table 2 of the FBA (OEH 2014). This data is assessed against benchmark data for PCTs and then entered into the BioBanking Calculator to assess the site value of each PCT in the Development Site.

The following abbreviations or symbols are used in the list:

NPS	native plant species
NOC	native overstorey cover
NMC	native midstorey cover
NGCG	native ground cover (grasses)
NGCS	native ground cover (shrubs)
NGCO	native ground cover (other)
EPC	exotic plant cover
NTH	number of trees with hollows
OR	overstorey regeneration, and
FL	total length of fallen logs.

Plot Name	NPS	NOS	NMS	NGCG	NGCS	NGCO	EPC	NTH	OR	FL	Easting	Northing	Zone
Zone 1: HN560 – Needlebush – Banksia Wet Heath on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition													
P04	16	5	2	0	5	100	0	0	1	0	312277	6294089	56
Zone 2: HN566 – Red Bloodwood – Scribbly Gum Heathy Woodland on Sandstone Plateaux of the Sydney Basin Bioregion – Moderate to Good Condition													
SR1	31	31.5	8	58	32	4	0	9	1	17	312225	6293930	56
P01	50	17	9.5	26	32	52	0	6	1	114	312439	6294082	56
P06	41	18.5	18	42	18	62	0	8	1	18	312324	6293932	56
Zone 3: HN582 – Scribbly Gum – Hairpin Banksia – Dwarf Apple Heathy Woodland on Hinterland Sandstone Plateaux of the Central Coast, Sydney Basin Bioregion – Moderate to Good Condition													
SH1	28	19	5	12	18	52	0	0	1	90	312393	6293502	56
P02	39	1	15.2	6	40	40	0	4	1	9	312429	6293364	56
P03	40	15	14	32	82	42	0	2	1	8	312389	6293681	56
Zone 4: HN586 – Smooth-barked Apple – Red Bloodwood – Sydney Peppermint Heathy Open Forest on Slopes of Dry Sandstone Gullies of Western and Southern Sydney, Sydney Basin Bioregion – Moderate to Good Condition													
P05	55	12.5	15.5	10	44	68	0	9	1	28	311956	6293801	56
EXTRA 1*	55	12.5	15.5	10	44	68	0	9	1	28	311956	6293801	56
EXTRA 2*	55	12.5	15.5	10	44	68	0	9	1	28	311956	6293801	56
EXTRA 3*	55	12.5	15.5	10	44	68	0	9	1	28	311956	6293801	56

#denotes plot/transect data duplicated for the Porters Road Offset Site.



APPENDIX C

Fauna Species List

Appendix C - Fauna Species List

The following fauna list was developed from surveys of the Development Site by Umwelt.

The following abbreviations or symbols are used in the list:

asterisk (*) Denotes species not indigenous to the project area;

subsp. Subspecies;

MIG Listed migratory species under the EPBC Act;

PV Potential to be a Vulnerable species (Identification method not sufficient to be certain)

V Vulnerable; and

E Endangered.

Birds recorded were identified using descriptions in Pizzey and Knight (2012) and the scientific and common name nomenclature of Birdlife Australia (Birdlife International 2013). Reptiles recorded were identified using keys and descriptions in Cogger (2014) and Wilson & Swan (2008) and the scientific and common name nomenclature of Cogger (2014).

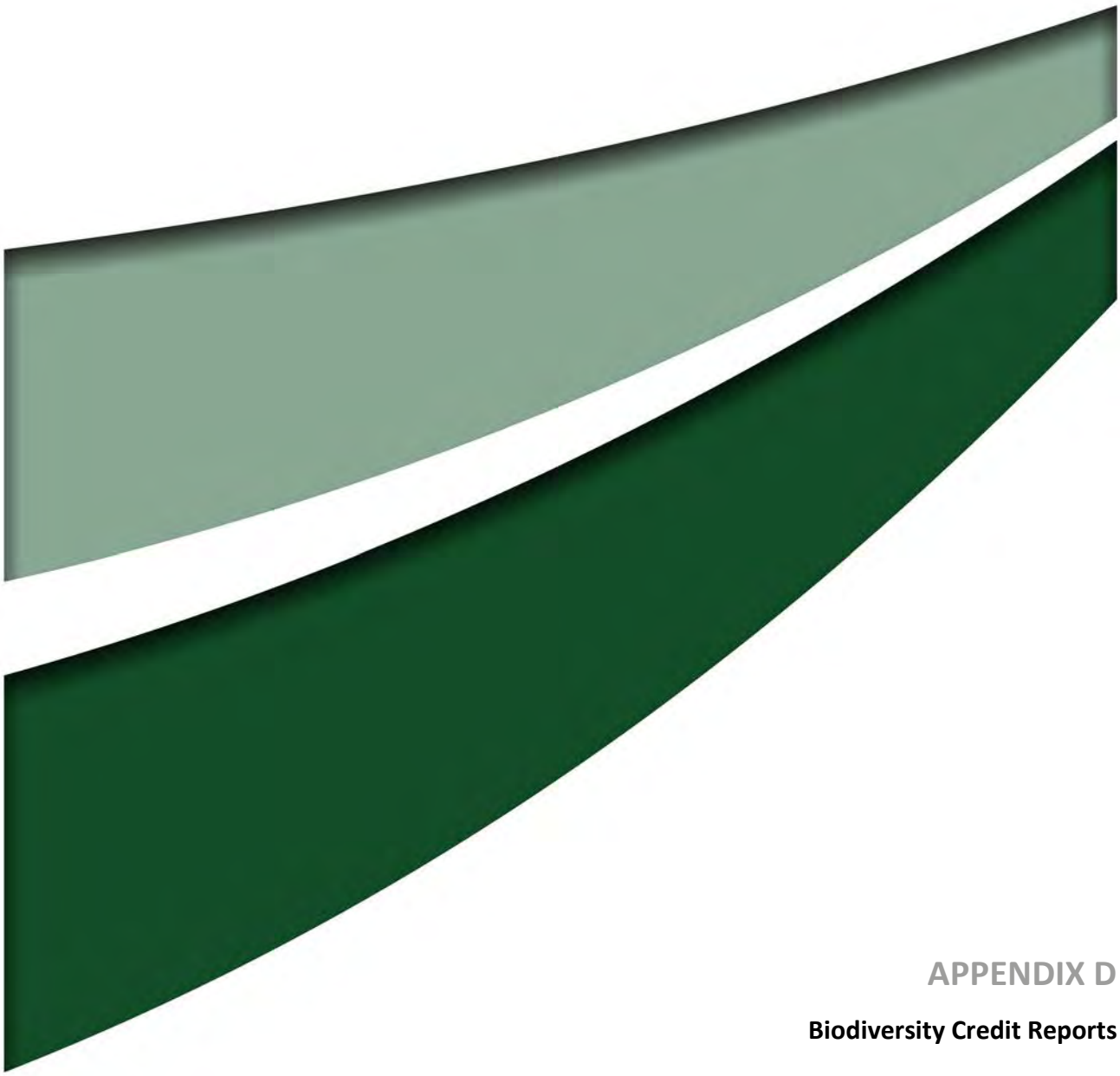
Amphibians recorded were identified using keys and descriptions in Cogger (2014), Robinson (1998), Anstis (2013) and Barker *et al*. (1995) and the scientific and common name nomenclature of Cogger (2014). Mammals recorded were identified using keys and descriptions in Van Dyck & Strahan (2008), and Menkhorst & Knight (2010) and the scientific and common name nomenclature of Van Dyck & Strahan (2008).

Scientific Name	Common Name	TSC Act	EPBC Act	MIGRATORY EPBC
PHYLUM MOLLUSCA				
GASTROPODA				
Myobatrachidae				
Pommerhelix duralensis	Dural woodland snail		**E**	
PHYLLUM CHORDATA				
AMPHIBIA				
Myobatrachidae				
Crinia signifera	common froglet			
Limnodynastes dumerilii	eastern banjo frog			
Limnodynastes peronii	brown-striped frog			
Uperoleia laevigata	smooth toadlet			
Uperoleia sp.	a ground frog			
Hylidae				
Litoria fallax	eastern dwarf tree frog			
Litoria latopalmata	Gunther's tree frog			

Scientific Name	Common Name	TSC Act	EPBC Act	MIGRATORY EPBC
Litoria peronii	Peron's tree frog			
REPTILIA				
Pygopodidae				
Pygopus lepidopodus	common scaly-foot			
Lialis burtonis	Burton's snake-lizard			
Scincidae				
Lygisaurus foliorum	tree-base litter-skink			
Varanidae				
Varanus variaus	lace monitor			
AVES				
Columbidae				
Geopelia humeralis	bar-shouldered dove			
Phaps chalcoptera	common bronzewing			
Alcedinidae				
Dacelo novaeguineae	laughing kookaburra			
Todiramphus sanctus	sacred kingfisher			
Cululidae				
Scythrops novaehollandiae	Channel-billed cuckoo			
Cacatuidae				
Calyptorhynchus lathami	glossy black-cockatoo	**V**		
Calyptorhynchus funereus	yellow-tailed black-cockatoo			
Psittacidae				
Platycercus eximius	eastern rosella			
Tytonidae				
Tyto javanica	eastern barn owl			
Anatidae				
Anas superciliosa	Pacific black duck			
Podicipedidae				
Tachybaptus novaehollandiae	Australasian grebe			
Ardeidae				
Egretta novaehollandiae	white-faced heron			
Accipitridae				
Elanus axillaris	black-shouldered kite			
Charadriidae				
Vanellus miles	masked lapwing			

Scientific Name	Common Name	TSC Act	EPBC Act	MIGRATORY EPBC
Psophodidae				
Psophodes olivaceus	eastern whipbird			
Climacteridae				
Climacteris picumnus	brown treecreeper			
Pardalotidae				
Pardalotus striatus	striated pardalote			
Meliphagidae				
Acanthorhynchus tenuirostris	eastern spinebill			
Lichenostomus penicillatus	white-plumed honeyeater			
Phylidonyris niger	white-cheeked honeyeater			
Acanthizidae				
Acanthiza lineata	striated thornbill			
Smicrornis brevirostris	weebill			
Sericornis frontalis	white-browed scrubwren			
Sericornis sp.	a scrubwren			
Pachycephalidae				
Pachycephala pectoralis	golden whistler			
Corvidae				
Corvus coronoides	Australian raven			
Rhipiduridae				
Rhipidura albiscapa	grey fantail			
Rhipidura leucophrys	willie wagtail			
Maluridae				
Malurus lamberti	variegated fairy-wren			
Malurus cyaneus	superb fairy-wren			
Nectariniidae				
Dicaeum hirundinaceum	mistletoebird			
Estrildidae				
Neochmia temporalis	red-browed finch			
MAMMALIA				
Tachyglossidae				
Tachyglossus aculeatus	short-beaked echidna			
Dasyuridae				
Antechinus sp.	a marsupial mouse			
Actrobatidae				
Acrobates pygmaeus	feathertail glider			

Scientific Name	Common Name	TSC Act	EPBC Act	MIGRATORY EPBC
Burramyidae				
Cercartetus nanus	eastern pygmy-possum			
Macropodidae				
Wallabia bicolor	swamp wallaby			
Petauridae				
Petuarus breviceps	sugar glider			
Phalangeridae				
Trichosurus vulpecula	common brushtail possum			
Peramelidae				
Isoodon sp.	a bandicoot			
Vombatidae				
Vombatus ursinus	common wombat			
Molossidae				
Tadarida australis	white-striped freetail-bat			
Mormopterus sp. 2	eastern freetail-bat			
Vespertilionidae				
Chalinolobus dwyeri	large-eared pied bat	**V**	**V**	
Chalinolobus gouldii	Gould's wattled bat			
Chalinolobus morio	chocolate wattled bat			
Miniopterus australis	little bentwing-bat	**V**		
Vespadelus pumilus	eastern forest bat			
Canidae				
**Canis lupus familiaris*	domestic dog			
**Vulpes vulpes*	red fox			
Leporidae				
**Lepus capensis*	brown hare			
Bovidae				
**Ovis aries*	sheep			
Muridae				
Rattus sp.	a rat			



APPENDIX D

Biodiversity Credit Reports

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 20/05/2016 Time: 10:20:11AM Calculator version: v4.0

Major Project details

Proposal ID:	0020/2016/2563MP
Proposal name:	Hearses Road Quarry
Proposal address:	75 York Street Teralba NSW 2284
Proponent name:	Umwelt
Proponent address:	75 York Street Teralba NSW 2284
Proponent phone:	49505322
Assessor name:	Travis Peake
Assessor address:	75 York St Teralba NSW 2284
Assessor phone:	02 4950 5322
Assessor accreditation:	0020

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	0.08	3.00
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	6.67	377.00
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	11.15	538.00
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	0.99	44.00
Total	18.89	962

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566)

Number of ecosystem credits created	377
IBRA sub-region	Yengo - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566) Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion, (HN587) Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion, (HN567) Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586) Spotted Gum - Grey Ironbark open forest in the Pittwater area, Sydney Basin Bioregion, (HN642) Sydney Peppermint - White Stringybark - Smooth-barked Apple forest on shale outcrops, Sydney Basin Bioregion, (HN644)	Yengo - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

2. Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586)

Number of ecosystem credits created	44
IBRA sub-region	Yengo - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586) Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion, (HN587) Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566) Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion, (HN567) Spotted Gum - Grey Ironbark open forest in the Pittwater area, Sydney Basin Bioregion, (HN642) Sydney Peppermint - White Stringybark - Smooth-barked Apple forest on shale outcrops, Sydney Basin Bioregion, (HN644)	Yengo - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

3. Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion, (HN582)

Number of ecosystem credits created	538
IBRA sub-region	Yengo - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Sandstone cliff soak moist shrubland of the Sydney Basin Bioregion, (HN580) Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion, (HN582)	Yengo - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

4. Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (HN560)

Number of ecosystem credits created	3
IBRA sub-region	Yengo - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (HN560) Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion, (HN563) Baeckea linifolia - Grevillea acanthifolia subsp. acanthifolia shrub/sedge swamp on sandstone, Sydney Basin Bioregion, (HN633)	Yengo - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Darwinia biflora	Darwinia biflora	18.00	360
Mitchells Rainforest Snail	Thersites mitchellae	17.82	1,372
Tetratheca glandulosa	Tetratheca glandulosa	18.00	288
Grevillea parviflora subsp. supplicans	Grevillea parviflora subsp. supplicans	13.00	338
Eastern Pygmy-possum	Cercartetus nanus	11.15	223

BioBanking credit report

This report identifies the number and type of credits required at a BIOBANK SITE

Date of report: 20/05/2016 Time: 10:21:57AM Calculator version: v4.0

Biobank details

Proposal ID:	0020/2016/3573B
Proposal name:	Hearses Road Offset
Proposal address:	75 York Street Teralba NSW 2284
Proponent name:	Umwelt
Proponent address:	75 York Street Teralba NSW 2284
Proponent phone:	49505322
Assessor name:	Travis Peake
Assessor address:	75 York St Teralba NSW 2284
Assessor phone:	02 4950 5322
Assessor accreditation:	0020

Additional information required for approval:

- ☐ Use of local benchmark
- ☐ Expert report...
- ☐ Request for additional gain in site value

Ecosystem credits summary

Plant Community type	Area (ha)	Credits created
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	0.93	11.00
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	0.78	6.00
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	1.52	17.00
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	0.36	4.00
Total	3.59	38

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566)

Number of ecosystem credits created	6
IBRA sub-region	Yengo - Hawkesbury/Nepean

2. Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586)

Number of ecosystem credits created	4
IBRA sub-region	Yengo - Hawkesbury/Nepean

3. Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion, (HN582)

Number of ecosystem credits created	17
IBRA sub-region	Yengo - Hawkesbury/Nepean

4. Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion, (HN560)

Number of ecosystem credits created	11
IBRA sub-region	Yengo - Hawkesbury/Nepean

Species credits summary

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Eastern Pygmy-possum	Cercartetus nanus	1.52	11
Darwinia biflora	Darwinia biflora	2.00	14
Mitchells Rainforest Snail	Thersites mitchellae	2.30	16
Tetratheca glandulosa	Tetratheca glandulosa	2.00	14

Additional management actions

Additional management actions are required for:

Vegetation type or threatened species	Management action details
Darwinia biflora	Feral and/or over-abundant native herbivore control
Eastern Pygmy-possum	Fox control
Mitchells Rainforest Snail	Exclude miscellaneous feral species
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Control of feral pigs
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Exclude miscellaneous feral species
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Needlebush - banksia wet heath on sandstone plateaux of the Sydney Basin Bioregion	Fox control
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Control of feral pigs
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Exclude commercial apiaries
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Exclude miscellaneous feral species
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Fox control
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Control of feral pigs
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Exclude miscellaneous feral species
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control

Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Fox control
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Control of feral pigs
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Exclude commercial apiaries
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Exclude miscellaneous feral species
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Fox control
Tetratheca glandulosa	Feral and/or over-abundant native herbivore control

BioBanking credit report

This report identifies the number and type of credits required at a BIOBANK SITE

Date of report: 5/07/2016 Time: 11:34:27AM Calculator version: v4.0

Biobank details

Proposal ID:	0020/2016/3576B
Proposal name:	Porters Road - Dixon Offset
Proposal address:	75 York Street Teralba NSW 2284
Proponent name:	Umwelt
Proponent address:	75 York Street Teralba NSW 2284
Proponent phone:	49505322
Assessor name:	Travis Peake
Assessor address:	75 York St Teralba NSW 2284
Assessor phone:	02 4950 5322
Assessor accreditation:	0020

Additional information required for approval:

- ☐ Use of local benchmark
- ☐ Expert report...
- ☐ Request for additional gain in site value

Ecosystem credits summary

Plant Community type	Area (ha)	Credits created
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	10.47	86.00
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	9.34	104.00
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	33.51	327.00
Total	53.32	517

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (HN566)

Number of ecosystem credits created	86
IBRA sub-region	Yengo - Hawkesbury/Nepean

2. Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (HN586)

Number of ecosystem credits created	327
IBRA sub-region	Yengo - Hawkesbury/Nepean

3. Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion, (HN582)

Number of ecosystem credits created	104
IBRA sub-region	Yengo - Hawkesbury/Nepean

Species credits summary

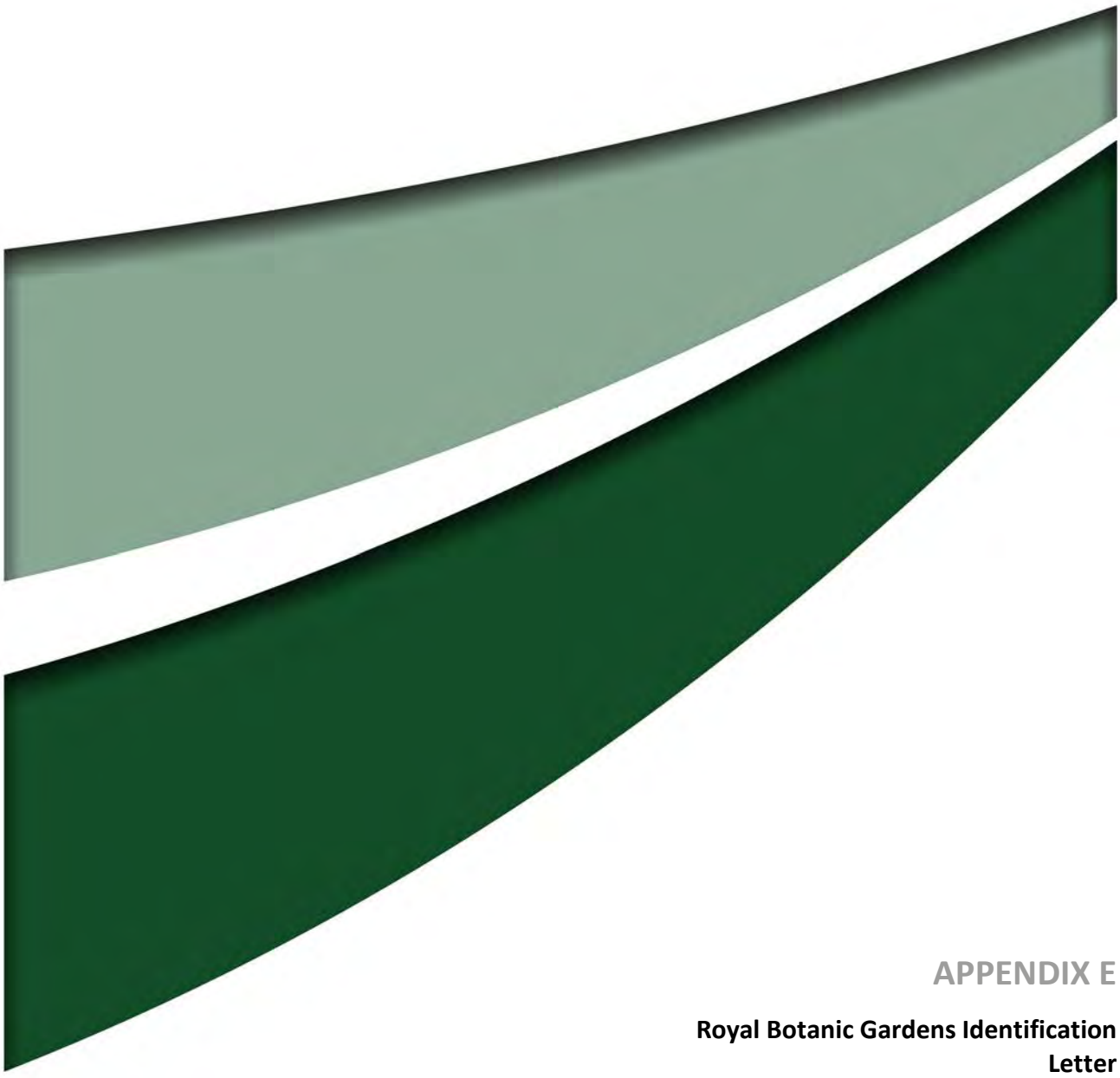
Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Bynoe's Wattle	Acacia bynoeana	20.00	142
Darwinia biflora	Darwinia biflora	20.00	142
Epacris purpurascens subsp. purpurascens	Epacris purpurascens subsp. purpurascens	20.00	142
Hibbertia superans	Hibbertia superans	20.00	142
Tetratheca glandulosa	Tetratheca glandulosa	20.00	142
Lasiopetalum joyceae	Lasiopetalum joyceae	9.00	64

Additional management actions

Additional management actions are required for:

Vegetation type or threatened species	Management action details
Darwinia biflora	Feral and/or over-abundant native herbivore control
Epacris purpurascens subsp. purpurascens	Feral and/or over-abundant native herbivore control
Epacris purpurascens subsp. purpurascens	Maintain or re-introduce natural flow regimes
Hibbertia superans	Feral and/or over-abundant native herbivore control
Hibbertia superans	Slashing
Lasiopetalum joyceae	Feral and/or over-abundant native herbivore control
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Control of feral pigs
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Exclude commercial apiaries
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Exclude miscellaneous feral species
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Fox control
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Control of feral pigs
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Exclude miscellaneous feral species
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Scribbly Gum - Hairpin Banksia - Dwarf Apple heathy woodland on hinterland sandstone plateaux of the Central Coast, Sydney Basin Bioregion	Fox control

Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Control of feral pigs
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Exclude commercial apiaries
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Exclude miscellaneous feral species
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Feral and/or over-abundant native herbivore control
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Fox control
Tetratheca glandulosa	Feral and/or over-abundant native herbivore control



APPENDIX E

Royal Botanic Gardens Identification Letter

The Royal
BOTANIC GARDENS
& Domain Trust

National Herbarium of New South Wales

Ryan PARSONS
Umwelt Pty Ltd
75 York Street
Teralba, NSW 2284

Enquiry No: 19561
Botanical.Is@rbgsyd.nsw.gov.au
Fax No: (02) 9251 1952
Ph No: (02) 9231 8111
Date: 20 April 2016

Dear Ryan PARSONS,

Thank you for your enquiry of 15-Mar-16. We are happy to provide the following information:

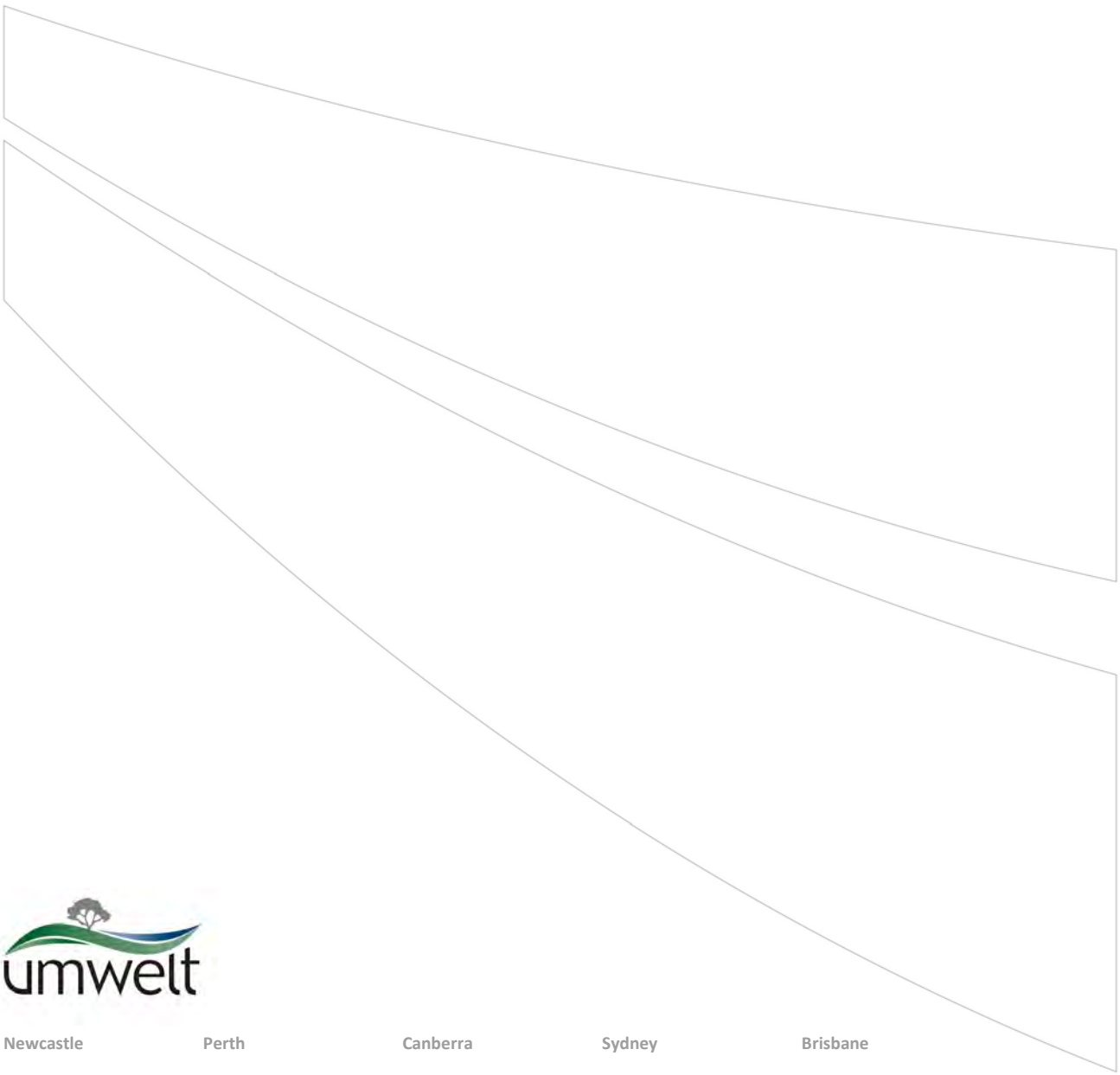
Dr Peter Wilson has examined your *Darwinia* collection from the Maroota area near Wisemans Ferry and our own herbarium collections from similar sites. The *Darwinia fascicularis* in the Maroota area have fewer flowers than you would expect for eastern populations of this species and require further study. I am sorry that we are unable to give you a complete report to subspecies at this point in time.
Your specimen has been retained for our herbarium collection and further study. There is no charge for this enquiry.

Thank you for your enquiry.

Yours sincerely

Barbara Wiecek
Identification Botanist
Botanical Information Service

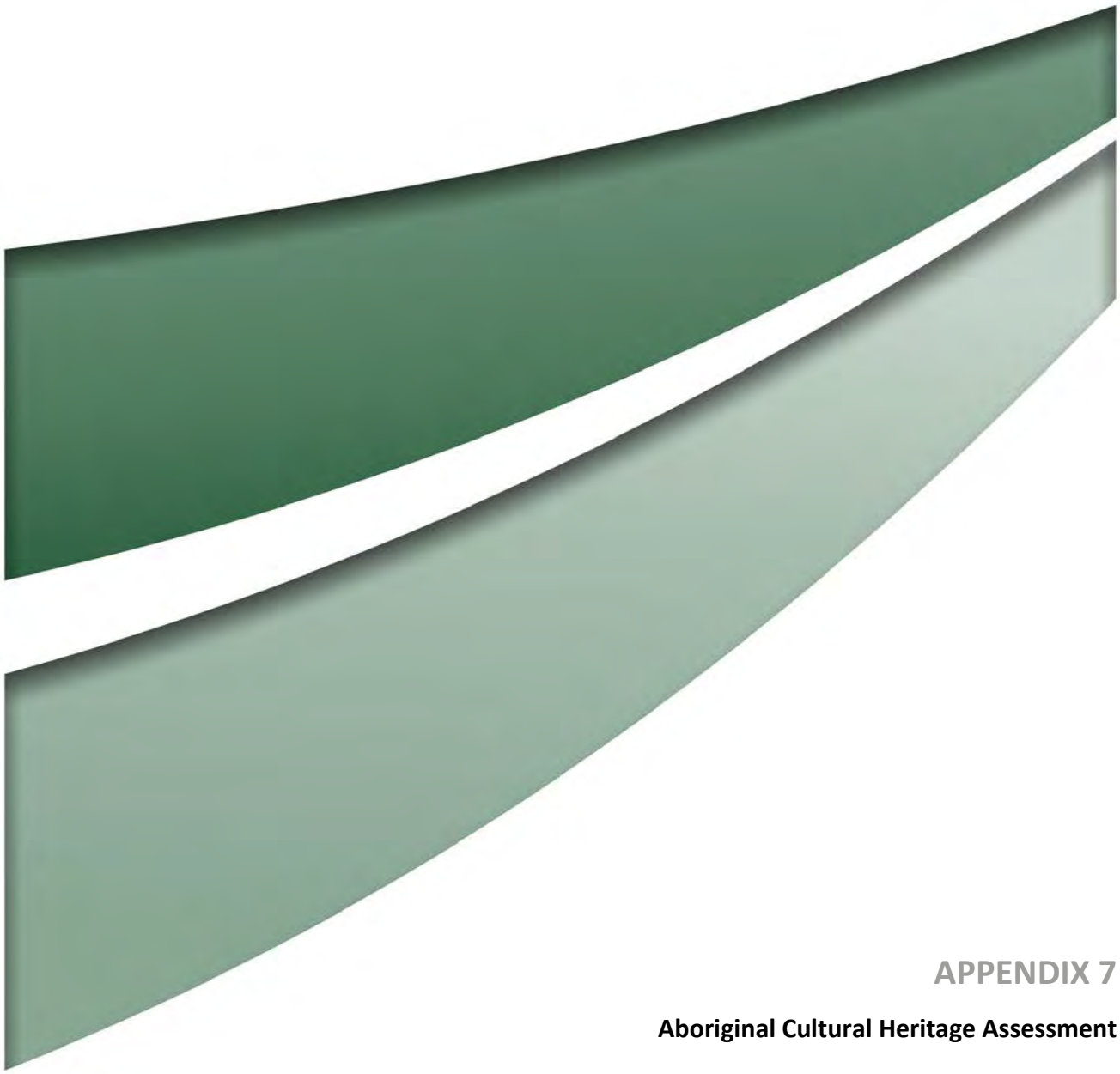
An estate of the Royal Botanic Gardens and Domain Trust, a statutory body within the Office of Environment and Heritage, Department of Premier and Cabinet.



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Newcastle	Perth	Canberra	Sydney	Brisbane
75 York Street Teralba NSW 2284	PO Box 8177 Subiaco East WA 6008 33 Ventnor Avenue West Perth WA 6005	PO Box 6135 56 Bluebell Street O'Connor ACT 2602	50 York Street Sydney NSW 2000	GPO Box 459 Brisbane QLD 4001
Ph. 02 4950 5322	Ph. 08 6260 0700	Ph. 02 6262 9484	Ph. 1300 793 267	Ph. 1300 793 267

www.umwelt.com.au



APPENDIX 7

Aboriginal Cultural Heritage Assessment

umwelt

Inspired people | Dedicated team
Quality outcomes

ABORIGINAL CULTURAL HERITAGE AND ARCHAEOLOGICAL ASSESSMENT

Haerses Road Quarry

FINAL

September 2016

ABORIGINAL CULTURAL HERITAGE AND ARCHAEOLOGICAL ASSESSMENT

Haerses Road Quarry

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Dixon Sand

Project Director:	John Merrelle
Project Manager:	Lachlan Sweeney
Technical Director:	Nicola Roche
Technical Manager:	Allison Lamond
Report No.	3479/R03/V3
Date:	September 2016

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Acknowledgement

Dixon Sand (Penrith) Pty Ltd (Dixon Sand) and Umwelt would like to acknowledge the Traditional Custodians of the Maroota area and pay respect to their cultural heritage, beliefs and continuing relationship with the land.

Dixon Sand and Umwelt would also like to acknowledge the post-contact experiences of Aboriginal peoples who have attachment to the Maroota area.

We pay our respect to the Elders – past, present and future – for they hold the memories, traditions, culture and hopes of Aboriginal peoples in the area.

Dixon Sand and Umwelt thank the registered Aboriginal parties for their participation in this project and for their valuable contribution to the assessment report.

Disclaimer

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1.0 Introduction

The Haerses Road Quarry, owned by Dixon Sand (Penrith) Pty Limited (Dixon Sand), is located on Haerses Road Maroota, NSW (refer to **Figure 1.1**). Haerses Road Quarry extracts Tertiary Maroota Sand from Lot 170 DP 664767, Lots A and B DP 407341, and Lots 176 and 177 DP 752039 (the site) in accordance with development consent DA 165-7-2005 (refer **to Figure 1.2**).

Dixon Sand was granted development consent for the State Significant Development DA 165-7-2005 under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) by the Minister for Planning on 14 February 2006. The development consent provides for the operation of a sand quarry on Haerses Road at Maroota with a total extraction of 7 million tonnes from the site over 25 years at a rate of 250,000 tonnes per annum (tpa). The consent allows for hauling of 190,000 tpa of screened sand to the processing facility at Dixon Sand's nearby Old Northern Road quarry and hauling of 60,000 tpa of screened sand direct to local and regional markets.

Due to the recent increase in demand for medium to coarse grain sands and specialist sands in the Sydney market, Dixon Sand is seeking a modification to DA 165-7-2006-5 for the Haerses Road quarry to increase the extraction area and to increase the volume of sand sold direct to market from the site. Umwelt (Australia) Pty Limited (Umwelt) has been engaged by Dixon Sand to prepare the necessary environmental assessments for the proposed modification, including this Aboriginal cultural heritage and archaeological assessment.



Image Source: Google Earth (2014)

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Haerses Road Quarry Site

FIGURE 1.1

Locality Map

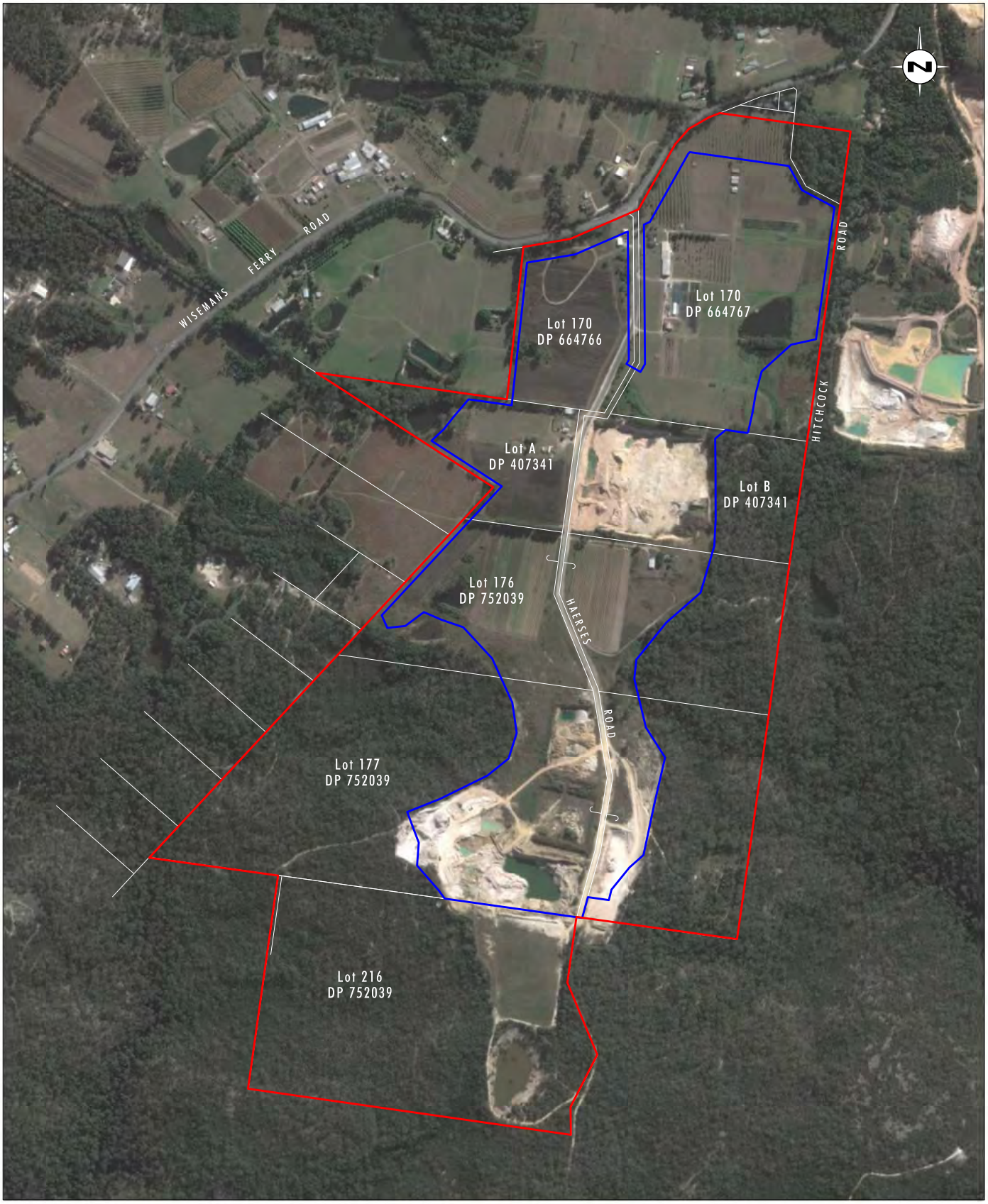


Image Source: Google Earth/DigitalGlobe (May/2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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- Haerses Road Quarry Site
- Approved Extraction Area

FIGURE 1.2

Haerses Road Quarry Site

2.0 Project Description

The proposed modification to DA 165-7-2006-5, being sought for the Haerses Road Quarry involves increasing the extraction area (as currently approved) as well as including a provision for mobile plant and equipment to be utilised on the site to avoid double handling and double processing of the product. The proposed modifications are:

- Increasing the extraction area by approximately 19.5 hectares to allow extension into the friable sandstone resource within Lots 177 DP 752039 and 216 DP 752039 (refer to **Figure 2.1**). The friable sandstone would be extracted using similar methods and equipment as currently used at the site, being a dozer, excavator, trucks and a loader. The existing dozer would be used to rip the friable sandstone on site which was not required for tertiary sand deposit in the original consent. The existing dry screening plant would utilise mobile crushers (one jaw crusher and one rotary crusher) to break sandstone clumps prior to screening

- No new traffic movements would be generated by the proposal with a reduction in traffic generation between quarries as a result of the proposed modification i.e. the modification would utilise existing traffic movements between Old Northern Rd and Haerses Rd Quarries to allow for blending of speciality sands

- Importation of up to 100,000 tpa of clean recycled sands for reprocessing (Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM)) from approved sites

- Use of mobile washing and processing plant on site, utilising water from existing water licence provisions

- Installation of detention basins

- Establishment of site office, workshop and weighbridge.

For the purposes of this assessment, the broader site area, including in the current operations and the modification is known as the Project Site. The current assessment is focused on the proposed modification covering the additional extraction area, comprising the western side of Lot 177 and Lot 216 of DP752039, and is referred to as the Project Area.

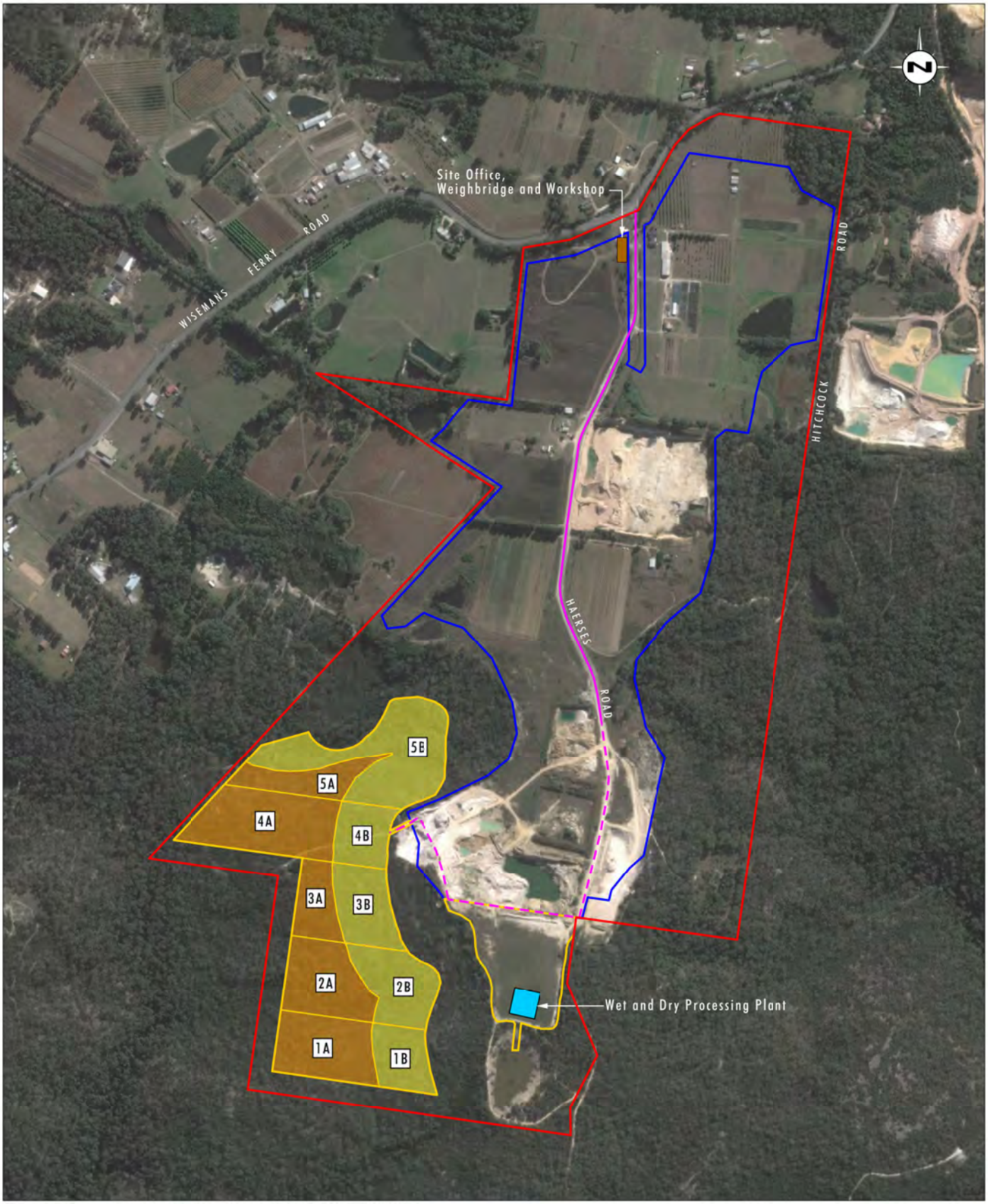


Image Source: Google Earth - DigitalGlobe (May 2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Proposed Extraction Area A
- Proposed Extraction Area B
- [1] Extraction Cell Number
- Site Office, Weighbridge and Workshop
- Wet Processing Plant
- Indicative Unsealed Haul Road
- Sealed Haul Road

FIGURE 2.1

Proposed Modification

File Name (A4): R03/3479_075.dgn
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3.0 Registered Aboriginal Party Consultation

The Aboriginal consultation regarding this Project has been undertaken in compliance with the Department of Environment, Climate Change and Water (DECCW, now Office of Environment and Heritage (OEH)) Aboriginal Cultural Heritage Consultation Requirements (ACHCRs) for proponents (2010a).

Registered Aboriginal Parties were encouraged to provide comments on the Aboriginal cultural values and significance of the extraction area and on a draft of this report for inclusion in this Aboriginal Cultural Heritage and Archaeological Assessment Report. A full consultation log and consultation records are attached in **Appendix A**.

3.1 Aboriginal Party Identification

In accordance with the ACHCRs, Umwelt, on behalf of Dixon Sand contacted the following organisations on 22 September 2015 to identify the upcoming Aboriginal heritage assessment in the Hearses Road quarry area and to request notification of any Aboriginal parties who may have an interest in participating in the assessment:

- Deerubbin Local Aboriginal Land Council (DLALC)
- Native Title Services Corp
- NSW and ACT Registry
- Office of the Registrar of Traditional Owners
- Office of Environment and Heritage
- Hawkesbury City Council
- Greater Sydney Local Land Services.

The closing date for the above agencies to identify Aboriginal parties who may have an interest in the Project was 7 October 2015.

The National Native Title Tribunal replied with a Native Title Search that indicated there were no registered Native Title applications in their search area, which covered Maroota Township.

Responses were received from DLALC, the Office of the Registrar and OEH advising of thirteen Aboriginal groups who may have an interest in being involved in consultation for the Project.

Based on the agency responses, two Local Aboriginal Land Councils were identified as having an interest in the Project site. OEH identified both DLALC and Metropolitan Local Aboriginal Land Council (MLALC) as the relevant Land Councils for consultation. The Land Council boundaries were investigated and it was found that the Project site falls within the DLALC boundary (refer to **Figure 3.1**), and therefore DLALC was the correct Land Council for consultation.

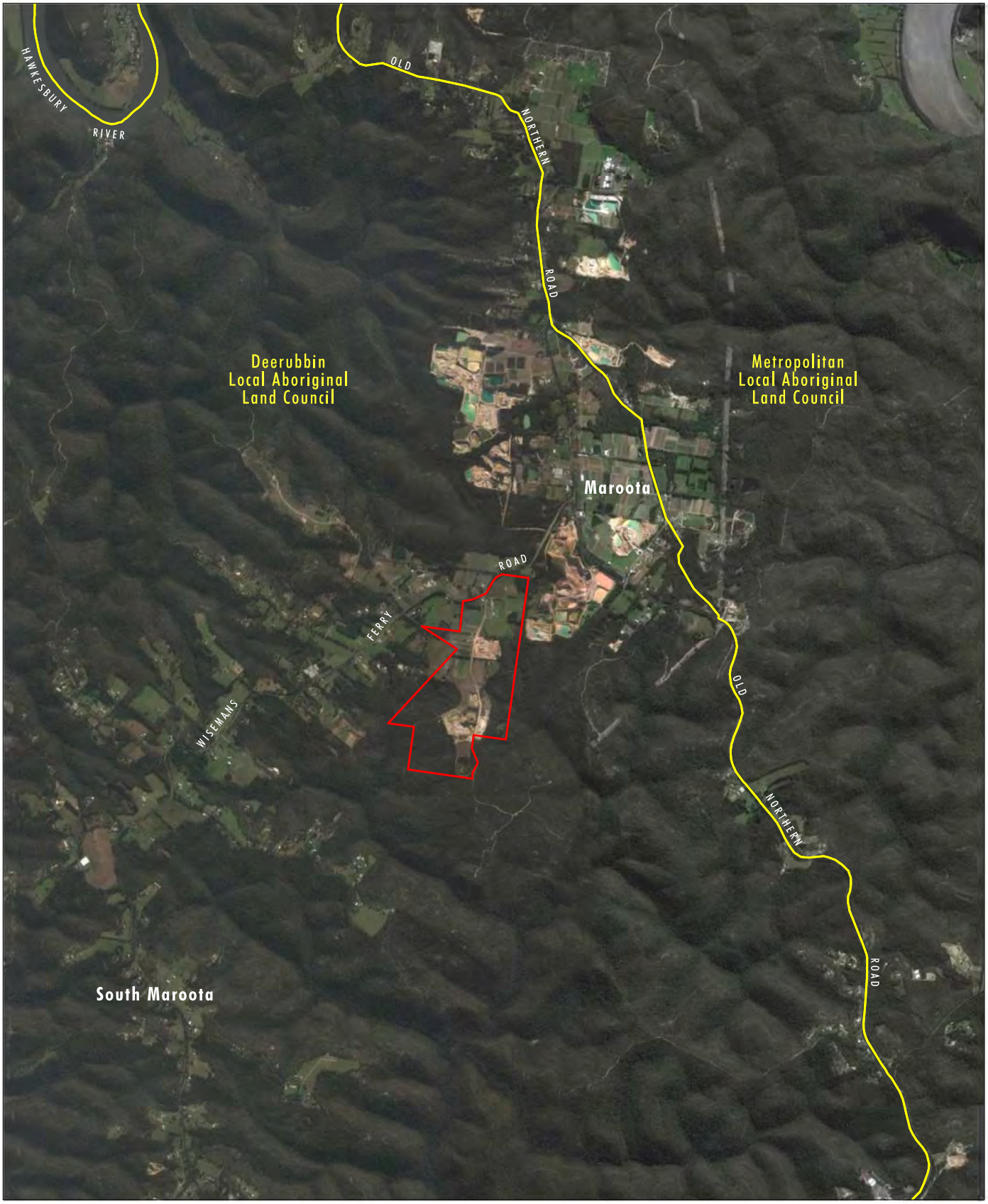


Image Source: Google Earth (2014)

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Legend

Haerses Road Quarry Site

Local Aboriginal Land Council Boundary

FIGURE 3.1

Haerses Road Quarry and
Local Aboriginal Land Council Boundaries

Local media advertising was also conducted to identify any additional interested Aboriginal Parties, with advertisements appearing in the Hawkesbury Gazette on 23 September 2015 and the Hawkesbury Courier on 24 September 2015, both with a closing date for registration of 7 October 2015.

On 28 October 2015, all Aboriginal parties identified during the notification process were sent a letter with a brief project introduction and information about the groups identified during the notification process. A proposed survey strategy and proposed project timeframe were included in the letter, asking groups to provide any comments or raise any concerns they may have with either. Those groups who had not previously registered an interest were also invited to register an interest in consultation for the Project by 12 November 2015.

As a result of the above notification process, the following organisations registered an interest in consultation for the Project:

- Deerubbin Local Aboriginal Land Council (DLALC)
- Darug Land Observations (DLO)
- Tocomwall
- Kawul Cultural Services.

On 21 December 2015 Darug Aboriginal Cultural Heritage Assessments (DACHA) contacted Umwelt, advising they only just received notification of the project through NTS Corp. The notification letter sent as a result of the OEH notification had also not been received. As a result, their registration in the project was accepted and a summary of the survey results was provided.

3.2 Registered Aboriginal Party Consultation and Involvement

OEH guidelines for Aboriginal heritage assessment and management acknowledge that it is primarily Aboriginal people who should determine the significance of their heritage and therefore OEH require applicants to demonstrate that Aboriginal people have been involved in the identification, assessment and management decisions relating to their heritage.

All registered Aboriginal parties were consulted throughout the course of the Aboriginal heritage assessment process from the time of their registration. In summary, this involved: attending meetings; providing cultural input throughout the assessment process; involvement in the archaeological surveys and review of key documents (including the draft survey strategy and draft assessment report). Copies of correspondence to registered Aboriginal parties are provided in **Appendix A**.

Appendix A of this report also contains a copy of all registered Aboriginal party statements provided during the course of the Project, including comment on the draft survey strategy, cultural significance and management options and recommendations.

3.2.1 Review of Draft Survey Strategy

A draft survey strategy, suggesting survey of all occurrences of landforms within the Project Area, which included two first order creek lines, spur crests and hill slopes, was provided to all registered Aboriginal parties and potential registrants identified by the agencies contacted in a letter sent out on 28 October 2015. The closing date for the return of comments was 23 November 2015. The survey strategy proposed to survey both creek lines, the spur crests and the slopes within the project Area.

Written comment on the draft survey strategy was received from one (Kawul Cultural Services) of the four registered Aboriginal parties by 23 November 2015, agreeing with the proposed survey strategy. Prior to undertaking the survey, on 8 December 2015, all registered Aboriginal parties were asked to confirm that they were satisfied with proposed survey strategy, or if they wished to raise any concerns with the survey strategy. No further comments regarding the proposed survey strategy were made. Registered Aboriginal party comments on this draft survey strategy are summarised in **Section 7.0** and included in **Appendix A**.

3.2.2 Fieldwork Participation

In recognition of the essential involvement of registered Aboriginal parties in the fieldwork program, Dixon Sand provided all registered Aboriginal parties with the opportunity to participate in the survey. All of the Aboriginal parties who had registered an interest in the Project at the time of the survey participated in the survey. Registered Aboriginal party participation in the fieldwork program is detailed in **Section 8.1**.

Darug Aboriginal Cultural Heritage Assessments (DACHA) registered for the project after the survey had taken place. Their registration was accepted and a summary of the survey and results was provided to them.

3.2.3 Review of Draft Aboriginal Archaeological Assessment Report

The draft Aboriginal cultural heritage and archaeological assessment report was provided to all registered Aboriginal parties on *3 May 2016* with 28 days provided for review and provision of advice and comments. Any comments on the draft report received from the Aboriginal parties are summarised below and included in full in **Appendix A**.

3.2.3.1 Darug Aboriginal Cultural Heritage Assessments (DACHA)

DACHA provided verbal comment in a phone call on 1 June 2016 stating they were happy with the assessment process, with nothing further to add to the report.

3.2.3.2 Darug Land Observations (DLO)

DLO provided written comment on 9 May 2016 requesting the opportunity to monitor the topsoil removal and all other works to be carried out on site. DLO also recommends that in the event of an artefact salvage under a Aboriginal Heritage Impact Permit the artefacts should be reburied on country within the study area.

3.2.3.3 Deerubbin Local Aboriginal Land Council (DLALC)

DLALC stated that as no Aboriginal cultural material was found they have no objection to the Haerses Road Quarry on the grounds of Aboriginal cultural heritage.

3.2.3.4 Tocomwall

Tocomwall provided via email on 31 May 2016 that they had no comments to make in relation to the assessment.

3.2.3.5 Kawul Cultural Services (KCS)

Despite numerous attempts via phone and email to contact KCS, they did not provide any comment on the report.

4.0 Environmental Context

The decisions that people make regarding such things as where they live, the range of resources they use and other aspects of daily life may be influenced by the environment in which they live. The preservation and visibility of sites is also affected by environmental factors such as vegetation cover, past land-use and disturbance. A review of the environmental context and historical land use of the Project Area is therefore integral to considerations of site visibility, preservation and occurrence within the Project Area.

4.1 Landscape Context

Knowledge about the landscape characteristics and resources of a region is important to the investigation of past Aboriginal landscape use and the analysis of the potential distribution of archaeological sites. The Project Area is bounded to the south by the Maroota Nature Reserve, which includes a series of ridges running towards the Hawkesbury River, which is situated eight kilometres to the north west. To the east it is bounded by the existing Haerses Road quarry, with rural properties and some of bushland to the north.

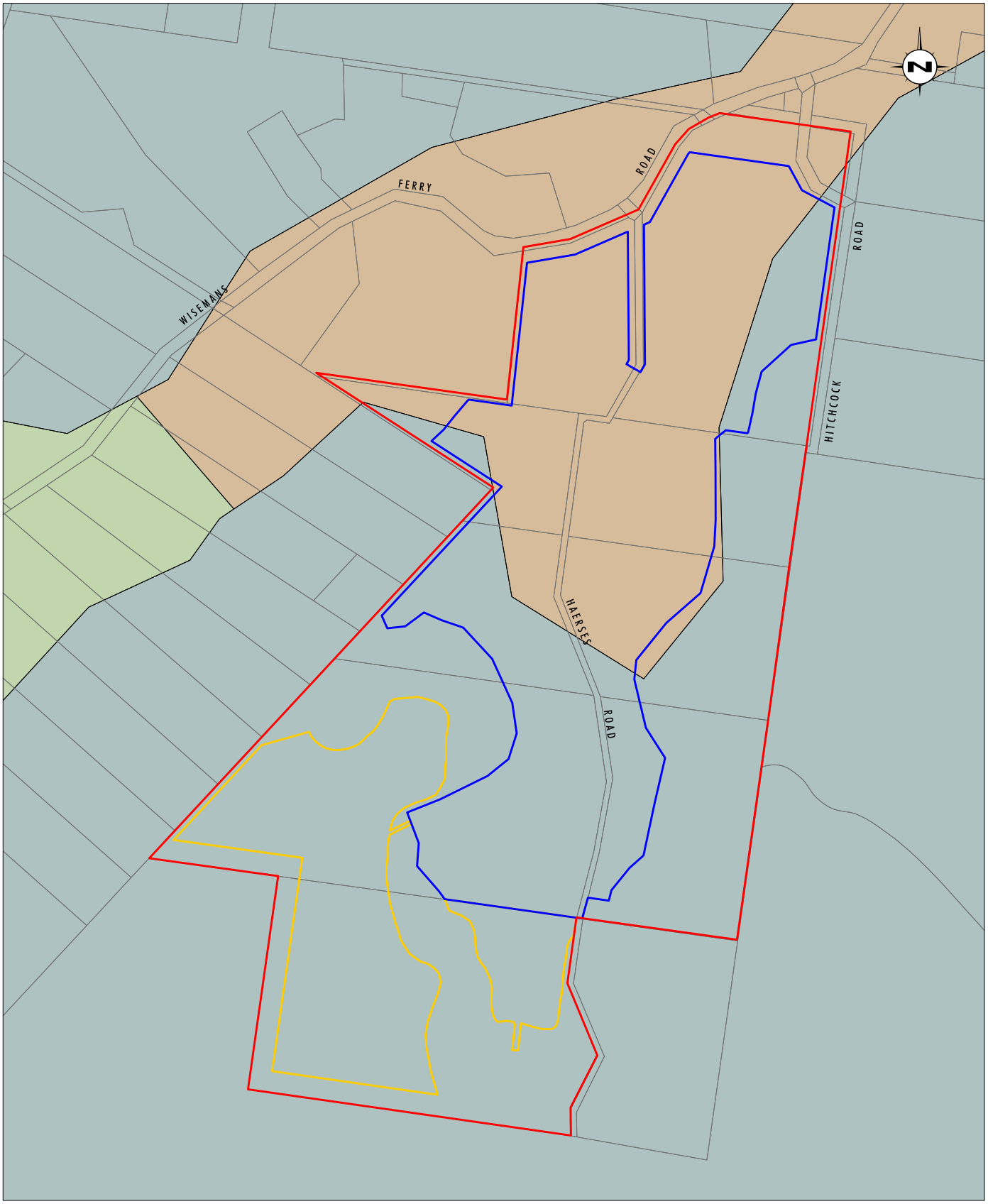
4.1.1 Geology

The Project Area is located in the Sydney Basin, which is generally composed of Narrabeen and Hawkesbury sandstones and shales (NPWS, 2001c). The Project Area is underlain by Hawkesbury Sandstone (McInnes, 1997) (refer to **Figure 4.1**).

Outcropping sandstone platforms used for grinding implements and sandstone overhangs used for shelter and rock art (paintings and engravings) have been identified throughout the Sydney Basin as being of importance to Aboriginal people (NPWS, 2003). There is a significant representation of these features in the region surrounding the Project Area (McInnes, 1997), however there are no outcropping sandstone platforms within the Project Area.

A key characteristic of the geology of the region that is of relevance to this assessment is the occurrence of surface outcrops of sandstone, which were used by Aboriginal people for the making of stone tools and engravings.

Where outcrops of sandstone are suitable, grinding grooves associated with creating cutting edges on tools such as stone axes, hatchets, adzes, chisels and fire hardened spear points are sometimes located. Most often this is in association with creek beds where water collects in rock pools or potholes, however grinding grooves have also been recorded on sandstone outcrops on ridge tops (Umwelt 2013: 4.2). These grinding grooves are located in association with depressions and potholes where water accumulates after rain. Outcrops of sandstone on ridge tops have also been used by Aboriginal people for rock engravings. Where sandstone outcrops exist in areas of steep terrain, sandstone outcrops may also form rockshelters. These sheltered areas were sometimes targeted by Aboriginal people for habitation or ceremonial purposes, and sometimes retain evidence of this use where floor deposits remain. As the geology of the extraction area is reliant on the presence of sandstone, there is the likelihood that visible sandstone suitable for grinding or engravings maybe present.



Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014), Mineral Resources NSW, December 2003

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Legend

- Haerses Road Quarry Site
- Approved Extraction Area
- Modification Disturbance Area
- Tertiary (Sand, silt, clay & gravel)
- Bringelly Shale, Minchinbury Sandstone, Ashfield Shale
- Hawksbury Sandstone

FIGURE 4.1

Geology

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4.1.2 Soils

The Project Area is located predominantly in the Gymea soil landscape with some small sections of Maroota soil landscape (refer to **Figure 4.2**).

The soils in the Gymea soil landscape are generally shallow Lithosols associated with rock outcrops and leading edges of benches. Soils are generally shallow to moderately deep on crests and inside of benches. Drainage lines are generally lined with shallow to moderately deep sands (McInnes 1997: 45). The soils are generally well-drained where overlying sandstone bedrock (McInnes 1997: 47). The soils are generally acidic (4.5 – 6.5 pH) and are generally subject to high levels of erosion when cleared of vegetation (McInnes 1997: 45).

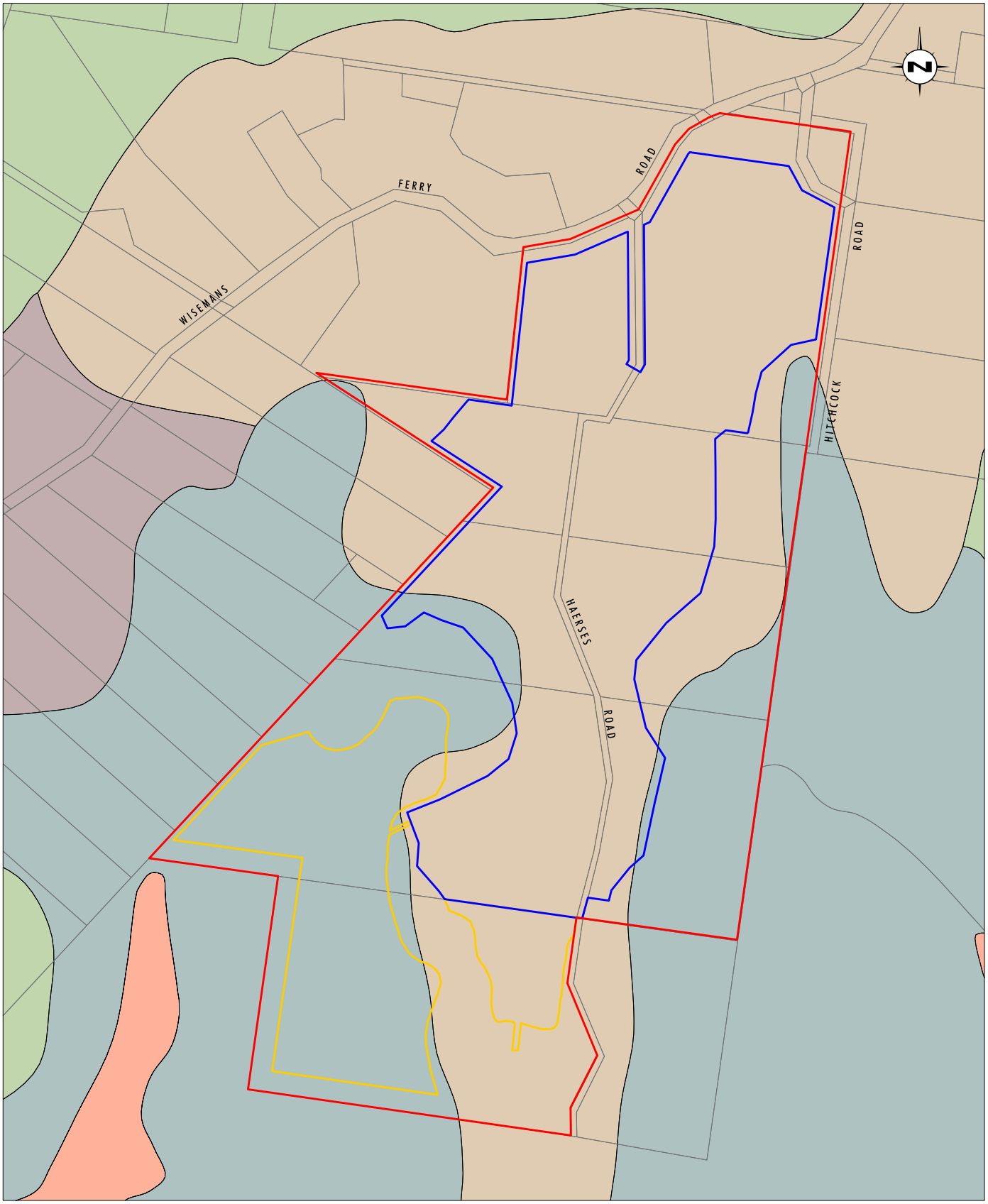
The soils in the Maroota soil landscape are generally moderately deep to deep Yellow Earths on crests and slopes with Podzoils associated with drainage lines. The soils are well drained sands on slopes and terraces and poorly drained leached sands along drainage lines. At the heads of drainage lines, the soils generally have deeper deposits accumulated. The soils are acidic (4.5 – 6.5 pH) and are generally subject to high levels of erosion when cleared of vegetation (McInnes 1997: 93.

The preservation of archaeological materials is influenced by many factors, such as soil pH, the activity of soil dwelling micro-organisms and the movement of water across the site. The soil pH levels of the soil landscapes across the Project Area vary between slightly acidic and strongly acidic. This suggests that survival of organics (bones, wooden implements) is unlikely across the Project Area, as neutral to alkaline soils are required for the preservation of organic materials. Water flow, such as would occur along the drainage lines, further aid the survival of the micro organisms, which act to increase decomposition of organic material (Mays, 1998:17-21).

4.1.3 Topography and Hydrology

The Gymea soil landscape is characterised by undulating to rolling low hills on Hawkesbury Sandstone. Local relief ranges from 20- 80 metres. Outcropping sandstone rock benches often form broken scarps (McInnes 1997: 45). The Maroota soil landscape consists of gently undulating rises on plateau surfaces with local relief limited to 20 metres. Crests tend to be broad, with long, smooth and gently elevated slopes free of rock outcrops (McInnes 1997: 91).

The Project Area is located within low sandstone hills and contains two first order tributaries of Stone Chimney Arm. The tributaries flow into a third order tributary 150 metres outside the Project Area. This tributary joins the main channel of Stone Chimney Arm approximately 250 metres downstream. The maximum height of the elevated hills is 170 metres AHD. Stone Chimney Arm begins 950 metres north-west of and flows north- south immediately west of the Project Area. Two third order streams meet 450 metres from the Project Area. Stone Chimney Arm joins Little Cattai Creek approximately two kilometres south of the Project Area. The close presence of a number of creeks with more reliable water suggests that Aboriginal people would not have relied on the Project Area for fresh water. The creeks flow through steep-sided valleys, and nearby in the Yengo National Park, most of the deeply incised creek lines and rivers have Narrabeen sandstone exposed in the lowest valley levels (McDonald, 2008).



Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014), OEH (2010)

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Legend

- Haerses Road Quarry Project Aite
- Approved Extraction Area
- Modification Disturbance Area
- Gymea Soil Lansdcape
- Colo Heights Soil Landscape
- Watagan Soil Landscape
- Maroota Soil Landscape
- Sydney Town Soil Landscape

FIGURE 4.2

Soils Lanscapes

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4.1.4 Flora and Fauna

The nearby Yengo and Wollemi National Parks (approximately 25 km north west of the Project Area) are part of the Greater Blue Mountains World Heritage area, which was gazetted in 2000 in recognition of its eucalypt habitats, heathlands, swamps, wetlands and grasslands. The World Heritage area has a significant representation of Australian flora, with a significant number of rare or threatened species (UNESCO, 2000) and is habitat to over 400 different faunal species (UNESCO, 2000) with 390 faunal species recorded in the Wollemi National park (NPWS 2001a) and 223 recorded in the Yengo National Park (including 41 mammal species, 128 bird species, 17 amphibian species and 37 reptiles) (NPWS 2001a).

Vegetation identified in the quarried area adjacent to the Project Area prior to sand mining included open forest woodlands of red bloodwood (*Corymbia gummifera*), scribbly gum (*Eucalyptus haemastoma*), forest oak (*Allococasuarina torulosa*), old man banksia (*Banksia serrata*), wattles (*Acacia*) and bracken (*Pteridium esculentum*).

Table 4.1 lists vegetation species identified within the Project Area during the field survey and their known Aboriginal use. As can be seen, the plants currently present within the Project Area provide food, economic and medicine resources and are likely to be representative of vegetation available to Aboriginal people in the past.

Table 4.1 Floral Species Identified in the Project Area and Known Aboriginal Use

Scientific Name	Name	Known Aboriginal Use	Reference
Acacia sp.	Wattle	Economic plant – timber often used for fuel, leaves crushed and soaked with nets to waterproof them – wood used for boomerangs, clubs and digging sticks Food plant – gum that exudes from wounds on trunk eaten; pink witchetty grub live under tree	Australian National Botanic Gardens Education Services, 2000 Gott, 1995 Stewart and Percival, 1997:8 Umwelt 2003
Angophora hispida	Dwarf Apple	Medicine plant – has astringent qualities, used for reducing blood flow and diarrhoea Burls on trunks removed an hollowed for use as containers and to boil water	Low, 1989 Umwelt 2003
Banksia sp.	Banksia	Food plant – nectar eaten Economic plant – cones used to carry fire	Low, 1989; Stewart & Percival, 1997

Scientific Name	Name	Known Aboriginal Use	Reference
Eucalypts sp.	Eucalypts	Food plant – roots chewed for water in dry areas Medicine plant – leaves used to reduce fever Economic plant – bark and heartwood of some species used for wooden bowls, shields, canoes	Australian National Botanic Gardens Education Services, 2000; MacDonald and Davidson, 1998
Grevillea sp.	Silky oak	Food – flowers sucked for nectar	Flood, 1980
Lambertia formosa	Mountain devil	Food plant – nectar sucked from flowers	Low, 1989: 170
Lomandra sp.	Mat rush	Food plant – edible flowers and leaf bases; seeds were husked and ground into flour Economic plant - strong leaves were made into net bags by Aboriginal women	Low, 1989: 131, 174; Zola & Gott, 1992:59
Melaleuca sp.	Paperbark	Medicine Plant – leaves were crushed and inhaled for coughs and colds. Leaves were also soaked to make an infusion to treat sores and burns Economic plant – the bark was used for bedding and for bandages and for wrapping babies and corpses	Low, 1989 Low, 1990: 95 Umwelt, 2003
Persoonia sp.	Geebung	Food plant – ripe fruit pulp eaten Medicine plant – fine scrapings of wood from young stems mixed with breast milk for eye treatment Economic plant – solution made from bark used to strengthen fishing lines	Stewart and Percival, 1997

Fauna that is likely to have occurred in the past would have included kangaroos, wallabies, koalas, wombats, possums, snakes, lizards and various insects. During previous surveys of the adjacent quarry a swamp wallaby was seen.

4.2 Land Use History

Maroota is situated along the Old Northern Road, one of the earliest routes north from Sydney to the Hunter Valley, which was originally surveyed between 1819 and 1833 (Casey & Lowe 1994: 4). The need to expand into the Hunter Valley arose because of the granting of all land on the Cumberland Plain. The first overland route from Sydney to the Hunter Valley, Finch's Track, was officially opened in 1823. By 1825, 283 settlers had arrived in the valley. The majority of these settlers were free immigrants, newly arrived in the Colony. Many appear to have been affluent and demanded the construction of a better road. In April 1826 they sent a petition to the Governor stating that a proper road was essential for the transportation of goods to Sydney (Casey & Lowe 1994: 4).

The supervision of the construction of the line of the Old Northern Road through Maroota is attributed to Lieutenant John Warner, who became Assistant Surveyor for the North Road in 1827. In June 1828 Lieutenant Percy Simpson took over from Warner. The road was constructed by convict work gangs and in March 1829 the section of road near Maroota was described as "the old bush track, merely a bush road"(Casey & Lowe 1994: 4).

The Old Northern Road between Castle Hill and Maroota was apparently abandoned for much of the nineteenth century and was not used during the second-half of the nineteenth century because of the preferred use of McGrath's Hill Road via Maroota and onto Wisemans Ferry. The road came into use again in the 1940s (Casey & Lowe 1994: 4).

Maroota was first settled in 1832 and was known as Forest Glen until the village was formally proclaimed in 1892. Army veterans were encouraged to farm the land, however poor soil quality meant cultivation was not possible and the settlement was closed in 1834 (Rowland, J: 2008).

Today, farming and quarrying are the two main industries in Maroota, with sand quarried to supply the wider Sydney region. The small town is surrounded by largely undeveloped state forest with views across to the Blue Mountains.

Current aerial photography of the Project Area shows that the area is heavily vegetated and the area adjacent to the Project Area has been cleared and impacted by sand quarrying (**Figure 4.3**). Some tracks able to be used for vehicles can be seen. It is likely that prior vegetation clearance may have occurred within the Project Area but sufficient time has elapsed to allow for the establishment of significant regrowth. This previous land use is unlikely to have impacted heavily on any Aboriginal sites that may be present within the Project Area.

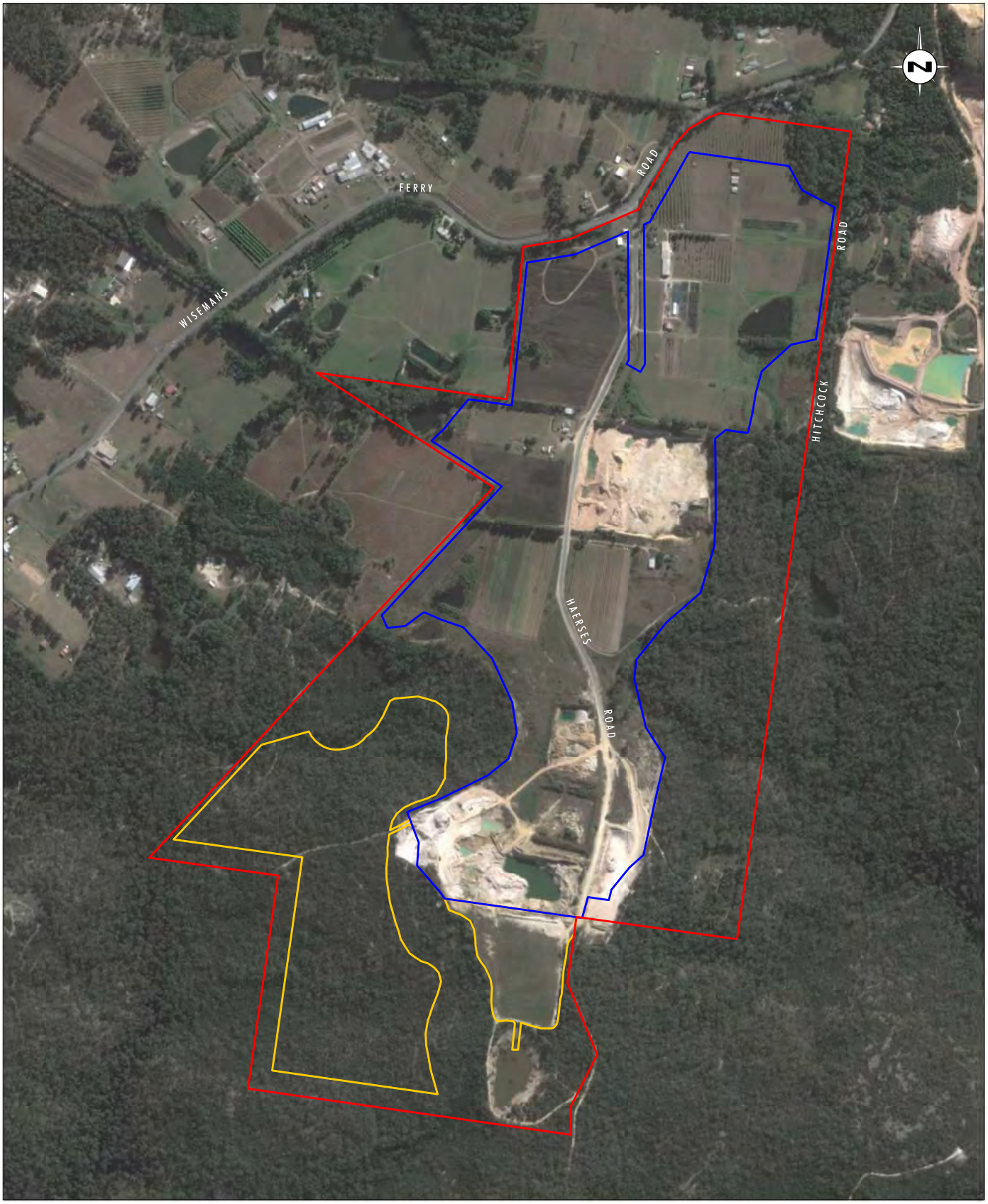


Image Source: Google Earth (2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Project Site
- Approved Extraction Area
- Modification Disturbance Area

FIGURE 4.3

Land Use

4.3 Implications

The geology of the Project Area is primarily Hawkesbury Sandstone. Sandstone outcrops are known to have been used by Aboriginal people for grinding stone implements and making engravings. Where evidence of grinding is present, there are often associated pools of water. It is possible that grinding grooves or engravings may be present where there are suitable sandstone outcrops.

Soils are generally shallow and well drained. The ridges and valleys provide a natural boundary between neighbouring Aboriginal groups. If sites of sufficient size and diversity are located within the Project Area, it is possible that their contents may be demonstrative of any natural division. Overhangs are unlikely based on the topography, however if present they may contain evidence of their use by Aboriginal people in the past.

Flora and fauna observed within the Project Area indicate that a range of Aboriginal resources would have been present in the past. A variety of Aboriginal resource plants with food, medicine and economic resources are present within the Project Area.

Historical land use of the Project Area is connected to the short-lived 1832 settlement of Maroota and later farming and quarrying.

5.0 Cultural Context

Historic records, such as official records, personal observations recorded in diaries or publications and paintings, can provide rare information on Aboriginal lifestyles of a region at the time of European contact. Although a valuable source of information, the limitations of these documents must be recognised as colonial observers generally tended to record unusual rather than everyday events, religious and social life rather than economic activity, and men's behaviour rather than that of women and children. As such, ethnohistoric records are neither unbiased nor complete, and they cannot provide a complete understanding of Aboriginal lifestyles at the time of contact. The records are also clouded by the late 19th Century/early 20th Century Anglophile perceptions of the recorders who often did not understand the meaning/background of the events they witnessed and thus may have drawn conclusions/made assessments that were not accurate.

A review of the available archaeological information for the region can assist in identifying patterns in the nature and distribution of archaeological sites. However, this information is also to some extent limited by the distribution and aims of previous archaeological survey.

5.1 Ethno-historic Context

The Project Area is located in the traditional land of the Darug people. The Aboriginal population of the Sydney area consisted of four language groups, the Darkinjung, Guringai, Darug and Tharawal, which were then broken down further into bands and tribes (McDonald 2008: 32). Based on economic behaviour, early sources suggest that Aboriginal people inland had very little contact with those on the coast (McDonald 2008: 22).

Within the Hawkesbury and Hills area Darug people were known to have used the ridgelines and creeklines for travel (Attenbrow 2010). Early observations of the Aboriginal people in the Sydney region were made by soldiers, with differences observed in tribal groups, economic and social divisions (McDonald 2008: 20). Despite a large number of rock art sites being present in the area, very little was described in the early accounts, likely because the creation was not observed.

The Darug people had carefully considered laws to prevent over-gathering or hunting and ensuring all members of the clan were fed (Kohen 1993: 39) The women were responsible to provide the majority of food, fish, fruits and tubers. Men would hunt, catching possums, goannas and wallabies (Turbin 1989: 65). Due to the steep and rugged terrain in the area, the ridgelines were used as travel ways across the landscape, a fact noted by early observers (McDonald 2008: 22).

An early nineteenth century expedition through Darug and Gandangara territories described the foods eaten by the Aboriginal people as possum, squirrels, kangaroo, kangaroo rats, lizards and grubs. The hunting of kangaroo was observed to be troublesome and requiring great numbers for hunting (McDonald 2008: 23). Tools observed for hunting and gathering these food resources include a simple hooked stick for collecting grubs and more complex 'squirrel traps' in hollow trees and decoys for ensnaring birds (McDonald 2008: 24). Early accounts remark on the tree climbing abilities of the men of the inland groups for catching possums. The creation of notches as toe holds in the trees was observed by some (McDonald 2008: 23).

In the vicinity of the Project Area, the narrow ridges and deep, steep sided valleys of the surrounding landscape provide natural features that have been reported by DECCW (2010b) as suitable for use as buffers or boundaries between other groups of Aboriginal Peoples, the Wiradjuri of the south west slopes; the Dharug [Darug] and Darkinjung of the coast and mountains; the Wonnarua of the middle Hunter; and the Kamilaroi of the north-west slopes as far south as the Upper Goulburn River tributaries (DECCW, 2010b). Pathways along the ridges, through the National Parks connect these groups.

5.2 Previously Registered Sites

In Wollemi National Park, 15 kilometres north west of the Project Area, and Yengo National Park, 13 kilometres north of the Project Area, there are more than 650 Aboriginal sites recorded (DECCW 2001b). This large number of sites has been recorded despite the limited number and extent of surveys conducted in these areas (DECCW 2010b). It would appear that given this paucity of research in the wider area that significantly more sites will exist than are currently recorded and registered. The Maroota area extends directly from these parks and it can be considered likely that a similar number and range of sites will be located there.

A search of the OEH Aboriginal Heritage Information Management System (AHIMS) database for the area surrounding the Project Area was undertaken on 5 January 2016 which resulted in identifying 64 Aboriginal sites (refer to **Table 5.1**). The sites identified are show in **Figure 5.1**. Of these sites, five are located within 2 kilometres of the Project Area and one site 45-2-0081 is located 650 metres east of the project Area.

Table 5.1 AHIMS Sites within 10 kilometres of the Project Area

Site Type	Number of Sites
Art (Pigment or Engraved)	20
Art (Pigment or Engraved): Grinding Groove, Water Hole	1
Grinding Groove with Art (Pigment or Engraved)	3
Artefact	5
Grinding Groove	8
Modified Tree (Carved or Scarred)	2
Rockshelter with Potential Archaeological Deposit (PAD)	3
Shelter with Art (Pigment or Engraved)	12
Shelter with Art (Pigment or Engraved): Artefact	6
Shelter with Art (Pigment or Engraved): Grinding Groove, Artefact	2
Shell: Artefact	1
Stone Arrangement	1
Total	**64**

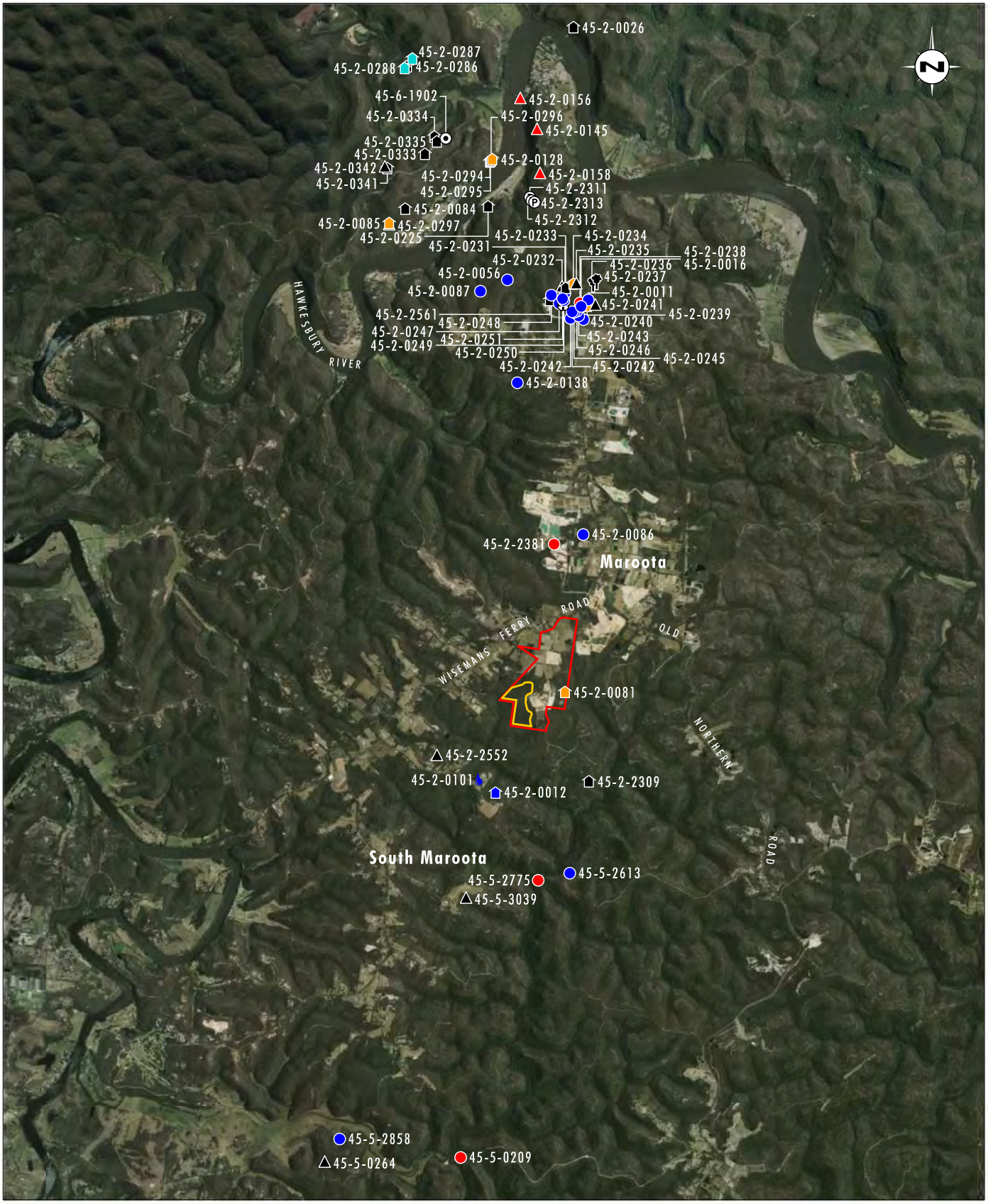


Image Source: Google Earth: Aerometrex (2016), Sinclair Knight Merz (2016), DigitalGlobe (2016), CNES/Astrium (2016)
Data Source: AHIMS (2016)

0 1.0 2.0 4.0km
1:90 000

Legend

- Haerses Road Quarry Site
- Proposed Extraction Area
- Artefact Scatter
- Rock Engraving
- Midden
- Shelter with Art
- Shelter with Deposit
- Shelter with Art & Deposit
- Scarred Tree
- Axe Grinding Groove
- Axe Grinding Groove, Shelter with Art, Shelter with Deposit
- Axe Grinding Groove, Rock Engraving
- Axe Grinding Groove, Rock Engraving, Water Hole/Well

FIGURE 5.1

Aboriginal Sites in the Vicinity of the Project Site

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Twenty-three of the sites listed in **Table 5.1** are rockshelter sites with one or more Aboriginal archaeological features, namely artefacts, deposit, art or grinding grooves. In addition, there are 24 rock engraving and grinding groove sites not associated with a shelter.

In a divergence from the typical distribution of sites within NSW, there are relatively few artefact scatter or isolated find sites with only five recorded in the search area. It is likely that many more artefact sites exist, however the limited survey means they have not been identified. The geology and landscape of the region is reflected in the site types located, which is typical for the region.

5.2.1 Previous Archaeological Research

This section discusses a number of archaeological studies that have been undertaken in the area, particularly those associated with sand mining.

5.2.1.1 Sim 1966

Sim (1966) located and recorded 22 groups of rock engravings in the MacDonald River Valley, approximately 30 kilometres north of the Project Area. Within these 22 groups of engravings there were 44 clusters of engravings, with emu tracks represented in a large number of sites. In the discussion of the engravings and the region, Sim notes that the southern section of the MacDonald River region is rugged and infertile, with the ridge tops almost devoid of water, apart from after heavy rains. Sim notes that the engravings are situated along the main ridges, with the majority being on the two ridges that provide routes between the more fertile valley areas in the region.

It was also highlighted that the engravings are limited to the area south of Putty and Wollombi, despite (painted) rockshelter art continuing north and west from the region. Sim avoided interpreting the engravings, apart from noting that many of the engraving sites were probably sacred sites.

Observations about the environment at the time were made, including a note that the MacDonald River had at one stage been a deep, permanent reliable source well stocked with fish, but by 1966 it was silted and shallow. It was also noted that within then living memory a number of reliable water holes at the heads of gullies had been destroyed by silting and scouring.

5.2.1.2 Harris, M 1979

This assessment related to an area approximately three kilometres northwest of the Project Area within which it was proposed to collect bush rock suitable for rockeries. The proposed works included the establishment of a small track, however large rocks and trees were just to be avoided.

The area assessed included rocky hills, noted as having limited water. Outcrops of exposed sandstone were observed, most were rough and some tessellated. There was one small watercourse with rock pools and sandstone platforms, however there were no engravings or grinding grooves located on this. No archaeological sites were located during the inspection of the area and it was assessed that the area had a low probability of containing artefacts.

5.2.1.3 Ross, B 1979

A survey of the current Haerses Road Quarry Project extraction area was undertaken to assess the area for impacts from quarrying. The predictive model for the assessment indicated it was unlikely to contain Aboriginal objects. The previous land use was identified as extensive, with over half of the area cleared for orchards and a substantial amount of the remaining area subject to clay extraction and dam construction. The land around this assessment area was mostly undisturbed.

Locals informed of two rock shelters in the area. One was located on the boundary of the assessment area and Maroota State Forest. The location of the second was not identified, as the knowledge holder was unavailable.

The shelter with art identified in this assessment is located approximately one kilometre east of the Project Area. The art consists of eight white ochre hand stencils in two groups and charcoal drawings, with a boomerang and a man in a canoe. The shelter also has evidence of use with stone artefacts scattered on the floor. No shell or bone was visible on the surface of the floor.

Other exposed sandstone platforms and overhangs were inspected, with no evidence of Aboriginal use observed.

5.2.1.4 Corkill, T 1989

Forty hectares of ridge top land at Maroota, approximately three kilometres north of the Project Area, were surveyed prior to sand mining. Previous land use included orchards and agriculture to the east and sand mining to the north, while the west and south were undisturbed bushland. Past land clearance on access tracks and the remains of a brick building were also observed.

Though the area was already disturbed, it was assessed that the area had the potential to contain rock engravings, grinding grooves and stone artefacts

No Aboriginal archaeological sites were located during the survey, although there were surfaces suitable for grinding grooves or engravings. It was noted, however that engravings were known to be rare on the west side of the ridge in the Maroota area. It was suggested that the rock shelters with pigment art were used as a substitute for engravings, though this was not related to any study. The other option suggested was that any engravings that were made had weathered away.

5.2.1.5 Corkill, T 1991

Corkill (1991) inspected an area proposed for sand mining two kilometres northwest of the Project Area. The area was focused on a two valley system with adjacent ridge tops. The ridge sides were steep with rocky scarps and these were separated by level benches. The ridge line was wide and extended through the central portion of the assessment area. Disturbance of the assessment area included clearance, track making, rubbish dumping and quarrying.

The proposed works were to result in the infilling of a valley over a 20 year period. A full survey of the proposed infill area was undertaken and no archaeological sites were identified during the survey, however one rockshelter with PAD was identified.

Ground surface visibility during the survey was minimal, except on exposed rock and vehicle tracks. The rockshelter with PAD was identified within the proposed infill area, and recommended for test excavation prior to any disturbance. Additionally, there were nine overhangs suitable for habitation identified. None of these had any archaeological material and they were not discussed further.

5.2.1.6 Kohen, J 1992

A survey approximately 3 kilometres north of the Project Area was undertaken, including Portions 196 and 29 at Maroota. This assessment area was located next to another existing sand mine operated by Dixon Sands. The closest previously recorded site was a rock engraving east of the survey area.

The survey area was located on a small ridge running to the southwest from the main ridge line, where the Great North Road passes. The slope was described as gentle, though increasing in steepness as it approached the gullies. The northern section of survey area contained an orchard, while the eastern section was under cultivation. While the southern section of the survey area was heavily vegetated, it was identified as regrowth.

The Maroota area was noted as having a range of archaeological sites, with high likelihood of engraving sites. The survey focused on rock surfaces, overhangs, large trees and ground surface exposures. Ground surface visibility was low in most of the survey area, however the areas of rock outcrop had good visibility. No Aboriginal archaeological sites and no areas of PAD were identified during the survey.

An overhang was located, consisting of an undercut sandstone outcrop, with a sandy alluvial soil. It was suggested that the creek may have flowed through it prior to a dam being constructed. The Project Area was not thought to contain potential archaeological deposits.

5.2.1.7 Corkill 1994

A survey for Aboriginal sites at Maroota, approximately five kilometres north of the Project Area, was undertaken for sand quarrying. The survey area covered 20 hectares on the eastern edge of the north/south tending Maroota Ridge. The survey area sloped gently to Cooper's Creek, which bisected it. Areas of exposed rock were targeted for examination for rock engravings and grinding grooves, and outcrops were targeted for evidence of use as a shelter.

Corkill identified four new archaeological sites during the survey; one grinding groove site with twenty grooves, one engraving and grinding groove site with two engravings and 11 grooves and two rock shelters with archaeological deposit. Artefacts in the shelters were made of silcrete and fine grained siliceous material. It was also notes that there was one rockshelter with PAD that had no visible artefacts. The archaeological significance of the sites was assessed as being high and it was recommended that the sites be protected.

5.2.1.8 Edgar, J 1995

Edgar undertook a survey of an area proposed for sand mining approximately one kilometre northeast of the Project Area. The area contained a number of ploughed fields, gentle slopes with regrowth vegetation, orchards and one area of steep hillside. Ground surface visibility was good in most part of the survey area due to extensive clearing and ploughing of fields in the survey area.

Three sites were located during the survey, one artefact scatter and two isolated artefacts. The isolated artefacts were not recorded as sites beyond their mention in the report. All three sites were in disturbed contexts. Artefacts were mudstone, silcrete and fine grained siliceous materials. The artefact scatter, MR1, consisted of five artefacts on a large cleared area. The artefacts consisted of three mudstone flakes, a red silcrete flaked piece and a fine grained siliceous flake. The two isolated finds each contained a mudstone flaked piece.

A lack of open artefact sites in the region was identified, increasing their significance, however the disturbed context of the sites limited their archaeological significance.

It was recommended that an Aboriginal Heritage Impact Permit be obtained for the artefact scatter site prior to any works occurring.

5.2.1.9 Corkill and Edgar 1999

Corkill and Edgar undertook a survey of an area proposed for sand mining approximately three kilometres northeast of the Project Area. The survey area was along a ridge top with no outcropping sandstone or mature trees. The ridge was thought likely to be part of an Aboriginal pathway between the Parramatta and Hawkesbury Rivers and on to the Hunter Valley. It is likely that areas used for camping were located on the slopes off of the ridge tops, more easily accessible to water.

The survey area contained a number of ploughed fields, gentle slopes, a steep earth bank, a knoll that had been cut and filled and an area of excavation and stockpiling. Previous land disturbance was extensive and no suitable rock outcrops were observed.

No Aboriginal archaeological sites or areas of PAD were identified during the survey and no further recommendations were made.

5.2.1.10 Appleton, J 2000

A survey was undertaken for the proposed installation of a rock crusher. The survey area was 10 kilometres south of Maroota.

The survey area was located perpendicular to the main north south trending ridge that is followed by the Old Northern Road and consisted of the upper slopes of the main ridge line, upper slopes and crest of a spur, steep sloped of a spur ridge and gullies between these.

The survey area had been heavily cleared and developed, with small undisturbed areas. Visibility varied from 5% to 35% across the survey area. No Aboriginal archaeological sites were located in the survey area. Exposed sandstone platforms suitable for engravings or grinding grooves were present within the survey area, although no grinding grooves or engravings were observed. Dams and other impacts to the creek meant that sites that may have been located here would likely have been destroyed. It was suggested that the survey area was used more as a travel way than a camping area.

5.2.1.11 Total Earth Care 2008

In 2008 a study of the Part Lot 3 DP567166 and Part Lot 2 DP510812 Quarry site at Maroota, approximately 4.5 kilometres north east of the Project Area, was undertaken for further sand extraction. The survey identified six previously identified Aboriginal sites, which included three rockshelters with deposit, two grinding grooves and a rock engraving and grinding groove. Two newly identified sites consisted of a set of grinding grooves as well as identifying artefacts within a rockshelter with PAD.

Two artefacts were located in the shelter, a quartz flake and a silcrete cobble used as a core and a hammerstone. The grinding groove site contained two shallow grinding grooves, which were noted as unlikely to be located except after heavy rainfall.

All six sites were identified as having high Aboriginal cultural significance, while two were identified as having high archaeological significance, three with potentially high archaeological significance and one with moderate archaeological significance. The two sites within the proposed extraction area were recommended to be fenced with a buffer to ensure their protection during mining.

5.2.1.12 Umwelt 2010

Umwelt undertook survey and assessment of an area within the Sugarloaf State Conservation Area. The topography of the Sugarloaf Range is similar to the Yengo and Wollemi National Parks, with steep narrow ridges and deep valleys. The ridge and spur crests in the Sugarloaf Range were the Aboriginal pathways through and across the mountains, similar to the main ridgelines through the Yengo and Wollemi National Parks.

The geology of the Sugarloaf Range is similar to that of the Yengo and Wollemi National Parks (refer to Section 3.2), consisting of Narrabeen Group sandstones and conglomerates (Matthei, 1995). Grinding groove sites were the dominant site type in the areas of steep terrain, with artefact sites most often located on spur crests that have access tracks with higher levels of visibility and soils prone to erosion. The ridgelines and gentle spurs in the Sugarloaf Range are known to have been the traditional Aboriginal pathways through the range, with most artefact sites being small scatters, likely to be indicative of transient use rather than prolonged camping.

The Sugarloaf Range differs from the Yengo and Wollemi National Park area, in that there are very few rockshelters with evidence of occupation in the Sugarloaf, as most shelters or overhangs are small with sloping floors and no deposit. There is also only one recorded art site, an engraving site associated with grinding grooves in a creek. Prior to systematic survey being undertaken in the Sugarloaf Range, a similar overall open site distribution to the Yengo and Wollemi National Parks could be seen, with previously recorded sites consisting predominantly of large numbers of grinding grooves in the upper reaches of the creek lines, where sandstone platforms in the creeks were suitable for grinding, with low numbers of other site types, including artefact scatters, isolated finds and scarred trees. The grinding grooves that were recorded were largely recorded by one person, whose activities targeted locating and recording grinding groove sites.

During the Umwelt (2010) survey 62 additional sites were recorded including 20 grinding groove sites, one site that had grinding grooves associated with a rockshelter and isolated artefact, one rockshelter with artefacts and deposit, 36 artefact scatters/isolated finds, three scarred trees and two stone arrangements.

After the systematic survey, that assessed all landforms, including ridges, spur crests, slopes and valleys, the number of recorded artefact sites within the Sugarloaf Range itself increased greatly. The artefacts in the Sugarloaf Range were all recorded on four wheel drive access tracks and motorbike trails on low gradient ridge and spur crests. A pattern of recurring artefact location on crests/benches between the upper tributary water courses rather than beside the water courses was noted. This was suggested to have three potential reasons: the steep gradient of the landforms associated with the watercourses making them unsuitable for camping, the gentle gradient of the spur crests were more suitable for camping and there was poor visibility next to the watercourses.

While this survey area is located a great distance from the Project Area (65 kilometres) the results demonstrate that the paucity of artefact scatters and isolated artefacts in country dominated by sandstone may demonstrate the nature of the survey focus, rather than a lack of artefactual material being present.

5.2.2 Summary

Within the broader region previous archaeological surveys have focussed on the ridges and areas of exposed sandstone. Previous investigations demonstrate that grinding grooves or engravings dominated the sites immediately surrounding the project area. While there are very few artefact sites recorded in the area, studies in comparable landscapes show that artefacts are likely to be present in low densities on ridgelines and travelways.

6.0 Predictive Model

Based on the environmental context of the Project Area it is considered that Aboriginal people may have utilised the area periodically for the purposes of hunting and gathering whilst moving through the landscape. Thus, artefact scatters and isolated finds are the most likely site type to occur in this area and are most likely to be located on the spur crests or in association with the watercourses. Grinding groove sites if they occurred in the vicinity would most likely have been associated with the creek lines, however, grinding grooves are unlikely to have survived due to the highly weathered nature of the sandstone bedrock. Engraving sites can be predicted in any landform where suitable sandstone platforms outcrop. However, like grinding grooves, this type of site is unlikely to have survived (if it ever existed within the Project Area) due to the advanced state of weathering of the sandstone bedrock. Scarred trees may occur if mature trees exist within the Project Area. Other site types such as rockshelters will not be present due to the lack of suitable geology (i.e. cliff lines).

The following predictive model has been formulated based on the information presented in **Sections 4.0** and **5.0** in an endeavour to indicate likely site types, site distribution and integrity for the Project Area. It is assessed that:

- based on the results of previous inspections in the region and the lack of permanent water, there is a very low likelihood that archaeological material/sites reflecting intensive use by Aboriginal people will be located in the Project Area
- if sites are located within the Project Area they are likely to be small artefact scatters and isolated finds resulting from transient use of the area by Aboriginal people
- if small artefact scatter sites and isolated finds are present they are most likely to be identified in areas with high levels of exposure in proximity to creek banks or in areas of prior disturbance
- if artefacts are located they are likely to have been manufactured from quartz, fine grained siliceous materials, quartzite or basalt. Flakes, broken flakes and flaked pieces are the most likely artefact types
- the nature of the sandy soil within the Project Area and surrounds mean that sites containing stone artefacts are likely to have been affected by ongoing taphonomic processes which may have acted to destroy sites through erosion or to bury the artefacts through soil aggradation at the base of slopes or through bioturbation
- the topography of Project Area and its distance from reliable water indicate it is more likely to have been used as a resource gathering area, or travel way to nearby resource gathering areas rather than for camping, with resource gathering and transit activities generally not associated with large amounts of artefact discard and making occupation/use difficult to discern
- grooves resulting from axe, hatchet and adze grinding and resharpening may occur in the Project Area on exposures of sandstone where they are associated with creek lines. Engravings may occur in the project area on sandstone exposures. However the likely occurrence/preservation of these sites is also influenced by the advanced state of weathering of the sandstone bedrock.

7.0 Survey Methodology

7.1 Proposed Survey Strategy

The Project Area is located in the south western portion of the Haerses Road quarry site. As shown on **Figure 7.1**, the survey area was predominantly composed of low gradient spur crests and moderate gradient spur slopes drained by upper order tributaries. Sandstone bedrock in this area is reported to be highly weathered and in a state of decomposition.

Based on the predictive model and on the limited size of the proposed impact area, the survey strategy covered 100% of the spur crests and creek lines and an adequate sample of the spur slopes. A small track was observed identified during the survey and was followed within the Project Area across multiple landforms. It was assessed as the most likely area to have exposures that may have visible artefacts. All sandstone outcrops encountered were inspected for grinding grooves and engravings and any remnant mature trees observed were inspected for scars/carving. The survey transects are mapped in **Figure 7.1** however it is noted that these transects represent the direct line inspected by one archaeologist, forming the centreline of the survey with Aboriginal party participants also walking parallel to the archaeologist, such that survey transects were 50-100m in width, as will be discussed in **Section 8.**

The survey methodology complies with the survey requirements of OEH's *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales*. During the survey all participants had the opportunity to discuss any potential impacts of the project on Aboriginal cultural heritage sites and values. Information recorded during the survey included:

- the nature of the landforms and vegetation;
- the levels of visibility and exposure within the extraction area
- the effects of erosion and disturbance
- the availability of Aboriginal resources, with a particular focus on the types of resource plants (bush tucker) that may be present in the extraction area
- detailed records of archaeological sites present
- the likelihood that potential archaeological deposits may be present within the extraction area
- information provided by Aboriginal parties regarding the cultural significance/or cultural values of the area.

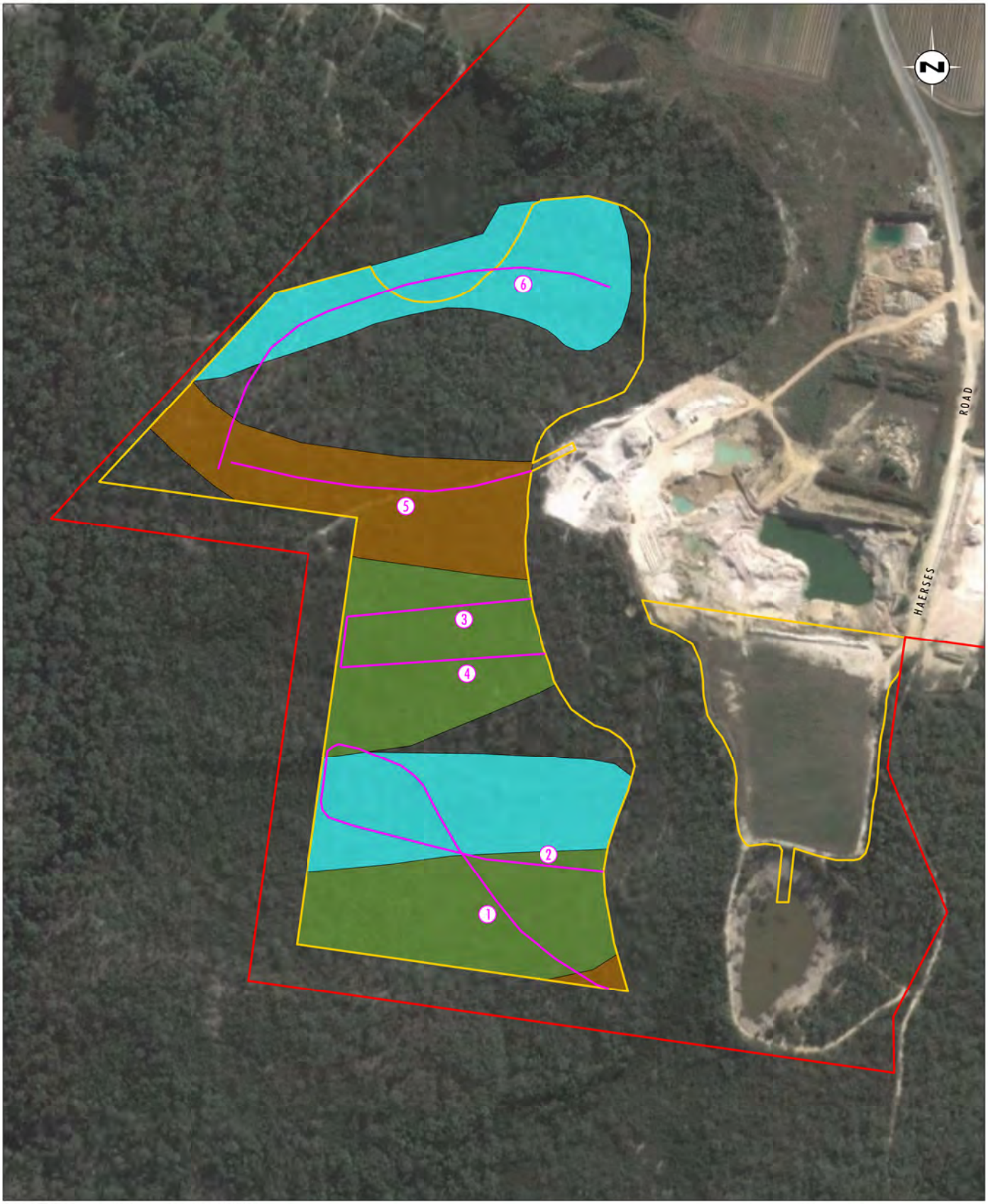


Image Source: Google Earth (2016)
Data Source: Mc Kinlay Morgan & Associates Pty Ltd (2014)

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Legend

- Haerses Road Quarry Project Site
- Modification Disturbance Area
- Slope
- Spur Crest
- Creek Line
- Transect

FIGURE 7.1

Survey Transects

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8.0 Survey Results

The survey of the extraction area was undertaken on 8 December 2015 by a field team of two Umwelt archaeologists and four Aboriginal party representatives with organisations/individuals involved listed in **Table 8.1**).

8.1 Survey Team

Table 8.1 Field Survey Team

Organisation	Representative
Darug Land Observations	James Eastwood
Deerubbin Local Aboriginal Land Council	Stephen Randall
Kawul Culture Services	Arika Jalomaki
Tocomwall	Jakub Czastka
Umwelt	Amanda Reynolds Kirwan Williams

Darug Aboriginal Cultural Heritage Assessments (DACHA) registered for the project after the survey had taken place. Their registration was accepted and a summary of the survey and results was provided to them.

8.2 Survey Coverage

A total of eight survey transects were conducted across the extraction area as illustrated on **Figure 7.1**. **Table 8.2** provides the survey coverage and effective coverage for each of the transects undertaken.

Table 8.2 Effective Coverage

Transect	Landform	Survey Unit Area (m^2) approx	Visibility %	Exposure %	Effective Coverage
1	Slope	20000m^2 (200 x 100m)	0	1	200m^2 1%
2	Creek Line	25000m^2 (250 x 100m)	0	0	0
3 + 4	Slope	20000m^2 (200 x 100m)	0	0	0

Transect	Landform	Survey Unit Area (m^2) approx	Visibility %	Exposure %	Effective Coverage
5	Spur Crest	35000m^2 (350 x 100m)	0	2	700m^2 2%
6	Creek Line	10000m^2 (200 x 50m)	0	0	0

As shown in **Table 8.2**, there was no visibility within the extraction area, due to heavy vegetation cover.

8.3 Results

No Aboriginal artefacts were identified during the survey of the extraction area. Outcrops of sandstone were observed on the slopes within the extraction area and were inspected for grinding grooves, engravings and other evidence of Aboriginal people using the landscape. The sandstone was highly weathered and no remains of Aboriginal use were identified.

The soil was observed to be sandy and skeletal. No areas of PAD were identified during the survey. The extraction area is considered to have low archaeological potential based on a number of factors including: the landforms are not suitable for camping, soils are skeletal and unlikely to retain deposit; and water sources in the immediate vicinity of the extraction area are ephemeral at best and would not support prolonged occupation. On this basis it is assessed that while Aboriginal people may have used the extraction area and the Project Area more broadly in a transitional fashion, this is unlikely to have resulted in the formation of archaeological deposits.

8.4 Input from Registered Aboriginal Parties

The registered Aboriginal parties present on-site during the survey indicated that they were happy with the level of survey coverage undertaken. No comments were made about expectations of grinding grooves or engravings.

The registered Aboriginal parties agreed with an on-site discussion suggesting that the slopes of most of the survey area would have limited its use as a camping area.

After the survey DLALC provided a letter summarising their involvement in the survey, noting that there was poor visibility and that no artefacts, engravings or grinding grooves were observed. DLALC raised no objections to the quarry extension.

8.5 Assessment of the Predictive Model

No Aboriginal archaeological sites were located in the survey area and there was no evidence of intensive use of the survey area. Based on the environmental context and ethno-history of the survey area, it was expected that artefact scatters and isolated artefacts would be the most likely artefact types, located on spur crests or associated with watercourses. The watercourses were heavily vegetated and had no water flowing.

The survey area is heavily vegetated and is likely to have been a resource area. While resources may not have been abundant, it is likely that Aboriginal people passing through the area could have obtained basic

resources as they passed. The banks of Stone Chimney Arm, 20 metres west of the extraction area are likely to have been a richer resource area. No significant Aboriginal resource plants were observed in the survey area, however previous European land use may have resulted in the removal of resource plants used by Aboriginal people.

The likelihood of identifying archaeological material was assessed as low. No archaeological evidence was identified, supporting the predictive model.

9.0 Significance Assessment

The Burra Charter defines cultural significance in terms of aesthetic, scientific, historic and social values. Aboriginal cultural heritage is typically assessed according to its social and scientific significance; however other values may also be of importance. The assessment of cultural significance is critical in establishing mitigation and management strategies for cultural heritage (refer to Pearson and Sullivan, 1995:21).

The assessment of significance provides a guideline for determining appropriate mitigation and management strategies. The relationship between levels of significance and management strategies can be summarised as follows:

- High significance – the site should be conserved and protected from the impacts of development, where possible.
- Moderate significance – the site should be protected if possible, however, if impacts to the site are unavoidable, appropriate mitigation strategies should be implemented prior to impact.
- Low significance – the site should be protected if possible, however, if impacts to the site are unavoidable, the presence of the site should not impede the proposed development.

9.1 Aboriginal Cultural Significance of the Landscape

As Aboriginal cultural significance relates to the values of a site, place or landscape to Aboriginal people, it must be determined by Aboriginal people. The registered Aboriginal parties participating in the project therefore have the right and obligation for assessing the significance of their cultural heritage. In assessing this significance a range of factors may be considered and this can extend beyond the physical presence of a site and its contents. Archaeological material, cultural knowledge, natural resources and landscape may all be considered.

Aboriginal parties on site during the survey noted that the area was rich with Aboriginal resources and the poor visibility limited the observation of any surface artefacts.

Any additional comments on the cultural significance of the survey area received from the Aboriginal parties will be summarised below and included in full in ***Appendix A****.*

9.2 Archaeological Significance

The criteria applied to the assessment of archaeological significance are listed in **Table 9.1**. As no Aboriginal sites were identified in the survey area, the assessment of archaeological significance is applied to the landscape within the survey area in **Table 9.2**.

Table 9.1 Criteria for Assessment of Archaeological Significance of the Landform

Criterion	Low	Moderate	High
Rarity	The landform within the surrounding landscape, its integrity, contents and/or potential for sub-surface artefacts, are common within the local and regional context.	The landform within the surrounding landscape, its integrity, contents and/or potential for sub-surface artefacts, are common within the regional context but not the local context.	The landform within the surrounding landscape, its integrity, contents and/or potential for sub-surface artefacts, are rare within the local and regional context.
Representativeness	This landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts, is common within a local and regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts, is uncommon within a local context but common in a regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts, is uncommon within a local and regional context and sites of similar nature (or in better condition) are not already set aside for conservation within the locality or region.
Research potential	The landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts has limited potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts has moderate potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The landform, when viewed in relation to its integrity, contents and/or potential for sub-surface artefacts has high potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.

Criterion	Low	Moderate	High
Education potential	The landform is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape has limited suitability to be used for educational purposes. Other sites with higher education potential are known to be present in the local area and region.	The landform is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape provides a tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. However, other sites with higher education potential are known or expected to be present in the local area or region.	The landform is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape, provides a very good tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. Other sites of higher education potential are generally not known to exist in the local area or region.
Integrity	Stratigraphic integrity of the landform has clearly been destroyed due to major disturbance/loss of topsoil. The level of disturbance is likely to have removed all spatial and chronological information.	The landform appears to have been subject to moderate levels of disturbance, however, there is a moderate possibility that useful spatial information can still be obtained from sub-surface investigation of the site, even if it is unlikely that any useful chronological evidence survives.	The landform appears relatively undisturbed and there is a high possibility that useful spatial information can still be obtained from sub-surface investigation of the site, even if it is still unlikely that any useful chronological evidence survives.

Table 9.2 Assessment of Archaeological Significance

Landform within the survey area	Rarity Value	Representative Value	Research Potential	Educational Potential	Integrity	Overall Archaeological Significance
Creek Line	Low	Low	Low	Low	Low	Low
Spur Crest	Low	Low	Low	Low	Low	Low
Slope	Low	Low	Low	Low	Low	Low

10.0 Management Recommendations

It is recognised that recommendations provided from an Aboriginal cultural perspective may differ to those based on an archaeological perspective. Scope is therefore provided for the inclusion of both sets of recommendations.

10.1 Aboriginal Party Recommendations

The recommendations presented below were discussed and the registered Aboriginal party representatives participating in the survey of the Project Area indicated that the recommendations were suitable provided that there was clarity about the nature and extent of works and that consideration was given to any future works.

The request from DLO to monitor top soil removal and all other works on site is not considered archaeologically necessary (refer to **Section 8.5**). This recommendation was not noted by the other registered Aboriginal parties and is therefore not proposed by Dixon Sand.

10.2 Archaeological Recommendations

The following recommendations have been developed from information detailed in this assessment and current cultural heritage legislation.

- Dixon Sand should ensure that its employees and contractors are aware that it is an offence under Section 86 of the *National Parks and wildlife Act 1974* (NPW Act) to harm or desecrate an Aboriginal object unless that harm or desecration is the subject of an Aboriginal Heritage Impact Permit (AHIP) or other approval.

- The Project Area does not contain any identified Aboriginal archaeological sites and therefore there is currently no requirement to obtain specific approvals relating to Aboriginal cultural heritage. However, in the unlikely event that previously unrecorded artefactual material is exposed during ground disturbance works within the extraction area, work must cease in the vicinity of the artefactual material and the registered Aboriginal parties contacted and the artefactual material managed in accordance with a methodology to be prepared in consultation with the RAPs and OEH, if required;

- In the event that suspected human skeletal material is identified within the Project Area, all works in the immediate vicinity of the suspected human skeletal material will cease and the skeletal material will be inspected to determine if it is human (including assessment by a forensic specialist if required). If the skeletal material is human, the NSW Police and OEH will be contacted. No excavation will proceed until an appropriate course of action has been determined in consultation with NSW Police, OEH and the Aboriginal parties.

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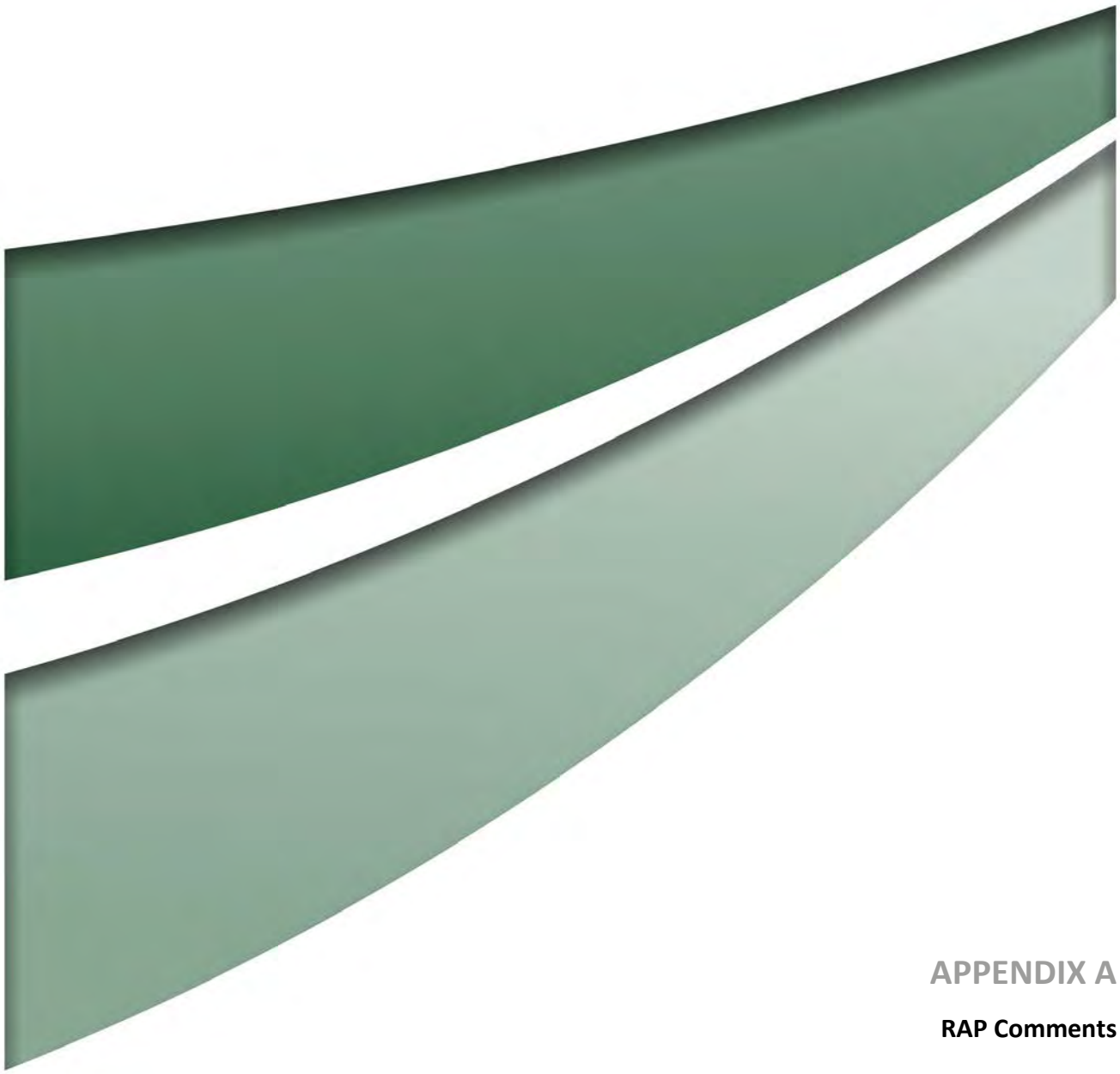
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APPENDIX A

RAP Comments

DARUG LAND
OBSERVATIONS PTY LTD
ABN 27 602 765 453

EMAIL: DARUGLANDOBSERVATIONS@GMAIL.COM
PO BOX 571 PLUMPTON NSW 2761
MOBILE: 0420 591 138 / 0413 687 279

9th May 2016

Alison Lamond
Umwelt (Australia) Pty Limited
75 York Street
Teralba NSW 2284

Dear Alison,

RE: Haerses Road Quarry, Haerses Road, Maroota

Aboriginal Cultural Heritage and Archaeological Assessment Report

Darug Land Observations Pty Ltd has reviewed the draft Aboriginal Cultural Heritage and Archaeological Assessment Report, and supports the draft methodology for the operation of a sand quarry on Haerses Road, Maroota.

In relation to the long-term storage of recovered artefacts, if any, Darug Land Observations Pty Ltd strongly believes that recovered artefacts should be re-buried on Country (the study area).

Darug Land Observations Pty Ltd would like to receive a copy of the Section 90 Aboriginal Heritage Impact Permit (AHIP).

Furthermore, Darug Land Observations Pty Ltd would be involved in the monitoring of the topsoil removal and all other form of works to be carried out on the site.

Yours sincerely,

Jamie Workman
Darug Land Observations Pty Ltd

Uncle Gordon Workman
Darug Elder

From:	Jakub Czastka
To:	Alison Lamond
Cc:	Danny Franks
Subject:	Re: Hearses Road Quarry
Date:	Tuesday, 31 May 2016 1:41:19 PM
Attachments:	8AC97A74-9858-49E4-8975-60A5C1A16263[9].png Supply nation logo[9].png

Alison,

I spoke with Danny this afternoon and he had no comments to make in relation to your ACHAR.

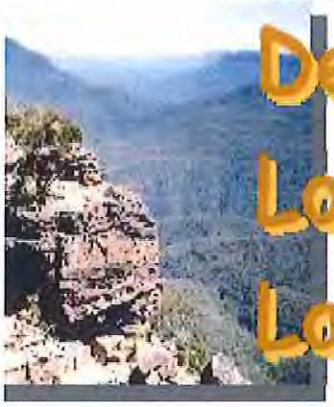
Regards,

Jakub Czastka (Chaz)
Senior Archaeologist

Tocomwall Pty Ltd
Suite 12, 103 George Street
PARRAMATTA NSW 2150
m: 0418 738 521
p: 02 8843 1326
f: 02 9524 4146
e: Jakub@tocomwall.com.au



www.tocomwall.com.au
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Deerubbin Local Aboriginal Land Council

Level 1, Suite 3
291-295 High Street
PENRITH NSW 2750

PO Box 40
Penrith BC
NSW 2751 AUSTRALIA

ABN:41 303 129 586
T: (02) 4724 5600
F: (02) 4722 9713
E: Reception@deerubbin.org.au
W: http://www.deerubbin.org.au

Dixon Sands (Penrith) Pty Ltd

P O Box 148

PENRITH NSW 2751

Our Ref: 2607

11 January 2016

PROTECTION OF ABORIGINAL CULTURAL HERITAGE

Proposed Quarry Additional Extraction Area

Haerses Road, Maroota

Attention: Mark Dixon,

A Deerubbin Local Aboriginal Land Council representative inspected the abovementioned location on Tuesday, 8 December 2015. An Aboriginal cultural heritage assessment was undertaken to evaluate the likely impact the proposed development has on the cultural heritage of the land.

Much of the proposed sand extraction area has little visibility, no Aboriginal cultural material (in the form of stone artefacts, for example) were found, nor any rock engravings, grinding grooves or habitational shelters.

Deerubbin Local Aboriginal Land Council therefore, has no objection for the proposed quarry extension of Haerses Road, Maroota on the grounds of Aboriginal cultural heritage

Yours Faithfully,

S Randall

Steven Randall

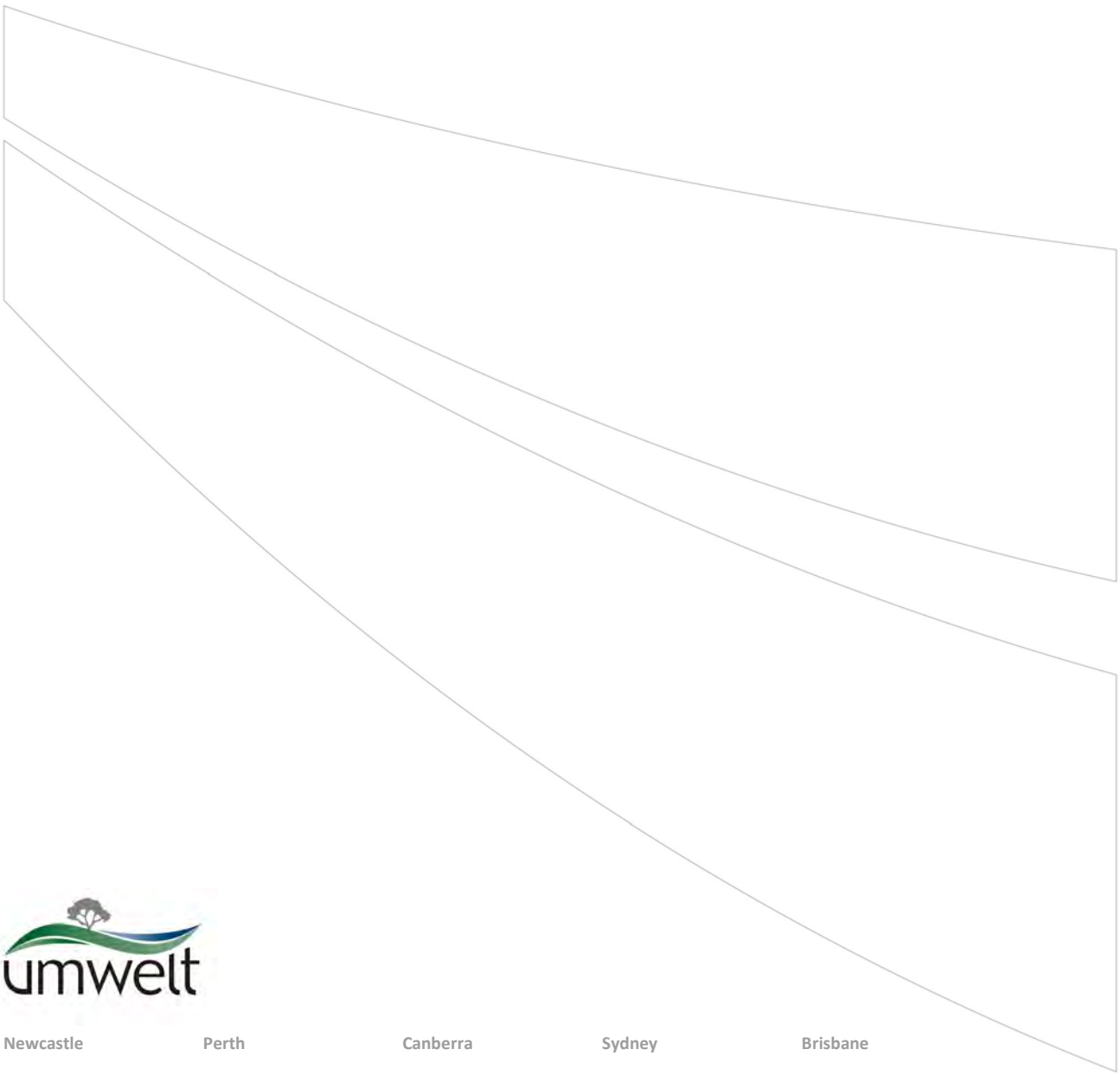
(Aboriginal Cultural Heritage Officer)

C.c. Miranda Firman – Office of Environment & Heritage

C.c. Amanda Reynolds – Umwelt (Australia) Pty Ltd



umwelt



umwelt

Newcastle	Perth	Canberra	Sydney	Brisbane
75 York Street Teralba NSW 2284	PO Box 8177 Subiaco East WA 6008 33 Ventnor Avenue West Perth WA 6005	PO Box 6135 56 Bluebell Street O'Connor ACT 2602	50 York Street Sydney NSW 2000	GPO Box 459 Brisbane QLD 4001
Ph. 02 4950 5322	Ph. 08 6260 0700	Ph. 02 6262 9484	Ph. 1300 793 267	Ph. 1300 793 267

www.umwelt.com.au