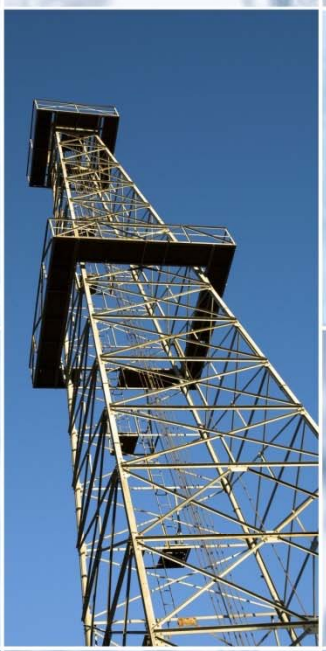
Appendix 16

Groundwater Impact Assessment Report

Hodgson Quarry Groundwater Assessment, Roberts Road, Maroota

Prepared for Nexus Environmental Planning Pty Ltd

AGT 1355-14-NAN
9/4/2015



Australian Groundwater Technologies

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Hodgson Quarry Groundwater Assessment

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Figures & Tables

1 Introduction

The Hodgson Quarry at Roberts Road, Maroota, extracts sand material from the Tertiary aged Maroota Sands Palaeochannel. The quarry has been in operation for approximately 15 years. The original application was approved by the then Minister for Planning pursuant to an Environmental Impact Statement (EIS) prepared by Nexus Environmental Planning Pty Ltd. The approved quarry depth was to 182 mAHD which is 2 m above the approved 'wet weather elevation' for the Maroota Tertiary Sands Groundwater Resource. This elevation was defined from water levels at groundwater monitoring bores and near-site dams that monitor the regional Maroota Sands Aquifer.

It is proposed to modify the existing consent. The modification does not intend to deepen the approved quarry depth (182 mAHD) but to modify the extraction methods and extend the quarry life to 2025. The location of the quarry is on Lot 1 and 2, DP228308, Maroota and is presented in Figure 1.

Since quarrying commenced, 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 Office of Water (NOW) requires evidence that the proposed modifications adhere to the above mentioned plans. For this reason Nexus Environmental Planning Pty Ltd (on behalf of the Hodgson Quarry) has commissioned Australian Groundwater Technologies (AGT) to undertake a groundwater assessment. The purpose of the assessment is to:

- Evaluate the approved depth (from the original EIS) in context of the proposed modification.
- Update the original groundwater assessment, including review of groundwater levels to confirm the extraction depth limit.
- 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 compliance against the WSP / AIP.

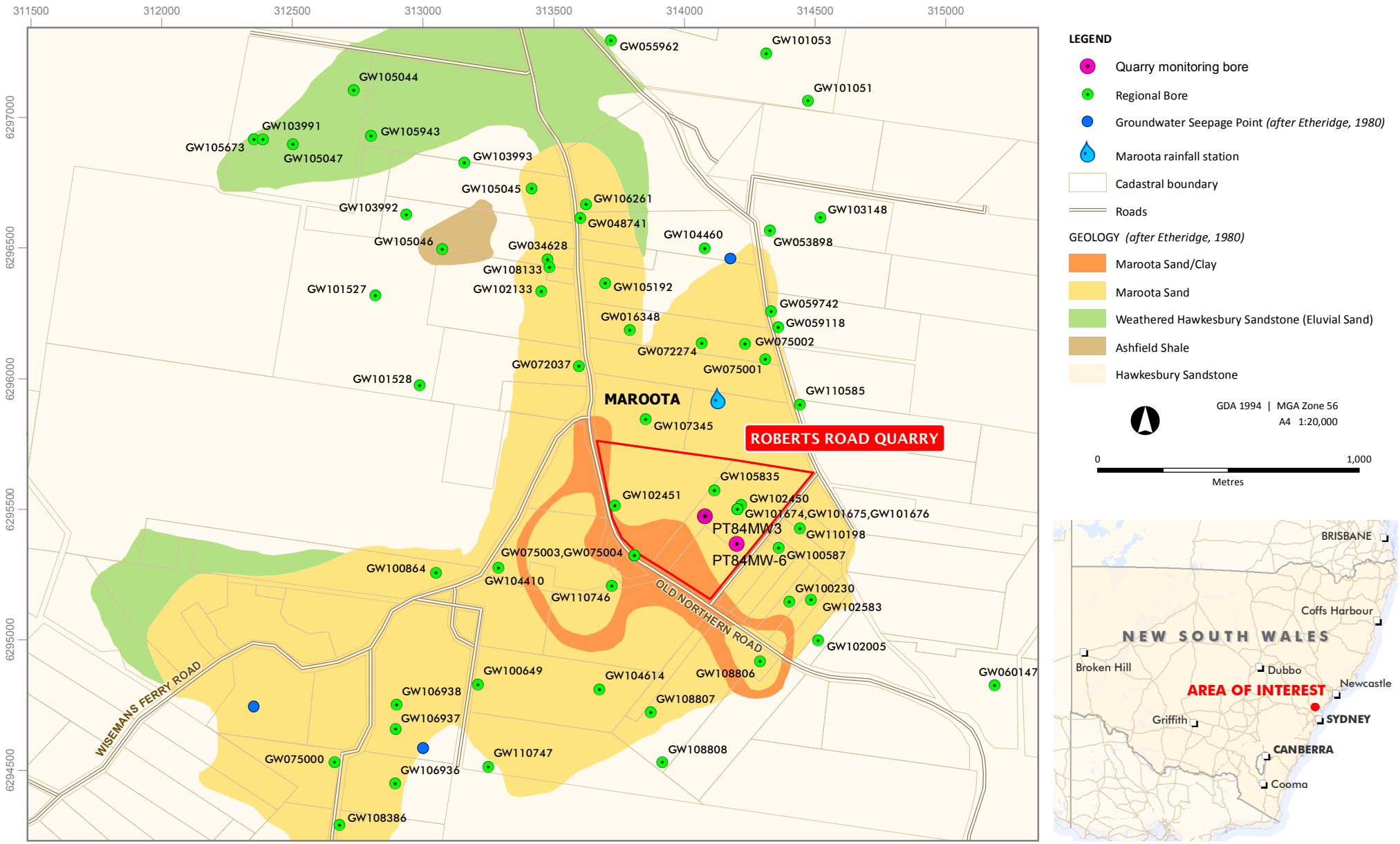

Figure 1 | Location Map and Geology, Hodgson's Quarry

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2 Proposed modifications

The consent for the Roberts Road Quarry was approved on 31st May 2000, for a period of 15 years. The original approval was based on an operations plan and resource estimate outlined in the original EIS (reference). Since the original consent, the operators have identified that some extraction methods are inefficient and the resource estimate was underestimated (Nexus, 2014). For these reasons modification to the existing consent is sought to capture the updated quarrying methods and to extend the quarry life to 2025.

Figure 2a illustrates the current depth of the quarry as of 2014. It can be seen from the figure that except for historical excavations (to 180 mAHD), the majority of the quarry depth is at relative levels (RL) above 182 mAHD. This was recently confirmed by an on-site investigation in October 2014 that recorded the deepest RL at 183.7 mAHD (Thomson, 2014).

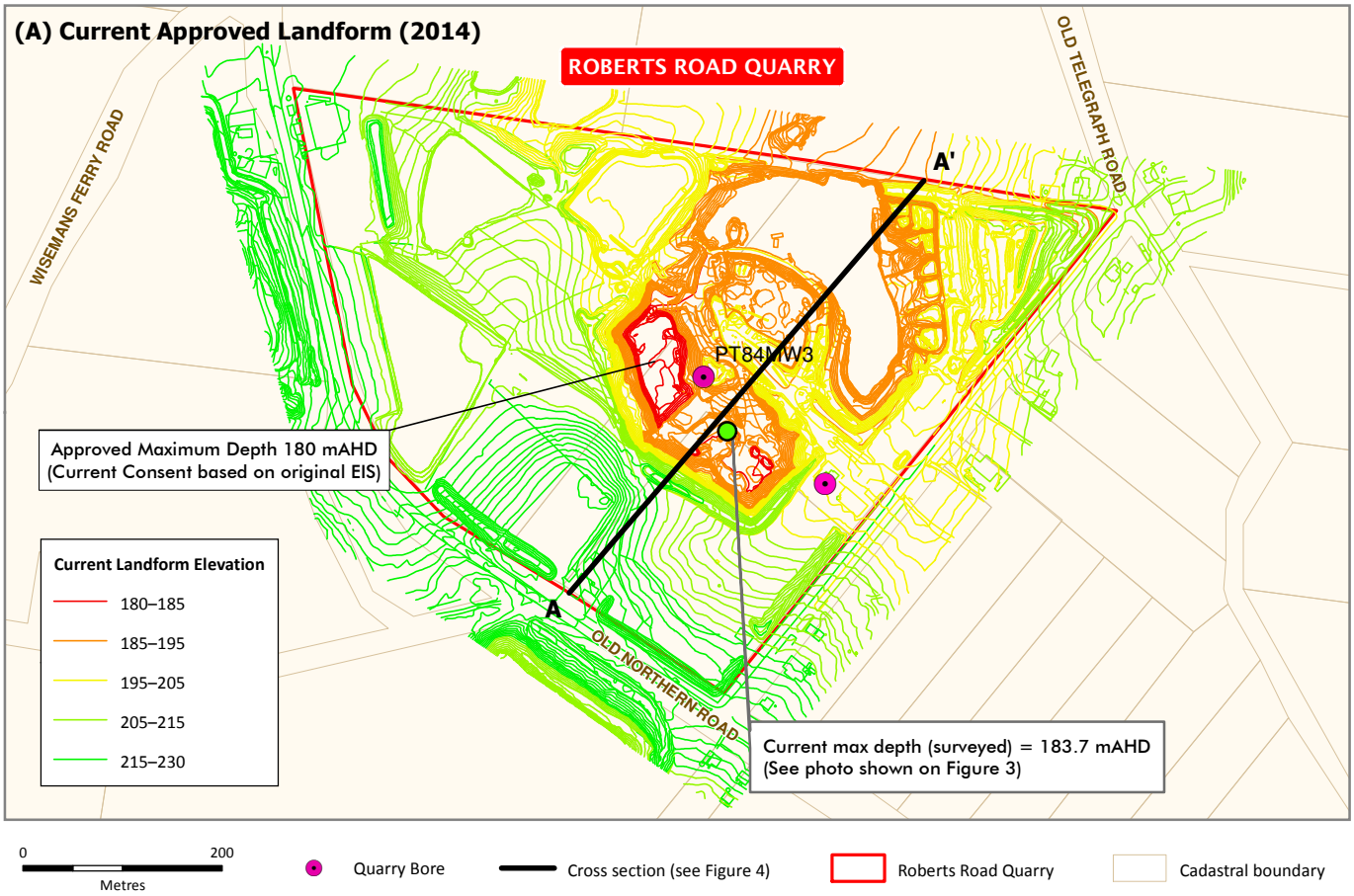
Figure 2b illustrates the final landform depth for the proposed modification (i.e. at year 2025). It can be seen from the figure that the final landform depth is 180 mAHD. Thus the proposed modifications will **not change** the final landform depth and remain within the conditions of the original consent. NOTE: Although the modification seeks approval to maintain extraction to the approved 180 mAHD, the recent inspection identified an unwanted clay band at a depth of 183.7 mAHD (Figure 3). The quarry owners have indicated that this is the lowest limit to be extracted.

2.1 Quarry Modifications

The following dot points summarise the proposed modifications to the current approval (Nexus, 2014). As seen most of the modifications are administrative in nature.

- The operators proposed to increase the duration of operations from 15 to 25 years. The proposed life of operations will extend to 31st May 2025 from the original expiry date of 31st May 2015.
- Condition 2 of the Consent will be updated to refer to the current Environmental Assessment (EA) in addition to the original EIS.
- Recent delineation drilling has updated the resource estimate from 2,144,000 m^3 to 4,607,822 m^3. This additional resources result from an underestimate of the bulk density of the rock, which has increased from 1.6 m^3/t to 2.0 m^3/t.
- It is proposed to construct the approved water supply dam in 3 stages, as opposed to the approved 2 stage construction. The dimensions of the dam will remain as per the original consent.
- The extraction method seeks to include the use of a dozer for ripping of hard sandstone layers. This differs from the original EIS that stipulates the use of an excavator only.

- The original EIS stipulates that sand won from excavation is fed directly to the mixing tank. The proposed modification proposes to include the use of a dump truck to cart the sand from the excavator to the mixing tank.



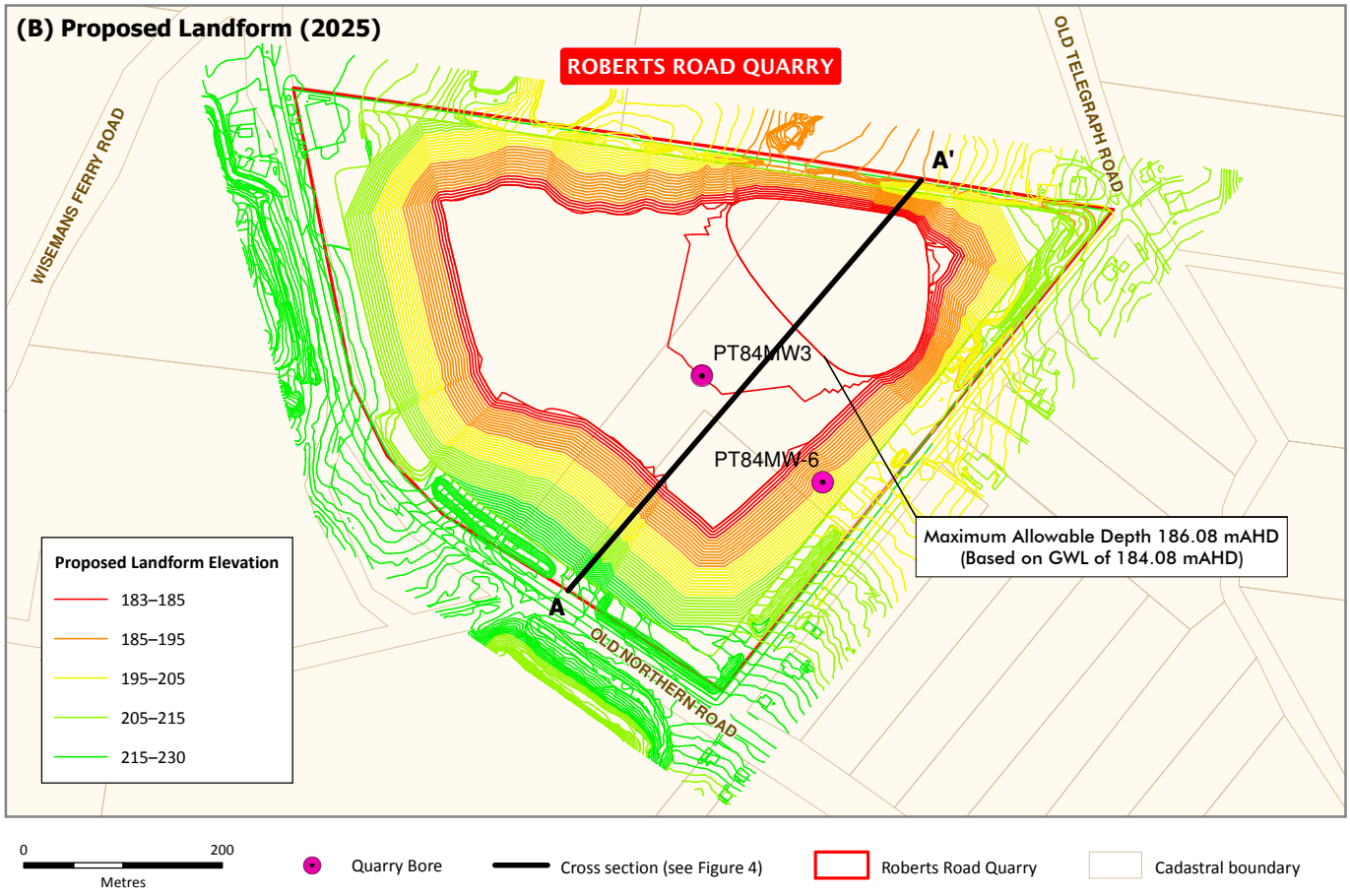


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Figure 2 | Current (2014) and Proposed (2025) Landform Contours

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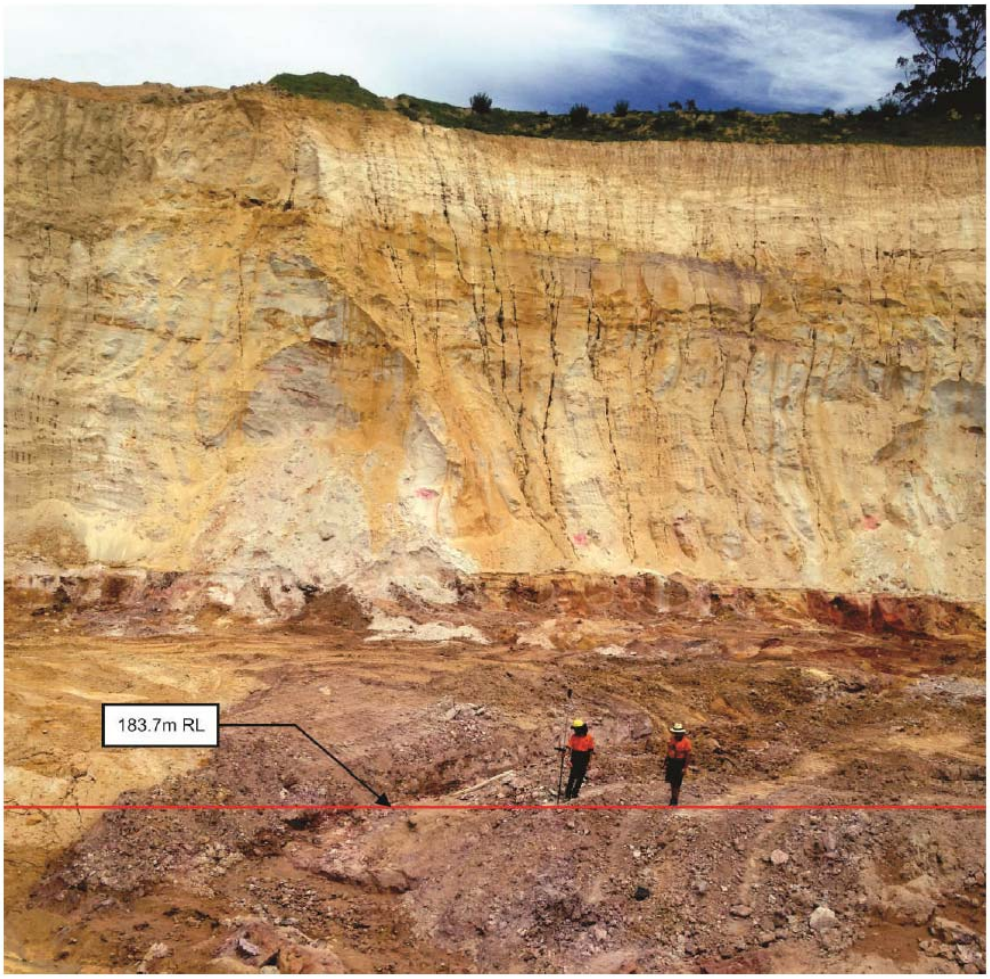

Figure 3. Quarry floor and clay base recorded at 183.7 mAHD (Thomson, 2014).

3 Project Background

The following information provides the geological and hydrogeological context for the proposed development modifications. Information is predominantly sourced from the groundwater investigation report by Woodward-Clyde (1999) which was undertaken as part of the EIS for the original application.

3.1 Geology

The Project is located in the Sydney Basin, a Permian to Triassic basin that extends from Batemans Bay in the south, to Port Stephens in the north. The Roberts Road quarry pits are south of Maroota and source material from the Maroota Sands Palaeochannel. The general stratigraphy of the area is presented in Table 1.

The local area was mapped by the Geological Survey of NSW (Etheridge, 1980) who identified outcropping rock sequences including the Hawkesbury Sandstone (Eluvial Sands) and Maroota Sands (Figure 1).

Table 1: Stratigraphic sequences at the project site (adapted from Woodward and Clyde (1999) after Etheridge (1980)).

Age	Unit	Lithology	Comment
Quaternary	Soils	Variable	
Tertiary	Unnamed	Basalt	-Not present at project site
	Maroota Sand	Sand, gravel, clayey sand and clay	-Reworked Hawkesbury Sandstone. -Palaeochannel sands including clay and ferricrete bands (ie cemented ironstone). -Outcrops at project site and is the target of quarry activities.
Triassic	Ashfield Shale	Shale and laminite	-Not present at project site
	Hawkesbury Sandstone	Quartzose sandstone with shale lenses	-Comprise weathered upper profile (Eluvial Sands) underlain by competent sandstone. -Eluvial Sands outcrops north and west of Project Site -Underlies project site but is not targeted for quarrying

3.2 Hydrogeology

The aquifers identified across the Maroota area incorporate the following hydrostratigraphic units:

- The Maroota Sands (MS) that constitutes the regional water table aquifer. Together with the upper part of the Hawkesbury Sandstone (Eluvial Sands) this unit forms the Maroota Tertiary Sands Groundwater Source (MTSGS).
- The Hawkesbury Sandstone, a regional fractured rock aquifer. The Hawkesbury Sandstone forms part of the Sydney Basin Central Groundwater Source (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 (Woodward and Clyde, 1999). At the project site, water well drilling has identified the MS to comprise thin layers of gravel, thick sequences of clay, and interbedded clays and sands (Woodward and Clyde, 1999; URS, 2013). These profiles are typical of palaeochannel sequences and represent the meandering nature of old river systems.

The Eluvial sands and Hawkesbury Sandstone underlie the project site and will not be targeted or intercepted during quarrying activities. As these units will not be intercepted they will not be discussed further in the context of this groundwater assessment.

3.3 Original EIS assessment

3.3.1 Potential Groundwater Impacts

In 1998, Woodward-Clyde conducted a groundwater impact assessment to support quarry extraction to 2 m above the 'wet weather' groundwater elevation. The study concluded that the average 'wet weather' groundwater elevation was 180 mAHD, allowing quarrying to a maximum depth of 182 mAHD (Woodward-Clyde, 1999). The assessment considered potential impacts including:

- reduced groundwater availability to users
- aquifer contamination
- reduced flow to streams
- increased turbidity to streams
- water table lowering.

The following summarise the outcomes from the assessment against the potential impact events. In addition, a provisional assessment has been conducted to highlight changes to the assessment for the proposed modification. This is discussed further in Section 7 and is assessed against principles in the AIP and WSP.

3.3.2 Reduced groundwater availability to users

Because the water table would not be intercepted, the original assessment concluded that there was low potential for a reduction in groundwater availability (ie quantity). In addition, the quarry was assessed as internally draining and with potential for pooling and recharge through the quarry excavations. This would have the effect of increasing, rather than decreasing groundwater levels.

Provisional Assessment
For the 2015 assessment the final landform is unchanged from the original depth of 182 mAHD. For this reason findings from the original assessment remain and a reduction in groundwater quantity and availability for existing users is not possible.

3.3.3 Aquifer Contamination

The original EIS identified the potential for aquifer contamination from fuel spillages principally from the operation of heavy machinery during quarry excavation. Woodward-Clyde (1999) assessed the risks from this activity as low provided adequate management strategies were in place ie appropriate fuel storages and implementation of a site management plan.

Provisional Assessment
There will be no change to fuel storage and management methods for the updated EA. For this reason findings from the original assessment remain valid, therefore risk profile is assessed as low.

3.3.4 Reduced flow to streams

The original assessment highlighted groundwater discharge points to streams where they intersect the Maroota Sands and Eluvial Sands of the Hawkesbury Sandstone. As illustrated in Figure 1, the groundwater discharge points are located near the perimeter of the Maroota Sands outcrop in lower parts of the landscape (Etheridge, 1980). These locations are between 1 and 2 km southwest, and 1 km north of the Hodgson's quarry, well away from the quarry footprint. The original EIS identified no credible risks to stream reduction from quarry activities as quarrying will not intercept the water table. As there is no groundwater extraction from on-site wells drawdown impacts to the MTSGS are not possible.

Provisional assessment
The 2015 quarry modifications are in line with the original assessment (i.e. maximum depth of 182 mAHD and internally draining site). The water table will not be intercepted nor lowered from groundwater pumping. For this reason impacts to the groundwater resource cannot occur and the risk profile is low.

3.3.5 Increased turbidity to streams

As the site is internally draining (Figure 2a, Figure 2b) there is no credible impact of enhanced turbidity to rivers or streams. Surface flow will remain almost entirely on site and turbid waters will be captured by the quarry pit footprint and on-site storage dams. This was highlighted in the original EIS and the situation has not changed for the current proposal.

3.3.6 Water table lowering

The original approval was for a landform depth to 182 mAHD, 2 m above the approved 'wet weather' groundwater elevation of 180 m AHD. Quarrying to this depth would not intercept the water table and lowering could not occur (Woodward-Clyde, 1999).

The current and future quarry depth will extend to a maximum depth of 182 mAHD consistent with the original consent. For this reason the assessment is unchanged and is deemed a low risk. Furthermore Woodward-Clyde (1999) highlighted that quarrying will enhanced recharge and increase groundwater levels due to clearing of vegetation and internal drainage towards the pit.

3.4 Wet weather groundwater elevation

In 1998 on-site monitoring bores were installed to characterise groundwater occurrence and levels within the MTSGS (Woodward-Clyde, 1999). Groundwater monitoring commenced in January 1999 using automated logging equipment and time series data was collected for 5 months. At the time, on-site monitoring data coupled with nearby 3rd party wells were reviewed to determine the *maximum wet weather groundwater elevation* as benchmarks for the permissible quarry depth. The following conclusions were drawn by Woodward-Clyde (1999):

- On site monitoring well PT84MW3 recorded a maximum groundwater elevation of 183.59 mAHD. Monitoring bore PT84MW3 was completed into the Maroota Sands, however subsequent investigation identifies this well as completed above an impermeable clay layer and not representative of the regional groundwater elevation.
- Private bore PF167MW1 (approx. 750 m south-west of the quarry boundary) recorded a groundwater elevation of 178.8 mAHD. This well was completed in the deeper MS and considered representative of the regional water table elevation.
- NSW Office of Water (NOW) Bores 75002/1 and 75002/2 (approx. 300 m northeast of the quarry boundary) recorded groundwater elevations of 180.59 and 178.58 mAHD. These wells were also completed in the deeper Maroota Sand and considered representative of the regional water table elevation.
- NOW bore 75000/1 (approx. 1300 m south-west of quarry boundary) recorded a groundwater elevation of 180.19 mAHD. This well was also completed in the deeper MS.
- Nearby dams excavated into the deeper parts of the Maroota Sand recorded water elevations between 177.0 and 180.29 mAHD.
- Based on the above, the wet weather groundwater elevation was proposed at 180 mAHD, with the maximum permissible quarry depth at 182 mAHD. This depth was accepted by the Department of Land and Water Conservation (DLWC) and incorporated into the original consent dated 31 May 2000.

Details of wells used to support the original quarry depth are presented in Table 2. Well locations are presented in Figure 1.

Table 2: Well and dam details used to determine the original "maximum wet weather groundwater elevation." Data sourced from Woodward-Clyde (1999).

Location	Well Name	Bore number	Aquifer monitored	Easting[1]	Northing[1]	Surface Elevation (mAHD)	Top of casing elevation (mAHD)	Total Depth (m BGL)	Total Depth (mAHD)	Screened interval (m AHD)	Maximum RSWL (mAHD)	Maximum RSWL date	Salinity (mg/L TDS)
Quarry Site	PT84MW-3		MS	314078	6295474	202.43	203.25	21.90	180.53	181.63 – 187.63	183.59	28/10/1998	266
Adjacent Landholdings. See Figure 1 for detail.		75000/1	MS (deeper)	314306	6296072	194.59	195.49	21.5	173.09		180.19	NA	79
		75002/1*	MS (deeper)	314227	6296134	187.59		12	177.59		180.59	NA^	207
		75002/2*	MS (deeper)	314227	6296134	187.78		23.0	164.78		178.58	NA^	54
		PF167MW1	MS (deeper)			187.64		22	165.64		178.64		
	Dam	Portion 167 SSW of site	MS (deeper)								179.5 min 177.0 max 181.3	NA^	
	Dam	Portion 84 Lot 2, DP228308	MS (deeper)								180.29	NA^	

*NOW observation wells. [1]Geodetic Datum of Australia 1994 Zone 56; mAHD – metres Australian Height Datum; m BGL – metres below ground level; RSWL – Reduced Standing Water level; TDS – total dissolved solids; ^not declared in EIS submission.

4 Quarry modification: proposed wet weather groundwater elevation

The proposed quarry modification presents an opportunity to review the maximum wet weather elevation for the MTSGS. As discussed in Section 3 the modification will not result in a deeper extraction limit from the original approval. The intent of this Section is to confirm that the original wet weather groundwater elevation approved in 2000 is appropriate for the remainder of quarry life (i.e. for quarrying until 2025).

Groundwater monitoring has been conducted from ~1999. This chapter provides a summary of water level and quality data collected since that time. Data presented incorporates information from on-site and other 3rd party wells owned by NOW and local landholders.

4.1 Current Monitoring Infrastructure

Quarry bores that target the deeper Maroota Sands are presented in Figure 4. The following general comments can be made with regard to these bores:

- PT84MW-6 (a replacement bore for PT84MW-3) was drilled in January 2015. The bore has been drilled to a total depth of 273.46 mAHD. Completion information is presented in Table 3.

4.1.1 Supporting Regional Bores

Groundwater monitoring information was collated from 3rd party bores located off site in the surrounding Maroota Area:

- Water level time series data was obtained from bore PF167MW-1 (GW100649) located on the quarry to the south-west (quarry owned by PF Formation, Figure 1).
- Standing water level was obtained from NOW bore GW75000/1. Readings from this well allow comparison with the original recordings taken prior to the original approval (Table 2).

Reduced standing water level (RSWL mAHD) from these bores are presented in Figure 5.

4.1.2 Quarry floor observations

On 28th October 2014 an in-pit investigation was conducted to determine whether groundwater inflows could be identified within the current pit footprint (Thomson, 2014). The investigation included in-pit surveys and observations from quarry faces. Rainfall for the month of October was recorded at 47.6 mm at the Old Telegraph Rainfall Station, Maroota (BoM station no 67014). The following observations were recorded during the investigation (Thomson, 2014):

- In-pit elevations were recorded between 215 and 183.7 mAHD.

- Inspection across the pit faces and quarry floor did not identify pit seepages or pooled water.
- An unwanted clay band was recorded at 183.7 m.

The following conclusions were drawn from the investigation:

- No groundwater inflow was occurring at the current extraction depth of 183.7 m.
- The unwanted clay band at 183.7 m is of low permeability and is classed as an aquitard. Based on data from observation well PT84MW-6 the regional MTSGS is located below this depth.

Figure 4: Monitoring wells, Hodgons Quarry.

Table 3. Completion information for bore PT84MW6.

Bore Name	License number	Aquifer monitored	Easting	Northing	Surface Elevation	Total Depth (m BGL)	Total Depth (mAHD)	Screen Interval (m	Screened interval (m	Collar Height	SWL (m bTOC)	RSWL (mAHD)
PT84MW-6	10BL605696	MS (deeper)	314200	6295366	202.46	29	173.46	24-29	173.46-177.46	203.13	20.03	183.10

4.2 Baseline Monitoring Data

4.2.1 Groundwater levels

Hydrographs of reduced standing water level (RSWL) and cumulative deviation from mean monthly rainfall are presented in Figure 5. The hydrographs incorporate RSWL readings from the commencement of quarrying representing approximately 14 years of data.

The following general comments can be made with regard to Figure 5:

- Recently installed PT84MW-6 recorded a RSWL of 183.10 mAHD on 3/03/2015. This well represents the most accurate recording for the MTSGR at the location in question and corresponds with a period of above average rainfall (Figure 5). Water level in the well remains below the current quarry depth (183.7 m) and is likely confined by the “unwanted clay band” (Section 4.1.2).
- Private monitoring well PF167MW-1 (GW100649) recorded RSWL between 179.50 and 182.50 mAHD. Groundwater levels fell during the period February 2002 and September 2004 coinciding with below average rainfall. The most recent water level was recorded at 180.10 mAHD on 13/4/2005.
- Recent groundwater monitoring at 75000/1 (22/9/2014), located 1.3 km to the SW recorded a water level of 181.09 mAHD. This level is marginally higher than that recorded during the original EIS (180.19 mAHD) recorded in January 1998. There is no time series data between the two readings but the data confirms that water levels have not significant deviated over a 15 years period.

The locations of the above monitoring bores are shown on Figure 1

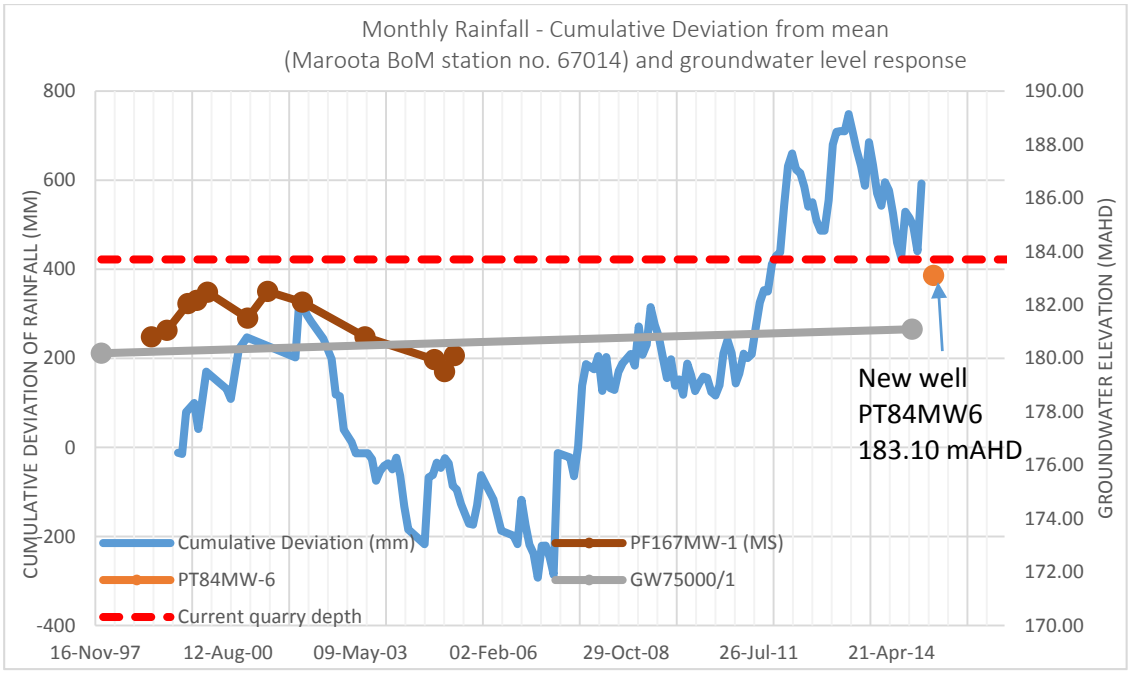

Figure 5: Groundwater hydrographs and cumulative deviation from the mean of monthly rainfall.

4.3 Proposed wet weather groundwater elevation

Based on well data (Figure 5), local and regional bores correlate with the water levels recorded from the EIS assessment (Woodward-Clyde, 1999). Monitoring from 1999 record water levels in the regional MTSGS between 178.64.5 and 184.23 mAHD.

A cross section showing the current landform and the proposed landform is presented as Figure 6. The wet weather elevation adopted by the original EIS assessment (existing consent) together with the revised wet weather elevation 2015 (this modification) are also shown on Figure 6 for comparison.

For the purpose of this assessment, PT84MW-6 is the most representative well and a maximum wet weather groundwater elevation is considered to be 183.10 mAHD. This would restrict the quarry pit depth to 185.10 mAHD. It should be noted however that the clay band identified at 183.7 mAHD locally confines the regional MTSGR, and quarrying to the preferred depth of 183.7 mAHD will not intersect groundwater.

In a recent submission to the Department of Planning and Environment (reference DA2671199 Mod 3), the NSW Office of Water stated that the highest water level measured beneath the site was 184.08 mAHD. We understand that this elevation was based on groundwater levels obtained from a historic bore known as PT84MW3, which no longer exists. Groundwater levels obtained from this bore were included in the original EIS (Woodward-Clyde, 1999) yet at this time, the approval to extract to 182 mAHD was based on a lower wet weather elevation of 180 mAHD recorded in other nearby bores.

The reason for neglecting the slightly higher groundwater elevation in PT84MW3 in the original EIS (and the original consent) was not clear, but as discussed under Section 3.4 above, a subsequent investigation indicated that the groundwater levels in PT84MW3 may be perched due to underlying clay layer and therefore water levels measured in PT84MW3 may not be representative of the MTSGR. It can be seen on Figure 6 that the bottom of PT84MW3 is completed above the bore screen of PT84MW6.

Given the uncertainty around PT84MW3, the groundwater level of 183.1 mAHD measured in monitoring bore PT84MW6 is considered to be the most reliable indication of groundwater elevation beneath the site and ongoing monitoring should be undertaken to confirm this. However, the groundwater level elevation of 184.08 mAHD and the extraction depth of 186.08 mAHD recommended by the NSW Office of Water should be adopted by Hodgson Quarry, and ongoing monitoring of the site bores (in particular PT84MW6) should be undertaken to confirm the groundwater elevations over time. The groundwater level monitoring data may be used to support changes to the extraction depth in the future.

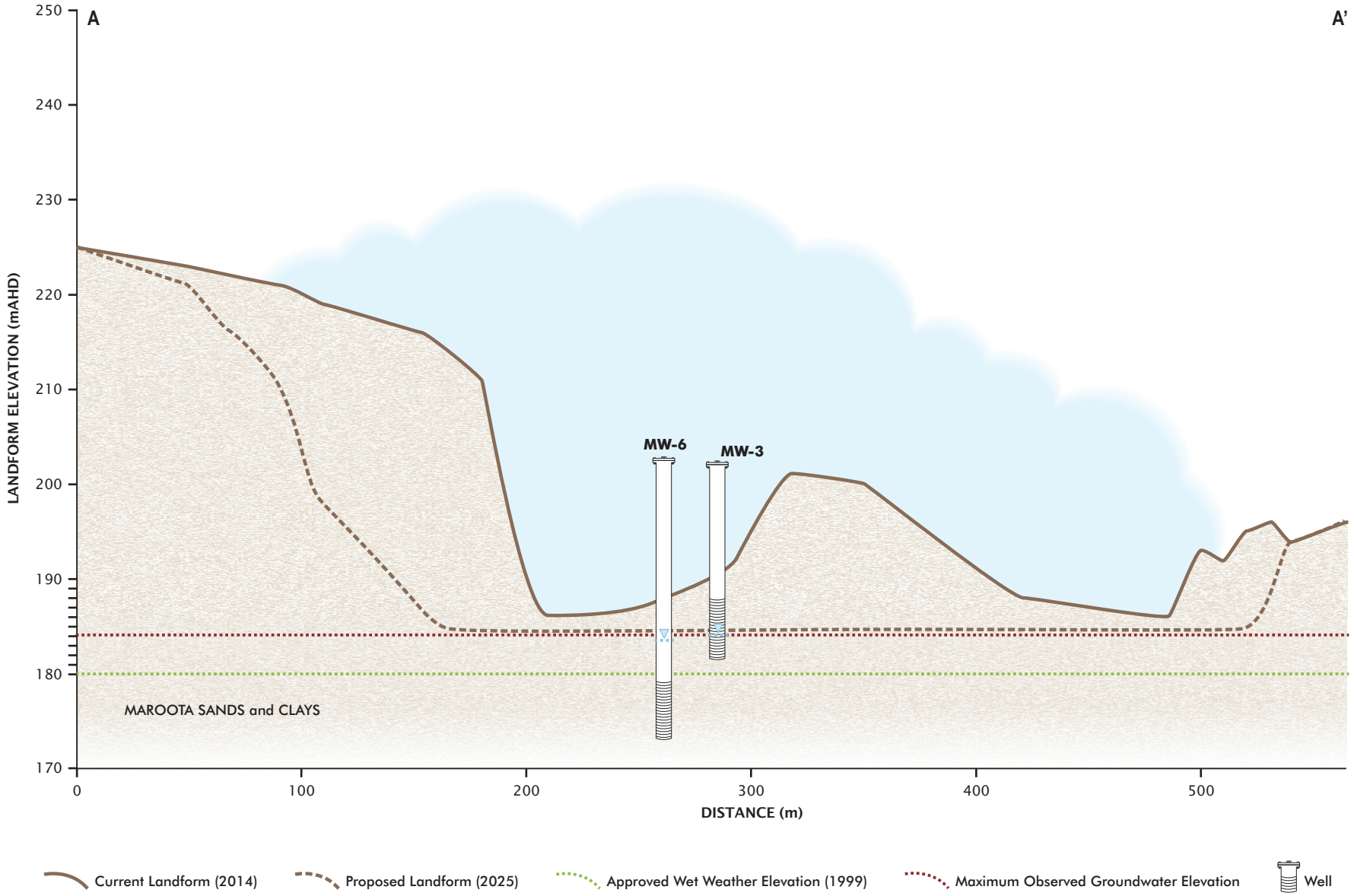

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Figure 6 | Representative Cross Section (for section line see Figure 2)

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5 Groundwater Monitoring

5.1 Existing Groundwater Monitoring Program

The location of the current groundwater monitoring bore (PTMW-6) is presented in Figure 4, with monitoring frequency presented in Table 4.

Table 4: Summary of existing groundwater monitoring program

Property	Bore	Monitoring	Installed	Monitoring data since	Water level frequency	Water quality frequency
Lot 2 DP228308	PT84MW-6	MTSGS	2015	January – March 2015	monthly	biannual

5.2 Proposed Groundwater Monitoring Program

Although quarrying will not intercept the regional groundwater (MTSGS), monitoring will be continued for the life of the project to detect any unforseen groundwater level or quality impacts, including any impacts to existing users. The ongoing monitoring program is summarised in Table 5. This program has been designed to detect changes in groundwater levels and groundwater quality. Key aspects include:

- Ongoing monitoring for SWL in the MTSGS.
- Water quality sampling on a biannual basis.
- Inspection of seepages across the quarry walls and floor. This will be correlated with rainfall records to assess whether groundwater or surface water inflows (surface runoff or incident rainfall) are likely. Any observed pooling or discharges should be quantified and analysed for salinity and major ions.

Table 5: Proposed groundwater monitoring program

During mining	Purpose	Weekly	Fortnightly	Monthly	Bi-annual
PT84MW-6	Ensure mining is maintained above the MTSGS			Water level (to verify automated pressure transducers)*	
	Monitor any unforseen 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 unforseen regional impacts, ensure there are no WL/WQ impacts to neighbouring private bores				
	Ongoing compliance with the WSP and AIP	No pit seepages are expected, but install a surveyed water level gauge in the unlikely event that measurable inflows occur.^ Water levels and quality to be quantified if seepage identified			
Post mining					
PT84MW-6	Monitoring of post mining water level and quality impacts and ensuring ongoing compliance with the WSP and AIP				Water level & Field Parameters

*PT84MW-6 will be fitted with an automatic pressure transducer. ^Inflows should be confirmed during dry periods to distinguish from internal surface drainage (i.e. from rainfall events). If pit seepages are detected, sample for field parameters, EC, TSS, pH and turbidity and present with rainfall records (cumulative deviation from mean monthly rainfall).

6 Management of Groundwater Impacts

6.1 Groundwater Management Strategy

The strategy for groundwater management is to minimise groundwater inflows from the MTSGS to the open cut and preservation of groundwater quality. It involves maintaining the depth of mining to an elevation which is at least 2 m above the 'wet weather' groundwater elevation. In this instance it could also be interpreted to extend to 2 m above the water cut, as the locally the MTSGS is confined by an impermeable clay layer (Thomson, 2014).

Aspects assessed to be at risk have been previously assessed by Woodward-Clyde (1999) and summarised in Section 3 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).
- Unforseen impacts on groundwater levels on neighbouring properties and on any users of groundwater.
- Unforseen 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 the pit extraction depth of 186.08 mAHD. This will ensure the pit floor remains at least 2 m above the 'wet weather' groundwater level of 184.08 m AHD, thereby mitigating any drawdown impact to the MTSGS.

It should be noted however that the current pit floor is approximately 183.7 mAHD with no observed in-pit seepages. The occurrence of the basal clay layer effectively precludes inflow from the underlying water table (it is an effective confining layer).This could form the basis of extending the extraction limit depth to 183.7 mAHD which would still be 1.7 m above the approved limited from the original EIS.

Regardless, 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 have established triggers, which will be used to indicate levels 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 mining remains above the Maroota Tertiary Sands Groundwater Source. Regular review of monitoring data to ensure mining is maintained above the elevation of the regional water table.	PT84MW-6	**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 Hodgsons Quarry operations or may potentially impact on adjacent bores or surface water users implement Section 6.2 of this report, which may include: Modify mine plan or obtain groundwater licence to offset impact;
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. Monitoring of pit will be undertaken as a first line of defence to detect & control the risk of groundwater contamination	PT84MW-6, 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 mining remains above the Maroota Tertiary Sands Groundwater Source. Regular review of monitoring data to ensure mining is maintained above the elevation of the regional water table.	PT84MW-6	**Water level**: Increase monitoring frequency to weekly to establish trend	
Pit inflows	Observed seepages from pit wall	Regular review of monitoring data to ensure mining is maintained above the elevation of the Maroota Tertiary Sands Groundwater Source. Monitoring of water quality in pit will be undertaken as a first line of defence to control the risk of groundwater contamination	PT84MW-6	**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	

6.2 Hodgsons Quarry Responsible Impacts Procedure

Where investigations detailed in the TARP determine that groundwater impacts are the result of Hodgson's Quarry operations or may potentially impact on adjacent bores, the following procedure is actioned:

- 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 timing of the above includes, but is 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.

6.3 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.

7 Assessment against the AIP and WSP

7.1 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 MTSGR and the final landform depth will be restricted to **186.08 mAHD**. 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).

Note: the Maroota Tertiary Sands aquifer falls under the category of a *highly productive alluvial aquifer* based on its characteristic geology (ie palaeochannel sands) and comprising groundwater of less than 1,500 mg/L total dissolved solids (TDS).

Table 7: Minimal impact considerations for aquifer interference activities. NB Table based on Table 1 of AIP (2012)

	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(6) 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 MTSGS. There will be no groundwater extraction or mine 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 on and off site. These wells 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.(a) 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 restricted to the MTSGS unit and will maintained 2 m above the wet weather regional groundwater level. The confined fractured rock Sydney Basin Central Groundwater Source is at depth and will not be intercepted or extracted during quarry activities. For this reason this principle is not applicable. **Monitoring**: Deep monitoring bores are already on site (GW75003, GW75004) that monitor the Sydney Basin Central Groundwater Source. These bores will be monitored and maintained during quarry operations to detect any unforseen 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 MTSGS. There are no water quality impacts as a result of the project. Mitigation measures such as those listed in Table 6 will be implemented to prevent contamination to the groundwater source. 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 to support notion of "minimal impact" from quarry activities

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 1998 for shallow and deep bores, over a range of climatic variations	Section 4 of this report; Woodward-Clyde (1999);
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 5 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 mining activities, nor will the Sydney Basin Central Groundwater Source.	Section 4 and 5 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 mining activities, nor will the Sydney Basin Central Groundwater Source.	Section 4 and 5 of this report.
Details of potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems	No GDE's identified in the study area	Woodward-Clyde (1999); Section 3.3 (this report).
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 6, 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	Mining will not be carried out near any creek or river.	Woodward-Clyde, 1999
Details of the method for disposing of extracted water (in the case of coal seam gas activities)	N/A	N/A

7.2 Compliance with Water Sharing Plan (2011)

The MTSGS and the Sydney Basin Central Groundwater Source are the gazetted groundwater resources underlying the development area. Geological mapping conducted the Geological Survey of NSW (Etheridge, 1980 as cited in Woodward-Clyde, 1999) confirms that the proposed development is fully encapsulated by outcropping Maroota Sands, with the Hawkesbury Sandstone located further to the west (see Figure 1) and at depths beyond the proposed final landform depth. For this reason rules in the Plan have only been considered against the Maroota Tertiary Sands Groundwater Source as detailed in Table 6.

Table 9: Summary spreadsheet of WSP rules and compliance for the MTSGS.

Access Rules	Relevance for this Development	Reason why rule is not applicable	Reference
Granting of access licenses may be considered for a listed number of activities	Not applicable	-The proposed work modifications do not seek an application license because the regional Maroota Sands aquifer will not be intercepted. Excavations from quarrying will extend to a maximum depth of 185.10 mAHD, 2 m above the approved 'wet weather' groundwater elevation (183.10 mAHD).	Section 4
Rules for managing water allocation accounts			
Carryover	Not applicable	-no application 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.	Section 4
Rules for Managing Access Licenses			
Managing surface and groundwater connectivity	Not applicable	-the existing pit is >40 m from the high bank of any river or creek as indicated in Figure 1 of this report. -The nearest groundwater seepage points are over 1 km to the south-west and north-east	Groundwater seepage points are

Access Rules	Relevance for this Development	Reason why rule is not applicable	Reference
		of the quarry site. -the MTSGS will not be intercepted over the life of quarrying therefore surface water impacts from groundwater related activities cannot occur. -groundwater is not abstracted as part of site operations. Water use is restricted to surface run-off captured in dams.	located on Figure 1 of this report
Rules for granting or amending water supply works approvals			
to minimise interference with neighbouring water supply networks	Not applicable	for the above reasons interference with neighbouring bores cannot occur.	
To protect bores located near contamination		-No application 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 500m of DP 228308 and DP 312327;	

Access Rules	Relevance for this Development	Reason why rule is not applicable	Reference
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.	Figure 1 shows the nearest environmental receptors are > 1 km from the quarry site.
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 mining plan, extraction methods and the estimated mine life.	
Rules for the use of water supply works approvals			

Access Rules	Relevance for this Development	Reason why rule is not applicable	Reference
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.	

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