NEW HOPE
GROUP

6. Groundwater Resources

Contents

6 Groundwater Resources

This Chapter describes the groundwater resources that may be affected by the revised Project, how they might be affected, and the measures required for the mitigation of potential negative effects.

The methodology undertaken for the assessment of groundwater resources draws on that set out in the *Framework for assessing potential local and cumulative effects of mining on groundwater resources* (NWC, 2011) and includes:

- a review of geological, hydrogeological and groundwater quality data collected for the Mine;
- a review of other background data available on local hydrogeology and groundwater use;
- the installation of 14 groundwater bores to characterise the local hydrogeology around the revised Project site;
- the undertaking of aquifer pumping tests to determine aquifer hydraulic parameters (transmissivity and storativity);
- the formulation of a hydrogeological conceptual model describing the groundwater system to serve as the basis for a numerical model;
- the undertaking of numerical modelling to estimate likely effects of the revised Project on groundwater levels; and
- the assessment of potential effects and mitigation measures.

The following Sections describe the regulatory framework for the revised Project with respect to groundwater resources and the results of the assessment undertaken to determine the effects on groundwater resources.

6.1 Regulatory Framework

6.1.1 Queensland Legislation

Groundwater use and management in Queensland is regulated under the Water Act and the EPP (Water).

In Queensland, a number of groundwater management areas have been declared under the Water Act. The revised Project sits within the Eastern Downs Groundwater Management Unit (GMU), and to a very minor extent the Oakey Creek Groundwater Management Area where alluvial sediments exist in the southeastern most portion of the revised Project site. **Section 6.2.3** describes the occurrence of alluvial sediments across the revised Project site.

Declaration of groundwater management areas under the Water Act means that a water licence is required to take or interfere with subartesian water in these management areas, and a development permit is required to construct or install works that take subartesian water.

The EPP (Water) aims to protect Queensland's environments by providing a framework to:

a) identify environmental values for Queensland waters;
b) decide and state water quality guidelines and objectives to enhance or protect the environmental values;
c) make consistent and equitable decisions about Queensland waters that promote efficient use of resources and best practice environmental management; and
d) involve the community through consultation and education and promoting community responsibility.

The values identified in the EPP (Water) under Section 7 are as follows.

- The "environmental values" of waters to be enhanced or protected under this policy include:

a) for a water in schedule 1, column 1; and
b) for another water – the qualities in sub-section (2).

The revised Project site is not listed in schedule 1, column 1 therefore, for the revised Project, the environmental values (EVs) for groundwater are based on the qualities identified in sub-section (2) which are described as:

- Aquatic Ecosystems
  a) for high ecological value waters—the biological integrity of an aquatic ecosystem that is effectively unmodified or highly valued;
  b) for slightly disturbed waters—the biological integrity of an aquatic ecosystem that has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators;
  c) for moderately disturbed waters—the biological integrity of an aquatic ecosystem that is adversely affected by human activity to a relatively small but measurable degree;
  d) for highly disturbed waters—the biological integrity of an aquatic ecosystem that is measurably degraded and of lower ecological value than waters mentioned in paragraphs (a) to (c).

- Regional, Agricultural and industrial Use
  a) for waters that may be used for producing aquatic foods for human consumption—the suitability of the water for waters that may be used for aquaculture—the suitability of the water for aquacultural use;
  b) for waters that may be used for agricultural purposes—the suitability of the water for agricultural purposes;
  c) for waters that may be used for recreation or aesthetic purposes, the suitability of the water for:
     1. primary recreational use; or
     2. secondary recreational use; or
     3. visual recreational use;

d) for waters that may be used for industrial purposes—the suitability of the water for industrial use;

e) the cultural and spiritual values of the water.

- Drinking water (Potable)

  a) for waters that may be used for drinking water—the suitability of the water for supply as drinking water as defined by the Australian Drinking Water Guidelines (ADWG).

Water Resource (Great Artesian Basin) Plan 2006

The *Water Resource (Great Artesian Basin) Plan 2006*, which is a subordinate regulation to the Water Act, covers the management of all artesian and subartesian water in the Eastern Downs GMU. This coverage includes management of the Walloon Coal Measures aquifer, Marburg Sandstone aquifer and Helidon Sandstone aquifer.

Water Resource (Condamine and Balonne) Plan 2004

The *Water Resource (Condamine and Balonne) Plan 2004,* which is a subordinate regulation to the Water Act, provides a framework for advancing sustainable management and efficient use of water by creating an effective cap on diversions from watercourses, lakes, springs and overland flows in the Condamine and Balonne Water Resource Plan (WRP) Area. The *Condamine and Balonne draft resource operations plan amendment* proposes amendments for the *draft Condamine and Balonne resource operations plan* and was released on 28 October 2013 for public comment. A moratorium is currently in place for Condamine and Balonne WRP Area that limits new development related to water in a watercourse or lake, water in springs not connected to artesian groundwater, and overland flow water.

Groundwater Management Units

The revised Project site is located within both the Eastern Downs GMU, and a small portion of the Oakey Creek Groundwater Management Area GMU where alluvial sediments associated with Oakey Creek and its tributaries lie within the southeastern most extent of the revised Project site (**Section 6.2.3** describes occurrence of this alluvium in relation to the revised Project site). The size of the Eastern Downs GMU in Queensland is 22,635 km^2 whilst the size of the Oakey Creek GMU is 213 km^2.

Capping of resource extraction volumes is an accepted way to manage overexploitation of groundwater. In both the Eastern Downs and Oakey Creek GMUs, a water resource cap has been placed on groundwater usage which applies to irrigation, urban supply, commercial / industrial, forestry, drought supply and mining / oil and gas. Groundwater users are required to hold entitlements to extract groundwater from the GMUs for these purposes. The water resource cap does not include stock and domestic supplies.

Environmental Authority

The Mine operates under EA EPML00335713 in accordance with the EP Act (1994). The EA includes requirements for the monitoring of groundwater levels and quality (Conditions C21 to C33). These requirements are discussed in **Section 6.2.6**.

For compliance purposes, groundwater level fluctuations are compared with groundwater levels observed in the reference bores. If the cause of observed fluctuations is not related to the licensed extraction from the aquifer, this change in level is required to be reported to the DNRM.

Under the current EA, NAC has recently received approval from EHP to allow the use of site specific groundwater quality guidelines for the Mine. These site specific guidelines were developed from a study conducted over a number of years.

6.2 Existing Environment

6.2.1 Project Location

The revised Project site is situated in the western portion of the Clarence-Moreton Basin. The Walloon Coal Measures within the Clarence-Moreton Basin underlie the revised Project site and regionally contain an estimated coal resource of over 800 million tonnes.

6.2.2 Hydrology and Landforms

The revised Project site is located in undulating terrain that spans two surface water catchments. The majority of the revised Project site drains to the ephemeral Lagoon Creek which traverses from northeast to southwest across the revised Project site. Both Lagoon Creek and Doctors Creek (south of the revised Project site) flow into the westwards draining Oakey Creek which is part of the larger Condamine-Balonne River Catchment. North of the revised Project site, Spring Creek drains westwards towards Myall Creek which is also part of the larger Condamine-Balonne River Catchment.

The hydrology of the revised Project site is discussed in more detail in **Chapter 5**.

6.2.3 Geology

This Section outlines the geology of the revised Project site and Study area.

Regional Geology

The revised Project site lies within the Cecil Plains Sub-Basin which is located within the western portion of the Clarence-Moreton Basin. In Queensland, the Clarence-Moreton Basin merges with the Surat Basin. The Kumbarilla Ridge is a basement high consisting of the Upper Devonian to Upper Carboniferous Texas beds and separates the Cecil Plains Sub-Basin of the Clarence Moreton Basin, from the Surat Basin. The Clarence-Moreton Basin represents an eastern portion of the Mesozoic GAB. In this portion, major aquifers of the GAB comprise the Marburg Sandstone and Helidon Sandstone. The Walloon Coal Measures is also considered to form a GAB aquifer.

The economic coal-bearing sediments of the Surat and Clarence-Moreton basins occur in the Walloon Coal Measures. The Walloon Coal Measures are Middle to Upper Jurassic in age and are a part of the Injune Creek Group. Although the Kumbarilla Ridge is considered to structurally separate the Clarence-Moreton Basin from the Surat Basin, the Walloon Coal Measures occur on both sides of the Kumbarilla Ridge and are laterally continuous between the Clarence-Moreton Basin and the Surat Basin.

The Injune Creek Group cannot be identified as a distinct unit in the western Clarence-Moreton Basin. However it is broken up into a productive coal bearing lower unit, the Walloon Coal Measures, and a coal resource barren upper unit, the Kumbarilla Beds. The upper unit is absent in the revised Project site.

Within the revised Project site, the major coal bearing unit within the Walloon Coal Measures is referred to as the Acland-Sabine Sequence. The Acland-Sabine Sequence occurs in the lower coal bearing unit (Taroom Coal Measures equivalent) of the Walloon Coal Measures.

Tertiary Basalts unconformably overlie the Walloon Coal Measures in some areas of the revised Project site. The Tertiary age was a period of intense volcanic activity during which the eroded palaeosurface of the Walloon Coal Measures at the revised Project site was covered with basalt flows. Basalt filled palaeo-channels occur within the north western and southern margins of the current Mine's Central and Southern Pits.

Quaternary age alluvium is associated with present day natural drainage channels within the region.

The geology of the region is summarised in **Table 6-1**.

Local Geology

The local geology of the revised Project site is described below. **Figure 6-1** presents the local surface geology of the revised Project site and **Figure 6-2** displays an indicative geological cross section through the revised Project site. The location of the cross section is shown on **Figure 6-1**.

Quaternary Deposits

Quaternary deposits consist of recent alluvium deposited by creeks and rivers. Within the revised Project site, these deposits are only likely to occur in association with the Lagoon Creek catchment in the west of the revised Project site. South and east of the revised Project site, major and widespread alluvium deposits are associated with Oakey Creek and its tributary Doctors Creek, and to the north of the existing Mine major and widespread alluvium deposits are associated with Myall Creek and its tributary Cain/Spring Creek.

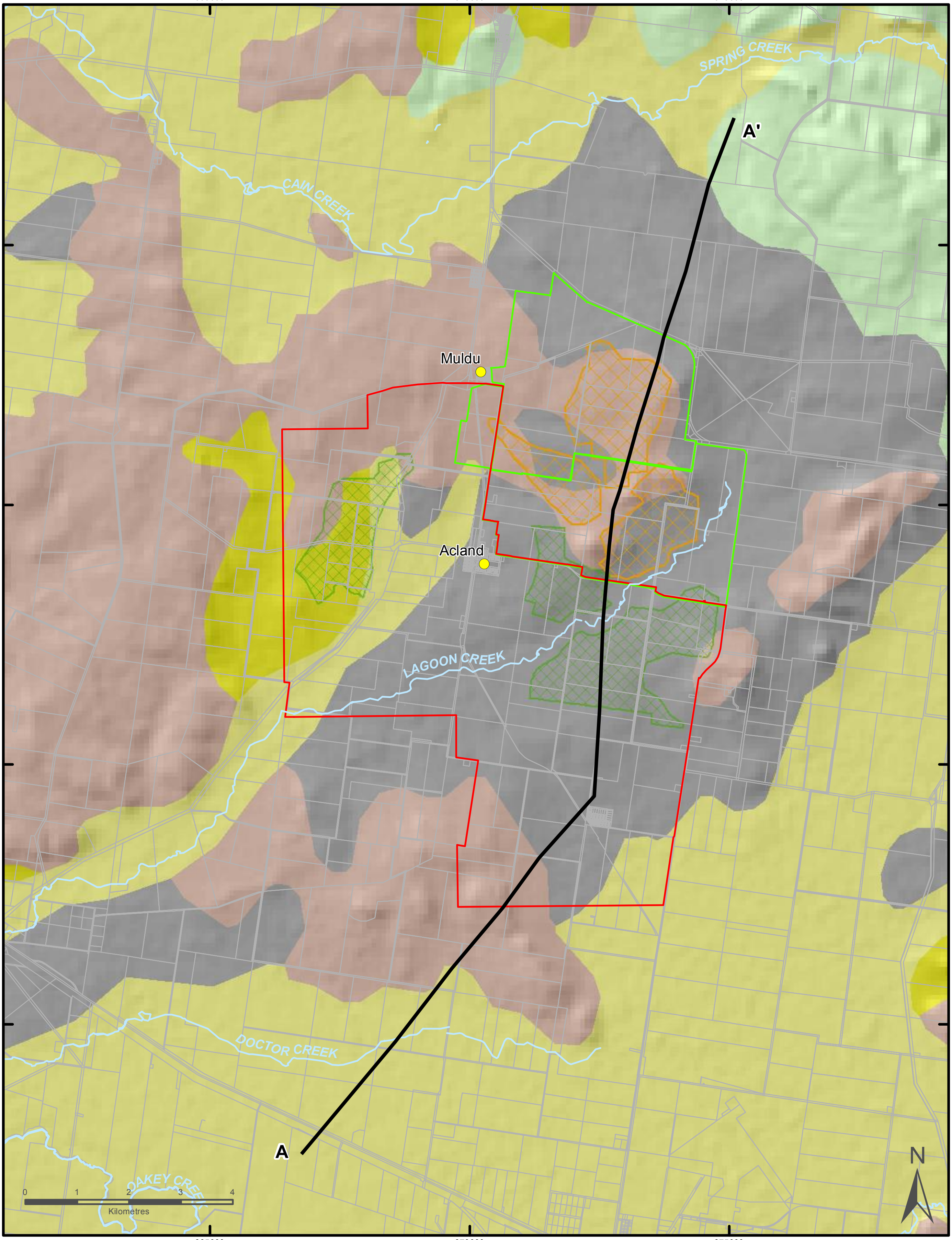
Tertiary Basalt

The Tertiary Basalt unconformably overlies the Walloon Coal Measures in several localities within the revised Project site. Remnants of Tertiary age basalt flows occur on hill tops, and show that the basalt formed as low lying horizontal continuous flows within palaeochannels eroded into the Walloon Coal Measures palaeosurface. Given the depositional environment, it is likely that in some locations the elevation of the base of the basalt flows lies below the elevation of the top of the older Walloon Coal Measures formation lying adjacent to the basalt flow, such that the basalt and coal measures in part lie at similar depths. Following basalt deposition, preferential erosion of the softer Walloon Coal Measures around the channelled basalt flows has resulted in the elevated basalt remnants currently seen at the revised Project site.

Table 6-1 Geology of the Region

<table>
<tr><th rowspan="2">Age</th><th rowspan="2" colspan="2">Geological Unit</th><th colspan="2">Clarence-Moreton Basin</th><th rowspan="2">Surat Basin</th><th rowspan="2">Lithology</th></tr>
<tr><th colspan="2">Acland Area</th></tr>
<tr><td>Quaternary</td><td colspan="2">-</td><td colspan="2">-</td><td>-</td><td>Alluvium: sand, clay, gravel</td></tr>
<tr><td>Tertiary</td><td colspan="2">Main Range Volcanics</td><td colspan="2">Tertiary Basalts</td><td>-</td><td>Olivine basalt, tuff, agglomerate</td></tr>
<tr><td>Upper Jurassic</td><td rowspan="8">Injune Creek Group</td><td>Kumbarilla Beds</td><td colspan="2">-</td><td>Springbok Sandstone</td><td>Claystone, siltstone, sandstone, minor coal</td></tr>
<tr><td rowspan="7">Middle Jurassic</td><td rowspan="6">Walloon Coal Measures</td><td colspan="2">Kogan</td><td rowspan="3">Juandah Coal Measures</td><td rowspan="6">Claystone, siltstone, sandstone, coal</td></tr>
<tr><td colspan="2">Macallister</td></tr>
<tr><td colspan="2">Wonkers</td></tr>
<tr><td colspan="2">Waipanna</td><td>Tangalooma Sandstone</td></tr>
<tr><td colspan="2">Acland/Sabine</td><td rowspan="2">Taroom Coal Measures</td></tr>
<tr><td colspan="2">Balgowan</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>Eurombah Formation</td><td>Claystone, siltstone, sandstone, minor coal</td></tr>
<tr><td rowspan="3">Lower Jurassic</td><td rowspan="3" colspan="2">Bundamba Group</td><td rowspan="2">Marburg Subgroup</td><td>Marburg Sandstone</td><td>Hutton Sandstone</td><td>Sandstone, minor siltstone claystone and coal</td></tr>
<tr><td>Evergreen Formation</td><td>Evergreen Formation</td><td>Interbedded shale and sandstone</td></tr>
<tr><td colspan="2">Helidon Sandstone</td><td>Precipice Sandstone</td><td>Interbedded shale and sandstone, quartz sandstone</td></tr>
<tr><td>Carboniferous to Devonian</td><td colspan="2">Texas Beds</td><td colspan="2">-</td><td>-</td><td>Greywacke, conglomerate, siltstone, mudstone, slate, local phyllite, chert, basalt, limestone and rare tuff</td></tr>
</table>

Notes: 1. The age of geological units shown is from most recent (Quaternary) to oldest (Carboniferous to Devonian) in formation. Source: New Hope Coal Life of Mine Plan 2008.



LEGEND

- Towns and Localities
- Watercourse
- Alignment of Geological Cross-section
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Existing Permission
- Stage 3 Pit Areas
- Cadastre

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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SINCLAIR KNIGHT MERZ SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-1 - Surface Geology

Scale 1:100,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

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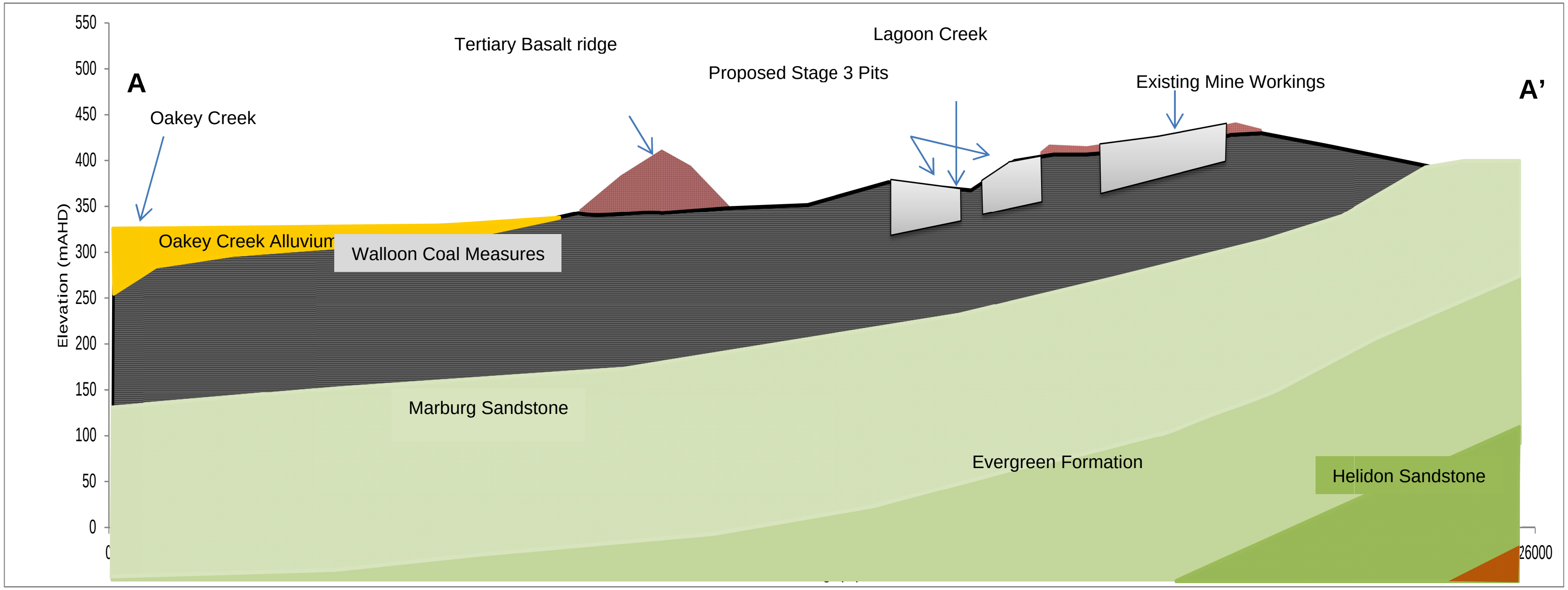


Note: Faulting not represented in conceptualised cross-section. Geologic information based on bore logs along cross-section, known ground elevations, surface geological mapping, and inferred depths for deeper formations due to lack of deep drilling information along section.

Figure 6-2 Conceptualised Geological Cross Section

The presence of weathered basalt below fresh basalt, in combination with relict soil profiles and sedimentary layers interbedded with the flows, indicates that there has been a succession of basalt flows within the revised Project site. Evidence of two to three distinct flows have been observed during drilling investigations. There is some outcrop of the Tertiary Basalt in the northern section of the revised Project site, but only very minor outcrop within the proposed western pit (Manning Vale West pit) area of the revised Project.

Borehole logs show that the basalt thickness is highly variable within the revised Project site. In general, whilst basalt extent and thickness is shown to be highly variable, it is known to become more prolific and widespread immediately west of the revised Project site.

In the revised Project site, the basalt thickness ranges from absent to 25 m as recorded in NAC exploration borehole AC2. In excess of 30 m of basalt was logged in the then DNRW boreholes (NS 26, 27, 28, 33, 42 and 44) located on or near the basalt ridge adjacent the current Mine's Centre Pit. Some 33 m of basalt was intersected in the NHG borehole AC515 located between the current Mine's Centre and South Pits. Around 90 m of basalt was recorded in AC480 located west of the current Mine's North Pit.

The unaltered basalts are black in colour and microcrystalline, whilst some basalt is porphyritic containing olivine phenocrysts. Vesicular and amygdaloidal basalts are common, and the base of the basalt flows is typically vesicular. Vesicles are often partially or completely infilled with zeolites, calcite and clay minerals. Products of the basalts decomposition include red clay in which magnesite is common.

Walloon Coal Measures

The Walloon Coal Measures are around 120 to 130 m thick across most of the revised Project site, although planned mining activities are limited to the base of the economically recoverable coal reserves lying less than 75 m below ground level at their deepest point.

The three major coal intervals identified within the lower Walloon Coal Measures (Taroom Coal Measures equivalent) are the Waipanna, Acland-Sabine, and Balgowan (as shown in **Table 6-1**). NAC mines the Acland-Sabine sequence within the lower Walloon Coal Measures. **Chapter 3** outlines the mine plan for the revised Project.

The Mine currently extracts coal from the Acland-Sabine interval. The Acland-Sabine interval contains six seam groups. From the top to bottom these are nominated as A to F. Each seam group contains up to 10 seam plies. Seam plies are discrete layers of coal within a seam group. In total, the Acland-Sabine interval has 47 seam plies. The average thickness of an individual seam ply is 0.23 m. Individual seam plies are unlikely to extend great lateral distances, but rather form isolated pods of coal.

The Waipanna interval contains six seam groups which contain 53 seam plies. The Balgowan interval contains seven seam groups which contain 21 seam plies.

The regional dip of the Walloon Coal Measures is one to three degrees south-southwest. Local variations of both dip and strike occur due to both folding and faulting. The general geological structure of the revised Project site can best be described as a fault modified southwesterly plunging syncline, with the fold axis centred on the Lagoon Creek drainage channel. Folding has been interpreted from photogeological interpretation, regional drilling and geological interpretation of the drilling results elsewhere in the Clarence-Moreton Basin.

Faulting is known to have occurred from observations made from underground mines in the Acland area and has also been interpreted from drilling results and from the existing open cut. Faulting is developed along two main trends, northeast-southwest and northwest-southeast, however, east-west faults with significant throws have also been observed in the Mine pits. The age of faulting is not known, however NAC's geologists have identified that basement faulting could have been re-activated during the Tertiary period synchronous with basalt deposition, i.e. the basalt overlying the Walloon Coal Measures may also have been faulted. Typically, the downthrown strata are on the downdip side of the fault.

Eurombah Formation

The Eurombah Formation underlies the Walloon Coal Measures and consists dominantly of fine grained sediments including siltstones, mudstones, fine sandstones and rare coals. The unit is difficult to distinguish between the overlying Walloon Coal Measures and often in literature the Eurombah Formation unit is not distinguished from the overlying Walloon unit. The main difference between the Eurombah Formation and the overlying Walloon Coal Measures is that the Eurombah Formation is comparatively coal barren.

Marburg Sandstone

The Marburg Sandstone is typically around 200 to 300 m thick at the revised Project site and regionally dips to the southwest. The unit outcrops 3 km northeast of the current New Acland Mine, however at the revised Project site the unit lies at a depth of approximately 150 m below ground surface and 75 m below the base of the current and proposed mine workings. The Marburg Sandstone is made up of poorly sorted, coarse to medium-grained, feldspathic sublabile sandstone and fine-grained, well sorted quartzose sandstone. Minor carbonaceous siltstone, mudstone, coal and rare pebble conglomerate also occur within the Marburg Sandstone. The unit grades into the underlying Evergreen Formation which can therefore be difficult to distinguish from the base of the Marburg Sandstone. The literature does not always separate these two units within the Clarence-Moreton Basin, possibly due to the gradational nature of the contact, with the entire sequence collectively termed the Marburg Subgroup.

Available bore log data for the Marburg Sandstone from deep production bores at the Mine site describe the unit as variably sandstone, siltstone and mudstone, with some clean quartzose sandstone intervals.

Evergreen Formation

The Evergreen Formation is a dominantly finer grained unit than the overlying and underlying Marburg and Helidon sandstones, and is generally up to 200 m thick in the revised Project site. As described above, the boundary is transitional with the overlying Marburg Sandstone which may be responsible for the Evergreen Formation not being described separately in some parts of the Clarence Moreton Basin. The Evergreen Formation has been described on the 1:250 000 Geology Map of Ipswich

(Geological Survey of Queensland, 1980) as consisting of sandstone, siltstone, shale, mudstone and oolitic ironstone.

Available bore log data for the deep production bores at the Mine site describe the Evergreen Formation unit as variably siltstone and mudstone with some sandstone.

Helidon Sandstone

The Helidon Sandstone is up to 170 m thick and is extensive within the Cecil Plains Sub-Basin of the Clarence-Moreton Basin. The unit is generally found at depths of between 500 and 600 m below ground level at the revised Project site, however the sandstone is known to outcrop near the township of Helidon located approximately 50 km southeast of the revised Project site. The Helidon Sandstone can be divided into two sections, an upper section of interbedded shale and sandstone with kaolinitic clays that is difficult to distinguish from the Evergreen Formation, and a lower section of fine to very coarse quartz sandstone.

Available bore log data for the Helidon Sandstone production bores at the Mine site describe the unit as variably sandstone, siltstone and mudstone.

Texas Beds

The Upper Carboniferous Texas Beds consist of greywacke, conglomerate, siltstone, mudstone, slate, local phyllite, chert, basalt, limestone and rare tuff. Generally, the Texas Beds are rich in felsic volcanic detritus which were derived from an active magmatic arc to the west. The Texas Beds are low grade regionally metamorphosed and variably deformed.

6.2.4 Hydrogeology

This Section provides a summary of the five aquifers which occur within the revised Project site. **Section 6.2.14** provides further information on these aquifers and discusses aquifer parameters including depth to groundwater, aquifer thickness, transmissivity/ hydraulic conductivity, and storativity.

Quaternary Alluvial Aquifer

The Quaternary alluvial aquifer is located within the Quaternary alluvium which consists of clay, silt, sand and gravel deposited by creeks and rivers. The Quaternary alluvium is limited in extent, being restricted to the lower lying areas associated with modern drainage lines. The nearest alluvium with significant groundwater supplies is associated with Oakey Creek (and its tributary Doctors Creek) approximately 15 km southeast of Acland Township. This aquifer may also exist in association with Lagoon Creek (another tributary of Oakey Creek); surface geological mapping as shown in **Figure 6-1** indicates some alluvium in the western part of the revised Project site, extending to the southwest of MLA 50232. No groundwater bores are present in this area however, suggesting the aquifer is either not well developed or is not present.

Tertiary Basalt Aquifer

The Tertiary Basalt aquifer consists of olivine basalts and where present, varies in thickness from 1 m to 90 m. The Tertiary Basalt aquifer is interbedded with low permeability sediments including clay which have the potential to act as a local aquitard within the Tertiary Basalt.

The Mine is currently permitted to draw groundwater from the Tertiary Basalt aquifer which is treated for potable use. This potable water supply is currently covered under a license for 160 ML/year, although actual use is much less than the allocation. **Section 6.2.5** describes Mine groundwater use in more detail. Groundwater extraction from the Tertiary Basalt aquifer is also undertaken by nearby private users.

Walloon Coal Measures Aquifer

The Walloon Coal Measures on a regional scale is not considered a major aquifer, consisting of low permeability shale, siltstone, carbonaceous mudstone, minor sandstone and coal layers. However, on a local scale, coal seams within the unit may have permeability suitably high to store and transmit useful quantities of water. This geological unit outcrops over much of the revised Project site with the coal seams being the principal conduit for groundwater. Despite comprising dominantly low permeability sediments, the unit is still considered a GAB aquifer in the Water Resource (Great Artesian Basin) Plan (2006) as some useful water supplies can be drawn from coal seams regionally.

Faulting within the Walloon Coal Measures unit has possible significance for the horizontal movement of groundwater. Pumping tests, groundwater levels and groundwater chemistry data (discussed later in this Chapter) indicate that the throw of some faults within the Walloon unit is sufficient to cause compartmentalisation of water bodies within the coal seams and also the overlying basalt. Observations of Mine pit inflows and also from nearby observation bores (discussed later in this Chapter) show that faults can also act as significant conduits for lateral groundwater flow within the Walloon Coal Measures aquifer.

The Mine uses groundwater which flows into the mine pit from the Walloon Coal Measures aquifer. The inflow is mainly used for dust suppression purposes. Neighbouring farm properties also use groundwater from the Walloon Coal Measures.

Within the Walloon Coal Measures, the Acland-Sabine interval which is mined by NAC is hydraulically separated from the underlying Balgowan interval by low permeability interburden sediments. In the vicinity of the revised Project site, the top of the Balgowan interval is approximately 30 m deeper than the lowest Acland-Sabine seam and is separated by clay-matrix sandstones which lack primary porosity and act as an aquitard between the two coal sequences.

Aquifer testing was conducted at two locations within the revised Project site as part of investigations for the revised Stage 3 Project. The locations of these bores are shown in **Figure 6-3**. Each location consisted of a production bore and two nearby observation bores, namely:

- Location 1: 120WB (Production bore) and 118P and 117PGC (Observation bores); and
- Location 2: 121WB (Production bore) and 113PGCA and 113PGCB (Observation bores).

The aquifer tests targeted the Walloon Coal Measures as the primary aquifer that will be affected by the revised Project. The two aquifer testing locations are approximately 2.5 km apart, and given the discontinuous nature of the coal seams within the Walloon Coal Measures as well as the different depths of testing at the two locations, it is considered unlikely that the two test locations tested the same laterally extensive coal seam.

Hydraulic properties of the Walloon Coal Measures aquifer were obtained by conducting a step test and a constant rate test at each pumping test site. The methodology used for aquifer testing and the data collected is provided in **Appendix G.4.1**.

Aquifer pumping test results were analysed to derive the hydraulic properties (transmissivity and storativity) for the Walloon Coal Measures aquifer within the revised Project site. Transmissivity values derived for the Walloon Coal Measures aquifer are summarised in **Table 6-2**. Outputs from these analyses are included in **Appendix G.4.1**.

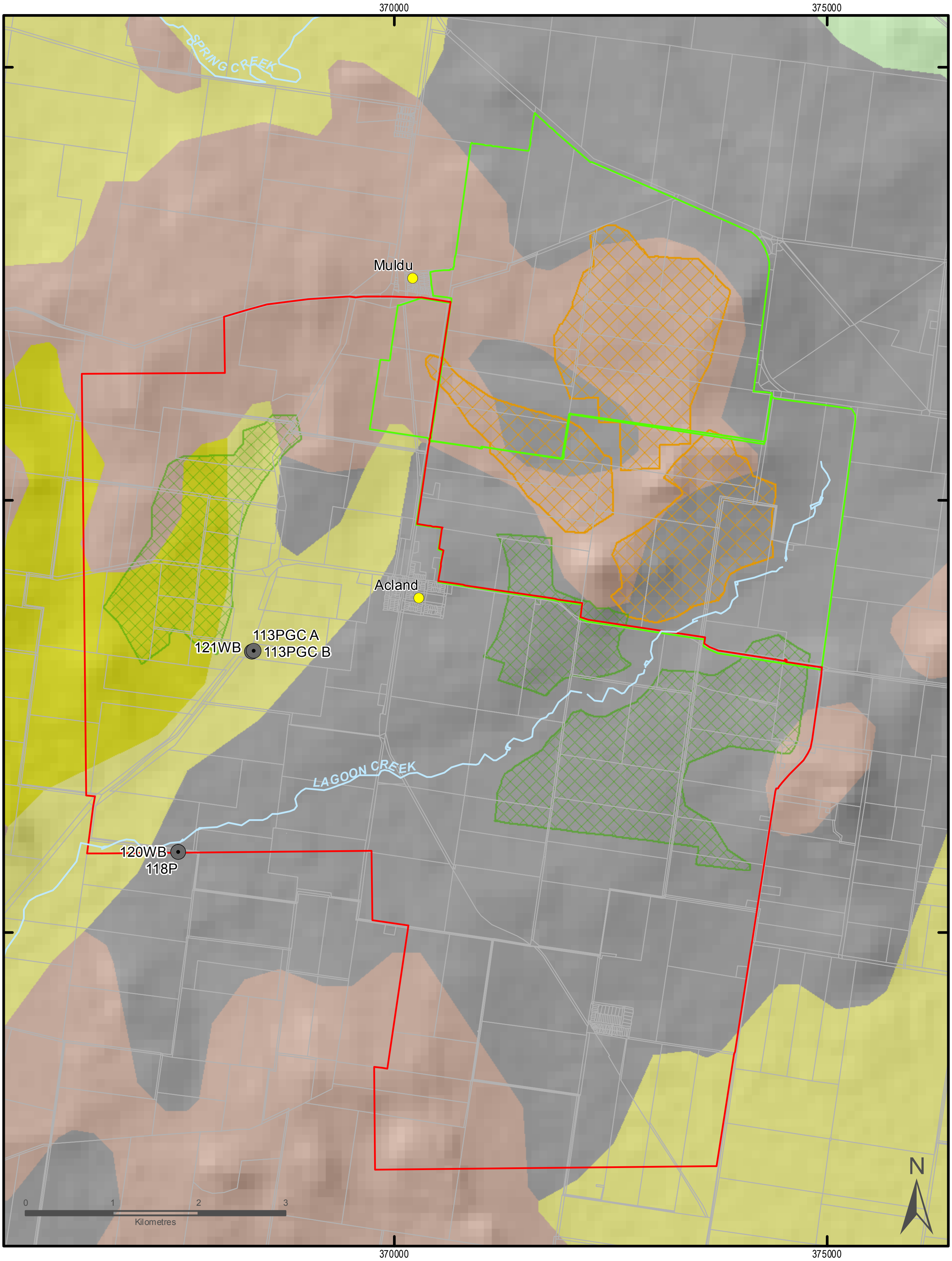
Table 6-2 Transmissivity Values for the Walloon Coal Measures

Location	Bore ID	Transmissivity (m^2/day)	Screen depth of bore (mBGL)	Unit
Location 1	120WB (pumped)	6	74 – 83.5	Acland/Sabine
	117P (obs)	8	74 – 83.5	Acland/Sabine
Location 2	121WB (pumped)	47	27 – 34	Acland/Sabine
	113PGCA (obs)	31*	27 – 34	Acland/Sabine

*Note: Value was derived using the Hantush-Jacob (1955) leaky aquifer solution. All other values derived using the Theis (1935) confined aquifer solution.

An assessment of the results suggests that transmissivity of the shallower coal seams is generally greater than the transmissivity of the deeper coal seams, although this conclusion is limited to data from the two tests sites only. However, this conclusion supports the widely accepted hydrogeologic concept that the hydraulic conductivity of coal seams decreases with depth of burial, due to the weight/pressure effects of burial closing cleats and joints within the seams.

Pumping tests conducted during the Stage 2 EIS indicated that transmissivity values of 30 m^2/day were observed within the Walloon Coal Measures aquifer. This result is consistent with transmissivity values observed for the shallower seams during the revised Project investigations.



LEGEND

Towns and Localities

Aquifer

Alluvium

Basalt

Coal Measures

Watercourse

New Acland Coal Mine

New Aland Coal Mine-Stage 3

Cadastre

Existing Permission

Stage 3 Pit Areas

Dominant Geology

Basalt (Tm)

Alluvium (Qa)

Colluvium (TQs)

Walloon Subgroup (Jw)

Marburg Sandstone (Jbm)

NEW HOPE GROUP

SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-3 - Location of Aquifer Testing Sites

Scale 1:60,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130605_NewHope_Groundwater_Figure6-3_LocationOfAquiferTestingSites.mxd

Produced: 25/11/2013

Table 6-3 Storativity Values

Location	Bore ID	Storage Coefficient (dimensionless)	Screen depth of bore (mBGL)	Unit
Location 1	120WB	-	74 – 83.5	Acland-Sabine
	117P	0.00006	74 – 83.5	Acland-Sabine
Location 2	121WB	-	27 – 34	Acland-Sabine
	113PGCA	0.006*	27 – 34	Acland-Sabine

*Note: Value was derived using the Hantush-Jacob (1955) leaky aquifer solution. All other values derived using the Theis (1935) confined aquifer solution.

The best fit solutions for calculating aquifer parameters from testing were mostly obtained with non-leaky solutions, suggesting that the interseam sediments are very ‘tight’ and did not contribute meaningful volumes of water to the pumped bores over the duration of testing.

Marburg Sandstone Aquifer

The Marburg Sandstone aquifer consists of sandstone, minor coal and conglomerate rock types. These water bearing units are interbedded with less permeable rock units such as mudstone, siltstone and shale.

The Marburg Sandstone aquifer is a confined aquifer which occurs at a depth of approximately 150 mBGL beneath the revised Project site. Non-coal aquitards within the Walloon Coal Measures act as effective confining layers for the Marburg Sandstone aquifer.

Aquifer parameters based on pumping tests conducted for the Stage 2 EIS for a single water bearing unit within the Marburg Sandstone indicate a transmissivity of 14 m^2/day and a storativity of 0.003.

The Mine previously extracted groundwater for industrial use from the Marburg Sandstone aquifer and still possesses an allocation of 271 ML/year. **Section 6.2.5** describes Mine groundwater use in more detail. Nearby private groundwater users are the main local sources of groundwater extraction from the Marburg Sandstone aquifer.

Helidon Sandstone Aquifer

The Helidon Sandstone aquifer is the deepest aquifer underlying the revised Project site and is separated from the shallower Marburg Sandstone aquifer by the intervening Evergreen Formation aquitard. The Helidon Sandstone aquifer is extensive within the Cecil Plains Sub-Basin of the Clarence-Moreton Basin and has been divided into two sub-aquifers. The upper aquifer consists of interbedded shale and sandstone. The lower section is made up of fine to very coarse quartz sandstone. The Helidon Sandstone is a confined, primary porosity aquifer and is isolated from the overlying aquifers by the relatively impermeable Evergreen Formation.

Pumping test data in previous investigations in the Mine area indicates the transmissivity of this aquifer varies between 45 and 200 m^2/day.

The Mine previously extracted groundwater from the Helidon Sandstone aquifer for industrial use and still possesses an allocation of 710 ML/year. **Section 6.2.5** describes Mine groundwater use in more detail. The Oakey Abattoir is the main local source of groundwater extraction from the Helidon Sandstone aquifer.

6.2.5 Groundwater Use

Groundwater Use adjacent to the Mine

DNRM database search

A search of the DNRM registered bore database was conducted in relation to the revised Project site. This survey identified a total of 939 registered groundwater bores within an 8 km radius of the revised Project site. The location of these bores is shown in **Figure 6-4**. The status of these groundwater bores is shown in **Table 6-4** (note that bores listed as "Abandoned and Destroyed" in the database are not shown in **Figure 6-4**).

Table 6-4 Status of DNRM groundwater bores

	Existing	Abandoned or Destroyed	Abandoned but still Useable	Proposed
Number of Bores	827	81	4	27

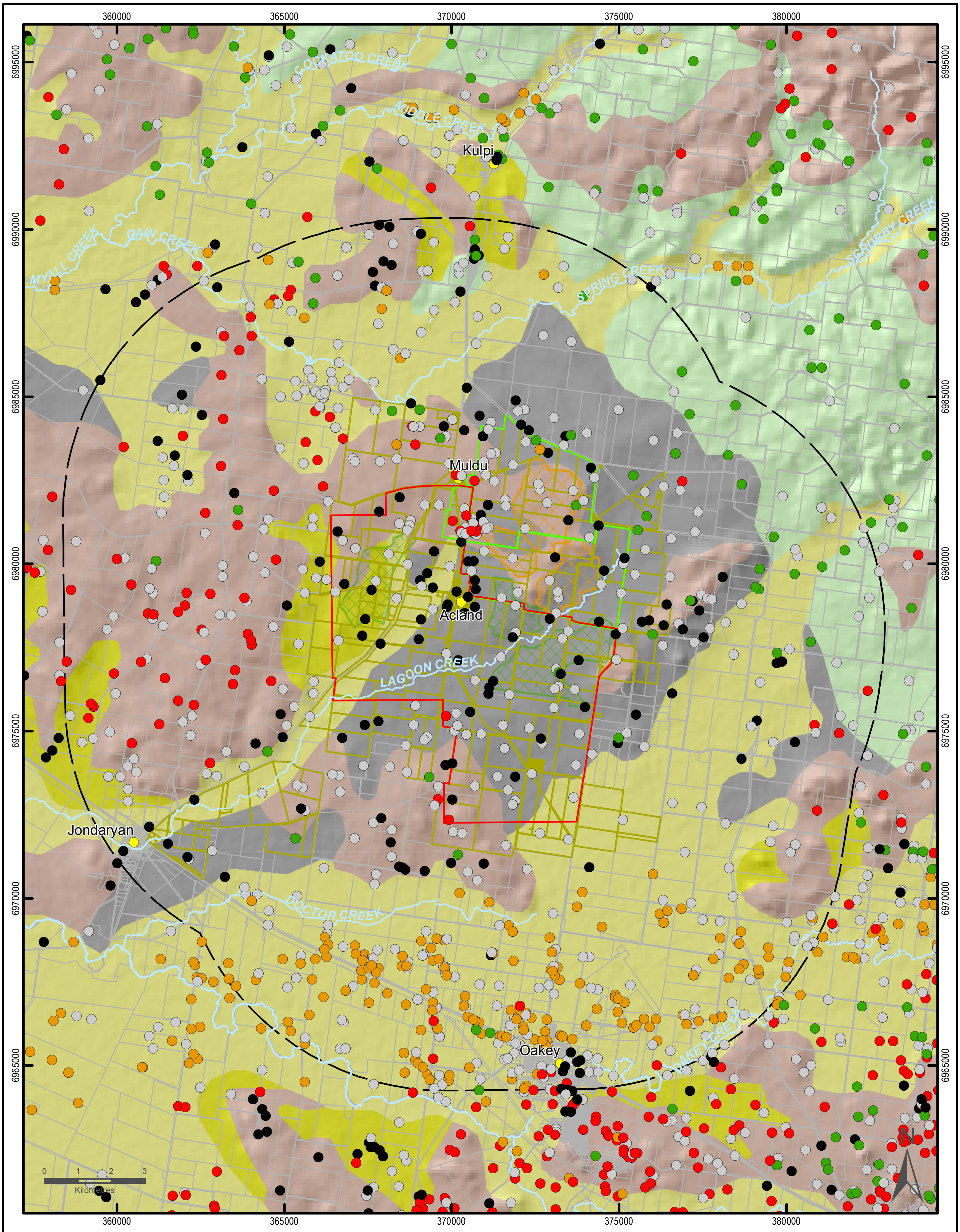
A review was undertaken of the available aquifer details for the identified bores. Only 447 (47%) of the 939 registered bores within 8 km of the revised Project site have information regarding the aquifer from which its groundwater is extracted. **Table 6-5** provides a summary of the bores that have been installed in each aquifer.

Table 6-5 Number of Bores with Known Aquifer

	Quaternary Alluvium	Tertiary Basalt	Walloon Coal Measures	Marburg Sandstone	Helidon Sandstone
Number of Bores	117	83	139	47	1

The available bore data were further reviewed to identify groundwater quality, yield and standing water levels (SWL) in each aquifer for these groundwater users. Available information is summarised in **Table 6-6**.

Registered groundwater bores accessing the alluvial aquifers report standing water levels which range from 8.5 to 33 mBGL. Groundwater quality ranges from "potable" to "salty" as described in the database, with bore yields ranging from 0.4 to 20 L/sec. The majority of bores are located to the south of the revised Project site within the Oakey Creek Alluvium, with several bores also located to the northwest of the revised Project site in association with the Myall Creek (including its tributaries Cain Creek and Spring Creek) Alluvium.



LEGEND

- Towns and Localities

DNRM Bores defined by Aquifer

- Not defined
- Alluvium
- Basalt
- Walloon Coal Measures
- Marburg Sandstone

- Watercourse
- 8km Buffer
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Cadastre
- Acland Pastoral Co Property
- Existing Permission
- Stage 3 Pit Areas

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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Figure 6-4 - Location of DNRM Registered Groundwater Bores

Scale 1:150,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 21/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130821_NewHope_Groundwater_Figure6-4_LocationOfDNRMRegisteredGroundwaterBores.mxd

Table 6-6 Groundwater Quality, Yield and SWL in Each Aquifer for Registered Bores within 8 km of the revised Project

Registration Number (RN)	Aquifer[1]	Quality[2]	Yield (L/sec)	SWL (mBGL)
86723	Alluvium	Potable	6.1	13
94974	Alluvium	Not available	3.8	Not available
94995	Alluvium	Not available	Not available	16.46
107119	Alluvium	Potable	4.7	13
107120	Alluvium	Potable	0.4	12.5
107538	Alluvium	Potable	4.1	13.4
107548	Alluvium	Not available	20	10.4
107225	Alluvium	Not available	Not available	12.6
119133	Alluvium	Salty	Not available	Not available
119297	Alluvium	Not available	3.8	25
119565	Alluvium	Not available	Not available	11.3
119566	Alluvium	Not available	Not available	15.2
137743	Alluvium	Potable	0.1	Not available
137888	Alluvium	Not available	Not available	8.53
137030	Alluvium	Brackish	0.6	13.8
147098	Alluvium	Not available	2	33
147099	Alluvium	Salty	Not available	Not available
147211	Alluvium	Potable	Not available	Not available
147317	Alluvium	Brackish	.7	13.2
147498	Alluvium	Salty	1.3	Not available
107838	Alluvium	Not available	Not available	18.9
147465	Alluvium	Potable	1.4	15.24
147352	Alluvium	Potable	0.7	17
147269	Alluvium	Not available	Not available	8.8
87330	Tertiary Basalt	Potable	9.6	Not available
87331	Tertiary Basalt	Potable	12.6	2.4
87365	Tertiary Basalt	Potable	7.0	4.9
94190	Tertiary Basalt	Potable to Brackish	4.5	6.8
94343	Tertiary Basalt	Potable	Not available	34.5
94423	Tertiary Basalt	Potable	2.8	21.9
94846	Tertiary Basalt	Potable	0.6	22
94919	Tertiary Basalt	Potable	Not available	Not available
94996	Tertiary Basalt	Brackish	1.9	45

Registration Number (RN)	Aquifer[1]	Quality[2]	Yield (L/sec)	SWL (mBGL)
107547	Tertiary Basalt	Not available	15.6	10.4
107145	Tertiary Basalt	Potable	1.9	3.96
107255	Tertiary Basalt	Potable	0.5	11
107357	Tertiary Basalt	Potable	2.1	Not available
107358	Tertiary Basalt	Potable	Not available	Not available
119008	Tertiary Basalt	Not available	6.3	Not available
119387	Tertiary Basalt	Brackish	0.1	8.3
119386	Tertiary Basalt	Brackish	0.6	8
119572	Tertiary Basalt	Potable	Not available	Not available
42231617	Tertiary Basalt	Not available	Not available	2.7
42231618	Tertiary Basalt	Not available	Not available	1.7
42231620	Tertiary Basalt	Not available	Not available	1.15
42231619	Tertiary Basalt	Not available	Not available	0.3
119944	Tertiary Basalt	Brackish	1.9	9.1
119951	Tertiary Basalt	Potable	Not available	Not available
137974	Tertiary Basalt	Brackish	0.5	16.8
147100	Tertiary Basalt	Potable	1.2	6.5
147104	Tertiary Basalt	Potable	3.0	25
147487	Tertiary Basalt	Not available	1.33	18.5
147489	Tertiary Basalt	Not available	0.5	18.5
147464	Tertiary Basalt	Potable	0.1	18.29
147526	Tertiary Basalt	Potable	0.8	41
83742	Walloon Coal Measures	Potable	Not available	Not available
87379	Walloon Coal Measures	Potable	Not available	Not available
94298	Walloon Coal Measures	Not available	0.4	Not available
94710	Walloon Coal Measures	Potable	3.3	13.1
94873	Walloon Coal Measures	Potable	Not available	Not available
94887	Walloon Coal Measures	Not available	0.8	30
107069	Walloon Coal Measures	Potable	Not available	Not available
107083	Walloon Coal Measures	Potable	3.3	103
107132	Walloon Coal Measures	Potable	0.2	24.4
107236	Walloon Coal Measures	Potable	Not available	Not available
107349	Walloon Coal Measures	Not available	0.5	Not available
107364	Walloon Coal Measures	Potable	0.4	Not available
107795	Walloon Coal Measures	Potable	1.2	17

Registration Number (RN)	Aquifer[1]	Quality[2]	Yield (L/sec)	SWL (mBGL)
107882	Walloon Coal Measures	Not available	Not available	22.2
107883	Walloon Coal Measures	Salty	Not available	21.5
107884	Walloon Coal Measures	Salty	Not available	23
119581	Walloon Coal Measures	Potable	Not available	Not available
42231622	Walloon Coal Measures	Not available	Not available	2.7
137284	Walloon Coal Measures	Not available	0.1	38.1
137270	Walloon Coal Measures	Brackish	0.2	47.85
137443	Walloon Coal Measures	Not available	12	53
137463	Walloon Coal Measures	Not available	5.4	60
107812	Walloon Coal Measures	Potable	0.8	36
147259	Walloon Coal Measures	Not available	2.1	13.4
147260	Walloon Coal Measures	Brackish	4.4	13.8
147262	Walloon Coal Measures	Not available	1.7	17
147497	Walloon Coal Measures	Salty	0.3	Not available
147480	Walloon Coal Measures	Not available	1.0	30
87941	Marburg Sandstone	Potable	Not available	Not available
94997	Marburg Sandstone	Potable	Not available	Not available
107121	Marburg Sandstone	Potable	5.4	Not available
107333	Marburg Sandstone	Potable	Not available	Not available
107371	Marburg Sandstone	Potable	Not available	Not available
107386	Marburg Sandstone	Potable	2.5	61
119007	Marburg Sandstone	Not available	1	21.84
119138	Marburg Sandstone	Potable	2.6	27.7
119328	Marburg Sandstone	Not available	10.7	20.8
119570	Marburg Sandstone	Potable	0.4	Not available
137228	Marburg Sandstone	Potable	5.6	Not available
137244	Marburg Sandstone	Brackish	Not available	73.76
137763	Marburg Sandstone	Not available	8.3	115
137768	Marburg Sandstone	Not available	0.4	120
147604	Marburg Sandstone	Potable	0.4	58.83
147605	Marburg Sandstone	Potable	1.5	21.95

Notes: 1. Helidon Sandstone bores not listed as Quality, Yield and SWL information not available within the search radius
2. Qualitative description as provided in the DNRM database

Investigations undertaken during the Stage 2 EIS show that groundwater use for stock and domestic purposes occurs locally in the Tertiary Basalt aquifer. There is a concentration of bores in the Tertiary Basalt aquifer to the west of the revised Project site where the basalt unit is known to increase in thickness. Information from the DNRM database shows that groundwater in the Tertiary Basalt aquifer has standing water levels which range from 0.3 to 45 mBGL and water quality is generally listed in the DNRM database as “potable” with some occurrences of “brackish” water. The groundwater yield from these bores is relatively low, ranging from 0.1 to 15.6 L/sec.

The Walloon Coal Measures aquifer supplies “potable”, “brackish” and “salty” (as listed in the DNRM database) water mainly for livestock use. Standing water levels in this aquifer range from 2.7 to 103 mBGL. Information from the DNRM database suggests that this aquifer generally produces yields which range from 0.1 to 5.4 L/sec, on average lower than those in the other aquifers.

Stock watering and municipal supplies are extracted from the Marburg Sandstone aquifer. The majority of the Marburg Sandstone bores are located to the northeast of the revised Project site where the aquifer is relatively shallow. Standing water levels in this aquifer are reported to range from around 21 to 120 mBGL. The DNRM survey data show that this aquifer is generally of “potable” quality (as listed in the database) and produces yields listed as ranging from 0.4 to 10.7 L/sec.

The single DNRM registered groundwater bore listed in the database as accessing the Helidon Sandstone aquifer within 8 km of the revised Project site is located adjacent the township of Oakey, 6.6 km south of the revised Project site. Neither quality, yield nor standing water level information is available in the database for this bore.

The DNRM also holds records of Water Entitlements (maximum licensed extraction volumes) for bores within 8 km of the revised Project site. This information is presented in **Table 6-7**. As shown, the Quaternary Alluvial aquifer is the most utilised by licensed volume, nearly three times greater than the next most utilised aquifer, the Tertiary Basalt. Licensed usage from the Walloon Coal Measures and deeper sandstone aquifers is approximately one third that of the Tertiary Basalt.

Table 6-7 Maximum Entitlement Volumes for Bores within 8km of the revised Project

	Quaternary Alluvium	Tertiary Basalt[1]	Walloon Coal Measures[1]	Marburg Sandstone[1]	Helidon Sandstone[1]
Volume (ML/year)	6,663	2,313	781	868	710

Notes: 1. Including licensed volumes at the Mine, see **Table 6-9**

Landholder Bore Survey

A landholder bore field survey was undertaken as part of the revised Project’s groundwater investigations. The survey was conducted in order to confirm and build on the information gathered from the DNRM database on groundwater occurrence and use in the vicinity of the revised Project.

Due to the large number of properties and groundwater bores adjacent the revised Project, only a selection of suitable, representative bores were targeted in the survey. The selection process was based on identifying properties within 3 km of the revised Project’s boundaries, and then selecting a representative distribution of properties surrounding the revised Project site that contain bores for which the source aquifer is known in the DNRM database. The bores/properties selected comprise a mixture of both private and Acland Pastoral Company (APC, owned by New Hope Group) land.

Following selection of sites, landholders were contacted to request participation in the survey. Where landholders were willing to participate, they were also asked to be present during the survey to provide additional anecdotal and historical bore information. Of the 19 originally selected private landholders/properties, 12 chose to participate in the program.

Information collected for each bore included (where available/possible):

- location GPS co-ordinates;
- current physical bore depth;
- construction details;
- source aquifer;
- current condition and status;
- details of pumping infrastructure;
- drilling & construction logs;
- licence details;
- current and historical usage;
- historical water quality information;
- field groundwater parameters (SWL, EC/TDS, pH, temperature, DO and Redox); and
- water samples for laboratory analysis.

Table 6-8 presents a summary of the landholder bore survey and **Figure 6-5** displays the location of bores assessed. As shown, a total of 50 bores were visited on 32 properties. Full details of the survey results are available in **Appendix G.4.2.**

Table 6-8 Summary of Landholder Bore Survey

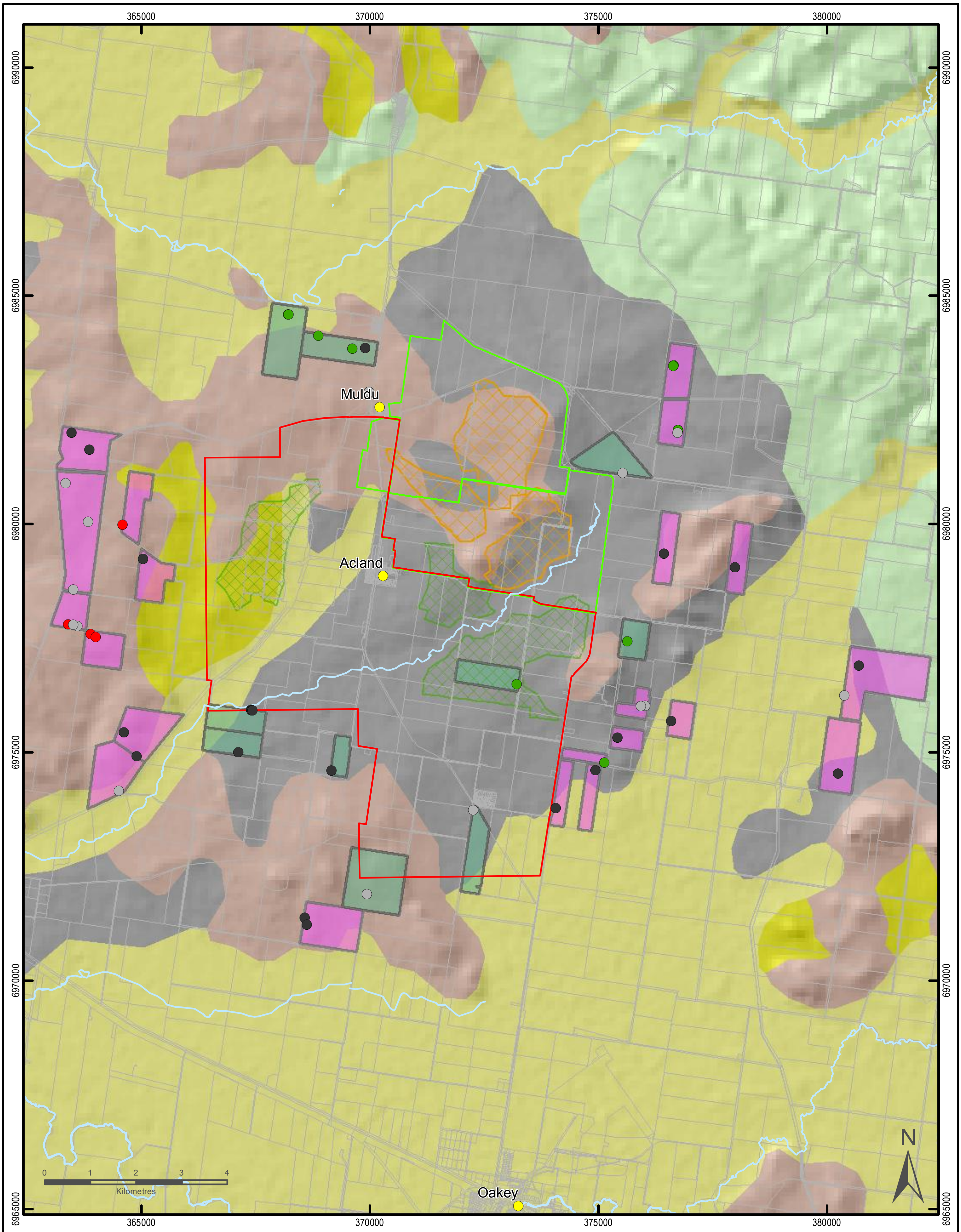
Aquifer[1]	Number of Bores Visited	Number of Bores with Water Level Information	Number of Bores with Water Quality Samples
Basalt	4	2	3
Walloon Coal Measures	21	9	8
Marburg Sandstone	11	4	6
Unknown	14	2	5
Total	**50**	**17**	**22**

Notes: 1. Based on information recorded in DNRM database, drillings logs, bore depth or landholder communication

The results of the landholder bore survey show that most bores surveyed access the Walloon Coal Measures aquifer (42%), followed by the Marburg Sandstone aquifer (22%) and finally the Tertiary Basalt aquifer (8%). It should be noted that 14 of the 50 surveyed bores (28%) were not able to be assigned to a specific aquifer, due to a lack of information contained within the DNRM bore database and that which was able to be provided by the bore owners.

Water level information was able to be collected from a total of 17 bores (34%) during the survey. Where water levels were unable to be collected, this was primarily as a result of installed pumping infrastructure limiting access, or abandonment of bores. Historical anecdotal water level information was also collected during the assessment; however this information has not been included in the count for the number of bores with water level information, as it was deemed unverifiable and possibly not representative of current conditions.

Water quality information was able to be collected from a total of 22 bores (44%) during the survey. Where water samples were unable to be collected, this was primarily as a result of a lack of installed and active pumping infrastructure.



LEGEND

- Towns and Localities

Landholder Survey Bores defined by Aquifer

- Not Defined
- Basalt
- Walloon Coal Measures
- Marburg Sandstone
- Watercourse

- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Cadastre
- Existing Permission
- Stage 3 Pit Areas

Cadastre- Survey Undertaken

- APC
- Public

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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Figure 6-5 - Location of Surveyed Landholder Bores

Scale 1:110,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 20/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130611_NewHope_Groundwater_Figure6-5_LocationOfSurveyedLandholderBores.mxd

Groundwater Use at the Mine

The Mine's main operational water supply is from fine tailings decant, supplemented by the WWRF Pipeline, groundwater sources and surface water captured in environmental dams and mine pit inflows. NAC currently holds water licenses to extract groundwater from the Cecil Plains Sub-Basin of the western section of the Clarence-Moreton Basin.

Table 6-9 summarises the licenced groundwater allocations for the Mine water supply bores as well as the current usage rates. The locations of the Mine's extraction bores are shown in **Figure 6-6**.

The WWRF Pipeline, established in 2010, has reduced the Mine's reliance on the Helidon Sandstone and Marburg Sandstone aquifers for industrial use. The Mine's recorded groundwater usage in 2012 (shown as "Current Usage" in **Table 6-9**) is significantly less than the licenced allocation before the WWRF Pipeline's commissioning.

Table 6-9 Groundwater Use at the Mine

Aquifer	Licence No.	Current Allocation (ML/year)	Current Usage (ML/year)[1]	Use
Helidon Sandstone	406524	710	17.1	Industrial
Marburg Sandstone	174733 and 403871	271	10.5	Industrial
Walloon Coal Measures	189552	271	2.6	Industrial
Tertiary Basalt	189547	160	11.0	Potable (after treatment)

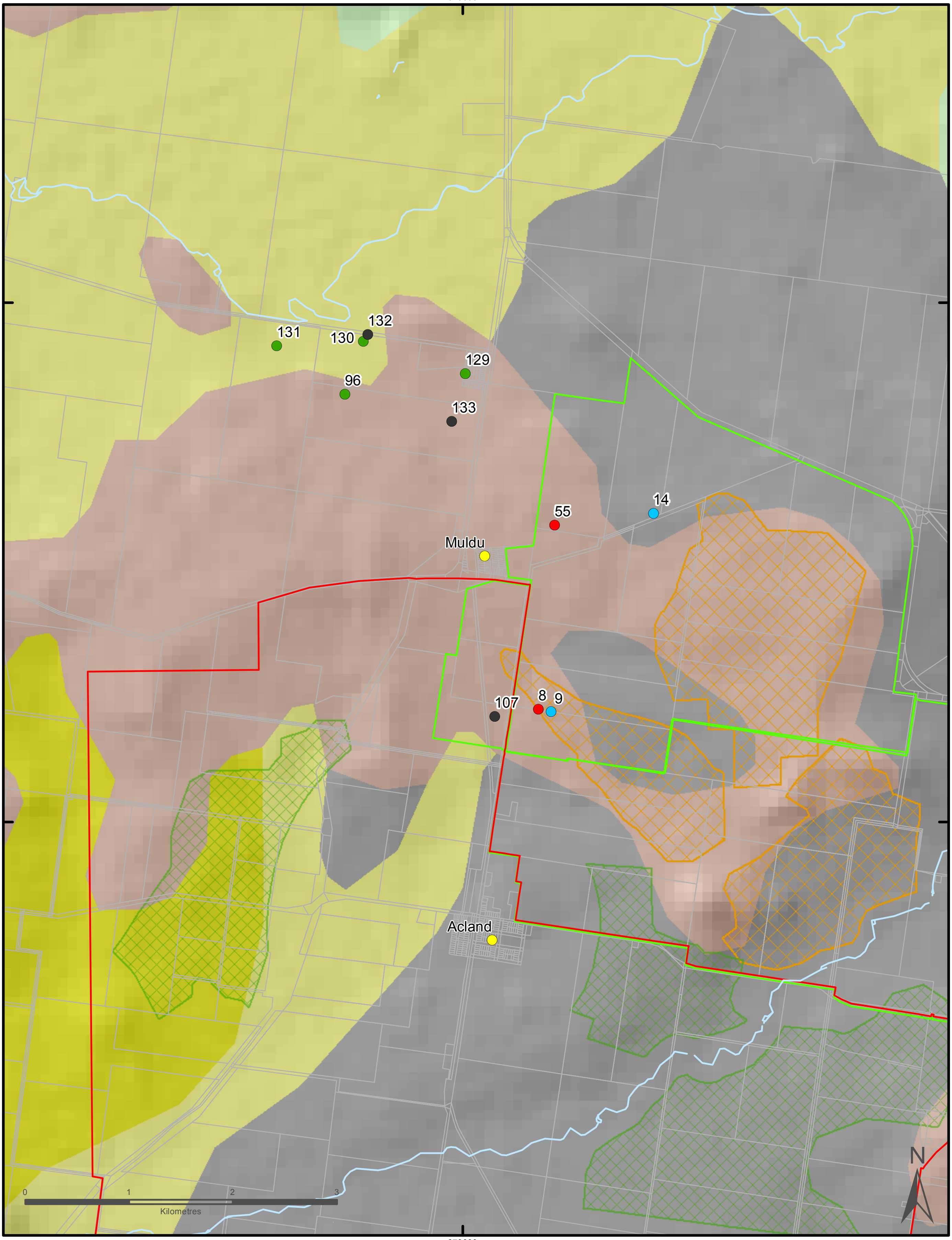
Notes: 1. Based on 2012 data

For the revised Project, the Tertiary Basalt allocation will continue to be partially used as the main water source to be treated for potable water. The Helidon Sandstone and Marburg Sandstone allocations will be maintained for emergency water supply purposes, which will involve periodic pumping of the associated bores to ensure groundwater extraction infrastructure is functioning efficiently. The extraction from the Walloon Coal Measures will be as a result of incidental groundwater inflows to the mine pit and will continue to be used for dust suppression.

6.2.6 Existing Mine Groundwater Monitoring

A groundwater monitoring program is currently in place for the Mine in accordance with NAC's EA. The groundwater monitoring program is summarised in **Table 6-10**. The locations of the groundwater monitoring bores for the Mine are shown in **Figure 6-7**.

Groundwater quality monitoring from compliance bores is conducted on a half yearly basis. The parameters monitored are shown in the notes at the end of **Table 6-10**. **Section 6.2.12** provides a summary of the groundwater quality monitoring results for the Mine.



LEGEND

Towns and Localities

APC Extraction Bores defined by Aquifer

- Basalt
- Walloon Coal Measures
- Marburg Sandstone
- Helidon Sandstone

Watercourse
New Acland Coal Mine
New Aland Coal Mine-Stage 3
Cadastre
Existing Permission
Stage 3 Pit Areas

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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Figure 6-6 - Location of NAC Extraction Bores

Scale 1:50,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 20/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130605_NewHope_Groundwater_Figure6-6_LocationOfNACExtractionBores.mxd

Table 6-10 Groundwater Monitoring Program defined by NAC's Mine EA

Site ID	Type	Aquifer	Groundwater Level Monitoring Frequency	WQ1[1] Monitoring Frequency
BMH1	Reference	Tertiary Basalt	Monthly	Half Yearly
CSMH1	Reference	Walloon Coal Measures		
2289Pc	Compliance	Walloon Coal Measures		
2291Pc	Compliance	Walloon Coal Measures		
18Pc	Compliance	Walloon Coal Measures		
25Pc	Compliance	Walloon Coal Measures		
26Pc	Compliance	Walloon Coal Measures		
27Pc	Compliance	Walloon Coal Measures		
28Pc	Compliance	Walloon Coal Measures		
81Pc	Compliance	Walloon Coal Measures		
82Pc	Compliance	Walloon Coal Measures		
83Pc	Compliance	Walloon Coal Measures		
84Pb	Compliance	Tertiary Basalt		
843b	Compliance	Tertiary Basalt		
848c	Compliance	Walloon Coal Measures		

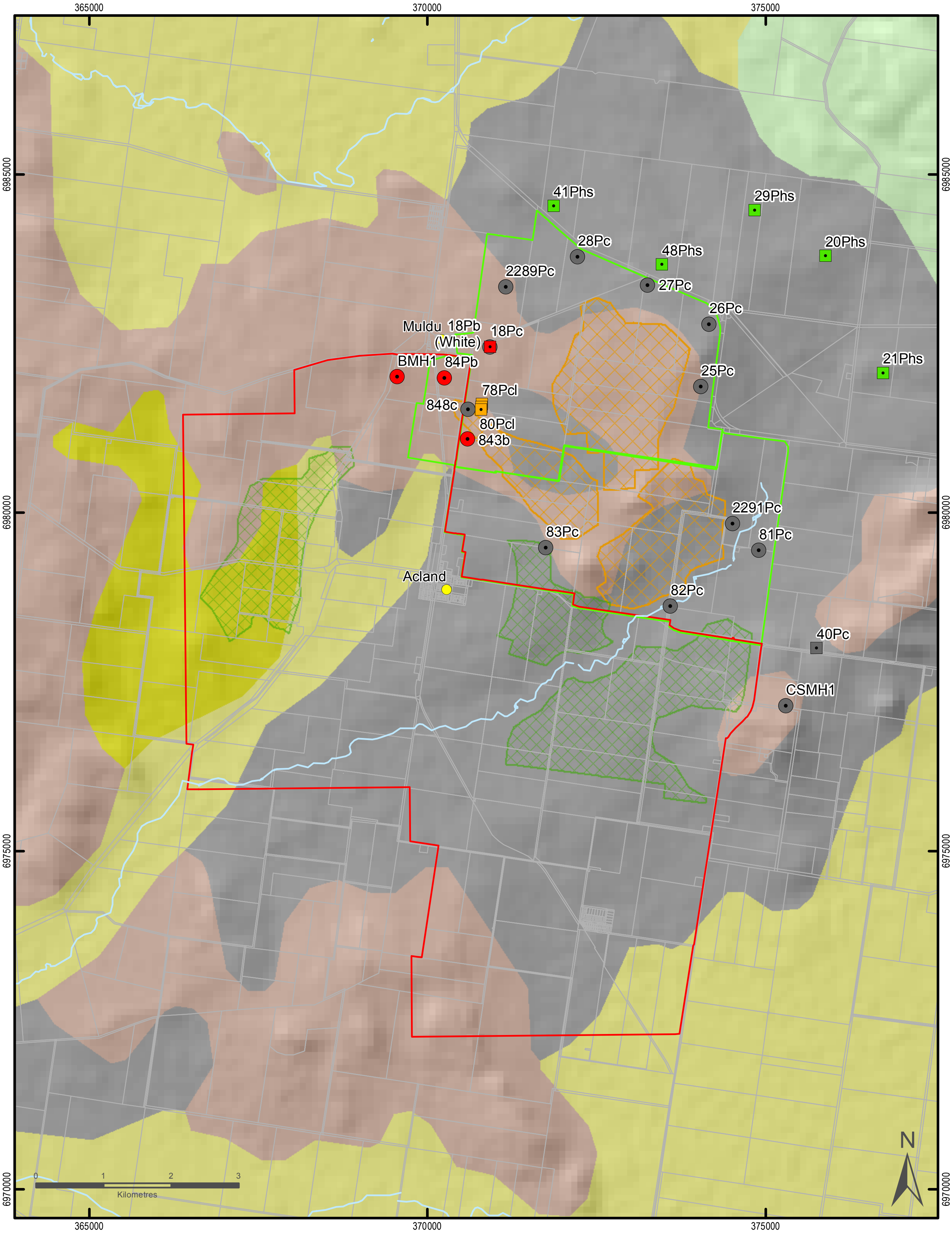
Notes: 1. Aluminium (Al), Arsenic (As), Selenium (Se), Copper (Cu), Fluorine (F), Iron (F), Total Nitrogen (Total N), Manganese (Mn); Calcium (Ca), Chloride (Cl), Potassium (K), Magnesium (Mg), Sodium (Na), Sulphate (SO4), Bicarbonate (HCO3), Carbonate (CO3), Total Dissolved Solids (TDS), Electrical Conductivity (EC); Acidity/Alkalinity (pH).

Groundwater level monitoring from compliance bores is conducted on a monthly basis. Groundwater levels which have been recorded at the Mine are summarised in **Section 6.2.8**.

In addition to the EA compliance monitoring sites, NAC undertakes groundwater level monitoring from additional groundwater monitoring bores. These are summarised in **Table 6-11** and locations are shown in **Figure 6-7**.

6.2.7 Revised Project Baseline Groundwater Monitoring

The purpose of the revised Project baseline groundwater monitoring is to expand the monitoring undertaken for the Mine to include the revised Project site. This expansion involved the installation of 14 groundwater monitoring bores at the revised Project site, which comprised 13 bores in the Walloon Coal Measures and one bore in the Tertiary Basalt. The locations of the additional Stage 3 groundwater monitoring bores are shown in **Figure 6-8**. A summary of the bore details is provided in **Table 6-12**.



LEGEND

Compliance\Reference Bores
- Tertiary Basalt
- Walloon Coal Measures

Additional Bores
- Clays (Alluvium)
- Tertiary Basalt
- Walloon Coal Measures
- Marburg Sandstone

- Towns and Localities
- Watercourse
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Cadastre
- Existing Permission
- Stage 3 Pit Areas

Dominant Geology
- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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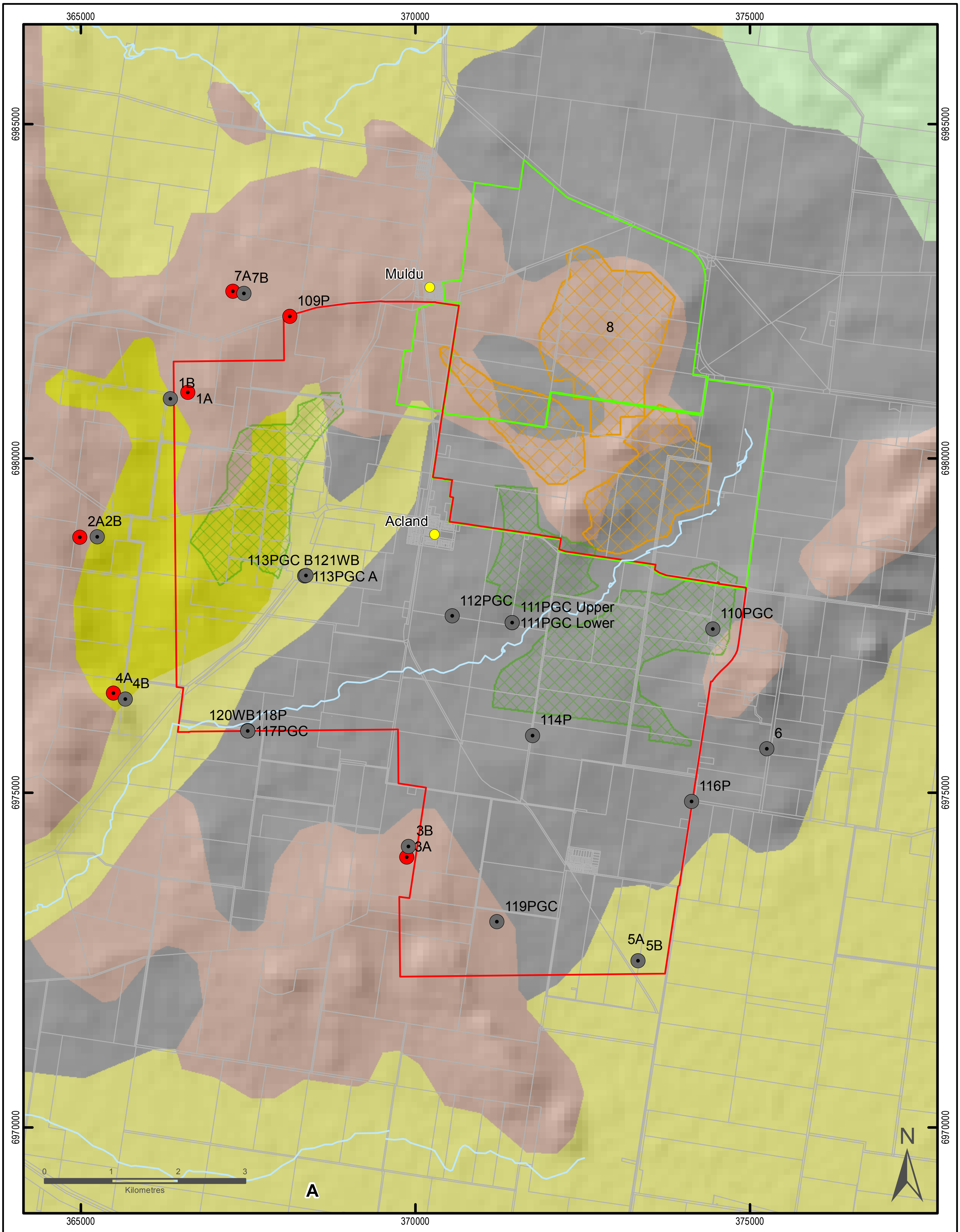
Figure 6-7 - Location of Mine Groundwater Monitoring Bores

Scale 1:75,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)



LEGEND

Towns and Localities

Aquifer

Basalt

Coal Measures

Watercourse

New Acland Coal Mine

New Aland Coal Mine-Stage 3

Existing Permission

Stage 3 Pit Areas

Cadastre

Dominant Geology

Basalt (Tm)

Alluvium (Qa)

Colluvium (TQs)

Walloon Subgroup (Jw)

Marburg Sandstone (Jbm)

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Figure 6-8 - Location of Stage 3 Groundwater Monitoring Bores

Scale 1:75,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130605_NewHope_Groundwater_Figure6-8_LocationOfStage3GroundwaterMonitoringBores.mxd

Produced: 20/08/2013

Table 6-11 Additional Mine Groundwater Monitoring Sites

Site ID	Type	Aquifer	Groundwater Level Monitoring Frequency
18Pb (White)	Additional	Tertiary Basalt	Two-Monthly
20Phs	Additional	Marburg Sandstone	
21Phs	Additional	Marburg Sandstone	
29Phs	Additional	Marburg Sandstone	
40Pc	Additional	Walloon Coal Measures	
41Phs	Additional	Marburg Sandstone	
48Phs	Additional	Marburg Sandstone	
78Pcl	Additional	Clays (Alluvium)	
79Pcl	Additional	Clays (Alluvium)	
80Pcl	Additional	Clays (Alluvium)	

Table 6-12 Summary of Stage 3 Monitoring Bore Details

Bore ID	Screen From (m)	Screen To (m)	Screened Aquifer
112PGC	35.5	41.25	Walloon Coal Measures
113PGCA	27	34	Walloon Coal Measures
113PGCB	43	50	Walloon Coal Measures
121WB	27	34	Walloon Coal Measures
117PGC	73.5	83.5	Walloon Coal Measures
118P	49	56	Walloon Coal Measures
120WB	73.5	83.5	Walloon Coal Measures
111PGC upper	28.5	33.5	Walloon Coal Measures
111PGC lower	39.5	45.5	Walloon Coal Measures
110PGC	39.5	54.5	Walloon Coal Measures
109P	98	102	Tertiary Basalt
116P	42	58	Walloon Coal Measures
119PGC	28.3	45.3	Walloon Coal Measures
114P	71	80	Walloon Coal Measures

Baseline groundwater monitoring is currently undertaken to assess the following attributes within the Walloon Coal Measures and Tertiary Basalt aquifers at the revised Project site:

- groundwater levels; and
- groundwater quality.

Groundwater monitoring at these bores continues on a monthly basis for levels and a six monthly basis for quality as part of the revised Project.

6.2.8 Groundwater Levels

Groundwater Levels at the Mine

Groundwater level monitoring has been undertaken in accordance with the Mine's EA on a monthly basis since 2003. From 2001 to 2003, groundwater level monitoring was undertaken in accordance with the Mine's pre-EA approval, which was the accepted Environmental Management Overview Strategy (NAC, 2001). These bores provide groundwater levels in various aquifers, including the Tertiary Basalt and Walloon Coal Measures aquifers. Non-EA mandated groundwater monitoring is also undertaken for the Marburg Sandstone aquifer.

Reduced water levels (mAHD) for the groundwater monitoring sites within the Walloon Coal Measures are shown in **Figure 6-9**. Bore locations for currently active monitoring bores are shown on **Figure 6-7**. There are 13 monitoring bores currently in place to monitor groundwater level changes in the Walloon Coal Measures aquifer adjacent the Mine. Monitoring within the Walloon Coal Measures commenced in early 2002 and is ongoing. Monitoring has been undertaken in a staged fashion, with more bores coming online as mining has progressed, consistent Mine expansions.

Monitoring in bores 18P, 27P and 28P show little influence from mining from 2002 through to 2010, with varying degrees of response to recharge events. The influence of a large rainfall event at the end of 2010 (and generally above average rainfall throughout 2010) is clearly evident in these bores, as well as most other Walloon monitoring bores, suggesting significant groundwater recharge from this period. Monitoring bore 848c shows a very clear influence from mining activities, with drawdown in 2006 reaching a peak of around 20 m, before recovering back to pre-2006 levels by the start of 2011. Bores 81P and 82P show drawdown influence of up to around 12 m attributed to mining from around 2011, and recent investigations by NHG have shown this may be a result of faulting-related preferential groundwater flow within the Walloon Coal Measures aquifer. Bores CSMH1, 42P, 40P are relatively stable over the period of monitoring, with water level fluctuations limited to less than 5 m. Bore 2289 shows recovery of around 6 m over the period of monitoring.

No monitoring bore shows drawdown impacts of more than around 20 m over the duration of monitoring, and all drawdowns appear to stabilise over a period of around two years (i.e. continuing drawdown at a rapid rate does not occur in any bore).

Figure 6-10 shows the groundwater levels (mAHD) for the groundwater monitoring sites within the Tertiary Basalts.

Tertiary Basalt monitoring bores display groundwater elevations ranging from 420 to 445 mAHD, with three of the monitoring bores displaying groundwater elevations that are consistently between 430 and 445 mAHD over the latter part of the monitoring period. The monitoring bore hydrographs show varying responses over the period of monitoring, with bores 18P and 843b show fluctuations of up to 15 m, and this may be related to their proximity to water supply bores sourcing water from the same aquifer. There is clear evidence of a recharge event in the Tertiary Basalt aquifer associated with significant rainfall during 2010 and start of 2011. Bore 843b displays both lower and more variable groundwater levels, and is located closest to Mine water supply bores (as shown in **Figure 6-6**), suggesting this bore is displaying groundwater level fluctuations associated with Mine water supply extraction.

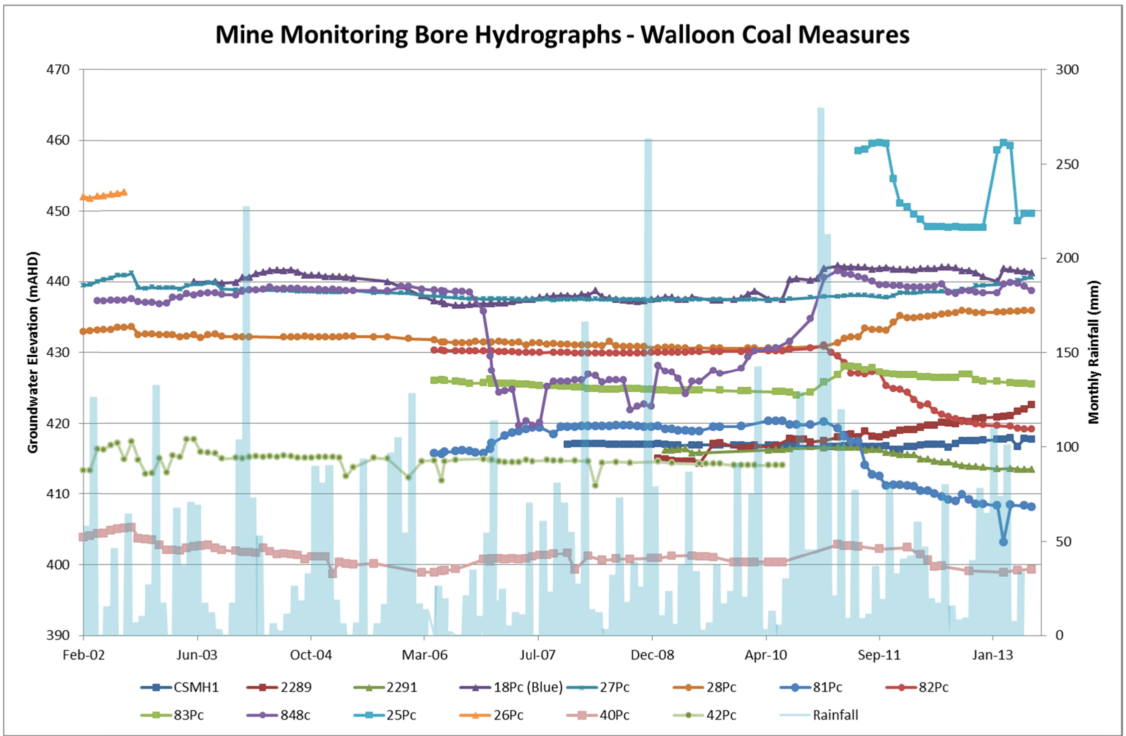


Figure 6-9 Walloon Coal Measures Compliance Monitoring Bore Hydrographs

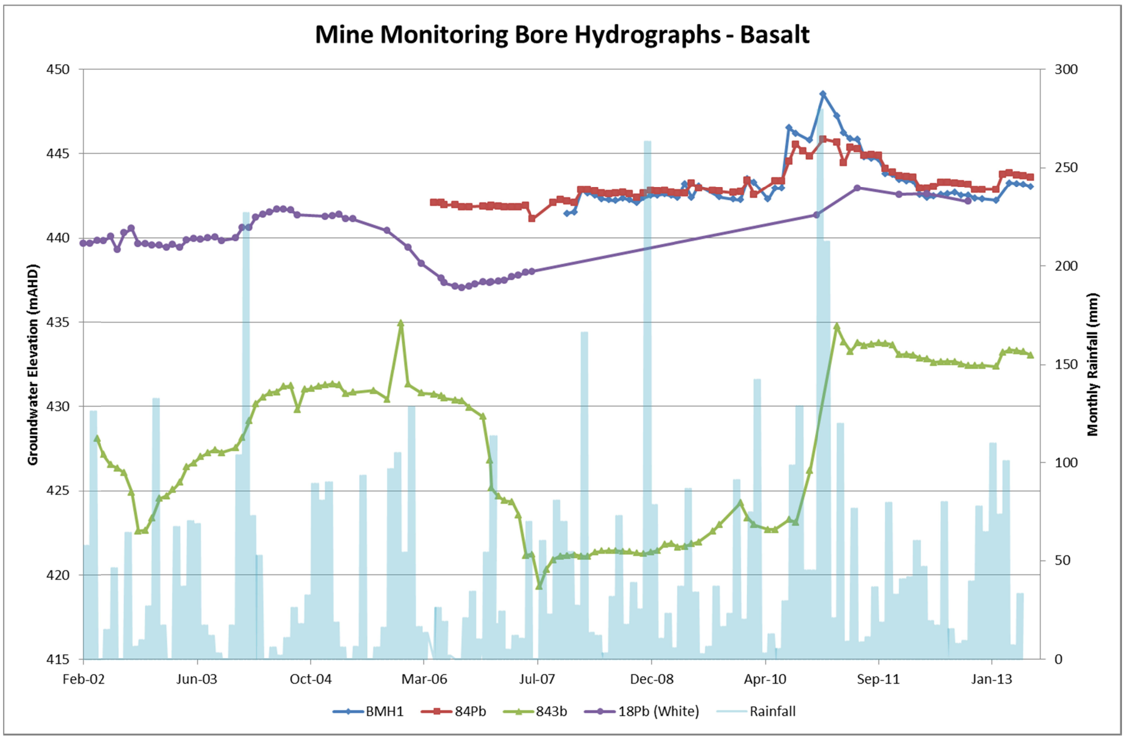


Figure 6-10 Tertiary Basalt Monitoring Bore Hydrographs

There are five bores currently used for monitoring Marburg Sandstone as shown in **Figure 6-11**. Marburg Sandstone monitoring bores show groundwater elevations ranging from 395 mAHD to 440 mAHD, and most show a distinct drawdown trend through to the end of 2008, likely associated with extraction for Mine water supply purposes. Groundwater elevations in the three monitoring bores showing this drawdown response range from 416 to 419 mAHD at the start of the monitoring record in 2002 before showing rapid drawdown from mid-2006. However, water levels show an increasing (recovering) trend from the start of 2009, and continue to recover through to present day. Recovery is associated with a reduction in Mine groundwater use due to the WWRF Pipeline coming online, and further recovery is expected to continue into the future. Bore 29P shows an elevated groundwater level compared to the other bores; the reason for this is currently unknown.

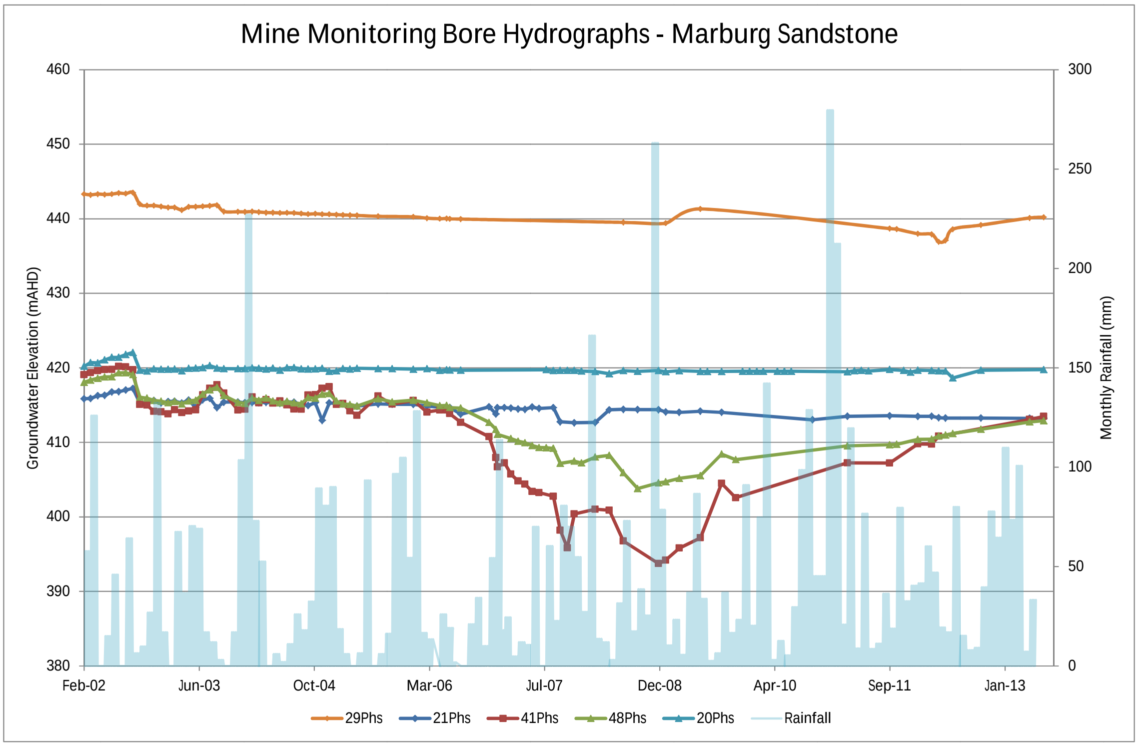


Figure 6-11 Marburg Sandstone Monitoring Bore Hydrographs

Groundwater Levels for the revised Project Site

Groundwater level monitoring results for the revised Project site are shown in **Figure 6-12**. Bore locations are shown on **Figure 6-8**. The majority of bores are screened in the Walloon Coal Measures except bore 109P which is screened in the Tertiary Basalt.

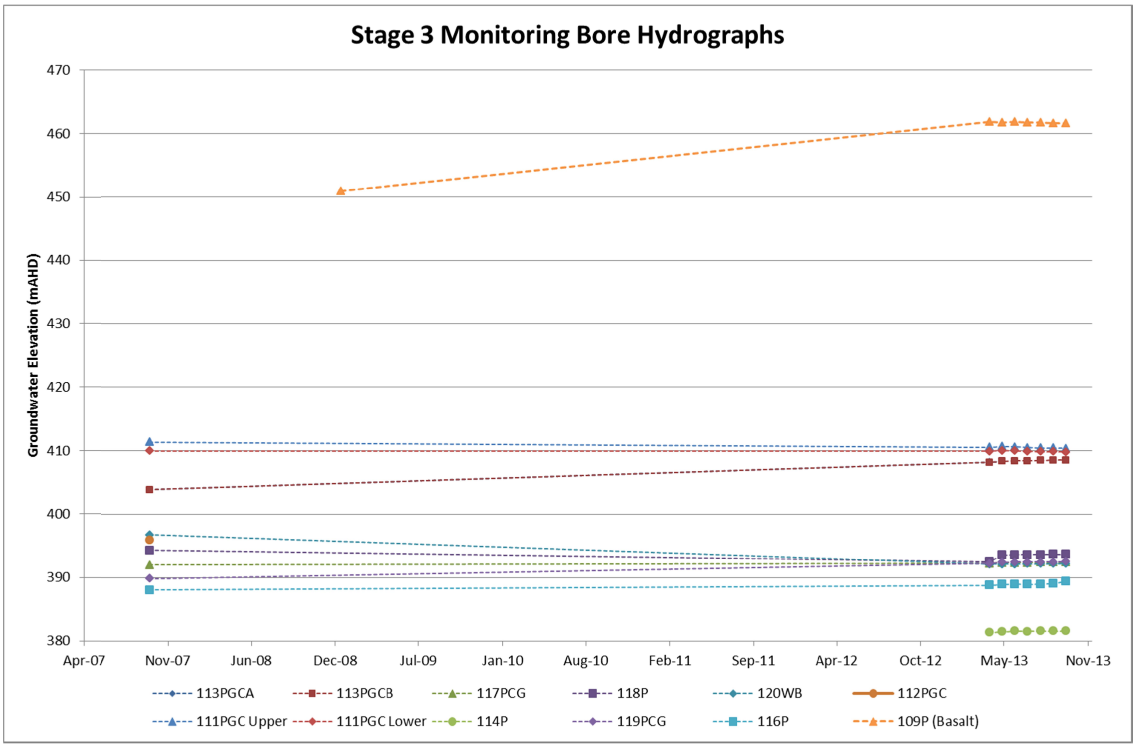


Figure 6-12 Stage 3 Monitoring Bore Hydrographs

Monitoring data prior to 2013 is available for a single monitoring event in 2007 for the Walloon Coal Measures and in 2008 for the Tertiary Basalt aquifer. Regular (monthly) monitoring was instigated in April 2013 and continues currently, with all bores added to the routine Mine groundwater monitoring schedule. The monitoring bores within the revised Project site show groundwater elevations ranging from 380 to 410 mAHD in the Walloon Coal Measures aquifer (appearing to be in quasi-steady state for individual bores), and 450 to 460 mAHD in the Tertiary Basalt aquifer. Although the data is limited from which to draw meaningful conclusions on long term trends, it is evident that groundwater levels have fluctuated over a range of up to 5 m in the Walloon Coal measures aquifer and 10 m (increase) in the Tertiary Basalt aquifer over the duration of monitoring (around 5 years), which possibly suggests some sensitivity to recharge events.

6.2.9 Groundwater Movement

The movement of groundwater within an aquifer is driven by the elevation of the groundwater potentiometric surface, which often mirrors topographic surface terrain in a more subdued manner, but is also influenced by various natural and anthropogenic factors including geological structure, enhanced or decreased recharge, and groundwater extraction.

Groundwater elevation contours (potentiometric surface) for the Walloon Coal Measures aquifer were constructed for the current Mine and the revised Project site for May 2013, based on data collected from Mine and Stage 3 monitoring bores and the known Mine pit extents and working depths at the time, and are shown on **Figure 6-13**.

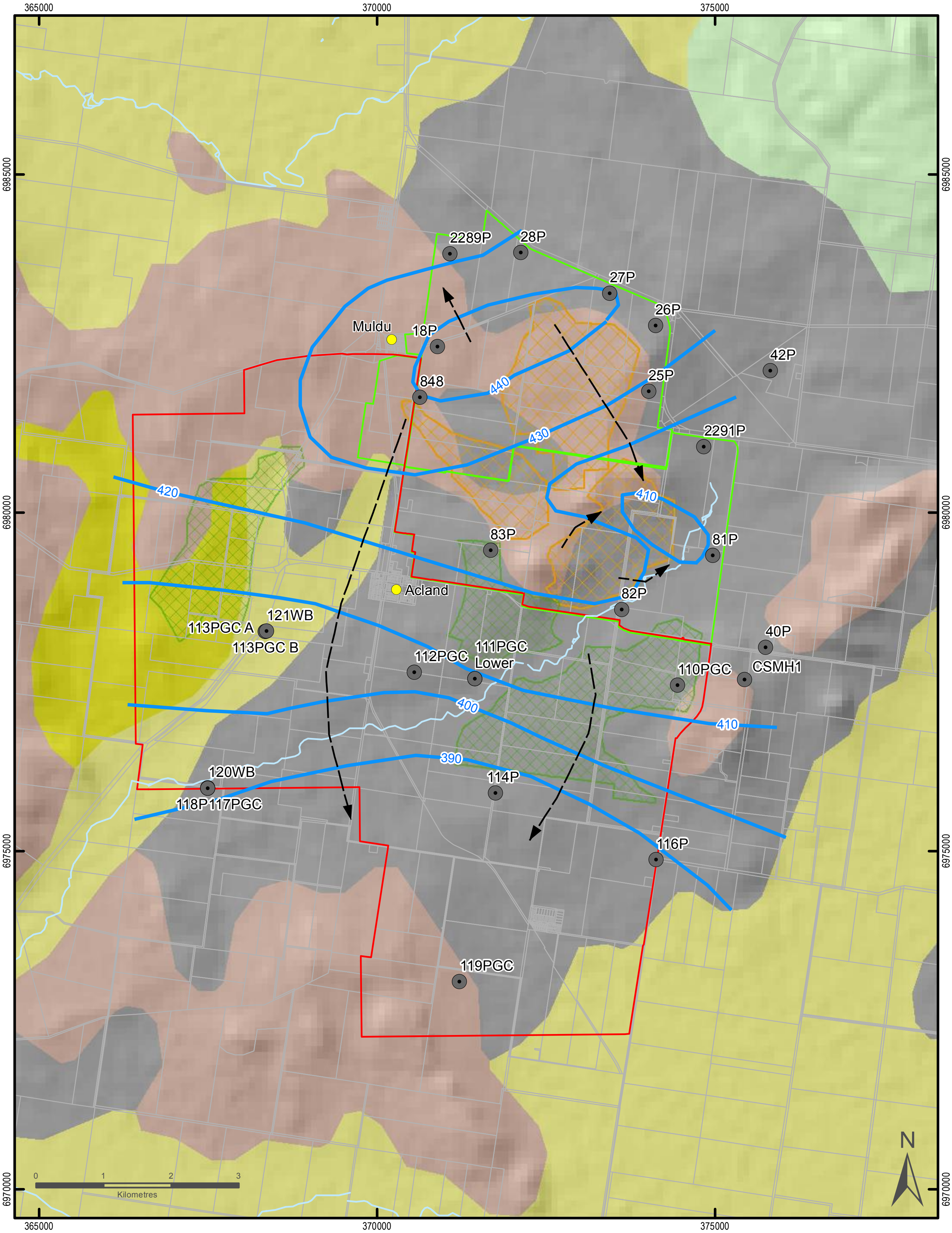
The groundwater level data indicate that the overall direction of groundwater flow in the Walloon Coal Measures aquifer beneath the revised Project site is to the south, from elevations of around 430 mAHD in the north to 390 mAHD in the south. This direction of flow is consistent with the regional topographic surface and the geological dip of the Walloon Coal Measures to the south-southwest.

The data show that there is an area of elevated groundwater levels (approximately 440 mAHD) within the Walloon Coal Measures in the north of the current Mining area, consistent with the location of the previously worked and backfilled mining areas and the location of in-pit tailings dams. The extent of this groundwater mounding is limited to 1 to 2 km from the mined and backfilled area, and inferred groundwater flow contours show that much of the mounded groundwater flows to the active mine pits which act as a groundwater sink.

The contours also show the extent of potentiometric surface disruption related to current mining, which appears to be limited to within 1 km of the currently active pit and currently show groundwater elevations of 410 mAHD.

The distribution of the Tertiary Basalt aquifer within the current mining area and revised Project site, and therefore the distribution of monitoring bores within the Mine and revised Project leases accessing that aquifer, is insufficient to draw meaningful conclusions of groundwater movement within the basalt aquifer. Further monitoring as proposed in **Section 6.4.1** is aimed at addressing these data gaps. However, currently available data for the northwest of the current Mine area show a general increase in groundwater elevation in the westerly direction, from around 433 mAHD to 460 mAHD in May 2013. These groundwater elevations in the Tertiary Basalt aquifer are generally slightly higher than groundwater elevations for the Walloon Coal Measures in the same area, especially to the west away from the Mine area, suggesting some degree of hydraulic disconnection between the two aquifers, and a downwards hydraulic gradient between them. However, the lower groundwater elevation at the closest basalt monitoring bore (853b, ~ 433 mAHD) may indicate some drawdown influence from historical mining activities.

The distribution of current Mine and revised Project monitoring bores within the Marburg Sandstone aquifer is insufficient to draw meaningful conclusions of the direction of groundwater movement within that aquifer; given the significant depth of this aquifer below the Mine workings the only requirement for monitoring in this aquifer to date has been in the area of the Mine's Marburg Sandstone water supply bores to the north of the current mining area. However, on a regional scale groundwater flow within the Marburg Sandstone is expected to be from the recharge areas northeast of the revised Project site where the formation outcrops, in a southwesterly direction consistent with the general structural dip of the formation.



LEGEND

- Towns and Localities
- Mine Monitoring Bores - Coal Measures
- Walloon Coal Measures Groundwater Elevation Contours (May 2013)(mAHD)
- Inferred Groundwater Flow Direction
- Watercourse
- Cadastre
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Existing Permission
- Stage 3 Pit Areas

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

NEW HOPE GROUP

SINCLAIR KNIGHT MERZ SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-13 - Potentiometric Surface - Walloon Coal Measures (May 2013)

Scale 1:75,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130605_NewHope_Groundwater_Figure6-13_PotentiometricSurface_WalloonCoalMeasures.mxd

Produced: 20/08/2013

6.2.10 Inter-aquifer Connectivity

The Quaternary Alluvial aquifer is shown to be unlikely to be present within the revised Project site. However, the aquifer is known to occur in association with Oakey Creek and its tributaries south of the revised Project site, and Myall Creek and its tributaries north of the revised Project site, where it directly overlies the Walloon Coal Measures in places. As such, the potential exists for hydraulic connection between the two units, especially if coal seams (the main water bearing units of the Walloon Coal Measures) subcrop in direct connection with the overlying alluvium. However, significant drawdown impact on the alluvial aquifer from mining activities associated with the revised Project would require substantial expansion of drawdown within the Walloon Coal Measures outside of the revised Project site to the north and south, which is considered unlikely.

Given that there is little occurrence of the basalt aquifer within the revised Project site, it is unlikely that mining activities will have a direct regional impact on the basalt aquifer. However, it is known that the Tertiary basalt aquifer was deposited in palaeochannels incised into the Walloon Coal Measures palaeosurface and so the potential exists for direct hydraulic connection between the basalt aquifer and the Walloon Coal Measures, especially if a coal seam (the main water bearing units of the Walloon aquifer) were exposed to the basalt-filled palaeochannels. This depositional environment means that mining undertaken as part of the revised Project has the potential to cause groundwater drawdown in the basalt aquifer as mining occurs below the water table in the Walloon Coal Measures. Similarly to the Quaternary Alluvial aquifer, the degree of drawdown in the basalt aquifer will depend on the extent to which drawdown in the Walloon Coal Measures expands outside of the revised Project site to where the basalt aquifer occurs (mainly to the south and west outside of the revised Project site).

The Marburg Sandstone aquifer lies at significant depth (>75 m) below the deepest proposed mining depths in the revised Project site, and is separated from the mined coal seams by dominantly low permeability sediments (mudstones and siltstones) of the Walloon Coal Measures and Eurombah Formation. These low permeability strata act as a confining aquitard to limit the hydraulic connection between the two units; as a result, little impact on the Marburg Sandstone aquifer is expected from mining activities. Hydraulic separation is supported by monitoring bore data from the current Mine monitoring network showing water levels in the Marburg Sandstone to be significant below those of the Walloon Coal Measures aquifer; this is highlighted in **Figure 6-8** and **Figure 6-10** showing bore 27P (Walloon Coal Measures) currently displaying a potentiometric head around 25 m above that of bore 48P (Marburg Sandstone) at a similar location (**Figure 6-6** shows bore locations). However, the occurrence of faults extending from the Marburg Sandstone to the coal seams of the Walloon Coal Measures cannot be discounted, and it is possible that some of these faults may act as conduits for groundwater flow.

The Helidon Sandstone aquifer is separated from the Marburg Sandstone aquifer by the dominantly low permeability Evergreen Formation which acts as a confining aquitard to limit the hydraulic connection between the two units. Again, the occurrence of faults extending from the Helidon Sandstone to the Marburg Sandstone or coal seams of the Walloon Coal Measures cannot be discounted, and it is possible that some of these faults may act as conduits for groundwater flow.

However, it is generally considered that the Helidon Sandstone aquifer is almost completely hydraulically isolated from the overlying units due to the presence of the Evergreen Formation.

6.2.11 Surface Water and Groundwater Interaction

Based on the studies undertaken as part of Stage 2 EIS, streams are assessed as being ephemeral and there are no perennial water courses or water holes present within the revised Project site. A comparison of groundwater levels and stream bed levels indicates that groundwater elevations lie below those of stream beds in the revised Project site, indicating groundwater does not contribute to surface water flow within these creeks and streams and that groundwater drawdown is unlikely to cause stream flow losses during flow events. After significant rainfall events which result in runoff to surface water drainage lines, it is anticipated that a component of surface flow will infiltrate and a small amount will reach the Quaternary Alluvial aquifer water table, which is generally several tens of metres below the stream beds. The majority of the infiltrated water is likely to be lost by direct evapotranspiration along the stream riparian zone.

6.2.12 Groundwater Quality

The following sub-sections provide a summary of the water quality data collected for the Mine and the revised Project site. As well as in consideration of the EPP Water as described in **Section 6.1.1**, groundwater quality data has been compared to the following guidelines based on the EVs of the revised Project site:

- ANZECC 2000 Guidelines;
- Queensland Water Quality Guidelines 2009 (QWQG); and
- Australian Drinking Water Guidelines 2011 (ADWG).

The revised Project site lies within the Murray-Darling Region of the QWQG. For this Region, the QWQG states that background water quality information is insufficient to set reliable guidelines and so water users may default to the ANZECC 2000 Guidelines. This suggestion has been followed in the following groundwater quality assessment.

Groundwater results were not compared to ANZECC Guidelines for the protection of aquatic ecosystems for reasons outlined in **Section 6.2.13**.

Groundwater Quality for the Mine

A groundwater quality monitoring program is undertaken at the Mine in accordance with the requirements of the EA. This monitoring is performed in accordance with EHP's Monitoring and Sampling Manual (2009). The monitoring program targets the Walloon Coal Measures aquifer and the Tertiary Basalt aquifer. **Appendix G.4.3** presents the results of all groundwater quality monitoring undertaken at the Mine from 2003 to 2012, including the results of monitoring for major ions and hydrocarbons. The following provides a summary of the groundwater monitoring results for the main groundwater quality indicators (pH, EC and TDS) that have been collected since the commencement of the program.

Walloon Coal Measures Aquifer

The results for pH from groundwater bores in the Walloon Coal Measures are shown in **Figure 6-14**. Based on the results obtained from groundwater monitoring bores installed in the Walloon Coal Measures, pH is generally neutral to slightly alkaline and ranges from 6.8 to 8.5 for most bores. Exceptions are an isolated anomalous measurement of pH > 9 for bore 18P and bore 2289 which reports highly variable pH readings of generally at or less than 7. No trends are evident in the data that can be directly attributed to mining. The ADWG suggest that the pH of drinking water should be between 6.5 and 8.5. The majority of the results are within this guideline limit.

The results for Electrical Conductivity (EC) from groundwater bores in the Walloon Coal Measures are shown in **Figure 6-15**. EC within the Walloon Coal Measures ranges from around 500 µS/cm to 11,000 µS/cm and is generally fairly stable, with a slightly declining trend possibly evident in some bores. Bore 2289 shows highly variable EC measurements, consistent with the highly variable pH readings.

Figure 6-16 shows the results for Total Dissolved Solids (TDS) for groundwater bores in the Walloon Coal Measures. TDS results range from around 300 mg/L to 7,000 mg/L, with fairly stable readings from individual bores with the exception of bore 2289. A slight decreasing trend may be evident in some bores. Again, bore 2289 shows significant variation in readings. The ADWG suggest that the TDS of drinking water should not exceed 600 mg/L. The majority of the results are well in excess of this guideline limit.

The tolerance of livestock to TDS in drinking water has been identified in the ANZECC Guidelines. In general terms, for no adverse effects to occur to animals the upper limit for TDS is 4,000 mg/L. The majority of results from the groundwater monitoring in the Walloon Coal Measures are within these guideline limits and therefore suggest that the quality of water in the bores monitored remains acceptable for livestock use. However bores, 27P, 28P and 2289 had results consistently above 4,000 mg/L which exceed the upper limit of the ANZECC Guidelines. The ANZECC Guidelines also state that when TDS ranges from 4,000 mg/L to 10,000 mg/L, animals may have an initial reluctance to drink, however, they should eventually adapt to these conditions without a measurable loss of production. EC values are generally in the range suitable only for irrigation where the crops are tolerant or very tolerant to salinity as described in the ANZECC Guidelines.

On the basis that results from bore 2289 were not found in any other bores, the results for bore 2289 have been considered to be anomalous and are possibly due to poor bore construction, minimal aquifer intersection, or erroneous sampling procedures in the field, all which can lead to sample contamination or false measurements.

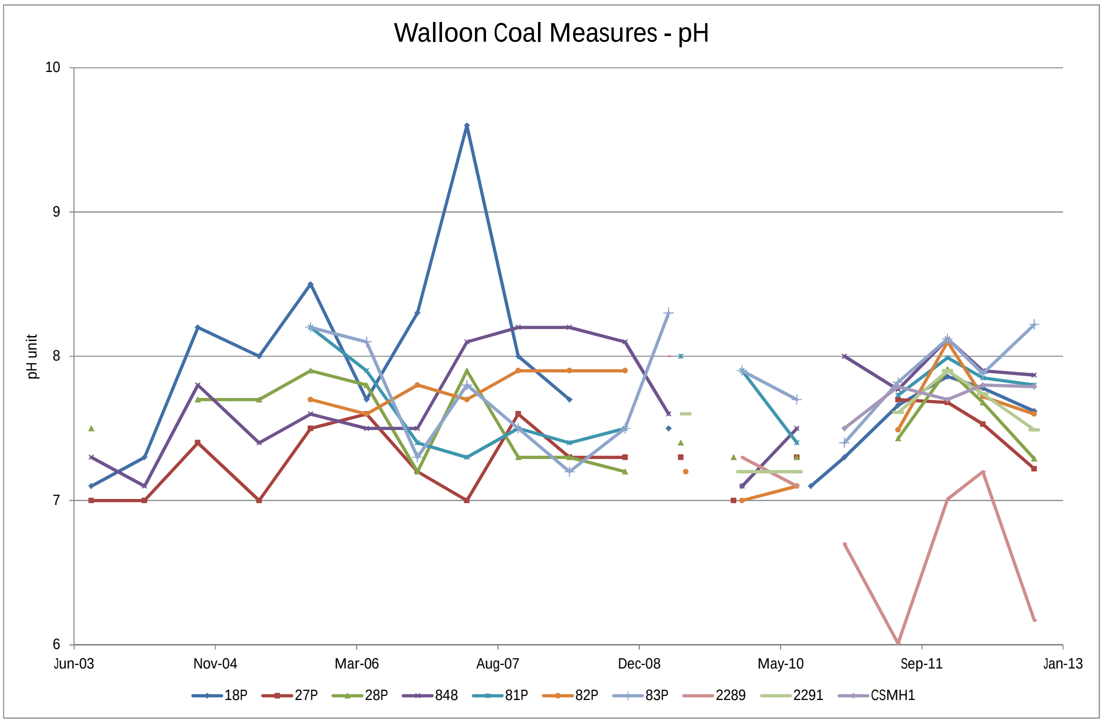


Figure 6-14 pH results for the Walloon Coal Measures

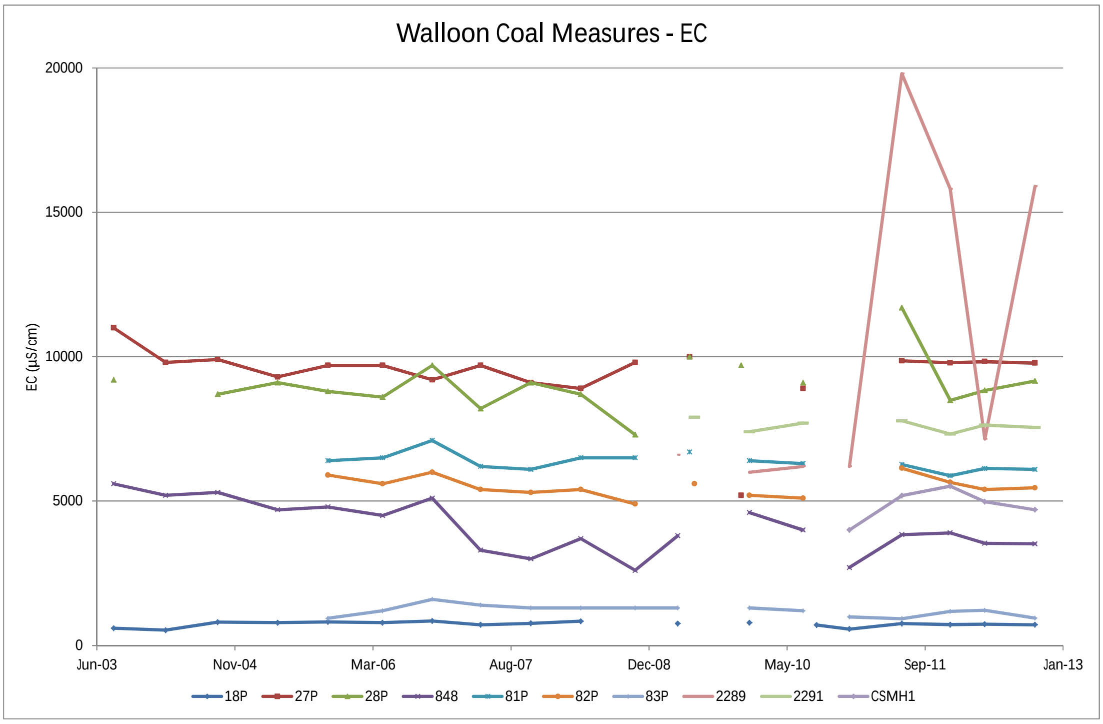


Figure 6-15 Electrical Conductivity results for the Walloon Coal Measures

Tertiary Basalt Aquifer

The results for pH in the Tertiary Basalts are shown in **Figure 6-17**. The results for pH within the Tertiary Basalts range from 7.2 to 8.2, which indicates that groundwater quality within the basalts is neutral to slightly alkaline. pH values are relatively stable over the period of monitoring with no trends discernible. Results fall within the ADWG limit of 6.5 to 8.5.

The results for EC from groundwater bores in the Tertiary Basalt are shown in **Figure 6-18** and **Figure 6-19** shows the results for TDS for groundwater bores in the Tertiary Basalt. No discernible trends that can be attributed to mining are evident in the data. However, there may be a rainfall (recharge) related trend as shown by increasing pH following 2010.

The groundwater salinity in the Tertiary Basalts is generally lower than the Walloon Coal Measures, with TDS ranging from 800 to 3,000 mg/L (i.e. 1,300 to 4,500 µS/cm EC), further suggesting a recharge related phenomena. Accordingly, a greater number of users extract groundwater from this aquifer for livestock and domestic purposes.

All of the groundwater monitoring results from the Tertiary Basalts were within the ANZECC Guidelines for livestock use of 4,000 mg/L. EC values are generally in the range suitable only for irrigation where the crops are moderately tolerant to salinity as described in the ANZECC Guidelines. The ADWG suggest that the TDS of drinking water should not exceed 600 mg/L. All results from the Tertiary Basalt are well in excess of this guideline limit.

Groundwater Quality for the revised Project site

Groundwater quality monitoring was undertaken from monitoring wells installed within the Walloon Coal Measures and Tertiary Basalt within the revised Project site. Physico-chemical results from the revised Project baseline groundwater monitoring program are summarised in **Table 6-13**.

As shown in **Table 6-13**, pH in groundwater ranged around neutral in the Walloon Coal Measures (6.8 to 7.4) and is slightly alkaline in the Tertiary Basalt (8.2). All of the results are within the ADWG limit for pH.

The EC and TDS results indicate that the groundwater within the Walloon Coal Measures is generally brackish beneath the revised Project site, with TDS results ranging from 1,240 to 6,610 mg/L. The majority of results from the groundwater monitoring in the Walloon Coal Measures are within the ANZECC Guidelines of 4,000 mg/L for TDS and therefore suggest that the quality of groundwater is acceptable for livestock use. Bores 118P and 111PGC had results above 4,000 mg/L which exceed the upper ANZECC Guideline limit for salinity. All results for the Walloon Coal Measures in the revised Project site are well in excess of the ADWG limit of 600 mg/L TDS.

Groundwater within the Tertiary Basalt aquifer is significantly fresher than the Walloon Coal Measures, with a TDS of 330 mg/L. This single recorded value for Tertiary Basalt salinity is at the lower end of measured salinities from basalt monitoring bores associated with the current Mine (and discussed in **Section 6.2.12**). The single TDS measurement from the Tertiary Basalt in the revised Project site is within the ADWG limit of 600 mg/L TDS.

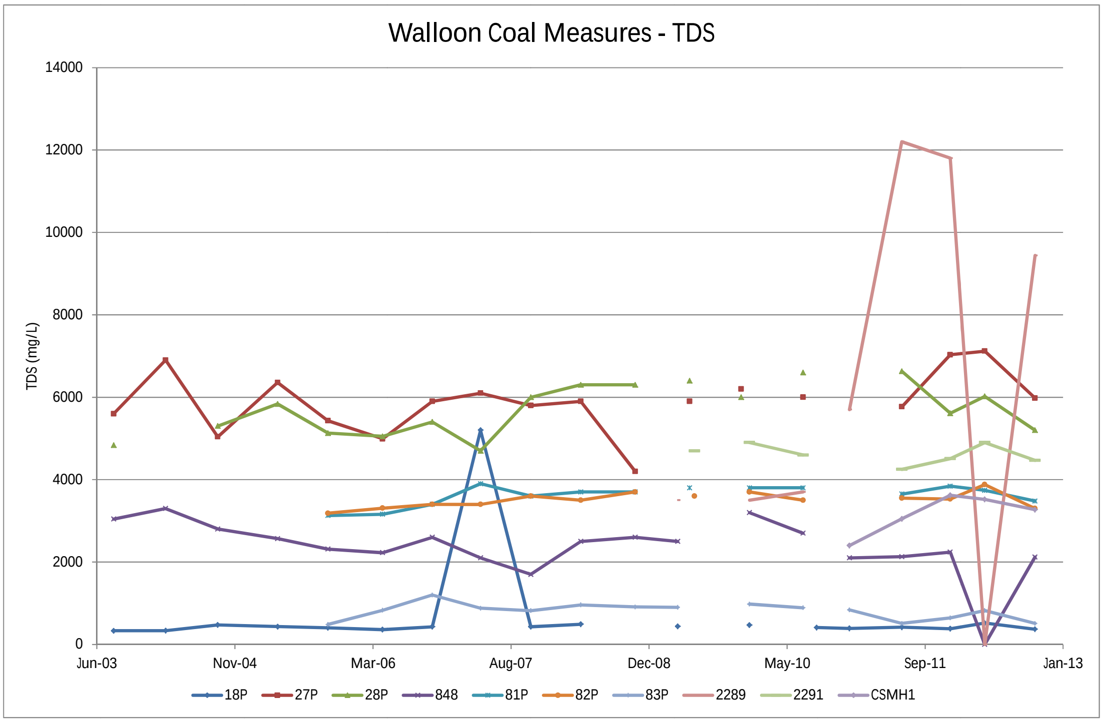


Figure 6-16 Total Dissolved Solids for the Walloon Coal Measures

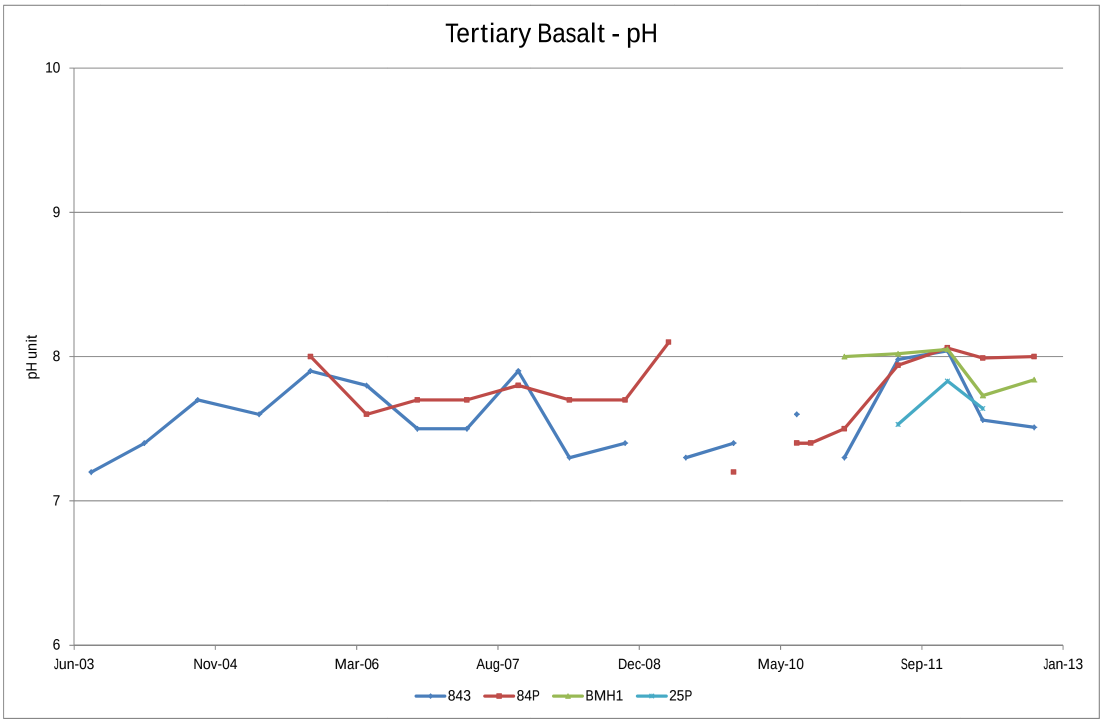


Figure 6-17 pH results for the Tertiary Basalts

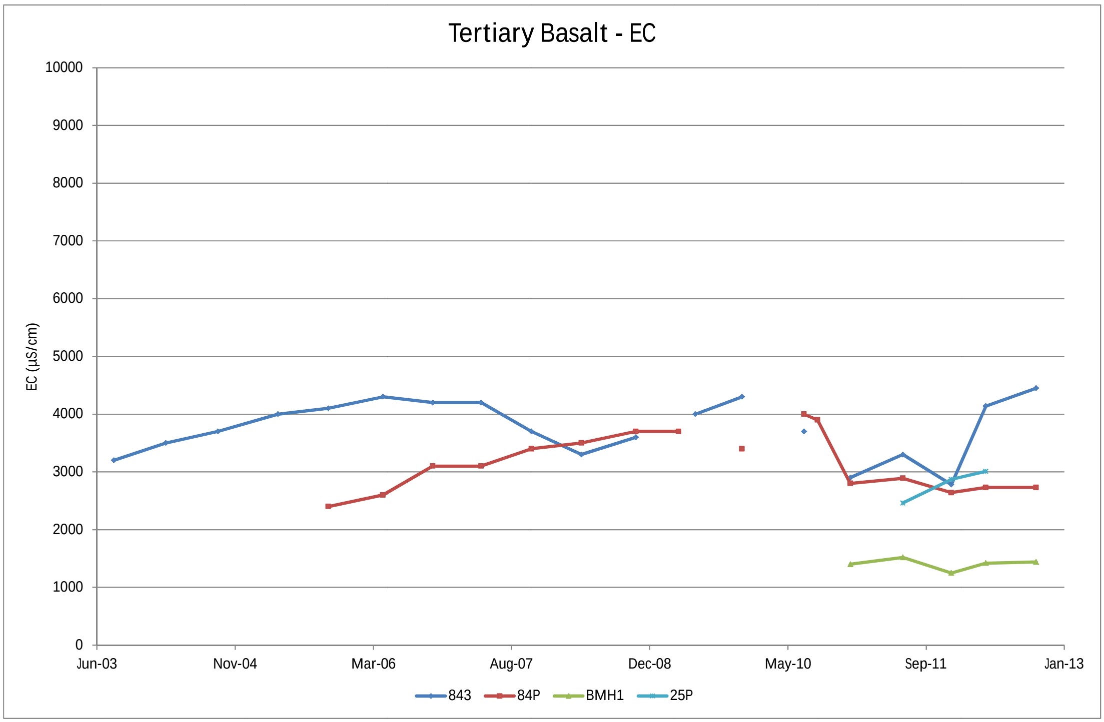


Figure 6-18 Electrical Conductivity results for the Tertiary Basalts

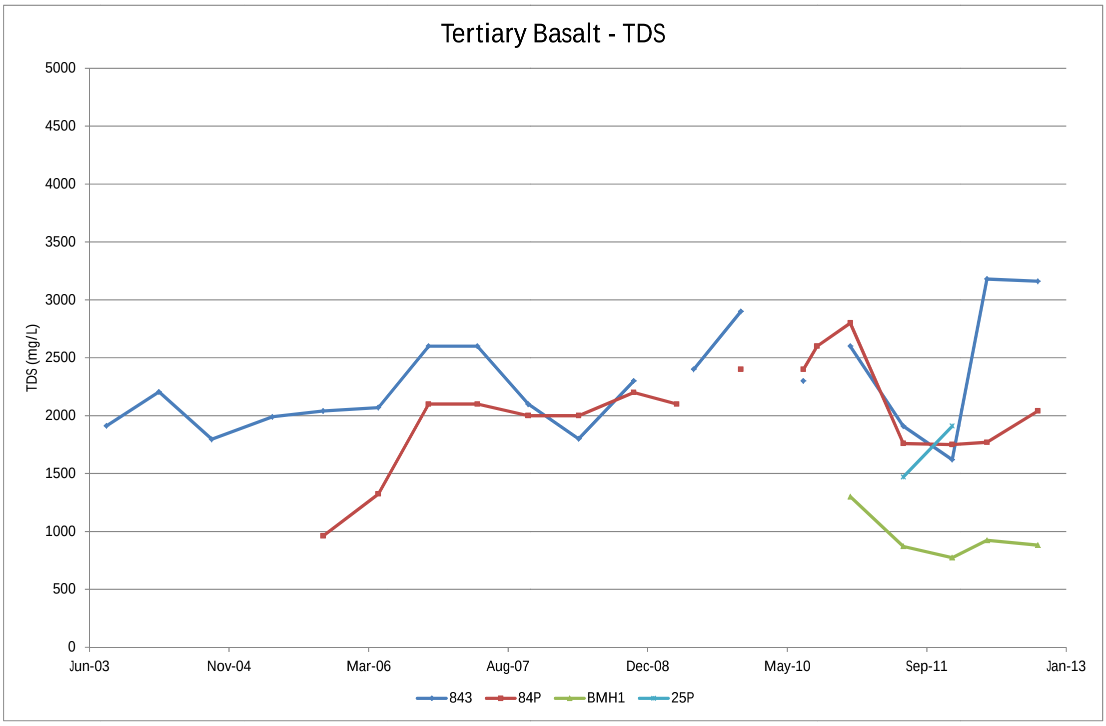


Figure 6-19 Total Dissolved Solids results for the Tertiary Basalts

Table 6-13 Physico-chemical Results from revised Project Groundwater Monitoring (October 2007)

Site Number	Dissolved Oxygen % Saturated	TDS (mg/L)	Electrical Conductivity (µS/cm)	pH	Redox (mV)	Temperature (ºC)
Walloon Coal Measures						
121WB	25.9	3,140	-	7.05	275	28.9
113PGC A	34.0	3,770	6,020	6.81	-178	30.1
113PGC B	18.4	2,930	4,770	6.95	-280	25.9
118P	33.7	6,610	10,340	7.06	-216	24.6
117PGC	43.4	2,740	4,530	7.43	-250	26.7
116P	47.9	1,240	2,260	7.38	85	31.3
111PGC lower	27.8	2,940	-	7.11	-2	24.2
111PGC upper	23.4	4,220	6,740	7.04	-299	23.4
119PGC	30.5	1,280	2,130	7.37	-32	24.5
Tertiary Basalt						
109P	15.2	330	-	8.17	-270	26.4

A single round of major ion and dissolved metals chemical analysis was undertaken for bores installed the revised Project site in October 2007. The laboratory results for the analysis are included in **Appendix G.4.4**. **Table 6-14** provides a summary of the results.

Based on the comparison of physico-chemical and groundwater quality results to the ANZECC Guidelines and ADWG, groundwater from the Walloon Coal Measures within the revised Project site is considered suitable for livestock watering, but only suitable for cropping for salt tolerant crops.

The normalised results from major ion chemistry analysis are presented as a Piper tri-linear diagram in **Figure 6-20**. Based on this plot, groundwater quality in the Walloon Coal Measures is generally brackish (saline) with sodium and chloride ions dominating. However, slight variations in water chemistry within the Walloon Coal Measures were present which may indicate the occurrence of different levels of water-rock interaction and natural heterogeneity within the aquifer. This characteristic is due to the residence time of the groundwater, weathering processes and recharge inputs.

Groundwater from the Tertiary Basalt is shown to be a different water type than the Walloon Coal Measures, having a comparatively greater proportion of bicarbonate and less chloride than the Walloon Coal Measures. This may indicate some degree of hydraulic disconnection between the two aquifers.

Table 6-14 Groundwater Quality Results from bores in the revised Project Site (Walloon Coal Measures)

Analyte	ADWG Drinking Water	ANZECC Irrigation	ANZECC Livestock	No. of Samples	Minimum	Median	Maximum
Hydroxide Alkalinity as CaCO3	-	-	-	9	<1	<1	<1
Carbonate Alkalinity as CaCO3	-	-	-	9	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	-	-	-	9	195	413	527
Arsenic	0.007	0.1	0.5	9	<0.001	0.0025	0.003
Cadmium	0.002	0.01	0.01	9	<0.0001	0.001	0.001
Chromium	0.05	0.1	1	9	<0.001	0.008	0.008
Copper	2	0.2	0.5	9	<0.001	0.002	0.004
Lead	0.01	2.0	0.1	9	<0.001	0.005	0.009
Nickel	0.02	0.2	1	9	<0.001	0.002	0.002
Zinc	3	2.0	20	9	0.005	0.011	0.046
Mercury	0.001	0.002	0.002	9	<0.0001	<0.0001	<0.0001

Note: All results and guideline values are reported in mg/L. ‘<’ signifies that laboratory reports concentrations below the level of reporting.

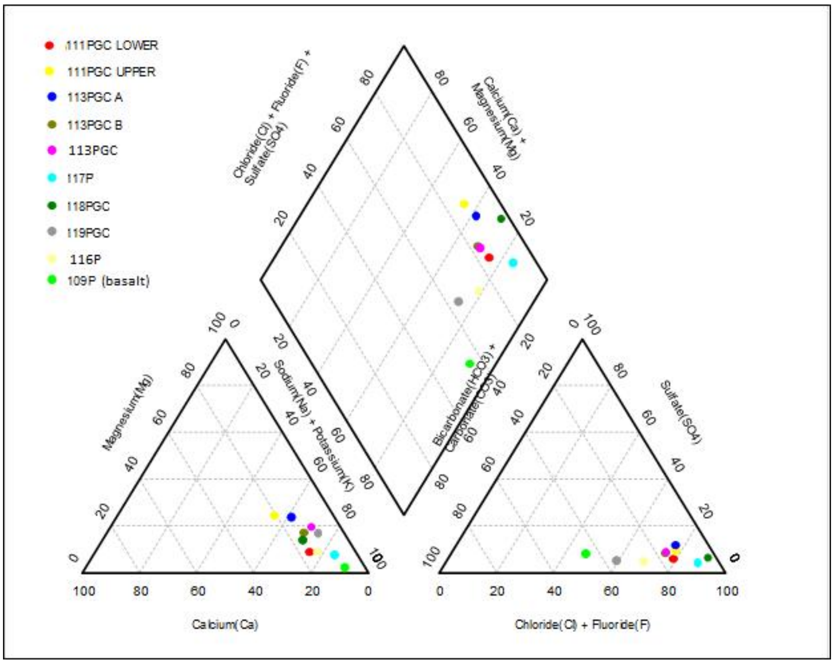


Figure 6-20 Piper tri-linear diagram showing groundwater composition type in the revised Project site (note all bores are Walloon Coal Measures except 109P which is Tertiary Basalt)

6.2.13 Environmental Values in the EPP Water

The following provides a comparison of the groundwater quality data with respect to the EVs for the revised Project site as listed in the EPP (Water).

Aquatic Ecosystems and GDEs

The EPP (Water) identifies that EV's for groundwater in the revised Project site may include aquatic ecosystems. Aquatic ecosystems reliant in some way on groundwater are a form of Groundwater Dependent Ecosystem (GDE). GDEs are ecosystems which have their species composition and natural ecological processes determined to at least some extent by groundwater (ARMCANZ & ANZECC, 1996). Hatton and Evans (1998) defined four functional groups of GDEs including terrestrial vegetation, river baseflow systems, aquifer and cave systems and wetlands. Clifton and Evans (2001) expanded this list to include fauna and estuarine systems dependent upon groundwater discharge. The health of a GDE is generally defined by four parameters: flux, level, pressure and quality (Clifton and Evans, 2001), with dependence potentially being a function of one or all of the above factors. Groundwater dependency can also vary spatially and temporally and is dependent upon whether the system represents a local or regional GDE.

A search of the BoM's GDE Atlas and also published DERM and Regional Ecosystem (2005) mapping data has identified no GDEs reliant on the surface expression of groundwater (such as rivers, springs or wetlands) within 10 km of the revised Project site. The same search has however identified a low to moderate potential for the presence of terrestrial vegetation that is reliant on the occurrence of subsurface groundwater within the revised Project site. **Chapter 7** describes the revised Project related terrestrial ecosystems in detail. A review of the terrestrial ecosystems existing within the vicinity of the revised Project site indicates that the water requirements for these species are likely to be derived from depths significantly shallower than 10 m below ground level. Given that the depth to the water table in the Walloon Coal Measures aquifer is between approximately 10 m to 50 m below ground level across the revised Project site, there are unlikely to be GDEs (including terrestrial vegetation reliant to some degree on groundwater) present within the revised Project site.

Groundwater elevations of all aquifers lie significantly below stream bed elevations in the revised Project site; studies undertaken as part of Stage 2 EIS compared groundwater levels to stream bed levels for Lagoon Creek under average conditions and found that there was significant separation such that groundwater does not contribute to surface water flows, i.e. Lagoon Creek is disconnected from the regional groundwater system. Accordingly it is considered unlikely that baseflow systems exist within the revised Project site and therefore unlikely that groundwater supports aquatic ecosystems within the revised Project site. Groundwater levels within the Oakey Creek alluvium to the south of the revised Project site are also known to be below the base of the stream channel. As a result, the potential for mining effects on groundwater to impact ecosystems is considered low.

Recreational, Agricultural and Industrial Use

Recreational uses for groundwater encompass primary and secondary contact such as swimming and boating respectively. Given that the depth to groundwater is generally greater than 10 mBGL, it is unlikely that there is input from the groundwater to water bodies which may be used for recreational purposes. Therefore, recreational use of groundwater within the revised Project site is considered negligible.

Agricultural uses of groundwater in the revised Project site are dominated by livestock watering and to a lesser extent irrigation. Groundwater use for livestock purposes has been identified to occur locally from the Tertiary Basalt aquifer. The Walloon Coal Measures aquifer supplies brackish livestock water and is generally low yielding (up to 1 L/sec). Livestock watering and municipal supplies have also been identified to be extracted from the Marburg Sandstone aquifer.

The Mine currently extracts groundwater for use at the Mine from the Tertiary Basalt aquifer. Groundwater flowing into the existing mine pits from the Walloon Coal Measures aquifer is also used by the Mine. Groundwater extraction by the Mine from the Helidon Sandstone and Marburg Sandstone aquifers is minimal and irregular by comparison.

Drinking Water

A comparison of the groundwater quality data to the ADW Guidelines indicates that groundwater within the Tertiary Basalt, Marburg Sandstone and Helidon Sandstone aquifers is generally suitable for potable use (based on TDS). Groundwater quality data demonstrates variability between and within aquifers. Groundwater use for domestic purposes has been identified to occur locally from the Tertiary Basalt aquifer.

Groundwater within the Walloon Coal Measures is generally unsuitable for potable use without treatment, primarily due to elevated salinity levels.

6.2.14 Conceptual Hydrogeological Model

A conceptual hydrogeological model has been formulated for the revised Project site based on the geological and hydrogeological data for the Mine and the revised Project. The data indicate that the geology and hydrogeology of the Mine is similar to that found within the revised Project site.

The conceptual hydrogeological model describes the aquifers present within the revised Project site, how they interact with each other and surface waters, and their attributes such as groundwater depth, thickness, transmissivity, storativity and hydraulic conductivity. The aquifers present within the revised Project site include the following:

- Quaternary Alluvial aquifer;
- Tertiary Basalt aquifer;
- Walloon Coal Measures aquifer;
- Marburg Sandstone aquifer; and
- Helidon Sandstone aquifer.

These aquifers are described further in the following Sections.

Figure 6-21 presents a schematic of the conceptual hydrogeological model for the revised Project.

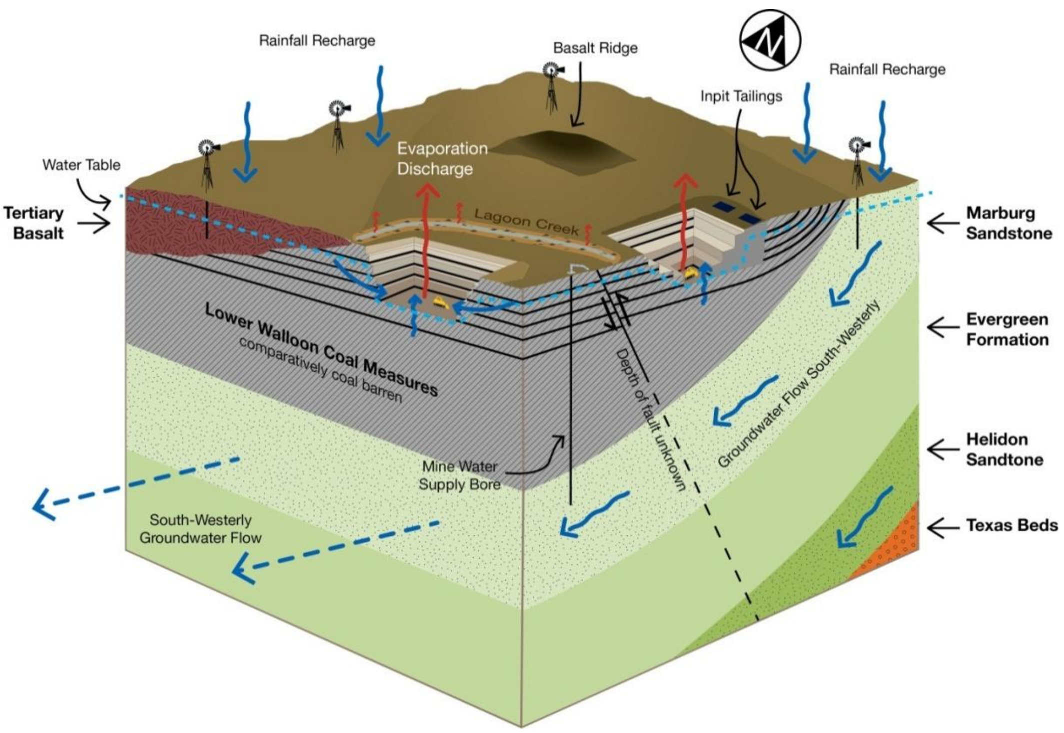


Figure 6-21 Conceptual Hydrogeological Model

The conceptual hydrogeological model has been developed using the best available data and assumptions. The conceptual hydrogeological model will continue to be updated and refined based on the results of a targeted groundwater monitoring program and further investigations into local bore information (e.g. landholder bore surveys).

Quaternary Alluvial Aquifer

The shallow Quaternary Alluvial aquifer is limited in aerial extent and unlikely to form a major aquifer at the revised Project site. The alluvial aquifer is known to occur south of the revised Project site in association with Oakey Creek and its tributaries, where it reaches a thickness of up to 60 m and contains significant groundwater supplies. Similarly, groundwater supplies may also be developed in association with this aquifer to the northwest of the current Mine site in association with Myall Creek and its tributaries.

The predominant mechanism for recharge of the alluvial aquifer is direct infiltration. Discharge is likely to occur via evapotranspiration and infiltration to underlying aquifers.

Due to the minor nature of this aquifer within the revised Project site, data on groundwater yield and quality within the revised Project site was not obtained. Due to the lack of alluvial aquifer presence close to current mining activities, the current Mine is not expected to be causing an impact to this aquifer.

Tertiary Basalt Aquifer

There is a minor occurrence of the Tertiary Basalt aquifer in the northwestern section of the revised Project site. The location of this aquifer in relation to the revised Project's mine pits means that this aquifer is unlikely to be affected by the revised Project, except where the western Manning Vale West Pit may intersect basalt to only a very minor degree. Where present in the revised Project site, the Tertiary Basalt aquifer varies in thickness from 1 m to 90 m.

Permeability within this aquifer is considered to consist of both primary and secondary porosity; however the latter is expected to dominate. The Tertiary Basalt aquifer has relatively shallow depth to groundwater at the revised Project site. Groundwater yield in the Tertiary Basalt aquifer can be up to 10 L/sec. An average bore yield of approximately 3 to 5 L/sec was reported in the Stage 2 EIS.

Pumping test data obtained from the Stage 2 EIS indicate a relatively high transmissivity of 150 m^2/day and storativity ranging from 0.001 to 0.05. The storativity values suggest that the aquifer is unconfined to semi-confined in the test locations.

The DNRM uses a uniform value of 80 mm of groundwater recharge per annum for basalt aquifers in the local area as part of water allocation assessments. This factor has been calculated to be approximately 12.7% of annual mean rainfall based on 635 mm mean annual rainfall observed at the Oakey Aero station. This suggests that recharge rates are relatively high for this aquifer.

The Mine currently draws groundwater from the Tertiary Basalt aquifer, covered under a license for 160 ML/year. However, the Mine uses only approximately 11 ML/year of this allocation. Groundwater extraction from the Tertiary Basalt aquifer is also undertaken by nearby private groundwater users, mainly to the west and northwest of the revised Project site. Groundwater salinity in the Tertiary Basalt aquifer is generally lower than in the Walloon Coal Measures aquifer. This fact is reflected by a greater number of livestock and domestic users in the Tertiary Basalt aquifer.

Given that there is little occurrence of the basalt aquifer within the revised Project site, it is unlikely that mining activities will have a direct impact on the basalt aquifer. However, it is known that the basalt aquifer was deposited in palaeochannels incised into the Walloon Coal Measures palaeosurface and so the potential exists for direct hydraulic connection between the basalt aquifer and the Walloon Coal Measures, especially if a coal seam (the main water bearing units of the Walloon aquifer) were exposed in the palaeochannels.

Walloon Coal Measures Aquifer

The Walloon Coal Measures will be the main aquifer which will be affected by the revised Project. The Walloon Coal Measures outcrop across much of the revised Project site with coal seams being the principal conduit for groundwater. Pumping tests undertaken in this aquifer, suggest that it is semi-confined, and of low to moderate transmissivity. Groundwater within the Walloon Coal Measures regionally flows from the north-east to south-west in accordance with the regional dip of the coal seams. Groundwater flow within this aquifer at the revised Project site is to the south, from potentiometric elevations of around 420 mAHD to potentiometric elevations of around 380 mAHD. A groundwater depression reaching around 410 mAHD exists in the vicinity of the current Mine workings, whilst a groundwater mound of around 440 mAHD exists in the vicinity of previously mined and backfilled northern Mine areas, where in-pit tailing dams now exist. The current Mine workings are likely to intercept much of this groundwater mounding given the close proximity and hydraulic gradient between the two features.

Recharge into the upper portions of the Acland-Sabine Sequence, is likely to be predominantly via coal subcrop areas on the upthrown side of faults and through deep drainage from the overlying basalt and alluvium where they occur. The comparatively higher salinity of groundwater in the lower seams of the Acland-Sabine interval and underlying Balgowan interval suggests that recharge zones for these measures are progressively more remote with depth and groundwater has longer residence times and longer migration paths. Leakage from underlying and overlying seams within the Walloon Coal Measures to these lower-lying coal seams is likely to be insignificant. Discharge from the Walloon Coal Measures aquifer occurs via mine pit dewatering and private bore extraction within the Clarence-Moreton Basin.

Significant surface water and groundwater interaction is unlikely for the Walloon Coal Measures aquifer. Groundwater has not been identified as contributing to surface water flows within nearby creeks and streams. Groundwater levels within the Walloon Coal Measures underlying the revised Project site range from around 6 to 55 mBGL.

The Walloon Coal Measures aquifer varies from being confined to semi-confined by low permeability mudstones and siltstones which occur in between the coal seams. Short term pumping tests indicate that the coal seams behave as separate aquifers. However, it is considered likely that over the long term the seams would behave as one aquifer system when stressed by dewatering in association with mining operations. Results from these tests suggest that a leaky aquifer system is likely to exist with vertical movement of groundwater occurring between seams, especially where the confining layer is thin, and via fractures within the coal measures aquifer system.

Transmissivity values within the Walloon Coal Measures were estimated to range between 7 and 47 m^2/day. Transmissivity values obtained from pumping tests undertaken for the Stage 2 EIS are consistent with those estimated from field tests undertaken for the revised Project. This result demonstrates that the transmissivity of the Walloon Coal Measures aquifer is similar from the Mine to the revised Project site.

Storage coefficients were estimated to range between 0.006 and 0.00006 for the shallow and deep coal seam aquifers respectively, suggesting the deeper seams act as confined aquifers whereas the shallow seams act as semi-confined aquifers. Bore yields for this aquifer are around 1 L/sec or less. Groundwater quality in the Walloon Coal Measures at the revised Project site is slightly acidic to slightly alkaline and is generally brackish with sodium chloride ions dominating.

Marburg Sandstone Aquifer

The Marburg Sandstone aquifer underlies the Walloon Coal Measures and is up to 500 m thick. This aquifer exists as a confined aquifer at a depth of about 150 m within the revised Project site and is a major aquifer of the GAB.

Aquifer parameters based on pumping tests conducted for the Stage 2 EIS indicate a transmissivity of 14 m^2/day and a storativity of 0.003.

Aquitards within the Walloon Coal Measures and the intervening lower permeability sediments of the Eurombah Formation act as effective confining layers for the Marburg Sandstone aquifer, hydraulically isolating it from the coal seams of the Walloon Coal Measures. Groundwater levels obtained from on and off site bores ranged from 410 m AHD to 425 m AHD. Typical production rates range from 5 L/sec to 25 L/sec within this aquifer. The higher yields indicate that the transmissivity of the aquifer may be larger than 14 m^2/day as indicated in the Stage 2 EIS pumping tests.

Recharge within this aquifer is likely to occur from surface water infiltration where the geological formation outcrops to the northeast of the revised Project site, with discharge via groundwater bores and throughflow to the southwest.

The Mine periodically extracts groundwater from the Marburg Sandstone aquifer at a rate of approximately 10 ML/year for industrial use and bore maintenance purposes.

The Marburg Sandstone aquifer is a confined aquifer located more than 75m below the base of the revised Project mine pits. Therefore, the revised Project's mine pits and depressed landforms (rehabilitated final voids) are unlikely to have an effect on this aquifer.

Helidon Sandstone Aquifer

The Helidon Sandstone is the deepest aquifer at the revised Project site and is a major aquifer of the GAB. This aquifer is separated from overlying aquifers by the relatively impermeable Evergreen Formation and is up to 170 m thick.

Pumping test data indicates the transmissivity of this formation is likely to vary between 45 m^2/day to 200 m^2/day. Recharge to the Helidon Sandstone aquifer occurs where the aquifer outcrops in the northeast. This area represents the primary source of recharge to the aquifer via infiltration of rainfall and overland surface water flow, with discharge occurring mainly via groundwater bores and throughflow to the southwest.

The Mine periodically extracts groundwater from the Helidon Sandstone aquifer at a rate of 17 ML/year for industrial use and has an allocation of 710 ML/year from this aquifer. Groundwater extraction from the Helidon Sandstone aquifer for industrial use reduced greatly once the WWRF Pipeline came into operation in 2010. The Mine and other nearby private groundwater users are the main sources of groundwater extraction from the Helidon Sandstone aquifer.

The Helidon Sandstone aquifer is a confined aquifer and is located below the relatively impermeable Evergreen Formation, which in turn is located below the Marburg Sandstone aquifer. Accordingly, it is unlikely the revised Project's mine pits and depressed landforms (rehabilitated final voids) will effect on this aquifer.

Groundwater Receptors

Table 6-15 presents a summary of the groundwater receptors that may be impacted by the revised Project, for each of the aquifers associated with the revised Project site. As shown, the primary groundwater receptors have been identified as anthropogenic groundwater users who extract groundwater via bores. Environmental users such as GDEs are not identified as groundwater receptors within and adjacent the revised Project site.

6.3 Impact Assessment

The revised Project will include a series of mine pits and depressed landforms (rehabilitated final voids) which will intersect the Quaternary Alluvial aquifer, the Tertiary Basalt aquifer and the Walloon Coal Measures aquifer.

The Quaternary Alluvial aquifer is considered to be a minor aquifer within the revised Project site itself and does not form a significant groundwater resource in the proposed mining area. The Tertiary Basalt aquifer will be intersected by mining to only a small degree on the northern and northwestern edges of the revised Project's western pit (i.e. the Manning Vale West Pit).

The Walloon Coal Measures is the main groundwater aquifer affected by the revised Project, and will be intersected by all proposed mine pits. As a result, potential effects to receptors from the revised Project are predominantly associated with the Walloon Coal Measures aquifer.

The following discussion provides an assessment of the potential effects from the revised Project on the Walloon Coal Measures aquifer and to a lesser extent the Tertiary Basalt and Quaternary Alluvial aquifers. The assessment includes:

- direct effects of mining on groundwater quality and quantity, aquifer integrity and groundwater-surface water interaction; and
- effects on potential receptors.

Table 6-15 Groundwater Receptor Identification for the revised Project site and Surrounds

Aquifer	Receptor Type		
	Environmental Use (GDEs, river baseflow, etc)	**Extractive Use – Private/Agricultural**	**Extractive Use - Industrial**
Quaternary Alluvium	No GDE's identified within or surrounding the revised Project site. Terrestrial vegetation present likely supported by direct rainfall and surface flows as groundwater levels are typically deeper than vegetation rooting depths.	No use within the revised Project site. Minor use around 3 km north/northwest of the current Mine and major use 3 km south of the revised Project site as shown in Figure 6-4.	None identified.
Tertiary Basalt	No GDE's identified within or surrounding the revised Project site. Terrestrial vegetation likely supported by direct rainfall and surface flows as groundwater levels are typically deeper than vegetation rooting depths.	Very minor use within the revised Project site, and extensive use west and northwest of the revised Project site as shown in Figure 6-4.	NAC currently extracts water that is treated for potable supply at the Mine. No other users are identified.
Walloon Coal Measures	No GDE's identified within or surrounding the revised Project site. Terrestrial vegetation likely supported by direct rainfall and surface flows as groundwater levels are typically deeper than vegetation rooting depths.	Commonly utilised within and for 3 km surrounding the revised Project site, and minor use greater than 3 km outside the revised Project site as shown in Figure 6-4.	NAC currently takes water as a result of incidental water make in open cut Mine pits. No other users are identified.
Marburg Sandstone	No GDE's identified within or surrounding the revised Project site. Aquifer lies at significant depth. Where the aquifer outcrops in the northeast, terrestrial vegetation likely supported by direct rainfall and surface flows as groundwater levels are typically deeper than vegetation rooting depths.	Minor use within 3 km the revised Project site, especially to the northeast as shown in Figure 6-4.	NAC periodically extracts water for industrial supply at the Mine. No other users are identified.
Helidon Sandstone	No GDE's identified within or surrounding the revised Project site. Aquifer lies at significant depth.	None identified as shown in Figure 6-4.	Oakey abattoir extracts water at approximately 1200 ML/year. No other users identified within 8km of the revised Project.

This Section does not include a specific assessment of potential effects from the Mine's current groundwater extraction from the Tertiary Basalt, Marburg Sandstone and Helidon Sandstone aquifers. Approval for the extraction of groundwater from these aquifers has already been obtained.

Groundwater extraction from the Marburg Sandstone and Helidon Sandstone aquifers for industrial has reduced significantly since 2010 once the WWRF Pipeline was brought into operation as described in **Section 6.2.5**.

6.3.1 Effects on Groundwater Levels

Throughout the operational phase of the revised Project, the mine pits will intersect the water table within the Walloon Coal Measures and some groundwater will discharge to the pits. Groundwater discharge into the mine pits will cause drawdown in groundwater levels in the Walloon Coal Measures aquifer. The mine pits will be excavated as a series of strips which will be backfilled and rehabilitated after each strip has been mined. Following cessation of mining, groundwater may continue to discharge to the depressed landforms (rehabilitated final voids) as a result of evaporative losses from the depressed landforms. The rehabilitation of the final voids to depressed landforms is described in **Appendix G.1.10** and **Appendix J.2**.

Numerical groundwater modelling has been conducted to determine the potential magnitude and extent of effect of mining on groundwater levels within aquifers located at and surrounding the revised Project site, including the potential effect on neighbouring groundwater users. The following Sections summarise the numerical modelling undertaken and the predicted effect on groundwater levels in aquifers located at and surrounding the revised Project site.

Numerical Groundwater Modelling

Model Description

A fully transient three dimensional finite difference groundwater flow model of the Mine, the revised Project site and its surroundings has been developed in the MODFLOW-2000 code using the Groundwater Vistas Version 6 Graphical User Interface. Full details of the model developed are presented in **Appendix G.4.5**. The model has been developed using the best available data, and where data was unavailable the most conservative assumptions have been made (e.g. the nature of the hydraulic connection (or lack thereof) between the Walloon Coal Measures and Tertiary Basalt aquifers is unquantified to date however the two units have been modelled as completely hydraulically connected). As a result, all hydrogeological model outputs represent a 'worst case' scenario to ensure the maximum potential groundwater impacts for the revised Project are identified for assessment and mitigation purposes. The model will continue to be updated and refined based on the results of a targeted groundwater monitoring program and further investigations into local bore information (e.g. landholder bore surveys) as described in **Section 6.3.4**.

The model covers an area of 1,908 km^2 extending 36 km in the east-west direction and 53 km in the north-south direction. It is centred on the Mine and revised Project site and has grid cells of 200 m by 200 m near the Mine and Project area and 400 m by 400 m in outer areas. The model domain and boundary conditions are shown in **Figure 6-22**.

The model consist of four layers with depth intervals that correspond to mapped or interpreted contacts between geological units and to the geometry of the historical, current and proposed mining pits. The layering structure is defined in Table 6-16 and is based on the hydrogeological conceptualisation defined in **Section 6.2.14**. Given the presence of the Evergreen Formation aquitard beneath the Marburg Sandstone, the thickness of the low permeability strata beneath the proposed mine pits, and the depth of the Helidon Sandstone below the proposed mine pits, it was decided that modelling of the Evergreen Formation and Helidon Sandstone was not warranted as measurable impacts from mining are not expected to occur in relation to these formations. Note that individual layers in the model include a number of different hydrogeological units based on mapped distribution of the various geologic units in the model domain.

Table 6-16 Definition of model layers

Model Layer	Elevation Range	Hydrogeological Units Present
1	Ground surface to base of Mine pits	Walloon Coal Measures, Tertiary Basalts, Quaternary Alluvium, Marburg Sandstone
2	Base of Mine pits to base of the Basalts	Walloon Coal Measures, Tertiary Basalts, Quaternary Alluvium, Marburg Sandstone
3	45 m thickness	Lower Walloon Coal Measures, Quaternary Alluvium, Marburg Sandstone
4	250 m thickness	Marburg Sandstone

The model provides for exchange of water with surrounding aquifers through the inclusion of Constant Head Boundary Conditions assigned to its northern, western, southern and eastern (in part) boundaries as depicted in **Figure 6-22**.

The southern part of the eastern lateral model boundary is defined as a no-flow boundary through which water cannot enter or leave the groundwater model domain.

A nominal level of rainfall recharge has been applied across the top surface of the model. Recharge values were set at a fixed percentage of rainfall measured at BOM rainfall gauging stations located within and near the model domain. The model is subdivided into four recharge zones according to the permeability of the outcropping hydrogeological units.

Myall Creek is modelled as a gaining stream using the Modflow Drain Boundary Condition and groundwater recharge through the creek bed is not allowed for in the model. This representation is consistent with the fact that it is an ephemeral water course that is not a consistent source of groundwater recharge throughout the year. Oakey Creek has been included in the model using the Modflow River Boundary Condition that allows groundwater to enter or exit the model depending on the predicted groundwater heads and those specified as the river stage, i.e. the creek is modelled as both a losing and a gaining stream depending on the groundwater heads adjacent the creek. Lagoon Creek is not included in the model as investigations have shown the ephemeral creek to be disconnected from the regional groundwater system as described in **Section 6.2.13**.

Inflows to the mining pit are modelled as time varying Drain Boundary Conditions that drain the pit to the elevation of the pit floor. The locations of Drain Boundary Conditions are also shown in **Figure 6-23**. Historical Mine water supply extraction from water supply bores was included in the model calibration, using historical usage data as supplied by NHG.

Model calibration (discussed below) highlighted the fact head differences measured in neighbouring groundwater monitoring bores suggest localised areas of low permeability and associated compartmental nature of the aquifers in the region of the Mine and revised Project site, derived from faulting. In the model the Modflow Horizontal Flow Barrier Package was implemented in order to represent faulting and the compartmental nature of the groundwater system. This package simulates thin, vertical low-permeability geologic features that impede the horizontal flow of ground water. Faults are approximated as a series of horizontal-flow barriers (or "walls") conceptually situated on the boundaries between pairs of adjacent cells in the finite-difference grid. Wall settings were adopted to represent the faulting present at the Mine and revised Project site. The locations, alignment and permeability of the flow "walls" were derived from faults mapped by NHG at the site and during model calibration process. The "walls" were defined through Layer 1 to Layer 4 and the locations of the walls are shown in **Figure 6-23**.

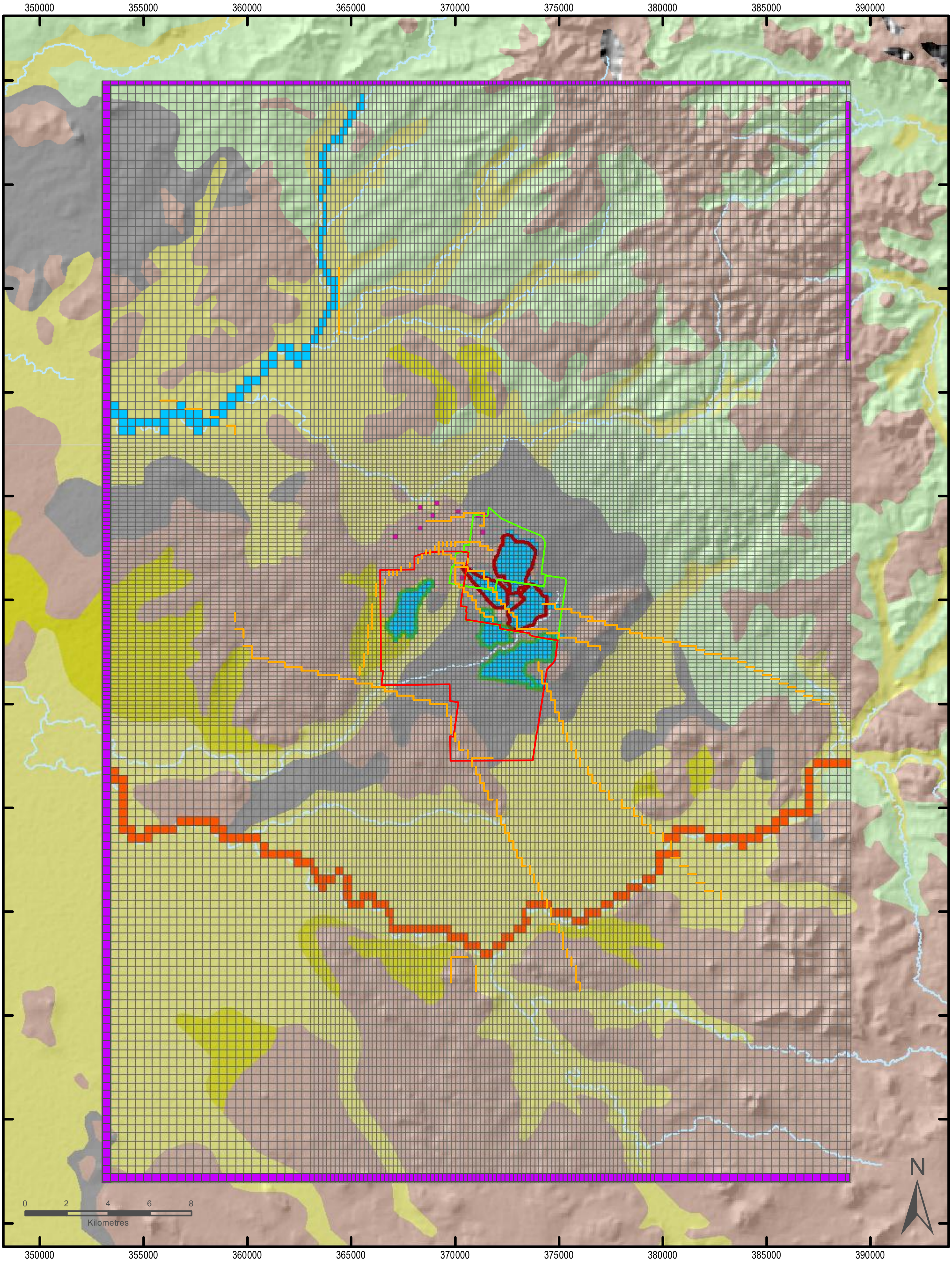
Model Calibration

Due to the history of mining development in the modelled region and lack of detailed site-specific pre-mining groundwater level information, steady-state (i.e. pre-mining) calibration was deemed unsuitable and not as reliable as a fully transient model calibration. Fully transient model calibration was therefore undertaken using historical Mine development information and groundwater level monitoring data for the period 2002 through to 2012.

During the model calibration process, modifications to the model parameters were made in an effort to improve the model's ability to replicate the observed responses. Manual trial and error calibration runs were followed by PEST automated calibration. The following constraints were placed on the calibration procedure:

1) Calibration was attempted without changing the hydrogeological zonation as defined by the interpreted distribution of the principal hydrogeological units present at the site.
2) Calibration was attained through refinement of the following model parameters and features:
    a) Hydraulic conductivity in the horizontal and vertical dimensions.
    b) Anisotropy between the principal components of horizontal hydraulic conductivity (i.e. the kx/ky ratio).
    c) Specific yield.
    d) Recharge.
    e) Hydraulic conductivity assigned to the "walls" used to replicate the influence of faults.
    f) Conductance assigned to the Drain cells that define the flux of water into the historical mining pits.

The only formation property not varied during calibration was specific storage. It was assumed that, due to the consolidated nature of the confined aquifers in the model domain, specific storage for these aquifers is equivalent to the compressibility of water (i.e. $5x10^{-6}$ /m).



LEGEND

- Model Grid
- Walls (Modelled Faults)
- Watercourse
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Existing Permission
- Stage 3 Pit Areas

Boundary Conditions

- Constant Head
- Drain
- Well
- River

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

NEW HOPE GROUP

SINCLAIR KNIGHT MERZ SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-22 - Model Domain and Boundary Conditions

Scale 1:250,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

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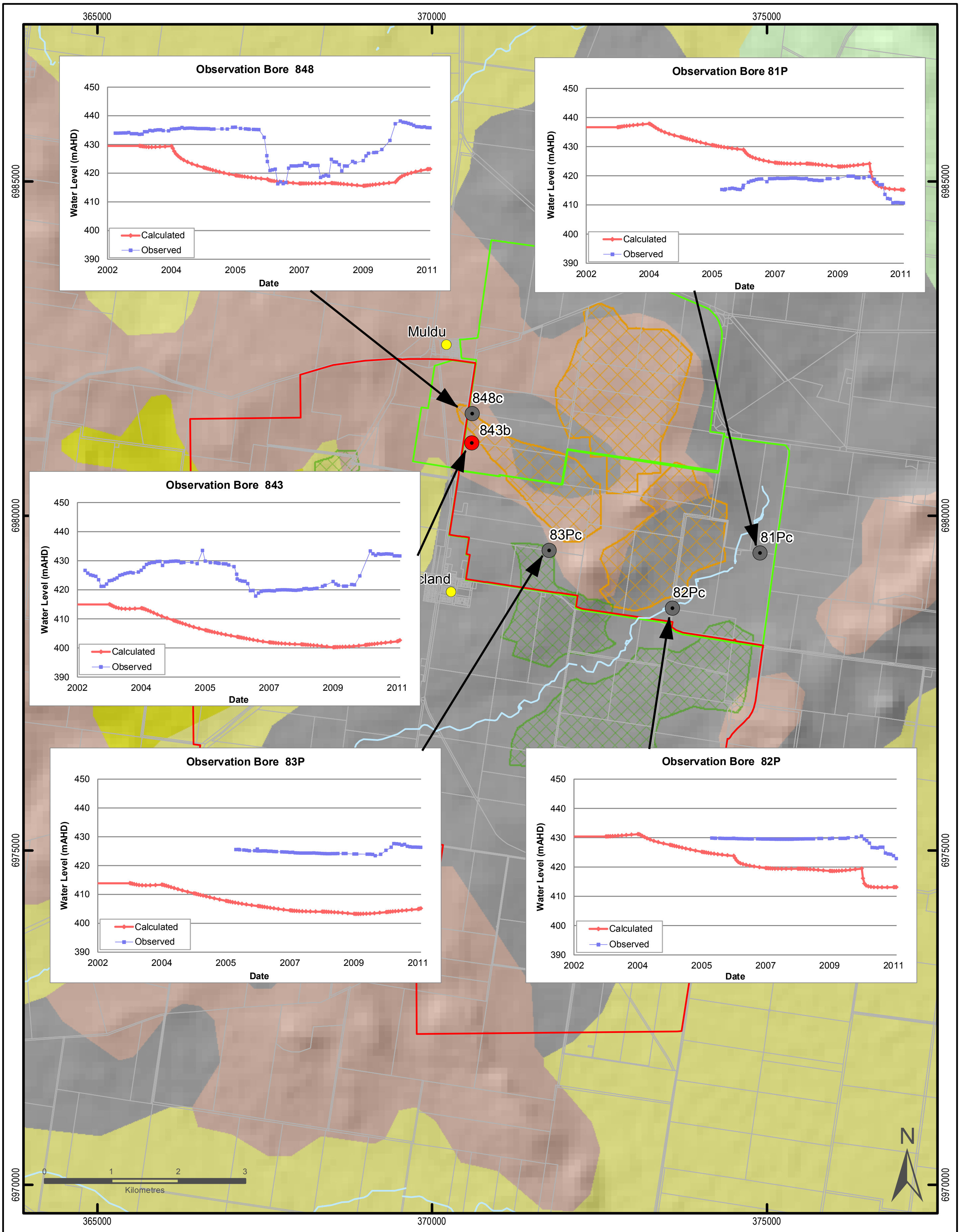


LEGEND

Compliance\Reference Bores

- Tertiary Basalt
- Walloon Coal Measures

- Towns and Localities
- Watercourse
- New Acland Coal Mine
- New Aland Coal Mine-Stage 3
- Cadastre
- Existing Permission
- Stage 3 Pit Areas

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

NEW HOPE GROUP

SINCLAIR KNIGHT MERZ SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-23
Model Calibration Hydrographs

Scale 1:75,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)

The results of the model calibration are illustrated by hydrographs showing the model match to observed groundwater responses in the region of the historical Mine pits, and are presented in **Figure 6-22**. The calibration to observed heads can be quantified through estimation of the scaled RMS error for the goodness of fit (in this case 8%). The scatter plot and estimates of goodness of fit are shown in **Figure 6-24**.

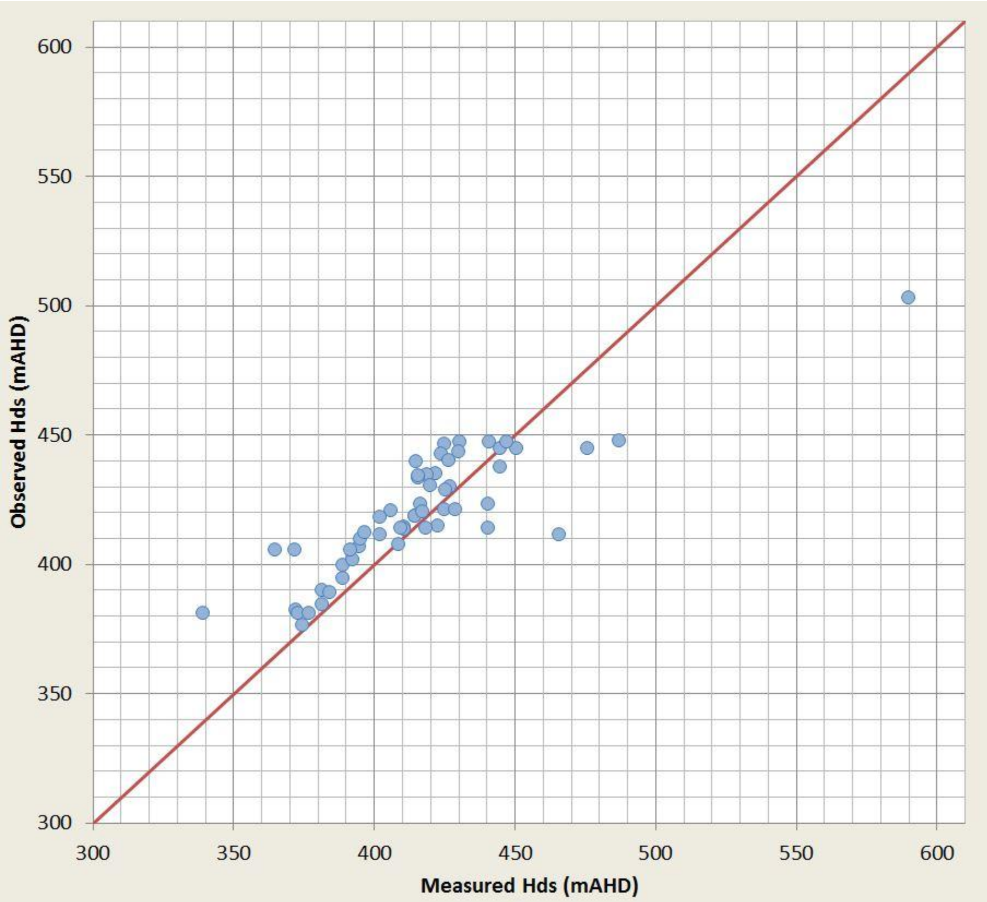


Figure 6-24 Calibration Results

Hydraulic conductivity, storage and recharge parameters included in the model as refined during the calibration procedure are presented in **Table 6-17**. Values of hydraulic conductivity are slightly lower than those indicated by pumping tests carried out in the Walloon Coal Measures as part of the revised Project EIS suggesting that on a regional scale the Walloon Coal Measures form a less significant aquifer than available individual bore tests might suggest. Similarly, the Marburg Sandstone hydraulic conductivity included in the model is higher than indicated by pumping tests associated with the Stage 2 Project EIS, suggesting the Marburg Sandstone forms a more prolific regional aquifer than available individual bore tests suggest. Parameter values included in the model provide a reasonable level of calibration and are consistent with observations from the mine and from the general recognition that the Marburg Sandstone is an important regional aquifer while the Walloon Coal Measures does not yield substantial quantities of water.

Table 6-17 Calibrated Model Parameters

Unit	Kx (m/d)	Kz (m/d)	Sy	Ss (/m)	Recharge (% of rainfall)
Myall Creek Alluvials	10	0.1	0.01	n/a	7.0
Oakey Creek Alluvials	10	0.1	0.01	n/a	7.0
Tertiary Basalt	3.0	0.004	0.007	5.0e-6	7.0
Walloon Coal Measures	0.5	0.0003	0.002	5.0e-6	0.1
Lower Walloon Coal Measures	0.2	0.0001	0.0004	5.0e-6	NA
Marburg Sandstone	1.0	0.0003	0.0004	5.0e-6	1.6

Effects on Groundwater Levels During Mining

Groundwater discharge into the revised Project mine pits will lead to a localised depression or drawdown of the groundwater levels in the Walloon Coal Measures aquifer within the vicinity of the revised Project site. This drawdown in the Walloon Coal Measures may in turn cause drawdown in adjacent aquifers. The calibrated numerical model was used to estimate groundwater level drawdown in aquifers that might be affected by the revised Project.

The groundwater predictive modelling assumes a mine progression according to the revised Project's mining schedule. Mining generally progresses in a southerly direction away from the current Mine area and ceases at the end of 2029. A series of Modflow Drain cells were assigned to the model to simulate the removal of water flowing into the mining pit throughout the life of the revised Project. These cells are activated and de-activated in a manner that replicates the mining schedule, where activation represents pit dewatering and deactivation represents backfilling of pits. The drain elevations have been set to the base of the planned mining pits as determined from revised Project mine planning information.

For the predictive modelling, rainfall and evapotranspiration parameters were assigned the long term average rates from available climate stations within the model domain. Extraction rates from Mine water supply bores were set equivalent to those rates recorded during 2012.

The predicted groundwater inflows to the revised Project's mining pits are shown in **Figure 6-25**. Inflows are expected to peak immediately prior to the completion of the mining phase (2030) at approximately 1,480 ML/year (4 ML/day), which will be spread variably across the three operational pits. The general increase in groundwater inflows to the revised Project's mining pits over the duration of the revised Project is a result of mining depths generally becoming greater as the revised Project progresses, especially in the Willaroo Pit.

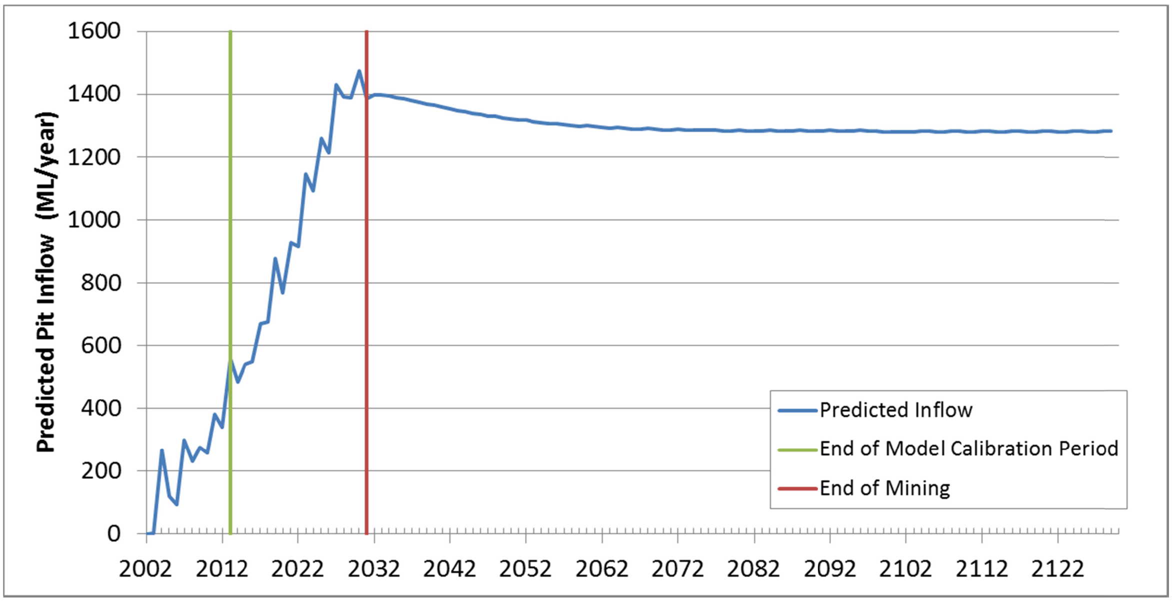
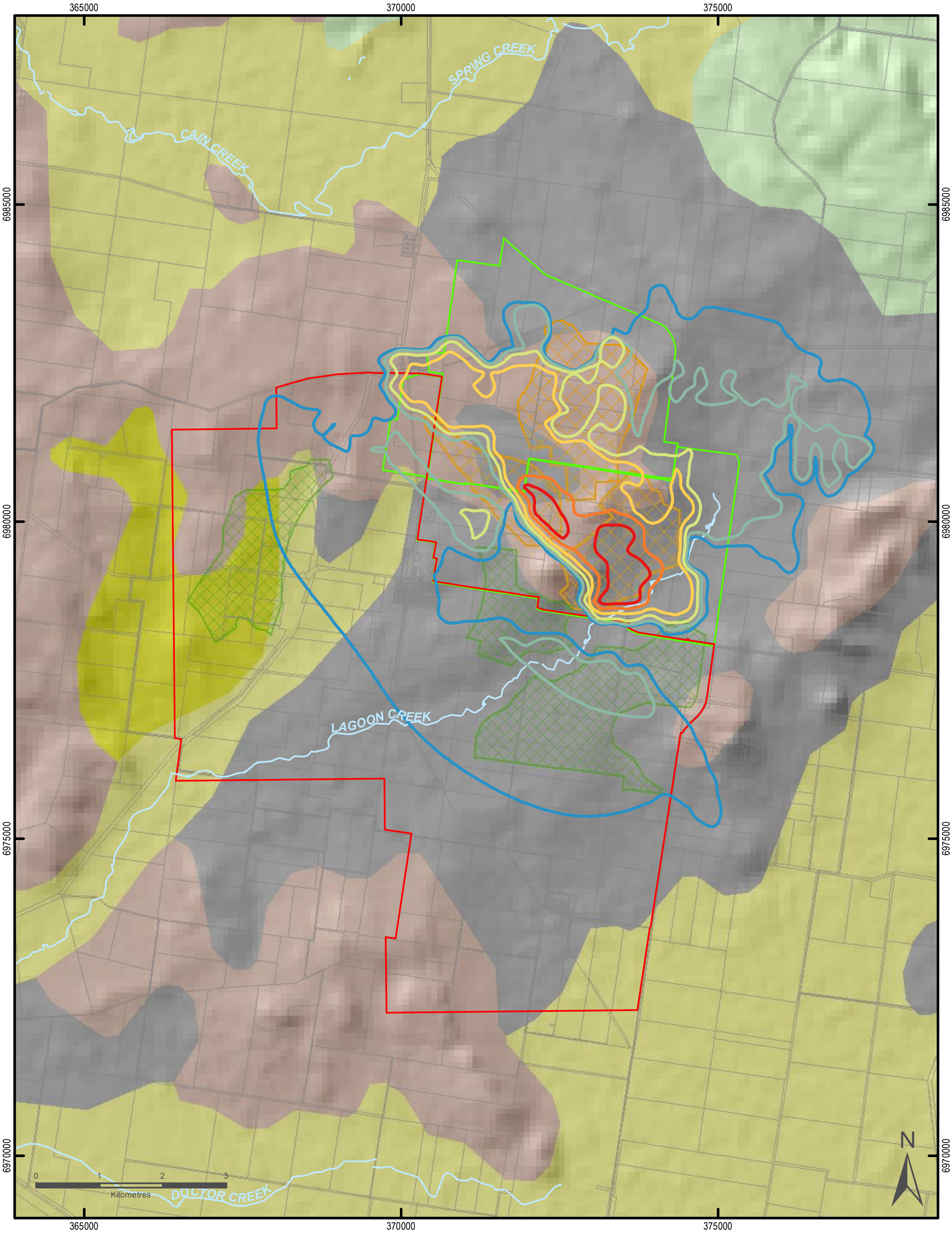


Figure 6-25 Predicted Inflow to revised Project Pits

Predicted groundwater level drawdown in the Tertiary Basalt and Walloon Coal Measures aquifers, arising from predicted revised Project pit inflows, are presented for selected years in **Figure 6-26** through **Figure 6-29**. The results indicate that groundwater drawdowns of greater than 5 m are not expected to extend more than around 3 km from the boundary of the revised Project site. The greatest drawdown is expected to occur at the end of mining (2030) in association with the Manning Vale West Pit reaching its greatest depth. Groundwater drawdown expansion away from the revised Project site occurs to a limited degree to the west and southwest, consistent with a thickening of the higher permeability Tertiary Basalt in this area.

At all times the drawdown in the Marburg Sandstone is predicted as being less than 3 m. Significant reversal of the existing downwards hydraulic gradient between the Walloon Coal Measures and Marburg Sandstone is unlikely, as the current hydraulic separation is around 25 m as described in **Section 6.2.10** and drawdowns in the Walloon Coal Measures exceeding 30 m are not predicted to occur over large areas as shown in **Figure 6-29**. **Figure 6-30** illustrates the predicted drawdown in the Marburg Sandstone at 2030, and shows that drawdown greater than 2 m is largely restricted to the revised Project lease area, with the 1 m predicted drawdown contour extending up to around 5 km from the site boundary to the west.

The impact of predicted groundwater drawdown associated with the revised Project mining activities on the alluvium of Oakey and Myall Creeks (including their tributaries of Doctors, Lagoon and Spring Creeks) is best represented by the predicted change in flows in the Oakey and Myall Creeks as shown in **Figure 6-31**. These indicate a maximum predicted loss of flow of around 0.35 and 0.2 ML/d for Oakey and Myall Creeks, respectively. Stream flow gauging data is not available for Myall Creek however DNRM data for Oakey Creek at Fairview (~37 km west of the revised Project site and the nearest downstream station from the revised Project site and confluence of Lagoon Creek).



LEGEND

Predicted Drawdown Contour (m)

- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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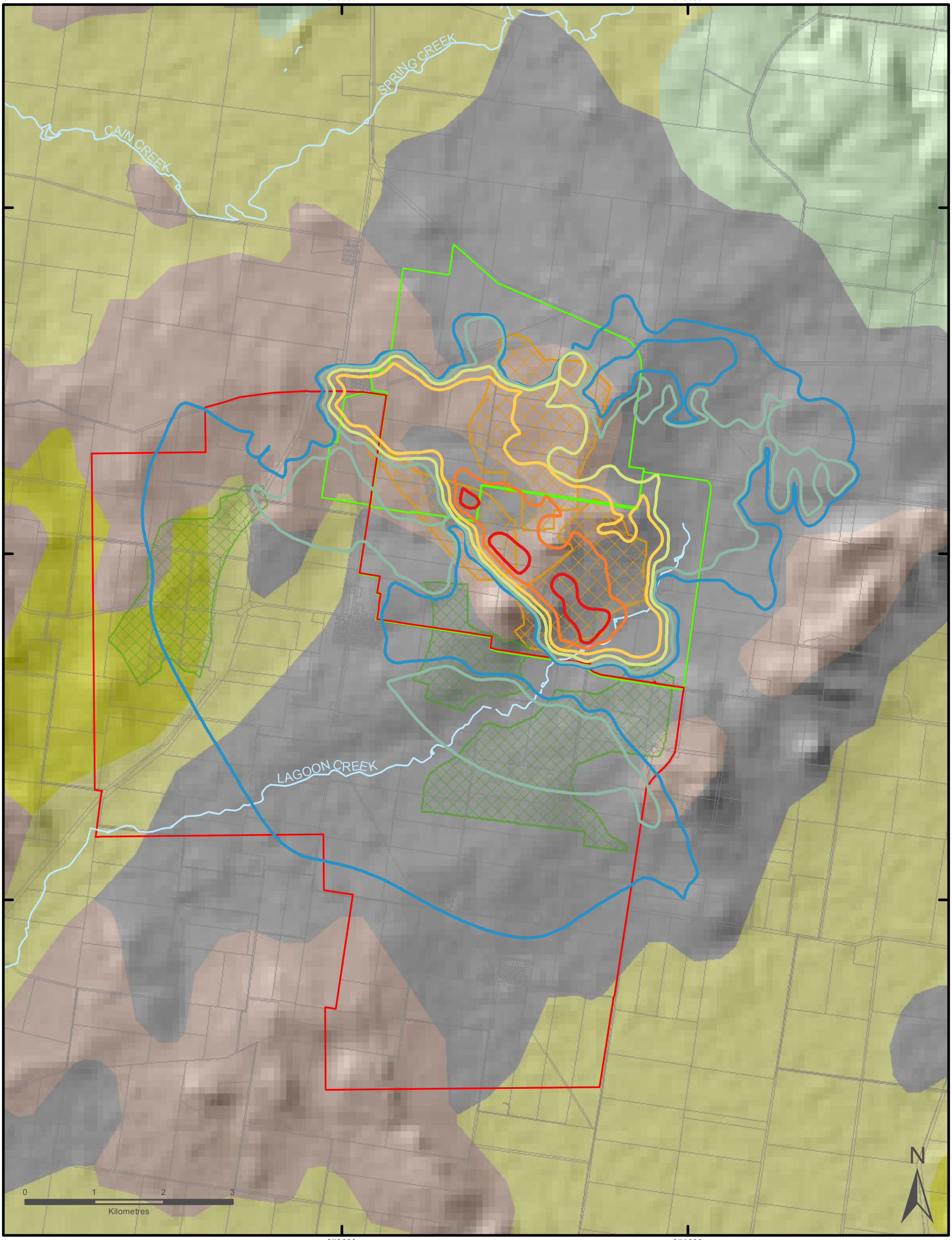
Figure 6-26 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 2015

Scale 1:80,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 23/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130823_NewHope_Groundwater_Figure6-26_PredictedDrawdownInTheWalloonCoalMeasures_2015.mxd



LEGEND

Predicted Drawdown Contour (m)
- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology
- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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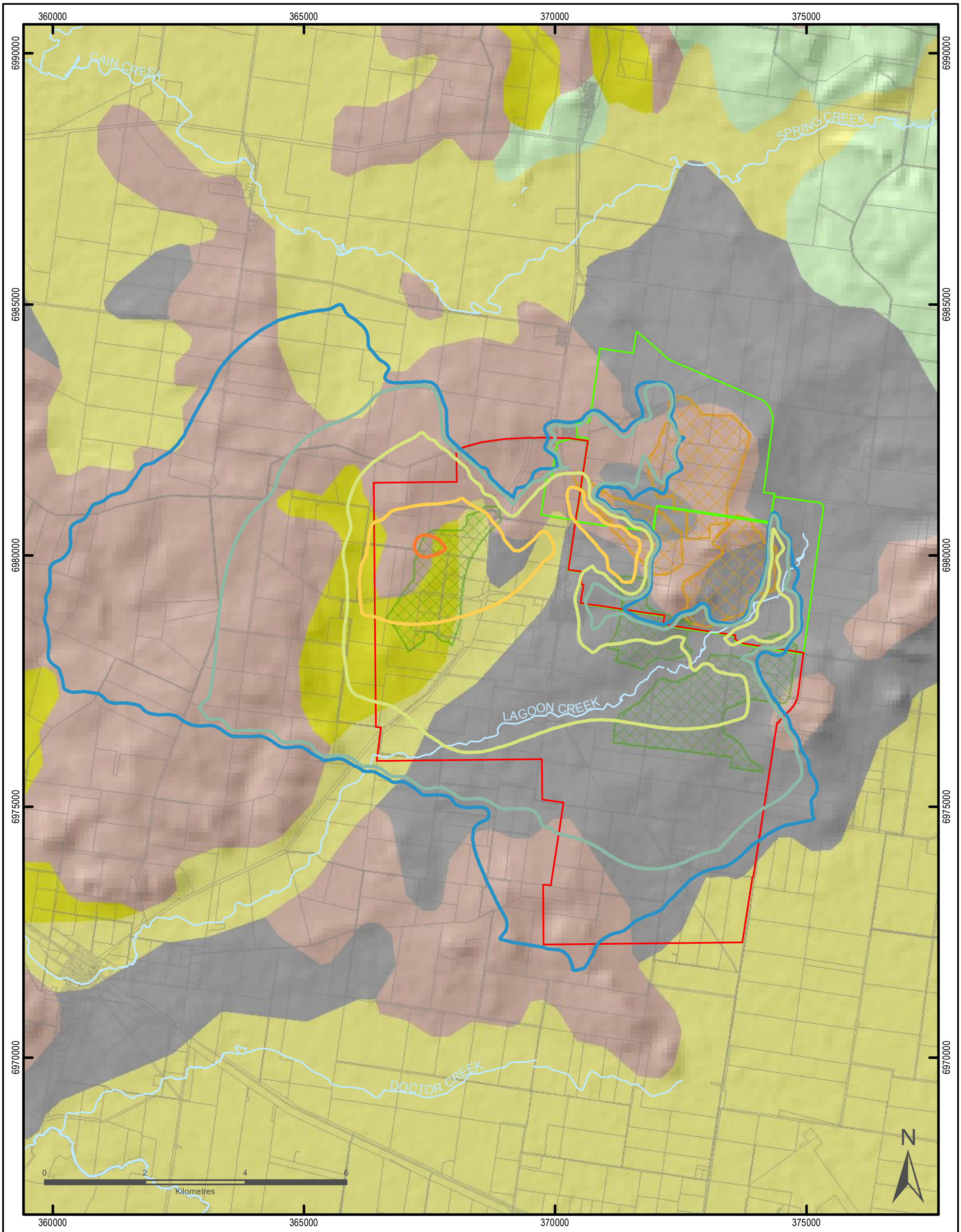
Figure 6-27 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 2017

Scale 1:75,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 23/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130823_NewHope_Groundwater_Figure6-27_PredictedDrawdownInTheWalloonCoalMeasures_2017.mxd



LEGEND

Predicted Drawdown Contour (m)
- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology
- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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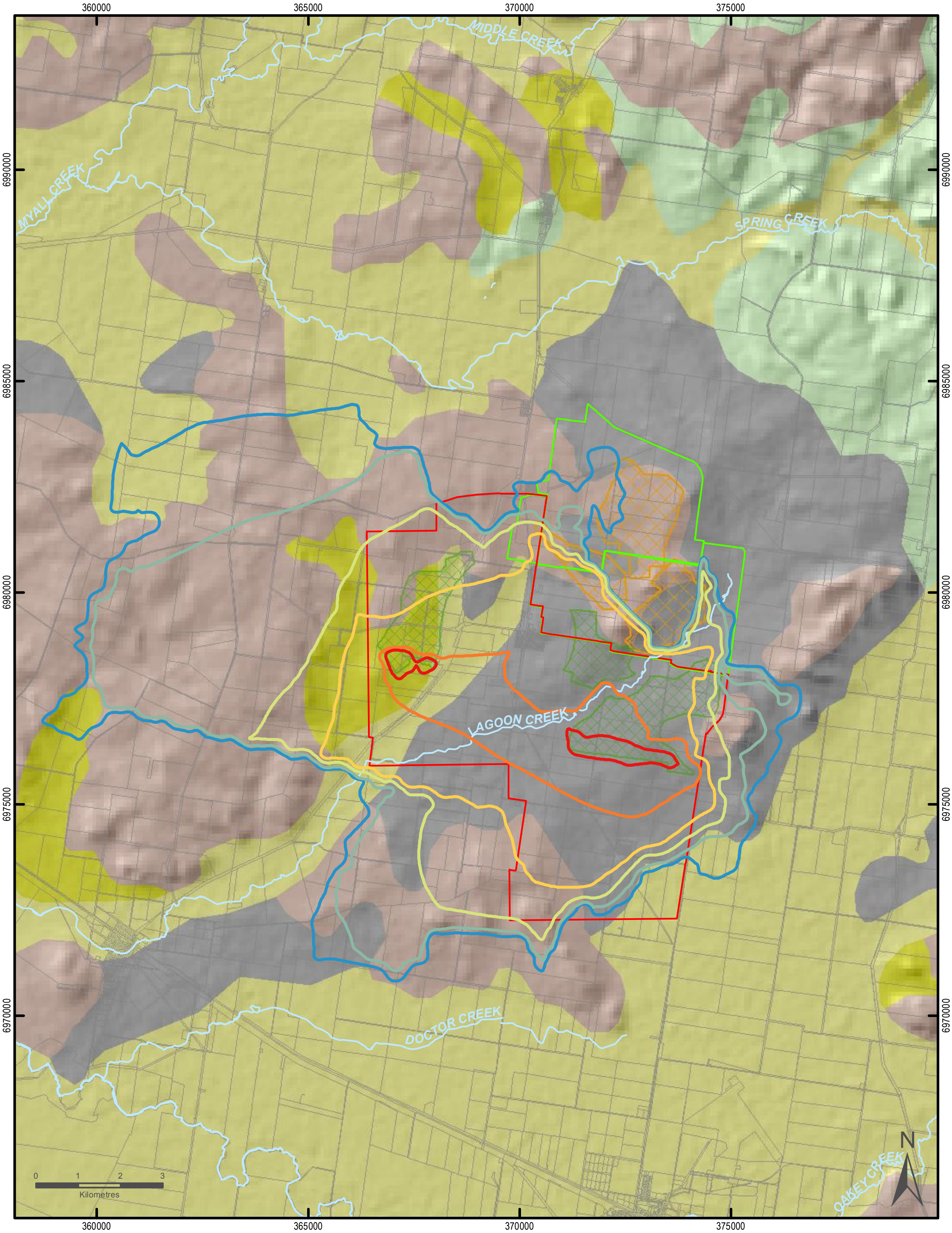
Figure 6-28 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 2021

Scale 1:100,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)



LEGEND
Predicted Drawdown Contour (m)

- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-29 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 2030 (End of Mining)

Scale 1:120,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)

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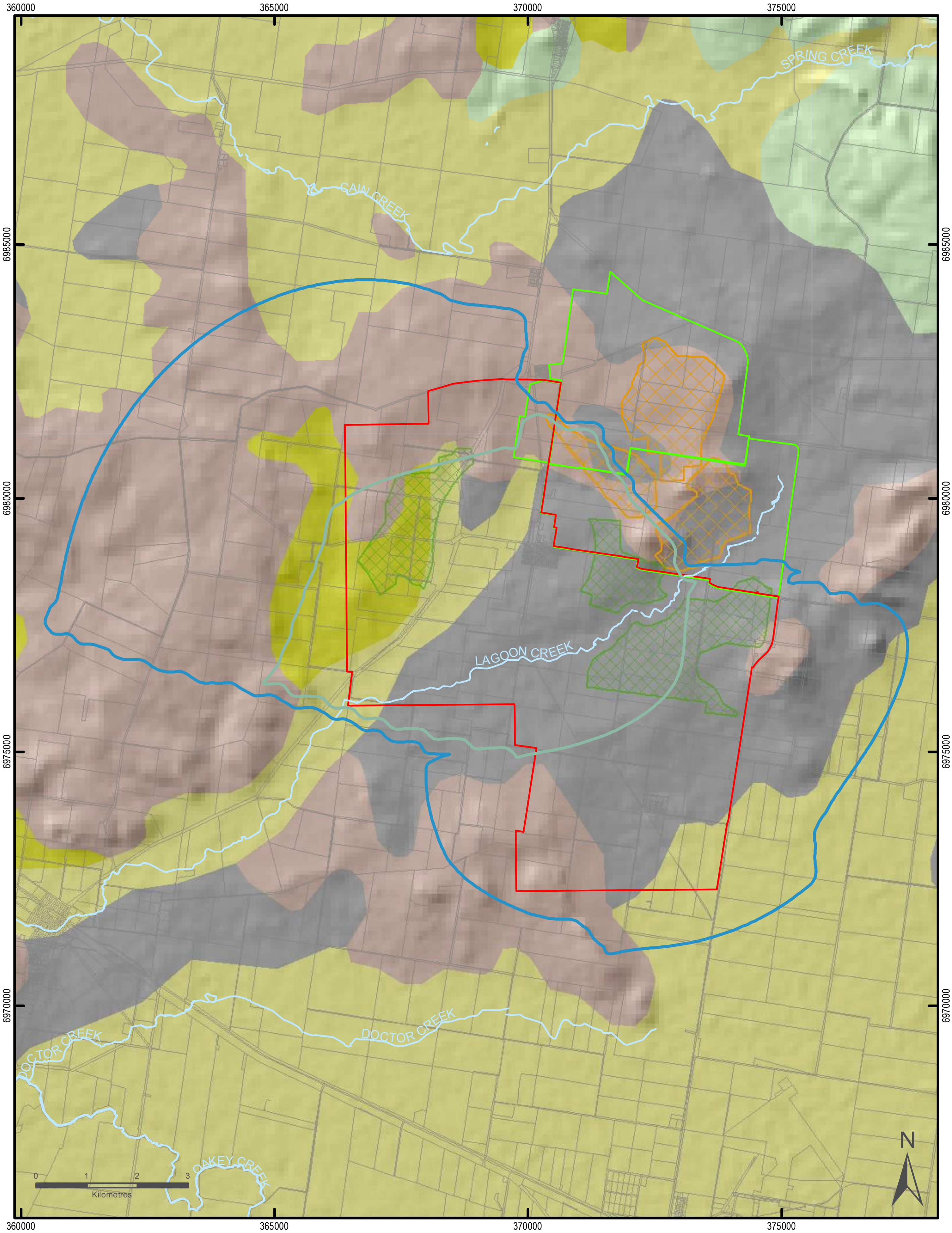

LEGEND

Predicted Drawdown Contour (m)

- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-30 - Predicted Drawdown in the Marburg Sandstone - 2030 (End of Mining)

Scale 1:100,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

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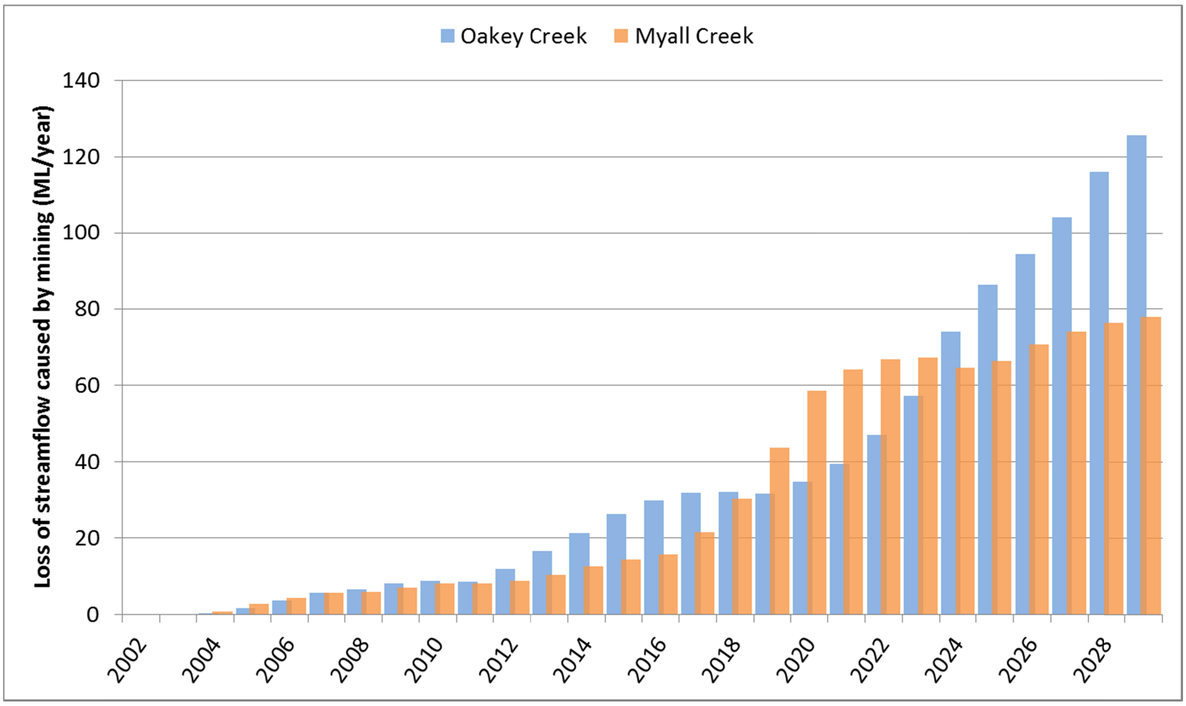


Figure 6-31 Predicted loss of stream flow in Myall and Oakey Creeks

Lagoon and Oakey creeks) indicate that the current 10, 50 and 90th percentile stream flow values are approximately 82, 10.5 and 0 ML/day respectively, with cease to flow occurrences of approximately 19% of the time.

Figure 6-32 presents flow duration curves for Oakey Creek at Fairview at various stages of mining, incorporating surface water releases from the revised Project to Lagoon Creek from 2020 onwards as described in **Chapter 5**. As shown, the predicted reduction in stream flow is small, with a 2% increase in the number of cease to flow occurrences and a 2% reduction in the 50% percentile flow volume at the end of mining. These small reductions in streamflow are in the order of 0.1 ML/day, which are considered to be within the groundwater model's range of error.

Lagoon Creek is not included in the groundwater model as investigations have shown the ephemeral creek to be disconnected from the regional groundwater system with only very minor occurrence of alluvium as described in **Section 6.2.13**.

Effects on Groundwater Levels Post Mining

The numerical model was used to predict groundwater level recovery post-closure. This component of the modelling requires representation of the final long-term depressed landforms (rehabilitated final voids) that will exist post-closure and will form long-term evaporative groundwater sinks.

In the model, the depressed landforms (rehabilitated final voids) were represented as regions of high hydraulic conductivity and storage for the simulation of a depressed landform in which water can accumulate. Rainfall and evaporation were assumed to be active on the depressed landforms (rehabilitated final voids) and these climatic stresses determine where the final water level will recover to in each of the three depressed landforms (rehabilitated final voids).

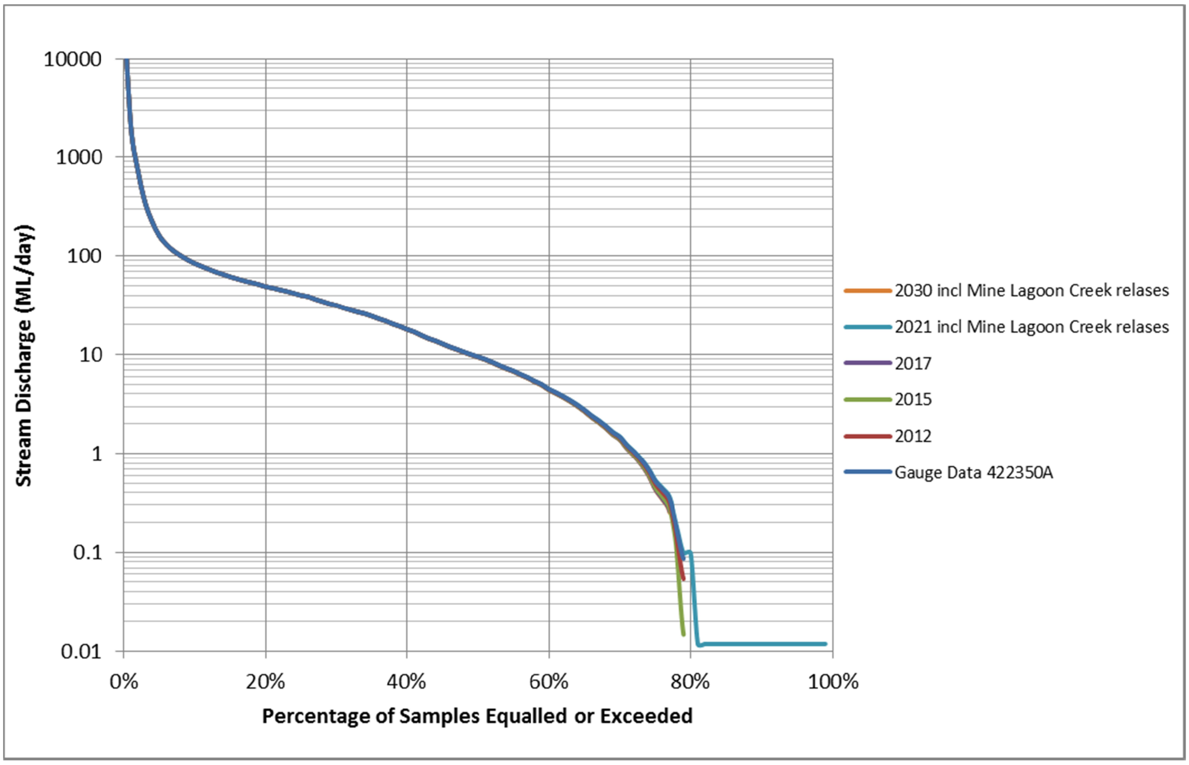
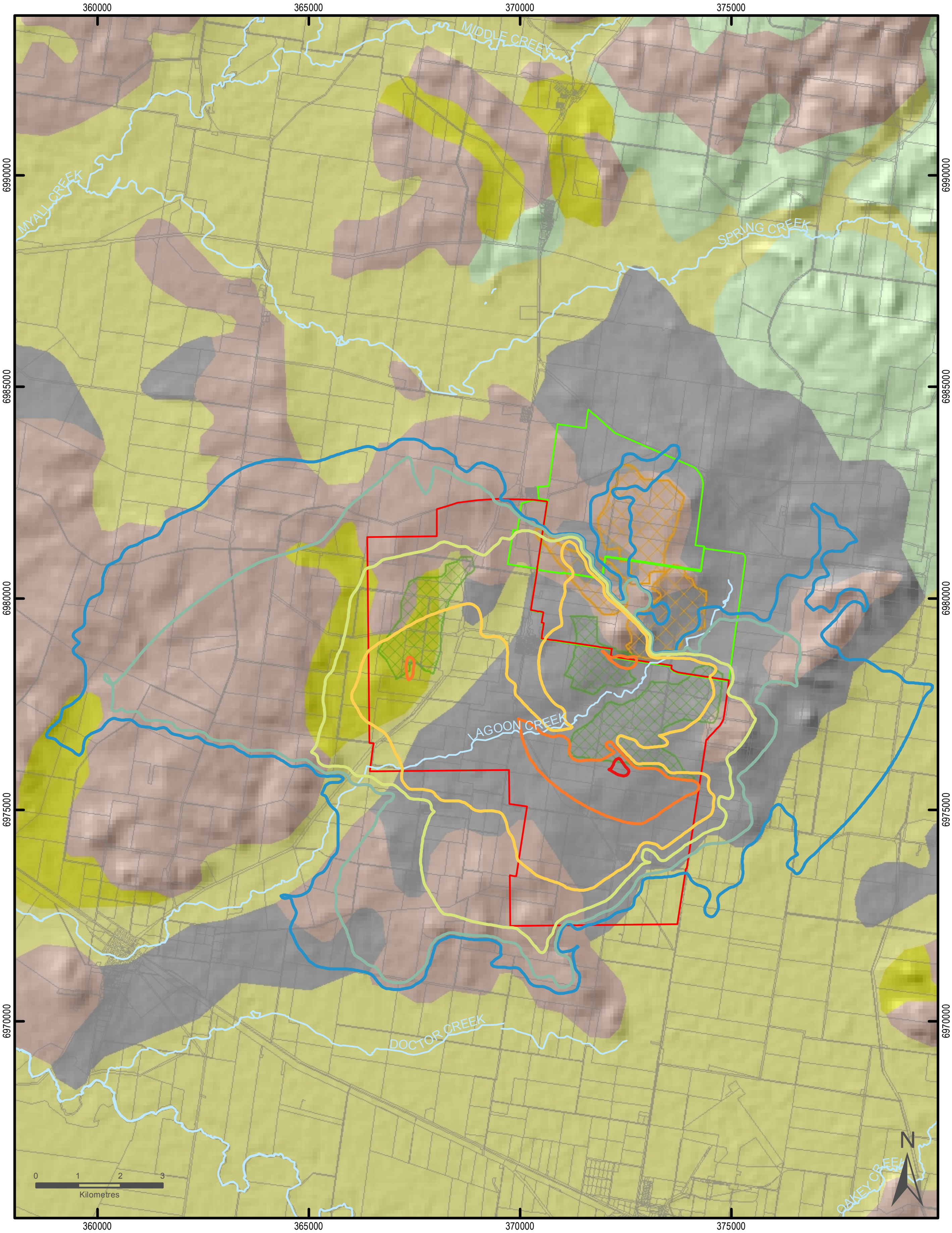


Figure 6-32 Stream flow duration curve - Oakey Creek at Fairview

After cessation of mining in 2030, groundwater levels are predicted to gradually recover so that for the most part there is less than 5 m residual drawdown outside the revised Project's boundary as depicted in **Figure 6-33** and **Figure 6-34**. Recovery to pre-mining conditions throughout the revised Project site is limited by evapotranspirative losses from the depressed landforms (rehabilitated final voids). Drawdown adjacent the last areas to be mined is predicted to remain relatively high (approximately 20 to 30 m) due to the ongoing evapotranspiration-driven groundwater discharge into the depressed landforms (rehabilitated final voids). The 1 m drawdown extent is predicted to remain at approximately 7 km from the revised Project boundary at its greatest (western) extent. Although recovery to pre-mining groundwater levels does not occur post-mining, the groundwater system recovers to a new steady-state equilibrium such that there are no additional groundwater impacts other than those that have already occurred during operation of the revised Project.



LEGEND
Contours - 50years Post Closure
- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology
- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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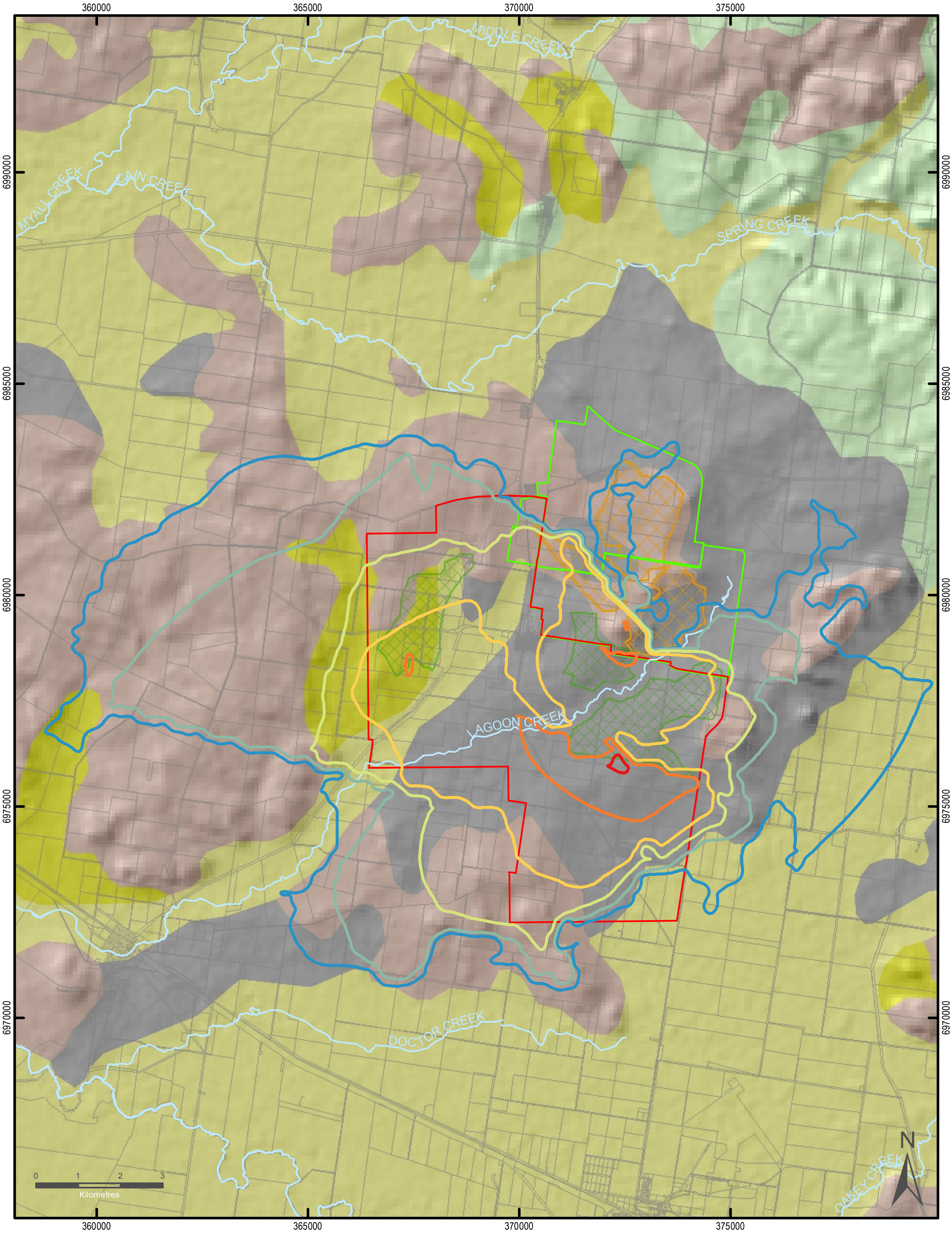
NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-33 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 50 years after Cessation of Mining

Scale 1:120,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 26/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130823_NewHope_Groundwater_Figure6-33_PredictedDrawdownInTheWalloonCoalMeasures_50years.mxd



LEGEND

Contours - 100years Post Closure

- 1
- 2
- 5
- 10
- 20
- 30

- Watercourse
- New Aland Coal Mine-Stage 3
- New Acland Coal Mine
- Cadastre
- Stage 3 Pit Areas
- Existing Permission

Dominant Geology

- Basalt (Tm)
- Alluvium (Qa)
- Colluvium (TQs)
- Walloon Subgroup (Jw)
- Marburg Sandstone (Jbm)

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NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 6-34 - Predicted Drawdown in the Walloon Coal Measures & Tertiary Basalt 100 years after the Cessation of Mining

Scale 1:120,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 26/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\130823_NewHope_Groundwater_Figure6-34_PredictedDrawdownInTheWalloonCoalMeasures_100years.mxd

The amount of groundwater discharge into the depressed landforms (rehabilitated final voids) after mining was completed would normally be expected to decline as groundwater gradually fills the depressed landforms (rehabilitated final voids) to form permanent pit lakes. However, with a potential annual evapotranspiration rate listed by the BOM of around 1,500 mm in the revised Project site and a total depressed landform area below the pre-mining water table of 1.6 km^2, the volume of water lost from these landforms due to evaporation is potentially as high as 2,400 ML/yr. This potential evapotranspiration rate is well in excess of the predicted inflows to the voids post-mining of approximately 1,300 ML/year as shown in **Figure 6-25**.

Due to the high evapotranspiration rate, groundwater discharge to the depressed landforms (rehabilitated final voids) is predicted continue at a rate only slightly less (3.5 ML/day) to that in the last year of mine operation, and the water levels within the depressed landforms (rehabilitated final voids) only partially recover towards pre-mining groundwater levels, with around 30 to 40 m long term residual drawdown within the depressed landforms (rehabilitated final voids) as shown in **Figure 6-35**.

A permanent lake is only predicted to form in the Manning Vale West depressed landform (rehabilitated final void) (**Figure 6-35**). Recovery of groundwater levels in this area is relatively rapid for the first few years post-mining. Formation of a lake within the Manning Vale East depressed landform (rehabilitated final void) is not predicted to occur, and formation of a lake within the Willeroo depressed landform (rehabilitated final void) is only predicted to occur to a minor extent (<4 m depth) for the deepest part of the landform. As such, formation of a lake in the southern depressed landform may be intermittent, driven by climatic water fluxes.

As a dynamic system, the quantity of water remaining in the depressed landforms (rehabilitated final voids) will be influenced over time by factors such as climate (e.g. ambient temperature and humidity profiles, rainfall patterns, and wind conditions), the type of vegetation present and the amount of overland flow directed to the depressed landforms (rehabilitated final voids). Nevertheless, evaporative loss from the depressed landforms (rehabilitated final voids) will remain high in comparison to the sum of the water inputs, especially as overland flow is planned to be diverted away from the depressed landforms (rehabilitated final voids). In addition, the vegetated rehabilitated slopes of the depressed landforms, which will include pasture grass species and possibly selected tree species, will further increase the water loss from the system through evapotranspiration.

6.3.2 Effects on Groundwater Quality

Effects on Groundwater Quality During Mining

The existing Mine operation has not had a detrimental effect on groundwater quality and therefore, the revised Project is not expected to have a detrimental effect on groundwater quality during mining.

Potential sources of contamination to groundwater may include incidents involving significant fuel or oil spills. In the event of this type of incident occurring, potential effects would be contained on the surface and unlikely to effect on groundwater resources. Depending on their size and volume, smaller oil spills will be treated in-situ and larger spills will be excavated and treated under a temporary land farm arrangement, which will include an impermeable base.

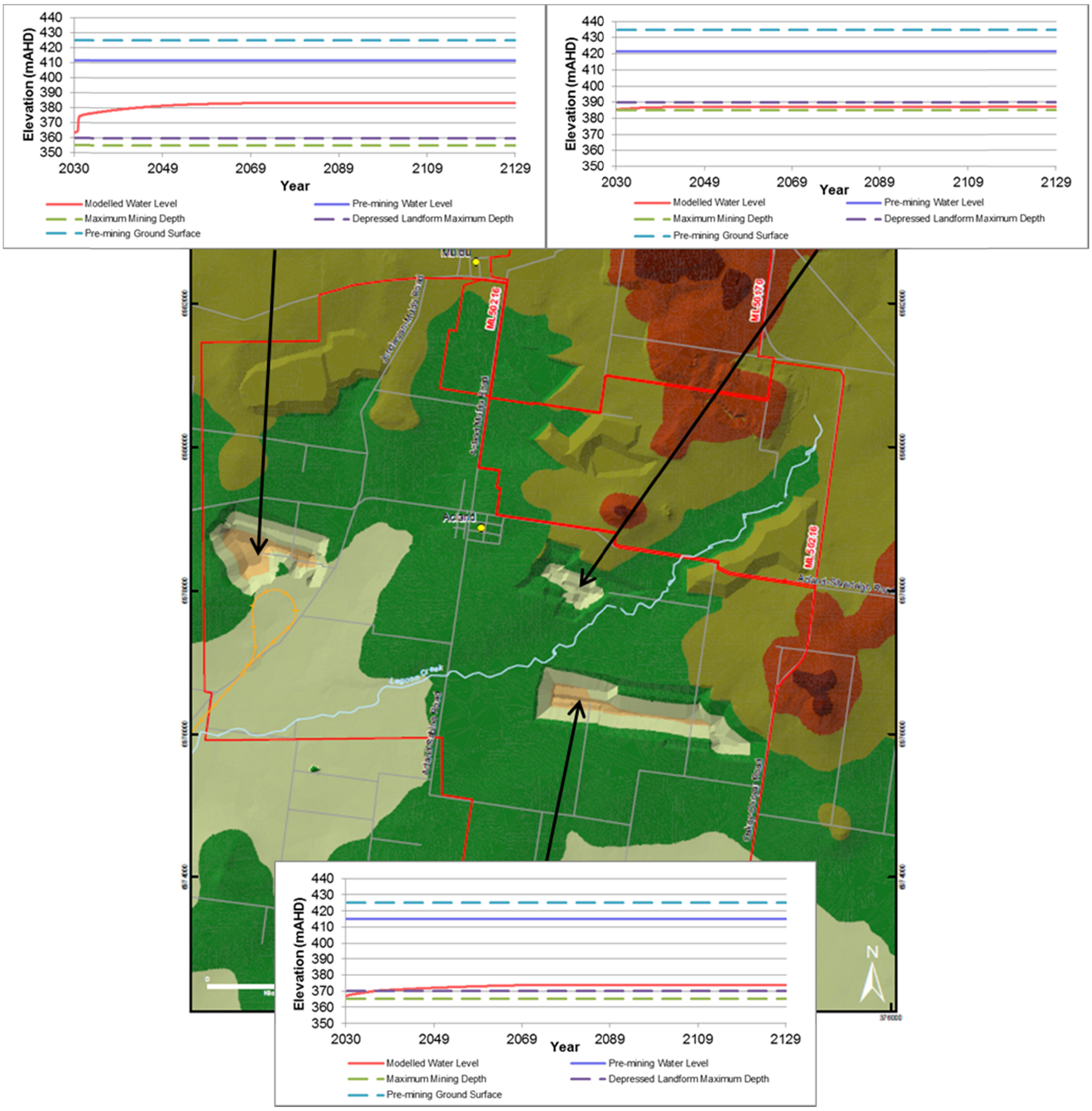


Figure 6-35 Predicted final depressed landform groundwater recovery

To date, net acid generation resulting in the lowering of pH in water in the Mine pits has not occurred at the Mine and is not expected to occur within the revised Project's new mining areas due to the similar geological nature of the current and new resource areas.

The extraction of groundwater within the revised Project site will create a depression in groundwater levels. As a result, groundwater in the Walloon Coal Measures aquifer surrounding the revised Project site will move towards this depression. The surrounding underlying aquifers in the revised projects vicinity will continue to receive recharge via the same processes that occurred prior to the operational phase of the revised Project. Therefore, the groundwater in the vicinity of the revised Project should be of similar quality to its current physico-chemical state.

Due to the confined state of the underlying Marburg Sandstone and Helidon Sandstone aquifers, potential effect to these aquifers is considered negligible. The Tertiary Basalt aquifer is not expected to be affected by the revised Project in terms of groundwater quality.

In summary, the operational phase of the revised Project is not expected to effect on groundwater quality. Groundwater quality will continue to be monitored throughout the life of the revised Project to confirm that potential effects are not occurring.

Effects on Groundwater Quality Post Mining

The depressed landforms (rehabilitated final voids) will potentially collect and accumulate water from:

- groundwater ingress from the Walloon Coal Measures aquifers; and
- incident direct rainfall within the depressed landforms (rehabilitated final voids).

Water quality in the depressed landforms (rehabilitated final voids) where pit lakes form will be moderately saline due to inflows of moderately saline groundwater from the Walloon Coal Measures, and any groundwater collected in the depressed landforms (rehabilitated final voids) will be further concentrated by evaporation, but offset by overland runoff into, and direct rainfall on, the pit lakes. Analytical calculations, based on the groundwater and surface water model results for the revised Project, suggest that the increase in salinity of the groundwater collected in the depressed landforms (rehabilitated final voids) resulting from evaporation is limited to a maximum of 25 to 30% of background groundwater salinity (i.e. limited to around 5,000 mg/L compared to background groundwater salinity of approximately 4,000 mg/L) in the long term. Any increase in salinity beyond this is shown to be limited by overland runoff into, and direct rainfall on, the pit lakes.

The depressed landforms (rehabilitated final voids) will act as groundwater sinks and as a result, will not permit pooled water to flow outwards into the regional system. Therefore, any pooled saline water should remain confined within the depressed landforms (rehabilitated final voids) and not have an impact on the water quality of the surrounding aquifers.

There is potential for density driven flow to groundwater in the Walloon Coal Measures aquifer immediately adjacent to the depressed landforms (rehabilitated final voids) due to the evaporative concentration of pooled water within the Manning Vale West (and potentially Willeroo) void lake and in the aquifer adjacent the depressed landform (rehabilitated final void). Should this occur, it is likely to be a localised effect immediately around the depressed landform (rehabilitated final void) areas. Although this has the potential to create a density contrast between the groundwater adjacent the depressed landform (rehabilitated final void) and the less saline native groundwater further from the depressed landform (rehabilitated final void), the resulting density difference calculated is not expected to be great enough to overcome the head gradient between the aquifer and the depressed landform (rehabilitated final void), and therefore density driven flow away from the depressed landform (rehabilitated final void) is not expected to occur.

It is unlikely that water captured in the depressed landforms (rehabilitated final voids) will become acidic from oxidation of pyrites in the Walloon Coal Measures because of the neutralising effect of the surrounding sediments which are alkaline by nature. In summary, the revised Project is not expected to effect on groundwater quality post mining.

6.3.3 Effects on Groundwater Users

Effects to Groundwater Users During Mining

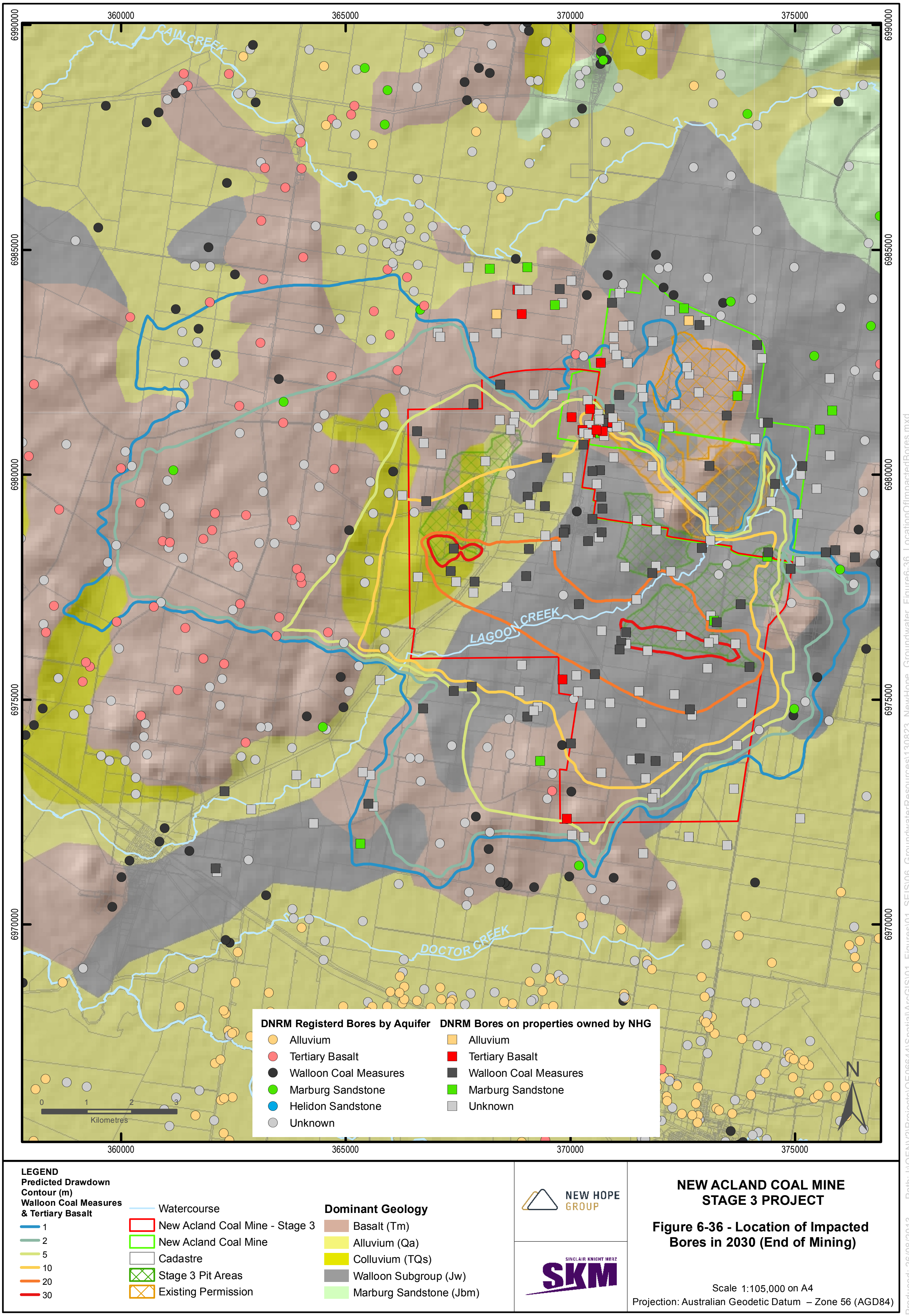
Based on the predicted groundwater level drawdown in **Section 6.3.1**, the influence of dewatering on adjacent groundwater users can be estimated. The numerical model predicts that the effect of groundwater drawdown in the Walloon Coal Measures and Tertiary Basalt at the end of the mine life extends to approximately 7 km west and northwest from the Project's boundary, but less than 2 km to the east and south. Properties within 3 km of the western boundary of the revised Project site are predicted to have the greatest effects, with drawdown in the Walloon Coal Measures of between 5 m and 20 m. **Section 6.4.4** describes proposed mitigation measures associated with affected groundwater users. **Figure 6-36** presents the location of affected groundwater bores at the time of maximum predicted groundwater drawdown (2030, corresponding to the end of mining).

Drawdown in the Marburg Sandstone is predicted to be less than 3 m at all times during mining and less than 2 m for most areas outside the revised Project site, and so no negative effects to groundwater users from this aquifer are expected.

Effects to Groundwater Users Post Mining

After cessation of mining in 2030, groundwater levels are predicted to gradually recover so that for the most part there is less than 5 m residual drawdown outside the revised Project's boundary in the long term for both the Walloon Coal Measures and the Tertiary Basalt aquifer. The 1 m drawdown extent is predicted to remain at approximately 7 km from the revised Project boundary at its greatest (western) extent. These small residual drawdowns outside the revised Project site are for the most part not expected to cause long term negative effect on groundwater users outside the revised Project site. **Section 6.4.4** describes proposed mitigation measures associated with affected groundwater users.

The groundwater quality within bores is not expected to change following the cessation of mining as described in **Section 6.3.2**.



NEW ACLAND COAL MINE
STAGE 3 PROJECT

Figure 6-36 - Location of Impacted Bores in 2030 (End of Mining)

Scale 1:105,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)

6.3.4 Effects on Groundwater Dependent Ecosystems

A search of the BoM's GDE Atlas and also published DERM and Regional Ecosystem (2005) mapping data has identified no GDEs reliant on the surface expression of groundwater (such as rivers, springs or wetlands) within 10 km of the revised Project site. The same search has however identified a low to moderate potential for the presence of terrestrial vegetation that is reliant on the occurrence of subsurface groundwater within the revised Project site.

Chapter 7 describes the revised Project related terrestrial ecosystems in detail. A review of the terrestrial ecosystems existing within the vicinity of the revised Project site indicates that the water requirements for these species are likely to be derived from depths less than 10 m below ground level. Given that the depth to the water table in the Walloon Coal Measures aquifer is between approximately 10 m to 50 m below ground level across the revised project site, there are likely to be no GDEs (including terrestrial vegetation reliant on groundwater to some degree) present within the revised Project site.

6.4 Mitigation Measures

This Section describes the measures proposed to mitigate the potential effects assessed in **Section 6.3**.

6.4.1 Groundwater Monitoring Program

The groundwater monitoring program for the revised Project combines the current monitoring program for the existing Mine with an extended network of monitoring bores enclosing the revised Project site. Data collected from the groundwater monitoring program will:

- be operated in accordance with the revised Project's approved EA, including adoption of suitable guideline criteria and temporal investigation;
- be used in the continued development and refinement of groundwater impact assessment criteria and investigation triggers;
- enable verification and refinement (where necessary) of the groundwater modelling predictions presented in this EIS; and
- be collated into a database that will be made available to the administering authority on request.

The current groundwater monitoring program conforms to Conditions C21 to C33 of the current EA EPML00335713 for New Acland Coal Mine. **Table 6-18** summarises the bores that will be monitored, monitoring parameters, and frequency. The groundwater monitoring program combines the existing Mine monitoring bores together with the seven additional bores already installed around the revised Project site.

In addition, a further 15 bores will be added to the monitoring network, which brings the total number of bores included in the groundwater monitoring program to 37. The monitoring program for new bores will be established prior to the commencement of mining to ensure there is sufficient baseline information on groundwater levels and quality for those bores.

The locations of the monitoring bores in **Table 6-18** are presented in **Figure 6-37**. Proposed additional monitoring bore locations have been chosen based on model drawdown predictions and presence of aquifers and receptors of interest. For example, new nested monitoring bores are proposed to be installed immediately west of the Manning Vale West pit area where model results indicate significant drawdown in the Walloon Coal Measures and Tertiary Basalt and some drawdown in the Marburg Sandstone. Installation of nested monitoring bores in these locations will allow early detection of impacts from mining in the Tertiary Basalt, Walloon Coal Measures and Marburg Sandstone aquifers, and also provide information on the degree of interconnectivity of these aquifers as mining progresses. In the southeast of the revised Project site, nested monitoring bores will be installed into the Oakey Creek Alluvium and the Walloon Coal Measures aquifer, to confirm model predictions of limited groundwater impact in those areas.

In addition, a single monitoring bore is proposed to be installed within the Mine's existing worked pit backfill area, given the apparent presence of a developing groundwater mound in this area. The final location of the proposed additional bores may vary slightly depending on land access and proximity to local groundwater users. These bores will be individually identified in accordance with the bore naming convention at the revised Project site.

The groundwater monitoring network will:

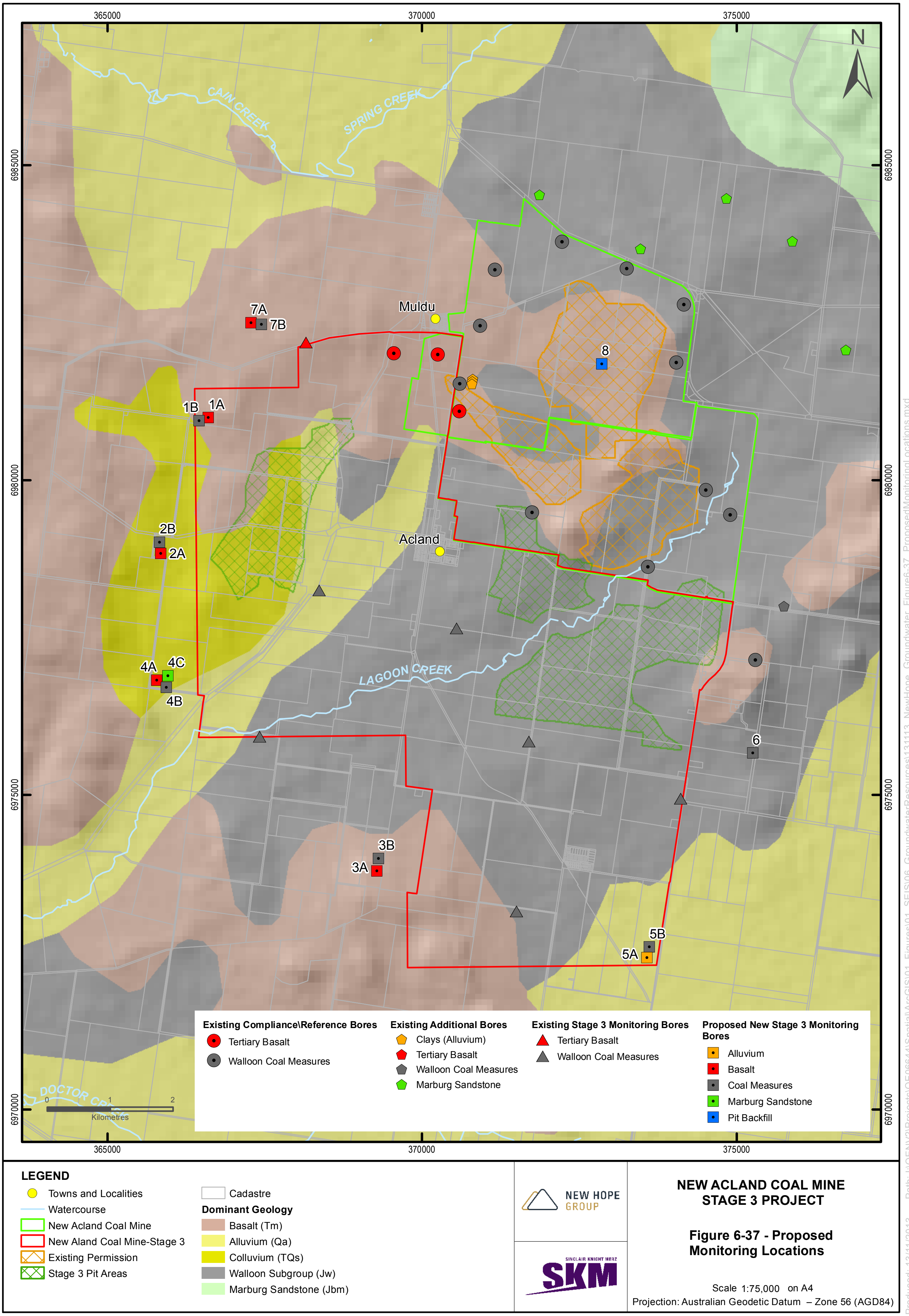
- be installed and maintained by a person possessing appropriate qualifications and experience in the fields of hydrogeology and groundwater monitoring program design to be able to competently make recommendations about these matters;
- be constructed in accordance with methods prescribed in the *"Minimum Construction Requirements for Water Bores in Australia"* (National Uniform Drillers Licensing Committee, 2012) by an appropriately qualified driller; and
- include a sufficient number of 'bores of compliance' that are located at an appropriate distance from potential sources of impact from mining activities and provide the following:
- representative groundwater samples from the uppermost aquifer;
- background water quality in hydraulically up-gradient or background bore(s) that have not been affected by any mining activities conducted by NAC; and
- the quality of groundwater down gradient of potential sources of contamination.

Groundwater monitoring will be undertaken by appropriately qualified personnel. Groundwater level measurements, sample collection, storage and transportation will be undertaken in accordance with procedures conforming to the current industry standard: AS/NZS 5667.1, .11 1998.

Table 6-18 Groundwater Monitoring Schedule

Monitoring Point	Aquifer	Parameter and Monitoring Frequency
Bores monitored under current monitoring program (Compliance and Reference bores)		
2289P	Coal Measures	Groundwater levels: monthly. Groundwater quality: six monthly to include: Al, As, Ca, Se, Cl, Cu, F, Fe, Total N, K, Mg, Mn, Na, SO_4, HCO_3, TDS, EC, pH
2291P	Coal Measures	
18P	Coal Measures	
25P	Basalt	
26P	Coal Measures	
27P	Coal Measures	
28P	Coal Measures	
843	Basalt	
848	Coal Measures	
81P	Coal Measures	
82P	Coal Measures	
83P	Coal Measures	
84P	Basalt	
BMH1	Basalt	
CSMH1	Coal Measures	
Existing monitoring bores to be incorporated into the revised Project's monitoring program		
109P	Basalt	Groundwater levels: monthly. Groundwater quality: six monthly to include: Al, As, Ca, Se, Cl, Cu, F, Fe, Total N, K, Mg, Mn, Na, SO_4, HCO_3, TDS, EC, pH
112PGC	Coal Measures	
114P	Coal Measures	
116P	Coal Measures	
119PGC	Coal Measures	
120WB	Coal Measures	
121WB	Coal Measures	
Proposed additional monitoring points which will be monitored as part of the revised Project's monitoring program		
1A	Basalt	Groundwater levels: monthly. Groundwater quality: six monthly to include: Al, As, Ca, Se, Cl, Cu, F, Fe, Total N, K, Mg, Mn, Na, SO_4, HCO_3, TDS, EC, pH
1B	Coal Measures	
2A	Basalt	
2B	Coal Measures	
3A	Basalt	
3B	Coal Measures	
4A	Basalt	
4B	Coal Measures	
4C	Marburg Sandstone	

Monitoring Point	Aquifer	Parameter and Monitoring Frequency
Bores monitored under current monitoring program (Compliance and Reference bores)		
5A	Oakey Creek Alluvium	
5B	Coal Measures	
6	Coal Measures	
7A	Basalt	
7B	Coal Measures	
8	Mine Pit Backfill	



365000
370000
375000
6985000
6980000
6975000
6970000
N
CAIN CREEK
SPRING CREEK
LAGOON CREEK
DOCTOR CR
Muldu
Acland
7A
7B
1A
1B
2A
2B
4A
4B
4C
3A
3B
5A
5B
6
8
0
1
2
Kilometres
Existing Compliance\Reference Bores
Tertiary Basalt
Walloon Coal Measures
Existing Additional Bores
Clays (Alluvium)
Tertiary Basalt
Walloon Coal Measures
Marburg Sandstone
Existing Stage 3 Monitoring Bores
Tertiary Basalt
Walloon Coal Measures
Proposed New Stage 3 Monitoring Bores
Alluvium
Basalt
Coal Measures
Marburg Sandstone
Pit Backfill
LEGEND
Towns and Localities
Watercourse
New Acland Coal Mine
New Aland Coal Mine-Stage 3
Existing Permission
Stage 3 Pit Areas
Cadastre
Dominant Geology
Basalt (Tm)
Alluvium (Qa)
Colluvium (TQs)
Walloon Subgroup (Jw)
Marburg Sandstone (Jbm)
NEW HOPE GROUP
SINCLAIR KNIGHT MERZ
SKM
NEW ACLAND COAL MINE
STAGE 3 PROJECT
Figure 6-37 - Proposed Monitoring Locations
Scale 1:75,000 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)
Produced: 13/11/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\06_GroundwaterResources\131113_NewHope_Groundwater_Figure6-37_ProposedMonitoringLocations.mxd

The data gathered from the groundwater monitoring program will be collated into a database which will include:

- a site plan showing sample locations;
- tabulated results of the monitoring compared with applicable background/trigger levels;
- all data collected during each monitoring round;
- a record of chain of custody of the samples from sampling through to analysis;
- laboratory analysis certificates;
- groundwater monitoring program reports, and
- a description of the procedures, methods and calculations used.

Groundwater sample analysis will continue to be undertaken by a laboratory accredited by the National Association of Testing Authorities (NATA). Field measurement of water quality parameters will continue to be undertaken using appropriate field equipment that is maintained and calibrated in accordance with the manufacturer's recommendations.

Data collected from landholder bores, wells, and waterholes will be used in conjunction with the groundwater impact investigation procedure to determine if contingency measures are required.

Groundwater levels will be monitored on a monthly basis and samples will be collected and submitted for the analytical suite set out in **Table 6-18** every six months.

The existing Mine EA reference bores (BMH1 and CSMH1) are located within the predicted zone of groundwater drawdown from operation of the revised Project. NAC will accordingly re-assess the location of these reference bores and if necessary install new reference bores outside the revised Project's predicted zone of groundwater drawdown.

Alluvium

The nearest alluvium with significant groundwater supplies is associated with Oakey Creek south of the revised Project site. A new monitoring bore installed at location 5A (**Table 6-18** and shown on **Figure 6-37**) will monitor groundwater levels and quality in the Oakey Creek Alluvium within the Project's southern boundary.

Basalt

Eight basalt bores will be monitored, including five new bores (**Table 6-18** and shown on **Figure 6-37**).

Walloon Coal Measures

The groundwater monitoring program includes 25 bores in the Walloon Coal Measures (**Table 6-18** and shown on **Figure 6-37**), including seven new bores.

Marburg Sandstone

Due to the lack of predicted impacts on the Marburg Sandstone aquifer arising from the revised Project, a single additional monitoring bore is proposed for this aquifer to confirm those predictions. This bore is located west of the revised Project site and is located in a nested configuration adjacent proposed monitoring bores in the Tertiary basalt and Walloon Coal Measures aquifers (**Table 6-18** and shown on **Figure 6-37**).

Pit Backfill

Due to the apparent presence of a developing groundwater mound in the existing Mine's backfilled pit area, a groundwater monitoring bore (**Table 6-18** and shown on **Figure 6-37)** will be installed in the mound area to directly test for its presence and monitor its development over time.

6.4.2 Landholder Bores

Groundwater monitoring will be undertaken at selected landholder bores surrounding the revised Project site, following consultation with relevant landholders. Primarily this will include monitoring of groundwater levels and groundwater quality in conjunction with metering groundwater abstraction rates at suitable bores in order to assess potential groundwater level impacts from mine dewatering in the context of any variations to bore pumping rates. Landholder bores targeted for monitoring will be selected based on a thorough review of bores within the predicted drawdown impact zone. **Section 6.4.4** details the approach for managing impacts on landholder bores in further detail.

6.4.3 Groundwater Impact Prediction, Validation and Review

During the life of the revised Project, data collected through the groundwater monitoring program, will be used to update and refine the revised Project's groundwater model and it's predictions to reflect the actual activities undertaken on site (e.g. mine development and sump locations).

The need to review and update the revised Project's model will depend on the stage of the revised Project's mine development, changes in the depth of working, and availability and results of new monitoring data. For example, at the conclusion of the installation program for new monitoring bores as detailed in **Section 6.4.1**, the data collected from the monitoring program will be used to immediately refine the model and produce a revised impact assessment. **Table 6-19** presents the proposed schedule for groundwater impact prediction, validation and review.

The results of the groundwater model verification and refinement, or the justification that this action is not necessary, will be documented, and as required, presented to the DNRM (regulatory authority).

Table 6-19 Schedule for Groundwater Impact Prediction, Validation and Review

Model Revision	Timing
Initial Review	At the conclusion of the revised monitoring network installation program
2nd Review	After one (1) year of operation of the revised Project
3rd and subsequent Reviews	Every three (3) years or if water level drawdown monitoring results exceed model predictions at any time of the revised Project operation

6.4.4 Mitigation Measures for affected Groundwater Users

NAC will undertake a program of works to characterise and assess predicted impacts on individual groundwater users within the predicted drawdown area. The work program will have the primary outcome of determining the most appropriate means of 'Make Good' for individual users should groundwater monitoring validate model predictions of groundwater effects on those users. Results of this characterisation work will also feed into the first revision of the groundwater model where possible.

If required in these circumstances, NAC will provide an alternative water supply arrangement to affected third parties. Due to the progressive nature of drawdown within aquifers, the provision of alternative supplies may be staged. Options for possible alternative supplies include:

- the deepening and / or refurbishment of existing bores;
- the installation of new pumps capable of extracting groundwater from greater depths within existing bores;
- the installation of a new bores at other locations on the affected landholder's property; and
- the installation of a new high yielding 'community bore' and subsequent pipeline to multiple affected landholders.

NAC will ensure its groundwater monitoring regime is adequate to identify possible effects to neighbouring groundwater users from the revised Project's operations (i.e., in relation to drawdown levels and water quality). NAC will review its groundwater monitoring regime on a regular basis in line with the progression of mining over the life of the revised Project. The revised Project's groundwater monitoring regime will be periodically updated in NAC's current Environmental Monitoring Plan, which forms a supporting document to the NAC Plan of Operations.

NAC will investigate all groundwater complaints related to the revised Project both during the operational phase and following mine closure. NAC will ensure all legitimate groundwater complaints are addressed in an expedient manner.

NAC has developed a Groundwater Monitoring and Impact Management Plan (GMIMP) to formalise the management of the revised Project's potential impacts on the surrounding groundwater environment. The GMIMP is based on the groundwater impact assessment work completed for the revised Project's EIS. The GMIMP will be regularly reviewed over the life of the revised Project, and as required, will be updated based on monitoring results, new outputs from revisions to the groundwater modelling and any other applicable groundwater management matters that relate to operation of the revised Project. The GMIMP will form a supporting document to NAC's Plan of Operations for the revised Project and is provided in **Appendix J.5**.

6.5 Conclusions

Five aquifers exist within the revised Project site; the Quaternary alluvial aquifer, the Tertiary basalt aquifer, the Walloon Coal Measures aquifer, and the deeper Marburg Sandstone and Helidon Sandstone aquifers.

The Quaternary Alluvial aquifer is limited in spatial extent and within the revised Project site may only exist within the westernmost part in association with Lagoon Creek, although investigations have shown that Lagoon Creek is very likely disconnected from the regional groundwater system. The alluvial aquifer is known to form a significant groundwater resource outside of the revised Project site, especially in association with Oakey Creek south of the revised Project site and Myall Creek northwest of the revised Project site.

A review of surface geological mapping and bore logs from drilling undertaken as part of the revised Project baseline assessment demonstrates that there is only minor outcrop of the Tertiary Basalt aquifer in the northwestern and extreme southwestern sections of the revised Project site. The basalt is known to form a major aquifer immediately west of the revised Project site.

The Walloon Coal Measures aquifer outcrops over much of the revised Project site, and forms the main groundwater aquifer intersected by the revised Project. On a regional scale the Walloon Coal Measures is considered a confining unit of the GAB however on a local scale it is known to support significant groundwater extraction for stock and domestic use. Groundwater is dominantly held and transmitted within the coal seams, although testing has shown the interburden strata may also hold and transmit significant quantities of water.

The Marburg Sandstone and Helidon Sandstone aquifers are major aquifers of the Great Artesian Basin and are the deepest semi-confined to confined aquifers underlying the revised Project site. These aquifers lie at significant depth below the revised Project's mine pits. As such only very small impacts are expected on the Marburg Sandstone aquifer and no impacts will occur to the Helidon Sandstone aquifer. The Marburg Sandstone aquifer is separated from the Project's mine pits by at least 75 m of low permeability Walloon Coal Measures/Eurombah Formation aquitard-forming strata, and the Helidon Sandstone aquifer is separated from the Marburg Sandstone aquifer by around 200 m of Evergreen Formation, which is a recognised aquitard.

Groundwater use in and adjacent the revised Project site is limited to landholders who draw on groundwater through bores for water supply purposes. Aquifers accessed by identified groundwater users include the Quaternary alluvium, Tertiary Basalt, Walloon Coal Measures and Marburg Sandstone. The current Mine uses groundwater from bores accessing the Tertiary Basalt aquifer as the main potable water supply, groundwater inflows to the mining pits from the Walloon Coal Measures aquifer for industrial purposes (dust suppression), and maintains access to the Marburg Sandstone and Helidon Sandstone aquifers as an emergency water supply for industrial purposes. In general, reliance on groundwater for industrial purposes has decreased significantly since the WWRF Pipeline was brought online in 2010. No environmental users of groundwater have been identified within or adjacent the revised Project site (i.e. Groundwater Dependent Ecosystems).

As part of the groundwater impact assessment process, a numerical groundwater model was used to predict the effect of groundwater drawdown from mine pit dewatering. The modelling was used to assess the potential effect of groundwater drawdown resulting from mine pit inflows on existing groundwater users. Mine pit inflows are predicted to range from 0.8 to 4.0 ML/day during mining, with drawdown of 1 to 5 m in the Walloon Coal Measures and Tertiary Basalt aquifers extending approximately 7 km west from the revised Project's boundary. Drawdown in the Walloon Coal Measures aquifer to the south and east of the Project area is not predicted to exceed much more than 5 m outside the Project's boundaries. Drawdown within the Marburg Sandstone aquifer is predicted to be less than 3 m throughout the revised Project's duration, with impacts greater than 2 m limited to the revised Project site. Off-site impacts are limited to drawdown of less than 2 m, with the predicted 1 m drawdown contour extending up to 5km from the revised Project boundary.

After cessation of mining in 2030, groundwater levels are predicted to gradually recover so that for the most part there is less than 5 m residual drawdown outside the revised Project's boundaries. Recovery to pre-mining conditions throughout the revised Project site is limited by evapotranspirative losses from the depressed landforms (rehabilitated final voids). Due to the high regional potential evapotranspiration rate, groundwater discharge to the depressed landforms (rehabilitated final voids) is predicted continue at a rate only slightly less (3.5 ML/day) to that in the last year of mine operation. Drawdown adjacent the last areas to be mined is predicted to remain relatively high (approximately 20 to 30 m) due to the ongoing evaporation-driven groundwater discharge into the depressed landforms (rehabilitated final voids). A pit lake is expected to form within the Manning Vale West depressed landform, but a lake may not form to any significant degree in the Willeroo depressed landform and is not expected to form at all in the Manning Vale East depressed landform. Groundwater level recovery within the depressed landforms (rehabilitated final voids) remains at to 30 to 40 m below the level of the pre-mining water table in the long term, due to the ongoing evapotranspirative groundwater discharge. As a result, the depressed landforms (rehabilitated final voids) form a depression of the potentiometric surface within the vicinity of the depressed landforms (rehabilitated final voids) and act as a groundwater sink that will not permit any pooled water within or adjacent to the depressed landforms (rehabilitated final voids) to flow outwards into the regional groundwater system.

The 1 m drawdown extent is predicted to remain at approximately 7 km from the revised Project boundary at its greatest (western) extent in the long term post-mining due to ongoing evapotranspiration-driven groundwater discharge to the depressed landforms (rehabilitated final voids). However, the groundwater system is expected to recover post-mining to a new steady state-equilibrium such that no additional groundwater impacts are expected other than those that exist at the end of mining in 2030.

The groundwater monitoring program currently being undertaken by the Mine will be extended to include additional locations within and outside the revised Project site, with new monitoring installations located in areas where drawdown impacts, and receptors sensitive to those impacts, are predicted to occur. Groundwater monitoring will be conducted on a regular basis and will provide information to detect any significant variations to the existing groundwater system over the life of the revised Project. The primary aim of undertaking groundwater monitoring on site is to ensure sufficient data is gathered for consideration of the following hydrogeological aspects:

- temporal and spatial variations in groundwater levels;
- temporal and spatial variation in groundwater quality; and
- groundwater level or quality effects including early detection of groundwater drawdown caused by dewatering of the mine pits.

The results of the groundwater monitoring program will be used to further inform and refine the groundwater impact assessment for the revised Project, with model refinement occurring on a regular basis.

The revised Project is not expected to have a detrimental effect to the groundwater quality at revised Project site. The vulnerability of the underlying aquifers to pollution is expected to be minimal.

Mitigation measures can be put into place should the effects of dewatering require alternative water supplies for affected users, such as installation of new pumps, deepening of existing bores or installation of a new bore at another location on the property. NAC will undertake a comprehensive bore characterisation program for third party groundwater users in the predicted impact area, to identify the exact requirements for 'Make Good' for those affected users.

NAC will manage the potential groundwater impacts from the revised Project using a dedicated GMIMP. The GMIMP is based on the groundwater impact assessment work completed for the revised Project's EIS. The GMIMP will be regularly reviewed over the life of the revised Project, and as required, will be updated based on monitoring results, new outputs from revisions to the groundwater modelling and any other applicable groundwater management matters that relate to operation of the revised Project. The GMIMP will form a supporting document to NAC's Plan of Operations for the revised Project.

NAC will discuss and agree with the administering authority, the need for on-going groundwater management, including monitoring during the decommissioning phase of the revised Project.