Appendix - G

Hydrogeological Impact Assessment (Aurecon, 2012)

Bore 8 - assessment of potential hydrogeological impacts

Springvale Colliery

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Centennial Coal

aurecon

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Contents

Executive Summary

An assessment has been made of the potential for impacts on the local and regional hydrogeology from activities associated with the construction and commissioning of the proposed dewatering Bore 8 to progressively replace the current mine dewatering system at Springvale Colliery as their mining progresses further to the east of the current workings. The surface infrastructure for the bore site is located in the Newnes State Forest, which contains a number of groundwater dependent ecosystems classified as 'Temperate Highland Peat Swamps on Sandstone' (THPSS). These swamps include Newnes Plateau Shrub Swamps (NPSS) and Newnes Plateau Hanging Swamps (NPHS).

The surface infrastructure for Bore 8 will require a cleared area or final footprint of 0.32 ha. Activities will include upgrade of an existing access track to Bore 8 location, construction of drilling pad, installation of erosion and sediment controls, trenching for utilities (power and pipeline), drilling four boreholes, partial rehabilitation of the site, and installation of submersible pumps in the bores and their subsequent commissioning. Bore 8 location been chosen to avoid known THPSS and other threatened and endangered flora species on Newnes Plateau.

The proposed four boreholes will be constructed by the process of blind boring. This involves drilling a pilot hole to the desired depth, followed by boring with a blind boring head, guided by the pilot hole, to produce a borehole of the desired diameter. Drilling mud with a controlled density is fed into the void above the cutting head to lubricate cutting and balance the hydrostatic pore fluid pressure. On completion of boring, the steel borehole liner with a capped bottom is lowered down the hole, displacing the drilling mud. Finally the annulus between the liner and borehole is fully grouted.

There are essentially three basic groundwater systems that have been identified in the region, and all have the potential to be impacted by the installation and operation of the proposed boreholes. These groundwater systems include:

- **Perched groundwater system** – a discontinuous, near-surface system generally independent of the regional groundwater systems, which supports NPHS.
- **Shallow groundwater system** –a regional groundwater system located in the Narrabeen Group above the Mount York Claystone, largely in the Banks Wall Sandstone, which contains aquifer zones that support Newnes Plateau Shrub Swamps, including the Sunnyside, Sunnyside East and Carne West Swamps.
- **Deep groundwater system** – a less important, deeper groundwater system exists in the strata below the Mount York Claystone, and includes the Illawarra Coal Measures.

The potential hydrogeological risks associated with the proposed construction and operation of the dewatering Bore 8 were identified, and include both local and regional impacts as follows:

- Draining of perched groundwater into mine workings via the boreholes
- Draining of shallow groundwater into mine workings via the boreholes
- Drainage of deep groundwater into mine workings via the boreholes
- Contamination of perched and shallow aquifers with drilling fluid
- Additional underground water make and discharge due to groundwater drainage via the boreholes
- Damage to hanging swamps due to diversion of surface water from disturbed areas
- Possible long-term drainage of shallow groundwater into mine workings via the boreholes

All of these potential risks were examined in detail and none were found to pose a risk to the local or regional hydrogeological regime, or the groundwater dependant ecosystems that rely on these groundwater resources.

Several avoidance measures were identified that will ensure that the risk of any adverse hydrogeological outcomes is minimised.

An assessment of future mine water inflows into LWs 415 to 419 concluded that Springvale will need to increase its current licensed discharge volume from 5958 ML/year by 222 ML/year to 6180 ML/year. This increase in volume of less than 4% will set the rate at the 95th percentile of recorded flows rather than the current 93.8th percentile.

A review of the potential impacts of this increase in inflows to the mine concluded that, since almost all of the additional groundwater inflows will originate from the coal measure strata, the extraction of LWs 415 to 419 will further dewater the coal measures, which have been largely drained of groundwater in the vicinity of Springvale by previous mining in the region (at Springvale and other adjacent mines). Since there are no known groundwater users downdip of the project area that use groundwater from the coal measure strata, and the coal measure strata do not provide any significant contribution to base flow in the local streams, this additional dewatering will have a negligible impact.

The review also concluded that the hydrogeological regime in the Banks Wall Sandstone above the Mount York Claystone (more than 200 metres above the mine) will be unaffected by the proposed extraction. Consequently, the important upper aquifers in the Banks Wall Sandstone will be unaffected, and the flow from these aquifers will be unchanged. As a result, the swamps that rely on these flows will also be unaffected.

The overall conclusion can be drawn that the additional inflows to Springvale Colliery from the extraction of LWs 415 to 419 will have a negligible and unmeasurable impact on the local hydrogeological regime, and on surface water flows.

A review of *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources, 2011* has indicated that it may not be applicable to the expected groundwater extraction within the proposed LWs 415 to 419. This should be confirmed by Centennial's Legal Branch.

1. Introduction

Springvale Colliery ("Springvale") and its parent company, Centennial Coal ("Centennial") propose to construct and operate infrastructure at a dewatering bore site, designated as Bore 8. The purpose of this bores is to progressively replace the current mine dewatering system as mining progresses further to the east.

The proposal will require a modification to Springvale Mine's Development Consent S91/06569//001, originally granted by the then Department of Planning in 1992 under the provisions of section 101 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This consent was for the construction and operation of an underground coal mine to produce up to 4.5 million tonnes per year of the run-of-mine coal.

In order to assist in the preparation of an *Environmental Assessment* in support of the proposal, a number of specialist environmental studies are being undertaken. The final *Environmental Assessment* will be submitted to the Department of Planning and Infrastructure (DP&I) for assessment under transitional Part 3A arrangements. In accordance with clause 12 of Schedule 6A (Transitional arrangements – repeal of Part 3A) of the EP&A Act and clause 8J(8) of the *Environmental Planning and Assessment Regulation 2000,* section 75W of the EP&A Act would continue to apply to the proposed modification of Springvale Mine's Development Consent.

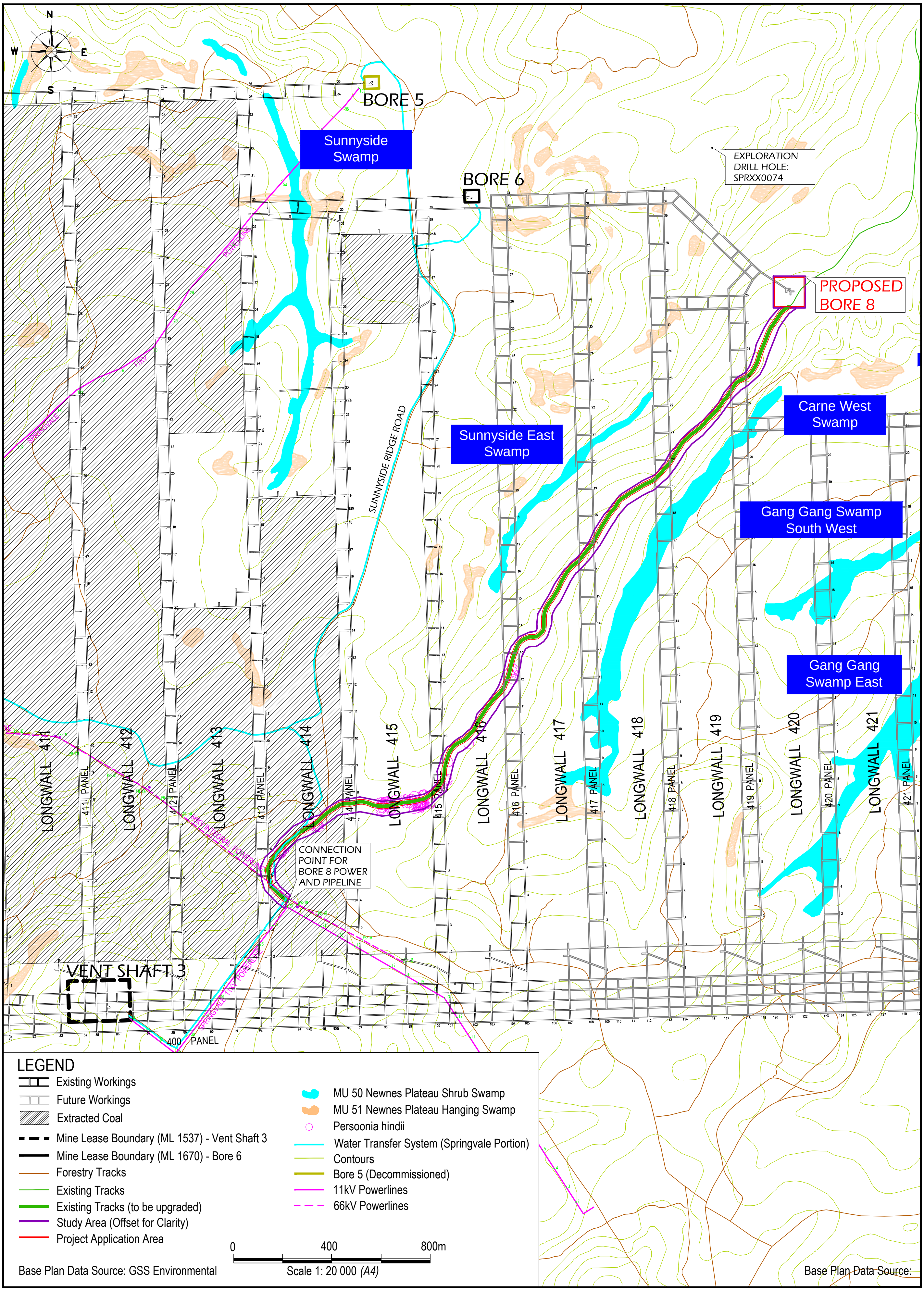
This report forms part of the overall *Environmental Assessment* and contains an assessment of the potential for impacts on the local and regional hydrogeology of the project area from activities associated with the construction and commissioning of Bore 8. This main report does not examine the issue of predicted groundwater inflow volumes from the extraction of the associated longwall panels. However, that issue is covered in Appendix A in this report (Merrick, 2012), which is a summary report from a more extensive review by the same author on the prediction of mine water inflows to the mine. The implications of the increase in predicted increase in mine water inflows are discussed in Section 5.

2. The proposal

Springvale currently operates one dewatering facility (Bore 6) on the Newnes Plateau (
Figure 1), which comprises three submersible pumps. The Bore 6 facility delivers water into the Springvale-Delta Water Transfer Scheme for delivery to the Wallerawang Power Station. The Springvale-Delta Water Transfer Scheme has the capacity to manage 30 ML/day of the mine water.

Springvale's proposal is to construct and operate one dewatering bore, identified as Bore 8 in Figure 1. This bore will form part of the mine's groundwater dewatering strategy as longwall mining progresses from LW416 to LW419.

The regional dip of the coal seam at Springvale is to the north and the east. Bore 6 is currently located at the lowest point in the mine, near the northern end of LW415, and is the mine's principal dewatering facility at present. However, as mine working progresses further to the east, additional dewatering facilities need to be established ahead of the workings to ensure water levels in the mine can be safely kept to manageable levels. Once Bore 8 is commissioned, the Bore 6 dewatering facility will be decommissioned.



Springvale Colliery
Bore 8 Project Application Area

FIGURE 1

The site for proposed dewatering Bore 8 has been selected to suit the anticipated seam floor contours and the proposed mine layout, together with suitable topography for the location of the surface facilities. Bore 8 is located at a low point in the mine workings, allowing water to drain under gravity to the dewatering point. A synclinal dip reversal trends E – W across the project area, located at the inbye end of LWs 414 – 418. These longwalls were terminated short to avoid mining through this structure, consequently reducing water management problems within the mine, and reduce potential safety problems.

The surface infrastructure for the Bore 8 site is to be located in the Newnes State Forest, which contains a number of groundwater dependent ecosystems classified as 'Temperate Highland Peat Swamps on Sandstone' (THPSS). These swamps include Newnes Plateau Shrub Swamps (NPSS) and Newnes Plateau Hanging Swamps (NPHS). The locations of the NPSS and NPHS in the vicinity of the bore site are shown on
Figure 1. Access to the surface facilities at the Bore 8 location will be largely via an existing track. This track will be upgraded and widened to establish an access track and ancillary infrastructure corridor totalling 10 m wide to Bore 8. 11 kV powerlines and water pipelines will be buried in the infrastructure corridor alongside the access track. Following installation of the pipelines and powerlines, the infrastructure corridor will be rehabilitated leaving a 5 m wide track to Bore 8.

The final footprint of the dewatering facility at Bore 8 will be approximately 0.32 ha. However, an area of approximately 0.77 ha will initially need to be cleared of vegetation and the area graded to form a level pad for construction of the boreholes, allowing for the movement of heavy vehicles and the installation of sumps to contain drilling fluids, as well as the storage of all required equipment and spares within the dewatering facility compound. Upon completion of construction and commissioning of the boreholes, the construction impact footprint of 0.77 ha will be partially rehabilitated leaving a final footprint of 0.32 ha, which will remain cleared and maintained for the duration of operation of Bore 8.

The Bore 8 site has been chosen to avoid known THPSS and other threatened and endangered flora species on Newnes Plateau.

Details of the proposed Bore 8 Facility are given in Table 1.

Table 1 - Details of Bore 8 Facility

Item	Specification
Number of dewatering holes at the site	four
Hole depth	470 m
Hole diameter	22" (c. 560 mm)
Collar casing	The collar of each hole is to be cased to the satisfaction of Springvale.
Downhole casing	Each hole is to be cased in its entirety with 18" OD (c. 460 mm) steel pipe: • 0 – 410 m, 10.3 mm thick casing • 410 – 470 m, 12.7 mm thick casing
Pressure cementing	Casing to hole wall annulus to be pressure cemented over the full length of each hole.
Hole deviation	< 12 m from target

The holes will be drilled using a conventional drill rig and additional plant and support vehicles as required. It is expected that it will take approximately one month to undertake pad set up, three months to construct, and two months to commission. Current mine scheduling indicates that Bore 8 will be required for use by May 2013.

3. Background

3.1 Geology

The plateau area has ridge crests up to 1160 m elevation, and is cut by several deeply incised creek valleys, which drain to the north and northeast of the lease area. The project area lies in the headwaters of the Wolgan River – Colo River catchment, which extends north and east from the project area. The local stratigraphy is summarised in Table 2, which also shows estimated heights of various horizons above the roof of the Lithgow seam at Springvale. Bedding generally dips northeast at about 1 to 2°. Structure contours on the seam are shown in Figure 2. A synclinal axis extends across the area at about the northern (inbye) end of LWs 414 – 418. The synclinal hinge plunges shallowly east. Closure on this structure decreases eastward, and the fold dies out by LW 419, where the strata dip uniformly northeast.

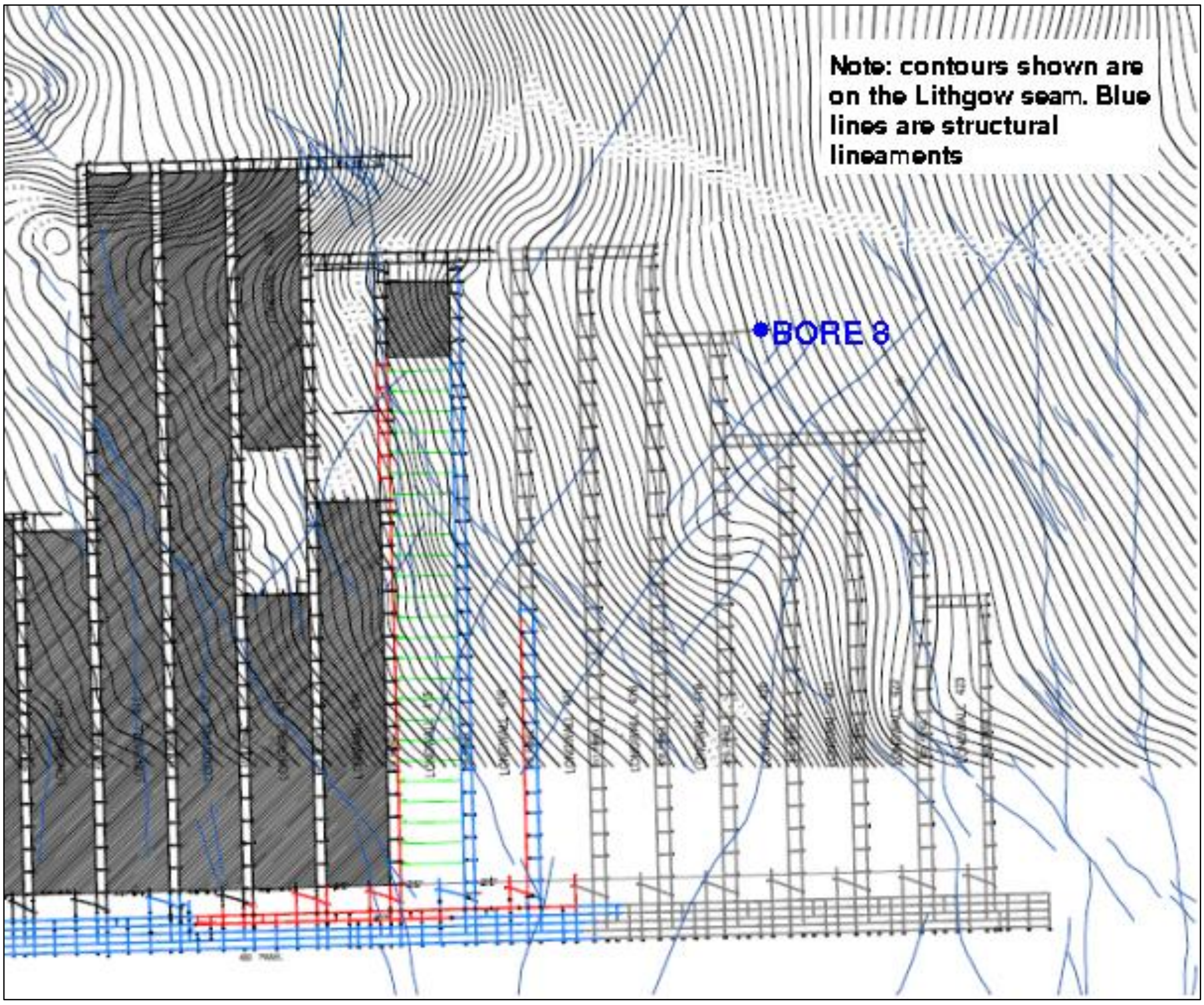


Figure 2 - Geology of the Bore 8 area and adjacent longwalls

Strata underlying the Newnes Plateau comprise mostly sandstones of the Triassic Narrabeen Group, which are interbedded with shale and siltstone beds. Narrabeen Group rocks are underlain by the Illawarra Coal Measures, which comprise interbedded sandstone, siltstone, shale, and coal.

In this area, the Narrabeen Group rocks near the surface belong to the Grose Subgroup, and include the Banks Wall Sandstone, the uppermost part of which is deeply weathered and generally very friable. The sandstone, which is up to 200 m thick in this region, is underlain by the Mt York Claystone, a fine-grained unit, with a thickness in this area ranging up to 28 m, that limits vertical infiltration of groundwater from the overlying strata. The underlying Burra-Moko Head Sandstone and Caley Formation make up the remainder of the lower part of the Narrabeen Group.

The Narrabeen Group rocks are underlain by the Illawarra Coal measures which comprise claystone, siltstone, sandstone and coal seams with a total thickness of up to 175 m in this area. The Lithgow seam is the lowermost seam in the coal measures and is located just above the base of the coal measures.

Fault structures at seam level in the area are also shown in Figure 2. The structural pattern over the area of LWs 415 – 423 consists of normal faults in an orthogonal set, striking northwest and northeast. Faults have dips ranging from 45 to 80 degrees, and have observed displacements of up to 0.7 m . The nearest fault to Bore 8 is a northeast-trending fault c. 100 m to the southeast. Thus there are no mapped faults in the immediate vicinity of the proposed dewatering bore location.

There are no dykes or other igneous features mapped in the vicinity of Bore 8.

Table 2 - Generalised Middle Permian to Tertiary stratigraphy of the Western Coalfield

Period/ Age	Stratigraphy: Group	Stratigraphy: Subgroup	Stratigraphy: Formation	Lithology	Approximate height above Lithgow seam roof*
Tertiary			Basalt	Basalt	
Triassic	Wiannamatta		Ashfield Shale		
		Hawkesbury Sandstone			
	Narrabeen Group	Grose Subgroup	Burralow Formation		
			Banks Wall Sandstone		Surface 413 m
			Mt York Claystone		238 m
			Burra – Moko Head Sandstone		
			Caley Formation		158 m
Permian	Illawarra Coal Measures	Wallerawang Subgroup	Farmers Creek Formation	Katoomba seam, sandstone, claystone, siliceous claystone	
			Gap Sandstone	Sandstone	
		Charbon Subgroup	State Mine Creek Formation	Coal, mudstone, claystone	
			Watts Sandstone	sandstone	
			Denman Formation	Interbedded mudstone / sandstone, claystone, mudstone	
			Glen Davis Formation	Coal, claystone	
			Newnes Formation	Coal, sandstone	
			Irondale seam	Coal	25 m
			Long Swamp Formation	Interbedded sandstone and siltstone	24 m
		Cullen Bullen Subgroup	Lidsdale Coal	Coal and claystone bands	0 m
			Blackmans Flat Formation	Sandstone, conglomerate	
			Lithgow seam	**Coal, claystone**	**-7 m**
			Marrangaroo Formation	Sandstone, conglomerate	
		Nile Subgroup	Gundangaroo Formation	Coal, sandstone claystone	-24 m
			Coorongooba Creek Sandstone	Sandstone	
			Mount Marsden Claystone	Claystone	
	Shoalhaven Group		Berry Siltstone		
			Snapper Point Formation		

* Heights based on Bore 6 stratigraphy

3.2 Hydrogeology

In general, the sedimentary strata in the Western Coalfield, comprise a non-uniform sequence of interbedded rocks of differing grainsize and strength properties. This invariably gives rise to layers of rock with a wide range of permeabilities, which form a sequence of aquifers and aquitards/aquicludes in the overburden. The term “aquifer”, as it is used here, is generally applied to any stratum that has a high groundwater carrying capacity relative to the surrounding rocks.

There are essentially three basic groundwater systems that have been identified in the region. These include:

- **Perched groundwater system** – a discontinuous, near-surface system generally independent of the regional groundwater systems, and located within 15 m of the ground surface. The perched groundwater is derived from excess rainfall which is largely prevented from infiltrating deeper down into the regional systems by the presence of near-surface fine grained beds, such as shale or siltstone. The occurrence of a perched groundwater system may produce lateral seepage which supports hanging swamps.
- **Shallow groundwater system** – this system is a regional groundwater system located in the Narrabeen Group, largely in the Banks Wall Sandstone. This system generally extends to a depth of up to 100 m. The CSIRO identified at least three main aquifer zones in the Banks Wall Sandstone system that are of high importance (AQ4-A, AQ4B and AQ5 on Figure 4), since they support groundwater dependent ecosystems such as the Newnes Plateau Shrub Swamps. Investigations have indicated that Sunnyside, Sunnyside East and Carne West Swamps (refer Figure 1) are supported by the same aquifer zone. Further to the east, another of these water-bearing zones, the Clarence Aquifer, provides a potable water supply for the village of Clarence. Most groundwater flow in the water-bearing sequence is generally in the horizontal direction along bedding planes, with some vertical flow occurring from the ground surface infiltration. A limited volume of groundwater may also flow vertically from one water-bearing zone to another, depending on the permeability of the intervening strata, and the degree of vertical jointing and faulting in the system. The Mount York Claystone forms a low permeability barrier to this vertical infiltration, so that most of the natural groundwater flow in the shallow groundwater system occurs above this horizon in aquifers in the Banks Wall Sandstone. The general flow direction in the aquifers in this system is sub-horizontally towards the northeast, away from the subcrop zone, where recharge to the lower aquifers can occur. This potential recharge zone is located to the west and southwest of the existing workings.
- **Deep groundwater system** – a less important, deeper groundwater system exists in the strata below the Mount York Claystone, and includes the Illawarra Coal Measures, which generally lie at a depth of more than 200 m. The majority of the coal measure strata overlying the Lithgow Seam in this area have a low permeability, however one or two beds have a slightly higher permeability, and could represent water-bearing zones (AQ1, AQ2 and AQ3 on Figure 4). The few water-bearing zones that do occur at depth in these strata are usually fractured rock aquifers. These include jointed coal seams and localised jointed or fractured zones, often adjacent to faults. The general flow direction in the water-bearing zones in this system is also sub-horizontally towards the northeast, away from the subcrop zone, where recharge can occur. The groundwater in this system is largely drained into the goaf following longwall mining and produces the majority of mine water inflows. There are no known local or regional users of this groundwater source.

A diagrammatic section of the local hydrogeological regime showing the three groundwater systems is included in Figure 3, while the aquifer zones identified by CSIRO are shown in Figure 4.

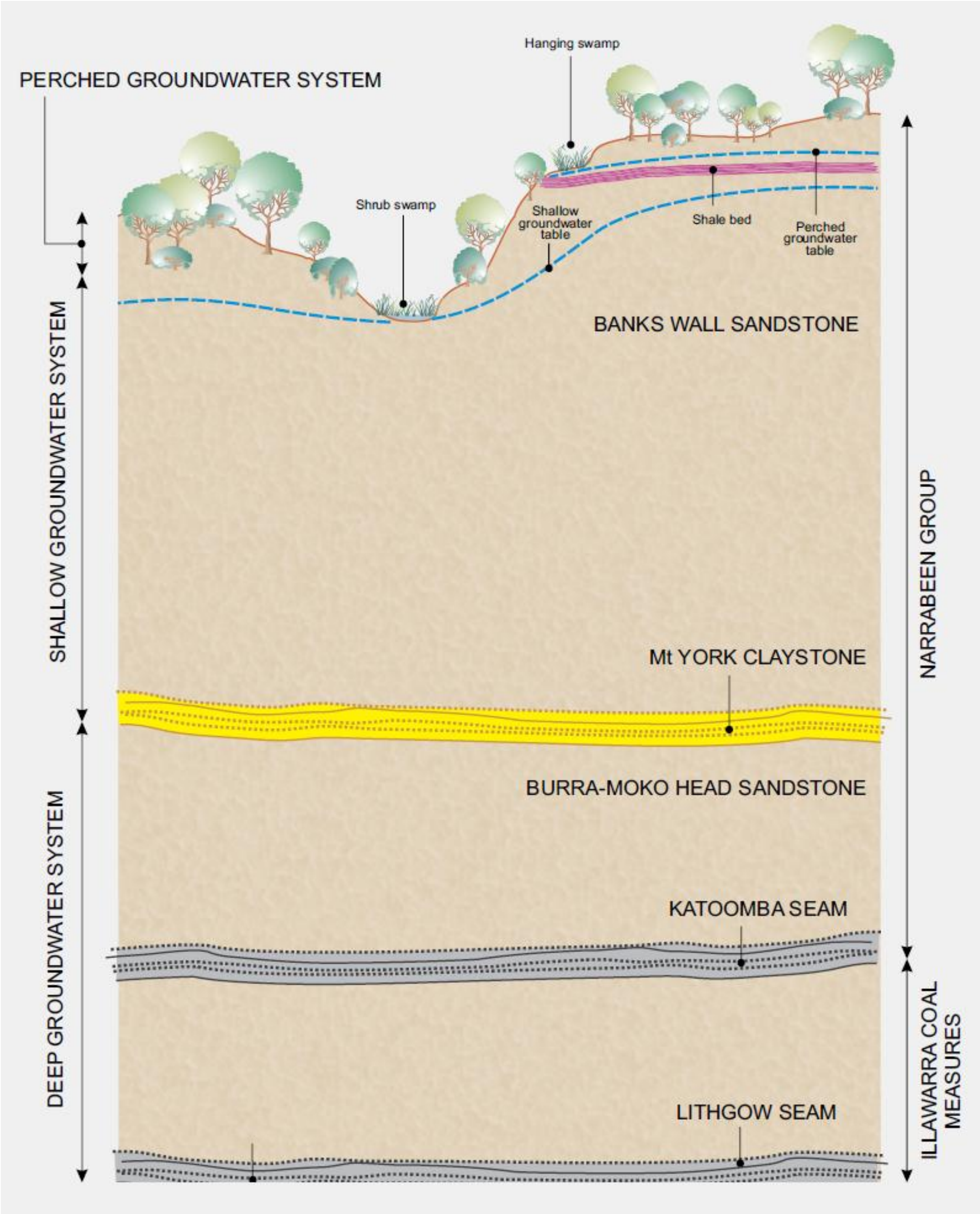


Figure 3 - Local hydrogeological regime

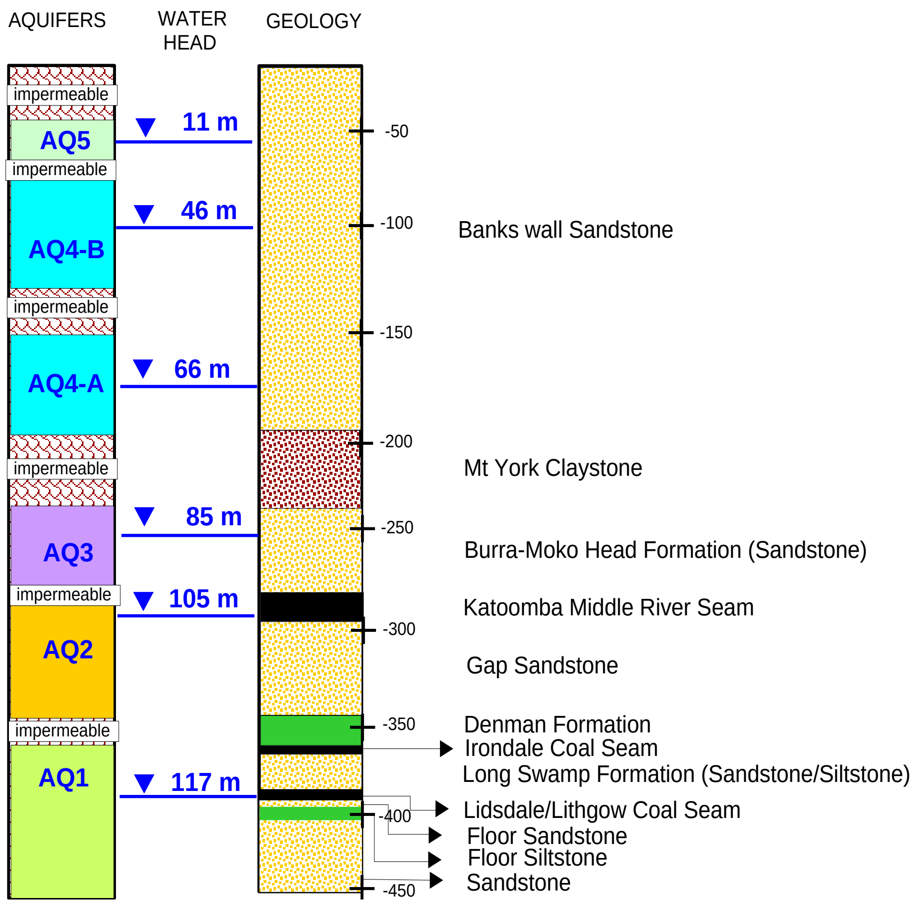


Figure 4 - Inferred hydrogeological section (CSIRO, 2010)

While no detailed permeability testing has been carried out in the Banks Wall Sandstone in the project area to confirm the presence of aquifers, continuous, full-depth permeability testing was carried out on this formation in borehole APR1PR located 3.2 km north northwest of the Bore 8 site, during exploration. This testing showed that the permeability of the Banks Wall Sandstone is mostly low ($<10^{-7}$ m/s), although three horizons showed a slightly higher permeability of between 10^{-6} and 10^{-7} m/s, and could be considered to be "relative" aquifers. Two of these horizons appear to correspond approximately with the CSIRO aquifer zone AQ4-A and one with AQ4-B. Although there is no certainty that these "aquifer" zones are present at the same horizons in the area of LWs 415 – 421, the presence of permanently waterlogged swamps (see below) in the area provides evidence of the existence of at least one major aquifer in this part of the section.

Limited investigations at Springvale have shown that the coal measure strata overlying the Lithgow seam in this area also have low permeabilities ($<10^{-8}$ m/s), however one or two layers may have a slightly higher permeability (up to 10^{-6} m/s), and could represent aquifers (Golder Associates, 2002). The few aquifers that do occur at depth in these strata are usually fractured rock aquifers (Bish, 1999). These include jointed coal seams and localised jointed or fractured zones, often adjacent to faults.

3.3 Swamps

The surface infrastructure for Bore 8 will be located in the Newnes State Forest, which contains a number of groundwater dependent ecosystems classified as 'Temperate Highland Peat Swamps on Sandstone' (**THPSS**). The THPSS are listed as an Endangered Ecological Community (**EEC**) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**). The Newnes Plateau Shrub Swamp (NPSS) and Newnes Plateau Hanging Swamp (NPHS) both form part of the THPSS community and are therefore also part of the listing. The NPSS is also listed as an EEC under

the NSW *Threatened Species Conservation Act 1995* (TSC Act). The location of NPSS and NPHS in the vicinity of Bore 8 is shown on
Figure 1.

Generally, Newnes Plateau Shrub Swamps have developed on the Newnes Plateau at altitudes in excess of 1,100 m, in valleys underlain by Narrabeen Group strata. The swamps have formed in areas which are subject to periodic or permanent waterlogging caused by a supply of water including groundwater, surface runoff, and rainfall.

The groundwater source is initiated when rainfall infiltrates the sandy soils and the permeable sandstone on the adjacent ridges. At relatively shallow depths in the sandstone there may be a thin layer of tightly cemented sandstone or claystone which is impervious to vertical groundwater percolation and forms an aquitard, confining the vertical movement of the water. The groundwater then travels laterally along the top of the aquitard, and exits the ridge in the floor of the flanking creek valley, which often has the same strong, tightly cemented sandstone layer forming the base. This shallow groundwater system can provide a constant source of moisture to the valley floors. Over a long period of time, flora species have gradually colonised these sites. Where the dip of the aquitard layer in the valley floor is relatively flat (<3%) in the downstream direction, these vegetation communities can form over several kilometres along the watercourses, given the right conditions. The constant saturation of the valley floor creates anaerobic conditions inhibiting the microbial breakdown of plant material. This organic matter accumulates in a partly decomposed state as peat. This material has an extraordinary ability to absorb water and acts like a sponge retaining rainfall and run-off for slow release. The peat material is often mixed with the sediment that is eroded from the ridges on either side of the swamp.

In general, 20% to 30% of the total rainfall in the area runs off the surface of the ridges and into the swamps. When this occurs, any voids in the dry peat fill up with water. When the peat is saturated, the excess water then discharges into the drainage lines. In contrast, less than 5% of the rainfall infiltrates the ground surface on the ridges and enters the local groundwater system. Some of this water then enters the swamp by seepage into the margins as described above. Unlike rainfall, the groundwater seepage is generally continuous and is proportional to the hydraulic head in the aquifer beneath the ridges.

The proportional contribution of groundwater to the swamp hydrology, relative to the rainfall/run-off contribution, can vary considerably between swamps, depending on the permeability of the overburden, the lateral hydraulic gradient and the efficiency of the aquifer feeding the swamp. While there are numerous swamps in this region that are primarily sustained by groundwater flow, in some swamps groundwater flow may represent only a small proportion of the total inflow, with runoff and rainfall providing the bulk of the water sustaining the swamp ecology. Any shortfall in groundwater in these circumstances may be wholly or partially made up by excess runoff that would have otherwise discharged into the watercourse.

The groundwater monitoring to date has confirmed that there is a range of swamp types, which appear to differ essentially in the relative contributions of groundwater and rainfall/run-off to the swamp hydrology (Aurecon, 2011). Those swamps that have a proportionately large groundwater contribution (ie. fed in large part by underground water) are resistant (to a large extent) to the natural variations that may occur in the local rainfall patterns. They are termed **permanently waterlogged** swamps, and generally have a constant water base flow from their downstream end and/or usually have persistent/recurring surface water expressions within the swamp. These swamps have a relatively stable, near-surface groundwater table that shows no major fluctuations, even after heavy rainfall or during prolonged dry periods. They are located mostly in broad deep valleys with a relatively large catchment. Both swamps (Sunnyside East and Carne West Swamps) close to the Bore 8 site are permanently waterlogged.

The swamps that have a relatively poor groundwater contribution are obviously more sensitive to the natural variations in rainfall patterns. These **periodically waterlogged** swamps normally do not have a constant flow from their downstream extremity, and show large variations in groundwater level, particularly after major rainfall events. They also tend to have small catchment areas, and can be located at the upstream end of permanently waterlogged swamps, or at high elevations with no significant flanking ridges or obvious drainage lines through the swamp. Because of the different hydrogeological conditions, these swamps support different vegetation communities to the permanently waterlogged swamps.

Newnes Plateau Hanging Swamps are supported by perched shallow aquifers or seeps (in the upper perched groundwater system) that provide a periodically waterlogged environment, and are usually located higher in the landscape on the flanks of ridges (as opposed to being located at the base of drainage lines). As a result, these swamps are heavily reliant on rainfall and can dry out during periods of below average rainfall, when there is no recharge to the shallow perched aquifers.

There are only two hanging swamps within the vicinity of the infrastructure for the Bore 8 site. One of these is located to the east of Bore 8 at the downstream end of the Carne West Swamp, and a second is located at the upstream end of Carne West Swamp to the east of the access road. These swamps are formed when infiltrating groundwater moves down through both the unconsolidated and consolidated porous sandstones and conglomerates of the Narrabeen Group until it encounters a claystone/shale horizon. Where the claystone/shale crops out in a topographically suitable location, the groundwater moves horizontally towards the valley side slope, forming an ideal environment for a swamp to form (McHugh, 2011).

The hanging swamps are mostly peat-based, but the peat layer is generally relatively thin due to the slope of the ground surface on the flanks of the ridges, which is not conducive to deep peat formation. The swamps develop over a long period of time from decaying swamp vegetation. They then progress down the gully side as the seeping water continues to travel further downslope encouraging the swamp vegetation to establish further downslope. Because the hanging swamps are stratigraphically controlled by the location of the claystone/shale layers, they often occur in a linear pattern along the sub-crop zone of the bedding.

Normally, the catchment area for most of the hanging swamps is relatively small, so that the groundwater flow dries up reasonably quickly following rainfall. This period will obviously vary and depends on a number of factors, including rainfall duration and intensity, catchment area, strata dip and overburden permeability. Nevertheless, the presence of the claystone/shale beds is the critical factor in directing any subsurface rainwater infiltration horizontally to the outcrop zone where the swamps form. Without the claystone/shale beds, which act as an aquitard, there would be no swamps.

The lack of large volumes of groundwater in hanging swamps is evidenced in the drilling of exploration boreholes in the region. Drillers very rarely report any high level water flow into the boreholes during drilling. This is because there is no aquifer as such, but just a periodically perched water table on top of the aquiclude (following rainfall) which seeps relatively quickly out to the subcrop zone. There is very rarely any free water flow from the downstream end of these swamps as there is from the permanently waterlogged shrub swamps.

4. Potential impacts of new dewatering bore 8

4.1 Risk assessment

A brief risk assessment was carried out and identified two main activities associated with the Bore 8 installation that have the potential to impact the local and regional hydrogeology:

- Construction and operation of the bores
- Construction of the drilling pad and access roads

The potential hydrogeological risks associated with these activities have been identified and can be categorised into local and regional impacts as follows:

Local impacts

- Draining of perched groundwater into mine workings via the boreholes
- Draining of shallow groundwater into mine workings via the boreholes
- Drainage of deep groundwater into mine workings via the boreholes
- Contamination of perched and shallow aquifers with drilling fluid
- Additional underground water make and discharge due to groundwater drainage via the boreholes
- Damage to hanging swamps due to diversion of surface water from disturbed areas

Regional impacts

- Possible long-term drainage of shallow groundwater into mine workings via the boreholes

These risks are discussed below, and where necessary, avoidance measures have been identified to minimise the risk of any adverse impacts on the hydrogeology and/or the swamps.

4.2 Potential local impacts of the proposed activities

4.2.1 Drainage of perched groundwater into the workings

Boring of the dewatering boreholes at the Bore 8 site is the main activity that has the potential to impact on the local hydrogeology. Four boreholes will be drilled between the ground surface and the seam to provide access for the submersible pumps. While this activity should cause no disruption to the overburden strata, the boreholes will intersect the perched groundwater system that supports many of the hanging swamps. Any disruption to this groundwater system could result in an adverse impact on the hanging swamps supported by the groundwater.

The proposed boreholes (4 at each bore site) will be constructed by the process of blind boring. This involves drilling a pilot hole, followed by boring with a blind boring head, following the pilot hole, to produce a borehole of the desired diameter. Drilling mud with a controlled density is fed into the void above the cutting head to lubricate cutting and balance the hydrostatic pore fluid pressure. Cuttings report to the surface where they are excavated from the process ponds and piled up. On completion of boring, the head is removed on the surface, and the borehole liner with a capped bottom is lowered down the hole, displacing the drilling mud. Finally the annulus between the liner and borehole is grouted. When the liner bottom is exposed by the underground mining operation, it must be removed to open up the borehole for dewatering purposes.

During construction of the bores using this method, it is unlikely that there will be any depletion of the perched groundwater in the boreholes. Whilst construction is in progress, the bores will form a void, into which there will be negligible drainage of groundwater, since the bores will be full of drilling fluids which are designed to block the pores in the strata so that there is minimal drilling fluid loss into the strata, and mud conditions are adjusted to equalise hydrostatic pore pressures. It is possible that if the fluid level in the borehole is lowered for some reason during drilling (such as when the rod string is withdrawn), that a small volume of groundwater will drain into the borehole through the mud cake on the borehole walls. The volume of groundwater inflow will be limited to the volume required to restore the borehole level to the groundwater level in the perched groundwater system. The disturbance to the groundwater system will therefore be minimal, temporary and restricted to a small area around the perimeter of the borehole (Figure 5).

The time for the groundwater level in the aquifer to recover will be probably within one day to one week. Any impact on the hanging swamp vegetation will be negligible, and would be limited to any swamps in the immediate vicinity of the boreholes. Since there are no hanging swamps in the immediate vicinity of the proposed bore sites, there will be no impacts on the swamps from the construction of the bores.

Once completed, the dewatering bores are fully cased, with the annulus between the casing and the borehole wall pressure grouted, to ensure that any aquifers are isolated from the future mine workings, and drainage into the workings does not occur during the operation period of the dewatering bores. The maintenance of groundwater systems in the area of the bores also depends on the integrity of the bore lining. It will therefore be necessary to maintain the steel/concrete lining during the life of the project to eliminate any impact on groundwater systems. This will form part of the normal maintenance regime for the bores.

Based on the above, it is possible to conclude that the risk of drainage of perched groundwater into mine workings via the boreholes is negligible.

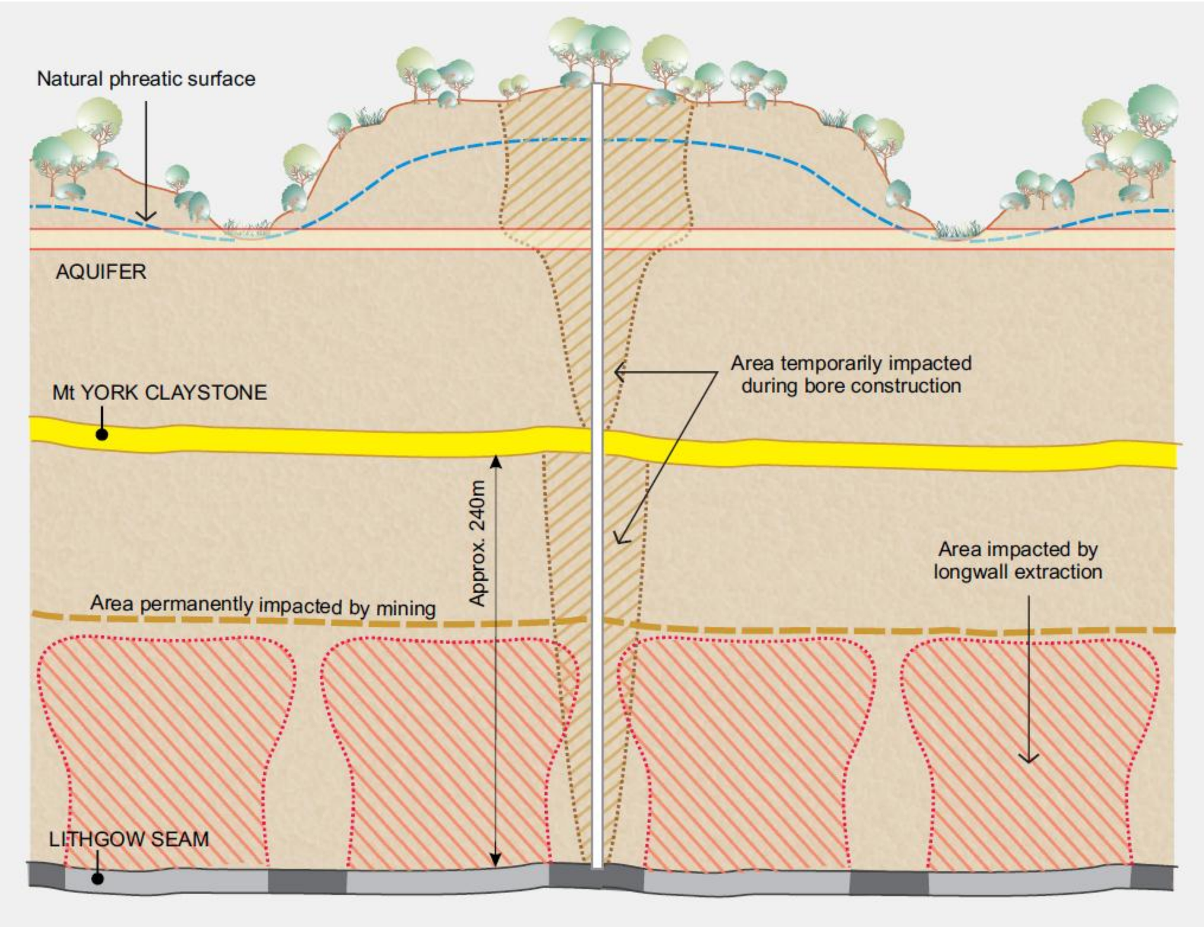


Figure 5 - Schematic diagram showing the extent of disturbance of strata related to construction of a dewatering bore, and progressive extraction of longwall panels. Not to scale.

4.2.2 Drainage of shallow groundwater into the workings

Any significant drainage of groundwater from the shallow groundwater table into the mine workings is to be avoided if at all possible, as this would have the potential to interfere with groundwater feed to the shrub swamps that are located in the watercourses on either side of the Bore 8 site. However, it should be noted, that the risk of any impacts on the shrub swamps is very low, as the bore site is located down-dip of the major shrub swamps in the area. Consequently, even if groundwater was drained from the shallow aquifer through the boreholes, it is highly unlikely that there would be any impact at all on the shrub swamps.

The discussion in Section 4.2.1 above on the perched groundwater system outlined the reasons why the proposed construction of the bores will have a negligible impact on the perched groundwater system, and why the construction of the boreholes will not result in any drainage of groundwater into the boreholes or the mine workings. These reasons are also relevant to the shallow groundwater system. The drilling and lining method that will be utilised for the construction of the bores (described in Section 4.2.1 above) precludes any significant drainage of groundwater from the shallow groundwater system. Consequently, no impacts are expected on the shallow groundwater system either during or after construction, and hence no impact is expected on the adjacent shrub swamps which depend on this groundwater source.

Based on the above, it is possible to conclude that the risk of drainage of shallow groundwater into mine workings via the boreholes is negligible.

4.2.3 Drainage of deep groundwater into the workings

The consequences of drainage of deep groundwater into the mine workings via the boreholes, either during or after construction, are negligible. This is because a large portion of the deep groundwater is drained into the mine opening as a result of the extraction of the longwall panels (Figure 5). In addition to this, the drilling and lining method that will be utilised for the construction of the bores precludes any large scale impacts on the deep groundwater system.

Based on the above, it is possible to conclude that the risk of drainage of deep groundwater into mine workings via the boreholes is negligible.

4.2.4 Contamination of perched and shallow aquifers with drilling fluid

It is normal practice for drilling fluids to be used to assist in the drilling process of large diameter bores. Since the bores will be topped up with drilling fluid during drilling, the flow direction will generally be from the borehole into the formation. This could lead to a small amount of drilling fluid entering the perched and shallow groundwater systems. However, since the drilling fluids are designed to block the pores in the strata and form a “skin” on the borehole walls, there is normally minimal drilling fluid loss to the strata, unless very open joints or faults are encountered.

The only materials that will be used in drilling of the bores are the commonly used polymer drilling muds or natural bentonite-based muds, which are not hazardous. These fluids have been used in drilling exploration bores around the site for many years, and are designed to be used for drilling through water-bearing strata without long-term impact. The polymer materials used are designed to increase the viscosity of the drilling fluid, and will degrade to water after a period of a few days. The bentonite material is naturally occurring clay and will not enter the pores in the strata, but will form a cake on the borehole wall.

An appropriate blend of drilling fluid additives is typically selected by first conducting a program of pilot testing using various compositions of drilling fluid and fresh samples of the strata, usually obtained from recent core. Data from previous well drilling or coring operations is also useful in developing the optimum fluid composition. For Springvale, previous experience in the area suggests that the heavily weathered strata through the top 60 to 80 m will require a bentonite based mud system to protect the un-cemented sands from unravelling and consequently undermining the weak clay and shale. Drilling without using bentonite or some other additives to the drilling fluid could perhaps lead to the bore walls collapsing before an intermediate casing could be installed.

There are a number of additives that may be used during the drilling process. All of the proposed additives in the muds are commonly used for drilling potable water wells in the Sydney catchment area. The additives may include the following: bentonite, polyanionic cellulose (PAC), gypsum, lime, potassium chloride (or low sodium alternatives that mimic the properties of potassium chloride), partially hydrolyzed polyacrylamide (also known as liquid polymer, PHPA, flocculant or ‘Quick Mud’), and carboxymethyl cellulose (CMC). The additives were reviewed in a hazard screening assessment and none were identified as posing a risk to groundwater quality.

Based on the above, the risk of contamination of perched and shallow aquifers with drilling fluid is considered to be negligible.

4.2.5 Additional underground water make and discharge due to groundwater drainage via the boreholes

If large volumes of groundwater are allowed to enter the bores from the local groundwater systems, this water will need to be removed from the mine by pumping. In extreme circumstances, this may necessitate an increase in the required pumping capacity in the mine. As indicated above, the drilling and lining method that will be utilised for the construction of the bores precludes any additional inflow of groundwater to the mine.

Based on the above, the risk of any additional underground water make and discharge from the mine due to groundwater drainage via the boreholes is considered to be negligible.

4.2.6 Damage to hanging swamps due to diversion of surface water from disturbed areas

Hanging swamps rely on the infiltration of rainfall to the perched groundwater system as a source of water. Any disruption to this process could result in a change to the recharge to the perched groundwater system and may have a deleterious impact on the swamp vegetation. Because of this, it will be necessary to ensure that run-off from large areas is not directed away from the catchment of any hanging swamps in the vicinity of the roads or drilling pads.

The hard stand areas and roadways will need to be designed to:

- minimise the area of impermeable surfaces
- allow run-off to drain naturally to the swamp catchment
- not direct large volumes of run-off away from the swamp catchments
- have appropriate erosion and sediment controls in place to prevent silt entering the hanging swamps

Nevertheless, provided appropriate measures are taken in the design and construction of the roads and drilling pads, it is unlikely that the infiltration and run-off to the hanging swamps will be materially affected. In addition, the two hanging swamps identified in the vicinity are sufficiently removed from the proposed works that the catchments will be only minimally impacted by the works.

Consequently, the risk of damage to hanging swamps due to diversion of surface water from disturbed areas can be managed by appropriate measures, and is considered to be negligible.

4.3 Potential regional impacts of the proposed activities

4.3.1 Possible long-term drainage of shallow groundwater into mine workings via the boreholes

Based on the conclusions in the previous section, there appears to be no possibility of any regional impacts from the proposed construction of the boreholes at the Bore 8 site. There will be no impact on the aquifer in the shallow groundwater system that is a groundwater source for a large number of the shrub swamps in the region. There will also be no connection established between the proposed bores and regionally significant aquifers such as the Clarence Aquifer, which supplies domestic groundwater for the village of Clarence, over 16 km to the southeast. This is because there is no hydraulic connection between this aquifer at Clarence and the same aquifer horizon at Springvale, due to the presence of the valley of Farmers Creek, which truncates the aquifer between the two sites.

A search of the NSW Office of Water database of groundwater bores has shown that there are no domestic, industrial or agricultural users of the groundwater resources in these aquifers in the area surrounding the Springvale Colliery, probably due to their depth, variable water quality, and the fact that most of the area is covered by the Newnes State Forest. As there will be no impact on the groundwater, there will be no impact on surface water flows that rely to some extent on groundwater feed. Consequently, there will be no impact on Forests NSW assets.

Despite the fact that no impacts are predicted, if the bores are left open in the longer term, the steel casing could rust out and a connection could be formed between the shallow and perched groundwater systems and the mine workings. This has the potential for depletion of groundwater from these systems. In order to prevent this occurring, during rehabilitation at the end of mine life, the shafts and bores will be fully backfilled with impermeable material, such as concrete to ensure no leakage occurs. Rehabilitation will be carried out in accordance with Division of Resources and Energy requirements at the time.

4.4 Cumulative effects

The Bore 8 site lies to the north and east of the existing Springvale Colliery workings. Since a number of other activities and projects, that have the potential to impact on the local regional hydrogeology, are located in the vicinity of Springvale, it is necessary to consider the cumulative effect of the impact of the current project with these other developments, both at Springvale and elsewhere.

At Springvale, the mine workings include both currently approved mining activities and the future longwalls 415 to 419.

In the vicinity of Springvale, activities and projects include:

- Forestry and recreational activities on the Newnes Plateau, including the immediate project area and further afield
- Clarence Colliery mine workings
- Angus Place Colliery mine workings, including proposed LW 900W and LW 910 to the west of the project area.
- Angus Place Colliery also proposes a number of ventilation shafts and service bores in the general area.
- Open cut mining at Pine Dale Coal Mine, 17 km west of the project area.

The blind boring method of borehole construction means that the impacts on groundwater during construction and operation will be negligible. The boreholes will be lined and grouted, and any changes in the groundwater level are expected to recover in a short time (< 1 week) after construction. The very limited extent of groundwater impact out from the footprint of mining activities means that the project is will not have an impact on other projects identified in the area.

There are no known groundwater users downslope of the project area. Agricultural activities in the Wolgan River valley may make use of river water, which includes a contribution of groundwater derived from the local strata over Springvale. By far the greatest groundwater contribution to the Wolgan River flow is from aquifers in the Banks Wall Sandstone. Since these will be unaffected by the installation of the bores, no adverse impacts will ensue. Outflows of groundwater from the coal measures into the Wolgan River are negligible compared to the flow from the upper aquifers, due to the lower permeability of the coal seams and their very limited sub-crop when compared to the sandstone aquifers. Coal measure groundwater drainage into the bores will also be negligible and hance will be unaffected by the installation of the bores. If any drainage does occur, the drawdown adjacent to the boreholes will extend for significantly shorter distances than the distance to Wolgan River outflow sites, and will be limited to during the construction period, after which lining of the bores will prevent groundwater drainage.

As a result, the cumulative impact of the project together with the other local activities is regarded to be no different to the impact from the currently approved workings alone, from a groundwater perspective.

4.5 Avoidance measures

Even though no cumulative, regional or local hydrogeological impact is expected from the proposed installation of bores at the Bore 8 site, the low level of risk relies on several avoidance measures that have been identified in Section 4 above. It is therefore appropriate to identify these avoidance measures to ensure that the potential for impacts on the groundwater and the groundwater dependent ecosystems is minimised.

Avoidance measures that can be used to minimise risk include:

- Use the blind boring method for construction of the bores, which reduces groundwater impacts by maintaining the borehole void full of drilling fluids, thereby preventing loss of groundwater into the void;
- Ensure that the borehole casing is fully grouted in the boreholes to ensure that there is no drainage of groundwater into the underground workings during the operation period of the dewatering bores;
- Use only approved drilling fluids in the borehole installation process;
- Minimise the area of any hardstand or road located in the catchment of identified Newnes Plateau Hanging Swamps;
- The access road to Bore 8 should be constructed to allow run-off to drain naturally to the swamp catchment, so that large volumes of run-off are not directed away from the swamp catchment;
- Roads and hardstands should have appropriate erosion and sediment controls in place to prevent silt entering the hanging swamps.

5. Potential impacts of increased water inflows

An assessment of future mine water inflows into Springvale Colliery has been undertaken by Dr Noel Merrick, and a summary report is included in Appendix A to this report. In this assessment, mine dewatering rates out to LW419 have been projected by means of two models currently used by Springvale Colliery to predict operational water make. The conclusion of the study is that Springvale will need to increase its current licensed discharge volume from 5958 ML/year by 222 ML/year to 6180 ML/year. This increase in volume of less than 4% sets the rate at the 95th percentile of recorded flows rather than the current 93.8th percentile. The potential impacts of this increase is discussed below.

5.1 Previous mining-related impacts on the hydrogeological regime

Underground mining in this region has been carried out for over a century, and longwall mining for more than 30 years, so that it is reasonable to assume that there has been some impact on the local hydrogeological regime due to the drainage of groundwater into these mines. There have been no fewer than seven mines operating in the immediate vicinity of Angus Place during this period. These include Springvale Colliery, Clarence Colliery, Lithgow State Mine (abandoned), Fernbrook Colliery (abandoned), Renown Colliery (abandoned), Kerosene Vale Open Cut (abandoned) and Newcom Colliery (abandoned). All of these have had some impact on the hydrogeological regime.

While bord and pillar mining does not result in any significant impacts on the hydrogeological regime, previous studies in the area (Aurecon, 2010 and 2011) have shown that the fractured zone above the longwall panels could extend up to 150 m above the extracted coal seam. If this is the case, then any water-bearing zones in the coal measures would be drained and depressurised some distance from the mine opening. Previous experience with extensometer and piezometric monitoring at Springvale Colliery (Aurecon, 2009) shows that the fractured zone extends to at least 100 metres above the longwalls (and possibly higher), resulting in the drainage of coal measure groundwater into the mine.

Based on these data, it is reasonable to assume that the strata for a height of up to 150 m above the Lithgow Seam may have already been depressurised and partially drained of groundwater by previous longwall mining in the area. While the exact height of depressurisation is not certain, it is highly likely that it is limited to the strata below the Mount York Claystone, which is more than 200 m above the coal seam and acts as a regional aquiclude (see Table 2). Consequently, the hydrogeological regime in the Banks Wall Sandstone above the Mount York Claystone has been relatively unaffected by the mining to date.

Since the hydrogeological regime in the Banks Wall Sandstone above the Mount York Claystone has most likely been unaffected, the upper aquifers in the Banks Wall Sandstone are unlikely to have suffered any significant long-lasting impacts due to the mining. As a result, the flow from these aquifers is unchanged, and the swamps that rely on these flows have also been unaffected. Because of this, the regional consequences on these aquifers from the previous mining in the area are judged to be negligible.

5.2 Additional impacts on the hydrogeological regime from LWs 415-419

The extraction of LW415 to 419 will further dewater the coal measures, and result in a small increase in the inflows to the mine from about 190 L/sec to 200 L/sec. Since it has been shown that the upper aquifers in the Banks Wall Sandstone are unaffected by mining, it is apparent that the increased inflows are derived from the coal measure strata, which will lead to an increased drawdown area where the coal measures are dewatered. It therefore needs to be established that this will not have any wide-ranging impacts on the local hydrological regime.

It has been shown in previous studies (CWPPI, 2005) that the drawdown in the coal measure strata can extend up to 1200 m from the workings, and continuous pumping in the future may extend the drawdown somewhat. Nevertheless, even if the drawdown radius expands, the impact should be minimal, as the water in these lower aquifers represents a negligible contribution to stream flow and vegetation support in the region, since their depth and the presence of the Mount York Claystone effectively prevents any significant upwards groundwater flow to local creeks or downwards flow from the important aquifers in the Banks Wall Sandstone. As for the previous mining, there will be no measurable impacts on these upper aquifers from the additional inflows due to the proposed extraction of LWs 415 to 419.

Previous investigations have indicated that there are no known groundwater users downdip of the project area that use groundwater from the coal measure strata. Agricultural activities in the Wolgan River valley may make use of river water, which comprises mostly rainfall runoff with a small contribution of groundwater derived from the local strata over Springvale. By far the greatest proportion of the groundwater contribution to the Wolgan River flow is from aquifers in the Banks Wall Sandstone. Since these will be unaffected by the extraction of the additional longwall panels, No adverse impacts will ensue. Outflows of groundwater from the coal measures into the Wolgan River are negligible compared to the flow from the upper aquifers, due to the lower permeability of the coal seams and their very limited sub-crop when compared to the sandstone aquifers.

The conclusion can therefore be drawn that the additional inflows to Springvale Colliery from the extraction of LWs 415 to 419 will have a negligible and unmeasurable impact on the local hydrogeological regime, and on surface water flows.

5.3 Other implications

The removal of groundwater inflows to a mine can trigger regulation of the discharge under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources, 2011,* which is a regulation made under the *Water Management Act 2000*. This Plan establishes a bulk access regime for the extraction of water under access licences to 13 specified groundwater sources (Part 1 Cl.4). One of the nominated groundwater sources, the *Sydney Basin Blue Mountains Groundwater Source*, is relevant to the extraction of LWs 415 to 419, as this water source lies in the Narrabeen Group rocks including the Banks Wall Sandstone. Two other groundwater sources in the region, the *Coxs River Fractured Rock Water Source* and the *Sydney Basin Coxs River Groundwater Source* do not apply as the proposed longwall panels are located in the Colo River Catchment.

Since the investigations have concluded that the aquifers in the Banks Wall Sandstone will be unaffected by the mining, it seems unlikely that the Plan will apply to the proposed extraction. However, there are two issues that reduce the certainty of this contention:

1. Part 1 Cl.4 (3) of the Plan notes that the specified groundwater sources " include all water contained within all aquifers below the surface of the ground shown on the Registered Map". Consequently, if the water-bearing zones in the coal measure strata are deemed to be aquifers, then technically they will be captured by the Plan as they lie below the Narrabeen Group aquifers.
2. The *Water Management (General) Regulation 2004* defines an "aquifer" as "a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water". This is of little assistance in determining whether the coal measures contain any "aquifers" or just interstitial groundwater.

The vision statement for the plan states that it "is to provide for healthy and enhanced water sources and water dependent ecosystems and equitable water sharing among users in these groundwater sources". Since there are GDEs in this area then there may be additional scrutiny on the extraction of the water inflows to the mine.

It is also important to note that the performance indicators for the Plan, amongst other things, include the:

- extent of groundwater level fluctuations,
- change in the ecological condition of representative groundwater dependent ecosystems, where groundwater extraction is recognised as the primary risk to their condition,

Obviously, the water level fluctuations in the coal measures are significant due to the undermining, but there has never been any change in the ecological condition of GDEs due to depletion of the groundwater.

While it seems unlikely that the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources, 2011* would be applicable to the expected groundwater extraction within the proposed LWs 415 to 419, this should be confirmed by Centennial's Legal Branch.

6. Conclusions

An assessment has been made of the potential for impacts on the local and regional hydrogeology from activities associated with the construction and commissioning of Bore 8. The main findings are as follows:

1. The surface infrastructure for the bore sites is located in the Newnes State Forest, which contains a number of groundwater dependent ecosystems classified as 'Temperate Highland Peat Swamps on Sandstone' (THPSS). These swamps include Newnes Plateau Shrub Swamps (NPSS) and Newnes Plateau Hanging Swamps (NPHS).

2. The surface infrastructure for the bores will require a final cleared area of about 0.32 ha. Activities will include clearing of access tracks, construction of drilling pads, installation of erosion and sediment controls, trenching for utilities, drilling the bores, partial rehabilitation of the site, and installation and commissioning of the bores. The Bore 8 site has been chosen to avoid known NPHS and other threatened and endangered flora species.

3. The proposed four boreholes at the Bore 8 site will be constructed by the process of blind boring. This involves drilling a pilot hole, followed by boring with a blind boring head, following the pilot hole, to produce a borehole of the desired diameter. Drilling mud with a controlled density is fed into the void above the cutting head to lubricate cutting and balance the hydrostatic pore fluid pressure. On completion of boring, the borehole liner with a capped bottom

is lowered down the hole, displacing the drilling mud. Finally the annulus between the liner and borehole is fully grouted.

4. There are essentially three basic groundwater systems that have been identified in the region, and all have the potential to be impacted by the installation and operation of the proposed boreholes. These groundwater systems include:

    - **Perched groundwater system** – a discontinuous, near-surface system generally independent of the regional groundwater systems, which supports NPHS.
    - **Shallow groundwater system** –a regional groundwater system located in the Narrabeen Group above the Mount York Claystone, largely in the Banks Wall Sandstone, which contains aquifer zones that support Newnes Plateau Shrub Swamps, including the Sunnyside, Sunnyside East and Carne West Swamps.
    - **Deep groundwater system** – a less important, deeper groundwater system exists in the strata below the Mount York Claystone, and includes the Illawarra Coal Measures.

5. The potential hydrogeological risks associated with the proposed construction and operation of the dewatering bores were identified and can be categorised into local and regional impacts as follows:

    Local impacts

    - Draining of perched groundwater into mine workings via the boreholes
    - Draining of shallow groundwater into mine workings via the boreholes
    - Drainage of deep groundwater into mine workings via the boreholes
    - Contamination of perched and shallow aquifers with drilling fluid
    - Additional underground water make and discharge due to groundwater drainage via the boreholes
    - Damage to hanging swamps due to diversion of surface water from disturbed areas

    Regional impacts

    - Possible long-term drainage of shallow groundwater into mine workings via the boreholes

6. All of these potential risks were examined in detail and none were found to pose a risk to the local or regional hydrogeological regime, or the groundwater dependant ecosystems that rely on these groundwater resources.

7. Several avoidance measures have been identified that will ensure that the risk of any adverse hydrogeological outcomes is minimised.

8. An assessment of future mine water inflows into LWs 415 to 419 concluded that Springvale will need to increase its current licensed discharge volume from 5958 ML/year by 222 ML/year to 6180 ML/year. This increase in volume of less than 4% will set the rate at the 95th percentile of recorded flows rather than the current 93.8th percentile.

9. A review of the potential impacts of this increase in inflows to the mine concluded that, since almost all of the additional groundwater inflows will originate from the coal measure strata, the extraction of LWs 415 to 419 will further dewater the coal measures, which have been largely drained of groundwater in the vicinity of Springvale by previous mining in the region (at Springvale and other adjacent mines). Since there are no known groundwater users downdip of the project area that use groundwater from the coal measure strata, and the coal measure strata do not provide any significant contribution to base flow in the local streams, this additional dewatering will have a negligible impact.

10. The review also concluded that the hydrogeological regime in the Banks Wall Sandstone above the Mount York Claystone (more than 200 m above the mine) will be unaffected by the proposed

extraction. Consequently, the important upper aquifers in the Banks Wall Sandstone will be unaffected, and the flow from these aquifers will be unchanged. As a result, the swamps that rely on these flows will also be unaffected.

11. The overall conclusion can be drawn that the additional inflows to Springvale Colliery from the extraction of LWs 415 to 419 will have a negligible and unmeasurable impact on the local hydrogeological regime, and on surface water flows.

12. A review of *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources, 2011* has indicated that it may not be applicable to the expected groundwater extraction within the proposed LWs 415 to 419. This should be confirmed by Centennial's Legal Branch.

7. References

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Appendix A

Springvale Colliery, Groundwater Mine Inflow Assessment for the Borehole 8 Modification
N Merrick

HERITAGE COMPUTING REPORT

<u>APPENDIX A</u>

SPRINGVALE COLLIERY

GROUNDWATER MINE INFLOW ASSESSMENT FOR THE BOREHOLE 8 MODIFICATION

FOR

SPRINGVALE PTY LTD

PO Box 198, WALLERAWANG NSW 2845

By

Dr N. P. Merrick

Report Number: HC2012/17
Date: July 2012

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REVISION	DESCRIPTION	DATE	COMMENTS
A	DRAFT	13 JUNE 2012	Original
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TABLE OF CONTENTS

1.0 INTRODUCTION

This report provides a component of the groundwater assessment being undertaken by Aurecon for Springvale Colliery for the proposed dewatering Bore 8. Bore 8 will form part of Springvale Collierys's groundwater dewatering strategy as longwall mining progresses downdip to the east from LW416 to LW419. An additional dewatering facility needs to be established ahead of the workings to ensure water levels in the mine can be kept to safe manageable levels.

Springvale Colliery currently operates one dewatering facility (Bore 6) on the Newnes Plateau. Three submersible pumps exist at the "Bore 6" facility. Bore 6 is located at what is currently the lowest point in the mine, near the northern end of LW416, and is the mine's principal dewatering facility at the present time.

Mine dewatering rates out to LW419 have been projected by means of two models currently used by Springvale Colliery to predict operational water make.

2.0 SCOPE OF WORK

The relevant component of the Scope of Works for the groundwater assessment for construction and operation of Springvale's Bore 8 is:

- *Quantification of the groundwater inflow into mine workings.*

A review of the numerical model developed by CSIRO for Springvale has been conducted according to established industry guidelines for reviewing groundwater flow models (MDBC, 2001). The results of the review are reported elsewhere (Merrick, 2012).

3.0 QUANTIFICATION OF MINE INFLOWS

Mine dewatering rates out to LW419 have been projected by means of three models: (1) An empirical algorithm (developed by Springvale Colliery) based on the perimeter of active workings; (2) A revised empirical algorithm also based on the perimeter of active workings; and (3) A coupled geomechanical - water flow numerical model developed by CSIRO.

For the revised empirical algorithm, the total mine inflow at the end of longwall panel *n+1* is:

$$\boldsymbol{Q_{n+1} = 14.2 * \{ P_n + 0.13\, P_{n-1} + 0.10\, P_{n-2} + 0.12\, P_{n-3} + 0.30\, P_{n-4} + 0.04 \sum_{i=1}^{n-5} P_i \}}$$

where P_i is the perimeter for longwall panel *i*. A comparison between actual mine inflow from 1996 to 2010 and the empirical estimate is shown in **Figure 1**.

Projected estimates of mine inflow for longwalls 415 to 419 are shown also in **Figure 1** for the revised empirical algorithm and the numerical model.

Due to the difficulty in fitting the mine inflow trend with a single mining attribute, there remains substantial uncertainty in projecting mine inflow estimates by an empirical method. However, the mine inflow at LW419 in 2018 is likely to be in the range 150-250 L/s, say 200±50 L/s (13-22 ML/day). On the other hand, the algorithm provides a very simple and rapid method of estimation for future longwalls, compared with the substantial effort required to satisfy a similar objective using a numerical model. The numerical model estimates will have lower uncertainty as other mining attributes, including geological structure, can be taken into account.

The numerical model estimates of mine inflow for LW416-LW419 range from about 160 L/s (14 ML/day) to about 220 L/s (19 ML/day), as panel averages, for two cases (Case 1 and Case 2) which differ in the degree of permeability enhancement due to rock deformation.

Figure 1 shows that the revised empirical model estimate of mine inflow for LW416-LW419 lies roughly midway between the Case 1 and Case 2 estimates, and both approaches have fairly steady inflow over the duration of LW416-LW419.

The separate mine inflow estimates for LW416 to LW419 are consistent (**Table 1**). The most likely average rate is about 200 L/s (about 17 ML/day) with an uncertainty range in the order of 50 L/s (about 5 ML/day).

Table 1. Springvale Mine Inflow Estimates for LW416-LW419

MODELLING METHOD	MINE INFLOW [L/s]	MINE INFLOW [ML/day]
Revised Empirical Algorithm	200 ± 50 L/s	17.5 ± 4.5 ML/day
Coupled Numerical Model	190 ± 30 L/s	16.5 ± 2.5 ML/day

The current licensed volume attached to Bore 6 is 5958 ML/year. This is close to the most likely annual volume expected for LW416-419, which is 6000-7000 ML/year as shown in **Table 2**. The upper limits of possible volumes are 7000-8000 ML/year. It is expected that the volumes will not vary appreciably for the duration of the future longwall panels.

The precautionary approach would be to seek an increase in the Bore 6 licence, when transferring to Bore 8, from 5958 to 8000 ML/year. This volume lies at the 99.8th percentile of recorded inflows.

Alternatively, it could be argued that the licensed volume should be set at the 95th percentile of recorded flows. This is 6180 ML/year, an increase of 222 ML/year. The current licence is at the 93.8th percentile.

Table 2. Springvale Mine Inflow Licence Estimates for LW416-LW419

MODELLING METHOD	EXPECTED AVERAGE INFLOW VOLUME [ML/a]	EXPECTED MAXIMUM INFLOW VOLUME [ML/a]
Revised Empirical Algorithm	6400	8000
Coupled Numerical Model	6000	7000

4.0 REFERENCES

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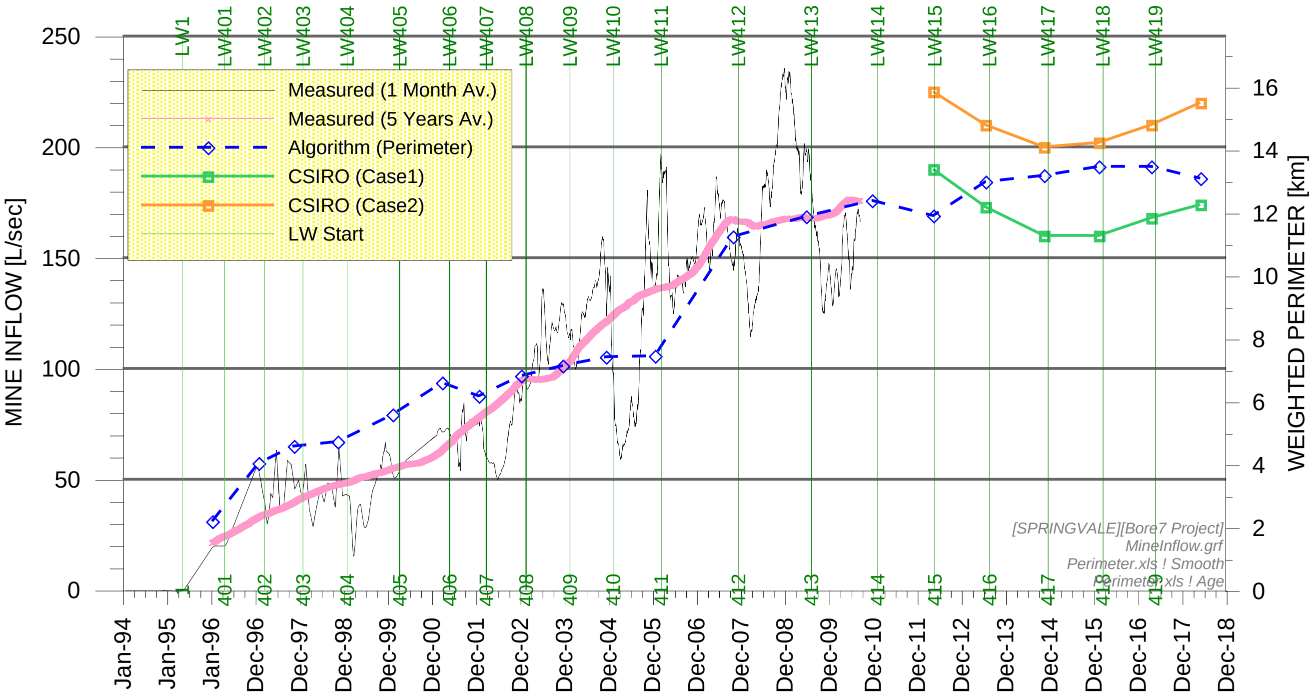

Figure 1. Actual mine inflow and projected mine inflow estimates