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14 October 2015

Yancoal Australia Ltd
Level 26, 363 George Street
Sydney NSW 2000

Attention: Mark Jacobs

Dear Mark,

Re: Austar Coal Mine – LWB1-LWB3 Modification – Groundwater Assessment

1. Background

The Austar Coal Mine is an underground mine located about 10 km southwest of Cessnock in the Newcastle Coalfields of NSW. The Austar Coal Mine incorporates the former Pelton, Ellalong, Cessnock No. 1 (Kalingo) and Bellbird South Collieries and is located in an area which has been an active mining area over many years. The locations of the Austar Coal Mine and previous underground workings in the area are shown on **Figure 1**.

The Austar Coal Mine is owned by Yancoal Australia Limited, and operated by its wholly owned subsidiary Austar Coal Mine Pty Ltd (Austar). Following its purchase in 2004, Austar recommenced underground mining in the Bellbird South Colliery area in 2005 under Development Consent DA29/95 (the Bellbird South Consent), later employing the Longwall Top Coal Caving (LTCC) mining method after modifications to the Bellbird South Consent were approved. Austar has completed coal extraction from the Greta Seam from the Bellbird South Colliery area (Longwalls A1 and A2 in Stage 1, Longwalls A3 to A5A in Stage 2), and from the Stage 3 area (Longwalls A7 and A8) employing the LTCC mining method. Austar has approval to mine Longwalls A9 to A19 in Stage 3.

Austar is seeking approval to modify Development Consent DA29/95 to allow the transfer and processing of coal from three additional Longwalls LWB1, LWB2 and LWB3, which would be located to the south of the previously mined Longwalls A2 to A5A and east of Longwalls 1 to 12A at the Ellalong Colliery (**Figure 2**).

Umwelt (Australia) Pty Ltd (Umwelt) has been engaged by Yancoal to prepare an Environmental Assessment for the proposed Modification. A review of existing available groundwater information was carried out by Umwelt to support the preparation of a qualitative groundwater impact assessment by Dundon Consulting Pty Ltd. This letter report presents the qualitative groundwater impact assessment findings.

2. Nature of the Modification

In summary, the proposed Modification comprises the following:

- extending the development consent area of the Bellbird South Consent to encompass the proposed Modification Area (refer to **Figure 2**);
- extending the life of the Bellbird South Consent by a further five years to allow for extraction of LWB1-B3; and
- replacing the existing SMP condition on the Bellbird South Consent with a contemporary Extraction Plan condition which extends to the secondary extraction of material from LWB1-B3.

No other changes to the approved mining operations or existing surface facilities are proposed as part of the modification.

The proposed longwalls will have void lengths of approximately 1880 m (LWB1), 1670 m (LWB2) and 1480 m (LWB3), and a void width including first workings of approximately 237 m (MSEC, 2015). The Greta Seam thickness in the proposed Modification area ranges from 3.3 to 4.6 m, and it is proposed that a constant seam thickness of 3.4 m will be mined by conventional longwall mining methods.

The locations of the proposed LWB1-B3 are shown on **Figure 2**.

3. Groundwater Impact Assessment Requirements

Umwelt has been engaged by Yancoal to prepare an Environmental Assessment to support the proposed Modification, and their scope of work included aspects of groundwater assessment, viz:

- Review existing subsidence and groundwater monitoring data
- Review the October 2007 Connell Wagner groundwater assessment for the Austar Mining Complex
- Review 2013 Aurecon groundwater verification report following completion of LWA5
- Review the draft subsidence impact assessment for LWB1-B3
- Collate relevant monitoring results
- Undertake preliminary assessment relevant to the LWB1-B3 Modification.

The above groundwater review and preliminary assessment work has been carried out by Umwelt and provided to Dundon Consulting Pty Ltd as briefing material to support the preparation of a qualitative groundwater impact assessment by Dundon Consulting Pty Ltd.

4. Description of Existing Hydrogeological Environment

The existing hydrogeological environment has been extensively described in previous groundwater reports, including the RPS Aquaterra (2014) groundwater monitoring and modelling plan for EL6598, and the Connell Wagner (2007) groundwater impact assessment report on future mine development at the Austar Coal Mine. The summarised description of the existing hydrogeological environment below draws heavily on these documents supplemented by the results of groundwater monitoring.

4.1 Climate

The lower Hunter Valley area where the Austar Coal Mine is located experiences a warm temperate climate, with seasonal variations from hot wet summers to mild dry winters. Rainfall in the region is generally summer dominant, and rainfall is less than potential evaporation for most months of the year.

4.2 Topography and Drainage

The following general descriptions of the site topography and drainage are derived mainly from the 2008 Flooding and Drainage Assessment for Stage 3 (Umwelt, 2008).

The proposed longwall panels are located beneath the Quorrobolong Valley, within which the Quorrobolong Creek / Cony Creek drainage system flows in a westerly direction across the mine area, eventually flowing into Wollombi Brook which in turn flows into the Hunter River. The main drainages of the Quorrobolong Valley are Quorrobolong Creek, Cony Creek and Sandy Creek. These creeks are largely ephemeral and are often present as a series of disconnected pools during the dry season. The catchment area of the Quorrobolong valley upstream of the Ellalong Bridge (about 2 km west of the proposed LWB1-B3) is approximately 80 km^2.

The surface elevations within the valley floor are around 130 mAHD, while the elevation rises to around 440 mAHD at the Myall Range to the south and to around 200 mAHD at the Broken Back Range to the north.

The three longwall panels proposed with this Modification are located on the southern flank of the valley, and partly lie beneath the small alluvial floodplain associated with an unnamed, small, north-flowing tributary of the main Quorrobolong Creek system. The area within the valley floor has been predominantly cleared for grazing. The creek lines on the valley floor mostly support riparian vegetation.

4.3 Stratigraphy and Structural Geology

The Austar Coal Mine extracts coal from the Greta Coal Seam of the Late Permian aged Greta Coal Measures.

The Greta Coal Measures (GCM) comprises the Neath Sandstone, Kurri Kurri Conglomerate, Kitchener Formation (including the Greta Seam) and the Paxton Formation, and all units are predominantly sandstone, conglomerate and coal. The top of the GCM is about 20 m or so above the top of the Greta Seam.

The GCM is overlain by a thick sequence of sedimentary rock including conglomerate, sandstone and siltstone of the Branxton Formation, and other higher units of the Maitland Group, which extend from the coal measures to outcrop. The project stratigraphy is summarised in **Table 1.** The geology of the proposed Modification Area is presented on **Figure 3**.

Table 1: Austar Coal Mine Stratigraphic Summary (after Hawley and Brunton, 1995)

Age	Stratigraphy		Lithology
Late Permian	Maitland Group	Mulbring Siltstone	Siltstone with minor claystone and sandstone lenses.
		Muree Sandstone	Sandstone with minor conglomerate and siltstone
		Branxton Formation	Conglomerate and sandstone towards base, siltstone becoming more common towards top
	Greta Coal Measures	Paxton Formation	Conglomerate and micaceous sandstone with minor claystone and siltstone beds. Coal (Pelton Coal Member) and coaly shale.
		Kitchener Formation (including the Greta Seam)	Coal with minor claystone, siltstone and sandstone
		Kurri Kurri Conglomerate	Orthoconglomerate, minor sandstone, siltstone, claystone and coal near base.
		Neath Sandstone	Sandstone, minor conglomerate siltstone and claystone
Early Permian	Dalwood Group	Farley Formation	Fossiliferous silty sandstone
		Rutherford Formation	Siltstone and minor sandstone, with thin limestone and marl horizons (Pokolbin area)
		Allandale Formation	Lithic sandstone and conglomerate containing abundant invertebrate fossils
		Lochinvar Formation	Poorly fossiliferous siltstone, claystone and sandstone and interbedded basalt flows.

Structurally the mine is situated on the south-eastern limb of the Lochinvar Anticline. The Greta Seam outcrops to the north near Cessnock, and dips variably to the south-east with a general dip of around 5 to 6 degrees. Within the current mining area, the seam occurs at depths ranging up to 740 m. In the proposed Modification Area, the expected depth of cover will be between 480 m and 555 m (MSEC, 2015).

Seam thickness generally increases eastward with thicknesses of up to 7 m in the Stage 3 mining area, and it is known to split along the eastern margin of the current mine area, with an interburden lens of siltstone, claystone and sandstone known as the Kearsley Lens.

Extensive faulting and deformation is associated with the Lochinvar Anticline, with a number of prominent fault zones controlling the longwall panel layouts, notably the Swamp Fault Zone, Quorrobolong Fault and the Abernethy Fault Zone. Dykes are also present in the Austar Coal Mine and have been intersected in the historical and current workings. The most prominent of these, the Central Dyke, runs parallel with the Quorrobolong Fault and forms the eastern boundary of the Stage 2 mining area.

A thin veneer of colluvium is believed to occur over the lower valley slopes, grading into alluvium associated with the main creeks and tributary streams.

4.4 Hydrogeological Units

Within the proposed Modification Area, two aquifer systems are identified, firstly the unconsolidated surficial material that includes alluvium, colluvium and weathered bedrock, and secondly the Permian hard rock aquifer system. A third potential source of water that needs to be considered in the assessment of groundwater impacts is the water stored in abandoned mine voids (RPS, 2014; Connell Wagner, 2008).

The main sources of water that make up the groundwater regime relevant to the Austar Coal Mine operations and proposed developments in the area are as follows:

- Alluvial aquifer system associated with the Quorrobolong Creek / Cony Creek drainages and their tributaries (modest localised aquifer).
- Non-alluvial hard rock aquifers (referred to as fractured rock aquifers in previous Austar Coal Mine groundwater assessment reports, and now formally termed ‘porous’ rock aquifers). The principal water bearing components of the hard rock aquifer system are the coal seams, which are relatively more permeable than the interburden and overburden sediments. Some fractured zones are present within the upper parts of the Branxton Formation.
- Water stored within abandoned underground mine voids.

Groundwater within the alluvial aquifer in the proposed Modification Area is part of the Congewai Creek Management Zone of the Upper Wollombi Water Source and is regulated by the *Water Management Act 2000*, under the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (WSPHUAWS). The non-alluvial groundwater is regulated under the *Water Act 1912*.

4.4.1 Alluvial Aquifer System

Distribution and Nature of Alluvium

The alluvial aquifer system comprises very poorly developed alluvial and/or colluvial deposits within the floodplain of Quorrobolong Creek and its tributaries. The estimated areal extent of alluvium associated with these creeks as shown on **Figure 4** has been derived initially from the 1995 published 1:100,000 scale map of the Newcastle Coalfield Regional Geology, and refined by Umwelt from topographic analysis.

Quorrobolong Creek and its tributaries comprise a series of ephemeral creeks which only flow after consistent or heavy rainfall. The alluvium associated with these surface drainage features in the vicinity of the proposed modification is generally shallow and low yielding (Connell Wagner, 2007). This is evidenced from the drilling log of a NSW Office of Water (NOW) monitoring bore (GW080974) located approximately 300 m northwest and downstream of the proposed modification area, in the alluvium of the unnamed tributary overlying LWB1-B3 (**Figure 4**). The log of this bore indicates the alluvium is less than 6 m thick in this location with a standing water level of 1 m and a yield of 2 L/s. Monitoring records for this bore from 2010 to 2014 (NOW on-line groundwater database) indicate a water level ranging between 0.5 and 2.3 m below ground level, suggesting a saturated alluvium thickness at this bore site varying seasonally between 3.7 and 5.5 m.

Austar has installed four shallow monitoring bores (AQD1073, WBH1, WBH2 and WBH3) in the vicinity of Quorrobolong Creek to the northeast of the proposed Modification Area. Locations are shown on **Figure 4**. AQD1073 was drilled in July 2006, and WBH1 to WBH3 in July 2011. Logs of these bores record only silts and clays grading downwards into weathered siltstone and fine-grained sandstone rock. RPS (2014) interpreted a thickness of alluvial sediments ranging up to 6.2 m in AQD1073A, WBH2 and WBH3, but the driller’s logs and photographs of cores from AQD1073A suggest that most of the unconsolidated material drilled in these four bores would be better described as colluvium or residual soils (extremely weathered rock). The log of WBH1 indicates less than 1 m of alluvial or colluvial material.

Groundwater Levels

Groundwater level hydrographs are plotted for all four monitoring bores on **Figure 5**. This figure also shows the Rainfall Residual Mass Curve, which is based on monthly rainfall data from the nearest reliable BOM station, ie Pokolbin Jacksons Hill Station No 061329 (approximately 10 km to the north of the Austar Mine site).

The Rainfall Residual Mass (RRM) curve plots the cumulative deviation from average rainfall, in this case based on comparing the actual monthly total rainfalls with the long-term average monthly total rainfalls from the chosen site. The RRM curve is a useful tool to assess whether there are any mining-induced impacts on the groundwater. In times of above average rainfall, the RRM will show an upward trend, while periods of below-average rainfall will result in a downward trend. The role of rainfall infiltration as a primary mechanism for groundwater recharge is shown by a similar trend in the groundwater level hydrographs. If there is an ongoing divergence over time in the trends between the groundwater levels and the RRM curve, it may indicate a mining-induced drawdown effect, which can be difficult to see otherwise because of the short term fluctuations in groundwater level.

The RRM curve is superimposed on the hydrographs on **Figure 5**. It can be seen that over the period of monitoring, there is no noticeable divergence between the RRM trend and the groundwater level hydrograph trends, suggesting no mining related impacts have occurred.

<u>Groundwater Quality</u>

Monitoring data from the Austar Coal Mine monitoring bores indicates that the shallow groundwater intersected by these bores is of variable quality, with reported EC values ranging from 33 to 2,632 µS/cm (RPS, 2014). A plot of EC versus time for the four alluvium monitoring bores is shown in **Figure 5**. AQD1073A water salinity was generally above 2,500 µS/cm between July 2010 and April 2011, but EC dropped markedly thereafter, and from July 2011, EC has been consistently less than 1,000 µS/cm. WBH1 to WBH3 were installed in July 2001, and the EC values have likewise been below 1,000 µS/cm since that time.

All four bores show the start of a rising EC trend towards the end of the monitoring record, in late 2013 and early 2014.

The RRM curve is superimposed on the EC plots on **Figure 5**. As with the water level hydrographs, there is close (inverse) relationship between the RRM curve and the EC trend, indicating that the groundwater salinity is very much related to recharge. In times of above average rainfall, and therefore active recharge, the groundwater salinity is lower than in times of low rainfall, and hence no or only limited recharge.

<u>Beneficial Use Potential</u>

The alluvial/colluvial aquifer associated with Quorrobolong Creek and its tributaries within the proposed Modification Area is limited in extent and depth, and is associated with ephemeral streamflow. The groundwater quality is variable, and is susceptible to elevated salinities in periods of low or no rainfall recharge. The alluvial aquifer system is therefore not characterised as a "highly productive" groundwater source or a highly connected surface water source, as defined by the NSW Aquifer Interference Policy. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the proposed Modification has limited potential for use as a water supply for stock, domestic or other consumptive purpose.

4.4.2 Non-alluvial Hard Rock Aquifer System

<u>Distribution and Nature of Hard Rock Aquifer System</u>

'Porous rock' aquifers within the Permian hard rocks are limited to the Branxton Formation and the Greta Coal Seam itself.

Branxton Formation

The Branxton Formation is part of the non-coal bearing marine sequence of the Maitland Group which overlies the Greta Coal Measures. The sandstone is generally strong and massive with a silica and or clay matrix. Due to the massive nature and very low interstitial permeability ($<10^{-3}$ m/d) of the Branxton Formation it contains few if any major water bearing zones and is not likely to provide a viable source of groundwater (Connell Wagner, 2007). Nevertheless, zones of jointing or fracturing associated with major faults may form localised aquifers. The sequence has very low vertical permeability, and there is very little potential for leakage between any water-bearing zones or aquifers.

Two registered bores located in the north-western corner of the proposed Modification Area target the Branxton Formation strata. These are NOW monitoring bore GW080973 and private stock bore GW054676 shown on **Figure 4**. Stock bore GW054676 was drilled to a depth of 39.6 m and intersected a shale water bearing zone between 10.1 m and 24.4 m below ground level. The bore reportedly has a low yield (approximately 1 L/s) and poor water quality (12,000 to 16,000 µS/cm EC). Monitoring bore GW080973 was drilled to a depth of 95 m and did not intersect any reported water bearing zones.

Drilling at the Austar Coal Mine indicates potential water-bearing zones in the Branxton Formation at a depth of around 100 to 130 m and at 170 m below ground level at bore locations across the mine area. Connell Wagner (2007) concluded that the importance of these water bearing zones as a water resource is likely to be minimal, since the water quality is poor (generally greater than 10,000 µS/cm EC) and the yield is low (generally less than 1 L/s).

Coal Measures

The Greta Coal Measures also have very low rock mass permeability (<10^{-3} m/d), but it contains occasional layers which have slightly higher permeability (Connell Wagner, 2007), generally the coal seams and occasional fracture or bedding plane features.

The coal seams are normally relatively more permeable than the interburden lithologies, and are therefore the main water-bearing zones in the coal measures due to the presence of cleats and fractures in the coal. For this reason the coal seams represent the major aquifer units purely by comparison with the much less permeable interburden strata, and their importance as an aquifer is generally minimal due to the poor quality groundwater as well as limited yield potential. Hitchcock (1995) concludes that the coal measures in the Newcastle Coalfield 'have a poor resource potential with low yielding aquifers of high salinity'.

Groundwater Levels / Pressures

In the vicinity of the proposed Modification, water levels are monitored at bore NER1010, which is approximately 415 m northwest of proposed LWB3. Bore NER1010 is a standpipe piezometer 102 m deep, and screened from 20 to 102 m in the Branxton Formation.

The water level in NER1010 is at around 10 to 25 m below ground surface, at around 100 to 115 mAHD (**Figure 6**), deeper than the shallow alluvium/colluvium standpipe piezometers AQD1073A, WBH1, WBH2 and WBH3, where water level is within 10 m of the ground surface, and at an elevation of 120 to 124 mAHD. The water level hydrographs for all 5 bores are shown for comparison on a composite plot on **Figure 7**. Groundwater levels are clearly deeper in the Branxton Formation than in the surficial aquifer (alluvium/colluvium/regolith), showing that there is potential for downward percolation of water from the surficial groundwater into the underlying hard rocks, if hydraulic connection were to exist.

The RRM curve plotted on **Figure 6** shows a broad correlation with the overall trend on the NER1010 hydrograph. The hydrograph shows periodic rapid rises in water level in response to rainfall events and rapid recession, but these short-term features are superimposed on a more slowly trending rise in level during periods of rising RRM and decline during periods of falling RRM. A similar broad correlation between the hydrographs for the shallow surficial groundwater and the RRM can be seen, but the response in the hard rock groundwater is larger in magnitude. This is likely due to the much lower specific yield value for the hard rock relative to the alluvium/colluvium, and the actual volume of groundwater recharge occurring in the hard rock is likely to be very much less than in the surficial aquifer system.

Groundwater pressures at greater depth in the hard rocks have also been monitored at a number of multi-level vibrating piezometer bores, the closest to the proposed Modification being AQD1121, which is located about 800 m east of the proposed Modification Area. This bore was installed in February 2015, and comprises 6 vibrating wire piezometers set at depths ranging from 280 to 617.8 m below surface (Douglas Partners, 2015). Monitoring results are presented in **Figure 8**, which is a composite plot of hydrostatic head profiles for several dates between installation and the present time.

Figure 8 shows a number of relevant features:

- There is substantial depressurisation of the strata at depth, below at least 500 m, shown by the divergence of the hydrostatic head profile plots from the 45º slope showed as a dotted line on **Figure 8**.

- The hard rock strata are unlikely to be saturated above a depth of about 60 mAHD (ie about 80 m below surface), shown by projecting the hydrostatic head traces back to the zero piezometer pressure axis. There may be perched groundwater above this elevation, but the top of continuous saturation would be at around 60 mAHD.
- The greatest depressurisation is around the level of the Greta Seam, with the lowermost three piezometers showing about 300 m of depressurisation in the latest data from August 2015.

Another multi-level vibrating wire piezometer bore AQD1077 is located approximately 3 km north from the northern end of the proposed LWB1-B3. AQD1077 has vibrating wire piezometers set at depths of 30 m, 200 m, 310 m, 360 m, 390 m, 424 m, 439 m and 451 m. The top of the Greta Seam is just above the second deepest (439 m) piezometer.

A composite plot of the hydrostatic head profile for AQD1077 is plotted on **Figure 9**. Hydrostatic head profiles are plotted for various dates between 8 September 2006 and 11 April 2008. This time period includes the extraction from longwall panel LWA2, and shows the progressive depressurisation effect of the subsidence accompanying that longwall extraction. The composite hydrostatic head profile plot is quite informative about groundwater pressure distribution within the hard rock, as well as vertical hydraulic connectivity in the sub-surface. The following general conclusions can be drawn:

- The highest groundwater in the bedrock has a pressure some 25 to 30 m below ground surface (based on the intercept of the hydrostatic head trace with the zero piezometer pressure axis).
- The uppermost groundwater in the bedrock is believed to be a perched aquifer, as the hydrostatic head trace between the 30 m and 200 m piezometer levels is steeper than 45º. If the groundwater were continuous between 30 m and 200 m, the trace would plot with a slope of 45º, which is shown on **Figure 9** by a dotted line.
- The 30m piezometer maintained a positive pressure only for a few weeks, from installation on 8 September 2006 until late October 2006. This suggests that the perched aquifer became dewatered over this time, probably indicating that it is ephemeral.
- Prior to extraction from LWA2, the groundwater would have been hydraulically continuous between 200 m and at least 310 m, denoted by the 45º slope of the hydrostatic head trace between the 200 m and 310 m piezometers on **Figure 9**.
- Below 310 m, at that time there was already some depressurisation effect observable in the data, due to prior mining in the area, demonstrated by the divergence of hydrostatic pressures away from the 45º line on **Figure 9** below 310 m. The greatest divergence away from the 45º line is seen to be at the Greta Seam (ie the 439 m piezometer), which is what would be expected as the greatest magnitude of depressurisation would occur laterally within the Greta Seam itself. The residual hydrostatic pressure in the Greta Seam at the location of AQD1077 was around 135 m when monitoring started on 8 September 2006.
- Over the ensuing months, as mining proceeded in LWA2, hydrostatic pressures were progressively reduced in the strata at and below 310 m, indicated by the progressive leftward shift in the head trace over time. Between February and June 2007, data from piezometers at 390 m, 424 m, 439 m and 451 m was lost, presumably as the down-hole cables became damaged as a result of ground movements. Higher piezometers were progressively lost thereafter, so that by April 2008, only the 200 m and 30 m piezometers remained. The 200 m piezometer was then lost, leaving only the 30 m piezometer still functioning.
- The monitoring data for the 200m piezometer shows that it did not undergo depressurisation until February 2008, but thereafter the pressure declined by about 20 m by the time contact with the piezometer was lost in April 2008. The lagged response in the 200 m piezometer suggests that it is situated above the zone of direct hydraulic connection with the goaf. The response could be a partial draining effect, or more likely it could be merely a bed dilation effect resulting from the subsidence accompanying longwall extraction.

In summary, the available water level data indicate very limited or negligible hydraulic interconnection between the groundwater in the hard rocks and surficial groundwater in the alluvium, colluvium and weathered bedrock zone.

The vibrating wire piezometer monitoring results from AQD1077, where cover depth above the Greta Seam was approximately 440m, indicate that there is unlikely to be direct hydraulic connection from the goaf to the ground surface following mining of the proposed LWB1-B3, where the depth of cover above the Greta Seam is expected to be 480 m and 555 m.

Groundwater Quality

Sampling from monitoring bore NER1010 shows salinity of groundwater in the upper parts of the Branxton Formation is similar to that in the surficial groundwater present in the alluvium, colluvium and weathered bedrock. EC ranged between 156 and 1658 µS/cm between July 2010 and February 2014 (**Figure 6**). This low salinity is believed to be due to its proximity to recharge from infiltration of local rainfall, rather than a reliance on flow from a distant recharge source that would apply to deeper hard rock groundwater. Groundwater sampled from the NOW monitoring bore GW054676 is reported to have a salinity in the range 10,000 to 16,000 µS/cm EC, which is believed to be more typical of salinity in the Branxton Formation, away from sources of local recharge from rainfall infiltration.

Groundwater deeper in the Branxton Formation and in the Greta Coal Measures is saline to highly saline. Monitoring shows that water inflow to the Austar Coal Mine has high salinity and generally low pH, as well as elevated dissolved iron (Connell Wagner, 2007), as in **Table 2** below:

Table 2: Mine Water Quality Data (Connell Wagner, 2007)

Location	pH	EC (µS/cm)	Fe (mg/L)
Ellalong goaf (No 2 Shaft pump)	4.7	18,733	575
West Pelton goaf	6.8	8,350	52
East Pelton goaf	3.8	11,960	851
LW13 flank hole (adjacent to Kalingo workings)	3.8	15,382	507
LWA1 13 C/T flank hole (adjacent to Aberdare Central workings)	3.9	11,823	1,700

The inflow water comprises a mixture of in situ groundwater and stored water, and the water stored in former mine workings has probably undergone some increase in salinity over time, but the salinity is ultimately derived primarily from the in situ groundwater within the coal measures.

Beneficial Use Potential

Based on generally low formation permeability and poor water quality, the porous rock groundwater sources within the proposed Modification Area are not characterised as “highly productive” groundwater sources, as defined by the NSW Aquifer Interference Policy as they do not meet the water quality and yield requirements for highly productive groundwater sources.

4.4.3 Water Stored in Former Mine Voids

There is a long history of underground mining in the region around the Austar Coal Mine. As shown on **Figure 1** there are a number of former mine workings (voids) adjacent to the Austar Coal Mine which are partially filled with water. Austar uses some of these voids as part of its approved water management strategy described in the Austar Site Water Management Plan (2013). Austar returns excess mine water to former mine workings located up dip of Austar’s current operations.

The quality of water in these old mine workings is extremely poor as evidenced by groundwater quality data obtained for water entering Austar workings through coal barriers from old workings. These data (**Table 2**) show salinity values of 8,350 to 18,733 µS/cm or greater with pH generally ranging between 3.8 and 6.8 (Connell Wagner, 2007).

Consequently, while the yield of these abandoned mine voids would theoretically satisfy the definition of a highly productive aquifer, the quality of the water within the old workings means it has limited beneficial use potential.

5. Potential Impacts of the Modification

The additional impacts from the proposed LWB1-LWB3 Modification overall are anticipated to be quite small, and all water takes would be able to be accounted through existing licensing held by Austar. The additional impacts are discussed in the following sections.

5.1 Predicted Subsidence Impacts

MSEC (2015) has assessed the likely subsidence impacts of the proposed Modification. MSEC's main findings from a groundwater perspective are summarised as follows:

- The depth of cover to the Greta Seam above the proposed longwalls LWB1, LWB2 and LWB3 varies between a minimum of 480 m to a maximum of 555 m.
- The Greta Seam thickness in the proposed Modification Area ranges from 3.3 to 4.6 m, and it is proposed that a constant seam thickness of 3.4 m will be mined by conventional longwall mining methods.
- Maximum predicted surface subsidence magnitudes for the proposed longwalls are 925 mm above LWB1, 250 mm above LWB2 and 700 mm above LWB3. The maximum value of 925 mm represents about 27% of the extraction thickness of 3.4 m.
- Predicted far-field horizontal movements resulting from extraction of the proposed longwall panels are very small.
- In relation to rock fracturing above the extracted panels, four deformation zones have been suggested by MSEC, viz
    - Caved or collapsed zone – loose blocks of rock detached from the seam roof, likely to contain large void spaces
    - Disturbed or fractured zone – in situ material that has sagged and suffered significant bending, fracturing, joint opening and bed separation, leading to large increases in both horizontal and particularly vertical permeability
    - Constrained or aquiclude zone – confined rock above the disturbed zone which has experienced insufficient disturbance to suffer significant fracturing or alteration of the original physical rock properties. Some bed separation and discontinuous vertical fracturing can occur. Some increase in horizontal permeability can occur, but minimal change to vertical permeability.
    - Surface zone – unconfined strata at the ground surface that can experience surface cracking or heaving, but no deep connective cracking.
- At the Austar Coal Mine, the combination of large cover depths and the bridging properties of the thick sandstones of the Branxton Formation limit the upward extent of connective cracking (ie **the disturbed or fractured zone**) above extracted longwall panels. Extensometers installed above panels LWA1 and LWA2 showed vertical fractured heights of 85 m for extensometer AQD1074 above LWA1, and 150 m for extensometer AQD1085 above LWA2. Similar heights are expected above the proposed LWB1-B3.
- The height of discontinuous fracturing above LWB1-B3 (ie **the constrained or aquiclude zone**) could extend to between 235 m and 355 m above the seam. This is well short of the ground surface (between 480 and 555 m above the seam) at the three proposed longwalls. Hence, the zone of discontinuous fracturing is not expected to reach the ground surface.
- Surface cracking (ie **the surface zone**) in the soils above the proposed longwalls is not expected to be observed, based on the depth of cover, and observations of prior panel extractions at Austar Coal Mine. Any surface cracking that might occur in the creek beds above the panels is expected to be minor and to infill naturally with subsequent streamflow events.

5.2 Mine Water Inflows

Mine inflows at the Austar Coal Mine are very complex, and comprise inflows both from the coal measures and from water stored in voids in abandoned former mine workings in the surrounding area.

The contribution from old mine voids has long been recognised by Austar, as water from the former mine workings enters the active workings primarily through the Greta Coal Seam around the periphery of the workings, and this inflow also includes the contribution coming from in situ groundwater within the coal seam and the floor and roof sediments.

Attempts have been made to quantify the contributions from in situ groundwater and void storages respectively. The most recent assessment was that reported in the 2013 draft groundwater verification review by Aurecon after completion of longwall LWA5 (Aurecon, 2013).

Aurecon (2013) commented that "... total water make is a noisy dataset, with numerous peaks and troughs". They reported that fluctuations are due principally to the location of mining activity. They note that net inflow increases when headings are being driven into new areas initially, and that after initial increases as new ground is entered by the drives, the rates of inflow tail off fairly quickly. They also note that there is usually not a noticeable increase in inflow rate when major geological structures are encountered in the mine, but rather when new areas are entered by the development headings.

Aurecon (2013) also concluded that cumulative water make by the mine has climbed fairly steadily over time. This would undoubtedly be due to the fact that mining is progressively extending into new areas generally down-dip to the south and southeast, creating exposure to more groundwater in the newly opened up mine areas.

Aurecon (2013) concluded that after each new increase in water inflow associated with drivage into a new area, the inflow rate settled down to a base level that was essentially the rate of seepage through the barriers from the water stored in voids in the adjacent former mine workings. They noted that at the time of their report, the base level of inflow was on a slow increasing trend over time.

In keeping with past experience at the Austar Coal Mine, it is expected that the proposed Modification will result in a small incremental increase in total water inflow to the mine, due to the extension of the mine into a new mining area. The inflow rate is likely to increase initially with the advance of the development headings for the proposed panels, but the increase is expected to be modest and short-lived, as the proposed panels are along strike rather than downdip from the closest previously mined LWA5 and LWA5A, which are only about 300 m to the northeast, and the Greta Seam and the immediate roof and floor sediments have already been substantially dewatered/depressurised.

The Modification LWB1-B3 will extend to within about 50m laterally from the Ellalong goaf, which is flooded with a water level approximately 50m higher than the Greta Seam floor elevation within LWB1-B3 at their closest point to the Ellalong goaf. The Greta Seam will be depressurised during the advance of the development headings for LWB1-B3, but water pressures in the Greta Seam may be somewhat higher at the south-western ends of the three new longwalls when longwall extraction commences.

This may cause a slightly higher rate of groundwater inflow at the south-western ends of the new longwalls than elsewhere. However, the magnitude of seepage inflows is predicted to be within the range of inflows that have been experienced in other locations of the Austar Coal Mine..

5.3 Impacts on Groundwater Levels / Pressures

5.3.1 Alluvium and Regolith

Previous mining of LWA4 and LWA5 which undermined the alluvium/colluvium monitoring bores AQD1073A, WBH1, WBH2 and WBH3 in March 2011 (LWA4) and August-October 2011 (LWA5), using the LTCC method, caused no observable drawdown of water levels in the surficial groundwater of the alluvium, colluvium and weathered bedrock. Based on this, with a slightly greater depth of cover above the proposed LWB1-B3 panels and a reduced extraction height (i.e. conventional longwall only) compared with the LTCC method, it is expected that the proposed Modification will have no adverse effect on groundwater levels in the surficial aquifer system.

A large part of LWB2 and LWB3, and a very small section of LWB1, underlie the alluvium associated with the unnamed tributary (**Figure 4**). Maximum surface subsidence predictions of 925 mm above LWB1, 250mm above LWB2 and 700 mm above LWB3 (MSEC, 2015) mean that some of the alluvial floodplain will develop shallow subsidence troughs. Within these troughs, there will likely be an initial drop in groundwater levels, as the base of the alluvium will subside by a similar magnitude to the ground surface. This decline in water levels will not represent a loss of groundwater from the alluvium, merely a drop in the aquifer as a whole. Experience elsewhere (eg the Bowmans Creek floodplain at the Ashton mine) has shown that groundwater levels within the subsidence trough will quickly rise to re-establish equilibrium with the adjacent sections of the alluvium outside the subsidence zone, resulting in a greater thickness of saturated alluvium, and a shallower depth to the water table, with the water table re-establishing at about the same absolute elevation (in mAHD) as pre-extraction conditions.

Apart from this small localised beneficial impact, no noticeable change in groundwater levels will be observed in the alluvium/colluvium/regolith aquifer after completion of the proposed Modification.

5.3.2 Branxton Formation

The bulk of the sediments overlying the Greta Seam are from the Branxton Formation. The uppermost water-bearing zones within the Branxton Formation are within the first 50 m or so below the base of weathering. In the vicinity of the proposed Modification, standpipe piezometer NER1010 monitors groundwater within the uppermost 100 m (approximately) of the Branxton Formation, and is screened from 20 to 102 m depth.

Water levels and salinity (EC) monitored in NER1010 are plotted on **Figure 7**. This figure shows that the EC of groundwater in NER1010 is similar to the EC of groundwater in the shallow alluvium/colluvium/regolith bores.

Based on the low salinity, it is likely that the groundwater monitored in bore NER1010 is from quite shallow depth (ie closer to 20 m below surface than 102 m below surface), and is recharged by local infiltration of rainfall like the nearby shallow bores which monitor surficial groundwater in the alluvium/regolith.

The upper 100 m or so of the Branxton Formation is the zone which is targeted in the Quorrobolong Valley by a small number of private registered water supply bores, one of which is located within the Modification Area (see **Section 4.4.2** above). It produces modest yields of moderately saline groundwater.

The uppermost 100 m of the Branxton Formation is more than 385m above the Greta Seam, and is therefore well above the predicted maximum height of connected fracturing from subsidence accompanying the proposed coal extraction from LWB1-B3, based on experience from extensometers above LWA1 and LWA2, and predictions by MSEC (2015). It is also above the predicted height of discontinuous fracturing, between 235 m and 355 m above the Greta Seam (MSEC, 2015). Hence groundwater levels in the uppermost 100 m or so of the Branxton Formation are predicted to be unaffected by the proposed Modification.

This prediction is also consistent with the hydrostatic head profiles from multi-level vibrating wire piezometer bores located close to extracted longwall panels (eg AQD1077) as discussed above in **Section 4.4.2**. AQD1077 showed that hydrostatic pressures are likely to be affected by subsidence induced fracturing up to at least 150 m above the seam, but not above about 200 m above the seam.

5.3.3 Coal Measures and Greta Seam

The Greta Coal Measures, including the Greta Seam, are predicted to be dewatered within the immediate proximity of LWB1-B3, and will also be substantially depressurised for some distance away from the longwalls, in a manner consistent with the already extracted longwall panels. As described above in Section 5.2, slightly higher inflows may be experienced at the south-western ends of LWB1-B3, due to the proximity to Ellalong goaf.

No beneficial users will be affected.

5.4 Baseflow/Leakage Impacts

Impacts on surface streamflows are predicted to be negligible. Apart from the small localised beneficial impact within the subsidence trough across the floodplain of the unnamed tributary above LWB2 and LWB3, the surficial groundwater will not be affected by the proposed Modification. Hence there will be no change to either baseflows or streambed leakage.

5.5 Impacts on Groundwater Recharge

As there are predicted to be no measureable impacts on the near surface groundwater in the alluvium/colluvium/regolith, groundwater recharge will be unaffected by the proposed Modification. Groundwater recharge occurs principally by direct infiltration of rainfall, and downward percolation into and through the alluvium/colluvium and weathered rock into the underlying Branxton Formation. Recharge to particular relatively more permeable zones within the Branxton Formation and the Greta Coal Measures likely occurs at some distance updip from the mine area, where those particular zones occur in subcrop beneath the surficial lithologies. This process will continue to occur and will be unaffected by the proposed Modification.

5.6 Groundwater Quality

As the region of connected fracturing due to subsidence is predicted to not extend to more than about 150 m above the Greta Seam, and the zone of discontinuous fracturing is predicted to extend to not more than 355 m above the Great Seam, as a result of the proposed Modification (MSEC, 2015), there will be no possibility of any adverse impact on groundwater quality in either the alluvium/colluvium/regolith, or the first 100 m or more of the Branxton Formation.

Salinity may increase over time in the mine inflow water from the deeper Greta Coal Measures, irrespective of whether the proposed Modification proceeds or not, partly from induced seepage from the less permeable parts of the coal measures, and partly through evaporation effects of recycling mine inflow water through the practice of storing excess water in the former mine workings of the Bellbird mine updip from the current active mine area. It is considered that the proposed Modification will have negligible contribution to this process.

5.7 Impacts on Water Users

There are no registered groundwater bores targeting the alluvium or colluvium within the vicinity of the proposed Modification, which is a reflection of the very limited yield potential of this groundwater source in that area. In any case, it has been concluded that the potential for the proposed Modification to impact on the alluvium/colluvium is negligible.

There are a small number of bores which target groundwater in the upper parts of the Branxton Formation (uppermost 100 m or so). One private stock bore, GW054676, is located just inside the proposed Modification Area (**Figure 4**). The NOW groundwater database indicates that this bore drilled in 1982 is 39.6 m deep, with an identified water-bearing zone in fractured shale at a depth of 10.1 to 24.4 m depth, and a yield of 1 L/s. The aquifer contributing water to this bore is too shallow to be affected by the subsidence impacts of the proposed Modification.

Lowering of the piezometric surface and changes to quality are considered highly unlikely as discussed in the preceding sections of this report. However, it is possible for lateral dislocation or blockage to occur if horizontal far-field displacements are significant. MSEC (2015) suggest that far-field horizontal displacements may occur, and their Figure 4.4 suggests a 90 per cent confidence level that horizontal displacement within a distance of 50 m from a single longwall would be less than about 150 mm.

There is no mention in the NOW records that GW054676 is cased, and may be an open hole as the water supply is obtained from the hard rock below the unconsolidated alluvium/colluvium. Theoretically, a differential horizontal displacement of 150 mm might be sufficient to result in casing damage. Presumably differential displacement would be somewhat less than 150 mm.

Nevertheless, although unlikely, it remains theoretically possible that some damage to bore GW054676 may occur. In that event, it would be necessary to either repair or replace the bore with an equivalent water supply.

5.8 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) identified in the proposed Modification Area include Riparian Swamp Oak Open Forest, Riparian Cabbage Gum Forest, and a small soak area (Umwelt, 2015).

As indicated above, the predicted heights of either connected or discontinuous fracturing above the Greta Seam as a result of subsidence are significantly less than the depth of cover above the Greta

Seam at the locations of the proposed longwalls. It has been concluded that any impacts on either the shallow surficial groundwater or on stream baseflows will be negligible.

Accordingly, no impacts on any GDEs dependent on the surficial groundwater or on groundwater baseflow are predicted to occur.

There are no known GDEs dependent on groundwater from the Branxton Formation or the Greta Coal Measures.

6. NSW Aquifer Interference Policy

The predicted groundwater impacts associated with the proposed Modification have been assessed against the NSW Aquifer Interference Policy which requires any mining activity to consider 'Minimal Impact Considerations' with respect to groundwater sources. The NSW Aquifer Interference Policy considers two categories of groundwater sources, viz 'highly productive' and 'less productive'. Both the alluvial and porous rock groundwater sources within the proposed Modification Area are considered 'less productive' sources as they do not meet the water quality and yield requirements for 'highly productive' groundwater sources.

Key criteria to demonstrate minimal impact for less productive groundwater sources include:

- less than 10% variation in the water table, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the WSPHUAWS;
- a maximum 2 m decline at any water supply work;
- no mining activity to be within 200 m laterally from the top of high bank or 100 m vertically beneath of a highly connected surface water source that is defined as a 'reliable water supply'; and
- any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

The closest high priority groundwater dependent ecosystem or high priority culturally significant site listed in Schedule 4 of the WSPHUAWS is located more than 30 km away from the proposed Modification area. The proposed Modification will not impact the water table at that distance.

The closest privately owned bore is GW054676 located just inside the proposed Modification Area, targeting a shallow water bearing zone in the Branxton Formation. As discussed in **Section 5.7**, the potential for the proposed Modification to impact on groundwater in the aquifer supporting this bore is considered negligible. However, should the privately owned stock bore experience adverse impacts to water level as a result of the proposed Modification, this would be readily rectified by repairing or replacing the bore.

There are no highly connected surface water sources as defined by the NSW Aquifer Interference Policy and Water Management Regulations within 200 m laterally or 100 m vertically of the proposed longwalls. Nor are there any water sources that represent a 'reliable water supply' as defined by the NSW Aquifer Interference Policy and Strategic Regional Land Use Plan – Upper Hunter.

The assessment in the preceding sections of this report has concluded that any impacts on either the surficial groundwater of the alluvium/colluvium/regolith, or the hard rock groundwater in the uppermost 100 m or so of the Branxton Formation, from the proposed Modification, will be negligible, due to a combination of the large cover depth over the Greta Seam and the limited height of either connected or discontinuous fracturing above the goaf (MSEC, 2015). This conclusion is consistent with observations of responses to prior mining of Stages 2 and 3 (Connell Wagner, 2007).

There are no known users of this groundwater resource within or near the proposed Modification Area and, as the impact on the aquifer is predicted to be negligible, any potential future groundwater users are unlikely to be adversely affected.

The quality of water within the alluvium/colluvium aquifer is variable and there is no known current use of the surficial groundwater. This is consistent with our conclusion the surficial aquifer has limited beneficial use potential. The proposed Modification is therefore not expected to further limit potential beneficial uses of this water supply.

Likewise, the generally poor quality of groundwater within the upper parts of the underlying Branxton Formation means that it has limited beneficial use potential. Nevertheless, the predicted negligible impact from the proposed Modification will not inhibit any potential future use of that aquifer system. Groundwater in the deeper parts of the Branxton Formation and the Greta Coal Measures is believed to be saline, and therefore has very low potential for future beneficial use other than for coal mining operations. Accordingly, the proposed Modification is not predicted to unduly restrict future use.

In summary, the alluvial/colluvial aquifer associated with Quorrobolong Creek and its tributaries within the proposed Modification Area is not characterised as a 'highly productive' groundwater source or a highly connected surface water source, as defined by the NSW Aquifer Interference Policy. The lack of registered bores within the area also indicates that the alluvial aquifer in the vicinity of the proposed Modification has limited use as a water supply for stock, domestic or other consumptive purpose.

On this basis, it is considered that the proposed Modification adequately satisfies the minimal impact considerations for less productive groundwater sources defined by the NSW Aquifer Interference Policy.

7. Groundwater Licensing Requirements

Groundwater impacts associated with the Austar Coal Mine involve a water take from the 'Porous Rock' groundwater source which is regulated by the *Water Act 1912*. No impacts are predicted on any water source regulated by the *Water Management Act 2000*.

The water takes from the 'porous rock' water source for the currently approved mine plan are estimated to be up to a maximum of approximately 550 ML/y. This is based on a rate of water removal from the mine of around 4.5 ML/d, of which approximately 3 ML/d is believed to be imported water. The proposed Modification is predicted to result in a minimal increase to the total water take from this source.

The current water takes are authorised under access licences 20BL171481, 20BL173349, and 20BL173350, which have a combined capacity of 770 ML/y.

It is concluded therefore that current water take from the hard rock water source is well below the current licence capacity, and an increase in the licence allocation will not be required for the proposed Modification.

8. Groundwater Management and Monitoring

The current groundwater monitoring program includes:

- Water production volumes from underground and through the water management system;
- Water levels in shafts or bores into the former workings, including Bellbird boreholes BB1 and BB2, Ellalong No 2 Shaft, and old mine shafts into Kalingo, Aberdare Central, Hepburn No 2 and Elrington (for locations see **Figure 1**), to monitor the accumulation of water in the former mine workings;
- Monitoring of groundwater levels and quality in 5 shallow bores in alluvium/colluvium or shallow Branxton Formation in the Stage 2 mining area, to the north of the proposed Modification;
- Monitoring of hydrostatic pressures at multi-level vibrating wire piezometer bore AQD 1121.

This monitoring program has shown no impacts on the surficial groundwater in the alluvium/colluvium aquifer or the upper parts of the Branxton Formation within the Stage 2 mining area to date. As a precautionary measure, it is recommended that water levels and water quality will continue to be monitored in the 5 shallow piezometers in this area on a regular basis, in accordance with the existing Site Water Management Plan (Austar, 2013), and EL6598 Groundwater Monitoring and Modelling Plan (RPS, 2014). These measures will be reflected in the proposed LWB1-B3 Extraction Plan to be prepared for the proposed Modification.

The following additional monitoring and management measures are recommended for incorporation into the extraction plan for LWB1-B3 and are consistent with the requirements of the existing approved Austar Site Water Management Plan (Austar, 2013):

- Establish one shallow groundwater monitoring bore in the alluvial area of the unnamed tributary of Quorrobolong Creek, and monitor the groundwater levels on a regular basis to give an indication of the impact of longwall mining on the groundwater in the alluvium. EC readings should be measured on samples taken in this bore and the 5 existing monitoring bores in the Stage 2 area every three months. The installation and final location of the groundwater monitoring bore would be subject to landholder agreement, but should be located centrally within the predicted subsidence zone across the alluvium if possible.
- Review local daily rainfall record when undertaking groundwater monitoring reviews so that the timing of any groundwater level fluctuations can be compared with the occurrence of rainfall events, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013).
- Review the results of the above monitoring at three monthly intervals and report results at the completion of each longwall panel, consistent with the requirements of the current approved Austar Site Water Management Plan (Austar, 2013).

9. <u>Conclusions</u>

This letter report details the expected incremental impacts of the proposed Modification, as described in **Section 2**.

The key findings of this assessment are:

- There are essentially two aquifer systems in the vicinity of the proposed Modification, namely a surficial aquifer system comprising unconsolidated material including alluvium ('alluvial' aquifer), colluvium and/or highly weathered bedrock, and a 'hard rock' aquifer system that includes fractured zones in the Permian Branxton Formation and the Greta Coal Measures.
- Both aquifer systems are assessed to be 'less productive' groundwater sources in terms of the requirements of the NSW Aquifer Interference Policy, on the basis of low yield potential, as well as marginal and variable salinity.
- A third potential source of water inflow to the Austar mine is water stored in nearby abandoned mine workings. This water source is saline to highly saline, and is not subject to any beneficial use.
- The depth of cover above the Greta Seam in the proposed longwalls is much greater than the predicted maximum extent of either connected or discontinuous fracturing above the goaf. Consequently, surficial groundwater in the unconsolidated material comprising alluvium, colluvium and weathered rock within the floodplain of Quorrobolong Valley overlying the longwall panels will not be impacted by the proposal.
- Likewise, groundwater in fracture zones in the uppermost 100 m or so of the Branxton Formation is predicted to remain un-impacted by the proposed Modification.
- The Greta Seam and the roof and floor sediments of the Greta Coal Measures are already substantially depressurised as a result of prior mining. They are expected to undergo only marginal additional depressurisation as a result of the proposed Modification.
- No changes to groundwater quality are predicted to occur as a result of the proposed Modification.
- No adverse impacts on either baseflow of stream leakage are predicted to occur as a result of the proposed Modification.
- A marginal increase in groundwater inflow to the mine is predicted to occur as a result of the Modification, consistent with the progressive slow increase in inflow rates as the mine is extended further downdip over time. As the proposed longwall panels are located along strike from the adjacent Stage 3 area, and the coal measures have already experienced significant depressurisation or dewatering in the vicinity of the proposed longwalls, they do not involve any real downdip extension of mining, and any increase in inflow rate will therefore be minimal.
- Slightly higher inflows may be encountered from the south-western ends of the new longwalls

where they will extend to within about 50 m of the flooded Ellalong goaf, which has a water level about 50 m higher than the Greta Seam floor elevation in that area. However, the inflows from this zone are expected to be within the range of inflows experienced elsewhere in new mining areas of the Austar Coal Mine.

- The additional groundwater inflows to the Modification will not result in the current licensed entitlement being exceeded, and no new licence will be required.
- There are no high priority GDEs listed in the WSPHUAWS within the region potentially impacted by the Austar Coal Mine. Accordingly, the proposed Modification will have no impact on any high priority GDEs. In any case, the surficial groundwater of the alluvium/colluvium/regolith is predicted to be un-impacted by the proposed Modification, by virtue of the very large depth of cover relative to the maximum predicted extent of both connected and discontinuous subsidence-induced fracturing above the goaf.
- Likewise, no existing groundwater user is expected to be impacted by the proposed Modification. No drawdown impacts are predicted to occur in the alluvial aquifer system, which in any case is not utilised by other users in the vicinity of the proposed Modification. The limited use of the upper 50 to 100 m of the Branxton Formation as a stock water supply is also predicted to be not adversely impacted by the proposed Modification, due to the large depth of cover relative to the predicted maximum heights of subsidence-induced fracturing.
- The current monitoring program should be continued, with the addition of a further shallow standpipe piezometer in the alluvium of the unnamed tributary, which should be monitored for both water level and water quality, in conjunction with the current monitoring regime. The installation and final location of the groundwater monitoring bore would be subject to landholder agreement,

In summary, the proposed Modification is predicted to not have a significant additional impact above the impacts associated with the approved mining at the Austar Coal Mine.

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Figures

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Figure 3	Surface Geology
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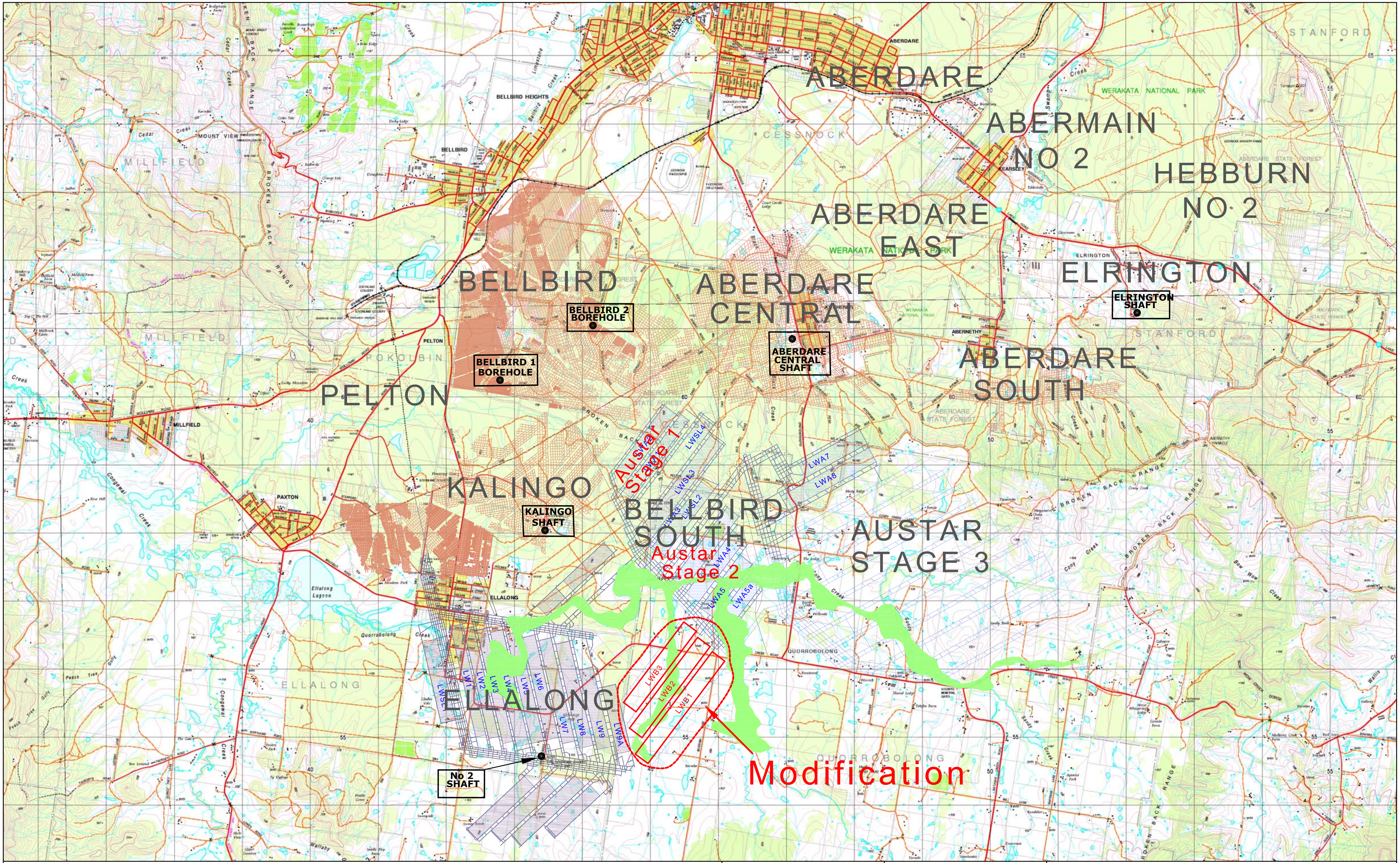
Tables

Table 1	Austar Coal Mine Stratigraphic Summary (Hawley and Brunton, 1995)
Table 2	Mine Water Quality Data (Connell Wagner, 2007)

Yours faithfully,

Peter Dundon



Legend

BELLBIRD 1 BOREHOLE	Shafts/Boreholes into Old Workings
	Former Mine Workings
	Ellalong / Bellbird South / Austar Stage 3
	Stage 3 / Bellbird South Modification First Workings
	Modification Longwall Panels
	Predicted 20mm subsidence line
	Alluvial floodplain

Date: 11 October 2015		Scale:	As shown
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Drawing No:	0294-001c	Rev:	C

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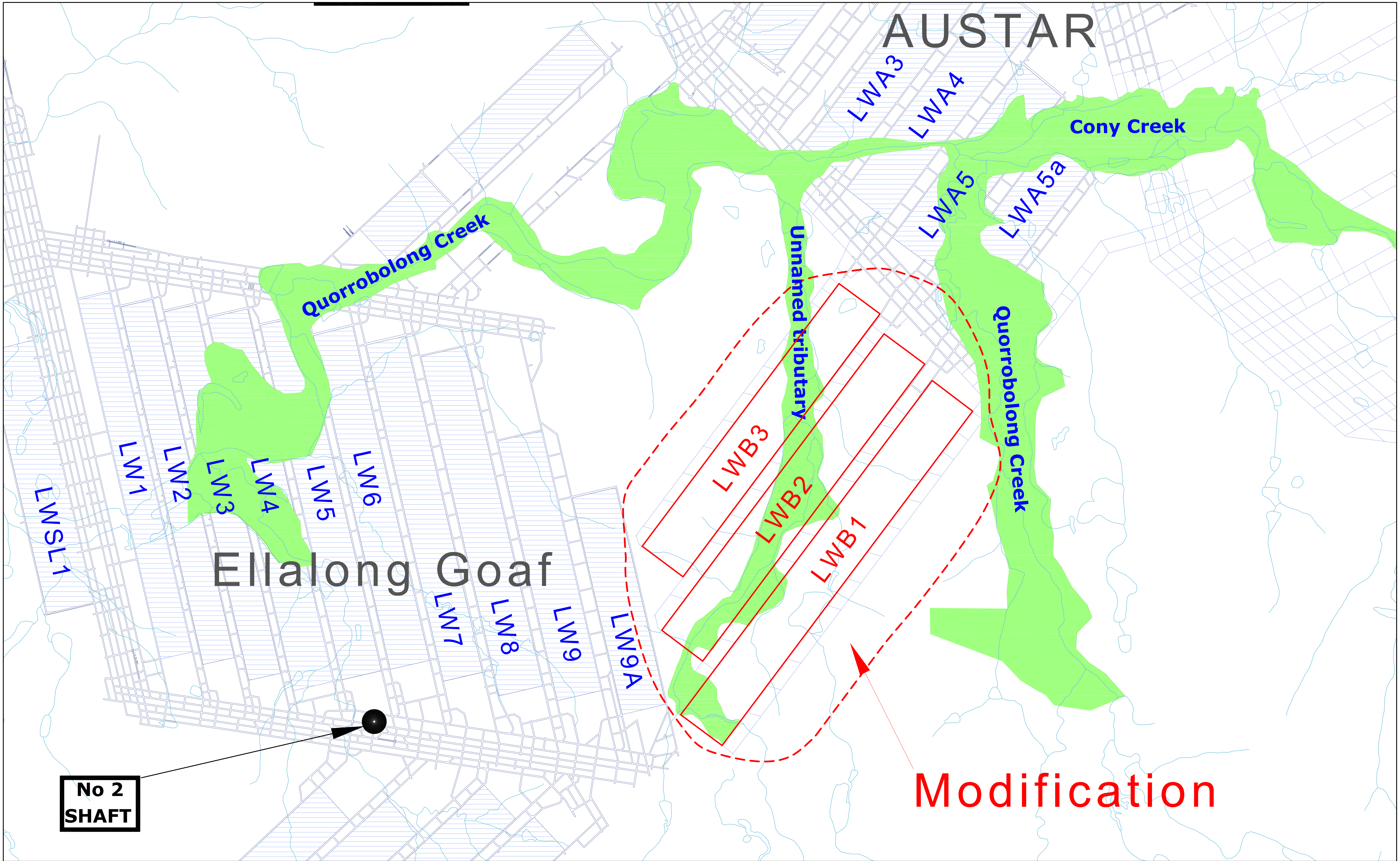
AUSTAR - BELLBIRD SOUTH MODIFICATION REGIONAL LOCATION

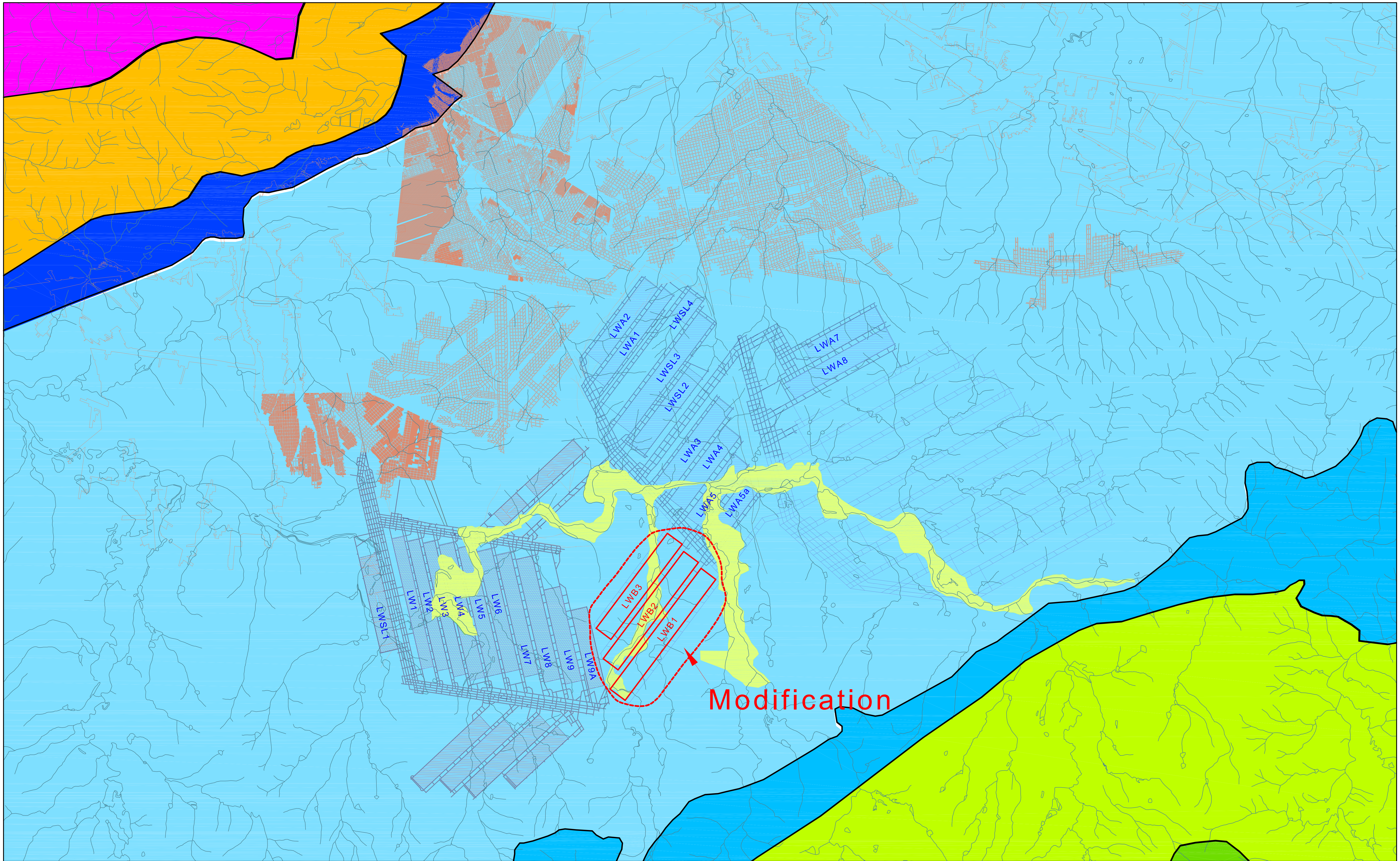
Figure 1



Legend

- Ellalong / Bellbird South / Austar Stage 3
- Stage 3 / Bellbird South Modification First Workings
- Alluvial floodplain
- Modification Longwall Panels
- Predicted 20mm subsidence line

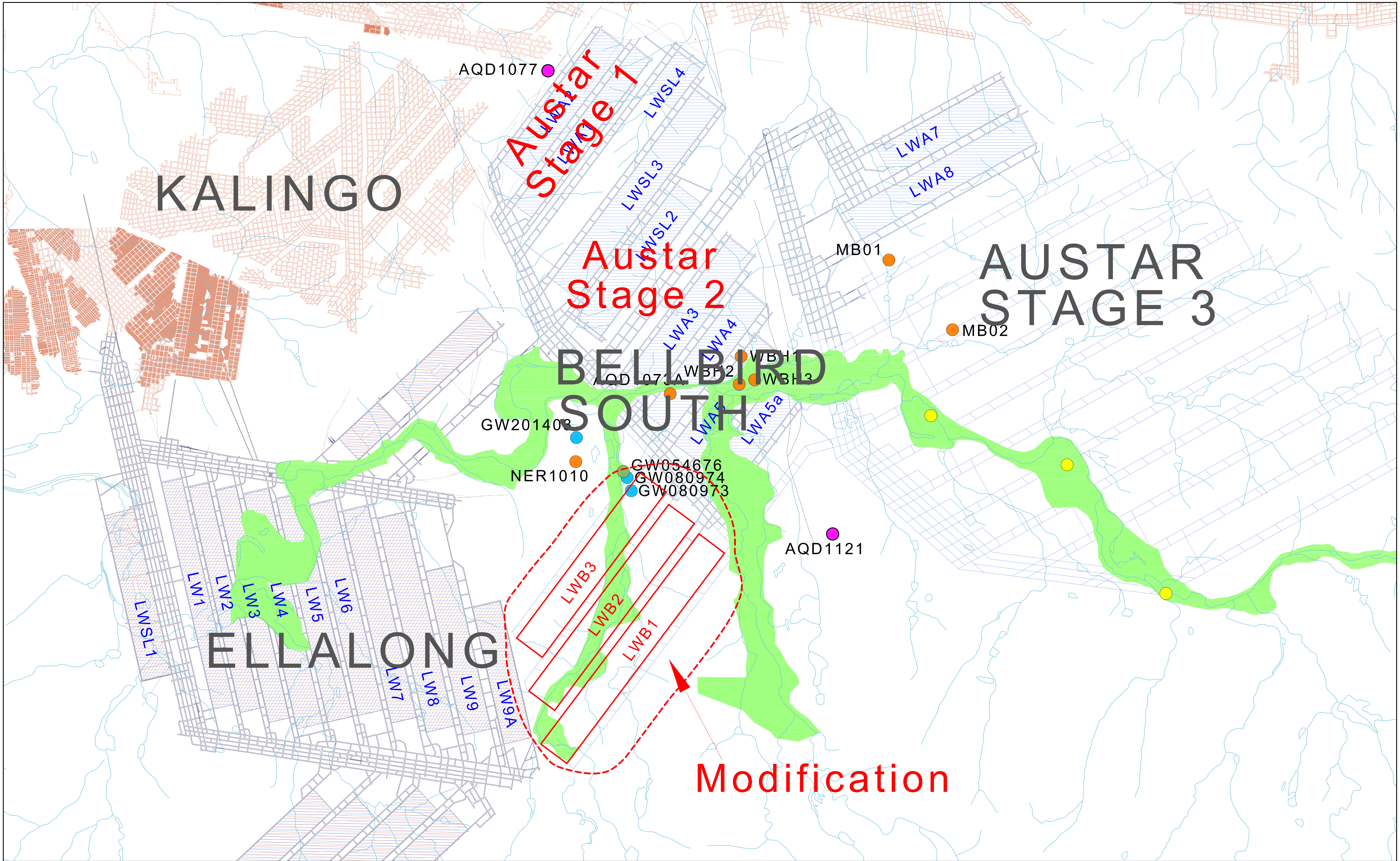
Date: 11 October 2015	Scale: As shown	**Austar Coal Mine Pty Ltd**
Initials: PJD	Job No: 15-0294	**AUSTAR - LOCATION OF PROPOSED MODIFICATION**
Drawing No: 0294-002b	Rev: B	
Dundon Consulting Pty Limited		**Figure 2**



Legend

Alluvium	Branxton Formation	Predicted 20mm subsidence line	
Narrabeen Group	Greta Coal Measures	Modification Longwall Panels	
Mulbring Siltstone	Farley Formation		
Muree Sandstone	Rutherford Formation		

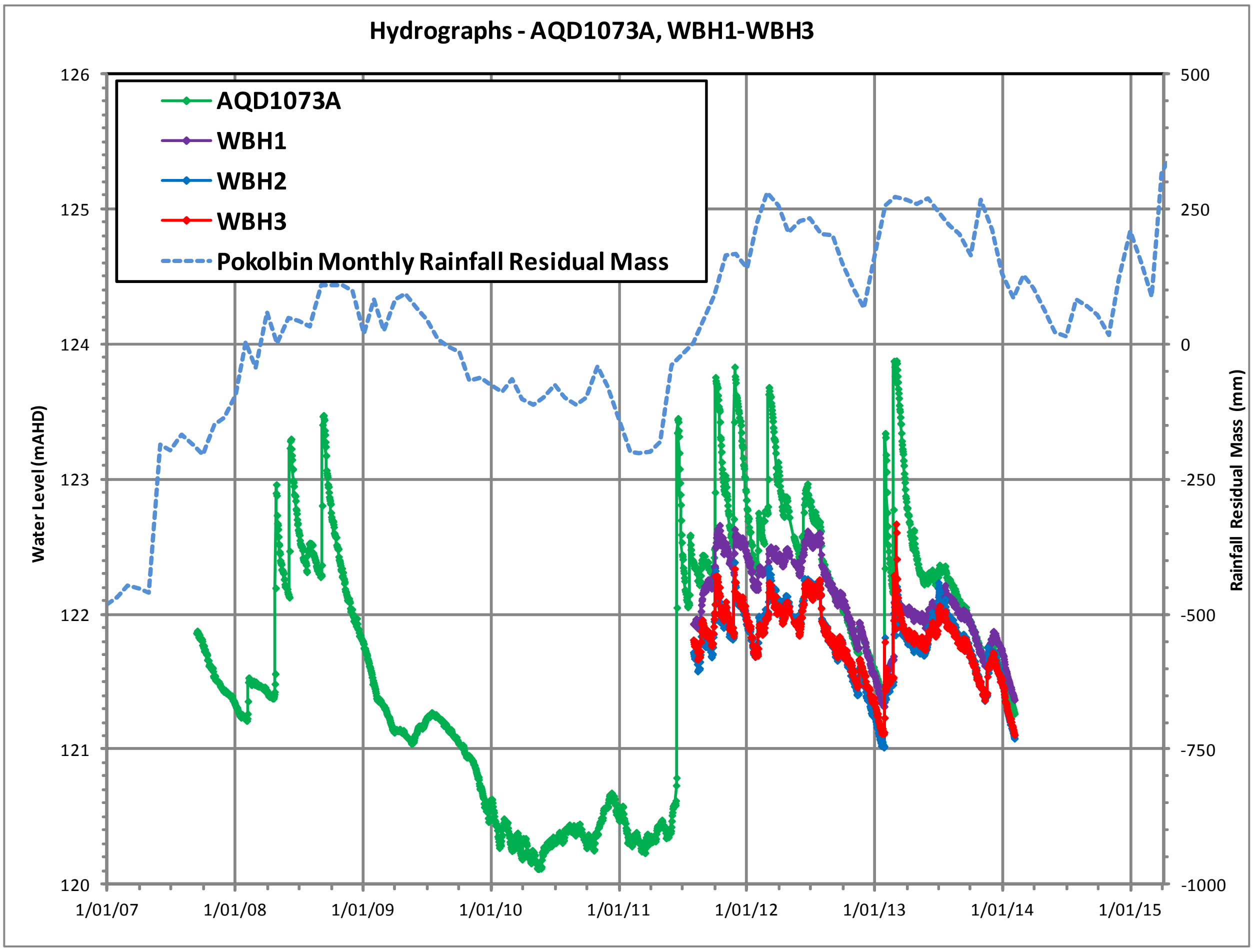
Date: 11 October 2015	Scale: As shown	**Austar Coal Mine Pty Ltd**
Initials: PJD	Job No: 15-0294	**AUSTAR - BELLBIRD SOUTH MODIFICATION SURFACE GEOLOGY**
Drawing No: 0294-003b	Rev: B	
Dundon Consulting Pty Limited		**Figure 3**

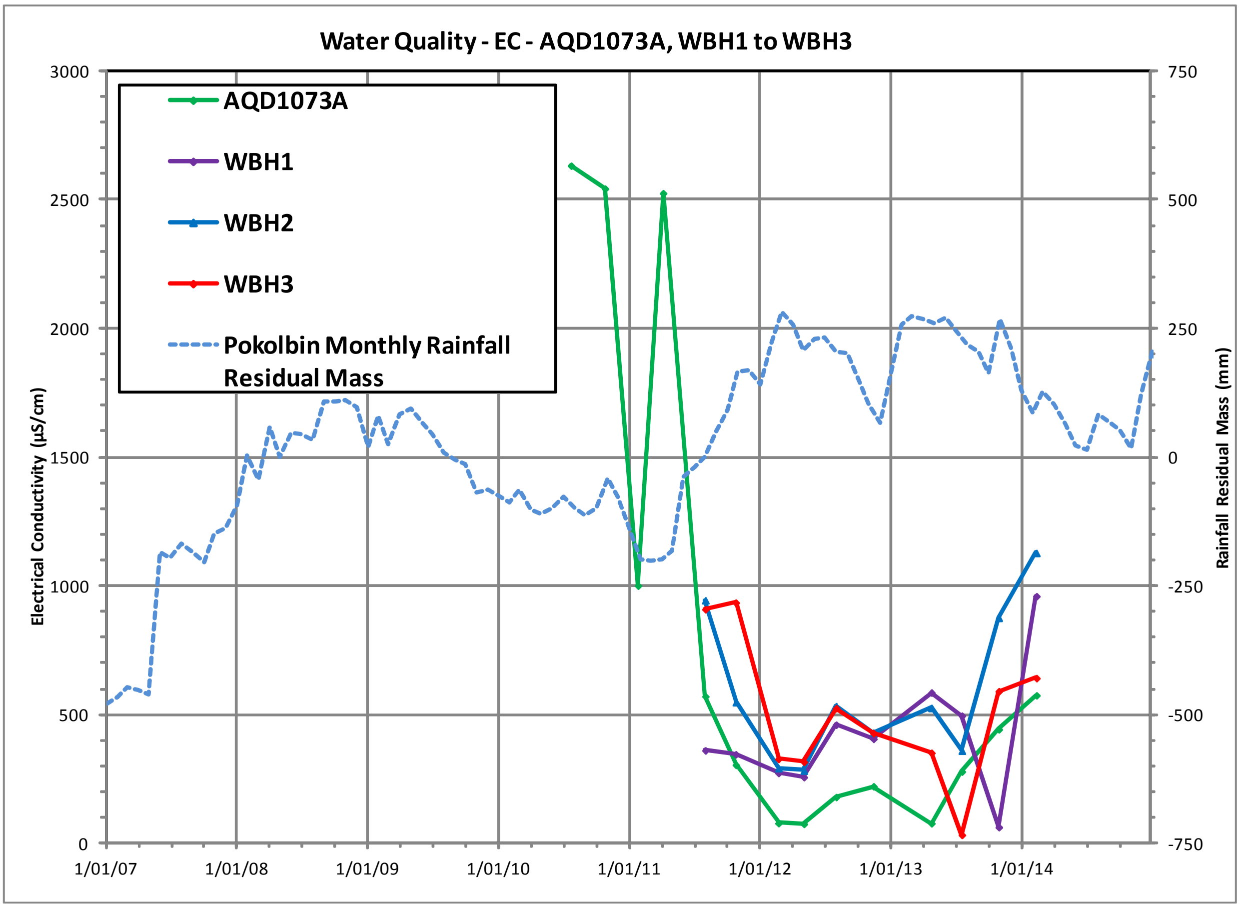


Legend

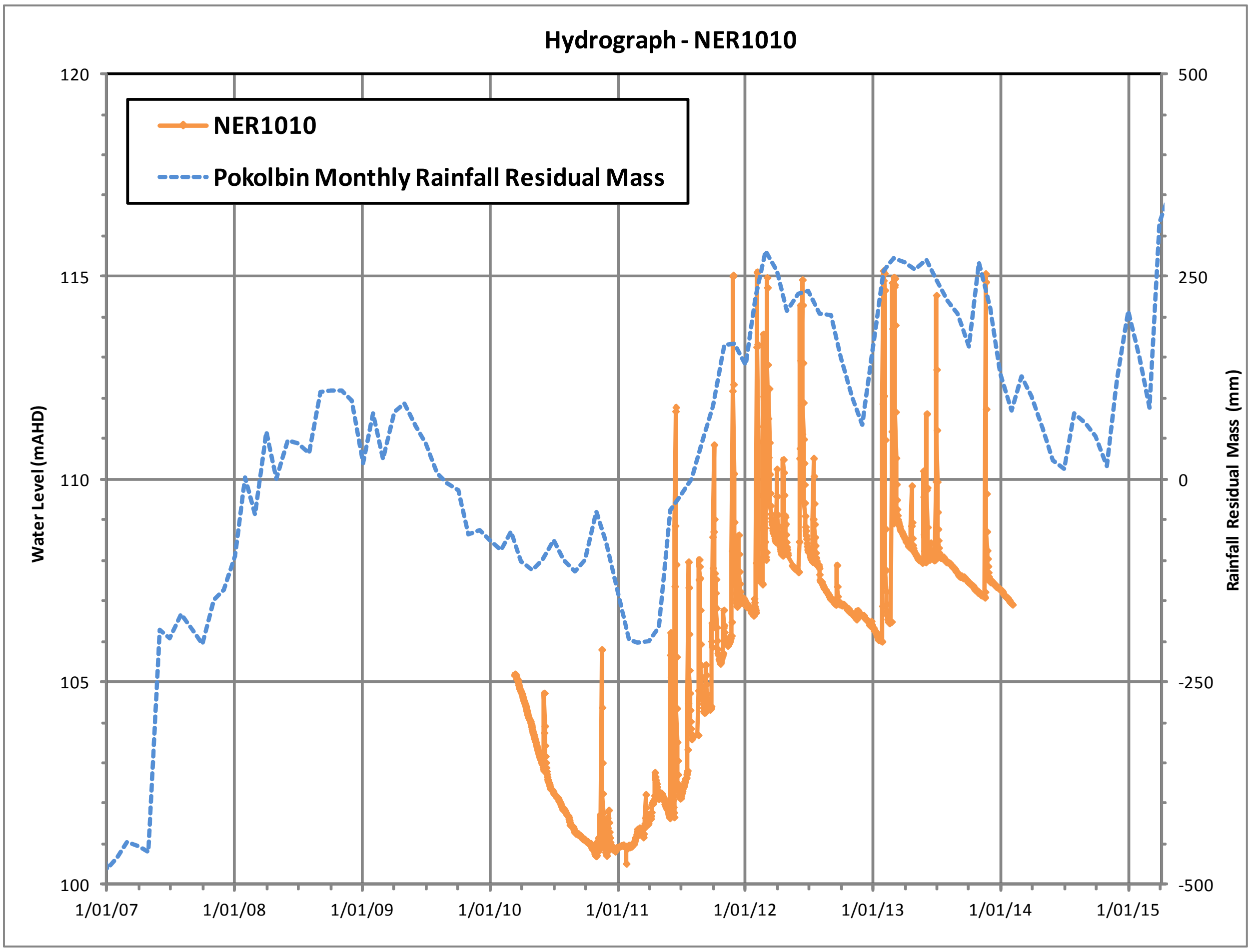
- **Ellalong / Bellbird South / Austar Stage 3**
- **Stage 3 / Bellbird South Modification First Workings**
- **Modification Longwall Panels**
- **Predicted 20mm subsidence line**
- **Austar Shallow Monitoring Bore**
- **Austar Proposed Shallow Monitoring Bore**
- **Austar Vibrating Wire Piezometer Bore**
- **NOW Monitoring Bore**
- **Registered Private Bore**

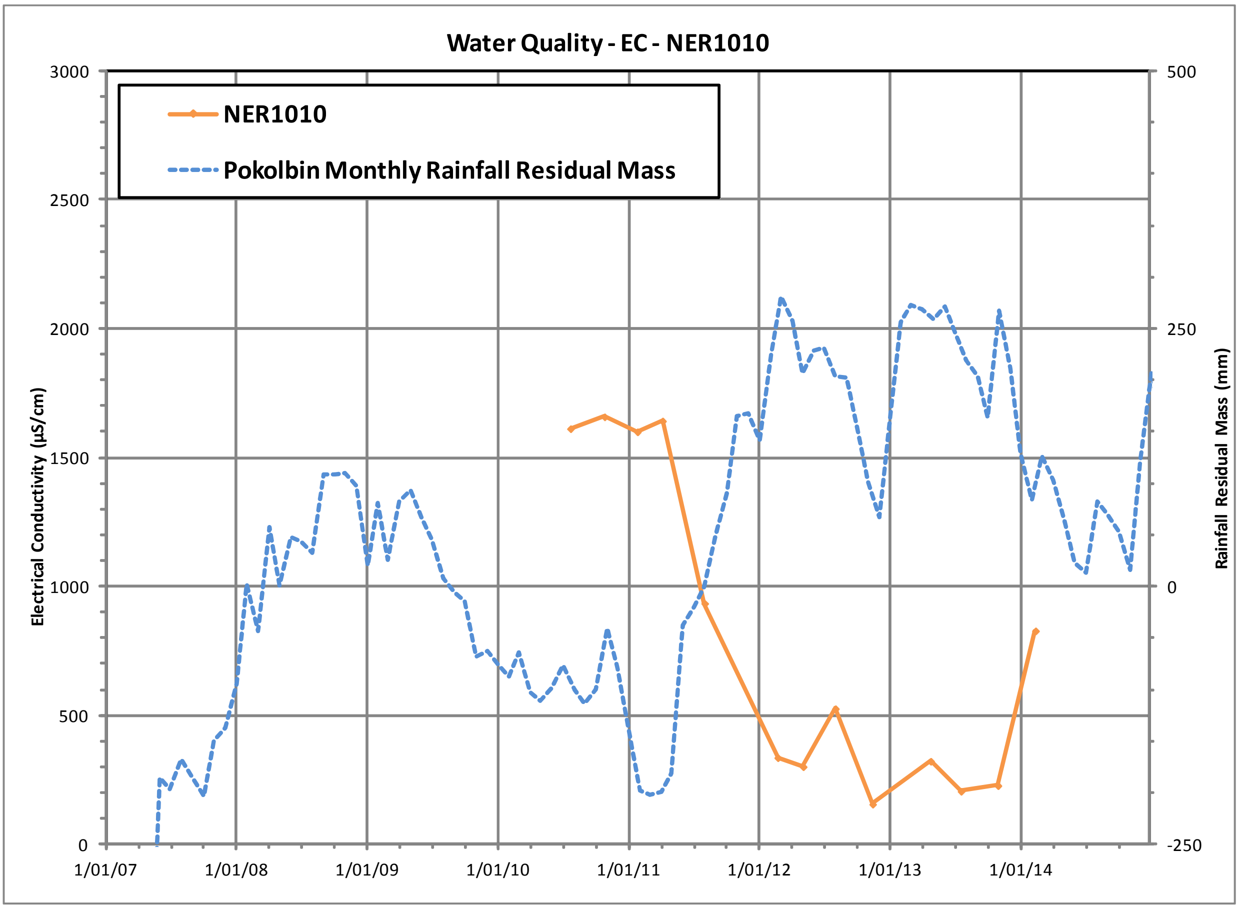
Date: 11 October 2015	Scale: As shown	**Austar Coal Mine Pty Ltd**	
Initials: PJD	Job No: 15-0294	**AUSTAR - BELLBIRD SOUTH MODIFICATION**	
Drawing No: 0294-004b	Rev: B	**ALLUVIAL FLOODPLAIN and BORE LOCATIONS**	
Dundon Consulting Pty Limited			**Figure 4**





DATE: 25 September 2015	SCALE: N/A	**Austar Coal Mine Pty Ltd**
AUTHOR: PD CHECKED: PD	PROJECT NO: 15-0294	**AUSTAR MINE - BELLBIRD SOUTH MODIFICATION WATER LEVEL and EC SURFICIAL GROUNDWATER**
DRAWING NO: 0294-005a	REVISION: A	
Dundon Consulting Pty Ltd		**Figure 5**





DATE: 25 September 2015	SCALE: N/A	**Austar Coal Mine Pty Ltd**
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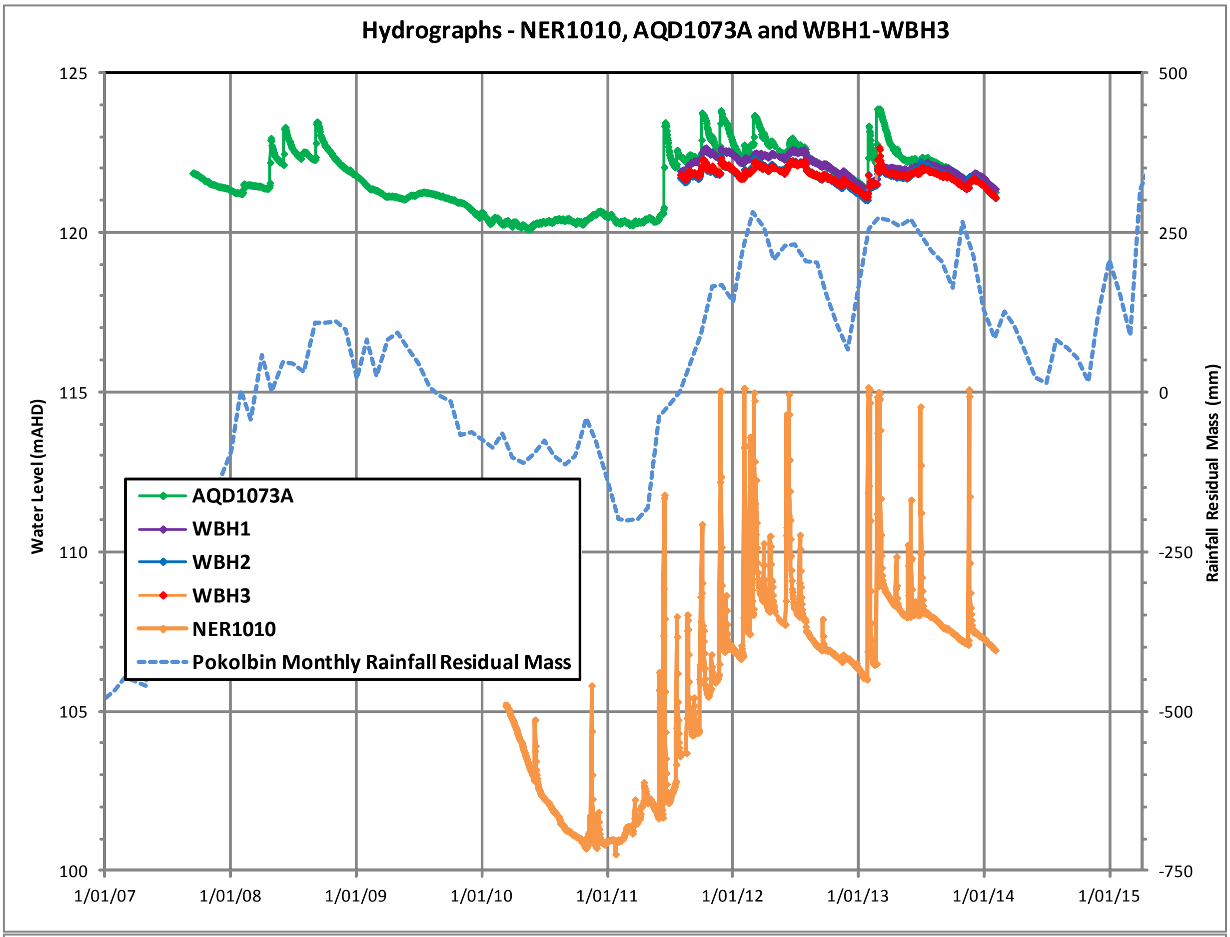
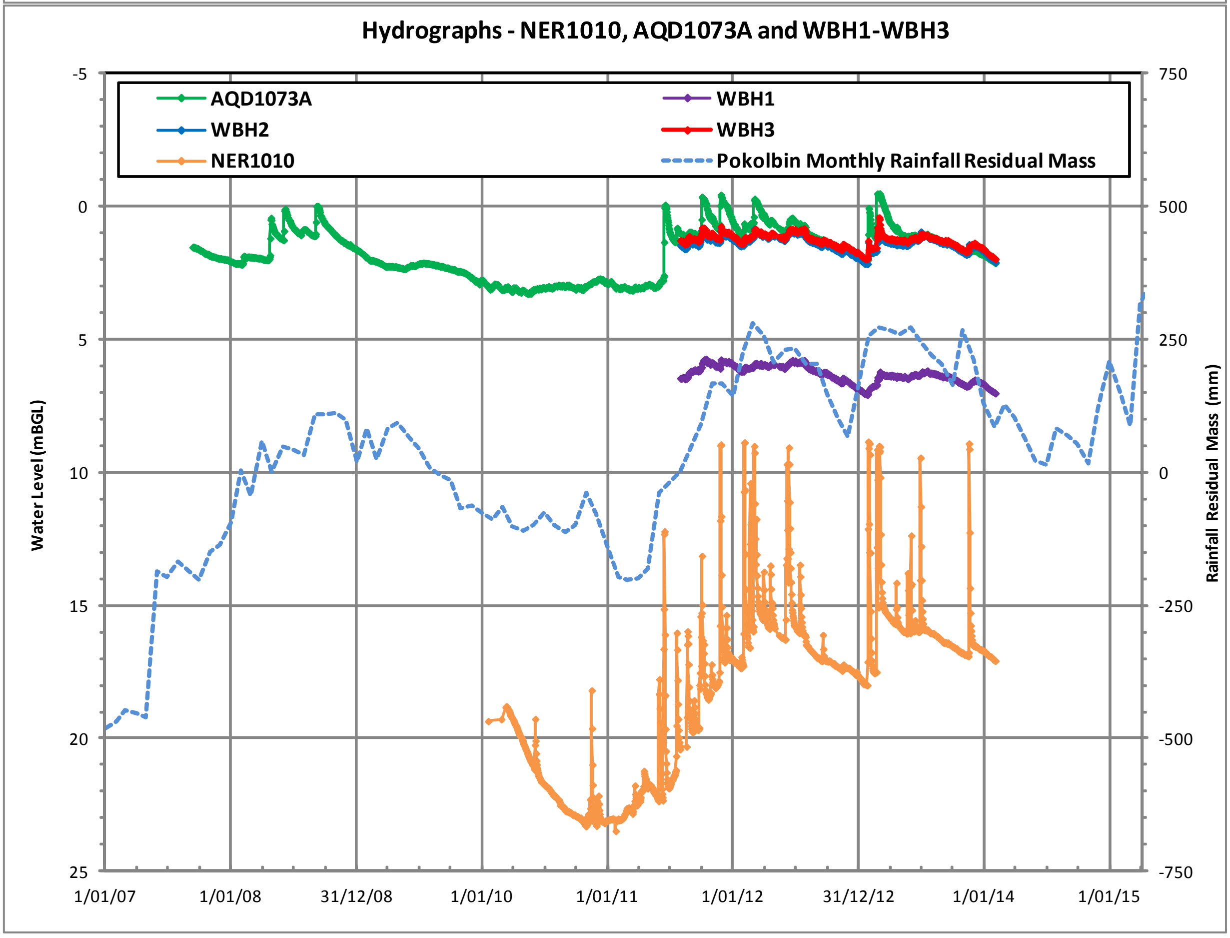
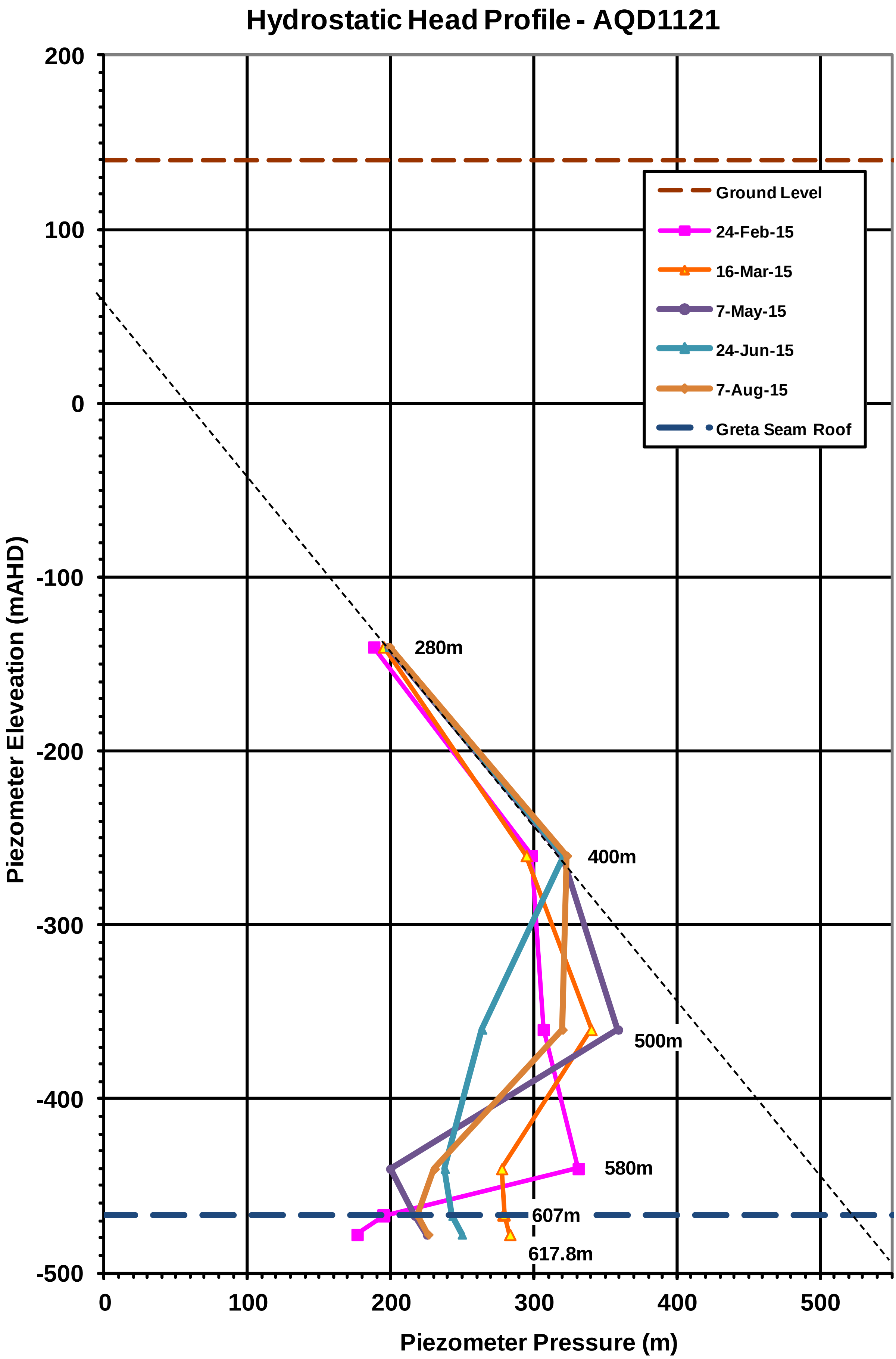
DRAWING NO: 0294-006a	REVISION: A	
Dundon Consulting Pty Ltd		**Figure 6**

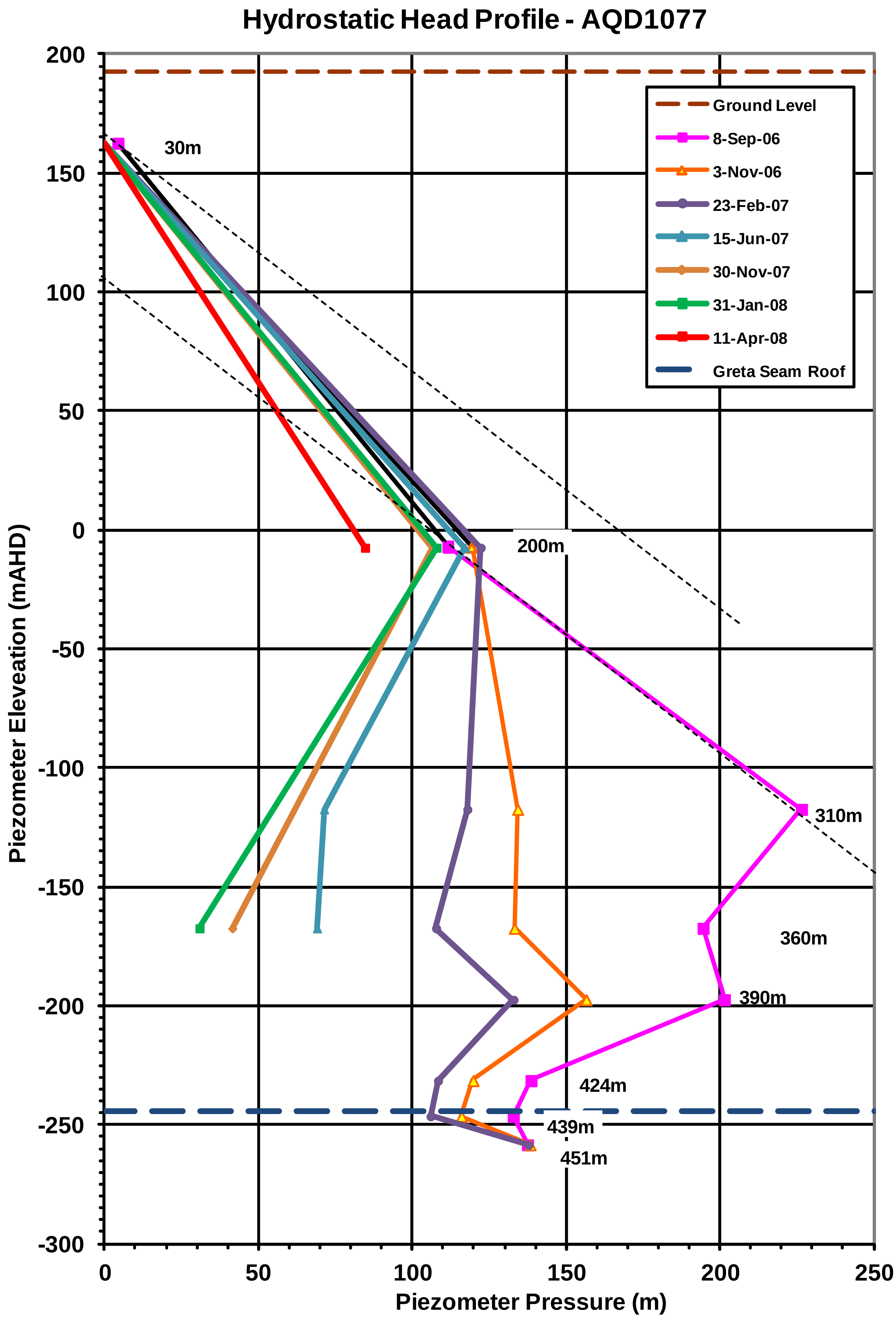




DATE: 25 September 2015	SCALE: N/A	**Austar Coal Mine Pty Ltd**
AUTHOR: PD CHECKED: PD	PROJECT NO: 15-0294	**AUSTAR MINE - BELLBIRD SOUTH MODIFICATION WATER LEVEL HYDROGRAPHS ALLUVIUM vs BRANXTON FORMATION**
DRAWING NO: 0294-007a	REVISION: A	
Dundon Consulting Pty Ltd		**Figure 7**



DATE: 25 September 2015	SCALE: N/A	**Austar Coal Mine Pty Ltd**	
AUTHOR: PD CHECKED: PD	PROJECT NO: 15-0294	**AUSTAR MINE - BELLBIRD SOUTH MODIFICATION HYDROSTATIC HEAD PROFILES AQD1121**	
DRAWING NO: 0294-008a	REVISION: A		
Dundon Consulting Pty Ltd			**Figure 8**



DATE: 25 September 2015	SCALE: N/A	**Austar Coal Mine Pty Ltd**
AUTHOR: PD CHECKED: PD	PROJECT NO: 15-0294	AUSTAR MINE - BELLBIRD SOUTH MODIFICATION HYDROSTATIC HEAD PROFILES AQD1077
DRAWING NO: 0294-009a	REVISION: A	
Dundon Consulting Pty Ltd		Figure 9