Groundwater monitoring report for August – September 2013

Springvale groundwater monitoring program

Centennial Coal

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1. **Introduction**

As part of the environmental management plans for Springvale Colliery, an intensive monitoring program has been implemented on the Newnes Plateau to detect any impacts from underground mining on the groundwater regime, and in particular the Newnes Plateau Shrub Swamps. The monitoring programs include the following main aspects:

- Groundwater levels are monitored in 10 swamps, with a total of 21 shallow groundwater observation bores.
- Flow from Junction Swamp is monitored through a v-notch weir, and flows in Sunnyside Swamp and Carne West Swamp are indicated by pool depth monitors.
- The groundwater level in the upper aquifer zone in the overburden is measured in 22 piezometers, which have been installed on the ridges between the swamps.
- A trial soil moisture monitoring program is also being undertaken in three of the swamps (Carne West, Sunnyside, and Sunnyside West).
- A basic weather station provides climatic data on the plateau.

Data are recorded at various frequencies: in the swamp and aquifer piezometers, data are recorded every three hours. Surface water level data in pools and weirs are recorded every hour. Multilevel piezometers generally record data once per day. Soil moisture and dipped aquifer piezometers are measured at each data collection trip. Barometric data are recorded every three hours for correction of piezometer data. Data are downloaded from these installations on site on a two-monthly basis. At this time, the condition of the instruments is checked, as well as the battery levels and the data quality.

This report presents the latest data downloaded from the installations, and includes an interpretation of the data which highlights any anomalies. Comments are also included on evidence of any mining-induced impacts, interpreted from the data over the review period, in swamps that are in the vicinity of active mining areas. Any impacts which exceed trigger levels set out in the Newnes Plateau Shrub Swamp Management Plan will be referred back to mine personnel so that the appropriate management or engineering solution can be implemented.

For the purposes of this report, the swamps in the monitoring program have been divided into two basic types based on the apparent source of groundwater within the swamp. The source of the groundwater in each swamp (and hence the swamp type) has been interpreted solely from the monitoring results to date. The two basic types are:

- **Type A** — dependent predominantly on rainfall infiltration (periodically waterlogged swamps)
- **Type C** — dependant predominantly on an aquifer water source as well as rainfall contribution (permanently waterlogged swamps).

The first swamp type (Type A — periodically waterlogged) can show large and reasonably rapid variations in groundwater level in response to significant rainfall events. Elsewhere on the plateau, the data for some swamps may also be affected by emergency discharge events from licensed discharge points and these are designated Type A*. There are no Type A* swamps in the Springvale area. The second swamp type (Type C — permanently waterlogged) has a reasonably static groundwater level that is relatively unaffected by climatic conditions. Since the percentage of groundwater contribution to the swamp hydrology will vary from swamp to swamp, there may be a range of hydrogeological conditions observed for this swamp type.
2. Review period

The latest data from the monitoring installations were downloaded over the period 23 - 27 September 2013. The analysis in this report covers the period from 22 July – 22 September 2013. The report period is marked on each data plot with pink vertical lines.

3. Rainfall data

Rainfall data are summarised below and on figure 1:

<table>
<thead>
<tr>
<th></th>
<th>Observed rainfall</th>
<th>Average rainfall</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Newnes Plateau (mm)</td>
<td>Lithgow (mm)</td>
</tr>
<tr>
<td>July 2013</td>
<td>25.6 (1.0 in period)</td>
<td>24.4 (1.2 in period)</td>
</tr>
<tr>
<td>August 2013</td>
<td>18.8</td>
<td>23.2</td>
</tr>
<tr>
<td>September 2013</td>
<td>44.8 (44.8 in period)</td>
<td>35.0</td>
</tr>
</tbody>
</table>

* Newnes Plateau average based on 1.18 x Lithgow average rainfall, which is the pooled long-term average multiplier.

Rainfall during the period was well below Average in Lithgow and on the Newnes Plateau. August, in particular, was very dry. Rainfall in September was concentrated on one wet day — 16 September, 38 mm fell on the Newnes Plateau.

4. Swamp groundwater monitoring

The monitoring results are plotted on figures 2 – 6, and the locations of all the monitoring boreholes are shown in the attached drawings. These drawings also show the current position of the longwall panels. Figures 3a, and 3b, display results from Type A and Type C swamps respectively.

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<tr>
<th>Monitoring site</th>
<th>Monitoring results</th>
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<tr>
<td>Sunnyside West Swamp / Heath (Type A)</td>
<td>The monitoring bore in the Sunnyside West Swamp/Heath continues to show a typical response to rainfall events for a periodically waterlogged vegetation community (figure 3a). Water levels during the period fell steadily for most of the period due to below-average rainfall, with a distinct response following good rain on 16 September 2013, and ended the period at 1.36 m depth. Pre-mining and post-mining groundwater behaviour is identical. <strong>Mining impacts:</strong> No mining impacts were evident from the data at this site, despite the fact that LW412 undermined the site in the first half of 2009, LW413 was adjacent to the site at the end of July 2010 and Longwall 414 passed the site in the latter half of 2011. The response to rainfall events continues to be typical for a periodically waterlogged swamp, and is identical to pre-mining response.</td>
</tr>
<tr>
<td>Sunnyside Swamp (Type C)</td>
<td>At the original monitoring bores (SS1 and SS2) in the upper part of Sunnyside Swamp, groundwater levels fell slowly in response to</td>
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</tbody>
</table>
Monitoring site Monitoring results

Five open hole piezometers:
- SS1, SS2 upstream
- SS3 midstream
- SS4, SS5 downstream

below-average rainfall (figures 2, 3b). SS2 shows a small spike in response to good rain on 16 September 2013. These piezometers ended the period at c. 0.25 m groundwater depth.

Distinct negative spikes are present in the data for SS1 and SS2, due to rapid drawdown of groundwater from sampling in the hole. In the past, this has been followed by complete recovery. It is notable that during the current period, a higher frequency of water sampling was used than seen previously. This substantially complicates the groundwater record, as complete recovery is not always occurring between sampling events. Recovery appears to take longer in SS1, possibly due to less permeable substrate at this site. It is again recommended that a separate borehole be constructed, approximately 50 m from the SS1 site, for groundwater sampling. This would allow the true groundwater pattern to be observed at SS1. Until a sampling bore is constructed, the water sampling frequency should be reduced to no more than once per month.

The three newer piezometers (SS3, SS4, SS5) in the middle and lower parts of the swamp all showed declining groundwater levels for most of the current period, again reflecting below-average rainfall, and all showed small spikes associated with good rain on 16 September 2013. All ended the period at depths of 0.1 m or less

The results are typical for a permanently waterlogged swamp.

Mining impacts:

LW413 is located approximately 200 m to the west of this swamp. For operational reasons related to poor seam-level geology, a block of unmined coal was left to the south west of Sunnyside Swamp. The longwall stopped around 220 m west of SS2, and mining recommenced around 720 m SW of SS2. The adjacent longwall panel, LW414, commenced about 100 m south of the southern end of the swamp earlier in 2011, and has now been completed. During 2012, LW415 was extracted immediately east of the swamp, with no impact on groundwater levels.

Data from piezometers SS3 and SS4, which are adjacent to the northern end of LW 415, where extraction occurred during 2013, show no indication of any mining impact from this panel. Extraction in the second half of 2012 passed east of SS1 and SS2, with no impact on the groundwater levels in the upper part of the swamp. As the strata dip northeast, the aquifer feeding Sunnyside Swamp has already been undermined by LWs 411, 412, and 413, without discernible impact on the swamp groundwater levels in any of the bores. The relatively high rainfall since 2010, following the mid-decade drought, brought groundwater levels in SS1 and SS2 to sustained, historic highs in the upper part of the swamp.

During September 2013, extraction in LW416 commenced, over 400 m east of SS3. The groundwater record for this piezometer shows no impact from this mining.

Sunnyside East Swamp
(Type A – SSE1; Type C – SSE2 and SSE3)

Three open hole piezometers:
- SSE1 upstream
- SSE2 midstream
- SSE3 downstream

The instrument at SSE1 was found lying on the ground next to the casing. The record from this instrument shows a steady pressure through most of the period, with a minor drop at 4 – 5 September. This date coincides with water sampling in other Newnes Plateau piezometers, and suggests that the instrument has not been replaced after sampling. Consequently, it is unclear what the true data record is after the middle of the reporting period. The instrument was
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reinstalled in the hole. **Springvale should ensure that water sampling personnel are aware of the need to replace instruments after sample collection.**

The early part of the record shows that the water level was near the bottom of the hole. At the time of data collection, the hole was dry, suggesting that the water level has been at or below the bottom of the hole for much of the period.

The groundwater level in SSE1, at the head of the swamp, continued at below 2 m depth, near the bottom of the hole during the period, with no significant rainfall response (figure 2, 3a). The pattern is similar to that seen in other periodically waterlogged swamps such as West Wolgan and Narrow Swamps. This behaviour and the depth to water table in this bore are consistent with the characteristics of a periodically waterlogged swamp.

SSE2, in the centre of the swamp, and SSE3, in the lower part of the swamp, both declined during most of the period, due to below-average rainfall. Good rain on 16 September 2013 resulted in a spike in SSE3, which was not observed in SSE2.

The records are consistent with previous behaviour in these piezometers.

This swamp continues to show groundwater level behaviour consistent with a transition from a periodically waterlogged swamp at the upstream end, to a permanently waterlogged swamp at the downstream end. The difference between piezometers SSE2 and SSE3 may reflect slow drainage of groundwater from the alluvial-peat mass in the middle part of the swamp to areas further downstream.

A fire passed through the area around 21 April 2010. Fortunately, none of the piezometers were lost in this swamp. To date there appear to be no impacts from the fire on groundwater behaviour measured by the three piezometers.

**Mining impacts:**

LW 415, about 300 m to the west, was extracted in the area adjacent to Sunnyside East Swamp during the first half of 2013. There is no evidence of any mining impact in the groundwater record from Sunnyside East Swamp.

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**Carne West Swamp**

(Type C – CW1, 2; Type A – CW 3, 4)

Four open hole piezometers:

- CW1 upstream in lower section of swamp
- CW2 downstream in lower section of swamp
- CW3 (new) upstream in upper section of swamp
- CW4 (new) downstream in upper section of swamp

Groundwater levels in both CW1 and CW2 piezometers were shallow, and declined slowly over the period in response to below-average rainfall (figures 2, 3b). CW2 showed small but distinct negative spikes caused by monthly water sample collection. The pattern is typical of permanently waterlogged swamps.

The data record in CW3 commenced on 14 October 2011. The hole remained dry until heavy rain in early 2012 caused groundwater to rise to ground level. Since that time the level declined slowly until it reached the base of the bore, where it has remained since early May 2012, until heavy rain on 23 February 2013 caused a transient spike, before the groundwater level declined to the bottom of the hole again, where it remained during the current period. (figure 3a). The pattern, with large fluctuations in groundwater level, is typical of a periodically waterlogged swamp.

The data record in CW4 commenced on 14 October 2011. Groundwater level in the hole rose rapidly to the surface following heavy rainfall during early 2012. Since then, the groundwater level...
Monitoring site | Monitoring results
--- | ---
Junction Swamp (Type A) | Water levels in all three of the piezometers adjacent to Junction Swamp declined steadily during the period, in response to below-average rainfall, but remain in the range of historically high values established by good rain since 2010 (figures 4, 5).
- D1 upstream
- D2 west of swamp
- D3 east of swamp

The groundwater gradient in the swamp during the period fell steadily from 3.4% to 3.1%, due to below-average rainfall. The decline in gradient was accompanied by a lack of surface flow in the swamp. As noted previously, flow does not occur at groundwater gradients of 2.5%, as they did before mining. It appears that much higher gradients are required to produce surface flow from the swamp, although rainfall intensity also appears to be a significant factor (figure 6).

The rainfall deficit remained level, due to good rain in June, and continued to track at c. 1150 mm (figure 5).

It is notable that groundwater levels are still about as high as in the pre-mining period. This suggests that the pre-mining levels were controlled in part by prevailing medium-term (scale of years) rainfall conditions, which at that time were below average. Wetter conditions that prevailed for much of the past three years were accompanied by rising groundwater levels. This also indicates that there is no significant vertical drainage of groundwater from the aquifer supporting the swamp.

While historically high groundwater levels combined with a continuing rainfall deficit may appear incongruous, the groundwater level depends on rainfall intensity for infiltration to occur, and not just on total rainfall. This suggests that there have been some high intensity rainfall events that have resulted in significant infiltration. The data record clearly shows the impact of a high intensity event such as the early March 2012 storm.

The lack of permanent flow from the swamp, given the high groundwater levels, is an anomaly. The groundwater gradient is sufficient to produce a flow, but there is only flow at the weir after heavy rain. This may be due to mining-induced tilting that has diverted the flow. The data indicate that tilting is the more likely cause, as the relative groundwater level movements between piezometers D2 and D3 suggest that flow may only return when the relative groundwater depths in these two piezometers are similar as was the pre-mining case (i.e. no cross fall in the hydraulic gradient). This will produce a flow downstream rather than at an angle to the channel that may bypass the weir. During rainfall in early 2012, the
Monitoring site | Monitoring results
---|---
Groundwater level in D2 increased more than that in D3, and was higher than D3. This partially restored the pre-mining groundwater level relativity between the two bores. The presence or absence of flow appears to be a complex interaction between relative groundwater levels, rainfall deficit, and rainfall intensity.

**Mining impacts:** There were no incremental mining impacts indicated by the monitoring results over the review period. Monitoring results appear to indicate that current groundwater conditions are similar to the pre-mining hydrogeological regime, with groundwater levels responding to variations in the rainfall deficit.

There does not appear to be any permanent adverse impact on the swamp from mining, as the groundwater levels are currently near historically high values. The most important aspect is that the swamp has been unaffected by mining, with its groundwater level restored to pre-mining levels.

### Gang Gang West Swamp
- Type C
- Two open hole piezometers:
  - GW1 upstream
  - GW2 downstream

The data record in GW1 commenced on 14 October 2011. The groundwater level was at surface when the hole was constructed, and has risen in the casing since then (figures 2, 3b). During the period, groundwater remained stable at the surface, with very subdued spikes related to rainfall. The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp.

The groundwater level data record in GW2 also commenced on 14 October 2011. It shows groundwater levels at a slightly deeper level than in GW1, and with a very slow decline over the current period (figure 2b). It also shows muted responses to rainfall. The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp.

**Mining impacts:** Nil. There is no mining nearby.

### Gang Gang Swamp
- Type C
- One open hole piezometer:
  - GG1 upstream

The data record in GG1 commenced on 14 October 2011. The groundwater level was 0.3 m deep at construction and rose steadily until establishing a level generally c. 0.1 m below surface. (figures 2, 3b). During the reporting period groundwater level remained steady. Rainfall spikes were muted during the reporting period. The pattern, with near-surface groundwater level and generally limited groundwater level variation, is typical of a permanently waterlogged swamp.

**Mining impacts:** Nil. There is no mining nearby.

### Carne Central Swamp
- Type C
- One open hole piezometer:
  - CC1 upstream

The data record in CC1 commenced on 4 November 2011. It shows groundwater levels initially just below ground level, rising steadily since construction. The groundwater level stood above the ground level during the reporting period (figures 2, 3b). It also shows very limited response to rainfall. The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp. The record also shows distinct negative spikes caused by water sample collection.

**Mining impacts:** Nil. There is no mining nearby.

### Bungleboori Swamp
- Type C
- Three open hole piezometer:
  - BS1 upstream in northern

The data record in BS1 commenced on 14 October 2011. It shows groundwater levels initially just below ground level, but for most of the record the water level is above ground level. During the reporting period, groundwater remained about 0.1 m above ground level, in the casing, with a very slow drop in level over the period, and with very
Monitoring site | Monitoring results
--- | ---
branch - BS2 upstream in southern branch - BS3 downstream at junction | subdued rainfall-related impacts (figures 2, 3b). The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp. The record shows the impact of closely-spaced groundwater sampling events, without sufficient time for recovery in between.
The data record in BS2 commenced on 4 November 2011. It shows groundwater levels initially just below ground level, rising rapidly after construction. Groundwater level stood about 0.1 m above surface level, in the casing, throughout the reporting period (figure 2c). It also shows very muted responses to rainfall. The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp.
The data record in BS3 commenced on 4 November 2011. It shows groundwater levels generally about 0.6 m below ground level (figure 2c). It generally shows muted responses to rainfall, although the heavy rain has resulted in distinct spikes on occasion. The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp.

**Mining impacts:** Nil. There is no mining nearby.

Marangaroo Swamp (Type C)
One open hole piezometer: - MS1 upstream | The data record in MS1 commenced on 4 November 2011. It shows groundwater levels initially 0.4 m below ground level, rising rapidly after construction. Groundwater during the reporting period declined overall, from c. 0.1 m to 0.2 m below the surface, with minor rainfall impact (figures 2, 3b). The pattern, with near-surface groundwater level and limited groundwater level variation, is typical of a permanently waterlogged swamp.

However, this piezometer also shows distinct impact from water sampling events that are closely spaced, without time for full recovery in between. This sampling may be having an impact on the water levels in this piezometer. The sampling spikes are quite wide, with relatively slow recovery, that obscures the groundwater record. As with piezometer SS1, it is again recommended that a separate borehole be constructed, approximately 50 m from the MS1 site, for groundwater sampling. This would allow the true groundwater pattern to be observed at MS1. Until a sampling bore is constructed, the water sampling frequency should be reduced to no more than once per month.

**Mining impacts:** Nil. There is no mining nearby.

5. Soil moisture monitoring

Soil moisture is measured at three sites adjacent to groundwater monitoring installations, and plotted in figures 7, 8a, 8b, and 8c. The location of these sites is shown on the attached drawings.

Monitoring site | Monitoring results
--- | ---
Three open access tubes to 1 metre depth Adjacent to monitoring bores: - CW1 (Carne West Swamp) Type C - SS2 (Sunnyside Swamp) Type C | The latest moisture level measurements (figures 7, 8) show the patterns displayed previously, with a tendency for drying out in the surface layer in most of the swamps.
The soil moisture data is an inherently variable data set — variations in soil moisture of 5 – 10% are not significant. It is a broad brush tool, and as such, demonstrates that there is a general distinction in soil
Monitoring site | Monitoring results
--- | ---
- **SW1 (Sunnyside West Swamp)** Type A | moisture between periodically and permanently waterlogged swamps, with discharge-impacted swamps in between. The data over time show that, in general, soil moisture values are higher in absolute terms and less variable in the permanently waterlogged swamps than in the periodically waterlogged swamps.

In CW1, the data show a marked drop in soil moisture in the near-surface, but deeper layers continue their generally wetter trends. The drying out is consistent with below-average rainfall over the current period (figure 8a).

Moisture contents at site SS2 also showed continuing low values near-surface, due to below-average rainfall during the period, with constant soil moisture deeper in the profile.

Moisture contents at site SW1 (figure 8c) generally fell slightly throughout the profile, but with less drying out in the near-surface.

The results are at each site consistent with the swamp type and previous records.

**Mining impacts:**
None are evident from the monitoring data.

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### 6. Aquifer borehole monitoring

Ridge boreholes have been established to monitor the groundwater level in the near-surface unconfined aquifer in the Banks Wall Sandstone (figures 9, 10). For the location of the monitoring boreholes see the attached drawings. Figure 9 shows data from open holes that are dipped at each data collection run every two months. Three dipped aquifer boreholes were installed, although only one is now monitored by dipping. Figure 10 shows data from open holes that have continuous pressure monitoring instruments installed.

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<th>Monitoring site</th>
<th>Monitoring results</th>
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| **Dipped aquifer piezometers over Springvale**
- RSE — on ridge between Wolgan East and Sunnyside Swamps
- RSS — on ridge between Sunnyside and Sunnyside East Swamps (now continuously monitored)
- RCW — on ridge between Sunnyside East and Carne West Swamps (no longer monitored) | The groundwater level in RSE remained below the bottom of the hole during the period and the hole was dry. The water level in RSE was previously at the base of the bore from October 2007 to early 2012 (figure 9).

A continuous reading instrument has been installed in RSS to provide continuous data in advance of future mining. The data from this instrument are discussed in the following section.

RCW was destroyed in the April – May 2010 period by forestry activity. A replacement bore has been drilled adjacent, and a continuous reading instrument installed on 3 November 2011 (SPR1104). The data from this instrument are discussed in the following section.

**Mining impacts:**
There was no mining activity near any of the bores during the current period. RSE was undermined by LW411 in mid-July 2006, and the data for this hole show no impact from mining. RSS was undermined by LW415 on September 2012, and the data for this hole show no impact from mining.

| Continuously monitored aquifer piezometers over | Open hole piezometers with continuous measuring instruments are installed over areas that are yet to be mined at Springvale (figure 10). |
Springvale:

Eleven open hole piezometers:
- RSS
- SPR1101
- SPR1104
- SPR1106
- SPR1107
- SPR1108
- SPR1109
- SPR1110
- SPR1111
- SPR1112
- SPR1113

Hole RSS is an aquifer piezometer that was initially monitored by dipping every two months, with a record extending back to December 2005 (figure 9). The available data show a groundwater level remaining fairly steady at around 31 to 32 m depth for the first half of the record, followed by water level slowly rising to about 30 m in November 2011. A subsequent rapid rise in water level to a depth of 28 m was observed in mid-December 2011. A continuous monitoring instrument was installed at that time (figure 10). The data record from the new instrument in RSS commenced on 14 December 2011. Compared to all the other aquifer groundwater records, that from RSS is highly variable. It showed rapid and large fluctuations in groundwater level — the largest rise was 5.5 m in 5 days. The spikes correspond to significant rainfall during the period. The behaviour is unusual for the aquifer piezometers, and while this could be due to rapid rainfall infiltration, it may also be due to penetration of rainfall around the well casing. The site was examined to see if there was any likely penetration of surface water from around the collar, but there was no evidence of this. The drillhole is located at a high topographic level, and the upper part of the Banks Wall Sandstone is known to be friable and possibly permeable. This may explain the rapid infiltration of rainfall at this site. During the current period, the groundwater level in RSS fell slowly, to a depth of 28.4 m, with a no marked rainfall response.

Similar irregular behaviour has also been observed in the dipped record at aquifer borehole REN, and there may be a similar explanation at that site.

The record in SPR1101 commenced on 14 November 2011. Since that time, groundwater level has remained nearly level, and is currently steady at around 35 m depth.

Hole SPR1104 was drilled adjacent to former hole RCW, a dipped aquifer well that was destroyed by forestry activity in early 2010. An instrument was installed on 4 November 2011. The installation was vandalised the next day and the instrument dropped to the bottom of the hole, along with installation cable, and sticks, where it remained until retrieved by the drillers on 9 February 2012. The instrument was checked and found to be still working, and pressure variations record the groundwater levels during this period. It was redeployed on 3 February 2012. The recent data record commences on 4 February 2012, but the data retrieved from the period when the instrument was sitting on the base of the bore has been corrected, and is included in the data record. It shows groundwater rising very slowly and steadily, to around 23 m depth. This is likely to represent the actual groundwater regime at this site during the period, as the period since drilling is probably long enough allow stabilisation of the water level. The water level currently stands at a depth of c. 25 m. There is no mining in the vicinity.

The record at SPR1106 commenced on 15 December 2011, and initially fell slowly and steadily by over 1 m. This may have been due to stabilisation of the groundwater level after drilling, or represent the true groundwater regime at this site. Since then, the groundwater level stabilised at around 44 metres deep. During the previous period, the trend was slowly declining until late April 2013, when the water level rose suddenly by 0.6 m in two weeks; this was followed by a stable trend, which continued during the current period. Groundwater level
Monitoring site | Monitoring results
--- | ---
now stands at 44 m depth. Bore 8 site is located approximately 300 m southwest of SPR1106. Mining activities at this site may be responsible for the sudden increase, but there does not appear to be any permanent impact from the construction of Bore 8.
The record in SPR1107 commenced on 4 November 2011. Initial stabilisation was followed by water level steady at c. 20 m depth. Since May 2013, water level has been dropping very slowly and steadily, and stood below 21 m depth at the end of the current period.
The record in SPR1108 commenced on 4 November 2011. Groundwater level initially fell relatively quickly by 3 m, until mid-February. Since then it has been steady at a depth of about 30 m. The falling leg is interpreted as stabilisation of the groundwater level after drilling, and the subsequent stable trend the actual groundwater level behaviour at this site.
The record in SPR1109 commenced on 14 December 2012. Since that time, groundwater level initially rose very slowly and steadily in the hole, and is now very slowly declining, at around 37 m depth.
The record in SPR1110 commenced on 14 December 2012 but the water level declined to below the base of the instrument. The instrument was repositioned and since that time, the groundwater level remained very steady, at around 58 m depth, for most of the record since then; the steadily declining trend seen during recent times continued, with water level now at c. 63.5 m. This decline commenced at the beginning of 2013, when LW 415 was more than 500 metres away to the north of the bore. During 2013, LW415 passed within 300 m to the west of the bore, with no change in trend observed. The distance from the longwall, and the regular nature of the trend, suggest that this decline is unrelated to mining. SPR1110 is located on a narrow ridge line, with the relatively deeply incised valleys of Sunnyside East and Carne West swamps on either side. This is probably why water level in this piezometer is deeper than in the other piezos and is slowly declining, particularly during recent periods of below-average rainfall. Similar effects have been noted in other piezometers on the Newnes Plateau that are located in similar topographic settings.
The record in SPR1111 commenced on 14 December 2011. Groundwater levels initially declined slowly by several metres, and subsequently levelled out at about 34 m depth. The previously stabilised record seen previously continued during the current period; water level at the end of the period was c. 36 m below ground level. The initial falling leg is interpreted as initial stabilisation of groundwater in the hole, which still contained drilling fluid at the time monitoring commenced.
The record in SPR1112 commenced on 15 December 2011. The initial record shows a markedly falling groundwater level. The falling leg is interpreted as stabilisation of groundwater in the hole, which may have contained substantial drilling water at the time of installation. On 16 January 2012, the water level fell below the piezometer. The instrument was rehung at a lower depth on 13 February 2012. The record since that time shows groundwater level very slowly rising, levelling, and then slowly declining. The declining trend continued during the current period. At times, the trend has been interrupted by rainfall spikes of c. 2 m. The groundwater level now stands at c. 22.5 m. The data from this hole suggest that the upper
part of the Banks Walls Sandstone is relatively friable and the standing water level responds to rainfall. A similar result is seen in some other holes on the Newnes Plateau.

The record in SPR1113 commenced on 13 February 2012. Since that time, groundwater level rise very slowly and steadily in the hole; the groundwater level steadied, remaining at c. 20.9 m for most of the period. However, on 15 May 2013, groundwater rose rapidly by 0.62 m in two days before levelling off again. The cause for this brief, sharp rise is unclear. Shaft sinking activities at Bore 8 were underway at the time, but approximately 2 km to the northwest. Piezometers SPR1104, SPR1111, SPR1112, and SPR1107 all lie between the location of SPR1113 and the Bore 8 site. There is no equivalent effect observed in any of these piezometers, so the impact is highly unlikely to be mining-related. Groundwater currently stands at c. 20 m depth.

**Mining impacts:**

LW415 at Springvale passed directly beneath borehole RSS in mid-September 2012. The groundwater level record for this period show its normal response to rainfall conditions, with no evidence of any impacts from the extraction (figure 10).

LW415 passed about 200 m to the west of SPR1101 in September 2012, with no evidence in the groundwater level record of any adverse impacts.

Bore sinking activities at Bore 8 site, approximately 300 m southwest of SPR1106, took place during April and May 2013. The period is marked on figure 10 as a horizontal blue line. The bore sinking include the period when water level rapidly rose a short amount. This may have been in response to increased formation pressures during shaft excavation activities. The data show that shaft sinking had no negative impact on groundwater levels at SPR1106.

There was no mining activity near any of the remaining bores during the period. The data show no impacts from mining in any of these boreholes.

### 7. Surface water monitoring

<table>
<thead>
<tr>
<th>Monitoring site</th>
<th>Monitoring results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction Swamp</td>
<td>There were no flows through Junction Swamp during the period (figure 6).</td>
</tr>
</tbody>
</table>

The lack of a permanent flow from the swamp, given the high groundwater levels, is an anomaly. The groundwater gradient is sufficient to produce a flow, but there is no flow at the weir. This may be due to some surface cracking between the swamp and the weir (resulting in underflow) or possibly due to tilting that has diverted the flow. The data indicate that tilting is the more likely cause, as the relative groundwater level movements between piezometers D2 and D3 suggest that flow may only return when the relative groundwater depths in these two piezometers return to their pre-mining levels (i.e. no cross fall in the hydraulic gradient). This will produce a flow downstream rather than at an angle to the channel that may bypass the weir. Although there is currently no flow from the swamp, the most important aspect is that the swamp has been unaffected by mining, with its groundwater levels near to pre-mining levels.
<table>
<thead>
<tr>
<th>Monitoring site</th>
<th>Monitoring results</th>
</tr>
</thead>
<tbody>
<tr>
<td>groundwate r monitoring August - September 2013 - final for comment</td>
<td></td>
</tr>
<tr>
<td>3 March 2014</td>
<td>Aurecon</td>
</tr>
<tr>
<td>Monitoring site</td>
<td>Monitoring results</td>
</tr>
<tr>
<td>Sunnyside Swamp Pool depth monitor SSP</td>
<td>Groundwater levels remain near historic highs and the behaviour continues to be typical for a periodically waterlogged swamp. <strong>Mining impacts:</strong> There were no incremental mining impacts indicated by the monitoring results over the review period.</td>
</tr>
<tr>
<td>Rainfall in November 2010 caused the v-notch weir to fail, and several attempts to repair it were unsuccessful. A replacement pool depth monitor was installed on 9 August 2011. Pool depth data show distinct spikes related to rainfall, as would be expected (figure 11). (Note that the absolute range of pool depth is generally of the order of 100 – 200 mm. The data are scaled to make them visible on figure 14. During the current period, baseline pool depth fell steadily due to below-average rainfall, with transient small spikes as responses to rainfall. The pattern of pool depth fluctuations reflects that seen previously from the v-notch data, and suggests no significant change in behaviour of stream flows. It is expected that pool depth will broadly relate to creek discharge, but the relationship between them has not been established at present.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In the absence of data from the v-notch weir, spot flow data are collected using a flow meter. Available fortnightly data are plotted on figure 11. The available flow meter data showed good agreement with the v-notch data, when the two were contemporaneous, and so may be used as a proxy for true flow data. As well, they show broad agreement with the pool depth data, given the discrete nature of flow monitoring data. <strong>Mining impacts:</strong> LW413 lies approximately 300 m west of the weir. The stream record shows no impact of mining on flows. LW414 commenced approximately 100 m south of the upstream end of the swamp in February 2011 with no impacts evident on the flows. Longwall 415 commenced during early 2012, and extraction has now continued south to beyond the headwaters of Sunnyside Swamp. There has been no evidence of any mining impact from LW 415 during the review period.</td>
</tr>
<tr>
<td>Carne West Pool Pool depth monitor SSP</td>
<td>A pool depth monitor was installed at the bottom end of Carne West Swamp on 30 May 2012. Pool data depths show distinct spikes related to rainfall (figure 12). Pool depths were generally low during the period, and regularly dropped below the level of the gauge, consistent with below-average rainfall. Despite pool water level falling below the level of the sensor, there is still flow coming out of the lower end of Carne West Swamp. It is noteworthy that spikes in pool depth do not always have a clear, immediate relationship to individual rainfall readings. Progressive increases in pool depth during periods of below average rainfall indicate that there is considerable storage retained in the swamp alluvium/peat, and a delayed release of this water to the stream is occurring. The lag appears to be a few days to a few weeks. <strong>Mining impacts:</strong> There is no mining in the vicinity.</td>
</tr>
</tbody>
</table>
8. Trigger Action Response Plan

The TARP for the groundwater and surface water monitoring program is provided in Appendix C. The data were evaluated and compared with trigger levels indicated in the TARP and the following trigger exceedences were noted:

- Surface water flows: NIL
- Aquifer groundwater levels: NIL
- Swamp groundwater levels: NIL
10. **Instrumentation condition report**

The groundwater level logging instruments are generally in satisfactory condition and performing as expected.

The following recommendations are made:

- Under the requirements of Centennial’s management plan titled “Temperate Highland Peat Swamps on Sandstone Monitoring and Management Plan for LWs 415 – 417”, dated September 2012, and the Springvale EPBC Approval 2011/5949 from the federal Department of Sustainability, Environment, Water, Population and Communities, Springvale Colliery is required to develop statistically-based trigger levels for parameters including groundwater level changes. **Now that LW416 has commenced extraction, this matter requires immediate attention.**

- Water quality sampling takes place in a number of holes. The sampling events are visible in the groundwater record as distinct, steep downward spikes with recovery after sampling. In piezometers SS1 and MS1, recovery is delayed to the extent that groundwater sampling is having a distinct impact on the record. Recovery does occur, but there is usually only a short period of “normal” trend before sampling occurs again. During the current period, closely spaced sampling events have resulted in disruption of the groundwater record, and incomplete recovery. **It is again recommended that separate groundwater sampling boreholes be constructed, approximately 50 m from the SS1 and MS1 sites.** This would allow the true groundwater pattern to be observed at these locations. Until a sampling bore is constructed, the water sampling frequency should be reduced to no more than once per month.

- **Water sampling personnel should be made aware of the importance of replacing instruments in swamp piezometers, after sampling activities have been completed.**

- As noted previously, installations at SPR1210 and SPR1112 have been vandalised. The padlocks were damaged; in the case of SPR1210 by gunfire. It is again recommended that the padlocks be replaced with system padlocks.

- As noted previously, the borehole at SPR1112 is adjacent to the road. The site has been rehabilitated; it is again recommended that fallen trees at the site be moved to shield the installation from view from the road, to reduce the possibility of further vandalism.
11. Summary

<table>
<thead>
<tr>
<th>Monitoring item</th>
<th>Comments</th>
<th>Mining impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swamp piezometers</td>
<td>Groundwater levels in the periodically waterlogged swamps are generally declining in the short term, due to below-average rainfall. There are minor declines or no significant changes in trend in the permanently waterlogged swamps.</td>
<td>In general, no mining impacts were observed. At Junction Swamp, no additional mining impacts were observed.</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>Previously observed trends continued, with no significant changes.</td>
<td>No mining impacts were observed.</td>
</tr>
<tr>
<td>Aquifer boreholes</td>
<td>In general, previously observed trends continued, with no significant changes.</td>
<td>The slightly elevated groundwater water level, probably due to shaft sinking activities at Bore 8, continued. There is no indication of loss of groundwater.</td>
</tr>
<tr>
<td>Surface water monitoring</td>
<td>In general, previously observed trends continued, with no significant changes.</td>
<td>No mining impacts were observed.</td>
</tr>
<tr>
<td>TARP</td>
<td>No TARP trigger exceedances noted</td>
<td></td>
</tr>
</tbody>
</table>

12. Certification

Report prepared by David Hilyard, Senior Consultant

21 October 2013
Figure 2 - Swamp Groundwater Levels 2013 - Springvale

Rainfall (mm)

Groundwater depth (m) bgl

Rainfall Period

SW1
SSE1
SSE2
SSE3
SS1
SS2
SS3
SS4
SS5
CW1
CW2
CW3
CW4
BS1
BS2
BS3
MS1
CW3
CW4
GW1
GW2
GG1
CC1
Figure 3a - Groundwater depths - Type A swamps - Springvale

Rainfall Period
SW1
SSE1
CW3
CW4

Groundwater Depth below surface (m)

Daily Rainfall (mm)

January 2005 to January 2014
Figure 3b - Groundwater depths - Type C swamps - Springvale
Figure 7 - Springvale soil moisture profiles (2-3 September 2013)
Figure 8a - CW1 Soil Moisture Profile - Springvale
Figure 8b - SS2 Soil Moisture Profile - Springvale

Groundwater depth (m)

Moisture Content (%)
Figure 8c - SW1 Soil Moisture Profile - Springvale

Groundwater depth (m)

Moisture Content (%)
Figure 9 - Dipped aquifer piezometers - Springvale

- **RSE**
- **RSS**
- **RCW**

- **Borehole destroyed**
- **Continuous monitoring instrument installed**

Groundwater depth (m)

Jun-05 to Jun-14
Figure 11 - Sunnyside Creek discharge, pool depth - Springvale
Figure 12 - Carne West pool - Springvale

Rainfall (mm)

Water depth (m)

Depth

Period

Rainfall

Figure 12 - Carne West pool - Springvale
Appendix C

Trigger Action Response Plan
## Trigger Action Response Plan

<table>
<thead>
<tr>
<th>Key Element</th>
<th>Trigger Response</th>
<th>Condition Green</th>
<th>Condition Amber</th>
<th>Condition Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment/ Public Safety</td>
<td>Piezometric Head Change</td>
<td>Trigger</td>
<td>No significant fall in piezometric height of aquifers above the Mt York Claystone.</td>
<td>A ‘stepped’, mining related, 5m piezometric head loss in any aquifer above the Mt York Claystone.</td>
</tr>
<tr>
<td>Key Element</td>
<td>Trigger</td>
<td>Condition Green</td>
<td>Condition Amber</td>
<td>Condition Red</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
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</tr>
<tr>
<td>Reduction in surface water flows</td>
<td>Trigger</td>
<td>Downstream flows are equal to or greater than upstream flows or consistent with historical pre-mining flows</td>
<td>Downstream flows are less than (85% volume) upstream flows and inconsistent with historical pre-mining flows</td>
<td>Downstream flows are less than (50% of less) upstream flows and inconsistent with historical pre-mining flows</td>
</tr>
<tr>
<td></td>
<td>Response</td>
<td>Continue monitoring program</td>
<td>Undertake regular field inspection to determine any cause in reduced downstream flows Consider increasing monitoring frequency Engage expert hydrologist to determine causes if required</td>
<td>Notify Principal Subsidence Engineers and Department of Water and Energy (as well as other relevant Government Departments) Undertake regular field inspection to determine any cause in reduced downstream flows Increase monitoring frequency Engage expert hydrologist to determine causes and impacts Undertake consultation with relevant Government Departments to determine remediation and/or further investigation</td>
</tr>
<tr>
<td>Swamp Piezometer monitoring</td>
<td>Trigger</td>
<td>No Visible Surface Cracking or visible water loss. No visible difference with control swamp. No significant fall in piezometric height of surface aquifers.</td>
<td>Surface Cracking Downstream flows are less than (85% volume) upstream flows and inconsistent with historical pre-mining flows. Significant change in species diversity compared with control swamp. 10% loss of saturated head within surface aquifers outside of climatic response behaviour</td>
<td>Surface cracking resulting in downstream flows less than (50% of less) upstream flows and inconsistent with historical pre-mining flows. Major dieback of flora compared to control swamp. Total loss of ground water.</td>
</tr>
<tr>
<td></td>
<td>Response</td>
<td>Monitor for, and record observations of, cracking and water flow with each pillar row extracted, after subsidence. Monitor quarterly over next 12 months.</td>
<td>Monitor over next 12 months. Check instrumentation / installations Continue flora monitoring. Undertaken geotechnical and groundwater investigation as required</td>
<td>Notify Principal Subsidence Engineer. Report to the Principal subsidence Engineer on action to rectify. Continue seasonal flora monitoring.</td>
</tr>
</tbody>
</table>