Temperate Highland Peat Swamps on Sandstone Monitoring and Management Plan LW 415 to 417

Annual Report

Springvale Mine

March 2016

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1. INTRODUCTION

Springvale Coal Pty Ltd (Springvale) is an underground longwall mine located 12km North West of Lithgow in NSW and 3 km south of the Centennial Angus Place Mine. The mine is a joint venture owned in equal share by Centennial Springvale Pty Ltd (a wholly owned subsidiary of Banpu Minerals Ltd) and Springvale SK Kores Pty Limited.

Approval 2011/5949 was issued to Springvale by the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) on the 14th of March 2012. Approval 2011/5949 is related to a controlled action area of the Springvale mine for mining of longwall panels (LW) 415 – 417 as shown in the figure below.

Figure 1 Controlled Action Area 415 to 417

On the 21st of October 2013 Springvale received approval from SEWPAC on the Temperate Highland Peat Swamps on Sandstone Monitoring Plan (THPSSMMP) for LW's 415 to 417 as required under Condition 7 of the EPBC approval.

This annual report has been prepared to satisfy Condition 10 of the EPBC approval which states:

"A report detailing the results of actions carried out under the monitoring and Management plan must be prepared and provided to the department annually on the anniversary date of this approval. The minister may request that the report be reviewed by an independent reviewer approved by the department".

The annual reporting period has been defined as the 1st of January to 31st of December 2015 to allow the compilation of data and input of specialist reports.

2. MONITORING SITES

2.1. Subsidence

Existing survey monitoring lines have already been installed in accordance with the approved *Springvale Subsidence Management and Reporting Plan for LW415 to 417 (September 2011)*. These lines include B, M, T, V, W, X and Y across Sunnyside East and Carne West THPSS. The survey lines installed to date have not been established in the THPSS to minimise impacts during the establishment of the lines and during monitoring.

Additional longitudinal centre lines have been installed at several key locations to provide early-warning and three dimensional (3-D) swamp subsidence data for trigger level review and corrective action management purposes should corrective action be required.

The location of the subsidence monitoring locations are shown in Figure 2.

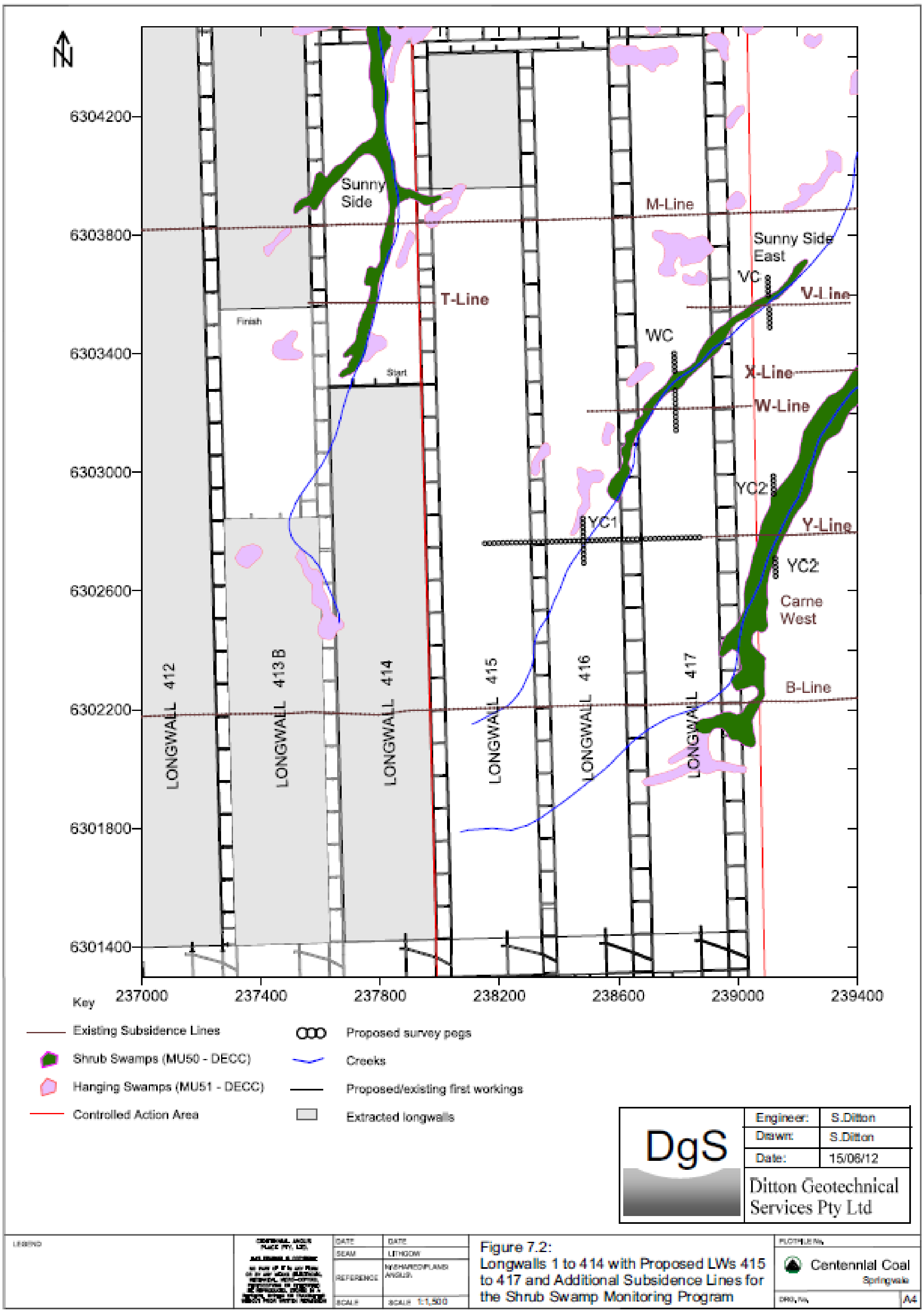

Figure 2 Subsidence Monitoring Locations

2.2. Flora

Centennial Coal has conducted flora monitoring of THPSS across the Newnes Plateau since 2003. Forty-six sites are now monitored which includes undermined swamps and swamps that have not been undermined. The data from these sites will be used as reference data where needed in combination with the specific sites that will be monitored as part of this MMP.

Table 1 provides details of the flora monitoring and reference sites with are part of the THPSSMP while their locations are shown in Figure 3.

Table 1.Flora Monitoring sites

Monitoring site name	Swamp	Easting (GDA94)	Northing (GDA94)	Description
Impact Sites				
WC01	Carne West Swamp	239461	6303219	Permanently wet, groundwater fed swamp. Dominated by *Gymnoschoenus sphaerocephalus*, *Lepidosperma limicola*, *Leptospermum grandifolium*, *Gleichenia dicarpa*, *Xyris gracilis ssp. gracilis* and Baeckea linifolia.
WC02	Carne West Swamp	239461	6303321	Permanently wet, groundwater fed swamp. Dominated by *Gymnoschoenus sphaerocephalus*, *Lepidosperma limicola*, *Leptospermum grandifolium*, *Gleichenia dicarpa*, *Xyris gracilis ssp. gracilis* and Baeckea linifolia.
WC03	Carne West Swamp	239195	6302908	Permanently wet, groundwater fed swamp. Dominated by *Gymnoschoenus sphaerocephalus*, *Lepidosperma limicola*, *Leptospermum grandifolium*, *Gleichenia dicarpa*, *Xyris gracilis ssp. gracilis* and Baeckea linifolia.
WC04	Carne West Swamp	239157	6302773	Permanently wet, groundwater fed swamp. Dominated by *Gymnoschoenus sphaerocephalus*, *Lepidosperma limicola*, *Leptospermum grandifolium*, *Gleichenia dicarpa*, *Xyris gracilis ssp. gracilis* and Baeckea linifolia.
SSE01	Sunnyside East	239022	6303531	Southern half is generally dry and channelized. Northern half likely permanently wet. Dominant species include *Gleichenia dicarpa, Leptospermum grandifolium*, *Baumea rubiginosa* and *Gahnia sieberiana*
Reference Sites				
TG01	Twin Gully	236565	6308755	Permanently wet, groundwater fed swamp. Dominant species include *Baeckea linifolia*, *Grevillea acanthifolia*, *Gleichenia dicarpa* and *Sphagnum cristatum.*
TG02	Twin Gully	236439	6308765	Permanently wet, groundwater fed swamp. Dominant species include *Baeckea linifolia*, *Grevillea acanthifolia*, *Gleichenia dicarpa* and *Sphagnum cristatum.*

TRI01	Tristar	236565	6308755	Permanently wet, groundwater fed swamp. Dominated by *Baeckea linifolia, Gleichenia dicarpa, Grevillea acanthifolia, Lepidosperma limicola, Leptospermum grandifolium*
TRI02	Tristar	236439	6308765	Permanently wet, groundwater fed swamp. Dominated by *Baeckea linifolia, Gleichenia dicarpa, Grevillea acanthifolia, Lepidosperma limicola, Leptospermum grandifolium*
LGG01	Lower Gang Gang Swamp	240148	6303040	Permanently wet, groundwater fed swamp, with channelised flows. Dominated by *Leptospermum grandifolium, Lepidosperma limicola, Boronia deanei and Gleichenia dicarpa.*
UGE01	Upper Gang Gang East Swamp	239928	6301878	Ephemeral, likely rainfall fed. Dominated by *Gleichenia dicarpa, Leptospermum grandifolium, Lepidosperma limicola, Gymnoschoenus sphaerocephalus and Xyris gracilis ssp. gracilis.*
BS01	Barrier Swamp	242111	6303738	Permanently wet, groundwater fed swamp. Dominated by *Gleichenia dicarpa, Leptospermum grandifolium, Lepidosperma limicola, Gymnoschoenus sphaerocephalus and Xyris gracilis ssp. gracilis.*
CCS01	Carne Central Swamp	241196	6302578	Ephemeral, likely rainfall fed. Dominated by *Lepidosperma limicola*, *Empodisma minus*, *Callistemon pityoides*, *Grevillea acanthifolia.*

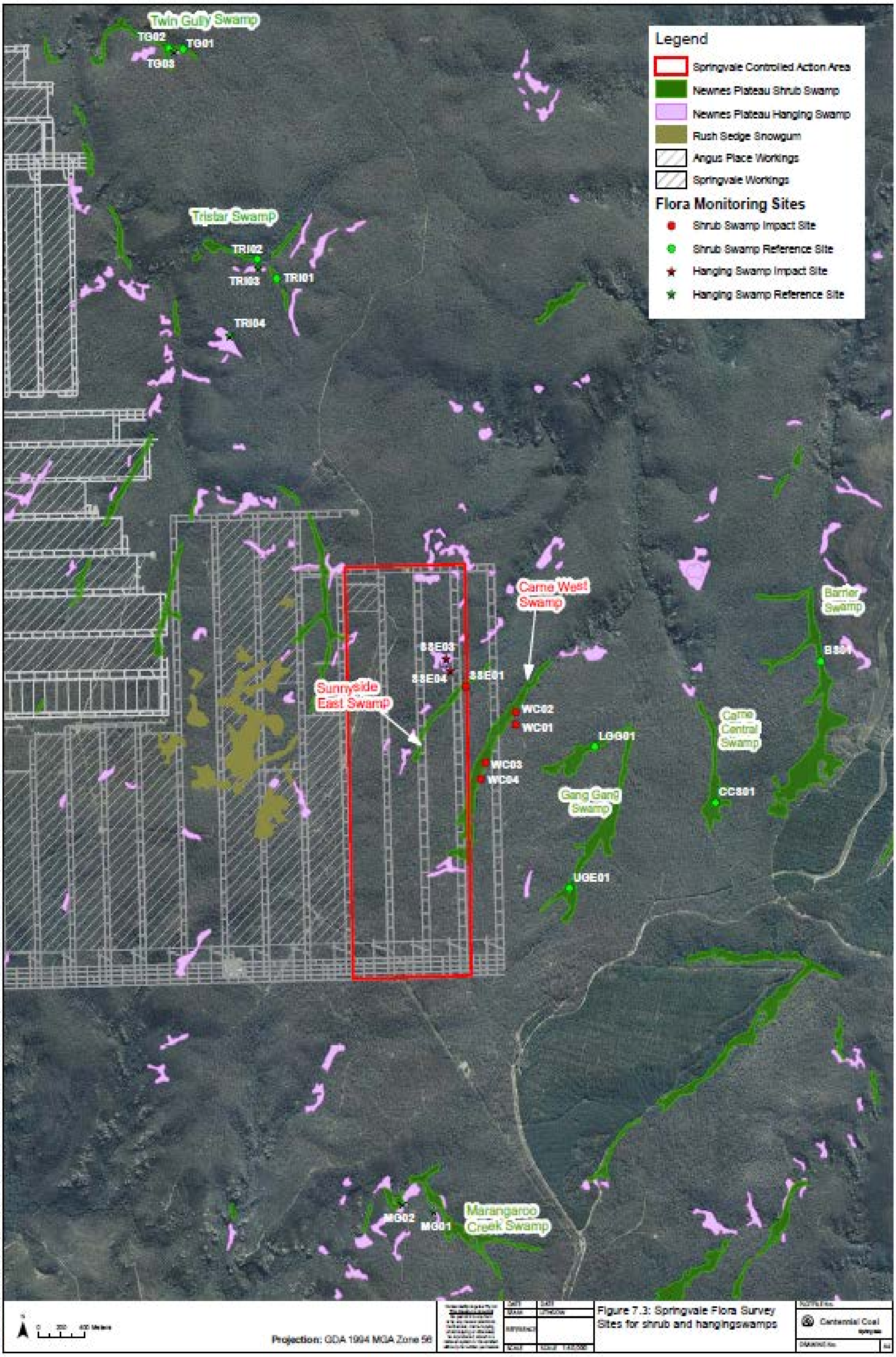

Figure 3 **Flora Monitoring locations**

2.3. Groundwater

The THPSS baseline groundwater monitoring program commenced in May 2005 and has been gradually expanded to incorporate groundwater level and groundwater quality monitoring.

Piezometers have been installed in swamp systems and are referred to as Swamp piezometers. These piezometers are hand augured to refusal and are shallow with a depth of up to 3 metres. These piezometers are used for direct measurement of swamp groundwater fluctuations.

Piezometers have also been installed outside of swamp systems and are referred to as aquifer piezometers. These piezometers often extend down through ridge lines and are deeper than the swamp piezometers extending to a depth of up to 30 metres. The aquifer piezometers are used to measure groundwater fluctuations outside of swamp systems.

Details of the groundwater monitoring program are presented below.

2.3.1. Swamp piezometers

The swamp piezometers are generally located on the edges of the swamps to minimise damage to swamp vegetation. The groundwater level measured at the swamp margin is representative of the groundwater level across the swamp.

Groundwater chemistry is monitored only in piezometers located in permanently waterlogged swamp conditions as sampling in periodically waterlogged conditions is often not possible due to the lack of groundwater in the piezometer.

Table 2 and 3 provides a summary of the groundwater monitoring undertaken at impact and reference swamps respectively.

Table 2.Groundwater Impact monitoring sites

Site name	Easting (GDA94)	Northing (GDA94)	Location	Mining date (estimated)	Parameters monitored	
					Depth	Water Quality
Sunnyside East Swamp						
SSE1	238668	6303143	Over proposed LW416/417	To be undermined December 2013 / March 2015	✓	
SSE2	238831	6303352	Over proposed LW 417	To be undermined December 2014	✓	
SSE3	239064	6303558	Over proposed LW 418	To be undermined November 2015	✓	✓
Carne West Swamp						
CW1	239352	6303196	Over proposed LW 419	To be undermined November 2016	✓	✓
CW2	239382	6303247	Over proposed LW 419	To be undermined November 2016	✓	✓
CW3	238977	6302179	Over proposed LW 417	To be undermined April 2015	✓	
CW4	239070	6302377	Over proposed LW 417	To be undermined April 2015	✓	

Table 3. Groundwater reference monitoring sites

Site name	Easting (GDA94)	Northing (GDA94)	Mining Area	Mining date (estimated)	Parameters monitored	
					Depth	Water Quality
Carne Central Swamp						
CC1	241193	6302693	East of LW 418	No approved mining to date	✓	✓
Marangaroo Swamp						
MS1	238860	6299169	East of LW 418	No approved mining to date	✓	✓
Tristar Swamp						
TS1	237559	6307289	Over Angus Place – NE Area	No approved mining to date	✓	
Twin Gully Swamp						
TG1	236438	6308766	Over Angus Place – NE Area	No approved mining to date	✓	

2.3.2. Aquifer piezometers

The aquifer piezometers are located outside of swamp systems in the laterally extensive shallow aquifer to monitor groundwater fluctuations around the periphery of THPSS. The data collected from these piezometers provides a comparison with any fluctuations measured in the swamp piezometers to detect any mining related impacts.

Groundwater chemistry is not monitored in aquifer piezometers because these piezometers are located at a greater depth from the surface (i.e. on ridge lines) than swamp piezometers and the oxidation of analytes such as Fe and Mn is unlikely due to a lack of freely available oxygen at this depth from surface.

Table 4 and 5 provides a summary of the groundwater monitoring undertaken at impact and reference swamps respectively.

Table 4. Aquifer impact monitoring sites

Site Name	Easting (GDA94)	Northing (GDA94)	Location	Mining date (estimated)	Parameters monitored	
					Depth	Quality
RSS	238072	6303500	Over LW 415	To be undermined Sep 2012 if approved	✓	
SPR1101	238484	6303627	Over LW 416	To be undermined Oct 2013	✓	
RCW/ SPR1104	239746	6303184	Over LW 420	To be undermined 2017 if approved	✓	
SPR1107	239739	6302330	Over LW 420	To be undermined 2017 if approved	✓	
SPR1109	239186	6303314	Over LW 418	To be undermined December 2015	✓	
SPR1110	238699	6302635	Over LW 416 / 417	To be undermined January 2014 / March 2015	✓	

Table 5. Aquifer reference monitoring sites

Site name	Easting (GDA94)	Northing (GDA94)	Location	Mining date (estimated)	Parameters monitored	
					Depth	Quality
SPR1108	239840	6301075	South of LW 420 Over LW427	To be undermined after 2025 if approved	✓	
SPR1111	240404	6303692	Nth of LW 422	Will not be undermined	✓	
SPR1113	240625	6302160	Over LW 423	To be undermined 2021 if approved	✓	
AP5PR	236523	6308535	NE of Angus Place Mine	Will not be undermined in the foreseeable future	✓	

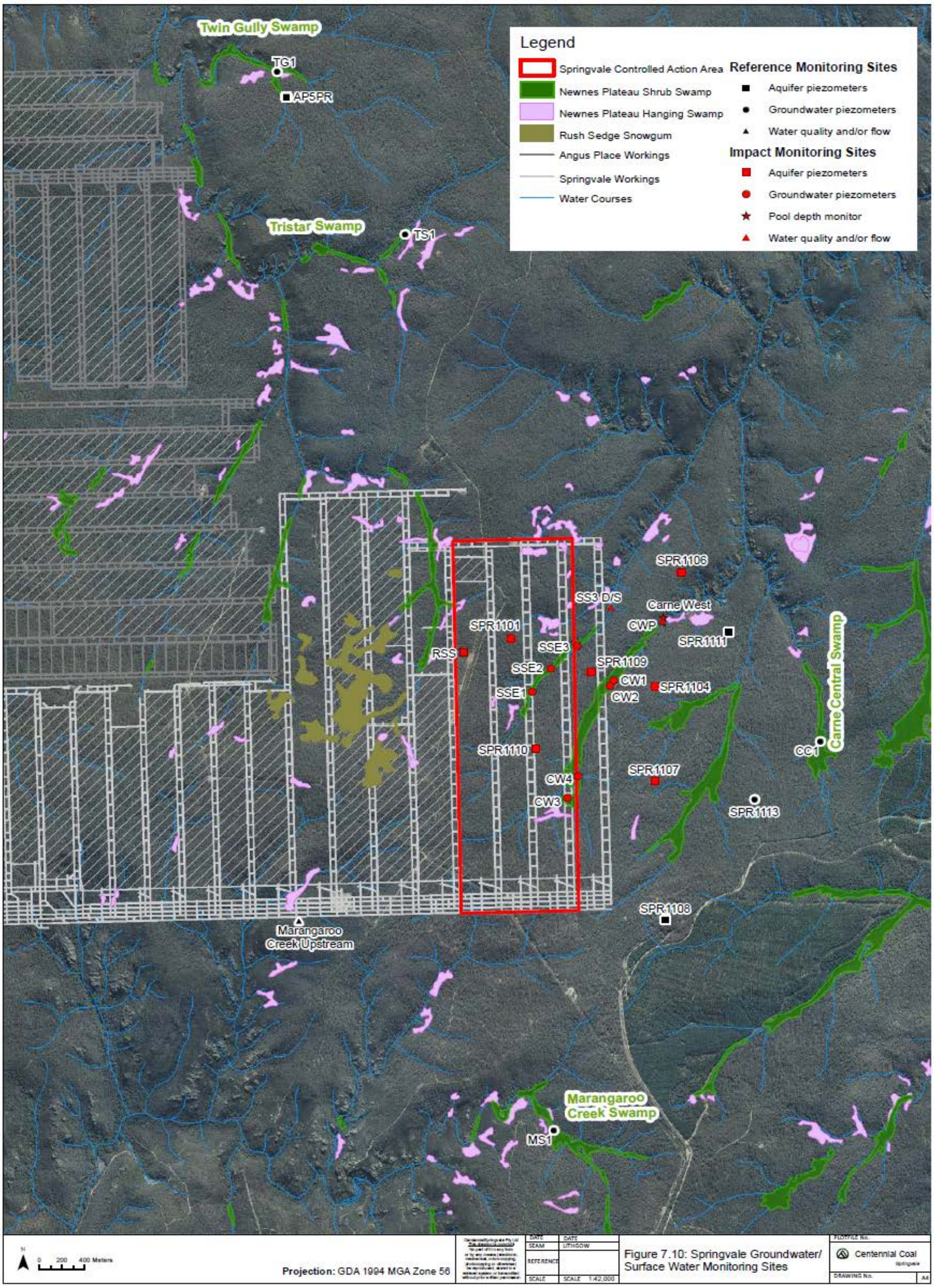

Figure 4 Groundwater and surface water monitoring locations

2.4. Surface water

The most significant surface water flows in the Springvale controlled action area in the drainage lines that feed into the sub-permanently and permanently waterlogged swamps.

Details of the surface water monitoring sites are given in Table 6.

Table 6.Surface water monitoring sites

Site Name	Easting (GDA94)	Northing (GDA94)	Location	Mining date (estimated)	Parameters monitored		
					water depth	flow rate	water quality
Surface Water Quality - Impact Sites							
Carne West	239808	6303782	Nth end of Carne West Swamp	Swamp will be undermined in April 2015 and November 2016		✓	✓
CWP	239816	6303814	Nth end of Carne West Swamp		✓		
SS3 D/S	239363	6303908	Nth end of Sunnyside East Swamp	Swamp to be undermined December 2013, December 2014, March/November 2015, August 2016			✓
Surface Water Quality - Reference Site							
Marangaroo Creek Upstream	236633	6301063	Marangaroo Creek upstream	Will not be undermined		✓	✓

Surface monitoring locations are shown in Figure 4 in Section 2.3.

3. MINING ACTIVITY

In 2015 coal was mined from Longwalls 417 and 418. Longwall 417 commenced on the 11th of October 2014 and was completed on the 4th of July 2015. Longwall 418 commenced on the 16th of October 2015. Reporting on Longwall 418 is covered under EPBC Act Approval 2013/6881. Reporting requirments for this approval are covered under a different annual report.

Mining activity undertaken in 2015 is shown in Figure 5.

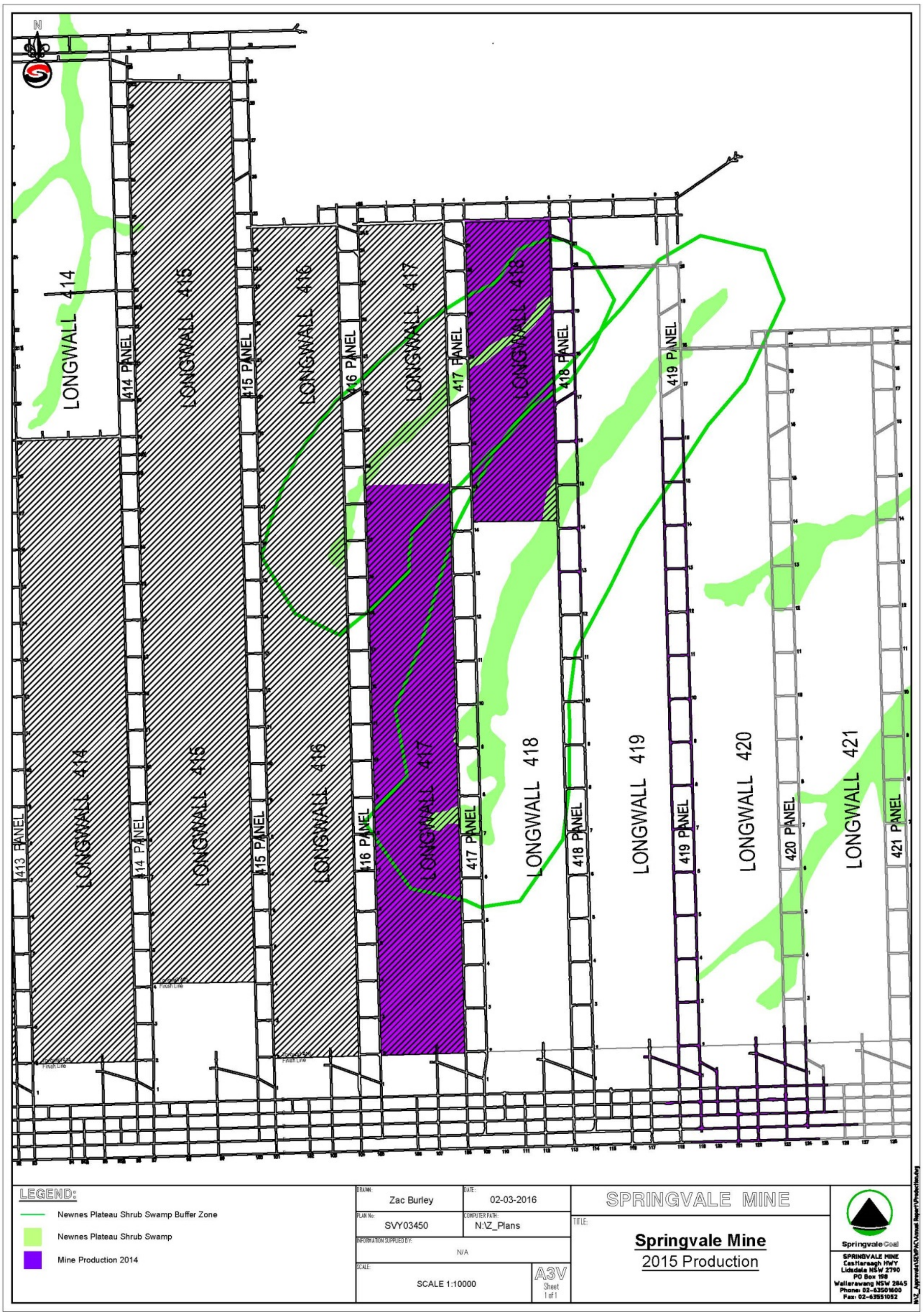

Figure 5 Mining undertaken during 2015

4. METEROLOGICAL CONDITIONS

Monthly rainfall data is summarised in Table 7 and presented in Figure 6.

Table 7.Comparison of Observed and Long-term Average Rainfall Data

	Observed Rainfall		Average Rainfall	
	Newnes Plateau (mm)	**Lithgow Maddox Lane(mm)**	**Newnes Plateau (mm)**	**Lithgow Maddox Lane (mm)**
January 2015	42.2	124.8	82	83.8
February 2015	51.4	31	130.4	80.2
March 2015	59.2	35	76.2	65.5
April 2015	206.2	184.2	43.8	42.5
May 2015	38.4	31	47.2	49.9
June 2015	39.6	26.2	84.6	49.4
July 2015	51.2	44.6	43.8	50.7
August 2015	42.2	31.6	53.3	64.5
September 2015	22.8	12.6	48.4	53.2
October 2015	68	32	65.6	67.3
November 2015	79.6	67.2	106.5	72.6
December 2015	87.8	58.6	112.2	73.9
Annual Total	788.6	678.8	894	753.5

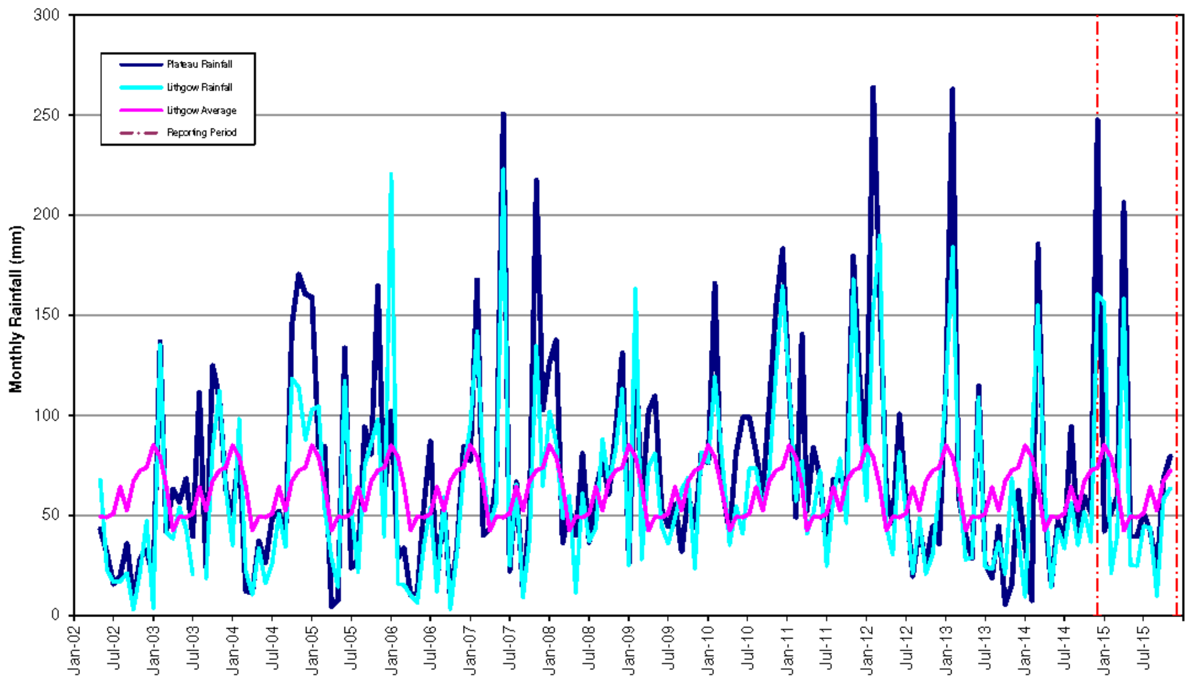

Figure 6 Rainfall

Overall for 2015 below average rainfall conditions were observed at both the Newnes Plateau and and Lithgow. The rainfall levels recorded at Newnes Plateau were higher than observed at Lithgow.

Apart from two large peaks in December 2014/January 2015 and April 2015 both plateau and Lithgow rainfall levels for 2015 generally remained close to or below the Lithgow long term average. Historically, the February 2012 and February 2013 rainfall has been the highest recorded since monitoring began (262.8 mm), while the corresponding rainfall at Lithgow during this rainfall event was the highest since June 2007.

5. MONITORING RESULTS

5.1. Subsidence

Subsidence monitoring has occurred in accordance with the Springvale Subsidence Management and Reporting Plan for LW415 to 417 (September 2011).

The following sections documents the maximum monitoring result for surveys undertaken throughout the reporting period. Results presented were based on the End of Subsidence Review completed for Longwall 417.

All recorded subsidence results were below the trigger values established in the THPSSMMP.

5.1.1. B Line Subsidence Monitoring

The following table summarises the results for the B Line. It is important to note that the B line uses the total station method which is known to be less accurate. Supplementary information may therefore be used to confirm results obtained in the event a trigger value is exceeded.

Table 8.B-Line Monitoring Results

	Subsidence (mm)		Tilt (mm/meter)		Tensile Strain (mm/meter)		Compressive Strain (mm/meter)	
	Max Result	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**
LW415	1231	1500mm	15.4	10	1.5	15	6.2	18
LW 416 to 418	920	1100mm	6.8	7	3.8	5	6.8	>6(plateaus) >14(valleys)

The exceedance of a subsidence trigger value has occurred in the tilt category. Tilt occurs when two points vertically displace at different rates resulting in an increase to the slope of the surface.
The subsidence event has occurred at a distance of approximately 630m from the nearest Temperate Highland Peat Swamp on Sandstone Ecological Community located in Carne West Swamp. This distance is approximately 450m greater than the distance specified for an anomalous subsidence trigger level.

The Temperate Highland Peat Swamp on Sandstone Monitoring and Management Plan for LW's 415-417 states that the anomalous subsidence trigger level for tilt is a value greater than 10mm/m when occurring within 200 metres of a Temperate Highland Peat Swamp on Sandstone Ecological Community. The value surveyed, located well outside the Buffer Zone, is between survey marks B345 and B346 at 15.2mm/m.

5.1.2. M Line Subsidence Monitoring

The following table summarises the results for the M Line.

Table 9.M-Line Monitoring Results

	Subsidence (mm)		Tilt (mm/meter)		Tensile Strain (mm/meter)		Compressive Strain (mm/meter)	
	Max Result	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**
LW415	842	1500mm	7.3	10	3.0	15	2.6	18
LW 416 to 418	342	1100mm	1.5	7	0.4	5	1.4	>6(plateaus) >14(valleys)

The table above demonstrates compliance with the trigger values defined in the THPSSMP.

5.1.3. V and VC Line Subsidence Monitoring – Sunnyside East Swamp

The following table summarises the results for the V and VC Lines.

Table 10. V and VC Monitoring Results

	Subsidence (mm)		Tilt (mm/meter)		Tensile Strain (mm/meter)		Compressive Strain (mm/meter)	
	Max Result	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**
LW417 to LW418	345	1100	3.5	7	0.5	5	4.7	14

The table above demonstrates compliance with the trigger values defined in the THPSSMP.

5.1.4. W and WC Line Subsidence Monitoring – Sunnyside East Swamp

The following table summarises the results for the W and WC Lines.

Table 11. W and WC Monitoring Results

	Subsidence (mm)		Tilt (mm/meter)		Tensile Strain (mm/meter)		Compressive Strain (mm/meter)	
	Max Result	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**
LW416 to 418	724	1100	5	7	1.6	5	5.8	14

The table above demonstrates compliance with the trigger values defined in the THPSSMP.

5.1.5. Y and YC2 Line Subsidence Monitoring – Carne West Swamp

The following table summarises the results for the Y and YC2 Lines.

Table 12. Y and YC2 Monitoring Results

	Subsidence (mm)		Tilt (mm/meter)		Tensile Strain (mm/meter)		Compressive Strain (mm/meter)	
	Max Result	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**	**Max Result**	**Trigger value**
LW416 to 418	406	1100	2.4	7	0.9	5	5.5	14

The table above demonstrates compliance with the trigger values defined in the THPSSMP.

5.1.6. LiDAR

The LiDAR campaign was undertaken in September 2015. There were no anomalous results detected from the flight.

5.2. Flora

Springvale engage a specialist consultant to undertake monitoring and examine the results of vegetation monitoring. Data Analysis focuses on trends that have been observed that possibly relate to mining impacts between seasons in 2013 and 2014, in addition to assessing the extent of variation in vegetation composition and condition between monitoring surveys in 2014 and those conducted in previous years.

The following sections present a summary of the 2015 Spring annual report.

The following table shows impact and reference sites to assist in the interpretation of data.

Table 13. Flora impact and reference sites

Impact Sites	Reference sites
SSE01	TG01
WC01	TG02
WC02	TRI01
WC03	LGG01
WC04	UGE01
	BS01
	CCS01

5.2.1. Native Species diversity

A modified Braun-Blanquet scale was used to visually estimate cover abundance for species occurring within each site

Total native plant species richness for impact and reference sites is shown in the following table. Results from the quadrat (400 m^2) and four 20 m transects are tabulated for comparison between sampling methods and reference/impact sites.

Table 14. Total native plant species richness

Site	Species Richness		Shannon-Wiener Index (point intercept method)	Evenness
	400m^2 Quadrat	Point Intercept Method		
Impact sites				
WC01	13	13	1.98	0.77
WC02	13	13	1.88	0.73
WC03	12	11	2.09	0.87
WC04	15	14	2.10	0.80
SSE01	26	26	2.48	0.76
Mean±SD	15.80 ± 5.81	15.4 ± 6.02	2.11 ± 0.23	0.79 ± 0.05
Reference sites				
TG01	18	18	2.22	0.75
TG02	18	16	2.24	0.79
TRI01	17	17	2.24	0.78
TRI02	17	17	2.02	0.71
LGG01	22	18	2.06	0.71
UGE01	21	19	2.31	0.78
BS01	12	11	2.01	0.84
CCS01	18	16	2.03	0.73
Mean±SD	17.88 ± 3.00	16.50 ± 2.45	2.14 ± 0.12	0.76 ± 0.04

Lower mean native species richness was observed in impact sites (15.80 ± 5.81) when compared with reference sites (17.88 ± 3.00). A similar observation was calculated from the point intercept method (impact = 15.40 ± 6.02; reference = 16.50 ± 2.45). Notwithstanding, a one way Analysis of Variance (ANOVA) indicated no significant difference between impact and reference sites (p value, 0.55).

A lower Shannon-Wiener Index score was calculated for impact sites (2.11 ± 0.23) compared with reference sites (2.14 ± 0.12) for the point intercept method. A one way ANOVA indicated no significant difference between impact and reference sites (p value, 0.74).

Analysis using the native plant species richness trigger levels indicated an 'exceedance' in one impact site (WC02: 13 versus a 13.3 trigger level) and three reference sites (TG02, TRI01 and BS01) for the spring monitoring period. **Figure 7** depicts the total native plant species richness results per site.

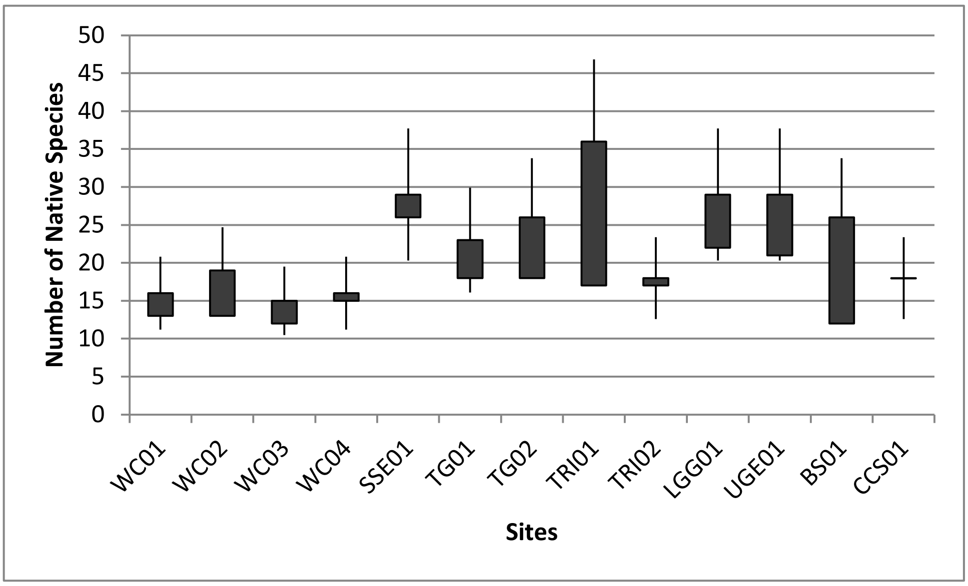

Figure 7 Spring 2015 Species richness, species richness and 30% trigger levels.

Reference sites were inexplicably found to fail the flora trigger levels more so than impact sites. The precise reasons for this are unknown although Erskine and Fletcher (2011) indicate a number of potential causal environmental factors other than mining (e.g. climate, biotic, or anthropogenic) requiring consideration.

5.2.2. Eucalypt recruitment

Non-swamp eucalypt presence was estimated by summing incidence recorded in each 0.5 m x 0.5 m quadrat centred on sequential 1 metre intervals along each of the four parallel transects. This provided a total of approximately 80 quantitative measurements of eucalypt presence per monitoring quadrat.

Eucalypt recruitment within monitoring sites for the spring period is shown in the table below.

Table 15. Eucalypt recruitment in spring 2015

Site	Transect (metre intercept)			
	2	4	5	18
Impact				
WC01	-	-	-	-
WC02	-	-	-	-
WC03	-	-	-	-
WC04	-	-	-	-
SSE01	1	-	-	2
Reference				
TG01	-	-	1	1
TG02	-	1	1	-
TRI01	-	-	-	-
TRI02*	-	-	-	-
LGG01	-	-	-	-
UGE01	-	-	-	-
BS01	-	-	-	-
CCS01	-	-	-	-

Spring monitoring results identified elevated Eucalyptus recruitment in one impact site (SSE01) and two reference sites (TG01 and TG02). None of the sites exceed the trigger value for eucalypt recruitment (i.e. more than 3 individual plants within a year). Detection of Eucalypt recruitment in spring has not shown advancement or indication of further recruitment from the previous winter monitoring event where Eucalypt recruitment was noted in two impact sites (WC02 and WC04) and one reference site (TRI02).

5.2.3. Species Condition scores

Four parallel transects were established to measure condition. The starting points of these transects were positioned randomly along a predetermined edge of the 400 m^2 permanent monitoring quadrat. A condition score was estimated for each plant species intersected every 0.5 m along this transect.

Mean species condition scores for impact and reference sites is shown in the following table.

Table 16. Species condition (mean)

Site	Mean condition of Key Species
Impact	
WC01	3.10
WC02	3.58
WC03	3.41
WC04	3.20
SSE01	4.85
Mean condition (impact)	3.63
Reference	
TG01	3.97
TG02	3.98
TRI01	4.15
TRI02	3.83
LGG01	3.67
UGE01	4.62
BS01	3.76
CCS01	3.91
Mean condition (reference)	3.99

The mean condition score for key species in impact sites was 3.63 compared with 3.99 for reference sites . None of the impact sites had a mean condition score of 2.5 or less, therefore none of the impact sites have triggered the performance criteria. A one way ANOVA indicated no significant difference between impact and reference sites (p value, 0.22).

5.2.4. Non Live ground cover

Bare earth scoring was estimated at each of the 0.5 m intervals inspected for species condition

Percent of non-live ground cover was estimated using both the Braun-Blanquet cover abundance scale for the entire 400 m^2 quadrat and the point intercept method. Results are tabulated in **Table 12**.

Table 17. Non-live ground cover (cover abundance and point intercept methods)

Site	Bare ground (modified Braun Blanquet cover abundance score)	Point intercept Method (%)
Impact		
WC01	1	1.25
WC02	1 (5%)	0.63
WC03	1	8.13
WC04	1	2.50
SSE01	1 (3%)	5.00
Reference		
TG01	1	0.00
TG02	1	1.25
TRI01	1	0.00
TRI02	1	0.00
LGG01	1 (3%)	0.00
UGE01	1 (3%)	9.38
BS01	1	0.00
CCS01	1 (5%)	1.25

Neither method identified a substantial area of bare earth within the impact sites with both methods obtaining similar results.

Data comparisons with trigger values show no increase of bare ground of more than 100 m^2. No trigger of this parameter was observed in the 2015 monitoring period.

5.2.5. Establishment of non-native weeds

Non-native weed presence was estimated by summing incidence recorded in each 0.5 m x 0.5 m quadrat centred on sequential 1 m intervals along each of the four parallel transects. Species name was recorded. This provided a total of approximately 80 quantitative measurements of weed presence per monitoring quadrat.

The main weed species previously observed in the monitoring sites are Catsear (*Hypochaeris radicata**) and Yorkshire Fog (*Holcus lanatus**). Spring monitoring detected the occurrence of weed species using both methods. Quadrat cover-abundance monitoring method detected the presence of Catsear in CCS01, while Yorkshire Fog was detected in LGG01 using the point intercept method. In both instances the two species continued to exhibit low cover abundance (i.e. 1). Yorkshire Fog was not previously detected in LGG01.

5.2.6. Conclusions

Monitoring results were compared with the flora trigger levels specified in the THPSS MMP. The results of this comparison are provided in **Table 18**.

Table 18. Monitoring results and flora trigger levels

Performance indicator	Parameter measured	Trigger level	Spring 2015
Change in species assemblage	Change in diversity of native species	A change in the number of species of greater than 30 % for a given site within a three year period.	Trigger in one impact site (WC02) and three reference sites (TG02, TRI01 and BS01).
	Recruitment of eucalypt species	An increase in eucalypts in an impact site compared to reference sites of more than three individual plants within a one year period.	No impact sites showed an increase in eucalypt recruitment beyond the trigger level. SSE01 has increased eucalypt recruitment approaching the trigger threshold.
Change in condition	Condition of key species	A decline in condition score at an impact site of more than 1.5 compared to the average condition score at reference sites within a one year period.	No impact sites showed a decrease in condition beyond the trigger level.
	Non-live ground cover	An increase of bare ground of more than $100m^2$ in a site within a three year period.	No impact sites showed an increase in bare earth beyond the trigger level.
	Non-native weeds	An increase in non-native weed species of more than 4 in a monitoring site (each having a cover of greater than 5%) compared to the average number in reference sites within a one year period.	No impact sites showed an increase in weed species beyond the trigger level. Invasive species previously detected in CCS01; recent detection in LGG01.

One trigger exceedance was observed for an impact site (WC02) and three for reference sites (TG02, TRI01 and BS01) during the 2015 monitoring period (winter and spring). Confounding environmental factors including weather, fire and logging were found to be active within the monitoring area. While inconclusive, the monitoring data indicates that prolonged dry and warm conditions on the Newnes Plateau are having a substantial impact on swamp condition and is likely to be acting independent of any mining related impacts. Unless future monitoring data indicates otherwise, it is considered that the trigger exceedances observed in 2015 are isolated and unrelated to any specific causal factor.

5.3. Groundwater

A specialist consultant is engaged by Centennial Springvale to analyse groundwater data results. The following sections summarise the results of the monitoring undertaken.

5.3.1. Swamp Results

Hydrographs in Figures 10 to 16 present the baseline level in the swamp monitoring network. The impact swamp hydrograph is shown in red across all the graphs with the reference swamps show in yellow, green blue and purple to help distinguish each series. The 95th percentile from the impact swamp derived between from data from 2005 to 2012 is show as a dashed orange line, and the 95th percentile derived from data between 2005 and 2014 is shown as a dashed pink line. The daily cumulative rainfall deviation (CRD) is presented on each graph as a black dashed line to allow for the interpretation of water level trends.

When the 95th percentiles were originally calculated between 2005 and 2012 the rainfall CRD was predominately influenced by an extended period of increased average rainfall between 2007 and 2012. Between 2012 and 2014 there has been an extended period of below average rainfall. Both 95th percentiles are displayed on the swamp graphs to show why most swamps have experienced decline in water level over the reporting period.

The figure below is an annotated hydrograph which compares standing water levels at SSE3 piezometer (the most permanently waterlogged monitoring site in Sunnyside East Swamp) and TS2 piezometers (a control site in Tri-Star Swamp) in the context of CRD. The figure clearly shows the ongoing impact of the 500mm rainfall deficit in 2013-2014 (almost half of the annual average rainfall) and the similarity in behaviour between SSE3 site and the TS2 control site in response to the most significant dry period sine 2006-07. It also illustrates the contrast in standing water level behaviour between the relatively wet period through 2010-12 and the dry period through 2013-14 (and subsequent ongoing effects in a period of normal rainfall through 2015).

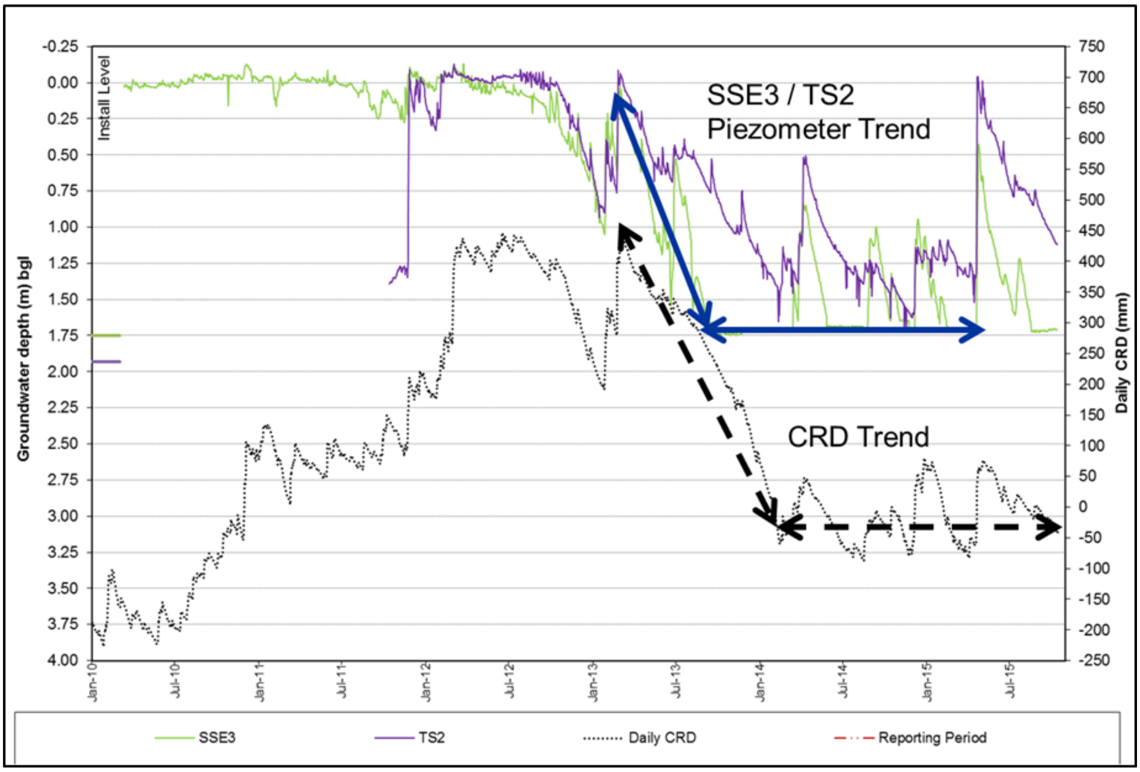

Figure 8 **Drought Impact (Sunnyside East Swamp Compared to Tri-Star Swamp)**

The following table presents a comparison of the baseline defined in the THPSSMP to the recalculated baseline based upon additional monitoring data presented prior to 200m from the piezometer location.

Table 19. Comparison of Swamp Piezometers 95th percentile

Impact Site	95th Percentile 2005-2012	95th Percentile 2005 to 2014	95th Percentile: difference between 2005-2012 and 2005-2014
SSE1	2.12	2.16	0.04
SSE2	0.7	0.86	0.16
SSE3	0.17	1.71	1.54
CW1	0.25	0.91	0.66
CW2	0.24	0.36	0.12
CW3	1.01	1.07	0.06
CW4	1.20	1.34	0.14

Sunnyside East

The water level at Sunnyside East Swamp is monitored at piezometers SSE1, SSE2 and SSE3. All three piezometers were installed in March 2010.

The following figure presents results for SSE1.

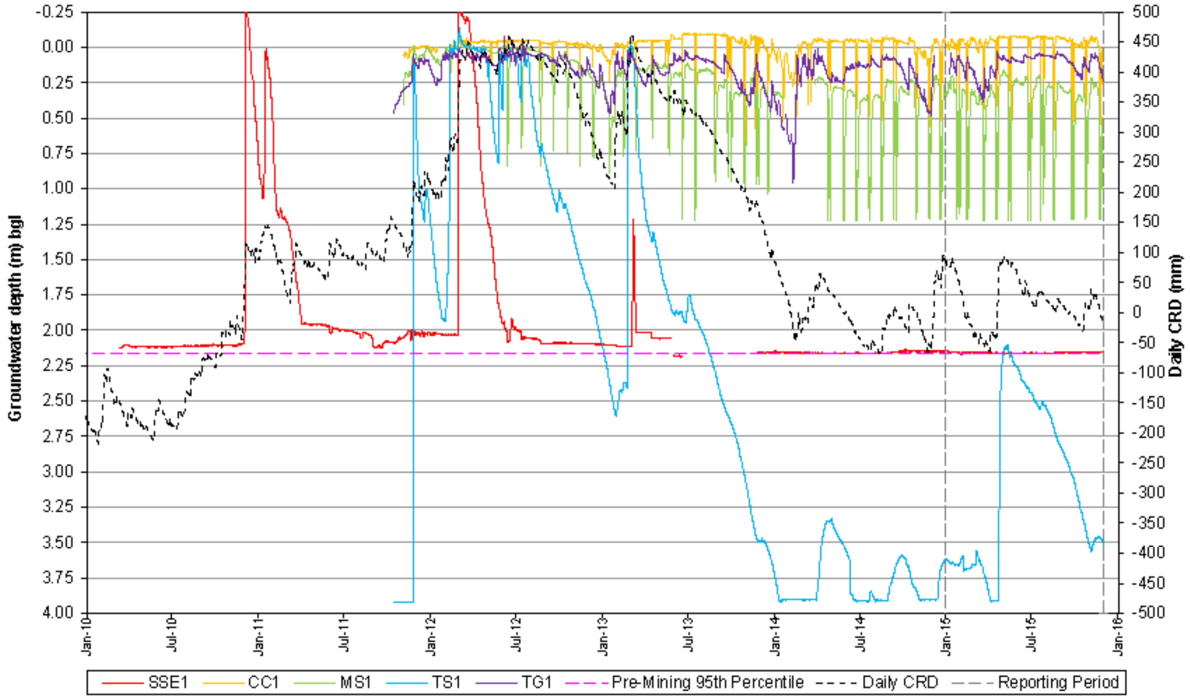

Figure 9 SSE1 Monitoring Data 2010 to 2016

SSE1 is the deepest of the three piezometers installed at Sunnyside East and has shown water levels to be typically 0 to 0.1m above the logger throughout 2015. These levels indicate that the sensors are measuring trapped water in the base of the piezometers and that actual swamp water levels are below the base of the piezometer. Therefore, these measurements are not representative of the water level in the surrounding horizon. Historically this site has shown some strong responses to rainfall but only after prolonged rainfall and higher than average seasonal rainfall. No responses to rainfall were observed in SSE1 in 2015. This is not uncommon for this piezometer, as frequently in previous years the water level in the piezometer remains unresponsive for durations of 8 to 10 months.

As the water level tends to remain below the bottom of the piezometer it is difficult to determine any mining influences at this location.

The recalculated 95th percentile has increased by 0.04m (Table 24) with the inclusion of data up until mining was within 200m of the piezometer.

SSE1 has exceeded the short term trigger level to initiate an investigation during the passing of LW416. The water level remained beneath the trigger level throughout the extraction of LW417. Findings of trigger investigations conducted is discussed in Section 6.3.

The following figure presents results for SSE2.

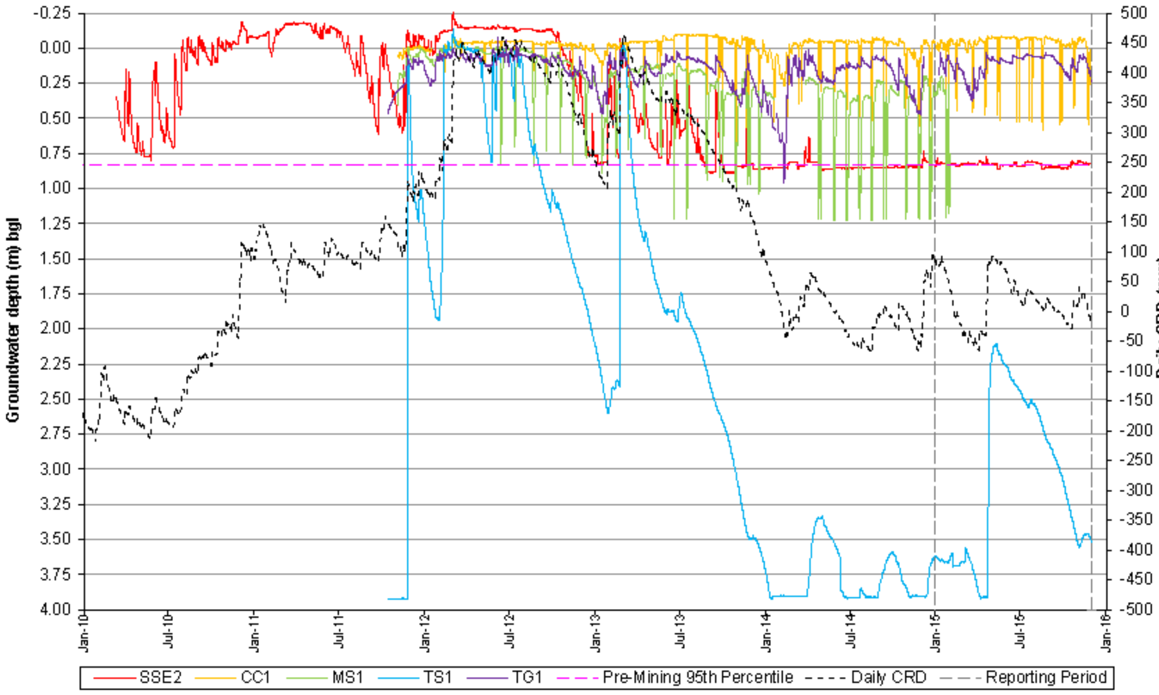

Figure 10 SSE2 Monitoring Data 2010 to 2016

The water level in SSE2 has predominantly remained below the base of the piezometer since 2013 following a period of decline that started in March 2013. The onset of this decline coincides with a prolonged period of below average rainfall, which has continued up to early 2014. Only minor water level responses are observed in this piezometer over the review period, however they do suggest that natural water levels are being observed as opposed to water trapped within the base of the piezometer.

The initial decline observed at SSE2 shows a similar, and more subdued, trend to reference swamp TG1. While it is difficult to make comparison with the water levels from 2014 onwards, it is worth noting that TG1 has only shown one water level response above the equivalent level to when SSE2 declined below the base of the piezometer in 2013 (approximately 2.5mbgl). This suggests that the responses observed during the reporting period are possibly due to natural climatic variations.

The recalculated 95th percentile has increased by 0.13m (Table 24) with the inclusion of data up to until mining was within 200m of the piezometer.

SSE2 has exceeded the short term trigger level to initiate an investigation during the passing of LW416. The water level remained beneath the trigger level throughout the extraction of LW417. Findings of trigger investigations conducted is discussed in Section 6.3.

The following figure presents results for SSE3.

There has been no mining within 200m of SSE3. Data presented is therefore considered baseline.

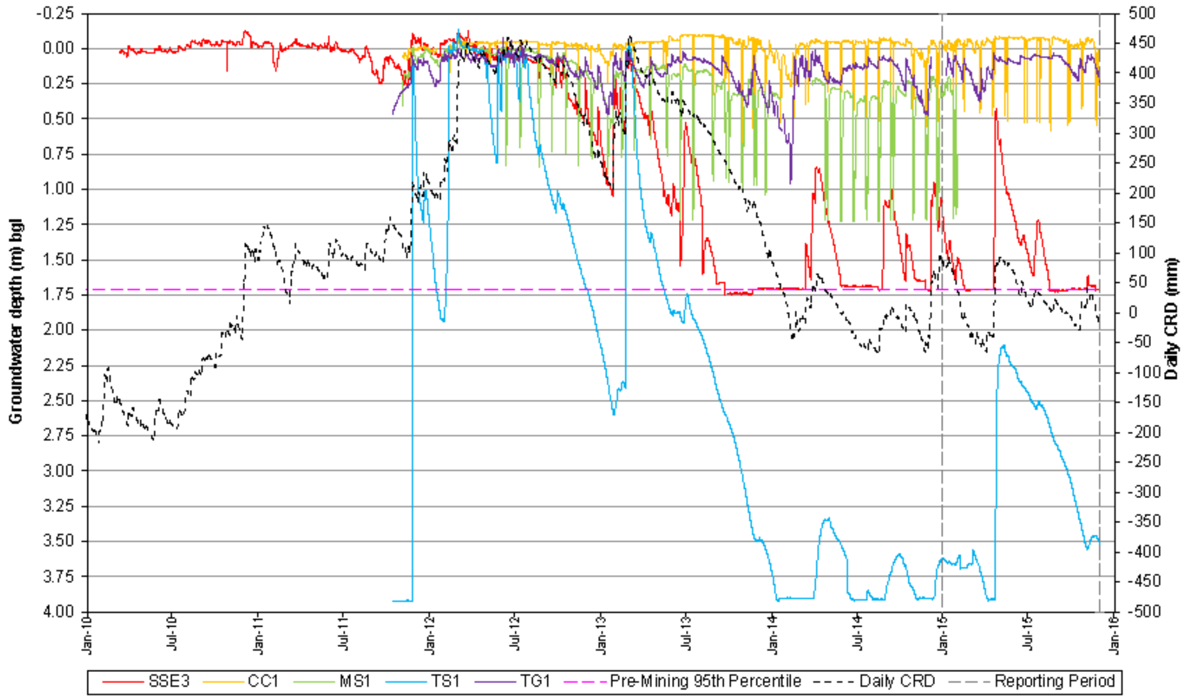

Figure 11 SSE3 Monitoring Data 2010 to 2016

SSE3 water levels have shown a very similar pattern to those in SSE2 with a decline from approximately ground level during the latter half of 2012 and commencing the current review period at around 1.7mbgl. The onset of this decline coincides with a prolonged period of below average rainfall, which has continued up to March 2014. During the current review period, SSE3 showed definitive responses to the two significant rainfall events of 2015 – in December/January and in April. Overall, during 2015, despite being below the base of the piezometer for considerable periods, the water levels showed a characteristic rainfall influenced trend only rising after prolonged and significant rainfall events.

SSE3 is responsive to moderate rainfall intensity events as well as extended period of below average rainfall. SSE3 shows similar trends to both SSE2 and TG1 although more accentuated. This highlights that the responses observed during the reporting period are likely due to natural climatic variations.

The recalculated 95th percentile has increased by 1.24m (Table 24) with the inclusion of data up to until mining was within 200m of the piezometer.

SSE3 has exceeded the short term trigger level to initiate an investigation during the passing of LW417. Findings of trigger investigations conducted is discussed in Section 6.3.

Carne West

The water level at Carne West Swamp is monitored at piezometers CW1, CW2, CW3 and CW4. CW1 and CW2 were installed in May 2005 while CW3 and CW4 were installed in October 2011 at the southern end of the swamp.

The following figure presents results for CW1.

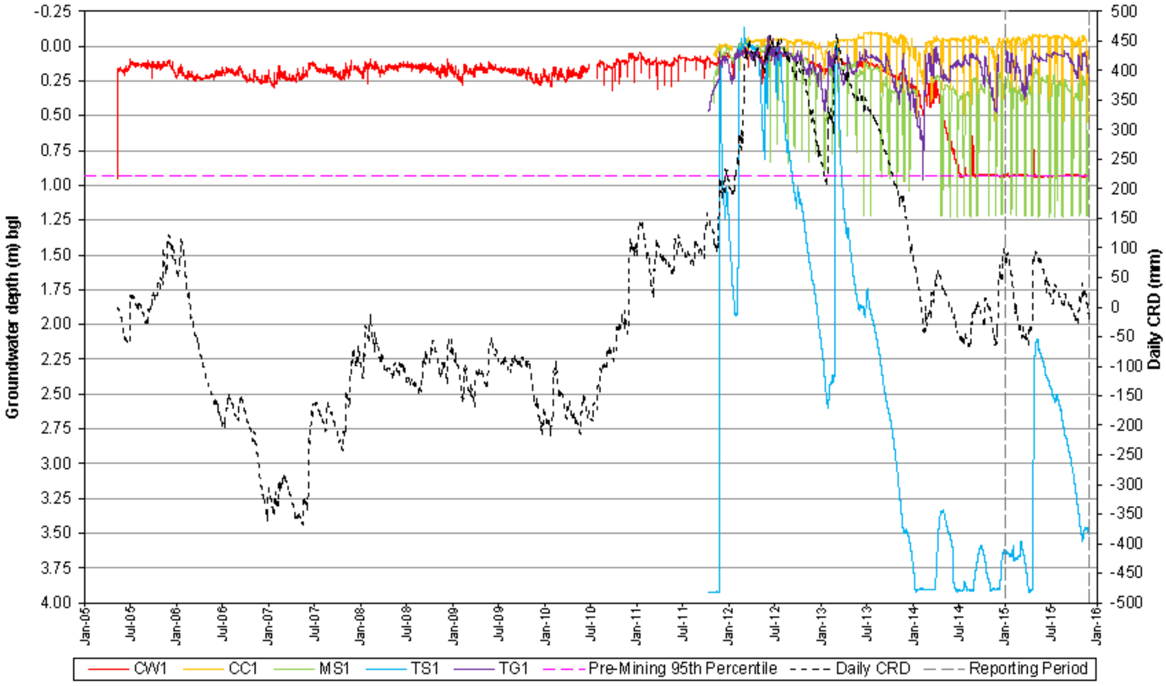

Figure 12 CW1 Monitoring Data 2005 to 2016

The water level observed in CW1 has shown a significant drop during 2014 and during the current review period has remained below the bottom of the casing. This decline started in March 2013 and continued throughout 2014 until the water level reached the bottom of the piezometer (approximately 0.92mbgl) in mid-July. This level represents the lowest water level since monitoring began. The water level has remained beneath the base of the piezometer throughout 2015.

CW1 has typically shown similar fluctuation magnitudes to reference sites CC1, MS1 and TG1. The rapid water level decline is not typical for the swamp and indicates there may be a loss of baseflow to the swamp. Whether this is mine related or due to the steady decline observed in the regional groundwater table is unclear.

The recalculated 95^{th} percentile has increased by 0.68m (Table 24) with the inclusion of data up until mining was within 200m of the piezometer.

CW1 has exceeded the short term trigger level to initiate an investigation during the passing of LW418. Findings of trigger investigations conducted is discussed in Section 6.3.

The following figure presents results for CW2.

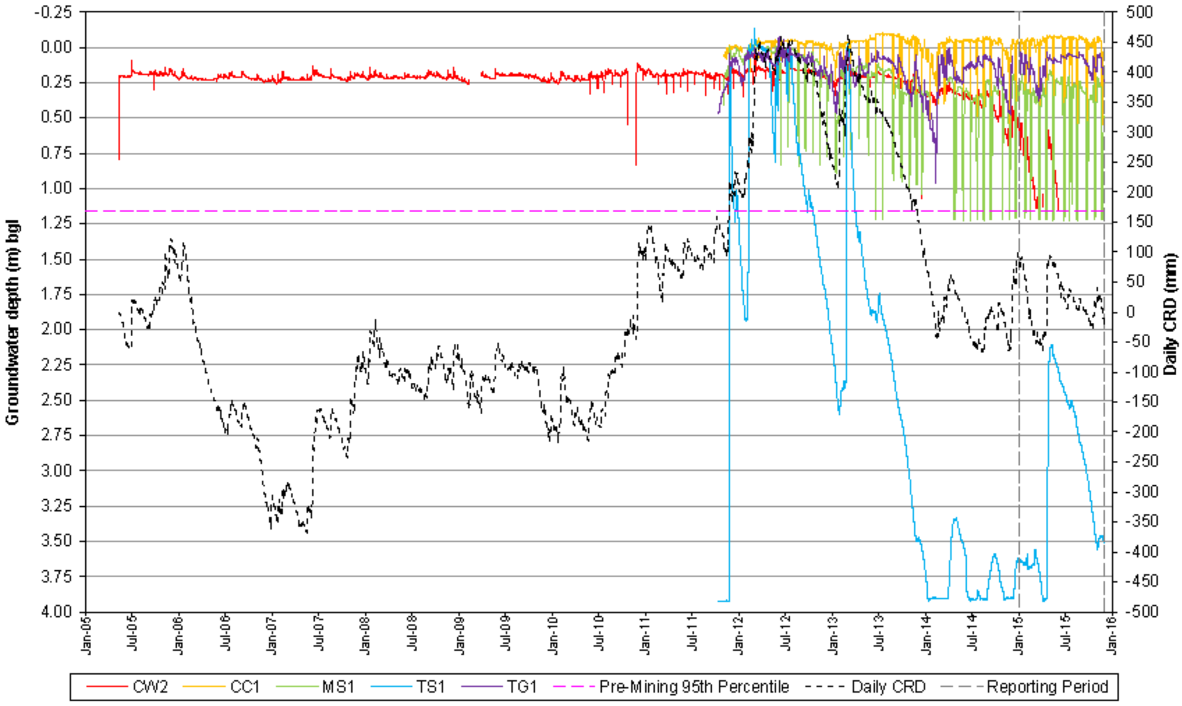

Figure 13 CW2 Monitoring data 2005 to 2016

The water level observed CW2 has shown a decline in standing water level throughout 2014 and into the current review period. The water level dropped below the base of the piezometer in March 2015. A short lived response to rainfall in April is observed followed by a rapid decline to below base of piezometer. No more responses are observed for the remainder of the review period.

CW2 has typically shown similar fluctuation magnitudes to reference sites CC1, MS1 and the recent decline is uncharacteristic and not consistent with responses observed at any of the reference swamps.

The recalculated 95th percentile has increased by 0.92m (Table 24) with the inclusion of data up to until mining was within 200m of the piezometer.

CW2 has exceeded the short term trigger level to initiate an investigation during the passing of LW418. Findings of trigger investigations conducted is discussed in Section 6.3.

The following figure presents results for CW3.

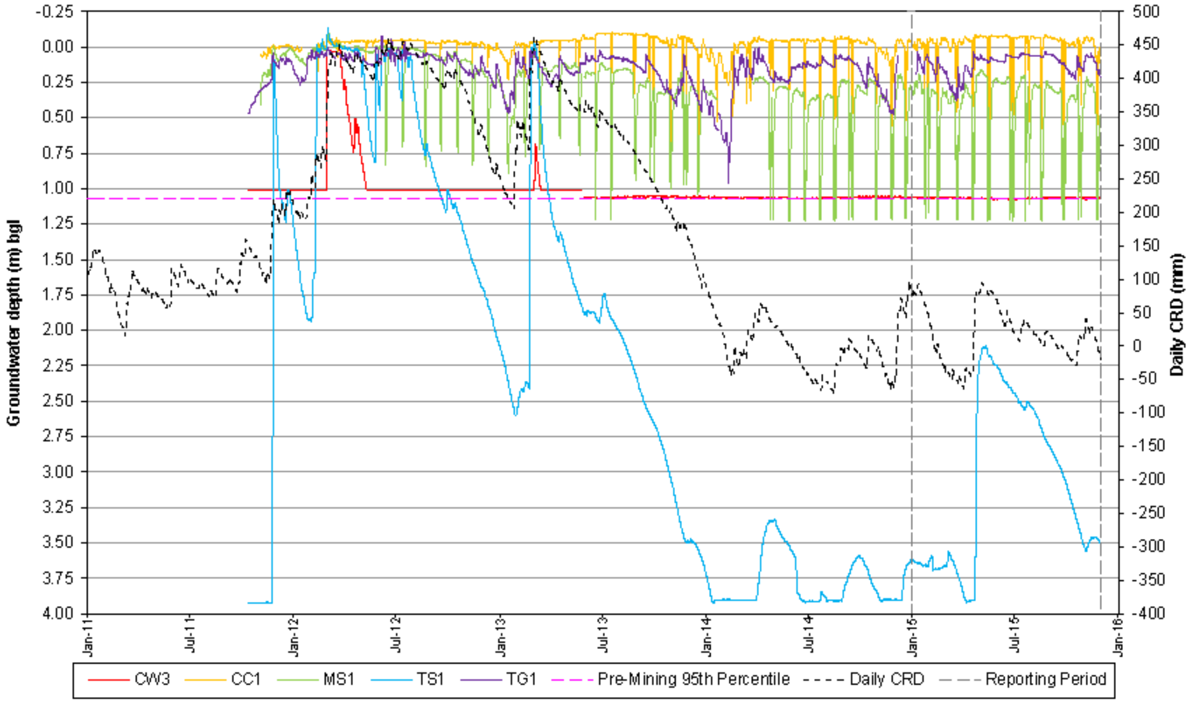

Figure 14 CW3 Monitoring data 2011 to 2016

The water level in CW3 remained below the base of the piezometer throughout the current review period. Since monitoring was initiated CW3 has only responds to significant and prolonged rainfall events on two occasions, once in march 2012 and again in February 2013. The characteristic response for this piezometer comprises rapid rises and subsequent declines in water level to a depth below the base of the piezometer. As described previously, a prolonged period of below average rainfall occurred from approximately March 2013 to March 2014. The hydrograph indicates that the influence of this period of below average rainfall was significant enough to lower the water level to a point where the two above average rainfall periods in 2014 did not result in observed water levels above the bottom of the piezometers in CW3.

The responses seen at CW3 are similar to those observed in reference site TS1. However, it is considered that there is too little data to be able to make any comparison.

The recalculated 95th percentile has increased by 0.06m (Table 24) with the inclusion of data up to until mining was within 200m of the piezometer.

CW3 exceeded the short term trigger level to initiate an investigation during the passing of LW417. A trigger notification was raised. Findings of trigger investigations conducted is discussed in Section 6.3.

The following figure presents results for CW4.

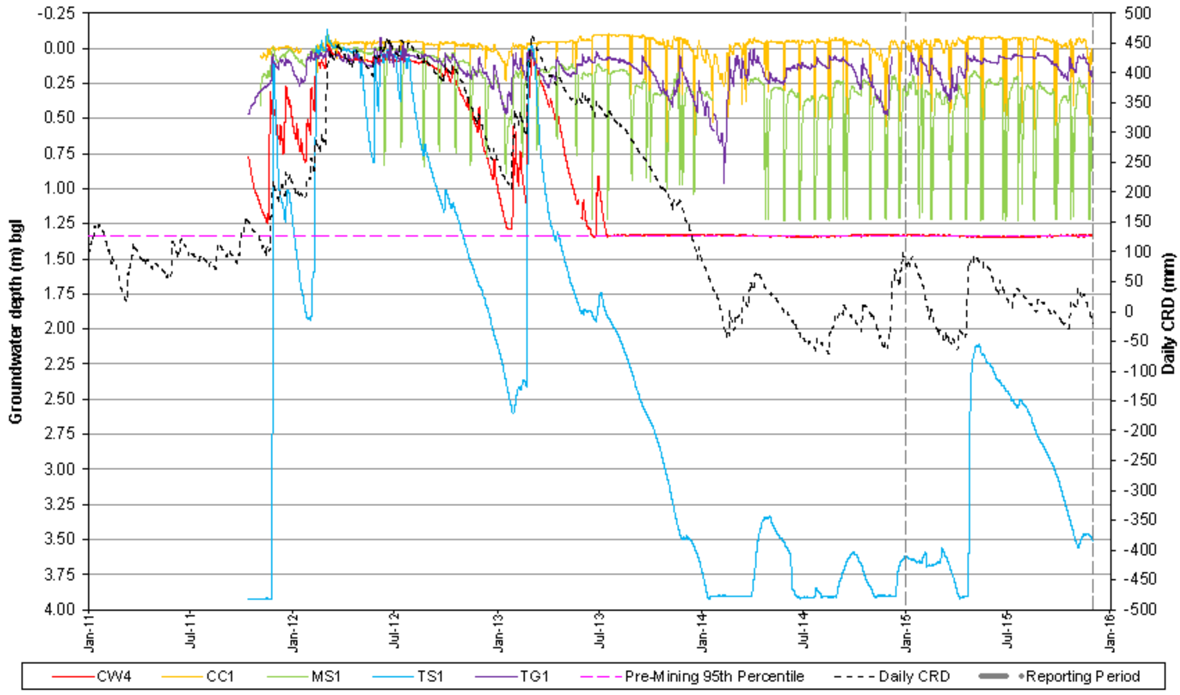

Figure 15 CW4 Monitoring Data 2011 to 2016.

The water level in CW4 remained beneath the base of the piezometer throughout the review period. Since monitoring was initiated CW4 has been highly responsive to rainfall events and water levels correspond closely with the CRD. With continued below average rainfall water levels at CW4 rapidly decline to a depth below the base of the piezometer.

CW4 has typically shown similar groundwater fluctuations as observed in reference sites TG1 and TS1 and is intermediate between the two.

The recalculated 95th percentile has increased by 0.13m (Table 15) with the inclusion of data up to until mining was within 200m of the piezometer.

CW4 exceeded the short term trigger level to initiate an investigation during the passing of LW417. A trigger notification was raised. Findings of trigger investigations conducted is discussed in Section 6.3.

5.3.2. Aquifer Results

There are six impact ridge piezometers impact swamps including RSS, SPR1110, SPR1104, SPR1107, SPR1109, and SPR1110 monitor the groundwater level in the near-surface unconfined aquifers in the Burralow Formation and Banks Wall Sandstone. Ridge piezometers are equipped with water level data loggers.

Hydrographs in Figures 17 to 22 present the water level in the regional aquifer groundwater monitoring network. The styling of the series used in each of these graphs follows that of the swamp hydrographs as discussed previously.

As discussed with the swamp results, the following table presents a comparison of the baseline defined in the THPSSMP to the recalculated baseline based upon additional monitoring data presented prior being within 200m of the instruments.

Table 20. Comparison of Regional aquifer piezometers 95th Percentile

Impact Site	95th Percentile 2005-2012	95thPercentile 2005 to 2014	95th Percentile: difference between 2005-2012 and 2005-2014
RSS	29.52	29.80	0.28
SPR1101	36.08	N/A	N/A
SPR1104	25.28	26.85	1.57
SPR1107	22.50	24.50	2.00
SPR1109	36.19	41.50	5.31
SPR1110	58.78	65.26	6.48

RSS

The following figure presents results for RSS.

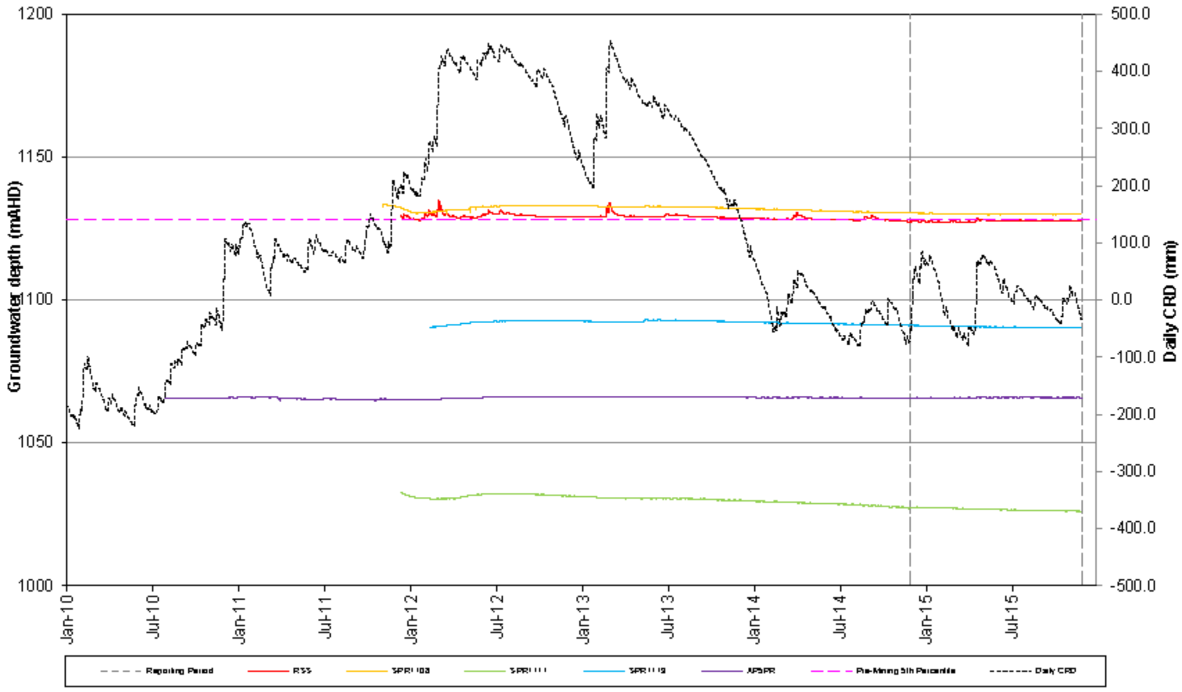

Figure 16 RSS Monitoring data 2010 to 2016

RSS is located directly overlying LW415. Apart from a slight rise in April, the water levels in this piezometer maintained a steady trend throughout 2015 with the stabilisation of a decline during previous years.

The recalculated 95th percentile has increased by 3.24m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

SP1101

The following figure presents results for SP1101.

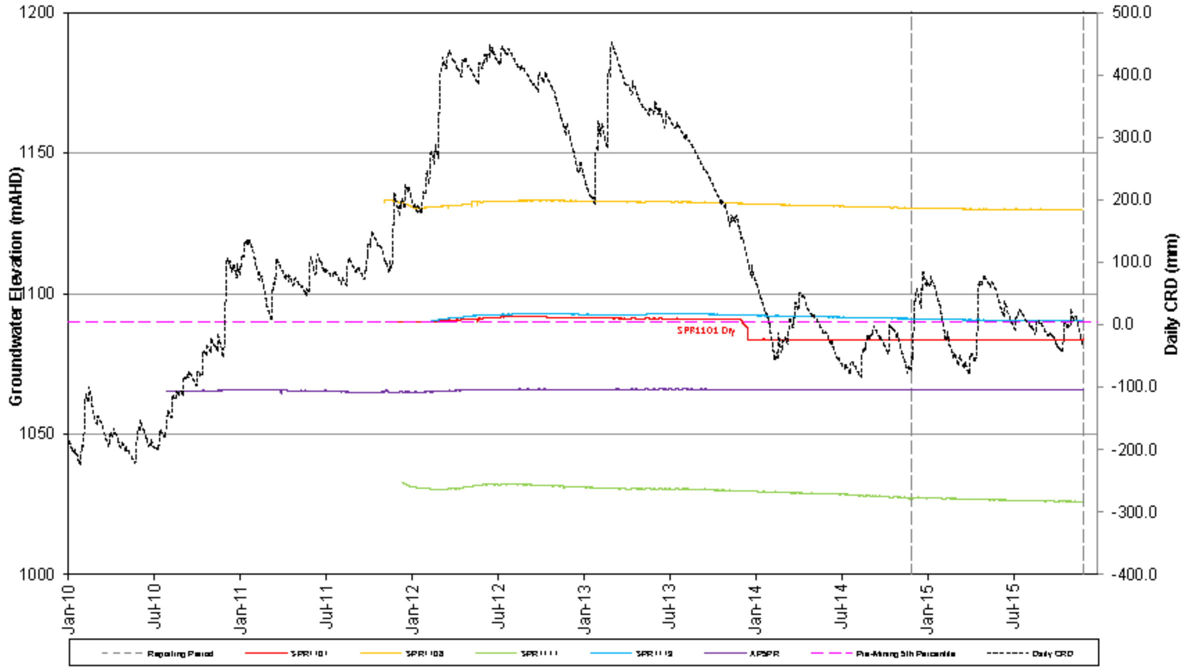

Figure 17 SP1101 Monitoring Data 2010 to 2016

The water level in this borehole has typically remained relatively stable at 35mbgl throughout its monitoring history. However, the water level began to decline on 3 December 2013 to 42.29mbgl on 22 December 2013. This represents a drop of 6.99m to a level below the bottom of the piezometer as the piezometer is dry. This period also corresponds to the time when LW416 was passing underneath. An investigation into the reason for the rapid drop in the water level in this monitoring point has been conducted. The investigation found that the piezometer hole was previously used as an exploration borehole and was drilled to a depth which intersected strata where bed separation effects and increased storage occurred, and while the water level has declined, it does not represent any net loss of water from the aquifer.

The replacement of SPR1101 with a deeper piezometer to intercept the reduced water level has been completed (SPR1401). A groundwater level logger was installed in this piezometer on 20 November 2014. The water level in SPR1401 declined to around 35mbgl in mid-2015 and then stabilised. The stabilisation confirms the decline to be due to bed separation effects.

The recalculated 95th percentile has increased by 0.87m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

Findings of trigger investigations conducted is discussed in Section 6.3.

SPR1104

The following figure presents results for SPR1104.

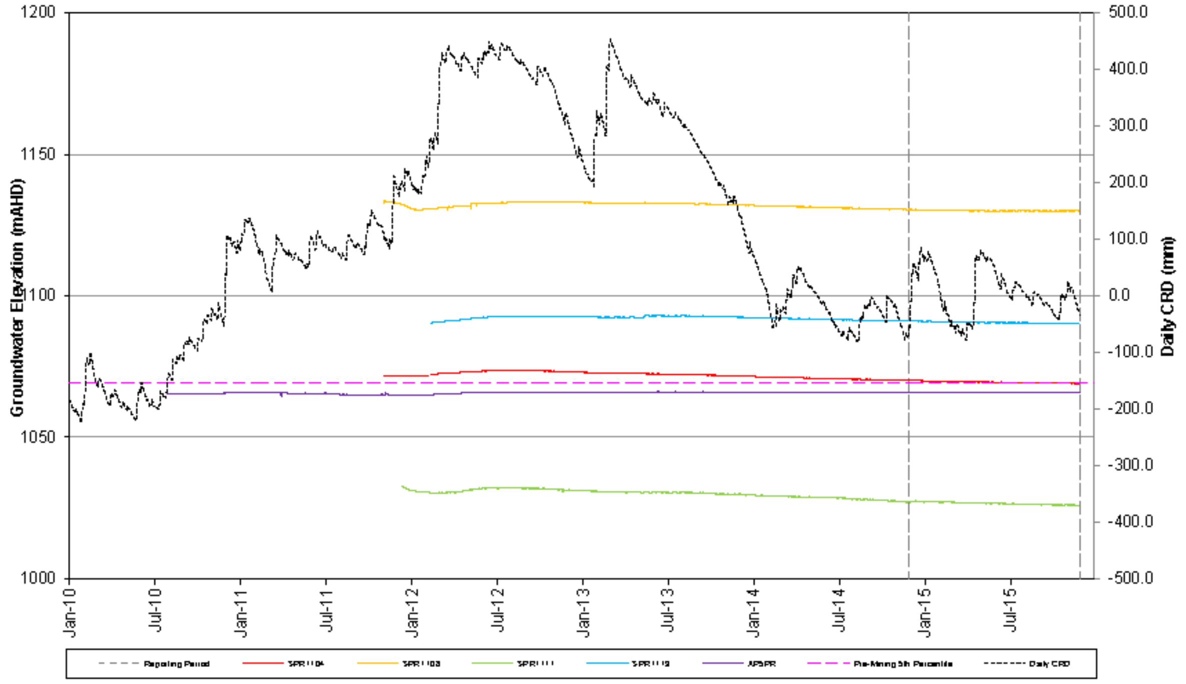

Figure 18 SPR1104 Monitoring Data 2010 to 2016

SPR1104 shows an almost identical groundwater level response to the reference piezometers SPR1113, SPR1108 and SPR1111, both historically and throughout the current review period. The groundwater level has gradually declined during the review period likely responding to longer term climatic influences.SPR1104 has not yet been undermined.

The recalculated 95th percentile has increased by 3.9m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

SPR1107

The following figure presents results for SPR1107.

Figure 19 SPR1107 Monitoring Data 2010 to 2016

SPR1107 shows similar groundwater level response to the reference piezometers SPR1113, SPR1108 and SPR1111, both historically and throughout the current review period. The groundwater level has gradually declined during the review period likely responding to longer term climatic influences. SPR1107 has not yet been undermined

The recalculated 95th percentile has increased by 7.5m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

SPR1109

The following figure presents results for SPR1109.

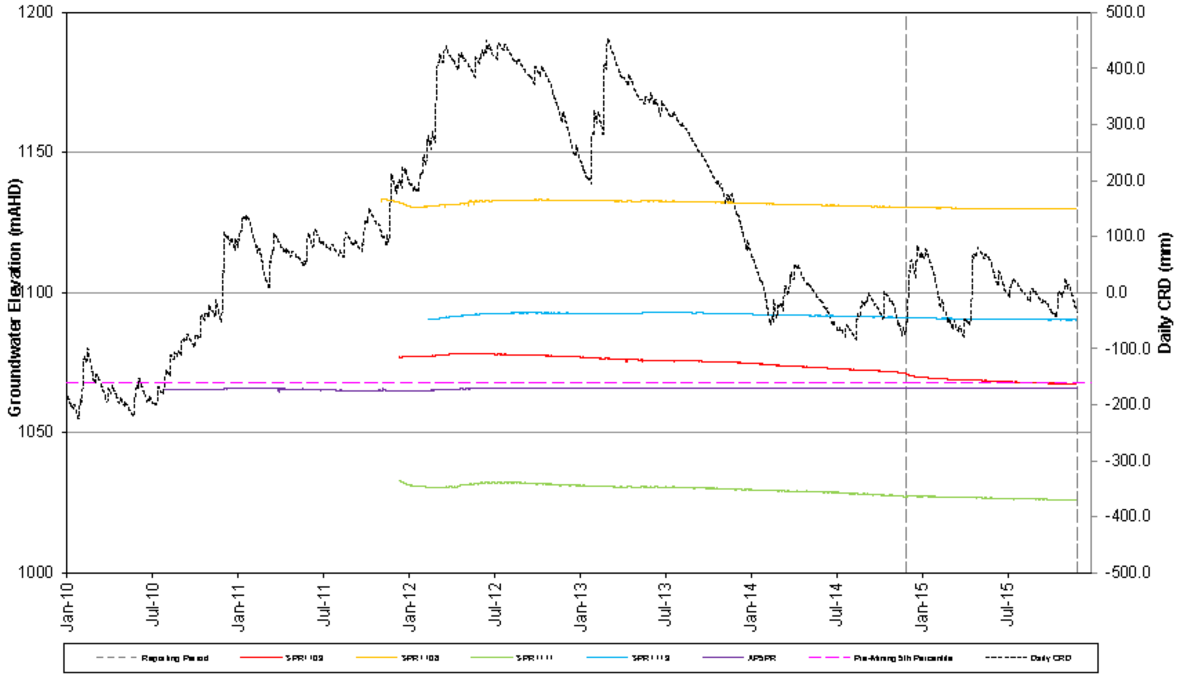

Figure 20 SPR1109 Monitoring Data 2010 to 2016

SPR1109 shows similar groundwater level response to the reference swamps SPR1113, SPR1108 and SPR1111. A slight increased decline is apparent at SPR1109 at the start of the current review period that is not seen in the other piezometers, however the decline then reverts to a trend similar to SPR1111 and SPR1113. SPR1109 has exceeded the short term trigger level during the mining of LW418 to initiate an investigation.

The recalculated 95th percentile has increased by 10.6m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

Findings of trigger investigations conducted is discussed in Section 6.3.

SPR1110

The following figure presents results for SPR1110.

Figure 21 SPR1110 Monitoring Data 2010 to 2016

SPR1110 is located above LW417 panel, a declining trend is observed in this piezometer during January 2013 with water levels declining to below the base of the piezometer. It is possible that SPR1110 is responding to longer term climatic trends, however no response is observed to individual rainfall events and the decline may also be due to a bed separation effects following LW416 extraction.

The recalculated 95th percentile has increased by 6.7m (Table 25) with the inclusion of data up to until mining was within 200m of the piezometer.

5.3.3. Groundwater Quality

Groundwater monitoring samples are collected opportunistically based upon groundwater level which is presented in Section 5.3.1.

All data presented represents baseline condition as there has been no mining within 200m of the piezometer location.

There have therefore been no triggers during the reporting period.

CW1

Water quality data for CW1 are available until May 2014, after this date the piezometer was largely dry and unable to be sampled. No Samples were able to be obtained from CW1 throughout 2015. Historic results are presented for reference

The following figure presents pH results for CW1.

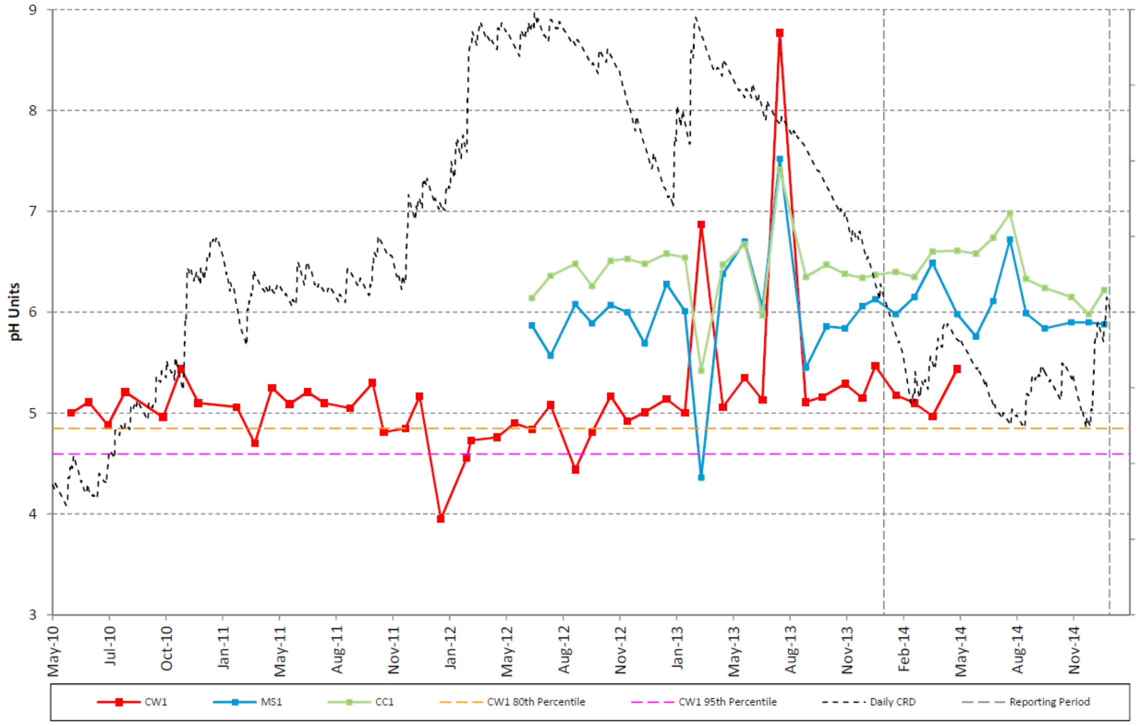

Figure 22 CW1 pH Monitoring Data Feb 2011 to 2015

The following figure presents Electrical Conductivity (EC) results for CW 1.

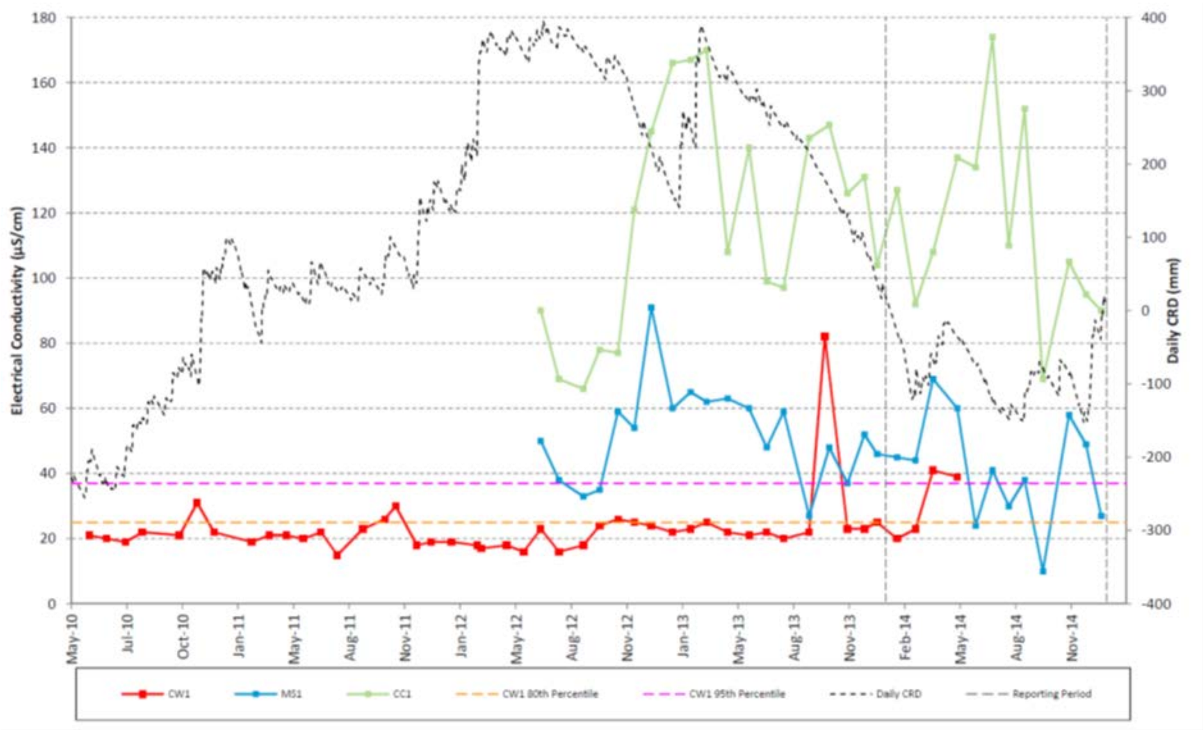

Figure 23 CW1 EC Monitoring Data Feb 2011 to 2016

The following figure presents Filterable iron results for CW1.

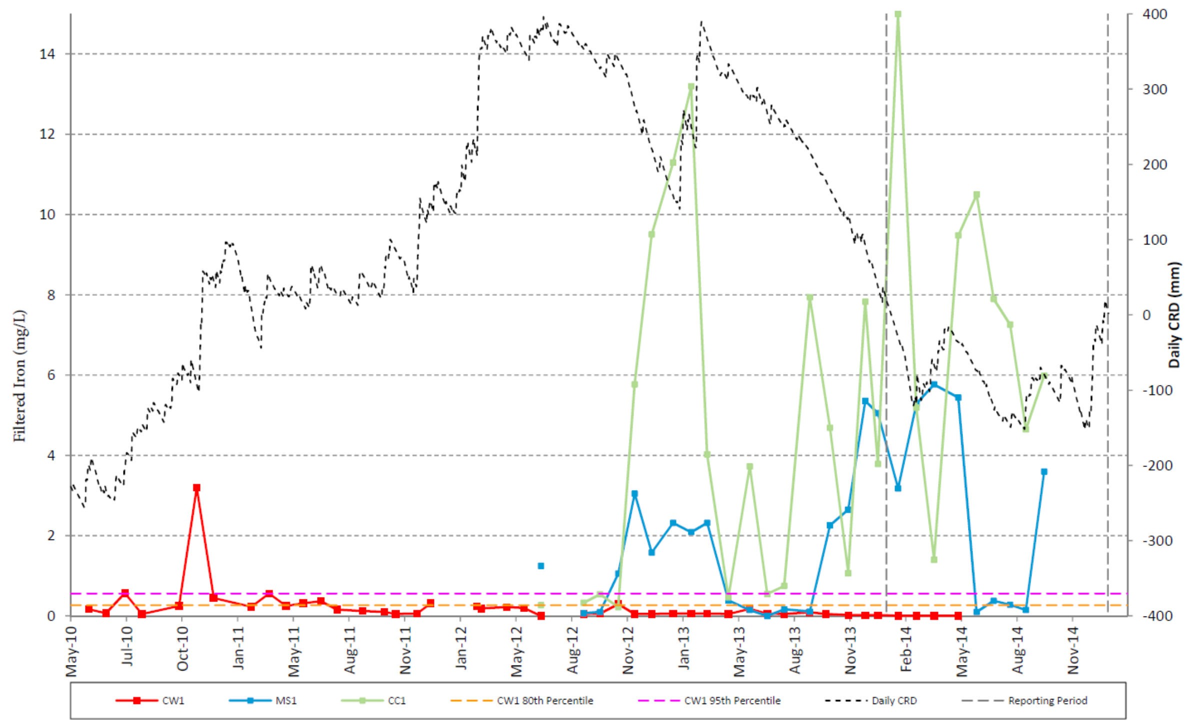

Figure 24 CW1 Filterable Iron Monitoring Data Feb 2011 to 2016

CW2

Water quality data for CW2 are available until May 2015, after this date the piezometer was largely dry and unable to be sampled. Only three samples were obtained from CW2 throughout 2015. Hostoric results are presented for reference

The following figure presents pH results for CW2.

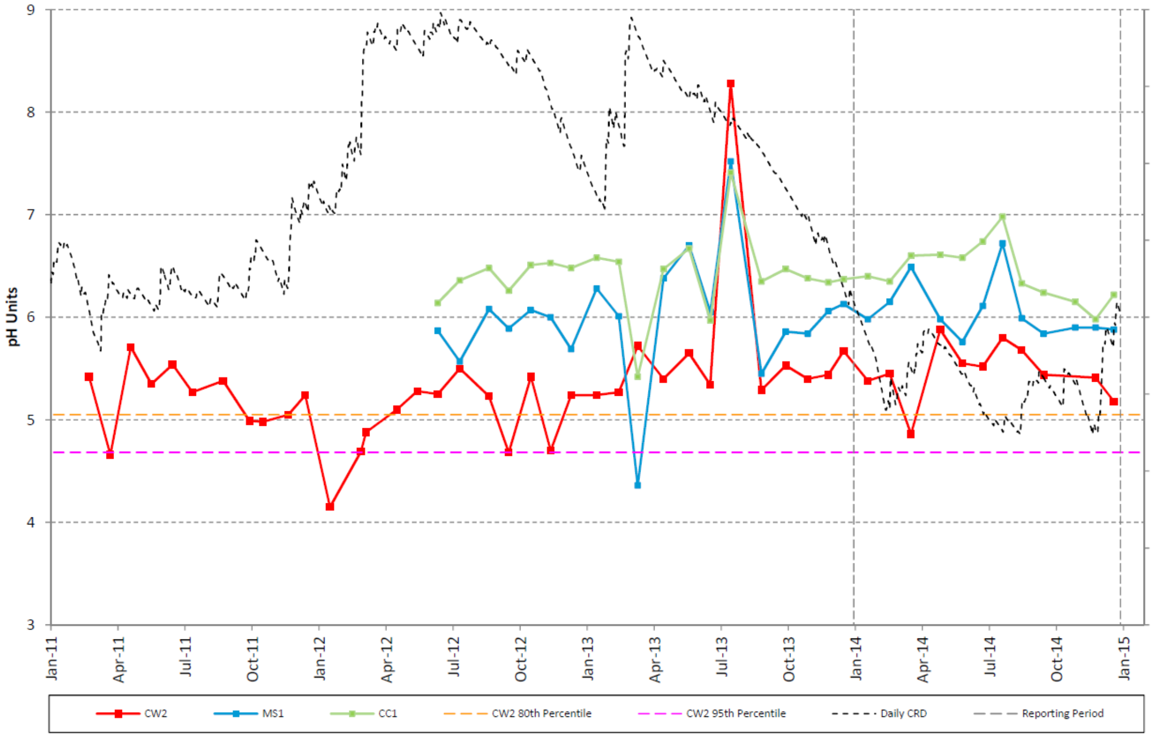

Figure 25 CW2 pH Monitoring Data Feb 2011 to 2016

The following figure presents EC results for CW2.

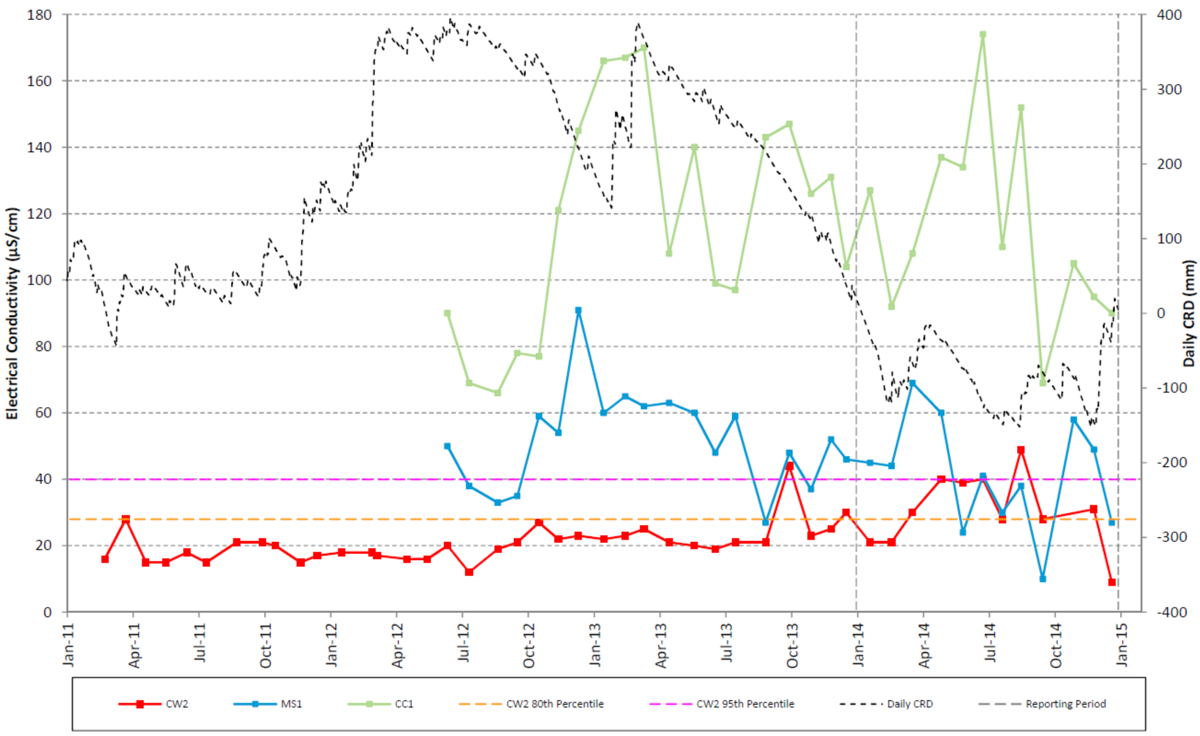

Figure 26 CW2 EC Monitoring Data Feb 2011 to 2016

The following figure presents filterable iron results for CW2.

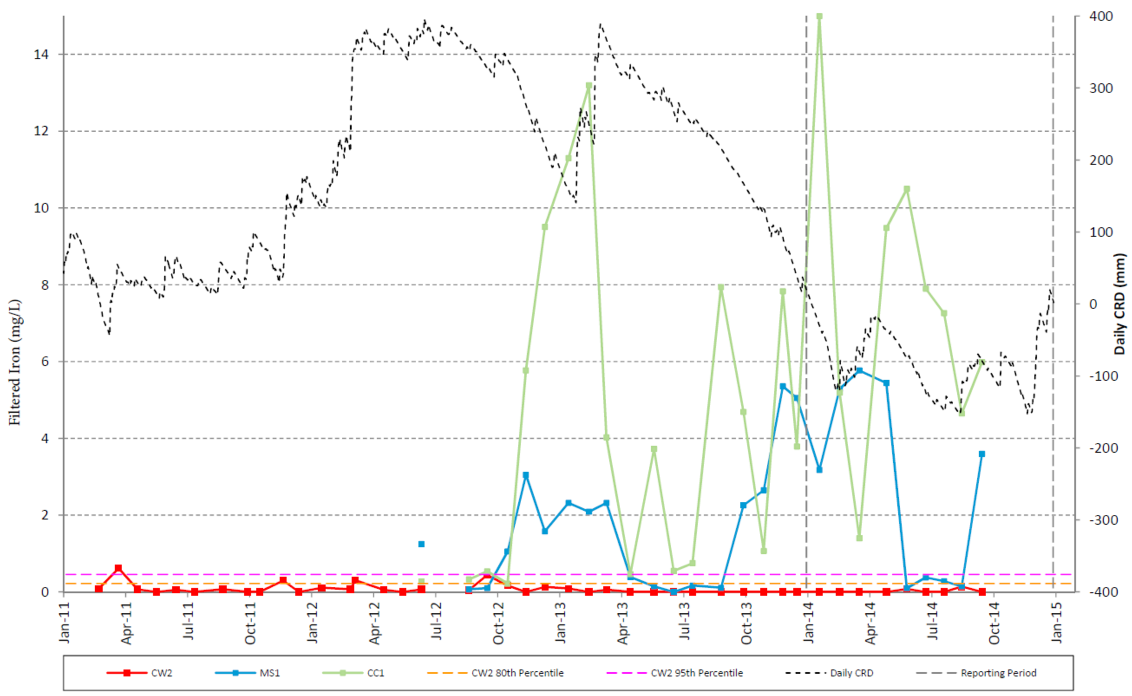

Figure 27 CW2 Filterable Iron Monitoring Data Feb 2011 to 2016

SSE3

A decline in water levels at SSE3 has meant that only limited sampling has been possible. Over the reporting period two samples for pH, EC and Fe have been obtained.

The following figure presents pH results for SSE3.

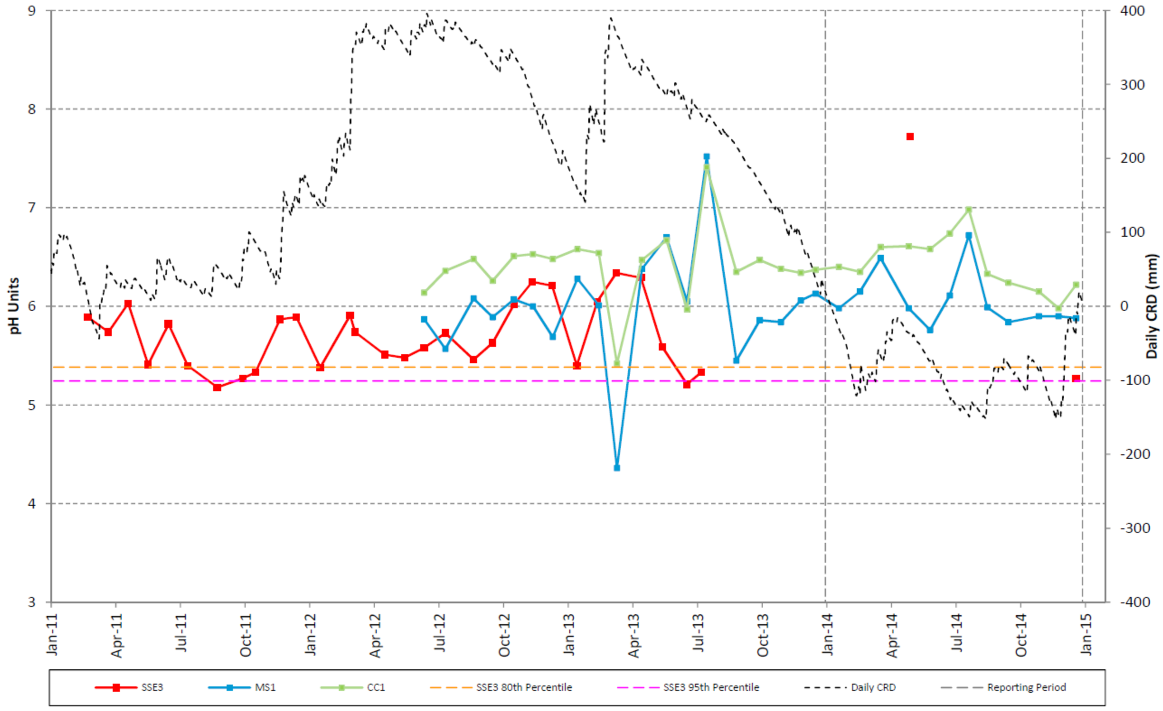

Figure 28 SSE3 pH Monitoring Data Feb 2011 to 2016

The pH at SSE3 has historically fluctuated between 5.2 and 6.3 pH units. These fluctuations are considered natural and are consistent with the reference swamps.

Over the review period both samples from SSE3 were below the 95th percentile for the entire review period.

The following figure presents EC results for SSE3.

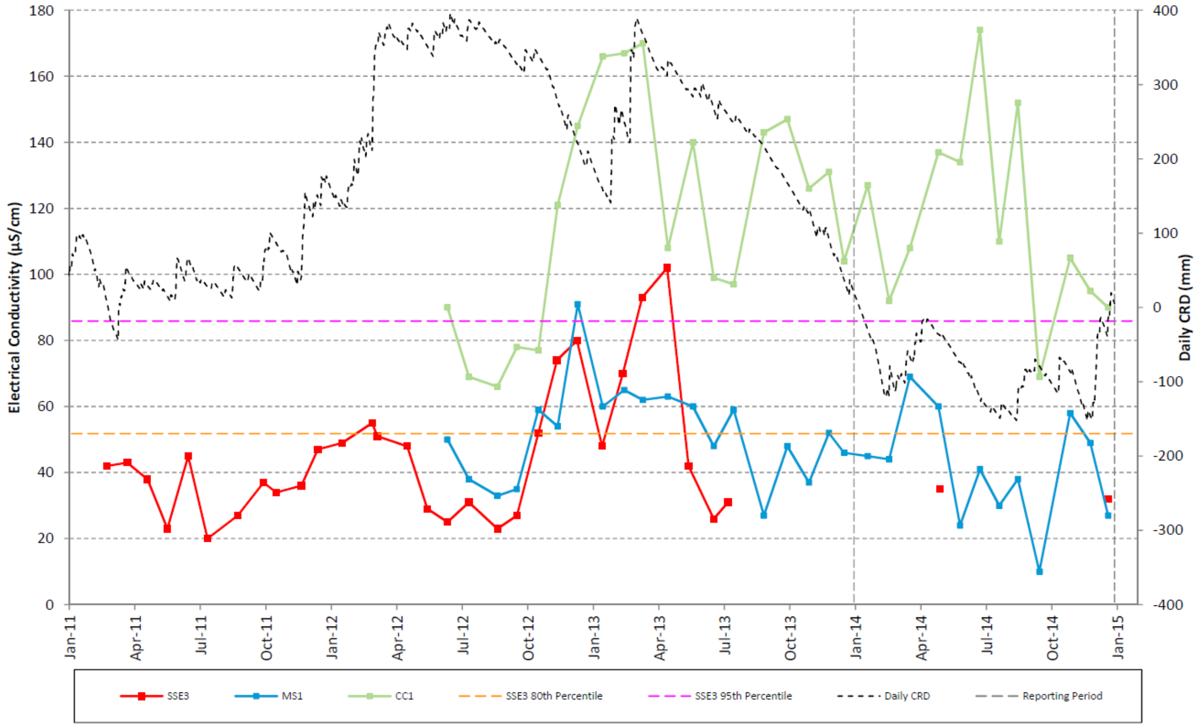

Figure 30 SSE3 EC Monitoring Data Feb 2011 to 2016

The EC at SSE3 is generally very fresh, historically ranging between 20 and 100µS/cm. This is similar to the MS1 reference site and less than the CC1 reference site.

During the review period the two measured EC values were well below the 80th and 95th percentile values.

The following figure presents filterable iron results for SSE3.

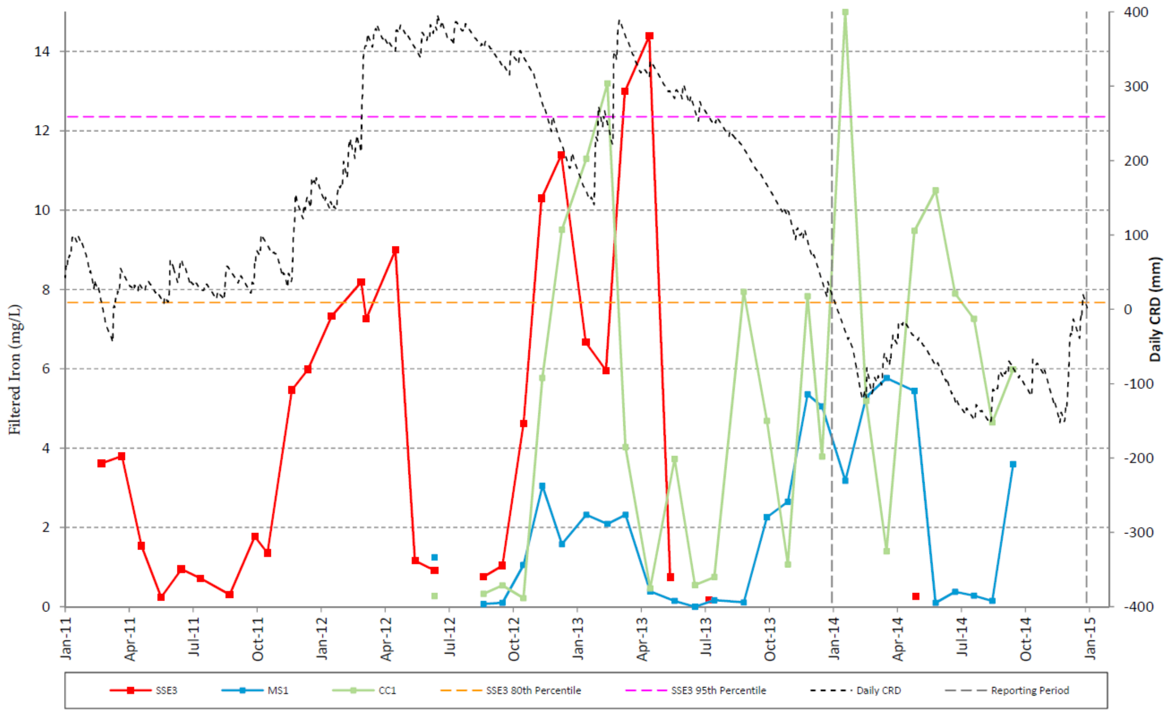

Figure 31 SSE3 Filterable Iron Monitoring Data Feb 2011 to 2016

The concentration of filtered iron at SSE3 has historically ranged between 0.18 and 14.4mg/L with elevated values correlating reasonably well with periods of above average rainfall.

Both samples obtained during 2015 were below the 80th and 95th percentiles.

5.4. Surface Water

Surface water monitoring samples are collected opportunistically based upon groundwater level flow rates.

All data presented represents baseline condition as there has been no mining within 200m of the piezometer location.

There have therefore been no triggers during the reporting period

5.4.1. Carne West

Flow rate

The following figure presents flow rate monitoring results for Carne West.

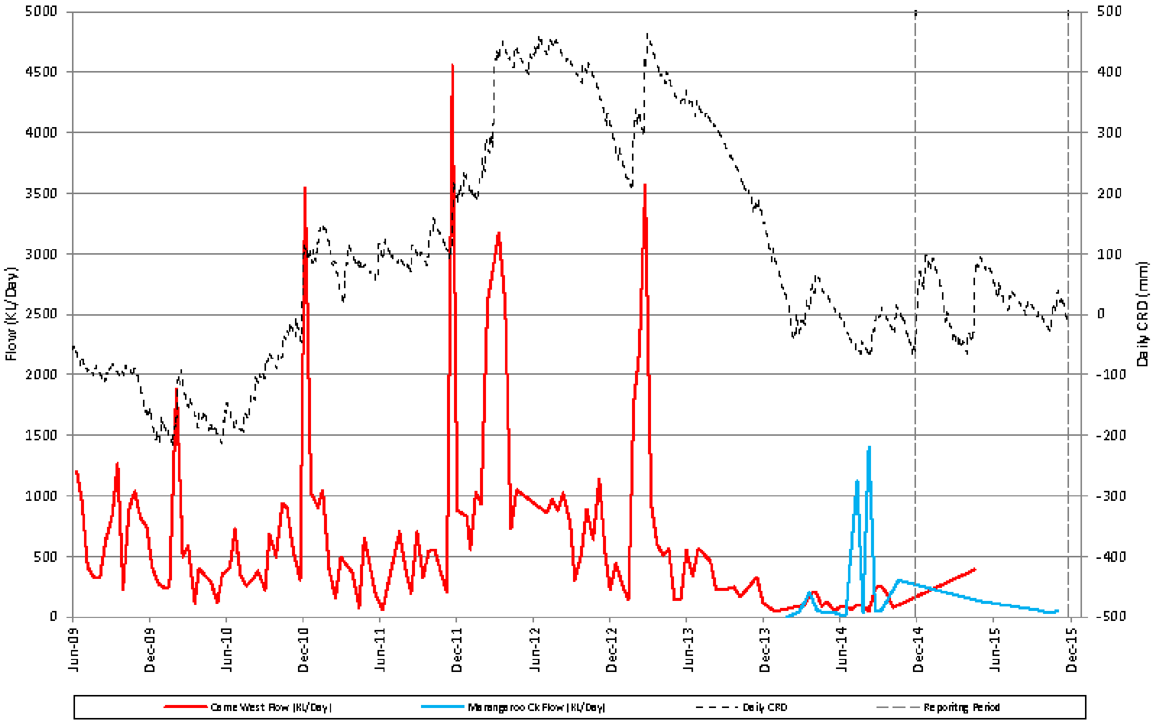

Figure 32 Carne West Flow Monitoring Results June 2009 to 2016

Flow volumes downstream of Carne West Swamp are shown on Figure 17. The flows show a close correlation with the CRD, increasing during periods of above average rainfall and spiking with large rainfall events.

Over the current review period flows at both sites were relatively low and responses to the larger rainfall events of December and April are not evident, although higher flows were recorded at Carne West in April. It is noted that the lack of responses are largely due to the limited monitoring data over this period.

Water Quality

Carne West pH results are presented in the following figure.

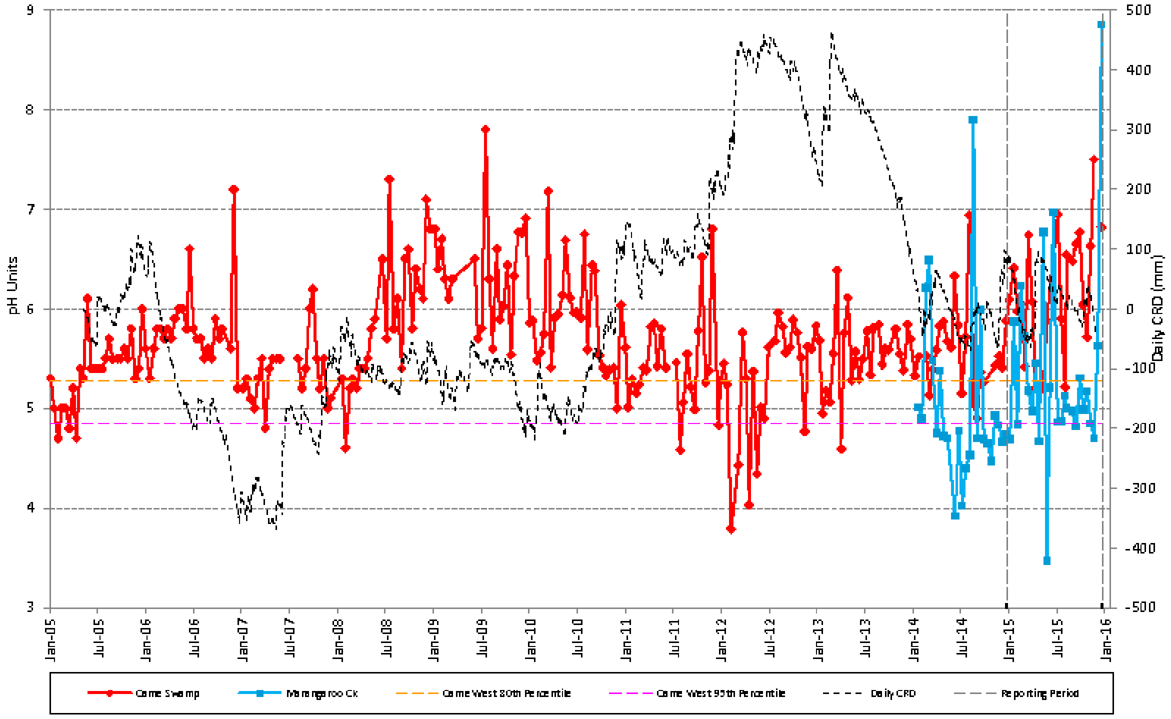

Figure 33 Carne West pH Monitoring Data 2005 to 2016

The pH at Carne West has historically fluctuated between 4 and 8 pH units. These fluctuations are considered natural given that the pH at Marrangaroo Creek fluctuates between similar levels

The pH at Carne West remained above the 95th Percentile for the entire review period and only rarely exceeded the 80th percentile. None of these exceedances were repeated so are interpreted as natural variations.

The following figure presents Carne West Electrical Conductivity (EC) results.

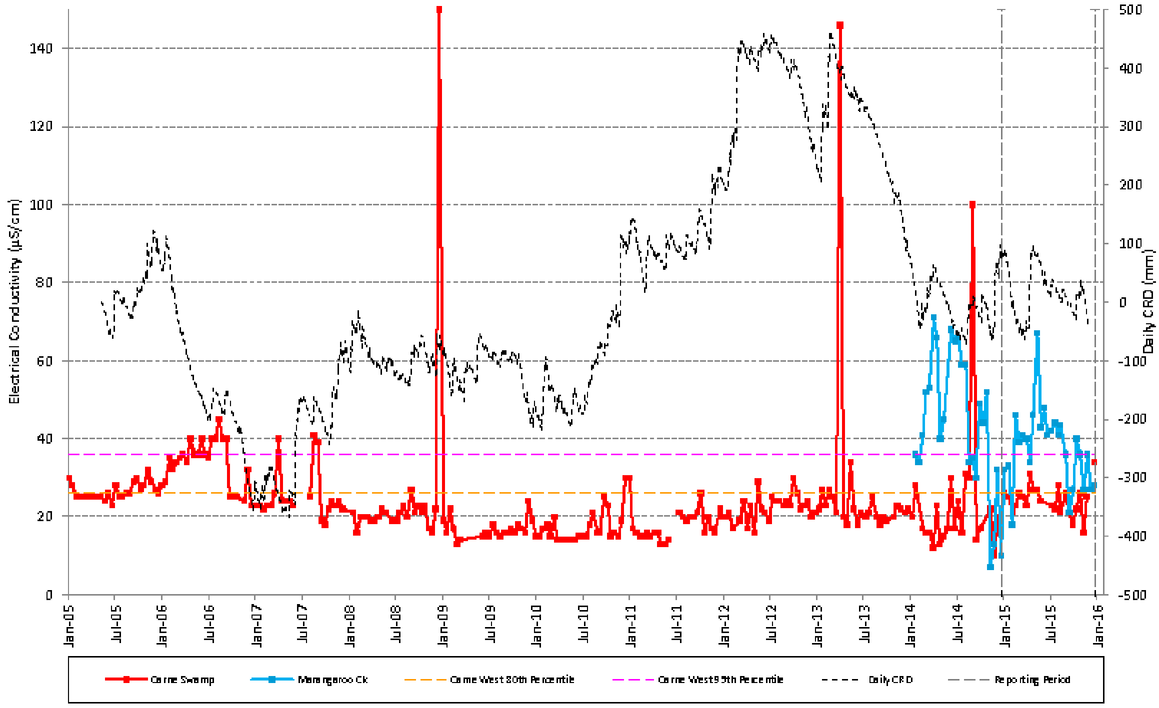

Figure 34 Carne West Monitoring Results 2005 to 2016

The EC at Carne West is extremely fresh ranging historically between 10 and 40µS/cm. which is close to the EC of rain water. Marrangaroo Creek has historically fluctuated between 10 and 70µS/cm, which is also considered fresh. The EC remained beneath the 95th percentile throughout the review period and rarely exceeded the 80th percentile.

The following figure present filtered manganese results for Carne West.

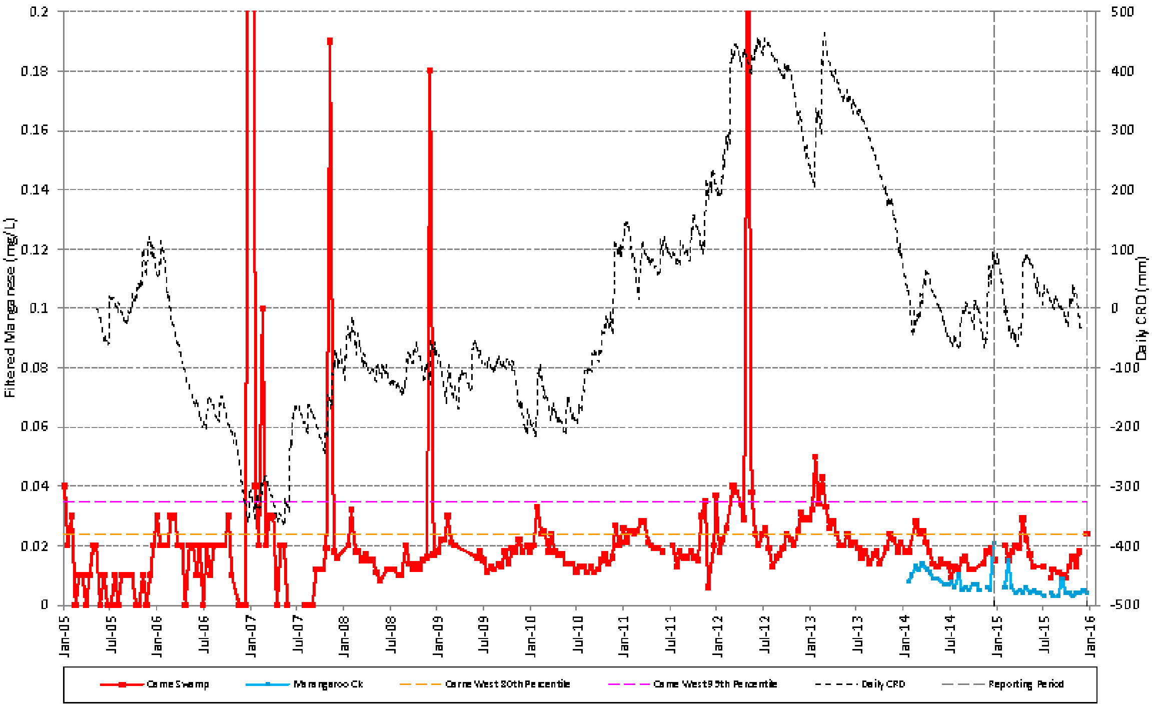

Figure 35 Carne West Manganese Results 2005 to 2016

The concentration of filtered manganese at Carne West historically fluctuates between 0 and 0.05mg/L with occasional spikes recorded during periods of increased rainfall. These results are similar to those recorded at Marrangaroo Creek. The concentrations remained beneath the 95th percentile throughout the review period and rarely exceeded the 80th percentile.

The following figure present filtered iron results for Carne West.

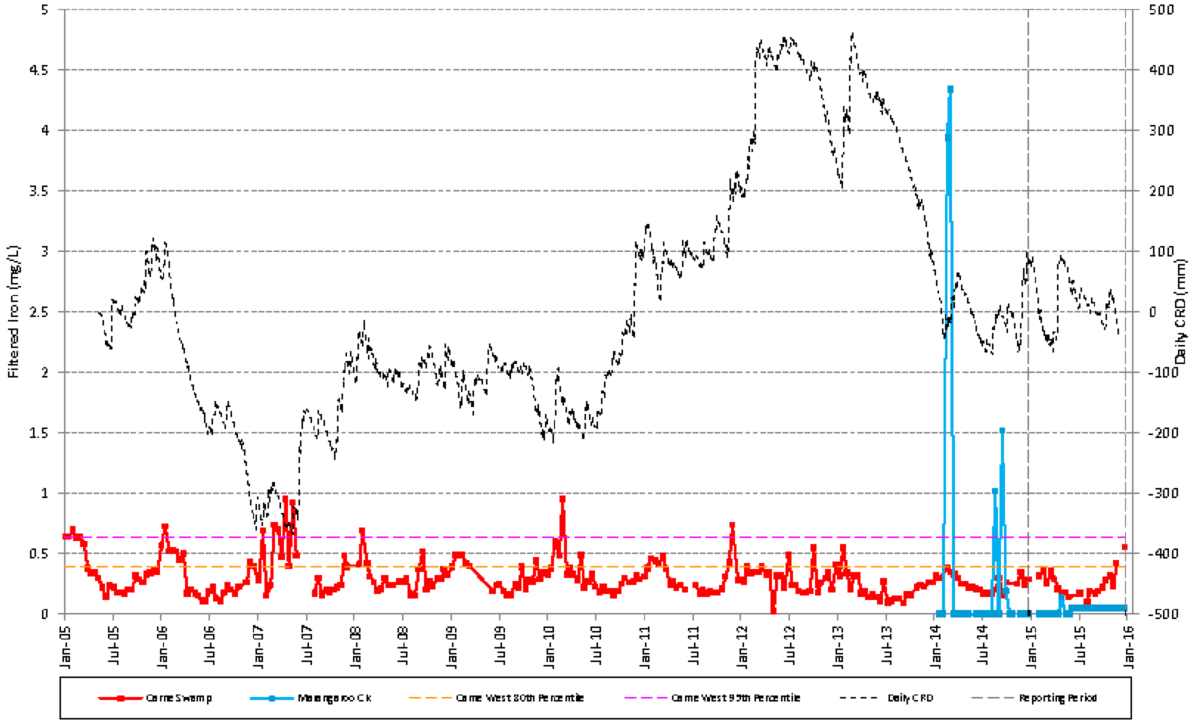

Figure 36 Carne West Filterable Iron Results 2005 to 2016

The concentration of filtered iron at Carne West historically fluctuates between 0.1 and 1.0mg/L with occasional spikes recorded during periods of increased rainfall. These results are similar to those recorded at Marrangaroo Creek. Concentrations remained within historic levels throughout the reporting period. The concentrations remained beneath the 95th percentile throughout the review period and rarely exceeded the 80th percentile.

5.4.2. Carne West Pool

Water Depth

Carne West Pool (CWP) water depth data is presented in the following figure.

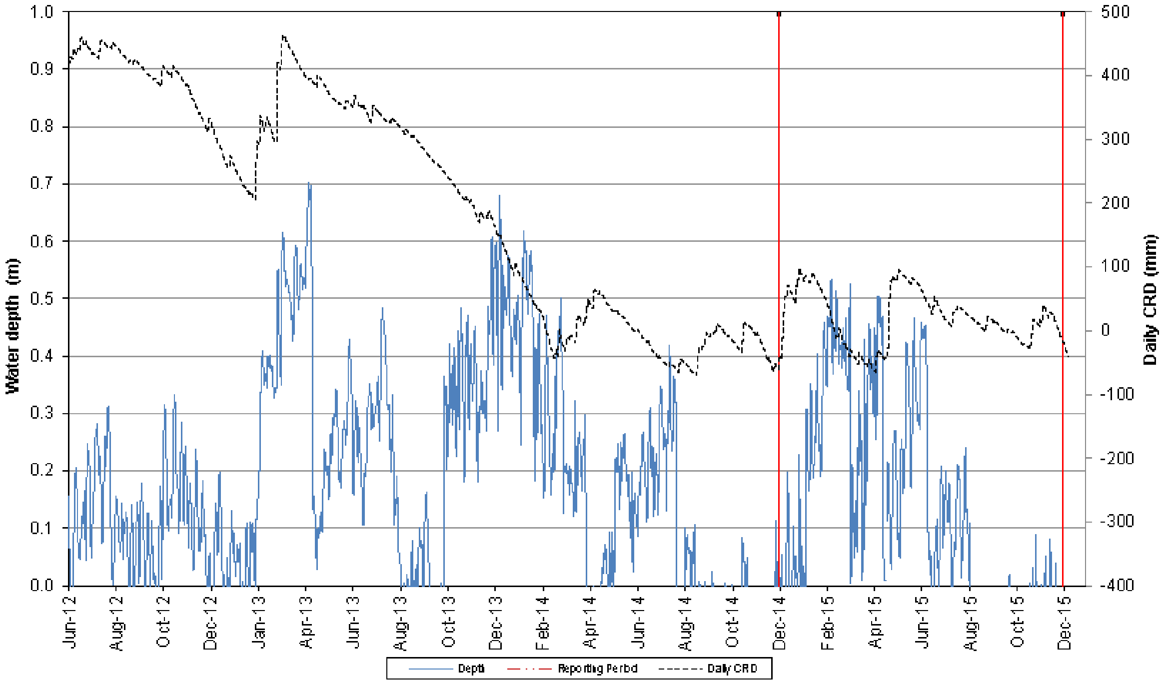

Figure 37 Carne West Pool Monitoring Data May 2012 to 2016

Pool data depths show characteristic spikes which correspond to rainfall (Figure 14). Pool depths were up during the first half of the review period in response to the elevated rainfall in December and April Pool depths then dropped off and were largely dry from August for the remainder of 2015.. Despite the pool water level falling below the sensors detection limit, flow continues to be observed downstream of the monitoring point. The observed responses are considered to be consistent with rainfall received and with past behaviour.

Spikes in pool depth do not always have a clear immediate relationship with rainfall events. 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.

5.4.3. SS3 Downstream

Water Quality

The following figure presents pH results for SS3 Downstream DS.

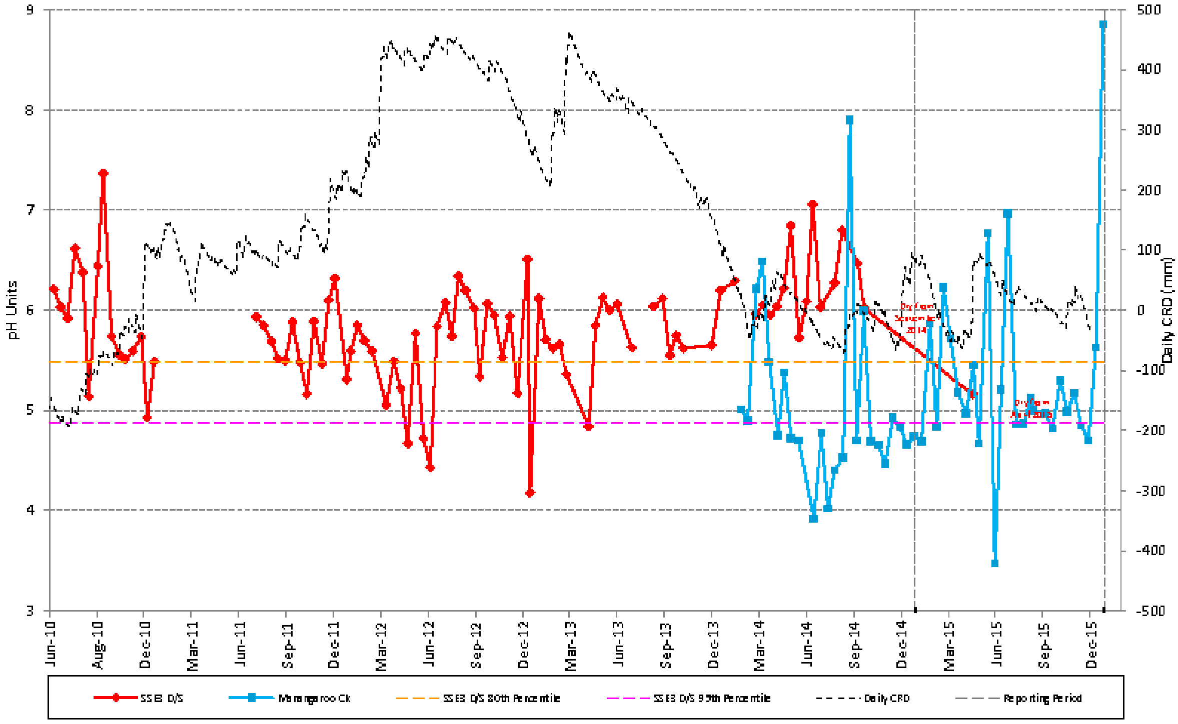

Figure 38 SS3 D/S pH Monitoring Results June 2010 to 2016

The pH at SSE3 D/S has historically fluctuated between 4.5 and 7.5 pH units. These fluctuations are considered natural given that the pH at Marrangaroo Creek fluctuates between similar levels.

The surface water level in SSE3/D/S was too shallow to sample throughout 2015 with the exception of the April sampling round.

The pH at SSE3 D/S was beneath the 95th Percentile during the April sampling round.

The following figure presents electrical conductivity results SS3 D/S.

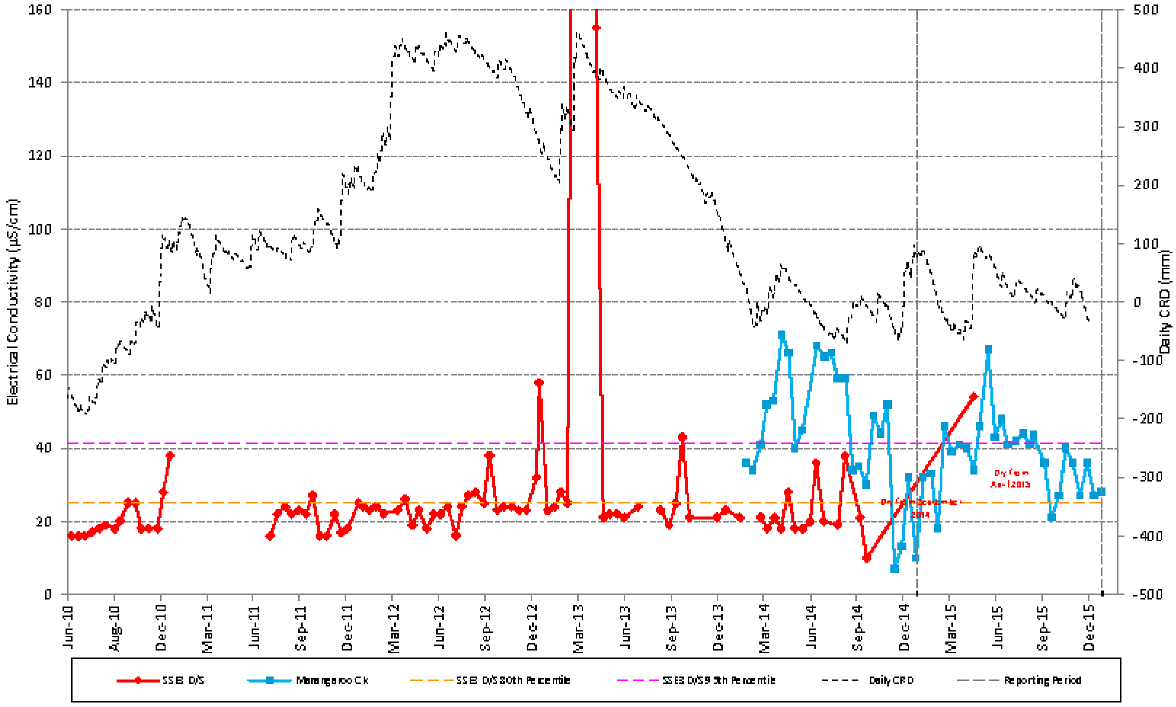

Figure 39 SS3 D/S Electrical Conductivity Results June 2010 to 2016

The EC at SSE3 D/S is extremely fresh ranging historically ranging between 10 and 40µS/cm. which is close to the EC of rain water. Marrangaroo Creek has historically fluctuated between 10 and 70µS/cm, which is also considered fresh. The EC spiked during the April sampling round to 54 µS/cm during the review period. This is still considered fresh and is likely due to the washing out of built up salts during the extended dry period built up during 2013 and 2014.

The following figure presents filterable manganese results for SS3 D/S.

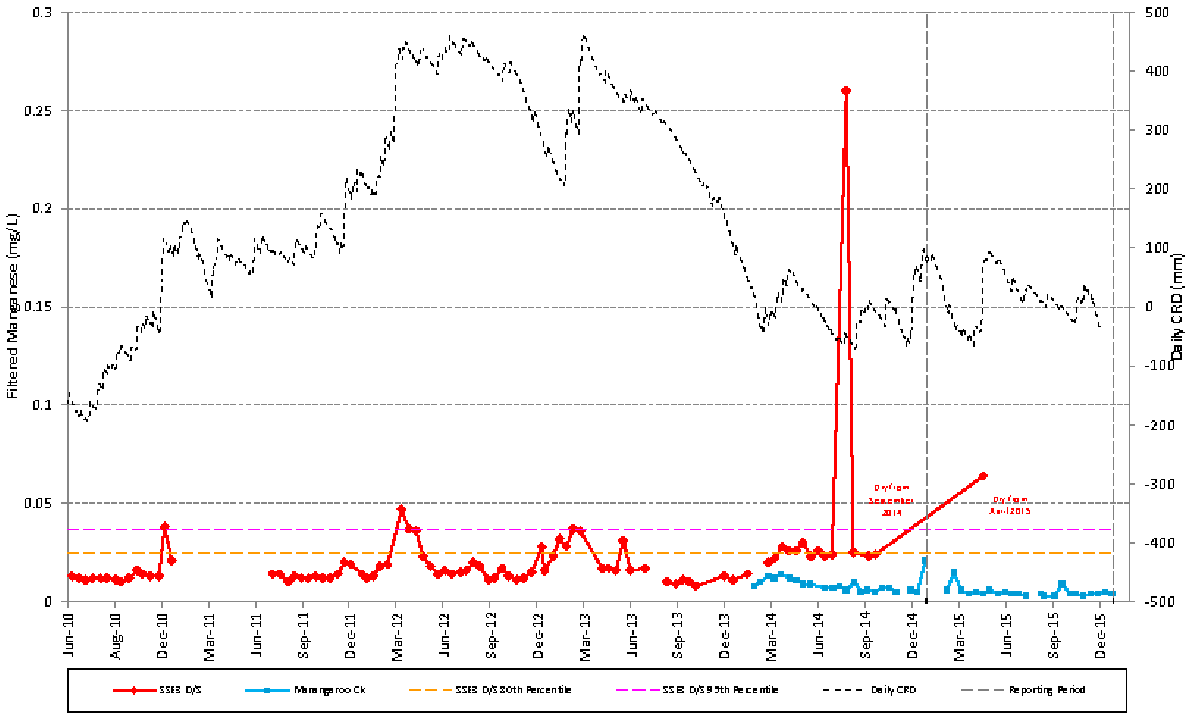

Figure 40 SS3 D/S Filterable Manganese Results

The concentration of Filtered Manganese at SSE3 D/S historically fluctuates between 0.01 and 0.05mg/L with occasional spikes recorded during periods of increased rainfall. These results are similar to those recorded at Marrangaroo Creek. One spike of 0.26mg/L was recorded during the April sampling round; this is considered a natural variation.

The following figure presents filterable iron results for SS3 D/S.

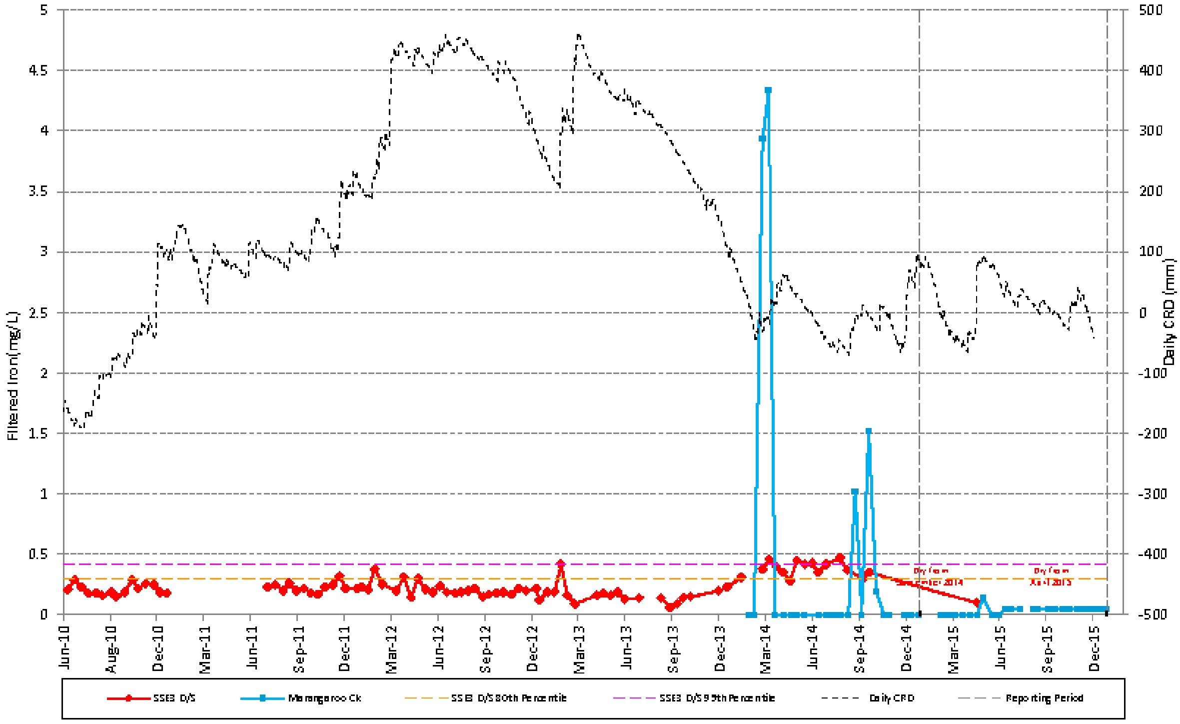

Figure 41 SS3 DS Filterable Iron Monitoring Results June 2010 to 2016

The concentration of Filtered Iron at SSE3 D/S historically fluctuates between 0.1 and 0.5mg/L with occasional spikes recorded during periods of increased rainfall. These results are similar to those recorded at Marrangaroo Creek. The iron concentration remained beneath the 95th and 80th percentile during the April sampling round.

6. TRIGGER LEVEL EXCEEDANCES

6.1. Subsidence

Triggers for subsidence have been developed following modelled predictions for subsidence above longwall panels 415, 416 and 417. The modelling is based on previous monitoring data as well as subsidence theory.

Anomalous subsidence is defined in the Springvale Coal EPBC approval 2011/5949. The subsidence trigger levels from the THPSMMP are presented in Table 17.

Table 21. Subsidence Trigger Levels

Location	Survey Sites	Performance Trigger Levels	
		Anomalous Subsidence	
LW415 **(W=315 metres)**	B and M Cross lines	Subsidence	>1.5 metres
		Tilt	> 10 mm/metres
		Tensile Strain	> 15 mm/metres
		Compressive Strain	>18 mm/metres
LW416 and 417 **(W=260 metres)**	B and M Cross lines	Subsidence	> 1.1 metres
		Tilt	> 7 mm/metres
		Tensile Strain	> 5 mm/m
		Compressive Strain	> 6 mm/m (plateaus) > 14 mm/m (valleys)
Sunnyside East Swamp	*V-VC and W-WC Lines* *LiDAR*	Subsidence	>1.1 metres
		Tilt	> 7 mm/metre
		Tensile Strain	> 5 mm/metre
		Compressive Strain	>14 mm/metre
Carne West Swamp	Y-YC1, YC2 and B Lines LiDAR	Subsidence	>1.1 metres
		Tilt	> 7 mm/metre
		Tensile Strain	> 5 mm/metre
		Compressive Strain	>14 mm/metre

6.2. During the reporting there were no anomalous subsidencewithin 200 metres of a Temperate Highland Peat Swamp on Sandstone Ecological Community. Flora

Triggers for flora have been developed using data collected from reference site monitoring carried out since 2003. The triggers have been developed based on an analysis of natural variance in vegetation communities which has been determined following an analysis of reference site data.

Details of trigger levels for flora are set out in Table 18. Each trigger has a defined level of change and a defined timescale in which this change is to be observed to determine whether an impact has occurred.

Table 22. Flora trigger levels

Performance indicator	Parameter measured	Trigger level
Change in species assemblage	Change in diversity of native species	A change in the number of species of greater than 30 % for a given site within a three year period.
	Recruitment of eucalypt species	An increase in eucalypts in an impact site compared to reference sites of more than three individual plants within a one year period.
Change in condition	Condition of key species	A decline in condition score at an impact site of more than 1.5 compared to the average condition score at un-impacted sites within a one year period. Details of the condition scores are shown in Table 7.2
	Non-live ground cover	An increase of bare ground of more than $100m^2$ in a site within a three year period.
	Non-native weeds	An increase in non-native weed species of more than 4 in a monitoring site (each having a cover of greater than 5%) compared to the average number in reference sites within a one year period.

In accordance with Chart 2 of the Trigger Action Response Plan in the LW415-417 THPSS MMP, ongoing flora monitoring is being under taken in response to WC02 as there are not evidence to support possible mining related impacts.

6.3. Groundwater

The methodology for developing groundwater level triggers to determine whether anomalous impacts have occurred is based on statistical analysis and the development of percentile based triggers.

Short-term significant changes in groundwater level are considered to occur at the 95th percentile level. However, exceedance of this level, by definition, will occur five percent of the time under natural conditions. This has led to the development of long term triggers that complement the short term triggers. Any mining-induced changes in groundwater levels will be inferred based on a set of trigger values for the groundwater depths in swamp piezometers and the groundwater elevations at ridge top aquifer piezometers installed beneath the ridges between swamps.

Table 23. Short and Long term change descriptions as relevant to groundwater depth and aquifer groundwater level

Type of change	Description
Swamp groundwater depth (from ground surface)	
Short-term changes	Trigger level is exceeded if the groundwater depth in any piezometer > 95th percentile pre-mining groundwater depth for more than 7 consecutive days
Long-term changes	Trigger level is exceeded if the post-mining 50th percentile groundwater depth for any piezometer > 80th percentile pre-mining level
Aquifer groundwater level	
Short-term changes	Trigger level is exceeded if the groundwater level > baseline 95th percentile or < baseline 5th percentile pre-mining groundwater level for more than one month
Long-term changes	Trigger level is exceeded if the post-mining 50th percentile groundwater level for any bore is > baseline 80th percentile or < baseline 20th percentile pre-mining level

Due to the relatively short time period since undermining long term changes to groundwater depth cannot yet be determined.

The trigger levels are based on the monitoring record from 1 January 2005 up to 31 December 2011 at the swamp piezometers and up to 30 April 2012 for aquifer piezometers.Groundwater triggers for swamp piezometer water are presented in table 20 while aquifer piezometer trigger levels are presented in table 21.

Baseline data collection is however considered up to the time until mining is within 200m of the piezometer. Trigger levels have therefore been recalculated when considering the results presented. Accordingly Centennial Coal will update the THPSSMP in consultation with Department of Environment (formally SEWPaC).

Table 24. Groundwater trigger levels for swamp piezometers

Location	LW 415-417 THPSS MMP Short-term Change 7-day moving average greater than the Pre-mining 95th Percentile for 7 days (metres below ground level)	Recalculated Pre-Mining Trigger Short-term Change 7-day moving average greater than the Pre-mining 95th Percentile for 7 days (metres below ground level	LW 415-417 THPSS MMP Long-term Change Post-mining median greater than the Pre-mining 80th Percentile (metres below ground level)	Recalculated Pre-Mining Trigger Long-term Change Post-mining median greater than the Pre-mining 80th Percentile (metres below ground level	Pre-mining calculated cut-off date
Permanently Waterlogged					
CW1	0.25	0.93	0.21	0.26	LW418 - 05/12/2015
CW2	0.24	1.16	0.22	0.28	LW418 - 03/12/2015
SSE3	0.17	1.71	0.04	1.48	LW417 – 12/11/2014
Periodically Waterlogged					
CW3^	1.01	1.07	1.01	1.06	LW417 – 19/03/2015
CW4	1.21	1.34	1.13	1.33	LW417 – 05/03/2015
SSE1	2.12	2.16	2.11	2.15	LW416 – 10/01/2014
SSE2	0.70	0.83	0.41	0.61	LW416 – 16/12/2013

A THPSS MMP TARP trigger (trigger) has been activated in a swamp piezometers SSE1,SSE2 and SSE3 in Sunnyside- East Swamp and CW1, CW2, CW3 and CW4 in Carne West Swamp.

Reporting of Exceedances has been undertaken in accordance with the LW 415-417 THPSS MMP in is outlined Section 7 which also provides details on the response strategy undertaken.

Table 25. Groundwater trigger levels for aquifer piezometers

Location	LW415-417 THPSS MMP: Short-term Change (7-day moving average less than the Pre-mining 5th Percentile for 1 month)	LW415-417 THPSS MMP: Short-term Change (7-day moving average greater than the Pre-mining 95th Percentile for 1 month)	Recalculated Pre-Mining Trigger Short-term Change (7-day moving average greater than the Pre-mining 95th Percentile for 1 month)	LW415-417 THPSS MMP: Long-term Change (Post-mining median less than the Pre-mining 20th Percentile)	LW415-417 THPSS MMP: Long-term Change (Post-mining median greater than the Pre-mining 80th Percentile)	Recalculated Pre-Mining Trigger Short-term Change (7-day moving average greater than the Pre-mining 95th Percentile for 1 month)	Pre-mining calculated cut-off date
RSS	1125.6	1131.4	1128.16	1127.9	1129.8	1128.86	LW415 - 20/09/2012
SPR1101^	1089.9	1090.8	1089.93	1090.0	1090.6	1090.03	LW415 – 18/09/
SPR1104	1070.1	1073.1	1069.2	1071.8	1072.8	1069.8	Ongoing- LW419 – Baseline (to 31/12/2015)-Present
SPR1107	1090.0	1093.7	1086.2	1090.5	1093.2	1087.3	Ongoing- LW419 – Baseline (to 31/12/2015)-Present
SPR1109	1077.0	1078.3	1067.7	1077.1	1078.0	1069.3	LW418 – 25/11/2015
SPR1110	1089.8	1090.1	1083.4	1089.8	1090.0	1083.6	LW416 – 18/09/2014

A trigger has been activated in aquifer piezometers SPR1101 and SPR1109. The trigger was based on historical monitoring data which indicated a decline in the water level in the aquifer piezometers.

Reporting of Exceedances has been undertaken in accordance with the LW 415-417 THPSS MMP in is outlined Section 7 which also provides details on the response strategy undertaken.

Triggers for groundwater quality have been developed using data collected from reference sites. This data has been assessed using the ANZECC (2000) Water Quality Guidelines for the Protection of Aquatic Life (95% species protection levels) to calculate the triggers. Groundwater quality triggers were developed using the ANZECC (2000) guidelines procedure for setting local guidelines when the water quality does not meet the default ANZECC (2000) guideline values because of local conditions. The 80th percentile value of background water quality is used as the local water quality value in the case where the background concentrations are higher than the ANZECC (2000) guidelines. The default is used if the 80^{th} percentile is lower than the default trigger value. This approach has been used to develop the water quality triggers for groundwater.

Trigger levels for groundwater quality are presented in Table 22.

Table 26. Groundwater quality trigger levels

Element	Short-term Minor Change (1)	Short-term Major Change (2)	80th Percentile Baseline
CW1			
pH	4.6 – 5.3	4.1 – 5.8	4.8 – 5.0
EC (uS/cm)	30	30	22
Fe (Filterable Mg/L)	0.57	1.69	0.37
CW2			
pH	4.5 – 5.6	4.0 – 6.2	4.8 – 5.4
EC (uS/cm)	23.1	27.1	20.2
Fe (Filterable Mg/L)	0.48	0.67	0.30
SSE3			
pH	5.2 – 5.9	4.8 – 6.5	5.3 – 6.1
EC (uS/cm)	52	69	48
Fe (Filterable Mg/L)	8.43	13.51	7.27

As there has been no mining within 200m of these locations the triggers all data collected is considered baseline and there has been no exceedances of the trigger values defined in Table 22.

6.4. Surface Water

Surface water quality triggers have been developed using the ANZECC (2000) water quality guidelines for protection of aquatic life (95% species protection levels). Minor and major variation / impacts will be assessed by using the ANZECC protocols of comparing the pre-mining 80th and 95th percentile baseline with the 50th percentile of the post-mining data and allowing for the effects of short-term spikes due to rainfall runoff events.

Table 23 provides a description short term and long term changes in reference to minor or major variations. The surface water triggers levels are presented in Table 24.

Table 27. Short and Long term change descriptions as relevant to minor and major changes in surface water

Type of change	Description
Minor Changes	
Long-term minor changes	For each analyte, if the post-mining 50th percentile ≤ baseline 80th percentile, the changes are considered minor and would not have an unacceptable impact on aquatic life (i.e. provided the long-term increase in concentrations is such that the 50th percentile does not exceed the baseline 80th percentile, the increase is considered to be minor)
Short-term minor changes –	For each analyte, if any measured parameter > baseline 80th percentile, but ≤ baseline 95th percentile (5th percentile for pH) trigger value for ≤ two months, the changes are considered minor and would not have an unacceptable impact on aquatic life. It should be noted that about 20% of observations will exceed the 80th percentile and these are usually short-term spikes in concentrations, which are often due to rainfall runoff events. These short-term spikes generally occur for less than two consecutive months.
Major Changes	
Long-term major changes	For each analyte, if the post-mining 50th percentile > baseline 80th percentile, the changes are considered major.
Short-term major changes	For each analyte, if any measured parameter > baseline 80th percentile by two standard deviations for more than two months, the changes are considered major

Table 28. Surface Water Quality Triggers

Element	Short-term Minor Change (1)	Short-term Major Change (2)	80th Percentile Baseline
Carne Swamp			
pH	4.80 – 6.8	4.1 – 7.3	5.3 – 6.1
EC (uS/cm)	40	51	27
Mn (Filterable Mg/L)	0.036	0.174	0.022
Fe (Filterable Mg/L)	0.69	0.77	0.44
Sunnyside East Swamp			
pH	5.0 – 6.5	4.5 – 6.5	5.5 – 6.0
EC (uS/cm)	27	33	24
Mn (Filterable mg/L)	0.037	0.037	0.019
Fe (Filterable Mg/L)	0.313	0.363	0.260
Marrangaroo Creek Upstream (Reference Site)			
pH	5.2 – 6.7	4.5 – 7.1	5.5 – 6.1
EC (uS/cm)	40	47	33
Mn (Filterable Mg/L)	0.02	0.11	0.01
Fe (Filterable Mg/L)	0.10	0.26	0.08

As there has been no mining within 200m of these locations the triggers all data collected is considered baseline and there has been no exceedances of the trigger values defined in Table 24.

7. RESPONSE STRATEGIES

As indicated in section 6 above both a number of groundwater trigger values defined in the THPSSMP have been exceeded. Accordingly, Centennial has notified the Department and undertaken investigations into the exceedances. The following section summarises actions undertaken in relation to each trigger. Additional detail is presented in the reports provided to the department

7.1. SSE1

7.1.1. Initital Notification

Notification of the decline in water level was received by Centennial from RPS on 24th March 2014 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 28th March 2014, as required under the response protocol in the THPSS MMP TARP.

7.1.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 19th of May 2014. Additional investigation details on the response startergy were provided by Centennial on the 19th of January 2016.

7.1.3. Response Stratergy

The following actions are currently being undertaken by Centennial:

- Recalculation of triggers to accommodate ambient condition changes since April 2012 will result in a more representative baseline 95th percentile value. It is likely that the recalculation would result in the current SSE1 water levels no longer activating a trigger response.
- Swamp ecosystem health assessment and reporting by University of Queensland ecologists
- Groundwater monitoring assessment and reporting by Heritage Computing (Noel Merrick).

7.1.4. Investigation Outcomes

In the case of the SSE1 swamp piezometer trigger, the preliminary investigation indicates that the likely cause was an extended period of dry weather, which contributed to the reduction in water level within the reference swamp piezometers (which are located away from mining activities).

Following the implementation of the action plan, reporting was conducted by RPS and Gingra Ecological Surveys.

RPS concluded that “water levels at TS1 and TG1 were both above the 95th percentile when the trigger level was exceeded in SSE1. The statistics for MS1 and CC1 are heavily skewed by sampling events which are displayed as sharp drawdown spikes in the hydrograph. These events are not reflective of mining activities and recover to normal groundwater level relatively quickly. Both these sites would have exceeded the 95th percentile if the sampling events were not taken into account. The reference sites support the low water levels observed in SSE1.”

Gingra concluded that “The patterns of decline observed in vegetation along Sunnyside East Swamp appear, at this stage, to be driven by the combination of the post-fire response of vegetation and climatic conditions which have prevailed since early 2012.”

7.2. SPR1101

7.2.1. Initial Notification

Notification of the decline in water level was received by Centennial from RPS on 24th March 2014 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 28th March 2014, as required under the response protocol in the THPSS MMP TARP.

7.2.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 19th of May 2014. Additional investigation details on the response startergy were provided by Centennial on the 19th of January 2016.

7.2.3. Response Strategy

The following actions are currently being undertaken by Centennial:

- Investigative Drilling Program - SPR1101SP Redrill Proposal
- Investigative Drilling Program - RSS Redrill Proposal
- Swamp Ecosystem Health Assessment (University of Queensland)
- Swamp Hydrological Assessment (Heritage Computing)

7.2.4. Investigation Outcomes

In the case of the SPR1101 aquifer piezometer trigger, the investigation indicated that the likely cause was the depth of drilling of the SPR1101 exploration borehole, which was subsequently inappropriately used as a water level monitoring bore. The drilling of the SPR1101 borehole intersected the zone of discontinuous fracturing (B-Zone) caused by subsidence related to the extraction of Longwall 416 at Springvale.

Historical monitoring indicates that the aquifers which supply groundwater to the swamp have not been impacted by adjacent mining activities. The SPR1101 borehole was drilled to a depth below the aquifers which supply groundwater to the swamp, and it is considered that the decline in water level based on data from this borehole does not represent an impact to the groundwater system which supplies water to the swamp.

7.3. SSE2 and SE3

7.3.1. Initial Notification

Notification of the decline in water level was received by Centennial from RPS on 27th March 2015 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 30th March 2015, as required under the response protocol in the THPSS MMP TARP.

7.3.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 22nd of May 2015.

7.3.3. Investigation

In the case of the SSE2 and 3 swamp piezometer triggers, the preliminary investigation indicates a rainfall deficient may have contributed to the reduction in water level at the before mentioned monitoring locations. The change in climatic conditions has resulted in a change in pre-mining groundwater levels which is not reflected by the triggers defined in the THPSSMMP.

7.3.4. Response Strategy

The following actions are recommended in relation the SSE2 and SSE3 triggers:

- Trigger levels will be reviewed to reflect the natural variation in water levels over time, which occur in the swamp systems this would enable any mining related impacts to be more easily identified
- Bandwidths for swamp water levels will be defined for reference swamps (based on the same statistical process that is used for impact swamps). This would allow for the timing of the exceedances (values outside bandwidth) for the reference swamps to be compared to those at impact swamps.

7.4. CW 3 and 4

7.4.1. Initial Notification

Notification of the decline in water level was received by Centennial from RPS on 29th of July 2015 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 5th of August 2015, as required under the response protocol in the THPSS MMP TARP.

7.4.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 22nd of September 2015.

7.4.3. Investigation

In the case of the CW 3 and CW 4 swamp piezometer triggers, the preliminary investigation indicates that given the trigger level was reached prior to mining within 200m of the monitoring location, a rainfall deficient is likely to have contributed to the reduction in water level at the before mentioned monitoring locations. The change in climatic conditions has resulted in a change in pre-mining groundwater levels which is not reflected by the triggers defined in the THPSS MMP. This behaviour is similarly exemplified in the Tri Star reference swamp.

7.4.4. Response Strategy

The following actions are currently being undertaken by Centennial:

- Trigger levels are currently being reviewed to reflect the natural variations in water levels over time, which occur in the swamp systems. This would enable any mining related impacts to be more easily identified.
- Bandwidths for swamp water levels should be defined for reference swamps (based on the same statistical process as that used for impact swamps). This would allow for the timing of exceedances (values outside bandwidth) for reference swamps to be compared to those at impact swamps.

7.5. CW 1 and 2

7.5.1. Initial Notification

Notification of the decline in water level was received by Centennial from RPS on 18th of December 2015 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 22nd of December 2015, as required under the response protocol in the THPSS MMP TARP.

7.5.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 12th of February 2016.

7.5.3. Investigation

In the case of the CW1 and CW2 swamp piezometer triggers, the preliminary investigation indicates that:

- Water levels at CW1 and CW2 piezometers now display trends that are more rainfall dependent as opposed to predominantly groundwater dependent, which had been the case for the entire baseline monitoring period from 2005 up to 2014
- Further data analysis is required to determine if the changes to water levels in Carne West Swamp are related to mine subsidence or the decline observed in the regional groundwater table aquifer, which appears to be a delayed response to longer term climatic influences.

7.5.4. Response Strategy

The following actions are recommended in relation the CW1 and CW2 triggers:

1. Conduct detailed investigation into the cause of the changes in groundwater behaviour patterns at CW1 and CW2 piezometers. This will include:
   a) detailed spatial and temporal analysis of all relevant geological, topographic, mine subsidence, groundwater, rainfall and underground monitoring data
   b) analysis of the relationship between water levels in the near surface groundwater aquifers and the adjacent swamp water levels
2. Conduct a specific swamp flora and fauna assessment to determine the effects of the changes in groundwater behaviour patterns at CW1 and CW2 piezometers.
3. Depending on the outcomes of Actions 1 and 2 (above), it may be necessary to review adaptive management options in order to prevent future changes to groundwater system behaviour.

7.6. SPR1109

7.6.1. Initial Notification

Notification of the decline in water level was received by Centennial from RPS on 29th of July 2015 following data verification and specialist hydrological interpretation. Notification of the triggers was provided to the Federal Department of Environment on 5th of August 2015, as required under the response protocol in the THPSS MMP TARP.

7.6.2. Investigation Report

A report on the preliminary findings was submitted to the Department on the 22nd of September 2015.

7.6.3. Investigation

In the case of the SPR1109 aquifer piezometer trigger, it is considered likely that the changes to aquifer groundwater levels at SPR1109 are consistent with a delayed response to longer term climatic influences.

7.6.4. Response Strategy

The following actions are currently being undertaken by Centennial:

- Recalculation of triggers to accommodate ambient condition changes since June 2015 will result in a more representative baseline 95th percentile value. It is possible that the recalculation would result in the current SSE1 water levels no longer activating a trigger response.
- Swamp ecosystem health assessment and reporting to be undertaken
- Groundwater monitoring assessment and reporting will be undertaken.

8. SUMMARY

Springvale received conditional approval to mine Longwalls 415 to 417 which are beneath Temperate Highland Peat Swamps on Sandstone (THPSS). A THPSS Management Plan (THPSSMP) has been developed and implemented in accordance with the conditions of approval. This includes and extensive monitoring program which covers both the controlled action and the surrounding environment to assist in identifying any potential impact from mining.

During 2015 coal was mined from Longwalls 417 and 418. Longwall 418 is covered under EPBC 2013/6881 and the Longwall 418 THPSS MMP.

Subsidence monitoring has been undertaken in accordance with the Springvale Subsidence Management and Reporting Plan for LW415 to 417. Subsidence, tilt, tensile strain and compressive strain results demonstrates compliance with the trigger values defined in the THPSSMP.

Climatic conditions must be considered when analysing monitoring data. Rainfall levels remained below the long-term average for the majority of the year. The most significant varaiation was observed in April 2015 where 206mm of rain was recorded.

Groundwater levels have exceeded both swamp and aquifer trigger values. Springvale has accordingly reported, investigated and undertaken action to determine any potential impact from mining.

One trigger exceedance was observed for a flora impact site and three flora reference sites during the 2015 monitoring period. The behaviour at reference sites supports that confounding enviroenmental factors are considered the cause of the exceedance.

Surface water flows and water chemistry show trends that are consistent with that observed in previous years monitoring showing no discernable effects from mining.

Overall the annual report prepared shows compliance with the requirements of the THPSSMP and no discernible impact from mining on THPSS.

Centennial Coal
Environment Matters