Centennial Coal

SUPPLEMENTARY DATA

Volume Two

EPBC Approval 2011/5949

Application to Allow Longwall Mining Under Temperate Highland Peat Swamps on Sandstone on the Newnes Plateau

Springvale Colliery

August 2013

Information Request Regarding Application to Allow Longwall Mining Under Temperate Highland Peat Swamps on Sandstone on the Newnes Plateau (EPBC Approval 2011/5949)

Background

On 30 April 2013 Centennial Coal representatives met with SEWPaC Post-Approvals Compliance Section representatives and gave a presentation on Centennial's Application to Allow Longwall Mining Under Temperate Highland Peat Swamps on Sandstone on the Newnes Plateau (the Application), which is required to be approved by the Minister under EPBC Approval 2011/5949 before mining beneath THPSS within the Controlled Action Area (CAA). Following the presentation, feedback was provided by SEWPaC to Centennial and specific information was requested to supplement the information provided in the Application.

- Information is required about the findings of East Wolgan Swamp (EWS) investigations.
    - Circumstances related to damage to East Wolgan Swamp
    - Reasons why similar event will not occur in the future
    - Reasons why East Wolgan Swamp has not been remediated yet

- Prepare detailed Case Studies for other swamps previously undermined, with relevant data for each location.

- Compare data in Case Study areas with proposed mining activities in the CAA

- Supply additional data regarding remediation case study (Metropolitan Colliery – Waratah Rivulet Rockbar remediation) including:
    - specific reports supporting case study
    - analysis of data (i.e. graph showing water level in pools pre and post PUR injection)
    - additional data regarding reduction in permeability since 2008

Scope Of Supplementary Data Submission

This submission is a summary of relevant data and analysis and references specialist reports where relevant. Relevant specialist reports are appended. Volume 2 (below) contains the case studies of other previously undermined swamps and the Sunnyside East and Carne West case studies.

Junction Swamp Case Study

Junction Swamp Case Study

The following is a case study of longwall mining beneath Junction Swamp on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 2.1 to 2.5. Table 2.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	Monitoring Data / Interpretation
Location	Newnes Plateau
Name	Junction Swamp
Geology (Swamp Substrate)	Burralow Formation
Depth of Cover (metres)	370 – 380m
Longwall Void Width (metres)	265m
Chain Pillar Width (metres)	45m
w/H Ratio	0.70 (Sub-Critical)
Timing of Longwall Mining	March 2003 and May 2004
Subsidence (Vertical) (metres)	0.9 -1.0m
Subsidence (Strains) (millimetres / metre)	(14)mm/m Compressive 3mm/m Tensile
Swamp Hydrology (Standing Water Level)	Baseline - Periodically Waterlogged No change due to longwall mining
Flora	Sites NP005 and NP006 showed stable condition and cover/abundance scores throughout 2012.

Table 2.1 – Summary of Key Data from Environmental Monitoring at Junction Swamp

Impacts from Mining Related Activites

Goldney et al (2010) reported the following regarding impacts to Junction Swamp
"(a) Major discontinuous incisions and slumping; significant vegetation dieback; active erosion and major sediment transport; dry peat and Sphagnum present; significant loss of ecosystem function and ecological resilience; impacts are vegetation dieback, major incision and major erosion down to gravel bed with loss of peat base, loss of ecosystem function and resilience, ecological and geomorphic thresholds exceeded; extremely unlikely that drought is cause of degradation.

(b) Immediately downstream of sample a; major incision that pre-dates LWM; significant vegetation dieback; active erosion and major sediment transport; dry peat and Sphagnum present; significant loss of ecosystem function and ecological resilience; impacts are vegetation dieback, major incision and major erosion down to

gravel bed with loss of peat base, loss of ecosystem function and resilience, ecological and geomorphic thresholds exceeded; major head cut still moving upstream & currently about 50 m below sample 1."

The erosional and flora impact effects described are consistent with those observed at East Wolgan and Narrow Swamps. It is understood that mine water discharges were released though Junction Swamp during failures of the Water Transfer Scheme which transfers water from Springvale and Angus Place. These failures were overflows of the "Gravity Tank" where water was stored prior to transfer off the Newnes Plateau. The Water Transfer Scheme was subsequently re-designed and the Gravity Tank was bypassed. Mine water is now piped directly from the bore pump to LDP09 (transfer point to Delta Electricity), without any staging on the Newnes Plateau. Since the Water Transfer Scheme was modified, there have been no further discharges of this kind.

Figure 2.5 shows hydrographs of the swamp piezometers installed at Junction Swamp together with the time of longwall mining beneath the piezometers (indicated by the vertical black lines) and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a very strong correlation between the trendlines of standing water levels beneath the swamp and the CRD trendline for all swamp piezometers over the eleven years of monitoring at this location. This data indicated that the swamp is periodically waterlogged (standing water levels respond to rainfall). The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining.

From the available data it appears that impacts at Junction Swamp were the result of mine water discharge and were not due to mine subsidence.

Summary of Junction Swamp Case Study Data

Environmental monitoring at Junction Swamp has been conducted over the last eleven years. Table 2.1 is a summary of key monitoring data. The key points from the case study of Junction Swamp are as follows:

- Burralow Formation Geology Substrate
- Periodically Waterlogged Swamp
- Standing Water Level Trends follow Cumulative Rainfall Deviation Trend
- Longwall Mining Under Junction Swamp in April 2003 and May 2004 – no correlation with hydrograph trends
- Subsidence up to 1.0m, Strains 3mm/m (tensile) to (14)mm/m (compressive)
- Pre-Mining Standing Water Level 3-5m below surface (similar to current Post-Mining Standing Water Level)

- No obvious long term mine subsidence impacts to hydrology
- Erosional impacts to swamp geomorphology caused by Mine Water Discharge as described above
- Impacts to swamp flora caused by Mine Water Discharge as described above
- Sites NP005 and NP006 (Figures 2.6 and 2.7) showed stable condition and cover/abundance scores throughout 2012.
- Site NP005, a hanging swamp (MU51), continues to demonstrate the highest species richness (>50) across sites at Springvale through 2012.

Junction Swamp

Case Study Figures

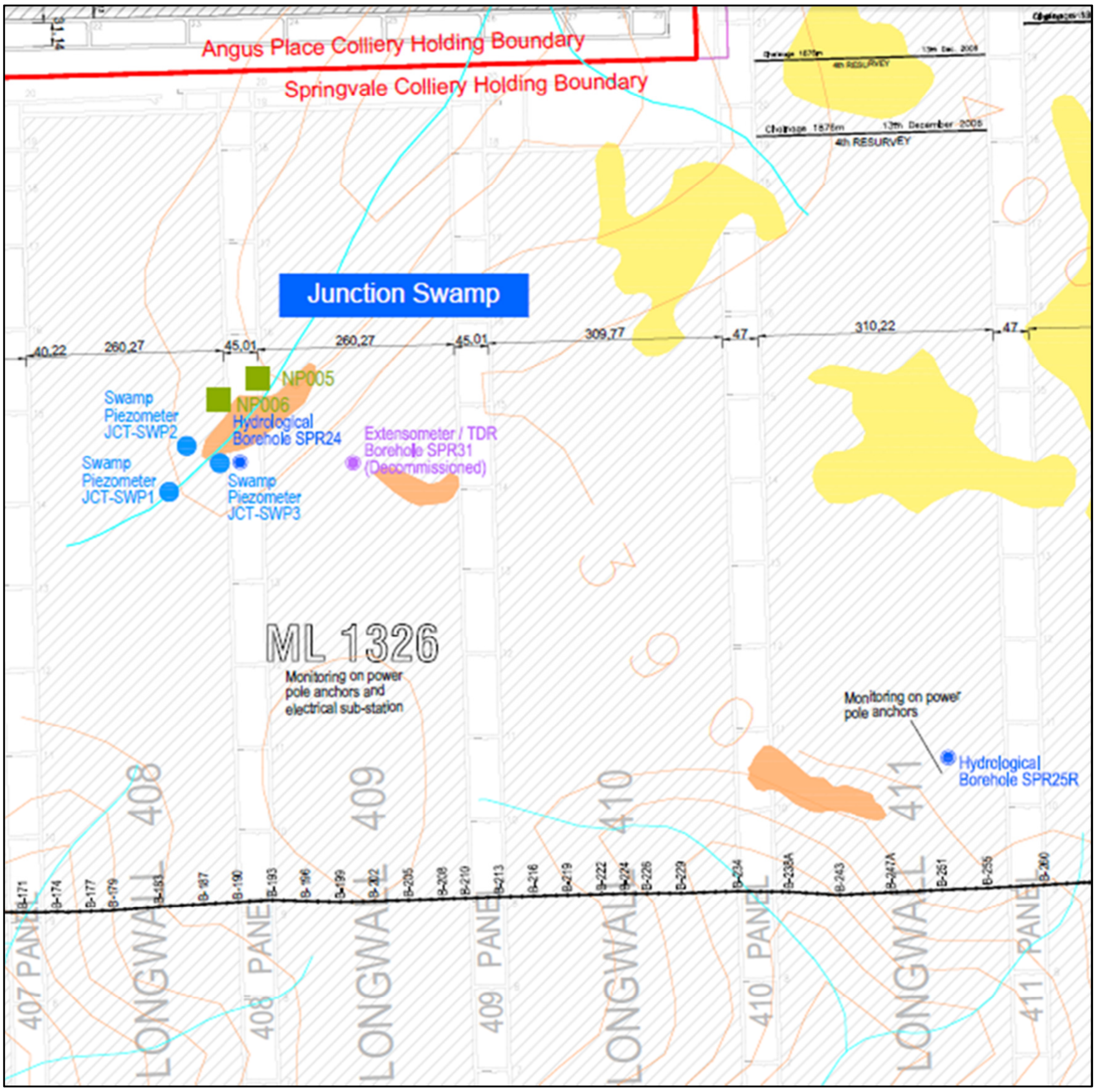


Figure 2.1 Junction Swamp Case Study Plan

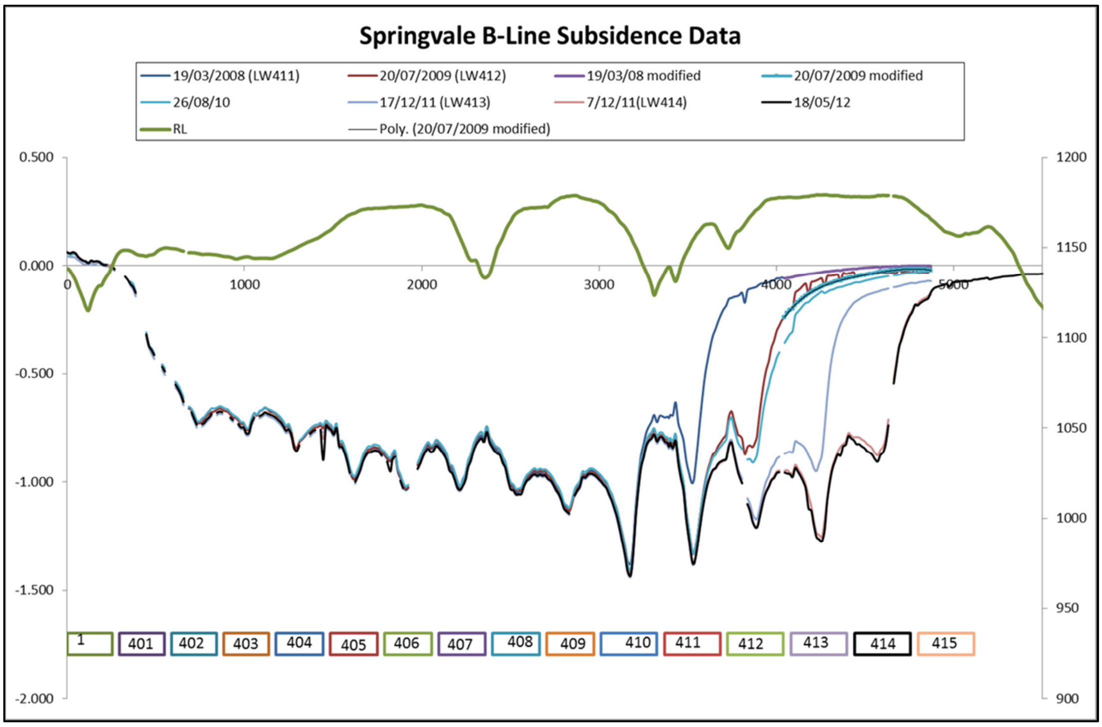


Figure 2.2 Cross Section Springvale Subsidence Monitoring (B-Line) Data Relative to Longwall Position and Surface Topography – note increase in measured vertical subsidence from Longwall 410 to Longwall 413 in response to increased longwall void width from 265m to 315m. Longwall 414 had not developed full subsidence at the time of the last survey on this graph.

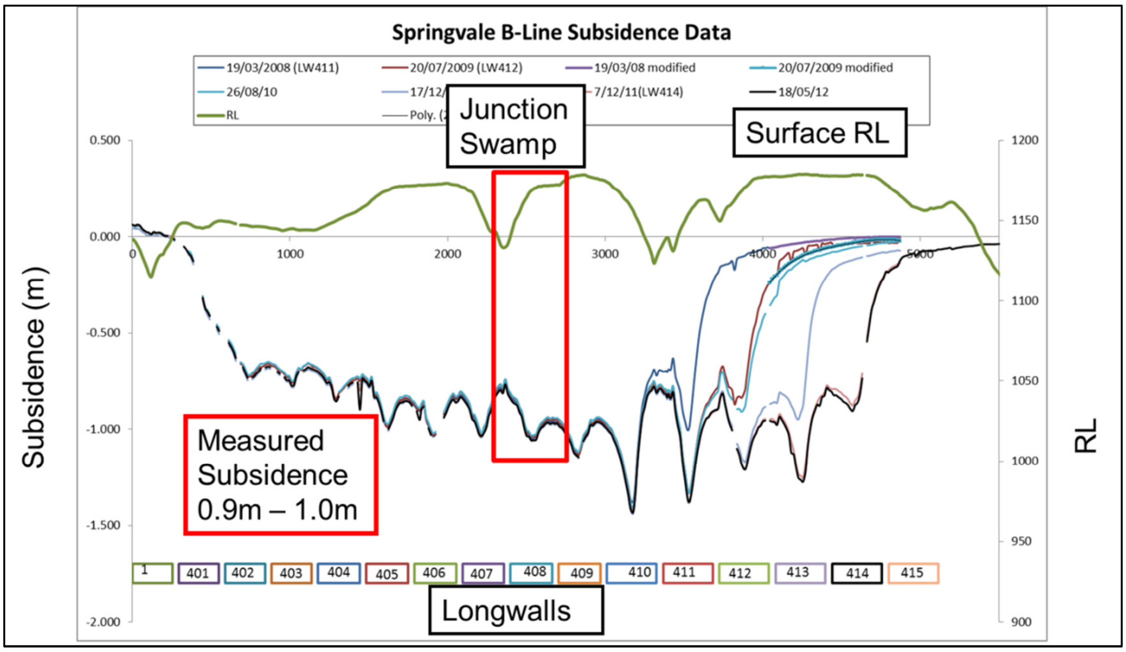


Figure 2.2(a) is the same as Figure 2.2 with explanatory notes about location of Junction Swamp relative to subsidence line (B-Line) and the measured vertical subsidence on the B-Line in the area of Junction Swamp. As shown in Figure 2.1, the B-Line does not cross Junction Swamp, but is the closest subsidence monitoring line and is representative of expected subsidence at Junction Swamp

due to its alignment perpendicular to the longwall panels i.e. it measures the full range of vertical subsidence values across the longwall panels.

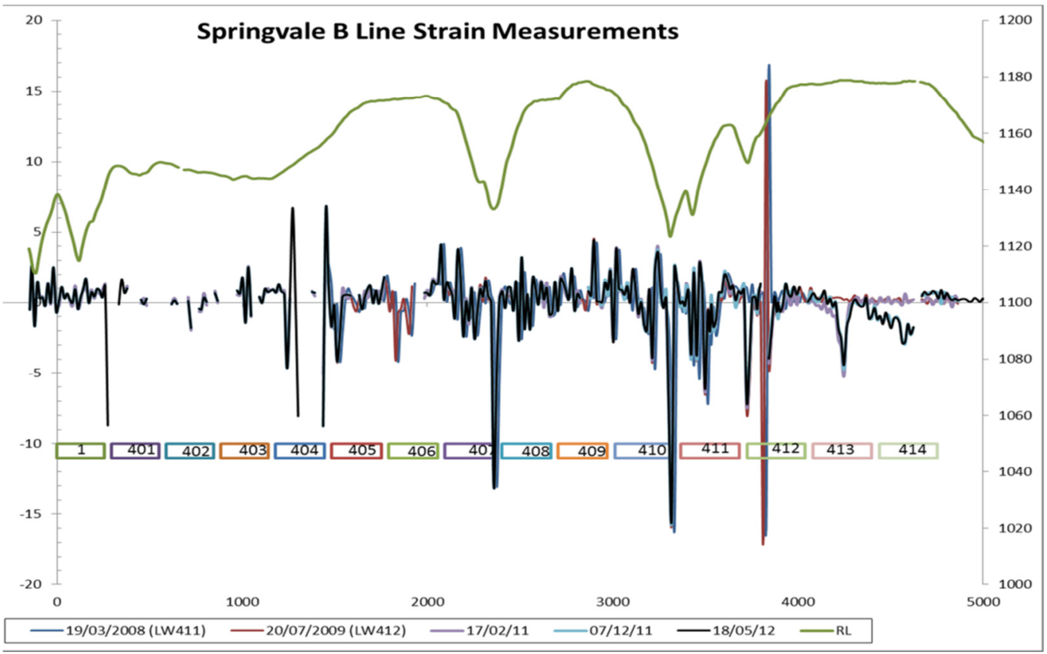


Figure 2.3 Cross Section Springvale Strain Monitoring (B-Line) Data Relative to Longwall Position and Surface Topography – note increase in measured strains from Longwall 410 to Longwall 413 in response to increased longwall void width from 265m to 315m. Longwall 414 had not developed full subsidence at the time of the last survey on this graph.

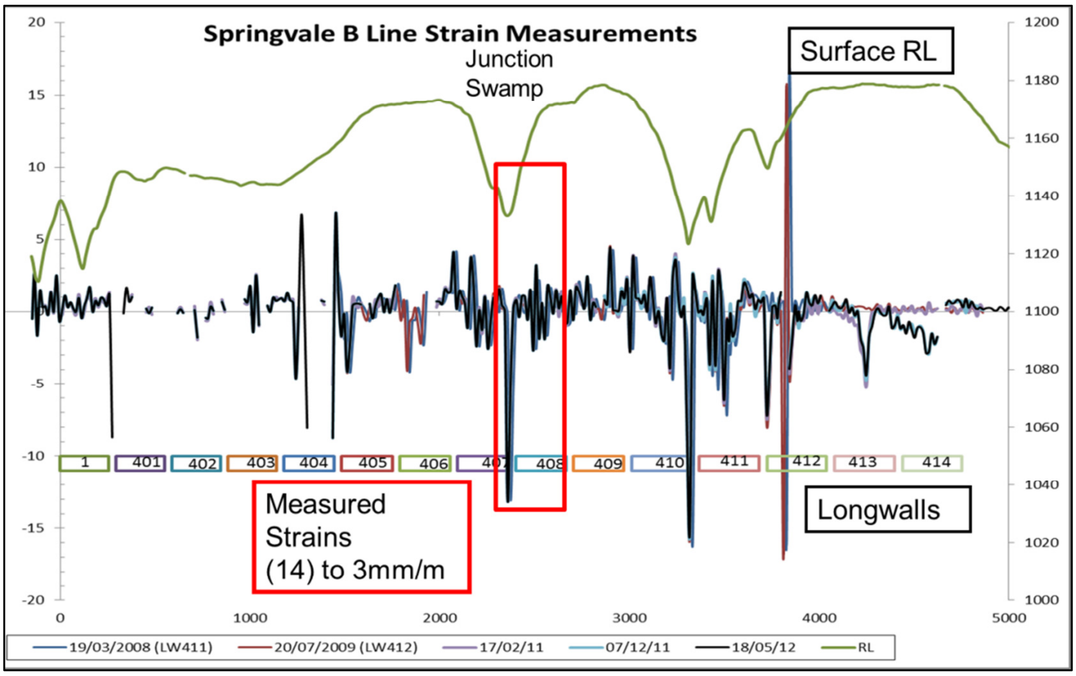


Figure 2.3(a) is the same as Figure 2.3 with explanatory notes about location of Junction Swamp relative to subsidence line (B-Line) and the measured strains on the B-Line in the area of Junction Swamp. As shown in Figure 2.1, the B-Line does not cross Junction Swamp, but is the closest subsidence monitoring line and is representative of expected subsidence at Junction Swamp due to

its alignment perpendicular to the longwall panels i.e. it measures the full range of strain values across the longwall panels.

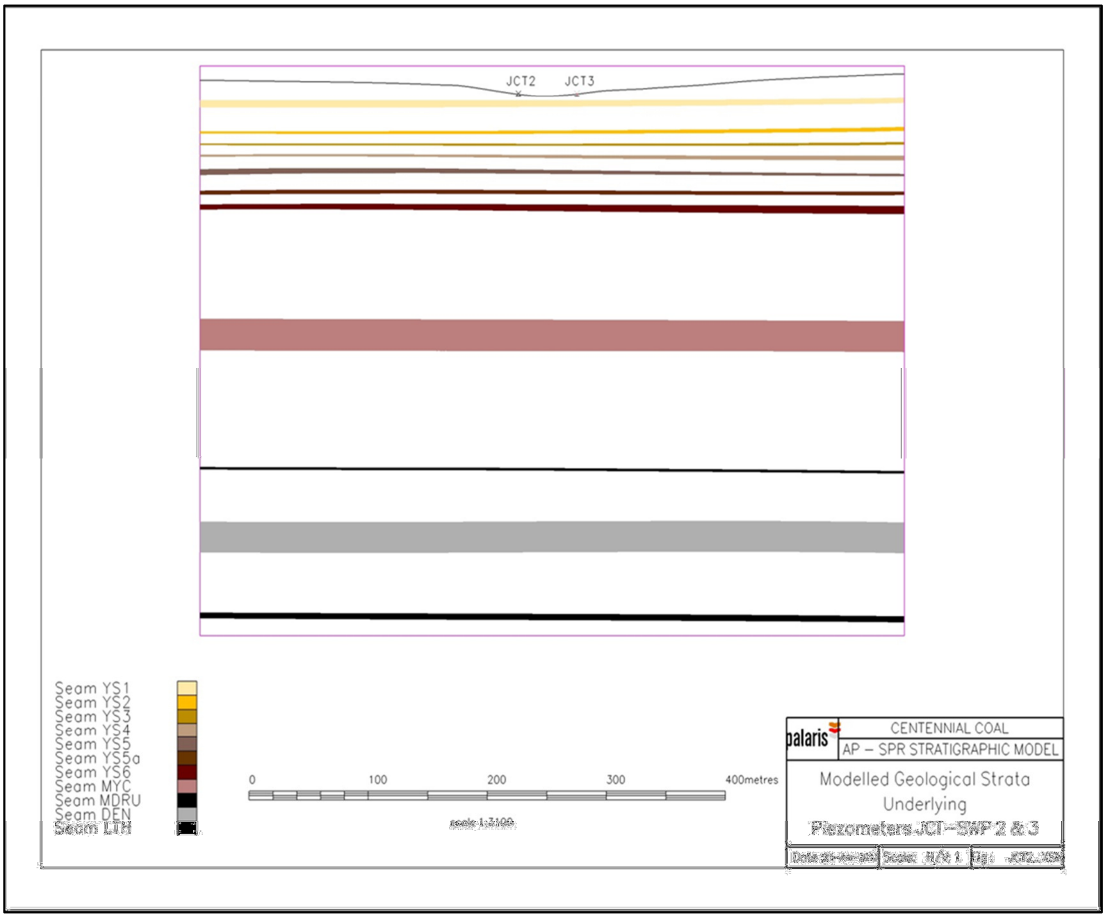


Figure 2.4 – Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Junction Swamp Piezometers JCT – SWP 2 and 3 which are located adjacent to Junction Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

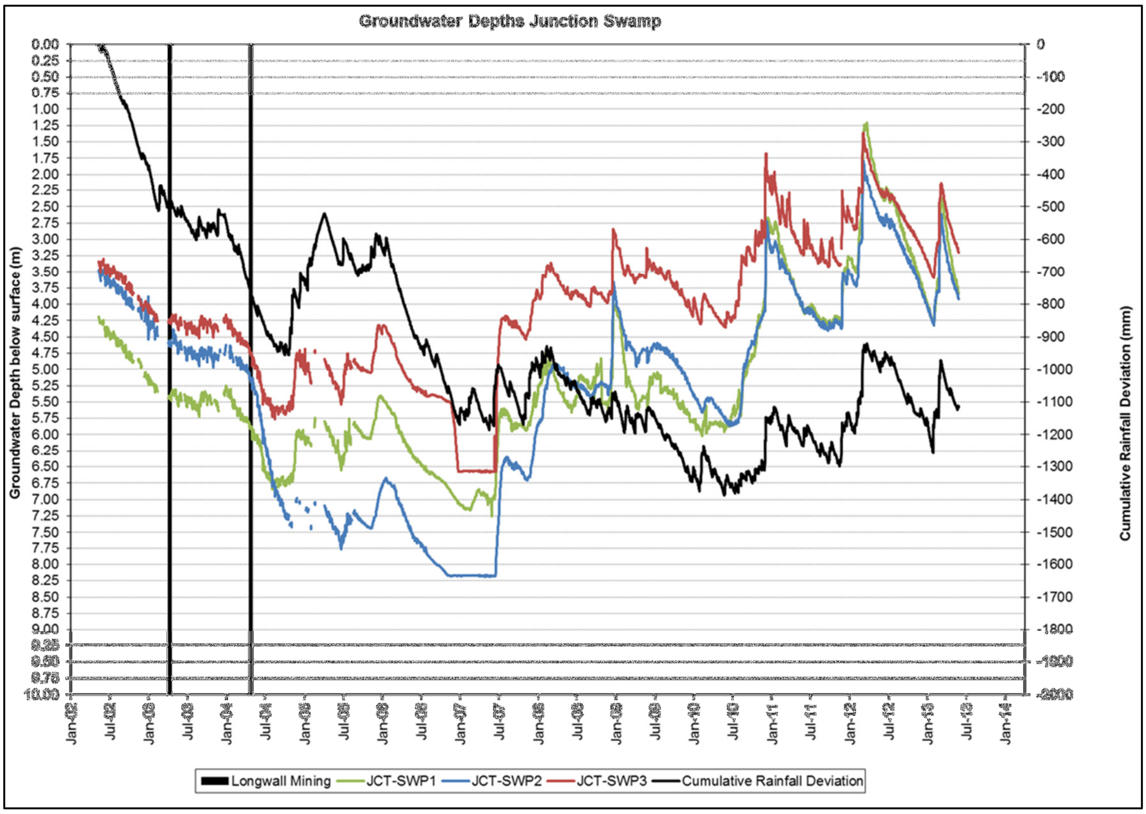


Figure 2.5 – Hydrographs of the swamp piezometers installed at Junction Swamp together with the time of longwall mining beneath the piezometers (indicated by the vertical black lines) and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a very strong correlation between the trendlines of standing water levels beneath the swamp and the CRD trendline for all swamp piezometers over the eleven years of monitoring at this location. This data indicated that the swamp is periodically waterlogged (standing water levels respond to rainfall). The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining.

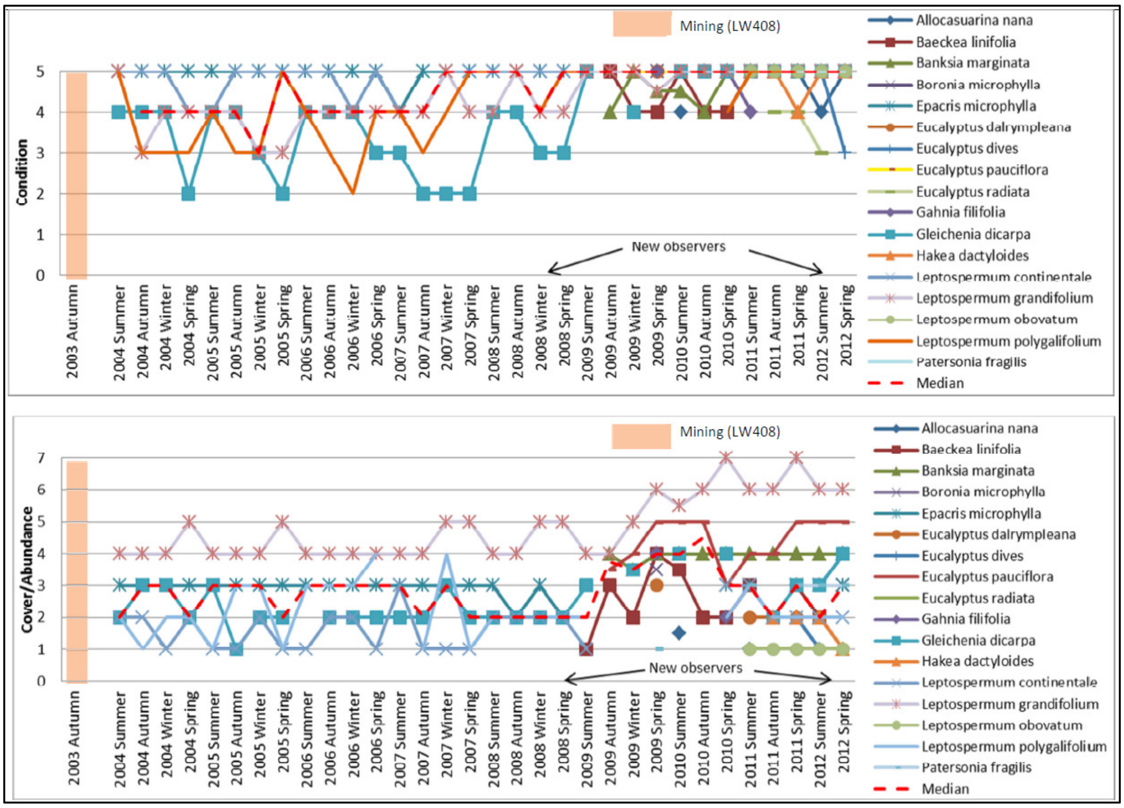


Figure 2.6 Condition (a) and Cover/Abundance (b) of species at NP005

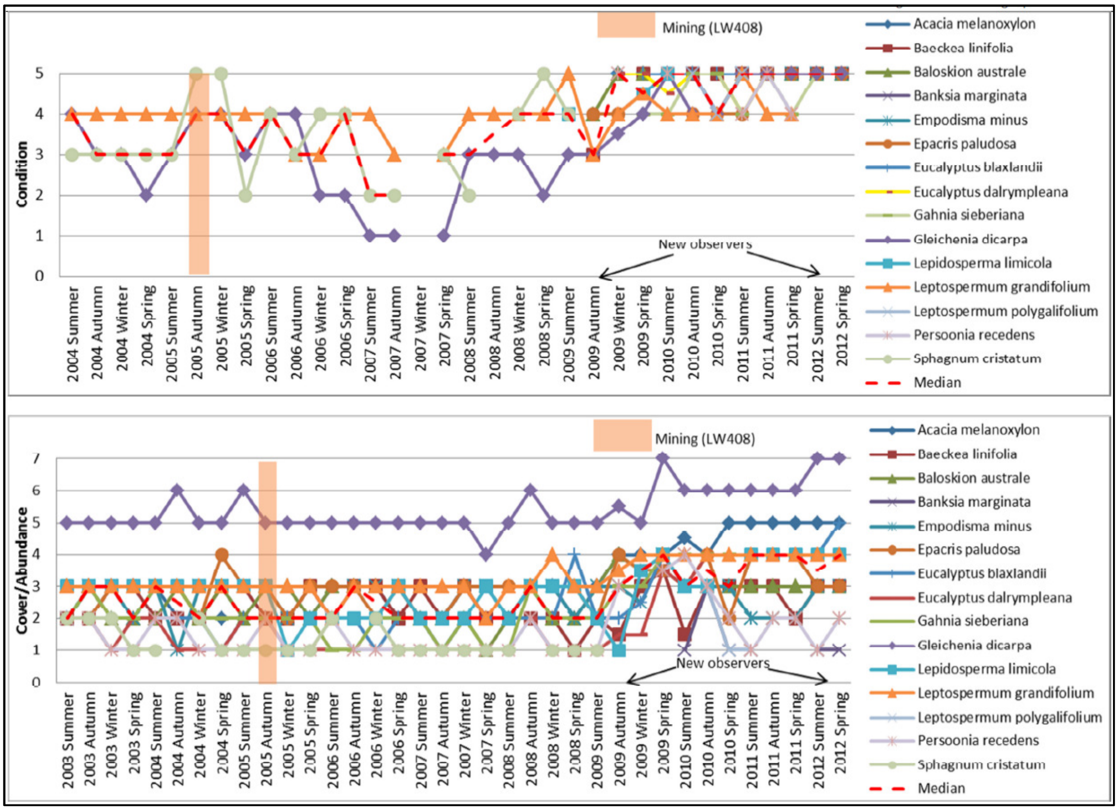


Figure 2.7 Condition (a) and Cover/Abundance (b) of species at NP006

Sunnyside West Swamp Case Study

Sunnyside West Swamp Case Study

The following is a case study of longwall mining beneath Sunnyside West Swamp on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 3.1 to 3.7. Table 3.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	Monitoring Data / Interpretation
Location	Newnes Plateau
Name	Sunnyside West Swamp
Geology (Swamp Substrate)	Burralow Formation
Depth of Cover (metres)	400m
Longwall Void Width (metres)	315m
Chain Pillar Width (metres)	47m
w/H Ratio	0.79 (Critical)
Timing of Longwall Mining	January 2009
Subsidence (Vertical) (metres)	1.4m
Subsidence (Strains) (millimetres / metre)	(17)mm/m Compressive 17mm/m Tensile
Swamp Hydrology (Standing Water Level)	Baseline - Periodically Waterlogged No change due to longwall mining
Flora	At site NP007 the condition and cover/abundance scores were generally stable

Table 3.1 – Summary of Key Data from Environmental Monitoring at Sunnyside West Swamp

Summary of Sunnyside West Swamp Case Study Data

Environmental monitoring at Sunnyside West Swamp has been conducted over the last eleven years. Table 3.1 is a summary of key monitoring data. The key points from the case study of Sunnyside West Swamp are as follows:

- Burralow Formation Geology Substrate
- Periodically Waterlogged Swamp
- Standing Water Level Trends follow Cumulative Rainfall Deviation Trend
- Soil Moisture variable - consistent with periodically waterlogged classification

- Longwall Mining under Sunnyside West Swamp in January 2009 – no correlation with hydrograph trends
- Subsidence up to 1.4m, Strains 17mm/m (tensile) to (17)mm/m (compressive)
- No obvious long term mine subsidence impacts to hydrology
- At site NP007 (Figure 52) the condition and cover/abundance scores were generally stable, apart from Grevillea acanthifolia, for which cover/abundance dropped from 4 to 1 between summer and spring.

Sunnyside West Swamp

Case Study Figures

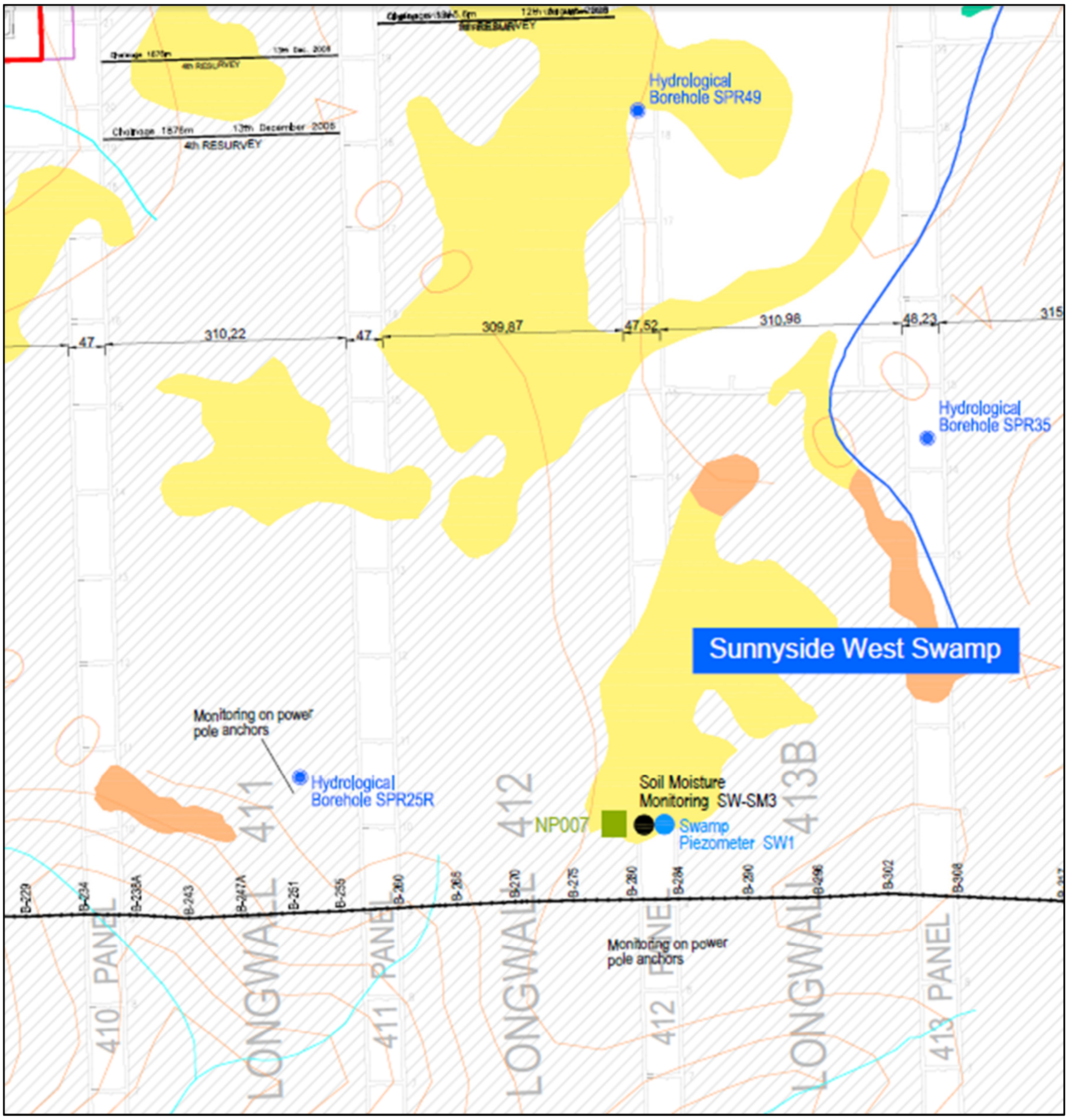


Figure 3.1 Sunnyside West Swamp Case Study Plan

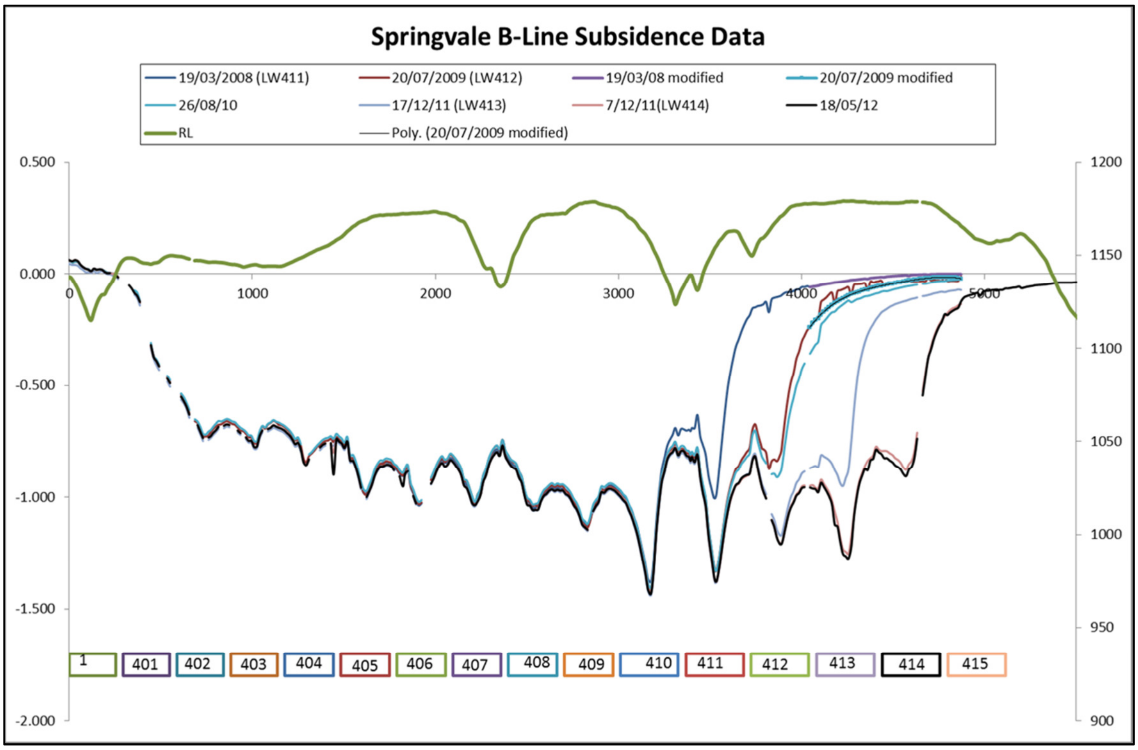


Figure 3.2 Cross Section Springvale Subsidence Monitoring (B-Line) Data Relative to Longwall Position and Surface Topography – note increase in measured vertical subsidence from Longwall 410 to Longwall 413 in response to increased longwall void width from 265m to 315m. Longwall 414 had not developed full subsidence at the time of the last survey on this graph.

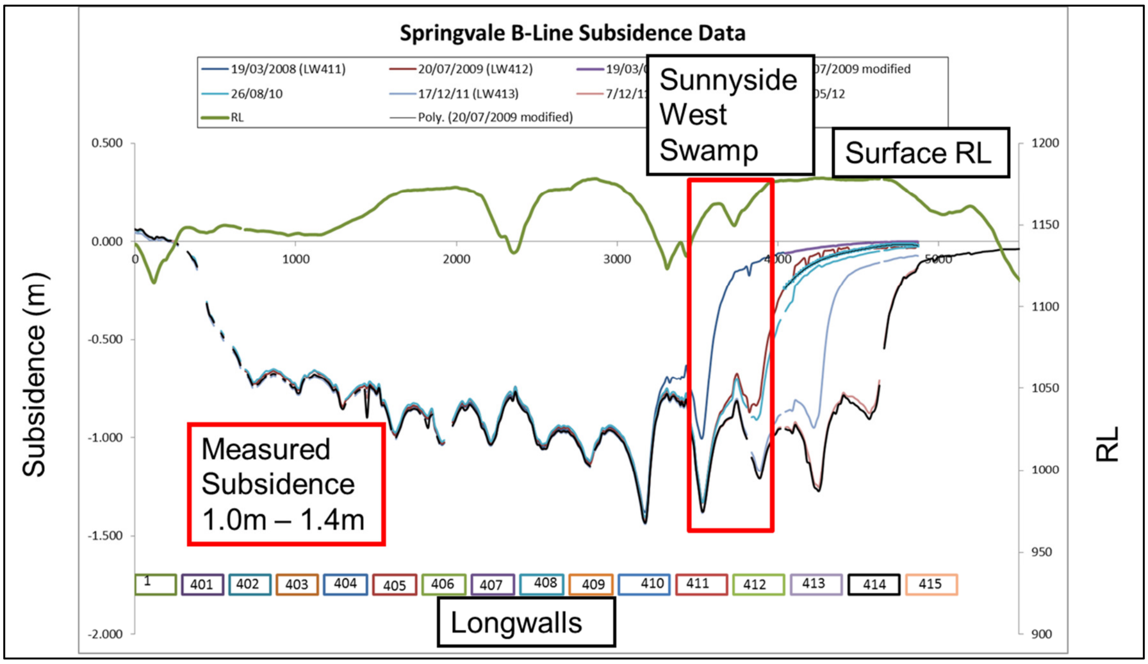


Figure 3.2(a) is the same as Figure 2.2 with explanatory notes about location of Sunnyside West Swamp relative to subsidence line (B-Line) and the measured vertical subsidence on the B-Line in the area of Sunnyside West Swamp. As shown in Figure 2.1, the B-Line does not cross Sunnyside West Swamp, but is very close and is representative of subsidence at Sunnyside West Swamp.

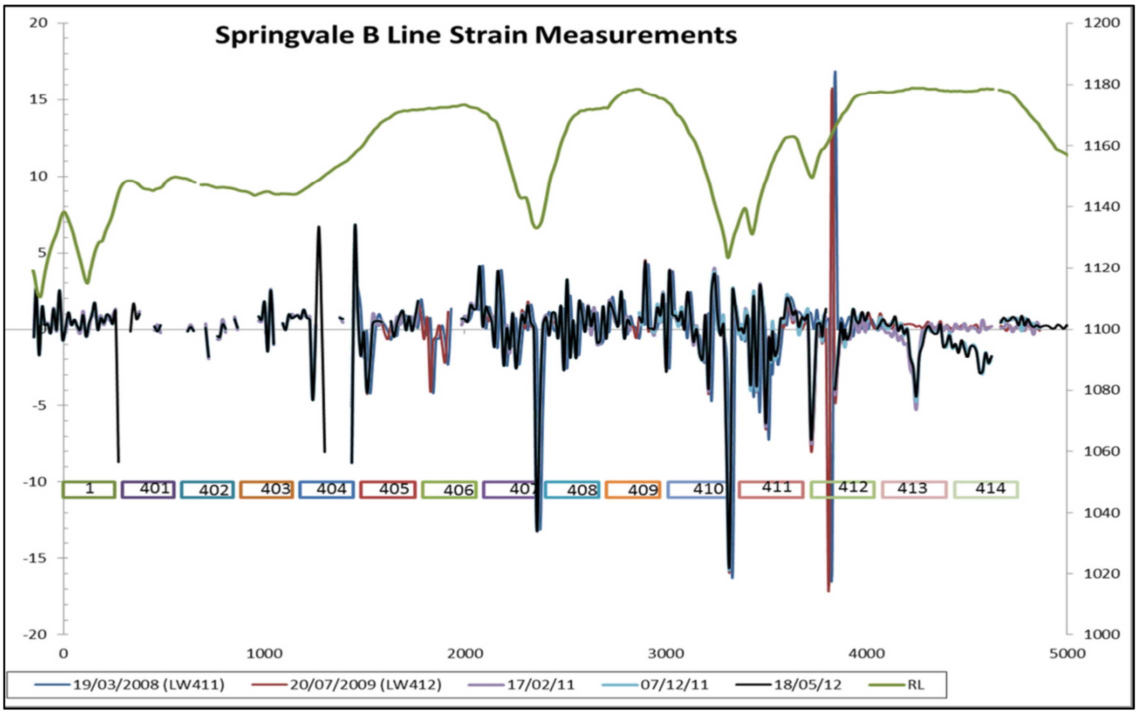


Figure 3.3 Cross Section Springvale Strain Monitoring (B-Line) Data Relative to Longwall Position and Surface Topography – note increase in measured strains from Longwall 410 to Longwall 413 in response to increased longwall void width from 265m to 315m. Longwall 414 had not developed full subsidence at the time of the last survey on this graph.

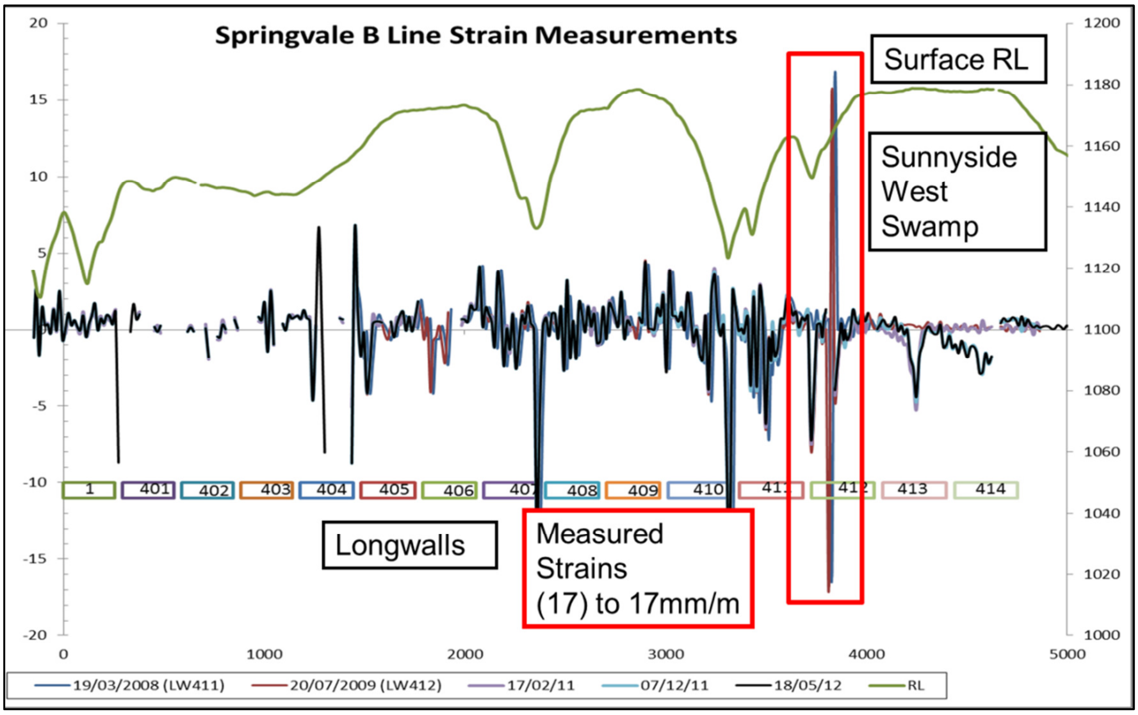


Figure 3.3(a) is the same as Figure 3.3 with explanatory notes about location of Sunnyside West Swamp relative to subsidence line (B-Line) and the measured strains on the B-Line in the area of Sunnyside West Swamp. As shown in Figure 3.1, the B-Line does not cross Sunnyside West Swamp, but is the very close and is representative of subsidence at Sunnyside West Swamp .

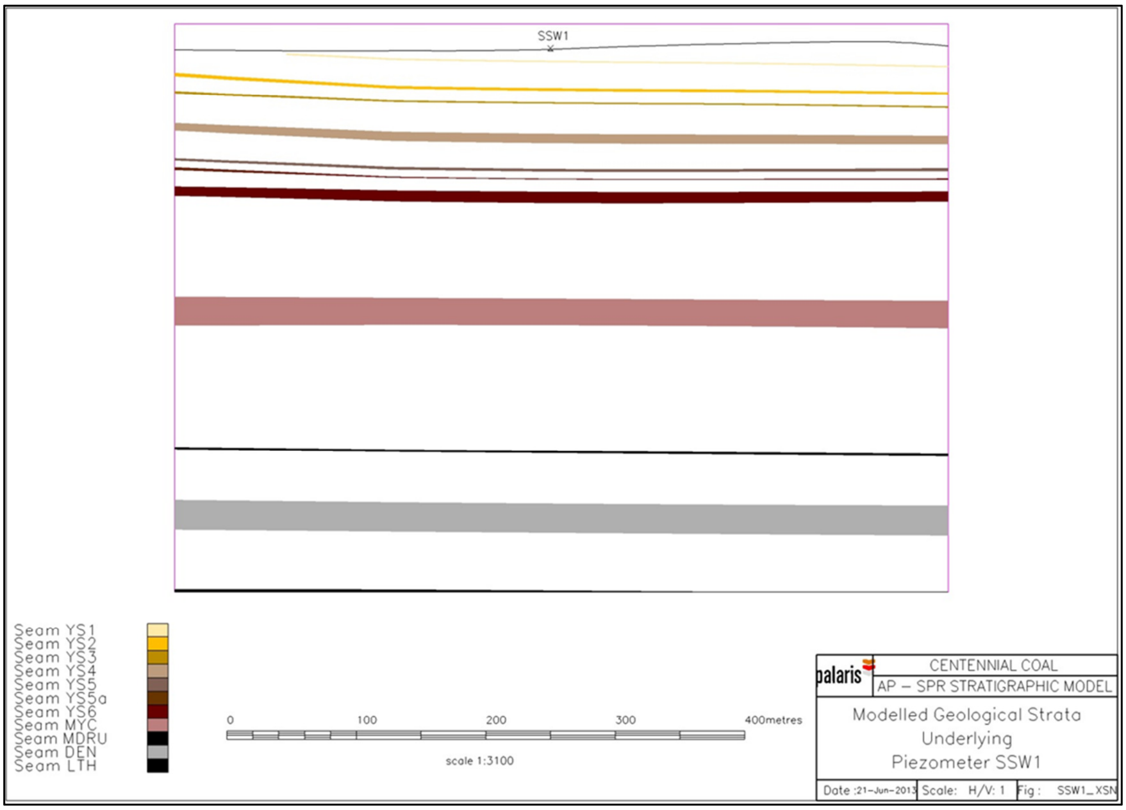


Figure 3.4 – Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Swamp Piezometer SSW1 which is located in Sunnyside West Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

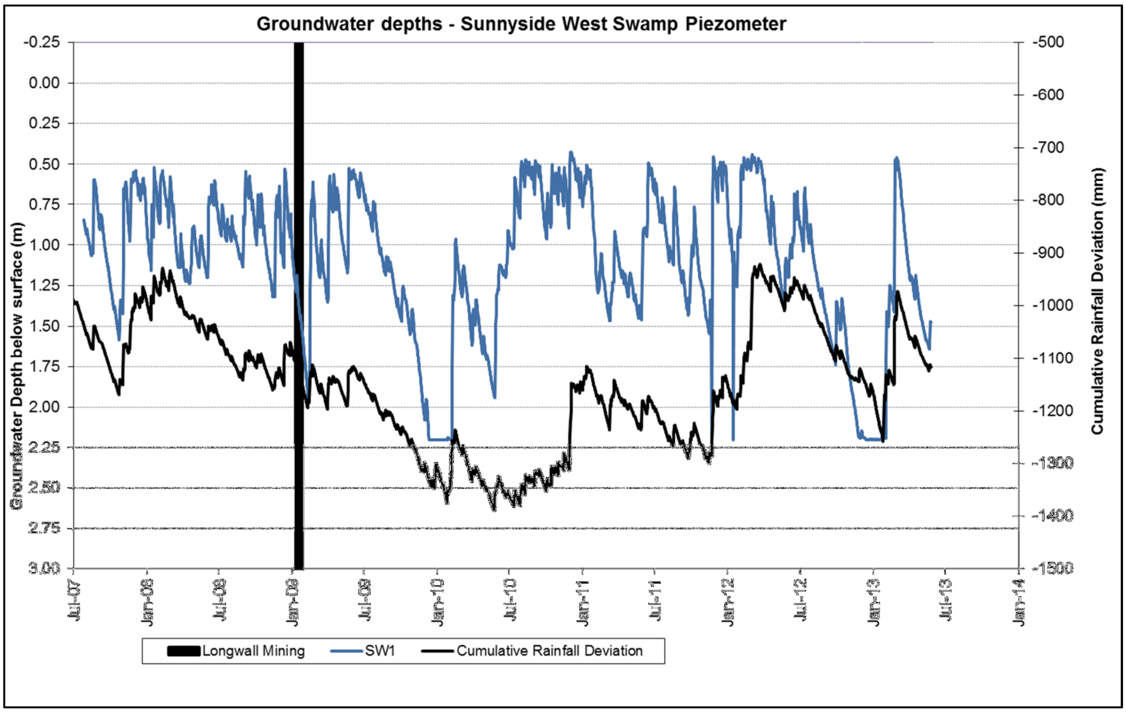


Figure 3.5 – Hydrographs of the swamp piezometers installed at Sunnyside West Swamp together with the time of longwall mining beneath the piezometers (indicated by the vertical black line) and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is

a very strong correlation between the trendline of standing water level beneath the swamp and the CRD trendline for the SSW1 swamp piezometer over the six years of monitoring at this location. This data indicated that the swamp is periodically waterlogged (standing water levels respond to rainfall). The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining.

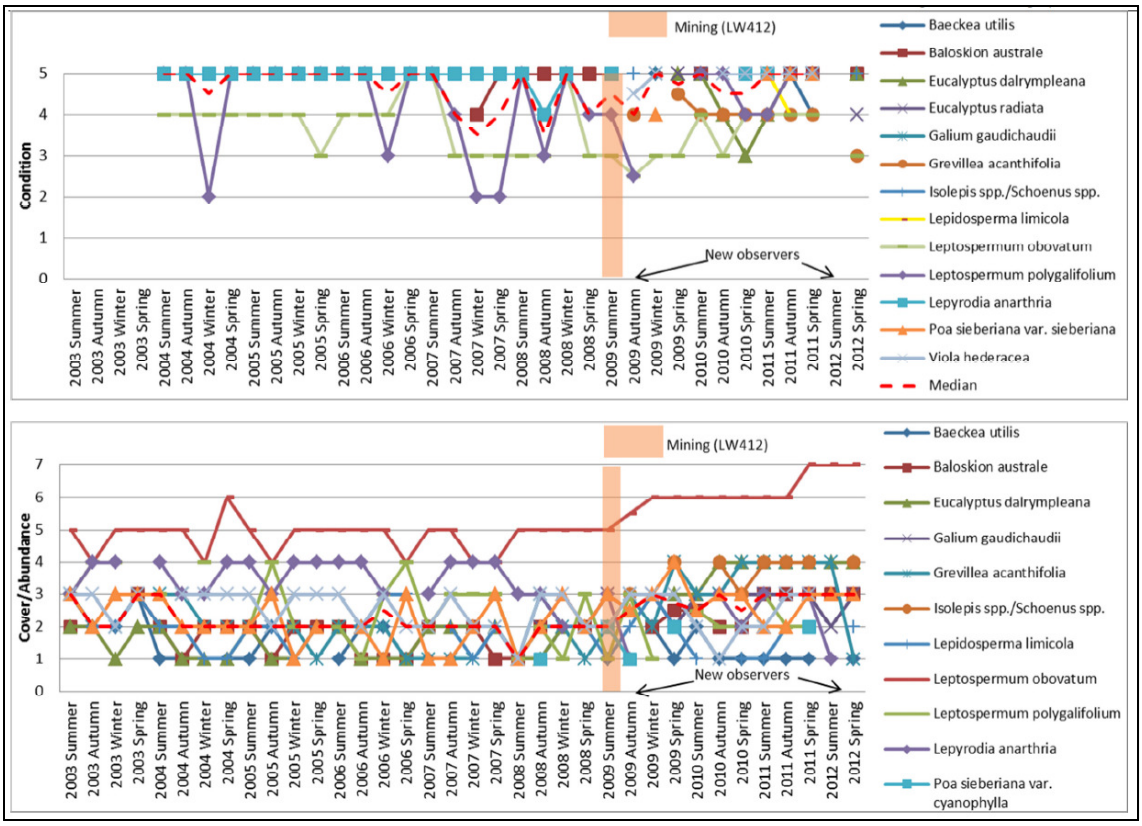


Figure 3.6 Condition (a) and Cover/Abundance (b) of species at NP007

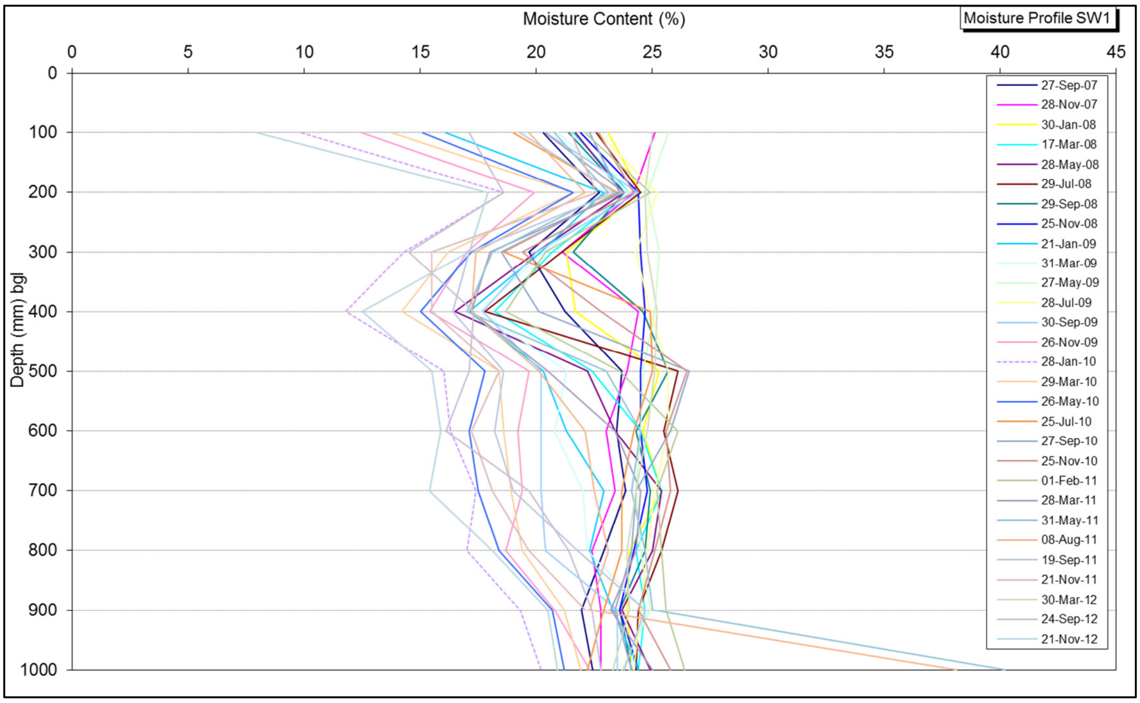


Figure 3.7 Soil Moisture Monitoring at Sunnyside West Swamp SW-SM3 showing variable soil moisture consistent with periodically waterlogged classification

West Wolgan Swamp Case Study

West Wolgan Swamp Case Study

The following is a case study of longwall mining beneath West Wolgan Swamp on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 4.1 to 4.13. Table 4.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	**Monitoring Data / Interpretation**
Location	Newnes Plateau
Name	West Wolgan Swamp
Geology (Swamp Substrate)	Burralow Formation
Depth of Cover (metres)	360m
Longwall Void Width (metres)	262 – 292m
Chain Pillar Width (metres)	40 - 43m
w/H Ratio	0.73 to 0.81(Critical)
Timing of Longwall Mining	June 2006 and November 2007
Subsidence (Vertical) (metres)	1.0m
Subsidence (Strains) (millimetres / metre)	(6)mm/m Compressive 2mm/m Tensile
Swamp Hydrology (Standing Water Level)	Baseline - Periodically Waterlogged No change due to longwall mining
Flora	Condition has remained consistently very healthy or healthy with the exception of WW04 where condition was lowest during the drought in 2006. This site has improved in condition as cumulative rainfall returned to long term averages

Table 4.1 – Summary of Key Data from Environmental Monitoring at West Wolgan Swamp

Summary of West Wolgan Swamp Case Study Data

Environmental monitoring at West Wolgan Swamp has been conducted over the last eleven years. Table 4.1 is a summary of key monitoring data. The key points from the case study of West Wolgan Swamp are as follows:

- Burralow Formation Geology Substrate
- Periodically Waterlogged Swamp
- Standing Water Level Trends follow Cumulative Rainfall Deviation Trend

- Longwall Mining under West Wolgan Swamp in June 2006 and November 2007 – no correlation with hydrograph trends
- Subsidence up to 1.0m, Strains 2mm/m (tensile) to (6)mm/m (compressive)
- No obvious long term mine subsidence impacts to hydrology
- The West Wolgan shrub swamp consists of a series of small communities linked by narrow Eucalypt canopied swamp like vegetation corridors. The monitoring plots are located within tea tree thicket dominated areas with relatively low species abundance. Condition has remained consistently very healthy or healthy with the exception of WW04 (Figure 4.9) where condition was lowest during the drought in 2006. This site has improved in condition as cumulative rainfall returned to long term averages. Weedy species are consistently present in the West Wolgan swamp complex and reported species richness increased with a peak in 2009 and subsequently have declined. This trend in weed species richness coincides with altered search methodology and broad rainfall patterns and has been consistently declining since 2009 (Figure 4.12). The pattern of weed species richness does not coincide with declines condition or abundance of native swamp species (Figures 4.6 to 4.11).

West Wolgan Swamp

Case Study Figures

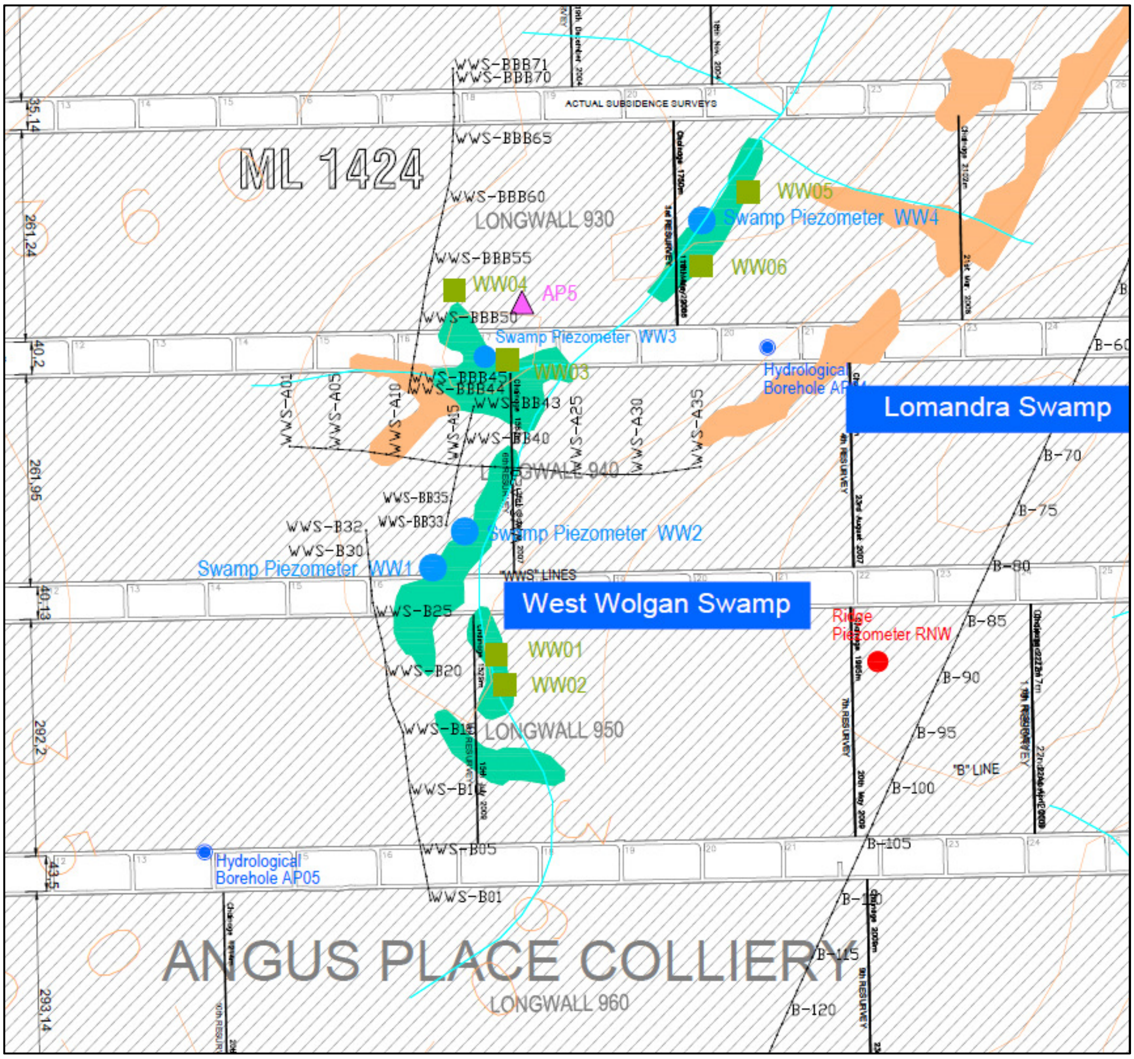


Figure 4.1 West Wolgan Swamp Case Study Plan

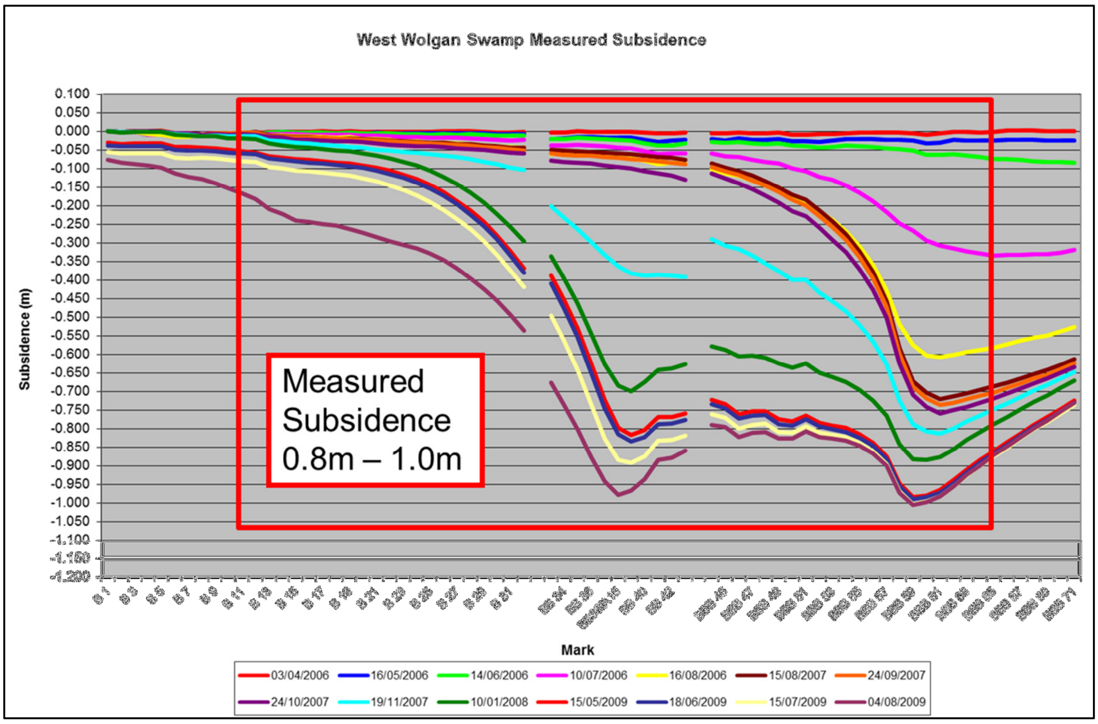


Figure 4.2 Cross Section Angus Place Subsidence Monitoring (WWS-Lines) Vertical Subsidence Data Relative to Longwall Position and Surface Topography – note the area in the red polygon represents the position of West Wolgan Swamp relative to the subsidence lines

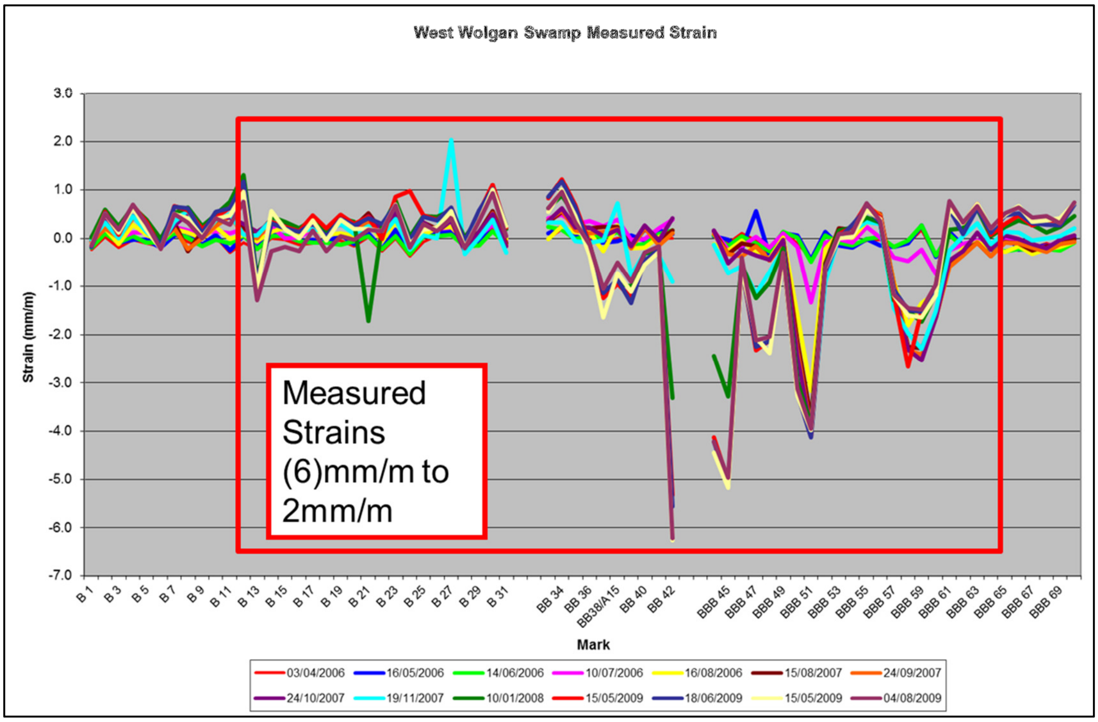


Figure 4.3 Cross Section Angus Place Subsidence Monitoring (WWS-Lines) Strain Data Relative to Longwall Position and Surface Topography – note the area in the red polygon represents the position of West Wolgan Swamp relative to the subsidence lines

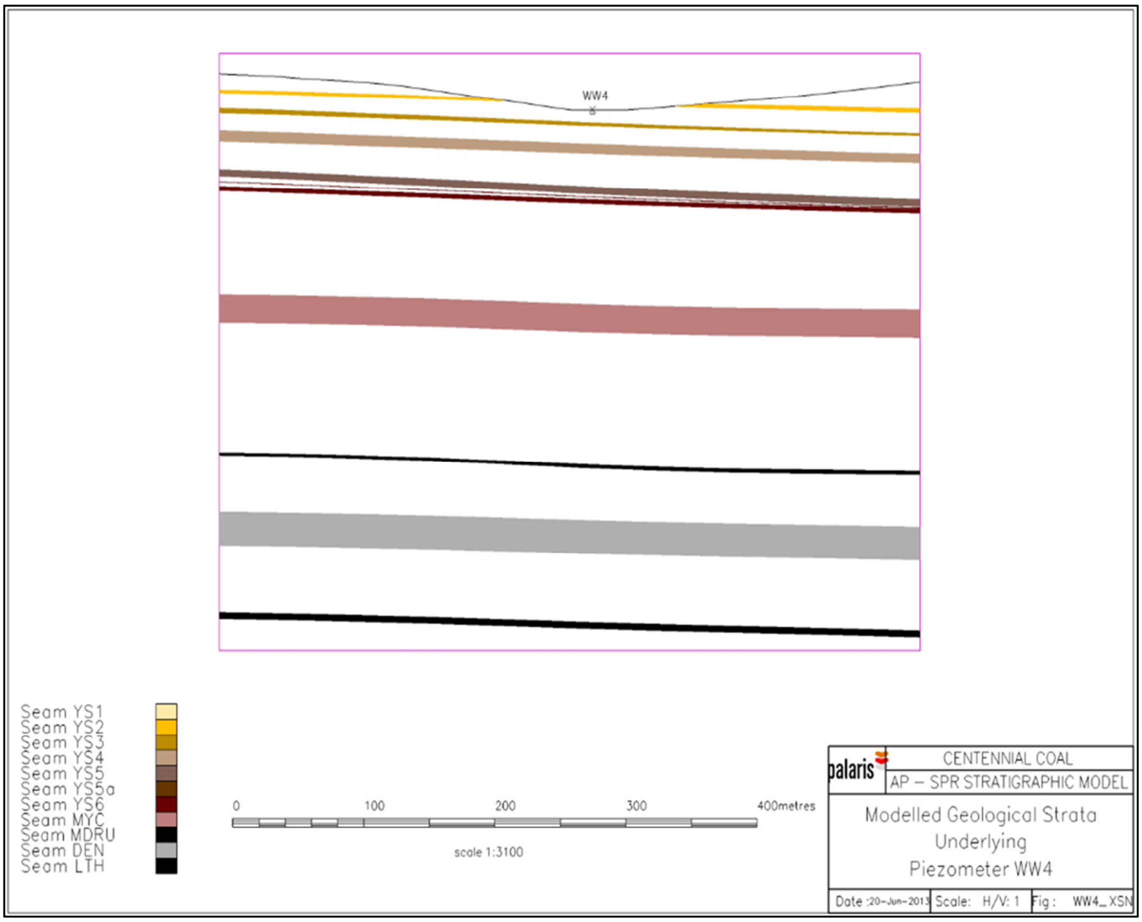


Figure 4.4 – Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Swamp Piezometer WW04 which is located in West Wolgan Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

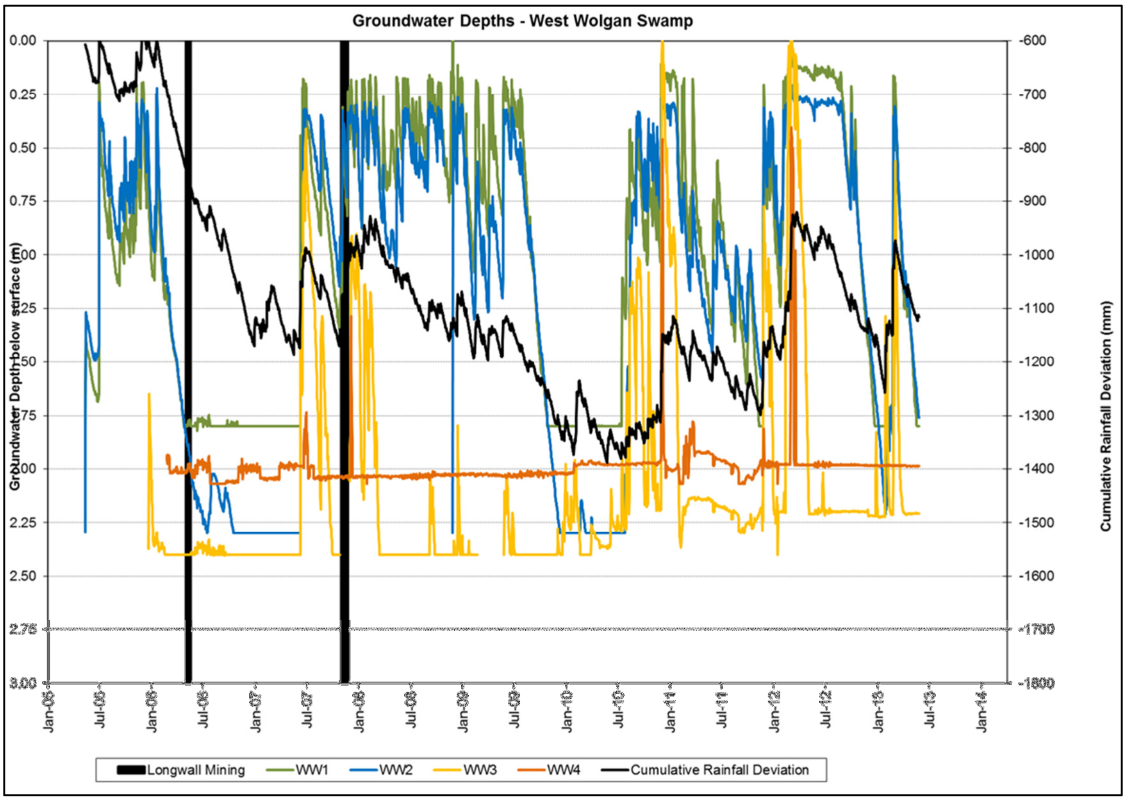


Figure 4.5 – Hydrographs of the swamp piezometers installed at West Wolgan Swamp together with the time of longwall mining beneath the piezometers (indicated by the vertical black lines) and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a very strong correlation between the trendline of standing water level beneath the swamp and the CRD trendline for the four West Wolgan Swamp piezometers over the eight years of monitoring at this location. This data indicated that the swamp is periodically waterlogged (standing water levels respond to rainfall). The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining.

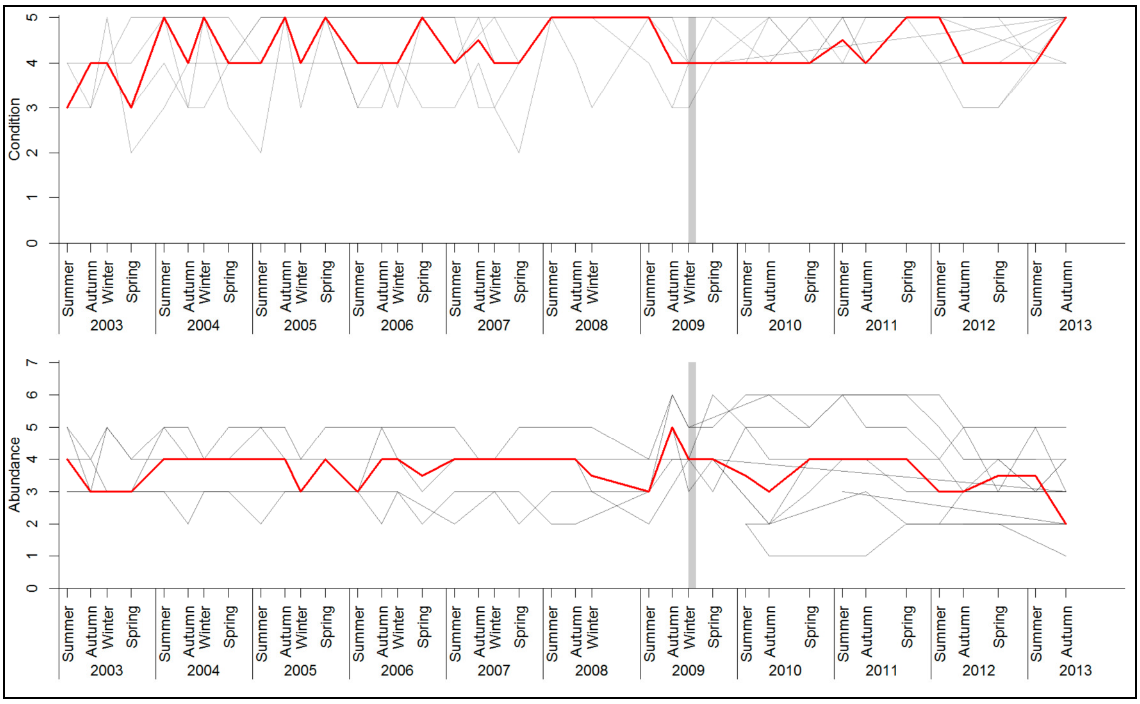


Figure 4.6: Median condition and abundance for West Wolgan 1 flora monitoring plot.

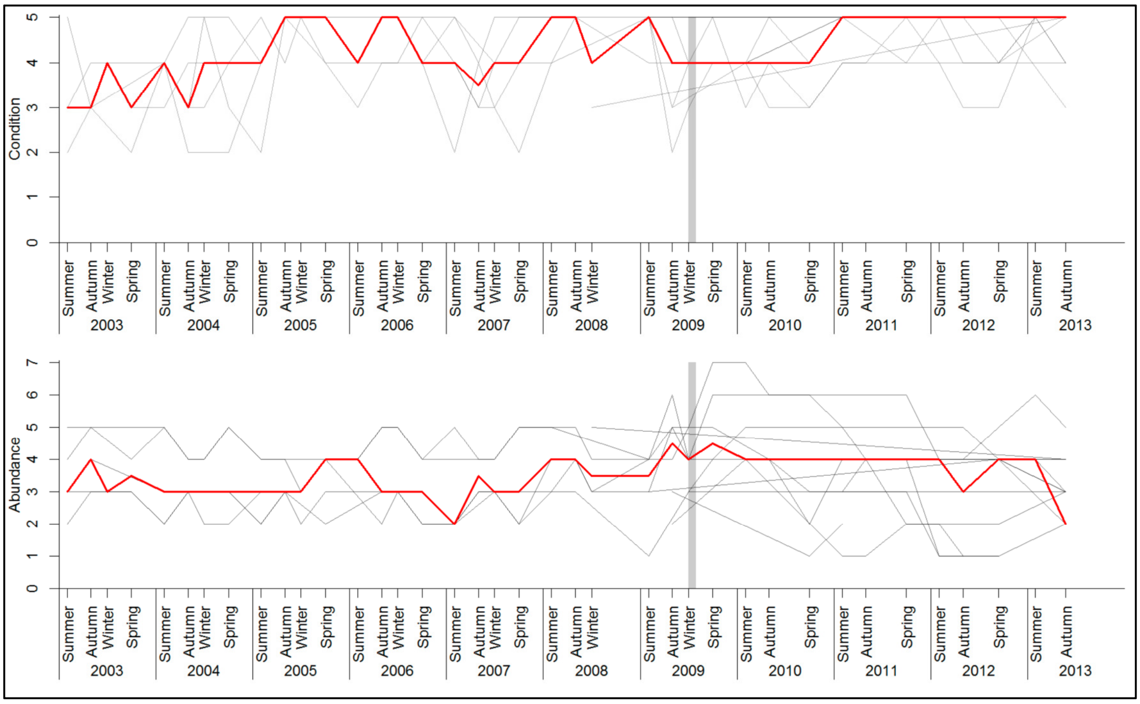


Figure 4.7: Median condition and abundance for West Wolgan 2 flora monitoring plot

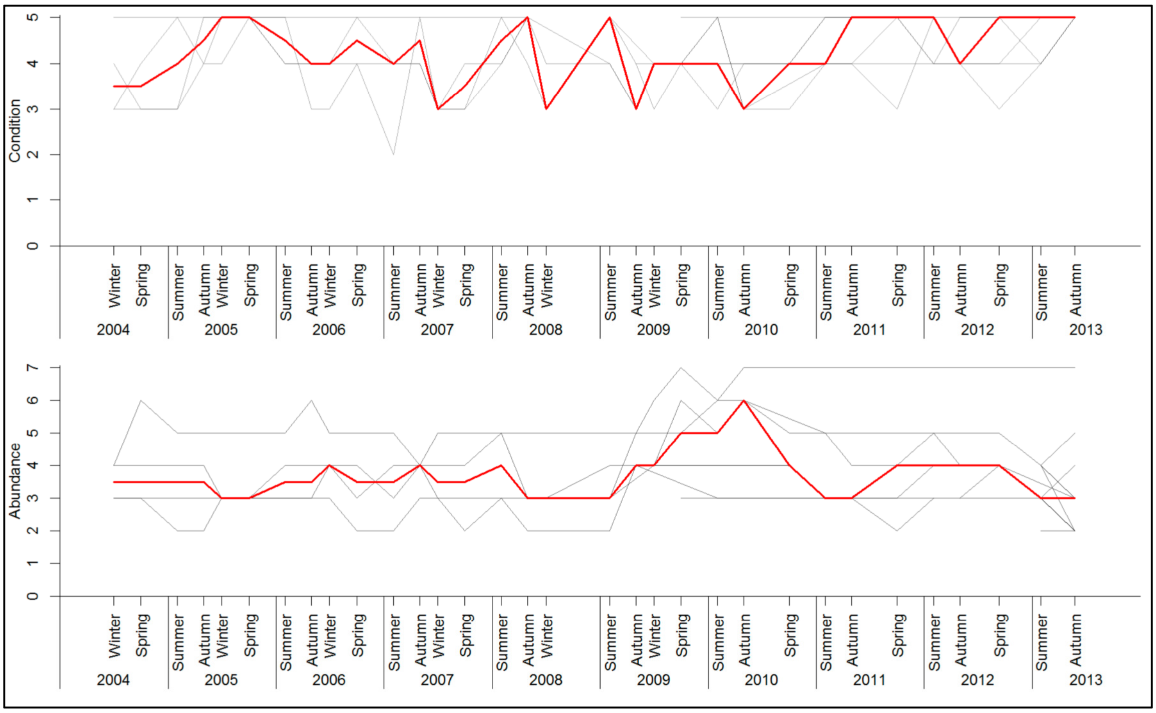


Figure 4.8: Median condition and abundance for West Wolgan 3 flora monitoring plot.

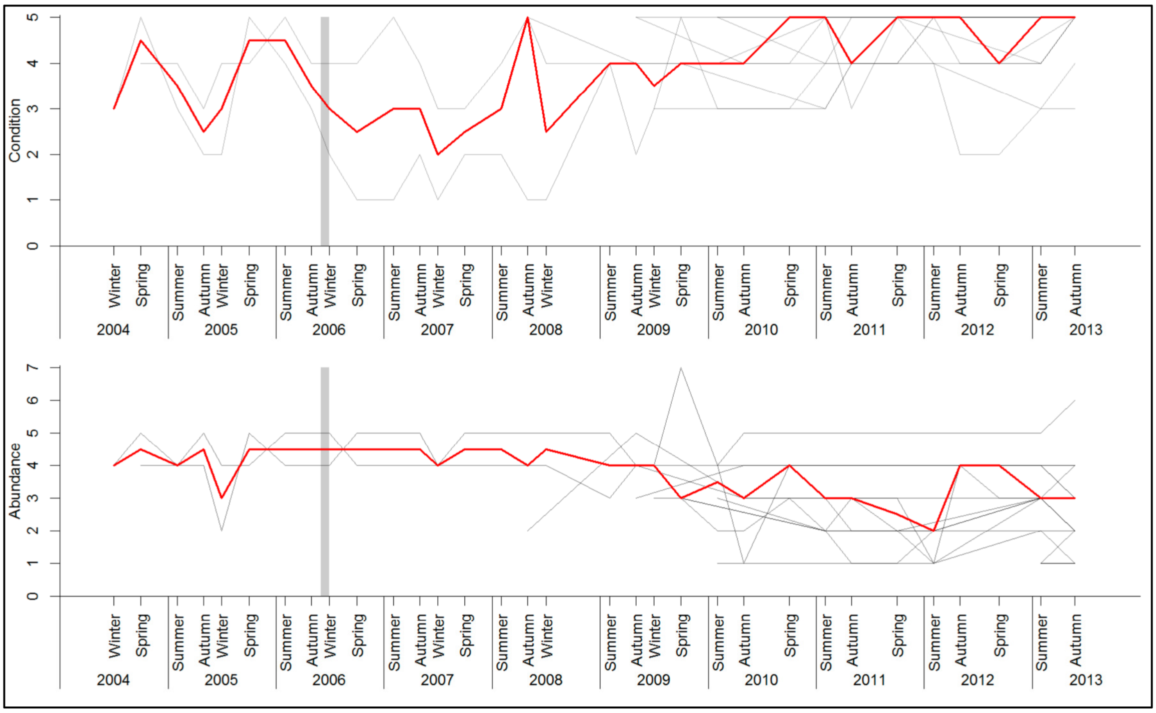


Figure 4.9: Median condition and abundance for West Wolgan 4 flora monitoring plot.

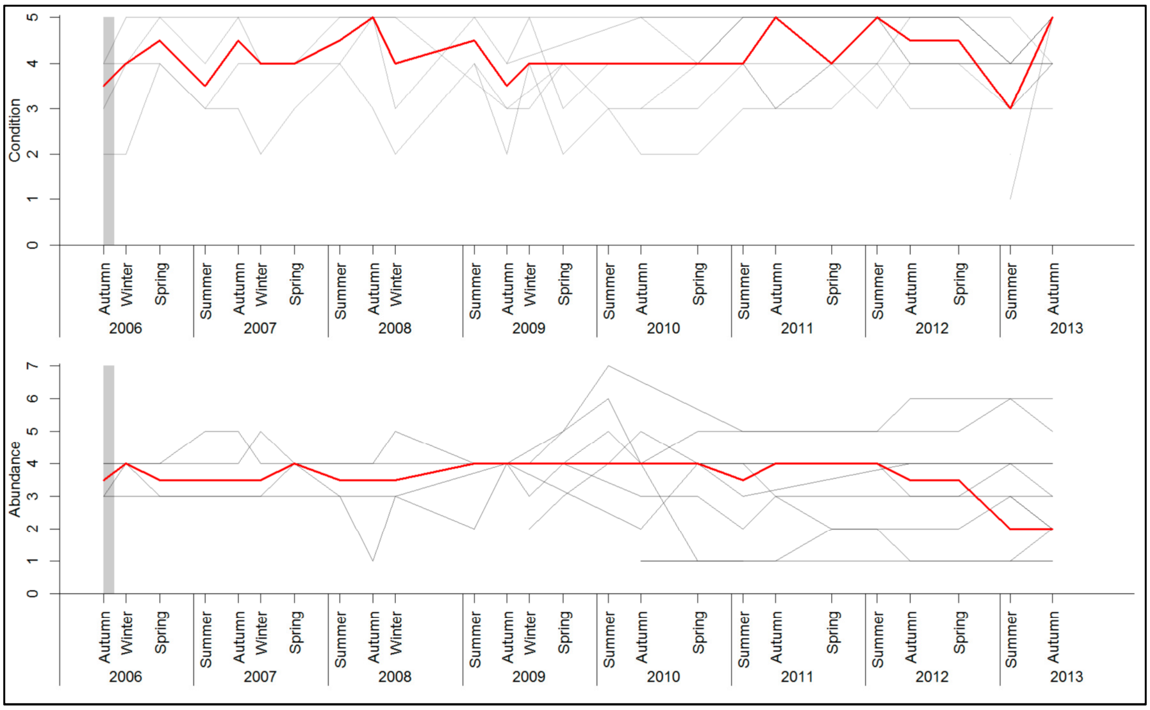


Figure 4.10: Median condition and abundance for West Wolgan 5 flora monitoring plot.

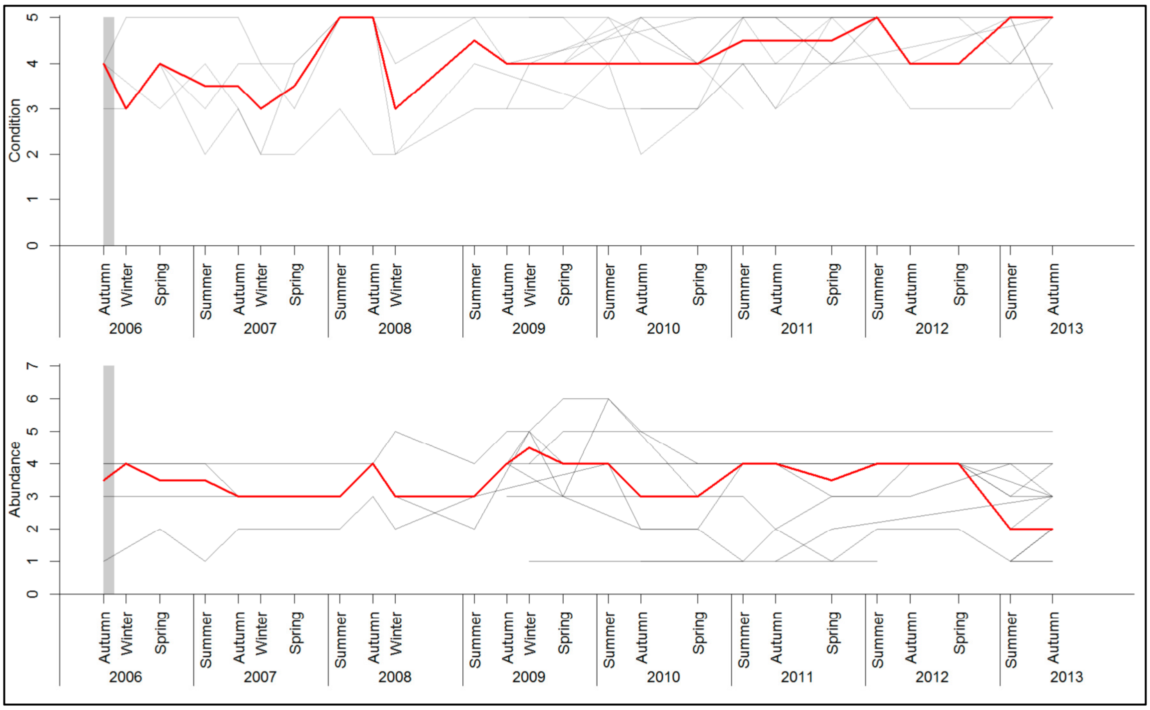


Figure 4.11: Median condition and abundance for West Wolgan 6 flora monitoring plot.

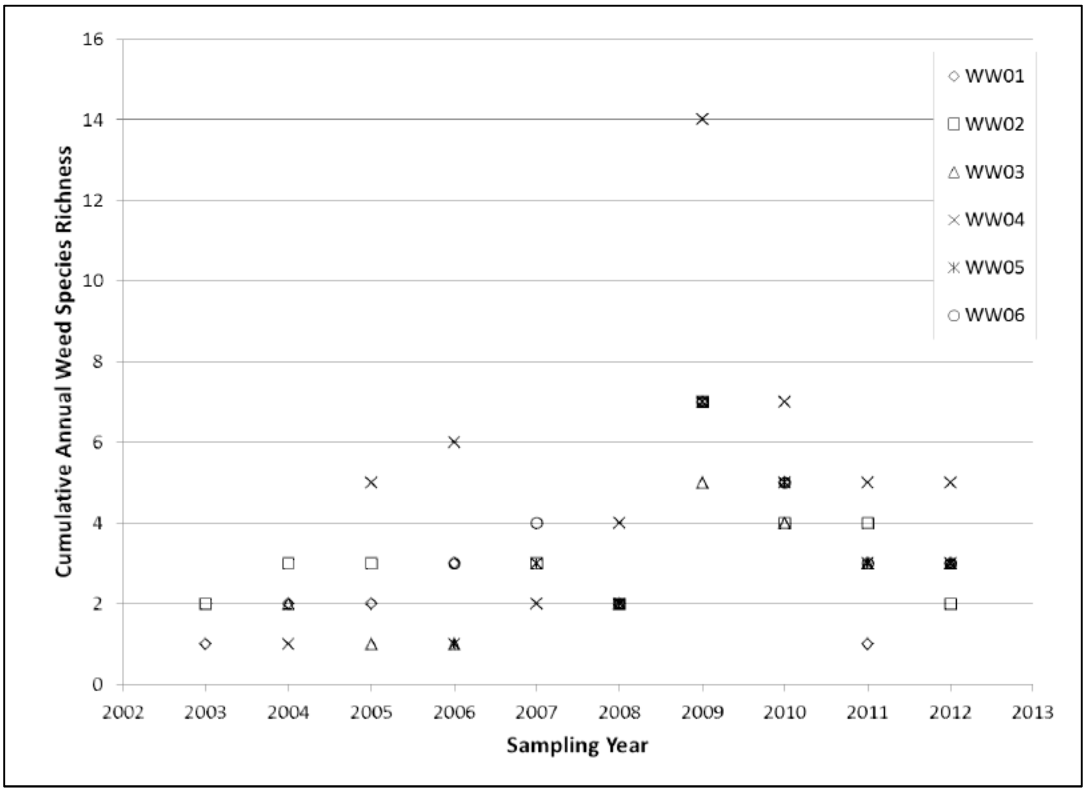


Figure 4.12: Cumulative annual species richness of weeds in West Wolgan swamp complex monitoring plots.

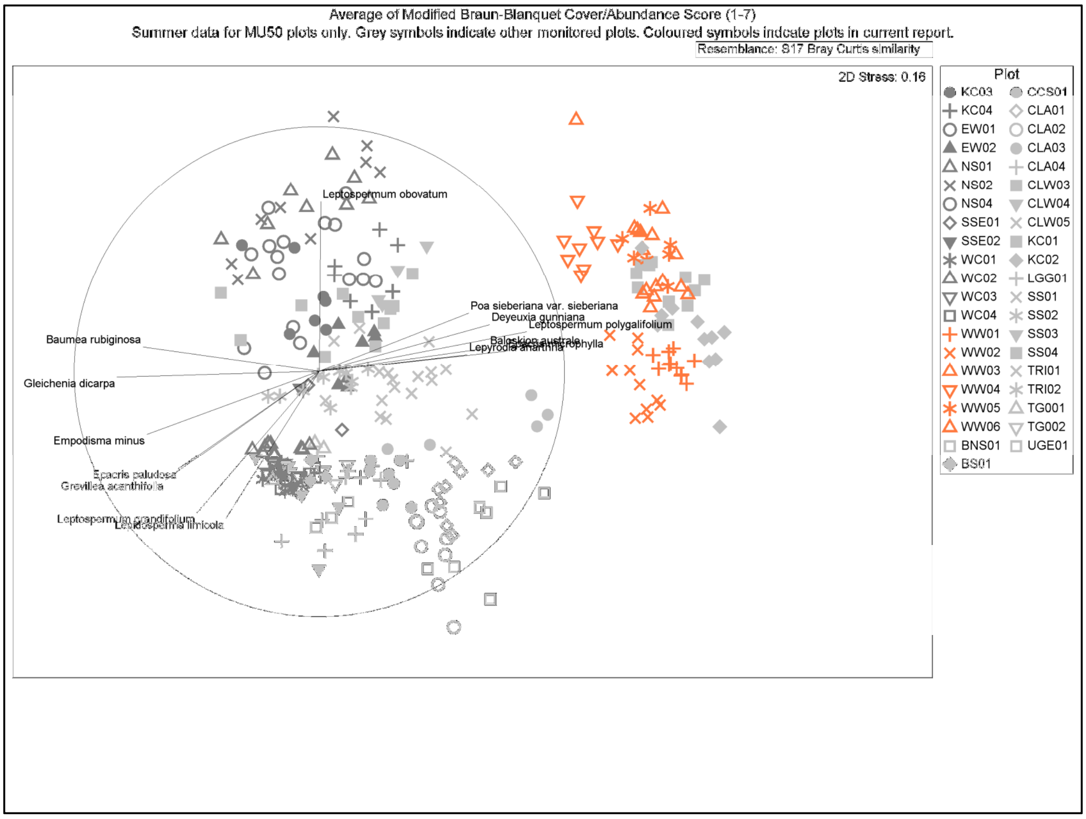


Figure 4.13: nMDS plot of all summer data for monitoring plots in West Wolgan swamp. Summer data for all other MU50 swamps provided for comparison.

Sunnyside Swamp

Case Study

Sunnyside Swamp Case Study

The following is a case study of longwall mining beneath Sunnyside Swamp on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 5.1 to 5.9. Table 5.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	**Monitoring Data / Interpretation**
Location	Newnes Plateau
Name	Sunnyside Swamp
Geology (Swamp Substrate)	Burralow Formation
Depth of Cover (metres)	350 - 390m
Longwall Void Width (metres)	315m
Chain Pillar Width (metres)	46 - 48m
w/H Ratio	0.81 to 0.9 (Critical)
Timing of Longwall Mining	August 2009 to October 2012
Subsidence (Vertical) (metres)	0.1m
Subsidence (Strains) (millimetres / metre)	(3)mm/m Compressive 1mm/m Tensile
Swamp Hydrology (Standing Water Level)	Baseline - Pemanently Waterlogged No change due to longwall mining
Flora	Data not available at time of report

Table 5.1 – Summary of Key Data from Environmental Monitoring at Sunnyside Swamp

Summary of Sunnyside Swamp Case Study Data

Environmental monitoring at Sunnyside Swamp has been conducted over the last eleven years. Table 5.1 is a summary of key monitoring data. The key points from the case study of Sunnyside Swamp are as follows:

- Burralow Formation Geology Substrate
- Permanently Waterlogged swamp
- Longwall Mining conducted to East, West and South of Sunnyside Swamp between August 2009 and October 2012. Note that mining was conducted within 26.5 degree angle of draw
- Subsidence 0.1m, Strains 1mm/m (tensile) to 3mm/m (compressive)
- No evidence of impacts to swamp hydrology

- Hydrograhs show no change in response to mining
- Flows from Sunnyside and Carne West Swamps very similar trends

Sunnyside Swamp

Case Study Figures

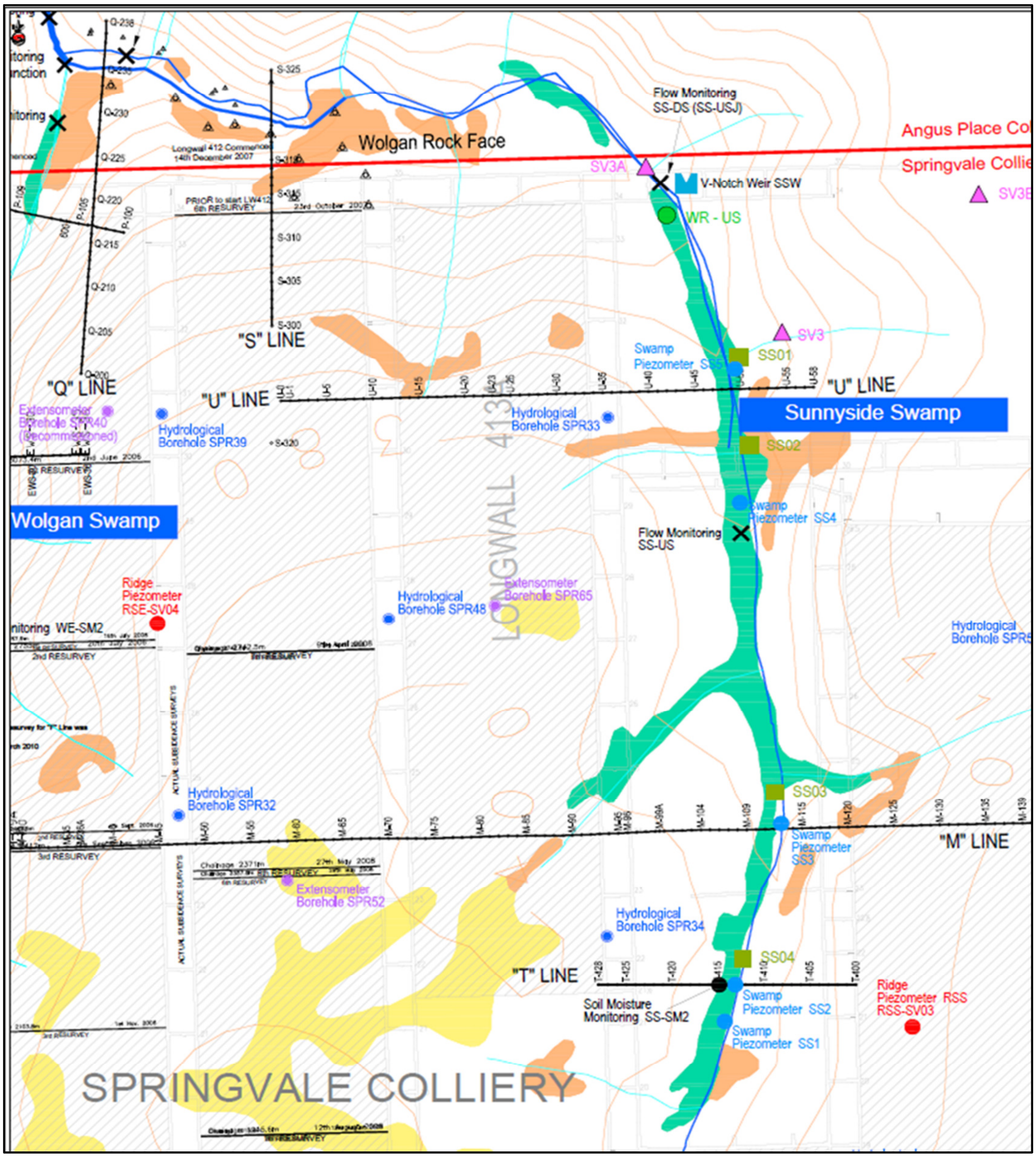


Figure 5.1 Sunnyside Swamp Case Study Plan

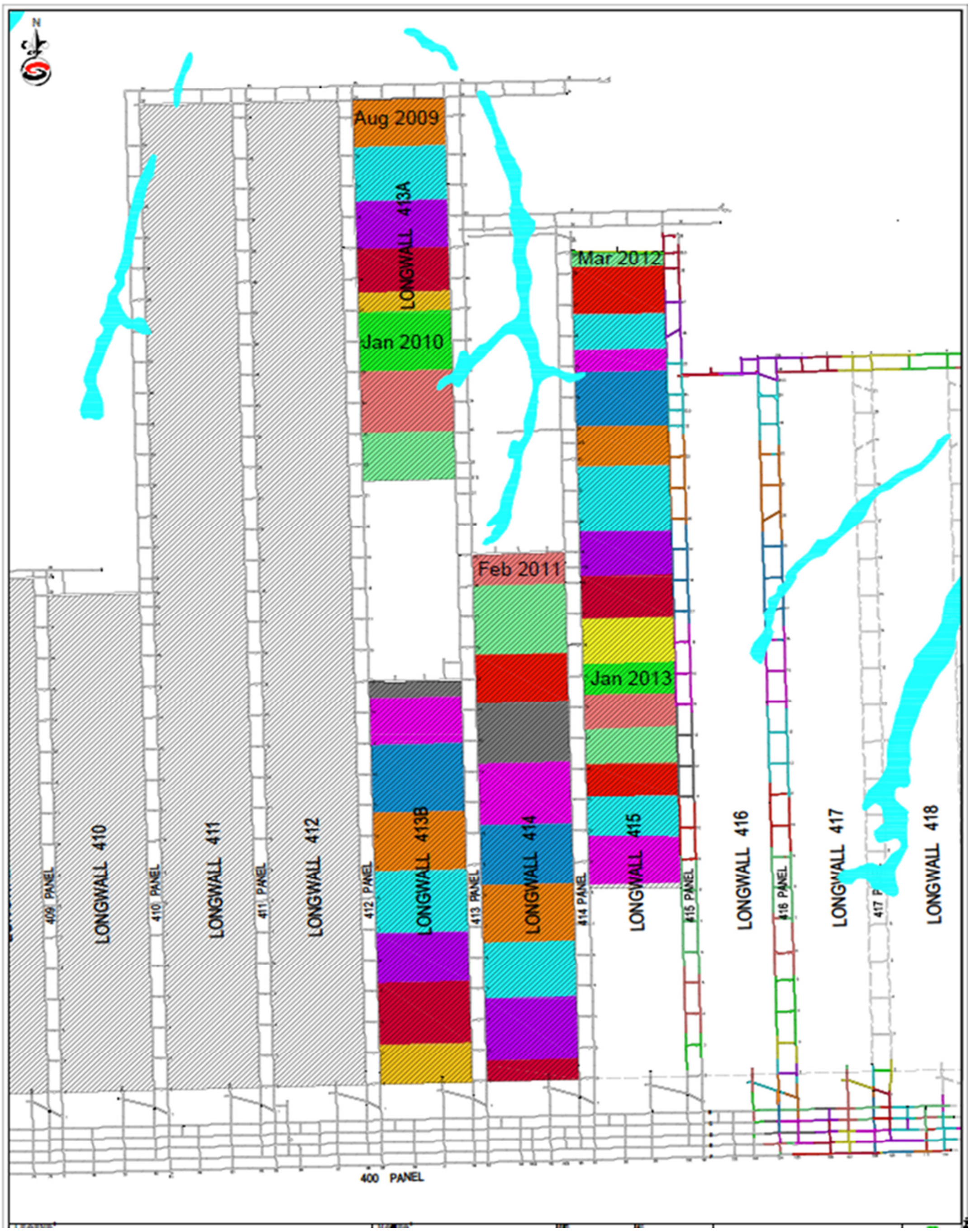


Figure 5.2 Plan showing Longwall Mining conducted to East, West and South of Sunnyside Swamp between August 2009 and October 2012. Note that mining was conducted within 26.5 degree angle of draw

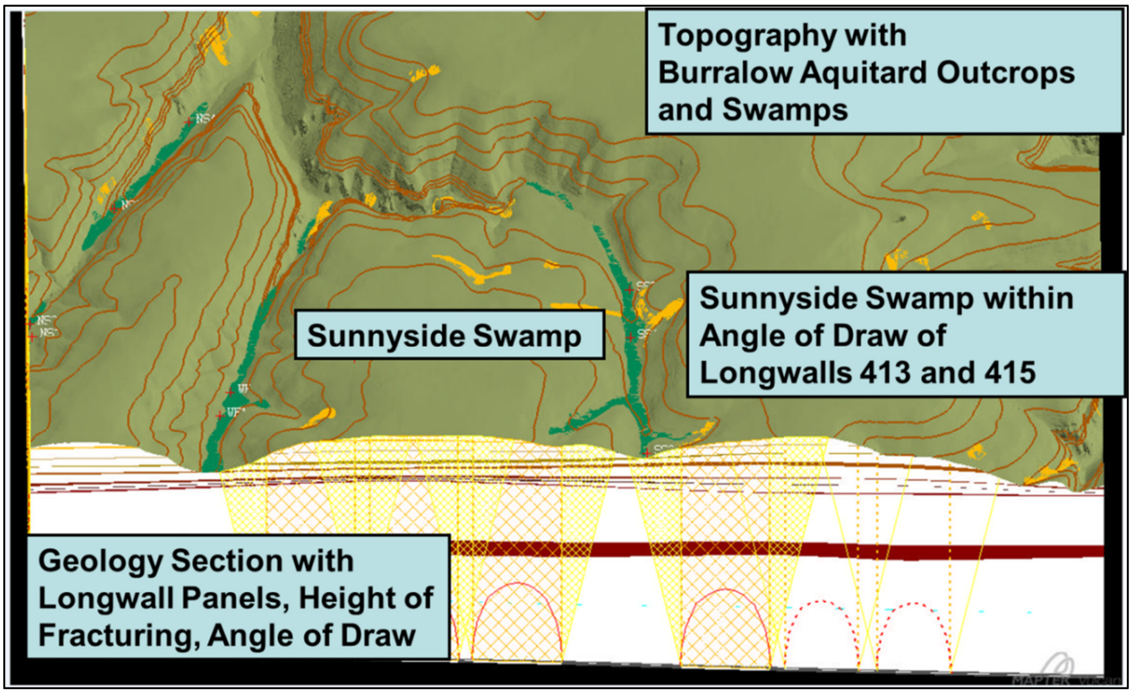


Figure 5.3 Annotated 3 Dimensional View of Longwall Mining Relative to Sunnyside Swamp. Note that Sunnyside Swamp is within the Angle of Draw of Longwalls 413 and 415 (yellow hatching)

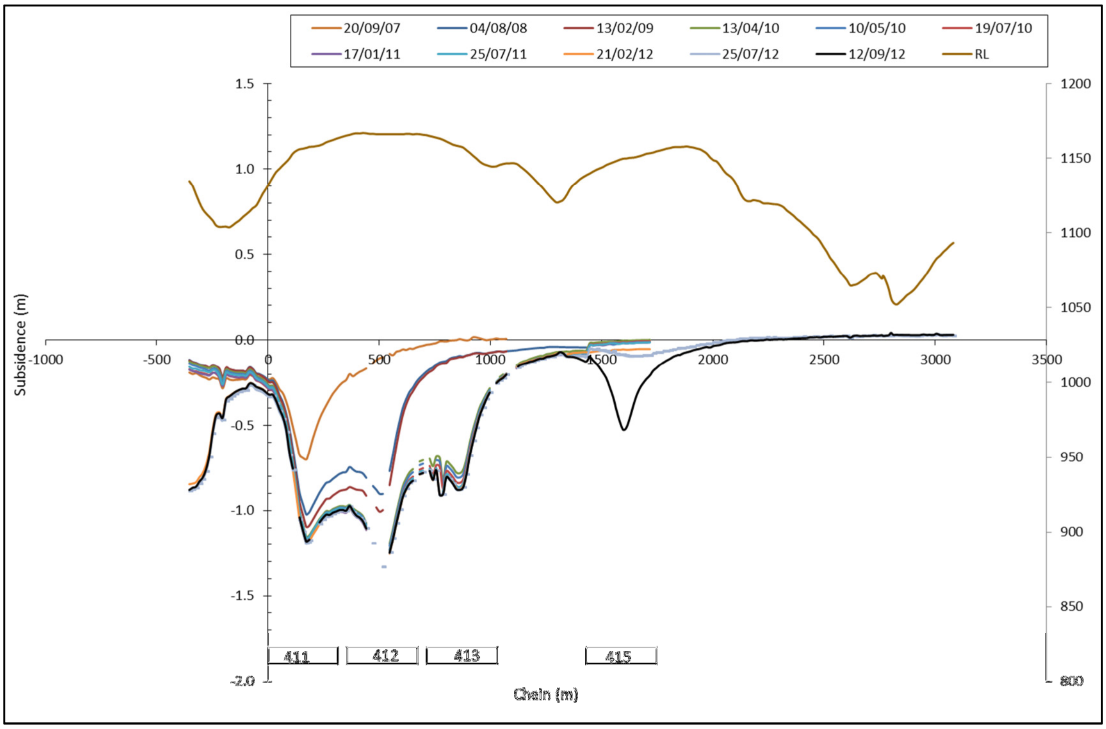


Figure 5.4 Cross Section Springvale Subsidence Monitoring (M-Line) Data Relative to Longwall Position and Surface Topography – note the reduction in vertical subsidence between Longwalls 413 and 415 due to Longwall 414 not being mined in the area of the M-Line.

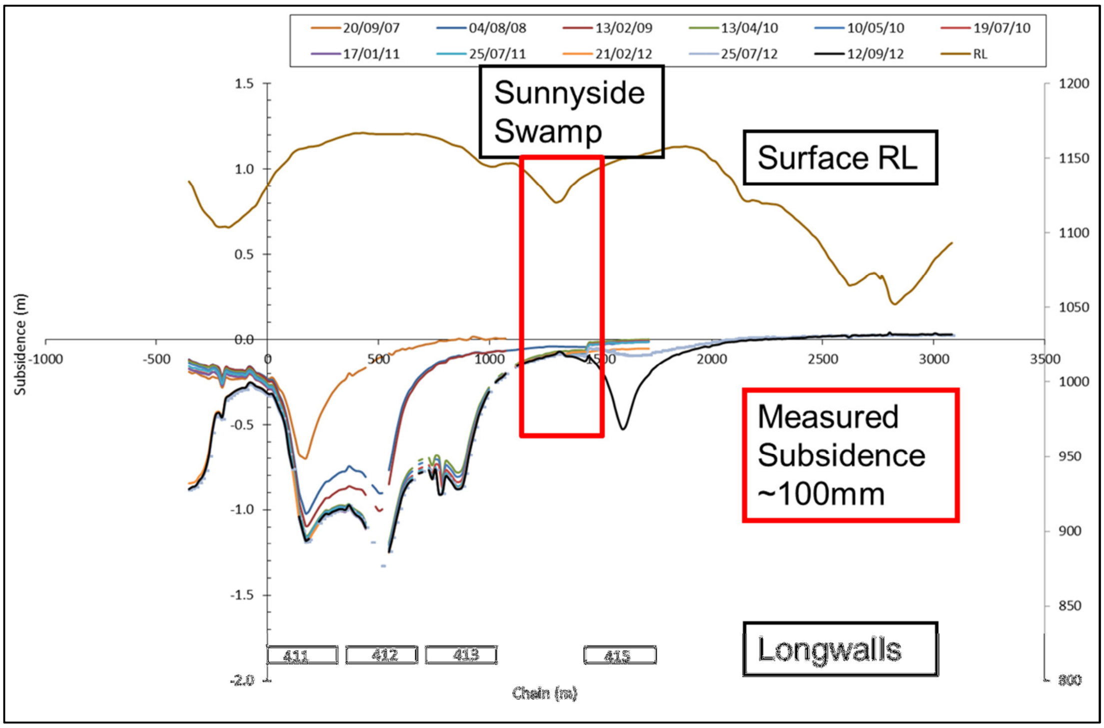


Figure 5.4(a) is the same as Figure 5.4 with explanatory notes about location of Sunnyside Swamp relative to subsidence line (M-Line) and the measured vertical subsidence on the M-Line in the area of Sunnyside Swamp. As shown in Figure 5.1, the M-Line crosses Sunnyside Swamp, and is representative of subsidence at Sunnyside Swamp.

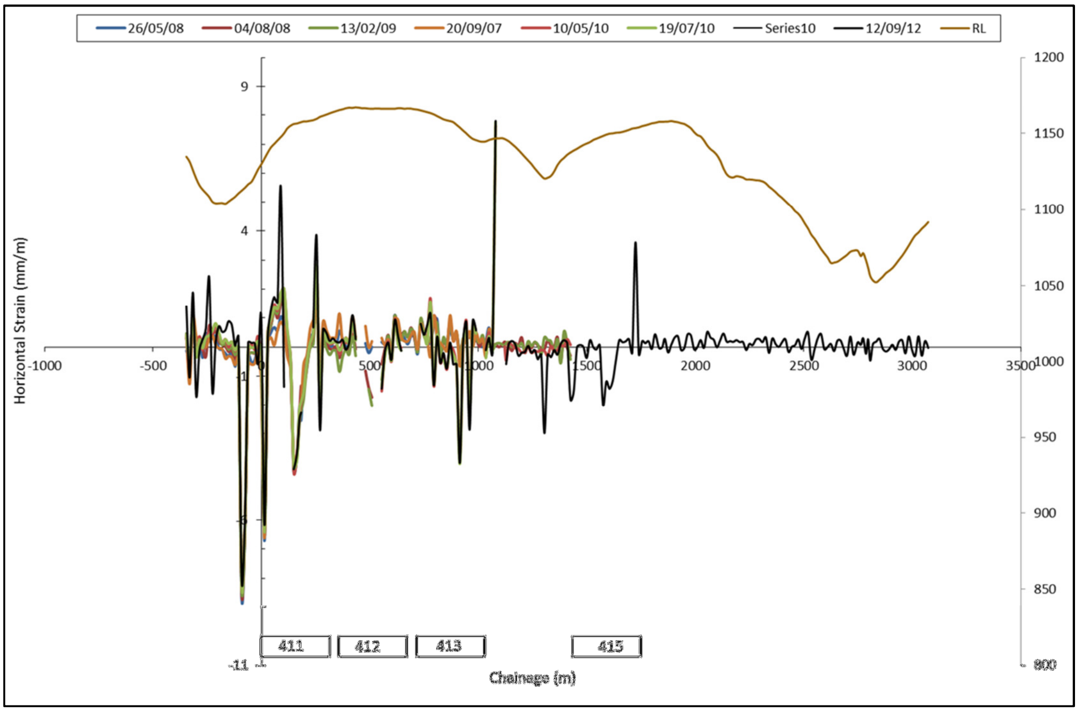


Figure 5.5 Cross Section Springvale Strain Monitoring (M-Line) Data Relative to Longwall Position and Surface Topography – note the increased strains between Longwalls 413 and 415 due to Longwall 414 not being mined in the area of the M-Line. As explained in the East Wolgan Swamp case study,

increased levels of strain are typically observed on subsidence cross lines (transverse across longwall panels) adjacent to large barrier pillars.

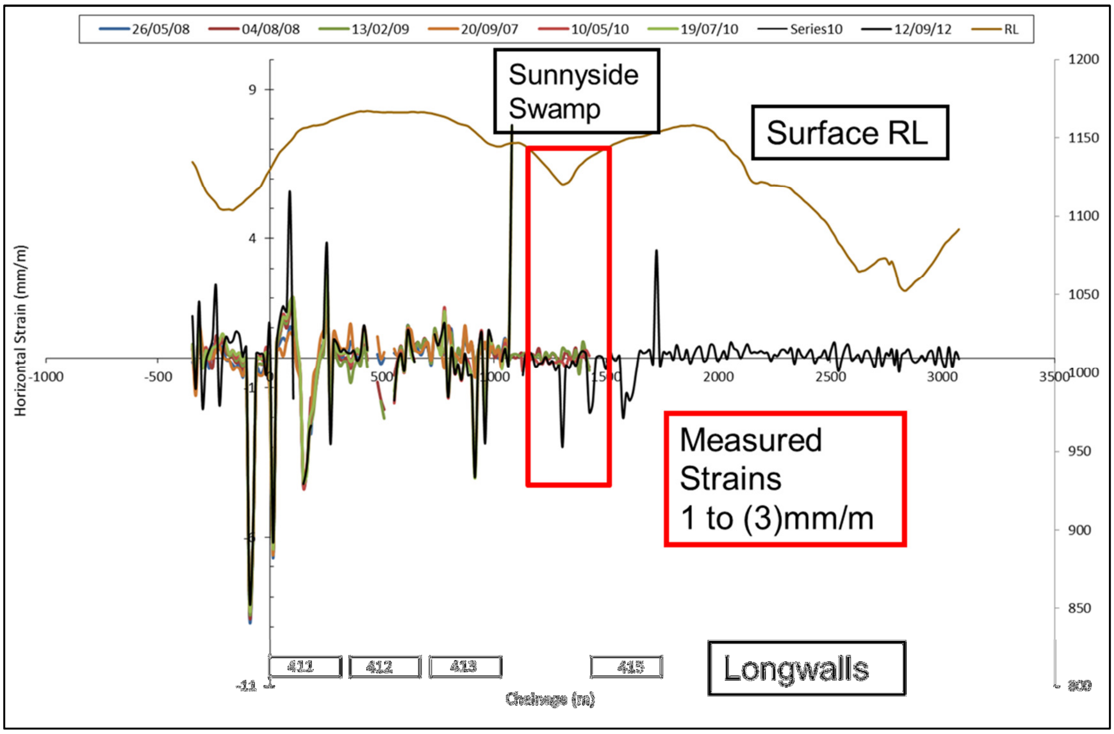


Figure 5.5(a) is the same as Figure 5.5 with explanatory notes about location of Sunnyside Swamp relative to subsidence line (M-Line) and the measured strains on the M-Line in the area of Sunnyside Swamp. As shown in Figure 5.1, the M-Line crosses Sunnyside Swamp, and is representative of strains at Sunnyside Swamp.

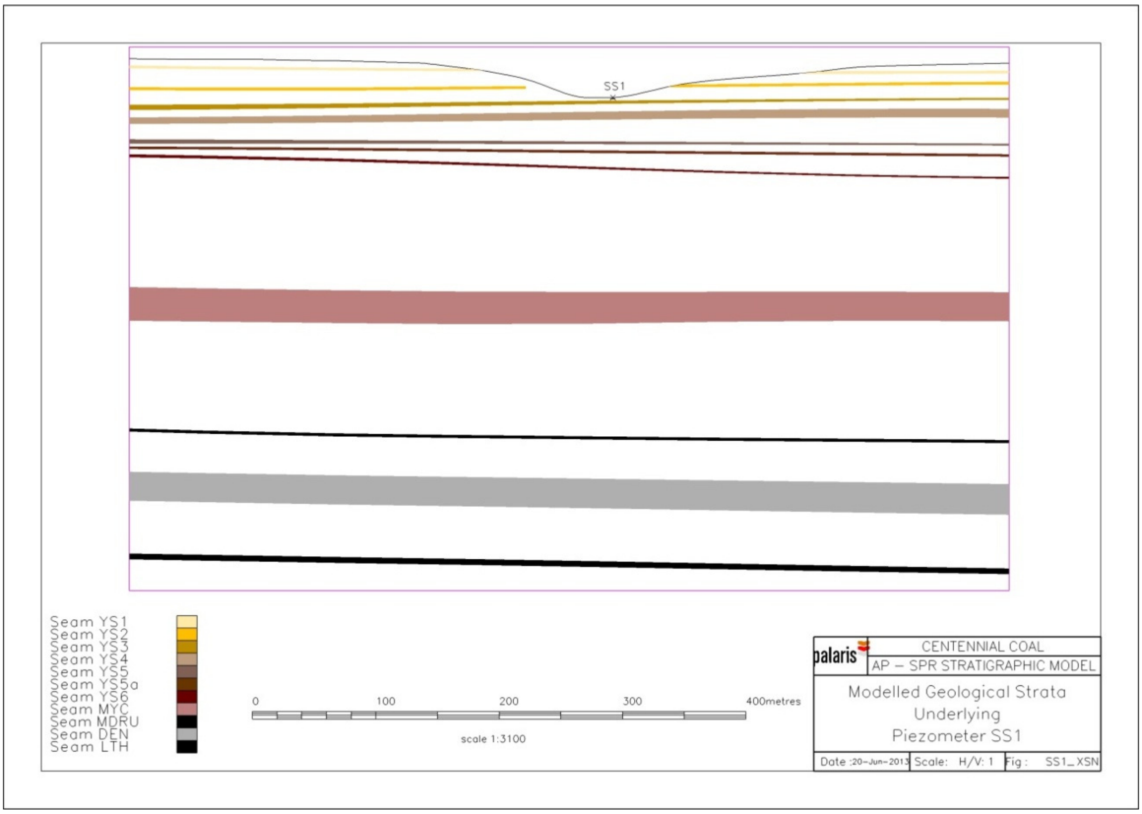


Figure 5.6 – Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Swamp Piezometer SS1 which is located in Sunnyside Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

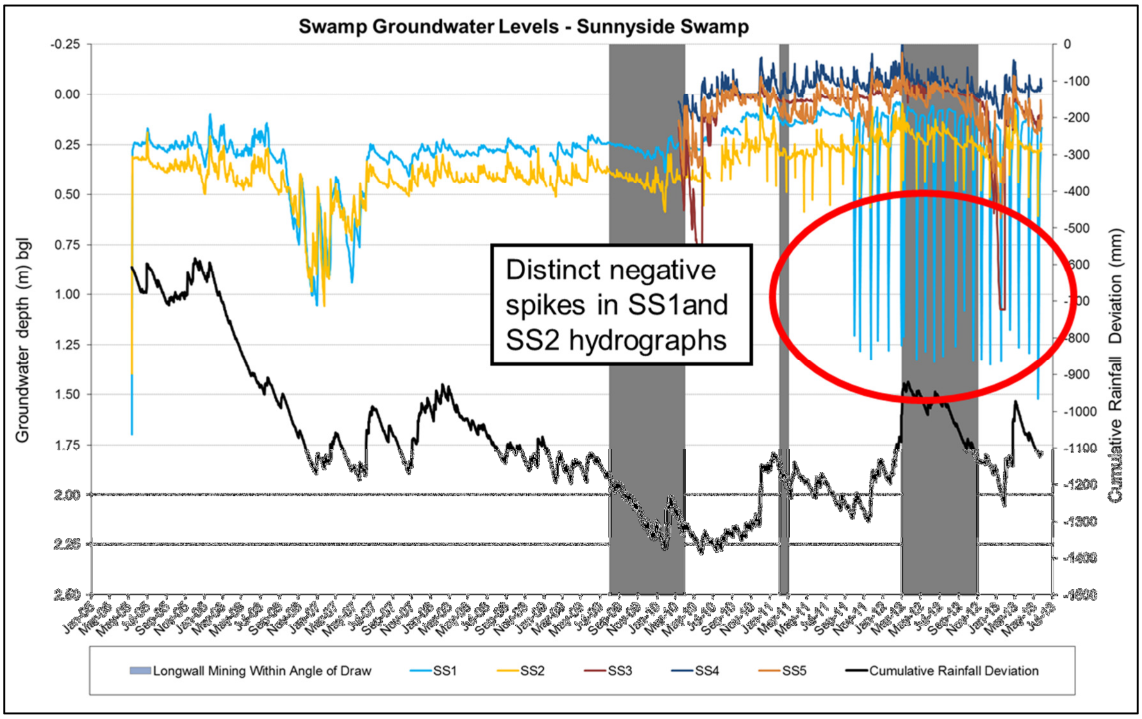


Figure 5.7 – Hydrographs of the swamp piezometers installed at Sunnyside Swamp together with the time of longwall mining within the Angle of Draw (periods indicated in grey) of Sunnyside Swamp

piezometers and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is not a strong correlation between the trendline of standing water level in the swamp and the CRD trendline for the five Sunnyside Swamp piezometers over the eight years of monitoring at this location. This data indicated that the swamp is permanently waterlogged. The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining within the angle of draw of Sunnyside Swamp. The distinct negative spikes in the SS1 and SS2 piezometer trendlines are indicative of water quality sampling at the piezometer boreholes, where a sample is drawn from the borehole for testing purposes.

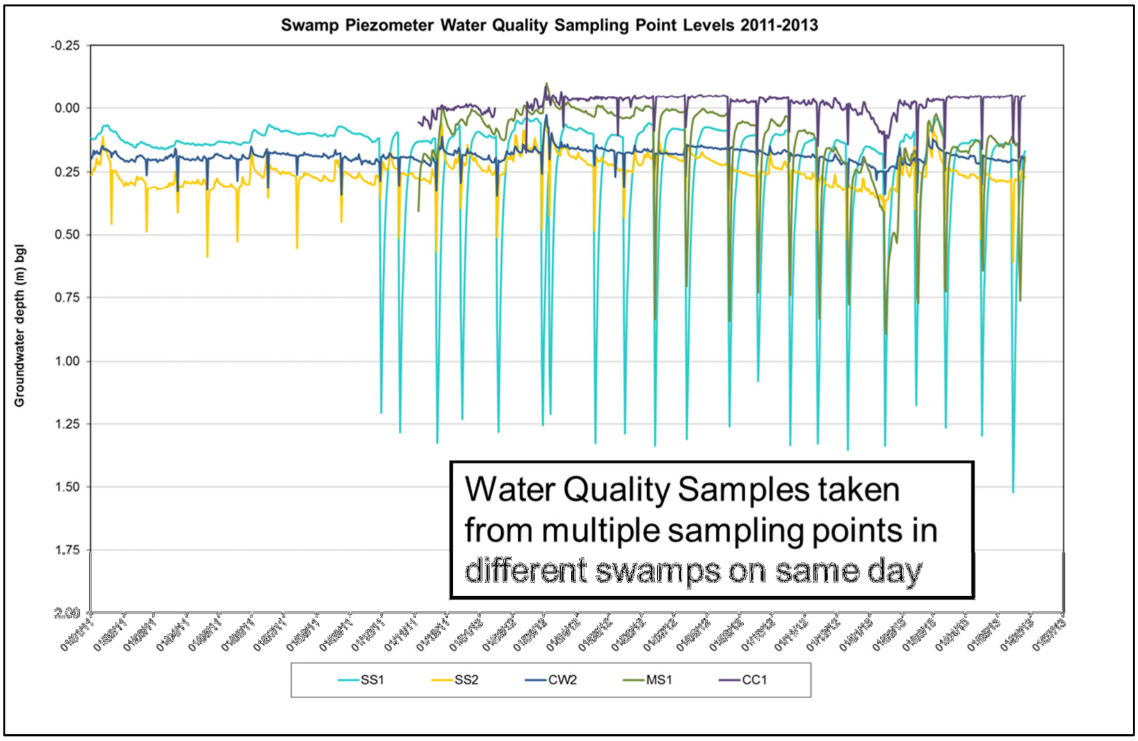


Figure 5.8 – Hydrographs of swamp piezometers used for water quality sampling. Note the distinctive pattern, where bailing results in immediate drawdown of the hole, followed by recovery of water level in an asymptotic manner over periods varying between a day and two weeks. Water levels completely recover on each occasion before the next sampling episode. Note also the coincidence of dates in the multiple sampling points in multiple swamps.

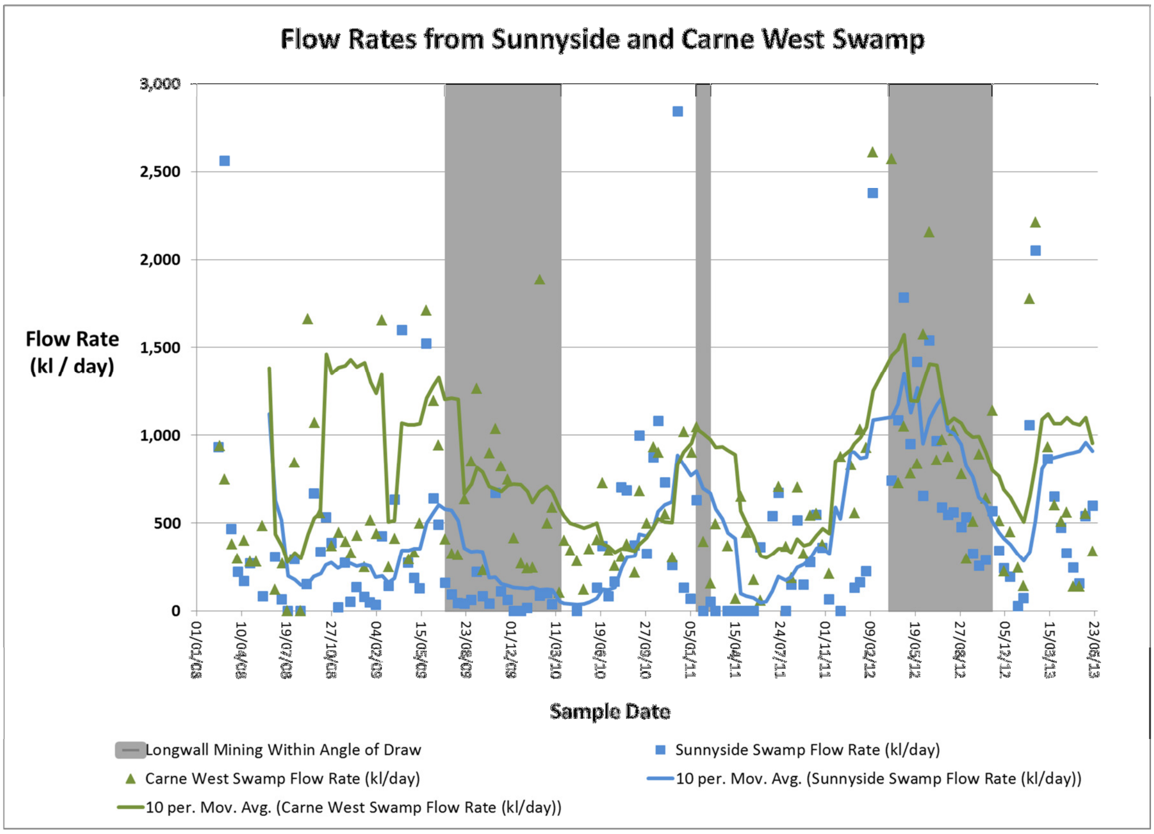


Figure 5.9 Surface Water Flows from Sunnyside Swamp and Carne West Swamp together with times when Sunnyside Swamp was within the angle of draw of longwall mining (periods indicated in grey). Note the similarities in the trendlines between Sunnyside Swamp and Carne West Swamp (unaffected by mining)

Kangaroo Creek Swamp

Case Study

Kangaroo Creek Swamp Case Study

The following is a case study of longwall mining beneath Kangaroo Creek Swamp on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 6.1 to 6.13. Table 6.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	Monitoring Data / Interpretation
Location	Newnes Plateau
Name	Kangaroo Creek Swamp
Geology (Swamp Substrate)	Burralow Formation (at KC02) Banks Wall Sandstone (at KC1)
Depth of Cover (metres)	280m
Longwall Void Width (metres)	262 – 292m
Chain Pillar Width (metres)	40 - 43m
w/H Ratio	0.94 to 1.04 (Critical)
Timing of Longwall Mining	May 2008 and January 2010
Subsidence (Vertical) (metres)	1.0m
Subsidence (Strains) (millimetres / metre)	(26)mm/m Compressive 6mm/m Tensile
Subsidence (Tilt) (millimetres / metre)	13mm/m
Swamp Hydrology (Standing Water Level)	Baseline - Periodically Waterlogged (upstream) to Permanently Waterlogged (downstream) No change due to longwall mining at KC02 Changes due to longwall mining at KC01(see discussion below)
Flora	There is no trend of decreasing condition and the abundance of the condition monitored species is not declining

Table 6.1 – Summary of Key Data from Environmental Monitoring at Kangaroo Creek Swamp

Kangaroo Creek Subsidence

Maximum vertical subsidence at Kangaroo Creek Swamp was measured to be 1.0m. High levels of differential movement were recorded, including strains (up to 6mm/m tensile and 26mm/m compressive) and tilts (up to 13mm/m). The reasons for the high levels of differential movement are as follows:

- Mine Design – w/H ratio of 0.94 to 1.04 (Critical Width). NB These are the highest w/H ratios of any of the longwalls at Angus Place and Springvale.

- Major Geological Structure Zone – Kangaroo Creek is located within the Kangaroo Creek lineament, which has been identified as “Type 1” Geological Structure Zone (see Figure 6.5)
- Topography – Valley slope angles >18 degrees (see Figure 6.5)
- Location of Swamp near Western end of Longwalls 940 and 950

It must be noted that future mine designs proposed in the area of Newnes Plateau Shrub Swamps have been based on Sub-Critical Longwall Widths i.e. w/H ratios of <0.75. The subsidence reductions which will occur as a result of these mine design changes are illustrated in Figures 2.2 and 3.2 (above).

Kangaroo Creek Swamp Hydrology

Longwall mining has resulted in groundwater level changes in the lower reaches of Kangaroo Creek due to mining-induced cracking. It is expected that over time any cracks present will gradually infill with sediment and that these effects will be temporary. Goldney (2010 reported “*Swamp cracking where it does occur is unlikely to cause other than short-term impacts to particular swamps. In-stream sediment is likely to rapidly in-fill such cracks – in effect they are likely to rapidly self-repair.*”

In terms of experience from the Southern Coalfields, Goldney (2010 reported “*Subsurface flows are not necessarily continuous along a streambed and result in no net loss of water within the catchment (Gilbert and Associates 2008; Merrick 2008). In the southern coalfields this phenomenon has been modelled and observed in tributary and major streams (Gilbert and Associates 2008; Merrick 2008). However, there have been little adverse impacts observed in undermined upland valley swamps in the southern coalfields*.”

However, the perennial spring which is fed by the aquifer-aquitard systems within the Burralow Formation was unaffected by mining and the creek remained permanently wet below the spring. This, together with the presence of healthy hanging swamps along the valley walls surrounding Kangaroo Creek shrub swamp, indicates that the water supply from the spring and valley wall seepage has not been interrupted by longwall mining and that groundwater inputs to the swamp hydrological system remain intact. Figures 6.7 - 6.12 are photographs which illustrate the Burralow Formation aquifer / aquitard system have not been affected by longwall mining evidenced by the Spring, Waterhole and Hanging Swamps surrounding Kangaroo Creek Swamp. Kangaroo Creek Swamp was assessed by RPS (2013) as a “*High Quality Shrub Swamp in Good Condition*.” UQ (2013) reported that “*There is no trend of decreasing condition and the abundance of the condition monitored species is not declining*”

The available evidence indicates that underground mining has not resulted in any long-term negative effects on Kangaroo Creek Shrub Swamp.

Kangaroo Creek Flora Monitoring

UQ (2013) reported "The Kangaroo Creek community was affected by subsidence on two occasions (Fig. 3, 4) in 2008 and 2010. Monitoring of this community commenced in Autumn 2007 approximately twelve months prior to undermining. Median condition has remained between categories three and five from 2007 to 2013. There is no trend of decreasing condition and the abundance of the condition monitored species is not declining. Median abundance has decreased from modified Braun-Blanquet score of 3 to 2 as a result of additional low abundance species incorporation into condition monitoring. Kangaroo Creek contains a low but consistent weedy species richness between one and three depending on season and year. Weed species richness is limited in comparison to East Wolgan and Narrow swamps. Kangaroo Creek plot species composition appears to be similar to the nearby East Wolgan and Narrow swamps with regard dominant native species. In the summers of 2007 and 2008 KC03 monitoring plot had nMDS locations similar to Narrow Swamp, however, since this time this plot has returned to near plot centre and appears has a stable composition that is not driven by non-swamp species. Plot KC04 is slightly more variable in composition but has not shown any clear direction since being undermined in 2008

Summary of Kangaroo Creek Swamp Case Study Data

Environmental monitoring Kangaroo Creek Swamp has been conducted over the last eleven years. Table 6.1 is a summary of key monitoring data. The key points from the case study of Kangaroo Creek Swamp are as follows:

- Subsidence up to 1.0m, Strains 6mm/m (tensile) to (26)mm/m (compressive), Tilts 3 to 13mm/m. The differential subsidence movements are high as discussed above.
- Mixed Burralow / Banks Wall Sandstone Geology Substrate
- Periodically to Permanently Waterlogged Swamp
- Groundwater Supply to Swamp has not been interrupted by longwall mining (evidenced by Spring, Waterhole, Hanging Swamp, Swamp Flora)
- Longwall Mining under Kangaroo Creek Swamp in May 2008 and January 2010 – correlation with reduction in water levels at KC1 piezometer. It is expected that cracks will infill with sediment over time.
- Standing Water Level Trends follow Cumulative Rainfall Deviation Trend
- There is no trend of decreasing flora condition and the abundance of the condition monitored flora species is not declining

- Despite piezometer hydrograph, there are no obvious long term mine subsidence impacts to hydrology – evidenced by Spring, Waterhole, Hanging Swamp, Swamp Flora

Kangaroo Creek Swamp

Case Study Figures

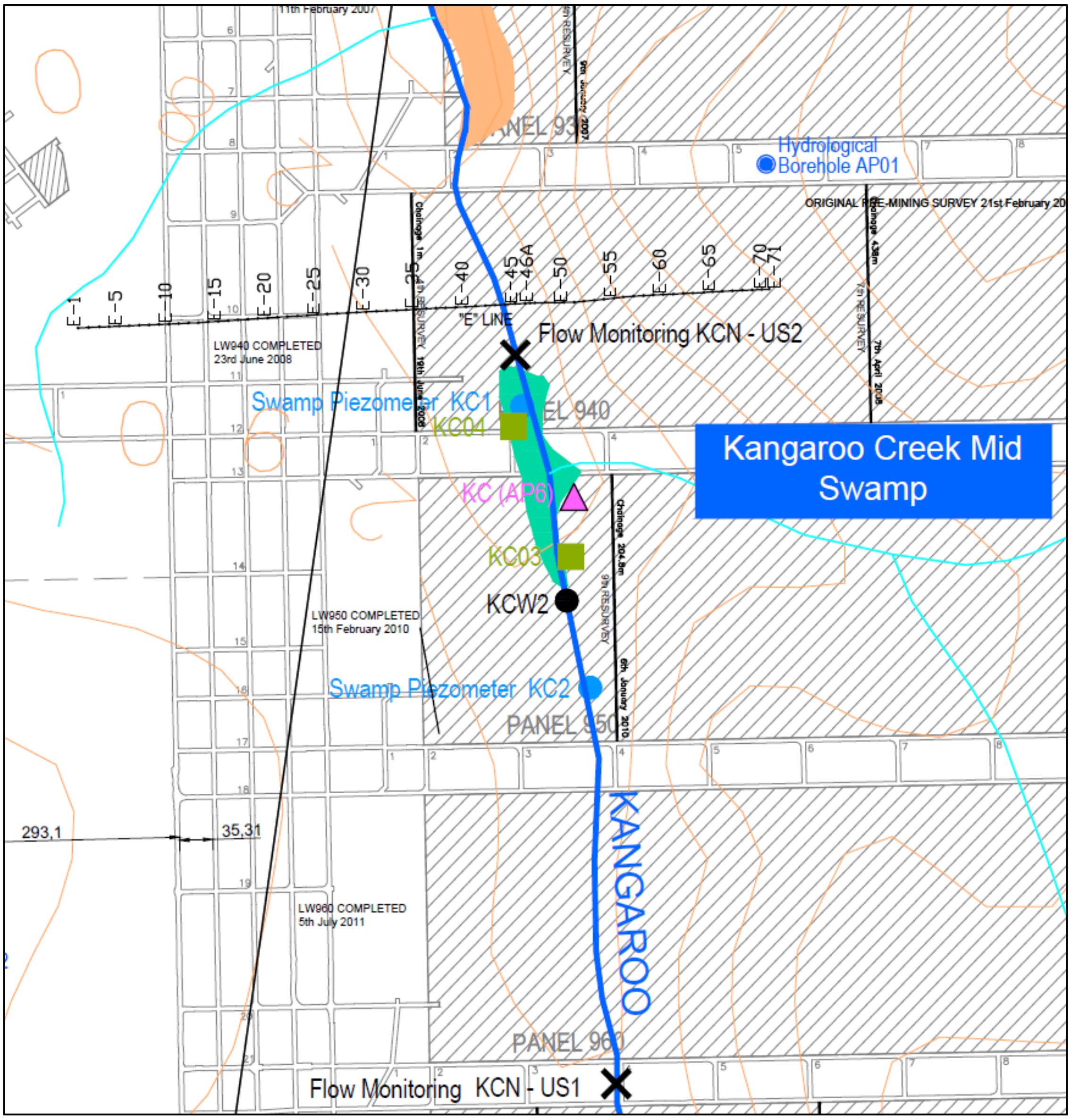


Figure 6.1 Kangaroo Creek Swamp Case Study Plan

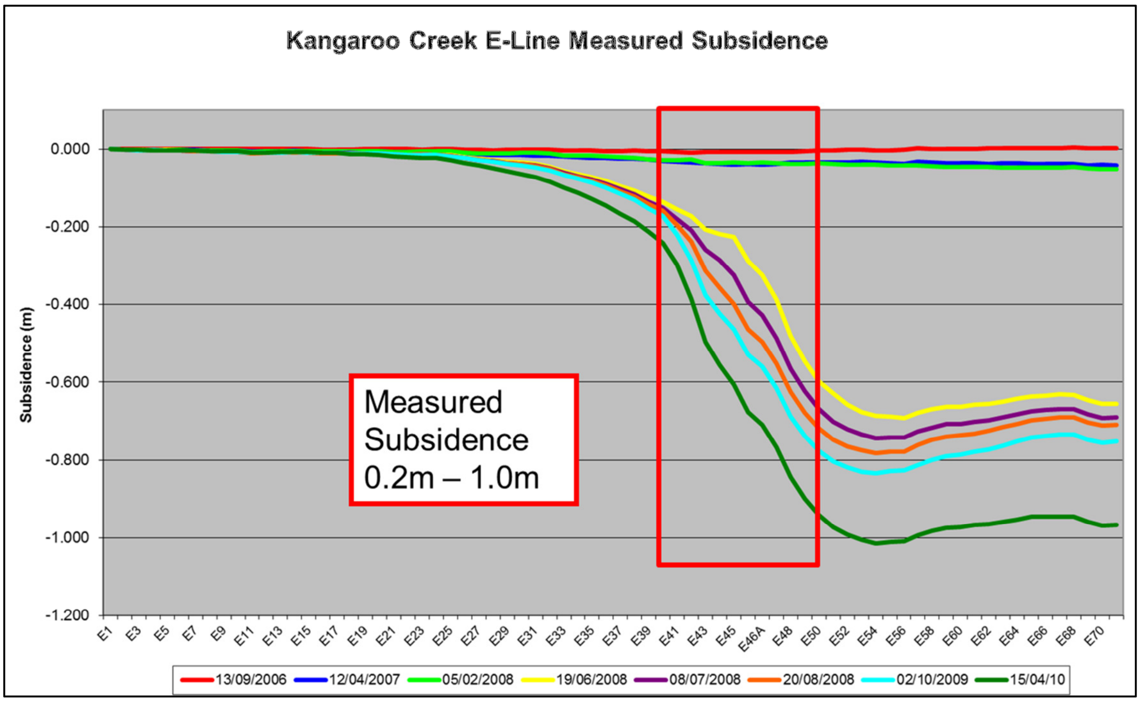


Figure 6.2 Cross Section Angus Place Subsidence Monitoring (E-Line) Vertical Subsidence Data Relative to Longwall Position – note the area in the red polygon represents the position of Kangaroo Creek Swamp relative to the subsidence line

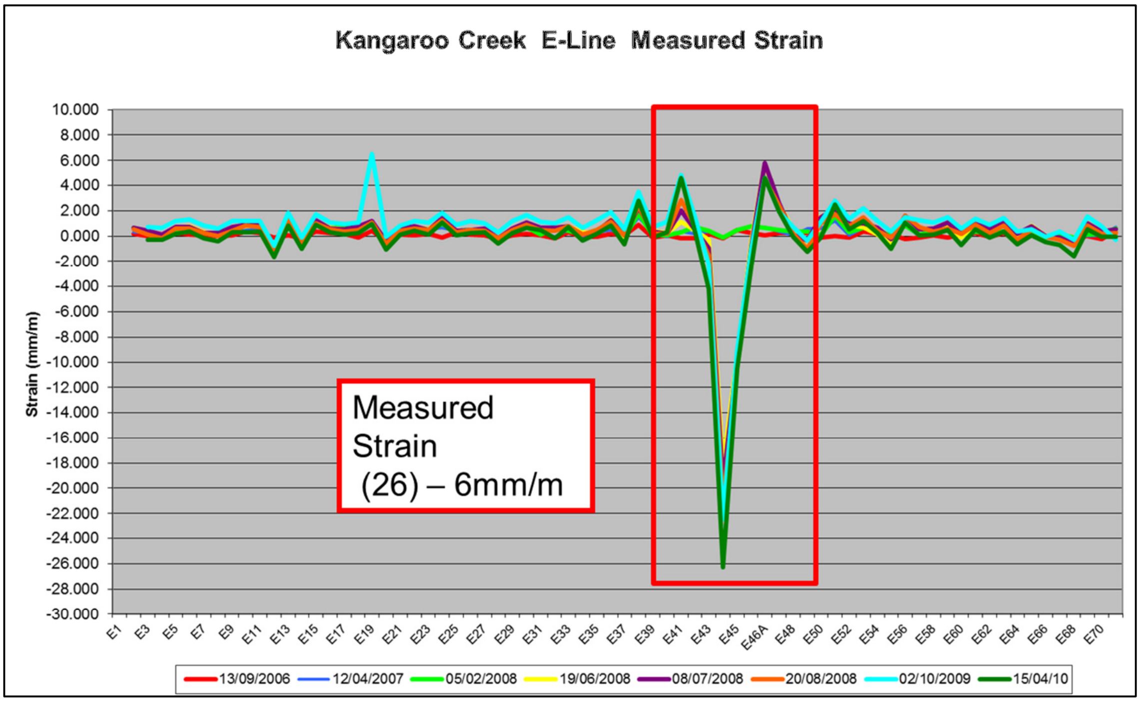


Figure 6.3 Cross Section Angus Place Subsidence Monitoring (E-Line) Strain Data Relative to Longwall Position – note the area in the red polygon represents the position of Kangaroo Creek Swamp relative to the subsidence line

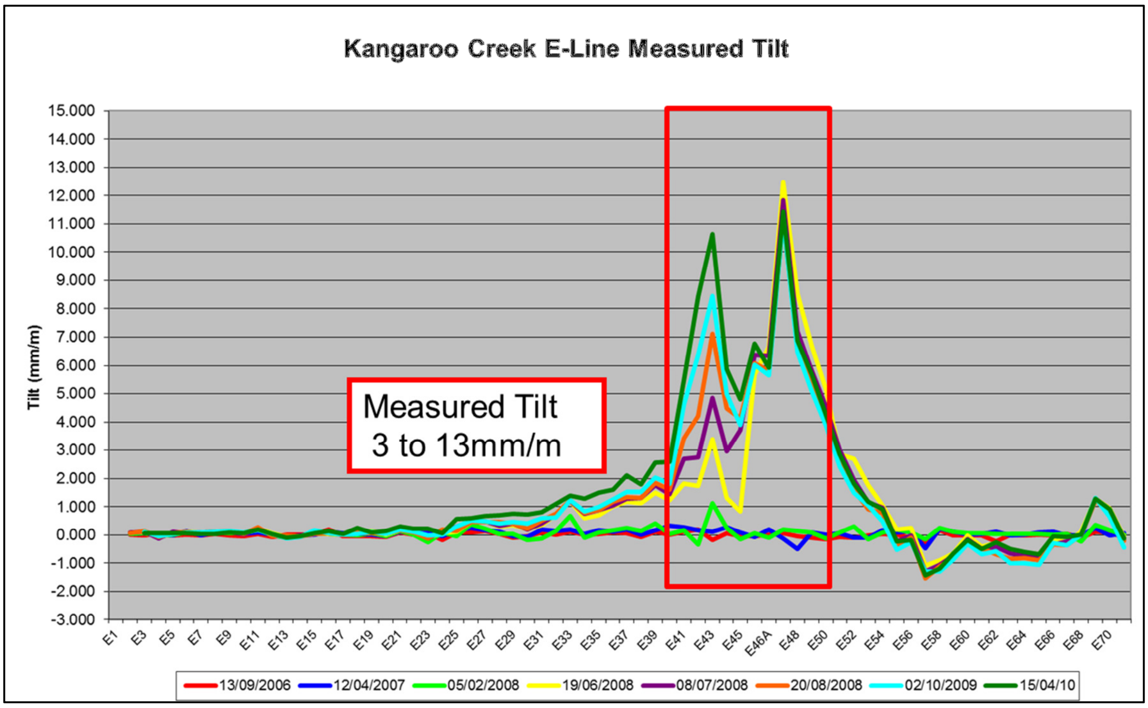


Figure 6.4 Cross Section Angus Place Subsidence Monitoring (E-Line) Tilt Data Relative to Longwall Position – note the area in the red polygon represents the position of Kangaroo Creek Swamp relative to the subsidence line

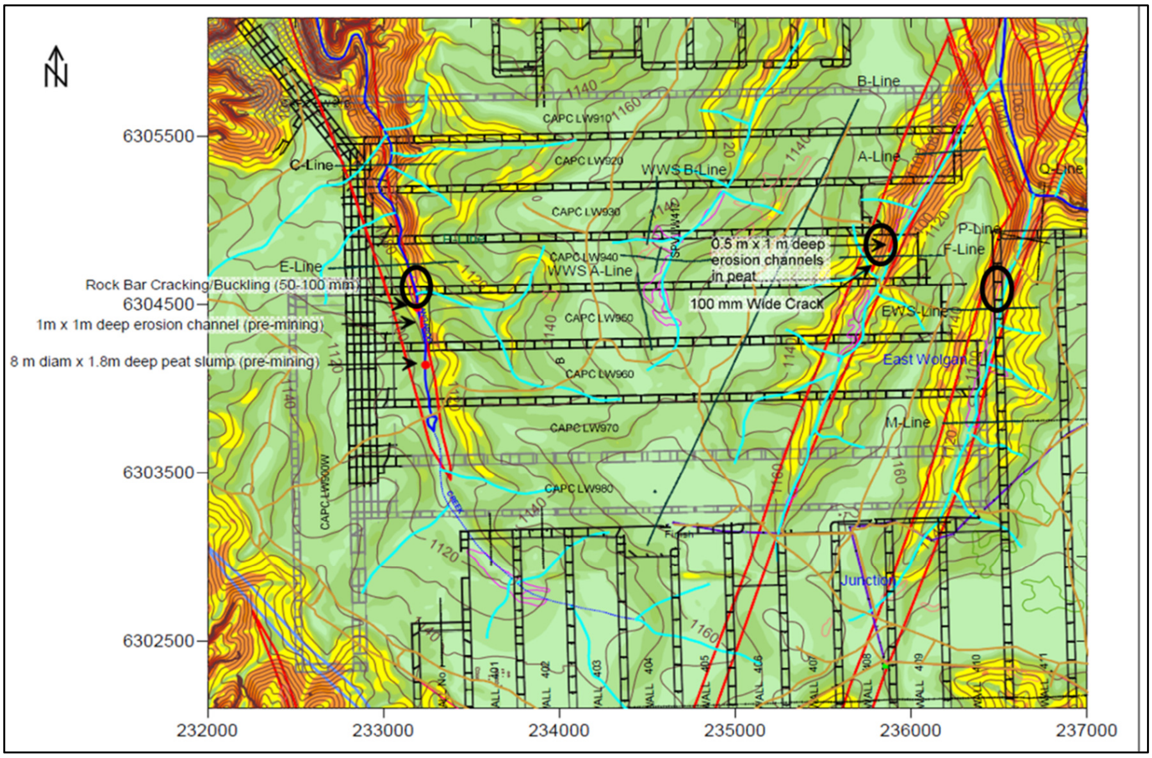


Figure 6.5 Springvale and Angus Place Mine Plan showing Major Fault Zones (Between Red Lines) AND Incised Valleys (Orange Areas on Plan with Slope Gradients > 18°) Together with Subsidence Cracking Impact Locations (Black Circles)

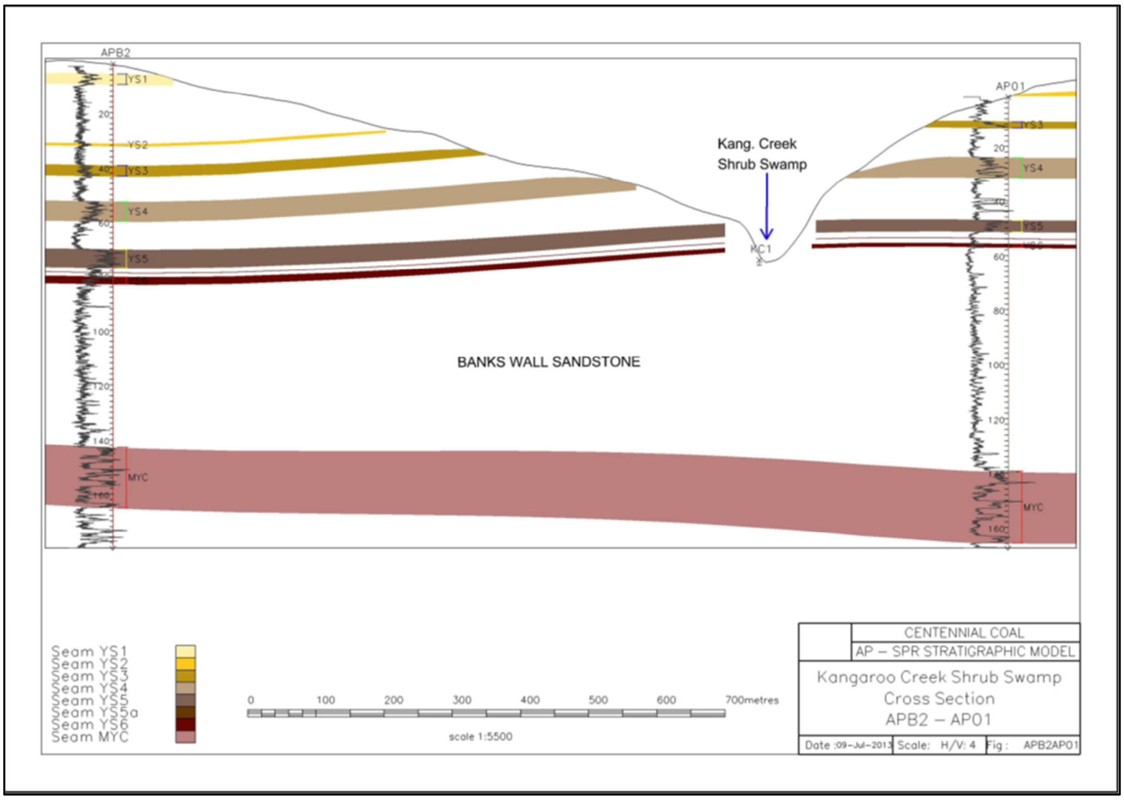


Figure 6.6 – Geological Cross Section Through Strata from the Mt York Claystone to the Surface at the Location of Swamp Piezometer KC01 which is located in Kangaroo Creek Swamp. The cross section shows the Banks Wall Sandstone which underlies the swamp. It also shows the Burralow Formation aquifers and aquitards which supply water to Kangaroo Creek Swamp from the Spring and Waterhole upstream of Kangaroo Creek Swamp and via Valley Wall seepage (as evidenced by healthy hanging swamp on the Western valley wall of Kangaroo Creek Swamp.

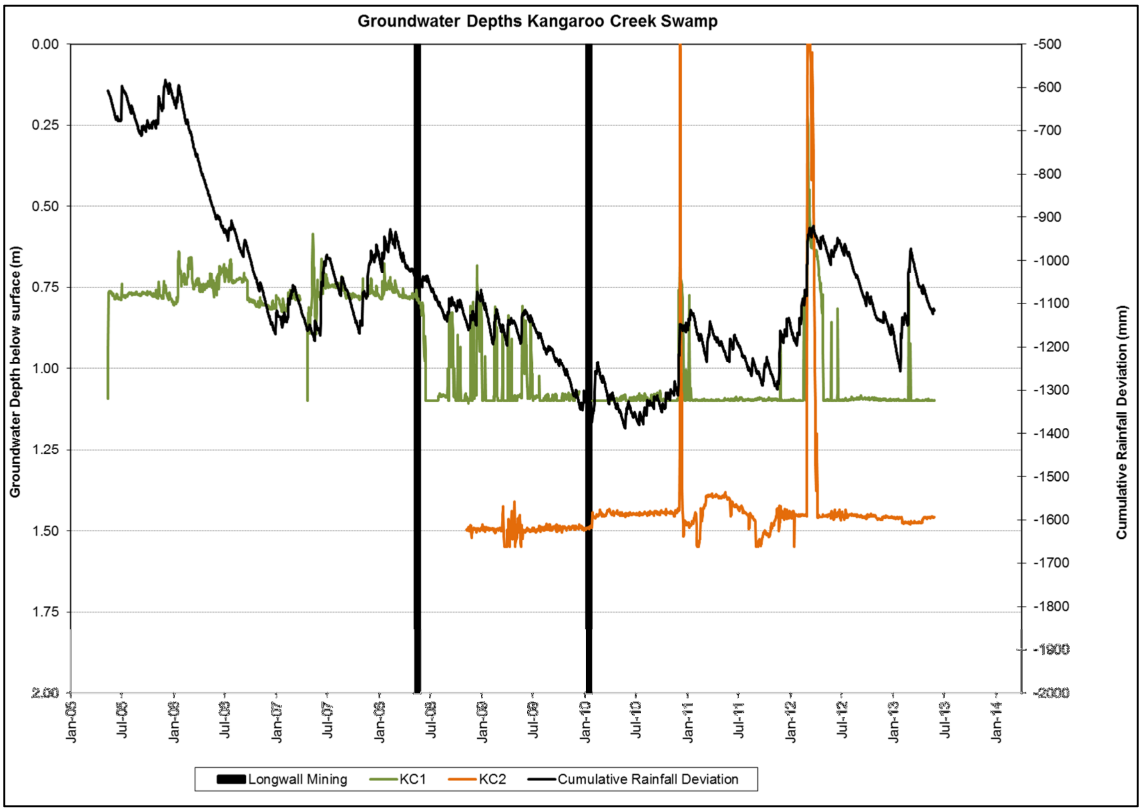


Figure 6.7 – Hydrographs of the swamp piezometers installed at Kangaroo Creek Swamp together with the time of longwall mining beneath the piezometers (indicated by the vertical black lines) and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a very strong correlation between the trendline of standing water level beneath the swamp and the CRD trendline for the KC2 piezometer over the eight years of monitoring at this location. This data indicated that the swamp is periodically waterlogged at this location (standing water levels respond to rainfall). The data also indicates that there have been no significant impacts to swamp hydrology in response to longwall mining at KC2.

Groundwater levels at KC1 appear to have been affected by the longwalling of Angus Place Longwall 940 which was below the lower reaches of the swamp, as there was a sudden reduction in groundwater levels in June 2008, unrelated to rainfall. As shown in Figure 4.5, measured groundwater levels respond to rainfall events, and standing water levels reach pre-mining levels after significant rainfall events. However, for KC1 measured groundwater levels have yet to completely return to pre-mining levels. It is expected that over time any cracks present will infill with sediment and that mining-induced effects will be temporary.

Figure 6.8 Spring Upstream of Kangaroo Creek Swamp – Unaffected by Longwall Mining

Figure 6.9 Detail of Spring Upstream of Kangaroo Creek Swamp – Unaffected by Longwall Mining

Figure 6.10 – Permanent Waterhole immediately upstream of Kangaroo Creek Swamp – looking upstream with Spring in the background

Figure 6.11 – Permanent waterhole immediately upstream of Kangaroo Creek Swamp looking downstream towards the swamp

Figure 6.12 – Hanging Swamp in Western Valley Wall above Kangaroo Creek Swamp – unaffected by Longwall mining. The hanging swamp is evidence of ongoing valley wall seepage into Kangaroo Creek Swamp from the Burralow Formation aquifer / aquitard system following longwall mining

Figure 6.13 Photo of Kangaroo Creek Swamp – looking upstream from the Southern end of the swamp. UQ(2013) reported that “There is no trend of decreasing condition and the abundance of the condition monitored species is not declining”.

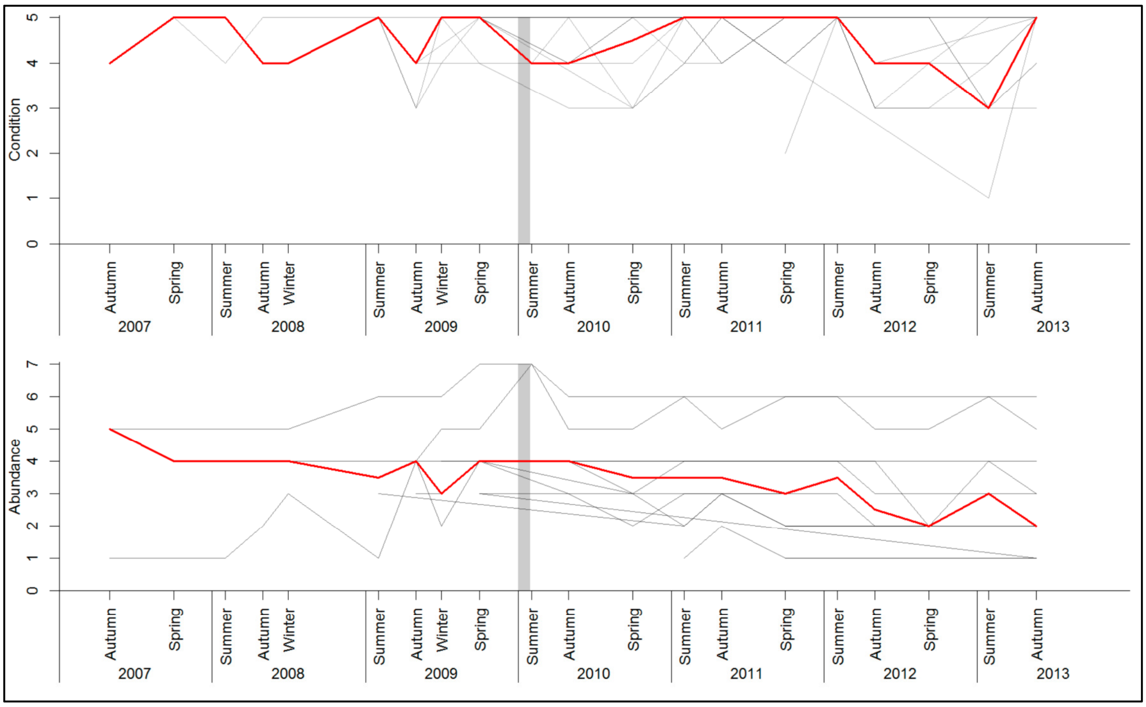


Figure 6.14 Median condition and abundance for Kangaroo Creek 3 flora monitoring plot.

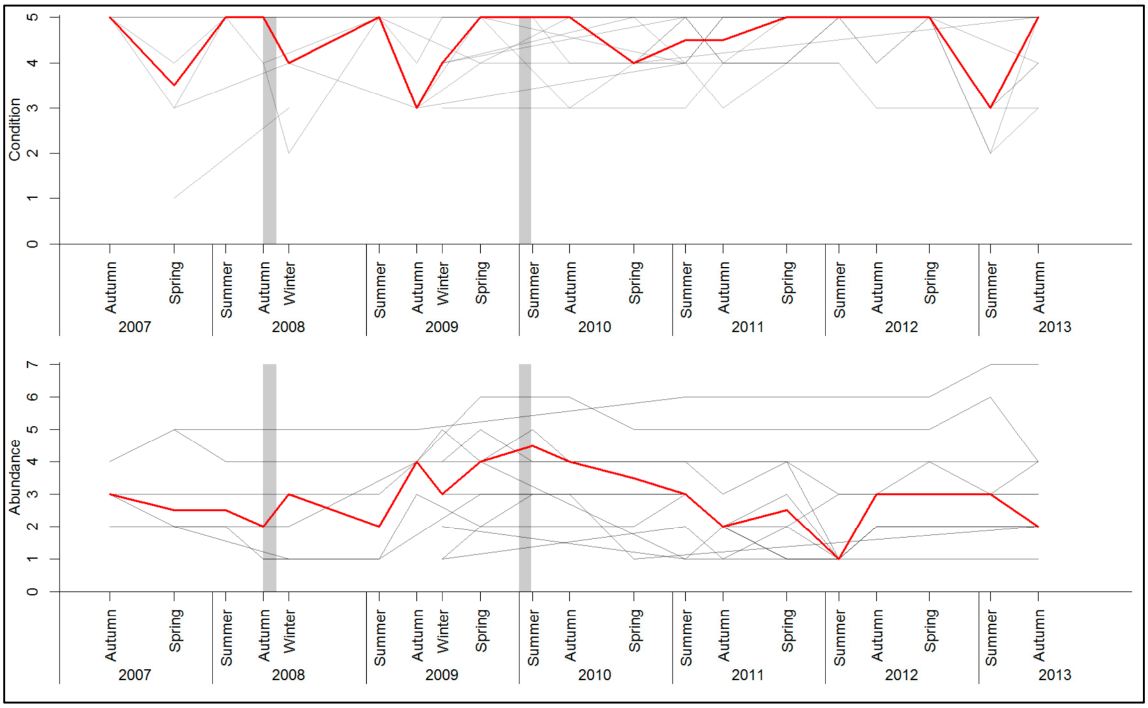


Figure 6.15 Median condition and abundance for Kangaroo Creek 4 flora monitoring plot.

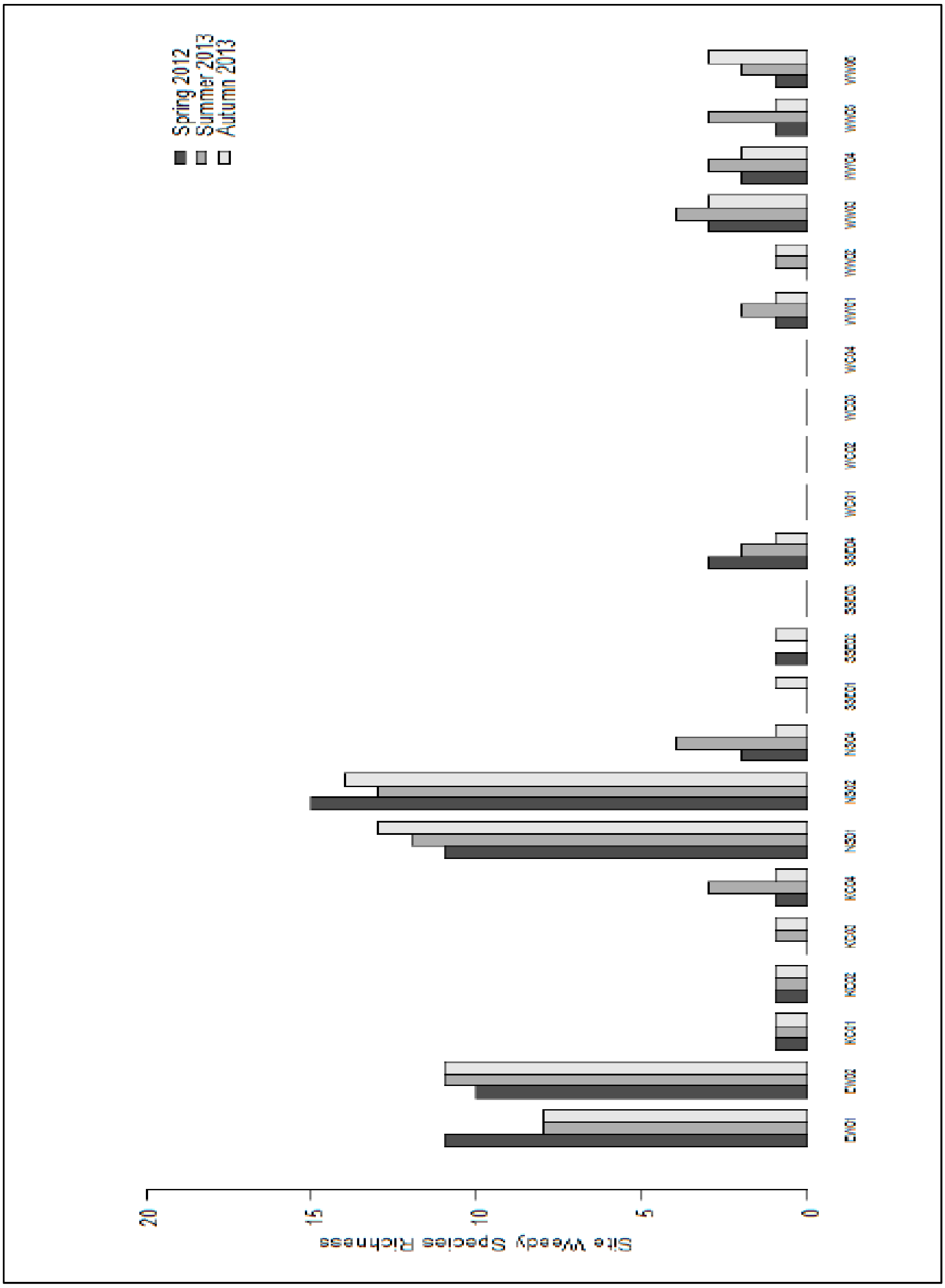


Figure 6.16 - Weedy species richness for the case study swamps over the past 12 months.

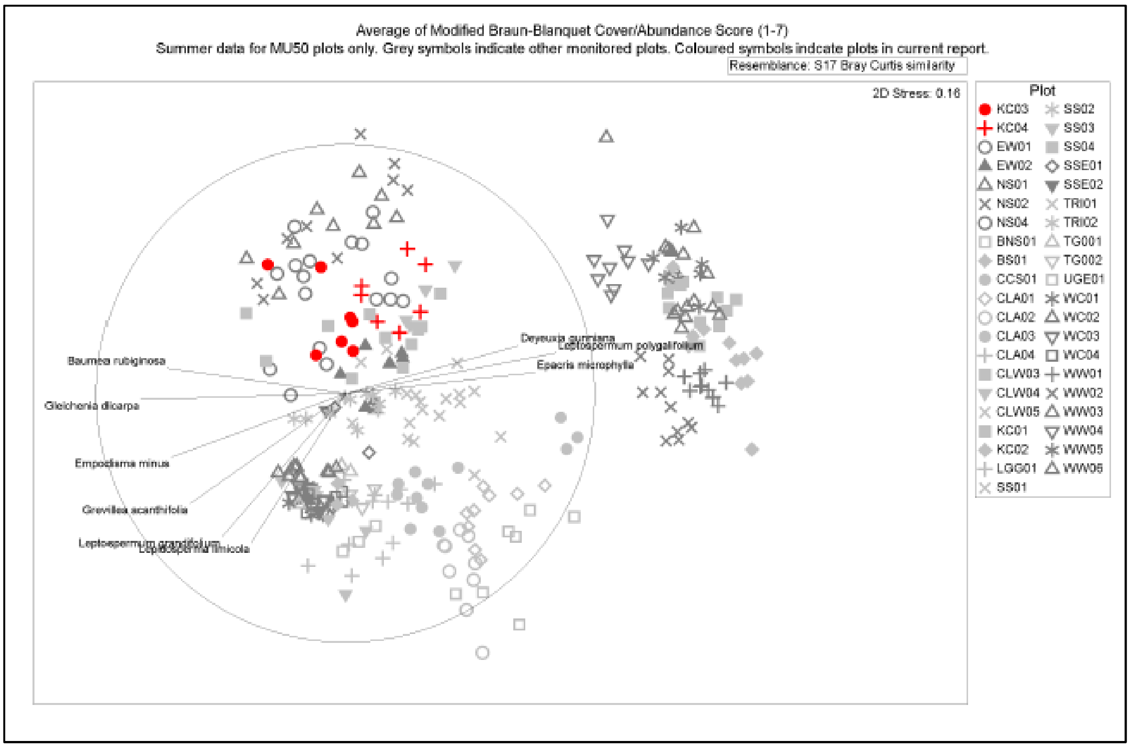


Figure 6.17 - 2D nMDS plot describing species composition of monitoring plots KC03-04 relative to all other MU50 monitoring plots for all summer monitoring conducted on the Newnes Plateau.

Sunnyside East and Carne West Swamp Case Study

Sunnyside East and Carne West Swamp Case Study

The following is a case study of longwall mining beneath Sunnyside East and Carne West Swamps on the Newnes Plateau. Details of data gathered from environmental monitoring programs are contained in Figures 7.1 to 7.24. Table 7.1 summarises key data below. A summary of key monitoring outcomes is also included below. Where necessary additional relevant information is also included.

Monitoring Parameter	**Monitoring Data / Interpretation**
Location	Newnes Plateau
Name	Sunnyside East and Carne West Swamps
Geology (Swamp Substrate)	Burralow Formation
Depth of Cover (metres)	350-370m (Sunnyside East Swamp) 350 – 380m (Carne West Swamp)
Longwall Void Width (metres)	260.9m
Chain Pillar Width (metres)	58m
w/H Ratio	0.69 to 0.73 (Sub-Critical)
Timing of Longwall Mining	Commencement 10 October 2013
Subsidence (Vertical) (metres)	1.1m
Subsidence (Strains) (millimetres / metre)	(14)mm/m Compressive 5mm/m Tensile
Subsidence (Tilt) (millimetres / metre)	7mm/m
Swamp Hydrology (Standing Water Level)	Baseline - Periodically Waterlogged (upstream) to Permanently Waterlogged (downstream)
Flora	The monitoring plots in Sunnyside East have to date recorded very healthy or healthy condition for a wide range of species. While this monitoring is only entering it's second year the vegetation in the monitoring plots appears to be stable and healthy. West Carne shrub swamp has a very stable composition of species through time with very little variability in almost a decade of monitoring

Table 6.1 – Summary of Key Data from Environmental Monitoring at Sunnyside East and Carne West Swamps

Predicted Sunnyside East and Carne West Swamp Subsidence

Maximum vertical subsidence at Sunnyside East and Carne West Swamps is predicted to be 1.1m. Maximum Strains are predicted to be 5mm/m (tensile) and 14mm/m (compressive). Maximum tilts are predicted to be 7mm/m.

Subsidence prediction have taken the following factors into consideration:

- Major Geological Structure Zone (see Figure 6.5)
- Topography – Valley slope angles >18 degrees (see Figure 6.5)

It must be noted that future mine designs proposed in the area of Newnes Plateau Shrub Swamps have been based on Sub-Critical Longwall Widths i.e. w/H ratios of <0.75. The subsidence reductions which will occur as a result of these mine design changes are illustrated in Figures 2.2 and 3.2 (above).

Baseline Sunnyside East and Carne West Swamp Hydrology

Baseline Standing Water Levels

Figure 7.4 shows hydrographs of all of the seven swamp piezometers installed at Carne West and Sunnyside East Swamps and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. There is a high level of variability in standing water levels along these swamps and there are long periods (up to 12 months) between rain events which can cause the standing water level to rise close to the surface of the swamp at a number of these piezometer locations.

Figure 7.5 shows plans of Carne West and Sunnyside East Swamps from RPS (2013) showing regions of variable hydrology along the length of both swamps which are both classified as the same MU50 vegetation community. The upper reaches of both swamps is classified as periodically waterlogged, with the lower reaches classified as permanently waterlogged (with a transitional zone between).

Baseline Soil Moisture Levels

Figure 7.6 shows the results of soil moisture testing at 50 mini-plot locations within Sunnyside East Swamp. Testing of swamp substrate volumetric moisture content was conducted to a depth of 0.2m. Soil Moisture was found to be variable (drier upstream – wetter downstream).

Baseline Water Quality Monitoring Data

Figures 7.7 and 7.8 show baseline water quality data from monitoring conducted at Sunnyside East Swamp and Carne West Swamps together with trigger values calculated for the THPSS Monitoring and Management Plan. The data is now being managed within EnviroSys, which is a purpose designed database for environmental monitoring data. Data loading and trigger notification protocols are currently being established in preparation for approval and implementation of the THPSS Monitoring and Management Plan

Flora Baseline Monitoring

Sunnyside East Swamp Flora Monitoring

UQ (2013) reported "*Sunnyside East is a narrow (often < 10m in width) and has recently (2010) been burnt as a result of Forestry fuel reduction. As a result parts of this community and its surrounding hanging swamps are undergoing rapid change as vegetation re-establishes. Monitoring plots are located at the downstream end of the swamp where groundwater levels are relatively stable and near the surface. The piezometer in the upstream half of Sunnyside East shrub swamp has recorded no groundwater near the surface (> 2m depth) in 16 months. The monitoring plots in Sunnyside East have to date recorded very healthy (median condition of five) or healthy (median condition of four) condition for a wide range of species (Figs 7.19, 7.20). While this monitoring is only entering it's second year the vegetation in the monitoring plots appears to be stable and healthy. While Sunnyside East shrub swamp has not been affected by mining activities to date it contains a low but consistent presence of weedy species (Fig. 7.23). The composition of Sunnyside East shrub swamp falls within the range of currently monitored shrub swamp communities in 2D nMDS space (Fig. 7.21).*"

Carne West Swamp Flora Monitoring

UQ (2013) reported "*West Carne shrub swamp has been used as a control swamp for a number of years as it has a very consistent vegetation assemblage. This community has not been exposed to any mining related activities. Condition and abundance measures in West Carne shrub swamp to date will approximate the variability to be expected as a combination of natural variation in vegetation and observer estimation. Median condition estimates varied between three and five with lowest values recorded in late 2007- early 2008 at the end of the period of extended deficit in average annual rainfall. Abundance of condition monitored species also varied with time with some increases and decreases in abundance (Figs 7.14 – 7.17). No weedy species have been recorded in monitoring plots within this swamp to date (Fig 7.23). West Carne shrub swamp has a very stable composition of species through time with very little variability in almost a decade of monitoring (Fig. 7.18). Vegetation composition is very stable due to a consistently high soil moisture with frequent standing water patches in the community. Composition is also stable due to a low species richness in this community (Fig. 7.22)*".

Summary of Carne West and Sunnyside East Swamps Swamp Case Study Data

Environmental monitoring at Carne West and Sunnyside East Swamps has been conducted over the last two years. Table 7.1 is a summary of key monitoring data. The key points from the case study of Carne West and Sunnyside East Swamps are as follows:

- Burralow Formation Geology Substrate
- Baseline Hydrology Established (>2 years data)
  - Periodically / Permanently Waterlogged swamp
  - Baseline Water Quality (pH, EC, Mn, Fe) & Statistically Derived Triggers
  - Baseline Standing Water Levels & Statistically Derived Triggers
  - THPSS MMP Contains Baseline Data and Triggers
  - Monitoring Data Management System (EnviroSys) Now Active\
- Baseline Flora Monitoring Eastablished (>2 years data)
  - *“West Carne shrub swamp has a very stable composition of species through time with very little variability in almost a decade of monitoring*
  - *The monitoring plots in Sunnyside East have to date recorded very healthy or healthy condition for a wide range of species. While this monitoring is only entering it’s second year the vegetation in the monitoring plots appears to be stable and healthy”*
- Longwall Design – Void Width 260.9m, Pillar Width 58m
- Mine Dewatering Systems deigned to ensure no mine water discharge into THPSS on the Newnes Plateau
- Predicted Subsidence Based on Geological Structure and Topography
  - Subsidence up to 1.1m,
  - Compressive Strains 2 to 5 mm/m (Plateau) and 10 mm/m (Valley)
  - Tensile Strains 3 to 6 mm/m (Plateau) and 14 mm/m (Valley)
  - Tilts 4 to 7 mm/m

Key Issues Addressed in Preparation for Longwall Mining Beneath Sunnyside East and Carne West Swamps

After detailed investigations into co-incident factors which lead to the anomalous subsidence and related impacts at East Wolgan Swamp the following factors have been assessed in terms of the risk of anomalous subsidence development for planned future mining at Angus Place and Springvale mines:

- Major Geological Structure Interpretation
- Topography (Valley Depth / Slope Angles)
- Swamp Geology and Hydrogeology

Further controls to prevent impacts to THPSS on the Newnes Plateau have been implemented. These include:

- Revised Mine Design Subcritical Void Width / Increased Pillar Width
- No Mine Water Discharge to Newnes Plateau THPSS

A comprehensive monitoring program has been implemented and a management system developed:

- Baseline Monitoring (2 years minimum)
- THPSS Monitoring and Management Plan
- EnviroSys Database implemented for data management and notification of triggers

Centennial has conducted a thorough risk based assessment of impacts caused by subsidence from previous mining activities. Centennial has now implemented the findings of these assessments in the design of mining related activities which could have impacts to THPSS on the Newnes Plateau. Centennial considers that the risks of significant impacts to THPSS on the Newnes Plateau are very low.

The THPSS Monitoring and Management Plan submitted to SEWPaC will allow monitoring results to trigger investigation and remediation actions on the basis of statistically based triggers, which are based on historical baseline data. The triggers will be verified on the basis of comparison of “impact” swamps to “control” swamps.

Centennial considers that Ministerial Approval should now be granted under Condition 1 of EPBC 2011/5949 to allow mining beneath THPSS on the Newnes Plateau.

Sunnyside East and Carne West Swamp Case Study Figures

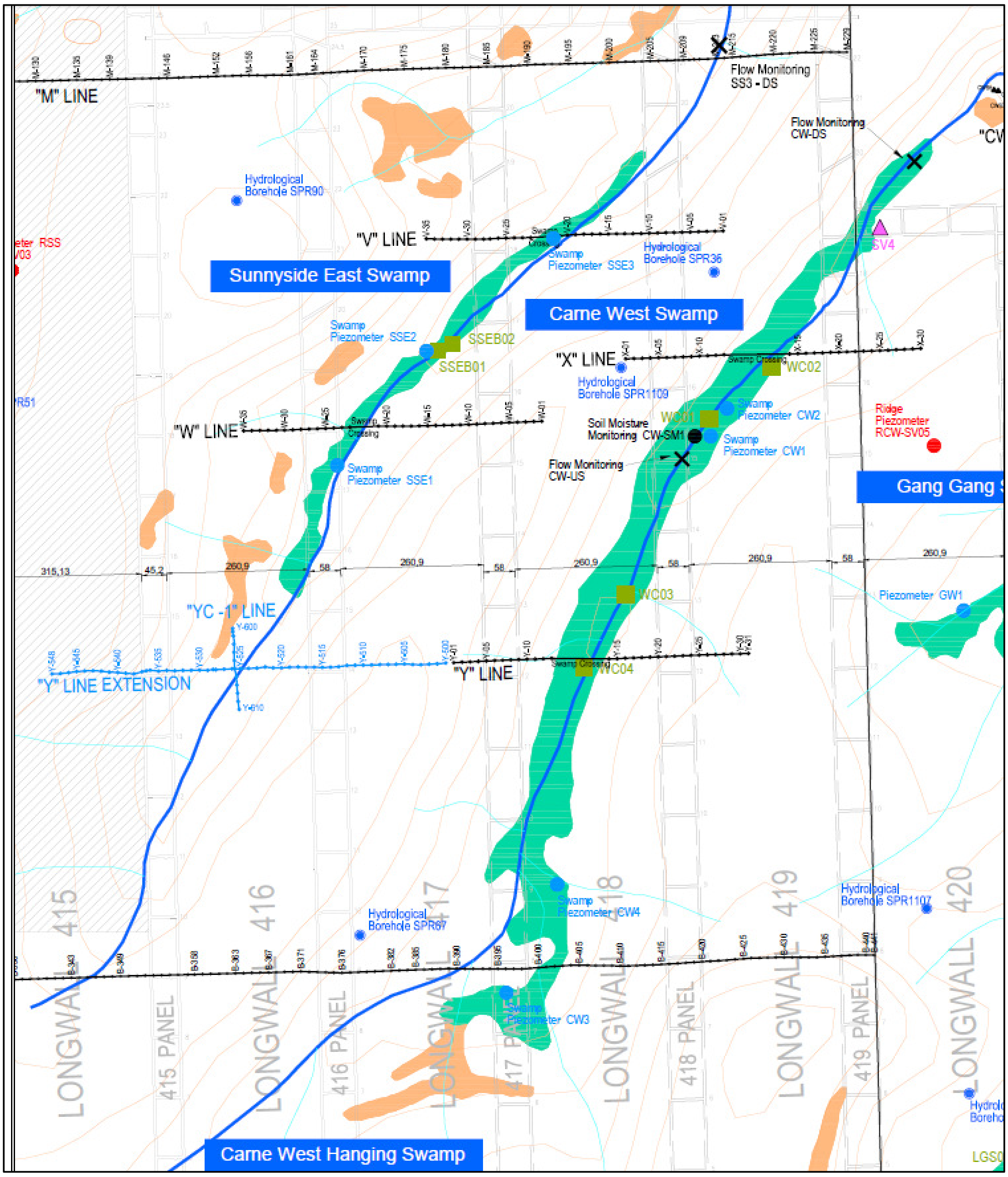


Figure 7.1 Sunnyside East and Carne West Swamp Case Study Plan

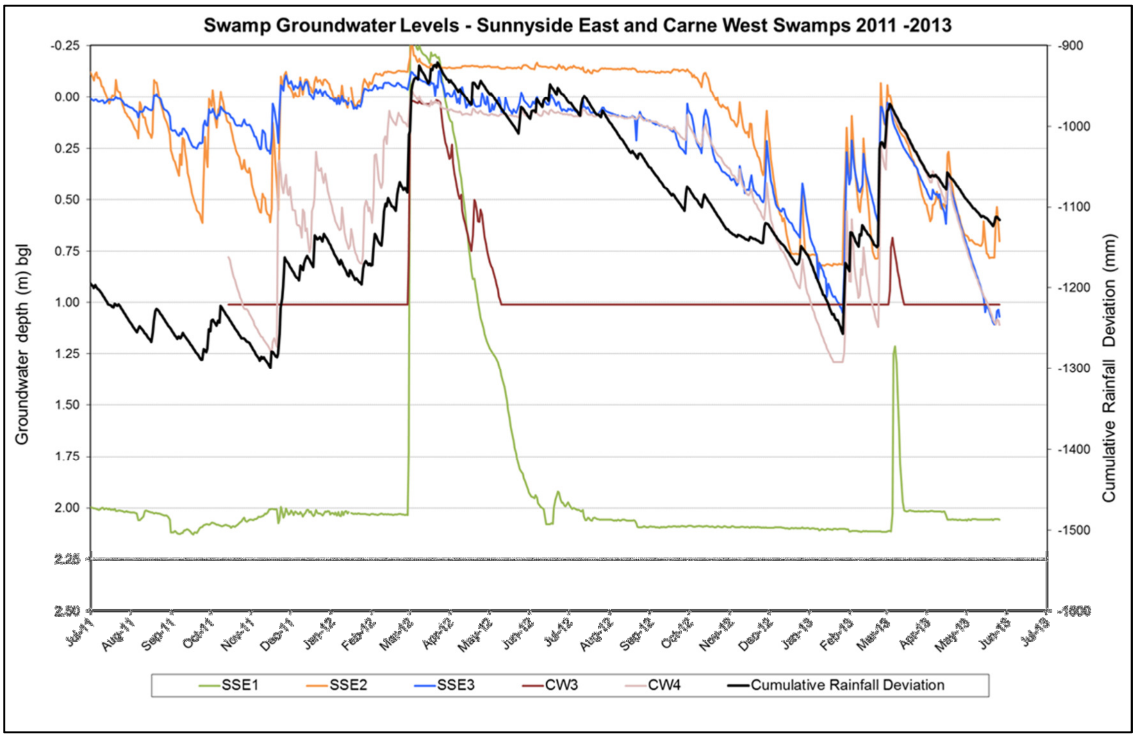


Figure 7.2 Hydrographs of five out of the seven swamp piezometers installed at Carne West and Sunnyside East Swamps (**CW 3 and CW4, SSE 1, SSE2 and SSE3)** and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a very strong correlation between the trendline of standing water level beneath the swamp at these piezometer locations over the last two years of monitoring at these locations. This data indicates that the swamps are periodically waterlogged at these locations (standing water levels respond to rainfall).

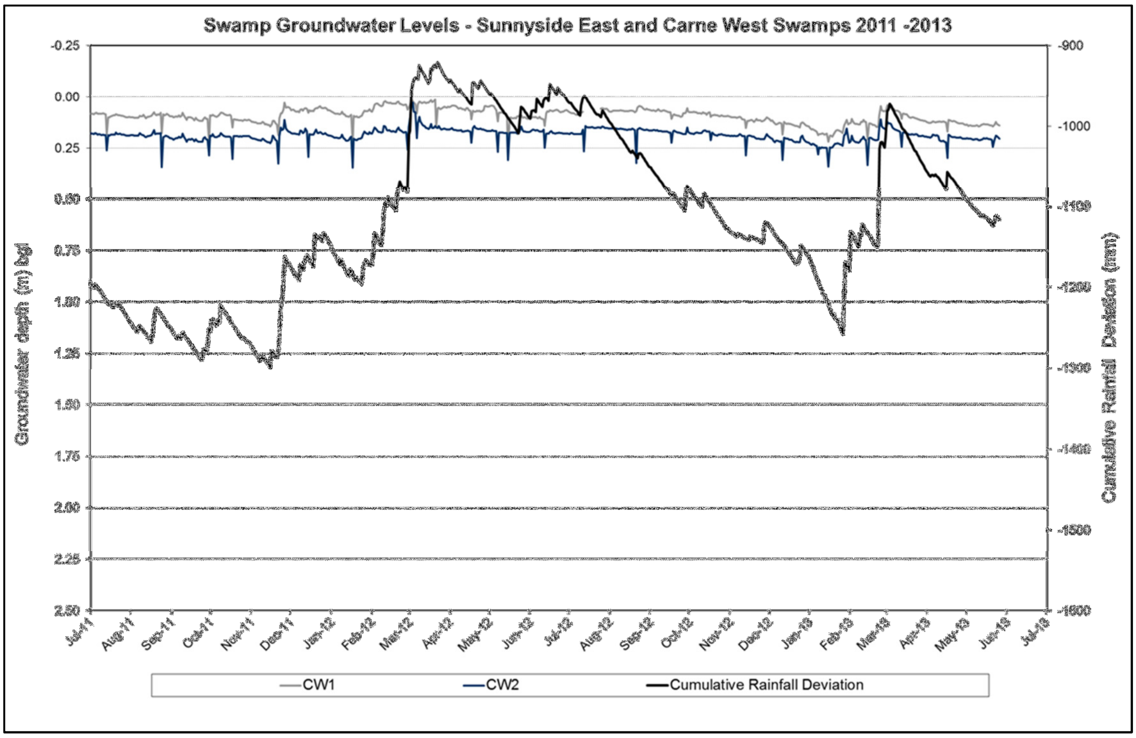


Figure 7.3 Hydrographs of two out of the seven swamp piezometers installed at Carne West and Sunnyside East Swamps (**CW 1 and CW2)** and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is not a strong correlation between the trendline of standing water level beneath the swamp at these piezometer locations over the last two years of monitoring at these locations. This data indicates that the swamps are permanently waterlogged at these locations (standing water levels do not respond to rainfall).

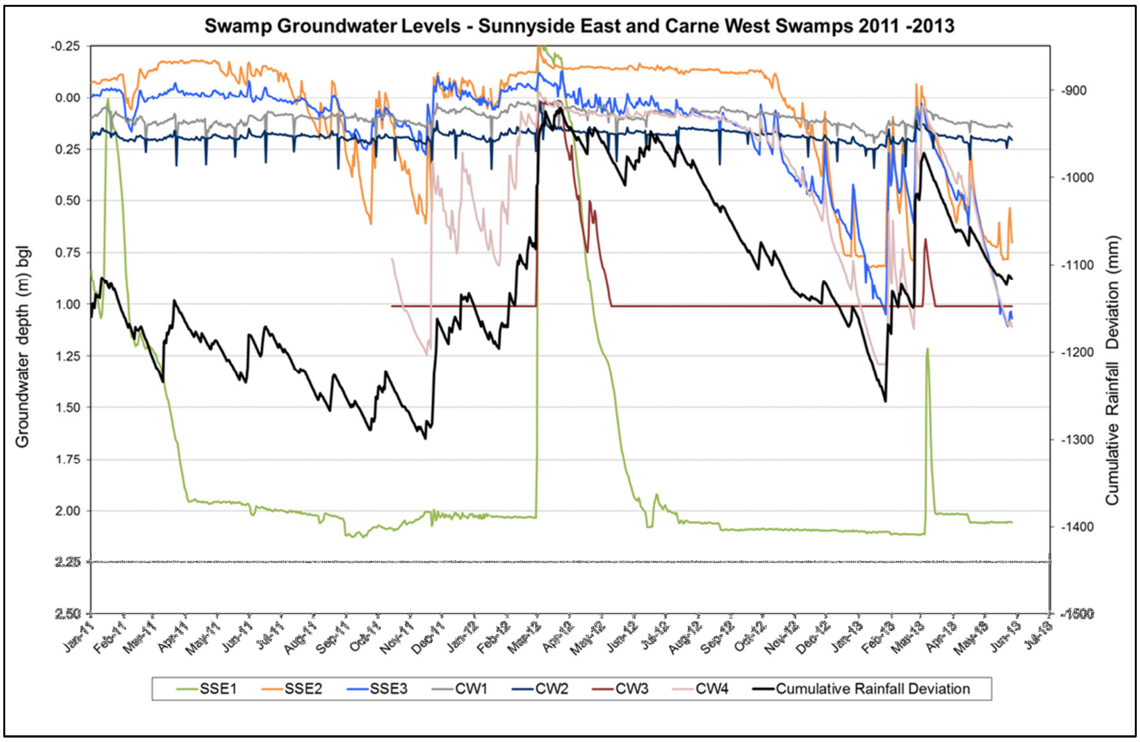
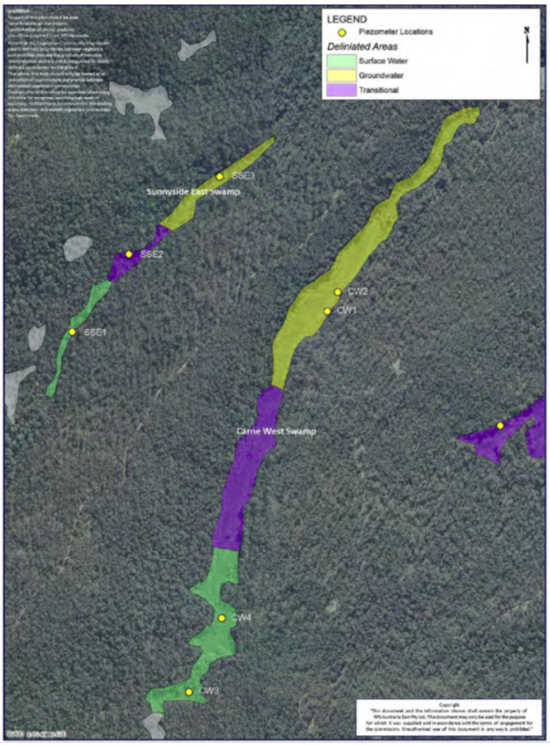


Figure 7.4 Hydrographs of all of the seven swamp piezometers installed at Carne West and Sunnyside East Swamps and the Cumulative Rainfall Deviation (CRD) which is indicated by the black trendline. Note that there is a high level of variability in standing water levels along these swamps and there are long periods (up to 12 months) between rain events which can cause the standing water level to rise close to the surface of the swamp at a number of these piezometer locations.



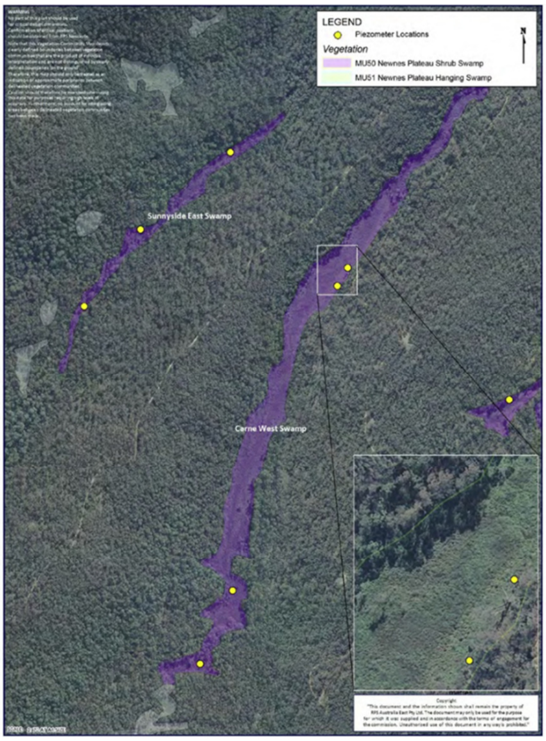


Figure 7.5 Plans of Carne West and Sunnyside East Swamps from RPS (2013) showing regions of variable hydrology along the length of both swamps which are both classified as the same MU50 vegetation community. The upper reaches of both swamps is classified as periodically waterlogged, with the lower reaches classified as permanently waterlogged (with a transitional zone between).

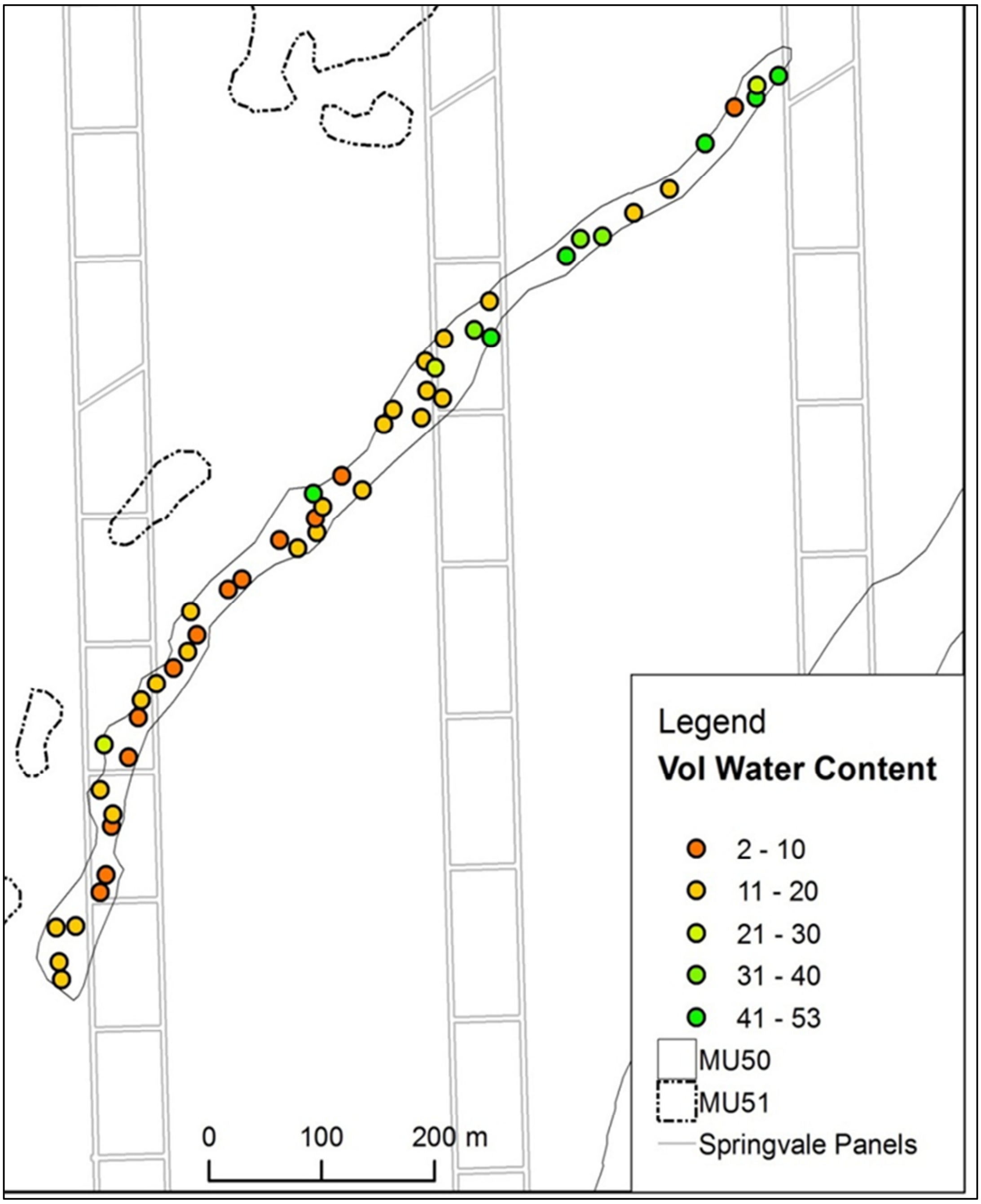


Figure 7.6 – Results of Soil Moisture Testing at 50 mini-plot locations within Sunnyside East Swamp. Testing of swamp substrate volumetric moisture content was conducted to a depth of 0.2m. Soil Moisture was found to be variable (drier upstream – wetter downstream). Sunnyside East Swamp is classified as an MU50 (Newnes Plateau Shrub Swamp) vegetation community.

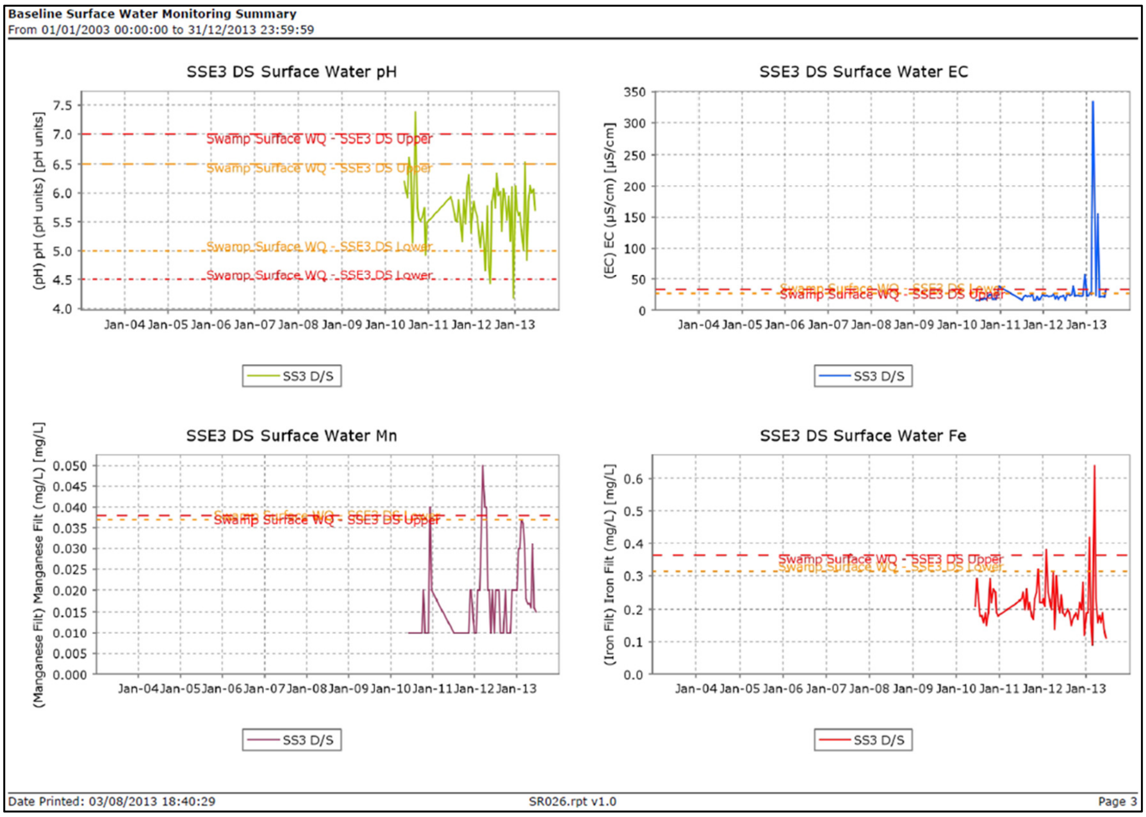


Figure 7.7 shows baseline water quality data from monitoring conducted at Sunnyside East Swamp together with trigger values calculated for the THPSS Monitoring and Management Plan. The data is now being managed within EnviroSys, which is a purpose designed database for environmental monitoring data. Data loading and trigger notification protocols are currently being established in preparation for approval and implementation of the THPSS Monitoring and Management Plan

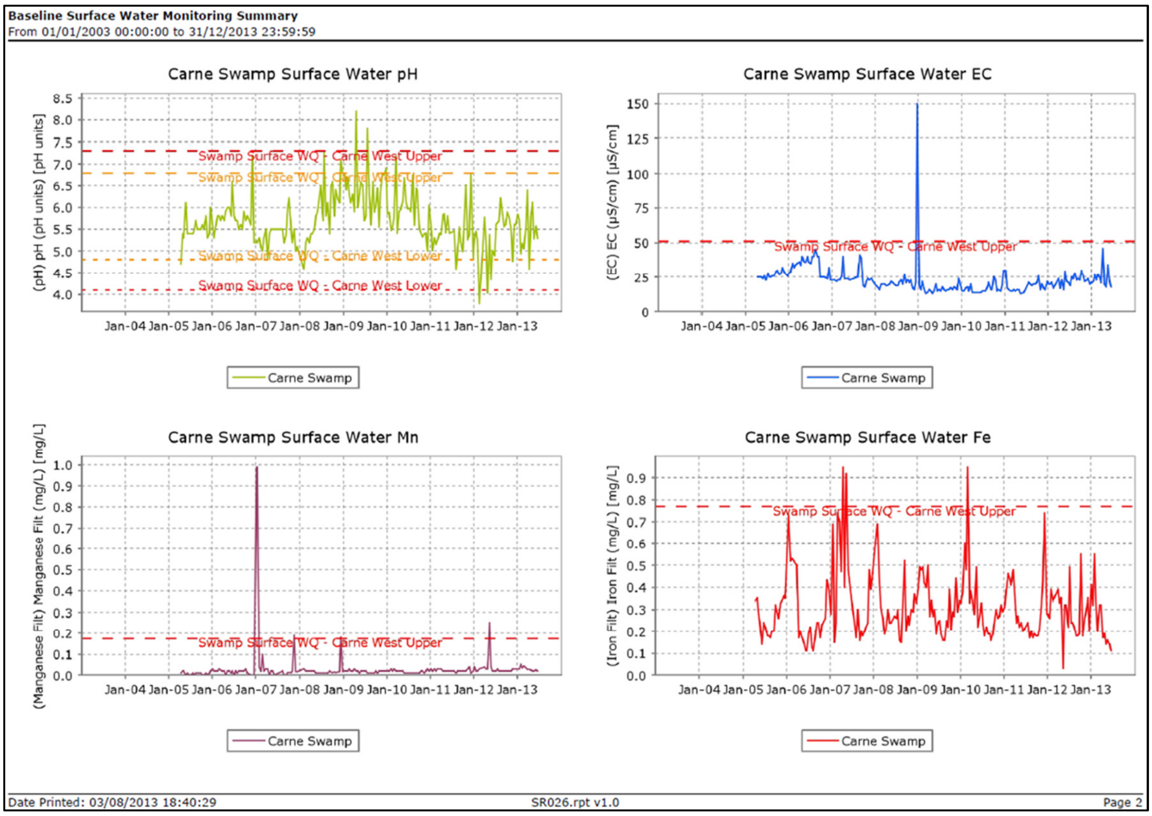


Figure 7.8 shows baseline water quality data from monitoring conducted at Sunnyside East Swamp together with trigger values calculated for the THPSS Monitoring and Management Plan. The data is now being managed within EnviroSys, which is a purpose designed database for environmental monitoring data. Data loading and trigger notification protocols are currently being established in preparation for approval and implementation of the THPSS Monitoring and Management Plan

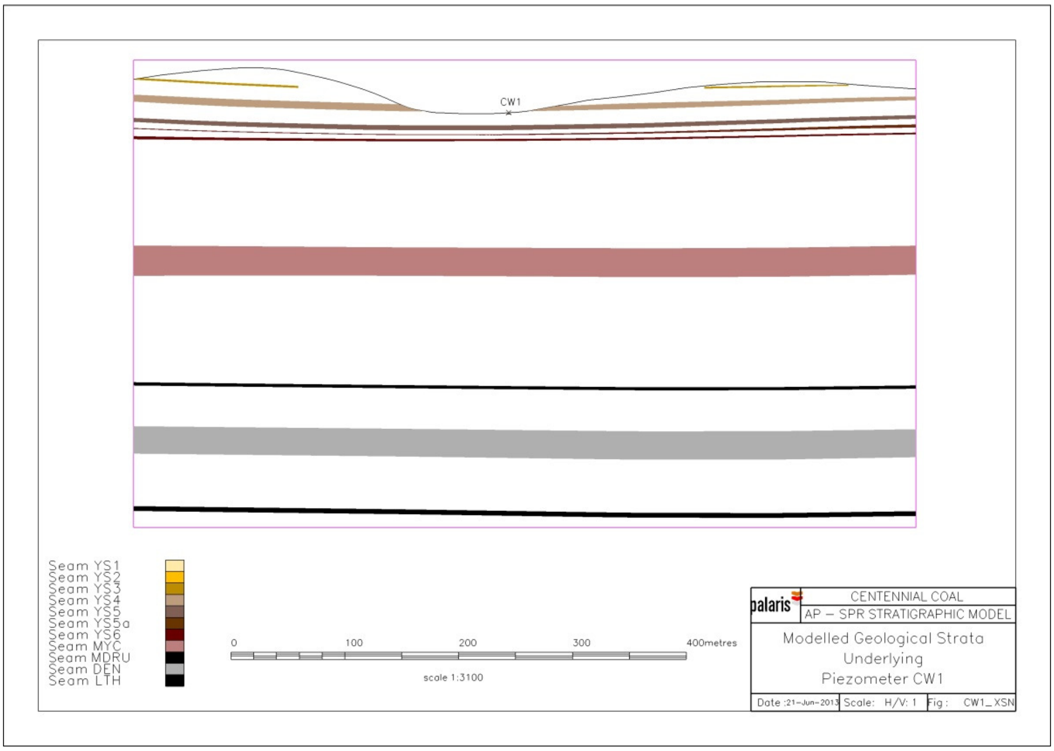


Figure 7.9 Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Swamp Piezometer CW1 which is located in Carne West Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

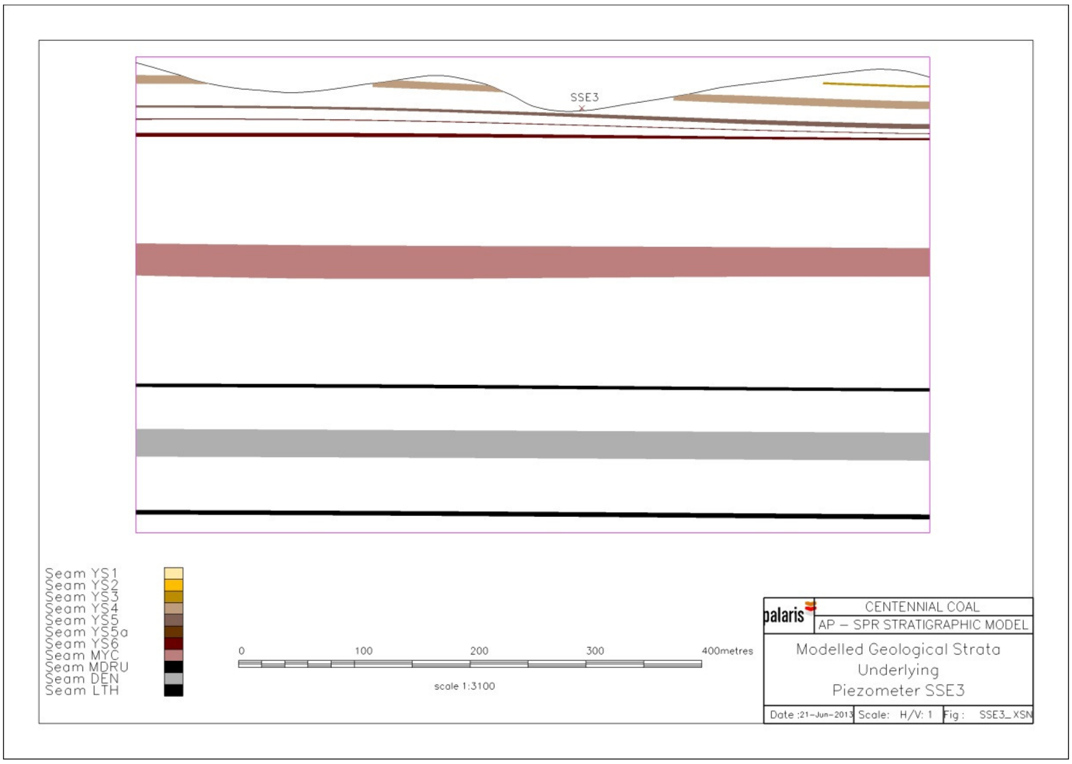


Figure 7.10 Geological Cross Section Through Strata from the Lithgow Coal Seam to the Surface at the Location of Swamp Piezometer SSE03 which is located in Sunnyside East Swamp. The cross section shows the Burralow Formation aquifers and aquitards which underlie the swamp.

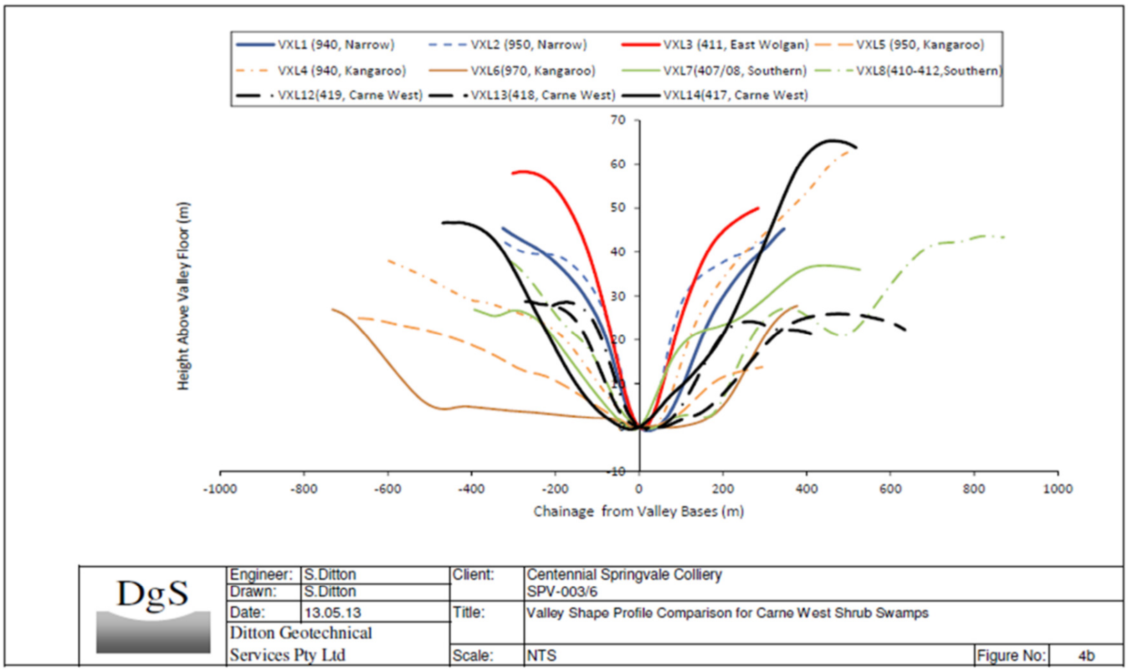


Figure 7.11 is a cross section showing valley profiles of several Newnes Plateau Shrub Swamp including Carne West Swamp (in black) compared to those at East Wolgan Swamp (in red).It can be seen that valleys at East Wolgan Swamp are significantly steeper (greater slope angle) and generally deeper than those at Carne West Swamp. This comparison has been done to identify whether topographic factors could contribute to anomalous mining subsidence. Based on the threshold value of 18 degree slope angle (see Figure 6.5 above), the risk that topographic factors could contribute to anomalous mining subsidence at Carne West Swamp is low.

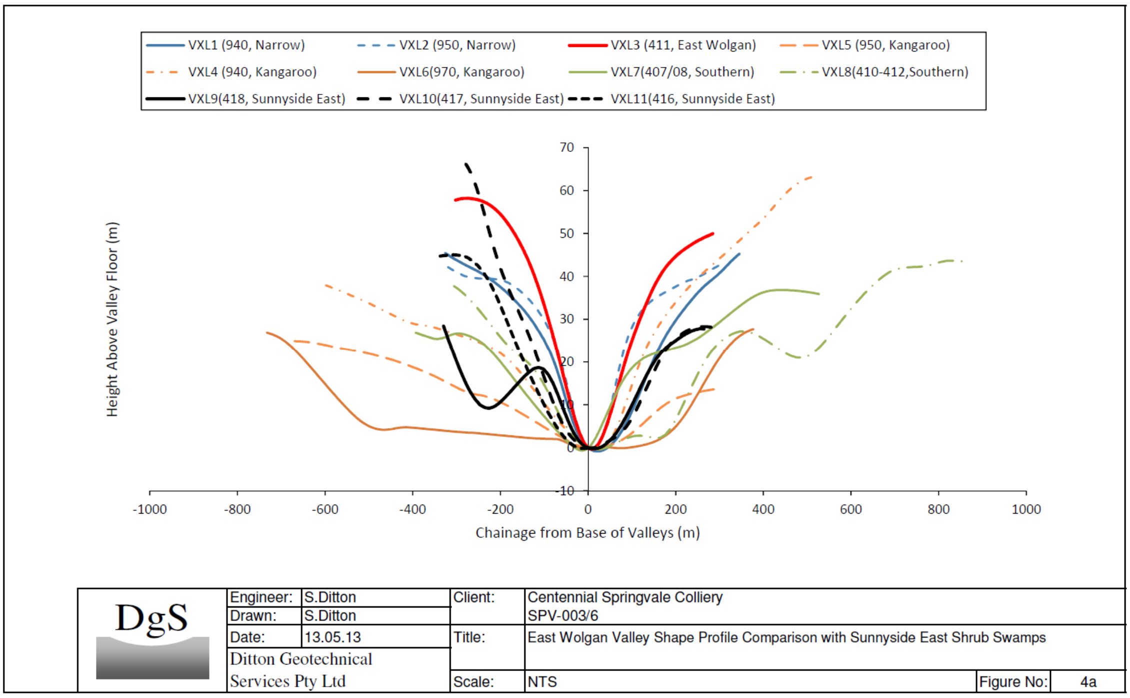


Figure 7.12 is a cross section showing valley profiles of several Newnes Plateau Shrub Swamp including Sunnyside East Swamp (in black) compared to those at East Wolgan Swamp (in red).It can

be seen that valleys at East Wolgan Swamp are significantly steeper (greater slope angle) and generally deeper than those at Sunnyside East Swamp. This comparison has been done to identify whether topographic factors could contribute to anomalous mining subsidence. Based on the threshold value of 18 degree slope angle (see Figure 6.5 above), the risk that topographic factors could contribute to anomalous mining subsidence at Sunnyside East Swamp is low.

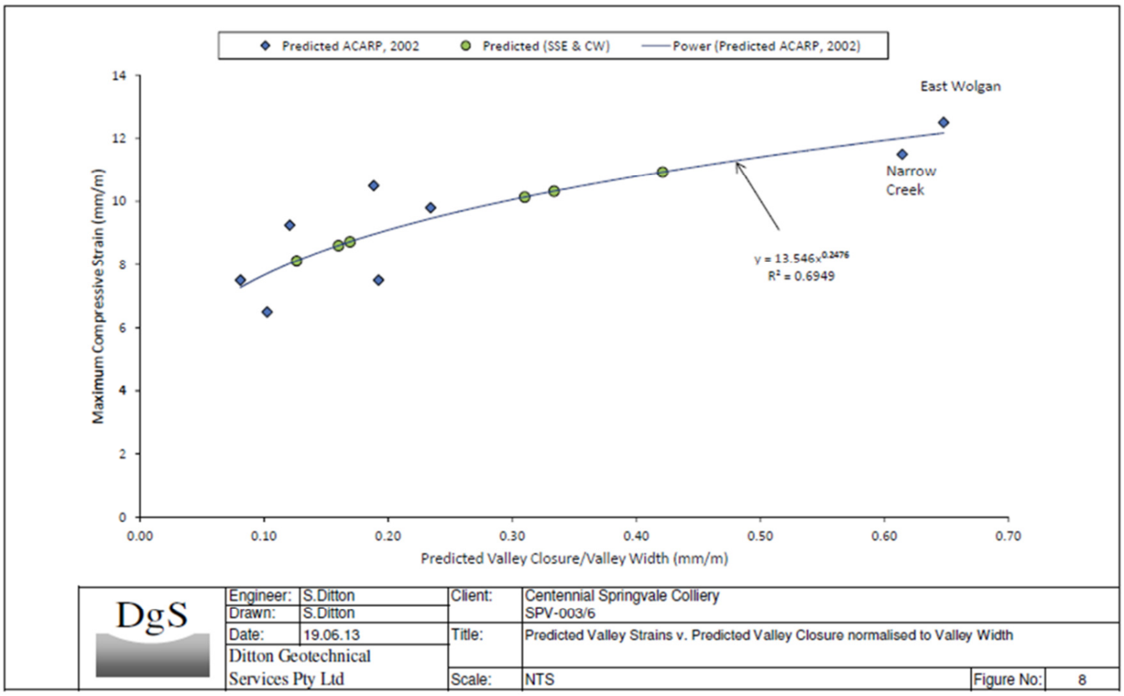


Figure 7.13 is a figure showing how the predicted valley closure movements have been normalised to valley width to make predictions for the proposed longwalls.

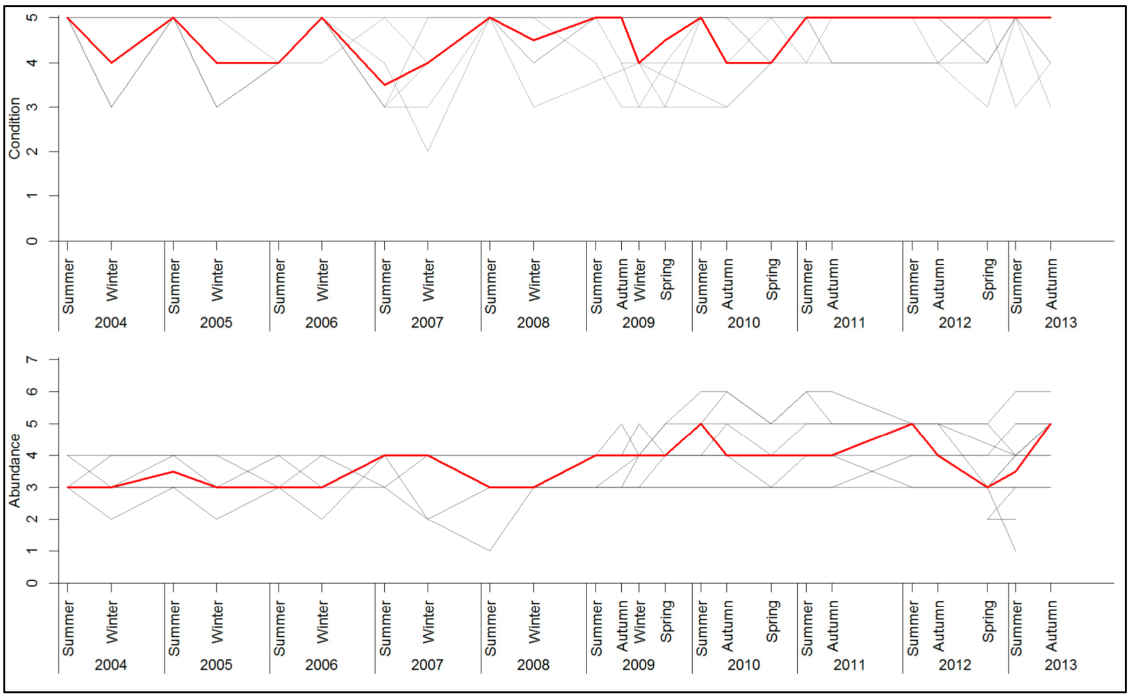


Figure 7.14**:** Median condition and abundance for West Carne 1 flora monitoring plot.

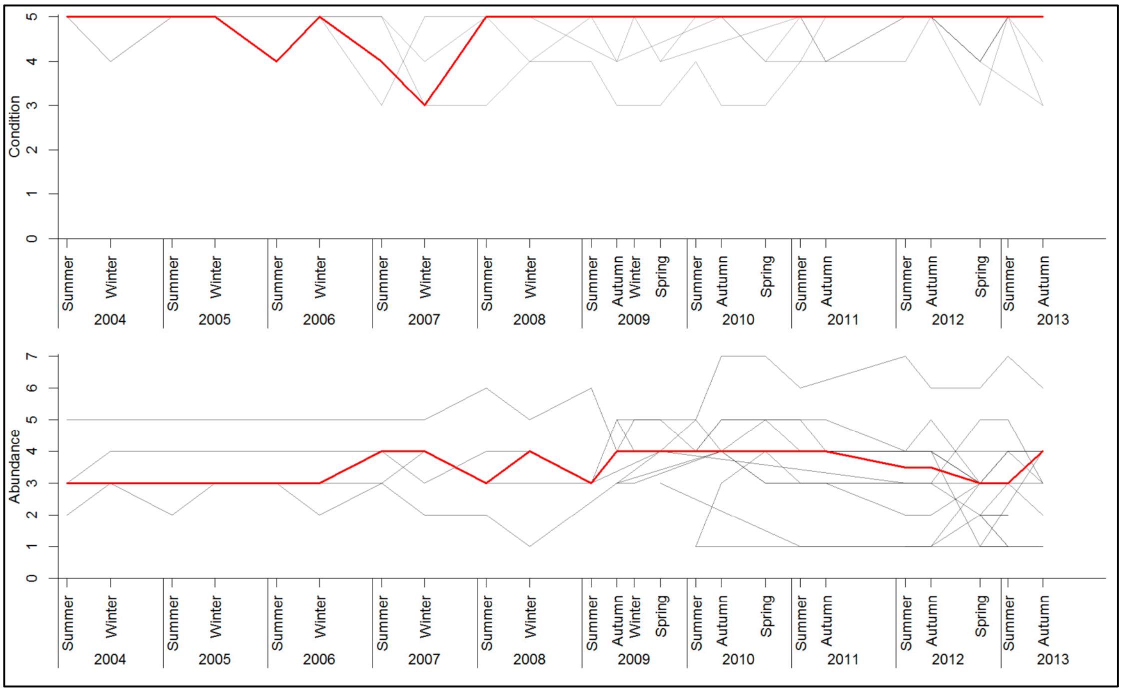


Figure 7.15 **:** Median condition and abundance for West Carne 2 flora monitoring plot.

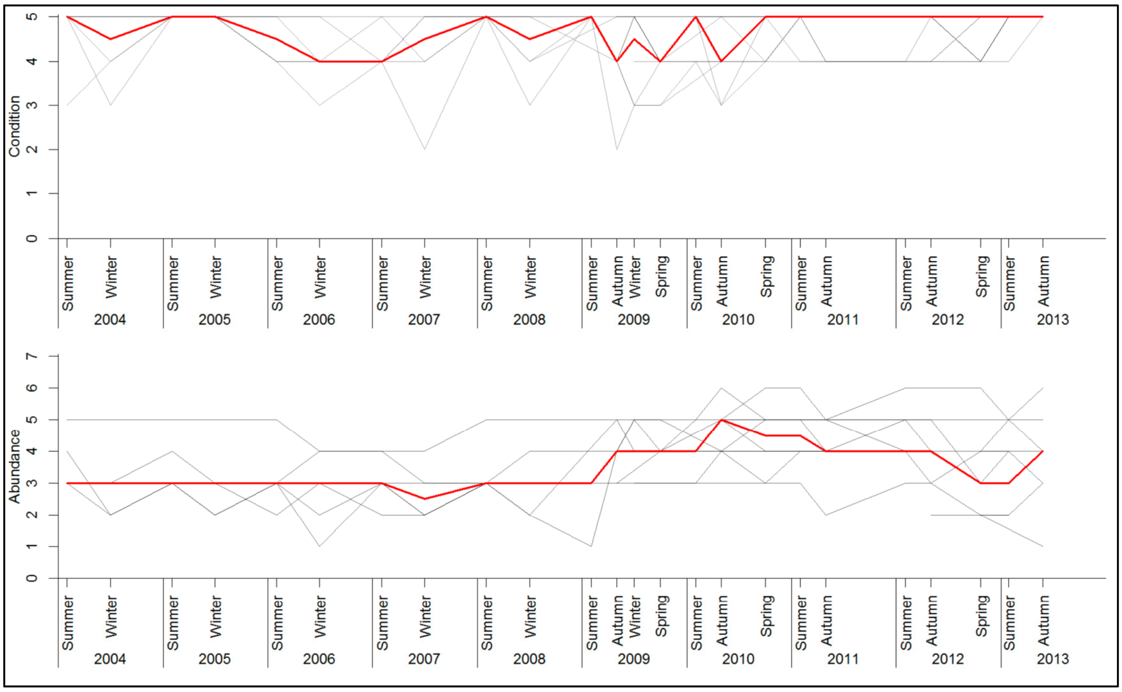


Figure 7.16: Median condition and abundance for West Carne 3 flora monitoring plot.

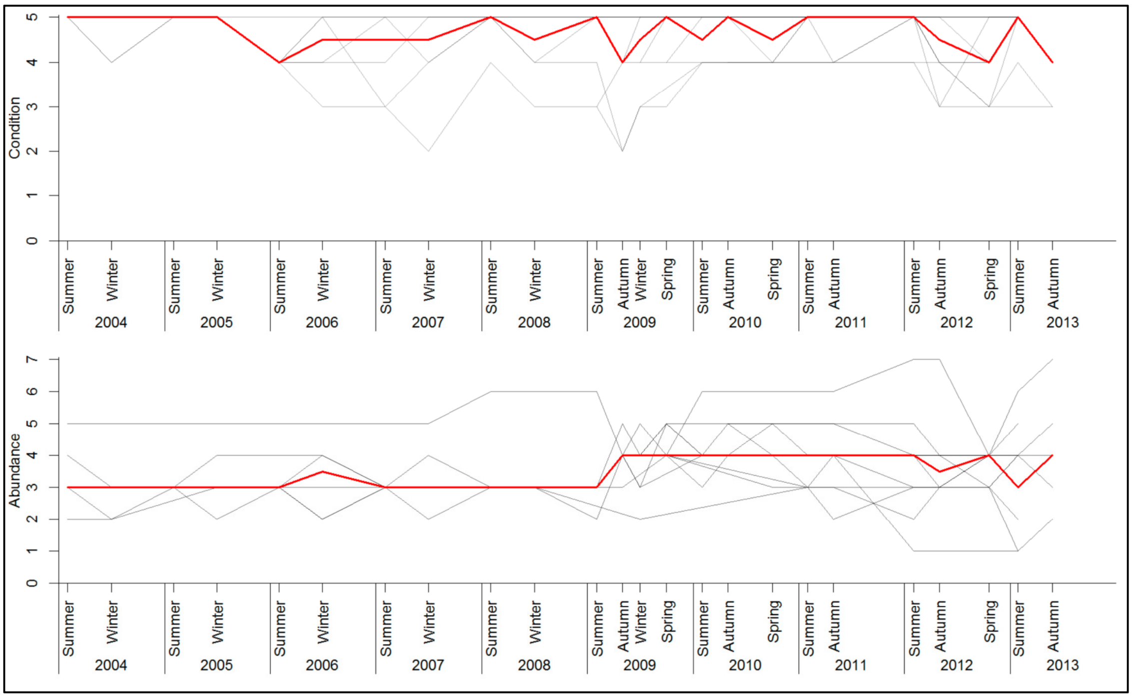


Figure 7.17: Median condition and abundance for West Carne 4 flora monitoring plot.

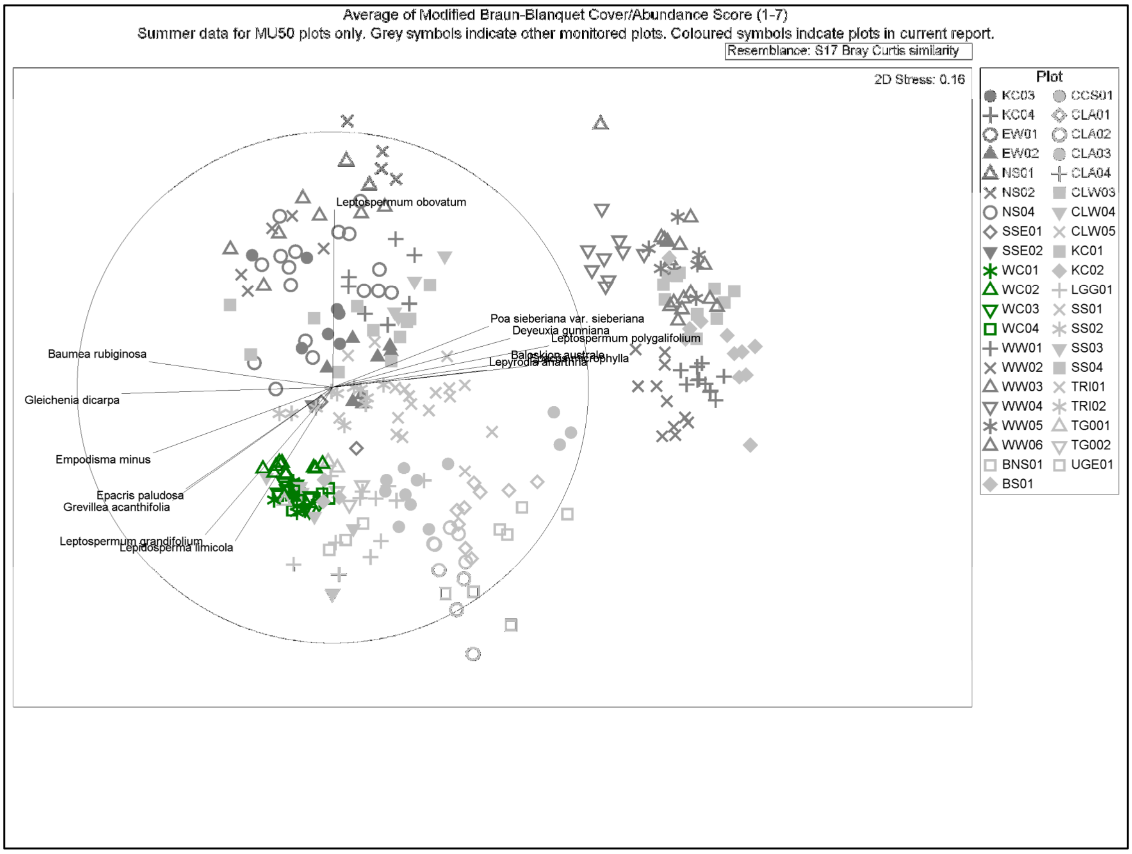


Figure 7.18: Species composition as 2D nMDS plot for summer across all monitoring years and four monitoring plots within West Carne shrub swamp community.

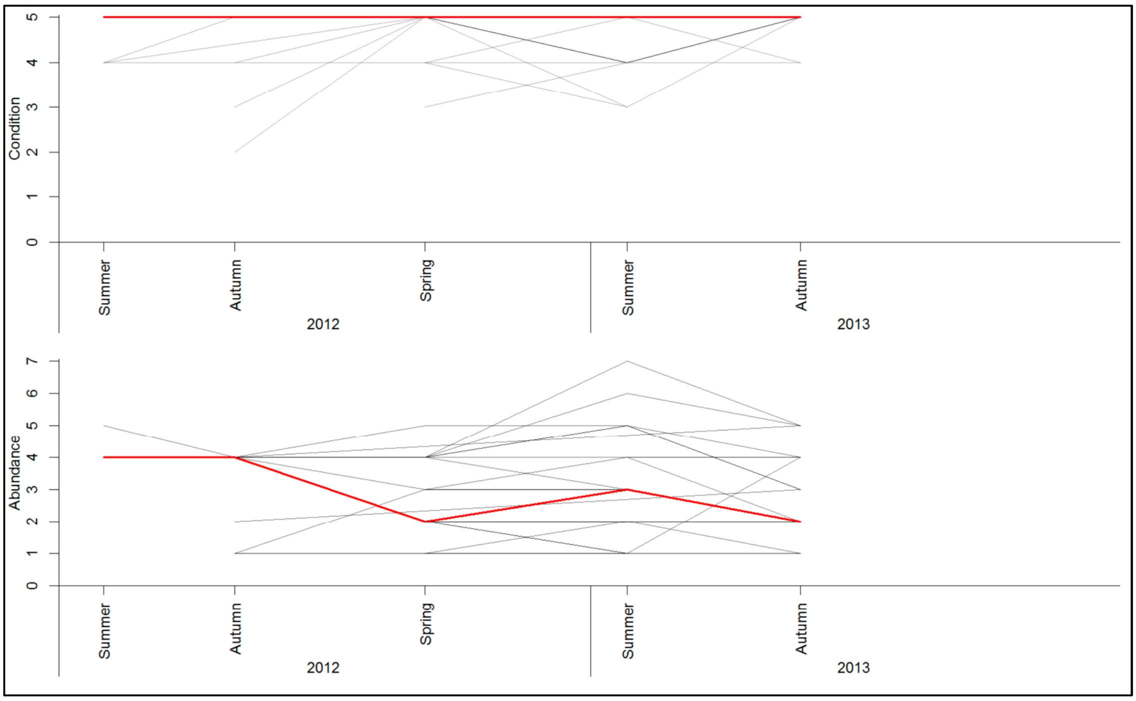


Figure 7.19: Median condition and abundance for Sunnyside East 1 flora monitoring plot.

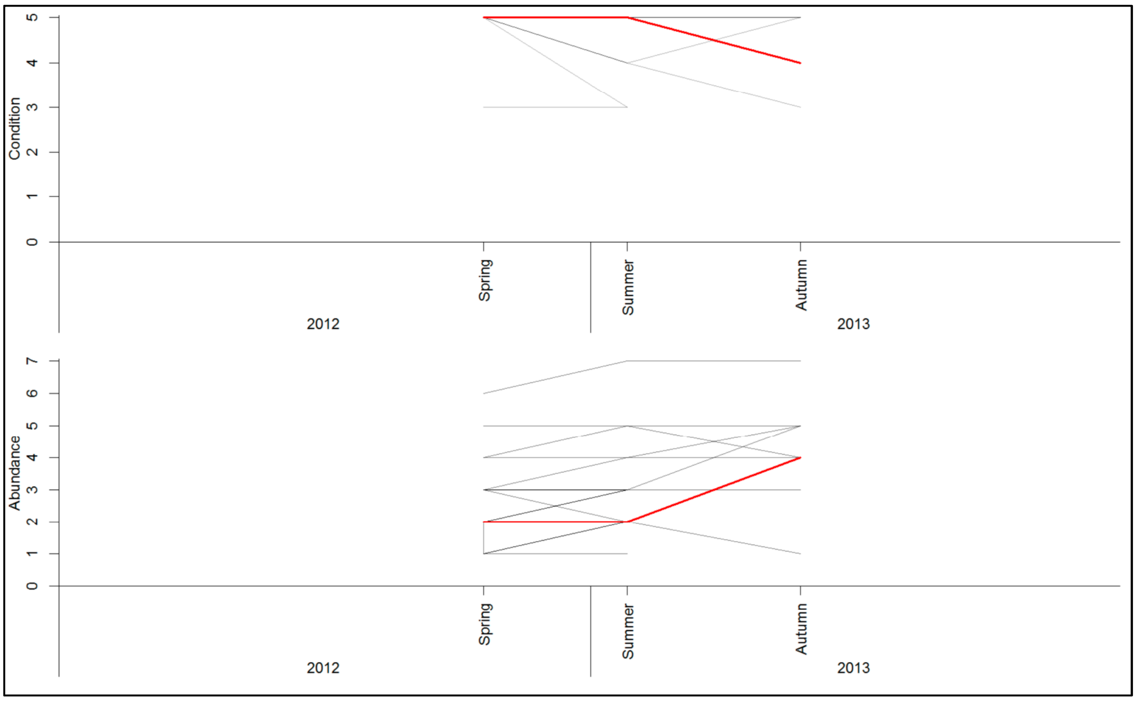


Figure 7.20: Median condition and abundance for Sunnyside East 2 flora monitoring plot.

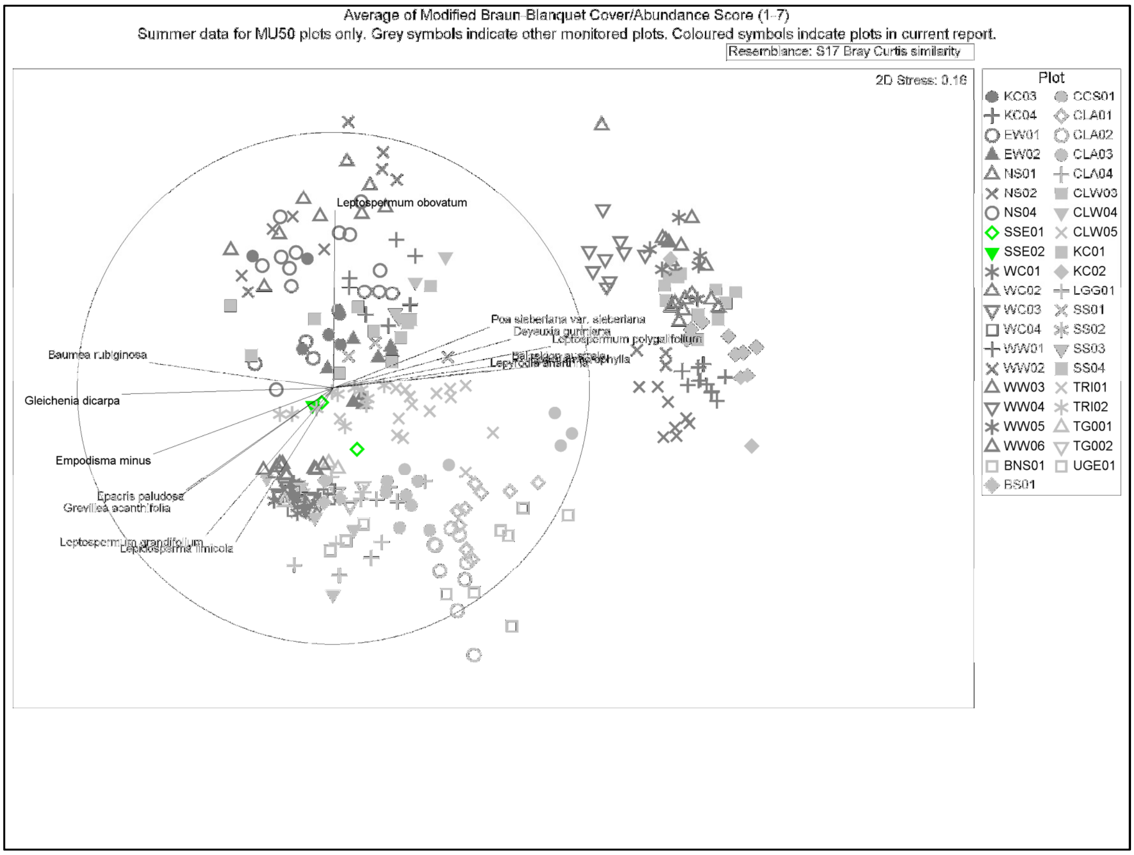


Figure7.21: Species composition as 2D nMDS plot for summer across all monitoring years and four monitoring plots within Sunnyside East shrub swamp community.

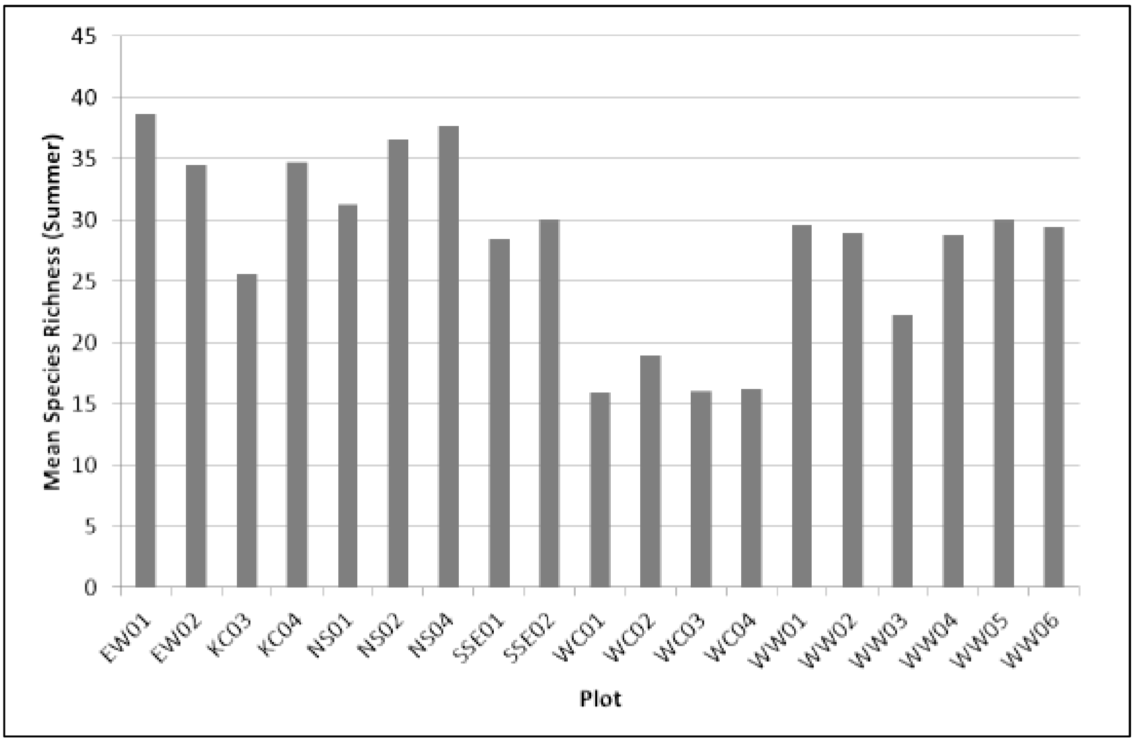


Figure 7.22: Mean species richness of plots in all summers of monitoring

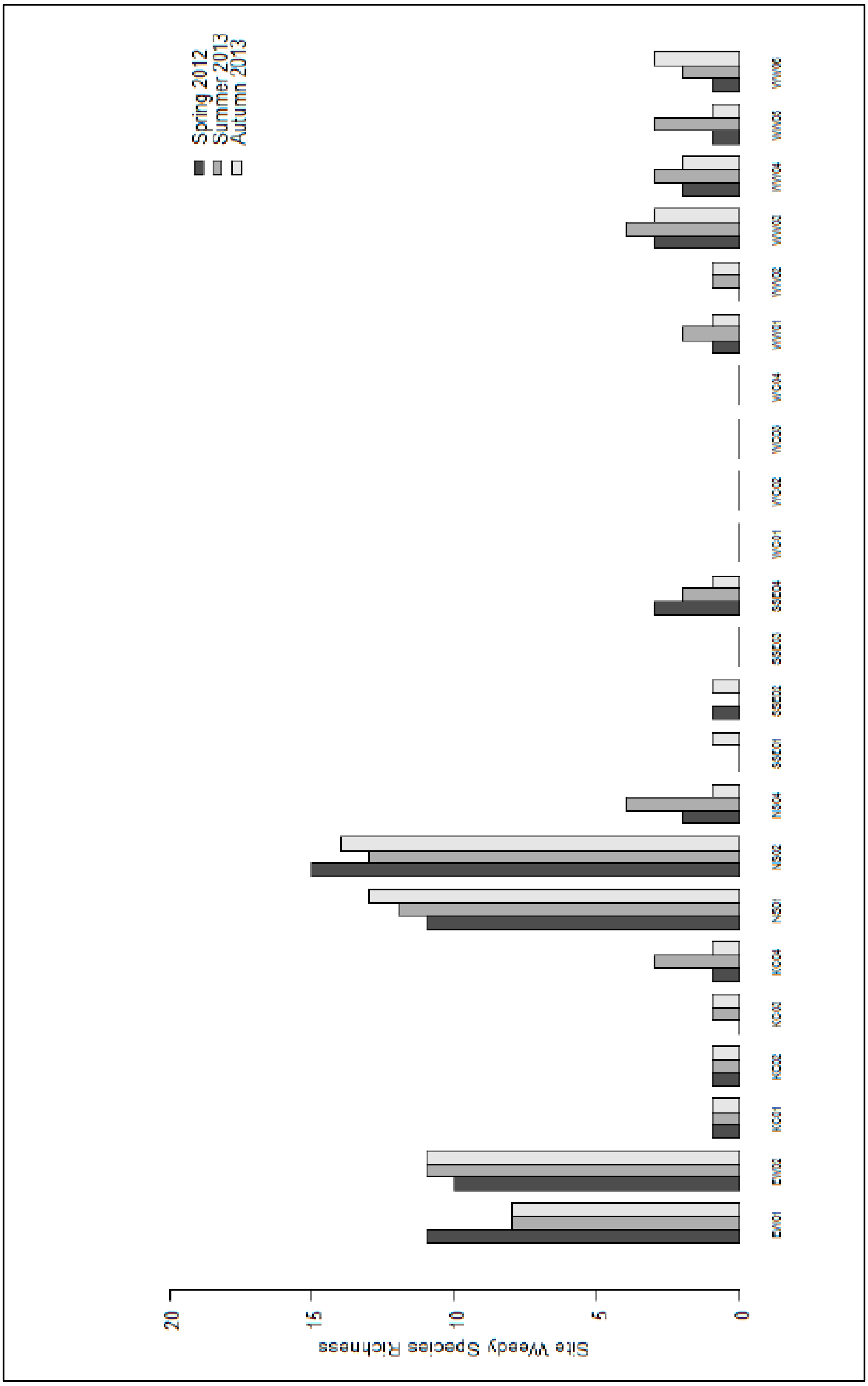


Figure 7.23: Weedy species richness for the case study swamps over the past 12 months

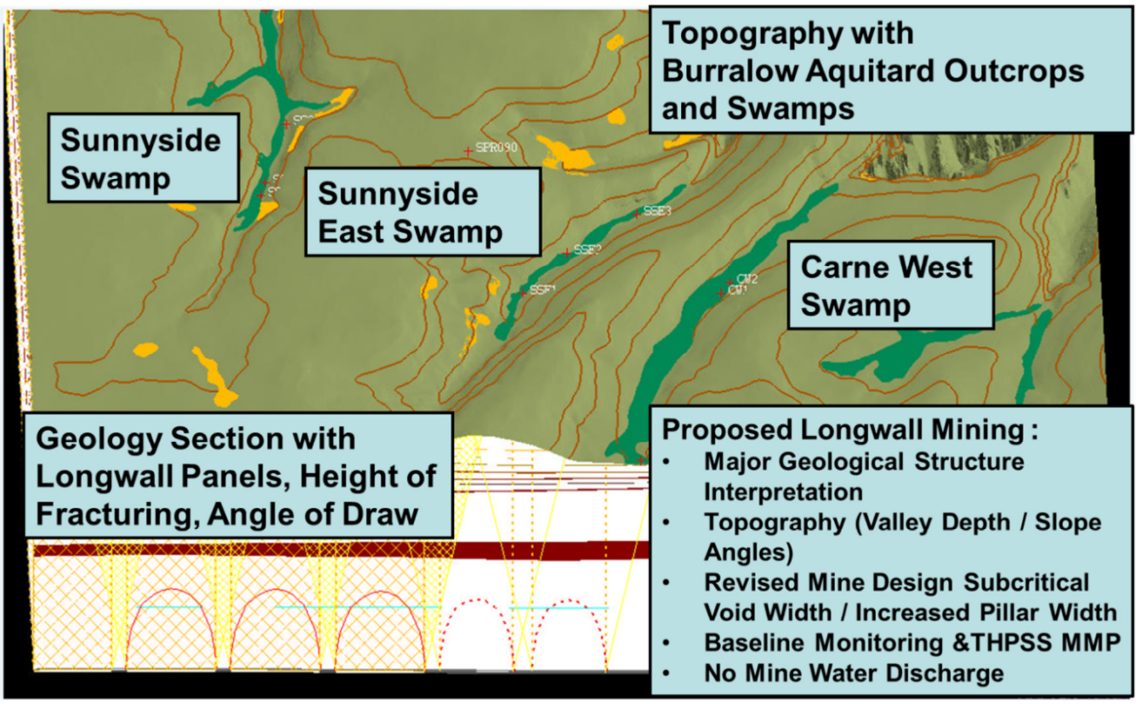


Figure 7.24 is an annotated 3 Dimensional plan showing the interactions of proposed longwall mining with Sunnyside East and Carne West Swamps. After detailed investigations into co-incident factors which lead to the anomalous subsidence and related impacts at East Wolgan Swamp the following factors have been assessed in terms of the risk of anomalous subsidence development for planned future mining at Angus Place and Springvale mines:

- Major Geological Structure Interpretation
- Topography (Valley Depth / Slope Angles)
- Swamp Geology and Hydrogeology

Further controls to prevent impacts to THPSS on the Newnes Plateau have been implemented. These include:

- Revised Mine Design Subcritical Void Width / Increased Pillar Width
- No Mine Water Discharge

A comprehensive monitoring program has been implemented and a management system developed:

- Baseline Monitoring (2 years minimum)
- THPSS Monitoring and Management Plan
- EnviroSys Database implemented for data management and notification of triggers