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Subsidence Impacts on Swamp 20 and Swamp 28

Metropolitan Colliery, Helensburgh, NSW

Assessment of Impacts on Threatened Flora, March 2021

Prepared for: Metropolitan Coal

18 March 2021 Version: Final 1.0

PROJECT NUMBER	**2020-240**	
PROJECT NAME	Subsidence Impacts on Swamp 20 and Swamp 28	
PROJECT ADDRESS	Metropolitan Colliery, Helensburgh, NSW	
PREPARED FOR	Metropolitan Coal	
AUTHOR/S	Elizabeth Norris	
REVIEW	Technical	QA
	Elizabeth Norris	Elizabeth Norris
VERSION	Version	Date to client
	Draft 1.0	23 February 2021
	Final 1.0	18 March 2021
ACKNOWLEDGEMENTS	This report has been prepared by Ecoplanning with support from Resource Strategies, Metropolitan Coal and Eco Logical Australia	
COVER PHOTO	Swamp 20 Terminal Rock Bar (20 January 2021) Elizabeth Norris.	

This report should be cited as: 'Ecoplanning (2021). Subsidence Impacts on Swamp 20 and Swamp 28– Metropolitan Colliery, Helensburgh, NSW. Prepared for Metropolitan Coal.'

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ECOPLANNING PTY LTD | 74 HUTTON AVENUE BULLI NSW 2516 | M: 0421 603 549

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1 Introduction

In accordance with the Longwalls 305-307 Biodiversity Management Plan (BMP), the exceedance of any biodiversity subsidence impact performance indicator triggers an assessment against the biodiversity subsidence impact performance measure: *'Negligible impact on threatened species, populations, or ecological communities',* where *Negligible* is defined in the Project Approval as "small and unimportant such as to be not worth considering'.

Swamp substrate water levels have been assessed against the following upland swamp groundwater performance indicator:

> *Surface cracking within upland swamps resulting from mine subsidence is not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.*

The upland swamp groundwater performance indicator has been exceeded at Swamp 20 since 2012 and Swamp 28 since 2016 (SLR 2021).

Vegetation within upland swamps is assessed against the following upland swamp vegetation performance indicator:

> *The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.*

Eco Logical (2021a) note that dieback of Gleichenia spp. across Swamp 20 has ceased and signs of recovery (regrowth) were observed in autumn 2020. Further, the ongoing decline in the vegetation condition of the Tea Tree Thicket component of Swamp 28 with regards to condition of understorey species and loss of species richness appears to have stabilized in autumn 2020, although species richness continues to fluctuate (Eco Logical, 2021b). The upland swamp vegetation performance indicator was not exceeded at Swamps 20 and 28 in autumn 2020 (Eco Logical Australia 2021a, 2021b).

In accordance with the Metropolitan Coal Longwalls 305-307 BMP, Ms Elizabeth Norris (Ecoplanning Pty Ltd) was commissioned by Metropolitan Coal to undertake an assessment of threatened flora that may be associated with Swamp 20 and Swamp 28 against the biodiversity subsidence impact performance measure.

This report is the ninth threatened flora species assessment report for Swamp 20, following previous reports undertaken from 2012 to 2016 (FloraSearch 2012-2016a), in 2017 (Eco Logical Australia 2017) and 2018-2019 (Ecoplanning 2019, 2020). This report is the fifth threatened flora species assessment report for Swamp 28, following previous assessments undertaken in 2016 (FloraSearch 2016b), 2017 (Eco Logical Australia 2017), and 2018-2019 (Ecoplanning 2019, 2020).

Delays to the originally scheduled site assessments in December 2020 were encountered due to the extended periods of heavy rainfall during December 2020 and early January 2021, resulting in continued catchment closures. This report is thus based upon the delayed site assessments conducted on 20 January 2021.

2 Potential Threatened Flora

Four threatened flora species listed under the *NSW Biodiversity Conservation Act 2016* (previously the *NSW Threatened Species Conservation Act, 1995*) were recorded in the baseline flora survey for the Project Area (Bangalay Botanical Surveys 2008), viz;

- *Acacia bynoeana* (Bynoe's Wattle)
- *Astrotricha crassifolia* (Thick-leaf Star-hair)
- *Melaleuca deanei* (Deane's Paperbark)
- *Pultenaea aristata* (Prickly Bush-pea)

Two threatened species (unconfirmed collections reported in the baseline flora survey of Bangalay Botanical Services 2008) also have the potential to occur in the Project Area;

- *Epacris purpurascens* var. *purpurascens*
- *Leucopogon exolasius* (Woronora Beard-heath)

Two additional threatened flora species, *Acacia baueri* subsp. *aspera* and *Cryptostylis hunteriana* (Leafless Tongue Orchid), have been recorded within the Project Area or surrounds since the baseline surveys by Eco Logical Australia.

Three threatened flora species are known to inhabit upland swamps within the Project Area; *Acacia baueri* subsp. *aspera, Pultenaea aristata* and *Cryptostylis hunteriana*, all of which are listed as Vulnerable under the *Biodiversity Conservation Act 2016*.

Acacia baueri subsp. *aspera* is found in low, damp heathlands, often on exposed sandstone ridges with *Banksia ericifolia subsp. ericifolia* (Benson & McDougall 1996). It prefers open conditions and is rarely observed where shrub or tree canopy development is present. As many observations have been made following fire it is suggested that the species prefers early successional habitats (OEH 2019). It has been recorded from the upper swamp margins of the control Swamp 111a (outside of the Project underground mining area) amongst *Banksia ericifolia* subsp. *ericifolia* and other heath species. Approximately six individuals have been recorded at this site. This species is not known from within or near Swamp 20 or Swamp 28.

Three individuals of *Cryptostylis hunteriana* were recorded in Swamp 92 within the Project Area. This species is known to occur in coastal plains in scribbly gum woodland (Benson & McDougall 2005), and at Swamp 92, it is found amongst wet heath to swampy vegetation dominated by *Banksia ericifolia* subsp. *ericifolia* over a dense ground layer of sedges. This species is not known from within or near Swamp 20 or Swamp 28.

Pultenaea aristata is a widespread and common species within the Project Area and surrounds (Bangalay Botanical Surveys 2008), and is found on moist sites on sandstone, in wet heath and shrubby sclerophyll woodland (Benson & McDougall 1996). *Pultenaea aristata* occurs on the margins of Swamp 20 near the downstream terminal step where the vegetation in this part of the swamp is dominated by *Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia.* This species is not known from within or near Swamp 28.

No threatened flora populations or critical habitat have been listed for Swamp 20, Swamp 28, or any other upland swamps on the Woronora Plateau.

At the time the Metropolitan Coal Project was approved, there were no state or Commonwealth listed threatened ecological communities that included, fully or in part, upland swamps on the Woronora Plateau (Metropolitan Coal 2019). In March 2012, *Coastal Upland Swamp in the Sydney Basin Bioregion* was listed as an endangered ecological community (EEC) under the *Threatened Species Conservation Act 1995* (now the *Biodiversity Conservation Act 2016*). Since the Project approval predates this listing, specific consideration is not required in this report consistent with the Longwalls 305-307 BMP. However, the observations made provide an assessment of swamp condition.

2.1 Key Assessment Considerations

Consistent with the Longwalls 305-307 BMP, factors to be taken into consideration in the assessment of threatened species are as follows:

1. *What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)?*
2. *What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)?*
3. *Which threatened species have the potential to be impacted?*
4. *What are the potential impacts on the lifecycle of the potential threatened species (e.g. foraging, breeding/reproduction, nesting, shelter and movement/dispersal)?*
5. *What are the potential impacts on the habitat of the potential threatened species (e.g. area affected)?*
6. *Has the habitat connectivity of the threatened species been affected (e.g. loss of stream pool habitat connectivity)?*
7. *What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?*

3 Background

3.1 Climatic Conditions

Table 1 provides the monthly rainfall data from the Helensburgh 2 Metropolitan Coal Weather Station located approximately 3 km east of the Project Area, for the period September 2008 to June 2020.

Following the previous inspection of Swamp 20 and Swamp 28 (Ecoplanning 2020), monthly rainfall from June 2019 through to June 2020 continued to be well below the long-term mean recorded at Darkes Forest (with the exception of September 2019 and February 2020 when well above average monthly rainfall was recorded) (**Table 1**).

Table 1: Monthly rainfall (mm) for the entire monitoring survey period (September 2008 to Autumn 2020) taken from Metropolitan Colliery Meteorological Station Helensburgh 2.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008									89.0	53.5	64.5	82.0
2009	35.5	210.0	102.0	155.5	152.5	80.5	55.5	5.0	26.0	120.5	63.5	63.5
2010	37.0	182.5	118.5	30.5	89.5	169.0	47.5	43.0	173.5	75.0	103.5	90.5
2011	42.0	4.0	164.5	59.5	51.0	167.0	169.5	91.0	75.0	80.0	162.5	76.0
2012	180.5	242.0	235.5	117.5	15.0	129.5	45.5	5.5	22.5	63.5	54.5	28.0
2013	171.0	220.5	67.0	104.5	106.5	283.5	7.0	11.0	80.5	12.0	217.5	54.5
2014	31.5	50.5	218.5	59.0	11.5	28.0	8.0	93.0	25.5	79.5	39.5	182.5
2015	113.5	96.0	32.5	445.0	101.5	62.5	53.0	81.5	38.5	30.5	119.0	60.5
2016	275.0	31.0	46.5	55.5	36.0	394.5	92.5	84.0	52.5	15.5	36.0	67.5
2017	63.0	172.0	404.5	70.0	13.5	174.5	12.5	18.5	0.5	37.0	39.0	52.5
2018	38.0	83.0	139.0	19.0	11.5	95.5	1.0	16.0	41.0	175.5	117.0	93.5
2019	58.0	44.0	180.5	24.0	6.5	88.5	36.5	48.0	130.0	29.5	40.0	2.5
2020	88.5	550.5	132.5	75.5	75.0	48.0	-	4.0	36.0	158.0	65.0	104.0
2021	122.0											
Mean[1]	**131.2**	**159.5**	**154.3**	**126.1**	**128.1**	**144.7**	**96.0**	**88.9**	**77.2**	**91.5**	**104.9**	**103.0**

[1] Mean data sourced from Bureau of Meteorology Station Number 068024 (Darkes Forest – Kintyre) (www.bom.gov.au March 2021). Each monthly long-term mean is calculated using all data obtained since the commencement of monitoring at Station 068024. Highlighted data refers to current reporting period, with February 2020 and September 2019 well above average.

The extended period of dry weather throughout 2018, 2019 and 2020 was evident in vegetation across the catchment by leaf yellowing and observed plant dieback, particularly for the ground layer species *Gleichenia microphylla, Empodisma minus* and *Bauera rubioides*. Some recovery of condition was observed in autumn with *Empodisma minus* found in healthy condition in a number of plots following the above average rainfall of February 2020 (Eco Logical Australia 2021a, 2021b).

3.2 Swamp 20 and Swamp 28 Groundwater Monitoring

The history of mining effects on substrate water levels in Swamp 20 and Swamp 28 (**Figure** 1) have been reported previously (Flora Search 2012-2016; Eco Logical Australia 2017-2020; Ecoplanning 2019, 2020), and a brief summary and update is provided below.

3.2.1 Swamp 20

Swamp 20 is located over Longwall 21. A mining effect to the substrate water levels of Swamp 20 was identified in 2012, associated with the passing of Longwall 21. Swamp 20 substrate water levels changed from being permanently saturated to being periodically saturated (**Chart 1**) (SLR, 2021).

There is a very strong correlation with rainfall trend at Swamp 20 and control swamp Woronora River Swamp 1 (WRSWAMP 1) over the period of record (**Chart 1**). As the rate of decline in the two piezometers is similar from 2013, but different in 2012, it is considered that Longwall 21 caused a mining effect at Swamp 20, but the effects have not been exacerbated by Longwalls 22-27 and Longwalls 301-305 (SLR 2021). During 2018 and 2019 Swamp 20 and the control swamps reported water levels at the base of the substrate apart from the rainfall event of September 2019. Both swamps increased in water levels after the large rain event in February 2020. However, following rainfall events throughout 2020 Swamp 20 exhibited a decrease in groundwater levels whereas the WRSWAMP1 water levels remained at near-saturated levels for the remainder of 2020 (SLR 2021).

3.2.1 Swamp 28

Swamp 28 is located over Longwall 24. A mining effect to the substrate water levels of Swamp 28 was identified in 2016 based on the incomplete recovery of substrate water levels following rainfall events (**Chart 2**) (SLR 2021). Swamp 28 is considered to have an impact from mining of Longwall 25, although no effect on swamp substrate water levels occurred when Longwall 24 passed directly beneath the monitoring site (SLR 2021). The substrate piezometer at Swamp 28 returned to dry conditions from September 2017, and remained so up to December 2019, as did the two control swamp piezometers (Swamps 137a and 137b) (SLR 2021). With the large rain in February 2020, the water level in both the Swamp 28 substrate and the shallow piezometer recovered. The substrate piezometer indicated saturated conditions until the end of the reporting period in December 2020. This recovery has placed substrate groundwater levels at Swamp 28 above the base of the 2σ bandwidth for the first time since July 2017 (SLR 2021). Both piezometers appear responsive to rainfall and fluctuate accordingly. Although recovery has also been observed at the 10 m piezometer, groundwater levels in Swamp 28 remain lower than those recorded prior to the crossing of Longwall 24 (SLR 2021).

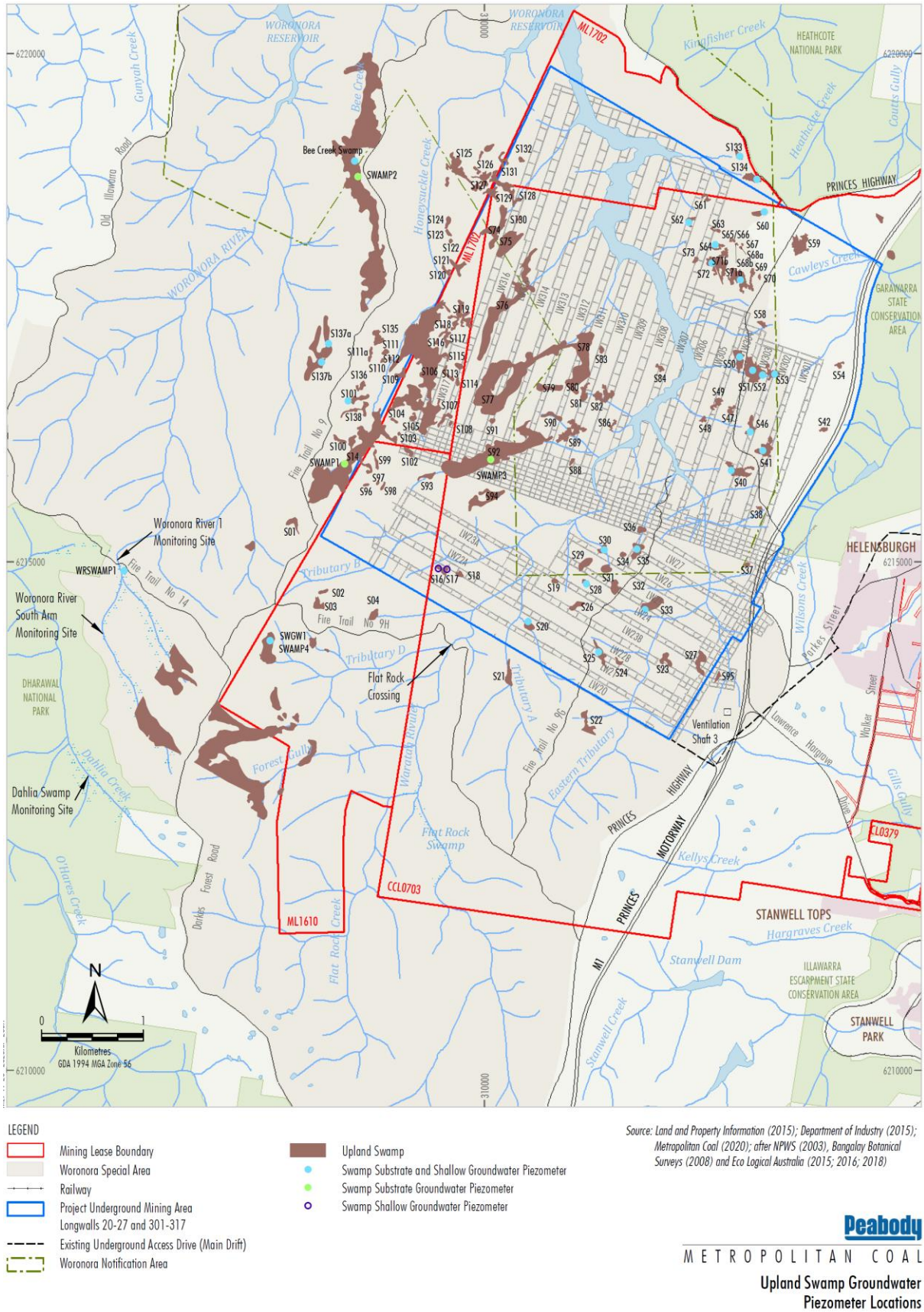

Figure 1: Upland Swamps Mapped Over Longwalls 20-27, Longwalls 301-317 and Surrounds.

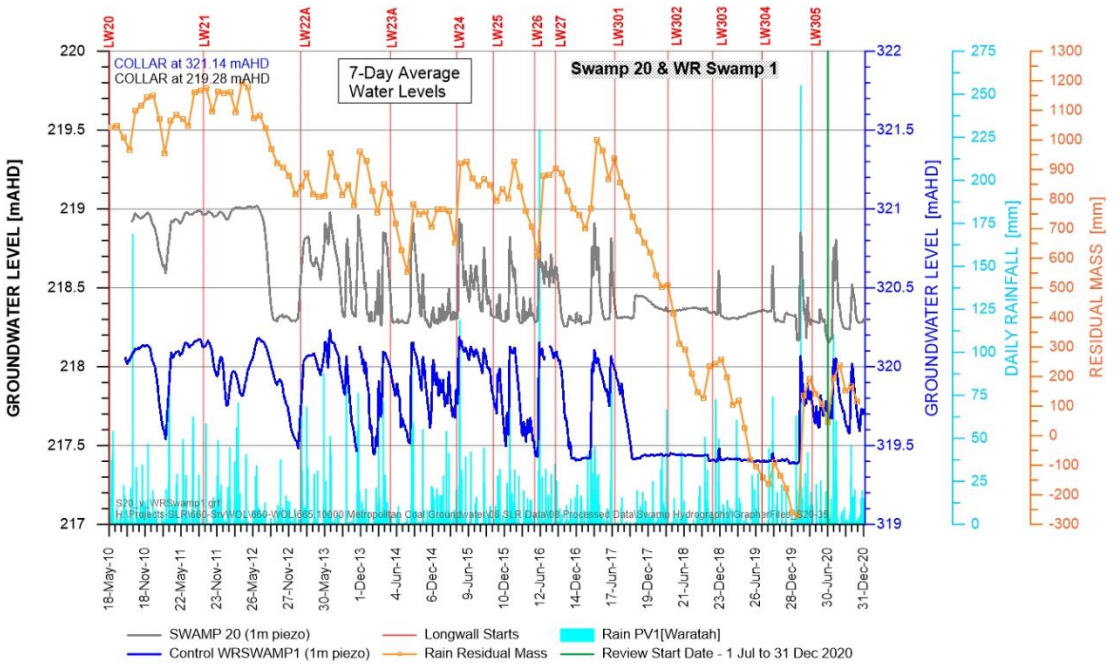

Chart 1: Groundwater Hydrographs at Swamp 20 and Woronora River 1 Control Swamp (SLR 2021)

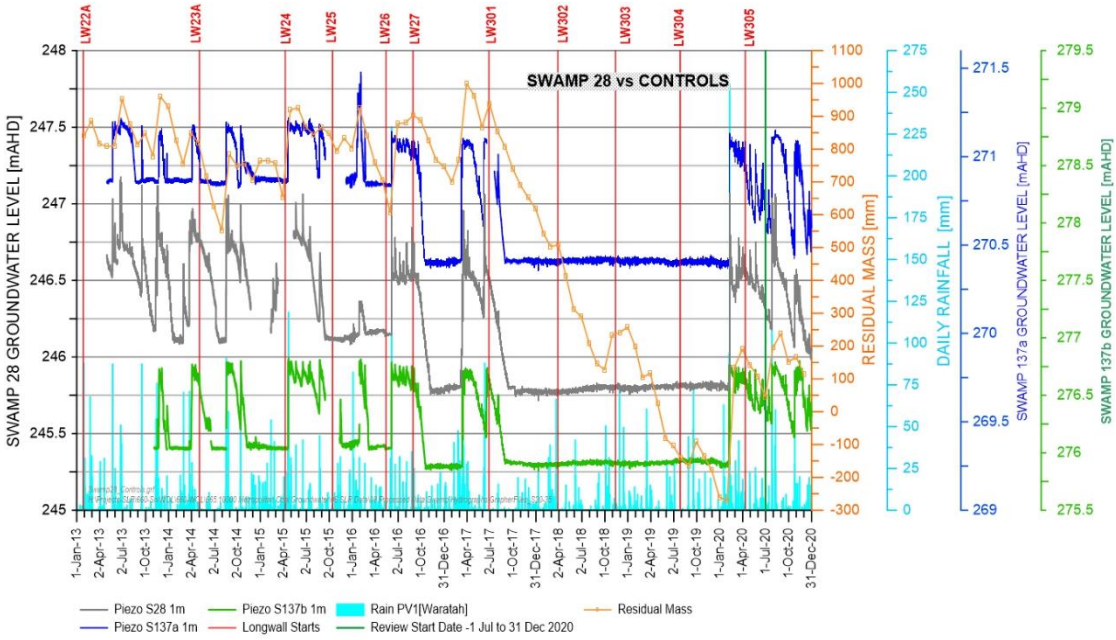

Chart 2: Groundwater Hydrographs at Swamp 28 and Control Swamps 137a and 137b (SLR 2021)

3.3 Swamp 20 and Swamp 28 Vegetation Monitoring

3.3.1 Swamp 20

Swamp 20 is a small in-valley swamp on a second order stream which supports Tea Tree Thicket vegetation (Metropolitan Coal 2014). As no swamps with similar geomorphic characteristics were known to occur, Tea Tree Thicket patches in three much larger swamps (Woronora River 1, Woronora River south arm and Dahlia Swamp) were selected as vegetation controls, with the proviso that the condition and floristics of the vegetation in all swamps is similar (Metropolitan Coal 2014).

Baseline monitoring of Longwalls 20-22 swamp vegetation monitoring sites began in spring 2008. Biannual monitoring of flora has been conducted in autumn and spring. Mining of Longwall 20 commenced in May 2010 and the mining of Longwall 22 was completed in April 2014. Monitoring of Longwalls 20-22 swamp vegetation monitoring sites has continued since the completion of Longwall 22.

Based on the results to autumn 2020, the upland swamp vegetation performance indicator, *the vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps*, is not considered to have been exceeded at Swamp 20 (Eco Logical Australia 2021a).

3.3.2 Swamp 28

Swamp 28 is a small moderately inclined valley side swamp with shallow light textured soils lacking peat development (Metropolitan Coal 2015). The vegetation was classified as comprising Sedgeland-heath complex (NPWS 2003) and Sedgeland-Heath (Bangalay Botanical Services 2008). However, subsequent field inspections by Eco Logical Australia for the Longwalls 23-27 Biodiversity Management Plan indicated the upper portion supports Banksia Thicket whilst the lower portion supports Tea Tree Thicket (Metropolitan Coal 2015).

No swamps with similar vegetation and geomorphic characteristics are known from elsewhere in the study area to provide a control for Swamp 28. Patches of Tea Tree Thicket in three much larger swamps (Woronora River 1, Woronora River south arm and Dahlia Swamp) were selected as controls for the Tea Tree Thicket in Swamp 28 with the proviso that the condition and floristics of the vegetation in all swamps is similar.

Baseline monitoring of Longwalls 23-27 swamp vegetation monitoring sites began in spring 2010. Biannual monitoring of flora has been conducted in autumn and spring. Mining of Longwall 23 commenced in May 2014 and the mining of Longwall 27 was completed in March 2017. Monitoring of Longwalls 23-27 upland swamp vegetation monitoring sites has continued since the completion of Longwall 27.

Based on the previous continual decline in condition of the understorey and species richness, and the high mortality rate of indicator species in comparison to the control swamps, the upland swamp vegetation performance indicator is considered to have been exceeded in the Tea Tree component of Swamp 28 from autumn 2017 to autumn 2019, however it was not exceeded in spring 2019 or autumn 2020 (Eco Logical Australia 2021b).

4 Site Inspections

4.1.1 Swamp 20 and Relevant Control Swamp

Swamp 20

Inspections of Swamp 20 in the vicinity of the piezometers indicated that the surface substrate was damp, however standing water and seepage from adjacent areas was absent. Overnight rainfall preceding the site inspection may have contributed to the surface dampness.

Inspection of the mid-swamp rocky step found seepage and water flow was uncommon across the mid-section of the step with low flow occurring across the step and into the downstream pool. Inspection of the terminal rock bar at the downstream end of Swamp 20 found only minor water flow was exiting the swamp, draining over the upper section of the rock bar. Seepage, wet rock surface areas and pools were also present but few. The iron-stained seep located at the eastern end of the step and reported by Eco Logical Australia since spring 2012, was absent. During autumn 2020, seepage was present and water flow was abundant over the mid rocky step and terminal rock bar (as observed in February 2020 site inspection following heavy rains) (as reported in Eco Logical Australia 2021a).

Consistent with the findings of Eco Logical Australia (2021a), the shrubs in Swamp 20 were found to be in good condition, with most *Baeckea linifolia, Hakea teretifolia, Callistemon citrinus, Melaleuca squarrosa* and *Leptospermum juniperinum,* with *L. juniperinum* in full flower. Minor dieback of *Banksia ericifolia* subsp. *ericifolia* continues to be observed adjacent to the terminal rock bar on the fringes of the swamp.

At the time of inspection, *Banksia robur* in Swamp 20 had recent signs of chewed and necrotic foliage, although new growth was observed. Several individuals in the vicinity of the mid rocky step were found to have brown discoloured leaves. *Banksia robur* in Woronora River 1 continues to be found in in poor condition in the vicinity of Transect 1 where individuals were observed with chewed and desiccated foliage but also having new growth. In the upstream areas of Woronora River 1 *Banksia robur* was found in similar condition to Swamp 20, i.e. a combination of chewed and necrotic foliage, brown discoloured leaves and new growth. Many individuals were developing new inflorescences.

Previously, the understorey species in the vicinity of the piezometer have shown signs of stress with dieback in sedges, particularly *Empodisma minus,* and many dead fronds on *Gleichenia microphylla* (Coral Fern) (Eco Logical Australia 2017). Inspection of these understorey species during the current inspection found these species to be in similar condition. In the area surrounding the mid-swamp rocky step, *Gleichenia microphylla* was found to be in poor health whilst *Empodisma minus, Lepyrodia scariosa* and *Bauera rubioides* were found in a healthy condition as did surrounding shrubs of *Hakea teretifolia*, *Callistemon citrinus, Epacris obtusifolia* and *Leptospermum juniperinum.*

In the vicinity of Transect 1, dieback of *Gleichenia microphylla* and *Gleichenia dicarpa* continues to remain with no new growth apparent at the time of inspection. Some degree of recovery of this species was recorded in autumn 2020 (Eco Logical Australia (2021a), possibly as a response to the heavy rainfall event of February 2020. The condition of *Gleichenia microphylla* upstream of Transect 1 and within the swamp was found to be healthy with only scattered patches of minor dieback observed. Dieback of *Gleichenia microphylla* was also observed in the vicinity of Transect 1 in control swamp Woronora River 1, but to a much greater degree.

The *Pultenaea aristata* population along the swamp margin north of the terminal rock bar was observed in good condition with new growth observed on most individuals. A total of six individuals were recorded adjacent to the access track.

Woronora River 1

Water flow was observed exiting the terminus of this control swamp during the current inspection. The soil surface in the vicinity of Transect 1 was dry, with eroded areas and exposed roots of *Gleichenia microphylla* and *Banksia robur* evident. Inspection of the swamp upstream of Transect 1 also found that standing water was absent. The soil surface was also dry in the vicinity of the piezometers and the water level in the stream located in the middle of the swamp at Woronora River 1 was lower than that observed in February 2020 but was clear with minor flow only. As water flow was observed exiting the swamp terminus, water flow through the Transect 1 area is subsurface.

In the vicinity Transect 1, *Gleichenia microphylla* was observed continues to display extensive dieback and lacks new growth. *Banksia robur* was observed with dieback and some leaf herbivory, however new growth and developing buds were present and most individuals were in relatively good health similar to Swamp 20. Evidence of previous high-water flows through the area of Transect 1 remains by the presence of flood-swept groundlayer species and severe sediment scouring exposing the root systems of *Gleichenia microphylla* and *Banksia robur.* New growth on *Empodisma* minus was common and found sprawling through dead *Gleichenia* fronds. Shrubs on the fringes of the Transect 1 area including *Banksia ericifolia* var*. ericifolia* and *Persoonia pinifolia* were observed in good condition and the sedge *Lepidosperma quadrangulata* was observed flowering for the first time.

Further upstream of Transect 1, and near the location of piezometers, *Banksia robur* was observed in better condition, with less chewed and necrotic foliage compared to individuals in the Transect 1 of this swamp. New growth and developing inflorescences were observed. Other shrub and groundlayer species were found in good condition, similar to individuals in Swamp 20, namely *Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia* on the fringe of the swamp*,* and *Callistemon citrinus* within the swamp*.* Understorey species including *Lepidosperma limicola, Eurychorda complanata, Bauera rubioides* and *Gymnoschoenus sphaerocephalus* appeared generally in good condition although yellowing foliage and minor dieback present on individuals. Similar to autumn 2020, *Gleichenia microphylla* in the vicinity of the piezometers and adjacent areas of Woronora 1 also showed signs of prominent dieback amongst healthy fronds, however upstream of Transect 1 and within the middle areas of the swamp, *Gleichenia microphylla* was observed in healthy condition.

No threatened flora species were observed or are known to occur in this swamp.

4.1.2 Swamp 28 and Relevant Control Swamps

Swamp 28

To date, standing water has not been recorded in Swamp 28 since the inception of vegetation monitoring, and at the time of inspection the surface sediments throughout the swamp were dry. Swamp 28 lacks a drainage channel but saturated surface sediments and evidence of overland water flow has been observed on previous occasions following periods of heavy rainfall. Swamp 28 is bounded by two ephemeral drainage lines and at the time of inspection both drainage lines were dry.

The soil surface in the vicinity of the piezometers and along Transects 1 was dry whilst further downslope in the vicinity of Transect 2, the soil surface was found to be slightly damp. The upslope vegetation in Swamp 28 (Transect 1 area) is dominated by Banksia Thicket characterised by dense thickets of *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* over the sedge *Empodisma minus.* The canopy of the shrub *Banksia ericifolia* var. *ericifolia* appeared sparse with some thinning of canopy branches and yellowing leaves on select individuals. Understorey species also showed signs of dieback and at the time of inspection was most evident on the sedge *Empodisma minus*. The condition of this species in Swamp 28 recorded in autumn 2020 was found to be in improved condition (Eco Logical Australia 2021b) possibly in response to the rainfall events of September 2019 and February 2020.

The downslope area of Swamp 28 (Transect 2 area) is more typical of Tea Tree Thicket vegetation, with the shrubs *Banksia ericifolia* var. *ericifolia, Banksia robur* and *Callistemon citrinus* commonly occurring and with an understorey dominated by *Empodisma minus* and *Gleichenia microphylla*. At the time of inspection *Banksia ericifolia* var. *ericifolia* and *Hakea teretifolia* were observed with branch dieback and a thinning canopy.

Extensive dieback continues to be observed on the understorey species *Gleichenia microphylla* and *Empodisma minus* throughout the swamp, with little signs of recovery. Few other smaller shrubs were observed in the understorey in the vicinity of Transect 2. Dieback of this species, and *Empodisma minus,* has been recorded for many years, considered to be due to shading by the dominant shrubs as they have grown denser and taller since the wildfire of 2002. At the time of the January 2021 site inspection, there appeared to have been no recovery of *Gleichenia microphylla* whilst *Empodisma minus* and another sedge, *Leptocarpus tenax,* were observed with some live stems.

No threatened flora species were observed or are known to occur in this swamp.

In relation to the control swamps inspected, Bee Creek Swamp and Swamp 137b are used as controls to assess the Banksia Thicket vegetation of Swamp 28 (note, the Banksia Thicket component of Swamp 28 has not exceeded the upland swamp vegetation performance indicator), while Woronora River 1 was used to assess the minor Tea Tree Thicket component of Swamp 28. As the large headwater swamps, Bee Creek Swamp and Woronora River 1, are not comparable from a groundwater perspective, Swamps 137a and 137b are used as control sites for groundwater monitoring.

Bee Creek Swamp

Bee Creek Swamp is a large headwater swamp with Banksia Thicket and a band of Tea Tree Thicket along the wetter drainage line in the centre of the swamp. Similar to Swamp 28, standing water has never been observed along the vegetation monitoring transects or around the piezometer sites, although the soils are often damp to moist and almost saturated. At the time of inspection, the soil surface, and several centimeters below the surface were dry in the vicinity of the piezometers. A small hole, first seen adjacent to the piezometer access track in February 2020 was re-inspected and found to be dry. No seeps were observed.

The dominant vegetation is Banksia Thicket dominated by *Banksia ericifolia* subsp*. ericifolia* and *Hakea teretifolia* over an understorey dominated by *Gleichenia microphylla* and sedge species. At the time of inspection, the shrub species were found to be in good health (*Banksia robur, Gahnia sieberi* and *Hakea teretifolia* with minor dieback (leaf yellowing) on adjacent individuals of *Banksia ericifolia* var. *ericifolia*. Similar to parts of Swamp 20 and Woronora 1, the *Gleichenia microphylla* and *Empodisma minus* growing adjacent to the piezometers and the monitoring transects was found with severe dieback, however growth of new fronds was present but uncommon. Overall, the shrub vegetation in Bee Creek Swamp was in better condition than the vegetation in Swamp 28, with the understorey species, in particular *Gleichenia microphylla* similar in condition to Swamp 28.

The small pool located downstream of the piezometer was found to partially filled with clear water to a depth of approximately 30 cm. Aquatic vegetation was present. The surrounding shrubs were observed in relatively good health, whilst the understorey species including *Gleichenia microphylla, Empodisma minus* and *Baumea rubiginosa* showed signs of dieback and plant death with little recovery at this time.

Swamp 137a

Swamp 137a is a valley side swamp mapped as having Restioid Heath vegetation (Metropolitan Coal 2015), but is now developing in parts into Banksia Thicket vegetation. Areas of dense low Banksia Thicket are present around the piezometer sites. Standing water has never been observed along the vegetation monitoring transects or around the piezometer sites, however the soil surface at the piezometer sites was found to be damp and abundant *Drosera spathulata* was seen indicating a prior period of increased surface water. Damp surface soils were also found to be present within vegetated areas adjacent.

The condition of the Banksia Thicket vegetation within Swamp 137a was generally found in healthy condition including *Banksia ericifolia* var. *ericifolia, Hakea teretifolia* and *Leptospermum squarrosum* with the latter species in flower. Ground layer sedges and forbs were generally in good health or with some yellowing of foliage present (*Lepyrodia scariosa, Leptocarpus tenax)* or dieback (*Empodisma minus)* observed in more open areas of the swamp, particularly around the edges of the piezometers where the groundlayer is more exposed.

Inspection of the rock platform between Transect 1 and Transect 2 found large areas of seepage draining from upslope within the swamp. Abundant *Utricularia* sp. and *Drosera spathulata* were observed across seepage areas, and the dominant sedge, *Lepyrodia scariosa,* was found in good condition. Dead standing shrubs were also present, these being recorded during previous surveys.

The *Pultenaea aristata* in the vicinity of the piezometer and throughout S137a are all deceased (Eco Logical Australia 2021b), having experienced a declining trend in mortality in since spring 2008. This trend has been observed in both control and longwall sites with initially a higher proportion in longwall sites compared to control sites. Since autumn 2018 there has been an increasing trend in mortality at control sites with the results for autumn 2020 bringing the mortality at control sites similar to that of longwall sites (Ecological Australia 2021b).

Swamp 137b

Swamp 137b is a valley side swamp mapped as having Banksia Thicket vegetation (Metropolitan Coal 2015). Dense Banksia Thicket was present around the piezometer sites and throughout the swamp. Standing water has at times been observed along the vegetation monitoring transects and across the terminal step. At the time of inspection, the soil surface near the piezometers was near saturated, with water coming to the surface under foot pressure. Abundant *Drosera peltata* were present.

Shrubs surrounding the piezometer site were observed in healthy condition with *Hakea teretifolia* and *Leptospermum squarrosum* in flower. The ground layer sedges *Cyathochaeta diandra, Schoenus brevifolius* and *Lepidosperma neesii* were generally in good health with some individuals displaying minor dieback. Standing litter was also present.

Seepage was absent along the terminal step at the time of inspection but has recently been present as evidenced by areas of shallow drying sediments across seepage areas. Surrounding shrub vegetation was found in healthy condition with *Hakea teretifolia, Baeckea imbricata* and *Leptospermum squarrosum* in flower. The groundlayer sedges *Chordifex fastigiata, Lepyrodia scariosa* and *Lepidosperma neesii* were observed with minor dieback and standing litter.

Pultenaea aristata has not been recorded in Swamp 137b monitoring area.

Woronora River 1

Woronora River 1 has been described in **Section 4.1.1** above and is repeated here.

Water flow was observed exiting the terminus of this control swamp during the current inspection. The soil surface in the vicinity of Transect 1 was dry, with eroded areas and exposed roots of *Gleichenia microphylla* and *Banksia robur* evident. Inspection of the swamp upstream of Transect 1 also found that standing water was absent. The soil surface was also dry in the vicinity of the piezometers and the water level in the stream located in the middle of the swamp at Woronora River 1 was lower than that observed in February 2020 by Eco Logical Australia (2021b) but was clear with minor flow only. As water flow was observed exiting the swamp terminus, water flow through the Transect 1 area is subsurface.

In the vicinity Transect 1, *Gleichenia microphylla* continues to display extensive dieback and lacks new growth. *Banksia robur* was observed with dieback and some leaf herbivory, however new growth and developing buds were present and most individuals were in relatively good health similar to Swamp 20. Evidence of previous high-water flows through the area of Transect 1 remains by the presence of flood-swept groundlayer species and severe sediment scouring exposing the root systems of *Gleichenia microphylla* and *Banksia robur.* New growth on *Empodisma* minus was common and found sprawling through dead *Gleichenia* fronds. Shrubs on the fringes of the Transect 1 area including *Banksia ericifolia* var*. ericifolia* and *Persoonia pinifolia* were observed in good health and the sedge *Lepidosperma quadrangulata* was observed flowering for the first time.

Further upstream of Transect 1, and near the location of piezometers, *Banksia robur* was observed in better condition, with less chewed and necrotic foliage compared to individuals in the Transect 1 of this swamp. New growth and developing inflorescences were observed. Other shrub and groundlayer species were found in good condition, similar to individuals in Swamp 20, namely *Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia* on the fringe of the swamp*,* and *Callistemon citrinus* within the swamp*.* Understorey species including *Lepidosperma limicola, Eurychorda complanata, Bauera rubioides* and *Gymnoschoenus sphaerocephalus* appeared generally in good condition although yellowing foliage and minor dieback was present on select individuals. Similar to autumn 2020, *Gleichenia microphylla* in the vicinity of the piezometers and adjacent areas of Woronora 1 also showed signs of prominent dieback amongst healthy fronds, however upstream of Transect 1 and within the middle areas of the swamp, *Gleichenia microphylla* was observed in healthy condition.

No threatened flora species were observed or are known to occur in this swamp.

4.1.3 Summary

The threatened species, *Pultenaea aristata,* has continued to increase in mortality since the inception of monitoring (spring 2010), initially with higher rates at longwall sites compared to control sites. Since spring 2018 an increasing trend in mortality has been recorded at control sites and by autumn 2020 the proportion of plants surviving at longwall and control sites are similar (Eco Logical Australia 2021a and 2021b).

The cause of dieback of *Gleichenia microphylla* and to a lesser extent *Empodisma minus* in areas across all swamps tends to indicate impacts attributable of below average rainfall over the past three years. However, similar to previous years the extent to which Swamp 28 is being stressed by the incomplete recovery of substrate water levels following rainfall events, versus the dry conditions, remains unclear.

5 Assessment

This section briefly addresses each of the key assessment considerations identified in the Longwalls 305-307 BMP as they relate to the condition of the vegetation observed on 20 January 2020.

5.1 Swamp 20

1. What is the nature of the environmental consequence?

As described in **Section 3.2.1**, Swamp 20 substrate water levels previously changed from being permanently saturated to being periodically saturated as a result of the passing of Longwall 21. Since then, the groundwater levels have regularly dropped below the level considered to be statistically significant. This trend has continued to be observed in 2020 (SLR 2021).

Based on the vegetation monitoring results to autumn 2020 the changes in vegetation in Swamp 20 are not considered to be significantly different to the changes in vegetation in control swamps (Eco Logical Australia 2021).

Observations in Swamp 20 and Woronora River 1 on 20 January 2021 found little difference in the condition of shrub vegetation between swamps, with both swamps having similar patterns of vegetation condition. Understorey vegetation at both swamps exhibited similar dieback and condition particularly on *Gleichenia microphylla* and *Empodisma minus.* Consistent with the previous inspections by Eco Logical Australia (2017) and Ecoplanning (2019, 2020), there continues to be no significant visible impact on the vegetation of Swamp 20 attributable to subsidence-induced water level reductions.

No evidence of decline in the health of *Pultenaea aristata* was observed.

2. What are the potential factors that may have contributed to the environmental consequence?

The passing of Longwall 21 is considered to have caused impacts to Swamp 20 substrate water levels, but the effects have not been exacerbated by Longwalls 22-27 or Longwalls 301-305 (**Section 3.2.1**). The subsidence predictions in the Metropolitan Coal Longwalls 20-22 BMP indicated that Swamp 20 was most at risk of subsidence impacts.

3. Which threatened species have the potential to be impacted?

The Prickly Bush-pea (*Pultenaea aristata*) has the potential to be impacted. *Pultenaea aristata* occurs on the margins of Swamp 20 near the downstream terminal step where the vegetation in this part of the swamp is dominated by *Banksia ericifolia* subsp. *ericifolia*, *Leptospermum squarrosum* and *Hakea teretifolia,* and being more akin to Banksia Thicket.

Acacia baueri subsp. *baueri* and *Cryptostylis hunteriana* have not been recorded within Swamp 20 (**Section 2**), and Swamp 20 is considered to represent marginal habitat for these species.

4. What are the potential impacts on the lifecycle of the potential threatened species?

Reductions in substrate water levels have the potential to stress individuals and result in death or dieback. At the time of inspection, individuals of *Pultenaea aristata* were found to be in good health.

5. What are the potential impacts on the habitat of the potential threatened species?

Potential impacts on the habitat of the threatened species include the drying out of the substrate, changes to the composition of the vegetation, increased potential of wildfire impacts and increased soil erosion. As reported previously (Eco Logical Australia 2017), there is also the potential for additional habitat to be created for *Pultenaea aristata* through the drying of substrate in the wetter areas of Swamp 20.

6. Has the habitat connectivity of the threatened species been affected?

The habitat connectivity of the threatened species has not been affected, nor has become fragmented for *Pultenaea aristata* in Swamp 20. A previously established access track is present along the edge of the population with most individuals found upslope of the track within the swamp margin.

7. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?

Since the impacts to upland swamp substrate water levels were identified to Swamp 20 in 2012/2013, no detrimental impacts on *Pultenaea aristata* in Swamp 20 have been observed to date. Appropriate actions include the continuation of groundwater and vegetation monitoring of Swamp 20 and visual monitoring of the *Pultenaea aristata* population.

5.2 Swamp 28

1. What is the nature of the environmental consequence?

As described in Section 3.2.1, the substrate water levels of Swamp 28 were considered to be impacted by the passing of Longwall 25 based on the incomplete recovery of substrate water levels following rainfall events. This trend has somewhat improved following the large rainfall event of February 2020 with the substrate piezometer indicting saturated conditions up to the end of December 2020 (SLR 2021).

Swamp 28 is very small, does not contain any internal drainage lines and free surface water has never been observed at this site since the inception of monitoring.

The ongoing decline in the vegetation condition of the Tea Tree Thicket component of Swamp 28 with regards to condition of understorey species and loss of species richness appears to have stabilized in autumn 2020, although species richness continues to fluctuate (Eco Logical, 2021b).

Leaf yellowing of shrub species (*Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia*) and foliage dieback (*Banksia robur, Gleichenia microphylla* and *Empodisma minus*) continued to be observed and remained widespread for the understorey species *Gleichenia microphylla* and *Empodisma minus* with little recovery observed. It is not clear to what extent Swamp 28 is being stressed by the incomplete recovery of substrate water levels following rainfall events, versus the dry conditions that have prevailed throughout 2017 to 2020, and previously reported shading by the dominant shrubs.

Despite the heavy rains experienced during of February 2020 overall rainfall remained well below average for most months in the first half of 2020 continuing the drying conditions experienced by the vegetation.

2. What are the potential impacts that may have contributed to the environmental consequence?

Swamp 28 is located over Longwall 24. Swamp 28 is considered to have an impact from mining of Longwall 25 (no effect on swamp substrate water levels occurred when Longwall 24 passed directly beneath the monitoring site) (**Section 3.2.1**).

FloraSearch (2016) noted that should a significant change in vegetation composition and structure occur in Swamp 28, the most likely driver would be the reduction in substrate water levels as a result of subsidence-induced cracking from longwall mining.

At present, vegetation structure remains similar to that recorded during the baseline period and subsequent periods. The autumn 2020 survey results indicate a decrease in species richness in the Tea Tree Thicket component (by three) has occurred since the spring 2019 survey (as monitored by Transect 2) (Eco Logical Australia 2021b), following general declines throughout the monitoring period. Previous analysis of the species contributing to decreases in species richness indicated that the changes have predominantly occurred prior to subsidence impacts occurring to swamp substrate groundwater levels in early 2016 (Eco Logical Australia 2018a).

For Transect 1 species richness increased in autumn 2020 following declines in autumn and spring returning to levels recorded in spring 2017 (Eco Logical Australia 2021). For Transect 2 species richness has experienced fluctuating declines with autumn 2020 decreasing in species richness compared to spring 2019 but remaining within previously recorded limits (Eco Logical Australia 2021b). Monitoring of species richness in Transect 2 of Swamp 28 should continue to be closely monitored in this regard as the overall declining trend is not matched by the control swamps.

3. Which threatened species have the potential to be impacted?

No threatened flora species have the potential to be impacted by reduced water levels in Swamp 28 as none are known to occur or considered likely to occur in this swamp.

4. What are the potential impacts on the lifecycle of the potential threatened species?

Not applicable.

5. What are the potential impacts on the habitat of the potential threatened species?

Swamp 28 currently supports dense tall heath vegetation that is unsuitable for *Pultenaea aristata, Acacia baueri* subsp. *baueri* and *Cryptostylis hunteriana.* The potential impact of water level reduction in Swamp 28 on habitat for these species is that the drying out of the substrate may result in a thinning and lowering of the dense vegetation making it more suitable as habitat for these three species.

However, it is also noted that a reduction in vegetation cover may result in increased soil erosion and substrate changes.

6. Has the habitat connectivity of the threatened species been affected?

The habitat connectivity of *Pultenaea aristata, Acacia baueri* subsp. *baueri* and *Cryptostylis hunteriana* has not been affected and is unlikely to be affected.

Pultenaea aristata is a widespread and common species in the Project Area and surrounds, *Acacia baueri* subsp. *baueri* has only been recorded on the margins of Swamp 111a where vegetation cover is low and open, and to date, *Cryptostylis hunteriana* has only been recorded in the Restioid Heath community of Swamp 92.

7. What actions, if any, are most appropriate to mitigate the impacts and/or minimize future impacts?

No detrimental impacts on *Pultenaea aristata, Acacia baueri* subsp. *baueri* and *Cryptostylis hunteriana* have occurred, or are considered likely to occur.

Based on the current site inspection (January 2021) and vegetation monitoring of Swamp 28 to autumn 2020, it is not clear to what extent Swamp 28 is being stressed by:

- the incomplete recovery of substrate water levels following rainfall events, versus dry climatic conditions of 2017 to 2020; and
- ongoing dieback in lower storey species following shading by the dominant shrubs as they continue to become denser and taller since the wildfire of 2002.

Continued groundwater monitoring and biannual visual and quantitative vegetation monitoring of Swamp 28 is considered the most appropriate action to continue.

6 Conclusions

The biodiversity impact performance measure, *Negligible impact on threatened species,* has not been exceeded as a result of subsidence impacts on Swamp 20 and Swamp 28.

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