ecoplanning

ecology | planning | offsets

Subsidence Impacts on Threatened Flora Species on the Eastern Tributary

Assessments of Impact on Threatened Flora. Metropolitan Colliery, Helensburgh, NSW

Assessment of Impacts on Threatened Flora on Waratah Rivulet and the Eastern Tributary, March 2020

Prepared for: Metropolitan Coal

18 March 2021 Version: Final 1.0

PROJECT NUMBER	**2020-240**	
PROJECT NAME	Subsidence Impacts on Threatened Flora Species on the Eastern Tributary	
PROJECT ADDRESS	Assessments of Impact on Threatened Flora. Metropolitan Colliery, Helensburgh, NSW	
PREPARED FOR	Metropolitan Coal	
AUTHOR/S	Elizabeth Norris	
REVIEW	Technical	QA
	Elizabeth Norris	Elizabeth Norris
VERSION	Version	Date to client
	Final 1.0	18 March 2021
ACKNOWLEDGEMENTS	This report has been prepared by Ecoplanning with support from Resource Strategies, Metropolitan Coal, Eco Logical Australia and Bio-Analysis.	
COVER PHOTO	Site ET2-2, Eastern Tributary (21 January 2021), Elizabeth Norris.	

This report should be cited as: 'Ecoplanning (2021). Subsidence Impacts on Threatened Flora Species on the Eastern Tributary– Assessments of Impact on Threatened Flora. Metropolitan Colliery, Helensburgh, NSW. Prepared for Metropolitan Coal.'

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

Contents

Figures

Tables

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'*.

Bio Analysis Pty Ltd monitors aquatic biota (macroinvertebrates and macrophytes) biannually in autumn and spring in streams within the Project area and surrounds. Aquatic ecology monitoring results are assessed by Bio Analysis Pty Ltd against the following aquatic biota performance indicator:

> *The aquatic macroinvertebrate and macrophyte assemblages in streams and pools are not expected to experience long-term impacts as a result of mine subsidence.*

In accordance with the Longwalls 305-307 BMP, the threatened flora assessments of aquatic ecology monitoring locations have been triggered by the exceedance of the aquatic ecology performance indicator at two locations on the Eastern Tributary. Specifically, the aquatic ecology performance indicator has been exceeded at the following locations (**Figure 1**) as reported in spring 2019 and autumn 2020 (Bio-Analysis 2020, 2021):

- Stream monitoring site ET1 on the Eastern Tributary due to increased variability in numbers of Leptophlebiidae between autumn 2015 and autumn 2019 but not in spring 2019, and altered macrophyte assemblage within the after-mining period since spring 2017.
- Stream monitoring site ET2 on the Eastern Tributary due to altered numbers of Atyidae between autumn 2016 and autumn 2019, and in autumn 2020, and the altered assemblage of aquatic plants since autumn 2016.

Ms Elizabeth Norris (Ecoplanning Pty Ltd) was commissioned by Metropolitan Coal to undertake an assessment of the subsidence impacts on threatened flora that may be associated with aquatic ecology monitoring Sites ET1 and ET2 on the Eastern Tributary. Site inspections were undertaken on 21 January 2020.

This report is the second threatened flora species assessment report for prepared for the aquatic ecology monitoring locations listed above.

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.

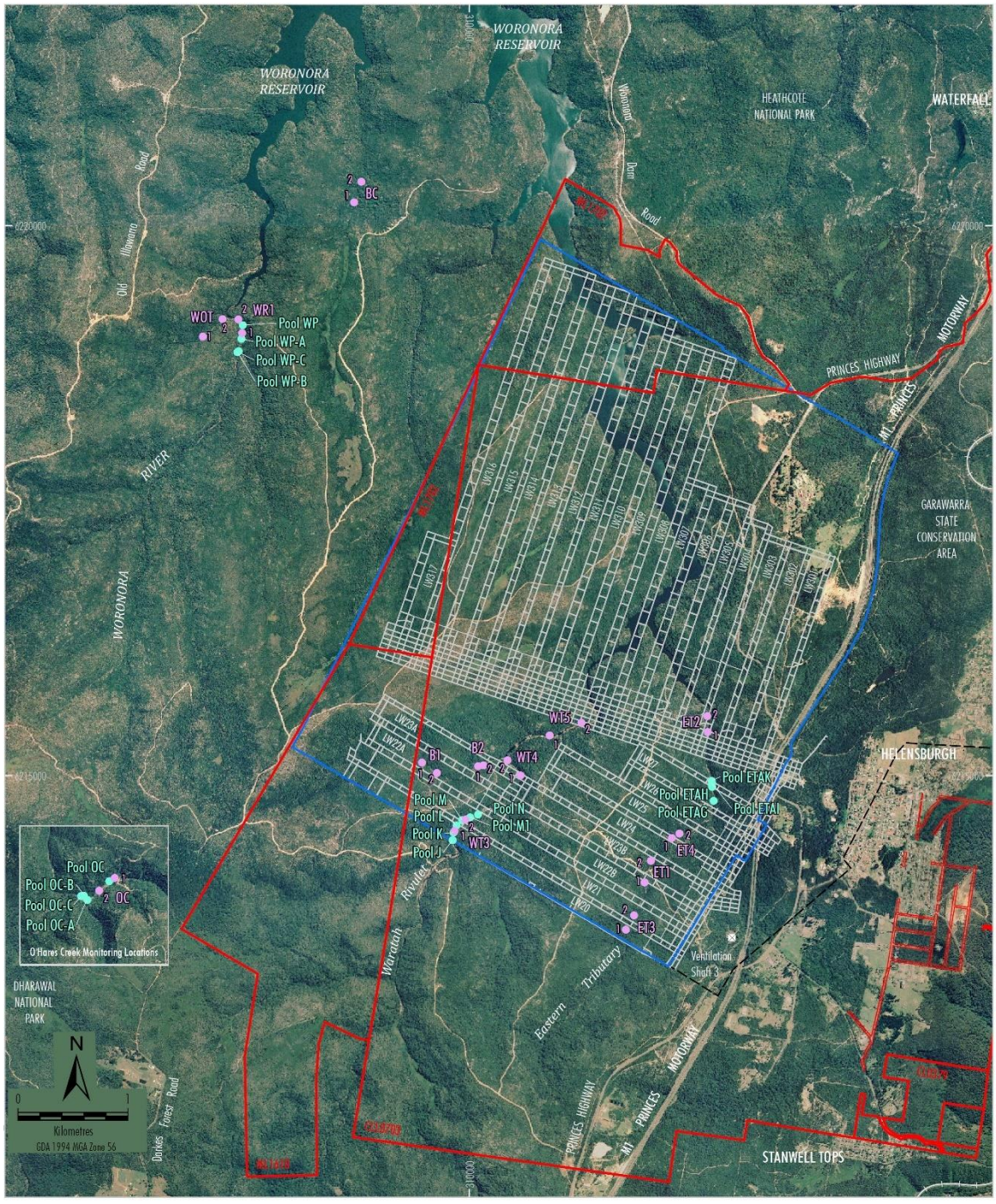

Figure 1: Aquatic Monitoring Sites

2 Potential Threatened Flora

Four threatened flora species listed under the *NSW Biodiversity Conservation Act 2016* (BC Act) (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.

Of these, three threatened flora species, *Astrotricha crassifolia*, *Pultenaea aristata* and *Leucopogon exolasius*, are known or have the potential to occur adjacent to or in riparian vegetation.

As described in the Longwalls 305-307 BMP, no threatened aquatic flora listed under the *Fisheries Management Act, 1994*, BC Act or *Environment Protection and Biodiversity Conservation Act, 1999* have been recorded within the Project underground mining area or in the Woronora Reservoir. Therefore, this assessment has been prepared with regard to the terrestrial threatened flora described below which are known or have the potential to occur adjacent to or in riparian vegetation.

Astrotricha crassifolia occurs in dry sclerophyll woodland on sandstone (Department of Planning, Infrastructure and Environment [DPIE] 2020a). It occurs on ridgetops on the Patonga Plateau north of Sydney, and in the Royal National Park and on the Woronora Plateau south of Sydney (Warman & Beckers 2011, Benson & McDougall 1993). In the Project Area it most often occurs in dry sclerophyll woodland on mid to lower slopes including adjacent to riparian scrub (Norris pers. obs.). One individual was recorded at riparian vegetation monitoring site MRIP07 (along the Eastern Tributary, downstream of Longwall 27) in all survey seasons inclusive of spring 2008 to autumn 2012 riparian vegetation surveys, however, has not been recorded at this site since spring 2012 due to flood impacts undermining the root zone of this individual (pers. obs.).

Several individuals of *Astrotricha crassifolia* have been recorded downstream of riparian vegetation monitoring site MRIP08 (along the Eastern Tributary, downstream of Longwall 27) in the vicinity of aquatic monitoring site ET2 (Ecoplanning 2020). Individuals were recorded adjacent to and in the riparian zone.

A population of *Astrotricha crassifolia* (some 55 individuals) was recorded in the vicinity of and downstream of riparian vegetation monitoring site MRIP12 on the Eastern Tributary (Eco Logical Australia, 2017b). Most individuals were recorded on lower slopes, above the riparian zone, however some (14 individuals) were also recorded in the riparian zone.

Astrotricha crassifolia has not been recorded within riparian vegetation monitoring sites on the Waratah Rivulet.

Pultenaea aristata is endemic to the Woronora Plateau and is often associated with upland swamp vegetation communities and in wet heath and shrubby sclerophyll woodland (Benson & McDougall 1996; DPIE 2020b). It is also known to occur in association with areas of impeded drainage and creek lines with sandstone woodland and gully forest communities. (DPIE 2020b). It's a widespread and common species within the Project Area and surrounds (Bangalay Botanical Surveys, 2008). This species has not been recorded within the riparian vegetation monitoring sites along the Eastern Tributary or within areas affected by dieback which are regularly traversed as part of the flora monitoring program (Ecological Australia various dates). A small population of *Pultenaea aristata* occurs above the riparian zone adjacent to the Eastern Tributary in the vicinity of Fire Trail 9J crossing.

Leucopogon exolasius generally occurs in woodland on sandstone (DPIE 2020c), in sparsely vegetated sand deposits, or on rocky sandstone hillsides near creeks (Benson & McDougall 1995). This species has not been recorded within monitoring sites on the Waratah Rivulet or Eastern Tributary, or within the areas affected by dieback which are regularly traversed as part of the flora monitoring program (Eco Logical Australia various dates).

No threatened flora populations or critical habitat have been listed for the Eastern Tributary, or any other streams on the Woronora Plateau.

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:

Key Assessment Considerations

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 spring 2019 inspections of the aquatic ecology monitoring locations (Bio-Analysis 2019), monthly rainfall from June 2019 through to June 2020 continued to be well below the long-term mean recorded at Darkes Forest (**Table 1**). Above average rainfall was recorded in September 2019 followed by three months of well below average rainfall particularly for December 2019. February 2020 recorded well above average rainfall followed by a return to below average rainfall up to September 2020.

Table 1: Monthly rainfall (mm) for survey period (September 2008 to March 2020)

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**	**159.6**	**154.3**	**126.1**	**128.1**	**145.8**	**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.

Overall, 2019 was the hottest year on record with above average temperatures recorded in conjunction with very low rainfall (BOM 2021). A similar trend continued in the first half of 2020. Despite below average rainfall for most of 2020 vegetation along and adjacent to the riparian areas appeared to be generally in good health during the current site inspection.

3.2 Aquatic Ecology Monitoring on the Eastern Tributary

Aquatic ecology monitoring is conducted biannually at a range stream monitoring sites in accordance with the approved monitoring program specified in the Longwalls 305- 307 BMP. Selected aquatic control sites for comparison against sites ET1 and ET2 are Woronora River (WR1 and WR2) and O'Hares Creek (OC1 and OC2) both located outside of the Project Area (**Figure 1**).

3.3 Site Inspections

Inspection of the riparian vegetation corridors occurring along the Eastern Tributary, Woronora River and O'Hares Creek adjacent to the aquatic ecology monitoring sites indicated that streamside shrubs and ground layer species continually incur flood impacts with flood-swept and prone vegetation commonly observed. A review of rainfall data (**Table 1**) indicated that above average rainfall was experienced in September 2019, February 2020 (over three times the average monthly rainfall over several consecutive days) and October 2020 further contributing to the flood impacts observed to streamside vegetation and sediments during the current site inspection. Below average rainfall was experienced at all other times from spring 2019.

3.3.1 Eastern Tributary –Stream Monitoring Site ET1

ET1-1

At the time of inspection, water flow was low and sporadic over the crossing at Fire Trail 9J with the upstream Pool ET1-1 near full. Stream water appeared yellow-brown in colour and cloudy, but little in-stream floc was present. A small tributary draining into Pool ET1-1 was dry and seepage was absent. Streamside erosion is evident in several areas where bank collapse has occurred destabilising streamside vegetation.

Riparian vegetation was flood-swept in appearance with individuals of *Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and *Bauera rubioides* fallen and partly submerged. Streamside sedges *Schoenus melanostachys* and *Sporadanthus gracilis* displayed minor dieback with yellowing leaves. Two *Lomatia myricoides* adjacent to the top of bank were observed with dead branches whilst other individuals were found to be in healthy condition.

Individuals of *Pultenaea aristata* occur sporadically in the vicinity of Pool ET1-1 and all were found to be in a healthy condition. A population of *Pultenaea aristata* has been recorded further downstream of Pool ET1-1 on the western slopes above the Eastern Tributary in the vicinity of Fire Trail 9J (Eco Logical Australia 2017a). This population was inspected and, similar to Ecoplanning's (2020) March 2020 assessment, several individuals appeared to be in a senescent state whilst others inspected were found to be in good health.

The RoTAP species *Hibbertia nitida* also occurs sporadically in the vicinity of Pool ET1-1 and were found to be in a healthy condition.

ET1-2

Site ET1-2 has previously been severely impacted by high water flows with large woody flood debris tangled amongst prone small trees, shrubs and ground-layer species. Similar to site ET1-1, the water colour was yellow to orange-brown at the time of inspection with little in-stream floc observed. Seepage was absent.

Prone shrubs and groundlayer vegetation was observed including individuals of *Allocasuarina distyla*. Individuals of *Lomatia myricoides* and *Baeckea linifolia* displayed minor dieback and some dead branches were also present. Several shrubs were in flower including *Lomatia myricoides, Persoonia pinifolia, Tristaniopsis laurina* and *Hakea teretifolia.* Leaf yellowing and minor dieback was observed on several *Banksia ericifolia* subsp*. ericifolia* and *Hakea salicifolia* where root zones were located at the top of bank.

Severe bank erosion and sand and gravel deposition is also present along the western streamside, with roots of ground layer vegetation eroded and exposed. Loss of litter cover has also occurred, and small areas of bank edge appear to be slumping and eroding towards the adjacent access foot track.

No threatened flora species were observed or are known to occur in the vicinity of site ET1-2. The RoTAP species *Hibbertia nitida* occurs sporadically in the vicinity of site ET1-2 and individuals were found to be in a healthy condition.

3.3.2 Eastern Tributary –Stream Monitoring Site ET2

ET2-1

The pool at site ET2-1 upstream of the rock bar was near full with low water flow occurring over the rock bar, disappearing underground downstream for approximately 100 m. The water was yellow-brown in colour, cloudy and iron floc was abundant on in-stream rocky surfaces.

Erosion of streamside sediments was evident where roots of shrub and ground layer species were exposed. Woody flood debris was present along the access foot track upstream and adjacent to site ET1-1 and evidence of flood-swept vegetation was seen on the streamside sedge *Schoenus melanostachys.*

Generally, streamside shrubs and ground layer species were observed in healthy condition, although several individuals (one each of *Hakea teretifolia, Banksia ericifolia* subsp. *ericifolia* and *Allocasuarina littoralis*) were prone over the pool with several senescent shrubs also present. Individuals of *Lomatia myricoides* and *Prostanthera linearis* were observed in healthy condition.

No threatened flora species were observed or are known to occur in the vicinity of Site ET2-1.

ET2-2

Surface water was observed just upstream of site ET2-2 after disappearing underground downstream of site ET2-1. The pool level at ET2-2 was low, the water colour was yellow-brown and iron floc was present on in-stream rocks and vegetation. Erosion of streamside sandy sediments has occurred on the western bank with flood debris, litter and several prone shrubs observed.

Stream-edge vegetation, namely *Baumea juncea*, was flood-swept but generally in healthy condition with new growth present. Most vegetation was found in healthy condition including *Tristania neriifolia, Bauera rubioides, Persoonia pinifolia* and most individuals of *Lomatia myricoides* with the latter two species in full flower.

Astrotricha crassifolia is known to occur in the vicinity of Site ET2-2. Inspection found that several individuals previously found growing adjacent to site ET2-2 were unable to be relocated, likely a result of high-water flow impacts removing the sandy unconsolidated sediment in which they were growing. The remaining individuals were found in healthy condition.

The RoTAP species *Hibbertia nitida* also occurs sporadically in the vicinity of site ET2-2 and individuals were found to be in a healthy condition. A second RoTAP species, *Lomandra fluviatilis*, also occurs sporadically in the vicinity of site ET2-2. Most individuals of this ground layer species were found with minor leaf dieback.

3.3.3 Woronora River (WR) and O'Hares Creek (OC)

Woronora River sites WR1 and WR2 and O'Hares Creek sites OC1 and OC2 are located outside of the Project Area to the north-west (Woronora Special Area) and south of the Project Area (Dharawal National Park) respectively.

At the time of inspection water flow was consistent at all sites with clear water present. Previous flood impacts were observed through the presence of prone shrubs, flood-swept streamside shrub and ground layer species and woody flood debris at both WR and OC sites. Erosion of sandy streamside sediments was observed at WR1 and OC1 and OC2 but were scattered and to a lesser degree than that observed at longwall sites. Several individuals of *Banksia ericifolia* subsp. *ericifolia* were observed with minor dieback and dead branches.

At O'Hares Creek, dense ground-layer is present along extensive areas of the stream edge, dominated by *Sporadanthus gracilis, Gleichenia microphylla* and *Schoenus melanostachys* with *Gleichenia microphylla* and *Schoenus melanostachys* in healthy condition. Several individuals of *Banksia ericifolia* subsp. *ericifolia* growing adjacent to the stream edge displayed some minor dieback (yellowing leaves).

No threatened flora species were observed or are known to occur in the vicinity of sites WR1and WR2 (DPIE 2021).

Leucopogon exolasius has previously been recorded in the vicinity of the Trail 10C crossing on O'Hares Creek at site OC1 (DPIE 2021) but was not relocated during the current site inspection.

The RoTAP species *Hibbertia nitida* also occurs sporadically in the vicinity of sites WR and OC with individuals found to be in a healthy condition. The RoTAP species *Lomandra fluviatilis* is also present within these sites and found to range from healthy condition to individuals having minor leaf dieback.

4 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 and any impacts to potential threatened flora observed on 21 January 2021 along the Eastern Tributary.

4.1 Waratah Rivulet and the Eastern Tributary

1. ***What is the nature of the environmental consequence?***

The observed changes at stream monitoring site ET1 on the Eastern Tributary, namely the increased variability in numbers of Leptophlebiidae between autumn 2015 and autumn 2019 but not in spring 2019, and altered macrophyte assemblage within the after-mining period since spring 2017 (Bio-Analysis 2020, 2021).

The observed changes at stream monitoring site ET2 on the Eastern Tributary, namely the altered numbers of Atyidae between autumn 2016 and autumn 2019, and in autumn 2020, and the altered assemblage of aquatic plants since autumn 2016 (Bio-Analysis 2020, 2021).

At the time of the January 2021 site inspection, impacts to terrestrial shrubs and ground cover species within the riparian zone along the Eastern Tributary appear to be as a result of high energy water flows over the previous 12 months, in particular during February and October 2020 due to well above average rainfall events. Impacts that may have resulted from changes in aquatic habitat and or hydrology prior to these, and earlier events, are uncertain.

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

See '1' above.

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

As described in **Section 2**, no threatened aquatic flora listed under the *Fisheries Management Act, 1994*, BC Act or *Environment Protection and Biodiversity Conservation Act, 1999* have been recorded within the Project underground mining area or in the Woronora Reservoir.

Three threatened terrestrial flora species have the potential to occur adjacent to or in the riparian areas in the vicinity of the aquatic ecology monitoring locations, namely *Astrotricha crassifolia*, *Pultenaea aristata* and *Leucopogon exolasius* (**Section 2**).

A population of *Pultenaea aristata* is known to occur in the vicinity of ET1-1 along the Eastern Tributary, upslope of the riparian zone. This species has not been recorded in the vicinity of the other aquatic monitoring sites along the Eastern Tributary discussed in this report.

A population of *Astrotricha crassifolia* is known to occur adjacent to and in the riparian zone of ET2-2 along the Eastern Tributary.

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

Potential impacts on the lifecycle of individuals of the threatened species include dieback and death of any individuals located within the riparian zone as a result of water ponding and inundation, high energy stream flow from flood impacts or as a result of reductions in pool water levels.

As *Pultenaea aristata* and *Leucopogon exolasius* are not known to occur in the areas affected, no impacts on the lifecycle of these species are expected to occur, or to place the local viable populations at risk of extinction. Suitable habitat for *Pultenaea aristata* and *Leucopogon exolasius* is not present within the area impacted (**Section 2**).

Downstream of ET2-2 is a small population of *Astrotricha crassifolia* (Ecoplanning 2020). For the most part, this population is located above the flood zone of the Eastern Tributary, however, two individuals were located within 2 m of the stream edge. During the current inspection one of these individuals was unable to be relocated, presumed missing due to high energy stream flow from flood impacts following the March 2020 site inspection. The loss of one individual will not place the local viable population at risk of extinction as the local population is located upslope and above the flood zone.

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

Potential impacts on the habitat of the threatened species include bank inundation, vegetation dieback, bank scouring/sediment loss, and sediment deposition causing impacts to potential habitat.

Potential habitat for *Astrotricha crassifolia* and *Pultenaea aristata* on the Eastern Tributary (refer **Section 2**) can interface with riparian vegetation but from the current site inspection, the main impacts to habitat have resulted from high energy water flows and physical damage from the movement of woody debris and sediment loss.

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

The habitat connectivity has not been affected, nor has become fragmented for *Astrotricha crassifolia* and *Pultenaea aristata* along the Eastern Tributary as a result of mine subsidence impacts. Suitable habitat is found adjacent and upslope of the riparian areas for both these species and is present elsewhere within the Project Area and will not be subject to fragmentation.

Leucopogon exolasius has not been recorded along the Eastern Tributary. This species is only known from individuals recorded downstream of all riparian monitoring sites along the Eastern Tributary where more suitable habitat is present (Bangalay Botanical Services 2008).

Populations of *Pultenaea aristata* located on slopes adjacent to ET1-1 have not been impacted by the changes in stream water levels. Habitat connectivity for the *Pultenaea aristata* has not been affected and is unlikely to be affected in the future by subsidence impacts to the Eastern Tributary. Extensive flora surveys for the Metropolitan Coal Project (Bangalay Botanical Surveys, 2008) and long-term observations of this species through the riparian vegetation monitoring program (Eco Logical Australia, various dates) has shown that *Pultenaea aristata* is widespread and common in the Project Area and surrounds, and that *Astrotricha crassifolia* is found in discrete populations at various localities in the Project Area on mid to lower slopes, adjacent to and in riparian areas.

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

No detrimental impacts on the *Astrotricha crassifolia*, *Pultenaea aristata* and *Leucopogon exolasius* have occurred and are considered unlikely to occur in the future along the Eastern Tributary as a result of the subsidence impacts recorded to date.

5 Conclusions

Based on the assessments detailed in **Section 4**, the biodiversity impact performance measure '*Negligible impact on threatened species',* has not been exceeded as a result of subsidence impacts on aquatic ecology along Eastern Tributary.

6 References

Bangalay Botanical Surveys (2008). *Metropolitan Coal Project Baseline Flora Survey – Proposed Longwall Mining Area*. Final Report to Helensburgh Coal Pty. Ltd.

Benson, D. and McDougall, L. (1993). Ecology of Sydney plant species: Part 1. *Cunninghamia* 3(2): 257-422.

Benson, D. and McDougall, L. (1995). Ecology of Sydney plant species: Part 3. *Cunninghamia* 4(2): 217-424.

Benson, D. and McDougall, L. (1996). Ecology of Sydney plant species: Part 4. *Cunninghamia* 4(4): 553-756.

Bio-Analysis Pty Ltd (2020). *Aquatic Ecology Monitoring Metropolitan Coal Longwalls 22-27 Spring 2019 Survey.*

Bio-Analysis Pty Ltd (2021). *Aquatic Ecology Monitoring Metropolitan Coal Longwalls 20-27 Autumn 2020 Survey*.

Bureau of Meteorology (2021) Climate Online Data http://www.bom.gov.au/climate/data

Eco Logical Australia (2017a). *Subsidence Impacts on Riparian Vegetation on Waratah Rivulet and Aquatic Macroinvertebrates in Tributary B - Assessment of Impacts on Threatened Flora, October 2017*. Report prepared for Metropolitan Coal.

Eco Logical Australia (2017b). *Eastern Tributary Rehabilitation Plan Pre-disturbance Vegetation Management.* Report prepared for Metropolitan Coal.

Ecoplanning (2020). *Subsidence impacts on Riparian Vegetation on the Eastern Tributary.* Report prepared for Metropolitan Coal.

Metropolitan Coal (2019). *Longwalls 305-307 Biodiversity Management Plan.* Peabody Energy.

NPWS (2003). *Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments. Sydney*. NSW National Parks and Wildlife Service.

NSW Department of Planning, Infrastructure and Environment (2020a) Thick -leaf Star-hair Profile. Accessed at: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10074

NSW Department of Planning, Infrastructure and Environment (2020b) *Pultenaea aristata* Profile . Accessed at: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10710

NSW Department of Planning, Infrastructure and Environment (2020c) *Leucopogon exolasius* Profile . Accessed at: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10473

NSW Department of Planning, Infrastructure and Environment (2021). BioNet Atlas. Accessed at: https://www.environment.nsw.gov.au/atlasapp/Default.aspx?a=1

Warman, D. and Beckers, D. (2011). Status of the Vulnerable shrub *Astrotricha crassifolia* (Araliaceae) in Brisbane Water National Park, NSW: an update. *Cunninghamia* 12(2): 137-142