

10. SUBSIDENCE PREDICTIONS AND IMPACTS ON ECOLOGY

Biosis Research undertook an assessment of the potential subsidence impacts of proposed mining of Longwalls 705 to 710 on terrestrial flora and fauna (refer **Appendix D**).

The Ecology Lab undertook an assessment of the potential subsidence impacts of proposed mining of Longwalls 705 to 710 on aquatic ecology (refer **Appendix C**).

The following summaries are taken from these reports attached as **Appendix C** and **D**.

10.1. PREDICTED IMPACTS OF MINING INDUCED SUBSIDENCE ON TERRESTRIAL FLORA AND FAUNA

Subsidence impacts within the Study Area may potentially result in; minor impacts to water quality in the Nepean River, the localised emission of gas, minor bank desiccation and scouring, and cracking in soils and fracturing of bedrock on the surface and possibly minor rockfalls and erosion events. However, these effects are not expected to represent a significant impact to the terrestrial flora and fauna values of the area.

10.1.1. Vegetation Communities

Five broad plant communities are recognised as occurring within the SMP Area. Four of these communities are listed as Endangered Ecological Communities on the *TSC Act* and/or the *EPBC Act*: Cumberland Plain Woodland, Shale Sandstone Transition Forest, Moist Shale Woodland and River-flat Eucalypt Forest.

Cumberland Plain Woodland, Moist Shale Woodland and Shale Sandstone Transition Forest occur on the undulating topography on shale derived and shale influenced sandy soils. While creeks and or drainage lines may cut through these plant communities, they are entirely terrestrial in nature. Unlike wetlands or other flow-dependent plant communities, they are not dependent on the flow of water from creeks or streams.

River-flat Eucalypt Forest (Alluvial Woodland) occurs along the shallow creeklines and drainage lines within the SMP Area. River-flat Eucalypt Forest (Riparian Forest) is also mapped as occurring adjacent to the Nepean River; however, vegetation in this area was found to be more closely aligned with Western Sandstone Gully Forest. However, Riparian Forest is likely to be present in the southern sections of the Study Area along the Nepean River, as recorded in previous surveys (Biosis Research, 2006).

Predicted impacts to the Nepean River include minor desiccation of small areas where the banks are shallow, less frequent inundation of higher elevations of the bank and minor fracturing as a result of the proposed longwalls mining. Predicted impacts to drainage lines and creeks in the SMP Area include minor increase in ponding and flooding and the possibility of some cracking which is not likely to result in a loss of water from the catchment. Given the minor nature of the impacts to the Nepean River and other drainage lines within the SMP Area, the proposed longwall mining is not likely to impact the plant communities occurring in these areas. This is because these plant communities are not reliant on surface water flows.

The possibility of minor rockfalls, surface cracking and erosion events are predicted in the MSEC report. These impacts are likely to be minor and temporary in nature and are unlikely to alter the species composition or distribution of plant communities in the SMP Area.

Gas emissions may result from sandstone fracturing above areas where coal is being extracted from longwalls. The liberation of gas emissions has been observed within the Cataract River above the workings of Tower Colliery and a discussion of the impact of these emissions on riparian vegetation is provided in **Appendix D**. The MSEC report states that gas emissions occurring in the Nepean River gorge are likely to be minor in nature given the distance of the gorge from the proposed longwalls. Furthermore, in the event that gas is liberated from above these workings it is likely to only occur within a limited area and would be unlikely to result in permanent vegetation die-off over a wide area. Gas emissions are unlikely to result in the alteration of species distribution or composition within the plant communities in the SMP Area. Further, recent extraction of coal from Longwall 701 has resulted in only minor gas emissions which have not affected riparian vegetation.

For these reasons listed above, it is considered unlikely that subsidence impacts would have a significant impact on the four EECs found within the SMP Area. However, as Shale Sandstone Transition Forest is listed as being affected by Key Threatening Processes (KTP) regarding subsidence due to longwall mining an Assessment of Significance under the *TSC* Act and Assessment of Significance under the *EPBC* Act have been completed for this community. Although River-flat Eucalypt Forest is not listed on the KTP, it is more likely to be affected by subsidence than Shale Sandstone Transition Forest due to its proximity to the Nepean River, thus Assessments of Significance have been carried out for this community also.

In these Assessments of Significance it was determined that there would be no significant impacts from the mining of the proposed longwalls on either Shale Sandstone Transition Forest or River-flat Eucalypt Forest and neither species impact statements (*TSC* Act) or Referrals under the *EPBC* Act are required.

Refer **Appendix D** for further detail on vegetation communities.

10.1.2. Flora

No threatened plant species were recorded in the SMP Area during the current surveys. It is considered unlikely that the population of *Pultenaea pedunculata* previously recorded in the SMP Area will be impacted by subsidence given that the habitat it has been recorded in is entirely terrestrial in nature and, unlike wetlands or other flow-dependent plant communities; it is not dependent on the flow of water from creeks or streams.

There are six other threatened plant species with potential habitat in the SMP Area, whose habitats are not likely to be impacted by subsidence. These are *Epacris purpurascens* var. *purpurascens*, *Grevillea parviflora* ssp. *parviflora*, *Persoonia bargoensis*, *P. hirsuta*, *Pimelea spicata* and *Thesium australe*. These species potentially occur within habitats on gently sloping hills, plains or ridges and are not likely to be dependant on water flows within creeklines or groundwater for survival. Nor are they likely to be impacted by gas emissions given that they do not occur along creeklines. Further, they are not likely to occur on cliff lines or on steep slopes that may be subject to erosion or cracking. There are no known mechanisms for subsidence that are likely to result in impacts to these species habitats.

Potential habitat within the SMP Area that could potentially be affected by the mechanisms of subsidence exists for three threatened species: *Eucalyptus benthamii*, *Pomaderris brunnea* and *Pterostylis saxicola*. Assessments of Significance under the *TSC* and *EPBC* Acts have been conducted for these species.

The volume of water available for plant use within the SMP Area is unlikely to be significantly impacted by subsidence from the proposed longwalls. Further, potential impacts from rock falls, erosion events and gas emission are likely to be minor and temporary in nature. It is therefore considered unlikely that subsidence impacts would result in impacts to the floristic composition of the SMP Area. However, subsidence may affect the way in which water is made available to plants within the area, leading to small, localised changes in riparian vegetation. Potential changes in the riparian vegetation may include:

- Loss of aquatic plants; and
- Loss of individuals, changes in species distribution and abundance for those species requiring moist conditions (e.g. *Drosera* spp.).

It is unlikely that any of the threatened flora species listed on the TSC Act or EPBC Act or any other significant flora species that have been recorded or have potential habitat within the SMP Area would be significantly impacted by subsidence resulting from the proposal.

There is no legislative mechanism to consider the impacts of the proposal on the ROTAP species *Lomandra fluviatilis*, *Darwinia grandiflora*, *Epacris coriacea* and *Pseudanthus pimeleoides*. However, it is considered highly unlikely that the proposal would have a significant impact on these species for the following reasons:

- Habitat for *Lomandra fluviatilis* and *Pseudanthus pimeleoides* within the SMP Area occurs within the riparian zone. Habitat for *Epacris coriacea* occurs in sandstone cliffs and rock crevices. If present within the SMP Area, the habitat for these species is unlikely to be significantly impacted. Potential impacts to the riparian zone include minor desiccation of the river bank over a very small area which may result from a maximum predicted uplift of 345 mm. Gas emissions within the riparian zone are predicted to be minor and insignificant. These emissions have been demonstrated to have only a very localised and short term impact on similar riparian vegetation.
- Habitat for *Darwinia grandiflora* occurs in dry sclerophyll forest, which is unlikely to be significantly impacted by any potential impacts of subsidence.

Refer **Appendix D** for further detail on flora.

10.1.3. Fauna

Potential impacts on fauna and their habitats will occur where the disturbance to the soils and near surface strata are the greatest, resulting in changes to surface water conditions. Where fauna and their habitats are reliant on these surface waters, some impacts are possible. It is possible that fracturing of the Nepean River bed will occur, however it is unlikely to result in any noticeable loss of surface water flows or quality.

Any fractures in feeder creeks may result in surface flows being redirected into the dilated strata below to re-surface downstream. MSEC (2008) indicate that surface flow diversions are generally limited to sections of river located directly above the longwalls. Creeks that will be directly mined beneath such as Foot Onslow Creek and small unnamed drainages are highly degraded and do not contain any significant fauna habitat that will be impacted.

Longwalls 705 to 710 will be offset from the Nepean River by at least 180 m. It is therefore unlikely that native fauna which rely on the Nepean River will be significantly impacted by the proposed longwall extraction.

Where the creeks have an alluvial bed above the strata, it is unlikely that cracking in the strata will continue up to the surface (MSEC, 2008). In the unlikely event that it does, the cracks are likely to be filled with alluvial material during subsequent flow events. Where the creek beds are exposed rock, there may be some redirection of water from the creek beds into the dilated strata beneath them and the draining of some of the pools that exist within the creek alignments (MSEC, 2008). However, the creek lines generally occur on gentle, undulating land and are unlikely to be significantly altered by mining induced subsidence. Furthermore, the creek lines and most associated pools are ephemeral and it is likely that fauna reliant on them would be adapted to using non-perennial water sources. It is therefore unlikely that native fauna which rely on these areas will be significantly impacted by the proposed longwall extraction.

As no cliffs or steep and rocky slopes along creeks will be directly mined beneath, MSEC (2008) predicts instabilities due to subsidence are unlikely. Consequently, it is unlikely that native fauna that live in such areas will be significantly impacted by the proposed longwall extraction.

Gas emission through alluvial or rocky substrate within a watercourse may affect water quality at low river flows and hence fauna habitat. However, these gas emissions are expected to be temporary and it is unlikely that any significant impacts on fauna or their habitats will occur.

Given the nature of the likely subsidence impacts and that significant fauna habitats will not be directly mined beneath by the proposal, it is considered that the proposed longwall extraction would be unlikely to have a significant impact on any important fauna habitats.

The SMP Area provides potential habitat for 42 threatened or migratory animal species that may occur in the locality. Four of these species, if present, are likely to be dependent on the Nepean River and tributaries for breeding or foraging. General comments on the likely impacts are provided below.

The Nepean River and pools associated with its tributaries may provide breeding or foraging habitat for frog species. A reduction in the amount of water present in some pools may reduce the available breeding habitat for frog species and possibly disrupt their life cycle. Frog species considered further in the impact assessment include the Giant Burrowing Frog, (*Heliophorus australiacus*), Littlejohn's Tree Frog, (*Litoria littlejohni*) and the Red-crowned Toadlet, (*Pseudophryne australis*). The impact assessment indicates that subsidence is unlikely to have a significant impact on these species as the SMP Area only provides marginal habitat and the impacts to potential habitat would be insignificant.

The Large-footed Myotis, (*Myotis macropus*) has previously been recorded within the SMP Area on the eastern side of the Nepean River. This species forages along the creek lines and pools where it feeds on small fish and insects. The potential short-term loss of pools in tributaries to the Nepean River as a result of subsidence may reduce the foraging area available to individuals. The impact assessment indicates that subsidence is unlikely to have a significant impact on this species given the minimal subsidence impacts to the Nepean River and the large areas of potential foraging habitat for this species in the vicinity of the SMP Area and the region.

Species which are dependant on caves, overhangs, rock crevices and steep slopes such as cave dwelling bat species, the Spotted-tailed Quoll, (*Dasyurus maculates*), Rosenberg's Goanna (*Varanus Rosenberg*), the Broad-headed Snake (*Hoplocephalus bungaroides*) and the Brush-tailed Rock Wallaby, (*Petrogale penicillata*), have been considered as there is possibility for impacts to this habitat. MSEC (2008) states that cliff failures in the Nepean gorge are considered unlikely in relation to the mining of Longwall 705 to 710 and that

rockfalls are unlikely to occur and if they do are likely to be isolated and minor in nature. As such assessments of significance were not prepared for these species.

There is a large camp of Grey-headed Flying Fox (GHFF), *Pteropus poliocephalus*, in the SMP Area on the western side of the Nepean River (Biosis Research 2006). Camps are important for GHFFs and disturbance to camps is a threat to this species survival. It is highly unlikely subsidence will cause any impacts to the habitat where this camp is located. There is a possibility of localised rock falls in some areas (MSEC, 2008) but these are expected to be minor and would be unlikely to affect the trees that this species roosts in and as such an assessment of significance was not prepared for this species.

The Cumberland Plain Land Snail was recorded during the current assessment in the north-west of the SMP Area in a patch of Cumberland plain Woodland adjacent to a tributary of Navigation Creek. This species has also previously been recorded east of the Nepean River in the SMP Area. This species primarily inhabits Cumberland Plain Woodland and is found under logs, bark and leaf litter. Impacts to this habitat type are considered highly unlikely and as such an assessment of significance was not prepared for this species.

The remaining threatened fauna species known to occur or with potential habitat within the SMP Area are unlikely to be significantly impacted by subsidence as habitat for these species occurs within woodland, or other habitats that are unlikely to be impacted by subsidence. Hence, Assessments of Significance under the *TSC* and *EPBC* Acts were not completed for these species.

10.2. PREDICTED IMPACTS OF MINING INDUCED SUBSIDENCE ON AQUATIC ECOLOGY

The proposed mine operation has the potential to impact aquatic habitats and biota within watercourses located within, and downstream of, the SMP Area. Potential impacts of mining on aquatic ecology include:

1. The loss and/or alteration of aquatic habitat;
2. Impacts on fish passage (connectivity between up and downstream habitat);
3. Changes in water quality; and
4. Impacts on species of conservation significance.

Subsidence is unlikely to have a significant impact on important components of aquatic environment including flow characteristics, and habitat connectivity, which support aquatic habitat and biota.

Ongoing monitoring of aquatic ecology, during and after extraction of longwalls is recommended. For the Nepean River and small surface watercourses within the SMP Area, it is recommended that aquatic macrophyte bed mapping, fish sampling, macroinvertebrate sampling and habitat assessment be used to monitor the effects of mine subsidence. This monitoring plan is a continuation and augmentation of the existing monitoring program approved for Appin Longwalls 701 to 704.

The following sections outline the predicted impacts which may affect aquatic ecology within the SMP area.

10.2.1 Nepean River

For predicted impacts of subsidence on the Nepean River refer **Section 8.1**.

10.2.2. Creeks

For predicted impacts of subsidence on the creeks refer **Section 8.2**.

10.2.3. Alterations to Flow

Subsidence predictions suggest the Nepean River may become shallower by a maximum of about 345 mm in section of the river where the maximum uplift is predicted (MSEC, 2008). These changes are relatively small when compared with the existing relief (pool depth of up to 8 m) of the riverbed and will only occur in small sections of the river. Furthermore, as a flooded system, the flow rates within this reach of the river are regulated and do not experience the same variation as an unregulated or ephemeral watercourse.

It is predicted that there will be no changes in flow characteristics in the SMP Area as a result of mine subsidence and that there will not be any significant impact on the aquatic habitat and biota present.

Within small surface watercourses, predicted increases in ponding and flooding and potential water loss through surface fractures are not predicted to have a significant impact on the ephemeral nature of the flow of these watercourses.

10.2.4. Connectivity

Continuity of a watercourse is ecologically important in maintaining connectivity between habitats. The minimum pool depths of approximately 1 to 1.5 m measured by The Ecology Lab within the SMP Area, suggest that these pools are sufficiently deep to ensure the entire length of river remains inundated following longwall extraction. Small areas of the shallower river margins may, however, become exposed, thus marginally reducing the wetted perimeter of the river (MSEC, 2008). Due to the relatively small area that may be exposed, no impact on aquatic biota resulting from fragmentation of habitat is expected as a result of mine subsidence within the Nepean River within the SMP Area.

Habitat within the small ephemeral watercourses within the SMP Area is generally discontinuous, except during periods of high rainfall. Impacts including possible increased ponding and flooding and possible draining of some pools are not considered likely to affect this connectivity.

10.2.5. Water Quality

Ecoengineers' (2008) assessment of surface water quality effects in relation to the proposed Longwalls 705 to 710 has identified potential mechanisms which may have adverse impacts on surface water quality as a result of mine subsidence.

For further detail on subsidence impacts on water quality refer **Section 9** and **Appendix B**.

10.2.6. Aquatic Macroinvertebrates

The occurrence of vertical movement in the bed and bank of the river resulting from subsidence could marginally re-position the edge of some pools (MSEC, 2008). Loss of edge habitat would occur where there is a relative (to an uplifted bank) fall in water level due to upsidence as predicted by MSEC (2008). The maximum predicted net upsidence of the

river bed is between 255 and 345 mm. It should be noted that where the banks are generally steep and the river is relatively deep, upsidence impacts occurring at the stream edge are likely to be of a much smaller magnitude than at the river bed, so extensive loss of edge habitat is not predicted. Areas likely to experience the greatest loss of edge habitat are those where upsidence of the riverbed coincides with shallow edge habitat. The potential loss of macroinvertebrate edge habitat, however, is predicted to be relatively small in the context of the available habitat within the reach of the Nepean River within the SMP Area. No significant impact on macroinvertebrate assemblages is therefore predicted to occur as a result of mine subsidence.

Where bedrock substratum of small watercourses is present within the SMP Area it is possible that surface fractures will occur (MSEC, 2008). These may result in surface water diversion into the dilated strata beneath with the potential for draining of pools. It is likely that such fractures will be quickly filled with alluvial deposits during subsequent flow events. The draining of pools may result in temporary loss of small areas of minimal to moderate aquatic habitat. Aquatic biota dependent upon this habitat (including aquatic macroinvertebrates) that are unable to relocate to other areas of habitat are likely to perish as a result of desiccation and/or predation as these pools drain. This impact is considered as being of low significance because of the highly degraded nature of existing aquatic habitat, and the temporary and limited nature of such impacts. This habitat is not considered as potential habitat for any listed threatened aquatic macroinvertebrate species.

The production of increased levels of iron precipitate (iron floc) as a result of the induction of ferruginous springs by mine subsidence may have an impact upon some aquatic macroinvertebrate species. The ecological effects of these flocs on aquatic biota are largely unknown, but may include reduction of interstitial benthic habitat through smothering.

Dissolved oxygen is necessary to maintain aerobic conditions in surface waters and is considered a primary indicator when assessing the suitability of surface waters to support aquatic macroinvertebrate life. Fluctuations in DO levels occur in natural stream ecosystems throughout 24 hour periods as a result of temperature fluctuations and biological activity. Sustained reductions in DO levels can have profound effects on the inhabitants. Much of the data that has been published focuses on the effects of oxygen levels on fish, but they conclude that as long as DO requirements are satisfactory to the fish communities, there will be no material impairment on the macroinvertebrate populations on which they feed (Doudoroff and Shumway, 1970; Davis, 1975). Because minimal research has been done on Australian macroinvertebrates with regard to DO concentrations, general comparisons can only be made at the family and order level of classification to account for spatial variation among taxa.

ANZECC (2000) guidelines for lowland rivers recommend healthy DO percent saturation levels between 85 to 110%. The stream macroinvertebrates sampled in the Nepean River by The Ecology Lab (2006) represent an aquatic community characteristic of a lentic environment and these populations would perform very well in conditions such as these. Most of these macroinvertebrates are extremely hardy and mesocosm experiments using entire assemblages of Australian, tropical lowland streams found that even 25 to 35% oxygen saturation did not cause any mortality over 5 day experiments (Connolly *et al.*, 2004).

10.2.7. Aquatic Macrophytes

The distribution of submerged (attached) macrophytes within the SMP Area may change in response to the vertical movement of the riverbed. A reduction of macrophyte coverage could occur as a result of desiccation. This could occur if macrophyte beds are located in any shallow areas of riverbed subject to net upsidence which exceeds the water depth. As the maximum predicted net upsidence following extraction within the Nepean River is 345

mm (MSEC, 2008), and this is predicted to occur in the middle of the channel, the reduction of macrophyte beds resulting from desiccation is likely to be confined to a very small proportion of any shallow margins of existing beds.

An increase in the coverage of macrophyte beds is also possible as a result of mine induced upsidence. A reduction in water level due to upsidence could increase the substrata available for macrophyte colonisation along the margin of macrophyte beds defined by available sunlight penetration. This effect is also likely to be proportionally very small compared with existing macrophyte coverage.

Variability in the spatial extent and species composition of macrophyte beds in the Nepean River has been observed between surveys conducted in 2003 and 2005, prior to the commencement of mine operations. It is expected that any change in macrophyte beds resulting from mine subsidence induced impacts will be minor and indistinguishable from the natural variability within the river. No significant impact on macrophyte composition or coverage is therefore predicted to occur as a result of mine subsidence.

10.2.8. Fish

The response of fish to the effects of mine subsidence impacts is dependent on changes in fish habitat resulting from changes in flow, connectivity, water quality, and aquatic macrophyte beds. As discussed above, changes in most of these habitat components are not expected to be of sufficient magnitude to have a significant impact on the overall aquatic habitat within the Nepean River.

Any impacts upon fish as a result of low DO in the Nepean River due to gas emissions would need to be assessed in the context of the actual DO concentration, spatial extent and duration of the DO sag, and the total available habitat within the Nepean River between Douglas Park Weir and Menangle Weir. As fish are highly mobile organisms, and there are no barriers to fish passage in the reach of the river between Douglas Park Weir and Menangle Weir, it would require prolonged, very low DO concentrations of this entire reach of the river to result in impacts such as a fish kill.

Fish that may utilise pool habitat within small ephemeral surface watercourses may be impacted by the draining of pools as a result of surface fractures. Some fish species (such as freshwater eels) may be able to relocate to nearby areas of aquatic habitat, however most species would perish as a result of desiccation and/or predation. This impact is considered as being of low significance because of the highly degraded existing aquatic habitat, and the temporary and limited nature of such impacts. This habitat is not considered as potential habitat for any listed threatened fish species. It was noted that only the introduced fish species, *Gambusia*, was present in some of these watercourses, however it is likely that some species including Freshwater Eels and Gudgeons may be present within these watercourses.

10.2.9. Threatened Species

Sydney Hawk Dragonfly

There are no records for this species within the SMP Area, however, it has been recorded by NSW Fisheries upstream in the Nepean River, at the Maldon Bridge near Wilton.

The Nepean River within the SMP Area appears to contain extensive suitable habitat for the Sydney Hawk Dragonfly. Predicted impacts on this habitat resulting from mine subsidence are likely, if they occur at all, to affect a very small percentage of the total available habitat. The possible occurrence of a widespread, prolonged DO sag in the river under low flow

condition could have a negative impact upon this species. Low DO conditions in the Nepean River can be caused from numerous natural and anthropogenic factors. These impacts are not likely to have a significant impact upon any local population of this species within the SMP Area or the greater regional setting. A species impact statement is therefore not recommended for the Sydney Hawk Dragonfly.

Adams Emerald Dragonfly

There does not appear to be suitable habitat within the SMP Area to support the Adam's Emerald Dragonfly, as the Nepean River does not contain appropriate riffle or cascade habitat. Foot Onslow Creek, Navigation Creek, Harris Creek and the small unnamed creeks do not have well defined riffle and pool habitat, and are likely to almost completely dry out during extended dry periods. These creeks are also highly altered in their upper reaches as a result of historical land clearing, farming and grazing. Furthermore, the sampling for this study and previous studies by The Ecology Lab, along with historical survey records for the Sydney area suggest the waterways in the SMP Area do not support an established population of Adam's Emerald Dragonfly, and therefore no further investigation is considered necessary.

Australian Grayling

The Australian Grayling is listed under the *EPBC* Act as a vulnerable species, and is protected from fishing under NSW legislation. It has been recorded within the Hawkesbury-Nepean catchment in the Grose River, however no records exist within the upper Nepean Catchment. The life cycle of the Australian Grayling is dependent upon migration to and from the sea, and as such it would not be expected to occur in the upper Nepean System above barriers such as Menangle Weir which has no provision for fish passage. Given that it is highly unlikely that the Australian Grayling occurs within the study area further investigation of this species is not considered necessary.

Macquarie Perch

The Nepean River within the SMP Area is unlikely to support a viable population of Macquarie Perch due to the absence of suitable spawning habitat and existing barriers to upstream migration. However, individuals may move into this area from viable populations upstream in the Cataract and Nepean Rivers. Even if Macquarie Perch were present and did constitute a viable population, the predicted impacts on this habitat resulting from mine subsidence are likely, if they occur at all, to affect a very small proportion of the total available habitat. Changes in water quality resulting from mine subsidence-induced effects are predicted to be localised and within the existing water quality variability. Thus, these impacts are not likely to have a significant impact upon any local population of this species within the SMP Area or the greater regional setting. A species impact statement is therefore not recommended for Macquarie Perch for this proposal.