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December 7[h] 2020

RE: presentation requested by Panel for DEP project - SSD 8194

Dear Mr O'Connor,

As requested, please find attached a copy of the presentation I gave on the first day of the Public Hearing regarding the proposed Dendrobium Extension Project (SSD 8194). As mentioned during that presentation, I'll elaborate on its points in a written submission. The attached includes a further reply to the question I was asked following the presentation.

Yours sincerely

Peter Turner

Mining Projects Science Officer
National Parks Association of NSW

Some Comments on the Dendrobium Extension Proposal

“The single most important land use in the Southern Coalfield is as water catchment”.
Southern Coalfield Inquiry, 2008.

“The Panel is of the view that it is no longer a viable proposition for mining to cause more than negligible damage to pristine or near-pristine waterways in drinking water catchments or where these waterways are elements of significant conservation areas or significant river systems. As noted in the Metropolitan PAC Report, this level of damage would not be acceptable in any other assessment of water resource use.”
Bulli Seam Operations Project, PAC Report, 2010.

“Given the inherent uncertainty of predicting and estimating the magnitude of stream flow losses to fracture networks and the potential long term implications of fracture networks for water quantity and, in particular, water quality in the Greater Sydney water catchment, the Panel considers that it would be wise to adopt a precautionary approach and base mine design on preventing the height of free drainage in the Special Areas from extending to the surface or interacting with surface fracture networks.” **IEPMC Report, Part 2, 2019.**

IPCN Presentation, December 2nd 2020.
Dr Peter Turner, National Parks Association of NSW.

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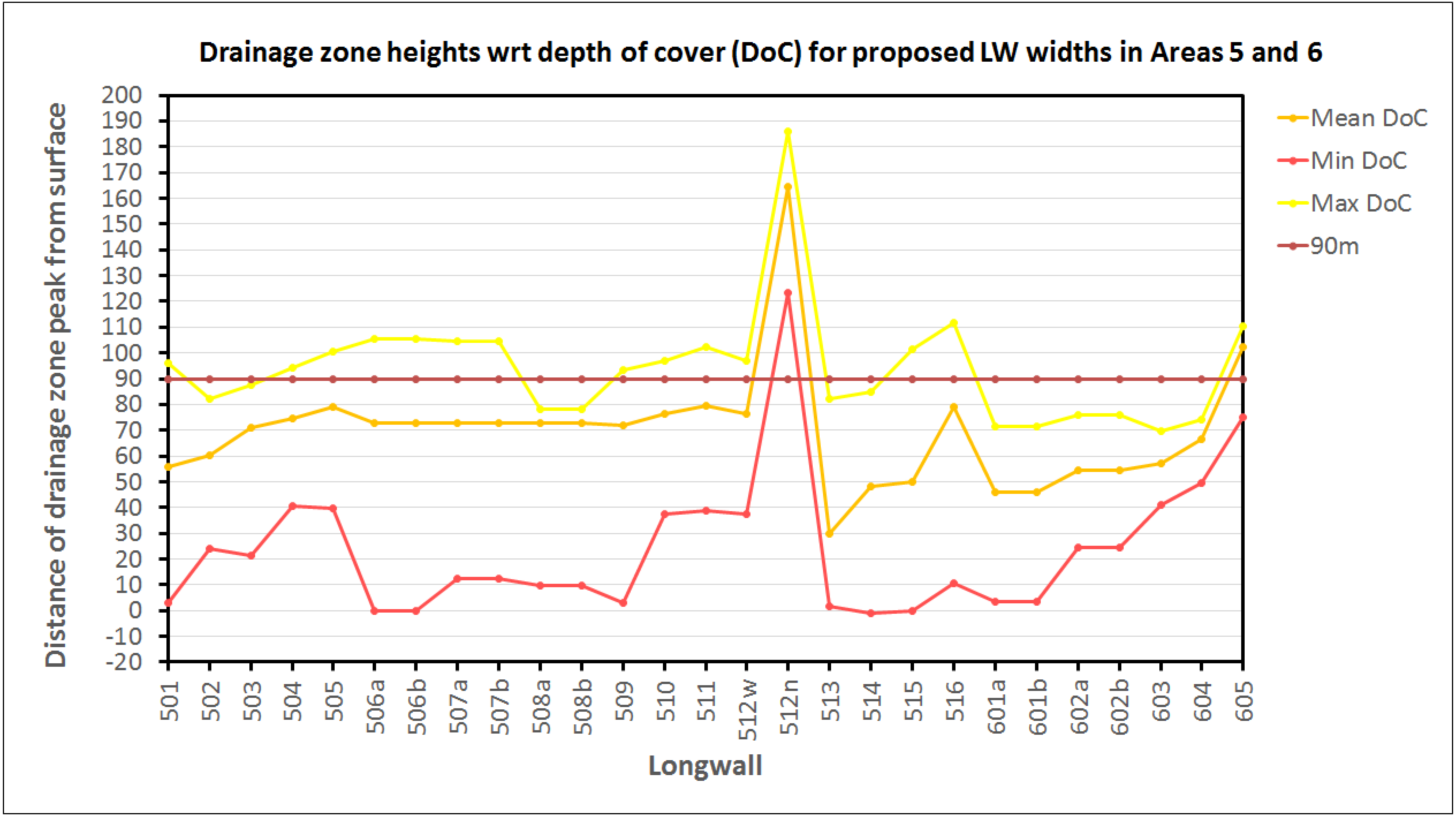
Some Concerns

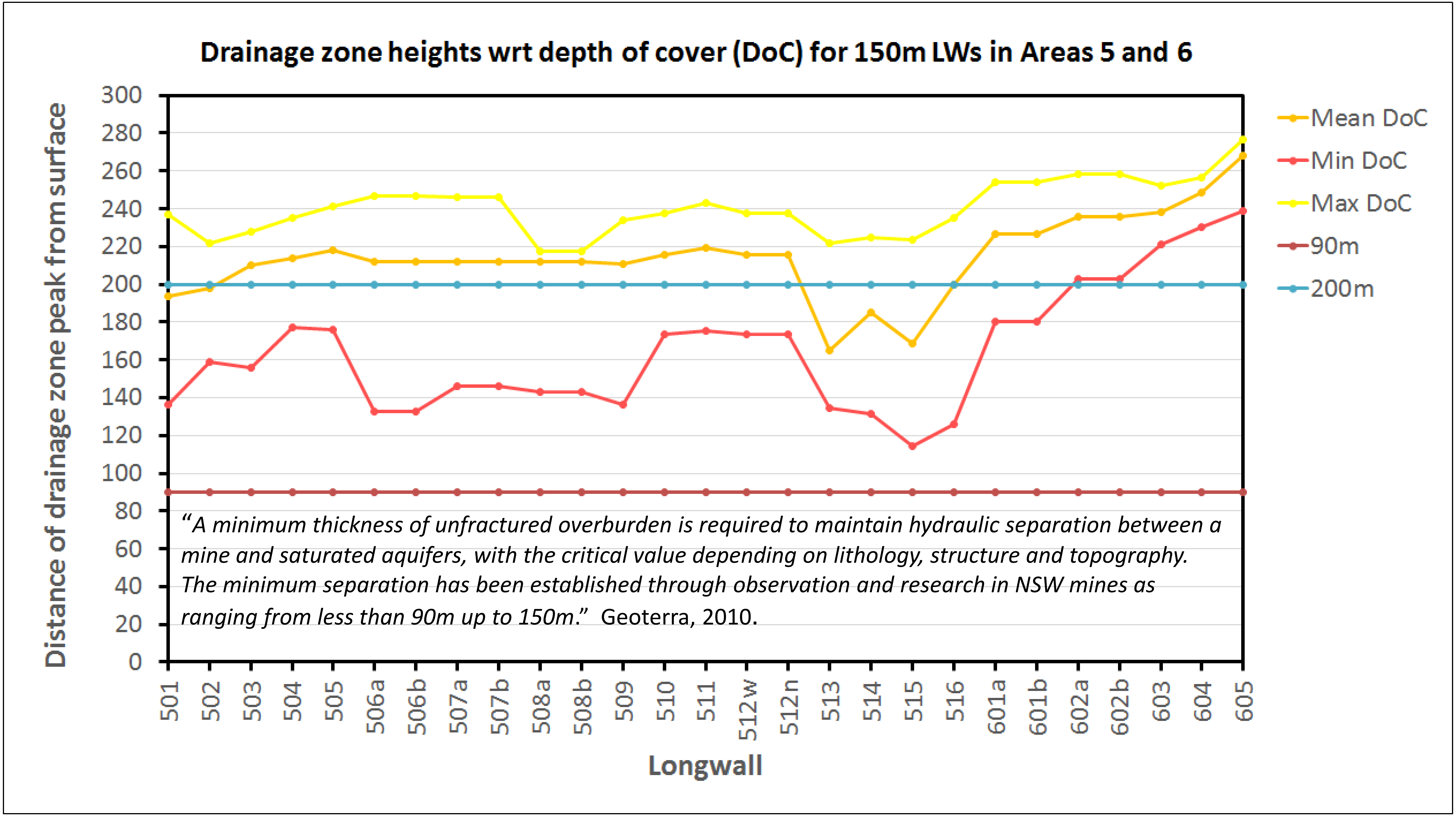
- Allowing the drainage zone to reach the surface (or surface fracture network), with possibly in perpetuity water quantity and quality losses, would seem to be fundamentally inconsistent with the intent of the Special Areas and best practise catchment management. Of note, the PAC's approval conditions for the Wallarah-2 project included "*No connective cracking between the surface, or the base of the alluvium, and the underground workings*".
- The proposed compensation for water quantity loss given in the amendment report doesn't seem to recognise in perpetuity. In the absence of the perspective of future generations, adequate compensation for in perpetuity water quantity and quality losses would appear to be impossible.
- Currently no reliable estimate of cumulative water loss volumes for the Special Areas; the IEPMC **8 Ml/day** estimate is a **significant underestimate**. Its currently not possible to reliably assess the significance of the proposal's water loss estimates with respect to cumulative losses to date. A 2016 tally from available reports **suggests between 29 and 42 Ml/day** flow into mines in and around the Special Areas, of which an unknown amount would be surface water. A 2018 WaterNSW scoping study suggests **24 Ml/day** of surface water flows in the mines; reflecting data limitations, the estimate is not reliable.
- **How much is too much?** There would appear to be no government determination or advice.
- Appears to be no consideration of increased fire hazard associated with groundwater loss and surface drying.
- Inadequate consideration of water quality loss. The current cumulative contaminant loading in the reservoirs as a consequence of mining is not known, but would seem likely to be significant. The then SCA (now WaterNSW) estimated that between February 2002 and June 2011, **19 and 5 tonnes of iron and manganese oxides/oxyhydroxides respectively** were added into Woronora Reservoir from Waratah Rivulet.

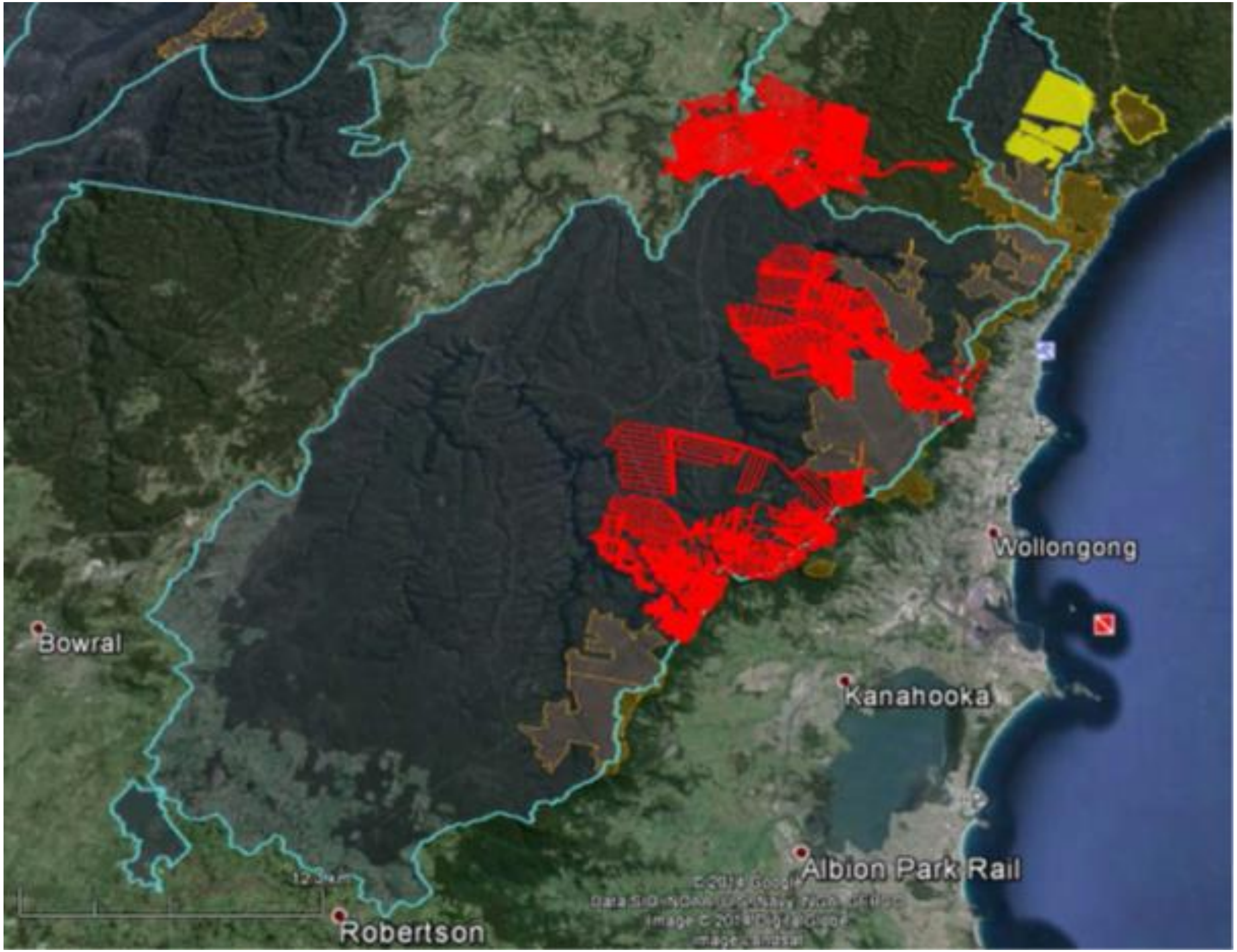
Some Concerns

- No recognition in the proposal or DoP assessment that conventional subsidence, which is extraction width sensitive, **compounds** the impacts and consequences of non-conventional subsidence, and vice versa. **Conventional subsidence impacts of 305m panels would be significantly greater than 150m**.
- **Unsupported** implicit assumption that all watercourses in the project area are in sufficiently steep valleys/gorges and/or high horizontal stress fields, that non-conventional subsidence would render differences in the conventional subsidence impacts (and consequences) between 150 and 305 metre extractions irrelevant. **This would appear to be physically implausible**. <u>The proposal doesn't comparatively assess the impacts and consequences of 150m panels.</u>
- Inadequate stream impact assessment. Apparent disregard for the vital role of 1st and 2nd order streams. Notably, they're important in protecting the continuity of flow and the quality of water conveyed between the upland swamps and the larger streams. Appears to have little regard for the BSO PAC assessment.
- Inadequate groundwater modelling and, accordingly, surface water modelling. The modelling does not appear to be adequately calibrated, may not be conservative and may underestimate water loss.
- Lack of recognition that the higher the drainage zone (zone of hydraulically connected fractures) the greater the spread and rate of upper strata depressurisation. This reflects horizontal conductivities being 10 to 1000 times vertical.
- Lack of mine closure plan and assessment of post closure discharges as a consequence of drainage zones intersecting the surface (seam to surface connected fractures). Wongawilli can't be sealed and is expected to discharge near Dombarton.
- Approval being sought in the context of a long standing absence of adequate monitoring, modelling, knowledge and understanding of mining the Special Areas. There should be no further mining approvals for mining the Special Areas until the long standing uncertainties and deficiencies are resolved.



Drainage zone heights wrt depth of cover (DoC) for proposed LW widths in Areas 5 and 6
Distance of drainage zone peak from surface
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
501
502
503
504
505
506a
506b
507a
507b
508a
508b
509
510
511
512w
512n
513
514
515
516
601a
601b
602a
602b
603
604
605
Longwall
Mean DoC
Min DoC
Max DoC
90m


Drainage zone heights wrt depth of cover (DoC) for 150m LWs in Areas 5 and 6
Distance of drainage zone peak from surface
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Mean DoC
Min DoC
Max DoC
90m
200m
"A minimum thickness of unfractured overburden is required to maintain hydraulic separation between a mine and saturated aquifers, with the critical value depending on lithology, structure and topography. The minimum separation has been established through observation and research in NSW mines as ranging from less than 90m up to 150m." Geoterra, 2010.
501
502
503
504
505
506a
506b
507a
507b
508a
508b
509
510
511
512w
512n
513
514
515
516
601a
601b
602a
602b
603
604
605
Longwall


Wollongong
Bowral
Kanahooka
Albion Park Rail
Robertson

Thank You

Dr Peter Turner, National Parks Association of NSW.

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Water Loss – Wongawilli Mine

Table 1 Local Mining Operations (2010 NRE Wongawilli Colliery Nebo Panels 1 to 6 Groundwater assessment)

MINE	Previous / Current Operator	Extraction	Depth of Cover (mbgl)	Max Mine Inflow
Dendrobium Area 2	BHP Billiton	Longwall	145 - 300	N.A.
Elouera	BHP / Delta Mining	Longwall	290 - 390	120L/sec (3785ML/year)
Wongawilli	BHP	Bord and Pillar	0 - 360	40L/sec max, background 20L/sec
Wongawilli Panels 11 to 19	Gujarat	Longwall	300 - 360	120L/sec max, background 50L/sec

Where 120 l/sec = **10.4 Ml/day**; 50 l/sec = **4.3 Ml/day**; 40 l/sec = **3.5 Ml/day**; 20 l/sec = **1.7 ML/day**

AR 2015: "*Extraction of LW19 resulted in restricted access to key storages of the underground reticulation system. Due to the restricted access to water underground, de-watering was stopped on 28th May 2011 to increase water storage levels underground. During the reporting period, mine de-watering has started again mainly due to lack of underground water usage for mining purposes and recent very intense rainfall events*."

AR 2019: "*The groundwater inflow to the mine is approximately* ***50 to 60 L/second*** *during normal conditions with* ***increases*** *to approximately* ***120 L/second*** *during prolonged periods of substantial regional rainfall. Mine de-watering can occur at an average rate of approximately 4.2 ML/day during normal mining operations*

ARs 2012,2013,2014: "*Wongawilli Colliery is generally considered a* **"wet" *mine*** *as it needs to be routinely dewatered*". **Inflows are sensitive to rainfall**.

Modelling Concerns

IAPUM: "*the groundwater model has been set up to conservatively simulate connective fracturing extending from the seam to the surface*."

HydroSimulations Appendix B: With respect to observed groundwater drawdown due to mining: **"***Within and adjacent to the connected fracture zone ② which, at Area 3B includes the Scarborough and Bulgo Sandstones, and in the Hawkesbury Sandstone. The drawdown is often > 50m or the strata become completely depressurised (pressure head is zero). Drawdown in the mid Hawkesbury Sandstone is about 10-20 m, and in the shallower horizons of the Hawkesbury Sandstone it has been observed to be <5 m (e.g. at S2192-S2220 directly overlying Longwall 9*)." No basis is provided for this characterisation; the complete drainage zone (connected fracture zone) is characterised by zero pressure heads. If the modelling is targeted to reproduce this representation, it would then underestimate flow through the drainage zone.

This concern is reinforced by the IAPUM's comments that the unusual approach taken in setting conductivities would result in low values.

IAPUM: The Tammetta equation "*generally produces the highest estimates of the height of connective fracturing for Dendrobium Mine and, therefore, predicts worst-case outcomes*

HGEO January 2020 Dendrobium Height of Fracture report: "*Observations from this investigation are most consistent with the empirical model of Tammetta (2013)*." This is reiterated in the May 2020 HGEO LW15 End of Panel Report and is first acknowledged in the May 2018 HGEO LW13 End of panel Report.

Evidently contrary to the IAPUM's view, the available information suggests the Tammetta equation would predict the most likely outcome.

Water loss – how much is too much?

IAPUM: Subject to ongoing assessments by WaterNSW of the potential impact of project and cumulative water losses on water supply, the Panel make the following comment with respect to water loss:

"It is not a central issue if the proposal for compensation for water loss is accepted. "

IEPMC: Suggesting current losses are small, the IEPMC compares its average water loss estimate of **8 ML/day with** the Sydney Desalination Plant capacity of approximately **250 ML/day** and estimated leaks from the Sydney Water supply infrastructure of approximately **130 ML/day** (Sydney Water, 2018).

The **8 ML/day** IEPMC estimate is, however, **a significant underestimate of losses** for at least three reasons:

(i) The IEPMC's estimate is a summation for Dendrobium, Metropolitan, Russell Vale and Wongawilli mines only, essentially because "*no estimates are available for most historical mines*."

(ii) The IEPMC's estimate of 0.8 Ml/day for the Wongawilli mine appears to be incorrect by a factor of 5 to 10.

(iii) The IEPMC's estimate of direct losses from Avon and Cordeaux reservoirs appear unlikely to be correct.

A 2016 summation of **mine inflow** numbers given in available mine report suggests inflows of **between 29 and 40 Ml/day** into current and past mine areas in and around the Illawarra Special Areas (Turner, 2016).

A 2018 WaterNSW scoping study suggests surface water losses of **24 Ml/day, though data limitations are such that the estimate is unreliable.** Also of note, the study doesn't include uncertain or unknown losses arising from the depletion of groundwater supply to the reservoirs, nor uncertain or unknown reservoir leakage volumes.

The estimates suggest the **possibility of current losses of up to 10% of the daily capacity of the Sydney Desalination Plant**, perhaps more.

Question from Panel

Would conventional and non-conventional subsidence impacts tend to cancel each other?

Further Reply

The two processes would not be expected to cancel each other out, except in the sense that upsidence can result in a lesser downward displacement in the centre of a steep valley/gorge. In some cases this leaves part of the valley floor at a higher elevation than it was before being impacted by mining. Nonetheless, the fracturing, void creation and shearing associated with each process would be expected to compound that of the other.

Depicted in Fig. 1 below, valley bulging is a natural process that mining impacts can accelerate and compound.[1] In discussing mining induced ground deformation in valleys and gorges, Section 10.4.4.4 in Prof. Jim Galvin's 2016 textbook[2] on coal mine engineering includes the following observations:

> "*Hence, the ground movements that occur around excavations are complex and may include classic subsidence ground responses to mining; elastic ground movements associated with redistribution of horizontal stress on a regional scale; gravity induced unravelling; and localised buckling and shear failure. It is difficult to identify the individual contributions of these components. Some components may even operate simultaneously in opposite senses. For example, an area could be subjected to downwards vertical displacement at the same time that it is being subjected to upwards valley bulging.*
>
> *If upsidence occurs within the angle of draw of the mine workings,* ***ground movements due to classic subsidence can also contribute to buckling and shear in the near-surface strata, thus generating an extensive network of fractures and voids in the valley floor***."

The 2008 Southern Coalfield Inquiry (SCI) report[3] comments as follows:

> "*Buckling and shear in the near-surface strata, which leads to upsidence, can also generate an extensive network of fractures and voids in the valley floor.* ***Ground movements due to conventional subsidence can also contribute to the formation of this network if the upsidence occurs within the angle of draw of the mine workings***.

Referring to observations at Waratah Rivulet, the SCI report comments;

> *"In general, the extent and intensity of the fracture network increases with upsidence which, in turn, increases with subsidence*."

In his 2007 study[4], Mill comments:

> **"***The main upsidence zone typically occurs within a 20-30m wide corridor where most of the differential horizontal movements and resulting vertical dilation is concentrated. The fractures in this zone develop progressively downward with increasing subsidence, usually to a final depth of about 6-12m below the surface*.**"**

And

> "*The basal shear fracturing zone extends laterally from the main fracture zone under the flanks of the valley. This zone tends to be better developed and more laterally extensive on*

the side of the valley closest to mining. The basal shear fracturing zone appears to comprise more than one bedding plane shear with ***shear movement progressively getting deeper with greater levels of subsidence and valley closure***."

As the paper notes, at that time subsidence in the Southern Coalfield was typically in the range 0.8-1.3m. the MSEC letter-report[5] provided to South32 suggests that subsidence in Area 5 and 6 would be 0.6 and 0.7m respectively for 150 metre extractions. In contrast, it would be 2.1 and 2.5 metres for 305m extractions; significantly greater than the range reviewed by Mills.

Mining induced upsidence typically occurs in a relatively thin surface zone in the central part of a valley/gorge (see Figs. 1 and 2) and dissipates compressive energy associated with valley closure and, depending on the location of the extraction(s). Conceivably valley closure and horizontal stress could delay the subsidence or upsidence of a narrow band of near surface rock that doesn't yield soon after the onset of subsidence over the void. I'm not aware of any reports that find this to have occurred and, it did occur, it would only delay the failure process.

Galvin observes the following in his 2016 book:

"*Studies have also revealed that besides upsidence extending for tens of metres laterally beneath valley sides, it may also not follow the line of the valley floor. Rather, it can cut across valley headlands and bends in the valley.*"

This would suggest that fracturing associated with valley closure may intersect fracturing associated with conventional subsidence from a nearby extraction, in addition to the extraction directly associated with the valley closure.

Galvin describes the following consequences of valley closure:

"*Buckling and fracturing provide an opportunity for some or all of the stream flow to be diverted into a freshly created sub-surface fracture network from where, depending on mining dimensions and hydrogeological conditions, water may re-emerge downstream of the affected area, escape to another catchment, or flow into the mine. Although flow re-emerges downstream of the upsidence affected area when a constrained zone is present, it has yet to be categorically confirmed that subterranean water flow is not diverted laterally through dilated upsidence zones into other catchments.*"

Fracturing from conventional subsidence would compound this risk of water loss.

In discussing water diversion, whether via conventional or non-conventional subsidence, in Section 3.2.2 of Part 2 of its final report, the IEPMC comments:

"*Diversions into deeper, dilated shear surfaces on bedding planes, where these form a conduit for lateral water flow, which may or may not report to the same catchment (i.e. it may become a permanent loss*".

The extent to which this occurs, if at all, is not known because of the ongoing absence of sufficient monitoring.

References

[1] Mine Subsidence Engineering Consultants (MSEC), ‘General Discussion on Systematic and Non Systematic Mine Subsidence Ground Movements’. Aug. 2007.

[2] J. Galvin, ‘Summary and Explanation of Height of Fracturing Issues at Dendrobium Mine’, Galvin & Associates, Prepared for NSW Department of Planning 1716–11/1b, Jun. 2017.

[3] B. K. Hebblewhite, J. Galvin, C. Mackie, R. West, and D. Collins, ‘Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review’. NSW Department of Planning, Jul. 2008, [Online]. Available: http://www.planning.nsw.gov.au/planningsystem/pdf/report_southern_coalfields_final_jul08.pdf.

[4] K. W. Mills, ‘Subsidence Impacts on River Channels and Opportunities for Control’, University of Wollongong, NSW, Nov. 2007.

[5] J. Barbato, ‘RE: Dendrobium Mine – Plan for the Future: Coal for Steelmaking Influence of longwall void width on the predicted subsidence effects’, Mine Subsidence Engineering Consultants (MSEC), Letter to South32 included in their reply to comments from WaterNSW, Sep. 2019.

Figures

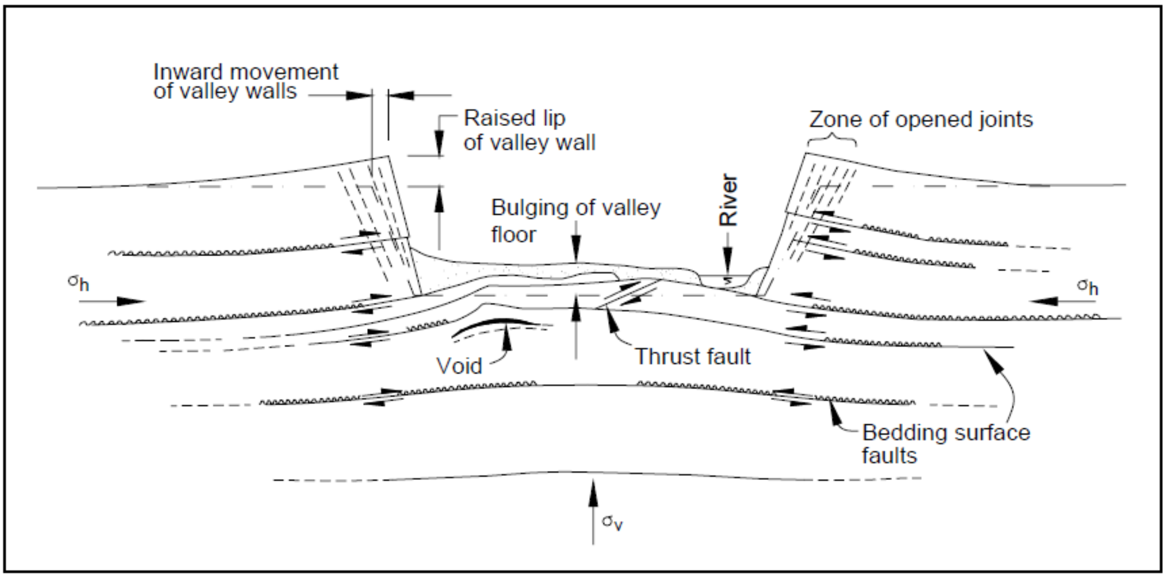

Fig. 1.14 Valley Formation in Flat-Lying Sedimentary Rocks (after Patton and Hendren 1972)

Fig. 1 Depiction of naturally occurring valley closure from a 2007 report by consultants MSEC.[1] Underground mining accelerates and compounds the natural process ,with additional void creation, shearing and fracturing that can extend outward from the valley by tens of metres.

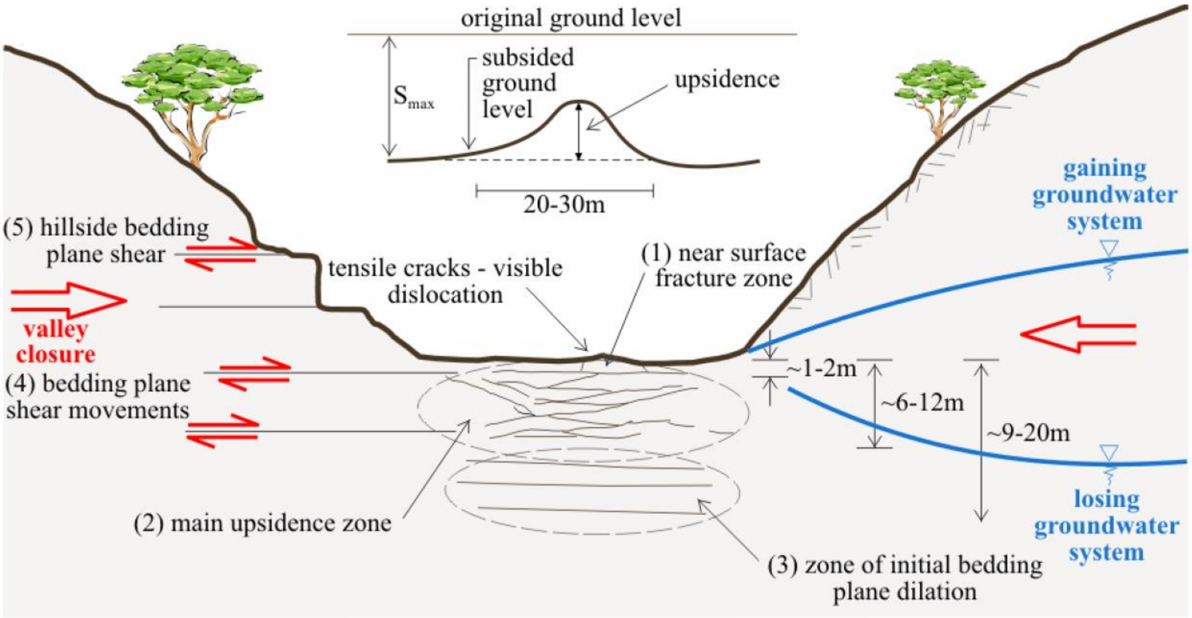

Fig. 2. Depiction of mining induced valley closure and upsidence from Mills.[4] Upsidence typically occurs in a relatively thin band of rock, some 6 to 12 metres, within a 20-30m wide corridor in the centre of the impacted valley.