26 June 2020

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Department of Planning, Industry and Environment
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via email: steve.o'donoghue@planning.nsw.gov.au

Dear Stephen,

RE: DENDROBIUM MINE – INDEPENDENT EXPERT SCIENTIFIC COMMITTEE RESPONSE TO EIS SUBMISSION

In response to the Department's letter dated 20 April 2020, please find enclosed (Enclosure 1) South32's responses to residual comments provided by the Independent Expert Scientific Committee (IESC) in its advice in regard to the *Dendrobium Mine – Plan for the Future: Coal for Steelmaking EIS* (the Project) dated 23 August 2019.

The Project was declared a "controlled action" by a delegate of the Federal Minister on 6 March 2017 (referral EPBC 2017/7855), with "water resources" a relevant controlling provision.

As such, the Commonwealth Department of the Environment and Energy (now the Department of Agriculture, Water and the Environment) and the New South Wales (NSW) Department of Planning, Industry and Environment (DPIE) requested the IESC provide advice in relation to potential impacts to "water resources".

We note the IESC stated in its advice: "…*the surface water assessments have been completed to a high standard and that the subsidence assessments have been completed to a good standard, particularly with respect to the use of existing observations of impacts at other areas of the Dendrobium Mine*".

The IESC also noted: "*However, information and a quantitative analysis needs to be provided on options for variations to the proposed mine plan, such as setbacks from swamps, or variations to longwall width (or other aspects of mine design and geometry) as these appear to be the only viable options, which could be used to reduce the predicted impacts. There is a lack of evidence for there being any other mitigation options that would protect upland swamps and high order streams from irreversible decline."*

The EIS and Submissions Report have considered various longwall layouts for the Project, and it should be noted:

- The proposed Project layout setbacks from dam walls, dam full supply levels, named watercourses and key stream features result in the sterilisation of approximately 25 million tonnes (Mt) of run-of-mine (ROM) coal within South32's existing mining tenement (Consolidated Coal Lease [CCL] 768) (adjacent to Area 5), worth some $3.58 billion and $222 million in associated royalties.

- A longwall layout that avoids undermining Upland Swamps was considered in the EIS (i.e. the 'minimum case'). This longwall layout is not considered to be reasonable given the significant additional resource sterilisation (21.2 Mt of ROM coal in addition to the 25 Mt of ROM coal described above) and reduction in net benefits to NSW of approximately $220 million in net present value (NPV) terms.
- Narrower panels would result in significant adverse impacts to the economic viability of the Project and continued operations of the approved Dendrobium Mine. Economic benefits potentially forgone if the Project does not proceed amount to a net benefit of $1,073 million in NPV terms to NSW.

Accordingly, it is considered that reasonable avoidance measures have already been incorporated into the Project design, with residual impacts to 'water resources' associated with the Project to be addressed as follows:

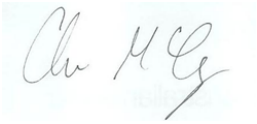
- Predicted surface water losses would be directly and/or indirectly offset to achieve a net gain to metropolitan water supplies.
- Residual potential impacts to Upland Swamps would be offset as per the Swamp Offset Policy.
- Residual potential impacts to relevant threated species with habitat that may be potentially affected by reductions in stream flow and/or impacts to swamps due to subsidence-related impacts from the Project would be offset in accordance with Government Policy.

Further detail is provided in the enclosed response.

If you have any queries please don't hesitate to contact me (Chris.McEvoy@south32.net or 0407 060 163).

Yours sincerely

SOUTH32 LIMITED



Chris McEvoy
Approvals Manager
Dendrobium Next Domain Project

ENCLOSURE 1

RESPONSE TO IESC COMMENTS

INDEPENDENT EXPERT SCIENTIFIC COMMITTEE (IESC)

Comment 1

IESC stated:

> *… information and a quantitative analysis needs to be provided on options for variations to the proposed mine plan, such as setbacks from swamps, or variations to longwall width (or other aspects of mine design and geometry) as these appear to be the only viable options, which could be used to reduce the predicted impacts.*

South32 Response

Consideration of Alternate Mining Geometry

South32 has considered various mining geometries in design of the Project, including panel widths of less than the proposed 305 metre (m) wide panels.

However, observations at the Dendrobium Mine and other mining operations shows that surface impacts related to subsidence (e.g. at watercourses and Upland Swamps) can occur at panel widths significantly narrower than 305 m (Section 6.5.3 of the Submissions Report and MSEC [2019a]).

Accordingly, adverse environmental impacts are still anticipated for reduced longwall widths down to approximately 150 m.

Therefore, the continuation of 305 m wide panels avoids further Project value loss and coal sterilisation when compared to mining with narrower longwall panels (e.g. due to reduced operational costs and increased coal recovery) and is consistent with previous mining experience at the Dendrobium Mine.

In regard to Upland Swamps, no material difference in the potential for impacts to Upland Swamps associated with alternative longwall widths is expected (Section 6.9.3 of the Submissions Report).

Setbacks from Built and Natural Features

South32 has incorporated a number of setbacks from built and natural features in the Project longwall layout:

- minimum 1,000 m setback from the Project longwalls (secondary extraction) to the Avon and Cordeaux dam walls;
- 300 m setback from the Avon and Cordeaux Reservoir full supply levels (FSL);
- setbacks from named watercourses (i.e. Avon River, Cordeaux River and Donalds Castle Creek) such that additional Project-related closure is restricted to 200 millimetres (mm); and
- setbacks from key stream features identified by South32.

The consequence of South32's decision to incorporate these setbacks is the sterilisation of approximately 25 Mt of ROM coal within South32's existing mining tenement (CCL 768) (adjacent to Area 5), worth some $3.58 billion and $222 million in associated royalties.

The Project EIS considered a 'minimum' case longwall layout which in addition to the mine design constraints adopted for the Project longwall layout which included setbacks from all Upland Swamps (Section 9.2.1 of the Project EIS).

However, it is not economically feasible to avoid the undermining of all Upland Swamps located within the Project area. While no specific setbacks were incorporated into the Project mine design from Upland Swamps a number of design considerations have been incorporated by South32 for the Project to avoid potential subsidence impacts (Section 6.9.3 of the Submissions Report):

- selection of Project Area 5 and Area 6 as opposed to Area 4 (due to the large number of swamps located within Area 4);
- siting surface infrastructure to avoid direct impacts to Upland Swamps (other than minor disturbance associated with the installation of monitoring equipment); and
- the various mine design constraints (i.e. setbacks from dam walls, reservoir FSLs, named watercourses and key stream features) would result in the direct avoidance of a number of Upland Swamps.

Residual impacts to Upland Swamps would be offset consistent with Government policy. Since lodgement of the EIS, South32 has purchased freehold land ('the Offset Property') which predominately comprises mapped upland swamp vegetation communities.

Comment 2

IESC stated:

> *Given the evidence for irreversible impacts on upland swamps elsewhere in the Southern Coalfield then further information and evidence to support the likely success of proposed remediation measures for swamps and streams (e.g. grouting and flow dispersion structures) is needed. To the IESC's knowledge there are no peer-reviewed publicly available reports to indicate that any such remediation attempts have been successful.*

South32 Response

Monitoring of Upland Swamps

South32 has undertaken monitoring of Upland Swamps within 400 m of longwalls since 2003, as well as monitoring of relevant control swamps. This monitoring focuses on vegetation change (floristic plots and photo monitoring) augmented with piezometer water level data and Airborne Laser Survey. This monitoring program collects data for 20 Upland Swamps at the Dendrobium Mine.

An assessment of monitoring data for impacted swamps within Dendrobium Area 3B is presented in Section 4.3 of the Surface Water Assessment (Appendix C of the EIS).

Watershed HydroGeo (2019) completed a detailed analysis of Upland Swamp shallow piezometer data for Dendrobium Mine Areas 2, 3A and 3B (Appendix 12 of Appendix D of the EIS).

The analysis of groundwater data found that almost all Upland Swamps directly above or within 60 m of previously-mined longwall panels exhibited a response (either as a reduction in the water level in the swamp and/or change in recession rate) greater than the 'negligible environmental consequences' criteria provided in the Swamp Offset Policy.

In regard to vegetation changes, a review undertaken by Niche (2019) of the monitoring data collected during the previous 11.5 years in Area 2, 7.5 years in Area 3A and 4.5 years in Area 3B did not conclude there is a strong link between subsidence effects and upland swamp vegetation response.

The Swamp Offset Policy also provides:

> *It is recognised that the impact of altering the hydrological regime within Coastal Upland Swamps is not equivalent to removing all vegetation …*

It is noted that, while no strong links between subsidence effects and vegetation response have been identified, the time between the impact and vegetative response may not be immediate and, therefore, not yet detected.

Vegetation monitoring of Swamp 15b, for example, which was undermined in 2010, confirms Upland Swamp vegetation persists following subsidence-related impacts (Plates 6-9A and 6-9B).

Plates 6-9A and 6-9B – Swamp Den 15b - Nine Years after Undermining
Source: Niche (2019).

Remediation of Upland Swamps

Please refer to response to Comment 1 above regarding avoidance of Upland Swamps and proposed offsetting measures.

In regard to swamp remediation, South32 is undertaking research into swamp rehabilitation for the approved Dendrobium Mine in accordance with the Area 3B Subsidence Management Plan (SMP) Approval conditions. This research is described in the *Dendrobium Area 3B Swamp Impact, Monitoring, Management and Contingency Plan* (South32, 2019a) and *Dendrobium Area 3B Swamp Rehabilitation Research Program* (South32, 2016).

Impacts to Upland Swamps for the Project would be offset in accordance with the Swamp Offset Policy. As such, swamp remediation would only be undertaken if current swamp rehabilitation research efforts for the approved Dendrobium Mine are successful, as described above, and the offset liability for the Project could be reduced accordingly.

Stream Remediation

South32 would implement remediation measures to mitigate physical damage to the named watercourses and key stream features where monitoring indicates that subsidence-related impacts have occurred as a result of the Project.

Remediation measures would be consistent with the existing mitigation and remediation measures described in the approved *Watercourse Impact, Monitoring, Management and Contingency Plan* (South32, 2019b), which would be reviewed and updated for the Project.

Examples of potential remediation works for physical impacts to streams that would be undertaken by South32 include remediation of surface and bedrock fracturing through surface sealing and injection grouting.

South32 would also use an adaptive management approach to incorporate any learnings and experience from existing Dendrobium Mine operations (e.g. results from rehabilitation trials) and other mining operations in the implementation of Project remediation and management works, for example:

- South32 is currently in consultation with Government agencies regarding the finalisation of trial rehabilitation for the undermined tributary WC21 at Dendrobium Mine;

- South32's rehabilitation plan for the Georges River (at the Bulli Seam Operations) is likely to be finalised in 2020, and would involve injection grouting at a number of sites to remediate subsidence impacts; and
- results of stream remediation undertaken at Tahmoor and Metropolitan Mines.

Stream remediation has been successfully undertaken at other mines in the Southern Coalfield, as noted by the Independent Expert Panel (IEP) Part 2 (2019b) report:

> *6.1.7 Remediation*
>
> - *Remediation efforts do not restore the entire watercourse to pre-impact conditions, but may restore water holding capacity to some rockbars and pools in streambeds.*
> - *Based on field observations and some submissions, the Panel considers that the PUR remediation technique used in Waratah Rivulet has been successful for restoring pool levels.*

Specifically, in regard to stream remediation undertaken at the Metropolitan Mine, the IEP (2019a) notes:

> *For Waratah Rivulet this has resulted in remediation of cracks in rockbars by grouting which, in terms of restoring pools, has been successful.*
>
> *…*
>
> *The Peabody (Metropolitan Mine) submission states that the PUR injection into the rockbars WRS3 and WRS4 on Waratah Rivulet has restored pool levels to pre-impact levels over time.[63] WaterNSW agreed that the remedial grouting has been successful in restoring a substantial proportion of natural flows, but commented that the actual proportion of natural flow cannot be quantified due to inadequate baseline monitoring and a lack of any agreed remedial success methodology.*
>
> *…*
>
> *Panel members who had walked Waratah Rivulet before remediation were impressed with the visual improvement in ecological values and water quality on the day of the field visit but, like WaterNSW, recognised that the extent of restoration of natural flow and ecological values could not be quantified due to a lack of baseline data.*

Further to remediation efforts, relevant performance measures and Trigger Action Response Plans (TARPs) for subsidence impacts on streams would be developed in consideration of the following:

- monitoring data from the Dendrobium Mine;
- existing SMP approvals; and
- in consideration of any Development Consent issued for the Project.

These performance measures and TARPs would be outlined in Extraction Plans developed for the Project longwalls.

Comment 3

IESC stated:

> *The irreversible impacts associated with near surface cracking and near surface ground movement requires further investigation, including additional monitoring, field investigations and analyses. For example, the limitations of using an equivalent porous medium (EPM) modelling approach in a highly disturbed or fractured area should be addressed.*

South32 Response

South32 agrees with the recommendation to continue research and investigation into surface cracking and ground movements as a result of mining related subsidence. South32 has conducted extensive investigations to this effect, including pre- and post-mining investigations at a number of sites (approximately 8-10 sites) located directly above longwall panels, as well as analysis of bore data to investigate the effect of ground movements adjacent to longwalls.

Notwithstanding, it is noted that the Project groundwater model conservatively assumed that the depth of surface cracking is 10 times the maximum longwall cutting height, which is greater than modelled depths of surface cracking simulated in other groundwater studies (e.g. 20-30 metres [m] for Springvale Mine).

Section 4.3.3 of the Australian Groundwater Modelling Guidelines (AGMG) states that "*Fractured rock aquifers are commonly modelled as equivalent porous media and this assumption is usually valid for large-scale groundwater flow models*". The AGMG also notes that dual porosity simulation (of matrix and fractures) is possible.

Turnadge, Mallants and Peeters (2019) also indicate that equivalent porous medium (EPM) simulation is appropriate for representing fracturing, and that explicit dual porosity simulation is uncommon and typically only applied in specific applications (coal seam gas applications). South32 considers that the application of EPM methods is appropriate, in particular at the regional scale of the Project EIS model. This method has been used successfully to predict groundwater level drawdown that reflects observed groundwater level drawdown in shallow piezometers adjacent to undermined creeks in other mines in the Southern Coalfield.

Comment 4

IESC stated:

> *Further information regarding the groundwater impact predictive scenarios (HydroSimulations 2019, pp. 91 – 92) and sensitivity analysis (HydroSimulations 2019, pp. 104 – 108) should also be provided to allow comparison of predicted results from a revised mine plan.*

South32 Response

The various predictive scenarios modelled assessed the effects of Project Areas 5 and 6, the Dendrobium Mine as well as cumulative impacts, and are not representative of alternative or revised mine plans (refer pp.91-92 of the Groundwater Assessment [Appendix B of the EIS]).

The respective scenarios were modelled to allow for predicted impacts to be calculated through the differences between each scenario. Table 8-1 of the Groundwater Assessment (Appendix B of the EIS) described the predictive scenarios modelled (reproduced below in Table 1).

Thus, comparison (via subtraction) of model results, for example, from Scenario A (full impact) and Scenario B (baseline – approved mining) allows the impact of the proposed Project extension into Area 5 and Area 6 to be estimated.

In addition, HydroSimulations (2019) conducted groundwater model uncertainty analysis by adopting a suite of deterministic scenarios, as per the *Update to IESC Information Guidelines* (IESC, 2018) and *Draft Explanatory Note on Uncertainty* (Middlemis and Peeters, 2018), which tests a number of changes to model properties (e.g. hydraulic conductivity and storage properties).

The Project groundwater model simulates a larger number of geotechnical changes than other groundwater models for NSW mining operations, and as such, a practical modelling method has been adopted (i.e. rather than calibration-constrained Monte Carlo analysis). This approach is supported by the IEP (2019b), who state the following in regard to quantitative uncertainty analysis:

> *"this requires careful consideration of achieving the suitable balance between model complexity and robustness of the quantitative uncertainty analysis (the complexity and computational burden of the current models may not permit the more comprehensive approaches to quantitative uncertainty analysis)".*

The groundwater model would continue to be updated as the Project mine layout is refined during the development of Extraction Plans for the Project (e.g. as a result of mine design setbacks, adaptive management etc.). Consistent with the recommendations of Dr Frans Kalf (Attachment 5 of the EIS) a full review of the groundwater model would be conducted every 3 to 5 years, including comparison (verification) of monitoring data against predictions and recalibration of the model if necessary.

Table 1: Summary of Predictive Scenarios

Scenario	Name	Dendrobium Mining Area				Other Mines	Comment
		Area 1-3B	Area 3C	Area 5	Area 6		
A	Full Impact	Y	Y	Y	Y	All	-
B	Baseline – Approved	Y	Y	N	N	All	Scenario A less Scenario B gives effects of Areas 5 and 6
C	Baseline – Other Mines	N	N	N	N	All	Scenario A less Scenario C gives effects of all Dendrobium and Project mining areas
D	Baseline – Natural ("Null")	N	N	N	N	None	Scenario A less Scenario D gives cumulative impacts
E	Historical Mining	Y (to end of LW14)	N	N	N	Y (to end of 2018)	Existing effects within the hydrogeological system

Comment 5

IESC stated:

> *The characterisation of geological structures and lineaments requires further consideration. This is needed to fully understand potential impacts to water assets in the region, and to allow the development of appropriate trigger-action response plans (TARPs).*

South32 Response

An investigation of geological structures (e.g. lineaments, faults, igneous intrusions and dykes) within Areas 5 and 6 was undertaken by Pells Sullivan Meynink (PSM) (2019) and is included in Appendix P of the EIS.

Following review of site-specific investigations undertaken by South32 as well as published data, PSM (2019) concluded that based on the information available, there is no strong evidence suggesting there are geological structures persistent from seam to surface that would be affected by Areas 5 or 6 mine subsidence.

South32 would continue to refine the identification of geological structures based on the ongoing investigations at the Dendrobium Mine (e.g. surface-based and in-seam exploration) and during the development of first workings and ongoing operations for the Project (Appendix P of the EIS).

The Project longwall layout would be reviewed based on the progressive update to the geological information available as a result of the ongoing investigations and, if required, will be modified to avoid the major geological features during the preparation of the Extraction Plans for the Project.

The groundwater model for the Project would continue to be updated to incorporate the latest geological information in consideration of potential impacts to water assets (i.e. the Avon and Cordeaux dams).

Comment 6

IESC stated:

> *The potential impacts from localised changes on ecological components of water resources also require further investigation and discussion to enable the development of appropriate monitoring, management and mitigation measures. The additional work should also consider how the predicted changes to water regimes will alter water quality.*

South32 Response

South32 agrees with the IESC's comment and would develop appropriate monitoring, management and mitigation measures for aquatic ecology in consultation with relevant agency stakeholders. In regard to water quality, the existing *Watercourse Impact, Monitoring, Management and Contingency Plan* (South32, 2019b), would be reviewed and updated for the Project. Further detail regarding potential impacts to water quality are described in Comment 20.

Potential impacts to aquatic ecology in the ephemeral drainage lines located directly above the proposed longwalls have been assessed on the basis that the full range of subsidence movements and subsidence impacts may occur.

Potential subsidence impacts resulting in changes to the availability of ephemeral aquatic habitat are not expected to result in any significant impacts to overall aquatic ecology, due to the limited value of habitat within ephemeral drainage lines (Cardno, 2019).

No significant impacts to aquatic ecology in watercourses downstream of the Project area or Avon Dam are predicted as a result of subsidence-related surface water diversion (Appendix E of the EIS), noting that flows in the Avon River and Cordeaux River are controlled by releases from the Avon Dam and Cordeaux Dam, respectively.

Potential subsidence-related impacts to aquatic ecology, as a result of changes in surface water quality, would be minor and short-term (Cardno, 2019).

For relevant fauna species listed under the NSW *Biodiversity Conservation Act, 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) that potentially have habitat along streams/swamps overlying the Project underground areas, biodiversity offsets are proposed to account for potential subsidence-related impacts to streams and the associated consequences to streamflow and habitat for these species.

As described above (refer to response to Comment 2), South32 would implement appropriate stream remediation measures to mitigate physical damage to the named watercourses and key stream features where monitoring indicates that subsidence-related impacts have occurred as a result of the Project.

Remediation measures would be based on the existing mitigation and remediation measures described in the approved *Watercourse Impact, Monitoring, Management and Contingency Plan* (South32, 2019b), which would be reviewed and updated for the Project.

South32 would also use an adaptive management approach to incorporate any learnings and experience from existing Dendrobium Mine operations (e.g. results from rehabilitation trials) and other mining operations in the implementation of Project remediation and management works.

Comment 7

IESC stated:

> a. *not all 26 swamps in Areas 5 and 6 are currently being monitored, potentially limiting swamp-specific information on their current condition. Baseline surveys (of suitable spatial and temporal extent – see response to question 12) of all swamps should be completed before any longwall approaches within 400 m of a swamp (i.e. before impacts due to ground movement occurs at the swamp).*

South32 Response

Baseline water level (including both perched aquifer and Hawkesbury Sandstone groundwater level) and soil moisture monitoring has been undertaken by South32 within underground mining Area 5 and Area 6 since 2017 (Figure 1).

Baseline surface water and groundwater monitoring (including shallow piezometers and soil moisture probes) of Upland Swamps within 400 m of the proposed Project longwalls would be undertaken for the Project to ensure greater than 2 years of baseline data is obtained.

In addition, as recommended by the IEP (2019a), paired piezometer monitoring is in place for key swamps within the current mining area and all swamps in Area 5 and Area 6, and is specified in the Project Surface Water Assessment (refer to Table 20 of Appendix C of the EIS).

Upland Swamp monitoring would be detailed in the Extraction Plans for the Project, and would include subsidence, surface water, groundwater and vegetation composition.

Comment 8

IESC stated:

> *The installation of six flow gauging sites within the proposed expansion area is commended. Ongoing monitoring needs to be supported by periodic review of the rating curves. The current monitoring of groundwater levels adjacent to swamps also provides useful baseline data. Additional gauges will need to be installed and monitored to include control sites that are not impacted by the project.*

South32 Response

South32 maintains an extensive surface water monitoring network, including stream flow monitoring of a number of ephemeral drainage lines proximal to Area 5 and Area 6 (refer to Figure 6-3C of the Submissions Report).

Consistent with the recommendations of the Surface Water Assessment for the Project (Appendix C of the EIS), the existing Area 5 and Area 6 surface water monitoring networks would be expanded and augmented for the Project, the details of which would be provided in Extraction Plans for the Project.

As identified in Dendrobium's *Area 3B Watercourse Impact, Monitoring, Management and Contingency Plan* (South32, 2019b), two primary and two secondary 'reference' sites are used for comparative analysis. South32 has recently installed an additional two potential reference sites proximal to Cordeaux Dam.

Surface water monitoring at the Dendrobium Mine has recently undergone an audit, including review of data-gathering procedures, data management and rating curve development. WaterNSW has recently provided South32 approval to install more gauges in the catchment. Review of rating curves would be ongoing at the Dendrobium Mine and for the Project.

South32 would continue to engage with WaterNSW regarding flow gauge upgrades and (if as a result it is determined) would implement actions that are identified as being required during the Extraction Plan stage of the Project.

Comment 9

IESC stated:

> *The estimates of surface subsidence are largely based on the use of an empirical method (Incremental Profile Method (IPM)) and numerical modelling (UDEC). While this method might be appropriate to estimate subsidence at the longwall scale, it is noted that the model materially underestimates observations of local ground movement within watercourses and near faults. Accordingly, the IESC has little confidence in the estimates of non-conventional subsidence at the local scale (and other associated ground movements) in areas that are most vulnerable to ecological decline.*

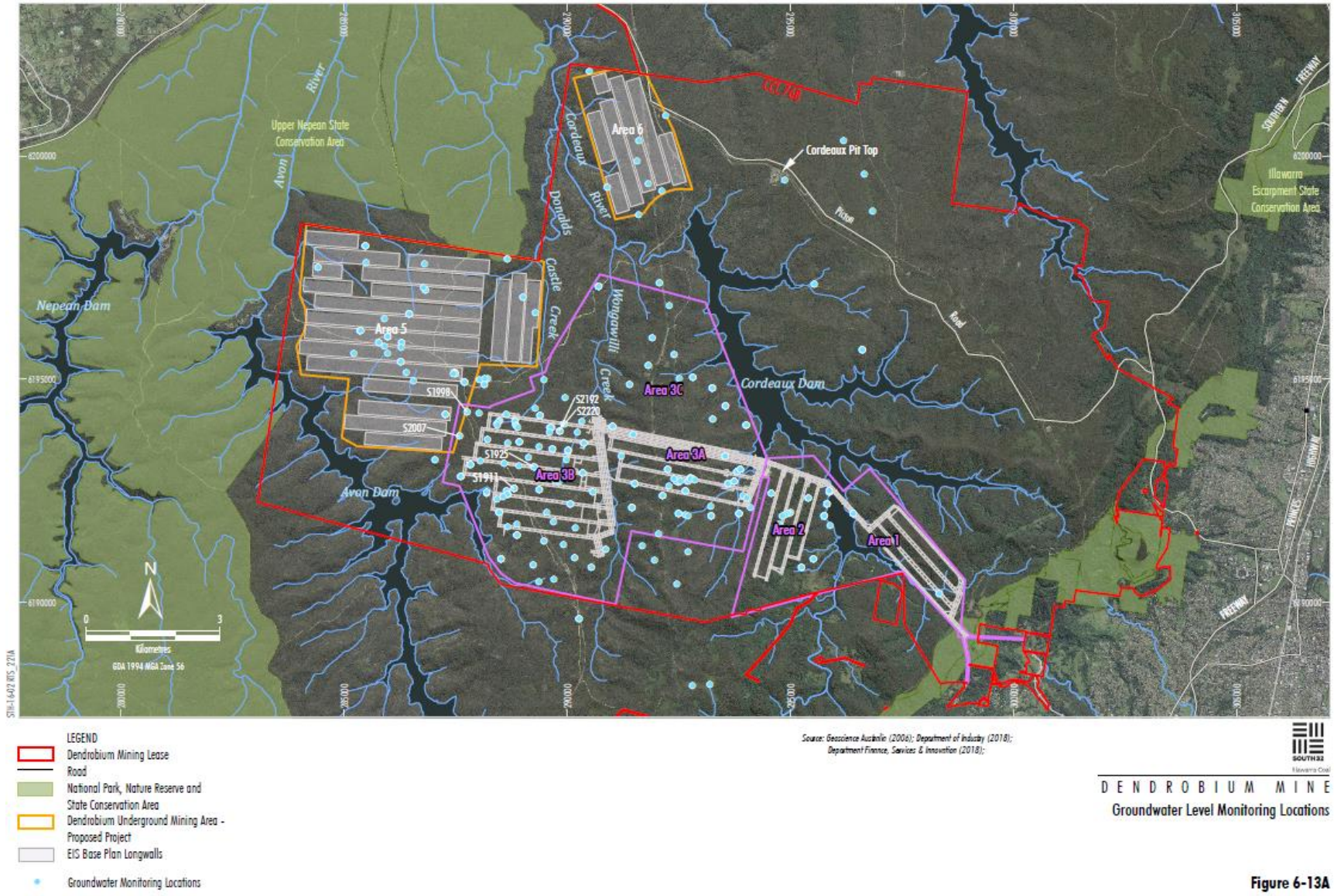


Figure 1 – Groundwater Level Monitoring Locations

South32 Response

Mine Subsidence Engineering Consultants (MSEC) has employed best practice subsidence modelling methodologies for the prediction and assessment of mine subsidence movements and potential subsidence impacts for the Project using the Incremental Profile Method (IPM).

The IPM has been used throughout the life of the Dendrobium Mine and has been calibrated to incorporate monitoring data from Dendrobium Mine Areas 1, 2, 3A and 3B. This approach and calibration of the model to monitoring data from the Dendrobium Mine for the Project is supported by the IESC (Section 6.5.3 of the Submissions Report).

Since model re-calibration to account for historical underpredictions, the IPM model used at the Dendrobium Mine has shown that subsidence movements observed at Dendrobium Mine are typically less than the subsidence predictions, and provides reasonable, if not, conservative predictions of the conventional and non-conventional subsidence effects (Section 6.5.3 of the Submissions Report).

The Subsidence Assessment (Appendix A of the EIS) also employed best-practice modelling methodologies in the prediction of non-conventional subsidence movements (e.g. valley closure and upsidence) for streams within Areas 5 and 6 using the ACARP empirical prediction method.

In addition, MSEC (2019) concluded that geological structures identified in Areas 5 and 6 are unlikely to affect subsidence predictions for these mining areas. This is supported by evidence from Dendrobium Mine Area 3B, where it was identified that there was no apparent increase in subsidence and closure movements measured at the locations where mapped lineaments and geological structures were present, when compared with the predictions and measurements at locations where these mapped features were not present.

Therefore, it is unclear what the basis is for the IESC's comment that "*the model materially underestimates observations of local ground movement within watercourses and near faults"* in regard to the subsidence prediction and assessment undertaken for the Project, as described above.

The EIS states that the ephemeral drainage lines located above the Project longwalls are expected to experience the full range of predicted subsidence movements and potential subsidence impacts and has considered the potential for physical impacts along named watercourses and the unnamed tributaries as a result of Project-related subsidence.

South32 has incorporated setbacks from named watercourses and key stream features to reduce the likelihood of potential subsidence impacts occurring at these relatively significant features.

Prediction of valley related movements and the 'rockbar model' has been used to estimate potential impacts to streams (i.e. setbacks from named watercourses such so that the maximum predicted additional Project closure is limited to 200 mm). The rockbar model has been used successfully at the Dendrobium Mine to date and at other mines in the Southern Coalfield as a setback design tool to significantly minimise the likelihood of impacts.

As a result, the likelihood of potential impacts resulting in fracturing and observable stream flow diversion are predicted to be low (less than 10%) for the small sections of Avon River, Cordeaux River and Donalds Castle Creek within 400 m the Project longwalls.

As described previously, if physical damage to named streams and key stream features occurs due to the Project as a result of subsidence impacts, appropriate remediation techniques would be implemented to repair the physical damage where possible.

Comment 10

IESC stated:

> *The groundwater model developed by the proponent is focused on simulating regional groundwater flows under the assumptions inherent in an equivalent porous media model. This model does not adequately incorporate the impacts of surface cracking and near-surface ground movement. This means the groundwater model does not address what is likely to be the main impact pathway on baseflow in nearby watercourses, and this has implications for assessing likely impacts on aquatic biota and ecological function. Accordingly, the IESC has a low level of confidence in the proponent's estimates of mining impacts on surface water-groundwater interactions.*

South32 Response

South32 does not agree with this comment. Please refer to response to Comment 3 regarding the applicability of EPM modelling methods.

The Project groundwater model adopted a number of conservative assumptions:

- The height of connective fracturing is assumed to extend from the seam to the surface fracture network for the Project longwall panels with void width of 305 m.
- The depth of surface fracturing is assumed to be 10 times the maximum longwall cutting height. This depth is greater than what is assumed in other contemporary groundwater studies.
- The model simulates the connected fracture zone, with model drain boundaries in the model layers from the mined seam up to the top of the assumed connected fracture zone.

In addition, surface water is modelled as being available to be lost at all times in ephemeral tributaries overlying the longwall panels, whereas in reality, the streams experience no to low flow much of the time, particularly during dry periods such as those experienced in 2018 and 2019.

Therefore, the risk of actual impacts (i.e. surface water losses) being significantly greater than those predicted from the groundwater model can be considered low. This conclusion was supported by Dr Frans Kalf in the peer review of the Groundwater Assessment for the Project:

> *KA has no objection to the use of this 'Stacked Drain' method as it has been used by MER [Mackie Environmental Research Pty Ltd] for a number of years and has proved to be suitable. In addition it has been found on some projects by MER to overestimate the mining effects such as drawdown and overall inflow and therefore can be considered to be a conservative overall methodology for determining fracture propagation and associated draining in the geological profile. …*
>
> *… the 'stacked drains' approach by HS would very likely capture most flow and therefore would indeed be conservative with respect to mine inflow.*

Review by DPIE's Independent Reviewer for groundwater modelling carried out for the Tahmoor South EIS (review by HydroGeoLogic [2019]) stated that:

> "*there is further conflation with other spurious issues* [by IESC]*, for example:*
>
> - *incorrectly suggesting that the porous medium modelling methods are inadequate and do not allow for temporal changes to parameters (inconsistent with IEPMC 2018 and the time-varying material properties capability of the modelling software applied in this case)".*

South32 understands that comparable methods for simulating surface cracking were used in the Tahmoor South Project EIS groundwater model as used in the Project EIS groundwater model.

Comment 11

IESC stated:

> *There is an unknown quantity of water lost via tortuous flow paths including fractures and bedding plane separations and shears in deeper strata overlying longwall panels (PSM 2017) and associated peer reviews including Mackie (2017) for a discussion of such processes. Accordingly, it is possible that a component of surface water flows may not be returned to the upland swamps and streams. The implications of this potential water loss for creeks and groundwater-dependent ecosystems during long-term operations and recovery of water levels after closure need to be considered in a manner that bounds the likely upper and lower range of impacts.*

South32 Response

The groundwater model has addressed surface water losses by conservatively assuming surface water from watercourses above the Project longwalls is permanently "lost" to the groundwater system.

The conservative nature of this assumption is that the majority of the surface water losses would be permanently lost from the catchment. The groundwater model also conservatively assumes surface water is always available to be lost from the ephemeral tributaries overlying the Project longwalls, when in reality, these tributaries experience no to low flow during dry periods.

Surface water losses were predicted considering 'dry' and 'wet' climatic conditions, with maximum predicted surface water losses of 1,935 ML/annum.

However, a significant portion of these losses are likely to re-emerge downstream of the mine footprint, as shown by the Area 3B gauging stations.

The conservative nature of this assumption is supported by the following observed effects:

- Loss of surface flow has been observable and discernible at stream flow gauges located immediately above or downstream of Area 3B (e.g. WC21, DC13S1 and DCS2). Losses at these sites can be significant, with reductions in median flow being approximately 50-80% of pre-mining median flow. Much of the effect is on low-flows, evidenced by increases in the number of cease-to-flow days in undermined sub-catchments. Such changes are considered likely to be permanent until the results of rehabilitation trials are analysed.
- For example, with respect to Donalds Castle Creek (DCU), the reduction in median flow at DC13S1 and DCS2 represents approximately 45 to 60% of median flow at the downstream gauge DCU. If the losses at DC13S1 and DCS2 were permanently lost from the catchment, then this reduction should be apparent at DCU (which is not the case). This indicates that the majority of the flow lost in the headwaters does re-emerge downstream. This does not equate to a finding that there is no change in the pattern of flow at DCU, because some changes to very low flows are likely, however the consistency of median flow is an indicator that the overall volume of flow is the same (Figure 2).
- However, corresponding changes in surface water flow at gauges further downstream were not discernible (i.e. DCU and WWL). This indicates that some portion of localised losses at WC21, DC13S1 and DCS2 re-emerged downstream and/or the volume of water lost was insignificant compared to the total flow at the downstream gauging stations (see Appendix B of the Project EIS as well as recent analysis in Watershed HydroGeo, 2019).

Therefore, the groundwater model assumption that stream flow diversion is permanently lost is likely conservative (due to observations at the downstream gauges in Area 3B).

The Groundwater Assessment (Appendix B of the EIS) predicted that groundwater levels would recover to pre-mining levels over a period of several decades, following the cessation of the Project. As groundwater levels recover over time, predicted surface water losses are also anticipated to reduce post-mining.

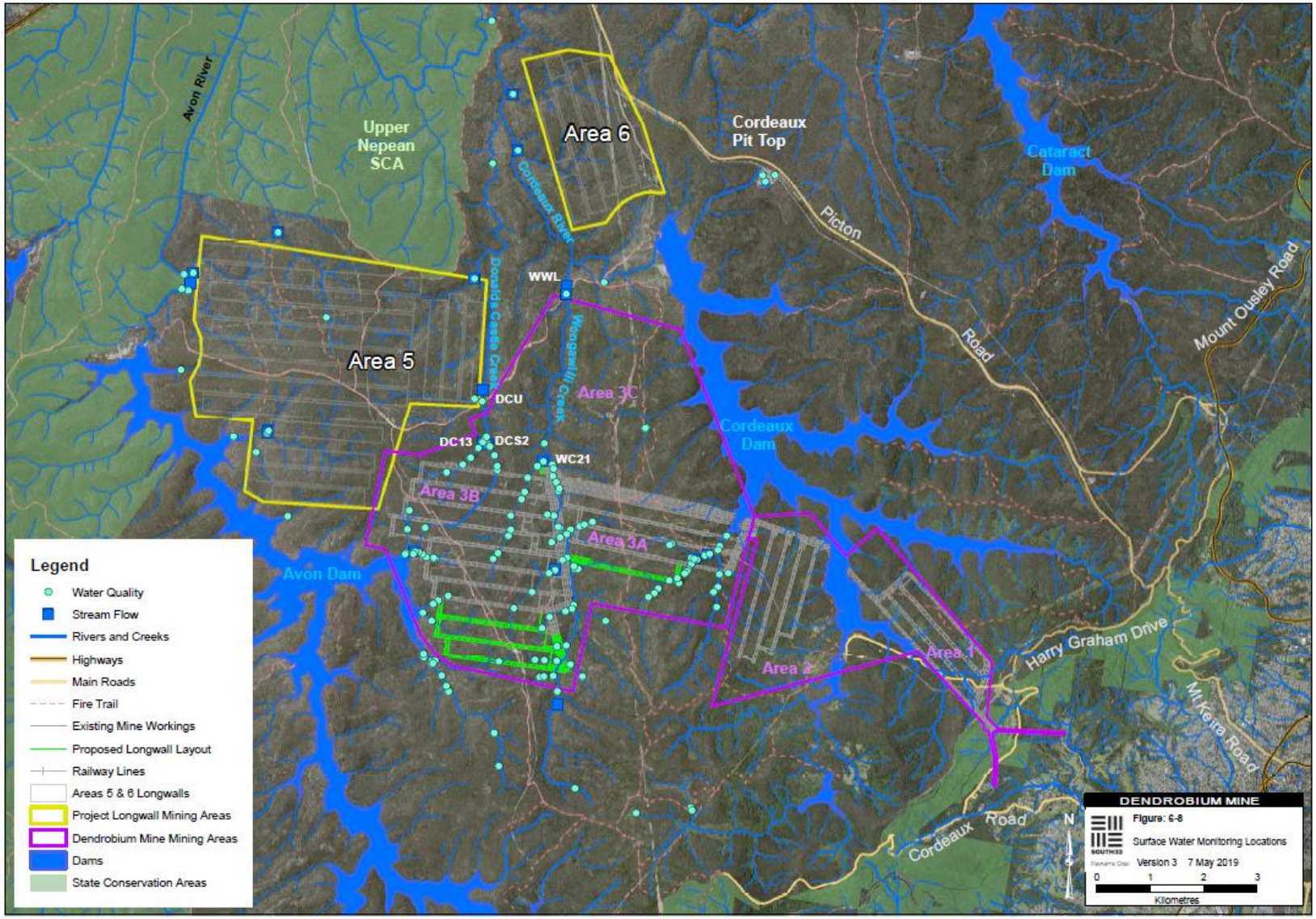


Figure 2 – Surface Water Flow Monitoring Locations

Comment 12

IESC stated:

> *The location of all monitoring bores that contributed to the model should be clearly displayed. The IESC notes that there are no multi-level piezometers above the coal seams in Area 6. In relation to Areas 5 and 6, monitoring is limited north of the proposed mine areas, and between the proposed mining areas and Lake Avon and Lake Cordeaux.*

South32 Response

Groundwater monitoring bores for which data was obtained and used in the groundwater model are shown in Figures A1 and A2 in Appendix A of the Groundwater Assessment, which are reproduced below (Figures 3 and 4) (Appendix B of the Project).

With respect to Area 6, South32 has installed a number of 'shallow sandstone' monitoring bores proximal to swamps, which monitor multiple horizons within the Hawkesbury Sandstone. The data obtained from these sites extends back to 2018 but was not available at the time of the EIS modelling, however, this data shows a good match with modelled groundwater levels.

Similar to the extensive monitoring effort within Area 3B, additional monitoring of the full stratigraphic sequence down to the coal seam, as well as specific monitoring of the HBSS and BGSS between the mining footprint and reservoirs and major watercourses, would be carried out in Area 5 and Area 6 subject to approval of the Project.

This would include the implementation of multi-level piezometers on the centreline of panels for the Project, with at least five transducers per borehole. More than two years of data would be obtained prior to undermining where practicable (for example, it may not be practical to drill piezometers at every longwall in the Metropolitan Special Area due to surface constraints).

Comment 13

IESC stated:

> *The groundwater model has not adequately simulated the dynamic changes in hydraulic properties associated with mining-induced ground movement under streams. Results from the sensitivity analysis (HydroSimulations 2019, pp. 104 – 108) should be clearly displayed or compared.*

South32 Response

Please refer to response to Comment 10 regarding the modelling of near surface dynamics (including modelling assumptions adopted) and potential surface water losses.

South32 considers the number of modes of geotechnical processes (i.e. connected fracturing, surface cracking and off-goaf deformation processes) simulated by the Project groundwater model to be more than that simulated by most other groundwater models in NSW (which is commensurate with risk).

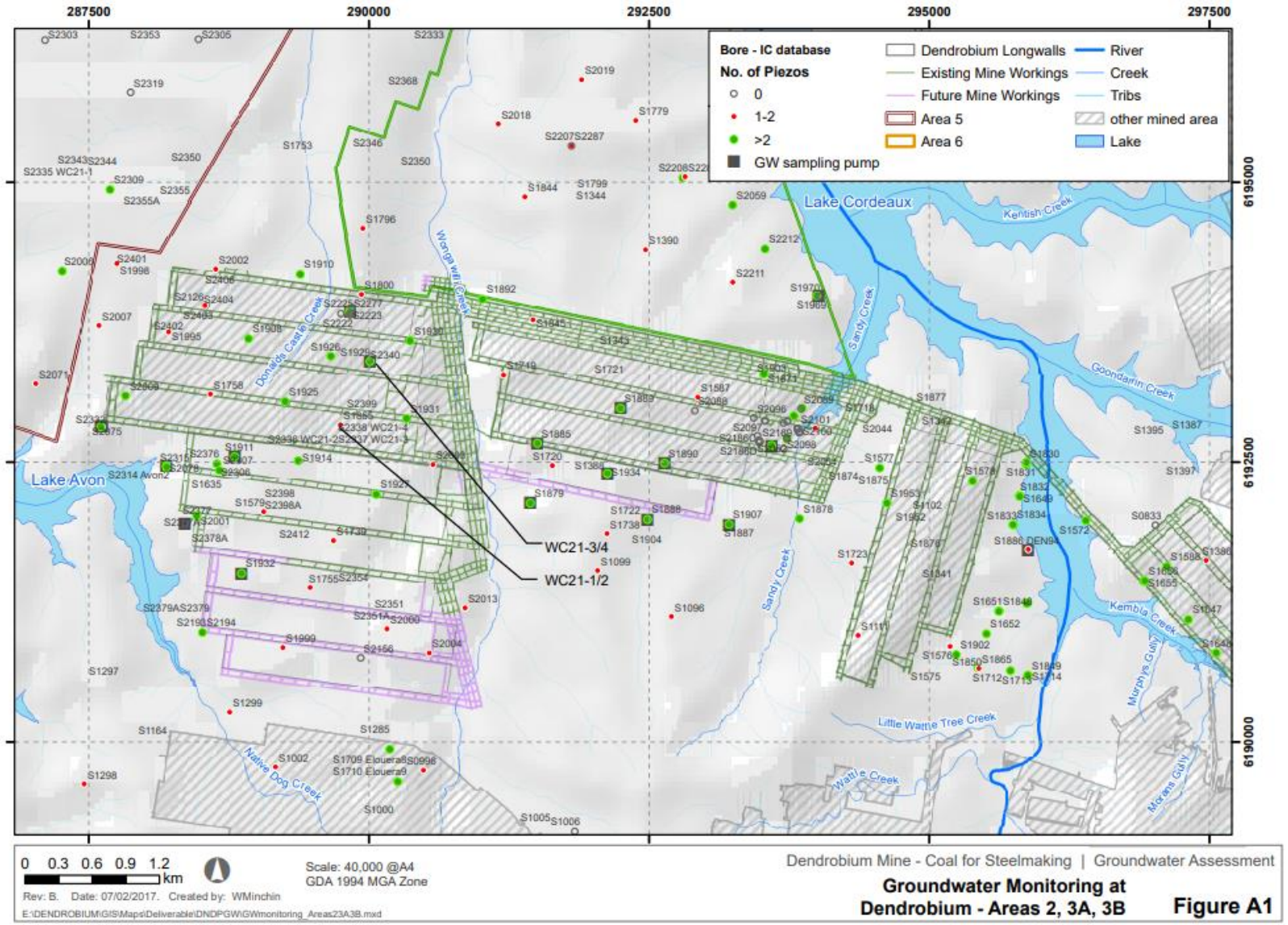


Figure 3 – Groundwater Monitoring at Dendrobium Areas 2, 3A and 3B (Source: Appendix B of EIS)

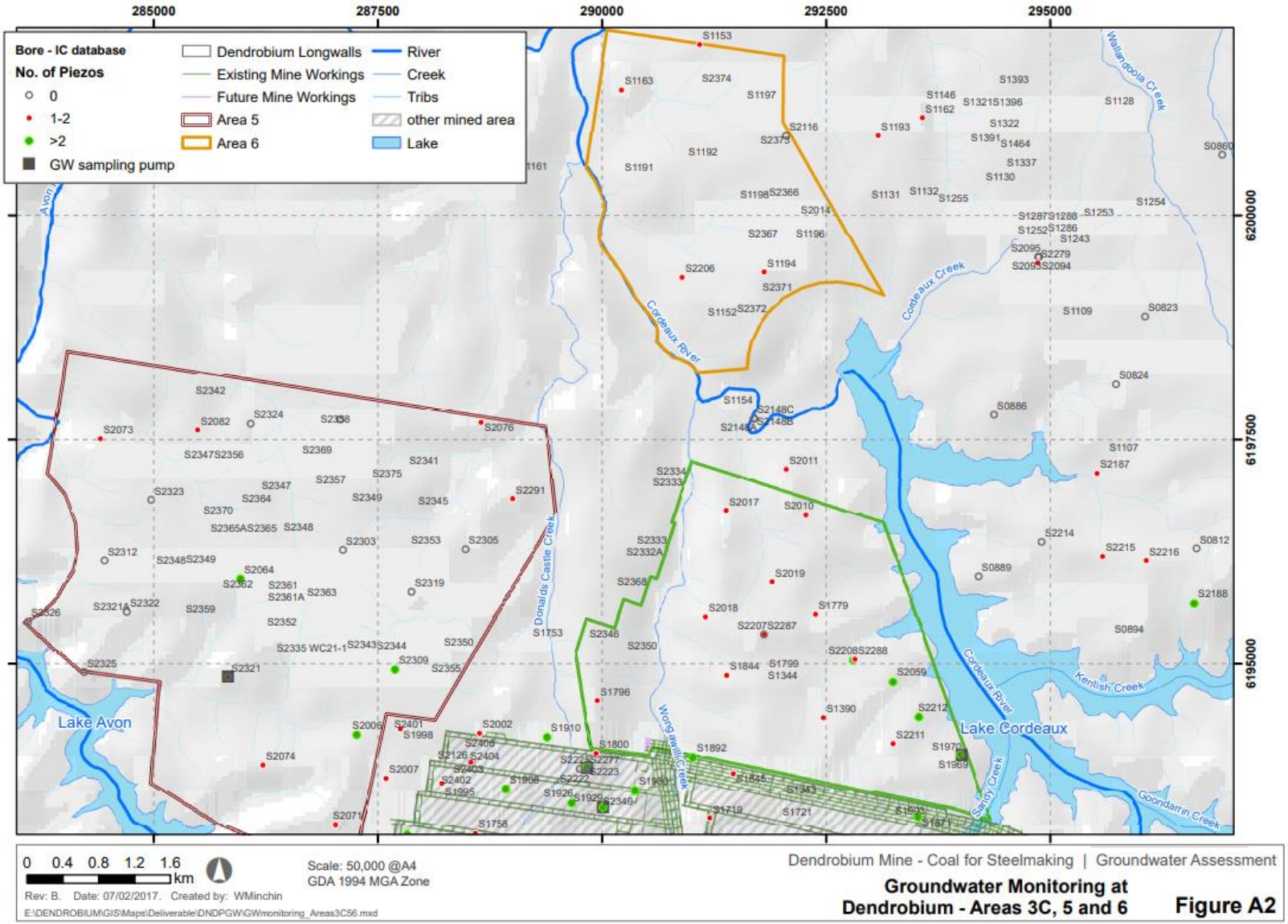


Figure 4 – Groundwater Monitoring at Dendrobium Area 3C and Project Areas 5 and 6 (Source: Appendix B of EIS)

Comment 14

IESC stated:

> *… it is not clear whether the hydraulic parameters used within the model are consistent with all available information. For example, the Bald Hill Claystone has similar hydraulic conductivity to adjacent strata (HydroSimulations 2019, Figures 4-2 – 4-8, pp. 145 - 151) and thus may not be an effective regional aquitard, particularly where ground movement due to mining occurs.*
>
> *i. The Bald Hill Claystone (Kh: 1.0 x 10-5 m/day) and Stanwell Park Claystone (Kh: 3.0 x 10-5 m/day; Kv: 6 x 10-6 m/day) are traditionally considered to act as regional aquitards and limit the vertical flow of water between the Hawkesbury Sandstone and the Bulgo and Scarborough sandstones of the Narrabeen Group (Herron et al. 2018). However, it is not clear whether the hydraulic parameters used within the model are consistent with all available information. For example, the Bald Hill Claystone has similar hydraulic conductivity to adjacent strata (HydroSimulations 2019, Figures 4-2 – 4-8, pp. 145 - 151) and thus may not be an effective regional aquitard, particularly where ground movement due to mining occurs.*
>
> *ii. Specific storage (Ss) is assumed to be constant in the modelled deformation zones (e.g. surface cracking or underlying strata). However, an increase of Ss that has been observed in these deformed zones (David et al. 2017) indicates that drawdown from overlying aquifers and losses from surface water may not be modelled in a realistic manner by assuming a constant Ss.*

South32 Response

i) Herron *et al* (2018) describes that the Bald Hill Claystone has similar permeability to overlying (e.g. Newport Formation) and underlying units (Bulgo/Colo Vale Sandstone). However, this similarity is mainly associated with horizontal permeability determined from packer testing (e.g. Figure 4-3 of the Project Groundwater Assessment). With respect to the role of a unit as an aquitard, the data on Figure 4-4 of the Project Groundwater Assessment presents core testing data on vertical permeability, and this shows contrast between the Bald Hill and overlying Hawkesbury Sandstone, and much less contrast with the underlying Bulgo Sandstone.

The field data presented is the basis for the selection of model parameters. A comparison of the core testing hydraulic conductivity (Kv) data and the modelled Kv relevant to IESC's comment is presented on Figure 5. This shows that the modelled values are well constrained by field data, and are typically slightly higher than the harmonic mean determined from the field data (i.e. the modelled values were not assigned based on broad descriptions of whether a unit is an "aquifer" or "aquitard").

Further, the modelled Kv for the Stanwell Park Claystone ranges from $2x10^{-6}$ to $3x10^{-5}$ m/d, which is similar to the $6x10^{-6}$ m/d value quoted from Herron *et al*, 2018.

It is important to note that the role of particular units as aquitards is generally reduced or diminished by the effects of subsidence and fracturing above historical and proposed longwalls at Dendrobium Mine (refer to Figure E4 of the Groundwater Assessment).

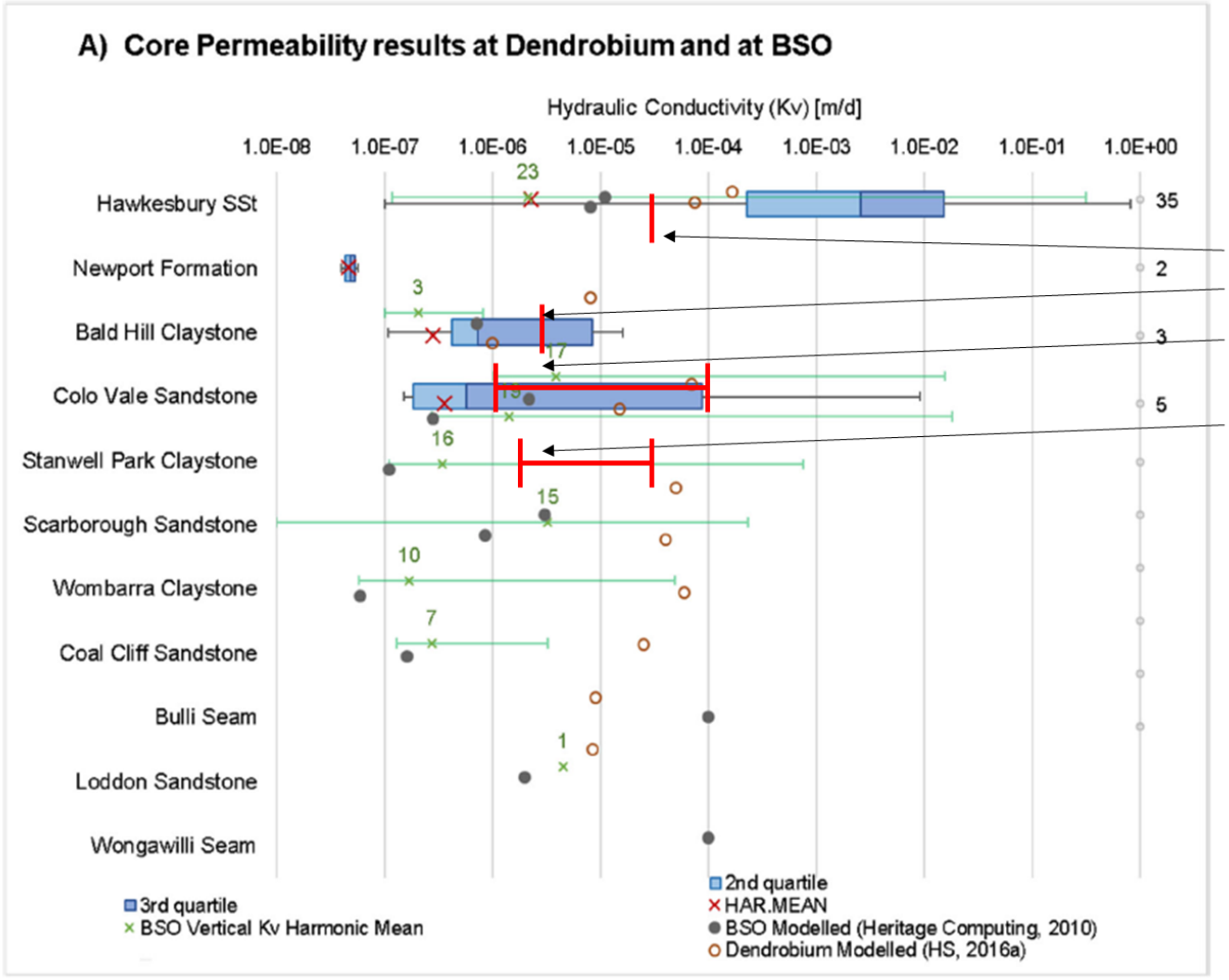
ii) David *et al* (2017) concluded "*drawdown and inflow estimation could be overestimated if constant Ss is assumed*".

The Project Groundwater Assessment (Appendix B of the EIS) assumed constant specific storage (Ss), therefore, an assessment of drawdown would be conservative.

Comment 15

IESC stated:

> *Surface cracking was simulated by assuming a depth of fracturing that was 10 times the longwall cutting height, with the model allowing for increased hydraulic conductivity but not storage. Whilst the depth of cracking may be considered a conservatively high assumption, there is a lack of evidence for the depth of surface cracking, or site data to justify the factors selected for increased horizontal and vertical hydraulic conductivity.*



Modelled

HBSS lower = 3E-5

Bald Hill Clst = 3E-6

Bulgo Sst upper = 1E-6 to 1E-4

Stanwell Park Clst = 2E-6 to 3E-5

Figure 5 – Comparison of Selected Modelled Kv vs Field Data (Source: Appendix B of EIS)

South32 Response

The height of surface cracking adopted for the Project EIS is in good agreement with the approximate depth of the fracture zone (in relation to cutting height) based on observations at nearby mines at Waratah Creek (Mills, 2007) and Redbank Creek (SCT, 2018).

It should be noted that the groundwater model assumed a connective fracture network that extends from the seam to the surface (i.e. the sub-surface fracture network generally interacts with the surface fracture network). Therefore, the surface water losses have been predicted on this basis.

Future updates to the groundwater modelling will incorporate relevant findings from field investigations conducted above longwall panels at Dendrobium Mine (refer to response to Comment 3). Additionally, modelling would be informed by and consider data from observations at other mines in the Southern Coalfield.

Details of future groundwater modelling undertaken for the Project would be specified in Extraction Plans developed for the Project.

Comment 16

IESC stated:

> *… a quantitative comparison of the tritium results with groundwater modelling fluxes layer by layer has not been undertaken to help confirm model predictions.*

South32 Response

South32 is currently investigating the use of tritium sampling results as a secondary calibration target for the groundwater model. Preliminary results from Area 2 and Area 3B (considered to be the 'end members' with respect to inflow behaviour and response to rainfall) suggest that:

- In Area 2, the measured tritium levels can be matched appropriately by the groundwater model.
- In Area 3B, the measured tritium levels are consistently lower than those simulated by the groundwater model. This suggests that the numerical model overestimates the contribution of 'modern water', which implies that the model simulates too much inflow being sourced from the outcropping Hawkesbury Sandstone and surface water. This would support the conservativeness of the EIS model predictions with respect to mine inflow and surface water take.

Consistent with existing operations, South32 would undertake water quality sampling for the Project, targeting tritium and other parameters (as an indicator of the presence of modern water), which would be described in Extraction Plans and Environmental Management Plans for the Project. It is anticipated that a combination of techniques would be used to confirm water pathways and complement the existing chemistry and tritium database for the Project.

Comment 17

IESC stated:

> *There appear to be some inconsistencies between the stratigraphic and modelled typical thicknesses of strata, notably for the Bulgo Sandstone (typically 95 m, modelled as upper and lower units each 40 – 60 m thick) (HydroSimulations 2019, pp. 23, 71) and the Wongawilli seam (the model assumes 4.2 m of the Wongawilli seam will be mined from the floor of the seam, which is 7 – 10 m thick but modelled as 4 – 10 m thick) (HydroSimulations 2019, pp. 25, 71). The materiality of these inconsistencies on modelling results is unclear.*

South32 Response

There are inherent differences between the stratigraphic thicknesses outlined in Table 3-1 (which are a summary of the Southern Coalfield stratigraphy) to those outlined in Table 6-1 of the Groundwater Assessment (Appendix B of the EIS), which have been refined to incorporate site-specific data, and also with some splitting or lumping of stratigraphic units into groundwater model layers (e.g. three layers for the Hawkesbury Sandstone) to allow more appropriate simulation of mining effects and environmental features.

Table 3-1 of the Groundwater Assessment (Appendix B of the EIS) provides a general summary of the typical thickness of the strata of the Southern Coalfield. Figures 3-4 to 3-6 of the Groundwater Assessment present detailed stratigraphic cross-sections showing the variable thickness of the stratigraphic units, based on the Illawarra Coal geological model.

The model layers incorporate site-specific data from the Illawarra Coal geological model (as per Figures 3-4 to 3-6 of the Groundwater Assessment), which is defined by hundreds of data points from exploration drill logs as well as data from other mining operations in the Southern Coalfield (e.g. Tahmoor Mine).

The stratigraphic layering (from the Illawarra Coal geological modelling) and the groundwater model layering are summarised in Tables 3-1 and 6-2 and Figures 3-4 to 3-6 of the Groundwater Assessment (Appendix B of the EIS), as well as Figure 6 which shows groundwater model layering.

With respect to the difference between ~4 m and 7 m thickness for the Wongawilli Seam, within the Dendrobium Mine lease, the groundwater model simulates only the working section (approximately 4 m) of the Wongawilli Seam. In areas away from mining, the model simulated the full thickness of the seam.

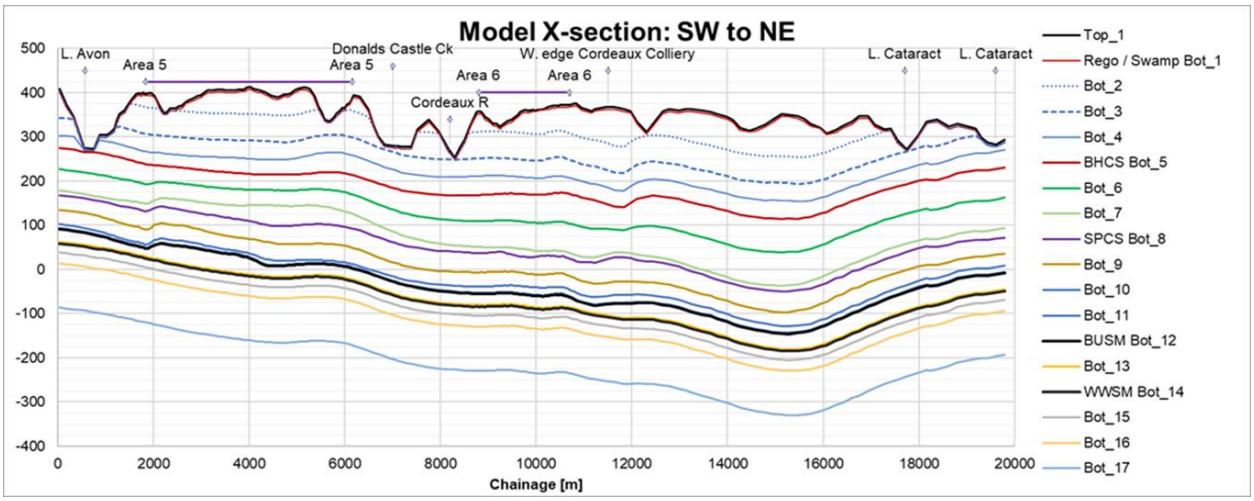


Figure 6 – Groundwater Model Layering (Cross-section SW to NE)

Comment 18

IESC stated:

> *The IESC notes that the regional groundwater model did not attempt to predict local scale impacts relevant to high order streams and swamps. While the impacts on swamps have been estimated using the VADOSE/W model (and validated using monitoring data from Area 3), the impacts to surface water streams (excluding swamp areas) are based on the results from the groundwater modelling. Accordingly, decision makers can have reasonable confidence in the estimates of mining impacts on swamps, but the estimates of impacts on high order streams can be given less confidence as the surface water modelling has relied upon the results provided by the groundwater model.*

South32 Response

The likely effects of the Project on streams considered the results of the groundwater modelling, rainfall runoff modelling and empirical evidence. In summary:

- undermined streams will be affected (reductions in low flow manifesting themselves as an increase in cease-to-flow frequency and duration, and reductions in median flow); and
- down-catchment changes in hydrology can occur, but based on monitoring, such changes are mild and difficult to discern beyond natural variability.

The Surface Water Assessment (HEC, 2019) uses the predictions of the groundwater model as an estimate of potential surface water losses. A rainfall-runoff model was then used to predict changes in flow duration under various rainfall conditions (refer to Section 3.3.2.3 and Figures 39-52 of HEC [2019]).

Comment 19

IESC stated:

> *a. As cross sections used to develop the groundwater model appear to be incomplete in representation of faults and strata thicknesses these need to be revised to be consistent with physical processes of deposition and movement.*
>
> *b. The location of bores used to develop cross sections is unclear. Without this information, it is not possible to validate the cross sections provided.*
>
> *c. A detailed topographic analysis of swamp location and linear structural features should be undertaken. This would help identify which swamps in Areas 5 and 6 are most at risk from anomalous ground movement.*
>
> *d. It is also unclear whether the potentially significant Elouera Fault has been included in the groundwater model. The IESC also notes that aspects of the geological structure review do not appear to be included in the groundwater model, including:*
>
> *i. a significant zone of disturbance described as the Potential Bulli Fault (PSM 2019, pp. 4, 13);*
>
> *ii. three regional faults inferred within Areas 5 and 6 (PSM 2019, p. 12); and*
>
> *iii. faults inferred in drawing 5 (PSM 2019).*

South32 Response

a) PSM (2019) is the primary reference for structural geology used to inform the groundwater model. South32 disagrees that the representation of strata thickness on the cross-sections in the Groundwater Assessment are not "consistent with physical processes of deposition and movement". The modelling of geology in the groundwater model is based on extensive exploration drilling from Dendrobium Mine and neighbouring mines as well as published mapping (e.g. Stroud et al, 1985).

   Groundwater modelling for the Project would continue to be informed by the identification of geological structures based on the ongoing investigations at the Dendrobium Mine and during the development of first workings for the Project. The Project longwall layout would be reviewed based on the progressive update to the geological information available and, if required, will be modified to avoid the major geological features during the preparation of the Extraction Plans for the Project.

b) The groundwater model layering and cross-sections rely primarily on the geological model developed by South32 geologists. The geological model is developed based on Illawarra Coal's exploration bore database (exploration bores are shown on Figure 3-2 of the Groundwater Assessment [Appendix B of the EIS]).

c) Geological structures identified in Area 5 and Area 6 are unlikely to affect subsidence predictions for these mining areas (Section 6.6.3 of the Submissions Report). This is supported by evidence from Dendrobium Mine Area 3B, where the effects of lineaments and geological structures on the measured subsidence effects were reviewed based on the ground monitoring data from Area 3B (MSEC, 2019b).

It was subsequently identified that there was no apparent increase in subsidence and closure movements measured at the locations where mapped lineaments and geological structures were present, when compared with the predictions and measurements at locations where these mapped features were not present (MSEC, 2019b). PSM (2019) concluded that based on the information available, there is no strong evidence suggesting there are geological structures persistent from seam to surface that would be affected by Areas 5 or 6 mine subsidence.

Upland Swamps within 60 m of the Project longwalls are assumed to be impacted and would be offset accordingly. Monitoring of swamps within 400 m of the Project longwalls would be undertaken, and if impacts are identified that are attributable to the Project, these swamps would be offset accordingly.

d) The Elouera Fault is not simulated within the groundwater model for the Project. Recent investigations at the Elouera Fault (HGEO, 2019) have focussed on characterising the structural details (offset of up to 40 m at seam level) and permeabilities that are variable, but generally statistically indistinct from that of the rock mass away from the fault zone. HGEO (2019) states "*despite the high fracture density, the permeability of the fault zone is typically within the range of Colo Vale Sandstone in pre-mining bores at Dendrobium*" and "*there is evidence for elevated permeability associated with high-angle joints at higher stratigraphic levels than the interpreted fault zone intersection (upper CVSS, NPFM/BACS and/or HBSS). These joint zones appear not to be associated with significant stratigraphic displacement*".

   Because this zone is most relevant to future Area 3B longwalls, this is the focus of Area 3B Subsidence Management Plan assessments, and less relevant to Area 5 and Area 6.

   The other structures noted in i), ii) and iii) are not included in the groundwater model for the Project. For example, (i) the potential Bulli Fault feature (inferred to have a displacement of 3 m [PSM, 2019]) is not included in the groundwater model as it would have minor displacement at the scale of the cross-sections presented in the Groundwater Assessment (Appendix B of the EIS). The recommendation of PSM (2019) was that this zone be investigated further to understand displacement and disturbance characteristics.

   The same approach would be taken with faults "unnamed fault" across Area 5 and structure A6FNNW3 (in particular) as shown on PSM Drawing 5. As described above, South32 would refine the identification of geological structures based on the ongoing investigations at the Dendrobium Mine and during the development of first workings for the Project. The Project longwall layout would be reviewed based on the progressive update to the geological information available and, if required, will be modified to avoid the major geological features during the preparation of the Extraction Plans for the Project.

   This has occurred previously at the Dendrobium Mine, for example, for Area 3B Longwall 18. A structural zone that mine geologists had identified in the vicinity of Area 3B Longwall 18 via seismic surveys in 2012 is described by Illawarra Coal (2020) as follows:

   > "*The exact nature of the zone was unclear from the seismic data at the time, apart from being indicative of faulting. That report recommended further UIS [in-seam drilling] drilling once workings were close enough and this occurred in 2018 with the drilling of WO3-D1-IS2 which hit stone in two branches in the middle of the Longwall 18 block. Further UIS drilling identified further stone consistent with a fault interpretation. Surface drilling was then able to determine the throw of the faulting as being some 10-15 m down to the south. This level of displacement has meant that the length of Longwall 18 has been shortened*".

   The result was the shortening of the panel by about 900 m to about 1,000 m (i.e. almost 50% reduction) in order to avoid intersecting this zone.

Comment 20

IESC stated:

> *Changes to water quality do not appear to be discussed. In particular, the IESC considers that potential long-term changes to surface water quality as groundwater levels recover post-mining, as well as the mechanisms which cause water quality changes to occur, should be considered.*

South32 Response

Potential impacts to water quality as a result of the Project are discussed in Section 6.6 of the EIS and Section 6.7 of the Submissions Report.

Subsidence effects due to longwall mining can, in isolated instances, result in impacts to surface water quality in watercourses and streams. These subsidence-related impacts to water quality can include temporary increases in dissolved iron, manganese and other metal concentrations, increases in pH and localised iron staining in creek beds at locations immediately downstream of where subsidence impacts have occurred.

Similar spikes in concentrations of iron and manganese have been observed to occur naturally in the areas of the Special Catchment Areas (i.e. in areas that are outside the influence of historic mining) (HEC, 2019).

Localised and short-term subsidence-related impacts to water quality in watercourses have not resulted in discernible changes in water quality downstream at the reservoirs in the Special Catchment Areas that would significantly affect treatment requirements for drinking water.

This conclusion was supported by the IEP Part 2 Report (2019b) (emphasis added):

> *Although surface fracturing elevates metal loads in watercourses, **there is no evidence** that mining in the Special Areas is currently compromising the ability of WaterNSW to meet raw water supply agreement standards.*

Similarly, this conclusion was supported by Advisian as part of a literature review undertaken into the effects of underground mining beneath the catchment areas for WaterNSW (emphasis added) (Advisian, 2016):

> *… although some consequences on water quality within the watercourses in the study are documented in the literature, these consequences are likely to be **short term, sporadic and localised**… Any consequences on water quality at the reservoirs **would be treatable** by the existing Sydney Water treatment plants.*

The conclusions of Advisian are also reflected by previous analysis from Professor Chris Fell AM, in the discussion paper regarding water treatment and the Sydney Drinking Water Catchment for the Office of the NSW Chief Scientist and Engineer (Fell, 2014) (emphasis added):

> *Although the impact of underground long-wall mining in the catchment could lead to small changes in the levels of impurities in water entering SCA's dams, these changes can be coped with by SW's [Sydney Water's] treatment plants as evidence to date **does not suggest** a sufficiently large change in soluble organic concentrations to be of concern.*

The potential impacts on surface water quality as a result of Project-related subsidence are predicted to be localised and temporary in nature, consistent with impacts observed due to historical mining (including post-mining). In the ephemeral drainage lines overlying Area 5 and Area 6, localised and temporary spikes in concentrations of iron and manganese are expected, similar to the spikes that have been observed to occur naturally.

Potential downstream impacts to the water quality of the reservoirs are expected to be negligible, consistent with previous observations and the findings of expert reviews previously conducted by the IEP (2019a, 2019b), Advisian (2016) and Fell (2014).

Post-mining, there is potential for groundwater that has been in contact with the coal seams to recover to levels within the shallow strata (i.e. via the goaf and sub-surface fracture network) such as the Bulgo Sandstone and potentially to within the Hawkesbury Sandstone in some areas. However, there would be significant dilution of groundwater recharge from the surrounding shallow strata, as well as rainfall.

In addition, any relatively high salinity groundwater would be expected to remain at depth (rather than move vertically upwards, as it would have greater density than the relatively fresher water recharged from the shallow strata and from rainfall). As such, potential long-term changes to surface water quality as a result of groundwater recharge is not anticipated (Section 6.13.3 of the Submissions Report).

Comment 21

IESC stated:

> *… mining-related water quality changes have the potential to cause localised impacts, particularly to flora and fauna within and adjacent to streams. Such impacts (e.g. from diversion of surface flows into fractures and re-emergence downstream) have been observed at other mines in the Southern Coalfield. These potential impacts and the subsequent effects on ecological components and processes (e.g. organic matter decomposition) of water resources have not been thoroughly investigated and discussed.*

South32 Response

Please refer to Comments 6 and 20 for responses regarding potential impacts to ecology and surface water quality, respectively.

It is noted that watercourses that have been impacted by subsidence (e.g. WC21 during mining of Longwalls 10 and 11 in Area 3B) have shown temporary increases in dissolved iron and manganese, and an increase in pH to near neutral (pH 7) at sampling locations immediately downstream (Appendix B). Subsidence effects have also resulted in localised iron staining in creek beds (Section 6.6.2 of the Project EIS).

South32 undertakes extensive landscape, water quality and ecological monitoring programs. Based on observations, while effects on surface water quality have been identified, these effects are expected to be localised and temporary in nature for the Project. Potential subsidence-related impacts to aquatic ecology, as a result of changes in surface water quality would be minor and short-term (Cardno, 2019).

Comment 22

IESC stated:

> *There is a lack of clarity in the assessment of potential cumulative impacts to surface water flows. While potential flow reductions and changes to flow regimes have been clearly identified and quantified, it remains unclear what the cumulative impacts to creeks such as Donalds Castle Creek will be given that the flow regimes of some creeks have been previously impacted by multiple longwall panels.*

South32 Response

The Project groundwater model adopted the conservative assumption that most surface water modelled as 'lost' from the ephemeral drainage lines that overlie the Project areas is permanently lost.

However, as described in the response to Comment 11, a significant portion of surface water is likely to re-emerge downstream of the mine footprint, as shown by the Area 3B gauging stations, including those located downstream of Donalds Castle Creek.

Specifically, in regard to Donalds Castle Creek, monitoring at the Dendrobium Mine shows that at stream flow gauges located above or immediately downstream of Area 3B (e.g. DC13S1 and DCS2 [refer to Figure 2]) loss of surface flow has been observable and discernible. Losses at these sites can be significant, with reductions in median flow being approximately 50-80% of pre-mining median flow.

However, at gauging stations located further downstream along Donalds Castle Creek (i.e. DCU) corresponding reductions in stream flow were not discernible. As such, if the losses at DC13S1 and DCS2 were permanently lost from the catchment, then this reduction should be apparent at DCU (which is not the case).

This indicates that some portion of localised losses at DC13S1 and DCS2 re-emerged downstream and/or the volume of water lost was insignificant compared to the total flow at the downstream gauging station DCU.

The Project incorporates setbacks from Donalds Castle Creek (as well as the Avon and Cordeaux Rivers) to reduce potential subsidence impacts (i.e. such that Project-related closure is restricted to an additional 200 mm).

The result of these setbacks is that only 4.5% of the total length of Donalds Castle Creek would be located within 400 m of the Project longwalls (i.e. portions predicted to experience potential Type 3 impacts) (refer to Appendix B of Appendix C of the EIS).

In regard to other named watercourses (i.e. the Avon and Cordeaux Rivers), flows in these rivers are regulated (i.e. flows are determined by dam releases). Historically, controlled flows have been in the order of 10 ML/day. With these flow rates, any Type 3 impacts (e.g. fracturing of the streambed – the likelihood of which is considered to be "low" within the portions located within 400 m of the Project longwalls) are unlikely to cause discernible periods of low or now flow, as the rate of any losses to the surface fracture network would be significantly lower than the regulated flows in the Avon and Cordeaux River.

Comment 23

IESC stated:

> *The subsidence predictions of potential impacts to streams and swamps predicts conventional subsidence-related movements at the longwall scale. Surface cracking and non-conventional ground movements also need to be considered.*

South32 Response

The EIS assessed potential Project-related impacts (including surface cracking and non-conventional ground movements) to the unnamed drainage lines (i.e. portions of first, second and third order streams) located directly above the Project longwalls, named watercourses (i.e. Avon River, Cordeaux River and Donalds Castle Creek), key stream features located along the unnamed drainage lines and named watercourses as well as Upland Swamps proximal to the Project longwalls.

As described in the response to Comment 9, this included the prediction of non-conventional subsidence movements (e.g. valley closure and upsidence) for streams within Areas 5 and 6 using best-practice modelling methodologies.

Comment 24

IESC stated:

> *A quantitative comparison of predicted subsidence impacts in Areas 3A and 3B with predictions for Areas 5 and 6 at swamps has not been provided. Historic performance of predicted and observed impacts as discussed in the Longwall Panel 13 End-of-Panel Report for the existing mine should also be provided to improve confidence in the current modelling (e.g. impacts to catchment yields, shallow water levels, baseflow losses, soil moisture, water quality parameters and aquatic ecology).*

South32 Response

The EIS incorporated the results of monitoring data from the Dendrobium Mine, as well as considered historical observations of subsidence movements in the assessment of potential impacts to Upland Swamps for the Project as follows:

- the subsidence model for the Project has been calibrated to incorporate monitoring data from Dendrobium Mine Areas 1, 2, 3A and 3B (following calibration, the model shows that observed subsidence movements at the Dendrobium Mine are typically less than the subsidence predictions);
- the groundwater model for the Project has been calibrated to mine inflow, with calibration statistics demonstrating that drawdown and mine inflows are adequately replicated (noting the model has a tendency to overpredict total historic mine inflows to Areas 1-3B by approximately 20%, in comparison to the 30-day average observed inflows);
- modelling of potential impacts at Upland Swamps for the Project has been verified by monitoring data for impacted swamps within Dendrobium Area 3B; and

- the calculated offset liability for Upland Swamps is based on the total area of Upland Swamps partially or entirely within 60 m of the proposed longwalls, developed following detailed analysis of Upland Swamp shallow piezometer data for Dendrobium Mine Areas 2, 3A and 3B (Watershed HydroGeo [2019]).

Comment 25

IESC stated:

> *The assessment of impacts to streams and swamps tends to consider each stream or swamp independently. However, these elements are part of a broader landscape of connected ecohydrological systems. How the changes to one component of the system may affect other components needs to be considered.*

South32 Response

The EIS assessed potential Project-related impacts to the unnamed drainage lines (i.e. portions of first, second and third order streams) located directly above the Project longwalls, named watercourses (i.e. Avon River, Cordeaux River and Donalds Castle Creek) as well as Upland Swamps proximal to the Project longwalls.

The EIS assesses the maximum impact to streams and watercourses assuming all impacts have occurred (i.e. assumes impacts as a result of mining in both Area 5 and 6, as well as cumulatively with the approved Dendrobium Mine). In reality, impacts would occur incrementally over the life of the Project and so the approach undertaken in the EIS is considered to be conservative.
At the catchment scale, it is noted that the majority of the footprint of Area 5 and Area 6 are located downstream of the Avon and Cordeaux Dam catchments.

Predicted surface water losses would result in a negligible reduction in the catchment yield of the Metropolitan Special Area (less than 1% reduction), noting that ephemeral streams and Upland Swamps that would potentially be impacted are widespread in the catchment.

The IESC (2019) states in its advice in regard to the Project EIS:

> *The IESC notes that reductions to Sydney's drinking water supply is predicted to be relatively small, where yields to Lake Avon and Pheasants Nest Weir are predicted to be reduced by 0.55% and 0.39% respectively in median years. These impacts are unlikely to be of material concern even in drought years or under expected future climate projections.*

Comment 26

IESC stated:

> *Using groundwater modelling parameterisation provides a practical means of estimating deep drainage, though in this case little confidence can be given to the groundwater model results due to the reason discussed in response to question 2, and the assumed 50% increase in recharge above the longwall panels (HydroSimulations 2019, p. 76).*

South32 Response

On a regional scale, the natural infiltration recharge rates used in the Project groundwater model are based on literature review, analysis of field data and comparison against other models including Bureau of Meteorology's AWRA-L modelling.

The uncertainties associated with enhanced recharge in areas above extracted panels is acknowledged in Section 5.2.5 of the Groundwater Assessment (Appendix B of the EIS).

Comment 27

IESC stated:

> *It is stated that the parameters of the AWBM model – the key tool used to simulate streamflows from rainfall and evaporation – were based on experience with similar projects. However, no mention was made of the number or quality of the prior calibration/validation results used, nor is any comment provided on the extent to which model simulations are consistent with more locally gauged data.*

South32 Response

Rainfall, evaporation and runoff parameters used in the AWBM model for each catchment were adopted from previously undertaken modelling of catchment areas as per the Bulli Seam Operations Surface Water Assessment (Gilbert & Associates, 2009).

The modelling indicates that for the drainage lines overlying Areas 5 and 6 under the median climate sequence: there is a predicted 6 to 22% reduction in stream flow in Area 5 and a 1 to 5% reduction in stream flow in Area 6, with increased durations of no-flow conditions predicted.

HEC (2019) concluded that simulated streamflow reductions are within the range of impacts observed in Dendrobium Area 3B following longwall mining.

Comment 28

IESC stated:

> *The surface water assessments are focused on overall measures relevant to catchment yield (i.e. streamflow volumes indicative of water resource availability). The potential impacts of these predicted changes on ecologically important flow components in higher order streams at the project site, and in turn flora, fauna and ecological processes that depend on such flow behaviour, have not been fully considered and discussed.*

South32 Response

Please refer to the response to Comment 6 regarding potential impacts to ecology.

Comment 29

IESC stated:

> *The irreversible impacts of the predicted hydrologic changes on swamp biota and ecological processes are not fully discussed. A better understanding of the resilience of the swamp ecosystems i.e. their ability to recover following partial or short-term drying, is needed to assess the magnitude of impacts to swamps.*
>
> a. *Recovery of swamps once they have been dry for an extended time is unlikely. The likely response of the aquatic biota and processes (both physical and ecological), and the possibility of hysteresis (Davis et al. 2010), under potential restoration scenarios needs to be considered.*
> b. *Time-series geophysical surveys should be considered to understand the depth of drying and fracturing and to help evaluate offsets.*
> c. *Given the Area 6 swamps are most likely to support the Giant Dragonfly, additional monitoring and evaluation of change and potential swamp recovery is needed in Area 6.*

South32 Response

Potential Impacts to Upland Swamps

Based on observed effects of longwall mining to Upland Swamps, the Project may result in the following subsidence-related impacts to Upland Swamps within 60 m of the proposed longwalls (Section 6.9.3 of the Submissions Report):

- A change to the hydrological regime of swamp sediments as a result of:
  - fracturing of downstream rockbars;
  - fracture networks forming in the bedrock below the swamp; and/or
  - upsidence and dilation of bedrock below the swamp.
- Alteration of surface drainage patterns due to subsidence-induced tilting, resulting in localised erosion or scour or alteration of water distribution.
- Consequential impacts to vegetation composition (i.e. transition to a drier community) due to changes in the soil moisture regime.

Swamp Monitoring Data

As described in the response to Comment 24, South32 has undertaken monitoring of Upland Swamps within 400 m of longwalls since 2003, as well as monitoring of relevant control swamps focusing on vegetation change (floristic plots and photo monitoring) augmented with piezometer water level data and Airborne Laser Survey. This monitoring program collects data for 20 Upland Swamps at the Dendrobium Mine (Section 6.9.3 of the Submissions Report).

Extensive baseline water level (including both perched aquifer and Hawkesbury Sandstone groundwater level) and soil moisture monitoring has also been undertaken by South32 within underground mining Areas 5 and 6 since 2017. Monitoring results are presented in Appendix A of the Surface Water Assessment (Appendix C of the EIS).

The results of baseline monitoring demonstrate that perched groundwater levels within Upland Swamps naturally recede during extended dry periods, and recover when rainfall events are sufficient to saturate the soil profile.

South32 acknowledges that changes to the hydrological regime of Upland Swamp sediments may be experienced in Upland Swamps within 60 m of the proposed longwalls. However, a review undertaken by Niche (2019) of the monitoring data collected during the previous 11.5 years in Area 2, 7.5 years in Area 3A and 4.5 years in Area 3B did not conclude there is a strong link between subsidence effects to hydrological regime and Upland Swamp vegetation response.

It is noted that, while no strong links between subsidence effects and vegetation response have been identified, the time between the impact and vegetative response may not be immediate and, therefore, not yet detected.

South32 would undertake baseline surface water and groundwater monitoring (including shallow piezometers and soil moisture probes) of Upland Swamps within 400 m of the proposed longwalls to confirm the Project's offset liability. Should monitoring indicate impacts greater or less than those predicted, the ultimate offset liability would be increased or decreased accordingly, consistent with the process in the Swamp Offset Policy.

Upland Swamp monitoring would be detailed in the Extraction Plans for the Project, and would include subsidence, surface water, groundwater and vegetation composition. Residual impacts to Upland Swamps located within 60 m of the Project longwalls would be offset in accordance with the Swamp Offset Policy.

Giant Dragonfly

The Project EIS identifies potential Giant Dragonfly habitat within Upland Swamps and potential impacts to this habitat would be offset in accordance with Government policy.

Monitoring of swamp water levels, soil moisture and vegetation composition would be conducted for the Project, as is conducted for the Dendrobium Mine, and would be detailed in Extraction Plans and Environmental Management Plans for the Project.

Comment 30

IESC stated:

> *It is noted that the above setbacks* [setbacks from the Avon and Cordeaux dam walls, Full Supply Levels, named watercourses and key stream features] *do not ameliorate the adverse impacts on the ecologically important water regime in higher order streams and upland swamps.*

South32 Response

South32 notes that it is not economically feasible to design a mine layout that avoids impacts to all features (consideration of the 'No Project' scenario is discussed in Section 9.4.4 of the EIS).

Notwithstanding, South32 has implemented the setbacks from the Avon and Cordeaux dam walls, FSLs of the reservoirs, named watercourses and key stream features to reduce potential subsidence impacts to these features.

Residual impacts to ephemeral drainage lines are described in the Project EIS and Submissions Report (Section 6.5.3 of the Submissions Report).

Comment 31

IESC stated:

> *The proponent proposes to measure the reduction in surface water flows entering the reservoirs and compensate the water supplier for these losses. The IESC notes that this will require upgrading the current monitoring network and is likely to require collection of considerable site-specific pre-impact flow data to enable accurate calculation of losses attributable to the project.*

South32 Response

As described above, South32 commits to implement (i.e. "direct" offset) or fund (i.e. "indirect" offset) works such that the Project results in a net gain to metropolitan water supplies.

The use of the Project groundwater model, supported by monitoring data, will be used to quantify losses.

The following methodology is proposed to calculate annual surface water losses:

1. The NSW water year is based on 1 July to 30 June. The volume of surface water losses from the Project would be determined annually using the groundwater model after the end of each water year.
2. The volume of surface water lost would be calculated after the water year to allow the model to account for actual measurements of mine inflows, groundwater levels, stream flow and rainfall. In effect, this means the model would be re-calibrated with this data each year. The ability to use real data to inform and constrain the model during this re-calibration will improve the accuracy of the calculated surface water losses.
3. The monitoring locations providing data to inform and constrain the model would be specified in Extraction Plans over the life of the Project. This would include:
    - stream gauges to monitor stream flow above the mining area and downstream;
    - multi-level piezometers to measure changes in groundwater pressure/levels and provide site-specific information on the height of fracturing above the longwall panels;

- Project-specific and regional meteorological monitoring to provide data on rainfall and evaporation rates; and
- pumping rates from the underground workings to calculate mine inflow volumes.

4. If required, annual surface water losses calculated using the groundwater model would be validated via the use of a surface runoff model calibrated based on pre-mining conditions and compared to gauging data from reference catchments (i.e. nearby catchments unaffected by mining with similar characteristics, such as vegetation and catchment size).

Comment 32

IESC stated:

> *Impact predictions in terms of groundwater depressurisation, flow reduction and alterations to flow regimes have been clearly identified in the EIS. However, the effects of these changes on surface water and groundwater-dependent ecosystems have not been adequately described and fully assessed.*

South32 Response

Review of the *Groundwater Dependent Ecosystem* (GDE) *Atlas* (Bureau of Meteorology, 2019) shows that there is a low potential for groundwater interaction with GDE's (which are potentially reliant on this interaction) to occur across the majority of the Project underground mining areas, primarily due to the elevated topography.

There is moderate potential for groundwater interaction in lower-lying areas within the Project underground mining areas, including along the Avon and Cordeaux Rivers downstream of the Avon and Cordeaux Dams.

Extensive baseline water level (including both perched aquifer and Hawkesbury Sandstone groundwater level) and soil moisture monitoring has also been undertaken by South32 at a number of swamps within underground mining Areas 5 and 6 since 2017. The monitoring indicates that the swamp perched aquifers are not sustained by groundwater from the Hawkesbury Sandstone aquifer.

Potential impacts to GDEs are described in Section 6.5 of the EIS and Section 6.13.3 of the Submissions Report. In regard to 'high-priority' GDEs, potential impacts are summarised as follows:

- the nearest 'high-priority' GDEs are located 13 to 18 km to the north-east of Area 6 (note Upland Swamps located within the Project area are not defined as 'high-priority' GDEs);
- no drawdown effects are predicted at the 'high-priority' GDEs; and
- the Project would have a 'Level 1' (i.e. minimal impact) to highly productive aquifers in accordance with the AIP.

Potential impacts to watercourses are described in Section 6.6 of the EIS as well as Section 6.3.4 of the Submissions Report. As described previously, South32 commits to offsetting predicted surface water losses (via 'direct' or 'indirect' offsets) such that there would be a net gain to Metropolitan water supplies.

Comment 33

IESC stated:

> *As discussed in paragraphs 16 – 18, the potential changes to surface flows and water regimes of streams and swamps, including under median percentile rainfall conditions, are likely to be considerable and persistent. Discussion and analysis of how these changes could impact the biota and ecological processes in swamp, instream and riparian ecosystems are inadequate and further work is required as outlined in the response to question 12. This additional work should include development of ecohydrological models at both the swamp/reach and catchment scale that consider connectivity between individual swamps, stream reaches and groundwater. Additional analysis is also required of how potential localised changes to water quality resulting from the project (e.g. increases in iron concentrations and changes to dissolved oxygen from diversion of surface flows) could affect water-dependent ecosystems.*

South32 Response

It is noted:

- The Surface Water Assessment for the EIS (HEC, 2019) considered the interaction of groundwater, stream reaches and individual swamps.
- Extensive data has been collected at the Dendrobium Mine in regard to water quality, and this would be continued for the Project.
- For the Project, potential impacts to swamps are required to be offset (refer to the response to comment 24).
- In addition, the Project would offset potential impacts to relevant threatened species with habitat that may be affected by reduction in stream flow due to subsidence-related impacts for the Project.

Comment 34

IESC stated:

> *Changes to swamp flow regimes may result in drying of several modelled swamp types particularly under the 10th percentile (dry) rainfall conditions. Drying of swamps will affect microbial activity and the rate of organic matter decomposition, changing the rate of peat deposition. None of these potential impacts have been clearly and adequately discussed. Further discussion of these impacts is needed to understand the potential for long-term changes to swamp ecology and catchment water quality.*

South32 Response

Please refer to response to Comment 24 regarding the requirement for the Project to offset potential impacts to swamps. In addition, as described in the Surface Water Assessment for the Project (HEC, 2019), swamps form a relatively small portion of the catchment area (i.e. comprise between 0-3% of the catchment areas of the individual drainage lines overlying Areas 5 and 6).

Subsidence-related impacts to water quality in Dendrobium Mine Area 3B watercourses have not resulted in discernible changes in water quality downstream at the reservoirs in the Special Catchment Areas.

This conclusion was supported by the IEP Part 2 Report (2019b):

> *Although surface fracturing elevates metal loads in watercourses, there is no evidence that mining in the Special Areas is currently compromising the ability of WaterNSW to meet raw water supply agreement standards.*

Comment 35

IESC stated:

> *Key Fish Habitat (types 1 and 2) has also been identified within the lower catchment areas of the project. The IESC considers that the project has the potential to impact Key Fish Habitat through flow reductions, including for protected species such as the Macquarie Perch.*

South32 Response

Baseline aquatic ecology surveys for the Project were undertaken at a total of seven sites within, as well as upstream and downstream of the Project area across the Avon River, Cordeaux River and Donalds Castle Creek, which did not identify the presence of Macquarie Perch. The surveys were undertaken consistent with relevant guidelines and methodologies.

Limited suitable Macquarie Perch habitat exists within the proposed underground mining area (first and second order ephemeral drainage lines which overlie the Project underground mining areas consist generally of disconnected pools, some also separated by waterfalls, providing barriers to fish movement and limiting the value of this habitat for fish) and, therefore, the Project is not expected to have a significant impact on the Macquarie Perch.

In addition, it is noted that flows in the Avon and Cordeaux Rivers are regulated (i.e. flows are determined by dam releases), with historical controlled flows in the order of 10 ML/day. With these flow rates, any Type 3 impacts (e.g. fracturing of the streambed – the likelihood of which is considered to be "low" within the portions located within 400 m of the Project longwalls) are unlikely to cause discernible periods of low or now flow, as the rate of any losses to the surface fracture network would be significantly lower than the regulated flows in the Avon and Cordeaux Rivers.

Notwithstanding, the consequences of subsidence-related impacts to relevant threatened species would be offset, as the Project Biodiversity Offset Strategy accounts for potential losses of habitat due to hydrological changes to ephemeral drainage lines overlying the Project underground mining areas (Section 6.9.3 of the Submissions Report).

Flow gauge data for Areas 2 and 3 suggest downstream impacts to surface water flows for the Project are unlikely to be measurable.

Comment 36

IESC stated:

> *The IESC notes that the current mine plan will have irreversible impacts to water resources (swamps and higher order streams of important environmental value), which are unlikely to be remediated through mitigation measures (refer to response to questions 11 and 12). Further modelling is unlikely to significantly change these predictions, but could be used to assess the benefits of a revised mine plan.*

South32 Response

The EIS and Submissions Report have considered various longwall layouts for the Project, and it should be noted:

- The Proposed Project layout setbacks from dam walls, dam full supply levels, named watercourses and key stream features result in the sterilisation of approximately 25 Mt of ROM coal within South32's existing mining tenement (CCL 768) (adjacent to Area 5), worth some $3.58 billion and $222 million in associated royalties.
- A longwall layout that avoids undermining Upland Swamps was considered in the EIS (i.e. the 'minimum case'). This longwall layout is not considered to be reasonable given the significant additional resource sterilisation (21.2 Mt of ROM coal in addition to the 25 Mt of ROM coal described above) and reduction in net benefits to NSW of approximately $220 million in NPV terms.
- Narrower panels would result in significant adverse impacts to the economic viability of the Project and continued operations of the approved Dendrobium Mine. Economic benefits potentially forgone if the Project does not proceed amount to a net benefit of $1,073 million in NPV terms to NSW.

Accordingly, it is considered that reasonable avoidance measures have already been incorporated into the Project design, with residual impacts to 'water resources' associated with the Project to be addressed as follows:

- Predicted surface water losses would be directly and/or indirectly offset to achieve a net gain to metropolitan water supplies.
- Potential impacts to Upland Swamps would be offset as per the Swamp Offset Policy.
- Potential impacts to relevant threated species with habitat that may be potentially affected by reductions in stream flow and/or impacts to swamps due to subsidence-related impacts from the Project would be offset in accordance with Government Policy.

Comment 37

IESC stated:

> *Groundwater triggers do not appear to be proposed. TARPs need to be developed to protect water-dependent ecosystems under any revised mine plan (see response to question 12).*

South32 Response

Groundwater monitoring and management measures including development of TARPs and relevant triggers would be undertaken following any approval granted for the Project and detailed in Extraction Plans. The groundwater TARPs would build on existing management measures at the Dendrobium Mine, and would take into consideration the relationship between groundwater levels in the Hawkesbury Sandstone and nearby swamps and watercourses or pools, as well as on groundwater levels in strata adjacent to the Avon and Cordeaux dams.

It is noted that South32 has already established a groundwater monitoring network in Area 5 and a significant amount of baseline data has already been collected which would continue for the Project.

Comment 38

IESC stated:

> *Further information on the 'minimum scenario' should be provided so that the scenario, or a variant of the scenario, can be considered to reduce the predicted considerable impacts to swamps and streams. Parameters that should be considered in the analysis include setbacks from swamps, or variations to longwall width (or other aspects of mine design and geometry) to reduce potential impacts of undermining.*

South32 Response

Please refer to response to Comment 1 in regard to consideration of reduced longwall width in Project mine design. In regard to streams, South32 has incorporated setbacks from named streams (i.e. the Avon River, Cordeaux River and Donalds Castle Creek) and key stream features to reduce potential subsidence impacts.

As described previously, the 'minimum case' incorporated the mine setbacks from named watercourses, key stream features, dam walls and the FSLs, and in addition avoided direct undermining of Upland Swamps.

The minimum case is not considered reasonable given the significant reduction in resource recovery and associated reduction in benefits to NSW (approximately $220 million in NPV terms). Furthermore, potential impacts to Upland Swamps from the proposed longwall layout for the Project would be offset by South32 as part of the Biodiversity Offset Strategy for the Project in accordance with State and Commonwealth legislation.

Comment 39

IESC stated:

> *Proposed monitoring and management plans were not discussed in detail in the EIS. Recommendations on the contents of these plans were included in several of the specialist impact reports. These recommendations should be incorporated during development/updating of the monitoring and management plans. Prior to the project commencing, the plans should be provided to the regulators for review to ensure that proposed monitoring and management strategies will be suitable and that there is adequate scope for monitoring and mitigation activities to be refined as more data becomes available.*

South32 Response

South32 agrees with this comment. It is noted that Section 8 of the EIS provided a summary of the proposed monitoring, mitigation and adaptive management measures for the Project, incorporating the recommendations of specialist studies undertaken as well as referencing existing Dendrobium Mine management plans (which would be updated for the Project, where relevant).

Details of monitoring and management measures would be described in Extraction Plans developed for the Project, which would be developed subject to approval of the Project based on the recommendations of specialist studies and in consultation with regulators.

Comment 40

IESC stated:

> *The IESC notes that for streams and swamps, proposed management and remediation measures are focused on the use of various types of grouting or installation of structures such as coir logs to promote ponding and water dispersion. Noting CoA (2014 and 2015), further evidence, including independent peer review, needs to be provided to show that these techniques have been successful in similar stream and swamp environments, preferably from the same region.*

South32 Response

Refer to response to Comment 2 in regard to stream remediation. South32 would implement remediation measures to mitigate physical damage to the named watercourses and key stream features where monitoring indicates that subsidence-related impacts have occurred as a result of the Project.

Remediation measures would be consistent with the existing mitigation and remediation measures described in the approved *Watercourse Impact, Monitoring, Management and Contingency Plan* (South32, 2019b), which would be reviewed and updated for the Project.

In regard to Upland Swamps, residual impacts as a result of the Project would be offset in accordance with the Swamp Offset Policy. Swamp remediation would only be undertaken if current swamp rehabilitation research efforts for the approved Dendrobium Mine are successful, and the offset liability for the Project could be reduced accordingly (refer to response to Comment 2).

Comment 41

IESC stated:

> *Potential adaptive management measures have not been considered in detail in the EIS. If adaptive management is proposed, which the IESC recommends, then the management plans and associated TARPs need to be clearly articulated and provided to the regulator as part of the management program, as outlined in paragraph 39 above.*

South32 Response

Proposed adaptive management measures for the Project were summarised in Section 8 of the EIS. Details of monitoring and adaptive management measures would be described in Extraction Plans developed for the Project, which would be developed subject to approval of the Project.

Comment 42

IESC stated:

> *Water quality data from streams unaffected by mining at the project site show exceedances of the ANZG (2018) guideline values for a number of analytes. The IESC suggests that site-specific guideline values should be developed for analytes where exceedances are known to occur as suggested by ANZG (2018) and Huynh and Hobbs (2019).*

These guideline values should be based on data that is not affected by mining; thus, sampling to enable this needs to occur prior to any potential mining impact.

South32 Response

South32 agrees that the baseline water quality data from unaffected catchment areas shows metal concentrations can be naturally elevated above default guideline levels. Water quality monitoring and associated TARPs would consider the results of baseline water quality data including the derivation of site-specific trigger values.

Comment 43

IESC stated:

Direct water licence offsets are proposed for groundwater impacts. The proponent states that they hold sufficient licences to account for peak predicted take within the Nepean Sandstone Management (Zone 2) water source, and has committed to obtain sufficient licences for the project in consultation with DI Water (South 32 2019, Att. 8, p. 8-6; South 32 2019, Att. 7, p. 7-7). The IESC notes that:

a. it is not clearly stated if these entitlements are also used as part of the existing approved mining areas; and

b. not all licences currently obtained by the proponent are within the appropriate aquifers.

South32 Response

South32 currently holds licenses (9,530 ML) to account for the volume of predicted groundwater plus surface water that may ultimately be diverted from the surface to the mine workings (Section 6.4 of the Submissions Report).

The licenses account for the maximum predicted whole-of-mine water take, which includes the existing/approved mine areas, as well as the Project (i.e. these licenses are used as part of the existing Dendrobium Mine).

However, these licenses are all held in the water sharing plan relevant to groundwater sources only. As outlined in the Minister's 18 April media release, the NSW Government intends to implement a "*licensing regime to properly account for any water losses*".

As such, South32 would hold appropriate licenses under the *Water Management Act 2000* to account for surface water losses for the Project.

Comment 44

IESC stated:

The IESC also notes that potential subsidence-related impacts to swamps are proposed by the proponent to be offset consistent with government policies. The IESC considers that further clarification is required, as many swamps contain endemic species and the impacts relate to an extensive area that is greater than the sum of its individual assets. Clarification is required on which swamps are proposed to be offset, and how their attributes compare to swamps that are likely to be impacted.

South32 Response

All swamps within 60 m of the Project longwalls are proposed to be offset where impacts are confirmed. Monitoring of swamp water levels would be conducted over the life of the Project at all swamps within 400 m to confirm the Project's offset liability as per the procedures in the Swamp Offset Policy.

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