

As requested by the Department, South32 has provided responses to recommendations from the IEPMC's Reports 1 and 2 which are detailed in Table 2 and 3.

Table 2 South32 response to recommendations from the Independent Expert Panel's Report 1.

Part 1 #	IEP Recommendation	South32 Response
5	<p>This monitoring standard should include provision for:</p> <ul style="list-style-type: none"> <li>i. installation of multi-level piezometers on the centreline of panels at Dendrobium and Metropolitan mines in order to monitor pore pressure changes associated with subsidence. These should include at least five transducers per borehole with installation being completed at least two years in advance of being undermined</li> <li>ii. daily monitoring of local rainfall and of mine water ingress from overlying and surrounding strata; and separation of rainfall-correlated inflows for base flow volumetric analyses</li> <li>iii. Dendrobium Mine and Metropolitan Mine to develop site-specific databases in relation to the height of complete drainage in lieu of relying on height of drainage equations.</li> </ul>	<ul style="list-style-type: none"> <li>i. Centreline groundwater monitoring prior to and following mining is currently adopted at the Dendrobium Mine.</li> <li>ii. Rainfall monitoring occurs at a number of sites at Dendrobium (A3A, A3B, A5, A6, Cordeaux pit top), and is augmented by available data from WaterNSW's Browns Road site (located above A3B) and by SILO Data Drill records to provide long-term context.</li> </ul> <p>'Baseflow' separation of mine inflow has occurred in the past by HGEO and is proposed to be continued (e.g. included in End of Panel reports). This would accompany assessment of mine inflow chemistry ('finger-printing'), tritium and 'modern water' analysis and analysis of the mine water balance.</p> <ul style="list-style-type: none"> <li>iii. Height of fracturing and groundwater depressurisation at Dendrobium Mine is measured by longwall centreline groundwater monitoring. This data is stored in two databases: <ul style="list-style-type: none"> <li>1. Height of fracturing - stored in a geodatabase which includes but is not limited to: lithology, defect log, geophysics and packer test data.</li> <li>2. Groundwater depressurisation – piezometer data is stored in spreadsheets which are maintained and stored in an online database.</li> </ul> </li> </ul> <p>HGEO is currently completing a report on recent centre-line investigations at Dendrobium (A3A and A3B), this will be peer-reviewed by Bruce Hebblewhite and provided to key stakeholders.</p>
8	Groundwater models should:	<ul style="list-style-type: none"> <li>i. The Dendrobium Groundwater model was last reviewed prior to the extraction of Longwall 15 and is required to be updated prior to the</li> </ul>

	<ul style="list-style-type: none"> <li>i. continue to be updated</li> <li>ii. be migrated from Modflow-Surfact to Modflow-USG only if significant benefits can be demonstrated</li> <li>iii. be underpinned by unified material properties (for common stratigraphic layers) unless differences can be demonstrated to exist through measurements.</li> </ul>	<p>commencement of extraction of Longwall 16, this is currently underway. Since 2012, the Dendrobium Model has been updated regularly, approximately 1 – 2 year intervals.</p> <p>ii. As noted in previous documentation (e.g. the Longwall 17 SMP Groundwater Assessment), we do not agree that specific software should be specified. Both SURFACT and USG have advantages and disadvantages. More detail on these advantages and disadvantages can be supplied upon request.</p> <p>iii. Model parameters are based on a database of material properties, particularly horizontal and vertical hydraulic conductivity (Kh and Kv) that is composed of data from Dendrobium, Bulli Seam Operations and Tahmoor Mines. Model parameters are refined when necessary. Furthermore, we are currently focussing on changes to hydraulic conductivity due to mine subsidence, of which the best available data is from Dendrobium.</p>
10	<p>Mine owners be required to produce robust, independent peer reviews and/or a demonstrated history of the reliability of mine design procedures and methodologies that underpin important aspects of mining approvals.</p>	<p>Mining approval applications including Environmental Impact Statements and SMPs are supported by specialist studies; including, but not limited to key assessments such as subsidence, groundwater, surface water, terrestrial ecology, aquatic ecology and aboriginal cultural heritage.</p> <p>The Dendrobium Groundwater and Surface Water Models have been peer reviewed by Dr Frans Kalf and Emeritus Professor Thomas McMahon, respectively.</p>
14	<p>In future, surface water monitoring requirements should include:</p> <ul style="list-style-type: none"> <li>i. a distinction between primary watercourse monitoring sites, which are the sites at which performance measures are specified; and secondary watercourse monitoring sites, which will provide additional information identified as necessary as the mine plan evolves</li> <li>ii. a specification of the minimum flow measurement accuracy required at the primary and secondary sites</li> </ul>	<ul style="list-style-type: none"> <li>i. Surface water monitoring sites with Performance Measures and TARPs are included in Attachment 1 of the WIMMCP. To improve clarity, these sites are included on figures in the WIMMCP.</li> <li>ii. Updated TARP options have been provided to DPIE and WaterNSW for review and the focus of these is on median flows, therefore the accuracy of monitoring sites needs to be focussed on measuring median flow (and slightly higher). For example, at WWL this means flows up to approx. 5 ML/d should be monitored within specified accuracy. An assessment of accuracy is being completed for IMC.</li> </ul>

	<ul style="list-style-type: none"> <li>iii. the identification of the primary sites in proposed future mining areas and the installation of flow monitoring at these sites at least four years in advance of mining activities</li> <li>iv. the identification of the secondary sites as the mine plan evolves and the installation of flow monitoring at these sites at least two years in advance of mining activities or a shorter time if approved as part of the mine plan approval</li> <li>v. paired piezometers in swamp sediments and nearby bedrock, and flow gauges at the swamp exit stream, at minimum for representative large valley infill swamps, and complemented by soil moisture sensors at selected sites</li> <li>vi. consistent use of inter-site comparisons</li> </ul>	<p>iii. South32 captures sufficient baseline monitoring. It should be noted that a minimum of four years of baseline data is not always possible due to changes in mine design and Government Agency requirements.</p> <p>All currently installed Area 5 and 6 surface flow monitoring sites will have at least 4 years baseline data prior to any proposed mining.</p> <p>iv. South32 captures sufficient baseline monitoring. It should be noted that at least 2 years of baseline data is not always possible due to changes in mine design and Government Agency requirements. However, where it is identified as being required, South32 will install sites.</p> <p>v. South32 has this monitoring in place for key swamps within the current mining area and all swamps in the potential future mining Areas 5 and 6.</p> <p>vi. Potential future mining areas 5 and 6, and currently mining area DA3B have inter-site comparisons available.</p>
15	<p>Surface flow monitoring associated with mining should be required to be continued until the consequences of mining (including any rehabilitation) have stabilised and/or the mine is considered by the relevant regulatory authorities to have been rehabilitated. This requires clear metrics of stabilisation.</p>	<p>Pool water level and flow monitoring sites have been established in Dendrobium Areas 3A, 3B and 3C for monitoring before, during and after mining. The monitoring program for any rehabilitation works deemed required would remain in place prior to, during and following the implementation of any remediation measures at Dendrobium Mine. There are no current plans to discontinue monitoring at any surface flow sites.</p>
17(i)	<p>Monitoring requirements at the Dendrobium Mine should include:</p> <ul style="list-style-type: none"> <li>i. an assessment of flow monitoring procedures, their accuracy and implications for confidence in compliance is undertaken by a suitable independent expert and published</li> </ul>	<p>i. Watershed Hydrogeo (2019) recently reviewed the surface water flow TARPs in light of recent improvements to stream gauging and past experience of implementing TARPs.</p> <p>In addition, ALS conduct regular water sampling campaigns at the Dendrobium Mine, providing independent field data collection.</p>

19(ii)	<p>In the future:</p> <ul style="list-style-type: none"> <li>ii. TARP triggers should be based on meaningful surface water loss indicators developed in consultation with relevant agencies with oversight and regulatory responsibilities for mining</li> <li>iii. TARPs should be related to the desired outcomes (such as maintenance of water flows) and be consistent both within and between mine domains. TARP triggers for surface and groundwater should be based on meaningful flow loss indicators developed in consultation with relevant agencies and authorities with oversight and regulatory responsibilities for mining</li> </ul>	<p>ii. Surface water flow TARPs have been reviewed in light of recent improvements to stream gauging and past experience of implementing TARPs.</p> <p>As part of the revised surface flow TARP discussions with WaterNSW and DPIE, the performance measures are being reassessed and quantified. A discussion paper (Watershed Hydrogeo 2019) was submitted to WaterNSW and DPIE.</p> <p>South 32 is currently revising the WIMMCP and SIMMCP accordingly based on the discussion paper and any feedback from WaterNSW and DPIE.</p> <p>iii. See response provided above (ii.)</p>
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Table 3 South32 response to recommendations from the Independent Expert Panel's Report 2.

Part 2 #	IEP Recommendation	South32 Response
4	<p>Management plans need to make provision for the early detection and control of the elevated risk that variance between predicted and measured subsidence effects, both conventional and non-conventional, when mining in areas sensitive to subsidence impacts, such as the Greater Sydney Water Catchment. This is especially the case when utilising longwall mining since the method is inflexible to immediate changes in mine layout to address of deviations from predictions</p>	<p>South32 have approved management plans in place that allow for early detection and control of impacts. The risk of variance between predicted and measured subsidence effects, both conventional and non-conventional, are considered when mining in areas sensitive to subsidence impacts. For example, a monitoring plan is detailed in Attachment 1 of the WIMMCP. If impacts to watercourses in the mining area are realised during a monitoring period, than the TARP (also available in Attachment 1) is used to quantify the level of impact. Management actions are then implemented corresponding to the level of TARP trigger.</p>
9	<p>TARP triggers for surface and groundwater should be based on meaningful indicators developed in consultation with relevant agencies and authorities with oversight and regulatory responsibilities for mining</p>	<p>Surface water flow TARPs have been reviewed in light of recent improvements to stream gauging and past experience of implementing TARPs.</p> <p>As part of the revised surface flow TARP discussions with WaterNSW and DPIE, the performance measures are being reassessed and quantified. A</p>

		<p>discussion paper (Watershed Hydrogeo 2019) was submitted to WaterNSW and DPIE.</p> <p>South 32 is currently revising the WIMMCP and SIMMCP on the basis of the discussion paper and any feedback from WaterNSW and DPIE.</p> <p>Swamp TARP triggers for groundwater are based on indicators which are directly related to the Addendum to <i>NSW Biodiversity Offsets Policy for Major Projects Upland swamps impacted by longwall mining subsidence</i> (OEH 2016). Changes associated reductions in groundwater levels result in escalation of TARP trigger levels and the required management actions. Further information on management actions are available in Attachment 1 of the SIMMCP.</p>
14	<p>A precautionary approach to mine design in the Special Areas should be taken that does not assume groundwater model outputs are accurate. Predictions of water losses should be conservatively high to allow for prediction uncertainty and where practicable the associated non-exceedance probability should be stated</p>	<p>Hydrosimulations (2019) discusses implementation of highly conservative height of connective cracking assumptions in the Dendrobium numerical groundwater model. Using the Tammetta equation and a surface-to-seam fracturing assumption for 300 m width longwalls allows for the current understanding of geotechnical assessments. The groundwater model and impact assessment adopt a conservative approach, in line with the interpretation of Parsons Brinckerhoff (2013) and Pells Sullivan Meynink (2017) and the model Peer Reviewer. It is as conservative, if not more so, than the IEP recommendation that the Tammetta model be used in favour over the methods of Ditton. That is, the assumption of connected fracturing from seam to surface above Longwall 9 and all longwalls of the same width. See Sections 3 and 5, Figure 5, Appendices B, C and D of the Longwalls 20 and 21 Groundwater Assessment (Hydrosimulations 2019) describing the conceptual model of height of connective cracking.</p>
15	<p>Additional flow gauges and improvements to existing flow gauges should continue to be undertaken selectively by mining companies in consultation with WaterNSW, or by WaterNSW (with potential financing from the companies) including aiming for at least 4 years of baseline flow data at sites that are important for quantifying water supplies including future performance measure sites and control sites</p>	<p>South32 will continue to engage with Water NSW regarding flow gauge upgrades and (if as a result it is determined) will implement actions that are identified as being required.</p> <p>South32 captures sufficient baseline monitoring. It should be noted that a minimum of four years of baseline data is not always possible due to changes in mine design and Government Agency requirements.</p>

16	<p>Monitoring of contaminant concentrations should be integrated with flow monitoring at operational mines to support calculation of contaminant loads at the main inputs to reservoirs and other key locations and to improve understanding of future contaminant loading risks. Relevant contaminants should be agreed between primary stakeholders</p>	<p>Water quality monitoring at watercourse sites includes the collection of in-field parameters pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxygen Reduction Potential (ORP) and laboratory tested analytes (DOC, Na, K, Ca, Mg, Filt. SO<sub>4</sub>, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, Si). Further details of water quality monitoring is detailed in section 3.4 of the Dendrobium Area 3C WIMMCP.</p> <p>South32 engages with various stakeholders during the development of monitoring plans, including DPIE, Water NSW, Biodiversity and Conservation Division and the Dams Safety NSW. Feedback provided from the Agencies is considered and where appropriate, incorporated into management plans.</p>
20	<p>Annual performance reports, end-of-panel reports and reports on studies required by development consent conditions, should:</p> <ol style="list-style-type: none"> <li>a. integrate hydrological and ecological impact and consequence assessments</li> <li>b. include discussion of the inter-related changes in hydrological and ecological consequences for swamps, rather than having only discrete chapters on each</li> <li>c. include results for the entire period of monitoring, rather than just the previous year, that should be assessed, not only for the current mining area but for previous mining domains</li> </ol>	<p>a. End of Panel Reports integrate hydrological impacts and ecological impact assessments. Trigger values for subsidence-induced decreases in groundwater levels, at surface and near-surface monitoring sites at swamps, have been established within the SIMMCP. Shallow groundwater level has been identified as an indicator of potential changes in ecosystem functionality of the swamps.</p> <p>Trigger values identified during the monitoring period are assessed against reference sites during the End of Panel Report to determine if an impact from mining has occurred.</p> <p>b. The annual terrestrial ecology study is undertaken for Areas 3A and 3B. The aim of the program is to determine whether subsidence effects associated with longwall mining result in impacts to terrestrial ecological values located above the longwalls. In order to achieve this aim, a Before- After Control-Impact (BACI) experimental design has been established and implemented.</p> <p>The BACI design investigates how sites that have been mined beneath change over time (Before-After) compared with change at control sites that have not been mined beneath (Control-Impact).</p>

		<p>c. Results for the entire period of monitoring are assessed, not only for the current mining area but for previous mining domains, including consideration of cumulative impacts. For example, the annual terrestrial ecology study compares potential vegetation die-back in Swamp 1B results over a period of 7 years (2013 -2018).</p>
23	<p>Remediation should not be relied upon for features, including watercourses and swamps, that are highly significant or of special significance (as per the guidance provided by the Planning Assessment Commission Panels for the Metropolitan Coal Project 70 and the Bulli Seam Operations Project 71)</p>	<p>There are no swamps that are considered “highly significant or of special significance” <i>Upland Swamp Environmental Assessment Guidelines Guidance for the underground mining industry operating in the southern coalfield draft</i>, Office of Environment and Heritage (2012) that are proposed to be impacted by Dendrobium Mine.</p> <p>As detailed earlier, South32 avoids significant impacts (exceedance of performance measures) to watercourses; including waterfalls and significant pools by adopting a mine layout which is designed to not mine under these features while maximising resource recovery and, where necessary mitigating and rehabilitating impacts. Where impacts cannot be mitigated South32 has provided offsets for these impacts. Subject to Condition 14 of Schedule 3 of the Development Consent, South32 transferred 33 ha of land adjacent to the Cataract River to Water NSW to provide suitable offsets for loss of water quality or water flows to Water NSW caused by its mining operations.</p>