

INDEPENDENT ADVISORY
PANEL FOR UNDERGROUND
MINING

ADVICE RE:

**APPIN COLLIERY
LONGWALLS 709-711 & 905
EXTRACTION PLAN**

June 2022

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EXECUTIVE SUMMARY

Appin Mine is an underground coal mine located approximately 25 kilometres (km) northwest of Wollongong. Appin Mine and the adjoining West Cliff are part of a mining complex, operating as the Bulli Seam Operations Project (BSO Project) under a State significant development consent (MP 08_0150). The consent requires the preparation of an Extraction Plan (EP) prior to the commencement of second workings.

Illawarra Metallurgical Coal Holdings Pty Ltd (IMC), (the Applicant) submitted the EP for Longwalls (LWs) 709-711 and LW 905 within Area 7 and Area 9 in October 2021. Mining is currently underway in both Area 7 and Area 9, with extraction of LW 709 and LW 904 in the two respective domains occurring concurrently.

The EP has identified potentially impacted built features including residential properties located on and above the steep slopes along Razorback Range. To assess these potential impacts, the EP included a Subsidence Predictions and Impacts Assessment report, prepared by Mine Subsidence Engineering Consultants (MSEC), and a Landslide Risk Assessment (LRA) prepared by GHD.

On 4 March 2022, the NSW Department of Planning and Environment (the Department) requested the Independent Advisory Panel for Underground Mining (the Panel) to provide advice in relation to the EP.

Specifically, the Department requested advice on the following:

- *the reliability of the damage predictions outlined in MSEC's Subsidence Assessment for houses on top of the Razorback Range and within 25 m of steep slopes in the EP Study Area;*
- *the adequacy of GHD's Landslide Risk Assessment to assess the landslide risks, site susceptibility and potential impact of mine subsidence with no supporting field-based geotechnical assessments at the potentially impacted houses; and*
- *the appropriateness of IMC's proposed monitoring for the management of mine subsidence and slope instability for houses and its additional commitment to undertake geotechnical assessments at potentially impacted residences prior to the extraction of the first influencing longwall.*

The Panel reviewed a range of documents in preparing its advice, met on multiple occasions via videoconference and requested supplementary information from the Applicant. The Panel concludes and recommends the following.

SUBSIDENCE EFFECTS AND IMPACTS

The Panel concludes:

- There is not an adequate database to support the pre-mining prediction of the likelihood of varying levels of damage to the each of the eight houses located at the top of Razorback Range that are of particular concern to Subsidence Advisory NSW.
- The approach proposed by IMC in this circumstance of implementing, on a longwall panel-by-longwall panel basis, adaptive management that is underpinned by a Property Subsidence Management Plan (PSMP) for each potentially affected property, is an

appropriate means for managing risk to achieve conformance with consent conditions, provided that the PSMP and supporting management process (including IMC's Structural Review Group) reflect at least the degree of technical detail and management due diligence evidenced and committed to in the EP, the additional information provided to the Department by IMC dated 8 June 2022, and due consideration to the Panel's recommendations in relation to land stability (included below).

SUBSIDENCE CONSEQUENCES FOR SLOPE STABILITY

The Panel concludes:

- The EP would benefit from a number of refinements (listed under Recommendations).
- Mining-induced changes in the slope (i.e. local gradients) of hillsides are very unlikely to change the risk profile for land instability.
- Mining-induced rockfalls from the escarpment are very unlikely to present a risk to structures. This should be confirmed for each structure prior to mining of the relevant panel(s).
- A very low (but finite) likelihood of irreversible damage to structures cannot be excluded. On this basis, the costs of responding to such damage should be specifically addressed in the Landscape Management Plan (LMP).
- Traditional monitoring may not provide forewarning of damage to structures as points monitored are not likely to coincide with locations of damage (both being quite local). It is usual for the structures themselves to provide the best leading indicator of consequential damage. On this basis, the Panel considers that detailed dilapidation surveys are essential for detecting early warning indicators such that the LMP Trigger Action Response Plan (TARP) responds in a timely manner, including keeping inhabitants informed.

The Panel recommends:

- GHD
 - complete the last three objectives of its Landslide Risk Assessment (LRA) as set out in Section 2.3 of its report.
 - provides advice on the expected range of effects associated with modification of groundwater due to mining-induced subsidence and how these effects can be mitigated.
- The EP be refined to include the following:
 - Reconciliation of the number of potentially affected properties.
 - Provision in management plans, if need be, for any new significant matters arising out of the completion by GHD of the last three objectives of its LRA and arising out of its advice on the expected range of effects associated with modification of groundwater due to mining-induced subsidence and how these effects may be mitigated.
 - A statement clearly identifying the limitations of the GHD LRA being a desktop, first pass and/or preliminary assessment and, therefore, the degree of reliance that can be placed upon it.

- Provision for undertaking site inspections (ground truthing) prior to the commencement of mining in the subject area of at least some of the Category E and Category F structures possibly affected by longwall mining in the EP. This is for the purpose of providing a level of confidence in GHD’s preliminary assessments and the appropriateness of the associated advice provided on the likelihood and magnitude of damage, especially irreversible damage, and proposed triggers and corrective actions.
- Identification by GHD of “*the techniques and management tools available and previously employed in similar geotechnical circumstances*” referred to in its LRA, where each has been adopted, why it was adopted and how successful it was.
- A commitment to the installation of any piezometers or inclinometers, including documented past usage and effectiveness and clear triggers for when and where these would be installed.
- Revision of the LMP TARP to clearly reference structures with quantitative triggers and commitments to defined corrective actions.
- Clarification in the LMP on accountability for the costs of responding to structural damage.

APPROPRIATENESS OF MONITORING AND MANAGEMENT OF MINE SUBSIDENCE AND SLOPE INSTABILITY

The Panel concludes:

- It is reasonable to expect that the EP will satisfactorily address the monitoring of the management of mine subsidence and slope instability provided that:
 - associated PSMPs are developed in a timely manner to at the least the standard evidenced in the documentation provided to the Panel under covering letter of 8 June 2020;
 - due consideration is given to the Panel’s recommendations in relation to the EP; and
 - the IMC Structural Review Group, established as part of the Built Structures Management Plan, meets regularly to review all results of subsidence monitoring.

The Panel recommends:

- Any endorsement of the EP for LW 709-711 and LW 905 include a condition to the effect that PSMPs are developed in a timely manner to at the least the standard evidenced and committed to in the documentation provided by IMC to the Department under covering letter of 8 June 2022.

1.0 BACKGROUND AND SCOPE OF WORKS

Appin Mine is an underground coal mine in the Southern Coalfield of New South Wales, located approximately 25 kilometres northwest of the City of Wollongong. Appin Mine and the adjoining West Cliff Colliery are part of a mining complex, operating as the Bulli Seam Operations Project (BSO Project). The project was approved by the then Planning Assessment Commission (PAC) on 22 December 2011 under Part 3A of the *Environmental Planning and Assessment Act 1979*. The project was transitioned to a State Significant Development on 23 November 2018 and operates under consent MP 08_0150.

Appin Mine and West Cliff Colliery, and their respective surface facilities, traverse the Wollongong, Wollondilly and Campbelltown local government areas. The mines are operated by South32's Illawarra Metallurgical Coal Holdings Pty Ltd (IMC).

Appin Mine produces high quality metallurgical coal for domestic and international consumption. It directly employs around 1,800 people.

The consent MP 08_0150 has been modified on three occasions and allows for the:

- extraction of up to 10.5 million tonnes per annum (Mtpa) of Run of Mine (ROM) coal from both Appin and West Cliff underground mining domains using longwall methods until 2041;
- operation of ancillary mine and mine ventilation facilities at Appin Mine and West Cliff Colliery's pit tops;
- processing of the ROM coal at the West Cliff Colliery's Coal Handling and Preparation Plant;
- transportation of up to 9.3 Mtpa of product coal by road to Port Kembla Coal terminal for export; and
- the transport and emplacement of coal reject materials at the West Cliff Emplacement Area.

Appin Mine operates two longwalls, one in Area 7 and the other in Area 9, with the extraction of LW 709 and LW 904 currently underway. Mining at Appin Mine occurs from the Bulli Seam, the uppermost seam of the Late Permian Illawarra Coal Measures. According to IMC, the Bulli Seam is the only economically mineable seam in the area.

Condition 5 of Schedule 3 of the consent requires the preparation of an Extraction Plan (EP) prior to the commencement of second workings (being longwall extraction in this instance). The EP must demonstrate that mining operations do not cause exceedances of performance measures identified in Table 1 (Natural and Heritage Features) (condition 1) and Table 2 (Built Features) (condition 3) of Schedule 3 of the consent.

In October 2021, IMC submitted an EP for the secondary extraction of LW 709, LW 710A, LW 710B, LW 711 and LW 905 within Areas 7 and 9. These longwalls have a different geometry or layout to that approved under the consent. According to IMC, the amendments to the approved layout were to increase setbacks from the Nepean River and the cliffs within the valley to ensure impacts on these features are minimised, and to optimise coal resource recovery.

Mining of the EP longwalls, however, would still occur under the Razorback Range, known to comprise cliff formations and steep slopes, located within the approved extent of longwall mining area. The EP has identified built features located on and above the steep slopes along Razorback Range within the EP Study Area, including residential properties, local roads, powerlines, telecommunication cables, powerlines, rural structures and survey control marks which could be potentially impacted. To assess these impacts, the EP included a Subsidence Assessment, prepared by Mine Subsidence Engineering Consultants (MSEC), and a Landslide Risk Assessment (LRA) prepared by GHD.

On 4 March 2022, the Director – Resource Assessments, NSW Department of Planning and Environment (the Department) requested the Independent Advisory Panel for Underground Mining (the Panel) to provide advice in relation to mining proposed under the Razorback Range in the EP for LW 709 – 711 & LW 905.

Specifically, the Department requested advice on the following:

- *the reliability of the damage predictions outlined in MSEC's Subsidence Assessment for houses on top of the Razorback Range and within 25 m of steep slopes in the EP Study Area;*
- *the adequacy of GHD's Landslide Risk Assessment to assess the landslide risks, site susceptibility and potential impact of mine subsidence with no supporting field-based geotechnical assessments at the potentially impacted houses; and*
- *the appropriateness of IMC's proposed monitoring for the management of mine subsidence and slope instability for houses and its additional commitment to undertake geotechnical assessments at potentially impacted residences prior to the extraction of the first influencing longwall.*

The Chair of the Panel (Emeritus Professor Jim Galvin) nominated Mr Garry Mostyn, Principal at PSM Consultants and a recognised expert in landslips and landslides, and himself (subsidence and mining) to prepare the requested advice. Mr Mostyn was formally appointed as a member of the Independent Advisory Panel for Underground Mining (IAPUM) for this purpose.

2.0 METHOD OF OPERATION

The Panel convened by teleconference and videoconference and was administratively supported by Secretariat staff provided by the Department. The Panel did not undertake a site inspection.

A wide range of documents was initially made available to the Panel for the purpose of preparing its advice. The principal ones are summarised in **Table 1**.

Table 1: Principal documents initially made available to the Panel by the Department

Document Reference	Document Name
Extraction Plan	<p>Extraction Plan – Appin – Longwalls 709, 710A, 710B, 711 and 905 – Subsidence Predictions and Impact Assessments – May 2021 including the following volumes:</p> <ul style="list-style-type: none"> • Appendix B – Subsidence Monitoring Program • Appendix E – Land Management Plan • Appendix H – Built Features Management Plan • BSO Regional Monitoring Program • Technical Report 1 – Subsidence Report (MSEC, 2021) • Technical Report 2 – Landslide Risk Assessment (included with Land Management Plan (GHD, 2021)
Agency Advice	<ul style="list-style-type: none"> • Subsidence Advisory Advice – 1 December 2021 • Subsidence Advisory Advice – 11 February 2022 • NSW Resources Regulator Advice – 12 November 2021
Applicant Response to Agency Advice	<ul style="list-style-type: none"> • IMC Response to Agency Advice – 11 February 2022 • IMC Response to SA NSW Residual Comments – 04 March 2022 • End of Panel Subsidence Monitoring Report – Appin Area 9 LW903 (MSEC, July 2021)
Additional Documents sought by the Panel	<ul style="list-style-type: none"> • LW709, LW710A, LW710B, LW711 “Steep Slopes” Landslide Risk Assessment – 5 Gibraltar Drive, Razorback, NSW (GHD, 2021) • LW709, LW710A, LW710B, LW711 “Steep Slopes” Landslide Risk Assessment – 8 Gibraltar Drive, Razorback, NSW (GHD, 2021) • LW709, LW710A, LW710B, LW711 “Steep Slopes” Landslide Risk Assessment – 10 Gibraltar Drive, Razorback, NSW (GHD, 2021) • Landslide Risk Assessment from Mine Subsidence Effects – Appin Area 9 Proposed Longwalls, Razorback Range, Douglas Parl, NSW (Coffey Geotechnics, 2012)
Other Documents	<ul style="list-style-type: none"> • Consolidated Consent MP08_0150 – MOD 3 • Environmental Assessment for the BSO Project: http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=2673

Given the nature of the advice being sought by the Department and the small Panel (2 members), the Panel mostly convened by teleconference on an as needed basis. Formal meetings occurred on:

- 26 May 2022 between the Department and the Panel Chair
- 27 May 2022 between the Department, Subsidence Advisory NSW (SA NSW), IMC and the Panel.

This process resulted in additional information being provided to the Panel by IMC on the proposed geotechnical assessments, monitoring and management process for 11 houses identified as Category F in GHD's LRA:

- Ltr DPIE - IAPUM and SA NSW Additional Information Final 08062022, dated 8 June 2022
- Structural Assessment Report: 5 Gibraltar Drive Razorback Range NSW, Inglis Engineering Pty Ltd, 26 February 2021
- Private Property Monitoring LW904: 5 Gibraltar Drive, South32 2021
- Slope Risk Assessment and Condition Report: 860 Menangle Road Douglas Park NSW, SLR Consulting Australia Pty Ltd, May 2021
- Review of the measured ground movements for LW904, MSEC, 14 September 2021

3.0 PRIMARY FOCUS OF THIS ADVICE

This advice is primarily focussed on four areas, namely:

- the reliability of MSEC's subsidence predictions that inform damage predictions to houses and the assessment of slope instability
- the reliability of the damage predictions to houses in the given circumstances
- the adequacy of GHD's Landslide Risk Assessment (LRA) taking into account any elevated risk of landslide due to mine subsidence impacts
- the appropriateness of subsidence and slope instability monitoring and management plans and opportunities for improvements.

The 2009 Inquiry into *The Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review* (DoP, 2008) and now generally referred to as '*The Southern Coalfield Inquiry*', identified the need to distinguish between subsidence effects, subsidence impacts and subsidence consequences and presented the following definitions for that purpose:

- *Effect* - the nature of mining-induced deformation of the ground mass. This includes all mining-induced ground movements such as vertical and horizontal displacements and their expression as ground curvatures, strains and tilts.
- *Impact* - any physical change caused by subsidence effects to the fabric of the ground, the ground surface, or a structure. In the natural environment these impacts are principally tensile and shear cracking of the rock mass, localised buckling of the strata and changes in ground profile.
- *Consequence* - any change caused by a subsidence impact to the amenity, function or risk profile of a natural or constructed feature. Some consequences may give rise to secondary consequences. For example, the redirection of surface water to the subsurface through mining-induced fractures may be a primary consequence for water inflow to a reservoir and result in secondary consequences for surface ecology.

These definitions have been widely adopted and are applied in preparing this advice under the general headings of 'Subsidence Effects and Impacts' and 'Subsidence Consequences for Slope Stability'

4.0 SUBSIDENCE EFFECTS AND IMPACTS

Mine Subsidence Engineering Consultants (MSEC) undertook the prediction of conventional and non-conventional surface subsidence effects (MSEC, 2021). The empirically based Incremental Profile Method (IPM) utilised for predicting conventional subsidence effects is well established and has been utilised extensively at Appin Mine and throughout the Southern Coalfield for over a decade. It is supported by regular calibration to extensive site-specific performance data. Overall, predictions are at least as reliable as alternative methods and MSEC has transparently identified the limitations of the method. The predictions of non-conventional subsidence effects, principally valley closure and upsidence, are also derived from empirical models. These were developed by MSEC and are based on extensive field performance data sourced from the Southern Coalfield. The prediction methodology is conservative (that is, it generally overestimates subsidence effects) and the dominant technique employed for predicting non-conventional subsidence effects in the Southern Coalfield.

The Panel concludes that the Department is entitled to rely on MSEC's predictions of conventional and non-conventional subsidence effects, subject to the limitations and constraints noted by MSEC.

Notwithstanding this, because of the site-specific nature of subsidence, the prediction of subsidence effects is not a precise science and a degree of uncertainty is associated with the outcomes of any prediction methodology. It is particularly important that consideration is given to how representative the empirical database underpinning predictions is of the specific site conditions for which predictions are being made. In this regard, MSEC has reported that eight houses located at the top of Razorback Range could experience higher unquantified subsidence effects.

SA NSW raised concerns as to the potential impacts this could have on local houses, noting that MSEC stated in its report accompanying IMC's project approval in 2009 that there was limited experience in mining beneath steep slopes in Wianamatta Shales and that where this has occurred at Appin and Westcliff collieries, the grades are substantially less than those found under the Razorback Range. SA NSW also submitted that the subsidence impact assessment for the EP should include a detailed analysis that summaries the likelihood of varying levels of damage to each individual structure within the EP area (being consequences arising from subsidence impacts).

IMC noted in response to SA NSW's submission that the steep slopes located within the study area are analogous to the slopes that have been mined beneath by eleven longwalls in the Appin Area 7 and Area 9 mining domains subsequent to project approval and that observed impacts have been generally within or less than pre-mining assessments. However, IMC has provided for increased monitoring in these circumstances and adopted an adaptive management approach on a longwall-by-longwall basis. This approach includes provision for more extensive and detailed monitoring, contingencies and responses to be incorporated, if need be, in respective Property Subsidence Management Plans (PSMPs).

The Panel met with IMC and SA NSW in the presence of Department representatives on 27 May 2022 to explore and clarify the nature and status of SA NSW's concerns and IMC's responses to them. A number of concerns were satisfactorily addressed and closed out during this meeting. It was agreed that IMC would provide additional documentation that demonstrated and confirmed how, up to this point in time, IMC has been undertaking additional geotechnical studies to those recorded in the EP and has been successfully managing similar concerns to those not formally closed out in the meeting. This additional information, in the

form of a letter report from IMC dated 8 June 2022 and supporting evidence, has been reviewed by the Panel and is adequate for the Panel to provide the following advice.

The Panel concludes that:

- there is not an adequate database to support the pre-mining prediction of the likelihood of varying levels of damage to the each of the eight houses located at the top of Razorback Range that are of particular concern to SA NSW.
- the approach proposed by IMC in this circumstance of implementing, on a longwall panel-by-longwall panel basis, adaptive management that is underpinned by a PSMP for each potentially affected property, is an appropriate means for managing risk to achieve conformance with consent conditions, provided that the PSMP and supporting management process¹ reflect at least the degree of technical detail and management due diligence evidenced and committed to in the EP, the additional information provided to the Department by IMC, and due consideration to the Panel's recommendations in relation to land stability (presented in the next section).

¹ which includes the IMC Structural Review Group (SRG)

5.0 SUBSIDENCE CONSEQUENCES FOR SLOPE STABILITY

5.1. LANDSLIDE RISK ASSESSMENT

In Section 11 - References of Appendix E of the Land Management Plan (LMC), IMC references GHD's LRA report as March 2021. The appended document (which constitutes Appendix A of Appendix E) is GHD Rev 1 dated 6 July 2021 and the revision table indicates that Rev 0 was dated 6 April 2021. The Panel assumes that IMC intends GHD Rev 1 to be considered.

In summary, the Panel consider that the GHD Rev 1 report presents a very well completed desktop landslide risk assessment of the Study Area. In undertaking the assessment, GHD has relied almost exclusively on data provided by others (see Section 4.1, Table 4.1), being:

- Aerial photography provided by IMC;
- Lidar contours provided by IMC;
- Slope gradient information provided by MSEC;
- Landslide susceptibility mapping conducted by Dr Phil Flentje of the University of Wollongong and reported in Coffey 2012; and
- Vertical subsidence prediction provided by MSEC.

The above sources were supplemented by a drive-by inspection, apparently of over 100 properties and structures and completed on one day. The Panel considers this approach appropriate for a desktop study and notes that GHD describes the work in numerous places as "*preliminary*" and as a "*first pass*".

GHD sets out the objectives of its report in Section 2.3, the last three objectives being:

- Outline a monitoring program (including identification of monitoring points) with appropriate trigger levels for corrective management actions for areas most at risk of landslide instability by considering the likelihood and consequences of instability;
- Provide descriptors of the corrective management actions proposed; and
- Assess potential cumulative effects.

It is not clear to the Panel that these objectives have been achieved or reported.

GHD sets out the methodology it adopted in Section 3 of the report. The Panel considers the methodology appropriate. GHD sets out the geotechnical information relevant to LRA in Section 3.3 of the report and notes that the following three are not warranted for a desktop study:

- Sub-surface investigations;
- Laboratory testing; and
- Geotechnical stability analysis.

While this is true as a matter of definition, GHD is not clear whether they are warranted to achieve the objectives listed in Section 2.

The outcomes of the assessment are provided in tables in Appendix B of GHD Rev 1 and summarised in Table 4.3. GHD assessed 112 structures on steep slopes in the EP Study Area and categorised each as Cat A to Cat G, as follows:

Table 4.2: *Category descriptors for table in Appendix B*

Category	Description
Cat A	No apparent slope issue relevant to the house structure - not likely to require assessment for slope instability.
Cat B	Property, including house, has been assessed previously - may require brief walkover and review.
Cat C	Sites over or close to areas already mined - not likely to require assessment since additional impacts unlikely to influence slope instability.
Cat D	Sites over solid coal - not proposed for mining – not likely to require assessment as additional impacts unlikely to adversely influence slope instability.
Cat E	Sites on gentle slopes on isolated hills or ridges or close to watercourse gullies, but not close to the Razorback Escarpment slopes - likely to require viewing (possibly brief in best circumstances), as whole of site could not be viewed clearly from roadway.
Cat F	Sites close to the Razorback escarpment, or on or close to steep mid to lower slopes of the escarpment or steeply sloping ridges forming the foot-slopes of the escarpment - these will be the sites requiring detailed LRM assessment.
Cat G	Sites for which LRM recently (2020) conducted.

The number of structures in each category are as follows:

Table 4.3: *Distribution of categorisation from first-pass desktop appraisal.*

	Cat A	Cat B	Cat C	Cat D	Cat E	Cat F	Cat G	Sum
Category totals	12	15	18	13	34	11	9	112
Brief site visit required to confirm setting	10	12	11	11	33	0	0	77
Category adopted as stands	2	3	7	2	1	11	9	35

From the notes to the table, it is apparent that 77 of 112 sites require a site inspection, with possibly 45 of these requiring a comprehensive landslide risk management assessment. The Panel notes that Section 6 of the LMP refer to 114 sites. This difference should be reconciled in the EP.

In Section 3.6, GHD states with respect to groundwater “*Modification due to mine subsidence is feasible...*” and “*it is sufficient in terms of appraisal of likelihood to expect that mine subsidence is a minor modifying impact.*”. While this might be true on average, even a minor impact can be significant locally and cause significant costs to individual landholders. GHD should provide advice on the expected range of effects and their mitigation.

The AGS2007 recommendations in Table 4.4 (Note 1) of the GHD report are said by AGS to be recommendations but that the actual adopted risk levels should be agreed by the stakeholders. GHD is not clear on what party should bear the expected increase in costs associated with the increased risk.

The key conclusion provided in Section 1 states (emphasis added):

*“The results of the preliminary investigations **indicate** that the structures located on the identified steep slopes **should be able** to be effectively managed, using the techniques and management tools available and previously employed in similar geotechnical circumstances, to permit Appin Mine to extract the proposed longwalls.”*

This quote is reproduced by IMC in Section 4 of the LMP. The Panel notes the words it has emphasised above. Further, at no point in the report does GHD actually list “*the techniques and management tools available and previously employed in similar geotechnical circumstances*”. The Panel notes these appear similar to those identified nearly a decade ago in Coffey (2012) Sections 11.4.1 and 11.4.2.

5.2. SLOPE INSTABILITY MONITORING AND TARP

The Panel accepts that monitoring subsidence is likely of more utility than attempting proactively to monitor instability. Subsidence is broadscale whereas instability is almost certainly very localised and difficult to predict. The Panel accepts that surface cracking is likely the best prior indicator that subsidence might have an effect on stability.

The Panel notes that Table 8 of the LMP contains no commitment to the installation of any piezometers or inclinometers. The EP should include clear triggers for when and where these would be installed and document past usage and effectiveness.

The Panel notes that the LMP Section 7 – Management and Mitigation Strategies – does not provide clear and measurable objectives and that Table 9 – the TARP – appears to relate entirely to natural ground and not the structures that are the subject of the GHD LRA. The TARP does not provide any details of mitigation or remedial actions if a structure is adversely affected by landsliding, and how it would be assessed if due, or incrementally due, to mine subsidence.

5.3. CONCLUSIONS

The Panel concludes that:

- The EP would benefit from a number of refinements (listed under Recommendations).
- Mining-induced changes in the slope (ie local gradients) of hillsides are very unlikely to change the risk profile for land instability.
- Mining-induced rockfalls from the escarpment are very unlikely to present a risk to structures. This should be confirmed for each structure prior to mining of the relevant panel(s).
- A very low (but finite) likelihood of irreversible damage to structures cannot be excluded. On this basis, the costs of responding to such damage should be specifically addressed in the LMP.
- Traditional monitoring may not provide forewarning of damage to structures as points monitored are not likely to coincide with locations of damage (both being quite local).

It is usual for the structures themselves to provide the best leading indicator of consequential damage. On this basis, the Panel considers that detailed dilapidation surveys are essential for detecting early warning indicators such that the LMP TARP responds in a timely manner, including keeping inhabitants informed.

5.4. RECOMMENDATIONS

The Panel recommends that:

- GHD
 - completes the last three objectives of its LRA as set out in Section 2.3 of its report.
 - provides advice on the expected range of effects associated with modification of groundwater due to mining-induced subsidence and how these effects can be mitigated.
- The EP be refined to include the following:
 - Reconciliation of the number of potentially affected properties.
 - Provision in management plans, if need be, new significant matters arising out of the completion by GHD of the last three objectives of its LRA assessment and arising out of its advice on the expected range of effects associated with modification of groundwater due to mining-induced subsidence and how these effects may be mitigated.
 - A statement clearly identifying the limitations of the LRA being a desktop, first pass and/or preliminary assessment and, therefore, the degree of reliance that can be placed upon it.
 - Provision for undertaking site inspections (ground truthing) prior to the commencement of mining in the subject area of at least some of the Category E and Category F structures possibly affected by longwall mining in the EP. This is for the purpose of providing a level of confidence in GHD's preliminary assessments and the appropriateness of the associated advice provided on the likelihood and magnitude of damage, especially irreversible damage, and proposed triggers and corrective actions.
 - Identification by GHD of "*the techniques and management tools available and previously employed in similar geotechnical circumstances*" referred to in its LRA report, where each has been adopted, why it was adopted and how successful it was.
 - A commitment to the installation of any piezometers or inclinometers, including documented past usage and effectiveness and clear triggers for when and where these would be installed.
 - Revision of the LMP TARP to clearly reference structures with quantitative triggers and commitments to defined corrective actions.
 - Clarification in the LMP on accountability for the costs of responding to structural damage.

6.0 APPROPRIATENESS OF MONITORING

Specific conclusions and recommendations regarding the appropriateness of IMC's proposed monitoring for the management of mine subsidence and slope instability for houses have already been noted in this advice. In light of its meeting with stakeholders and the subsequent additional documentation provided by IMC:

The Panel concludes that:

- it is reasonable to expect that the EP will satisfactorily address the monitoring of the management of mine subsidence and slope instability provided that:
 - associated PSMPs are developed in a timely manner to at the least the standard evidenced in the documentation provided to the Panel under covering letter of 8 June 2020;
 - due consideration is given to the Panel's recommendations in relation to the EP; and
 - the IMC Structural Review Group, established as part of the Built Structures Management Plan, meets regularly to review all results of subsidence monitoring.

The Panel recommends that:

- Any endorsement of the EP for LW709-711 and LW905 include a condition to the effect that PSMPs are developed in a timely manner to at the least the standard evidenced and committed to in the documentation provided by IMC to the Department under covering letter of 8 June 2022.

REFERENCES

- COFFEY (2012). Landslide Risk Assessment from Mine Subsidence Effects: Appin Area 9 Proposed Longwalls Razorback Range Douglas Park NSW (Jon Thompson), Coffey Geotechnics Pty Ltd, March 2012.
- DoP (2008). Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review. (Hebblewhite, B.K., Galvin, J.M., Mackie, C.D., West, R. & Collins, D.). ISBN 978 0 7347 5901 6. Sydney: NSW Government, Department of Planning.
- MSEC (2021). Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of the Proposed Longwalls 709, 710A, 710B, 711 and 905 at Appin Colliery. Mine Subsidence Engineering Consultants. Report No. MSEC1117 Rev B. May 2021.