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Latrobe Planning Scheme Amendment C87, Qualitative Risk Assessment

Submitted to:
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Melbourne Vic 3000

REPORT

Report Number 1539765-003-R-Rev0

Golder Associates

Table of Contents

TABLES

APPENDICES

Extracts from The Landslip Risk Management guidelines (AGS) 2007 - Appendix C

APPENDIX D
Amendment C87 documents provided to Golder

APPENDIX E
Council Reports from the Latrobe City Council Pathway System

1.0 ENGAGEMENT

Maddocks (Lawyers) has engaged Golder Associates Pty Ltd (Golder) on behalf of Latrobe City Council (Council) to undertake a Qualitative Risk Assessment of the potential consequences of not extending the existing one kilometre buffer zone from the top of Loy Yang Open Cut Mine.

Our Qualitative Risk Assessment was undertaken in accordance with our proposal dated 22 October 2015 (Ref 1539765-002-L-Rev0). Approval to proceed with this work was provided by an email from Maddocks dated 5 November 2015.

2.0 BACKGROUND AND SCOPE OF WORK

This report follows on from the geotechnical peer review conducted by Golder (Ref 1539765-001-L-Rev1 dated 21 October 2015) of a PSM Consult Pty Ltd (PSM) report entitled "Latrobe Planning Scheme Amendment C87: Traralgon Growth Area Review, Submission Number 22, Loy Yang Mine" dated 14 April 2015 Ref PSM2690-001R (PSM Report). The PSM Report is presented as a Witness Statement prepared by Mr Tim Sullivan, of PSM, and sets out his views regarding a number of matters relating to the impact and potential future impact of nearby mining activities on development and potential future development within the township of Traralgon.

The PSM Report provides PSM's view with respect to the sufficiency or otherwise of the current 1 km buffer distance around the mine provided under Clause 21.07 of the Latrobe Planning Scheme. Clause 21.07-4 Coal Buffers Overview states that "*Buffer areas extend for a distance of 750 m (±75 m) from an urban settlement boundary to the perimeter of a 250 m wide coal operational area. The total separation area between an urban settlement boundary and the crest of any future open cut development should not be less than 1 km in width*". The Latrobe Planning Scheme contains a provision for The Environmental Significance Overlay Schedule 1 (ESO 1) 'Urban Buffer'. This applies to land broadly between Loy Yang Mine and the Traralgon Township, for a distance up to 1 km to 1.5 km from the Northern Batter crest (refer to Figure B3, Appendix B).

Golder's peer review of the PSM Report included general comments on risk to the Traralgon township from geotechnical hazards associated with the mining. It identified additional work required to provide a qualitative risk assessment to assess whether the identified issues are significant or are likely to only be within acceptable levels for societal risk.

The scope for the qualitative risk assessment was developed in conjunction with Maddocks and Latrobe City Council. The agreed scope of work was for Golder to provide a report that included:

- A discussion on the potential hazards which we identify could be associated with existing and future mining activities at Loy Yang within and adjacent to the nominated extended buffer zone, that could impact on future development.
- A map presenting hazard zones within the proposed extended buffer zone depicting the areas where these hazards might be present, separating out as considered relevant the nature of and potential severity of such hazards. In the report, this is presented in the form of a "Risk Map".
- A discussion on the potential impact each of the identified hazards might have on development. This discussion will compare, as considered relevant, the impact of these hazards to other hazards commonly considered in design, and construction, such as swelling soils.
- Commentary on the likelihood of significant localised ground movement within the proposed extended buffer zone, such as the development of discrete cracks or shear displacements, as distinct from relatively uniform settlement or horizontal strain associated with mine activities (including aquifer depressurisation associated with groundwater extraction), and the potential impact of such movement.

The above approach assumed either Maddocks or Council would be able to provide the following:

- Relevant base plans of the study area, in CAD or GIS format.

- Reports referenced by Mr Sullivan, and any other relevant reports providing data not previous provided or available.
- Mine development plans, showing the planned expansion of the mine and the anticipated timeframe for the expansion (e.g. top of mine batter, depth of mine vs. time). If possible, this same information for the historic development of the mine was requested to be provided to allow comparison of recorded movements with mine development.
- Groundwater extraction history and monitoring data, sufficient to establish changes to the groundwater regime during development of the mine and so allow comparison to recorded settlement data. If available, it was indicated planned future dewatering and any predictions of associated drawdown would provide useful input to the assessment.
- Access to Council officers familiar with any observations of distress or movement which may have been thought to be associated with the mine development, and of any other distress which may potentially be due to other causes.

3.0 AIMS OF THE ASSESSMENT

The aim of the risk assessment is to estimate the severity of differential horizontal and vertical ground movement (the hazard) throughout the "Area of Influence" described by PSM, and to assess the risks associated with these ground movements to development, services and infrastructure.

The "Area of Influence" is described by PSM as "*the zone outside the mine crest that has undergone significant movement in the past and or is subject to significant ongoing movement in the future as a result of mining activities*". The Area of Influence proposed by PSM extends beyond the current 1 km buffer zone and encroaches into the Traralgon township. PSM do not define or describe what they consider "significant" to mean in the context of their adopted Area of Influence. To be able to undertake this risk assessment, it was necessary to assign levels of movement attributable to mining activities, which could be deemed "tolerable", or not, in relation to commonly accepted values. This is described in Section 8.0 of this report

Whilst the identification of an Area of Influence delineates an area which has the potential to experience ground movement from mining activities, it does not necessarily mean that development within this area has an unacceptable level of risk from ground movement associated with mining activities.

4.0 METHOD OF ASSESSMENT

To produce the outputs detailed in the scope of works, the study and risk assessment included:

- A general site inspection of the area surrounding the Loy Yang Mine, to assess whether there is any obvious evidence potentially related to the impact of mining, including what distress (if any) is apparent to pavements, infrastructure and buildings (observed from street level). The focus area for this inspection was within the limits of the proposed extended buffer zone proposed by PSM, and within the 500 m to 1 km region inside the present buffer boundary specified in ESO 1.
- A general site inspection of the Morwell Township in the area adjacent to the Northern Batters of the Hazelwood Mine, north of the Princes Freeway. The purpose of inspecting this area was to assess whether there is any obvious evidence of ground movements and associated distress on infrastructure, potentially due to the impact of mining, at a much closer distance to a mine crest (within 200 m to 400 m).
- Meeting with relevant Council officers to discuss past experience with observed movements (if any) and relevant associated distress, which is thought could have been due to mining activities. The areas of focus for these discussions were the zone from 500 m to 2 km from top of mine batter and surrounding areas of the Loy Yang and Hazelwood Mines.
- Further analysis of the monitoring data presented in the PSM report to assess the magnitude of differential movements.

- Review other data that we may have in our files in relation to such movements (in as much as this data can be used in this context), together with any other data Council or Maddocks are able to provide in the form of other reports prepared by Mr Sullivan, or others, in relation to movements associated with mining activities in the Latrobe Valley.

5.0 INFORMATION USED IN THIS STUDY

The following information was provided to Golder:

- The PSM report entitled "Latrobe Planning Scheme Amendment C87: Traralgon Growth Area Review, Submission Number 22, Loy Yang Mine" dated 14 April 2015 Ref PSM2690-001R.
- Package of Latrobe City Council Documentation regarding Amendment C87 (refer to Appendix D for list of documents provided).
- GHD (2010), Latrobe Valley Regional Groundwater & Land Level Monitoring Report 5 Year Review, RGMC – Draft.
- AGL (2015), Loy Yang Work Plan Variation (WPV), Mining License 5189. Volume 1 Main Text and Figures.
- Council reports from the Latrobe City Council Pathway System relating to properties 2.5 km north of Loy Yang Mine at the Southern end of Traralgon (refer Appendix E).
- Council GIS Information.
- As noted, we also met with Council officers to gain the benefit of local knowledge.

6.0 GROUND MOVEMENT IN LATROBE VALLEY

Although this assessment focusses on potential hazards associated with mining related ground movements for an area between Loy Yang Mine and the Traralgon township, it is necessary to provide some context as to the regional ground movement that has and is occurring in the Latrobe Valley.

The PSM Report identifies the following sources of on-going mine related ground movements in the Latrobe Valley:

i) movements (settlements) due to local and regional dewatering and depressurisation of the aquifers underlying the mines and the Latrobe Valley in general. These ground movements are relatively wide spread. However, as discussed in Section 6.1, once away from the mine these ground movements are relatively uniform, as evidenced by monitoring data and little if any observed damage to property;

ii) settlement and horizontal movement caused by excavation of the pit and subsequent relief of in situ stresses. These ground movements are relatively localised closer to the mines, but can continue to occur as creep after mining has been completed; and

iii) movements related to instability.

Survey monitoring data does not differentiate between settlement induced directly from mining activity and that from the effect of groundwater lowering.

The analysis of ground movement conducted in this assessment was based on information made available. This did not include any raw survey data. The data used in this study was interpreted from hard copy information. However, this is considered sufficient for the purposes of understanding general ground movement trends.

6.1 Regional Ground Movement

Ground movement in the Latrobe Valley has been monitored since the 1950's by surveying a network of pins located throughout the Latrobe Valley. The pin network generally has a higher density of points close to each mine, which then radiate out from the mine crest and into Latrobe Valley townships.

The package of information provided to Golder by Maddocks included a report entitled "Latrobe Valley Regional Groundwater & Land Level Monitoring Report 5 Year Review – Draft", RGMC, dated December 2010 (GHD Report). The report includes analysis of data from the 2009/2010 land level survey of the regional pin network. The location of pins is shown in Figure 18 of the GHD report (this is contained in Appendix A)

This analysis suggests that Traralgon township has experienced settlement of approximately 0.2 m to 0.5 m, and Morwell up to approximately 2.5 m adjacent to Hazelwood Mine (refer to GHD Figure 19, Appendix A).

In relation to subsidence[1] the GHD Report concludes, inter alia, the following:

- *The results of the 2009/2010 land level survey indicate that the greatest total movements due to aquifer depressurisation are centred on Hazelwood and Loy Yang Mines. The maximum subsidence adjacent to Hazelwood and Loy Yang Mines Mine is 2700 mm and 2370 mm respectively, resulting from the combination of depressurisation and horizontal batter movement into the open cut voids. Total subsidence reduces rapidly away from the mines, to less than 500 mm regionally. A greater impact on land levels is evident around Hazelwood Mine as it has the longest history of aquifer depressurisation with some contribution from Yallourn Mine. However, a significant impact is continuing to develop in the Loy Yang Mine area as a consequence of aquifer depressurisation.*
- *Analyses of survey data indicates that over the review period since 2005/2010 the regional settlement rates have generally been less than 5 mm/year with up to 15 mm/year being recorded in the Hazelwood Mine area with the highest rate of 29 mm/year recorded adjacent to the West Field. Similar rates of settlement are also being recorded in the Loy Yang Mine area but with larger settlements up to 61 mm/year have been* (sic) *recorded adjacent to its northern batters.*
- *Review of subsidence trend indicates that the rates of subsidence have generally increased in the Hazelwood - Yallourn Mine area. The greatest increase in subsidence rates has been in the Loy Yang Mine area, in particular to the north and east due to the mine development over the past five years. The land survey results indicate that there is no significant differential land movement in the Latrobe Valley and that reductions in land levels are in the form of a uniform lowering of land surface centred on the mines.*

With respect to existing and future development in the area outside the current 1 km buffer zone at Loy Yang, a key hazard is the magnitude of differential movements and the gradients of horizontal movement (or horizontal strain) and settlement (or vertical strain) with length (over the width of a house or street for example). Therefore two key conclusions from the GHD Report to this assessment are, (1) that there is no significant differential settlement in the Latrobe Valley and (2) that the total settlement reduces rapidly away from the coal mines.

Specific information on particular survey pins within the Latrobe Valley is shown in Figure 4 of the PSM Report (refer to Appendix A). This figure shows that settlement of between 0.15 m and about 1 m has occurred over the last 50 or 60 years at various locations throughout the Latrobe Valley (including in the townships). The monitoring results indicate that these settlements are on-going, and continue for many years after mining activity has ceased in the adjacent areas. However, about 10 to 15 years after mining ceases, it appears the rate of settlement and horizontal movement reduces to between about 5 mm and 25 mm per year. In the case of settlement, the monitoring data does not differentiate between settlement induced directly from mining activity, and that from the effect of groundwater lowering. However, for comparison, (developed) areas of South Melbourne are settling at not dissimilar rates of between 5 mm and 10 mm per year.

In 2014, the former Department of Environment and Primary Industries (Victoria) conducted a study to identify and measure subsidence in the Gippsland Basin. The University of New South Wales was commissioned to undertake the assessment using InSAR (Interferometric Synthetic Aperture Radar) data

[1] 'Subsidence' is generally used to describe surfaces above underground voids that subside. In our view, the use of the term 'settlement' is more applicable to ground movements experienced in the area assessed.

from 1992 to 2011. On a regional scale the study found that the Gippsland Basin was stable over the period of the analysis. However, the study found that around the coal mines within the Latrobe Valley a maximum rate of 30 mm per year had occurred in that period. In addition to around the coal mines, localised subsidence of 30 mm per year was identified in the Stradbroke and Holy Plains area. A possible reason identified for settlement in these areas was a change in land use from dry land pasture to plantation forestry.

6.2 Local Ground Movement (North of Loy Yang Mine)

Survey data indicates that at Traralgon the greatest vertical and horizontal movements occur closest to the mine batters and generally decrease rapidly with distance from the mine crest (GHD Figure 19, Appendix A).

Appendix E of the PSM report provides both vertical (settlement) and horizontal ground movement information for three "Stability Lines", N3, N5 and N7A. Each of these Stability Lines has survey pins located on it (or in close proximity), both on the batters and extending out orthogonal to the pit crest for a distance of approximately 1.4 km.

Appendix E of the PSM report provides charts of each of the three Stability Lines. These are contained in Appendix A. The maximum horizontal ground movements of between about 1.8 m and 3.5 m have been measured on and behind the northern mine batter since 1988. However, at a distance of approximately 1 km from the crest of the mine batter, the total measured horizontal ground movement has reduced to between about 0.3 m and 0.5 m.

Peak movement rates on the batters and behind the mine crest typically occur above areas in the pit where coal extraction rates are greatest. Recorded survey information suggests that as the mining front (operating batters) passes a location and mining ceases at the batter toe, the magnitude and rate of movement both on the batters and behind the crest decreases.

The data presented for the three Stability Lines indicates horizontal ground movement of approximately 0.15 m per year occurs at the crest when there is mining on the batters or at the toe below. As mining progresses eastward the rate of horizontal movement at each Stability Line reduces, and in the case of Stability Line N3, to about 0.01 m per year for the last 10 years of records (2004-2014). Outside a distance of 1 km from the mine crest, these areas not only experience an overall slower rate of movement, but also are not influenced greatly by where excavation is occurring in the mine.

Settlements of between 1.5 m and 1.8 m have been measured since about 1988 at up to about 300 m from the crest of the mine batter. However, the charts also show that at a distance of about 1 km from the crest of the mine batter, the total measured vertical settlement has reduced to between about 0.3 m and 0.8 m. The settlement rate at surveyed locations is also reducing over time, with survey information in the later years showing approximately 0.015 m per year at a distance of 1 km from the crest.

Using the information presented in the PSM report for the three Stability Lines, where possible, the horizontal strain and deflection (vertical) between consecutive pins on each line was estimated. The assessment found that the total horizontal strain (elongation) was in the order of 0.2 % to 0.4 % at pins close to the pit crest, decreasing to 0.01 % to 0.03 % at a distance of about 1.3 km to 1.4 km from the pit crest For vertical settlement, close to the crest 3 mm/m to 4 mm/m was interpreted, decreasing to about 0.3 mm/m at approximately 1 km from the crest, and 0.2 mm/m at a distance of approximately 1.4 km from the crest.

It should be noted that these values are the total strain and deflection measured. As discussed above, the rate (particularly within approximately 700 m of the crest) changes depending on where mining occurs in the pit. For more recent years horizontal strain and deflection recorded behind the crest at Stability Lines N3 is at a level so small it is difficult to interpret it from the stability charts provided. Stability Lines N5 and N7A show a similar trend, with the rates at N5 and N7A reducing for approximately the last 13 and 5 years of measurements, respectively.

In 2015 AGL made submission to the Hazelwood Mine Fire Inquiry that states "*The landform created by mining over the past 33 years at AGL LY Mine is stable, with no significant geotechnical failures in the landforms created to date. Future mine development plans will continue and improve the practices that have*

resulted in this long term stability". This does not preclude the ground movements (settlement) associated with aquifer depressurisation and stress relief (refer to Section 6.0).

6.3 Instability Incidents in the Latrobe Valley

The PSM Report (at Section 7, page 7) identifies a number of mining related stability incidents that have occurred in the Latrobe Valley since 2003. These incidents all occurred within or close to the mines in question and their immediate impact (with respect to stability) was restricted to well within a distance of 1 km from the crest of the nearest relevant mine batter[2]:

With respect to the Area of Influence as defined by PSM, the impact of the various Latrobe Valley instability incidents considered in the PSM report is restricted to within about 730 m from the toe of the relevant mine batter where the instability occurred (PSM Figure 15, Appendix A). This corresponds to about 300 m to 450 m from the crest of the mine batters, which is well within the current 1 km buffer zone that is applied to the Loy Yang Mine.

The stability incidents identified within the PSM Report are discussed in the Golder Peer Review (document no. 1539765-001-L-Rev1). From that review we opined:-

iv) Stability incidents have been caused by an increase in ground water levels (usually from infiltration of water from the surface into the coal joints) or due to sudden release of stress concentration as a result of mining. The instability is short lived, with movements effectively ceasing once ground water levels drop or stresses are relieved;

v) Their immediate impact (with respect to stability) has been restricted to well within a distance of 1 km from the mine. That is, there is no evidence that we are aware of that identifies significant stability issues at a distance of more than 1 km from the mine batter crests at any of the mines in the Latrobe Valley.

vi) The stability incidents have generally occurred independent of when mining was undertaken, in some instances many years after mining was completed in the area (e.g. Northern batters of Hazelwood mine). This is in contrast to general horizontal movement and settlement (due to mining, not groundwater lowering), the rate of which generally diminishes with time after completion of mining activity.

7.0 FIELD OBSERVATIONS

A site visit was undertaken by Golder on 9 December 2015. The purpose of the site visit was to assess what observable distress (if any) is apparent to infrastructure and whether it can potentially be attributed to mining activities. The site inspection was limited to publically accessible areas only. No formal inspection of specific properties was conducted. Private dwellings were observed from the street front only.

The site visit focussed on two areas:

- An area approximately 1 km to 2 km from the crest of the Loy Yang Mine northern batters (Figure B1, Appendix B).
- An area of the Morwell township that is northeast of the Princes Freeway, within approximately 200 m to 500 m of the crest of the Hazelwood Mine (Figure B2, Appendix B).

The roads/streets highlighted north of Loy Yang Mine in Figure B1 (Appendix B), were travelled along by means of a walk-over and/or drive-by. At Morwell, the streets highlighted in orange were walked along during the inspection.

Gaining access closer than approximately 1 km to the Loy Yang Mine was limited, due to the area having restricted entry or being private property. The survey points of Stability Lines N3, N5 and N7 (as shown in

[2] Many of the figures in the PSM report do not contain a distance scale which makes it difficult to assess accurately the distance from the crest of the batters where cracking and movement have been observed/measured. We have used other sources of information as well as scaling from the PSM figures to estimate distances from the crest of the batters.

the PSM report) are mostly within the area of restricted access and it was not possible to do a "walkover" of these lines. The closest point to the mine accessed was outside the Traralgon Transfer Station, approximately 550 m from the pit crest and 200 m to the east of Stability Line N3.

The purpose of the Morwell site inspection was to observe a developed area located much closer to a mine batter than the 1 km buffer zone that is present at Loy Yang, and if possible identify areas where differential ground movements had occurred and then potentially observe a correlation between damage level to infrastructure and distance from the mine.

The Latrobe City Council conducted a search of their "Pathways System", filtered for records relating to maintenance, roads, drains and infrastructure for an area within 2.5 km of the Loy Yang Mine crest. The purpose of the exercise was to identify infrastructure that might show signs of ongoing damage which could potentially be related to ground movements, and then focus the site inspection on those areas. Although numerous reports were extracted from the database search, no reports identified ground movements or damage attributable to mining activity.

Golder attended a meeting with several Council representatives to potentially identify areas that might be of interest in terms of known ongoing ground movement related issues in the areas surrounding both Loy Yang and Hazelwood Mines. Council employees who live in the residential area north of Loy Yang Mine suggested that to their knowledge mine related ground movement had not caused damage to houses in the region. For Morwell, no particular areas of concern were conveyed to Golder. The site inspection in Morwell therefore covered several streets within an area that is in close proximity to northern Hazelwood Mine batters.

The following observations were made in the area north of Loy Yang during the site inspection:

- No obvious sign of ground movement, for example tension cracking, that potentially related to mining was observed. Access could not be gained within the area 1 km north of the mine (refer to figure B1, Appendix B).The landscape directly north of the mine crest was observed from a distance and consisted of grassed or cropped paddocks. This made it impossible to observe the ground surface close up and hence we were not able to determine if there was any ground disturbance or cracking which may have resulted from ground movement.
- Most dwellings appeared to have been constructed in the 1950's to 1970's using brick veneer, with some cladding (weatherboard) homes in pockets.
- No obvious sign of damage to dwellings that could be potentially related to ground movement associated with mining activities was observed.
- Cracking (up to approximately 5 mm) of some brick walls/fences at the street front was observed, but given the age and construction method, this is not considered unusual for such structures.
- Drainage structures on dwellings such as gutters appeared to be aligned correctly. Most dwellings appeared to have the original gutters in place.
- No damage to sealed roads and footpaths, or unexpected changes in pavement gradients was observed.
- Fence lines appeared to be aligned as expected.
- Power poles appeared to be aligned as expected with no unusual tightening or sagging of power lines.

In the areas inspected, the following observations were made in Morwell in the area located north of the Hazelwood Mine northern batters:

- At the time of the inspection no noticeable sign of ground movement potentially related to mining such as tension cracking or differential settlement.
- No obvious sign of damage to dwellings potentially related to ground movement associated with the mining activities.

- Most dwellings appeared to be constructed using brick veneer and cladding during 1950's to 1970's. There are some relatively new homes in a pocket on Wallace Street that back on to the Princes Freeway.
- As in Traralgon, drainage structures on dwellings such gutters appeared to be aligned correctly. Most dwellings appeared to have the original gutters in place.
- No observable damage to sealed roads or noticeable changes in pavement gradients. This includes the relatively extensive sealed car park associated with the Morwell Bowling Club. It is understood this car park was recently constructed in 2014.
- Wallace Street appeared to be more recently resurfaced at the eastern end (from Tarwin Street) compared to surrounding streets. Newer curb/channel and footpath was also constructed along the resealed section of Wallace Street, therefore any noticeable damage would have been relatively recent.
- Footpaths around the eastern intersection of Hazelwood Road and Wallace Street did not have any significant cracking or displacement[3].
- No obvious ground movement related damage around the Morwell Football Club clubhouse (Morwell Recreation Reserve). The clubhouse is located adjacent to the Princes Freeway, approximately 200 m from the crest of the northern batters of Hazelwood Mine.
- During the meeting with Council representatives, it was mentioned that dwellings at the eastern end of Wallace Street are located on an old waste dump. This area is several metres higher in elevation than the surrounding areas. Dwellings on this material also did not have any obvious sign of ground movement related damage when inspected from the street.
- Power poles appeared to be aligned as expected with no unusual tightening or sagging of power lines.

In summary, visual observations suggest that the condition of dwellings and observed structures is within the norms of would be expected for their age and construction method. Damage was not observed to infrastructure in the areas inspected that could potentially be related to ground movements associated with mining activity. As mentioned previously, the visual inspection of dwellings was only from the adjacent footpath or street: no private property was entered. It is possible that damage may have occurred, or is occurring, to structures within the area covered that is not obvious from street level, but this was not identified.

The Council provided observations and some historical information relating properties and pavements at the eastern end of Wallace Street. This included information relating to a section of curb and channel displacement and pavement subsidence outside 4/2 Wallace Street. The curb and channel at this location is understood to be approximately 7 years old, within that period, up to 3 cm of displacement has occurred at one curb joint and the pavement up to 7.5 cm of subsidence. Approximately two years ago the Council were regularly (fortnightly) filling the location with gravel.

[3] The PSM Summary of Morwell Land Movement Survey and Report (2011) found that at the eastern end of Wallace Street, the majority of cracks were observed on the concrete pavements, footpath or driveways. PSM observed that the cracks or openings in most parts were filled with soil, grass or moss and interpreted them as older features.

Source: LaTrobe City Council

Council also provided observations that included cracking of concrete aprons within and adjacent to two properties located in Wallace Street. Stormwater outlets from two other properties have also had to be realigned to allow drainage to occur.

Council provided information indicating that there have been alleged drainage issues between the Wallace Street area and the Princes Highway sound mound and the documents note that under certain circumstances these issues may have the potential to contribute to mine slope instability. Council further referred to a number of historical documents from the 1970s that acknowledged land movement north of the Hazelwood coal mine generally around the Wallace Street, Morwell area.

In 2011 the former Department of Primary Industries (DPI) Victoria, conducted the *Morwell Land Movement Survey*. The project included a survey (inspection) of both private and public areas along the 200 m western section of Wallace Street and the southern 200 m of Hazelwood Road, Morwell. This area is located approximately 200 m to 450 m of the Hazelwood Mine Northern Batters.

The survey took place approximately six months after movement of the Hazelwood Northern Batters that resulted in cracks on the Princes Freeway and adjoining area. The survey included the following observations and assessments:

- *Some evidence of the sense of movement is given by leaning power poles and signage, displaced kerbs (up to 5mm) on the road, and horizontal exaggerations (up to 50mm) of construction joints between slabs at the town houses*.
- *The movement direction is observed to be a North-South separation at the southwest corner of the project area. The sense of this movement becomes less pronounced east of the town houses at 2 Wallace Street and north of the tennis courts, in these areas, the cracks were observed to be filled with soil/grass/moss and were typically less in magnitude (length, vertical and horizontal exaggeration)*.
- *This area of recent movements since February 2011 shows a change in the direction of movement from towards the north to southwards, towards the mine.*
- *Cracks in concrete slabs in driveways or footpaths that were filled with soil, grass or moss were assessed to be pre-existing prior to February 2011. There is no evidence of these having recently opened up further.*
- *Other external factors, most notably poor local drainage, reactive soils and inadequate design, construction or maintenance of buildings and infrastructure could contribute to the observed cracks and openings in the project area.*

It should be noted that the tennis courts that were present during the 2011 survey are now the site of the Morwell Bowling Club car park. The 2011 report concluded that "*There are a number of factors which may have contributed to the observed land movement in the project area. An ongoing monitoring and visual inspection program is recommended for this area*".

8.0 RISK ASSESSMENT

8.1 Adopted Method

This qualitative risk assessment has been undertaken to estimate the potential severity of mining related ground movement in the area to the north of the Loy Yang Mine and assess the risk to development, services and infrastructure associated with these ground movements.

In undertaking the risk assessment the guidelines for Landslip Risk Management published by the Australian Geomechanics Society (AGS) (2007) have been used.

Risks from geotechnical related hazards are usually assessed on the basis of either being "tolerable" or "unacceptable" risk in respect to both risk to life and risk to property. The AGS (2007) guidelines define tolerable risks as *"risks within a range that society can live with so as to secure certain benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if practicable."* It is in this context that the assessment of potential impacts from mining activities at Loy Yang Mine has been undertaken.

The assigned risk requires an assessment of the likelihood of a hazard being present and the consequences of that hazard, usually assessed by reference to a "risk analysis matrix". An example of such a risk analysis matrix, extracted from AGS (2007) is presented in Appendix C.

For this assessment, the terminology of "likely", "possible" and "unlikely" in relation to Likelihood have been adopted from AGS (2007)

The key hazards to property from mining related ground movements are:

1) A mine instability incident (such as slope failure or sudden development of tension cracks).

2) Ground movement (primarily differential horizontal and vertical ground movement) related to mine excavation and subsequent stress relief.

3) Ground movement (primarily differential horizontal and vertical ground movement) related to aquifer depressurisation.

In the case of 1), and possibly 2), above, the ground movement can be sudden and result in localised significant differential movement, which could result in significant consequences if property or other infrastructure was able to be impacted by such movement. However, with distance away from the mine, the consequences of 2) will diminish as the movements (strain) become more uniform and without sudden differential changes (refer Section 6.2). In the case of aquifer depressurisation (3 above), except for localised high gradient settlement immediately adjacent to the mine, the influence of this activity is manifested in relatively uniform (no sudden differential) settlement, as described in Section 6.1

It is in this context that the risk assessment has been undertaken.

8.2 Tolerable Movements for Residential Structures

Engineering and design techniques are commonly applied to various types of structure to minimise the risk associated with possible ground movements and potentially unstable foundation material. Mine subsidence is a form of ground movement that has been accommodated in design within Australia for several decades.

Considerations when designing for a potential mine subsidence should be given to:

- Design to accommodate differential settlement (curvature)
- Design for vertical subsidence

- Design to accommodate strains
- Design to accommodate tilt

Not all mining related movements cause damage to surface structures. The risk to development will depend not so much on the total magnitude of vertical or horizontal movement, but on the differential movement from one point to another. Provided the differential movements are small enough, the assessed risk will be within tolerable limits.

Design criteria relating to tolerable limits of differential settlement (deflection) for footings are outlined in *AS 2870-2011 Residential slabs and footings.* This is shown in **Table 1**. In the absence of specific construction information the tolerable limits adopted are the lesser of the two values given in **Table 1**.

Table 1: Maximum Design Differential Footing Deflection for Design of Footings and Rafts (adopted from AS2870-2011, Table 4.1)

Type of construction	Maximum differential Deflection, as a function of span (mm)	Maximum differential deflection (mm)[4]
Clad Frame	L/300 (or 3.3 mm/m)	40
Articulated masonry veneer	L/400 (or 2.5 mm/m)	30
Masonry veneer	L/600 (or 1.7 mm/m)	20
Articulated full masonry	L/800 (or 1.2 mm/m)	15
Full masonry	L/2000 (or 0.5 mm/m)	10

Vertical subsidence is considered a rigid body movement and generally has no adverse impact on buildings with a footprint size of most residential dwellings. Vertical subsidence is more relevant over large areas and can be considered in design of services such as water, sewerage and drainage.

Ground strains are a result of differential horizontal movement between two points causing a change in the length of the surface between the two points. Tensile strain is a result of an increase in surface length and compressive strain a result of a reduction in surface length. Both of these ground strains can cause cracking to some building types as most components are weaker in tension.

The amount of strain that is transferred is a function of the soil (or rock) interaction with the foundation system. The stiffened raft is an example of footing design that can separate the structure from horizontal ground strains.

Burland and Wroth (1974) suggest that for brickwork and block work set in mortar the average critical tensile strain at which visible cracking occurs is in the range of 0.05 mm/m to 1.0 mm/m (or 0.05 % to 0.1 %) and for reinforced concrete between 0.3 mm/m to 0.5 mm/m (or 0.03 % to 0.05 %).

In general ground tilt has minimal structural impact. Serviceability issues such as drainage, for example the slope of gutters, could be encountered with severe tilts, but most single storey buildings usually remain serviceable when tilts are less than 7 mm/m (Mine Subsidence Board (NSW) Graduated Guidelines Vol. 1).

The limits described above were adopted in the risk assessment presented below, and may be a useful basis for Council to adopt in relation to development in this area.

8.3 Risk Assessment

The area inside the nominated Area of Influence (as yet to be reasonably defined by PSM), but outside the existing buffer zone is of primary interest to the Council. This is the area in which development has

[4] Maximum differential deflection over the width of the defined structure.

occurred, or may continue to occur, and which has and may continue to experience ground movements (as distinct from instability) as a result of mining activities.

For this assessment three risk zones have been adopted, as described in **Table 2**. The Qualitative Risk Level and Potential for Development within each of the three risk zones is presented, based upon whether ground movements (associated with mining activities) within each Zone are likely to be tolerable (or not). It should be noted that these risk categories might or might not align with the Council's views.

Table 2: Adopted Risk Categories

Zone	Risk Level	Potential For Development	Description
1	High to Very High	Development Unlikely*	Ground movement due mine excavation and subsequent stress relief is likely to be greater than that considered tolerable for most potential development. This is the area closest to the mine crest, where the possibility of a mine instability incident adversely impacting development also exists.
2	Low to Moderate	Development Possible with restrictions	Ground movements due to mine excavation and/or aquifer depressurisation may be greater than those considered tolerable for structures associated with any potential development. Unlikely to be impacts on property due to a mine instability incident. The movements in areas defined by this category are possibly tolerable for some structures.
3	Very Low	Development Possible	Ground movements due to mine excavation and/or aquifer depressurisation unlikely to be greater than those considered tolerable by structures associated with potential development. The likelihood of a mine instability incident impacting property is remote. The risk to property is within "societal norms". The movements in areas defined by this category are likely to be tolerable for most structures.

*Note: Traralgon Transfer Station currently exists in this zone and associated structures are understood to be performing to an acceptable level. It is understood to have mostly been constructed after 2012.

Ground movements within Zone 1 are mostly caused by excavation of the pit and subsequent relief of in situ stresses, with some component of the ground movement due to aquifer depressurisation. This area has the potential to experience rates of ground movement higher than tolerable and also has the potential to be influenced by ground movement related to mine instability. The development of tension cracks or shear displacement occurring is possible within this Zone, particularly closer to the mine batter.

Areas within Zone 2 are also subject to ground movements related to relief of in situ stresses associated with the pit and as a result of depressurisation of aquifers. However, impacts due to instability incidents are considered unlikely. It is possible some forms of development could be allowed in this Zone (see 8.4.2).

For Zone 3, ground movements are mostly due to depressurisation of the aquifers. A negligible amount of movement related to in situ stress relief may occur in some parts of the defined area.

Currently no ground movement data relating to Stability Lines other than N3, N5 and N7A has been made available to Golder. Therefore there is greater uncertainty relating to historical and predicted ground movements for much of the area behind both the current and proposed mine crest.

8.4 Risk Map

Each risk category, or zone, was applied to areas north of the Loy Yang Mine to form a "Risk Map", as shown on Figure B3, Appendix B. On this figure, the spatial position of each zone is shown. A line representing 1 km from the mine crest (as in the AGL, WPV) is also shown on the map, this is the minimum separation distance required to an urban settlement boundary. This approximately corresponds to the existing 1 km buffer from the mine crest. In general, Risk Zones 1 and 2 lie within the existing ESO 1 buffer zone (generally 1km), but at the eastern end Risk Zone 2 has been extended to about 1.3 km from the proposed crest of the mine, due to the planned greater depth of mine in this area (see Section 8.4.2).

Figure B4, Appendix B is a Risk Map that takes into consideration the previously approved 1997 Loy Yang development boundary. The Risk Zones on this figure have been adjusted to reflect this boundary, providing a comparison to Figure B3, Appendix B which considers the proposed mine development in the AGL, WVP.

Information taken into consideration when developing the risk maps included:

- Observations made during the site visit.
- Ground movement information presented in the PSM Report.
- Information presented by AGL for the WPV and Planning Panel Submission.
- Known historical instability incidents associated with coal mines in the Latrobe Valley.
- Ground movement information and conclusions made in the GHD 2010 Report (Draft).
- Golder's knowledge from involvement in projects throughout the Latrobe Valley.
- Anecdotal evidence from Council employees who have been long involved in the construction and maintenance of infrastructure and survey.
- Anecdotal evidence from Council employees that have been long-term residents in the region, with some currently living in the residential area immediately north of Loy Yang Mine.
- A typical design life of 50 years for permanent structures used by people, however local Council policies might require longer.

Assumptions when developing the risk map include:

- The historical magnitude and rate of ground movement at survey pins along Stability Lines N3, N5 and N7A is representative of the likely future movements behind the pit crest of associated with further mine development.
- Groundwater extraction rates are similar to those that have occurred historically.
- Future mine crest positioned as shown in plans presented in AGL, WPV.
- The maximum depth of the Loy Yang Coal Mine and rate of excavation is consistent with what is shown in the AGL WPV.
- Future permanent batters have a configuration similar to that which has been mined with overall slopes of 1V:3H adopted (consistent with what is shown in Figure 15 of the AGL WPV).
- Appropriate slope and risk management practices are used at Loy Yang Mine.
- Future rehabilitation practices do not result in significantly greater ground movements (magnitude or rate) or risk of slope instability.
- Tolerable deflection limits for common construction methods (Table 1).
- Application of good design practice and construction methods to future areas of development.
- A mine instability incident impacting development outside the existing 1 km buffer zone is not credible.

8.4.1 Zone 1 (High to Very High Risk)

The area within Zone 1 is highlighted red on Figure B3, Appendix B. This area has an assessed current level of risk to development that is high to very high and development in this area is therefore unlikely. The area defined as Zone 1 generally extends 700 m behind the current and proposed crest of the Loy Yang Mine pit, but to the east has been extended to 1.0 km, as discussed below. This Zone is exposed to ground movement both due to stress relief and aquifer depressurisation, and closer to the mine crest (within this Zone) to the potential hazard of mine related instability.

Ground movement information presented in the PSM Report relating to Stability Lines N3, N5 and N7A suggests that some ground in this area has experienced differential movement greater than what is considered tolerable for some construction types (Table 1). For example full masonry construction might not be an inappropriate method for construction in this area. It is possible that more flexible forms of construction (e.g. weatherboard) could be permitted, particularly toward the outer limits of this zone. However, any development in this Zone would require a development specific risk assessment, based upon the prevailing circumstances (observed movements, is mining complete, etc.)

The data from survey pins located on the three Stability Lines indicates that the rate of ground movement, particularly horizontal, can be relatively high up to a distance of approximately 700 m from the crest as the mining front passes and excavation occurs at the batter toe. Of the three Stability Lines presented in the PSM Report, N7A is the most easterly, and it shows that the rate and amount of ground movement (particularly horizontal) is potentially starting to "taper off" for survey pins along this line. To the west of Line N7A, at Stability Lines N5 and N3, survey data suggests that the ground movement rate has peaked and the amount of horizontal movement currently occurring is minimal.[5] Settlement is still occurring at these locations but at a much slower rate with advancement of the mining front eastward.

As the proposed northern crest aligns to a more east-west orientation, Zone 1 has been extended out to 1 km behind the behind the crest (equal to the current buffer limit). This adjustment in distance is based on the planned increase in pit depth to approximately 250 m (Stage C of mine development in the AGL, WPV). At this depth the pit will be approximately 100 m deeper than the current Loy Yang Mine pit, and deeper than other coal mines in the Latrobe Valley. We consider it reasonable to assume the increase in mine depth will result in greater magnitudes and rates of movement behind the pit crest than currently observed, but to what extent is not known. For the purposes of this study we have considered the 300 m widening to be prudent.

Areas defined to be within Zone 1 area are also potentially exposed to the impacts of mine instability. As previously mentioned, known instability incidents at coal mines within the Latrobe Valley have impacted within about 300 m to 450 m of the crest of the mine batters. However with deepening of the Loy Yang Mine towards the east, we consider it prudent to assume the impacts of a potential mine instability incident (or incidents) might extend further than those historically experienced at the present Latrobe Valley coal mines.

8.4.2 Zone 2 (Low to Moderate Risk)

The area indicated by yellow shading in Figure B3, Appendix B, is defined as Zone 2. The data available suggests that the areas defined by this risk category are likely to be at a distance from the mine sufficient that development is possible with application of appropriate design and construction technologies, particularly after mining moves eastward.

This area is 300 m in width and, at the western end of the study area ranges from 0.7 km to 1 km from the current and proposed crest location (i.e. within the present buffer zone). However, at the eastern end, due to the wider Zone 1 (see above), the 300 m wide Zone 2 area extends to 1.3 km from the planned mine crest(i.e. outside the 1 km buffer). This takes Zone 2 into proposed the development area of rural living (Planning Zone 21) that is located behind the proposed northern crest location.

Within Zone 2, we expect most types of construction (detailed in **Table 1**), potentially including full masonry, could tolerate the anticipated ground movements in this area due to mining. Nevertheless, in the absence a favourable assessment of more monitoring data within the nominated Zone 2, we consider it prudent that full masonry construction be precluded. We do not have details of the construction types used for the existing dwellings within Rural Living Zone 21, which are outside the current buffer zone but within this Zone 2, but it is assessed unlikely these will be adversely impacted by the future mining. However, we consider it would be prudent to undertake an existing condition survey of each of these dwellings, to obtain a base line from which any implied future distress associated with mining could be assessed. We are not aware if the mine

[5] For comparison, refer to Appendix A, charts of Horizontal Movement versus Distance from Toe of Pit Wall for N3, N5 and N7A,

has any survey lines extending into this area, but regardless this would also be prudent so that mining related ground movements can be monitored as mining progresses to the east.

After mining has progressed to the east, potentially resulting in a reduction of ground movement in some areas, it is possible that the level of risk might be lower for those areas and restrictions on development could be adjusted accordingly. Historical dwelling condition surveys and ground movement survey data (if available) would provide important information for determining if changes to the level of risk are to be considered.

8.4.3 Zone 3 (Very Low Risk)

The area to the north of the Zone 2 Risk area is considered as having Very Low risk in relation to the impact of mining activity related ground movement. This area includes Traralgon township (Figure B3, Appendix B). This zone begins at a distance of between 1 km from the current mine crest and up to 1.3 km from a section of the proposed crest (in the AGL, WPV).

The risk to property within this area is expected to be tolerable and within societal norms. Key information used in defining this area was the magnitude and rate of recorded ground movement (locally and regionally), observations made in the field, Council records and anecdotal evidence from long-term Council employees and residents within relevant parts of the township.

Although the data available was limited and spatially scattered in this area, the historical differential ground movement recorded appears to be well within what is tolerable. It is expected that future differential vertical and horizontal ground movement would be negligible, and not outside that which can be related to other common design hazards such as shrinking soils.

8.5 Appropriateness of 1 km Buffer

All the area designated as being at High to Very High risk (i.e. Zone 1), and most of the Low to Medium Risk area (Zone 2), with respect to the potential impacts of mining related ground movements, falls within the present 1 km buffer zone. As such, the present 1 km buffer zone is considered to be appropriate for all of Zone 1, and where Zone 2 also falls within this buffer zone.

At the eastern end, the designated Low to Moderate risk area extends up to 300 m outside the presently defined buffer zone, and encroaches into proposed areas for future development (Planning Zone 21, Figure B3, Appendix B). This might be of particular interest to the planning authority responsible for any future amendments to the buffer zone (ESO 1). However, subject to the discussion above, resetting the buffer zone in this area may not be necessary subject to monitoring and provided sufficient controls linked to this monitoring are put in place.

Beyond the proposed limits of Risk Zones 1 and 2 (i.e. Zone 3), the risk to property due to mining related ground movements is assessed to be Very Low and within what could be considered “societal norm”.

When determining the extent of Zones 1 and 2, a level of uncertainty needed to be considered in relation to future ground movements associated with deepening of the mine. However, as mining progresses and with access to more extensive monitoring data (as is expected to be available to the east of Stability Line N7A, but not made available to us for this study), this current level of uncertainty may be reduced and any future planning controls relaxed. For example, at present full masonry construction should likely not be permitted in Zone 2, but subject to the results of further monitoring information, this could be relaxed. As noted previously, any development proposed within Zone 1 should be subject to a development specific risk assessment. Again, further monitoring data could inform this process.

Whilst there are potential implications for any development within Risk Zone 2, it does not necessarily mean that development cannot occur. Modification to development proposals within these areas to mitigate the risk to property might include:

- Limit the use of construction types or methods. As noted, movements in this Zone are expected to be tolerable for most domestic construction types, but prudency would suggest full masonry construction, and perhaps also articulated full masonry, should be precluded until monitoring data suggests the risks

associated with this form of construction are acceptable. For industrial development, the design would need to be able to accommodate the equivalent differential and total deflections applicable to masonry veneer, or possibly articulated full masonry, as described in Table 1.

- Delay development until ground movements are predicted to be within tolerable limits (applicable to the proposed development). This might be related to a time period after the mining front passes, or mining ceases, and be subject to review of monitoring data. Note that whilst the overall risk consequences might be less for development in areas of low density development (e.g. rural living) than normal urban development, we consider the implications for specific structures would likely inform such decisions.
- Develop appropriate risk mitigation strategies in conjunction with the mine. These might include ongoing, regular reporting to the Council of appropriate ground movement data assessments.

As mentioned it might be possible that analysis of ground movement information not made available to this study could result in spatial adjustment of the risk categories shown in Figure B3, Appendix B.

9.0 CONCLUSIONS

- The qualitative risk assessment established three risk zones for the area north of the Loy Yang Mine, as shown in Figure B3, Appendix B. The Qualitative Risk Level and Potential for Development within each of the three risk zones is presented, based upon whether ground movements (associated with mining activities) within each Zone are likely to be tolerable (or not).
- Risk Zone 1 (High to Very High risk level is situated within the WPV 1 km buffer and does not extend beyond the northern boundary of the ESO 1 (Urban Buffer). Development within this Zone is unlikely.
- Risk Zone 2 (Low to Moderate risk level) is mostly located within the AGL, WPV 1 km buffer and does not extend beyond the northern boundary of the ESO 1 (Urban Buffer). However, at the eastern end this Risk Zone 2 extends up to 300 m beyond the present AGL, WPV 1 km buffer. This adjustment in distance is based on the planned increase in pit depth to approximately 250 m (Stage C of mine development in the AGL, WPV). At this depth the pit will be approximately 100 m deeper than current Loy Yang Mine pit, and deeper than other coal mines in the Latrobe Valley. Within Zone 2, development may be possible with restrictions on the form of construction.
- Risk Zone 3 (Very Low risk level), is defined as an area mostly 1 km from the proposed crest (in the AGL, WVP), but with the exception of the eastern end where it is located 1.3 km from the proposed mine crest (in line with Risk Zone 2). No development restrictions associated with mine related ground movements are necessary in this area.
- Risk Zone 2 encroaches into Planning Zone 21 (Rural Living), which we understand to be largely fully developed. Most forms of construction within this area are expected to be able to tolerate future ground movements as the mining progresses. However, it is considered prudent that an existing condition survey of each of the dwellings in this area be undertaken, to obtain a base line from which any implied future distress associated with mining could be assessed.
- For the balance of Risk Zone 2, for future development full masonry construction, and perhaps also articulated full masonry, should, be precluded until monitoring data suggests the risks associated with this form of construction are acceptable.
- For any planned development within Risk Zone 1, a development specific risk assessment would be required based upon the prevailing circumstances (observed movements, is mining complete, etc.).
- The proposed Traralgon Bypass is shown in Figure B3, Appendix B. This figure indicates that some sections of the proposed alignment are located within Risk Zones 1 and 2. The design and construction of the bypass should take into consideration potential future ground movements throughout this area.

10.0 REFERENCES

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Report Signature Page

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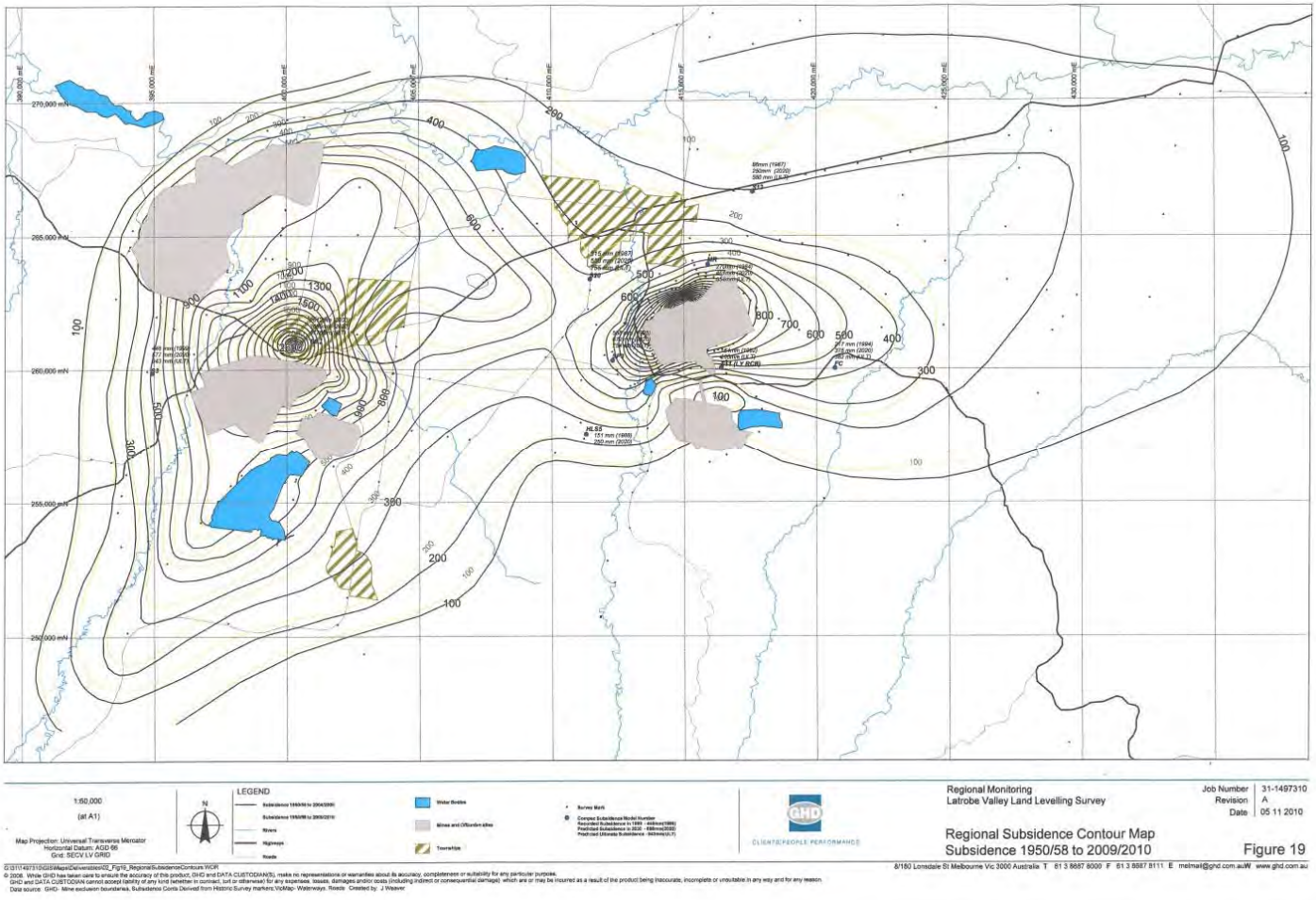
APPENDIX A

Extracted Figures (from other reports)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Regional Monitoring
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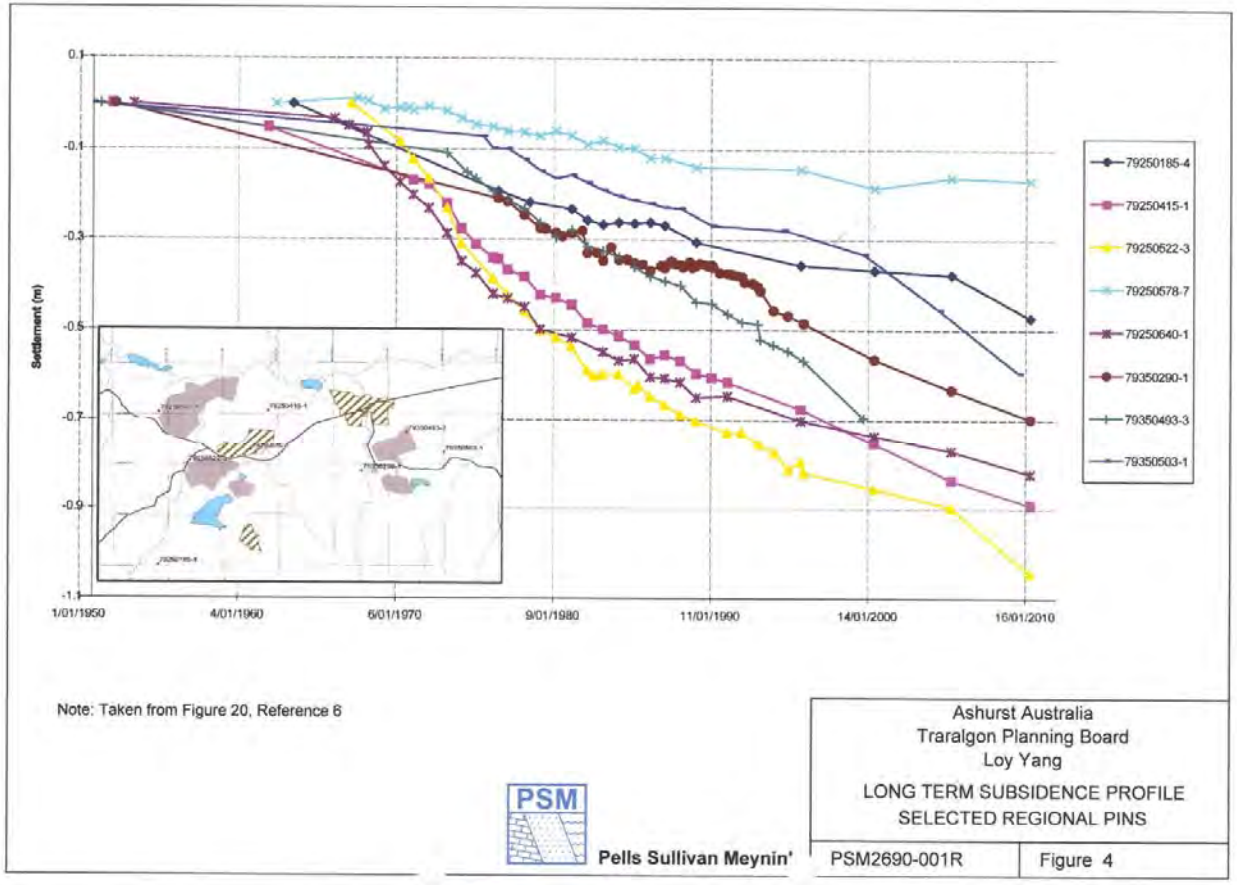
Regional Subsidence Contour Map
Subsidence 1950/58 to 2009/2010
Job Number 31-1497310
Revision A
Date 05 11 2010
Figure 19
CLIENT/PEOPLE/PERFORMANCE
8/180 Lonsdale St Melbourne Vic 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au


0.1
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-0.3
-0.5
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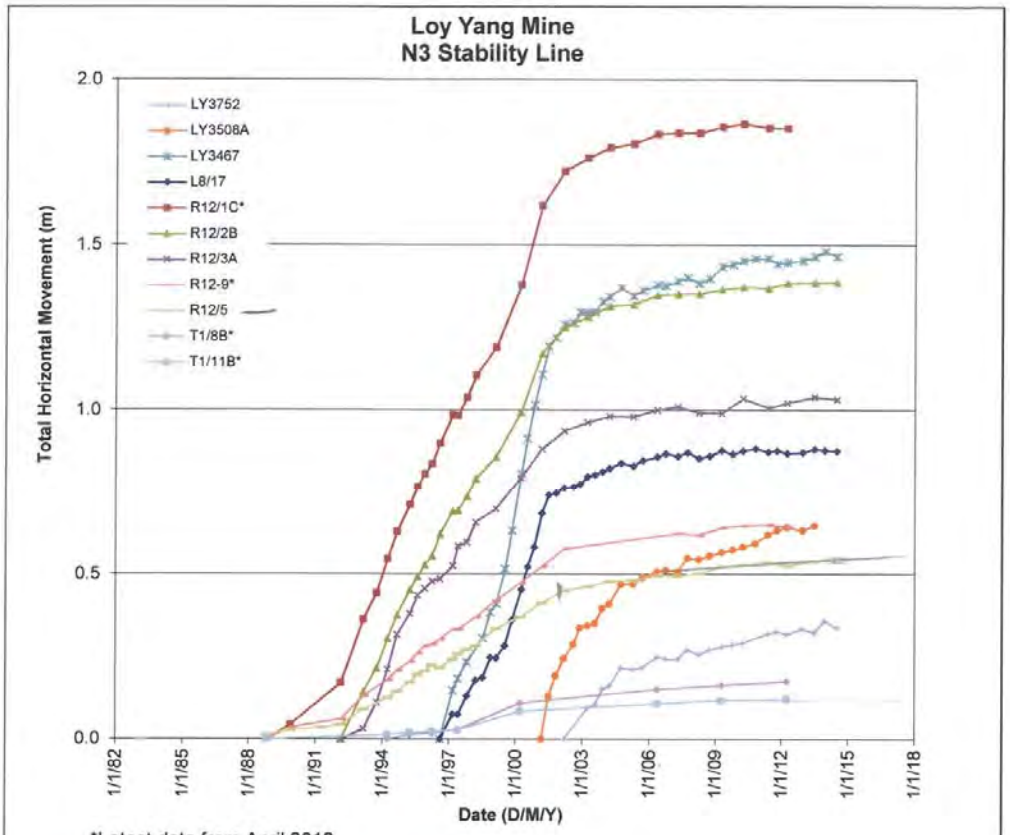
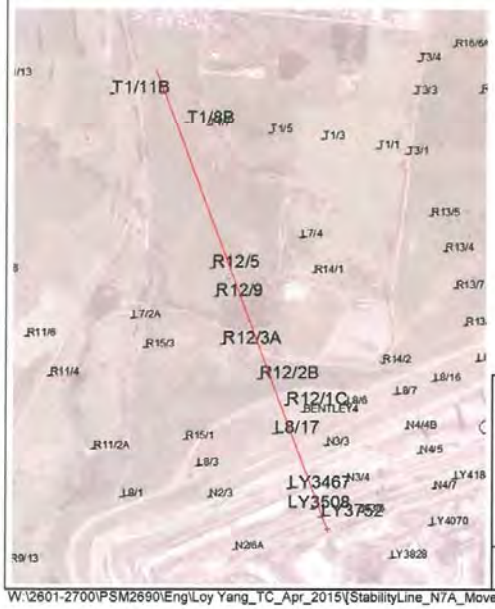
-0.9
-1.1
Settlement (m)
1/01/1950
4/01/1960
6/01/1970
9/01/1980
11/01/1990
14/01/2000
16/01/2010
79250185-4
79250415-1
79250522-3
79250578-7
79250640-1
79350290-1
79350493-3
79350503-1
Note: Taken from Figure 20, Reference 6
PSM
Pells Sullivan Meynin'
Ashurst Australia
Traralgon Planning Board
Loy Yang
LONG TERM SUBSIDENCE PROFILE
SELECTED REGIONAL PINS
PSM2690-001R
Figure 4





Ashurst Australia
Loy Yang Mine

TOTAL HORIZONTAL MOVEMENT v TIME
N3 STABILITY LINE

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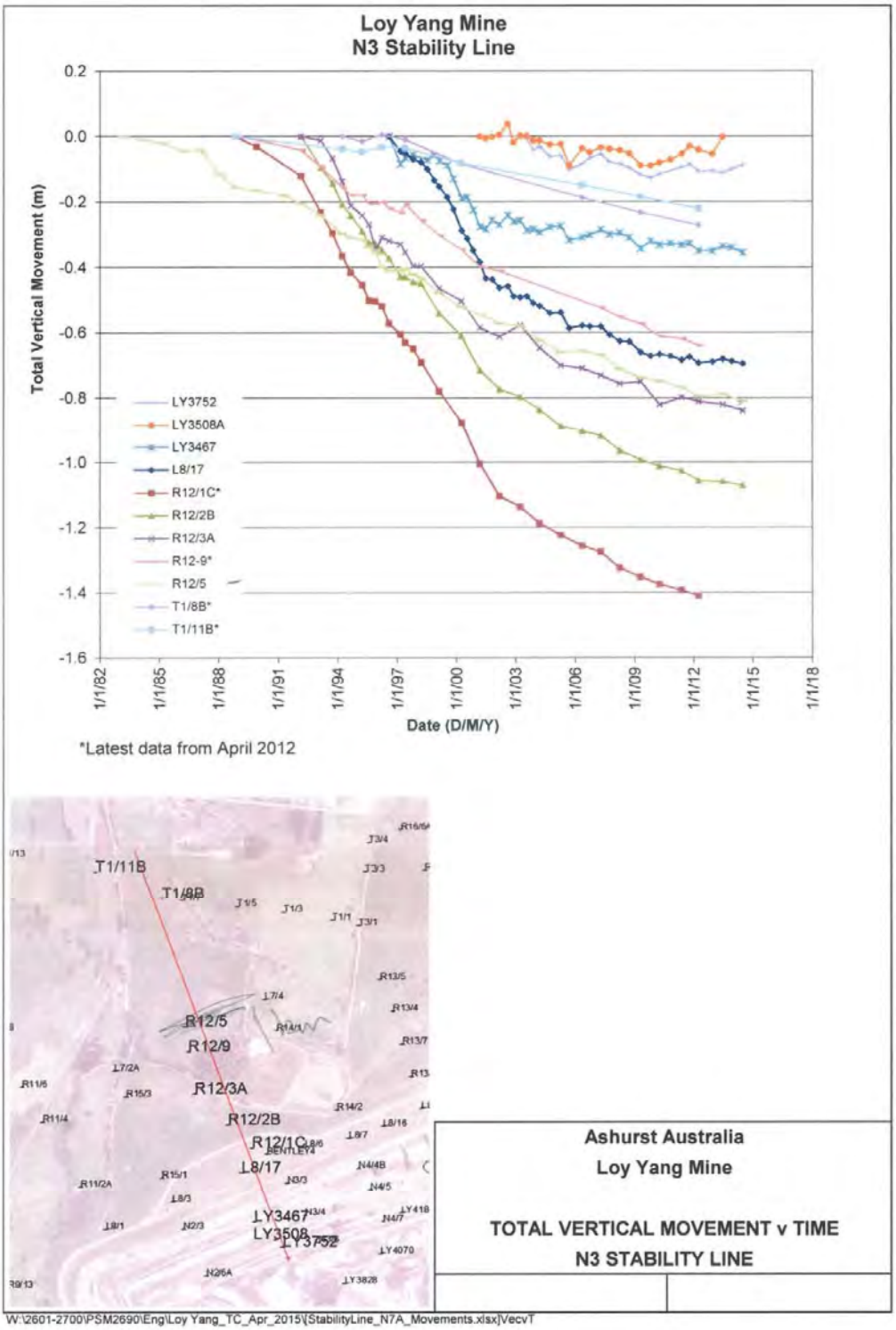
Loy Yang Mine
N3 Stability Line
Total Vertical Movement (m)
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
1/1/82
1/1/85
1/1/88
1/1/91
1/1/94
1/1/97
1/1/00
1/1/03
1/1/06
1/1/09
1/1/12
1/1/15
1/1/18
Date (D/M/Y)
LY3752
LY3508A
LY3467
L8/17
R12/1C*
R12/2B
R12/3A
R12-9*
R12/5
T1/8B*
T1/11B*
*Latest data from April 2012
T1/11B
T1/8B
R12/5
R12/9
R12/3A
R12/2B
R12/1C
L8/17
LY3467
LY3508
LY3752
Ashurst Australia
Loy Yang Mine
TOTAL VERTICAL MOVEMENT v TIME
N3 STABILITY LINE
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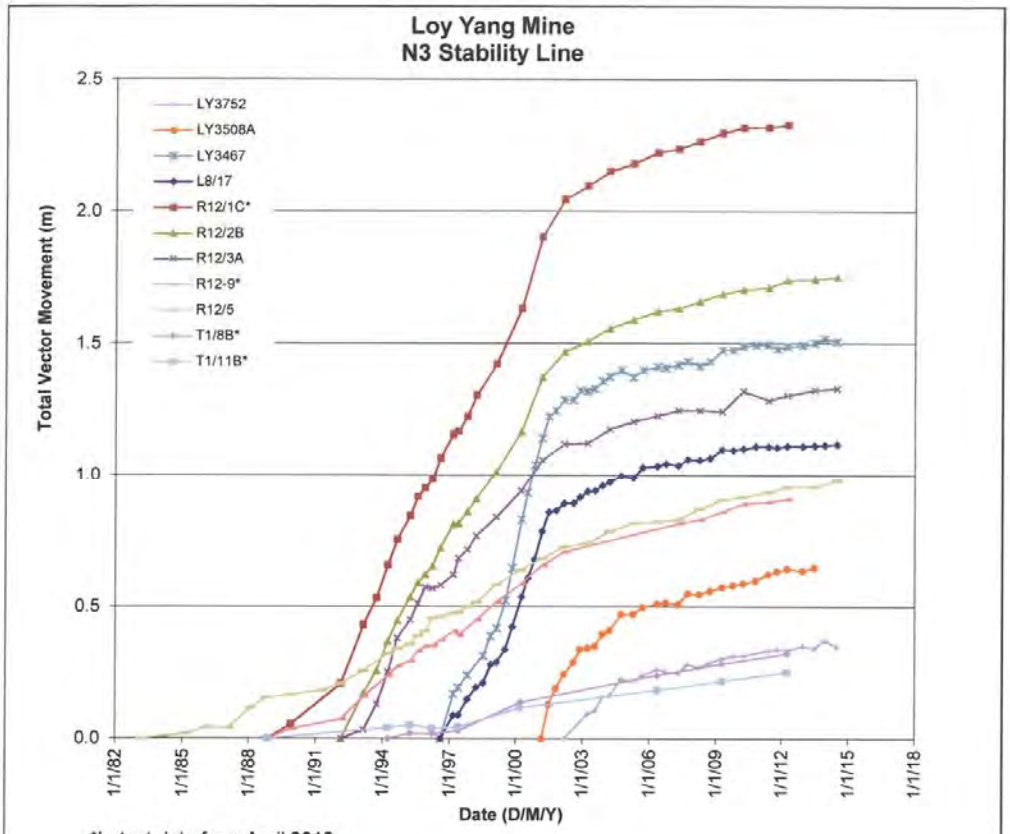

Ashurst Australia
Loy Yang Mine

TOTAL VECTOR MOVEMENT v TIME
N3 STABILITY LINE

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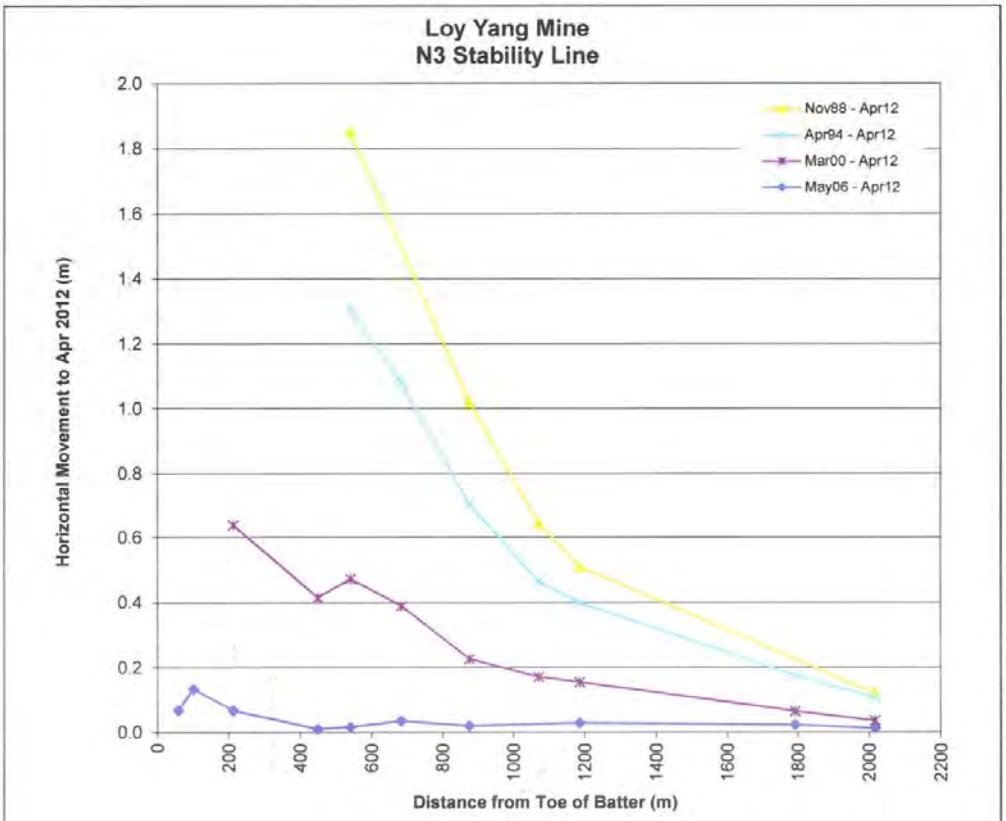

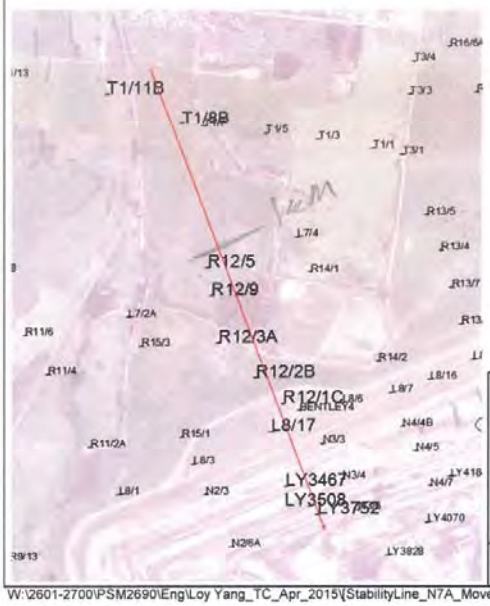

Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N3 STABILITY LINE 2012

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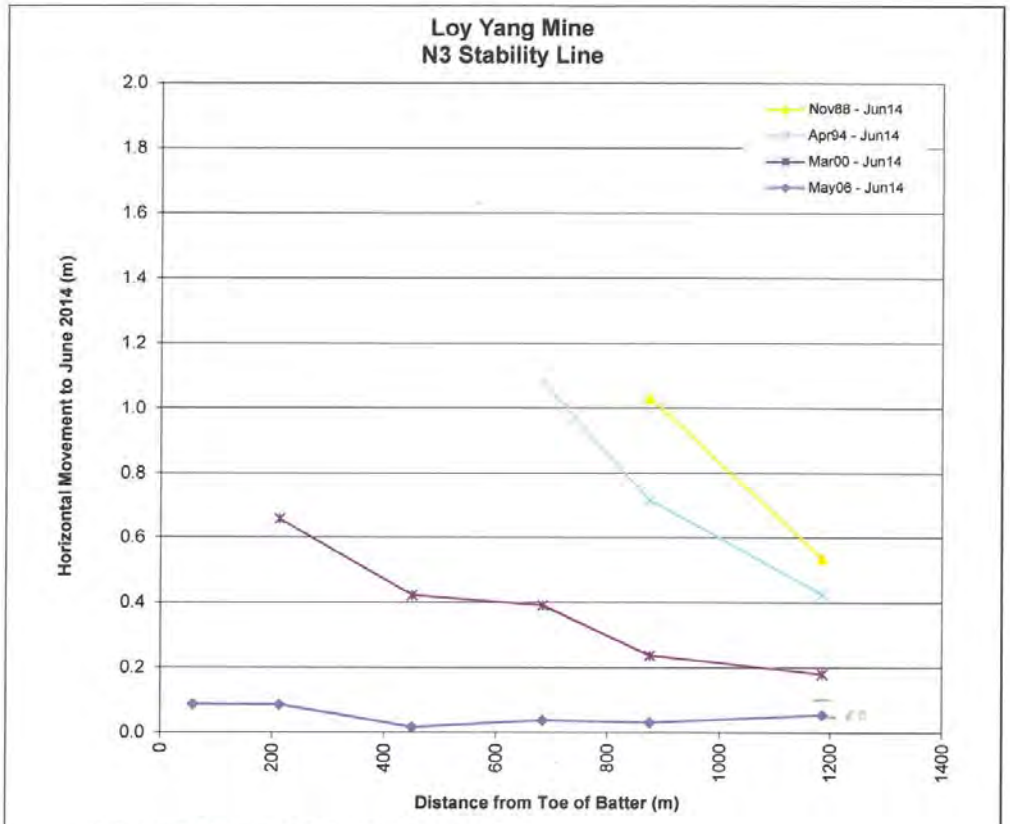

Note: Some pins were not monitored in June 2014

Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N3 STABILITY LINE 2014

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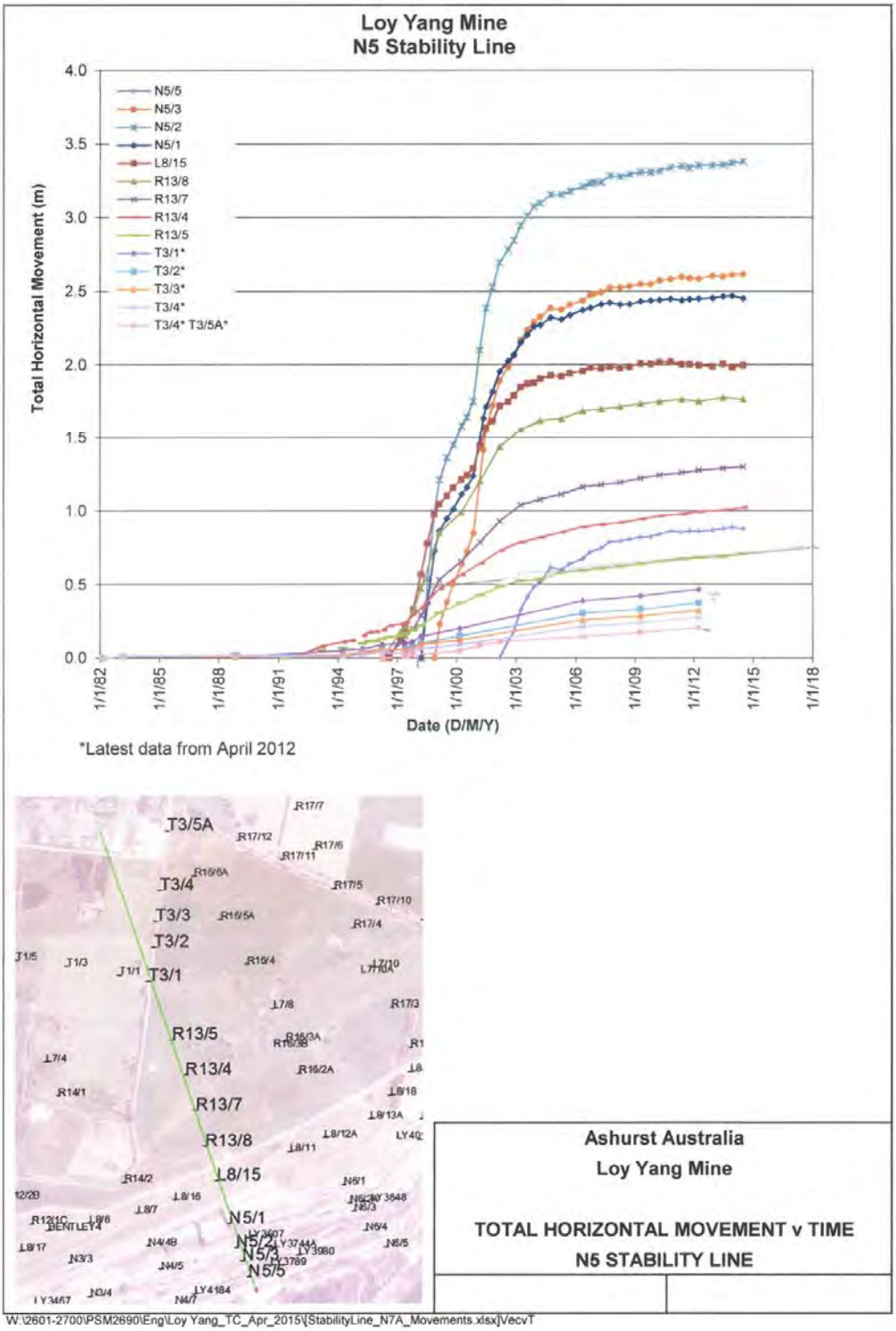
Loy Yang Mine
N5 Stability Line
Total Horizontal Movement (m)
Date (D/M/Y)
N5/5
N5/3
N5/2
N5/1
L8/15
R13/8
R13/7
R13/4
R13/5
T3/1*
T3/2*
T3/3*
T3/4*
T3/4* T3/5A*
*Latest data from April 2012
T3/5A
T3/4
T3/3
T3/2
T3/1
R13/5
R13/4
R13/7
R13/8
L8/15
N5/1
N5/2
N5/3
N5/5
Ashurst Australia
Loy Yang Mine
TOTAL HORIZONTAL MOVEMENT v TIME
N5 STABILITY LINE
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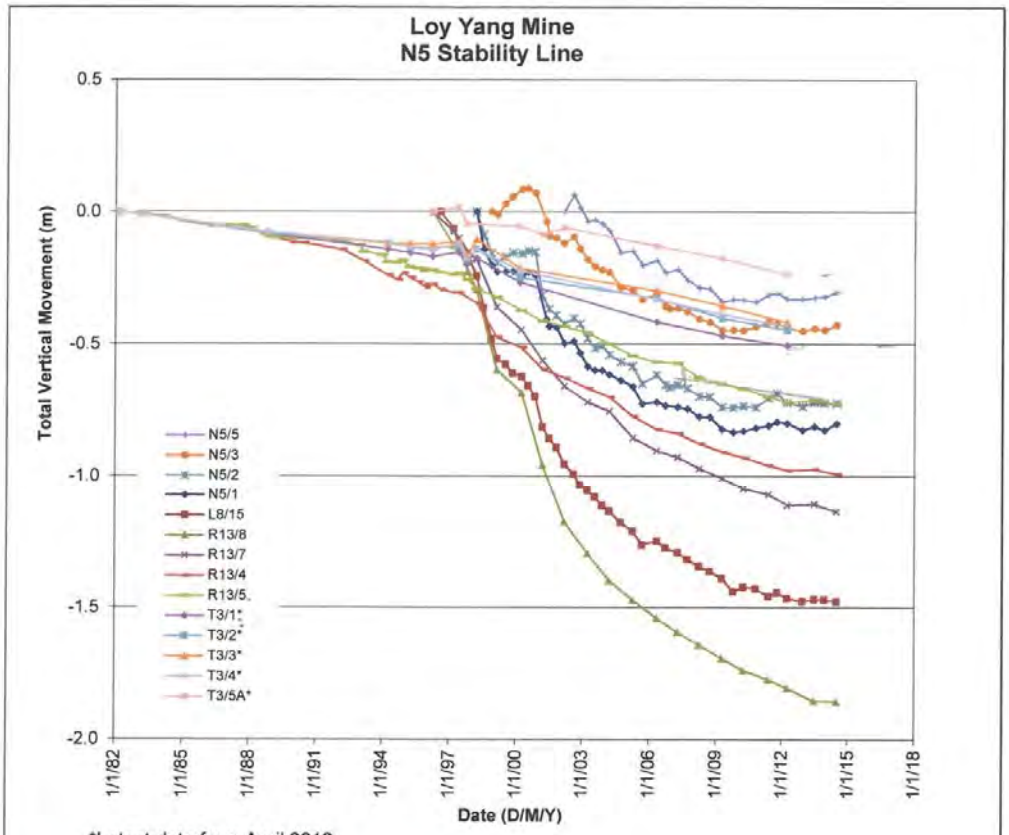
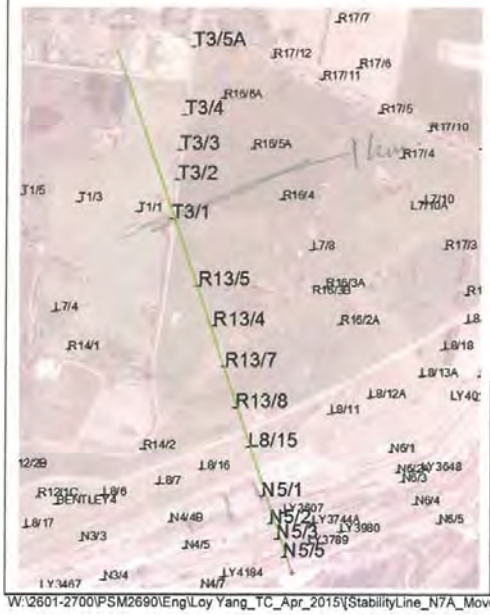
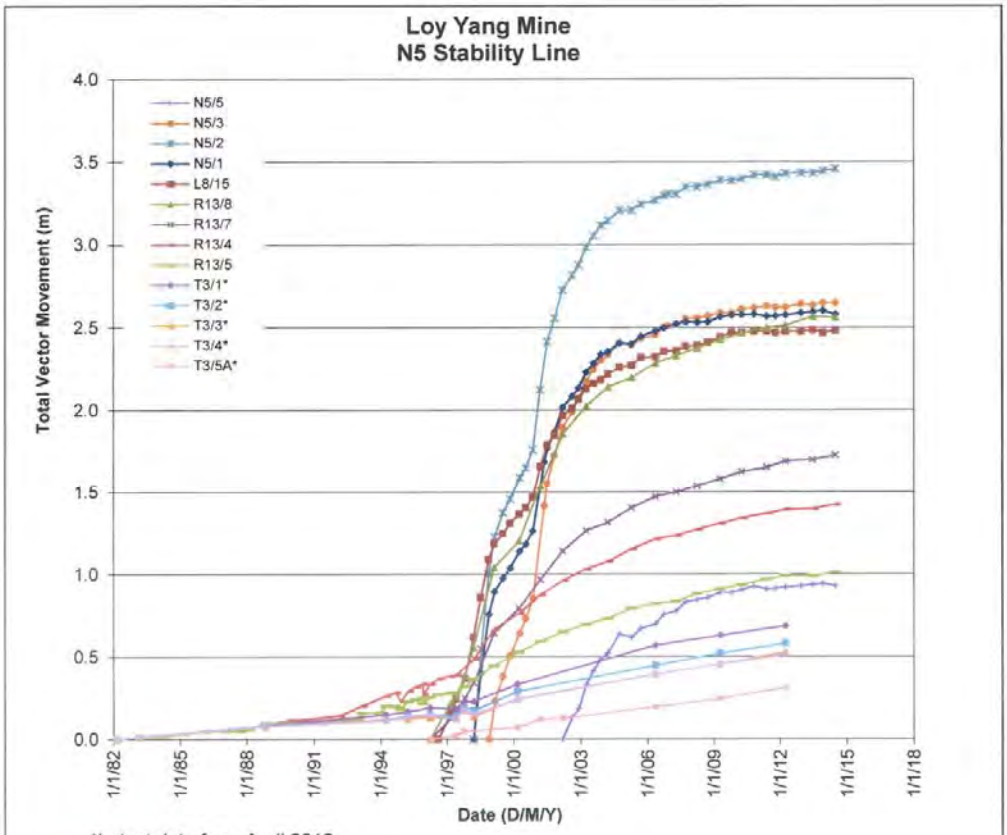


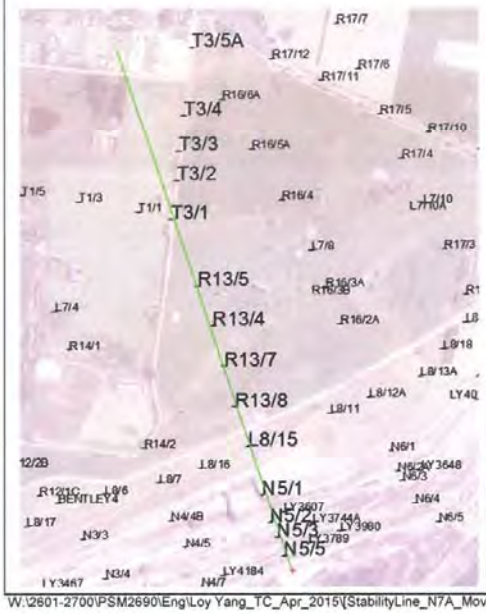
*Latest data from April 2012



Ashurst Australia Loy Yang Mine TOTAL VERTICAL MOVEMENT v TIME N5 STABILITY LINE	

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

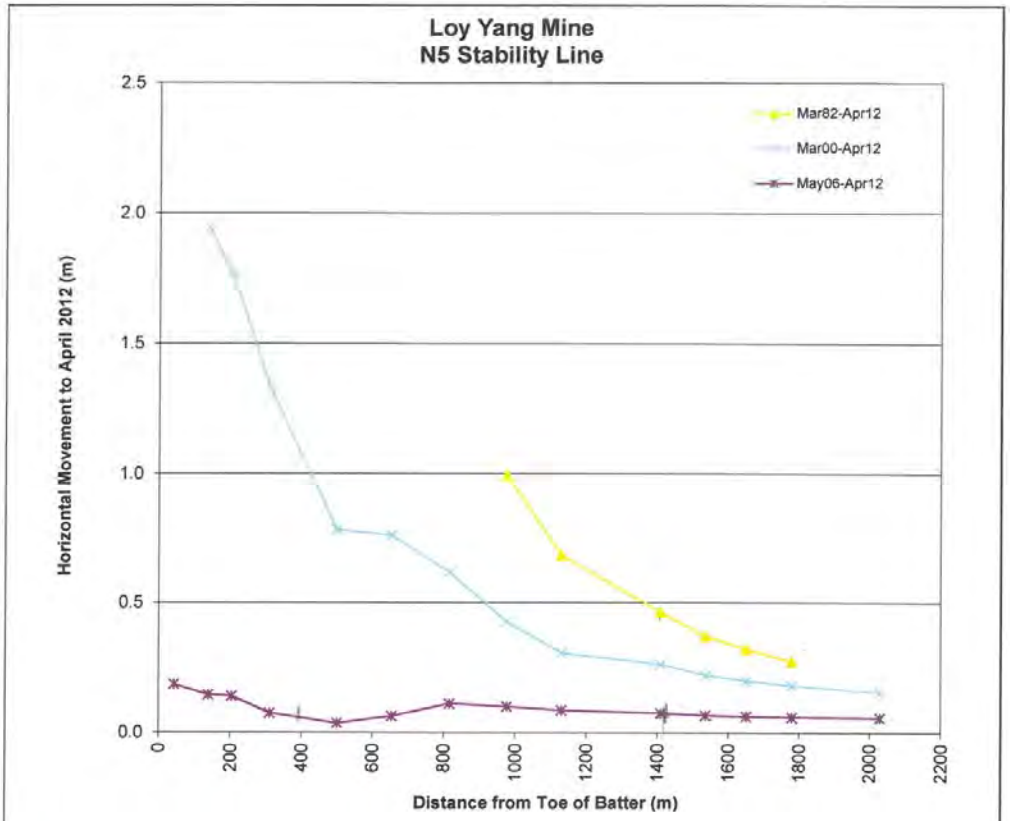


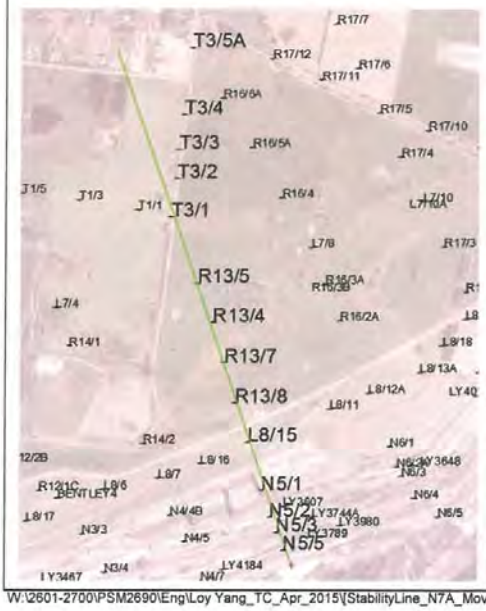


Ashurst Australia
Loy Yang Mine

TOTAL VECTOR MOVEMENT v TIME
N5 STABILITY LINE

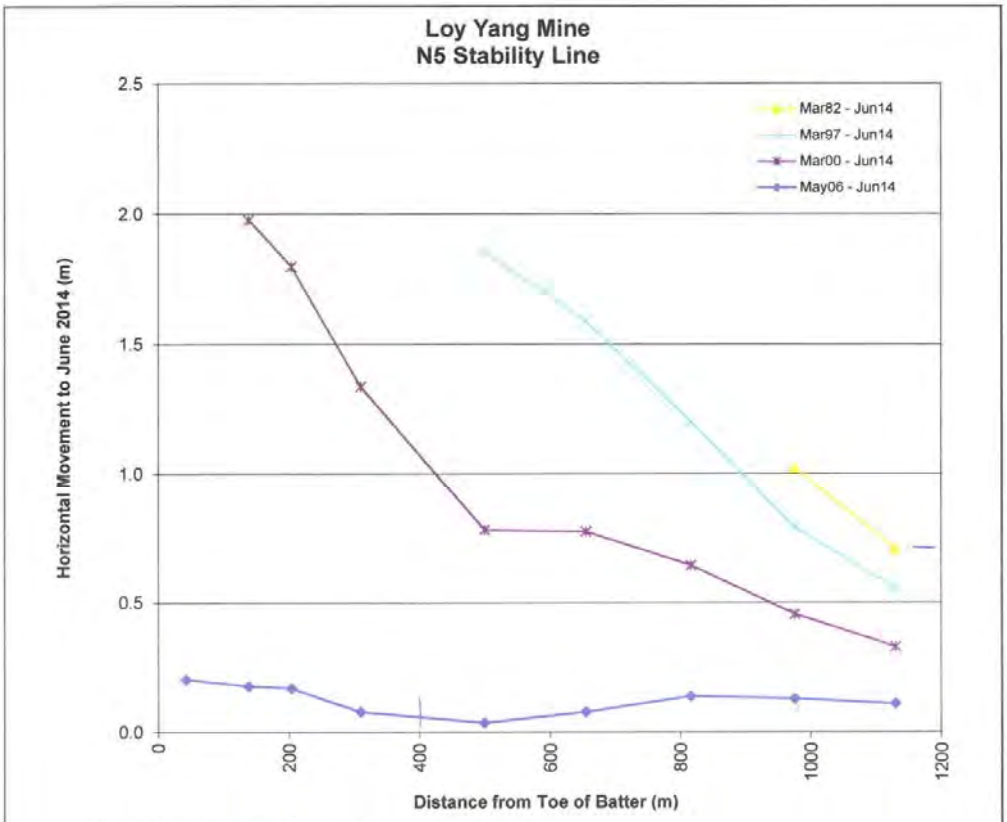
W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT



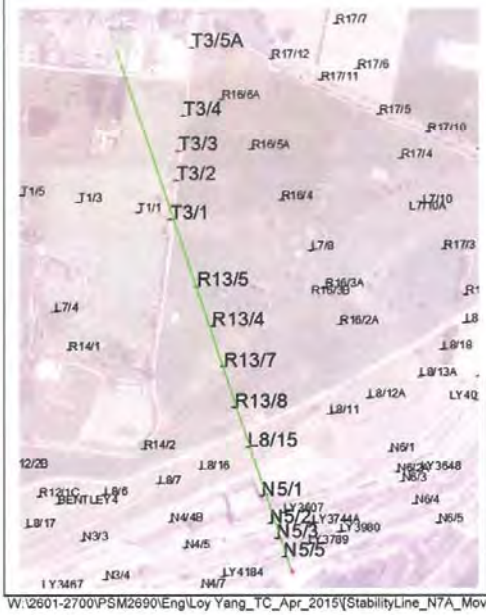


Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N5 STABILITY LINE 2012

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

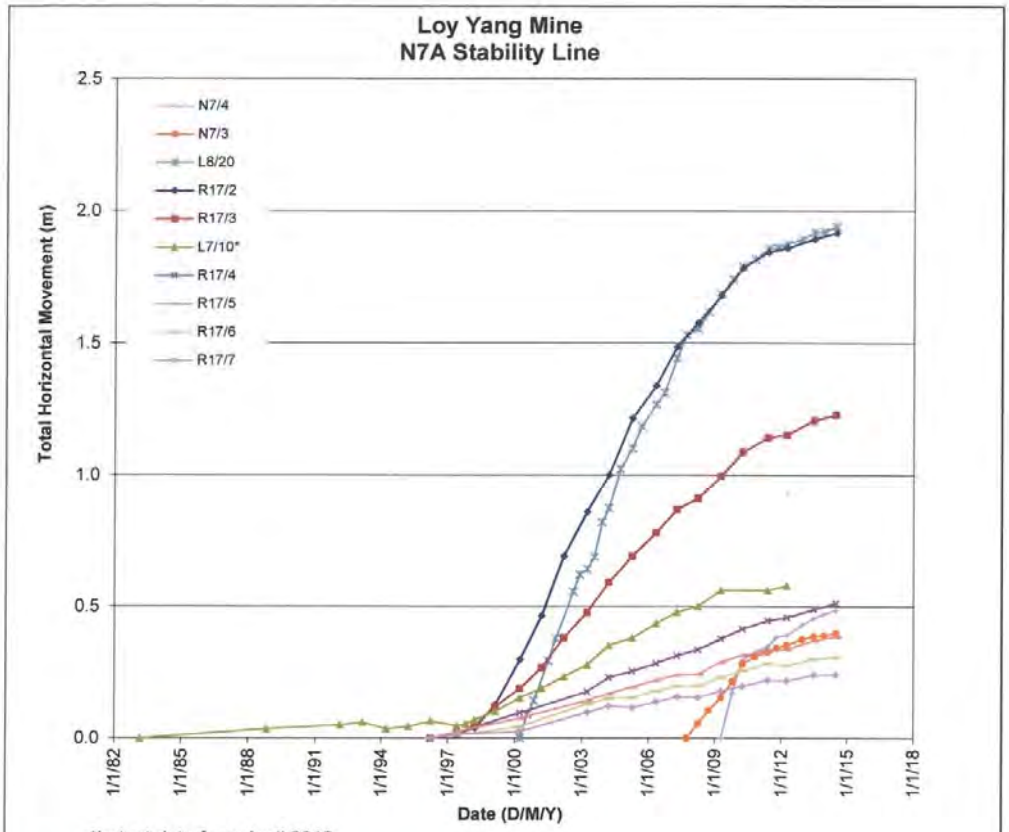


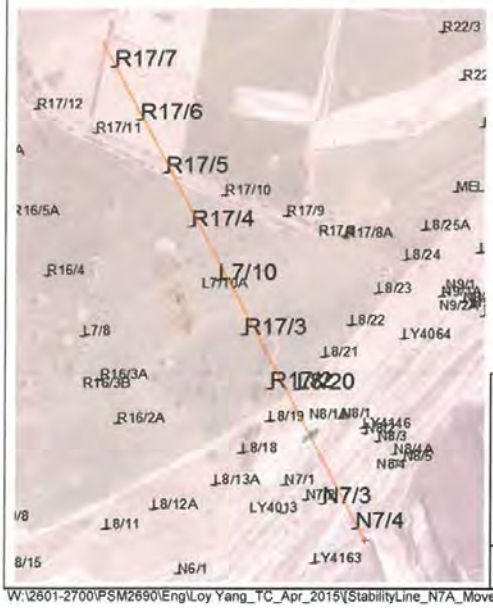
Note: Some pins were not monitored in June 2014



Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N5 STABILITY LINE 2014

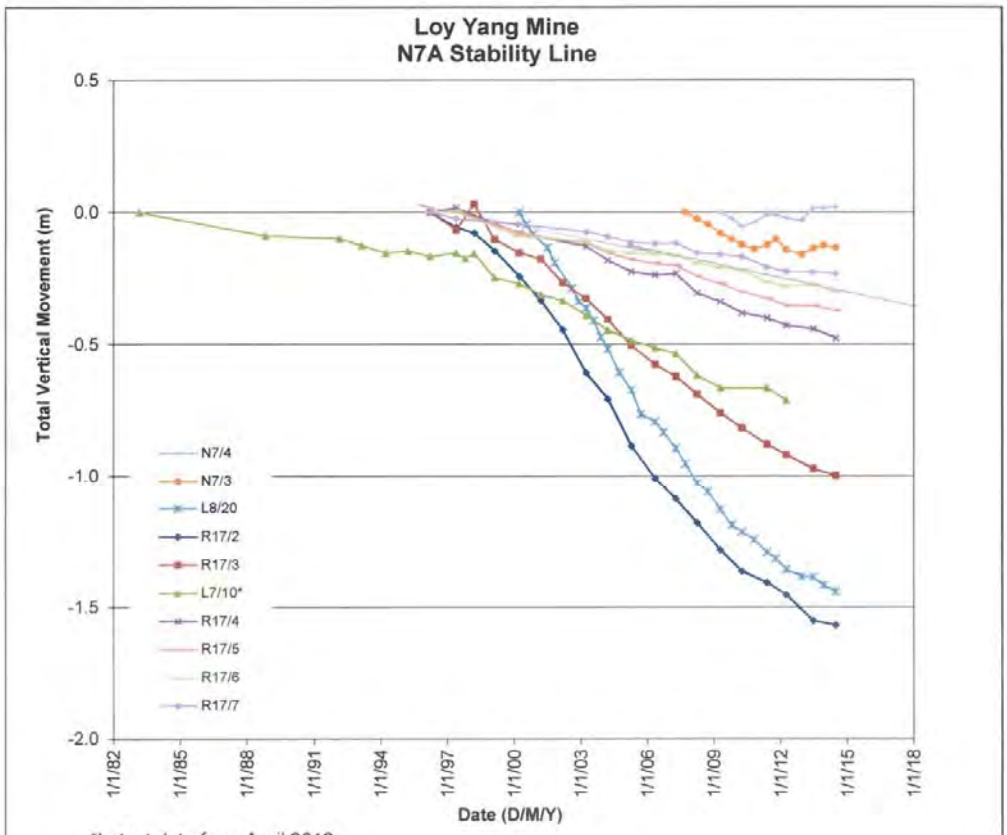
W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

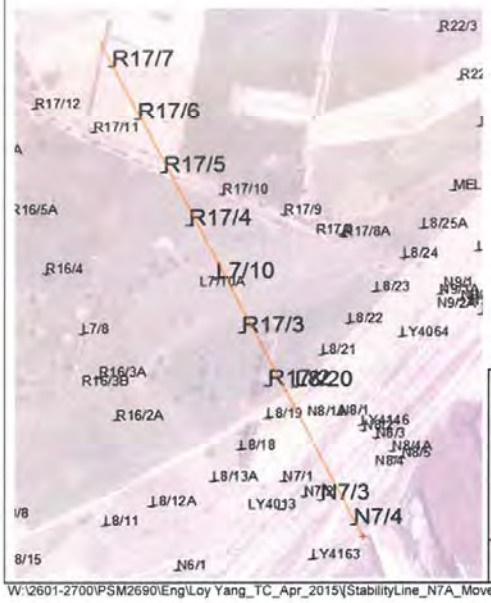




Ashurst Australia Loy Yang Mine TOTAL HORIZONTAL MOVEMENT v TIME N7A STABILITY LINE	

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

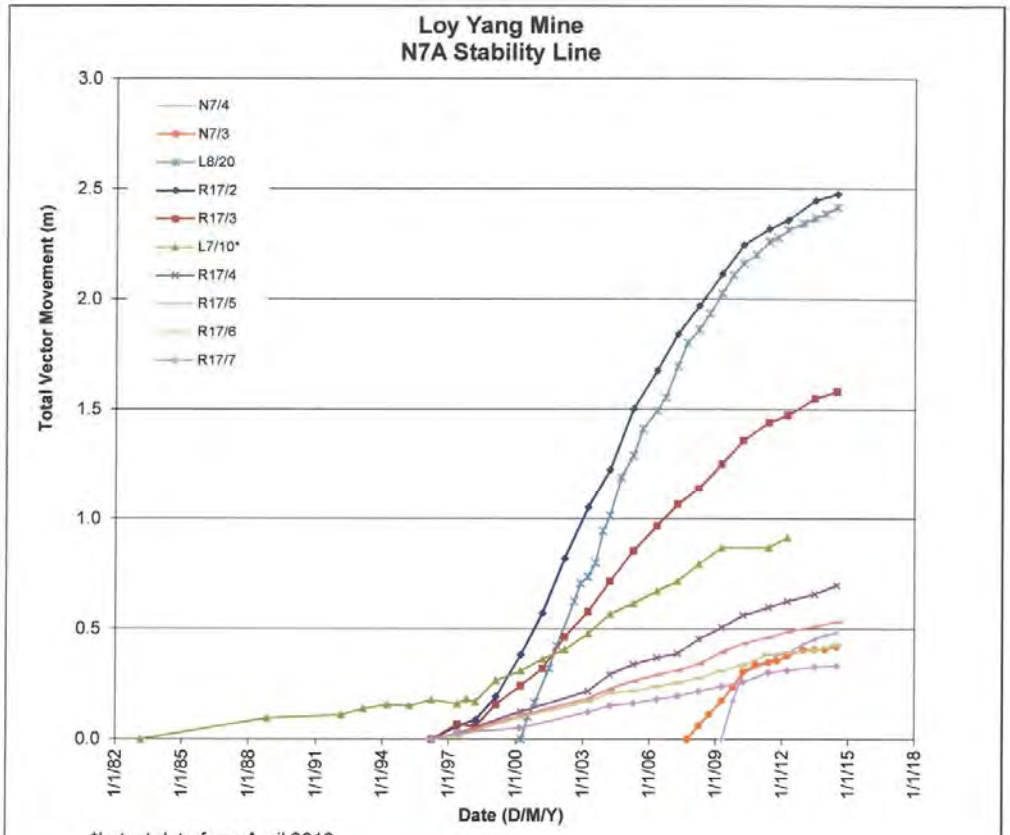


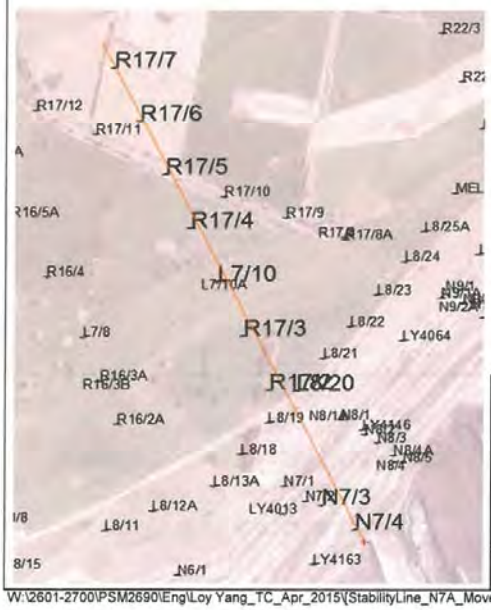


Ashurst Australia
Loy Yang Mine

TOTAL VERTICAL MOVEMENT v TIME
N7A STABILITY LINE

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

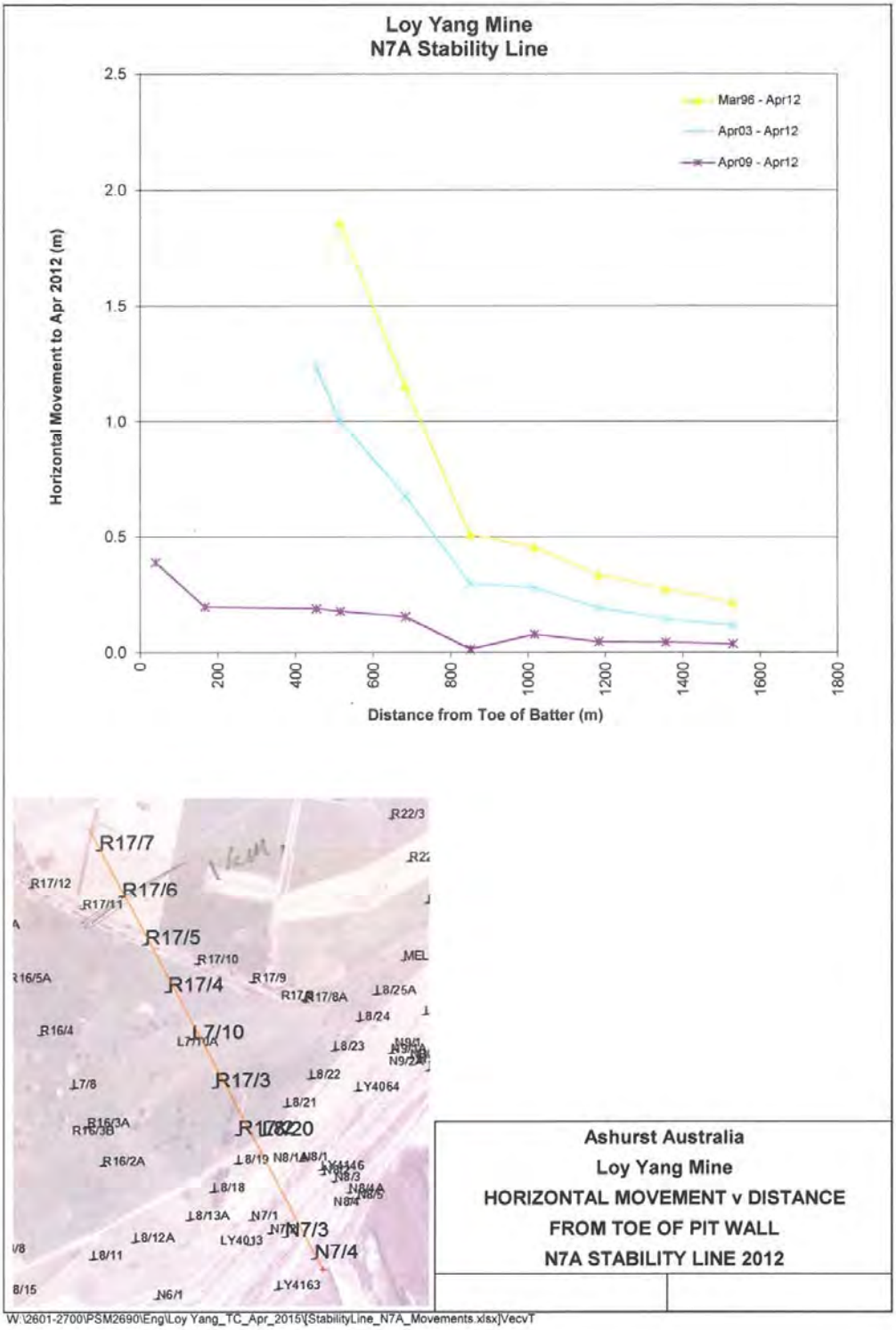


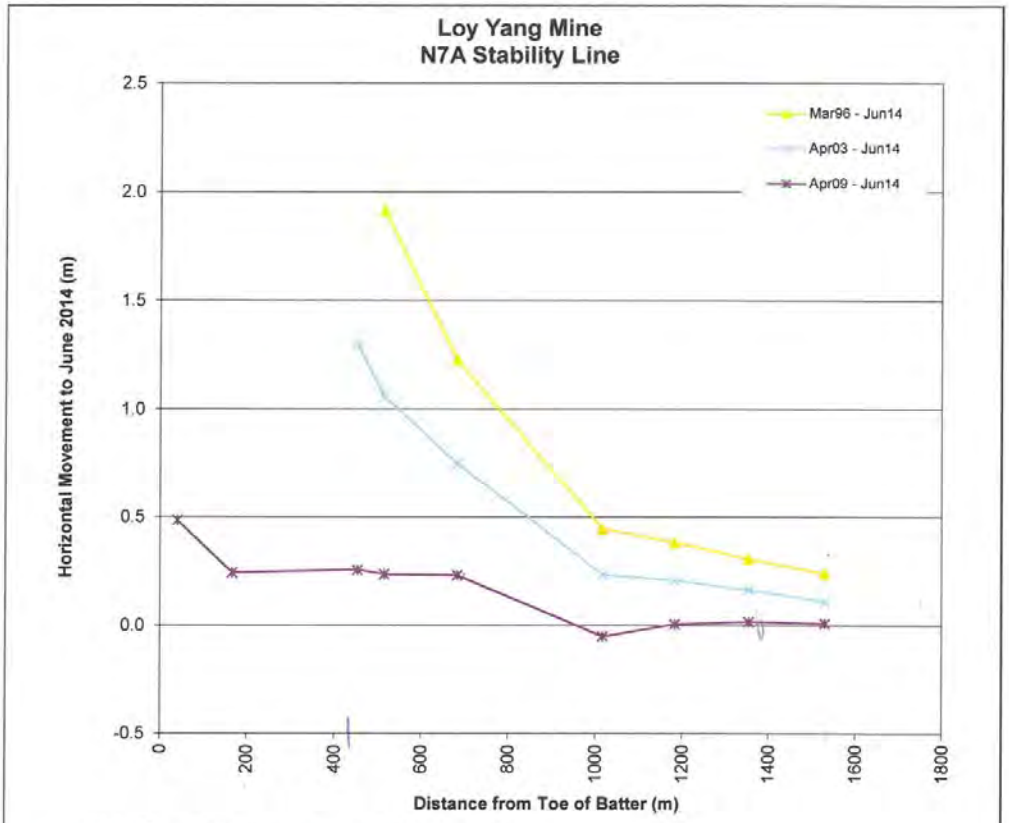


Ashurst Australia
Loy Yang Mine

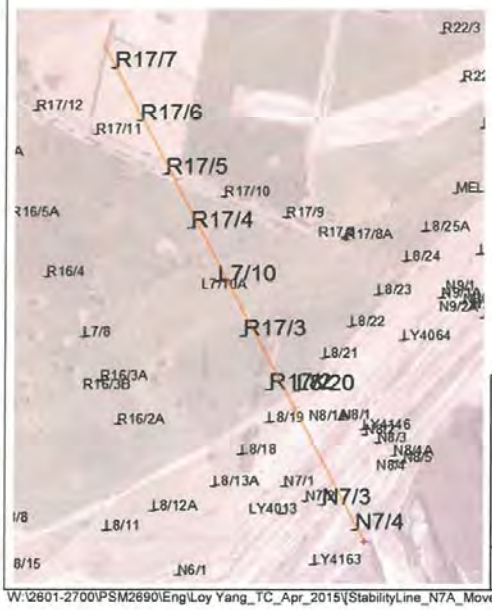
TOTAL VECTOR MOVEMENT v TIME
N7A STABILITY LINE

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT


Loy Yang Mine
N7A Stability Line
Mar96 - Apr12
Apr03 - Apr12
Apr09 - Apr12
Horizontal Movement to Apr 2012 (m)
Distance from Toe of Batter (m)
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
R17/7
R17/6
R17/5
R17/4
R17/3
R17/2
R17/1
R17/12
R17/11
R17/10
R17/9
R17/8A
L7/10
L7/8
R16/4
R16/5A
R16/3A
R16/3B
R16/2A
L8/25A
L8/24
L8/23
L8/22
L8/21
L8/19
L8/18
L8/13A
L8/12A
L8/11
L8/15
N7/1
N7/3
N7/4
N6/1
LY4064
LY4163
R22/3
MEL
Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N7A STABILITY LINE 2012
W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT

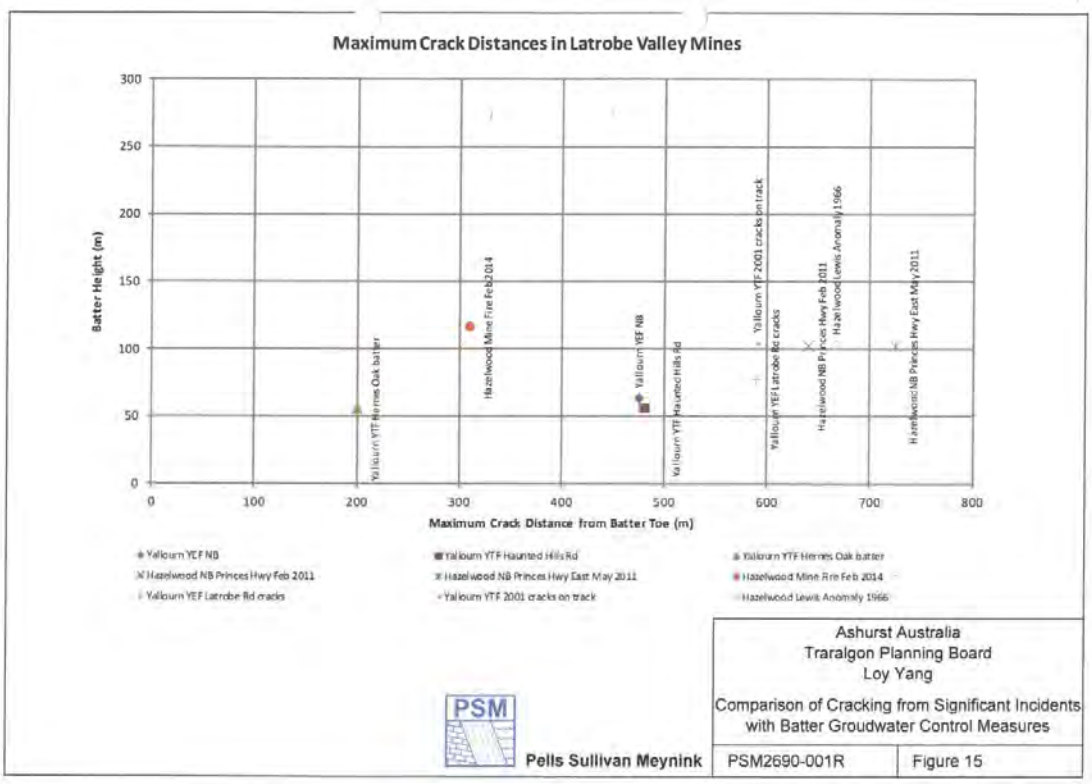


Note: Some pins were not monitored in June 2014



Ashurst Australia
Loy Yang Mine
HORIZONTAL MOVEMENT v DISTANCE
FROM TOE OF PIT WALL
N7A STABILITY LINE 2014

W:\2601-2700\PSM2690\Eng\Loy Yang_TC_Apr_2015\[StabilityLine_N7A_Movements.xlsx]VecvT


Maximum Crack Distances in Latrobe Valley Mines
Batter Height (m)
Maximum Crack Distance from Batter Toe (m)
0
50
100
150
200
250
300
0
100
200
300
400
500
600
700
800
Yallourn YTF Hermes Oak batter
Hazelwood Mine Fire Feb2014
Yallourn YEF NB
Yallourn YTF Haunted Hills Rd
Yallourn YTF 2001 cracks on track
Yallourn YEF Latrobe Rd cracks
Hazelwood NB Princes Hwy Feb 2011
Hazelwood Lewis Anomaly 1966
Hazelwood NB Princes Hwy East May 2011
Yallourn YEF NB
Hazelwood NB Princes Hwy Feb 2011
Yallourn YEF Latrobe Rd cracks
Yallourn YTF Haunted Hills Rd
Hazelwood NB Princes Hwy East May 2011
Yallourn YTF 2001 cracks on track
Yallourn YTF Hermes Oak batter
Hazelwood Mine Fire Feb 2014
Hazelwood Lewis Anomaly 1966
PSM
Pells Sullivan Meynink
Ashurst Australia
Traralgon Planning Board
Loy Yang
Comparison of Cracking from Significant Incidents with Batter Groudwater Control Measures
PSM2690-001R
Figure 15

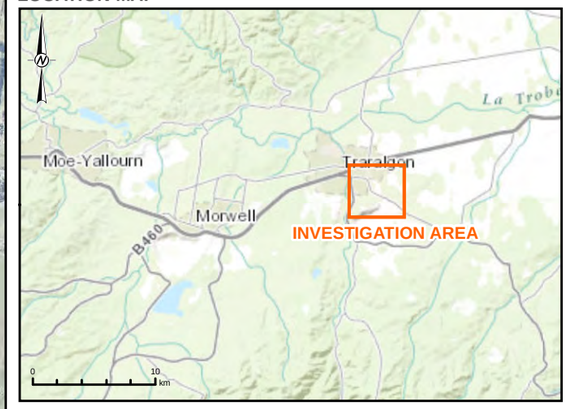

Traralgon
Public Acquisition Overlay for Proposed Transport Corridor
BATTER ANGLE TRANSITION ZONE
No 3 CREEK
Sheepwash Creek Diversion Stage 3
Extraction Limit
Mining Licence Boundary (MIN 5187)
Traralgon Creek Rd
Hyland Hwy
Shilling Rd
Loy Yang A Power Station
Loy Yang B Power Station
External Overburden Dump
Ash Pond
Ash Basin Reservoir
Traralgon South Rd
Legend
Development Stage E (Base) with Approx. Toe Levels (mAHD)
Development Stage E (Intermediate Toes)
Internal OB Dump
Internal Waterbodies
Bund Toe
Bund Top
Extraction Limit and Dump Limit
Mining Licence Boundary
Stage 3 Sheepwash Creek Diversion
Contours (10m)
Highway
Sealed road (arterial & local)
Unsealed road
Stream
Connector
Public Acquisition Overlay
Urban Settlement Boundary
Overall Batter Grades (V:H) Crest to Mine Floor
1:30,000 at Paper Size A3
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Australian 1966
Grid: SECV Latrobe Valley
Energy in action
AGL
AGL Loy Yang
Mining Licence
Work Plan Variation
Development Stage E
Mine Closure
Job Number 31-2072315
Revision 3
Date 29 May 2015
Figure 15
Barton Lane Traralgon VIC 3844 Australia T 61 3 5173 3700 F 61 3 5173 3298 W www.agl.com.au

APPENDIX B

Figure B1, Figure B2, Figure B3, Figure B4

SHAKESPEARE STREET
CRAIGBURN PLACE
MELROSSA ROAD
NO ACCESS
CAMERON STREET
STUART STREET
NO ACCESS
NO ACCESS
LANSDOWNE ROAD
BAYLEY DRIVE
RETREAT ROAD
LIDDIARD ROAD
STABILITY LINE N3
STABILITY LINE N5
STABILITY LINE N7A
NO ACCESS
Traralgon Transfer Station
LOY YANG MINE

LOCATION MAP



LEGEND

Streets/Roads Observed

Stability Line

NOTES

1. Current crest of mine sourced from Figure 6, Extraction Limits Operational Buffers (AGL, WPV).
2. Road and property information, sourced from VicMap, 30/03/2015.
3. Imagery dated 30/04/2015, sourced from nearmap.com.
4. Location map sourced from Esri online basemaps.

0 250 500 750 1,000
METRES

REFERENCE SCALE: 1:15,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
MADDOCKS

PROJECT
LATROBE PLANNING SCHEME AMENDMENT C87, QUALITATIVE RISK ASSESSMENT

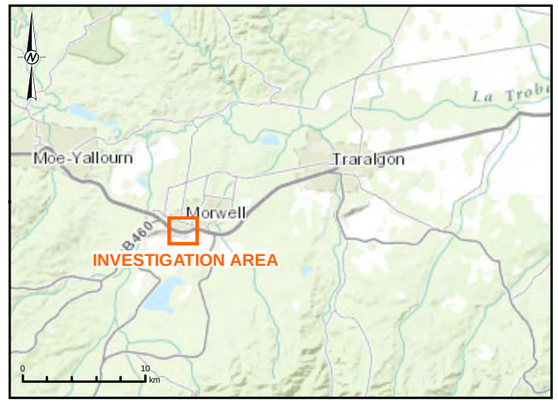
TITLE
SITE OBSERVATION LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-22
PREPARED	CJS
DESIGN	-
REVIEW	LJT
APPROVED	ASR

PROJECT No.	CONTROL	Rev.	FIGURE
1539765	003-R	0	**B1**

LOCATION MAP



LEGEND

- Streets/Roads Observed
- Stability Line

NOTES

1. Current crest of mine sourced from Figure 6, Extraction Limits Operational Buffers (AGL, WPV).
2. Road and property information, sourced from VicMap, 30/03/2015.
3. Imagery dated 30/04/2015, sourced from nearmap.com.
4. Location map sourced from Esri online basemaps.

0 100 200 300 400 500
METRES

REFERENCE SCALE: 1:7,500 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
MADDOCKS

PROJECT
LATROBE PLANNING SCHEME AMENDMENT C87, QUALITATIVE RISK ASSESSMENT

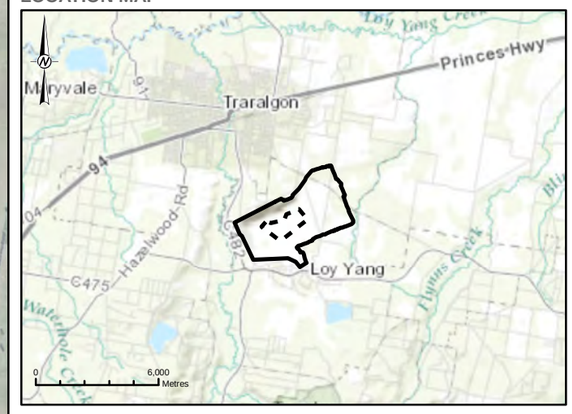
TITLE
SITE OBSERVATION LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-22
PREPARED	CJS
DESIGN	-
REVIEW	LJT
APPROVED	ASR

PROJECT No.	CONTROL	Rev.	FIGURE
1539765	003-R	0	**B2**

LOCATION MAP



LEGEND

- Current Base of Mine
- Current Crest of Mine
- 2024 Base of Mine
- 2024 Crest of Mine
- 2030 Base of Mine
- 2030 Crest of Mine
- 2054 Crest of Mine
- Extraction Limit and Dump Limit
- 1997 Extraction Limit - 1000 buffer
- WPV Extraction Limit - 1000m buffer

Zoning

- Future Industrial
- Future Residential
- Future Rural Living

Site Features (polygon)

- Risk Zone 1 (High - Very High Risk Level)
- Risk Zone 2 (Low - Moderate Risk Level)
- Risk Zone 3 (Very Low Risk Level)
- ESO1-Urban Buffer

Proposed Traralgon Bypass

NOTES

1. Extraction limits sourced from Figure 6, Extraction Limits Operational Buffers (AGL, WPV).
2. Imagery dated 30/04/2015, sourced from nearmap.com.
3. Location map sourced from Esri online basemaps.

0 600 1,200 1,800 2,400
METRES

REFERENCE SCALE: 1:30,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
MADDOCKS

PROJECT
LATROBE PLANNING SCHEME AMENDMENT C87, QUALITATIVE RISK ASSESSMENT

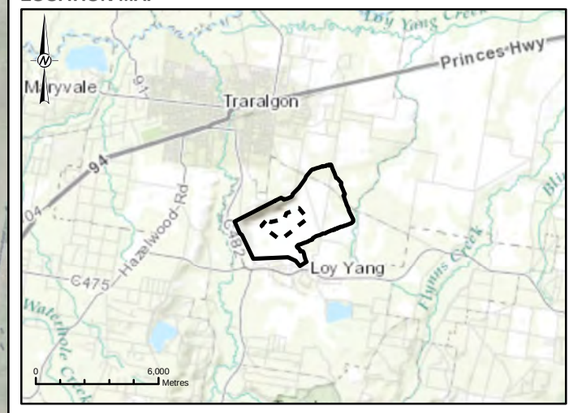
TITLE
RISK MAP (BASED ON AGL, WPV PROPOSED CREST POSITION)

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-04-20
PREPARED	CJS
DESIGN	-
REVIEW	LJT
APPROVED	ASR

PROJECT No.	CONTROL	Rev.	FIGURE
1539765	003-R	0	**B3**

LOCATION MAP



LEGEND

- Current Base of Mine
- Current Crest of Mine
- 2024 Base of Mine
- 2024 Crest of Mine
- 2030 Base of Mine
- 2030 Crest of Mine
- 2054 Crest of Mine
- Extraction Limit and Dump Limit
- 1997 Extraction Limit - 1000 buffer
- WPV Extraction Limit - 1000m buffer

Zoning

- Future Industrial
- Future Residential
- Future Rural Living

Site Features (polygon)

- Risk Zone 1 (High - Very High Risk Level)
- Risk Zone 2 (Low - Moderate Risk Level)
- Risk Zone 3 (Very Low Risk Level)
- ESO1-Urban Buffer

Proposed Traralgon Bypass

NOTES

1. Extraction limits sourced from Figure 6, Extraction Limits Operational Buffers (AGL, WPV).
2. Imagery dated 30/04/2015, sourced from nearmap.com.
3. Location map sourced from Esri online basemaps.

0 600 1,200 1,800 2,400
METRES

REFERENCE SCALE: 1:30,000 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
MADDOCKS

PROJECT
LATROBE PLANNING SCHEME AMENDMENT C87, QUALITATIVE RISK ASSESSMENT

TITLE
RISK MAP (BASED ON 1997 DEVELOPMENT BOUNDARY)

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-04-20
PREPARED	CJS
DESIGN	-
REVIEW	LJT
APPROVED	ASR

PROJECT No.	CONTROL	Rev.	FIGURE
1539765	003-R	0	**B4**

APPENDIX C

Extracts from The Landslip Risk Management guidelines (AGS) 2007 - Appendix C

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	[illegible]	[illegible]	[illegible]	H	M or L (5)
B – LIKELY	10^{-2}	[illegible]	[illegible]	H	M	L
C – POSSIBLE	10^{-3}	[illegible]	H	M	M	VL
D – UNLIKELY	10^{-4}	H	M	L	L	VL
E – RARE	10^{-5}	M	L	L	VL	VL
F – BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
[illegible]	[illegible]	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

APPENDIX D

Amendment C87 documents provided to Golder

Attachments

	Document	Date
Amendment C87 Documents		
1.	C87 Panel Report	22 June 2015
2.	Latrobe City Council C87 Submission, Part A and B	April 2015
3.	Latrobe City Council C87 Expert Witness Report prepared by Hansen	10 April 2015
4.	**Scheme Provisions – Latrobe City Council C87**	
	Post-Exhibition Changes	
	Instruction Sheet	
	A3 set of all Plans	
	Clause 21.02	
	Clause 21.04	
	Clause 21.05	
	Clause 21.06	
	Clause 21.07	
	Clause 21.08	
5.	Explanatory Report – C87	August 2014
6.	**Reference Documents**	
	Traralgon Growth Area Review Background Report	August 2013
	Traralgon Growth Area Review Framework	
	Traralgon West Structure Plan	
	Australian paper: Maryvale Pulp Mill Buffer Requirements	July 2011
AGL Loy Yang Expert Reports		
7.	Expert Evidence of Tim Sullivan, Pells Sullivan Meynink	14 April 2015
8.	Expert Evidence of Stuart McGurn, ERM	April 2015
9.	Location Plan Maps	10 April 2015
Other reports		
10.	*Overview of Managing Groundwater and Impacts and Loy Yang Open Cut* – Foley, Nicol and Missen	2012
	Geotechnical Advice – Response to Submissions 24 and P89A Traralgon Bypass Bypass	September 2014

Part of the attachment has been removed from the Report as these matters are considered to be confidential in accordance with section 89 (2) (h) of the *Local Government Act* 1989 as it deals with a matter that the Council or Special Committee considers would prejudice the Council or any person.

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