Technical Review Board Annual Report 2011-2012

September 2012

State Government Victoria

DEPARTMENT OF PRIMARY INDUSTRIES | earth resources regulation

The TRB may be contacted through the TRB Executive Officer:
TRB EO: Mark Pratt
Telephone: (03) 5160 5006
Email: mark.pratt@dpi.vic.gov.au

If you would like to receive this information/publication in an accessible format (such as large print or audio) please call the Customer Service Centre on 136 186, TTY 1800 122 969, or email customer.service@dpi.vic.gov.au.

Published by the Department of Primary Industries
Earth Resources Regulation, September 2012.

Authorised by the Department of Primary Industries
1 Spring Street, Melbourne 3000.

ISSN: 2201-4535 (print)
ISSN: 2201-456X (online)

Contents

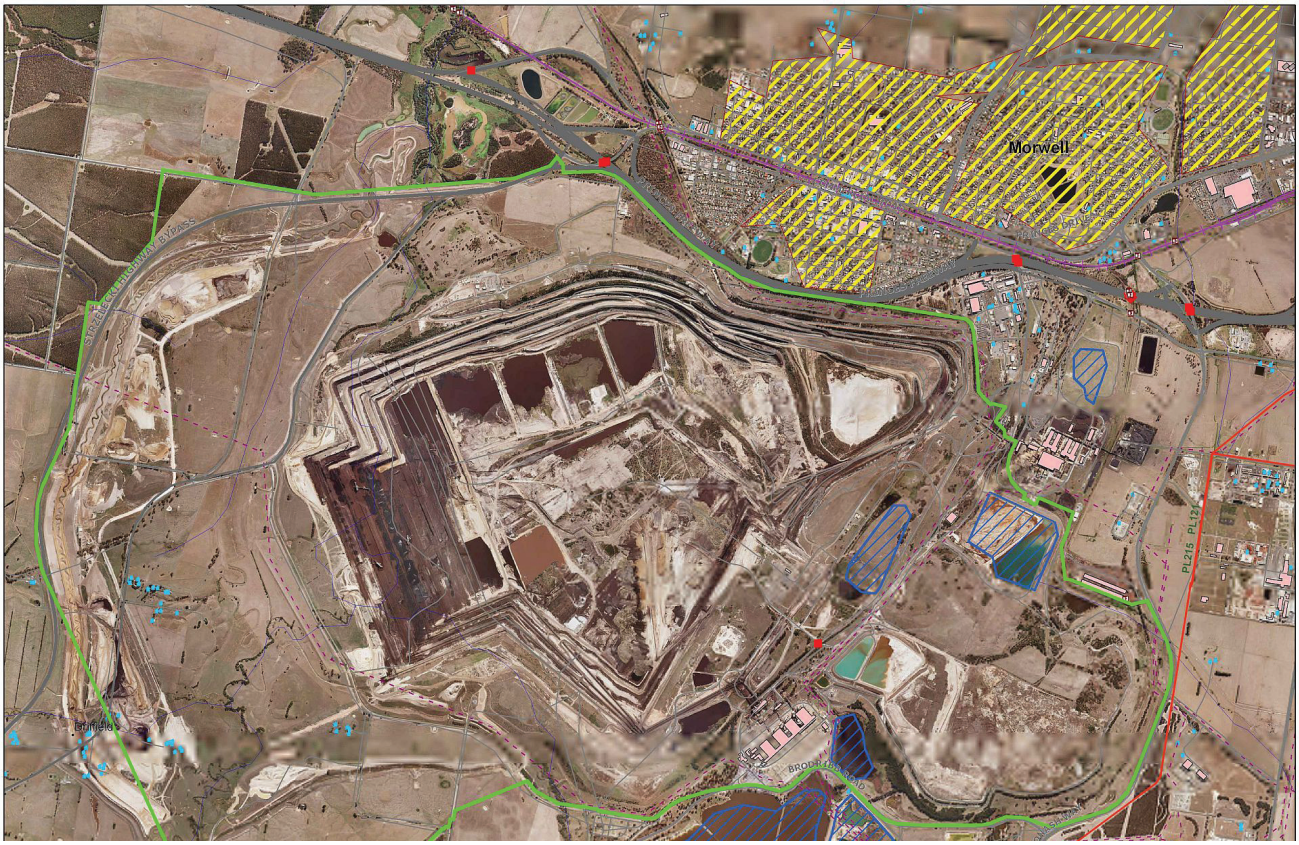
Executive Summary

The TRB was constituted in 2009 following the Warden's Inquiry into the collapse of the North East Batter at Yallourn Mine. A primary function of the TRB is to provide independent advice to assist the Minister for Energy and Resources, the Department of Primary Industries and industry better manage ground control associated with mining in Victoria, in order to mitigate the risks this presents to public safety, environment, public infrastructure and security of power supply.

This annual report covers the activities of the TRB during the first year of its second term, being September 2011 to August 2012. The board met formally on eight occasions during this period. Additionally, board members individually and collectively had involvement in a range of other activities associated with the TRB's Terms of Reference. These included:

1. Latrobe Valley mines - Ongoing familiarisation, review of major stability reports and identification of key stability issues across the region.
2. Other mines and quarries – Review of stability issues at Alcoa Anglesea coal mine.
3. Review of Workplan variations.
4. Review of stability issues and guidelines for the Victorian mine and quarry industry.
5. Interaction with Latrobe Valley coal industry concerning best practice geotechnical methods.
6. Consideration of the brown coal - research and development program of the Geotechnical and Hydrogeological Engineering Research Group (GHERG) based at the Gippsland Campus of Monash University.
7. Preliminary consideration of the Morwell River Diversion failure at Yallourn Mine.

During its first term, the TRB identified seven 'at risk' ground structures within the brown coal sector, of which three have subsequently failed and one is reported to have been stabilised. Currently, the TRB can give no assurance that all 'at risk' structures in this mining sector have been identified or that there will be no further failures of identified structures. It has become clear to the TRB that the situation with regard to brown coal mine stability has reached a serious state. The mines are complex structures that are large by world standards and continue to become larger and deeper.



History demonstrates that managing mine stability and the risks associated with instability to an acceptable standard requires high level, ongoing assessment, investigation, design, implementation and re-assessment on both mine specific and regional scales. Prior to privatisation, this role was essentially fulfilled by the former State Electricity Commission of Victoria (SECV), which developed skill platforms, information bases and technical and management processes for this purpose over a number of decades. Since the demise of the SECV, there appears to have been a significant reduction in the scope, depth and extent of these important tasks and a loss of corporate memory. Furthermore, mine operators have become conditioned to risk and are normalising risk (that is, some risks are now viewed as 'normal, to be expected') and the risk acceptance criteria and risk appetite of the present owners are higher than that of the SECV.

This has led to the current situation where there has been virtually no advancement for many years in the industry's understanding of the characteristics, mechanisms, and movements of slopes and batters and the consequences of these movements for public safety, surrounding infrastructure, continuity of coal supply and the environment. This is particularly unfortunate as it coincides with an increase in the number, density and proximity of surrounding infrastructure, increased public scrutiny, and requirements for higher standards of environment and community governance.

Technical areas that appear not to have experienced continuity and ongoing development at all mines in recent years include:

1. Construction of both local and regional geological cross-sections and models.
2. Determination of geotechnical properties of strata to underpin design and stability assessment.
3. Hydrogeological measurements to support mine design, verification of design effectiveness, and timely detection of changed conditions.
4. Stability assessment techniques.
5. Regular stability inspections.
6. Extent, regularity and presentation detail of monitoring.
7. Hazard mapping, risk assessment and mitigation.
8. Planning for mine closure.

The TRB is of the view that stakeholder culture needs to change in regard to managing ground control in a risk management framework if further incidents of major instability are to be avoided. There is a need to improve significantly the technical expertise and understanding of all stakeholders in the Victorian brown coal sector so that standards, practices and risk management are commensurate with international best practice.

Given the nature of the legacies and the complexity of the issues, it will take some time to develop, implement and refine effective solutions. The TRB has identified a range of initiatives for addressing matters raised in this annual report, with the six principal initiatives relating to:

1. Improving the standard of future geotechnical studies to support mine planning and ground control management plans.
2. Incorporating contingency planning into ground control risk management.
3. Improving the standard of monitoring, data processing and reporting to support ground control management plans.
4. Rehabilitation of mine batters.
5. Future research and education directions of GHERG.
6. Changing stakeholder culture.

Solutions require constructive and collaborative engagement and dialogue between all stakeholders and for mine design and operation to be premised on sound risk management, supported by research and education. Subject to the Minister's knowledge and approval, the TRB will be focussing its attention in the following year on facilitating and supporting this process.

1. Introduction

The Technical Review Board (TRB) was constituted in 2009 after the collapse of the North East Batter at Yallourn Mine and the subsequent Warden's Inquiry, which identified a number of areas where improvements in the mining industry could be made. It was established as an Advisory Panel under Sections 54A, 54C, 54D and 54E of the Mineral Resources (Sustainable Development) Act 1990 for the purpose of providing independent advice to the Minister for Energy and Resources (the Minister) and the Department of Primary Industries (the Department) on mine and quarry stability issues with respect to reducing risks within the mining industry. The TRB's activities are focussed specifically on risks to the environment, to public safety, to infrastructure and to continuity of coal supply.

2. Terms of Reference

The Terms of Reference (TOR) for the TRB have a wide scope, calling for advice to be provided to the Minister and the Department in the following general areas:

a) Strategy;

b) Stability Assessments;

c) Workplans; and

d) Other activities, including education, research and interaction with industry.

The TOR were framed with the overall aim of improving the geotechnical and hydrogeological performance and knowledge within the Victorian mining industry.

"The Board will report to the Minister on an annual basis. The Minister may subsequently release the Board's report to the Department and relevant industry stakeholders.

The Board will periodically provide advice on mine and quarry stability, to the Minister and Department, in the following areas:

a) Strategy

Written and or verbal advice on the Department's strategies and regulatory approach to mine and quarry stability and geotechnical issues.

Written and or verbal advice on new developments in technology and science relating to the understanding, monitoring or management of mine and quarry stability and related geotechnical and hydrogeological issues.

b) Stability Reports

Review and interpret mine and quarry stability reports including monitoring data that has been submitted to the Department and provide written advice to the Minister.

c) Workplans

Assess workplans and variations to workplans and provide written advice to the Department on mine and quarry stability and related geotechnical and hydrogeological issues."

d) Other Activities

Advise the Minister in formulating appropriate response to significant events related to mine and quarry stability and related geotechnical and hydrogeological issues.

Advise the Minister on appropriate guidelines and educational initiatives related to mine and quarry stability.

With the knowledge and agreement of the Minister, interact directly with industry on mine and quarry stability and related geotechnical and hydrogeological issues, including participation in site visits, presentations and dialogue, particularly with respect to communicating findings of reviews with relevant stakeholders.

In conjunction with the Department, interact directly with Monash University in relation to the Research and Development program on brown coal geotechnical and hydrogeological issues."

3. Board Members

The board comprises four members. During the reporting period, one position was filled and another became vacant.

Emeritus Professor Jim Galvin - Board Chairman

Professor Galvin has extensive international experience in mining and geotechnical engineering, risk management and OH&S. His career encompasses working in and managing underground mines, leading and directing research bodies, headship of the School of Mining Engineering at UNSW, and consulting. Current and recent appointments include independent member of the Health, Safety, Environment and Community (HSEC) Advisory Committees to the Boards of BHP Billiton, Solid Energy New Zealand, and WorkPac; and chair of the Federal Government Australia/China Joint Safety Taskforce to Improve Safety in Coal Mining, and the Continuing Professional Development Committee of the Mine Managers Association of Australia. Professor Galvin was appointed Chairman of the Technical Review Board in 2011.

Professor Ian Johnston - Board Member (from February 2012)
Golder Associates Chair of Geotechnical Engineering
Department of Infrastructure Engineering
University of Melbourne

Professor Johnston graduated from the University of Southampton, UK with a bachelor's degree in civil engineering and a PhD in geotechnical engineering. After a few years in practice in the UK, USA and Europe, he joined Monash University in 1975. He became Dean of Engineering at Victoria University in 1993 and five years later moved to Coffey Geotechnics where he was a Senior Principal. In 2009, he accepted the Golder Chair of Geotechnical Engineering at the University of Melbourne. He has over 40 years experience in geotechnical engineering, both as an academic and as a consultant for major projects in Australia and overseas. His interests cover a wide range of topics and he is particularly well known for his work on soft and weak rock and the engineering problems associated with the stability of this material in civil and mining engineering.

Professor Rae Mackay - Board Member
Geotechnical and Hydrogeological Engineering
Director of the Geotechnical and Hydrogeological Engineering Research Group
Monash University, Gippsland Campus.

Professor Mackay holds a degree in civil engineering from Imperial College, London University and a PhD in Hydrogeology from the University of Newcastle upon Tyne. Prior to moving to Australia in 2011, he was an advisor to the UK nuclear waste management programme and Professor of Hydrogeology and Head of the Hydrogeology Research Group at Birmingham University, UK, where he worked on a diverse range of subjects including arid zone hydrogeology, sustainable urban water resources, geothermal energy exploitation and nuclear waste disposal. His current research role is directed at understanding risks and impacts of the ongoing development and eventual long-term rehabilitation of the brown coal mines in the Latrobe Valley, with his primary interests being in understanding subsurface flow and transport processes and developing predictive models for engineering and environmental applications.

Emeritus Professor Edwin (Ted) Brown AC - Board Member (to April 2012)

Professor Brown began his career in the Latrobe Valley with the then SECV. He has wide international experience as a consultant, researcher, author and teacher in geotechnical engineering, specialising in civil engineering and mining rock mechanics. His major appointments have been as Professor of Rock Mechanics and Dean of the Royal School of Mines, Imperial College, London, and as Dean of Engineering, Deputy Vice-Chancellor and Senior Deputy Vice-Chancellor of the University of Queensland.

4. Previous Work of the TRB (2009-2011)

During its first term, the activities of the TRB were focussed on familiarisation with the Yallourn, Hazelwood, Loy Yang and Anglesea brown coal mines. These included reviews of information and documentation pertaining to these mines, general reviews of stability in some key areas, and identification of issues for further investigation and resolution. The work extended to include assessments of the current and future legislative framework for the industry and consideration of the research and development program of the Geotechnical and Hydrogeological Research Group (GHERG) established at the Gippsland Campus of Monash University.

During the course of its familiarisation activities, the TRB identified a number of key elements of brown coal mining in the Latrobe Valley that had a bearing on its terms of reference and forward program of activities. These included:

1. The very long history of mining.
2. The scale of the mines, which are very large by world standards.
3. The mines are situated in a semi-rural to semi-urban environment and are surrounded by natural and man-made infrastructure.
4. The mines comprise not just the active mining areas, but also very large worked out areas that have not been rehabilitated and for which there are, in most instances, currently no viable, sustainable long term rehabilitation plans.
5. There are substantial ongoing local and regional ground movements.
6. Roles, responsibilities and focus of the mines have changed since they were privatised in the mid 1990s.
7. The state owned group responsible for overseeing the local and regional stability aspects of these operations within the State Electricity Commission for Victoria (SECV) was also privatised. This similarly led to changes in the roles, responsibilities and focus for this group.
8. The power stations supply a very high proportion of Victoria's power requirements and this places a significant social emphasis on the management of ground stability within the mines so that instability does not jeopardise power generation.

Of particular relevance to the assessment of geotechnical risks to the environment, public safety, and infrastructure are the scale of movements, occurrence of natural and man-made infrastructure within the mines radius of influence, and the understanding and management of the geotechnical risks that reflect these contributions.

Four components of movement were identified from the TRB's initial review of the history of brown coal mining in Victoria, namely:

1. Widespread surface settlement induced by groundwater extraction.
2. Significant horizontal and vertical movements well away from the mine edge, during and soon after the completion of mining.
3. Ongoing ground movements, in some cases decades after mining was completed in the immediate area.
4. Slope failure.

Early assessments by the TRB identified that a satisfactory understanding of the complex mechanisms leading to slope failure is yet to be developed and captured in mine design.

The zone of significant movement typically extends 400 to 700m from the edge of the mine. Today, there is important natural and man-made infrastructure located within this zone, including highways, train lines, power lines, rivers and drains. The power stations and coal conveying infrastructure are also located within this zone. Prior to privatisation, ground movements and the resultant impacts were regularly monitored and assessed by the SECV. However, it appears that after privatisation, monitoring in many areas ceased, potential impacts were no longer assessed and important areas tended to be forgotten. This suggests a significant loss of corporate understanding and history.

Against this background, the preliminary work of the TRB identified substantial limitations to design methodologies and approaches as currently used in the brown coal sector in Victoria. Two examples of slopes that were of concern to the TRB in its first term were examined in detail to highlight the issues. The first was the Herne's Oak batters at Yallourn where there were indications of significant movement. The second was the Northern Batters at Hazelwood. The TRB's highlighted concerns were realised, with both locations experiencing large unplanned movements and movement of Hazelwood Northern Batters resulting in the closure of the Princes Highway for 7 months.

In summary, the extensive work of the TRB in the period 2009-2011 lead to the following conclusions in respect of ground control:

1. There has been a critical loss of corporate memory.
2. The industry has not continued to develop the geotechnical models required for analysis and prediction.
3. There is a lack of technical rigour in the investigation, analysis and design process and in the assessment of potential stability problems.
4. Sectors of the industry have become conditioned to risk, with the result that risk associated with ground control is not being managed in a manner commensurate with the potential consequences associated with loss of control.

The initial site visits by the TRB to all mines, as well as the remedial works carried out in relation to the Hazelwood Northern Batter movement, reinforced the need for a set of detailed mine reviews and a special review of Hazelwood Northern Batters. These four reviews were commissioned in 2011 by the Department to provide the evidence base for its work.

5. Current Reporting Period

The first term of the TRB expired in August 2011. Cognisant of the TRB's findings to that point in time, the new board membership was constituted with a skill set directed at dealing with the apparent issues.

A summary list of key TRB activities during the year is presented in Table 1. The board met formally eight times, with all members attending all board meetings.

TABLE 1: SUMMARY LIST OF KEY TRB ACTIVITIES SEPTEMBER 2011 to AUGUST 2012

DATE	WHO	ACTIVITY	
2011	13 September*	All Board	New Board Inaugural Meeting
	14 September	All Board	TRB Chairman presentation on Risk Management to industry forum - Latrobe Valley (LV)
	15 December*	All Board (I Johnston observer status)	Board meeting - Board Planning & Program Review
2012	13-17 February*	All Board	Preliminary Review - Yallourn Stability Assessment & Hazelwood North Batter Movement Reports; Industry meeting - LV mine managers
	5-6 March	All Board	Yallourn and Loy Yang mine site visits
	10-13 April*	All Board	Board meeting - Yallourn Stability Assessment Report final review – recommendations to DPI
	13 April 26 April	J Galvin	Participation in State Emergency Risk Assessment Project
	7-11 May*	All Board	Board meeting - Hazelwood Northern Batter Movement Report initial review; TRUenergy presentation - Yallourn MRD performance; Industry meeting - LV mine managers
	15 June	J Galvin I Johnston	Yallourn MRD failure site visit
	11-13 July*	All Board	Board meeting - Hazelwood Northern Batter Movement Report initial review; meeting with Minister Michael O'Brien; planning of Draft TRB Annual Report 2011 – 2012.
	30 July- 2 August*	All Board	Meeting with industry – LV mine CEO's and Mine Managers; Hazelwood Northern Batter Movement Report discussion with PSM (Tim Sullivan), preparation of TRB Annual Report 2011 – 2012.
	9 August	All Board	Letter to Minister Michael O'Brien re: Status of Mine Stability - Brown Coal Mines
2012	21 August	J. Galvin I Johnston	Meeting with Minister Michael O'Brien.
	24 August*	All Board	TRB Recommendations to DPI re: PSM Hazelwood Northern Batter Movement Report.

*Board Meetings

Two of the four mine reviews commissioned by the Department during the first term of the TRB were completed in the current reporting period and submitted to the TRB for assessment and the provision of advice and recommendations to the Minister. These related to Yallourn Mine and to the Hazelwood Northern Batters. The assessments and advice included critical review of the performance of the Morwell River Diversion and prompted the TRB to call a meeting of stakeholders to express its concerns and the need for a more robust approach to managing the risk of mine instability. Subsequently, towards the end of the current reporting period, the Morwell River Diversion failed.

This event and other unresolved issues has caused the TRB to elevate its concerns to the highest levels within industry and government and to formulate a range of initiatives for stakeholders to address the effective management of mine stability risk in the Latrobe Valley.

On the basis of the work undertaken by the TRB, particularly over the last year and in combination with various events that have occurred in the mines, it has become clear to the TRB that the situation with regard to mine stability has reached a serious state. The mines are complex structures that are large by world standards and continue to become larger and deeper. History demonstrates that managing mine stability and the risks associated with instability to an acceptable standard requires high level, ongoing assessment, investigation, design, implementation and re-assessment on both mine specific and regional scales.

Prior to privatisation in 1995, this role was essentially fulfilled by the former State Electricity Commission of Victoria (SECV) which, over a number of decades, developed skill platforms, information bases and technical and management processes for this purpose. Since the demise of the SECV, there appears to have been a significant reduction in the scope, depth and extent of these important tasks on both a mine specific and regional scale and a loss of corporate memory. Furthermore, mine operators have become conditioned to risk and are normalising risk (that is, some risks are now viewed as 'normal, to be expected') and the risk acceptance criteria and appetite of the present owners are higher than that of the SECV.

This has led to the current situation where there has been virtually no advancement for many years in the industry's understanding of the characteristics, mechanisms, and movements of slopes and batters and the consequences of these movements for public safety, surrounding infrastructure, continuity of coal supply, and the environment. This is particularly unfortunate as it coincides with an increase in the number, density and proximity of surrounding infrastructure, increased public scrutiny and requirements for higher standards of environment and community governance.

Technical areas that appear not to have experienced continuity and ongoing development at all mines in recent years include:

1. Construction of both local and regional geological cross-sections and models.
2. Determination of geotechnical properties of strata to underpin design and stability assessment.
3. Hydrogeological measurements to support mine design, verification of design effectiveness, and timely detection of change.
4. Stability assessment techniques.
5. Regular stability inspections.
6. Extent, regularity and presentation detail of monitoring.
7. Hazard mapping, risk assessment and mitigation.
8. Planning for mine closure.

Hazelwood Mine site visit

The TRB is of the view that stakeholder culture needs to change in regard to managing ground control in a risk management framework if further incidents of major instability are to be avoided. There is a need to improve significantly the technical expertise and understanding of all stakeholders in the Victorian brown coal sector so that standards, practices and risk management are commensurate with international best practice. A number of initiatives identified by the TRB in this regard are presented in a later section of this annual report.

Potential and actual mine instability events in the brown coal sector have caused the TRB to focus its attention during the reporting period on ongoing familiarisation, review of major stability reports and identification of key stability issues across the Latrobe Valley.

The board has also been involved with a range of other activities. These include:

1. Maintaining a watching brief on identified ground control issues at Anglesea coal mine.
2. Liaising with Clean Coal Victoria to share information on potential interactions and implications of activities and findings.
3. Review and advice on stability issues in the Victorian mine and quarry sector and the development of a guideline for managing these issues.
4. Review of Workplan variations.
5. Participation in the State Emergency Risk Assessment Project.
6. Presentation on risk management to an industry forum in the Latrobe Valley.
7. Input into the research program of the Hydrogeological Engineering Research Group (GHERG) based at the Gippsland Campus of Monash University.
8. Preliminary consideration of the Morwell River Diversion failure at Yallourn Mine.

Loy Yang site visit

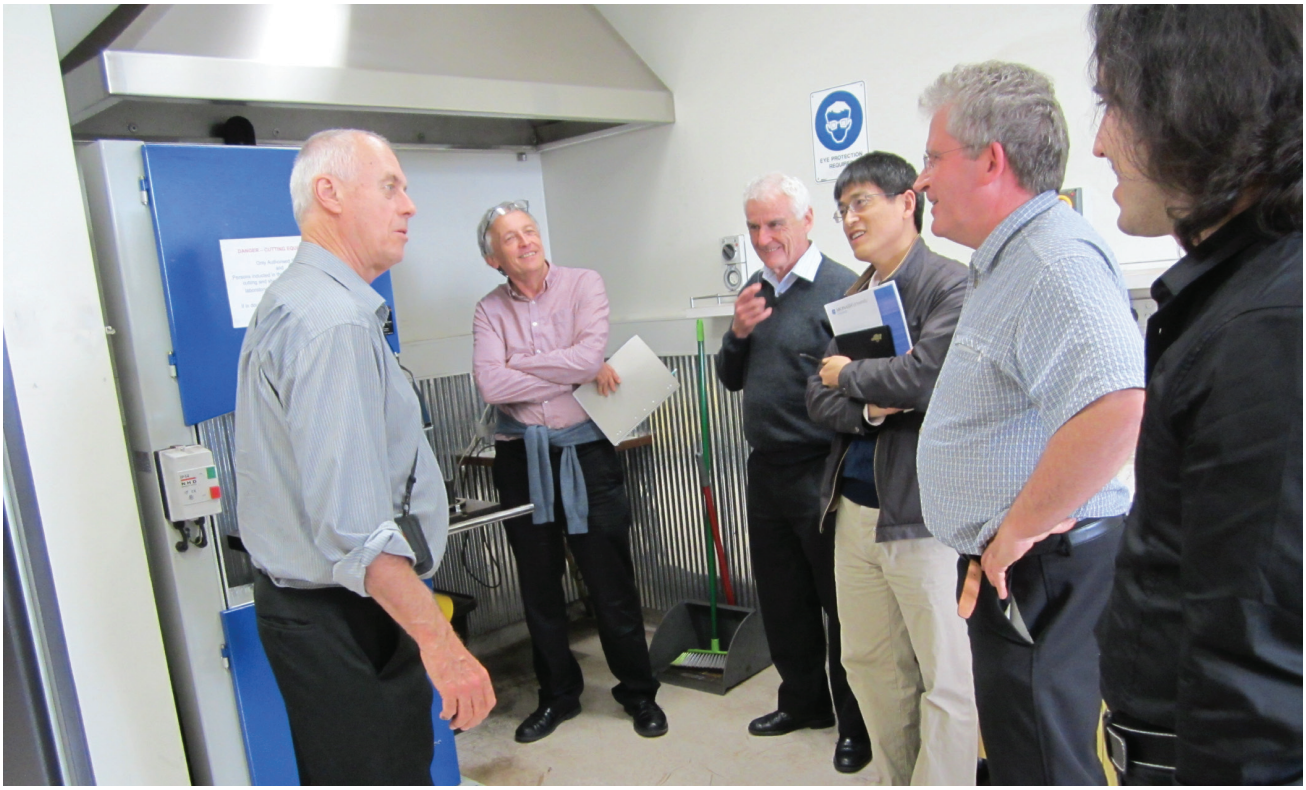
6. Monash Contributions

The Geotechnical and Hydrogeological Engineering Research Group (GHERG) was established through a five year contract principally funded by DPI in June 2009 at Monash University Gippsland Campus. Its function is to undertake geotechnical and hydrogeological research focused on the identified stability issues for the Latrobe Valley Brown Coal Mines and to implement education and training for those working for and with the Latrobe Valley mines. In accordance with its TOR, the TRB interacts directly with Monash University in relation to GHERG's Research and Development program.

GHERG has undertaken a range of educational activities during the 12 months to August 2012 as well as initiating new research. Four workshops have been held in the reporting period covering introductions to both engineering geology and groundwater. A seminar on risk assessment was also delivered by Professor Galvin early in this period. Significantly, a new part-time Masters in Geomechanics and Geohydrology, co-developed by GHERG and the School of Applied Sciences and Engineering at Monash Gippsland Campus, has received University approval to commence in March 2013. The new Masters is focussed on open-cut mining.

Research is developed under three theme headings: slope stability, mine rehabilitation and groundwater assessment. The development of new projects has been preceded by the collation, organisation and evaluation of the extensive historical information and data characterising the material properties of the major geological formations, the superficial deposits, the major coal seams and the interseam formations of the Latrobe Valley. Reviews of the historical records inform all new research. GHERG has established new laboratories for water and geotechnical testing along with a workshop for field and laboratory based test equipment construction and sample handling. New field equipment has also been procured with support from the Collier Foundation. State of the art geotechnical modelling tools have also been procured. Using these facilities, research studies have been progressed on coal consolidation, tensile and creep properties and processes alongside field and modelling studies of groundwater surface water interactions and slope stability modelling. The early results of these studies have been presented at two international conferences held in Australia (ANZ2012, Melbourne and 34th IGC, Brisbane).

Further details of GHERG's background and current research are presented in Appendix A.



GHERG laboratory inspection

7. Initiatives for Going Forward

The TRB has identified a range of initiatives for addressing matters previously raised in this annual report, with the six principal initiatives relating to:

1. Improving the standard of future geotechnical studies to support mine planning and ground control management plans.
2. Incorporating contingency planning into ground control risk management.
3. Improving the standard of monitoring, data processing and reporting to support ground control management plans.
4. Rehabilitation of mine batters.
5. Future research and education directions of GHERG.
6. Changing stakeholder culture.

Geotechnical Studies

Over the last several years there has been a loss of corporate memory with respect to geotechnical understanding at the brown coal mines as well as a reduction in the capacity of each mine to manage the numerous factors involved with assessing overall stability. With recent failures and with other areas for which there is mounting concern, the time has come to re-establish a robust technical platform to manage geotechnical risk at each mine.

Therefore, the TRB recommends that geotechnical studies are undertaken at each of the Latrobe Valley mines and the Anglesea Mine. The requirement for specific geotechnical studies is guided by the identification of all public infrastructure and significant natural features within one kilometre of the crest of the mine batters, and their classification as being of minor, moderate or major significance according to the potential consequences arising from mining-induced ground movement.

Depending on the classification and distance from the crest of the mine, the infrastructure and features may need to be subjected to a geotechnical study. This study may need to be supplemented by sustained and regular monitoring as well as the development of a Trigger Action Response Plan (TARP). Risk assessments may also be required to identify control measures and to formulate management plans.

A key component of these proposed geotechnical studies should be rigorous independent expert peer review.

Further details of the proposed geotechnical studies are presented in Appendix B.

Contingency Planning

It is evident that there are many key activities and operations that are not clearly supported by contingency measures in the event of being impacted by ground instability. Examples include:

- all conveyors systems from a mine to a power station concentrated in one location, thereby threatening power production should this location be impacted by a ground failure event;
- major water courses through and around mine sites for which there are no alternative storage or diversion plans;
- transport links (road and rail) not having clearly defined and proven strategies for closure and rerouting should they be impacted ,
- adjacent water storage areas for which there are no strategies for controlled drawdown should instability extend into their area of influence.

It is recommended that each of the mines review their operations to identify vulnerable infrastructure, activities and operations, with a view to developing appropriate contingency measures.

Monitoring, Data Processing and Reporting

There is an extensive array of monitoring equipment installed in and around the mines for measuring ground displacements, pore water pressures and water flow volumes. These installations are essential for providing data to allow assessment of stability. However, for the equipment to be effective, the data, its processing and reporting needs to be provided in a manner and a time frame that allows appropriate action to be taken. In particular, when a pre-set alarm level is set for a particular instrument or group of instruments, it is important that action is taken soon after the alarm has been triggered, not several days, weeks or even months after, or indeed if at all.

There appear to be variable levels of monitoring across the mines and the reliability and utilisation of the data obtained is much less than desirable. The reasons for this includes the way the data is presented, the scales used, the legibility of the data and its correlation with other interactive events (such as rainfall), the correlation of this data with the actual location of the instrument, the alarm levels set, and the actions that should be triggered upon alarm. A vital element is the time taken for the data to be made available to all stakeholders involved in the overall process.

While it is always important for the monitoring data to be used effectively, it is particularly important now because of the increased number, frequency and intensity of rainfall events and the ground failures and movement events which have occurred recently.

The TRB recommends that the monitoring, data processing and reporting processes, including lines of communications between the mines and the regulators be reviewed immediately and appropriate action taken. It is considered important that these measures are developed with close involvement of the mines so that the processes are effective, transparent and inclusive.

Rehabilitation

It is inevitable that current and new mines will be faced with closure at some point in time. Based on its analysis and insights from recent instabilities, the TRB is of the opinion that the measures which have been considered to date for the rehabilitation of a mine fall well short of what could reasonably be considered as adequate. There seems to be a general presumption and acceptance that the mines will simply become flooded to form inland lakes, with no consideration having been given to a range of issues that include:

- The ongoing stability of the batter slopes, many of which have a variety of forms of infrastructure relatively close to the crests of the mine.
- Ongoing movements of the areas adjacent to (and some distance from) these same batters and the consequences of these movements.
- The responsibility of the mine owners in these matters and who would be liable for any consequences.
- The effect that the water retained in the abandoned mine would have on the adjacent batters and their long term stability.
- The extent to which the mines would fill, the length of time taken to fill and the time when it would be appropriate to turn off the pumps currently depressurising the formations below and around the perimeter of the mines.
- The characteristics of the water that fills or partly fills each mine and safety aspects associated with its potential uses.
- The influence that one mine closure may have on adjacent mines.

There are many more issues which need careful consideration; some of a general nature and many others specific to each mine.

In order to develop appropriate measures and processes for closure, considerable study, assessment, evaluation, implementation and ongoing monitoring with action plans are required. This will take time to develop and will be a costly process.

It is recommended that steps are taken immediately to begin an assessment of the issues, the processes, the risks and their amelioration, the time lines and priorities and, most importantly, the cost liabilities required for closure of each existing mine.

Future Directions for GHERG Research and Education

TRB's recommendations arising from the reviews carried out on the Yallourn and Hazelwood mines have highlighted research and education needs that should be considered for inclusion into the research and education programs of GHERG in the next year. The key elements of the work that should be undertaken are:

1. Establish equivalence relationships between standard factor of safety results from slope stability assessment and the risk of failure of the slope determined using probabilistic risk assessment techniques.
2. Seek new monitoring evaluation strategies that can provide better trigger points for use by the mines for assessing the risks from slope movements.
3. Evaluate the requirements for the number and type of underpinning data for application of probabilistic risk assessment methods to slope stability analysis.
4. Deliver a training workshop series on the use of probabilistic risk assessment methods for slope stability analysis and the interpretation of the results.
5. Commence a review of the geotechnical parameters used in assessing batter stability at the mines with particular reference to the equipment used, the testing procedure followed and the interpretation of the results obtained.

Changing Stakeholder Culture

The TRB has developed a proposal for changing stakeholder culture in going forward that is currently being considered by government, although some elements are in early stages of implementation. The proposal is premised on:

1. Greater engagement between stakeholders, at all levels within organisational structures.
2. Increasing the technical capability of the DPI in the short term in order to identify and assess the key relevant issues.
3. The development of a geotechnical guideline by an industry working party, with input from the TRB as required.
4. The development and implementation by each mine of a robust, risk based, Ground Control Management Plan that incorporates up-to-date geological and geotechnical models and hazard plans.
5. An increased emphasis on research and education forums.
6. A move towards probabilistic based design.
7. A higher focus on independent, external peer review.

It is pleasing to report that this approach has produced promising outcomes to date.

8. Concluding Remarks

During its first term, the TRB identified seven 'at risk' ground structures, of which three have subsequently failed and one is reported to have been stabilised. Currently, the TRB can give no assurance that all 'at risk' structures have been identified or that there will be no further failures of identified structures. Clearly, given the nature of the legacies and the complexity of the issues, it will take some time to develop, implement and refine effective solutions.

A range of initiatives have been identified and articulated that should provide a pathway to achieving the future long-term stability of the mines and the control of future risks at levels that are acceptable to the mine operators and the Department. Solutions require constructive and collaborative engagement and dialogue between all stakeholders and for mine design and operation to be premised on sound risk management, supported by research and education. Subject to the Minister's knowledge and approval, the TRB will be focussing its attention in the following year on facilitating and supporting this process.

Appendix A

Geotechnical and Hydrogeological Engineering Research Group

Introduction

The Geotechnical and Hydrogeological Engineering Research Group (GHERG) was established in June 2009 at Monash University Gippsland Campus to undertake geotechnical and hydrogeological research focused on the identified stability issues for the Latrobe Valley Brown Coal Mines and to implement education and training for those working for and with the Latrobe Valley mines. GHERG commenced its research and education program in August 2010 and achieved its full complement of staff and students in February 2012.

The stated objectives for GHERG are:

a) to address the issue of insufficient expertise and skill shortage by providing broad range geotechnical and hydrogeological research and development support to the Latrobe Valley coal mines;

b) to foster research and innovation in coal geotechnical and hydrogeological engineering, particularly in the areas of mine stability, mine monitoring systems and interpretation, ground subsidence, effect on rigid structures such as infrastructure, ground and surface water control in mines, and evaluation of models used in practice;

c) to review and develop systems modelling approach to planning, involving issues such as mine water quality, quantity, contamination, ground subsidence, safety risks and bushfires;

d) to provide support to the Technical Review Board (TRB), which will review all mining operations and their potential impacts; and

e) to develop training programs for mine personnel through short courses presented by members of the research group, as well as local or international academic and industrial experts. Other training may be provided through elective units in current civil engineering courses and/or a Masters level course.

Staff and Facilities

The Director of GHERG is Professor Rae Mackay who, in this role, has standing membership of the TRB. GHERG has five full time staff, part-time access to a laboratory technician and a number of higher degree research students. In addition, three members of Academic staff of the School of Applied Sciences and Engineering at Monash Gippsland Campus are closely involved with GHERG.

Other Monash University staff collaborate on specific research and training initiatives in areas of hydrology, soil microbiology and environmental chemistry.

Building space has been allocated by the Monash Gippsland campus comprising offices, research laboratories and a workshop. The laboratories and workshop have been refurbished and equipped to carry out a broad range of geotechnical and hydrogeological experimental investigations and testing on the Latrobe Valley geological formations. The new workshop allows tailored field and laboratory equipment to be designed and constructed as required. Specialised engineering facilities are provided through agreed access to campus and industrial engineering workshops in Latrobe City. Additional facilities are provided by access to the engineering, chemical and microbial laboratories at the Gippsland campus, the engineering laboratories at Monash Clayton campus and the geotechnical laboratories of GHD Ltd in Morwell.

In addition to laboratory and workshop facilities and equipment, the group has procured state-of-the-art geotechnical and hydrogeological modelling software, as well as visualisation and mapping tools.

The current staff and facilities of the group provide an excellent resource for the Latrobe Valley coal mines and the Department of Primary Industries. GHERG staff are supported by an Advisory Board comprised of members of the Mine companies and regional stakeholders including the Minerals Council, GHD Ltd, the Department of Sustainability and Environment and the Department of Primary Industries.

Research Activities to August 2012

GHERG's research has developed around three themes: slope stability, mine rehabilitation and groundwater assessment. Work on these themes has been preceded by the collation, organisation and evaluation of the historical information and data characterising the material properties of the major geological formations, the superficial deposits, the major coal seams and the interseam formations of the Latrobe Valley. This was an essential starting point for successful delivery of new research outputs. Understanding the knowledge acquired during the early development of the three brown coal open-cuts has yielded clear insights into the existing knowledge in the Latrobe Valley and the knowledge gaps defining the forward research agenda. The development of the program of research has been responsive to observed gaps in the historical records, the issues and concepts identified by the work of the TRB and the proposals of the GHERG advisory board.

Historical Data Collection

The data collation project, supported by Clean Coal Victoria (CCV), has progressively unlocked the contents of the historical (pre-1995) data archive developed by the State Electricity Commission of Victoria (SECV). The original data were archived as images on compact disks with little cataloguing. Using image conversion to text software, the contents of the records have been identified, catalogued and, as appropriate, cross referenced. On completion the catalogue will be searchable. Research staff and students have extracted and analysed catalogued data in the following areas: ground consolidation, material creep; shear testing and groundwater.

Slope Stability

It is apparent that slope stability in each of the mines is driven by two connected issues. The first relates to the mining controlled movements of the coal blocks in the batters as a result of two processes: (1) stress release in the coal due to excavation and (2) compaction of the coal connected to depressurisation of the underlying aquifers. A third, but unproven, process is creep.

The second issue relates to excess hydraulic pressures due to high groundwater tables in the coal joints and underlying clays, compounded by additions of water from surface water bodies and rainfall through cracks penetrating the surface soils. Other secondary processes may include weathering or temperature variation. Feedbacks are likely between these processes While understanding the processes of slope movement is important, the primary question is how to predict from monitoring when long term movements and inflows change from tolerable to unacceptable and pose a high risk of slope failure. Following on from this question, it is necessary to establish what methods are appropriate to reduce the risk of slope failure once a predicted risk is considered too high. At the present time, it is unclear whether it is possible to completely prevent unacceptable movements from occurring in the long term and several lines of investigation are being pursued.

Mine Rehabilitation

As the mines enlarge, progressive rehabilitation is required to reduce the environmental risks and costs of mine operation. If a mine closes, rehabilitation of the mines such that they are left in a safe and stable condition without the need for long-term interventions is a priority. One aspect of rehabilitation being examined by GHERG concerns the provision of stable soils to cover the exposed (rehabilitated) land surfaces, the overburden dumps. Insufficient natural soils are available to at least one of the mines and options for importing soils are currently limited. A proposal for research into the use of artificial soils based on waste products from the mines and the power stations is being examined with a view to meeting the shortfall.

Groundwater Assessment

Numerous groundwater models have been developed for the mining area and the Latrobe Valley to investigate the impacts of mine dewatering on the groundwater regime and to assess subsidence risks across the area. The least developed aspect of these models is the interface with the land surface and the interactions between the groundwater and surface waters. This is the subject of current research through a further program of modelling.

Education Activities to August 2012

A seminar, a series of 6 one-day workshops covering ground engineering subjects relevant to civil works and mining engineering and a new part-time, distance learning Masters in Geomechanics and Geohydrology have been established over the last year through GHERG and the School of Applied Sciences and Engineering at Monash University. The start date for the new Masters degree is March 2013.

The first four of the six workshops were completed prior to the end of August 2012, with the following two to be delivered in September and October 2012. Attendance at the first four workshops was excellent, averaging sixteen persons per course. The first seminar held in 2011 and attended by over thirty persons was presented by Professor J. Galvin, TRB Chairman, and covered an introduction to risk assessment and management.

In addition to specific training activities, a presentation on the work of GHERG was made by Professor Mackay to a large audience of the regional group of Engineers Australia in May 2012. Early research results were also presented at the International Geomechanics Conference in Melbourne in July 2012. Two conference papers were published detailing the results presented. Further dissemination of the group's research also took place at the International Geological Congress in Brisbane in August 2012. Three presentations were given on coal creep, coal consolidation and groundwater surface water interactions.

Appendix B

Geotechnical Studies

Arising from its review of mine stability, the TRB recommends the following in respect of all declared brown coal mines and the Anglesea Mine:

1. The identification of all public infrastructure and significant natural features within a one kilometre zone of the crest of the mine batters.

2. These man-made and natural features be classified as being of minor, moderate or major significance according to the consequences arising from mining-induced ground movement. Input has been sought from the mines on classification criteria.

3. On this basis:

   i. A geotechnical study, as discussed below, is mandatory for all man-made and natural features classified as being of major significance.

   ii. A geotechnical study is mandatory for all man-made and natural features classified as being of moderate significance if they are located within 600m or 3 times mining depth of the crest of a mine batter, whichever is greater.

   iii. A specific geotechnical study is not mandatory for man-made and natural features classified as being of minor significance.

   iv. For all significance classifications, sustained and regular monitoring to the one kilometre boundary is mandatory.

   v. Monitoring be supported by a Trigger Action Response Plan (TARP) to identify if these criteria are adequate or if geotechnical studies need to be initiated and/or extended outside of the mandated zones.

4. Undertake risk assessment to identify control measures and to formulate management plans.

5. All geotechnical studies and risk assessments should be subjected to rigorous independent expert peer review.

The threat to public safety, security of power supply and the environment presented by ground instability impacting infrastructure within a mine shell is yet to be addressed by the TRB.

The application of the approach recommended above can be expected to identify requirements that detailed geotechnical studies be carried out in particular areas. The TRB recommends that these studies use an approach that differs in some respects from that used to date for geotechnical stability studies in Victoria's brown coal mines.

In particular, it is recommended that a probabilistic as well as the traditional deterministic approach be used in making stability assessments. This approach involves the estimation of probability density functions for the demand or driving forces (gravity loads, forces arising from water pressures) and for the capacity or available resistance (usually derived from material shear strengths). Obviously, the estimation of useful probability density functions for geotechnical material properties requires the availability of a range of reliable test data. The application of a probabilistic approach does not obviate the need to identify and evaluate the sometimes complex deformation and failure mechanisms involved.

In general, the geotechnical engineering studies required will include a number of elements:

1. The development of a comprehensive geotechnical model that includes, but is not limited to:

   i. the complete stratigraphic profile through the area, including the interseam sediments;

   ii. the geotechnical engineering properties of each of the stratigraphic layers or units including the interseam sediments and their spatial variabilities;

   iii. the locations and shear strengths of any sub-horizontal geological structures and clay-rich layers within the sequence and their spatial variabilities; and

   iv. the distribution of groundwater pressures including artesian pressures in the area and their potential variabilities.

2. A review of current geotechnical and groundwater monitoring and the installation of any additional monitoring required to satisfy the requirements discussed above and to enable improved assessments of the geotechnical model and observed movement to be made, including the effects of hydrogeological and geotechnical coupling.

3. The development and probabilistic analysis of a comprehensive stability model which explains the controls on stability and the observed movements and informs the monitoring program and the TARP.

4. The development of strategies and time-frames for stabilisation of the area in the event that the previous steps indicate that stabilisation is necessary. In this context, stabilisation refers to any measures that may be required to arrest movement, including the reduction of groundwater pressures.

The areas over which these detailed geotechnical engineering studies will be required can be expected to vary from case to case. In general, the area should include the floor in front of or below the batter or structure concerned and the surface some distance behind the batter crest to enable impacts on man-made and natural features to be assessed.

ADP - 0300