Doyalson Wyee RSL

Structure Plan 80 to 120 Pacific Highway
Planning and concept design for mine subsidence

June 2019

Table of contents

Table index

Appendices

1. Introduction

This report presents the outcome of consultation by GHD and Urbis on behalf of Doyalson Wyee RSL, with Subsidence Advisory NSW (SA NSW) and Centennial Coal regarding mine subsidence, together with advice for Stage 2 of the Doyalson Wyee RSL 'Structure Plan'.

The subject site is defined as property numbers 80, 90, 100, 110 and 120 Pacific Highway, Doyalson and is shown on Figure 1 in Appendix A. The existing RSL club is located on 80 Pacific Highway. Relocation of the club to 110 Pacific Highway, together with development of a medical centre, childcare centre, fast service uses, residential and seniors living development is proposed.

The purpose of this report is to provide mine subsidence advice to assist in planning and concept design for the above potential future developments. The goal is to communicate the anticipated development constraints and design requirements associated with mine subsidence and to provide preliminary guidance on ways to accommodate these. For example, advice on the types of buildings that would be suited to different subsidence design criteria and advice on infrastructure considerations to reduce the impact of potential mine subsidence.

1.1 Limitations

This report has been prepared by GHD for Doyalson Wyee RSL and may only be used and relied on by Doyalson Wyee RSL for the purpose agreed between GHD and the Doyalson Wyee RSL as set out in Section 1 of this report. GHD otherwise disclaims responsibility to any person other than Doyalson Wyee RSL arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

GHD has prepared this report on the basis of information provided by Doyalson Wyee RSL and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to site conditions. GHD is also not responsible for updating this report if conditions change.

2. Site and mining overview

The site boundary and property numbers are shown on Figure 1 in Appendix A.

The entire site is within Consolidated Coal Lease (CCL 721), held by Centennial Mannering Pty Ltd (Centennial). This lease expires in 2026 and is sub-leased to LakeCoal (wholly owned by LDO Coal Pty Ltd) who operate the adjacent Chain Valley Colliery and became the operator of Mannering Colliery in 2013 under agreement with Centennial.

The past mining beneath the site was part of Wyee Colliery (owned by Powercoal Pty Ltd) and occurred in the late 1990's and up to 2002. In 2004, Wyee Colliery changed name to Mannering Colliery when it was purchased by Centennial. The mining occurred in the Great Northern Seam at depths of about 170 m to 200 m beneath parts of 110 and 120 Pacific Highway, as well as beneath land to the north and east. The method of mining employed was bord and pillar first workings with a single longwall panel (LW1) extracted in 1999. The extent of the mine workings is shown in Figure 1. The Great Northern Seam is approximately 2.9 m thick in this area. Of this between about 1.8 m to 2.6 m thickness of coal was mined. The extraction of LW1 resulted in surface subsidence up to about 0.9 to 1.0 m.

No mining beneath the site has occurred since 2002.

Further to the north, beneath 130 Pacific Highway, the Fassifern Seam was mined between 2005 and 2012 at depths of about 200 m to a height of about 3.2 m. The edge of these workings is at least 200 m from the northern boundary of 120 Pacific Highway and far enough away to warrant no further consideration here.

While Centennial has no plans to mine coal beneath the site, it is underlain by mineable coal within the Great Northern Seam and there is potential for future mining in this seam.

3. Subsidence responsibility and approvals

The site is within a designated Mine Subsidence District. Therefore, Subsidence Advisory (SA NSW) is an approval authority under Part 3 of the Coal Mine Subsidence Compensation Act 2017 No. 37 (the Act). SA NSW will be consulted on rezoning applications and be an integrated referral authority for any subdivision applications or building applications, including master planning development applications.

With respect to development planning purposes, the entire site is classified by SA NSW as 'Surface Development Guideline 7 – on application'. Guideline 7 is applied to properties assessed as being at risk of subsidence with unknown or severe criteria, or properties affected by shallow mine entries or shafts.

Additionally, the site is considered an 'active coal mine' under the Act and, under Part 2 Section 8, the miner (Centennial) may be liable for subsidence related damages to surface improvements. However, in the case of this site and only where non-active mine workings exist, liability for subsidence related damages remains with SA NSW under a NSW government gazette. Elsewhere, the leaseholder (Centennial) is responsible.

While approval authority rests with SA NSW, the future mining plans and predicted ground surface movements as advised by Centennial, will be taken into consideration by SA NSW when considering their conditions of approval.

4. Design constraints and criteria

On behalf of Doyalson Wyee RSL, GHD and Urbis have liaised with SA NSW and Centennial to arrive at agreed development conditions, including subsidence design criteria. This section sets out these anticipated conditions. Reference should be made to the most recent project correspondence from SA NSW and Centennial to confirm these conditions.

4.1 Maintain as Guideline 7

Lot numbers 80, 90, 100, 110 and 120 Pacific Highway are to be left as Guideline 7, a copy of which can be found on the SA NSW website: http://www.subsidenceadvisory.nsw.gov.au/development-guidelines.

Under Guideline 7, all development is assessed by SA NSW risk engineers. Following construction, a certifier must be engaged to sign off that the improvements have been constructed in accordance with the approved plans and conditions of approval. A copy of this certification must be provided to SA NSW.

4.2 Subsidence design criteria

Centennial have provided two sets of subsidence design criteria for purposes agreed with Doyalson Wyee RSL. These are summarised below in Table 4-1 with the commercial precinct boundary shown on Figure 1 in Appendix A.

These criteria are from Centennial's letter to Doyalson Wyee RSL Club, dated 2 October 2018 (Centennial Ref. APP178713). They apply to both new buildings as well as associated infrastructure such as pavements, retaining walls, detention basins, kerb and gutter, stormwater drains, in-ground and above ground utilities.

Table 4-1 Subsidence design criteria, 2 October 2018

Subsidence criteria		Applicable areas [A]	Applicable development
Maximum horizontal ground strain: Maximum tilt: Minimum radius of curvature:	2 mm/m tensile or compressive 4 mm/m 10 km (hogging and sagging)	100 and 110 Pacific Highway commercial precinct	• RSL Club Building • Health and Wellness Centre • Medical Centre • Motel/Hotel Building • Childcare Centre • Six Fast Service buildings
Maximum horizontal ground strain: Maximum tilt: Minimum radius of curvature:	5 mm/m tensile or compressive 7 mm/m 3 km (hogging and sagging)	All other parts of the site not included in the above precinct	• Recreational Warehouse and Arrival Centre • Leisure and Recreational Uses • Seniors Living Development • Residential Development • Villa Accommodation
A: Precinct boundary shown on Figure 1 in Appendix A			

4.3 SA NSW approval conditions

In addition to designing buildings, structures and infrastructure for the subsidence design criteria nominated by Centennial as presented in Table 4-1, SA NSW is expected to place the following conditions on their approval.

- Buildings to be designed and constructed in accordance with the current editions of AS1684, AS2870, AS3600, AS3700, AS4773, the Building Code of Australia, any other relevant applicable Australian Standards and good engineering practice.
- Application for approval lodged with SA NSW in accordance with Section 22 of the Act.
- All development to be assessed by SA NSW risk engineers 'on merit'.
- Following construction, a certifier must be engaged to sign off that the improvements have been constructed in accordance with the approved plans and conditions of approval. A copy of this certification must be provided to SA NSW.

The above anticipated conditions have been taken from SA NSW Guideline 7 and would be applicable to the entire site. For areas not within the agreed commercial precinct, the following additional conditions, taken from Guideline 4, may be applied to proposed residential or seniors living development.

- Residential development constrained to single storey clad frame buildings, erected on reinforced concrete strip footings or waffle raft slab to minimum H2 site classification to AS2870. Maximum height of foundation brickwork 1.5 m and limited to a maximum length of 18 m and a maximum footprint of 250 m^2.
- Gradients on wet area floors and roof gutters increased to ensure they remain serviceable.
- Flexible joints in pipes designed in accordance with AS3500 to minimum H2 site classification specifications to accommodate curvature in any plane, coupled with tensile or compressive strain.
- Branches, bends and valve stems protected by flexible wrapping or shrouds to prevent shearing of the pipes as ground movement occurs. Flexible joints provided where pipes are connected to chambers or gullies.

The anticipated conditions should be confirmed with SA NSW by submitting a development application and seeking conditional approval.

5. Planning and design strategies

5.1 General philosophy

Buildings should be designed to be safe, serviceable and economically repairable under normal load combinations as well as forces induced by subsidence and differential ground movement caused by mine subsidence.

In the event of subsidence, some repair of buildings and infrastructure is tolerable but will need to be reduced through planning, design and construction to what SA NSW consider 'economically repairable'. As a general guide, elements should be designed as far as practicable and economical, to maintain safe, serviceable operation in the event of subsidence and reduce the cost of repair through:

- Selection of flexible and lightweight materials rather than brittle materials
- Provision for articulation, adjustment and ease of replacement or repair
- Reducing transfer of ground strains to structure footings
- Consideration of post-subsidence safety and functionality of drains and surface water storages elements such as stormwater detention basins, swales and gravity pipes

More specific guidance is provided in the following sub-sections for the subsidence design criteria nominated by Centennial. General comments on design for tilt, strain and curvature are also provided. Information sheets published by the Mine Subsidence Board (predecessor to SA NSW) provide additional background information and are included in Appendix B.

Tilt

Tilt is the first derivative of the vertical subsidence profile, or the rate of change of vertical subsidence. It is calculated as the change in vertical subsidence between two points divided by the horizontal distance between those two points. The base length is typically the standard mine survey peg spacing of 1/20th the depth of mining. In this case, a base length of about 20 m is anticipated.

Tilt should primarily be considered in the context of serviceability. For example, providing generous falls for roof gutters and wet area floors.

Curvature

Curvature is the second derivative of subsidence, or the rate of change of tilt. It is calculated as the change in tilt between two adjacent sections (bays) of the tilt profile divided by the average length of those sections. The radius of curvature (R) is expressed as follows.

$$R = \frac{\text{sum of the lengths of successive bays}}{2\ x \text{ differential tilt between them}}$$

Building length (L) should take differential deflection (Δ) into consideration through review of the design radius of curvature (R). The following from Burland and Wroth (1974) provides the mathematical relationship:

$$\Delta = \frac{L^2}{8R}$$

For example, a 10 km radius of curvature and 50 m long building results in differential deflection of 31 mm.

Australian Standard AS 2870-2011 Residential Slabs and Footings (Table 4.1) provides recommended maximum permissible footing and raft deflections for residential structures.

Consideration of curvature is also relevant in the context of ensuring adequate fall (post subsidence) for drainage elements such as stormwater drains and gravity sewers.

The effects of ground curvature can be minimised by panelling and articulating walls to move without developing excessive strains, cracks or causing doors and windows to jam. Damage due to curvature can also be minimised by eliminating brickwork above windows and doorways.

For moment resisting framed structures, induced stresses due to differential settlement of columns will be required. This can be accommodated by choosing appropriate column spacing.

Strain

Strain is the first derivative of horizontal movement, or the rate of change of horizontal movement. It is calculated as the change in horizontal length of a section of the subsidence profile divided by the initial horizontal length of that section.

$$Strain = \frac{\text{new horizontal distance} - \text{original horizontal distance}}{\text{original horizontal distance between the pegs}}$$

By convention, tensile strains are positive and compressive strains negative.

Ground strains are transferred into footings by friction beneath footing elements or by pushing against footing sides. Reinforced concrete footings are more capable of withstanding ground strains than masonry footings (for example) and footing systems such as raft slabs are less susceptible to strain effects than strip footings generally.

The amount of strain transferred into a footing can be reduced by providing a slip layer between the structure and the ground. Other techniques such as strain relief trenches and compressible inclusions can also be effective. The detailing of these items needs specific consideration and planning during design development so that the system is consistent with the requirements for the structure’s capacity to resist wind and seismic loading.

5.2 Within the commercial precinct

Maximum horizontal ground strain:	2 mm/m tensile or compressive
Maximum tilt:	4 mm/m
Minimum radius of curvature:	10 km (hogging and sagging)

5.2.1 Non-residential buildings

As a guide, buildings should be either clad frame (steel, reinforced concrete or timber) or articulated masonry (not rendered) structures. For individual masonry buildings, length should be limited to 30 m. For clad frame buildings, length should be limited to 40 m.

Australian Standard AS2870-2011, Residential Slabs and Footings, is used primarily for the design of footing systems for class 1 and 10 buildings, however it can be used as a guide for other forms of construction if similar to houses in size and flexibility. The deemed to satisfy provisions in AS2870 are for buildings up to 30 m long. Longer buildings can be designed using the principles of AS2870 with specific engineering review and accommodation of building articulation. Attention to articulation of building fabric and detail of floor, wall and ceiling linings at articulation locations is also required. Joints in brittle finishes should align with building frame joints and be detailed appropriately for the potential movement.

Building height should be limited to reduce the cost of post-subsidence repair. While the number of storeys acceptable is for Centennial and SA NSW to decide rather than a technical design limitation, consideration will also need to be given to acceptable lateral drift between storeys and at the top of buildings as well as potential impact on gravity services in the upper floors.

Entrances to basement car parks should consider differential movement and ensure adequate grade separation post-subsidence to keep stormwater flows from entering the basement.

Planning and preliminary sizing of main structural elements should be carried out early in concept design so that the effects on location and sizes from induced stresses as a result of subsidence can be established and accommodated.

5.2.2 Infrastructure

The design constraints on infrastructure within the commercial precinct are expected to be low for the nominated subsidence criteria. However, we recommend the following be considered:

- Stormwater and sewer run distance to the front of the property are up to about 200 m. This equates to 500 mm differential deflection over the run for a 10 km radius of curvature. This potential change in grade should be accommodated by provision of additional fall. If this is not possible, provision of holding tanks and pumps may be required.
- Flexible pavements rather than bound or rigid pavements with either spray-seal or asphalt wearing course are recommended.
- Additional joints (articulation) provided in concrete footpaths, apron slabs, kerb and gutter.

5.3 Not within commercial precinct

Maximum horizontal ground strain:	5 mm/m tensile or compressive
Maximum tilt:	7 mm/m
Minimum radius of curvature:	3 km (hogging and sagging)

5.3.1 Buildings

For practical purposes and economy, buildings are likely to be constrained to residential development as defined in AS 2870.

Residential development would likely be constrained to single storey clad frame buildings, erected on reinforced concrete strip footings or waffle raft slab to minimum H2 site classification to AS 2870 or on framed flooring systems. Maximum height of foundation brickwork 1.2 m and limited to a maximum length of 18 m and a maximum footprint of 250 m^2.

Gradients on wet area floors and roof gutters should be increased to ensure they remain serviceable.

5.3.2 Infrastructure

The design constraints on infrastructure not within the commercial precinct are expected to be significant for the nominated subsidence criteria. Recommended preliminary considerations are provided under the following sub-headings.

Pipes

- Stormwater and sewer run distance to the front of the property are in the order of up to 500 m. Across this distance, differential settlements from subsidence of up to about 1.5 m is conceivable (using longwall LW1 subsidence monitoring data as an analogue) with radius of curvatures of up to 3 km (400 mm over 100 m run). The potential change in grade should be accommodated by provision of additional fall. If this is not possible, provision of holding tanks and pumps may be required.

- Flexible joints in pipes designed in accordance with AS3500 to minimum H2 site classification specifications to accommodate curvature in any plane, coupled with tensile or compressive strain.
- Branches, bends and valve stems protected by flexible wrapping or shrouds to prevent shearing of the pipes as ground movement occurs. Flexible joints provided where pipes are connected to chambers or gullies.
- Sewer pipes with rubber ring joints with 3 m maximum pipe lengths.
- Polyurethane pipes used for in ground water services.
- Stormwater either FRC rubber ring jointed pipes or RCP rubber ringed jointed pipes where flows dictate the use of larger pipes. The connection to pits with rocker joints.

Power

- High voltage power above ground on poles and wires. Low voltage power in HDPE conduit with additional pits to provide flexibility and ease of repair.

Pavements

- Flexible pavements rather than bound or rigid pavements with cheaper spray-seal wearing course recommended until after mining has occurred.
- Where required for separation and drainage purposes where earth swales cannot be accommodated, kerb or kerb and gutter edging to roads to convey flows to stormwater infrastructure.
- Additional joints (articulation) provided in kerb and gutter.

Footpaths

- Additional joints (articulation) should be provided in concrete footpaths or use segmental pavers. Dowelled joints should be installed in concrete paths to minimise differential movement at the joint. Out of level segmented pavers post subsidence would need to be removed and reinstalled.

Retaining walls

- Cut and fill batters preferred over retaining walls. Where retaining walls are required, flexible walls such as gabions or dry stacked unit masonry walls are preferred with additional lay-back to avoid over vertical walls post subsidence and consideration of compressible foam to reduce strain induced loading of wall footing. If reinforced concrete or reinforced masonry walls are used, similar considerations to the building structures will be required. Adequate articulation and detail for the subsidence effects will be required.

6. References

Burland J.B. and Wroth C.P. Allowable and differential settlements of structures, including damage and soil-structure interaction. Proceedings of settlement of structures conference. British Geological Society. ISBN 0 7273 1901 9.

Letter from Centennial Coal to Doyalson Wyee RSL Club. Subsidence Design Criteria for the Proposed New Doyalson Club. Ref. APP178713, 2 October 2018.

Mine Subsidence Board. Guide to Designing for Mine Subsidence.

Mine Subsidence Board. Guidelines to Coal Mining and Roads with respect to subsidence 1997.

Appendices

Appendix A – Figures

Figure 1 – Indicative Concept Plan for Doyalson Wyee RSL Club Redevelopment

INDICATIVE CONCEPT PLAN

FIGURE 1 Indicative Concept Plan for Doyalson Wyee RSL Club Redevelopment

Appendix B – MSB information sheets

A guide to designing for mine subsidence. Mine Subsidence Board, 2007

Guidelines for coal mining and roads with respect to subsidence. Mine Subsidence Board, 1997

A GUIDE TO DESIGNING FOR MINE SUBSIDENCE

MINE SUBSIDENCE BOARD

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INTRODUCTION

This information is provided by the Mine Subsidence Board as general guidance only and in no way can replace the services of a professional consultant on a particular project.

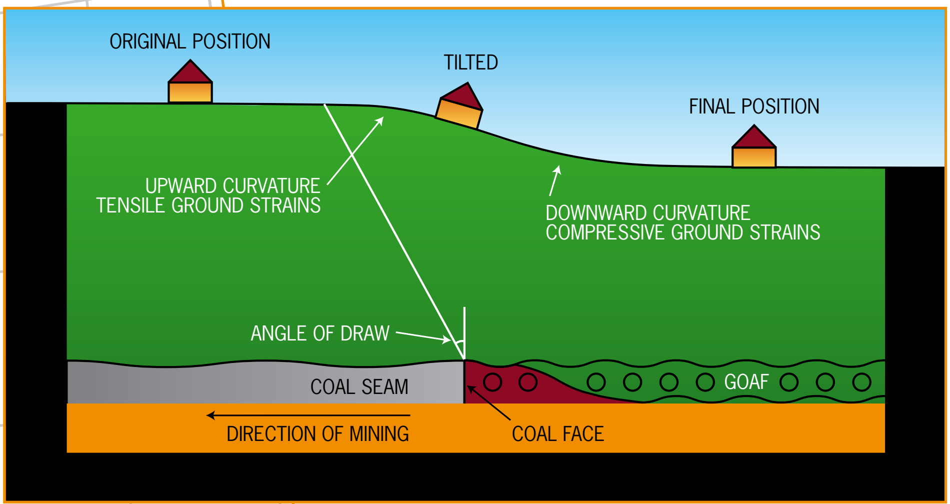
The Mine Subsidence Board is a service organisation operating for the community in coal mining areas of NSW and manages the scheme of compensation as provided for in the Mine Subsidence Compensation Act.

The Act provides for compensation or repair services where improvements are damaged by mine subsidence resulting from the extraction of coal. The Act also gives the Board the responsibility of reducing the risk of mine subsidence damage to properties by assessing and controlling the types of buildings and improvements which can be erected in Mine Subsidence Districts.

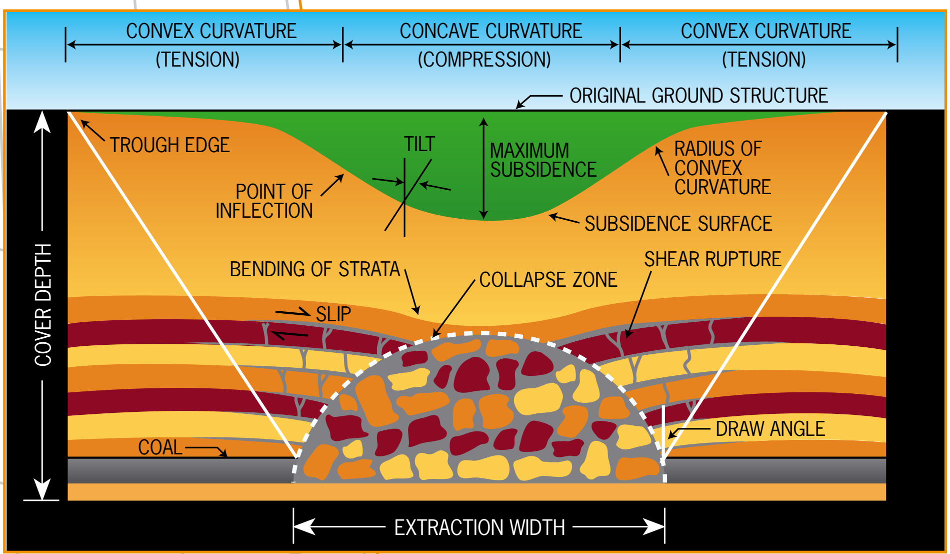
EFFECTS OF MINING

Movement of the ground surface following the underground extraction of coal results in the following:

1. *Vertical subsidence*
2. *Horizontal displacement*
3. *Horizontal strains*
4. *Curvature*
5. *Tilt*



Surface Effects of Longwall Mining - Long Section ▲



Surface Effects of Longwall Mining - Cross Section ▲

Not all mining results in subsidence nor does all subsidence cause damage to surface structures.

Engineering and architectural considerations can significantly minimise the risk of all types of structures experiencing mine subsidence damage. Special design and detailing techniques are adopted to allow structures, including buildings, roads, railways, services, etc, to withstand anticipated movements from earthquakes and unstable foundation material. Mine subsidence is just another form of ground movement that can be designed for. Design principles and techniques that allow structures to accommodate ground movement resulting from mine subsidence have been used extensively in England and Europe since the 1920s and in Australia since the 1960s.

Generally it is the strains and curvature that damage structural elements of buildings. If strains in the ground are transferred into the structure, the tensile and compressive strains may cause building elements to crack, shear or buckle.

Tilt does not normally cause structural damage, however, in severe cases it may affect the usage of a building.

At the design stage it is possible to select a type of structure that, with appropriate detailing, will allow the structure to accommodate these subsidence effects. Designers aim to provide a structure where any damage is non structural and the building remains:

a) Safe - no danger to users
b) Serviceable - available for its intended use
c) Repairable - damaged components economically replaceable

DESIGN OF STRUCTURES

Design for Vertical Subsidence

In general terms, ground subsidence represents a rigid body movement that has no effect on surface structures. As such, it is seldom a significant factor in the design of individual buildings. Structures will be left at a lower level but this normally has no adverse effect on them except in the case of buildings in close proximity to watercourses that may pose a flooding problem. Generally services such as drainage would subside with the building so no differential movement would occur.

Where geological conditions are present which may induce stepping such as along fault or fissure lines, differential vertical movement may be an issue. However, such geological features are often hidden beneath the surface soils and it is unlikely that their presence will be known at design stage unless a detailed site investigation has been undertaken.

This situation is most likely to be of relevance over areas larger than most residential dwelling footprints. Services such as water, sewerage and drainage may require additional care in design and detailing.

Design for Horizontal Displacements

Horizontal movements due to mining occur in such a way that points on the surface move in towards the centre of the subsidence trough. Differential movements result in strains. Overall horizontal movements are generally small except where there are unusual topographical features such as steep slopes, gorges or geological features.

Design for Horizontal Strain

Ground strains occur as a result of differential movement between two points causing a change in length of the surface between the two points. If the length of the surface increases, a tensile strain is induced and if the length of the surface reduces, a compressive strain is created.

Both tensile and compressive strains can generate damage in buildings. In most buildings, the materials are generally weaker in tension than compression, hence tensile forces are the more difficult to accommodate.

Tensile strains can cause cracks in brickwork, internal linings such as plasterboard, pulled joints in pipework, cracks and separation of joints in paving.

Compressive strains can cause spalling of brickwork, crushing of components, closure of door and window openings, buckling of materials, buckling of pipes, paving and other components.

Not all strain in the ground will be transferred into the structure. This is due to a number of factors including foundation type, ground material, the presence of sliding layers, the location and orientation of the mining in relation to the structure and so on.

In general terms, ground strains are transferred into footing systems by friction beneath and beside the footing elements. The obvious solution, therefore, is to reduce such friction and - wherever possible - separating the footing structure from the soil. This may be achieved by providing a slip layer between the structure and the ground to allow the ground to move without damaging the structure.

Footings can be designed to minimise the effect of strains on the superstructure by making them as shallow as possible and by placing them on slip layers. When deep foundations are unavoidable, the forces imposed can be reduced by excavating trenches around the structure. These trenches are placed as near as practical to, and extend to just below the underside of, the foundation. They can be backfilled with a compressible material which is strong enough to support the sides of the excavation but more compressible than the natural soil. This fill will crush and not transfer all of the forces to the foundation. Coke, slabs of expanded polystyrene foam, vermiculite, cork and void formers have been used for this purpose.

Various techniques have been used to allow footings to slip relative to the foundation material. The sides and bottoms of footings and slabs are kept as smooth as practical and are often poured on slip layers that incorporate plastic or bituminous membranes over layers of granular materials (sands). Exaggerated slopes are used on transition zones between stiffening beams and slabs to facilitate shearing actions.

The use of concrete slab on ground footing systems is now close to 90% in NSW with the emergence in recent years of the waffle raft system as the preferred reinforced concrete slab footing system. This is a fortunate outcome as the waffle raft system is ideal as a mechanism for isolation of the superstructure from horizontal ground strains.

Design for Curvature

Curvature results from differential settlement across the ground surface and is considered the most damaging of the mine subsidence parameters to impact on a building. Curvature is normally defined by the deflection ratio or the radius of curvature.

In practice, damage from mine subsidence will often be a result of the combination of curvature and ground strains.

The effects of ground curvature can be minimised by panelling and articulating walls to move without developing strains or cracks or causing doors and windows to jam. Vertical articulation joints are provided at appropriate intervals and at sections where the wall stiffness changes. Damage due to curvature can also be minimised by eliminating brickwork above windows, doorways and arches. If such details are included, special attention must be paid to provision of bond beams and strengthening panels that incorporate arches.

Design for Tilt

Ground tilt results from a differential vertical subsidence between two points that changes the slope of the surface between the two points. Ground tilts that occur during the course of mining operations may be either a temporary or permanent phenomenon depending on their location in reference to the subsidence trough.

Structures subject to tilt are only adversely affected if they remain in a significant permanent tilt at the conclusion of subsidence. This normally occurs when a structure is located on the edge of the subsidence trough.

Small tilts generally do not affect the usage of a building and can be catered for by providing such things as generous falls for services. Tilts over 7 mm/m will start to affect the serviceability of the building and the type of construction will be restricted to allow economical repair. Suspended flooring systems can be relevelled economically where access is available to the supporting bearers and joists.

If sufficient ceiling height has been provided in the original design, and if appropriate detailing has been adopted, it may be possible to relevel floor slabs by adding a topping layer to recover original grades.

Domestic floor slabs are not normally strong enough to withstand relevelling by jacking. Other types of slabs may be designed with jacking points and sufficient strength to be relevelled after subsidence.

Considerable research effort has been expended in recent years in relation to designing footing systems that are capable of being relevelled if unacceptable tilts result from mining operations. This research will continue in an attempt to find solutions to the relevelling issue.

Combined Effects

In reality the damage that occurs to a building is a result of a combination of some or all of these parameters. The deformation of the ground surface as a result of subsidence can lead to both curvature and strain affecting a structure with the possibility of tilts affecting the serviceability.

Generally a building should be designed taking a conservative approach and assuming a full transfer of strains and displacements from the ground to the structure.

OTHER REQUIREMENTS

Pothole Type Subsidence

Where movements of the ground surface occur over old shallow abandoned underground mine workings it can result in a localised depression or 'pothole' in the surface. The majority of these types of subsidence are generally small, however, the design parameter used by the Board is for a potential pothole up to 5 metres in diameter.

For further information on designing for pothole subsidence refer to the Mine Subsidence Board brochure "Designing For Pothole Subsidence".

MINE SUBSIDENCE BOARD REQUIREMENTS

Approval must be obtained from the Mine Subsidence Board prior to any building activity or extensions for sites within Mine Subsidence Districts. The Board may grant unconditional approval of the application or stipulate certain conditions that must be met prior to final approval. In some extreme cases, where the risk of mine subsidence damage is too great, the Board may refuse a building application.

Architectural plans submitted to the Mine Subsidence Board for approval must show the location and detailing of articulation/ control joints in brickwork to comply with the requirements of the Building Code of Australia and best building practices.

Please contact any of the Board's offices for further information and advice.

PRACTICE

It is essential that good building practice be complied with in conjunction with any design features. The correct placement and detailing of articulation joints, detailing of brickwork above windows and doors, internal wall detailing and so on are all important to achieve a structure that is capable of handling the subsidence movements.

Some publications relevant to the description and implementation of these best practice procedures are referenced below.

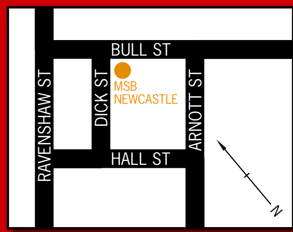
1) Technical Note 61 - “Articulated Walling”, Cement and Concrete Association of Australia
2) Techniques 11 - “Articulation Joints & Control Gaps for Full Brick Houses”, Clay Brick and Paver Institute
3) Australian Standard AS2870
4) The Building Code of Australia

REFERENCES

1) R.G. Hanson., “Designing For Subsidence”. Mine Subsidence Board Annual Review 1988-89.
2) Holla L., “Mining Subsidence in New South Wales - 2. Surface Subsidence Prediction in the Newcastle Coalfield.” NSW Department of Mineral Resources.
3) Australian Standard AS2870.
4) The Building Code of Australia.

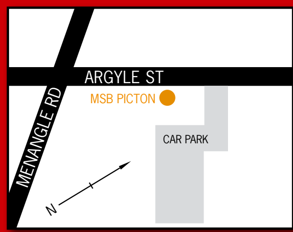
NEWCASTLE

Ground Floor
NSW Government Offices
117 Bull Street, Newcastle 2300
Telephone: (02) 4908 4300
Facsimile: (02) 4929 1032



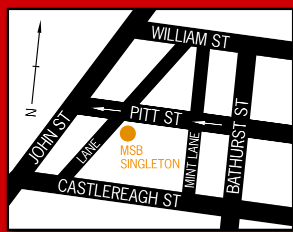
PICTON

100 Argyle Street, Picton 2571
Telephone: (02) 4677 1967
Facsimile: (02) 4677 2040



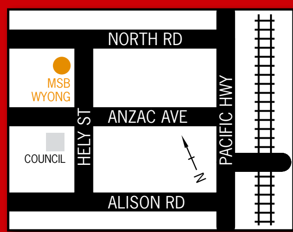
SINGLETON

The Central Business Centre
Unit 6, 1 Pitt Street, Singleton 2330
Telephone: (02) 6572 4344
Facsimile: (02) 6572 4504



WYONG

Suite 3 Feldwin Court
30 Hely Street, Wyong 2259
Telephone: (02) 4352 1646
Facsimile: (02) 4352 1757



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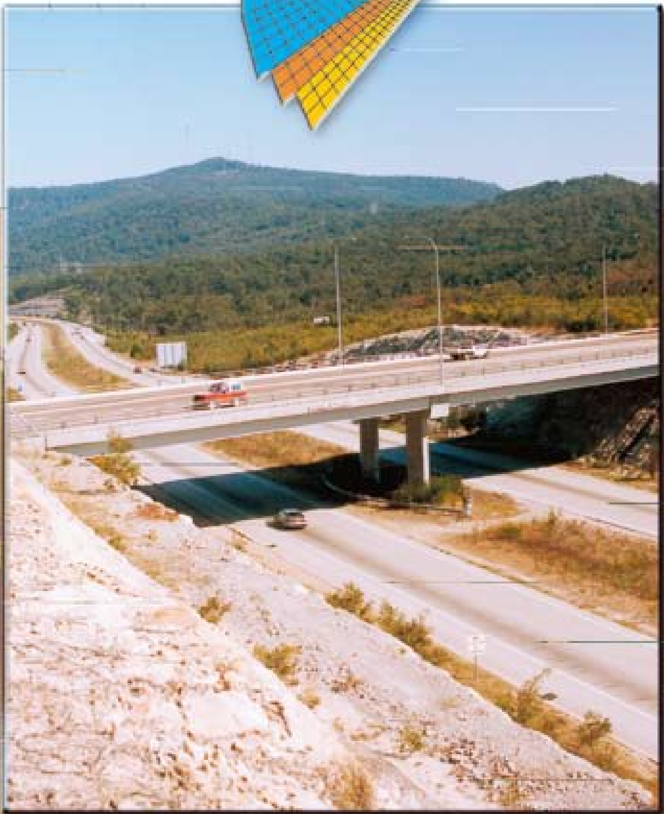

first edition 1997

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

MINE SUBSIDENCE BOARD

IN ASSOCIATION WITH

ROADS AND TRAFFIC AUTHORITY
COAL OPERATIONS AUSTRALIA LIMITED
DEPARTMENT OF MINERAL RESOURCES
DEPARTMENT OF URBAN AFFAIRS AND PLANNING
NSW MINERALS COUNCIL

PUTTING SERVICE AND THE NEEDS OF PEOPLE FIRST

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CONTENTS

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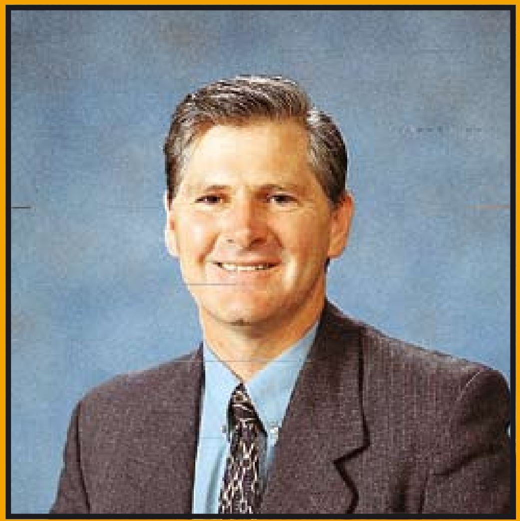


GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

FOREWORD

In May 1991, with the successful completion of the restoration of a subsided section of the Pacific Highway south of Newcastle, the then Wallarah Working Party, which played an important role in this success story, extended its terms of reference to cover all roads in NSW. The terms were:

(a) To provide a detailed analysis of the nature and extent of the damage

(b) To formulate recommendations on the action required

(c) To recommend actions to minimise subsidence damage to other highways and freeways by future mining operations (not to minimise mining)

(d) To produce a document entitled "Guidelines for Coal Mining and Roads with Respect to Subsidence"

In line with this change, it also adopted a new name, the Roads and Coal Mining Working Party. From its inception in 1986, the Working Party was under the chairmanship of the then Chief Executive Officer of the Mine Subsidence Board, Mr E M To. He was instrumental in seconding various people to the Committee to bring their knowledge and expertise to bear on the various issues canvassed by the Working Party. The results of the Committee's investigations have been assembled in the form of a booklet that has the central purpose of co-ordinating road construction and operation, and coal mining.

Over the intervening years, membership of the Committee has been dynamic due to organisational changes and retirements. The Committee will be reconvened to provide a forum for the exchange of information and to consider and advise on any proposals to undermine major roadways. This will ensure that the maximum recovery of coal resources can be maintained while the impact on the community and the roadway network is minimised.

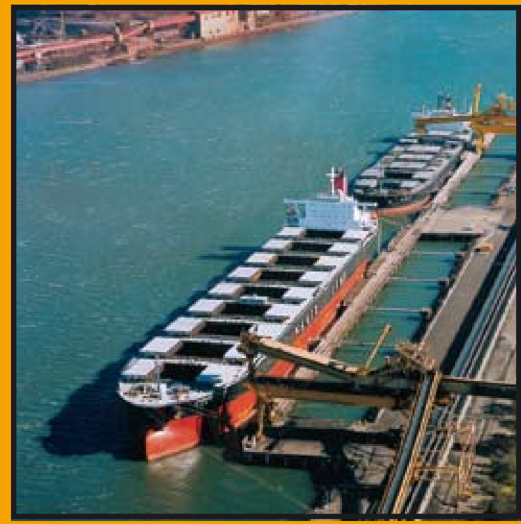
The reader's attention is drawn to a similar booklet, "Guidelines for Coal Mining and Transmission Lines with Respect to Subsidence", now in its third edition. The two documents have a similar format, with specific sections covering the roles of power supply authorities and the Roads and Traffic Authority, and matters relating specifically to transmission lines or roadways.

I take this opportunity to thank all Committee Members, past and present, for their valuable contribution to the Guidelines. Particular recognition must go to the Mine Subsidence Board's Subsidence Risk Engineer, Mr Graham Hanson, who has followed the project through from its inception. The efforts of our Minute Secretary, Mrs Joanne Rose, are also acknowledged.

G Cole-Clark BE(Syd), MBA

Chairman Committee on Roads

June 1997



SECTION 1

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

POLICY STATEMENT

The efficient extraction of coal and the provision of a safe, reliable and economical road system are both vital to the NSW economy.

The coal mining industry and the Roads and Traffic Authority are interdependent in that road networks often overlay mineable coal resources.

The coal mining companies and the Roads and Traffic Authority NSW each have extensive infrastructures, which will be expanded in the future.

There may be some conflict of interest between coal mining and road systems.

It is the intention of the Mine Subsidence Board that decisions made in such cases, be made in co-operation with the parties involved within the framework of the Mine Subsidence Compensation Act 1961, and the Roads Act 1993.

SECTION 2

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

EFFECTS OF COAL MINING ON ROADS

The effects of underground coal mining on roads are the resultant ground movements and damage. Damage is caused by vertical subsidence, horizontal strains, ground curvature and tilt. Subsidence effects may affect the serviceability of roads, bridges and roadside structures. 'Minor' damage, not leading to unserviceability is also a possibility.

The effect of subsidence on roads and bridge structures can be limited by designing them to accommodate specified strains and displacements, or by carrying out mitigatory works.

The effects of open cut coal mining on roads are different, in that relocation or deviation of a road is often possible, but may involve substantial costs and a suitable alternative route must be found.

Further details of the impact of coal mining on roads are included in Appendix B.

Throughout this document the term roads is to be interpreted as meaning "public and classified roads under care and control of Roads and Traffic Authority of NSW or Local Government", but excluding local streets, lanes and secondary roads.

SECTION 3

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

PROCEDURES

3.1

GRANT OF MINING LEASES AND APPROVALS TO EXTRACT PILLARS/ LONGWALLS

3.1.1 Grant of Mining Leases

Leases to mine coal (mining leases), either for the establishment of new coal mines or for additions to existing coal mines, are granted pursuant to the Mining Act 1992.

Before the Minister for Mineral Resources grants a mining lease, the Mining Act requires notices of the proposal to be served, by the Department of Mineral Resources, on each government agency that would be materially affected by the grant of the lease. The Act gives the government agency, upon whom a notice has been served, a statutory right to object to the granting of the lease or to require conditions to be included in the lease. Provision is made in that Act for the resolution of any dispute. Subject to the grant of development consent, mining leases are granted by the Minister for Mineral Resources - Refer Flow Chart.

Under its charter, the Mine Subsidence Board is not bound to object on grounds of damage compensation, but may advise the Chief Inspector of Coal Mines of the risk of damage, if any.

Similarly, before inviting tenders for a mining lease, the Mining Act requires the Minister for Mineral Resources to follow the above procedures.

Reference: Schedule 1, Part 2, Division 1, Sections 5-10, Mining Act 1992.

3.1.2 Approvals to Extract Pillars/Longwalls

Section 138 of the Coal Mines Regulation Act 1982, provides that no method of mining other than the bord and pillar system shall be used except with the approval of the Minister. Pillar extraction and longwall mining applications are normally approved by the Chief Inspector of Coal Mines under delegation from the Minister for Mineral Resources and subject to such conditions as may be imposed.

In accordance with approved practice, the Chief Inspector of Coal Mines examines all applications for approval under Section 138 of the Coal Mines Regulation Act and processes them in accordance with Section 3.3.3 - Undermining Existing Roads.

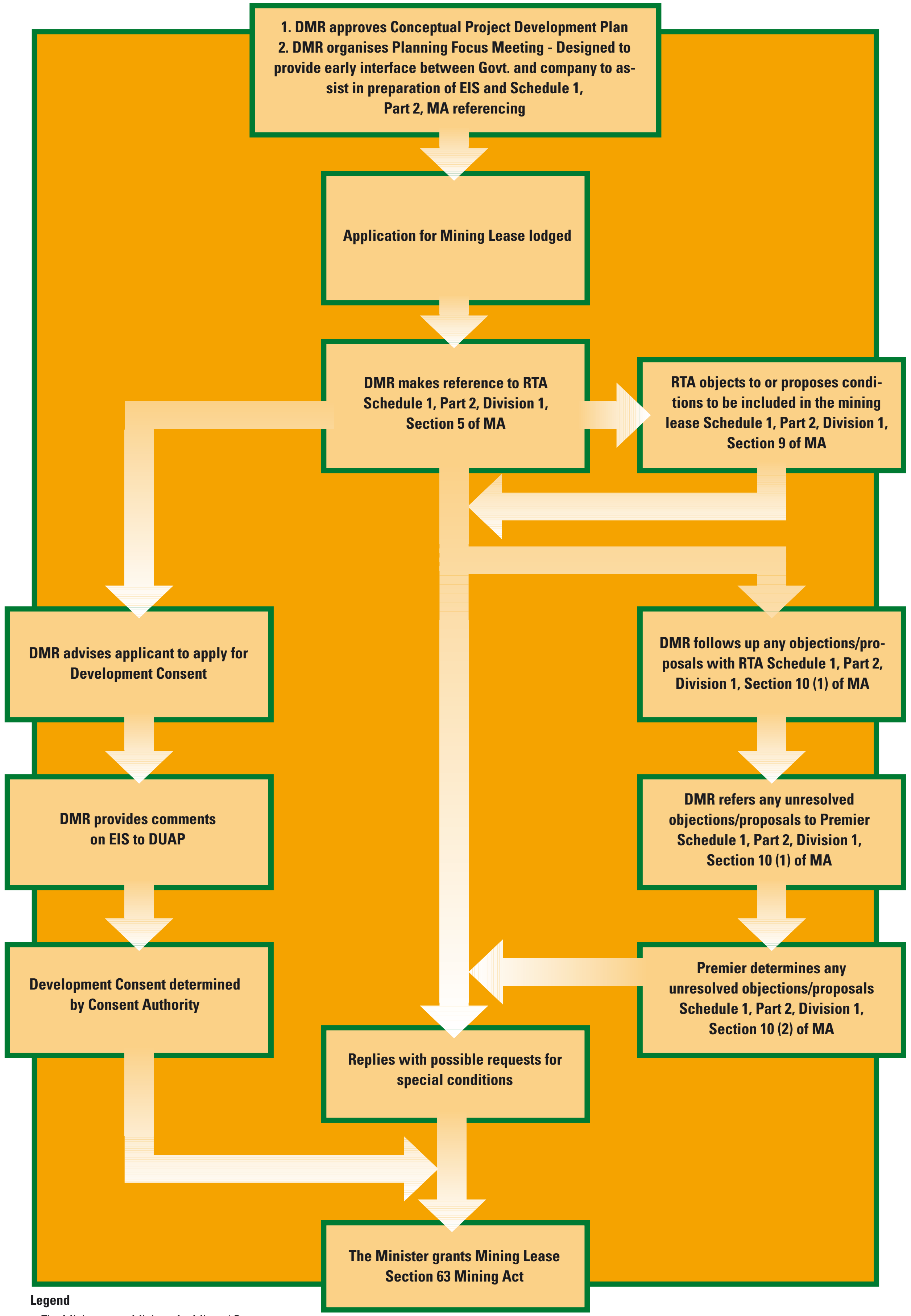
3.2

ROAD ROUTE SELECTION

3.2.1 General

The selection of a route for a road involves consideration of environmental, social, economic, technical and geometric constraints. On occasions, the various constraints conflict and it is necessary to achieve a compromise which optimises the public interest and also recognises the legitimate rights of all persons concerned.

FLOW CHART FOR GRANT OF MINING LEASE



Legend

- The Minister - Minister for Mineral Resources
- MA - Mining Act, 1992
- RTA - Roads and Traffic Authority
- DUAP - Department of Urban Affairs and Planning

3.2.2 Constraints

In general, route selection involves the determination of the most suitable route between two nominated end points, but from time to time, there are complicating factors such as the desirability or necessity for the road to pass via a third locality which may be a centre of growing demand. A range of factors which may affect the final selection of a road route include:

- Traffic Demands
- Topography
- National Parks and Nature Reserves
- State Forests
- Mineral Prospects and Mining Operations
- Airstrips
- Urban and Industrial Areas
- Areas of Significant Environmental, Historical or Archaeological Interest
- Scientific Establishments
- Pipelines
- Railway Lines
- Other Roads
- Communication Networks
- Irrigation Areas
- Property Owner Requirements
- Flood Prone Areas
- River Crossings
- Geotechnical Aspects
- Projected Growth Areas

3.2.3 Consultation with Public Authorities

As a standard procedure, the Roads and Traffic Authority exchanges correspondence with numerous Commonwealth, State and Local Government authorities regarding its major road deviation proposals. The Department of Mineral Resources and the Mine Subsidence Board are included in this process when appropriate. All potentially affected authorities are requested to comment on the Authority's proposals and, where appropriate, to provide any information that may be relevant to the detailed route location, road design, and environmental assessment of the project.

Where roads are to be constructed through Mine Subsidence Districts, this process of consultation should, in most cases, lead to the accommodation of the Board's requirements concerning the siting and design of the roads and bridges. Formal application and approval to construct is required under the Mine Subsidence Compensation Act. Formal application before the detailed design stage will facilitate meeting the Board's requirements without delay or change to design. Application should be made as soon as the particular route is proposed.

3.2.4 Procedures under the Environmental Planning and Assessment Act

Roads are generally covered by the provisions of Part V of the Environmental Planning and Assessment Act, 1979, which makes the Roads and Traffic Authority the 'Determining Authority' for its road projects. This requires the Authority to carry out an environmental assessment of all its road proposals.

If it is decided that a particular road will have a significant impact on the environment, an Environmental Impact Statement is prepared by the Roads and Traffic Authority, placed on public display, and submissions from interested parties are received and assessed.

Finally, a determination report recommending a particular route for the road is prepared and also made public. In general, for all major roads and bridges in urban areas it is necessary to prepare Environmental Impact Statements.

3.3 CO-ORDINATION OF MINING AND ROAD BUILDING ACTIVITIES

3.3.1 Planning New Roadways

(a) General

When the Authority is planning routes for new or replacement roads and/or associated infrastructure, the Department of Mineral Resources and the Mine Subsidence Board will be notified of the proposed route as part of the Authority's planning procedures. The proposed route would be assessed in terms of its interaction with proposed or existing coal mining in the area traversed.

In order to facilitate these assessments, the Authority will, in conjunction with the Department of Mineral Resources and Mine Subsidence Board, arrange liaison meetings where the proposed route can be considered in relation to any mining (planned or existing). The Department of Mineral Resources will arrange for the appropriate collieries to attend or be represented at these liaison meetings.

(b) Liaison Meetings

The goals of the liaison meetings are to:

(1) identify coal resources and their mining status
(2) establish realistic subsidence design parameters
(3) identify the most appropriate design solution (including deviation and relocation) for the roadway and infrastructure, and the associated costs
(4) determine the type and degree of monitoring that may be appropriate

(c) Design Solutions

When identifying the appropriate design solution, consideration will be given to designing roads and structures to:

(1) accommodate the predicted subsidence parameters
(2) make provisions for mitigatory or preventative works in the future when and if appropriate

In selecting the appropriate design solution, consideration will be given to designs that provide the optimal economic solution for the community.

The liaison meetings will consider the costs of proposed design solutions and make recommendations to the Department of

Mineral Resources and the Mine Subsidence Board regarding the allocation of costs, particularly when structures are designed to make provision for future protective and mitigatory works.

(d) Design Approvals/Parameters

The above procedure will be modified slightly depending on whether or not the proposed route lies in a declared Mine Subsidence District.

(1) In a Mine Subsidence District

Once the route has been selected and the EIS process completed, the Authority should submit a formal building application to the Mine Subsidence Board for the roads and any associated infrastructure. Any approval granted by the Mine Subsidence Board will be subject to conditions. Typically these include the submission of detailed engineering drawings certifying that the structures have been designed to accommodate subsidence parameters attached to the approval, or detailing any provision for future mitigatory works. Normally such an application need only be accompanied by plans showing the location and outline of the structures. The Board's approval should be obtained prior to any detailed design works being undertaken.

As part of the approval process, the Mine Subsidence Board will obtain current mine subsidence parameters from the Department of Mineral Resources and include them in the approval conditions.

(2) Not in a Mine Subsidence District

Before detailed design is commenced, the Authority should obtain formal subsidence parameters from the Department of Mineral Resources.

The Authority should notify the Mine Subsidence Board of the subsidence parameters adopted for the design, to assist the Mine Subsidence Board with administration of claims in the future.

To ensure that the road network and coal mining operations in the area can co-exist, it is important that effective liaison is maintained during the entire planning process. Participants must acknowledge that considerable lead times are involved in the various stages of the process, and must be allowed for in any time scheduling.

3.3.2 Provision for Future Subsidence of Proposed Roads

Where firm mining plans have been developed which are liable to cause subsidence along the route of a proposed road, the Regional Office of the Department of Mineral Resources undertakes to advise the Roads and Traffic Authority in response to the Authority's initial approach to public bodies and any subsequent Environmental Impact Statement associated with the proposal.

Where the Authority proposes to proceed with a route crossing coal bearing lands where established mining plans are expected to affect the road within 10 years, the Authority will consult with the Department of Mineral Resources and mining companies when appropriate, regarding design and construction of the road to withstand the anticipated subsidence. In all cases, Ministerial approval will be obtained by the Department of Mineral Resources to restrict mining to the extent to ensure subsidences are limited to those designed for. The use of subsidence tolerant structures will be considered for all affected bridges. In the case of bridges for which suitable designs are not available, the location of the bridges will be optimised relative to the mine development plans.

Where mining plans are not firm, but the route is expected to be affected by mine subsidence within 20 years or within the proposed life of the road, the Authority will also consult with the Department of Mineral Resources and the mining companies concerned to decide upon the design measures for the road to provide for future subsidence. An alternative will be to consider modifying the road in the event that this is necessitated by open cut or underground mining projects at some future time.

Where the Department of Mineral Resources advises that an economic coal resource exists, but where there are no established mining plans, the Authority will decide on the extent of design measures to be taken to provide for future subsidence in the light of any submission made by the Mine Subsidence Board and the advice of the Regional Office of the Department of Mineral Resources.

Where there is a Mine Subsidence District, the Authority will design and construct the road to withstand subsidence to the extent that may be required by the Mine Subsidence Board. Formal approval by the Mine Subsidence Board to the proposed road before detailed design must be obtained to avoid design changes or delay. This approval will ensure compensation for damage if the Authority has constructed the works according to Mine Subsidence Board requirements.

3.3.3 Undermining Existing Roads

Pillar extraction and longwall mining applications are normally approved by the Chief Inspector of Coal Mines under delegation from the Minister for Mineral Resources under the provisions of the Coal Mines Regulation Act 1982.

(a) Pillar/Longwall Extraction Approvals

As part of the application process for approval for pillar or longwall extraction of coal by underground methods, collieries are required to address issues associated with the mining plan and its effect on the ground surface and existing structures. They are required to identify all structures affected by the proposed mining, and to assess the effect of resulting subsidence on them. In this context:

(1) structures includes formed roads, batters, embankments, drains, etc

(2) subsidence means all horizontal and vertical ground movements resulting from mining, and when major services and infrastructure are involved, the colliery should assume conservative values for the angle of draw, say 35°, even though subsidence calculations and assessments may be based on lesser values. This will ensure that the owners/operators of major services are made aware of mining in the vicinity of their installations and will allow the effects of subsidence on them to be assessed independently.

(b) Liaison Meetings

Collieries preparing such an application should arrange a liaison meeting with the Authority, the Department of Mineral Resources and the Mine Subsidence Board to allow:

(1) discussion of the mining plan prior to formal application being made to the Chief Inspector of Coal Mines. The colliery will provide the following information:

* Depth of the extraction;
* Thickness of the seam to be extracted;
* Types of extraction (eg, pillar or longwall);
* Proposed start and finish dates;
* Location of proposed starting point;
* A scale drawing (1:8,000 or less) locating the proposed mining and showing appropriate easting and northing co-ordinates and location of affected structures;
* The maximum subsidence, strains and tilts at each of the structures;
* Details of any known geological anomalies that may affect subsidence.

(2) the Department of Mineral Resources to assess and ratify the colliery's subsidence predictions

(3) the Authority to assess what, if any, mitigatory works and/or monitoring is appropriate, and to submit any special requirements that should be attached to the approval to the Chief Inspector of Coal Mines

(4) the Mine Subsidence Board to determine if the affected structures are eligible for compensation under the Mine Subsidence Compensation Act, to assess the cost of mitigatory works and advise the Chief Inspector of Coal Mines if appropriate

(5) the Authority to negotiate with the colliery regarding the allocation of costs that may not be compensatable under the Mine Subsidence Compensation Act

(6) the colliery to finalise details of the application

(7) the Authority to submit a claim for compensation to the Mine Subsidence Board and to obtain their approval for any design and mitigatory works that may be necessary when the application is approved by the Chief Inspector of Coal Mines

(c) Lead Times

The existence of considerable lead times that can be involved in mitigatory works must be acknowledged by all concerned parties. Some details of the type of works that may be required and the times involved are given in Section 3.3.4.

(d) Monitoring

It should also be noted that survey and visual monitoring may be required in cases where no physical mitigatory works are necessary. It will need to commence prior to mining affecting structures and to continue until, for practical purposes, mine subsidence has ceased.

3.3.4 Protective Measures

(a) Roads Constructed to Normal Design Standards

For roads which have not been designed to withstand ground subsidence, the Authority would generally require considerable lead time of at least 12 months to be able to organise the carrying out of any necessary precautionary measures to mitigate the subsidence effect on the affected roads or to enable a suitable alternative route to be arranged to allow such work to take place.

If the expected ground subsidence effects are so severe, particularly in regard to bridges, that practical measures to be taken to relieve the subsidence effects would not be adequate, the Authority would require either the undermining of such structures to be restricted to partial extraction or, alternatively, the relevant structure to be relocated, depending on which is the more practicable and least costly option. The cost of the work meeting the approval of the Mine Subsidence Board, will be paid by the Board subject to the provisions of the Mine Subsidence Compensation Act.

(b) Roads Constructed to Withstand Subsidence

If the road which is to be undermined has been designed to withstand the effects of a predetermined amount of ground subsidence, the Authority would consider the application referred to it bearing in mind the design parameters which have been incorporated.

Although a road has been designed for ground subsidence effects, it may still be necessary to do some work on the road, such as survey monitoring. The Authority would generally require considerable lead time of at least three months before the undermining was to take place.

(c) General

Notwithstanding any other modifications or design features, it may also be necessary in isolated occurrences to take a road out of service during the actual period of undermining. At the very least, an alternative route would need to be available in case the road was damaged during undermining. In addition, the Authority would probably arrange for its own survey monitoring of the road before, during, and after the undermining of the road. Again, the Authority would generally require considerable lead time before the undermining is to take place.

All costs of mitigatory works, adjustments, repairs etc approved by the Mine Subsidence Board, will be paid by the Board subject to the provisions of the Mine Subsidence Compensation Act.

3.3.5 Open Cut Mining

It is not possible for roads and structures to remain within open cut mining sites. It is therefore a basic requirement in route selection that road routes be located away from areas where there are firm plans to mine by open cut, and where suitable alternatives are available, away from areas likely to be mined by open cut within the life of the road.

Where prospective open cut mining areas are large and mining plans are not firm, it may not be possible for a proposed new route to avoid such areas altogether. In such a case the Authority will determine the most practical route having regard to all constraints including the possible future mining.

Open cut mining operations are matters which will be approved or refused by the Minister for Mineral Resources under the provisions of the Mining Act and the conditions of coal leases granted thereunder.

The Department of Mineral Resources undertakes to refer applications for this type of mining to the Roads and Traffic Authority for comment where such mining would directly affect an existing road or a road proposal.

If open cut mining is later proposed and affects the chosen route, the matter of satisfactory deviation of the road shall be subject to agreement between the Authority and the mining company concerned.

In order to relocate a section of an existing road, the Authority would generally need at least three (3) years notice and should be informed as soon as a mining proposal is available. (Note: This assumes that an Environmental Impact Statement for the road deviation is not required.) In general the Roads and Traffic Authority has agreed to deviate roads wherever an acceptable alternative route could be obtained and agreement could be reached in respect of costs.

The Authority recognises that ground consolidation can be a very lengthy process at sites where open cut coal mining has formerly been conducted and the areas have been rehabilitated.

The Authority will select any route in close proximity to an existing or proposed open cut mine, or crossing an area formerly mined, in the light of appropriate geotechnical reports, with a view to ensuring that the road is not damaged by ground movement precipitated by the mining. In a Mine Subsidence District, the Mine Subsidence Board's approval will be explicitly obtained in the usual way.

Where operations of an open cut mine are being planned to take place adjacent to an existing transmission line, typical conditions that the Authority may request the Chief Inspector of Coal Mines to attach to any approval are:

(1) prohibition of excavation within the road easements.
(2) provision of appropriate geotechnical report detailing estimated ground movements. The geotechnical report should also include a stability analysis of the high wall and take into consideration any adverse effects on the slope stability due to blasting of the overburden.
(3) requirement to perform inclinometer and survey monitoring of the ground movement at appropriate intervals.
(4) requirement that areas of open cut mines adjacent to existing roadways be backfilled as soon as mining in the vicinity of the affected roadway is complete.

3.3.6 Forward Mining Plans

The Mine Subsidence Board has current programmes to monitor mining under major structures subject to potential subsidence damage. These involve annual liaison meetings between the Department of Mineral Resources, collieries and the Mine Subsidence Board. Roads are recognised as major structures within these programmes.

Under these programmes, coal mining companies are requested to supply mining plans which may affect major structures on the ground. Generally, both short term and long term mining plans are obtained from mining companies. The Mine Subsidence Compensation Act 1961 contains provisions that, if necessary, require mining companies to provide information required by the Mine Subsidence Board. The Board undertakes to supply this information to the Roads and Traffic Authority promptly on becoming aware of a plan affecting any major structure under the Authority's control.

3.3.7 Mine Subsidence Board Approval Process

The Board approves building applications received from the Roads and Traffic Authority for proposed roads, road structures and road realignments and deviations in Mine Subsidence Districts, subject to conditions.

The approval process has been designed so that developers can submit building applications, including conceptual plans, at the planning stage. This allows subsidence design parameters to be determined prior to detailed design and planning being commenced.

Typically, these conditions of approval may require that:

(a) Final engineering drawings are submitted to the Board prior to the commencement of construction.
(b) Final drawings are certified by an appropriately qualified engineer that improvements constructed in accordance with the specifications and drawings will be safe, serviceable and repairable, taking into account specific mine subsidence parameters for the site(s) involved. (Site specific parameters would normally be specified as part of the approval.)
(c) Other special conditions, if appropriate, eg,

- Requirement that a geotechnical report be supplied
- Requirement that special supervision be undertaken
- Requirement that work as executed drawings be submitted on completion
- Requirement that special features be catered for or provided for in the design (eg, provision of platforms and access for relevelling jacks)
- Requirement that progress reports or specific events be reported to the Board (eg, notice of concrete pours, etc)
- Specification of a design levels in flood prone areas
- Requirement that geotechnical exploration be undertaken to define limits and extent of old workings

Improvements constructed in a Mine Subsidence District that do not satisfy the conditions of approval, are not eligible for compensation under the Mine Subsidence Compensation Act.

Typically, the following subsidence parameters would be specified in the conditions of approval:

Vertical Subsidence	x mm
Compressive Strains	y mm/m
Tensile Strains	z mm/m
Tilts	w mm/m
Radius of Curvature	v km

The Board requires the designer to certify on the drawings that improvements covered by the approval will remain safe, serviceable and repairable in the event of the structures being subjected to the specified subsidence. The designer is to state on the drawings the subsidence parameters that were included in the design. This would normally be included with statements detailing design loads (ie, dead, wind, live and any special loads).

Where a condition of approval requires certification of plans by designer:

- after subsidence, any damage will be repaired under the provisions of the Mine Subsidence Compensation Act, but the damage is expected to be consistent with design requirements.
- serviceable means that the improvement must be able to continue to be used for the purpose for which it was designed.
- safe means that occupants and users of the improvement must not be at risk from loss or reduction of asset integrity.
- repairable means that materials and their method of utilisation allows damage after subsidence to be repaired/replaced economically.

3.4 CHOOSING BETWEEN ROAD MODIFICATIONS AND COAL STERILISATION

3.4.1 The Least Community Cost Principle

It is anticipated that, from time to time, situations will arise where, as a result of a road being affected by a mining proposal, it is necessary to choose between sterilising coal reserves and relocating or repairing a road to make safe. Whilst it is not practicable to quantify in general terms the relative community and economic merits of sterilising amounts of coal against relocating or modifying specific road structures, it is possible to assess all situations in terms of an agreed guiding principle.

On this basis, it is agreed that each individual situation will be assessed on its own merits and the course of action which represents the least cost to the community will be given due weight. That is, if the cost to the community of coal sterilisation is less than the cost of modifying or relocating specific road structures, then, subject to the Minister's approval, the coal will be sterilised. If the cost to the community of coal sterilisation is greater than the cost of road modification, then consideration will be given to the practicality of relocating the road.

3.4.2 Traffic Costs

In determining the cost of any road modifications which may be necessary to allow undermining to proceed, three factors that need to be considered are:

(a) Actual Direct Cost of Modifications

The actual cost of road modification/repairs or mitigatory works, including the provision and maintenance of any temporary infrastructure, depends on the amount of work required, and whether the affected road is already in service or in the planning/design stage. The more structures that require modifying or the longer the section of road requiring relocating, the higher the cost. In addition, the type of road construction greatly influences cost. Finally, the scope for modifying an existing road other than by reconstruction is limited when compared to the scope available at the planning/design stage.

The actual cost of any particular proposal is readily definable in that the Roads and Traffic Authority can provide budget estimates for the various types of road construction. If necessary, these estimates can be verified by the calling of tenders for the work involved. As discussed in previous sections, these costs will normally be borne by the Mine Subsidence Board for undermining of existing roads.

In a major road system such as the NSW classified network, it is of paramount importance that the system is operated with optimal efficiency at all times to ensure that the cheapest reliable road transport is provided to the community.

(b) Increased Traffic Operational Costs

Increased traffic operational costs will result when it is necessary to take a particular road out of service to allow modifications, repairs or mitigatory works to be performed.

When taking an existing road out of service for modification or reconstruction, arrangements have to be made to ensure that the system is operated such that there is sufficient reserve capacity to cover the unexpected loss of another network element. In addition, because of the unavailability of a particular road for service, it may be necessary to alter the operating conditions of the system with the result that cost penalties are incurred. Depending on the nature of the road being taken out of service, and the conditions applying at the time, these cost penalties may vary and may be obtained from the Authority.

(c) Community Costs

Environmental considerations associated with the modification or relocation of a road may incur costs to the community.

These considerations will vary and each case must be assessed on its own merits. Some of the factors which merit consideration include visual impact, affect on natural amenity, noise, vibration, dust, and the availability/desirability of alternative routes.

3.4.3 Coal Mining Sterilisation Costs

The determination of the cost of sterilisation of coal due to the need to protect surface structures, is quite complex. Factors to be considered are:

(a) The value of coal directly sterilised;

(b) The value of coal indirectly sterilised due to subsidence restrictions; including the effect of the loss of the affected portion of the coal mine on the overall operations and viability of the mine;

(c) The community cost arising from the loss of a non-renewable resource and the shortening of mine life.

Coal is sterilised directly when it is left in place in order to support a surface structure. The two normal methods used to provide such support are total sterilisation within a nominated angle of draw or the use of a subsidence control mining method, such as panel and pillar extraction, that may reduce the percentage of coal recovered from 90% to less than 50%.

As well as coal being sterilised directly by subsidence restrictions, a further quantity is likely to be lost due to the geometric constraints placed on the mine layout. For example, if a road cuts across one end of a proposed longwall panel at an oblique angle, the whole panel, and possibly an adjacent one also, may be sterilised because of the practical inability to rotate panels or to extract irregular pockets of coal by modern, high production longwalls.

As a typical longwall panel can contain in excess of 1,000,000 tonnes of coal, the quantity lost due to indirect sterilisation can quickly become very significant.

Once the total quantity of coal to be sterilised, both directly and indirectly, has been determined, the next step is to assign a value to it. For the purposes of these guidelines, the value per tonne of coal sterilised will be taken as being the difference between the market price (at the mine gate) and the incremental cost per tonne of winning the coal. This value of coal might be higher if other factors have stronger influences, such as export demands, etc. Users should check this value at time of estimate.

From an economic viewpoint, it is desirable that non-renewable resources such as coal be exploited to the fullest extent possible. Similarly, from the viewpoint of the mining industry, it is desirable to extend the economic life of each mine for as long as possible by ensuring that the greatest possible percentage of the coal is mined. However, as with the "community cost" of road works, it is not possible to define a simple approach to the assignment of value to this factor. Nevertheless, when evaluating a proposal which will involve sterilisation of coal, every effort should be made to determine whether it is appropriate to adopt a purely economic evaluation that only considers utilisation of the resource, or should the evaluation be expanded to include community cost, environmental impacts, community attitudes, etc.

3.4.4 Procedural Matters

In order to afford the maximum flexibility in modifying mine layouts, road locations and designs, it is important that consultation and the assessment of the relative merits of coal sterilisation and road modification be carried out at the earliest possible time.

Accordingly, as soon as it becomes apparent that a coal mining proposal is affected by an existing road or a road proposal is affected by an existing coal mining operation, consultation should commence. This will be initiated by any of the involved parties depending on circumstances, eg, by the Board when the road is in a Mine Subsidence District; by the Department of Mineral Resources when the road is not in a Mine Subsidence District; by the Roads and Traffic Authority when a road proposal is involved; by the mining company when required by condition of approval of the particular extraction.

Once a course of action has been determined in acordance with the principles outlined in 3.3.1, 3.3.2 and 3.3.3, it is likely that compensation or reimbursement will be payable under the provisions of the Mine Subsidence Compensation Act 1961 or if the Act does not apply, under the terms of a prior agreement between the Roads and Traffic Authority and the mining company.

Where an existing road is involved, the costs associated with precautionary and/or remedial measures by the Roads and Traffic Authority, including the cost of survey monitoring, will be reimbursed by the Mine Subsidence Board subject to compliance with the provisions of the Mine Subsidence Compensation Act.

Reference is made to Section 3.3.2 in respect of designing for future subsidences.

SECTION 4

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

LEGISLATION

Legislation referred to in the Guidelines includes:

* **Roads Act 1993** - which governs the opening, control, administration, construction and maintenance of the public and classified roads and the relationship between the Chief Executive of the Roads and Traffic Authority and the other Government and Local Government Authorities and instrumentalities.
* **Environmental Planning and Assessment Act 1979** - which embodies the general provisions relating to land use planning, zoning, preparation and exhibition of environmental planning instruments, local environment plans, and environmental impact statements.
* **Land Acquisition (Just Terms Compensation) Act 1991** - under which the Authority is empowered to resume land for its various undertakings.
* **Mining Act 1992** - covering the issue of titles to mine for and/or prospect for minerals and coal, and also includes provisions for including in the Register of Colliery Holdings new colliery holdings or making amendments to existing holdings. Approvals for open cut coal mining activities are dealt with under this Act.
* **Mine Subsidence Compensation Act 1961** - under which the Mine Subsidence Board controls, among other things, the establishment of roads through Mine Subsidence Districts and considers claims for compensation for damages as a result of underground coal mining.
* Other legislation which can affect the siting of roads includes various Acts covering the operation of other public authorities including, but not limited to:

  National Parks and Wildlife Service

  State Forests of NSW

  Heritage Commission (Commonwealth)

  Heritage Council of NSW

  National Trust of Australia (NSW)

  Sydney Water Corporation

  Hunter Water Corporation

  Department of Land and Water Conservation

  Telstra

  Department of Transport NSW

  State Rail Authority of NSW

  Department of Urban Affairs and Planning

  Department of Public Works and Services

APPENDIX A

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

COAL MINING AND ITS EFFECTS

A1

TECHNOLOGY OF MINING

In 1982-83, nearly 70% of coal in NSW was won by underground mining methods and the remaining 30% by open cut methods; longwall mining provided approximately 12% of the underground coal production. In 1993-94, 50% of coal was won by underground mining methods, 77% of which was by longwall. The total production in NSW has increased from 67 million tonnes in 1982-83 to 84 million tonnes in 1993-94. More recent figures are available from Joint Coal Board publications, Australian Black Coal Statistics and NSW Coal Year Book.

Underground extraction of coal in NSW is generally carried out at present at depths of mostly less than 500 metres. Nearly 50% of total coal production in 1982-83 was at depths less than 200 metres. Mining at depths greater than 200 metres is increasing, especially in longwalls.

For coal mineable by underground methods, a practical minimum seam thickness is 1 metre. The seams mined in the past mostly fall within the thickness range of 2.5 to 3.5 metres and most underground coal production was derived from seams within this range.

Open cut coal extraction in NSW is generally confined to linear overburden to coal ratios not greater than 10:1 and a maximum mining depth of 300 metres. In practice, however, coal by open cut methods is currently mined at much shallower depths. During 1982-83 the greatest depth worked was 88.5 metres and the weighted average overburden to coal ratio was 4.6:1. These figures have not changed significantly.

A2

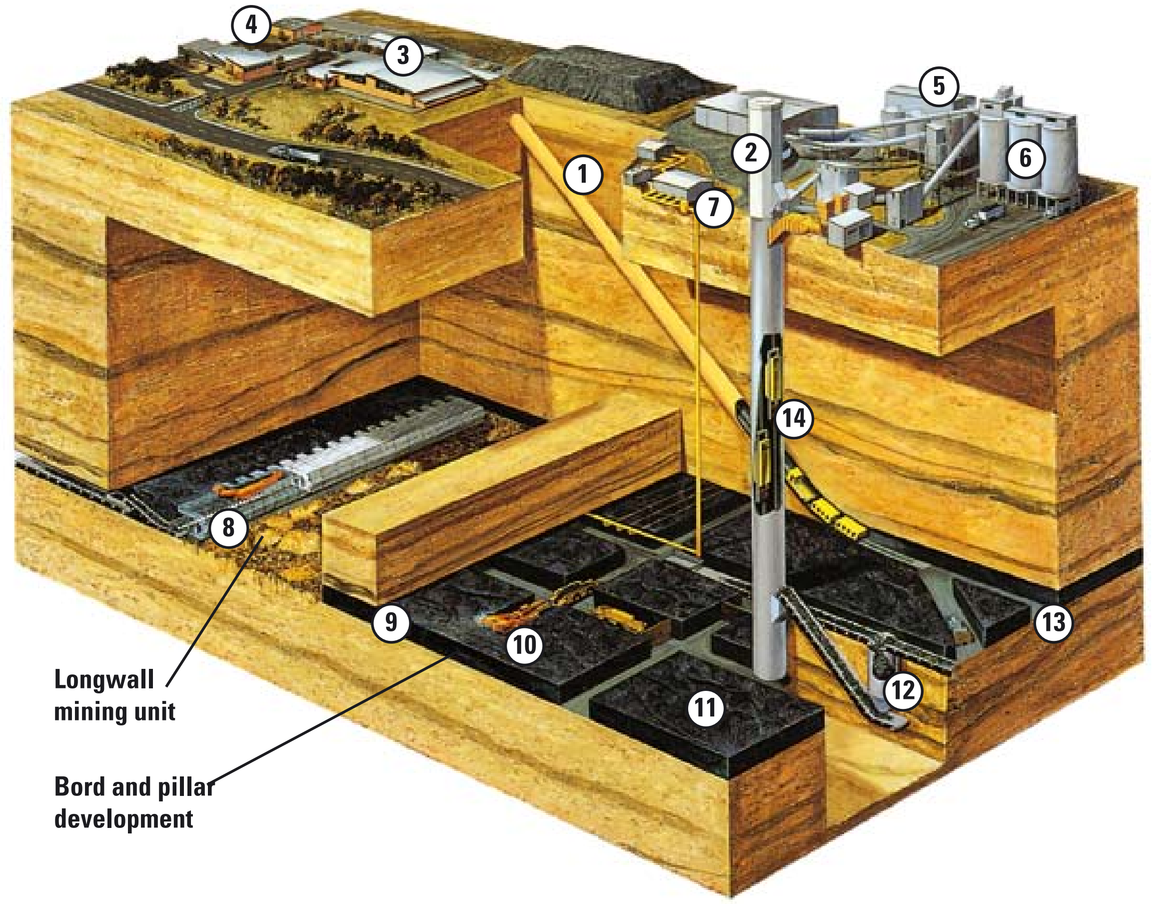
UNDERGROUND MINING

Underground mining practices followed in NSW fall into three main categories: bord and pillar mining (first workings), partial extraction, and total extraction.

Development Headings are roadways (tunnels) that are driven to provide access to areas of virgin coal. Normally driven in groups of up to four roadways with cut-throughs between them, they form a development panel and are used to block out large areas of coal that will be extracted by longwall or pillar extraction methods.

Bord and Pillar methods of mining are well established and widely varied. They comprise a network of underground roadways (tunnels), interconnected as shown in Figure 1, leaving blocks of coal, generally square or rectangular in plan view. These are termed pillars. Historically, the sizes of pillars and roadways formed in this system of mining have been specified in lease conditions and under the provisions of the Coal Mines Regulation Act, 1982. In recent years, pillars have been required to be designed with long term stability to ensure mine safety.

CUTAWAY VIEW OF TYPICAL MODERN COLLIERY

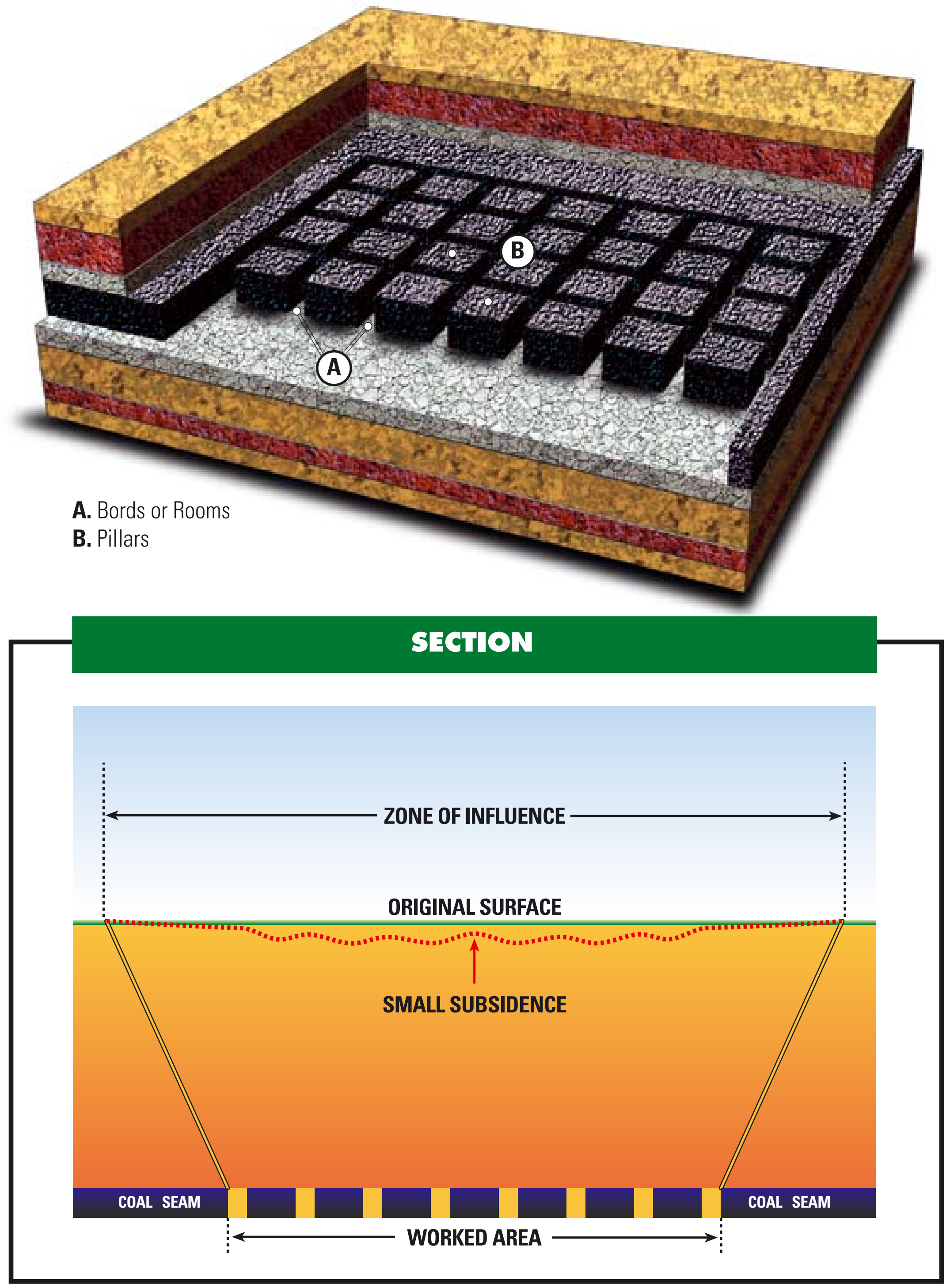


1 Drift for men and materials access
2 Shaft winder house
3 Bathhouse and administration building
4 Workshops
5 Coal preparation plant
6 Coal storage bins
7 Gas drainage system
8 Longwall mining unit
9 Coal seam
10 Continuous miner
11 Coal pillar
12 Underground coal bin
13 Main roadway
14 Coal "skips" bring coal to the surface

(Not to scale. Diagrammatic only)

FIGURE 1

SUBSIDENCE FROM BORD AND PILLAR MINING



(Not to scale. Diagrammatic only)

Pillar sizes, and the number of roadways in any particular panel (mining region), also vary considerably depending on the purpose of the panel. Any of the extraction systems discussed below require access to the coal to be extracted, and so bord and pillar workings are used as the means of blocking out the coal for this purpose. In this sense, the bord and pillar workings are also referred to as first workings, or development workings.

When bord and pillar workings are developed, they cause negligible surface subsidence and consequently no mining-induced ground strain (see Section Figure 1).

Partial Extraction can take various forms depending on mining conditions, production requirements and constraints such as subsidence control. Essentially, partial extraction refers to any mining method where, within a block of coal, large quantities of coal are removed, but some remains. This may take the form of partial pillar extraction, or pillar splitting, within a panel of bord and pillar workings, or it may be on a larger scale where alternate panels are fully extracted while the intervening blocks of coal are left intact.

This latter method, sometimes referred to as panel and pillar mining (Figure 2), is a variation of selective partial pillar extraction methods and is used to prevent or control surface subsidence. In this method, panels are separated by long 'barrier' pillars of sufficient width to support the overlying strata, even if the immediate roof over the extracted panels sags considerably or fails (caves). By careful selection of the panel and pillar geometry relative to mining height, depth of workings and strata conditions, surface subsidence can be controlled successfully and the level of differential subsidence or lateral strain affecting surface features or structures, can be restricted.

Total Extraction is an extension of partial extraction whereby as much coal as can safely and economically be mined is removed from each panel, leaving only small remnant pillars or narrow barrier pillars and pillar regions. These often crush out as the major overlying roof strata settle and the surface subsides. Total extraction is achieved either by large scale pillar extraction from bord and pillar workings over a large area, or by mining of wide blocks of coal between narrow development panels using the longwall method (see Figure 3).

Total extraction is the favoured mining method where subsidence is not restricted, as it leads to maximum coal recovery, and minimum sterilisation of resources. Where the coal can be totally extracted, prior to construction of surface structures, they can be built on stable ground which has already undergone complete subsidence. Total extraction results in more predictable and uniform strains and subsidences which simplifies the control of surface development.

A3

SUBSIDENCE EFFECTS

A3.1 General

A subsidence basin forms on the surface when coal is extracted over a wide area. The amount and extent of subsidence depends on many factors which include the geometry of the extracted area, the layout of unmined pillars, the number of seams mined, the coal recovery from each seam, the nature of the superincumbent strata and other geological factors.

When development headings are driven, no significant subsidence occurs. Generally, for bord and pillar workings, subsidence can be around 20 mm. Over a large area of pillar or longwall extraction where the critical extraction width is exceeded, subsidence can be up to 65% of seam thickness.

The main elements of a subsidence profile are the vertical displacement (subsidence), the change in ground slope and the curvature of the ground surface which determines the amount of surface strain. These elements can be calculated from field observations of level of and distance between monitoring points using standard survey techniques. Profiles of subsidence and associated characteristics are derived from the field data. Some of the terminology used in defining surface subsidence is shown in Figure 4.

In the case of longwall mining, most of the subsidence generally takes place soon after mining. In a virgin area, up to 10% of maximum subsidence can occur as 'delayed subsidence'. In the case of pillar extraction with standing unmined pillars in the goaf, subsidence can continue for a long time due to the collapse or gradual failure of any unmined pillars over time.

Dykes or fault planes can affect subsidence and strain profiles. They can provide a plane of weakness in the strata which under certain circumstances could facilitate subsidence movements. Surface cracking need not necessarily occur when such geological features are present. The occurrence of surface cracking and its extent, generally depends on the amount of strain.

The effects of ground movements are important in areas when there are structures or surface features which require protection. Different types of structures have different tolerances to subsidence.

Construction of new structures can be deferred until mining has taken place and subsidence is complete. It may be possible to modify existing structures to enable them to withstand anticipated subsidence. Proposed structures can be built with allowances for subsidence. Whether subsidence movements occur or are allowed to occur under structures or surface features depends on several factors. The importance of the structure and any socio-economic consequences of damage will need to be carefully considered in relation to the coal which could otherwise be sterilised.

A3.2 Underground Extraction

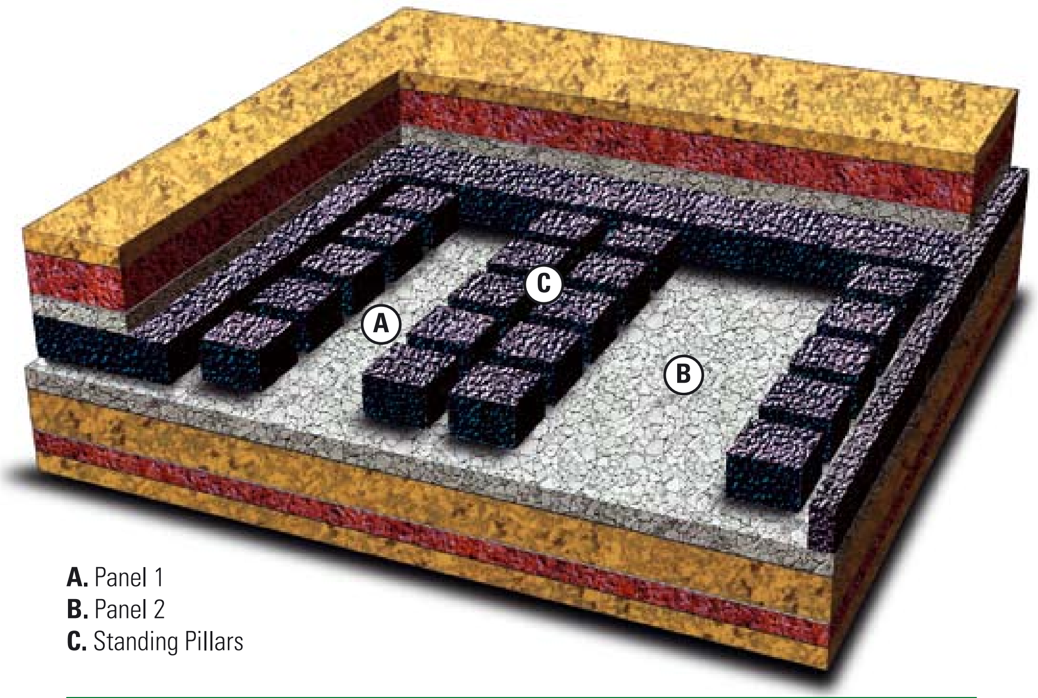
(a) Bord and Pillar Mining (First Workings)

Studies in NSW have observed subsidence values over bord and pillar workings without pillar extraction of approximately 20 mm.

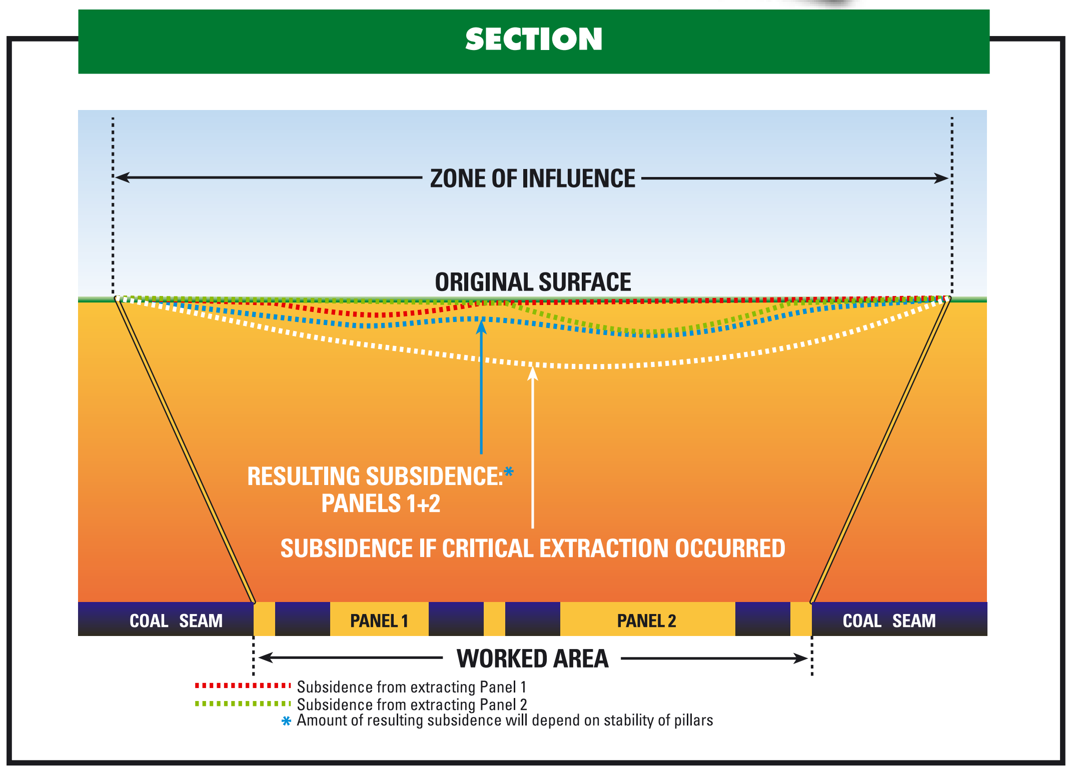
Determining values of mine subsidence for values of this magnitude is complicated by other factors. Standards and tolerances of surveys have to be considered and changes resulting from natural groundwater movement or swelling/contraction of surface soils/clays in excess of 50 mm are not uncommon. This ground movement occurs quite independently of any mining influence.

FIGURE 2

SUBSIDENCE FROM PANEL AND PILLAR MINING



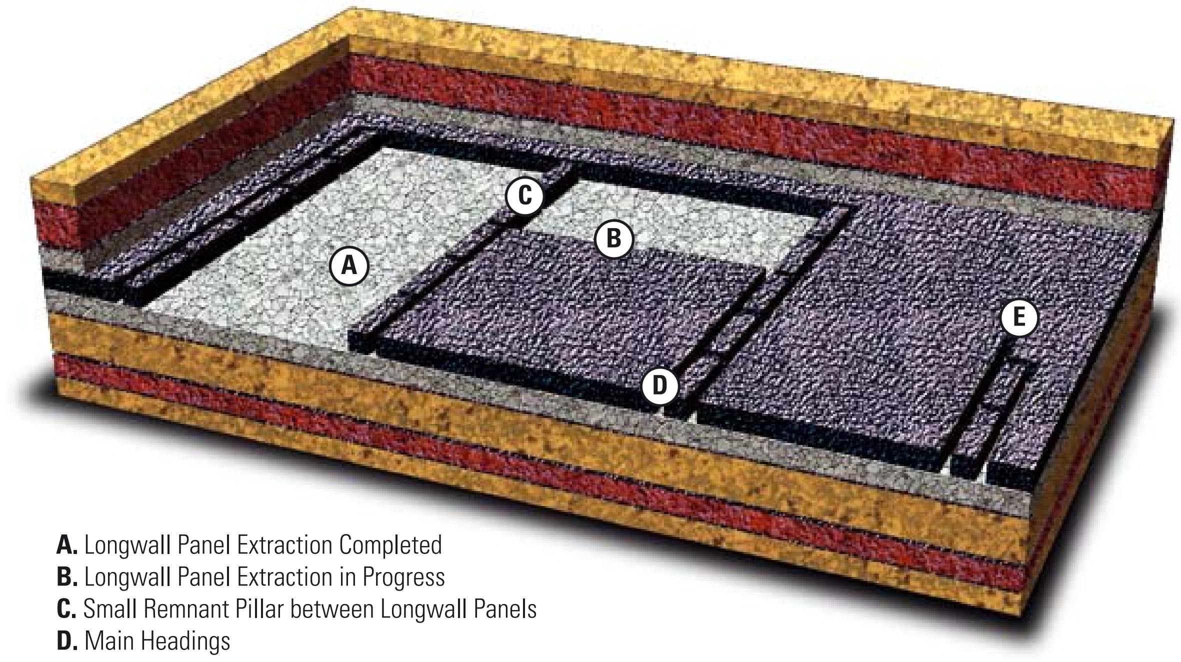
A. Panel 1
B. Panel 2
C. Standing Pillars



(Not to scale. Diagrammatic only)

FIGURE 3

LONGWALL MINING



A. Longwall Panel Extraction Completed
B. Longwall Panel Extraction in Progress
C. Small Remnant Pillar between Longwall Panels
D. Main Headings
E. Development Headings to create next Longwall Panel

(Not to scale. Diagrammatic only)

Undetected geological anomalies or poor mining practice may lead to unusual subsidence.

Limits can be placed with reasonable confidence on surface movements due to mining as empirical and mathematical methods have been proved reliable.

In summary, given good mining design and practice, bord and pillar (first) workings should cause no damaging surface subsidence.

(b) Partial Extraction

The subsidence effects of irregular partial extraction methods can be quite significant on the surface in terms of both vertical displacement and strain. Where the partial extraction involves pillar splitting or extensive pillar extraction there can be also a significant time delay in the development of total subsidence.

In a panel and pillar extraction operation, it is possible to carefully control and limit the amount of surface subsidence. This can be achieved by designing the widths of both panels to be extracted and the barrier pillars between them to suit strata conditions and depth. Of more importance, the differential subsidence over pillars and panels can be carefully evened out so that the surface strains are negligible, thereby protecting any sensitive surface features.

(c) Total Extraction

Total extraction generally results in 80%-90% recovery, by plan, of the coal seam. In NSW strata conditions, maximum surface subsidence can amount to approximately 65% of the extracted seam thickness, once the total extraction area exceeds a critical width.

Over the extremities of the extracted area, peak strains occur at the surface (see Figure 4). The magnitude of these strains is dependent on depth and strata conditions. The angle of draw defining the limiting lateral extent of subsidence is also very dependent on strata conditions and can vary typically from 0° to 35°.

In total extraction, as with all mining methods, given a combination of empirical guidelines based on measured subsidence data, structural and geotechnical strata properties and modern numerical design techniques, it is possible to design mining layouts to predict and hence control surface subsidence with a reasonable degree of reliability.

A3.3 OPEN CUT OPERATIONS

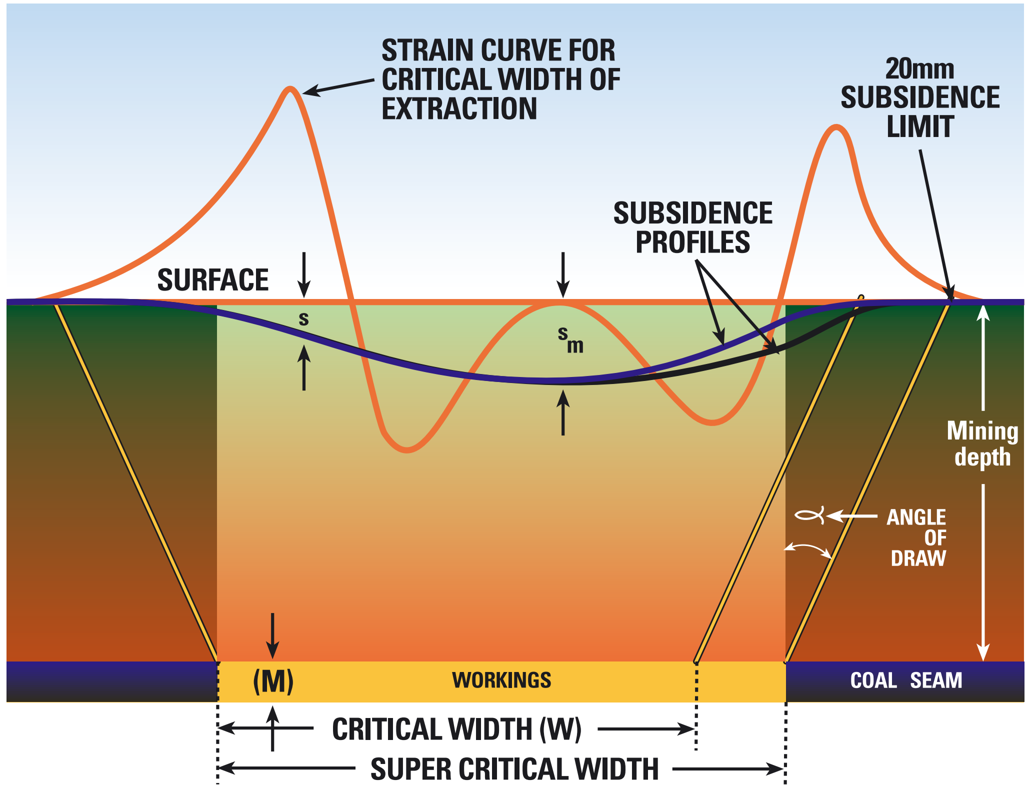
Ground movements can occur both during the mining operation and after rehabilitation due to the consolidation of the backfill. Very little published information is available in Australia on the ground movements associated with the consolidation and settlement of backfilled areas of open cut mines.

The area of influence behind the crest of a deep excavation slope depends upon the type of coal measures. Movements have been observed for a distance of 2.5 and 3.0 times the height of the slope behind the crest in clayey soils. In excavations in the stronger coal measures, it is generally believed that this distance reduces to less than the height of the slope. In clayey material, the movements are presumed to

FIGURE 4

TERMINOLOGY ASSOCIATED WITH SUBSIDENCE

(Source: National Coal Board 1975)



∝	**ANGLE OF DRAW** (or Limit Angle)	- Angle between vertical at edge of workings and line joining edge of workings to 20mm subsidence point at surface
s_m	**MAXIMUM SUBSIDENCE**	- Occurs at the centre of the panel when workings reach critical width and length
±E	**±STRAIN**	- Lengthening or shortening in subsidence trough per unit length
M	**SEAM THICKNESS** (extracted)	
W	**WIDTH OF WORKINGS**	

(Not to scale. Diagrammatic only)

result from elastic recovery following lateral and vertical stress relief. In the coal measures, the movements are frequently traced to shear failure along discontinuities such as bedding planes.

Displacements after backfilling are due to the consolidation of the backfill material and are a function of the type of material and the depth of the fill. Observations have been made over a period of between three (3) and six (6) years when backfill material was placed in an open cut. The maximum consolidation of 40 metres of overburden was observed to be 200 mm in this case. The consolidation was also found to be irregular, reflecting variations in the type of material and the degree of compaction.

Further work is required to predict subsidence in rehabilitated areas of open cut operations. Structures in the vicinity of open cut mines could suffer damage if these are located within the zone of influence of the workings. The development of rehabilitated lands should take account of ground movements due to the consolidation of the backfill for a number of years.

APPENDIX B

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

THE IMPACT OF COAL MINING ON ROADS

B1

GENERAL

The primary effects of mining on road pavements and structures are subsidence displacements, ground strains, tilt and deformation of structures or footings.

All structures within the angle of draw of the extraction will be affected by the ground displacements and resulting strains and tilts. The magnitude of these subsidence effects can be predicted prior to mining and their effect on existing and proposed structures can be assessed.

B2

STRUCTURE TYPES AND FUNCTIONS

Subsidence may affect:

(a) Road Geometry
Horizontal and vertical alignment, sight distances, etc

(b) Road Structures
Drainage culverts, subsoil drains, concrete kerbs, guardrails, barriers, sumps and outlets, embankments, batter slopes, etc

(c) Natural Features
Water courses

APPENDIX C

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

DESIGN MEASURES TO PROVIDE FOR SUBSIDENCE

Selection of types of pavements and structures that have some inherent flexibility and that may accommodate some of the subsidence movements are appropriate strategies to adopt when designing roadways that will be exposed to mine subsidence.

Structures can be detailed to incorporate joints that allow the effects of ground strains, curvatures and vertical subsidence to be accommodated. Such details will allow mitigatory works to be carried out prior to undermining taking place. This will include providing access and details that allow girders and headstock to be realigned by jacking, or supported on hydraulic jacks during the subsidence event.

When mining plans are available that allow subsidence parameters to be established with some confidence, road geometry and grades of drainage lines, etc may be designed to allow for the effects of subsidence, tilts and curvatures on the road surface, drains, etc.

APPENDIX D

GUIDELINES FOR COAL MINING AND ROADS WITH RESPECT TO SUBSIDENCE

CASE STUDIES

The attached case studies have been included in the Guidelines to illustrate the types of roads that have been undermined and the type and extent of mitigatory works and monitoring that have been adopted.

The examples have been selected to illustrate the range of works that have been undertaken to date when underground mining has produced surface subsidence with the potential to affect roads.

As a result of the work undertaken, the roads have remained in service and underlying coal resources have been recovered.

1. Pacific Highway Catherine Hill Bay
2. Freemans Drive Cooranbong
3. George Booth Drive Edgeworth
4. Link Road - F3 Freeway to Pacific Highway Doyalson
5. Rockford Road Bridge Tahmoor

1. Pacific Highway Catherine Hill Bay

Location:	Pacific Highway Catherine Hill Bay
Owner:	Roads and Traffic Authority
Colliery:	Wallarah Colliery
Mining Type:	Pillar Extraction in two seams (1984-1988)
Depth of Cover:	150 and 180 metres
Subsidence Predictions:	
Maximum Subsidence	1400 mm
Maximum Tensile Strain	3.5 mm/m
Maximum Compressive Strain	5.5 mm/m
Length of Road Affected:	1,200 metres
Actual Subsidence:	
Maximum Subsidence	1300 mm
Maximum Tensile Strain	12.3 mm/m
Maximum Compressive Strain	6.3 mm/m
Actual Damage:	Surface damaged by compression humps and tension cracks. Road surface was considered very rough.
Method of Repair:	Heavy patch failed areas, place rubber bitumen and geotextile bandage over cracks, overlay pavement with 175 mm asphaltic concrete and spray seal, raise guardrails, reconstruct surface drains, replace pavement markings and signposts.
Estimated Cost of Repairs:	$2,263,608

2. Freemans Drive Cooranbong

Location:	Freemans Drive Cooranbong Main Road 392
Owner:	Lake Macquarie City Council
Colliery:	Cooranbong Colliery
Mining Type:	Longwall (2 longwall panels 1992)
Depth of Cover:	120 metres
Subsidence Predictions:	
Maximum Subsidence	1400 mm
Maximum Tensile Strain	15 mm/m
Maximum Compressive Strain	20 mm/m
Length of Road Affected:	900 metres
Actual Subsidence:	
Maximum Subsidence	1200 mm
Maximum Tensile Strain	14 mm/m
Maximum Compressive Strain	20 mm/m
Actual Damage:	Tension cracks and compression humps to the road surface. Some ponding of water and loss of crossfall drainage.
Method of Repair:	Repairs were carried out under the supervision of a consultant engaged by the Mine Subsidence Board. Repairs involved the removal of the existing seal, regrade and recompact the existing pavement and overlay with a 125 mm thick road base, two coat seal, line marking.
Estimated Cost of Repairs:	$332,928

3. George Booth Drive Edgeworth

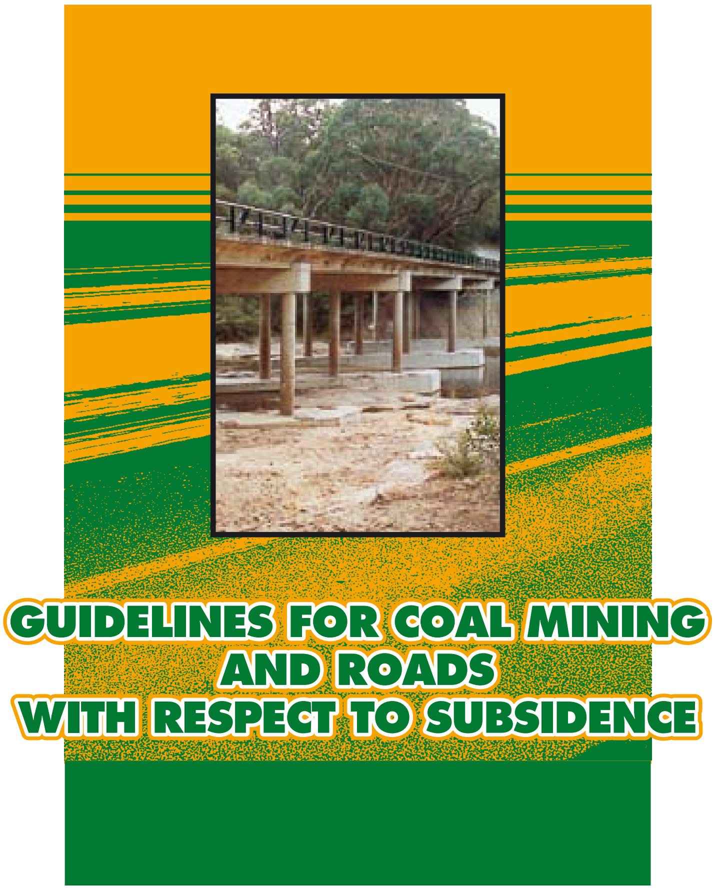
Location:	George Booth Drive Edgeworth Main Road 223
Owner:	Lake Macquarie City Council
Colliery:	West Wallsend Colliery
Mining Type:	Longwall (3 adjacent longwall panels 1994-1995)
Depth of Cover:	160 metres
Subsidence Predictions:	
Maximum Subsidence	1500 mm
Maximum Tensile Strain	6 mm/m
Maximum Compressive Strain	6 mm/m
Length of Road Affected:	450 metres
Actual Subsidence:	
Maximum Subsidence	1100 mm
Maximum Tensile Strain	3 mm/m
Maximum Compressive Strain	3.5 mm/m
Actual Damage:	Cracking and distortion to the road surface.
Method of Repair:	Repairs involved the rotomilling of the failed sections of the road surface to a depth of 30 to 50 mm and resheeting with asphaltic concrete.
Estimated Cost of Repairs:	$52,627

4. Link Road - F3 Freeway to Pacific Highway Doyalson

Location:	Link Road - F3 Freeway to Pacific Highway Doyalson
Owner:	Roads and Traffic Authority
Colliery:	Munmorah Colliery
Mining Type:	Pillar Extraction (1995)
Depth of Cover:	180 metres
Subsidence Predictions	
Maximum Subsidence	1000 mm
Maximum Tensile Strain	4 mm/m
Maximum Compressive Strain	4 mm/m
Length of Road Affected:	1,000 metres
Actual Subsidence:	
Maximum Subsidence	944 mm
Maximum Tensile Strain	3 mm/m
Maximum Compressive Strain	1.9 mm/m
Actual Damage:	Cracking and distortion to the road surface in the form of tension cracks and compression humps.
Method of Repair:	Repairs were carried out by the Roads and Traffic Authority and included milling and paving with asphaltic concrete to the distorted and cracked sections to provide a smooth wearing surface. Signs warning motorists of potential deformations were erected. Some final repairs may be required.
Estimated Cost of Repairs:	$32,387

5. Rockford Road Bridge Tahmoor

Location:	Rockford Road Bridge Tahmoor
Owner:	Wollondilly Shire Council
Colliery:	Tahmoor Colliery
Mining Type:	Longwall (2 adjacent longwall panels 1994)
Depth of Cover:	425metres
Subsidence Predictions:	
Maximum Subsidence	670 mm
Maximum Tensile Strain	1.6 mm/m
Maximum Compressive Strain	2.1 mm/m
Length of Road Affected:	75 metre long bridge
Actual Subsidence:	
Maximum Subsidence	550 mm
Maximum Tensile Strain	2.6 mm/m
Maximum Compressive Strain	4.4 mm/m
Note:	97% of measured strain values lay between 0.5 and 1.5 mm/m
Actual Damage:	The bridge remained operational during subsidence with some restrictions on speed and lane closures.
Method of Repair:	Preventative work put in place prior to subsidence occurring had the bridge deck supported by reaction trusses and hydraulic jacks supported by steel falsework. Hydraulic pumps were used to automatically compensate for any movement of the bridge deck, keeping it level during subsidence.
Estimated Cost of Repairs:	$1,231,339



INITIAL CONTACTS FOR ENQUIRIES RELATING TO MATTERS COVERED BY THE GUIDELINES

Mine Subsidence Board

Chief Executive Officer

District Supervisor - District Offices at Newcastle, Wyong, Speers Point, Picton and Singleton

Department of Mineral Resources

Coal Mining Inspectorate and Engineering Services

Offices at St Leonards, Cardiff, Wollongong, Lithgow and Singleton

Colliery

Superintendent/Manager of Colliery involved

Roads and Traffic Authority

General Manager Infrastructure and Maintenance - Sydney

Regional Manager Hunter (Newcastle), Regional Manager Southern (Wollongong), Regional Manager Western (Dubbo), Regional Manager South Western (Wagga Wagga), Regional Manager Northern (Lismore)

GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310

T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com

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3	S. Mackenzie	S. Amoroso	S. Amoroso	S. Amoroso	S. Amoroso	24/06/2019

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