Strata Control Technology

REPORT TO:

ASHTON COAL MINE

Subsidence Assessment for Ashton Coal Mine Longwalls 5 to 9

ASH3391A

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REPORT TO	Shane Pegg Technical Services Manager Ashton Underground Mine PO Box 699 SINGLETON NSW 2330
SUBJECT	Subsidence Assessment for Aston Coal Mine Longwalls 5 to 9
REPORT NO	ASH3391A
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SUMMARY

Ashton Coal Operations Pty Ltd (Ashton) is proposing to mine a series of longwall and miniwall panels in the Pikes Gully Seam as part of their ongoing operations near Camberwell in the Hunter Valley. Ashton commissioned SCT Operations Pty Ltd to undertake a subsidence assessment suitable for submission as part of the Subsidence Management Plan (SMP) Approval documentation being prepared on their behalf by Maunsell Australia Pty Ltd. This report presents the results of our subsidence assessment for the surface area above Longwalls 5, 6 and 9, and Miniwalls 5-9, collectively referred to as Longwalls 5-9.

The proposed mining is located in an area below Bowmans Creek. The mine layout has been designed specifically to limit the subsidence on Bowmans Creek and the associated alluvium by narrowing the sections of each panel that are located directly below the creek and associated alluvium. The basis for this design and the studies that underpin it are reported elsewhere and have not been included in this report.

In the area of the reduced panel widths (60-93m), surface subsidence is expected to be limited to less than 350mm and to be generally less than 200mm. At the southern ends of Longwalls 5 and 6 where 215m wide panels are proposed, the maximum subsidence is expected to be less than 1600mm and most likely in the range 1.2-1.3m. At the northern end of Longwall 9 the maximum subsidence is expected to be less than 1200mm and most likely in the range 0.5-1.0m.

Estimates of strains and tilts are based on guidelines developed in the Western Coalfield and the results of the monitoring over Longwalls 1 and 2.

Mining within the Application Area is expected to cause low levels of subsidence along Bowmans Creek with maximum subsidence of 350mm over a few tens of metres of the creek channel in the centre of Miniwall 7 and up to 300mm at the other crossing points.

Mining subsidence is expected to cause cracking in the ground surface above Longwalls 5 and 6 and cracks may also be apparent on the tarseal surface of Brunkers Lane above Longwall 9. Subsidence may lead to localised ponding areas following rain in flatter areas over Longwalls 5 and 6. This potential has been assessed separately by others.

Much of the surface and surface infrastructure within the Application Area is owned by Ashton and improvements are therefore not required to be assessed within the SMP Approval process. However the mining impacts on most of Ashton infrastructure have been assessed within the body of this report for completeness and where there is potential for consequential impacts.

A 132KV electricity line that traverses the surface above the southern end of all the panels is not likely to be significantly impacted by mining subsidence movements based on previous experience of mining under the line. However, a three poled structure with bracing stays located at a bend in the line at above Longwall 5 is likely to be sensitive to subsidence movements and requires specific assessment.

Two high voltage electricity lines are located alongside the New England Highway. These are located outside the area where subsidence movements are expected to occur. A buried fibre optic cable also located in this area is outside the area where subsidence movements would be expected.

The New England Highway and the concrete bridge over Bowmans Creek is located over and adjacent to the main headings. The bridge is located approximately 250m from the northern end of Miniwall 5 where the panel is narrowed to 60m and is outside the area likely to be affected by mining subsidence. The main headings are expected to be long term stable. No perceptible subsidence movements are expected within the road reserve.

A local distribution electricity line traverses the Application Area. This line is likely to remain serviceable throughout mining provided the conductors are placed in sheaves and any stays are adjusted as poles are undermined to prevent them becoming overloaded.

A buried Telstra cable traverses the Application Area. Mining subsidence may render this cable unserviceable, although a similar line has remained serviceable during mining of Longwalls 1 and 2.

Farm buildings and a house located on Ashton property over Longwall 6 are likely to experience the full range of subsidence movements and are unlikely to remain serviceable after Longwall 6 has been mined unless some mitigatory works are undertaken to isolate them from the subsidence movements.

Brunkers Lane may experience surface cracking and buckling during mining of Longwall 9, but is expected to remain serviceable with suitable management. Along the section of Brunkers Lane located above Longwall 9, up to 1200mm of subsidence is expected with horizontal strains of up to 20mm/m and maximum tilts of 50mm/m (25mm/m in the direction of the road). We recommend a management plan for Brunkers Lane is developed in consultation with the relevant stakeholders so that access can be maintained to Macquarie Generation land and to Ravensworth Open Cut when required.

Mining subsidence movements are not expected to have any perceptible impact on Narama Dam.

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1. INTRODUCTION

Ashton Coal Operations Pty Ltd (Ashton) is proposing to mine a series of longwall and miniwall panels in the Pikes Gully Seam as part of their on going operations near Camberwell in the Hunter Valley. Ashton commissioned SCT Operations Pty Ltd to undertake a subsidence assessment suitable for submission as part of the Subsidence Management Plan (SMP) Approval documentation being prepared on their behalf by Maunsell Australia Pty Ltd. This report presents the results of our subsidence assessment for the surface area above Longwalls 5, 6 and 9, and Miniwalls 5-9, collectively referred to as Longwalls 5-9.

The report is structured to provide:

1. A description of the general area including the proposed mining geometry, overburden depth and other parameters of relevance to a subsidence assessment.

2. Specific detail of the features, both natural and man-made that have been identified as likely to be impacted by mining subsidence.

3. A review of the specific requirements of the SMP Approval process.

4. Subsidence estimates based on the previous subsidence monitoring at the mine and for panels elsewhere of similar panel width to overburden depth ratios.

5. Specific assessments of the likely subsidence impacts on the surface features identified.

6. Recommendations for subsidence monitoring programs and strategies to manage the subsidence impacts identified.

2. SITE DESCRIPTION

Figure 1 shows a plan of the proposed longwall area, the SMP Application Area, and the location of surface features superimposed onto a 1:25,000 topographic series map of the area (updated to reflect changes since the map was produced in 1982). Figure 2 shows the longwall layout and Application Area superimposed onto a more recent aerial photograph.

2.1 Surface Features and Improvements

The Application Area is predominantly cattle grazing land on either side of Bowmans Creek. The area is located between the current mining area to the east and the original alignment of Brunkers Lane to the west, the New England Highway to the north and the Hunter River to the south. Most of the surface area is owned by Ashton, but there is a triangle of land owned by Macquarie Generation in the north-western corner of the application that has been used as an out of pit spoil dump for the adjacent open cut mine.

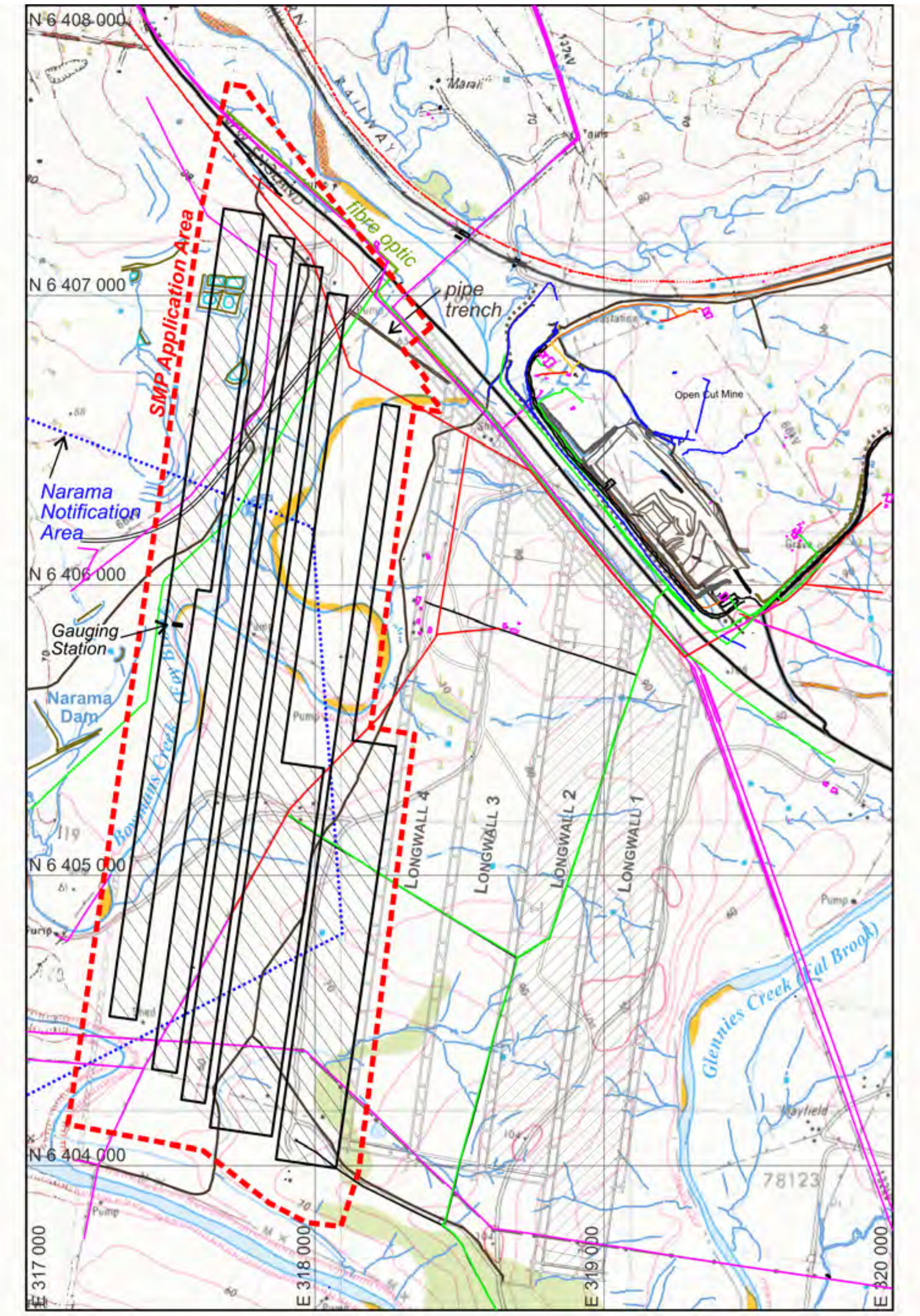

Figure 1 Site plan superimposed onto 1:25,000 topographic series map.

Figure 2 Longwall layout superimposed onto aerial photograph.

The major natural feature within the area is Bowmans Creek. The mine layout has been specifically designed to limit the impacts of subsidence on Bowmans Creek and its associated alluvium by reducing the width of individual panels in the areas directly below these features.

The major infrastructure within the Application Area includes the New England Highway in the northern part of the area, a buried fibre optic cable alongside the highway, and three high voltage electricity lines, two alongside the highway and a third that traverses the southern end of the panels.

Other non-mining related infrastructure includes a local area electricity line, two buried Telstra copper wire lines, and a river gauging station on Bowmans Creek.

Mining related infrastructure that is not owned by Ashton includes a private road that provides secondary access to Macquarie Generation land and Ravensworth Underground as well as access to Ravensworth Open Cut, clay lined sedimentation ponds located on the waste rock spoil pile, an 11kV power line servicing Ravensworth Open Cut, and a large diameter polyline understood to carry fresh water from Narama Dam to Mt Owen Mine.

The Dam Safety Committee (DSC) Notification area for Narama Dam overlaps the Application Area, although the dam itself is located outside the Application Area, some 270m at its nearest point from Longwall 9. A second water storage dam is planned west of the north-western corner of the Application Area within the timeframe of mining Longwalls 5-9. This dam will also be located outside the mining area, but the DSC Notification Area will overlap with the Application Area.

Ashton owned infrastructure located within the Application Area includes several farm buildings and houses, three farm dams, farm roads, fences, a fresh water polyline from the Hunter River, the mine pump out polyline from the southern end of the panels, and four polylines that pass under the New England Highway below the bridge over Bowmans Creek.

2.2 Mining Geometry

Miniwalls 5 to 9 are designed to limit hydraulic connection between the mine and Bowmans Creek and its associated alluvium. The panels are narrowed directly under the creek and alluvium but are mined full width elsewhere. The width of Longwall 9 is limited by proximity to the lease boundary.

The chain pillars are 35m wide measured centre to centre with cut-throughs at 100m centres, except for the maingate chain pillar of Longwall 9 which is at 25m centres.

Table 1: Summary of Panel Widths for Proposed Longwalls

Longwall	Panel Width (m)	Overburden Depth (m)	W/D (Max)
LW5	216	110-155	1.4-2.0
MW5	60	100-125	0.5-0.6
LW6	216	130-160	1.3-1.7
MW6	70	115-150	0.5-0.6
MW7	81	130-170	0.5-0.6
MW8	87	140-175	0.5-0.6
MW9	93	160-190	0.5-0.6
LW9	141	140-180	0.8-1.0

Figure 3 shows a plan of the overburden depth and thickness of the proposed mining section in the Pikes Gully Seam. The seam ranges in height from 2.3m at the southern end of Longwall 5 to 3.1m at the north-western corner of Longwall 9 due to thickening of inter-seam plys. The seam section to be extracted is 2.3-2.4m. The seam dips to the south-west at a grade of up to about 1 in 10.

The overburden depth ranges from 100m at the northern end of Miniwall 6 to 190m above Miniwall 9 principally as a result of seam dip.

The miniwalls are designed to limit subsidence below Bowmans Creek. The maximum panel width to overburden depth directly below Bowmans Creek and associated alluvium is designed to be 0.6. Longwalls 5 and 6 are designed to maximise coal resource and are each of super-critical width, in subsidence engineering terms, so these panels are expected to experience full subsidence of up to 65% of seam thickness over the central part of each longwall panel. The subsidence control panels are designed so that the maximum subsidence is less than 10% of the seam thickness extracted.

3. DESCRIPTION OF NATURAL FEATURES AND SURFACE IMPROVEMENTS

The natural features and surface improvements in the Application Area have been identified on the basis of several site visits to walk over the surface, discussion with colliery personnel, and discussion with other specialist groups working for the colliery. In this section, these features and improvements are described in greater detail to provide a context for the assessment of likely subsidence impacts.

3.1 General Character of Area

Figure 4 shows two photographic panoramas looking south-west and north-west across the Application Area from a point on the eastern edge of Longwall 5.

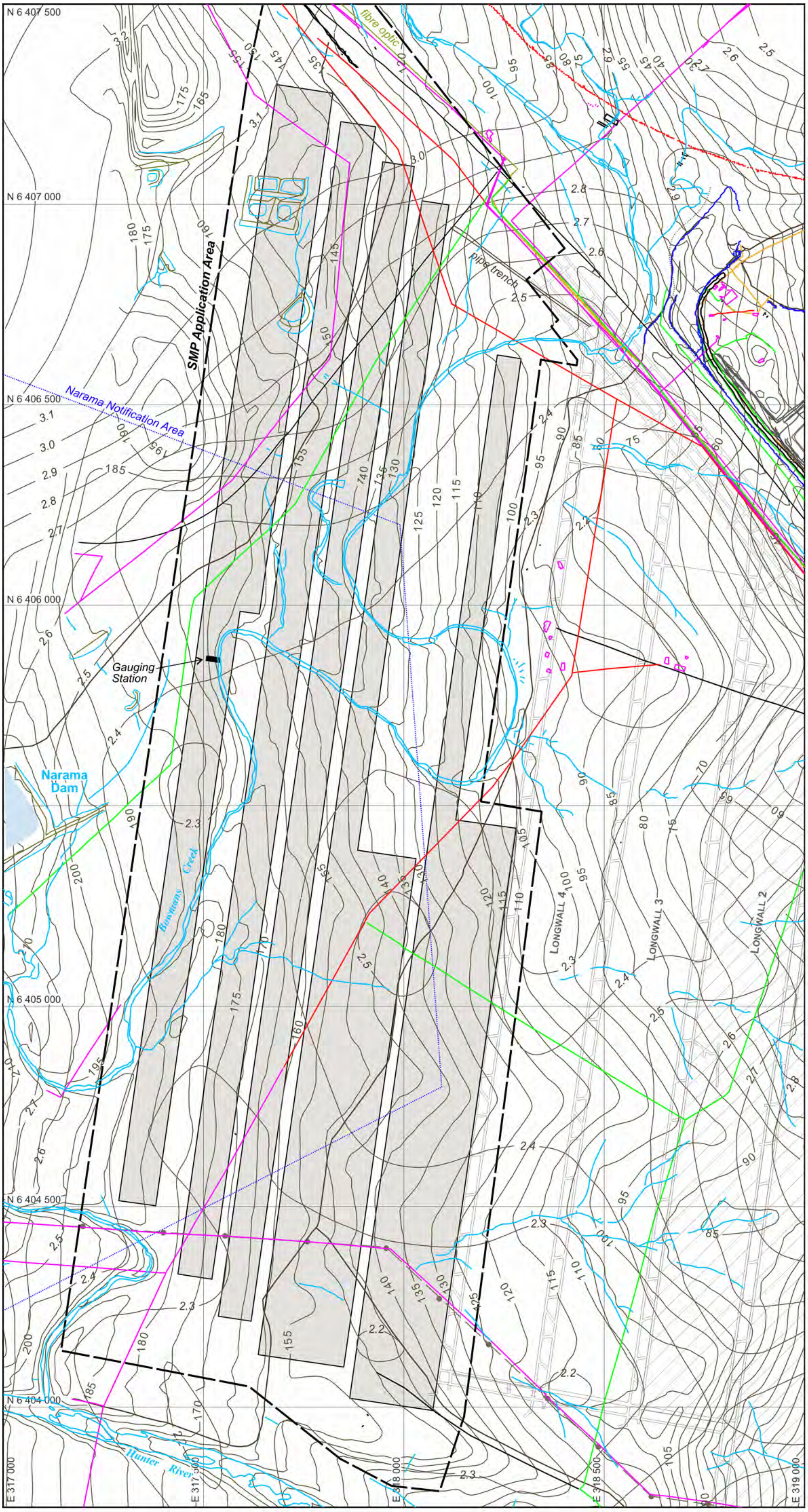

Figure 3 Plan showing overburden depth and seam thickness isopachs together with the location of surface infrastructure.

— 2.2 — Seam thickness
—105— Overburden

Figure 4 Panoramas looking northwest and southwest across application area.

The surface topography is gently undulating rising on either side away from Bowmans Creek.

The portion of the surface within the Application Area that is not owned by Ashton is located in the north and north-west. The New England Highway and associated road reserve is administered by the Roads and Traffic Authority (RTA). A triangle in the north-western corner is owned by Macquarie Generation.

3.2 Natural Features

The main natural features of interest in and adjacent to the Application Area are Bowmans Creek and its associated alluvial flats, and the Hunter River.

3.2.1 Bowmans Creek

Bowmans Creek meanders from north to south across the Application Area. In the north, the stream channel is cut into the surrounding countryside to a depth of several metres. In the south, near the confluence with the Hunter River, the channel is deeply incised to a depth of 10-15m below the surrounding countryside.

The stream channel comprises a series of pools retained behind gravel bars. There are conglomerate rock exposures in the banks at several locations, typically near sharp changes in direction, but along most of its length, the channel is cut into the alluvium and the banks comprise sand, silt, and clay material. There are two ponded sections of a previous stream channel that have become disconnected from the main channel and several tributaries draining off the surrounding countryside.

Figure 5 shows a selection of photographs of Bowmans Creek illustrating the nature of various sections of the stream channel. The photographs were taken shortly after a period of heavy rain when the flow in the river was still several hundred megalitres per day. In extended dry periods, the stream channel is reduced to a series of ponds with surface flow reduced to only a few megalitres per day.

3.2.2 Hunter River

The Hunter River is located to the south of, and outside of, the Application Area. The closest point of longwall mining is the start corner of Longwalls 5 and 6 which are approximately 260m from the Hunter River. The overburden depth at this point is approximately 140m, so the river is protected by a barrier approaching twice the overburden depth. Figure 6 shows a photograph of the Hunter River.

Figure 5 Photographs of Bowmans Creek.

Figure 6 Photograph of the Hunter River south of the application area.

3.3 Surface Improvements

The various items of surface infrastructure located within the Application Area are described in detail in this section starting with major and minor non-mining infrastructure within the Application Area, mining infrastructure associated with operations other than Ashton, and finishing with Ashton owned infrastructure.

3.3.1 New England Highway

Figure 7 shows a photograph looking east along the edge of the New England Highway road reserve in an area where a buried fibre optic cable and two high voltage electricity lines are located.

The southern edge of the New England Highway road reserve is located some 70-90m from the northern ends of Miniwalls 6-8 and Longwall 9. The main headings pass directly under the highway. The depth of overburden in this area ranges from 90-130m.

Figure 7 Photograph looking east along New England Highway road reserve.

3.3.2 Buried Fibre Optic Cable

The Powertel fibre optic cable follows the alignment of the 132kV power lines on the southern side of the New England Highway as shown in Figure 8 up to the intersection with the realigned Brunkers Lane where it crosses under the highway and is located on the northern side of the highway from there on.

Available plans indicate that the fibre optic cable comes within 100m of the end of Miniwall 6. The overburden depth at this location is approximately 120m.

3.3.3 132kV & 66kV Electricity Lines

Two electricity lines (one 132kV and one 66kV) supported on single poles are located along the southern side of the New England Highway as shown in Figures 7 and 8. Both cross the highway near the intersection with Brunkers Lane. The poles are supported with multiple stays in this area.

An 11kV line also supported on the poles of the southern 66kV line continues along the southern side of the highway.

Figure 8 Photograph of Powertel cable and high voltage power lines in New England Highway road reserve.

The corner poles are located approximately 100m from the end of Miniwall 6. The overburden depth at this location is approximately 120m.

A second 132kV electricity line crosses the southern end of all the longwall panels. This line is supported on a two pole structure for the straight sections as shown in Figure 9a and three stayed poles at changes in direction as shown in Figure 9b. The three stayed poles are located over Longwall 5 approximately 40m from the maingate goaf edge at an overburden depth of approximately 130m. Two of the two pole structures are located over Longwalls 5 and 6 where a full range of subsidence movements are expected. There are also two twin pole structures located over the low subsidence areas.

3.3.4 Local Area Electricity Lines

Several local area electricity lines cross the Application Area. The 11kV line supported on the 66kV poles at the northern end of the panels has already been noted (Figure 7).

There is a line located on the Macquarie Generation land that skirts the edge of the spoil dump. The single pole structures on this line are shown in Figure 10a and 10b. They are stayed at changes in direction, but these points are mainly over the narrower panels where subsidence is expected to be low.

Figure 9 Photographs of 132kV line at the southern end of the application area.

Figure 10 Photographs of single pole structures on 66kV power lines.

There is a line that extends north to south across the Application Area that services the Ashton owned properties and continues south across the Hunter River after passing under the 132kV line. The line also branches at the southern edge of the Application Area, servicing Ashton's submersible pump and crossing Bowmans Creek. Figure 11 shows a selection of photographs of this line. The line is supported on single pole structures.

3.3.5 Buried Telstra Lines

Three buried, copper wire, Telstra lines cross the Application Area. The western line crosses the southern end of Longwall 9 and the low subsidence areas at the northern end of Miniwalls 6 to 8. This line previously serviced the gauging station and provides future connection for subdivided blocks that form part of the southern extent of the Ravensworth lease.

The other two lines are branches off the line located over Longwalls 1-3 that service the house located over Longwall 6 and another Ashton owned building located over Longwall 5. These lines are understood to be currently active.

3.3.6 Bowmans Creek Flow Gauging Station

A flow gauging station is located on Bowmans Creek above the centre of Miniwall 9. Figure 12 shows photographs of this installation. We understand that the station was previously used for the Hunter Salinity Trading Scheme.

3.3.7 Brunkers Lane (Private Road)

Brunkers Lane is the name given to a tarsealed section of road that was realigned from its location on the western edge of Ashton's lease to its current location during open cut mining operations on the site now owned by Macquarie Generation. Figure 13 shows a photograph of the section of road located over Miniwalls 6-8 and Longwall 9.

Although the road is accessible to the public along the section that is within the Application Area, we understand that the road is not actually a public road. Macquarie Generation maintains this roadway as a private roadway as far as the Void 4 access gate as an alternate access for heavy vehicle traffic to the mine when access via the normal route becomes restricted. The road is also planned to be used for heavy vehicle movements associated with construction of the Void 4 dam. The road has recently been upgraded including the highway intersection.

Ravensworth Open Cut makes use of this road as a rear access to their site through a locked gate but we understand they have no legal right of way.

The overburden depth ranges from 120m to 170m along the length of the tarsealed section of Brunkers Lane.

Figure 11 Photographs of single pole structures on local electricity lines.

Figure 12 Flow gauging station on Bowmans Creek.

Figure 13 Sealed section of Brunkers Lane.

3.3.8 Macquarie Generation Access Road

The alternative access to Macquarie Generation land continues from Brunkers Lane on a gravel road as shown in Figure 14. This road is mainly located over the low subsidence area at the northern end of Miniwall 8, but also crosses the northern end of Longwall 9. The overburden depth in this area is approximately 145m.

3.3.9 Macquarie Generation Sedimentation Ponds

Figure 15 shows a panorama of the surface above the out of pit spoil pile. The surface has been substantially rehabilitated and revegetated. There are four clay lined sedimentation ponds and a fifth downstream dam that are still used. All five dams are located over Longwall 9 and the overburden depth is approximately 150m.

3.3.10 Polyethylene Water Pipes

A polyethylene pipeline from Narama to Mt Owen is buried for most of its length, but is exposed where it passes through a culvert below Brunkers Lane (Figure 16). The pipeline crosses Longwall 9 and Miniwall 8 before passing through a culvert and continues buried through to Mt Owen.

Figure 14 Unsealed access road on Macquarie Generation lease.

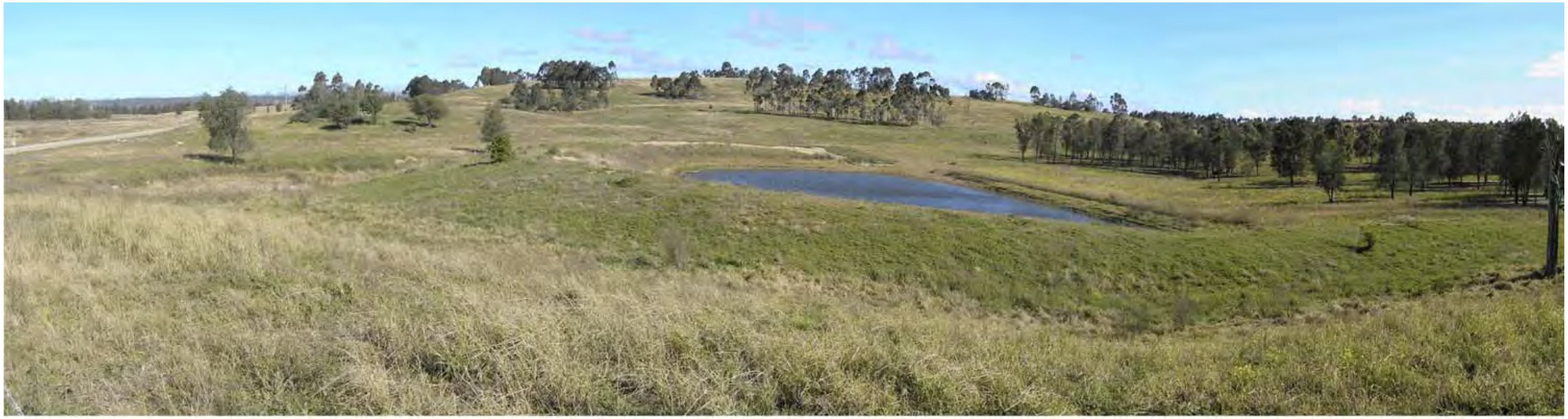

Figure 15 Panorama of surface above out of pit spoil pile.

a)

b)

c)

Figure 16 Polyethylene pipelines

A separate group of pipes associated with Ashton tailings transfer and water reclamation from Void 4 are in an open trench across Macquarie Generation's lease (Figure 16b). These are buried in a shallow trench across Miniwall 6 and pass under Brunker's Lane, alongside Bowmans Creek and under the New England Highway at the Bowmans Creek Bridge (Figure 16c).

The diameters of these pipes range from 110mm to 315mm. All the lines except the fresh water line from the Hunter River carry mine water.

3.3.11 Narama Dam

Narama Dam is a 1,000Ml capacity earth dam located outside the Application Area west of Miniwall 9. Figure 17a shows the dam wall and downstream structures. Figure 17b shows the dam wall looking from the nearest point above Miniwall 9.

We understand that Narama Dam provides water for Mt Owen Mine and other Xstrata mining operations. Although the toe of the dam is 270m from the nearest goaf edge of Miniwall 9, the DSC Notification area for Narama Dam falls within the Application Area. A concrete structure downstream of the dam on the original watercourse and associated steel pipes are located approximately 400m from the nearest goaf edge of Miniwall 9. The overburden depth at this location ranges 190-200m.

3.3.12 Proposed Water Storage Dam

A second water storage dam is planned west of the north-western corner of the Application Area within the timeframe of mining Longwalls 5-9. This dam will also be located outside the mining area, but the DSC Notification Area will overlap with the Application Area.

3.3.13 Ashton Infrastructure

Ashton owned infrastructure located within the Application Area includes several farm buildings and houses, three farm dams, farm roads, fences, a fresh water polyethylene pipe from the Hunter River, and the mine pump out polyethylene pipe from the southern end of the panels.

Figure 4 shows panoramas that include most of the surface infrastructure within the Application Area that is owned by Ashton. Most of this infrastructure is located within the full width panels Longwalls 5 and 6 where the full range of subsidence movements is likely to be experienced. The overburden depth in this area ranges from 120m to 160m.

Ashton also pumps fresh water from the Hunter River and mine water from the southern end of the longwall panels through two polyethylene pipes that traverse the surface above Longwalls 5 and 6 in shallow trenches.

a)

b)

Figure 17 Namara Dam.

3.3.14 Disused and Dilapidated Infrastructure

There are two disused pump stations located along Bowmans Creek within the Application Area. Figure 18 shows a photograph of the northern one of these. All that remains is a small tin shed which is in an advanced state of disrepair. The power supply and pump out line have been disconnected and all the machinery has been removed.

Figure 19 shows a photograph of a shed that Macquarie Generation has advised is not occupied and is in an advanced state of disrepair.

4. SUBSIDENCE ESTIMATES

The subsidence estimates provided in this report are intended to be used in the context of an Application for Subsidence Management Plan Approval as outlined in the guidelines produced by the NSW Department of Mineral Resources (December 2003). These guidelines require:

1. A description of methods employed to estimate subsidence resulting from the proposed underground coal mining.
2. A discussion of all factors that may affect the development of subsidence over the application area.
3. Relevance of all input data, including results of previous relevant subsidence monitoring, which has been utilised or considered to develop the predictions.
4. Identification of all assumptions used, especially those which may significantly affect the outcome of the subsidence predictions, and discussion of their relevance.
5. Reliability of the subsidence predictions and the level of uncertainties involved, in particular, any potential deviations from the predictions due to factors such as topographic, geological or geotechnical conditions or variations.

Our assessment is aimed to address each of these issues in the following sections.

4.1 Prediction Methodology

The subsidence predictions used for assessment purposes at Ashton are based on the empirical experience elsewhere in NSW at similar panel width and overburden depth as an indication of the maximum, and previous subsidence monitoring over Longwalls 1, 2 and 3 as an indication of the likely range. Subsidence monitoring at Ashton is most relevant to the subsidence behaviour over full width panels. However centreline subsidence lines located over the start of Longwalls 1, 2 and 3 provide an indication of the bridging characteristics of the overburden strata for narrow width longwall panels. As the longwall face moves away from the starting rib, the effective width of the void increases. The subsidence characteristics for a range of panel widths can thus be measured, albeit as dynamic subsidence profiles.

Figure 18 Disused pump shed adjacent to Bowmans Creek.

Figure 19 Disused shed beyond the northern end of Longwall 9.

The results of this start line monitoring from Longwall 1 indicated significantly greater overburden bridging than measurements have indicated at other sites including the start of Longwall 2. While, the mechanics of the process that caused this greater bridging at the start of Longwall 1 are not fully understood, this result is considered to be an aberration and has been disregarded for estimating subsidence over the narrow panels within the Application Area.

Profiles of subsidence for Ashton are based on the subsidence profiles measured over Longwalls 1 and 2 with allowance for differences in overburden depth and panel geometries. Estimates of strains and tilts are based on guidelines developed in the Western Coalfield and the results of previous monitoring over Longwalls 1 and 2. The Western Coalfield guidelines have been chosen because the database of experience is for similar overburden depths and panel geometries as those at Ashton.

An upper limit approach to estimating subsidence and subsidence parameters has been used. There is considered to be no potential for vertical subsidence of greater than 1.6m and actual subsidence is expected to be 70-80% of this maximum.

At the low levels of subsidence predicted over the narrower panels, there is some potential for natural variations in overburden behaviour to cause predicted subsidence to be exceeded because of the low levels involved, but the approach adopted is nevertheless considered to be conservative.

4.2 Discussion of Factors that Affect the Development of Subsidence

Within the Application Area, there are essentially three different subsidence areas: full width panels in Longwalls 5 and 6 where subsidence behaviour is likely to be similar to Longwalls 1-4, the low subsidence areas where panel widths are less than approximately 0.6 times overburden depth, and Longwall 9 where panel width is constrained by the lease boundary.

In the full panel width areas, subsidence is likely to develop over each individual longwall panel, effectively independently of any subsidence that has occurred in the adjacent panels. Maximum subsidence is governed by the height of the seam section mined and is expected to be less than 65% of this height based on experience elsewhere in NSW. Experience over Longwalls 1, 2 and 3 indicates a maximum subsidence of 50-55% of the seam thickness mined is most likely.

In the low subsidence areas, the sag subsidence above individual panels associated with overburden bridging is reduced to less than about 10% of the seam thickness extracted by keeping the panels narrow relative to overburden depth. However, in addition to the sag subsidence, there is also some elastic compression of the chain pillars and surrounding strata as a result of redistributed overburden loads. This elastic compression causes a general lowering of the surface that tends to increase with overburden depth.

In Longwall 9, the panel width to depth ratio ranges 0.8-1.0, so the panel is of sub-critical width, but too wide for effective bridging. The maximum subsidence in this situation is likely to be sensitive to small changes in overburden behaviour. A conservative approach is necessary for estimating maximum subsidence.

For practical purposes, the subsidence profiles developed over each goaf edge are expected to be essentially similar. The dynamic profile developed over the longwall panel as it retreats may be flatter than the final goaf edge profiles developed over the start, finish and sides of each panel, but any differences are not expected to alter the impacts significantly and will tend to be temporary in nature.

Permanent strains and tilts are expected to develop over each of the longwall goaf edges, although these will be much more significant over Longwalls 5, 6 and 9 than over the narrower panels. Transient tilts and strains up to near maximum values are expected above the retreating longwall face.

4.3 Relevance of Input Data

Previous monitoring experience at Ashton relates to overburden depths of less than about 90m. The overburden depth within the Application Area ranges from 100-190m, so while there is likely to be a softening of the strain and tilt magnitudes with depth, the general subsidence behaviour is not expected to be significantly different for full width panels.

For the narrower panels, only the previous subsidence monitoring results from the start of Longwalls 1, 2 and 3 is relevant. However, there was a significant difference between the results from these three panels, so the more conservative Longwall 2 results were used for design and experience from elsewhere has been used to confirm the bridging behaviour that is expected.

The Western Coalfield experience has been used to estimate subsidence at Ashton because the overburden stratigraphy, overburden depth and longwall widths on which the Western Coalfield experience is based is essentially similar to those at Ashton. Maximum values from the Western Coalfield experience have been used to provide a conservative, upper bound estimate of the subsidence that is likely, recognising that the subsidence monitoring over Longwalls 1, 2 and 3 is generally within the predicted range using this approach.

The strains and tilts are expected to be sufficiently high to cause significant disturbance to the surface and infrastructure directly over the full width longwall panels. Any inaccuracy in the predictions is not expected to alter the outcomes in these areas.

Much lower subsidence values are expected over the narrower panels, but in these areas there is potential for inaccuracies in the predictions to significantly alter the outcomes. A conservative approach has been used.

4.4 Identification of Assumptions

The predictions of maximum subsidence at Ashton are based on the observation that maximum subsidence above longwall panels in New South Wales for single seam operations has not been recorded as exceeding 65% of the seam thickness mined. The maximum subsidence at Ashton is expected to be less than this maximum.

For the low subsidence areas, there is more potential for natural variations in strata behaviour to cause more or less subsidence than predicted. The assumption is made that the subsidence behaviour over the narrow longwall panels will be similar to the bridging behaviour observed over narrow panels at the start of Longwalls 2 and 3, as well as at other sites.

There is also an implicit assumption that the bridging subsidence measured over Longwall 2 as dynamic subsidence and at other sites within the timeframe of mining or soon after, reflect the long term subsidence behaviour. While there may not be any significant changes in loading in the long term depending on future mining, the strength of bridging rock may reduce over time.

There may therefore be potential for some additional subsidence movements to gradually develop over the long term in the areas above the narrow panels where bridging occurs. A program of ongoing monitoring is recommended to measure whether this effect is significant or not.

At Ashton, the mine is expected to fill up with water once mining is complete, so any discrepancies between the short and long term subsidence behaviour are not likely to have a significant hydrogeological impact on Bowmans Creek in the long term.

4.5 Reliability of Predictions

For the full width panels, the subsidence predictions and the goaf edge subsidence profiles are expected to provide an upper limit estimate of the subsidence. It is considered most unlikely that maximum subsidence would exceed predictions, but actual maximum subsidence at any one point may well be up to 30% less than predicted. This reduction may occur as a result of natural variations in overburden strata behaviour.

In the low subsidence areas above the narrow panels, the upper limit on the sag subsidence can be predicted with reasonable confidence in the short term based on previous monitoring. The actual maximum subsidence may be much less than the maximum but is unlikely to be significantly greater than the predicted maximum. Any increase over the long term as a result of gradual failure of the overburden bridge is less predictable and monitoring will be required to confirm whether or not there is any significant increase over time.

The magnitude of vertical subsidence over the chain pillars is not likely to be predicted with the same level of accuracy as the maximum subsidence over the centre of each longwall panel. The pillars range from normal size longwall pillars to much larger pillars between the narrow panels. While there is a large database of subsidence experience above normal size chain pillars on which to base predictions, there is less experience above the larger pillars. However, recognising that the subsidence levels over the larger pillars will be lower, any error in magnitude of subsidence is of relatively little significance compared to the larger subsidence movements over the longwall panels themselves.

5. SUBSIDENCE ESTIMATES FOR ASHTON

The subsidence predictions at Ashton are based on the empirical experience at similar panel width and overburden depth including measurements at the start of Longwalls 2 and 3. This experience is summarised in Figure 20. The subsidence predictions are divided into three sections to reflect the different panel width to depth ratios.

5.1 Full Width Panels – Longwalls 5 and 6

For the full width panels, Longwalls 5 and 6, maximum subsidence is expected to be less than 65% of seam thickness. Over Longwalls 1 and 2 maximum subsidence was 50-55% of seam thickness, but for impact assessment purposes, a conservative approach has been adopted and maximum subsidence of 65% of seam thickness is used. For a seam thickness of 2.4m, maximum subsidence over Longwalls 5 and 6 is expected to be less than 1.6m.

Empirical experience also indicates that, at overburden depths of 150m, subsidence above the chain pillars that separate individual longwall panels is likely to be in the range 150-250mm. For the chain pillar between Longwall 4 and Longwall 5 at 130m overburden depth, chain pillar compression is expected to be less than 200mm and for the chain pillar between Longwall 5 and Longwall 6, subsidence is expected to be less than 250mm.

Maximum strains, tilts and curvatures are predicted on the basis of empirical relationships that have been developed from observations in the Western Coalfield (Holla 1991). This empirical dataset has been chosen because the overburden stratigraphy and longwall panel geometries at Ashton are more typical of the Western Coalfield than of the Newcastle Coalfield. The Western Coalfield guidelines give estimated strains and tilts that are higher than those indicated by the Newcastle Coalfield guidelines so the predicted subsidence values are expected to be conservative and proved to be so over Longwall 1.

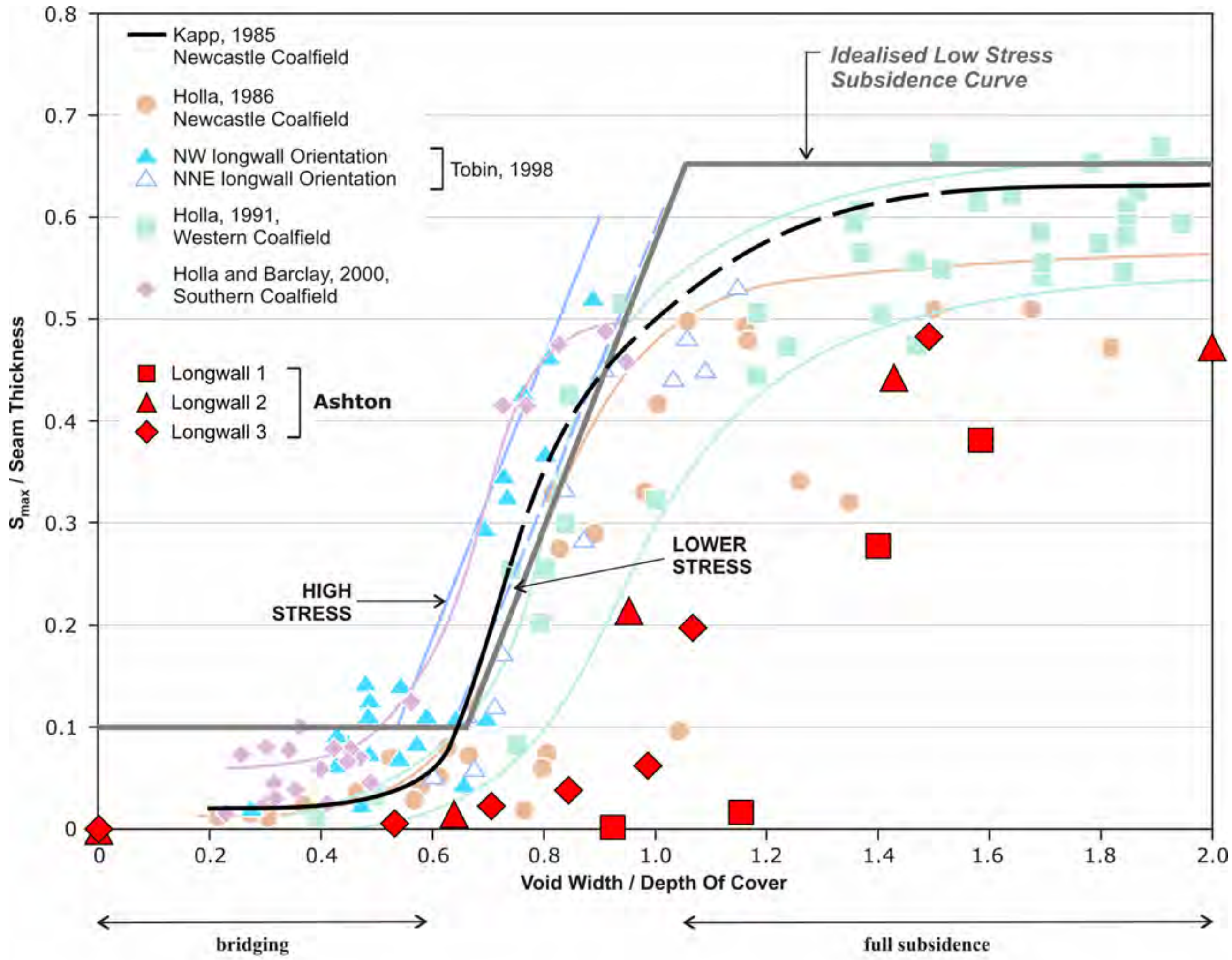

Figure 20 Summary of dynamic subsidence plotted against panel width to depth ratio.

Maximum strain and tilt parameters have been calculated using the formulae:

$$E_{max} \text{ (tensile strain)} = K_1 S_{max} / D$$
$$E_{max} \text{ (compressive strain)} = K_2 S_{max} / D$$
$$G_{max} \text{ (tilt)} = K_3 S_{max} / D$$

Where K_1, K_2 and K_3 are nominally constants although in practice there is a large natural variation at any given site, Smax is the maximum subsidence and D is the overburden depth. K values of 1500, 2000 and 5000 respectively are used for prediction of strain and tilt when the maximum subsidence of 65% of seam thickness is used. In practice, the maximum subsidence has been approximately 50% of seam thickness extracted at Ashton and the maximum strains and tilts have been approximately half the predicted values in most cases, but for impact assessment purposes these generic values are considered appropriate.

Table 2: Predicted Subsidence Movements

Domain	Maximum Subsidence (mm)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)	Maximum Tilt (mm/m)
LW5	1600	20	27	67
LW6	1600	17	23	57

Goaf edge subsidence is expected to be less than 100mm and the angle of draw to 20mm is expected to be less than 17°.

Minimum systematic curvature is expected to be less than 2.5km based on experience in the Western Coalfield (Holla 1991).

Systematic horizontal movements of 0.3-0.5m are expected, with the ground initially moving in a direction toward the approaching longwall panel and then, once the longwall face is approximately 0.2-0.3 times depth (25-40m) past, the direction of movement reverses and is toward the retreating longwall face, typically leaving a permanent offset of up to 0.2m in the direction of mining.

In areas of sloping surface topography, downslope movement of up to about 0.3m is likely to be superimposed onto the systematic horizontal movement.

Surface cracks are expected to be less than 200mm wide at 100m overburden depth and less than 50mm wide at 200m overburden depth. Cracking is likely to be most apparent at the start of each panel and parallel to the longwall goaf edges. Permanent tension cracks are expected to develop over all the goaf edges in a direction parallel to the goaf edge. Surface cracking is expected to occur from just outside the goaf edge and increase in magnitude with distance over the goaf reaching a peak at the largest crack located approximately 25-40m from the goaf edge. Cracks are also expected to develop in an arcuate shape around the corners of the longwall panel to become parallel with the longwall face in the centre of each panel.

5.2 Narrow Panels – Miniwalls 5-9

In the narrow panels below Bowmans Creek, maximum subsidence is a combination of low levels of sag subsidence over individual panels and more general lowering of the surface associated with elastic compression of the chain pillars and the rock strata above and below these pillars.

For panel width to depth ratios of 0.6, maximum sag subsidence is expected to be less than 10% of the seam thickness extracted and may be as low as 2% depending on the overburden strata behaviour. For 2.4m extraction height, the maximum sag subsidence is expected to be in the range 0.05-0.24m.

Subsidence associated with elastic compression of the chain pillars depends on the relative geometry of individual chain pillars and the weight of overburden strata that is redistributed onto these chain pillars.

Miniwalls 5 and 9 are isolated between large barrier pillars so that there is unlikely to be any significant chain pillar compression and subsidence is due entirely to sag subsidence. Maximum subsidence above both these panels is therefore expected to be in the range 50-240mm.

Miniwalls 6, 7 and 8 are separated by 30m wide chain pillars at depths ranging from 120m to 180m. Consideration of the weight of overburden strata redistributed from above each longwall panel onto the chain pillars indicates that elastic pillar compression is likely to be in the range 100-200mm. The total subsidence in the centre of the longwall panels is the sum of the chain pillar compression and sag subsidence less an allowance for the goaf edge subsidence. The goaf edge subsidence is associated with sag subsidence but occurs over the chain pillars where pillar compression occurs. For the narrow panels at Ashton, goaf edge subsidence is expected to be less than about 40mm.

Table 3 summarises the maximum subsidence parameters that are expected over the various narrow panels based on the sag subsidence of 240mm. Values of K_1 = 2000, K_2 = 2600 and K_3 = 7000 have been used because these better fit the actual measured results over Longwall 1 and are more conservative to use than the generic Western Coalfield data based on maximum subsidence of 65% of seam thickness extracted.

Table 3: Summary of Predicted Maximum Strains & Tilts for Narrow Panels

Site	Maximum Subsidence (mm)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)	Maximum Tilt (mm/m)
Miniwalls 5 and 9	200	3.2	4.2	11
Miniwalls 6, 7 and 8	350	3.2	4.2	11

Goaf edge subsidence over the narrow panels is expected to be less than 40-50mm and the angle of draw to 20mm is likely to be less than 10°.

The radius of ground curvature is expected to be less than 2.5km based on experience in the Western Coalfield.

Horizontal subsidence movements of up to 200mm are considered possible in sloping terrain adjacent to Bowmans Creek, but horizontal movements over the narrow panels are likely to be generally less than 50mm.

Surface cracking is possible on hard surfaces such as rock outcrop and tarsealed road, but most of the surface area above the narrow panels is pasture and perceptible surface cracking is not expected.

5.3 Longwall 9

Longwall 9 is constrained to be less than full width by the lease boundary. The width to depth ratio of the panel is approximately 1.0 which makes the prediction of maximum subsidence difficult because small differences in overburden behaviour can result in large differences in maximum subsidence.

Full subsidence of 50-55% of seam thickness develops when the panel width to depth ratio reaches 1.2. Monitoring at the start of Longwall 2 showed maximum dynamic subsidence of approximately 20% of seam thickness when the width to depth ratio was 1.0, but measurements from other sites in the Hunter Valley have shown maximum subsidence up to 40% of seam thickness for width to depth ratios of 1.0. For impact assessment purposes, the maximum subsidence over Longwall 9 is estimated using 50% of seam thickness recognising that the actual maximum ground subsidence is likely to be in the range 0.5-1.0m based on previous monitoring. The surface subsidence may be greater in the area of the spoil pile. The strain and tilt values are calculated using K values of 1500, 2000 and 5000.

Table 4: Predicted Maximum Strains & Tilts for Longwall 9

Site	Maximum Subsidence (mm)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)	Maximum Tilt (mm/m)
Longwall 9	1200	15	20	50

Much of the surface above Longwall 9 is part of an out of pit spoil dump. Whittaker and Reddish (1989) provide a method for estimating the additional subsidence that can be expected when a spoil dump is subsided. This method is summarised in Figure 21. Assuming the average height of the spoil pile is 15m, and the average overburden depth is 150m, the Whittaker and Reddish approach indicates that most likely subsidence of 0.8m at the ground surface has the potential to cause an additional 0.2m of surface subsidence at the top of the spoil pile. This extra subsidence is within the upper bound estimate of 1.2m.

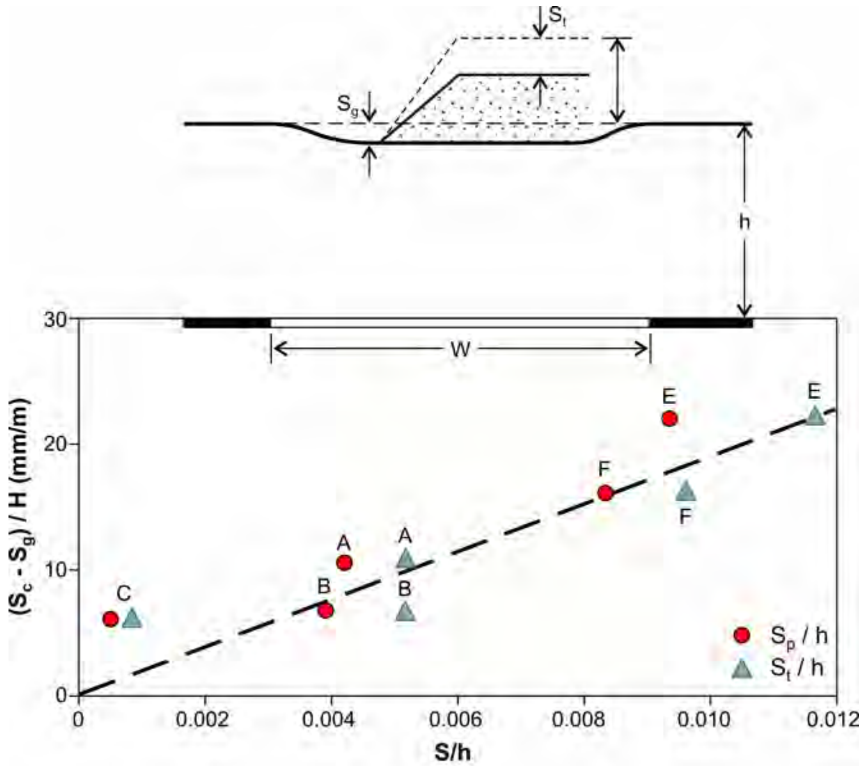

Figure 21 Summary of subsidence estimate technique
(after Whittaker and Reddish.)

On natural surfaces, goaf edge subsidence is expected to be less than 100mm and the angle of draw to 20mm less than 17°, however these may increase in spoil pile areas depending on the thickness of spoil and how well it has been compacted.

Systematic horizontal movements of 0.3-0.5m are expected, with the ground initially moving in a direction toward the approaching longwall panel and then, once the longwall face is approximately 0.2-0.3 times depth (30-45m) past, the direction of movement reverses and is toward the retreating longwall face, typically leaving a permanent offset of up to 0.2m in the direction of mining.

In the spoil dump area, movement in a downslope direction of up to about 0.5m is likely to be superimposed onto the systematic horizontal movement.

Surface cracking of up to about 200mm is expected in the vicinity of the longwall goaf edges. Permanent tension cracks are expected to develop over all the goaf edges in a direction parallel to the goaf edge. Surface cracking is expected to occur from just outside the goaf edge and increase in magnitude with distance over the goaf reaching a peak at the largest crack located approximately 25-40m from the goaf edge. Cracks are also expected to develop in an arcuate shape around the corners of the longwall panel to become parallel with the longwall face in the centre of each panel.

5.4 Profiles and Contours of Final Subsidence

Figure 22 shows a summary of the range of goaf edge subsidence profiles that have been measured over longwall panels at similar overburden depth in the Western Coalfield. These profiles are used to predict the subsidence profiles at Ashton. The ground surface at Ashton is expected to drape over the solid goaf edges with subsidence profiles within the limits shown in Figure 22. The measured results show the range of natural variability that can be expected.

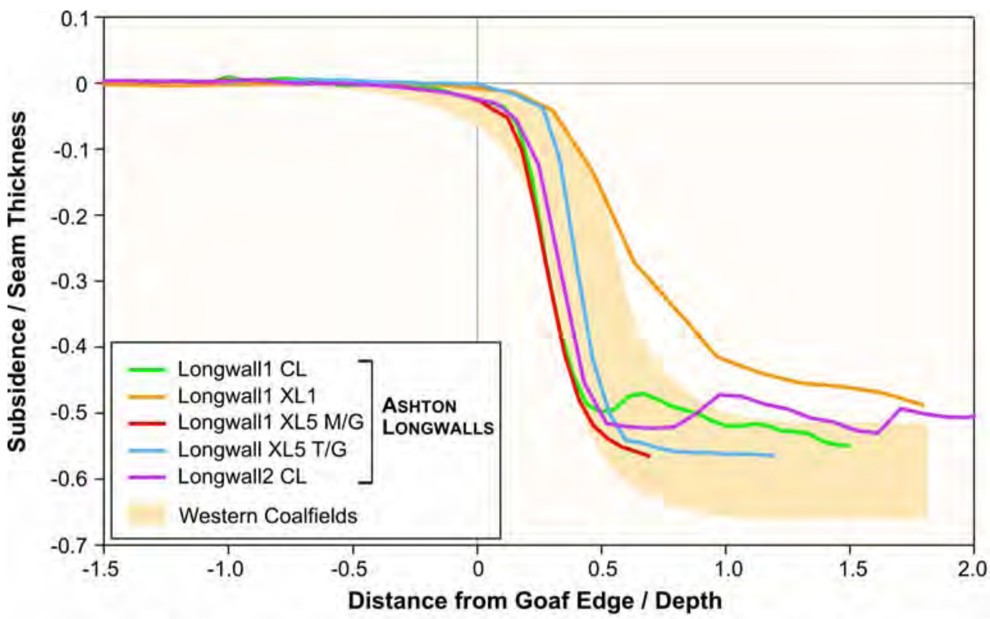

Figure 22 Summary of the goaf edge subsidence profiles from western coalfields and Longwalls 1-3 at Ashton.

Figure 23 shows cross-sections of the final subsidence profiles that are expected based on the upper bound (greatest subsidence) goaf edge subsidence profiles shown in Figure 22 with allowance for panel width and overburden depth.

Figure 24 shows contours of the final subsidence that is expected at the completion of mining.

6. ASSESSMENT OF SUBSIDENCE IMPACTS

In this section, the impacts on the natural features and surface improvements of the expected subsidence movements are assessed and described.

6.1 Natural Features

The main natural features of interest in and adjacent to the Application Area are Bowmans Creek and its associated alluvial flats, and the Hunter River.

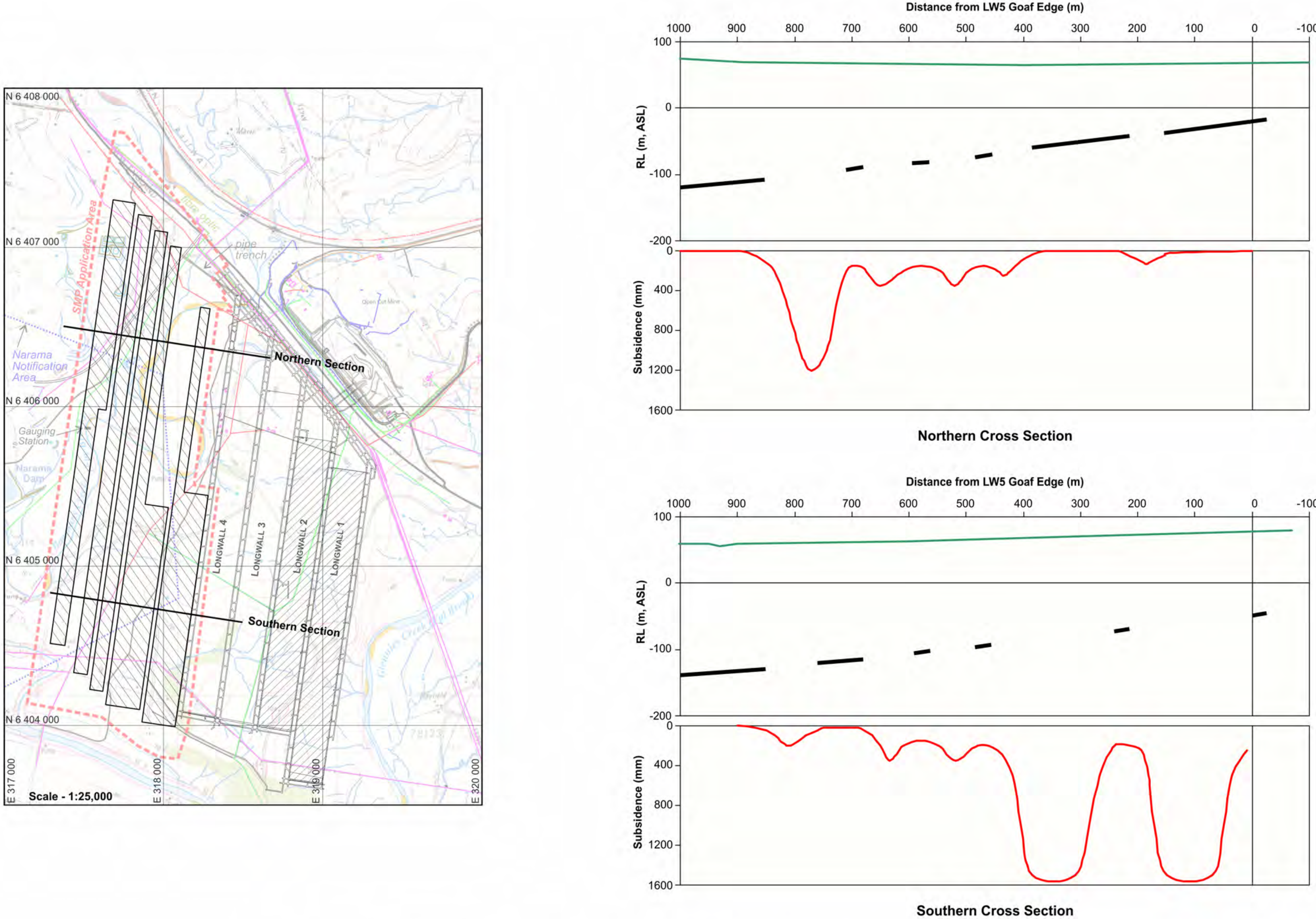

Figure 23 Cross section of final subsidence profiles expected on two cross sections.

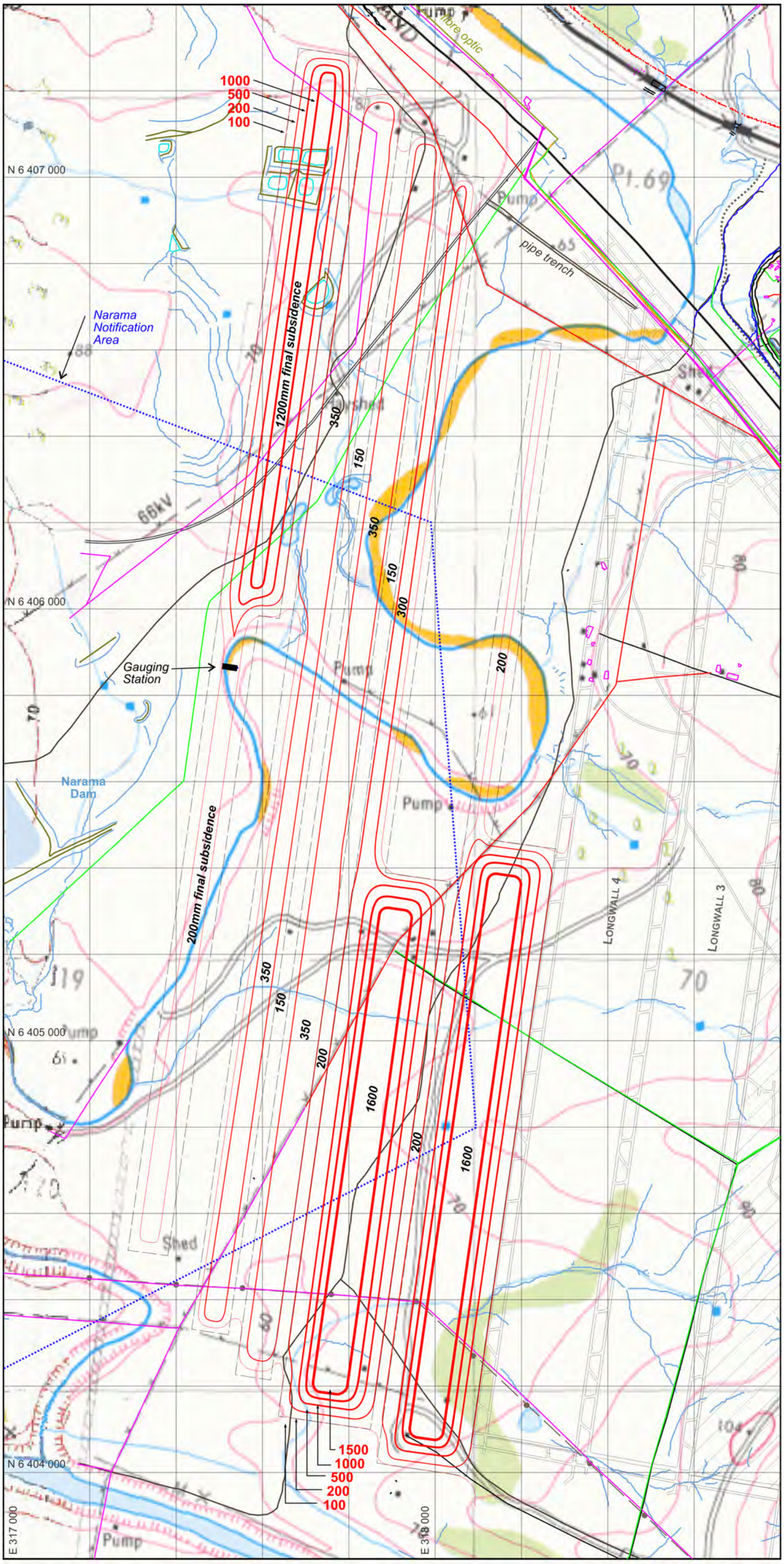

Figure 24 Contours of final subsidence expected at the completion of mining.

6.1.1 Bowmans Creek

The mine layout has been designed specifically to control the hydraulic interaction between the surface water in Bowmans Creek and adjacent alluvium and the underground mine. Numerical modelling (reported elsewhere) has indicated that by narrowing the individual panels to approximately 0.6 times overburden depth, the hydraulic interaction between the mine and Bowmans Creek can be controlled to acceptable levels.

The proposed mine layout is expected to cause vertical subsidence along Bowmans Creek of up to approximately 350mm where it crosses Miniwalls 7 and 8. Over Miniwall 6, vertical subsidence of up to 300mm is expected. Over Miniwalls 5 and 9 vertical subsidence of up to 240mm is expected. The sections of the creek channel subject to the peak subsidence are likely to be only 5-10m long with subsidence decreasing back to less than 150mm over the chain pillars.

There is therefore some potential for localised ponding within the creek channel, but this level of ponding is considered unlikely to be outside the variability that is currently evident within the channel or that occurs naturally during flood scouring.

Strains of less than 3-4mm/m are unlikely to be evident in the floor of the creek channel.

Local tilting of the surface may cause the stream channel to move sideways within the creek bed, but for the low tilt levels expected and the short distances over which tilting is occurring, the changes are expected to be within the natural variation that is evident naturally in the creek.

6.1.2 Hunter River

The Hunter River is located 260m outside the Application Area, consistent with the 200m offset from the Hunter Alluvium specified in the Development Consent. There is considered to be no potential for subsidence to impact on the Hunter River itself.

There is considered to be potential for hydraulic interaction between the Hunter River alluvium and the goaf of the proposed longwall and miniwall panels through overlying seams that may subcrop in the base of the Hunter River. We understand that this potential has been assessed by Aquaterra (2008) in a hydrogeological context and found to be insignificant.

6.1.3 Ponding Above Longwalls 5 and 6

Subsidence over Longwalls 5 and 6 is expected to cause vertical subsidence of up to 1600mm. The ground slope above Longwalls 5 and 6 is expected to be sufficient to allow continued surface flow to the south into a section of natural water channels that has been dammed to act as a water storage reservoir.

There is potential for ponding on the flatter ground either side of the spur that leads down to the house and other buildings located above the northern end of Longwall 6. Some channel excavation is likely to be necessary to re-establish a natural flow path, but there is sufficient fall to Bowmans Creek and tributary drainage gullies for such a channel to be developed with only minor earthworks. The cutting of such a channel would not be out of character with other surface drainage works that have previously been undertaken for agricultural purposes.

6.1.4 General Surface Cracking

The surface cracking that is expected to develop over the goaf edges of Longwalls 5, 6 and 9 as a result of mining subsidence is likely to require remediation to prevent ingress of surface water, injury to livestock, or entrapment of small animals. This process has been successfully undertaken over Longwalls 1 and 2 and there does not appear to be any impediment to similar treatment within the Application Area.

6.2 Surface Improvements

The impacts of mining subsidence on the various items of surface infrastructure located within the Application Area are assessed in this section starting with major and minor non-mining infrastructure within the Application Area, mining infrastructure associated with operations other than Ashton, and finishing with Ashton owned infrastructure.

6.2.1 New England Highway

The southern edge of the road reserve is located some 70-90m from the northern ends of Miniwalls 6-8 and Longwall 9. The main headings pass directly under the highway. The depth of overburden in this area ranges from 90-130m.

The main heading pillars are nominally 18m wide with variable length ranging from 30-100m. The pillars are nominally 2.7m high giving them a width to height ratio of 6.7 and a nominal strength of approximately 24MPa. The tributary load from the weight of overburden rock at 120m deep is approximately 5MPa, so the pillars are only lightly loaded and would be expected to remain stable for the long term.

The subsidence expected above Miniwall 5 is less than 240mm and the distance from the end of the panel to the bridge over Bowmans Creek is approximately 300m, so the bridge is not expected to experience any perceptible subsidence movements as a result of mining within the Application Area.

The end of Miniwall 8 comes within approximately 70m of the New England Highway road reserve and is the closest of all the panels. The subsidence movements within the highway road reserve are expected to be imperceptible for all practical purposes. Vertical subsidence is expected to be less than 20mm at a distance of less than 20m from the goaf corner and horizontal subsidence movements are expected to be imperceptible beyond about 40m from the goaf corner. No impacts on the New England Highway road reserve are expected.

6.2.2 Buried Fibre Optic Cable

The Powertel fibre optic cable comes within 100m of the end of Miniwall 6 before it passes under the highway and follows the northern side of the highway further west. The overburden depth at this location is approximately 120m. Subsidence movements at the location of the fibre optic cable are expected to be imperceptible for all practical purposes. The effective angle of draw is approximately 40° from the corner of a panel where the maximum vertical subsidence is less than 300mm. This geometry and the low level of subsidence are expected to be sufficient to provide a high level of protection to the buried fibre optic cable.

6.2.3 132kV & 66kV Electricity Lines

Two electricity lines (one 132kV and one 66kV) supported on single poles are located along the southern side of the New England Highway. Both lines cross the highway near the intersection with Brunkers Lane. The poles are supported with multiple stays in this area. The corner poles are located approximately 100m from the end of Miniwall 6. The effective angle of draw is approximately 40° from the corner of a panel where the maximum vertical subsidence is less than 300mm. This geometry and the low level of subsidence are expected to be sufficient to provide a high level of protection to these lines.

A second 132kV electricity line crosses the southern end of all the longwall panels. This line is supported on a two pole structure for the straight sections and three stayed poles at changes in direction. The two and three pole structures located over the two full width panels, Longwalls 5 and 6, are expected to experience the full range of subsidence movements.

Similar two pole structures above Longwall 1 remained fully operational through the full range of subsidence movements. The conductors were placed in sheaves, but no other mitigation works were required. The two pole structure above the eastern side of Longwall 5 may become permanently tilted in a westerly direction by up to about 70mm/m and move horizontally in the same direction at the base by up to 200mm. Assuming the poles are 18m high, up to 1.5m of permanent westward movement at the top of both poles is possible. However, it has been common to find that the maximum tilt at ground level is not reflected in the tilt of the poles because of ground loosening and other effects. The differential movement between the two poles is expected to be less than it was for the poles located over the centre of Longwall 1.

The braced three pole structure is located approximately 45m from the goaf edge. The poles are double braced with wire stays and tied together at the top of each pole. The conductors are also fixed to the poles. Each stay is approximately 6m from the base of the pole it braces. The entire footprint is approximately 20m in size.

With maximum horizontal strains of up to 25mm/m, differential horizontal movements of up to 500mm are possible, although in reality they are likely to be less than 300mm because of the direction of maximum strain is not likely to coincide with the long axis of the structure. Most of the early differential movement is likely to be tensile or stretching with some late stage compressive movement possible depending on the exact location of the poles.

Maximum tilts are expected to cause up to 1.3m of movement at the top of each pole.

The distance between points of maximum tilt and strain and points where there is no tilt or strain is expected to be less than 20m, so it is likely that the ground around the first pole will be at maximum tilt with maximum horizontal movement in a south-easterly direction before the northern-most stay has begun to move. Similarly, the southern pole will have finished moving, probably with some residual tilt and horizontal movement, by the time that the northern pole is experiencing full tilt and horizontal movement.

The three poles are joined together at the top in tension, so there is likely to be some load redistribution. We recommend that the structures are assessed to determine the level of mitigation measures that may be required.

6.2.4 Local Area Electricity Lines

Several local area electricity lines cross the Application Area. These are supported on single pole structures, some with the conductors suspended from insulators and others fixed directly to cross-arms.

Single pole structures are typically capable of accommodating subsidence movements. It is sometimes necessary to disconnect individual conductors and suspend them in sheaves to avoid overloading the cross-arms.

Poles located over the narrow longwall panels are not expected to require any mitigatory work. Poles located over Longwalls 5, 6 and 9 are likely to require the conductors to be placed in sheaves during the period of undermining and may require poles located near the edge of panels, where tilts are permanent, to be straightened as part of routine maintenance once mining is complete. Poles that are braced with wire stays need to be individually assessed to determine the level of mitigatory work required.

6.2.5 Buried Telstra Lines

Three buried, copper wire, Telstra lines cross the Application Area. A section of these lines that crosses Longwalls 1 and 2 has remained serviceable throughout the mining of both panels. Typically buried copper lines in good repair are likely to remain serviceable where ground strains are less than about 20mm/m. Maximum ground strains over Longwalls 1 and 2 reached 40mm/m in some areas where the Telstra line is buried. Predicted ground strains are generally less than 5mm/m over the narrow panels, but reach 20-30mm/m over the full width panels.

There is considered to be some potential for the Telstra cable to become unserviceable as a result of the proposed mining. However, we understand Ashton will have the western line tested prior to mining and returned to its pre-mining state of serviceability at the completion of mining. The eastern line within the Application Area, only services Ashton properties and consultation with the users will result in remediation of any line damage as required.

6.2.6 Bowmans Creek Flow Gauging Station

A flow gauging station is located on Bowmans Creek above the centre of Miniwall 9. Subsidence at the location of the weir is expected to reach a maximum of 200mm at the western end and 140mm at the eastern end. The gauging house is expected to subside approximately 200mm.

The section of the channel where the weir is located will also subside by a similar amount, so there is not expected to be more than a few centimetres of relative movement once mining has finished, but there will be a transient effect when mining is proceeding directly under the site.

Tilting of the weir and possible structural cracking of the concrete may affect the accuracy of the flow gauging station, so it is possible that some remedial work may be required to bring that weir back into operation.

The detail of the cables connecting the weir to the gauging house have not been investigated, but at the low levels of strain expected, damage to the cabling is not anticipated. The radio communication link used for regional data transfer from this station is not expected to be impacted by mining subsidence.

6.2.7 Brunkers Lane (Private Road)

The tarsealed section of Brunkers Lane is expected to subside up to 350mm above Miniwalls 6-8 (up to the gate to Macquarie Generation land) and up to 1200mm above Longwall 9 (between the gate to Macquarie Generation and the gate to Ravensworth). The impacts for these two sections are described separately.

Along the section of Brunkers Lane between the New England Highway and the Macquarie Generation gate, maximum strains are likely to be less than 3-4mm/m and tilt along the alignment of the road is likely to be less than 5mm/m. Some cracking of the pavement surface is likely to be perceptible and dips in the road over each panel may also be perceptible. However, this section of the road is expected to remain serviceable throughout mining with some maintenance and minor regrading possibly required to accommodate heavy traffic or low clearance, low-loaders carrying heavy machinery.

Along the section of Brunkers Lane located above Longwall 9, up to 1200mm of subsidence is expected with horizontal strains of up to 20mm/m and maximum tilts of 50mm/m (but only 25mm/m along the direction of the road).

These levels of vertical subsidence, strains and tilts are expected to cause perceptible cracking and buckling of the pavement surface starting soon after Longwall 9 mines under the road continuing until it is approximately 100m past. Gradual subsidence of 100-200mm may continue for some months before it stabilises at a final level expected to be less than 1200mm and most likely in the range 0.5-1.0m.

We recommend that a management plan for the road is developed in consultation with the relevant stakeholders so that access can be maintained to Macquarie Generation land and to Ravensworth Open Cut when required. Some filling, regrading and resealing of the road is likely to be required once subsidence is complete, particularly along the section south of the Macquarie Generation gate.

6.2.8 Macquarie Generation Access Road

The alternative access to Macquarie Generation land continues from Brunkers Lane as a gravel road. This road is mainly located over the low subsidence area at the northern end of Miniwall 8, but also crosses the northern end of Longwall 9. The overburden depth in this area is approximately 145m.

Subsidence movements are expected to cause perceptible cracking and grade changes on this road, but remediation is likely to be much simpler than along the tarsealed section of Brunkers Lane. Regrading and filling of cracks as required is expected to be an effective control measure.

6.2.9 Macquarie Generation Sedimentation Ponds

The four clay lined sedimentation ponds and a fifth downstream dam located over Longwall 9 at an overburden depth of approximately 150m are expected to experience the full range of subsidence movements.

Mining subsidence movements are expected to cause temporary and permanent tensile cracking in the ponds with up to about 1.0m of differential settlement across the two western ponds and the downstream dam. The two eastern ponds are likely to experience mainly transitory subsidence.

Some remedial work is likely to be required to restore the overflow levels to their pre-mining condition. Some resealing of cracks may also be necessary to ensure the integrity of the dams. We would recommend that the dams are pumped down during the few weeks of mining under them as a precaution against cracks that may allow uncontrolled discharge and possible erosion of the dam wall.

6.2.10 Polyethylene Water Pipes

The polyethylene pipes located in open trenches or laying on the surface are not expected to be impacted by mining subsidence.

The buried polyethylene pipes located over Longwalls 5, 6 and 9 are expected to experience the full range of subsidence movements including tensile strains of up to 20mm/m and compressive strains of up to 27mm/m. These strains are expected to exceed the 5-10mm/m working strains of polyethylene if they are concentrated at a point and there is tight contact between the fill material and the pipe. However, the contact between the ground and the pipe is not expected to be sufficiently tight for all the ground strains to be transferred to the pipe.

Peng (1992) reports findings from Kratzsch (1983) that show that 300mm diameter pipelines without bituminous coating are capable of generating 5 tonnes/m of axial load in the pipe when buried in a sand matrix. Assuming that all of the predicted strain is concentrated on one or two cracks, instead of spread out across a standard 8m bay length (for 160m deep), the cracks would be up to 160mm wide. Cracks of this width have been previously observed at Ashton, but at generally shallower depth. Assuming that the ground is capable of generating 5 tonnes/m, the ground movements would be able to generate sufficient axial load to overstress the pipe (15-30 tonnes depending on the pipe size) every 3-6m.

On the basis of these calculations, it would appear that there is potential for the buried polyethylene pipes to become overstressed if there is good contact between the backfill and the pipe, particularly if subsidence movements are concentrated at large cracks or compression humps.

A failsafe strategy would involve exposing the buried pipeline so that shear could not be generated between the soil and the pipe or bypassing sections across the surface with a temporary pipe and reconnecting back to the buried pipe once it is confirmed that the buried section remains serviceable.

The subsidence cracks generated at the start of Longwalls 5 and 6 are expected to be the largest of any cracking likely to develop within the Application Area. A trial of the response of the Ashton owned buried water pipe to subsidence movements in this area is recommended to confirm that the pipes can sustain the subsidence movements without becoming overloaded.

6.2.11 Narama Dam

Narama Dam is an earth dam located outside the Application Area west of Miniwall 9. The toe of the dam is 270m from the nearest goaf edge of Miniwall 9 and the maximum subsidence anticipated above Miniwalls 7-9 is 350mm. Subsidence movement at Narama Dam are expected to be imperceptible. We recommend that the existing network of survey pegs around Narama Dam is monitored at the completion of each of Miniwalls 7-9 to confirm the low levels of movement expected.

6.2.12 Proposed Water Storage Dam

A second water storage dam is planned west of the north-western corner of the Application Area within the timeframe of mining Longwalls 5-9. This dam will also be located outside the mining area, but the DSC Notification Area will overlap with the Application Area. The details of this dam remain uncertain, but we recommend that it is located remote from Longwall 9 and designed to accommodate the small horizontal movements that may occur as a result of up to 1.2m of subsidence over Longwall 9.

6.2.13 Ashton Infrastructure

Ashton owned infrastructure located within the Application Area includes several farm buildings and houses, three farm dams, farm roads, fences, a fresh water polyethylene pipe from the Hunter River, and the mine pump out polyethylene pipe from the southern end of the panels.

The Ashton owned houses and farm buildings located within the footprint of Longwall 5 and 6 are expected to experience the full range of subsidence movements. Typically strains greater than about 7mm/m cause structural damage, so the predicted strains of 20-27mm/m are likely to render the houses and associated buildings, particularly the brick buildings unserviceable. Buried pipe work, sewerage and stormwater drainage are likely to be damaged. The house over Longwall 6 is expected to remain permanently tilted by up to 50mm/m. Given that the house is likely to be permanently damaged, removal or isolation prior to subsidence may be more cost effective than remediation afterwards. Depending on how this structure is viewed, mitigation and remediation work may be covered by the Mine Subsidence Board.

The two Ashton owned polyethylene pipes that traverse the surface above Longwalls 5 and 6 provide an opportunity to confirm the resilience to subsidence of these types of buried pipes ahead of mining under similar pipes associated with adjacent mining operations.

6.2.14 Disused and Dilapidated Infrastructure

The two disused pump stations located along Bowmans Creek and a dilapidated shed located on the Macquarie Generation land beyond the northern end of Miniwall 7 are currently in an advanced state of disrepair. Any mining subsidence movements are not likely to significantly change this status.

7. RECOMMENDATIONS FOR SUBSIDENCE MONITORING

A program of subsidence monitoring is recommended to confirm that the subsidence behaviour is developing as expected.

A cross-line with pegs spaced at 5m centres and measured in three dimensions is recommended across the middle of all the southern panels and a second line across the middle of all the northern panels. Peg to peg strain measurement is not required given the high strain levels anticipated. It is recommended to survey this line for each panel once the longwall has mined at least 150m past. Additional surveys as the longwall face approaches and passes would provide useful information on the development of vertical and horizontal subsidence movements over longwall panels at Ashton.

A longitudinal subsidence line at the start of each longwall panel is recommended to continue to provide early confirmation of the overburden strata bridging behaviour at Ashton. Once the longwall had retreated 200m, it would no longer be necessary to continue surveying. The line should extend 50m beyond the start of the block.

Monitoring of individual items of infrastructure is recommended on an as required basis.

8. CONCLUSIONS

In the area of the reduced panel widths (60-93m), surface subsidence is expected to be limited to less than 350mm and to be generally less than 200mm. At the southern ends of Longwalls 5 and 6 where 215m wide panels are proposed, the maximum subsidence is expected to be less than 1600mm and most likely in the range 1.2-1.3m. At the northern end of Longwall 9 the maximum subsidence is expected to be less than 1200mm and most likely in the range 0.5-1.0m.

Estimates of strains and tilts are based on guidelines developed in the Western Coalfield and the results of the monitoring over Longwalls 1 and 2.

Mining within the Application Area is expected to cause low levels of subsidence along Bowmans Creek with maximum subsidence of 350mm over a few tens of metres of the creek channel in the centre of Miniwall 7 and up to 300mm at the other crossing points.

Mining subsidence is expected to cause cracking in the ground surface above Longwalls 5 and 6 and cracks may also be apparent on the tarseal surface of Brunkers Lane above Longwall 9. Subsidence may lead to localised ponding areas following rain in flatter areas over Longwalls 5 and 6. This potential has been assessed separately by others.

Much of the surface and surface infrastructure within the Application Area is owned by Ashton and improvements are therefore not required to be assessed within the SMP Approval process. However the mining impacts on most of Ashton infrastructure have been assessed within the body of this report for completeness and where there is potential for consequential impacts.

A 132KV electricity line that traverses the surface above the southern end of all the panels is not likely to be significantly impacted by mining subsidence movements based on previous experience of mining under the line. However, a three poled structure with bracing stays located at a bend in the line at above Longwall 5 is likely to be sensitive to subsidence movements and requires specific assessment.

Two high voltage electricity lines are located alongside the New England Highway. These are located outside the area where subsidence movements are expected to occur. A buried fibre optic cable also located in this area is outside the area where subsidence movements would be expected.

The New England Highway and the concrete bridge over Bowmans Creek is located over and adjacent to the main headings. The bridge is located approximately 250m from the northern end of Miniwall 5 where the panel is narrowed to 60m and is outside the area likely to be affected by mining subsidence. The main headings are expected to be long term stable. No perceptible subsidence movements are expected within the road reserve.

A local distribution electricity line traverses the Application Area. This line is likely to remain serviceable throughout mining provided the conductors are placed in sheaves and any stays are adjusted as poles are undermined to prevent them becoming overloaded.

A buried Telstra cable traverses the Application Area. Mining subsidence may render this cable unserviceable, although a similar line has remained serviceable during mining of Longwalls 1 and 2.

Farm buildings and a house located on Ashton property over Longwall 6 are likely to experience the full range of subsidence movements and are unlikely to remain serviceable after Longwall 6 has been mined unless some mitigatory works are undertaken to isolate them from the subsidence movements.

Brunkers Lane may experience surface cracking and buckling during mining of Longwall 9, but is expected to remain serviceable with suitable management. Along the section of Brunkers Lane located above Longwall 9, up to 1200mm of subsidence is expected with horizontal strains of up to 20mm/m and maximum tilts of 50mm/m (25mm/m in the direction of the road). We recommend a management plan for Brunkers Lane is developed in consultation with the relevant stakeholders so that access can be maintained to Macquarie Generation land and to Ravensworth Open Cut when required.

Mining subsidence movements are not expected to have any perceptible impact on Narama Dam.

9. REFERENCES

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