7. SUBSIDENCE PREDICTIONS AND IMPACTS

(SMP Guidelines Section 6.7)

7.1. BACKGROUND

Coal extracted through longwall mining methods results in subsidence of the surface. Mining Subsidence Engineering Consultants (MSEC) prepared detailed subsidence predictions for Longwalls 705 to 710 and these are fully described in the report, provided as **Appendix A**.

Using these predictions, specialist consultants identified the likely impacts of the proposed mining on features including the landscape and ecology. Full reports are provided in the appendices to this document. The following sections outline the results of these detailed predictions and impact assessments.

7.2. PREDICTION METHOD AND RELIABILITY

Subsidence predictions are one of the essential input parameters for the assessment of risk and the severity of the consequences associated with the potential impacts on natural and man made features.

In the context of management, the importance of accurate subsidence predictions relates to the quality and effectiveness of the managed solutions.

The *Incremental Profile Method* used by MSEC makes its predictions based on extensive databases of historical monitoring data in the Southern Coalfield. This ensures good confidence in the maximum subsidence profiles predicted.

7.3. METHODS EMPLOYED

The predicted parameters were obtained using the Incremental Profile Model for the Southern Coalfield based on monitoring data from the Bulli Seam. This method is described in detail in **Appendix A**.

The method is an empirical model that is used to predict subsidence, tilts, curvatures and strains likely to be experienced as longwall mining proceeds and assess the likely effects on surface features. The model uses the surface level contours, seam floor contours and seam thickness contours (extraction height) to make the predictions.

The Incremental Profile Method is based on predicting the incremental subsidence profile for each longwall in a series and adding the respective incremental profile to show the cumulative subsidence profile at any stage of extraction.

The method predicts profiles in both the transverse and longitudinal directions, allowing the subsidence, tilts, systematic curvatures and systematic strains to be predicted at any point on the surface. It also allows the magnitude of both transient and residual tilts and curvatures within the subsidence trough to be determined.

The Incremental Profile Method provides a greater understanding of subsidence over a series of panels and allows a detailed prediction of subsidence parameters to be made for any point in the subsidence profile.

Due to the inherent advantages of the Incremental Profile Method, it has been used to make the detailed subsidence predictions for this project. Further details of the Incremental Profile Method are provided in MSEC's report presented as **Appendix A** and the information presented below has been drawn from this report (MSEC, 2008).

7.3.1. Development of Subsidence

The development of subsidence is complex and is a function of geology (e.g. stratigraphy, rock strength, spacing of joints), topography (including location of creeks and rivers) and mining parameters (e.g. depth and method of mining). In the subsidence report prepared by MSEC, further details of the factors that may affect the development of subsidence over the SMP Area are provided.

7.3.2. Assumptions Used

The Incremental Profile Method of subsidence prediction is based on the following assumptions:

- Impacts will be similar to those previously observed in comparable areas;
- There may be anomalous cases where subsidence will not occur as predicted;
- Surface features and land use at the time of the assessment remains similar; and
- Effects on infrastructure include ground strains being fully transferred to the feature.

7.3.3. Reliability of Subsidence Predictions

A summary of the reliability of the predictions is provided below and detailed discussion is provided in the **Appendix A**.

For the proposed longwalls, the predicted maximum values of the subsidence and tilt, obtained using the Incremental Profile Method, are greater than those obtained using the DMR Handbook Method.

The predicted levels of strain obtained using the Incremental Profile Method, are greater than those obtained using the DMR Handbook Method.

The predictions obtained using the DMR Handbook Method are located on the steepest part of the curves. Therefore a small increase in width-to-depth ratio results in a large decrease in strains and curvatures.

Therefore, the Incremental Profile Method should provide realistic, if not conservative predictions of subsidence, tilt and systematic curvature and strain over the proposed Longwalls 705 to 710.

The tilts and systematic curvatures can be predicted to the same level of accuracy, but the measured curvatures and strains can vary considerably from the predicted systematic values due to variations in geology, thick soils masking bedrock movements, strain measurement giving false impressions of the state of strain in the ground and survey errors.

It is also recognized that the ground movements above a longwall can be affected by the gradient of the coal seam, the direction of mining and the presence of dykes, which can result in a lateral shift in the subsidence profile.

The predicted maximum tilts and strains within the SMP Area are, generally, those which are aligned in the transverse direction to the longwall. However, at the ends of the longwall, the maximum tilts and strains are at right angles to the subsidence contours and these values have been calculated where appropriate.

In some cases, the transient or travelling longitudinal tilts and strains can be greater than the transverse values, in which cases the travelling longitudinal values have been adopted for the impact assessments.

7.3.4. Reliability of Closure and Upsidence Predictions

The development of predictive methods for closure and subsidence are the result of relatively recent research and the methods do not at this stage, have the same confidence level as systematic subsidence prediction techniques. As further case histories are studied, the method will be improved, but it can be used confidently so long as suitable factors of safety are applied. This is particularly important where the predicted levels of movement are small, and the potential errors, expressed as percentages, can be higher.

While the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor is thought to influence the closure and subsidence movements, is the level of an in-situ horizontal stress that exists within the strata.

In-situ stresses are not regularly measured and the limited availability of data makes it impossible to be definitive about the influence of the in-situ stress on the closure and subsidence values.

7.4. PREDICTED REGIONAL HORIZONTAL MOVEMENTS

MSEC notes that in addition to the systematic movements that have been predicted above and around the proposed Longwalls 705 to 710, and the closure and subsidence movements that have been predicted within the creeks, it is probable that some regional horizontal movements will also be experienced as mining occurs.

The predicted subsidence parameters vary considerably over the proposed Longwalls 705 to 710 due to the variations in the depths of cover and seam thickness, which are illustrated in the depth of cover contours, surface contours, seam floor contours and seam thickness contours in **Appendix A**.

7.5. THE LIKELIHOOD OF IRREGULAR PROFILES

Wherever faults, dykes and abrupt changes in geology are present at the surface, it is possible that irregularities in the subsidence profiles could occur. Similarly, where surface rocks are thinly bedded, and where cross-bedded strata exist close to the surface, it is possible for surface buckling to occur, leading to irregular movements. By far the greatest number of irregularities in subsidence profiles, however, can be explained by the presence of surface incisions such as gorges, river valleys and creeks.

The geological structures which have been identified at seam level are shown in **Figure 4.3**. The geological features identified at seam level within the SMP Area include the series of dykes which cross the western parts of the proposed longwalls and two faults which cross the eastern parts of the proposed longwalls. It is possible that anomalous movements could occur as a result of the extraction of the proposed longwalls, as these have occurred in the past in the Southern Coalfield. Given the relatively low density of surface features within the SMP Area, the probability of an anomalous movement coinciding with a surface feature sensitive to these movements is assessed as low.

Irregularities also occur in shallow mining situations, where the collapsed zone, above the extracted seam, extends all the way to the surface. This type of irregularity is generally only seen where the depth of cover is less than 100 metres, which does not occur above the proposed longwalls.

Irregular profiles can also occur where longwall mining is carried out beneath previous workings such as bord and pillar extractions. In such situations, the stooks left in the upper seam can collapse, when mining occurs beneath them, leading to localised subsidence and irregular subsidence profiles. There are no earlier workings above the proposed longwalls and this kind of irregularity will not occur in this case.

7.6. SUMMARY RESULTS OF SUBSIDENCE PREDICTIONS

The following tables provide the maximum predicted systematic subsidence parameters resulting from the extraction of proposed Longwalls 705 to 710 at Appin Colliery.

Table 7.1 - Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each Proposed Longwall 705 to 710

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Tensile Strain (mm/m)	Maximum Predicted Incremental Compressive Strain (mm/m)
Due to LW705	1025	7.0	0.9	2.1
Due to LW706	995	6.8	0.9	1.9
Due to LW707	1035	7.0	0.9	2.0
Due to LW708	990	6.7	0.8	1.8
Due to LW709	1025	7.1	0.9	2.1
Due to LW710	1065	7.4	0.9	2.2

Table 7.2 - Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each Proposed Longwall 705 to 710

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW705	1365	7.2	1.3	2.0
After LW706	1430	6.9	1.3	2.0
After LW707	1495	7.2	1.3	2.0
After LW708	1500	6.9	1.3	2.0
After LW709	1505	7.2	1.3	2.1
After LW710	1510	8.0	1.3	2.3

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 702 to 704.

Table 7.3 - Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each Proposed Longwall 705 to 710

Longwall	Maximum Predicted Travelling Tilt (mm)	Maximum Predicted Travelling Tensile Strain Tilt (mm/m)	Maximum Predicted Travelling Compressive Strain (mm/m)
During LW705	3.5	0.5	0.4
During LW706	3.3	0.5	0.4
During LW707	3.4	0.5	0.4
During LW708	3.2	0.4	0.3
During LW709	3.6	0.5	0.4
During LW710	3.7	0.5	0.4

The predicted systematic subsidence parameters have been determined along Prediction Line 1, the location of which is shown in **Figure 7.1**. Details are provided in **Table 7.4**.

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bhpbilliton

ILLAWARRA COAL
APPIN COLLIERY
PREDICTION LINE 1

DATE:	SCALE:		Rev No
20 June 2008	1:30000	Figure 7.1	R0

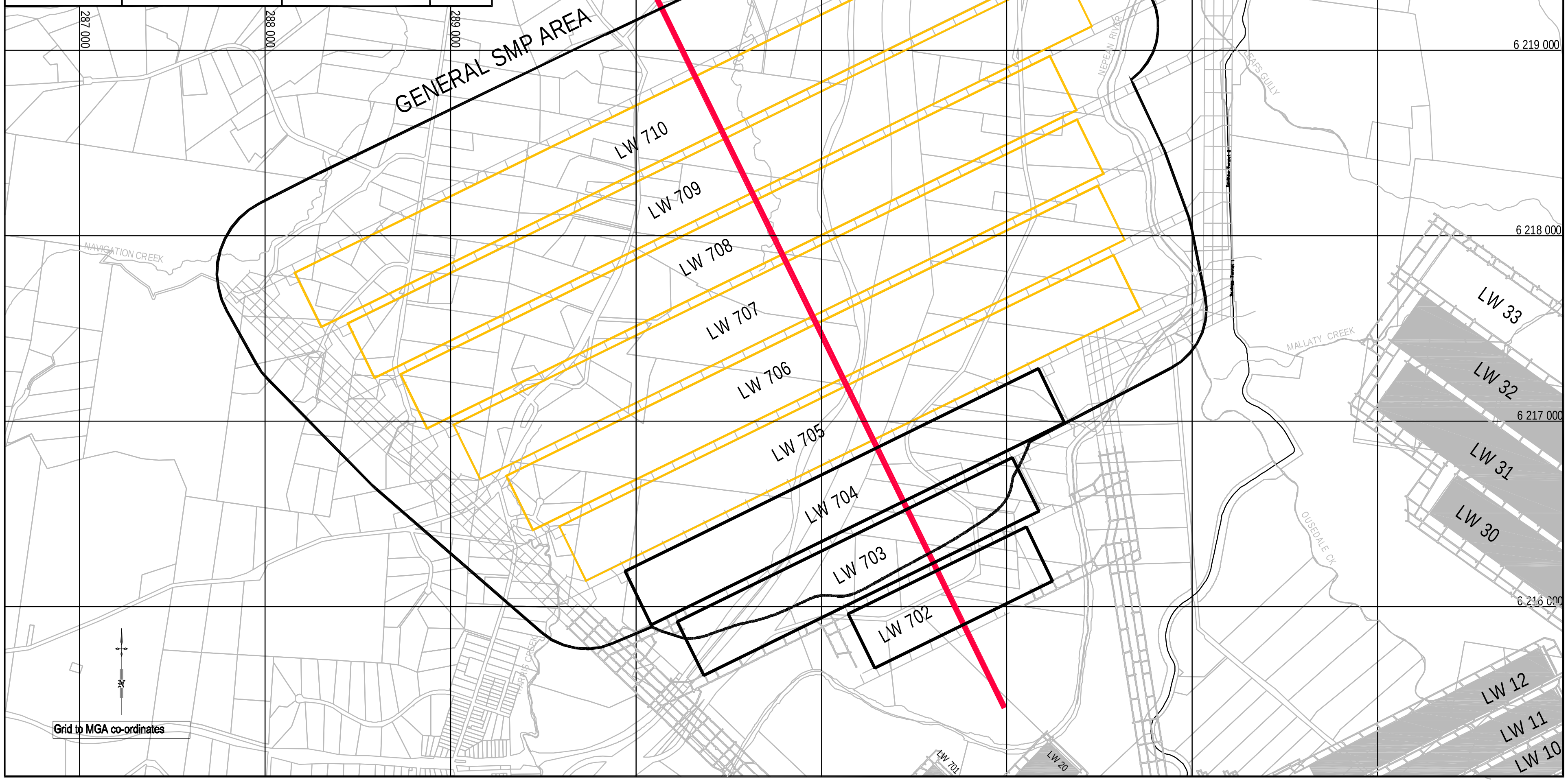
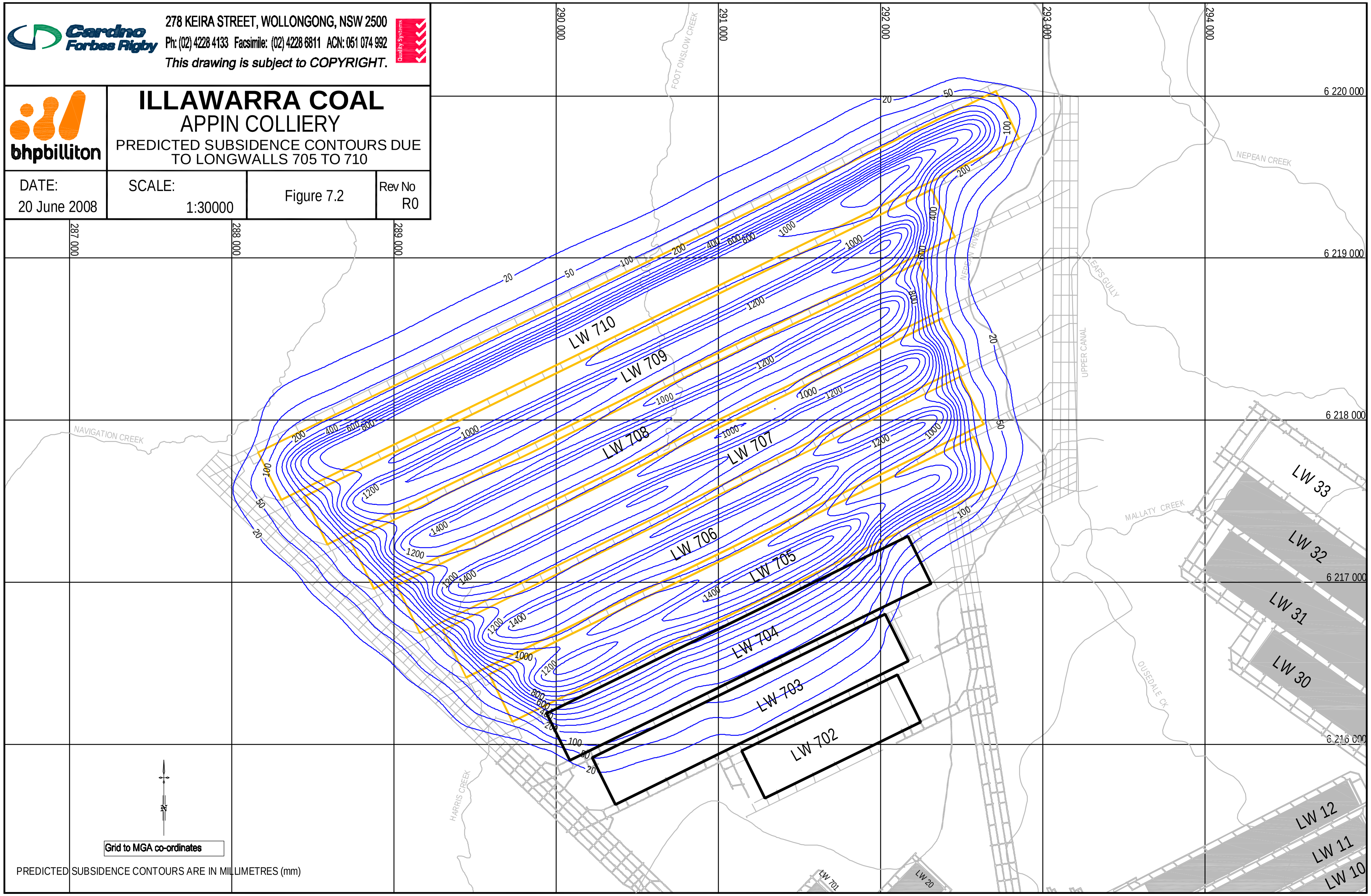


Table 7.4 - Maximum Predicted Cumulative Systematic Subsidence Parameters along Prediction Line 1 Resulting from the Extraction of Longwalls 705 to 710

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Tensile Strain (mm/m)	Maximum Predicted Cumulative Compressive Strain (mm/m)
After LW705	1350	6.8	1.1	1.9
After LW706	1425	6.8	1.1	1.9
After LW707	1490	6.9	1.2	1.9
After LW708	1495	6.7	1.2	1.9
After LW709	1495	6.4	1.2	1.9
After LW710	1495	6.3	1.2	1.9

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters along Prediction Line 1 which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 702 to 704.

The maximum predicted cumulative systematic subsidence resulting from the extraction of Longwalls 705 to 710 is shown in **Figure 7.2**.



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ILLAWARRA COAL
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PREDICTED SUBSIDENCE CONTOURS DUE TO LONGWALLS 705 TO 710
DATE: 20 June 2008
SCALE: 1:30000
Figure 7.2
Rev No R0
LW 710
LW 709
LW 708
LW 707
LW 706
LW 705
LW 704
LW 703
LW 702
LW 701
LW 20
LW 33
LW 32
LW 31
LW 30
LW 12
LW 11
LW 10
NAVIGATION CREEK
FOOT ONSLOW CREEK
NEPEAN CREEK
NEPEAN RIVER
LEAFS GULLY
UPPER CANAL
MALLATY CREEK
OUSEDALE CK
HARRIS CREEK
287 000
288 000
289 000
290 000
291 000
292 000
293 000
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6 220 000
6 219 000
6 218 000
6 217 000
6 216 000
Grid to MGA co-ordinates
PREDICTED SUBSIDENCE CONTOURS ARE IN MILLIMETRES (mm)