ASHTON COAL PROJECT

SUBSIDENCE MONITORING PROGRAM
UPPER LIDDELL SEAM
LONGWALLS 1-8

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1.0 INTRODUCTION

This Subsidence Monitoring Program has been prepared to document the monitoring of subsidence movements and subsidence impacts associated with underground mining activities at the Ashton Coal Project (ACP). This program applies to extraction of Longwalls (LW) 1-8 within the Upper Liddell (ULD) Seam.

The Ashton Coal Environmental Management Strategy (see Figure 3 of the Extraction Plan) provides the strategic context for the environmental management of the ACP. The Extraction Plan forms part of the Environmental Management Strategy (EMS) and is required by the ACP development consent. The Extraction Plan provides a framework for the management of subsidence impacts associated with Ashton Coal Operations Pty Ltd's (ACOL's) underground mining activities and details the proposed workings, including dimensions, overburden depth and mining schedule.

This Subsidence Monitoring Program is a sub-set to the Extraction Plan and has been prepared in accordance with Condition 3.12 of the development consent (309-11-2001-i), which states *inter alia*:

3.12 The Applicant shall prepare and implement an Extraction Plan for the second workings within each seam to be mined to the satisfaction of the Director General. Each Extraction Plan must:

(g) Include to the satisfaction of DRE:

- *a subsidence monitoring program to:*
  - *provide data to assist with the management of the risks associated with subsidence;*
  - *validate the subsidence predictions; and*
  - *analyse the relationship between the subsidence effects and impacts under the plan and any ensuing environmental consequences;*

This program has also been prepared in accordance with a standard condition of Subsidence Management Plan (SMP) Approvals, which requires the following information to be submitted to the Principal Subsidence Engineer (PSE) for approval:

- Inspection regimes;
- Layout of monitoring points;
- Parameters to be measured;
- Monitoring methods and accuracy;
- Timing and frequencies of surveys and inspections; and
- Recording and reporting of monitoring results.

This Subsidence Monitoring Program provides a description of the:

- Features potentially affected by underground mining in the Extraction Plan area and summary of revised subsidence predictions, categorised into: natural features, public utilities, farm land and facilities, industrial commercial and business establishments and items of archaeological significance.
- Survey monitoring standards, method, and program;
- Summary of monitoring of subsidence consequences to built features (full details are provided in the Built Features Management Plan);
- Summary of monitoring measures provided for environmental features;
- Review and reporting mechanisms; and
- Responsibilities of relevant ACOL personnel under this plan.

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2.0 SURFACE FEATURES

2.1 SCOPE

This Subsidence Monitoring Program has been prepared to address subsidence monitoring across ULD LW1-8. However, it is noted that at present, this monitoring program does not include full details of monitoring to be conducted across LW5-8. As discussed in more detail in the Extraction Plan, approvals are being sought in a staged manner, and this plan will be reviewed and updated to provide greater detail for LW5-8 prior to seeking approvals for secondary extraction in those panels.

The surface area impacted by mining of these longwall panels is summarised below. The following identification of surface and sub-surface features has been prepared in consideration of the SMP Guidelines (DMR, 2003: p25). It is noted that there are no public amenities, items of architectural significance, permanent survey control marks, or residential establishments affected by ULD LW 1-8.

2.2 NATURAL FEATURES

Natural features potentially impacted by mining activities and monitored under the scope of this document include:

- Rivers and Creeks:
  - Bowmans Creek overlies the ACP underground area, including morphology and condition of natural, excised, and diverted channel sections, water quality and stream health; and aquatic habitat species, and diversity;
  - Glennies Creek occurs to the east of LW1; and
  - Hunter River occurs to the south of the ACP longwalls.
- Aquifers, known groundwater resources:
  - Alluvial aquifers associated with Bowmans Creek overlying the underground mine;
  - Alluvial aquifers associated with Glennies Creek and Hunter River occur to the east and south of the mine plan respectively; and
  - Saline groundwater associated with the coal measures.
- Land prone to flooding or inundation:
  - LW 1 and LW5-8 are partially located beneath the floodplain associated with Bowmans Creek and the Hunter River.
- Swamps, wetlands, water related ecosystems:
  - Aquatic habitat associated with existing Bowmans Creek and rehabilitated habitat to be provided within Bowmans Creek diversions as proposed under the BCD EA and Rehabilitation Strategy (Evans & Peck: 2009 and Ashton Coal 2010); and
  - Groundwater dependent ecosystem (GDE) - downstream of LWs 6B, 7B and 8 (see below).
- Threatened and protected species:
  - The ACP is known to support threatened bird species (i.e. grey-crowned babbler and hooded robin) and a stand of River Red Gums (a GDE and endangered population in the Hunter Valley).
- Natural vegetation:
  - Woodland contained within the Southern Woodland – voluntary conservation area; and

- Narrow corridor of native riparian vegetation occurs along the bank of Bowmans Creek and isolated stands of trees elsewhere on the floodplain (predominantly pasture).

2.3 PUBLIC UTILITIES

Land overlying LW1-8 and associated first workings is owned by ACOL, Macquarie Generation (MacGen) and the Roads & Maritime Services (RMS). At some point during secondary extraction of ULD LW1-8, it is anticipated that a public road reserve will be dedicated and handed over to Singleton Shire Council associated with the realignment of Lemington Road being undertaken by Ravensworth Operations. A detailed list of all affected built features (existing and proposed) is provided in the Built Features Management Plan (BFMP).

Potentially affected public utilities include:

- Roads (and associated bridges and culverts):
  - New England Highway, and Bowmans Creek Bridge; and
  - Planned realignment of Lemington Road (as a public road) and/or activities and infrastructure required during construction.
- Electricity transmission lines:
  - Ausgrid 132kV, 66/11 kV, and 11kV transmission lines; and
- Telecommunications lines:
  - Fibre-optic cable (AAPT)
  - Copper cables (Telstra)
- NoW Gauging Station ('Foy Brook Station' No 210310 located on Bowmans Creek, south west of the oxbow).

2.4 FARM LAND AND FACILITIES

With the exception of areas of rehabilitated open cut (refer to **Section 2.5**), the land has been historically used for agriculture (grazing, some cropping) and consists of:

- Agricultural utilisation or agricultural suitability:
  - Pasture (Class 2 agricultural suitability on floodplain/natural landform, Class 4 on rehabilitated open cut areas);
- Farm Dams:
  - Earth embankment storage dams on ACOL property and Property 130.
- Farm buildings / sheds:
  - Dilapidated shed structure – abandoned, partially collapsed (MacGen)
  - Two farm sheds (Property 130)
  - Various lightweight sheds (ACOL)
- Fences:
  - Fences delineating property boundaries and internal paddocks for stock management; and
  - Gates.

2.5 INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS

Land above the underground workings is partially owned by private landowner (Property 130) and Macquarie Generation and includes former open cut area (now rehabilitated). The land is also utilised by Xstrata – Ravensworth Operations and Xstrata –

Ravensworth Underground Mine for access to their facilities and to locate some mine-related infrastructure.

Mining infrastructure features associated within this area include:

- Gas and / or fuel storages and associated plants:
  - ACOL gas drainage boreholes and compounds associated with underground workings; and
  - Proposed gas drainage easement across MacGen land.
- Surface mining (open cut) voids and rehabilitation areas:
  - Former open cut void – rehabilitated with spoil.
  - Sedimentation dams (four) clay-lined with spillways discharging into a clean-water drain that conveys water to Bowmans Creek.
  - Small dams (two) downstream of sedimentation basins and clean water drainage line to Bowmans Creek.
- Electricity transmission lines
  - Xstrata 33kV transmission line; and
  - Proposed Xstrata 330kV transmission line.
- Mine infrastructure including tailings dams and emplacement areas:
  - Mt Owen - Ravensworth water pipeline.
  - ACOL tailings and decant return pipeline.
  - Various ACOL pipelines (Hunter River, mine water)
  - Prescribed Dam Notification Areas (Narama Dam and Void 5 Ash Dam).
  - Ravensworth Underground Mine No. 5 Shaft (under construction).

2.6 AREAS OF ARCHAEOLOGICAL AND/OR HERITAGE SIGNIFICANCE

The surface area overlying LW1-8 includes known Aboriginal heritage sites and areas of potential archaeological deposit (PAD). These are identified and managed in accordance with the ACOL Aboriginal Cultural Heritage Management Plan (ACHMP).

Monitoring or mitigation of impacts to Aboriginal heritage is not referenced or addressed under the scope of this Subsidence Monitoring Plan – please refer to the latest ACHMP or AHIP for further information.

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3.0 SUBSIDENCE MONITORING

3.1 OVERVIEW

The objectives of this monitoring program are to:

- Obtain data on subsidence parameters and subsidence impacts relating to LW1-8 in the ULD Seam;
- Identify subsidence parameters and subsidence consequences to surface features for the purposes of mitigation and management of impacts;
- Validate the subsidence predictions; and
- Extend the subsidence database at the ACP and wider mining community for the purpose of future mine planning and subsidence predictions.

The subsidence monitoring program consists of survey monitoring to quantify subsidence parameters, i.e. vertical movements, ground tilts and strains (refer to **Section 3.2**) and subsidence impact monitoring (refer to **Section 3.3**) to monitor and identify environmental consequences to natural and built features.

3.2 SUBSIDENCE MONITORING

Subsidence monitoring lines will be established across the surface of LW 1-8 and consist of:

- Centrelines to identify centreline subsidence, travelling abutment subsidence rate and residual strains and tilts at abutment; and
- Cross lines to measure subsidence, pillar compression and residual strains and tilts, assist with refinement of visualisation model, and monitor effects of adjacent longwall on creeks (natural and manmade).

Subsidence monitoring survey locations are shown in **Drawing No. B – 3002** (included as **Appendix C**). The monitoring program for ULD LW1-4 centrelines and cross-lines is further described in **Table 1**. This program, and associated subsidence monitoring, will be reviewed to incorporate LW5-8 prior to undertaking secondary extraction in these panels (refer to **Section 4.3**).

Surveys will be undertaken in accordance with the survey standards indicated in **Table 1**. Ashton Coal's adopted survey standards, detailing the methods and accuracy for subsidence monitoring are detailed in **Appendix A**.

ACOL propose to introduce the use of Aerial Laser Scanning (ALS) / LiDAR survey techniques to monitor subsidence across all eight longwall panels. This data will enable the comprehensive monitoring of ground movements across the underground and is expected to provide an accuracy of +/- 0.1m. The LiDAR surveys will be linked into existing survey control marks and the observed subsidence calibrated against the subsidence data obtained using the conventional survey cross-lines and centrelines. It is expected that this 3D data will be particularly valuable in validating the multi-seam subsidence models used at ACOL and for identifying impacts to the landform and topography. This data will enable the ongoing improvement and calibration of the numerical subsidence models for the purpose of future subsidence prediction (refer to **Section 4.3**).

ACOL also propose to investigate the monitoring of far-field subsidence associated with secondary extraction of the ULD Seam. SCT (2011) provide some preliminary recommendations in this regard, and given the proximity to other open cut and underground mines in the locality, ACOL propose to consult with adjacent operations to develop a

program to investigate the occurrence and nature of far-field effects of underground mining in the locality, with a focus on differentiating and attributing which movements (if any) can be associated to ACOL activities.

Initially it is proposed that existing, class B or better, state survey control marks surrounding the ACOL mining area be used as a base for Far Field monitoring. The marks used will need to be at least 800m but preferably about 2km from existing underground and/or opencut operations. Where no state survey marks exist, a mark will be established and co-ordinated. A GNSS control survey from suitable state survey, or newly established survey marks onto our existing network will be performed prior to longwall extraction commencing in the Upper Liddell Seam and after the completion of every third ULD Seam longwall. The survey marks selected for the initial survey will continue to be used for each subsequent far field survey. Our existing survey control network will be adjusted accordingly after each far field survey.

3.3 SUBSIDENCE CONSEQUENCES MONITORING

Subsidence impacts monitoring is summarised in **Table 2**. All subsidence impacts monitoring is detailed in the relevant environmental management plan or sub-plan to the Extraction Plan for LW1-8. These plans include:

- Built Features Management Plan (BFMP);
- Extraction Land Management Plan (ELMP) ;
- Flora and Fauna (Biodiversity) Management Plan (FFMP);
- Aboriginal and Cultural Heritage Management Plan (ACHMP); and
- Water Management Plan (WMP).

Table 1 Subsidence Monitoring Program

Subsidence Line/Location	Location	Purpose	Survey Marks	Mark Spacing	Monitoring Frequency	Survey Standard (refer to Appendix A)
Centreline 1 **Southern End of each LW block (excluding ULD LW1)**[1]	Southern end of each LW block (exc. ULD LW1) from a distance approximately equivalent to the angle of draw of 26.5° + 50m outside the goaf edge to an approximate distance equivalent to the LW block width into the goaf. Line to extend into PG-ULD multi-seam goaf where applicable. Approximate centreline of multi-seam goaf zone	Centreline subsidence, travelling abutment subsidence rate and residual strains and tilts at abutment.	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level.	5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam	Prior to adjacent LW mining commencing or adjacent LW retreating face being within 200m of centreline, whichever is applicable. Every 80m (+/- 20m) of retreat when the associated LW is passing under the subsidence line. Then 1x monthly survey, then at completion of associated and subsequent longwall.	1
Sections of Centreline 1 or standalone centrelines that extend over PG goaf edge **Southern End of LW Blocks over existing Pikes Gully LW Goaf Edge**	Transition from ULD single seam goaf zone to PG-ULD multi-seam goaf zone	Centreline subsidence, travelling abutment subsidence rate and residual strains and tilts over Pikes Gully multi-seam goaf edge	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level.	5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam	When associated LW is within 40m of PG LW goaf edge and then for every 20m of retreat until the LW is 40m past PG goaf edge (+/- 10m) Then revert back to monitoring frequency as specified above for centreline 1 Original Pikes Gully centrelines only to be monitored as per centreline 1 above, i.e. every 80m of retreat.	1

[1] As LW1 in the ULD Seam is equivalent to single-seam mining and as ACOL has extensive single-seam mining data, centreline survey monitoring of LW1 is not proposed: it is not recommended by SCT and has been requested not to occur by the landowner of Property 130.

Subsidence Line/Location	Location	Purpose	Survey Marks	Mark Spacing	Monitoring Frequency	Survey Standard (refer to Appendix A)
Centreline 2 **Centreline 3 (LW4)** **Northern End of each LW block**	Northern end of each LW block From a distance approximately equivalent to the angle of draw of 26½° + 50m outside the goaf edge to an approximate distance equivalent to the LW block width into the goaf. Approximate centreline of multi-seam goaf zone.	Centreline subsidence, travelling abutment subsidence rate and residual strains and tilts at abutment.	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level.	5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam	Prior to adjacent LW retreating face being within 200m of the centreline. When the associated LW retreating face is at 200m from take-off position (Ch0) and then at every 80m (+/- 20m).of retreat, then at completion of the LW. After completion, monthly for 2 months, then at completion of subsequent LW.	1
Cross-line 5 (XL5)	LW 1-8 Starting at Glennies Creek and extending to edge of Bowmans Creek. Perpendicular to Longwall Centrelines.	Subsidence, pillar compression and residual strains and tilts. To assist with refinement of visualisation model.	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level.	5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam.	When associated LW retreating face is 120m on the approach side of XL5 and then for every 40m of retreat until 80m past XL5, then at 160m and 400m past (+/- 20m). Full survey of XL5 to TG1 at completion of LW4 and LW7.	1

Subsidence Line/Location	Location	Purpose	Survey Marks	Mark Spacing	Monitoring Frequency	Survey Standard (refer to Appendix A)
Original Cross-lines (XL1 to XL4 , XL6 and XL7)	LW1 Starting at eastern base of steep slopes associated with Glennies Creek and extending west to TG1 of Pikes Gully LW1, with XL4 and XL7 extended west to approximate mid-point of ULD-LW1 Perpendicular to Longwall Centrelines.	Subsidence, pillar compression and residual strains and tilts. Monitor effects of adjacent longwall on creeks (natural and manmade). To assist with refinement of visualisation model.	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level. Galvanised spikes in bedrock.	Generally at 5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam	Prior to retreating face of LW1 being within 50m of cross-line, then when LW is approximately adjacent to cross-line, then when LW is some 200m past cross-line (+/- 20m).	1
Supplementary Cross-line (Diagonal XL8)	LW1 XL8 starting at top of New England Highway cutting and running diagonally (SW) over Pikes Gully LW1 goaf.	Subsidence, pillar compression and residual strains and tilts. Monitor effects of adjacent longwall on creeks (natural and manmade) and Highway cutting. To assist with refinement of visualisation model.	1650-1800mm star pickets driven into ground to refusal & cut to height of ~0.2m above ground level. Galvanised spikes in bedrock.	Generally at 5m or at 10m for depth of cover greater than 100m to Pikes Gully Seam	When LW1 retreating face is at 200m from take-off position (Ch0) and then for every 100m of retreat, then at completion of LW1 (+/- 20m). After completion, monthly for 2 months, then at completion of subsequent LW	1

Subsidence Line/Location	Location	Purpose	Survey Marks	Mark Spacing	Monitoring Frequency	Survey Standard (refer to Appendix A)
Far Field Subsidence Monitoring	At least 800m but preferably about 2km from existing underground and/or opencut operations	To allow comprehensive monitoring of ground movements beyond the underground mining area.	Class B or better, state survey control marks.	NA	Prior to commencement of ULD Seam (baseline) and following completion of LW3, LW 6B panels in ULD Seam and prior to extraction in ULLD Seam	
Property 130 (inc. ULD XL101)	Property 130 ▪ Major access roads ▪ Farm dams and associated infrastructure External fence of residence.	Assets to be monitored in consultation with land holder (preferably by non-invasive GPS survey methods).	Wooden pegs (flush with ground level). Or Suitable marks placed in base of existing fence posts	Pegs to be placed at ~50m intervals on edge of access tracks (outside of vehicle interference were possible) Pegs to be placed around other assets at intervals so that adequate subsidence profiles can be determined.	When LW is within 50m of asset then every 50m of retreat until LW is 100m past, then monthly until LW is past northern property boundary, then 3 monthly for 6 months.	1A

Table 2 Subsidence Impacts Monitoring

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
Built Features Management Plan (Summary of monitoring actions only – full details provided in actual management plan)			
Ausgrid AMP	All poles and conductors	Pre-mining	Baseline - obtain xyz coordinates of poles and lines in the affected area (Survey Standard 2 – refer to **Appendix A**).
	All support poles and transmission lines	Pre-mining	Baseline photographic survey and visual assessment (refer to **Appendix B**).
	All power pole alignments	Pre-mining	Review of pole type (height and spacing), mitigation measures (if required), clearance and capacity of lines.
	All power lines	Daily, from 100m before until the active face is 100m past the power line location.	Visual inspections noting condition and line clearances (refer to **Appendix B**).
	All support poles	Commencing from 50m before and at 50m intervals until the active face is 200m past the support pole(s) location.	Survey for tilt and subsidence of poles (Survey Standard 2 – refer to **Appendix A**). Survey of line clearance only if visual inspections indicate possible exceedance of predictions.
Xstrata - Ravensworth Operations AMP	Private Roads	*Private roads are monitored in accordance with the Macquarie Generation Asset Management Plan.*	
	Fences	Prior to commencement of mining; Weekly visual investigations during active subsidence; and At completion of each longwall panel.	Visual inspection / monitoring of gates and fences on private property and ACOL boundary fences.
	Narama Dam	Prior to secondary extraction within Prescribed Dam Notification Area	Survey of established survey pegs to provide baseline data for future comparison.
	Narama Dam	As per DSC Conditions or at completion of active subsidence.	Survey of established survey pegs and compare with baseline data to determine any movements being experienced.
	Narama Dam	Following completion of active subsidence.	Final survey to confirm no subsidence impacts.
	33kV Transmission Line	Prior to mining ULD LW7B and LW8.	Baseline - obtain xyz coordinates of poles and lines in the affected area (Survey Standard 2 – refer to **Appendix A**).
	33kV Transmission Line	Prior to mining ULD LW7B and LW8.	Baseline photographic survey and visual assessment (refer to **Appendix B**).
	33kV Transmission line	Daily, from 100m before until the active face is 100m past the power line location.	Visual inspections noting condition and line clearances (refer to Appendix B).

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	33kV Transmission line support poles	Commencing from 100m before and at 50m intervals until the active face is 100m past the support pole(s) location.	Tilt, subsidence and line clearance (Survey Standard 2 – refer to Appendix A).
	Proposed 330kV Transmission Line	Prior to subsidence impact.	*In consultation with Ravensworth Operations ACOL will review the Xstrata – Ravensworth Operations Asset Management Plan for the monitoring of Proposed 330kv Transmission Lines prior to commencing affected longwalls.*
	315 mm Diameter Pipeline	▪ Prior to commencement of mining; ▪ Weekly visual investigations during mining; and ▪ At completion of each longwall panel.	Visual inspection / monitoring of exposed sections of pipeline.
	315 mm Diameter Pipeline	Ongoing during subsidence if pipeline is operational and flow monitoring gauges are installed.	Flow monitoring to identify pipeline leakage.
Xstrata - Ravensworth Underground Mine AMP	Private Roads	Daily during active subsidence.	Visual inspection of surface roads to identify any subsidence impacts that could affect the safety of vehicles (refer to Macquarie Generation AMP monitoring below).
Macquarie Generation AMP	Private Roads	Prior to subsidence impacts.	Pre-mining condition assessment to document pre-subsidence condition of the road, including photographic records of any observed existing pavement fatigue or failure or similar existing damage.
	Private Roads	Daily during active subsidence.	Visual inspection of roads to identify any subsidence impacts that could affect the safety of vehicles.
	Private Roads	Once active subsidence has ceased.	Post mining condition assessment road infrastructure to confirm that any perceptible subsidence impacts have ceased and document the post-subsidence status of the road.
	Fences	▪ Prior to commencement of mining, ▪ Weekly visual investigations during mining; and ▪ At completion of each longwall panel.	Visual inspection / monitoring of gates and fences on private property and ACOL boundary fences.
	Surface Water Dams (exc. Void 5 Ash Dam)	Prior to longwall extraction.	Assessment of the risk of farm dams and sedimentation basins draining into underground workings or the dam wall being compromised.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Surface Water Dams (exc. Void 5 Ash Dam)	Prior to each longwall extraction.	Monitoring of dams and sedimentation basins to include a survey of each dam regarding shape, wall height, level of spillway depth, storage capacity and photographic record.
	Surface Water Dams (exc. Void 5 Ash Dam)	Weekly inspection during active subsidence to dams.	Monitoring of dams within the Application Area to detect any subsidence impacts that may require management. Monitor water level using markers.
	Surface Water Dams	Post long wall extraction.	Monitoring of dams within the subsidence impact area to identify perceptible subsidence impacts have ceased and remediation works needed. Comprises: ▪ Photographic records. ▪ Final survey of each dam to determine post subsidence shape, wall height, level of the spillway (if present), depth and storage capacity.
	Void 5 Ash Dam	Once dam commissioned by MacGen, and prior to commencement of secondary extraction of the next LW panels.	Detailed assessment of potential subsidence impacts to Void 5 Ash Dam in accordance *with Dams Safety Act 1978*.
	Void 5 Ash Dam	Once dam commissioned by MacGen, and prior to commencement of secondary extraction of the next LW panels.	Survey of established survey pegs to provide baseline data for future comparison.
	Void 5 Ash Dam	Once dam commissioned by MacGen, and at the completion of LWs 7B and 8.	Survey of established survey pegs and compare with baseline data to determine any movements being experienced.
	Void 5 Ash Dam	Following completion of active subsidence in ULD Seam.	Final survey to confirm no subsidence impacts.
	All features	On completion of each longwall.	Undertake an inspection of assets in conjunction with MacGen.
Roads and Maritime Services AMP	New England Highway	Pre-mining	Subsidence monitoring (survey, photographic, and visual) of the New England Highway in accordance with the Control Management Plan (Table 10) and Subsidence Monitoring Program.
	New England Highway	Pre-mining	Install new pavement survey marks, where necessary, at 50m intervals along both sides of highway pavement from the eastern end of the cutting westwards to limit of mining (~2800m). Methodology to be confirmed with RMS (i.e. drill-hole in kerbs through cutting, and survey marks i.e. star pickets installed to ground level, behind guard rail in fill areas).

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	New England Highway	Pre-mining	Install infill road reserve survey marks at 50m intervals between existing highway cutting marks and road reserve marks. *Note: Previous survey marks installed have been covered by new pavement seal.*
	New England Highway – Bridge	Annually (nominally)	RMS Bridge Inspection Report (Undertaken by RMS) *(Note last report 25August 2011 and next due Mar-2012)*
	New England Highway	Annually (nominally)	Annual Roadway Report (Note last 2011 reports include Skid, Profilometry and Road cracking in MS Excel format). (Undertaken by RMS)
	New England Highway – Culverts	Annually (nominally)	Culvert Inspection Report (ACOL July 2012)
Telstra AMP	Telstra Cables	Pre-mining (completed).	An accredited service locator will be used to find and mark the position of all Telstra cables throughout the Mining Lease area. Ashton Surveyors will then record the position of all cables. This information will assist in locating the cables to undertake repairs (if required) and to ensure that other subsidence remediation activities do not inadvertently damage sub-surface cables.
	Telstra Cables	Prior to telecommunications cable being affected by subsidence (pre-mining).	Cables will be tested to confirm they are in working order.
	Telstra Cables	Completion of active subsidence.	Post-mining monitoring and ongoing liaison with affected stakeholders will assist to identify any subsidence-induced damage to cables and highlight if any repairs are required.
	Telstra Cables	Completion of active subsidence.	Where cables are not in service, a qualified contractor will be engaged to confirm the future serviceability of these cables at the completion of mining.
NSW Office of Water AMP	Stream Gauging Station	*No additional subsidence monitoring is proposed. Survey and testing of the telecommunications cables is addressed in the Telstra AMP.*	
Powertel (AAPT) AMP	Fibre Optic Cable	Pre-mining (completed).	An accredited service locator will be used to find and mark the position of the fibre optic cable in relation to the subsidence area. Ashton Surveyors will then record the position of all cables. This information will assist in locating the cables for future reference and to ensure that other subsidence remediation activities do not inadvertently damage sub-surface cables.
	Fibre Optic Cable	Completion of active subsidence.	Monitoring will assist to identify any subsidence-induced damage to cables and highlight if any repairs are required.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Private Roads	Prior to subsidence impacts.	Pre-mining condition assessment to document pre-subsidence condition of the road, including photographic records of any observed existing cracking, potholes or similar damage.
	Private Roads	Prior to subsidence impacts.	Pre-mining assessment of trees adjacent to private roads; identification potential hazards resulting from subsidence and reporting of dead or diseased trees to Ashton Environmental Officer.
	Private Roads	Daily during active subsidence.	Visual inspection of roads to identify any subsidence impacts that could affect the safety of vehicles.
	Private Roads	Once active subsidence has ceased.	Post mining condition assessment road infrastructure to confirm that any perceptible subsidence impacts have ceased and document the post-subsidence status of the road.
	Fences	▪ Prior to commencement of mining; ▪ Documented weekly visual investigations during mining; and ▪ At completion of each longwall panel.	Visual inspection / monitoring of gates and fences on private property and ACOL boundary fences.
	Tailings Pipelines	▪ Prior to commencement of mining; ▪ Documented weekly visual investigations during mining; and ▪ At completion of each longwall panel.	Visual inspection of pipeline.
	Tailings Pipelines	When operating/in use.	Continuous flow monitoring to identify pipeline leakage via CHPP control room.
	Tailings spill basin (adjacent to Brunkers Lane)	Prior to longwall extraction.	Assessment of the risk of the spill basin draining into underground workings or being otherwise compromised.
	Tailings spill basin (adjacent to Brunkers Lane)	Prior to longwall extraction.	Pre-mining monitoring of spill basin to include a survey regarding shape, wall height, level of spillway depth, storage capacity and photographic record.
	Tailings spill basin (adjacent to Brunkers Lane)	During long wall extraction; weekly visual inspections of dams behind the longwall face and up to 800 m in front of the longwall.	Monitoring of spill basin within the application area to detect any subsidence impacts that may require management and water level monitoring.
Property No. 130 AMP	Buildings (farm sheds)	▪ Prior to completion of mining; and ▪ At completion of each longwall panel.	Visual inspection of farm sheds condition, including photographs, to record any damage / issue and identify any preventative work or repairs.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Private Roads	Prior to subsidence impacts.	Pre-mining condition assessment and survey to document pre-subsidence condition of the road, including photographic records of any observed existing cracking, potholes or similar damage.
	Private Roads	Prior to subsidence impacts.	Pre-mining assessment of trees adjacent to private roads; identification potential hazards resulting from subsidence and reporting of dead or diseased trees to Ashton Environmental Officer.
	Private Roads	Daily during active subsidence.	Visual inspection of roads to identify any subsidence impacts that could affect the safety of vehicles.
	Private Roads	Once active subsidence has ceased.	Post mining condition assessment road infrastructure to confirm that any perceptible subsidence impacts have ceased and document the post-subsidence status of the road.
	Fences, gates and grids	▪ Prior to commencement of mining; ▪ Weekly visual investigations during active subsidence; and ▪ At completion of each longwall panel.	Visual inspection / monitoring of gates and fences on private property and ACOL boundary fences.
	Water tanks & subsurface pipes	▪ Prior to commencement of mining; ▪ Weekly during mining; and ▪ At completion of undermining.	Documented visual inspection / monitoring of exposed sections of pipeline.
	Surface water dams	Prior to longwall extraction.	Assessment of the risk of farm dams draining into underground workings or the dam wall being compromised.
	Surface water dams	Prior to each longwall extraction.	Survey of each affected dam and contour bank regarding shape, wall height, level of spillway depth, storage capacity and photographic record.
	Surface water dams	Weekly inspection during active subsidence to dams.	Monitoring of dams within the Application Area to detect any subsidence impacts that may require management. Monitor water level using markers.
	Surface water dams	Post long wall extraction.	Monitoring of dams within the subsidence impact area to identify that perceptible subsidence impacts have ceased and remediation works needed. Comprises: • Photographic records and comparison to pre-mining condition. • Final survey of affected each dam and contour bank to determine post subsidence shape, wall height, level of the spillway (if present), depth and storage capacity.
Singleton Shire Council (SCC) AMP	New Lemington Road	Prior to secondary extraction in LW5-8	Develop a subsidence monitoring plan to review actual versus predicted subsidence and cracking in relation to the advancing longwall face.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	New Lemington Road	Prior to secondary extraction in LW5-8	Visual inspection to identify surface condition, potential safety risks and any existing surface cracks.
Environmental Management Plans (Summary of monitoring actions only – full details provided in actual management plan)			
Extraction Land Management Plan	Land surface – cracking immediately behind the longwall face	Weekly	Visual inspection of the area immediately behind the longwall faces passage to identify/map subsidence cracking. Documented inspection of steep slopes along the Hunter River and Glennies Creek to identify cracking requiring remediation.
	Entire Application Area	Prior to and following completion of secondary extraction in ULD Seam	Light Detection and Ranging (LiDAR) data will be captured across the entire Application Area to document baseline landscape morphology and to quantify topographic change, including creek slope, width and depth as outlined within the Extraction Land Management Plan.
	Agricultural attributes	Prior to mining within the ULD and repeat annually in early spring.	Agricultural monitoring will assess attributes that relate to pasture productivity and soil nutrient status and will include the sampling of a single 20 x 20 m and 1 x 1 m quadrats within each of the 4 impact zones (longwall, transition, pillar and control) as outlined within the Extraction Land Management Plan.
	Land Surface – Drainage lines	Following rainfall (>50mm in 24 hours) and weekly during active subsidence.	Visual inspections of drainage lines to identify potential erosion, or the development of nick points where erosion could advance.
	Temporary stockpiles of alluvial material	Following heavy rainfall and weekly during active subsidence.	Inspect temporary stockpiles of alluvial material to ensure adequate vegetative cover and integrity of bunds and erosion controls.
	Land Surface – Low-lying areas	Following rainfall (>50mm in 24 hours) and weekly during active subsidence.	Visual inspection of low lying areas following heavy rainfall to identify if any surface ponding is occurring.
	Land Surface – Entire Application Area	Following longwall extraction in closest panel.	Reassessment of the site slope stability by a suitably qualified geotechnical engineer.
Flora and Fauna (Biodiversity) Management Plan	Established monitoring sites within Application area	Completed prior to commencement of underground mining operations.	Collect baseline data prior to the commencement of the underground mining operations, to be used to monitor the impact of the operations on the aquatic ecosystem health.
	Hunter River temporary monitoring sites	Prior to mining Longwall 1 (if full length).	Collect baseline data from temporary monitoring sites on the Hunter River prior to the commencement of Longwall 1, to be used to monitor the impact of the operations on the aquatic ecosystem health.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Established monitoring sites within Application area	Bi-annually	Undertake terrestrial fauna and habitat monitoring in accordance with the monitoring methodology (as outlined in the Biodiversity Management Plan). If no rainfall has been recorded for the season, the amphibian survey must take place in the last week of the season.
	n/a	To be incorporated into the bi-annual monitoring program.	Conduct a research program to test roost box preference based on design, positioning and colour of the artificial roost. As many arboreal roosting and denning species may take several years to utilise artificial dens and roosts, roost and den box design and positioning will be re-evaluated every five years if targeted species are not using the boxes.
	Bowman's Creek	Bi-annually during mine operations and for at least 5 years following the completion of longwall mining under Bowmans Creek or until no significant impact can be confirmed.	Undertake aquatic fauna and habitat monitoring at established locations along Bowmans Creek in accordance with the monitoring methodology (as outlined in the Biodiversity Management Plan) to assess the long term stability of ecosystems against the pre-mining benchmarks.
	Bowman's Creek	Prior to commencement of the Bowmans Creek diversion works.	Establish additional long-term stream monitoring sites in the excised sections of Bowmans Creek and in each of the diversion channels to monitor developing aquatic habitat attributes against existing habitat attributes.
	Bowman's Creek	Monthly	Undertake monthly water quality monitoring program, with the location of monitoring sites within Bowmans Creek to be adjusted as the creek diversions come on line (refer to Water Management Plan).
	Established rehabilitated tree plots	Annually three years after commencement of rehabilitation activities.	Undertake vegetation surveys within established rehabilitated tree plots, in accordance with monitoring methods outlined in (as outlined in the Biodiversity Management Plan).
	Bowmans Creek riparian corridor	Monthly following the commencement of the construction and rehabilitation works.	Undertake monthly weed monitoring surveys within the Bowmans Creek riparian corridor.
	Areas overlying longwalls	On completion of each longwall panel.	Conduct field assessment of the areas overlying longwalls at the completion of each mining pass, to ascertain the extent of subsidence impacts on excised creek and riparian channel ecosystems. Where required, targeted riparian or habitat enhancement/protection measures will be recommended.
	Bowman's Creek	Twice within 1 year of the longwall passing beneath the excised sections of Bowmans Creek.	Conduct post-mining aquatic monitoring to assess impacts to fish, fish passage, macro invertebrates and aquatic habitat, and impacts to existing communities along Bowmans Creek from subsidence.
	Hunter River	On completion of Longwall 1 (if full length).	Conduct post-mining aquatic monitoring to assess impacts to aquatic habitat, and impacts to existing communities along the Hunter River from subsidence.

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Nest and den trees subject to subsidence impacts	Fortnightly	Fortnightly monitoring of and searches for new breeding sites within the impact area should commence immediately and continue for a minimum of 3 years or until completion of underground mining within the extraction area.
	Nest and den trees subject to subsidence impacts	Prior to subsidence impacts	Permanent marking of all nest and den trees within the impact area during bi-annual terrestrial fauna and habitat monitoring.
Water Management Plan	Surface water quality in Bowmans Creek, Glennies Creek and Hunter River	▪ Monthly: screening analysis; ▪ Annually: comprehensive analysis; and ▪ Event based (1:20yr and/or 1:100yr event).	Screening analysis pH, Electrical Conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), Total Hardness (CaCO3) and Oil and Grease Comprehensive analysis also includes: Physical Parameters – pH, EC, TDS, TSS, Total Hardness (CaCO3) and turbidity; Major Ions – Ca, Mg, Na, K, Cl, SO4, HCO3 and CO3; Dissolved Metals – Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se and Zn; and Nutrients/other – Ammonia, Nitrate and Fluoride. Trigger levels have been developed based on the 20th and 80th percentile values determined by baseline site monitoring and in accordance with the ANZECC (2000) *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*. Implementation of Trigger –Action-Response-Plan (TARP) for observations outside of the trigger levels.
	Surface Water Level	As above	Visual observation at all surface water monitoring sites/ in Glennies Creek, Bowmans Creek (Pool 1, Pool 2) using installed markers
	Water level – Glennies Creek	Monthly	Water level observations using installed monitoring staffs to produce three-dimensional representations of the alluvium water table and the coal measures potentiometric surface
	Water level – Bowmans Creek	Monthly	Water level observations using installed monitoring staffs to guide construction of the block banks (on the Bowmans Creek Diversion) to their final level
	Surface Water Level / Flow	Continuous water level recorders (upstream and downstream of diversion).	Continuous water level recorders (upstream and downstream of diversions), correlated against the NOW Gauge, with monthly downloading and checking of data.
	Groundwater level – impacts to Bowmans Creek	Fortnightly and when mining immediately below.	Water level monitoring in groundwater bores east of LW6B (WMLP311, WMLP323, WMLP324, WMLP325).

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Groundwater quality – impacts to Bowmans Creek	Quarterly – field parameters Annually – comprehensive analysis	Groundwater bores east of LW6B (WMLP311, WMLP323, WMLP324, WMLP325) Field parameters: EC, TDS and pH Comprehensive analysis: EC, pH, temperature, TDS, Na, K, Ca, Mg, F, Cl, SO_4, HCO_3, NO_3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Total Alkalinity, Total Cyanide, Turbidity.
	Hydraulic connection with Bowmans Creek and alluvium	Water level: prior to, and fortnightly thereafter until completion of extraction in proximity to Bowmans Creek alluvium. Water quality: Quarterly comprehensive analysis.	(Refer to WMP for full list of borehole locations) Water level Field analysis and comprehensive analysis as above.
	Hydraulic connection with Glennies Creek and alluvium	Water level: Prior to, and fortnightly thereafter during mining in proximity to Glennies Creek and alluvium Water quality: Quarterly field parameters, Annually comprehensive analysis.	Groundwater bores located between Glennies Creek and eastern side of LW1 (WML120B, WML129), and bores located at the end of the panel (WML172, WML173, WML174, WML239, WML240, WML241, WML243, WML249, WML250, WML252, WML253, WML256) Water level Field analysis and comprehensive analysis as above.
	Hydraulic connection with Hunter River and alluvium	Water level: Prior to, and fortnightly thereafter during mining adjacent to Hunter River and alluvium. Water quality: Quarterly field parameters, Annually comprehensive analysis.	Groundwater bores located between longwall panels and Hunter River (RA27 WML180, WMLP275, WMLP276, WMLP277, WMLP278, WMLP279, WMLP280) Water level Field analysis and comprehensive analysis as above.
	Glennies Creek barrier	Water level: Prior to, and fortnightly thereafter during mining in proximity to Glennies Creek and alluvium. Permeability: following completion of LW1 Water quality: Quarterly field parameters, Annually comprehensive analysis.	Groundwater bores along ridgeline barrier between Glennies Creek and LW1 (WML119, WML120A, WML181 – 186, WML302, WML261, WML262 , WML301 Water level Permeability – in-situ hydraulic testing Field analysis and comprehensive analysis as above.
	Glennies Creek barrier	Water level – fortnightly	Water level at WMLC248
	Permian coal measures	Water level – fortnightly	Water level monitoring using vibrating wire piezometers into PG Seam (WML21, WML106 (VW* 84m) , WML115 (VW 144m) , WML213 (VW 205.5m) , WML189 (VW 93m)) and other seams (WML106 - WML115, WML189, WML191, WML213, WML333) to identify extent of connective cracking from the goaf to the ground surface

Management Plan	Aspect / Feature	Frequency	Monitoring Measures
	Mine inflows – flow rate	Daily	Daily inspection of workings by mining supervisors.
	Mine inflows – flow rate	Monthly – pump station flow rate	Monthly measurement of flow rate at all underground pump stations
	Mine inflows – flow rate	Quarterly, or in event that a significant change in flow rate or discolouration of water is observed during daily/monthly monitoring above.	Detailed visual inspections of the underground workings noting any changes in roof or floor conditions and the locations and flow rates of individual water inflows
	Mine inflows – water quality	On-site screening analysis: Quarterly or in event that a significant change in flow rate or discolouration of water is observed during daily/monthly monitoring above. Comprehensive analysis: Annually	Screening analysis (pH, EC, TDS, and temperature) at all underground pump stations. Comprehensive analysis (as above) at all underground pump stations.

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4.0 IMPLEMENTATION AND OPERATION

4.1 RESOURCES & RESPONSIBILITIES

To ensure adequate implementation of this monitoring program, the following ACOL responsibilities have been assigned to relevant ACOL personnel (see **Table 3**). It is also noted that additional responsibilities are referred to within the relevant management plans.

Table 3 Roles and Responsibilities

Roles	Responsibilities
General Manager	• Ensure that adequate resources are available to ACOL personnel to facilitate the completion of their responsibilities under this program
Underground Mine Manager	• Ensure this Subsidence Monitoring Program is implemented and adhered to.
Technical Services Manager	• Ensure that all monitoring and reporting under the BFMPs and Subsidence Monitoring Program is carried out within the timeframes specified, and is checked, processed and filed appropriately. • Liaise with relevant stakeholders regarding subsidence impact management.
Environment & Community Relations Manager	• Ensure that all environmental monitoring and reporting is undertaken in accordance with the relevant environmental management plans and various approval requirements, and is checked, processed and filed appropriately. • Liaise with relevant stakeholders regarding subsidence-related environmental consequences.
Mine Surveyor	• Ensure that all subsidence monitoring is carried out to the accuracy required, within specified timeframes and are checked, processed and filed appropriately.

4.2 REPORTING

4.2.1. End of Panel Report

ACOL have also committed to the ongoing preparation of End of Panel reports for each longwall panel with a focus on subsidence. End of Panel reports will include:

- Summary of the subsidence monitoring results for the applicable longwall panel;
- Analysis of the monitoring results against the impact assessment criteria, predictions in the Environmental Assessment and monitoring results from previous panels; and
- Description of actions taken to ensure adequate management of any subsidence impacts due to longwall mining.

End of Panel reports will be prepared and submitted to Department of Planning and Infrastructure (DP&I) and DRE.

4.2.2. Subsidence Management Status Reports

ACOL will prepare and maintain a Subsidence Management Status Report which will include:

- Current face position of the longwall being extracted;
- Summary of any subsidence management actions undertaken by ACOL in the period subsequent to the last regular submission of the status report;
- Summary of any comments, advice and feedback from consultation with stakeholders in relation to subsidence management undertaken in the reporting period and a summary of ACOL's responses;

- Summary of the observed and/or reported subsidence impacts, incidents, service difficulties, community complaints, and any other relevant information reported to ACOL in the reporting period and a summary of ACOL's response to these issues;
- Summary of subsidence development based on monitoring information compared with any defined triggers and/or the predicted subsidence (to facilitate early detection of potential subsidence impacts);
- Summary of the adequacy, quality and effectiveness of the implemented management processes based on the monitoring and consultation information summarised above; and
- Statement regarding any additional and/or outstanding management actions to be undertaken or the need for early response or emergency procedures to ensure adequate management of any potential subsidence impacts due to longwall mining.

The Subsidence Management Status Report will be updated at least every 14 days and regularly submitted to the PSE and the owners of affected infrastructure. The status report will also be available upon request to the Mine Subsidence Board, Director of Environmental Sustainability, and owners/operators of any affected infrastructure.

4.3 AUDIT AND REVIEW

An internal review of this Subsidence Monitoring Program and will be conducted in response to:

- An incident recorded as a result of the operations that has implications for how subsidence impacts and consequences are monitored (i.e. exceedance of predicted subsidence values);
- A significant change in operation that may affect built features covered by program;
- Statutory requirements or directions/conditions of approvals requiring such action; or
- Recommendations as a result of internal or external audits.

This Subsidence Monitoring Program may be audited (if required) under the scope of any external environmental compliance audits.

A review and update of the Subsidence Monitoring Program will be undertaken prior to seeking approval for second workings to progress into ULD LW5-8 subsequent seams.

5.0 REFERENCES

ACOL & AECOM (2011) **Built Features Management Plan, Pikes Gully Seam LW6B-8**

ACOL & AECOM (2011) **Extraction Plan, Pikes Gully Seam LW6B & 7B**

ACOL (2006) **Aboriginal Heritage and Cultural Heritage Management Plan – Part 2**

ACOL (2006) **Erosion and Sediment Control Management Plan**

ACOL (2006) **Site Water Management Plan – Part 2**

ACOL (2010) **Bowmans Creek Diversion Rehabilitation Strategy**

ACOL & Aquaterra (in prep) **Water Management Plan**

Department of Mineral Resources (2003) **Guidelines for Applications for Subsidence Management Plan Approvals.**

Evans & Peck (2009) **Bowmans Creek Diversion Environmental Assessment**

Insite Heritage (2011) **Aboriginal Cultural Heritage Management Plan, Underground Area – Western Panels**

NSW Government (2011) **Surveying and Spatial Information Act 2002**, NSW Government Legislation http://www.legislation.nsw.gov.au/ [Accessed: 4/07/2011]

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APPENDIX A SURVEY STANDARDS & METHODS

A.1 GENERAL

- All surveys are to be in MGA East, North, and R.L.
- Survey to be conducted in accordance with the *Surveying and Spatial Information Act 2002.*

A.2 EQUIPMENT

Equipment	Accuracy
Total Station - Trimble S6 Robotic or similar	Angular +/-1" Horizontal and Vertical; Distance EDM & Reflectorless +/-3mm
GNSS - Trimble R6 or similar	Able to achieve Class C or better as per Inter-governmental committee on surveying and mapping, standards and practices for control surveys (SP1) - ICSM-SP1.
Digital Level - Leica DNA 10 or similar	Standard deviation of 1.5mm/km, measuring to 0.1mm.
Staff – 3 piece fibreglass bar-coded or similar.	N/A

A.3 SURVEY STANDARD 1 – TOTAL STATION SURVEY OF GENERAL SUBSIDENCE MARKS: 1650-1800MM STAR PICKET

- 1650-1800mm star picket subsidence marks driven to 200mm above ground level or to refusal and trimmed to ~200mm above ground and centre-punched.

A.3.1 Method - Total Station Coordination

- Station and/or backsight/s to be on existing stable survey control that is outside of the influence of subsidence from the current mining operations.
- Traverse to the first subsidence traverse station on the subsidence line, measuring a minimum of 4 rounds of angles and distances (BS FS FS BS).
- Set on the first traverse subsidence station, measure 1 round to subsequent subsidence marks (BS FS1 FS2 FS3 FSn…FSn FS3 FS2 FS1 BS) for a maximum distance of 100m, preferably using a 100mm high mini ranging pole and prism or equivalent.
- Traverse to subsequent subsidence traverse station every 200m chainage maximum.
- Repeat for the entire line and close onto existing stable control outside influence of current subsidence.
- Process using least squares software (i.e. CompNet) and calculate subsidence, tilts and strains for survey marks measured.

A.4 SURVEY STANDARD 1A – GNSS SURVEY OF GENERAL SUBSIDENCE MARKS: 1650-1800MM STAR PICKET

- 1650-1800mm star picket subsidence marks driven to 200mm above ground level or to refusal and trimmed to ~200mm above ground and centre-punched.

A.4.1 METHOD - GNSS COORDINATION

- All monitoring survey marks are to be occupied for a minimum of 5 seconds.
- A check occupation is to be taken on a known fixed point at least twice during the survey.
- Survey to be processed using a least squares adjustment (CompNet or similar software) producing 3D MGA coordinates and calculate subsidence, tilts and strains for survey marks measured.

A.1 SURVEY STANDARD 2 - POWER POLE MONITORING

The following monitoring points are to be surveyed.

- Base of pole – a permanent mark is to be placed on the pole within 2m of the base of the pole, clear of obstructions and possible interference by fauna.
- Top of pole – radiation to a re-definable point, or where possible to a mini-prism placed by authorised electrical personnel, at or near the top of each power pole.
- Power lines - for power lines reflectorless radiations are to be observed to at least 3 points along the lowest power line between each pole and also radiations, or GPS RTK observations, to ground points below the line to determine ground clearances.

A.1.1 Method - Total Station Coordination

- Station and/or backsight/s to be on existing stable survey control that is outside of the influence of subsidence from the current mining operations.
- Traverse or re-sect to a station near the power poles, measuring a minimum of 4 rounds of angles and distances (BS FS FS BS) x4.
- Radiate to survey marks at the base of the power pole, to the top of the power pole and for ground clearance survey to a minimum of 3 points along the lowest power line and to ground points under the power line.
- Calculate subsidence, direction and magnitude of tilt, direction and magnitude of horizontal movement and ground clearance.
- Provide MGA coordinates (East, North and R.L.) of each monitoring point.

A.2 SURVEY STANDARD 3 – PIEZOMETER BOREHOLE MONITORING

- Total Station or GNSS coordination of Piezometer boreholes.

A.2.1 Method - Total Station or GNSS Coordination

- Survey Station and/or backsight/s to be set on existing control outside influence of subsidence, GNSS survey to check on existing control outside influence of subsidence.
- Radiate to or GNSS RTK observation of Piezometer stations.
- Calculate subsidence of station.
- Each piezometer is to be surveyed prior to the commencement of the associated longwall or prior to the longwall being within 200m of the piezometer and then at the completion of the associated LW extraction.

A.3 SURVEY STANDARD 4 – NEW ENGLAND HIGHWAY MONITORING

Within Road Reserve

- 1650-1800mm star picket subsidence marks driven to 200mm above ground level or to refusal and trimmed to ~200mm above ground and centre-punched.

Road Pavement

- 150mm x 9mm galvanized deck spikes, or similar, driven into bitumen.
- Total Station coordination of survey marks prior to mining.
- All other surveys using Total Station, GNSS coordination or digital level, or as required by RMS.

A.3.1 Method - Total Station Coordination

- Station and/or backsight/s to be set on existing control outside area of mining.
- Radiate to marks using EDM and prism.
- Process MGA coordinates (East, North and RL).

A.3.2 Method - GNSS Coordination

- All monitoring survey marks are to be occupied for a minimum of 5 seconds.
- A check occupation is to be taken on a known fixed point at least twice during the survey.
- Survey to be processed using a least squares adjustment (CompNet or similar software) producing 3D MGA coordinates.

A.3.3 Method - Digital-Levelling

- Start on known BM outside influence of subsidence, level through 2nd BM outside area of mining
- Level through each consecutive subsidence mark
- Close levels onto BM outside area of mining
- Distance between consecutive change points will not exceed 100m
- Other survey methods, including aerial mapping by photogrammetric and/or LiDAR as approved in consultation and agreement with the RMS.

A.4 SURVEY STANDARD 5 – BOWMANS CREEK SURVEY MONITORING

- Total Station of creek monitoring cross-sections and along the thalweg.
- Sufficient data points across the monitoring section are to be obtained to adequately define the channel cross-section shape and area including channel invert, high definition within channel (max RL change between points 0.2m) top and bottom of bank, water level.

A.4.1 Method - Total Station Coordination

- Station and/or backsight/s to be set on existing control outside area of mining.
- Radiate to marks using EDM and prism.
- Process MGA coordinates (East, North and RL).

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APPENDIX B VISUAL MONITORING

In general, areas affected by mining will be visually inspected for cracking, cracking which may provide means of inflow of air or water into the mine, compression humps, and any other possible disturbances caused by mining.

B.1 METHOD

- The area may be driven or walked.
- Each individual inspection will be documented.
- The document will include Date, Name of person carrying out inspection, Longwall chainage, area of examination, location and magnitude of cracking or compression, any observed damage of infrastructure, any other relevant information, and a record of actions taken.
- Photographic records will also be taken of all key areas prior to mining.
- Photographic records will be taken of any relevant detected changes.

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APPENDIX C SUBSIDENCE MONITORING LINES

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N
W E
S

New England Hwy

Bowmans Creek

ML 1623

Train Loading

ML 1529

CHPP

Opencut
(Abandoned)

Underground
Operations

Glennies Creek Rd

Glennies Creek

Sedimentation Dam
for Ventilation Shafts
- SEOC Conveyor

New England Highway

Brunkers Lane
(Lemington Rd Re-alignment)

LW 8

LW 108

LW 107B

LW 106B

LW 6B

LW 4

LW 104B

LW 3

LW 2

LW 1

LW 7A

LW 107A

LW 6A

LW 106A

LW 5

LW 105

LW 104A

LW 103

LW 102

LW 101

ML 1533

XL13
XL12
XL10
XL9
XL8
XL7
XL6
XL5
XL4
XL3
XL2
XL1
XL1A1

LW108-CL2
LW107-CL4
LW106-CL4
LW105-CL1
LW104-CL3
LW103-CL1
LW107-CL1
LW106-CL3
LW105-CL3
LW107-CL2
LW106-CL2
LW104-CL2
LW103-CL2
LW102-CL2
LW101-CL2
LW106-CL1
LW105-CL2
LW104-CL1
LW103-CL3
LW102-CL1
LW101-CL1
LW4 CL1 - PG
LW3 CL1 - PG
LW2 CL1 - PG
LW1 CL1 - PG
LW102-CL1A

Bowmans Creek

Hunter River

Glennies Creek

LEGEND

- Proposed Subsidence Line - 5m intervals
- Existing Subsidence Line / Station - 5m Interval
- Proposed Subsidence Line - 10m intervals
- Existing Subsidence Line / Station - 10m Interval
- Pikes Gully 100m Depth of Cover Contour
- Existing Pikes Gully Seam Workings
- Existing ULD Workings
- Proposed ULD Workings
- Powerline (11kV, 33kV, 66kV, 132kV)
- Surface Contour
- Telstra Cable (Buried)

50 0 100 200 300 400 500
All measurements are in metres

AshtonCoal
PO Box 699 Singleton NSW 2330
Phone 61+ 02 6576 1111 Fax 61+ 02 6576 1122

ASHTON UNDERGROUND MINE
Proposed ULD Seam Subsidence Monitoring
Surface Features, PG and ULD Layouts

Drawing No.	Revision No.	Sheet Size
B–3002_3	3	A0

Date	Scale:	Drawn	Checked	Approved
01/08/12	1:5000	JIP		