Delta coal	Doc Owner: **Mine Surveyor**

CHAIN VALLEY COLLIERY

Subsidence Monitoring Program

Miniwall S5 and Northern Mining Area Pillar Extraction

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Date:	20 Nov 2020

Table of Contents

List of Figures / Tables

1 Introduction

Chain Valley Colliery is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station, producing thermal coal for the domestic and export markets.

A formal Extraction Management Plan has been developed in order to manage the process of mining layout design and mitigate any subsidence impacts on surface infrastructure and/or stakeholders.

The Subsidence Monitoring Program is an element of the Chain Valley Colliery Extraction Management Plan, and has been developed to satisfy the requirements of Development Consent SSD-5465, condition 7(k) and Tables 8-9 in Schedule 4, which states:

"7. The Applicant shall prepare and implement an Extraction Plan for all second workings on site, to the satisfaction of the Director-General. Each Extraction Plan must:

(k) include a Subsidence Monitoring Program which has been prepared in consultation with DRE, which:

- Provides data to assist with the management of the risks associated with subsidence;
- Validates the subsidence predictions
- Analyses the relationship between the predicted and resulting subsidence effects and predicted and resulting impacts under the plan and any ensuing environmental consequences; and
- Informs the contingency plan and adaptive management process;

Condition 1, Schedule 4 of SSD5465 states:

"The Proponent shall ensure that vertical subsidence within the High Water Mark Subsidence Barrier and within Seagrass beds is limited to a maximum of 20 millimetres (mm)."

In addition to the above, Condition 2 within Schedule 4 of SSD-5465 also requires that:

"The Applicant shall ensure that the development does not cause any exceedance of the performance measures in Table 8 to the satisfaction of the Director-General."

The relevant subsidence monitoring requirements from Table 8 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in Table 1.

Table 1 - Subsidence Impact Performance Measures - Natural and Heritage Features

Biodiversity	
Threatened species or endangered populations	Negligible environmental consequences
Seagrass beds	Negligible environmental consequences including: • Negligible changes in size and distribution of seagrass beds; • Negligible change in the function of seagrass beds; and • Negligible change to the composition or distribution of seagrass species within seagrass beds.

Benthic communities	Minor environmental consequences, including minor changes to species composition and/or distribution
Mine Workings	
First Workings under an approved Extraction Plan beneath any feature where performance measures in this table require negligible environmental consequences	To remain long term stable and non-subsiding
Second Workings	To be carried out only in accordance with and approved Extraction Plan.

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*

- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*

- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent*

Condition 4 within Schedule 4 of SSD-5465 also requires that:

"The Applicant shall ensure that the development does not cause any exceedances of the performance measures in Table 9, to the satisfaction of the Director-General.

The relevant subsidence monitoring requirements from Table 9 within Schedule 4 of the Development Consent, including the relevant notes (Table 2).

Table 2 - Subsidence Impact Performance Measures – Built Features

Built Features	
Trinity Point Marina Development Other built features	• Always safe • Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated • Damage must be fully compensated
Public Safety	
Public Safety	Negligible additional risk

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*

- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*

- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*
- *Requirement's regarding safety or serviceability do not preclude preventative actions or mitigation being taken prior to or during mining in order to achieve or maintain these outcomes.*
- *Requirement's under this condition may be met by measures undertaken in accordance with the Mine Subsidence Compensation Act 1961.*

2 Purpose

The purpose of this Subsidence Monitoring Program is to:

- define the subsidence monitoring scope;
- outline subsidence predictions;
- outline the methodology to be used to monitor subsidence impacts
- identify subsidence monitoring locations;
- identify reporting requirements;
- analyse the relationship between predicted and resulting subsidence effects;
- identify the requirements for incident or exceedances reporting.

3 Background

3.1 Operations

Chain Valley Colliery is an underground coal mine with current coal mining methods including development of roadways in the coal seam known as first workings and secondary extraction. These first workings develop panels to support the installation of a miniwall, a modern secondary coal extraction method.

Lake Macquarie is the largest saline lake in New South Wales. It lies on the central coast between Sydney and Newcastle within the local government areas of Wyong and Lake Macquarie. Lake Macquarie has a catchment of 700 square kilometers and a water surface area of 125 square kilometers (Bell & Edwards, 1980). The lake has a permanent entrance to coastal waters at Swansea and has an average depth of around 6 meters (Laxton, 2005).

The catchment of Lake Macquarie is largely rural with large areas of bush land and grazing land. The shoreline of Lake Macquarie is heavily urbanised, especially the eastern, western and northern shorelines. The region has a relatively long history of coal mining and power generation, with mining occurring since the late 1800s and the first power station at Lake Macquarie commencing operations in 1958.

The Chain Valley Colliery is situated on the southern shores of Lake Macquarie near Mannering Park, NSW. The mine has been operating since 1962. Mining is currently undertaken using miniwall methods with first workings to support the development in advance of each miniwall panel. All secondary extraction is currently occurring in the Fassifern seam, in line with Development Consent SSD–5465. The general layout of the Chain Valley Extension Project in respect to Lake Macquarie is shown on **Figure 1**.

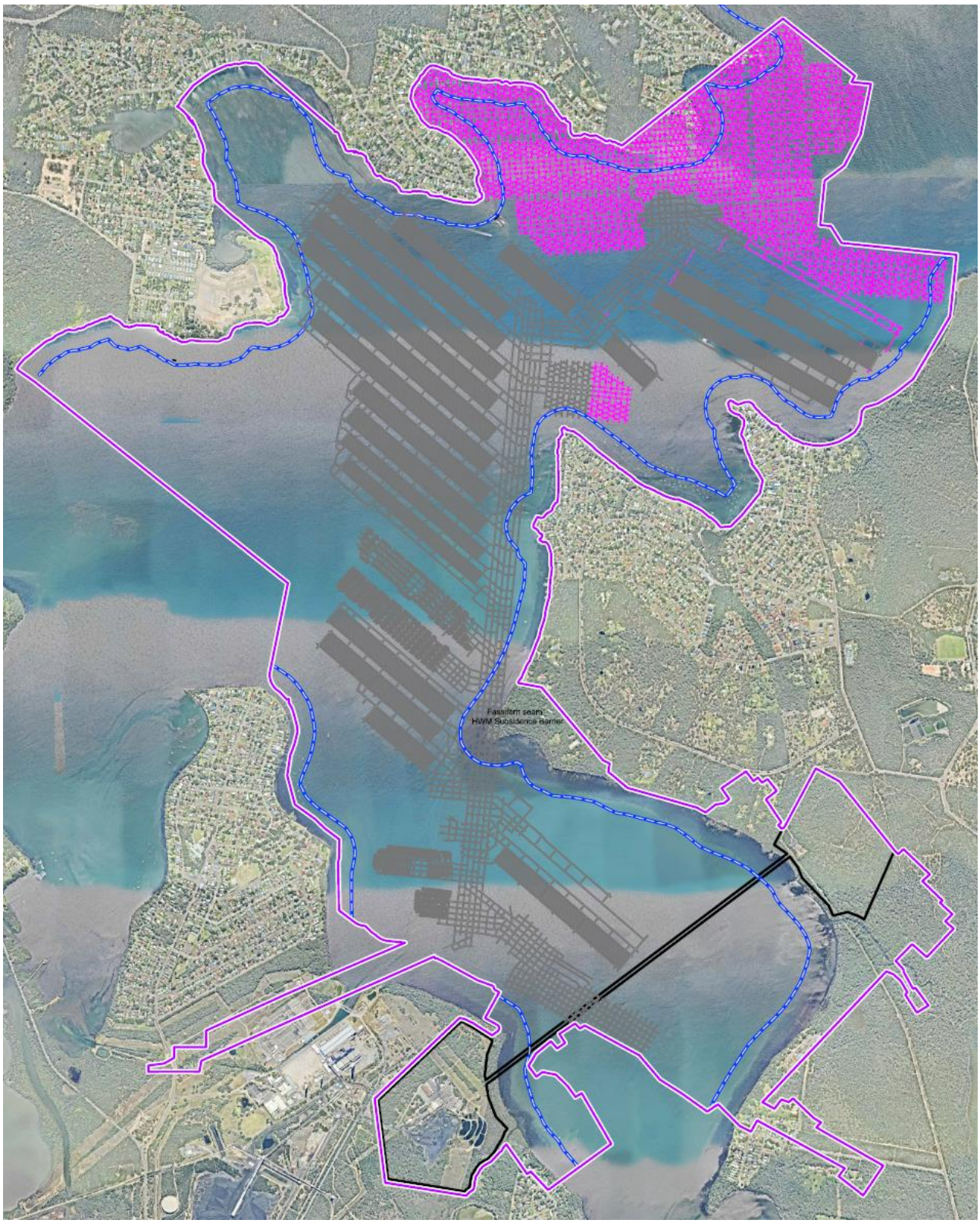

Figure 1: General Layout of the Chain Valley Northern Mining Domain (DC Plan C1P0003_rev8)

3.2 Subsidence Predictions

This management plan references reports completed by Mr David Hill of Strata2 Ground Control Consulting for Miniwall panels S2-S5.

- "*Geotechnical Aspects of S2 and S3 Panel Design"* Strata2 Report: CHV-006 (Hill, 2018)
- *"Geotechnical Aspects of S4 Panel Design"* Strata2 Report: CHV-010 (Hill, 2019)
- *"S5 Panel - Geotechnical Environment, Subsidence Estimates and Impacts"* Strata2 Report: CHV-019 (Hill, 2020)
- *"Miniwall S5 and the Adjacent Herringbone Panels of the Northern Mining Area (NMA) - Geotechnical Environment, Subsidence Estimates and Impacts"* Strata2 Report: CHV-024 (Hill, 2020)

Subsidence modelling has predicted up to approximately 500mm of subsidence to the Lake floor associated with the planned miniwall mining in S2 to S5 and adjacent pillar extraction **(Figure 2).**No additional subsidence is expected to occur within the seagrass or foreshore areas as a result of Fassifern extraction. *(Hill, 2018, 2019, 2020).* Areas where multiple pillar extraction panel are planned has been assessed at 400-500mm, against an approved maximum of 780mm (SSD 5465).

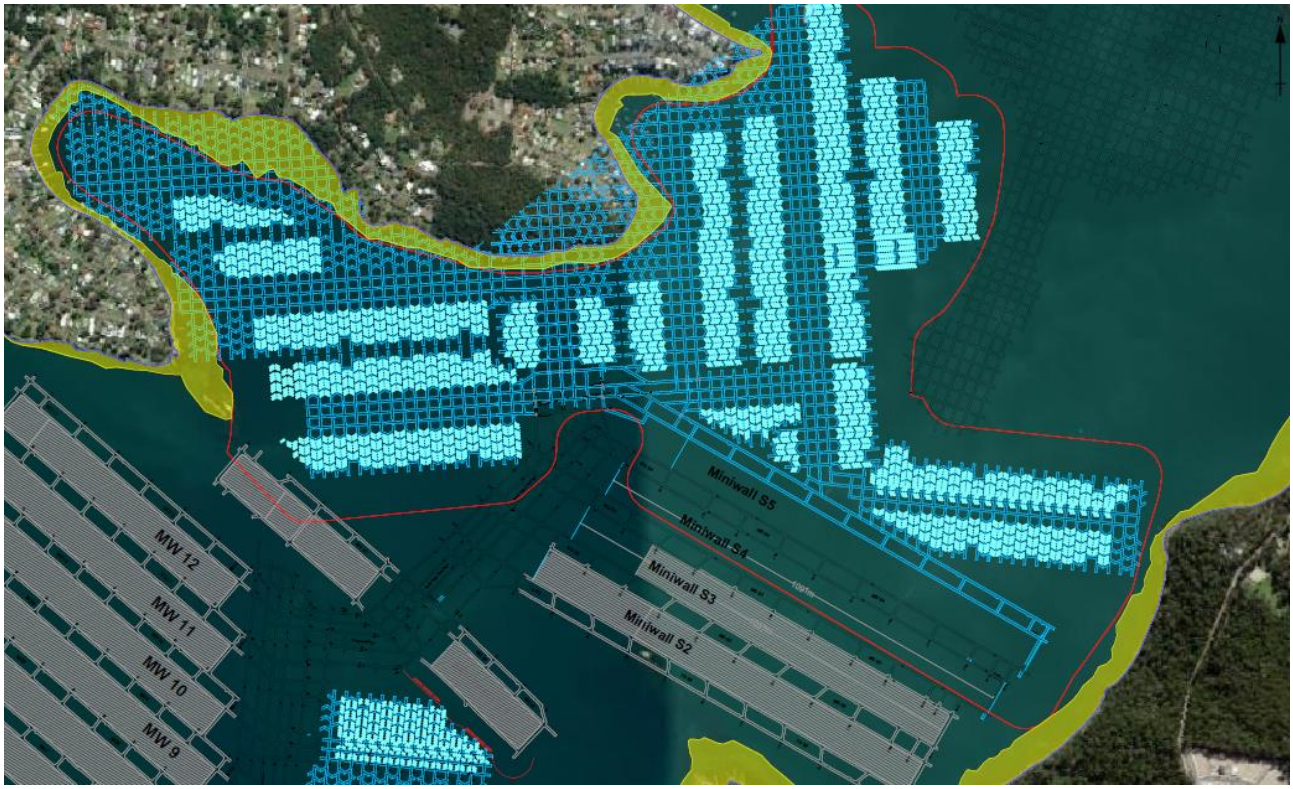

Figure 2 - Predicted Subsidence impact areas due to extraction of S2 - S5 panels and pillar secondary extraction (Hill, 2020)

Respective triggers points for additional monitoring and response are included in the Subsidence Management TARP.

3.3 Surface Monitoring - Scope

3.3.1 Shoreline (High Water Mark)

The shoreline of Lake Macquarie is protected under Mining Lease Conditions requiring Ministerial Approval to carry out mining operations within the High Water Mark Subsidence Barrier (HWMSB). The HWMSB is defined in the seam by a line defined by an angle of draw of 35° drawn lakewards from the high water level of Lake Macquarie, and on the land side, a line drawn from the 2.44m contour at 35° towards the land (Figure 5).

Condition 1, Schedule 4 of SSD5465 states:

"The Proponent shall ensure that vertical subsidence within the High Water Mark Subsidence Barrier and within Seagrass beds is limited to a maximum of 20 millimetres(mm)…."

A key objective of the mine design is to minimise vertical subsidence within the HWMSB and prevent additional subsidence above the high water mark. To ensure effectiveness of the mine design, monitoring of the shoreline is proposed via the installation and monitoring of fixed reference marks surveyed at regular intervals.

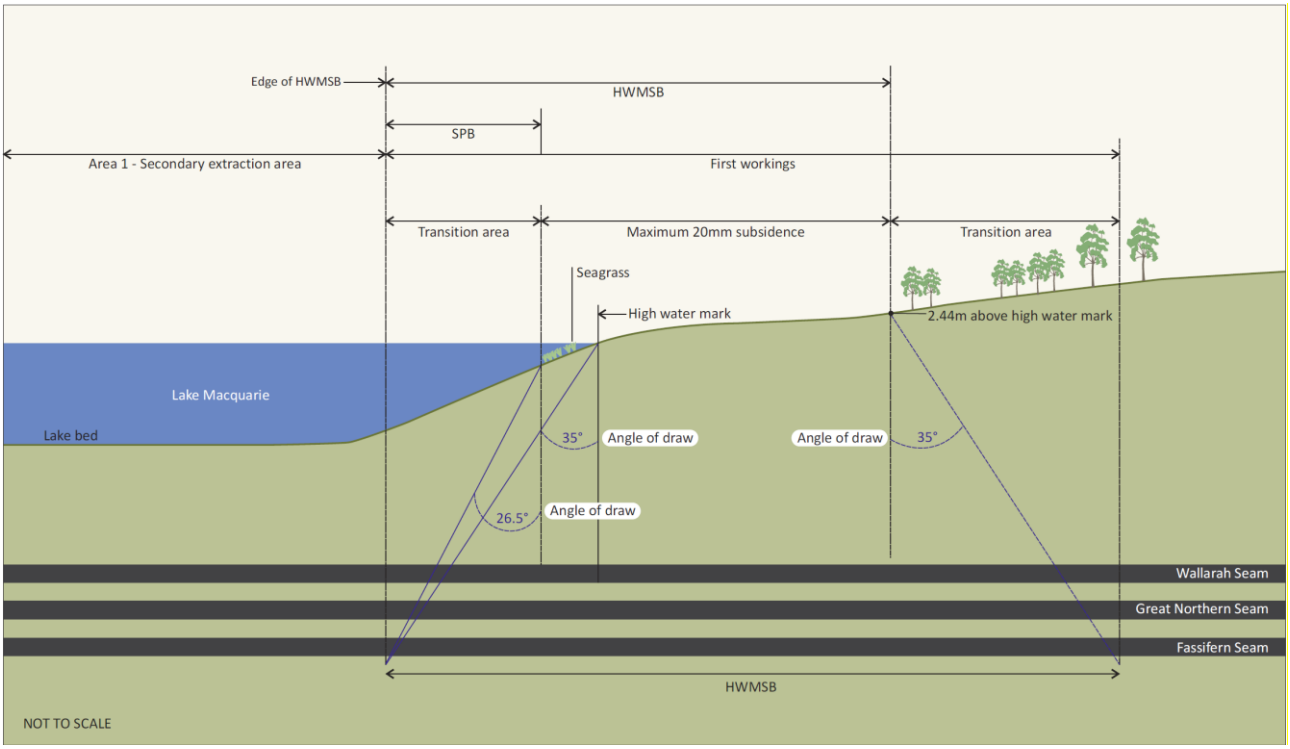

Figure 3 - High Water Mark Subsidence Barrier Typical Diagram

3.3.2 Seagrass

Condition 2, Schedule 4 of SSD-5465 specifies negligible environmental impacts on the species of seagrass found within the current area of mining operations as a condition of approval.

Seagrass distribution within estuaries is naturally influenced by light penetration, depth, salinity, nutrient status, bed stability, wave energy, estuary type, and the evolutionary stage of the estuary.

Surveys of the seagrass extents are undertaken in order to monitor impacts on the seagrass population. Delta Coal's *Seagrass Management Plan* outlines the methodology used to determine changes to composition and quantity of seagrass populations in Lake Macquarie.

A 26.5° line taken from the lake side of the mapped seagrass location projected to the Fassifern Seam has been defined as a protection barrier, and no miniwall extraction is to take place within this barrier.

Subsidence Monitoring of the lakebed is also proposed via bathymetric survey over the current mining area in order to validate the subsidence prediction model.

3.3.3 Benthic Communities

The basin is inhabited by a diverse number of marine organisms. Condition 2, Schedule 4 of SSD-5465 specifies minor environmental consequences on the Benthic communities, including minor changes to species composition and/or distribution as a condition of approval. Regular surveys of the lake bed are undertaken in order to monitor variations in the composition and density of benthos due to mining, environmental and/or other seasonal factors. Delta Coal's *Benthic Communities Management Plan* outlines the methodology used to determine changes to species diversity and abundance.

Subsidence monitoring of the lakebed is also proposed via bathymetric survey over the current mining area in order to validate the subsidence prediction model, and to determine approximate levels of subsidence on specific benthic sample locations.

4 Subsidence Monitoring

4.1 Subsidence Monitoring Methods

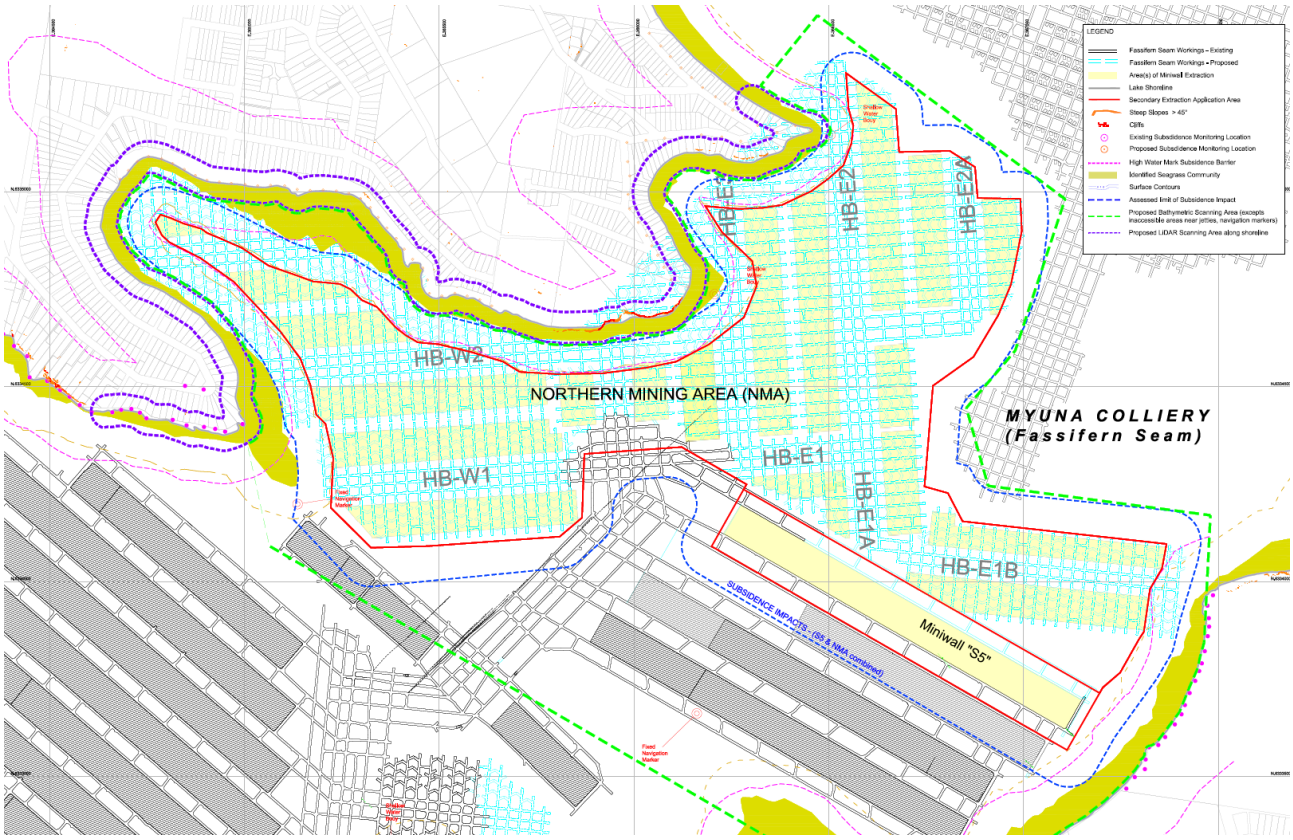

Figure 4 - Proposed Shoreline Subsidence Monitoring Locations, Summerland Point (Delta Coal Plan C4A0099_7)

4.1.1 Bathymetric Surveys

Bathymetric data from the NSW Office of Environment and Heritage (OEH) was obtained in draft format

during 2012. Delta Coal was granted a license to use this OEH data for the purposes of monitoring changes in the bed of Lake Macquarie, and acknowledges the OEH's data which has enabled the subsidence comparison to be undertaken based on this 2010 data and data subsequently obtained in 2012 by Delta Coal. OEH notes that the data was obtained via use of differential GPS and a 200 kHz echosounder, which is noted to provide general data accuracy of 0.1m.

Delta Coal commissioned Astute Surveying in 2012 to undertake a bathymetric survey annually over the areas of current and proposed workings. The primary purpose of this survey was to obtain accurate baseline data for future subsidence assessments and to enable comparison with the draft OEH data from 2010. Importantly, the ongoing surveys provided accurate details of the Lake depth within the proposed mining areas, which would enable future surveys to use as baseline data to monitor the future subsidence levels as a result of mining activities.

Comparative analysis of the surveys highlights some elevation changes which are unrelated to mining, generally however these appear to be minor movements, perhaps related to movement of sediment as a result of the wave climate in the Lake. The surveys have shown that subsidence from the miniwall mining can be monitored with a useful level of accuracy and annual surveys over the extraction area will be continued to cover future mining areas and areas where mining has been completed.

4.1.2 Fixed Foreshore Monitoring Surveys

Subsidence monitoring around Pt Wolstoncroft and Brightwaters peninsula have already been established due to previous mining operations to the immediate south of the extraction area (**Figure 4**). Additional monitoring points will be established along the foreshore in relevant locations at approximately 20-30m intervals and will be reestablished where missing. New monitoring locations will be subject to landholder access arrangements and permission.

The foreshore monitoring points will be monitored as follows:

- The points are to be established as per **Miniwall S5 & NMA Pillars Extraction Plan - Plan 7**.
- X and Y locations will be measured using GPS equipment for plotting purposes (±0.050m)
- AHD RL (Z) component will be leveled using Automatic or Digital levelling equipment to an accuracy of 5mm/km.
- Surveys are to be conducted at intervals prescribed in **Table 3**, during mining operations and after completion of a panel.
- The results are uploaded to DRE's online subsidence web portal within 14 days of survey.

4.1.3 Remote LiDAR Monitoring Methods

Due to the nature of the shoreline in the vicinity of the mine subsidence monitoring areas, it may at times not be practical to install fixed monitoring marks due to access arrangements, environmental/cultural sensitivity and worker safety concerns. It is planned to utilise airborne LiDAR (Light Ranging and Detection) techniques to monitor area of the shoreline where land access may not be available. Calibration, or 'ground-truthed' locations will be established and monitored with the same techniques utilised for the fixed foreshore monitoring surveys.

The remote scanning methodology would be carried out by:

- Utilising a survey ground crew to ground truth designated control sites
- LiDAR and imagery flown
- Low level drone imagery collected of the steep slope / cliff face areas
- Filtering drone imagery data and merge with LiDAR information

Areas to be monitored via these remote LiDAR techniques are shown on **Plan 7** of the **Miniwall S5 & NMA Pillars Extraction Plan** figures.

Results of the post mining monitoring will be provided to the DRE once surveys have been completed and all digital data processed.

4.1.4 Visual Inspection Methods

Additional as a part of the foreshore survey monitoring, observations will be made for visual impact or changes to public safety risk. A Subsidence Inspection Proforma will be completed with each survey. The proforma includes visual inspection of steep slopes, boulder or tree instability, ponding and other potential effects of mine subsidence.

4.2 Subsidence Monitoring Frequency Requirements

Due to the general locality of the mining subsidence monitoring areas, it may be at times not reasonably practical to install, maintain and access fixed monitoring points for shoreline monitoring, due to environmentally sensitive areas, landowner or physical access issues. Where fixed foreshore monitoring surveys cannot be carried out, bathymetric surveys are planned to be substituted to confirm nil impacts outside the proposed subsidence impact area. If fixed monitoring points are to be installed after commencement of extraction, a baseline survey of these points will be undertaken coinciding with a bathymetric monitoring survey to calibrate the monitoring results.

Based on the monitoring program outlined above, the following monitoring frequencies are to be established to validate model outcomes, enable early detection of subsidence trending to increased impact levels over that predicted, allow early application of containment, adaptive and contingency measures to prevent impact outside approved and particularly increased impact to the foreshore.

All evaluations are to be made against the criteria outlined in the Subsidence Monitoring TARP.

Table 3 - Subsidence Monitoring Frequencies (S2-S5, NMA Pillar extraction Panels)

	Areas	Pre-Extraction	During Extraction	Post Extraction
Bathymetric surveys	Area per Plan 7 of the Miniwall S5 & NMA Pillars Extraction Plan	Baseline survey prior to commencement of extraction	End of panel survey for S5 Annual surveys over areas of pillar extraction	Annual for 3 years unless TARP triggered
Terrestrial based subsidence monitoring	Points Plan 7 of the Miniwall S5 & NMA Pillars Extraction Plan, subject to land access	Baseline survey prior to commencement of extraction	End of panel survey for S5 Annual surveys during extraction unless TARP triggered	Annual for 3 years unless TARP triggered
Remote Sensing LiDAR	As per Plan 7 of the Miniwall S5 & NMA Pillars Extraction Plan	Baseline survey prior to commencement of pillar extraction	Annual surveys during extraction unless TARP triggered	Annual for 3 years unless TARP triggered

4.3 Subsidence Monitoring Review

Chain Valley Colliery will undertake a review of available subsidence monitoring data against predictions and expected outcomes annually within its Annual Review as required by SSD-5465.

4.4 Consultation

The Subsidence Monitoring Plan is required to be prepared in consultation with DRE. DRE have been consulted during the submission of the Extraction Plan and will also be consulted as a part of the High Risk Activity Notification for Miniwall S5 extraction.

Roads and Maritime Services Project Officer (North Area) has been contacted during the development of the Extraction Plan and referred the matter to the RMS asset team, with the monitoring program developed in consultation with RMS representatives.

The Community Consultative Committee (CCC) for the mine will be routinely updated on subsidence monitoring results and any change in impact or public safety concern.

5 Roles and Responsibilities

Roles, responsibilities specific to completing the requirements of this Subsidence Monitoring Program are identified in **Table 4**.

Table 4: Subsidence Monitoring Program Roles and Responsibilities

Role	Responsibilities
Mine Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the Subsidence Monitoring Program

Mine Surveyor	• Co-ordinate subsidence monitoring, through the use of bathymetric surveys, conventional surveys along foreshore and underground data collection.
	• Review subsidence monitoring results against Subsidence Management TARP triggers
	• Inform relevant stakeholders as to the subsidence monitoring results
	• Review, and if necessary revise this document:
	  ○ In the event of any exceedance in impact thresholds
	  ○ Following any modification to the development consent

Environment Compliance Coordinator	• Develop management actions in consultation with regulatory agencies as/if required from the monitoring results. • Respond to any potential or actual non-compliance and report these as required to regulatory bodies and other stakeholders. • Notify the relevant Government Agencies and other affected parties of any exceedances of the performance measures • Coordinate the meeting of the Subsidence Review Committee • Ensure complaint handling and response is undertaken, including determination of sources and potential remedial action to avoid recurrence.