PROJECT CHINA STONE

Draft Subsidence Management Plan

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DRAFT SUBSIDENCE MANAGEMENT PLAN

for

MacMines Austasia Pty Ltd

March 2015

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

PROJECT CHINA STONE

DRAFT SUBSIDENCE MANAGEMENT PLAN

Prepared by:

HANSEN BAILEY
Level 15, 215 Adelaide Street
BRISBANE QLD 4000

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For:

MACMINES AUSTASIA PTY LTD
320 Adelaide Street
BRISBANE QLD 4000

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1 INTRODUCTION

1.1 BACKGROUND

Project China Stone (the project) involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland (Figure 1). Coal will be mined using both open cut and underground mining methods. Underground mining will involve up to three operating longwalls in the Northern and Southern Underground Mining Areas (Figure 2). It is anticipated that mine construction will commence in 2016. First open cut and underground coal production is scheduled to commence in 2018.

The Terms of Reference (TOR) for the project Environmental Impact Statement (EIS) require a Subsidence Management Plan (SMP) to be developed, in accordance with Section 5.2.3 of the TOR and the Draft Department of Environment and Heritage Protection (EHP) guideline "*Watercourse Subsidence – Central Queensland Mining Industry, (Version 7)*". This Draft SMP addresses the management of subsidence impacts from the project and has been prepared in accordance with the TOR requirements.

1.2 SCOPE AND STRUCTURE

The Draft SMP addresses the management of subsidence effects on both environmental and man-made features and is structured as follows:

- Section 1 – Introduction
- Section 2 – Statutory Requirements
- Section 3 – Overview of the Project
- Section 4 – Subsidence Predictions
- Section 5 – Environmental Features
- Section 6 – Infrastructure
- Section 7 – Monitoring and Rehabilitation
- Section 8 – Reporting and Review
- Section 9 – Conclusion

The subsidence predictions and the prediction method are described in Section 4 – Subsidence. The impacts and management of subsidence on environmental and man-made features, including proposed monitoring programs, are described in Section 5 – Environmental Features and Section 6 – Infrastructure.

A summary of the monitoring and rehabilitation requirements for subsidence management is provided in Section 7 – Monitoring and Rehabilitation. Section 8 – Reporting and Review describes the reporting requirements and the process for review of the effectiveness of this Draft SMP.

2 STATUTORY REQUIREMENTS

2.1 REGULATORY CONTEXT

The Draft SMP has been prepared to address the requirements of section 5.2.3 of the EIS TOR for the project, which required the preparation of *a detailed subsidence management plan in accordance with the draft guideline Watercourse Subsidence – Central Queensland Mining Industry (latest version) (Department of Environment and Resource Management 2011c) for remediation and monitoring of subsidence cracking and ponding.*

The requirements of the EHP draft Watercourse Subsidence guideline are tabulated in Appendix A, together with a reference to where each guideline requirement has been addressed in this Draft SMP document.

3 OVERVIEW OF PROJECT CHINA STONE

The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland. The project site (the area that will ultimately form the mining leases for the project) is remote, being located approximately 270 km south of Townsville and 300 km west of Mackay at the northern end of the Galilee Basin (Figure 1). The closest townships are Charters Towers, approximately 285 km by road to the north, and Clermont, approximately 260 km by road to the south-east. The project site comprises approximately 20,000 ha of well vegetated land, with low-lying scrub in the south and east and a densely vegetated ridgeline, known as ‘Darkies Range’, running north to south through the western portion of the site.

The mine will produce up to approximately 55 million tonnes per annum of Run of Mine thermal coal. Coal will be mined using both open cut and underground mining methods. Open cut mining operations will involve multiple draglines and truck and shovel pre-stripping. Underground mining will involve up to three operating longwalls. Coal will be washed and processed on site and product coal will be transported from site by rail. It is anticipated that mine construction will commence in 2016 and the mine life will be in the order of 50 years.

The majority of the mine infrastructure will be located in the eastern portion of the project site (Figure 2). Infrastructure will include coal handling and preparation plants, stockpiles, conveyors, rail loop and train loading facilities, workshops, dams, tailings storage facility and a power station. A workforce accommodation village and private airstrip will also be located in the eastern part of the project site.

3.1 LONGWALL MINING AND MINE LAYOUT

3.1.1 Overview of Longwall Mining and Subsidence

A longwall is a complex system of mining equipment that incorporates hydraulic roof supports (called ‘shields’), coal cutting and coal transport equipment. Longwall mining involves extracting rectangular panels of coal, typically around 150 m to 400 m wide, up to 7 km long and 2 m to 5 m thick (Figure 3). Longwall panels are defined by access roadways that are constructed around the perimeter of each longwall panel. These roadways provide access for the installation of the longwall mining equipment, mine workers and equipment and services.

The longwall mining equipment (coal shearer) travels back and forth across the width of the longwall panel, starting from the furthest point progressively removing the coal from the panel back to the main headings. The shearer cuts the coal from the coalface on each pass and delivers the coal to a face conveyor that runs along the full length of the longwall. The face conveyor transports the coal from the coalface to another conveyor in an access roadway. Coal is then transported to the surface via a series of connecting underground conveyors.

The roof at the coalface is held up by a series of hydraulic roof supports (Figure 4). The supported section of roof provides space for the shearer, face conveyor and man access. After each shear of coal is removed, the face conveyor, hydraulic roof supports and the shearer are moved forward.

The roof immediately above the mined seam collapses into the void (called a 'goaf') that is left as the roof supports progressively retreat through the panel. As the roof material collapses into the goaf behind the roof supports, the fracturing and settlement of the rocks progresses through the overlying strata and results in the sagging and bending of the near surface rocks (Figure 4). This can result in the progressive formation of gentle trough-like depressions on the surface relative to the natural topography (called subsidence). The subsidence effect moves across the ground at approximately the same speed as the advance of the mining face, which is typically up to 100 m per week. The majority of subsidence at a point on the surface typically occurs within six weeks of undermining and all subsidence is generally completed within 12 months. Subsidence is discussed further in Section 4.

3.1.2 Longwall Layout

The project longwall layout is shown in Figure 5. The target seams are the A and D seams in the Northern Underground, and the C seam in the Southern Underground. The longwall panels are designed to be 300 m wide and range from 0.4 to 4.8 km long. The planned extraction height in the A and C seams is 4.5 m. The extraction height in the D seam has a progressive reduction from 4.5 m down to 3 m towards the south due to a decrease in seam thickness. The width of the chain pillars (the coal left between the longwall panels) is 35 m.

The depth of cover to the D seam longwall mine ranges from 200 m to 490 m. The A seam longwall mine is typically 50 to 70 m above the D seam longwall at depths ranging from 140 m to 420 m. The C seam longwall mine ranges in depth from <100 m to 450 m.

4 SUBSIDENCE

4.1 INTRODUCTION

A detailed subsidence assessment for the project, including subsidence predictions, was undertaken as part of the EIS for the project. The results of this assessment are presented in the EIS Subsidence Report. The following sections summarise the results of the assessment.

4.2 SUBSIDENCE PREDICTION METHOD

The Surface Deformation Prediction System (SDPS) was used to model and predict subsidence, tilt and strain profiles for the mine longwall layout. This method involves the development of a model using coal seam floor contours, coal seam thickness contours and the mine plan. The SDPS models the shape of the subsided surface using a Gaussian curve calibrated to surface data and mine geology. The modelling has taken into account the various extraction heights that will be mined and has considered the effects of dual seam mining.

The SDSP is a proven and reliable prediction methodology widely used throughout Queensland and New South Wales for underground coal mine environmental impact studies. The subsidence assessment has also referenced published literature with regard to single seam and dual seam longwall experience from the Australian and overseas coal mining industry.

4.3 SUBSIDENCE PREDICTIONS

4.3.1 Vertical Subsidence

The mine plan for the project was designed to ensure that surface subsidence will not occur outside the project site boundary.

The total surface area affected by mine subsidence (not including the part of the Southern Underground that will also be open cut mined) will be approximately 4,950 ha (i.e. the area within the limit of measurable subsidence). Predictions of vertical subsidence are shown in Figure 6 for the Northern Underground and Figure 7 for the Southern Underground. The post-mining surface topography is developed by subtracting subsidence profiles from pre-mining surface topography. Pre and post-mining topography are shown in Figure 8 and Figure 9, respectively.

As shown in Figure 6, the predicted maximum vertical subsidence is 6 m in the Northern Underground where dual seam mining is undertaken and 2.6 m where only one seam is mined. The predicted maximum vertical subsidence is 2.7 m in the Southern Underground

(Figure 7). The maximum vertical subsidence is predicted to occur in the Northern Underground where dual seam mining is proposed to be undertaken and the depths of cover are the shallowest.

The limit of measurable subsidence is defined as vertical ground movement of 20 mm or less. This limit is used to define the extent of subsidence as vertical movements of 20 mm or less occur naturally as a result of ground heave and shrinkage caused by changes in moisture content of surface soils and are therefore not differentiated from small vertical movements due to mine subsidence.

4.3.2 Tilting

The formation of subsidence troughs at the surface will change the ground surface slopes. The pre-mining surface slopes in the proposed underground mining areas range from very steep in the Northern Underground to relatively flat in the Southern Underground. The post-subsidence surface slopes will be steepened in localised areas around the edges of the subsidence troughs. Maximum tilts developed on the surface after the extraction of both seams in the Northern Underground range up to 11% while in the areas of single seam mining maximum tilts approach 3.9%. Maximum tilts developed on the surface after mining in the Southern Underground range up to 16.5%.

4.3.3 Surface Cracking and Buckling

The differential lowering of the ground surface due to subsidence creates areas of tensile strain. Tensile strains can lead to the formation of tension cracks (subsidence cracks) on the ground surface. After longwall mining has been completed, permanent tension cracks can potentially develop in limited areas around the perimeter of the subsidence troughs, in areas of residual tensile strain.

Tension cracks are anticipated to a width of up to 0.2 m, and larger cracks may occur in isolated locations. Depending on the thickness of the near surface strata layers, the soil type, and the mining depth, surface cracking can extend to depths in the order of 10 to 15 m. Based on experience in the Bowen Basin, subsidence cracking is expected to occur in less than 20% of the perimeter of the mined longwall panel sections within the residual tensile strain zone.

Buckling of surface soil may occur due to compressive strain on the ground surface. Buckling will potentially occur near the centre of the longwall panels in the zone of maximum compressive strain. Buckling typically results in mounds of soil being produced in areas where transient tension cracks above the longwall have over-closed.

Proposed rehabilitation measures for cracking and buckling are described in Section 4.5.

4.3.4 Sub-Surface Cracking

Sub-surface cracking and fracturing occurs in the strata overlying the area from which coal has been extracted (i.e. the goaf). Figure 10 shows the various zones that form above the goaf, including the caved zone and fractured zone (area of continuous and discontinuous cracking).

Connective cracking occurs when fracturing above the goaf extends directly to the ground surface or cracking in the fractured zone joins with cracking in the surface zone. Connective cracking may create new flow paths for surface water or groundwater.

The EIS Subsidence Report predicts that connective cracking may occur up to 120 m above areas where single seam extraction is undertaken and 180 m above the A seam in the dual seam mining areas of the Northern Underground. Figure 9 shows surface areas within the underground mining areas where connective cracking to the surface could potentially occur (i.e. areas where fracturing above the goaf is predicted to reach the ground surface).

Predictions of potential connective cracking from the project have been taken into account in assessing the impact of subsidence on groundwater and further detail is provided in the EIS Groundwater Section and the EIS Groundwater Report.

4.4 SURVEY OF SUBSIDENCE LEVELS

A survey of the actual subsidence levels, including mapping of subsidence profiles, will be undertaken following the extraction of each longwall panel, or at minimum 12 month intervals. This survey will enable the comparison of the predicted subsidence levels with the actual subsidence. The results of this work will confirm the accuracy of the subsidence predictions and associated impact assessments. Any significant differences in the survey levels of actual subsidence compared to the predictions will trigger a review of the relevant impact assessments and associated mitigation and management measures, where necessary. This work will also provide additional calibration data for any future subsidence predictions and assessments of subsidence effects.

This work will be undertaken either by ground survey, or through the use of LiDAR survey data. Reconciliation of the actual versus predicted subsidence would be achieved by establishing a long section down the centre line of each longwall panel, together with representative cross sections. The subsided ground profile will then be compared to the existing ground level data, which has been established through LiDAR survey, and the predicted subsidence profiles.

4.5 CRACK REHABILITATION

The proposed subsidence crack rehabilitation program is as follows:

1. A survey of potential subsidence cracking areas will be undertaken within six months of subsidence to locate individual cracks and assess the level of treatment required to rehabilitate each crack. Six months will allow sufficient time for the full effects of subsidence to take place and ensure that remedial works are not undertaken prematurely before the full development of all the surface subsidence effects. Subsidence crack treatment will involve:
    - Ripping or ploughing minor cracks (<0.2 m width) using a small tractor or dozer. These areas will be allowed to regenerate naturally through inherent seed resources, vegetation propagation from rootstock and recruitment from adjoining undisturbed edges.
    - Stripping large cracks (>0.2 m width) of topsoil, excavating and backfilling the cracks. Topsoil will then be replaced over the area and the site will be allowed to regenerate naturally from the seed bank and root stock in the topsoil. Areas disturbed as part of the crack rehabilitation program will generally comprise a narrow strip typically up to 2 to 3 m wide and for the length of the crack (typically up to a maximum of 50 m).
2. The subsidence crack rehabilitation work area will be clearly delineated in order to limit disturbance to the minimum area necessary and prevent unnecessary encroachment of disturbance. Disturbance of mature trees will be avoided, where possible. These requirements will be managed through the proponent's Permit to Disturb process.
3. Erosion and sediment controls will be implemented in areas disturbed as part of the subsidence crack rehabilitation program. This may include the installation of minor diversion drains, hay bales and/or silt fences.
4. Grazing pressure will be managed in areas that have been disturbed as part of the subsidence crack rehabilitation program. This may involve the temporary exclusion of stock through the use of fencing, if appropriate.
5. Pest animal and weed control measures will also be implemented for the project.
6. A monitoring program will be established for areas that have been disturbed as part of the subsidence crack rehabilitation program. The program will initiate crack rehabilitation maintenance work, where necessary, and ensure that the cracks have been successfully rehabilitated and any disturbed vegetation is regenerating.
7. The ultimate aim of the rehabilitation and monitoring program will be to confirm that any areas disturbed as part of the subsidence crack rehabilitation program are re-established with vegetation communities consistent with the pre-disturbance vegetation communities.

Buckling will be rehabilitated as required through regrading excess soil material in any areas of buckling. Regeneration of vegetation and monitoring will be as per the subsidence crack rehabilitation program described above.

It should be noted that surface subsidence cracks and associated rehabilitation will occur progressively over approximately 47 years of mining. Only relatively small areas of the longwall mining areas will therefore potentially be disturbed by cracking, buckling and associated rehabilitation works, at any point in time.

5 ENVIRONMENTAL FEATURES

The key environmental features with the potential to be affected by subsidence from the project are groundwater, surface water and flora and fauna. The following sections describe the potential subsidence impacts on these features, as well as management and mitigation measures to address these impacts. These sections are based on the work completed for the EIS.

5.1 GROUNDWATER

A groundwater impact assessment was undertaken for the EIS and is presented in the EIS Groundwater Report. The groundwater assessment includes an assessment of the hydrogeology of the longwall mining areas. The following sections summarise the findings of this assessment.

5.1.1 Existing Environment

Background

The regional hydrogeology within the vicinity of the longwall mining areas consists broadly of the following units:

- A veneer of highly weathered Tertiary sediments and localised fluvial Quaternary sediments;
- Triassic Clematis Sandstone which is a recognised regional aquifer of the Great Artesian Basin and is the most productive unit in the vicinity of the project site;
- Triassic Rewan Formation which is a recognised regional aquitard and acts as a basal confining unit to the overlying Clematis Sandstone aquifer; and
- Permian Betts Creek Beds comprising very low yielding to essentially dry sandstone and siltstone with low to moderately permeable coal seams which are the primary water bearing strata within this unit.

Figure 11 shows the distribution of solid Triassic and Permian geology across the underground mining areas. Cross-sections shown in Figure 12 illustrate the groundwater regime in the underground mining areas.

Quaternary Sediments

Published regional geological mapping indicates the presence of fluvial sediments associated with present day drainage features. The distribution of these sediments in the vicinity of the project site was further investigated through targeted groundwater drilling and stream geomorphology assessments.

These studies confirmed that the minor drainage features and overland flowpaths present within the project site and downstream catchment are characterised by rock channels or exposed Tertiary materials. Extensive, deep alluvial deposits and associated shallow groundwater are therefore absent from the project site and surrounding area. Fluvial sediments present in the vicinity of the project site are limited to thin (less than 1 m) patches of mud and gravel that dry quickly following flow events.

The absence of a shallow groundwater is further evidenced by the documented history of difficulties in finding water for cattle in the grazing properties that make up the project site. There are no confirmed alluvial bores in the vicinity of the project site.

This contrasts with the extensive alluvial deposits associated with the regionally significant Belyando and Carmichael River systems. These alluvial deposits are recharged by direct rainfall to large catchments and seepage from major rivers during periods of surface flow. These alluvial deposits are known to support a perennial water table and exhibit high yields and permeability. The Belyando River alluvium is located 50 km downstream of the project site and Carmichael River alluvium is located in a separate catchment from the project site.

Tertiary Sediments

The Tertiary sediments comprise claystone and weakly indurated sandstone and siltstone. This unit is a highly weathered, low to moderate permeability detrital deposit that covers much of the low-lying areas either side of the Darkies Range ridgeline. These sediments typically increase in thickness with distance from Darkies Range and within the project site range from zero to 60 m. The Tertiary sediments are thin or absent on the elevated ridge of Darkies Range.

In elevated areas, recharge is diffuse and limited to sporadic rainfall events over small catchment areas. As a result of the limited recharge, the localised Tertiary sediments along Darkies Range are dry and unsaturated. In the lower lying areas beyond Darkies Range, recharge is expected to be enhanced as the topography transitions from the sloping ridge to flatter plains, and the diffuse rainfall catchment areas increase.

A water table is formed within these sediments in the south-east of the project site and extends east towards the Belyando River. The hydraulic gradient of this groundwater body is also to the east, reflecting the regional topography and surface water catchment setting. Where present within the project site the water table is generally deep (25 to 55 m below ground level) and entirely disconnected from local drainage features. Further east, the water table is typically 15 to 20 m below North Creek and 20 to 25 m below Tomahawk Creek. Groundwater from this unit is likely to discharge to the Belyando River.

Tertiary sediments are present within the Lake Buchanan drainage basin to the west of Darkies Range. These sediments are discontinuous with the Tertiary sediments east of

Darkies Range. The Tertiary sediments underlying Lake Buchanan host a shallow water table that is a regional discharge point for groundwater from underlying units.

Due to the lack of a shallow groundwater resource associated with drainage features, local water use is focussed within the Tertiary sediments. A total of 17 private bores target groundwater within the Tertiary sediments within 20 km of the project site. Private bores are typically 20 to 30 m deep and yield fresh to slightly brackish water suitable for use as cattle watering supply.

Clematis Sandstone

The Clematis Sandstone is a massive sandstone unit, with minor interbeds of siltstone and claystone. This unit outcrops to form the western slopes of Darkies Range where is it is up to 200 m thick along the ridgeline. In this area, the formation is deeply weathered resulting in a clay-bound, low to moderately permeability unit.

Due to the prominence of the outcropping relative to the surrounding area, the Clematis Sandstone is generally dry within the project site. Where present in this area, the water table is at depths in excess of 100 m.

In the north of the project site, a normal fault is present in this unit and the underlying Betts Creek Beds. To the east of the fault, a thin wedge of Clematis Sandstone has been downthrown by approximately 100 m and is now truncated against the Rewan Formation on the west of the fault. In this area, the deeper Clematis Sandstone lies below the water table. The saturated thickness of this unit reaches 50 m close to the fault and gradually reduces to the east as the base of the unit rises above the water table.

The generally dry nature of the Clematis Sandstone and relatively deep water table within the vicinity of Darkies Range indicate a low rate of groundwater recharge in this area. Groundwater flow reflects surface topography and catchment boundaries, with limited discharge into overlying formations. Lake Buchanan is an inferred discharge zone for the Clematis Sandstone groundwater. The salt pans that surround Lake Buchanan and the saline water quality indicate that volumes of groundwater discharging to the lake are low and readily removed by evaporation.

This unit is a recognised regional aquifer of the Great Artesian Basin and is the most productive unit in the vicinity of the project site. However, as this unit is dry and unsaturated there is no private use of the Clematis Sandstone within the project site. A total of eight private bores target groundwater within this unit within 20 km of the project site. These bores show moderate yields (up to 6 L/s) of fresh to slightly brackish water typically used as cattle watering supply.

Rewan Formation

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone and minor fine grained sandstone. This unit outcrops along the eastern margin of Darkies Range where the Clematis Sandstone has been removed by erosion. This unit has also been subject to erosion and disconformably overlies the Betts Creek Beds. The potentiometric groundwater surface is relatively deep under Darkies Range where groundwater levels within the Rewan Formation can be more than 100 m below the surface.

The Rewan Formation is a recognised regional aquitard and acts as a basal confining unit to the overlying Clematis Sandstone aquifer. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between any localised fractures. This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing and private bores.

Rainfall recharge to the Rewan Formation is very low due to limited diffuse rainfall infiltrating Darkies Range and the overlying Tertiary sediments. Runoff from the eastern slopes of Darkies Range may concentrate at the break of slope and act to locally enhance recharge into this unit. However, recharge is further limited by the layered low permeability of this unit. The generally very low rates of recharge are confirmed by the typically dry and unsaturated nature of these sediments along Darkies Range. Where present in this unit, the potentiometric groundwater surface is typically deep (i.e. 100 m below ground level).

Groundwater movement is a subdued reflection of the typography and surface water catchments. Limited discharge into overlying formations is the main discharge mechanism. However, discharge volumes are similarly very low due to the very low rates of groundwater recharge.

This unit is typically dry and unsaturated at the project site. In the vicinity of the project site, private use of the Rewan Formation is also limited. A total of three private bores within 20 km of the project site may intersect localised fractures containing groundwater. These private bores are 55 m to 100 m deep and are expected to yield low volumes of fresh to moderately saline water typically used as cattle watering supply.

Betts Creek Beds

The Betts Creek Beds sub-crop under the Tertiary sediments immediately east of Darkies Range and dip gently towards the west. The sub-cropping Betts Creek Beds are deeply weathered and the coal seams are typically absent within this weathered profile. As this unit dips under Darkies Range, the depth increases to between approximately 200 m and 450 m at the western extent of the project site.

Groundwater storage and movement occurs within the cleats that intersect the coal seams. Other sediments in the coal overburden and interburden sequence exhibit very low permeability and form discrete confining units between the seams. The Betts Creek Beds may therefore be categorised into the following hydrogeological units:

- Hydraulically "tight" and hence very low yielding to essentially dry sandstone and siltstone that comprise the majority of the Betts Creek Beds interburden/overburden; and
- Low to moderately permeable coal seams which are the primary water bearing strata within the Betts Creek Beds.

Data shows that limited recharge occurs through the elevated topography of Darkies Range into the underlying Betts Creek Beds. However, this recharge is limited by the layered, low permeability interburden and overlying Rewan Formation that retard downward flow. Slightly more recharge is expected where the coal seams subcrop against the weathered Betts Creek Beds, although the clayey nature of this weathered material will also limit recharge. Ephemeral runoff from Darkies Range that collects in drainage lines and the break of slope are also considered areas where recharge to the Betts Creek Beds could occur, although the recharge volumes will be limited by the small size of these recharge zones and the thickness of overlying Tertiary sediments. Overall, the Betts Creek Beds recharge rate will be low. The relatively deep water levels support this conclusion.

Groundwater movement is a subdued reflection of the typography and surface water catchments (i.e. from topographically elevated areas to lower lying parts of the landscape). Darkies Range acts as a groundwater divide, with groundwater flowing west towards Lake Buchanan, and east to south-east following the surface water catchments generally towards the Belyando River.

Limited discharge into overlying formations is the main discharge mechanism. However, discharge volumes are similarly very low due to the very low rates of groundwater recharge.

Due to the significant depth of these sediments west of Darkies Range, private bores within this unit are located in the shallower deposits close to the subcrop line (Figure 11). A total of 14 private bores within 20 km of the project site target groundwater within the Betts Creek Beds (and underlying Joe Joe Group). Private bores are between 4 m and 150 m deep with low yields (less than 4 L/s). These yields represent the bores that successfully intersected cleats and fractures and are considered representative of the more permeable profiles within this unit.

Groundwater quality is highly variable with depth and location. Bores screened within the coal seams yield slightly brackish to brackish groundwater, whilst bores screening the interburden yield fresh to slightly brackish groundwater. Groundwater is also slightly less saline at the break of slope from Darkies Range, where salinity is reduced by enhanced recharge. Groundwater is suitable for use as cattle watering supply.

5.1.2 Impacts from Subsidence

Underground Mining Activities
Key potential impacts on the groundwater regime that could arise from underground mining include direct impacts on the Permian Betts Creek Beds from extraction of the target coal seams, as well as sub-surface cracking in areas that have been subject to longwall mining.

When longwall mining takes place, sub-surface fracturing occurs in the strata overlying the area from which coal has been extracted (the goaf). This fracturing exhibits increased vertical and horizontal transmissivity and storativity, and results in drainage of water from overlying strata into the mine. The height of fracturing is important in assessing the impact of mining on the groundwater regime and groundwater inflow to the mine. The predicted height of fracturing will be up to 120 m above the coal seam in single seam mining areas, and 180 m above the A seam in the dual seam mining areas of the Northern Underground.

The majority of the Northern Underground involves dual seam mining (A and D seams). This area is overlain by the Betts Creek Beds, Rewan Formation and Clematis Sandstone. The interburden thickness between the A Seam and the base of the Clematis Sandstone is variable with a minimum thickness of 115 m to 120 m on the western side of the fault, and 140 m to 160 m on the downthrown eastern side. The 180 m predicted height of connective cracking would therefore extend through the Betts Creek Beds and Rewan Formation, and intersect the overlying Clematis Sandstone (including localised areas where this unit is below the water table).

The western panels of the Southern Underground are overlain by the Betts Creek Beds, Rewan Formation and Clematis Sandstone. The Clematis Sandstone is thin and effectively dry and unsaturated in the Southern Underground Mining Area. The eastern panels of the Southern Underground are located beyond the subcrop of the Clematis Sandstone and Rewan Formation, and in this area the Betts Creek Beds are typically overlain by dry and unsaturated Tertiary sediments. Subsidence fracturing is not likely to intersect significant water-bearing strata in the Southern Underground Mining Area.

Predicted Effects of Mining Activities
A 3D numerical groundwater flow model was developed to predict the extents of depressurisation and the associated impacts on groundwater users and the surrounding environment. The 3D numerical model included changes to model parameters to simulate the effects of subsurface subsidence cracking.

In the Northern Underground longwall mining will depressurise the coal seams and overlying and underlying strata. Depressurisation will propagate through the Betts Creek Beds, Rewan Formation and Clematis Sandstone (where saturated), and will be enhanced by the increased hydraulic conductivity of connective subsurface subsidence cracking. The Clematis Sandstone is predicted to be depressurised most significantly where it is saturated on the eastern side of the fault (Figure 12). The saturated thickness of the Clematis Sandstone prior to mining in this area is approximately 50 m. The modelling predicts that the potentiometric surface may be lowered by up to 33 m in response to mining. Beyond the extents of mining subsidence, the depressurisation effects within the Clematis Sandstone rapidly diminish with distance. Tertiary sediments do not occur on Darkies Range in the Northern Underground where dual seam mining is proposed, and therefore will not be affected. The extents of depressurisation within the coal seams and broader Betts Creek Beds in the north of the project site are localised to a radius of approximately 2 km from the proposed underground mine workings. In general, the lateral extent of depressurisation is constrained by the largely dry and unsaturated nature of the elevated, outcropping units in this area.

Depressurisation in the remainder of the project site differs from the Northern Underground, because the Clematis Sandstone is typically absent, except in the south-west of the project site where it is essentially dry and unsaturated. Groundwater within the Clematis Sandstone will not be intersected by connective subsidence cracking above the Southern Underground. The Clematis Sandstone aquifer may therefore only be impacted indirectly by longwall mining reducing pressures in the Rewan Formation as it is cracked above the underground mine, resulting in pressure reduction propagating into the Clematis Sandstone. This results in a limited zone of depressurisation extending 2 km from the project site as shown in Figure 13. Groundwater levels may be lowered by up to 2 m in a localised zone south-west of the Southern Underground.

The zone of depressurisation in the target coal seams is comparable across the project site and is constrained to within a zone of about 2 km around the project site boundary.

The water table within the Tertiary sediments will be affected by depressurisation, resulting in drawdown of the groundwater level within a radius of up to 5.5 km although this is predominantly due to open cut mining.

Groundwater inflow to the mining operations will occur from the coal seams and from overlying strata where fracturing is predicted to occur above mined longwall panels. Numerical modelling predicts that inflow volumes to the underground mines will peak at approximately 4 ML/day in the Northern Underground and 2.5 ML/day in the Southern Underground.

Seepage rates to the Northern Underground vary from 1 to 2 ML/day over the first 30 years of the project. Following completion of the D seam underground mine, seepage rates into the overlying A seam underground mine are predicted to increase up to 4 ML/day. This increase is due to the height of connective cracking in dual seam mining areas and intersecting and draining water from the overlying Clematis Sandstone where it is saturated above the mine.

Impacts on the Great Artesian Basin

The groundwater model has been used to estimate the 'water take' from the Great Artesian Basin aquifers due to the depressurisation induced by mining. Water take will gradually increase over the project life to approximately 4 ML/day as mining moves from areas where the Clematis Sandstone is dry to the saturated areas above the Northern Underground. The water take will peak at 9 ML/day when subsurface subsidence cracking from the A seam longwall first interconnects the Northern Underground with the saturated Clematis Sandstone on the downthrown side of the fault. For the purposes of modelling worst-case water take from the Great Artesian Basin, the groundwater assessment has conservatively assumed that the permeability of the cracked strata overlying the mine is effectively 'free-draining'.

The volume of the water take reduces post mining due to the lesser hydraulic gradients present around the mining areas. The long-term water take from the Great Artesian Basin peaks below 0.5 ML/day.

The predicted peak water take of up to 9 ML/day is inconsequential when compared to the estimated 65,000,000 GL estimated to be stored within the Great Artesian Basin. On a local scale the acceptability of the predicted water take depends on the impact upon existing users of the Great Artesian Basin.

Impacts on Springs

The closest springs to the project site are Doongmabulla Spring Complex, 22 km to the south of the proposed mining area. The Clematis Sandstone is the source aquifer for the springs. As discussed above, the project site is located at the eastern margins of the Clematis Sandstone where this unit is largely dry and unsaturated. In the south of the project site, closest to the Doongmabulla Spring Complex, the Clematis Sandstone is generally absent (Figure 11). In this area, subsurface subsidence cracking above the Southern Underground will intersect a minor area of thin, essentially dry Clematis Sandstone. The only mechanism by which the underground mining could impact on the springs would be via depressurisation of the underlying low permeability Betts Creek Beds and Rewan Formation in the Southern Underground propagating upwards to the Clematis Sandstone and laterally 22 km to the springs. The maximum predicted extent of depressurisation in the Clematis Sandstone extends to 2 km from the project site (Figure 13). This means that no significant depressurisation of the Clematis Sandstone due to the project will occur within 20 km from the Doongmabulla Spring Complex during or post mining and therefore no impacts on the springs are predicted.

Impacts on Groundwater Users

A bore census was carried out to identify private bores surrounding the project site that could potentially be impacted by the project. The project is not predicted to result in any impacts on bores located beyond the project site during mining operations. Post mining, up to 19 bores beyond the project site are predicted to be potentially impacted by the project. Of these, five are owned by Adani Mining Pty Ltd. Groundwater monitoring will be conducted over the 50 year life of the mine to confirm the actual extent of groundwater impacts and validate the conservative predictions. The results of the groundwater monitoring conducted over the life of the mine will be used to inform the reassessment of potential post-mining groundwater impacts and identification of any bores that will potentially be impacted in the long-term post mining. As part of mine closure planning, the proponent will enter into agreements with landholders of any potentially impacted bores. Any impacts on private bores within the project site will be managed through land access arrangements with landowners.

Impacts on Surface Water and Drainage Features

Lake Buchanan is located 17 km to the west of the proposed mining area and is considered to be an area of groundwater discharge and evaporation. The lake is underlain by Tertiary sediments and the deeper Moolayember Formation, which subcrops west of the project site and therefore is not directly impacted by underground mining activities. Depressurisation of the Tertiary sediments and Moolayember Formation could theoretically occur indirectly, through propagation of depressurisation impacts from Betts Creek Beds, Rewan Formation and Clematis Sandstone. However, modelling shows that the maximum predicted zone of depressurisation will not reach Lake Buchanan and lake levels are unlikely to be impacted by the project.

No watercourses as defined under the *Water Act 2000* are located on the project site. As discussed above, there is a general absence of shallow groundwater in the vicinity of the project site. This is because the project site is located in the headwaters of the catchment where the topography is elevated and recharge relatively low. The surface drainages have only short duration highly ephemeral flows following rainfall. Within the predicted extents of drawdown (Figure 13), the water table is at least 15 m, and more typically at least 20 m, below the base of any drainage feature and confirms that there is no direct groundwater – surface water interconnection in this area. The significant separating depth confirms that groundwater does not provide baseflow to drainage features in the vicinity of the project site, and therefore drawdown on the water table will not impact the overlying drainage features.

Impacts on Groundwater Dependent Ecosystems

Due to the depth of the water table, there are no Groundwater Dependent Ecosystems (GDEs) within the project site.

Impacts on Stygofauna

A desktop review confirmed that there is limited potential for significant stygofauna habitat or assemblages to occur within the project site. A field investigation was undertaken that confirmed these findings. The project is unlikely to result in significant stygofauna impacts due to the nature of the existing groundwater setting, the localised effects of groundwater depressurisation, and the lack of any confirmed stygofauna assemblage within the vicinity of the project.

Cumulative Impacts

The proposed Carmichael Coal Mine located immediately south of the project site has the potential to contribute to cumulative groundwater impacts. The cumulative depressurisation effects will be most extensive in the coal seams targeted by the mining operations, with cumulative depressurisation predicted in the A, C and D seams by the end of mining. The project effects on groundwater levels are most extensive in the Southern Underground, where up to 200 m additional depressurisation will occur. Outside this area, the project could add between 1 m to 50 m to the depressurisation predicted for the Carmichael Coal Mine.

The Carmichael Coal Mine does not propose to directly mine the Clematis Sandstone within the open cut mining areas, or fracture this unit above the underground mines. The Carmichael Project EIS groundwater assessment predicts no significant depressurisation of the Clematis Sandstone during or post mining. Cumulative impacts on the Clematis Sandstone are therefore unlikely.

The method of superimposition has been used to assess cumulative groundwater impacts associated with the Carmichael Coal Mine. Depressurisation predictions for each stratum due to each project were overlaid on a single map to identify overlap of impacts. Cumulative impacts could potentially occur within the overlapping zones. By comparing the maximum predicted extents of depressurisation for each mine, this approach provides a conservative assessment of the cumulative worst-case in terms of changes to groundwater levels. Predictions relating to the Carmichael Coal Mine were sourced from the Carmichael Coal Mine EIS and Supplementary EIS documents. The 1 m drawdown contour has been taken as the limit of impact for each project.

During mining there is no cumulative drawdown on the water table within the Tertiary sediments. Post mining, the project may increase the drawdown predicted for the Carmichael Coal Mine by up to 20 m. It should be noted that with respect to the Quaternary sediments, cumulative impacts are not predicted due to the relative catchment settings of these projects and the absence of these deposits in the vicinity of the project site.

The zone of cumulative impact is concentrated largely in the area where the two projects adjoin. Groundwater use is very limited in this area, with only three bores potentially experiencing a cumulative impact (Figure 14). RN103875 is located within the project site and will be effectively dealt with by the land access agreement for the mining lease application. RN132938 is located within the proposed Carmichael Coal Mine site and will be impacted by the Carmichael Coal Mine. This bore is owned by the proponent for the Carmichael Coal Mine. Allen's Bore is also predicted to be impacted by the Carmichael Coal Mine and is therefore likely to be subject to a make good agreement with the proponent for the Carmichael Coal Mine.

The Carmichael Coal Mine is predicted to result in impacts to the Doongmabulla Spring Complex. However, as discussed above, the project is not predicted to result in significant impacts to any springs. Therefore the project will not result in additional impacts to the Doongmabulla Spring Complex affected by the Carmichael Coal Mine.

The Carmichael Coal Mine is predicted to result in impacts to the Carmichael River, as well as several minor drainage features. However, as discussed above, the project is not predicted to result in significant impacts to watercourses, lakes or other surface water features. Therefore the project will not result in additional impacts to surface waters affected by the Carmichael Coal Mine.

5.1.3 Mitigation and Management

The EIS groundwater assessment concluded that the project has a very low risk of significant adverse impacts on environmental values for groundwater. Despite this low risk, the assessment noted that the established groundwater monitoring program will be continued throughout the life of the project.

The details of the proposed groundwater monitoring program are provided in Tables 1 and 2.

Table 1
Groundwater Monitoring Program – Locations

Monitoring Location Reference	**Easting (GDA 94)**	**Northing (GDA 94)**	**Geological Unit**
Boreholes			
MB03	414830	7589056	Betts Creek Beds (Coal Seam)
MB04	413863	7590355	Tertiary Sediments
MB05	413873	7590356	Betts Creek Beds
MB06	413874	7590369	Betts Creek Beds (Coal Seam)
MB07	415547	7590584	Tertiary
MB08	415553	7590570	Betts Creek Beds
MB09	414434	7592831	Tertiary
MB10	414439	7592830	Betts Creek Beds
MB11	414442	7592837	Betts Creek Beds (Coal Seam)
MB12	410626	7590113	Rewan Formation
MB13	408638	7594223	Rewan Formation
MB14	407589	7598323	Rewan Formation
MB15	409522	7602328	Rewan Formation
MB16	417115	7585134	Tertiary Sediments
MB17	417118	7585137	Tertiary Sediments
MB18	414442	7583778	Tertiary Sediments
MB19	414446	7583780	Rewan Formation
MB20	420926	7589917	Tertiary Sediments
MB21	407809	7592771	Clematis Sandstone
MB22	409254	7588046	Clematis Sandstone
MB23	410019	7595392	Rewan Formation
MB24	408081	7596736	Rewan Formation
MB25	407410	7596980	Rewan Formation
MB26	407115	7601043	Rewan Formation
MB27	407959	7600572	Rewan Formation
MB28	409796	7599783	Rewan Formation
MB29	407367	7608867	Clematis Sandstone
MB30	409939	7609491	Clematis Sandstone
Vibrating Wire Piezometers			
VWP1	410643	7590108	Rewan Formation / Betts Creek Beds
VWP2	408642	7594211	Betts Creek Beds
VWP3	407578	7598319	Rewan Formation / Betts Creek Beds
VWP4	409533	7602316	Rewan Formation

Table 2
Groundwater Monitoring Program – Frequency

Monitoring Locations	Monitoring Frequency	Monitoring Parameters
Boreholes	Quarterly Monitoring frequency to be reviewed prior to construction	Groundwater level Groundwater quality: • Physical parameters (pH, electrical conductivity and total dissolved solids); • Major anions (CO_3, HCO_3, Cl, SO_4); • Major cations (Ca, Mg, Na, K); • Dissolved and total metals/metalloids (Al, As, B, Cd, Cr, Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Ag, U, V, Zn); • Nutrients (ammonia, nitrite, nitrate, total phosphorus); and • Hydrocarbons (TRH and BTEXN).
VWPs	Daily data collected and downloaded quarterly	Water level (in the form of daily water pressure data)

The results of groundwater monitoring will be interpreted and compiled in an annual report confirming the findings of the groundwater assessment. Refer to Section 8 for reporting requirements.

5.2 SURFACE WATER

A surface water assessment was undertaken for the EIS (EIS Surface Water Section), and included an assessment of the impacts of subsidence on surface drainage. The findings of the assessment are summarised in the following sections.

5.2.1 Existing Environment

Catchment Setting

The project site is located within the Belyando Basin, a sub-basin of the Burdekin Basin (Figure 15). The Burdekin Basin has a total catchment area to the coastline of approximately 135,000 km^2. The Belyando Basin is in the upper catchment of the larger Burdekin Basin. The Belyando Basin, together with the Cape Campaspe, Upper Burdekin and Suttor Basins, form the catchment of the Burdekin Falls Dam (Figure 15). Burdekin Falls Dam is approximately 255 km downstream of the project site. It is the largest dam in Queensland and has a total catchment area of approximately 114,000 km^2 and a full storage capacity of 1,860 Giga Litres (GL). The dam is at the upstream end of a regulated water supply scheme involving a series of downstream weirs that are fed by controlled releases from the dam.

The local catchment setting is shown in Figure 16. The majority of the project site is drained by the headwaters of Tomahawk Creek and North Creek. These creeks flow to the south-east to the Belyando River downstream of the project site. The Belyando River is an ephemeral, regionally significant watercourse that enters the Suttor River upstream of the Burdekin Falls Dam (Figure 15). The dominant land use in the Belyando Basin is cattle grazing.

The catchment of Lake Buchanan extends from Darkies Range to the west of the site (Figure 16). Only a very minor portion of the project site is within the Lake Buchanan catchment. Minor areas in the south-west of the project site also drain to the Carmichael River catchment via minor drainage lines (Figure 16).

The site is located at the head of the Tomahawk and North Creek catchments and site drainage is therefore highly ephemeral. There are no major waterways traversing the project site. The Department of Natural Resources and Mines (DNRM) has conducted a watercourse determination, under the *Water Act 2000*, which confirmed there are no watercourses within the project site.

The majority of the project site drains towards the east from Darkies Range at the western boundary of the site. Site drainage features include a network of gullies in the steeper topography associated with Darkies Range (Figure 17). These gullies are characterised by steep rocky sides confining narrow rocky channels. The site drainage features transition from the steep gullies in the western area to minor drainage lines on the flatter areas of the site to the east of Darkes Range. The minor drainage lines in the south-eastern area of the project site have wide shallow flow paths (Figure 17).

Wherever possible, runoff from undisturbed areas will be diverted around areas disturbed by mining activities and allowed to drain from site. The site drainage strategy involves diverting runoff from truncated catchment areas upstream of the open cut pit around the open cut mine and mine infrastructure area. This will be achieved by the construction of permanent drains along the final highwall of the open cut pit and the establishment of drainage corridors at the northern and southern ends of the open cut mine and infrastructure areas (Figure 18). Sections of both the northern and southern highwall drains will be located over areas that will be subject to subsidence from underground longwall mining. The drains have been scheduled to be constructed after any subsidence is complete and the constructed drain sections will therefore not be subsided.

5.2.2 Impacts from Subsidence

Summary of Subsidence Impacts

No watercourses will be subsided as part of the project. Subsidence effects on surface waters are therefore limited to changes in the ground surface, potentially resulting in runoff ponding in subsidence depressions and geomorphic impacts on subsided drainage features.

A summary of the predicted impacts of subsidence upon surface waters is included in the following sections.

Subsidence Impacts on Southern Drainage Corridor

In the southern drainage corridor downstream of the southern highwall drain, peak flow velocities are predicted to increase within the subsided area above the Southern Underground (Figure 18). However, existing peak flow velocities are typically low in this area and increased velocities are limited to the subsided area.

Geomorphic impacts due to subsidence above the Southern Underground will be limited to areas within the project site boundary. Hydraulic modelling results indicate that the drainage features within the subsidence zone could potentially experience erosion over the life of the project. This area will be monitored for erosion after flow events and erosion control measures will be installed, if necessary. These monitoring and mitigation measures are discussed in Section 7.

Subsidence Impacts on Drainage Features

Subsidence above the Northern Underground will affect minor rock gullies and may result in localised changes to gully bed elevations. The changes in bed elevation will result in flow velocity changes. Flow velocities will increase as drainage flows into subsided areas and decrease across the downstream extent of the subsided area. In high sediment load drainage systems, this can result in erosion (e.g. headcuts) and sedimentation across the subsidence area. However, the gullies at the project site are rock controlled channels with limited bed sands due to the naturally high velocities experienced during ephemeral flows. Consequently, the potential for subsidence induced channel instability in these areas is negligible.

Nonetheless, subsidence of drainage gullies will be monitored to identify any geomorphic impacts. Remedial stabilisation will be undertaken, where necessary. Monitoring and remediation is discussed in Section 7.

Runoff from Subsided Areas

Subsidence can result in the ponding of water in localised shallow surface depressions. Subsidence ponding will be mitigated by the installation of minor remedial drainage earthworks to re-establish free drainage. With the installation of minor remedial drainage earthworks and the re-instatement of free drainage, there will be no significant residual ponding caused by mine subsidence and consequently no impact on vegetation due to ponding of water. Areas of potential subsidence ponding and proposed remedial drains are shown in Figure 18. Proposed mitigation measures are detailed in Section 7.

5.2.3 Mitigation and Management

General Mitigation and Management

Visual inspections of active subsidence areas will be undertaken monthly during the extraction of each longwall panel and 2 months after the completion of each panel. These inspections will identify any potential ponding areas and drainage line instability as well as areas of cracking or buckling. This monitoring will inform the need for crack rehabilitation, remedial drainage works or erosion protection. The subsidence crack rehabilitation program is described in Section 4.5.

Drainage works may include the construction of excavated trapezoidal drainage channels, designed with sufficient capacity to cater for contributing catchments and with stable batter slopes. These channels would enable free drainage of subsidence depressions. Drainage channels will be located to avoid sensitive features and vegetation communities, as far as practicable. Erosion protection works may involve regrading and revegetation and/or installing scour protection.

Following construction, the channels will be vegetated with grass species. Monitoring of remedial drainage works will be undertaken quarterly and following runoff events to ensure successful revegetation, and to inform the need for erosion protection or reseeding. Similarly any erosion protection works will be monitored at the same time to ensure it remains effective.

5.3 TERRESTRIAL ECOLOGY

A terrestrial ecology assessment was undertaken as part of the EIS, and is documented in the EIS Terrestrial Ecology Report. The assessment included terrestrial biology field surveys of the longwall mining areas. The findings of the assessment are summarised in the following sections.

5.3.1 Existing Environment

The longwall mining areas are covered by remnant vegetation (Figure 19), comprising Eucalyptus and Acacia open woodland. The majority of the vegetation communities in the project site are listed as Least Concern under the Queensland *Vegetation Management Act 1999* (VM Act), however one vegetation community listed as Of Concern occurs in the project site: RE 10.10.3: *Eucalyptus drepanophylla* open woodland on sandstone ranges (Figure 19). No threatened ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were recorded during field surveys or predicted to occur within the project site.

No threatened flora species listed under the EPBC Act or *Nature Conservation Act 1992* (NC Act) were recorded during field surveys or predicted to occur within the project site.

Overall, the majority of the fauna species recorded within the project site are common and widespread, however the Squatter Pigeon (southern subspecies) (*Geophaps scripta scripta*) (listed as vulnerable under both the EPBC Act and NC Act), Black-throated Finch (white-rumped subspecies) (*Poephila cincta cincta*) (listed as endangered under both the EPBC Act and NC Act), Koala (*Phascolarctos cinereus*) (listed as vulnerable under the EPBC Act and special least concern under the NC Act) and Short-beaked Echidna (*Tachyglossus aculeatus*) (listed as special least concern under the NC Act) were recorded from the project site. Other threatened species were considered to have some potential to occur on the basis of available habitat. The field survey also recorded the presence of a number of birds listed as Marine and Migratory under the EPBC Act and indicated that there was potential for further migratory birds to be present.

Three general habitat types are located across the project site, providing varying degrees of habitat value. These include sand plains and savannah woodlands; elevated sandstone ranges, plateau margins, talus slopes and ironstone jump-ups; and quaternary alluvial environments. The project site is not considered to be of particular importance for values such as high biodiversity, important feeding areas, high endemism, unusual fauna assemblages, or unique habitat types or assemblages.

5.3.2 Subsidence Impacts and Management

Tension Cracking and Buckling

Tension cracking and buckling will not necessarily impact on vegetation communities or threatened fauna species habitat. However, it may be necessary to undertake small scale rehabilitation works to ensure that subsidence cracks do not erode or pose a hazard to people, wildlife or stock. The proposed rehabilitation of subsidence cracks is non-intrusive and targeted in order to minimise potential disturbance of vegetation, and will be undertaken in accordance with the subsidence crack rehabilitation program, which includes a monitoring plan to ensure that any disturbed vegetation regenerates. It involves monitoring areas potentially subject to subsidence cracking and repairing any individual cracks that develop. The proposed rehabilitation program for subsidence cracking is described in Section 4.5. Monitoring to ensure successful revegetation following the subsidence crack rehabilitation program is discussed in Section 7.

Changes to Surface Drainage

Subsidence can alter surface drainage paths and may lead to the ponding of water in localised shallow surface depressions. Without mitigation, these ponding areas may result in localised dieback of canopy trees due to waterlogging, and the loss of high value habitat for threatened fauna species.

Free drainage will be achieved through the installation of minor remedial drainage earthworks as described in Section 5.2.3. No long term impacts on flora and fauna from changes to drainage are predicted, given that remedial drainage works will be installed.

Drainage channels will be located to avoid sensitive features and vegetation communities, as far as practicable.

Groundwater Dependent Ecosystems

The Australian Groundwater Dependent Ecosystem Toolbox (GDE Toolbox), prepared by the National Water Commission (2011), defines GDEs as "Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain the communities of plants and animals, ecological processes they support, and ecosystem services they provide". The potential for GDEs to be present within the project site was reviewed, with the review consisting of:

- A search of the Queensland Springs Database;
- A search of the Bureau of Meteorology's (BoM) GDE Atlas; and
- Groundwater field investigations, as described in the EIS Groundwater Report.

A search of the Queensland Springs Database indicated that no spring wetlands are located within the project site. The nearest springs are approximately 22 km south of the southern boundary of the project area. BoM's GDE mapping shows that there are several potential GDEs in the project site.

Section 5.1 provides an overview of the regional hydrogeology and water-bearing strata within the project site. As indicated in Section 5.1, there is no shallow groundwater within the project site. In the elevated Darkies Range ridgeline, groundwater is typically more than 100 m below ground level. In low lying areas, east of Darkies Range, the groundwater table is at least 25 m below ground level and disconnected from surface water features. Given this lack of shallow groundwater, BoM's GDE mapping of the project site does not appear to be consistent with the hydrogeological setting of the project site. In addition, the vegetation survey did not identify any areas of vegetation that would appear to be dependent on groundwater. Consequently, it is concluded that there are no GDEs within the project site.

5.4 AQUATIC ECOLOGY

An aquatic ecology assessment was undertaken as part of the EIS, and is documented in the EIS Aquatic Ecology Report. The assessment included aquatic biology field surveys of the longwall mining areas. The findings of the assessment are summarised in the following sections.

5.4.1 Existing Environment

The project site comprises three different aquatic habitat types, namely naturally occurring ephemeral drainage lines; seasonal wetlands; and artificial farm dams (Figure 20). No permanently flowing waterway or artesian springs or bores occur in the project site, and all of the drainage lines that occur are highly ephemeral and dependent on seasonal rainfall. These drainage lines originate in the higher elevation areas to the west of the project site and flow eastwards towards lower, flatter land (Figure 20). A watercourse determination was undertaken by the DNRM for the project in order to identify any watercourses in the project site. It determined that there are no watercourses as defined by the *Water Act 2000* in the project site.

No groundwater fed waterways are present in the project site, and the only sources of water in the dry season are remnant pools in some ephemeral drainage lines, and farm dams that are deep enough to retain water.

As shown on Figure 20, a number of ephemeral drainage lines, as well as the northern seasonal wetland and Red Dog Dam will be subject to subsidence.

The northern seasonal wetland covers an area of approximately 127 ha and has been mapped as a wetland of high ecological significance (HES) by the EHP. This seasonal wetland has been created by rainfall pooling and accumulating during the wet season, however it has been enhanced by the construction of a farm dam (Red Dog Dam) that helps retain water in this area. Drilling undertaken in the area of the northern seasonal wetland has determined that the watertable in this area of Darkies Range is very deep, being some 100 m below the land surface. This means the wetland does not interact with the underlying groundwater systems, and the source of the water is purely runoff from the local catchment. This wetland only provides aquatic habitat during the wet season as it dries out during the dry season.

Red Dog Dam is a stock water dam that has been developed by excavating a section of the seasonal wetland in the north of the project site. This dam only provides aquatic habitat during the wet season and during the dry season becomes highly turbid with no fringing vegetation or woody debris.

No aquatic flora or fauna species or communities listed under the EPBC Act or NC Act were found or predicted to occur within the project site.

5.4.2 Subsidence Impacts and Management

As shown on Figure 20 and described in Section 5.4.1, a number of ephemeral drainage lines, as well as the northern seasonal wetland and Red Dog Dam will be subject to subsidence. Potential impacts and management of subsidence on aquatic ecology are discussed in the following sections.

Subsidence of Ephemeral Drainage Lines

Section 5.2 discusses predicted impacts on ephemeral drainage lines and proposed management measures.

Subsidence cracking may occur within the bed and banks of the ephemeral drainage lines located within the limit of measureable subsidence. These cracks are likely to be shallow and any cracks in the bed of drainage lines are likely to fill quickly with sediment following flow events. A rehabilitation program for subsidence cracking will be implemented for the project to ensure that all cracks are remediated. This will involve monitoring areas potentially subject to subsidence cracking and repairing any individual cracks that develop. This non-intrusive, targeted method of subsidence crack rehabilitation has been proposed in order to minimise disturbance to vegetation and drainage lines. This approach does not involve any routine clearing of vegetation. Erosion control measures will be implemented as part of this approach.

The EIS Subsidence Report concludes that sub-surface cracking is not predicted to impact the overlying ephemeral drainage lines.

Overall, subsidence is not predicted to give rise to any long-term, significant impacts on ephemeral drainage lines or their ecological values. This conclusion is supported by monitoring work undertaken at other Queensland coal mines, where watercourses have been subsided a number of times, without any significant impact on channel stability. Nevertheless, the mitigation measures described in Section 5.2.3 will be adopted in relation to any subsidence of ephemeral drainage lines.

Northern Seasonal Wetland

Subsidence cracks that form within the ponded area of the wetland are likely to be shallow, and will have no connection to underground workings. If cracks form at a time when the wetland contains water, the cracks would fill with water and the cracks would ultimately fill with the sediment. Monitoring of cracks will be undertaken and individual cracks will be repaired, as necessary. Cracks that form when the wetland is dry would be repaired in accordance with the subsidence crack rehabilitation program described in Section 4.5.

Figure 21 shows the pre and post-subsidence topography in the vicinity of the wetland.

The northern seasonal wetland is a depression where surface runoff ponds. It does not overflow, given its small isolated catchment and relatively large storage area. Changes in the surface topography due to subsidence may change the area and depth of the wetland pond. In order to ensure that the wetland pond continues to retain water following subsidence, a small bund will be constructed along the eastern margin of the northern seasonal wetland (Figure 21). The bund will be small scale structure – approximately 1 m in height, 3 m wide at the crest, and 460 m long.

Subsidence will also have the effect of increasing the surface area and storage capacity of the wetland pond. The wetland's pond area before mining is approximately 127 ha and it will increase to approximately 199 ha as a result of subsidence.

The wetland pond catchment will also be potentially affected by subsidence and it is anticipated that the catchment will change in size from 2,711 ha pre-mining to 2,399 ha post-mining, resulting in a 12% reduction in the size of the catchment.

These changes to the pond storage and catchment area of the wetland will result in changes to ponding characteristics of the northern seasonal wetland. For a particular rainfall event, the water level of the seasonal wetland will be reduced following subsidence, compared to the wetland pre-subsidence. This will also mean that the wetland will dry out more rapidly and more frequently. This will impact on the flora and fauna that depend on aquatic habitat by reducing the length of time that aquatic habitat is available in each season. However; as explained previously, the northern seasonal wetland is highly seasonal and only contains water during the wet season, and for a variable time following the wet season, depending on the amount and duration of rainfall. The aquatic species that utilise the wetland are accustomed to it providing habitat for a limited period of time every year and for a varying period of time, and it is likely that the species that currently utilise this area will be able to continue to do so.

The northern seasonal wetland is a HES wetland and consequently it will be necessary to provide offsets under the *Environmental Offset Regulation 2014* in the event of the project giving rise to significant, residual impacts on the wetland. The need for offsets will be determined prior to any subsidence of the wetland and based on detailed mine planning and subsidence predictions for the area. The subsidence impacts on the wetland, as indicated in Figure 21 are based on the current EIS mine layout, however detailed design supported by further exploration work is still to be undertaken. Even minor changes in the mine plan could significantly alter the nature and extent of impacts on the wetland. It is therefore proposed to:

- Undertake detailed ground survey of the wetland prior to subsidence;
- Undertake a detailed review of potential impacts on the wetland, making use of subsidence predictions based on the detailed mine plan;
- Design any necessary drainage works, such as drains or levees, in order to reduce potential impacts on the wetland; and
- Determine the need for offsets if significant, residual impacts on the wetland are predicted.

Red Dog Dam

Red Dog Dam, which is located within the northern seasonal wetland, will be subsided. This dam is used for stock watering and there are signs of recent cattle activity at the dam. The potential impact of subsidence on the dam will depend on the relative location of the dam embankment and pond area in relation to the surface subsidence profile. Potential effects may include cracking of the earth embankment and changes in the lateral extent and depth of the pond area. The EIS Subsidence Report has concluded that there will be no connection between the dam and the underground workings due to sub-surface cracking. Consequently, sub-surface cracking would not lead to the loss of any water from the dam.

Based on experiences at other longwall mines in Queensland and New South Wales, any subsidence effects on small earth dams can be easily remedied with minor civil earthworks and subsidence does not generally give rise to any lasting adverse impacts on the use and functioning of the dams, including any ecological values.

6 INFRASTRUCTURE

There is no public infrastructure traversing the project site. Mine infrastructure has been located in areas outside of the predicted limit of measurable subsidence and will not be impacted by subsidence.

Highwall drains and parts of the proposed open cut mining area will be constructed on subsided ground after longwall mining and subsidence is completed.

7 MONITORING AND REHABILITATION

Proposed monitoring and rehabilitation procedures to manage subsidence effects are described in Sections 4 and 5 and are summarised in Table 3.

Table 3
Subsidence Monitoring and Rehabilitation Requirements

Task	Description	Frequency
Subsidence Survey	• Establish long section down centre line of each longwall panel, together with representative cross sections. • Compare subsided ground profile to existing ground level data (from LIDAR) and predicted subsidence profiles (EIS Subsidence Report).	Following extraction of each longwall panel, or at a minimum, 12 month intervals.
General Inspection of Active Subsidence	During active subsidence, undertake visual inspection of subsidence areas to identify potential tension cracks and buckling, subsidence ponding and drainage line erosion instability. This monitoring will inform the need for tension crack rehabilitation works, as discussed in Section 4.5 or remedial drainage works, as discussed in Section 5.2.3. Following completion of tension crack rehabilitation or remedial drainage works, affected areas will be inspected to confirm the effectiveness of these works, including the success of revegetation. This will include photopoint monitoring to compare the rehabilitated areas to the pre-existing condition. Photopoint monitoring will involve taking a photo of the cracked or ponded area before and after rehabilitation. Photos of the rehabilitated area will also be compared to similar adjacent undisturbed areas to determine the effectiveness of the works.	<u>Inspection of Subsidence Areas</u> Monthly during extraction of each longwall panel, then 2 months after completion of panel extraction. <u>Monitoring of Tension Crack Rehabilitation</u> Quarterly following rehabilitation, for at least 12 months. Then every 12 months until revegetation is successfully completed. <u>Monitoring of Remedial Drainage Works</u> Visual inspection quarterly and following runoff events for 12 months following construction, then annually and following runoff events until revegetation/stabilisation is successfully completed.
Northern Seasonal Wetland Monitoring	The northern seasonal wetland is located above the northern underground and is located within the limit of measureable subsidence (Figure 20). As described in Section 5.4.2, management measures for the northern seasonal wetland will include accurate ground survey of the wetland; a detailed assessment of the potential impacts of subsidence on the wetland (based on the mine plan developed as part of detailed mine planning) and prescriptions for the installation of remedial works to limit any impacts on the wetland.	Detailed ground survey of the wetland prior to subsidence. Further survey work to be determined dependent on the results of the initial survey and assessment.

Task	**Description**	**Frequency**
Red Dog Dam Monitoring	Red Dog Dam will be subsided due to longwall mining (Figure 20). As described in Section 5.4.2, the dam will be inspected within 2 months after subsidence and repairs completed where necessary. Repairs will also ensure that there is no adverse impact from subsidence on the operation of this dam in terms of downstream surface water impacts.	Visual inspection of farm dams 2 months after subsidence. Visual inspection of farm dam repair works (if required), to confirm effectiveness.
Groundwater Monitoring	As discussed in Section 5.1.3, the groundwater monitoring program established as part of EIS groundwater investigations will be continued throughout the life of the project. Recording of groundwater levels from existing 31 monitoring bores and 4 vibrating wire piezometers (VWPs) will continue and will enable natural water level fluctuations (such as responses to rainfall) to be distinguished from potential water level impacts due to depressurisation resulting from mining activities. Groundwater quality sampling of existing monitoring bores will continue in order to provide longer term baseline groundwater quality, and to detect any changes in groundwater quality during and post mining. The details of the proposed groundwater monitoring program are provided in Tables 1 and 2. Data will be reviewed prior to construction to establish which water quality parameters should continue to be monitored.	The details of the proposed groundwater monitoring program are provided in Tables 1 and 2. Boreholes will be monitored quarterly. Daily data will be collected from VWPs and downloaded quarterly. Monitoring frequency to be reviewed prior to construction.

8 REPORTING AND REVIEW

The SMP will be reviewed annually and updated to reflect the progression of longwall mining operations and associated monitoring and management of subsidence effects for the next 12 month period. An annual report will also be prepared recording the subsidence monitoring and management conducted for the previous year including a review of the effectiveness of subsidence management. Where necessary, the annual review of the effectiveness of subsidence management will inform amendments to the subsidence management strategies for the subsequent annual SMP revision. This process will ensure the SMP remains informed by the results of monitoring to validate the accuracy of predictions of subsidence impacts, and the effectiveness of management measures.

9 CONCLUSION

This Draft SMP has been prepared to meet the requirements of the Project China Stone EIS TOR. The Draft SMP sets out the proposed measures to manage the predicted impacts of subsidence from the project. Implementation of these measures will confirm the results of the assessments to date, and ensure the successful rehabilitation of affected areas.

The Draft SMP includes reporting and review requirements to allow for modification of management measures throughout the life of the mine, as monitoring results become available.

* * *

for
HANSEN BAILEY

Daniel Sullivan
Senior Environmental Scientist

Peter Hansen
Director

10 REFERENCES

Australasian Groundwater and Environmental Consultants, December 2014, *Project China Stone Groundwater Report*

Cumberland Ecology, March 2015, *Project China Stone Terrestrial Ecology Impact Assessment*

Cumberland Ecology, March 2015, *Project China Stone Aquatic Ecology and Stygofauna Impact Assessment*

Gordon Geotechniques, October 2014, *Subsidence Prediction Report for Project China Stone*

WRM, November 2014, *Project China Stone EIS Open Cut Mine Drainage Assessment*

FIGURES

PROJECT CHINA STONE

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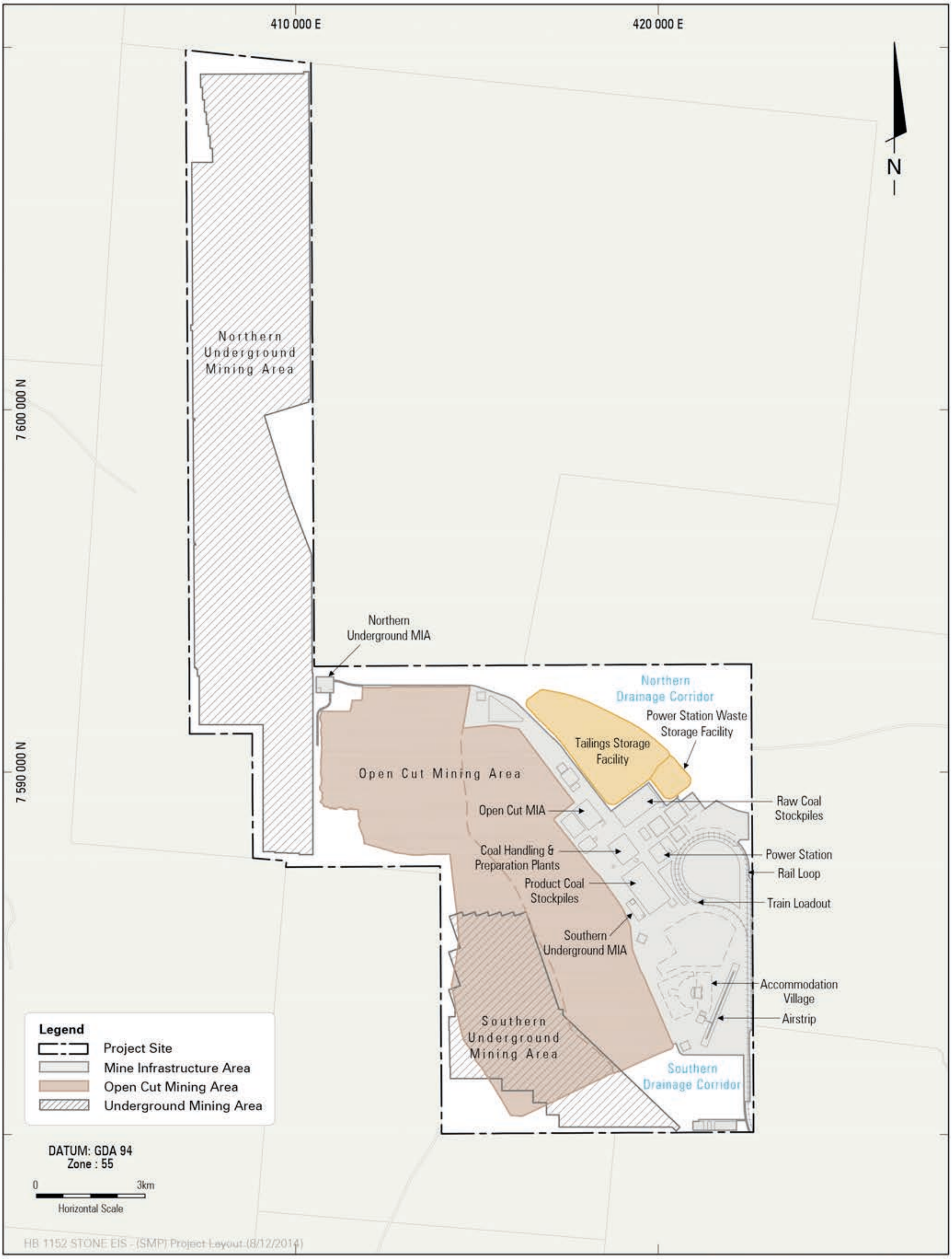
Project Location

FIGURE 1



PROJECT CHINA STONE

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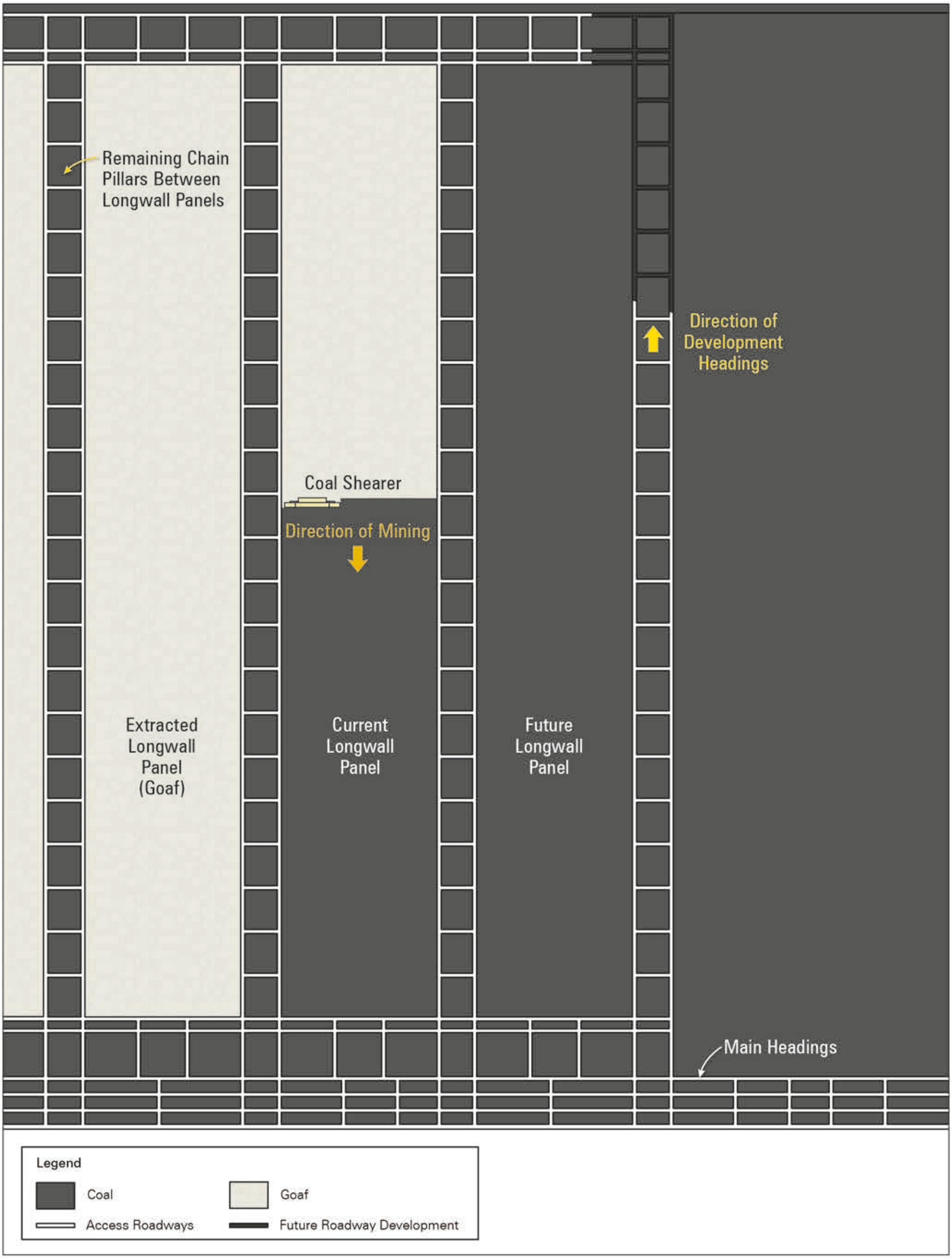
Project Layout

FIGURE 2



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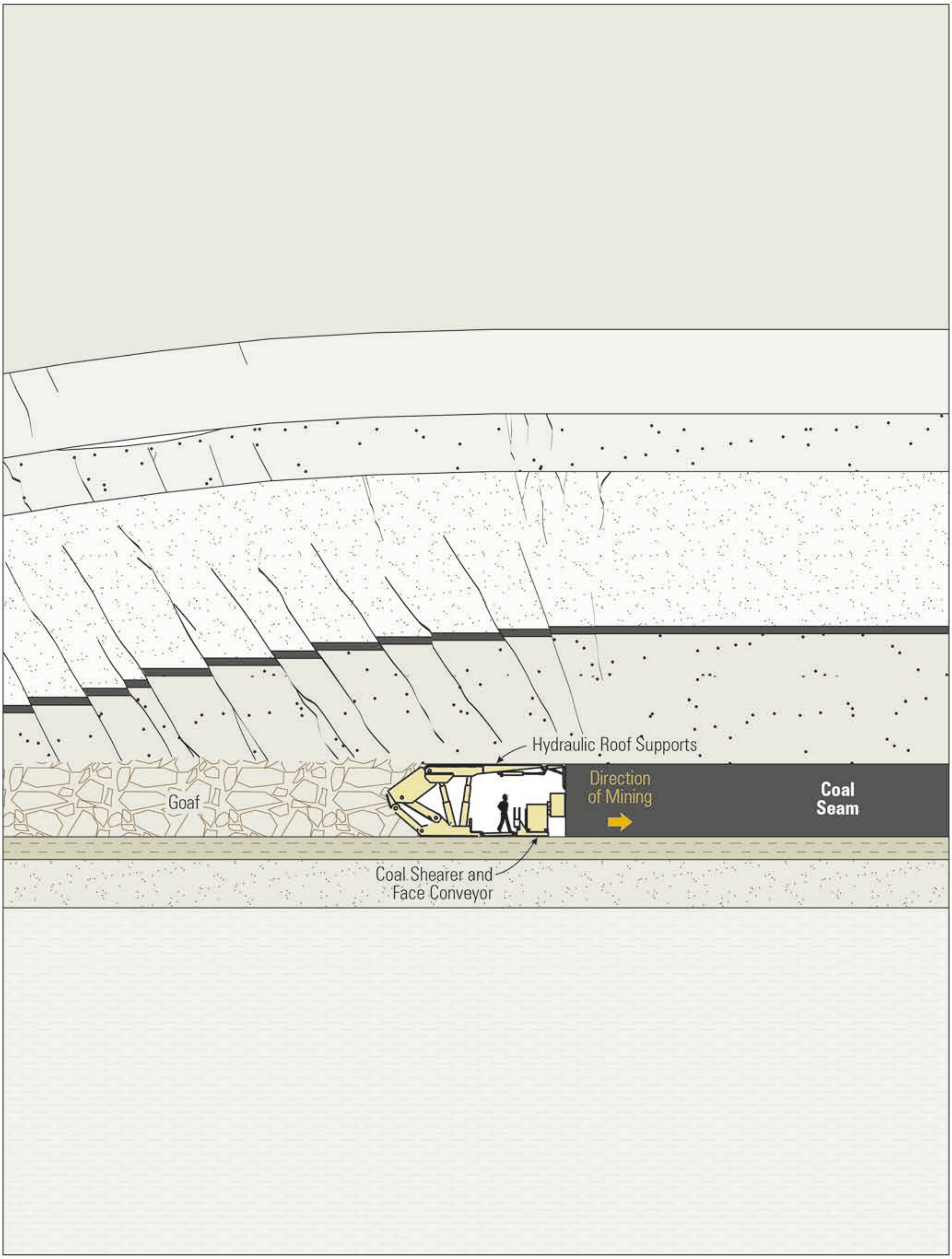
Typical Longwall Layout

FIGURE 3



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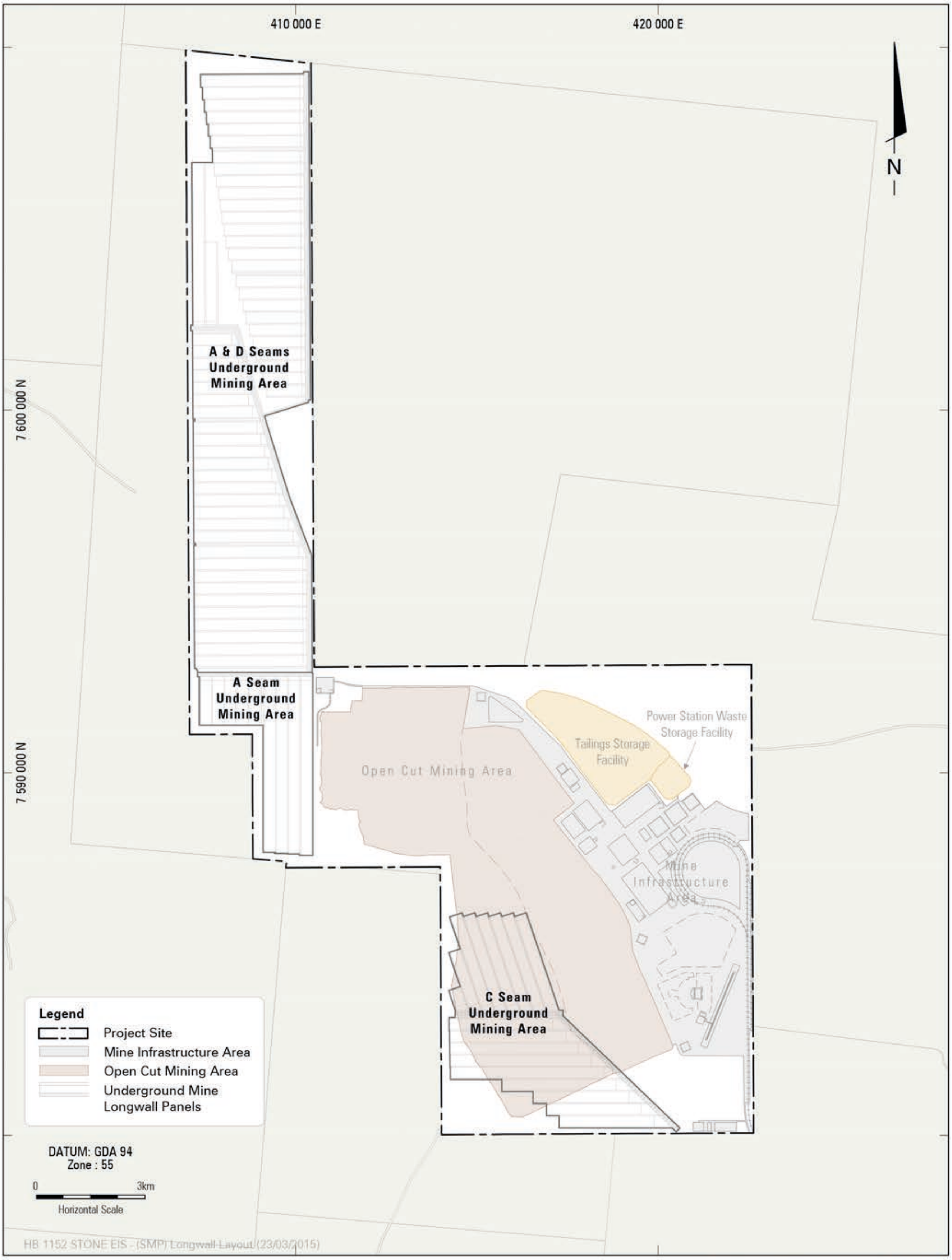
Cross Section Through Typical Longwall Face

FIGURE 4



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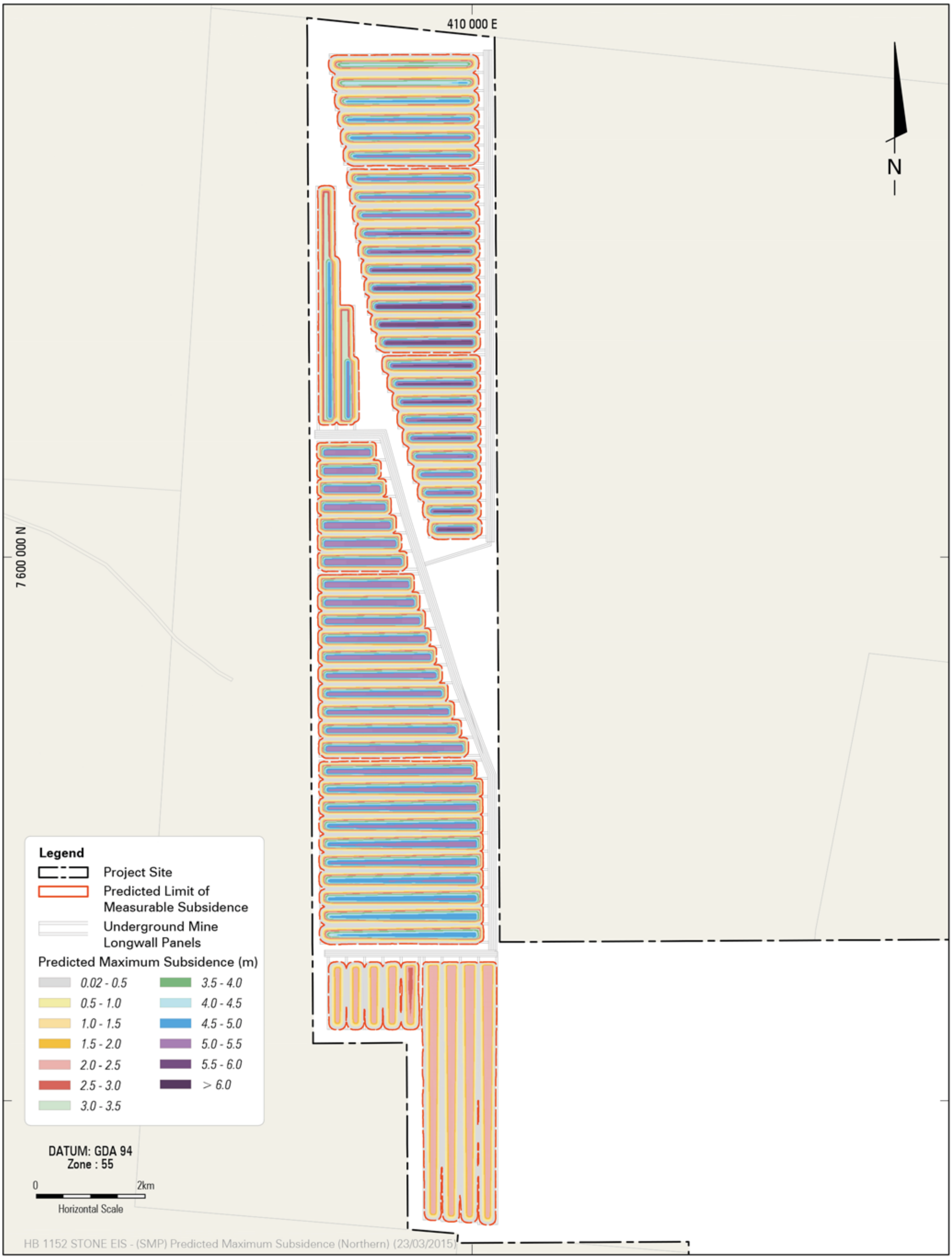
Longwall Layout

FIGURE 5



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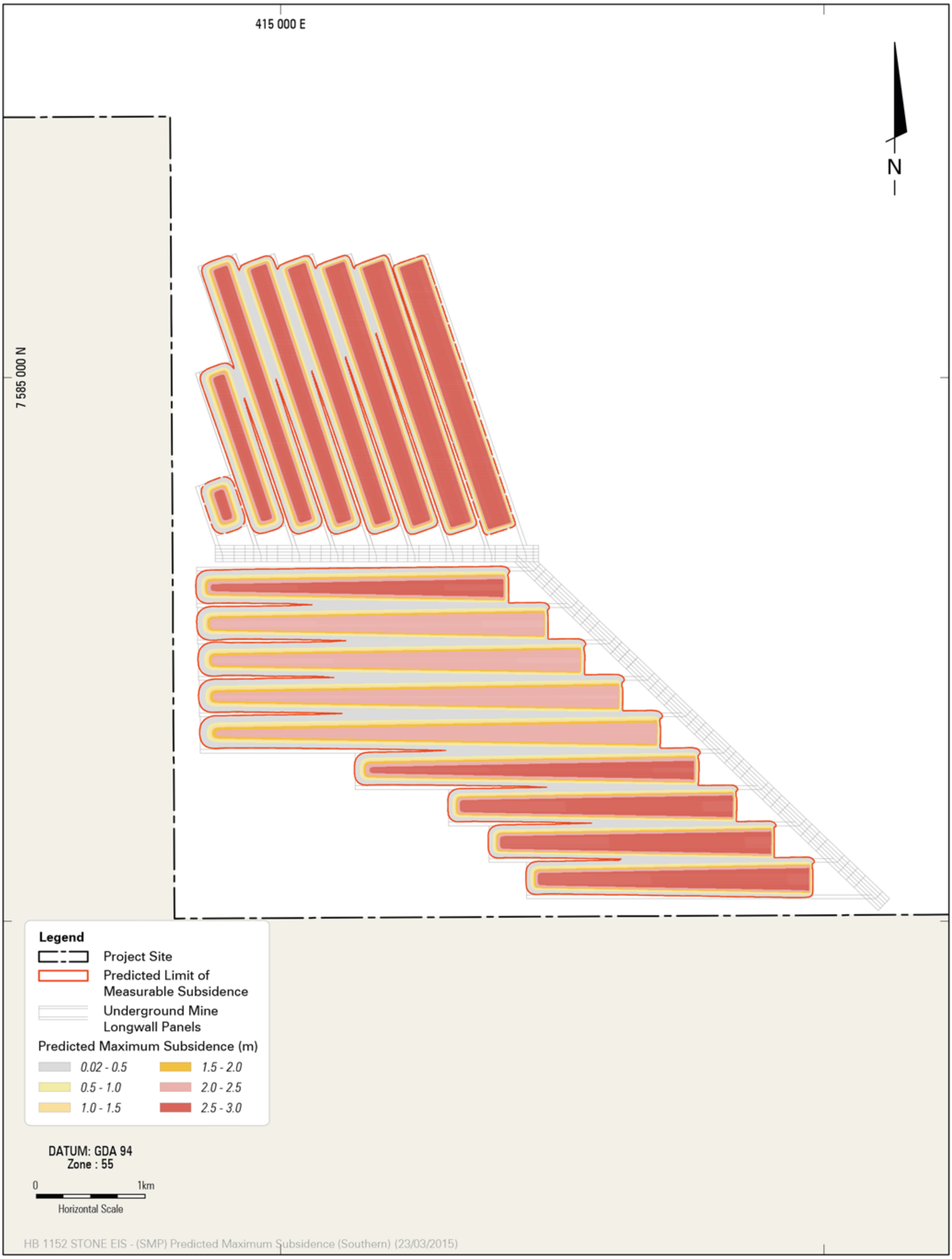
Northern Underground
Predicted Maximum Vertical Subsidence

FIGURE 6



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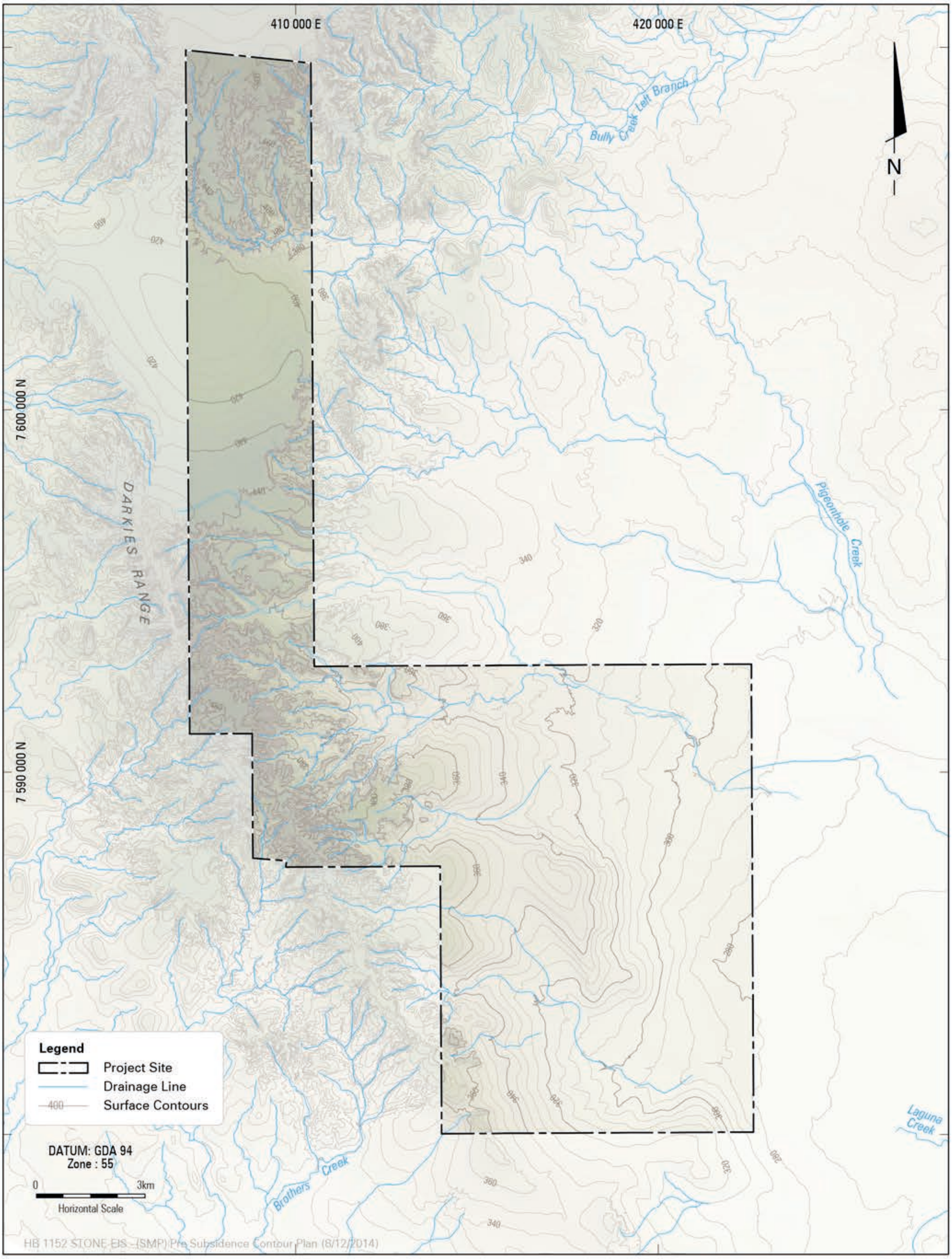
Southern Underground
Predicted Maximum Vertical Subsidence

FIGURE 7



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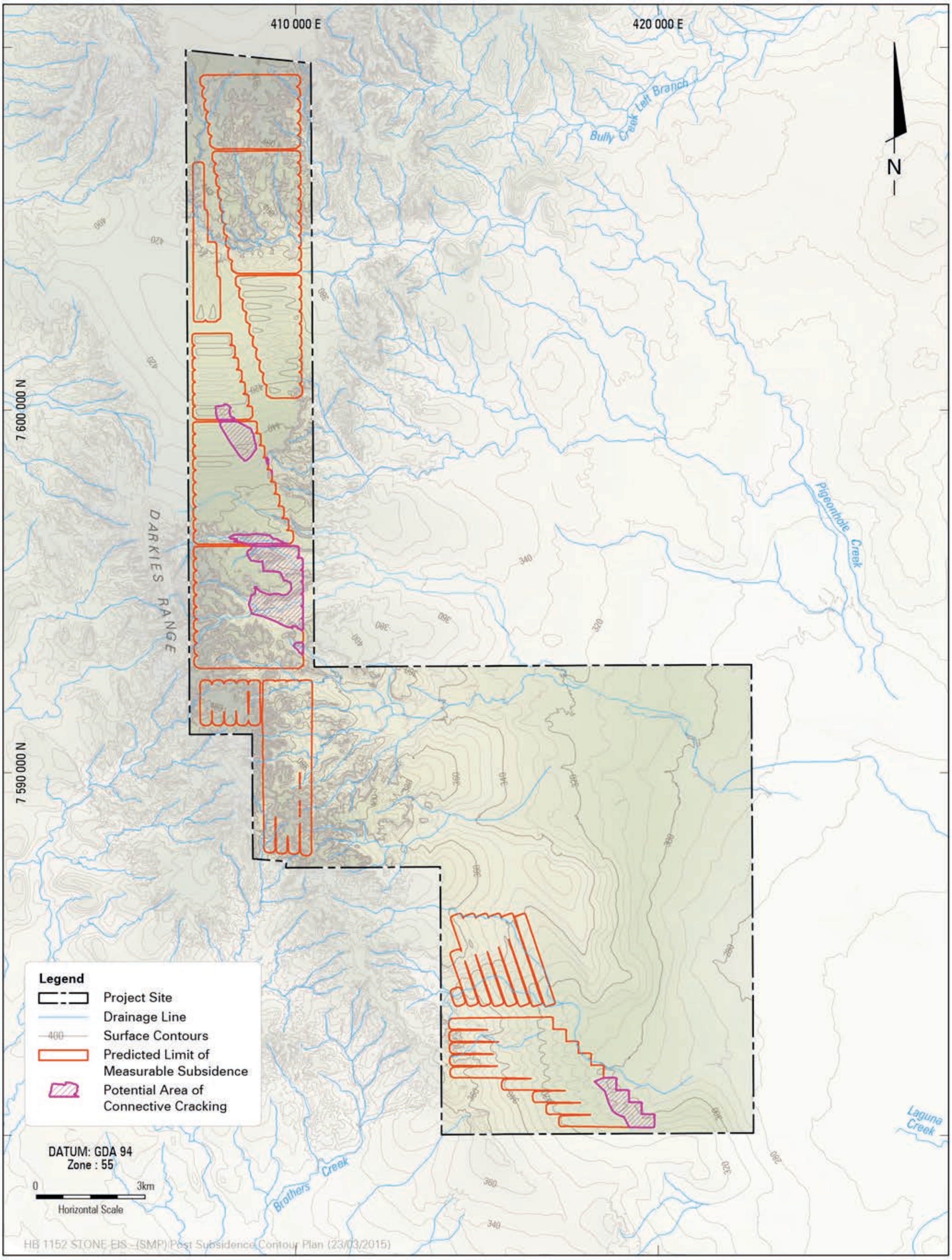
Pre-Subsidence Contour Plan

FIGURE 8



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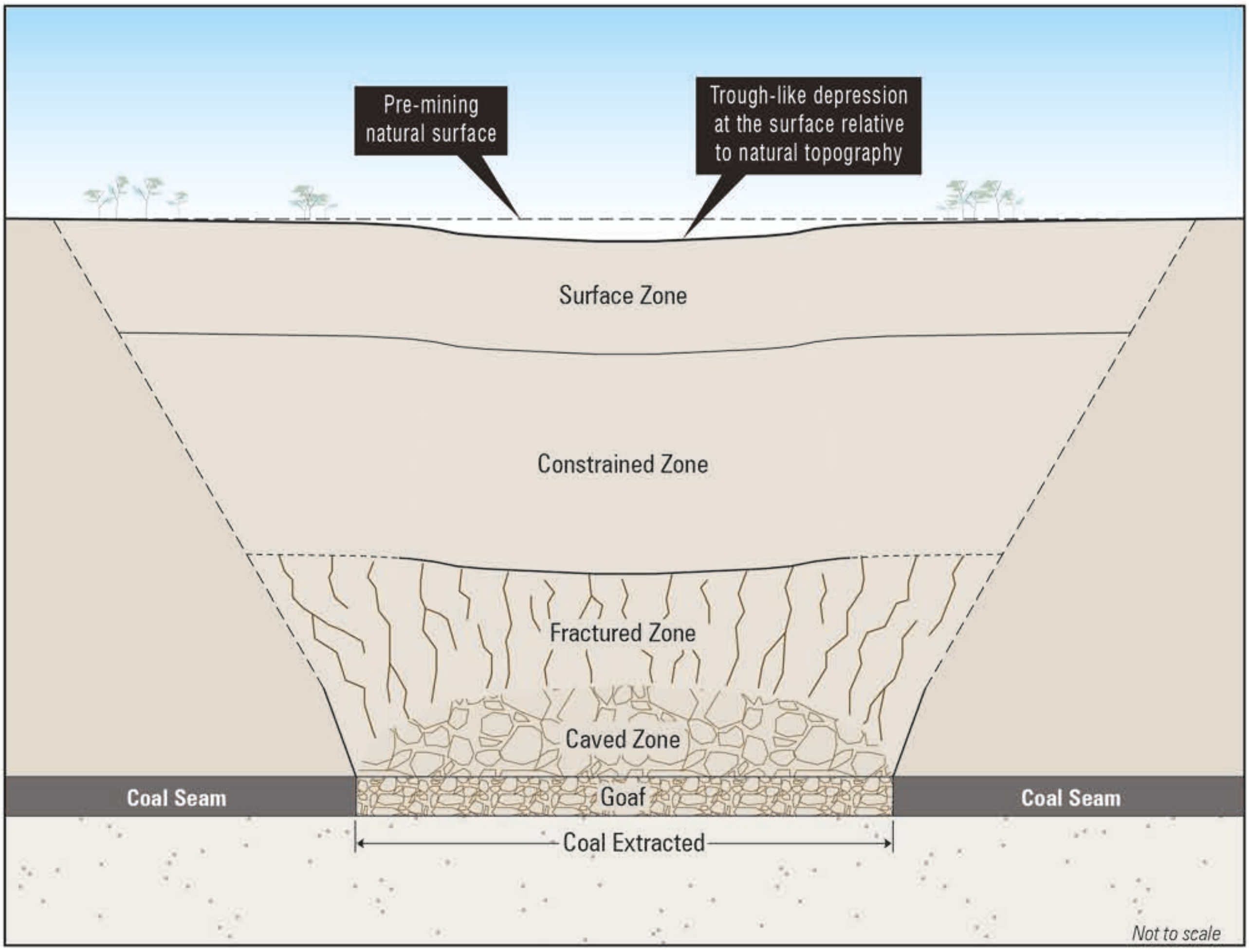
Post Subsidence Contour Plan

FIGURE 9



Plan based on MSEC Figure

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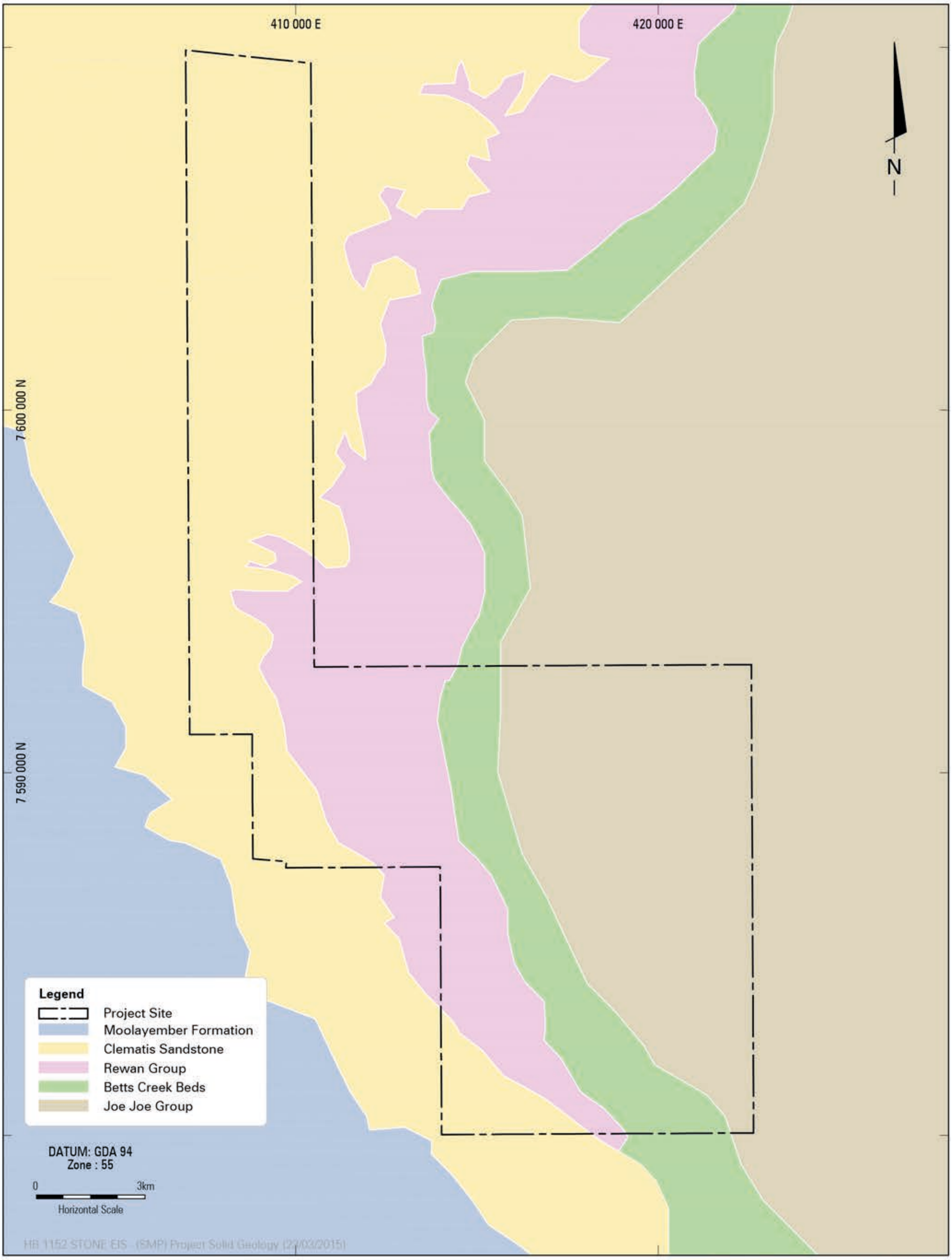
Subsidence Schematic

FIGURE 10



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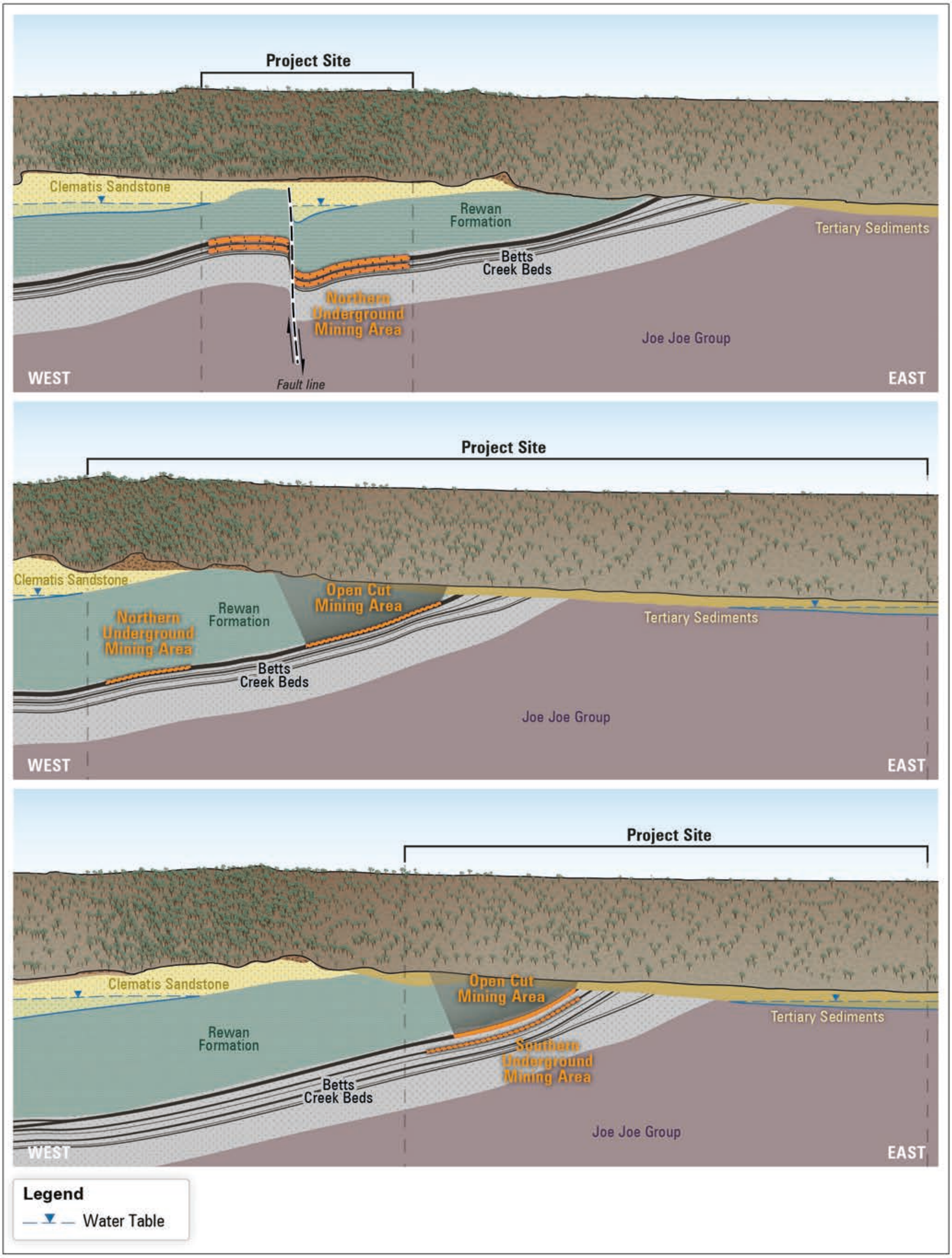
Solid Geology

FIGURE 11



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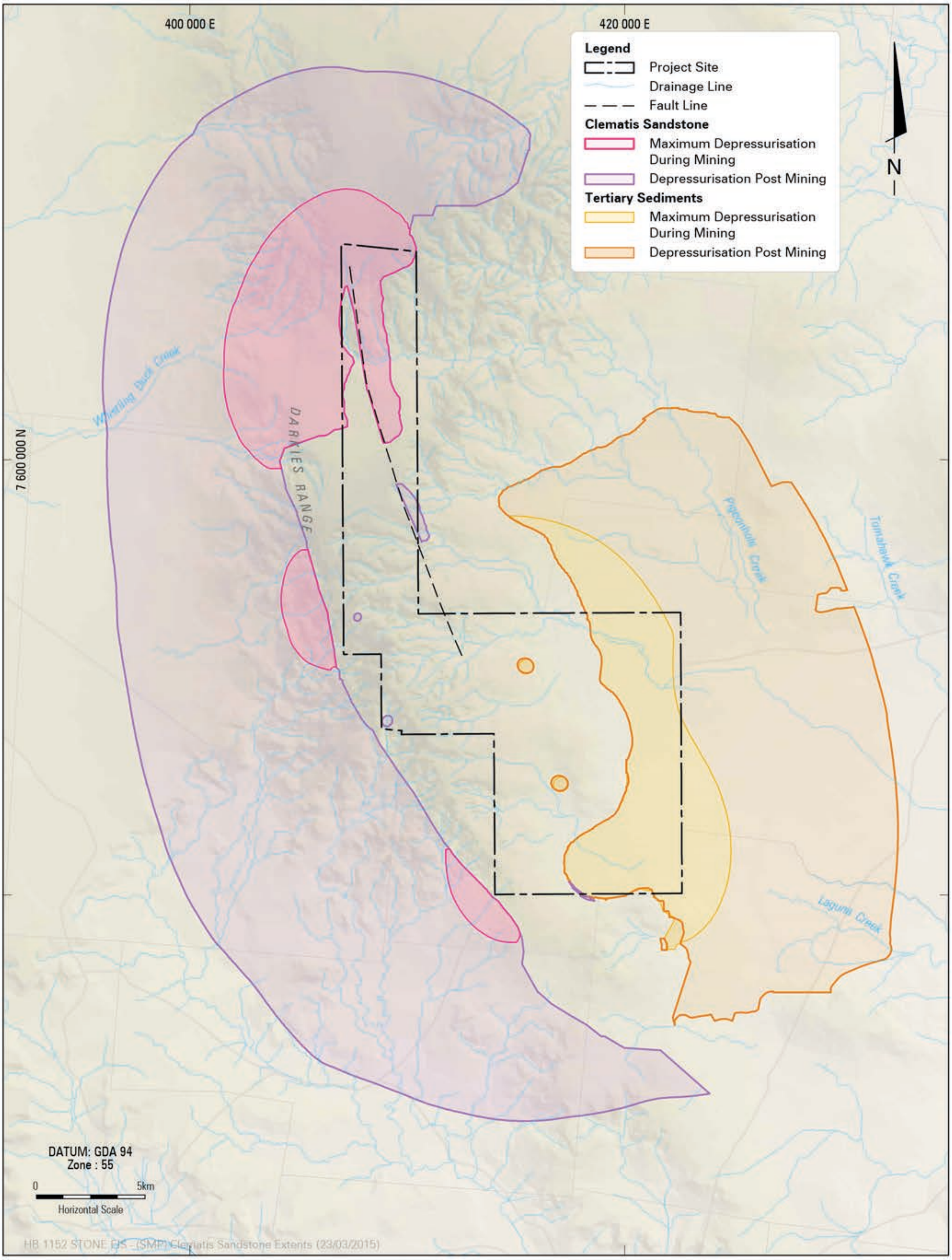
Hydrogeological Cross-Sections of Project Site

FIGURE 12



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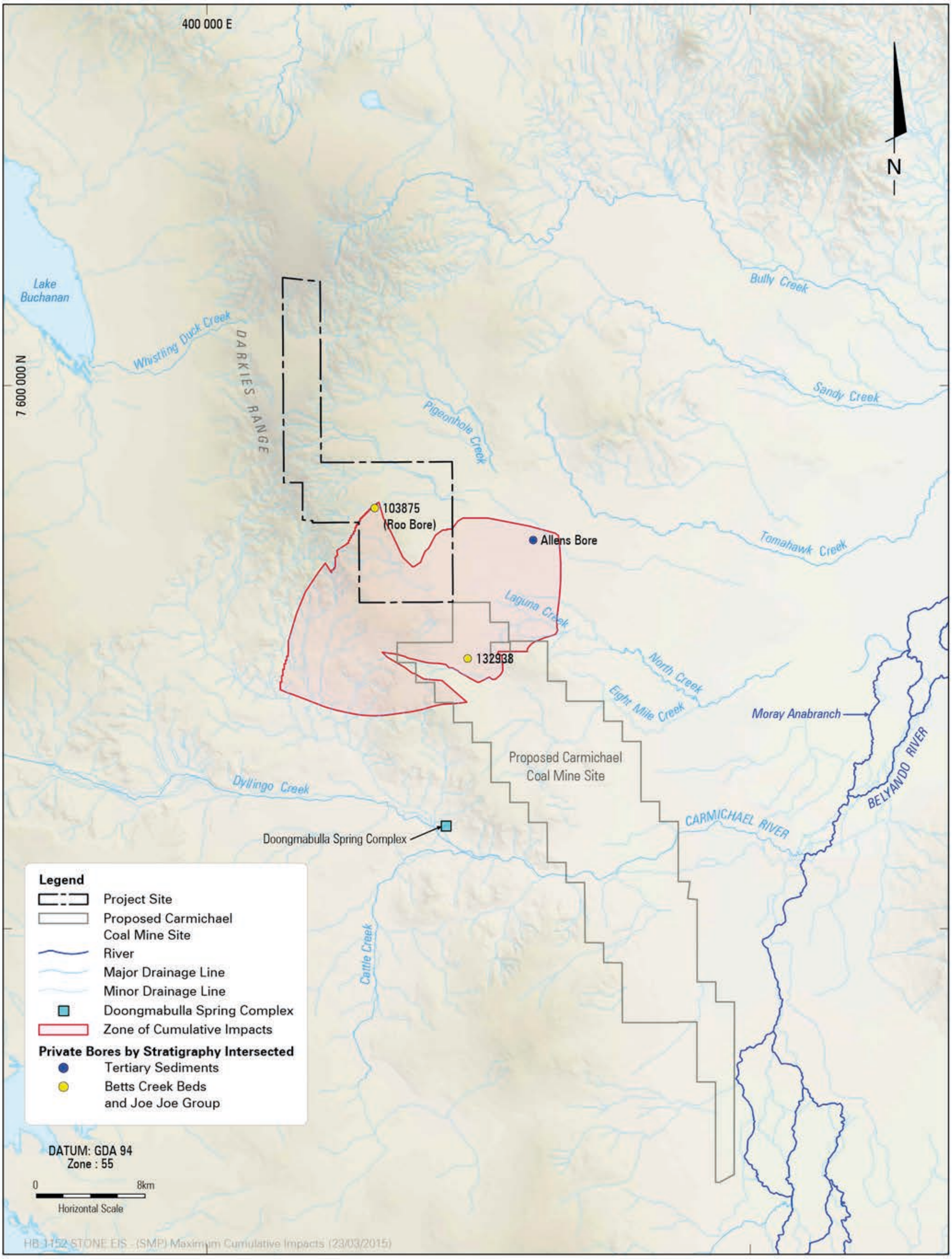
Predicted Groundwater Depressurisation

FIGURE 13



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Maximum Predicted Extent of Cumulative Drawdown Impacts

FIGURE 14

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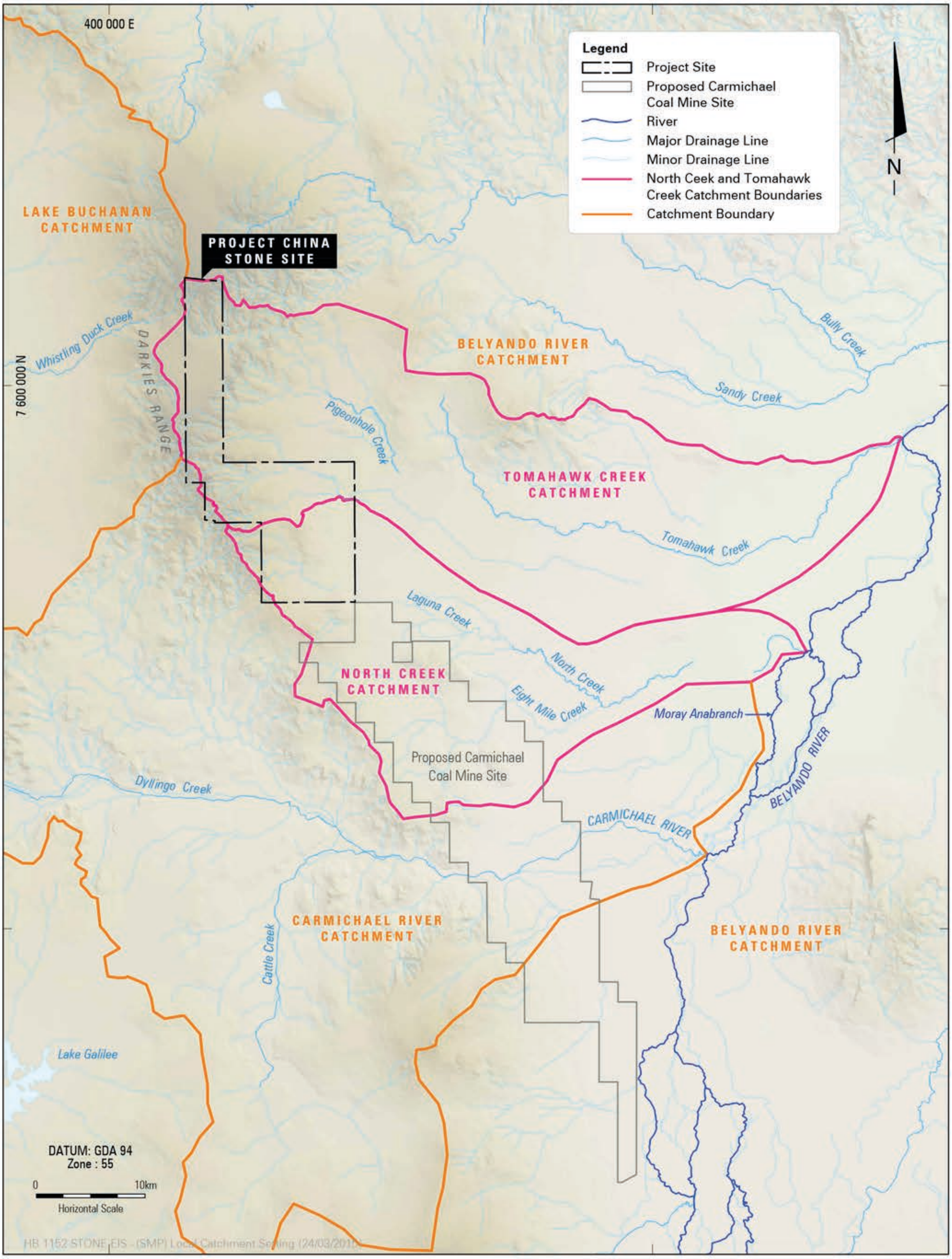
Regional Catchment Setting

FIGURE 15



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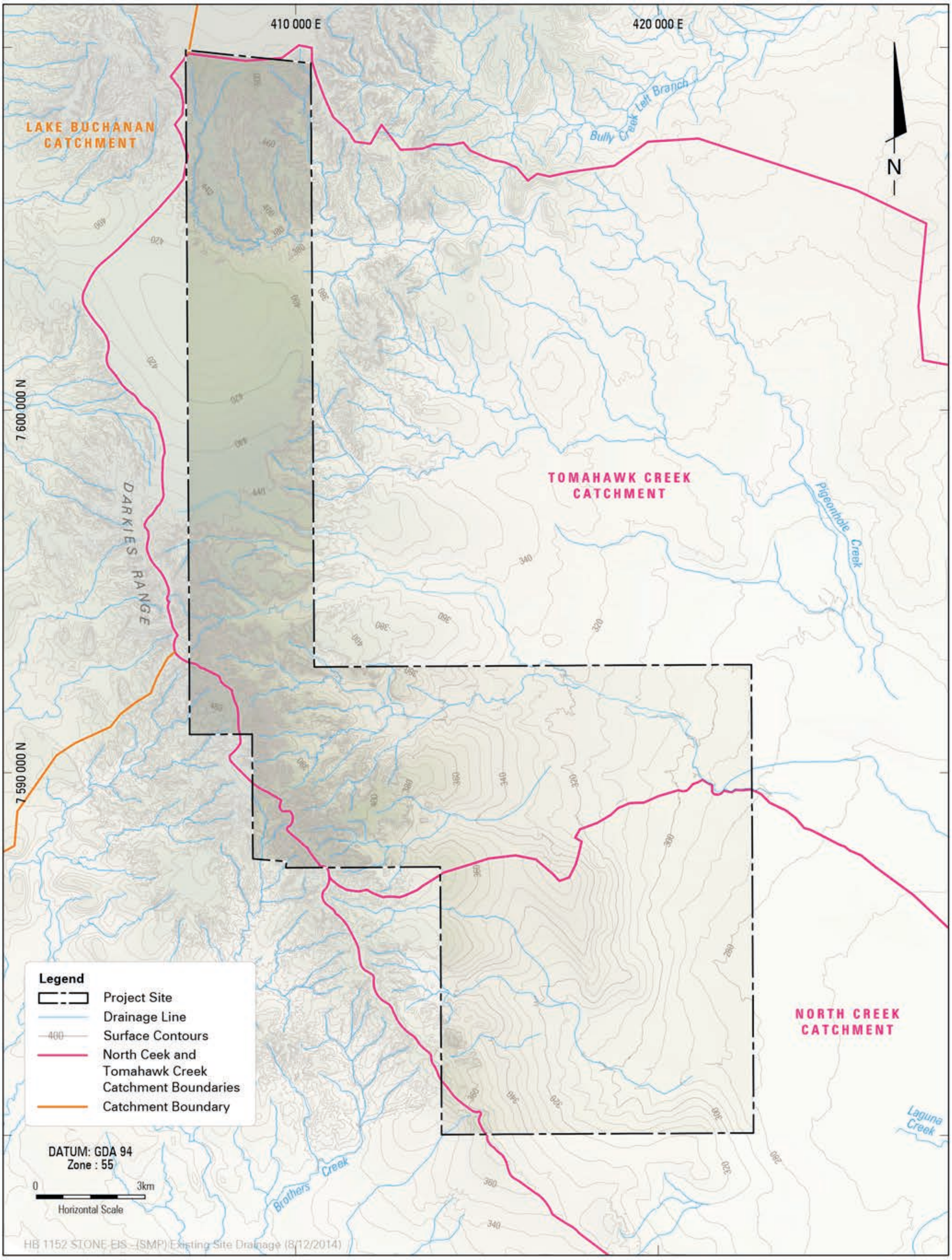
Local Catchment Setting

FIGURE 16



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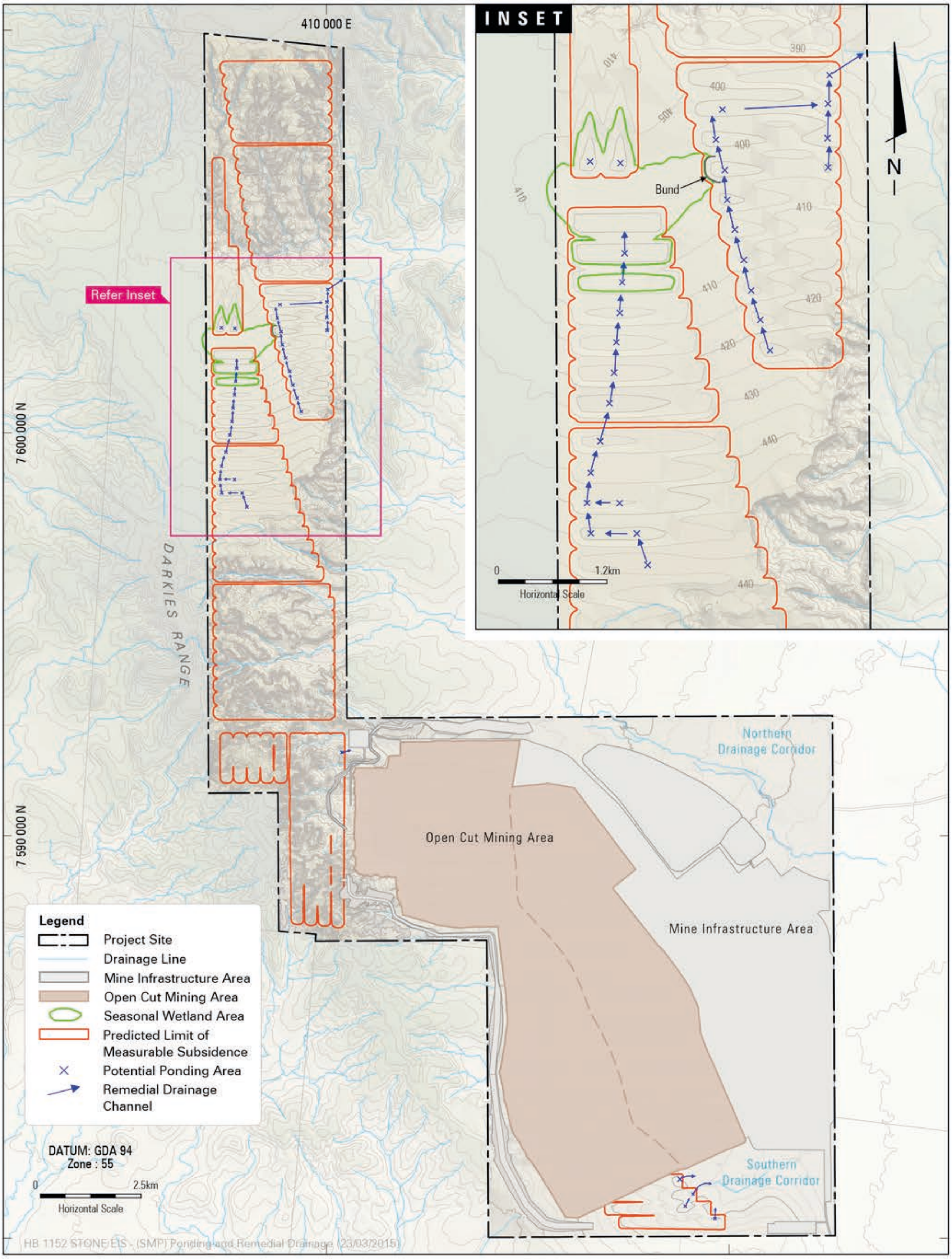
Existing Site Drainage

FIGURE 17



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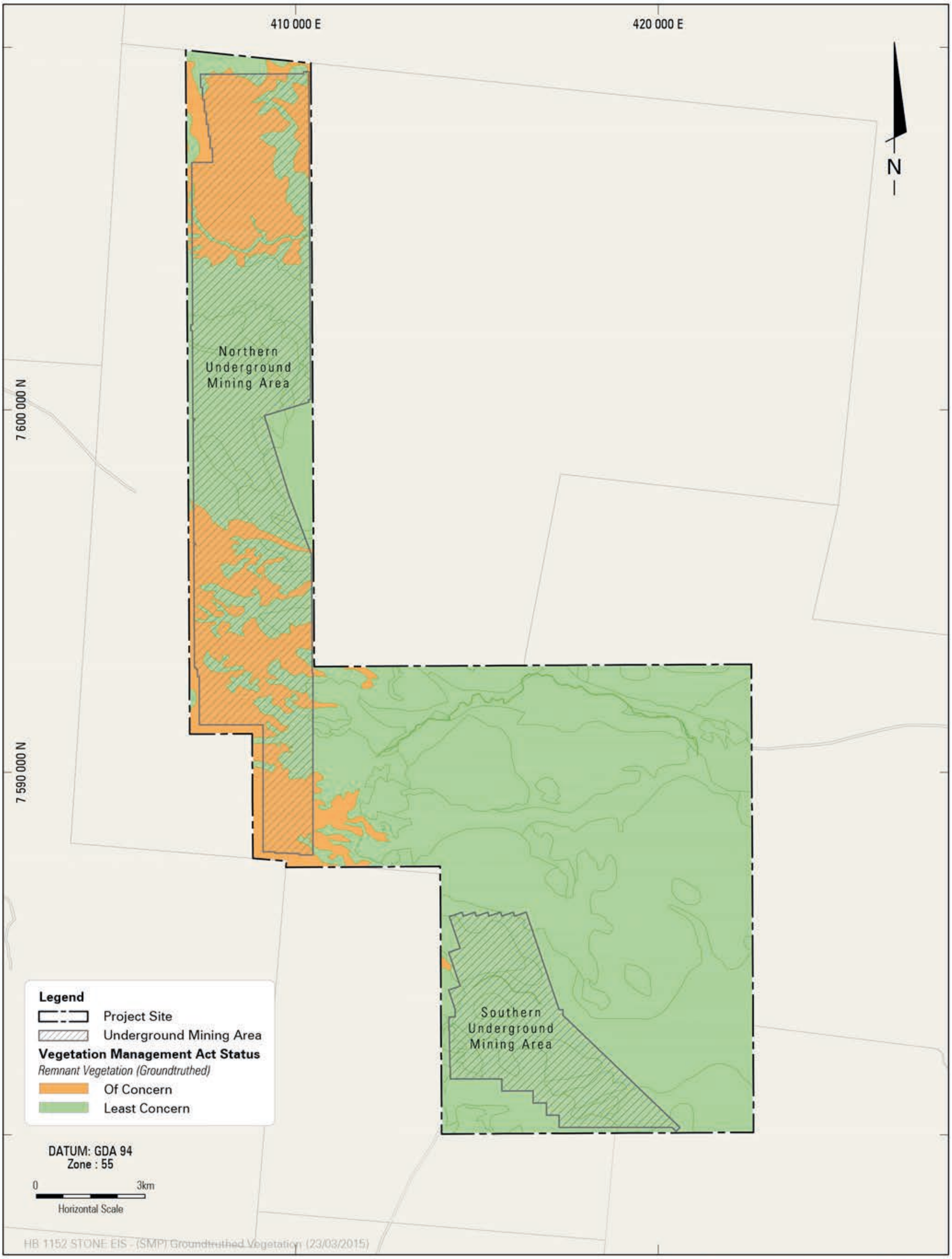
Subsidence Ponding and Remedial Drainage

FIGURE 18



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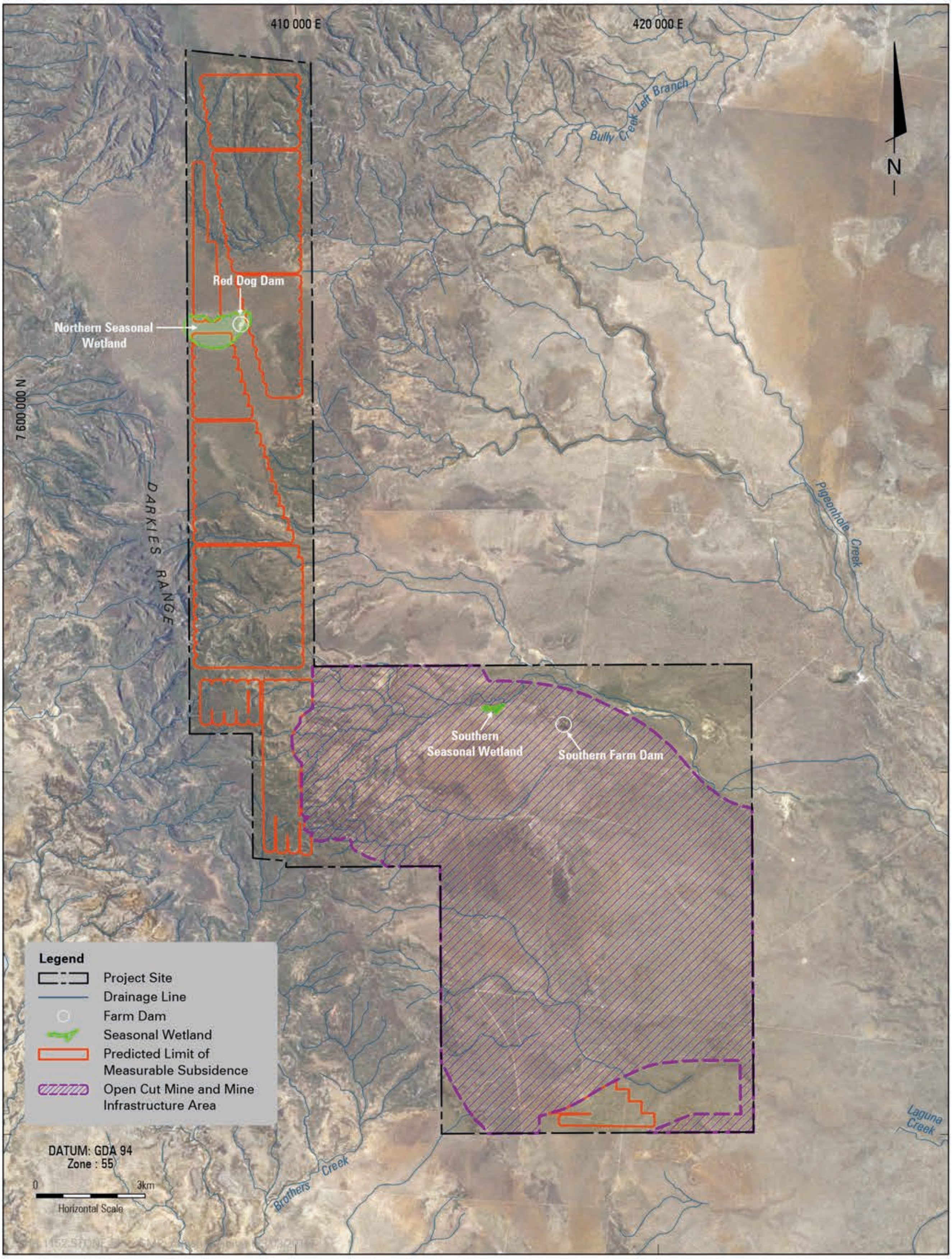
Groundtruthed Vegetation Communities

FIGURE 19



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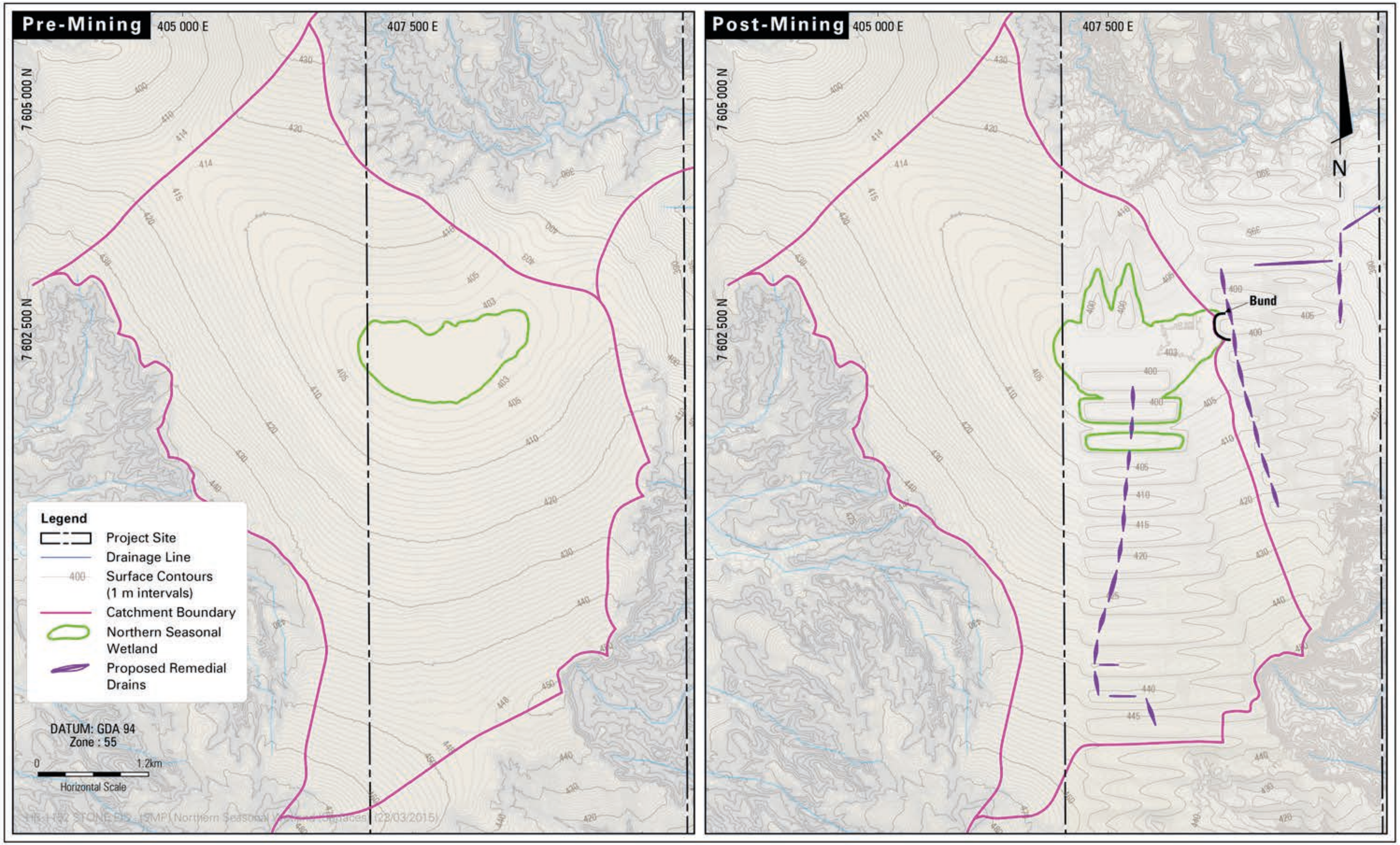
Aquatic Habitat within Disturbance Boundary and Predicted Limit of Measurable Subsidence

FIGURE 20



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Northern Seasonal Wetland - Pre and Post-Mining

FIGURE 21

APPENDIX A

Draft EHP Watercourse Subsidence Guideline

Subsidence Guideline Reference

Guideline Requirement	**Draft SMP Reference**
A subsidence management plan must address the following issues:	
1. Description of Pre Subsidence Situation & Survey (i) A general description of the area pre subsidence including photographic record should be provided. (ii) Survey of cross-section and longitudinal profiles should be undertaken on all watercourses with potential to be impacted through subsidence. Permanent transects should be detailed within the proposed Subsidence Management Plan. Surveys should include the confluence with any other watercourses in the impacted area as well as any infrastructure spanning the watercourse. Surface drainage patterns should be investigated to determine current paths of water movement through the landscape. This path of water movement should be maintained where possible post-subsidence.	Descriptions of the pre-subsidence situation are provided in Sections 5 and 6. There are no watercourses within the project site. The management of impacts on surface drainage is addressed in Section 5.2.3.
2. Predicted Subsidence The degree of anticipated subsidence should be provided, including the length of watercourse to be impacted and the average depth of subsidence across individual panels. The predicted subsidence should be modelled to indicate the change in surface elevations expected. The volumes of water expected to be captured within the bed of the watercourse due to creation of waterholes should be provided. Consequences of any lowering of the high banks of the watercourse should be discussed, including impacts associated with greater floodplain interaction and potential for creation of new channels.	Subsidence predictions are contained in Section 4 and the EIS Subsidence Report. Surface water impacts are addressed in Section 5.2.
3. Infrastructure Prior to mining, the anticipated impacts from subsidence should be determined on all infrastructure located within or above the watercourse to be subsided along with measures to be implemented to mitigate any impacts. Priority should be given to infrastructure which provides services to external parties (other mines, towns, industry). Measures for dealing with any interruption to such services should be outlined. Relocation of infrastructure may be necessary should the proposed subsidence pose sufficient risk.	N/A – no watercourses on project site.
4. Preventative Works Where preventative measures are required to ensure the stability of the bed and banks of the watercourse (establishment of pile fields, exclusion of cattle, bentonite treatment) these should be discussed in the Subsidence Management Plan, including supporting evidence outlining the legitimacy of such works. These works may be required where self-repair by natural processes will not provide adequate remediation of impacted areas. Where there is potential for root shear to result in significant loss of riparian vegetation, mitigation measures may be required.	No watercourses on project site and no preventative measures necessary for surface drainage effects.

Guideline Requirement	Draft SMP Reference
5. Engineered Structures Engineered works may be required to maintain the stability and function of a watercourse impacted by subsidence. These works are often constructed prior to subsidence occurring within the watercourse. Such works can include timber pile fields, rock revetment, reshaping of existing stream banks, and river bed treatment to prevent increased ingress of surface water into underground aquifers. Where subsidence mitigation measures require engineered structures be installed, the design, monitoring and maintenance of these structures should be detailed in the Subsidence Management Plan. The plan should detail the purpose of each structure and any consequences should the structure fail to be installed. Appropriate design plans including the location of each structure will be required. As a minimum, fourth and fifth order watercourse will require the installation of engineered structures. Works undertaken within the bed and banks of a watercourse aimed at mitigating or remediating any physical impacts pre or post-subsidence are authorised under the conditions of the Environmental Authority. Where a separate report has been produced for engineered structures, this should be included as an appendix to the Subsidence Management Plan.	N/A – no watercourses on project site.
6. Erosion The Subsidence Management Plan should detail the current watercourse condition to be impacted by subsidence. Identification of erosion zones which are likely to be exacerbated through tension cracking should be stabilised using appropriate methods. Such areas may include reaches with elevated rates of bed and bank erosion, access tracks and areas with poor quality, sparsely populated riparian vegetation. Sufficient riparian vegetation should be established prior to subsidence to assist with initial stabilisation of the bed and banks. Removal of grazing animals to allow establishment or recovery of riparian vegetation may be required for an extended period prior to subsidence.	N/A – no watercourses within project site. Measures to manage the impacts of subsidence, including erosion control measures, are described in Section 5.2.3 and summarised in Section 7.
7. Groundwater Where groundwater aquifers exist beneath the mine plan area, investigations should be undertaken regarding the potential for impacts on these aquifers as a result of subsidence. The Subsidence Management Plan should discuss these aquifers, any anticipated impacts on each aquifer and proposed measures for mitigating these impacts. Any anticipated movement of surface water into underlying aquifers should be discussed, as this can result in loss of surface water from the system and impacts on water quality in these aquifers. Geotechnical assessment across the bed and banks of the watercourse should be undertaken to provide an indication of potential permeability issues related to sub-surface cracking and interaction with local groundwater tables. Monitoring bores should be established in each aquifer prior to subsidence and monitored for a period of time sufficient for obtaining background water levels and trends. Monitoring of these bores should continue post-subsidence to aid the detection of impacted aquifers.	Section 5.1 and the EIS Groundwater Report describe the existing groundwater environment and potential impacts of the mine. The proposed groundwater monitoring program is detailed in Section 5.1.3 and summarised in Section 7.

Guideline Requirement	Draft SMP Reference
8. Surface Water (i) Baseline Monitoring The Subsidence Management Plan should detail baseline condition monitoring of all watercourses likely to be impacted through subsidence. The preferred monitoring assessment technique for stream condition in the Bowen Basin is the Index of Diversion Condition. This methodology was established as a result of the Australian Coal Association Research Program (ACARP) Project C9068. Monitoring of watercourses should extend a minimum of 1km upstream and downstream of the proposed area to be impacted and should include a geomorphic assessment of the entire reach. Where a baseline monitoring assessment has been undertaken as part of an Environmental Impact Statement (EIS) process, this may be considered sufficient provided there has been no subsequent modification or interference to the watercourse. The condition of riparian vegetation should also be detailed. (i) Cumulative Impacts on Watercourses With an increasing number of mines being established in close proximity to watercourses, a proponent utilising longwall mining methods may be requested to investigate the cumulative impact of these activities on the watercourse.	N/A – no watercourses on project site.
Monitoring and Reporting Requirements	
<u>Monitoring</u> • Representative sites need to be identified that allow the impacts of subsidence to be assessed in a particular watercourse with particular attention to the following: - Sites must be located at all pillar zones intersecting a watercourse or tributary. - Sites must include representative locations at the interface of natural ground level and observed changes in surface elevation from subsidence within a watercourse. • Control sites beyond proposed mining extents should be established to verify pre-mining conditions. In watercourses, the sites should extend a minimum of 1km both upstream and downstream of the subsidence reach. • Assessment of watercourse condition: Specific monitoring assessment techniques for watercourse condition should include but not be limited to the Index of Diversion Condition, as outlined in the ACARP Project C9068. • Vegetation and ecological condition assessments should form part of the baseline dataset. • Rainfall monitoring should be undertaken within areas proposed to be impacted by subsidence. In addition, flow event monitoring should occur in watercourses proposed to be impacted by subsidence. The type of monitoring devices and locations to be installed should be detailed in the Subsidence Management Plan. • Where preventative works are undertaken pre-subsidence, subsequent	N/A – no watercourses on project site. The baseline condition of ecological features within the proposed underground mining areas are described in Section 5.3.1, the EIS Terrestrial Ecology Report and the EIS Aquatic Ecology Report. No preventative works (pre-subsidence) are considered necessary or proposed. The proposed groundwater monitoring program is detailed in Section 5.1.3 and summarised in Section 7. Proposed surface water monitoring is

Guideline Requirement	Draft SMP Reference
monitoring assessments should include the integrity and effectiveness of these works in reducing the impact of subsidence within the watercourse. • Surveys must include cross-sectional area and bed slope throughout all monitored reaches of impacted watercourses. • Annual aerial photography and Digital Terrain Mapping is required to verify predicted subsidence surface profiles, and to identify potential short and long term erosion issues resulting from subsidence of watercourses. • Surveys pre-subsidence should quantify the following features within watercourses: - pool/riffle sequences - bed controls - entry points of other watercourses and localised tributaries - existing bed and bank scour points - infrastructure located within the watercourse. • Surveys post-subsidence should quantify any changes to the pre-mining conditions including: - erosion or deposition processes that have occurred as a result of subsidence, - migration of head cut erosion within watercourses and tributaries, - localised changes to stream bed slope, - localised widening of channels, - destabilisation of stream bed and banks including fracturing and incision, - localised changes to bank heights, - size of subsidence void created within the watercourse. • The subsidence monitoring program for groundwater must include the following information: - Sites must include representative locations at the interface of natural ground surface and observed changes in surface elevation from subsidence. - Monitoring bores should be established in each aquifer at each monitoring site. - Monitoring must include both water level measurements and water quality sampling in accordance with the following: (ii) water level measurement to be taken quarterly (iii) water quality field conductivity measurement to be taken 6 monthly (iv) full chemical analysis of water samples to be taken annually.	detailed in Section 5.2.3 and summarised in Section 7.

Guideline Requirement	Draft SMP Reference
<u>Frequency of Monitoring</u> A proposed timeframe should be provided by the proponent in relation to the monitoring outlined in the Subsidence Management Plan. The Department, upon review of the proposed Subsidence Management Plan will determine a suitable monitoring timeframe based on the information provided. Monitoring requirements will depend on a number of factors, including the stream order of the watercourse proposed to be impacted. As a guide: *Stream Order 1, 2 and 3* Monitoring must be undertaken at the following intervals: • immediately prior to subsidence, • within two (2) months of the initial subsidence, • following a rainfall event of **1 in 2 year** ARI for the duration equal to the time of concentration for the catchment at the location of the subsidence. • following a peak flow event of greater than a **1 in 2 year** ARI and • annually. *Stream Order 4 and higher* Monitoring (including surveys) must be undertaken at the following intervals: • immediately prior to subsidence, • within two (2) months of the initial subsidence, • following a rainfall event of **1 in 5 year** ARI for the duration equal to the time of concentration for the catchment at the location of the subsidence. • following a peak flow event of greater than a **1 in 5 year** ARI, and • annually.	The proposed monitoring program for subsidence impacts is described in Sections 5.1.3, 5.2.3, 5.3.2 and 5.4.2 and summarised in Section 7.
<u>Cumulative Impacts</u> Where subsidence is proposed in a Subsidence Management Plan, and the watercourse has already been subsided upstream or downstream, the monitoring assessment must determine not only the localised impacts on the watercourse resulting from the proposed subsidence, but also any cumulative impacts on the watercourse as a result of all other subsidence events.	No cumulative impacts are predicted.
<u>Assessment</u> The design and assessment of engineered structures should be performed by a Registered Professional Engineer of Queensland (RPEQ). All other assessments should be performed by suitably qualified and experienced persons in the fields that they are assessing.	N/A – no watercourses within the project site.

Guideline Requirement	Draft SMP Reference
• The results of all monitoring activities should be reviewed by a suitably qualified person and detailed in the associated monitoring report. • Recommendations should be made after assessment of the results regarding any specific treatment, remediation works, or engineered structures required post-subsidence to achieve stability in the watercourse.	
<u>Reporting</u> An annual report will be requested by the administering authority post-subsidence. The report should detail mining activities and all monitoring and rehabilitation activities as outlined within the Subsidence Management Plan. The reporting date will be determined in consultation with the administering authority. • A monitoring report should contain the results of all monitoring activities, the assessment of these results, and recommendations for any remedial works required. The report should comment on the following: - Watercourse condition and geomorphic processes; - The condition of vegetation in riparian zones; - Examination of pillar zones in watercourses with particular attention to potential for tension cracking; - The creation of in-stream waterholes; - Any impacts on groundwater. • Where preventative works were undertaken pre-subsidence, subsequent monitoring assessments should include assessment of the integrity and effectiveness of these works in mitigating the impacts of subsidence. • An annual report in the form of two (2) hard copies and one electronic copy shall be furnished to the administering authority. The report should in addition to addressing specific monitoring requirements provide comment on: - The current state of the groundwater and surface water resources; - Any impacts on these features; - Any remedial works required to be undertaken including a timetable for implementation. - Commitment from the proponent to addressing the recommendations in the report.	Section 8.
<u>Mitigation</u> Where recommendations are made regarding specific treatment, remediation works, or engineered structures required post-subsidence to achieve stability in the watercourse, the proponent must ensure this work is undertaken.	All sections.