PROJECT CHINA STONE

Rehabilitation 8

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8 REHABILITATION

8.1 INTRODUCTION

This section describes proposed rehabilitation and decommissioning strategies for Project China Stone (the project). It also provides an overview of the *Soils and Land Suitability Report* (Appendix E) undertaken by GT Environmental Pty Ltd. This section includes:

- An overview of the various rehabilitation and mine closure activities that will be undertaken as part of the project, and a description of the methods that will be used (Section 8.2);
- An overview of pre-mining soil types, land suitability and agricultural land classes (Section 8.3) and a description of post-mining land suitability and agricultural land classes (Section 8.4); and
- A description of the way in which topsoil resources will be managed (Section 8.5).

8.2 REHABILITATION

The rehabilitation and mine closure strategies described in this section have drawn on the objectives of the following two key rehabilitation guidelines produced by the Department of Environment and Heritage Protection (EHP):

- *Rehabilitation Requirements for Mining Projects* (EHP, 2012) and
- *Code of Environmental Compliance for Exploration and Mineral Development Projects* (EHP, 2013).

Rehabilitation for the project will be conducted in accordance with a Rehabilitation Management Plan (RMP) and mine closure will be conducted in accordance with a Mine Closure Plan (MCP). Further detail on the RMP and MCP is included in Section 24 – Environmental Management. The following sections describe the geochemistry of the mine waste materials and proposed rehabilitation and mine closure for key components of the project.

8.2.1 Open Cut Mine Overburden Emplacements

Introduction

Overburden material that will be excavated from the open cut mining areas will be stored in the overburden emplacement areas. Other project waste materials that will be disposed of in the overburden emplacement areas include coarse coal reject material that will be generated from the processing of coal at the Coal Handling and Preparation Plants and power station waste which will be generated from the burning of coal in the on-site power station.

The following sections describe the geochemistry of the overburden, and other waste materials to be stored in the overburden emplacement, and the overburden emplacement rehabilitation strategy.

Geochemistry of Mine Wastes

RGS Environmental Pty Ltd completed a geochemical assessment of the mine and power station waste materials from the project. The *Geochemistry Report* (Appendix D) describes the geochemical assessment in detail and key results relevant to the overburden emplacement are summarised below.

The objectives of the geochemical assessment were to:

- Investigate the geochemical and physical characteristics of representative samples of overburden, coal reject and power station waste materials;
- Assess the level of risk from acid generation, presence and leaching of soluble metals and salts, and/or other salinity/erosion issues; and
- Address any rehabilitation and environmental management issues related to the geochemical and physical properties of overburden, coal reject and power station waste materials.

Methodology for Sampling of Materials

The geochemical assessment commenced with a review of existing information related to the geochemical and physical characteristics of mine and power station waste materials likely to be generated from the project. This process was used to develop a sampling and testing program to obtain representative samples of overburden, coal reject and power station waste materials for the project.

The following technical guidelines for geochemical assessment of mining waste were referenced to ensure that the sampling and testing program was appropriate:

- *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*. (DME Guideline) (DME, 1995).
- *Leading Practice Sustainable Development Program for the Mining Industry: Managing Acid and Metalliferous Drainage*. (DITR, 2007).
- *Application Requirements for Activities with Impacts to Land Guideline.* (EHP, 2013).
- *Development of ARD Assessment for Coal Process Wastes*. (ACARP, 2008).
- *Global Acid Rock Drainage Guide* (GARD Guide). (INAP, 2009).

Geochemical sampling sites are shown in Figure 8-1. A total of 285 overburden samples were selected from 18 drill holes representative of the open cut mining area. The program focussed on acquiring representative samples of the main overburden types (including interburden and roof and floor material types).

Representative samples of coarse and fine reject materials were generated by processing reserve samples of raw coal materials at a coal quality laboratory (Bureau Veritas in Brisbane). A total of 56 coal samples from the target seams were obtained from five drill holes. The coal samples were subjected to simulated coal washability tests in order to generate 23 representative samples of coarse reject that will be stored within the overburden.

A bulk sample of power station feed coal was submitted to ALS Coal Technology laboratory at Riverview, Queensland for use in a coal ash generation (combustion) procedure. The bulk coal ash sample generated was then used in the geochemical test program.

Methodology for Characterisation of Materials

Static Geochemical Testing

All samples were subjected to a series of static geochemical tests. The geochemical test program was designed to assess the degree of risk from the presence and potential oxidation of sulphides, acid generation and leaching of soluble metals and salts. The assessment included the characterisation of standard soil parameters including salinity, cation exchange capacity, potential nutrients and major metal compositions.

The geochemical characterisation program followed the DME Guidelines in that all samples were screened for:

- pH (1:5 solid: water);
- Acidity and alkalinity;
- Electrical Conductivity (EC) (1:5 solid: water);

- Total sulfur and soluble sulfur;
- Chromium reducible sulfur;
- Acid Neutralising Capacity; and
- Net Acid Producing Potential.

Screening was undertaken at a National Association of Testing Authorities certified laboratory in Brisbane (ALS Brisbane).

After the results of the static testing were reviewed, sub-samples were selected for multi-element testing based on material type, location, lithology and geochemical characteristics. Thirty-three mine waste sub-samples and one power station waste sub-sample underwent multi-element testing on their solid and soluble fractions. These samples were tested for:

- Alkalinity or acidity (pH dependent) (1:5 solid: water);
- Total metals (aluminium, antimony, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, phosphorus, selenium, thorium, uranium, vanadium, zinc);
- Total cations (calcium, magnesium, sodium, potassium);
- Soluble metals (aluminium, antimony, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, thorium, uranium, vanadium, zinc);
- Exchangeable cations (calcium, magnesium, sodium, potassium); and
- Major anions (fluorine –coal ash only, chlorine, sulphate and phosphate).

Twenty-two of the 33 selected mine waste samples comprised overburden materials and these samples were subjected to an additional test for exchangeable cations (calcium, magnesium, sodium, potassium). The results enabled the evaluation of 'soil quality' and sodicity of overburden materials likely to report to the overburden emplacement areas.

For the power station waste sample, the range of geochemical tests described above was supplemented by additional geochemical tests, appropriate for coal ash material, including:

- Total organic carbon;
- Multi-element analyses in solids (aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, phosphorus, selenium, silver, thallium, tin, titanium, thorium, uranium, vanadium, zinc);
- Total and soluble mercury;
- Soluble hexavalent and trivalent chromium;
- Total and soluble nitrogen compounds (ammonia, total kjeldahl nitrogen, nitrate, nitrite, total nitrogen and cyanide);
- Total and soluble phosphorus;
- Radionuclide activity (gross alpha, gross beta and potassium-corrected gross beta in water);
- Total Dissolved Solids (1:5 solid: water);
- Moisture Content (1:5 solid: water); and

- ASLP bottle leach procedure using deionised water [AS 4439.3-1997] to simulate multi-element solubility under neutral pH conditions. Soluble multi-element analyses included aluminium, antimony, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, thorium, uranium, vanadium, zinc.

Kinetic Geochemical Testing
Following interpretation of the static geochemical test results, eight Kinetic Leach Column (KLC) tests were completed on four overburden samples and four coal reject samples. These samples were tested for:

- pH and EC;
- Acidity and alkalinity;
- Dissolved metals (aluminium, antimony, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, phosphorus, selenium, vanadium, zinc);
- Major cations (calcium, magnesium, sodium, potassium); and
- Major anions (chlorine and sulfate).

Similarly, following interpretation of the static geochemical test results for power station waste materials, two KLC tests were completed. These samples were tested for:

- pH and EC;
- Alkalinity and acidity;
- Soluble metals (aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, thallium, tin, titanium, thorium, uranium, vanadium, zinc);
- Dissolved mercury;
- Dissolved hexavalent chromium;
- Major cations (calcium, magnesium, sodium, potassium);
- Dissolved sulfate;
- Dissolved chloride and fluoride;
- Nitrogen compounds (ammonia, total kjeldahl nitrogen, nitrate, nitrite, total nitrogen and total cyanide); and
- Dissolved phosphate.

Overburden Waste Material Geochemical Characterisation Results

The geochemical assessment concluded that:

Water Quality
- Surface runoff and leachate from overburden, coarse rejects and power station waste to be stored in overburden emplacement areas are likely to exhibit low acidity and be slightly alkaline; and
- Salinity will be low due to a low level of dissolved solids.

Acidity and Metals
- Overburden, coarse reject and power station waste material are considered to be non-acid forming with significant excess acid neutralising capacity. These materials have a high factor of safety with respect to potential for acid generation;
- The concentration of total metals in the materials is low and within applied guideline criteria for soils and is unlikely to present any environmental issues associated with rehabilitation and final land use;

- The concentration of soluble metals and major ions in runoff and seepage from the materials is likely to remain within applied water quality guideline criteria and is unlikely to present any significant environmental risks for on-site or downstream water quality; and
- The radionuclide content of power station waste material is likely to be low.

Revegetation Implications

- Overburden is likely to have low sodicity levels and therefore have a relatively low risk of being susceptible to significant dispersion and erosion;
- Whilst fertiliser and gypsum addition could be considered for some overburden material, such amelioration measures are not likely to be required for bulk overburden materials to provide a reasonable growth medium for revegetation and rehabilitation works; and
- Based on the benign nature of the overburden, coarse rejects and power station waste materials, no special management measures are required for their handling and storage in the overburden emplacement areas.

Rehabilitation

Overview

As described in the sections above, the geochemical analysis indicates the overburden material is relatively benign with low sodicity. Consequently the construction of the overburden emplacements will not require any selective handling of overburden.

Similarly, the coarse coal reject material and power station waste that will be stored within the overburden emplacements were also found to be relatively benign. However, these materials are not likely to be a suitable growth medium for revegetation. These materials will be buried within the overburden with a minimum 2 m cover and will not be present at the surface of the final landform.

Based on the geochemistry and physical properties of the overburden emplacement materials, no special rehabilitation techniques are required for the overburden emplacement areas and a “conventional” overburden emplacement rehabilitation strategy is proposed. Overburden emplacement rehabilitation will be undertaken progressively over the life of the open cut mine. The conceptual progressive rehabilitation program for the overburden emplacement areas is illustrated in Figures 8-2 to 8-5.

The key components of the overburden emplacement rehabilitation strategy are described in the following sections.

Landform

The final landform of the overburden emplacement is shown in Figure 8-5. It will have maximum external slopes of 6H:1V. The top plateau areas of the overburden emplacements will have a 2% grade to promote runoff and prevent ponding. Surface drainage will be incorporated in the final landform and slopes, and will limit the maximum effective slope length to 100 m.

Drainage

Drainage on the rehabilitated overburden emplacements will include conventional drainage berms and/or contour drains on the external slopes. These drains will be incorporated in the external slopes to achieve a maximum effective slope length of 100 m. Contour drains will also be installed on the plateau areas, where necessary. Erosion and sediment control will be conducted in accordance with the Erosion and Sediment Control Plan (ESCP). Further details on management of overburden emplacement area drainage are provided in Section 13 – Surface Water.

Revegetation

Topsoil from the open cut mining area will be stripped and stockpiled ahead of mining (Section 8.5.3). Completed and profiled overburden emplacement areas will be covered with 0.3 m of topsoil and contour ripped. The overburden emplacement will be revegetated with grass and native trees. Fertiliser and/or hay mulch will also be applied, as necessary. Native trees and shrubs will be planted on the overburden emplacement to establish a self-sustaining native bushland.

8.2.2 Underground Mine Subsidence Areas

Underground longwall mining will result in surface subsidence. Subsidence predictions are provided in Section 6 – Subsidence. The key subsidence effects requiring management are:

- Formation of surface tension cracks;
- Formation of surface buckling effects (which may require management in some instances);
- Ponding of water in shallow surface depressions caused by subsidence;
- Potential erosion in minor surface drainage lines; and
- Impacts on the contributing catchment and ponding area of the northern seasonal wetland.

The rehabilitation of surface tension cracks and buckling is discussed below.

Potential ponding due to subsidence is discussed in Section 13 - Surface Water. As explained in Section 13, minor remedial drainage earthworks will be installed to re-establish free drainage in any ponding areas and there will be no significant residual ponding impacts.

Subsidence impacts on minor drainage lines are also discussed in Section 13 – Surface Water. Due to the rocky nature of the drainage gullies that will be subsided, they are not expected to be susceptible to significant erosion and instability following subsidence.

Assessment of the potential impacts and the proposed management approach for subsidence of the northern seasonal wetland are described in Section 10 - Aquatic Ecology.

Further detail on the proposed management of subsidence impacts is also provided in the *Draft Subsidence Management Plan* (Appendix B).

Description of Predicted Tension Cracking and Buckling

Surface areas predicted to be affected by mine subsidence are shown in Figure 8-6 (i.e. the areas within the predicted limit of measurable subsidence). Subsidence may give rise to localised surface cracking within the limit of measurable subsidence due to tensile strain on the ground surface. Residual tensile strain and potential tension cracks will occur around the perimeter of each underlying longwall panel, in the vicinity of the chain pillars and at each end of the panels. The exact location of cracks can only be confirmed through monitoring, although the majority of the subsided surface area will be unaffected by cracking. Residual tension cracks occur within a few weeks of an area being mined.

Tension cracks are anticipated to a maximum width of up to 0.2 m, and larger cracks may occur in isolated locations. Surface cracking is expected to extend to maximum depths in the order of 10 to 15 m. Larger subsidence cracks will potentially erode if not remediated. Remediation of cracks is therefore necessary to prevent erosion, to alleviate safety risks associated with open cracks and to ensure productive post-mining land use.

Buckling of surface soil may also 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 low mounds of soil being produced in areas where transient tension cracks above the retreating longwall have over-closed.

Proposed Mitigation for Tension Cracking and Buckling

The proposed rehabilitation program for tension cracking is described below. The approach involves monitoring areas potentially subject to tension cracking and repairing any individual cracks that develop. This targeted method of surface subsidence crack rehabilitation has been proposed in order to minimise disturbance of vegetation. It is consistent with the method used at a number of other operating longwall mines in Central Queensland.

The proposed subsidence crack rehabilitation program is as follows:

- 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).
- 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.
- 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.
- 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.
- Pest animal and weed control measures will also be implemented for the project.
- 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.
- 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 effects will be rehabilitated as required through re-grading any areas of buckling. Regeneration of vegetation and monitoring will be as per the tension crack rehabilitation plan described above.

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

8.2.3 Tailings and Power Station Waste Storage Facilities

Section 7 – Tailings and Power Station Waste Storage Facilities, describes the construction, operation and rehabilitation of the Tailings Storage Facility (TSF) and the Power Station Waste Storage Facility (PSWSF). Rehabilitation of these facilities will involve construction of the landform, provision of capping and topsoil layers, and seeding. A self-sustaining native ecosystem will be established on the mine waste storage facilities. Further detail on rehabilitation of the mine waste storage facilities is provided in Section 7 – Tailings and Power Station Waste Storage Facilities.

8.2.4 Rehabilitation Management and Monitoring

Rehabilitation will be managed in accordance with a RMP. The RMP will include detailed rehabilitation designs and procedures in accordance with the strategies outlined in this section. The RMP will also including monitoring and maintenance programs for site rehabilitation. This will include monitoring of revegetation and erosion. Maintenance works will be undertaken as necessary on the basis of monitoring results. Maintenance works will likely include:

- Ripping and reseeding areas of poor germination;
- Maintenance of rehabilitation drainage and sediment control works; and
- Installation of additional drainage and controls for erosion areas.

Rehabilitation goals, objectives, indicators and completion criteria are included in Section 24 – Environmental Management.

8.2.5 Decommissioning and Mine Closure

Following cessation of mining activities the rehabilitation of the open cut and underground mining areas, and the TSF will be completed (as described in Sections 8.2.1, 8.2.2 and 8.2.3). Mine infrastructure areas will also be decommissioned and rehabilitated. A MCP will be prepared to provide guidance on mine closure activities and will include:

- Rehabilitation goals;
- An overview of closure and rehabilitation activities;
- Performance criteria; and
- Monitoring and reporting.

During site decommissioning all buildings and mine infrastructure will be dismantled and removed from site. The infrastructure hardstand areas will be inspected for any hydrocarbon contamination and remediated, as necessary. Sediment and mine water dams not required post mining will also be decommissioned by breaching the dam embankments and re-contouring the embankment and storage areas to a stable and free draining state. Mine water dams will also be inspected for any contamination and remediated, as necessary. The hardstand and dam areas will then be topsoiled, ripped and seeded with the aim of restoring the site to the required land use. Topsoil will be placed at a minimum depth of 0.3 m. Revegetation species will include a mixture of grasses and native trees. The portals of the underground mine access drifts and ventilation shafts will be permanently sealed at mine closure in accordance with the requirements of the Department of Natural Resources and Mines.

The open cut mine final voids and ramps will be left in a geotechnically stable form. The catchment area of the final voids will be limited by the highwall drains and the externally draining overburden emplacement areas (Figure 8-5). Modelling of the final void water balance indicates that a lake will form in the final void. The modelling indicates that the lake will reach a quasi-equilibrium level approximately 50 m below the spill point of the final void. Overflow from the final void is therefore very unlikely. The predicted lake level is also below the level of the pre mining water table. This means that the final void will continue to act as a groundwater sink and void lake water will not migrate away from the void and potentially contaminate groundwater. Groundwater modelling also indicates that groundwater inflows to the final void will be relatively minor in the post mining phase, based on conservative groundwater modelling assumptions. The surface water and groundwater assessments for the final void are discussed in more detail in Section 13 – Surface Water and Section 12 – Groundwater, respectively.

The decommissioned site will be free draining with the exception of the final voids. Flood modelling conducted for the project indicates that the decommissioned site has a suitable drainage arrangement and the final voids will have immunity from the Probable Maximum Flood. Site drainage is discussed in more detail in Section 13 – Surface Water.

8.3 PRE-MINING SOILS AND LAND SUITABILITY

8.3.1 Soils and Land Suitability Assessment Methodology

A detailed soils and land suitability assessment was undertaken, covering the full extent of the project site. The results of the study are provided in the *Soils and Land Suitability Report* (Appendix E).

Soils Assessment

A desktop review of relevant regional data sources was used to prepare a site investigation plan for the study area (total area of approximately 20,000 ha). The investigation scale, density, layout and assessment methods were prepared with reference to relevant guidelines and best practice, including:

- *Guidelines for Agricultural Land Evaluation in Queensland* (DPI, 1990) and the associated *Regional Land Suitability Frameworks for Queensland*, (DPI, 2013);
- *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME, 1995);
- *Australian Soil and Land Survey: Field Handbook* (National Committee on Soil and Terrain, 2009);
- *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al*., 2008); and
- *Australian Soil Classification* (Isbell, 2002).

The field investigation plan comprised 363 investigation sites of which 281 sites were surface observations and 82 were detailed soil profile descriptions. Soils within the project disturbance boundary were mapped at a scale of 1:50,000 or better. This satisfies the requirements of McKenzie *et al*., 2008.

Representative sites within each soil type were sampled for laboratory analysis of major soil horizons. Analytical determinants were selected to provide specific information on the physical and chemical properties of the soils that influence erosion potential, stormwater run-off quality, rehabilitation and agricultural productivity.

Based upon field and laboratory data, soil mapping units (SMUs) were delineated and mapped. SMUs are defined according to their basic soil morphology, position in the landscape and parent material.

The suitability of soils for stripping and reuse in rehabilitation was also assessed. SMUs within the TSF and PSWSF footprints were further assessed to determine whether available soil material would be suitable for use as capping for rehabilitation of the storage facilities. Proposed soil stripping depths and management measures are provided in Section 8.5.

Land Suitability Assessment

Land suitability in Central Queensland is assessed according to the Land Suitability Assessment Techniques (LSAT) (DME 1995) and the recent draft of the *Guidelines for Agricultural Land Evaluation in Queensland: Second Edition* (Draft ALE Guidelines), released by the Queensland Government in 2013. LSAT and the Draft ALE Guidelines provide general land suitability class criteria and threshold values for assessment of soil limitations to rainfed broadacre cropping and beef cattle grazing. Land suitability classes range from 1 to 5, with 1 being suitable land with negligible limitations for the designated land use, and 5 being unsuitable land with extreme limitations that preclude its use. Burgess (2003) and Shields and Williams (1991) were also referenced to support the methods for land suitability classifications.

Field and laboratory data was used to assess the severity of any limitations and the land suitability class of each SMU against the Draft ALE Guidelines. Factors assessed as major limitations included plant available water capacity, nutrient deficiency, salinity, physical factors, rockiness, micro-relief, susceptibility to water erosion and flooding.

A search of the Queensland government mapping shows that there are no strategic cropping areas, as defined by the *Regional Planning Interests Act 2014* (RPI Act), within the project site.

The Agricultural Land Classification approach used also forms the basis of the assessment of agricultural land within Priority Agricultural Areas, defined under the RPI Act and *State Planning Policy 2014* (SPP). Queensland government mapping shows that no Priority Agricultural Areas are present in the vicinity of the project site. It is noted that the SPP supersedes the *State Planning Policy 1/92: Development and Conservation of Good Quality Agricultural Land*, including the replacement of Good Quality Agricultural Land with Priority Agricultural Areas.

8.3.2 Soil Mapping Units

Eleven SMUs were identified from the soils assessment. These are shown on Figure 8-7. Further detail on each SMU is provided in the *Soils and Land Suitability Report* (Appendix E) and Table 8-1 shows the land suitability of each SMU.

8.3.3 Land Suitability

Land Suitability Classes

All SMUs are suited to beef cattle grazing with large areas having marginal potential for improved pastures (Figure 8-8). This is consistent with the current use of the project site for cattle grazing on native pastures. All SMUs were found to be unsuitable for rainfed broadacre cropping (Figure 8-9).

Agricultural Land Class

The majority of the project site (consisting of SMUs A2, E1, E2, E3, E4, E5, U1 and U2(b)) is considered agricultural land class C3 and is suitable for light grazing of native pastures in accessible areas. The remainder of the project site (SMUs A1, A1(sv) and U2(a)) is considered agricultural land class D which is land not suitable for agricultural land uses. Figure 8-10 provides a map of agricultural land classes within the project site.

A summary of the pre-mining land suitability and agricultural land class areas is presented in Table 8-1.

Table 8-1 Pre-Mining Land Suitability and Agricultural Land Class

SOIL MAPPING UNIT	AREA (ha)	DESCRIPTION	LAND SUITABILITY CLASS: CROPPING	LAND SUITABILITY CLASS: GRAZING	AGRICULTURAL LAND CLASS
A1	484	Active drainage lines, lower fluvial deep sandy loams	5	5	D
A1(sv)	106	Relic drainage lines, hard setting and scalded surface sandy loams	5	5	D
A2	109	Palustrine area with silty clays	5	4	C3
E1	895	Low lying red deep >150cm red sandy earth	5	4	C3
E2	3,071	Low lying greyish / yellow deep > 150 cm yellow sandy earth	5	4	C3

SOIL MAPPING UNIT	AREA (ha)	DESCRIPTION	LAND SUITABILITY CLASS: CROPPING	LAND SUITABILITY CLASS: GRAZING	AGRICULTURAL LAND CLASS
E3	3,685	Mid to upland red sandy loam, firmer surface with silty loam	5	4	C3
E4	5,662	Mid to upland sandy loam with 60% yellow and 40 % red interfingering loamy earths	5	4	C3
E5	125	Mid to upland duplex, loamy sands above hard silty clay loams, Yellowish grey, minor conspicuous bleach	5	4	C3
U1	423	Silty rocky channels and loamy foot slope areas associated with rocky uplands	5	4	C3
U2(a)	4,746	Upland skeletal, rugged scarps, ridges and valleys. Extensive outcropping hard laterite and gravelly skeletal soils	5	5	D
U2(b)	783	Lower sloping plateaus and drainage basins with shallow to moderately deep loams	5	4	C3
TOTAL	**20,088**				

8.4 POST-MINING LAND SUITABILITY

8.4.1 Land Suitability

The key areas of disturbance associated with the project are discussed in the following sections, together with their impact on land suitability and agricultural land class. A summary of the project's impacts on land suitability and agricultural land class are provided in Table 8-2 and shown in Figure 8-8 to Figure 8-10.

Open Cut Mine Areas

Following open cut mining the overburden emplacement areas and final voids will not be able to be restored to their pre-mine land suitability for grazing. These areas will not be suitable for grazing because of their slopes and will be class 5 land for grazing and agricultural land class D.

Underground Mine Areas

Following underground mining surface subsidence effects will result in the development of a series of shallow troughs relative to natural topography with gentle slopes. Surface tension cracks will be rehabilitated and minor remedial drainage earthworks will be installed to re-establish free drainage. Subsidence will not alter the land suitability for grazing and subsided areas will be able to continue to be used for grazing post-mining. Subsidence will not impact agricultural land class.

TSF and PSWSF

The TSF and PSWSF will be rehabilitated as a native ecosystem post-mining. No grazing is proposed for these areas in order to protect the integrity of the capping layer and rehabilitation. The TSF and PSWSF will therefore have a land suitability of class 5 for grazing with an agriculture land class of D.

Mine Infrastructure Areas

Mine infrastructure will be dismantled and removed from site and infrastructure areas will be rehabilitated as part of mine closure. These areas will be restored to their pre-mining land suitability, where possible. Management measures will be put in place to ensure that the suitability of land for grazing is unchanged.

Table 8-2 Pre and Post-Mining Land Suitability and Agricultural Land Class

ASSESSMENT CATEGORY		IMPACT ASSESSMENT		
		Pre-Mine (ha)	Post-Mine (ha)	Change in Area (ha)
Land Suitability Class (Rainfed Broadacre Cropping)	1	-	-	-
	2	-	-	-
	3	-	-	-
	4	-	-	-
	5	20,088	20,088	0
Land Suitability Class (Beef Cattle Grazing)	1	-	-	-
	2	-	-	-
	3	-	-	-
	4	14,752	8,653	-6,099
	5	5,336	11,435	+6,099
Agricultural Land Class	A	-	-	-
	B	-	-	-
	C1	-	-	-
	C2	-	-	-
	C3	14,752	8,653	-6,099
	D	5,336	11,435	+6,099

8.5 MANAGEMENT OF TOPSOIL RESOURCES

8.5.1 Topsoil Resources

An assessment of the suitability of soils for stripping and reuse in rehabilitation was undertaken. Where an SMU lies within the footprint of the TSF and PSWSF further assessment was undertaken to determine whether the soil was suitable for use as capping material for rehabilitation of the storage facilities.

The depth of topsoil resources in each SMU are presented in Table 8-3.

Table 8-3 Depth of Available Top Soil Resources (m)

SMU	TOPSOIL (m)	SUITABILITY FOR REHABILITATION
A1	0.6	■ Not preferred as a plant growth medium on rehabilitation as it is likely to set hard and seal. ■ Main value for rehabilitation is as capping material.
A1(sv)	0.1	■ Poor quality topsoils for rehabilitation, considered to be strongly acidic.
A2	0.3	■ This soil is useful for a range of rehabilitation applications although potential problems may be encountered in the initial establishment of fine seeded pastures due to poor soil to seed contact as a result of the shrinking / swelling soil attributes.
E1 E2	1.0	■ These soils are better suited to application on lower sloping sites due to a higher erosion potential. ■ Generally no significant salinity or sodicity issues to at least 1.0 m depth. ■ They readily germinate and support both grasses and native trees.
E3	1.0	■ These soils are better suited to application on lower sloping sites due to a higher erosion potential. ■ Generally no significant salinity or sodicity issues to at least 1.0 m depth. ■ These soils would be suitable for topsoil and capping reuse. ■ They readily germinate and support both grasses and native trees.
E4	1.3	■ These soils are better suited to application on lower sloping sites due to a higher erosion potential. ■ Generally no significant salinity or sodicity issues to at least 1.3 m depth. ■ These soils would be suitable for topsoil and capping reuse. ■ They readily germinate and support both grasses and native trees.
E5	0.1	■ Elevated salinity and sodicity issues at depth.
U1	1.1	■ Not preferred as a plant growth medium on rehabilitation as it is likely to set hard and seal. ■ Main value for rehabilitation is as capping material.
U2(a)	0.2	■ Main value for rehabilitation is as capping material.
U2(b)	0.1	■ Main value for rehabilitation is as capping material.

8.5.2 Topsoil Availability

The soils assessment has identified a significant surplus of topsoil resources are available to rehabilitate the project site with approximately 490 Million m^3 available to be stripped within the project disturbance area. As such the proposed stripping depths will be refined as part of the Topsoil Management Plan for the project.

Mine Infrastructure Area

Available soils will be stripped as part of the construction of the mine infrastructure area. The topsoil depth within the footprint of the mine infrastructure area varies between 0.1 m and 1.3 m. Topsoil will be stored within designated topsoil stockpile areas.

Open Cut Mine Areas

Available topsoil will be stripped from the footprint of the open cut mine area as mining advances from east to west. The topsoil depth within the footprint of the open cut mine area varies between 0.1 m and 1.3 m. Topsoil will be stockpiled temporarily within the footprint of the open cut mining area, where possible, in order to limit the disturbance footprint of the project. Where this is not possible it will be stored within the designated topsoil stockpile areas (Figure 8-2 to Figure 8-4).

TSF and PSWSF

The footprint of the TSF and PSWSF consists of SMUs A1 and E4 which offers a significant source of soil material for rehabilitation and capping.

As described in Section 7 – Tailings and Power Station Waste Storage Facilities, the TSF and PSWSF will be rehabilitated with a capping layer (growth medium) of approximately 1 m in thickness and 0.3 m of topsoil material. The soils assessment indicates that there is more than sufficient suitable topsoil and subsoil material available within the TSF/PSWSF footprint and the adjacent mine infrastructure area to provide the proposed depth of capping material and topsoil cover.

Topsoil and capping material will be stored within the designated topsoil stockpile areas.

8.5.3 Soil Management Measures

Topsoil stripping, stockpiling, maintenance and respreading will be managed in accordance with a Topsoil Management Plan (Section 24 – Environmental Management). Topsoil and subsoil management measures will include:

- Soil stripping plans will be developed showing the depth of topsoil to be stripped to ensure that all suitable materials are salvaged and that the quality of stripped soil is not reduced through contamination with unsuitable soils;
- Earthmoving plant operators will be trained and/or supervised to ensure that stripping operations are conducted in accordance with stripping plans and in situ soil conditions; and
- Care will be taken to ensure soil moisture conditions are appropriate (i.e. not too wet) during stripping, stockpiling, and re-spreading to ensure that structural degradation of the soil is avoided.

Measures to be adopted during stockpiling topsoil and subsoil include:

- Soil will be stored within delineated topsoil stockpile areas (Figure 8-2 to Figure 8-4) or stockpiled within the footprint of the open cut mining area where required, in order to limit the disturbance footprint of the project;
- Drainage will be diverted around stockpiles to prevent erosion;
- Sediment control in accordance with the Erosion and Sediment Control Plan will be installed downstream of the stockpiles to collect any washed sediment;
- Topsoil stockpiles will be formed in mounds up to a maximum height of approximately 10 m consistent with the storage area available;
- Long-term stockpiles, not used for over six months, will be deep ripped and sown with local grass seed-stock and legumes in order to keep the soil healthy and maintain biological activity;
- Soil stockpiles will be clearly signposted for easy identification and to avoid any inadvertent losses;
- Establishment of weeds on the stockpiles will also be monitored and controlled; and
- An inventory of available material, including soil types, will be maintained to ensure adequate materials are available for planned rehabilitation activities.

Measures to be adopted during re-spreading topsoil and subsoil include:

- Mine rehabilitation planning will include balancing the topsoil and subsoil quantities required for rehabilitation against stored stockpile inventories. Topsoil used in rehabilitation will be applied in accordance with the specifications in the Topsoil Management Plan;
- Soil material will be re-spread in even layers at a thickness appropriate for the intended land use of the area to be rehabilitated and volume of soil available; and
- Soils will be selectively placed, with more erodible materials being placed on flatter areas in order to minimise erosion.

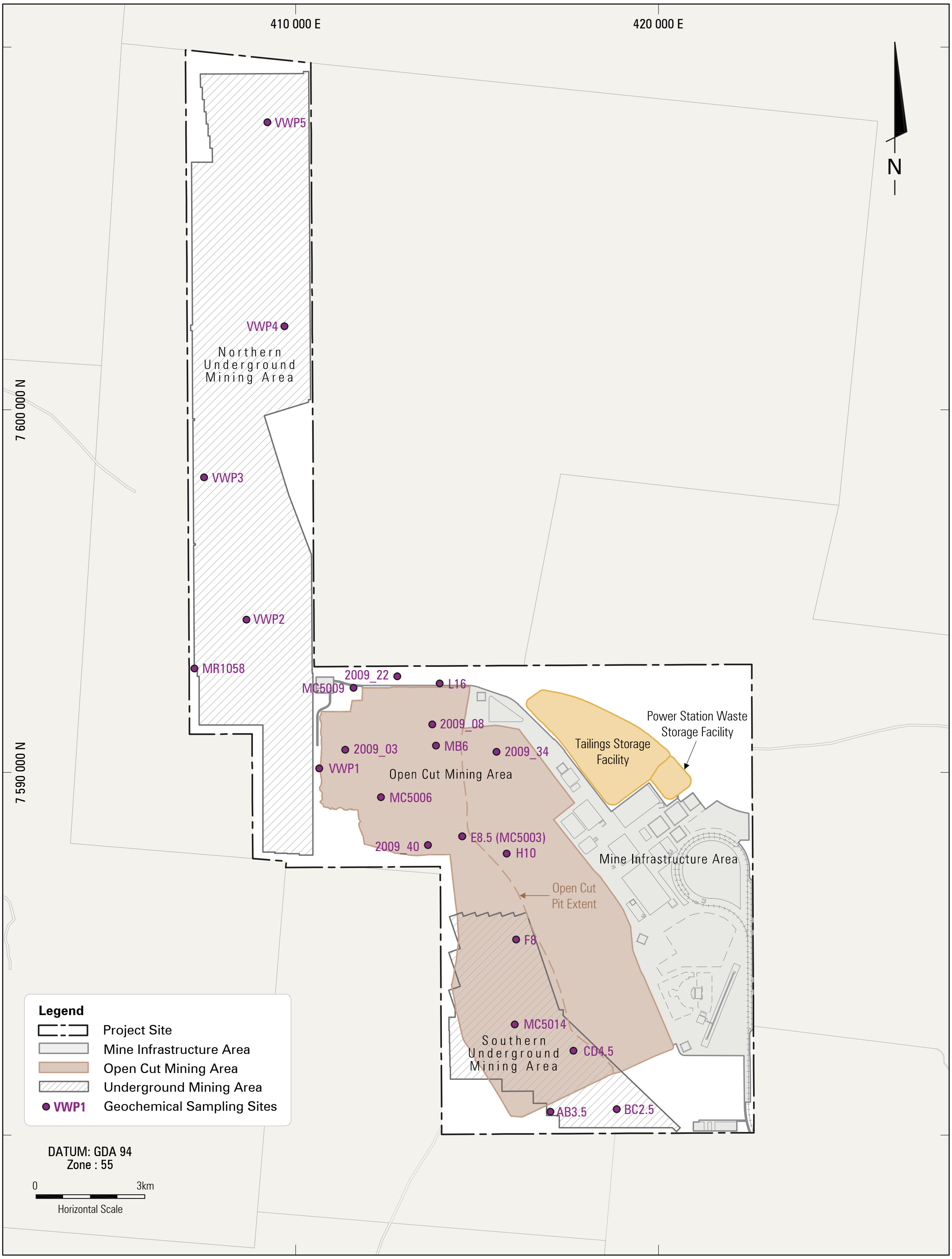
Soil loss from rehabilitated areas will be minimised through:

- Contour ripping to encourage rainfall infiltration and minimise runoff;
- Reseeding soon after re-spreading to establish a vegetation cover as early as possible;
- Installing slope drainage control to limit slope lengths and runoff velocities; and
- Installing collection drains and sediment dams to collect runoff and control suspended sediment.

The following erosion and sediment control measures will be implemented during the project to conserve the soil resources on the project site:

- Vegetation clearing will be conducted progressively so that the minimum area necessary for construction and operations is cleared at any time;
- Runoff from higher areas will be directed around disturbed areas;
- Runoff from bare earthworks areas will be collected in drains and directed through sediment traps and settling ponds to control suspended sediment prior to discharge from the site;
- Earthworks batters will be constructed to stable slopes and re-vegetated soon after construction; and
- Earthworks areas will be landscaped and re-vegetated as soon as possible after construction is completed.

FIGURES



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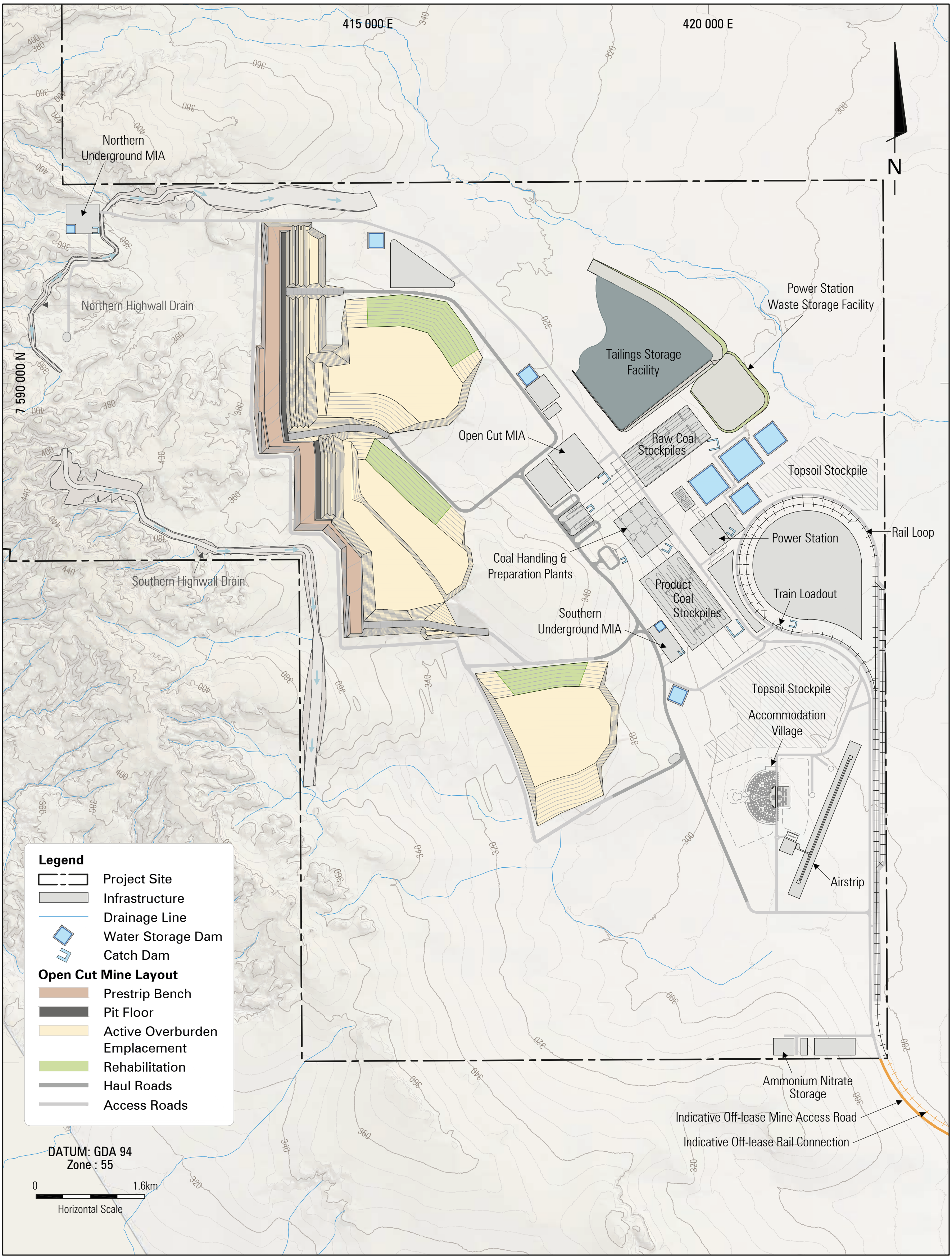
Geochemical Sampling Sites

FIGURE 8-1



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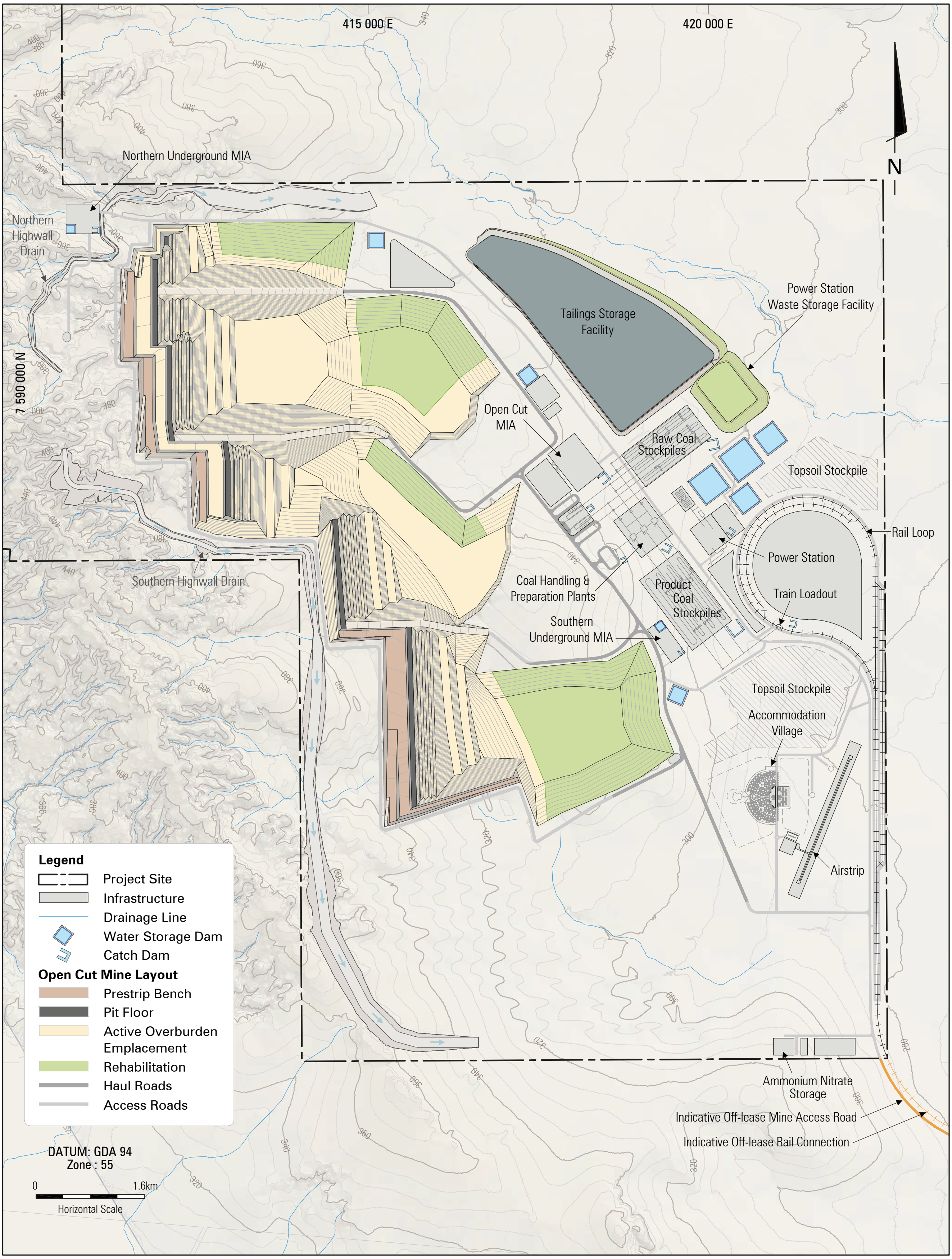
Open Cut Mine Layout - Year 5

FIGURE 8-2



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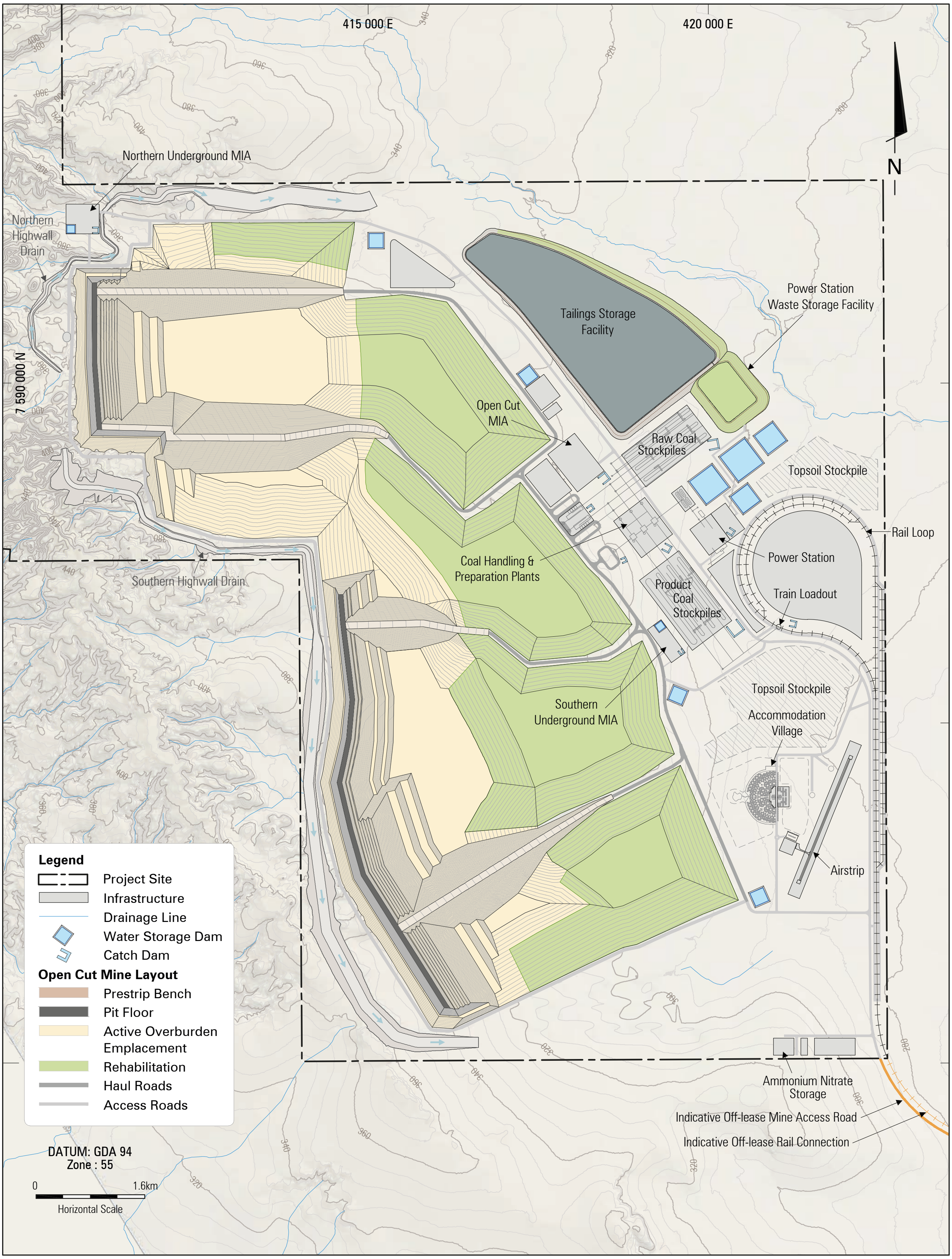
Open Cut Mine Layout - Year 15

FIGURE 8-3



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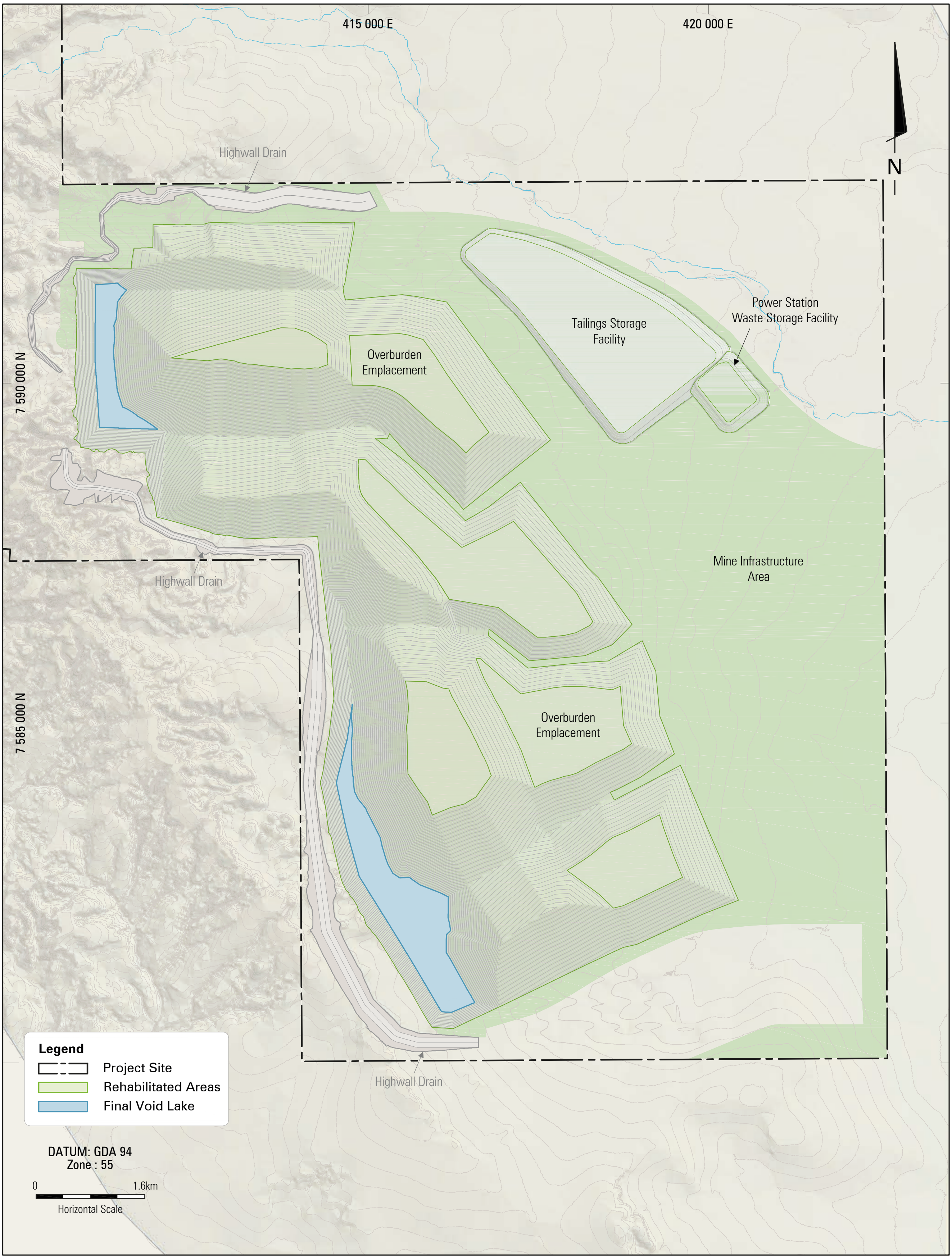
Open Cut Mine Layout - Year 30

FIGURE 8-4



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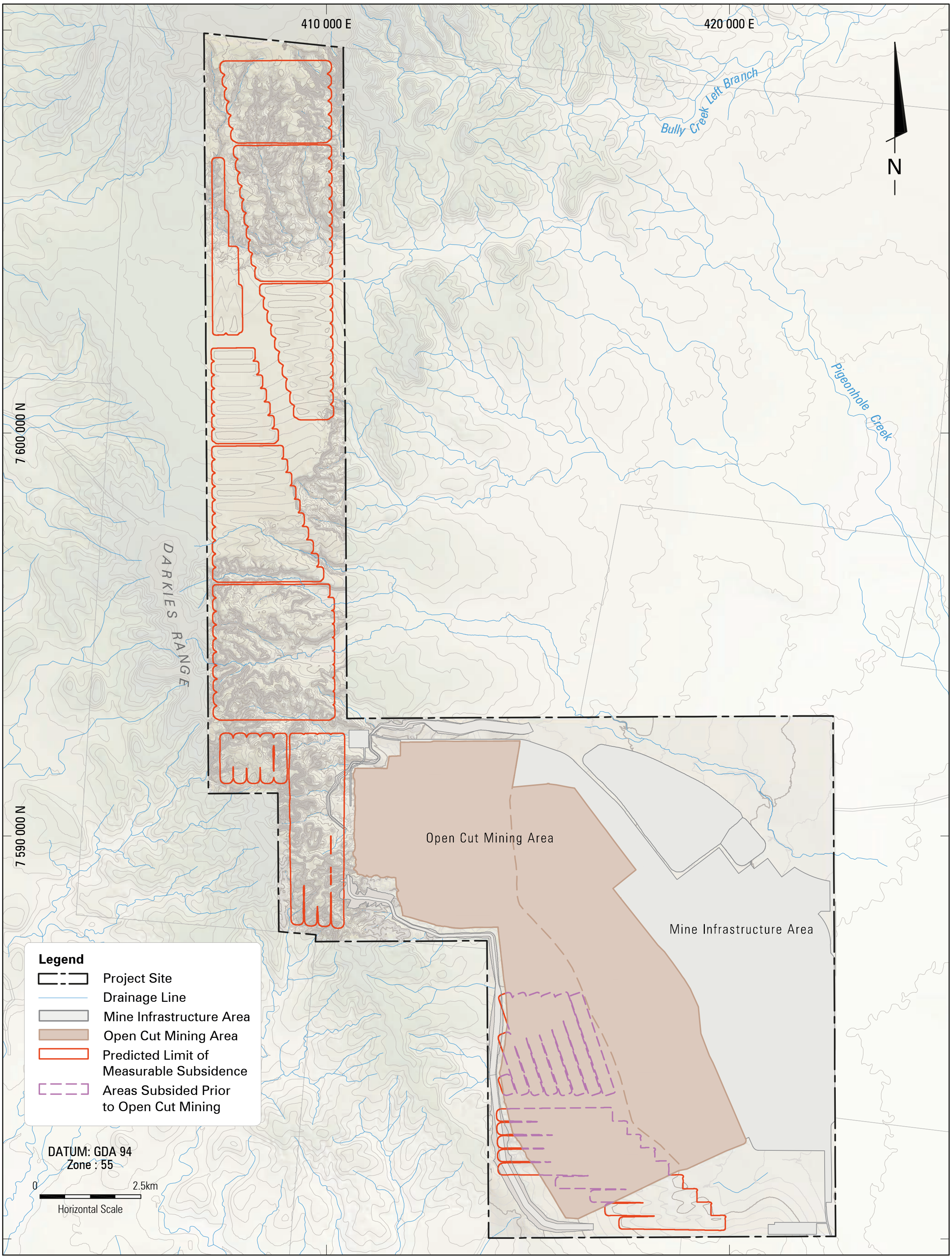
Conceptual Decommissioning Plan

FIGURE 8-5



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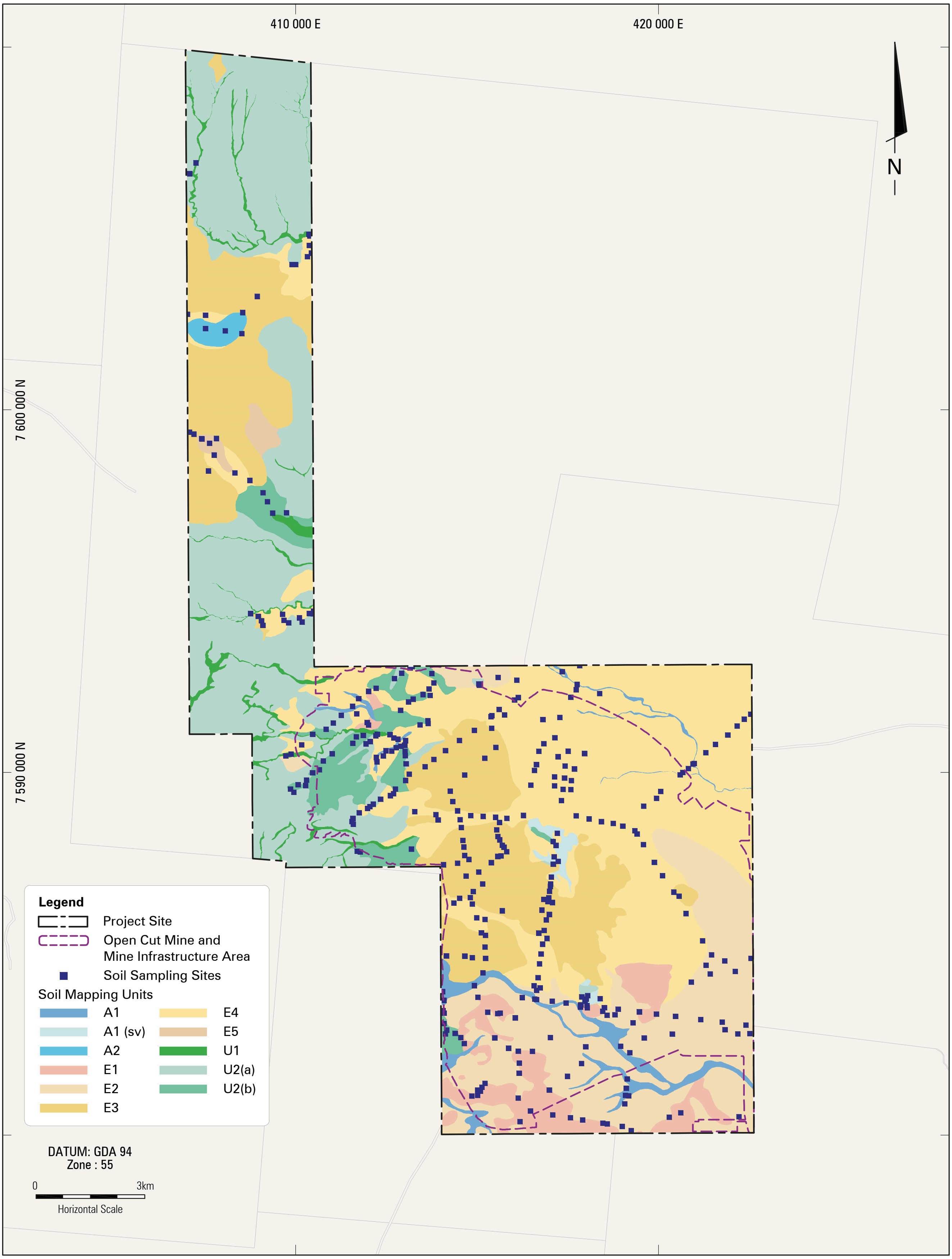
Mine Subsidence Areas

FIGURE 8-6



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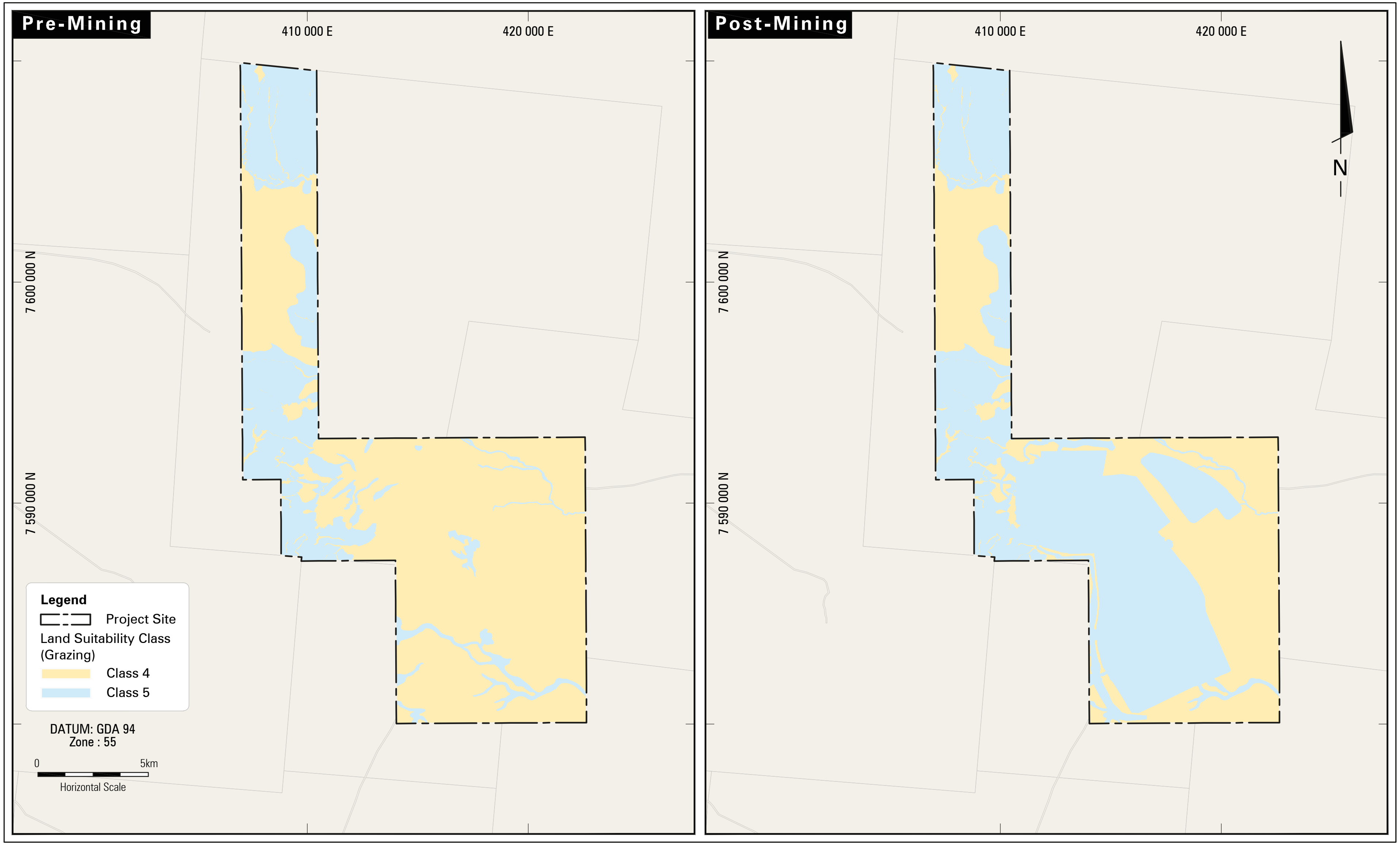
Soil Mapping Units

FIGURE 8-7



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Land Suitability - Beef Cattle Grazing (Pre and Post-Mining)

FIGURE 8-8

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Land Suitability - Rainfed Broadacre Cropping
(Pre and Post-Mining)

FIGURE 8-9

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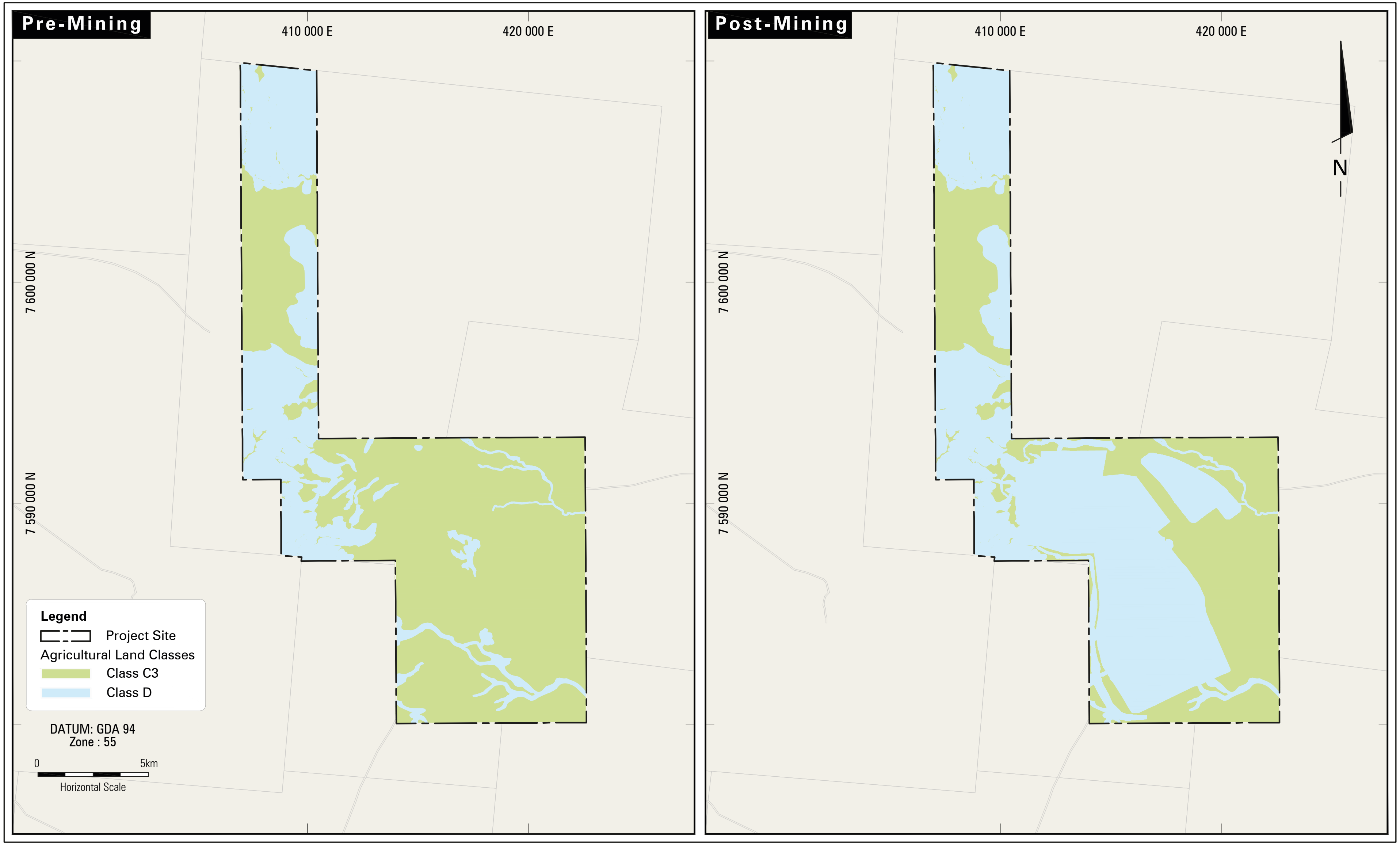

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Agricultural Land Classes (Pre and Post-Mining)

FIGURE 8-10