PROJECT CHINA STONE

Tailings and Power Station Waste Storage Facilities

7

CONTENTS

Tables

Figures

7 TAILINGS AND POWER STATION WASTE STORAGE FACILITIES

7.1 INTRODUCTION

This section describes the proposed storage of tailings in the Tailings Storage Facility (TSF) and power station waste material in the Power Station Waste Storage Facility (PSWSF). It includes description of the geochemical properties of the tailings and power station waste material, as well as the design, construction, operation and rehabilitation of the TSF and PSWSF (Figure 7-1). Further detail is provided in the *Mine Waste Storage Facility Conceptual Design Report* (Appendix C) and the *Geochemistry Report* (Appendix D).

Section 8 – Rehabilitation describes the management of other mine waste materials (including overburden, coal rejects and power station waste after Project Year 10) that will be disposed of in the open cut mine overburden emplacements.

In addition, the potential impacts associated with the construction and operation of the TSF and PSWSF are discussed in the relevant technical sections of the Environmental Impact Statement (e.g. dust from the waste storage facilities is addressed in Section 15 – Air Quality; potential impacts on groundwater are addressed in Section 12 – Groundwater).

7.2 OVERVIEW OF TAILINGS AND POWER STATION WASTE STORAGE

The project will involve coal processing at the Coal Handling and Preparation Plant (CHPP) and generation of coal tailings. Life-of-mine tailings will be stored in a conventional wet TSF. The tailings will be pumped from the CHPP to the TSF as a slurry via a surface pipeline. The geochemical properties of the tailings are discussed in Section 7.3 and the conceptual design of the TSF is discussed in Section 7.4.

The proposed power station will generate dry waste in the form of fly ash, bottom ash and clinker. Waste from the power station will be transported by haul truck for storage in the PSWSF. The PSWSF will be a dry emplacement area constructed in a similar manner to an out-of-pit overburden emplacement. The PSWSF will have sufficient capacity to store power station waste for the first 10 years of operations. After this time, power station waste will be stored within the open cut mine overburden emplacement areas. The storage of power station waste in the overburden emplacement areas is discussed in Section 8 – Rehabilitation. The geochemical properties of the power station waste are discussed in Section 7.3 and the conceptual design of the PSWSF is discussed in Section 7.4.

7.3 GEOCHEMICAL CHARACTERISATION OF TAILINGS AND POWER STATION WASTE MATERIAL

7.3.1 Overview of Geochemistry

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 tailings and power station waste are summarised below.

The objectives of the geochemical assessment were to:

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

7.3.2 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 tailings 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:

- Queensland Department of Mines and Energy (DME) (1995). *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*.
- Department of Industry, Tourism and Resources (DITR) (2007). *Leading Practice Sustainable Development Program for the Mining Industry: Managing Acid and Metalliferous Drainage*. Canberra ACT.
- Department of Environment and Heritage Protection (EHP) (2013). *Application Requirements for Activities with Impacts to Land Guideline.*
- ACARP (2008). *Development of ARD Assessment for Coal Process Wastes*. ACARP Project C15034. University of South Australia.
- International Network on Acid Prevention (INAP) (2009). *Global Acid Rock Drainage Guide* (GARD Guide). Document prepared by Golder Associates on behalf of INAP.

Tailings

Representative samples of coarse reject and fine reject (tailings) 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 two representative samples of tailings that will be stored within the TSF.

Power Station Waste Material

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.

7.3.3 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 (1995) 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. The tailings and power station waste sub-samples underwent multi-element testing on their solid and soluble fractions. These samples were tested for:

- Alkalinity or acidity (pH dependent) (1:5);
- 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).

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, Kinetic Leach Column tests were completed on four coal reject samples and two power station waste samples. 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.

7.3.4 Geochemistry of Tailings and Power Station Waste Materials

The geochemical assessment concluded that:

Water Quality

- Surface runoff and leachate from stored tailings and power station waste material 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

- Tailings and power station waste materials 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 tailings and power station waste is low and within applied guideline criteria for soils and is unlikely to present any environmental issues associated with TSF/PSWSF rehabilitation and final land use;
- The concentration of soluble metals and major ions in runoff and seepage from the tailings and power station waste 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.

Storage Implications

- Based on the benign nature of the tailings and power station waste materials, no special management measures are required for handling and storage within the TSF and PSWSF.

7.3.5 Management and Monitoring

The management of tailings and power station waste will consider the geochemistry of these materials with respect to their potential risk to cause harm to the environment. The proposed design, operation and rehabilitation of the TSF and PSWSF are discussed in Section 7.4.

Surface runoff and any seepage from the TSF and PSWSF will be monitored to confirm runoff and leachate water quality. In particular, water samples will be taken on a quarterly basis from the Return Water Dam, TSF decant pond, PSWSF runoff collection sumps and TSF/PSWSF seepage collection sumps. Water quality parameters that will be monitored include:

- pH;
- EC;
- Total suspended solids;
- Dissolved trace metals/metalloids; and
- Major ions.

Groundwater monitoring is discussed in Section 12 – Groundwater.

7.4 CONCEPTUAL DESIGN OF THE TSF AND PSWSF

Golder Associates Pty Ltd completed a conceptual design of the TSF and the PSWSF. The work is described in the *Mine Waste Storage Facility Conceptual Design Report* (Appendix C) and included:

- Calculation of the volume of life-of-mine tailings and power station waste produced in the first 10 years of operations;
- Sizing of the TSF and PSWSF and associated ultimate footprint areas;
- Preparation of staged development plans and operating methods for the TSF and PSWSF;
- Geotechnical field investigations of the TSF and PSWSF foundation; and
- Design analyses of the TSF and PSWSF.

7.4.1 Geotechnical Testing of the TSF/PSWSF Foundation

A field investigation program was undertaken to assess the geotechnical characteristics of the foundation materials of the TSF and PSWSF. It involved the investigation of 35 sites, including 23 test pits and 12 boreholes across the combined footprint of the storage facilities. The investigation sites were characterised in the field and geotechnical samples of selected subsurface material were subject to laboratory testing. Laboratory testing included soil classification (particle size distribution, moisture content and plasticity), Emerson Class, compaction and permeability.

The findings of the field investigation indicate the foundation area of the TSF/PSWSF is characterised by highly weathered tertiary sediments of claystone and fine to medium grained, weakly indurated sandstone. The investigation program allowed soil strength; rock strength; soil permeability; dispersivity; and the availability of construction materials to be determined. The material properties were taken into account in designing the TSF and PSWSF.

Key findings from an environmental management perspective are:

- Soil Permeability – The near surface soils vary from clays to clayey sands which will lead to some natural variability in permeability. Testing of two undisturbed samples from 1.2 m depth gave coefficient of permeability values of 1.6×10^{-10} m/s and 9.3×10^{-10} m/s, which is consistent with literature values for clays. The permeability of clayey sands is expected to be greater, though still relatively low as the clay content typically exceeds 20%;
- Dispersivity – Testing indicates that the soil at the site does not disperse when immersed in distilled water, even when remoulded and therefore standard measures to manage erosion could be employed; and
- Construction Materials – Soils that are mixtures of sand and clay are typically good construction materials as they can be readily handled and in the right proportions, can be compacted to achieve relatively low permeability and high strength fills. The clays are typically of medium plasticity which reduces the likelihood of shrinkage cracking. The clay has a low permeability when compacted (around 1.9×10^{-10} m/s) making it suitable for embankment construction and preparation of a low permeability foundation layer.

7.4.2 Overview of the TSF and PSWSF Design

The waste storage facilities will be located on the eastern side of the project site as indicated on Figure 7-1.

The TSF has been designed with a total storage capacity of approximately 96 Mm^3. This is sufficient for life-of-mine tailings storage. The TSF will have a maximum embankment height of approximately 34 m and a final footprint area of approximately 603 ha (Figure 7-2). The final external embankment slopes will be 1V:6H. The final top surface of the TSF will have a 2% cross fall to promote runoff. The TSF embankment will be rehabilitated progressively over the life of the mine.

The PSWSF has been designed to have a total storage capacity of approximately 16 Mm^3. This is sufficient to store power station waste for the first 10 years of operations. After this time the remaining power station waste will be stored within the open cut mine overburden emplacement as described in Section 8 – Rehabilitation. The PSWSF will have a maximum height of approximately 30.5 m and a final footprint area of approximately 80 ha. The external slopes of the PSWSF will be shaped to provide an overall slope of 1V:6H and the top surface of the PSWSF will have a 2% cross fall to promote runoff. The outer slopes of the PSWSF will be rehabilitated progressively, as they are constructed. Final rehabilitation of the PSWSF will be completed following Project Year 10 once it has been filled to capacity.

7.4.3 TSF and PSWSF Construction and Operation

Topsoil and Capping Material Removal

At the commencement of construction of the PSWSF and each stage of the TSF, the foundation area will be cleared and grubbed. Grubbing will be followed by the removal and stockpiling of available soil resources from the foundation areas, including materials suitable for use as topsoil and/or capping material in rehabilitation. The *Soils and Land Suitability Report* (Appendix E) provides further information on available topsoil and capping material resources. Further detail on the management of soil resources is provided in Section 8 – Rehabilitation.

Foundation Preparation

After the topsoil and capping material have been removed, the foundation area will be inspected and suitable preparation measures implemented to provide a low permeability foundation. It is anticipated that this will involve:

- Ripping the upper soil layers;
- Moisture conditioning (i.e. watering) of the clay foundation materials to achieve close to optimum moisture condition so that a low permeability layer is formed during compaction; and
- Compaction of the clay foundation using a pad-foot or sheeps-foot roller to achieve compaction of at least 95% of standard dry density.

Should the inspection show that insufficient clay soils are present to achieve design requirements an alternative design solution would be developed and this may include imported clay materials or an engineered liner solution.

Seepage Collection System

A seepage collection system will be installed along the downstream toe of the TSF embankment and along the downstream toe of the external PSWSF slope to collect and contain any water seeping from the TSF and PSWSF. The location of the seepage collection system is shown in Figure 7-2.

The seepage drain will be lined with geo-fabric material and will include slotted pipes surrounded by gravel. The seepage collection system will drain to a series of collection sumps. Seepage water from the collection sumps will be pumped to the TSF decant pond.

Further detail on water management relevant to the TSF and PSWSF is presented in Section 13 – Surface Water.

Materials Placement

The tailings deposition strategy will involve sequencing of active tailings discharge spigots in order to progressively develop a beach around the perimeter embankment towards the centre of the TSF. This method will maintain a tailings decant water pond in the central low point of the active TSF area. Tailings water will collect in the decant pond following deposition of solids from the tailings slurry on the beach areas. Rainfall runoff from within the active TSF area will also collect in the decant pond. For each TSF development stage the spigot off-take system will be set around the inner crest of the TSF embankments to ensure the tailings beach can be maintained, ensuring the efficient placement of tailings solids within the TSF and maintenance of the central decant pond. This deposition strategy will also allow for the progressive drying and consolidation of successive layers of deposited tailings which will increase the shear strength of the final tailings beach. This deposition strategy is well-established and commonly used in conventional wet tailings storage facilities in the coal mine mining industry.

The dry power station waste will be placed in the PSWSF using trucks in a similar fashion to development of an out-of-pit overburden emplacement. Each truck will be loaded at the power station and transported to the designated active fill area of the PSWSF. Initially, the material will be paddock dumped across the site at a specified lift height. Subsequent lifts will continue to be placed, with the extent of each lift designated to form the ultimate 1V:6H external slopes.

Water Management

The drainage and water management strategy for the TSF is summarised as follows:

- Prior to the construction of the TSF embankment around the full perimeter of the TSF, diversion drains will be constructed at the northern end of the TSF to isolate the active TSF catchment.
- Once the full embankment is constructed around the perimeter of the TSF it will isolate the TSF catchment.
- Runoff from the external slopes of the TSF embankment will drain to collection drains and will be directed to sediment traps for control of suspended sediment prior to draining from site. Drainage from established rehabilitation on the external TSF embankment slopes will be allowed to drain from site.
- A pontoon mounted return water pump will be moored in the TSF decant pond. The pump will operate automatically to maintain a low water level within the decant pond. The pump will transfer water from the decant pond to the Return Water Dam. The Return Water Dam will be a priority water supply for the CHPP.

The drainage and water management strategy for the PSWSF is summarised as follows:

- Diversion drains will be constructed around the perimeter of the PSWSF to isolate the active PSWSF catchment.
- The active emplacement areas will be developed so that surface runoff drains to internal collection sumps. Runoff that collects in these internal sumps will be pumped to the TSF decant pond.

- Runoff from the external slopes of the PSWSF embankment will drain to collection drains and will be directed to sediment traps for control of suspended sediment prior to draining from site. Drainage from established rehabilitation on the external PSWSF embankment slopes will be allowed to drain from site.

Further detail on the site water management is provided in Section 13 – Surface Water.

7.4.4 Staging of the TSF and PSWSF

TSF

The TSF has been designed to accommodate life-of-mine tailings. The progressive development of the TSF is shown in Figure 7-2.

The TSF embankments will be raised in stages. Table 7-1 presents the tailings volumes to be stored at the selected years of mine operation, including closure, as well as both the TSF embankment elevation and maximum embankment height required.

Table 7-1 TSF Staging

PROJECT YEAR	CUMULATIVE TAILINGS (Mm^{3})	EMBANKMENT ELEVATION (RL m)	EMBANKMENT HEIGHT (m)
5	9.4	315.9	12.4
10	30.1	322.8	19.3
15	51.7	327.7	24.2
20	68.7	331.5	28.0
30	93.5	336.8	33.3
49	96.1	337.5	34.0
Closure	96.1	337.5	34.0

PSWSF

The PSWSF has been designed with capacity to store power station waste estimated to be generated over the first 10 years of the project. The progressive development of the PSWSF is shown in Figure 7-2.

Table 7-2 presents the volumes of power station waste to be stored in the PSWSF during operations and at closure.

Table 7-2 PSWSF Staging

PROJECT YEAR	CUMULATIVE WASTE (Mm^{3})	EMBANKMENT ELEVATION (RL m)	EMBANKMENT HEIGHT (m)
5	2.7	307	9.5
10	16.4	320	30.5
Closure	16.4	320	30.5

7.4.5 Rehabilitation and Decommissioning

Overview

As described in Section 7.3, the geochemical assessment concluded that the risk of potential environmental impacts from the tailings and power station waste material to be stored in the TSF and PSWSF is expected to be low. Accordingly no special management measures or rehabilitation techniques are required for the tailings and power station waste material.

Rehabilitation of available areas of the TSF and PSWSF will be undertaken progressively throughout the mine life and will be an integral part of the development and operation of the facilities. Rehabilitation will involve shaping of the landform and provision of capping, topsoil layers and seeding, as described in the following sections.

Landform

At closure any remaining decant water will be pumped out of the TSF decant pond and the final surface of the tailings will be allowed to dry. Mine overburden or coarse rejects will be used to fill the TSF to the final design level below the capping material. The final top surface will be profiled with a 2% cross fall to promote runoff and minimise ponding of water. Mine overburden will also be placed on any external 1V:4H embankment slopes of the TSF to provide final slopes of 1V:6H.

The external slopes of the PSWSF will also be shaped to provide an overall slope of 1V:6H at closure. This will be achieved by dozing any temporary benches and inter-bench slopes. The top surface of the PSWSF will be profiled with a 2% cross fall to promote runoff.

Both facilities will have maximum final rehabilitation slopes of 1V:6H with maximum slope heights of 34 m. Based on successful rehabilitation experience at other mine sites these slopes and maximum slope heights should result in a stable landform.

Runoff Management

The TSF and PSWSF will be shaped at closure to promote runoff and runoff control structures will be installed to manage design flows. Runoff will be controlled using contour drains constructed at regular spacing on the slopes. The contour drains will be constructed with a gradient of approximately 1% and will be topsoiled and seeded with grass.

Revegetation

Tailings and power station waste material is not typically suitable as plant growth material. In order to ensure successful revegetation of the storage facilities, and a stable final landform, the rehabilitation strategy involves placing a 1 m thick layer of benign capping material (soil or suitable subsoil) over the final surface of the tailings and power station waste. A 0.3 m layer of topsoil will then be spread over the capping layer. Section 8 – Rehabilitation describes the availability of capping and topsoil material and confirms that there is sufficient material available.

The capping layer will provide a root growth zone beneath the topsoil layer and use of a capping layer is an established technique for successful revegetation of mine waste storage facilities. Once the topsoil has been spread, the completed landforms will be revegetated. A self-sustaining native ecosystem will be established on the TSF and PSWSF final landforms.

7.4.6 Design Analyses

Slope stability analyses were undertaken for the TSF and PSWSF landforms with the intent of estimating the factor of safety (FOS) of the proposed closure and temporary operational slopes under a variety of load conditions.

The analysis was undertaken using Slope/W 2012 which uses limit equilibrium methods to solve for FOS, and the Morgenstern-Price method was adopted. The Slope/W analyses indicate that both the closure and temporary operational slopes exceed the minimum FOS requirements.

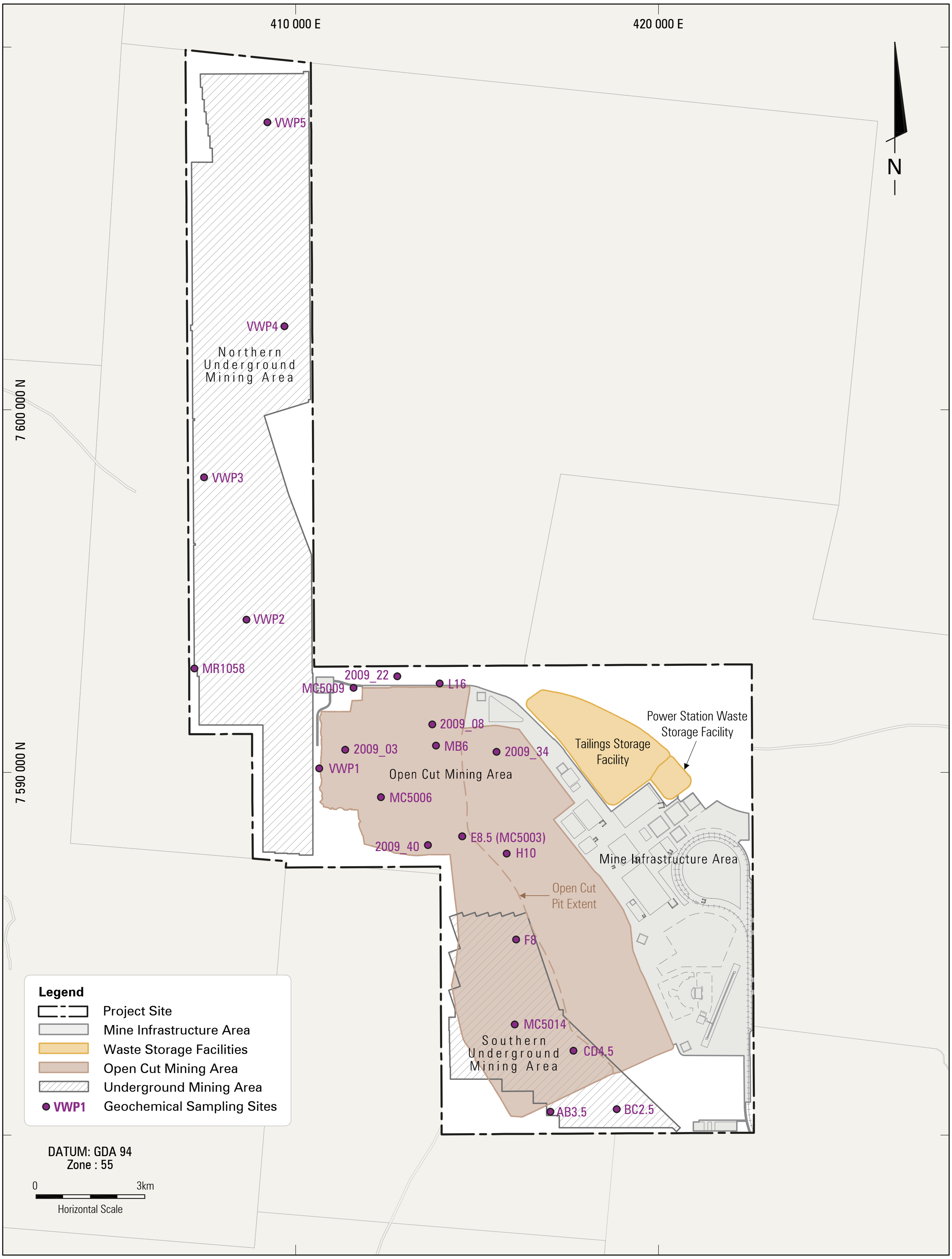
7.5 MONITORING

Monitoring programs will be implemented for the TSF and PSWSF to monitor key environmental and design performance indicators.

- Monitoring for the TSF will include:
  - Regular inspections and annual survey of the deposited tailings beach and decant pond;
  - Regular inspection of the spigot off-take system, tailings deposition and operation of the decant pumping system;
  - Regular inspection of the surface drainage around the perimeter of the TSF and the seepage collection system;
  - Annual engineering inspection of the TSF embankment and spillways;
  - Surface water monitoring including TSF decant pond water quality and return water volumes pumped to the Return Water Dam (refer to Section 13 – Surface Water for details);
  - Monitoring of pore water pressures in the TSF embankment; and
  - Monitoring of groundwater levels and water quality in the vicinity of the TSF (refer to Section 12 – Groundwater for details).
- Monitoring for the PSWSF will include:
  - Regular and annual surveys of the emplaced power station waste including assessment of storage capacity and monument survey to assess settlement of the facility with annual engineering survey reports;
  - Regular inspection of the surface drainage around the perimeter of the PSWSF and the seepage collection system;
  - Regular inspection of the internal drainage collection system and monitoring of internal surface runoff quality;
  - Monitoring of pore water pressures in the PSWSF; and
  - Monitoring of groundwater quality in the vicinity of the PSWSF (refer to Section 12 – Groundwater for details).

The results of the monitoring will be used to assess the performance of the TSF and PSWSF and to undertake regular reviews of the design and operating plans.

FIGURES



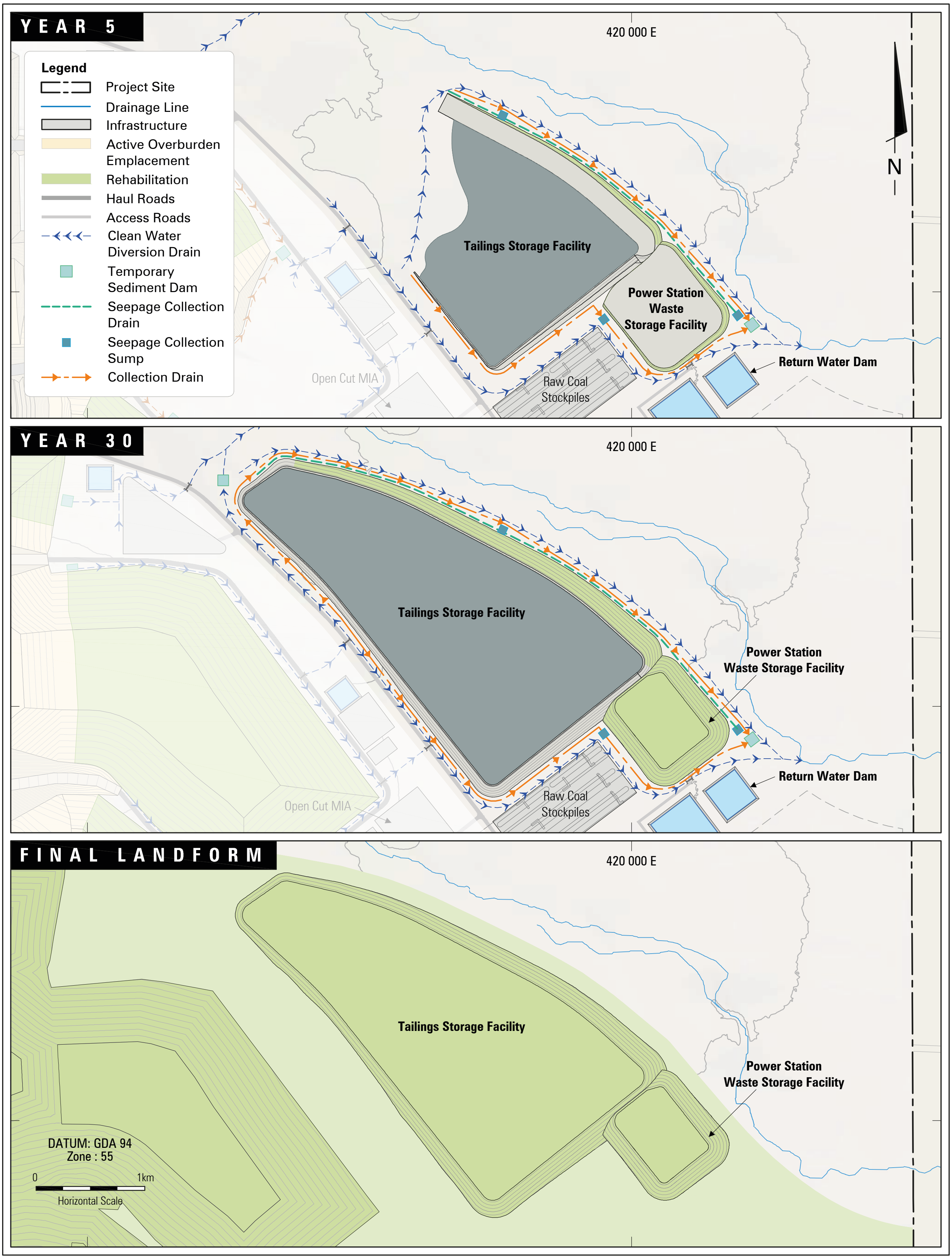
PROJECT CHINA STONE

MACMINES AUSTASIA

Hansen Bailey ENVIRONMENTAL CONSULTANTS

Geochemical Sampling Sites

FIGURE 7-1



PROJECT CHINA STONE

MACMINES AUSTASIA | Hansen Bailey ENVIRONMENTAL CONSULTANTS

TSF and PSWSF Staged Development

FIGURE 7-2