CHAPTER 13

SOIL AND LAND QUALITY

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Subject to that declaration:

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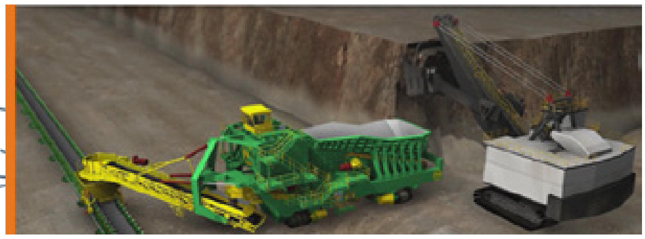

13 Soil and Land Quality

Currently, the land located within the site of the proposed mining lease (the mine site) supports ongoing agricultural activity including mixed crops. The soils in the region are generally nutrient poor; however, when managed appropriately can be improved to provide significant economic returns (Soil Quality 2014).

This chapter provides an overview of the existing environmental values relevant to soil and land quality at the mine site, including a review of soil characteristics, salinity and the potential for known or suspected areas of site contamination or acid sulfate soils (ASS). Soil disturbance during construction and operation has the potential to affect existing environmental values by reducing land quality and compromising the ability of both the mine site and adjoining areas to support current and envisaged future land uses. The scale of effects on existing environmental values is discussed and, where relevant, management and/or mitigation measures that would minimise impacts and risks are identified.

13.1 Applicable Legislation and Standards

The *Environment Protection Act 1993* (together with the *Environment Protection Regulations 2009*) is the key legislation relevant to soil and land quality at the mine site. The Regulations outline activities that have the potential to result in site contamination. The *Mining Act 1971* (Mining Act) also provides a legislative framework which seeks to ensure that mining operations manage environmental impacts and risks as far as reasonably practicable through the establishment of a Program for Environment Protection and Rehabilitation (PEPR). The PEPR sets out environmental outcomes which are expected to occur as a result of the mining operations and specific criteria to measure the environmental outcomes.

Additional legislation relevant to soil and land quality is as follows:

- *Natural Resource Management Act 2004*
- *Development Act 1993*
- *Explosives Act 1936*

Further information regarding the requirements and relevance of the legislation is provided in Chapter 4 Statutory Framework. Specifically, the following standards provide a range of criteria relevant to land quality:

- National Environment Protection (Assessment of Site Contamination) Measure 1999
- Site contamination – acid sulfate soil materials (EPA 2007a)
- Bunding and spill management guideline (EPA 2007b)
- AS 1940-2004: The storage and handling of flammable and combustible liquids
- AS 1692-2006: Steel tanks for flammable and combustible liquids
- AS 2187.2-2006: Explosives: Storage and use – Use of explosives

The National Environment Protection Council's (1999) *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM) is established to provide a nationally consistent approach to identifying and managing site contamination. The NEPM refers to three different types of investigation levels: Ecologically-based Investigation Levels (EILs), Health-based Investigation Levels (HILs) and Groundwater Investigation Levels (GILs) which provide criteria (concentrations of contaminants) to guide the assessment of risks to human health and the environment. This approach ensures sound environmental management practices are adopted by all stakeholders when managing site contamination.

The EPA guidelines relating to bunding and spill management provide a framework for the storage and handling of chemicals and hazardous materials. Similarly, the ASS materials guidelines outline measures for the identification of ASS materials and practices for the management of such materials should they be encountered. The measures outlined in each of the guidelines will be incorporated into the design and control measures utilised during construction, operation or closure of the mine site.

The nominated Australian standards each specify specific design criteria that will be incorporated into the design of the mine site to protect the key environmental and stakeholder values relevant to land quality.

13.2 Assessment Method

A desktop environmental site history review and ASS desktop review (Jacobs 2014a) was undertaken to determine the potential risk of site contamination or ASS at the mine site. The site history review identified whether there was the potential for significant site contamination to be present at the mine site based on current and historical land uses.

The ASS desktop assessment was undertaken with reference to available information sourced from Soil of South Australia's Agricultural Lands (DWLBC, 2002). Soil characteristics were identified through preliminary topsoil management planning for the CEIP (Jacobs 2014b). Soil characteristics identified in desktop investigations were confirmed during on-site geotechnical investigations and soil sampling.

A review of geochemical data and supporting information for all mine waste materials and the magnetite concentrate was undertaken (MWH 2015a and MWH 2015b) in consideration of the requirements for mine waste geochemical characterisation, as recommended by the Global Acid Rock Drainage Guide (INAP 2009). Soil properties were delineated through analysis of the 9,135 available oxide drillholes and 82 available magnetite concentrate data taken from the mine site.

A preliminary assessment of landform design and closure concepts of the integrated waste landform (IWL) was undertaken which verified soil characteristics for the local and regional soils. This is provided in Appendix S.

13.3 Existing Environment

This section provides an overview of the existing environment within the mine site in relation to soils and land quality. Soil characteristics are identified, as well as any areas of known site contamination or ASS.

13.3.1 Topsoil and Subsoil

The majority of the mine site is characterised by undulating sand plains, comprising older, eroded and partly consolidated carbonate sands of the Bridgewater Formation in the western half of the project area, with younger overlying quartz sands in the north and east. The Australian Soil Resource Information System (ASRIS) distinguishes the three broad soil types occurring within the study area being Calcarosols, Sodosols and Chromosols (McKenzie *et al.* 2005). The most common soils in the region and the only soil type occurring on the mine site are Calcarosols (soils containing calcium carbonate). These soils are widespread in the pastoral districts of South Australia and the drier margins of the agricultural districts.

The mine site currently supports a range of vegetation; predominately in the form of crops such as barley or wheat and also small areas of native vegetation (discussed in Chapter 12). The mine site is part of the Western Eyre Peninsula Agricultural District; responsible for a total crop production of 932,850 t in the 2013/14 season. Overall, the Eyre Peninsula region contributed approximately one third of the total State crop production (8,546,480 t) in the 2013/14 season (PIRSA 2014). Significant crop production occurs despite soils within the Eyre Peninsula being generally nutrient poor. Soil characteristics in the region of the mine site are depicted in Figure 13-1.

Physical and Chemical Characteristics

Calcarosols are characterised by their calcium carbonate content, which ranges from 0-10% in surface soils and up to 60% in the subsoils. Two types of Calcarosols are predominant in the area of the mine site: calcareous earths and shallow sands over calcrete. Calcareous earths are easy to cultivate and their productivity for cereals in the agricultural regions of the Eyre Peninsula has been greatly enhanced through the application of fertilisers. Typical characteristics of the calcareous earth in the Eyre Peninsula include:

- Surface soils neutral to alkaline
- Surface soils prone to water repellence and erosion
- Shallow depth and effective rooting depth
- Low water retention
- Subsoils high in salinity, alkalinity and boron toxicity
- Nutrients unavailable to plants
- Low to moderate fertility

Shallow sands over calcrete are common on the dunes, plains and low hills of aeolianite (wind-blown deposits) and dune limestone. They typically reach 60 cm in depth and are permeable. Typical characteristics of shallow sand over calcrete in the Eyre Peninsula include:

- Slightly acid to slightly alkaline
- Surface soils prone to water repellence and erosion
- Shallow depth and effective rooting depth
- Low water retention
- Boron in the subsoil
- Nutrients unavailable to plants
- Low inherent fertility
- Subsoils high in salinity

Sodosols and Chromosols in the study area typically include the following characteristics:

- May be acidic
- Prone to water repellence and erosion
- Low organic carbon
- Low inherent fertility
- Compact, slowly permeable soils
- Subsoil sodicity (Sodosols)

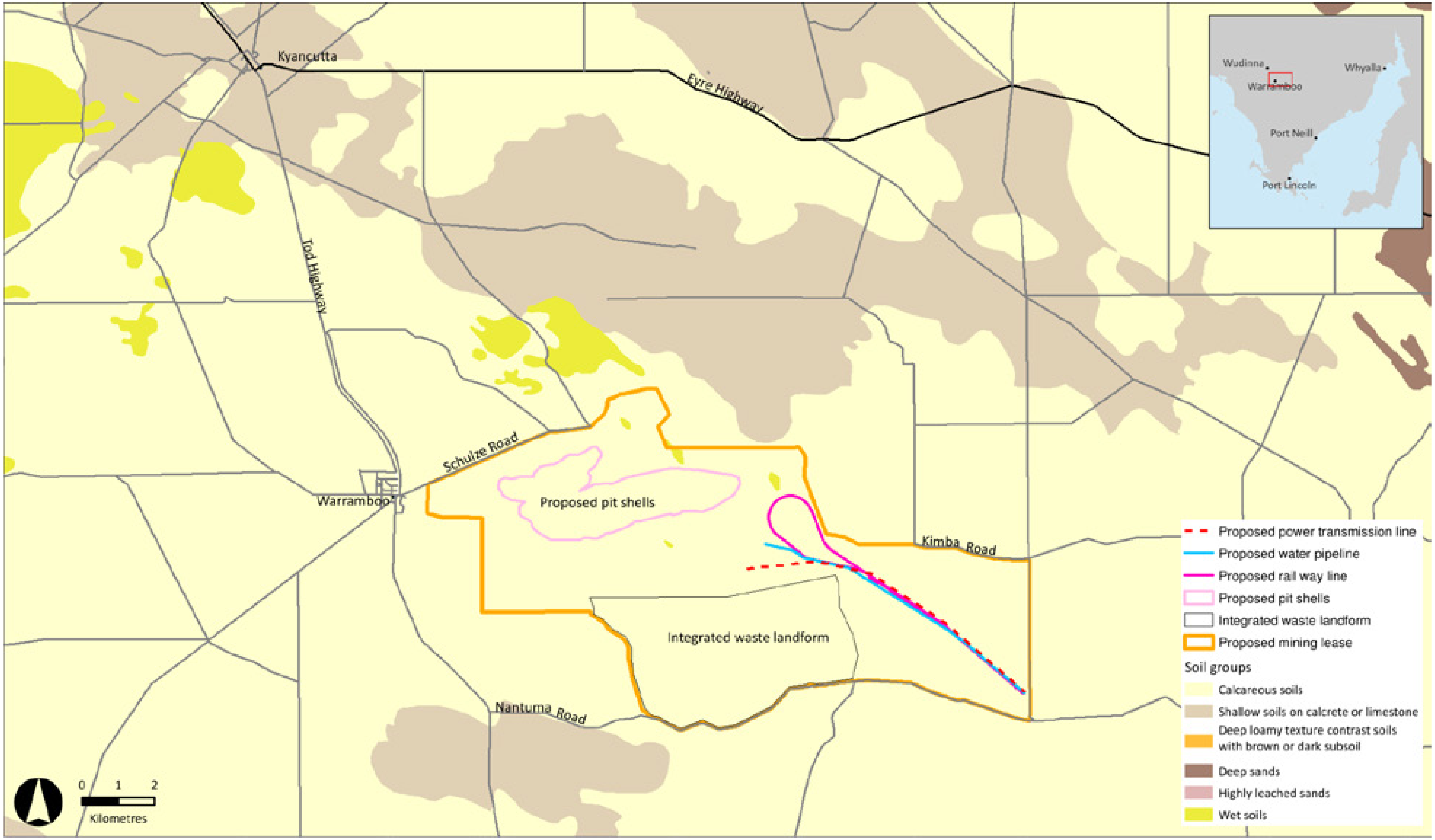

Figure 13-1 Soil Characteristics (from Jacobs 2014b and on-site investigations)

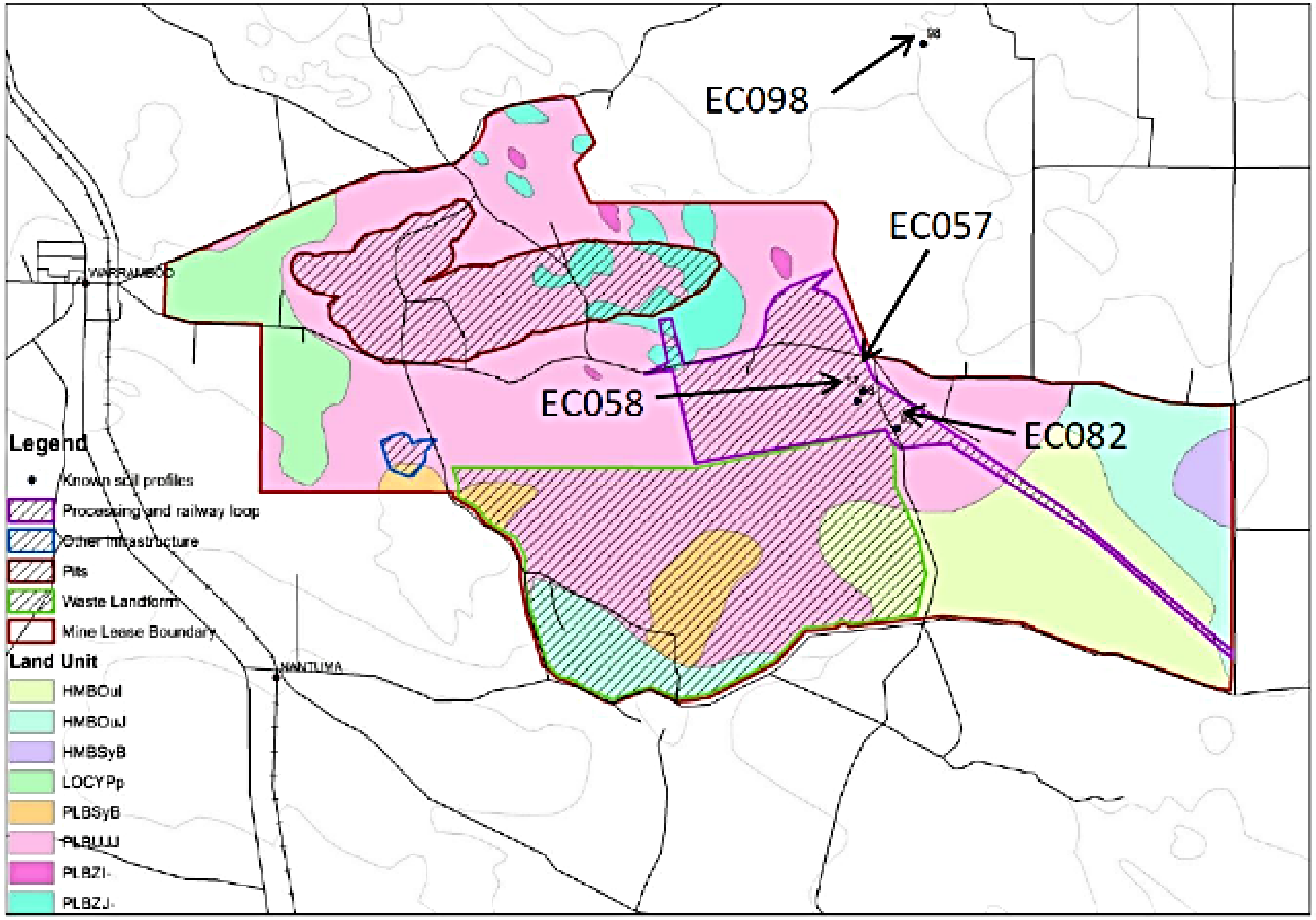

Figure 13-2 ASRIS Soil Landscape Map Units Occurring Within the Study Area (McKenzie *et al*. 2005)

Soil Profiles

The soil landscape map units in Figure 13-2 from ASRIS are consistent with analyses of soils present within samples obtained from geotechnical investigations across the study area. Soil material information from existing boreholes and test pits within the mine pit and IWL footprint areas was compiled by Jacobs (2014c). Table 13-1 presents the soil descriptions derived from this information. DWLBC (2002) also provides a description of landscape units and soil characteristics. From this information, the dominant soil profiles within these areas are:

- Highly calcareous sandy loam
- Deep (rubbly) calcareous loam
- Rubbly calcareous loam on clay
- Siliceous sand

Further details regarding soil horizon depths and chemical and physical characteristics for these soil profile types are detailed in the DWLBC soil database (2002).

Table 13-1 Ground model soil descriptions derived from borehole and geotechnical test pit information (Jacobs 2014c)

Footprint area	Depth (mbgl)	Soil material
Mine pits (Boo-Loo and Murphy)	0 – 0.3	Topsoil – Silty SAND, Sandy SILT
	0.3 – 3.5	Silty/Clayey SAND, SAND, Sandy SILT, some calcrete layers
	3.5 – rock[1]	Sandy/Silty CLAY, CLAY, some SAND
IWL	0 – 0.27	Topsoil – Silty/Clayey SAND, Sandy/gravelly SILT
	0.27 – 0.6	Silty/Clayey SAND, SAND, Sandy CLAY
	0.6 – 2.0[2]	Calcrete

1 Depth to rock varies from 27 to 47 m below ground level (bgl).

2 Depth to base of calcrete varies from 1.0 to 3.2 m bgl.

Water Holding Capacity

The water holding capacity (WHC) is classified as the water content of the soil after which drainage of water from the soil profile materially ceases. The WHC of the soils within the mine pit and waste landform footprints was estimated using expected soil profile characteristics and considered water holding characteristics from DWLBC (2002). The WHC for expected soil horizons and profiles are provided in Table 13-2.

Table 13-2 Horizon Water Holding Capacities for Each Soil Profile as Described by DWLBC (2002) and Proportion (%) Expected Across the Waste Landform and Pit Areas

Soil Profile	%	Water Holding Capacity (% vol.)		
		A horizon	B1 horizon	B2/B3 horizon
Highly calcareous sandy loam	21	30.0	26.6	17.3
Deep (rubbly) calcareous loam	30	28.6	26.3	24.3
Rubbly calcareous loam on clay	8	26.6	21.0	32.9
Siliceous sand	22	18.0	16.0	16.6
Other	19	21.5	18.2	22.8

13.3.2 Acid Sulfate Soils and Potential Acid-forming Material

An elemental analysis of core samples taken from within the area of the mine site was undertaken and is presented in Table 13-3. The samples were analysed at the top of the core (top layer of earth to a depth of 60 m) and at the bottom of the core where the iron deposits are found (from 60 m to a depth of 400 m).

The radioactivity of core samples was also tested. The background readings for the area are 0.2 uSv/hr. The analysis of the cores showed no samples greater than this figure, with the average being below background at 0.18 uSv/hr. Asbestos and other fibres were tested for and found not to be present.

Table 13-3 Elemental Analysis

Analyte	Weathered Surface Soils (surface – 60 m depth) Percentage of Core Sample	Weathered Surface Soils (60 m – 400 m depth) Percentage of Core Sample
Aluminium Oxide (Al_2O_3)	16.145	12.657
Arsenic (As)	0.003	0.006
Barium (Ba)	0.036	0.106
Calcium Oxide (CaO)	0.709	1.376
Chlorine (Cl)	1.086	0.056
Cobalt (Co)	0.007	0.007
Chromium (Cr)	0.009	0.016
Chromium Oxide (Cr_2O_3)	0.013	0.023
Copper (Cu)	0.006	0.008
Iron (Fe)	8.400	16.000
Potassium Oxide (K_2O)	1.287	3.020
Magnesium Oxide (MgO)	0.680	2.277
Manganese (Mn)	0.156	0.838
Manganese Oxide (MnO)	0.202	1.082
Sodium Oxide (Na_2O)	0.833	1.385
Nickel (Ni)	0.005	0.009
Phosphorus (P)	0.036	0.082
Lead (Pb)	0.005	0.006
Sulphur (S)	0.286	0.033
Silicon Oxide (SiO_2)	59.310	55.048
Tin (Sn)	0.005	0.014
Strontium (Sr)	0.008	0.021
Titanium Oxide (TiO_2)	0.663	0.535
Vanadium (V)	0.012	0.008
Zinc (Zn)	0.012	0.015
Zirconium (Zr)	0.007	0.007

Note: The sum of all listed analytes does not add up to 100% as there are a number of elements / compounds not included (e.g. oxygen, carbon, nitrogen, water)

Acid Sulfate Soils

ASS are naturally occurring and form in waterlogged areas with the presence of iron, sulphide and organic material. If exposed to air as a result of excavation or drainage, ASS can react with oxygen to form sulfuric acid. Sulfuric acid can be toxic to flora and fauna, contaminate water supplies, or damage man-made structures (EPA 2014).

Figure 13-3 depicts the ASS potential of topsoil across the mine site and surrounding areas from desktop review of potential ASS (DWLBC 2002) and took into account any available information with regard to:

- Groundwater conditions
- Site setting (i.e. topography, land clearance, low lying areas, floodplains, site area)
- Watercourses and surface water features, where present

Only a small portion of the site is considered to have an elevated risk of ASS potential, largely restricted to low-lying areas with groundwater close to the surface. These areas are highlighted on Figure 13-3 as having 30 – 60% potential of the presence of ASS, as inferred from DWLBC data (2002).

Potentially Acid-forming Material

The pit will mine through a mix of deeply weathered and oxidized upper surface waste materials, including sands, calcrete and clay/saprolite approximately 40 to 70 m deep, below which the highly competent unweathered gneiss ore zone commences. A review of the available oxide drill hole database was undertaken by MWH (Appendix S) to determine the extent of the elevated sulphur concentrations, mine waste materials from the mine pit and any potential for acid mine draining issues. This included the selection of 24 core samples to test for acid mine drainage and neutralising capacity, as well as review of magnetite concentrate data undertaken on the fresh rock material (82 records). Samples were selected from different geological units, in order to confirm the presence or absence of potentially acid-forming (PAF)/ non-acid forming (NAF) / acid neutralisation capacity (ANC) for all the different units (MWH 2015a). Analysis of these samples provides information for preliminary AMD assessment and neutralising capacity.

In analysing the data within the drill holes, the following trends were observed:

- Elevated sulphur values are offset by neutralising CaO (interpreted as calcrete) within 15 m of the pre-mining surface in nearly all cases and could be classified as NAF.
- At least 90% of the oxide overburden to be stripped will be inert.
- Of the PAF oxide material, the majority of this (90%) has total sulphur less than 0.5%.
- PAF material with total sulphur exceeding 1% comprises approximately 0.5% of the entire overburden material. This material is considered to be a low net acid production potential.
- Oxide material with potential buffering capacity (mostly calcrete with CaO greater than 10%) is present within the overburden at higher volumes than PAF material greater than 1% S.
- Potential buffering material is likely to be excavated and placed in the IWL either prior to, or co-disposed with the PAF material.

Bulk samples of the combined coarse and fine pilot tailings were also subject to laboratory testing (MWH 2015a) to determine the geochemical characteristics of the materials to be deposited to the integrated waste landform. The three pilot tailings samples were analysed to determine net acid production potential (Table 13-4) and can be summarised as follows:

- Classified as non-acid forming, based on acid-base accounting results
- Low total sulphur (average of 0.03%)
- Negative Net Acid Production Potential
- Alkaline Net Acid Generation pH
- High Acid Neutralisation Capacity
- Negligible or low metal and elemental concentrations, with the exception of manganese

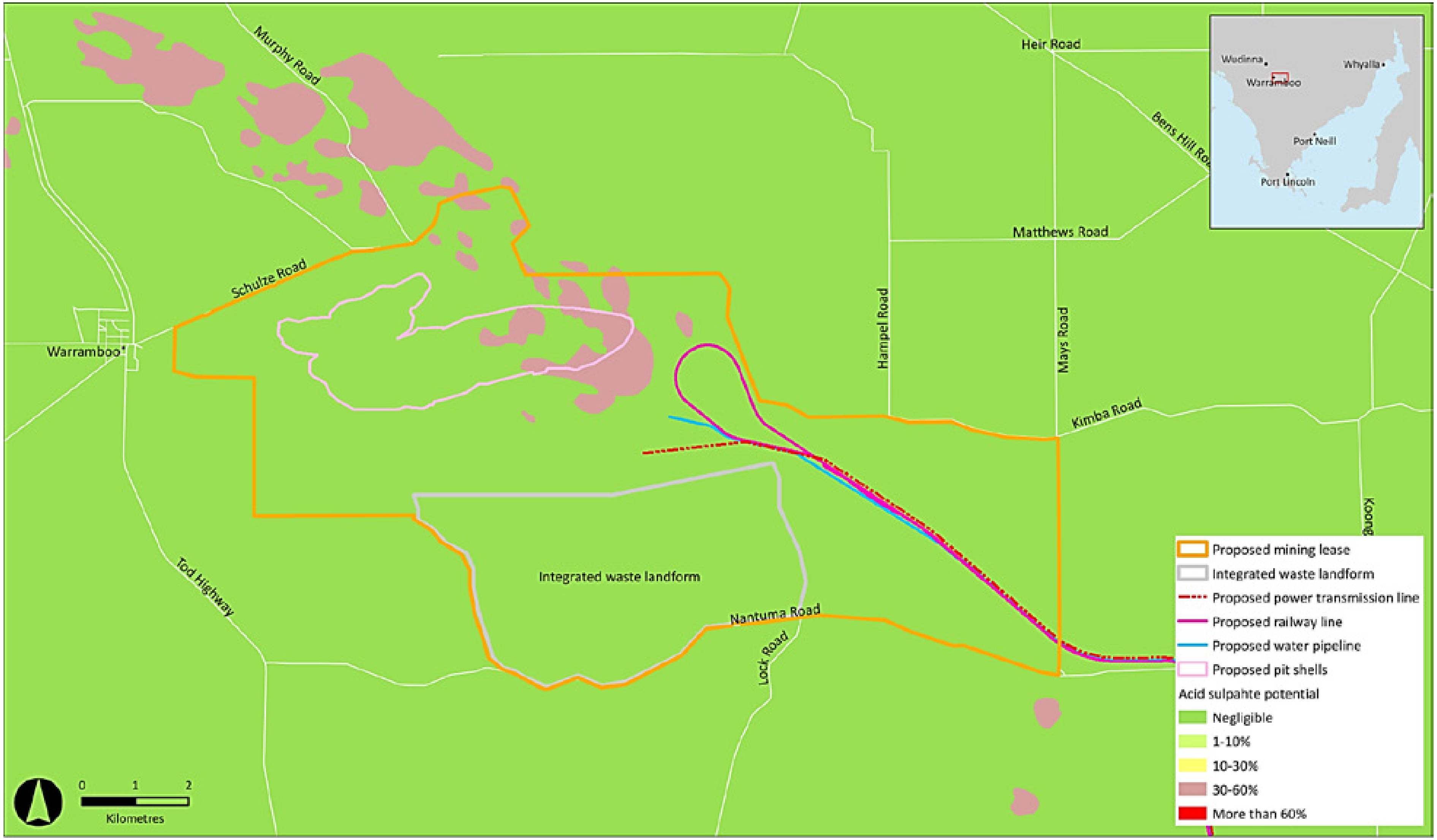

Figure 13-3 Acid Sulfate Soils

Table 13-4 Geochemical Assessment of Tailings

Sample ID	Total S (%)	MPA^2	NAG [3] pH 4.5 (kg H_2SO_4/t)	pH 7.0 (kg H_2SO_4/t)	NAG pH(ox)	ANC [4] % $CaCO_3$	ANC [4] kg H_2SO_4/t	ANC / MPA ratio	NAPP [5] (kg H_2SO_4/t)	Acid-forming potential [6]
Sub-sample 1	0.03	0.92	<0.1	<0.1	8.0	1.6	15.4	16.8	-14.5	NAF
Sub-sample 2	0.03	0.92	<0.1	<0.1	7.9	1.6	16.0	17.4	-15.1	NAF
Sub-sample 3	0.03	0.92	<0.1	<0.1	8.1	1.6	15.4	16.8	-14.5	NAF
Average	**0.03**	**0.92**	**-**	**-**	**8.0**	**1.6**	**15.6**	**17.0**	**-14.7**	**-**
LOR [1]	**0.01**	**0.92**	**0.1**	**0.1**	**0.1**	**0.1**	**0.5**	**16.8**	**0.5**	**-**

[1] LOR: Limit of Reporting
[2] MPA: Maximum Potential Acidity
[3] NAG pH(ox): Net Acid Generation pH after oxidation
[4] ANC: Acid Neutralisation Capacity
[5] NAPP: Net Acid Production Potential
[6] Determined as either NAF (Non-acid forming) or PAF (Potentially acid forming)

13.3.3 Site Contamination

The mine site is currently occupied by six separate farming residences, three of which are occupied and three abandoned and or derelict. These farming residences include a small number of storage sheds and associated agricultural infrastructure. A review of historical site ownership indicated that the owners' occupations were generally listed as farmers and/or graziers.

EPA records indicate that no agreements, orders, licences or other authorisations exist relating to the site. The EPA further advised that it does not possess any records or reports in respect to any previous environmental and/or contamination assessment of the land. No licences for the storage of dangerous goods exist for the area of the mine site within the SafeWork SA database.

Based on a review of available historical information, significant site contamination is considered unlikely. Potential site contamination issues are summarised in Table 13-5 (Sinclair Knight Merz 2013).

Table 13-5 Potential Site Contamination Issues

Issue / Source	Potential Contaminants	Likelihood of Significant Contamination
Historical farming practices	Organochlorine pesticides and organophosphorous pesticides	Considered to be low; however there may be isolated hot spots near sheds
Potential historical weeding practices	Broadleaf herbicides and weedicides	Considered to be low
Potential termiticide treatment beneath buildings present across the site	Organochlorine pesticides and arsenic	Considered to be low

Issue / Source	Potential Contaminants	Likelihood of Significant Contamination
Potential fill materials on site beneath buildings / structures and roadways (and other areas of site)	Broad range of contaminants including heavy metals	Considered to be low
Onsite sewerage treatment systems at farming residences (e.g. septic tank, soakage trench)	Microbiological contaminants (e.g. Escherichia coli)	Considered to be low; however there may be isolated hot spots near residences
Potential fuel storage on farming residences	Total petroleum hydrocarbons, benzene, toluene, ethylbenzene and xylenes and polycyclic aromatic hydrocarbons	Considered to be low; however there may be isolated hot spots near sheds
Individual rural landfills	Broad range of contaminants including heavy metals, phenols, methane	Considered to be low, but may be isolated hot spots
Potential asbestos-containing materials in older buildings and structures	Asbestos	Considered to be low. Potentially limited to buildings and associated infrastructure

Based on the current and historical use and development of the mine site (and its immediate surrounds) the potential for significant site contamination to be present is considered to be low.

13.3.4 Dispersive Materials

Dispersive soils are soil materials susceptible to tunnel erosion and piping. This occurs through the separation of individual soil particles with the application of excess water (DMP/EPA 2015). Soils which are susceptible to dispersion contain high levels of exchangeable sodium, whilst non-dispersive soils can become dispersive over time with the application of saline water.

Preliminary laboratory test work performed on the combined tailings found the physical characteristics to be non-dispersive and structurally stable. Geotechnical investigations of the oxide profile found the oxide waste material to have variable dispersion potential, from non-dispersive to highly dispersive (Appendix S). Further information regarding the geochemical characteristics and analysis of soil data is provided in Appendix S.

13.3.5 Summary of Key Environment Values

The mine site and surrounding area is currently used for agricultural purposes; predominately grain cropping and some grazing. Soils within the region are generally nutrient poor; however, they have been improved through the application of fertilisers and appropriate management to support agriculture. There are areas of low-lying saltpans within the central and northern sections of the mine site, which are not suitable for agriculture.

Two types of soil are prevalent across the mine site: calcareous earths and shallow sands over calcrete. Characteristics of these soil types are largely consistent: prone to water repellence and erosion, shallow effective rooting depth, high levels of salinity, low inherent fertility and low levels of water retention.

Geochemical analysis of more than 9,000 drillholes determined that approximately 2% of all mine waste is considered to be potentially acid forming (refer to Appendix S for detailed analysis). In nearly all cases of samples taken from the surface to 15 m in depth, elevated sulphur values are offset by neutralising calcium oxide (calcrete). Areas of PAF material correlate with the Neogene geological unit and the upper groundwater surface interface at depths between 15 to 35 m and with the Palaeogene and Saprolite geological units at depths between 45 to 75m (MWH 2015a).

The likelihood of existing significant site contamination is considered to be low given current and historical uses of the mine site.

Only a small portion of the site is considered to have an elevated risk of ASS potential, largely restricted to low-lying areas with groundwater close to the surface. The overall likelihood of significant ASS being present within topsoils of the mine site is largely considered to be low, with the exception of small areas of PAF material as outlined in Section 13.3.2.

13.4 Context and Views of Affected Parties

Stakeholders relevant to soils and land quality include the local landholders, Wudinna District Council, agricultural industry, Eyre Peninsula Natural Resources Management Board, DSD and the EPA. The key environmental value identified by local stakeholders is the importance of the mine site and surrounding area as a productive agricultural landscape. The long-term retention of agricultural land is considered paramount to the local community. Minimising the initial disturbance footprint and maximising the proportion of the mine site able to be successfully returned to a productive use following mine closure was highlighted. DSD and the EPA have expressed a need to correctly demonstrate the level of risk present as a result of potentially acid-forming materials within the pit shell.

Given the long-term sustainability of the agricultural industry was the main priority for local landowners and the community, stakeholders are seeking the following outcomes in relation to soils and land quality:

- No reduction in productivity from saline water (used for dust suppression and as run-off from the integrated landform) introducing salt to agricultural land (IM_13_02 and IM_13_03).
- No spillage or accidental release of chemicals or hydrocarbons reducing land productivity and quality and resulting in potential human health risks (IM_13_12).
- No loss of soil quality as a result of soil disturbance, material movements, compaction or erosion (IM_13_08, IM_13_09, IM_13_11 and IM_13_13).
- No contamination of soils limiting future agricultural use of the land (IM_13_07).

All issue raised by stakeholders across the entire project are presented in Chapter 5 Stakeholder Consultation and summarised in Table 5-8. Impacts and risks relevant to each of the existing environmental values associated with soil and land quality and potential issues identified by stakeholders are discussed below and summarised in Table 13-7. All impact events across the entire project are presented in the Impact and Risk Register in Appendix C.

13.5 Potentially Impacting Events

Considering the views and contexts of affected parties and the issues raised during technical studies, an assessment of Source, Pathway, Receptor (SPR) has been undertaken, as per the methodology outlined in Chapter 6 Assessment Methodology, to determine which potential impact events are considered applicable to this project. Potential impact events associated with the construction, operation and closure of the mine site that have a confirmed SPR linkage which effects soil and land quality include:

- Migration of salts into cover profile of IWL leads to deterioration of soil quality (IM_13_01).
- Elevated soil salinity on and off proposed mining lease due to use of saline water for dust suppression (IM_13_02 and IM_13_03).
- Deposition of sediments from erosion of slopes of IWL during operations affects productive land on and off proposed mining lease (IM_13_04 and IM_13_05).
- Deposition of sediments from erosion of slopes of IWL post closure affects productive land (IM_13_06).

- Soils on site impacted due to contamination within existing materials (including PAF and ASS) (IM_13_07).
- Reduced soil quality, capacity as a result of material handling (e.g. stockpiling) compromises rehabilitation (closure and post closure) (IM_13_08 and IM_13_09)
- Compacted soil reducing productivity and/or vegetation growth (IM_13_11).
- Contamination of land from spills, leaks and uncontrolled releases (IM_13_12).
- Loss of topsoil as a result of erosion (IM_13_13).

For soil and land quality, a number of potential impact events (listed below) are not considered further as there is no confirmed linkage between source, pathway and receptor, as demonstrated in Appendix C. These include:

- Acidification of soils off the mine site as a result of disturbance to PAF and ASS. Small areas of the site may contain ASS and 2% of mine waste is considered to be PAF. As noted above, in nearly all cases of drillhole samples taken from the surface to 15 m in depth, elevated sulphur values are offset by neutralising calcium oxide (calcrete). Pathways for offsite impacts include surface and groundwater and wind erosion. Given the volume of material, limited surface water flows on site and the large volume of neutralising material, it is not reasonably expected that harm to offsite receptors will occur (PIM_13_08).
- Land quality reduced on site as a consequence of microclimatic changes adjacent to the IWL (wind, shade) (PIM_13_11).
- Disturbance of existing contaminated land by mining operations results in adverse health or amenity impacts on local residents as no significant site contaminated has been identified and if encountered will be managed appropriately to ensure that there is no pathway for adverse health impacts (PIM_13_15).

13.6 Control Measures to Protect Environmental Values

This section identifies design measures and management or control strategies which will be implemented to mitigate the level of impact and risk associated with soil and land quality, such that it is considered as low as reasonably practicable (ALARP).

13.6.1 Design Measures

The following design control measures have been incorporated to minimise impacts and risks to soil and land quality as a result of activities involved with the construction, operation and closure of the proposed mine:

- Waste materials footprint minimised through an integrated waste landform.
- Hydrocarbon and chemical storage facilities designed in accordance with Australian Standards, relevant legislation and best practice guidelines.
- Fuel and lubricant storage and dispensing facilities designed and installed in accordance with:
    - AS 1940-2004: The storage and handling of flammable and combustible liquids
    - AS 1692-2006: Steel tanks for flammable and combustible liquids
    - Bunding and spill management guideline (EPA 2007b)
    - Relevant South Australian legislation
    - Best practice guidelines
- Design and construction of the explosive magazines in accordance with the Explosives Act 1936 and Australian Standard AS 2187.2-2006.
- Establishment of designated haul routes and light vehicle roads to restrict soil compaction to designated areas.

- The geological matrices of the integrated waste landform designed to retain water rather than shed water, resulting in reduced surface water runoff.
- Surface water design measures outlined in Chapter 18, including the establishment of defined drainage channels and earthen bunds to control runoff from the integrated waste landform.
- Establishment of bunded vehicle washdown areas with controlled surface water runoff.

13.6.2 Management Strategies and Commitments

In order to minimise and mitigate impacts to soil and land quality during construction, operation and closure activities, control and management strategies would be incorporated into the PEPR and implemented for relevant project phases. Key control and management strategies are outlined in Table 13-6.

Table 13-6 Control and Management Strategies: Soil and Land Quality

Control and Management Strategies	Project Phase [1]
SOIL STOCKPILING, EROSION AND COMPACTION	

Develop and implement a soil management programme to manage soil compaction and loss of soil quality, including:
· Vehicle movements limited to predetermined haul routes and light vehicle roads to minimise vehicle compaction of soil.
· Soils deep ripped beneath compacted areas during site rehabilitation to facilitate nutrient cycling and biological processes to support agriculture or revegetation.
· Procedures developed and implemented to minimise off-road driving and access to non-designated areas.
· Topsoil stripped prior to disturbance along with any vegetative material and stockpiled outside the area of disturbance in a series of mounds at a height of no greater than 2 m to minimise compaction and ensure the soil does not have to be repeatedly moved throughout the life of the project.
· Topsoil and subsoil placed in separate stockpiles with separate stockpiling of sodic, clayey subsoil.
· Subsoil only stripped to a specified depth to ensure that any potentially sodic, saline or clay-rich subsoil that may be considered unsuitable for use as a surface rehabilitation material is not collected as part of the subsoil resources.
· Where practicable, topsoil collected from vegetated areas at a time when the seedbank is likely to be the highest and this soil stored separately to the soil from cropping areas.
· Stockpiles located away from surface water flows and trafficked areas.
· Vegetation cover over stockpiles maintained (where soil cannot be immediately reused) and weed control implemented.
· Procedures developed for management of dispersive soils to ensure they are not exposed to rain and stockpile areas containing dispersive soils are monitored closely.
· A topsoil inventory developed and maintained detailing:
    · Original location of the topsoil
    · Likely seedbank properties within stockpiles
    · The volume of topsoil stockpiled
    · Stockpile location
· Topsoil progressively distributed on rehabilitated surfaces where practical. Opportunities for immediate reuse identified in the final mining plan.
· Saline water for dust suppression purposes not allowed during the stripping of topsoil to maintain the quality of stockpiled material.
	Construction
	Operation
	Closure

Vegetation clearance restricted to the project footprint and progressive rehabilitation undertaken where practicable to minimise erosion.	Construction Operation

Control and Management Strategies	Project Phase [1]
Erosion controls implemented and surface water runoff controlled in accordance with management measures outlines in Chapter 18 Surface Water to reduce loss of topsoil.	Construction Operation Closure
APPLICATION OF SALINE WATER	
Water used for dust suppression and runoff from areas subject to saline water application controlled and directed to sedimentation ponds. Salt collected in the ponds periodically removed. Inspections of ponds undertaken following rainfall events to assess potential adverse impacts to performance.	Construction Operation
Adverse impact as a result of elevated soil salinity monitored and soil salinity monitored (for electrical conductivity) at sites located within and adjoining the mine site.	Construction Operation
Erosion controls implemented and surface water runoff controlled in accordance with management measures outlined in Chapter 18 Surface Water to reduce transport of saline materials.	Construction Operation Closure
Areas subject to elevated soil salinity as a result of mining activities rehabilitated in accordance with the mine closure plan and include: · Stripping and disposal of contaminated soils · Application and stabilisation of stockpiled soils to areas of rehabilitation · Revegetation with suitable native species	Operation Closure
STORAGE AND HANDLING OF HYDROCARBONS AND CHEMICALS	
For appropriate storage and handling of hydrocarbons and chemicals, the following measures will be implemented: · Chemical and fuel storage, handling and emergency response procedures developed and implemented in accordance with AS 1940-2004. · A regular inspection programme developed and implemented to audit and monitor fuel and chemical storage areas to ensure integrity, housekeeping and correct use. · Appropriate spill kit/clean up material maintained as required by the developed procedures.	Construction Operation
ACID SULFATE SOILS AND POTENTIALLY ACID-FORMING MATERIAL	
As ASS has been identified as potentially occurring within the mine site, an ASS management plan will be prepared. The ASS management plan will be developed on the principles of avoidance, minimisation of disturbance and treatment using a risk-based approach: · **Avoidance** – avoiding potential areas of ASS maximised when finalising the construction methodology and location of temporary construction areas at the mine site. · **Minimisation of disturbance** – when disturbance of potential ASS cannot be avoided, alterations to the design and construction methodology investigated to limit the extent of disturbance of potential ASS material. · **Treatment** – where required, based on a risk assessment, application of alkaline materials (e.g. lime dosing) undertaken to mitigate impacts should the presence of ASS material be confirmed in construction areas. Soils identified to require treatment will be immediately neutralised and managed at the excavation site, or segregated and isolated from uncontaminated soil and treated at a separate facility.	Construction Operation
Further characterisation of PAF material. Separation of PAF material from the outer zones of the IWL and containment in neutralising material (with more detailed measures to be identified in the PEPR and an IWL plan).	Construction Operation Closure
SALINE AND DISPERSIVE WASTE MATERIAL	
Further characterisation of potentially dispersive material. Separation of saline and dispersive material from the outer zones of the IWL (with more detailed measures to be identified in the PEPR and an IWL plan).	Construction Operation Closure

13.7 Impact and Risk Assessment

This section identifies and assesses impact and risk associated with soil and land quality values as a result of the construction, operation and closure of the proposed mine. Impact events (confirmed by presence of a source, pathway and receptor) are those which are predicted to occur as a result of the development, whilst risk events would not be expected as part of the normal operation of the project, but could occur as a result of uncertainty in the impact assessment process. Although the risks may or may not eventuate, the purpose of the risk assessment process is to identify management and mitigation measures required to reduce the identified risks to a level that is ALARP. This assessment has been undertaken in accordance with the methodology outlined in Chapter 6 Assessment Methodology.

Impact and risk events were identified through technical studies and stakeholder consultation. Impact events can include multiple sources, pathways or receptors which have been grouped together where practical to minimise duplication of information. Risks are events that would not be expected as part of the normal operation of the project, but could occur as a result of either uncertainties with the impact assessment, or as a result of faults, failures and unplanned events. A summary of impact and risk events relating to soil and land quality is presented in Table 13-7 (with Impact IDs). A complete register of impact and risk events by source, pathway and receptor is provided in Appendix C. Acts and risks are assessed following the application of the design measures outlined in Section 13.5. Where required, management measures are proposed to reduce the impact to a level that is considered ALARP. Through the adoption of design modification or specific mitigation measures, all identified impacts and risks were categorised as low (or negligible) and considered ALARP. The key environmental risks would be monitored through the environmental management framework.

13.7.1 Elevated Soil Salinity

The use of saline water for dust suppression will affect soil quality on land within the mine site. Saline water will only be used for dust suppression purposes on designated haul routes and areas already clear of vegetation; however uncontrolled discharge of saline materials may potentially elevate soil salinity levels, reducing soil quality and therefore restricting vegetation growth and agricultural productivity.

Water used for dust suppression and runoff from areas subject to saline water application will be controlled and directed to sedimentation ponds, drainage channels and bunded areas. Salt collected in ponds will be periodically removed to maintain performance (refer to Chapter 18, Surface Water, for further details of surface water management measures). Regular inspection of water distribution infrastructure will be undertaken to facilitate early detection and rectification of potential spills or leaks.

Saline material within the IWL is expected to be retained within the structure. The landform design aims to achieve a 'store and release' structure with a topsoil/subsoil and waste rock mix cover profile with a capillary break beneath to reduce upward capillary action. Concave slopes with back-benches and perimeter bunds also assist in retention of rainfall within the landform and reduced erosion. Modelling indicates that the landform will act as a water retaining structure with minimal seepage through the landform. Salt in dust from the IWL is expected to have a negligible impact on salt levels in surrounding soils. As a result, negative effects to soil quality (productive land on and off the mine site) as a result of saline material within the IWL are expected to represent a **negligible impact**.

Impacts associated with the use of saline water will be contained to isolated areas of the mine site and typically targeting internal haul routes. As such, impacts associated with the use of saline water represent a long-term negative change to soil quality (the life of the mine) affecting local receivers (within the mine site) and are therefore considered to represent a **medium impact**. As a result of the implementation of design and control measures, elevated soil salinity off the mine site is not anticipated to occur and therefore represents a **negligible impact**, but is considered further as a potential risk.

Saline water will be used in processing and a variety of other activities, including dust suppression and does remain a risk from the project. Uncontrolled discharge of saline materials may potentially elevate soil salinity levels within areas outside of the mine site, reducing soil quality and therefore restricting vegetation growth and agricultural productivity.

An uncontrolled discharge may occur as a result of uncertainties in the application of control measures, such as:

- Failure of surface water design or management controls to contain runoff
- Spill or leak from water distribution infrastructure or water storage infrastructure
- Drift of dust suppression spray if application occurs during extreme weather events (e.g. wind)
- Overuse of saline water for dust suppression

Negative effects to soil quality (productive land on and off the mine site) as a result of surface water or deposition of saline material contained within the IWL is considered to represent a **moderate** consequence and is considered **unlikely** off site and **possible** on site, given the design measures in place to avoid run-off or sedimentation. As such, the risk to land quality from saline material from the landform represents a **medium** risk.

If elevated soil salinity off site does occur due to the release of saline material, the consequences are considered to be **minor**, reversible damage to local property. Water used for dust suppression and runoff from areas subject to saline water application will be controlled and directed to sedimentation ponds. Salt collected in ponds will be periodically removed to maintain performance. As a result of this, in addition to the surface water management strategies outlined in Chapter 18, it is considered **unlikely** that the discharge of saline water will limit the viability of off site soils to support vegetation or agriculture. As such, saline water discharge affecting soil and land quality outside of the mine site is considered to be a **low** risk.

The possibility of seepage through the IWL raising salinity levels in groundwater, elevating groundwater levels and subsequent impacts to agricultural land are discussed in Chapter 19, (Impact ID21_04) and are considered to represent a **low impact** and a **low risk** as a result of the very low predicted seepage rates, current depth to groundwater and already highly saline groundwater.

13.7.2 Sediment Deposition

Deposition of sediments from erosion of slopes of the IWL could affect productive land both on and off the mine site, during construction and operation of the landform and post-mine closure should the landform not be geotechnically stable. The concept landform design represents an extremely conservative approach to landform stability with the inclusion of a series of concave slopes and back-sloping benches, as well as earthen bunds around perimeters of each outer bench. In addition, the landform includes a surface cover which comprises stabilising waste rock mixed with top-soil and sub-soil. The rock material assists with holding the material in place, while the soil provides a growth medium to enable effective rehabilitation of surface slopes, which in turn assists with retaining surface water flows. In addition, the IWL does not contain hazardous material. If erosion did occur, it would predominantly be of topsoil placed on the slopes which is similar material to surrounding land.

Sedimentation can also occur through tunnel erosion of dispersive or potentially dispersive soils. Water ponded on saline sodic materials can result in the leaching of salt by the ponded water, reduced soluble salt, increased dispersion followed by development of tunnel erosion. For non-cohesive materials, long durations of ponding are also a major factor in developing tunnel erosion (DMP/EPA 2015).

Dispersive soils will be identified and characterised through analysis of the expected micro-structural, chemical and mineralogical evolution of mine waste material. Stripping of subsoil will be restricted to a depth that minimises collection of dispersive material, where practicable. Materials that potentially present a risk will be contained within the IWL and isolated from the outer areas. Given the low seepage rates predicted through the IWL, it is considered appropriate management will prevent the formation of any significant tunnel erosion.

Sedimentation to agricultural land on and off the mine site is considered to represent a **low impact**, localised issue and able to be rectified in the short term. Consequences of sedimentation if it does occur are considered to be **minor** (given the surface material will be of similar composition to surrounding agricultural land) and given the design and management controls in place, this event is considered to be **unlikely**. Therefore, reduced soil quality as a result of sedimentation is considered to represent a **low risk**, both on and off the mine site.

13.7.3 Contamination or Acidification of Soil Resources

This section discusses the impacts and risks associated with the contamination or acidification of soil resources. The impact of acid-forming material on groundwater resources is discussed in Chapter 19 Groundwater.

Mobilisation of Chemicals or Hydrocarbons

The presence of any existing site contamination has not been confirmed anywhere within the mine site and as outlined in Section 13.3 is considered unlikely to be encountered. Therefore, the disturbance of existing site contamination is not anticipated to occur and is considered to be a **negligible impact**.

Pre-existing site contamination can represent a threat to public safety or the environment if not appropriately managed. If site contamination is encountered, the consequences will be **moderate**; localised and, at worst, able to be remediated in the long term. Based on the current and historical use and development of the mine site (and its immediate surrounds), the potential for significant site contamination to be present is considered to be low. As such, the likelihood of disturbing existing site contamination is considered to be **rare**. Therefore the disturbance of existing site contamination is considered to be a **low risk**.

Mobilisation of Existing ASS

Geochemical analysis of drillholes from the mine site indicates that there are areas of potentially acid-forming material; however, the presence of any ASS has not been confirmed. If ASS is identified, it will be appropriately managed through the ASS management plan as outlined above. Therefore, the disturbance of existing on site ASS is not anticipated to affect soil resources and is considered to be a **negligible impact**.

ASS can represent a threat to public safety or the environment if not appropriately managed. A desktop review of potential ASS indicated that isolated areas of the mine site (shown on Figure 13-3) have a 30 – 60% potential for the presence of ASS. Geochemical analysis of mine waste material and the magnetite concentrate validated the presence of potential acid-forming material. As such, it is considered **possible** that ASS will be encountered during construction, operation or closure of the mine site. Given the management measures outlined in Section 13.6.2, the consequences of encountering ASS are considered to be **minor**; effecting local soil resources and able to be remediated. Therefore, disturbing ASS materials is considered to be a **low risk**.

Mobilisation of Potentially Acid-forming Material

As outlined in Section 13.3.2, geochemical analysis of drillholes from the mine site indicates that a small percentage of the waste material from the mine pit excavation and processing contains potentially acid-forming material (approximately 2% of all waste material). This material is offset by high acid neutralisation capacity also contained within waste materials, resulting in a negative net acid production potential (see Appendix S for details). Mobilisation of PAF materials requires an effective pathway such as air-born dust or surface water erosion and subsequent deposition. Given the surface cover proposed for the IWL of waste rock and top-soil/sub-soil material and the water-retaining design features of the landform, the mobilisation of acid-forming material is not anticipated, so is not anticipated to affect soil resources. Impacts of potentially acid-forming material to land quality are therefore considered to represent a **negligible impact**.

Given the presence of a small volume of potential PAF material in the waste stream, incorrect handling of this material in the construction of the IWL could result in a **moderate** consequence for soil quality, in that it may require remediation in the long term. Taking into account the significant volumes of acid-neutralising materials, the co-disposal of waste streams and the outer surface cover material to be placed on the landform, such an event is considered **unlikely**. Therefore, disturbing PAF material during mining is considered to represent a **medium risk**.

13.7.4 Loss of Topsoil during Stockpiling

Topsoil will be stripped from areas of disturbance within the mine site and stockpiled from the commencement of construction. Stockpiles will be categorised based upon the former land use and the seedbank they contain (i.e. native seedbank, agricultural seedbank). The topsoil will be stockpiled until it is utilised in progressive rehabilitation or mine closure, exposing the stockpiles to wind and rain for an extended duration. Without appropriate management, the extended exposure of stockpiles can result in decreased seedbank viability and exposure to weeds. Stockpiles are also vulnerable to erosion by wind and water, contributing to dust generation and loss of topsoil.

A soil management procedure will be established to minimise the loss of soil and provide for the appropriate stockpiling of soil, including maximising opportunities for progressive rehabilitation. Specifically, soils beneath compacted areas during site rehabilitation will be deep ripped to facilitate nutrient cycling and biological processes to support reintroduction of agriculture or revegetation. Dispersive soils will be managed to ensure they are not exposed to rain and areas containing dispersive soils are monitored more closely. Topsoil will be stripped prior to disturbance for use during rehabilitation (refer Section 13.5 for further information).

Waste material and soil balance calculations were undertaken as part of the IWL design and closure concept development (Appendix S) to confirm the availability of adequate soil required for progressive rehabilitation and determine the volumes of waste material produced during mining. Investigations also identified storage capacity requirements of materials, landform stability, placement of growth medium materials and review and inventory of soil and waste materials characteristics. These calculations and additional information are provided in Appendix S and indicate that ample topsoil and subsoil is available. The indicative volume of topsoil required for the IWL is 2.95 Mm^3 with 10.2 Mm^3 potentially available on the mine site. Similarly, 24.5 Mm^3 of subsoil is required with 39.8 Mm^3 potentially available. Timing of topsoil stripping and management of topsoil will be further refined as detailed mine planning proceeds.

Soil stockpiling activities will largely maintain the quality of soil within the mine site, maximising the amount of soil suitable for rehabilitation and future resumption of agricultural activities at temporarily disturbed areas. As such, no significant loss of usable topsoil is anticipated at the mine site as a result of topsoil stripping or stockpiling activities and is considered to be a **negligible impact**.

Loss of Soil Quality and Seedbank

Topsoil stripped from areas of disturbance within the mine site would be stored from the commencement of construction until mine closure, or used during progressive rehabilitation throughout the life of the mine. Improper storage or management of topsoil may result in the topsoil becoming unusable for rehabilitation purposes. Improper stockpiling does not compromise rehabilitation practices which can still be undertaken through seed collection and direct seeding if required.

Successful soil management programmes have been undertaken at a number of mine sites throughout South Australia, resulting in successful rehabilitation of land within a mine site boundary. For example, Arrium's Southern Iron operations successfully rehabilitated 76 ha of previously cleared land during the 2012-13 financial year utilising the local seedbank (Arrium 2013).

Given the management strategies outlined in Section 13.5, it is considered **rare** that topsoil will be improperly stockpiled. The consequences of incorrectly managing stockpiles are considered to be **moderate**; localised and able to be resolved in the long term. As such, the risks associated with improper topsoil stockpiling are considered to be a **low**.

13.7.5 Soil Compaction

Soil will be compacted with the establishment of roads and hardstand areas (including temporary construction areas) throughout the mine site. Compaction of soil would result in a number of detrimental effects on soil structure and quality and future crop yield potential (Department of Primary Industries 2004) including:

- Reduced capacity for water infiltration into soil
- Increased potential for surface water runoff and soil erosion
- Impeded root growth and decreased capability of crops to take up nutrients and water from soil
- Altered soil structures including reduced pore space size and altered distribution resulting in reduced cycling and release of plant-available nutrients

As outlined in Section 13.5, deep ripping of compacted soil will be undertaken in areas to be rehabilitated for agricultural or revegetation purposes. Vehicle movements will be limited to predetermined routes within the mine site to minimise the widespread compaction of soil. Areas of the mine site to be rehabilitated include temporary construction areas such as hardstands and laydown areas. Impacts associated with soil compaction will be limited within the proposed CEIP Infrastructure footprint and are able to be remediated in the short term through deep ripping of compacted areas. As such, the overall impact associated with soil compaction is considered to be a **low**.

As outlined in Section 13.6.2, vehicle movements will be limited to predetermined routes within the mine site to minimise the widespread compaction of soil. Deep ripping of compacted soil will be undertaken in areas to be rehabilitated for agricultural or revegetation purposes. Vehicle movements or creation of hardstand areas outside of the nominated development envelope may result in the additional compaction of soils. It is considered that the consequences of additional compaction of soil are **minimal** and would have an insignificant effect on the land, or the attainment of rehabilitation objectives. Despite the implementation of control measures, the compaction of soil beyond nominated areas is considered **likely** during construction, operation and/or closure of the mine site. As such, uncertainty in the implementation of control measures to limit the area of soil compaction is considered to represent a **low risk**.

13.7.6 Contamination of Soil

The overarching objective in the storage and handling of hydrocarbons and chemicals is to prevent spills from occurring and as such, spillage is not planned as part of the project. Therefore, the spillage of hydrocarbons or chemicals is considered to be a **negligible impact**.

The storage and handling of hydrocarbons and chemicals at the mine site creates potential for soil contamination to occur as a result of uncontrolled releases. At a local level, soil or groundwater contamination may reduce the ability of temporary construction areas to support agriculture, inhibit revegetation and limit future land uses. More broadly, soil contamination can represent a threat to human health and biological processes.

Given the design or control measures previously described in Section 13.5 fail, the consequences of spill or leakage are considered to be **minor**; localised and able to be remediated. Considering that a range of hydrocarbons and chemicals are to be stored and used at various locations across the mine site, it is considered **possible** that a spill or leak will occur at some point during construction, operation and/or closure. As such, the uncontrolled release of hydrocarbons and chemicals is considered to represent a **low risk**.

13.7.7 Topsoil Loss from Erosion

As detailed in Chapter 18, Surface Water, there are no creeks or surface water drainage lines within the area of the mine site due to the low rainfall and the permeability of soils which occur across the majority of the site.

In heavy rain events, rainfall runoff may erode soil, especially where that soil is exposed and unprotected. Erosion is most likely to occur at locations of uncontrolled flow concentration, such as drainage gullies, near culverts and on slopes (e.g. slopes of the IWL). As alterations to the existing landform are limited to the area of the mine site, erosion of topsoil will be limited to the mine site boundary. Given the implementation of controls to minimise erosion (refer Chapter 18 Surface Water), it is anticipated that topsoil erosion will be minimal and restricted to the area of the mine site and considered to be a **low impact**.

If erosion does occur, sediment laden runoff will be contained within bunds, ponds and the mine pits. The consequences of reduced water quality from erosion are considered to be **minor** and will not have a significant effect on topsoil quantity at the proposed mine. Despite the implementation of the proposed design controls and management methods, localised erosion to disturbed areas such as the integrated waste landform, the mine pits and material stockpiles due to rainfall runoff events is considered to be **possible**. As such, the overall risk is considered to be **low**.

13.7.8 Summary of Impacts and Risks

With the implementation of design and management measures, all residual impacts have been categorised as low or negligible, with the exception of elevated soil salinity on the mine site, which is considered to represent a medium impact. All risks have been reduced to a level of low or medium. The impacts and risks were considered to be ALARP and not warrant further specific control measures other than the environmental management controls and measures outlined here. A summary of each of the identified impacts and risks associated with soil and land quality at the mine site is presented in Table 13-7.

Table 13-7 Impact and Risk Summary: Soil and Land Quality

Impact ID	Impact Event	Level of Impact [1]	Level of Risk [2]
IM_13_01	Migration of salts into cover profile of IWL leads to deterioration of soil quality	Negligible	Medium
IM_13_02	Elevated soil salinity on proposed mining lease due to use of saline water for dust suppression	Medium	Low
IM_13_03	Elevated soil salinity off proposed mining lease due to use of saline water for dust suppression	Negligible	Low
IM_13_04	Deposition of sediments from erosion of slopes of IWL during operations affects productive land on proposed mining lease	Negligible	Low
IM_13_05	Deposition of sediments from erosion of slopes of IWL during operations affects productive land off proposed mining lease	Negligible	Low
IM_13_06	Deposition of sediments from erosion of slopes of IWL post closure affects productive land	Negligible	Low
IM_13_07	Soils on site impacted due to contamination within existing materials (including PAF and ASS)	Negligible	Medium
IM_13_08	Reduced soil quality, capacity as a result of material handling (e.g. stockpiling) compromises rehabilitation	Negligible	Low
IM_13_09	Reduced soil quality, capacity as a result of material handling (e.g. stockpiling) compromises rehabilitation	Negligible	Low
IM_13_11	Compacted soil reducing productivity and / or vegetation growth	Low	Low
IM_13_12	Contamination of land from spills, leaks and uncontrolled releases	Negligible	Low
IM_13_13	Loss of topsoil as a result of erosion	Negligible	Low

[1] Impact events are expected to occur are part of the project. Level of impact is assessed post control strategies, as per the impact assessment methodology provided in Chapter 6.

[2] Level of risk reflects the risk that the assessment of impact is incorrect due to uncertainties in the assessment method, the control strategies, or in assumptions uses. Risk is assessed post control strategies, as per the risk assessment methodology provided in Chapter 6.

13.7.9 Justification and Acceptance of Residual Impact and Risk

With the implementation of design and operational management measures, all impacts associated with soil and land quality are considered to be **low** (or **negligible**) with the exception of salinisation of soils on the mine site and reduced productivity on adjacent lands due to shading which represents medium impacts due to the longer-term nature of the impacts. All risks have been reduced to a level of **low**, with the exception of reduced soil quality as a result of mobilisation of saline materials from the IWL and contamination of soils on site from PAF material which represent a **medium** risk. The impacts and risks are considered to be ALARP.

13.8 Proposed Outcome(s) and Criteria

In accordance with the methodology presented in Chapter 6, Assessment Methodology, outcomes have been developed for all impact events with a confirmed linkage between source, pathway and receptor. Each outcome is supported by measureable assessment criteria that will be used to assess compliance against the proposed outcomes during the relevant phases (construction, operation, closure) of the project. Whilst outcomes may be the same for multiple impact events, separate measurement criteria and leading indicators are proposed to demonstrate compliance. Proposed outcomes and measurement criteria have been developed for each of the impact events identified with a confirmed linkage and these are presented in Table 13-8. Outcomes for the entire project are presented with all impact events in Appendix C.

Table 13-8 Outcomes and Assessment Criteria: Soil and Land Quality

Proposed Outcome	Impact ID	Impact Event	Draft Outcome Measurement Criteria	Draft Leading Indicator Criteria
Designated rehabilitation sites are established self-sustaining systems.	IM_13_01	Migration of salts into cover profile of IWL leads to deterioration of soil quality.	Ecosystem Function Analysis (or similar) at representative sites on rehabilitated areas demonstrates that rehabilitation will achieve sustainability thresholds.	None proposed
No impacts to agricultural productivity for third party land users as a result of mining operations, including: • reduction in crop yield; • reduction in grain quality; or • adverse health impacts to livestock other than where agreed between the tenement holder and the affected user.	IM_13_03	Elevated soil salinity off proposed mining lease due to use of saline water for dust suppression.	Soil testing on adjoining land demonstrates there is no statistically significant increase in the level of salinity.	None proposed
	IM_13_04	Deposition of sediments from erosion of slopes of IWL during operations affects productive land on proposed mining lease.	Monthly inspection confirms there is no visible sedimentation from runoff from the IWL outside the designated buffer. Mine records demonstrate characterisation and placement on dispersive material is in accordance with IWL design specifications. Should the crop productivity monitoring program (YieldProphetTM) be supported by surrounding	None proposed
	IM_13_05	Deposition of sediments from erosion of slopes of IWL during operations affects productive land off proposed mining lease.		None proposed

Proposed Outcome	Impact ID	Impact Event	Draft Outcome Measurement Criteria	Draft Leading Indicator Criteria
			landowners, then crop yields as determined by YieldProphet on properties within the proposed mining lease are comparable with control sites during construction, operation and closure of the mine, measured annually.	
Rehabilitated IWL is stabilised so that erosion from landform slopes will not result in adverse impacts on productive land.	IM_13_06	Deposition of sediments from erosion of slopes of IWL post closure affects productive land.	Ecosystem Function Analysis at representative sites on rehabilitated areas demonstrates that rehabilitation will achieve sustainability thresholds. Landform modelling based on established integrated waste landform material parameters and geometry confirm alignment with outcomes from conceptual modelling. Independent audit at mine completion of quality assurance data confirms the IWL has been constructed to design specifications.	None proposed
No adverse impacts on soil quality or quantity within the proposed mining lease that could compromise the post mining land use.	IM_13_02	Elevated soil salinity on proposed mining lease due to use of saline water for dust suppression.	Soil testing on undisturbed areas demonstrates salinity levels will not prevent the growth of crops on the land.	None proposed
	IM_13_07	Soils on site impacted due to contamination within existing materials (including PAF and ASS).	Mine records demonstrate all areas of PAF and ASS encountered are appropriately contained and/or treated.	None proposed
	IM_13_08 IM_13_09	Reduced soil quality, capacity as a result of material handling (e.g. stockpiling) compromises rehabilitation.	Annual audit of soil movement records shows no measurable decline in soil quality or quantity. Ecosystem Function Analysis (or similar) demonstrate progress towards achieving closure criteria.	None proposed
	IM_13_12	Contamination of land from spills, leaks and uncontrolled releases.	All chemical and hydrocarbon spills greater than 20 L are remediated to meet EPA standards within 48 hours of the spill, or a longer time agreed by the	None proposed

Proposed Outcome	Impact ID	Impact Event	Draft Outcome Measurement Criteria	Draft Leading Indicator Criteria
			Director of Mines.	
	IM_13_13	Loss of topsoil as a result of erosion	Annual audit of soil movement records shows no measurable decline in soil quality or quantity	None proposed
Designated rehabilitation sites are established self-sustaining systems.	IM_13_11	Compacted soil reducing productivity and / or vegetation growth	Ecosystem Function Analysis (or similar) of rehabilitation areas demonstrates they will achieve critical thresholds for sustainability	None proposed

13.9 Findings and Conclusion

Soil and land quality impacts within the mine site are expected as part of the proposed development. Impacts include stripping of topsoil, compaction of soils along designated internal roads and beneath constructed infrastructure and localised reduction of soil quality as a result of saline dust suppression spray and run-off from the integrated waste landform.

Risks to the soils and land quality will be alleviated wherever possible through the implementation of control and management strategies. Risks identified include the potential for saline water (run off or from dust suppression spray drift) to reduce the soil quality on land outside the mine site or within the mine site to a greater extent than anticipated, the possibility for soil contamination as a result of leaks and spills during construction and operation, the potential presence of ASS, risks to soil quality from PAF in mine waste and a loss of soil quality and seedbank viability as a result of poorly managed stockpiles.

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