

Chapter 17
Waste

ESMERALDA GRAPHITE PROJECT

aarc ENVIRONMENTAL SOLUTIONS
APEM Group

GRAPHINEX

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Glossary, acronyms and abbreviations

Acronym or Abbreviation	Meaning
AARC	AARC Environmental Solutions Pty Ltd
ADWF	Average Dry Weather Flow
AHD	Australian Height Datum
AMD	Acid Mine Drainage
ANC	Acid Neutralising Capacity
ANCOLD	Australian National Committee on Large Dams
ARRF	Advanced Resource Recovery Facility
AS	Australian Standard
CCA	Consequence Category Assessment
CLR	Contaminated Land Register
DES	Department of Environment and Science
DESI	Department of Environment, Science and Innovation
DETSI	Department of the Environment, Science, Innovation and Tourism
DIR	Design Irrigation Rate
DUL	Drained Upper Limit
EA	Environmental Authority
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994*
EP Regulation	Environmental Protection Regulation 2019
ERA	Environmentally Relevant Activities
ESCP	Erosion and Sediment Control Plan
FNQROC	Far North Queensland Regional Organisation of Councils
GABORA	Great Artesian Basin and other regional aquifers
mbGL	Metres below ground level
HDPE	High-Density Polyethylene
IECA	International Erosion Control Association
IMP	Irrigation Management Plan
LC	Low Capacity

Acronym or Abbreviation	Meaning
LOM	Life of Mine
MAW	Mine affected water
MEDLI	Model for Effluent Disposal using Land Irrigation
MIA	Mine infrastructure area
MPP	Mineral processing plant
MR Act	*Mineral Resources Act 1989*
MRF	Material Recovery Facility
MT	Million tonnes
MW	megawatt
NAF	Non-acid forming
NMWMP	Non-Mineral Waste Management Plan
NPI NEPM	National Environment Protection (National Pollutant Inventory) Measure 1998
NWQ	Northwest Queensland
NZS	New Zealand Standard
OM	Operations Manuals
PAF	Potentially acid forming
PPE	Personal protective equipment
PRCP	Progressive Rehabilitation and Closure Plan
QA/QC	Quality Assurance and Quality Control
QFAO	Queensland Flood Assessment Overlay
QLD	Queensland
RE	Regional Ecosystems
ROM	Run-of-Mine
RRR	Regional Resource Recovery Plan
SMDD	Standard maximum dry density
SRE	Soil and Rock Engineering Pty Ltd
STP	Sewage treatment plant
TDS	Total Dissolved Solids
TOR	Terms of Reference
TSF	Tailings Storage Facilities
WRD	Waste rock dumps

Acronym or Abbreviation	Meaning
WRR Act	*Waste Reduction and Recycling Act 2011*

17 Waste

This chapter details all the expected waste streams (mineral and non-mineral) from the Esmeralda Graphite Project (the Project) site during the construction, operation, and rehabilitation and decommissioning phases.

It assesses the expected quantities and characteristics of these waste streams, the potential impacts, and the proposed relevant mitigation and management measures to ensure minimise risk or cause of environmental harm.

To assess the potential impacts of waste, the following assessments were undertaken:

- Esmeralda Graphite Project – Groundwater Impact Assessment by Hydrogeologist (Appendix L);
- Land-based Effluent Disposal Assessment Report by AARC Environmental Solutions Pty Ltd (Appendix M);
- Technical Report for Tailings Storage Facilities by Soil and Rock Engineering Pty Ltd (SRE) (Appendix W);
- Air Quality Assessment by Katestone Environmental Australia Pty Ltd (Katestone) (Appendix A);
- Greenhouse Gas and Decarbonisation Technical Report by Katestone (Appendix B);
- Geochemistry Assessment of Mine Materials and Tailings by RGS Environmental Consultants Pty Ltd (RGS) (Appendix U); and
- Pit Void Water Quality Modelling Report by RGS Environmental Consultants Pty Ltd (RGS) (Appendix V).

The assessment considered the following guidance:

- *Waste – EIS information guideline*, ESR/2020/5311 (EIS waste guideline); and
- Application requirements for activities with waste impacts, ESR/2015/1836.

In accordance with the EIS waste guideline, the purpose of the chapter is to identify waste streams within the impact assessment area, assess the potential impacts and identify appropriate mitigation measures to address such impacts.

17.1 Environmental objectives

The detailed assessment in this chapter demonstrates that the Project will achieve the requirements of the Terms of Reference (TOR), in relation to waste generation and management. A reconciliation table for the TOR is in Section 17.8.

The specific waste environmental objective, prescribed in Schedule 8, Part 3, Division 1 of the Environmental Protection Regulation (EP Regulation) 2019 was observed:

- Any waste generated, transported, or received as part of carrying out the activity is managed in a way that protects all environmental values.

The content of this chapter thus traces the storage, treatment, management, movement, reuse and disposal of waste as relevant and practicable. It demonstrates that the Project will achieve the environmental objectives and waste management performance outcomes relevant to Schedule 8 of the EP Regulation for waste because:

- waste will be generated, transported or received is managed in accordance with the waste and resource management hierarchy under the WRR Act; and
- if waste is disposed of, it is disposed of in a way that prevents or minimises adverse effects on environmental values.

With regards to waste management, the Project design and all phases are to:

a) Avoid, minimise and/or mitigate adverse impacts of hazardous contaminants and waste generated by the Project to protect people, property and the environment.

b) Manage any waste transported, generated, or received as part of carrying out the activity in a way that protects all environmental values and community enjoyment of the region.

c) Ensure waste infrastructure has the capacity to adequately accommodate waste, and any upgrades to waste infrastructure are funded by the Proponent.

These performance outcomes will be achieved as outlined in this chapter with proposed measures consistent with best practice environmental management and community standards.

- Related to waste, the Project will achieve the performance outcomes for the water environmental objective of performance outcome 2 a, b, c, d, e and h of Schedule 8 of the EP Regulation because:
    - the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks;
    - contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water;
    - the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment;
    - the disturbance of any acid sulfate soil, or potential acid sulfate soil, will be managed to prevent or minimise adverse effects on environmental values;
    - acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered;
    - the activity will be managed so that adverse effects on environmental values are prevented or minimised.

Related to groundwater, the Project will achieve the performance outcomes for the groundwater environmental objective 1 and 2 of Schedule 8 of the EP Regulation because:

- The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

Related to land, the Project will achieve the performance outcomes for the land environmental objective of performance outcome 2 of Schedule 8 of the EP Regulation because:

- activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land;
- areas disturbed will be rehabilitated or restored to achieve sites—
    (i) that are safe and stable; and
    (ii) where no environmental harm is being caused by anything on or in the land; and
    (iii) that are able to sustain an appropriate land use after rehabilitation or restoration;
- the activity will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants;
- the application of water or waste to the land will be sustainable and managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

17.2 Legislation and guidelines

17.2.1 Environmental Protection Regulation 2019

The Environmental Protection Regulation 2019 (EP Regulation) authorises provisions for waste related management, including, regulated waste, which is defined under the regulation (Section 42), waste tracking requirements, the National Pollutant Inventory and reporting requirements, and Environmentally Relevant Activities (ERAs). The ERA relevant to sewage treatment is ERA 63 (Schedule 2 of the EP Regulation), as detailed in Table 17-1.

Table 17-1: Sewage ERA

ERA	Description	Activity summary
63(3)(1)(b)(i) Sewage Treatment	Operating a sewage treatment works at a site that has a total daily peak design capacity of more than 100 but not more than 1500 equivalent persons.	A sewage treatment plant will accommodate an approximate peak of 192 equivalent persons.

17.2.2 Waste Reduction and Recycling Act 2011

The objects of the *Waste Reduction and Recycling Act 2011* (WRR Act) are:

- to promote waste avoidance and reduction, and resource recovery and efficiency actions;
- to promote and facilitate Queensland's transition to a circular economy;
- to promote activities across government, business, industry and the community that extend the life cycle of products and materials;
- to reduce the consumption of natural resources and minimise the disposal of waste by encouraging waste avoidance and the recovery, re-use and recycling of waste;
- to minimise the overall impact of waste generation and disposal;
- to ensure a shared responsibility between government, business and industry and the community in waste management and resource recovery;
- to support and implement national frameworks, objectives and priorities for waste management and resource recovery.

Achieving the objectives of the WRR Act are guided by:

- the waste and resource management hierarchy; and
- following the waste and resource management principles (refer to Section 17.2.2.1).

Section 8AA of the WRR Act defines waste as anything that is:

a) left over, or an unwanted by-product, from an industrial, commercial, domestic or other activity; or

b) surplus to the industrial, commercial, domestic or other activity generating the waste.

17.2.2.1 Waste management principles

Each potential waste stream generated by the Project, and the subsequent proposed avoidance and management methods, will consider the following principles:

- the polluter pays principle;
- the user pays principle;
- the proximity principle; and
- the product stewardship principle.

Polluter pays principle

The polluter pays principle is the principle that all costs associated with managing waste should be borne by the persons who generated the waste. All costs associated managing Project waste will be borne by the Proponent.

User pays principle

The user pays principle is the principle that all costs associated with the use of a resource should be included in the prices of the goods and services (including government services) that result from the use.

All waste management costs will pass through to the user of the Project's product. For the Project, no government subsidy, incentive payment or grant has been accounted for. On the contrary, the Project will contribute substantially to the regional and national economies.

Proximity principle

The proximity principle is the principle that waste and recovered resources should be managed as close to the source of generation as possible.

When selecting waste management and disposal contractors, wherever practicable, waste and recovered resources are proposed to be disposed of as close to the Project as possible.

17.2.2.2 Waste and resource management hierarchy

Potential impacts (environmental and otherwise) of waste will be managed in accordance with established industry practices and to contemporary community standards, that of s.9 of the *Waste Reduction and Recycling Act* 2011 (WRR Act). The hierarchy lists the preferred waste and resource management options in the following order:

a) **AVOID** unnecessary resource consumption;

b) **REDUCE** waste generation and disposal;

c) **RE-USE** waste resources without further manufacturing;

d) **RECYCLE** waste resources to make the same or different products;

e) **RECOVER** waste resources, including the recovery of energy;

f) **TREAT** waste before disposal, including reducing the hazardous nature of waste; and

g) **DISPOSE** of waste only if there is no viable alternative.

All forms of waste expected to be generated have been assessed for their environmental risk, and management approaches have been developed by considering:

- the identified environmental risk;
- the available local and regional waste management services and facilities; and

- the waste management hierarchy (Refer to Section 17.2.2.2).

17.2.2.3 End of waste codes

End of Waste (EoW) codes specify outcomes that need to be achieved for a waste to be deemed a resource. It states requirements for the registered resource producer as well as conditions for the use of the resource (Queensland Government 2026).

Potentially relevant EoW codes include:

- end-of-life tyres (ENEW07503018).

Waste material such as end-of-life tyres which are generated as part of Project activities will be managed by a licensed contractor in accordance with relevant waste management provisions under the Environmental Protection Act 1994 (EP Act) and Waste Reduction and WRR Act.

17.2.3 Water Plan (Great Artesian Basian and Other Regional Aquifers) 2017

The Project falls under the *Water Plan (Great Artesian Basian and Other Regional Aquifers) 2017* (GABORA Water plan). Applying for licenses for a water supply under the Water Act and the GABORA Water plan will be subject to separate assessment and approval processes.

The Project water balance, water resources and management is detailed in Chapter, 14 Water Resources.

Potential water contamination of any relevant aquifers from stored mineralised mine waste are detailed in Chapter 15, Water Quality.

17.3 Existing Environment

17.3.1 Regional waste management infrastructure

The remoteness of the Gulf Savannah regions, supporting approximately 31,000 people in discrete communities covering an area of 350,000 km^2, have historically been a barrier to improved waste management (NWQ Regional Waste Management Plan 2023). The councils, in and around the vicinity of the Project, are so dispersed that it is not viable to share waste management infrastructure with neighbouring councils; and it is generally cost prohibitive to send materials to the nearest regional city for recovery (Department of Environment & Science and Arcadis 2019). Waste management challenges include large transport distances, lack of infrastructure and aging assets, lack of local markets and economies to scale and diverse waste streams.

The Far North Queensland Regional Organisation of Councils (FNQROC) has developed a Regional Resource Recovery Plan (RRR) comprising of eight key action steps to improve resource recovery outcomes while meeting state targets for good environmental and social outcomes (FNQROC Regional Recovery Plan 2023). The Croydon Shire Council is a member of both the NWQ Regional Waste Management Plan and the FNQROC, with the aim of improving their waste management and reducing the risk of environmental harm.

Currently, all councils operate their own waste management facilities, except Richmond council, where operations have been outsourced to a private contractor. Waste management facilities accepting domestic and commercial waste are operated by local councils in the Croydon Shire, Etheridge Shire, Richmond Shire, McKinlay Shire and Mt Isa City (Table 17-2).

The closest facilities to the Project, located within Croydon Shire Council and Etheridge Shire Council, do not have capacity for very high volumes of waste but are sufficient for the waste management purposes of their local area (Croydon Shire Council n.d.). There is limited kerbside collection services provided by the Croydon Shire Council. The only recycling opportunities for used packaging in the region is through the Containers for Change program, managed by COEX with a mobile service to communities in the Croydon Shire Council.

The closest Material Recovery Facility (MRF) to the Project is at Mt Isa. The Advanced Resource Recovery Facility (ARRF) is located at Portsmith in Cairns, and the Springmount Waste Management Facility, Mareeba. All these facilities are over 400 km from the township of Croydon.

Commercial operators for recycling and disposal of waste operate in the region and include JJ Richards and Cleanaway. They operate from Mt Isa and Mareeba.

Given the type and scale of the proposed mining activities, the Croydon Landfill Facility may have some capacity to accept non-mineralised waste. Options for onsite reuse, recycle or disposal of wastes will be considered as much as possible. Wastes will be transported by licenced contractors to appropriately licensed waste management facilities in accordance with the waste management principles.

Table 17-2: Council operated waste management infrastructure

Facility	Waste types	Facility capacity (tonnes/year)	Opening days	Opening hours
Croydon Shire				
Croydon Landfill Facility	General waste, regulated waste	<60,000	7 days	8 am – 3 pm
Richmond Shire				
Richmond Waste Disposal Facility	General waste, regulated waste	<50,000	7 days	6 am – 6 pm
McKinlay Shire				
Julia Creek Recycling and Waste Management Facility	General waste, regulated waste (limited)	50 to 2,000	Monday to Friday	7 am – 3:30 pm
Kynuna Landfill	General waste, regulated waste (limited)	50 to 2,000	Monday to Friday	7 am – 3:30 pm
McKinlay Landfill	General waste, regulated waste (limited)	50 to 2,000	Monday to Friday	7 am – 3:30 pm
Nelia Landfill	General waste, regulated waste (limited)	50 to 2,000	Monday to Friday	7 am – 3:30 pm
Etheridge Shire				
Georgetown Landfill	General waste, green waste	<5000	7 days	8:30 am – 4:30 pm
Mount Isa City				
Mount Isa Waste Management Facility	General waste, green waste, hazardous material	<50,000	7 days	7:30 am – 4:45 pm
Materials Recovery Facility	Recyclables	<400	7 days	7:30 am – 4:45 pm

17.3.2 Contaminated land

No lots within Project footprint are listed on the Contaminated Land Register (CLR) as per the search undertaken on the 14 April 2026 (Attachment 3).

On-site soil assessments were undertaken as part of the Soils and Land Suitability Assessment (Appendix H, Soil and Land Suitability Assessment). Occurrences of acid sulphate soil were assessed as extremely low. All soils in the Project area are deemed suitable for reuse in rehabilitation activities (refer to Section 17.3.4.3).

17.3.3 Waste generation overview and inventory

This section provides a waste inventory for all expected Project waste streams generated by the Project activities during the construction, operational, rehabilitation and decommissioning phases. The types of waste expected to be generated at each phase of the Project include:

Construction phase:

- vegetation cleared from the infrastructure footprint of the Project;
- subsoils excavated to construct infrastructure foundations and footings;
- regulated waste (as defined by the EP Regulation), including used oils and oily wastes, paint residues, detergents, solvents, batteries and tyres;
- recyclable waste (e.g. codes 1, 2, 3 and 5 plastics, metals, paper and cardboard);
- general waste (e.g. food scraps, non-recyclable plastics);
- re-useable and refurbishable items (e.g. pipes, fittings, pumps, etc.);
- used tyres from light and heavy vehicles;
- primary treated sewage effluent;
- secondary treated sewage and effluent for irrigation;
- reverse-osmosis brine; and
- clinical waste (e.g. first aid, medical waste).

Operational phase:

- vegetation progressively cleared prior to developing the mine pit, out-of-pit waste rock dumps (WRDs), tailings storage facilities, and topsoil stockpiles;
- mineral waste (e.g. waste rock, process tailings;
- regulated waste (as defined by the EP Regulation), including used oils and oily wastes, oil- contaminated materials (used oil filters and containers), greases and oily rags, paint residues, detergents, solvents, batteries and tyres;
- recyclable waste (e.g. codes 1, 2, 3 and 5 plastics, metals, paper and cardboard);
- general waste (e.g. food scraps, non-recyclable plastics);
- reverse osmosis brine;
- reusable and refurbishable items (e.g. pipes, fittings, pumps, etc.);
- used tyres from light and heavy vehicles, conveyor belts and synthetic and natural rubber items;
- primary and/or secondary treated sewage effluent and residual sewage sludge;
- timber from packaging; and
- clinical waste (First Aid, medical waste).

Rehabilitation and decommissioning phases:

- regulated waste (as defined by the EP Regulation), including used oils and oily wastes, paint residues, detergents, solvents, batteries and tyres;

- general waste (e.g. food scraps, non-recyclable plastics);
- recyclable waste (e.g. codes 1, 2, 3 and 5 plastics, metals, paper and cardboard);
- reusable and refurbishable items (e.g. pipes, fittings, plant and equipment);
- used tyres (from light and heavy vehicles); and
- primary and/or secondary treated sewage effluent and residual sewage sludge.

Non-mineral waste will be generated during each of the three Project phases. The operational phase will generate the greatest volumes of waste.

On-site infrastructure that is not to be retained or reused will be decommissioned in accordance with the progressive rehabilitation and closure plan (Appendix T, PRCP). The PRCP will incorporate progressive rehabilitation milestones that will be submitted to the Department of Environment, Tourism, Science and Innovation (DETSI) for approval.

Inert construction and demolition waste will either be removed from the site or placed within an operational waste rock dump (WRD). During decommissioning, consideration will be given to the waste management hierarchy with reuse and recycling options pursued where possible. Disposing waste will be the last option.

Areas of potential contamination will be investigated and managed/remediated as required.

A waste inventory and potential disposal options for the waste streams is provided in Table 17-3 and Table 17-2. This is based on the identified waste sources and a review of the activities expected during construction, operation and decommissioning phases of the Project. Estimated quantities of waste generated during construction and operational stages of the Project, along with specific management strategies have been identified.

Site infrastructure to manage waste (refer to Chapter 4 Project description), will include dedicated areas for the waste stream in Table 17-3. They include:

- a sewage treatment plant (STP) and irrigation area;
- collection and storage areas for general waste, reusable items storage, recyclables, and regulated waste storage areas;
- topsoil, subsoil and vegetation stockpile areas; and
- mineral waste storage areas (refer to Section 17.3.4).

Table 17-3: Anticipated waste generation and management strategies

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
General Waste							
General waste *(i.e., food scraps, non-Class 1, 2 and 5 plastics)*	Solid	Kitchenettes, crib rooms, administration areas, workshop, etc.	<25 t	<38 t	General waste will be stored on-site in closed, green bins for regular transport off-site by a licensed waste transport contractor to a licensed landfill.	Waste disposal	General waste will be transported off-site by a licensed waste contractor to an approved landfill.
Recyclable waste *(i.e., aluminium, steel cans, Class 1, 2 and 5 plastics, paper towels, paper and cardboard)*	Solid	Kitchenettes, crib rooms, administration areas, workshop, etc.	<10 t	<15 t	Recyclable waste will be stored on-site in designated bins for regular transport off-site by a licensed waste transport contractor for recycling.	Waste recycling	Recyclable waste will be transported off-site by a licensed recycling contractor to an approved recycling facility.
Timber/reusable pallets	Solid	Workshop and administration areas	<20 t	<20 t	Reusable pallets will be returned to the supplier.	Waste reuse	Return to supplier for reuse.
					Where pallets are unable to be reused, they will be sent to general waste.	Waste disposal	Pallets that are not reusable will be transported off-site by a licensed waste contractor to an approved landfill.
Refurbishable items *(i.e., pipe work and associated components and fittings, wing nuts, conveyor rollers and belt)*	Solid	Mineral Processing Plant (MPP) and workshops	<10 t	<10 t	Refurbishable items will be stockpiled within a designated area. If condition is acceptable, items will be reused directly.	Waste reuse	Reuse on-site.
					Where items are unable to be reused, they will be collected and disposed by a licensed waste contractor. Where items are contaminated with hydrocarbons, they will be managed as regulated waste.	Waste disposal	Refurbishable items will be disposed of off-site by a licensed waste contractor to an approved waste facility.

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
Personal protective equipment (PPE) and other small items *(i.e., gloves, hard hats, safety glasses and face masks)*	Solid	Bathhouse and contractor facilities	<20 kg	<50 kg	Equipment that is not damaged will be reused on-site.	Waste reuse	Reuse on-site.
					Equipment that is sufficiently used and/or damaged will be disposed.	Waste disposal	PPE will be transported off-site by a licensed waste contractor to an approved landfill.
Scrap metal *(i.e., stainless steel, aluminium and any item considered to be metal [ferrous or non-ferrous] including machine and vehicle parts)*	Solid	Construction activities, infrastructure maintenance and workshops	<50 t	<100 t	Small scrap metal items will be placed in scrap metal skips. All grease and oils will be removed prior to placement in skips. Specific arrangements will be made for the collection of larger scrap metal items. A licensed contractor will remove all scrap metal for segregation at a licensed recycling facility.	Waste recycling	Scrap metal will be transported off-site by a licensed contractor to an approved recycling facility.
Air filters *(i.e., engine air filters)*	Solid	Vehicle and machinery maintenance at workshops	<10 t	<70 t	Air filters will be temporarily stored in the appropriate air filter skip and will be disposed of off-site by a licensed waste contractor.	Waste recycling	Air filters will be transported off-site by a licensed waste contractor to be recycled.
Green & Biosecurity Wastes							
Green waste *(i.e., grass, cleared timber and weeds)*	Solid	Clearing vegetation	As per schedule	As per schedule	Beneficial material. Green waste will be mulched and/or placed in timber stacks for reuse on-site during rehabilitation.	Waste reuse	Reuse on-site.
Green waste *(i.e., topsoil)*	Solid	Topsoil stripping for construction activities	As per schedule	As per schedule	Beneficial material. To be used for rehabilitation	Waste reuse	Resue on-site

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
Regulated Wastes							
Excavated material	Solid	Mining activities	n/a	Up to 4.5 Mt per annum on an average	Excavated waste rock is suitable for and will be used as backfill or placed in out-of-pit dumps as bulk fill/cover.	Waste disposal	Excavated waste rock will be disposed of within the mine pit and out-of-pit waste rock dump. It will be used for rehabilitation.
Process tailings	Solid/ Liquid	Mining activities	n/a	Up to 3.25 Mt per annum on an average	Flotation tailings discharge into the TSFs via pumped discharge spigots around the perimeter of the TSFs, tailings deposited in purpose-built TSFs.	Waste disposal	Disposal of process tailings will occur within the purpose-built Tailings Storage Facilities (TSF). Toward the end of mine life, tailings contained in the first 3 TSF cells will be progressively backfilled into the open-cut void. Embankments for cells 1 to 3 will be returned to the void and the final TSF cell will be capped. All TSFs except the 4th cell will be deconstructed and returned to the mine pit void.
Engine oil/fuel filters	Solid/ Liquid	Vehicle and machinery maintenance at workshop	50 each	780 each	Engine oil filters will be collected and stored in sealed oil filter disposal pod. They will be transported by a licensed regulated waste contractor to a licensed regulated waste receiver for recycling.	Waste recycling	Engine oil/fuel filters will be recycled by a licensed regulated waste receiver at an approved recycling facility.

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
Waste grease *(i.e., from machinery)* *Waste oils*	Liquid	Workshop, large machinery maintenance Machinery and vehicle maintenance and workshop	<50 kL	<500 kL	Waste grease will be stored in sealed containers or tanks in a designated bunded area, which will then be transported off-site by a licensed regulated waste contractor. Waste grease will be recycled at a licensed waste facility. Waste oils will be transported off-site by a licensed regulated waste contractor and will be reused or recycled by a licensed regulated waste receiver.	Waste recycling Waste reuse or recycling	Waste grease will be recycled at an approved off-site facility by a licensed regulated waste contractor. Waste oils will be recycled by a licensed regulated waste contractor.
Empty waste oil containers	Solid	Workshop	<1 t	<10 t	All drums will be segregated and sealed prior to collection by a licensed regulated waste contractor and transported to a licensed waste receiver for recycling.	Waste recycling	Empty waste oil containers will be recycled off-site by a licensed regulated waste receiver.
Paints *(i.e., general paint, air dried insulating varnish)*	Liquid /Gas	Industrial area infrastructure and workshop	<10 t	<10 t	Paints will be transported to a designated sealed and bunded area to be collected by a licensed regulated waste contractor and transported to a licensed regulated waste receiver for treatment before disposal.	Treat waste before disposal	Empty waste oil containers will be recycled by a licensed regulated waste contractor.
Hydrocarbon contaminated material *(i.e., oily rags)*	Solid/ Liquid	Workshop servicing trucks and light/heavy vehicles	<10 t	<50 t	Hydrocarbon contaminated material will be stored in temporary storage facilities in the mine infrastructure area (MIA), which will then be collected for off-site disposal.	Waste disposal	Hydrocarbon contaminated material will be disposed of by licensed waste transport operators at an appropriately licensed waste disposal facility.
Miscellaneous chemicals *(i.e., engine coolant, solvents, sealants, etc.)*	Liquid /Gas	Workshop and administration	<1 kL	40 kL	Miscellaneous chemicals will be transported to a designated sealed and bunded area for collection by a licensed regulated waste contractor and transported to a licensed regulated waste receiver for treatment and disposal.	Treat waste before disposal	Miscellaneous chemicals will be disposed off-site by a licensed regulated waste contractor at an approved licensed facility.

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
Batteries *(i.e., dry cell, gel cell, lead acid)*	Solid	Operation of portable electrical equipment (radios, phones, etc.) within the workshop and other areas	<10 t	<200 t	Batteries will be segregated and stored within dedicated containers in the battery storage area, which will then be collected and transported by a licensed regulated waste contractor to a licensed regulated waste facility for recycling.	Waste recycling	Batteries will be recycled by a licensed regulated waste contractor at a licensed regulated waste facility.
					Remaining batteries that are not recyclable will be disposed of by a licensed regulated waste contractor.	Waste disposal	Batteries will be disposed off-site by a licensed regulated waste contractor at a licensed regulated waste facility.
Ozone depleting substance *(i.e., refrigerants and air conditioning substances)*	Liquid /Gas	Air conditioning units, fridges and cars throughout site	<10 kg	<10 kg	Ozone depleting substances will be stored at the source in cylinders and returned to the supplier for reuse and recycling.	Waste reuse and recycling	Ozone depleting substances will be recycled by a licensed regulated waste contractor.
Clinical waste (*i.e., First Aid, medical*)	Solid/ Liquid	First Aid kits, medical kits	< 30 kg	<30 kg	Clinical waste will be stored in labelled receptacles	Waste disposal	Removed by licensed contractor to a medical waste facility for treatment and disposal
Limited Regulated							
Tyres *(i.e., light and heavy vehicle tyres)*	Solid	Tyres from light and heavy vehicles	200	500	Tyres will be segregated and re-purposed on-site in a designated area where there will be no flammable materials within a 10 m radius. Tyres will then be transported off-site to a supplier for re-treading. Tyres will be placed in a manner that prevents water retention and minimise mosquito breeding.	Waste reuse	Reuse on-site for alternate purposes.

Waste type/waste category	Form	Source	Approximate quantity (per annum)		Storage and management strategies	Management hierarchy	Proposed disposal location
			Construction	Operation			
					The remainder of tyres that will not be re-purposed will be disposed of on-site in a designated tyre disposal area of the backfilled mine pit. The disposal area of the backfilled mine pit will not be directly on the pit floor and will ensure it does not impede saturated or unsaturated aquifers or compromise the stability of the consolidated landform.	Waste disposal	Tyres will be predominantly disposed on-site within a designated tyre disposal area of the backfilled Pit. Where possible, they will be recycled through operators.
Sewage	Liquid	Offices, workshops and accommodation facility	< 7,500 kL	<15,000 kL	Sewage generated on-site will be pumped to the sewage treatment plant (STP) at the accommodation facility. Treated effluent will be irrigated with sprinklers to a designated area located at a distance of at least 50 m away from site offices and residences.	Treat waste before disposal	Treated effluent will be irrigated with sprinklers to a designated area.
					Sewage sludge will be directed to the septic systems and will be removed as required by a certified regulated waste contractor for off-site disposal.	Disposal	Waste sludge will be disposed of by a regulated waste contractor.

17.3.4 Mineral waste generation and storage

The two main sources of mineral waste generated from the mining process are:

- overburden and non-ore material (waste rock); and
- tailings from on-site mineral processing.

Other mine materials generated from the Project are discussed in Section 17.3.4.3.

Waste rock stockpiles and tailings storage facilities are shown in Figure 17-1.

17.3.4.1 Overburden and waste rock

An estimated 188.05 Mt of overburden will be excavated over the life of the mine. The majority will be generated in the first 18 years of the mine life, although it will continue to be generated until approximately year 42 (refer Table 17-4).

Excavated overburden and non-ore-bearing material will be removed and placed in the two out-of-pit waste dumps located adjacent to the mining void.

For closure, waste rock from one of the WRDs will be used as backfill and capping material for the backfilled void. The other WRD will remain as a landform at closure.

Table 17-4: Indicative mine schedule

Year	Overburden (Mt)	ROM Ore (Mt)	Total Tailings to TLD1-4 (Mt)	Void backfill (Mt)
-2	0.0	0	0	0
-1	0.1	0	0	0
1	18.5	3.5	1.2	0
2	0.036	3.5	2.4	0
3	14.7	3.5	3.3	0
4	4.2	3.5	3.3	0
5	16.7	3.5	3.3	0
6	3.5	3.5	3.3	0
7	16.8	3.5	3.3	0
8	0.7	3.5	3.3	0
9	9.9	3.5	3.3	0
10	6.5	3.5	3.3	0
11	8.9	3.5	3.3	0
12	12.8	3.5	3.3	0
13	11.7	3.5	3.3	0
14	11.7	3.5	3.3	0
15	3.0	3.5	3.3	0
16	0.004	3.5	3.3	0

Year	Overburden (Mt)	ROM Ore (Mt)	Total Tailings to TLD1-4 (Mt)	Void backfill (Mt)
17	0	3.5	3.3	0
18	4.1	3.5	3.3	0
19	2.8	3.5	3.3	0
20	1.4	3.5	3.3	0
21	0.3	3.5	3.3	0
22	0.1	3.5	3.3	0
23	0.02	3.5	3.3	0
24	0.09	3.5	3.3	0
25	0.9	3.5	3.3	0
26	0.1	3.5	3.3	0
27	0.1	3.5	3.3	0
28	3.0	3.5	3.3	0
29	3.0	3.5	3.3	0
30	0.2	3.5	3.3	0
31	5.4	3.5	3.4	0
32	1.1	3.5	3.4	0
33	2.2	3.5	3.3	0
34	0.1	3.5	3.3	0
35	1.9	3.5	3.3	0
36	2.7	3.5	3.3	0
37	5.9	3.5	3.3	15.1
38	4.5	3.5	3.3	15.1
39	0.9	3.5	3.3	0
40	4.6	3.5	3.3	0
41	2.8	3.5	3.3	5.6
42	0.1	3.5	3.3	24.6
43	0	3.5	3.3	27.1
44	0	3.5	3.3	18.3
45	0	3.5	3.3	9.7
46	0	3.5	3.3	6.4
47	0	3.5	3.3	18.6
48	0	3.5	2.3	20.1
49	0	2	1.05	20.1
50	0	0	1.05	20.1

Year	Overburden (Mt)	ROM Ore (Mt)	Total Tailings to TLD1-4 (Mt)	Void backfill (Mt)
51	0	0	1.05	20.1
52	0	0	1.05	20.1
53	0	0	1.05	4.2
Total	188.05	170	159.85	245.2

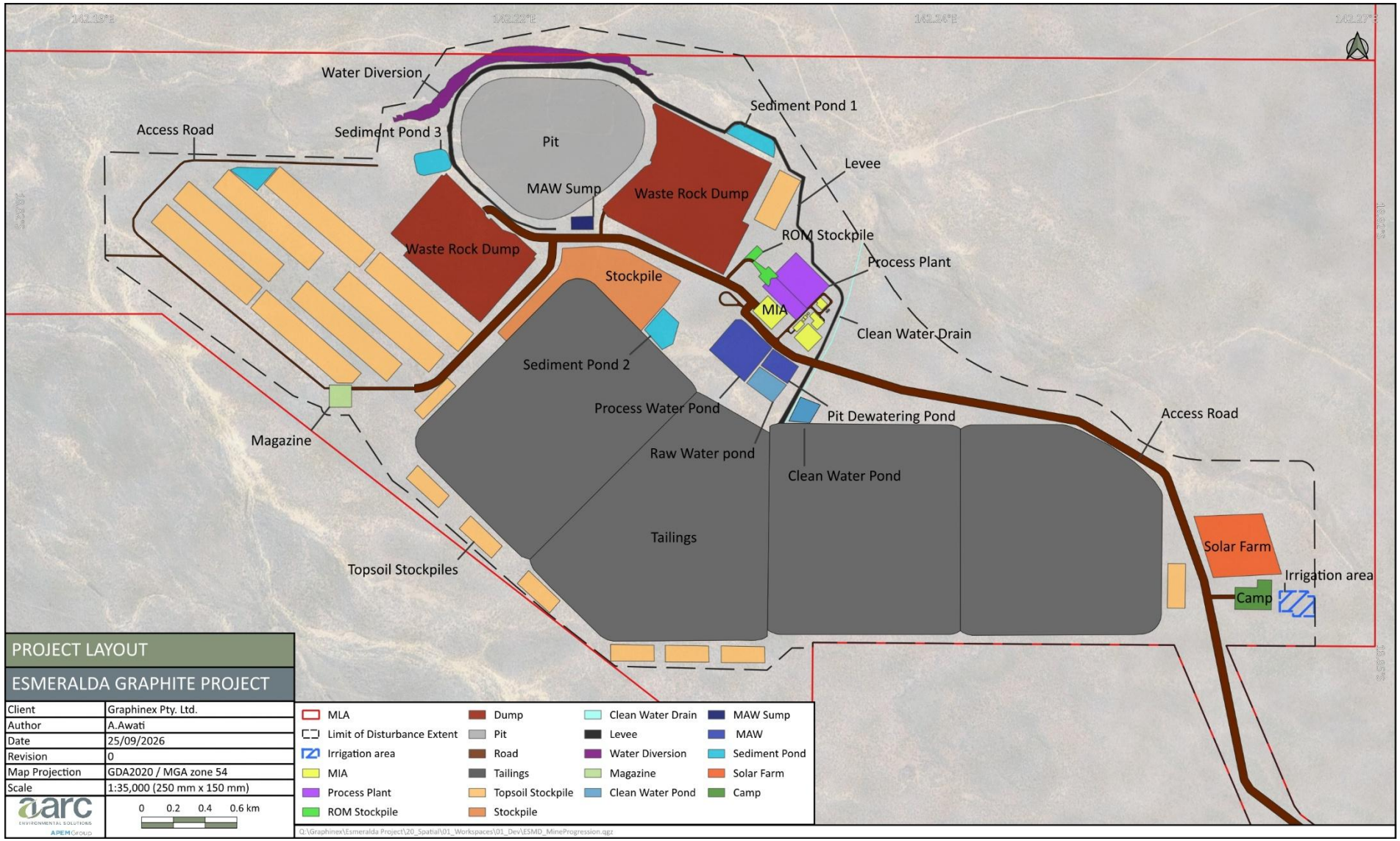


Figure 17-1: Project layout and waste storage areas

17.3.4.2 On site mineral processing overview

Graphite ore processing will commence with an initial crushing and milling circuit, where the ore will be fed from the ROM stockpile to a crusher. The size of the ore will be reduced in the primary crusher before entering the milling circuit, liberating the graphite as a 106-micron product.

Adequately sized ore will be fed into a flotation circuit consisting of rougher, scavenger, and cleaner flotation stages. The ore slurry will pass through a series of flotation cells, where gangue material (commercially worthless material) will be liberated by milling; and removed, to upgrade the graphite concentrate grade.

Rougher flotation tailings will be processed in the scavenger flotation circuit to recover the remaining graphite, with concentrate advancing through the cleaner flotation stages. Scavenger tailings will be directed to the tailings dewatering circuit, where they will be thickened and pumped via the tailings thickener underflow pumps to one of four engineered TSFs.

The flotation concentrate will be dewatered in the concentrate thickener and filter, then dried to a moisture content of >0.1% w/w in the concentrate flash dryer. From the dryer, the concentrate will be conveyed pneumatically to lined shipping containers for dispatch. They will be transported to an Active Anode Material refinery in Townsville.

A process flow block diagram is provided in Figure 17-2.

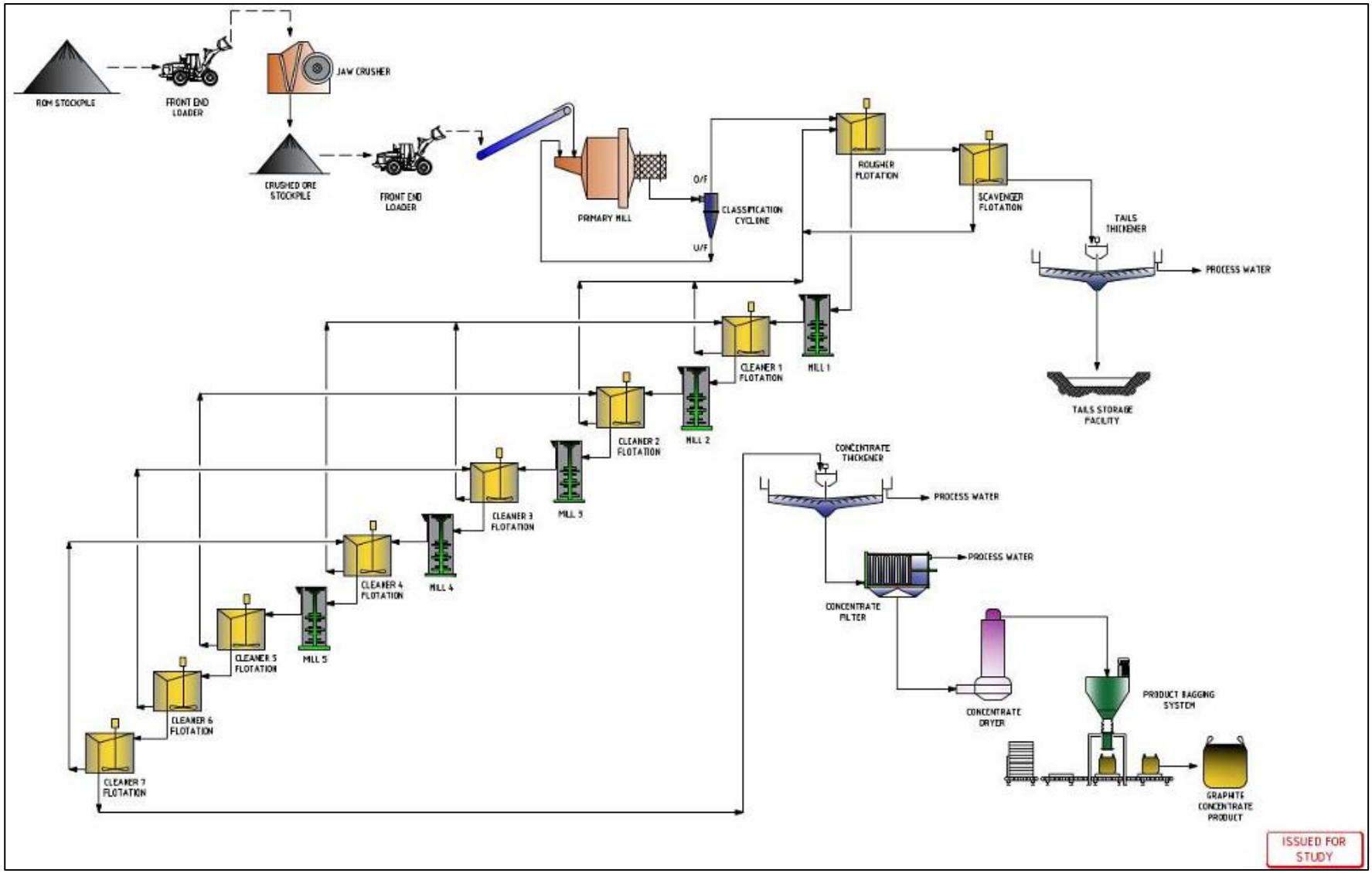


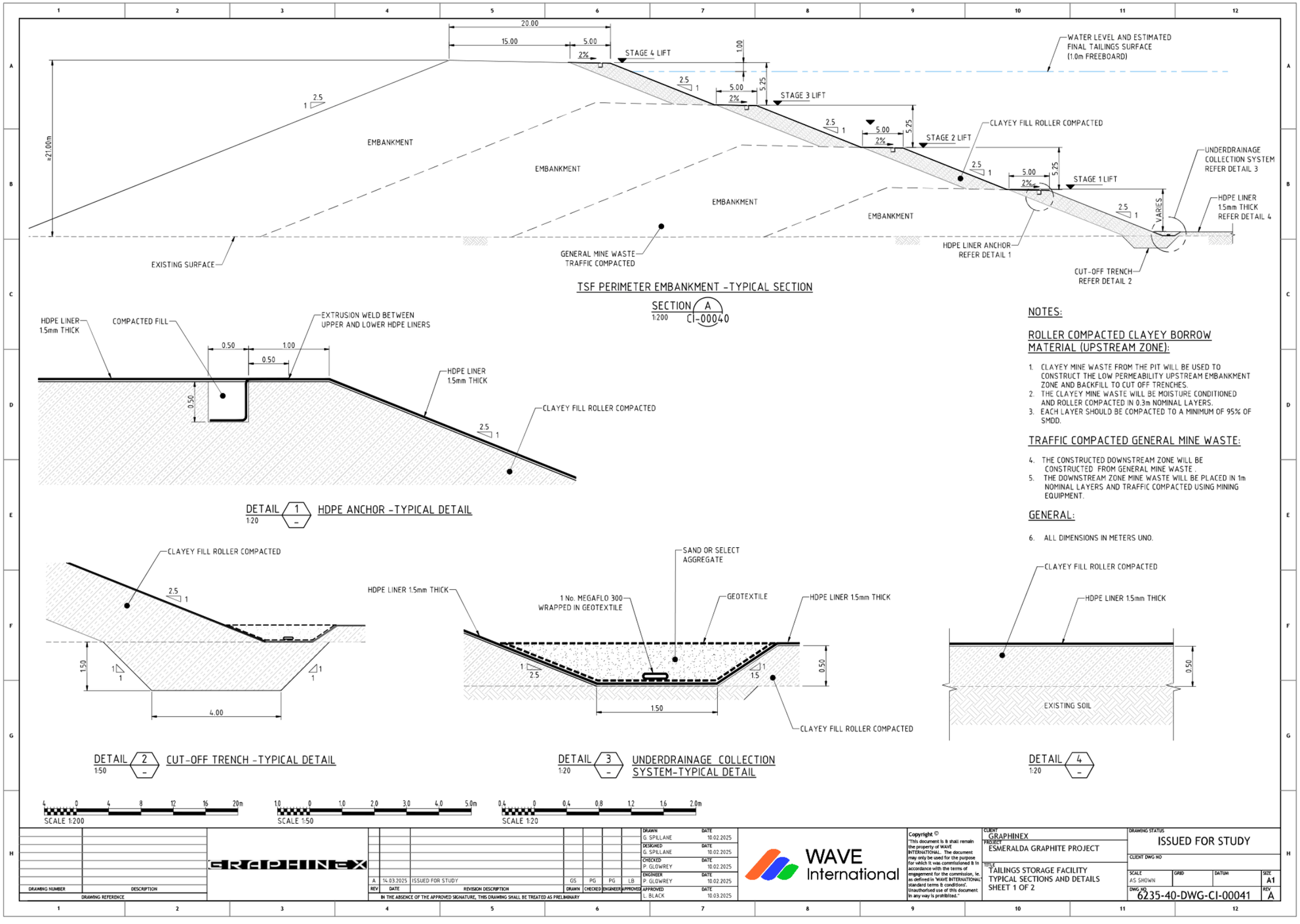
Figure 17-2: Process flow block diagram

17.3.4.3Tailings

As detailed above, a tailings stream will be generated as a biproduct of the mineral processing circuit, with approximately 159.85 Mt of tailings generated from across the life of the Project. Tailings generated from the mineral processing will be stored in four engineered tailings storage facilities (TSFs).

Floatation tailings will be discharged into the TSFs via pumped discharge spigots around the perimeter of the TSF. Water produced from the tailings will settle and, along with rainfall, be decanted via a sump and pumped back for re-use in the mineral processing plant (MPP). The volume of tailings and decant water will be monitored throughout the process and checked for leakages during routine maintenance inspections.

As part of the mine schedule, tailings will be transferred to the open pit and deposited at the base of the pit as part of a final rehabilitation strategy that results in no final void. In-pit backfilling will occur from approximately year 35. Ex-pit tailings waste from three of the four TSFs will be progressively transported to the base of the pit void. In-pit waste backfill will be ramped up in year 46, until three of the four TSFs have been completely deposited in-pit. One TSF will remain as a landform on the surface at closure.



NOTES:

ROLLER COMPACTED CLAYEY BORROW MATERIAL (UPSTREAM ZONE):

1. CLAYEY MINE WASTE FROM THE PIT WILL BE USED TO CONSTRUCT THE LOW PERMEABILITY UPSTREAM EMBANKMENT ZONE AND BACKFILL TO CUT OFF TRENCHES.
2. THE CLAYEY MINE WASTE WILL BE MOISTURE CONDITIONED AND ROLLER COMPACTED IN 0.3m NOMINAL LAYERS.
3. EACH LAYER SHOULD BE COMPACTED TO A MINIMUM OF 95% OF SMDD.

TRAFFIC COMPACTED GENERAL MINE WASTE:

4. THE CONSTRUCTED DOWNSTREAM ZONE WILL BE CONSTRUCTED FROM GENERAL MINE WASTE .
5. THE DOWNSTREAM ZONE MINE WASTE WILL BE PLACED IN 1m NOMINAL LAYERS AND TRAFFIC COMPACTED USING MINING EQUIPMENT.

GENERAL:

6. ALL DIMENSIONS IN METERS UNO.

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Figure 17-3: Typical TSF cross-section

17.3.4.4 Mine materials geochemistry

An assessment of mine materials was undertaken by RGS Environmental Consultants (Appendix U, Geochemistry Assessment of Mine Materials and Tailings).

The geochemical characteristics of soil, waste rock and overburden indicate a low risk of acid generation and will be reused for rehabilitation of the site. These materials will used to backfill the void, construct waste rock dumps, as a capping material, or for surface dressing.

Other materials, including ore, low grade ore, and tailings have geochemical properties requiring consideration for storage to avoid environmental harm.

The geochemical properties of each mine material are summarised in Table 17-5; including the two main waste streams —overburden and tailings.

Table 17-5: Summary of geochemical characteristics for mine materials

Description	$pH_{1:5}$	Geochemical classification	Metal/ metalloids
Soil	5 to 6	NAF-B	Al, Cd, Cu, Pb, Zn
Overburden	7 to 8	NAF-B	Al, Mo, Se, CaSO4
Waste rock	Alkaline	NAF-B	F, Al, Cu
Ore body	Slightly alkaline and low pH value	Occasionally NAF/NAF-B. Mostly PAF-LC/PAF	Mn, Cu, Ni, Zn, Pb, As, Co, Cr, S
Low grade ore	Low pH	Mostly NAF/NAF-B. Occasionally PAF	Higher C content
Tailings	6 to 9	PAF	Al, Cr, Cu, Mn, Ni, and Zn Minor Cu, Mo, Re, S and Te

Soil

Soils are generally mildly acidic with low salinity, negligible sulphur, and low acid neutralising capacity, and are classified as NAF-Barren. Some metals may leach at low concentrations due to the mineralised parent material. The soil is considered beneficial and suitable for use as a rehabilitation growth medium. It will be reused for rehabilitating the site (Chapter 13 Rehabilitation and closure).

Overburden

Overburden consists of claystone, sandstone, and siltstone, typically slightly alkaline with low salinity and negligible sulphur. It has low to moderate neutralising capacity and is classified as NAF-Barren. While some elements may leach under alkaline conditions, concentrations are not expected to persist. Overburden is suitable as bulk fill or cover material without Acid Mine Drainage (AMD) management requirements.

Waste Rock

Waste rock comprises fresh to slightly weathered dolerite and metasediments with low sulphur and moderate neutralising capacity. It is alkaline, classified as NAF-Barren, and may initially release minor concentrations of some elements that decrease over time. Waste rock is suitable for bulk fill, cover material, and rehabilitation uses without requiring AMD management.

Ore Body

The ore body is generally circumneutral (nearly neutral) to slightly alkaline, but contains elevated sulphur and low neutralising capacity, resulting in most material being classified as PAF. Acid generation is relatively slow due to sulphur mineralogy, though risks increase with higher sulphur and carbon content. Ore is intended for processing, with resulting tailings managed to limit oxidation. It is unsuitable for direct use as general fill or surface material.

Low Grade Ore

Low grade ore is typically slightly alkaline with low salinity and low to moderate neutralising capacity and is mostly classified as NAF-Barren. Some variability exists, with occasional higher-risk samples. It is considered low risk and will be stockpiled for future processing, or used as backfill, if not processed.

Tailings

Tailings are composed primarily of fine-grained material, behaving predominantly as sand with silt and clay. The tailings are classified as PAF; and enriched, above normal background levels, with a range of metal elements, including Copper (Cu), Molybdenum (Mo), Rhenium (Re), Sulphur (S), and Tellurium (Te). Thus, tailings are slightly alkaline with low neutralising capacity with increased reactivity due to fine particle size. While initial water quality is near neutral, oxidation can mobilise metals under acidic conditions. It is unsuitable for use as surface material without treatment. Tailings will be managed by being placed in engineered TSFs or backfilled into the mine. Tailings management is detailed further in Section 17.7.3.

17.4 Potential impacts

Potential impacts that may arise from Project wastes have been identified to address management and mitigation options to demonstrate compliance with Schedule 8 of the EP Regulation. The impacts of each waste type and reference to the chapter section describing management strategies is in Table 17-6.

Table 17-6: Waste streams and potential impacts

Waste type	Potential impacts	Management options
Non-mineral wastes		
General waste	• impacts to health and hygiene; • increased waste going to landfill; • ongoing pressure on local and regional commercial waste collection, treatment and disposal facilities; • land, surface water and groundwater contamination from leachate or run-off originating from unsealed waste collection and storage areas; • health and hygiene issues resulting from the inadequate management of putrescible wastes; • attraction of pest fauna species (e.g. feral pigs, black rats, feral cats, native rodents and scavenging bird species) arising from an inadequately managed waste collection area; • litter in and around the Project site impacting local visual amenity, creating a fauna entrapment hazard, increasing fire risk or creating a health risk by providing a mosquito breeding habitat; • resource inefficiencies arising from inadequate recycling and/or reuse of waste materials; • infrastructure not to be retained on site at decommissioning; and • litter in and around the Project site: ○ visual amenity;	Section 17.5, Section 17.5.2

Waste type	Potential impacts	Management options
	○ impacts to fauna and flora habitats; ○ increased risk of fire; and ○ creating a health risk by providing a mosquito breeding habitat.	
Regulated waste	• risks to workplace health and safety resulting from unsafe or inadequate storage, containment and/or handling of hazardous wastes; • resource inefficiencies arising from inadequate recycling and/or reuse of waste materials; and • pollution to the receiving environment (e.g. surface water and land). • Any major contamination from waste storage onsite has the potential to degrade land values by reducing the land's functionality for grazing and agricultural use.	Section 17.5.2, Section 17.6.1
Sewage	• pollution to the receiving environment (e.g. surface water and land); • resource inefficiencies arising from inadequate recycling and/or reuse of waste materials; • spills or leaks into the surrounding environment; and • land, surface water and groundwater contamination from inappropriate and/or inadequate treatment and management of sewage effluent.	Section 17.6.3
Mineral wastes		
Overburden and waste rock	• risks to workplace health and safety resulting from unsafe or inadequate storage, containment and/or handling of mine materials; • visual amenity; • land, surface water and groundwater contamination from seepage from waste rock emplacements; • resource inefficiencies arising from inadequate recycling and/or reuse of waste materials; and • impacts to visual amenity due to the planned spoil emplacements of excavated waste and overburden.	Section 17.7.1
Tailings	• risks to workplace health and safety resulting from unsafe or inadequate storage, containment and/or handling of mine materials; • visual amenity; • land, surface water and groundwater contamination from seepage from TSF; • impacts to visual amenity due to the planned TSFs.	Section 17.7.3

The following sections further discuss some of the potential impacts.

17.4.1 National Environment Protection (National Pollutant Inventory) Measure 1998

The Project will be assessed against the requirement of the *National Environment Protection (National Pollutant Inventory) Measure 1998* (NPI NEPM).

17.4.2 Impact to air quality

No burning of waste is anticipated by the Project, meaning toxic fumes associated with this activity will not be generated that could affect sensitive receptors. Dust emissions are not predicted to affect any sensitive receptors. Further details are presented in Chapter 23, Air Quality.

17.4.3 National Pollutant Inventory assessment

An indicative assessment of the Project's potential emissions to air and land against the NPI reporting thresholds has been undertaken. This assessment considers the peak operations in year 42, and therefore is a conservative over-estimate of other, lower impact years. Emissions to air, as assessable under the NEPM NPI are listed in Table 17-7. Emissions to land are listed in Table 17-8. A threshold determination against NPI categories is presented in Table 17-9.

Following the commencement of the Project, an annual assessment of the Project as a facility against NPI thresholds will be undertaken, in accordance with the most current version of the NPI guide, and industry reporting materials provided by DETSI. For any exceedance of thresholds, the Project will lodge an NPI report with DETSI.

Table 17-7: Estimated peak emissions to air

Substance	Est. t/annum	Source
PM_{10}	1,800	Haulage, wind erosion, crushing and screening, gensets, blasting
$Pm_{2.5}$	290	Haulage, wind erosion, crushing and screening, gensets, blasting
Oxides of Nitrogen	3,500	Diesel generators
Carbon monoxide	780	Diesel generators
Sulfur dioxide	1.3	Diesel generators
Total VOC	Not quantified	Combustion of diesel, refuelling
MIBC (as Total VOC)	765	Flotation cells, thickeners, TSF surfaces
Metals and compounds in dust	Mn: ~0.88 Cu, Ni, Zn: ~0.3 each Pb: ~0.070 As, Co: ~0.050 each Cr: ~0.04 – 0.4	Ore, tailings, waste rock dust

Table 17-8: Estimated peak emissions to land

Substance	Estimated quantity	Source
Tailings	3.25 Mtpa	Processing plant, stored in TSFs.
Waste rock	Up to 4.5 Mtpa	Initial overburden and waste rock removal, majority within first 18 years of operation.
Treated effluent	15,500 kL/year	Sewage treatment plant and irrigation.

Table 17-9: Estimated peak NPI threshold determination

NPI category	Threshold	Project	Outcome
Cat 2a – fuel burnt	> 400 t/annum	~ 24,500 t/annum	Triggered
Cat 2b- fuel burnt	> 2000 t/annum	~ 24,500 t/annum	Triggered
Cat 1 – Substance usage	10 t/annum (handling, processing, usage)	Ore (3.5 Mtpa), waste rock, and tailings (3.25 Mtpa)	Triggered for Mn, Cu, Ni, Zn, Pb, As, Co, Cr
Cat 1a – Total VOC	25 t/annum	~ 3,300 t/annum	Triggered
Cat 3 – Total Nitrogen (N) / Phosphorous (P) to water	15 t/annum N 3 t/annum P	< 1 t/annum	Not triggered

17.4.4 Flora and fauna impacts

Waste may impact ecological values through litter or by causing an increase in pest and feral animals if waste areas and food stores are not properly managed. Measures to prevent waste impacts on ecological values will be required. This is detailed further in Chapter 18, Flora and Fauna.

17.4.5 Hydrological changes

17.4.5.1 Non-mineralised waste impacts

Waste and its storage could impact surface water values through contaminant releases or non-biodegradable objects finding their way into watercourses. Further details about surface water features are discussed in Chapter 15, Water Quality.

There is potential for groundwater quality to be altered by release of contaminants. Details of the existing groundwater environment is provided in Chapter 14, Water Resources and Chapter 15, Water Quality.

17.4.5.2 Mineralised waste impacts

During the operations, the excavated overburden and non-ore-bearing material removed from the open pit will be placed in two out-of-pit waste dumps located adjacent to the mining void. Extracted ore will be stockpiled or taken directly to the on-site mineral processing plant. Tailings generated from the mineral

processing will be stored in four TSFs. Storing the waste rock and overburden, ore, and tailings has the potential to impact surface and groundwater quality by releasing contaminants.

A closure, waste rock from one of the WRDs will be used to backfill the pit and as capping material for the backfilled void. The other WRD will remain as a landform. The tailings will be transferred to the open pit in-pit backfilling. One TSF will remain as a landform. Storing the waste rock and overburden, ore, and tailings has the potential to impact surface and groundwater quality by releasing contaminants and AMD. Storing the waste rock and overburden, and tailings in landforms has the potential to impact pit surface water and groundwater via release of contaminants. Placing the waste rock and tailings in the pit has the potential to impact groundwater quality by releasing contaminants.

17.5 Waste avoidance, mitigation and management

The Project has implemented the waste management hierarchy within the waste management measures to be implemented during construction, operation and decommissioning phases of the Project. This will be underpinned by the early identification of predicted waste streams and their quantities, so that mitigation and management measures aimed at reducing social, economic and environmental impacts can be effectively implemented.

The proposed methods for managing waste streams based on appropriate guidelines and industry best practices described in Sections 17.5 to 17.7.

17.5.1 Optimising natural resource use, reuse, recycling and recovery processes

The following sections describe aspects of the Project that have considered optimising efficient use of natural resources, reuse, recycling and recovery processes. These include activities relating to:

- resource extraction;
- mine operating;
- water use; and
- energy use.

17.5.1.1 Project design to efficiently extract and process the resource

To embed efficiency concepts in the Project design, the environmental management system is based on preventative principles and encompasses eco-efficiency and pollution prevention, with risk reduction to humans and the environment.

The following cleaner production principles have been embedded into the Project:

- Project site layout and design to limit the extent of land to be disturbed during the construction and operational phases;
- efficient resource extraction by utilising optimal geological models and mine planning software;
- optimising mine planning outcomes by selecting the most efficient and productive mining machinery and equipment suited to the geological structure and sequence of the mine;
- selecting efficient and practical extraction and processing technologies and equipment suited to the geochemical and physical characteristics of the run of mine (ROM); and
- establishing recycling programs for used materials where practical and feasible.

17.5.1.2 Natural resource use efficiency— Water

Due to the remote location of the Project, water security is a key factor for Project viability. Water is required to:

- operate the mineral processing plant;
- operate the accommodation facility and sewage treatment plant;
- consider re-use options for reverse osmosis brine; and
- dust suppression during construction and operational phases throughout the site.

Water required for construction and operational activities will be supplied by recycling water on the mine site. Sources will include groundwater infiltrating into the pit, which will require dewatering to enable the mining operations. Water will also be recovered from the processing circuit and from the TSF and recycled for reuse in operational activities.

Other available sources of water, required for operational activities, will be from:

- mine affected water storages;
- sediment storages;
- raw water harvesting system;
- authorised take with underground water as part of approved mining operations under the MR Act; and
- storage and drainage diversion of undisturbed catchments.

A potable water supply will be supplied using an on-site reverse osmosis (RO) water treatment plant to reuse and process site water. Potable water may also be transported to site.

Applying for licenses for a water supply under the Water Act and the GABORA Water plan will be subject to separate assessment and approval processes. The Project water balance, water resources and management is detailed further in Chapter 14, Water Resources.

17.5.1.3 Natural resource use efficiency— Energy

The Project has an expected peak operational power demand of approximately 30 MW, including mining, accommodation, administration, and processing demand.

There is no existing connection to the regional electricity, therefore power will be supplied by an onsite 10MW solar farm and associated 5MW / 35MWh energy storage system, supported by diesel power generation as supplementary loading. Infrastructure for distribution will include transmission-lines and an onsite switching/substation located adjacent to the mine infrastructure area.

These energy sources will ensure electricity demand can be met during peak energy periods. To minimise disruption to operations, critical infrastructure will have emergency diesel generators installed to run in the event of an outage. Diesel generators will be required during the construction phase to supply until the solar array and battery energy storage system has been developed.

Energy efficiency principles will be implemented in mine infrastructure design and operation, including installing energy efficient fit-outs such as lighting and appliances.

17.5.2 Implementing the waste management hierarchy

17.5.2.1 Waste avoidance

Where possible, raw materials will be delivered in bulk form to minimise packaging waste. Purchase and procurement will consider packaging in the supplier selection where feasible. Where bulk delivery is not

feasible, consideration will be given to packaging and storage, and if practicable, preference given to returnable containers or containers and packaging utilising recyclable and/or biodegradable materials. Alternative raw materials will also be considered where it achieves waste avoidance.

Contracted caterers will be informed of the estimated number of personnel on-site to support appropriate meal preparation and minimise food waste. The primary contributors to general waste are food containers, cans and bottles.

The Proponent will aim to foster a culture of waste minimisation through education and by issuing or encouraging reusable drink and food containers, which can then be recycled as part of the recycling program (refer to Section 17.5.2.2). Efforts will also be made to minimise plastic use in this context.

Water refill stations will be provided, where practicable, in work areas and accommodation facilities.

17.5.2.2 Waste reduction

The amount of waste being produced throughout the Project will be reduced by limiting the number of materials brought onto the site to those necessary for the operation.

17.5.2.3 Waste reuse, recycling and recovery

A recycling program will be established and promoted to encourage the recycling of waste materials, including paper, cardboard, ferrous and non-ferrous metals and air filters. The recycling program will utilise coloured bins and signage for waste segregation. Waste oils are expected to be recycled by a licensed, regulated waste contractor and may be reused. Ferrous and non-ferrous metals will be recycled where possible. Where practicable, timber and air and oil filters will be recycled. Cardboard and general recyclables will be taken in bulk by waste contractors to a licensed recyclable facility.

Food scraps and other organic waste will be collected and stored at a designated location and transported off-site for beneficial reuse, including composting or other decomposition processes, thereby preventing disposal to landfill. No waste will be incinerated.

Other potentially recyclable materials will be reassessed at an appropriate frequency to determine if new or innovative recycling technologies can be utilised. A waste collection area will be established to facilitate the collection and separation of waste and recyclable streams and provide storage infrastructure appropriate for the various waste streams on-site.

17.5.2.4 Treatment

The Project will not be connected to a regional sewage system. As such, apart from the collection and segregation of waste streams, the only waste treatment to occur on-site will be the treatment of sewage generated at the Project. An on-site sewage treatment plant will be constructed, while a primary sewage treatment process will be installed during the construction phase. A package STP will be constructed during this phase of works to support operational effluent management and used once operational. Sewage waste management is discussed in Section 17.6.3.

17.5.2.5 Disposal

There will be no general, regulated, or putrescible waste landfill on-site. Only inert materials (e.g. used mining equipment tyres, green waste, used road base, concrete etc.) will be disposed of on-site, and then within designated areas within the WRDs and pit, where practicable. All other wastes will be transferred to a licensed waste disposal facility by a registered, commercial waste contractor as outlined in this chapter. In accordance with the 'Operational Policy: Mining, Disposal and Storage of Scrap Tyres at Mine Sites' (DESI 2024), and where practicable, purchase agreements for mine equipment tyres will seek take-back clauses and recycling opportunities will be explored. If surplus used tyres remain, these will be disposed of at depth within the backfilled mine pit. Tyre disposal will occur above the backfilled tailings and mixed with overburden, ensuring tyres are not directly placed on the pit floor. This approach will ensure that it will prevent interference with the stability of the consolidated layers of the backfilled tailings or tailings capping

layer. Waste rock and overburden backfilled above the tailings and tailings capping layer will be relatively unconsolidated by nature. Therefore, tyres or other inert material would not affect the stability of this landform.

Several licenced operators, such as Tropical Waste, provide regulated waste removal for mines and industrial operations in the North Queensland region, and it is expected that regulated waste removal will be viable for the Project.

17.6 Non-mineral waste management

This section details the non-mineral waste management practices to be implemented for the Project.

No external waste (including tyres) will be received for disposal on-site. However, ERA 60(1)(a) at threshold (d) (more than 200,000t), is considered relevant for the Project for the handling and disposal of waste including:

- tyres;
- concrete; and
- other suitable site-generated waste.

The quantity of this waste is not expected to exceed 200,000t in any given year, however in combination with mineral waste (as described in Section 17.7), 200,000t in some years will be exceeded due to movement and disposal of tailings and waste rock.

17.6.1 General waste handling, storage, collection and disposal

A designated on-site waste collection area will allow for the temporary collection, segregation and storage of waste prior to disposal off-site. Skips, bins and other receptacles will be located at appropriate locations around the site to facilitate the collection and segregation of waste streams, prior to transfer to the waste collection area. General waste will be segregated into non-recyclable and recyclable streams.

All non-recyclable general waste, including putrescible and non-recyclable/refurbishable wastes will be collected in front-lift bins for weekly collection by a licensed waste management contractor. Waste will be stored securely to prevent attraction of, and access by, scavenging fauna.

The management of recyclable waste and the recycling program are discussed in Section 17.5.2.3.

Reverse osmosis brine will be assessed for quality following determination of a specific system, as this may be suitable for non-potable water uses such as processing water.

ln accordance with the waste management hierarchy, waste materials will be segregated during handling and storage on-site. To efficiently manage waste streams, solid waste will be separated before transportation to the appropriate facility. Locations for waste separation and storage will be located throughout the Project infrastructure and administrative areas.

Separate waste bins for general waste, cardboard, scrap metal and comingled recycling will be provided. Co-mingled recycle and general waste bins will be strategically located around site to enable easy segregation and recycling at the point of use or waste stream generation.

Materials such as metals, solvents, oils and wood products will be segregated and where possible reused. Opportunities for recycling of other wastes will be utilised where practicable. Storage of waste will differ according to the specific waste type (refer to Section 17.5.2.3).

Flammable and combustible liquid wastes will be stored in accordance with AS1940–2017 ‘The Storage and Handling of Flammable and Combustible Liquids’ to prevent contamination of land, surface water and

groundwater. If waste materials cannot be reused onsite, then they will be stored in skips and collected by licensed contractors for offsite reuse, reprocessing, recycling or final disposal.

Final disposal of wastes will be undertaken by a registered contractor to a licensed waste facility that is suitable for the type and quantity of waste. Local facilities which may be considered for the final disposal of wastes are the Croydon Landfill Facility. Where local facilities are unable to accept Project waste types or quantity, it may be transported to larger facilities in Mt Isa or Mareeba.

17.6.2 Regulated waste

Regulated wastes, including waste oils, oil filters, waste grease, paints and various hydrocarbon contaminated materials will be handled and disposed of in accordance with the properties of the specific materials, best practices and Australian Standards. This will include storage in bunded areas and immediate clean-up of spills.

The most significant regulated waste stream is waste oil that has the potential to be re-refined through for reuse. Minor regulated waste streams will be collected and stored at the Project waste collection facility and batch disposed of to various specialist waste treatment, recycling or disposal facilities. Pre-emptive disposal will be undertaken prior to forecast adverse weather events, including cyclones. Regulated waste will be managed and stored at the MIA and the camp (Chapter 4 Project description, Figure 4-2).

17.6.3 Sewage

The Project will construct a package Sewage Treatment Plant (STP) at the on-site accommodation facility (Figure 17-1). Sewage generated at the accommodation facility and MIA will be pumped to a package STP by way of underground sewage pump stations and underground rising mains. Due to the remote location of the Project, the disposal method of choice for the sewage effluent generated on-site from the STP is via land application through irrigation. Prior to site development, sewage effluent generated during the construction phase will be managed and disposed of by private contractors, including temporary storage and removal by truck. The on-site accommodation camp will have capacity to accommodate a peak operational workforce of 192 workers on different roster configurations and a peak construction workforce of 100 workers.

The sewage treatment activities constitute an Environmentally Relevant Activity (ERA 63) under the *Queensland Environmental Protection Regulation 2019*. Wastewater will be generated from the use of toilets (classified as black water) and showers, laundry, kitchen (classified as grey water) and will be treated to ensure protection of environmental values, followed by appropriate land-based disposal. Hence, an environmental assessment of effluent disposal sustainability was undertaken in accordance with the Queensland Government's Model for Effluent Disposal using Land Irrigation (MEDLI) (refer Appendix M, Land-based Effluent Disposal Assessment Report). As a conservative estimate, the MEDLI assessment assumed 200 workers onsite each day. Additionally, the assessment also determined the preferred STP design, suitability of proposed irrigation area, irrigation schedules, potential environmental risks and associated mitigation and management measures. The Soils and Land Suitability Assessment (Appendix H) also informed this assessment.

The STP will be designed to treat 100% of the wastewater (modelled at 200 L per person per day) assumed to become wastewater requiring treatment in the plant. It is important to note that wastewater from mine water and sediment water will be stored and handled in a separate manner. The following sections will discuss the existing environment, specifically with regards to the MEDLI to identify potential impacts and associated management and mitigation measures to ensure sustainable effluent irrigation for the predicted volume of sewage that will be generated and treated and subsequently land irrigated.

17.6.3.1 Existing environment considered for sewage disposal

A proposed irrigation area for treated effluent disposal is located within the Project footprint, sited > 50 m away from the mine camp (refer Figure 17-4). This area is considered suitable as:

- it is within close proximity to the primary source of wastewater (the proposed mine camp), therefore minimising pumping requirements;
- it is at similar elevation to the primary source of wastewater (the proposed mine camp), therefore minimising pumping requirements;
- it will be highly accessible from the proposed access road; and
- there is sufficient space to allow for placement of an irrigation area and still maintain large buffers from sensitive receptors such as waterways, sensitive ecosystems, the mining camp, the MIA, and the mine itself.

A detailed review of environmental factors relevant to the proposed sewage irrigation area is provided in the following subsections.

Climate factors

The site has a hot semi-arid climate with distinct wet and dry seasons, with evaporation rates generally exceeding rainfall throughout the year (Engeny 2026). The wet season (December to March) receives an average of approximately 140 mm of rainfall, while the dry season (April to November) experiences average rainfalls of approximately 12 mm. Average maximum temperatures are around 36.7°C and minimum temperatures are 23.1°C.

Topography, drainage and groundwater

Regional topography is very flat, contributing to hydraulic interaction between the main waterways during significant wet-season events. Within the Project area, the landform is flat to gently undulating, with elevations ranging between 120 m and 140 m AHD. The site is traversed by unnamed tributaries of Warrigal Creek that drain from south-east to north-west. Flow within this system is largely restricted to the wet season (December to March).

The groundwater table elevation broadly reflects the topography in the region, flowing from west southwest to east northeast The depth of the groundwater table is approximately 10 mbGL within the Project area and hosted in the Gilbert River Formation. There is no evidence of dry or wet season baseflow or interactions between groundwater and watercourses/drainage features (Hydrogeologist 2026). This makes the proposed area ideal for effluent irrigation.

Land use and vegetation

The land in the Project footprint is mapped as Agricultural Land Class C2 (pasture land: native pastures), and no Important Agricultural Areas occur within 80 km of the site. Surface conditions comprise a hard-setting soil with no coarse fragments, no rock outcrops and no evidence of erosion, except where minor impacts occur due to existing cattle grazing. The proposed irrigation site is located on a level sand plain of a brown tenosol soil type (1Cl(Ck), Figure 17-6) within least concern corymbia open woodland of RE 2.5.28a (Figure 17-5).

Flood immunity

A review of the Croydon Shire Planning Scheme Map indicates there is a Queensland Flood Assessment Overlay (QFAO) approximately 3 km south west from the proposed irrigation investigation area. The QFAO was developed for use by local governments as a potential flood hazard area and represents an estimate of areas potentially at threat of inundation by flooding. Topography surrounding the Project area is very flat which leads to flooding during localised flood events due to interactions between major waterways.

Flood modelling undertaken by Engeny (2026) identified localised flood impacts in rarer flood events, however there is limited receptors associated with the flooding changes. Given that unnamed Stream Order 3 waterway intersecting the site from the east is required to be diverted around the proposed mining pit extent in consideration of breakout flows from Warrigal Creek and that the proposed implementation of

clean catchment diversions over the Project life is expected to mitigate the risk of any uncontrolled mine water overflow and minimise downstream streamflow impacts, the irrigation investigation area is not expected to be subject to flooding. Refer Appendix K, Surface Water Assessment for further details.

Sensitive receptors

The irrigation area is located at a safe distance from the proposed accommodation facilities and even greater distances to the mine pit and mine infrastructure area. At such large distances, workers will not be affected by any spray aerosols, and such distances are well beyond the minimum of 50 m buffer from residential facilities/public amenities recommended by the QLD Government Technical Guideline for Disposal of Effluent via Irrigation (DES 2020).

Summary

The environmental values of the proposed sewage irrigation area against recommended criteria (AS/NZS 1547:2012) is presented in Table ***17-10***.

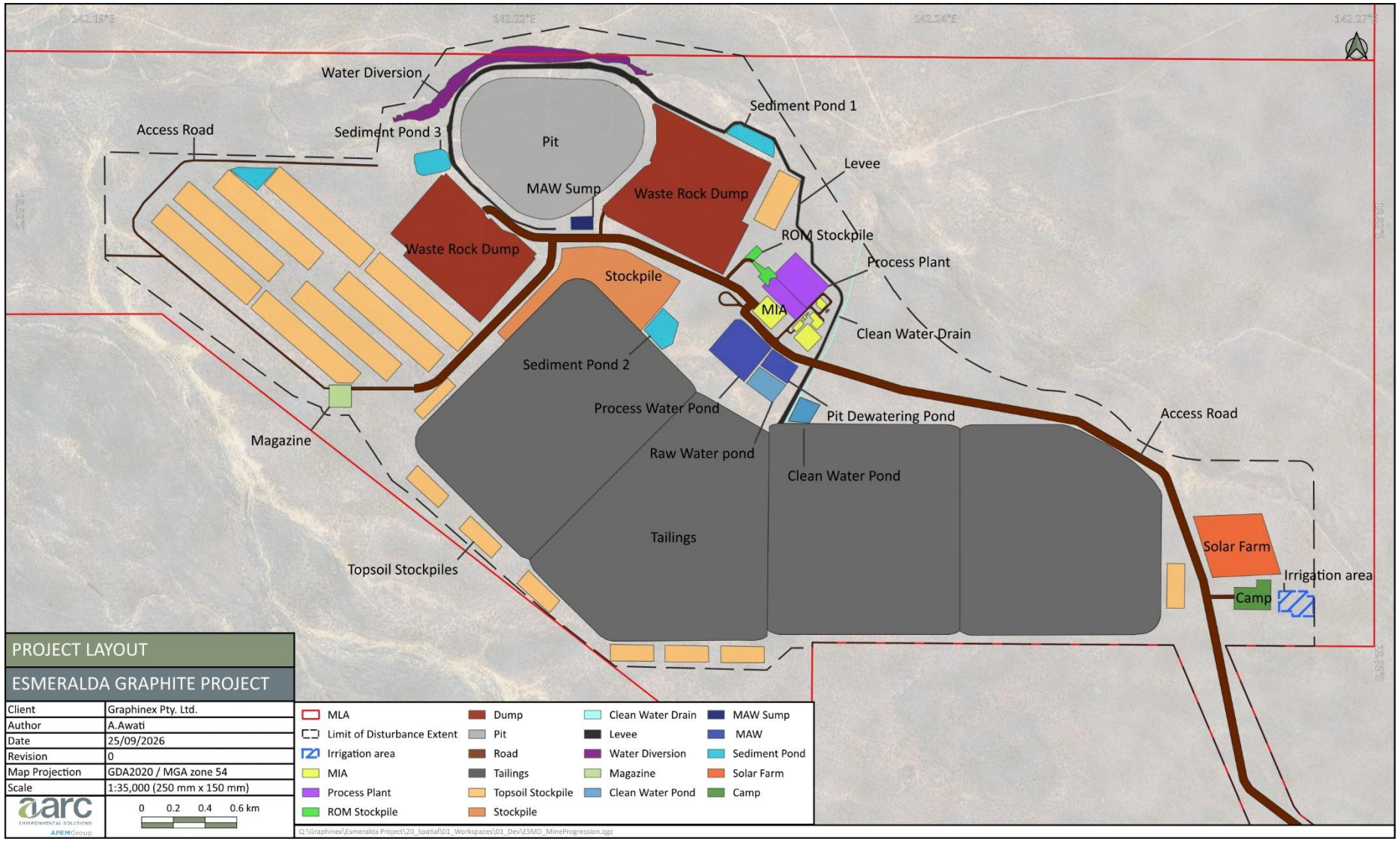


Figure 17-4: Proposed irrigation area for treated effluent disposal

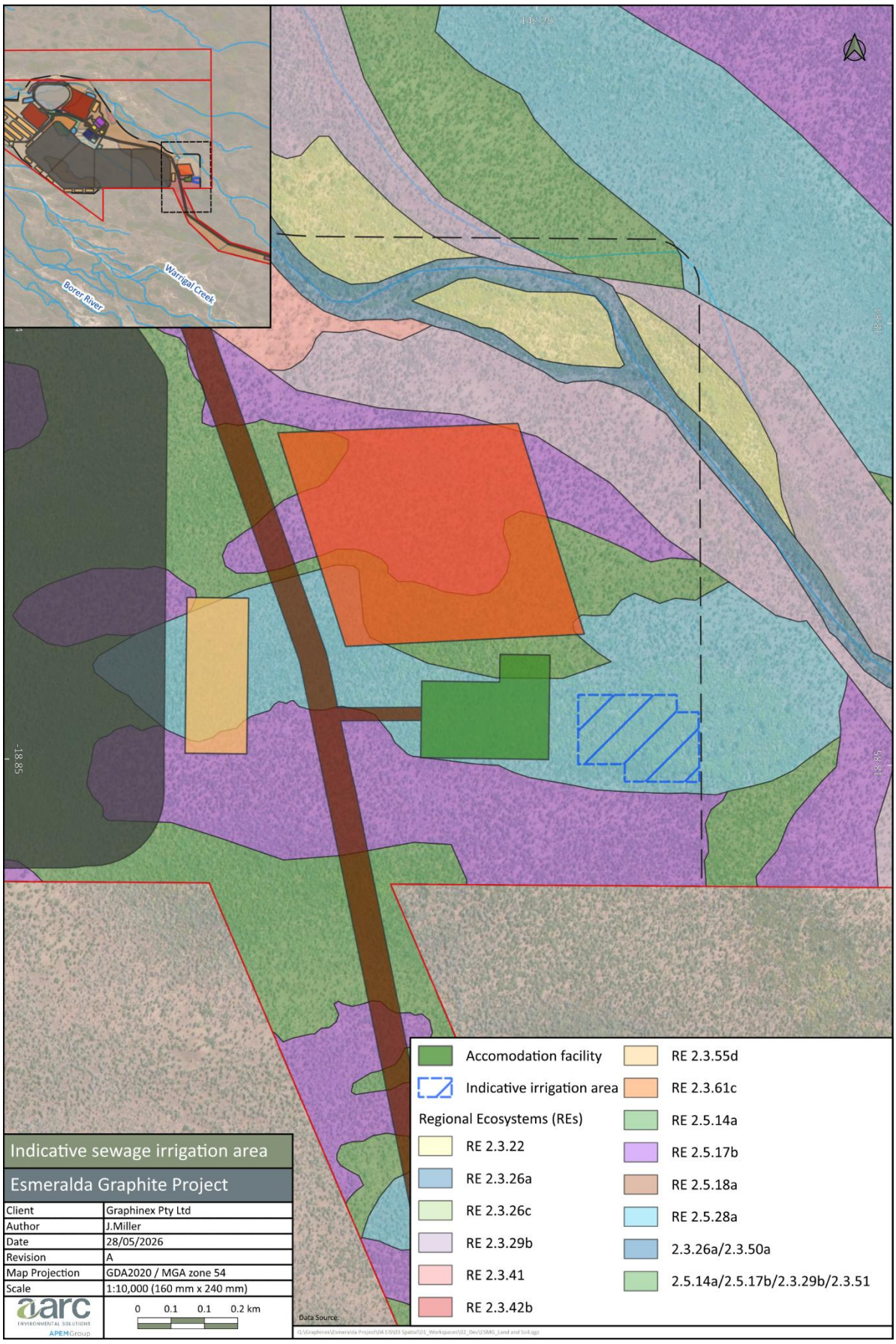


Figure 17-5: Sewage irrigation area with regional ecosystem context

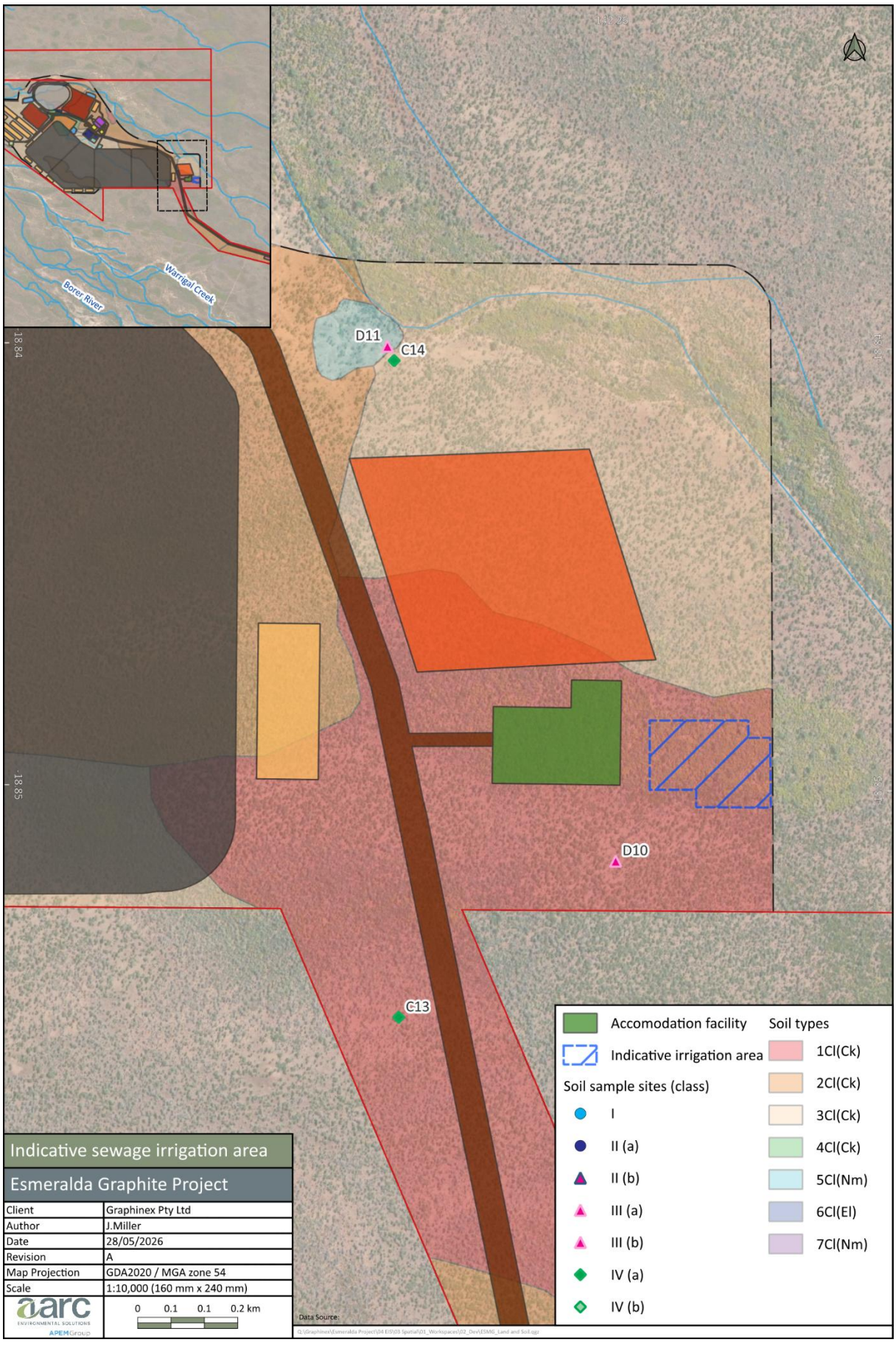


Figure 17-6: Sewage irrigation area with soil type context

Table 17-10: Selection criteria for irrigation system areas (AS/NZS 1547:2012)

	Slope Gradient	**Soil Depth**	**Soil Category Number**	**Depth to seasonal water table**	**Duration of continuous seasonal soil saturation**	**Dispersive (sodic) soil**	**High content of stones, cobbles, or boulders**	**Climatic factors**
Recommendation	Steep slopes can cause greater run-off during wet weather (< 10%)	A minimum of 0.6 m desirable	Categories 1 and 2 may lead to nutrients reaching groundwater Categories 4-6 may require large irrigation fields	>1.2 m depth	Prolonged saturation of upper soil impedes treatment and hinders adsorption.	Sodic soil may lose permeability during life of system.	Unless extremely stony or covered in boulders, not relevant as delivery pipes need not be dug in soil in straight line.	Best in climates where intense rainfall events are uncommon and evapotranspiration exceeds rainfall in most months
Conditions apparent on site	Site slopes (< 1%)	Soil profile > 0.8 m deep	Category 4	Groundwater approx. 10 m below ground	Saturation generally is not an issue given the dry climate with exception of prolonged wet season.	Mixture of non-sodic and sodic at deeper levels of subsoil	Gravel and stone not observed in soil samples	Climate mostly suitable; net evapotranspiration exceeds rainfall year-round

17.6.3.2 Impact assessment

An irrigation area located close to the on-site accommodation has been proposed and assessed in accordance with the assessment guideline "*assessing applications for sewage treatment works".* The Project does not propose the release of wastewater to Queensland waters.

A Model for Effluent Irrigation using Land Disposal (MEDLI) assessment was conducted for the proposed sewage irrigation area (Appendix M). This section describes the modelling scenarios and justifies the chosen land-based disposal method validated through the MEDLI results. The MEDLI software is used to 'simulate how effluent stream is stored, treated and ultimately disposed of, with a particular focus on the water, nitrogen, phosphorus, and soluble salts' (Queensland Government 2025).

Wastewater from sewage plants is commonly reused for land irrigation. The effluents or wastewater generally contain high levels of nutrients as well as contaminants like pathogens and suspended solids. As such it must be managed carefully to ensure continued protection of environmental values such as protecting the soil and the surrounding environment. The MEDLI is used to assess the sustainability of effluent irrigation schemes and identify possible impacts on the environment through design and testing of various modelling scenarios (DETSI 2026). The modelling scenarios are required to reduce uncertainty and demonstrate that the chosen effluent irrigation schedule is both feasible and operationally safe over the long term.

Modelling scenarios for irrigation schedule options

The assessment used three different modelling scenarios to investigate different irrigation scheduling options. Model inputs for Scenarios 1 and 2 had variations in the scheduling trigger and the application rate of wastewater being irrigated. A third scenario was undertaken as a sensitivity analysis for nutrient leaching.

- Scenario 1 – Drained Upper Limit (DUL)

  The DUL represents soil water content after free drainage has ceased (commonly referred to as field capacity). In a MEDLI assessment, the DUL influences the soil water storage capacity, onset of drainage and irrigation triggering and cessation characteristics. In this scenario, irrigation is to occur every day until the DUL (field capacity) of the soil layer is reached.

  This scenario is not constrained by standards or soil category and instead applies irrigation only when required to refill the soil profile to its Drained Upper Limit (DUL). It is designed to test the soil's hydraulic limits by ensuring saturation is not exceeded and to assess drainage and nutrient movement under ideal moisture control conditions.

- Scenario 2 – Design Irrigation Rate (DIR)

  The DIR refers to the amount of irrigation applied per unit area over a period of time. This scenario represents a realistic and compliant operational system that can be implemented in practice. It requires adherence to soil classification, the prescribed Design Irrigation Rate (DIR), and practical scheduling rules.

  In this scenario, irrigation is triggered to occur every day to a fixed depth, based on a DIR provided in AS/NZS 1547:2012 for the soil texture identified. A DIR of 3.5 was selected to match a soil category 4, which is the soil category adopted for the Project effluent irrigation area, based on the field soil assessment at Site D10/the indicative irrigation area (Figure 17-4). The DIR was matched to the soil category to prevent any harm to surface water and groundwater environmental values.

  Soil category 4 represents a moderate to low permeability soil, meaning water is absorbed at a controlled, limited rate. This DIR is set to align with the soil's long-term hydraulic capacity, ensuring wastewater application does not exceed what the profile can sustainably accept. It is specifically intended to prevent prolonged saturation of the clay-influenced subsoil, limit excessive deep drainage and allow adequate time for plant uptake and soil treatment processes.

- Scenario 3 - Sensitivity Analysis

A Rhodes grass pasture option was modelled separately as a sensitivity analysis, representing a deliberately high nitrogen-uptake and high-transpiration endmember. This scenario was included to test:

- the influence of enhanced biological uptake on nutrient leaching outcomes; and
- whether conclusions regarding irrigation area sizing and groundwater risk were dependent on vegetation optimisation.

Overall, Scenario 1 is used to understand system limits and sensitivity, while Scenario 2 relies on compliance with standards for design and approval. The modelled conditions focus on the most critical factor for sewage irrigation sustainability; soil water availability and nutrient uptake by plants, which determine the risk of nutrient leaching and groundwater impact.

Additionally, wet-weather effluent storage has been sized to encapsulate approximately 60 days of Average Dry Weather Flow (ADWF) to accommodate prolonged wet-season conditions typical in north-west Queensland that may limit irrigation schedules. This conservative, standard design ensures continuous system operation without uncontrolled discharge during extended rainfall periods. In the MEDLI modelling, the wet-weather storage was represented as a fully enclosed storage tank.

MEDLI input modelling parameters

A summary of the MEDLI input parameters is detailed in Table 17-11. Further details regarding input parameters can be found in Land-based Effluent Disposal Assessment Report and the MEDLI output report (Appendix M)

Table 17-11: MEDLI input parameters

Parameter	Proposed System
Climate data	Years 1976 – 2025 Average rainfall – 774.7 mm/yr Temperature (mean monthly maximum and minimum) - 14.2°C to 37.6°C
Effluent quantity	40,000 L/day
Wet Weather Storage Tank Volume/Capacity	60 days
Effluent Irrigation Area	1 – 5 ha
pH	5.0 – 8.5
Conductivity (µs/cm)	1600
Total Nitrogen	30 mg/L
Total Phosphorous	10 mg/L
Total residual chlorine, if used for disinfection	1 mg/L
Pasture Type	Monthly Green Deciduous Forest cover and Rhodes Grass
Soil Type	A four-layer soil profile, splitting the topsoil (A horizon) into two layers and the subsoil (B horizon) into two layers, with parameters based on site data and standard texture-based modelling assumptions

The following sections discuss the outputs of the MEDLI modelling. Further details can be found in Appendix M, Land-based Effluent Disposal Assessment Report.

MEDLI output summary

Several scenarios were run to test the irrigation scheduling and undertake sensitivity analysis. MEDLI Output reports for each scenario are provided in Appendix M, with a summary of key parameters provided in Table 17-12.

The multirun feature of MEDLI v2 was used to assess sizing options from 1.0 to 5.0 ha, at 1 ha intervals to test the wet weather storage size, increasing from 60 to 90 days storage, at 10-day intervals. Reviewing the multirun outputs determined that the 60-day wet weather storage option was appropriate with no significant decrease in overtopping with increases in storage size. The outputs also demonstrated that optimal irrigation area size is 3 to 4 ha.

Table 17-12: MEDLI output summary

Parameter	**Units**	**Scenario 1 – DUL – 3 ha**	**Scenario 2a – DIR – 3 ha**	**Scenario 2b – DIR – 4 ha**	**Rhodes Grass Sensitivity Analysis – 3 ha**	**Rhodes Grass Sensitivity Analysis – 4 ha**
Irrigation Area	ha	3	3	4	3	4
Wet Weather Storage Volume	kL	2,400	2,400	2,400	2,400	2.400
Irrigation Control		Every 1 day to 0mm beyond DUL (Excl. rainfall days)	Every 1 day to 3.5 mm (Excl. rainfall days)	Every 1 day to 3.5 mm (Excl. rainfall days)	Every 1 day to 3.5 mm (Excl. rainfall days)	Every 1 day to 3.5 mm (Excl. rainfall days)
Pond Inflow	kL/year	15,704	15,704	15,704	15,704	15,704
Irrigation Volume	kL/year	15,477	15,685	15,687	15,685	15,687
Overflow Volume	kL/10 years	2,104	5.54	0	5.54	0
No. of Days Overflow	Days/10 years	41.2	0.2	0	0.2	0
Overall Reuse	%	99	100	100	100	100
Rainfall	mm/year	775	775	775	775	775
Irrigation Applied	mm/year	516	523	392	523	392
Soil Evaporation	mm/year	353	353	296	5.9	11.1
Transpiration	mm/year	710	704	642	912	810
Rain Runoff	mm/year	21.7	26.4	24.7	52.9	49.4
Irrigation Runoff	mm/year	0	0	0	0	0
Drainage	mm/year	205	213	202	325	295
Plant Species		Monthly Green Covers – Deciduous Forest Cover	Monthly Green Covers – Deciduous Forest Cover	Monthly Green Covers – Deciduous Forest Cover	Rhodes Grass Pasture	Rhodes Grass Pasture
No. of Plant Harvests		N/A	N/A	N/A	2.28	1.76

Parameter	Units	Scenario 1 – DUL – 3 ha	Scenario 2a – DIR – 3 ha	Scenario 2b – DIR – 4 ha	Rhodes Grass Sensitivity Analysis – 3 ha	Rhodes Grass Sensitivity Analysis – 4 ha
Salinity of Soil Solution at Base of Rootzone	dS/m	4.27	4.17	3.33	2.63	2.23
Average Nitrate Conc. Of Deep Drainage	mg/L	N/A	N/A	N/A	0.03	0.04
Average Phosphorus Conc. Of deep drainage	Mg/L	N/A	N/A	N/A	0.0011	0.0009
Design Soil Profile Storage Life for Phosphorus	years	N/A	N/A	N/A	407	499
Nitrogen Irrigated	kg/ha/year	144	145	109	145	109
Nitrogen Uptake		N/A	N/A	N/A	151	114
Phosphorus Irrigated	kg/ha/year	49	49	36	49	36
Phosphorus Uptake		N/A	N/A	N/A	34.2	26

Irrigation scheduling results

The irrigation diagnostics and paddock water balance outputs indicated that there was little practical difference between Scenario 1 and Scenario 2 in terms of irrigation application frequency, total annual irrigation volume and overall soil water behaviour. Total annual irrigation volumes differ only marginally between the scenarios and are well within inter-annual climate variability.

The similarity arises because rainfall largely governs when irrigation is applied or suspended. In both scenarios, irrigation was consistently suspended on days with measurable rainfall (>0 mm), which resulted in approximately the same number of days per year being excluded from irrigation in both cases. As a result:

- irrigation was suspended during wet periods regardless of the scheduling method;
- the soil profile frequently approached or exceeded DUL due to rainfall alone; and
- the opportunity for irrigation to top up to DUL in Scenario 1 was often pre-empted by rainfall.

This meant rainfall events largely controlled irrigation interruptions and limited any meaningful divergence between approaches. As a result, both methods frequently converged toward similar soil moisture conditions, with the soil profile often approaching or exceeding DUL due to rainfall alone.

The outputs showed that Scenario 1 and 2 had similar outcomes, even though Scenario 1 allowed variable irrigation up to the DUL and Scenario 2 had a fixed rate of 3.5 mm/day. The design rate of 3.5 mm/day in Scenario 2 matches the average soil water deficit targeted in Scenario 1, resulting in similar soil moisture outcomes. This occurs because the soil water content is typically only slightly below the DUL, thereby needing only a small amount of irrigation. The fixed application rate of 3.5 mm/day is thus sufficient to meet this deficit. As already discussed, when the soil is already close to DUL, both scenarios result in minimal or no irrigation being applied.

As a result, over time, the total irrigation volumes produced by both scenarios are nearly identical, with any minor differences considered negligible and primarily attributable to natural climatic variability, such as fluctuations in rainfall.

Further, both scenarios also achieve near-complete effluent reuse, indicating that the design irrigation rate is appropriately matched to soil capacity and is neither over nor under-loading the system. Similarly, soil water balance results show comparable outcomes in transpiration, deep drainage and seasonal soil moisture dynamics. This confirms that long-term soil water behaviour is controlled primarily by climate and soil properties rather than differences in irrigation scheduling logic.

Overall, while Scenario 1 is theoretically more optimised through DUL-based control, in practice both approaches produce functionally equivalent long-term outcomes. However, Scenario 2 provides a simpler and more operationally realistic irrigation rule, with no material change to environmental performance.

Irrigation area size results

As discussed in the section on MEDLI outputs, several scenarios were run to test the irrigation scheduling, and undertake sensitivity analysis using a high uptake pasture species. Irrigation area sizes of 3 ha and 4 ha were assessed as most optimal from the outputs. The 3 ha and 4 ha area sizes provided sufficient land area to accommodate all effluent irrigation while avoiding significant overtopping of the wet-weather storage, which is critical given the high wet-season rainfall that could prevent irrigation during those periods.

Results demonstrated that the irrigation area size is not a limiting factor for system operability or effluent disposal reliability as long as the assessed range is over 3 ha. Both the 3 ha and 4 ha irrigation configurations achieve near complete effluent reuse, stable soil water balance and effective wet weather storage operation. Increasing the irrigation area from 3 ha to 4 ha reduces per hectare hydraulic and nutrient loading. However, this does not result in a material reduction in total deep drainage volumes, nutrient leaching risk, or overall environmental performance. Drainage processes continue to be primarily governed by climate and inherent soil properties with wet season rainfall driving the majority of downward water flux independently of irrigation area or scheduling.

Therefore, 3 ha was chosen as the irrigation area size as there is little to no additional benefits from increasing to 4 ha in terms of environmental outcomes.

Nutrient balance results

Nitrogen leaching (N)

Results show nitrogen leaching risk is minimal and does not significantly change between 3 ha and 4 ha irrigation areas.

The operational deciduous forest scenario does not report nitrate concentrations in deep drainage, so the Rhodes grass pasture scenario was used to assess nitrogen leaching under the same irrigation and effluent conditions. Results for a 3 ha area show very low nitrogen losses, ~146 kg N/ha/year applied, with only ~0.10 kg N/ha/year leached (<0.1% of applied N). This indicates nitrogen loss to leaching is negligible with most nitrogen applied to the irrigation area remaining in the soil or taken by plants. Average deep drainage nitrate concentrations are extremely low (0.01–0.03 mg/L long-term), with temporary short-term peaks (<1 mg/L) only in early years or after wet season drainage.

Phosphorous leaching (P)

Results show phosphorus leaching risk is minimal. For the 3-ha deciduous forest scenario with 3.5 mm/day irrigation, ~146 kg P/year (~49 kg P/ha/year) is applied, and nearly all phosphorus is retained in the soil through adsorption and incorporation into soil pools. Over time, there is no increase in dissolved or mobile phosphorus and it is retained in the soil at a steady state.

Salinity

Modelling using Rhodes Grass (considered to be moderately salt-tolerant) indicated stable long-term conditions, with no accumulation in the root zone and salinity levels remaining well below agronomic and environmental thresholds. The MEDLI outputs indicated:

- average annual salt added and leached at steady state: approximately 5,110 kg/ha/year; and
- average rootzone salinity (ECe): approximately 0.63 dS/m.

The irrigation scheme will not result in impacts to grass tolerance threshold and has negligible environmental impact.

Sewage sludge, waste solids, and gases

It is noted that the final STP technology has not yet been selected. However, based on package treatment plants commonly utilised at remote mining accommodation facilities of similar scale (approximately 200 EP), the treatment process is expected to generate relatively small quantities of biological sludge, gross waste solids and trace odorous gases.

Sludge generation is anticipated to be in the order of several tonnes of dry solids per annum and would be periodically removed from the facility for off-site management by appropriately licensed contractors. Final sludge production rates, composition, storage requirements and management measures will be confirmed during detailed design and selection of the preferred STP system.

Published wastewater treatment references indicate that a commonly adopted conventional wastewater treatment system sludge generation rate for planning purposes is 0.24 kg dry solids/m3 of wastewater treated (Turovskiy & Mathai 2006). Applying this factor to the worst-case scenario projected wastewater generation of approximately 40 kL/day suggests sludge production may be in the order of 3–4 tonnes of dry solids per annum, although actual volumes will depend on the treatment technology selected and site-specific operating conditions.

The sewage sludge generated by the proposed package STP is expected to comprise predominantly biological solids, stabilised organic matter, nitrogen and phosphorus nutrients, and minor quantities of inert materials such as grit and fine mineral particles. Consistent with domestic wastewater treatment systems, the sludge would largely comprise microbial biomass generated during the biological treatment process and is not expected to contain significant quantities of industrial contaminants (ANZBP n.d.).

Final sludge production rates, composition, storage requirements and management measures will be confirmed during detailed design and selection of the preferred STP system.

Minor quantities of gross solids may be removed through preliminary treatment processes such as screening and grit removal, depending on the final STP design. These wastes are expected to comprise predominantly paper products, organic matter and other domestic refuse captured prior to treatment, and will be stored in bins for disposal at an appropriately licenced waste management facility.

Modern package STPs are typically compact, enclosed treatment systems, with process units generally contained within tanks or enclosed infrastructure. As a result, opportunities for emissions are limited, with any gaseous releases typically associated with ventilation requirements and minor odour emissions generated during normal wastewater treatment processes.

Consistent with the requirements of ERA 63, sewage treatment wastes will be managed through appropriately designed treatment, storage, monitoring and disposal arrangements to minimise the risk of impacts on human health, land, groundwater and surface water environmental values.

The selected STP will also incorporate appropriate operational and maintenance measures to manage odour and ensure the ongoing protection of environmental values. Based on the remote location of the Project and the separation distances available within the mining lease, any residual odour emissions are expected to be localised and not result in significant impacts to surrounding sensitive receptors.

Groundwater impacts

Groundwater is located at a consistent depth between 8-10 mbGL with substantial unsaturated zones that provide separation between the irrigated soils and the groundwater table. The groundwater table does not intersect the ground surface within the irrigation area or adjacent drainage features, and does not contribute baseflow to local creeks or waterways. Groundwater levels decrease from about 120-125 mAHD in the east-southeast to 100-105 mAHD in the west-northwest, resulting in a consistent flow direction toward the west–northwest, aligned with surface drainage patterns.

The effluent irrigation area overlies the same regional hydrogeological setting assessed for the Project, hydraulically up-gradient of the mine pit. The mine pit is located down-gradient of the irrigation area, in the direction of the regional groundwater flow path. Hence groundwater flow directed toward the mine pit, which will operate as a long-term hydraulic sink due to active dewatering. Additionally, there is no groundwater flow pathway from the irrigation area toward off-site receptors or external groundwater users. Consequently, the likelihood of offsite groundwater impacts from effluent irrigation is considered very low.

Summary

Overall, the model confirmed that a 3 ha irrigation area, operated using a simple, fixed, daily design irrigation rate and supported by a 60-day wet weather storage capacity, provides robust and environmentally sustainable effluent disposal performance. The 4 ha option does not materially improve compliance, risk reduction, or operational resilience and would increase land disturbance and management requirements without delivering a proportional environmental benefit. On this basis, the 3 ha irrigation area is considered the most appropriate and proportionate design for the Project and will be implemented.

17.6.3.3 Mitigation and management measures

Mitigation and management measures detailed in the following sub-sections have considered national and state guidelines, including the Queensland Health's Guideline for low-exposure recycled water schemes (Queensland Health 2025), and *National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006*.

Irrigation scheduling and application rate

A spray irrigation system will be adopted for the site. A fixed daily design irrigation rate of approximately 3.5 mm/day, consistent with AS/NZS 1547:2012 for the site soil category will be adopted. Irrigation will not occur on days with measurable rainfall (>0 mm) on-site.

Irrigation system design specifications

A 60-days of wet-weather effluent storage based on Average Dry Weather Flow will be used to manage prolonged wet seasons and prevent uncontrolled discharges when irrigation is not practicable.

The spray irrigation system will be operated to ensure:

- distribution of effluent evenly across the designated area;
- minimise aerosol formation and spray drift through appropriate sprinkler selection, operating pressures, and inward throw design;
- compliance with signage and public safety requirements in accordance with AS 1319 / AS/NZS 1319; and
- ensure runoff beyond the designated irrigation area does not occur.

Aerosols and pathogen risk management

The exposure to aerosols emitted from sprays will be managed by meeting required pathogen reduction targets (viruses, protozoa and bacteria) through treatment and/or exposure controls. Required pathogen reductions will be achieved through a combination of:

- secondary treatment with disinfection; and
- exposure reduction measures such as restricted access during irrigation, buffer distances, spray drift controls, vegetation screening, and irrigation timing to avoid adverse wind conditions.

Odour and toxin exposure

Odour from the treatment plant and irrigation will be managed through treatment, buffer distances, spray control and timing irrigation to avoid sensitive conditions such as wind toward accommodation and utilizing calm nights.

Wastewater will be treated to a very high level to reduce exposure to toxins. Additionally, other relevant measures undertaken include a reduction in aerosol generation, implementing access restrictions to buffer area and maintenance of buffer zones. The following buffer distances in accordance with Queensland Government technical guidelines, including:

- ≥ 100 m to natural waterways;
- ≥ 50 m to accommodation or public access areas (as a conservative measure);
- ≥ 250 m to domestic water bores; and
- maintaining a minimum groundwater separation of ≥ 3 m.

Monitoring and adaptive management

An Irrigation Management Plan (IMP) consistent with the DETSI Technical Guideline for Disposal of Effluent Using Irrigation will be developed and implemented.

The monitoring program will include:

- periodic soil and groundwater monitoring for nutrients, salinity and sodicity;
- regular reviews of irrigation performance, monitoring results, and operational practices; and
- updates to relevant management measures to ensure ongoing compliance with licensing requirements and environmental objectives.

17.6.4 Non-mineral waste management plan

A Non-Mineral Waste Management Plan (NMWMP) will be finalised prior to commencing, and incorporate the following principles:

- Waste will be segregated into general waste, various recyclable wastes and regulated waste.
- General waste will be collected in clearly designated bins.
- Waste oils, chemicals, batteries and other hazardous and/or regulated substances will be stored in bunded areas or on bunded pallets within the waste collection area.
- Recyclable waste will be separated and stored for collection into streams, including paper and cardboard, metals and recyclable plastics.

- All used tyres will be managed in accordance with the operational policy 'Disposal and storage of scrap tyres at mine sites' (DETSI 2024). This may result in used heavy machinery tyres being disposed of within the backfilled mine pit if other higher order options are not feasible. In this case, the locations of deposited used tyres within the backfilled mine pit will be surveyed and recorded on a register.
- Different forms of waste (e.g. metals, paper, oils, batteries, general waste, etc.) will be stored on-site according to waste stream. The design of the waste collection facility will consider public health, hygiene and safety standards. For example, flammable material or combustible liquid wastes will be stored in facilities designed to meet 'AS 1940:2017, The storage and handling of flammable and combustible liquids.
- Bins located within offices and workshops will be labelled to avoid cross-contamination and provide for separation of different waste streams. Bins will be emptied regularly to minimise vermin and pests. Pest species observed on site will be reported to the party responsible for waste management.
- Regulated and/or hazardous waste will be stored in a separate storage area to ensure that the potential for environmental harm is minimised.
- All trackable waste as defined by Schedule 11 of the EP Regulation will be tracked in accordance with the requirements of Part 9 of the EP Regulation.

The NMWMP will also have verification and performance indicators, including:

- waste monitoring and reporting; and
- site and disposal area inspections.

Review periods for the management plan will be developed, and roles and responsibilities for implementation of the plan will be established.

17.7 Mineral waste management

The management of mineral waste materials is outlined in this section. Additional details in relation to their placement and are provided in Chapter 10, Land —geology, geomorphology, topography and soils, and Chapter 13, Rehabilitation and closure.

Mineral waste generated by the Project, and the proposed storage of these waste materials, is outlined in Section 17.3.4.

Potential impacts for storing mine waste materials during operations and closure are discussed in Section 17.4.5.2.

A PRCP has been developed for the Project in accordance with the requirements of the EP Act, which will be submitted concurrently with this EIS. This plan will represent the Proponent's objective to provide a rehabilitation strategy that benefits both environmental and stakeholder interests. The PRCP describes rehabilitation of all operational activities and associated infrastructure areas for the Project on the mine site, including the open-cut mining area, waste rock dumps, TSF, stockpile areas, mine infrastructure areas, and water storage areas (Appendix T, PRCP).

A Mineral Waste Management Plan (MWMP) will be prepared for the Project, and include procedures for:

- effective management of mineral waste;
- backfilling of the mining void to natural surface level using a combination of tailings waste co-disposed with and capped by an engineered low permeability layer, and suitable waste rock , to minimise the risk of acid mine drainage conditions developing;
- the management of seepage and leachates both during operation and post-closure;
- maintaining records of the location and nature of all mineral waste disposed of in the mining void; and
- rehabilitation.

An Erosion and Sediment Control Plan (ESCP) will be prepared by suitable certified personnel and developed in accordance with the *Best Practice Erosion and Sediment Control* (IECA 2008) (refer to Chapter 10, Section 10.4.2). It will be implemented for all stages of mining activities on site. Its purpose will include:

- minimising erosion and release of sediment to receiving waters and contamination of stormwater;
- ensuring all hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods are stored and handled in accordance with the current Australian standard, where applicable; and
- minimising the potential for contamination of land and waters by diverting stormwater around contaminated areas and facilities used for the storage of chemicals and flammable or combustible liquids.

17.7.1 Waste rock and overburden

The waste rock and overburden are considered to have low total sulphur content, low to moderate ANC, and most are classified as NAF-Barren. They have a negligible risk of acid generation and a high factor of safety with respect to potential for acidic mine drainage (refer to Section 17.3.4.3). Some overburden materials may produce elevated concentrations of aluminium, molybdenum and selenium in alkaline pH conditions and may produce neutral mine drainage (NMD); however, the concentrations are expected to typically decrease over time and not persist in the long-term. Runoff and infiltration from the WRDs will be directed to sedimentation dams (refer to Chapter 15, Water quality, Section 15.1.3.1). Seepage from the waste rock dumps is expected to be low-risk and unlikely to adversely affect sediment dam water quality or downstream environments.

The overburden and waste rock materials are considered suitable to be disposed of as backfill at closure, be retained as an out-of-pit waste rock dumps and not require management for acidic drainage. At closure, waste rock from the southeastern WRD will be used as backfill and capping material for the backfilled void. The overburden is proposed to be used as a capping material for the open pit. Seepage from these materials following placement in-pit is expected to be low-risk and unlikely to adversely affect groundwater quality.

The other WRD will remain as a landform at closure. The final landforms will be reshaped, topsoiled and revegetated to ensure safe, stable and non-polluting landforms post-mining, in accordance with rehabilitation milestones in the PRCP (Appendix T). The retained landform is to be low-risk and unlikely to adversely affect sediment dam water quality or downstream environments.

17.7.2 Ore

Ore will be processed, and therefore not a waste stream. Acid generation is relatively slow due to sulphur mineralogy, though risks increase with higher sulphur and carbon content (Section 17.3.4.3). Ore will be stored on the ROM stockpile prior to processing, which will be surrounded by a diversion levee to divert flood water. The MAW sump will collect run off from the ore stockpile area. By implementing these measures, it is therefore expected to be low-risk and unlikely to adversely affect hydrological values.

Low grade ore will be stockpiled and processed in the later stages of mine life, and stockpiled areas will be progressively rehabilitated. The low grade ore is typically slightly alkaline with low salinity and low to moderate neutralising capacity and is mostly classified as NAF-Barren (Section 17.3.4.3). It is considered suitable to be used as backfill if not processed. Ore will be stored on the ROM stockpile prior to processing, which will be surrounded by a diversion levee to divert flood water. The MAW sump will collect run off from the ore stockpile area. The low grade ore is expected to be low-risk and unlikely to adversely affect hydrological values.

17.7.3 Tailings

A technical report for Project TSFs was prepared by SRE (Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF). The report utilised the geochemical assessment of the tailings stream (Appendix U, Geochemistry Assessment of Mine Materials and Tailings) to design an appropriate Tailings Storage Facility to manage tailings. These assessments will ensure that tailings management will be appropriately managed to minimise environmental impacts. Management measures to be implemented are consistent with best practice environmental management, including the waste management hierarchy.

The volumes of tailings (Section 17.3.4.3) will be managed in two stages for the Project:

- initially, the tailings from on-site mineral processing will be stored in the four engineered tailings storage facilities (TSFs);
- towards the end of mining, tailings will be backfilled into the open-cut pit. Tailings waste from three of the four TSFs will be progressively transported to the base of the pit void; and
- one TSF will remain as a rehabilitated landform on the surface at closure.

17.7.3.1 Tailings Storage Facility design

The design has generally been compiled in accordance with the requirements of the following documents, as appropriate:

- DETSI 'Regulated structures—EIS information guideline', dated June 2024.
- DETSI 'Manual for assessing consequence categories and hydraulic performance of structures', dated June 2024.
- Australian National Committee on Large Dams (ANCOLD) 'Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure', Rev 1, July 2019.
- Australian National Committee on Large Dams ANCOLD "Guidelines on the Consequence Categories for Dams", October 2012.

Based on the mining schedule, the design parameters for the TSF are in Table 17-13 and the physical characteristics of the TSF cells are in Table 17-14.

Table 17-13: Design parameters

Annual tailings production (Mtpa)	TSF Life (years)	Project Life (years)	Life of Mine (LOM) (MT)	Tailings Slurry Density % Solids	Operating (hrspa)
3.25	45	63	175	60	8000

The storage volume for the tailings will be approximately 93.6 Mm^3, based on an assumed average in-situ dry density for the tailings of 1.55 t/m^3.

To provide maximum storage capacity of the TSF, Cells 1 to 4 will be High-Density Polyethylene (HDPE) contained embankments. The expected maximum depth of tailings is 16.8m, raised by downstream construction in four stages. The containment embankments will comprise traffic compacted mine waste in the downstream zone, with a crest width of 15 metres, with roller-compacted clayey fill in the upstream zone to support placing the HDPE liner. The crest width of the upstream zone will be five metres.

Table 17-14: Physical characteristics of the TSF cells

Cell No	Internal Containment area (ha) at crest RL	Expected maximum depth of tailings (m)	Estimated usable storage volume (Mn^3)	Storage Capacity Mt@1.35 t/m^3
1	131.9	16.80	24.20	36.31
2	139.2	16.80	23.88	37.01
3	138.3	16.80	22.75	35.26
4	138.3	16.80	22.75	35.26
Total			**93.57**	**143.43**

The design concept for each cell is to incorporate a pontoon mounted return water recovery system and perimeter monitoring/recovery bores located around the TSF (Refer to Appendix L, Groundwater Impact Assessment). The monitoring bores will be located within potential flow paths, controlled structurally and lithologically by fractured rock. The bores can be used to monitor groundwater quality during operations and may be supplemented with recovery bores, where required to return any seepage from the TSFs to the process plant.

Hydrogeological considerations

The Groundwater Impact Assessment (Appendix L) was utilised to design the TSFs, including:

- The geology of the site beneath the TSF has a low to very low permeability.
- Groundwater recharge from any fugitive seepage out of the deposited tailings in the TSF is expected to be low, as
    - the TSF is fully HDPE lined;
    - the geotechnical properties of the tailings demonstrate that the rapid settling characteristics of the tailings indicate that a high rate of supernatant water recovery is possible.
    - The presence of the upstream toe drain over the HPDE liner in the base of each TSF cell provides a preferential flow path to the external sump for water recovery and recycling;
- The cone of predicted drawdown from pit dewatering extends beneath the TSFs such that any seepage would be captured by the mine pit dewatering activities.

Geotechnical considerations

The geotechnical site investigation by Cartledge (in Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF), relevant to the mine pit and inferred to be relevant to the TSF indicates that the ground conditions comprise:

- Fine-grained sand - the predominant surface material observed across the Project area with an indicated thickness of approximately 1.0 m.
- An underlying sedimentary sequence comprising flat-lying, laminated and interbedded layers of highly to extremely weathered sandstone, siltstone and claystone, which is approximately 60–70 m thick.
- A transition zone from the sedimentary sequence to granite, consisting of approximately 10–15 m of moderately weathered sandstone.
- Granite, which is the host rock for the graphite, was encountered at approximately 70m.

The tailings properties adopted for the design, based on the testwork executed by E-Precision (in Appendix W), are:

- Low plasticity sandy clay/sandy silt, with a low plasticity clay fraction;
- Final in-situ dry density tailings is in the range from 1.55 to 1.65 t/m^3;
- Final in-situ dry density of the tailings deposited back into the mine pit being in the range from 1.65 to 1.85 t/m^3;
- The tailings have good consolidation characteristics; and
- Hydraulic conductivity is in the range of 3.6 x 10^{-8} to 5.7 x 10^{-11} m/s.

There is a tendency for the tailings materials, which have a low plasticity clay fraction, to be susceptible to liquefaction under sufficiently adverse conditions of saturation, in-situ stress and cyclic loading. As the tailings will be contained within an above ground facility raised by downstream construction and ultimately back into the pit, effectively an in pit TSF, it is highly unlikely that the deposited tailings would form a foundation for future embankment raises and therefore, apart from some settlement of the tailings in the pit as a result of any seismic activity, there are no adverse consequences if the tailings were to liquefy.

Geochemical considerations

The geochemical characteristics for the tailings are described in Section 17.3.4.3. They have a neutral pH and classified as PAF. Seepage is moderately saline, typical of tailings. If the tailings are left unmanaged and allowed to oxidise, several metals/metalloids, including aluminium, boron, cadmium, copper, lead, manganese, nickel, and zinc can mobilise into pore water under weakly acidic conditions. Leachate produced under saturated (anoxic) conditions maintains a neutral pH and lower concentrations of metal/metalloids. Concentrations of soluble hydrocarbons (sourced from flotation reagents) in tailings are initially above background soil but then diminish rapidly. All of the tailings behave predominantly as a sand. They are likely to be permeable, to drain quickly, and have low water retention characteristics. The tailings are classified as Emerson Class 3 or 4 and are expected to have good structure and stability, with limited shrink / swell behaviour.

In summary, the tailings are:

- Moderate to high risk material. Classified as PAF;
- Disposal into the backfilled void with a waste rock cover and soil capping is recommended;
- Requires an AMD management strategy. Preferably inundated with groundwater. Tailings are unsuitable as a bulk fill.

The tailings are to be contained within HDPE-lined Cells forming the TSF and as such, it is considered there is a very low risk of seepage with potential adverse consequences for the environment below the TSF. Nevertheless, monitoring bores are recommended, with standing water level measurements and water samples taken on at least a quarterly basis to monitor water quality adjacent to the TSF.

17.7.3.2 Monitoring and inspection program

In accordance with ANCOLD guidelines, the TSF has a consequence category assessment (CCA) of High C, which requires and inspection program to be implemented, which will include:

- Monitoring will be utilised to monitor water levels and water quality, including within the TSFs, and by a network on shallow monitoring bores installed around the perimeter to identify any incidental seepage. Refer to Chapter 16, Flooding and Regulated Structures, for further detail.
- To manage and operate the tailings storage in general accordance with the Operations Manuals (OM) prepared as part of the detailed design, with annual engineering reviews of the TSFs. Preliminary

operating requirements as per Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF, Section 7.

17.7.3.3 Materials placement, embankment geometry, and management

A detailed summary of the placement and design of the TSFs from the Graphinex Esmeralda Graphite Technical Report for TSF (Appendix W) is as follows:

- Zone 1 — The base of all the TSF cells is to be lined with 1.5 mm HDPE, which will be placed over the compacted, highly to extremely weathered sandstone, siltstone, and claystone, with a minimum thickness of 500 mm to form a low-permeability zone beneath the HDPE liner.
    - The perimeter embankments, including the dividing embankment between Cells 1 and 2, 2 and 3 and 3 and 4 will comprise 2 zones.
    - A rolled compacted zone comprising 'select' fill sourced from the upper layers of the sedimentary rock sequence (highly to extremely weathered sandstone, siltstone, and claystone).
    - The seepage cutoff soil embankment will have a cutoff trench on the upstream face, with a minimum crest width of 5 m, comprising suitable materials sourced from mine waste (sedimentary rock sequence), which will be moisture-conditioned and compacted to 95% standard maximum dry density (SMDD).
    - These requirements, materials selection and compaction will ensure the upstream zone of the TSF will comprise low-permeability zone beneath the HDPE liner. The locally-sourced mine waste materials may require some screening to remove oversized materials to achieve the following requirements for placement and compaction in Zone 1. Technical specifications for placing the materials are in Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF.
- Zone 2 —The downstream section of the embankment will have a minimum crest width of 15 m and comprise traffic compacted mine waste also derived from the sedimentary rock sequence.
    - Downstream construction stages will be implemented with the Stage 1 embankment crest being not less than RL 133.5 m. Further staged embankment raising is planned to RL 138.75 m, RL 144 m, and RL 149.25 m, which will also be executed by downstream construction.
    - Current indications are that adequate volumes of mine waste are available from pre-strip mining operations to meet the current LOM tailings storage embankment construction requirements. Further detail including drawings, schedules of materials, construction methodology are in Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF.
- Liner —The design concept includes:
    - a single HDPE-lined floor (1.5mm) of the TSF and upstream embankments to the RL 149.25 m.
    - The basal layer will be a HDPE liner, placed over a layer of compacted oxide mine waste or compacted in-situ low permeability subgrade, free of gravel, cobbles and boulders with a minimum thickness of 300mm.
    - A single liner applied to the upstream face of the embankments – stages 1 to 4.
    - Stringent surface preparation of the underlying subgrade and deploying geotextile underlay where suitable material is not available.
- Embankment construction— Typical construction requirements for the TSF implementation include the following:
    - Inspection of the seepage cut-off and the alignment of the embankment.
    - Inspection of the compacted base of the TSF prior to liner construction.

    - Compliance testing of the floor of the TSF, seepage cut-off and perimeter embankment, to ensure:
        - Moisture curing of materials as required during the upstream embankment construction with
        - content at the time of placement and compaction within -2%, +2% of the optimum moisture content.
        - Compaction is to achieve a density ratio greater than 95% of standard maximum dry density as determined by laboratory compaction testing (AS 1289 5.1.1) and confirmed by field density testing (AS1289.5.8.4 or approved alternative).
    - Materials used in the upstream embankment construction shall comprise clayey material having a fines content (material finer than 75 microns) greater than 30% for the compacted clay liner.
    - Mine waste materials used in the downstream embankment shall be spread with a maximum loose thickness not exceeding 750 mm. This material shall be compacted using smooth drum vibrating rollers of not less than 11 tonnes front module mass, in layers of loose-lift thickness not exceeding 750 mm.
    - Supervision by a suitably qualified engineer, construction supervision and construction reporting.
    - Laboratory testing of construction materials, including the liner, compacted earthworks, and a QA/QC manual will be developed for construction.
- Seepage monitoring — by installing a Megaflo underdrain along the upstream toe of the Stage 1 starter TSF embankment, above the HDPE liner, for the 4 cells. The underdrain will recover water from the base of the tailings stack for re-circulation and reuse in the process plant.
- Slope stability analysis —
    - A numerical geotechnical site geotechnical stability assessment of the design meets the minimum ANCOLD geotechnical stability requirements (in Appendix W, Graphinex Esmeralda Graphite Project Technical Report for TSF).
    - The stability results confirmed that the proposed TSF design is robust, with the Factors of Safety, FoSslope comfortably exceeding the minimum ANCOLD requirements, thus providing long-term environmental and structural stability. The results of this stability assessment also demonstrate the flexibility of the design concept, where the availability of mine waste for downstream embankment construction comfortably meets the design requirements. Furthermore, the assessment indicates the impounded tailings are only likely to have limited/negligible influence on the geotechnical stability of the TSF embankment.
- A groundwater level of approximately 8 m has been adopted for the slope stability analysis, although it is recognised that pit dewatering may lower the groundwater table beneath the TSF. The change in groundwater elevation will not significantly change the results of the stability modelling
- Seismic stability assessment – the proposed design of the TSF, based on the HPDE lined design, and based on a downstream raising of all the perimeter embankments has created a robust structure which is unlikely to be impacts by a seismic event with Peak Ground Acceleration of 0.01g.
- Consequence assessment and management as a regulated structure— has been prepared. Refer to Chapter 16 Flooding and regulated structures, Section 16.3.5.2.
- Water management —water recovery will be maintained during the wet season when the water balance indicates excess water, to avoid the buildup of excess water on the TSF, which would otherwise consume tailings solids storage capacity.
    - Additional water will be recovered if the density of the deposited tailings increases.
- Erosion from external sources is expected to be negligible, from the internally HDPE surfaces, and rock armouring on the external surfaces. Inspections will be regularly conducted during operations.

- The freeboard will maintain adequate freeboard at all times. By incorporating the spillway for each stage of each cell, they would be operated as a no release facility ie design capacity would exceed storm events, and the spillway would only operate during extreme events.
- Consolidation will be by compressive deformation of the deposited tailings.
- Minimal disturbance of land will be performed to allow the TSF to be constructed.
- Pipelines to and from the TSFs will be bunded with sumps in low-lying locations to prevent spillage of tailings or return water into the surrounding area in the event of pipeline failure.

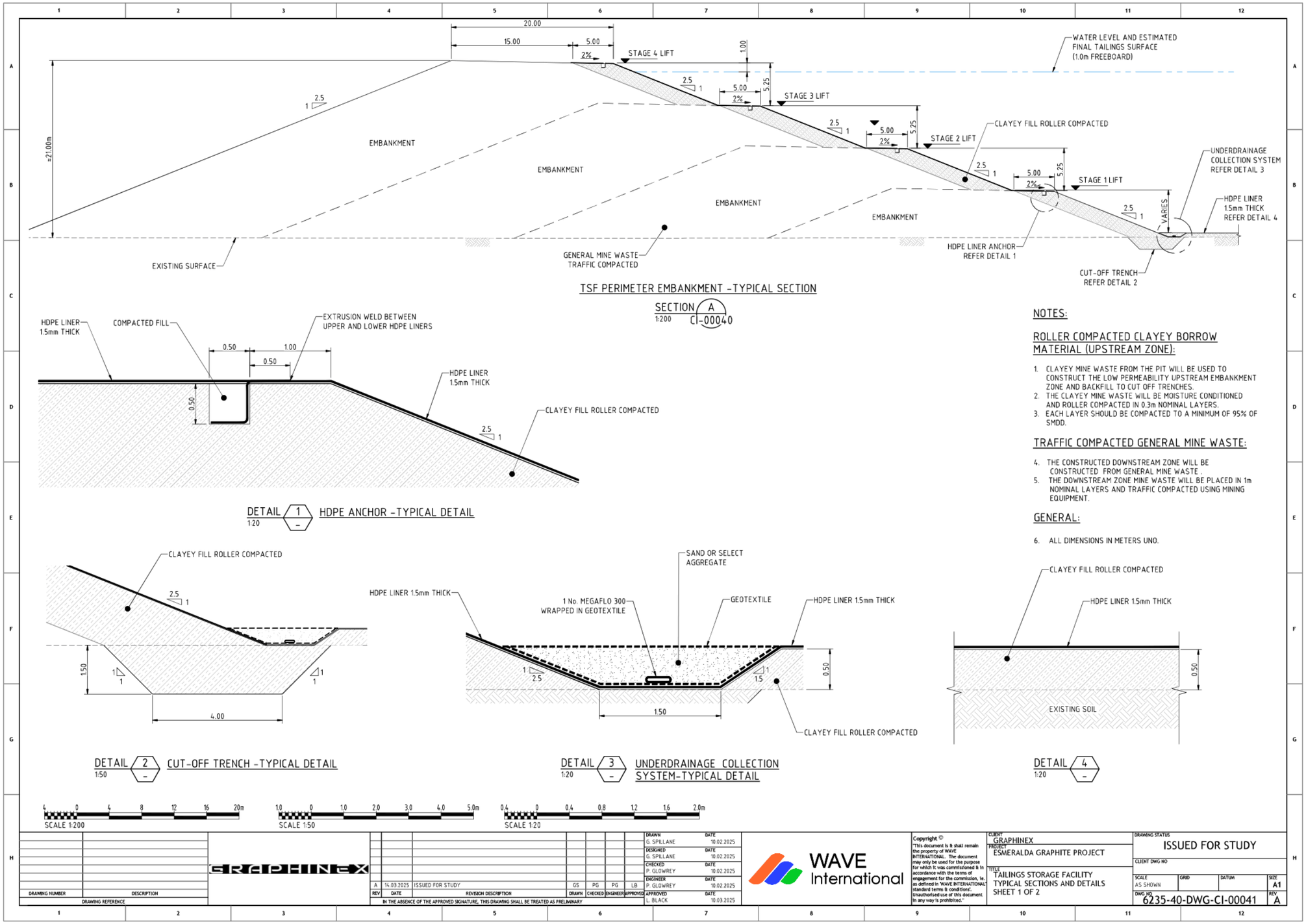


Figure 17-7: Typical cross-section of a TSF cell design

17.7.3.4 Managing tailings at closure

Three tailings cells and embankments will be deconstructed and returned to the mine pit void in the late stages of the Project. Modelling of pit void water quality was (Appendix V) undertaken by RGS, and supported by modelling of post-closure groundwater conditions as part of the Groundwater Impact Assessment (Appendix L). An assessment of post-closure pit void water quality and potential impacts on environmental values is detailed in this section.

Backfilling the pit void

Tailings will be backfilled in the base of the pit void from three TSFs (cells 1, 2 and 3), before being covered with waste rock and capped to minimise was infiltration, potential acid generation, and seepage. The backfilling will occur to the pre-mining ground surface, inclusive of compaction of the surficial material. The final landform at surface will be engineered and designed to shed rainfall.

Backfilling will be undertaken in two phases. In the first phase, tailings will be excavated from the TSFs, hauled using trucks and deposited for within the low permeability, granite stratigraphy, at the base of the pit. Initial placement will be below the ground water level, from approximately -157 mAHD to approximately 42 mAHD. Groundwater will saturate the tailings material and reduce AMD potential.

Once the three tailings cells have been backfilled, an engineered capping process will be undertaken to establish a hydraulic isolation barrier of the tailings from the regional groundwater table. This will achieve a water infiltration rate of approximately 3% and align with technical analysis and modelling undertaken by RGS to ensure low risk and magnitude of potential impacts. The final phase will return benign waste rock from the out of pit waste rock dumps above the tailings and capping, initially within the basement material and then within the sedimentary sandstone stratigraphy known as the Gilbert River Formation (approximately 42 m AHD up to ground level 123 mAHD). This will be undertaken in a manner that further hydraulically isolates the backfilled tailings, reducing water incursion post-closure. The void will continue to be backfilled to approximately 1-2 m above natural surface level, allowing for consolidation over time, and preventing any final void. The waste rock top surface will be shaped to facilitate surface water drainage and rehabilitation.

In surface TSFs, tailings will be isolated from conditions that cause acid generation, such that pore-water quality remains controlled through acid neutralisation. Once the tailings are excavated, transported dry and exposed in the pit, they may temporarily be more susceptible to oxidation and acid formation. However, once they are backfilled into the pit, the in-pit conditions are expected to reduce leachate formation from occurring by water saturation.

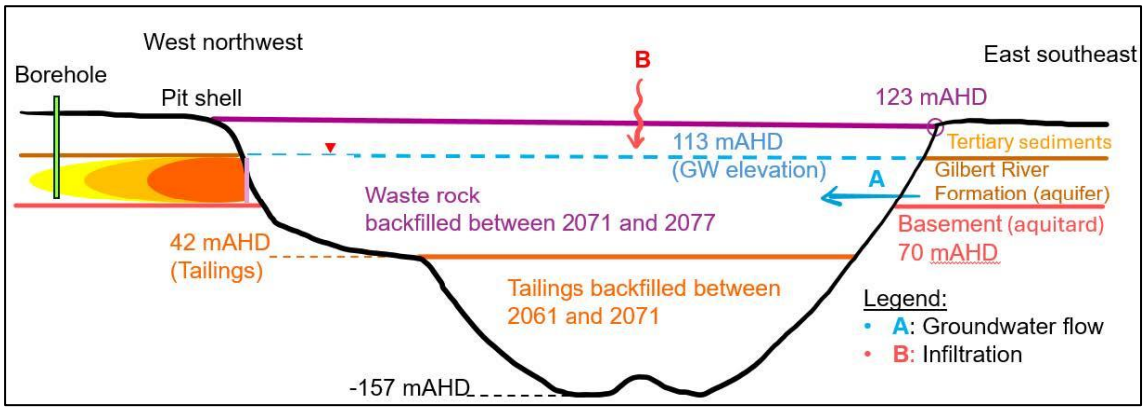


Figure 17-8: Post-closure backfilled pit void

Dewatering of pit will continue until backfilling is complete to maintain operational safety and ensure that the backfill level is higher than the pre-mining groundwater level. Post mining, groundwater inflow from the Gilbert River Formation will contribute to groundwater level recovery in the Project mining area. Surface infiltration to the backfilled final void will also form a minor contribution to the groundwater level recovery.

The backfilled final void will gradually fill with groundwater over time, and a groundwater table will establish in the backfilled final void after approximately 100-150 years. As there will be no pumping or evaporative losses from the backfilled final void, the groundwater levels in the backfilled final void are expected to recover to pre-mining groundwater levels (Appendix L). The backfill material will be in hydraulic connection with the surrounding groundwater system including the Gilbert River Formation. Groundwater levels will continue to recover until regional groundwater flow is established within and around the upper backfill material.

Throughout this recovery phase, the pit will continue to behave as a sink, with groundwater flowing inward from surrounding aquifers until hydraulic equilibrium is reached. After approximately 100-150 years post closure, groundwater levels within the backfilled void will be consistent with the pre-mine groundwater table. In the long-term, the backfilled void will act as a flow through system, maintaining groundwater flow conditions that are in hydraulic connection with the Gilbert River Formation.

Advective transport (or advection) is the process by which groundwater (and dissolved solutes within it) moves with the bulk flow of water through the pore spaces of an aquifer. This is calculated to predict how long it takes for groundwater to move from point A (i.e. the backfilled void) to point B (i.e. a downgradient receptor). Advection does not allow for the processes of dispersion, diffusion, sorption, or chemical reaction. Advective transport calculations indicate that groundwater movement from the backfilled pit void through the Gilbert River Formation to the northwest would occur over extremely long timescales. Using site-specific parameters for hydraulic gradient, hydraulic conductivity, and effective porosity, the calculated advective travel time is approximately 5,000 years for a path length of 1 km. This result demonstrates that, even under conservative assumptions, groundwater migration from the backfilled pit void to the would take place over millennial timescales.

Hydrogeochemical modelling was undertaken to understand long-term water chemistry and address lateral movement of void water (Appendix V, Pit Void Water Quality Modelling). During the estimated 60 years post closure, groundwater cannot leave the pit as hydraulic gradients are directed inwards, towards the pit. Groundwater inflows will gradually fill up the pore spaces in the backfilled material (tailings and waste rock), leading to increased concentrations of total dissolved solids (TDS) and other solutes in the pore water.

Once groundwater levels have recovered, pore water from the saturated backfill material may percolate into the adjacent Gilbert River Formation aquifer. This mainly occurs through groundwater flows upgradient into the east-southeast side of the pit and rainfall infiltrating the top surface of the backfill material (Figure 17-8). This will result in pore-water with elevated salinity relative to the existing groundwater being generated. As a result, void water spills from the pit can leak out and gradually mix with regional groundwater, forming a plume of pit-affected water extending outwards from the pit. Long-term pore water chemistry is strongly influenced by whether the saturated tailings remain hydraulically connected to the advective flow pathway.

By placing the tailings at the base of the pit to minimise interaction with groundwater at higher levels in the backfill; and minimising tailings oxidation during transfer from surface facilities to the pit; modelling results indicate that the proposed design will result in the lowest element concentrations being released (Appendix V, Pit Void Water Quality Modelling). Additionally, there will be:

- lower salinity (~2,000 mg/L) with hydraulic isolation of saturated tailings.
- aluminium, arsenic, chromium and lead, modelled long-term concentrations will be comparable, or below guideline values for protection of moderately disturbed freshwater aquatic ecosystems. (Exceptions include molybdenum, selenium, and vanadium, due to elevated source term concentrations.)
- there will be lower guideline value exceedances of trace element concentrations for cadmium, cobalt, nickel and zinc associated with low pH tailings.

Preliminary seepage transport calculations indicate a delay of more than 500 years before detectable changes occur at receptors located approximately 100 m downgradient of the pit. This reflects the slow advective velocity and dispersion within the Gilbert River Formation aquifer. Further details are provided in Chapter 15, Water quality.

Rehabilitation measures for the final landform

The final (fourth) TSF cell will remain in the final landform post-closure. Rehabilitation will include capping with competent waste rock, profiling surfaces, applying growth media, and revegetating with native grass species. Ongoing rehabilitation monitoring will track performance against closure criteria and guide updates to the closure plan and influence closure design decisions over the life of the Project. Further details can be found in Chapter 13, Rehabilitation and Closure and the PRCP (Appendix T).

17.8 Performance monitoring and review

Monitoring of materials and contact water associated with the Project will be an important part of the on-site management of non-mineral and mineral waste materials, and will be completed in accordance with the approved Environmental Authority (EA).

- Water quality monitoring will be undertaken as part of ongoing surface water and groundwater monitoring, as detailed in Chapter 15, Water Quality.
- The waste streams, quantities produced, and implemented management practices will be recorded over the life of the Project and reviewed regularly.
- Principal waste management contractors will be required to provide reports on material volumes transferred, the condition of waste collection facilities and opportunities for improvement.
- Waste management aspects will be included as components of regular housekeeping checklists, inspections and audits.
- Management reviews addressing waste management performances will form part of the annual environmental management system review.
- Employees will be advised of their obligations to report incidents that have potential to cause, or threaten to cause, material or serious environmental harm, in accordance with Section 320B of the *Environmental Protection Act 1994* (EP Act).
- Corrective actions will be recorded, and responsibilities will be assigned to the appropriate site personnel for action and close-out.
- Adaptive management processes will be included as part of monitoring and review of the environmental management system to be implemented on-site.
- Routine reviews of waste management practices and processes will take place, if there is an identified need, appropriate action will be taken.
- The mine operations department will be responsible for communicating the outcomes of a review of the backfill performance to site personnel and contractors.
    - An annual review of water quality data will be undertaken by the mine operations and technical services department and/or suitably qualified specialist consultants.
    - All matters relating to mined materials and process tailings will also be managed by them. If management practices are not effective, changes to the management will be made and implemented.
    - The review process will include consideration of monitoring results. Any changes in operational practices will be incorporated into the documentation and communicated to responsible employees and contractors.

17.9 TOR Reconciliation table

Terms of reference - Content requirements of the EIS		EIS Section
Section 17 - Waste		
17.1	The following guidance is relevant for the assessment of waste: (a) Queensland Government, Waste – EIS information guideline, ESR/2020/5311 (b) Queensland Government, Application requirements for activities with waste impacts, ESR/2015/1836.	Section 17
Waste - Existing environment		
17.2	Describe any current waste management infrastructure/facilities relevant to the project, including location, capacity, and accepted waste streams. Evaluate waste-related constraints and considerations relevant for the impact assessment.	Section 17.3.1
17.3	Describe and map any actual or potential contaminated material, including any emerging contaminants within the project footprint, including details of relevant site investigations and details of management or disposal obligations/requirements.	Section 17.3.2
Waste - Impact assessment		
17.4	Provide a waste inventory for all expected project waste streams generated by project activities during the construction, operational, rehabilitation and decommissioning phases. Describe the source, quantity/volume, and waste type (solid, liquid, regulated (category 1, category 2) etc.). Discuss whether waste would be reused, recycled, disposed or managed under an end of waste approval.	Section 17.3.3
17.5	Describe the quantity, and physical, chemical and toxicological characteristics of each waste stream, any contaminants of concern, any attributes that may affect its management (dispersal, chemical reactivity and persistence in the environment), and its associated risk of causing environmental harm. Describe how waste would be stored, handled, transported, treated, disposed or managed in another way at each stage of the project to minimise risks to environmental values.	Sections 17.3.3, 17.3.4
17.6	Detail the geochemistry of all waste rock, including spoil, tailings and rejects. Assess potential risks associated with this waste stream and describe the management of progressive placement and any disposal strategy to minimise any potential impacts on environmental values.	Section 17.3.4
17.7	Describe waste treatment, reuse, recycling and recovery processes to be carried out within the project footprint, including end uses.	Sections 17.5.1, 17.5.2
17.8	Identify the likely destination for waste streams to be disposed of or recycled off-site and determine the capacity of waste disposal facilities to accept project waste.	Section 17.3.3
17.9	If relevant, provide information on proposed on-site disposal of general and/or regulated waste relevant to ERA 60, by referring to relevant policies and guidelines.	Section 17.6

Terms of reference - Content requirements of the EIS		EIS Section
17.10	Provide relevant information on existing and proposed sewage infrastructure relevant to ERA 63, by referring to relevant policies and guidelines, depending on the proposed sewage collection and treatment infrastructure the reuse and/or disposal of treated wastewater and sewage wastes generated. Provide details of the sewage treatment process and related infrastructure, including daily peak design capacity and the amounts and compositions of waste solids, liquids and gases.	Section 17.6.3
17.11	Undertake water balance modelling applying appropriate techniques (MEDLI) to ascertain suitable wet weather storage volume(s), sufficient irrigation area(s), suitable effluent irrigation rates and suitable vegetation to be irrigated to ensure sustainable effluent irrigation for the predicted volume of sewage that will be generated and treated, then land irrigated.	Section 17.6.3
17.12	Identify end of waste codes under the Waste Reduction and Recycling Act 2011 which may be relevant for the project.	Section 17.2.2.3
17.13	Discuss any obligations under the National Environment Protection (National Pollutant Inventory) Measure 1998 (NPI NEPM) and ensure data provided meets the requirements of the NPI NEPM and its subordinate legislation. Identify the types and amounts of certain substances being emitted to air, land, and water and both on-site and off-site waste transfers that may need to be reported.	Section 17.4.1, Chapter 23 Air Quality, Chapter 27 Greenhouse Gas
Waste - Mitigation measures		
17.14	Describe proposed measures to avoid or minimise environmental impacts as a result of waste storage, handling, transport, disposal, or other management at each stage of the project. Demonstrate that proposed measures are consistent with best practice environmental management, including the waste management hierarchy.	Sections 17.5, 17.6, 17.7
17.15	Demonstrate how the project will meet the environmental objectives and performance outcomes in Schedule 8 of the EP Regulation.	Section 17.1
17.16	Describe how the achievement of environmental objectives and associated performance outcomes would be monitored, audited and reported, and how corrective/preventative actions and continual improvement would be managed.	Section 17.8