Geosyntec consultants

engineers | scientists | innovators

Groundwater Monitoring and Management Plan

Eramurra Solar Salt Project

Leichhardt Salt Pty Ltd
28 March 2025

ESSP-EN-14-PLN-0004 AU424012-001-R-GMMP_Rev 1

Quality Management

Document Distribution

Issue/Revision	Issue A	Issue B	Revision 1	Revision 2
Remarks	DRAFT	DRAFT	Issue 01	
Date	10 February 2025	25 February 2025	28 March 2025	
Prepared by	Frederic Cosme/Tristan Goodbody	Frederic Cosme/Tristan Goodbody	Frederic Cosme/Tristan Goodbody	
Reviewed by	Karen Mackenzie	Karen Mackenzie	Karen Mackenzie	
File reference	AU424012-001-R-GMMP_RevA_DRAFT.docx	AU424012-001-R-GMMP_RevB_DRAFT_for Issue.docx	AU424012-001-R-GMMP_RevB_DRAFT_for Issue.docx	
Distribution	• CDM Smith Australia Pty Ltd • Geosyntec Electronic File	• Leichhardt Salt Pty Ltd • Geosyntec Electronic File	• Leichhardt Salt Pty Ltd Geosyntec Electronic File	

This report was prepared in accordance with the scope of services set out in the contract between Geosyntec Consultants Pty Ltd (ABN 23 154 745 525) and the client.

Geosyntec Consultants Pty Ltd
ABN 23 154 745 525
www.geosyntec.com.au

Executive Summary

Proposal name	Eramurra Solar Salt Project
Proponent name	Leichhardt Industrials Pty Ltd
Ministerial Statement number	Case Number CMS 18032
Purpose of the EMP	Provide monitoring actions, triggers and contingency protocols for protection of project Environmental Values (EV's): • EV1 – Groundwater dependant ecosystem – aquatic fauna i.e. Stygofauna • EV2 – Groundwater dependent terrestrial vegetation (GDE Atlas) • EV3 – Terrestrial vegetation (Priority Ecological Community) • EV4 – Algal mats and Samphire • EV5 – Aquatic vegetation (mangroves) • EV6 – Stock water wells • EV7 – Cultural and spiritual (springs and pools)
Key environmental factor/s, outcome/s and/or objectives	Key Factors are Benthic communities and habitats: *To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.* and Inland waters: *"The occurrence, distribution, connectivity, movement, and quantity (hydrological regimes) of inland water including its chemical, physical, biological and aesthetic characteristics (quality)."* The environmental outcomes for EVs are: • Outcome 1: No changes to the environmental health of the receptors of the site EV1 – Aquatic Groundwater Dependent Ecosystem (GDE) • Outcome 2: No changes to the environmental health of the receptors of the site EV2 and EV3: Terrestrial Groundwater Dependant Ecosystem, (GDE) • Outcome 3: No changes to the environmental health of the receptors of the site EV4: Algal mats and Samphire • Outcome 4: No changes to the environmental health of the receptors of the site EV5: Aquatic Vegetation (mangroves) • Outcome 5: No changes to the environmental health of the receptors of the site EV7 and EV8: Soaks and Pools • Outcome 6: No changes to the environmental health of the receptors of the site EV9: Santos Gas Pipeline
Condition clauses (if applicable)	Not applicable

Key components in the EMP (if applicable)	Provided as a table. **Table 2.2**
Proposed construction date	MM/YYYY – To Be Confirmed
EMP required pre-construction?	No

A summary of the key criteria adopted to protect EVs are presented below.

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Outcomes 1-4: No changes to the environmental health of the receptors of the site					
Trigger Criterion 1. Increasing TDS concentration trend in sentinel wells Leading Indicator for Threshold Criterion 1 – TDS concentrations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 1.** • For locations that have been sampled at least four times, the threshold is considered to be exceeded if the result is greater than the mean plus two standard deviations (SD) of the previous results for that location.	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have the laboratory check the results and, if possible, reanalyse the sample. - If the laboratory-confirmed result is not consistent with trends, or if the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. • Risk Assessment - If the result from re sampling and an inconsistent trend are confirmed, evaluate the potential for a change in	**Indicator** • Increase in TDS concentration in excess of expected variation based on baseline data. **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 1 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk***	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk, continue wet and dry season monitoring program	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
• For locations that have been sampled less than four times, the threshold is considered to be exceeded if a result is greater than the current maximum result	the risk profile for the impacted location by comparing with the site data/threshold. - Assess whether the change may result in a potential unacceptable risk to a receptor(s). Consider other monitoring locations located between the sentinel well and the receptor. If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location for assessment or saline water extraction. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	• Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 1 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** • No further action			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Trigger Criterion 2. Change in groundwater flow regime (mounding and flow direction) Leading Indicator for Threshold Criterion 2 – groundwater elevations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing measurements. **Threshold Criterion 2.** Based on a groundwater flow contour map prepared by a suitably qualified hydrogeologist using most recent groundwater (and surface water, if any) gauging data of the entire site network, there is a change in the flow direction indicative of one or more of the following: • Groundwater mounding underneath the site ponds and other operational setting • Change in the role played by the sabkhas along the coastline (e.g. more frequent inundation/evidence of more persistent surface water) • Change in the interaction between the creek and groundwater (e.g. increase in salinities of receiving environment outside the	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have a review of the field sheets against well survey data and, if possible, regauge the well. - If the review confirms the change in flow direction, or if the suitably qualified hydrogeologist cannot confirm the result from the field sheet review, then re-gauge all the well from the network within a month, access permitting. - If the regauging confirms the change in flow direction, evaluate the potential for a change in the risk profile for the impacted location by assessing the potential for pathway completeness • Risk Assessment - Assess whether the change in flow direction may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells to further understand the	**Indicator** • Change in groundwater flow direction **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater regauging of the full network • Within a month from initial gauging, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 2 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
range measured prior to operation).	potential for the degree of pathway completeness. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	• Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** No further action			
Outcome 5: Monitoring and assessment of potential leaks, spills and losses from plant fuel storage area					
Trigger Criterion 3. Change in water quality at the plant area (Fuel storage) – dissolved phase petroleum hydrocarbons detected in groundwater Leading Indicator for Threshold Criterion 4 – TRH concentrations detected show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 3.** • Total Recoverable Hydrocarbons (TRH),	**Threshold Criterion 3.** Assessment of changes in the risk profile by one or more of the following actions: • Have the laboratory check the results and, if possible, reanalyse the sample. • If the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. • If the result from re sampling confirms the exceedance of Threshold Criterion 3 • Review fuel storage records (wet stock analysis, spill records) to identify potential for Threshold Criterion 3 to	**Threshold Criterion 3.** **Indicator** • TRH and/or BTEXN concentration **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 3 • Within a month from initial sampling location, access permitting	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Benzene, Toluene, Ethylbenzene, total Xylenes, Naphthalene (BTEXN) detected in sample analysis **Threshold Criterion 4.** • LNAPL detected in groundwater.	indicate leaking fuel storage infrastructure. • Assess whether the change may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location. • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater No further action if there is no unacceptable risk **Threshold Criterion 4.** • Review fuel storage records (wet stock analysis, spill records) to identify potential for Threshold Criterion 3 to indicate leaking fuel storage infrastructure. • Installing more wells around the location to delineate the extent of LNAPL and associated dissolved phase impacts. • Evaluate emergency response options such as LNAPL recovery (Multiphase extraction (MPE), bailers, skimmer pumps and adsorbent media).	***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 3 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater remediation If there is no unacceptable risk No further action **Threshold Criterion 4.** **Indicator**			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	• Assess whether the change may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater	• Measurable LNAPL **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Review fuel storage records (wet stock analysis, spill records) to identify leaking fuel storage infrastructure. • Installing more wells around the location to delineate the extent of LNAPL and associated dissolved phase impacts. ***If there is a potential for an unacceptable risk*** • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater including implementation of emergency response measures If there is no unacceptable risk • Remediating the impacted groundwater to the extent practicable			

Complexity of changes	**Minor revisions**	**Moderate revisions**	☐	**Major revisions**	☐
Number of Key Environmental Factors			**One ☐**	**2-3 ☐**	**> 3 ☐**
Date revision submitted to EPA: DD/MM/YYYY – To be confirmed					
Proponent's operational requirement timeframe for approval of revisionReason for Timeframe:		**< One Month ☐**	**< Six Months ☐**	**> Six Months ☐**	**None ☐**

Itemno.	**EMP section no.**	**EMP page no.**	**Summary of change**	**Reason for change**
1.			No changes – First Issue Revision 1.0	No changes – First Issue Revision 1.0
2.				
3.				

Table of Contents

Appendices

List of Figures

List of Tables

List of Abbreviations

ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
BCH	Benthic Communities and Habitats
BTEXN	Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene
COC	Chain Of Custody
DO	Dissolved Oxygen
DQI	Data Quality Indicators
DQO	Data Quality Objectives
EP Act	Environment Protection Act
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
EC	Electrical Conductivity
ET	Evapo-transpiration
EV	Environmental Value
EWR	Environmental Water Requirement
GDE	Groundwater Dependent Ecosystem
GMMP	Groundwater Monitoring and Management Plan
IW	Inland Waters
LOR	Limit of Reporting
LNAPL	Light non-aqueous phase liquid
LTV	Long-term Trigger Value
m AHD	metre Australian Height Datum
m/d	metre per day
NATA	National Association of Testing Authorities
QA/ QC	Quality Assurance / Quality Control
RPD	Relative Percent Difference
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TRH	Total Recoverable Hydrocarbon
TSS	Total Suspended Solids
US EPA	US Environmental Protection Agency

1 Context, Scope and Rationale

Leichhardt Salt Pty Ltd (Leichhardt) engaged Geosyntec Consultants Pty Ltd (Geosyntec) to develop a groundwater monitoring and management plan (GMMP) for the Eramurra Solar Salt Project (the Project), located approximately 55 km west-southwest of Karratha on the Pilbara coast of Western Australia (**Figure 1-1**).

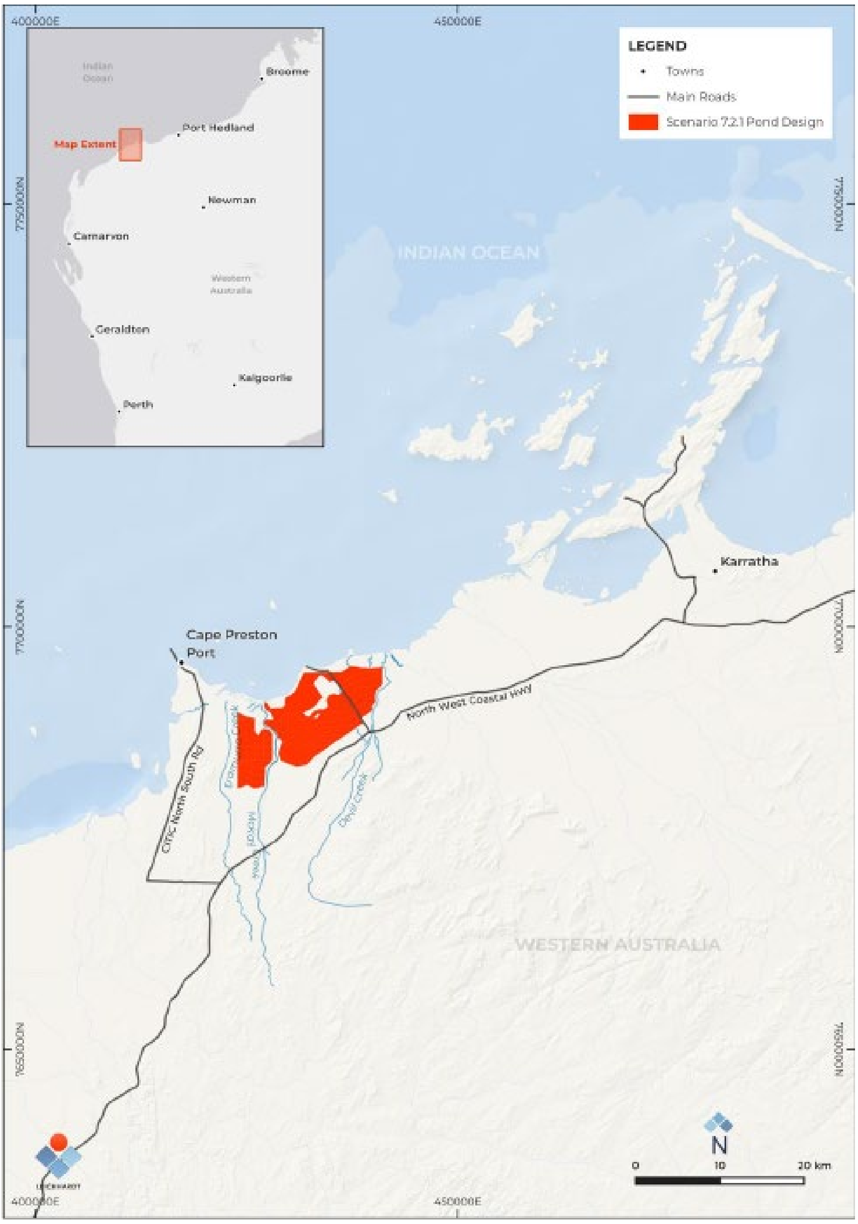

Figure 1-1: Proposed Project Location (courtesy of Leichhardt)

1.1 Proposal

1.1.1 General

The Project is located east of Cape Preston East Multi-Commodity Port on land parcels between Eramurra Creek along western edge and Devil Creek on eastern edge. The current design of the project development area will contain 90 km^2 of concentrator area, 20 km^2 of crystalliser area and marine dredging in addition to the plant processing area (**Figure 1-2**).

To produce salt, a series of concentrator evaporation ponds will be constructed. The perimeter embankment around the concentrator ponds and the pad for crystalliser area may alter existing waterways flowing towards the Indian Ocean as well as tidal flooding of the project land parcels.

The highly saline water within the concentration pond area has potential to increase salinity of local surface water, as well as potentially impacting groundwater quality. In addition to the direct impacts from the addition of salinity to the groundwater and surface water environments, excavations for the construction of the evaporation ponds and associated infrastructure (bunds, roads, pipelines and culverts) may disturb acid sulfate soils, which in turn will provide an additional salinity source.

As part of the approval requirements a number of environmental studies have been conducted across the site and surrounds. These studies include (but not limited to) study of the receiving environment (terrestrial, aquatic and marine), the installation of a groundwater monitoring network; five groundwater elevation and gauging events; development of a numerical groundwater model with scenario modelling to assess groundwater effects from seepage and climate change/sea level changes. Surface water modelling has also been completed to assess the projects impact to surface water flows and drainage.

The outcomes of these investigations are assisting with ongoing characterisation of baseline hydrogeological regimes and water quality both in a local and regional context. The findings have been used to develop the management measures described in this GMMP.

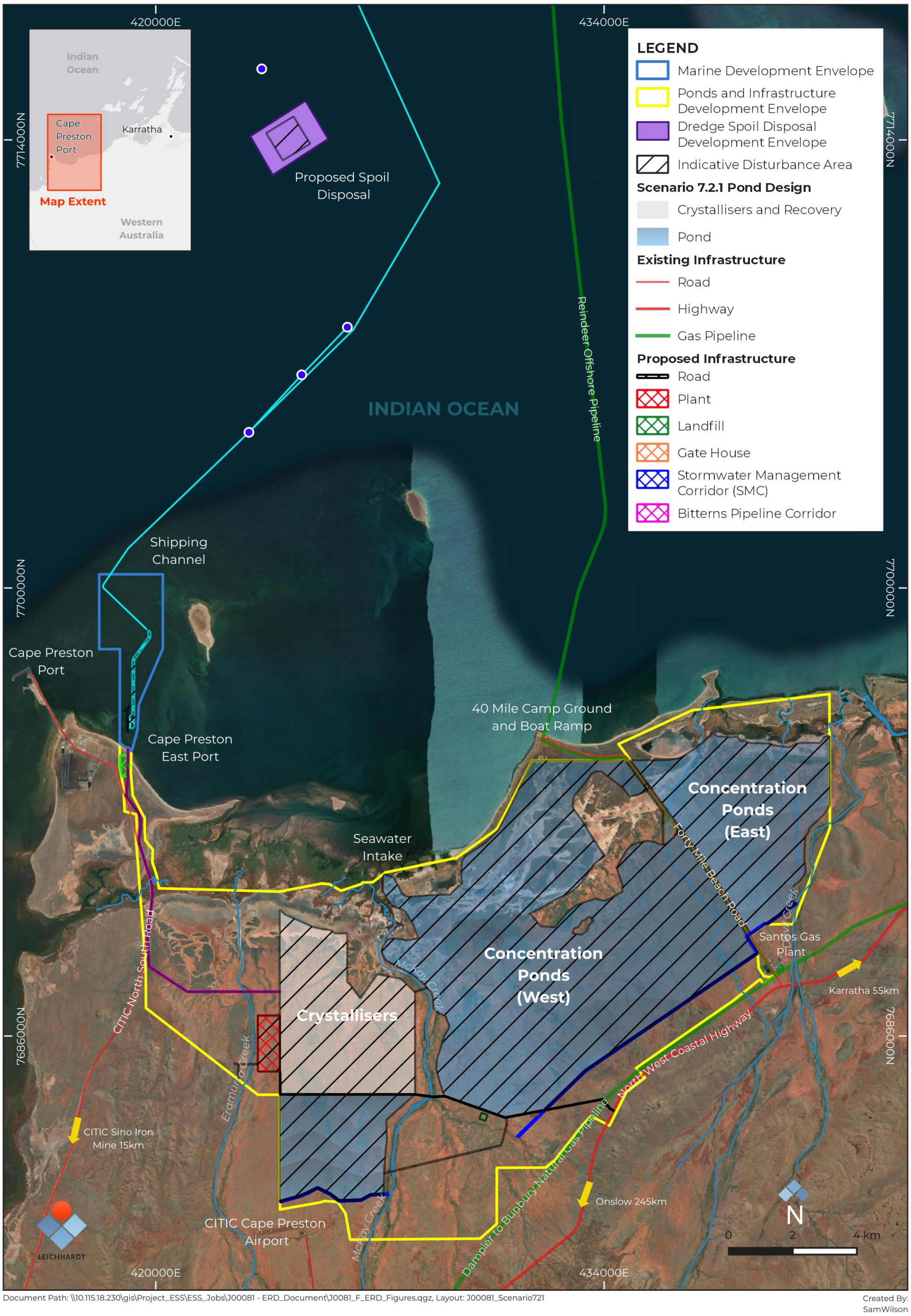

Figure 1-2 Indicative disturbance envelope and infrastructure location (courtesy of Leichhardt)

1.1.2 Progress Towards Environmental Approval

The Western Australian Government Environmental Protection Agency (EPA) has a 5 stage approvals process:

Stage 1 – Referral – submission of an environmental scoping document

Stage 2 - EPA to decide on whether to assess the proposal

Stage 3 – Assessment of proposal

Stage 4 – EPA report on assessment of a proposal

Stage 5 – Implementation of proposal

Leichhardt's proposal has been submitted to the WA Government EPA where a decision was made to assess the project. The Environmental Scoping Document (ESD) was approved in June 2023. The current program of work is based on the requirement presented in the ESD which formed the basis of the scope of studies required to inform an update of the Environmental Review Document (ERD). It was noted by the EPA that the development of environmental management plans is required to manage and or mitigate any identified or perceived environmental concerns.

Currently the project is classed as being at Stage 3 of the approvals process. This version of the GMMP has therefore been developed to inform the assessment process by providing information to regulators and the public about how groundwater seepage and mounding will be mitigated.

1.1.3 Project Summary and Site Selection

The Project will utilise seawater and natural solar evaporation processes to produce a concentrated salt product. An annual average production capacity of up to 5.2 Million tonnes per annum (Mtpa) is being targeted with up to 6.8 Mtpa of high-grade salt deposited in a low rainfall year.

The following infrastructure will be developed (**Figure 1-2**):

- Seawater intake, pump station and pipeline;
- Concentrator ponds totalling approximately 11,665 hectares (ha);
- Crystalliser ponds, totalling approximately 1,345 ha;
- Drainage channels and bunds;
- Process plant and product dewatering facilities;
- Water supply (desalination plant and/or groundwater bores);
- Bitterns disposal pipeline and outfall;
- Power supply and power lines;
- Pumps, pipelines, roads, and support buildings including offices and communications facilities;
- Workshops and laydown areas;
- Landfill; and
- Other associated infrastructure.

The export of salt is proposed to be via a trestle jetty. The jetty and associated stockpiles will be located at the Cape Preston East Port. Dredging will be undertaken as part of this Proposal to remove high points at the Cape Preston East Port.

Dredged material will either be disposed of at one or more offshore disposal locations, or onshore within the Ponds and Infrastructure Development Envelope. The Cape Preston East Port jetty and associated stockpiles are excluded from the Proposal.

The Project will produce a salt concentrate according to the following processes:

- Seawater will be pumped into the first concentrator pond and commence progressive concentration by solar evaporation as it flows through successive concentrator ponds;
- Salt is deposited onto a pre-formed base of salt in the crystalliser ponds;
- Salt will be removed from the drained crystalliser ponds by mechanical harvesters and stockpiled adjacent to the processing facilities;
- Salt concentrate will be trucked to the trestle jetty approved by MS 949 for export; and
- Bitterns (5-6 gigalitres per annum (GLpa)) will be pumped and released via an ocean outfall diffuser within the marine Development Envelope.

The location of the project, on the Pilbara coast is one conducive to salt production due to the low rainfall and relatively high evaporative rates leading to a net evaporative environment and access to clean seawater (LWC, 2024b, CDM Smith, 2023b, and CDM Smith, 2024b). Given these conditions, surface water in the region is therefore highly ephemeral with few permanent water bodies. Surface water monitoring at the site over the past four years has confirmed the dry conditions as surface water has only been recorded in two out of five monitoring events and at only three locations (LWC 2024b, CDM Smith 2024b). A summary of the outcomes of the surface water modelling is presented in **Section 1.8.5.**

The topography of the site is relatively flat with dolerite dykes forming natural walls across the site.

Salt production has been undertaken in the region for many years for example at Dampier where Rio Tinto operate the Dampier Salt project. In addition to this operational facility, additional production capacity in the region is currently under construction with the recent approval of the Mardie salt facility south-west of Eramurra.

Although the natural environment at Eramurra is saline, hydrogeological studies completed at the site have identified potential changes to groundwater elevation and salinity from the construction and operation of the project which may pose a threat to environmental values (EV's).

The hydrogeological setting at the site is quite complex (CDM Smith 2024b), with highly variable ground conditions and yields being described during site drilling programmes. A total of 21 wells have been drilled at the site ranging in depth from 15 – 60 m below ground level. A summary of the site hydrogeological setting developed from publicly available and site-specific data acquisition is presented in **Section 1.6.3.**

The perimeter embankment around the concentration ponds and the pad for the crystalliser area will likely alter the site hydrology and surface water flows towards the Indian Ocean as well as groundwater flow paths and tidal flooding of the Project land parcels. These activities have the potential to impact environmental values (EVs) residing within the Project area such as algal mat communities known to occur in the onshore environment.

Studies on benthic communities and habitats were completed by O2 Environment (2023). Modelled direct effects with the potential to impact environmental values (EVs), alteration of groundwater levels, flow and quality (salinity), from seepage and resultant mounding of groundwater, associated with the proposed project infrastructure, are presented in *Eramurra Solar Salt Project – Groundwater Effects Assessment and Seepage Modelling* provided by CDM Smith (2023b). Details of the potential threats to the identified environmental values are presented in **Section 1.8.1**.

1.1.4 Relevant Technical Studies

Comprehensive technical studies have been undertaken to support the development and /or implementation of this GMMP.

Significant work, including bore installation and monitoring, monitoring at surface water locations, and groundwater modelling, has been completed in support of developing the GMMP and to support the Environmental Review Document (ERD).

A summary of the key studies and investigations that have been undertaken, or are ongoing, is provided in **Table 1.1.** This GMMP is intended to be reviewed and updated as ongoing monitoring and operations progress.

A list of individual reports which have been prepared as part to the technical studies is presented below.

- CDM Smith, 2022. Eramurra Solar Salt Project – Review of hydrogeological information and gap analysis, Technical Letter prepared for Land and Water Consulting.
- CDM Smith, 2023a. Noorea Soak hydrogeological assessment, prepared for Land and Water Consulting, 29 June 2023.
- CDM Smith, 2023b. Eramurra Solar Salt Project – Groundwater Effects Assessment and Seepage Modelling, prepared for Land and Water Consulting, 13 December 2023.
- CDM Smith, 2024a. Eramurra Solar Salt Project – Groundwater Drilling 2023/2024, prepared for Land and Water Consulting, 28 March 2024.
- CDM Smith, 2024b. Eramurra Solar Salt Project – Site Setting and Groundwater Baseline Update, prepared for Geosyntec Consultants Pty Ltd 15 November 2024
- CMW Geosciences (CMW), 2020. Eramurra Salt Cape Preston, WA Geotechnical Desk Top Study Report For Eramurra Salt Ponds. Prepared for Leichhardt Salt Pty Ltd, August 2020.
- CMW Geosciences (CMW), 2022. Eramurra Salt Project - Cape Preston, WA Geotechnical Investigation Report. Prepared for Leichhardt Salt Pty Ltd, March 2020.
- LWC, 2024b, July 2024 Groundwater Monitoring Event and Logger Data Collection - Eramurra Salt Project, prepared for Leichhardt Industries Pty Ltd, December 2024
- LWC, 2024a. November 2023 and February 2024 Groundwater and Surface Water Monitoring Event and Logger Install - Eramurra Salt Project prepared for Leichhardt Industries Pty Ltd, March 2024.
- LWC, 2023a. November 2022 Groundwater and Surface Water Monitoring Event - Eramurra Salt Project, prepared for Leichhardt Industries Pty Ltd.
- LWC, 2023b. December 2023 Groundwater Monitoring and Management Plan – Eramurra Salt Project, prepared for Leichhardt Salt Pty Ltd,
- LWC, 2023c. Eramurra Salt Project Hydrologic Assessment for Scenario 7.2 Prepared for Leichhardt Salt Pty Ltd, July 2023.
- LWC, 2022a. December 2021 Groundwater Well Installation and Monitoring Event – Eramurra Salt Project. Prepared for Leichhardt Salt Pty Ltd, April 2022.
- LWC, 2022b. March and May 2022 Groundwater and Surface Water Monitoring Events Eramurra Salt Project. Prepared for Leichhardt Salt Pty Ltd, July 2022.
- LWC, 2022c. Eramurra Salt Project Hydrologic Assessment. Prepared for Leichhardt Salt Pty Ltd, September 2022.
- LWC 2022d Baseline Soil and Sediment Testing. Eramurra Salt Project. Leichhardt Salt Pty Ltd., November 2022.
- LWC, 2021. Desktop Study of Soils, Sediments and Groundwater Quality – Eramurra Salt Project, Pilbara Coast, Western Australia. Prepared for Leichhardt Salt Pty Ltd, March 2021.

- O2 Environment, 2023. Eramurra Salt Project – Benthic Communities and Habitat Monitoring and Management Plan. Draft Issued 30 October 2023

The reports from the list above which have been directly referenced in this GMMP are documented in the reference list at the end of this GMMP.

1.1.5 Data Gaps

The environmental approval process identified the following critical gaps that are currently being addressed and that will be managed through the implementation of this GMMP:

- In low lying areas adjacent to the coast, salt flats or saline mudflats are common, formed through the interaction of surface and groundwater with evaporites. These environments are characterised by high salinity, shallow water tables and periodic flooding. There is a need to further refine the understanding of surface and groundwater requirements of the water balance in this area to allow for the salinity distribution to be better defined and accurate trigger and threshold criteria to be established.
- In the broad vicinity of the ephemeral creek that cross the site area, the groundwater salinity appears to be fresher. This may be indicative that the creek act as a losing feature during periods of higher rainfall, which is in contrast to the generally saline nature of groundwater. Further understanding of the role of the ephemeral creeks on the groundwater quality is required. This will be particularly relevant in the portion of Eramurra Creek where the crystallisers are planned to be constructed due to their higher potential to result in TDS-impacted groundwater mounding.
- Noorea Soak and Devils Pool are two surface water features that have cultural and spiritual values in the site area. While the current information supports that these features do not support substantial groundwater inflows, additional groundwater data collected from their vicinity is required to confirm this assertion.

The data gaps are proposed to be addressed via further site characterisation. Further considerations on the site characterisation have been integrated into this plan and are provided in **Section 2.2**.

1.2 GMMP Objectives

The objective of this document is to outline the groundwater management and monitoring strategies for the Project by:

- Presenting the context, rationale and approach for implementing the GMMP, which includes an overall understanding of the environmental values at risk of harm from alteration of the groundwater environment at the site (this section – **Section 1**);
- Defining the management and monitoring plan, which include the proposed monitoring locations and monitoring frequencies, trigger levels and threshold limits (**Section 2**);
- Outlining the adaptive management and early response in case of trigger threshold limits are reached (**Section 3**).

This GMMP is outcome-focused and is compliant with the Environmental Protection Authority (EPA) instructions on "*How to prepare Environmental Protection Act 1986 Part VI environmental management plans*" (EPA, 2024).

1.3 Key Environmental Factors

The key environmental factors considered in this GMMP are Fora and Vegetation, Inland Waters (IW) and the Benthic Communities and Habitats (BCH) (EPA, 2023):

- The EPA objective for IW is to "*maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected"*;
- The EPA objective for BCH is to "*protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*".

Secondary factors, which are dependent upon the outcomes to GDE, IW and BCH, are marine fauna and terrestrial fauna (including significant species), and social surroundings (cultural connection, livestock bores and Santos pipeline).

Sub-terranean fauna are not a key environmental factor at this site (EPA WA correspondence) however, they are known to be present at the site and are a groundwater dependant ecosystem. In this GMMP stygofauna are discussed in terms of their presence at the site as a groundwater user and thus as an aquatic groundwater dependant ecosystem.

Proposal activities that may affect these factors are described in **Table 1.1**.

Table 1.1: Potential Impacts to Flora and Fauna Inland Waters and/or Benthic Communities and Habitats

Key Environmental Factors:	Inland Waters and/or BCH
Proposal activities that may affect these factors	• Evaporation Ponds • Crystalliser Ponds • Bitterns storage dams and pipelines
Environmental values that may be affected by implementing the Proposal.	• EV1 – Groundwater dependant aquatic ecosystem i.e. Stygofauna • EV 2 – Groundwater dependant terrestrial vegetation • EV 3 – Terrestrial vegetation (Priority Ecological Community) • EV4, EV5 – Benthic communities and habitats (BCH), including mangrove, algal mat and samphire communities, as well as the biological systems that they support. • EV 7, EV 8 – Cultural and spiritual (soaks, springs and pools) - Water levels and/or water quality in Noorea Soak and Devils Pool as a result of changes to groundwater regimes or groundwater quality. • EV 6 – Livestock watering bores. • EV 9 – Santos Gas Pipeline
Ecosystem health condition / sensitive component of the key environmental factor	• Groundwater salinity • Groundwater level
Existing and/or potential uses	• Pastoral station (cattle)

1.4 Environmental Scoping Documents requirements

The Eramurra Solar Salt project has been referred to the EPA and the ESD approved. The ESD documents requirements related to groundwater assessment, the requirements of which are summarised in **Table 1.2**. Also presented in **Table 1.2** are details of the studies completed to date to address each requirement.

Geosyntec consultants

Table 1.2: ESD Requirements and Status of Key Studies and Investigations

ESD Requirement #	Condition Requirement	How/Where addressed in the project studies
24	• Conduct permeability assessment of pond floors and walls to determine the likelihood of groundwater seepage and mounding interactions with underlying groundwater. If significant interactions are predicted, then conduct hydrostatic modelling to determine the potential for movement of hypersaline groundwater towards key BCH and assess potential impacts.	Assessment of the permeability of surface residual soils at the site was attempted early in the project development by Leichhardt and during the geotechnical program of work competed by CMW Geosciences in 2022. The data gathered was not deemed useful by Leichhardt therefore the conservative approach of undertaking seepage modelling using the three dimensional groundwater model developed for the site was taken in 2023: CDM Smith 2023b *Groundwater effects assessment and seepage modelling (V3).* The outcomes of the modelling exercise have been used to develop the management measured in this GMMP.
32	• Undertake a study to predict the likely seepage from salt ponds and groundwater mobilisation into the receiving environment (including groundwater and surrounding tidal creeks/near shore marine waters) and potential flow-on effects to surrounding ecosystems (such as mangroves and algal mats).	Following development of a site wide three dimensional numerical groundwater model seepage scenario modelling was completed to assess the potential for mounding to develop during pond operation (Appendix A of CDM Smith 2023b). Modelling was limited to a simplified and **conservative approach due to limited site specific data**. The model simulates flow within the sedimentary hydrostratigraphic units (HSUs) and assumes no flow in the underlying bedrock. Uncertainty analysis was completed to account for seawater-groundwater interactions and the effects of sea level rise. The results of the modelling completed demonstrated the following: • Marginal groundwater elevation changes (<0.5m) are predicted to occur at the coastal PEC, elevation changes in the order of 2m - 4m may occur directly beneath the ponds but groundwater is not expected to daylight, with levels remaining at least 2m below ground surface. • Similarly, only marginal changes to groundwater levels (<0.5m) at the stock water wells are predicted. • Noorea Soak is modelled as a basement high and therefore no groundwater elevation changes were predicted in the model at this location. • The greatest predicted groundwater elevation changes are predicted to occur at Devils Pool and the Santos Gas Pipeline, with increases in the order of 3-5m predicted by year 100 of the model. • In addition to groundwater elevation, groundwater salinities across the site were also modelled. Salinities across the site are variable, however with the development of the project, salinities are noted to increase in line with where mounding and elevated groundwater levels were noted, such that the ponds control the salinity of groundwater beneath the evaporation ponds, pond perimeters and creeks, with salinities up to 210 g/L possible (constrained to within 1 km of the pond walls). • At the sabkha area evapotranspiration (ET) is the controlling factor for salinity, with little influence of this from the project (mean increase in salinity

ESD Requirement #	Condition Requirement	How/Where addressed in the project studies
		from groundwater influence likely to be in the order of 5g/L). • It is noted that the lack of salinity data for the site at the time the modelling exercise was completed meant that **there is a considerable amount of uncertainty** in the results obtained, however, they are indicative of the scale of the likely changes.
89	• Outline the proposed avoidance and mitigation measures to reduce the potential impacts of the Proposal. Include proposed management and/or monitoring plans that will be implemented pre- and post-construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans are to be presented in accordance with the EPA's instructions and comply with the Environmental Management Plan Guidelines (Cth DotE, 2014).	The project deliverables have input from an ecohydrogeologist (Dr Jon Fawcett). Effects on EVs from groundwater affecting activities have been assessed and reported in the Groundwater Effects and Seepage Modelling report (CDM Smith 2023b). Following additional site characterisation (drilling, well installation and groundwater monitoring) the site hydrogeological setting has been re-conceptualised: CDM Smith 2024b *Eramurra Solar Salt Project Site Setting and Groundwater Baseline Update.* This update identified greater variability in the site conditions that previously documented further validating the recommendation that additional well installation be undertaken as soon as practicable to allow for assessment of the likely pathway of groundwater from the pond footprint to identified EVs particularly at the creeks, pools and soaks. Progressive installation of baseline groundwater monitoring well is ongoing, as approval of drilling work is achieved. Additionally, assessment of baseline groundwater conditions, with the most recent monitoring event presented in LWC, 2024, the results of which have been considered in the CDM Smith, 2024b.
102	• Undertake a study to predict the quantity and quality of likely seepage of saline water from salt ponds and potential mobilization into the surrounding environment and potential for soil contamination.	Seepage modelling study described above included quality and quantity predictions. CDM Smith 2023b *Groundwater effects assessment and seepage modelling (V3).*
135	• Identify and characterise any environmental receptors that may be impacted by changes to inland waters as a result of this proposal.	Groundwater effects assessment identifies the EVs likely to be impacted by changes in the hydrogeological conditions (physical and chemical) – CDM Smith 2023b *Groundwater Effect Assessment and Seepage Modelling Report* It is understood that Leichhardt have continued to undertake studies of the benthic habitat and algal matt and terrestrial communities, but that no additional EV's have been defined in addition to those documented in **Section 1.3.** A summary of identified EVs is presented in **Section 1.8.1.**
139	• Undertake a groundwater model to assess the following: - Impacts on the surface-groundwater interaction, groundwater flow directions and hydraulic loading by proposed structures.	As discussed above, the groundwater modelling undertaken to date has included evaluation of: • Groundwater quality and flow (velocity and direction) • Mounding, magnitude and extent

ESD Requirement #	Condition Requirement	How/Where addressed in the project studies
	- Hydraulic loading surface expressions and subsequent impacts on vegetation. - The influence of density-driven flow induced by seepage from structures, and subsequent impacts to vegetation and • The extent of seawater intrusion and how this may be influenced by the Proposal, with subsequent flow-on impacts.	• The potential for surface expressions of groundwater, • Potential impacts on vegetation and other EVs. • Scenarios included assessment of density driven flow induced by seepage. • Solute transport to address salinity changes were also modelled. • Seawater intrusion considering changes in sea level from climate change (increase of 0.9m) were included. • Climate change scenarios also included alteration of evapotranspiration (ET) rates. Work to address surface water groundwater interaction is planned. Groundwater bore installation is ongoing and includes shallow and deep bores as close to creek lines as practicable with the purpose of assessing potential surface water groundwater interaction at these inland areas.
144	• Characterise the baseline hydrological and hydrogeological regimes and water quality, both in a local and regional context, including but not limited to the water levels·, stream flows (ephemeral and flowing), climate, flood patterns, and water quantity and quality.	Geotechnical, geological, soil, sediment and hydrological assessments have been undertaken at the site. These data have been combined to develop a conceptual hydrogeological site model, prepared by CDM Smith 2024, and presented below in **Section 1.6.3**. CDM Smith 2024b *Eramurra Solar Salt Project Site Setting and Groundwater Baseline Update.*
147	• Discuss the proposed management, monitoring and mitigation to avoid and minimise impacts to inland waters, and potential flow-on effects on the surrounding environment as a result of implementing the Proposal. If management plans are to be developed to address specific impacts, they are to comply with the Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f) and Environmental Management Plan Guidelines (Cth DotE, 2014).	Addressed in this GMMP **Sections 2** and **Section 3.**
148	• Detail the management, monitoring and mitigation measures to be implemented to ensure residual impacts on inland waters are not greater than predicted.	Monitoring locations have been defined considering: • Heritage • Surrounding landuse and other stakeholders • Geology • Hydrogeology • Hydrology • EVs Monitoring program for all wells considering timing of well installation and minimum monitoring requirements prior to implementation of the proposal is presented in **Section 2.4.**

1.5 Rationale and Approach

1.5.1 Regulatory Framework

Part IV of the *Environmental Protection Act 1986* (EP Act 1986 (amended in 2020)) makes provision for the EPA to undertake an Environmental Impact Assessment (EIA) of significant proposals. Key concepts in the Act that are relevant for the GMMP are summarised below.

- The five environmental principles (section 4A of the Act):
  - The precautionary principle
  - The principle of intergenerational equity
  - The principle of the conservation of biological diversity and ecological integrity
  - Principles relating to improved valuation, pricing and incentive mechanisms
    - Environmental factors should be included in the valuation of assets and services.
    - The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement
    - The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes
    - Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.
  - The principle of waste minimisation.
- The EPA environmental factors and objectives (EPA, 2023) provides further guidance on the EIA process by defining objectives for 14 environmental factors under five themes as follows:
  - Sea: benthic communities and habitats, coastal processes, marine environmental quality, marine fauna,
  - Land: flora and vegetation, landforms, subterranean fauna, terrestrial environmental quality, terrestrial fauna,
  - Water: inland waters,
  - Air: air quality, greenhouse gas emissions, and
  - People: social surroundings, human health.
- The mitigation hierarchy is a sequence of actions to help reduce adverse environmental impacts:
  - Avoid – avoid the adverse environmental impact altogether. This may include reducing the footprint or changing the location of the footprint to avoid areas with high environmental values.
  - Minimise – limit the degree or magnitude of the adverse impact. This may include reducing the footprint or carefully selecting technologies, processes (such as re-use of waste products) and management measures (such as bunding or dust and noise control measures) to reduce the impact.
  - Rehabilitate – repair, rehabilitate or restore the impacted site as soon as possible. Adequate rehabilitation information is integral to the mitigation hierarchy to ensure early

identification of knowledge gaps and risk as well as development of criteria and research to meet objectives.

- Offset – undertake a measure or measures to provide a compensatory environmental benefit or reduction in environmental impact to counterbalance significant adverse environmental impacts from implementation of a proposal. The measure(s) are taken after all reasonable mitigation measures have been applied and a significant environmental risk or impact remains. Offsets are not appropriate for all proposals and will be determined on a proposal-by-proposal basis.

1.5.2 Strategy to Protect Groundwater

The objective of a management strategy is to minimise the likelihood of an identified risk occurring with a view to also minimising the impact and consequence of that risk.

At the present time, given that direct effects to groundwater are expected to occur in the site area (CDM Smith 2023b), there is a need to consider a range of active groundwater management measures for the project.

The groundwater management measures to be adopted at the site will consider the outcomes of the baseline studies and will be reviewed pending interpretation of data gathered post construction and during operation.

The current hydrogeological baseline studies as discussed in the sections below are designed to reduce the hydrogeological uncertainty by assessing natural variability of measurable parameters in terms of water quality, quantity and levels.

In general accordance with the advice provided by Thomann and co-authors (Thomann et al, 2022), the measures to be employed will be designed with due consideration of the following:

- The severity of the impact
- The permanence of the impact
- The potential effects to the environment from employing the action.

1.5.3 Roles and Responsibilities

The roles and responsibilities in relation to implementation of the GQMP are summarised in **Table 1.3**.

Table 1.3: Stakeholders and responsibilities for implementation of the GQMP

Stakeholder	Role	Responsibilities
Leichhardt Salt Pty Ltd	Duty holder	• Comply with obligations under the Act and the environmental approval • Inform EPA of any significant findings or alterations to the approach outlined in this GMMP throughout its implementation • Engage/manage environmental consultants and remediation contractors to perform works required under the GMMP • Advise/ liaise with EPA as appropriate • Advise other stakeholders (including site tenants and owners/occupants of off-site areas impacted by site contaminants) of GMMP-related outcomes as appropriate
Leichhardt Salt Pty Ltd or their appointed Environmental consultants	GMMP Implementation	• Conduct monitoring works and prepare reports as required under the GMMP • Ensure compliance with work health and safety (WHS) and regulatory guidelines in completion of assessment/remediation works • Manage subcontractors as required in implementing the GMMP • Advise Leichhardt throughout GMMP implementation as necessary

1.6 Other Stakeholders

Other stakeholders include:

- Traditional Owners
- Environmental Protection Authority
- Mardie Station owners
- Pilbara Ports Authority
- Department of Biodiversity, Conservation and Attractions
- Department of Planning, Lands and Heritage
- Santos

1.7 Summary of Site Physical and Hydrogeological Setting

The site physical and hydrogeological setting is summarised in this section based on information provided by CDM Smith (CDM Smith, 2024b) and Land and Water Consulting (LWC, 2023b).

1.7.1 Surrounding Land Use and Topography

The topography of the site area and surface water catchments are illustrated in **Figure 1-3**.

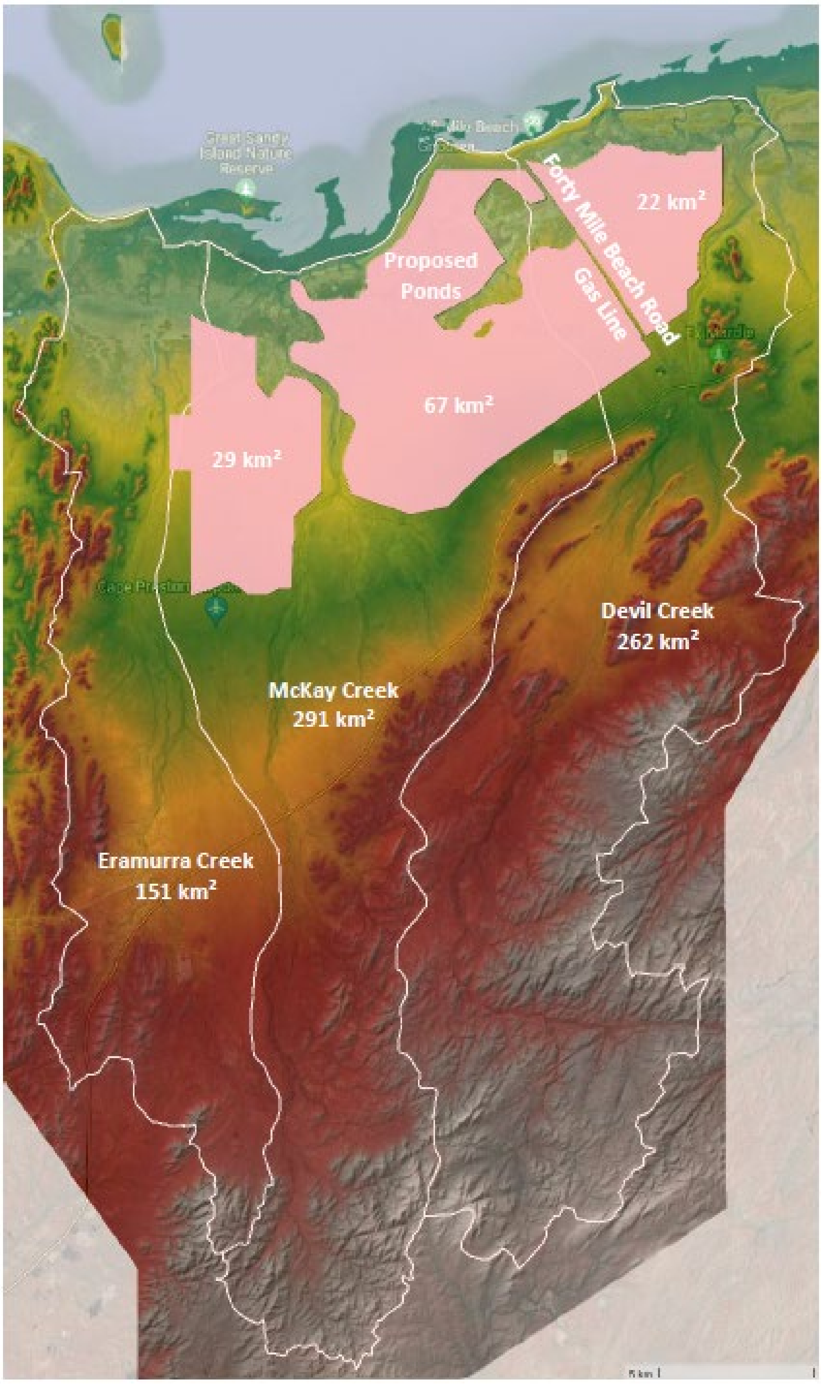

Figure 1-3: Site Topography and Catchments (LWC, 2022a)

The northern fringe of the site area is a low-lying coast. Its central and eastern parts comprise a line of coastal beach ridges, dunes and cheniers forming a coastal barrier. The barrier rises locally to over 12 m along the crest of the main dune.

Behind the coastal barrier has formed a backwater of inter and supra tidal flats. Several small (high tide) islands are present in the backwater providing evidence of former coastlines which are now partially buried beneath the backwater lagoonal sediments.

Sabkha-like environments (i.e. salt flats or saline mudflats) are common in low lying areas adjacent to the coast, formed through the interaction of surface and groundwater with evaporites. These environments are characterised by high salinity, shallow water tables and periodic flooding.

The digital elevation model indicates that the backwater and inter / supra tidal flats areas are lower than the mean high tide level, forming a topographic low point at the site ranging between 0 and 5 m AHD.

Inland of the inter and supra tidal flats is an area of alluvial outwash, falling at a gradient of about 1 m in 300 m from the southeast towards the northwest.

The predominant land use in the area surrounding the Site appears to generally comprise pastoral land use (Mardie Station), recreational land (40-Mile Beach) and lands currently being managed by the Department of Biodiversity, Conservation and Attractions for the control of fire, feral animals and weeds and proposed for formal reservation under the *Conservation and Land Management Act 1984* (CALM Act).

The Devil Creek Gas Plant pipeline (leading from the plant to the coast) transects the north eastern portion of the Site. The North Western Costal Highway bounds the project area along its south western to eastern boundary.

1.7.2 Drainage System and Key Surface Water Features

The Project area resides within three sub-catchment areas belonging to Eramurra Creek, McKay Creek and Devil Creek forming a combined catchment area of around 704 km^2 (LWC, 2022c) (**Figure 1-3**):

- Eramurra Creek, located on the western side of the site area, adjacent to the proposed crystalliser ponds.
- McKay Creek, located within the central Project area between the proposed crystalliser and concentration ponds.
- Devil Creek, located on the eastern side of the site area.

Due to the high evaporation rates and low rainfall within the region, no natural permanent water bodies are known to exist, however, ephemeral water courses and soaks/pools have been documented.

Two surface water features, Noorea Soak and Devils Pool, are documented to occur within the site area and have cultural and spiritual values (**Figure 1-3**):

- Noorea Soak is located within the central point of the western concentration ponds in a topographical low point that is coincides with basement rock outcrop. Available information (CDM Smith, 2024b) suggests that this is not a permanent water feature. While groundwater contributions to this feature are possible, the lack of permanent inundation, anticipated depth and fluctuation of groundwater in the surrounding areas, and the low permeability of the basement rock support that the soak does not currently receive substantial groundwater inflows.
- Devils Pool is located immediately west of the site operations. It is also an ephemeral surface water feature and coincides with basement rock outcrop. Statistical analysis of data support that Devils Pool holds water less than 2% of the time (CDM Smith, 2024b). For similar reasons to Noorea Soak, the current data collected in the pool vicinity (CDM Smith, 2024b) do not support that Devils Pool receives substantial groundwater inflows.

In low lying areas adjacent to the coast, the salt flats or saline mudflats act as receptors for surface water following high rainfall events. Based on the evaporation rates at the site, any surface water will quickly evaporate leaving its dissolved solute content as evaporitic salts on the soil and sediment surface in this area. This area also acts as a receptor for groundwater, when high ET rates occur, numerical modelling has demonstrated that groundwater is also likely evaporated in this zone which limits interaction of groundwater from the project area with the marine environment (CDM Smith 2023b). This is further discussed below.

1.7.3 Site Hydrogeological Setting

Two distinct aquifer systems occur within the site area (**Figure 1-4**):

- A shallow sedimentary aquifer system where groundwater resides in the Quaternary and Tertiary sediments that mainly consists of aeolian sand, intertidal and supratidal muds, alluvial outwash and older alluvium in the deeper parts of palaeochannels that are carved in the underlying basement rock. This aquifer system is porous and typically unconfined, with finer sediments acting as leaky and confining zones to the deeper sedimentary strata. Associated with this aquifer system is the highly weathered zone of the basement (termed “eluvium”) that is also expected to act as a porous aquifer unit.
- A deep fractured rock aquifer system where groundwater resides in the weathered and crystalline basement rock of the Dampier Granitoid Complex. The aquifer system is fractured, typically confined expect in areas where the rock outcrops. This is the rock that has been carved over the geological times to host the above sediments.

The thickness in sediment ranges from zero (i.e. where the rock is outcropping) to about 50 m (i.e. in the centre of the palaeochannels). The sediments are considerably more permeable than the underlying rock, with the higher range of hydraulic conductivities ranging from 10^{-1} metre per day (m/d) to 10 m/d across the vertical profile. The hydraulic conductivities in the basement rock are lower, around 10^{-3} to 10^{-1} m/d for moderately weathered basement and 10^{-5} to 10^{-4} m/d for crystalline basement.

Further information about the hydrogeological conceptualisation can be found in CDM Smith (2024b).

Groundwater level contours have been developed using July 2024 data (**Figure 1-5**). Groundwater elevations range from approximately 11 m AHD in the southeast to near sea level (i.e. 0 m AHD) adjacent to the coast. The distribution in levels indicates that groundwater predominantly flows in a north to north-westerly direction, towards the inter- and supratidal flats (i.e. sabkha). As they act as a natural low point in the topography, the flats are expected to be the main regional groundwater discharge zone.

Water level data from monitoring wells in the broad vicinity of ephemeral drainages (within 150 m) suggest groundwater could be encountered at around 2 m beneath creek beds. This supports the potential for interaction between groundwater and the creek under some circumstances. For example, fresher runoff water is likely to recharge groundwater in the vicinity of the creeks.

Although additional nested or clustered wells are recommended to better understand the hydraulic gradient with depth, there seems to be little difference in water levels between the shallow sedimentary aquifer system and the deeper basement rock.

Groundwater salinity within the site area ranges from 710 mg/L to 130,000 mg/L Total Dissolved Solids (TDS), with the highest reported TDS concentrations tending to be in groundwater wells in close proximity to the coast. The distribution in TDS indicates a strong hypersaline interface in the backwater (sabkha) areas adjacent to the coast with relatively steep salinity gradients to the north and south of this feature. This demonstrates that the main receiving environment for the regional groundwater discharge is naturally hypersaline.

Along the creeks, there is indication that the TDS concentration is lower in the shallow part of the aquifer system (710 mg/L in MB33S) than in its deeper part (17,000 mg/L in MB33D). This is hypothesised to be associated with preferential runoff infiltration that is likely to occur along these creeks during wetter conditions, which would sustain the occurrence of fresher groundwater in these areas. This hypothesis should be verified due to the possible important implications on the EVs of groundwater along the creeks.

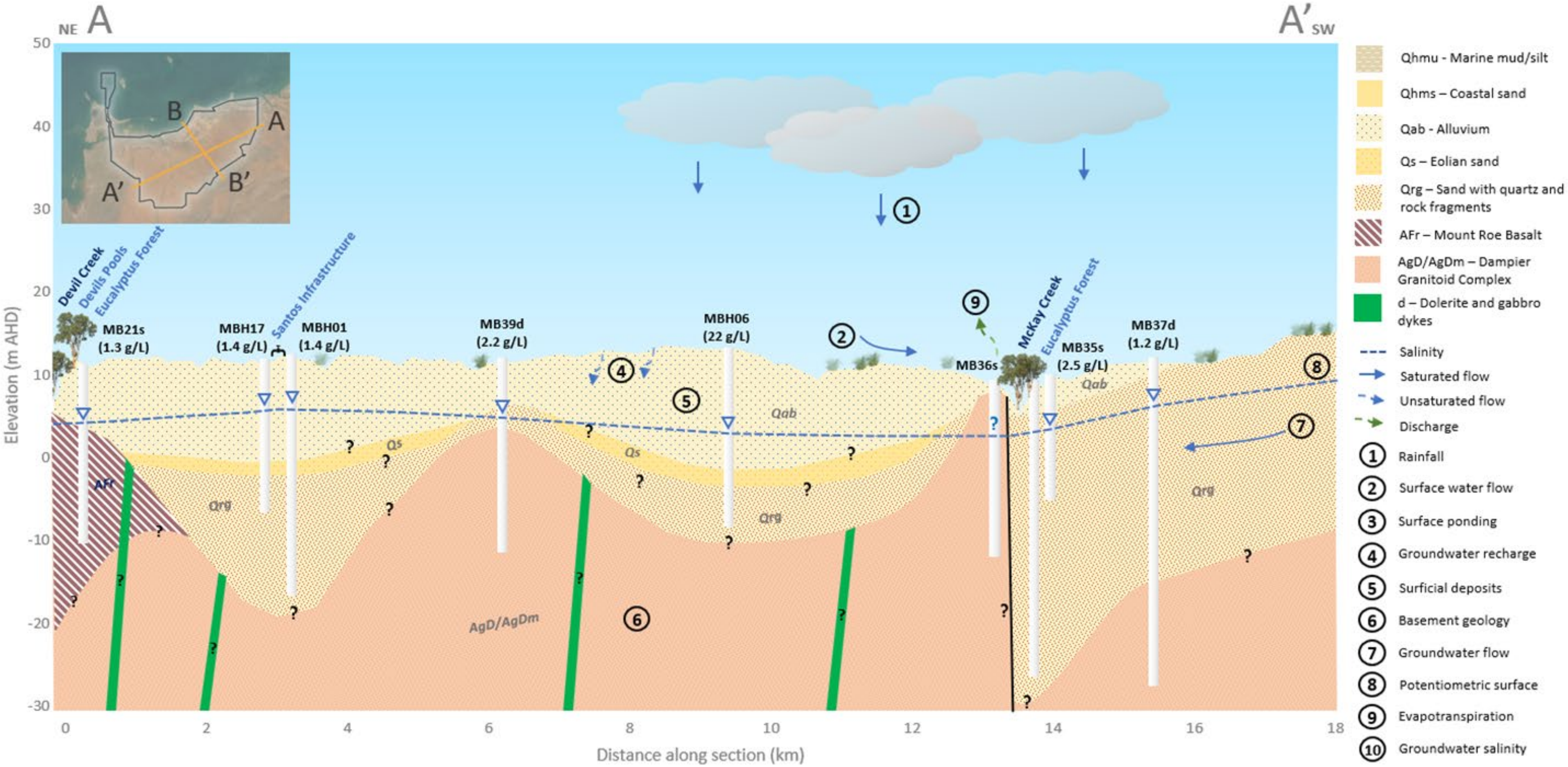

Figure 1-4: Conceptual Hydrogeological Model (NE-SW) (CDM Smith, 2024b)

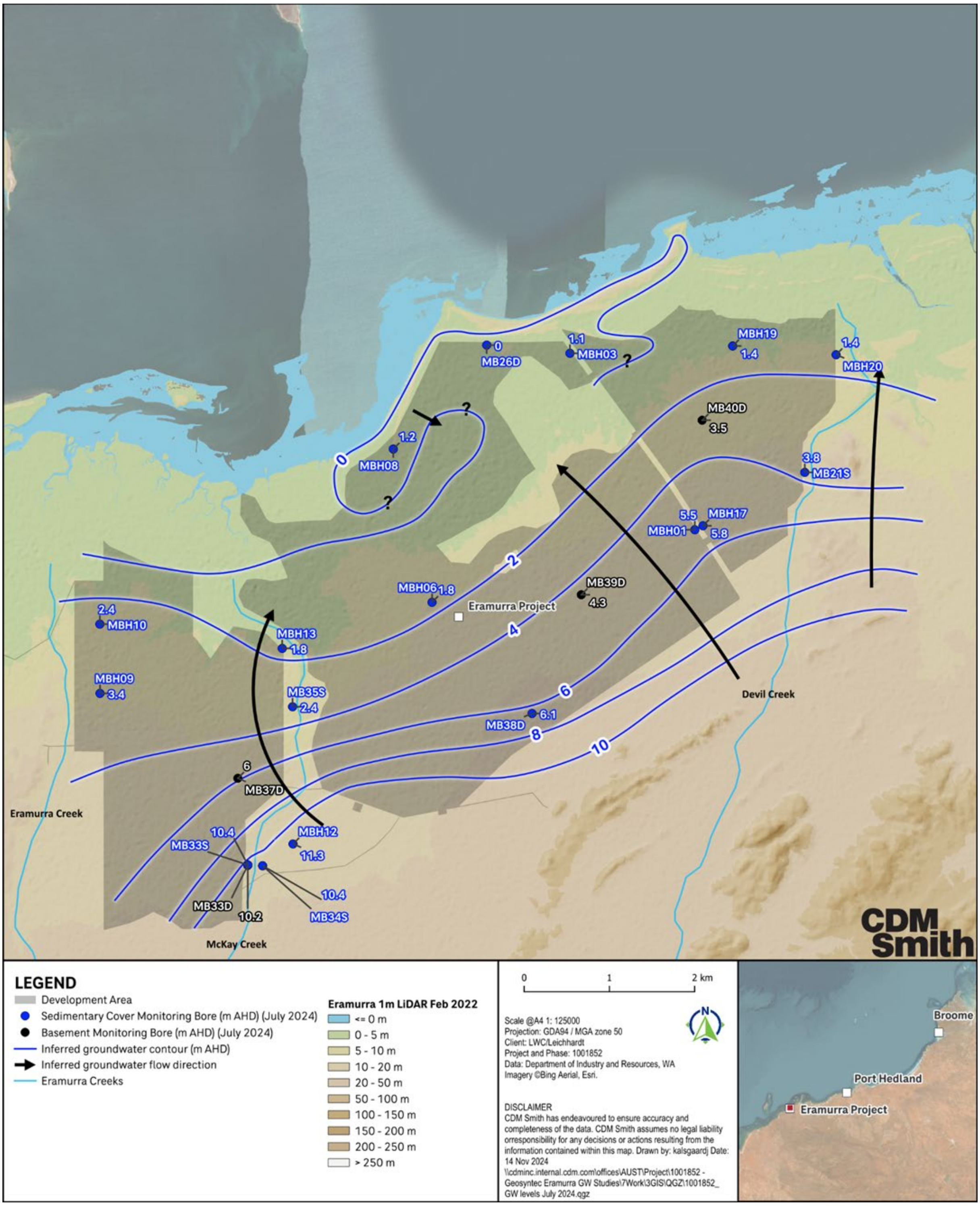

Figure 1-5: Inferred Groundwater Level Contours and Flow Direction (CDM Smith, 2024b)

1.8 Monitoring Network

The groundwater and surface water monitoring network is illustrated in **Figure 1-6**. The network includes current and proposed (conceptual) locations.

> The proposed locations are conceptual in nature as their relevance in the network will depend on:
>
> - the practicability and operational constraints associated with their installation
> - their ability to adequately address the data gaps outlined in **Section 1.1.4**
> - the subsurface conditions that will be encountered at the time of their installation and the data that will be collected as part of their monitoring.
>
> Hence additional well installation prior to and during operation may occur.

The current and proposed groundwater well locations are summarised in **Table A.1**, **Appendix A** along with their rationale and key construction details. A summary of the surface water monitoring locations is provided in **Table A.2**, **Appendix A**.

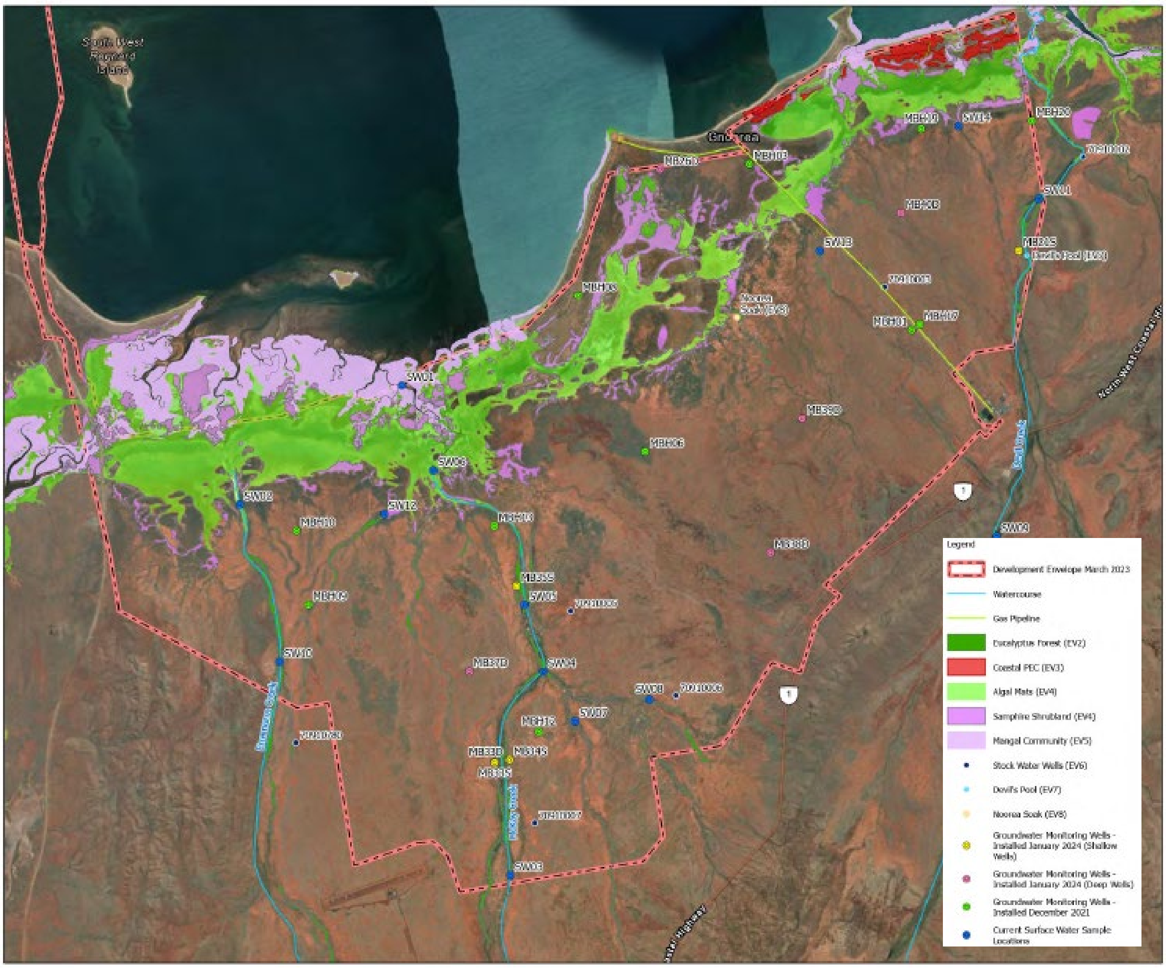

Figure 1-6: Current and Proposed (Conceptual) Groundwater Well and Surface Water Monitoring Location

1.9 Summary of Potential Groundwater Impacts and Risk

An understanding of the potential for groundwater to be impacted by site operations and their associated risks are summarised in this section by:

- Identifying the Environmental Values (EVs) relevant for groundwater and their vulnerability to the site operations;
- Summarising the baseline groundwater data.

1.9.1 Environmental Value and Threat Assessment

Studies completed to date have assisted in understanding the potential direct effects of alteration of groundwater levels and flow (volumes and direction) from seepage and resultant mounding of groundwater associated with the proposed project infrastructure to identified EVs. As per the outcomes of "*Eramurra Solar Salt Project – Groundwater Effects Assessment and Seepage Modelling*" provided by CDM Smith (2023b) and studies on benthic communities and habitats completed by O2 Environment (2023), **Table 1.4** below summarises the considered EV's and predicted outcomes of the threat to these values in the absence of mitigation (noting that EVs listed below are those that may be affected by water affecting activities (WAA) and not those disturbed by other activities such as construction of the ponds).

The outcomes of these assessments have assisted in refining the requirements of further baseline groundwater and surface water monitoring and the need for additional monitoring infrastructure to characterise areas predicted to be at risk.

Table 1.4: Environmental Values and Outcomes of Threat Assessment (CDM Smith, 2023b)

Environmental Value (receptor)	Direct Effect (pathway)	Outcome of Threat Assessment (in the absence of mitigation)	Relevant Monitoring Bores
EV1 EV2 and EV 3 – Groundwater dependent ecosystem (GDE) Stygofauna Terrestrial vegetation (GDE Atlas) Terrestrial vegetation (Priority Ecological Community)	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in groundwater flow	Groundwater modelling has indicated that mounding of the water table will occur, however, this will not result in a reduction in stygofauna habitat. Groundwater levels are expected to increase by around 3 m within the creeks and drainages within the Project area, notably Devil Creek to the Project's east and McKay Creek situated between the evaporation ponds in the centre of the Project area. This may cause water logging of the unsaturated root zone, impacting the reserve of fresher soil water used by the trees for transpiration, as these species cannot draw water from completely saturated soil (below the water table). *Eucalyptus* species within McKay and Devil Creek that occur within 1 km of the evaporation ponds, and within Eramurra Creek up to 3 km from the evaporation ponds will likely be threatened by the Project development and potentially result in permanent loss of vegetation. Permanent loss of vegetation is not expected provided an unsaturated zone remains (i.e. the eucalypts are not exposed to permanent inundation). The modelling predicts an unsaturated zone will remain, but there is uncertainty around this key prediction. Reducing this uncertainty will be a focus area for model refinement. It is anticipated that groundwater salinity within the Project area will increase by up to the point of salt saturation during operations. Salinity increases to the groundwater at the modelled concentrations will likely affect the vadose zone and impact the water (groundwater) uptake during dry periods when fresher waters supplies are diminished. Eucalypt species are documented to viably use groundwater with salinity of less than around 13 g/L, while they have also been shown to use groundwater between 7 to 21 g/L (CDM Smith, 2023b). These	EV1 MB26d MB38d EV2: MB30d MB30s MB31s MB32d MB32s MB33d MB33s MB34s MB35d MB35s MB36s MB54s MB54d EV3: MB23s MB24s MB25s

Environmental Value (receptor)	Direct Effect (pathway)	Outcome of Threat Assessment (in the absence of mitigation)	Relevant Monitoring Bores
		tolerance ranges are far below the modelled salinity increases at the Project creeks, for which increases of almost 350 g/L are expected in some locations. The consequence of such a direct effect is increased tree stress during dry periods and potential permanent loss of vegetation. This will also likely impact stygofauna habitat. Groundwater modelling indicates the Project will change groundwater flow resulting in greater discharge to the coast rather than the current condition where groundwater flows from the coast inland with only minor discharge to the ocean. This process, however, is unlikely to impact stygofauna habitat significantly, as stygofauna are thought to exist predominantly in areas further inland and outside of the hypersaline backwater zone adjacent to the coast. The threat to stygofauna as a result of the Project development is expected to be localised to the evaporation ponds and a small extent outside of these areas impacted by salinity increases and unlikely to have a significant impact in terms of the conservation of fauna communities more regionally. It is understood that the EPA has stated that that although stygofauna exist at the site, the species present are typical of the Pilbara region and not specific to this site. Shallower groundwater levels will extend the periods of surface water inundation within creeks from the baseline condition. This effect alone generally will not result in an adverse effect unless it induces a prolonged period of water logging that entirely inundates the unsaturated zone or combines with direct effects associated with salinity increases, e.g., if the surface water becomes saline as a result of groundwater interactions, or groundwater from beneath the evaporation ponds seep to within these drainages. The consequence of such a direct effect is increased tree stress during dry periods, reduction of the number and frequency of emergent saplings and potential permanent loss of vegetation.	
EV4 – Algal mats and Samphire	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	It is expected that most of the increased recharge will discharge via groundwater evapo-transpiration (ET, water loss) and as outflow to the sea. Outside of the evaporation pond areas, the zone of water level influence remains relatively constrained to within a kilometre buffer zone however, no expressions of groundwater or permanent wetting are predicted, suggesting the impact to algal mat and samphire communities from increased groundwater recharge is negligible, but possible. A minor increase to groundwater salinity in the areas immediately adjacent to the evaporation ponds in the northeast and northwest of the Project is expected. As algal mats and samphire are groundwater dependant species, direct effects relating to groundwater quality (i.e., increased salinity) will only pose as an exposure pathway should groundwater become contacted with these EVs. Groundwater discharge is not expected in areas other than through groundwater ET or direct discharge to the coast. The salinity of groundwater discharging to the coast is expected to be equal to seawater and slightly higher (up to 4 g/L) in very localised areas. The impact from increased groundwater salinity to algal mats is expected to be localised to areas along the coast where groundwater discharges, however, algal mats are expected to be resilient to the predicted salinity increases. Salinity impacts to samphire might occur should their habitat (i.e., the backwater areas) become permanently inundated. No change in groundwater levels is expected within 1 km distance (within the algal mat area) of the evaporation ponds. Minor change in groundwater levels is likely immediately adjacent to the evaporation ponds which may impact the	MB27s MB28s MB43s MB44s MB45s

Environmental Value (receptor)	Direct Effect (pathway)	Outcome of Threat Assessment (in the absence of mitigation)	Relevant Monitoring Bores
		wetting and drying processes of algal mats and samphire; however, permanent inundation is not expected and groundwater mounding surrounding the evaporation ponds is unlikely to have a significant effect on the wetting and drying cycles within the backwater area. There is uncertainty around this key modelling outcome. Reducing this uncertainty will be a focus area for model refinement. The expected change in groundwater flow will result in some additional flow occurring towards the ocean (under the most likely operation scenario), which might impact algal mats that exist within tidal areas that coincide with groundwater discharge. This direct effect, however, will not change the overall flow process towards the backwater areas meaning an adverse effect is not expected to samphire. The impact to samphire will depend on water logging and salinity change and tolerance of this EV to those changes.	
EV5 – Aquatic vegetation (mangroves)	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	It is expected water levels within the mangrove areas will not increase as a result of water impoundment due to the hypersaline backwater zone buffering the increased recharge through increased groundwater ET. The mangrove site is likely to be relatively insensitive to the operations, possibly due to the buffer provided by ET in the low-lying area. Given its proximity to the sea, this area is more susceptible to sea water intrusion in the sea level rise scenario. The salinity level is further increased by evapo-concentration (hence it can go beyond the sea salinity of 35 g/L), although this is an effect of sea level rise, not of the operations. Wetting and drying cycles are unlikely to be impacted as groundwater levels in mangrove areas are unlikely to increase. It is expected that the groundwater outflow to the sea will increase by around 500 kL/d under the mean sea level scenario and 300 kL/d under the sea level rise scenario.	MB29s MB46s MB47s MB48s MB49s MB50s MB51s MB52s
EV6 – Stock water wells	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	Two stock water wells (70910002 and 70910780) will likely become inoperable due to salinity increases in the groundwater. The salinity is expected to increase by around 50 g/L. Other stock water wells are unlikely to be impacted by groundwater salinity increases, however, the uncertainty in the salinity predictions is large and the baseline salinity is unknown and will need to be confirmed to understand the threat to stock water wells. Additionally, the influence of pumping from stock water wells has not been assessed to predict whether groundwater abstractions could draw hyper saline groundwater from under the evaporation ponds to these wells. The consequence of this direct effect is loss of stock watering infrastructure. Leichhardt will be relocating stock watering wells. This will eliminate the threat of stock watering infrastructure loss to pastoral lease owners, as such EV6 is not considered further in this GMMP.	No wells – Stock Wells to be relocated.
EV7 - Cultural and spiritual (springs and pools)	DE1 – Increased recharge DE2 – Increased salinity	Devil's Pools, a surface water body located within Devil Creek to the east of the Project has the potential to be impacted by changes in groundwater salinity as a result of groundwater level increase. Note, an increase in salinity or groundwater levels alone would not produce an impact to the pools, it is the combination of water level rise and salinity increase that could change the character of the pools. Groundwater salinity in the Devil Creek area is expected to increase by around 260 g/L after around 100 years of operation and under the worst case this increase could occur	MB55 MB21s

Environmental Value (receptor)	Direct Effect (pathway)	Outcome of Threat Assessment (in the absence of mitigation)	Relevant Monitoring Bores
	DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	within 20 years of the beginning of operation, however as the project lifespan is only 60 years the increase may not be as large as modelled. Groundwater levels are expected to rise by around 3 m but remain 2 m below the ground surface. It is possible that the combination of these effects could cause the pools to switch from temporary fresh water to permanent saltwater pools. It should be noted that little is known about the current condition of this EV and whether the pools represent permanent expression of groundwater or if such a connection exists. It is understood that the pool does not contain water permanently and is therefore not currently likely to be supported by groundwater. The rise in expected groundwater levels caused by mounding (increase of around 3 m) could increase the chances of connection at this EV and therefore, increases in salinity to the levels expected will likely alter the current ecological condition of Devil's Pools and permanently disrupt the EVs reliant upon the pool to meet their environmental water requirement (EWR).	
EV8 – Cultural and spiritual (soaks)	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	Site surveys have identified the presence of a soak (Noorea Soak) within elevated basement geology which outcrops west of the Santos Gas Pipeline in a gap between the proposed evaporation ponds. Remote sensing investigations (CDM Smith, 2023b) suggest this EV is not a permanent water feature and is unlikely to receive groundwater inflows. The soak is conceptualised to be supported by surface water runoff that collects during rainfall events due to its location within a natural landscape depression. Although not a groundwater EV, it is recognised this EV has potentially signific spiritual importance and as such, has been included further in this assessment to investigate the changes to the groundwater system beneath the soak. Groundwater modelling indicates there will be no change to the water levels in the soak therefore there is no mechanism for the project to alter water quality at the soak from interaction with groundwater under the current conceptual model which will be refined as additional monitoring data becomes available.	MB22d MB22s
EV9 – Santos Gas Pipeline	DE1 – Increased recharge DE2 – Increased salinity DE3 – Change in groundwater levels DE4 – Change in Groundwater Flow	It is predicted that a substantial rise in groundwater level at the Santos Gas Pipeline transfer station (located upgradient of the ponds) of around 5 m and a smaller rise (less than 0.5 m) at the northern end of the pipeline may occur. The predicted groundwater level is below the land surface and below the elevation of the pipeline (1.2 m bgl) as the rise is dampened by ET and therefore no direct adverse effect is likely. There is uncertainty around this key prediction. Reducing this uncertainty will be a focus area for model refinement. Saline groundwater has the potential to impact the pipeline directly (depending on the material) should groundwater come into contact with the pipeline and the concrete formations (where they occur) causing corrosion that can be problematic should it reach the steel structure within. The pipeline is installed to 1.2 m bgl and groundwater is not expected to reach this level. In addition, the pipeline has been designed in consideration of the saline environment and in accordance with appropriate Australian Standards (AS2885.1) that address the matter of corrosion mitigation. Groundwater modelling predicts groundwater flow will occur as mounding slightly up gradient of the evaporation ponds and increase quantities of water beneath the Santos Gas Pipeline. However, this impact alone is unlikely to result in an adverse effect to this EV.	MBH017

Table 1.5 provides a summary of the active exposure pathways and potentially threatened groundwater EV's (CDM Smith, 2023b). CDM Smith (2023b) detail a total of eight EV's that are potentially threatened by the Project as described above; however, the potential impact is expected to be mostly constrained to within a 1-3 km zone surrounding the evaporation ponds. The results suggest that EV's may be impacted by direct effects relating to increased recharge, increased salinity, change in groundwater levels and change in groundwater flow. These direct effects will require monitoring and management to decrease the likelihood of the indirect effects occurring. As such ongoing baseline groundwater monitoring, modelling and additional monitoring infrastructure as documented in this report has been proposed. This advice has considered inputs from groundwater modelling (including modelled uncertainty) and, terrestrial and marine surveys completed to date.

Table 1.5: Summary of the Identified Potentially Threatened Environmental Values (CDM Smith, 2023b)

Environmental Value (receptor)	Direct Effect (pathway)	WAAs (Source)
EV1 – Stygofauna	DE2 – Change in salinity	WAA1 – Water impoundment
EV2 – Groundwater dependent terrestrial vegetation (GDE Atlas)	DE1 – Increased recharge DE2 – Change in salinity DE3 – Change in groundwater levels	
EV3 – Terrestrial vegetation (Priority Ecological Community (PEC))	DE2 – Change in salinity	
EV4 – Algal mats and Samphire	DE2 – Change in salinity DE4 – Change in groundwater flow	
EV5 – Aquatic vegetation (mangroves)	DE2 – Change in salinity DE4 – Change in groundwater flow	
EV6 – Stock water wells	DE2 – Change in salinity	
EV7 – Cultural and spiritual (springs and pools)	DE1 – Increased recharge DE2 – Change in salinity DE3 – Change in groundwater levels	
EV8 – Cultural and spiritual (Soaks)	DE1 – Increased recharge DE2 – Change in salinity DE3 – Change in groundwater levels	

The locations of identified environmental values are presented on **Figure 1-7**. Modelled direct effects, change in groundwater levels and increased salinity are presented on **Figure 1-**8 and **Figure 1-9**, respectively.

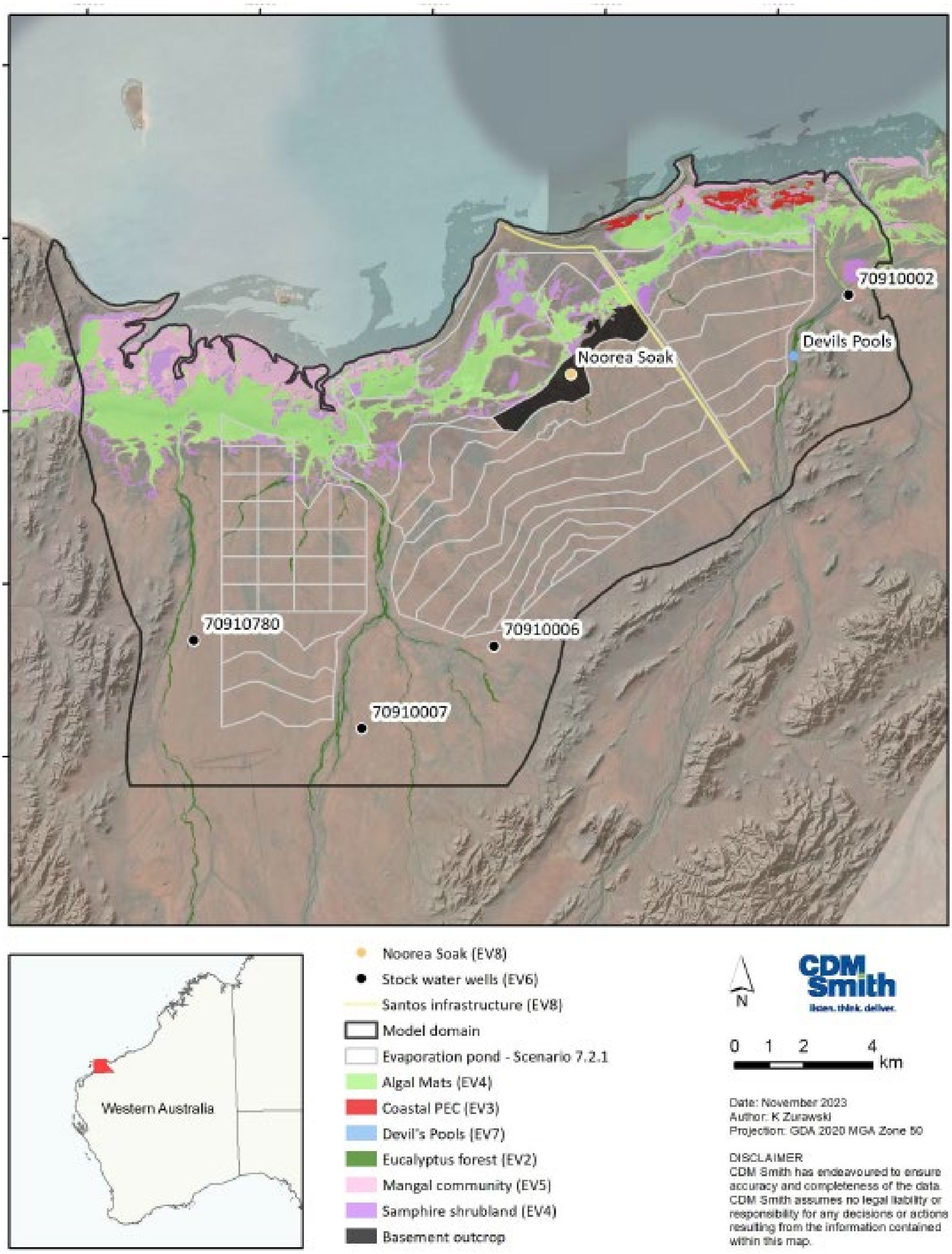

Figure 1-7: Identified environmental values within the Project area (EV1 – Groundwater Dependent Aquatic Ecosystems not shown) (CDM Smith, 2024b)

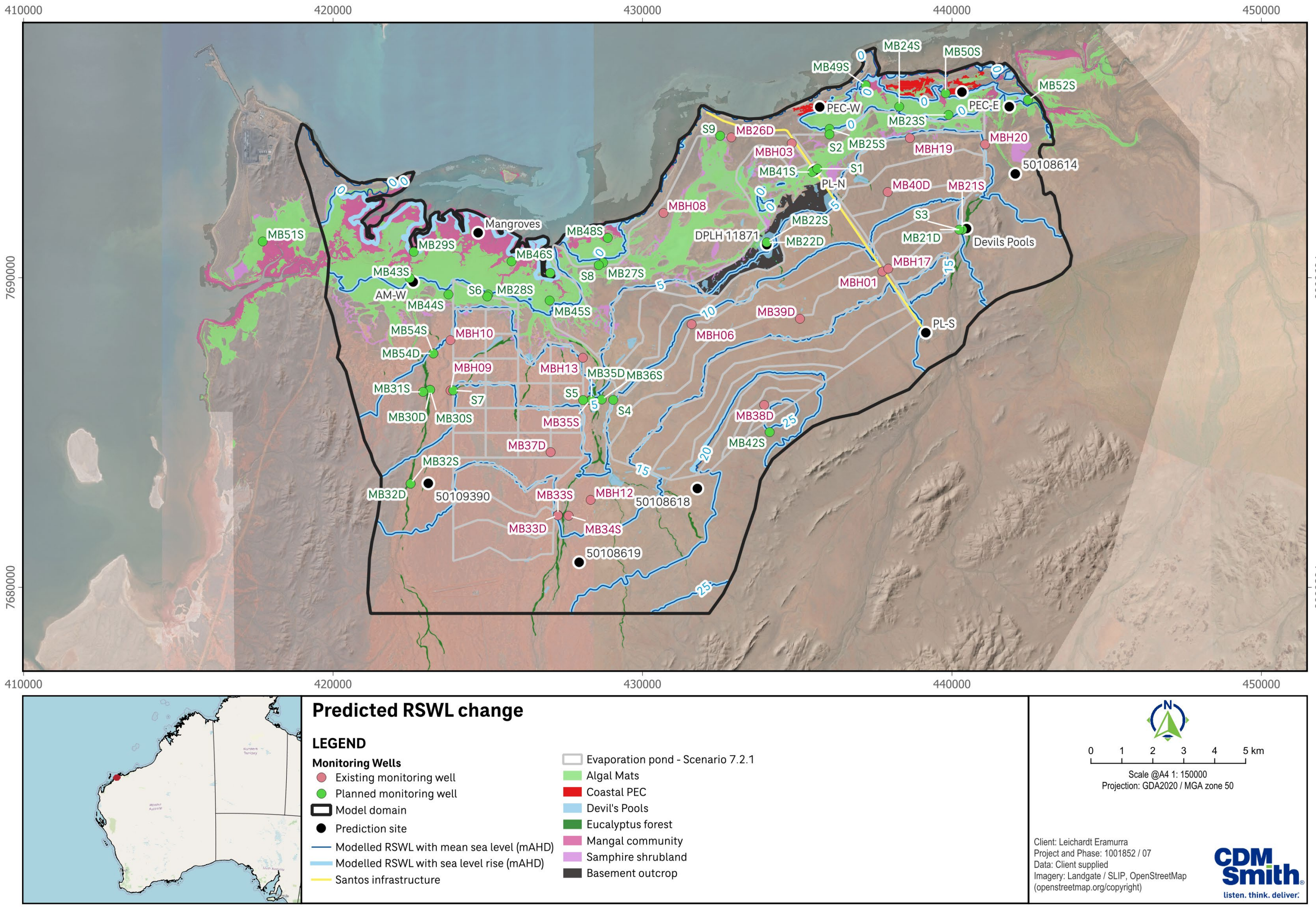

Figure 1-8: Predicted groundwater level change after 100 years of operation, mean sea level scenario (CDM Smith)

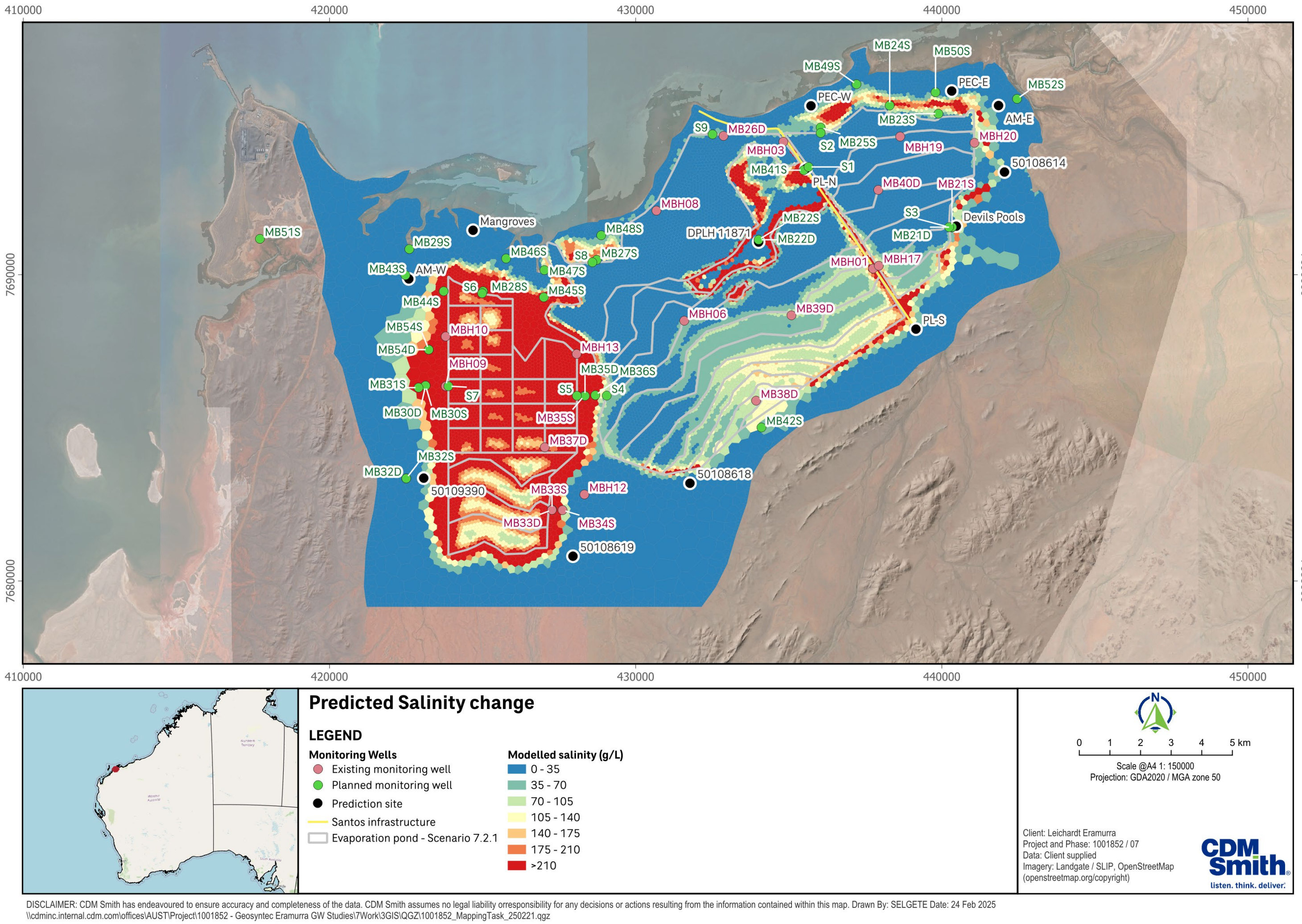

Figure 1-9: Predicted salinity change after 100 years of operation (CDM Smith)

1.9.2 Baseline Groundwater Quality

A groundwater monitoring well network was established in December 2021 and initially comprised of comprises a total of eleven (11) groundwater wells (refer to **Section 1.7**). The groundwater monitoring well locations were selected to provide a general spatial coverage of the site as well as to target identified key regional features.

An additional 10 wells were installed at the end of 2023 these wells were designed to target key EVs and the deeper aquifer extending the depth of data to 60m below ground level.

Groundwater monitoring data for the initial 11 wells is available from 2022 to July 2024, two rounds of monitoring have been completed for the more recently installed wells; January 2024 and July 2024.

Field parameters collected at the site over the period of investigation were summarised by LWC in their most recent report; LWC 2024b, and are presented here in **Table 1.6.**

Groundwater salinity within the Project area ranges from 1,008 mg/L (MBH33S) to 124,232 (MBH19) Total Dissolved Solids (TDS), with groundwater wells closer to the coast reporting higher TDS concentrations. pH ranges from 5.95 (MBH19) to 7.22 (MBH12), and EC ranges from 1,550 (MB33S) to 191,126 (MBH19).

CDM Smith has provided a map of groundwater salinity over the Project area using the most recent groundwater quality data from 2024 (**Figure 1-8**). This figure shows a strong hypersaline interface in the backwater (sabkha) areas adjacent to the coast with relatively steep salinity gradients to the north and south of this feature. To the north of the feature, a reverse saline water interface exists between the backwater areas and the ocean, whereas to the south of the backwater areas and coastline, groundwater salinity decreases substantially with distance from these features and in proximity of ephemeral drainages where it is likely recharge occurs. Although the groundwater salinity of the basement monitoring bores is fairly consistent with shallow monitoring bores, a notable difference in salinity is observed between nested sites MB33S (710 mg/L) and MB33D (17,000 mg/L) where salinity ranges by more than 16,000 mg/L. This observation supports the conceptualisation of shallow recharge occurring through the ephemeral drainages and may also suggest groundwater salinity increases with depth, either as a function of longer residence times of recharging groundwater or MB33d intersecting deeper fractures hosting saline groundwater.

While the updated salinity contours share some spatial similarities with those previously interpreted for the Project's density flow model (CDM Smith, 2023b), the latest results show notable fluctuations in groundwater salinity when compared to historical measurements (**Figure 1-9**). From a spatial sense, monitoring bores with the highest fluctuations are generally located to the northeast of the Project area and closer to the coast. For many of these wells, the TDS measurements taken in July 2024 (LWC, 2024b) represent the lowest concentration to date and appears to reflect a downwards trend in salinity over time. It should be noted that the size of the current monitoring dataset limits the ability to draw definitive and statistical conclusions from the current data. Further investigation is required to better understand the process(es) which could be contributing to the salinity fluctuations.

Further investigation should include:

- A review of salinity data including the current monitoring approach, to confirm the data is accurate.
- Additional assessment of the routine monitoring data collected for the Project.
- Investigation of depth profiles of salinity, soil physical information (field sampling or geophysical assessment) to understand the vertical distribution of salinity, and flow dynamics at specific landscape locations, in particular in the coastal areas where the greater changes in groundwater salinity have been observed.

- Installation of electrical conductivity data loggers in selected groundwater wells to capture a greater resolution of salinity variation to assist in identifying potential drivers of the salinity changes.
- Conceptualisation of potential processes that drive the change in salinity (such as recharge, throughflow, or other) that may require supportive information such as 2D modelling

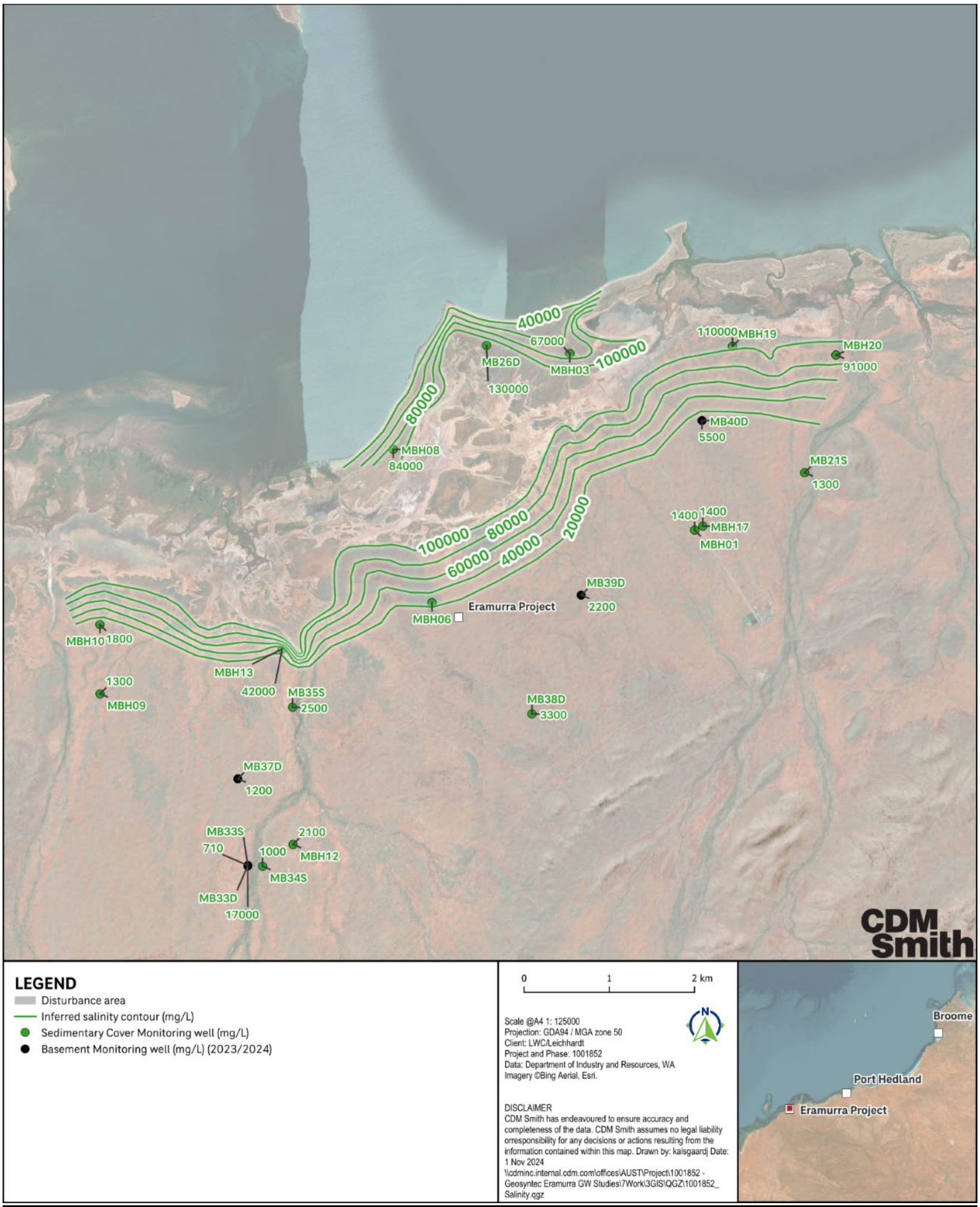

Figure 1-10: Interpreted Groundwater Salinity 2023/2024 Samplings Periods (CDM Smith, 2024b)

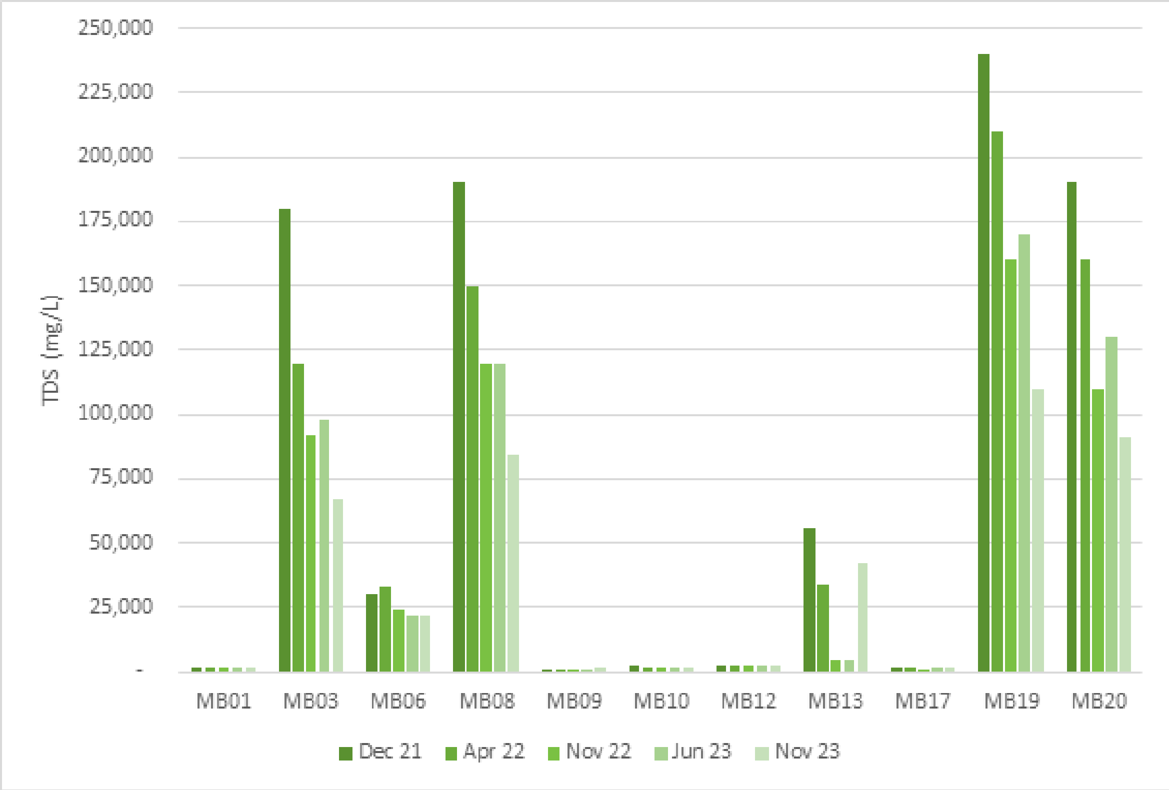

Figure 1-11 Summary of Total Dissolved Solids Measurements over Groundwater Monitoring Events (LWC, 2023b; 2024a) for the bores with the most data.

Generally, shallow bores adjacent to creeks and away from the coast observe lower salinities than deeper bores and those closer to the coast. This supports the concept of groundwater recharge occurring primarily through diffuse rainfall recharge and as leakage beneath ephemeral streams. Groundwater modelling by CDM Smith (2023b) predicts a component of groundwater inflow (~1.2 ML/d) also occurs from the ocean to the adjacent backwater areas. Inflow of groundwater from the coast can be interpreted through site observations of groundwater heads prior where groundwater elevations in monitoring bores adjacent to the coast (MB26D, MBH08 and MBH03) range between 0 and 1.2 m AHD. With the elevation of the low-lying backwater areas ranging between 0 and 5 m depth, groundwater beneath this area is expected to be influenced by evapotranspiration which, as predicted by the Project's groundwater model, creates a natural depression in groundwater heads that results in drawing of water from the coast.

Recharge rates for the Project area have been estimated by CDM Smith using deep drainage data from the Australian Water Outlook database (Bureau of Meteorology, 2023). This database suggests annual deep drainage between 1985 and 2022 varies between 2 and 18% of rainfall with a mean of 6%, or 17.4 mm/year when considering the mean recorded rainfall for Karratha. While these values were used to inform the calibration of the Project's groundwater flow model (CDM Smith, 2023b), the geometric mean recharge rate from the 100 calibrated model realisations (considered the most likely scenario) is more than an order of magnitude lower at around 0.3% for the sedimentary cover and around 0.1% for the bedrock. This suggests the Project area experiences low recharge rates, potentially lower than what is estimated regionally.

Groundwater discharge is expected to occur predominantly as evapotranspiration within the backwater areas adjacent to the coast, where depth to water is shallow. While a component of groundwater inflow has been predicted from the ocean (~1.2 ML/d), groundwater modelling (CDM Smith, 2023b) predicts a smaller quantity of outflow (~0.25 ML/d) may also occur as net outflow towards to the coast. Net outflow (i.e. the resulting outflow after other hydrogeological processes have taken place) is expected to vary depending on the timing and magnitude of the tidal system, amount of evapotranspiration, surface water inflows and the interaction of groundwater and surface water connection along the coast. Discharge to the ocean is considered most likely to occur away from the low-lying backwater areas which are dominated by evapotranspiration processes and/or in areas with higher permeability that allow for faster transport of groundwater towards the coast.

Observations from recent groundwater monitoring (LWC, 2024a and b) and groundwater drilling (CDM Smith, 2024a) suggest the depth to water beneath the Project's ephemeral drainages is at least several metres deep. This observation suggests groundwater is unlikely to discharge to creeks directly, however, due to the depth to groundwater being within the rooting depth potential of eucalypt species which reside in the Project's drainages, it is likely groundwater discharge occurs through evapotranspiration from these vegetation species. As such, the extinction depth to which evapotranspiration processes can discharge groundwater is therefore, likely to vary across the Project area, with a deeper extinction depth expected within and around drainage lines. To understand potential variations in evapotranspiration extinction depths, confirmation of the rooting depth of terrestrial vegetation within the Project's creeks may be required.

In the area for the proposed plant (MBH009), hydrocarbons are assessed in groundwater; total recoverable hydrocarbons (TRH) for all fractions/chain lengths; carbon # C_6-C_{40}). Results of monitoring to date have not reported any hydrocarbon above the adopted limited of laboratory reporting (e.g. LWC 2024b).

It is noted here that acid sulfate soils (ASS) are likely to exist within the low lying coastal region to the north of the proposed ponds (LWC 2022c). Construction within this area will require consideration of this and further investigation within proposed excavation areas is required. Poorly managed ASS have the potential to alter surface and groundwater quality should the scale of disturbance be great enough. The current groundwater quality suite is considered sufficient to provide baseline data to qualify whether the area can manage acid input. Once the area of disturbance is defined, an investigation scope and proposed management measures can be developed. The disturbance will not be due to the construction of the ponds, but potentially from a very limited area of the overall project; that of the construction of the seawater inlet or other excavations that may be required. As such, the management of ASS and its impact to groundwater and surface water quality are not included in this GMMP, they will be addressed separately should it not be possible to avoid disturbance by engineering design.

1.9.3 Baseline groundwater flow regime

A baseline groundwater elevation contour plan has been developed based on the network of groundwater monitoring wells and the latest groundwater level data (CDM Smith 2024b), presented as **Figure 1-10**.

Groundwater elevations range from approximately 11 m AHD in the southeast to near sea level (i.e. 0 m AHD) adjacent to the coast. Within the inter- and supratidal flats (i.e. sabkha), where a natural low point in the topography exists. In general, the water level data indicate groundwater flows in a north to northwest direction across the Project area, flow is also understood to occur in a southeast direction as inflow from the ocean. There is currently limited data available to support a detailed understanding of groundwater levels and flow conditions within the backwater area.

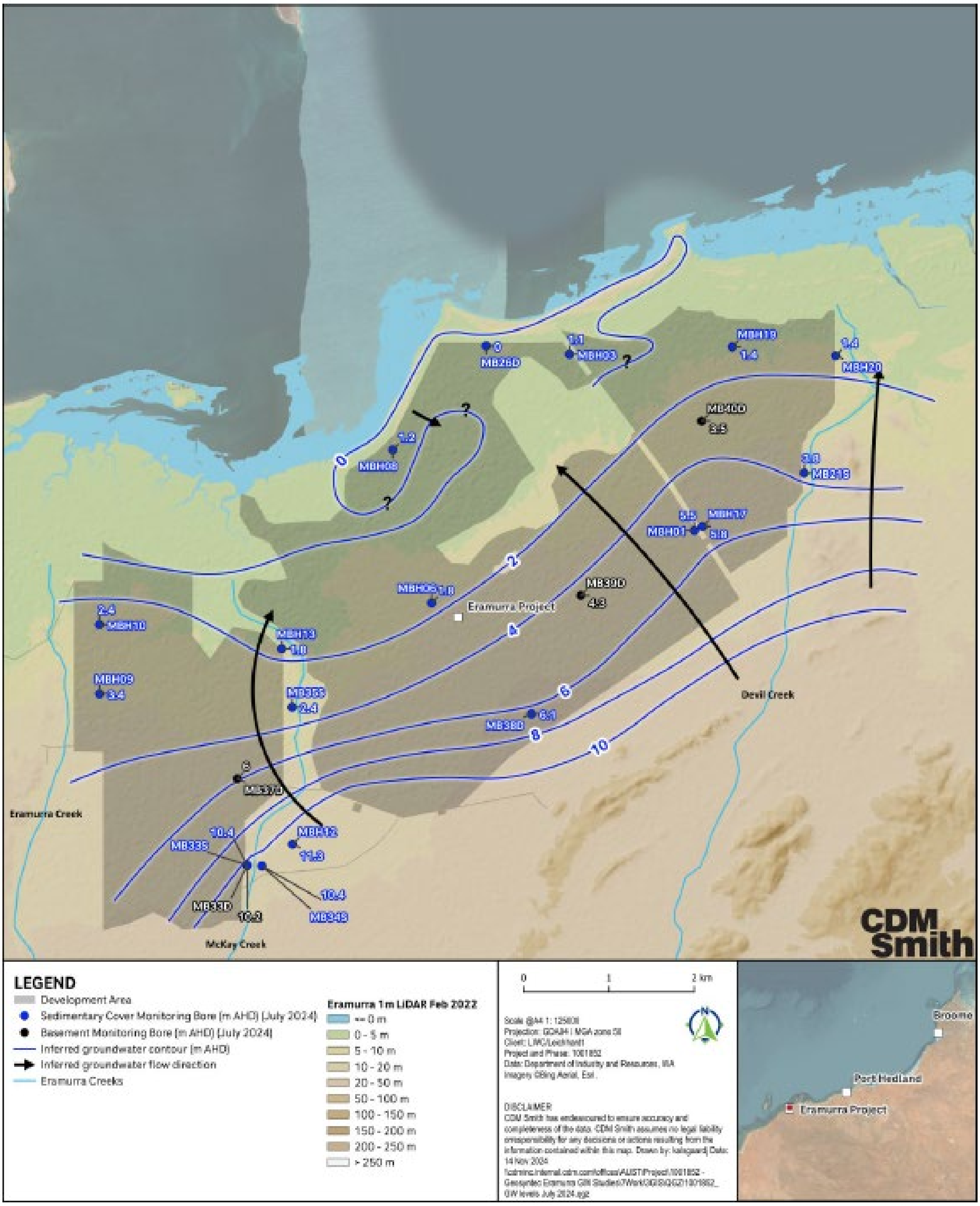

Figure 1-12 Inferred groundwater elevation contours and flow direction at July 2024 (CDM Smith 2024b)

1.9.4 Baseline data for receiving environments – Creeks and Pools

Limited rainfall and the high evaporation rate at the site has hindered the assessment of surface water quality at the Project.

Nevertheless, over the period of study, surface water quality data has been gathered across the site. From these limited results it is evident that there is spatial variability in the salinity measured across sampled locations, where samples located closer to the marine environment, the coast, reported higher TDS concentrations (**Table 1.6**). Standing water in close proximity to the sabkha area, SW 12 indicates the relatively high TDS at that location compared to standing water sampled in creek beds. TDS of standing water in creeks sampled shortly after a rainfall event range from 48-350 mg/L (**Table 1.6**).

Temporal variability is evident in the coastal sampling locations; sampling in the summer months at the creek outlets is when the highest TDS is reported (SW02 230,000 mg/L and SW06 380,000 mg/L).

Table 1.6: Distribution of Laboratory Total Dissolved Solids Concentrations (mg/L) in Surface Water (LWC 2024b)

Sample Location	Creek Line	Targeted Feature	March 2022	May 2022	November 2022	June 2023	November 2023	July 2024
SW01	Mangrove area	Coastal outlet/mangrove area in marine environment	64,000	-	42,000	45,000	40,000	44,000
SW02	Eramurra Creek	Eramurra Creek outlet near marine environment	72,000	38,000	230,000	89,000	91,000	-
SW03	McKay Creek	McKay Creek upstream location within project area	-	-	-	-	-	-
SW03R	McKay Creek	McKay Creek at the crossover with North West Coastal Highway	-	350	-	-	-	-
SW04	McKay Creek	McKay Creek within central portion of the Site	-	66	-	-	-	-
SW05	McKay Creek	McKay Creek within central portion of the Site	-	99	-	560	-	-
SW06	McKay Creek	McKay Creek outlet near marine environment	120,000	98,000	380,000	110,000	91,000	-
SW07	McKay Creek Tributary	Upstream tributary of McKay Creek	-	66	-	-	-	-
SW08	McKay Creek Tributary	Upstream tributary of McKay Creek	-	140	-	-	-	-

SW09	Devil Creek	Devil Creek upstream of the project area	-	-	-	-	-	-
SW10	Eramurra Creek	Eramurra Creek within project area	-	89	-	-	-	-
SW10R	Eramurra Creek	Eramurra Creek at the crossover with North West Coastal Highway	-	84	-	-	-	-
SW11	Devil Creek	Devil Creek within project area	-	230	-	-	-	-
SW11R	Devil Creek	Devil Creek at the crossover with North West Coastal Highway	-	48	-	-	-	-
SW12	Unnamed creek	General floodplain area	-	61,000	-	-	-	-
SW13	Unnamed creek	General floodplain area	130	84	-	390	-	-
SW14	Unnamed creek	General floodplain area	-	200	-	550	-	810

1.9.5 Surface Water Modelling and Groundwater/Surface Water Interaction

Hydrological studies at the Eramurra Project have demonstrated the lack of surface water within the surface water creeks and pools over the period of investigation (e.g. LWC 2024a and b). Seventeen (17) logger locations with surface water monitoring locations are currently installed at the site, 14 of which have had surface water sampled on at least one occasion during the monitoring program (**Table 1.6**, LWC 2024a and b).

The only locations with a time series are those at the mouth of the creeks where they discharge to the sea (SW02 at Eramurra Creek and SW06 at McKay Creek, near the proposed outlet to the marine environment).

Thus, there is limited surface water data to validate the hydrological environment at the site, or to evaluate surface water and groundwater interaction.

In order to gain a preliminary understanding of the hydrology of the site, a HEC-RAS model was developed using data from a cyclonic event which occurred in August 2019 (LWC 2021). LiDAR data collection was undertaken in 2022, allowing for refinement of the HEC-RAS model (LWC 2022c).

Thus, the hydraulic modelling studies to date (LWC 2022c and 2023b) have focussed on scenarios where rainfall events of varying magnitude and frequency are modelled to assess the inundation event, surface water levels, flow paths and flow velocities with a view to advising on erosion and sedimentation for the existing and future project conditions.

The results of the modelling have demonstrated that decreased water elevations are exhibited downstream from the ponds (800mm at 10% AEP) resulting in approximately 17-18% reduction of freshwater input to the ocean (LWC 2023b).

Increased surface water elevations are exhibited in a 7 km reach of McKay Creek and a 3 km reach of Devil Creek. Water surface elevations are approximately 300mm as a maximum and any effect on surface water elevation is expected to be limited to within 500m of the pond walls (LWC 2023b). The reduction of input through surface water flows to creek flow and levels from the project is considered to be negligible (LWC 2023b).

At the gas pipeline (KP 2.4 to 5.3) ponding of up to 3m was predicted (1% AEP). Given this outcome, advice was provided on the size and proposed alignment of additional drainage requirements, supported by modelled outcomes demonstrating the effectiveness of the proposed drainage solution (LWC 2023b).

2 Groundwater Management and Monitoring Plan

2.1 Approach

This GMMP is outcome-based. This section covers the following components of an outcome-based management plan in general accordance with the 2024 EPA guidelines:

- **Outcome** – The outcome of the GMMP is to provide an understanding of the changes in the risk profile posed by the future site operations on the EVs of groundwater. In particular:
  - No changes to the health, extent or diversity of groundwater dependant ecosystems and intertidal benthic communities and habitat, including mangrove, samphire and algal mat, as a result of changes to groundwater regimes or groundwater quality associated with the proposal.
  - No adverse impact to water level or water quality in Noorea Soak or Devils Pool as a result of changes to groundwater regimes or groundwater quality
- **Indicators** – The indicators selected for monitoring to assess potential environmental impacts are described in **Section 2.4**. The appropriate indicators for trigger criteria, which provide early warning of potential impacts and threshold criteria are provided in **Section 2.5.1**.
- **Response actions** – The corresponding contingency actions are outlined in **Section 2.5**.
- **Monitoring** – The proposed monitoring plan is described in **Section 2.4** along with the quality procedures, the monitoring methodology and the approach for the well inspection that should be carried out prior in **Appendix B**.
- **Reporting** – The proposed reporting outline is provided in **Section 2.6**.

As outlined in **Section 1.1.5**, there is recognition that gaps are in the process of being addressed via further site characterisation. The proposed approach for further site characterisation is outlined in **Section 2.2**.

2.2 Further Site Characterisation

It is proposed that guidance on site characterisation is taken from national contaminated sites risk based approach to site assessment. The premise here is that we are taking the approach to prevent contamination, thus the assessment steps inform the data gathering required during any monitoring program.

One of the fundamental components of the of the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) (NEPC, 2013) is its Schedule A. Schedule A comprises a flow chart of the recommended general process for the assessment of site contamination and its relationship to the management of site contamination. A simplified version of the flow chart is illustrated in **Figure 2-1**.

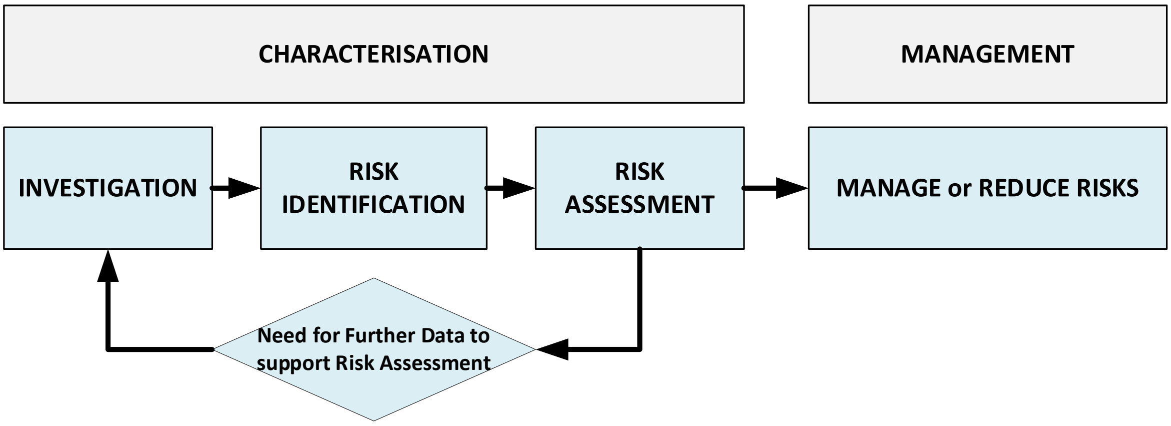

Figure 2-1: Summary of ASC NEPM Schedule A

As outlined in **Section 1.1.5**, there is acknowledgement that further site characterisation is required to address the data gaps. Proposed well locations to address these gaps are provided in **Section 1.7** and **Appendix A**. These locations will be installed in a staged manner based on merit and operational constraints, further informing approaches to manage or reduce the risks.

2.3 Risk Mitigation Measures

Risk mitigation measures employed at the site will be an important component to assist in reducing risks to groundwater. These measures will consider:

- The water affecting activity of water impoundment may lead to mounding of groundwater levels beneath the pond which will extend beyond the pond walls and which has the potential to result in higher salinity groundwater discharge in inland creeks.
- Any mounding will not lead to a permanent surface expression of groundwater including unforeseen impacts.
- Seepage directly from the pond walls may occur; the pond walls will be natural features in the landscape which will be engineered to meet the needs of the project.
- The use of fuels and other chemical compounds will be limited at the site.

The options currently being considered to manage the direct effects of the water affecting activity include engineering controls and active solutions/management measures. These measures have been considered during the design of the proposed monitoring network.

Preliminary engineering design of the ponds in terms of lateral extent have been completed, however detailed designs to describe how the ponds will be constructed and the materials available at the site for construction are in the planning stage. Consequently, detailed designs of the infrastructure which will be installed at the Site to manage groundwater cannot be provided. Nevertheless, the following provides details of the options currently under consideration.

Controls:

- Engineering controls
  - Development of pond floor which minimises the potential for seepage. A salt crust will be developed and maintained as an engineered control in both the crystallisers and concentration ponds. In addition, the concentration ponds the salt crust will be colonised by salt tolerant bacterial species. The combined outcome will be a stable base which will act to limit seepage from each pond once established.

  - Installation of sentinel wells at/in the pond walls to monitor groundwater physical parameters and levels. The information from these wells will trigger any active management at the site.
  - Consideration of constant data capture and real time monitoring through telemetry.
  - Consideration and concept design of interception systems to capture and return saline water to the ponds.
  - Bunding of areas where chemicals may be used.
  - Suitable siting, design and construction of waste storage facilities.
- Operational controls
  - Safe operation and maintenance of ponds for example, introduction of water to the ponds at such a rate as to minimise scour and maximise evaporation.
  - Design of a selection of the groundwater well infrastructure to enable these to be equipped with pumps and assist in providing hydraulic control, should this be required.
  - Appropriate spill management procedures.
  - Implementation of the groundwater monitoring and assessment procedures presented in this GMMP including installation of sentinel wells (refer to **Appendix A**).

Active Management Measures:

- Installation and operation of pumping wells to pump water back into the ponds should triggers be exceeded.
- Installation of additional wells to delineate impacts and to increase the network of wells used for active management purposes should levels not return to agreed values within a specified period.

2.4 Rationale for Monitoring and Frequency

2.4.1 Sampling Frequency

To ensure the groundwater wells installed have a large enough data set to support the trigger and contingency protocol outlined in **Section 2.5**, all wells will be monitored quarterly for at least 18 months (six data points) to establish baseline conditions.

Analysis of trends is to be undertaken following the completion of the first six rounds of monitoring, consideration of whether a suitable data set is available for each hydrostratigraphic unit is available at this time.

Following this, unless the data suggests otherwise, the frequency of monitoring should be reduced to biannually.

2.4.2 Path Forward for Assigning Sentinel Wells

The positioning of sentinel wells will be commensurate on the identification of potential pathways.

At the present time, sentinel wells are located at the toe of the pond walls in areas close to the EVs identified as at greatest risk from seepage, namely the pools and creeks, and in the coastal benthic communities and habitat (BCH).

2.4.3 Rationale for Laboratory Testing

Currently, water quality is being assessed for a range of analytes (**Table 2.1**). The suite was designed to assess possible impacts to a range of potential EVs, prior to any assessment of the site EVs or water affecting activities.

The groundwater effects assessment (CDM Smith 2023b) provided clarity on the range of EVs at the site and advised that the analytical suite be maintained, however, it has been demonstrated that the primary stressors at the site to the identified EVs are changes to groundwater level and salinity.

As such, the detailed water quality data being collected will provide a baseline for groundwater quality for operational activities, but not all data have been used to develop the triggers discussed in this GMMP at the present time.

Once the full network of wells at the site have been installed, and there is sufficient data to assess any possible correlation between trace elemental content and salinity and/or location, site-specific trigger values should be developed for operational management. For example, in specific areas where fuels may be used.

Table 2.1: Proposed Analytical Schedule

Analytical Suite	Comment	Target Location
The baseline analytical schedule included the following: • Electrical Conductivity (EC) • Total dissolved solids (TDS) and Total Suspended Solids (TSS). • Laboratory pH • Major Ions including calcium, sodium, potassium, magnesium, chloride, sulphate, bicarbonate and carbonate. • Hydroxide alkalinity as CaCO3, carbonate alkalinity as CaCO3 and bicarbonate as CaCO3. • Water Hardness • Total and dissolved metals including Al, As, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Sb, Ag, SiO2, Se, Sr, Th, Ti, U, V, Zn and Zr. • Speciation of Ferric Iron and Ferrous Iron (actual and not calculated). • Nutrients including total nitrogen, nitrate as N, nitrite as N, ammonia, Total Kjeldahl Nitrogen (TKN) and filtered reactive phosphorous. •	This laboratory suite provides a comprehensive assessment of key analytes (i.e., those that are sensitive to geochemical changes, for example variation in acidity and concomitant changes in pH). The suite is robust with respect to chemical substances likely to be associated with operations. At the completion of baseline assessment the analytical suite may be reduced for operational monitoring.	All locations
Hydrocarbons: • Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, total Xylenes, Naphthalene (BTEXN)	Petroleum hydrocarbons are a potential chemical substance of concern with respect to future operations around the plant area.	MBH09 (located near the proposed wash plant area)
Rinsate Screen: • Total metals including Al, As, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Li, Mn, Mo, Ni, Pb, Sb, Ag, SiO2, Se, Sr, Th, Ti, U, V, Zn and Zr.	Results can be inferred across the broader analytical suite	1 sample per day of sampling with the groundwater pump
Trip blank • TRH Fraction C6-C10 and BTEXN	-	1 sample per batch of samples containing samples to be analysed for volatile compounds

2.5 Triggers and Contingency Protocol

Following each monitoring event, the groundwater data collected will be reviewed using a number of triggers as a guide. Where triggers are activated, a contingency protocol will be implemented.

Triggers and contingency protocols aid in establishing a decision framework, **Figure 2-2**. The first step of the framework consists of conducting an assessment of the existing trends for the proposed trigger, for example the use of Mann-Kendall analysis, which is a tool to evaluate the rate of change. If an increasing trend is indicated, it will trigger a revaluation of the risk profile.

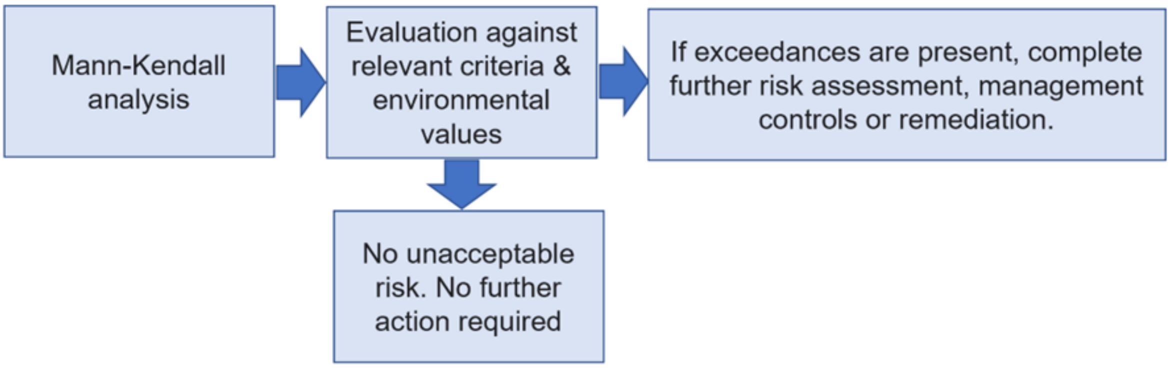

Figure 2-2: Trigger and Contingency Framework

2.5.1 Triggers

Contingency protocols will be triggered if one of the following conditions is met:

- There is an increasing concentration trend of the primary stressor (e.g. salinity) in sentinel wells, OR
- The distribution in groundwater levels indicates a change in the groundwater flow regime (e.g. significant changes in hydraulic gradient or groundwater flow direction) based on the evaluation from a suitably qualified hydrogeologist. Examples of significant changes are presented in **Table 2.2**.

For the purposes of assessing an increasing concentration trend, the trend is assessed using the following:

- For established wells (i.e. wells that have been sampled at least four times), Mann-Kendall analysis could be used to determine concentration trends or an evaluation of the deviation from the mean of the previous data for the trigger, i.e. an increase equal to or greater than 2 times the standard deviation (SD) from the mean.
- For recently installed wells (i.e. wells that have been sampled less than four times), an unacceptable increase would occur if a result is greater than the current maximum measured result.

These measures are presented along with the relevant actions in **Table 2.2**

2.5.2 Outcome Based Provisions

The objectives of the contingency protocols will be to evaluate whether further investigation or intervention is required through assessing whether the identified changes resulting from the trigger conditions are acceptable in the context of the surrounding locations and nearby receptors.

The contingency protocols for each of the trigger condition are listed in **Table 2.2**. In the interest of expediency, if resampling is required as part of the contingency protocols, the results will be reported under separate cover.

It is noted that as the primary stressors (groundwater level and salinity) are generally consistent, contingency protocols for each outcome are similar, with the exception of Outcome 7.

Table 2.2. Summary of Contingency Protocols

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Outcome 1: No changes to the environmental health of the receptors of the site EV1, EV2 and EV3 (GDE)					
Trigger Criterion 1. Increasing TDS concentration trend in sentinel wells Leading Indicator for Threshold Criterion 1 – TDS concentrations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 1.** • For locations that have been sampled at least four times, the threshold is considered to be exceeded if the result is greater than the mean plus two standard deviations (SD) of the previous results for that location. • For locations that have been sampled less than	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have the laboratory check the results and, if possible, reanalyse the sample. - If the laboratory-confirmed result is not consistent with trends, or if the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. Where available additional wells between the sentinel well(s) and the EV receptor in the direction of groundwater flow should also be sampled and assessed. • Risk Assessment	**Indicator** • Increase in TDS concentration in excess of expected variation based on baseline data. **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 1 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 1 to assess	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk, continue wet and dry season monitoring program	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
four times, the threshold is considered to be exceeded if a result is greater than the current maximum result.	- If the result from re sampling and an inconsistent trend are confirmed, evaluate the potential for a change in the risk profile for the impacted location by comparing with the site data/threshold. - Assess whether the change may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location for assessment or saline water extraction. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** • No further action			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Trigger Criterion 2. Change in groundwater flow regime (mounding and flow direction) Leading Indicator for Threshold Criterion 2 – groundwater elevations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing measurements. **Threshold Criterion 2.** Based on a groundwater flow contour map prepared by a suitably qualified hydrogeologist using most recent groundwater (and surface water, if any) gauging data of the entire site network, there is a change in the flow direction indicative of one or more of the following: • Groundwater mounding underneath the site ponds and other operational setting • Change in the role played by the sabkhas along the coastline (e.g. more frequent inundation/evidence of more persistent surface water) • Change in the interaction between the creek and groundwater (e.g. increase in salinities of receiving environment outside the range measured prior to operation).	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have a review of the field sheets against well survey data and, if possible, regauge the well. - If the review confirms the change in flow direction, or if the suitably qualified hydrogeologist cannot confirm the result from the field sheet review, then re-gauge all the well from the network within a month, access permitting. - If the regauging confirms the change in flow direction, evaluate the potential for a change in the risk profile for the impacted location by assessing the potential for pathway completeness • Risk Assessment - Assess whether the change in flow direction may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells to further understand the potential for the degree of pathway completeness.	**Indicator** • Change in groundwater flow direction **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater regauging of the full network • Within a month from initial gauging, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 2 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: •	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	• Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	- Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** No further action			
Outcome 2: No changes to the environmental health of the receptors of the site EV4: (Algal mats and Samphire)					
Trigger Criterion 1. Increasing TDS concentration trend in sentinel wells Leading Indicator for Threshold Criterion 1 – TDS concentrations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 1.** • For locations that have been sampled at least four times, the threshold is considered to be exceeded if the result is greater than the mean plus two standard deviations (SD) of the previous results for that location. • For locations that have been sampled less than	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have the laboratory check the results and, if possible, reanalyse the sample. - If the laboratory-confirmed result is not consistent with trends, or if the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. • Risk Assessment - If the result from re sampling and an inconsistent trend are confirmed, evaluate the potential for a change in the risk profile for the	**Indicator** • Increase in TDS concentration in excess of expected variation based on baseline data. **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 1 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk, continue wet and dry season monitoring program	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
four times, the threshold is considered to be exceeded if a result is greater than the current maximum result..	impacted location by comparing with the site data/threshold. - Assess whether the change may result in a potential unacceptable risk to a receptor(s). Consider other monitoring locations located between the sentinel well and the receptor. If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location for assessment or saline water extraction. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	affected by exceedance of Threshold Criterion 1 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** • No further action			
Trigger Criterion 2. Change in groundwater flow regime (mounding and flow direction) Leading Indicator for Threshold Criterion 2 – groundwater elevations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have a review of the field sheets against well survey data and, if possible, regauge the well.	**Indicator** • Change in groundwater flow direction **Method for data collection and analysis** ***For assessing changes in the risk profile***	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
is available, two consecutive increasing measurements. **Threshold Criterion 2.** Based on a groundwater flow contour map prepared by a suitably qualified hydrogeologist using most recent groundwater (and surface water, if any) gauging data of the entire site network, there is a change in the flow direction indicative of one or more of the following: • Groundwater mounding underneath the site ponds and other operational setting • Change in the role played by the sabkhas along the coastline (e.g. more frequent inundation/evidence of more persistent surface water) • Change in the interaction between the creek and groundwater (e.g. increase in salinities of receiving environment outside the range measured prior to operation).	- If the review confirms the change in flow direction, or if the suitably qualified hydrogeologist cannot confirm the result from the field sheet review, then re-gauge all the well from the network within a month, access permitting. - If the regauging confirms the change in flow direction, evaluate the potential for a change in the risk profile for the impacted location by assessing the potential for pathway completeness • Risk Assessment - Assess whether the change in flow direction may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells to further understand the potential for the degree of pathway completeness. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	• Groundwater regauging of the full network • Within a month from initial gauging, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 2 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** No further action			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
Outcome 3: No changes to the environmental health of the receptors of the site EV5: (Aquatic Vegetation (mangroves))					
Trigger Criterion 1. Increasing TDS concentration trend in sentinel wells Leading Indicator for Threshold Criterion 1 – TDS concentrations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 1.** • For locations that have been sampled at least four times, the threshold is considered to be exceeded if the result is greater than the mean plus two standard deviations (SD) of the previous results for that location. • For locations that have been sampled less than four times, the threshold is considered to be exceeded if a result is greater than the current maximum result.	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have the laboratory check the results and, if possible, reanalyse the sample. - If the laboratory-confirmed result is not consistent with trends, or if the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. • Risk Assessment - If the result from re sampling and an inconsistent trend are confirmed, evaluate the potential for a change in the risk profile for the impacted location by comparing with the site data/threshold. - Assess whether the change may result in a potential unacceptable risk to a receptor(s). Consider other monitoring locations located between the sentinel well and the receptor. If there is a potential for an unacceptable risk, consider minimisation measures such as:	**Indicator** • Increase in TDS concentration in excess of expected variation based on baseline data. **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 1 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 1 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity.	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk, continue wet and dry season monitoring program	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	• Installing more wells around the location for assessment or saline water extraction. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	- Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** • No further action			
Trigger Criterion 2. Change in groundwater flow regime (mounding and flow direction) Leading Indicator for Threshold Criterion 2 – groundwater elevations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing measurements. **Threshold Criterion 2.** Based on a groundwater flow contour map prepared by a suitably qualified hydrogeologist using most recent groundwater (and surface water, if any) gauging data of the entire site network, there is a change in the flow direction indicative of one or more of the following: • Groundwater mounding underneath the site ponds	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have a review of the field sheets against well survey data and, if possible, regauge the well. - If the review confirms the change in flow direction, or if the suitably qualified hydrogeologist cannot confirm the result from the field sheet review, then re-gauge all the well from the network within a month, access permitting. - If the regauging confirms the change in flow direction, evaluate the potential for a change in the risk profile for the impacted location by assessing the potential	**Indicator** • Change in groundwater flow direction **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater regauging of the full network • Within a month from initial gauging, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 2 to assess the extent of potential unacceptable risk.	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
and other operational setting • Change in the role played by the sabkhas along the coastline (e.g. more frequent inundation/evidence of more persistent surface water) • Change in the interaction between the creek and groundwater (e.g. increase in salinities of receiving environment outside the range measured prior to operation).	for pathway completeness • Risk Assessment - Assess whether the change in flow direction may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells to further understand the potential for the degree of pathway completeness. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	• Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** No further action			
Outcome 4: No changes to the environmental health of the receptors of the site EV7 and EV8: (Pools and Soakes)					
Trigger Criterion 1. Increasing TDS concentration trend in sentinel wells Leading Indicator for Threshold Criterion 1 – TDS concentrations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 1.**	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have the laboratory check the results and, if possible, reanalyse the sample. - If the laboratory-confirmed result is not consistent with trends, or if the laboratory cannot	**Indicator** • Increase in TDS concentration in excess of expected variation based on baseline data. **Method for data collection and analysis** ***For assessing changes in the risk profile***	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk, continue wet and dry season monitoring program	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
• For locations that have been sampled at least four times, the threshold is considered to be exceeded if the result is greater than the mean plus two standard deviations (SD) of the previous results for that location. • For locations that have been sampled less than four times, the threshold is considered to be exceeded if a result is greater than the current maximum result	confirm the result, then re-sample the well within a month, access permitting. • Risk Assessment - If the result from re sampling and an inconsistent trend are confirmed, evaluate the potential for a change in the risk profile for the impacted location by comparing with the site data/threshold. - Assess whether the change may result in a potential unacceptable risk to a receptor(s). Consider other monitoring locations located between the sentinel well and the receptor. If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location for assessment or saline water extraction. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	• Groundwater sampling at the locations affected by exceedance of Threshold Criterion 1 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 1 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk***			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		• No further action			
Trigger Criterion 2. Change in groundwater flow regime (mounding and flow direction) Leading Indicator for Threshold Criterion 2 – groundwater elevations show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing measurements. **Threshold Criterion 2.** Based on a groundwater flow contour map prepared by a suitably qualified hydrogeologist using most recent groundwater (and surface water, if any) gauging data of the entire site network, there is a change in the flow direction indicative of one or more of the following: • Groundwater mounding underneath the site ponds and other operational setting • Change in the role played by the sabkhas along the coastline (e.g. more frequent inundation/evidence of more persistent surface water) • Change in the interaction between the creek and groundwater (e.g. increase in salinities of receiving environment outside the range measured prior to operation).	Assessment of changes in the risk profile by one or more of the following actions: • Data Review: - Have a review of the field sheets against well survey data and, if possible, regauge the well. - If the review confirms the change in flow direction, or if the suitably qualified hydrogeologist cannot confirm the result from the field sheet review, then re-gauge all the well from the network within a month, access permitting. - If the regauging confirms the change in flow direction, evaluate the potential for a change in the risk profile for the impacted location by assessing the potential for pathway completeness • Risk Assessment - Assess whether the change in flow direction may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells to further understand the	**Indicator** • Change in groundwater flow direction **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater regauging of the full network • Within a month from initial gauging, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations affected by exceedance of Threshold Criterion 2 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either:	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	potential for the degree of pathway completeness. • Reducing the salt discharge from the site production to the aquifer No further action if there is no unacceptable risk	- Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater extraction system ***If there is no unacceptable risk*** No further action			
Outcome 5: Monitoring and assessment of potential leaks, spills and losses from plant fuel storage area					
Trigger Criterion 3. Change in water quality at the plant area (Fuel storage) – dissolved phase petroleum hydrocarbons detected in groundwater Leading Indicator for Threshold Criterion 4 – TRH concentrations detected show an increasing trend (Mann-Kendall Analysis α 0.05), or where insufficient data is available, two consecutive increasing concentrations. **Threshold Criterion 3.** • Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, total Xylenes, Naphthalene	**Threshold Criterion 3.** Assessment of changes in the risk profile by one or more of the following actions: • Have the laboratory check the results and, if possible, reanalyse the sample. • If the laboratory cannot confirm the result, then re-sample the well within a month, access permitting. • If the result from re sampling confirms the exceedance of Threshold Criterion 3 • Review fuel storage records (wet stock analysis, spill records) to identify potential for Threshold Criterion 3 to indicate leaking fuel storage infrastructure.	**Threshold Criterion 3.** **Indicator** • TRH and/or BTEXN concentration **Method for data collection and analysis** ***For assessing changes in the risk profile*** • Groundwater sampling at the locations affected by exceedance of Threshold Criterion 3 • Within a month from initial sampling location, access permitting ***If there is a potential for an unacceptable risk*** • Install additional groundwater wells in the vicinity locations	• Baseline and routine monitoring on a six monthly basis. • Monthly if there is a potential for an unacceptable risk • No further action if there is no unacceptable risk	• Annual groundwater report with inclusion of all results of monitoring completed.	• TBA

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
(BTEXN) detected in sample analysis **Threshold Criterion 4.** • LNAPL detected in groundwater.	• Assess whether the change may result in a potential unacceptable risk to a receptor(s). If there is a potential for an unacceptable risk, consider minimisation measures such as: • Installing more wells around the location. • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater No further action if there is no unacceptable risk **Threshold Criterion 4.** • Review fuel storage records (wet stock analysis, spill records) to identify potential for Threshold Criterion 3 to indicate leaking fuel storage infrastructure. • Installing more wells around the location to delineate the extent of LNAPL and associated dissolved phase impacts. • Evaluate emergency response options such as LNAPL recovery (Multiphase extraction (MPE), bailers, skimmer pumps and adsorbent media). • Assess whether the change may result in a potential unacceptable risk to a receptor(s).	affected by exceedance of Threshold Criterion 3 to assess the extent of potential unacceptable risk. • Collect and interpret results within four months. In data interpretation consider: - How does the data align with precited results, does it warrant a re-assessment of the current conceptualisation, a re-run of the model or more localised assessment of the change in water level and or salinity. - Do these data alter the current risk profile from the Project and warrant an updated GMMP • Based on the additional data and interpretation either: - Implementation of operational measures to reduce the salt discharge from the site production (e.g. leaky pond or pipeline) - Design and implementation of groundwater remediation If there is no unacceptable risk No further action **Threshold Criterion 4.** **Indicator** • Measurable LNAPL **Method for data collection and analysis** ***For assessing changes in the risk profile***			

Indicators:	Response actions:	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	If there is a potential for an unacceptable risk, consider minimisation measures such as: • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater	• Review fuel storage records (wet stock analysis, spill records) to identify leaking fuel storage infrastructure. • Installing more wells around the location to delineate the extent of LNAPL and associated dissolved phase impacts. ***If there is a potential for an unacceptable risk*** • Repair or replace leaking infrastructure (if applicable) • Remediating the impacted groundwater including implementation of emergency response measures If there is no unacceptable risk • Remediating the impacted groundwater to the extent practicable			

If the evaluation results in a potential for an adverse change in the risk profile, further risk assessment should be commenced. If there is a potential unacceptable risk, an appropriate approach to minimise risks should be implemented.

2.6 Reporting

An annual GMMP report should include the following:

- Description of works undertaken
- A general comment on the integrity of the monitoring well network, and, if needed, make recommendations for maintenance
- A summary table of historical and current groundwater analytical results, with laboratory reports for the current sampling event provided as an appendix. Where trend assessments are undertaken, these will be included within the report, e.g. trend graphs provided as an appendix and a brief comment provided on whether the reported analytical results are consistent with the historical dataset and associated data validation
- A review of current and historical water levels and a general comment on potential changes to groundwater flow direction
- Assessment of compliance with the QA/QC objectives set out in **Appendix B** of this GMMP, based on the samples collected during the current monitoring event. A methodology for sample collection is presented in **Appendix B** of this GMMP. In addition, a methodology for determining the integrity of a well is also provided in **Appendix C** of this GMMP.
- Recommendations for further data evaluation based on the Contingency Response Plan if it has been triggered. If the Contingency Response Plan triggers re-sampling or an increased frequency, it will be reported as part of the same monitoring report.
- An appendix containing copies of field sampling records and calibration records.
- Figures of wells sampled and documented information generated from the monitoring event, e.g. weather, air and water temperature, water elevations, concentrations of key constituents.

3 Adaptive Management and Review

3.1 Adaptive Management Process

Leichhardt is committed to improving environmental outcomes and management practices throughout the implementation of this GMMP. Adaptive management practices will include:

- Address the data gaps by conducting further characterisation and monitoring to support a better understanding of the risk profile in a manner that is integrated with site operations and development.
- Monitor and evaluate the effectiveness of the risk mitigation measures against the trigger and contingency protocol.
- Review the monitoring approach and assign sentinel wells at key locations that are representative of the risk profile.
- Where the changes in the risk profile are triggered by the trigger and contingency protocol, further assess the risk.
- If required, develop measures to manage or reduce the risks.

3.2 Updates and Revisions

Where necessary, an interim update may be made to this GMMP for the following reasons:

- To decommission and/or relocate monitoring wells
- To include additional monitoring locations or analytes
- To modify procedures (within reasonable costs and methodology) which are assessed to improve the representativeness of the samples
- If the regulator recommends changes to the monitoring plan

3.3 Continuous Improvement

This GMMP is based on the principle of continuous improvement. The stakeholders outlined in **Section 1.5.3** and **Section 1.6** are encouraged to provide their feed-back to Leichhardt such that it can be integrated in a subsequent version of this document.

4 References

Australian Bureau of Meteorology (BOM), 2023. Climate Data Online, Commonwealth of Australia, available at <http://www.bom.gov.au/climate/data/?ref=ftr>.

Australian Bureau of Meteorology (BOM),. Groundwater Dependent Ecosystems Atlas http://www.bom.gov.au/water/groundwater/gde/

CDM Smith, 2023b. Eramurra Solar Salt Project – Groundwater Effects Assessment and Seepage Modelling, prepared for Land and Water Consulting, 13 December 2023.

CDM Smith, 2024a. Eramurra Solar Salt Project – Groundwater Drilling 2023/2024, prepared for Land and Water Consulting, 28 March 2024.

CDM Smith, 2024b. Eramurra Solar Salt Project – Site Setting and Groundwater Baseline Update, prepared for Geosyntec Consultants Pty Ltd 15 November 2024

EPA, 2023. Statement of Environmental Principles, Factors, Objectives and Aims of EIA. Environmental Protection Authority. Dated April 2023.

EPA, 2024. How to prepare Environmental Protection Act 1986 Part VI Environmental Management Plans. Environmental Protection Authority. Dated March 2024.

LWC, 2021. Desktop Study of Soils, Sediments and Groundwater Quality – Eramurra Salt Project, Pilbara Coast, Western Australia. Prepared for Leichhardt Salt Pty Ltd, March 2021.

LWC, 2022a. December 2021 Groundwater Well Installation and Monitoring Event – Eramurra Salt Project. Prepared for Leichhardt Salt Pty Ltd, April 2022.

LWC, 2022c. Eramurra Salt Project Hydrologic Assessment. Prepared for Leichhardt Salt Pty Ltd, September 2022.

LWC, 2023a. Groundwater Monitoring and Management Plan. Eramurra Salt Project. Leichhardt Salt Pty Ltd. December 2023.

LWC 2023b Hydrologic Assessment for Scenario 7.2, Eramurra Salt Project. Leichhardt Salt Pty Ltd. July 2023.

LWC, 2024a. November 2023 and February 2024 Groundwater and Surface Water Monitoring Event and Logger Install. Prepared for Leichhardt Salt Pty Ltd. Dated March 2024.

LWC 2024b. July 2024 Groundwater Monitoring Event and Logger Data Collection. December 2024.

NEPC, 2013. National Environment Protection (Assessment of Site Contamination) Measure 1999 as amended (NEPM). National Environment Protection Council. Dated May 2013.

O2 Environment, 2023. Eramurra Salt Project – Benthic Communities and Habitat Monitoring and Management Plan. Draft Issued 30 October 2023

Thomann, J.A; Werner A.D and Irvine D.J. (2022). Developing Adaptive Management Guidance for Groundwater Planning and Development. Volume 322 Journal of Environmental Management. 15 November 2022.

U.S. Environmental Protection Agency (EPA) (2000). Guidance for the Data Quality Objectives Process (QA/G-4). EPA/600/R-96/055. Office of Environmental Information.

Appendix A Tables

Geosyntec consultants

Table A.1: Summary of Existing and Proposed Groundwater Well Locations

Well ID	Location	Target	Well Type	Well Depth (m BGL)	Screened Geology	Easting	Northing
MBH001	Adjacent southern extent of gas pipeline	Pressurised gas pipeline Pond development area – Stage 1	n/a	25.5	Gravelly Clay	437748.850	7690196.420
MBH003	Adjacent northern extent of gas pipeline	Pressurised gas pipeline Pond development area – Stage 1	n/a	5.5	Gravelly. Clayey Sand	434817.750	7694338.300
MBH006	Central portion of the Site	General spatial coverage Pond development area – Stage 1	n/a	22.5	Clayey Gravelly Sand/ Gravel	431582.990	7688494.710
MBH008	North/central portion of the Site	General spatial coverage Pond development area – Stage 1	n/a	13	Clayey Sand	430672.720	7692093.180
MBH009	Western portion of the Site	Possible plant/processing area Targeting the fractured rock aquifer	n/a	13.5	Gravel	423794.000	7686355.710
MBH010	Northwestern portion of the Site	General spatial coverage Near Eramurra Creek	n/a	15.8	Clayey Gravelly Sand	423792.010	7687984.080
MBH012	Southwestern portion of the Site	General spatial coverage Upgradient aspect of pond development area Targeting the fractured rock aquifer	n/a	9.5	Gravel	428320.420	7682825.440
MBH013	Central portion of the Site	General spatial coverage Pond development area – Stage 1 Near McKay Creek	n/a	14	Clayey Sandy Gravel/ Gravel	428069.770	7687412.700
MBH017	Adjacent southern extent of gas pipeline	Pressurised gas pipeline Pond development area – Stage 2	n/a	18	Sandy Clay	437939.670	7690291.580
MBH019	Northeastern portion of the Site	General spatial coverage Pond development area – Stage 2	n/a	22.5	Clayey Sand	438641.250	7694510.220

Well ID	Location	Target	Well Type	Well Depth (m BGL)	Screened Geology	Easting	Northing
MBH020	Northeastern portion of the Site	General spatial coverage Adjacent pond development area – Stage 2 Near Devil Creek	n/a	22	Sandy Clay	441063.780	7694306.410
MB21s	Eastern portion of Site/ adjacent west of Devil's Creek	Devils Pools	Shallow	24	Dolerite dyke or outcropping basalt	440329.000	7691543.000
MB22d	Proposed	Noorea Soak	Deep	30 (target)	n/a	434013.019	7691139.798
MB22s	Proposed	Noorea Soak	Shallow	10 (target)	n/a	434013.019	7691139.798
MB23s	Proposed	PEC-W	Shallow	10 (target)	n/a	439887.188	7695254.294
MB24s	Proposed	PEC-W	Shallow	10 (target)	n/a	438294.678	7695523.008
MB25s	Proposed	PEC-W	Shallow	10 (target)	n/a	436040.801	7694803.331
MB26d	North eastern portion of Site/ edge of proposed concentration pond	Paleo Chan/Ocean	Deep	36	Potential paleochannel	432867.00	7694530.00
MB27s	Proposed	Algal Mat/Mangroves	Shallow	10 (target)	n/a	428724.923	7690483.831
MB28s	Proposed	Algal Mat/Mangroves	Shallow	10 (target)	n/a	425012.262	7689456.341
MB29s	Proposed	Mangroves	Shallow	10 (target)	n/a	422604.073	7690834.793
MB30d	Proposed	Terrestrial Vegetation	Deep	60 (target)	n/a	423132.745	7686376.246
MB30s	Proposed	Terrestrial Vegetation	Shallow	20 (target)	n/a	423132.745	7686376.246
MB31s	Proposed	Terrestrial Vegetation	Shallow	20 (target)	n/a	422904.93	7686310.71
MB32d	Proposed	Terrestrial Vegetation	Deep	60 (target)	n/a	422503.17	7683346.58
MB32s	Proposed	Terrestrial Vegetation	Shallow	20 (target)	n/a	422503.17	7683346.58
MB33d	Southern portion of Site/ adjacent to the western side	Terrestrial Vegetation	Deep	60	Granodiorite (Dampier Granitoid Complex)	427261.00	7682320.00

Well ID	Location	Target	Well Type	Well Depth (m BGL)	Screened Geology	Easting	Northing
	of McKay Creek						
MB33s	Southern portion of Site/ adjacent to the western side of McKay Creek	Terrestrial Vegetation	Shallow	20	Eluvium	427265.00	7682331.00
MB34s	Southern portion of Site/ adjacent to the eastern side of McKay Creek	Terrestrial Vegetation	Shallow	20	Eluvium	427608.00	7682312.00
MB35d[1]	Southern portion of Site/ adjacent to the western side of McKay Creek	Terrestrial Vegetation	n/a	42	n/a	428356.00	7686032.00
MB35s	Central portion of Site/ adjacent to the western side of McKay Creek	Terrestrial Vegetation	Shallow	15	Eluvium	428313.00	7686043.00
MB36s[1]	Central portion of Site/ adjacent to the eastern side of McKay Creek	Terrestrial Vegetation	n/a	20	n/a	428649.00	7685974.00
MB37d	Central portion of Site/ within proposed crystallisation area	Basement	Deep	42	Granodiorite (Dampier Granitoid Complex)	427028.00	7684363.00
MB38d	Central portion of Site/ within proposed crystallisation area	Basement	Deep	49.6	Eluvium or Tertiary alluvium	433931.00	7685886.00
MB39d	Central eastern portion of Site/ within proposed concentration pond	Basement	Deep	27	Granodiorite (Dampier Granitoid Complex)	435086.00	7688672.00
MB40d	Eastern portion of Site/ within proposed	Basement	Deep	60	Granodiorite (Dampier Granitoid Complex)	437922.00	7692766.00

Well ID	Location	Target	Well Type	Well Depth (m BGL)	Screened Geology	Easting	Northing
	concentration pond						
MB41s	Proposed	Basement	Deep	50 (target)	n/a	435486.573	7693411.246
MB42s	Proposed	Basement	Deep	50 (target)	n/a	434106.793	7685010.517
MB43s	Proposed	Algal Mats. Samphire	Shallow	20 (target)	n/a	422475.835	7689984.396
MB44s	Proposed	Algal Mats. Samphire	Shallow	20 (target)	n/a	423725.641	7689458.162
MB44d	Proposed	Algal Mats. Samphire	Deep	60 (target)	n/a	423725.641	7689458.162
MB45s	Proposed	Algal Mats. Samphire	Shallow	20 (target)	n/a	426996.653	7689261.609
MB46s	Proposed	Mangroves	Shallow	20 (target)	n/a	425764.798	7690527.075
MB47s	Proposed	Mangroves	Shallow	20 (target)	n/a	427014.604	7690148.844
MB48s	Proposed	Mangroves	Shallow	20 (target)	n/a	428872.868	7691283.536
MB49s	Proposed	Mangroves	Shallow	20 (target)	n/a	437210.39	7696216.98
MB50s	Proposed	Mangroves	Shallow	20 (target)	n/a	439792.227	7695953.863
MB51s	Proposed	Mangroves	Shallow	10 (target)	n/a	417723.283	7691168.423
MB52s	Proposed	Mangroves	Shallow	10 (target)	n/a	442456.287	7695740.081
MB54s	Proposed	Terrestrial Vegetation	Shallow	20 (target)	n/a	423237	7687552
MB54d	Proposed	Terrestrial Vegetation	Deep	60 (target)	n/a	423237	7687552
MB55	Proposed	Devils Pools	Deep	40 (target)	n/a	440301.6	7692083.7
S1	Proposed	Seepage	Shallow	20 (target)	n/a	435644.575	7693516.404
S2	Proposed	Seepage	Shallow	20 (target)	n/a	436039.429	7694626.648
S3	Proposed	Seepage	Shallow	20 (target)	n/a	440235.406	7691549.489
S4	Proposed	Seepage	Shallow	20 (target)	n/a	429051.305	7686050.946

Well ID	Location	Target	Well Type	Well Depth (m BGL)	Screened Geology	Easting	Northing
S5	Proposed	Seepage	Shallow	20 (target)	n/a	428077.851	7686044.413
S6	Proposed	Seepage	Shallow	20 (target)	n/a	424981.092	7689391.068
S7	Proposed	Seepage	Shallow	20 (target)	n/a	423881.057	7686358.825
S8	Proposed	Seepage	Shallow	20 (target)	n/a	428583.361	7690403.722
S9	Proposed	Seepage	Shallow	20 (target)	n/a	432508.209	7694579.69

ML = Mining Lease
1) Boreholes were drilled but a groundwater monitoring well was not installed.

Table A.2: Summary of Previous and Existing Surface Water Sampling Locations

Location ID	Creek Line	Target	Status	Easting	Northing
SW01	Mangrove area	Coastal outlet/ mangrove area in marine environment	Existing	426567	7690763
SW02	Eramurra Creek	Eramurra Creek outlet near marine environment	Existing	422700	7688584
SW03	McKay Creek	McKay Creek upstream location within project area	Historical	n/a	n/a
SW03R	McKay Creek	McKay Creek at the crossover with North West Coastal Highway	Existing	427210	7679823
SW04	McKay Creek	McKay Creek within central portion of the Site	Existing	428645	7684150
SW05	McKay Creek	McKay Creek within central portion of the Site	Existing	428455	7685608
SW06	McKay Creek	McKay Creek outlet near marine environment	Existing	426950	7688822
SW07	McKay Creek Tributary	Upstream tributary of McKay Creek	Existing	429140	7682919
SW08	McKay Creek Tributary	Upstream tributary of McKay Creek	Existing	430819	7683139
SW09	Devil Creek	Devil Creek upstream of the project area	Existing	438880	7685441
SW10	Eramurra Creek	Eramurra Creek within project area	Historical	n/a	n/a
SW10R	Eramurra Creek	Eramurra Creek at the crossover with North West Coastal Highway	Existing	422981	7685222
SW11	Devil Creek	Devil Creek within project area	Historical	n/a	n/a
SW11R	Devil Creek	Devil Creek at the crossover with North West Coastal Highway	Existing	440946	7692589
SW12	Unnamed creek	General floodplain area in marine environment	Existing	425739	7688051
SW13	Unnamed creek	General floodplain area	Existing	436045	7692225
SW14	Unnamed creek	General floodplain area	Existing	439461	7694439

Appendix B Data Quality Objectives and Groundwater and Surface Water Monitoring Quality Procedures

Data quality Objectives

Data Quality Objectives (DQO) are required to ensure that sufficient data is collected to meet the monitoring program objectives. The DQO process:

- Clarifies study objectives;
- Defines appropriate types of data to collect (based on activity and chemicals of interest); and
- Specifies the tolerable levels of potential decision-making errors.

The DQO process, as defined by the US Environmental Protection Agency (US EPA, 2000), consists of seven distinct steps.

Step 1 - State the Problem

Regarding the proposed development of Eramurra Solar Salt Project, highly saline water within the concentration pond area has potential to increase salinity of local surface water, as well as potentially impacting groundwater quality.

Step 2 - Identify the Decision

Detect/ identify changes in chemical composition of groundwater that may indicate/ represent unacceptable increase in the concentrations of ambient concentrations.

Step 3 - Identify Inputs into the Decision

To make the decision, the following input is required:

- Spatial and temporal information on the concentrations of chemical substances in groundwater from baseline, through operation and post closure.
- Concentrations of chemical substances in groundwater within the assessment area.

The following sub-inputs are required:

- Baseline concentrations of chemical substances in groundwater within the assessment area.
- The nominated assessment criteria.
- The geological and hydrogeological conditions.

Step 4 - Define the Study Boundaries

The Assessment Area is associated with the proposed development area of Eramurra Solar Salt Project (Refer to **Figure 1-2**).

Step 5 - Develop a Decision Rule

The concentration of chemical analytes analysed in groundwater from the monitoring well network are to be compared against background concentrations. Mann-Kendall statistical trend analysis of analyte concentrations within the groundwater well network will determine if there is an increasing or decreasing trends at 80 and 90 percent confidence intervals.

The acceptable levels for quality assurance / quality control (QA/ QC) samples are described below.

Step 6 - Specify Limits on Decision Errors

To ensure the quality of the environmental data that is collected, detailed QA/QC measures will be applied. The QA/QC measures must be followed from the inception of the project, during field works, laboratory analysis of samples and data reporting.

A decision error in the context of the decision rules in Step 5 would lead to either under-estimation or overestimation of the risk level associated with the activity. Decision errors may include:

- Sampling errors: where the sampling program does not adequately detect the variability of a contaminant spatially across the investigation area.
- Measurement errors: these can occur during sample collection, handling, preparation, analysis and data reduction.

Proactive steps / measures to mitigate these errors are as follows:

- Field staff to follow a standard procedure when collecting samples;
- Laboratories to follow a standard procedure when preparing and analysing samples; and
- Laboratories to report quality assurance / quality control data for comparison with the Data Quality Indicators (DQI) established for the project.

The aim of this step is to assist in calculating the tolerable decision error rates and a consideration of the consequences of making an incorrect decision.

The quality of the data collected as part of the sampling is thus assessed on a range of factors including:

- Documentation and data completeness; and
- Data quality – comparability, representativeness, precision, and accuracy of data.

Precision

Precision is a quantitative measure of the variability (or reproducibility) of data. Suitable criteria and/ or performance indicators for assessment of precision include:

- Performance of laboratory duplicate sample sets through the calculation of Relative Percent Differences (RPDs);
- Performance of intra-laboratory field duplicate sample sets through calculation of RPDs; and
- Performance of inter-laboratory field duplicate sample sets through calculation of RPDs.
- The RPDs will be assessed as acceptable if less than 30% as per the Schedule B3 of the ASC NEPM (NEPC, 2013). Where the results show greater than 30% difference a review of the cause will be conducted. It is noted that RPDs that exceed this range may be considered acceptable where:
    - Results are less than 10 times the Limit of Reporting (LOR); and
    - Results are less than 20 times the LOR and the RPD is less than 50%.

Accuracy (Bias)

Accuracy is a quantitative measure of the closeness of the reported data to the true value and is assessed through the review of performance of:

- Method blanks (analysed for analytes targeted in the primary samples);
- Matrix spike and matrix spike duplicates;
- Surrogate recoveries; and
- Laboratory control samples.

Representativeness

Representativeness is the confidence (expressed qualitatively) that data are representative of the media present. To ensure that data is representative, the following is undertaken:

- Review of RPD values for field and laboratory duplicates to provide an indication that the samples are generally homogeneous, with no unacceptable instances of significant sample matrix heterogeneities; and
- The appropriateness of sample collection methodologies, handling, storage and preservation techniques will be assessed to ensure/ confirm that there was minimal opportunity for sample interference or degradation.

Completeness

Completeness is a measure of the amount of useable data from a data collection activity. In validating the degree of completeness of the analytical datasets acquired during the program the following is considered:

- Whether standard operating procedures have been adhered to;
- Copies of all Chain of Custody (COC) documentation are reviewed and presented along with appropriate data validation.
- It can therefore be considered whether the proportion of useable data generated in the data collection activities is sufficient for the purposes of assessing the problem as stated in Step 1 (State the Problem).

Comparability

Comparability is a qualitative assessment in the confidence that data may be equivalent for each sampling and analytical event. Issues of comparability between datasets are addressed through adherence to standard operating procedures and regulator endorsed or made guidelines and standards on each data gathering activity.

Data Quality Indicators and Tolerable Limits

The acceptance criteria / tolerable limits for the data quality indicators (DQI) are summarised in **Table B.1**.

Table B.1: Acceptance Criteria / Tolerable limits for DQIs

DQI	Acceptance / Tolerable Limit
Rinsates (where sampling equipment is reused)	Less than the laboratory LOR
Method Blank	Less than the laboratory LOR
Trip Blank	Less than the laboratory LOR
Field duplicates (intra and inter)	RPD limits as follows: • Results <10 times the LOR – no limit; • Results between 10 and 20 times the LOR – RPD <50% • Results >20 times the LOR – RPD <30%
Laboratory duplicates	PDs less than • 20% for high level laboratory duplicates (i.e. >20 x LOR) • 50% for medium level laboratory duplicates (i.e. 10 to 20 x LOR)

DQI	Acceptance / Tolerable Limit
Matrix Spikes	Recoveries between 70 – 130 % of the theoretical recovery or dynamic limits established by the laboratory (phenols excepted).
Laboratory Control Samples	Recoveries between laboratory specified range for each analyte and analytical suite.
Surrogates	Recoveries between 70 – 130 % of the theoretical recovery or dynamic limits established by the laboratory (phenols excepted).

In the event that acceptance criteria are not met, consideration will be given to excluding the data or using the data as semi-quantitative data or with clarification on data interpretation.

Step 7 - Optimise the Design for Obtaining Data

The seventh and final step involves identifying the most effective sampling and analysis design for generating the data that is required to satisfy the monitoring program objective and data quality objectives. Considering the information presented in steps 1 to 6 of the DQO Process, the sampling design optimisation sampling plan (and sampling methodology) in set out in below.

Groundwater Monitoring Methodology

The groundwater monitoring methodology is summarised in **Table B.2.**

Table B.2: Summary of Groundwater Sampling Methodology

Activity / Item	Details
Groundwater Elevation Gauging	Prior to sampling, monitoring wells will be gauged for water level elevations using a calibrated electronic interface water level probe. The water level probe must be thoroughly decontaminated and rinsed between locations. Water levels will be gauged from the surveyed point on the casing. Details of the gauging dates and depths recorded are to be provided as part of reporting requirements. Frequent water level data will be captured from an array of loggers place in wells across the site.
Well Surveying	Groundwater monitoring wells are surveyed into metres Australian Height Datum. If any Site development works necessitate a changing of monitoring well surface levels, a licensed surveyor is to be engaged to resurvey the location and elevation of groundwater monitoring wells to Australian Height Datum (m AHD).
Analytical Laboratories	Both the primary and secondary analytical laboratory shall be accredited by the National Association of Testing Authorities (NATA) for the analyses to be undertaken.
Quality Assurance/ Quality Control (QA/QC)	Quality Assurance procedures will include the collection and analysis of field QC samples, in accordance with the ASC NEPM (NEPC 1999 – amended 2013) – this will include the following during each groundwater monitoring event: • 1 in 20 intra-laboratory field duplicates; • 1 in 20 inter-laboratory field triplicates; • Rinsate blanks (collected from the pump equipment only) per each day of groundwater sampling to ensure appropriate decontamination processes occurred (submitted for analysis of metal suite with results inferred across the broader program); and • Trip blank for volatile analysis sent to both laboratories in order to confirm the appropriate storage and transport of samples being tested for volatile hydrocarbons.
Decontamination Procedures	Monitoring and sampling equipment (water level probe, pump housing) shall be decontaminated according to the following procedure: • Wash with Decon 90 or similar decontaminant/ water solution and rinse. • Triple wash with laboratory supplied deionised water.

Activity / Item	Details
Groundwater Sampling	Groundwater must be sampled using low-flow techniques. The method includes placement of the pump inlet at the midpoint of the standing water column and pumping at an appropriate discharge rate that maintains drawdown at <0.1 m during purging. Initial pumping rates for each groundwater monitoring location will be based on the rate of discharge from the previous monitoring event, or where previous records are not available, the lowest discharge rate of the pump. During purging and sampling, the groundwater level will be gauged to ensure that the drawdown limit is not breached, (e.g., greater than 10 cm), to provide groundwater extracted from the well which comprises fresh groundwater obtained from the adjacent formation and not stagnant water contained in the well water column. The measurement of field water parameters will be undertaken every five minutes until at least three stable sets of stable field quality parameters have been obtained (i.e., within 3% EC, 0.05 pH units, 10% Dissolved Oxygen (DO), 10 mV redox and 0.5°C temperature). Field parameters will be recorded on a suitable Geosyntec groundwater purge sheet to ensure stable geochemical conditions exist and are recorded prior to the collection of the groundwater sample. The water quality meter must be calibrated prior to the commencement of purging – i.e., at the start of each day of purging/ sampling.
Laboratory Analysis	Water samples must be placed in laboratory cleaned bottles containing appropriate preservatives and then placed into a chilled esky for transport to the laboratories under standard Geosyntec Chain of Custody protocols which are consistent with the requirements of Schedule B(2) of the ASC NEPM (NEPC,1999 as amended 2013). Groundwater samples analysed for metals must be filtered in the field using dedicated 0.45-micron filters and placed in pre-acidified bottles.

Groundwater Well Integrity Inspections

The purpose of the groundwater well integrity inspection program is to maintain serviceability of the well network such that samples of acceptable quality can be collected from the groundwater wells. Groundwater wells in the monitoring network should be inspected at some time before the monitoring round, so that maintenance and repairs can be undertaken to enable wells to be monitored during the monitoring round.

In addition, the integrity of each well will be assessed during the groundwater monitoring event. Serviceability and integrity issues will be recorded on the field sampling record. Items to be inspected include:

- Condition of the surface cement surrounding the flush well-head cover or well monument (if present)
- Erosion or ponding of surface water around the casing
- Subsidence of the soil materials surrounding the casing
- Obstructions which prevent access to the well/bore
- Condition of the flush well-head cover or well monument and well cap or J-cap
- Lock/security fittings on the external protective casing including bolts
- Water in the annular space between the well-head cover or well monument and the well casing
- Existence of loose, bent, or damaged casing
- Presence of obstructions in the well casing
- Evidence that the well has been tampered with by a third party
- Other conditions which affect the integrity of, access to, or the obtaining of samples from the well/bore or recording of fluid levels or sampling depth from the top of the groundwater monitoring well head.

Anomalies and deficiencies noted during the groundwater well integrity inspection program should be rectified in a timely manner and before the next sampling event. Repairs to the in-ground structure of groundwater monitoring wells, such as repairs to the casing, should be made by an accredited drilling contractor. Where repairs are made that are likely to change the elevation or position of the reference point of a monitoring well, i.e., the gauge point for a monitoring well, the repaired well and reference point should be resurveyed by a licensed surveyor.

Wells that have been damaged such that they are no longer serviceable should be decommissioned in accordance with the National Uniform Drillers Licensing Committee minimum guidelines (refer to current revision at the time of decommissioning). If monitoring wells within the network are assessed as being permanently inaccessible or are required to be decommissioned and redrilled. Depending on the well location, the redrilled well may be sampled in an out of sequence monitoring event.

Geosyntec consultants

We are engineers, scientists and innovators

Geosyntec consultants

BRISBANE GOLD CAST SYDNEY MELBOURNE PERTH

www.geosyntec.com.au