Eramurra Solar Salt Project

Public Environmental Review

Greenhouse Gas Emissions

Leichhardt Doc No ESSP-EN-14-RGL-0002
Document ID: ECS-010-02-RPT-01
Revision ID: 2
Revision Date: 22 June 2024

Elemental Consulting Services - Controlled document

Eramurra Solar Salt Project

Public Environmental Review – Greenhouse Gas Emissions

Elemental Consulting Services Pty Ltd
ABN: 32 612 085 319
117 Grand Prom
Bedford, WA 6052

ECS document control information

Document Number	ECS-010-02-RPT-01	Revision	2

Revision history

Rev No.	Description	Date	Prepared By	Approved By
REV 0	Report formally issued	8 July 2022	John Torkington	Tye Pope
REV 1	Updated to include information on: • Construction emissions • Emissions related to land clearing • Possible climate change impacts	18 October 2022	John Torkington	Tye Pope
REV 2	Updated to include changes to project configuration: • Electrical power generation • Revisions to evaporator pond configuration	22 June 2024	John Torkington	Tye Pope

Cautionary Statement

Elemental Consulting Services Pty Ltd (ECS) has been commissioned by Leichhardt Salt Pty Ltd to prepare a report estimating the operational greenhouse gas emissions from the proposed Eramurra Solar Salt Project and to place those emissions in the context of Australia's and Western Australia's annual greenhouse gas emissions. The report is to estimate the project's greenhouse gas emissions intensity, compare that intensity estimate with publicly available data on similar projects, and summarise opportunities for the future reduction in those emissions.

In preparing this report, ECS has relied upon data and information provided by Leichhardt Salt Pty Ltd. ECS makes no warranty as to the accuracy, veracity, or completeness of that data or any analysis or statements contained in this report which were based on the information supplied by Leichardt Salt Pty Ltd.

Due care and skill have been exercised in the preparation of this report. Notwithstanding, ECS disclaims any liability, including liability for negligence, loss howsoever caused damage, injury, expense, or cost incurred by any person as a result of accessing, using, or relying upon any of the information or data in this report, to the maximum extent permitted by law. No representation, expressed or implied is made as to the currency, accuracy, reliability, or completeness of the information contained in this report. The reader should rely on their inquiries to independently confirm the information and comment on which they intend to act.

Contents

Tables

Figures

1. INTRODUCTION

This report has been prepared with the intent that it may be included as part of the documentation comprising the Environmental Review Document to be issued for Public Environment Review for the Eramurra Solar Salt Project (the Proposal).

The greenhouse gas emissions from the Eramurra Solar Salt Project, once in steady-state operations, are estimated at approximately 45,000 tonnes of CO_2e per year.

This estimate has been developed based on the anticipated fuel and electricity requirements for the overall project and includes the activities subject to the Proposal and the activities related to the operation of the previously approved Cape Preston East Port. The inclusion of emissions for Cape Preston East Port with the Eramurra Solar Salt Project has been done to ensure transparency regarding the Proposal's greenhouse gas emissions and to enable a like for like comparison with other projects.

Anticipated annual steady state greenhouse gas emissions from only the activities subject to the Proposal are estimated at approximately 29,000 tonnes CO_2e per year[1].

The greenhouse gas emissions intensity for the entire Eramurra Solar Salt Project compares favourably with salt projects operating or soon to be under construction in Western Australia and is about one-third that of one of the world's largest international salt producers.

It is estimated that approximately a further 109,000 tonnes of greenhouse gas will be emitted from activities under the Proponent's operational control during construction. Of these emissions 78,000 tonnes of carbon dioxide are estimated to be due to changes in land use. The land use change estimate is heavily reliant on assumptions made in the absence of measured data.

Finally, an assessment of the likely changes to meteorological and ocean conditions on the Proposal was undertaken to assess the Proposal's resilience to climate change. This assessment highlighted the project was resilient to most impacts of climate change but care is required in the design of the embankments to avoid the potential for overtopping during periods of more intense cyclones, combined with higher sea level.

1.1 Eramurra Solar Salt Project – overview

Leichhardt Salt Pty Ltd (the Proponent) proposes to construct and operate the Eramurra Solar Salt Project approximately 55 km southwest of Karratha in Western Australia. The Eramurra Solar Salt Project is proposed to have an annual average production capacity of 5.2 million tonnes per annum of high-grade sodium-chloride (NaCl) salt from sea water. In years of low rainfall, production may reach 6.8 million tonnes of high-grade salt. The salt will be produced using a series of concentration ponds and crystallisers with a processing plant, transport

[1] An additional 16,000 tonnes CO_2e per year are estimated for operation of activities at the previously approved Cape Preston East Port and while integral to the Eramurra Solar Salt Project, are outside the boundary of the Proposal currently being assessed.

corridor, stockpiling and export from the Cape Preston East Port. The concentration ponds and crystallisers will be located on mining leases.

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 approved by Ministerial Statement 949. Dredging of the proposed channel and berth pocket will be undertaken as part of this Proposal. Dredged material will be disposed both at an offshore location and onshore within the Port infrastructure Development Envelope.

The Cape Preston East Port Jetty and associated stockpiles are excluded from the Proposal but operational greenhouse gas emissions have been noted in this report to facilitate benchmarking with other projects.

Infrastructure to be developed as part of the Proposal includes:

- A seawater intake pump station
- Solar concentration ponds totalling approximately 10,000 ha, and includes several pump stations and pipelines
- Crystalliser ponds, totalling approximately 1,500 ha
- Recovery crystallisers of approximately 500 ha
- Drainage channels and bunds
- Process plant, product stockpiles and dewatering facilities
- Desalination plant for the provision of fresh water
- Bitterns disposal pipeline and outfall
- Supporting infrastructure includes electrical power supply and power lines, pumps, pipelines, roads, support buildings and communications facilities.

The stockpiling and export of salt is proposed to be via the previously approved Cape Preston East port. Salt will be removed from the recovery crystalliser ponds by mechanical harvesters and delivered by truck to the wash plant facilities. Following processing, the salt is stockpiled, then trucked to the Port for export via ship to overseas markets.

The indicative layout of the Proposal is provided in Figure 1-1.

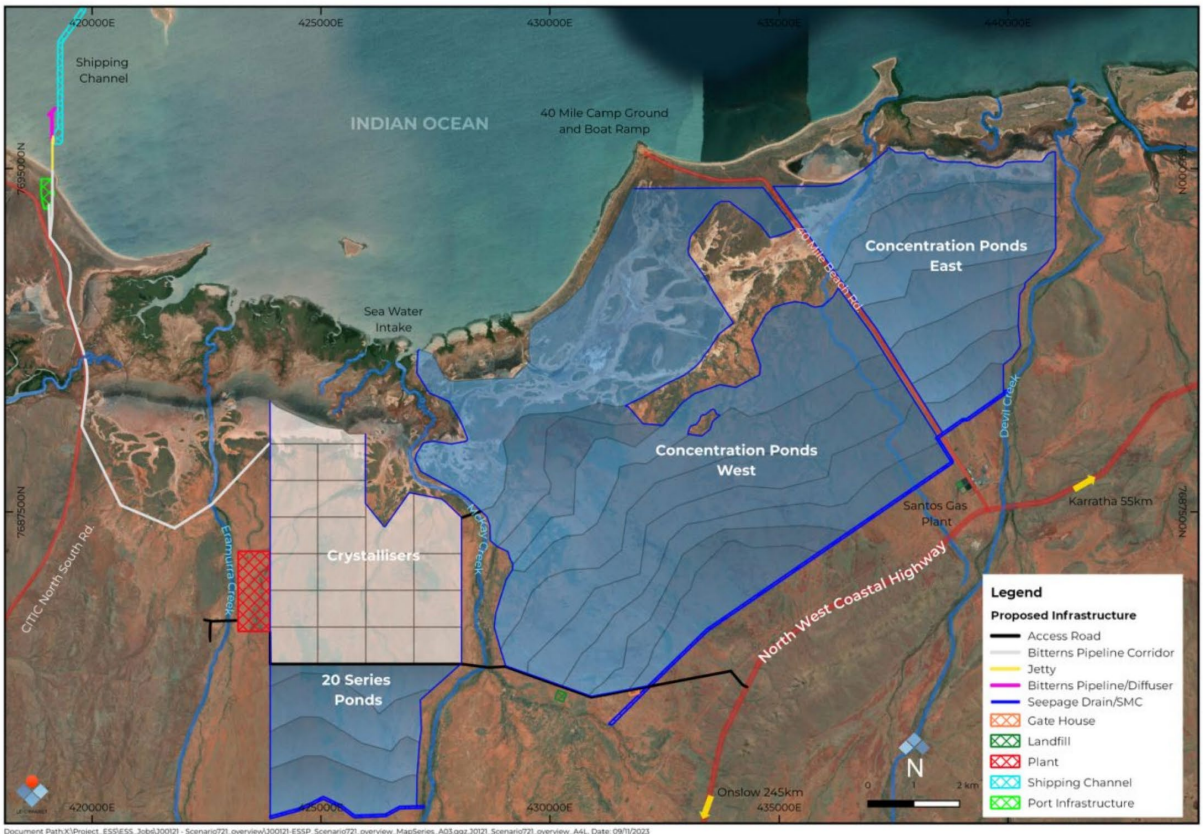

Figure 1-1 Indicative layout of the Proposal

2. ESTIMATED GREENHOUSE GAS EMISSIONS

2.1 Construction

Greenhouse gas emissions under the operational control of the Proponent during the construction of Eramurra Solar Salt Project involve emissions from:

- consumption of diesel fuel
- oxidisation of carbon stored in the landscape because of land clearing or disturbance.

Table 2-1 provides an estimate of greenhouse gas emissions during construction.

Table 2-1 Estimated greenhouse gas emissions from the combustion of diesel and land use change during construction

Emissions source	Estimated diesel consumption (megalitres)	Estimated greenhouse gas emissions
Diesel Use		
Electrical generation	0.6	
Marine surveys	0.01	
Dredging	0.2	
Earth works	4.5	
Dozers and graders	0.8	***31,000 tonnes CO_2e***
Borrow pit haulage	1.0	
Rock armour haulage from Maitland	2.0	
Light vehicles and buses	0.3	
20% contingency	1.9	
Sub Total	***11.31***	
Land use change		***78,000 tonnes CO_2e***

It is estimated that construction activities will use around 9.4 megalitres of diesel fuel. For this assessment, an additional 20% fuel usage contingency has been assumed.

All electricity used during construction is proposed to be generated on-site and has been included in the emissions estimates for diesel consumption.

No assessment has been provided for activities outside the operational control of the Proponent.

2.1.1 Land use change emissions

Table 2-2 lists the estimated area of land disturbance anticipated for the major types of infrastructure to be constructed as part of the Proposal.

Table 2-2 Infrastructure land disturbance

Proposed infrastructure	Estimated disturbed area (hectares)	Land disturbance
Embankments	320	Removal of surface vegetation and some soil
Crystalliser ponds	1500	Area is levelled with any vegetation being tilled into soil
Evaporation ponds	10,000	Area is not disturbed prior to flooding
Recovery ponds	500	Area is levelled with any vegetation being tilled into soil
Roads	510	Removal of surface vegetation and some soil
Process infrastructure	380	Removal of surface vegetation and some soil

In Australia, the responsibility for estimating and reporting greenhouse gas emissions from land use, land use change and forestry (LULUCF) reside with the Australian Government and is undertaken by the Department of Climate Change, Energy, Environment and Water[2].

The EPA's determination on the assessment of the Eramurra Solar Salt Project did not identify greenhouse gas emissions as a preliminary key environmental factor. Consequently, the extensive surveys required to measure the stored carbon in the landscape were not included in the environmental surveys undertaken to inform the development of the Environmental Review.

In the absence of site-specific survey data, estimates of carbon in the landscape and the likely impacts on those carbon stocks from the implementation of the Proposal have been derived by using the Australian Government's Full Carbon Accounting Model (FullCam) model.

Both the Australian Government and proponents of land use change and forestry offset projects, use FullCam, to estimate carbon stocks in the landscape and to model changes to those carbon stocks over time. FullCAM estimates the carbon stock change in ecosystems including:

- above and below ground biomass
- standing and decomposing debris
- soil carbon resulting from land use and management activities.

FullCam underpins the Australian Government's National Inventory Reports and reports to the United Nations Framework Convention on Climate Change secretariate. Further information on the FullCam model can be found at: https://www.dcceew.gov.au/climate-change/publications/full-carbon-accounting-model-fullcam.

An exhaustive literature search failed to find any published studies considering the degree to which landscape carbon is oxidised to carbon dioxide because of land clearing activities in the northwest of Australia.

In the absence of published studies, estimates of initial carbon stored in the landscape and the likely impact on those carbon stocks from land disturbance in the area impacted by the Proposal have been derived using FullCam.

FullCam uses a single-point geographic location (Latitude and Longitude) representative of a project area as the basis of its calculations. Given the size and diversity of vegetation types over the area of the Proposal, twenty geographic locations were sampled in FullCam. For each of the twenty locations sampled, FullCam only allowed the selection of 'tidal muflat, samphire and bare areas, claypan, sand, rock, salt lakes, lagoons and freshwater lakes' to be selected as the 'forest type'. The twenty sampled points showed minimal variability in the amount of

[2] The exception to this is LULUCF offset generation projects undertaken in accordance with the *Carbon Credits (Carbon Farming Initiative) Act 2011 (Cth)* and the Act's subordinate regulations and methods. The proponents of these offset projects are required to estimate and report changes in carbon stored in the landscape associated with their projects to the Clean Energy Regulator as part of the process of crediting the greenhouse gas offsets.

landscape carbon between sample points, likely reflecting the spatial sampling at which FullCam operates.

FullCam does not model land use change such as the burial or submergence of vegetation relevant to much of the Proposal. As a proxy, the impact of a fire event on carbon stocks relevant to the 'forest type' was modelled from the standard events list.

The average of the 20 sample points in FullCam yielded an estimated average initial carbon stock over the Proposal area at:

- above ground vegetation 15.4 tonnes carbon per hectare
- debris 15.1 tonnes carbon per hectare
- soil carbon 44.9 tonnes carbon per hectare.

Only the oxidisation of carbon, to carbon dioxide, has been considered in this calculation. No attempt has been made to estimate methane and nitrous oxide emissions given the absence of any published information on emissions rates.

FullCam estimated a hot fire event, would reduce carbon in vegetation by around 3%, in debris by around 45% and in the soil by less than 1%.

For this assessment the following assumptions have been made:

- Evaporation ponds – Areas are not disturbed prior to flooding - assumed all carbon remains in place although in time vegetation and debris may become soil carbon – no net change to levels of stored carbon
- Crystalliser and recovery ponds – Areas are levelled with above ground carbon being flattened and tilled into the soil – 5% of above ground carbon (vegetation and debris) is oxidised
- Embankments, roads and process infrastructure – Assumed all vegetation and a portion of soil is removed and stockpiled. Cleared vegetation is buried in the stockpiles and over time will become part of the soil carbon stock. During this process, it is assumed 20% of the total carbon stock is oxidised. This is higher than for the crystalliser and recovery ponds due to the increased disturbance involved in removing, transporting, and stockpiling the vegetation and soil material.

At the closure of the Eramurra Solar Salt Project, the site will likely be rehabilitated including the reestablishment of vegetation. The increase in landscape carbon due to rehabilitation has not been factored into these estimates.

The estimated carbon stocks were multiplied by the area of each disturbance type and the assumed oxidisation rates to yield the total mass of carbon oxidised. This is then converted to the mass of carbon dioxide. Table 2-3 summarises that calculation.

Table 2-3 Estimated carbon dioxide emissions due to land disturbance

	Estimated disturbed area (hectares)	Impacted carbon stock (tonnes carbon / ha)	Assumed oxidisation factor	Oxidised carbon (tonnes)
Embankments, roads and process infrastructure	1210	75.4	20%	18,247
Crystallizer and recovery ponds	2000	30.5	5%	3,050
Carbon dioxide emissions from land disturbance			***78,000 tonnes CO_2***	

2.2 Operations

The Scope 1 greenhouse gas emissions from the Eramurra Solar Salt Project, once in steady-state operations, are estimated to be approximately 45,000 tonnes of CO_2e per year. This estimate includes activities subject to the Proposal and the activities related to operations at the previously approved Cape Preston East Port that are related to the Proposal.

It is estimated the annual greenhouse gas emissions from only those components of the project subject to the Proposal will average around 29,000 tonnes of CO_2e per year.

It is likely to take several years to establish the concentrator and crystalliser ponds before the Proposal is operating in a steady state. Salt harvesting operations are likely to vary from month to month, and year to year depending on local weather patterns. Consequently, these estimates should be considered an annual average once in steady-state operations. Actual emissions are likely to vary from year to year.

The Proponent has estimated that project energy use during operations will comprise approximately:

- 55,500 megawatt-hours per year of electricity consumption (includes an allowance for power distribution losses)
- 4.2 megalitres of diesel per year for mobile equipment, heavy vehicles, and maintenance equipment
- 4.4 megalitres of diesel per year for marine vessels (trans-shipment vessels etc)
- 0.1 megalitres of diesel per year for light vehicles.

A breakdown of these emissions is provided in Table 2-4. These estimates have been determined using the emissions factors provided in Section 2.3. As electricity generation will be undertaken onsite, these are all classified as Scope 1 emissions.

Table 2-4 Estimated annual greenhouse gas emissions from the Eramurra Solar Salt Project[3]

Emissions source	Estimated annual energy use	Estimated annual greenhouse gas emissions
Electricity Seawater intake Brine pumping transfers Services and bitterns Wash plant and product stacking Office/workshops/lighting/desalination Port materials handling	5,100 MWh 28,000 MWh 4,000 MWh 6,600 MWh 1,800 MWh 10,000MWh	22,200 tonnes CO_2e (from the onsite consumption of LNG)
Diesel Use Mobile equipment, heavy vehicles etc Marine vessels (trans-shipment vessels, tugs etc) Light vehicles	4.2 megalitres 4.4 megalitres 0.1 megalitres	23,000 tonnes CO_2e
Annual Total		***45,200 tonnes CO_2e***

Table 2-5 sets out the estimated annual Scope 1 greenhouse gas emissions from just those operations subject to this Proposal.

Table 2-5 Estimated annual greenhouse gas emissions from the Proposal[4]

Emissions source	Estimated annual energy use	Estimated annual greenhouse gas emissions
Electricity Seawater intake Brine pumping transfers Services and bitterns Wash plant and product stacking Office/workshops/lighting/desalination	5,100 MWh 28,000 MWh 4,000 MWh 6,000 MWh 1,800 MWh	17,550 tonnes CO_2e (from the onsite consumption of LNG)
Diesel Use Mobile equipment, heavy vehicles etc Light vehicles	4.2 megalitres 0.1 megalitres	11,600 tonnes CO_2e
Annual Total		***29,150 tonnes CO_2e***

Section 6 of this Report sets out future options that may be considered to further reduce the estimated annual greenhouse gas emissions

[3] Includes emissions estimates from the operation of both the Proposal and the Cape Preston East Port

[4] This excludes emissions related to the operations at the Cape Preston East port.

2.2.1 Electrical Power Generation

The current design envisages that the proposals electricity will be generated on site using a combination of liquefied natural gas (LNG) fuelled gas engine generators and solar photovoltaic cells. The Proponent estimates that on average around 35% of the total electricity produced would be supplied by solar photovoltaic cells.

The proponent estimates approximately 30,000 megawatt hours of electricity per year will be supplied from onsite LNG fuelled gas engine generators. The proponent further advises that given the volume of LNG proposed and the high ambient temperatures, the LNG can be gasified using the natural boil off, supplemented with air heat exchangers. Accordingly, no provision has been made for the use of LNG to fire gasification heaters.

The LNG is proposed to be supplied by road tanker from the nearby Maitland LNG Plant. Greenhouse gas emissions associated with the production of the LNG and road transport to the Eramurra Solar Salt Project have not been included in this report as they are outside the operational control of the Proponent.

2.3 Emissions factors

Table 2-6 lists the factors used in this report to estimate the Project's annual emissions and to evaluate future emissions reduction opportunities. The factor for the consumption of diesel fuel has been taken from the most recent publication of the National Greenhouse Accounts Factors (Ref 1).

Table 2-6 Emissions factors

Energy Type	Factor	Units	Other
Scope 1 factors			
LNG for electrical power generation	0.6	kg CO_2e/kilowatt hour of electricity generated	
Diesel oil*[1]	70.20	kg CO_2e/GJ	38.6 GJ/kL
Notes 1 - Assumes heavy vehicles operating to Euro iv or higher design emissions standards			

The Clean Energy Regulator publishes data on the electricity production and greenhouse gas emissions of designated generation facilities. These data show the emissions intensity of gas fired electrical generation is dependent on the generation technology and how that technology is deployed. The Derby and Fitzroy Crossing power stations both of which are supplied with road transported LNG report an emissions intensity in 2022-23 of 0.61 and 0.58 tonnes CO_2e per megawatt hour of electricity generated respectively (Ref 2). For the purposes of this assessment the emissions intensity of the 0.6 tonnes CO_2e per megawatt hour of electricity has been assumed.

The NGER reporting system requires the reporting of greenhouse gas emissions from sources such as the combustion of lubricating oils and greases and where natural gas is used, emissions from incomplete combustion. These emissions sources are generally non-material in the

context of the overall emissions estimations for the Proposal and have not been included in the estimations provided in this report

3. NATIONAL AND WESTERN AUSTRALIAN CONTEXT

Australia publishes a series of emissions estimates under various international conventions:

- UNFCCC classification system
- Kyoto Protocol classification system (Cancun Agreement QEERT)
- Kyoto Protocol second commitment period.

Data reported under these protocols tend to be based on calendar year estimates, whereas data published by the Australian Government for domestic consumption are usually based upon a July to June reporting year. Data reported between these protocols can vary slightly.

The Australian Government's Department of Climate Change, Energy, the Environment and Water provides a disaggregation of annual greenhouse gas emissions estimates for each Australian State and Territory. This data is extracted from the emissions estimates in the National Inventory Report submitted to the United Nations Framework Convention on Climate Change.

The most recent data (2022) available from the National Inventory Report is shown in Figure 3-1. The data includes emissions from energy, industrial processes, agriculture, land use and land-use change, and the waste sectors (Ref 3).

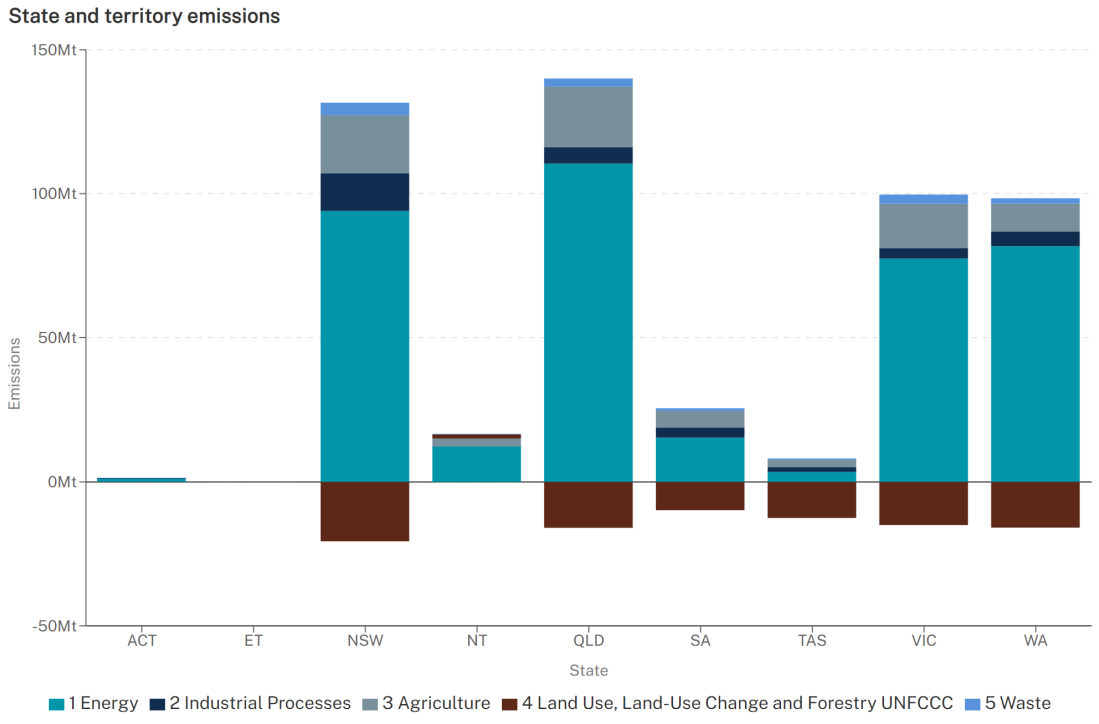

Figure 3-1 2022 State and Territory greenhouse gas emissions

Table 3-1 shows the estimated annual operational greenhouse gas emissions for the Proposal compared with Australia's and Western Australia's estimated greenhouse gas emissions for 2022.

Table 3-1 Project emissions relative to Australian and Western Australian emissions

	2022 WA or Australian Emissions	Estimated annual Project emissions	Percentage change to Western Australian and Australian Emissions
Australian emissions	520.27 million tonnes (CO_2e)	45,000 tonnes CO2e	0.009% increase
Western Australian emissions	98.4 million tonnes (CO_2e)		0.046% increase
*Excludes negative emissions due to land use, land use change, and forestry.			

4. GREENHOUSE GAS EMISSIONS INTENSITY

Industrial salt is produced from either the underground mining of rock salt deposits or the vacuum or solar evaporation of sea water or naturally occurring underground brine deposits. Of these methods, the solar evaporation of seawater is likely to be the most sustainable and least emissions intensive.

4.1 Proposal emissions intensity

Dividing the annual greenhouse gas emissions estimated in Section 2, by the planned production of approximately 5.2 million tonnes per year of concentrated salt, gives a Scope 1 average emissions intensity of approximately 8.7 kgCO_2e per tonne of produced salt. This is equivalent to a Scope 1 and 2 emissions intensity for other projects where those projects import electricity rather than generate electricity onsite.

4.2 Comparison with other projects

Publicly available data on the greenhouse gas emissions intensity of comparable salt projects is not widely available. Within Australia, all salt production operations fall below the publication thresholds established under the *National Greenhouse and Energy Reporting Act 2007 (Commonwealth)* and operators generally do not volunteer data on their greenhouse gas emissions or energy consumption. The exception is Dampier Salt which published a Sustainability Report in 2015 (Ref 4) setting out its greenhouse gas emissions and emissions intensity over the period 2010 to 2015. Dampier Salt does not appear to have published more recent reports although some data is included in their parent company's reporting[5].

[5] Equity share data is included in the reports of Rio Tinto.

Table 4-1 sets out the greenhouse gas emissions and emissions intensity from salt producers where data could be identified. An attempt was made to capture all Australian salt producers and data on the major global salt production companies. Not shown in Table 4-1 are data on the major global salt production operations of:

- Cargill
- China National Salt Industry Group Corporation
- Tata Chemicals Limited
- INEOS Enterprises

These companies either do not publish greenhouse gas emissions data or only publish corporate-level data. As such, the emissions and emissions intensity of their salt operations is not publicly available.

Table 4-1 Salt production emissions and emissions intensity

Company/Project	Annual salt production	Market	Annual Scope 1 and 2 greenhouse gas emissions	Published/estimated Scope 1 and 2 emissions intensity
International producers				
Compass Minerals International[6] (85% sourced from underground mining) (Ref 5)	11.7 million tonnes (2020)*[1]	80+% of production is used in highway de-icing with the remainder packaged for consumer and industrial use	315,000 tonnes CO_2e*[2]	27 kg CO_2e per tonne salt produced
Australian producers				
Dampier Salt (Dampier, Port Hedland and Lake MacLeod operations) (Ref 4)	8.7 million tonnes (2021)*[3]	Industry, with the majority targeted at Chlor-alkali production	Not disclosed	5.4 kg CO_2e per tonne of salt produced (2015) Data ranges between 5.0 and 5.7 over the period 2010 to 2015
Shark Bay Salt (Shark Bay Resources and Onslow Salt operations)	~4.0 million tonnes	Industry, with the majority targeted at Chlor-alkali production	Not disclosed	
Cheetham Salt	800,000 tonnes	Food, swimming pool, stock feed, hide, water treatment	Not disclosed	
Australian Saltworks	Not disclosed estimated <100,000 tonnes	Swimming pool, food, stock feed, hide, water treatment, general industrial	Not disclosed	
WA Salt Group	Not disclosed estimated <100,000 tonnes	Swimming pool, food, stock feed, hide, water treatment, general industrial	Not disclosed	
Olssons Salt	Not disclosed estimated <20,000 tonnes	Food, cosmetics and stock feed	Not disclosed	
Proposed Projects*[4]				
Eramurra Solar Salt Project	Targeting 5.2 million tonnes	Industry, with the majority targeted at Chlor-alkali production	45,200 tonnes CO_2e per year	8.7kg CO_2e per tonne produced salt
Mardie Project (BCI Minerals – In construction)*[5](Ref 6)	4 million tonnes of salt + 100,000 tonnes of	Industry, with the majority targeted at Chlor-alkali production	53,292 tonnes CO_2e per year*[6]	13 kg CO_2e per tonne produced salt and sulphate of potash

[6] Compass Minerals International is one of the worlds largest producers of salt and related products with operations across North America and the United Kingdom https://www.compassminerals.com

Company/Project	Annual salt production	Market	Annual Scope 1 and 2 greenhouse gas emissions	Published/estimated Scope 1 and 2 emissions intensity
	sulphate of potash			
Ashburton Salt (K+S proposed 2017) (Ref 7)	4.7 million tonnes	Industry, with the majority targeted at Chlor-alkali production	57,000 tonnes CO_2e per year[*7]	12 kg CO_2e per tonne produced salt.

Notes

1 - Annual production capacity is 16.2 million tonnes per year of salt + 360,000 tonnes per year of Sulphate of Potash, Production data for 2021 is available but 2020 has been used to align with available greenhouse gas data.

2 - Estimated from Compass Minerals published intensity of 27.4 kg/ton production.

3 - Based on Rio Tinto's reporting of equity share (68%) production.

4 – Fin Resources Limited hold tenements near Onslow and have proposed developing these into a solar salt project. A referral for approval under the *Environmental Protection Act 1986 (WA)* has not yet been made and credible information on likely production rates and greenhouse gas emissions has not been published. Accordingly, this proposal has not been considered further in this assessment.

5 - Investment decision to proceed with the first phase of the Mardie Project targeting 4 million tonnes of salt and 100,000 sulphate of potash per year was made during October 2021 with construction to commence in 2022. A proposal to expand the project to 5.36 million tonnes of salt and 140,000 tonnes of sulphate of potash per year is currently being assessed for approval.

6 – The EPA noted an additional 45,600 tonnes CO_2e per year over two years related to land clearing. These are construction-related emissions and over the life of the project should largely be offset by vegetation regrowth after the site has been closed and rehabilitated.

7 – The proponent of the Ashburton Salt proposal estimated these emissions by applying the emissions intensity reported in the Mardie Project approvals. It appears the proponent did not prepare its own greenhouse gas emissions estimates.

Based on the limited data available, the Proposal's anticipated greenhouse gas emissions intensity sits mid-way between the established Dampier Salt operations and the estimates for the Mardie Salt project. Significantly, the Western Australian operations where data is available, have or are projected to have, a greenhouse gas emissions intensity significantly less than the only major international operator for which credible data could be located.

The Proposal's greenhouse gas emissions intensity is around one-third that of the salt produced by Compass Minerals which is not surprising given that over 80% of the salt produced by Compass Minerals is sourced from underground mining.

5. DOWNSTREAM SCOPE 3 EMISSIONS

The estimation of downstream Scope 3[7] emissions for salt production is problematic given the many applications in which salt can be used[8].

It is anticipated that much of the salt produced by the Proposal will be used in chemical processing, particularly as a raw material in the manufacturing of caustic soda (sodium

[7] Greenhouse gas emissions from the operation of the Cape Preston East port have not been included in the downstream Scope 3 assessment but are identified in Section 2 – Estimated Operational Greenhouse Gas Emissions.

[8] Some papers suggest industrial salt and products derived from salt are used as a feedstock in over 4000 chemical products.

hydroxide), chlorine, and sodium carbonate (Chlor-alkali production). The products from this process are in turn used as feedstocks in the manufacture of a large number of other chemicals and products such as sodium sulphate, sodium carbonate, hydrochloric acid, sodium bicarbonate, liquid sodium, metallic sodium and sodium nitrate, which in turn are widely used across industry. Figure 5-1 outlines some of the ways salt and the Chlor-alkali products derived from industrial salt are used in the global economy.

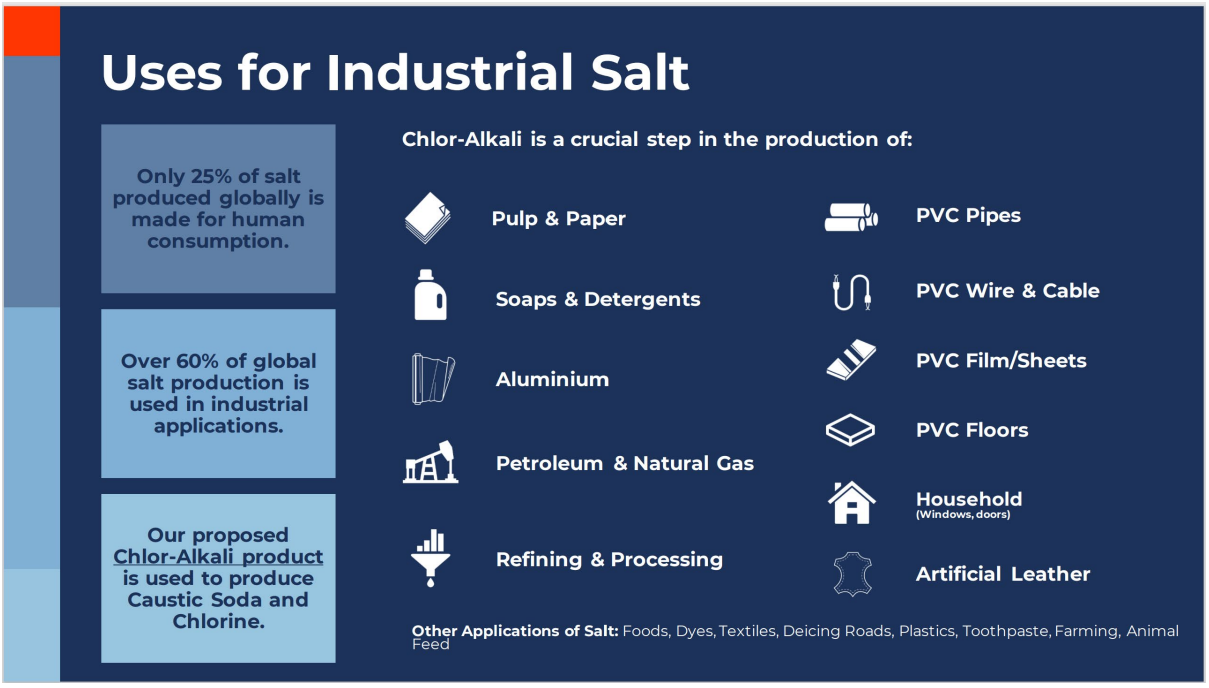

Figure 5-1 Salt and Chlor-alkali applications

To enable ease of comparison, the same factors and assumptions adopted by Rio Tinto in their 2021 Scope 1, 2 and 3 greenhouse gas emissions assessment (Ref 8), have been used for this assessment.

This assumes all the salt produced by the Project is used to produce sodium hydroxide (and chlorine) with the emissions intensity for that process being sourced from the SimaPro[9] database. Based on these assumptions, the production of 5.2 million tonnes per year of salt from the Proposal is estimated to be associated with an additional 6.3 million tonnes of greenhouse gas emissions from the manufacture of sodium hydroxide.

Annual Scope 3 emissions related to shipping the produced salt to the customer are estimated at around 18,200 tonnes CO_2e per year. This calculation is based upon an assumed distance

[9] SimaPro is a commercial database of emissions factors enabling users to undertake rapid life cycle and carbon footprinting analyses. https://www.simapro.co.uk

to the destination port of 7,000km and applying an indicative bulk shipping emissions intensity of 0.0005Kg CO_2e per tonne kilometre, from Sims et al (2014) (Ref 9).

These figures are highly dependent on the location of the chemical conversion and the emissions intensity of the electricity used to undertake the conversion. Accordingly, it should be viewed as indicative only. The Scope 3 figure does not include emissions associated with the use of sodium hydroxide in further chemical processing.

6. FUTURE EMISSIONS REDUCTION OPPORTUNITIES

The Scope 1 greenhouse gas emissions estimates provided in this report represent a high emissions case and assume:

- all electrical power requirements are supplied by onsite generation using LNG fuelled gas engine generators supported by solar photovoltaic cells
- all mobile equipment is powered by diesel fuel.

During the detailed design of the Proposal, options to future integrate additional renewable electricity generation and battery storage into the project will be considered. Improvements in the economics or grid scale batteries will be the enabler for an increased in the use of renewable generation.

The use of diesel in mobile equipment is responsible for over half of the projects greenhouse gas emissions. Options to reduce emissions from this equipment include:

- electrification of mobile equipment (supplied with renewable electricity)
- replacement or conversion of equipment to operate on lower-emissions fuels such as natural gas or hydrogen
- substitution of diesel with bio- or renewable-diesel.

While many suppliers are studying the electrification of mobile heavy equipment or fuelling such equipment with hydrogen, these options are not yet commercially proven. The Proponent will continue to monitor progress towards the commercialisation of these technologies for application at the Proposal.

The substitution of diesel with bio- or renewable diesel is technically mature and can reduce life cycle emissions in the use of heavy mobile equipment by around 80 to 90%. The current challenge with this alternative is that the unsubsidised cost (ex Singapore) is currently four to five times the cost of mineral diesel, primarily due to a shortage of the raw materials used in the production process. Should these alternative fuels become cost-effective, they represent a practical emissions reduction opportunity.

7. POSSIBLE FUTURE CLIMATE CHANGE IMPACTS

Site selection and design of the Proposal has been undertaken in the context of historical meteorological and ocean conditions and with a view to how these conditions may vary due to climate change.

In September 2021 the Western Australian Department of Water and Environmental Regulation published its projections for climate change in Western Australia (Ref 10). These projections are based on the projections produced by the Commonwealth Scientific and Industrial Research Organisation and the Bureau of Meteorology in 2015. The projections summarise the changes in climate and sea levels likely to occur over the coming decades for the monsoonal north, rangelands and southwest flatlands, Natural Resource Management regions of Western Australia.

The Western Australian projections consider changes to climate under a business-as-usual case and three scenarios of increased global gas concentrations established by the Intergovernmental Panel on Climate Change. The scenarios modelled are:

- Business as usual
- High Case – RCP8.5 Little global action to reduce greenhouse gas emissions, similar to business as usual
- Intermediate Case – RCP4.5 Strong global action to reduce emissions towards the end of the century
- Low Case – RCP 2.6 Ambitions global action to reduce emissions in line with the Paris Agreement to keep global warming below 2°C above pre-industrialised temperatures.

Figure 7-1 shows the levels of atmospheric carbon dioxide recorded by the CSIRO from the Cape Grim atmospheric monitoring station (Ref 11). These data show the level of carbon dioxide has continued to increase (with a slight acceleration) since the world's nations came together at the Rio Earth Summit in 1992 and agreed the urgent need to address climate change.

In line with this trend, the analysis presented in this assessment only considers the High Case (RCP8.5) scenario. In effect this represents a near worst-case outcome.

Figure 7-1 Atmospheric carbon dioxide concentrations

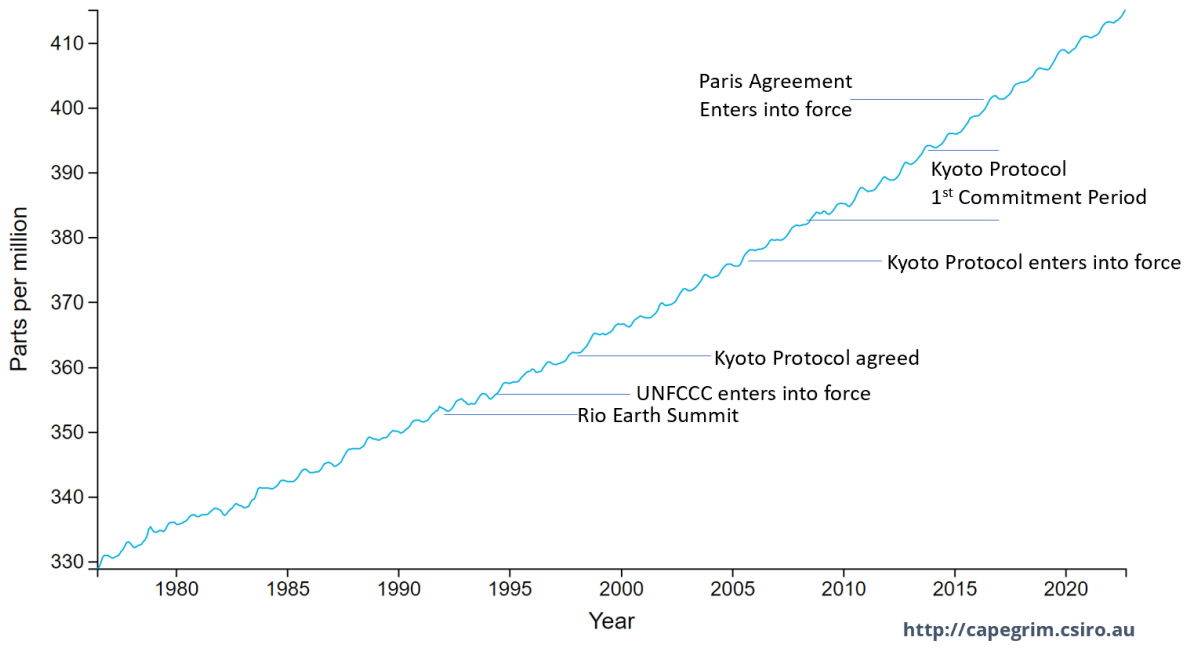

Table 7-1 summarises the climate change risk assessment for the Proposal. This lists the possible impacts on the Proposal for each of the changes to the climate identified in the Western Australian projections. Where the change is likely to be material a mitigation is proposed.

Based on this assessment the most significant risk is the potential for the embankments to be overtopped as a consequence of cyclonic storm surge combined with increased sea level rise. Overtopping could result in damage to the embankments and dilution of process brine. The risk of overtopping can be mitigated through the design of the embarkments.

The risk of dilution of the concentrated brines due to heavy rainfall, possibly associated with more intense cyclones is not able to be mitigated cost-effectively.

Lesser risks include an increase in risk of heat stress for workers and loss of site access which can be mitigated through operational planning.

Overall, the likely impacts of climate change are not anticipated to have a material impact on the design or operation of the Proposal.

Table 7-1 Climate change risk assessment

Possible impacts	Possible impact on Proposal	Proponent mitigations
Higher temperatures Mean temperatures have increased by about 1.0 °C since 1910 Mean, maximum and minimum temperatures are projected to continue to rise By 2030, the mean annual warming across all emissions scenarios is projected to be about 0.6 to 1.4 °C above the climate of 1986–2005 By 2090, temperatures are projected to be 2.9 to 5.3 °C warmer A substantial increase in the temperature reached on the hottest days and the frequency of hot days is projected with very high confidence	Increased evaporation rates Increase in risk of heat exhaustion for workers Increased energy requirements for cooling systems (air conditioning)	No mitigation required Incorporate increased risk into safe work procedures Adopt energy efficiency improvements in air conditioning technology as available
Higher sea levels and more frequent sea level extremes There is very high confidence that sea levels will continue to rise during the 21st century By 2030, the projected range of sea-level rise at Port Hedland is 0.07 to 0.17 m above the 1986–2005 level, with only minor differences between emission scenarios By 2090, projected sea level rise is: 0.40 to 0.84m (with at least 66 per cent probability)	Combined with storm surge may lead to overtopping of embankments resulting in damage to embankments and dilution of concentrated salt brines	Increase height of embankments and rock armour on seaward facing embankments
Warmer and more acidic oceans By 2090 in the region, coastal waters are projected to warm by 2.4 to 3.7 °C There is very high confidence that oceans will become more acidic and that the rate of ocean acidification will be proportional to carbon dioxide emissions By 2030, pH is projected to fall by an additional 0.07 units in the coastal waters of the Rangelands region By 2090, a decrease of up to 0.3 pH units is projected	An increase in inlet water temperature may marginally increase initial evaporation rates An increase in acidity may result in higher rates of corrosion of equipment	No mitigation required Operations are designed for equipment to operate in a highly corrosive environment
Fewer but possibly more intense tropical cyclones	Combined with storm surge may lead to overtopping of	Increase height of embankments and rock

Possible impacts	Possible impact on Proposal	Proponent mitigations
The north-west coastline between Exmouth and Broome is the most cyclone-prone region of the Australian coast The frequency of cyclones has remained relatively stable in WA but it is thought that the intensity has increased This trend is expected to continue with medium confidence.	embankments resulting in damage to embankments and dilution of concentrated salt brines Associated rainfall will dilute concentrated salt brines Impact on supporting infrastructure (roads) may restrict access to site following event	armour on seaward facing embankments No cost-effective mitigation available Emergency response plans to incorporate loss of road access following major cyclone event.
Less rainfall in winter. Changes in other seasons unclear Observations show an increasing trend in summer rainfall over the north-west of the Rangelands, although with intermittent periods of wetter and drier conditions throughout the 20th century Year-to-year variability is strongly influenced by the El Niño Southern Oscillation Changes to rainfall are possible but the direction of change cannot be confidently projected given the spread of model results Impact and risk assessments in this region should consider the risk of both a drier and wetter climate.	Outside of cyclone impacts available data does not enable an impact on the Proposal to be determined	Not applicable
Increased intensity of heavy rainfall events, changes to drought are less clear Increased intensity of heavy rainfall events. Changes to drought less clear Under all emissions scenarios, there is high confidence that the intensity of heavy rainfall events will increase There is low confidence in projecting how the frequency and duration of extreme meteorological drought may change, although there is medium confidence time spent in drought will increase by 2090.	Heavy rainfall events will dilute concentrated salt brines	No cost-effective mitigation available
Increased evaporation rates, and reduced soil moisture. Changes to runoff unclear Potential evapotranspiration is expected to increase in all seasons, with the largest absolute rates occurring in 2090 Soil moisture projections suggest overall seasonal decreases by 2090 but predominately in winter	Positive impact on Proposal leading to overall increase in productivity	Not applicable
A harsher fire weather climate Bushfire in the Rangelands depends highly on fuel availability, which mainly depends on rainfall. As a result, bushfire activity is very episodic in most of the Rangelands There is high confidence that climate change will result in a harsher fire weather climate in the future There is low confidence in the magnitude of the change as this is strongly dependent on rainfall projections	No direct impact on Proposal but may impact access to the Project area for brief periods	No mitigation proposed

8. REFERENCES

Ref 1 National Greenhouse Gas Accounts Factors, Australian Government - Department of Industry, Science, Energy and Resources, August 2021. Accessed at Australian National Greenhouse Accounts Factors (dcceew.gov.au) on 13 April 2024..

Ref 2 Greenhouse and energy information by designated generation facility 2022-23 Accessed at https://cer.gov.au/markets/reports-and-data/nger-reporting-data-and-registers/electricity-sector-emissions-and-7#designated-generation-facility-data-2022-23 on 13 March 2024.

Ref 3 State and Territory Greenhouse Gas Emissions: 2022 Emissions, Australian Government – Department of Industry, Science, Energy and Resources. Accessed at https://greenhouseaccounts.climatechange.gov.au/ on 13 April 2024.

Ref 4 Dampier Salt, Sustainable Development Report 2015. Accessed at https://pdf4pro.com/cdn/dampier-salt-limited-sustainable-development-report-2015-403223.pdf on 7 June 2022.

Ref 5 Compass Minerals 2020 ESG Report. Accessed at https://www.compassminerals.com/wp-content/uploads/2021/09/Compass-Minerals-2020-ESG-Report.pdf?x48751 on 7 June 2022.

Ref 6 Mardie Project, Environmental Assessment Report – Report 1704, Environmental Protection Authority, June 2021. Accessed at https://www.epa.wa.gov.au/sites/default/files/EPA_Report/EPA%20Report%201704%20-%20Mardie%20Project%20-%20assessment%20report.pdf on 3 June 2022.

Ref 7 Ashburton Salt Project – Public Environmental Review – 30 May 2023. Accessed at https://www.epa.wa.gov.au/proposals/ashburton-salt-project on 15 April 2024

Ref 8 Rio Tinto Scope 1, 2 and 3 Emissions Calculation Methodology 2021. Accessed at https://www.riotinto.com/-/media/Content/Documents/Invest/Reports/Climate-Change-reports/RT-Climate-scope-123-report-2021.pdf?rev=02ff321e0574403a91912babcbb341cd on 8 June 2022.

Ref 9 Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M.J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J.J. Schauer, D. Sperling, and G. Tiwari, 2014: Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Ref 10 Western Australian climate projections – Summary, Department of Water and Environmental Regulation, September 2021. Accessed at

https://www.wa.gov.au/system/files/2022-01/Western_Australian_Climate_Projections_Summary.pdf on 15 October 2022

Ref 11 Accessed at https://capegrim.csiro.au/ on 15 October 2022