ACT MATERIALS RECOVERY FACILITY

ADDENDUM TO APPENDIX N CLIMATE RISK ASSESSMENT

Prepared for Veolia Environmental Services (Australia) Pty Ltd | 2 April 2025

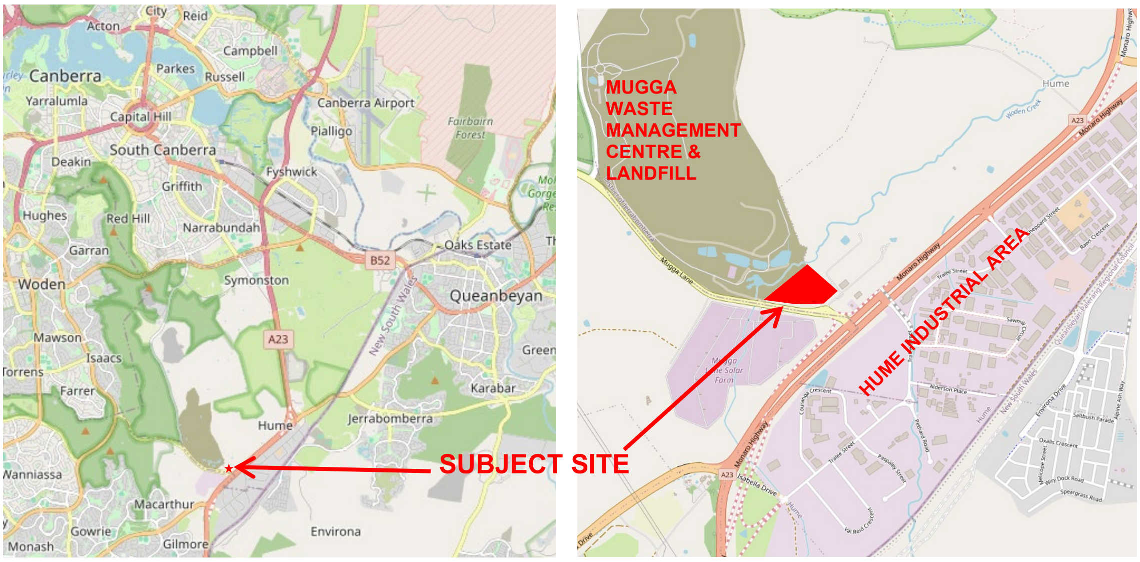
elementenvironment.com.au

Introduction

This report is prepared as an Addendum to *Appendix N Climate Change Risk Assessment* prepared by GHD for ACT NoWaste in 2023 and submitted with a draft EIS for a new Materials Recovery Facility (MRF) on Block 12 Section 25 Hume, refer Figure 1. A further Climate Change Risk Assessment was undertaken by GHD in June 2024 in response to ACT Agency feedback on the 2023 draft EIS. This revised 2024 GHD assessment forms part of Appendix N attached to the revised final EIS.

Since that time ACT NoWaste has passed the responsibility to finalise the EIS to Veolia. GHD are not in a position to complete the EIS and as such, Veolia has engaged Element Environment to undertake this work.

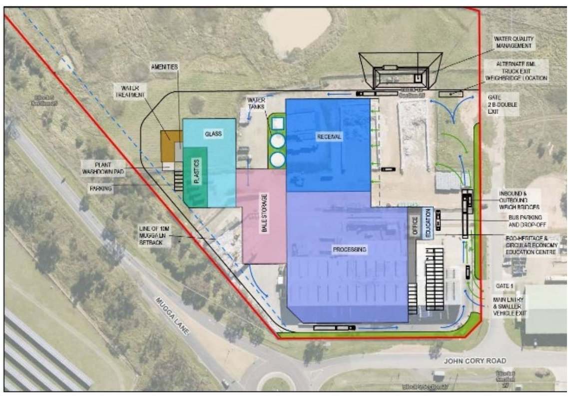
Figure 1: Site Location



Veolia has made changes to the proposed site layout and design of the MRF to achieve operational efficiencies (refer Figure 2 & 3).

Figure 2: Veolia Revised Site Plan

Figure 3: GHD Concept Plan



Assessment

The GHD *Appendix N – Climate Change Risk Assessment* included climate projection data for two scenarios including a mid-term and a long-term projection, under the moderate emissions scenario (RCP4.5) for 2050 and extreme emissions scenario (RCP 8.5) for 2090 as recommended under AS5334.

The climate risk assessment considered nineteen impacts across the different climate event scenarios. Four of those risks are associated with the construction phase, ten identified risks returned a risk rating of low for baseline and RCP 8.5 2030 and nine identified risks returned a risk rating of low for RCP 2050 conditions.

For construction, risks resulting from extreme heat are the primary concern resulting in a medium risk during the construction period. During operation, extreme heat and extreme rainfall are found to be the highest risks to operation.

The revised Veolia site layout and changes to operation do not introduce any new climate change risks in regard to construction of the facility or operation of the plant.

Conclusions

It is considered the revised Climate Change Risk Assessment prepared by GHD in June 2024 remain relevant to Veolia's development proposal as their proposal will not result in any greater risks to flooding and is not more susceptible to extreme heat than the previous concept design presented in the draft GHD EIS

GREENHOUSE GAS CALCULATIONS
VEOLIA MATERIALS RECYCLING FACILITY
AT HUME

Element Environment

3 April 2025

Job Number 25011834

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Greenhouse Gas Calculations

Veolia Materials Recycling Facility at Hume

DOCUMENT CONTROL

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Todoroski Air Sciences has prepared these greenhouse gas calculations for the proposed Veolia Materials Recycling Facility (MRF) located at Hume, Australian Capital Territory (ACT) (hereafter referred to the as Project).

1.1 Overview of the Project

The Project involves the construction of a new MRF on Block 12, Section 25 Hume, ACT to replace the existing facility that was extensively damaged due to fires on 26 December 2022. The main shed remains standing and is currently being used as a waste transfer station to accept, sort and store recyclable materials before being shipped to other processing facilities.

The proposal is designed to process up to 115,000 tonnes per annum (tpa) of mixed recyclables. The capacity provides for population growth and changing consumer behaviours which are expected to contribute to increases in recoverable materials over time.

Key features of the proposal include:

- New MRF building of approximately 11,719 metres squared (m^2), including:
  - Receival area of 2,073m^2
  - Processing area of 4,990m^2
  - Glass recycling area of 1,254m^2
  - Product storage area of 2,700m^2
  - Workshop and staff amenities of 170m^2
  - Education facility of 213m^2
  - Pump room of 59m^2
  - Covered water treatment area of 260m^2
- Weighbridges;
- Site driveways and hardstand area;
- Water tanks for roof water capture and on-site re-use;
- Bioretention pond for surface water management; and,
- Wastewater leachate treatment system.

The facility will provide technological improvements to enable greater resource recovery by both increasing the quality of recycled materials and by reducing the amount of nonrecyclable residual waste that is currently sent to landfill.

During the construction phase it will create 112 jobs and 24 permanent roles as part of the facility's operations.

When the plant is at full capacity it is anticipated to operate for 10 hours per day for 6 days per week. Until this capacity is reached, the plant will operate for 8 hours per day for 5.5 days per week.

1.2 Project setting

The Project site is located within the industrial suburb of Hume on the corner of Mugga Lane, John Cory Road and Recycling Road, to the west of the Monaro Highway. The subject site is 5.052 hectares (ha) and zoned IZ1 General Industry under the Territory Plan 2023. Approximately 60% of the area of Block 12 (or 30,000m^2) will be used by the new MRF with the remaining area being retained as grassland with an existing dam.

Figure 1-1 presents the location of the Project.

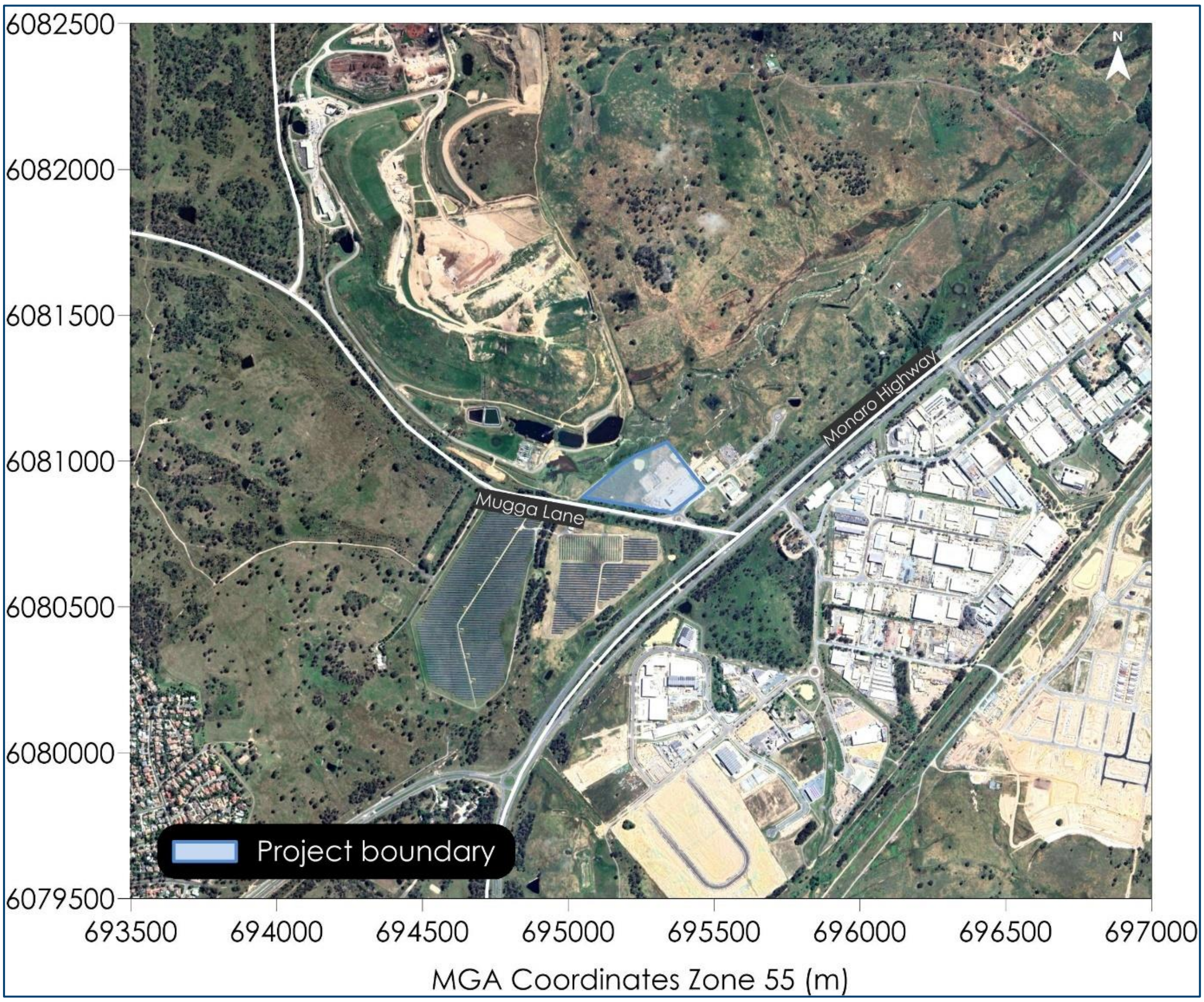

Figure 1-1: Project location

Figure 1-2 presents a representative three-dimensional visualisation of the terrain features surrounding the Project location. The local topography is undulating in places with increasing elevations moving northwest and west of the site and to the south.

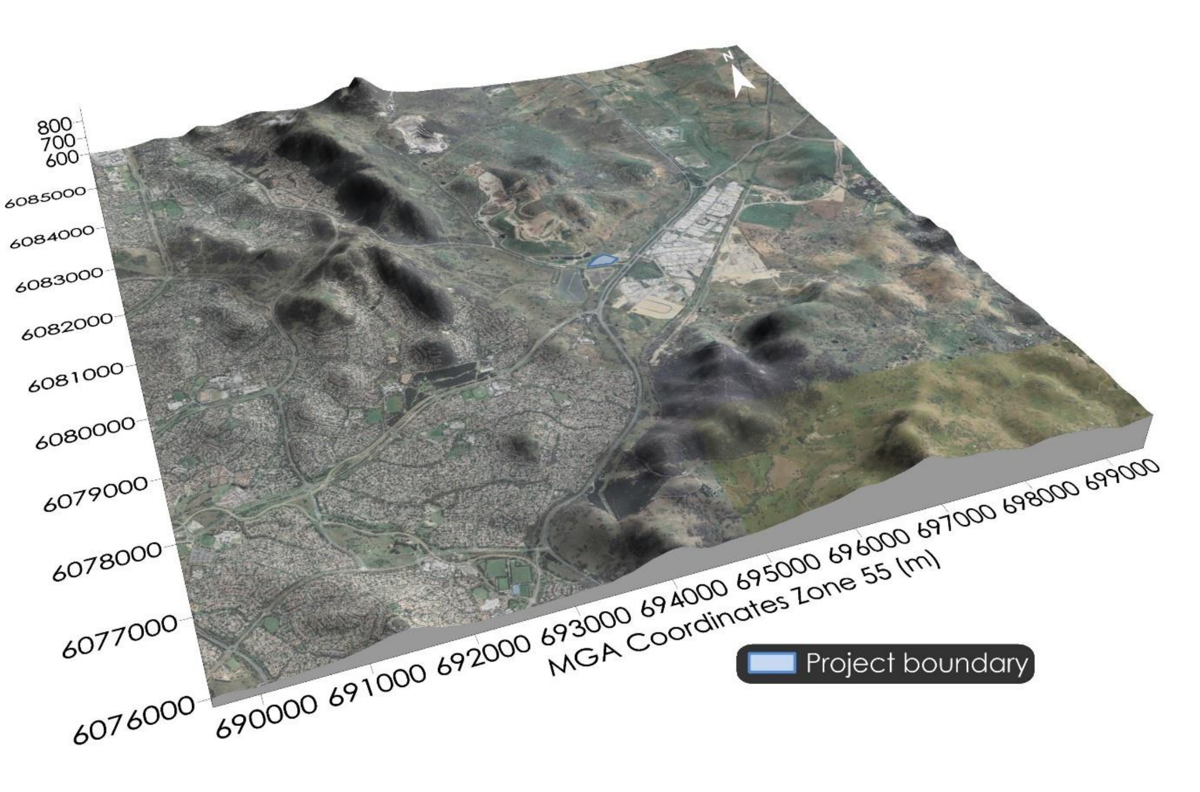

Figure 1-2: Representative visualisation of the local topography surrounding the Project

2 EXISITING ENVIRONMENT

This section describes the existing environment including the climate in the area surrounding the Project.

2.1 Local climate

Long-term climatic data from the Bureau of Meteorology weather station at Tuggeranong (Isabella Plains) Automatic Weather Station (AWS) (Site No. 070339) were analysed to characterise the local climate in the proximity of the Project site. The Tuggeranong (Isabella Plains) AWS is located approximately 5km southwest of the Project.

Table 2-1 and **Figure 2-1** present a summary of data from Tuggeranong (Isabella Plains) AWS collected over an approximate 14 to 29-year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 29.4 degrees Celsius (°C), July is the coldest month with mean minimum temperatures of 0.1°C.

Rainfall is highest during the warmer seasons, with an average annual rainfall of 657.6 millimetres (mm) over 67.6 days. The data show November is the wettest month with an average rainfall of 77.9mm over 7.2 days and May is the driest month with an average rainfall of 29.8mm over 3.9 days.

Relative humidity levels exhibit some variability over the year and seasonal fluctuations. Mean 9am relative humidity levels range from 59% in December to 83% in June. Mean 3pm humidity levels vary from 34% in January and December to 57% in June.

Wind speeds have a relatively similar spread between the 9am and 3pm conditions throughout the year. The mean 9am wind speeds range from 6.5 kilometres per hour (km/h) in March and May to 11.3km/h in October. The mean 3pm wind speeds vary from 13.2km/h in May to 18.7km/h in October.

Table 2-1: Monthly climate statistics summary – Tuggeranong (Isabella Plains) AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	29.4	27.9	25.2	20.9	16.5	13.1	12.4	14.2	17.7	21.0	24.2	27.2	20.8
Mean min. temp. (°C)	14.5	14.1	11.4	6.9	2.6	1.2	0.1	1.0	3.7	6.6	10.0	12.4	7.0
Rainfall													
Rainfall (mm)	60.9	73.1	57.6	38.5	29.8	51.7	36.6	48.9	57.0	57.7	77.9	69.6	657.6
No. of rain days (≥1mm)	5.8	5.8	5.3	4.0	3.9	5.7	5.4	6.0	5.9	6.6	7.2	6.0	67.6
9am conditions													
Mean temp. (°C)	19.6	18.6	15.7	13.1	8.3	5.9	4.8	6.9	10.9	13.9	15.8	18.2	12.6
Mean R.H. (%)	61	68	70	69	78	83	82	73	65	60	62	59	69
Mean W.S. (km/h)	8.4	7.7	6.5	8.0	6.5	7.1	7.1	8.9	10.8	11.3	10.1	9.6	8.5
3pm conditions													
Mean temp. (°C)	27.8	26.6	24.3	20.1	15.6	12.1	11.3	12.8	16.2	19.2	22.5	25.5	19.5
Mean R.H. (%)	34	39	38	42	50	57	56	50	46	41	39	34	44
Mean W.S. (km/h)	16.2	15.4	14.7	13.8	13.2	13.5	14.3	16.5	18.5	18.7	17.3	17.7	15.8

Source: **Bureau of Meteorology, 2025**

RH = Relative Humidity, WS = Wind speed

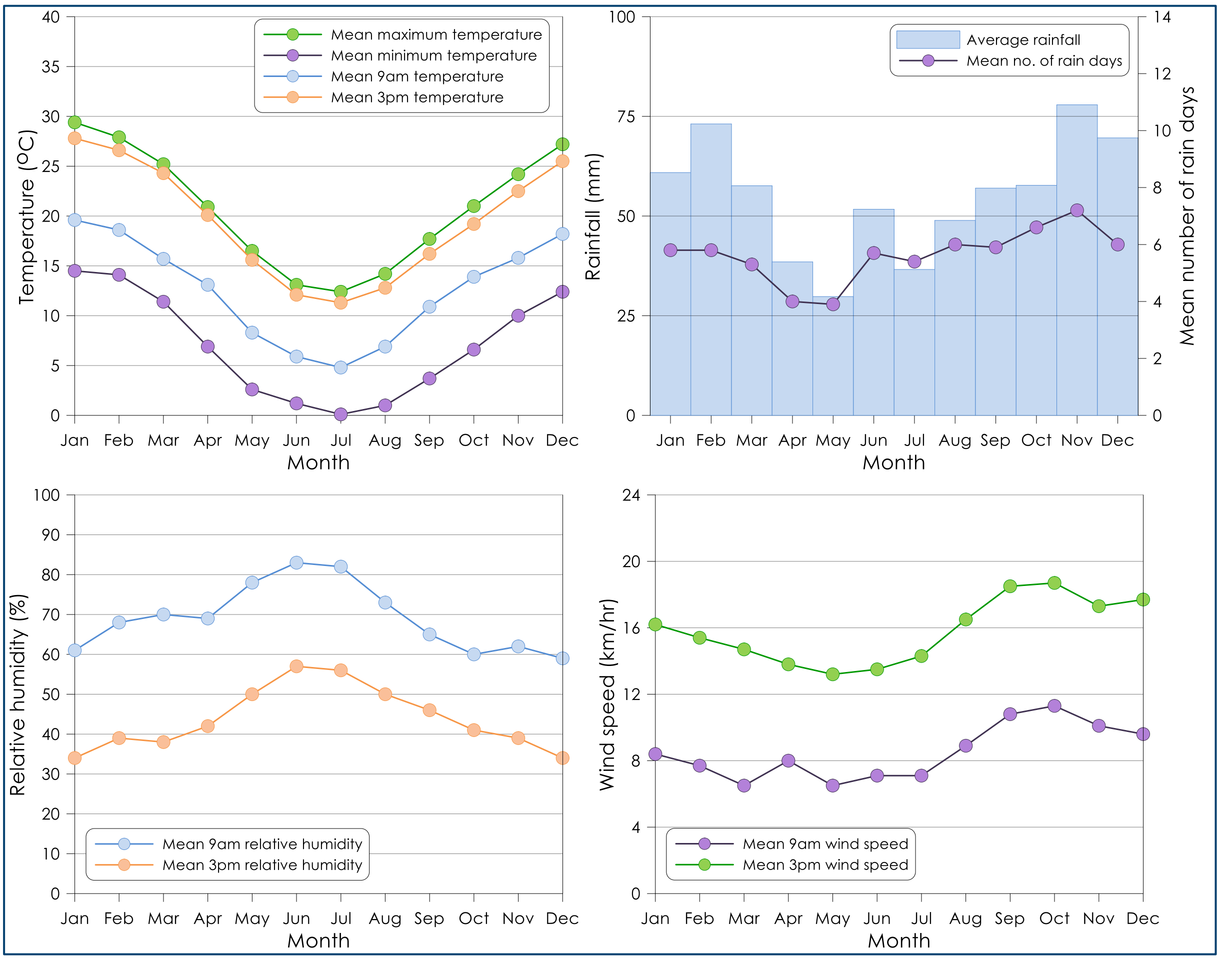

Figure 2-1: Monthly climate statistics summary – Tuggeranong (Isabella Plains) AWS

2.2 Local meteorological conditions

Annual and seasonal windroses generated from data from Tuggeranong (Isabella Plains) AWS during 2024 are presented in **Figure 2-2**.

On an annual basis, winds predominantly occur from the northwest quadrant and the east. The summer, autumn and spring windroses have a similar wind distribution to the annual windrose with the most prevalent winds from the northwest quadrant, east and east-northeast. In winter, dominant winds typically occur from the northwest quadrant.

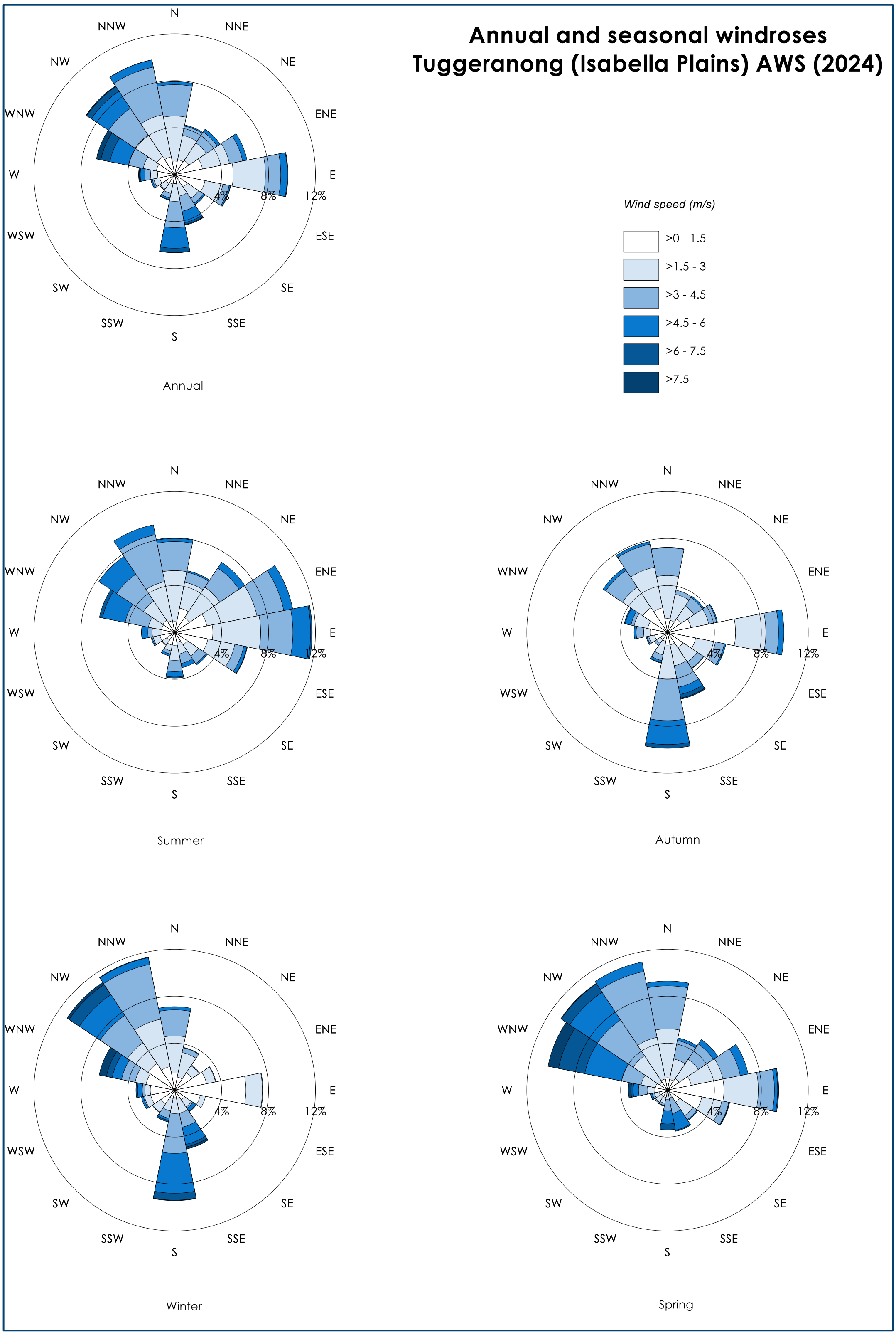

Figure 2-2: Annual and seasonal windroses for Tuggeranong (Isabella Plains) AWS (2024)

3 GREENHOUSE GAS INVENTORY

The Australian *National Greenhouse Accounts Factors* (NGA Factors) document published by the Commonwealth Department of Climate Change, Energy, the Environment and Water (Cth DCCEEW) (**2024a**) defines three scopes (Scope 1, 2 and 3) for different emission categories based on whether the emissions are from "direct" or "indirect" sources.

Scope 1 emissions encompass the direct sources from the Project defined as:

> "*...produced from sources within the boundary of an organisation and as a result of that organisation's activities*" (**Cth DCCEEW, 2024a**).

Scope 2 emissions are produced by the burning of fossil fuels to generate electricity and defined as:

> "*...indirect emissions which occur as a result of activities that generate electricity, heating, cooling or stream that is consumed by an organisation but which is generated outside that organisation's boundaries*" (**Cth DCCEEW, 2024a**).

Scope 3 emissions are other indirect emissions which:

> "*...occur outside of the boundary of an organisation as a result of actions by the organisation*" (**Cth DCCEEW, 2024a**).

For the purpose of this assessment, emissions generated in all three scopes defined above provide a suitable approximation of the total greenhouse gas (GHG) emissions generated from the Project.

Scope 3 emissions can be a significant component of the total emissions inventory; however, these emissions are not directly controlled by the operation. These emissions are understood to be the Scope 1 emissions from other various organisations.

3.1 Emission sources

Scope 1 and 2 GHG emission sources identified from the Project are the on-site combustion of diesel fuel, petrol, and on-site consumption of electricity. Scope 3 emissions have been identified as resulting from the purchase of consumables for use on-site and the transport of and residual wastes generated.

Estimated quantities of materials and variables used to calculate the potential GHG emissions associated with Scope 1, 2 and 3 emissions for the Project have been described for the construction and operational phases. These estimates are based on the maximum Project production and would provide a reasonable worst-case approximation of the potential GHG emissions for the purpose of this assessment.

Table 3-1 summarises the quantities of materials estimated for the construction and operational phases of the Project.

For the purposes of this assessment, it is assumed the construction phase will last 12 months and includes the site preparation and infrastructure development. Construction emission sources are identified as diesel-powered construction plant, petrol used in small plant and electricity usage.

The operational phase is based on the maximum designed capacity of the Project of 115,000tpa. Operational emission sources are identified as diesel use in on-site equipment, diesel use for ongoing maintenance and electricity usage.

Scope 3 emissions include the transport and emplacement of waste materials to landfill. Waste materials are identified as the contaminants in the feedstock that cannot be processed at the MRF. The assumed contamination rate of the incoming recyclables feedstock is 12%. The estimated diesel use for the transport is calculated from the approximate distance to the landfill assuming average fuel consumption of 53.1L/100km for articulated trucks is applied (**ABS, 2025**).

Other Scope 3 emissions also arise from a number of other sources indirectly associated with the operation of the MCCM such as emissions generated by employees travelling to and from the site. These relatively minor individual contributions are difficult to accurately quantify due to the diversity and nature of the sources and have not been considered further in this assessment.

Table 3-1: Summary of quantities of materials estimated for the Project

Phase	Activity	Unit	Quantity
Construction	Diesel – construction equipment	kL	250
	Petrol – construction equipment	kL	15
	Electricity – construction	MWh	170
Operation	Diesel – heavy vehicles	kL	305
	Diesel – on-site equipment	kL	133
	Electricity – operations	MWh	3,024
	Electricity – maintenance	MWh	96
	Diesel – heavy vehicles to landfill	kL	4
	Waste material sent to landfill	t/y	13,800

3.2 Emission factors

To quantify the amount of carbon dioxide equivalent (CO_2-e) material generated, emission factors were obtained from the NGA Factors (**Cth DCCEEW, 2024a**).

The emission factors used in this assessment are summarised in **Table 3-2**.

Table 3-2: Summary of emission factors

Type	Energy content factor (GJ/kL)	Emission factor			Units	Scope
		CO_2	CH_4	N_2O		
Diesel	38.6	69.9	0.1	0.2	kg CO_2-e/GJ	1
		17.3	-	-		3
Petrol	34.2	67.4	0.2	0.2	kg CO_2-e/GJ	1
		17.2	-	-		3
Diesel - Transport	38.6	69.9	0.1	0.4	kg CO_2-e/GJ	3
Municipal solid waste to landfill	-	1.6	-	-	t CO_2-e/t	3

Note: GJ/kL = gigajoule per kilolitre, CO_2 = carbon dioxide, CH_4 = methane, N_2O = nitrous oxide, kg CO_2-e = kilograms of carbon dioxide equivalent and t CO_2-e/t = tonnes of carbon dioxide equivalent per tonne of waste

The emissions from the ACT electricity grid is taken to be zero as it is supplied with 100% renewable electricity (**ERM, 2024**).

3.3 Summary of GHG emissions

Table 3-3 summarises the estimated annual CO_2-e emissions for the Project.

The estimated annual CO_2-e emissions for the Project is also presented graphically in **Figure 3-1** and **Figure 3-2**. These figures illustrate that the majority of emissions generated by the Project for the construction phase would be from diesel fuel consumption and from the operational phase would be from waste material sent to landfill.

The Project is calculated to generate approximately 711 t CO_2-e emissions for the construction phase and 1,187 t CO_2-e emissions for the operational phase. These emissions are associated with diesel and petrol use. Scope 2 emissions are calculated at 0 t CO_2-e as the ACT electricity grid relies on 100% renewable sources. For Scope 3 emissions, emissions during the operational phase are dominated by the waste material sent to landfill that would be covered in the Scope 1 emission estimates for the landfill operation.

Table 3-3: Summary of CO_2-e emissions for the Project (t CO_2-e)

Phase	Activity	Scope 1	Scope 2	Scope 3
Construction	Diesel – construction equipment	677		167
	Petrol – construction equipment	33.6		8.5
	Electricity – construction		0	
	Total	**711**	-	**175**
Operation	Diesel – heavy vehicles	827		204
	Diesel – on-site equipment	360		89
	Electricity – operations		0	
	Electricity – maintenance		0	
	Diesel – heavy vehicles to landfill			12
	Waste material sent to landfill			22,080
	Total	**1,187**	-	**22,385**

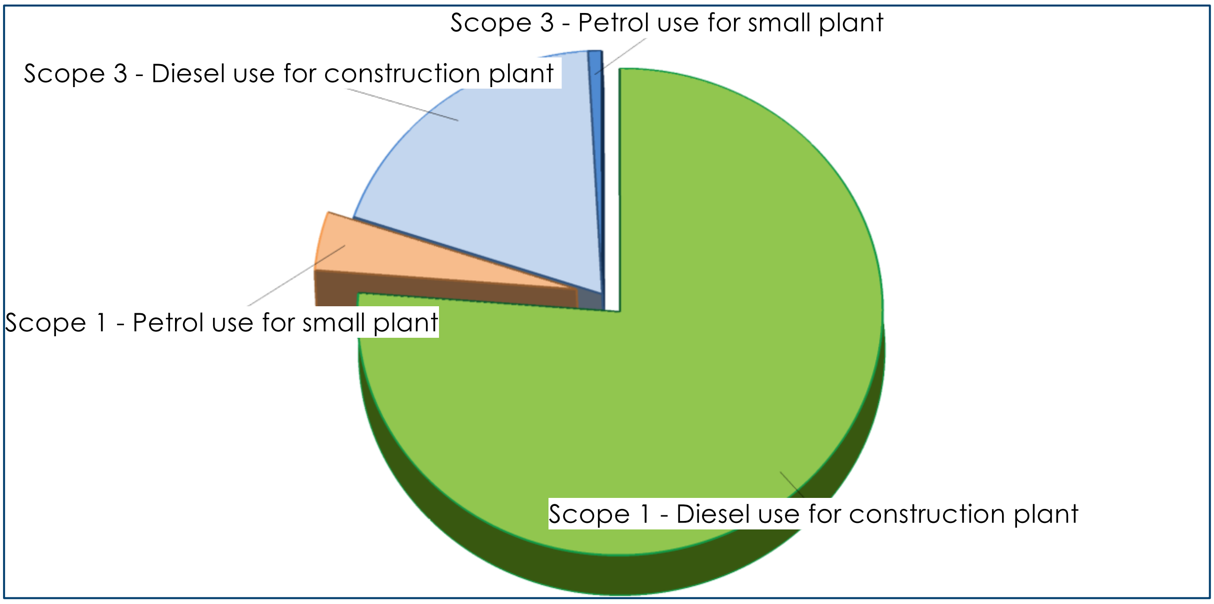

Figure 3-1: CO_2-e emissions for the Construction phase of the Project

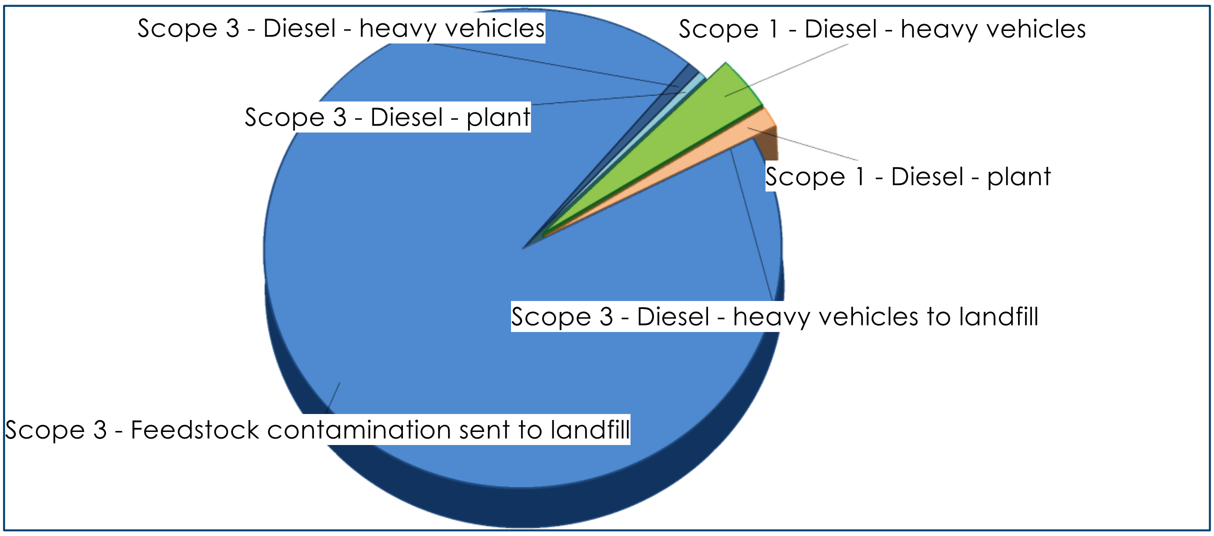

Figure 3-2: CO_2-e emissions for the Operational phase of the Project

3.4 Contribution of GHG emissions

The estimated annual GHG emissions for Australia up to June 2024 was 440.6 Mt CO_2-e (**Cth DCCEEW, 2024b**). In comparison, the estimated annual average GHG emissions for the Project is 0.0012 Mt CO_2-e (Scope 1 and 2). Therefore, the annual contribution of GHG emissions from the Project Only scenario in comparison to the Australian GHG emissions for the 2024 period is estimated to be approximately 0.0003%.

At a state level, the estimated GHG emissions for ACT in the 2022 period were 1.28 Mt CO_2-e (**Cth DCCEEW, 2025**). The annual contribution of GHG emissions from the Project (Scopes 1 and 2) in comparison to the ACT GHG emissions for the 2022 period is estimated to be approximately 0.09%.

4 GREENHOUSE GAS MITIGATION AND ABATEMENT MEASURES

Veolia have considered a range of best-practice greenhouse gas mitigation and abatement measures to apply to the Project which include:

- Incorporate into the design of the Project measures, where reasonable and feasible, to minimise greenhouse gas emissions.
- Service and maintain all machinery, as far as reasonably practical, in accordance with original equipment manufacturer recommendations for maintenance.
- Target equipment maintenance to ensure, as far as reasonably practical, equipment remains fit for purpose over its whole life cycle.
- Undertake periodic reviews of technologies and abatement measures to reduce GHG emissions from the Project, including whether these measures are reasonable and feasible to implement at the Project.

5 SUMMARY AND CONCLUSIONS

This study has assessed the potential GHG emissions associated with the Project.

The estimated annual average GHG emission for the Project is 0.0012 Mt CO_2-e (Scope 1 and 2), which is calculated to be approximately 0.0003% of the Australian GHG emissions for the period to June 2024 and approximately 0.09% of the ACT GHG emissions for the 2022 period.

6 REFERENCES

ABS (2025)

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Climate statistics for Australian locations, Bureau of Meteorology website. Accessed February 2025. <http://www.bom.gov.au/climate/averages>

Commonwealth Department of Climate Change, Energy, the Environment and Water (2024a)

"Australian National Greenhouse Accounts Factors – For individuals and organisations estimating greenhouse gas emissions", Department of Climate Change, Energy, the Environment and Water [DCCEEW], August 2024.

Commonwealth Department of Climate Change, Energy, the Environment and Water (2024b)

"Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2024", Department of Climate Change, Energy, the Environment and Water [DCCEEW], November 2024.

Commonwealth Department of Climate Change, Energy, the Environment and Water (2025)

State and Territory greenhouse gas inventories: 2022 emissions - Department of Climate Change, Energy, the Environment and Water [DCCEEW] website, Accessed January 2025. https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2022/state-and-territory-greenhouse-gas-inventories-2022-emissions

ERM (2024)

"ACT Greenhouse Gas Inventory for 2023-24", prepared for Environment, Planning and Sustainable Development Directorate, ACT Government by ERM, October 2024.

1. ASSET DESCRIPTION

On this tab details about the asset's location, functions, and a listing of the system components that work together to enable the asset to operate are entered.

Asset name:	Material Recovery Facility (MRF)
Description:	The MRF would accept up to 115,000 tonnes per year of comingled recyclables from the ACT and surrounding councils. The facility would sort, segregate and process incoming materials using a combination of manual, mechanical and optical sorting and screening processes, as well as magnetic and eddy current separation equipment. This process would generate specific marketable product streams such as paper and cardboard, mixed plastics, PET, HDPE, glass, aluminium and other metals. The facility would also further process the segregated glass via washing, crushing and screening and beneficiate the segregated plastics by further sorting by polymer type, washing, chipping/flaking and potentially pelletising.
Location:	Recycling Road, Hume, ACT
Primary function:	Recycling facility

Example component names

Component #	Component name	Design life
1	permanent mechanical systems, stationary equipment, tanks and building elements	20
2	replaceable mechanical equipment and critical components	10
3	mobile plant and equipment	7

2. CLIMATE PROJECTION DATA

Cli-1 Level 2: a number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset

On this tab climate and climate change projection data, based on the reporting of reputable scientific and research organisations, is provided to assist with the risk assessment.

Asset name: Hume MRF
Location: Hume, ACT

DATA SOURCES AND NOTES ON CLIMATE PROJECTIONS

The Intergovernmental Panel on Climate Change (IPCC) has developed four scenarios for global climate projections that relate to how the world may respond to the challenge of a changing climate, the need to continue to produce and use energy and resources, and the global greenhouse gas emissions that may occur. These scenarios incorporate diverging tendencies based on alternative economic, globalisation and environmental pathways. These have been modified through subsequent reports and renamed as Representative Concentration Pathways (RCPs) in the IPCC's Fifth Assessment Report.
The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM) released the Climate Change in Australia Technical Report in 2015, which links strongly to findings of the latest IPCC Fifth Assessment Report, and updates the projections previously outlined in the 2007 Technical Report. The 2015 Technical Report uses over 40 global climate models to produce climate change projections as they relate to IPCC RCP scenarios. These RCPs include:
> RCP2.6 requiring very strong emission reductions from a peak at around 2020 to reach a CO2 concentration at about 420 parts per million (ppm) by 2100
> RCP4.5 with slower emission reductions that stabilise the CO2 concentration at about 540 ppm by 2100
> RCP6.0 with some mitigation strategies and technologies, reaching 660 ppm by 2100 and total radiative forcing stabilising shortly after 2100
> RCP8.5 which assumes little curbing of emissions and increases leading to a CO2 concentration of about 940 ppm by 2100
This range of emissions scenarios is broader than those used for the 2007 projections
Below, climate projection data has been provided for two scenarios including a mid term and a long term projection, under the moderate emissions scenario (RCP4.5) for 2050 and extreme emissions scenario (RCP 8.5) for 2090 as recommended under AS5334 The time periods represent scenarios that are 30 and 70 years from now, and so can have relevance to the various components compirsing the infrastructure asset, depending on their design life. The main reason for adopting the 2090 projection is to provide some perspective on the more extreme climate changes that may arise in coming decades (noting that the projections for these time extents may indeed arise much earlier or later than indicated, if at all; such is the uncertainty associated with the climate modelling and international responses to climate change) and whether these would eventuate into posing risks to the infrastructure. Projections for 2050 and 2090 are also more robust as these variables are reported for the Murray Basin Cluster by CSIRO which provides greater specificity.

PROJECTED CLIMATE CHANGES

A summary of current climate conditions and CSIRO's projected climate changes for various scenarios is tabulated below.

VARIABLE	BASELINE DATA		CLIMATE CHANGE PROJECTIONS			
	CURRENT CLIMATE - Annual historical trend Canberra Airport Comparison (070014)	*Baseline period*	*Reported as*	*Short term, high scenario scenario 2030, RCP 8.5*	*Medium term, high scenario 2050, RCP 8.5*	*Source*
Temperature						
Mean maximum daily temperature (°C) - Annual	20.0	1986 to 2005	Absolute change	+0.9 (0.7 to 1.3) ie 20.9°C (20.7 to 21.3)	+1.9 (1.4 to 2.3) ie 21.8°C (21.3 to 22.3)	1,2
Mean maximum daily temperature (°C) - Summer (DJF)	27.3	1986 to 2005	Absolute change	+1.1 (0.6 to 1.5) ie 28.4°C (27.9 to 28.8)	+1.9 (1.4 to 2.6) ie 29.2°C (28.7 to 29.9)	1,2
Mean minimum daily temperature (°C) - Annual	6.8	1986 to 2005	Absolute change	+0.9 (0.7 to 1.2) ie 7.7°C (7.5 to 8)	+1.6 (1.3 to 2) ie 8.4°C (8 to 8.7)	1,2
Days p.a. over 35 °C	5.0	1986 to 2005	New value	8 days	12.5 days	1,2
Days p.a. over 40 °C	0.0	1986 to 2005	New value	0.4 days	0.7 days	1,2
Highest temperature for baseline 1986-2005 (°C)	40.0 18/1/1998	Discrete event	Absolute change	+1.3 (0.6 to 1.8) ie 41.3°C (40.6 to 41.8)	+2.4 (1.3 to 3.4) ie 42.4°C (41.3 to 43.4)	3
Highest temperature for years on record at AWS (°C)	42.2 24869	Discrete event	n/a	n/a		n/a
Days p.a. under 0°C	53.5	1986 to 2005	New value	42.1 days	33.9 days	1,2
Days p.a. under 2°C	84.6	1986 to 2005	New value	69.3 days	58.4 days	1,2
Lowest temperature for baseline 1986-2005 (°C)	-8.5 9/8/1994	Discrete event	Absolute change	+0.5 (0.4 to 1.1) ie -8°C (-8.1 to -7.4)	+1.3 (1 to 1.7) ie -7.2°C (-7.5 to -6.8)	3
Lowest temperature for years on record at AWS (°C)	-10 11/07/1971	Discrete event	n/a	n/a		n/a
Precipitation						
Mean Rainfall (mm) - Annual	616.8	1986 to 2005	Percentage change	-1% (-11 to 5) ie 610.6 mm (548.9 to 647.6)	-3.7% (-14.2 to 8) ie 593.9 mm (529.2 to 666)	1,2
Mean Rainfall (mm) - Spring (SON)	181.2	1986 to 2005	Percentage change	-6% (-17 to 7) ie 170.3 mm (150.4 to 193.9)	-5.4% (-28.1 to 9.6) ie 171.5 mm (130.2 to 198.7)	1,2
Mean Rainfall (mm) - Summer (DJF)	164.5	1986 to 2005	Percentage change	+1% (-9 to 16) ie 166.2 mm (149.7 to 190.8)	+1.3% (-17.2 to 13.6) ie 166.6 mm (136.2 to 186.9)	1,2
Mean Rainfall (mm) - Autumn (MAM)	127.3	1986 to 2005	Percentage change	-1% (-21 to 12) ie 126.1 mm (100.6 to 142.6)	-5.2% (-20 to 19.7) ie 120.7 mm (101.9 to 152.4)	1,2
Mean Rainfall (mm) - Winter (JJA)	143.7	1986 to 2005	Percentage change	-5% (-17 to 7) ie 136.5 mm (119.3 to 153.8)	-3.9% (-16 to 8.6) ie 138.2 mm (120.7 to 156.1)	1,2
Highest daily rainfall event for baseline 1986-2005	126 15/3/1989	Discrete event	Percentage change	+6.4% (-3.6 to 14.4) ie 134.1 mm (121.5 to 144.1)	+6.1% (-7.4 to 15.8) ie 133.7 mm (116.7 to 145.9)	3
Highest daily rainfall (mm) for years on record at AWS	126 15/3/1989	Discrete event	n/a	n/a		n/a
Maximum 1 day rainfall for a 20 year ARI event	n/a	n/a	Percentage change	+9.3% (-4.7 to 22.5)	+8% (-5.8 to 22.5)	3
Hail	2.5 hail-producing thunderstorms/ year	1990-2007		6 hail-producing thunderstorms / ye		6
Extreme events						
Lightning	10 - 20 thunder days per year	1990 to 1999	Percentage change	5-6% increase per 1°C warming ie 7% to 8.4% increase in lightning frequency	ie 18.5% to 22.2% increase in lightning frequency	
Severe fire danger days per year	1.4	1986-2005	Absolute change (applied)	1.7 to 2.1 days	2.1 to 5.9 days	4
Daily variables						
Evapotranspiration (%)	n/a	n/a	Percentage change	+3.1% (1.9 to 5.1)	+5.5% (3 to 8.5)	1,2
Maximum wind gust speed (km/h) for baseline	72.7	1986-2005	Percentage change	n/a ie 124 km/h (124 to 124)	n/a ie 124 km/h (124 to 124)	5
Avg. 9 am wind speed (km/h)	8.4	1986 to 2005	Percentage change	+0.1% (-2.6 to 2.4) ie 8.4 km/h (8.1 to 8.6)	+0.1% (-2 to 2.4) ie 8.4 km/h (8.2 to 8.6)	1,2
Avg. 3 pm wind speed (km/h)	17.6	1986 to 2005	Percentage change	+0.1% (-2.6 to 2.4) ie 17.6 km/h (17.2 to 18.1)	+0.1% (-2 to 2.4) ie 17.7 km/h (17.3 to 18.1)	1,2
Avg. 9 am relative humidity (%)	73.3	1986 to 2005	Percentage change	-0.9% (-2.3 to 0.2) ie 72.6 % (71.6 to 73.5)	-1.4% (-2.9 to 0.6) ie 72.3 % (71.2 to 73.7)	1,2
Avg. 3 pm relative humidity (%)	46.7	1986 to 2005	Percentage change	-0.9% (-2.3 to 0.2) ie 46.3 % (45.7 to 46.9)	-1.4% (-2.9 to 0.6) ie 46.1 % (45.4 to 47)	1,2
Mean daily solar exposure (MJ/(m*m))	17.2	1990 to 2005	Percentage change	+1% (-0.4 to 2) ie 17.4 MJ/(m*m) (17.2 to 17.6)	+1.3% (0 to 3) ie 17.5 MJ/(m*m) (17.2 to 17.8)	1,2
Soil moisture	n/a	n/a	Percentage change	-3.1% (-5.1 to -0.4)	-7% (-10 to -1)	1

TABLE NOTES
*Baseline data uses a 20-year average (1986-2005) to align with the baseline used by CSIRO projection models to predict the future climate. In reality the 2020 climate may have already experienced the influence of increased emissions, therefore additional climate data is used to consider the whole picture such as "Highest temperature on record to date"

1. CSIRO BOM 2015, Climate Change in Australia Projections Cluster Report - Murray Basin, Appendix Table 1
2. CSIRO BOM 2015, Climate Change in Australia Summary Data Explorer, Murray Basin Cluster Projections
3. CSIRO BOM 2015, Climate Change in Australia Extremes Data Explorer, Murray Basin Cluster Projections
4. CSIRO BOM 2015, Climate Change in Australia Projections Cluster Report - Murray Basin, Appendix Table 2, Projections and baseline for Canberra
5. CSIRO BOM 2015, Climate Change in Australia Projections Cluster Report - Murray Basin, Figure 4.5.2
6. State of NSW and Department of Environment, Climate Change and Water 2010, Impacts of Climate Change on Natural Hazards Profile, Riverina Murray Region
7. IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

NB: Severe fire danger days per year and soil moisture data are based on RCP 4.5 2030 data due to the unavailability of RCP 4.5 2050 data
NB: Highest temperature recorded in baseline period uses CSIRO projection for 'hottest day' for summer (DJF)
NB: Highest daily rainfall provides indication of change to most extreme annual rainfall event using CSIRO 'wettest day' projections (annual)
NB: all projections use global climate models from the IPCC's Fifth Assessment report, excepting hail and lightning projections

NOTES ON UNCERTAINTY

Although the climate projections included above represent the presently accepted forefront of climate change science, there is still a high level of uncertainty that exists in regard to the climate changes that may actually eventuate. This uncertainty becomes more pronounced as the timescale of the projection is extended. Several areas of uncertainty exist which influence the accuracy of climate change projections, including:

> Scenario uncertainty, due to the uncertain future emissions and concentrations of greenhouse gases and aerosols, resulting from uncertainties regarding the current and future activities of humans;
> Response uncertainty, resulting from limitations in our understanding of the climate system and its representation in climate models;
> Natural variability uncertainty, stemming from unperturbed variability in the climate system;
> Uncertainties regarding the assignment of probability distributions to regional climate change projections; and
> Uncertainties associated with projecting climate change at small spatial scales, particularly for coastal and mountainous areas.
Accordingly, a key principle toward adapting to a future with an uncertain climate may be to adopt 'adaptive management', *i.e.* implementing incremental changes and adaptation measures based on climate and scientific monitoring and prescribed responses. Some adaptation options for infrastructure that may be deemed appropriate in response to the most extreme climate projections may require large-scale engineering or other works, the need (or otherwise) for which will depend on the extent of climate change that actually transpires over time, as opposed to the conditions that were modelled. More guidance on risk management approaches is provided on Tab 3.

Source:
AS 5334-2013

TABLE B1 RISK CRITERIA—EXAMPLE OF QUALITATIVE MEASURES OF CONSEQUENCES

Consequence descriptor	Adaptive capacity (see Note 1)	Infrastructure, service	Social/cultural	Governance	Financial (see Note 2)	Environmental (see Note 3)	Economy (see Note 4)
Insignificant	No change to the adaptive capacity	No infrastructure damage, little change to service	No adverse human health effects	No changes to management required	Little financial loss or increase in operating expenses	No adverse effects on natural environment	No effects on the broader economy
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored	Localized infrastructure service disruption No permanent damage. Some minor restoration work required Early renewal of infrastructure by 10–20% Need for new/modified ancillary equipment	Short-term disruption to employees, customers or neighbours Slight adverse human health effects or general amenity issues	General concern raised by regulators requiring response action	Additional operational costs Financial loss small, <10%	Minimal effects on the natural environment	Minor effect on the broader economy due to disruption of service provided by the asset
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity	Limited infrastructure damage and loss of service Damage recoverable by maintenance and minor repair Early renewal of infrastructure by 20–50%	Frequent disruptions to employees, customers or neighbours. Adverse human health effects	Investigation by regulators Changes to management actions required	Moderate financial loss 10–50%	Some damage to the environment, including local ecosystems. Some remedial action may be required	High impact on the local economy, with some effect on the wider economy
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity	Extensive infrastructure damage requiring major repair Major loss of infrastructure service Early renewal of infrastructure by 50–90%	Permanent physical injuries and fatalities may occur Severe disruptions to employees, customers or neighbours	Notices issued by regulators for corrective actions Changes required in management. Senior management responsibility questionable	Major financial loss 50–90%	Significant effect on the environment and local ecosystems. Remedial action likely to be required	Serious effect on the local economy spreading to the wider economy
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service Loss of infrastructure support and translocation of service to other sites Early renewal of infrastructure by >90%	Severe adverse human health effects, leading to multiple events of total disability or fatalities Total disruptions to employees, customers or neighbours Emergency response at a major level	Major policy shifts Change to legislative requirements Full change of management control	Extreme financial loss >90%	Very significant loss to the environment. May include localized loss of species, habitats or ecosystems Extensive remedial action essential to prevent further degradation. Restoration likely to be required	Major effect on the local, regional and state economies

NOTES:
1 Adaptive capacity relates to the ability of the infrastructure element and/or organization to adapt/change/cope with change in the climate change variable.
2 Financial loss will be relative to the infrastructure element being considered (i.e. a single building, coastal town, rail system). Dollar values need to include replacement cost for the infrastructure item and financial loss/costs relating to the loss of the service provided by the infrastructure item.
3 While the term ‘environment’ can include both man-made and natural systems, in this Standard ‘environment’ is limited to the natural environment outside the asset being considered.
4 Economy refers to the local economy (e.g. town or region), the state economy, or the economy of Australia as a whole. Significance of this measure will depend on the asset being considered.

Appendix B AS 5334 risk matrix and descriptors

TABLE C1 QUALITATIVE MEASURES OF LIKELIHOOD			
Rating	**Descriptor**	**Recurrent or event risks**	**Long term risks**
Almost certain	Could occur several times per year	Has happened several times in the past year and in each of the previous 5 years or Could occur several times per year	Has a greater than 90% chance of occurring in the identified time period if the risk is not mitigated
Likely	May arise about once per year	Has happened at least once in the past year and in each of the previous 5 years or May arise about once per year	Has a 60–90% chance of occurring in the identified time period if the risk is not mitigated
Possible	Maybe a couple of times in a generation	Has happened during the past 5 years but not in every year or May arise once in 25 years	Has a 40–60% chance of occurring in the identified time period if the risk is not mitigated
Unlikely	Maybe once in a generation	May have occurred once in the last 5 years or May arise once in 25 to 50 years	Has a 10–30% chance of occurring in the future if the risk is not mitigated
Rare	Maybe once in a lifetime	Has not occurred in the past 5 years or Unlikely during the next 50 years	May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period if the risk is not mitigated

RISK MATRIX EVALUATION TABLE					
Risk Ratings: E - Extreme, H - High, M - Moderate, L - Low	**CONSEQUENCE**				
	INSIGNIFICANT	**MINOR**	**MODERATE**	**MAJOR**	**CATASTROPHIC**
LIKELIHOOD: ALMOST CERTAIN	L	M	H	E	E
LIKELY	L	M	M	H	E
POSSIBLE	L	L	M	H	E
UNLIKELY	L	L	M	M	H
RARE	L	L	L	M	M

LEGEND:
E = Extreme risk, requiring immediate action.
H = High risk issue requiring detailed research and planning at senior management level.
M = Moderate risk issue requiring change to design standards and maintenance of assets.
L = Low risk issue requiring action through routine maintenance of assets.

DESCRIPTION OF IMPACTS AND CONTROLS									RISK ASSESSMENT									ADAPTATION RESPONSES	RESIDUAL RISK		
EXPOSURE AND VULNERABILITY			COMPONENTS POTENTIALLY IMPACTED					PLANNED CONTROLS	RATING FOR BASELINE CONDITIONS			RATING FOR 2030 RCP 8.5 PROJECTION			RATING FOR 2050 RCP 8.5 PROJECTION			MANAGEMENT OPTIONS	RESIDUAL RISK RATING POST ADAPTATION		
Risk ID:	*Climate variable*	*Description of impact*	*permanent mechanical systems, stationary equipment, tanks and*	*replaceable mechanical equipment and critical components (fire and water*	*mobile plant and equipment*	*Construction*	*Operations*	*Description of controls either planned within current design or assumed to be planned for future packages of work*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Adaptation Details*	*Likelihood*	*Consequence*	*Risk*
001	Drought	Drought affects near surface ground movement, potentially causing differential settlement and expansion/contraction of soils, resulting in movement of infrastructure.	x					Geotechnical investigation inform site design (foundations, concrete slab	Rare	Insignificant	L	Rare	Insignificant	L	Unlikely	Insignificant	L	Conduct localised repairs (general maintenance) where required.	Rare	Minor	L
002	Extreme heat	Extreme heat affects materials causing cracking and damage, resulting in reduced reliability and design life.	x				x	Concrete is inherently resilient to this risk. Expected thermal movement is a parameter used in design and materials selection. Monitoring of concrete condition. Design to consider temperatures under high emission scenario (eg 44 degrees).	Unlikely	Minor	M	Unlikely	Minor	M	Unlikely	Minor	M	No further adaptation measures identified.	Unlikely	Minor	M
003	Extreme heat	Increasing greenhouse gases (e.g. CO2) leads to increased rate of concrete carbonation, reducing service life of concrete elements through corrosion of reinforcement.	x					No planned controls identified at this stage.	Rare	Insignificant	L	Rare	Insignificant	L	Rare	Insignificant	L	Monitoring of concrete condition. Consider surface treatment.	Rare	Insignificant	L
004	Extreme heat	Extreme heat impacts on mobile plant equipment			x			Select mobile equipment that considers expected temperature ranges in their operations	Rare	Minor	L	Rare	Minor	L	Rare	Minor	L	No further adaptation measures required.	Rare	Minor	L
005	Extreme heat	Extreme heat impacts on permanent equipment	x	x			x	Select permanent equipment that considers expected temperature ranges in their operations or where possible consider HAVAC Systems	Rare	Minor	L	Rare	Minor	L	Rare	Minor	L	No further adaptation measures required.	Rare	Minor	L
006	Extreme heat	Extreme heat effects concrete temperature management for early age crack risk and for concrete curing resulting in reduced reliability and design life of concrete foundations.				x		Planned controls documented in design and construction specifications, and include the thermal control plan and the concrete specification. Plan for concrete pours to occur during cooler/ finer weather conditions	Unlikely	Minor	M	*Risk only applicable to the construction phase*						n/a			
007	Extreme heat	Increase in extreme heat days resulting in 'stop work' days, and greater delays to the construction program than accounted for.				x		Additional buffer in program to account for increase in extreme weather days (i.e. 5 days per year).	Possible	Minor	M	*Risk only applicable to the construction phase*						n/a			
008	Extreme heat	Increase in extreme heat days resulting in 'stop work' days during operations					x	WHS management procedures for extreme heat days are covered in the facilities operational plans.	Possible	Minor	M	Possible	Minor	M	Possible	Minor	M	Regularly update WHS management plan and procedures to adjust to conditions. Considerations of occasional operational work at night to avoid heat during day time.	Possible	Insignificant	L
009	Extreme rainfall	Extreme rainfall leading to flooding of the site and facilities leading to impact on open processing of recyclables and contamination of flood water leaving the site (water quality compliance issues)					x	Rainwater captured on site for re-use and appropriate site drainage for hardstand areas. Drainage for excess stormwater would be directed to Mugga Lane.	Rare	Moderate	M	Rare	Moderate	M	Rare	Moderate	M	Detailed design will consider additional protection structures (levies etc.). Flood modelling would be re-run at DA stage.	Rare	Minor	L
010	Extreme rainfall	Extreme rainfall leading to flooding of the site and facilities leading to damage of facility components	x	x	x			Facility has been designed as far away from the creek as possible and would not contribute to additional water flow into Dog Trap Creek.	Rare	Moderate	M	Rare	Moderate	M	Rare	Moderate	M	Detailed design will consider additional protection structures (levies etc.). Flood modelling would be re-run at DA stage.	Rare	Minor	L
011	Storms	Increased frequency, severity, and duration of significant storm events leading to unsuitable and unsafe conditions (e.g. localised flooding of site and access roads) for construction to proceed, resulting in 'stop work' days and greater delays to the construction program than accounted for.				x		Scheduling allows for anticipated wet weather days and their affect on construction duration and cost. Flood diversion in place during construction. Additional buffer in program to account for increase in extreme weather days .	Possible	Insignificant	L	*Risk only applicable to the construction phase*						n/a			
012	Storms	Lightning strike causes equipment failure e.g. electrical, equipment and systems.		x	x			Lightning protection will be provided for electrical and communication systems	Rare	Minor	L	Rare	Minor	L	Rare	Minor	L	No further adaptation measures required.	Rare	Minor	L
013	Storms	Increased frequency, severity, and duration of significant storm events including hail cause damage to the sites exposed components such as roofs and uncovered equipment	x	x	x			Consider use of materials (especially roofing) that can withstand potential hail damage. Ensure that mobile and permanent equipment is sufficiently covered	Likely	Minor	M	Likely	Minor	M	Likely	Minor	M	No further adaptation measures identified.	Likely	Minor	M

DESCRIPTION OF IMPACTS AND CONTROLS									RISK ASSESSMENT									ADAPTATION RESPONSES	RESIDUAL RISK		
EXPOSURE AND VULNERABILITY			COMPONENTS POTENTIALLY IMPACTED					PLANNED CONTROLS	RATING FOR BASELINE CONDITIONS			RATING FOR 2030 RCP 8.5 PROJECTION			RATING FOR 2050 RCP 8.5 PROJECTION			MANAGEMENT OPTIONS	RESIDUAL RISK RATING POST ADAPTATION		
Risk ID:	*Climate variable*	*Description of impact*	*permanent mechanical systemes, stationary equipment, tanks and*	*replaceable mechanical equipment and critical components (fire and water*	*mobile plant and equipment*	*Construction*	*Operations*	*Description of controls either planned within current design or assumed to be planned for future packages of work*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Adaptation Details*	*Likelihood*	*Consequence*	*Risk*
014	Storms	Severe wind/ storm event has higher wind loading than designed, causing stress to site structures resulting in damage, reduced design life or safety hazard.	x					Site to be designed in accordance with Australian Standards in regards to wind loading. Maintenance of vegetation in the surroundings of the site	Rare	Minor	L	Rare	Minor	L	Unlikely	Minor	M	Ongoing monitoring of site components and maintenance if deficiencies are identified.	Rare	Minor	L
015	Bushfires	Extreme heat generated by bushfires (>300 degrees) comes in direct contact with site components causing damage.	x	x	x			Implementation of asset owner bushfire management plan and operational protocols. Maintenance slashing of vegetation in and regular updating and review of bushfire management plan.	Rare	Moderate	M	Rare	Moderate	M	Rare	Moderate	M	No further adaptation measures identified.	Rare	Moderate	M
016	Bushfires	Bushfires moves onsite and cuts off access roads impacting access.					x	Implementation of asset owner bushfire management plan protocols.	Rare	Insignificant	L	Rare	Insignificant	L	Rare	Insignificant	L	Maintenance slashing of vegetation and regular updating and review of bushfire management plan	Rare	Insignificant	L
017	Bushfires	Bushfires in region delay construction programme due to restricted access to site and/or health concerns from increased smoke and ash.				x		Monitor bushfire warnings. Implement protocols of the bushfires management standards and operations plan to the level required	Rare	Minor	L	*Risk only applicable to the construction phase*						n/a			
018	Snow & Frost	Snow and frost affect materials (e.g. concrete) resulting in reduced durability and/or design life.	x	x	x			Design concrete to resist freeze / thaw damage.	Rare	Insignificant	L	Rare	Insignificant	L	Rare	Insignificant	L	Ongoing monitoring of infrastructure and maintenance if deficiencies are identified.	Rare	Insignificant	L

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