Appendix Y Ecologically Sustainable Development

Upper South Creek Advanced Water Recycling Centre

Ecologically Sustainable Development Report

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1 Introduction

This Ecological Sustainable Development (ESD) report has been prepared to support the Environmental Impact Statement (EIS) for the Upper South Creek Advanced Water Recycling Centre (USC AWRC) and associated pipelines (the Project). The EIS supports a State Significant Infrastructure Application (SSI Application) to the NSW Department of Planning Industry and Environment (DPIE) by Sydney Water. Sydney Water is seeking staged approval under Division 5.2 of the EP&A Act.

This ESD report outlines the vision, framework, governance and implementation process of sustainability initiatives that have been integrated into design and how these contribute to the achievement of the Project's sustainability outcomes.

This report responds to the Secretary's Environmental Assessment Requirements (SEARs) for the Project and seeks to demonstrate how sustainability objectives for the project will be met through the delivery of an integrated water management solution that includes the integration of key sustainability initiatives. In addition, this report will also identify how the integration of key sustainability initiatives will align with key objectives identified within Sydney Water's strategy and sustainability policies.

1.1 SEARS

The SEARs for this Project relating to ESD and climate change are outlined below in Table 1, which indicates where each of the SEARs has been addressed in this report and/or other technical studies.

Table 1: Project SEARS

Project SEARS requirements for sustainability		
SEARs matter to be addressed by the ESD Report		**Report Section**
Ecological sustainable development (ESD) – including:		
57.	An assessment against an accredited ESD rating system or an equivalent program of ESD performance. This should include a minimum rating scheme target level	Section 4.2 and 5.2
58.	How ESD principles (as defined in clause 7(4) of Schedule 2 of the Regulation) will be incorporated in the design and ongoing operation phases of the development.	Section 5.6
Climate Change – including:		
61.	Assessment of the risk and vulnerability of the Project to climate change in accordance with the current guidelines, including any Regional Water Strategy and associated climate change modelling as relevant to the Project.	Section 0 and 5.4
62.	Quantified specific climate change risks with reference to the NSW Government's climate Projections and incorporate specific adaptation actions in the design.	Section 0 and Appendix A
63.	An assessment of potential future climate variability impacts on the operation and management of the Project and associated delivery works (such as water deliver by way of river operations, or pipe infrastructure), having regard to research on groundwater recharge and surface run-off and the NSW Climate Impact Profile.	Refer to Appendix A

Project SEARS requirements for sustainability		
64.	Assessment of the greenhouse gas emissions from the construction and operation of the Project for the life of infrastructure, including: a) documentation and justification of an appropriate methodology for estimating greenhouse gas emissions for the Project as a water storage, or water reservoirs Project where permanent land use change occurs. b) assessment of carbon dioxide, nitrous oxide and methane gas emissions, including gases emitted by decomposing plants and organic material within the dam inundation area. c) quantitative assessment of Scope 1, 2 and 3[1] greenhouse gas emissions. d) an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency. e) Project emissions as a proportion of NSW and Australia's greenhouse gas emissions budgets. f) details of all proposed mitigation, management and monitoring measures.	Section 4.5, 5.5 and Appendix B

1.2 Project objectives

The project objectives are indicated within Table 2. The assessment of sustainability undertaken for the project and outlined in this report will seek to demonstrate how, through the integration of key sustainability initiatives, the project will meet the 'sustainable solutions' project objective.

Table 2: Project Objectives

Project Objectives	
Objective	**Objective Detail**
Sustainable solutions	– Demonstrating leadership in integrated and sustainable water management, including: 1. Preserving waterways health and amenity values of the Hawkesbury-Nepean River, South Creek, and tributaries 2. Retaining water in the landscape to mitigate urban heating and create green and vibrant places 3. Supplying recycled water for non-drinking purposes for use in homes and businesses, for agricultural purposes or irrigation of public open space 4. Pursuing circular economy approaches to waste management by explicitly adopting renewable energy solutions and resource reuse
Respond to growth	Provide wastewater services to the SWGA and WSAGA, in line with the NSW Government's long-term population forecast and Sydney Water's licence obligations

– [1] Scope 1: direct emissions which occur within the site boundary from owned or controlled sources e.g. emissions from site plant and equipment.

– Scope 2: indirect emissions which occur outside the site boundary from the generation of purchased energy.

– Scope 3: all indirect emissions (not included in scope 2) that occur in the value chain of the reporting body.

Project Objectives	
Provide cost effect service	Provide a cost-effective value for money wastewater treatment service that is financially sustainable for Sydney Water and minimises impact on customer bills.
Minimise disruption	Plan, construct and operate the infrastructure required to deliver service with minimum disruption to the community.
Adaptable solution	Incorporate into the solution, alternative futures, addressing a range of demand scenarios (including before 2025), meeting customers changing aspirations

2 Project description

Sydney Water is seeking approval for the construction and operation of a wastewater treatment plant in Western Sydney known as the Upper South Creek, Advanced Water Recycling Centre (USC AWRC). The Project's key components are:

- A wastewater treatment plant that includes production of:
  - High quality treated water suitable for a range of uses including recycling and environmental flows
  - Renewable energy
  - Biosolids suitable for beneficial reuse
  - New pipeline from the Water Recycling Centre to the Nepean River to release excess treated water
  - New infrastructure from the Water Recycling Centre to South Creek to release excess treated water and wet weather flows
  - New pipeline extension from the new Nepean River pipeline to the Warragamba River for environmental flows
  - New pipeline from the Water Recycling Centre to Sydney Water's existing wastewater system to discharge brine.

The concept component of the Project comprises all the above elements, with the Water Recycling Centre sized to treat an average dry weather flow of up to 100ML/day and to transport and release the equivalent volume through the pipelines.

Sydney Water is also seeking detailed approval for Stage 1 that comprises:

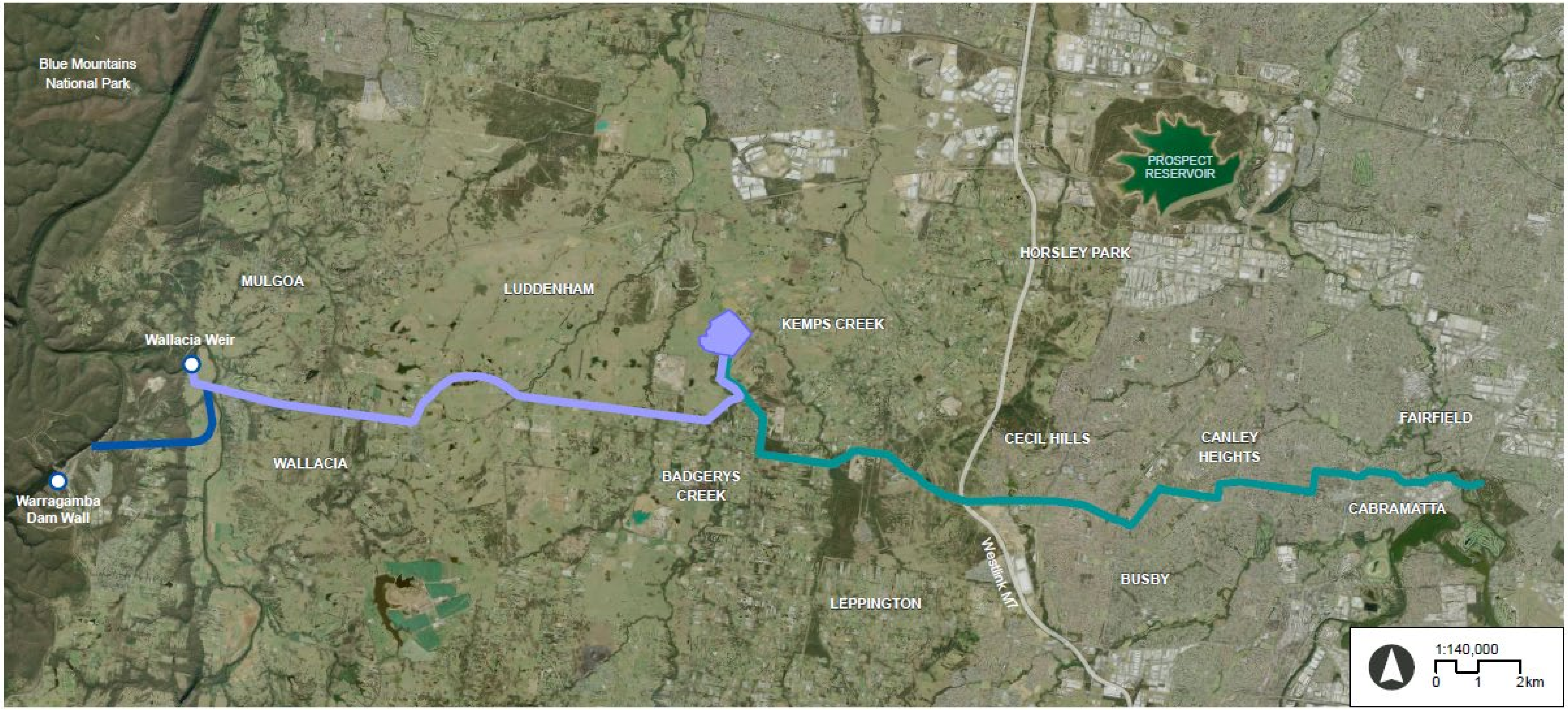
- Building and operating the Water Recycling Centre sized to treat an average dry weather flow of up to 50ML/day
- Building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 Water Recycling Centre.

2.1 Project Sustainability

The project presents an integrated water management solution that combines advanced wastewater treatment techniques with the recycled water function of the plant. Sustainable solutions for the Water Recycling Centre also include:

- Retaining water in the landscape to mitigate urban heating (landscaping and including Water Sensitive Urban Design)
- Circular Economic approaches to waste management by explicitly adopting renewable energy solutions and resource re-use (co-generation and biosolids for beneficial re-use)
- Installation of roof-mounted and ground mounted solar photovoltaics.
- Adaptation measures to improve climate resilience, ensuring the project can adapt to increasing risks from flooding and bushfires

Figure 1 provides an overview of the Project.

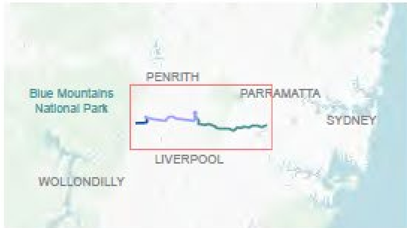


Upper South Creek Advanced Water Recycling Centre

Treated Water Pipeline

Brine Pipeline

Environmental Flows Pipeline



Projection: GDA 1994 MGA Zone 56
Project infrastructure locations are indicative and will be refined during design

Figure 1: Site location and context

3 Legislation and policy context

This section identifies the key strategic and regulatory drivers that will govern sustainability outcomes and influence changing trends in future planning and design of the Project. These drivers frame sustainability actions and considerations embedded in the Project's design and delivery.

Table 3: Legislation and Policy context

Legislation and Policy relevant to study		
Legislation/policy	**Key aspects**	**Relevance**
Commonwealth legislation and policy		
Commonwealth National Greenhouse and Energy Reporting Act (2007)	This Act provides a single national reporting framework for information related to greenhouse gas emissions, greenhouse gas projects, energy consumption and energy generation.	The Act provides the determination relevant to estimating fugitive emissions from wastewater treatment. Refer to the Greenhouse Gas Assessment (GHG) in Appendix B for its application.
National Greenhouse and Energy Reporting (Measurement) Determination 2008 (2017)	This determination is made under Sections 7B and 10 of the *National Greenhouse and Energy Reporting Act 2007*. It provides the measurement of GHG emissions arising from the operation of facilities providing methods and criteria for the measurement of Scope 1 and 2 GHG emissions.	The determination provides a method for estimating fugitive emissions from wastewater treatment; a critical component of the GHG assessment for the Project. Refer to Appendix B for its application.
The current Australian National Greenhouse Accounts, National Greenhouse Accounts Factors (2019)	Draws on the National Greenhouse and Energy Reporting (Measurement) Determination 2008 to provide methods to estimate a broad range of GHG emissions and including Scope 1, 2 and 3.	Provides methods for estimating Scope 1, 2 and 3 emissions not covered in the National Greenhouse and Energy Reporting (Measurement) Determination 2008. Refer to Appendix B for its application.
Australian Greenhouse Office, Factors and Methods Workbook (2004)	Provides a single source of current GHG emission factors for use in the estimation of emissions and emission abatement	Provides a method for estimating impact of land use change. Refer to Appendix B for its application.
The National Climate Resilience and Adaptation Strategy (2015)	The Strategy articulates how Australia is managing the risks of a variable and changing climate. It identifies a set of principles to guide effective adaptation practice and resilience building and outlines the Government's vision for a climate-resilient future.	In accordance with the Strategy, significant climate risks will be identified over the life of the Project, enabling adaptation to be prioritised to enhance resiliency and adaptivity. Refer the Climate Change Risk Assessment (CCRA) in Appendix A for risk identification and adaptation.

Legislation and Policy relevant to study		
Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard (2005)	The protocol provides internationally recognised guidelines and standards to assist companies and organisations with developing a GHG inventory. The protocol aims to provide consistency and completeness in GHG accounting.	The standard has been applied to the development and justification of the GHG assessment method and definition of the emission boundary for the Project. Refer to Appendix B for its application.
State legislation and policy		
NSW Environmental Planning and Assessment Act (1979)	The objectives of the EP&A Act are to encourage: • Legislate for ESD principles • The proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment	This policy is relevant in requiring the Project to demonstrate how it achieves the ESD principles. This is also a requirement of the SEARs. Refer to section 5.6 for how ESD principles are considered by the Project.
NSW Environmental Planning and Assessment Regulation (2000)	The EP&A Act legislates for ESD while the Regulation describes the ESD principles. ESD principles as defined in clause 7(4) of Schedule 2 of the EP&A 2000 Regulation are as follows. *The precautionary principle* – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by: (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and (ii) an assessment of the risk-weighted consequences of various options, *Inter-generational equity* - namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations. *Conservation of biological diversity and ecological integrity* – namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration *Improved valuation, pricing and incentive mechanisms* – namely, that environmental factors should be included in the valuation of assets and services such as - (i) polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,	The Project is required to demonstrate how these ESD principles are achieved. Refer to section 5.6 for how ESD principles are considered by the Project.

Legislation and Policy relevant to study		
	(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste, (iii) environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.	
NSW Climate Change Policy Framework (2016)	The Climate Change Policy Framework developed by the NSW Government endorses the Paris Agreement[2], and complements actions consistent with the level of effort to achieve Australia's commitments to the Paris Agreement. The framework sets policy directions to guide implementation of the framework and NSW commitments to achieving long term objectives of net zero emissions and resiliency to climate change.	The Project seeks to align with Sydney Water's Strategy that aims to meet NSW's aspirational objective of net-zero emissions by 2050, increase resilience to a changing climate, connect with customers and use water in the landscape to shape liveable places. Refer to section 3.1.1 for the Strategy Objectives and sections 5.5.1, 5.7.1 and 5.7.2 for how the project contributes towards net-zero emissions.
NSW Net Zero Plan Stage 1 (2020-2030)	The NSW Government Net Zero Plan Stage 1: 2020-2030 is the foundation for the State's action on climate change and its goal to reach net zero emissions by 2050. It outlines the NSW Government's plan to grow the economy while creating jobs and reducing emissions over the next decade. The plan aims to enhance the prosperity and quality of life of the people of NSW while helping the state to deliver a 35% cut in emissions by 2030 compared to 2005 levels.	The Project seeks to align with Sydney Water's Strategy. The strategy looks to help meet NSW's aspirational objective of net-zero emissions by 2050. Refer to section 3.1.1 for the Strategy Objectives and sections 5.5.1 and 5.7.2 for how the project contributes towards net-zero emissions.
NSW Government Resources Efficiency Policy (2019)	This policy acts to drive resource efficiency by NSW Government agencies in four main areas - energy, water, waste and air emissions. The policy aims to ensure NSW Government agencies; meet the challenge of rising costs for energy, water clean air and waste management; use power purchasing to drive down the cost of resource-efficient technologies and services; and show leadership by incorporating resource efficiency in decision making.	The Project seeks to align with Sydney Water's Strategy. The strategy looks to beneficially recover and reuse resources and reduce waste. Refer to section 3.1.1 for the Strategy Objectives and sections 5.1, 5.5.1 and 5.7.2 for how the project contributes towards resource efficiency.

[2] The Paris agreement is a legally binding international treaty on climate change. Adopted in 2015, its goal is to limit global warming to well below 2, preferably 1.5 degrees Celsius, compared to pre-industrial levels.

Legislation and Policy relevant to study		
NSW Circular Economy policy statement	The NSW Government has developed a Circular Economy Policy to deliver positive economic, social and environmental outcomes. The policy aims to change the way we produce, assemble, sell and use products to minimise waste and to reduce our environmental impact.	The Project seeks to align with Sydney Water's Strategy. The strategy looks to beneficially recover and reuse resources and reduce waste. Refer to section 3.1.1 for the Strategy Objectives and sections 5.1, 5.5.1 and 5.7.2 for how the project contributes towards resource efficiency.
Western Sydney Aerotropolis Plan (WSAP) (2020)	This plan developed by the Western Sydney Planning Partnership and sets a vision for the Western Sydney Aerotropolis as Australia's next global gateway, built around the planned Western Sydney International Nancy-Bird Walton Airport. The Plan sets out a sequenced approach to precinct planning that aims to optimise planned investment in major infrastructure and create the impetus for the early activation of the Aerotropolis. Detailed precinct planning will aim to stage and sequence development within and between precincts to optimise infrastructure provision.	The Project is located within the Aerotropolis and will seek to align with WSAP sustainability objectives. Refer to section 5.7.3 for further details.

3.1 Sustainability Drivers and Context

3.1.1 Sydney Water Strategy 2020-2030

Sydney Water's Environment Strategy is currently being replaced with one overarching strategy. The Strategy will help deliver Sydney Water's vision of creating a better life with world class services. The Strategy will direct activities for the next decade and enable Sydney Water to respond to key challenges facing customers, business and the environment. The Strategy identifies 4 key strategic outcomes:

- First choice of customers and partners
- Successful and innovative business
- High performance culture
- Thriving, liveable and sustainable cities.

It is the 'Thriving, liveable and sustainable cities' outcome which is most relevant to this Project. Meeting this outcome will require delivering on the following objectives:

- Our cities waterways are clean, healthy and safe for swimming and recreation
- Our system is resilient to shocks and disruptions (e.g. we have achieved advanced system reliability and performance)
- Our water and waterways are world class and support thriving liveable and sustainable cities
- Our environmental performance is world class
- We are a resource recovery business with an increasing portfolio of circular economy products and services

- We have made substantial progress towards zero impact on the environment (focus on water, waste and carbon)

See 5.7.1 for details of how the project aligns with these strategic objectives.

3.1.2 Sydney Water Energy Masterplan

Sydney Water has a vision of ensuring that it purchases, uses and generates energy in a way that delivers the lowest cost of water services to its customers, which also helps limit its environmental impact and manages the risks from a changing energy market. To achieve this, the Energy Masterplan sets a series of aspirational goals around energy resource recovery, self-generated renewable energy, energy efficiency and electricity procurement:

- 60% of our electricity costs not exposed to the short-term electricity market by 2030, increasing to 80% by 2050. All key processes not exposed to grid outages by 2030.
- Maintain grid-sourced electricity demand below 1998 levels to 2030. Self-generate 35% of our electricity by 2030 by installing 4.5MW of cogeneration & hydro and 13.5MW of solar & wind
- Net-zero carbon emission sources (either through onsite renewable generation or through the procurement of off-site renewable electricity) provide 75% of our electricity demand by 2030 and 100% by 2050

For further details of how the project aligns with the Energy Masterplan, see 5.7.2Table 13. In addition, the GHG assessment outlines mitigation measures included in the design which contribute to the above goals, see Section 5.5 for further details.

3.1.3 Sydney Water Resilience Policy

Sydney Water is committed to providing secure and reliable essential services. By building infrastructure, community and organisational resilience it will ensure public health and safety, environmental outcomes, economic prosperity and social cohesion of our city.

A systems approach is required to protect against all possible shocks and stresses. Sydney Water reduces likelihood and impact of failures by leveraging infrastructure, community and organisational resilience as well as multi-stakeholder approaches. The following elements of resilience and their scope underpin the strategy towards resilience:

- Resistance: Ability to continue service provision through withstanding and preventing reasonably foreseeable threats, hazards, shocks and stressors.
- Reliability: Capability of infrastructure and organisation to maintain service and meet obligations in a variety of conditions
- Redundancy: Adaptability of an asset, network or group to maintain service and meet obligations with loss of individual components in a variety of expected conditions
- Response: Preparation for and actions taken during an evolving adverse event to limit impact. Response includes monitoring conditions to guide adaptive strategies and trigger planning and investment.
- Recovery: Restoring vital functions as quickly as possible to limit damage caused by a failure, Lessons learned should be used to improve the resilience of Sydney Water’s assets and systems.

The CCRA outlines design and mitigation measures considered to address the above elements. For further details of how the project aligns with the resilience policy, see section 5.7.4. Section 5.4 provides further details key mitigation measures within the CCRA.

3.1.4 Western Sydney Aerotropolis Plan (WSAP)

The Aerotropolis is a 11,200-hectare region within the Penrith and Liverpool local government areas (LGAs) centred around the Western Sydney International Nancy-Bird Walton Airport. The AWRC site is in the Kemps Creek and Wianamatta South-Creek precincts .The Aerotropolis will evolve to become the home to global industries providing jobs and investment while contributing to the future vision of a ‘cool, green and connected’ Western Sydney. The Plan contains the following objectives that are relevant to the Project’s sustainability outcomes:

- Objective 4: A landscape led approach to urban design and planning
- Objective 5: A sustainable low carbon Aerotropolis that embeds the circular economy
- Objective 6: A resilient and adaptable Aerotropolis

For further details of how the project aligns with the WSAP, see section 5.7.3.

3.1.5 ISCA IS Rating Tool

The ISCA rating tool (IS rating tool) was developed in collaboration with industry to drive and measure sustainability within infrastructure projects and assets. The IS version 1.2 (ISv1.2) tool builds on current guidance and practices. It provides industry with an incentive to achieve sustainability performance outcomes in the planning, design, construction and/or operations phases.

The IS rating tool aims to:

- Provide a common language for sustainability in infrastructure
- Provide a vehicle for consistent application and evaluation of sustainability in tendering processes
- Help in scoping whole-of-life sustainability risks for Projects and assets, enabling smarter solutions that reduce risks and costs
- Foster resource efficiency and waste reduction therefore reducing costs
- Foster innovation and continuous improvement in the sustainability outcomes from infrastructure
- Build an organisation’s credentials and reputation in its approach to sustainability in infrastructure

Across Australia the IS rating tool has become a standard measure of performance for major infrastructure programs and projects with 63 certified projects to date. The IS rating tool is also a recognised standard by many investors who consider this a material factor in asset valuations. This is because it can help create more efficient and resilient assets, increasing the assets value and lowering risk.

The Project will aim to achieve an ISCA score of at least 65 points (i.e. Excellent rating). This will help set quantifiable benchmarks to monitor and measure performance and will clearly define to the Project team their responsibilities for achieving the target ISCA rating. Further details of how the Project will align with the target ISCA see Section 5.2.

Table 4: ISCA ratings

ISCA Ratings	
Score	**Rating**
<25	Not eligible to apply for a certified rating
25 to <50	Commended
50 to <75	Excellent
75 to 100	Leading

3.1.6 United Nations Sustainable Development Goals (UN SDGs)

The 17 UN SDGs were developed by the United Nations as an internationally agreed blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice.

- Sydney Water is part of an industry wide commitment to delivering the UN SDGs. Our Strategy 2020-2030 is committed to achieving Thriving liveable, sustainable cities and contributing to the following SDGs.
- SDG 3: Good health and wellbeing
- SDG 6: Clean water
- SDG 7: Affordable and clean energy
- SDG 9: Industry innovation and infrastructure
- SDG 11: Sustainable cities and communities
- SDG 12: Responsible consumption and production
- SDG 13: Climate Action
- SDG 14: Life below water
- SDG 15: Life on land
  - This report will seek to demonstrate how the project responds to the SDG's through the implementation of sustainable solutions. See section 5.1, Table 5 for details of which of our key commitments contribute to the above SDGs.

3.2 Western Sydney challenges and opportunities

Greater Sydney's population is forecast to reach eight million people over the next 40 years, and around half of those people are expected to be living west of Parramatta. However, Sydney's population, economic activity and infrastructure has historically been concentrated in the eastern part of the City, around the Harbour and Sydney's established Central Business District. There is a pressing need to support this new growth in the West by providing economic and social opportunities along with the infrastructure necessary to support growth.

This is the basis of the Greater Sydney Commission's (GSC's) Greater Sydney Region Plan – A Metropolis of Three Cities (Greater Sydney Commission, 2018), which outlines a vision for three cities – the Eastern Harbour City, the Central River City and the Western Parkland City. Each city will aim to provide residents will access jobs, education, health facilities, and services within 30 minutes of where they live.

3.2.1 The Western Parkland City

The GSC defines the Western Parkland City as the area covered by the LGAs of Blue Mountains, Camden, Campbelltown, Fairfield, Hawkesbury, Liverpool, Penrith and Wollondilly. The area is itself expected to grow from 740,000 people in 2016 to over 1.5 million people by 2056: representing 20% of the projected growth across Greater Sydney. The growth will be spurred by the new Western Sydney International Nancy-Bird Walton Airport, the surrounding Aerotropolis and large expected investments in housing, transport projects, job creating industries and other infrastructure. New blue and green infrastructure[3] will be introduced to balance the expansion of built assets to enhance amenity and liveability in the region and to provide urban cooling.

To reflect the importance and strategic vision on the area, the GSC developed a balanced liveability, productivity and sustainability framework that provides the ten directions for the development of the metropolis of three cities, see Figure 2 below.

Figure 2 Liveability, Productivity and Sustainability Framework

There is an opportunity for Sydney Water to support these directions, particularly with regards to creating an efficient and resilient city. For 130 years, Sydney has taken a traditional single use approach to water and wastewater services. This entails taking rainwater from dams, treating it and supplying it to users for drinking and other purposes, before collecting wastewater from those same users, treating it and then discharging it directly to the ocean. However, there is however a growing imperative, supported by community pressure, to further explore beneficial and safe reuse options that use resources more wisely and adapt to changing demands and future stresses.

[3] Blue infrastructure refers to water elements like rivers, canals and wetlands while green infrastructure refers to green assets like trees, parks and gardens.

3.2.2 Challenges for Western Sydney

Transforming Western Sydney into a city that continues to be liveable, sustainable and productive in line with the GSC's vision poses an increasingly complex challenge. Below are some of the greatest challenges Western Sydney is facing:

- Water availability
  - More people moving into the city means more water will be needed
- Protecting waterways
  - More waste flows will need to be collected and treated to protect our waterways
- Climate change
  - The influence of climate change will see more temperature extremes and severe weather
- Drought
  - Drought is likely to occur more frequently and severely, creating a need to better manage water and stormwater systems
- Urban densification
  - Changing the city landform and influencing the urban heat island effect

3.2.3 Project Opportunities

By managing water holistically, recognising it as a valuable and scarce resource, Sydney Water is planning for a city where recycled water is the norm, WSUD supports a cool and green city and where the city is resilient and prepared for droughts and flood.

The Project presents the following opportunities for the Western Sydney region:

- An advanced wastewater recycling centre that enables the beneficial reuse of resources such as recycled water, biosolids and energy
- Development of an effluent management solution that supports waterway health outcomes for the Hawkesbury-Nepean River
- A solution that supports the GSC's vision for liveability, productivity and sustainability in Western Sydney

See Table 5 for the Projects key commitments that seek to align with these opportunities.

3.2.4 Project contribution to place based outcomes in Western Sydney

Sydney Water is participating in the NSW Government's Western Sydney Place-based Infrastructure Compacts (PICs). The purpose of the PIC is to coordinate planning and delivery of new jobs and housing in Western Sydney and ensure the necessary infrastructure is in place to support that growth. There is potential for the Project to contribute to place-based outcomes for Western Sydney in the following ways:

- Treatment of wastewater generated in the USC catchment for beneficial reuse, including irrigation, agriculture, non-potable domestic, commercial and industrial uses, as well as environmental flows. Water reuse for these purposes will lead to a reduced demand for potable water and increased climate resilience.

- As part of a total water cycle management approach, treated water can help retain water in the landscape for cooling and greening, thereby contributing to improved microclimate.
- Delivery of wastewater solutions that meet criteria to protect the health of waterways by treating effluent and minimising overflows.
- Improvements in health and wellbeing of local communities by providing recycled water for the greening of shared spaces, creating better places that can lead to a stronger sense of place-based identity.

Having an asset in the community that adopts an integrated management approach has many other community, social and environmental benefits. These include increased opportunity for community sustainability education, engagement with local businesses and social enterprises, improved connectivity, and the creation of active transport (walking and cycling) corridors due to green and blue infrastructure, and the opportunity to (re) create valuable ecological habitats.

4 Method and approach

Overview

The approach to assessing the sustainability of the Project is described in the following sections. The aim was to define and assess project sustainability by:

- Reviewing the Project design to identify sustainability initiatives and management measures from the EIS,
- Undertaking an initial assessment with an infrastructure sustainability rating tool and
- Demonstrating alignment of sustainability initiatives with key policies and project objectives.
- Following a review of the Project, key sustainability commitments were shown to align with Sydney Water environmental and sustainability policies and key policies guiding the planning and development of Western Sydney. For this Project, key sustainability commitments have been defined as those sustainability initiatives with potential to have the greatest impact or influence on Project sustainability outcomes.

ISCA Benchmarking and alignment

A preliminary ISCA scorecard weighting assessment was undertaken to define the minimum ISCA target rating of 65 points, demonstrating that sustainability outcomes will be delivered by the project. The Project scorecard and IS strategy benchmarked against the IS certified “Excellent” Lower South Creek (LSC) project for continuity. LSC is a Sydney Water Project delivering upgrades to three of Sydney Water's major inland wastewater treatment plants, Riverstone, St Marys and Quakers Hill. It was assumed that the approach to the Management & Governance, Using Resources, and People & Place themes would be the same for USC AWRC as LSC. It is intended that mechanisms and processes which were successful in the Design rating for LSC will be carried over to the Project and lessons learned will provide insight into the USC AWRC’s ISCA journey. These assumptions have informed our preliminary materiality assessment for the scorecard as well as the IS strategy. Expected key points of difference will be the Project’s location (predominantly greenfield), asset scope, and early targeted focus on ISCA alignment throughout the Project’s development.

Greenhouse Gas Impact Assessment

To demonstrate the Project’s commitment to reducing emissions, a quantitative GHG assessment sought to identify overall project emissions throughout construction and operation. The assessment identified the effectiveness of carbon reduction measures and compared the residual impact to state and national carbon budgets, while identifying reduction measures for further consideration. The Project’s contribution to the key targets and objectives within the energy masterplan sought to demonstrate how alignment will be achieved.

Climate Change Risk Assessment

To demonstrate the Project’s commitment to being climate resilient, a climate change risk assessment was undertaken to qualitatively evaluate projected climate risks to project infrastructure using both Commonwealth Scientific and Industrial Research Organisation (CSIRO) and NSW and ACT Regional Climate Modelling (NARCliM) scenarios. Two models were used in response to the IS v1.2 ‘Cli-1’ recommendation to allow the design to explore the effects of different model sensitivities. In addition, the use of NARCliM satisfies the SEARs requirement to quantify risk with reference to the NSW Government’s climate projections. By working with the project team to identify adaptation measures, the measures were assessed on the ability to manage climate risks to the AWRC and pipeline infrastructure under the projected scenarios.

The Project's relative contribution to Sydney Water Resilience Strategy and overarching climate related targets, as outlined in section 3, sought to demonstrate how alignment will be achieved. In addition, the Cross Dependency Initiative (XDI), which assesses and quantifies extreme weather climate change impacts on a wide range of utility assets, was reviewed at a high level and its findings considered within the risk assessment.

This ESD assessment involved:

1. Developing a Project Sustainability Initiatives Register (SIR) to identify potential sustainability related design, construction and operational opportunities and document those initiatives included in the Project. From the sustainability register, identify key commitments and alignment with key policies and objectives.
2. Developing an initial strategy to ensure alignment with the Project's ISCA target. This further aided the development of the SIR to inform the key commitments for the Project.
3. Reviewing key initiatives and management measures from other environmental disciplines that have been identified to manage environmental impacts arising from the project and identifying alignment with ISCA and environmental policies.
4. Undertaking a Climate Change Risk Assessment (CCRA) to identify key climate risks to the project, infrastructure and assess the effectiveness of identified adaptation measures on managing climate related impacts
5. Undertaking a GHG Impact Assessment to determine the impact of the Project on the carbon budget and identifying management measures and opportunities for GHG reduction.

4.1 Developing the Project Sustainability Initiatives Register and Key Commitments

The SIR was a collaborative process that involved:

1. Holding a UN SDG and ISCA materiality workshop
   - A preliminary workshop was held with the Project team and key stakeholders. Using the IS Materiality workshop as a framework, the group evaluated the impact of the Project against the UN SDGs. Collectively the group then developed initiatives that could mitigate identified impacts as well as contribute to have lasting sustainability outcomes for the Project.
2. Attending design team meetings
   - Design team meetings were held with team leaders and key design staff to discuss key ISCA requirements as well as initiatives from the preliminary workshop. Key initiatives were further considered and developed for all Project phases but with a focus on the current stage of design.
3. Undertaking global best practice benchmarking
   - Case studies of similar assets were reviewed for insight into best practices or design that the Project could consider. Initiatives were added to the SIR and discussed during design meetings.

Following the development of a long list of possible initiatives, priority initiatives were then identified as key commitments for the Project. The key commitments are initiatives assessed to have the greatest impact or influence on the Project's sustainability outcomes. The intention is that these initiatives will evolve over time as the detailed design progresses and as the ISCA strategy takes effect. The SIR is also a requirement of ISCA.

4.2 ISCA Benchmarking and ISCA framework alignment

The delivery of the ISCA strategy involved:

1. Reviewing the sustainability frameworks:
   - The ISCA IS rating tool is the benchmark infrastructure ESD framework in Australia, becoming the standard measure of performance for major infrastructure programs and projects to date. As such, it was determined by Sydney Water that the tool is the most suitable to identify sustainability opportunities and respond to the SEARs.
2. Undertaking a preliminary performance review:
   - An initial performance review of the current design was carried out against the ISCA tool through the ISv1.2 scorecard. The preliminary scorecard used the ISv1.2 default weightings for a wastewater asset with additional input from the Project and design team. Proposed credit levels used benchmarking from Sydney Water's Lower South Creek IS performance as well as input from design meeting feedback. It is acknowledged that the 'Excellent' rating is only suggestive of performance as ISCA engagement is required for any definitive scoring and this more detailed process will occur during the subsequent stages of the project.
3. Developing an ISCA early works strategy
   - The ISCA early works strategy informs a pathway to achieving the target IS rating. It will ensure that future design decisions will support and not negatively affect the intended IS Rating. This was facilitated by an ISCA materiality workshop and design meetings. In addition, ISCA framework alignment was investigated by undertaking a credit analysis to ensure initiatives were captured in the SIR as this aligns with the ISCA strategy.

4.3 Sustainability initiatives from other environmental disciplines

Initiatives from other environmental disciplines which lead to positive environmental impacts and outcomes also contribute to the Projects sustainability performance. These initiatives, which are currently being developed, will also contribute to the projects target ISCA rating. This includes how the project has avoided and minimised impacts to the environment from the project, especially through the design phase. Management measures that will be implemented across the projects to further minimise and manage impacts will also contribute to the ISCA rating.

4.4 Climate Change Risk Assessment

The CCRA involved:

1. Determining relevant scenarios of present and future climate change for use in risk assessment
   - Potential risks were identified based on the latest climate projections for cities using CSIRO and NARCiM data. Representative Concentration Pathways (RCPs) 4.5 and 8.5 and Special Report on Emission Scenarios (SRES) A2 were considered in line with ISCA requirements, and two time periods, 2030 and 2070 were selected to represent the near-term and long-term design life of the Project.
2. Undertaking a preliminary risk assessment

- A preliminary risk assessment was undertaken using a qualitative method with local climate data to understand the likelihood and consequence of climate change risks that could affect the Project's delivery.

3. Undertaking stakeholder consultation and risk validation
   - A climate change risk assessment workshop was held and was attended by the relevant designers, engineers and climate change specialists. The risks were qualitatively rated with the stakeholders to identify which components were more at risk than others. The risks were qualitatively assessed as either low, medium, high or extreme based on a consequence and likelihood risk matrix. This enabled the Project team to prioritise risks and identify a list of actions and responsibilities for all medium and high risks identified.
   - Where risks have been highlighted as 'high', adaptation measures have been implemented to reduce these risks to medium or lower. Intervention measures have also been considered for a minimum of 50% of 'medium' risks identified, in line with the relevant IS climate change adaptation credit i.e. ISv1.2 Cli-2 Level 2.

4.5 Greenhouse Gas Impact Assessment

The GHG Impact Assessment involved:

1. Defining emission boundary and sources
2. Quantifying emissions sources
3. Calculating emissions

Scope 1, 2 and 3 emissions were identified, GHG emissions were calculated, and mitigation measures were defined. Further GHG reducing measures were also identified for further consideration.

5 Outcomes and Results

This section provides further context to the items described in the section above, detailing the outcomes and their implementation to establish a clear pathway for the delivery of sustainability over the lifetime of the Project. The following section outlines how each SEARs matter has been addressed and how the design has incorporated sustainability commitments and initiatives to ensure the realisation of the Project objectives. This section also demonstrates how the Project will seek to align with the UN SDGs, WSAP objectives and Sydney Water Strategy.

5.1 Sustainability Initiatives Register and Key Commitments

The SIR draws from the regulatory context, ISCA materiality workshop, design team meetings and global best practice to inform the Project's vision for sustainability. The SIR allowed the Project to record all sustainability initiatives included as part of the current design, while identifying opportunities that have potential to achieve further sustainable outcomes in the future. It provides ongoing tracking of initiatives and commitments throughout the design process to help enable alignment with key regulatory and best practice drivers.

As per Section 4.1, the SIR was used to develop a long list of approximately 380 potential initiatives. The initiatives in Table 5 below, along with the corresponding themes from the SIR, are identified as key commitments as they have the greatest ability to impact or influence the Project’s sustainability outcomes, including, contribution to the minimum ISCA rating. The key commitments in Table 5 demonstrate Project alignment with the UN SDGs, Project objectives, WSAP planning principles, Sydney f and ISCA. Sections 5.2 to 5.7 provide further explanation as to how the key commitments align with key policies and objectives.

Table 5: Summary of key sustainability commitments

Key sustainability commitments for the Project						
Theme	**Key sustainability commitment**	**Relevant UNSDG**	**Project Sustainable solutions objective**	**Western Sydney Aerotropolis Plan 2020**	**Sydney Water Strategy objectives to 2030**	**ISCA ISv1.2 Category**
Sustainable design	**ISCA** - attain an 'Infrastructure Sustainability Council of Australia' (ISCA) rating of at least 'Excellent', and preferably 'Leading' for design, as built and asset in operation stages (with a minimum score of 65 points)	All	All	✓	✓	All
Energy	**Electricity use** - supplement 50% of Stage 1 project electricity use by: • self-generating renewable energy from installation of solar PV panels and recovered biogas to fuel cogeneration purchasing grid renewable energy.	7: Affordable and clean energy 12: Responsible consumption and production 13: Climate Action	4. Pursuing circular economy approaches to waste management	✓	✓	Energy and Carbon Waste

Key sustainability commitments for the Project						
Theme	**Key sustainability commitment**	**Relevant UNSDG**	**Project Sustainable solutions objective**	**Western Sydney Aerotropolis Plan 2020**	**Sydney Water Strategy objectives to 2030**	**ISCA ISv1.2 Category**
Circular economy	**Beneficial reuse of biosolids** – reuse all biosolids to maximise reuse and recovery of resources **Recycled Water** - Enable 100% of wastewater treated to be re-used for the purpose of off-setting drinking water supply, including as environmental flows, recycled water for local supply or purified recycled water for drinking in the future. Provide a source of water that can be used for green space and tree canopy irrigation to support urban cooling and greening objectives in Western Sydney	9. Industry innovation and infrastructure 12: Responsible consumption and production	4. Pursuing circular economy approaches to waste management	✓	✓	Waste Water
Water Management	**Integrated water management solution** – meet EPA nutrient load limits in the Yarramundi 2 subzone and maintain or improve instream water quality and macroinvertebrate diversity attributable to the project's operational waterway releases. Support customers to develop high quality integrated water management solutions that consider a range of sources including rain/stormwater and recycled water from the AWRC where appropriate.	3. Good health and wellbeing 6: Clean water and sanitation 9. Industry innovation and infrastructure 12: Responsible consumption and production 14. Life below water 15. Life on land	1. Preserving waterways health and amenity values 3. Supplying recycled water for non-drinking purposes	✓	✓	Discharges to Air, Land and Water Ecology

Key sustainability commitments for the Project						
Theme	**Key sustainability commitment**	**Relevant UNSDG**	**Project Sustainable solutions objective**	**Western Sydney Aerotropolis Plan 2020**	**Sydney Water Strategy objectives to 2030**	**ISCA ISv1.2 Category**
Sustainable communities	**Urban design/landscaping** – develop and implement a landscape-led Masterplan for the AWRC site, as outlined in more detail in Chapter 5 of the EIS. **Water Sensitive Urban Design** – design stormwater management at the AWRC site with the aim of meeting waterway objectives for South Creek. **Community -** celebrate cultural and scientific heritage and providing future opportunities for community access.	11: Sustainable cities and communities	2. Retaining water in the landscape to mitigate urban heating and create green and vibrant places	✓	✓	Urban and Landscape Design Water
Environment	**USC AWRC Environmental Impact Statement outcomes -** manage environmental impacts arising from construction and operation of the AWRC and pipelines.	11: Sustainable cities and communities 14: Life below water 15: Life on land	All	✓	✓	All
Flood Management	**Flood Management –** not contribute to existing flood management issues in the Hawkesbury Nepean or South Creek catchments.	11. Sustainable cities and communities 14. Life below water 15. Life on land	N/A	✓	✓	Lan-4

Key sustainability commitments for the Project						
Theme	**Key sustainability commitment**	**Relevant UNSDG**	**Project Sustainable solutions objective**	**Western Sydney Aerotropolis Plan 2020**	**Sydney Water Strategy objectives to 2030**	**ISCA ISv1.2 Category**
Climate Resilience	**Infrastructure resilience and opportunities for improved drought resilience in Western Sydney** - manage the impacts of a changing climate by including adaptation measures to support resilience of the AWRC and pipeline infrastructure.	11: Sustainable cities and communities 13: Climate action	1. Preserving waterways health and amenity values 3. Supplying recycled water for non-drinking purposes	✓	✓	Climate

5.2 Project alignment with ISCA strategy

Table 6 shows how key commitments align with specific ISv1.2 categories and will contribute to meeting the IS Excellent rating. A preliminary ISCA weightings assessment was done to assess how the Project may perform across fifteen categories. The categories are made up of 44 credits, which asses an aspect of performance within the category. The credits may address mitigation or improvement as well as processes that support realisation of sustainable outcomes. The preliminary draft IS scorecard weighting assessment has suggested that the most influential categories for the Project will be Materials, Energy and Carbon (i.e. it is likely that the Project can achieve the most points by performing well in these credits).

Table 6: Alignment with Material ISv1.2 Categories

Material ISv1.2 Categories for USC AWRC			
Material Category	**ISCA Credit**	**Aims**	**Project Alignment with Credit Aims**
Energy and Carbon	Energy and carbon monitoring and reduction	To reward monitoring and minimising of energy use and GHG emissions across the infrastructure lifecycle	GHG assessment, commitment to cogeneration and solar PV
	Use of renewable energy	To reward investigation of, and use of, renewable energy.	As above
Materials	Materials lifecycle impact measurement and reduction	To reward design and practice that reduces lifecycle environmental impacts of materials.	Early procurement involvement, design meeting discussing the increased use of precast concrete, and incorporation of lessons learned from LSC
	Environmentally labelled products and supply chains	To reward procurement of major materials that have environmental labels or are from sustainable supply chains.	As above

Outside of the most material categories it's expected that significant categories will also be Urban Design, Ecology and Discharges to Water. Urban Design for the Project has been a central component to the achieving identified Project objectives, meeting environmental standards and sustainable outcomes. The Project's Sustainability team met throughout early design with the Urban Design team to discuss how design could influence sustainability and support the IS rating (Urb-1, Urb-2, Her-1, Lan-4). This alignment ensured continuity of a sustainable approach throughout design and is reflected within the Project's Urban Design report. Water quality and ecological habitat preservation have also been considered and feedback from subject matter experts were fed into the ISCA strategy and scorecard. Water quality and ecology are expected to be significant areas of focus for the Project and it's IS submission.

Due to the 'greenfield' location of the site and scope of the of asset, these results are appropriate and typical. There is a good degree of confidence that when an official IS scorecard is undertaken with ISCA the same categories will be identified as material. The IS analysis shows that design so far is in good alignment with the Lower South Creek's material categories and commitments like minimisation of using non-renewable energy and non-potable water are well placed to support an 'Excellent' rating.

5.3 Sustainability Initiatives from other environmental disciplines

Initiatives from other environmental disciplines which lead to positive environmental impacts and outcomes also contribute to the Projects sustainability performance. These initiatives, which are currently being developed and identified as part of the EIS process, will also contribute to the projects target ISCA rating.

5.4 Climate Change Risk Assessment

As per section 0, a CCRA has been undertaken following a risk assessment and stakeholder consultation to understand the implications of projected climate change on the design, construction and operations of the proposed wastewater treatment and associated ancillary assets. Adaptation options have been considered and included in the design and operational intent of the Project to improve the climate resilience. Table 7 presents those risks rated as high at any point from the present day to 2070.

Bushfires restricting site access is the only high-risk present across the Project's life. High risks in the future (e.g. by 2070) would relate to:

- Increased temperatures impacting chemicals used in operation and causing operational constraints in terms of working outdoors.
- Increased flood risks causing damage to infrastructure, reduced access to the site and impacting wastewater treatment performance.

The full CCRA is provided in Appendix A.

Table 7: Project Medium & High-Risk Adaptation Response Strategy

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
Change in annual mean air temperature										
3	Increased septicity in incoming sewers due to higher anaerobic biological activity (Higher sulphide production)	Increased odour generation at AWRC leading to impacts to surrounding residents	Medium	Medium	Medium	No further adaptation measures proposed as impact not considered high risk		Likely	Minor	Medium
Increase in extreme weather events – increased days >35°C										
5	More hazardous outdoor working conditions due to extreme heat	Increased health and safety issues due to heat exposure	Medium	Medium	High	Management plans in place to outline procedures for working in extreme weather conditions. Shading of footpaths where appropriate.	Investigate opportunities to bring equipment inside and under shelter, building ventilation and green/blue infrastructure to keep the AWRC site cool (e.g. use of irrigation in the days leading up to hot days to	Possible	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
							reduce temperature on site). Passive architectural design to assist with natural cooling of buildings. E.g. orientation, cross wind flows, landscaping and shading of facades and openings			
8	Due to a single extreme event of >49°C temperatures exceed design parameters for expansion and contraction	Higher temperatures cause structural damage cracking, pipe buckling	Medium	Medium	Medium		Review maximum ambient design temperatures for infrastructure	Likely	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
Increased peak precipitation										
9	Increased frequency and intensity of peak wet weather flows to AWRC	Adding to flows beyond assumed to cause more frequent plant bypasses (performance impact) or upstream discharge of sewage if system overloaded (environmental impact). Impacting the network feeding the plant.	Medium	Medium	Medium		Wastewater collection network designed to minimise wet weather infiltration to reduce volume of incoming flows to the AWRC	Possible	Minor	Low

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
10	Increased frequency of peak wet weather inflows to AWRC	More primary treated only water discharging to waterways which may affect the wider Hawkesbury license for nutrient discharge	Medium	Medium	Medium		Reduce infiltration of wet weather flows in the collection network which will reduce the occurrence of primary treated water being released from the AWRC to South Creek	Possible	Moderate	Medium
11	Increase in wet weather sewerage flowrate	Malabar system likely to be at capacity more frequently during wet weather reducing availability for brine release. Reduction in availability of the AWTP therefore releasing less advanced treated water to Nepean River.	Medium	Medium	Medium	• Up to three days storage time for brine tanks to accommodate wet weather events which will allow for the advanced treatment process to continue to operate during this time.		Possible	Minor	Low

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Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
12	Increased flooding risk from South Creek	Inundation leads to damage to infrastructure (e.g. flooding of switchboards), or staff can't access site, resulting in process impacts with reduced quality treated water (performance risk)	Medium	Medium	High	Locate critical infrastructure outside the 1:100 flood level to sufficiently reduce the likelihood of flooding.		Possible	Moderate	Medium
15	Increased frequency high intensity rainfall leading to increased stormwater runoff Flooding risk	Increased stormwater runoff from the site exceeding capacity of stormwater detention facilities	Medium	Medium	Medium	WSUD stormwater facilities will be designed to accept stormwater flows up to 100yr flood events in consultation with relevant councils. Any excess water not contained in the storm water system will make its way into the flood plain.		Possible	Minor	Low

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
16	Increased Flooding risk from South Creek	Flooding from south creek and unsafe working conditions for AWRC operators. Restricted access to assets	Medium	Medium	Medium	AWRC staff will not access certain parts of the AWRC during storms greater than the 100yr flood event Additional security around low level infrastructure		Possible	Minor	Low
Bushfires										
20	Smoke and reduced visibility/air quality resulting from nearby bushfires	Hazardous working environment for AWRC staff	Medium	Medium	Medium	Primary offices and work areas will be air-conditioned with options to recirculate internal air. Will be managed with additional protocols and procedures to ensure safety.		Possible	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures Implemented	Measures for implementation	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
21	Bushfire threat to infrastructure	Fire damage to infrastructure / operational equipment, wiring and electrics and security of energy supply	Medium	Medium	Medium	Bushfire management measures have been incorporated into the reference design of the AWRC to reduce the risk of any potential damage to infrastructure.		Unlikely	Moderate	Medium
22	Bushfires restrict access to AWRC site	Restricted access during bushfire events for operational purposes - potentially causing performance risks.	Medium	High	High	Remote operation capability of site can reduce the frequency and need for staff to be present. As part of the bushfire recommendations provisions will be made for fire suppression and fire trail around perimeter of site		Possible	Moderate	Medium

5.5 Greenhouse Gas Impact Assessment

As per section 0, a GHG assessment has been undertaken to demonstrate the Projects commitment to reducing emissions. The assessment is based on Stage 1 of the Project which comprises the following infrastructure:

- Building and operating the AWRC to treat an average dry weather flow of up to 50ML per day.
- Building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 AWRC.

Additional wastewater treatment infrastructure will be added to the Stage 1 infrastructure via the delivery of 'future stages', which have not been included in this assessment. The GHG impacts of 'future stages' are considered in Appendix B.

Table 8 summarises the total emissions calculated for each GHG scope for Stage 1. The percentage of total emissions is also provided.

Table 8: GHG emissions summary

Summary of scope emissions		
Emissions scope	**Total emissions ($tCO_{2\text{-}e}$)**	**% of total emissions**
Scope 1	163,179	24%
Scope 2	138,732	21%
Scope 3	372,075	56%
Total	673,986	100%

Table 9 presents how the estimated Project emissions compare to regional and national budgets. For ease of comparison, the Project emissions have been converted from tCO_{2e} to $MtCO_{2e}$ where 1 tCO_{2e} = 0.000001 $MtCO_{2e}$.

Table 9: Carbon budgets

Carbon budget comparison				
Total estimated Project emissions ($MtCO_{2e}$)	**Carbon Budget ($MtCO_{2e}$)**		**Project emissions as % of carbon budget**	
	NSW	**National**	**NSW**	**National**
0.674	1,551	5,500	0.04%	0.01%

5.5.1 Mitigation Measures

Following the quantitative assessment of Scope 1, 2 and 3 emissions and comparison to carbon budgets, mitigation measures included within the Project were assessed to estimate the savings that will be achieved, as shown in Table 10. These mitigation measures and savings are linked to the energy commitments within Table 5. Had these measures not been included, the unmitigated total GHG emission inventory would increase from 673,986 to 1,074,019 tCO2-e. Combined, these measures result in a saving of 28.6% when compared to the unmitigated GHG inventory. These measures also directly support Sydney Water's Energy Master Plan which aims to maximise the renewable electricity generation potential of our assets, maximise the economic benefit of our generation and leverage renewable electricity to improve energy security in our system. For further details see section 5.7.2.

Table 10: Mitigation measures

Mitigation measures included			
Mitigation measure	**Description**	**Estimated saving (tCO_2-e)**	**Estimated saving (%)**
Methane capture/flaring	Biogas will be produced in digesters and stored in gas bubbles that sit on the digesters. The majority of methane in the biogas (approximately 60% composition of biogas by volume) will be combusted in cogeneration engines. Although standard practice, direct emissions will be further reduced by flaring when biogas flow exceeds the capacity of cogeneration. This will result in zero fugitive methane emissions throughout the operation of the wastewater treatment facility.	315,000	29%
Co-generation + PV	The capture of methane to generate renewable electricity through cogeneration plant and the installation of solar photovoltaics, will offset electricity that otherwise would be purchased from the grid.	85,033	8%
Total		**400,033**	**29.32%**

5.6 Project alignment with EP&A Regulation 2000 ESD principles

SEARs 58 requires details of how ESD principles (as defined in clause 7(4) of Schedule 2 of the Regulation) will be incorporated in the design and ongoing operation phases of the development. The ESD principles defined in clause 7(4) of Schedule 2 have been detailed in section 3. These include high level principles, concepts and ideologies to be incorporated into the design, construction and operation of the Project including commitments to relevant industry benchmarks, climate change risk mitigation and adaptation and best practice in water, energy and waste. Table 11 outlines how the Project responds specifically to the defined ESD principles.

Table 11 Alignment with EP&A Regulation 2000 ESD principles

EP&A Regulation 2000 ESD principles	
ESD principle	**Project Alignment with ESD principles**
The precautionary principle	The precautionary principle relates to the scientific uncertainty about environmental impacts of during decision-making processes. It states that where there is potential for irreversible environment impact and degradation, the absence of complete scientific certainty should not be a reason to postpone management measures to prevent the potential impact. This principle was considered throughout the options assessment and reference design processes in deciding the preferred location for the AWRC and pipeline alignments and the approach to construction and design. Multi-criteria analysis and risk assessments have been completed throughout the project to ensure serious and adverse damage to the environment is avoided. The EIS communicates and assesses the potential environmental impacts associated with the construction and operation of the project. The EIS has assessed worst-case impacts and has completed detailed technical environmental assessments to minimise environmental risks and identify appropriate environmental management measures. Throughout the development of the EIS, Sydney Water has collaborated with the community and relevant government departments and agencies which has further informed the design and impact assessment process. The project also aligns with a range of Sydney Water and external policy requirements relating to sustainability, as outlined in section 3 . Due to uncertainty in population growth forecasting in the servicing area of the project, multiple sizing and capacity options for the AWRC were considered. The EIS has assessed the worst case scenario by assessing a larger sized plant. An initial ISCA pathway assessment has been completed to assist the project in moving beyond a compliance approach to one that ensures best practice in sustainability and environmental responsibility. There has been a specific focus on ensuring that the AWRC has reduced its carbon emissions as far as practicable, by reducing the reliance on energy from the grid and incorporated technologies, such as photovoltaic solar and co-generation, to produce energy.
Inter-generational equity	Inter-generational equity relates to the equal distribution of economic, social and environmental costs and benefits for current and future generations. The AWRC will be delivered in stages, meaning it can provide wastewater and recycled water services to current and future generations. The environmental assessment and design of the project has considered intergenerational equity by considering the future ultimate capacity of the system and taking into consideration future sensitive receivers. The project's resilience to future changes in climate has been assessed, with specific adaptation measures incorporated into the design and operation. The AWRC will allow for the production of recycled water which will provide water supply security for future generations where the availability of water may reduce under future climate change scenarios. The components of the AWRC have a specific design life, however, the operation of the AWRC as a whole will be required well into the future and will support the needs of the current and future populations in Western Sydney. The project has been designed with a focus on energy efficiency and reduced carbon footprint during operation. This approach will reduce the reliance on the power grid for energy and incorporate technologies, such as solar and co-generation, to produce energy. This will reduce the greenhouse gas emissions of the project and contribute to slowing climate change. Construction and operation of the project will result the consumption of fossils, including diesel, which may negatively impact future generations.

EP&A Regulation 2000 ESD principles	
	The project is considered to align with the principle of inter-generational equity firstly through its consideration of the long-term needs of its stakeholders and the community and has sought to embed ESD principles throughout the design and planning process to achieve these desired outcomes. This has resulted in the uptake of sustainability initiatives which have been integrated into the design and the decision-making process to ensure consistent actions towards desired outcomes through the life of the project, while advancing its social, environmental and economic performance. The project will ensure that consumption of resources and materials during the construction and operation of the asset will be significantly reduced compared to a 'business-as-usual' approach. This will be achieved through applying the rigorous standards prescribed by in the ISCA rating tool. A waste management plan will also be developed to ensure waste is reduced as far as possible and where it can't be reduced, diversion from landfill will be prioritised.
Conservation of biological diversity and ecological integrity	Minimising and avoiding impacts to biodiversity and maintaining ecological integrity is a fundamental component of the outcome of the project. Impacts to biodiversity were considered throughout the development of the reference design, including the options selection process for the AWRC as outlined in Chapter 4. The reference design process was completed with the aim to identify biodiversity constraints, avoid, minimise and manage impacts. Management measures to avoid and minimise impacts to biodiversity including the use of tunnelling construction methodology for pipelines, especially under waterways. This can be seen in areas such as Lansdowne Reserve for the brine pipeline, and along Elizabeth Drive where the treated water pipeline will be tunnelled under a number of waterways. Alignment changes to avoid sensitive biodiversity, such as through Western Sydney Parklands, and along Park Road, Wallacia were also adopted to minimise the overall biodiversity impact of the project. About 13.76 hectares (ha) of native vegetation across eight plant community types (PCTs) will be cleared for the project. This includes impacts to vegetation listed under the NSW Biodiversity and Conservation Act and the Commonwealth Environmental Protection and Biodiversity Conservation Act. The project will result in the removal of the following threatened flora individuals / habitat: • Downy Wattle – 7 individuals, 0.15 ha of known habitat • Native Pear – 1 individual, 0.03 ha of known habitat • Sydney Bush-pea – 4 individuals, 0.01 ha of known habitat • Spiked Rice-flower – 0 individuals, 2.94 ha of expert mapped habitat • The project will result in the removal of the following habitat of 'known' threatened fauna: • 1.54 ha low potential breeding habitat for the Large Bentwing-bat • 1.94 ha additional species credit forage habitat for Large –eared Pied Bat • 7.63 ha of species credit habitat for Southern Myotis • 8.95 ha of expert mapped habitat for Cumberland Plain Land Snail • 14.45 ha of expert mapped habitat for Dural Land Snail. The total impact area of the project equates to about 213 ha, covering over 40 kms of linear area. The removal of 13.76 ha of native vegetation equates to just 6% of the total area impacted by the project. Substantial efforts have been made throughout the project to reduce and minimise

EP&A Regulation 2000 ESD principles	
	impact to native vegetation habitats, and this process has resulted in the residual impacts being largely comprised of degraded, fragmented, and edge effected ecological values. Aquatic ecology impacts are likely to be positive as a result of increased water quality from the release of advanced treated water The EIS outlines the management measures to further minimise impacts to biodiversity, as well as the how the impacts will be offset. The project also seeks to improve biodiversity on the AWRC site as part of landscaping the parkland area.
Improved valuation, pricing and incentive mechanisms	To ensure the successful integration of the principles of ESD and to secure long-term sustainable development, it is important that these measures and incentives are appropriately valued and costed into the project. The project has applied the INSW business case gateway template that specifically addresses the social, economic and environmental sustainability requirements of the project. This will ensure ESD is appropriately considered, valued and priced at each stage of the project lifecycle. This is an important approach to the project as it allows for identification of more sustainable and resilient infrastructure as it can be identified and accounted for effectively in the INSW business case process and recognise the long-term value for the community and the environment.

5.7 Project alignment with Sydney Water and local policy

The following section provides further evidence as to how the key commitments, provided in Table 5, align with Sydney Water Policy objectives. This alignment demonstrates how the key commitments contribute to Sydney Waters overarching goals and ambitions.

5.7.1 Sydney Water Strategy

Table 12 outline how the key commitments align with the strategic objectives of the Sydney Water Strategy.

Table 12 Alignment with Sydney Water Strategy

Current Environment Plan and group plan focus				
Current Environment strategy objective overview	**Environmental Strategic Objectives to 2030**	**Target**	**Relevant Commitment Theme**	**Project Alignment with Strategic Objectives and Targets**
• Objective 1. • Healthy waterways and clean beaches	• Our cities waterways are clean, healthy and safe for swimming and recreation	• See our work contribute to increase proportion of waterways meeting community expectations and environmental objectives • Enhance integrated water planning by working collaboratively with government agencies and stakeholders.	• Water management	• The project aims to protect, maintain, or improve waterway values and has identified waterways objectives against which to measure project impacts. • The objectives are specific to this project and were developed in accordance with the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (OEH 2017). The numerical criteria are sourced from existing guidelines and objectives. Predicted impacts from the project will be assessed against the waterway objectives. The Risk-based Framework defines waterway objectives as consisting of: • community's environmental values and uses of the water • indicator(s) and corresponding numerical criteria to assess whether the waterway will support a particular environmental value or use. • The values and uses adopted for the Nepean and Warragamba Rivers and South Creek are: • aquatic ecology • recreation and aesthetics • primary industries • drinking water (Nepean River only).

Current Environment Plan and group plan focus				
Current Environment strategy objective overview	**Environmental Strategic Objectives to 2030**	**Target**	**Relevant Commitment Theme**	**Project Alignment with Strategic Objectives and Targets**
• Objective 2. Create resilient and liveable places	• Our system is resilient to shocks and disruptions (e.g. we have achieved advanced system reliability and performance) • Our water and waterways are world class and support thriving liveable and sustainable cities	• Be a benchmark leader for climate readiness and service continuity to contribute to our communities being more resilient to a changing climate	• Climate Resilience	• The project will be resilient to a changing climate. The project has committed to managing the impacts of a changing climate by including adaption measures in the reference design to support resilience of the AWRC and pipeline infrastructure. The project will incorporate outcomes from the Adaptwater™ too to embed climate change preparedness within Sydney Water.
• Objective 3. • Care for Nature, Land and Heritage	• Our environmental performance is world class	• Increase the availability of our land for agreed community use of public open space year on year	• Sustainable Communities	• The project will commit to a landscape lead masterplan with particular consideration for water quality, cultural and natural heritage and the role the AWRC will have in the community. Landscaping will have multiple functions which include stormwater management, habitat creation on the riparian corridor, maximising the use of flood prone land, management of bushfire hazards interpretation of aboriginal and non-aboriginal cultural values, opportunities for community interaction with outdoor educational facilities and walking trails. The landscape lead masterplan forms part of the visual mitigation strategy assessed in the Landscape Character and Visual Impact Assessment at section x. Further details of the landscape lead masterplan are discussed at section x.

Current Environment Plan and group plan focus				
Current Environment strategy objective overview	**Environmental Strategic Objectives to 2030**	**Target**	**Relevant Commitment Theme**	**Project Alignment with Strategic Objectives and Targets**
• Objective 4. Efficient and sustainable resource use	• We are a resource recovery business with an increasing portfolio of circular economy products and services • We have made substantial progress towards zero impact on the environment (focus on water, waste and carbon)	• Obtain sustainability benchmark ratings for all major infrastructure projects •	• Sustainable design	• The project will progress a preliminary ISCA scorecard containing indicative credit ratings and will commit to progressing an independent sustainability 'Design' rating using the Infrastructure Sustainability (IS) rating tool. The project will commit to a minimum target rating of 65 points.
		• Provide 75% of our electricity demand from net-zero emissions sources and 100% by 2050[4] • Maintain our grid- sourced electricity demand below 1998 levels[5] • Achieve 35% of our electricity demand for self-generated renewable electricity[6] • Move towards energy self-sufficiency at our major wastewater treatment plans	• Energy	• The project will implement Sydney Water energy masterplan initiatives through a commitment to the generation of renewable energy from recovered biogas to fuel cogeneration and through the installation of solar photovoltaic panels. Specific contribution of project to energy masterplan initiatives are indicated at section x below.

[4] Energy masterplan initiative
[5] Energy masterplan initiative
[6] Energy Masterplan initiative

Current Environment Plan and group plan focus				
Current Environment strategy objective overview	**Environmental Strategic Objectives to 2030**	**Target**	**Relevant Commitment Theme**	**Project Alignment with Strategic Objectives and Targets**
		• Identify alternative uses for biosolids recovered from wastewater treatment to maintain 100% beneficial use of biosolids	• Circular Economy	• The project will promote circular economic processes by committing to 100% beneficial reuse of biosolids generated from the AWRC.
		• Develop innovative servicing solutions that make the best use of water for priority growth areas considering recycled water, stormwater and decentralised approaches	• Circular Economy	• The project will provide opportunities to enhance water resilience in Western Sydney, by providing treated water for residential, commercial and agricultural purposes. There will be opportunity for increased urban cooling and environmental flows providing improvements to waterway health and supporting the vision of the parkland city.

5.7.2 Sydney Water Energy Masterplan

Table 13 shows how the Project aligns with the targets of the Energy Masterplan.

Table 13 Alignment with Energy Masterplan

Key Objective for the Sydney Water Energy Masterplan		
Objective	**Targets**	**Project Contribution**
Minimise Energy Exposure	60% of our electricity costs not exposed to the short-term electricity market by 2030, increasing to 80% by 2050. All key processes not exposed to grid outages by 2030.	The Project is estimated to remove 38% of electricity costs from exposure to the short-term electricity market.
Maximise Energy Productivity	Maintain grid-sourced electricity demand below 1998 levels to 2030. Self-generate 35% of our electricity by 2030 (in line with the NSW Net Zero Plan 2020-2030) by installing 4.5MW of cogeneration & hydro and 13.5MW of solar & wind	The Project is estimated to install 1.2MW of cogeneration and 3.8MW of solar PV, contributing towards 27% and 28% of these targets alone.
Contribute to a Decarbonised Future	Net-zero carbon emission sources (either through onsite renewable generation or through the procurement of off-site renewable electricity) provide 75% of our electricity demand by 2030 and 100% by 2050	The project is estimated to offset 37% of total emissions through cogeneration and solar PV (section 5.5). By reducing carbon emissions, the project will contribute to NSW aspirational objective of net-zero emissions by 2050 Co-generation and solar PV are estimated to provide 38% of the total electricity demand.

All activities related to energy resource recovery, self-generated renewable electricity and energy efficiency would only be delivered where it is reasonable and feasible for Sydney Water to do so. An energy implementation plan has been developed that details the specific actions required to achieve the outcomes listed in Table 13 above.

5.7.3 Western Sydney Aerotropolis Plan 2020

The Western Sydney Aerotropolis Plan (WSAP) was finalised in 2020 (Western Sydney Planning Partnership, 2020a). A range of planning instruments support delivery of the WSAP, including a State environmental planning policy (SEPP), development control plan (DCP) and precinct plan.

The WSAGA is built around the new global gateway of Western Sydney International Airport and contributes to diverse housing and a significant increase in jobs for Western Sydney. It proposes a landscape-led approach, integrating urban planning, landscape and urban design. This includes developing a network of parklands and waterways focused around the South Creek corridor and a foundation of respecting and connecting with Country. The WSAGA will be developed to facilitate and encourage innovative industries, including sustainable food production, and to align with circular economy principles. It will be supported by a range of sustainable and efficient transport options for people and freight.

The project provides an important contribution to the WSAP's vision and aligns with its planning principles. For example, it:

- provides essential wastewater services to facilitate population growth in the WSAGA and service Western Sydney International Airport
- has been designed to safeguard airport operations in terms of building height, lighting and wildlife management
- takes a landscape-led approach to urban design at the AWRC site, including establishing a green space area to form part of the green spine along South Creek, implementing water sensitive urban design and providing opportunities to celebrate heritage
- has been designed to avoid, minimise and manage potential impacts on biodiversity, waterways and flooding
- includes production of renewable energy, beneficial reuse of biosolids and enables further circular economy opportunities over time.

5.7.4 Sydney Water Resilience Policy

Table 14 shows how the Project aligns with the Sydney Water Resilience Policy.

Table 14: Alignment with Sydney Water Resilience Policy

Sydney Water Resilience Policy objectives and Project contribution	
Objective	**Project Contribution**
Resistance: Ability to continue service provision through withstanding and preventing reasonably foreseeable threats, hazards, shocks and stressors.	As identified from the CCRA, the greatest risks posed to the project are due to an increased number of hot days, flooding and bushfire events. The intervention measures described in section 5.4 ensure that the project is able to maximise its resistance to these risks, while increasing reliability and redundancy. These include a management plan to outline procedures for working in extreme heat, free board to reduce flood risk and fire trail/suppression around the site. Procedures to increase the level of preparedness will also be implemented, as well as a continual review and update of the risks and response. This will ensure Sydney Water maintain the appropriate level of response required.
Reliability: Capability of infrastructure and organisation to maintain service and meet obligations in a variety of conditions	
Redundancy: Adaptability of an asset, network or group to maintain service and meet obligations with loss of individual components in a variety of expected conditions	
Response: Preparation for and actions taken during an evolving adverse event to limit impact. Response includes monitoring conditions to guide adaptive strategies and trigger planning and investment.	
Recovery: Restoring vital functions as quickly as possible to limit damage caused by a failure, Lessons learned should be used to improve the resilience of Sydney Water's assets and systems.	

6 Conclusion

This ESD Report has outlined the legislative and policy drivers for implementing sustainability principles into the Project. The goals and objectives of this report, which are to meet the SEARs and contribute to the Project's overarching sustainability goals, have been achieved by:

- Summarising the approach to beyond 'business-as-usual' sustainability initiatives
- Outlining the assessment of Project sustainability with the ISCA ISv1.2 tool
- Summarising the climate change risk and adaptations for the Project
- Summarising the greenhouse gas (GHG) impact and mitigations for the Project

Sydney Water has asserted its commitment to "*deliver a world-class water system that enables sustainable, efficient, and affordable reuse of resources that is appropriate for the future*." This has been demonstrated through a range of key commitments detailed throughout to ensure the responsible use of energy and reduction in emissions; embed circular economy principles; address sustainable water management, climate resilience and urban heat island impacts; and to support developing sustainable communities. This report has demonstrated how these key commitments align with the Projects target ISCA rating, Sydney Water's organisational policy and local policy and strategies.

ESD principles have been embedded throughout the development process and integrated into the Project to contribute towards the achievement of sustainability outcomes which are both technically and economically appropriate.

7 References

Department of Planning, Industry and Environment 2019 *Net Zero Plan Stage 1: 2020-2030*

Greater Sydney Commission 2017 *Western City District Plan – connecting communities*

ISCA. [no date]. *Lower South Creek Treatment Program* [online]. Available from: https://www.isca.org.au/Ratings-Directory/Lower_South_Creek_Treatment_Program [Accessed 10/06/2020 June 2020].

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NSW Government 2020 *Western Sydney Aerotropolis Plan*

Office of Environment and Heritage, 2016 *NSW Climate Change Policy Framework*

Office of Environment and Heritage, 2019 *NSW Government Resource Efficiency Policy*

Sydney Water (no date), *Lower South Creek Treatment Program* available from https://www.sydneywatertalk.com.au/lower-south-creek-treatment-program [Accessed 10/06/2020 June 2020]

Appendix A - Climate Change Risk Assessment

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Upper South Creek Advanced Water Recycling Centre

Climate Change Risk Assessment

Job title	Upper South Creek Advanced Water Recycling Centre			Job number	
Document title	Climate Change Risk Assessment Draft 2			File reference: as above	
Document ref	Draft 2				

Revision	Date	Filename	Climate Change Risk Assessment Draft 1		
Draft 1	21/04/2020	Description			
			Prepared by	**Checked by**	**Approved by**
		Name	Linda Slechta Ethan Monaghan-Pisano	Lauren Delony	Miranda Snowdon
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Draft 2	26/02/2020	Filename	Climate Change Risk Assessment Draft 2		
		Description	Draft 2 following Draft 1 comments		
			Prepared by	**Checked by**	**Approved by**
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Draft Final	15/03/2021	Filename	Climate Change Risk Assessment Draft Final		
		Description	Responding to Draft 2 comments		
			Prepared by	**Checked by**	**Approved by**
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		Signature			
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		Description	Responding to Draft Final Comments		
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		Signature			

Issue Document Verification with Document ✓

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1 Introduction

The climate has already changed over the past decades impacting both the built and natural form, through heatwaves, more intense extreme weather, and bushfires. Projected changes in our climate are predicted to further exacerbate these risks, meaning what we design and build today needs to be adaptable for the future climate.

The purpose of this assessment is to understand the implications of projected climate change on the design, construction and operations of the proposed wastewater treatment plant (known as the Upper South Creek Advanced Water Recycling Centre) and associated ancillary assets including new pipelines for connection to existing systems. The assessment seeks to satisfy the specific Secretary's Environmental Assessment Requirements (SEARs) matters 61 and 62. The below table provides details of each SEARs requirements and outlines where each matter is addressed in the following report.

Table 1-1 Project SEARS requirements

SEARs matter to be addressed by study		Location SEARs addressed in the report
61.	Assessment of the risk and vulnerability of the Project to climate change in accordance with the current guidelines, including any Regional Water Strategy and associated climate change modelling as relevant to the Project.	Section 5 and 6
62.	Quantified specific climate change risks with reference to the NSW Government's climate Projections and incorporate specific adaptation actions in the design.	Section 5, 6 and 7
63.	An assessment of potential future climate variability impacts on the operation and management of the Project and associated delivery works (such as water deliver by way of river operations, or pipe infrastructure), having regard to research on groundwater recharge and surface run-off and the NSW Climate Impact Profile.	Sections 6 and 7

2 Project description

Sydney Water is seeking approval for construction and operation of a wastewater treatment plant, known as the Upper South Creek Advanced Water Recycling Centre in Western Sydney. The project site is located within the Western Parkland City on the confluence of Kemps Creek and South Creek. The site is surrounded by semi urban land, with the Blue Mountains National Park located to the west. There are currently a small proportion of residential and rural properties in proximity of the site, with the creation of new communities proposed with the development of surrounding greenfield and the nearby Aerotropolis. The project consists of the following:

- a wastewater treatment plant that includes production of:
  - high quality treated water suitable for a range of uses including recycling and environmental flows
  - renewable energy
  - biosolids suitable for beneficial reuse
- new pipeline from the Water Recycling Centre to the Nepean River, to release excess treated water
- new infrastructure from the Water Recycling Centre to South Creek, to release excess treated water and wet weather flows
- new pipeline extension from the new Nepean River pipeline to the Warragamba River for environmental flows
- new pipeline from the Water Recycling Centre to Sydney Water's existing wastewater system to discharge brine.

The concept component of the project comprises all the above elements, with the Water Recycling Centre (AWRC) sized to treat an average dry weather flow of up to 100ML/day, and to transport and release the equivalent volume through the pipelines.

Sydney Water is also seeking detailed approval for Stage 1 which comprises:

- building and operating the Water Recycling Centre sized to treat an average dry weather flow of up to 50ML/day
- building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 Water Recycling Centre.
- The timing and scale of future stages will be phased to respond to drivers including population growth rate and the most efficient way for Sydney Water to optimise its wastewater systems. Together, the AWRC and associated treated water and brine pipelines will be known as the 'project'. An overview of the site location is provided in Figure 1.

Figure 1 Site context

Upper South Creek Advanced Water Recycling Centre

Treated Water Pipeline

Brine Pipeline

Environmental Flows Pipeline

Projection: GDA 1994 MGA Zone 56
Project infrastructure locations are indicative and will be refined during design

3 Policy context

This section identifies the key legislation and policy relevant to this assessment as well as key drivers that will inform Sydney Waters future climate adaptation strategy.

Table 3-1 Legislation and policy context

Policy Document	Description	Relevance to study
The National Climate Resilience and Adaptation Strategy (2015)	The strategy articulates how Australia is managing the risks of a variable and changing climate. It identifies a set of principles to guide effective adaptation practice and resilience building and outlines the Government's vision for a climate-resilient future.	In accordance with the Strategy, significant climate risks will be identified over the life of the Project, enabling adaptation to be prioritised to enhance resiliency and adaptivity.
NSW Climate Change Policy Framework (2016)	The Climate Change Policy Framework developed by the NSW Government endorses the Paris Agreement, and complements actions consistent with the level of effort to achieve Australia's commitments to the Paris Agreement. The framework sets policy directions to guide implementation of the framework and NSW commitments to achieving long term objectives of net zero emissions and resiliency to climate change.	The Project seeks to align with Sydney Water's Environment Strategy that aims to meet NSW's aspirational objective of net-zero emissions by 2050, increase resilience to a changing climate, connect with customers and use water in the landscape to shape liveable places.
Metropolitan Water Plan (2017)	NSW Government's plan to ensure sufficient water to meet the needs of the people and environment of the Greater Sydney region now and for the future.	This climate change risk assessment seeks to align with the goals and outcomes of this Plan by delivering an asset that is resilient to shocks and stresses by identifying and mitigating risks to water security.
AS 5334 Climate change adaptation for settlements and infrastructure - A risk based approach	Provides principles and generic guidelines on the management of the risks that settlements and infrastructure face from the impacts of climate change. In particular it describes a systematic approach to planning the adaptation of settlements and infrastructure based on the risk management process given in AS/NZS ISO 31000:2009.	This climate change risk assessment has been developed in line with the recommendations of this standard
AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines and ISO/IEC 31010 Risk Management – Risk assessment techniques	ISO 31000 helps organizations develop a risk management strategy to effectively identify and mitigate risks, thereby enhancing the likelihood of achieving their objectives and increasing the protection of their assets. Its overarching goal is to develop a risk management culture where employees and stakeholders are aware of the importance of monitoring and managing risk. Implementing ISO 31000 also helps organizations see both the positive opportunities and negative consequences associated with risk, and allows for more informed, and thus more effective, decision making	This climate change risk assessment has been developed in line with the recommendations of this standard

Policy Document	Description	Relevance to study
Infrastructure Sustainability Council of Australia, IS Rating Tool v.1.2, credits 'Cli-1' and 'Cli-2'	The ISCA rating tool (IS rating tool) was developed in collaboration with industry to drive and measure sustainability within infrastructure projects and assets. The IS version 1.2 (ISv1.2) tool builds on current guidance and practices. It provides industry with an incentive to achieve sustainability performance outcomes in the planning, design, construction and/or operations phases.	The project will be targeting an 'excellent' ISCA rating and therefore the requirements of credits 'Cli-1' and 'Cli-2' have been applied to this risk assessment. The credits reward projects that assess climate change risks and implement suitable adaptation measures.
Climate Change impacts and risk management. A guide for business and government	Provides a guide for integrating climate change impacts into risk management and other strategic planning activities in Australian public and private sector organisations.	This climate change risk assessment has been developed in line with the recommendations of this standard

3.1 AdaptWater

The Climate Change Adaptation Program (2008-2010; 2010-2013) was a three-year program undertaken to qualitatively assess the impacts of climate change on Sydney Water's infrastructure, maintenance and operations and understand the vulnerability of the business to these impacts. The key finding of this assessment identified many of the recognised risks which were already being addressed within the organisation, however climate change could alter the likelihood and consequence of these risks occurring.

As a result of this, costed and prioritised adaptation options for the business to implement were developed, resulting in the development of AdaptWater, a climate change adaption quantification tool and information hub for the water industry. Implementation of AdaptWater allows the assessment and quantification of the impact of climate change and extreme events on Sydney's water supply and sewerage assets and compares adaptation responses. The technology behind the AdaptWater tool has been subsequently expanded in development of the now named XDI tool (Cross Dependency Initiative) which assesses and quantifies extreme weather climate change impacts on a wide range of utility assets.

The XDI tool was reviewed at a high level, with similar inputs and variables to this qualitative assessment used to determine what, if any high or extreme risks were evident at the site as a result of changing future climate conditions. The outputs indicated potential hazards relating to soil movement as the highest contributor to risk at the site, with hazards associated with extreme heat contributing to the highest probability of asset failure, with increasing risk across the projection timescales. Whilst these risks were identified within the XDI report, the actual risk rating output was low in consideration of the asset's location and design life, with a low XDI asset risk rating overall.

Identification of these risks are in line with those considered within this CCRA as part of the assessment undertaken with the design team. Notwithstanding, appropriate adaptation measures have been identified as part of this assessment and can be further validated from a cost benefit perspective during later design stages through the use of the XDI tool. This climate change risk assessment will draw out specific risks relevant to the project to help inform inputs into the tool, which can be used to guide impact mapping and compare adaptation options across Sydney Water's assets.

3.2 Infrastructure Sustainability Council of Australia

The ISCA rating tool (IS rating tool) was developed in collaboration with industry to drive and measure sustainability within infrastructure projects and assets. The IS version 1.2 (ISv1.2) tool builds on current guidance and practices, it provides industry with an incentive to achieve sustainability performance outcomes in the planning, design, construction and/or operations phases.

- The IS rating tool aims to:
  - Provide a common language for sustainability in infrastructure
  - Provide a vehicle for consistent application and evaluation of sustainability in tendering processes
  - Help in scoping whole-of-life sustainability risks for Projects and assets, enabling smarter solutions that reduce risks and costs
  - Foster resource efficiency and waste reduction, reducing costs
  - Foster innovation and continuous improvement in the sustainability outcomes from infrastructure
  - Build an organisation’s credentials and reputation in its approach to sustainability in infrastructure

Across Australia the IS rating tool has become a standard measure of performance for major infrastructure programs and projects with 63 certified projects to date. The IS rating tool is also a recognised standard by many investors who consider this a material factor in asset valuations. This is because it can help create more efficient and resilient assets, increasing the assets value and lowering risk.

The Project will aim to achieve an excellent rating (e.g. a score above 65 points). This will help set quantifiable benchmarks to monitor and measure performance and will clearly define the project team actors and their responsibilities for achieving the target ISCA rating. Achieving this target will require alignment with the requirements of IS v1.2 credits ‘Cli-1’ and ‘Cli-2’ which are detailed below. This report will provide input into the further climate change risk assessment which will test the identified impacts through the project lifecycle to influence detailed design and construction requirements.

	Level 1	Level 2	Level 3
Benchmark	A readily available climate change projection is identified and adopted for the asset region over the forecast useful life of the asset. AND Direct climate change risks to the asset over the forecast useful life are identified and assessed.	The requirements of Level 1 are achieved. AND A number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset. AND The climate change risk assessment also considered indirect climate change risks to the asset. AND A multi-disciplinary team participated in identifying climate change risks and issues.	The requirements of Level 2 are achieved. AND Modelling is undertaken to characterise the likely impacts of the projected climate change for all High and Extreme priority climate change risks. AND A comprehensive set of affected external stakeholders participated in identifying climate change risks and issues.
Evidence	Climate change study report showing identification and adoption of a suitable projection. Risk register or report.	Evidence as for Level 1 Minutes of risk assessment meeting(s).	Evidence as for Level 2. Model(s) of impacts from high and extreme priority climate change risks.

Figure 2: IS v1.2 'Cli-1 Climate change risk assessment'

	Level 1	Level 2	Level 3
Benchmark	Adaptation options to treat all extreme and high priority climate change risks are identified, assessed and appropriate measures implemented. AND After treatment there are no extreme priority residual climate change risks.	The requirements of Level 1 are achieved. AND Adaptation options to treat 25-50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented.	The requirements of Level 2 are achieved. AND The optimal scale and timing of options is addressed (which may be triggered by when a specific climate threshold is likely to be achieved). AND Adaptation options to treat at least 50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented. AND After treatment there are no high priority residual climate change risks.
Evidence	Risk register or report. Report(s) or management plans demonstrating that adaptation measures from the risk register have been implemented.	Evidence as for Level 1.	Evidence as for Level 2.

Figure 3 IS v1.2 'Cli-2 Adaptation Measures'

3.3 UN Sustainable Development Goals

The UN SDGs have been used as a framework to explore and prompt potential opportunities that could be utilised and incorporated in design or realised later in operations. SDG theme 13 *Climate Action* focuses on the need to take urgent action to combat climate change and its impacts. Consideration and planning for future climate change and its impacts will help reduce potential risk on the project infrastructure over time whilst also contributing to a low carbon future.

4 Historic and existing climate context

This section provided a snapshot of the historic and existing climate for the Sydney Area. Sydney has a temperate climate with warm and hot summers, mild springs and autumns and mild to cool winters (City of Sydney, 2018). The following figures 4 - 6 illustrate the climate statistics from the Bureau of Meteorology (BoM) between 1965 and 2018 for Prospect Reservoir, the closest weather station with long term climate statistics and similar climate conditions to the subject site, located approximately 4 km to the north east of the site. While the project spans across a significant area, the change in climatic conditions is considered negligible. The key observations are:

- annual mean maximum and minimum temperatures are 22.2^{o}C and 12.3^{o}C respectively; the mean number of days per year above 35^{o}C is 10 days
- the total annual mean rainfall is 873.7mm, with mean rainfall higher in February and March; the mean number of days per year with rainfall above 10mm is 23.9 days
- relative humidity (RH) at 9am typically ranges between 65-80%, and RH is generally greater in the autumn months
- Sydney has north-westerly prevailing winds, winter is typically windier than other months with a mean wind speed of up to 10km/h at 9am.

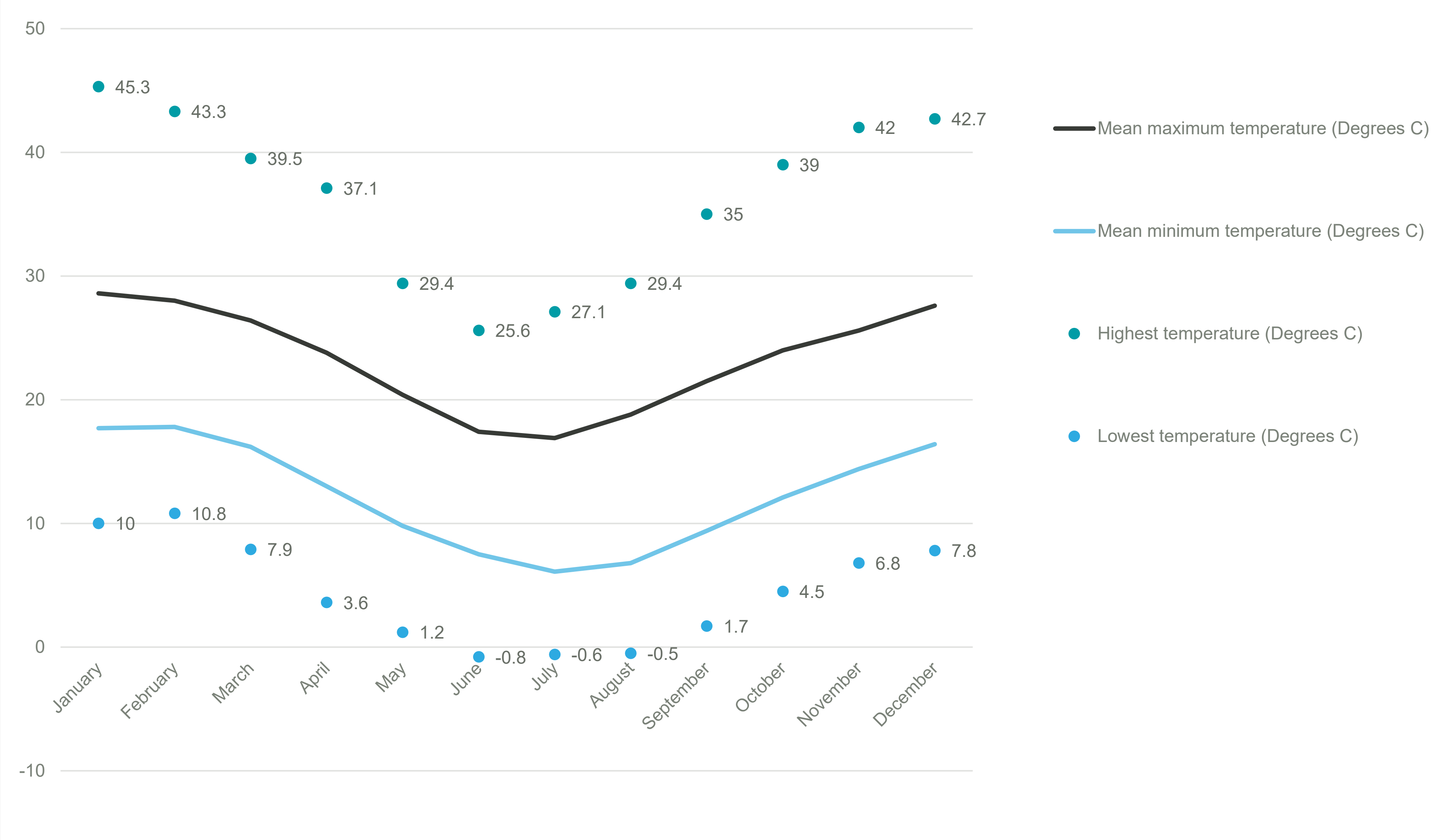
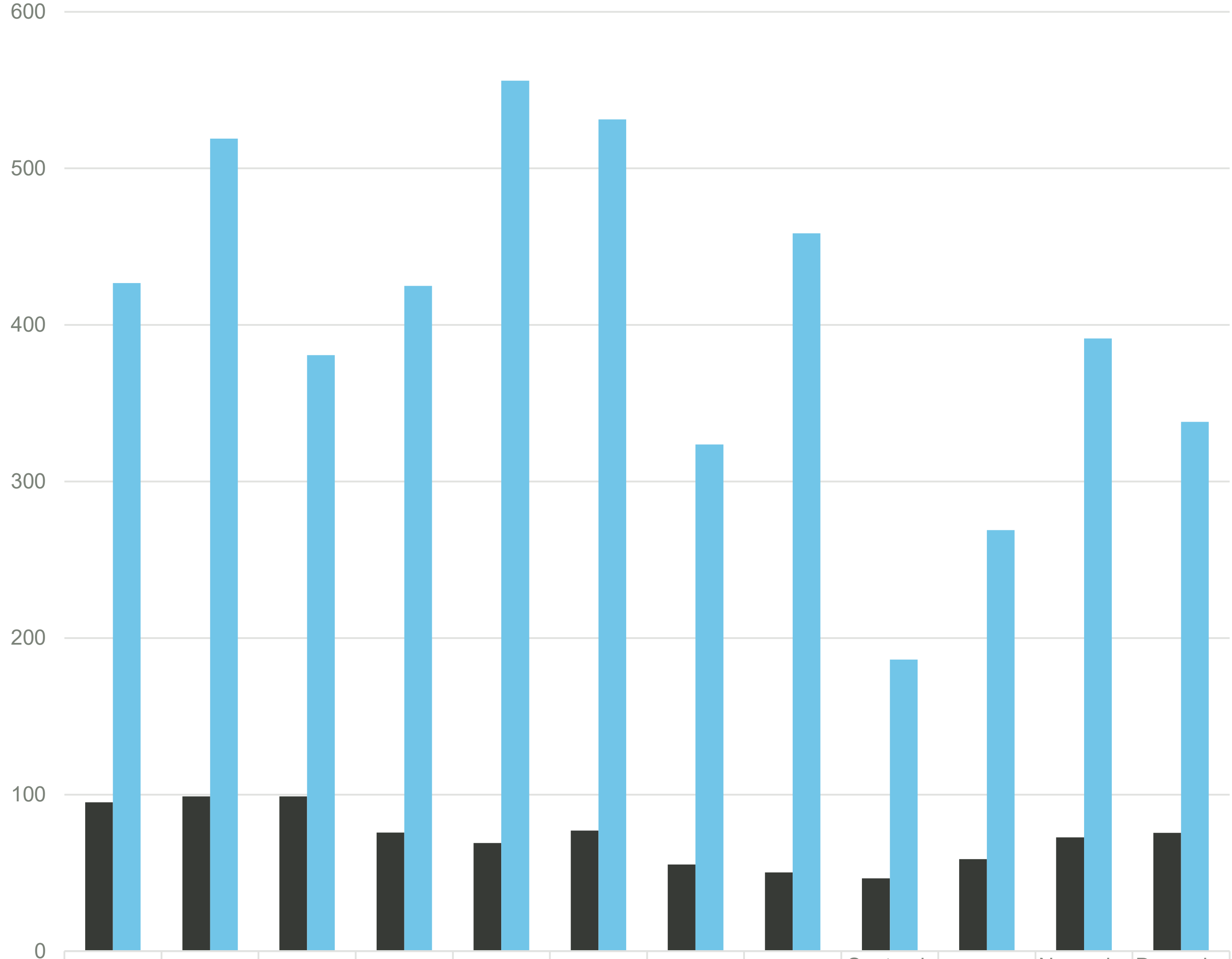
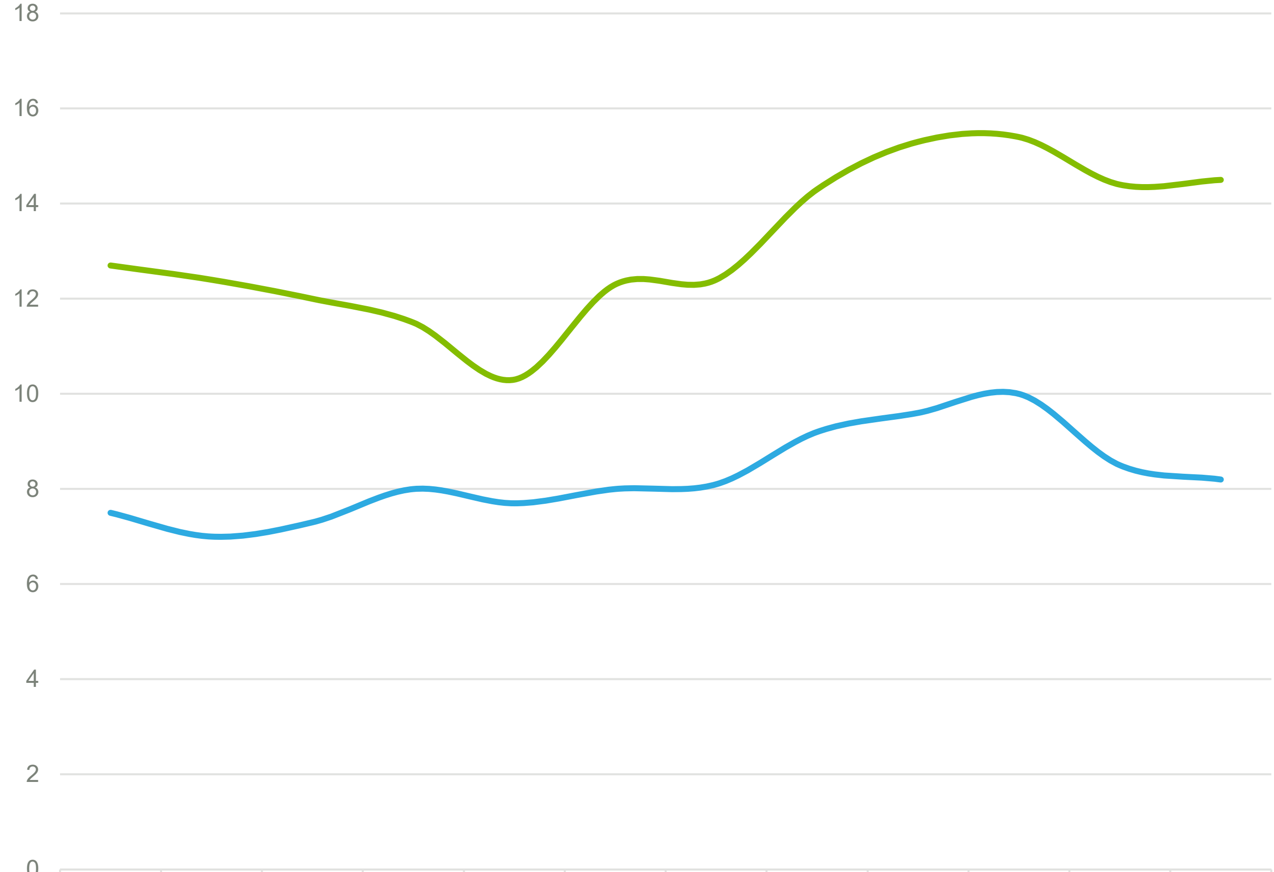


Figure 4: Statistical temperature data between 1965 and 2018 (BoM, 2020)



	January	February	March	April	May	June	July	August	September	October	November	December
Mean rainfall (mm)	95.1	98.8	98.8	75.7	69	77	55.4	50.2	46.5	58.8	72.6	75.5
Highest rainfall (mm)	426.7	519.1	380.7	425	556	531.3	323.7	458.5	186.3	269	391.3	338.1

Figure 5: Statistical rainfall data between 1887 and 2020 (BoM, 2020)



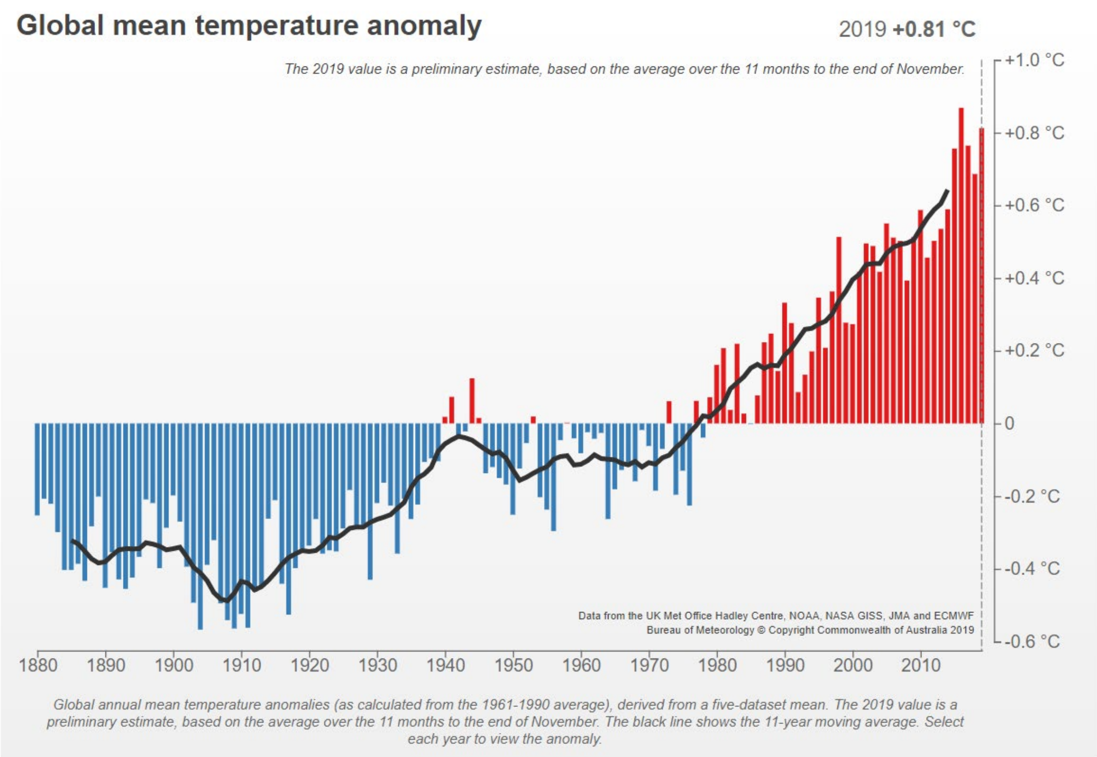
	January	February	March	April	May	June	July	August	September	October	November	December
Mean 9am wind speed (km/h)	7.5	7	7.3	8	7.7	8	8.1	9.2	9.6	10	8.5	8.2
Mean 3pm wind speed (km/h)	12.7	12.4	12	11.5	10.3	12.3	12.4	14.3	15.3	15.4	14.4	14.5

Figure 6: Statistical relative wind speed data at 9am and 3 pm between 1969 and 2001 (BoM, 2020)

4.1 Mean temperature anomalies

Australia's warmest year on record; 2019 had an annual national mean temperature 1.52 °C above average, surpassing the previous record of +1.33 °C in 2013. Warmth was widespread and persistent throughout 2019 — January, February, March, April, July, October, November, and December were all amongst the ten warmest on record for Australian mean temperature for their respective months. January, March, and December were the warmest on record, with January and December exceeding their previous records by a substantial 0.98 °C and 1.08 °C respectively.

The following charts are from global and national data which demonstrate mean temperature anomalies year on year.



Global mean temperatures were above average throughout 2019, with all months to November amongst the four warmest on record for their respective months.

Figure 7: Global mean temperature anomalies (1880 – 2010) (BOM, 2019)

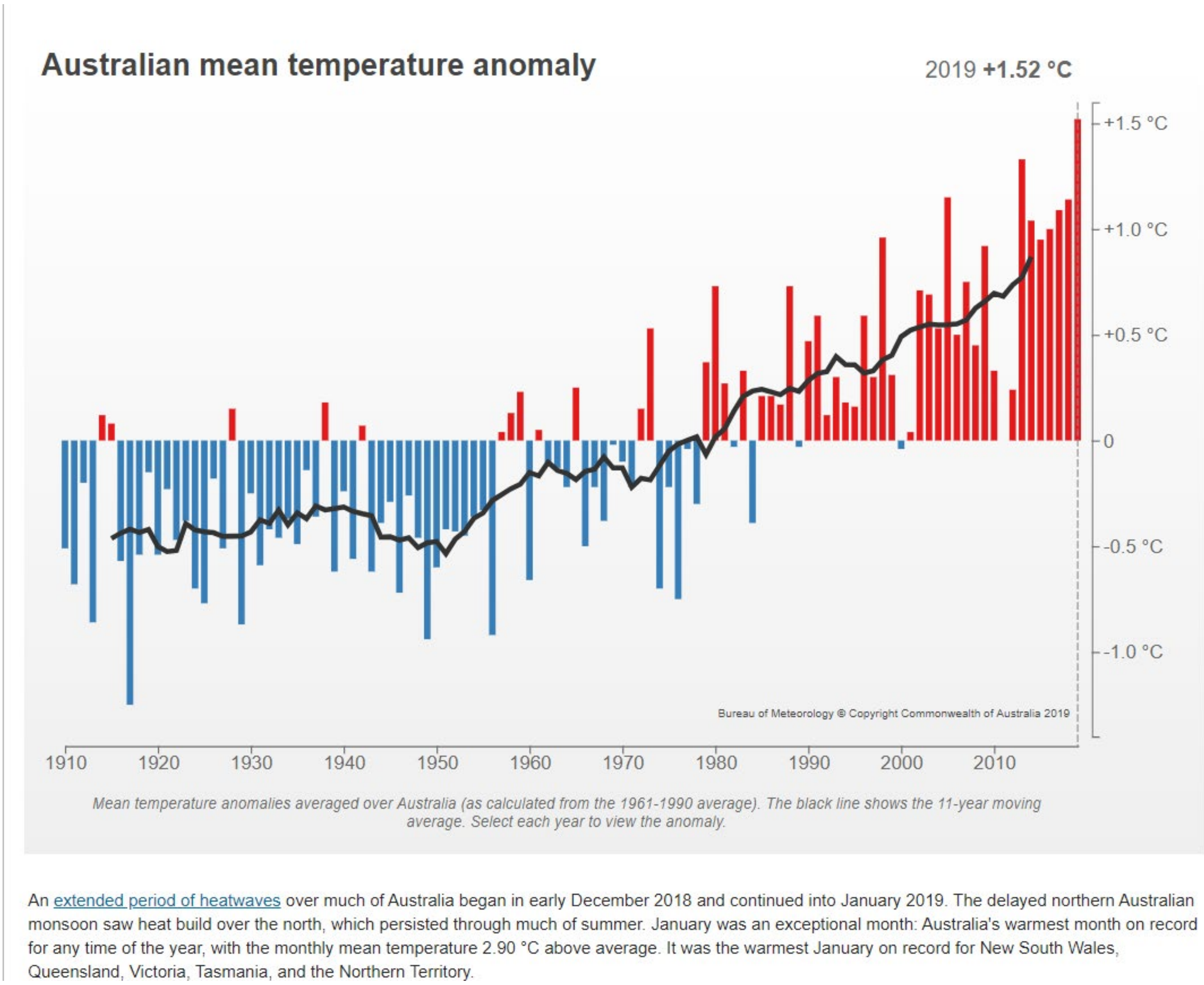


Figure 8: Australian mean temperature anomalies (1910 – 2010) (BOM, 2019)

4.1.1 Greater Sydney regional variances

While the average temperatures reflect the overall scenario, the variance on a local scale between western Sydney and the CBD regions is significant. The western suburbs of Sydney tend to be significantly hotter than the CBD area, mostly due to the built environment - urban sprawl exacerbating the urban heat island effect and geography - less exposure to mitigating sea breezes. The Sydney Water commissioned study *Cooling Western Sydney* identified suburbs in western Sydney experience temperatures 6 – 10°C higher during extreme events in the summer months compared to the eastern suburbs.

Data from the Greater Sydney Commission resilient city dashboard compares the number of days with temperatures exceeding 35°C during 2018-19 across the greater Sydney region. Over the 2018-19 summer, Penrith in the western city district, experienced 37 hot days over 35°C, while during the same period, Terrey Hills and the CBD area experience only six hot days of the same magnitude (Greater Sydney Commission, 2019) as represented in Figure 9.

Figure 10 shows the historic trend of days greater than 35°C over time at three locations spanning from western Sydney to the CBD region. This indicates while there are fluctuations over time, the current trend shows an overall increase in the number of days >35°C.

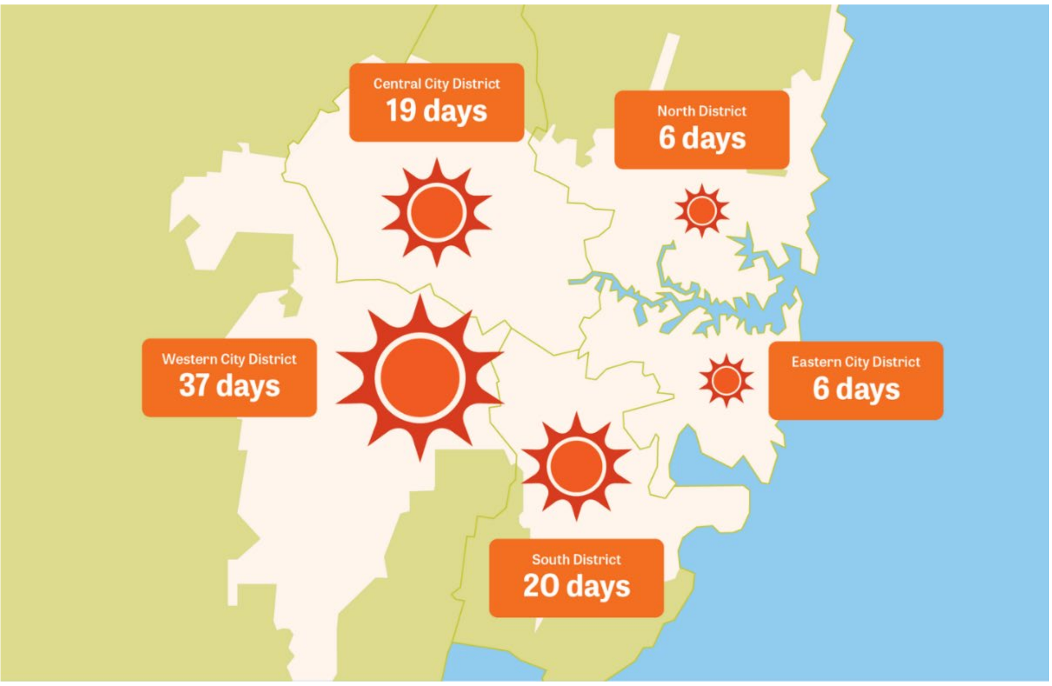


Figure 9: Average number of days with temperatures >35°C during 2018-19 (BoM, 2019)[1]

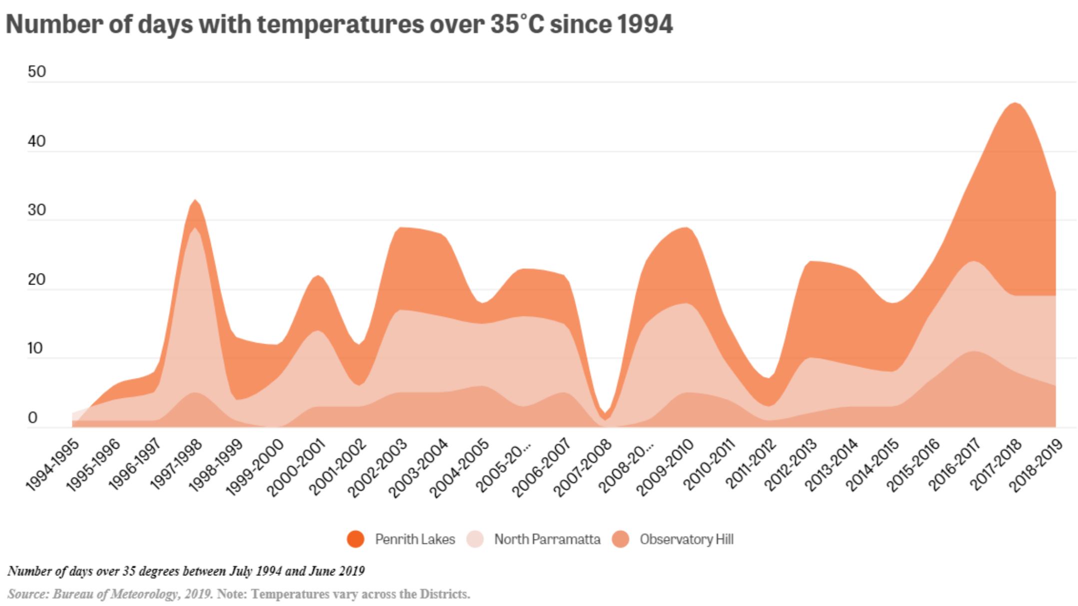


Figure 10: Actual Number of days with temperatures >35°C since 1994 (BoM, 2019)

[1] Note: Temperatures vary across the Districts. Weather stations shown above are for Penrith Lakes (Western City District), North Parramatta (Central City District), Observatory Hill (Eastern City District), Terry Hills (North District) and Bankstown Airport (South District).

5 Methodology

In the development of the Climate Change Risk Assessment (CCRA) for the project, the climate risk and adaptation assessment has been undertaken in three stages:

1. Determining relevant scenarios of present and future climate change for use in risk assessment;
2. A preliminary risk assessment;
3. Stakeholder consultation and risk validation.

This assessment aligns with the objectives of the Metropolitan Water Plan for Sydney (2017) by identifying the most significant risks for the project due to a changing climate and identifying possible adaptation actions to mitigate these risks. Any potential change in risk to the design and operational scenarios would be reassessed as part of the EIA for future stages (which doubles capacity of the facility), to ensure the appropriate adaptation measures are still relevant and appropriate.

This assessment has been developed in accordance with:

- the recommendations of AS5334 Climate change adaptation for settlements and infrastructure— A risk based approach
- the requirements of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) rating tool credits ‘Cli-1’ and ‘Cli-2’ (v1.2).

5.1 Present and future scenarios for climate change

The first stage of the climate change risk assessment was the identification of the present or ‘baseline’ climatic conditions for the project area using historic data from Commonwealth Scientific and Industrial Research Organisation (CSIRO), Bureau of Meteorology (BOM) Climate Change and NSW and ACT Regional Climate Modelling (NARCliM). CSIRO’s Australian Climate Futures (Climate Futures), and NARCliM data was then then used to project future climate change scenarios using selected greenhouse gas (GHG) concentrations, details on the GHG concentration pathways embedded into CSIRO and NARCliM are provided below.

5.1.1 GHG Concentration Pathways

5.1.1.1 CSIRO - Representative concentration pathways (RCPs)

In 2013, the International Panel on Climate Change (IPCC) released its Fifth Assessment Report. This incorporated the latest versions of climate models and focuses on a new set of scenarios. These scenarios span a range of plausible concentration pathways called RCPs.

The RCPs describe four plausible climate futures for the project, changing the levels of greenhouse gasses emissions that could be expected.

The RCPs are:

- RCP 2.6 – assumes global annual GHG emissions (measured in CO2-equivalents) peak between 2010-2020, and then decline substantially thereafter
- RCP 4.5 – assumes global annual GHG emissions peak around 2040, and then decline
- RCP 6 – assumes global annual GHG emissions peak around 2080, and then decline
- RCP 8.5 – assumes global annual GHG emissions continue to rise throughout the 21st century

The climate models developed by CSIRO suggest that global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP 2.6.

5.1.1.2 NARCliM - Special Report on Emission Scenarios (SRES)

In 2010, the SRES outlined emission scenarios that were used in the IPCC's ensemble of climate models for its Fourth Assessment Report. These ranged from A1FI, a future world of rapid economic growth with fossil-intensive technologies to B1, rapid transformation to a service and information economy with clean and resource-efficient technologies. In contrast to CSIRO, NARCliM adopts a single emission scenario, SRES A2, which projects warming of approximately 3.4°C by 2100. SRES A2 has a similar trajectory to that of RCP 8.5 up to the mid 2030's. However, beyond this point RCP 8.5 follows a steeper incline of CO_2 concentration, as shown by Figure 11.

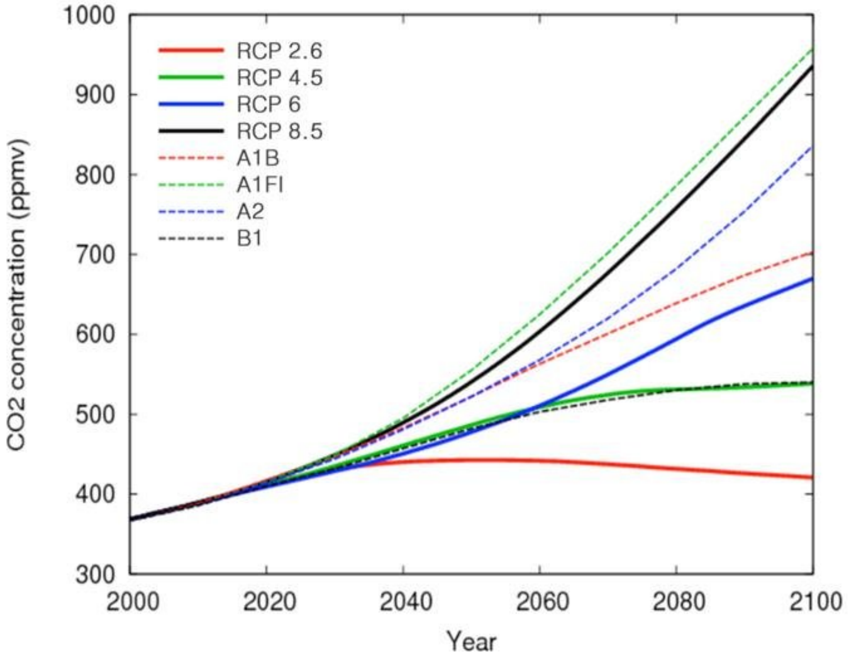


Figure 11: Comparison of Carbon dioxide concentrations scenarios

5.1.2 NARCliM and CSIRO Comparison

The most notable difference between the emission pathways embedded into CSIRO and NARCliM, is that CSIRO allows comparison of the four separate RCPs, while NARCliM includes just one pathway, SRES A2. The two also differ in terms of data granularity, NARCliM was developed to respond to the need for high resolution climate change projections at the state level, thus data can be generated at a 10-kilometre grid scale providing greater resolution. Meanwhile CSIRO is nationwide and typically uses resolution over hundreds of kilometres. It should also be noted that NARCliM only provides projections for temperature, precipitation and bushfires.

For this assessment, both CSIRO and NARCliM have been used for the climate projections for completeness. This is also in response to the IS v1.2 'Cli-1' recommendation to allow the design to explore the effects of different model sensitivities. In addition, the use of NARCliM satisfies the SEARs requirement to quantify risk with reference to the NSW Government's climate projections.

To compare different model sensitivities, CSIRO RCP 4.5 and RCP 8.5 were used. RCP 4.5 is considered an intermediate scenario which assumes a stabilisation of GHG emissions following a peak in the near future, whereas RCP 8.5 is considered a worst-case scenario with modest rates of technological change and energy intensity improvements and with weak climate policy commitments, leading in the long term to high energy demand and GHG emissions.

Two time periods, 2030 and 2070 were selected to establish climate scenarios that represent the near-term and long-term design life of the wastewater infrastructure and associated assets. Combining this with the adopted projections, the future climatic scenarios for this risk assessment were: 2030 RCP4.5, RCP 8.5 & SRES A2 and 2070 RCP 4.5, RCP 8.5 &SRES A2.

The results of these climate change projections are found in Section 6 where Table 6-1 and Table 6-2 provide a summary of the projections for the below where applicable:

- Annual mean max. temperature
- Annual mean min. temperature
- Number of hot days (>35°C)
- Annual rainfall
- Sea-level rise
- Relative Humidity change
- Drought
- Flood
- Wind
- Cyclones
- Bushfires

5.2 Risk assessment

Once the climate change projections had been established, the second stage involved conducting a preliminary risk assessment to develop an understanding of climate change risks. A preliminary likelihood & consequence assessment was undertaken to determine potential risks (likelihood and consequence) for the project, and the potential risks to people.

Stakeholder engagement was carried out to identify the potential impacts from the climate projections for 2030 and 2070. Where CSIRO and NARCliM had varied projections, the most extreme of the projections were assumed. A risk assessment was then undertaken to assess the potential impacts identified for the development.

It is recognised Sydney Water use a different version of the risk matrix for asset purposes to inform appropriate planning and design. While there are slight differences in the consequence scale and measure of likelihood between the two matrices, the overarching intent is similar. For the purpose of this climate change risk assessment and in order to demonstrate alignment with the requirements of the IS rating tool, the risk matrix outlined in AS5334 has been adopted in line with national best practice for sustainability around a risk-based approach for climate change adaptation.

5.2.1 Risk assessment approach

To evaluate the risks associated with impacts as a result of the projected climate change for 2030 and 2070 timescales, a qualitative risk assessment framework in line with the AS 5334 was undertaken. The risk management process is illustrated in Figure 12.

Risk is defined as the combination of consequences and likelihood. For each potential climate impact, the consequences and likelihood of occurrence were determined in accordance with Table 5-1 and Table 5-2. The risk rating for each combination of consequences and likelihood was outlined in Table 5-3.

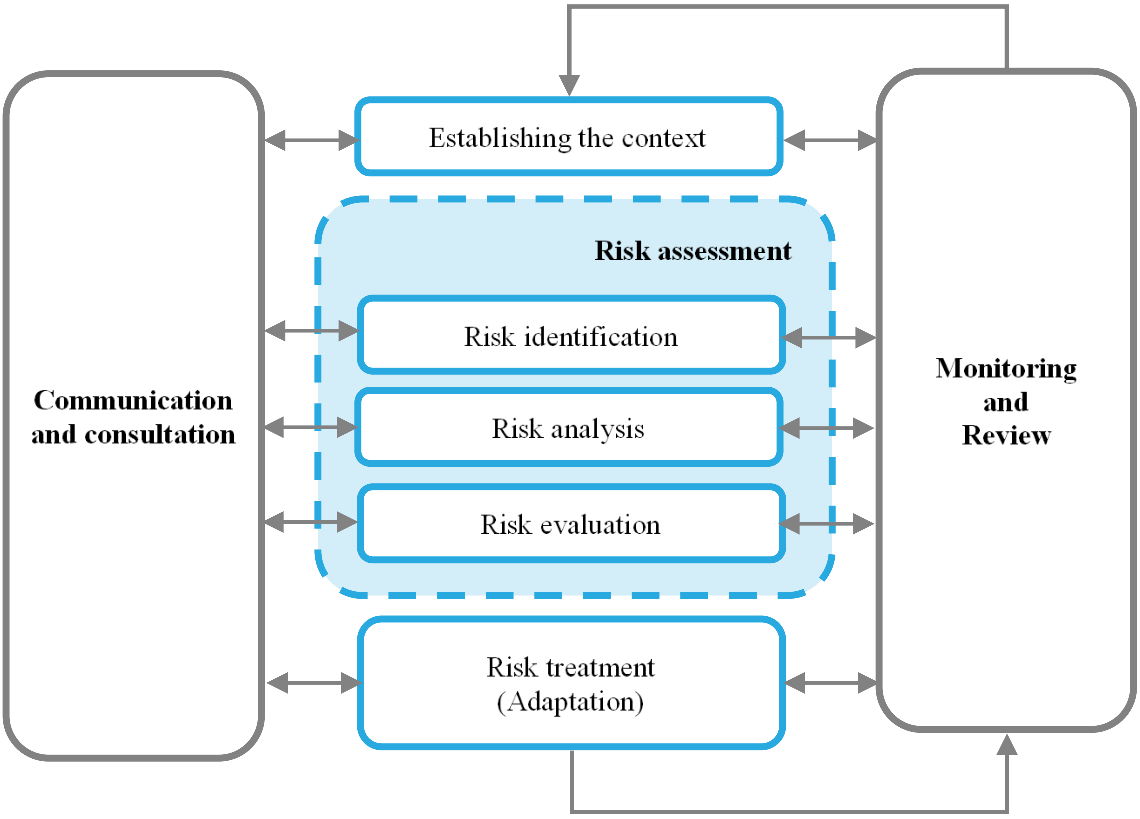


Figure 12: Risk management process (adapted from AS 5334-2013)

Table 5-1: Consequence scale

Level	Descriptor	Consequence	Environmental	Social	Financial
1	**Insignificant**	No change, limited impacts	No adverse effect on natural environment	No adverse human health effects or complaints.	Insignificant financial loss
2	**Minor**	Localised service disruption. No permanent damage. Some minor restoration work required. Lifespan reduced by 10-20%	Minimal effects on the natural environment.	Short-term disruption to employees, residents or businesses. Slight adverse human health effects or general amenity issues. Negative reports in local media.	Additional operational costs. Minor financial loss
3	**Moderate**	Widespread damage. Damage recoverable by maintenance and minor repair. Partial loss of local infrastructure. Lifespan reduced by 20-50%.	Some damage to the environment, including local ecosystems. Some remedial action may be required	Frequent disruptions to employees, residents or businesses. Adverse human health effects. Negative reports in state media.	Moderate financial loss
4	**Major**	Extensive damage requiring extensive repair. Lifespan reduced by >50%.	Significant effect on the environmental and local ecosystems. Remedial action likely to be required.	Permanent physical injuries and fatalities may occur from an individual event. Negative reports in national media. Public debate about performance.	Major financial loss
5	**Catastrophic**	Permanent damage and/or loss of service Retreat and translocation of development.	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be requirement.	Severe adverse human health effects – leading to multiple events of total disability or fatalities. Emergency response. Negative reports in international media.	Significantly high financial loss

Table 5-2: Likelihood scale

Level	Descriptor	Description	Recurrent risk
A	**Almost Certain**	Event is almost certain to occur (90% probability) within the next 12 months or is imminent.	May occur several times per year
B	**Likely**	Event is likely to occur within the next 12 months (greater than 60% probability).	May arise about once per year
C	**Possible**	Event is possible within the next 12 months (30% probability) OR, has a reasonable chance (more than 50% probability) of occurring in next 3 years.	May arise once in 10 years
D	**Unlikely**	Event is not likely to occur in a given year (less than 30% probability).	May arise once in 10 to 25 years
E	**Rare**	The event may occur in exceptional circumstances (less than 1% probability) within the next 3 years).	Unlikely during the next 25 years

Table 5-3: Risk matrix

			Recurrent risk				
Likelihood			**1**	**2**	**3**	**4**	**5**
			Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	A	**Almost Certain**	Low	Medium	High	Extreme	Extreme
	B	**Likely**	Low	Medium	Medium	High	Extreme
	C	**Possible**	Low	Low	Medium	High	High
	D	**Unlikely**	Low	Low	Medium	Medium	High
	E	**Rare**	Low	Low	Low	Medium	Medium

5.3 Stakeholder consultation and risk validation

The third stage of the CCRA preparation included stakeholder consultation and risk validation, involving relevant designers, engineers and climate change specialists. The consultation aimed at analysing and evaluating the key risks and understanding the likelihood/consequences of climate change risks, using expert and local knowledge of the site and infrastructure components. See Table 6-3 section 6 for the resultant risk assessment.

An internal climate change risk assessment workshop was held in April 2020 and was attended by the key stakeholders with unique knowledge of the project. The risks were qualitatively rated with the stakeholders to identify which components were more at risk than others. This enabled the project proponents and designers to qualitatively prioritise risks and identify a list of actions and responsibilities for all high and extreme risks identified, see section 7 for the adaptation responses.

The key stakeholders of the project are listed below:

- client representative (Sydney Water)
- landscape architect
- mechanical, electrical, hydrology, hydraulics and constructability
- networks and factory design
- waste and energy specialist
- climate change and ESD consultants
- environmental consultant

6 Results

6.1 Climate change projections

Projected changes for each of the climate variables relevant for the Project area are presented in Table 6-1 and Table 6-2 below, for CSIRO and NARCliM respectively. The CSIRO projections are representative of the NSW area, while NARCliM shows projections for the Western Sydney area. As shown, the baseline varies between models due to a difference in time periods and model granularity. As discussed, the most extreme of the projections were assumed when conducting the risk assessment.

The most contrasting projections between the two models relates to annual rainfall. Both project decreasing rainfall in winter and spring, however NARCliM projects increased rainfall in summer and autumn resulting in annual increases in the near and far future. Meanwhile CSIRO projects annual decreases in rainfall in the near and far future. As a result, both the impacts of increased rainfall leading to flooding and decreased rainfall leading to drought have been considered in the risk assessment.

In response to SEARs 63, the NARCliM data includes projections for groundwater recharge and surface run-off, which were used to inform the assessment. Note that these projections are for Metropolitan Sydney rather than Western Sydney due to data availability. Further details on groundwater and surface run-off can be found in the Groundwater Assessment Report.

Table 6-1: CSIRO Climate change projections for NSW

Type of Effect	Climate variable	Indicator	Projections under scenarios					Outcome
			Baseline[2]	2030[3] RCP 4.5	2030[4] RCP 8.5	2070[5] RCP 4.5	2070[6] RCP 8.5	
Primary	Temperature	Annual mean max. temperature	24°C	+1.15°C	+1.30°C	+2.05°C	+3.82°C	Increase in average annual temperatures (minimum and maximum), and number of extreme heat days. Reduced number of extreme cold days (Very high confidence)
		Annual mean min. temperature	10.9°C	+0.92°C	+1.01°C	+1.96°C	+3.58°C	
		Number of hot days (>35 °C)	11.4	+7.21	+7.82	+10.15	+14.4	
	Precipitation	Annual rainfall	658.1 mm	-4.6%	-6.3 %	-6.9%	-6.3 %	Decrease in average annual rainfall in winter and spring. (Medium confidence)
	For 20-year period centred on 2030 (2020-2039)	Sea-level rise	-	-	0.14m	-	0.66m[7]	Sea levels will continue to rise. (Very high confidence)
Secondary	Humidity	Relative humidity change	73%	-5.7%	-2.5%	-1.7%	-1.7%	Humidity will decrease (medium confidence).
	Drought	Time spent in drought is projected, with medium confidence, to increase over the course of the century.						
	Flood	Increase in intensity of rainfall events, is likely to lead to an increase in flooding events especially in urbanised areas (with low permeability; high confidence)						

[2] Projections relative to the Sydney region baseline period 1965-2018
[3] For 20-year period centred on 2030 (2020-2039)
[4] For 20-year period centred on 2030 (2020-2039)
[5] For 20-year period centred on 2070 (2060-2079)
[6] For 20-year period centred on 2070 (2060-2079)
[7] The available figure for RCP 8.5 scenario is based on 2090

Type of Effect	Climate variable	Indicator	Projections under scenarios					Outcome
			Baseline[2]	2030[3] RCP 4.5	2030[4] RCP 8.5	2070[5] RCP 4.5	2070[6] RCP 8.5	
	Wind	Annual wind speed change	-	-0.6%	-0.5%	-0.8%	-1.1%	-
	Cyclones	Cyclones are very unlikely to impact Sydney. However, a greater proportion of high intensity storms is projected.						
	Bushfire	An increase in frequency of very high and extreme fire danger days is projected. This is due to harsher fire weather climate - increasing fuel dryness and hot, dry, windy conditions (high confidence).						

Table 6-2: NARCliM Climate change projections for Western Sydney

Type of Effect	Climate variable	Indicator	Projections under scenarios			Outcome
			Baseline[8]	2030[9] SRES A2	2070[10] SRES A2	
Primary	Temperature	Annual mean max. temperature	20-22°C	+0.7°C	+1.9°C	Increase in average annual temperatures (minimum and maximum), and number of extreme heat days. Reduced number of extreme cold nights
		Annual mean min. temperature	8-12°C	+0.64°C	+2.0°C	
		Number of hot days (>35 °C)	10-20	+5-10	+10-20	
	Precipitation	Annual rainfall	200-300 mm	+0-5%	+5-10%	Decrease in average annual rainfall in winter and spring towards 2030 but increasing in summer and autumn
Secondary	Runoff[11]	Annual runoff	55mm	+4%	+17.6	Increase in runoff in the near and far future
	Recharge	Annual recharge	67mm	-5%	+12.5%	Decrease in recharge in the near future, increasing in the far future

[8] Projections relative to the Sydney region baseline period 1990-2009
[9] For 20-year period centred on 2030 (2020-2039)
[10] For 20-year period centred on 2070 (2060-2079)
[11] Runoff and recharge projections are for Metropolitan Sydney rather than Western Sydney

Type of Effect	Climate variable	Indicator	Projections under scenarios			Outcome
			Baseline[8]	2030[9] SRES A2	2070[10] SRES A2	
	Bushfire	Average fire weather is projected to increase in spring by 2070. Severe fire weather days are projected to increase in summer and spring by 2070.				

6.2 Risk analysis

The climate projections were used to inform the stakeholder workshop, where the likelihood and consequence was identified for associated impacts. This was undertaken as a first pass and discussed and agreed with the relevant technical leads to support the identification of relevant adaptation measures.

The following table presents the likelihood, consequences and residual risks for the three timescales considered by the project team. The likelihood was largely determined by the climate variable and risk event whilst the consequences were indicated by the project team.

Table 6-3: Risk assessment for present, 2030 and 2070

Item Number	Details of risk event	Impact of the risk event	Present Risk			2030						2070					
						RCP 4.5 (2030)			RCP 8.5 (2030)			RCP 4.5 (2070)			RCP 8.5 (2070)		
			Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk
Change in annual mean air temperature																	
1	Heating up of chemicals	Greater chemical use	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low
2	Elevated temperature creating higher biodynamic activity	Marginally oversized process infrastructure	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low
3	Increased septicity in incoming sewers due to higher anaerobic biological activity (Higher sulphide production)	Increased odour generation at AWRC leading to impacts to surrounding residents	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium
4	Aeration process becomes less efficient (reduced oxygen – water solubility)	Larger blowers/ equipment required leading to increased energy usage.	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low
Increase in extreme weather events – increased days >35°C																	
5	More hazardous outdoor working conditions due to extreme heat	Increased health and safety issues due to heat exposure	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Major	High	Likely	Major	High
6	Equipment operational design temperature exceeded	Damage to switchboards causing equipment failure across AWRC treatment processes e.g. cooling equipment (blowers) overheating	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Possible	Minor	Low	Possible	Minor	Low

Item Number	Details of risk event	Impact of the risk event	Present Risk			2030						2070					
						RCP 4.5 (2030)			RCP 8.5 (2030)			RCP 4.5 (2070)			RCP 8.5 (2070)		
			Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk
7	Equipment working harder to maintain process performance increasing likelihood of damage and failure over time	Potentially reduce lifespan of equipment	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Possible	Moderate	Low	Possible	Minor	Low
8	Due to a single extreme event of >49°C temperatures exceed design parameters for expansion and contraction	Higher temperatures cause structural damage cracking, pipe buckling	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium
Increased peak precipitation																	
9	Increased frequency and intensity of peak wet weather flows to AWRC	Adding to flows beyond assumed to cause more frequent plant bypasses (performance impact) or upstream discharge of sewage if system overloaded (environmental impact). Impacting the network feeding the plant.	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
10	Increased frequency of peak wet weather inflows to AWRC	More primary treated only water discharging to waterways which may affect the wider Hawkesbury license for nutrient discharge	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium
11	Increase in wet weather sewerage flowrate	Malabar system likely to be at capacity more frequently during wet weather reducing availability for brine release. Reduction in availability of the AWTP therefore releasing less advanced treated water to Nepean River.	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium

Item Number	Details of risk event	Impact of the risk event	Present Risk			2030						2070					
						RCP 4.5 (2030)			RCP 8.5 (2030)			RCP 4.5 (2070)			RCP 8.5 (2070)		
			Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk
12	Increased flooding risk from South Creek	Inundation leads to damage to infrastructure (e.g. flooding of switchboards), or staff can't access site, causing process impacts with poor quality effluent (performance risk)	Unlikely	Major	Medium	Unlikely	Major	Medium	Unlikely	Major	Medium	Possible	Major	High	Possible	Major	High
13	Increase in frequency of damaging storms	Essential parts of site inundated.	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low
14	Increased Flooding risk from other watercourses along pipeline alignment	Increased loading on pipelines at dam/river crossing, potentially causing them to fail with sewerage discharge to the environment.	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low
15	Increased frequency high intensity rainfall leading to increased stormwater runoff Flooding risk	Increased stormwater runoff from the site exceeding capacity of stormwater detention facilities	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium
16	Increased Flooding risk from South Creek	Flooding from south creek Unsafe working conditions for AWRC operators. Restricted access to assets	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium

Item Number	Details of risk event	Impact of the risk event	Present Risk			2030						2070					
						RCP 4.5 (2030)			RCP 8.5 (2030)			RCP 4.5 (2070)			RCP 8.5 (2070)		
			Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk
Sea Level Rise																	
17	Sea level rise causing movement of people inland	More people relocating to Western Sydney region than current infrastructure has been planned for.	Rare	Minor	Low	Rare	Minor	Low	Rare	Minor	Low	Rare	Minor	Low	Rare	Minor	Low
Relative Humidity																	
18	Drier ambient conditions	longevity of component parts for AWRC and pipelines compromised.	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low
Drought																	
19	Lower rainfalls/extended droughts	Leading to erosion and/or soil movements and exposure of pipelines/cracking of pipes (environmental risk)	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low
Bushfires																	
20	Smoke and reduced visibility/air quality resulting from nearby bushfires	Hazardous working environment for AWRC staff.	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
21	Bushfire threat to infrastructure	Fire damage to infrastructure / operational equipment, wiring and electrics and security of energy supply	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium	Unlikely	Moderate	Medium
22	Bushfires restrict access to AWRC site	Restricted access during bushfire events for operational purposes - potentially causing performance risks.	Unlikely	Major	Medium	Likely	Major	High	Likely	Major	High	Likely	Major	High	Likely	Major	High

Seven climate scenarios as outlined in Table 6-3 above were identified as relevant to the project, including extreme weather events – increased days >35°C, change in average air temperature, precipitation, sea level rise, relative humidity and bushfires. Based on outcomes of the risk workshop and the likelihood and consequence scenarios, four 'high' risks were identified under varying timescales relating to extreme weather events -– increased days >35°C, increased peak precipitation and bushfires.

6.2.1 Opportunities

Although not part of the scope of works for Stage 1 of the project, the AWRC has the potential to produce recycled water that will be available for a range of uses in the community and environment. Recycled water has the potential to alleviate some of the potential impacts from climate change that that would otherwise put an increased demand on potable water use. These include an increase in annual mean air temperature, humidity and an increased frequency and duration of drought. Table 6-4 outlines the potential impacts and opportunities in more detail. The use of recycled water produced by the AWRC is being investigated as part of a separate Sydney Water project, including the recycled water infrastructure, and has not been assessed in the projects Environmental Impact Statement (EIS).

Table 6-4: Recycled water opportunities

Risk Event	Impact	Opportunity
Change in annual mean air temperature		There is an opportunity for Sydney Water to alleviate the impacts of these risk events by providing recycled water flows.
Warmer temperatures affecting consumer water use.	Increased potable water demand putting pressure on supply. greater demand for recycled water	
Relative Humidity		
Drier ambient conditions affecting customer water use	Increase potable water demand putting pressure on supply e.g. consumers taking showers and more laundry => greater wastewater volumes.	
Drier ambient conditions affecting customer water use	Greater demand for recycled water for municipal/domestic irrigation/ garden watering	
Drought		
Less available water due to lower rainfalls	Greater demand for recycled water and potential to exceed supply capacity from the facility	

Risk Event	Impact	Opportunity
Prolonged low flows in receiving waterways	Insufficient flow in the destination waterways limiting dilution and discharge ability	
Prolonged low flows in receiving waterways	More demand for environmental -flows - but less water available for release as environmental flows due to increases in recycled water use, degradation to creeks that will rely on eflows in the present scenario	

7 Adaptation responses

As a result of the risk assessment and stakeholder consultation, the following adaptation options have been considered and included in the design and operational intent of the project to improve the climate resilience. Where risks have been highlighted as 'high', adaptation measures have been implemented to reduce these risks to medium or lower. Intervention measures have also been considered for a minimum of 50% of 'medium' risks identified, in line with ISCA requirements.

Table 7-1: Project Medium & High-Risk Adaptation Response Strategy

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
Change in annual mean air temperature										
3	Increased septicity in incoming sewers due to higher anaerobic biological activity (Higher sulphide production)	Increased odour generation at AWRC leading to impacts to surrounding residents	Medium	Medium	Medium	No further adaptation measures proposed as impact not considered high risk		Likely	Minor	Medium
Increase in extreme weather events – increased days >35°C										
5	More hazardous outdoor working conditions due to extreme heat	Increased health and safety issues due to heat exposure	Medium	Medium	High	Management plans in place to outline procedures for working in extreme weather conditions.	Investigate opportunities to bring equipment inside and under shelter, building ventilation and green/blue infrastructure to	Possible	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
						Shading of footpaths where appropriate.	keep the AWRC site cool (e.g. use of irrigation in the days leading up to hot days to reduce temperature on site). Passive architectural design to assist with natural cooling of buildings. E.g. orientation, cross wind flows, landscaping and shading of facades and openings			
8	Due to a single extreme event of >49°C temperatures exceed design parameters for expansion and contraction	Higher temperatures cause structural damage cracking, pipe buckling	Medium	Medium	Medium		Review maximum ambient design temperatures for infrastructure	Likely	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
Increased peak precipitation										
9	Increased frequency and intensity of peak wet weather flows to AWRC	Adding to flows beyond assumed to cause more frequent plant bypasses (performance impact) or upstream discharge of sewage if system overloaded (environmental impact). Impacting the network feeding the plant.	Medium	Medium	Medium		Wastewater collection network designed to minimise wet weather infiltration to reduce volume of incoming flows to the AWRC	Possible	Minor	Low
10	Increased frequency of peak wet weather inflows to AWRC	More primary treated only water discharging to waterways which may affect the wider Hawkesbury license for	Medium	Medium	Medium		Reduce infiltration of wet weather flows in the collection network which will reduce the occurrence of primary treated water being released from	Possible	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
		nutrient discharge					the AWRC to South Creek			
11	Increase in wet weather sewerage flowrate	Malabar system likely to be at capacity more frequently during wet weather reducing availability for brine release. Reduction in availability of the AWTP therefore releasing less advanced treated water to Nepean River.	Medium	Medium	Medium	• Up to three days storage time for brine tanks to accommodate wet weather events which will allow for the advanced treatment process to continue to operate during this time.		Possible	Minor	Low

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
12	Increased flooding risk from South Creek	Inundation leads to damage to infrastructure (e.g. flooding of switchboards), or staff can't access site, resulting in process impacts with reduced quality treated water (performance risk)	Medium	Medium	High	Locate critical infrastructure outside the 1:100 flood level to sufficiently reduce the likelihood of flooding.		Possible	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
15	Increased frequency high intensity rainfall leading to increased stormwater runoff Flooding risk	Increased stormwater runoff from the site exceeding capacity of stormwater detention facilities	Medium	Medium	Medium	WSUD stormwater facilities will be designed to accept stormwater flows up to 100yr flood events in consultation with relevant councils. Any excess water not contained in the storm water system will make its way into the flood plain.		Possible	Minor	Low
16	Increased Flooding risk from South Creek	Flooding from south creek and unsafe working conditions for AWRC operators. Restricted access to assets	Medium	Medium	Medium	AWRC staff will not access certain parts of the AWRC during storms greater than the 100yr flood event Additional security around low level infrastructure		Possible	Minor	Low

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
Bushfires										
20	Smoke and reduced visibility/air quality resulting from nearby bushfires	Hazardous working environment for AWRC staff	Medium	Medium	Medium	Primary offices and work areas will be air-conditioned with options to recirculate internal air. Will be managed with additional protocols and procedures to ensure safety.		Possible	Moderate	Medium
21	Bushfire threat to infrastructure	Fire damage to infrastructure / operational equipment, wiring and electrics and security of energy supply	Medium	Medium	Medium	Bushfire management measures have been incorporated into the reference design of the AWRC to reduce the risk of any potential damage to infrastructure.		Unlikely	Moderate	Medium

Item Number	Details of risk event	Impact of risk event	Risk rating			Measures incorporated in project	Measures for investigation separate to the project	Residual Risk		
			Present	2030	2070	Response to high risk (and at least 50% of 'medium' risks)		Likelihood	Consequence	Risk
22	Bushfires restrict access to AWRC site	Restricted access during bushfire events for operational purposes - potentially causing performance risks.	Medium	High	High	Remote operation capability of site can reduce the frequency and need for staff to be present. As part of the bushfire recommendations provisions will be made for fire suppression and fire trail around perimeter of site		Possible	Moderate	Medium

7.1 XDI tool assessment of adaptation measures

An assessment of proposed adaptation measures in the XDI tool concluded:

- All adaptation measures in the climate change risk assessment to mitigate heat stress were effective to manage heat below current levels until 2060
- Implementing controls such as a fire trail around the site will be sufficient to adequately reduce risk levels to no greater than today's levels.

Limitations of the XDI tool include:

- it focuses on risks at a point rather than across a whole site. We have minimised this limitation by testing several points across the AWRC site
- it is based on typical site information rather than focusing on vulnerability of specific assets or processes to specific climate risks
- it generalises climate adaptation measures for bushfire risks and cannot provide an exact level of risk reduction
- it does not capture measures for stormwater runoff or localised flooding and ponding.

7.2 Next steps

The following items are noted as the next steps following design progression and detailed design:

- Work with relevant stakeholders, including external stakeholder organisations to enable aligned approach to adaptation and response to climate change impacts across the broader infrastructure assets portfolio.
- Assess future stages.

7.2.1 Future stages

Future stages will involve the facility doubling in capacity which is expected to take place around the year 2034. Therefore, any potential change in risk to the design and operational scenarios between the present day and 2034 should be reassessed at this time to ensure the appropriate adaptation measures are still relevant and appropriate. This will ensure the project has considered the future operating environment along with relevant climate factors or variables which may impact the asset.

8 Conclusion

This report summarises the outcomes of potential climate change impacts on the USC Advanced Water Recycling Centre through completion of a climate change risk assessment. The report demonstrates a rise in climate uncertainty affecting the future asset, resulting in considerations to be made through the design stage to account for the rise in temperatures, the increase in the number of heatwaves per year and the potential for flooding.

Both direct climate change impacts (such as change in average temperatures) and indirect climate change impacts (such as reduced precipitation resulting in drought conditions) need to be taken into consideration when carrying out future climate change risk assessments.

Current weather conditions that lead to flooding and heatwaves, are predicted to increase in intensity over the coming years within the region due to an increase in temperatures and the number and intensity of storms. Through construction and operations, future climate change assessments will assist in protecting the asset from future extreme weather conditions.

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Appendix B – Greenhouse Gas Assessment

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Upper South Creek Advanced Water Recycling Centre

Greenhouse Gas (GHG) Impact Assessment

Job title	Upper South Creek Advanced Water Recycling Centre	**Job number**	
Document title	Draft GHG Assessment	**File reference:** as above	
Document ref	Draft		

Revision	**Date**	**Filename**	Draft GHG Assessment		
Draft 1	23/10/2020	**Description**	Draft prior to client comments		
			Prepared by	**Checked by**	**Approved by**
		Name	Ethan Monaghan-Pisano	Jo Walton-Hespe	Miranda Snowdon
		Signature			
Draft 2	27/11/2020	**Filename**	Draft 2 GHG Impact Assessment		
		Description	Draft 2 following Draft 1 comments		
			Prepared by	**Checked by**	**Approved by**
		Name	Ethan Monaghan-Pisano	Jo Walton-Hespe	Miranda Snowdon
		Signature			
Draft Final	10/02/2021	**Filename**	USC AWRC GHG Impact Assessment Draft Final		
		Description	Draft Final following Draft 2 comments		
			Prepared by	**Checked by**	**Approved by**
		Name	Ethan Monaghan-Pisano	Jo Walton-Hespe	Miranda Snowdon
		Signature			
Final	22/06/2021	**Filename**	USC AWRC GHG Impact Assessment Final		
		Description	Final following Draff Final comments		
			Prepared by	Checked by	Approved by
		Name	Ethan Monaghan-Pisano	Jo Walton-Hespe	Miranda Snowdon

		Signature			

Issue Document Verification with Document ✓

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1 Introduction

This greenhouse gas (GHG) assessment has been prepared for Stage 1 of the Upper South Creek Advanced Water Recycling Centre (the project), which is State Significant Infrastructure. The assessment seeks to satisfy the specific Secretary's Environmental Assessment Requirements (SEARs) matter 64, which requires an assessment of the GHG emissions from the construction and operation of the project over the lifetime of the infrastructure. An assessment methodology has been developed which effectively addresses each of the requirements contained in SEARs matter 64. Table 1 of section 2.2 details where each matter is addressed in the following report.

2 Project Description

2.1 Project Summary

Sydney Water is seeking approval for construction and operation of a wastewater treatment plant, known as the Upper South Creek Advanced Water Recycling Centre in Western Sydney including:

- a wastewater treatment plant that includes production of:
  - high quality treated water suitable for a range of uses including recycling and environmental flows
  - renewable energy
  - biosolids suitable for beneficial reuse
- new pipeline from the Water Recycling Centre to the Nepean River, to release excess treated water
- new infrastructure from the Water Recycling Centre to South Creek, to release excess treated water and wet weather flows
- new pipeline extension from the new Nepean River pipeline to the Warragamba River for environmental flows
- new pipeline from the Water Recycling Centre to Sydney Water's existing wastewater system to discharge brine.

The concept component of the project comprises all the above elements, with the Water Recycling Centre (AWRC) sized to treat an average dry weather flow of up to 100ML/day, and to transport and release the equivalent volume through the pipelines.

Sydney Water is also seeking detailed approval for Stage 1 which comprises:

- building and operating the Water Recycling Centre sized to treat an average dry weather flow of up to 50ML/day
- building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 Water Recycling Centre.

Stage 1 also includes the following mitigation measures that reduce the GHG emissions and are therefore relevant to this assessment.

- Biogas capture and flaring
  - Biogas is produced during the wastewater treatment process by the breakdown of organic matter in the absence of oxygen. Biogas contains methane (approximately 60% composition of biogas by volume) which as a harmful greenhouse gas. To prevent the release of biogas into the environment, all biogas will either be combusted in cogeneration engines or flared via waste gas burners when biogas flow exceeds the capacity of cogeneration.
- Cogeneration
  - Cogeneration is the process of collecting the biogas to use as fuel for on-site engines which produce renewable electricity. Two cogeneration engines with a combined capacity of 1200 kWe will be included. By generating low-carbon electricity on-site, cogeneration reduces the amount of electricity the facility needs to purchase from the grid therefore reducing its greenhouse gas impact.

- Solar photovoltaics
  - Solar photovoltaics (Solar PV) convert sunlight into renewable electricity. A combination of roof and ground mounted solar PV with a combined capacity of 4,000 kW will be included.

Together, the AWRC and associated treated water and brine pipelines will be known as the ‘project’. An overview of the site location is provided in Figure 1.

2.2 Project Planning and Staging

Sydney Water is planning to deliver the above infrastructure in stages to respond to the projected population growth in the surrounding catchment area, which will eventually require additional wastewater treatment capacity. This Greenhouse Gas (GHG) assessment will be delivered for the project which comprises of Stage 1 and the following infrastructure:

- Building and operating the AWRC to treat an average dry weather flow of up to 50ML per day.
- Building all pipelines to their ultimate capacity, but only operating them to transport and release volumes produced by the Stage 1 AWRC.

The assessment of the above infrastructure is based on a reference design, which may change once developed through detailed design, but is currently the most up to date design information available at this time. A capacity of 50ML per day represents the ‘worst-case’ assessment scenario for the project, therefore should the delivery change or the principal contractor need to alter the design, the environmental outcome/impacts described in the EIS will likely still be met.

This assessment considers both the construction and operation of Stage 1 of the project in order to assess the impact throughout the projects lifetime. It is anticipated that around the year 2034, additional wastewater treatment infrastructure will be added to the existing Stage 1 infrastructure, via the delivery of ‘future stages’. Prior to this, the future stages will undergo a similar assessment to understand the total GHG impact of the additional infrastructure and ongoing operation of the existing Stage 1 infrastructure. Therefore, this study will only consider the impact of Stage 1 up to the anticipated delivery of the future stages. This avoids estimating operational impacts too far into the future which comes with increasing margins of error. Below summarises the assumed timeframes for the Stage 1 construction and operating periods which form the basis of this assessment.

- AWRC and Pipelines
  - Construction period – 2022 to 2024 (3 years)
  - Operating period – 2025 to 2034 (10 years)

A GHG assessment of the ‘future stages’, which will increase capacity to 100ML per day, will be considered at high level in this report, outlining how a future GHG assessment will be approached and estimating the expected impact. For the assessment of the future stages refer to section 9.

As discussed, this assessment seeks to satisfy the specific Secretary’s Environmental Assessment Requirements (SEARs) matter 64, requiring an assessment of the GHG emissions due to the construction and operation of the project. Table 1 below outlines where each matter is addressed in the following report.

Table 1 Project SEARS requirements

SEARS matter to be addressed by Study	Location SEARS addressed in the report
64 Assessment of the greenhouse gas emissions from the construction and operation of the project for the life of infrastructure, including: a) documentation and justification of an appropriate methodology for estimating greenhouse gas emissions for the project as a water storage, or water reservoirs project where permanent land use change occurs.	Section 3
b) assessment of carbon dioxide, nitrous oxide and methane gas emissions, including gases emitted by decomposing plants and organic material within the dam inundation area[1].	Section 5 & 6
c) quantitative assessment of Scope 1, 2 and 3 greenhouse gas emissions	Section 6
d) an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency	Section 7
e) project emissions as a proportion of NSW and Australia's greenhouse gas emissions budgets	Section 8
f) details of all proposed mitigation, management and monitoring measures	Section 7

[1] A dam inundation area is not included in the existing design therefore is not applicable to this assessment.

Figure 1: Site context

Upper South Creek Advanced Water Recycling Centre

Treated Water Pipeline

Brine Pipeline

Environmental Flows Pipeline

Projection: GDA 1994 MGA Zone 56
Project infrastructure locations are indicative and will be refined during design

3 Methodology

The following section provides a detailed description and justification of the GHG methodology that was undertaken in order to estimate the GHG emission inventory due to the construction and operation of the project.

3.1 Assessment methodology

The assessment methodology consisted of the following steps:

1. Defining emission boundary and sources: the emission boundary was defined identifying emission sources that are relevant[2] to the assessment.
2. Quantifying emissions sources: the quantity of each relevant emission source was estimated in its relevant units utilising project specific data and information. Where project estimates were not available, data from existing comparable projects was used as a proxy or to support reasonable assumptions. Note, this step considered the emission sources inclusive of the mitigation measures outlined in section 2.1.Project Summary
3. Calculating emissions: Once the emissions sources had been estimated in their relevant units, these were then converted to CO_2 equivalent units using known emission factors and industry recognised calculation methods to estimate the GHG emissions from the identified sources.

The AWRC and pipelines were assessed and reported on separately for improved clarity and to enable more granular analysis of the results.

3.1.1 Guiding principles

The GHG assessment methodology is based on recognised GHG reporting legislation, international reporting guidelines and tools to ensure the delivery of robust and justifiable outputs. The following policy documents were key in the methodology development:

Table 2 Relevant documents

Policy Document	Description	Relevance to study
Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard (World Council for Sustainable Business Development and World Resources Institute, 2005)	Provides internationally recognised guidelines on developing a GHG emission inventory	Supports the justification of the methodology and definition of emission boundary
National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Office of parliamentary Council, Canberra, 2017)	Provides methods and criteria for the measurement of scope 1 and 2 GHG emissions	Provides methodology for estimating fugitive emissions from wastewater treatment

[2] Emissions deemed relevant contribute to a significant proportion of the total GHG inventory emissions and are within the control and influence of the reporting entity.

Policy Document	Description	Relevance to study
The current Australian National Greenhouse Accounts, National Greenhouse Accounts Factors (NGA Factors, Department of the Environment, August 2019)	Draws on the National Greenhouse and Energy Reporting (Measurement) Determination 2008 to provide methods to estimate a broad range of GHG emissions inventories	Provides methodologies for estimating scope 1, 2 and 3 emissions.
AGO Factors and Methods Workbook (Australian Greenhouse Office, August 2004)	Provides a single source of current GHG emission factors for use in the estimation of emissions and emission abatement	Provides methodology for estimating impact of land use change
ISCA materials calculator version 2.0	Provides industry recognised embodied emission factors for materials	Supports the calculation of embodied emissions from materials

In addition to the above, the following best practice principles were adhered to when calculating the GHG emission inventory:

- Relevance: ensure the GHG emission inventory appropriately reflects the GHG emissions attributable to the project.
- Completeness: account for and report all GHG emissions sources within the defined boundary, justifying any exclusions.
- Consistency: use consistent data and calculation methodologies to allow for meaningful comparisons.
- Transparency: compile, analyse and document GHG information clearly so that auditors and the public may evaluate its credibility.
- Accuracy: ensure the quantification of GHG is unbiased and uncertainties are reduced as much as reasonably practical.

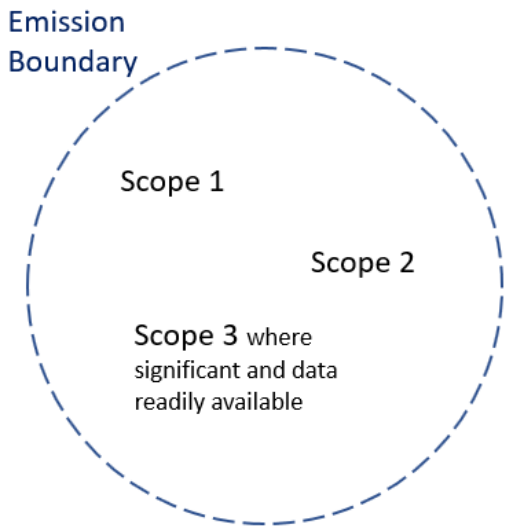
3.2 Defining emission boundary and sources

The first step in calculating the GHG emission inventory is establishing the perimeter of the emission boundary, as this defines which emissions sources are to be either included in or excluded from the assessment. Emission sources are typically categorised into three distinct scopes in order to provide clarity and consistency:

- Scope 1: direct emissions which occur within the site boundary from owned or controlled sources e.g. emissions from site plant and equipment.
- Scope 2: indirect emissions which occur outside the site boundary from the generation of purchased energy.
- Scope 3: all indirect emissions (not included in scope 2) that occur in the value chain of the reporting body.

SEARs matter 64c requires that scope 1, 2 and 3 are to be included in the emission boundary for assessment. With regards to scope 3, only scope 3 emissions where there is readily available data and where the emissions represent a significant proportion of the total emission inventory have been included, as indicated by Figure 2.

Figure 2 Emission boundary



Based on the above emission boundary, the following emission sources were included within the assessment, as indicated by Table 3. These emission sources were accounted for across both the construction and operation phases where applicable.

Table 3 Emission sources considered within boundary

	Construction	Operation
Scope 1	• Fuel for equipment and machinery	
	• Vegetation clearance	• Wastewater treatment
Scope 2	• Electricity	
Scope 3	• Embodied emissions from materials • Indirect transport emissions • Indirect waste emissions • Indirect emissions from electricity transmission and distribution losses • Indirect emissions from fuel use	

Scope 1 emissions due to the inundation of existing riverbank vegetation have not been included within the emission boundary as the GHG emissions associated are considered negligible. Modelling undertaken as part of the Ecohydology and Geomorphology impact assessment (Streamology, 2021) indicates water surface elevation changes will lead to an increase in the inundation of bank vegetation upstream of Wallacia Weir, however this will be well within the existing channel extents and will not result in flooding or engagement of floodplain areas. Additionally, the Aquatic and Riparian Ecosystem Assessment (CT Environmental, 2021) predicts minor increases in water surface elevation is expected to have a minor impact on riparian flora within the Nepean and Warragamba Rivers.

4 Quantifying emission sources

For many emission sources, estimating the quantity was achieved by using known project information and data. In the event of a lack of project information to derive an estimate, proxy data from comparable projects was used to estimate quantities for the project.

While it is recognised that not every emission source attributable to the project has been included, those not included represent a negligible impact compared to the total GHG emission inventory at this stage of the project. Below provides a summary of the key emission sources included and what they account for.

- Scope 1
  - Fuel: accounts for the use of on-site fuels for equipment and machinery during both construction and operation of the AWRC and pipelines
  - Wastewater treatment: accounts for the fugitive methane and nitrous oxide emissions from the operations of the AWRC wastewater treatment process
  - Vegetation clearance: accounts for emissions due to the clearing of vegetation, and subsequent loss of sequestration during the construction phase
- Scope 2
  - Electricity: accounts for the indirect emission from the generation of purchased electricity during construction and operation
- Scope 3
  - Materials: accounts for the embodied emissions released during the lifecycle of materials used during construction and operation
  - Transport: accounts for emissions from the use of vehicles during construction and operation which occurs outside the site boundary
  - Waste: accounts for the emissions from the decomposition of waste sent to landfill during construction and operation
  - Electricity and fuel: accounts for emissions due to electricity transmission and production losses and the extraction and production of fuels

Table 4 provides a summary of the quantity of emission sources, as well as the method and assumptions used to derive the value. Quantities have been provided for the total period of construction and/or operation and are based on the Stage 1 plant operating at the design capacity of 50ML per day for the 10-year operational period.

Table 4 Estimated quantity of emission sources

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
Scope 1	Fuel	Construction	AWRC	Diesel	2,452	kL	*Due to a lack of project information on the use of fuel during construction, estimates were made using known data as reported by contractors from a comparable project. The proxy project involved the construction of a 14ML facility, therefore the average annual fuel consumption was extrapolated for a 50ML facility and multiplied by the number of construction years*
				E10			
				Ethanol	2	kL	
				Gasoline	15	kL	
				LPG	3	kL	
				Gasoline	62	kL	
			Pipelines	Diesel	2,082	kL	*Estimated using known fuel consumption per km of pipeline for a comparable project. The consumption per km was scaled for the total length of pipeline to be delivered*
				Gasoline	8	kL	
		Operation	AWRC	Diesel	179	kL	*Due to a lack of project information on the use of fuel during operation, estimates were made using known data as reported by contractors from a comparable project. The proxy project involved the operation of a 14ML facility, therefore the average annual fuel consumption was extrapolated for a 50ML facility and multiplied by the number of operational years*
				Gasoline	36	kL	
				Natural gas	167,846	GJ	*Estimated from process engineering calculations*
	Wastewater treatment	Operation	AWRC	Methane	Refer to section 5.1.1.2 for summary		
				Nitrous Oxide	Refer to section 5.1.1.2 for summary		

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
	Vegetation clearance	Construction	AWRC	Grassland cleared	52.94	ha	*Based on current GIS layouts. Assumptions on vegetation types were provided by Biosis and the Environment Team.*
				Open forest cleared	27.06	ha	
			Pipelines	Grassland cleared	33.01	ha	*Based on current GIS layouts. Only land where vegetation currently exists was considered and where open trenching is used to lay the pipework. Where pipework runs beneath roads and where under-bore trenching is used, the land area was not considered in the total area to be cleared.*
				Open forest cleared	35.29	ha	
Scope 2	Electricity	Construction	AWRC	Electricity	14.34	MWh	*Similarly, to fuel use during construction, the average annual electricity usage for a 14ML facility was used to extrapolate for a 50ML facility. This value assumed no on-site generation during construction.*
		Operation	AWRC	Electricity	213,660	MWh	*An operational energy model has been used to estimate the annual energy consumption (36,713 MWh) and on-site renewable energy generation (152,47MWh) thereby providing an estimate for the net annual consumption (net consumption = total consumption minus renewable generation) multiplied by the years of operation. Changes in annual energy consumption due to efficiency measures or improvements have not been accounted for. The total energy consumption is based on a worst-case scenario of operating at 50ML from day 1.*

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
			Pipelines	Electricity	36,713	MWh	*Based on the operational energy model, it is assumed that the pumping station for the pipelines amounts to 10% of the AWRC annual electricity consumption. All on-site generation is attributed to the AWRC therefore the pipeline consumption equals 10% of 36,713 MW per year, amounting to 36,713 over the 10years of operation.*
Scope 3	Materials	Construction	AWRC	Reinforced Concrete			
				Steel (rebar)	3,261	tonnes	*Volumes of reinforced concrete to be used during construction were estimated from a material bill of quantities (32611m3). Based on the assumption of 100kg of rebar per m3 of reinforced concrete, the tonnage of rebar was estimated*
				Concrete	77,263	tonnes	*Using known densities of rebar, the tonnage was converted to m3 (418m3) and subtracted from the volume of reinforced concrete to calculate the volume and tonnage of concrete*
				Concrete works	62,760	tonnes	*Based on estimates from the material bill of quantities*
				Building brick work	2,384	tonnes	*The area of brickwork was estimated and assumptions around the building heights (2 storey) and wall thickness (assumed double brick wall each 110mm thick) were used to estimate the volume and tonnage*
				Steel tanks	3,697	tonnes	*Based on the estimated dimensions of the tanks and the wall, roof and floor thicknesses (20, 10 & 50mm respectively) to calculate the volume and tonnage.*

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
Scope 3	Materials	Construction		Plywood formwork	278	tonnes	*Based on the estimated area of formwork (18,500 m2) and thickness (25mm) to calculate the volume and tonnage*
				Structural Steel			
				Beams & columns	27,000	tonnes	*The total tonnage of structural steel was estimated from the bill of quantities, assumed that 90% is beams and columns*
				Steel plate	3,000	tonnes	*The total tonnage of structural steel was estimated from the bill of quantities, assumed that 10% is steel plate*
			Pipelines	OD560 PE 100 PN16	1,716	tonnes	*The estimated length (22,000m), diameter (560mm) and thickness (51mm) of the pipe was used to calculate the volume of material. The density of Polyethylene (PE) was then used to calculate the weight.*
				OD560 PE 100 PN20	73	tonnes	*The estimated length (780m), diameter (560mm) and thickness (63mm) of the pipe was used to calculate the volume of pipe material. The density of Polyethylene (PE) was then used to calculate the weight.*
				DN700 RCP Class 4	154	tonnes	*The estimated length (200m), diameter (864mm) and thickness (134mm) of the pipe was used to calculate the volume of material. The density of reinforced concrete pipes (RCP) was then used to calculate the weight. Assumed flush joint pipes when estimating dimensions.*

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
Scope 3				DN900 RCP Class 4	649	tonnes	*The estimated length (680m), diameter (1029mm) and thickness (136mm) of the pipe was used to calculate the volume of material. The density of reinforced concrete pipes (RCP) was then used to calculate the weight. Assumed flush joint pipes when estimating dimensions.*
				DN1200 RCP Class 4	467	tonnes	*The estimated length (280m), diameter (1359mm) and thickness (180mm) of the pipe was used to calculate the volume of material. The density of reinforced concrete pipes (RCP) was then used to calculate the weight. Assumed flush joint pipes when estimating dimensions.*
				DN1500 RCP Class 4	4,173	tonnes	*The estimated length (1740m), diameter (1676mm) and thickness (208mm) of the pipe was used to calculate the volume of material. The density of reinforced concrete pipes (RCP) was then used to calculate the weight. Assumed flush joint pipes when estimating dimensions.*
				OD508 Steel Cement Lined Pipe			
				Steel	89	tonnes	*The estimated length (1200m), diameter (508mm) and thickness (6mm) of the pipe was used to calculate the volume of material. The density of steel was then used to calculate the weight.*
Scope 3				*Cement*	53	tonnes	*The estimated length (1200m), diameter (502mm) and thickness (12mm) of the pipe was used to calculate the volume of material. The density of cement was then used to calculate the weight.*

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
				OD1016 Steel Cement Lined Pipe			
				Steel	456	tonnes	*The estimated length (1850m), diameter (1016mm) and thickness (10mm) of the pipe was used to calculate the volume of material. The density of steel was then used to calculate the weight.*
				Cement	221	tonnes	*The estimated length (1850m), diameter (1006mm) and thickness (16mm) of the pipe was used to calculate the volume of material. The density of cement was then used to calculate the weight.*
				OD1283 Steel Cement Lined Pipe			
				Steel	6,230	tonnes	*The estimated length (16670m), diameter (1283mm) and thickness (12mm) of the pipe was used to calculate the volume of material. The density of steel was then used to calculate the weight.*
				Cement	2,990	tonnes	*The estimated length (16670m), diameter (1271mm) and thickness (19mm) of the pipe was used to calculate the volume of material. The density of cement was then used to calculate the weight.*
				OD711 Steel Pipe	358	tonnes	*The estimated length (2600m), diameter (711mm) and thickness (8mm) of the pipe was used to calculate the volume of material. The density of steel was then used to calculate the weight.*
		Operation	AWRC	Alum	77,453	tonnes	*Values estimated from the wastewater treatment process mass balance*
				Citric Acid	2,300	tonnes	

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
				Ferric Chloride	39,535	tonnes	
				Liquid Polymer	532	tonnes	
				Methanol	19,454	tonnes	
				Sodium Bisulphite	561	tonnes	
				Sodium Hypochlorite	7,215	tonnes	
				CO2	2,011	tonnes	
				Lime	6,592	tonnes	
				Powder Polymer	1,669	tonnes	
	Transport	Construction	AWRC	Site establishment (Diesel)	1	kL	*Values were estimated based on the estimated number of trips for each transport activity, estimated trip origins and distances and fuel efficiency. It was assumed that rigid trucks are to be used for all deliveries and transportation of heavy loads, while light commercial vehicles will be used for mechanical and electrical install and landscaping. Passenger vehicles will be used for workers trips. For rigid truck deliveries, different fuel efficiencies were used for the inbound and outbound journeys due to non-freight carrying trucks having a greater fuel efficiency.*
				Fill import (Diesel)	87	kL	
				Earthworks waste disposal (Diesel)	15	kL	
				Concrete delivery (Diesel)	77	kL	
				Sand/other deliveries (Diesel)	13	kL	

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
				Mech and elec install (Diesel)	6	kL	
				Landscaping and restoration (Diesel)	3	kL	
				Workers trips (Gasoline)	131	kL	
			Pipelines	Site establishment (Diesel)	7	kL	*The same approach was taken for the pipelines as outlined above*
				Fill import (Diesel)	75	kL	
				Earthworks waste disposal (Diesel)	21	kL	
				Concrete delivery (Diesel)	63	kL	
				Sand/other deliveries (Diesel)	137	kL	
				Mech and elec install (Diesel)	1	kL	
				Landscaping and restoration (Diesel)	6	kL	
				Workers trips (Gasoline)	131	kL	

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
		Operation	AWRC	Chemical deliveries (Diesel)	273	kL	*The same approach was taken for the operation of the AWRC as outlined above. It was assumed that rigid trucks are used for both chemical deliveries and biosolids outload.*
				Biosolids outload (Diesel)	81	kL	
	Waste	Construction	AWRC	Demolition waste	1,160	tonnes	*Based on the Waste Management Impact Report. Materials which were recycled were not included. A worst case scenario where paper is not recycled has been assumed.*
				Food waste	40	tonnes	
				Green waste	3,456	tonnes	
				Other construction waste	7,836	tonnes	
				Paper and cardboard	20	tonnes	
				Tyres	6	tonnes	
				Wood waste	78	tonnes	
			Pipelines	Food waste	47	tonnes	*The same approach was taken as outlined above*
				Green waste	7,320	tonnes	
				Other construction waste	3,072	tonnes	
				Paper and cardboard	23	tonnes	

Emission scope	Emission category	Development phase	Project component	Emission Source	Quantity	Unit	Method and assumptions used for estimation
				Tyres	55	tonnes	
				Wood waste	41	tonnes	
		Operation	AWRC	Food waste	20	tonnes	*The same approach was taken as outlined above*
				Green waste	100	tonnes	
				Paper and cardboard	10	tonnes	
				Wood waste	1.2	tonnes	
	Electricity & Fuel	Construction	AWRC	Refer to Scope 1 fuel and Scope 2 electricity for quantities			
			Pipelines				
		Operation	AWRC				
			Pipelines				

5 Calculating emissions

This section details the calculation methods and emission factors used to convert the quantity of emission sources as reported in Table 4 into tonnes of CO_2-equivalent (tCO_{2-e}). A summary of the approach taken, and assumptions made to derive the relevant emissions factors is provided for each scope and emission source. Where emission sources exist in both the construction and operation phase, the emission factor is identical therefore has not been reported separately. Table 15 in section 6 provides a summary of the results, containing complete emission source quantities, respective emission factors and final calculated emissions, reported separately for construction, operation and the AWRC and pipelines.

5.1.1 Scope 1

5.1.1.1 Fuel

Scope 1 emissions from fuel consumption accounts for the use of on-site fuels for equipment and machinery during both construction and operation of the AWRC and pipelines. Note this does not include emissions from delivery vehicles and private transport entering the site boundary, which is assumed to be negligible compared to emissions which occur outside the site boundary (See Scope 3 transport emissions section 5.1.3.2).

The following method was used to calculate the Scope 1 GHG emissions from the combustion of fuels (stationary) as sourced from the National Greenhouse Accounts (NGA Factors 2019):

$$\text{GHG emissions } (tCO_{2-e}) = ((Q \times ECF)/1000) \times (EF_{CO2} + EF_{CH4} + EF_{N2O})$$

Where:

Q is the quantity of fuel (kL)

ECF is the relevant energy content factor (GJ/kL)

EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (kg CO_2-e/GJ)

EF_{CH4} is the relevant Methane (CH_4) emission factor (kg CO_2-e/GJ)
EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (kg CO_2-e/GJ)

Table 5 Fuel emission factors

Fuel Type	Energy content factor (GJ/kL)	Emission factor (kg CO2-e/GJ)			Emission factor (tCO2-e/kL) or (tCO2-e/GJ) for Natural gas	Source
		CO2	CH4	N2O		
Diesel	38.6	69.9	0.1	0.2	2.7	(National Greenhouse Accounts Factors, 2019)
Ethanol	23.4	0	0.07	0.2	0.006	
LPG	25.7	60.2	0.2	0.2	1.6	
Gasoline	34.2	67.4	0.2	0.2	2.3	
Natural gas	Na	51.4	0.1	0.03	0.05	

Note that Natural gas consumption was measured in GJ rather than kL. Refer to Table 15 for the resultant emissions.

5.1.1.2 Wastewater Treatment

Scope 1 emissions from wastewater treatment accounts for the release of fugitive emissions during the operation of the Water Recycling Centre. These fugitive emissions are due to two emissions sources, sludge biogas which results in the release of methane, and nitrogen present within the wastewater which results in the release of nitrous oxide. The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination 2008) provides a methodology for calculating both the amount of methane and nitrous oxide released for a variety of wastewater treatment processes. Unlike other emissions sources presented in this assessment, the calculation process is not a simple matter of estimating the quantity of an emission source and multiplying this value by an emission factor. This is because the emissions occur as a result of multiple processes and variables and the resulting emissions vary from each process. As a result, a series of calculation steps are required to derive the methane and nitrous oxide emissions.

To calculate the methane fugitive emissions, Method 2 (NGER Determination 2008) was used to maintain consistency with other Sydney Water wastewater facilities. At all Sydney Water facilities, methane is destroyed through a process of flaring waste gas, use of the cogeneration process captures fugitive methane to generate electricity, and/ or the use of boiler heaters that burn the biogas to generate heat for digesters. Because of this and calculations that show no leakage from the digesters, no fugitive methane is expected to be released during the operational phase. To calculate the fugitive nitrous oxide, Method 1 (NGER Determination 2008) was selected as the inputs are most aligned to the projects wastewater treatment process. Refer to Table 15 for a summary of both results noting that results provided are for the total operational period of the project.

The below sections provide further explanation of the calculation processes used to derive the values in Table 15.

Methane

Utilising Method 2, the amount of methane released from the facility is calculated by the following calculation:

$$\text{GHG emissions } (tCO_{2\text{-}e}) = CH4_{genz} - \gamma(Q_{capz} + Q_{flaredz} + Q_{trz})$$

Where:

$CH4_{genz}$ is the estimated quantity of methane in sludge biogas generated by the facility during the reporting year
Q_{capz} is the quantity of methane (m^3) in sludge biogas that is captured for combustion by the facility during the reporting year
$Q_{flaredz}$ is the quantity of methane (m^3) in sludge biogas flared by the facility during the reporting year
Q_{trz} is the quantity of methane (m^3) in sludge biogas transferred out of the plant during the reporting year
γ is the factor $6.784 \times 10^{-4} \times 25$ converting m^3 of methane to $tCO_{2\text{-}e}$

The method to calculate $CH4_{genz}$ is dependent on the result of the following:

$$\gamma(Q_{capz} + Q_{flaredz} + Q_{trz}) / [(COD_{wz} - COD_{slz} - COD_{effz}) \times MCF_{wwz} \times EF_{wijz} + (COD_{slz} - COD_{trlz} - COD_{troz}) \times MCF_{slz} \times EF_{slijz}]$$

Where:

CODwz is the quantity of Chemical Oxygen Demand (COD) in wastewater entering the facility during the year, measured in tonnes of COD

CODslz is the quantity of COD removed as sludge from wastewater and treated in the facility, measured in tonnes of COD

CODeffz is the quantity of COD in effluent leaving the sub-facility during the reporting year, measured in tonnes of CODCODtrlz is the quantity of COD in sludge transferred out of the facility and removed to landfill, measured in tonnes of COD

CODtroz is the quantity of COD in sludge transferred out of the facility and removed to a site other than landfill, measured in tonnes of COD

EFslijz is the default methane emission factor for sludge with a value of 6.3 CO2-e tonnes per tonne of COD (sludge)

EFwijz is the default methane emission factor for wastewater with a value of 6.3 CO2-e tonnes per tonne of COD

MCFslz is the methane correction factor for sludge treated at the facility during the reporting year

MCFwwz is the methane correction factor for wastewater treated at the facility during the reporting year

Based on the inputs provided by Table 6 the above calculation results in a value equal to 8.2.

Therefore, CH_{4genz} is calculated as:

$$CH_{4genz} = \gamma(Q_{capz} + Q_{flaredz} + Q_{trz}) * (1/1)$$

Thus,

$$\text{GHG emissions } (tCO_{2\text{-}e}) = \gamma(Q_{capz} + Q_{flaredz} + Q_{trz}) - \gamma(Q_{capz} + Q_{flaredz} + Q_{trz}) = 0$$

Due to the capture and flaring of all generated methane, no methane is released as fugitive.

Table 6 Fugitive methane emission inputs

Input	Value	Unit	Method and assumptions used to derive value
Qcapz	1,709,272	m^3	Based on process calcs. Average of 7,831 Nm3/d biogas for the 50 MLD facility. Assumes 92% availability for cogeneration and 65% methane content of biogas
Qflaredz	148,632	m^3	8% flared due to availability of cogeneration assumed as 92%. Design intent and Sydney Water specifications are such that any biogas not captured for reuse is flared. Waste gas flaring systems required to have "2n" capacity i.e. a full 100% standby capacity. Also assumes 65% methane content of biogas.
Qtrz	0	m^3	Assuming none exported at this stage, all can be reused on site.
CODwz	15,056	tonnes	Calculated from the water treatment process mass balance. BioWin calcs has 36,650 kg/d COD in the influent

Input	Value	Unit	Method and assumptions used to derive value
CODslz	12,329	tonnes	Calculated from the water treatment process mass balance
CODeffz	694	tonnes	Assumes 1,902.51 kg/day COD in effluent, as estimated in BioWin modelling undertaken during reference design.
CODtrlz	0	tonnes	Assumes no sludge transferred to landfill
CODtroz	12,330	tonnes	Assumes no sludge transferred to landfill, instead sludge is converted into biosolids
EFslijz	6.3	CO_2 per tonnes COD removed	Default values from National Greenhouse and Energy Reporting (Measurement) Determination 2008
EFwijz	6.3	CO_2 per tonnes COD removed	Default values from National Greenhouse and Energy Reporting (Measurement) Determination 2008
MCFslz	0.8		All sludge treated through anaerobic digestion, thus adopted the 0.8 value from National Greenhouse and Energy Reporting (Measurement) Determination 2008.
MCFwwz	0.3		Assumes unmanaged aerobic treatment (worst case). Values from National Greenhouse and Energy Reporting (Measurement) Determination 2008

Nitrous Oxide

Utilising Method 1, the amount of nitrous oxide released from the facility is calculated by the following calculation:

GHG emissions ($tCO_{2\text{-}e}$) = (Nin – Ntrl - Ntro – Noutdisij (effluent) - Noutdisij (brine)) x EFsecij + (Noutdisij x EFdisij) (effluent)

(Noutdisij x EFdisij) (brine)

Where:

Nin is the quantity of nitrogen entering the plant during the year, measured in tonnes

Ntrl is the quantity of nitrogen in sludge transferred out of the plant and removed to landfill during the year, measured in tonnes

Ntro is the quantity of nitrogen in sludge transferred out of the plant and removed to a site other than landfill during the year, measured in tonnes

Noutdisij is the quantity of nitrogen leaving the plant, differentiated by discharge environment
EFsecij is the emission factor for wastewater treatment.

EFdisij is the emission factor for nitrogen discharge, differentiated by the discharge environment.

The wastewater treatment plant produces high quality effluent which is sent to Wallacia Weir and the Warragamba River, both inland waterways. Meanwhile the brine is sent to the Malabar wastewater network before being discharged to the ocean. Given the different discharge environments, EFdisij will vary accordingly.

The following formulas were used to derive the above inputs where required:

$$Nin = Protein \times Fracpr \times P$$

Where:

Protein is the annual per capita protein intake of the population being served by the plant, measured in tonnes per person

Fracpr is the fraction of nitrogen in protein
P is the population serviced by the plant during the year

$$Ntrl = FNtrl \times Mtrl$$

Where:

FNtrl is the fraction of nitrogen in the sludge transferred out of the plant to landfill

Mtrl is the dry mass of sludge transferred out of the plant to landfill during the year, measured in tonnes

$$Ntro = FNtro \times Mtro$$

Where:

FNtro is the fraction of nitrogen in the sludge transferred out of the plant to a site other than landfill

Mtro is the dry mass of sludge transferred out of the plant to a site other than landfill during the year, measured in tonnes

Refer to Table 15 for the estimated nitrous oxide emissions during the operation of the project.

Table 7 Fugitive nitrous oxide emission inputs

Input	Value	Unit	Method and assumptions used to derive value
Protein	0.036	tonnes per person per year	Assumption from National Greenhouse and Energy Reporting (Measurement) Determination 2008
Fracpr	0.16	Tonne N per tonne protein	Assumption from National Greenhouse and Energy Reporting (Measurement) Determination 2008
P	375,000	people	Known value from current growth forecasts

Input	Value	Unit	Method and assumptions used to derive value
FNtrl	0.05		Assumption from National Greenhouse and Energy Reporting (Measurement) Determination 2008
Mtrl	0	tonnes	Assuming none sent to landfill
FNtro	0.05		Assumption from National Greenhouse and Energy Reporting (Measurement) Determination 2008
Mtro	1,308	tonnes	From wastewater treatment process calcs, there is an average estimate of 16,288 kg/d sludge. Peak is 21,453 kg/d (as "wet sludge"). Dry mass is estimated assuming 22%DS as the final dewatered sludge solids concentration, as per process calcs.
Noutdisij (effluent)	8.3	Tonnes N per year	Calculated from the water treatment process mass balance
Noutdisij (brine)	62.9	Tonnes N per year	Calculated from the water treatment process mass balance
EFsecij	4.9	tonne $CO_{2\text{-}e}$ per tonne N	Default values from National Greenhouse and Energy Reporting (Measurement) Determination 2008
EFdisij (effluent)	4.7	tonne $CO_{2\text{-}e}$ per tonne N	Default value from National Greenhouse and Energy Reporting (Measurement) Determination 2008 where nitrogen is discharged to an enclosed inland waterway.
EFdisij (brine)	0	tonne $CO_{2\text{-}e}$ per tonne N	Default value from National Greenhouse and Energy Reporting (Measurement) Determination 2008 where nitrogen is discharged to open coastal waters.

5.1.1.3 Vegetation removal

Scope 1 emissions from vegetation removal accounts for the loss of vegetation, and subsequent loss of sequestration during the construction phase. The Greenhouse Gas Assessment Workbook for Road projects (TAGG, 2013) provides a methodology for estimating the loss of carbon sequestration associated with the removal of vegetation due to land clearing activities during construction.

The methodology provided in Appendix E (TAGG, 2013) is in line with the methodology used by the Australian Government Department of Agriculture, Water and the Environment to estimate Australia's national GHG emissions for reporting under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The methodology is based on a conservative approach and the following assumptions:

- All carbon pools are removed as part of the clearance of vegetation (e.g. debris and soil)
- All carbon removed is converted to CO2 and released to the atmosphere
- Sequestration as a result of any revegetation works carried out as part of the project is not included in the assessment.

The methodology estimates the GHG emissions associated with the loss of carbon sequestration that exists in vegetation at the time of clearing and the potential carbon that could have been sequestered in the future if the vegetation had not been cleared. The following steps were followed to establish the emission factors for the construction of the AWRC and pipelines:

- The potential maximum biomass 'Maxbio' class was determined for each site location using vegetation maps provided in Appendix E of the TAGG Workbook
- The class of vegetation (Table 1 Appendix E) and the area in hectares for each vegetation type to be cleared was identified
- The vegetation clearance emissions factors for each vegetation class for the selected 'Maxbio' class from Table 2 of the TAGG Workbook Appendix E were identified.

By assessing the location of the AWRC and pipelines, it was determined that the impacted land for both project components consists of grassland and trees. The GIS model used to determine the areas of vegetation is not able to determine the species of trees impacted, therefore a worst-case scenario of open forest was assumed, given a 'Maxbio' class of 4. Areas of vegetation were cross calculated with assumptions provided by the environment and ecology team. Following the identification of the vegetation type the ensuing method was used to calculate the Scope 1 emissions due to the removal of vegetation:

$$\text{GHG emissions } (tCO_{2\text{-}e}) = Q \times EF$$

Where:

Q is the area of land cleared (hectares)

EF is the relevant emission factor ($tCO_{2\text{-}e}$ per hectare)

Table 8 Vegetation emission factors

Vegetation type	Vegetation class	Emission factor (tCO2-e per hectare)	Source
Grassland	I	110	(Greenhouse Gas Assessment Workbook for Road Projects, 2013)
Open Forrest	C	521	

5.1.2 Scope 2

5.1.2.1 Electricity

Scope 2 emissions from the consumption of electricity accounts for the indirect emissions released from its production. The following method was used to calculate the Scope 2 GHG emissions from the consumption of electricity as sourced from the National Greenhouse Accounts (NGA Factors, 2019):

$$\text{GHG emissions } (tCO_{2\text{-}e}) = Q \times EF$$

Where:

Q is the quantity of purchased electricity (MWh)

EF is the emission factor for NSW ($tCO_{2\text{-}e}$ / MWh)

The amount of emissions per MWh of electricity consumed is dependent on the process used in its generation i.e. the more fossil fuels used the higher the emission factor per MWh. Since the energy mix within the electricity grid is constantly changing, the electricity emission factor is also changing in response. With NSW targeting net zero emissions in 2050, the rate of uptake of renewable energy onto the grid is expected to increase in the coming years resulting in a lower emission factors moving forwards. The National Greenhouse Accounts (NGA Factors 2019) provide estimates up to 2019 however given construction is due to commence in 2022 and operation of the project is to run until 2034, these values must be projected forwards to capture the anticipated change.

The Climate Change Authority provides four scenarios for how electricity emission factors could change towards 2030 in its Climate Change Mitigation Scenarios (2013) report. Scenarios depend on whether a carbon price is introduced, and whether a high or low carbon price is implemented. Accurately predicting which scenario will prove to be most accurate is a difficult task, as there are many factors which can influence rate of uptake of renewable energy e.g. national and state policy/funding, levels of private investment, market performance/costs and social acceptance. In acknowledgment of this unpredictability, and to maintain a balanced approach, the mid-range of all scenarios was selected as the preferred trajectory. As the scenarios only run up to 2030, the average annual change in emission factors between 2025 and 2030 was used to project towards 2034.

Table 9 Electricity emission factors

Year	Emission factor (tCO2-e per MWh)	Source and assumptions to derive values
2022	0.69	The emission factor for 2019 was obtained from (National Greenhouse Accounts Factors, 2019) and the mid-range of the projected year on year change (Climate Change Authroity, n.d.) was used to project the emission factor towards 2030. The average annual % change from the last 5 years (2025-2030) was used to project the emission factors towards 2034.
2023	0.67	
2024	0.65	
2025	0.63	
2026	0.60	
2027	0.58	
2028	0.57	
2029	0.55	
2030	0.55	
2031	0.53	
2032	0.52	
2033	0.51	
2034	0.50	

5.1.3 Scope 3

5.1.3.1 Materials

Scope 3 emissions from materials account for the embodied GHG emissions released during the lifecycle of materials used during construction and operation. The ISCA materials calculator was utilised to obtain emission factors for the relevant materials or products. The calculator is a nationally recognised tool, which references emission factors from reputable and reliable sources such as The Australian National Life Cycle Inventory Database (AusLCI) and in the case of specific products, Environmental Product Declaration's (EPD). These are independently verified and registered documents that communicate transparent and comparable information about the life-cycle environmental impact of products. In the event where a relevant emission factor was not present within the ISCA materials calculator, the Transport for NSW Carbon Estimate Reporting Tool (CERT) or TAGG workbook (2013) were used as alternative sources as shown in Table 10.

Once all emission factors had been sourced, the following method was used to calculate the Scope 3 embodied material emissions:

$$\text{GHG emissions } (tCO_{2\text{-}e}) = Q_t \times EF$$

Where:

Q_t is the quantity of material (tonnes)

EF is the relevant emission factor ($tCO_{2\text{-}e}$ / tonne)

Table 10 Material emission factors

Material type	Emission factor (tCO2-e/tonne)	Source	Assumptions
Construction - AWRC			
Reinforced Concrete	-	-	-
Steel (rebar)	1.800	ISCA Materials - OneSteel Reinforcing Rod, Bar & Wire 2016 (EPD855)	
Concrete	0.185	CERT tool	Based on 50MPa concrete
Concrete works	0.138	CERT tool	Based on 32MPa concrete
Building brick work	0.390	TAGG Workbook (2013)	
Steel tanks	2.750	ISCA Materials - BlueScope XLERPLATE plate steel 2016 (EPD558)	Based on steel plate
Plywood formwork	0.907	ISCA Materials - FWPA Plywood 2015 (EPD564)	
Structural Steel	-	-	-

Material type	Emission factor (tCO2-e/tonne)	Source	Assumptions
Beams and columns	2.850	ISCA Materials - BlueScope Welded Beams and Columns 2016 (EPD559)	
Steel plate	2.750	ISCA Materials - BlueScope XLERPLATE plate steel 2016 (EPD558)	
Construction – Pipelines			
Polyethylene Pipe (PE) 100	5.025	ISCA Materials - EPD	
Reinforced Concrete Pipe (RCP) Class 4	0.328	ISCA Materials - AusLCI Shadow database	
Steel Cement Lined Pipe	-	-	
Steel	2.971	ISCA Materials - AusLCI Shadow database	Based on steel pipe and tube
Cement	0.984	ISCA Materials - AusLCI Shadow database	
Steel Pipe	2.971	ISCA Materials - AusLCI Shadow database	Based on steel pipe and tube
Operation - AWRC			
Alum	0.722	ISCA Materials - AusCI Shadow database	
Citric Acid	4.044	ISCA Materials - ecoinvent 3	
CO2	0.943	ISCA Materials - AusCI Shadow database	
Ferric Chloride	0.593	ISCA Materials - AusCI Shadow database	
Lime	0.779	ISCA Materials - AusCI Shadow database	
Liquid Polymer	2.905	ISCA Materials - AusCI Shadow database	
Methanol	0.727	ISCA Materials - AusCI Shadow database	

Material type	Emission factor (tCO2-e/tonne)	Source	Assumptions
Powder Polymer	2.905	ISCA Materials - AusCI Shadow database	Emission factor assumed equal to liquid polymer
Sodium Bisulphite	1.763	ISCA Materials - AusCI Shadow database	
Sodium Hypochlorite	8.387	ISCA Materials - AusCI Shadow database	

5.1.3.2 Transport

Scope 3 emissions from transport accounts for the use of vehicles during construction and operation which occurs outside the site boundary of the AWRC and pipelines.

The following method was used to calculate the Scope 3 GHG emissions from the combustion of fuels (transport) as sourced from the National Greenhouse Accounts (NGA Factors, 2019):

$$\text{GHG emissions } (tCO_{2\text{-}e}) = ((Q \times ECF)/1000) \times (EF_{CO2} + EF_{CH4} + EF_{N2O})$$

Where:

Q is the quantity of fuel (kL)

ECF is the relevant energy content factor (GJ/kL)

EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (kg CO_2-e/GJ)

EF_{CH4} is the relevant Methane (CH_4) emission factor (kg CO_2-e/GJ)
EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (kg CO_2-e/GJ)

Table 11 Transport fuel emission factors

Fuel Type	Energy content factor (GJ/kL)	Emission factor (kg CO2-e/GJ)			Emission factor (tCO2-e/kL)	Source
		CO2	CH4	N2O		
Diesel	38.6	69.9	0.01	0.6	2.7	(National Greenhouse Accounts Factors, 2019)
Gasoline	34.2	67.4	0.02	0.2	2.3	

5.1.3.3 Waste

Scope 3 emissions from waste accounts for transfer of waste streams to landfill during construction and operation and the resultant GHG emissions which occur as the waste decomposes.

The following method was used to calculate the Scope 3 GHG emissions from the decomposition of waste as sourced from the National Greenhouse Accounts (NGA Factors 2019). This method is used to produce an estimate of lifetime emissions from waste degradation in a landfill. In reality waste disposed in a landfill will degrade and emit over a period of decades.

$$GHG\ emissions\ (tCO_{2\text{-}e}) = Q \times EF$$

Where:

Q is the quantity of waste by type tonnes
EF is the emission factor of waste per tonne

Table 12 Waste emission factors

Waste type	Emission factor (tCO2-e/tonne)	Source
Demolition waste	0.2	(National Greenhouse Accounts Factors, 2019)
Food waste	1.9	
Green waste	1.4	
Other construction waste	0.2	
Paper and cardboard	2.9	
Tyres	2.9	
Wood waste	0.6	

5.1.3.4 Electricity and Fuel

Scope 3 emissions from electricity and fuel accounts for electricity transmission and production losses and the extraction and production of fuels. The following method was used to calculate the Scope 3 GHG emissions from electricity as sourced from the National Greenhouse Accounts (NGA Factors, 2019).

$$GHG\ emissions\ (tCO_{2\text{-}e}) = Q \times EF$$

Where:

Q is the quantity of purchased electricity (MWh)
EF is the scope 3 emission factor for NSW ($tCO_{2\text{-}e}$ / MWh)

Similarly, to scope 2 electricity emission factors, Scope 3 emission factors also vary with time. Values up to 2019 are provided within the National Greenhouse Accounts (NGA Factors, 2019), therefore in order to project these values towards 2034, the end of the projected operational period of the project, the average year on year reduction for the last five years was calculated and projected forwards.

Table 13 Scope 3 electricity emission factors

Year	Emission factor (tCO_2-e per MWh)	Source and assumptions to derive values
2022	0.090	The emission factor for 2019 was obtained from (National Greenhouse Accounts Factors, 2019) the average annual % change from the last 5 years (2014-2019) was used to project the emission factors towards 2034.
2023	0.086	
2024	0.081	
2025	0.077	
2026	0.073	
2027	0.070	
2028	0.066	
2029	0.063	
2030	0.060	
2031	0.057	
2032	0.054	
2033	0.051	
2034	0.049	

The following method was used to calculate the Scope 3 GHG emissions from fuel as sourced from the National Greenhouse Accounts (NGA Factors 2019).

$$\text{GHG emissions } (tCO_{2\text{-}e}) = ((Q \times ECF)/1000) \times (EF)$$

Where:

Q is the quantity of fuel (kL)
ECF is the relevant energy content factor (GJ/kL)
EF emission factor (kg CO_2-e/GJ)

Table 14 Scope 3 fuel emission factors

Fuel Type	Energy content factor (GJ/kL)	Emission factor (kg CO2-e/GJ)	Emission factor (tCO2-e/kL) or (tCO2-e/GJ) for Natural gas	Source
Diesel	38.6	3.6	0.14	(National Greenhouse Accounts Factors, 2019)
LPG	25.7	3.6	0.09	
Gasoline	34.2	3.6	0.12	
Natural gas	Na	12.8	0.01	

6 Results

Following the quantification of the emission sources in Table 4 and a summary of the calculation methods and emissions factors in section 5, the following section provides a summary of the final calculated GHG emission inventory. Table 15 below outlines the results, containing the emission source quantities, respective emission factors and final calculated emissions (tCO_{2-e}), reported separately for construction and operation for the AWRC and pipelines. Note that emission source quantities and calculated emissions are reported for the total construction and operational periods.

Table 15 Summary GHG emission inventory

Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor ($tCO_{2\text{-}e}$/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
Scope 1	Fuel	Construction	AWRC	Diesel	2,452	kL	2.7	6,645	0.99%	3.22%
				E10						
				Ethanol	2	kL	0.006	0.01	0.000002 %	
				Gasoline	15	kL	2.3	34	0.01%	
				LPG	3	kL	1.6	5	0.001%	
				Gasoline	62	kL	2.3	143	0.02%	
			Pipelines	Diesel	2,082	kL	2.7	5,641	0.84%	
				Gasoline	8	kL	2.3	18	0.003%	
		Operation	AWRC	Diesel	179	kL	2.7	485	0.07%	
				Gasoline	36	kL	2.3	83	0.01%	
				Natural gas	167,846	GJ	0.05	8,649	1.28%	
	Wastewater treatment	Operation	AWRC	Methane	Refer to section 5.1.1.2			0	0.00%	14.77%
				Nitrous Oxide	Refer to section 5.1.1.2			99,537	14.77%	
	Vegetation clearance	Construction	AWRC	Grassland cleared	52.94	hectares	110	5,823	0.86%	6.22%
				Open forest cleared	27.06	hectares	521	14,098	2.09%	
			Pipelines	Grassland cleared	33.01	hectares	110	3,631	0.54%	
				Open forest cleared	35.29	hectares	521	18,386	2.73%	

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Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
Total (Scope 1)								163,179	24.21%	
Scope 2	Electricity	Construction	AWRC	Electricity	14.34	MWh	0.56	10	0.001%	20.58%
		Operation	AWRC	Electricity	213,660	MWh	0.33	118,381	17.56%	
			Pipelines	Electricity	36,713	MWh	0.33	20,341	3.02%	
Total (Scope 2)								138,732	20.58%	
Scope 3	Materials	Construction	AWRC	Reinforced Concrete						49.67%
				Steel (rebar)	3,261	tonnes	1.8	5,870	0.87%	
				Concrete	77,263	tonnes	0.185	14,326	2.13%	
				Concrete works	62,760	tonnes	0.138	8,682	1.29%	
				Building brick work	2,384	tonnes	0.390	930	0.14%	
				Steel tanks	3,697	tonnes	2.750	10,166	1.51%	
				Plywood formwork	278	tonnes	0.907	252	0.04%	
				Structural Steel						
				Beams and columns	27,000	tonnes	2.850	76,950	11.42%	
				Steel plate	3,000	tonnes	2.750	8,250	1.22%	
			Pipelines	OD560 PE 100 PN16	1,716	tonnes	5.025	5,192	0.77%	
				OD560 PE 100 PN20	73	tonnes	5.025	221	0.03%	
				DN700 RCP Class 4	154	tonnes	0.328	50	0.01%	

Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
Scope 3	Materials	Construction		DN900 RCP Class 4	649	tonnes	0.328	213	0.03%	
				DN1200 RCP Class 4	467	tonnes	0.328	153	0.02%	
				DN1500 RCP Class 4	4,173	tonnes	0.328	1,368	0.20%	
				OD508 Steel Cement Lined Pipe						
				Steel	89	tonnes	2.971	263	0.04%	
				Cement	53	tonnes	0.984	52	0.01%	
				OD1016 Steel Cement Lined Pipe						
				Steel	456	tonnes	2.971	1,355	0.20%	
				Cement	221	tonnes	0.984	217	0.03%	
				OD1283 Steel Cement Lined Pipe						
				Steel	6,230	tonnes	2.971	18,509	2.75%	
				Cement	2,990	tonnes	0.984	2,942	0.44%	
				OD711 Steel Pipe	358	tonnes	2.971	1,064	0.16%	
		Operation	AWRC	Alum	77,453	tonnes	0.722	55,893	8.29%	
				Citric Acid	2,300	tonnes	4.044	9,304	1.38%	
				Ferric Chloride	39,535	tonnes	0.943	23,462	3.48%	
				Liquid Polymer	532	tonnes	0.593	1,546	0.23%	

Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
				Methanol	19,454	tonnes	0.779	14,138	2.10%	
				Sodium Bisulphite	561	tonnes	2.905	989	0.15%	
				Sodium Hypochlorite	7,215	tonnes	0.727	60,520	8.98%	
				CO2	2,011	tonnes	2.905	1,896	0.28%	
				Lime	6,592	tonnes	1.763	5,133	0.76%	
				Powder Polymer	1,669	tonnes	8.387	4,848	0.72%	
	Transport	Construction	AWRC	Site establishment (Diesel)	1	kL	2.7	3	0.001%	0.44%
				Fill import (Diesel)	87	kL	2.7	238	0.04%	
				Earthworks waste disposal (Diesel)	15	kL	2.7	40	0.01%	
				Concrete delivery (Diesel)	77	kL	2.7	209	0.03%	
				Sand/other deliveries (Diesel)	13	kL	2.7	35	0.01%	
				Mech and elec install (Diesel)	6	kL	2.7	17	0.003%	
				Landscaping and restoration (Diesel)	3	kL	2.7	9	0.001%	
				Workers trips (Gasoline)	131	kL	2.3	302	0.04%	
			Pipelines	Site establishment (Diesel)	7	kL	2.7	20	0.003%	
				Fill import (Diesel)	75	kL	2.7	204	0.03%	

Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
Scope 3				Earthworks waste disposal (Diesel)	21	kL	2.7	58	0.01%	
				Concrete delivery (Diesel)	63	kL	2.7	173	0.03%	
				Sand/other deliveries (Diesel)	137	kL	2.7	372	0.06%	
				Mech and elec install (Diesel)	1	kL	2.7	2	0.0003%	
				Landscaping and restoration (Diesel)	6	kL	2.7	17	0.003%	
				Workers trips (Gasoline)	131	kL	2.3	302	0.04%	
		Operation	AWRC	Chemical deliveries (Diesel)	273	kL	2.7	744	0.11%	
				Biosolids outload (Diesel)	81	kL	2.7	220	0.03%	
	Waste	Construction	AWRC	Demolition waste	1,160	tonnes	0.2	232	0.03%	2.71%
				Food waste	40	tonnes	1.9	75	0.01%	
				Green waste	3,456	tonnes	1.4	4,838	0.72%	
				Other construction waste	7,836	tonnes	0.2	1,567	0.23%	
				Paper and cardboard	20	tonnes	2.9	57	0.01%	
				Tyres	6	tonnes	2.9	17	0.003%	
				Wood Waste	78	tonnes	0.6	47	0.01%	
			Pipelines	Food waste	47	tonnes	1.9	89	0.01%	

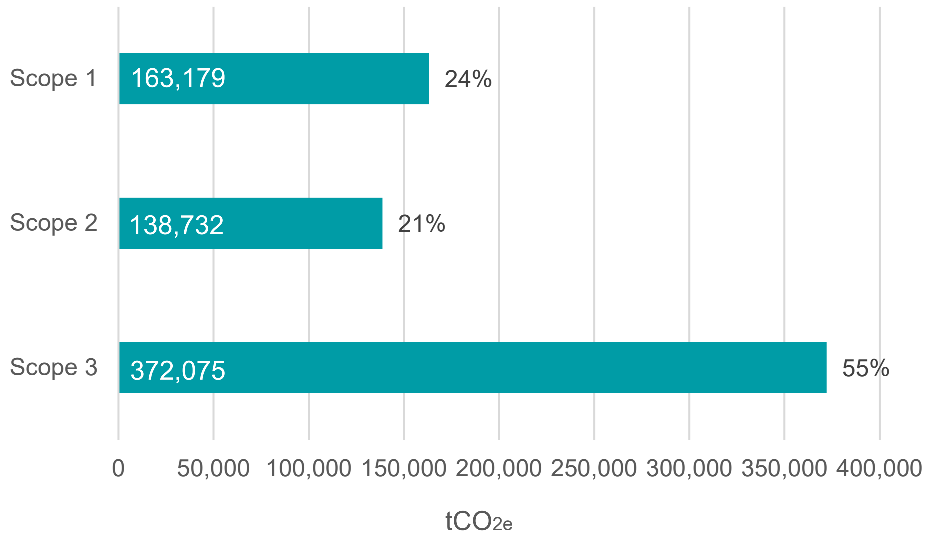
Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
Scope 3				Green waste	7,320	tonnes	1.4	10,248	1.52%	
				Other construction waste	3,072	tonnes	0.2	614	0.09%	
				Paper and cardboard	23	tonnes	2.9	67	0.01%	
				Tyres	55	tonnes	2.9	160	0.02%	
				Wood waste	41	tonnes	0.6	25	0.00%	
		Operation	AWRC	Food waste	20	tonnes	1.9	38	0.01%	
				Green waste	100	tonnes	1.4	140	0.02%	
				Paper and cardboard	10	tonnes	2.9	29	0.00%	
				Wood waste	1.2	tonnes	0.6	0.7	0.00%	
	Electricity and fuel	Construction	AWRC	Electricity	14.34	kL	0.073	1.1	0.00%	2.39%
		Operation	AWRC	Electricity	213,660	kL	0.053	11,344	1.68%	
			Pipelines	Electricity	36,713	kL	0.053	1,949	0.29%	
Scope 3	Electricity and fuel	Construction	AWRC	Diesel	2,452	kL	0.14	341	0.05%	
				E10						
				Ethanol	2	kL	0	0	0.00%	
				Gasoline	15	kL	0.12	2	0.0003%	
				LPG	3	kL	0.09	0.3	0.00005%	
				Gasoline	62	kL	0.12	7.6	0.001%	

Emission Scope	Emission category	Development Phase	Project component	Emission Source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2e})	% of total (emission source)	% of total (emission category)
			Pipelines	Diesel	2,082	kL	0.14	289	0.04%	
				Gasoline	8	kL	0.12	0.9	0.0001%	
		Operation	AWRC	Diesel	179	kL	0.14	24.9	0.004%	
				Gasoline	36	kL	0.12	4.4	0.001%	
				Natural gas	167,846	GJ	0.05	2,148	0.32%	
Total (Scope 3)								372,075	55.21%	
Total (All Scopes)								**673,986**	**100%**	

6.1 Results Summary

Figure 3 provides a summary of the total emissions calculated for each scope across construction and operation of the project. Also shown are the percentages when compared to the total emissions. As indicated by Table 15 Summary GHG emission inventory, the total emissions amount to 673,986 tCO_{2-e}.

Figure 3 Summary of scope emissions



The emissions from the project can also be assessed by comparing the construction and operation phases. Construction accounts for about one third of all emissions from the project, and operation about two thirds. The major contributors to the construction emissions are materials for the AWRC (of which structural steel is the largest contributor at 54%) and vegetation clearing. The major contributors to the operation emissions are chemicals used for the water treatment process and electricity purchased from the grid.

Table 16 provides a summary of the results showing the largest contributing emission sources for each of the scopes. These emission sources account for greater than 10% of the total emission inventory individually and 85% when combined therefore have been used to inform and develop a mitigation strategy for the total remaining emissions. Details of the targeted mitigation measures for consideration can be found in section 7.2.

Table 16 Largest emission sources

Emissions scope	Total emissions (tCO2-e)	Largest emission sources	Emissions (tCO2-e)	% of total emissions
Scope 1	163,179	Nitrous Oxide from wastewater treatment	99,537	14.77%
Scope 2	138,732	Electricity consumption	138,732	20.58%
Scope 3	372,075	Materials	334,754	49.67%
Total			**573,023**	**85%**

7 Mitigation Measures

This section outlines the mitigation measures that have been included in the project as well as identifying additional measures that if adopted, can effectively drive down the GHG emission inventory.

7.1 Mitigation measures

Table 17 details the mitigation measures included in the project design. Had these measures not been included, the unmitigated total GHG emission inventory would increase from 673,986 to 1,074,019 tCO_2-e. Combined, these measures result in a saving of 28.6% when compared to the unmitigated GHG inventory. These measures also directly support Sydney Water's Energy Master Plan which aims to maximise the renewable electricity generation potential of our assets, maximise the economic benefit of our generation and leverage renewable electricity to improve energy security in our system. As part of these aims, we are targeting self-generating 35% of our electricity by 2030 by installing 4.5MW of cogeneration & hydro and 13.5MW of solar & wind. The project will install 1.2MW of cogeneration and 3.8MW of solar PV, contributing towards 27% and 28% of these targets alone.

Table 17 Mitigation measures included

Mitigation measure	Description	Estimated saving (tCO_2-e)	Estimated saving (%)
Biogas capture/flaring	Biogas will be produced in digesters and stored in gas bubbles that sit on the digesters. The majority of methane in the biogas (approximately 60% composition of biogas by volume) will be combusted in cogeneration engines. Although standard practice, direct emissions will be further reduced by flaring when biogas flow exceeds the capacity of cogeneration. This will result in zero fugitive methane emissions throughout the operation of the wastewater treatment facility.	315,000	29%
Cogeneration + solar PV	The capture of methane to generate renewable electricity through cogeneration plant and the installation of solar photovoltaics, will offset electricity that otherwise would be purchased from the grid.	85,033	8%
Total		**400,033**	**37%**

When the methane is flared, it releases carbon dioxide, water vapour and small amounts of nitrous oxide. Because the burning process is not 100% efficient it also produces trace amounts of carbon monoxide and residual unburnt hydrocarbons. The $tCO_{2\text{-}e}$ released from the flaring of methane is however negligible and amounts to less than 0.1% of the total GHG emission inventory. This is also the case of the methane released during the cogeneration process.

7.2 Mitigation measure opportunities

The GHG assessment has identified the emission categories and sources which contribute most to the overall GHG emission inventory for the project. Mitigation measures which represent an opportunity to reduce the impact further have therefore been selected to target these emissions as outlined below in Table 18. The mitigation measures related to wastewater treatment efficiency under Electricity (scope 2) are aligned with Sydney Water's Design Guideline document for best practice in energy efficiency. It is recommended that ways to improve energy efficiency in line with Sydney Water best practice should be considered at the detailed design stage.

Table 18 Mitigation measure opportunities

Emission Category	Measure for consideration	Description	Phase where measure is implemented	Phase where resultant saving is realised
Materials (scope 3)	Increase the proportion of recycled and reused materials	Seek to procure recycled or reused materials where the options exist, and comparable performance can be achieved. Targeting materials which have the highest impact (such as concrete) and are most easily recycled (such as steel) will result in the greatest savings.	Detailed design	Construction
	Design for enhanced material efficiency	Review and develop the design to identify where reductions in material quantities can be made, while maintaining the design performance.	Detailed design	Construction
	Consider alternative materials	Identify materials which can be substituted for lower embodied carbon alternatives. Targeting possible alternatives for wastewater treatment chemicals such as Alum and Sodium Hypochlorite will result in the greatest savings.	Detailed design	Construction
	Design for circular economy	Consider the lifetime of the asset in the design, particularly with regards to decommissioning. Design for materials and construction processes which enable the recovery and reuse of materials.	Detailed design	Operation

Emission Category	Measure for consideration	Description	Phase where measure is implemented	Phase where resultant saving is realised
Electricity (scope 2)	Reduce demand via passive design measures	Use passive design measures such as optimum solar orientation, shading and natural ventilation to reduce demand for heating and cooling of occupied site buildings.	Detailed design	Operation
	Reduce demand in buildings via active design measures	Use active design measures such as LED lighting, high efficiency appliances, low carbon heating/cooling solutions to reduce the operational energy demand.	Detailed design	Operation
	Improve efficiency of wastewater treatment process	Align equipment and process selection with the Design Guideline – Best Practice energy Efficiency (D0001653) This includes high-speed turbo blowers and motors compliant to IE4 and above, as well as active controls to prevent electricity waste, such as control of dissolved oxygen (DO) setpoints using ammonia probes to minimise use of air, control of UV output by measuring transmissivity and control of the compressed air output by using variable speed drives (VSDs) to control motor speed.	Detailed design	Operation
	Increase generation of biogas	During the early years of operation before the digesters reach full capacity, there is an opportunity to accept organic food waste which can be added to the digesters. This will enable more biogas to be generated and therefore more electricity.	Detailed design	Operation
	Increase solar PV generation	Increase the capacity of the on-site solar PV to offset electricity purchased from the grid.	Detailed design	Operation

Emission Category	Measure for consideration	Description	Phase where measure is implemented	Phase where resultant saving is realised
	Invest in carbon offsets or PPA's	Offset emissions from purchased electricity by purchasing large scale generation certificates (LGCs) or entering into a power purchasing agreement where electricity is sourced from off-site renewable energy.	Operation	Operation
Wastewater Treatment (scope 1)	Optimise the activated sludge process to increase the rate of denitrification	The activated sludge process involves nitrification (the conversion of nitrogen compounds into oxidised forms), followed by denitrification (the conversion of oxidised compounds into reduced forms), therefore increasing the rate of denitrification will reduce the rate of nitrous oxide emissions. Example technologies for considerations include: Aerobic bioreactor packed with carbon fibres as an alternative to conventional activated sludge treatment, simultaneous nitrification-denitrification process in extended aeration plants.	Detailed design	Operation

8 Carbon Budgets

As part of SEARs matter 64e, the project emissions are to be compared to Australia and NSW carbon budgets in order to contextualise the impact. A carbon budget is an amount of greenhouse gas that can be 'spent' (emitted) for a given level of global warming. If we exceed this budget, then global temperatures will increase. Given that this assessment has not only considered carbon but also non-CO_2 gases such as methane and nitrous oxide, the carbon budgets must also include non-CO_2 gases to enable equal comparisons.

8.1 National Carbon Budget

Australia does not have a commonly accepted and up-to-date carbon budget. Historic calculation of carbon budgets has resulted in a wide range of variation due to different approaches, timeframes, estimates of warming to-date and other factors. In addition, carbon budgets often do not include non-CO_2 gases. However, a recent study by the University of Melbourne (Meinshausen A. M., 2019) has provided a robust estimate for Australia's remaining carbon budget in $GtCO_{2e}$ i.e. the maximum amount of carbon that Australia can emit between now and 2050 to avoid global temperatures increasing 1.5 degrees above pre-industrial levels. The authors referenced the International Panel on Climate Change (IPPC) Special Report (IPCC, 2018), which provides global budget estimates of 580 $GtCO_2$ (excluding permafrost feedbacks) based on a 50% probability of limiting warming to 1.5 degrees. They then converted the budget to include non-CO_2 gases and applied the method of modified contraction and convergence (as adopted by the Climate Change Authority) to allocate Australia's fair share of the global budget, which amounts to 5.5 $GtCO_{2-e}$ between 2017-2050.

8.2 NSW Carbon Budget

To determine the 'fair share' for NSW of the national emission budget, another study by the University of Melbourne, (Meinshausen, 2019) was used as it provides a series of relative emission shares for all territories. The shares vary depending on the method used to derive the value, however by taking a balanced approach of the average of all five methods, a share for NSW of 28.2% was calculated to determine a budget of 1,551 $MtCO_{2-e}$.

8.3 Project emissions compared to NSW and National Carbon Budgets

Table 19 presents how the estimated emissions for stage 1 compare to the above regional and national budgets. For ease of comparison, stage 1 emissions have been converted from tCO_{2-e} to $MtCO_{2e}$ where 1 tCO_{2-e} = 0.000001 $MtCO_{2-e}$.

Table 19 Carbon budget comparison

Total estimated project emissions (MtCO2e)	Carbon Budget (MtCO2-e)		Project emissions as % of carbon budget	
	NSW	National	NSW	National
0.674	1,551	5,500	0.04%	0.01%

To add further context to the total emissions, the total impact of stage 1 of the project throughout construction and operation is equal to the total emissions (including scope 1, 2 and 3) attributable to operating approximately 37,450 average Australian homes for one year[3].

[3] This is based on the average Australian household emitting 18 tonnes of CO_{2-e} per year.

9 Impact of future stages

As stated in the introduction a GHG assessment of the future stages, which will increase capacity to 100ML, will be considered at high level outlining how a future GHG assessment will be approached and estimating the expected impact. It is proposed that any future assessment adopts similar guidelines and processes utilised in this assessment, while ensuring to incorporate any ongoing changes to reporting standards and national/international best practice which may occur in due course.

The future stages will involve the expansion of the AWRC to an increased capacity of 100ML, however the pipelines will have been constructed to accept the increased flows, therefore no additional pipelines construction will be required, only an increase in operational capacity. As such, the following steps and assumptions have been followed to estimate the impact of the future stages using the Stage 1 GHG assessment as a basis.

- Estimated construction emissions for a 100ML facility assuming the impact is equal to an additional 50ML facility, excluding construction emissions attributed to the pipelines.
- Estimated operational emissions for a 100ML facility assuming the impact is equal to an additional 50ML facility for both the AWRC and pipelines and factoring for operational duration (see final point).
- Assumed future stages to have the same construction duration (3 years).
- Assumed future stages to operate until demand projections exceed the 100ML capacity (approximately 20 years).
- Based on these assumptions, the construction emissions for an additional 50ML plant amount to 160,223 tCO2-e and the operational emissions for an additional 50ML for 20 years amount to 883,695 tCO2-e, resulting in the total estimated impact of 1,043,918 tCO2-e, which is 155% of the projects GHG emission inventory.

10 Conclusion

It has been estimated that the scope 1, 2 and 3 emissions due to the whole period of construction and operation of the project amount to a total of 673,986 tCO_{2}-e. While this figure represents a relatively small proportion of regional and national carbon budgets, its impact is significant approximately equal to the emissions attributable to operating 37,450 homes for one year.

Measures have been included in the project design to reduce the GHG emissions. These measures include the capture and flaring of methane as well as the inclusion of cogeneration plant and solar PV to generate renewable energy. If it were not for these measures, the total GHG emissions would amount to 1,074,019 tCO_{2}-e, therefore these measures are responsible for a collective saving of 37%.

Of the remaining total GHG emissions, scope 3 emissions account for 55.21% of the total which is due to emissions from materials being the largest emitter (49.67%). Scope 2 emissions from electricity consumption and scope 1 nitrous oxide emissions from wastewater treatment are the 2^{nd} and 3^{rd} biggest emitters (20.58% and 14.77% respectively).

Mitigation measures to reduce the impact are therefore focused on these emission sources. The mitigation measures have the combined potential to further reduce the total inventory significantly and are recommended for further consideration as the project develops through detailed design.

11 References

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