Addendum

18 November 2021

To	Suzannah Byers		
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Subject	Climate Change Mitigation and Adaptation Addendum - Flooding	**Project no.**	12555493

1. Introduction

1.1 Purpose and scope

GHD have been engaged by the Department of Planning, Industry and Environment (DPIE) to provide this Addendum to LAHC's 2020 Climate Change Adaptation Report for the Planning Proposal Assessment stage at the Waterloo Estate (South) Precinct (the precinct).

As per Section 1.1 of the main Flooding and Stormwater Report, the 27 April Planning Proposal Gateway Determination recommended that the amendment to the Sydney Local Environment Plan (LEP 2012) addresses the following condition: Condition 10: Climate Change Mitigation and Adaptation - An addendum report to address storm events and flooding with the amended proposal.

The purpose of this addendum is to present the results from an updated Climate Change Risk Assessment (CCRA) regarding rainfall events and associated flood risks involved with the precinct. Specifically, this addendum:

- Discusses the appropriateness of future rainfall climate values utilised for previous reporting and details the additional climate change projection data used in the revised flooding and stormwater assessment.
- Identifies potential risks and vulnerabilities of the proposed design from flooding as a climate change hazard and updates the associated risk rankings based on updated flood modelling.
- Identifies adaptation measures that can be implemented during design to minimise this vulnerability and enhance asset resilience.

1.2 Assumptions and limitations

This report has been prepared by GHD for DPIE and may only be used and relied on by DPIE for the purpose agreed between GHD and DPIE as set out in Section 1.1 of this addendum.

GHD otherwise disclaims responsibility to any person other than DPIE arising in connection with this addendum. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this addendum were limited to those specifically detailed in the addendum and are subject to the scope limitations set out in the addendum.

The opinions, conclusions and any recommendations in this addendum are based on conditions encountered and information reviewed at the date of preparation of the addendum. GHD has no responsibility or obligation to update this addendum to account for events or changes occurring subsequent to the date that the addendum was prepared.

The opinions, conclusions and any recommendations in this addendum are based on assumptions made by GHD described in this addendum. GHD disclaims liability arising from any of the assumptions being incorrect.

The following assumptions and limitations apply to this CCRA:

- The analysis of climate change risk presented herein was based on two climate scenarios (RCP 4.5 i.e. 10% increase in rainfall intensity and RCP 8.5 i.e. 20% increase in rainfall intensity) developed and described in Section 2.1. These two scenarios are based on climate change projections available at the time of assessment as well as floodwater modelling provided by GHD. We consider these to be appropriate projections of likely future climatic conditions available for the purposes of this addendum. However, the projections have inherent uncertainties as to the likelihood of occurrence and intensity of events (refer Section 2.1.1.1).
- This assessment has been performed in consultation with the project personnel listed in Section 3.2. The project personnel were required to provide input on levels of assessed risk and the identification of adaptation measures which has been relied upon for this risk assessment.
- Due to the future being uncertain and the risk assessment being limited to the process being undertaken, no warranty is provided that all relevant climate risks have been identified, that the assessment of likelihood and consequence of each identified risk is accurate, or that identified control measures will be as effective as assumed during the assessment performed as reflected in this addendum. Climate change risk assessments per AS5334 are an iterative and going process that should incorporate updated knowledge and information, e.g. updated climate projections, fresh perspectives on relevant risks and better information on effectiveness of controls, as the project progresses through design, construction and operation.
- The focus of this addendum is on mitigating climate change through design, and therefore operational mitigation and adaptation measures have not been included in this addendum.

2. Background

2.1 Climate change

2.1.1 Climate change projections

The Intergovernmental Panel on Climate Change (IPCC) has developed four scenarios for global climate projections that relate to how the world may respond to the challenge of a changing climate, the need to continue to produce and use energy and resources, and the global greenhouse gas emissions that may occur. These scenarios incorporate diverging tendencies based on alternative economic, globalisation and environmental pathways. These have been modified through subsequent reports and renamed as Representative Concentration Pathways (RCPs) in the IPCC's Fifth Assessment Report (AR5) (IPCC, 2014). Whilst from 2014, AR5 is the latest (current) global compilation of updated climate science and projections. The fourth assessment report was made in 2007 and the sixth assessment cycle is due to be complete by 2022[1].

CSIRO and BOM released the Climate Change in Australia Technical Report in 2015 (CSIRO and BOM, 2015), which links strongly to findings of IPCC's AR5 and uses over 40 Global Climate Models (GCMs) to produce climate change projections as they relate to RCP scenarios presented in IPCC's AR5 in an Australian context.

These RCPs are described according to atmospheric CO_2 concentration levels and may also be described by anomalies in global mean surface air temperatures for the period 2081-2100 relative to the average period 1986-2005, (refer to Table 1) (CSIRO and BOM, 2015).

[1] Note that the Working Group I contribution to the Sixth Assessment Report is available now. The IPCC is now in its sixth assessment cycle, in which the IPCC is producing the Sixth Assessment Report (AR6) with contributions by its three Working Groups and a Synthesis Report, three Special Reports, and a refinement to its latest Methodology Report. The Synthesis Report will be the last of the AR6 products, currently due for release in 2022.

Current atmospheric concentration of CO_2 as of May 2021, is at approximately 416 parts per million (ppm) (NOAA, 2021), up from being stable at about 280 ppm prior to the industrial revolution and increasing by approximately 2.5 ppm per year (NOAA, 2020). Global mean atmospheric temperatures have increased slightly over 1 degree Celsius (°C) compared to pre-industrial levels (NASA, 2020), and Australia's climate has warmed in both surface air and surrounding sea surface temperatures by around 1.44°C since 1910 (BOM and CSIRO, 2020).

Table 1 Climate change emission scenarios

Global climate response	RCP scenario	Projected increase in global surface temperature by 2081 – 2100 (per AR5)
Strong immediate response, emissions peak by 2020, with rapid decline in emissions thereafter from global participation and application of technologies	**RCP 2.6**, atmospheric concentration of CO_2 projected at approx. 420 ppm by 2100	Mean projected increase **1.0°C** Anomaly range +0.3 to 1.7°C
Slower response, emissions peak around 2040, then decline	**RCP 4.5**, atmospheric concentration of CO_2 projected at approx. 540 ppm by 2100	Mean projected increase **1.8°C** Anomaly range +1.1 to 2.6°C
Slow response, application of mitigation strategies and technologies	**RCP 6.0**, atmospheric concentration of CO_2 projected at approx. 660 ppm by 2100	Mean projected increase **2.2°C** Anomaly range +1.4 to 3.1°C
Little curbing of emissions, continuing rapid rise throughout the 21st century	**RCP 8.5**, atmospheric concentration of CO_2 projected at approx. 940 ppm by 2100 and continuing to increase	Mean projected increase **3.7°C** Anomaly range +2.6 to 4.8°C

2.1.1.1 Climate change uncertainty

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

- Scenario uncertainty: due to the uncertain future emissions and concentrations of greenhouse gases and aerosols, resulting from uncertainties regarding the current and future activities of humans.
- Climate response uncertainty (climate sensitivity): resulting from limitations to scientific understanding of the climate system and its representation in climate models, and consequently how much the climate will change due to increased atmospheric concentration of greenhouse gases. This includes natural variability uncertainty, stemming from unperturbed variability in the climate system.
- Location specific uncertainties: regarding the assignment of probability distributions to regional climate change projections, and projecting climate change at small spatial scales, particularly for coastal and mountainous areas.

The inevitability of uncertainty is considered in the climate risk assessment methodology, refer section 3 below. It is recognised that decisions and adaptation planning processes should be flexible enough to cope with potential knowledge gaps.

2.1.2 Rainfall and flooding

The focus of this report is on flooding, how changes in rainfall may impact flooding at the Waterloo Estate (South). To date, significant increases in rainfall intensity have been detected in Australia for short duration rainfall events and are projected to become more evident towards the end of the 21st century. CSIRO and BOM (2015) project increased intensity of extreme rainfall events due to climate change with high confidence.

The Australian Rainfall and Runoff – A Guide to Flood Estimation (ARR 2019) (Ball J, 2019) is a guidance documented aimed to provide the best available information on design flood estimation in a manner suitable for use by Australian practitioners with varying levels of knowledge about the design flood

problems, flood processes and engineering hydrology. The ARR 2019 recognise that understanding the risks associated with climate change is critical for better planning new infrastructure and mitigating the potential damage to existing infrastructure.

Accordingly, the ARR 2019 Data Hub draws on the most recent climate science, including the IPCC's AR5 (IPCC, 2014) and the climate change projections for Australia (CSIRO and BOM, 2015) to provide climate change factors for rainfall intensity. The factors are provided for three RCP scenarios across multiple timeframes that can then be applied to bespoke flood models to account for the changes to flood patterns due to climate change. The climate change factors applicable to this project are provided in Table 2 below. The specific scenarios and factors adopted for this assessment have been detailed in section 3.1.

Table 2 ARR 2019 Climate change rainfall intensity factors

Year	RCP 4.5	RCP 6	RCP 8.5
2030	0.869 (4.3%)	0.783 (3.9%)	0.983 (4.9%)
2040	1.057 (5.3%)	1.014 (5.1%)	1.349 (6.8%)
2050	1.272 (6.4%)	1.236 (6.2%)	1.773 (9.0%)
2060	1.488 (7.5%)	1.458 (7.4%)	2.237 (11.5%)
2070	1.676 (8.5%)	1.691 (8.6%)	2.722 (14.2%)
2080	1.810 (9.2%)	1.944 (9.9%)	3.209 (16.9%)
2090	1.862 (9.5%)	2.227 (11.5%)	3.679 (19.7%)

3. Methodology

This climate change risk assessment was conducted in accordance with the following documents:

- Australian Standard AS 5334:2013 Climate change adaptation for settlements and infrastructure – A risk based approach (AS 5334) (Standards Australia, 2013)
- AS/NZS ISO 31000:2018 – Risk Management –Guidelines (ISO 31000:2018) (Standards Australia, 2009)
- Australian Rainfall and Runoff – A Guide to Flood Estimation (Ball J, 2019)

It should be noted, that considering this document is intended to act as an Addendum to LAHC's 2020 Climate Change Adaptation Report. As such where appropriate, information including risk statements and proposed adaptation measures were taken from LAHC's report and updated for this assessment.

3.1 Climate change scenarios and flood modelling

The climate change scenarios selected and modelled for this assessment were as follows:

- RCP 4.5 at 2090 – i.e. 9.5% (rounded to 10%) increase in rainfall intensity
- RCP 8.5 at 2090 – i.e. 19.7% (rounded to 20%) increase in rainfall intensity.

As per AS5334 these projections are current, authoritative and credible. This assessment builds upon the 2020 study by AECOM (which used RCP4.5 at 2090 i.e. 10%) and is consistent with AS5334 which recommends using multiple emissions scenarios to account for the uncertainty of the global emissions scenario that will actually transpire. Moreover, ARR 2019 recommends the use of RCPs 4.5 and 8.5 for impact assessments to ensure both a low and high concentrations pathways are considered.

Numerical flood modelling was conducted by GHD to assess potential flooding associated with climate change and to inform stormwater and flood management of the project. For the purposes of assessing flood risk associated with climate change the main flood parameter that was reviewed was the 1 in 100 Annual Exceedance Probability (AEP) being representative of the extreme rainfall events that pose the most risk to the asset and are expected to increase in intensity with climate change. This modelling took into consideration the impacts of climate change on extreme rainfall by considering the two climate change

scenarios detailed above i.e. the 10% and 20% increase in rainfall intensity associated with the RCP 4.5 (moderate) and RCP 8.5 (extreme) scenarios respectively.

More detail on the flood modelling performed by GHD including the parameters modelled is provided in the main Flooding and Stormwater Report, refer Section 5.

3.2 Risk assessment update

To ensure the appropriate quantification of, and adaptation to climate change risk a three-step approach was performed:

1. GHD reviewed and where appropriate included the risk statements and adaptation measures (related to extreme rainfall and flooding) from LAHC's 2020 Climate Change Adaptation Report in this updated CCRA.
2. GHD's Sustainability team consulted inhouse to identify any further climate change risks related to flooding based on the updated flood modelling.
3. A CCRA workshop was held to discuss and validate the risks identified, to document planned controls and adaptation measures, to reassess the 'residual risk' in light of the identified potential adaptations and to identify any risks not yet considered. This workshop was attended by the personnel listed in Table 3.

The assessment utilised the same risk matrix adopted for LAHC's 2020 report at the client's request. This risk matrix is from the Australian Greenhouse Office (AGO), *Climate Change Impacts and Risk Management – A Guide for Business and Government.* The risk matrix and the associated consequence and likelihood descriptors are provided in Appendix A. Consequences include consideration of community and lifestyle impacts, environmental and sustainability, service quality, development delivery and community confidence.

Table 3 List of personnel at CCRA workshop

Name	Company	Title
Lauren Harrington	GHD	Sustainability & Climate Change Consultant (Facilitator)
Tim Dunn	GHD	Senior Engineer - Sustainable Buildings
Natasha Karim	GHD	Sustainability Consultant
Rod Towner	GHD	Senior Civil Engineer
Dr. Rainer Berg	GHD	Senior Technical Director: Hydrology, Stormwater & Flooding
Suzannah Byers	DPIE	Senior Planning Officer
Alan Bright	DPIE	Director State Significant Acceleration
Andrew Golden	DPIE	Principal Planning Officer
Mark Parker	DPIE	Principal Planning Officer

4. Results

4.1 Flood simulations

The flood modelling results are provided in the main Flooding and Stormwater report, refer Section 5. Reviewing the 1 in 100 AEP event, the primary flood maps analysed included:

- *C13 Design Conditions – 1 in 100 AEP:* which provided the base case 1 in 100 AEP flood levels without considering climate change.
- *C24 Flood impact - 1 in 100 AEP Design (10% rainfall increase on Design):* which provided the 1 in 100 AEP flood levels considering the moderate climate change scenario i.e. RCP 4.5 at 2090.
- *C27 Flood impact - 1 in 100 AEP Design (20% rainfall increase on Design):* which provided the 1 in 100 AEP flood levels considering the extreme climate change scenario i.e. RCP 8.5 at 2090.

Whilst the modelling results were reviewed in their entirety, two locations were given particular attention including the intersection of George St and McEvoy St and the intersection of Cope St and John St, being identified as areas with the greatest potential climate change impact since flood waters pool in these locations. Table 4 provides the 1 in 100 AEP flood level at these two locations, as well as the impact and associated flood level considering the two climate change scenarios adopted for the assessment.

Table 4 Waterloo Estate (South) – 1 in 100 AEP event flood levels and impact considering climate change

Location	Flood level (mAHD)	Flood level increase (m)		Flood level (mAHD)	
		10% Climate Change	20% Climate Change	10% Climate Change	20% Climate Change
Intersection George and McEvoy Streets	16.89	0.03	0.05	16.92	16.95
Cope Street between John and Wellington Street	15.64	0.03	0.08	15.67	15.72

Flood maps C13, C24 and C27, and the results presented in Table 4 illustrate that flooding does present a risk to the Waterloo Estate (South) during extreme rainfall events such as the 1 in 100 AEP event and that this impact is expected to increase under both climate change scenarios. However, Table 4 also highlights that the flood risk only increases by a minor amount due to climate change, with the additional impact ranging from 0.03 m under the moderate climate change scenario up to 0.08 m under the extreme climate change scenario. The insights from these flood modelling results informed the identification of risks as well as the allocation of risk likelihoods and consequences during the completion of climate change risk assessment (detailed below).

4.2 Climate change flood risks and adaptation measures

4.2.1 Initial risk profile

Through the risk assessment process, eight climate change impacts due to extreme rainfall and flooding were identified across the two climate projection scenarios applied. In the initial risk profile, two ‘low’ and six ‘medium’ risks were found for the 2090 RCP 4.5 scenario and one ‘low’, five ‘medium’ and two ‘high’ risk were found for the 2090 RCP 8.5 scenario. Further detail including the risk statements identified through the assessment are detailed in Table 5, with the entire assessment provided as Appendix B.

4.2.2 Adaptation measures

Using the results of the risk assessment, adaptation measures were identified with the aim to address the extreme rainfall, flood and stormwater related risks posed to the Waterloo Estate (South) and reduce the residual risk. These measures were identified for consideration by DPIE for design including both current and future stages.

Table 5 provides the complete list of adaptation measures identified for each risk statement. Through the identification of these adaptation measures, the residual risk profile was reduced to three ‘low’ risks, five ‘medium’ risks and no ‘high’ or ‘extreme’ risks. In this way, all of the high risks were mitigated.

Table 5 Climate change risk assessment

Risk ID	Risk statement	Risk Rating RCP4.5	Risk Rating RCP8.5	Adaptation Measures	Adaptation Timing	Residual Risk Rating
001	Extreme rainfall leads to flood levels that can enter property/ buildings causing damage to floor	Medium	High	– Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater	Design	Medium

Risk ID	Risk statement	Risk Rating RCP4.5	Risk Rating RCP8.5	Adaptation Measures	Adaptation Timing	Residual Risk Rating
	levels, floor linings, resulting in repairs & increased maintenance costs.			Climate Change report (GHD November 2021). – Design buildings with floor levels in accordance with design guidelines. – Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard.		
002	Inundation of roads, footpaths and other site infrastructure by water, limiting access and egress and potentially leading to isolation.	Medium	Medium	– Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). – As part of future trunk drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly).	Design	Medium
003	Extreme rainfall event results in increased flood levels and flows which presents safety hazard to personnel, residents, and transport customers.	Low	Medium	– Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). – Design buildings with floor levels in accordance with design guidelines. – Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard. – As part of future trunk drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly.	Design	Low
004	Greater intensity of rainfall and runoff overwhelming drainage capacity and causing flooding and inundation of roof, ground, and subterranean systems.	Medium	Medium	– As part of future trunk and building drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly. – Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning	Design	Low

Risk ID	Risk statement	Risk Rating RCP4.5	Risk Rating RCP8.5	Adaptation Measures	Adaptation Timing	Residual Risk Rating
				Proposal Flooding Stormwater Climate Change report (GHD November 2021).		
005	Greater intensity of rainfall and runoff causing inundation of underground utility (electricity distribution, fibre cables, pumping stations, other network infrastructure malfunctions).	Medium	Medium	– Design utilities and critical infrastructure with levels in accordance with design guidelines. – Locate utilities above ground in flood prone area where possible. – Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021).	Design	Medium
006	Extreme rainfall can cause inundation of car parks, tunnels and other below-ground infrastructure resulting in transport network disruption.	Medium	Medium	– Design buildings entries with floor levels in accordance with design guidelines. – Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). – Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard.	Design	Medium
007	Extreme rainfall events resulting in flooding, leading to vehicle accidents resulting in potential health and safety incidents for road user or active transport users.	Medium	High	– Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021).	Design	Medium
008	Extreme rainfall event results in flooding and associated damage to vegetation in parks resulting in additional repair & maintenance costs.	Low	Low	– Ensure WSUD/retention measures are implemented in design as appropriate.	Design	Low

5. Conclusion

This report identifies and assesses the potential impacts from flooding associated with climate change on the Waterloo Estate (South). Through this assessment GHD have identified methods through which DPIE

can enhance their resilience to flooding, through the implementation of design measures both in the short term and long term.

The following is a summary of the initial risk profile for Waterloo Estate (South) with regards to flooding prior to the implementation of identified adaptation measures:

- In total 8 rainfall / flooding risks potentially impacted by climate change were identified for the project.
- Considering the most extreme climate change scenario, none of these risks were rated ‘extreme’, 2 risks were rated ‘high,’, 5 were rated ‘medium,’ and 1 was rated ‘low’.

Through the implementation of the identified management measures the flooding risk to Waterloo Estate (South) can be reduced, with the following a summary of the residual risk profile:

- In total 8 flooding risks were identified for the project.
- No ‘extreme’ or ‘high’ rated risks to the asset were identified, largely reflecting the effectiveness of the additional controls developed by GHD and DPIE.
- 5 were rated ‘medium,’ and 3 were rated ‘low’. These ratings were reduced from their initial ratings through the proposed adaptation measures.

It should be emphasised however, that the current risk profile of Waterloo Estate (South) is represented, not through the residual risk ratings, but rather through the initial risk ratings. In order to increase the resilience of the Estate to climate change, DPIE should implement the adaptation measures detailed in Section 4.2.2 and Appendix B.

Regards

Lauren Harrington
Sustainability & Climate Change Consultant

6. References

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Appendices

Appendix A

Risk Matrix

Appendix A – Risk Matrix

Table A.1 Risk Matrix

			Consequence				
			Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
			C1	C2	C3	C4	C5
Likelihood	**Almost Certain**	L1	Medium	Medium	High	Extreme	Extreme
	Likely	L2	Low	Medium	High	High	Extreme
	Possible	L3	Low	Medium	Medium	High	High
	Unlikely	L4	Low	Low	Medium	Medium	Medium
	Rare	L5	Low	Low	Low	Low	Medium

Table A.2 Likelihood criteria

Code	Rating	Recurrent Risks	Single events
L1	Almost Certain	Could occur several times per year	More likely than not – Probability greater than 50%.
L2	Likely	May arise about once per year	As likely as not – 50/50 chance.
L3	Possible	May arise once in ten years	Less likely than not but still appreciable – Probability less than 50% but still quite high.
L4	Unlikely	May arise once in ten years to 25 years	Unlikely but not negligible – Probability low but noticeably greater than zero.
L5	Rare	Unlikely during the next 25 years	Negligible – Probability very small, close to zero.

Table A.3 Consequences and Success Criteria

Code	Consequence and success criteria	Community and Lifestyle	Environment and Sustainability	Service Quality	Development Delivery	Community Confidence
C1	Catastrophic	The region would be seen as very unattractive, moribund, and unable to support its community.	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage.	Services would fall well below acceptable standards and this would be clear to all.	Development potential word be restricted delivered late, or not at all in a large number of cases.	There would be widespread concern about our capacity to serve the community.
C2	Major	Severe widespread decline in services, accessibility, and quality of life within the community.	Severe loss of environmental amenity and danger of continuing environmental damage.	The general public would regard the development's services as unsatisfactory	There would be isolated instances of development being restricted, delivered late, or not at all in a large number of cases.	There would be serious expressions of concern about our capacity to serve the community.
C3	Moderate	General appreciable decline in services and accessibility.	Isolated significant instances of environmental damage that might be reversed with intensive efforts.	Services old be regarded barely satisfactory by the general public and the developments project team.	There would be isolated but important cases of development being restricted or delayed.	There would be isolated expressions of concern about our capacity to serve the community.
C4	Minor	Isolates but noticeable examples of decline in services and accessibility.	Minor instances of environmental damage that could be reversed.	Services would be regarded as satisfactory by the general public but the developments project team would be aware of the deficiencies.	There would be isolated instances of development delivery failing to meet acceptable standards to a limited extent.	There would be some concern about our capacity to serve the community but it would not be considered serious.
C5	Insignificant	There would be minor areas in which the region was unable to maintain its current services.	No environmental damage.	Minor deficiencies in principle that would pass without comment.	Minor technical shortcomings in service delivery would attract no attention.	There would be minor concerns but they would attract no attention.

Appendix B

Climate Change Risk Assessment

CLIMATE CHANGE RISK ASSESSMENT

DESCRIPTION OF IMPACTS AND CONTROLS											RISK ASSESSMENT						ADAPTATION RESPONSES			
EXPOSURE AND VULNERABILITY			COMPONENTS POTENTIALLY IMPACTED								RATING FOR 2090 RCP 4.5 PROJECTION			RATING FOR 2090 RCP 8.5 PROJECTION			MANAGEMENT OPTIONS	RESIDUAL RISK RATING AFTER ADAPTATION		
Risk ID:	*Climate variable*	*Description of impact*	*Building*	*Roads, footpaths*	*Drainage systems*	*Other site infrastructure*	*Utilities*	*Below ground infrastructure*	*Water catchment*	*Personnel / Residents*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Adaptation Details*	*Likelihood*	*Consequence*	*Risk*
001	Extreme Rainfall and Flooding	Extreme rainfall leads to flood levels that can enter property/ buildings causing damage to floor levels, floor linings, resulting in repairs & increased maintenance costs.	•								Possible	Moderate	Medium	Likely	Moderate	High	–Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). –Design buildings with floor levels in accordance with design guidelines. –Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard.	Possible	Moderate	Medium
002	Extreme Rainfall and Flooding	Inundation of roads, footpaths and other site infrastructure by water limiting access and egress and potentially leading to isolation.	•	•						•	Possible	Minor	Medium	Likely	Minor	Medium	–Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). –As part of future trunk drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly.).	Possible	Minor	Medium
003	Extreme Rainfall and Flooding	Extreme rainfall event results in increased flood levels and flows which presents safety hazard to personnel, residents and transport customers								•	Unlikely	Minor	Low	Possible	Minor	Medium	–Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). –Design buildings with floor levels in accordance with design guidelines. –Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard. –As part of future trunk drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly.	Unlikely	Minor	Low
004	Extreme Rainfall and Flooding	Greater intensity of rainfall and runoff overwhelming drainage capacity and causing flooding and inundation of roof, ground and subterranean systems.			•						Possible	Minor	Medium	Likely	Minor	Medium	–As part of future trunk and building drainage design in the precinct, review design in the light of Climate Change and in accordance with the Climate Change procedures of ARR 2019, and design accordingly. –Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021).	Unlikely	Minor	Low
005	Extreme Rainfall and Flooding	Greater intensity of rainfall and runoff causing inundation of underground utility (electricity distribution, fibre cables, pumping stations, other network infrastructure malfunctions).					•				Unlikely	Moderate	Medium	Possible	Moderate	Medium	Design measures –Design utilities and critical infrastructure with levels in accordance with design guidelines. –Locate utilities above ground in flood prone area where possible. –Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021).	Unlikely	Moderate	Medium
006	Extreme Rainfall and Flooding	Extreme rainfall can cause inundation of car parks, tunnels and other below-ground infrastructure resulting in transport network disruption.						•			Unlikely	Moderate	Medium	Possible	Moderate	Medium	–Design buildings entries with floor levels in accordance with design guidelines. –Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021). –Consider designing to the 2090 RCP 4.5 and/or RCP 8.5 flood level, where the appropriate Flood Planning Level is documented as the 1 in 100 AEP flood level, without freeboard.	Unlikely	Moderate	Medium
007	Extreme Rainfall and Flooding	Extreme rainfall events resulting in flooding, leading to vehicle accidents resulting in potential health and safety incidents for road user or active transport users.								•	Unlikely	Major	Medium	Possible	Major	High	–Adopt stormwater and flood management strategies as documented in the Waterloo Estate (South) Planning Proposal Flooding Stormwater Climate Change report (GHD November 2021).	Unlikely	Major	Medium

DESCRIPTION OF IMPACTS AND CONTROLS												RISK ASSESSMENT						ADAPTATION RESPONSES			
EXPOSURE AND VULNERABILITY			COMPONENTS POTENTIALLY IMPACTED									RATING FOR 2090 RCP 4.5 PROJECTION			RATING FOR 2090 RCP 8.5 PROJECTION			MANAGEMENT OPTIONS	RESIDUAL RISK RATING AFTER ADAPTATION		
Risk ID:	*Climate variable*	*Description of impact*	*Building*	*Roads, footpaths*	*Drainage systems*	*Other site infrastructure*	*Utilities*	*Below ground infrastructure*	*Water catchment*	*Personnel / Residents*	*Likelihood*	*Consequence*	*Risk*	*Likelihood*	*Consequence*	*Risk*	*Adaptation Details*	*Likelihood*	*Consequence*	*Risk*
008	Extreme Rainfall and Flooding	Extreme rainfall event results in flooding and associated damage to vegetation in parks resulting in additional repair & maintenance costs.									Unlikely	Minor	Low	Unlikely	Minor	Low	–Ensure WSUD/retention measures are implemented in design as appropriate.	Unlikely	Minor	Low