Government of **Western Australia**
Department of **Finance**

Technical Guideline (TG050)

Climate Adaptation and Resilience

June 2025

Document control

Revision history

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Contents

1. Purpose

1.1. Changing Climate

Our planet is warming, and a clear correlation has been established between the rate of warming and the accumulation of greenhouse gases in the atmosphere. Efforts to reduce anthropogenic greenhouse gas emissions are underway in most regions of the world, to try and contain the warming to no more than 2°C above the 1850-1900 baseline.

Australia's commitment to the global emission reduction response, in-line with many developed countries, was to set a target of net zero greenhouse gas emissions by 2050, referred to as our commitment to the Paris Agreement. The Western Australian state government has affirmed their support to this target.

As noted by the WA state government:

> *The science is clear. Western Australia's climate has changed, and further change is inevitable.*[1]

The current level of warming (approx. 1.3°C in 2024), is already affecting weather patterns around the world, and leading to climate impact events of a catastrophic nature.

As it is not clear if our planned efforts to reduce emissions will achieve the level of containment hoped for, in parallel with emission reduction, action is needed to prepare for extreme weather events.

1.2. Climate Adaptation Strategy

To assist with preparedness for these extreme weather events, leading world organisations, and indeed the Australian and WA state government, are engaged in modelling and preparing predictions of future climate scenarios for our region.

Based on current projections, the WA state government released their Climate Adaptation Strategy (CAS) in July 2023, which aims to build a resilient future for WA.

The CAS covers a wide range of sectors including water, environment, communities, infrastructure and built environment, in general - all areas of the state's economy.

[1] DWER: Climate Adaptation Strategy, July 2023

Adapting infrastructure and buildings to climate change impacts is a key part of the WA Government's CAS and this Technical Guideline (TG050 – Climate Adaptation & Resilience) provides the guidance for project teams, customer agencies, and building operators, with respect to all non-residential government buildings procured through the Department of Housing & Works (DHW).

1.3. Adaptation Planning Process

Adaptation planning will assist with building resilience in the built environment. The process starts with gaining an understanding a project's function and Importance Level (IL), and the climate hazards that may impact the project based on the project's location. With this information the projects level of vulnerability can be determined, potential changes to the criteria throughout the life of the project should be considered when assessing the projects vulnerability.

In support of the adaptation planning process, TG050 aligns with the CAS by providing guidance on adaptation measures to be considered by project teams engaged on non-residential government building projects for DHW. The process covers the four key stages of the project, where DHW has an influence on the building's resilience: Project Definition Plan (PDP), Design, Construction, and Operation, as shown in Figure 1 below.

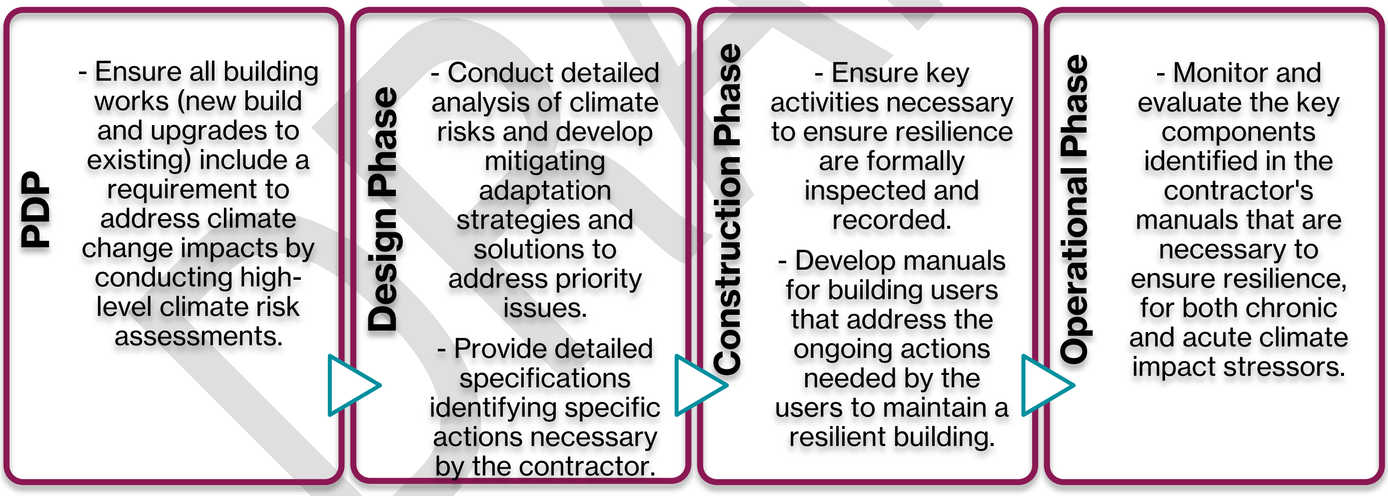

Figure 1. Adaptation Planning Process for DHW Projects

2. Responsibilities

Customer Agencies are responsible for lodging and obtaining Government approval for each project, including establishing an appropriate scope to meet its service delivery requirements and address stakeholder concerns, securing sufficient budget, and setting achievable timelines for delivery, in accordance with the Western Australian Public Sector's Strategic Asset Management Framework[2].

When undertaking the Business Case and Project Definition Plan, it is incumbent on each Customer Agency to ensure high-quality cost estimates are prepared, including commitments to address climate change impacts, and to champion the highest resilience standards that will be supported during the Expenditure Review process.

DHW is responsible for delivering capital works projects for its Customer Agencies within appropriate time-cost-quality parameters, in accordance with Government priorities and procurement requirements, including the imperative to achieve value for money outcomes. Government also expects DHW, as a central agency independent of its Customer Agencies, to review and at times challenge the appropriateness of design and its alignment to Government's policies and priorities.

DHW, and by extension the design team engaged by DHW, is committed to collaborating with its Customer Agencies and being responsive to Customer Agency requirements, in the context of its primary responsibilities to, and the priorities of Government. Design teams shall be fully engaged and responsible for the building achieving the required Environmentally Sustainable Design (ESD) performance, within the project budget and throughout the duration of the project.

Design teams shall be fully engaged and responsible for the building achieving the required resilience performance, within the project budget and throughout the duration of the project. Refer to the State Government's Architectural Services Brief for Non-Residential Government Buildings that outlines consultants' responsibilities within the project context.

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[2] Department of Treasury, Government of Western Australia, 2024

3. Guideline Application

3.1. Importance Level

Importance Level (IL) is a classification system used to determine the level of building design and construction required for buildings and structures. It reflects the potential consequences of a building's failure, especially regarding human safety and property damage. The National Construction Code (NCC) in Australia, defines four Importance Levels: 1 (lowest), 2 (default), 3 (higher occupancy or critical facilities), and 4 (essential post-disaster recovery or hazardous facilities).

*When applying TG050, the IL of a building needs to be considered. DHW have developed an IL Classification table aligning with the NCC that is to be used for all DHW projects (*Table 1*). Any deviations from the IL Classifications requires justification from the Customer Agency and Project team.*

Table 1. Importance Level Classification for DHW Projects

Importance Level Classification				
	IL1	IL2	IL3	IL4
NCC Definition	Buildings or structures presenting a low degree of hazard to life and other property in the case of failure	Buildings or structures not included in Importance Levels 1, 3 and 4.	Buildings or structures that are designed to contain a large number of people.	Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities.
DHW Building Type Examples	• Agricultural Shed • Greenhouse • Minor Storage Facility, e.g: - Fertiliser store • Minor Temporary Facility	• Low rise residential - Residential College - Step up/ step down facility • Transportable school building • Low rise office building • Manufacturing Facility • Laboratory • Medical facility (no surgery or emergency treatment facilities) capacity <50 occupants e.g.: - Community health clinic - Renal dialysis clinic - Dental clinic - Aged/ palliative care facility	• Primary school* • Secondary school* • Early childhood facility* • TAFE building • Recreation centre • Prison/ detention centre • Courthouse • Medium to large office • Medical facility (no surgery or emergency treatment facilities) capacity >50 occupants e.g.: - Community health clinic - Renal dialysis clinic - Dental clinic - Aged/ palliative care facility • Buildings where >300 people can congregate in one area • Buildings with >5000 occupants **Primary School Brief/Secondary School Planning Guide requirements*	• Police station • Fire station (career or volunteer) • Emergency vehicle garage • Emergency rescue facility • Building with a post disaster function, e.g., emergency shelter • Hospital/ medical facility with emergency or surgery facilities • Facility capable of causing hazardous conditions beyond property boundaries

3.2. Applicability

TG050 is intended to be used by project managers, designers and engineers in project teams to provide climate adaptation guidance for non-residential government buildings. A step-by-step process based on risk levels has been adopted, where:

- All DHW buildings will be required to undertake a high-level climate resilience assessment; and
- Depending on the assessment results, projects that are subject to priority hazards (as defined in Section 4) will be required to conduct detailed risk assessment (Section 5) and adopt climate adaptation strategies (Section 6).

TG050 applies to non-residential government buildings and certain residential Class 3 buildings that provide a social, educational or health related function (such as prisons, residential colleges, aged care facilities). TG050 also applies to Class 10 non-habitable shed type structures in the following categories:

- Structures housing building equipment necessary to support the function of the building (e.g. mechanical, electrical, and plumbing (MEP) equipment); or,
- Structures located in high wind regions (C & D); or,
- Structures housing high value assets.

Specifically excluded are Class 1, 2 and 6 buildings, and projects valued at $100m or greater, unless specifically requested by the Customer Agency.

3.3. Document Control

Legislation at the state and federal level, and government climate requirements will continue to evolve in response to the latest scientific advice, and the need for urgent action on climate change. Consequently, there is a need to ensure that any guideline is sufficiently adaptable to enable realignment with new, or interim government targets or requirements. Therefore, the targets provided in this Guideline may be more frequently updated.

The design for all non-residential government building projects, whether new works or significant upgrades to existing, will need to comply with the version of this Guideline current at the commencement of the project design phase, unless otherwise instructed by DHW's Project Manager.

4. Climate Hazards

4.1. Climate Hazard Types

In Australia, climate change manifests through two types of physical hazards: chronic and acute (Table 2).

- Chronic hazards are long-term, gradual changes such as rising average temperatures, shifting rainfall patterns, and sea level rise.
- Acute hazards are sudden, extreme events including heatwaves, storms, floods, landslides, droughts, and wildfires.

Table 2. Climate Hazard Types in Australia

	Temperature related	Wind related	Water related	Others
Chronic (long term)	Changing temperature Heat stress Temperature variability	Changing wind patterns	Changing precipitation patterns Precipitation and/or hydrological variability Sea-level rise Drought	Coastal erosion Soil degradation Soil erosion
Acute (short term extreme events)	Heat wave	Cyclone Storm Tornado	Drought Heavy precipitation (rain/hail) Flood (coastal, fluvial, pluvial, groundwater)	Bushfire Landslide Subsidence

It is important to understand that climate conditions are expected to evolve over the lifespan of a building, depending on various **projection scenarios** (Appendix 2). Therefore, a thorough climate resilience assessment should ideally include an analysis of **both current and projected climate data** for the building's location.

To support this, a list of recommended climate data sources is provided in Appendix 8 for practitioners to develop a well-informed understanding of how to interpret and apply climate data in climate resilience assessments.

4.2. Exposure and Sensitivity of Building

In the context of the built environment, **exposure** refers to the presence of a built asset in a specific location, making it susceptible to potential climate-related impacts. Exposure is closely tied to the geographic location of the asset than to its type or function.

Sensitivity refers to the extent to which a system or species is affected – positively or negatively – by climate variability or change. When evaluating a building's sensitivity, its type and function should be key considerations. For instance, critical facilities like hospitals may require a more detailed assessment due to the vulnerability of their occupants.

The structural characteristics of a building also influence its sensitivity to specific climate hazards. High-rise buildings, for example, are more susceptible to strong winds, while structures with underground levels may be particularly vulnerable to flooding. Occupancy is another crucial factor; the nature of the building's users can significantly affect its sensitivity and the potential impacts. For example, care home residents are generally more vulnerable to heatwaves than office workers, necessitating additional adaptation measures to protect their well-being.

Other elements within the building's site boundary should also be considered, such as pathways, parking areas, and connecting bridges. These features become especially relevant in multi-building complexes like campuses.

4.3. Vulnerability of Building to Hazard

Vulnerability refers to the tendency or predisposition of a system to be negatively impacted by climate change. It is understood as a combination of susceptibility and adaptive capacity. For practical purposes, vulnerability is often assessed as the outcome of both exposure and sensitivity analyses.

In TG050, a building's vulnerability to climate hazards is determined by evaluating its exposure to each specific hazard alongside its sensitivity to those hazards. This combined analysis provides a more comprehensive understanding of how susceptible the building is to climate-related impacts.

To support this assessment, Table 3 below presents a vulnerability matrix, which rates the overall vulnerability of a building on a scale from very low to very high.

Table 3. Vulnerability Analysis Matrix

Exposure → Sensitivity ↓	Very high	High	Medium	Low	Very low
Very high	Very high	Very high	High	Medium	Medium
High	Very high	High	Medium	Medium	Medium
Medium	High	Medium	Medium	Medium	Medium
Low	Medium	Low	Low	Low	Very low
Very low	Medium	Low	Low	Very low	Very low

4.4. Climate Impact

The impacts of climate change on buildings are becoming increasingly apparent, driven by the combined effects of climate hazards, structural exposure, and inherent vulnerabilities (Figure 2). These impacts include physical damage, service disruptions, and reduced building performance. The impacts can lead to increased maintenance and repair needs, higher operational costs, reduced occupant comfort, and more frequent building downtime. Appendix 1 outlines specific climate hazards and their associated effects on buildings in WA.

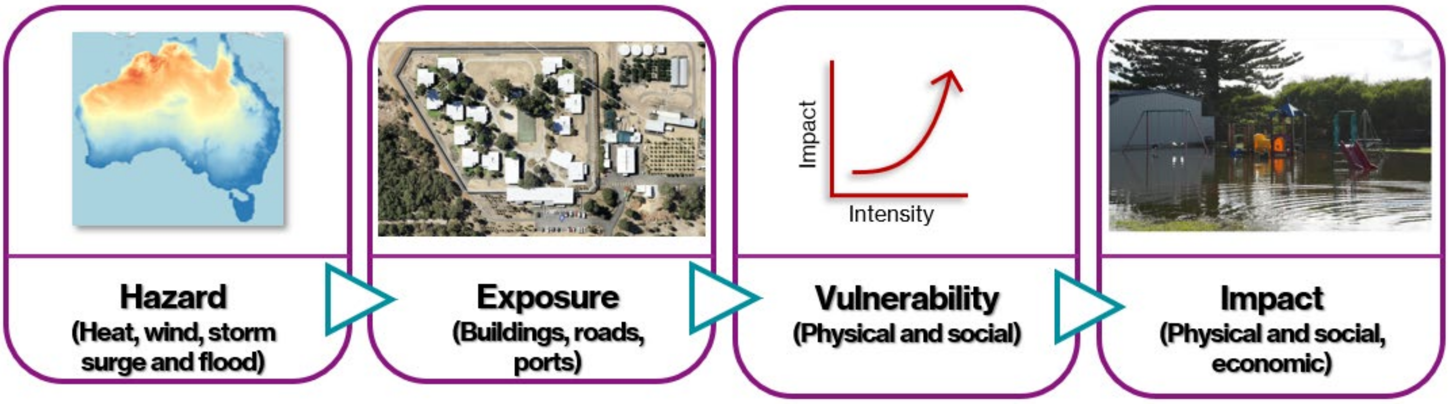

Figure 2. Causes and Effects of Climate Change

Being resilient to the impacts of climate change is essential for government buildings, as these buildings often provide critical services such as healthcare facilities, law and order enforcement and detention facilities. Many of these services are required to remain functional during and post extreme climate events.

4.5. Considerations for Minimising Climate Impact

- **Vulnerability of our buildings**

In Western Australia, approximately 80% of government buildings are situated in the Perth metropolitan and South-West regions, which are classified as non-cyclonic zones with a mild temperate climate under AS1170.2 (ABCB, 2022). Many of these buildings possess design features that increase their vulnerability to extreme weather events – such as low-rise structures with shallow footings, large roof overhangs, single-glazed windows, and close proximity to tree canopies or flood-prone areas. These risks are expected to intensify, as climate change projections indicate more frequent and severe heatwaves in these regions, along with cyclones potentially shifting further south due to a warming climate.

Buildings are not currently being designed to cope with projected climate hazards. The NCC and Australian standards typically rely on historic weather data; this can result in buildings being ill equipped to cope with the future extreme weather events.

Government buildings often accommodate populations that are particularly vulnerable to the impacts of climate-related hazards. These include elderly individuals, patients, and children – groups that are especially susceptible to extreme heat and may experience limited mobility during severe weather events. Consequently, it is imperative that the design of such facilities incorporates robust climate resilience measures to ensure the safety, accessibility, and well-being of all occupants.

- **Key considerations for climate resilience**

For WA's government buildings to continue servicing community, it is important to incorporate climate resilience into project's planning and delivery. Below considerations should be taken into account:

- Climate change trends indicate that extreme weather events are likely to continue to increase in frequency and/ or intensity. When considering climate hazards, the building occupancy, location, and criticality should be considered.
- Since the current National Construction Code (NCC) does not comprehensively address climate change considerations, it is recommended that project teams exceed the minimum NCC requirements by considering future climate data, particularly for critical government buildings.
- Local government hazard emergency plans offer a valuable starting point for identifying relevant climate hazards. Project teams are encouraged to consult with local authorities to access the most up-to-date climate emergency planning and projection data to inform their design decisions.
- Certain non-residential government buildings provide critical services to communities or accommodate vulnerable occupants; such building types should consider climate hazards irrespective of the current hazard zoning in view of future change of climate data. (Table 4).

Table 4 Key Considerations for High Importance Projects

No.	Key Recommendations
1.	**Importance Level 4 (IL4) facilities should not be located within designated flood hazard areas. In circumstances where no alternative site is available, comprehensive flood modelling must be undertaken, and appropriate adaptation measures must be implemented to mitigate associated risks.**
2.	**IL3 or IL4 facilities in lower hazard Wind Regions (e.g. A0) should consider provisions for cyclonic design.**
3.	**Heatwave adaptation strategies should be considered for all facilities with vulnerable occupants (children, elderly, infirm) irrespective of climate zones.**
4.	**Projects should be assessed on a case-by-case basis with consideration of the building occupants and the criticality of the building to the wider community.**

5. Climate Adaptation Planning

5.1. Overall Adaptation Planning Process

Adaptation Planning should be included as the project initiates and should be incorporated in the business case and Project Initiation and Definition Planning (PDP) phase to avoid costly retrofits and disruptions during a climate hazard event. Table 5 outlines the three Adaptation planning phases.

Table 5. Overall Process of Climate Adaptation Planning

Step	Description	Output
Step 1: **Climate Resilience Assessment (CRA)**	• Evaluate climate conditions and projections. • Identify applicable climate hazards that the project is exposed to. • Identify project's Importance Level and sensitivity to the hazard. • Assess project vulnerability to climate hazard	Priority Hazards applicable to the project are identified.
Step 2: **Risk Assessment**	• Identify a list of detailed risk items that apply to various building systems. • Conduct analysis on the likelihood and consequence of individual risks items. • Identify Risk Levels of individual risk items (refer Section 5.3, Table 8).	Risk items that are rated High or Extreme for treatment are identified.
Step 3: **Adaptation (risk treatment)**	• Establish adaptation strategies to treat the identified risk items • Identify Adaptation Strategies to be implemented (refer Section 5.4, Table 9). • Identify owners and implementation phases of the Adaptation Strategies. • Document overall Climate Resilience Assessment outcomes, with attachment describing design features and specifications to hand over to facility managers.	Adaptation Strategies are adopted in the design decisions. Required Resilience Scores are achieved.

The three steps and associated activities should be carried out in suitable phases in the project delivery process to avoid afterthoughts and costly variation works. For instance, Climate Resilience Assessment (CRA) should be considered in the Business Case drafting or Project Initiation and Definition Planning (PDP) phase. The flow chart below (Figure 3) can be used as a reference for climate adaptation planning.

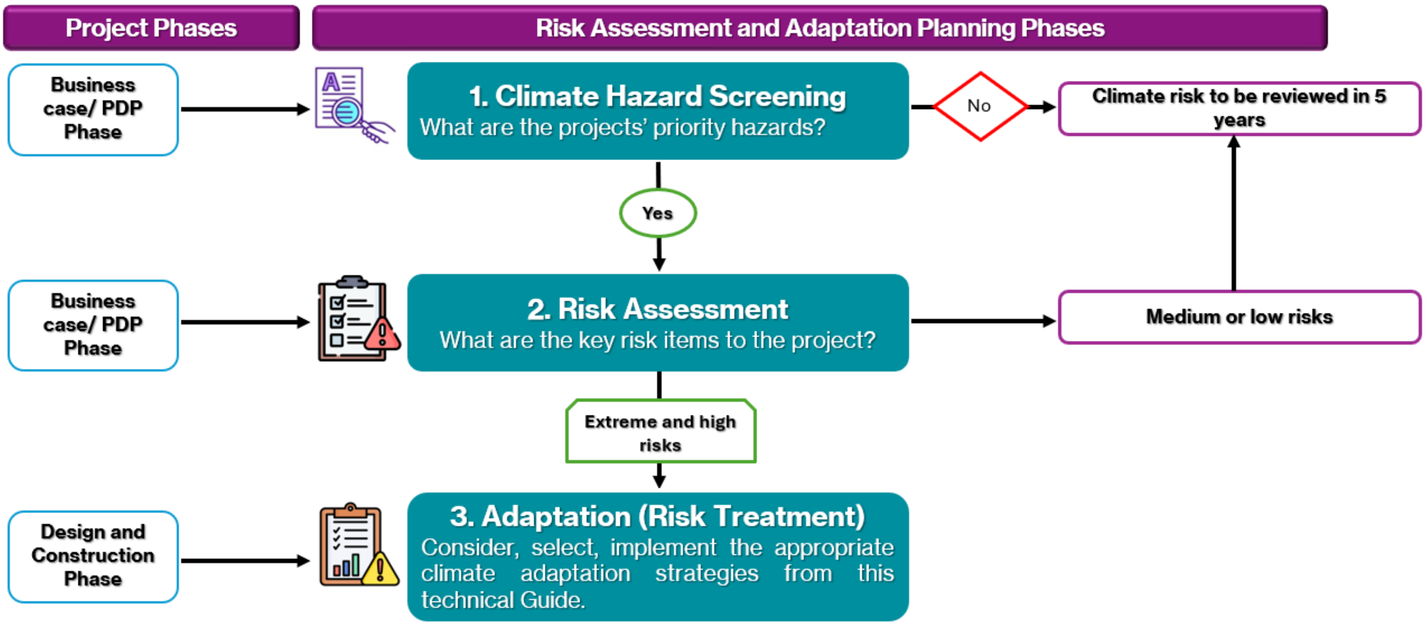

Figure 3. Climate Adaptation Planning during Project Delivery

5.2. Climate Resilience Assessment

A climate resilience assessment (CRA) identifies a project's vulnerability and Priority Hazards that are applicable to the project, considering impacts of climate change.

This includes evaluation of climate hazards of today and future projections, the project's geographic location, building typology and occupants. A technical professional familiar with climate resilience should be engaged to analyse the climate hazards and project vulnerability. For example, if the project is exposed to tropical cyclones and the building accommodates vulnerable occupants (i.e. children, elderly and infirm), these factors would be captured in the CRA.

In CRA, it is recommended to use a high emissions scenario (RCP8.5 or SSP3-7.0) at various time horizons based on the project design life.

To assist the project team to understand the potential climate hazard, a Climate Hazard Pre-Screening Questionnaire can be utilised (see Table 6 which was adapted from GBCA, 2024).

Table 6. Climate Hazard Pre-Screening Questionnaire and Resources

Hazard	Resources	Yes or No
Is the project located in a cyclone zone?	Refer to AS1170.2, Figure 3.1(A) - Wind regions – Australia	
Is the project in or adjacent to a floodplain?	Department of Water and Environment Regulation have published a Floodplain Mapping Tool for Western Australia providing floodplain maps, levels, and development strategies (where applicable) (DWER, 2023b).	
Is the project located within 10km of tidally influenced coastline?	Refer to Google Earth or similar mapping software.	
Is the project susceptible to extreme heat?	Climate Council have published a Climate Risk Map and a Climate Heat Map identifying climate vulnerable areas of Australia (Climate Council, 2025).	
Has the location had historic extreme events?	Contact the Local Government of the project location to identify historic extreme climate events.	
Additional Resources	The Climate Change in Australia (CCiA) and CSI climate data portal provides updated climate projections for Western Australia (CSIRO, 2025). Climate Resilience Map for WA Public Buildings provides a holistic assessment of hazards with future climate projections based on CCiA data.	

In addition to the pre-screening, project teams should use the Climate Resilience Assessment Template to identify Priority Hazards that are applicable to the project.

Project teams / consultants should conduct a vulnerability assessment as part of CRA. This includes an evaluation of the buildings IL and occupancy sensitivity. If the project is assessed to be vulnerable to some specific hazards such as heatwave, cyclone, and/or flooding, these hazards should be identified as Priority Hazards.

5.3. Risk Assessment

With priority hazards now identified, the project will advance to a detailed assessment of climate-related risks and their potential impacts across various building systems.

Similar to the CRA, the risk assessment should be based on a high emission scenario of RCP 8.5/ SSP3-7.0, under a timeframe that is aligned with the project's design life (e.g. 50 years from 2025). At least two time horizons should be used in the assessment, capturing the risk levels in both the near term and the long term.

The risk assessment process involves three steps to assess, analyse and evaluate the diverse physical risks to buildings due to climate change:

1. Identify the detailed climate risk items that are specific to the project. The climate risk items will require multidisciplinary stakeholder inputs to ensure each risk has been assessed,
2. Analyse the risk items qualitatively based on AS5334: 2013 (refer to Appendix 4) (Standards Australia, 2013), and
3. Evaluate the climate risks which are a combination of likelihood and consequences (Table 7).

Table 7. Risk Consequence and Likelihood Matrix

Consequence (C)→ Likelihood (L)↓	Insignificant (C1)	Minor (C2)	Moderate (C3)	Major (C4)	Catastrophic (C5)
Almost Certain (L5)	Medium	Medium	High	Extreme	Extreme
Likely (L4)	Low	Medium	High	High	Extreme
Possible (L3)	Low	Medium	Medium	High	High
Unlikely (L2)	Low	Low	Medium	Medium	Medium
Rare (L1)	Low	Low	Low	Low	Medium

Table 8 below is an example of initial risk assessment for a critical healthcare building in Roebourne, WA before adaptation[3]. The building is classified as an IL 4 structure, located in cyclonic region (Wind Region D) and within a tropical climate zone (Climate Zone 1) (ABCB, 2022; Standards Australia, 2021). The building has a minimum design life of 60 years, and therefore the assessment is based on a 2090 scenario. The risk assessment is based on a high emission scenario (RCP8.5).

[3] The initial risk assessment should be conducted at PDP or SD phase for identifying risks and adaptation planning. After adaptation measures are confirmed, the residual risk should be assessed using the same Table.

Table 8. Example of Risk Assessment of a Healthcare Project Using a High Emissions Scenario

Climate hazard	Risk statement	Consequence (Impact)	Likelihood (Occurrence)	Risk Level	Adaptation recommendation (refer to Table 9)
Changes in Temperature including Extreme Heat	Impacts on the thermal performance levels of buildings leading to reduced comfort levels for building occupants including vulnerable occupants.	C2	L5	Medium	H1 to H7
	More demanding heating, ventilation and air conditioning (HVAC) requirements, needing a higher capacity system resilient to extreme temperatures.	C2	L5	Medium	H5 (optional)
	Increased energy demand across the site	C3	L5	**High**	H1 to H7
	Increased need to cool buildings resulting in increased load on vital equipment and services.	C2	L4	Medium	H5 (optional)
	Impacts on building structures and materials, increasing risks of movement, cracking and failure of building envelopes.	C3	L3	Low	S9
	External building materials becoming too hot to touch (such as handrails, seats).	C1	L3	Low	H7
Increase in intensity of tropical cyclones	Windborne debris damaging the building envelope and structural elements, roof drainage components, glazing (if not laminated glass) and building façade.	C4	L2	Medium	S2, S5
	Regular interaction with high wind can degrade the building material's integrity and longevity.	C3	L1	Low	S9
	High winds can damage the roof connection with superstructure by exerting periodic extra uplift loads.	C4	L3	**High**	S4
	Solar panels can be damaged due to differential pressure on solar panels and extra net forces on anchorage points with roof.	C3	L3	Medium	S10
	High winds can cause severe damage to the landscaping and trees especially in the cyclonic regions C and D, contributing to wind borne debris.	C4	L3	**High**	HD3
	Cyclones can be a cause of increased incidents of growth of mould and fungi due to rainwater intrusion.	C2	L2	Low	S7

Climate hazard	Risk statement	Consequence (Impact)	Likelihood (Occurrence)	Risk Level	Adaptation recommendation (refer to Table 9)
	Extreme wind events are often accompanied by rain. Wind-driven rain can be driven into the building envelope by a combination of mechanisms: Differential pressure across the building envelope can force the water through any small gaps in the building envelope. Wind can drive the water up roofing, gutters or even up walls so that it passes underneath flashings that are designed to deflect downward-moving water.	C3	L4	**High**	S7
Water Management • **Flooding** • **Sea level rise** • **Drought**	Increased flood levels due to climate change, increasing the risk of buildings being inundated with flood waters.	C3	L2	Medium	W1 - W6
	Rainfall intensities increasing (15% per degree of warming for hourly rainfall), leading to instances of flash flooding and water entering buildings.	C3	L2	Medium	W1, W2, W5, W6, W7, W8, W9
	Stormwater management systems under designed for future rainfall intensities and unable to sufficiently divert water away from the building.	C2	L2	Medium	W7, W8, W9
	Rising sea levels increasing the vulnerability of buildings and infrastructure in coastal areas.	C3	L1	Low	W11
	Drought can cause differential settlement in reactive soils, leading to damage to structural foundations.	C3	L1	Low	W10
	Drought causes a scarcity of water supply to the site	C2	L1	Low	Refer Technical Guide TG037

All risk items identified as **"high" or "extreme"** level above should be addressed using adaptation strategies (refer to Section 6). This project would be recommended to go through the climate adaptation planning process and implement climate adaptation strategies to improve resilience and ensure functionality is maintained during and post extreme climate events.

5.4. Risk Treatment

Risk treatments refer to implementation of climate adaptation measures in design and construction to address the climate risks. As detailed in previous section, extreme heat, storms, wind events, and increasing intensities of rainfall have a range of impacts on buildings and sites. While a building designed and constructed using the NCC and Australian Standards meets the minimum technical requirements and provides certain extent of hazard protection, TG050 aims to provide a more comprehensive guidance on adaptation options that can account for future climate conditions. This will be detailed in Section 6: Adaptation Strategies.

5.5. Risk Management, Monitoring and Reporting

In the context of TG050, the climate risk management involves identifying, evaluating, communicating, monitoring and reporting the potential climate change risks on non-residential government buildings. These risks include physical and transitional risks.

The risk monitoring and reporting process should be aligned with government policy and building owner's asset management framework (e.g. WA's climate policy and Strategic Asset Management Plan). It ensures the climate risks and treatment measures are understood, implemented, and remain functional to serve the purpose during operation and maintenance phase.

The monitoring and reporting process should:

- Monitor the progress of actions identified in risk treatment.
- Regularly review the priority climate risks.
- Ensure all the relevant stakeholders are aware of how risks and opportunities are being managed.

After the project's handover, building owners or facility managers should conduct regular checks and maintenance based on 6-month, 1-year and 3-year increments. This should include activities below:

- Include resilience features into the scope of building's schedule maintenance to ensure all adaptation measures implemented are fully functional and properly maintained post occupancy.
- Ensure the resilience features to be activated to boost building's preparedness to forecast extreme events.
- Conducting regular updates on building's resilience scores, considering change of building's function, Importance Level, and occupancy types.

It is particularly important to ensure high importance buildings are safe, compliant and fully operational during and post climate events.

6. Climate Adaptation Strategies

Climate adaptation strategies are design and construction measures that reduce the overall level of hazard exposure and building vulnerability. The adaptation strategies are best practices drawn from the latest Australian and international standards, research and analysis, expert consultancy and case studies.

The adaptation strategies should be implemented on a case-by-case basis to address project's priority hazards and vulnerability identified during the climate risk assessment.

6.1. Adaptation Strategies and Resilience Rating

Project teams are encouraged to adopt one or several adaptation strategies to improve their project's climate resilience. A catalogue of these adaptation strategies, together with a resilience rating tool, is provided for project teams to conduct adaptation planning (Table 9 and Figure 4. Resilience Rating

- For each hazard, the corresponding adaptation strategies are assigned dedicated **resilience scores** to reflect the effectiveness of these strategies.
- The sum of the resilience scores, expressed in percentage of the total achievable scores, represents the project's resilience level to the corresponding hazard(s). An overall resilience rating can be visualised for all applicable hazards (Figure 4).
- There are three levels of Resilience Ratings achievable for individual projects, i.e. NCC compliance level (50%), Resilience Level (75%), and Robustness Level (90%)
- For IL3 and IL4 projects, it is strongly recommended that project teams aim to achieve a Resilience Level (minimally 75%) or higher.

The adaptation strategies listed in the Table 9 generally consists of two levels of requirements, i.e. NCC compliance level where buildings comply with relevant clauses in NCC, and advanced level where additional measures that exceed the NCC requirements are adopted (such as the use of future climate in the design).

- Buildings that comply with the NCC typically earn 1 point for each criterion met. This is required for projects from IL1 to IL4.
- Building that adopted measures to achieve resilience performance beyond the minimum NCC requirements will achieve additional resilience scores. This is particularly recommended for IL3 and IL4 projects.

Table 9. Adaptation Strategies

Abbreviations

Architectural Design (ARCH), Civil Design (CIVIL), Electrical Design (ELEC), Mechanical Design (MECH), Hydraulic Design (HYDR), Landscape Design (LAND), Structural Design (STRU), Environmentally Sustainable Design (ESD). Low Cost ($), Medium Cost ($$), High Cost ($$$)

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
Heatwave and rising temperature **(H)**	ARCH MECH ESD	**H1. Thermal Comfort Design Criteria (Rising Temperature)** Thermal Comfort Design Criteria should be considered based on the building occupants' vulnerability and should be met for future climate projections. **The PMV index should be used for air-conditioned buildings.* **Adaptive thermal comfort should be used for spaces under mixed mode ventilation and natural ventilation.* **Buildings that are unoccupied or not regularly occupied are excluded. For specialist building types where specific indoor environmental conditions are required (i.e. greenhouse, manufacturing buildings) input from a technical professional should be sought.*	5	$	IL1	Not Applicable
					IL2, IL3 and IL4	• Comply with NCC DTS (1 Point) • Consider vulnerability of building occupants (1 Point) * • Demonstrate NCC compliance through thermal comfort modelling (1 Point) ** • Demonstrate NCC compliance through thermal comfort using future climate projections (2 Points) *** **For a building housing vulnerable population such as disabled, elderly or infirm, a thermal comfort level of between a Predicted Mean Vote of 0 to +1.0 is achieved across not less than 95% of the floor area of all occupied zones for not less than 98% of the annual hours of operation of the building. Refer to ISO 28803-2012 Ergonomics of the Physical Environment-Application of International Standards to people with special requirements.* <u>OR</u> ***For mixed-mode buildings in naturally ventilated state, comply with adaptive model ANSI/ASHRAE Standard 55.* **** Use RCP8.5/ SSP3-7.0 2050 scenario.* *Note: The ESD consultant shall attach a list of parameters used for thermal modelling.*
			5	$$$	IL1	Not Applicable

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		H2. Thermal Comfort Design Criteria (Heatwave) Thermal Comfort Design Criteria should be met for design summer year (DSY) weather or future climate under RCP8.5/ SSP3-7.0 2090 scenario.			IL2, IL3 and IL4	• Specify dedicated design condition for heatwave (2 Points) • Assess building overheating hours using design summer year (DSY) weather data. (2 Points) * • Demonstrate indoor temperatures do not exceed 3 °C above the comfort temperature for 3 % of occupied hours (1 Point). **Refer to CIBSE, TM52 The Limits of Thermal Comfort: Avoiding Overheating in European Buildings. The Chartered Institution of Building Services Engineers, London (2013) for guidance. Note: When DSY weather is unavailable, RCP8.5/ SSP3-7.0 2090 scenario should be used as a proxy.* *Note: The ESD consultant shall attach a list of parameters used for thermal modelling.* *Comply with the criteria outlined in the 'Thermal Comfort Design Criteria (Rising Temperature)' section of this table.*
	ARCH LAND ESD	**H3. Limit Solar Heat Gain** • **Shading** Natural shading should be prioritized and combined with built shading solutions, considering the sun's position and outdoor areas usage patterns, using locally native trees that suit the local soil type and microclimate. Promote adjustable shading to reduce solar radiation and improve seasonal adaptability. • **Light colour finishes** Walls, roofing materials and window and door frames to be light in colour to reduce summer overheating and minimize solar radiation	4	$$	IL1	Not Applicable
					IL2, IL3 and IL4	• Comply with NCC DTS (1 Point) • Demonstrate at least 10% improvement in thermal performance as compared to NCC reference building (1 Point) • Demonstrate at least 10% improvement in thermal performance as compared to NCC reference building using future projections (2 Points) *Note: The ESD consultant shall attach a list of parameters used for thermal modelling.*

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		absorption. A solar reflectance index of 80 or above is recommended. • **Glazing** Use climate appropriate glazing with U-values and Solar Heat Gain Coefficients (SHGC). Aim to achieve 10% better thermal performance than NCC: Part J4 Building fabric.				*Note: In cyclone prone areas, additional glazing requirements are detailed in the Tropical cyclones and Windstorm section of this table.*
	ARCH ELEC ESD	**H4. Limit Internal Heat** • **Reduce Lighting Power** Reducing internal heat gains from lighting. • **Reduce Plug Load** Reducing internal heat gains from plug loads.	4	$	IL1	Not Applicable
					IL2, IL3 and IL4	• Comply with NCC DTS (1 Point) • Specify individual strategies to limit internal heat gain (1 Point) • Specify combination of strategies to limit internal heat gain* (2 Points) **Including but not limited to (1) Demand-responsive lighting and plug load systems that include occupancy sensors, load shedding, dimmable lighting, plug load management systems etc. (2) Smart plug load controls.*
	ARCH MECH ESD	**H5. Mechanical Systems and Control Strategies** Design mechanical systems to meet future thermal demands.	5		IL1	Not Applicable
					IL2, IL3 and IL4	• Allow for additional plant space to accommodate larger thermal equipment. (1 Point) • Demonstrate the air conditioning system's external plant would be capable of operating under the extreme ambient temperatures specific to the project locality (1 Point) * • Consider the potential effects of climate change and adjust the design temperature data

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
						in line with the latest high emission projections. (1 Point) • Use of Advanced Building Management Systems (BMS) and Zonal Control Strategies (1 Point) **In accordance with AIRAH Application Manual DA09 – Air Conditioning Load Estimation and Psychometrics, Appendix A. Note: It is acknowledged that under these extreme conditions, the system may not maintain the intended indoor design conditions.*
	ARCH MECH STRU	**H6. Air Flow Management and Infiltration Control** Strategy to manage internal heat and prevent unwanted air exchange. • **Ceiling Fans** Installation of ceiling fans assist in air circulation and can be included in passive design features to reduce reliance on other building services, as well as fully air-conditioned rooms. • **Natural ventilation** Promote natural ventilation that accounts for seasonal climate variations, building orientation and wind direction to maximise natural airflow, promoting use of passive design features. • **Airtightness** Consider building sealing to ensure airtightness for all spaces, enhancing thermal efficiency and providing protection against weather. This strategy minimizes uncontrolled air infiltration, reducing cooling and heating loads and preventing moisture-related issues.	4	$	IL1	Not Applicable
					IL2, IL3 and IL4	• Install mechanical exhaust fans to extract heat (1 Point) • Install operable windows or vents near the ceiling or at high lintel levels to allow hot air to escape (1 Point) • Use of natural ventilation approaches (cross ventilation, stack ventilation etc.) (1 Point) • Use mechanical fans to assist in moving warm air out of space (1 Point) *Note: Refer to TG040 Environmentally Sustainable Design Guideline for Non-Residential Government Buildings for airtightness.*

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	ARCH STRU ESD	**H7. Heat Resilient Materials**	3	$$	IL1	Not Applicable
		• **Thermal Mass** Thermal mass may be chosen based on diurnal temperature fluctuations, with low thermal mass for low variations and high thermal mass for higher variations. • **Building Fabric** Improve thermal insulation to reduce heat transmission through building fabric. • **High temperature endurance materials** Use of materials that have high endurance to elevated temperatures. Consider low conductivity materials for handrails and outdoor equipment such as wood or recycled plastic.			IL2, IL3 and IL4	• Demonstrate at least 10% improvement in thermal performance as compared to NCC reference building (1 Point) • Demonstrate at least 10% improvement in thermal performance as compared to NCC reference building using future projections (1 Point) *Guidance: Diurnal temperature ranges less than 6°C are suited for low thermal mass, ranges between 6°C and 10°C for moderate thermal mass, and ranges over 10°C for high thermal mass.* *Note: Extreme climate regions require careful consideration. For example, CZ1, which experiences high nighttime temperatures and a limited diurnal range, is best suited for low thermal mass solutions.* *In CZ3 and CZ4, due to high diurnal temperature ranges, a combination of high thermal mass and high insulation is preferred.* *Furthermore, in multistorey building, high thermal mass should ideally be used on lower levels and low thermal mass on the upper levels. This clause can be applied to all climate zones.* *Consider selecting the materials that are not extremely hot after prolonged sun exposure.*
Flood Levels	ARCH	**W1a. Determining Finished Floor Levels using AEP**	5	$	IL1	• 1% AEP + 0.3m Freeboard (1 Point)

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	CIVIL	Finished Floor Levels (FFLs) to be raised above the 1% AEP with an increased freeboard to account for climate change. This applies where Local Government flood mapping levels are available and indicate the site is flood affected or if the project is proposed to be located: • Within or adjacent to a flood plain; or, • Adjacent to a waterway; or, • On or adjacent to a site that has historically flooded (contact the Local Government)				*Note: Where Local Governments (LG) have flood planning requirements that require a higher level of resilience to flooding (i.e. higher FFL's), the LG requirements will take precedence. If the Local Government area does not have any flood mapping/ data available, IL1 & IL2 projects to conduct design flood estimation.*
				$$	IL2	• 1% AEP + 0.5 Freeboard (1 Point) *Note: Where Local Governments (LG) have flood planning requirements that require a higher level of resilience to flooding (i.e. higher FFL's), the LG requirements will take precedence. If the Local Government area does not have any flood mapping/ data available, IL1 & IL2 projects to conduct design flood estimation.*
		W1b. Determining Finished Floor Levels using Design Flood Estimation Design flood estimation shall incorporate scaling factors linked to global temperature as detailed in the current Australian Rainfall and Runoff (ARR) guidelines (refer Book 1, Section 6) apply. Design flood estimation is recommended where Local Government flood mapping is unavailable and the project is proposed to be located: • Within or adjacent to a flood plain; or, • Adjacent to a waterway; or, • On or adjacent to a site that has historically flooded (contact the Local Government)			IL3 and IL4	• For design flood estimation and flood modelling, climate scenario SSP3-7.0 at the end of the building lifecycle or 2100 (whichever is greater) to be used. Refer to the ARR Data Hub for climate change factors • Once the 1% AEP flood level is determined a 0.5m freeboard shall be applied (3 Points). *If the Local Government area does not have any flood mapping/ data available, IL1 & IL2 projects to conduct design flood estimation.*
		W1c. Determining Finished Floor Levels using Flood Modelling				

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		Flood modelling is recommended for Importance Level 4 buildings located: • Within or adjacent to a flood plain; or, • Adjacent to a waterway; or, On or adjacent to a site that has historically flooded (contact the Local Government).				
	CIVIL STRU	**W2. Fill for Flood Affected Sites** Where a site level is filled above the flood level, the fill is required to be stable under conditions of flooding (rapid rise and rapid drawdown, prolonged inundation, and erosion and scour) without exceeding the maximum design differential movement of the footing system as specified in AS 2870.	2	$$	IL1 to IL4	• The structural engineer to assess and provide design advice on fill (2 Points) *Fill levels should be modelled to assess flooding impacts in surrounding areas.* *Refer to the ABCB: Construction of buildings in flood hazard areas for additional requirements. Note, where the ABCB require a higher level of compliance it shall take precedence.*
	CIVIL STRU	**W3. Flood Actions** Flood actions shall be designed for in accordance with Part 2.3 of the Australian Building Codes Board (ABCB): Construction of buildings in flood hazard areas. For high Importance Level (3, 4) buildings, the responsible structural engineer should assess whether the Flood Load Factor (Y_f) detailed in Table 2.3.7 should be increased. The structural design of footing systems shall comply with Part 2.5 of the ABCB: Construction of buildings in flood hazard areas.	2	$$	IL1 to IL4	• Complying with Part 2.3 of the ABCB: Construction of building in flood prone areas (1 Point) • For high Importance Level (3, 4) buildings, the responsible structural engineer should assess whether the Flood Load Factor (Y_f) detailed in Table 2.3.7 should be increased (1 Point). *Refer to the ABCB: Construction of buildings in flood hazard areas for additional requirements. Note, where the ABCB require a higher level of compliance it shall take precedence.*

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	ARCH ELEC MECH	**W4. Building Utilities** Utilities and associated equipment (including back-up utilities and systems) shall be located above the climate adjusted flood level unless the utilities and equipment have been specifically designed to resist flood actions (hydrostatic, hydrodynamic, buoyancy forces etc.) and cope with flood water inundation. A statement from the utility manufacturer (where applicable) shall be provided confirming the utility system is suitable to be installed below the flood level. If building utility systems are buried, the depth the system is placed at shall be sufficient to prevent damage during a flooding event.	3	$$	IL1 to IL4	• Utilities are raised a minimum of 1m above the 1% AEP (2 Points) • Provide a statement from manufacturer confirming the utilites can be below the flood level (where applicable) (1 Point). *Refer to the ABCB: Construction of buildings in flood hazard areas for additional requirements. Note, where the ABCB require a higher level of compliance it shall take precedence.*
	ARCH	**W5. Wet Floodproofing** Wet floodproofing should be applied to existing buildings located below the climate adjusted AEP levels during refurbishment works to improve the climate resilience of existing building stock. Wet floodproofing is applicable to projects located or proposed to be located: • Within or adjacent to a flood plain; or, • Adjacent to a waterway; or, On or adjacent to a site that has historically flooded (contact the Local Government)	3	$$	IL1 to IL4	• Wet floodproofing to be applied to buildings located less than 0.5m above the 1% AEP (3 Points). *The Queensland Flood Resilient Building Guidance for Queensland Homes can be referred to for examples of wet floodproofing.*
	HYDR	**W6. Stormwater Management and Design**	3	$$	IL1 to IL4	• A 10% increase in rainfall intensities for roof and site drainage design in addition to the standard rainfall intensity data detailed in AS3500.3 (3 Points).

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		A 10% increase in rainfall intensities for roof and site drainage design is recommended in addition to the standard rainfall intensity data detailed in AS3500.3.				
	HYDR	**W7. Roofs and Gutters** Install gutters with overflows for all perimeter gutters. Locate gutter brackets no more than 600mm apart and no more than 150mm from any angled stop end. Avoid box gutters and minimise number of valley gutter systems. Eave overhangs and eaves gutters are preferenced**.**	3	$	IL1 to IL4	• Install gutters with overflows for all perimeter gutters and locate gutter brackets no more than 600mm apart and no more than 150mm from any angled stop end. • Avoid box gutters and minimise number of valley gutter systems. • Minimum 600mm eave overhangs and eaves gutters**.** • If the function of the building is sensitive to water damage (e.g. housing electronic equipment, critical facilities etc.) box and valley gutters shall be avoided. Incorporating the above items gives the resilience score of 3.
	HYDR CIVIL	**W8. Site Design** On-site stormwater detention to factor in 10% increase in rainfall intensity. Incorporate Water Sensitive Urban Design (WSUD) principles and drought resilient landscape design. Reduce impermeable exterior surfaces, consider permeable paving and green and blue spaces.	3	$	IL1 to IL4	• On-site stormwater detention to factor in 10% increase in rainfall intensity (1 Point). • Incorporate Water Sensitive Urban Design (WSUD) principles and drought resilient landscape design (1 Point). • Reduce impermeable exterior surfaces, consider permeable paving and green and blue spaces (1 Point).

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
						A maintenance and cleaning routine should be established for permeable pavement. Without proper maintenance, the permeability of permeable paving reduces significantly over time.
Drought	STRU	**W9. Changes in Soil Moisture (Drought Conditions)** Where reactive soils (e.g. clay-type soils that are prone to swelling and shrinkage) are identified as part of the geotechnical report, the responsible structural engineer shall consider the impacts of drought conditions on structural foundations and provide design advice.	3	$$	IL1 to IL4	This applies to the following soil classifications: • Soil classification M (1 point) • Soil classifications H1, H2 and E (2 Points) For non-reactive sites, this adaptation measure is not applicable. *Note, for water efficiency refer to Technical Guide 037.*
Sea Level Rise	ARCH	**W10. Wet or Dry Floodproofing** For projects in areas at risk of inundation, wet or dryfloodproofing should be implemented.	3	$$$	IL1 to IL4	It is strongly recommended to avoid building new projects in areas at risk of sea level rise, storm surge, or coastal erosion.
Wind/ Cyclone	STRU	**S1. Wind Region** Wind regions should be defined as per latest AS/NZS 1170.2.	3	$$	IL1 to IL4	• Designer should define the wind region as per latest AS/NZS 1170.2: 2021 (2 points). • Building designed for higher wind region/high resilience standard beyond current zoning (1 point). **Based on wind speed and frequency of extreme weather events, primarily cyclonic activity. Different regions experience varying wind speeds and patterns, which can significantly impact the loads a structure must withstand.*

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	ARCH STRU	**S2. Internal Pressure** Design high importance level (IL) buildings for high internal pressure even in the non-cyclonic wind regions considering recent high wind incidents in wind regions A and B.	4	$$$	IL1 and IL2	• Designed in accordance with WA Part B2 Changes to AS/NZS 1170.2: 2021 (5.3.1) (2 Points).
					IL3 and IL4	• Internal pressure selected based on a higher-level wind zone. (2 Points) *Note: It is encouraged to design for high internal pressure in wind region A, although it is not required in AS/NZS 1170.2. This measure will improve the resilience of the building in non-cyclone region.*
	STRU	**S3. Climate Change Factor** Incorporate climate change factor Mc= 1.05 in building design in wind regions B2, C and D as per AS 1170.2.	3	$	IL1 to IL4	Refer to Appendix 05 for the Design Brief Matrix for the climate change factor. • The structural engineer should confirm the implementation of climate change factor. The climate change factor Mc should be used in region A as well to account for expected increases in the strength of thunderstorms. This is now included in AS/NZS 1170.2:2021. (1 point) • The value of 1.05 is acceptable for a building life of 50 years as it anticipates increase in wind speed over the next 50 years. The value of 1.05 may not be enough for buildings with a life of 100 years as during its lifetime, the wind speeds may increase even more (1 Point). • Mc used 1.1 considering for higher wind loads in future case scenario. (1 point)

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	ARCH STRU	**S4. Stiffness and Strength** Improve the stiffness and strength between roof and super structure. For example, use cyclone rated straps, tie downs and J bolts etc.	3	$$	IL1 to IL4	Buildings shall comply with the requirements applicable in the current version of NCC. • The designers shall mandate the installation of cyclone ties and straps and connecting the rafters/trusses directly to the top plate to address uplift and lateral forces especially in wind regions B2, C and D. (2 points) * • Tested and verified in laboratory or by authorised structural engineer before and after construction. (1 point) **Provide a continuous load path to safely transfer the roof loads to the foundations.* *Use heavy-duty bracing between the rafters or trusses to address the rotational forces and to distribute the load. Give preference to the usage of adhesive with fasteners to improve the shear capacity of the roof coverings.* *Use triple grip, gusset plates, and metal brackets at joints, and tighten the bolted connection as per AS/NZS 1252.1 (High Strength Structural Bolts) and AS4100 (Steel Structures) standards.*
	ARCH STRU	**S5. Protection of building openings** High durability materials should be used for external building protection for buildings in which people will be working during a cyclone. Use cyclone shutters for windows and door protection against wind-borne debris.	3	$$	IL3 to IL4	• It is encouraged that cyclone shutters to be installed on doors and windows in the cyclonic regions A2, C and D (2 point). • The design for internal pressure will ensure that even if windows and doors are broken, the building is robust, and it would be only the room

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
						with the broken doors or windows that is affected (1 point). *However, if people are in the building, they may be injured within the affected room, so that is why the debris protection of those rooms is warranted.*
	ARCH STRU	**S6. Cyclonic Designed Openings** Install cyclonic designed doors and windows, in Wind Regions C & D.	3	$$$	IL1 to IL4	• Cyclone-rated doors (2 Points). • Install laminated glass in cyclonic wind regions C and D (1 point). *These specially engineered components are designed to withstand the extreme forces of high wind, flying debris, and pressure fluctuations that occur during severe storms or tropical cyclones especially in cyclonic wind regions.*
	ARCH STRU	**S7. Seal Water Ingress** All windows and doors to have seals that exceed the water penetration tests in AS 2047. Select systems with flaps over weep holes to reduce water ingress if the wind pressures are near the serviceability pressure. All apron flashings, ridge caps, hip flashings and any valley gutters to have closed cell foam under the flashing or roofing.	3		IL1 to IL4	• Windows and doors to have seals that exceed the water penetration tests in AS 2047 (2 Points). • Project drawings showing separate details of flashings and seals will be encouraged. (1 point) *The flashings have to be fastened with screws at less than 500 mm centres already in AS/NZS 1562.1. However, there is no NCC requirement for closed cell foam – this requirement is above the minimum required in the NCC.*
	ARCH		3	$$	IL1	Not Applicable

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		S8. Wind Resilient Glazing If broken glass could compromise the function of the building, laminated glass should be specified for windows and doors. Float and annealed glass types should not be used anywhere.			IL2, IL3 and IL4	• Comply with NCC DTS (1 Point) • Install laminated glass in cyclonic wind regions C and D (2 points).
	STRU ESD	**S9. Material Robustness** Material robustness must be a proactive consideration starting from the earliest planning phase and continuously evaluated through to construction and maintenance, considering the following parameters: – Building age – Future climate conditions – Building Type	2	$$	IL1 to IL4	• Material robustness specified (2 Points). * **Materials such as Structurally Insulated Panels (SIPs) that retain integrity, performance, and safety for decades after installation demonstrate superior robustness.* *Architects, in collaboration with ESD consultants, should recommend robust materials, considering the building's age and its expected service life. This ensures material resilience, reducing the risk of damage and minimising long-term repair costs.* *The purpose/usage of the building adds more logic to the recommendation and selection of the robust construction materials considering the whole life cycle assessment process.* *It is highly encouraged to conduct structural health monitoring to identify material's performance and environmental impact. This will help in identifying materials with lower environmental impact, while considering their robustness to ensure durability and performance.*
	ARCH STRU	**S10. Ancillary Items** Ancillary items (aerials, satellite dishes, solar photo voltaic panels (PVs), solar hot water panels and tanks, roof-top ventilators, split system air conditioners; roof-top HVAC; attached verandas, patios	3	$$	IL1 to IL4	• Installation of ancillary items using the right mounting systems, such as rails, bolts, tripod mounts, raised kerb mounts, etc in all building types and in all wind regions (2 Points) • Items are anchored to the roof's structural elements, i.e., rafters/trusses, and use lag bolts

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
		and window awnings) should be installed securely considering the following factors: – Number of items to be installed – The size of the ancillary items – Strength of attachments – Protection from storm/cyclone surge Structural health monitoring of already installed items				or roof anchors to address the unexpected extra loads during storms/cyclones (1 Point). *The penetrations should be sealed professionally after the installation, and regular inspections carried out to verify the structural soundness against corrosion.*
Holistic Design	ESD	**W1: Climate Resilience Assessment (CRA)** Conduct an initial Climate Resilience Assessment in accordance with Section 5 and Appendix. For projects that require detailed climate risk assessment and adaptation, conduct detailed adaptation planning, including identifying primary hazards, setting goals based on resilience scores, incorporate adaptation into building design (Table 7 in Section 6), tracking and documenting implementation for hand-over.	1	$	IL1 to IL4	• CRA is conducted and has informed design decisions (1 point) *Lead Consultant or ESD consultant to coordinate with relevant disciplinaries; Considering both positive and negative impacts of the adaptation measures (e.g. impact on embodied carbon, impact on other hazards).*
	ARCH ELEC ESD	**W2: Power and grid resilience** Provide on-site generation and energy storage capacity to provide power for critical systems in the event of grid outage or blackout.	3	$	IL2 to IL4	• Provision of energy generation or storage capability capable of serving vital loads during blackouts (2 points) • The electricity peak demand reduced by 10% of the building's annual peak electricity demand (1 point)

Climate Hazard	Area of Impact	Adaptation Measures	Score (1-5)	Cost Est.	IL	Remark
	ARCH CIVIL LAND	**W3: Resilient landscaping and transitional spaces** Landscape and outdoor space design with consideration of resilience to applicable hazards, such as specifying materials of pavement, outdoor furniture with heat reflectivity, durability, water and water proofing requirements, clever use of veranda, pergolas, porches, to manage outdoor thermal comfort while ensuring flood and wind resilience. **Wind Resilient Tree Species** Plant wind resilient tree species to avoid impact damage and wind-borne debris, landscape designer to provide guidance, in wind regions C & D.	4	$$	IL1 to IL4	• Use greenery and tree planting to provide shading for outdoor thermal comfort (1 point) • Hardscaping elements fully shaded or have a SRI>39 (1 point). • Use of veranda, pergola, porches to provide thermally comfortable spaces. • Other measures (e.g. wind proofing design for outdoor furniture, canopies, signboards, etc) • Landscape designers to recommend resilient tree species. • it is recommended not to plant large trees within the fall radius of buildings.
	ARCH CIVIL ESD	**W4: Advanced resilience features** Provide innovative and advanced design solutions to address climate hazards	2	$$	IL1 to IL4	• Use of innovative design solutions.

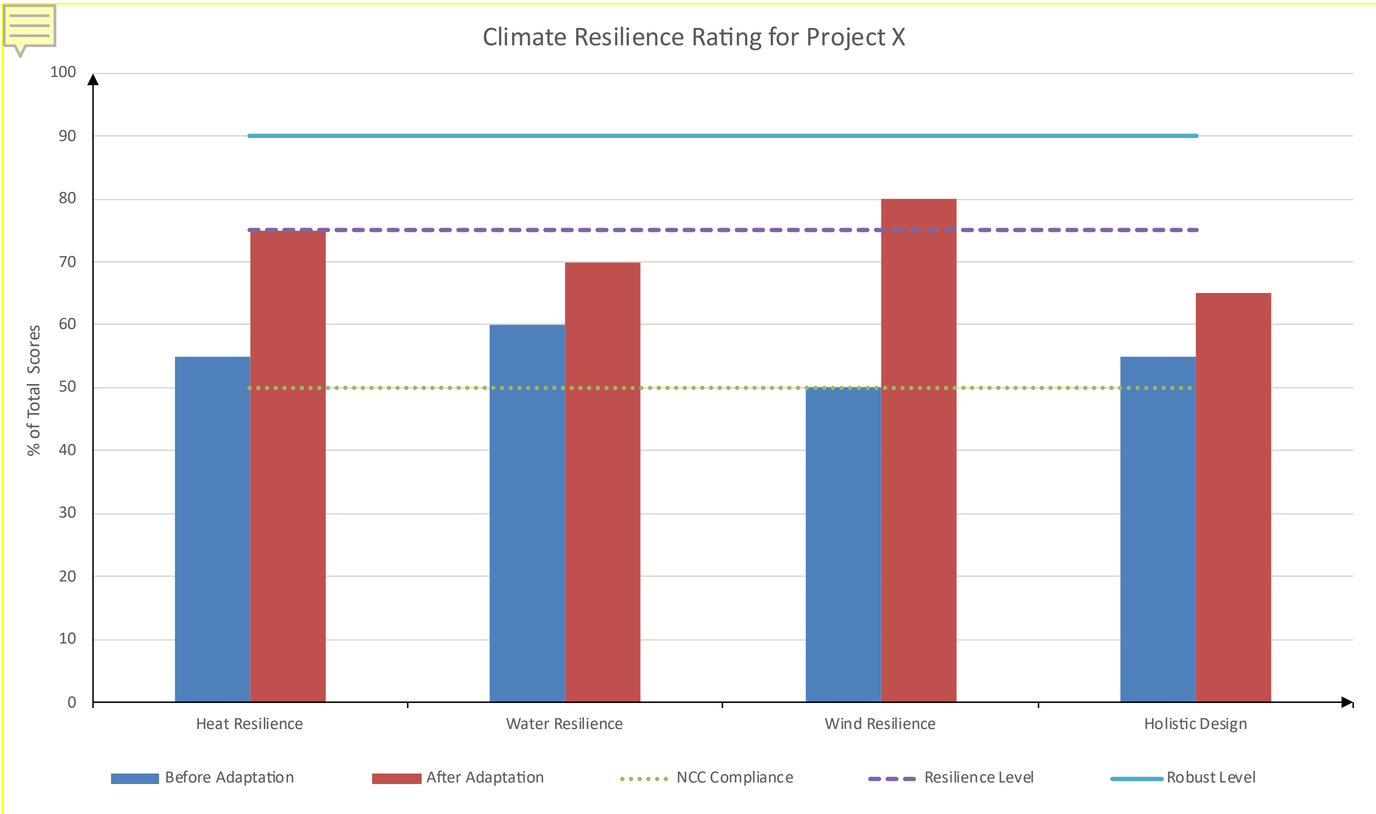

Figure 4. Resilience Rating for A Case Study

A Climate Resilience Scoring Tool is provided for project team's use as part of TG50. Figure 4 above presents a sample output from the tool using a case study school project as a reference.

6.2. Design Register

A design register (Appendix 6) has been developed to guide the project team in integrating adaptation measures identified in the Table 9 above. The register can be used at various stage of design phases, enabling the team to assess and track the project's resilience to specific hazard and take actions accordingly.

The register should be filled in by relevant professionals and checked by the project design engineer.

6.3. Construction Register

Inspection and monitoring play a critical role in ensuring that construction activities align with the intended design of the adaptation strategies (Section 6.1). They help detect deviations, confirm proper implementation of adaptation measures, and uphold quality control throughout the project lifecycle.

To support the effective on-site implementation of adaptation measures identified during the design phase, a dedicated construction register has been developed (Appendix 7). This register serves as a practical tool to verify that the specified adaptation strategies are both implemented and operational. It is recommended that this checklist be adopted across all projects to promote consistent application of climate adaptation strategies.

7. Project Deliverables

During the project planning phase, project teams should clearly define expectations and deliverables related to climate resilience at each stage of project delivery. These requirements should be integrated into the project's design and construction documentation, including the service brief, design reports and drawings, construction documents, and technical specifications.

Table 10. Project Deliverables

Description	Activities	Key Deliverables & Documents
Project Planning, Initiation and Definition		
Customer Agency Project Planners prepare a Business Case to define the scope of the procurement, develop the implementation strategy. The DHW Project Manager prepares a Project Definition Plan (PDP) to define the approach to be used by the project team to deliver the intended scope whilst ensuring the minimum requirements of design brief are understood, achievable and will be met.	Project planners indicate potential climate risks, if any, together with project's environmental risks. Customer Agency and DHW ensures climate risk assessment included in design brief. PM sets specific requirements for Climate Risk Screening as part of PDP stage consultancy. Climate risk is tabled as an item for discussion in Risk Workshop. For high-risk projects identified by the Workshop, BTS review is required.	Climate Impact is captured in • Project Business Case (e.g. section on Environmental Impact) • Project Definition Plan (PDP) (Section 13.6: Risk Management Plan) • Project Management Plan (PMP) (Section 6: Risk Management) • Briefs for architectural services and engineering services Climate Resilience Assessment using the template. Climate Risk included in Risk Workshop and Risk Register

Description	Activities	Key Deliverables & Documents
Design Phase		
<u>Schematic Design (SD)</u> Preliminary designs that define overall scope and systems. <u>Design Development (DD).</u> Refinement of building design and complete definitions of all systems. All design decisions are completed during this phase. <u>Construction Document (CD)</u> Design is translated into detailed, technical documents used for construction	Lead consultants or ESD consultants conduct Climate resilience assessment and adaptation planning. Discipline consultants incorporate adaptation measures into design decisions.	• Climate Risk Assessment Report • Climate adaptation design solutions are incorporated into lead consultant's reports and drawings. • Climate adaptation design solutions are incorporated into discipline consultant's reports and drawings. • Climate adaptation features reflected in construction specifications. • Climate Resilience Design Register
Construction Phase		
Construction per approved documents	Consultants respond to contractor questions Shop drawings Change orders Inspections	Climate Resilience Construction Register
Post-Construction Phase		
Ensure the building is ready for occupancy, operates as intended and is properly handed over to the owner or facility manager.	Commissioning Final inspection and certifications Handover and documentation Defects Liability Period (DLP) Post-Occupancy Evaluation (POE) Maintenance planning	• Commissiong reports of adaptation measures (e.g. thermal comfort, standby power) • Operation and maintenance (O&M) for adaptation measures • POE reports capturing adaptation measures • Maintenance schedule

Glossary, Abbreviations and Limitations

A. Definitions and key terms

Term	Definition
Adaptive capacity	The ability of a system to accommodate climate changes or to expand the range of changes with which it can cope.
Climate adaptation	The process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities.
Climate change	A change in the state of the climate that persists for an extended period, typically decades or longer.
Climate projections	Climate projections are simulations of Earth's climate in future years in response to a set of greenhouse gas, aerosol, and land-use scenarios. The scenarios are consistent with socio-economic assumptions of how the future may evolve.
Climate resilience	The ability of a system to survive an immediate shock, adapt to ongoing consequences, and thrive in a changed long-term landscape.
Climate risk	The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from the potential impacts of climate change as well as human responses to climate change.
Climate variables	Factors that determine and govern the climate. Main factors include rainfall, atmospheric pressure, wind speed, wind direction, humidity and average and maximum temperature. Changes in climate variables (such as temperature) can lead to changes in climate hazards (such as heatwaves).
Consequence	Outcome of an event affecting objectives, for example the consequence of an extreme wind event may be that a buildings envelope is penetrated by debris, in turn increasing the internal pressure leading to structural damages from excessive uplift forces acting on the structural tie down systems,
Exposure	The presence of buildings and building occupants in locations that could be adversely impacted by climate change.
Extreme weather event	An event that is rare at a particular place and time of year. The characteristics of extreme weather may vary from place to place.
Hazard (climate hazard)	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.
Likelihood	The chance of something happening.

Term	Definition
Representative concentration pathways (RCPs)	Prescribed pathways used in the IPCC AR5 report for greenhouse gas and aerosol concentrations, together with land use change, that are consistent with a set of broad climate outcomes used by the climate modelling community. The pathways are characterised by radiative forcing (extra heat in lower atmosphere) produced by the end of the 21st century.
Resilience	Resilience in the context of this Technical Guide means a building can remain mostly functional during an extreme event, with a quick return to full functionality.
Robust	Robustness in the context of this Technical Guideline means that during an extreme climate event, the building will have continued function.
Scenario	Climate change scenarios refer to a coherent, plausible and simple description of the possible future state of the climate, which forms the basis of climate change projections.
Shared Socioeconomic Pathways (SSPs)	The latest IPCC Assessment Report 6 (AR6) identified the following Shared Socio-economic Pathways (SSPs), SSPs provide baseline narrative scenarios that identify socio-economic and geopolitical assumptions, and economic and technological trends.
Vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

B. Abbreviations

Abbreviation	Definition
AR	Assessment Report
BOM	Bureau of Meteorology
CMIP	Coupled Model Intercomparison Project
CSIRO	Commonwealth Scientific and Industrial Research Organization
CZ	Climate Zone
DD	Design development
DWER	Department of Water and Environmental Regulation
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety

Abbreviation	Definition
ESD	Environmentally Sustainable Design
HVAC	Heating, Ventilation and Air Conditioning
IL	Importance Level
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
NCC	National Construction Code
SD	Schematic Design
PDP	Project Definition Plan
TG	Technical Guide

C. Exclusions and limitations

This Technical Guide focuses on climate adaptation and resilience only and is to be read in conjunction with the suite of Finance Technical Guidelines. The following exclusions and limitations apply to this document:

- This TG has been developed using the current available climate projection data for Western Australia, i.e. data from CSIRO based on CMIP5 RCP scenarios as per IPCC AR5 (IPCC, 2013). Climate change projections based on CMIP6 SSP scenarios as per IPCC AR6 report (i.e. CMIP6, using SSP scenarios) (IPCC, 2023) have not yet been downscaled for Western Australia at the time of TG drafting. It is expected climate research and projections based on AR6 will advance and get ready, and the TG may will be updated accordingly.
- This guide focuses on climate resilience and adaptation for extreme weather events and chronic climate change, such as heatwave, extreme wind and storm, flooding, drought, sea level rise and coastal erosion. Impacts from other climate hazards (bushfire, lightning, hail etc.) are excluded from this guide. Note, Finance Technical Guide TG015 Building in Bushfire Prone Areas (DOF, 2021) should be referred for bushfire affected land.
- This guide provides a general framework that is applicable to both new and existing building stock. The resilience of our older building stock is more difficult to assess, partly due to lack of information about the stock of buildings. Good maintenance and upgrading are the key to resilience for older buildings, with due consideration including the age and significance of the building, cost and the risk.

- This TG is related to but does not explicitly address climate mitigation and carbon emission reduction. Please refer to Technical Guide TG040 Environmentally Sustainable Design Guideline for Non-Residential Government Buildings (DOF, 2024).

While every effort is made to make this TG consistent with National Construction Codes and other national standards, this TG aims to promote best practices beyond the minimum code requirements. Where there are inconsistencies or technical restrictions, project teams should adopt a case-by-case approach in decision making.

References

ABCB. (1996). *Building Code of Australia*.

ABCB. (2022). *National Construction Code 2022*. https://ncc.abcb.gov.au/editions/ncc-2022

AHIA. (2024). *Climate Resilience and Adaptation Guide*. https://aushfg-prod-com-au.s3.amazonaws.com/Climate%20resilience%20and%20adaptation%20guide.pdf

Anthony Lymath. (2014). *Climate change adaptation in buildings: Flooding (Part one) | NBS*. https://www.thenbs.com/knowledge/climate-change-adaptation-in-buildings-flooding-part-one

Climate Coucil. (2025). *Climate Risk Map*. Https://Www.Climatecouncil.Org.Au/Resources/Climate-Risk-Map/.

CSIRO. (2025). *Climate Change in Australia (CCiA)*. https://www.climatechangeinaustralia.gov.au/en/

CSIRO and BOM. (2024). *State of the Climate 2024: Bureau of Meteorology*. http://www.bom.gov.au/state-of-the-climate/references.shtml

CSIRO and BOM. (2022). *State of the Climate 2022*.

DOF. (2021). *TG015 Building in Bushfire Prone Areas*.

DOF. (2022). *TG037 Water Efficiency Technical Guideline.*

DOF. (2024). *TG040 Environmentally Sustainable Design Guideline for Non-Residential Government Buildings*.

DOT. (2024). *Strategic Asset Management Framework*.

DPLH and DOT. (2019). *Coastal erosion hotspots in Western Australia*.

DWER. (2023a). *Climate Adaptation Strategy: Building WA's climate resilient future*.

DWER. (2023b). *Floodplain Mapping Tool*. Https://Www.Wa.Gov.Au/Service/Natural-Resources/Water-Resources/Floodplain-Mapping-Tool.

GBCA. (2024). Green Star Buildings v1 Submission Guidelines. In *Green Building Council of Australia*. https://www.gbca.au/product/green-star-buildings-v1-submission-guidelines

Geoffrey Boughton. (2025). *Technical advice on Building Resilience and Adaptation to Extreme Wind Conditions due to Climate Change.*

Standards Australia. (2021). The 2021 Australian/New Zealand Standard, AS/NZS 1170.2:2021. In *Wind and Structures, An International Journal* (Vol. 37, Issue 2). https://doi.org/10.12989/was.2023.37.2.095

IPCC. (2013). IPCC Fifth Assessment Report (AR5) - The physical science basis. In *IPCC AR5*. https://doi.org/10.1017/CBO9781107415324.004

IPCC. (2023). SYNTHESIS REPORT OF THE IPCC SIXTH ASSESSMENT REPORT (AR6): Summary for Policymakers. In *European University Institute* (Issue 2).

JCU. (2025). *CTS Technical Reports*.

Smith, D. J., Edwards, M., Parackal, K., Ginger, J., Henderson, D., Ryu, H., & Wehner, M. (2020). Modelling vulnerability of Australian housing to severe wind events: past and present. *Australian Journal of Structural Engineering*, *21*(3). https://doi.org/10.1080/13287982.2020.1744900

Standards Australia. (2013). *AS 5334-2013 Climate change adaptation for settlements and infrastruc*. https://www.intertekinform.com/en-au/standards/as-5334-2013-119943_saig_as_as_251367/?srsltid=AfmBOoq1qzA0bViWTagiDuY69oafetcfT_dTYHSMDheofCdl3t_wdifw

Standards Australia. (2021). *AS/NZS 3500.3 Plumbing and drainage, Part 3: Stormwater drainage*.

UBA. (2017). *Guidelines for Climate Impact and Vulnerability Assessments*.

WACOSS. (2025). *Heat Vulnerability Index Project*. Https://Www.Wacoss.Org.Au/Heat-Vulnerability-Project/.

Appendix 1: Climate Change in Western Australia

Western Australia (WA) is on the frontline of climate change, experiencing impacts of climate extremes and higher average temperatures. The south-west will continue to become drier, especially during winter and spring, with less runoff and recharge (CSIRO and BOM, 2024). The northern regions of WA are projected to experience fewer but more intense Tropical Cyclones (TC). Rainfall associated with extreme storm events is projected to increase in intensity with each degree of warming, short-term (hourly) rainfall intensities are expected to increase more significantly than longer-duration intensities. The **Error! Reference source not found.** reflects Australia's average annual temperature relative to 1861-1900 period.

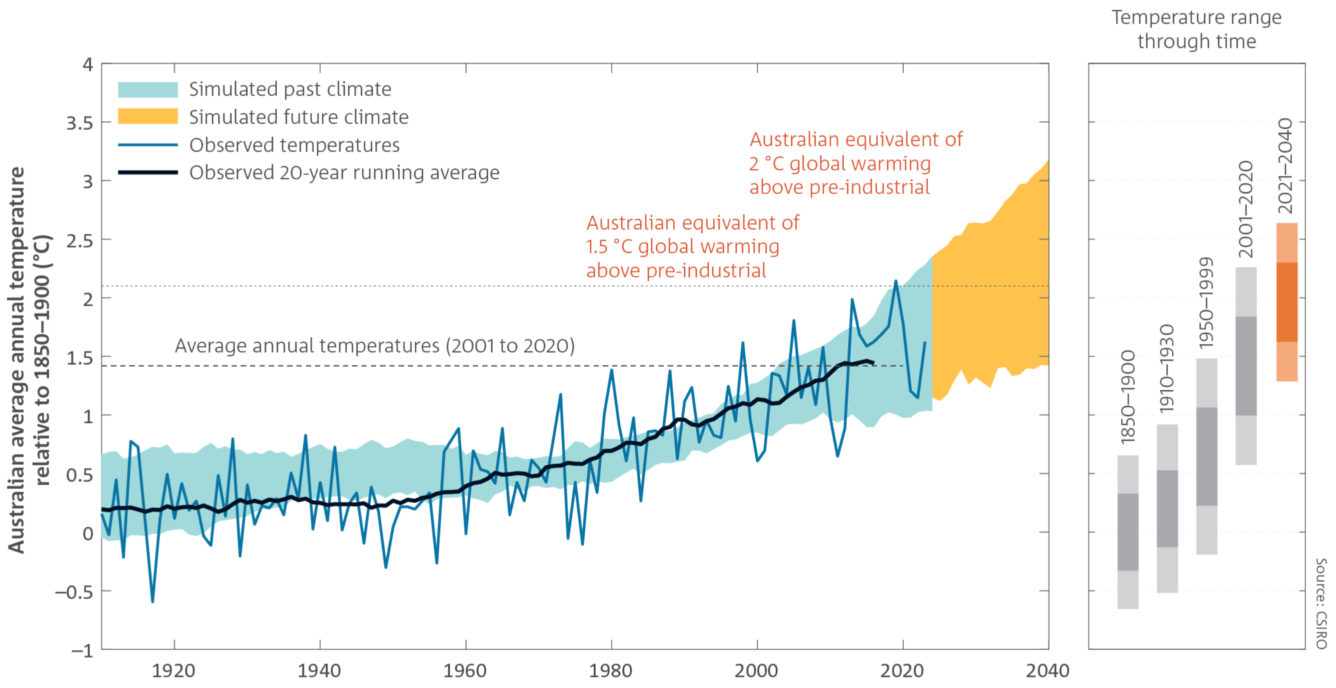

Figure 5. Australian average annual temperature in observations and global climate models. Source: CSIRO and BOM, 2024

Australian average annual temperature in observations and global climate models shown relative to the 1850–1900 baseline approximating the pre-industrial era. Past and future-coloured bands show the 20-year running average from models for historical conditions and plausible future scenarios to 2040. Black dashed lines show the average warming expected for Australia when the global average temperature reaches 1.5 and 2.0 °C above the pre-industrial era. The panel to the right shows the range of temperatures (one and 2 standard deviations) in various epochs from observations and the 2021–2040 period as simulated by one climate model (the results from which are close to the mean of all models)

The rate of sea level rise is accelerating, increasing to 3 cm per decade since the 1990s (CSIRO and BOM, 2022). This amplifies the impacts of storm surge associated with extreme storm events and increases the risks of coastal erosion and inundation. A total of 55 coastal erosion hotspots in Western Australia have been identified where sea level rise is expected to affect public and private physical assets and require adaptation action within 25 years. Twenty-one hotspots require urgent action, and a further 31 locations are on a watchlist (DWER, 2023a). Rising sea levels and coastal erosion and inundation pose significant risks to Western Australia's coastal infrastructure.

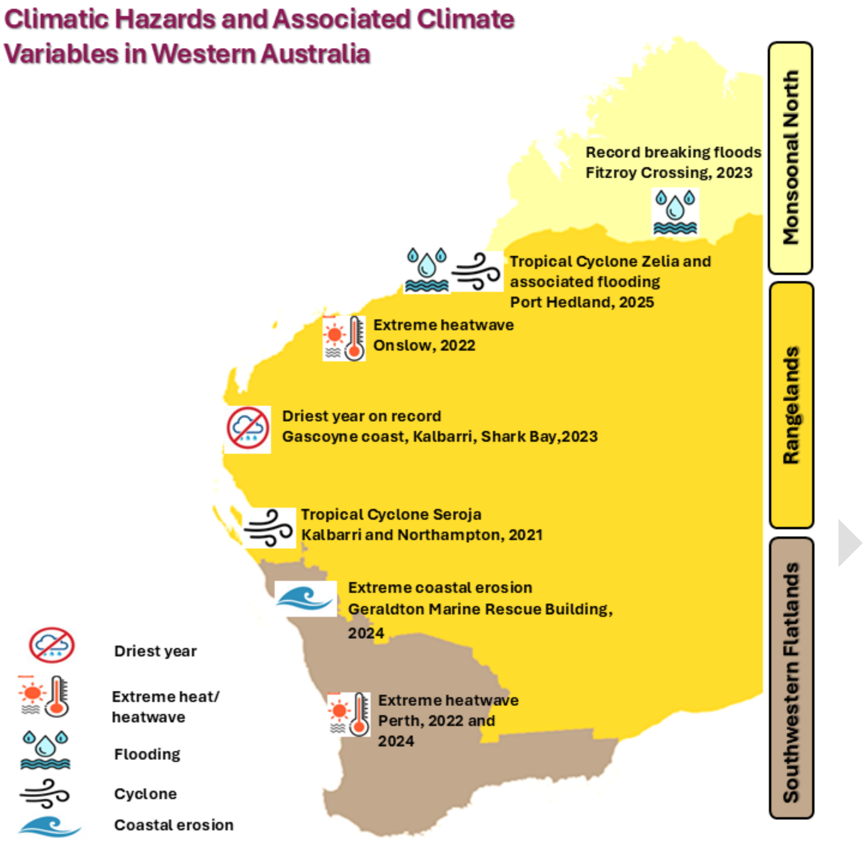

Figure 6. Recent Climate Hazard Events in Western Australia

In WA, we have already witnessed extreme climate events causing damage to non-residential buildings. Heatwaves have caused HVAC failures throughout the State, extreme flooding events have damaged buildings and infrastructure and disrupted communities, and TC's and tornadoes have caused widespread and significant damage to buildings and properties. Implementing climate adaptation measures can improve the resilience of Finance projects reducing rectification and maintenance costs and improving safety for building occupants.

From 2000 to 2024, Western Australia has faced numerous climate-related disasters, including cyclones, flooding, heatwaves, and bushfires. The summary of these events and their patterns are shown below.

Table 11. Frequency and Severity of Climate Hazards

Climate Hazards	Frequency and Severity	Trends
Cyclones and Windstorms	Cyclones have been a recurring threat, particularly in the northern regions. Notable cyclones include Cyclone George in 2007 and Cyclone Veronica in 2019, Seroja in 2021, Tornado and Thunderstorm in May 2024, Cyclone Sean in January 2025 and	The intensity of cyclones has increased, with more severe storms causing greater damage. This trend is linked to rising sea surface temperatures, which fuel stronger cyclones. Further to that the

Climate Hazards	Frequency and Severity	Trends
	Cyclone Zelia in February 2025, causing significant damage to infrastructure and communities (JCU, 2025).	cyclones reoccurrence trend is moving towards southwest region of Western Australia.
Heatwaves	Heatwaves have become more common and intense. The 2019-2020 summer was particularly severe, with record-breaking temperatures across the state.	The average temperatures have increased in WA. The frequency and duration of heatwaves have also increased.
Flooding	Flooding has become more frequent, especially in the northern and central parts of the state. Major floods occurred in 2010, 2017 and 2023 causing widespread damage and displacement (Anthony Lymath, 2014).	Increased short duration (hourly) heavy rainfall events have led to more severe flooding. This is partly due to changes in weather patterns influenced by climate change. With each degree of warming, a 15% increase in the intensity of extreme short-term rainfall is projected.
Sea Level Rise and Coastal Erosion	Sea level rise will increase as a result of the warming climate, this will increase the frequency and amplify the risks of coastal inundation, storm surge, and erosion. Ref State of the Climate Report).	Sea level rise is projected to accelerate under all emissions scenarios, the average rate around Australia, after removing the variations correlated with the El Niño–Southern Oscillation, increased from 1.6 mm/yr (1976–2010) to 2.7 mm/yr (1993–2010) (Ref State of the Climate Report)
Drought	Under a warming climate, drought conditions in Australia are projected to be longer and more intense, particularly in southern and eastern parts of the country.	Annual rainfall in WA has declined over the past 60 years along the west coast, and particularly in the far south-west.

Table 12. Climate change hazards and the associated impact on buildings

Climate Hazard	Impact
Average temperature increases and more extreme temperature events	Higher cooling demands and associated costs.
	The building envelope, including roofing, cladding, and window systems, faces a greater risk of cracking or failure due to material degradation. Sealants and finishes may also be impacted.
	Increased thermal discomfort and heat stress for occupants.
	Lower winter heating loads and costs
	Reduced water heating loads and related costs.
More intense tropical cyclones and storms	Structural loading by pressure forces, leading to structural failure (e.g. removal of individual tiles or iron sheeting through to uplifting of entire roofs or collapsing walls)
	General structural failure of building components leading to potential for total building collapse and destruction
	Impact damage from flying debris
	Rain/moisture penetration leading to internal damage

Climate Hazard	Impact
Sea-level rise, coastal and inland flooding	Water damage to infrastructure and building contents (interior linings, furnishings, appliances, equipment and plant)
	Undermining and/or destruction of foundations, potentially leading to structural failure
	Coastal erosion (in some areas likely to be severe) resulting in loss or damage to property.
Increasing intensity of heavy rainfall events	Increased instances of flash flooding and water ingress into buildings damaging building materials and contents
	Stormwater management systems unable to cope with increased rainfall leading to site flooding issues and challenges conveying stormwater away from buildings.
	Insufficient level of permeable surface collecting rainfall, increasing the volume of stormwater runoff and potentially leading to water entering buildings.
Increased in length of drought conditions/ dry spells	Pressures on urban water resources, opportunities for water storage and reuse should be considered
	Changes in soil moisture in reactive soils can impact the integrity of foundations due to differential settlement.

*Climate change patterns and their impact are region specific and can vary across Western Australia

Appendix 2: Climate Projection Scenarios

Climate Projection Scenarios

Climate change projections illustrate plausible future climate conditions under different levels of greenhouse gas emissions and help us to understand potential changes in climate variables such as average annual rainfall or number of days of extreme heat.

The Intergovernmental Panel on Climate Change (IPCC), a leading authority on climate science, has created several sets of these scenarios. For example, in the IPCC's fifth assessment report (AR5) (IPCC, 2013), Representative Concentration Pathways (RCPs) were used. Each RCP is named after the amount of extra energy (or radiative forcing) trapped in the Earth's atmosphere by 2100, measured in watts per square metre (W/m^2). For instance, RCP8.5 represents a scenario where the extra energy is 8.5 W/m^2 by 2100, indicating a high level of emissions and significant global warming. These scenarios were based on the Coupled Model Intercomparison Project Phase 5 (CMIP5).

In the recent Sixth Assessment Report (IPCC, 2023), the IPCC introduced a new set of scenarios called Shared Socioeconomic Pathways (SSPs). These new scenarios are based on updated climate models (CMIP6) and consider different socioeconomic futures (Figure 7).

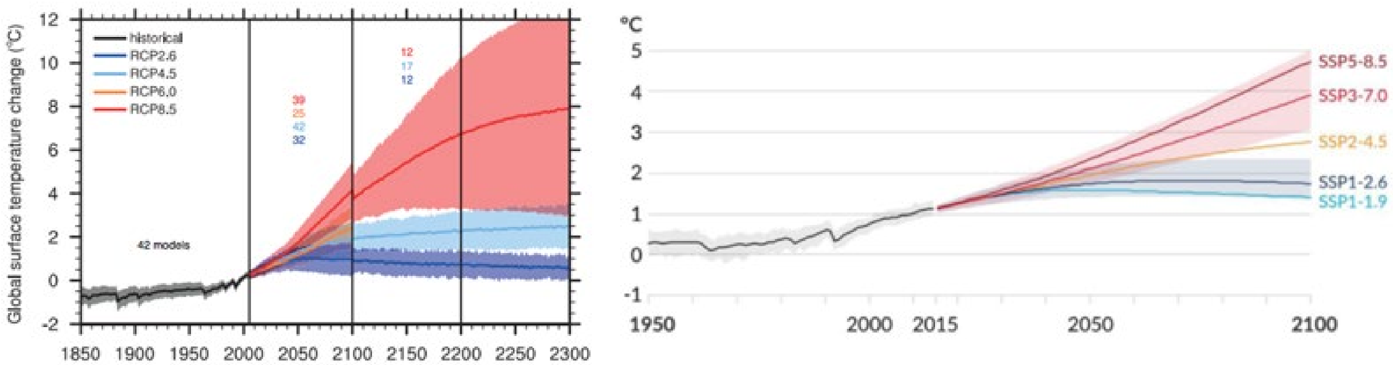

Figure 7. Climate change scenarios in IPCC AR5 (left) and AR6 (right)

	SSP1-1.9 "SUSTAINABILITY"	SSP1-2.6 "SUSTAINABILITY"	SSP2-4.5 "MIDDLE OF THE ROAD"	SSP3-7.0 "REGIONAL RIVALRY"	SSP5-8.5 "FOSSIL-FUELLED DEVELOPMENT"
RCP equivalent	No equivalent RCP	RCP2.6	RCP4.5	No equivalent RCP	RCP8.5
THE WAY THE WORLD MIGHT CHANGE IN THE FUTURE					
Emissions reduction	Very high and immediate	High and immediate	Moderate from 2040s	None (minor slowing)	None (accelerating)
WHAT THE FUTURE CLIMATE MAY LOOK LIKE UNDER EACH SSP					
Global warming by 2100	1.0-1.8°C	1.3-2.4°C	2.1-3.5°C	2.8-4.6°C	3.3-5.7°C
Resulting global warming levels*	Due to past emissions all SSPs reach 1.5°C in the 2030s and then diverge				
	Overshoots 1.5C slightly around 2050 then returns and stabilises near 1.5C by 2100	Reaches 2°C around 2050s and stabilises	Reach 2°C around 2050s 2.7°C by 2100	Reach 2°C around 2050s 3°C around 2070s 4°C possible by 2100	Reach 2°C around 2050s 3°C around 2060s 4°C by around 2080s

Figure 8. Climate change scenarios, RCPs and SSPs

Appendix 3: Adaptation Planning for Project Delivery and Asset Management

A comprehensive approach to climate adaptation in a project involves addressing new constructions, renovations/upgrades, and operations/services. For new builds, the process begins with the business case and planning, which includes considering climate risks to the project. This is followed by the design phase, where adaptation strategies are developed to address priority climate-related risks and then implemented during construction. The project then enters normal operation, which involves prioritizing, monitoring, and evaluating climate risks and the efficacy of the adaptation strategies.

For renovations and upgrades, the process starts with assessing existing projects against projected climate hazards to identify vulnerabilities. Design strategies are then developed and implemented to address these risks, followed by monitoring during and after construction to ensure effectiveness.

Operations and services excluded from this Technical Guide (TG) involve climate risk assessments for physical risk operations and utilities, which are not directly related to building design strategies. This ensures a holistic approach to climate adaptation, covering all aspects of a project's lifecycle.

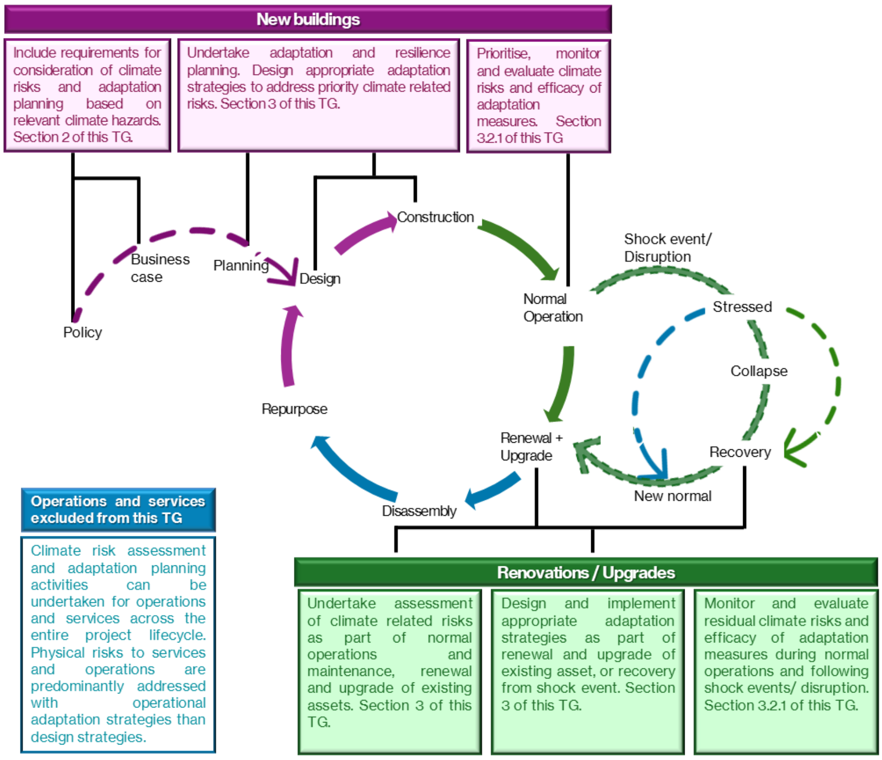

Figure 9. When to conduct climate risk assessment and adaptation planning in the project lifecycle for new buildings and renovation/ upgrade works (AHIA, 2024)

Appendix 4: Risk Assessment (Likelihood and Consequence criteria)

*Tables below are prefilled based on Table 11 of Climate change impact and risk management - A guide for business and government (Australian Greenhouse Office 2006).

Table 13. Likelihood Criteria (DWER first pass risk assessment)

Rating	Recurrent risks	Single events
Almost certain	Could occur several times per year	More likely than not – probability greater than 50%
Likely	May arise about once per year	As likely as not – 50/50 chance
Possible	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely	May arise once in 10 to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare	Unlikely during the next 25 years	Negligible – probability very small, close to zero

Table 14. Consequence criteria (acquired from DWER first pass risk assessment)

Consequence and success criteria	Public safety	Local growth and economy	Community and lifestyle	Environment and sustainability	Public administration
Catastrophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	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	Public administration would fall into decay and cease to be effective
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive, and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely
Moderate	Small numbers of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure
Insignificant	Appearance of a threat but no actual harm	Minor shortfall relative to current forecasts	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	There would be minor instances of public administration being under more than usual stress, but it could be managed

Appendix 5: Design Matrix for Wind Resilience

Issue	Wind Region	If Design Brief is for a building with quick return to functionality after the event	If Design Brief is for a building that gives safe shelter during the event	If Design Brief is for a building that remains operational functionality during the event
Building Importance level (Note 1)	Region A	Importance Level 3	Importance Level 3	Importance Level 4
	Region B2, C and D	Importance Level 3	Importance Level 3	Importance Level 4
Climate change multiplier (M_c) used in AS/NZS 1170.2. Buildings with 50-year life.	Region A	M_c = 1.05	M_c = 1.05	M_c = 1.05
	Region B2, C and D	M_c = 1.05	M_c = 1.05	M_c = 1.05
Climate change multiplier (M_c) used in AS/NZS 1170.2. Buildings with 100-year life.	Region A	M_c = 1.05	M_c = 1.1	M_c = 1.1
	Region B2, C and D	M_c = 1.1	M_c = 1.1	M_c = 1.1
Internal pressures used in design Use only: Pressures from Table 5.1(B) AS/NZS 1170.2:2012 (Note 3)	Region A	An external door open	a ratio of openings = 6	a ratio of openings = 6
	Region B2, C and D	a ratio of openings = 6	a ratio of openings = 6	a ratio of openings = 6
Doors, garage doors and windows (Note 4)	Region A	All doors, garage doors and windows wind rated	All doors, garage doors and windows wind rated, windows debris rated or protected	All doors, garage doors and windows wind rated, windows debris rated or protected
	Region B2, C and D	All doors, garage doors and windows wind rated	All doors, garage doors and windows wind rated, windows debris rated or protected. Avoid garage doors in areas in which people may be sheltering.	All doors, garage doors and windows wind rated, windows and doors debris rated or protected. Avoid garage doors in areas where there may be people.

Issue	Wind Region	If Design Brief is for a building with quick return to functionality after the event	If Design Brief is for a building that gives safe shelter during the event	If Design Brief is for a building that remains operational functionality during the event
Automatically opening glass doors **Plan for there to be an alternative entrance to the space e.g. a wind rated swinging glass door, so that the automatic door can be disabled and braced.** **In addition:**	Region A	No special measures.	Disable the door and temporarily brace the automatically sliding glass door at the bottom.	Disable the door and temporarily brace the automatically sliding glass door at the bottom.
	Region B2, C and D	Disable the door and temporarily brace the automatically sliding glass door at the bottom.	Disable the door and temporarily brace the automatically sliding glass door at the bottom. Protect the door with plywood sheeting.	Disable the door and temporarily brace the automatically sliding glass door at the bottom. Protect the door with plywood sheeting.
Window glass	Region A	No special measures beyond requirements of Australian Standards	Laminated Glass with debris protection	Laminated Glass
	Region B2, C and D	Laminated glass	Laminated glass with debris protection	Laminated glass with debris protection
Ensure that critical elements in the tie-down chain can be checked and maintained easily	Region A	Inspection of roofing fasteners.	Inspection of roofing fasteners, purlin to rafter connections.	(Inspection of roofing fasteners, purlin to rafter connections.
	Region B2, C and D	Inspection of roofing fasteners, purlin to rafter connections	Inspection of roofing fasteners purlin to rafter and roof to wall connections.	Inspection of roofing fasteners, purlin to rafter and roof to wall connections.
Details for flashings – apron flashings, ridge flashings, hip flashings and where installed, valley gutters **Turn up pans under all ridges, hips and apron flashings.**	Region A	No special measures beyond requirements of Australian Standards	Closed cell foam under apron flashings	Closed cell foam under apron flashings, valleys
	Region B2, C and D	Closed cell foam under apron flashings	Closed cell foam under apron flashings, valleys	Closed cell foam under apron flashings, valleys, ridges, hips

Appendix 6: Climate Resilience Design Register

Identifier	
Job title	
NCC Building Class	
Building Function	
Design Life	
Importance Level	
Client	
Designer	

S. No.	Heading	Item	Reference Document	Checked Yes/No
		Climate Resilience		
1	General	Has the design used the latest future climate data under CSIRO RCP 8.5 or SSP3-7.0 2050 scenario?		
		Has the risk assessment been carried out in accordance with TG050.		
		Has the project area previously been impacted by extreme climate events (e.g. storms/tropical cyclones, extreme rainfall and flooding, damaging winds, damaging hail, bushfires, heatwaves, drought, or coastal inundation).		
		Is the project located in a cyclone zone?		
		Is the project located in or adjacent to a flood prone area?		
		Is the project located at or adjacent to the coastline or tidally influenced waterway?		
		Would the project accommodate occupants vulnerable to the impacts of climate extremes (e.g. children, elderly, infirm, low mobility, seeking medical treatment)?		
		Civil & Structural Design		
2	Foundation design	Are reactive soils present on site, if so, has the structural engineer considered the impacts of reactive soils on building foundations?		
3	Structural design	Has the climate change factor for wind (M_c) been considered?		
		Has the internal pressure been considered according to the WA variation of NCC 2022?		
		Have apron flashings, ridge caps, hip flashings and any valley gutters incorporated closed cell foam under the flashing or roofing?		
4	Roof design	Have box and valley gutters been avoided?		
		Have eaves and eaves gutter systems been used in design (minimum width = 600 mm)?		
		Have roof attachments (e.g. signs and antennas) been approved by structural engineer?		
		If flues and extractor fans are proposed. Have fastening details to the roof structure been provided?		
		Has the roof been designed to accommodate future installations (e.g. Solar PV Systems)?		

S. No.	Heading	Item	Reference Document	Checked Yes/No
	External Fabric	Has the design considered using laminated glass in the cyclone regions?		
	Others (TBC)			
MEP Services Design				
5	Mechanical Design	Has an additional plant space been provided to accommodate larger thermal equipment in future?		
		Considering the potential effects of climate change, has the mechanical design temperature been adjusted in line with the latest high emission projections?		
6	Electrical Design	Has any provision of energy generation or storage capability capable of serving vital loads during blackouts been provided?		
		Does the project incorporate a demand response management strategy (e.g. power sharing of 10% peak electricity)?		
7	Hydraulic Design	Have gutter overflows been provided to all eaves' gutters?		
		Has the design considered climate change factor for future rainfall intensity?		
	Others (TBC)			
Architectural & landscape design				
8	Architectural Design	Has the architect conducted site analysis considering future climate impacts on the project?		
		Is the roof shape designed considering the wind/storm resilience (e.g. Pitch angle)?		
		Are the passive design measures prioritized overactive measures in the project design?		
		Have building utilities been raised above flood levels or protected against flood waters?		
		Does the site design incorporate permeable surfaces (permeable paving and green spaces)?		
		Is any consideration given to durability of the construction materials in relation to the design life?		
9	Landscape Design	Has designer recommended wind resistance tree species in landscape design?		
		Is natural shading prioritized before built shading solutions?		
		Has the design incorporated Water Sensitive Urban Design?		
		Has the landscape designer considered drought resilient tree species?		
	Others (TBC)			
ESD				
10	Climate Resilience Assessment (CRA)	Has CRA been conducted following the recommended adaptation strategies.		
11	Thermal Comfort Design Criteria	Has thermal modelling been conducted?		
		Is project meeting thermal comfort requirements as mentioned in the TG050?		
	Others (TBC)			
Remarks:				

Appendix 7: Climate Resilience Construction Register

S.no	Items	Compliant Yes/ No	Sign off
	Groundworks		
1	Is a survey plan provided detailing the site levels confirming the levels are above the flood hazard level?		
	Masonry/Structural Steel/ Timber		
2	Is a signed document provided confirming the installation of wall and roof tie down systems and load distribution path are compliant with the structural engineering details?		
3	Has project consultant inspected, photographed, and confirmed that the insulation has been installed in accordance with the ESD design report?		
	Roofing		
4	Is a signed document provided by the structural engineer confirming roof structural members layout (spacing, sizing, arrangement) have been installed and are compliant with the structural engineering details?		
5	Are flashing and gutters installed as specified in drawings?		
	Doors and Windows Installation		
6	Are the glazing types been installed in accordance with the approved plans and are screened where indicated on the plan set?		
7	Is laminated glass been used in wind regions C and D?		
	Building Utilities		
8	Is a signed document provided confirming that building utilities (including back-up utilities) have been elevated above the flood hazard level or have been protected from flood waters?		
9	Are the building utilities been installed as per design documentations, plans and located 1m above 1% AEP flood level?		
	Landscaping		
10	Are the tree species been planted in the locations nominated on the landscape drawings?		
11	Are resilient tree species been selected and planted for the nominated wind region?		
	Resilient Finishes		

S.no	Items	Compliant Yes/ No	Sign off
12	Are the resilient finishes installed as per the drawings?		
13	Are the joints tightly fit showing no visible gaps and are filled with specified resilient materials?		
Remarks:			

Appendix 8: Useful Resources

Design standards

Standard	Description and relevance
AS 5334:2013 Climate change adaptation for settlements and infrastructure – a risk-based approach	Australian standard that provides a framework and guidelines for assessing risks to infrastructure and settlements from climate change. It provides a structure and approach to planning and adaptation based on the risk management process in ISO 31000 (Standards Australia, 2013).
ISO 14090:2019 Adaptation to climate change: principles, requirements and guidelines	International standard that outlines guidelines and requirements for adapting to climate change. It is a non-linear approach so organisations can implement the principles at different stages. Organisations can use it to inform decisions and to better understand the impacts of climate change (ISO, 2019).
ISO 14091:2021 Adaptation to climate change: guidelines on vulnerability, impacts and risk assessments	International standard that outlines the process for assessing risks related to the impacts of climate change. It provides guidance on understanding vulnerability and developing a risk assessment for the impacts of climate change. Also, while giving understanding of vulnerabilities, it gives structure to preventing or mitigating the impacts while also considering the opportunities (ISO, 2021).
ISO 31000:2018 Risk management: guidelines	International standard that provides structure and guidelines for risk management. It includes guidance on implementing risk management practices, criteria for monitoring and improvement of risk management, and integration into an organisation (ISO, 2018).

Useful data sources

- National Institute of Water and Atmospheric Research, Climate change scenarios for New Zealand
- <https://niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios>
- Ministry for the Environment, Climate change projections for New Zealand
- <http://www.mfe.govt.nz/publications/climate-change/climate-change-projections-new-zealand>
- Ministry for the Environment, Environment Aotearoa 2022
- <https://environment.govt.nz/assets/publications/>
- CSIRO, Projections tools <https://www.climatechangeinaustralia.gov.au/en/projections-tools/>
- CSIRO & Bureau of Meteorology, Victorian climate projections 2019
- <https://www.climatechangeinaustralia.gov.au>
- Bureau of Meteorology, State of the climate 2022 <http://www.bom.gov.au/state-of-the-climate/2022/>
- Bureau of Meteorology, Climate data online <http://www.bom.gov.au/climate/data/>
- Geoscience Australia, Community safety data and products <https://www.community-safety.ga.gov.au/data-and-products>
- CoastAdapt, CoastAdapt datasets <https://coastadapt.com.au/tools/coastadapt-datasets>
- New South Wales Government, Climate Data Portal <https://climatedata-beta.environment.nsw.gov.au/>
- Queensland Government, Future Climate Dashboard <https://www.longpaddock.qld.gov.au/qld- future-climate/dashboard/>
- Victorian Government, Future climate tool <https://vicfutureclimatetool.indraweb.io/>
- Government of South Australia, Climate projections viewer
- <https://www.environment.sa.gov.au/climate-viewer/>
- Government of Western Australia, Western Australian climate projections
- <https://www.environment.sa.gov.au/climate-viewer/>
- Climate Council, Climate risk map of Australia

- <https://www.climatecouncil.org.au/resources/climate-risk-map/>
- Australian Government/ Geoscience Australia: Australian Rainfall and Runoff Guidelines

Risk assessments

- Victorian Government, Guidelines for sustainability in health care capital works
- <https://www.vhba.vic.gov.au/sites/default/files/2021-10/Sustainability-guidelines-for-capital-works- VHBA-Revised-October-2021.pdf>
- New South Wales Government, Climate risk assessment tool
- <https://www.climatechange.environment.nsw.gov.au/sites/default/files/2021-11/Appendix%20C_Climate%20Risk%20Assessment%20Tool_2021.xlsx>
- New South Wales Government, Climate risk ready NSW guide
- <https://www.climatechange.environment.nsw.gov.au/sites/default/files/2021-06/NSW%20Climate%20risk%20ready%20guide.pdf>
- Government of Western Australia, Climate change risk management guide
- <https://www.wa.gov.au/system/files/2022-06/WA-climate-change-risk-management-guide.pdf>
- Queensland Health, Climate change adaptation planning guidance guidelines
- <https://www.health.qld.gov.au/ data/assets/pdf_file/0026/1125962/climate-change-guideline.pdf>
- Government of South Australia, Climate change adaptation guideline
- <https://www.dit.sa.gov.au/ data/assets/pdf_file/0010/165943/DIT_Climate_Change_Adaptation_G uideline.pdf>
- Royal Australasian College of Physicians, Climate change and Australia's healthcare systems
- <https://www.racp.edu.au/docs/default-source/advocacy-library/climate-change-and-australias- healthcare-systems-a-review-of-literature-policy-and-practice.pdf?sfvrsn=efe8c61a_4>
- World Health Organization, Operational framework for building climate resilient and low carbon health systems <https://iris.who.int/bitstream/handle/10665/373837/9789240081888-eng.pdf?sequence=1>
- Health New Zealand, Heat health plans guidelines

- <https://www.tewhatuora.govt.nz/assets/Publications/Environmental-health/Heat-Health-Plans- Guidelines.pdf>
- New Zealand Government, A framework for the national climate change risk assessment for Aotearoa New Zealand https://environment.govt.nz/assets/Publications/Files/arotakenga-huringa- ahuarangi-framework-for-national-climate-change-risk-assessment-for-aotearoa-FINAL.pdf

Useful Resources for acquiring Climate Data

- Bureau of Meteorology Climate Data Online portal and State of the Climate report
- CSIRO Climate Change in Australia and National Institute of Water and Atmospheric Research climate change projections
- Geosciences Australia specialist data sources – for example, Tropical Cyclone Risk Model, ShakeMap.
- CoastAdapt or Coastal Risk Australia for coastal-related hazards
- Climate Council Climate Risk Map of Australia
- State-level sources – for example, AdaptNSW, Queensland Future Climate Dashboard, Victoria Future Climate Tool

Appendix 9: Case Studies

A. Madora Bay Primary School

Madora Bay Primary School (MBPS) is a 6,863 sqm DoE primary school in southwestern WA. The design adheres to standard design requirements following Finance/DoE Primary School Brief. Located in Climate Zone 5 (Warm Temperate) and Wind Region A1, its design complies with building codes. With a projected mean temperature rise of 1.66°C – higher than the 0.8°C used in design – there is a need for climate adaptation planning. It serves as a good case study of new public schools.

The MBPS design has incorporated several notable design features that cater for heat resilience such as:

- Use of thermally reflective roof paint (Colorbond: Surfmist), insulated masonry and clad walls, and single-layer low-E glazing exceeding NCC Section J energy efficiency requirements.
- A high-efficiency VRF system (COP > 4.0) reduces energy consumption while maintaining indoor thermal comfort.
- Incorporation of verandas, shelters, and vertical shading screens helps reduce solar heat gain, especially for the 2nd Storey Classrooms
- Ceiling fans enhance airflow, reducing dependency on air-conditioning.
- Landscaping and vegetation lower ambient temperatures, contributing to better thermal comfort.
- The VRF system is designed for peak loads at 37°C DB/24°C WB, providing a 2.1°C buffer above current AIRAH standards, sufficient for projected 2050 temperature increases under the worst-case RCP8.5 scenario.
- The installation of PV panels for renewable energy generation and reduced carbon emission.
- The use of skylights for increased natural light.

While MBPS has several best practices in heat resilience, there are opportunities for further enhancements:

- Future designs could incorporate projections like RCP8.5/SSP3-7.0 for long-term resilience, preparing the school for increasing climate hazards.
- Depending on climate projection scenarios (i.e. RCP2.6, 4.5, or 8.5), a typical north-facing classroom is expected to have a cooling load that is 7% to 33% higher than current loads. This highlights the importance of considering climate change when designing a building's thermal systems. It is recommended to adopt RCP8.5/SSP5-8.5 projections following NCC 2025 guidelines.

Overall, while MBPS incorporates several best practices in energy efficiency and heat resilience, improvements in climate adaptation strategies and natural ventilation could further enhance its long-term sustainability.

B. Bunbury Regional Prison

The pre-release unit (PRU) of Bunbury Regional Prison was constructed in 2008. It is a facility designed to assist inmates in preparing for their release back to society. A typical PRU comprises several bedroom units and shared facilities such as kitchen and lounge.

The one-storey building was constructed using double-leaf masonry on the slab-on-grade foundation. The roof framing is timber truss with tie-downs to be embedded into the foundation.

Located in non-cyclonic zone (A1), the PRU was designed to be equivalent to Importance Level 2, with ultimate design wind speed of 45 m/s..

During a tornado incident that occurred on the 10th of May 2024, while the extreme wind's speed was about the ultimate design wind speed, the roof of one PRU was peeled off and subsequently caused damage to a neighbouring unit as windborne debris. It was also found several other units sustained different levels of storm damage.

Although the PRUs are not located in cyclonic areas and hence are not designed to withstand extreme wind events, there are good learning points that might be useful for important government buildings in non-cyclonic regions to consider, given that climate change is changing the wind patterns in Western Australia.

For example, there seems to be several vulnerabilities in typical constructions for low rise government buildings in Southwest of WA. These include a vague classification of Importance Level, lack of emphasis on tie-down connections such as the use of nails instead of screws, common use of roofs that are vulnerable to strong winds (e.g. low pitch monoslope roofs), inadequate fixing of the timber top plate with the steel beam, and opening of clerestory windows.

To address these vulnerabilities, the latest version of design standards AS1170.2:2021 should be introduced, with variation for WA's situations (WA Variation to NCC2022[4]) and other guidelines introduced by DEMIRS.

In addition, projects of high importance levels (IL3 or IL4) should consider below strategies.

- Design for high internal pressure even in the non-cyclonic wind regions considering recent high wind incidents in wind regions A.
- The stiffness and strength levels between roof and super structure should be tightened and specified clearly, such as the use better quality cyclone straps, tie downs and J bolts etc, give preference to the usage of screws and skew nails where possible.
- Incorporate climate change factor Mc= 1.05 into building design to improve resilience as per AS1170.2.
- Use of cyclonic designed doors and windows.
- Seal all water ingress locations i.e., roof flashings, roof gutters and doors and windows frames.
- Plant wind resilient tree species to avoid impact damage and wind-borne debris.
- The structural inspections for high importance projects should be mandatory during and after the building construction, preferably by the third-party professionals.

[4] Industry Bulletin 147, DEMIR 2024

C. Roebourne District High School

Roebourne District High School (RDHS) is a major redevelopment in the City of Karratha, located in the town of Roebourne in northwest region. The town is bounded to the East by the Harding River and is in proximity to the coastline (roughly 5.4km from the closest tidal mudflats). The site has been identified to sit above of the 0.2% AEP storm surge event modelling, and the 0.2% AEP riverine flood, it is also unlikely that Roebourne will be affected by coastal erosion with the tidal mud flats dissipating energy from water coming overland.

The project in located in Climate Zone 1, Wind region D and has an Importance Level 3. Situated on a challenging site exposed to various climate challenges, the project includes 11 buildings with a total gross floor area (GFA) of 7,749 square meters, providing learning spaces for students from kindergarten to Year 12. The climate analysis of RDHS projects a temperature rise of 1.94º C by 2050 under high emissions scenario, with extreme hot days increasing from 169 to 201.

The RDHS design has incorporated several notable design features that cater for climate resilience such as:

- The design incorporates 150mm thermal insulation, ceiling fans, veranda-provided window shading, and inverter air-conditioning.
- Inclusion of extensive green space to reduce the perceived temperatures. The computer simulation and analysis indicate that appropriate greenery can reduce the perceived temperatures by 2-3º C.
- The project incorporates design to withstand internal pressures. This approach ensures that the structures are more robust, preventing progressive collapse in the event of an unforeseen failure in the building.
- The site is unsuitable for below ground stormwater infiltration due to the low hydraulic conductivity of the soils. A stormwater management design using swales which connect into

overland flow paths, along with raising ground levels around buildings has been implemented to prevent stormwater entering buildings.

- While RDHS has several best practices in climate resilience, there are opportunities for further enhancements:
- The project used weather condition data from 1975-1984. As a result, the design temperature is about 1°C lower than the prevailing AIRAH design conditions, which is based on data from 2000-2014. With a projected temperature rise of 1.94°C, this HVAC design may not cope with the increasing cooling demand required to maintain indoor thermal comfort. It is therefore, recommended to use the latest climate projections and consider climate change factor in HVAC systems design.
- Surface coatings and reflective materials can reduce surface temperatures by 20° C on hot days, translating into a reduction of ambient air temperature by 1-2°C leading to a better thermal environment both inside and outside the building. This presents an excellent opportunity for adaptation, and it is recommended that these solutions be considered to enhance thermal comfort and energy efficiency.
- The prevailing standard AS-1170.2 recommends including a climate change multiplier (Mc=1.05) in load calculations to account for increased wind loads during extreme wind events. However, the project drawings do not specify detailed design calculations, and the structural brief does not mention the inclusion of climate change factor. It is recommended to consider this factor to enhance structural robustness.
- Conducting a vulnerability assessment using a computer software program to model the vulnerability and adaptation to wind of the building such as the Vulnerability and Adaptation to Wind Simulation (VAWS) tool. While this is considered a good practice, it was not utilized in the project.
- Consideration of increasing intensity in short-term heavy rainfall events due to climate change could increase the risk of flash flooding. Site specific modelling based on climate projections at the end of the building's lifecycle could identify if flash flooding could impact the buildings on site.
- Wet floodproofing and raising building utilities would improve the resilience and recovery time for buildings that may be impacted by water ingress under future climate scenarios.