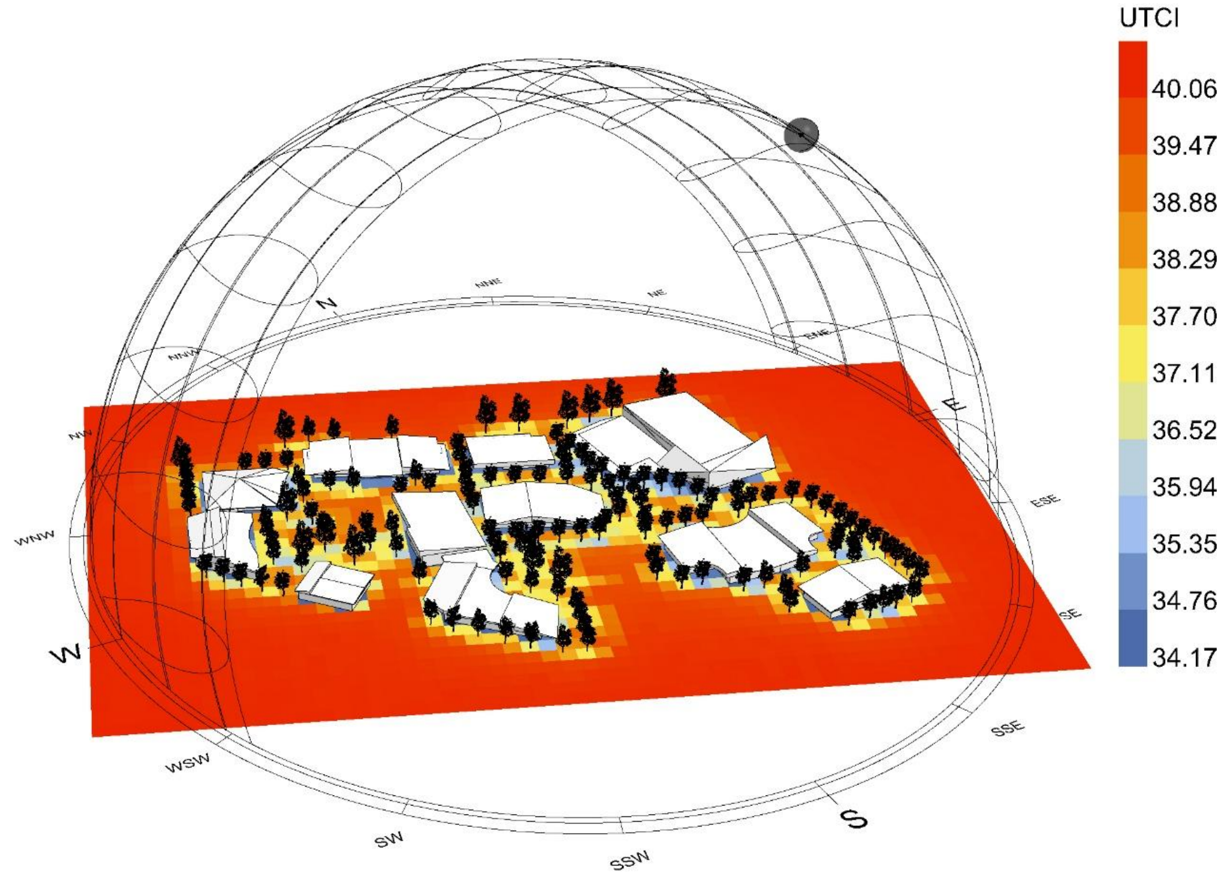
Government of **Western Australia**
Department of **Housing and Works**



Technical Guideline (TG050)

Climate Resilience and Adaptation

Aug 2025

Document control

Revision history

Version	Date	Author/Editor	Summary of changes
1.0	04/04/2025	FG, MB, JS, RM	First Draft
2.0	04/06/2025	FG, MB, JS, RM	Second Draft
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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 (WA) state government has affirmed their support to this target.

As noted by the WA state government (DWER 2023):

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

The current level of warming (approx. 1.55°C in 2024 according to World Meteorological Organisation (WMO)), 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.

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

To enhance the climate adaptability of DHW projects, climate adaptation planning should be embedded throughout the project lifecycle. This process begins with the screening of potential climate hazards and determining the vulnerability of the project during the Project Definition Plan (PDP) phase. It then advances to detailed risk assessment and the integration of climate adaptation measures during the Design Phase. Climate adaptation measures are implemented during the Construction Phase and continuously monitored and maintained throughout the Operation Phase (Figure 1).

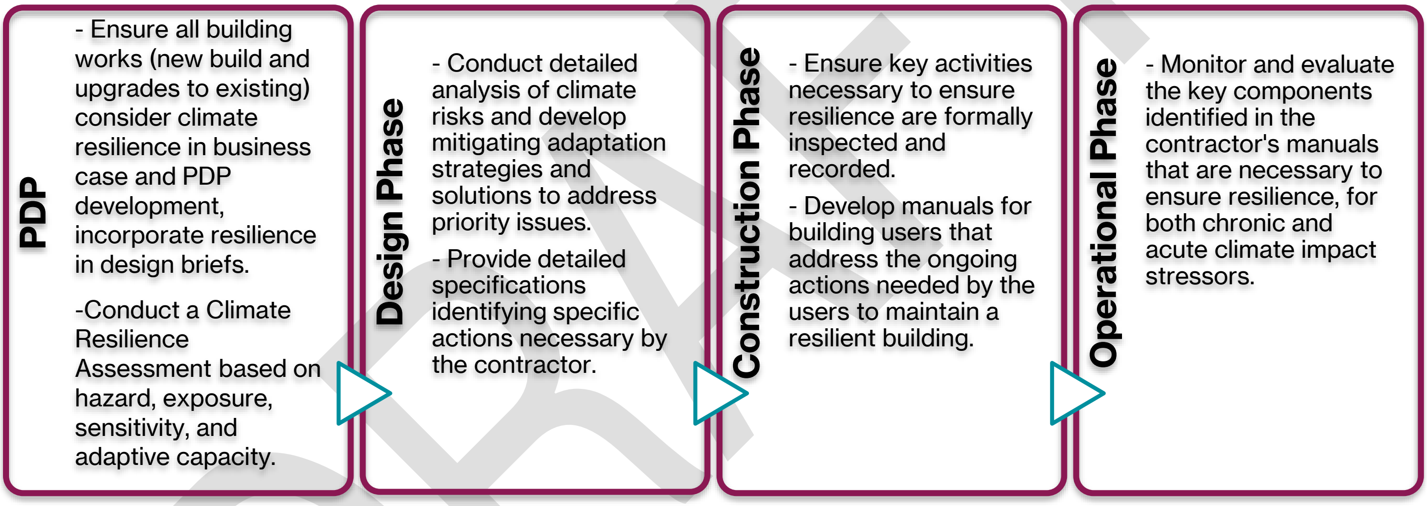

Figure 1. Adaptation Planning Process for DHW Projects

For capital works projects, it is crucial to address climate resilience early in the planning and design phase. Early integration of climate resilience helps avoid costly impacts during later stages of project delivery. A three-step process is recommended to provide a structured approach to managing climate risks effectively (Table 1).

Table 1. Three-Step Adaptive Design Process for DHW's Capital Works Projects

Design Phase & Process		Key Activities	Outputs	Reference in TG050
PDP	Step 1 Climate Resilience Assessment (CRA)	• Establish the context, identifying project location and project-specific climate/hazard zoning. • Conduct climate hazard analysis, including historical and future climate data analysis and exposure analysis. • Conduct vulnerability assessment, considering project's Importance Level, sensitivity and potential adaptive capacity. • Identify priority hazard(s) the project is vulnerable to	• Priority Hazards applicable to the project are identified	Section 5.2
SD	Step 2 Risk Assessment	• Identify detailed risk items for building components and systems • Analyze likelihood and consequence of risks • Determine Risk Levels	• High or Extreme Risk items are identified	Section 5.3
DD & CD	Step 3 Adaptation (Risk Treatment)	• Establish adaptation strategies to achieve the targeted resilience level (with acceptable Risk Levels). • Identify implementation strategies through Design and Construction Registers. • Document design features and specifications	• High or Extreme Risks are reduced to acceptable risk levels. • Project's Resilience Levels before and after adaptation are identified • Design Registers are completed • Adaptation features are incorporated into specifications	Section 5.4 & 6.1

2. Responsibilities

Customer Agencies are responsible for lodging and obtaining Government approval for each project. As part of this process, Customer Agencies establish the appropriate scope to meet its service delivery requirements and address stakeholder concerns, secure sufficient budget, and set achievable timelines for delivery, in accordance with the Western Australian Public Sector's Strategic Asset Management Framework (SAMF).

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 climate 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.

3. Guideline Application

3.1. Importance Level

Understanding Importance Level is fundamental to integrating climate resilience into design practices.

The Importance Level (IL) classification system is used in the National Construction Code (NCC) to reflect the importance of a building based on its significance to public safety and structural integrity. The NCC categorises buildings into four ILs:

- IL 1: Buildings that pose a low risk to life and property in the event of failure.
- IL 2: Low-rise residential buildings and structures that do not exceed the limits set for IL3.
- IL 3: Buildings with a higher level of occupancy and where failure could result in significant risk to life or property.
- IL 4: Essential facilities that must remain operational during and after a disaster or emergency.

Based on NCC classification, DHW have developed a specific IL Classification table that is to be used for all DHW projects (Table 2). This IL classification is to be used by all applicable DHW projects to meet TG050 requirements.

Key Messages #1

- *During the PDP phase, it is essential to establish the project's IL. This determination should be informed by design briefs, relevant agency design guides, and inputs from customer agencies.*
- *The IL is assessed on a case-by-case basis and agreed upon by all key stakeholders including the client agency, DHW, and all relevant consultants.*
- *The IL classifications outlined in TG50 (*Table 2*) should serve as the default reference for design and construction projects under DHW. Any proposed deviations from these classifications must be clearly justified and agreed upon by all stakeholders.*

Table 2. IL Classification for DHW Projects

	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 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 mandated 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. TG050 has been made adaptable to the changing legislative landscape and will be updated accordingly. Projects applying TG050, whether new works or upgrades to existing facilities, will need to comply with the version of TG050 that is current at the commencement of the PDP phase for the project.

4. Climate Hazards and Impacts

4.1. Introduction

The changing climate in Western Australia presents significant challenges to DHW's buildings in maintaining functionality and delivering essential services to the community. Therefore, adaptation planning should begin with a thorough understanding of climate hazards and their potential impacts on our infrastructure.

4.2. Key Concepts and Definitions

A **hazard** is the potential occurrence of a natural or human-induced physical event or trend 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.

Climate change hazards can be categorised as chronic or acute:

- 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.

Both hazard types pose significant risks to the built environment as detailed in Table 3 below.

Table 3. Climate Hazard Types in Western 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	Increased heavy rainfall events Flash flooding (coastal, fluvial, pluvial, groundwater) Storm surge	Bushfire Landslide Subsidence

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 rather than its type or function. Climate exposure in the built environment refers to the degree to which a buildings location is impacted by climate related hazards. Understanding exposure is a crucial first step in assessing how vulnerable a building might be to the changing climate. For example, a well-designed building that is located on a floodplain or in a high wind region still has high exposure due to the location being susceptible to these climate hazards. which reflects how likely the projects is to encounter climate hazards based on the hazard historical trends, future projections and geographic location.

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

The design characteristics of a building also influence the sensitivity to specific climate hazards. For example, buildings with complex roof geometry involving many intersecting planes will be less resilient to wind driven rain and require more complex structural connections to resist wind damage. Simple roof geometries (hip or gable) are structurally efficient involving few complex connections and are simpler shapes to create effective flashings for which improve the buildings resilience to wind hazards.

Other features within the building's site boundary should also be considered, such as pathways, parking areas, and connecting bridges. These features provide site access and egress and should consider climate hazards, for example flooding from more intense rainfall events may render these features unusable if inappropriately designed.

Adaptive capacity refers to the ability of systems, institutions, individuals, and other organisms to adjust to potential damage, capitalize on opportunities, or respond effectively to consequences. This concept is especially relevant to buildings due to their diverse user groups and plays a critical role in vulnerability analysis. Adaptive capacity can be assessed either alongside or after sensitivity analysis. Key factors to consider when evaluating a building's adaptive capacity include the ability of occupants to respond to climate change (closely linked to vulnerability), as well as spatial flexibility and limitations – both internally and externally.

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 determined by its **exposure**, **sensitivity** and **adaptive capacity**.

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.

4.3. Climate Impacts on Buildings

The impacts of climate change on buildings are driven by the combined effects of climate hazards, 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).

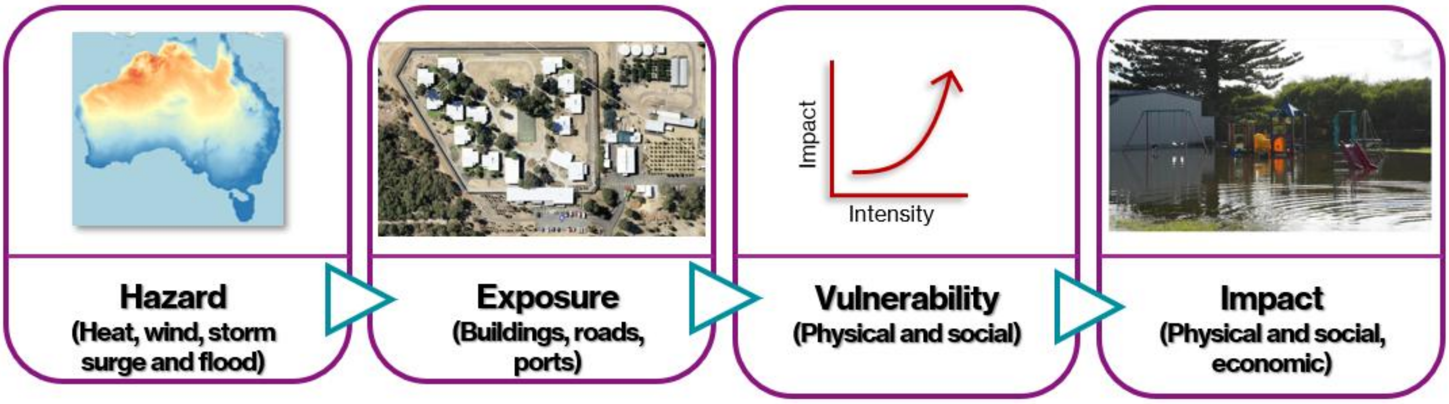

Figure 2. Causes and Effects of Climate Change

4.4. Considerations for DHW Project Planning and Delivery

Climate change is already impacting Western Australia, with noticeable effects on non-residential government buildings. To ensure these buildings continue to serve our communities effectively, the following considerations should be integrated into project planning and delivery:

- 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, importance level 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. It is recommended buildings with high importance

levels should consider climate hazards irrespective of the current hazard zoning in view of future change of climate data.

Key Messages #2

- *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 considering future climate projections, and appropriate adaptation measures must be implemented to mitigate associated risks.*
- *IL3 and IL4 facilities should consider designing to meet the standards of a wind region classification one level higher than their current designation.*
- *Heatwave adaptation strategies should be considered for all facilities with vulnerable occupants (children, elderly, infirm) irrespective of climate zones.*
- *Each project should be assessed individually for its resilience to climate change, considering both the needs of building occupants and the building's critical importance to the broader community.*

5. Climate Adaptation Planning

5.1. Overall Adaptation Planning Process

A three-step process is recommended for DHW's project planning and delivery (Table 1). The flow chart below (Figure 3) should be used as a reference for climate adaptation planning.

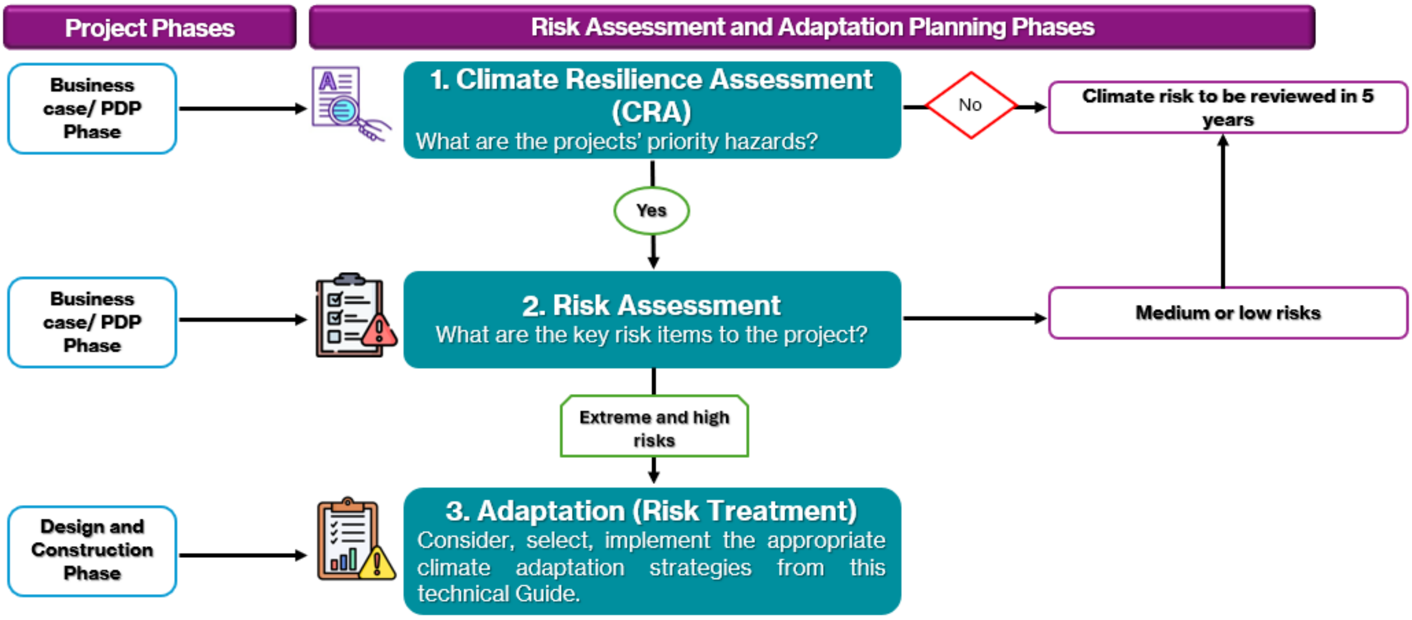

Figure 3. Climate Adaptation Planning during Project Delivery. Source: DHW

Key Messages #3

- *All new building and major retrofit projects are required to undertake a high-level climate resilience assessment (CRA). Exceptions should be justified by project teams.*
- *Based on the CRA results, projects exposed to priority hazards will be required to undertake a detailed risk assessment.*
- *For any identified high or extreme risks, the project should implement climate adaptation strategies outlined in Section 6 to effectively mitigate them.*
- *For the operation and maintenance of existing projects, it is recommended that TG050 be used as a reference to support asset planning and facility management activities.*

5.2. Climate Resilience Assessment

Climate Resilience Assessment (CRA) is the process where an ability of a system to survive an immediate shock, adapt to ongoing consequences, and thrive in a changed long-term landscape is analysed. Project teams should use the Climate Resilience Assessment Template for the CRA.

The CRA involves a screening of climate hazards and a vulnerability analysis to identify the priority hazards relevant to the project. The CRA process is structured into two main steps, as outlined below:

1. **The climate hazard screening** evaluates the current and projected climate hazards, using a high emissions scenario (RCP8.5 or SSP3-7.0) at a minimum of two time horizons based on project design life.

To help the project team assess potential climate hazards, resources listed in Table 4 may be used to support a preliminary screening exercise.

Table 4. 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.	

As part of the Climate Resilience Assessment (CRA), project teams are encouraged to assess the project's climate conditions and consider how design conditions should be adjusted to reflect the impacts of a changing climate. The Tables in Appendix may be prepared by suitably qualified professionals to support discussions with stakeholders during the PDP Risk Workshop.

2. The **vulnerability assessment** evaluates the projects exposure, sensitivity and adaptive capacity for each climate hazard.

To support this assessment, Table 5 below presents a vulnerability matrix, which rates the overall vulnerability of a building on a scale from very low to very high.

Table 5 Vulnerability 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

If the project is assessed to be vulnerable to specific hazards such as heatwave, cyclone, and/or flooding, these hazards would be considered **priority hazards**.

5.3. Risk Assessment

The climate adaptation process will advance to a detailed climate-related risk assessment following the identification of priority hazards. The risk assessment is the overall process of risk identification, risk analysis and risk evaluation (Standards Australia, 2013). This includes assessing consequence and likelihood scenarios. Consequence is the outcome of an event affecting objectives and likelihood is the chance of something happening (Standards Australia, 2013).

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

1. Identify 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 6).

Table 6. 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

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.

Error! Reference source not found. below is an example of initial risk assessment for a critical healthcare building in Roebourne, WA before adaptation. The building is classified as an IL4 structure, located in cyclonic region (Wind Region D) and within a tropical climate zone (Climate Zone 1) (ABCB, 2022; Standards Australia, 2021). As an example, only one time horizon of 2090 is used for the assessment considering the building has a minimum design life of 60 years. However, it is recommended that the actual assessments should be conducted to cover two-time horizons, i.e. a 2030 scenario representing the near term and a 2090 scenario representing the long term.

Table 7 Example of Risk Assessment of a Healthcare Project Using a High Emissions Scenario (RCP8.5) in 2090

Climate hazard	Risk statement	Consequence (Impact)	Likelihood (Occurrence)	Risk Level	Adaptation recommendation (refer to Error! Reference source not found.)
Rising temperature and heatwaves	Impacts on the thermal performance levels of buildings leading to reduced comfort levels for building users including vulnerable occupants.	C2	L5	Medium	H1 to H7
	Increased HVAC demand to accommodate operational demands and extreme temperature conditions resulting in reduced efficiency, frequent equipment tripping, and potential individual HVAC equipment failure.	C2	L4	Medium	H5 (optional)
	Increased need to cool buildings resulting in increased load on vital equipment and services, causing accelerated equipment deterioration.	C3	L4	**High**	H1 to H7
	Increased overall energy demand across the site, causing risk of overall power outage. potentially disrupting operations and compromising system reliability.	C3	L3	Medium	H5 (optional)
	Impacts on materials of building structures and external fabrics, increasing risks of thermal movement, cracking and failure of building fabric.	C4	L2	Medium	S9
	External features becoming too hot to be functional (such as handrails, seats), rendering them unusable and compromising their intended functionality.	C1	L2	Low	H7
Tropical cyclones and windstorms	Windborne debris may damage the building envelope and structural elements, roof drainage components, glazing (if not laminated glass) and building façade, incurring extra repair costs.	C3	L3	Medium	S5, S9
	Regular interaction with high wind can degrade the building material's integrity and longevity.	C3	L2	Medium	S8
	High winds can damage the roof connection with superstructure by exerting periodic extra uplift loads, causing roof damage or complete failures.	C3	L4	Medium	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	S9

Climate hazard	Risk statement	Consequence (Impact)	Likelihood (Occurrence)	Risk Level	Adaptation recommendation (refer to Error! Reference source not found.)
	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	L4	**High**	HD3, S5
	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	L3	Medium	S6
	Cyclones can be a cause of increased incidents of growth of mould and fungi due to rainwater intrusion.	C2	L2	Low	S6
Water related hazards • **Flooding** • **Drought** • **Sea level rise**	Intensifying rainfall elevates the risk of flash flooding and higher flood levels, increasing the likelihood of water ingress and material and structural damage to buildings.	C3	L2	Medium	W1 – W6
	Stormwater systems under-designed for intensifying rainfall, leading to floodwater accumulation and ineffective drainage away from buildings.	C2	L2	Medium	W7, W8, W9
	Drought can damage surrounding landscaping and vegetation, which may reduce shading and increase heat exposure to buildings, compounding thermal stress.	C3	L3	Medium	W8
	Drought conditions can cause shrinkage in moisture-sensitive soils – particularly reactive clays and expansive soils – leading to ground subsidence that compromises building foundations. This movement can result in structural cracking and long-term damage to buildings.	C3	L1	Low	W9
	Rising sea levels are increasing the exposure of coastal buildings and infrastructure to storm surge and coastal erosion. These hazards pose a significant risk of structural and material damage, compromising long-term functionality and resilience.	C3	L1	Low	W10, W11
	Limited water availability can affect building operations, particularly in rural or remote areas where rainwater tanks or bore water are common.	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. This will be detailed in Section 6: Climate Adaptation Strategies.

5.5. Risk 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 required to address the high and extreme risk items identified in Section 5. In doing so, they are encouraged to adopt one or more adaptation strategies to enhance their project's resilience to climate change holistically.

A catalogue of these strategies, along with a resilience rating tool, is provided to support adaptation planning (see **Error! Reference source not found.** and Figure 4).

- Each climate hazard is paired with specific adaptation strategies; each assigned a resilience score reflecting its effectiveness.
- The total resilience score – expressed as a percentage of the maximum achievable score – indicates the project's resilience level for each relevant hazard. An overall resilience rating can be visualized across all applicable hazards (Figure 4).
- Three levels of resilience ratings are defined:
    - I. NCC Compliance Level (50%)
    - II. Resilience Level (75%)
    - III. Robustness Level (90%)

The adaptation strategies outlined in **Error! Reference source not found.** are generally structured into two levels of requirements:

- **The Basic Level**, where buildings meet the relevant provisions of the National Construction Code (NCC)*, industry standards (e.g. AS), and agency design brief; and
- **The Advanced Level**, which involves implementing additional measures that go beyond the minimum NCC requirements – such as incorporating future climate projections into the design**.

*Projects that meet basic level requirements typically earn 1 or more base point(s) per criterion, which is required for all applicable buildings from IL1 to IL4. These criteria are underlined in Table 8.

**Projects that adopt advanced measures to exceed minimum NCC standards receive additional point(s), a practice particularly recommended for IL3 and IL4 facilities.

Key messages #5

- *All extreme and high risks identified during the risk assessment must be treated through targeted adaptation strategies—such as those outlined in Table 8—to ensure that the residual risk is reduced to an acceptable level.*
- *Project teams are encouraged to define their targeted Resilience Rating at the onset of adaptation planning. For IL3 and IL4 projects, it is strongly recommended to aim for at least the Resilience Rating (75%) or higher.*
- *Although* ***Error! Reference source not found.*** *outlines key best practices for DHW projects, project teams are encouraged to explore and implement additional strategies that align with the goal of enhancing climate resilience.*

Table 8 Adaptation Strategies

(Continued on next page)

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
Heatwave and Rising Temperature	**H1. Thermal Comfort Design Criteria (Rising Temperature)** Design the building systems to achieve thermal comfort of occupants, considering climate change and user vulnerability. **H1.1.** Demonstrate compliance with thermal comfort requirements, such as design conditions in design brief, agency guidelines, or suitable industry standards such as ASHRAE Standard 55. ○ ASHRAE Standard 55 suggests PMV for air-conditioned buildings and adaptive thermal comfort models for naturally ventilated and mixed mode buildings. **H1.2**. Demonstrate that the thermal comfort design considers the needs of vulnerable occupant groups – such as the elderly, disabled, or infirm – by achieving a Predicted Mean Vote (PMV) within the range of 0 to +1.0, or meeting Category I comfort standards as defined by the Adaptive Thermal Comfort model. Note: Refer to ISO 28803-2012: Ergonomics of the physical environment. **H1.3.** Demonstrate compliance with thermal comfort requirements through dynamic thermal modelling using future climate projections RCP8.5/ SSP3-7.0 scenario.	IL2 to IL4	**H1.1** - 2 Points **H1.2** -2 Points **H1.3** - 1 Point	05 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	H2. Thermal Comfort Design Criteria (Heatwave) Design the building systems to achieve thermal comfort of occupants during heatwave. **H2.1.** For critical spaces serving vulnerable user groups in Importance Level (IL) 3 or IL 4 buildings – such as kindergarten classrooms or patient wards – indoor thermal conditions should comply with the CIBSE TM52 Category I standard, using current weather files for simulation.: ○ In mechanically cooled spaces, the number of overheating hours – defined as periods exceeding the PMV/PPD or operative temperature thresholds – should not exceed 3% of total occupancy hours. ○ In naturally ventilated or mixed mode ventilation spaces, overheating hours – defined as periods exceeding the TM52 criteria – should not exceed 3% of total occupancy hours. **H2.2.** Achieve the same performance using future weather files based on RCP8.5/ SSP3-7.0 scenario. Note: (1) Refer to TM52-2013 The Limits of Thermal Comfort: Avoiding Overheating, Section 6.1 and 6.2. (2) The future weather data reflecting extreme heat conditions impacted by climate change include: ○ Future Extreme Meteorological Year (fXMY), ○ Future Design Summer Year (fDSY), and ○ In the absence of the above, CSIRO's projected Typical Meteorological Year (TMY) files based on the RCP8.5/ SSP3-7.0, 2090 scenario may be used as a proxy	IL2 to IL4	**H2.1** – 2 Points **H2.2 -** 2 Points	04 Points
	H3. Limit External Heat Gain Incorporate passive design measures in building design to reduce excessive solar heat accumulation. **H3.1.** Demonstrate compliance with the requirements specified in the NCC 2022 Part J4. **H3.2.** Demonstrate at least 10% reduction of solar heat gain as compared to NCC J1V3 reference building through thermal modelling with climate data based on high emission RCP8.5/ SSP3-7.0 2050 scenario.	IL2 to IL4	**H3.1** – 2 Points **H3.2** – 2 Points	04 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	H4. Limit Internal Heat Minimize internal heat accumulation by reducing lighting power and managing plug loads. **H4.1.** Demonstrate compliance with the requirements specified in the NCC 2022 Part J7, F6 and Specification 40. **H4.2.** Demonstrate at least 10% reduction of internal heat as compared to NCC J1V3 reference building through thermal modelling with climate data based on high emission RCP8.5/ SSP3-7.0 2050 scenario. ○ This can be achieved using combination of strategies 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. to limit internal heat gain.	IL2 to IL4	**H4.1**- 2 Points **H4.2**-2 Points	04 Points
	H5. Mechanical Systems and Control Strategies Design mechanical systems to meet future thermal demands. **H5.1.** Design mechanical systems using climate data specific to the project location, sourced from datasets updated after 2020. ○ Refer to the latest versions of ASRHRAE Handbook – Fundamentals AIRAH Application Manual DA09 – Appendix A. **H5.2.** Demonstrate that the potential effects of climate change have been considered and the design temperature data has been adjusted in line with the latest high emission projections RCP8.5/SSP3 7.0. ○ Use updated climate resources such as Climate Change in Australia datasets (CCiA) or CSIRO's future weather files to incorporate projected temperature increases into the design. **H5.3.** Demonstrate that the building design includes provision for additional plant space to accommodate larger thermal equipment and locates HVAC outdoor equipment into optimal spaces with improved shading and ventilation. **H5.4.** Demonstrate that Building Management Systems (BMS) and zonal control strategies have been implemented to ensure thermal comfort during heatwave conditions.	IL2 to IL4	**H5.1**-2 Points **H5.2** – 1 Point **H5.3** – 1 Point **H5.4** – 1 Point	05 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	H6. Natural Ventilation and Airflow Management Design the building systems to manage internal heat and prevent unwanted air exchange. **H6.1.** Demonstrate compliance with the requirements specified in the NCC 2022 Part J6 and F6. **H6.2.** Design effective natural ventilation systems to manage heat and moisture, reduce dependence on mechanical cooling and power systems. Strategies may include: o Single-sided or cross ventilation using operable windows to promote airflow; o Stack-effect ventilation to extract internal heat, particularly in atriums and spaces with high ceilings. Note: Refer to CIBSE AM10 Natural ventilation in non-domestic buildings (2005), AM13 Mixed mode ventilation systems (2000).	IL2 to IL4	**H6.1**- 2 Points **H6.2**-2 Points	04 Points
	H7. Material Selection for Heat Resilience Design the building with materials selected for heat resilience, such as thermal mass, thermal insulation, and low-conductivity materials to reduce peak cooling loads. **H7.1.** Demonstrate compliance with the requirements specified in the NCC 2022 Part J4. **H7.2.** o Incorporating thermal mass into the building fabric to reduce peak cooling demand, with a target of at least a 2% reduction compared to a reference code-compliant building under the NCC. **H7.3.** Demonstrate that the building design incorporates materials that have high endurance to elevated temperatures. **H7.4.** Demonstrate that the building design incorporates low conductivity materials for handrails and outdoor equipment such as wood or recycled plastic.	IL2 to IL4	**H7.1** - 1 Point **H7.2** – 1 Point **H7.3** – 1 Point **H7.4** - 1 Point	04 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
Wind/Cyclone	**S1. Wind Region** Design the building with applicable Wind Region classification as per NCC. **S1.1.** Demonstrate compliance with the requirements specified in the latest version of NCC and AS/NZS 1170.2: 2021. **S1.2.** Design the building for higher wind region beyond Wind Region classification as per NCC. ○ Refer to Appendix 5 for further guidance.	IL1 to IL4	**S1.1 -**1 Point **S1.2 -**1 Point	02 Points
	S2. High Internal Pressure Design the building for higher internal pressure. **S2.1.** Design the building for higher internal pressure beyond current version of NCC and referenced Australian standards. ○ Although it is not required in AS/NZS 1170.2, due to recent tornado activity in Bunbury region, consider designing for high internal pressure for wind region A, in addition to regions B2, C and D. ○ Refer to Appendix 5 for further guidance.	IL1 to IL4	**S2.1-**2 Points	02 Points
	S3. Climate Change Multiplier Incorporate climate change factor Mc in building design. **S3.1.** Demonstrate compliance with the requirements specified in the latest version of NCC and referenced Australian standards in all wind regions. **S3.2.** Demonstrate that the design incorporates Mc = 1.05 in wind region A **S3.3.** Demonstrate that the design incorporates Mc = 1.1 in wind region B2, C and D ○ Climate change will increase the wind speeds impacting the building resilience, the approach of Mc=1.1 would be able to accommodate the future increase in wind loads. ○ Refer to Appendix 5 for further guidance.	IL1 to IL2 IL3 to IL4	**S3.1** – 2 Point **S3.2 -** 1 Points **S3.3-** 1 Points	04 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	S4. Critical Elements Connection Design the critical building connections to withstand the extra wind loads exerted on the building during a cyclonic event. **S4.1.** Demonstrate compliance with the requirements specified in the latest version of NCC Part B1 and referenced Australian standard. **S4.2.** Design for greater connection strength with extra connections as compared to NCC Part B1 such as installation of a greater number of tie downs, triple grip and J bolt connections. ○ Consider installation of extra 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; ○ 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; or ○ Consider the selection of the next larger size of fastener gives sufficient redundancy.	IL1 to IL4	**S4.1 -** 1 Points **S4.2-** 2 Points	03 Points
	S5. Robustness of load path design Design tie-down load paths with sufficient redundancy in case of extreme wind events. **S5.1.** Demonstrate the requirements specified in the latest version of NCC Part B1 and referenced Australian standard. **S5.2.** Design an alternative load path to accommodate local failures to create a mechanism that can arrest a failure if it starts.	IL1 to IL4	**S5.1 -** 2 Points **S5.2-** 2 Points	04 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	S6. Ancillary Items Design buildings for extra loads exerted by 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 and window awnings) should be installed securely. **S6.1.** Demonstrate compliance with the requirements specified in the latest version of NCC and referenced Australian standard. **S6.2.** Design support for ancillary items with extra 50% load as compared to the NCC current version and referenced Australian Standards. ○ A combination of strategies including but not limited to. The wind actions that are transferred to the roof structure by PV panels fixed parallel to the roof or inclined to the roof should be provided so designers can correctly design or modify buildings under the panels, so they are able to transfer the extra wind actions from the PV panels safely through the structure to the ground. ○ Refer to Appendix 5 for further guidance.	IL1 to IL4	**S6.1 -** 2 Points **S6.2-** 2 Points	04 Points
	S7. Wind and Debris Resilient Glazing Design building's doors and windows with laminated glass. **S7.1.** Demonstrate compliance with the requirements specified in the latest version of NCC – Part 3.6, AS 1170.2 and AS2047 – 2014. **S7.2.** Install laminated glass in all doors and windows. ○ It is encouraged to use the wind rated doors and windows in cyclonic regions B2, C and D. ○ Laminated glass is a viable option to be used in buildings, if broken glass could compromise the function of the building, laminated glass should be specified for windows and doors. ○ Refer to Appendix 5 for further guidance.	IL1 to IL4	**S7.1 -** 1 Point **S7.2 -** 2 Points	03 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	S8. Seal Water Ingress (Doors and Windows) Design building's doors and windows to make building envelope watertight for any water ingress. All windows and doors to have seals that exceed the water penetration tests in AS 2047. **S8.1.** Demonstrate compliance with the requirements specified in the latest version of NCC and AS 2047 -2014. **S8.2.** The doors and windows must be resistant to the penetration of uncontrolled water when tested in accordance with AS 4420.5 under a test pressure of 770 Pa. o Select systems with flaps over weep holes to reduce water ingress if the wind pressures are near the serviceability pressure. **S8.3.** For IL3 and IL4 buildings, or buildings providing safe shelter or designed to function during severe wind events, use wind-rated doors in all wind regions including Region A.	IL1 to IL4	**S8.1-**1 Points **S8.2-**2 Points **S8.2-**1 Points	04 Points
	S9. Seal Water Ingress (Flashings) Design building to make building envelope watertight for any water ingress. All flashings need to be watertight to avoid any water ingress due to wind driven rains. **S9.1.** Demonstrate compliance with the requirements specified in the latest version of NCC and AS – 1562.1. **S9.2.** Use apron flashings, ridge caps, hip flashings and any valley gutters to have closed cell foam under the flashing or roofing. o According to AS/NZS 1562.1, flashings must be fastened with screws at intervals of less than 500 mm. However, the use of closed-cell foam is not mandated by the National Construction Code (NCC); it is an additional requirement that exceeds the NCC's minimum compliance standards. o Refer to Appendix 5 for further guidance.	IL1 to IL4	**S9.1-**2 Points **S9.2-**2 Points	04 Points
Flooding/ Increasing	**W1. Raising Finished Floor Levels (FFLs)**			

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
Rainfall Intensities	Raising Finished Floor Levels (FFLs) improves flood resilience by reducing the risk of water ingress during extreme rainfall and flood events. Elevated FFLs protect building interiors, critical infrastructure, and occupants from damage associated with inundation. The architect should clearly notate the FFL on the plan set. **W1.1.** Set Finished Floor Levels a minimum of 0.5 metres above the projected 1% Annual Exceedance Probability (AEP) flood level. It is recommended to use the future 1% AEP flood level (2050 or end of buildings lifecycle) where available. **W1.2.** Where climate-adjusted flood mapping is unavailable, determine FFLs using Design Flood Estimation or site-specific flood modelling, incorporating climate change scaling factors as outlined in the Australian Rainfall and Runoff (ARR) guidelines – Book 1, Section 6. Where Local Government flood planning requirements specify higher levels of flood protection (e.g. higher FFLs), those requirements shall take precedence.	IL2	**W1.1** – 1 Point **W1.2**–2 Points	03 Points
	Site-specific flood modelling is recommended for IL3 & IL4 projects to ensure a high level of flood resilience. Accurate modelling supports informed design decisions and helps safeguard critical infrastructure against future climate-related flood risks. **W1.3.** Conduct site-specific flood modelling for IL3 & IL4 projects to determine future flood risk exposure. o Use climate scenario SSP3-7.0, projected to the end of the building's design life or to 2050, whichever is greater. Refer to the Australian Rainfall and Runoff (ARR) Data Hub for applicable climate change scaling factors. o Once the future 1% AEP flood level is established, apply a minimum freeboard of 0.5 metres to determine the Finished Floor Level (FFL). Where Local Government flood planning requirements specify higher levels of flood protection (e.g. higher FFLs), those requirements shall take precedence	IL3 & IL4	**W1.3** – 2 Points	02 Points
	W2. Fill for Affected Sites Fill placed on flood-affected sites must be engineered to remain stable under a range of flood conditions. Properly designed fill reduces the risk of structural damage, ground movement, and erosion, supporting long-term resilience of buildings and infrastructure.			

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	W2.1. Where site levels are raised above the flood level using fill, the fill must be engineered for stability under flood conditions, the structural and geotechnical engineer should collaborate and confirm the fill is designed to withstand: o Rapid rise and drawdown of floodwaters o Prolonged inundation o Erosion and scour forces The fill must not cause differential ground movement that exceeds the allowable limits for the footing system, as specified in AS 2870 – Residential Slabs and Footings.		**W2.1**–2 Points	02 Points
	W3. Designing for Flood Actions Buildings located in flood affected areas must be structurally designed to withstand flood actions, including hydrostatic and hydrodynamic forces, buoyancy, scour, and differential movement. This ensures long-term stability and safety under future flood conditions. **W3.1.** Design for flood actions must comply with Part 2.3 of the ABCB Standard: Construction of Buildings in Flood Hazard Areas (National Flood Standard). **W3.2.** It is recommended that the responsible structural engineer assess whether the Flood Load Factor (Yf), as specified in Table 2.3.7 of the National Flood Standard, requires adjustment based on: o Site-specific flood risk o Building function and criticality o Projected climate conditions **W3.3.** The structural design of footing systems must comply with Part 2.5 of the ABCB Standard, ensuring stability under flood conditions including: o Buoyancy forces o Scour and erosion o Differential ground movement	IL2 to IL4	**W3.1 -** 1 Point **W3.2** -1 Point **W3.3**- 1 Point	03 Points
	W4. Designing Building Utilities for Flood Conditions			

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	Utilities and associated equipment, including backup systems, must be protected from flood-related impacts to ensure continued operation and safety during flooding events. This includes elevating equipment above flood levels or designing systems to withstand inundation and associated forces. The architectural drawings and applicable MEP drawings are expected to demonstrate compliance with the below. **W4.1.** Utilities and associated equipment, including backup systems, are recommended to be located above the climate-adjusted flood level (identified in W1/ W2), unless specifically engineered to resist flood-related impacts including: o Hydrostatic and hydrodynamic forces o Buoyancy o Prolonged water inundation **W4.2.** Where utilities are installed below the flood level, the following requirements must be met: o Equipment must be engineered to resist flood actions and remain functional during and after inundation o A manufacturer's statement, where applicable, must confirm the system's suitability for installation below the flood level o Mechanical, electrical, and plumbing (MEP) components such as cables, connectors, and materials must be flood-resilient and securely anchored to prevent displacement or damage o Buried utility systems must be placed at a depth sufficient to protect them from damage during flooding events **W4.3.** For Importance Level 4 (IL4) buildings, utilities must either be located above the climate-adjusted flood level or be specifically engineered to remain operational during flood conditions.	IL2 to IL4	**W4.1** – 1 Point **W4.2** – 1 Point **W4.3**–1 Point	03 Points
	W5. Wet Floodproofing Design new and existing buildings located below the 1% AEP flood level plus 0.5m freeboard to incorporate wet floodproofing strategies that enhance resilience to inundation and facilitate recovery. **W5.1.** Apply wet floodproofing to buildings with finished floor levels below the 1% AEP flood level plus 0.5m freeboard, including both new developments and major refurbishments of existing buildings. Wet floodproofing measures may include the use of flood-resistant materials, controlled water entry and drainage design, and protection of internal finishes and systems above flood levels.	IL2 to IL4	**W5.1** – 2 Points	

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	Refer to the Queensland Flood Resilient Building Guidance for Queensland Homes for examples and best practices in wet floodproofing design and construction.			02 Points
	W6. Stormwater Management and Design (Rainfall Intensity Adjustment) Design stormwater management systems to accommodate increased rainfall intensity projections due to climate change. **W6.1.** Increase the rainfall intensity values found in Appendix D of AS3500.3, using the ARR Data Hub Climate Change Rainfall Factors. It is recommended to use the following Rainfall Factors: o Climate Scenario SSP3-7.0 o Year 2050, 2070, or 2090 (whichever aligns with the project design life) o Duration <1 hour Ensure stormwater systems are designed to manage the increased runoff volumes and flow rates resulting from adjusted rainfall intensities.	IL2 to IL4	**W6.1** –2 Points	02 Points
	W7. Roofs and Gutters (Rainwater Management and Building Envelope Protection) Design roof drainage systems to reduce the risk of water ingress and structural damage during extreme rainfall events. **W7.1.** Roof eave gutters, external downpipes, and site drainage systems must be designed in accordance with AS/NZS 3500.3 to accommodate a rainfall event based on projected rainfall data according to SSP370 scenario. **W7.2** Install gutters with integrated overflow provisions for all perimeter gutters to prevent backflow and roof flooding. **W7.3.** Position gutter brackets at intervals no greater than 600mm, and no more than 150mm from any angled stop end to ensure structural stability and performance under load. **W7.4.** Avoid the use of box gutters and minimize valley gutter systems where possible. o Preference should be given to eaves gutters and minimum 600mm eave overhangs to enhance drainage and reduce splashback.	IL2 to IL4	**W7.1** – 1 Point **W7.2** – 0.5 Point **W7.3** –0.5 Point **W7.4** –1 Point	03 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	For buildings with functions sensitive to water damage (e.g. housing electronic equipment or critical infrastructure), box and valley gutters must be avoided to reduce risk of internal water ingress.			
	W8. Site Design (Stormwater and Landscape Resilience) Design site infrastructure to manage increased rainfall intensity and enhance resilience through sustainable landscape strategies. **W8.1.** Size detention systems to manage increased peak flows and runoff volumes resulting from the adjusted rainfall intensities (using the ARR Data Hub parameters in W7 with the appropriate duration) ensuring post-development discharge rates do not exceed pre-development conditions. **W8.2.** Incorporate Water Sensitive Urban Design (WSUD) principles and drought-resilient landscape design to improve water management and ecological performance. Conveyance and infiltration features (e.g. swales) should be designed with consideration of the adjusted rainfall intensities (using the ARR Data Hub parameters in W7 with the appropriate duration) **W8.3**. Reduce impermeable exterior surfaces by integrating permeable paving, green spaces, and blue infrastructure to support infiltration and reduce runoff. Establish a maintenance and cleaning routine for permeable pavements to preserve long-term functionality. Without proper upkeep, permeability can decline significantly over time.	IL2 to IL4	**W8.1**– 1 Point **W8.2**– 1 Point **W8.3**–1 Point	03 Points
Drought Conditions	**W9. Changes in Soil Moisture (Drought Conditions)** Design structural foundations to account for the effects of drought on reactive soils, which may swell or shrink significantly under changing moisture conditions. **W9.1.** Where reactive soils are identified in the geotechnical report (e.g. clay-type soils), the structural engineer should consider the impact of drought conditions on foundation performance and design accordingly. This applies to the following soil classifications: o Soil classification M – moderate reactivity (Score: [Insert]) o Soil classifications H1, H2, and E – high to extreme reactivity For non-reactive sites, this adaptation measure is not applicable.	IL2 to IL4	**W9.1**–2 Points	03 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
Coastal Hazards and Sea Level Rise	**W10. Site Selection** Conduct thorough site assessments for locations within 5km of the coastline to ensure long-term resilience against sea level rise, storm surge, and coastal erosion. Review relevant data sources to assess coastal hazard exposure: o Areas at risk of inundation publications o Sea level rise or inundation studies published by Local Government o Local planning guidelines and State Planning Policy 2.6 (SPP2.6) o Site elevation and drainage characteristics o Historic flooding records and future mitigation plans (consult Local Government) **W10.1.** Elevate buildings to comply with coastal hazard planning requirements under SPP2.6. **W10.2.** Incorporate future climate change projections and sea level rise into design decisions, including: o Building elevation and protection o Site drainage o Material selection It is strongly recommended to avoid developing new projects in areas at risk of sea level rise, storm surge, or coastal erosion. Projects located outside of at-risk areas will receive full resilience score for this item.		**W10.1**–1 Point **W10.2**–2 Points	03 Points
	W11. Resilience to Sea Level Rise and Inundation (Coastal Flood Adaptation) Design buildings in areas susceptible to sea water inundation to withstand both short-term and long-term impacts through integrated floodproofing and resilient systems. **W11.1.** Use materials that are resistant to water damage and corrosion and apply appropriate sealants and coatings to reduce sea water intrusion. **W11.2.** Install flood barriers to prevent sea water from entering the building. *Note: The impact of flood barriers on adjacent land and buildings must be assessed.* **W11.3.** Engage a civil engineer to design integrated drainage systems capable of managing and effectively draining sites subject to sea water inundation.		**W11.1**–1 Point **W11.2**–1 Point **W11.3**–1 Point **W11.4**–1 Point	03 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	W11.4. Ensure backup systems (e.g. power, communications, critical infrastructure) are located above inundation levels to maintain functionality during flood events.			
Holistic Design	**D1. Climate Resilience Assessment (CRA)** Conduct the Climate Resilience Assessment in accordance with Section 5 of TG050. <u>**D1.1.** CRA is conducted and has informed design decisions (1 point)</u> ○ For projects that require detailed climate risk assessment for identified priority hazards, conduct detailed adaptation planning for the project, including identification of detailed risk items and adaptation strategies, integrating into building design solutions (Table 7 in Section 6), documentation for project hand-over.	IL2 to IL4	**D1.1** - 1 Point	01 Point
	D2. Backup power and Redudancy Provide on-site energy generation and storage capacity to provide backup power for critical systems in the event of grid outage or blackout. <u>**D2.1.** Install resilient backup power systems (e.g., battery energy storage systems, diesel or gas generators) capable of supporting all identified critical loads during extended blackouts for IL3 and IL4 facilities.</u> **D2.2.** Deploy on-site renewable energy generation (e.g., solar PV) integrated with battery storage to supply and sustain vital loads during grid disruptions. **D2.3.** Implement load management strategies that is capable of electrical load shedding to turn off non-essential equipment when needed, thereby enhancing system resilience and reducing backup capacity requirements.	IL2 to IL4	**D2.1** - 1 Point **D2.2** - 1 Point **D2.3** - 1 Point	03 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	D3: Resilient Landscaping and Outdoor Space 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. **D3.1.** Incorporate blue and green infrastructure and strategic tree planting to provide natural shading and ameliorate urban heat island effects. **D3.2.** Ensure all hardscape surfaces are either fully shaded or constructed with materials having an initial Solar Reflectance Index (SRI) greater than 39, in accordance with ASTM E1980 standards. **D3.3.** Select tree species with proven resistance to cyclonic winds or ensure planting at safe distances from structures to minimize wind-related damage. Avoid planting dense vegetation close to buildings because it can trap moisture against exterior walls, leading to increased humidity levels and potential moisture damage. **D3.4.** Use drought-tolerant plants and landscaping techniques that require minimal irrigation and maintenance. **D3.5.** Specify outdoor furniture and features that are designed to withstand extreme weather conditions. This includes secure anchoring systems, waterproofing measures, and materials resistant to heat expansion. **D3.6.** Raise (essential) external services including sewage pumping stations and associated electricity supply to levels above future flood levels, accounting for climate change amplification over the life of the service.	IL2 to 4	**D3.1** - 1 Point **D3.2** - 1 Point **D3.3** – 0.5 Point **D3.4** – 0.5 Point **D3.5** – 0.5 Point **D3.6** – 0.5 Point	04 Points
	D4: Advanced resilience features Provide innovative and advanced design solutions to address impacts of climate change, such as: **D4.1.** Embed climate resilience into master planning by incorporating climate risk assessments into zoning, road network design, shelter placement, reinforced infrastructure zones, and emergency access/egress routes. **D4.2.** Develop an asset-wide drainage strategy with consideration of the implications for neighbouring communities. **D4.3.** Identify any contaminated sites in areas at future flood risk and establish clean-up procedures or implement options that reduce the potential for leakage during flood events.	IL2 to IL4	**D4.1-7** - 1 Point each	02 Points

Climate Hazard	Adaptation Measures	IL	Allocated Points	Total Points
	D4.4. Relocate and raise external switchboards. Location should ensure safe access during intense rainfall events. **D4.5.** Identify and design "refuge" rooms and/or strengthen areas for vulnerable user groups (e.g. at-risk patients). **D4.6.** Consider extra storage and reuse of runoff to use stormwater during dry periods. **D4.7.** Specify the use of low embodied carbon materials (e.g., recycled aggregates, sustainably sourced timber) supported by Environmental Product Declarations (EPDs) to reduce lifecycle emissions and support integrated sustainability outcomes.			

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.

Figure 4. Resilience Rating for A Case Study

6.2. Design Register

A design register (Appendix 6) has been developed to guide the project team in integrating adaptation measures identified in the **Error! Reference source not found.** 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

Project teams should clearly define climate resilience expectations and deliverables for each stage of project delivery. These requirements should be embedded within the project's design and construction documentation, including the service brief, design reports and drawings, construction documents, and technical specifications.

Table 9. 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 strategies are incorporated 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	• Commissioning reports of adaptation strategies (e.g. thermal comfort, standby power) • Operation and maintenance (O&M) manual for adaptation measures • POE reports capturing adaptation measures' performance • Operation & Maintenance schedules for adaptation features

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
ABCB	Australian Building Codes Board
AEP	Annual Exceedance Probability
AR	Assessment Report
ARR	Australia Rainfall and Runoff
BOM	Bureau of Meteorology
CAS	Climate Adaptation Strategy
CCiA	Climate Change in Australia
CD	Construction Document

Abbreviation	Definition
CMIP	Coupled Model Intercomparison Project
CRA	Climate Resilience Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organization
CZ	Climate Zone
DD	Design development
DOE	Department of Education
DOF	Department of Finance
DHW	Department of Housing and Works
DTS	Deem to Satisfy
DWER	Department of Water and Environmental Regulation
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety
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
PDP	Project Definition Plan
PMP	Project Management Plan
RCP	Representative Concentration Pathway
SD	Schematic Design
SSP	Shared Socioeconomic Pathway
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.

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Appendix 1: Climate Change and Impact on WA Government Buildings

Climate Change in WA

Australia is experiencing the effects of climate change with increasing intensity. Rising temperatures, more frequent and severe bushfires, prolonged droughts, and extreme weather events such as floods and cyclones are becoming more common across the country (Figure 5). These changes are impacting ecosystems, agriculture, infrastructure, and communities, highlighting the urgent need for climate adaptation and resilience strategies at both national and local levels.

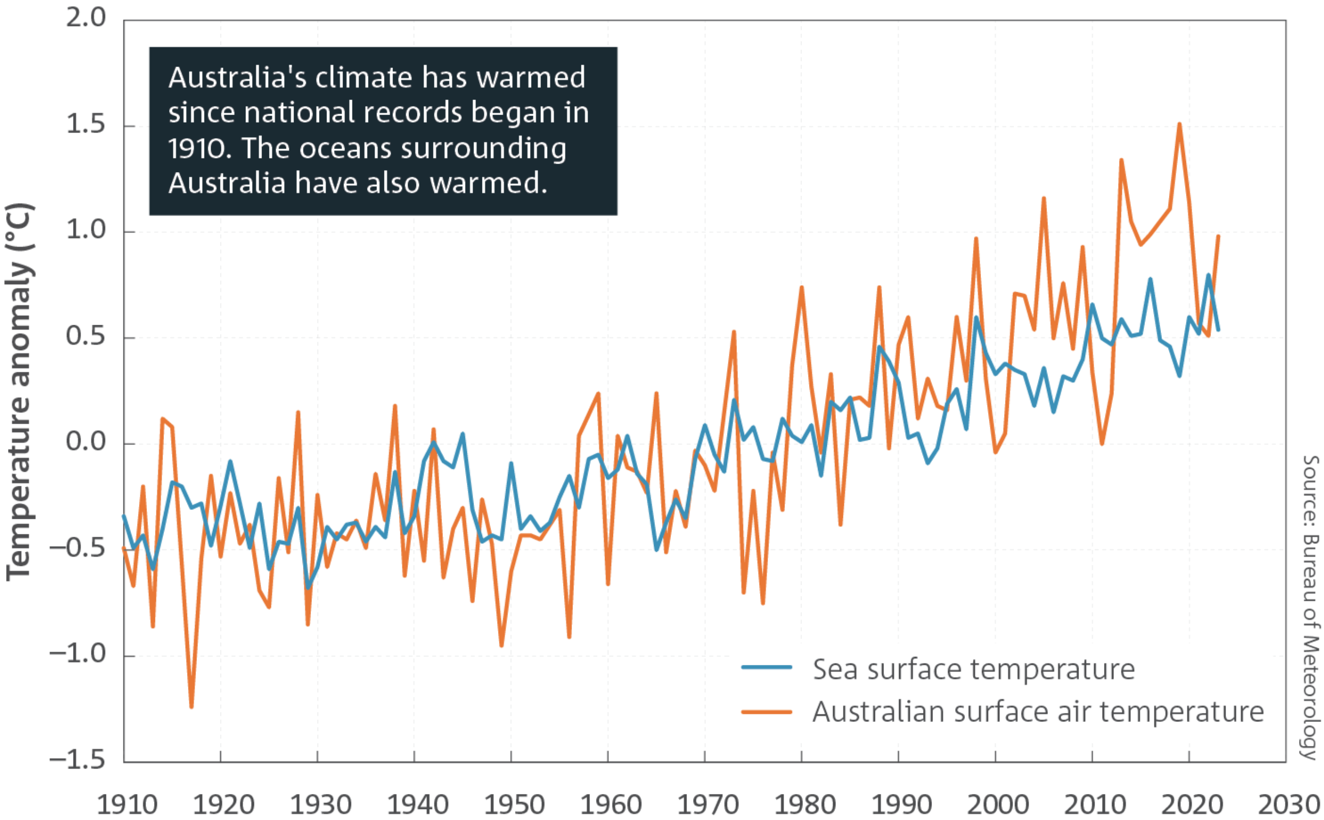

Figure 5. Australian average annual temperature in observations

Australia's climate has warmed by an average of 1.51 ± 0.23 °C since national records began in 1910 (Source: CSIRO, BOM).

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 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.

Climate Hazards and Extreme Events in WA

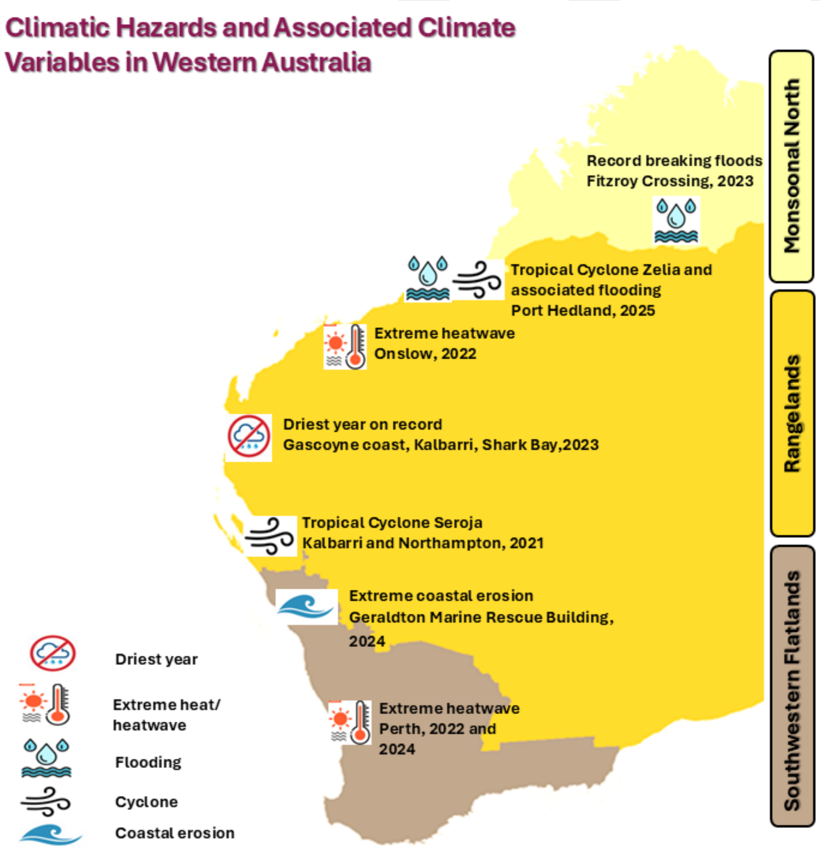

Figure 6. Recent Climate Hazard Events in Western Australia. **Source: DHW**

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 10. 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 Cyclone Zelia in February 2025, causing significant damage to infrastructure and communities (JCU, 2025).	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 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.

Climate Change Impacts on WA Government Buildings

Climate change is having a growing impact on buildings across Australia. Rising temperatures, more intense storms, and increased frequency of bushfires and flooding are placing greater stress on building materials, structural integrity, and energy systems. 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. Coastal buildings face heightened risks from sea level rise and erosion, while inland structures must contend with extreme heat and shifting weather patterns (Table 11).

Currently, building design standards – such as those in the National Construction Code (NCC) and Australian Standards – are based on historical climate data. This approach risks leaving buildings unprepared for future extreme weather conditions.

These challenges are prompting a shift toward climate-resilient design, including improved thermal performance, flood mitigation strategies, and the use of durable, low-carbon materials. Adapting buildings to withstand these evolving conditions is essential to protect communities and maintain infrastructure reliability. It can also reduce rectification and maintenance costs and improving safety for building occupants.

Table 11. 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
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.

Currently, around 80% of government buildings in Western Australia are located within the Perth metropolitan and South-West regions – areas classified by AS1170.2 as non-cyclonic zones with a mild temperate climate (ABCB, 2022). Many of these buildings feature design elements that heighten their vulnerability to extreme weather events. Common characteristics include low-rise construction with shallow foundations, expansive roof overhangs, single-glazed windows, and placement near tree canopies or flood-prone zones.

These vulnerabilities are expected to worsen as climate change drives more frequent and intense heatwaves in these regions. Additionally, cyclonic activity may extend further south due to rising temperatures, increasing the exposure of these buildings to hazards they were not originally designed to withstand.

It should be noted that government buildings often serve populations that are especially sensitive to climate-related hazards, including the elderly, patients, and children. These groups are particularly susceptible to heat stress and may face mobility challenges during emergencies. Therefore, it is essential that the design of these facilities integrates strong climate resilience measures to safeguard the health, safety, and accessibility of all occupants.

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/m²). For instance, RCP8.5 represents a scenario where the extra energy is 8.5 W/m² 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).

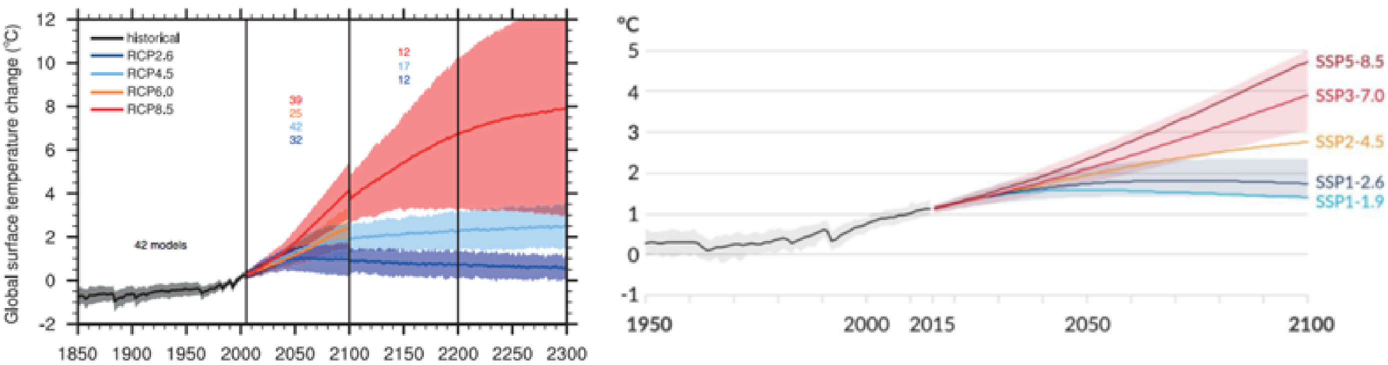

Figure 7. Climate change scenarios in IPCC AR5 (left) (IPCC, 2013) and AR6 (right) (IPCC 2023).

	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 (Watercom, 2025)

Appendix 3: Design Conditions for Climate Resilience

Table 12 Design Conditions for Climate Resilience Analysis (CRA)

Description	Current Design Conditions	Estimated Conditions in 2070 or End of Building Life (based on SSP3-7.0 or RCP8.5)
Building Class		
Design Life		
Importance Level		
No. of Occupants		
Heat		
Climate Zone Classification		
Design Temperature (Summer)	_____°C (DB) _____°C(WB)	_____°C (DB) _____°C(WB)
Design Temperature (Winter)	_____°C (DB) _____°C(WB)	_____°C (DB) _____°C(WB)
Number of days above 35°C		
Number of days above 40°C		
Tropical Cyclones and Windstorms		
Wind Region Classification		
Design Wind Speed	_____ m/s	_____ m/s
Water (Flooding, Sea-level rise, drought etc)		
Global Mean Surface Temperature Projections (ΔT)	_____°C	
Rainfall Depth (<1 hour)	_____ mm	_____ mm
Rainfall Depth (>24 hour)	_____ mm	_____ mm
Initial Loss (IL)	_____ mm	_____ mm
Continuing Loss (CL)	_____ mm/hr	_____ mm/hr
Sea Level Rise (SLR) + Highest Astronomical Tide (HAT)	_____ m	_____ m

Notes:

Please refer to Appendix 6 for relevant data, including:

- CSIRO, Projections tools
- Geoscience Australia: Australian Rainfall and Runoff Guidelines
- CoastAdapt, CoastAdapt datasets

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 (L5)	Could occur several times per year	More likely than not – probability greater than 50%
Likely (L4)	May arise about once per year	As likely as not – 50/50 chance
Possible (L3)	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high
Unlikely (L2)	May arise once in 10 to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare (L1)	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 (C5)	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 (C4)	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 (C3)	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 (C2)	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 (C1)	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

Add in a part to explain rationales for this Matrix, extracting from Geoff's Executive Summary

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)?		
	External Fabric	Has the design considered using laminated glass in the cyclone regions?		

S. No.	Heading	Item	Reference Document	Checked Yes/No
	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

Source: Carabiner. https://www.carabiner.com.au/schools/madora-bay-primary-school

Madora Bay Primary School (MBPS) is a 6,863 m² Department of Education (DoE) facility located in southwestern Western Australia. Its design follows the latest Finance/DoE Primary School Brief, making it a representative model for future school developments. Situated in Climate Zone 5 (Warm Temperate) and Wind Region A1, the school complies with current building codes. However, with a projected mean temperature increase of 1.66°C due to climate change, MBPS – like many future schools – faces the growing challenge of managing heat stress among students.

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 demand while maintaining indoor 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.
- 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 installation of PV panels for renewable energy generation.

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

- A **Climate Resilience Assessment (CRA)** should be undertaken at the outset of the project. This high-level assessment evaluates potential climate hazards based on future climate projections, identifies priority areas – such as pre-kindergarten spaces – and provides valuable insights to inform early design decisions.
- **Thermal comfort modelling** should be conducted in identified high-risk areas, such as north-facing kindergarten classrooms. Research indicates that by 2050, a typical north-facing classroom could experience a cooling load increase of over 33% compared to current levels. This underscores the importance of detailed thermal comfort analysis in vulnerable spaces.
- **Outdoor shading,** while partially provided by landscaping, may not be immediately effective due to the time required for trees to mature. Additionally, the campus includes extensive hardscape areas, such as car parks, which can contribute to heat retention. Although outdoor spaces are less frequently occupied than indoor areas, they influence the microclimate and can impact indoor thermal comfort. Further investigation into shading solutions and the use of thermally reflective materials is recommended.

B. Bunbury Regional Prison

Source: C&S Inspection Report (2024)

The Pre-Release Unit (PRU) at Bunbury Regional Prison, constructed in 2008, is designed to support inmates transitioning back into the community. Typical PRUs include multiple bedroom units and shared amenities such as kitchens and lounges. The single-storey structure was built using double-leaf masonry on a slab-on-grade foundation, with a timber truss roof system secured by tie-downs embedded into the foundation.

Located in Wind Region A1 (non-cyclonic), the PRU was designed to Importance Level 2 standards, with an ultimate design wind speed of 45 m/s. However, during a tornado event on 10 May 2024, wind speeds approached this design threshold. Despite this, one PRU roof was torn off, causing debris damage to an adjacent unit. Several other units also sustained varying degrees of storm damage.

Although PRUs are not located in cyclonic zones and are not required to withstand extreme wind events, this incident highlights critical vulnerabilities in typical low-rise government buildings in Southwest Western Australia – especially in the context of evolving wind patterns due to climate change.

Typical construction practices for low-rise government buildings in Southwest Western Australia reveal several vulnerabilities. These include unclear classification of Importance Levels, insufficient emphasis on secure tie-down connections (e.g., using clout nails instead of bolts), widespread use of wind-susceptible roof types such as low-pitch monoslope roofs, inadequate anchoring of timber top plates to steel beams, and the presence of vulnerable openings like clerestory windows.

To address these issues, it is recommended that the latest design standard – AS1170.2:2021 – be adopted, incorporating Western Australia-specific variations (WA Variation to NCC2022[1]) and additional guidance provided by DEMIRS.

For projects classified as high importance (IL3 or IL4), the following strategies should be considered to enhance resilience against extreme wind events, even in non-cyclonic regions:

- **Design for elevated internal pressure**, acknowledging recent high-wind incidents in Wind Region A.
- **Strengthen the connection between the roof and superstructure** by specifying higher stiffness and strength connection requirements. This includes using high-quality cyclone straps, tie-downs, J-bolts, and prioritizing bolts or screws over standard nails.
- **Incorporate the climate change multiplier (Mc = 1.05)** into structural design, as recommended in AS1170.2, to account for future climate conditions.
- **Install cyclonic-rated doors and windows** to reduce vulnerability to wind pressure and debris.
- **Seal all potential water ingress points**, including roof flashings, gutters, and window and door frames.
- **Plant wind-resilient tree species** to minimize the risk of impact damage and wind-borne debris.
- **Mandate structural inspections** during and after construction, preferably conducted by qualified third-party professionals, to ensure compliance and performance.

[1] Industry Bulletin 147, DEMIR 2024

C. Roebourne District High School

Source: ADCO Constructions. https://www.adcoconstruct.com.au/case-study/roeburne-district-high-school-dhs-new-school-redevelopment/

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 high internal pressures in accordance with NCC. This approach ensures that the structures are designed to ensure occupants' safety in the event of tropical cyclone.

- 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 current design temperature appears to be based on outdated historical weather data and should be updated. With a projected temperature increase of 1.94°C, existing cooling systems may struggle to manage the additional thermal load during heatwaves. To address this, there are opportunities to enhance HVAC system performance and incorporate higher outdoor temperature thresholds in future retrofit cycles, accounting for climate change impacts.
- Advanced thermally reflective coatings and materials could 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.
- The latest standard AS1170.2 recommends including a climate change multiplier (M_c=1.05) in load calculations to account for increased wind loads during extreme wind events. Consideration this factor during structure and roof maintenance could help enhance resilience.
- It would be useful to conduct a vulnerability assessment using a computer software program such as the Vulnerability and Adaptation to Wind Simulation (VAWS) tool[2]. This could help identify weak points of the current structure design and address them accordingly.
- Consideration of increasing intensity in short-term heavy rainfall events due to climate change could increase the risk of flash flooding. Design based on climate projections at the end of the building's lifecycle could inform the stormwater management and drainage system design.
- 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.

[2] James Cook University and Geoscience Australia 2019 (Link)