Report

Climate Change Resilience Statement

ALTERATIONS AND ADDITIONS TO MERIDEN SCHOOL, STRATHFIELD

Allen Jack & Cottier Architects

Report

Norman Disney & Young
A TETRA TECH COMPANY

CONFIDENTIAL

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EXECUTIVE SUMMARY

The projected impacts of climate change on the proposed Meriden School Project development were assessed in conjunction with the project's early-phase design and longevity, based on predicted climate change models. This Climate Change Resilience Statement was prepared for inclusion in the DA submission and in response to SEARs conditions for the project.

Projections in this report were based on outputs from global climate models (GCMs) with data provided by CSIRO's Climate Change in Australia's database relevant to the Strathfield region. The results showed the following (CSIRO Climate Change Projections, East Coast Cluster Report 2015):

- More hot days and warm spells are projected with *very high confidence*.
- Extreme temperatures are projected to increase with *very high confidence* and substantial increases in temperatures reached on hot days, as well as the frequency of hot days, and the duration under the highest impact scenario (i.e. rapid convergent growth, fossil fuel intensive (A1FI) (IPCC AR4, 2007).
- Average temperatures will continue to increase in all seasons (*very high confidence*).
- Generally less rainfall is expected in winter (*medium confidence*) but the intensity of extreme rainfall events is projected to increase (*high confidence*)
- Time spent in drought is projected to increase (*medium confidence*) over the course of the century.

A climate change risk assessment was undertaken as per AS 5334-2013 and Green Star Design & As Built v1.2 requirements using CSIRO projections for the East Coast (South) sub-cluster to identify expected impacts from climate change. A risk profile and mitigation approach for the following climate change projected impacts was conducted:

- Hotter days;
- More frequent heatwave events;
- Extended drought periods;
- More extreme rainfall events; and,
- Gustier wind conditions.

The design's responsivity to the above impacts was then assessed, which included consideration of landscape design, material selection and social equity aspects (e.g. respite/shelter areas).

This climate change risk assessment considered prescribed design features and current controls to mitigate future climate risks for the project. Outcomes of the assessment have shown that there are no major risks remaining in the design at this early stage of development. Key design elements have been highlighted for consideration in design development, and appropriate maintenance after project completion should ensure that the project remains resilient to future climate change impacts.

1 INTRODUCTION

1.1 The Meriden School Project Description

1.1.1 Site

The Meriden School is situated at Redmyre Road and Margaret Street, Strathfield. Site coordinates are 33° 52’ 27” S, 151° 5’ 24” E. The project consists of the following major scope elements:

- The development comprises Class 9b education facilities across 2 buildings:
  - The Centre for Music & Drama (CMD) building will comprise of 3 storeys providing classrooms, training facilities, performance areas and staff areas; and,
  - The Administration & Student Centre (ASC) building will comprise of 2 storeys providing administration, IT and lounge spaces.
- The buildings will comprise of approximately 13,900m^2 NLA.

1.1.2 Location

The Meriden School Project is located at Redmyre Road and Margaret Street, Strathfield. This falls within the East Coast (South) Sub-cluster, as defined by the CSIRO and Australian Bureau of Meteorology. In their “Climate Change in Australia” climate projections, Australia is categorised into natural resource management (NRM) regions that are defined by catchments and bioregions (refer Figure 1).

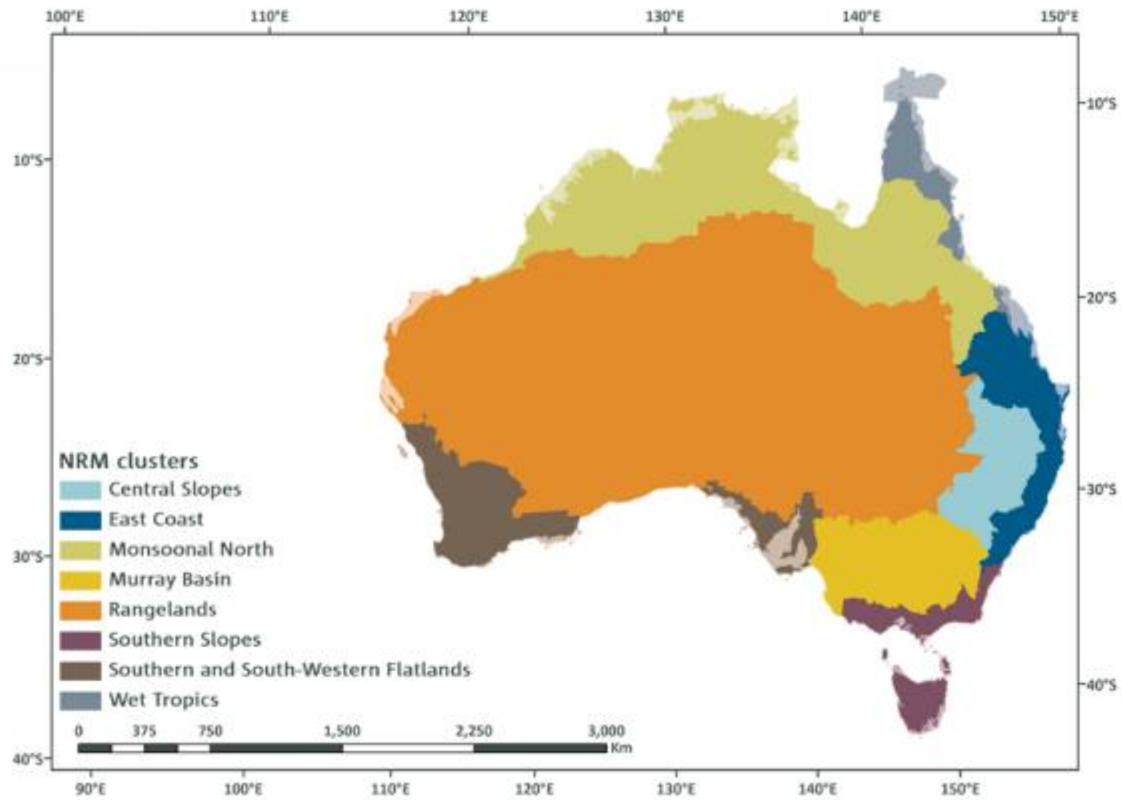


Figure 1: NRM Clusters – East Coast (South) Sub-cluster Location

1.1.3 Climatic Characteristics

Climatic characteristics for the East Coast Cluster, in which the Meriden School project is located, are as follows.

The East Coast Cluster includes an area of approx. 395,000km^2 across New South Wales and Queensland and comprises of 6 natural resource management regions which either have a Subtropical (East Coast North) or a Temperate (East Coast South) climate and stretch across an extensive coastal zone (CSIRO Climate Change in Australia Projections, 2015).

As it spans a large range of latitudes and altitudes, the East Coast Cluster experiences a range of climate influences and drivers, both within and between regions, which result in a vast array of diverse bioclimatic zones. The cluster comprises the central part of the eastern seaboard of Australia and includes the drainage basins of several major rivers. The cluster contains both temperate broadleaf and mixed forests as well as tropical and subtropical grasslands, savannahs and shrublands.

The daily mean temperatures in the East Coast (South) Sub-cluster range from 10°C (winter) to 22°C (summer), with a minimum of 4°C in July and a maximum of 28°C in January (CSIRO Climate Change Projections, East Coast Cluster Report 2015). The rainfall characteristics of the region are a result of the interactions between several rain-bearing weather systems with monthly mean rainfall ranging from around 45 to 135mm (CSIRO Climate Change Projections, East Coast Cluster Report 2015). As a result of the varying rainfall and diverse land forms, the vegetation types, hydrology regimes and land-uses vary greatly across this sub-cluster (CSIRO Climate Change in Australia Projections, 2015).

1.2 Climate Change Risk Assessment Overview

Norman Disney & Young (NDY) were commissioned to undertake a climate change risk assessment for the Meriden Schools Project prepared for inclusion in the DA submission and in response to specific SEARs conditions. The risk assessment is in line with current predictions to determine the hazards/risks associated with future climatic conditions and how these are likely to affect this building into the future.

This Climate Change Resilience Statement details the methodologies and outcomes of the climate change risk assessment, using current scientific predictions, performed at this early design phase and used to inform detailed design for the project. The climate change risk assessment was developed in accordance with AS 5334-2013 *Climate Change Adaptation for Settlements and Infrastructure*, with reference made to the Australian Government guideline document *Climate Change Impacts & Risk Management: A Guide for Business and Government (2006)*.

The risk assessment is detailed in Section 4 of this report. It is broken into a description of the predicted climate scenarios and impacts, as per the following SEARs conditions:

- Hotter days;
- More frequent heatwave events;
- Extended drought periods;
- More extreme rainfall events; and,
- Gustier wind conditions.

A risk assessment then follows, detailing how these climate change conditions are likely to impact the building and its users into the future.

This climate change risk assessment considered prescribed design features and current controls to mitigate future climate risks for the project. Outcomes of the assessment have shown that there are no major risks remaining in the design at this early stage of development. Key design elements have been highlighted for consideration in design development, and appropriate maintenance after project completion should ensure that the project remains resilient to future climate change impacts.

2 CONTEXT ESTABLISHMENT

2.1 Scope & Purpose

NDY was engaged to prepare a Climate Change Resilience Statement in accordance with recognized standards for The Meriden Schools Project, which incorporates education facilities, in response to the SEARs conditions. This assessment was undertaken at the early design stage of the project to assess the development's responsivity to the CSIRO projected impacts of climate change.

NDY set out to assess the site's climate conditions and select and consider climate change scenarios for two time scales relevant to the project's lifespan, which in this case included 2030 (Practical Completion + 10 years) and 2090 (+ 70 years), and identify associated potential direct and indirect climate change impacts.

The preparation of a climate change risk assessment was undertaken based on AS5334 which identified the likelihoods and consequences of potential risks of expected climate change projections sought from the CSIRO's Climate Change in Australia Projections (CSIRO Climate Change in Australia Projections, 2015).

2.2 Climate Change Context/Scenarios

2.2.1 Greenhouse Gas Emissions Scenarios

Although future emissions growth is complex and uncertain, the Intergovernmental Panel on Climate Change (IPCC) developed a range of potential future greenhouse gas emissions scenarios to address this uncertainty and represent a plausible set of future economic and social conditions on which emission levels were generated (Australian Government Department of Climate Change, 2009).

The following IPCC climate change scenarios from the CSIRO's Climate Change in Australia Projections (as at 2015) were used in this impact assessment. These reflect the global climate model (GCM) simulations, as defined by the Representative Concentration Pathways (RCPs) used by the IPCC, with a particular focus on RCP4.5 and RCP8.5.

Representative Concentration Pathway 4.5 (RCP4.5)
This scenario represents a pathway consistent with low-level emissions, which stabilise the carbon dioxide concentration at about 540 ppm by the end of the 21st century and assumes that global annual GHG emissions (CO_2-e) peak around 2040 before declining (CSIRO Climate Change in Australia Projections, 2015).

Representative Concentration Pathway 8.5 (RCP8.5)
This scenario is representative of a high-emission scenario, for which the carbon dioxide concentration reaches about 940 ppm by the end of the 21st century and assumes that global annual GHG emissions (CO_2-e) continue to rise through to 2100 (CSIRO Climate Change in Australia Projections, 2015).

2.2.1.1 Justification for Selecting these RCP Scenarios

As per guidance in the AGO's Guide, "Climate Change Risks and Impacts: A Guide for Government and Business", Section B4.1, a limited number of scenarios covering the most plausible future climate changes was used for this analysis. This was deemed necessary to gain a holistic picture of predicted climate change impacts for this site.

These include the high emissions scenario (RCP8.5) which represents 'business as usual' and combines assumptions regarding the absence of climate change policies with higher world populations and modest rates of technological change or energy intensity improvements which culminate in higher energy demands and therefore Greenhouse Gas emissions increasing year on year.

The other, more optimistic emissions scenario utilised in this assessment includes emissions peaking at around 2040 and then declining due to rapid stabilization of Greenhouse Gas emissions in the global economy as a result of implementation of effective climate change policies (such as a price on emissions) and swift introduction of new, more resource efficient technologies that balance renewable energy sources with fossil-fuel sources and keep global mean warming within a 2 °C increase from pre-industrial levels.

2.2.2 Future Time Slices

Two time slices were chosen for the site in accordance with the requirements of Green Star, and for the purpose of assessing climate risks across a range of potential future greenhouse gas emissions scenarios. The first time slice – 2030 – was selected to represent short-term climate impacts. The second time slice – 2090 – was selected to represent the approximate lifespan of the CMD and ASC buildings and the approximate time at which they would require major refurbishment.

2.2.3 Climate Variables

On the basis of the site's location, vulnerabilities, and the explicit SEARs conditions, the following climate variables have been considered:

- Hotter days;
- More frequent heatwave events;
- Extended drought periods;
- More extreme rainfall events; and,
- Gustier wind conditions.

2.2.4 Standards

The recognised standard utilised to carry out this assessment was AS5334. Section B, Sub-sections 4 to 6 of the AGO Guide, "Climate Change Risks and Impacts: A Gide for Government and Business" was also utilised to establish the context for this assessment.

2.2.5 Climate Data

In summary the following are key projections for the East Coast (South) Sub-cluster (CSIRO Climate Change Projections, East Coast Cluster Report 2015):

- Mean, maximum and minimum temperatures will continue to increase in all seasons (*very high confidence*).
- More hot days and warm spells are projected with *very high confidence*. Fewer frosts are projected with *high confidence.*
- Natural climate variability will remain the major driver of rainfall changes (*high confidence*). Generally, less rainfall in the winter is projected with *medium confidence*. Increases and decrease to summer, spring and autumn rainfall are possible but less clear.
- Increased intensity of extreme rainfall events is projected, with *high confidence*.
- Greater time spent in meteorological drought is projected, with *medium confidence.* An increase in frequency and duration of extreme drought is projected, with *low confidence.*
- Small changes in mean surface wind speed is projected with *high confidence.* Winter decreases are projected with *medium confidence* whilst spring increases are projected with *low confidence*.
- Little change is projected for solar radiation (*high confidence)* for the near future (2030).
- Little change in relative humidity (*high confidence*) for the near future (2030).
- Mean sea level will continue to rise (*very high confidence*).

- A harsher fire-weather climate is projected in the future (*high confidence*).

2.2.6 Past Meteorological Records

Data for the Sydney Airport ('Sydney AP') weather station was used on the basis that its years of record (1981 – 2010) aligned most closely with the base case climate data used in the Climate Change in Australia projections (1986 – 2005) and due to its relative proximity to the Meriden School site location. Other weather data sets considered but not used included:

- Rockhampton;
- Amberley;
- Brisbane;
- Coffs Harbour;
- Williamtown; and,
- Richmond.

2016 Intensity-Frequency-Duration (IFD) data regarding individual rainfall events was obtained for the site from the Bureau of Meteorology website.

2.3 Stakeholders

The following key stakeholders were identified for the project:

- Allen Jack & Cottier Architects(Project Architect)
- Norman Disney & Young (Sustainability)
- Meriden School
- NSW Department of Education
- Services Consultants
- Builder (TBC)

3 CLIMATE CHANGE PROJECTIONS FOR EAST COAST (SOUTH)

The following climate change projections have been assigned a confidence rating which follows IPCC likelihood terminology. The IPCC uses the following terminology for certainty/likelihood of outcomes

The confidence rating does not equate to a probabilistic confidence, rather it covers the quality, type, and quantity of evidence, and the extent of agreement (IPCC, IPCC WGI AR5 Climate Change 2013: The Physical Science Basis, 2013). The following terminology for certainty / likelihood of outcomes are used in this report:

- Low confidence;
- Medium confidence;
- High confidence; or,
- Very high confidence.

It is important to understand that climate change is not expected to be linear or smooth. It is anticipated that climate change will be characterised by extreme events that are hard to predict and even harder to manage and as a result many ecosystems, both natural and man-made, will find it difficult to adapt (IPCC, IPCC WGI AR5 Climate Change 2013: The Physical Science Basis, 2013).

3.1 Temperature

3.1.1 Higher Temperatures

Continued increases in mean, daily maximum and daily minimum temperatures are projected for the East Coast cluster with *very high confidence* with the near future (2030) projected increase of mean annual temperature around 0.4 to 1.3 °C above the climate of 1986–2005, with only minor differences between RCPs (CSIRO Climate Change Projections, East Coast Cluster Report 2015). For late in the century (2090), there is a large difference between scenarios, with projected warming of 1.3 to 2.5 °C for RCP4.5 and 2.7 to 4.7 °C for RCP8.5 (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

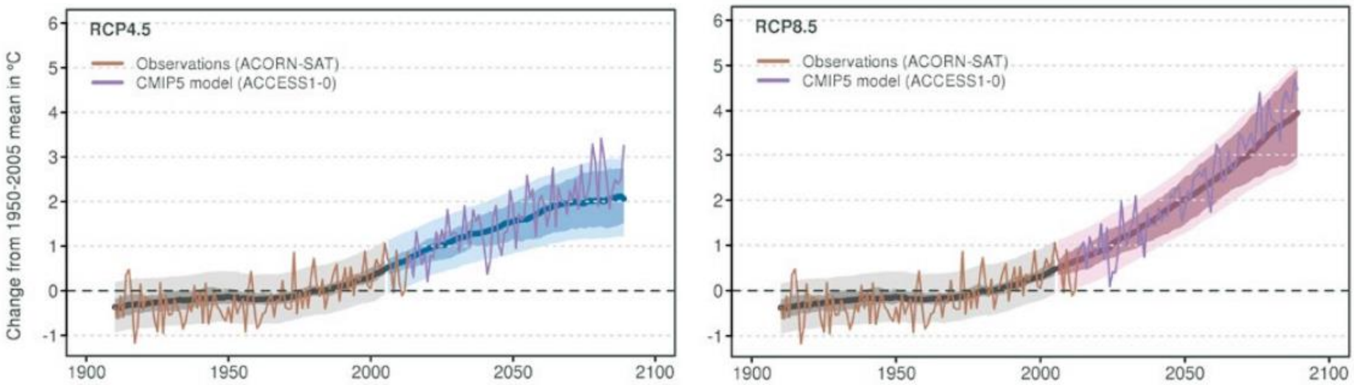


Figure 2: East Coast Annual Average Surface Air Temperature (°C) for 1910–2090 (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

Table 1: Sydney Airport (AP) Average 3pm Seasonal Temperature (Bureau of Meteorology) and Future Projections (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

Season	Baseline (1981-2010)	2030 @ RCP4.5	2090 @ RCP8.5
Summer	25.1° C	26.0° C *(+0.9° C)*	28.8° C *(+3.7° C)*
Autumn	21.7° C	22.5° C *(+0.8° C)*	25.4° C *(+3.7° C)*
Winter	16.9° C	17.8° C *(+0.9° C)*	20.5° C *(+3.6° C)*
Spring	21.1° C	22.0° C *(+0.9° C)*	25.0° C *(+3.9° C)*

The temperature change values indicated in grey (Table 1) are the simulated changes for the 2020-2039 (2030) and the 2080-2099 (2090) periods relative to the 1986-2005 period for the East Coast Cluster (CSIRO Climate Change Projections, East Coast Cluster Report 2015). The 1981-2010 temperatures from the BOM have been utilized as the baseline temperatures as they align most closely with the base case climate data used in the Climate Change Projections (1986-2005).

3.1.2 Hotter and More Frequent Heatwave Events, Fewer Frosts

A substantial increase in the temperature reached on the hottest days, the frequency of hot days and the duration of warm spells are projected with *very high confidence* and as a result an expected decrease in the frequency of frost-risk days is projected with *high confidence* (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

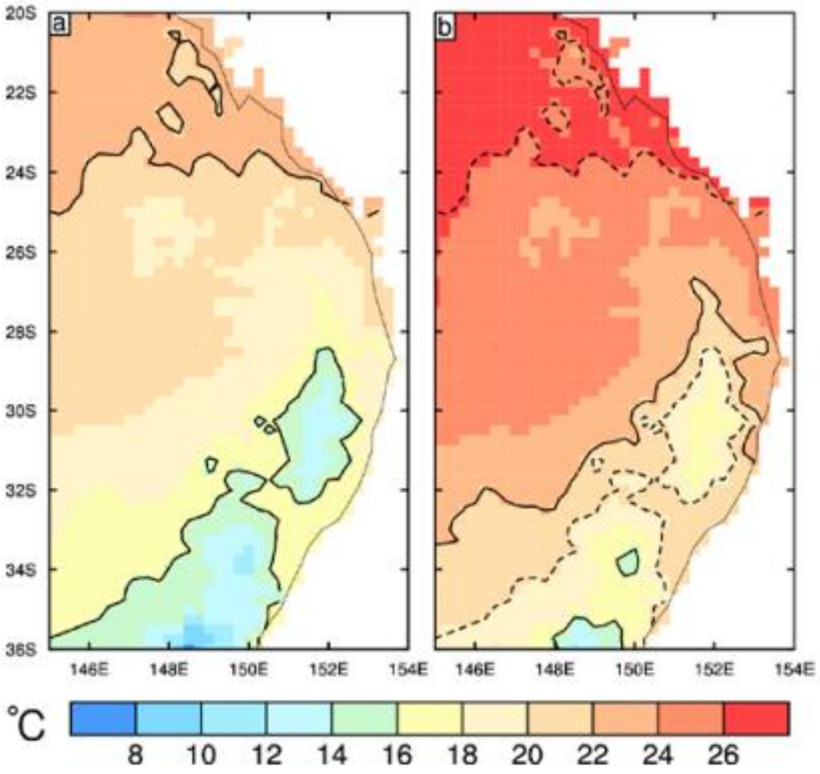


Figure 3: Annual Mean Surface Air Temperature (°C), for the Present Climate (A), and for Median Warming under RCP8 5 for 2090 (B) (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

Table 2:East Coast South – Average Annual Number of Days above 35°C and below 2 °C {Frosts} (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

Threshold	East Coast (South) Sub-cluster			
	Current	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5
Over 35 °C	3.1	4.3 (4.0 to 5.0)	6.0 (4.9 to 8.2)	11 (8.2 to 15)
Over 40 °C	0.3	0.5 (0.5 to 0.8)	0.9 (0.8 to 1.3)	2.0(1.3 to 3.3)
Below 2 °C	0	0	0	0

The risk of line outages, blackouts and asset failures is likely to increase (IPCC, IPCC WGI AR5 Climate Change 2013: The Physical Science Basis, 2013). This is due to increases in peak demand from increased air-conditioning use exceeding base load increases. Although the main drivers for energy consumption are demographic and socio-economic factors, climatic conditions are also linked to average and peak energy demands. (CSIRO Climate Change in Australia Projections, 2015).

Higher rates of infectious and water borne disease as well as increased rates of heat-related stress and mortality, particularly among the aged and vulnerable populations, are likely outcomes (Grose et. al, 2015).

The frequency of hot days and the frequency of high fire risk weather is likely to increase. The East Coast (South) currently experiences temperatures above 35°C, on average, 3.1 days per year. Studies have highlighted that by 2030 this is predicted to increase to 4.3 days per year and by 2090 to between 6 and 11 days per year (CSIRO Climate Change Projections, East Coast Cluster Report 2015).This has important ramifications for air pollution and health, with ozone pollution events linked to the frequency of hot, sunny days, and with the highest particle pollution concentrations linked to the presence of bushfire smoke (Grose et. al, 2015).

3.2 Precipitation

3.2.1 Extended Drought Periods

There is *medium confidence* that the time spent in drought will increase over the course of the 21st century in line with changes to mean rainfall, but *low* confidence in projecting the frequency and duration of extreme droughts (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

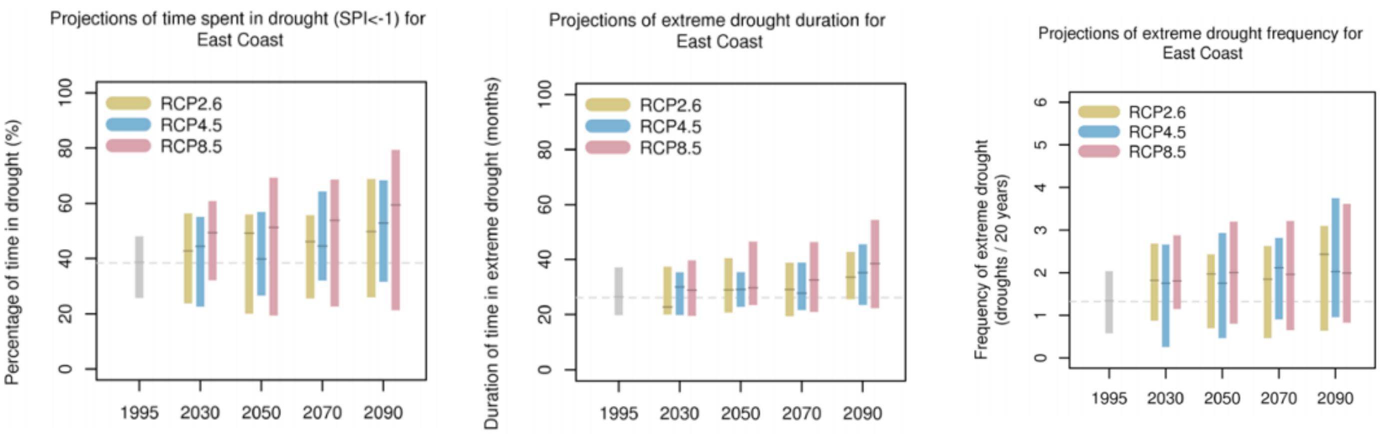


Figure 4: Time in Drought (Left), Duration of Extreme Drought (Middle), and Frequency of Extreme Drought (Right) (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

3.2.2 Extreme Rainfall Events

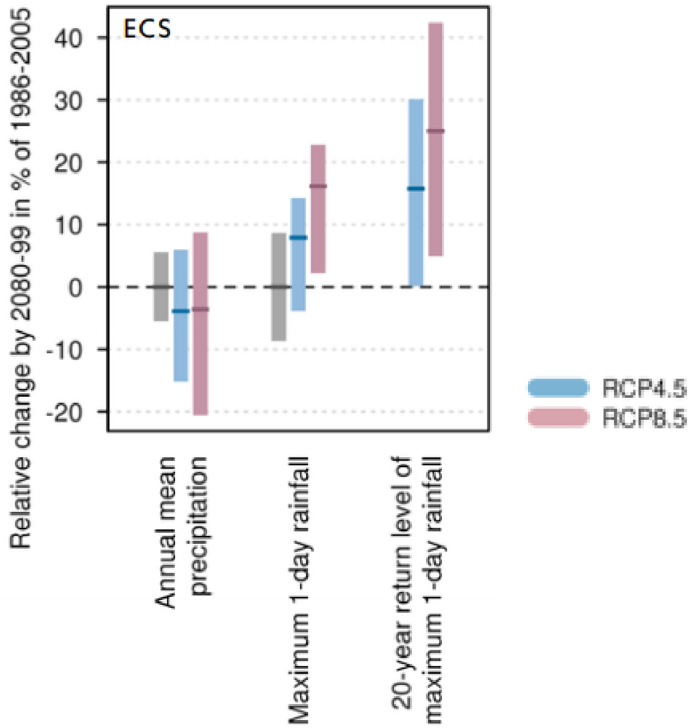
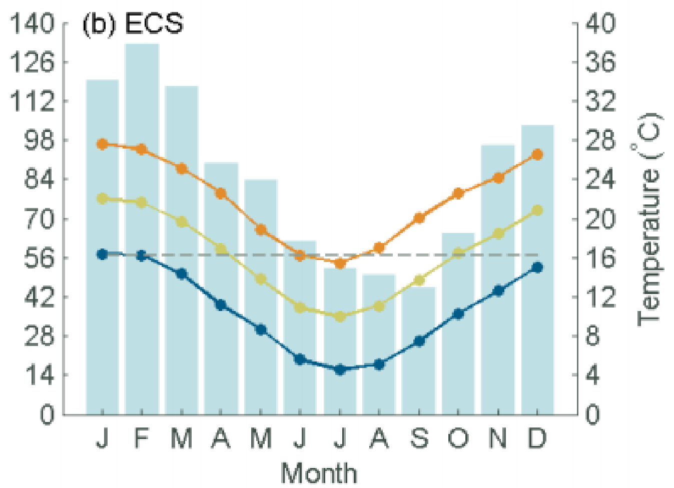


Figure 5: Projected Changes in Mean Rainfall, Magnitude of Annual Maximum 1-Day Rainfall, and Magnitude of 1 in 20-Year Rainfall Events for 2090 (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

There is *high confidence* that whilst the intensity of heavy rainfall extremes will increase, the magnitude of change cannot be reliably projected (CSIRO Climate Change Projections, East Coast Cluster Report 2015). The trend of annual mean rainfall is unclear and tending toward decrease whilst increased magnitudes of extreme rainfall events is projected. The magnitude of the anticipated extremes of rainfall are highly reliant on emission scenario and the future time period.

3.2.3 Average Rainfall



Rainfall has not shown any long-term trends, rather the East Coast cluster has experienced intermittent wetter and drier periods. The observed trends in rainfall throughout the East Coast cluster are not very significant, with *low confidence* in both the magnitude and sign of observed trends. (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

Rainfall is projected to decrease in winter, consistent with a reduction in the number of storms (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

3.3 Sea Level Rise

Relative sea level has risen around Australia at an average rate of 1.4 mm per year between 1966 and 2009, and 1.6 mm per year after the influence of the El Niño Southern Oscillation (ENSO) on sea level is removed (CSIRO Climate Change Projections, East Coast Cluster Report 2015). Increasing global temperatures has a direct impact on sea level as water expands with temperature and increases can also be expected from melting glaciers and ice caps. As temperatures are virtually certain to rise, so are sea levels virtually certain to rise, in line with IPCC predictions (CSIRO Climate Change in Australia Projections, 2015). There is *very high confidence* that sea level will continue to rise during the 21st century. In the near future (2030) the projected range of sea level rise for the cluster coastline is 0.08 to 0.18 m above the 1986–2005 level, with only minor differences between RCPs (CSIRO Climate Change Projections, East Coast Cluster Report 2015). As the century progresses, projections are sensitive to emissions pathways. By 2090, RCP4.5 gives a rise of 0.30 to 0.65 m, and RCP8.5 gives a rise of 0.44 to 0.88 m (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

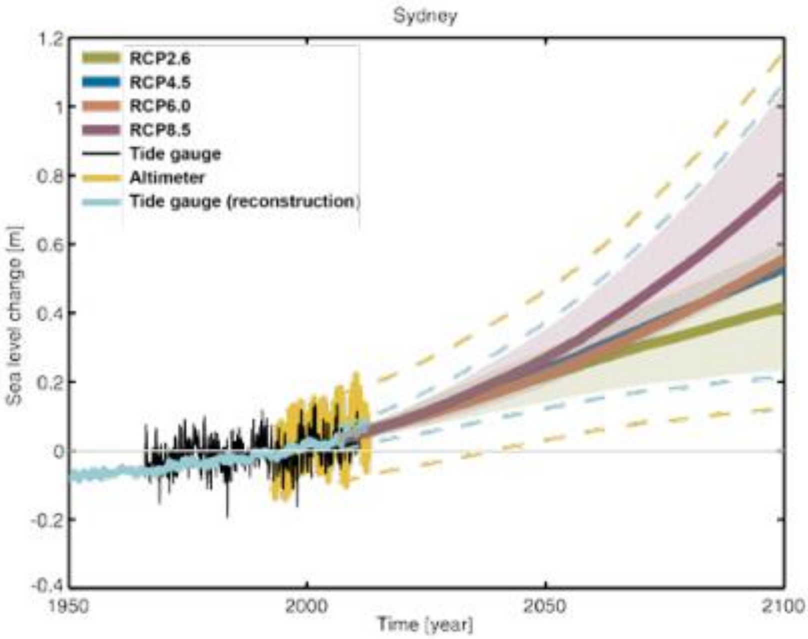


Figure 6: Figure 1. Observed and Projected Relative Sea Level Change (m) for Sydney (which has continuous records available (1966–2010) (CSIRO Climate Change Projections, East Coast Cluster Report 2015)

The Meriden School is located approximately 20m above sea level (Leaflet Maps, OpenStreetMap 2018) – well above even the most extreme CSIRO Climate Change Projections. Sea level rise is therefore not an impact that is relevant to the project.

3.4 Gustier Wind Conditions

There is *high confidence* in little change to mean wind speed under RCP4.5 and RCP 8.5 scenarios by 2030. For 2090 changes are projected to remain small with *medium confidence* under RCP4.5 and winter wind speed is projected to reduce with *medium confidence* under RCP8.5. These reduced winter wind speeds are assumed to be due to a projected southward movement of storm tracks and the subtropical ridge thus weakening westerly winds. There is *medium confidence* that there will be a reduction in extreme wind speeds (CSIRO Climate Change Projections, East Coast Cluster Report 2015).

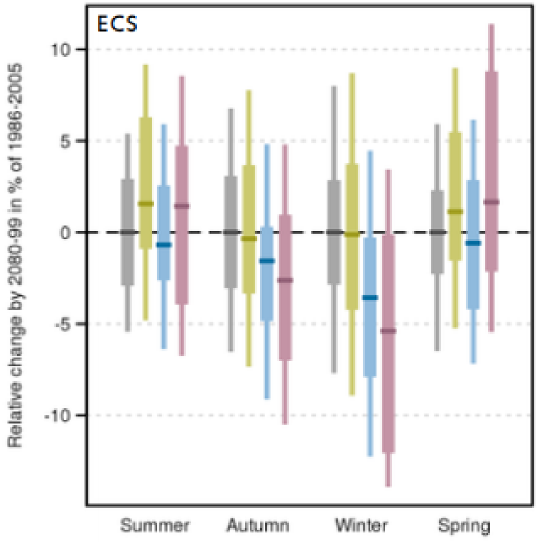


Figure 7: Projected Near-Surface Wind Speed Changes for 2090. Anomalies Are Given As A Percentage With Respect to the 1986-2005 Mean.

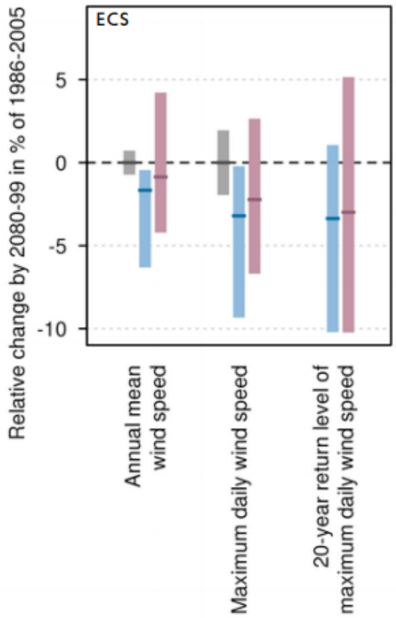


Figure 8:Projected Near-Surface Annual Mean Wind Speed, Annual Maximum Daily Wind Speed and the 20-year Return Value for the Annual Maximum Daily Wind Speed for 2090. Anomalies Are Given As A Percentage With Respect to the 1986-2005 Mean.

4 RISK ASSESSMENT & ADAPTATION PLAN

4.1 Risk Criteria

4.1.1 Risk Assessment Likelihood Scale

The following likelihood scale, taken from AS 5334-2013, was used in the risk assessment for the project for recurrent and single events.

Table 3: Risk Assessment Likelihood Scale

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

4.1.2 Risk Assessment Consequence Scale

The following consequence scale, adapted from *Climate Change Impacts & Risk Management*, was adopted for the risk assessment.

Table 4: Risk Assessment Consequence Scale

Descriptor	Service Quality	Compliance	Infrastructure	Financial
Insignificant	Minor deficiencies in principle that would pass without comment	Concerns about compliance would be resolved without special attention	No infrastructure damage, little change to infrastructure service	Little financial loss or increase in operating expenses
Minor	Services would be regarded as satisfactory but personnel would be aware of deficiencies	Minor perceived or actual breaches of compliance would be resolved	Localised infrastructure service disruption, no permanent damage. Some minor restoration work required. Early renewal of infrastructure by 10-20%. Need for new/modified equipment	Additional operational costs. Financial loss is small <10%.
Moderate	Services would be regarded as barely satisfactory by the general public and the organisation's personnel	Formal action would be required to answer perceived breaches or charges of compliance failure	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 20-50%	Moderate financial loss 10-50%
Major	The general public would regard the organisation's services as unsatisfactory	Significant amounts of management and advisers' effort would be required to answer charges of compliance failures	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service. Early renewal of infrastructure by 50-90%	Major financial loss 50-90%
Catastrophic	Services would fall well below acceptable standards and this would be clear to all	Obvious and proven breaches of legal and regulatory requirements with the prospect of corporate or individual penalties	Significant permanent damage and/or complete loss of the infrastructure and infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal of infrastructure by >90%	Extreme financial loss >90%

4.1.3 Risk Rating Matrix

The following risk rating matrix, taken from AS 5334-2013, was used to determine risk levels.

Table 5: Risk Priority Matrix

		Likelihood				
		Rare	**Unlikely**	**Possible**	**Likely**	**Almost Certain**
Consequence	**Catastrophic**	Low	Medium	High	Extreme	Extreme
	Major	Low	Medium	Medium	High	Extreme
	Moderate	Low	Low	Medium	High	Extreme
	Minor	Low	Low	Medium	Medium	High
	Insignificant	Low	Low	Low	Medium	Medium

4.2 Risk Assessment

NDY's assessment of Meriden Schools' early phase development design identified risks directly related to the site and project risks associated with climate change. These risks were then evaluated using knowledge of existing controls that are already designed to mitigate these risks, the consequences of the risks identified as well as the likelihood of their occurrence for this site. This in turn informed the priority rating for each risk identified in Table 6 below. Additional risk controls have been included for consideration in the developed design phase.

Table 6: Climate Change Risk Register

Aspect	Description of Hazard (Cause & Effect)	Existing Controls	BAU 2030 @ RCP8.5			BAU 2070 @ RCP8.5			Proposed Additional Controls
			Conseq.	Likel.	Risk	Conseq.	Likel.	Risk	
Hotter days More frequent heatwave events Extended drought periods	Soft landscape damage due to high temperatures or drought.	Drought tolerant plant selection and irrigation to include subsoil drippers with moisture sensors.	Insignificant	Possible	Low	Insignificant	Possible	Low	Replacement of species as required.
Hotter days	Cracking and/or failure of seals due to stronger solar radiation and/or extreme temperatures.	Seals to be specified with a 10 year warranty (which is typical). When they need to be replaced, it is anticipated that the market will have shifted to a new technology that is more UV stable to accommodate higher solar radiation.	Minor	Unlikely	Low	Minor	Possible	Medium	When seals are to be replaced look to substitute these with products that have the highest UV protection available at the time of purchase.
Hotter days	Health of maintenance staff and users of external landscaped areas during heat waves.	OHS legislation covers allowable working conditions. Design incorporates external shading elements. Selection of 'cooler' landscaping materials, therefore reducing urban heat island effect, to be incorporated into design. Solar PV and solar hot water incorporated on roof spaces will further prevent unwanted heat gains.	Moderate	Possible	Medium	Moderate	Possible	Medium	None.
Hotter days	Changes in occupant behaviour during heat waves.	Expectation is that Meriden School policy will adapt over time. Design elements include high efficiency building envelopes, mixed mode ventilation, enhanced greening (e.g. green walls and planters), and external shading to support cool and flexible indoor environments.	Insignificant	Possible	Low	Minor	Possible	Medium	May be mitigated via adaptive timetabling (e.g. use of mechanically ventilated classrooms as required).

<table>
<thead>
<tr><th>Aspect</th><th>Description of Hazard</th><th>Existing Controls</th><th colspan="3">BAU 2030 @ RCP8.5</th><th colspan="3">BAU 2070 @ RCP8.5</th><th>Proposed Additional</th></tr>
</thead>
<tbody>
<tr><td>Hotter days</td><td rowspan="2">Increase in electricity and heat rejection water consumption due to higher temperatures.</td><td rowspan="2">The CMD building design already incorporates passive design elements (natural ventilation or mixed-mode ventilation) to reduce electricity consumption from mechanical ventilation, and solar PV. The design also incorporates high-performance building sealing (e.g. glazing, insulation), and enhanced greening (e.g. green walls and planters) for added cooling effects.
The ASC design incorporates high performance building sealing to reduce demand on mechanical ventilation, and solar hot water.
The project also incorporates high efficiency fittings and fixtures to reduce water consumption, and rainwater harvesting.</td><td rowspan="2">Moderate</td><td rowspan="2">Possible</td><td rowspan="2">Medium</td><td rowspan="2">Moderate</td><td rowspan="2">Possible</td><td rowspan="2">Medium</td><td rowspan="2">Size of solar PV, solar hot water, and rainwater tank should be maximised.</td></tr>
<tr><td>More frequent heatwave events</td></tr>
<tr><td>More frequent heatwave events</td><td>HVAC or natural ventilation not maintaining internal conditions during heat waves.</td><td>Passive design elements (e.g. external shading, high-efficiency insulation) and high-efficiency building sealing included at this early stage of design will reduce demand for mechanical ventilation. Spill air from conditioned spaces to the naturally ventilated spaces in the CMD building will help to maintain comfortable internal conditions.</td><td>Minor</td><td>Possible</td><td>Medium</td><td>Minor</td><td>Likely</td><td>Medium</td><td>HVAC design conditions to take into account climate change specific to Meriden School / Strathfield region.
Chiller replacement is likely prior to 2090 and replacement equipment will be expected to have increased efficiencies to better cope with extreme temperatures.</td></tr>
<tr><td>Extended drought periods</td><td>Decrease in available rainwater due to lower rainfall (impact on water harvesting and opportunity for reuse).</td><td>Rainwater harvest system to reduce potable water consumption when rainwater is available. Main potable water to support usage when rainwater not available. Additional cost of mains potable water is the main impact.</td><td>Insignificant</td><td>Possible</td><td>Low</td><td>Insignificant</td><td>Possible</td><td>Low</td><td>None.</td></tr>
</tbody>
</table>

Aspect	Description of Hazard	Existing Controls	BAU 2030 @ RCP8.5			BAU 2070 @ RCP8.5			Proposed Additional
More extreme rainfall events	Rainwater / stormwater system blockage as a result of higher flows, dust and silting.	There are a number of collection points that would accumulate silt, meaning there is no single point of failure. Rainwater tank to have drainage valve incorporated into the design for maintenance.	Minor	Unlikely	Low	Minor	Possible	Medium	Increase frequency of maintenance in line with more intensive rainfall events.
More extreme rainfall events	Water entering ground floor of CMD or ASC due to overland flow and/or localised flooding. Water entering below-ground levels of CMD, and critical infrastructure rooms (e.g. electrical substation, gas meter room). May affect access to the building for students and staff, or emergency services. Sediment / debris may build up in surrounding drainage infrastructure due to less frequent washout in drought).	CMD and ASC designs incorporate a high level of building sealing, particularly around windows and doors. Interior finishes (e.g. flooring, plasterboard) selected for their resilience and non-slip qualities. Entry mats to be quick-dry (standard). Rainwater tank and pump located in Level -2 of CMD.	Moderate	Unlikely	Low	Moderate	Possible	Medium	Rainwater catchment landscaping to prevent overland flow (e.g. from turning circle into the ASC or between Hope Turner and CMD buildings).
Extended drought periods	Airborne dust soiling ventilation filters, dirtying solar panels and facade more rapidly.	Easy access to HVAC equipment and the facade is provided for regular maintenance. Solar PV panels mounting to be considered in developed design – angled mounting would provide a degree of self-cleaning. The facade cleaning regime will typically occur on a six-monthly basis as standard.	Minor	Unlikely	Low	Minor	Unlikely	Low	Filter replacement is part of the maintenance regime. Replacement of filters will likely be required on a more frequent basis.

Aspect	Description of Hazard	Existing Controls	BAU 2030 @ RCP8.5			BAU 2070 @ RCP8.5			Proposed Additional
Gustier wind conditions	Structural failure (e.g. external shading, glass balustrade) due to stronger winds.	Structural items are designed in accordance with AS1170.2 (wind code) for a return period of 1 in 500 year ultimate wind speed event. Negligible wind speed increase anticipated at either time slice or RCP at the time of assessment.	Catastrophic	Rare	Low	Catastrophic	Rare	Low	None, likelihood of occurrence has been designed away.

5 RECOMMENDATIONS

The climate change risk assessment process has assessed all risks, including existing controls, as being either 'low' or 'medium'. This is a reflection on the fact that the designers of the project have already incorporated a number of adaptation measures – either intentionally or serendipitously – into the design.

The process has identified a number of additional adaptation measures which may be adopted to reduce risk to ALARP (as low as reasonably practicable) levels. Key recommendations include those listed below:

- HVAC design conditions to take into account climate change specific to Meriden School / Strathfield region.
- When chilled water plant is replaced mid-life, take into account current climate and projected climate change, and ensure replacement equipment is able to maintain conditions during extreme temperature events.
- During drought and after periods of heavy rainfall, increase maintenance of rainwater and stormwater drainage systems to avoid blockages and clean out siltation.
- Building management should have an emergency management plan (with effective incident response actions) in place for major and catastrophic events. The plan should include a methodology for effective communication to building users and regular updates.
- If dust storms or bushfires with heavy smoke do eventuate, urgently undertake cleaning of ventilation system filters, and prioritise cleaning of solar panels and the facade.

NDY recommends that this adaption plan should be reviewed again during design development, and on a regular basis (every 5 years) after project completion. The data should be reviewed to ensure that accuracy is maintained and new data is captured so that changing circumstances can be taken into account and evaluated.

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