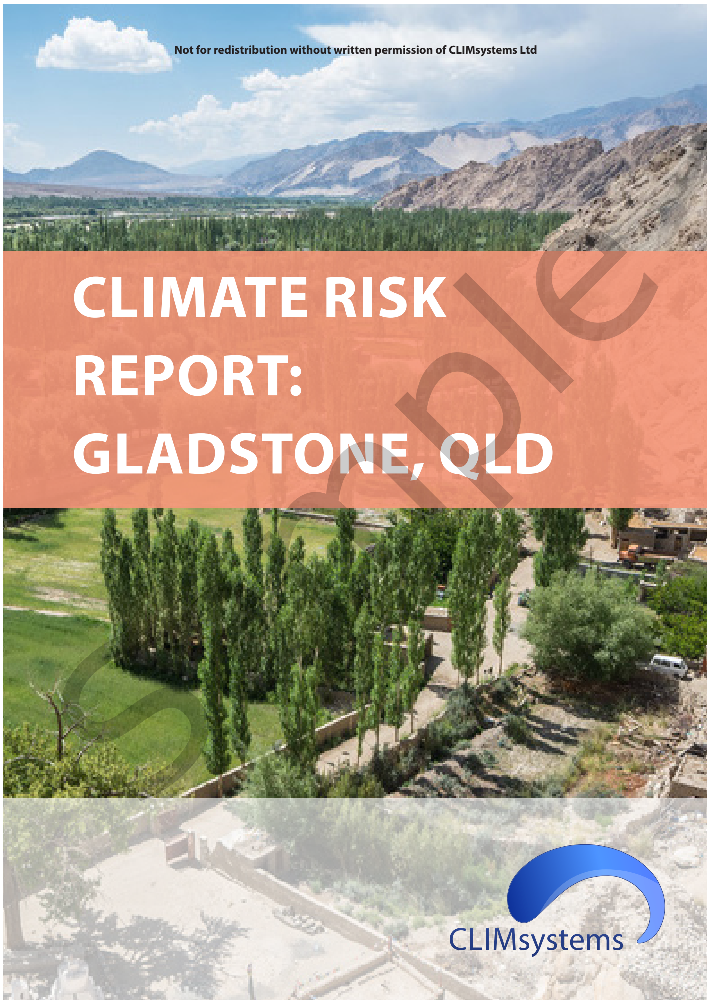


CLIMATE RISK REPORT: GLADSTONE, QLD

CLIMsystems

INTRODUCTION

CLIMATE CHANGE
2050 COMPARED TO 1995
RCP 8.5 HIGH EMISSIONS

This report assesses the climate change effects expected for Gladstone, QLD, by 2050. As this is about the future, assumptions are made on the greenhouse gas emissions between 1995 (the baseline year) and 2050. In line with the IPCC Fifth Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPPC, 2013), the RCP8.5 emission pathway was selected to describe these future emissions. Although it is the pathway with the highest emissions, it still conforms with a business-as-usual scenario where limited measures are taken to decrease the global emissions of greenhouse gases.

HIGH CLIMATE SENSITIVITY

Another assumption is made about climate sensitivity. This is a factor that describes the relation between the increase in atmospheric greenhouse gas concentrations and the resulting increase in air temperature. Some Global Circulation Models (GCMs) show a high sensitivity, while others show a lower response. This report uses the high climate sensitivity in order to capture the upper echelon of climate change effects.

MONTHLY VALUES SEASONS

Where possible, results in this report are disaggregated to a monthly level, next to the change in yearly values. This allows for showing differences in climate change between wet/dry and colder/warmer seasons.

LIMITED SCOPE

As this report is the result of a quality-controlled but semi-automated process, it is necessarily limited in the scope of the outputs presented.

ISSUES

Has detailed high resolution modelling of extreme wave height and point over threshold modelling of all the components of an extreme sea level rise event been completed including local bathometry?

Has modelling been undertaken to forecast the required capacity draining and recovery of Port infrastructure from the combined effects of a storm surge and sea flooding and extreme rainfall, land-based flooding that includes the wider supply chain for the Port's commodity products including potential loss of production from mines themselves owing to extreme rainfall, flood or drought and fire-related hazards such as loss of power supply. If at risk, what measures are in place to mitigate these risks?

What are the current design thresholds/ parameters in relation to climate stress (temperature, extreme wind, flooding, fire etc)? Are failure limits sufficient under future climate?

Has water scarcity in the future been addressed for commodity suppliers (mines) and also for the Port itself through increasing storage capacity or supply contracts?

METHODS

AR5
CMIPS
CLIMSYSTEMS

The outputs in this report are generated using the results of the IPCC Fifth Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPPC, 2013). These results are freely available to the public, on the CMIP5 website (http://cmip-pcmdi.llnl.gov/cmip5/data_portal.html). However, the formats and sheer quantity of information make it challenging to process and apply the data to generate useful information. That is where CLIMsystems comes in. We have downloaded, processed and analysed the data and transformed these in change patterns (see Annex 1 for a list). Change patterns describe the (linear) relationship between a local change and a global change for any of the climate variables.

CHANGE PATTERNS
STATISTICAL DOWNSCALING

Change patterns have a spatial resolution that in first instance is dictated by the Global Circulation Model (GCM) they are based on. Using additional information, the patterns can be "downscaled" to a higher resolution. We are using "statistical" downscaling to generate higher resolutions.

FULL ENSEMBLE OF GCMS

The different GCMs produce different results, because they use different sets of processes, different spatial and temporal resolutions, and are validated on different datasets, with different emphasis on locations. Thus instead of using just one GCM, the preferred approach is to use an ensemble of GCMs, whereby their results are combined (Tebaldi and Knutti, 2007). Research (Wigley, 2008) has shown that an ensemble outperforms any single member of that ensemble. This report uses the full set of available GCMs for each specific output.

RCP

Future greenhouse gas concentrations are determined by future greenhouse gas emissions. In AR5, these emissions are described by the RCP's, Representative Concentration Pathways, with four different definitions, each presenting a different society with different policies and use of energy resources like fossil fuels.

RCP 8.5

The outputs of this study are based on the RCP8.5 pathway with the highest emissions, as this is the path we are currently following, with no clear reductions of emissions anytime soon. It will therefore show what will happen if we do not act.

CLIMATE SENSITIVITY
HIGH

Climate sensitivity describes the relation between the increase in atmospheric greenhouse gas emissions and the resulting increase in air temperatures. It is not an input to the GCMs but a result of all the physical, chemical and biological interactions that are modelled. Some GCMs show a high sensitivity, while others show a lower sensitivity. This report uses the high climate sensitivity in order to capture the potentially upper echelon of climate change effects.

CLIMATE VARIABLE

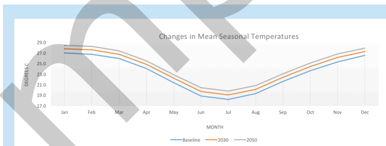
TEMPERATURE

Summary of Impacts: Slow onset warming that is moderated somewhat by the proximity to the sea whose temperatures rise more slowly than more continental areas. Extremes rising in magnitude along with heatwaves that will become more frequent and also with greater maximum temperatures with implications for health and social services and also energy demand.

	Temperature	Units	Baseline	2030	2050	Trend	Confidence
Mean	Annual Temp.	°C	23.1	23.9	24.6		Very Likely
	Change in Global Mean Temp.	±°C		0.74	0.94		Very Likely
	Change in Regional/Local Mean Temp.	±°C		0.80	1.50		Very Likely
Extreme	1/100yr Extreme Max. Temp.	°C	41.8	42.6	43.2		Very Likely

a. Monthly and Mean Temperature

Summary of data: Projected change in daily maximum temperature from an ensemble of GCMs. The 10- and 90-percentile are given as well as the median. The 90-percentile corresponds to the value that 90% of the GCMs stay below. The change in temperature is relatively uniform over the year as depicted in the monthly graphic. There is a slight increase in the range of temperatures in the winter (greater increase month on month) than in the summer months meaning that overall winters will become milder and the increase in temperatures relative to the baseline temperature will be greater in the winter months than in the summer months.



Temperature C	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
	Baseline	26.9	26.7	25.8	24	21.3	18.7	18.1	19.2	21.5	23.6	25.2	26.4	23.1
	2030	27.7	27.5	26.6	24.8	22.1	19.6	19	20	22.3	24.3	26	27.2	23.9
	2050	28.3	28.1	27.3	25.4	22.7	20.4	19.7	20.7	23	25	26.7	27.8	24.6
10 per	2030	27.5	27.3	26.4	24.6	21.9	19.3	18.7	19.8	22.1	24.2	25.9	27	23.7
	2050	27.9	27.8	26.8	25.1	22.4	19.8	19.2	20.3	22.6	24.7	26.4	27.5	24.2
90 per	2030	28	27.8	26.9	25	22.3	19.8	19.3	20.3	22.5	24.6	26.3	27.6	24.2
	2050	28.9	28.7	27.8	25.8	23.2	20.7	20.3	21.2	23.3	25.5	27.1	28.5	25.1

a. Monthly and annual average daily maximum temperature

Ramifications: There is a slight increase in the range of temperatures in the winter (greater increase month on month) than in the summer months meaning that overall winters will become milder and the increase in temperatures relative to the baseline temperature will be greater in the winter months than in the summer months. Overall this will lead to a shortening of the cooler period for Gladstone resulting in longer summers and earlier springs. By 2050 this will mean approximately one additional month of summer and spring time temperatures arriving one month earlier or a shortening of the winter temperature period by two months.

The shift in temperature regimes, effectively shortening the length of winter time low temperatures. Extremes in temperatures increases on a annual basis are moderated somewhat for Gladstone by its proximity with the sea. The days when cooling will be required could extend markedly by 2050 with a potential additional two months added to the warmer season and this will have concomitant impacts on energy demand and potentially water. There can be health implications with changes in length of warm season with disease vectors able to overwinter.

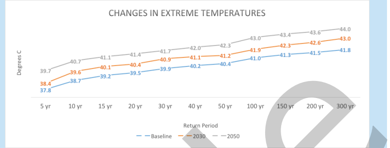
b. Heat Waves and Cooling Degree Days

Data Summary: Heat waves are periods of consecutive days with high temperatures. They are extreme events, which show a stronger response to climate change than averages (i.e. monthly temperatures). The table shows the change in average maximum temperatures from 5-day periods for different return periods. A return period, also known as a recurrence interval, is an estimate of the likelihood that an event (such as an earthquake or flood) will occur. For example, the probable incidence of a particular level of flooding might be once every 100 years (return period); otherwise expressed as its probability of occurring being 1/100, or 1% in any one year.

Ramifications: Heat waves not only occur more often they will also become hotter. The one in two year events of 5 consecutive days with a temperature above 34.2 degrees will occur every year by 2050. The one in five year event will have a 70 percent probability of occurring in any one year by 2050 or 2.5 times more frequently. The 1 in 100 year event could have a 14 percent risk of occurring each year by 2050. Moreover the five day temperatures would be hotter at 35.7 degrees by 2050 for the 1.4 year return period for the current 2 year return period and 38.4 degrees for five days running for the 7.1 year return period in 2050 for the current 1 in 100 year event. Heat waves can also be related to cooling degree days that are translated to energy demands. The table for cooling degree days for Gladstone shows a steady increase with near 14 percent more cooling degree days in 2030 and 23 percent by 2050.

	Cooling Degree Days	
Baseline	1621	% change
2030	1883	13.9
2050	2111	23.2

Degree days and climate change



b. Changes in extreme temperature values by return period.

Heath issues are paramount during extreme temperature events. Worker performance and injury during heat waves is already an issue and will only be exasperated by the shift toward ever warmer temperatures and more frequent return periods for such extreme events. Energy demands for cooling will become greater while efficiency for fossil fuel based generation units declines as temperatures rise. Energy transmission infrastructure is also taxed by high temperature events and the confluence of high temperatures, high energy demands, reduced generation efficiency and infrastructure overloading issues point toward risks to the power grid and serious community health risks if power supplies are interrupted. As the degree day table depicts upward to a 25 percent increase in cooling degree days by 2050 will translate to a considerable impact on energy required for cooling. Of course technology changes cannot for discounted but the potential for a sharp increase in energy demand in line with population growth and greater night time temperatures and higher day time temperatures all factor into demand.

5 Day Heat wave		Future 5 Day Temp		Baseline Rtn Period Yrs	
Return period Yrs	Baseline Degrees C	2030 Degrees C	2050 Degrees C	2030	2050
2	34.2	35.1	35.7	1.2	1.0
5	35.1	36.0	36.6	2.1	1.4
10	35.6	36.5	37.2	3.5	1.9
20	36.1	36.9	37.6	5.8	2.7
50	36.6	37.4	38.1	11.7	4.7
100	36.9	37.8	38.4	19.8	7.1

Degree days and climate change

CLIMATE VARIABLE

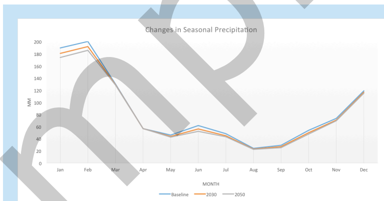
PRECIPITATION

Summary of Impacts: Slow onset climate change will result in a reduction in annual precipitation with most of that reduction coming from the wetter summer months with winter precipitation largely unchanged. Extremes will however become slightly more extreme with implications for flood management.

	Precipitation	Units	Baseline	2030	2050	Trend	Confidence
Mean	Mean Annual Precip.	mm	762	731	705		Likely
	Change in Local Mean Annual Precip.	%		-4	-7		Likely
Extreme	Intensity of a 1/100yr Event	mm	301	322	339		Likely
	Intensity Changes of a 1/100yr Event	%		7	11		Likely
	Number of Days of Severe Drought	days	59	60	59		Likely

a. Annual and Monthly Mean Precipitation

Summary of data: The change in precipitation as a result of climate change is different from place to place. While some locations show an increase, others show the opposite. It can also change through the year. The table below shows the change from a full GCM-ensemble per month, as well as annually, showing both the average and median (as a percentage of the baseline), which are usually close. It also shows the 10- and 90 percentile values, which express the uncertainty in the modelling results. Some locations/months will show both negative and positive values, indicating that precipitation could increase or decrease.



Precipitation	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
	Baseline	153.1	144.9	90.0	48.2	58.5	37.8	34.5	32.0	26.9	58.6	72.4	132.0	888.9
	2030	146.0	138.9	89.3	48.1	56.2	34.5	32.6	30.7	24.9	54.6	70.4	129.4	855.4
	2050	140.3	134.1	88.7	48.0	54.2	31.9	31.0	29.6	23.2	51.3	68.7	127.3	828.3
10 per	2030	125.9	125.6	78.3	35.6	48.9	28.0	27.1	26.1	20.0	44.5	55.9	106.1	722.1
	2050	103.8	110.1	68.9	25.4	41.2	20.1	21.2	21.4	14.4	33.0	42.5	85.2	587.3
90 per	2030	179.9	173.2	112.1	58.2	69.9	46.5	37.8	43.0	30.7	67.2	83.9	143.9	1046.2
	2050	201.5	196.1	130.0	66.3	79.0	53.6	40.4	51.9	33.7	74.1	93.1	153.6	1173.3

a. Monthly and annual average daily maximum temperature

Ramifications: Gladstone is likely to face a decrease in annual precipitation over time with the majority of the trimming in rainfall coming during the wetter months with the drier winter months remaining relatively stable. It is not a profound decrease but considering that over time extremes are likely to increase then the time between rainfall events and the intensity (decrease) of the interim rainfall could become more noticeable and have wider impacts.

These changes in rainfall regime with changes in temperature could lead to additional water stress that is of short duration but would still have consequences for water supply. Overall the implications are related to management of the water supply given the overall decrease in annual rainfall in light of growing demand with population growth and industrial development of the port and the wider region. This also needs to be considered in conjunction with the rising temperatures and lengthening of the warmer season and shortening of the cooler winter period when water demand is reduced. Evapotranspiration rates will increase and demands for water for non-household use could increase and alternative approaches to storage of rainy season precipitation may need to be considered such as household water tanks and community water tanks capturing water from larger paved areas. Commercial properties may already be considering rainwater capture for non-potable water applications.

b. Extreme Precipitation Events

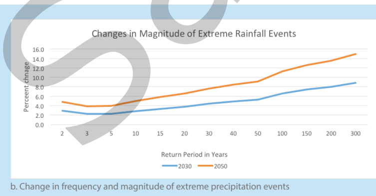
Summary of data: Percentage change in the magnitude of extreme daily events for given return periods. The same percentage change value can be used for different-length extreme events (from 1-day to multi-day). In general, the percentage increase for the more rare events (100+ year events at the bottom of the table) will be higher than the increase of the more frequent events (at the top of the table).

Ramifications: Extreme events and their magnitude change marginally for the shorter return period events of between 2 and 5 year return periods. They do intensify slightly in contrast with the decline in annual precipitation expected across the region. Implications for shifts in flooding are not strongly related to the increase in the intensity of individual events but are marked by an increase in frequency. The shortening of return periods is telling with the 1 in 100 year event almost doubling in frequency by 2050.

The methodology used is capable of showing an increase in extreme event magnitudes even for locations where the climate change drives a decrease in average precipitation. The methodology can therefore indicate that although monthly and annual precipitation may be declining for a specific locality when an extreme rain event does occur then the models do show that this event may in fact be more intense in the future. This is a very important aspect of climate modelling that indicates that short term extreme events must be modelled and the results managed differently than longer temporal analysis (monthly and yearly totals). For example, it is becoming apparent that short term but high intensity rainfall events are becoming more common and local capacity for managing such events needs to be considered. Not only does new infrastructure design and upgrading of old infrastructure need to be considered but also emergency services need to factor in such changes in their disaster risk and recovery planning. Therefore the two ends of the temporal spectrum need attention: the very short duration (minutes to hours) events can cause considerable disruption and damage and while not modelled here the shift in their frequency and magnitude with climate change can be. Also the greater magnitude events are can also tax infrastructure and cause disruption to economic activities.

Return Period	Baseline	2030		2050	
Years	mm	mm	Base RP	mm	Base RP
2	99	101.9	1.9	104	1.8
3	122.9	125.7	2.9	127.8	2.8
5	150.1	153.4	4.7	156.1	4.5
10	185.1	190.3	9.1	194.6	8.4
15	205.2	212.2	13.2	217.9	12
20	219.5	228	17.2	234.9	15.4
30	239.8	250.7	24.7	259.6	21.7
40	254.3	267.2	31.9	277.7	27.5
50	265.6	280.3	38.9	292.2	33
100	301.1	322.3	70.8	339.4	57.2
150	322.3	347.9	100	368.8	78.2
200	337.4	366.7	127.3	390.4	97.2
300	359.1	393.8	178.2	422.2	131.5

b. Change in frequency and magnitude of extreme precipitation events

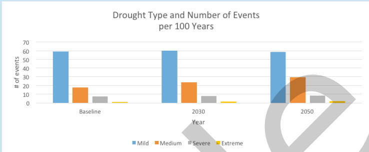


b. Change in frequency and magnitude of extreme precipitation events

c. Drought Conditions

Summary of data: Drought is a natural phenomenon, and waxes and wanes in extent and duration in an apparently random manner. However, drought is predominantly controlled by precipitation and, to a lesser extent, by air temperature. Both of these climate variables are projected to change along with global warming, which will cause possible frequency and severity changes of drought conditions. One way to manage the randomness of drought occurrence is to examine the potential changes in the frequency of specific drought intensities. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The positive sum of the (Standard Precipitation Evapotranspiration Index) SPEI for all the months within a drought event can be termed the drought's "magnitude".

Ramifications: Mild droughts occur in the Gladstone just about every year. Over time the number of mild droughts will remain stable. The greatest change over time in drought frequency is with medium droughts that will change from an average of 1 in 6 years to 1 in 4 and 1 in 3 years respectively by 2030 and 2050. The severe and extreme drought frequency will stay relatively unchanged over time.



	Baseline	2030	2050	RTN 2030	RTN 2050
Mild	59.2	60	58.6	1 in 0.6	1 in 0.7
Medium	17.7	23.5	29.5	1 in 4	1 in 3
Severe	7.2	7.6	8.2	1 in 14	1 in 13
Extreme	0.9	1.5	1.9	1 in 66	1 in 52

b. Change in frequency and magnitude of extreme precipitation events

Drought is a test of societal resilience. In Australia many communities are accustomed to and adapted for mild drought especially when water stress occurs on an almost annual basis. With the increase in intensity of drought resilience can be tested. With the return period of medium drought shortening the resilience of society may be tested as recovery periods shorten prior to the potential onset of the next mild or medium drought and potentially more severe events although they are more rare. Investment in resilience can take many forms from reducing demand for water year around so that supplies can be maintained during periods of stress to enhancement of storage to mitigate risks to some extent for medium and more severe events.

CLIMATE VARIABLE

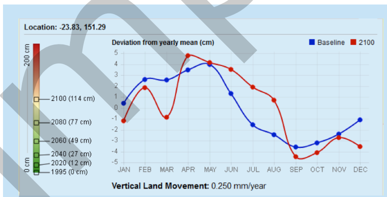
SEA LEVEL RISE

Summary of Impacts: The changes in sea level with time and the rate of change for the Gladstone can signify important thresholds for decision making on management of the coastal zone. For Ports and other critical infrastructure recent analyse has shown that only an 11 cms rise in sea level can lead to a doubling of losses. In general, damages typically increase faster than sea level rise itself. With extreme surge events exacerbated by sea level rise risks and loss and damage will increase if proactive adaptation measures are not taken.

	Sea Level Rise (cms)	Units	Baseline	2030	2050	Trend	Confidence
Mean	Change in Global Mean Sea Level	±mm	-	13	25	●	Very Likely
	Change in Local Sea Level	mm	-	20	38	●	Very Likely
Extreme	Magnitude of a 1/100yr Storm Surge	m	1.2	1.5	1.5	○	Very Likely
	Magnitude Changes of a 1/100yr Storm Surge	%		-	-	●	Very Likely

Sea Level Rise and Storm Surge

Summary of data: As with the other variables, sea level and its rate of rise are not constant over the year. Besides the projected increase in sea level for different projection years (2020, 2040, 2060, 2080 and 2100) the image to the right also shows the monthly anomalies (the deviations of the yearly average) for both the baseline (1995) that is considered as 0.0 cms of sea level rise although we are aware that there has been sea level rise prior to 1995 and the future year of 2100.



b. Change in frequency and magnitude of extreme precipitation events

Ramifications: Within the Gladstone region the seasonal range is approximately 7.5 centimetres with above average months from January through June when tropical cyclones can influence extreme sea level rise events for the region versus the late winter and early spring months when such storms are not a risk. The change in seasonal variability from the baseline to 2100 does change for Gladstone with the higher range prevailing through to August while the range increases to closer to 10 cms.

Sea level rise is important for coastal urban areas as these tend to be ports and/or recreational or lifestyle choice zones for human development that involves substantial infrastructure and public and personal investment. The use of a projected global value of close to 1 metre or 3 feet of sea level rise by 2100 is not an appropriate approach to the management of change: sea level rise varies in its slow onset around the Earth, as one of its key drivers (thermal expansion, the process whereby water expands in volume as it increases in temperature) is different as geographies change. Moreover, the sea level rise that is experienced locally, also depends on the local vertical land movement: if land moves up, it diminishes the impact of local sea level rise but if land is subsiding this can exacerbate local sea level rise. Sea level rise also varies seasonally and the application of newly available data on monthly sea level rise permits us to now examine these seasonal variations that can lead to different risk profiles at certain times of year over others and these seasonal variations will also change with climate change. Sea level rise and storm surge will both increase and the movement of the cyclone belt further south while not necessarily leading to greater intensity cyclones could lead to more frequent events which could be exacerbated by rising sea levels with implications for port infrastructure and coastal erosion.

The changes in sea level with time and the rate of change for the Gladstone can signify important thresholds for decision making on management of the coastal zone. For Ports on other critical infrastructure recent analyse has shown that only an 11 cms rise in sea level can lead to a doubling of losses. In general, damages typically increase faster than sea level rise itself (Boettle et al., 2016).

Soft and hard technologies and strategies for staged retreat from the coast can all be influenced by the not only the shear rise in sea level rise but also the rate of change. Further analysis can be considered for extreme sea level rise events which can cause considerable damage over the short term and which will be further exacerbated as sea levels rise with time.

		2030	2050
Changes in Global Mean Sea Level Rise	M	0.17	0.32
Changes in Local Sea Level	M	0.2	0.50
	Units	**2030**	**2050**
Magnitude of a 1/100yr Storm Surge	Metre	1.35	1.49
Magnitude Changes of a1/100yr Storm Surge	%	11.1	19.5
Storm Surge With Sea Level Rise		1.55	2.05

Global and local Sea level change with storm surge.

CLIMATE VARIABLE

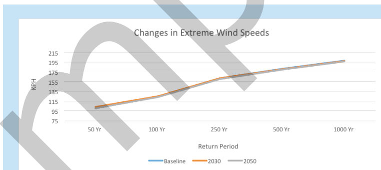
WIND SPEED

Summary of Impacts: Projecting changes in wind-speed from climate change can be challenging: there is typically a high level of disagreement between the GCMs, while an ensemble average/median can be a very low figure. However, a value properly defined by the limitations of the modeling is far better than no value at all, therefore the results for changes in wind-speeds are presented in the same way as for temperature and precipitation diminishes the local sea level rise.

	Wind Speed	Units	Baseline	2030	2050	Trend	Confidence
Mean	Annual Mean Wind Speed	±km/hr	29	30.0	30.4	●	About as likely as not
	Change in Local Average Wind Speed.	±km/hr		3.0	4.6	●	About as likely as not
Extreme	Magnitude of a 1/100yr Cyclone Wind Speed	km/hr	123.7	125.0	123.3	●	About as likely as not
	Magnitude Changes of a 1/100yr Cyclone Wind Speed	%	-	1.0	-0.5	●	About as likely as not

a. Annual and Monthly Mean Wind Speed

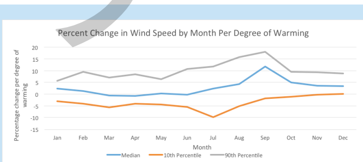
Summary of data: Projecting changes in wind-speed from climate change can be challenging: there is typically a high level of disagreement between the GCMs, while an ensemble average/median can be a very low figure. However, a value properly defined by the limitations of the modelling is far better than no value at all, therefore the results for changes in wind-speeds are presented in the same way as for temperature and precipitation.



	50 Yr	100 Yr	250 Yr	500 Yr	1000 Yr
Baseline	100	124	162	181	198
2030	102	125	162	180	197
2050	100	123	161	180	197

a. Change in extreme wind speed by return period

Ramifications: The return periods for extreme winds are in line with historical events. Gladstone has not experienced many high wind cyclones over the last 100 years. Majority are Category 1 which is reflected in the baseline data. The fact that winds drop in later periods is part of the GCM output that do indeed show tropical cyclone wind speeds dropping in some areas of the globe in the future and points to the wide range of uncertainty in future climate change cyclone wind modelling.



a. Change in extreme wind speed by return period

Cyclone events while rare for this part of the Queensland coast can have implications for continuity of supply chains given the rising importance of the port. As noted with sea level rise the implications of cyclone-related storm surge with the compounding factor of sea level rise will mean that wind speeds will influence storm surge and wave set up. The trend into the future in not for a great intensification of extreme wind speeds. The frequency of events is likely to increase as tropical cyclones in this part of the world migrate further and further south at the rate of about 62 kilometres per century (Kossin et al. 2014). This could have implications for the number of cyclones impacting on Gladstone over the coming decades in conjunction with storm surge and sea level rise could be a major area for consideration in future planning for port development and resilience enhancement.

Category	Maximum Wind Gust (km/hr)	Potential Damage
1	<125	minor
2	125-170	moderate
3	170-225	major
4	225-280	devastating
5	>280	extreme

Date	Name	Category	Pressure
5/04/21		1	988
30/05/41		?	?
30/04/48		1	1002
2/03/49		3	972
26/02/50		1	998
22/03/53		1	1009
21/02/71	Fiona	1	996
2/04/72	Emily	2	974
5/03/73	Dawn	1	988
15/02/92	Fran	2	980

a. Change in extreme wind speed by return period

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GLOSSARY OF TERMS

The following glossary is extracted largely from the WMO Book of Climate knowledge for action: a global framework for climate services – Empowering the most vulnerable.

Adaptation: The process or outcome of a process that leads to a reduction in harm or risk of harm, or a realisation of benefits associated with climate variability and climate change.

Capacity building: The process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems, and the wider social and cultural enabling environment.

Climate: Climate is typically defined as the average weather over a period of time. The quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense, is the state of the climate system, including its statistical description. For the purposes of this report, we have used the term climate to represent time periods of months or longer.

Climate change: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The Intergovernmental Panel on Climate Change uses a relatively broad definition of climate change that is considered to mean an identifiable and statistical change in the state of the climate which persists for an extended period of time. This change may result from internal processes within the climate system or from external processes. These external processes (or forcing) could be natural, for example volcanoes, or caused by the activities of people, for example emissions of greenhouse gases or changes in land use. Other bodies, notably the United Nations Framework Convention on Climate Change, define climate change slightly differently. The United Nations Framework Convention on Climate Change makes a distinction between climate change that is directly attributable to human activities and climate variability that is attributable to natural causes. For the purposes of this report, either definition may be suitable, depending on the context.

Climate change projection: A projection of the response of the climate system to emission scenarios of greenhouse gases and aerosols, or radiative forcing scenarios based upon climate model simulations and past observations. Climate change projections are expressed as departures from a baseline climatology, for example, that future average daily temperature in the summer will be 2°C warmer for a given location, time period and emissions scenario.

Climate model: A simplified mathematical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedbacks between them.

Climate variability: Climate variability refers to variations in the mean state and other statistics relating to the climate on all temporal and spatial scales beyond that of individual weather events. Climate can and does vary quite naturally, regardless of any human influence. Natural climate variability arises as a result of internal process with the climate system or because of variations in natural forcing such as solar activity.

Downscaling: The process of reducing coarse spatial scale model output to smaller (more detailed) scales.

Ensemble: A set of simulations (each one an ensemble member) made by either adjusting parameters within plausible limits in the model, or starting the model from different initial conditions. While many parameters are constrained by observations, some are subject to considerable uncertainty. The best way to investigate this uncertainty is to run an ensemble experiment in which each relevant parameter combination is investigated. This is known as a perturbed physics ensemble.

External climate forcing: One component of the Earth's natural climatic variability, is that due to external variability factors, which arise from processes external to the climate system, chiefly, volcanic eruptions and variations in the amount of energy radiated by the sun.

Extreme weather and climate events: Extreme events refer to phenomena such as floods, droughts and storms that are at the extremes of, or beyond, the historical distribution of such events.

Forecast: Definite statement or statistical estimate of the likely occurrence of a future event or conditions for a specific area. Generally used in reference to weather forecasts, and hence to weather a week or so ahead.

General Circulation Model (GCM): A General Circulation Model, or sometimes called a global climate model, is a mathematical model of the general circulation of the planet's atmosphere or oceans based on mathematic equations that represent physical processes. These equations are the basis for complex computer programs commonly used for simulating the atmosphere or oceans of the Earth. General Circulation Models are widely applied for weather forecasting, understanding the climate, and projecting climate change.

Greenhouse gas: A gas within the atmosphere which absorbs and emits energy radiated by the Earth. Carbon

dioxide is the most important greenhouse gas being emitted by humans.

Mitigation: Action taken to reduce the impact of human activity on the climate system, primarily through reducing net greenhouse gas emissions.

Observation: Observation, or observed data, refers to any information which has been directly measured. In climatology, this means measurements of climate variables such as temperature and precipitation.

Prediction: The main term used for estimates of future climatic conditions over a range of about a month to a year ahead.

Probability: Probability is a way of expressing knowledge or belief that an event will occur, and is a concept most people are familiar with in everyday life. Probabilistic climate projections are projections of future absolute climate that assign a probability level to different climate outcomes.

Projection: A Projection is an estimate of future climate decades ahead consistent with a particular scenario. The scenario may include assumptions regarding elements such as: future economic development, population growth, technological innovation, future emissions of greenhouse gases and other pollutants into the atmosphere, and other factors.

Regional Climate Model (RCM): A regional climate model is a climate model of higher resolution than a global climate model. It can be nested within a global model to provide more detailed simulations for a particular location.

Risk: Risk is conventionally defined as the combination of the likelihood of an occurrence of an event or exposure(s) and the severity of injury or cost that can be caused by the event or exposure(s). Understanding the risks and thresholds, including uncertainties, associated with climate is one principle of good adaptation.

Risk management: The systematic approach and practice of managing uncertainty to minimize potential harm and loss. Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimise risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts and damage from fire and natural hazards. Risk management is a core issue for sectors such as water supply, energy and agriculture whose production is directly affected by extremes of weather and climate.

Sea level rise: Sea level rise can be described and projected in terms of absolute sea level rise or relative sea level rise. Increasing temperatures result in sea level rise by the thermal expansion of water and through the addition of water to the oceans from the melting of ice sheets. There is considerable uncertainty about the rate of future ice sheet melt and its contribution to sea level rise.

Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Uncertainty: Uncertainty refers to a state of having limited knowledge. Uncertainty can result from lack of information or from disagreement over what is known or even knowable. Uncertainty may arise from many sources, such as quantifiable errors in data, or uncertain projections of human behaviour. Uncertainty can be represented by quantitative measures or by qualitative statements. Uncertainty in climate change projections is a major problem for those planning to adapt to a changing climate. Uncertainty in projections of future climate change arises from three principal causes: natural climate variability; modelling uncertainty, referring to an incomplete understanding of Earth system processes and their imperfect representation in climate models; and uncertainty in future emissions.

Variable: The name given to measurements such as temperature, precipitation, etc. (climate variables), sea level rise, salinity, etc. (marine variables) and cooling degree days, days of air frost, etc. (derived variables).

Vulnerability: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Vulnerability to climate change refers to the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects. The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions. All societies have inherent abilities to deal with certain variations in climate, yet adaptive capacities are unevenly distributed, both across countries and within societies. The poor and marginalised have historically been most at risk, and are most vulnerable to the impacts of climate change.

Weather: The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity and barometric pressure.