Byron and Tweed Shire Councils

Climate Change Risk Assessment

Final Report

May 2009

Australian Government

Department of Climate Change

This report has been partly funded by the Australian Government Department of Climate Change under its Local Adaptation Pathways Program. It was prepared by GHD Pty Ltd on behalf of Byron Shire Council and Tweed Shire Council.

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Executive Summary

The Australian Government recognises the need for local government to understand the risks posed by climate change and has provided initial funding for local councils. As a component of the Local Adaptation Pathways Program (LAPP), Byron and Tweed Shire Councils conducted a risk assessment for the potential impacts of climate change [relevant to both the councils], which will be followed by the development of an Adaptation Planning exercise. The scope of this project included the geographic region of the Byron Shire Council and Tweed Shire Council.

The risk assessment was conducted using the prescribed methodology for funding approval as defined in *Climate Change Impacts and Risk Management: A Guide for Business and Government* (AGO[1], 2006), which is aligned with the Australian Standard for Risk Management (AS/NZ 4360 - 2004). The risk framework utilised was based on the consequence and likelihood criteria defined in the Australian Greenhouse Office (AGO) Guide. Please note that the AGO no longer exists and the functions have now been transferred to the Australian Government Department of Climate Change (DCC).

The Risk Assessment Workshop identified twenty-five risks, of which twenty-two of these risks were analysed for Level of Risk (the three risks were not rated due to the limited time available at the workshop). A Risk Level summary is provided in Table 1 and Figure 1 below.

Table 1 Number of risks in each category

Risk Level	2009	2030	2070	Residual Risk
Low	10	3	2	7
Medium	10	13	6	12
High	2	6	8	2
Extreme	0	0	6	0
Residual risk not rated				1*
Total	22	22	22	22

In the Context Setting phase of this project the Council's identified flooding, coastal erosion and inundation, emergency response and transportation capability for small communities, bushfire risk and water security as priority concerns under future predicted climatic conditions.

The following two significant risks, that is risks that receive an 'Extreme' or 'High' risk rating, under current climatic conditions (2009) were assessed as requiring immediate attention:

» ***Item 1: The introduction or proliferation of exotic species due to increased temperature*** (Environment) [High Risk Level]; and

» ***Item 22: Increased flood level and frequency due to increased storm intensity*** (Human Life & Health) [High Risk Level].

[1] Please note that the AGO no longer exists and many of the functions of the AGO have been transferred with the recently formed Australian Government Department of Climate Change (DCC). The Local Adaptation Pathways Program is under the control of the DCC.

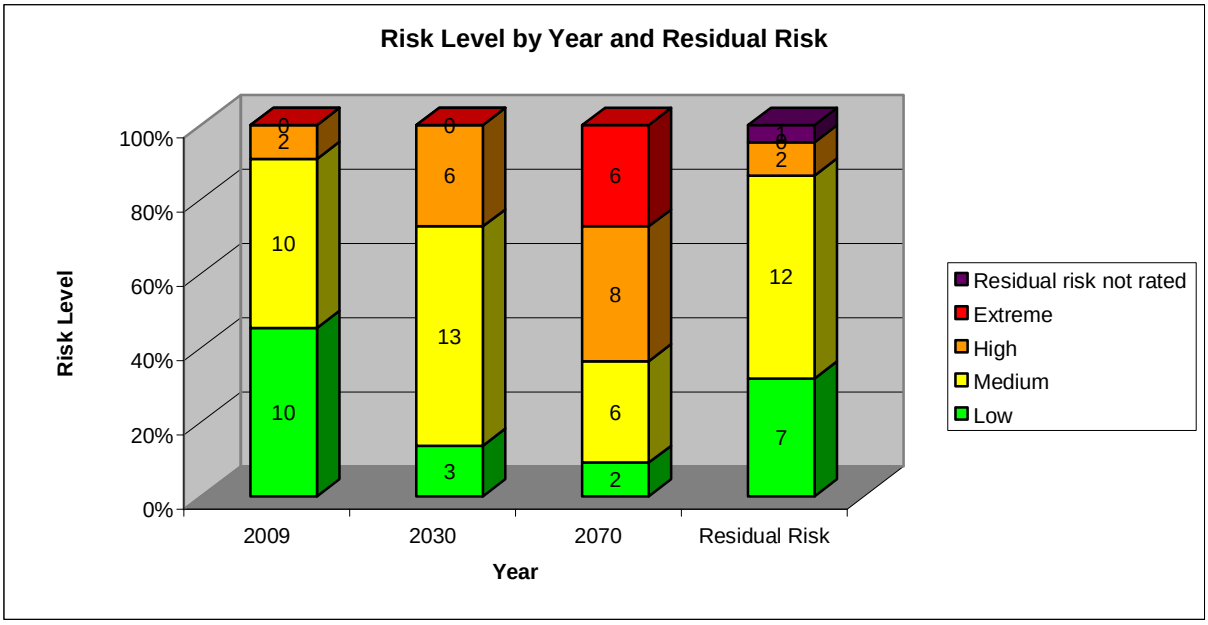
For 2030 and 2070 a further six and fourteen risks respectively received 'Extreme' or 'High' Level ratings. All the risks rated Extreme on the register were a result of assessing the risk item against the Climate Change variable 'Sea Level Rise'. In total seven 'Sea Level Rise' risks were rated and its is six (of seven) of these risks that received an 'Extreme' risk rating in 2070 (see Figure 1 below).

Two risks received a 'High' **Residual Risk** Level rating namely:

» ***Item 2: Sea level rise impacting upon loss of biodiversity*** (Environment) [Extreme Residual Risk Rating]; and

» ***Item 22: Increased flood level and frequency due to increased storm intensity*** (Human Life & Health) [High Residual Risk Rating].

Figure 1 Summary of Risk Level's for 2009, 2030, 2070 and Remaining Residual Risk



Any risk which receives an 'Extreme' or 'High' priority level demands urgent attention at the most senior level of Council and cannot be accepted as part of the routine operation of Council without Executive sanction. Table 2 provides a summary of the eight areas of concern requiring attention following analysis of the risks.

Table 2 Eight Areas of Concern that received a High or Extreme Risk Rating

2009	2030	2070
1. The introduction or proliferation of exotic species Increased Temperature ***(Item 1)***	3. Loss of current or existing biodiversity Sea level rise ***(Item 2)*** * Other risk items related to the area of concern on the Risk Register include: Increased temperature (Item 6)	6. Increased bushfire events (and intensity) Increased temperature [leading to a loss of property] ***(Item 9)*** Other risk items related to the area of concern on the Risk Register include: Increased temperature: [leading to loss biodiversity] considered a moderate risk in 2070 (tem 11) Increased temperature [leading to loss of life and safety issues] considered a moderate risk in 2070 (Item 10)
2. Increased flood level and frequency/ flooding Impacts on coastal development Increased Storm Intensity ***(Item 22)*** Other risk items related to the area of concern on the Risk Register include: Storm Intensity (Item 20) Sea level rise (Item 8, 19 & 21) *	4. Effect on freshwater supply Sea level rise ***(Item 7)*** * Item specific to Tweed	7. Higher evaporation and longer drought periods Increased temperature ***(Item 15)*** Decreased Rainfall ***(Item 25)*** Other risk items related to the area of concern on the Risk Register include: Drought (Item 16) Decreased rainfall: (Item 4)
	5. Coastal Erosion Sea level rise ***(Item 23)**** Item specific to Byron (Planned retreat)	8. Decline in the local economy leading to a loss of tourism and agricultural productivity More sever weather events from increased rainfall and extended drought periods. ***(Item 3)***

***Denotes the risk items on the Risk Register that received an Extreme risk rating (2070) due to Sea Level Rise [Items 2, 7, 8 19, 21 and 23 on the risk register] discussed above.

Please refer to Table 13 in Appendix E for the consolidated vulnerabilities and current control as per the list above.

These risk ratings are not surprising given the significance of biodiversity and natural assets in the two Council areas. The current vulnerability of the coast and floodplain areas to natural hazards such as sever flooding and storms also introduces new risks and elevates existing risks under predicted climate changes for the region. Consequently these risks all received higher-level ratings in the risk assessment exercise. Sea level rise is not an immediate concern but the impacts over the medium and long term are evident across a number of risks.

In carrying out a risk assessment certain characteristics of the population and area are especially important as they influence the sensitivity and vulnerability of the population to climate change impacts. Age distribution and affluence of a community are important to determine the health related effects of extreme changes in climate, in particular the impact of heat stress on infants, young children and the elderly. Affluence indicated by level of income and type of dwellings are important in gauging the ability of a community to either cope with extreme events and ability to adapt to changing climate conditions and secondary impacts associate with these changes.

There may be other impacts from climate change on the community that could not be fully assessed in this process due to the limitations of the exercise. For instance there may be flow through (tertiary) risks that will impact on local business and the community. For example, the failure of utilities such as electricity due

to extreme events, result in interrupted services to businesses, that further inconvenience the community that rely on these businesses for the services they provide. Some further examination of flow through effects may need to be conducted to ascertain the exact nature and magnitude of these impacts.

Most risks increased in severity into the future - at the future dates of 2030 and 2070. It was however possible to improve the risk level for each risk item considered, by introducing a number of potential controls. This is investigated in more depth in the next phase of the process - the Adaptation Planning phase. In this component participants brainstormed potential controls, the Adaptation Phase will analyse all potential controls and assess the adequacy of each individual controls.

In order to carry out an assessment of the risks of climate change it is necessary to define how the climate for the region is projected (or assumed) to change in the future. This is achieved through using climate change projections. Both the Australian Commonwealth Scientific and Research Organization (CSIRO) and the Department of Environment and Climate Change NSW (DECC) have produced regional climate change projections, which present broad regional climate change projections that have been used in this assessment.

For consistency a 'High' emissions scenario only was selected again for 2030 and 2070. This also means that the Councils are taking a consistent approach and applying a precautionary approach to this assessment. This assessment utilizes the 'High' emissions scenarios for two future dates for both 2030 and 2070 as scientific consensus is that observed carbon dioxide concentration; global mean temperatures and sea level rise have been tracking at the upper end of the IPCC scenario range from 1990 to 2006 (see Section 4.1 for further information). The CSIRO advises that although this '17-year' period to 2030 is very short, the mid and low projections may be less likely than the high projections, with significant implications for risk management (CSIRO, 2007, p.46).

In addition a number of climate change variables were selected that were judged to be pertinent to the region. The climate variables, projected changes to each climate variable, the impact to council activities and assets and then the resulting consequences or risks were examined. The Level of Risk for each impact was analysed for the present day (2009), 2030 and 2070. A Residual Risk[2] was also rated following consideration of all potential adaptation controls for events. The climate variables considered in the Tweed and Byron climate change risk assessment process included:

» Increased temperature,

» Sea level rise

» Rainfall, and

» Extreme weather events (storm intensity, flooding, drought, bushfire).

(Other climate variables such as evaporation was considered in conjunction with drought and other variables such as high wind speeds and humidity were not considered in detail).

A summary of the risks identified is included in Table 7 and a copy of the Risk Register can be found in Appendix D.

The Risk Assessment exercise conducted was a high level assessment, and as such not all risks may have been identified in detail. The study was reliant on the data available at the time, and it is quite possible that the qualitative evaluation may change as knowledge improves in this emerging area. Climate change is an

[2] Residual Risk is defined as the risk or danger of an action or an event, where residual means "the quantity left over at the end of a process; a remainder". It is therefore the remaining risk after all relevant controls have been taken into account.

emerging issue and the workshop team sought to qualitatively understand the effects and risks using reasonable assumptions as set out in this document. It was not possible for the two Councils to identify all risks, given knowledge, budget and time limitations. It is quite likely that more risks will be identified as time progresses and the results of this process are reviewed and updated.

A number of controls have been identified for the management of climate change impacts that are already incorporated in existing Council plans and management strategies. Existing council strategies maybe captured during the Adaptation Planning exercise but it is recommended that all these key plans be reviewed for their adequacy to manage the identified climate change risks. It is also recommended that Council incorporate the short, medium and long-term action items into these planning processes as a matter of urgency.

This report is to be presented to the elected Councillors of Byron Shire and Tweed Shire. It is in consultation with the Councillors that a decision will be made in regard to the wider communication of the findings presented in this report.

1. Introduction

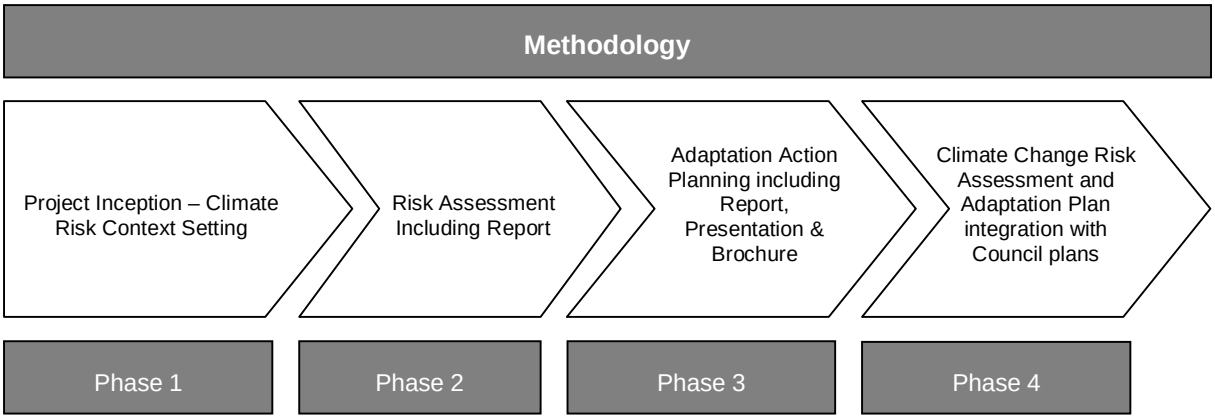
1.1 Objective

GHD have been commissioned by the Byron Shire Council and Tweed Shire Council to undertake a Risk Assessment to examine the potential impacts and opportunities of climate change on key services and activities. The Risk Assessment will be followed by the development of a Byron and Tweed Shire Council Adaptation Action Plan, which will focus on adapting to, and mitigating, the areas of concern identified in the Risk Assessment, and will also consider opportunities associated with building each council's adaptive capacity.

The risk methodology is consistent with the Australian Government *Local Area Adaptation Pathways Program* funding requirements including the *Climate Change Impacts and Risk Management: A Guide for Business and Government* (AGO, 2006) and thus Australian Standard *AS4360:2004 Risk Management*.

The four phases of the project methodology is summarised in Figure 2:

Figure 2 Project Phases



GHD requested a list of information from the Byron and Tweed Shire Councils to inform the Risk Assessment process and the outcomes of the context setting stage are included in this risk report.

1.2 Risk Assessment

The Australian Government recognises the need for local government to understand the risks posed by climate change and has provided initial funding for local councils. As a component of the Local Adaptation Pathways Program (LAPP), Byron and Tweed Shire Councils conducted a Risk Assessment for the potential impacts of climate change relevant to both the Councils, which will be followed by the development of an Adaptation Planning assessment.

The Risk Assessment was conducted using the prescribed methodology for funding approval as defined in *Climate Change Impacts and Risk Management: A Guide for Business and Government* (AGO, 2006), which is aligned with the Australian Standard for Risk Management (AS/NZ 4360 - 2004). The risk framework utilised was based on the consequence and likelihood criteria defined in the AGO Guide. The objective of this exercise is to identify those activities and assets of the councils that are at risk from a changing climate. This was carried out drawing upon the professional knowledge of the council participants as to which assets and activities are **sensitive to climate change** and then whether based upon the judgement of the participants **whether climate change is a significant source of risk** to the assets and

activities.

The AGO (DCC) Consequence Scale & Success Criteria table was referred to during the Risk Assessment Workshop to determine the resulting consequence level (i.e. Catastrophic, Major, Moderate, Minor and Insignificant) [Table C.1 in Appendix C]. The five Success Criteria namely Public Safety, Local Economy & Growth, Community & Lifestyle, Environment & Sustainability, and Public Administration, are combined in a Consequence Scale to describe the level of consequence to each risk associated with the predicted future climatic conditions. The workshop participants chose to adopt the AGO (DCC) Consequence Scale & Success Criteria descriptors as it provided more detail to assist in more clearly identifying the relevant consequence level.

Please note that whilst the rating descriptions against the five AGO (DCC) Success Criteria categories where utilised to guide the choice of the resulting consequence, the categories in the Risk Register and this report are still in line with the three broad Council categories as per the Byron and Tweed Shire Consequence Scale & Success Criteria (Table C.1.1 in Appendix C]:

» Human Life & Health [AGO (DCC) equivalent: Public Safety and Community & Lifestyle];

» Environment [AGO (DCC) equivalent: Environment & Sustainability]; and

» Property & Finance [AGO (DCC) equivalent: Local Economy & Growth and Public Administration]

In order to carry out an assessment of the risks of climate change it is necessary to define how the climate for the region is projected (or assumed) to change in the future. This is achieved through using climate change scenarios. Both CSIRO and the Department of Environment and Climate Change NSW (DECC) have produced regional climate change scenarios, which present broad regional climate change projections that have been used in this assessment.

The climate variables, projected changes to each climate variable, the impact to Council activities and assets and then the resulting consequences were examined. The **Level of Risk** for each impact was analysed for now (2009), 2030 and 2070. A **Residual Risk**[3] was also rated following consideration of all potential adaptation controls for events.

As stated above the AGO's (DCC) *Climate Change Impacts and Risk Management: A Guide for Business and Government (2006)* publication (Australian and New Zealand Standard AS/NZ 4360) for a risk management framework underpins the Risk Assessment process used. This process includes two participatory risk workshops involving key council staff and facilitated by experienced risk and climate change personnel from GHD.

Phase 2 has now been completed. A one day Risk Assessment Workshop, was held on 12 February 2009 with Byron and Tweed Council representatives and a half day workshop was carried out on the following week on the 18 February with a GHD representative and the Sustainability Officers from each council to complete the risk rating of items that were not addressed in the workshop due to lack of time. The Risk Assessment aimed to identify, analyse, evaluate and identify treatment for each identified risk related to climate change in the region. Risk is commonly referred to as a combination of the likelihood of an occurrence and the consequence of the occurrence. Publications by the AGO (DCC) (2006) suggest that climate change is not expected to create new risks, but potentially change the frequency and intensity of existing risks. There are a range of uncertainties around global climate scenarios and the resultant

[3] Residual Risk is defined as the risk or danger of an action or an event, where residual means "the quantity left over at the end of a process; a remainder" . it is therefore the remaining risk after all relevant controls have been taken into account.

modelling has varying degrees of confidence. Likewise regional climate change projections used in this assessment are subject to these uncertainties and varying degrees of confidence.

The outcomes of the workshop and further analysis by the climate change Risk Assessment Team have been documented in this Report.

1.3 Report Structure

This report documents the available information, the methodology followed and the outcomes of the Risk Assessment in the following sections:

- Section 2 details the scope of the study and stakeholders involved;
- Section 3 provides background information on the Byron and Tweed Shire Local Government Areas;
- Section 4 provides a summary of relevant climate change variables;
- Section 5 documents the outcomes of the Risk Assessment process and provides recommended next steps for consideration by the Shires, and;
- Section 6 details the concluding remarks.

2. Scope and Stakeholders

2.1.1 Scope

The geographic scope of the Byron and Tweed Shire Council Risk Assessment covers each of the Shires in their entirety, as depicted in Figure 3 and Figure 4 respectively. The Context Setting meeting confirmed the geographical boundaries of the study as well as the following key parameters: scope of assessment in terms of council business and organisational factors, success criteria (Environment, Human Life & Heath and Property & Finance), key council responsibilities to be assessed and climate change scenarios and variables for assessment.

Figure 3 Locality Map of Byron Shire

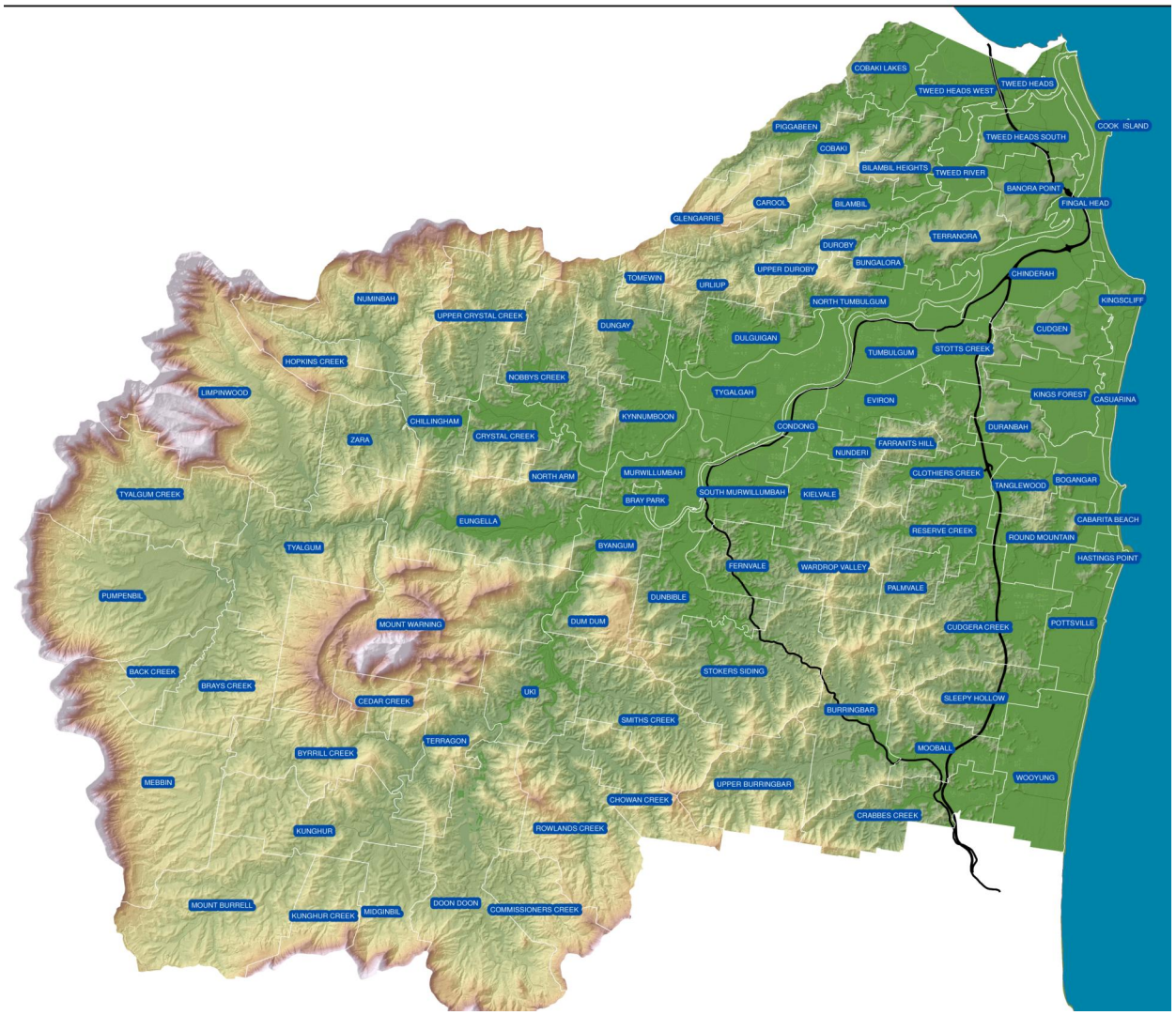


Figure 4 Locality Map of Tweed Shire

2.1.2 Stakeholders

The stakeholders involved in the area for both Byron and Tweed Shires include agricultural stakeholders, industries such as tourism, visitors, public utilities, the State Government and the community in general.

The workshop participants identified impacts on behalf of these stakeholders during the Risk Assessment Workshop.

3. Byron and Tweed Shire Background

Table 3 Summaries for Byron and Tweed

Parameter	Byron	Tweed
Major Population centres	Major urban areas are Byron Bay (with its satellites Suffolk Park and Ewingsdale); Brunswick Heads; Mullumbimby; Billinudgel/New; Brighton/Ocean Shores; and Bangalow.	Tweed Heads (including Tweed Heads South and West), Bilambil, Terranora, Banora Point and Kingscliff Murwillumbah
Area	567m2	1303m2
Population:	30,329 *	81,953 *
Far North Coast Population	N/A	118,750 (2031)**
228 000 (2006)		
289 000(2030)		
Median age of persons		
Far North Coast		
39 years (2006)		
51 years (2031)	41	44
Total Private dwellings	10,711	31,121
Far North Coast Dwellings		
51 000 additional homes by 2030		

*ABS 2006 census

** Tweed Shire Community Profile, May 2008

The Far North Coast Region, also referred to as the "Region" in the document, is the most biologically diverse region in NSW and the third most in Australia. The Region is comprised of the six Local Government Areas (LGAs) of Ballina, Byron, Kyogle, Lismore, Richmond Valley and Tweed. Around half the Region's population live in coastal or non-coastal villages, smaller communities, hamlets and rural areas. The largest population increases in the Region have been in the coastal Local LGAs of Tweed, Byron and Ballina. Tweed Shire with its proximity to South East Queensland has shown the strongest growth over the past decade.

Byron Shire is situated in far north-eastern New South Wales. It comprises most of the catchment area of the Brunswick River, and part of that of the Richmond River. It adjoins the shires of Tweed (to the north) and Ballina (south), and the City of Lismore (west). The Shire is bounded in the east by the South Pacific Ocean, in the south partly by Skinners Creek and the Wilson River, in the southwest partly by Coopers Creek, and in the north-west partly by the Nightcap Range (Figure 3). The area of the shire is 567 square kilometres.

Tweed Shire covers 1303 square kilometres and adjoins the NSW Local Government Areas of Byron, Lismore and Kyogle, with the NSW/Queensland border to its north where it divides the twin towns of Tweed Heads and Coolangatta. 64% of the shire's population is located in the Tweed Heads area, which consists

of Tweed Heads (including Tweed Heads South and West), Bilambil, Terranora, Banora Point and Kingscliff. (ABS 2006). 25% of the shire's population is located in the rural areas of the shire, which consists of Murwillumbah, Uki, Tyalgum, Chillingham and the other villages surrounding these areas. (ABS 2006). 1% of the Shire's population is located in the coastal areas of the LGA, which consists of the villages and townships south of Kingscliff. (ABS 2006).

3.1 Community

In carrying out a Risk Assessment certain characteristics of the population and area are particularly important as they may influence the sensitivity and vulnerability of the population to climate change impacts. The proportion of the population in the Region aged 65 years or more is expected to more than double by 2031. Age distribution and affluence of a community are important to determine the health related effects of extreme changes in climate, in particular the impact of heat stress on infants, young children and the elderly. Affluence indicated by level of income and type of dwellings are important in gauging the ability of a community to either cope with extreme events and ability to adapt to changing climate conditions and secondary impacts associate with these changes. For example caravan parks are particularly vulnerable to extreme weather conditions. The NSW Government's 25-year land use strategy for the Far North Coast Regional Strategy expects an increase in the population by 60 400 people (26% increase) by 2031. The population of the Region is increasing by 2,500 people on average each year. Around half the Region's population live in coastal or non-coastal villages, smaller communities, hamlets and rural areas. Up to 51,000 additional homes will be needed.

Impacts of climate change on the community can include:

» Pressures on transport infrastructure due to affects of peak oil and associated fuel costs;

» Increased population pressures due to extreme climate change impacts in other parts of Australia;

» Potential for a 'climate change refugees' (from within Australia and internationally);

» Uncertainties for employment;

» Pressures on providing social structures due to affects of increasing costs of general living; and,

» Displacement and higher density living may potentially induce social problems.

3.2 Employment

The Far North Coast is experiencing an ageing population. The proportion of young people is projected to decline 14% leaving 54% of the population in the working age group. The Far North Region has traditionally been dominated by agriculture and is now dominated by service sector industries (84%) and manufacturing and construction (12%). The service sector comprises of predominantly retail, hospitality and tourism, education and health sectors with employment in agriculture, forestry and fishing. The Strategy estimates that a further 32,000 new jobs will be required in the region. The Regional Industry and Economic Plan (2005) prepared by the Northern Rivers Regional Development Board has identified tourism, education, creative inductees, horticulture, health, aquaculture, residential development and construction, forestry, meat and dairy, and transport as key industry growth sectors.

The 2006 statistics on the labour force for the Byron Shire indicated a number of characteristics concerning employment trends compared to the rest of Australia, most notably that there is a very high ratio of part time employment in the shire.

» High unemployment figures in comparison to the national average

» A high ratio of part time employment compared to the national average

» A low ratio of full time employment compared to the national average

(Source: Byron Shire Emergency Risk Management Study 2008)

51% of the Byron population over 15 years of age had employment in 2006. There are about 3,700 businesses in the Shire of which 60% are sole traders. Of the balance, 60% employ less than 5 persons and 31% employ between 5 and 19 persons.

The proportion of persons over the age of 15 in employment, either full time or part time, increased at the local, regional and State level throughout the 1996, 2001 and 2006 Census periods. In Byron Shire the growth was more pronounced rising by 14.2% during that period compared to 8.4% and 2.0% at the regional and State level respectively. In 2006, the proportion of full time workers (i.e. working 35 or more hours) to total workers is 1.9% in Byron compared to 59.8% in the region and 69% across the State *(Source: Byron Shire Council Representative).*

Table 4 provides time series data for changes in the number of employees by Industry. The most significant change has been the decline in Agricultural, forestry and fishing by 32.21% (1996 to 2006)and an increase in the proportion of persons employed in the services sectors. See section 3.3.1 for more detail to Tweed Shire's changes to industrial base.

Table 4 Changes in number of employees in industries in Tweed Shire 1996 – 2006

	Number of Persons Employed				
Industry	1996	2001	Percentage change 1996-2001	2006	Percentage change 2001-2006
Agriculture, forestry & fishing	1,427	1,271	-10.93%	939	-26.12%
Mining	55	55	0%	90	63.63%
Manufacturing	1,533	1,751	14.22%	1,981	13.13%
Electricity, gas, water & waste services	164	185	12.80%	234	26.48%
Construction	1,825	2,152	17.91%	3,566	65.70%
Wholesale trade	791	850	7.45%	831	-2.23%
Retail trade	2,575	3,306	28.38%	4,141	25.25%
Accommodation & food services	2,336	2,555	9.37%	2,967	16.12%
Transport, postal & warehousing	881	979	11.12%	1,178	20.32%
Information media & telecommunications	328	303	-7.62%	344	13.53%
Financial & insurance services	475	450	-5.26%	534	18.66%
Rental, hiring & real estate services	509	577	13.35%	687	19.06%
Professional, scientific & technical services	764	884	15.70%	1,177	33.14%
Administrative & support services	593	784	32.20%	920	17.34%
Public administration & safety	901	1,151	27.74%	1,572	36.576%
Education & training	1,437	1,678	16.77%	2,096	24.91%
Health care & social assistance	2,080	2,620	25.96%	3,611	37.82%

	Number of Persons Employed				
Arts & recreation services	314	403	28.34%	499	23.82%
Other services	912	931	2.08%	1,110	19.22%
Inadequately described/Not stated	679	613	-9.72%	783	27.73%
Total	20,579	23,498	14.18%	29,260	24.52%

Source: Tweed Shire Community Profile 2008

3.3 Business

Byron Shire boasts a strong network of home-based businesses. A Community Survey conducted in 2007 indicated about 22% of residences in the Shire had at least one home-based business. This business segment covers a range of activities from traditional pursuits such as agriculture and various trades to those involved in creative industries. The Byron lifestyle are attracting an increasing number of people who can 'work from a distance' using the combination of high-speed telecommunication and airports that provide ready access to both domestic and international markets.

In 2007, it is estimated that tourism spending in Byron was $350 million. That level of spending is estimated to create or maintain about 2,650 full time equivalent jobs.

Individual sectors experienced significant employment growth in the Shire over the 2001- 2006 period. Significant increases in mining (albeit from a low base), construction and professional scientific and technical services would have been influenced by major road works. A fall in manufacturing jobs in Byron and for the State was not experienced in the region where manufacturing increased. Agricultural jobs declined across the Shire, region and the State *(Source: Byron Shire Council Representative).*

Please refer to section 3.3.1 below for Tweed Shire changes in employment by industry.

3.3.1 Industry

Tourism is the predominant source of industry for the Coastal North area of the Byron LGA. Brunswick Heads is a popular holiday destination for many families with three Caravan parks and many holiday rental apartments. The Billinudgel Industrial Estate is home to the majority of Coastal North based business and is situated off the Pacific Highway near Ocean Shores. The other area of industrial development is located in the Byron Bay Arts and Industrial Estate. Tourism success is currently based on aesthetic values in the area.

The Byron Bay Arts and Industrial Estate is located north of Ewingsdale Road along the western entrance to Byron Bay and houses up to 300 business encompassing fashion, art, antiques and home wares, hospitality, health and childcare, sport and dance along with the traditional trade and building supplies *(Source: Byron Shire Council Emergency Risk Study, 2008).*

Tweed Shire's industry base has changed significantly over the last decade. Agriculture declined with a drop of 32.21% from 1996 to 2006 as did mining (down 1.94% from 2001).Retail trade remained the number one industry across all three census dates, an increase of59.73% between the 1996 and 2006 and 25.24% from 2001 to 2006. The same period shows rapid growth in a number of industries including health and community services construction (which rose 91.18% from 1996, 65.08% from 2006), accommodation, and education and training. These changes reflect the rapid population changes in the area, and the commensurate increase in demand for personal services.Tourism and its associated industries continue to play a major part in the development of Tweed Shire. The total number of persons employed in the tourism industry in 2006 was 418, up from 182 in 2002 (a rise of 129.67%). The total takings were $10.66m for the

Tweed compared to $367,000 for Lismore and $16.66m for Byron. While there has been a consistent demand for construction in Tweed Shire over the last five years, demand for houses overall has dropped. The total number of houses approved in 2001- 2002 was 674, dropping to 401 in 2006-2007. Approvals for other residential have, however, risen from 140 in 2001-2002 to 303 in 2006- 2007 (a rise of 116.42%). The Tweed Shire accounts for 51.41% of the value of all residential building approved in the Far North East. (Tweed Shire Community Profile, 2008)

3.3.2 Agriculture

The NSW North Coast region supports a wide range of agricultural activities, from intensive horticulture to broad acre cropping and grazing. Approximately 1 in 12 working people on the North Coast are employed in agriculture, and the farm gate value of agricultural production on the North Coast is in excess of $650 million, rising to about $1 billion when processing is included, particularly, in the meat, milk, sugar and macadamia industries (NSW Agriculture, 2000. *North Coast Agriculture*).

Agriculture is the third largest source of income for Byron Shire, after tourism and social security payments, generating approximately between $35 million (ABS 2000/01) and $57.5 million (ABS 1999/2000) annually. Production in the Shire is characterised by relatively smallholdings involved in intensive production with over 53% (derived 2000/01 ABS) of landholders involved in some form of horticulture

Most farmland is used for grazing of beef and dairy cattle in the Tweed Shire. Sugar cane occupies about 7% of the Shire, mostly floodplains (1-2m above sea level). Other agricultural activity includes banana growing, horticulture and market gardens.

3.4 Infrastructure & Development

The Far North Coast Strategy envisions the region to be characterise by a series of contained centres with growing towns and villages and the protection of coastal areas from inappropriate development. Lismore and Tweed will continue to be major regional centres, with Ballina emerging as a major centre. Byron Bay is to remain known as a national and international tourist destination and will retain the village character (Far North Coast Regional Strategy, NSW Planning 2006)

The Far North Coast Strategy has mapped Town and Village Growth Boundaries within the six LGAs. The Strategy will reduce the proportion of additional dwellings in the Coastal Area to 60% by limiting future development. A further 51 000 dwellings will be required in the region to keep pace with the projected population growth. ‘Green breaks’ will be introduced between coastal settlements to protect coastal biodiversity and help strengthen the ‘region of villages’ concept. For example the strip of vegetation from Broken Head to Lennox Head character (Far North Coast Regional Strategy, NSW Planning 2006).

3.4.1 Energy

Transgrid operates the high voltage transmission network in the Region, whilst the supply to customers is taken care of by Country Energy. The identification of coal seam gas reserves provides the opportunity for the development of a local energy industry (Far North Coast Regional Strategy, NSW Planning 2006) In Byron substations receiving supply are located in Mullumbimby and Ewingsdale, which then provide feeders to the North and South of the Shire. In Tweed electricity is sourced from the east coast transmission network. Two facilities produce electricity in the Tweed being, the Condong Sugar Mill cogeneration facility and the methane extraction facility at the Stotts Creek Landfill. These facilities generate enough power for approximately 15,000 homes and 400 homes respectively. In the event of a major supply disturbance in the region, priority of supply is given to feeders that are supplying critical infrastructure such as Hospitals, Sewer and Water Treatment Plants.

3.4.2 Transport

The two main road networks in the Region include the two major north-south corridors; the Pacific Highway and Summerland Way and east-west link, the Bruxner Highway. It is a high traffic region with estimated 380 million trips made by resident and visitors and 20 million tonnes of freight moved. The Pacific Highway is being upgraded to dual carriageway. 140 kilometres of the Pacific Highway runs through the region. The main Sydney to Brisbane rail corridor passes through the western part of the Region. There are three main airports servicing the region. Coolangatta in Queensland (Domestic and some international flights), Ballina providing domestic services and Lismore providing commuter flight services to Sydney (character (Far North Coast Regional Strategy, NSW Planning 2006). Byron Shire transport assets comprise of approximately 419.74 km of local sealed roads, 96.35km of local unsealed roads, 50.23km of regional roads, and over 28km of state roads. The Casino-Murwillumbah rail line runs through the Shire, but has not been operating since May 2004 (*Source: Byron Shire Council Representative*). Approx 1200km of local roads are under the responsibility of Tweed Council (i.e. does not include the Pacific Highway). The rail-line to Casino is no longer in operation, however a number of lobby groups continue to fight for its re-establishment (*Source: Tweed Shire Council Representative).*

3.4.3 Water

There are three water supply networks in the Tweed Shire. Two small networks supply the rural villages of Tyalgum and Uki, while the major network supplies Tweed Heads and surrounds, the Tweed Coast and the Murwillumbah district. The major network draws its water from the Tweed River, upstream of the Bray Park weir. The weir acts as a tidal barrage, preventing salt water from the estuary getting in to the fresh water supply. Clarrie Hall Dam is only to supplement the town water supply and to maintain environmental flows in the Tweed River. For much of the year it is natural flows in the Tweed River that supplies more than 80% of the shire population. Water is only released from Clarrie Hall Dam when flows in the freshwater section of the Tweed River fall below 95%, usually during winter and spring. Significant future growth forecast for Tweed Shire will exceed the current capacity of the existing Bray Park Water Treatment Plant of 50 million litres per day (50 ML/day) in the next few years. The construction of a new membrane ultra filtration plant will increase capacity to 100ML / day. Completion of the new plant is expected in November 2009 (*Source: Tweed Shire Representative).*

The Rous Water supplies a majority of towns and villages in and around Lismore, Ballina, Byron and the Lowe Richmond Valley. Water is also sourced from Laverty's Gap Weir, which draws its water from the upper reaches of the Wilson's River. Established in 1926, the weir is highly valued by the community in terms of drinking water, historical significance, environment and recreation. In a bid to reduce water extraction from rivers and groundwater, Councils in the region are developing Integrated Water Cycle Management Plans. With the projected population growth government is review future supply options and the Department of Natural Resources will determine environmental flow and water access rules for both surface and groundwater through the macro water-sharing process (*Source: Byron Shire Council Emergency Risk Management Study, 2008).*

3.4.4 Sewerage System and Treatment Plants

Byron Shire Council Water and Recycling Management Services manage the sewerage system and have five (5) sewage treatment plants (STP).

Tweed Shire Council Water Unit manage the sewerage infrastructure network for the shire which services approximately 82% of the population and consists of Wastewater Treatment Plants (WWTP) at Banora Point, Tweed Heads West (decommissioned), Kingscliff, Hastings Point, Tumbulgum, Murwillumbah, Uki and Tyalgum (*Source: Tweed Shire Representative).*

3.4.5 Telecommunications

Internet access is relatively high in Byron Shire with 66.4% having a connection of some description in the household, compared with 55.5% and 61.5% for the region and the State. Broadband take up in Byron is comparable to the State and higher than at the regional level (*Source: Byron Shire Council Representative.).* An Optus trunk main runs all the way down the coastal strip. 4 radio towers in the Tweed Heads area, 4 radio towers between Tweed Heads and Murwillumbah, 6 radio towers in Murwillumbah (*Source: Tweed Shire Council Representative.)*

3.5 Planning Characteristics specific to Byron and Tweed LGA

The Strategic Planning documents for Councils are listed in Figure 5 and include Council LEPs and the Far North Coast Regional Strategy, 2006. The following preliminary issues were identified by Council representatives:

- Town planning may become more centralised.
- Seawater/groundwater/salt intrusion affecting agricultural lands/soil and existing infrastructure (e.g. subterranean structures/pipelines) potentially exacerbating future problems;
- Sea level rise (infiltration) is currently affecting the constructed weir at Murwillumbah water supplies as increasing of weir would also affect agricultural land.
- Future legislative changes could include altering water supplies operated by State government as opposed to local government.
- Existing infrastructure collapse and restricted ability to cope with emergencies induced by climate change;
- Potential isolation of rural dwellings due to cut off from main access roads;

(Source: Byron & Tweed Shire Council Representatives)

3.6 Health

Each Area Health Service appoints an Area HSFAC to control health operations in an emergency within their boundaries, and to coordinate support from within their Area Health Service. The Area HSFAC controls all area health emergency operations:[Paragraph 304 NSW HEALTHPLAN February 2008].

Byron LGA and T weed LGA are part of the North Coast Area Health Service (NCAHS). NCAHS came into existence on January 1, 2005 as part of the NSW Department of Health's health reform package. The reforms included a reduction in the number of Area Health Services from 17 across NSW to 8 through a series of Area Health Service mergers and boundary changes.

In 2006 Tweed Hospital is the hospital with the highest number of separations (25,805) and Murwillumbah Hospital was ranked eighth with 5,925 separations in the North Coast Area Health Service. The Tweed Hospital is also in the top rankings for overnight bed days and total bed days. The Tweed Hospital also had the highest number of emergency department attendances of any hospital in the North Coast Area Health Service (*Source: Tweed Shire Council Community Profile 2008.)*

3.7 Emergency Services

There exists an inter-regional emergency response approach with individual budgets for council cleanup and emergency responses. A majority of these services are found in both Councils. These include: the Police, Volunteer Fire Brigade, Volunteer Rescue, Fire Service, SES,North Coast Area Service, St Vincent de Paul Society, Coast Guard (Tweed),Volunteer Marine rescue (Tweed), Volunteer Coastal Patrol,

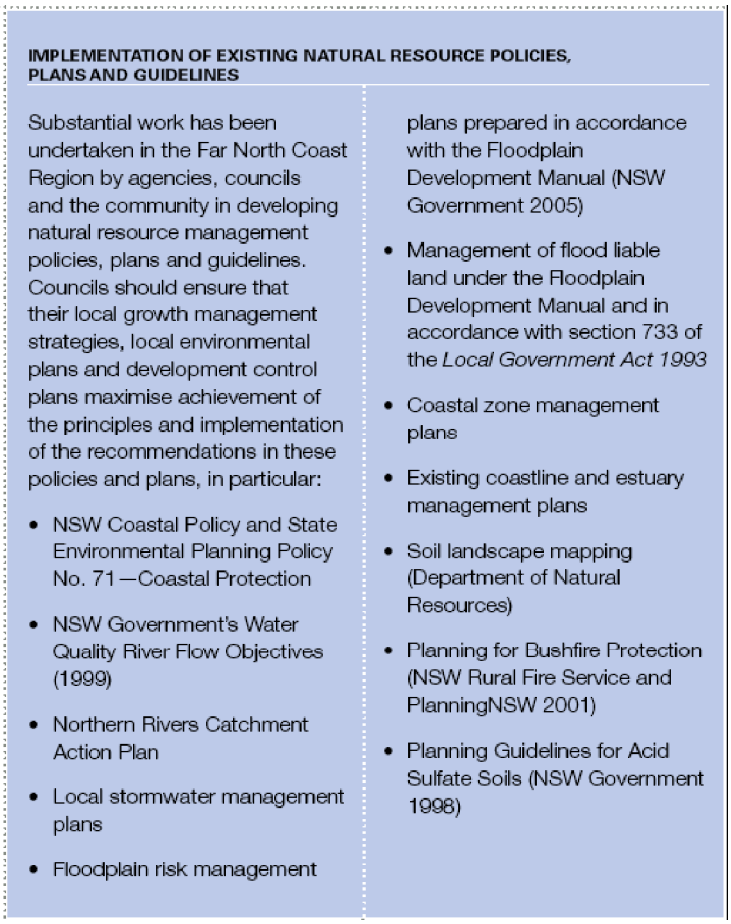
National Parks and Wildlife Service, County Energy, Department of Primary Services, and Centrelink.

3.8 Natural Assets

The Far North Coast Region is the most biologically diverse region in NSW and the third most in Australia. The Byron and Tweed Shires lie within the McPherson / MacLeay overlay and are recognised for their extremely high biodiversity.

The Region has 21 national parks of which several are World Heritage listed and over 1200 public reserves. The area is rich in natural resources such as timber, groundwater, extractives resources and productive soils important to the regional economy. Development pressure needs to be balanced with protection of productive farmland. Some areas in the Region are subject to natural hazards such as acid sulphate soils, flooding, coastal inundation and recession

The Far North Coast Region has experienced many server floods and as such the Strategy requires that councils develop their local environmental plans (LEPs) consistent with the Government's Floodplain Development manual and in accordance with Coastal Zone Management Plans. Councils are required to undertake investigations of lands with the potential to be affected by sea level risk and inundation and make provision for adequate setbacks to manage the risks associated with climate change before rezoning or approving new development or redevelopment in potential hazard areas (Far North Coast Regional Strategy, NSW Planning 2006)



IMPLEMENTATION OF EXISTING NATURAL RESOURCE POLICIES, PLANS AND GUIDELINES

Substantial work has been undertaken in the Far North Coast Region by agencies, councils and the community in developing natural resource management policies, plans and guidelines. Councils should ensure that their local growth management strategies, local environmental plans and development control plans maximise achievement of the principles and implementation of the recommendations in these policies and plans, in particular:

- NSW Coastal Policy and State Environmental Planning Policy No. 71—Coastal Protection
- NSW Government's Water Quality River Flow Objectives (1999)
- Northern Rivers Catchment Action Plan
- Local stormwater management plans
- Floodplain risk management plans prepared in accordance with the Floodplain Development Manual (NSW Government 2005)
- Management of flood liable land under the Floodplain Development Manual and in accordance with section 733 of the *Local Government Act 1993*
- Coastal zone management plans
- Existing coastline and estuary management plans
- Soil landscape mapping (Department of Natural Resources)
- Planning for Bushfire Protection (NSW Rural Fire Service and PlanningNSW 2001)
- Planning Guidelines for Acid Sulfate Soils (NSW Government 1998)

Figure 5 Existing State Natural Resource Policies, Plan and Guidelines (Far North Coast Regional Strategy, NSW Planning 2006, pg.24)

Byron Shire comprises of natural coastline together with wetlands, estuarine forests, farmland and hinterland rainforest and riparian ecosystems. The Shire is a major international and national tourist destination, famed for beautiful surf beaches, scenic bushwalking, vibrant creative and music industries, healing modalities and alternative lifestyle culture. The region is recognised as one of Australia's most diverse in terms of its natural terrain, flora and fauna. Byron Shire lies within an area of extremely high biodiversity, containing approximately 170 species of endangered or threatened flora and fauna. The biogeographical province is known as the McPherson-Macleay overlap zone (BSC, 2001). Approximately 12 low-lying EEC's containing flood plain species exist within the Byron Shire.

The main threats affecting biodiversity in Byron Shire include:

» Habitat loss resulting from habitat clearing, fragmentation, modification and disturbance

» The introduction and establishment of exotic species

  – loss of local genetic vigour for certain species;
  – direct exploitation; and
  – impacts associated with pollution of air, land and water (BSC, 2001).

Byron Shire is bounded in the east by the South Pacific Ocean, in the south partly by Skinners Creek and Wilson River, in the southwest partly by Coopers Creek, and in the northwest partly by the Nightcap Range. The Brunswick, Byron and Belongil Creek catchments are the most significant in the Shire *(Source: Byron*

Shire Council Representative).

15% of the Shire comprises National Parks include Border Ranges, Night Cap, Mount Warning, Mebbin, Mooball, Mount Jerusalem and Wollumbin. Nature Reserves in the Shire include Limpinwood, Stotts Island, Cudgen and Nullum. Mount Warning National Park, Nightcap National Park and Border Ranges National Park were added to the World Heritage List in 1996 because of their exceptional natural beauty and ecological importance. This land totals approximately 1400ha of environmental estate. (Source: Tweed Shire Community Profile 2008).

The Tweed Shire comprises of 37km coastline and approximately 1400ha of environmental estate (15% of the shire) including 7 National Parks. The shire boundaries are also the geographical boundaries of the catchment. This creates a range of opportunities for the sustainable management of the water, sewerage, drainage and ecosystem services.

Pressures on waterways in the Shire include those from development, commercial, industrial and recreational uses, structures within waterways, removal of riparian vegetation, the impacts of agriculture and the disturbance of acid sulphate soils (BSC, 2001). The export of sediment and major nutrients, nitrogen and phosphorus, from catchments and the resulting eutrophication of streams and estuaries has been highlighted as one of the major water quality problems in the coastal zone (Pont, 1997).

The Tweed River catchment is covers an area of approximately 1100 km^2. It is comprised of numerous smaller sub-catchments. The Tweed River catchment has three major arms, the Rous, Oxley and Tweed. The Tweed River discharges into the Pacific Ocean at Point Danger. (*Source: Tweed Shire Community Profile 2008).*

3.9 Current Climatic Conditions

The future climate of the Northern Rivers Catchment is likely to be warmer. Although projected changes in average rainfall are currently not clear, with projected increases in evaporation, the catchment is likely to be drier. Such climate change would also increase heat waves, extreme winds and fire risk. Nevertheless, despite this trend toward drier conditions, there is also potential for seasonal increases in extreme rainfall events. Modelling of weather patterns along the NSW coast indicates the potential for increases in the frequency of weather events that contribute to extreme winds and, subsequently, storm surges (CSIRO, 2007).

The interim findings of the University of NSW commissioned study on behalf of DECC find that a North Coast region will experience a reduction in winter rainfall. A decrease in soil moisture in winter and spring is also projected for this region. Sea level rise is also expected to change flood patterns. Minimum temperatures across all seasons are projected to be warmer (1 to 3°C). Winter will experience the greatest increase by 2 to 3°C and summer by 1 to 1.5°C (DECC, 2008).

Further potential changes in climatic conditions identified by Council representatives include:

- More rain expected in the hills (up to 2-3mm), with hinterland acting as large catchment area. (Current estimates suggest that Tweed valley receives 30% of rainfall, coastal flood plains receive 10% and the hinterland receives 60% of annual rainfall).
- Byron Bay displays similar characteristics to Tweed with regards to rainfall and location.
- 20-year projections may not be accurate regarding extreme rainfall, as variations are continually occurring making quantification difficult. This is leading to questioning on 100 year projections also.
- Average sea surface temperatures for the region range from 17^0C in winter to 25^0C in summer.
- Bureau of Meteorology presented risks and concerns regarding cyclone occurrence in these areas in

2007.

» Cyclical weather patterns tend to occur in this region.

» More focussed on summer and winter averages as opposed to annual rainfall.

» Hailstorm frequency increasing over the last 2-3 years.

» Coastline and erosion processes as an area of focus/consideration.

» Tweed utilises 100-year flood line regularly. However, uncertainty exists as to its accuracy/reliability.

» Storm (hail) frequency increases affecting crops.

(Source: Byron & Tweed Shire Council Representatives)

The Table 28 and Table 29 in Appendix F provide baseline data taken as a historical average to account for natural decadal variations for the Byron and Tweed LGA. Byron current climate data has been sourced from the Cape Byron Lighthouse and is a BOM average from 1961 to 1990. Current climate data for Tweed Shire has been sourced from the closest weather station, Coolangatta, as Tweed does not have a weather station of its own. This weather station has been operating only from 1982 and hence the historical average available is from 1982 to 2008. Figures for humidity and wind speed are available from the early 1990s onwards. For climate projections please refer to Table 5 in Section 4 “Summary of Climate Variables for the North Coast”.

3.10 Natural Disasters

3.10.1 Storm and Cyclone Events

An East Coast Low (ECL) is an intense low-pressure system, which occurs, on average, several times a year off the eastern coast of Australia. The ECL is most prevalent during the winter and autumn months. A Tropical Cyclone develops over warm tropical waters and has a much longer lifecycle. The severity of a Tropical Cyclone is much higher than that of an ECL with wind speeds that can exceed 180 km/h, heavy rainfall, coastal erosion and inundation caused by storm surge.

In recent years there have been 12 Tropical Cyclones that have had significant impacts on the Byron LGA and five (5) East Coast Lows. It must be noted that the past 25 years has been a period of reduced Cyclonic activity on the East Coast of Australia and subsequently the Byron LGA.

Anecdotal and recorded evidence is that the most severe cyclonic events in memory took place in 1954, 1967 and 1974. Without exception, each of these events occurred in association with high spring tides, and with an accompanying storm surge due to atmospheric pressure and wind stress.

From 26 June to the 30 June 2005 an ECL caused widespread flooding as a result of extreme rainfall with both Mullumbimby and Byron Bay recording their highest ever daily rainfall totals. A 1% AEP flood occurred in the Coastal North region inundating areas of Ocean Shores, Billinudgel, New Brighton and South Golden Beach. Flooding also occurred in Mullumbimby and Byron Bay with one local resident losing his life in floodwaters surrounding Ewingsdale Road. A total of 150 people were evacuated across the Byron LGA during this event. There were significant land slips in the rural area and also part of Lighthouse Road where the boardwalk and road collapsed (*Source: Byron Shire Council Emergency Risk Management Study, 2008)*.

On October 26 2007, a large storm cell with destructive hail and intense rainfall affected Byron Bay and Mullumbimby. Myocum received 4 (four) inches of rain within a half hour period. The Byron CBD suffered flash flooding with water also over Ewingsdale Road for several hours. The worst affected area was Dunoon located in the Lismore Local Government Area. The storm resulted in a Tornado, which devastated

the township, decimating the school, destroying the church, the sub station and many homes. Up to 20 homes and buildings were considered severely damaged. The school had three classrooms destroyed and flying debris smashed into the Country Energy substation based at Dunoon causing power outages for approximately 48 hours to some homes. The NSW Government estimated that the cost of the damage is over $1 million. The SES logged over 100 calls for assistance in this small community. (*Source: Byron Shire Council Emergency Risk Management Study, 200))*

Severe storms have been identified as a number three priority for management under the Tweed Shire Emergency Risk Management Plan (*Source: Tweed Shire Emergency Risk Management V14 July 2007)*

3.10.2 Flooding

Byron LGA

Flooding which affects the Byron LGA is of a seasonal nature with the majority of recorded floods occurring between February and September. They are generally the result of Cyclones or rain depressions caused from Ex Cyclones and intense rain depressions (East Coast Low's). The Bureau of Meteorology provides a comprehensive warning system for the build up of each of these events and they can generally be tracked long before the effects of them are experienced. Historically, the Byron LGA can expect up to 2-3 types of rain events each year. Byron Shire Council has considered a report and adopted at its meeting of 13 December 2007 a resolution with respect to Climate Change. The report prepared is BSC 100 year Climate Change Flood Planning Scenarios *(Source: Byron Shire Council Emergency Risk Management Study, 2008)*

Tweed LGA

Flooding has been identified as a number one priority for management under the Tweed Shire Emergency Risk Management Plan. *(Source:Tweed Shire Emergency Risk Management V14 July 2007)*

3.10.3 Bushfire history

The region is relatively low fire risk and high average annual rainfall may help insulate it from some of the threat that climate change may pose from bushfires, particularly when compared with more arid regions. Nevertheless, fire and drought risk are projected to increase in the region. The risk of property loss due to bushfire is also likely to increase. Bushfire has however been identified as a number two priority for management under the Tweed Shire Emergency Risk Management Plan. (*Source: Tweed Shire Emergency Risk Management V14 July 2007).* Please refer to Appendix F – Context Setting in Detail for maps detailing Bushfire History in the Tweed LGA.

4. Climate Change Variables

There is increasing scientific evidence that human activities are leading to adverse changes in global and regional climate as a result of the emission of carbon dioxide and other greenhouse gases from the burning of fossil fuels and other sources. Climate change will affect local council's activities and assets through primary changes in the climate variables and secondary changes in the frequency and intensity of extreme events. Severe weather events, storm surges, changing patterns and intensity of cyclones, increased bushfire hazard, along with rising sea level and sustained heat waves are likely to have significant impact on the region. Prolonged instances of heat, wind and rainfall, and increased variations in these phenomena, can also lead to accelerated structural fatigue and greater demands on construction and draining needs.

The CSIRO and DECC have produced regional climate change projections under differing greenhouse gas emission scenarios for 2030, 2050 and 2070 which have been used in this assessment. The summary of climate change variables provided below have been referenced from the two main regional NSW government published documents relevant to the Byron and Tweed Shires. The most recent data is the DECC (2008) Summary of Climate Change Impacts, North Coast Region (for 2050), NSW Climate Change Action Plan, prepared by the University of NSW for DECC. The second data set is derived from the CSIRO (2007) 'Climate Change in the Northern Rivers Catchment (for 2030 & 2070),' prepared for the NSW Government by CSIRO. Table 5 below provides the data as appears for 2030 (CSIRO), 2050 (UNSW) and 2070 (CSIRO), note again that 2050 data is based on the most recent calibrations. The CSIRO projections for rainfall and temperature were update by UNSW to adjust for rainfall variability, and it is these figures that have been adopted by NSW government. Please also note that the CSIRO present day rainfall conditions are based on long-term averages from the Bureau of Meteorology (BOM), temperature is based on the maximum January and maximum July temperature for 1990, extreme temperature days are averaged from 1964 to 2003 data and the number of drought days is centred on 1990 data.

4.1 Greenhouse Gas Emission scenarios

The IPCC published the *Special Report on Emission Scenarios* (SRES). These scenarios were developed from four different storylines, with each one representing different demographic, social, economic, technological, and environmental developments. The four storylines are described in the report as follows:

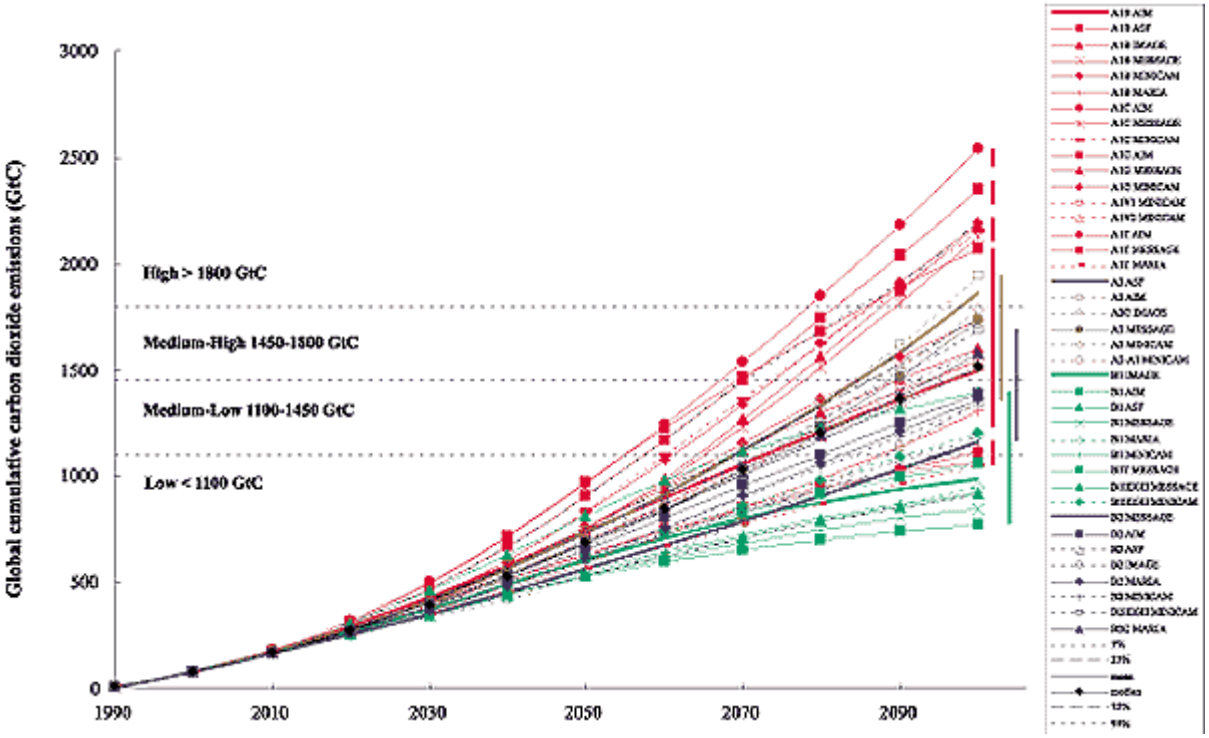
- The A1 storyline and scenario family describes a future world of very rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into four groups that describe alternative directions of technological change in the energy system, including coal (A1C), oil and gas (A1G), non-fossil fuel (A1T) and a balanced approach (A1B). The groups A1C and A1G were combined to create A1FI which is a fossil-fuel intensive group.
- The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in high population growth. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines.
- The B1 storyline and scenario family describes a convergent world with the same low population growth as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability,

including improved equity, but without additional climate initiatives.

» The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with moderate population growth, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

The storylines were used to develop several different scenarios using different modelling approaches to examine the range of emission outcomes arising from a variety of models that use similar assumptions about driving forces. The results of the scenario modelling, estimated global cumulative carbon dioxide emissions for each scenario are depicted in Figure 6 below.

Figure 6 SRES Emission Scenarios



Source: IPCC Special Report on Emission Scenarios

4.2 Climate Change Estimation

To estimate the level of climate change across a range of variables, the CSIRO OzClim database was used, which incorporates the SRES emission scenarios above to generate estimates.

The climate change value used within the OzClim database is determined by the combination of emission scenario and climate sensitivity. For the purpose of the Risk Assessment, the climate change value selected was 'High'. A high rate of climate change is based on the SRES A1FI storyline and scenario family, and assumed high climate sensitivity, i.e. a sensitivity corresponding to a global warming of 4.2 degrees for a doubling of CO_2 from 280 ppm to 560 ppm.

Selection of the 'High' range emissions scenario for both 2030 and 2070 for this assessment was due to scientific evidence that observed carbon dioxide concentration; global mean temperatures and sea level rise have been tracking at the upper end of the IPCC scenario range from 1990 to 2006. The CSIRO

advises that although this 17-year period to 2030 is very short, the mid and low projections may be less likely than the high projections, with significant implications for risk management (CSIRO, 2007, p.46). Whilst it is not possible to make this assumption for 2070 for the purposes of this assessment it was decided in the Context Setting Workshop that a 'High' Scenario should also be used for 2070 to provide consistency and to also take a 'precautionary approach'.

4.3 Climate Change Variables

The following climate change variables were recommended for consideration in the workshop:

- Temperature changes
- Sea Level Rise
- Rainfall
- Extreme events

A summary of predicted changes according to CSIRO data (published in 2007) and DECC data (published in 2008), is provided in Table 5 below. The Risk Assessment takes into account the level of risk for the present day (2009), and for the years 2030 and 2070 for Byron and Tweed Shire Council areas.

As more up to date data becomes available, it is recommended that each council review the Risk Assessment and identify any potential changes in risk level based on the revised climate change data.

Table 5 Summary of Climate Variables for the North Coast from NSW Government supported studies

Climate Variable		Current Average	Predicted Change		
			CSIRO (2007) 2030	UNSW (2008) 2050	CSIRO (2007) 2070
Temperature	Annual Average Temperature (°C)	CSIRO **1990** base line - avg max July and max Jan temp Armidale: 12 - 27ºC Coffs Harbour: 19 - 27ºC Lismore: 20 - 30ºC Yamba: 19 - 27ºC (CSIRO **North Rivers** projections)	+0.2 - +1.8ºC (CSIRO **North Rivers** projections) +0.2 to +2.8ºC (CSIRO NSW projections)	+1 to +3ºC	+0.7 - +5.6ºC (CSIRO **North Rivers** projections) +0.7 to +6.4ºC (CSIRO NSW projections)
Summer Temperature	Average	*See BOM data in Table 26 & 27* *NB: Data not verified by NSW Govt*	+0.2 to +2.3 ºC (CSIRO NSW projections)		+0.7 to + 7.1 ºC (CSIRO NSW projections)
	Average Max	*See BOM data in Table 26 & 27* *NB: Data not verified t*	Data not available	+1.5 to +2ºC	Data not available
	Average Min	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+2 to +3ºC	Data not available
Autumn Temperature	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	+0.2 to +1.9 ºC (CSIRO NSW projections)		+0.7 to +5.6 ºC (CSIRO NSW projections)
	Average Max	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+1.5 to +2ºC	Data not available
	Average Min	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+2 to +3ºC	Data not available
Winter Temperature	Average	*See BOM data in Table 26 & 27* *NB: Data not verified t*	+0.2 to +2.3 ºC (CSIRO NSW projections)		+0.7 to +5.6 ºC (CSIRO NSW projections)

Climate Variable		Current Average	Predicted Change		
			CSIRO (2007) 2030	UNSW (2008) 2050	CSIRO (2007) 2070
	Average Max	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+2 to +3ºC	Data not available
	Average Min	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+2 to +3ºC	Data not available
Spring Temperature	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	+0.2 to +2.1 ºC (CSIRO NSW projections)		+0.7 to +7.1 ºC (CSIRO NSW projections)
	Average Max	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+1.5 to +2ºC	Data not available
	Average Min	*See BOM data in Table 26 & 27* *NB: Data not verified*	Data not available	+2 to +3ºC	Data not available
Extreme Temperature (CSIRO, data averaged 1964 to 2003)	Annual average number of cold days (below 0°C)	Yamba: 0 (CSIRO **North Rivers** projections)	Yamba: 0 (CSIRO **North Rivers** projections)	Data not available	Yamba: 0 (CSIRO **North Rivers** projections)
	Annual average number of hot days (over 35°C)	Yamba: 1 (CSIRO **North Rivers** projections)	Yamba: 1-2 (CSIRO **North Rivers** projections)	Data not available	Yamba: 1-7 (CSIRO **North Rivers** projections)
	Annual average number of hot days (over 40°C)	Yamba: 0 (CSIRO **North Rivers** projections)	Yamba: 0 (CSIRO **North Rivers** projections)	Data not available	Yamba: 0 (CSIRO **North Rivers** projections)
Rainfall	Annual average rainfall	Armidale: 790 mm Coffs Harbour: 1,647 mm Lismore: 1,343 mm Yamba: 1,457 mm (CSIRO **North Rivers** projections)	-7 -+7% (CSIRO **North Rivers** projections) -13 to +7 % (CSIRO NSW projections)		-20 - +20% (CSIRO **North Rivers** projections) -40 to +20 % (CSIRO NSW projections)

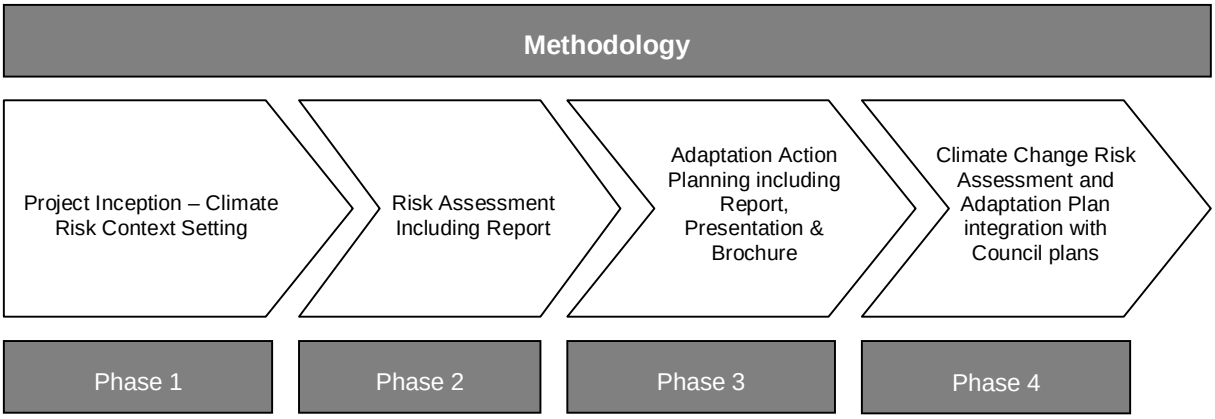
Climate Variable		Current Average	Predicted Change		
			CSIRO (2007) 2030	UNSW (2008) 2050	CSIRO (2007) 2070
Summer Rainfall	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	-13 to +13 % (CSIRO NSW projections)	-5 to +5 %	-40 to +40 % (CSIRO NSW projections)
Autumn Rainfall	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	-13 to +13 % (CSIRO NSW projections	-5 to +5 %	-40 to +40 % (CSIRO NSW projections)
Winter Rainfall	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	-13 to +7 % (CSIRO NSW projections)	-10 to +5 %	-40 to + 20 % (CSIRO NSW projections)
Spring Rainfall	Average	*See BOM data in Table 26 & 27* *NB: Data not verified*	-20 to +7 % (CSIRO NSW projections)	-10 to +5 % [Please note the seasonal rainfall distribution indicates that Tweed may experience a –5 to +5% change, whilst Byron may experience dryer conditions with a change of –10 to +5%]	-60 to + 20 % (CSIRO NSW projections)
Extreme Rainfall	1 in 40 year 1-day rainfall	Refer to other studies if available	-10-+5% (CSIRO **North Rivers** projections)	Data not available	+5 - +10% (CSIRO **North Rivers** projections)
Run-off	Average Maximum	Refer to other studies if available		-10 to 20% in dryer periods	
Summer Run-off	Average			+4 to -15%	
Autumn Run-off	Average			-12 to +16%	
Winter Run-off	Average			-20 to +8%	
Spring Run-off	Average			-14 to +4%	
Evaporation	Annual Average (%)	Refer to other studies if available	+1 - +13% (CSIRO **North Rivers** projections)	Data not available	+4 – +40% (CSIRO **North Rivers** projections)

Climate Variable		Current Average	Predicted Change		
			CSIRO (2007) 2030	UNSW (2008) 2050	CSIRO (2007) 2070
Number of droughts per decade (CSRIO, centred on 1990 data)		2 (CSIRO **North Rivers** projections)	2-4 (CSIRO **North Rivers** projections)	Data not available	1-9 (CSIRO **North Rivers** projections)
Wind Speed	Average Annual Wind Speed (%) 50th percentile	*See BOM data in Table 26 & 27* *NB: Data not verified*	-2 to +2% CSIRO online database	Data not available	+2 to +5% CSIRO online database
Extreme Wind		Refer to other studies if available	-5 to +8 % (CSIRO **North Rivers** projections)	Data not available	-16 to +24% (CSIRO **North Rivers** projections)
Relative Humidity	Summer Average (%) 50th percentile	*See BOM data in Table 26 & 27* *NB: Data not verified*	-0.5 to +0.5%	Data not available	0.5 to –1%
Number of Fire days		Coffs harbour: 4 (CSIRO **North Rivers** projections)	Coffs harbour: 5 - 6 (CSIRO **North Rivers** projections)	10 to 15	Coffs harbour: 5 - 8 (CSIRO **North Rivers** projections)
Downward Solar Radiation	Summer Average (%) 50th percentile	Refer to other studies if available	-1 to +1%	Data not available %	-1 to +1%
Sea Level Rise	Above 1990 base line	Globally, the average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm per year and since 1993 at 3.1 mm [2.4 to 3.8 mm per year, with contributions from thermal expansion, melting glaciers and ice packs, and the polar ice sheets].IPCC		+40cm	+90cm (by 2100, UNSW data and level adopted by NSW Govt)
Sea Surface Temperature Change	Average (ºC)	Refer to other studies if available	+0.3 to +0.6 ºC		+1.5 to +2 ºC

5. Risk Assessment Workshop Findings

Considering the limited resources available for this project, this initial study is a high level qualitative assessment to establish the high level risks and areas for further investigation. Additional analysis will need to be undertaken to determine which specific assets, activities or areas are vulnerable to climate change and in some cases a more detailed semi-quantitative Risk Assessments may need to be undertake. For example, the risk workshops have identified that each individual Council assets need to be determined and assessed for specific sea level and storm surge risk.

Project Phases



Progress to date on the Project:

Phase 1	1. Establish the Context	Complete
Phase 2	2. Identifying Impacts	Complete
	3. Analyse Impacts	Complete
	4. Evaluate Impacts	Complete
Phase 3	5. Adaptation Planning	Adaptation Workshop to be undertaken

5.1 Phase 1 – Context Setting and Areas of Concern

Council representatives provided a list of concerns they would like to be addressed during the Context-Setting Phase. Similar issues across both Councils included flooding, coastal erosion and inundation. Flooding is of particular concern to Byron Shire as a result of recent modelling carried out by Byron Council. Tweed Shire were concerned with water security. Tweed Shire were particularly concerned about the rising sea levels which may lead to seawater breaking over the weir and resultant in the contamination of fresh water supplies. In addition concern around emergency response for small communities and bushfire risk were also of particular concern to the Tweed Shire. This data has used as a point of reference in the Risk Assessment Workshop results (please refer to 5.7 Risk Analysis) and to determine if any areas of concern have either not been analysed or will need to be further addressed in the Adaptation Phase.

The areas of concern are listed below:

5.1.1 Byron

» Flooding across the local government area

» Coastal erosion.

» Coastal inundation

» Planned retreat and compensation for property owners - Byron modelling suggests that town centre is at risk.

Source: Byron Shire Council Representative.

5.1.2 Tweed

» Inundation of water and sewer infrastructure from sea level rise combined with existing flooding issues and flooding in coastal communities.

» Emergency response for small communities specifically for access.

» Bushfire risk to housing and community infrastructure.

» Peak oil impacts on transportation capability of the community.

» Coastal erosion and inundation.

» Water security for growing population.

» Ecosystem services and the resilience of the natural environment to cope with climate change pressures.

Source: Tweed Shire Council Representative.

5.2 Phase 2 – Risk Assessment

The risk workshop was held at the Byron Shire Council on the 12th February to identify, analyse, and evaluate risks related to climate change that could impact on both Councils. A following workshop was carried out with a GHD representative and the Sustainability Officers on the 18th February to finalise the Risk Matrix. The participants at the workshop are identified in Table 11 in the Appendices.

Please refer to Appendix C, for detail regarding the methodology followed in Phase 2 - Identifying, Analysing and Evaluating Impacts.

5.3 Risks Identified

Taking each key element and each climate change variable in turn, risks associated with climate change and potential impacts on the Shire were brainstormed for the scenarios below:

» Current (2009);

» 2030; and

» 2070

Twenty-five potential climate change impacts were identified for the Councils over these time periods. Although the climate change variables of increased rainfall, increased temperature, increased sea level and storm events were addressed separately, there were incidences where the potential impacts could in fact be a result of a combination of the variables. For example, a combination of higher temperatures and

reduced rainfall could result in a reduction in crop production and therefore revenue in the local economy.

5.4 Risks Analysed

For each of the risks and potential impacts identified, any existing controls were noted and then, taking these controls into account, the existing level of consequence and likelihood were agreed by the workshop participants. Then, taking into account the projected changes in climatic variables for 2030 and 2070, the level of consequence and likelihood for each risk impact were reassessed for each of these two future dates. Potential controls to be introduced to mitigate these risks were also discussed and the Residual Risk at 2030, assuming the identified controls were in place, was then analysed.

The Risk Register, which details each of these elements, is contained in Appendix D. A number of current and potential controls were identified during this stage and these are discussed in more detail in Sections 5.7 and 5.8.

5.5 Risk Prioritisation

In total there were twenty-five risks identified, with twenty-two analysed for level of risk. A summary of the number of risks in each risk level is contained in Table 6. A snapshot of the risks identified and the associated Risk Levels can be found in Table 7. A graphical representation of the output can be found in Figure 7,Figure 8,Figure 9,Figure 10 and Figure 11below.

The Risk Register attached in Appendix D is a record of the workshop assessment. As such, the climate variables addressed do not follow a particular order and were recorded as participants covered them. The idea was to capture all thoughts first without breaking the flow of thought. Provides the output from the risk register grouped by the Climate variables (below) and provides a snap shot of the risk ratings for each risk item analysed during the risk workshops. In summary:

- Increased Temperature (13)
- Sea Level Rise (7)
- Increased Storm Intensity (2)
- Rainfall (Decreased) (2)
- Rainfall (Increased) (1)

A priority list has been developed based on the risk analysis with priority given to risk that received a significant rating under the ‘Current’ timeframe and referred to as risk items requiring immediate attention. Significant risks in this assessment are referred to as those risks the participants rated either ‘Extreme’ or ‘High’. The same analysis was carried out on the risk analysis for the 2030 timeframe, which fall into the medium term and for the 2070 timeframe, falling into the long-term. Please note that even though most risks develop into significant risks over the 2030 and even the 2070 timeframe, this should not be taken as a reason to delay action. The possibility exists that delaying action now, will result in more costly measures having to be taken in the future. Risk items with similar vulnerabilities and controls were grouped together in this analysis. Table 8 below provides a summary of the priority risks. A summary of the remainder of the risks rated Moderate to Low is provided in Table 9 below.

The two significant risks under current climatic conditions (2009) requiring immediate attention include:

» ***Item 1: The introduction or proliferation of exotic species due to increased temperature*** (Environment) [High Risk Level]; and

» ***Item 22: Increased flood level and frequency due to increased storm intensity*** (Human Life & Health) [High Risk Level].

For 2030 and 2070 a further six and fourteen risks respectively received 'Extreme' or 'High' Level ratings. All the risks rated Extreme on the register were a result of assessing the risk item against the Climate Change variable 'Sea Level Rise'. In total seven 'Sea Level Rise' risks were rated and its is six (of seven) these risks that received an 'Extreme' risk rating in 2070.

Two risks namely received a 'High' **Residual Risk** Level rating:

» ***Item 2: Sea level rise impacting upon loss of biodiversity*** (Environment) [Extreme Residual Risk Rating]; and

» ***Item 22: Increased flood level and frequency due to increased storm intensity*** (Human Life & Health) [High Residual Risk Rating];

Any risk which receives an 'Extreme' or 'High' priority level demands urgent attention at the most senior level of council and cannot be accepted as part of the routine operation of council without executive sanction.

Most risks increased in priority over time. It was however be possible to improve the risk level for each risk item considered, by introducing potential controls. This is investigated in more depth in the next phase of the process - the Adaptation Planning phase. In this component participants merely brainstormed potential controls, the adaptation phase will analyse all potential controls and assess the adequacy of individual controls.

The participants were able to lower the Residual Risk rating of all risks with suggested potential controls, with the exception of one risk, which produced a risk rating of 'Extreme' for 2070 and the Residual Rsk. This sensitive risk is the ***Item 2, Loss of existing biodiversity' due to sea level rise***. The workshop assessed that given current knowledge, by 2070 there would be no foreseeable way to prevent the inundation of floodplain or adapt the floodplain to save the existing habitat. Measures such as biodiversity/gene banking will assist in saving species of flora and fauna but measure such as sea walls and floodplain defences will need to face rigorous cost/benefit analysis. Further offline studies will need to be undertaken to validate the Residual Risk Assessment.

On the other side of the coin, two other risk items were reduced from 'Extreme' in 2070 to a Residual Risk rating to 'Low. ***Item 7, Impact on fresh water supply,*** as result of ***climate variable 'Sea Level Rise'*** (NB: This risk is specific to Tweed.). Concern surrounded the incursion of seawater into the water supply in the Dam as it over-tops the current weir height with the sea level. Participants determined that if weir augmentation is carried out before sea level rises by another 10cm from current level, the Residual Risk of seawater contamination of the freshwater supply is lowered to 'Low'.

Item 23, Coastal erosion, as a result of the ***climate change variable 'Sea Level Rise'*** similarly had an 'Extreme' rating for 2070 ('High' rating for 2030). The Residual Risk could be managed down to 'Low' but this would involve taking the only viable option available of planned retreat. (Note: The risk treatment was relevant only to Byron Shire). There was a concern that all other potential engineered mitigation measures, such as sea walls and coastal buffers could be are considered unviable due to the cost/benefit analysis and/or the suggested engineered controls would not be adequate.

Table 6 Number of risks in each category

Risk Level	2009	2030	2070	Residual Risk
Low	10	3	2	7
Medium	10	13	6	12
High	2	6	8	2
Extreme	0	0	6	0
Residual risk not rated				1
Total	22	22	22	22

As demonstrated in Table 6 above and Figure 7 below, it is anticipated that there will be a general increase in the level of risk associated with each of the risks. This is expected, as without Adaptation Planning (i.e. business operates as usual) the current controls may not be able to adequately manage the impacts of the changed climate.

With the implementation of the potential adaptation control strategies, the Residual Risk level results are two significant risks (rated as 'Extreme' or 'High'), twelve risks rated as 'Moderate' (consequences are ranked either 'Minor' to 'Moderate' and the likelihood as 'Possible' or "Likely") and six risks rated as 'Low' (majority of the consequences are minor, and the likelihood of occurrence is unlikely).

It must be noted however that the initial estimate of Residual Risk was based on the professional opinions of the workshop attendees, and may be revised with subsequent adequacy assessment in the Adaptation Workshop process. The current Residual Risk represents an initial guidance about the risk reduction potential given the nature of each impact and likely ability to manage it based on current knowledge, without budget limitations.

Figure 7 Summary of Risk Level's for 2009, 2030, 2070 and Remaining Residual Risk

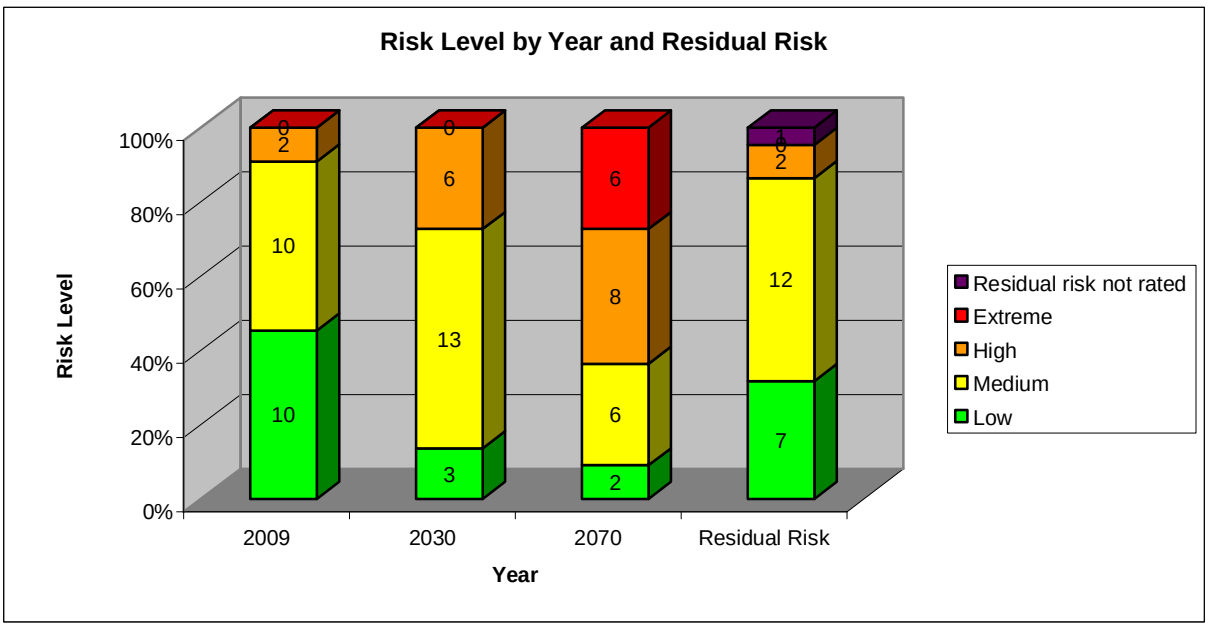


Figure 8 Risk Level by Year for Sea Level Rise

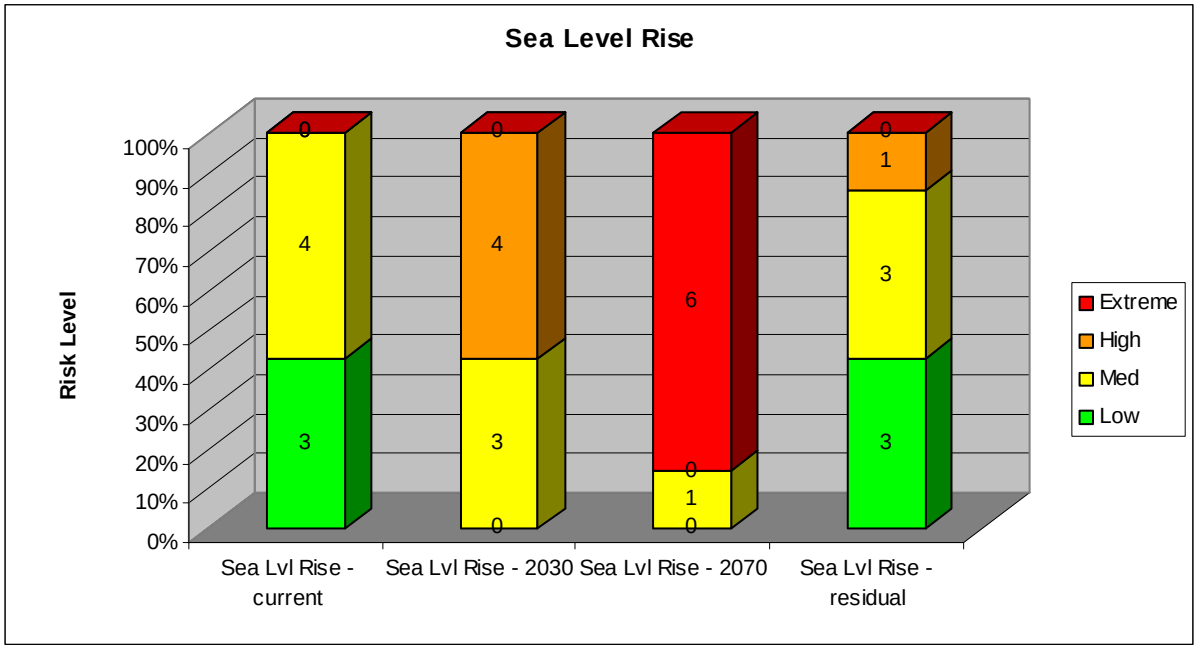


Figure 9 Risk Level by Year for Increased Temperature

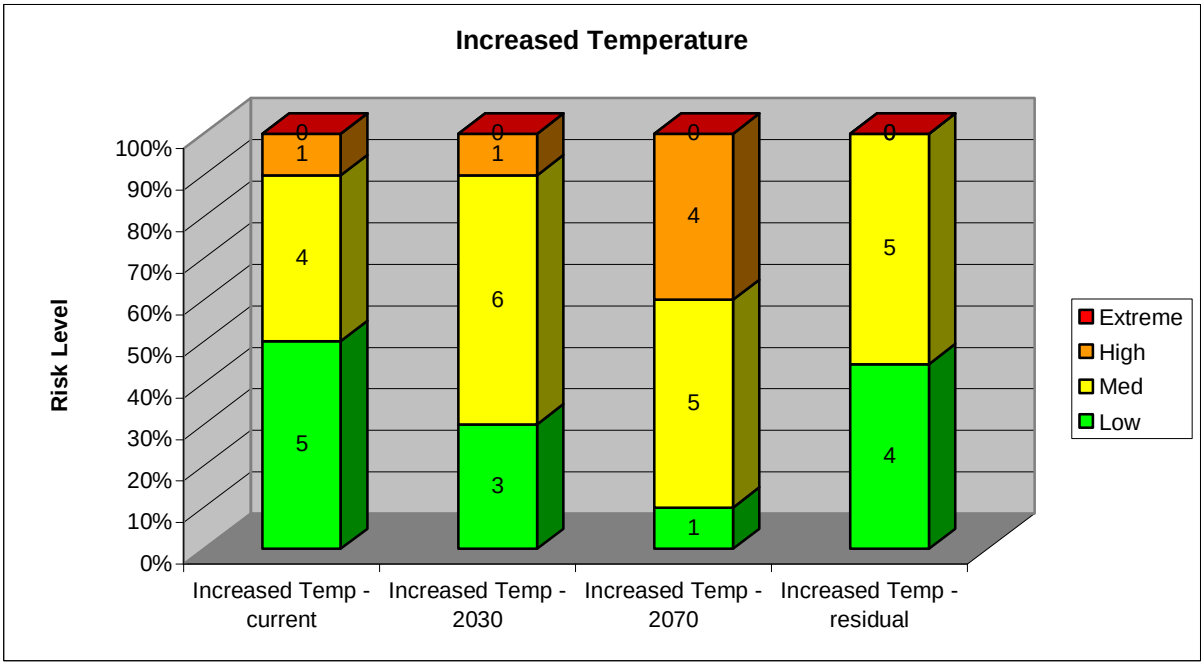


Figure 10 Risk Level by Year for Increased Storm Intensity

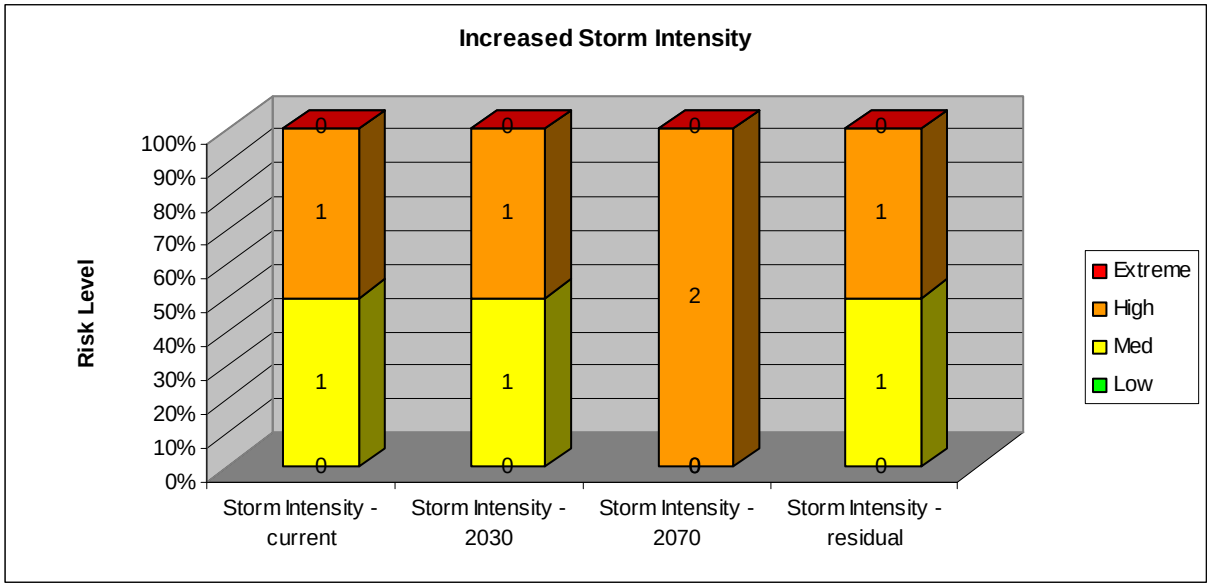
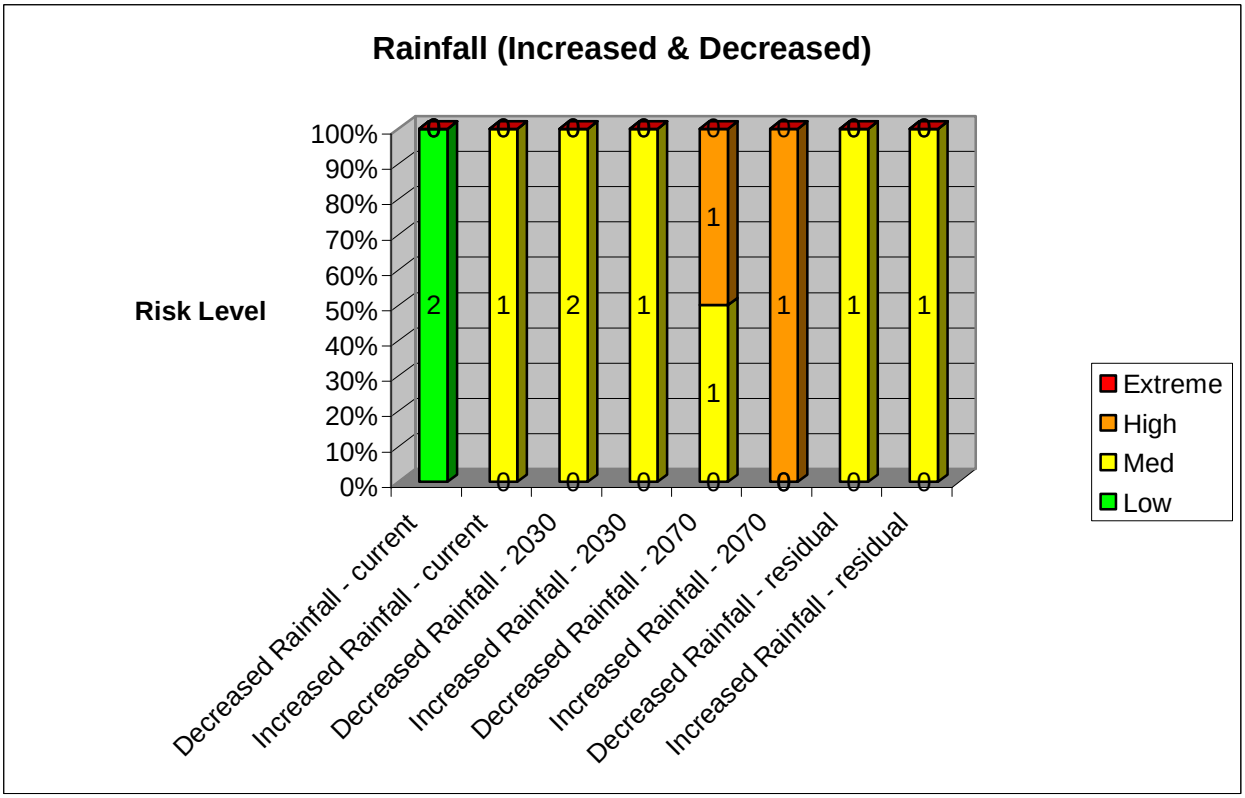


Figure 11 Risk Level by Year for Rainfall (Increased & Decreased)



Please note that the graphs above are represented as a percentage graphs to allow for comparison across the time lines current, 2030, 2070 and resulting residual risk. The number of risks analysed within the each climate variable analysed [Increased Temperature, Sea Level Rise, Increase Storm Intensity and Rainfall (both increased and decreased rainfall variables are represented on the same graph)] have been provided within each column. Note the increasing severity across all climate variables.

Table 7 Risks sorted by Climate Variables

Climate Variable	Register Item	Risk	Risk Category	Current	2030	2070	Residual
Increased Temperature (13)	1	The introduction or proliferation of exotic species	Environment	High	High	High	Medium
	6	Habitat displacement	Environment	Low	Medium	High	Medium
	9	Increased bushfire events (and intensity)	Property & Finance	Medium	Medium	High	Medium
	10	Increased bushfire events (and intensity)	Human Life & Health	Low	Low	Medium	Low
	11	Increased bushfire events [Environment]	Environment	Medium	Medium	Medium	Medium
	12	Decreased water flows into dam or catchments	Human Life and Health	Medium	Medium	Medium	Medium
	13	Decreased water flows into dam or catchments]	Environment	Not Rated	Not Rated	Not Rated	0
	14	Spread of mosquito Bourne diseases	Human Life & Health	Low	Medium	Medium	Low
	15	Higher evaporation and longer drought periods	Property & Finance	Medium	Medium	High	Low
	16	Increased evaporation and drought	Human Life & Health	Low	Low	Low	0
	17	Infrastructure services - Degradation of roads	Property & Finance	Not Rated	Not Rated	Not Rated	0
	18	Heat stress	Human Life & Health	Low	Low	Low	Medium
	24	Impact on Parks	To be analysed	Not Rated	Not Rated	Not Rated	0
Sea Level Rise (7)	2	Loss of current or existing biodiversity	Environment	Medium	High	Extreme	High
	5	Increased groundwater level leading to intrusion of pipe works	Property & Finance	Low	Medium	Medium	Low
	7	Effect on freshwater supply	Property & Finance	Medium	High	Extreme	Low
	8	Impacts on coastal development	Property & Finance	Medium	Medium	Extreme	Medium
	19	Increased flood level and frequency	Human Life & Health	Low	High	Extreme	Medium
	21	Flooding	Property & Finance	Medium	Medium	Extreme	Medium
	23	Coastal Erosion	Property & Finance	Medium	High	Extreme	Low
Increased Storm Intensity (2)	20	Increased flood level and frequency	Property & Finance	Medium	Medium	High	Medium
	22	Increased flood level and frequency	Human Life & Health	High	High	High	High
Rainfall (Decreased) (2)	4	Drought	Property & Finance	Low	Medium	Medium	Medium
	25	Drought	Environment	Low	Medium	High	Medium
Rainfall (Increased) (1)	3	Decline in the local economy due to reduced tourism and appeal	Property & Finance	Low	Medium	High	Medium

Table 8 Eight Areas of Concern that received a High or Extreme Risk Rating

2009	2030	2070
1. The introduction or proliferation of exotic species Increased Temperature ***(Item 1)***	3. Loss of current or existing biodiversity Sea level rise ***(Item 2)*** * Other risk items related to the area of concern on the Risk Register include: Increased temperature (Item 6)	6. Increased bushfire events (and intensity) Increased temperature [leading to a loss of property] ***(Item 9)*** Other risk items related to the area of concern on the Risk Register include: Increased temperature: [leading to loss biodiversity] considered a moderate risk in 2070 (tem 11) Increased temperature [leading to loss of life and safety issues] considered a moderate risk in 2070 (Item 10)
2. Increased flood level and frequency/ flooding Impacts on coastal development Increased Storm Intensity ***(Item 22)*** Other risk items related to the area of concern on the Risk Register include: Storm Intensity (Item 20) Sea level rise (Item 8, 19 & 21) *	4. Effect on freshwater supply Sea level rise ***(Item 7)*** * Item specific to Tweed	7. Higher evaporation and longer drought periods Increased temperature ***(Item 15)*** Decreased Rainfall ***(Item 25)*** Other risk items related to the area of concern on the Risk Register include: Drought (Item 16) Decreased rainfall: (Item 4)
	5. Coastal Erosion Sea level rise ***(Item 23)**** Item specific to Byron (Planned retreat)	8. Decline in the local economy leading to a loss of tourism and agricultural productivity More sever weather events from increased rainfall and extended drought periods. ***(Item 3)***

***Denotes the risk items on the Risk Register that received an Extreme risk rating (2070) due to Sea Level Rise [Items 2, 7, 8 19, 21 and 23 on the risk register] discussed above.

Please refer to Table 13 in Appendix E for the consolidated <u>vulnerabilities and current control</u> as per the priority list above.

Sea level rise is not an immediate concern but the impacts over the medium and long term are evident across a number of risks. Increased temperature impacts become more evident with significant impacts occurring both immediately and then again over the longer term.

The risks listed below are a combination of risks that have a 'Low' to 'Moderate' rating and risk items.

Table 9 Remainder of the risks rated Moderate to Low (Four Areas of Concern)

	Risk Description	Risk Item	Consequences/ Vulnerability	Current Controls
1	Heat stress	Increased Temperature [Human life & health] (Item 18)	Heat related stress and injury Death Vulnerable elderly and children Loss of motivation Increased conflict amongst people	Air conditioners Swimming Re-hydration Building codes Outdoor staff amended work hours
2	Decreased water flows into dam or catchments	Item 12 [Human life & health] Item 13 [Environment] Note that this risk in relation to environment has not been analysed	Inability to service suburban water demands Drop in water quality Algal blooms	Dam locations, demand management strategies, safe yield projections
3	Spread of mosquito Bourne diseases	Item 14	Increased hospitalisations, sick leave (loss of livelihood)	Mosquito and biting midge control plan
4	Increased groundwater level leading to intrusion of pipe works	Item 5	Inability of infrastructure to function	Coastal Zone Management Plan (estuary and coastal and floodplain) - protect/retreat strategy maintain current dune structure via engineering works i.e. rock walls, barriers Flood Gates systems and levies Infrastructure design

Finally the three risks not rated on the register include due to restricted time available at the workshop:

Item 13 - Decreased water flows into dam or catchments against the risk category of Environment noted above

Item 17 - Infrastructure services **- Degradation of roads**

Item 24 - Impact on parks

Risk not rated for Residual Risk

Item 16 - Increased evaporation and drought [Human Life & Health] has not been rated for Residual Risk

5.6 Issues and Opportunities

Table 12 in Appendix E documents the issues and opportunities raised during the Context Setting Phase. These issues and opportunities have been grouped into the following areas: Governance, Planning & Legislation; Health; Data; Climate; Climate Scenarios; Emergency Response; Biodiversity and Agriculture. This output will be used as a guide during the Adaptation Planning workshop as starting point for potential barriers that may need to be considered during the Implementation of resulting actions following the Adaptation Workshop.

5.7 Current Controls in place as per the Risks Identified

The controls identified during the Risk Assessment Workshop may be categorised into Management Plans & Policies, Community Services and Awareness Programs, State or National Controls and Engineering or Physical Controls. A summary of the controls utilized by the Councils is demonstrated in Table 10. These control strategies are a compilation of current controls that arose during the Risk Assessment Workshop with additional relevant strategies supplemented for a more comprehensive set of strategies. Please refer to Table 13 in Appendix E for the consolidated vulnerabilities and current control as per the eight areas of concern listed in Table 8 above.

The detail of and commitment to these controls is vital to ensuring the level of risk associated with climate change is reduced to as low as reasonably practicable.

An indication of the adequacy of the current controls of the risks is shown in the Level of Risk assigned, i.e. where this is ‘Medium’ or ‘Low’. The number of incidents occurring demonstrates another indication of control adequacy.

Climate change risks are unique in terms of their control strategies. When looking into the future, at 2030 and 2070, it is notable that the level of risk increases, if controls are not modified. In most cases the controls are aimed at managing the current level of risk, and some future climatic conditions may not be suitably controlled by these current measures. The Residual Risk component is an initial brainstorm of potential controls that may be available (based on current knowledge) that could lower the risk rating. For example, stormwater collection is presented as a control for the reduction in the supply of water due to reduced rainfall. However in the future, the window of opportunity for collecting stormwater may be limited due to the reduced rainfall, and hence it is important to monitor the effectiveness of controls (Note: Water supply is an issue mainly with Tweed Shire – see Item 18). There will be a requirement to expand and compliment the water management program and look at alternate means for supplying water.

Multiple climate change variables may also interact in the future, rendering some current controls inadequate. For example, drainage maintenance will need to take into consideration increased groundwater levels due to sea level rise (see Item 5) as well as intrusion into pipes and the integrity of the drainage system in the even of a flood due to increased storm intensity and increased sea level (Item 20 & 22 and Item 19 & 21).

Table 10 A Summary of Current Controls Utilized by Byron and Tweed Shire Councils

Management Plans & Policies	Community Services And Awareness Programs	State or National Controls	Engineering / Physical Controls
Coastal Zone Management Plan, coastal dune rehabilitation, set backs, sea walls	Pest control education awareness	State Biodiversity plans	Coastal dune rehabilitation, set backs, sea walls, sand pumping
Weed control which includes joint programs (work on private properties)	Bushfire eduction	State legislation: - Water for example MWSP, Stormwater, Bushfire, Planning, LEP , Coastal/Flood	Integrated water cycle management, water tanks, water recycling, stormwater harvesting
Local Environmental Plans – zoning	Water scarcity community awareness	Federal legislation – EPBC Act	Temporary barrier over weir
Development Control Plans - zoning	Community preparedness for storms and floods	State and Federal funding and grants	Hazard reduction burning
Predator and pest eradication program – Cane Toad and Indian Myna Bird control program, Mosquito and Biting Midge Program	Demand Management	DECC policy, guidelines and manuals e.g. Floodplain	Weed Control
Tourism promotion - Increased advertising post sever wet weather	Biodiversity Management Programs	BASIX	Infrastructure design – flood gates systems and levies
Water Management Plan – demand management, water tanks, water recycling, safe yield projections, Macro Water Sharing plans (under development), restriction levels, integrated water cycle management, Water Sensitive Urban Design,		Building Construction Standards	Operational Management Plans for example temporary barrier over weir, drainage maintenance
Catchment Management Plan, catchment zoning (LEP zoning), augmentation Management Plans, dam location		Tourism – marketing and campaigns	House raising
Stormwater harvesting management		Local Government Act provision	Road Maintenance Program
Infrastructure design – flood gates systems and levies		Catchment Management Plans Catchment Action Plan (CAP)	Floodplain management and zoning
Vegetation Management Plans			Tree Management
Operational Management Plans for example temporary barrier over weir, drainage maintenance			Sewer Overflow Abatement Strategy – barriers, sand pumping
Landuse Planning framework, land tenure			
Voluntary measures - purchase of land by council or house raising by residents			
Local Government Act provisions			

Management Plans & Policies	Community Services And Awareness Programs	State or National Controls	Engineering / Physical Controls
Asset Management Plans (Tweed complete, Byron in the process of developing an AMP)			
Monitoring			
Research			
Agricultural management			
Asset Protection Zones			
Bushfire Management Plan – Hazard reduction burning fire mapping, ignition management, training, operational readiness			
Road Maintenance Program			
Agricultural Management			
Disaster Plan – Emergency Services, road closures			
Floodplain management and zoning			
Tree Management			
Sewer Overflow Abatement Strategy – barriers, sand pumping			
Personnel insurance			
Hazard Identification procedures			
Coastline Management Plan with a asset focus			

5.8 Adaptation Planning

Following the establishment of areas of concern/opportunities GHD runs further participatory processes to develop options for treating these risks. This involves identifying and selecting the best options to treat the areas of concern and to harness significant opportunities. GHD has developed a *Climate Change Adaptation-Planning Tool* (CCAPT) to assist in this process that includes some multi criteria assessment so that cost considerations and benefits can be integrated into the prioritisation process. This tool is customised to the participating Council's needs. The process identifies leverage points where each Council has ability to directly address each area of concern as well as external leverage points where external support is required. An Adaptation Response Strategy is prepared. It is envisaged that Council may also want to articulate at this point its public policy stance with respect to climate change impacts, so that it can work with policy makers to secure the increased certainty needed for the operation of its business into the future

An Adaptive Capacity Assessment will be carried out to assess the adaptive capacity of existing assets and activities (e.g. exposure, sensitivity, potential impacts, adaptive capacity and vulnerability), the aim is to identify actions that increase the climate resilience of key council plans and policies, such as council asset management, emergency response plans and Bushfire Management Plans. In carrying out a risk assessment certain characteristics of the population and area are particularly important as they influence the sensitivity and vulnerability of the population to climate change impacts. Age distribution and affluence of a community are important to determine the health related effects of extreme changes in climate, in particular the impact of heat stress on infants, young children and the elderly. Affluence indicated by level of income and type of dwellings are important in gauging the ability of a community to either cope with extreme events and ability to adapt to changing climate conditions and secondary impacts associate with these changes. There may be other impacts of climate change on the community that could not be fully assessed in the Risk Assessment process due to the limitations of the exercise. For instance there may be flow through (tertiary) risks that will impact on local business and the community such as increased storms, rainfall and temperatures. Some further examination of flow through effects may need to be conducted at the Adaptation Planning phase to ascertain the exact nature and magnitude of these impacts.

As noted, it is considered feasible to be able to reduce the Risk Level associated with a number of risks by implementing the potential controls identified during the Risk Assessment Workshop. The preliminary potential controls identified for Adaptation Planning can be found in Table 14 in Appendix E.

5.8.1 Plans

As a basis to managing potential climate change impacts, key documentation the Councils utilises to operate and manage its business should be reviewed and updated to reflect considerations of climate change. These documents and processes may include, but are not limited to:

- Town Planning Schemes;
- Council Approvals;
- Infrastructure Management Policies;
- Waste Water Management Plan;
- Fire Protection Plan;
- Fire Permits and Management Plan;
- Flood Management Plan; and

» Disaster Management Plans.

The potential controls will be investigated further during the Adaptation Planning stage of the project. However, in order to prepare for the adaptation phase, consideration of the potential controls should be made in regards to:

» Alignment to future business plans;

» Alignment with any existing or future sustainability programs;

» Alignment with State and Federal initiatives;

» Biodiversity philosophy and adaptation approach; and

» Future local climate change investigation programs.

In order to fully comprehend the communities understanding of climate change, and ascertain initiation points for the implementation of potential controls, consideration should be given to:

» Align Council's response with the regional social values;

» Monitoring key climate indicators (e.g. water availability, pest levels, number of frost days, changes in rainfall patterns);

» Development of key initiation points for the implementation of key adaptation actions;

» Development of relationships with universities and research facilities in order to be conversant and up to date with new technology that may be used in the control of climate change consequences and integrate this new technology into Council activities as they become available.

Climate change and global economic pressure may also increase the future cost of living due to escalating costs of necessities such as fuel, power and water. Consideration should be given to the implications of these cost increases on the local business and communities. It is suggested that an independent study on this interaction in particular between greenhouse gas abatement strategies and their implications for the community at large and this climate change adaptation process be conducted as a separate exercise.

5.8.2 Planning and Adaptation Horizons

Climate Change is a topical issue for the communities of Byron and Tweed with broad expression of concern in relation to water security, coastal retreat and property encroachment, energy use/efficiency, flooding issues, and impacts to agriculture and tourism business. In response to this, Council have developed a number of initiatives to benefit sustainability and greenhouse gas minimization across the region including (for Tweed): Sustaining the Tweed– A Local Agenda 21 Program, The Sustainable Households Project, Tweed Community Greenhouse Gas Reduction Local Action Plan, the Methane Power Plant at Stott's Hill Landfill and for Byron: The Byron Shire Greenhouse Action Strategy and the Sustainable Agriculture Strategy. The ongoing pressures of growth in the area will require a strategic approach to managing population growth while minimizing greenhouse gas emissions.

As the face of the community, councils are often under the spotlight when contentious issues arise in the local area. As with all other community related issues, councils could be the first to recognise community apprehension and hardship. Byron and Tweed Shire Councils have the ability to identify regional issues at an early stage and take action in coordination with State and Australian Government bodies. Some initiatives that should be considered are listed below.

Short-term actions:

» Study ecosystem health on floodplain

» Check controls for Biodiversity Management Plan, determining specific locations at risk and potential for future research;

» Set up monitoring programs in key areas such as exotic species, this could include alliances with universities and research organisations;

» Utilise relevant monitoring programs for key areas where data gaps from government agencies in the region;

» Development of short term funding requests to State and Australian Government for key areas, studies and infrastructure (i.e. infrastructure, including coastal infrastructure, biodiversity programs, flooding);

» Identify opportunities to reduce reliance on private motor vehicles for transportation;

» Work with local/regional and state economic development agencies to improve economic resilience to climate change impacts; and

» Work with health agencies to address knowledge gap relating to health and the impacts of heat stress.

Medium term actions:

» Review Planning approvals processes for larger projects;

» Planning Scheme amendments to address flooding such as further retreat;

» Investigating support for business transition in the region, especially for agriculture and tourism;

» Assess property numbers and infrastructure impacted by storm surge/ sea level rise impacts; and

» Council insurance and liability clarification.

Long term actions / controls to consider:

» Asset Management and infrastructure budgets reassessed;

» Building programs aligned;

» Water supply augmentation management programs reviewed;

» New Strategic Planning approach in most vulnerable areas for example the Byron Town Centre and Tweed Floodplains; and

» Further investigation into regional and seasonal rainfall to integrate into current yields modelling.

5.9 Exclusion and Gaps

The Risk Assessment exercise conducted was a high level assessment, and as such not all risks have been identified in detail due to the vast scope of risks. It is expected that there will be gaps in the total Adaptation Planning process and as such will need to be addressed when the Risk Assessment process is revisited in future. It was not possible for the two Councils to identify all risks, given knowledge, budget and time limitations. The scope of risks identified was limited only to significant activities and assets of the Councils that are at risk from a changing climate. This was carried out drawing upon the

professional knowledge of the council participants as to which assets and activities are **sensitive to climate change** and then whether based upon the judgement of the participants **whether climate change is a significant source of risk** to the assets and activities. For example gaps include emergency planning procedures due to increasing flooding, storm and bushfire activity, the impacts on business and agriculture, and the compounding effects on community vulnerability. It is quite likely that more risks will be identified as time progresses and the results of this process are reviewed and updated.

The study was reliant on the data available at the time, and it is quite possible that the values may change as knowledge improves in this emerging area. Climate change is an emerging issue and the workshop team sought to qualitatively understand the effects and risks using reasonable assumptions as set out in this document.

A number of controls have been identified for the management of climate change impacts that are already incorporated in existing Council plans and management strategies. It is recommended that all these key plans be reviewed for their adequacy to manage climate change. It is also recommended that Council incorporate the short, medium and long-term action items into these planning processes as a matter of urgency. As stated above a preliminary identification of adaptation controls was conducted in the Risk Workshops and a more detailed assessment of the adequacy of controls will be undertaken in the next phase of the project, Adaptation Planning.

6. Conclusions

As consistent with the Local Adaptation Pathways Program (LAPP) funding, a risk assessment was conducted for Byron and Tweed Shire Councils utilising the methodology outlined in *Climate Change Impacts and Risk Management: A Guide for Business and Government* (AGO, 2006).

The risk assessment identified twenty five risks relevant to the Byron and Tweed Councils based on the assessment of the climate variables of reduced average annual rainfall, sea level rise, increased average temperature and extreme events (storms, flooding, bushfire, high winds) for the timeframes of 2009, 2030 and 2070.

Of the twenty-two risks analysed for level of risk, there was a general increase in severity of risk as the timeframe extended into the future. For the current timeframe one risk was two risks were rated as 'High', ten as 'Medium' and ten as 'Low'. This increased to six 'High', thirteen 'Medium' and three 'Low' for 2030. This increased again in 2070 to six 'Extreme', eight 'High', six 'Medium' and two 'Low' in 2070.

With the implementation of the potential adaptation control strategies, the Residual Risk level was reduced to two 'High', twelve 'Medium' and the remaining seven risks being 'Low'. It must be noted however that the initial estimate of Residual Risk was based on the professional opinions of the workshop attendees.

It is recognised that there may be other impacts from climate change on the community that could not be fully assessed in this process due to the limitations of the exercise. Whilst the Byron and Tweed Councils are not directly responsible for the management of businesses located in the area, there may be flow through (tertiary) risks that will impact on local business and the community such as increased rainfall and increased temperatures. Council may have some ability to influence the business direction of the local area therefore alternative businesses, which could be more resilient to climate change, need to be identified and given opportunity to develop in the region. Some examination of flow through effects onto the community may need to be conducted to ascertain the exact nature and magnitude of these impacts.

As the climate change projections by the CSIRO and the DECC are approximate by nature, it is possible that the climate change and ensuing regional consequences that actually occur for the Byron and Tweed area may not be an exact fit to those assumed in this exercise. Climate change assessment by its nature is a dynamic and ongoing process. It is therefore also recommended that Council set up monitoring programs to ensure that any critical climate change variables are tracked so that the consequential changes are detected early, enabling appropriate programs to be implemented in a timely fashion.

As an outcome of this exercise, short, medium and long-term action items should be incorporated into the appropriate current Council planning processes. In order to achieve the estimated risk reduction it is important that the potential adaptation control strategies should be aligned with future business plans, sustainability programs, and State and Federal initiatives in the region. Further investigation of the adaptation control strategies will be conducted during the next phase of the project - Adaptation Planning

A large number of risks where identified that relate to sea level rise and storm intensity, which has impacts on the areas coast and floodplains. Byron and Tweed Councils need to continue their reviews of their planning schemes and coastal and floodplain management to include provisions to better manage these climate change risks. In particular they will need to consider developing procedures and processes for assessing potential climate change impacts on the future developments and structures they are asked to approve as part of their planning processes. These decisions can have significant financial impacts for developers, designers and builders. The impacts on key infrastructure will also need to be carefully assessed, perhaps as part of the Council's asset management processes. There is

also the risk of exposing both Shires to liabilities from third parties if these are not executed properly.

Recent advice to the Sydney Coastal Councils Group from the Environment Defenders Office on coastal planning and climate change highlights the myriad of existing controls (16 legislative instruments and 20 NSW Government policies) that contain reference to climate change or terms of interest. These were found to impose limited responsibilities for councils but required climate change to be considered in a genuine manner. There are also common law liabilities, in particular negligence and nuisance, which can impact on councils in relation to climate change risks so councils need to adopt clear policies to protect themselves.

Use of This Report

This report is to be presented to the elected Councillors of Byron Shire and Tweed Shire. It is in consultation with the Councillors that a decision will be made in regard to the wider communication of the findings presented in this report. This report has been prepared as a component of the Local Adaptation Planning Program (LAPP) for the Byron and Tweed Councils and is for the sole purpose of evaluating the risks associated with climate change for Byron Shire Council and Tweed Shire Council.

This report is not for use by any related or third party or for any other project. The information and recommendations are to be read and considered as a whole and the content is not to be used selectively as this may misrepresent the content of the report and provide erroneous project or decision outcomes.

Byron and Tweed Shire Council representatives largely provided the information utilised in this climate change risk assessment and the outputs of the Risk Assessment Phase checked by key Council staff.

The analysis, recommendations and summaries presented in this report are based on information provided by Byron and Tweed Shire Councils, *ABS, CSIRO, IPCC, the Department of Climate Change (DCC), Department of Environment and Climate Change (DECC) and other similarly recognised government bodies*. This information has not been independently verified. Assumptions and recommendations which need further testing are noted in the text of the report.

The data and process used as the basis for conducting the climate change risk assessment was approved by Byron and Tweed Shire Councils and was based on the AGO Guidelines as per the requirements of LAPP.

Appendix A

Abbreviations

ALARP	As Low As Reasonably Practicable
AGO	Australian Greenhouse Office (no longer exists)
AS	Australian Standard
BOM	Bureau of Meteorology
CMA	Catchment Management Authority
CSIRO	Australian Commonwealth Scientific and Research Organization
DCC	Department of Climate Change (functions of the AGO have been transferred to the recently formed DCC)
DECC	Department of Environment and Climate Change
DSE	Department of Sustainability and Environment
EPA	Environmental Protection Authority
IPCC	Intergovernmental Panel on Climate Change
LAPP	Local Adaptation Pathways Program
LGA	Local Government Area
SRES	Special Report on Emission Scenarios

Appendix B

Workshop Participants

Byron and Tweed Climate Change Risk Assessment Workshop

12 February 2009

Workshop Participants

Table 11 Workshop Participants

Name	Position	Council / Company	Mobile / email
James Flockton	Flood & Drainage Engineer	BSC	James.flockton@byron.nsw.gov.au
Ben Fitzgibbon	Coastal & Estuary Officer	BSC	Ben.Fitzgibbon@byron.nsw.gov.au
Shayn French	Manager CP & NR	BSC	Shayne.French@byron.nsw.gov.au
Graeme Williams	Sustainability Officer	BSC	Graeme.Williams@byron.nsw.gov.au
Danny Rose	Planning and Infrastructure	TSC	drose@tweed.nsw.gov.au
Stuart Russell	Strategic Planner	TSC	srussell@tweed.nsw.gov.au
Peter Pennycuick	Water and Sewerage Engineers	TSC	peterp@tweed.nsw.gov.au
Rachel Nicholson	Work Experience	TSC	Rachel.Nicholson2@student.griffith.edu.au
Mark Kingston	Biodiversity Programme Leader	TSC	mkingston@tweed.nsw.gov.au
Dan Walton	Sustainability Programme Leader	TSC	danw@tweed.nsw.gov.au
Iain Lonsdale	Coordinator Planning Reforms	TSC	ilonsdale@tweed.nsw.gov.au
Lawrence McCoy	Community Safety Officer, WSWRFS	Rural Fire Service	Lawrence.mccoy@rfs.nsw.gov.au
Sandy Pimm	Specialist Planner/Ecologist	TSC	spimm@tweed.nsw.gov.au
Lisa Wrightson	Team Leader Community Planning	BSC	Lisa.wrightonson@byron.nsw.gov.au
Peter Ganser	Building & Recreational Assets Coordinator	TSC	pganser@tweed.gov.au 02 6670 2725

Appendix C

Workshop Methodology

Risk Assessment Framework and Methodology

C.1 Risk Assessment Framework

The Risk Assessment framework used for the Byron and Tweed Shire Climate Change Risk Assessment is based on the Australian Greenhouse Office (AGO) [4] Climate Change Risk Management Framework. This framework is consistent with the Australian and New Zealand Standard for Risk Management, AS/NZS 4360:2004.

The framework defines the method for Risk Assessment by clarifying the objectives and success criteria for the Shire, and establishing scales for measuring consequences, likelihoods and risk priorities.

C.2 Definitions

The definitions of the risk management terminology are provided below:

- **Risk** – The chance of something happening that will have an impact upon objectives. It is measured in terms of consequence and likelihood;
- **Success Criteria** – The Councils objectives linked to the Risk Assessment process by adopting the main criteria for measuring success namely: Human Life & Health; Environment and Property & Finance. These Success Criteria are a summary of Councils long-term objectives. These are combined in a Consequence Scale to describe the level of consequence to the Councils of each risk associated with the predicted future climatic conditions;
- **Consequence** – The outcome or impact of an event expressed qualitatively or quantitatively, ranging from positive to negative;
- **Likelihood** – Used as a general description of probability or frequency. It can be expressed qualitatively or quantitatively;
- **Risk Management** – The culture, process and structures that are directed towards effective management of potential opportunities and adverse effects.
- **Residual Risk** - Residual Risk is defined as the risk or danger of an action or an event, where residual means “the quantity left over at the end of a process; a remainder”. It is therefore the remaining risk after all relevant controls have been taken into account

The types of risks to be considered in the Climate Change Risk Assessment include:

- **Strategic Risk** – e.g. risks arising from policy decisions or major decision affecting organizational priorities; risks arising from senior level decisions on priorities;
- **Financial Risk** – e.g. risks arising from spending on capital projects or fraud or impropriety; risks from failed resource bids and insufficient resources;
- **Operational Risk** – e.g. risks associated with the delivery of public services; risks associated with recruitment difficulties or diversion of staff to other duties; risks surrounding IT systems;
- **Environmental** – e.g. risks arising from sustainability or pollution; risks associated with EPA compliance and climate change such as storms, floods, heavy rain, reduced rainfall, longer hot days;
- **Community** – e.g. risks arising from public health and safety, public relations and Council reputation.

[4] Please note that the AGO no longer exists and many of the functions of the AGO have been transferred to the recently formed Australian Government Department of Climate Change (DCC). The Local Adaptation Pathways Program is under the control of the DCC.

C.3 Objectives, success criteria and consequence scales

Success criteria are measures of an organization's ability to meet its objectives. The success criteria and consequence scales used for the Byron and Tweed assessment were those suggested for local government authorities in the AGO framework (2006). These success criteria included:

- Maintenance of public safety;
- Protection and enhancement of the local economy;
- Protection of existing community structures and the lifestyle enjoyed by the people of the region;
- Sustain and enhancement of the physical and natural environment; and
- Ensure sound public administration and governance.

Five consequence ratings (from insignificant to catastrophic) for each success criteria were used to create the consequence scale matrix as depicted in Table C.1 below: Table

Table C.1 AGO (DCC) Consequence Scale & Success Criteria

Success Criteria / Rating	Public Safety	Local Economy & Growth	Community & Lifestyle	Environment & Sustainability	Public Administration
Catastrophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	The region would be seen as very unattractive, moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Public administration would fall into decay and cease to be effective
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely
Moderate	Small number of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure
Insignificant	Appearance of 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

Source: AGO (2006), Climate Change Impacts & Risk Management - A guide for Business and Government

Table C.1.1 Consequence Scale & Success Criteria for Byron and Tweed Shire Council

Byron and Tweed Shire Consequence Scale

Success Criteria ► / Rating ▼	Human Life and Health	Property and Financial	Environmental
Insignificant	No injuries or fatalities; small number or no people are displaced and only for a short duration; little or no personal support required (support not monetary or material).	Inconsequential or no damage; little or no disruption to the community; little or no financial loss.	No measurable impact on the environment.
Minor	Small number of injuries but no fatalities; first aid treatment required; some displacement of people (less than 24 hours); some personal support required; some disruption (less than 24 hours).	Some damage; some financial loss.	Small impact on the environment with no lasting effects
Moderate	Medical treatment required but no fatalities; some hospitalisation; localised displacement of people who return within 24 hours; personal support satisfied through local arrangements.	Localised damage that is not rectified through local arrangements; normal community functioning with some inconvenience; significant financial loss.	Some impact on the environment with no long-term effect or small impact on the environment with long-term effect.
Major	Fatalities; extensive injuries, significant hospitalisation; large number displaced (more than 24 hours duration); external resources required for personal support.	Significant damage that requires external resources; community only partially functioning, some services available; significant financial loss, some financial assistance required.	Some impacts on environment with long-term effects.
Catastrophic	Significant fatalities; large number of severe injuries; extended and large numbers requiring hospitalisation; general and widespread displacement for extended duration.	Extensive damage; extensive personal support; community unable to function without significant support.	Significant impact on the environment and/or permanent damage.

Source: *Byron Shire Council Emergency Risk Management Study (2008) and Tweed Shire Emergency Risk Management Study (Version 1, July 2007)*

C.4 Likelihood scales

Likelihood scales are used to predict the probability of a risk, based on the assumption that the climate change scenario occurs. The likelihood scales used are those suggested in the AGO framework. These can be used to assess both single event and recurrent risks as provided below in Table C.2.

Table C.2 AGO (DCC) Likelihood (given that the climate scenario arises)*

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

Source: AGO (2006), Climate Change Impacts & Risk Management - A guide for Business and Government

C.5 Risk Priority Levels

The likelihood and consequence scales are combined in a matrix to determine the priority of the risk. The priority may be classed as low, medium, high or extreme depending on the combination. The AGO matrix is provided below.

Table C.3 AGO (DCC) Risk Priority Matrix

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

Source: AGO (2006), Climate Change Impacts & Risk Management - A guide for Business and Government

The risk priority level then informs the urgency and suggested treatment of the risk by the organisation. A summary of suggested priority level treatments is provided below in Table C4.

Table C.4 Risk Priority Level Descriptors

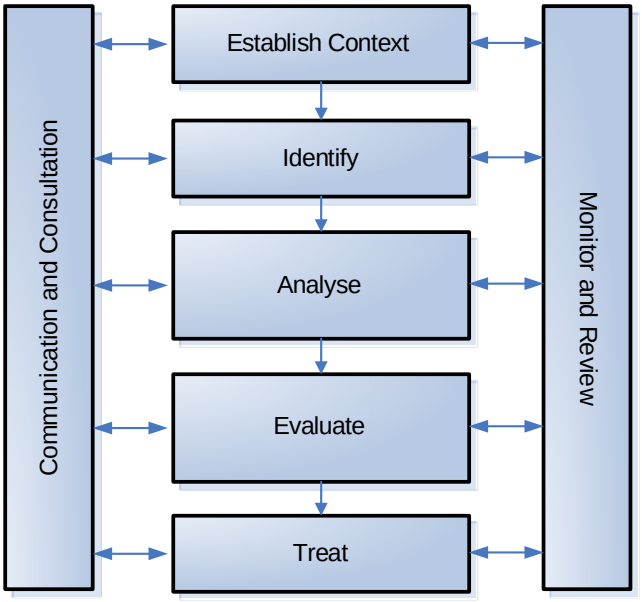
Extreme	Risks demand urgent attention at the most senior level and cannot be simply accepted as part of routine operations without executive sanction.
High	Risks are the most severe that can be accepted as part of routine operations without executive sanction but they will be the responsibility of the most senor operational management and reported upon at the executive level.
Medium	Risks can be expected to form part of routine operations but the will be explicitly assigned to relevant managers for action, maintained under review and reported upon at senior management level.
Low	Risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

Source: AGO (2006), Climate Change Impacts & Risk Management - A guide for Business and Government

C.6 Risk Assessment Methodology

The Risk Assessment methodology recommended by the AGO is adapted from AS 4360: 2004, the Australian Standard for Risk Management. A simplified summary of the methodology is represented in Figure C.1.

Figure C.1 Risk Assessment Methodology



The main elements are described in the following subsections.

C.6.1 Establish Context

In order to maximise the efficiency of the Risk Assessment Workshop, a context setting document was prepared prior to the workshop and sent to all relevant parties. The purpose of this document was to:

- Establish the agenda for the workshop;
- Introduce global and local climate change projections, trends and effects to the workshop participants;
- Introduce the Risk Assessment methodology to the workshop participants;
- Provide copies of the Risk Matrices to the workshop participants for familiarisation; and
- Provide background information relevant to the climate change scenarios that were to be discussed in the workshop;

C.6.2 Identify

During the Risk Assessment Workshop, the hazards and risks associated with climate change relating to the shire and the operations of the Council were identified. This was done by taking each climate change variable in turn and discussing associated risks until the main issues were felt to have been examined sufficiently.

C.6.3 Analyse

Once the risks and their causes were identified, the likelihood of the risks manifesting themselves and their consequence were measured. The assessment tables in Section 0 were used to determine the likelihood and consequence levels.

For each risk:

- Existing controls already in place to mitigate the risk were identified;
- Consequences arising from the risks were identified and controls for each of the scenarios under consideration were determined using the adopted consequence scale;

- The likelihood of the consequence given the controls for each of the scenarios under consideration was determined using the adopted likelihood scale; and
- An initial priority was assigned to each scenario based on the likelihood and consequence of the risk. The adopted risk matrix was used to achieve this.

C.6.4 Evaluate

After all relevant climate change variables had been considered; all the risks were assembled into a single set and reviewed as a whole.

Any risks found to have been over or under-rated were manually altered to illustrate the workshop agreed priority. The outcome was a list of risks with all the information recorded in the identification and analysis stage.

C.6.5 Treat

Based upon the findings of the workshop, a planning exercise known as the Adaptation Approach will be carried out as a second workshop to identify methods or controls to mitigate risks that were deemed as high in the first workshop.

This plan will establish the method by which these new controls or methods can be implemented and integrated into the design and existing systems within the Council.

C.6.6 Monitor and Review

Ongoing review is essential to ensure that the management plan remains relevant. As the project progresses, drawings and project documentation will be verified at regular intervals to make sure that control measures and special requirements are constructed and documented as required.

Appendix D

Risk Register

Climate Change Risk Assessment

							Current Risk									Residual Risk				
							Now			2030			2070							
No	GHG Emissions Scenario	Climate Change Variables	Risk	Risk Category	Current Controls	Specific Consequences / Vulnerability	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Potential Controls	Consequence	Likelihood	Risk Level	Comments
1	High	Increased temperature	The introduction or proliferation of exotic species	Environment	Byron - Cane toad control programs Tweed/Byron - Indian Myna Weed control - some joint programs - eg work on private property Community education programs and monitoring Cane Toad muster & fences Biodiversity plans Policy plans and programs State biodiversity plans Zoning - DCPs and other policies Local policies Federal Policies - EPBC Act Funding and grants both State and Federal	Impacts associated with pollution of air, land and water Competition and predation of native flora and fauna Confluence with other risk scenarios such as sea level rise Loss of biodiversity- eg cane toad and red belly black snake reduction Destruction of habitat eg proliferation of weeds - morning glory displaces natives. Fauna - Indian mynas The loss of existing biodiversity	Moderate	Likely	High	Moderate	Likely	High	Moderate	Almost Certain	High	Increased funding for existing controls to be expanded in scale Possible technological controls	Moderate	Possible	Medium	Need to break down to specific areas of flora and fauna Need to look at the effectiveness of various programs and grants Majority of current exotic species control programs are limited in thier effectiveness. Eg toads and mynas populations are still increasing No research evidence to back up increase in temperature impacts. Evidence is anecdotal to date for example will the veracity of exotic/invasive species be more prevalant in winter due to increased temperatures Difficult to provide a blanket control across a variety of flora and fauna. For example invasive trees and vines will react differently. ACTION: Will need further analysis to determine the individual risks inorder to apply appropriate controls.Research needs to be more precise. Research into exisiting native species required. For example, Beech forest may be sensitive to a 1.5C inrease Comment made that if there was a similar level of funding to tackle invasive species as has been assigned for new parks ($30 million) then an impact could be made.
2	High	Sea Level Rise	Loss of current or existing biodiversity	Environment	Coastal Zone Management Plan (estuary and coastal and floodplain) - protect/retreat strategy maintain current dune structure via engineering works ie rock walls, barriers Flood gates systems and levies Legislative controls - coastal vegetation, endangered communities Land zoning, buffers as coastline retreats Development control plans Funding - State - for planning (biodiversity planning)	Loss of coastal ecosystems, dunes Loss of estuarine environment Migration of salt marsh Loss of flood plain vegetation Habitat clearing Fragmentation Habitat modification Disturbances	Insignificant	Possible	Low	Moderate	Likely	High	Catastrophic	Almost Certain	Extreme	Ensure connectivity of corridors (biomes links) Translocation Development controls - buffer Floodplain defences Seawalls Technology Comprehensive mapping - for planning purposes Biodiversity banking/gene banking Ranking of areas, selection of key areas	Moderate	Likely	High	Residual Risk Rated against 2030 . Acting now may reduce costs latter for the community Should tease out coastal and floodplain later on in detail. Insufficient data on flood plain response to sea level rise to date. Possibly will need study Initial assessment appears lot of money for little improvement, further offline study required for validation Seperate habitat from biodiversity as seperate lines in the matrix A holistic approach will need to be taken into biodiversity planning. Alignment of all levels i.e. National, State and Local - control, planning & programs, research both existing and proposed. Fine level of profiling of ecosystems and species on the floodplain will be required to appropriately ACTION: A study maybe be required of the health of ecosystem on the floodplain. Determine if flora and fauna can cope with the rate of change. Need for environmental buffers. Review the risk rating for this CC variable currently classified as catastrophic even with Potentail C
3	High	More sevear weather events from increased rainfall and extended drought periods.	Decline in the local economy	Property & Finance	Increased advertising post severe wet weather	Loss of income from tourism & agricultural productivity.	Insignificant	Possible	Low	Minor	Possible	Medium	Moderate	Likely	High	Management Plan for the reduction of economic reliance on tourism e.g diversification Diversitifcation of crops and cropping regimes Protection of prime agricultural land Education (agricultural practices and community food literacy) Sustainable Agricultural Strategy Regional Food Trail eg speciality	Minor	Possible	Medium	
4	High	Decreased rainfall	Drought	Property & Finance	Water storages and water supply Use of recycled water Rainwater tanks	Change in the location of infrastructure Loss of property amenity and function	Insignificant	Unlikely	Low	Minor	Possible	Medium	Minor	Possible	Medium	Integrated water cycle management including demand management, water sensitive urbane design etc.	Minor	Possible	Medium	Need to review risk once better climate data for area is available.
5	High	Sea Level Rise	Increased groundwater level leading to intrusion of pipe works	Property & Finance	Coastal Zone Management Plan (estuary and coastal and floodplain) - protect/retreat strategy maintain current dune structure via engineering works ie rock walls, barriers Flood gates systems and levies Infrastructure design	Inability of infrastructure to function	Insignificant	Unlikely	Low	Minor	Possible	Medium	Moderate	Possible	Medium	Mapping of at risk infrastructure across the area. Identify areas requiring capital works. Implementing a planning policy for new infrastructure.	Minor	Unlikely	Low	Rising groundwater levels are compounding the sea level rise and storm surge issue.
6	High	Increased temperature	Habitat displacement	Environment	Vegetation management plans across the shire. SEPP's EEC LEP zones	Isolation (fragmentation) and reduced resilience due to climate change	Insignificant	Unlikely	Low	Minor	Possible	Medium	Moderate	Likely	High	Identification of at risk habitat Improving connectivity Translocation of species	Minor	Possible	Medium	Taken for 2030 Timeframe
7	High	Sea Level Rise	Effect on freshwater supply	Property & Finance	Operation management system - temporary barrier over the weir	Seawater incursion as it overtops current weir height	Minor	Almost Certain	Medium	Moderate	Almost Certain	High	Major	Almost Certain	Extreme	Weir augmentation before sea level rises 10cm from current level	Minor	Unlikely	Low	This is a risk that is specific to the Tweed Shire Legal arguments over the weir in Tweed which has implications for farmers but can be resolved with a relatively simple engineering solution. (Will need further clafification) There has been a loss of property now. Please clarify to what extent - how many properties/ area. Risk of sea level rise contaminating fresh water supply, especially a concern for Tweed. Current occurs twice a year with King Tides. Weir augmentation will be required before sea levels rise a futher 0.1 meters from current level. Note that as sea levels continue to rise, this may possibly become a constant event affecting the functionality of the community ($10-$20 million BAU).

Climate Change Risk Assessment

							Current Risk									Residual Risk				
							Now			2030			2070							
No	GHG Emissions Scenario	Climate Change Variables	Risk	Risk Category	Current Controls	Specific Consequences / Vulnerability	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Potential Controls	Consequence	Likelihood	Risk Level	Comments
8	High	Sea Level Rise	Impacts on coastal development	Property & Finance	DCPs Levies Floodgates Flood pumps Landuse planning framework Drainage maintenance Zoning Voluntary purchase of land Voluntary house raising Local Government Act DECC policy and guidelines and manual (floodplain) Coastline Management Plan with an Asset focus Flood studies Asset Management Plans (Tweed in place, Byron progressing) Monitoring Grant funding Research Agricultural management -how land is managed, crop type See Items 19, 20, 21, 22, 23	Property damage Devaluation of land Council liability Loss of property Loss of development potential Class Actions Community outrage Loss of agricultural yield Impact on SES Increased cost to develop Loss of income Loss of taxation revenue Insurance - increased property insurance Councils own insurance rating - higher premiums Damage to infrastructure Disruption to utilities Cost to government for natural disaster recovery Disruption to STPs Salinity infiltration to sewage piping Salt instruction - Stormwater pipes	Insignificant	Almost Certain	Medium	Minor	Almost Certain	Medium	Major	Almost Certain	Extreme	Potential rate increase (Climate Change levy) Specific state funded allocation Planned retreat Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastructure Insurance clarification See Items 19, 20, 21, 22, 23	Minor	Almost Certain	Medium	
9	High	Increased temperature	Increased bushfire events (and intensity)	Property & Finance	Asset protection zones Hazard reduction burning Bushfire Management Plans Fire mapping See Items 10 & 11 below	Increased bushfire events leading to loss of property (infrastructure and community assets) Increased insurance premiums Reduction in community services Increased resource requirements for bushfire management See Items 10 & 11 below	Minor	Likely	Medium	Minor	Almost Certain	Medium	Moderate	Almost Certain	High	Increased bushfire management and resources Fuel reduction strategies Sighting of new infrastructure See Items 10 & 11 below	Minor	Possible	Medium	ACTION: Check exiting bushfire controls in the Bushfire Management Plan (repeated against items 8,9,10) ACTION: Need to determine what the specific risks and consequences will be at a given location. The suggestion is to divide the area into 9 precincts (eg separate line items perhaps NB each precinct may again need to be categorised by the 3 risk categories i.e. environment, property and health [and analyse on a case by case basis to more tailor the potential controls. Cannot provide a blanket control to determine residual risk level. - Rural Fire Service will need to be consulted.(repeated against items 8,9,10) ACTION : Check figures for the number of total fire bans / yr now and into the future. Currently there are 4/yr but said to increase 10 fold..(repeated against items 8,9,10)
10	High	Increased temperature	Increased bushfire events (and intensity)	Human Life and Health	Ignition management Hazard reduction Community education Preparedness - operational readiness Training Bushfire Management Plan Development controls See Items 9 & 11	Increased bushfire events leading to loss of life Safety issues See Items 9 & 11	Insignificant	Unlikely	Low	Minor	Unlikely	Low	Moderate	Possible	Medium	Increased bushfire management Fuel reduction strategies Increased resources Sighting of new infrastructure Community education Improved health services (managing responses to bushfire injuries) See Items 9 & 11	Minor	Unlikely	Low	Split into 8 or 9 precincts and analyse case by case ACTION: Check exiting bushfire controls in the Bushfire Management Plan (repeated against items 8,9,10) ACTION: Need to determine what the specific risks and consequences will be at a given location. The suggestion is to divide the area into 9 precincts (eg separate line items perhaps NB each precinct may again need to be categorised by the 3 risk categories i.e. environment, property and health [and analyse on a case by case basis to more tailor the potential controls. Cannot provide a blanket control to determine residual risk level. - Rural Fire Service will need to be consulted.(repeated against items 8,9,10) ACTION : Check figures for the number of total fire bans / yr now and into the future. Currently there are 4/yr but said to increase 10 fold..(repeated against items 8,9,10)
11	High	Increased temperature	Increased bushfire events	Environment	Ignition management Hazard reduction Community education Preparedness - operational readiness Training Bushfire Management Plan Development controls See Items 9 & 10 above	Increased bushfire events leading to loss biodiversity See Items 9 & 10 above	Minor	Possible	Medium	Moderate	Possible	Medium	Moderate	Possible	Medium	Increased bushfire management Fuel reduction strategies Increased resources Sighting of new infrastructure Community education Improved health services (managing responses to bushfire injuries) WIRES Cool burns	Moderate	Possible	Medium	ACTION: Check exiting bushfire controls in the Bushfire Management Plan (repeated against items 8,9,10) ACTION: Need to determine what the specific risks and consequences will be at a given location. The suggestion is to divide the area into 9 precincts (eg separate line items perhaps NB each precinct may again need to be categorised by the 3 risk categories i.e. environment, property and health [and analyse on a case by case basis to more tailor the potentail controls. Cannot provide a blanket control to determine residual risk level. - Rural Fire Service will need to be consulted.(repeated against items 8,9,10) ACTION : Check figures for the number of total fire bans / yr now and into the future. Currently there are 4/yr but said to increase 10 fold..(repeated against items 8,9,10) Is there a greater focus on property and people and to reduce risk from fire? increased fire management may have a negative impact on the environment if the management regiemes don't incorporate site specific environmental considerations
12	High	Increased temperature	Decreased water flows into dam or catchments	Human Life and Health	Dam locations Demand Management Strategies Safe yield projections	Inability to service suburban water demands Drop in water quality Algal blooms	Minor	Likely	Medium	Moderate	Possible	Medium	Minor	Possible	Medium	Development of alternative water supplies Water supply augmentation Increased resources for demand management.	Minor	Possible	Medium	ACTION: What are the figures for water use reduction as a result of Council programs? Fresh water supply is an issue faced mainly by Tweed (action repeated item 15 - Higher Evaporation and longer drough periods below) ACTION: Better regional and season climate change data on rainfall in particularly should be plugged into modelling when available. This could change the risk rating and should be included as a potential control (action repeated item 15 - Higher Evaporation and longer drough periods below)
13	High	Increased temperature	Decreased water flows into dam or catchments	Environment	**To be analysed**	**To be analysed**			0			0			0				0	**Risk to be rated**
14	High	Increased temperature	Spread of mosquito Bourne diseases	Human Life and Health	Mosquito and biting midge control plan	Increased hospitalisation Sick leave (loss of livelihood)	Insignificant	Unlikely	Low	Minor	Possible	Medium	Minor	Possible	Medium	Increase services for mosquito control and mosquito bourne disease treatment. Building codes changed to better manage mosquitos.	Minor	Unlikely	Low	ACTION : What are the potential vector Bourne diseases that may arise? Eg speed of mosquitoes further south as temperature rises There is like to be an increase between 2030 and 2070 although not significant enough to change ranking. Decentralised water may increase risks.
15	High	Increased temperature	Higher evaporation and longer drought periods	Property & Finance	Water Sharing Plans (under development) Restriction levels Demand Management Strategy Integrated Water Cycle Management Strategy Catchment Zoning - LEP zoning Catchment Management Plans Augment Management Plans Asset Management Plans Community awareness State government BASIX Water Sensitive Urban Design User pays/step pricing Stormwater harvesting management Wastewater reuse	Reduction of yield of water supply Water shortage Impact on community Water quality Reduced irrigation rights	Minor	Possible	Medium	Minor	Possible	Medium	Major	Possible	High	Sewer mining Better climate change data over the next 5 to 10 years Decentralising water supply Increased scale of rates - user pays increase Greywater reuse Dry toilets Dual reticulation Retrofitting depending on economics Potable reuse Landscape design Change in cropping regime (drought hardy species and GM)	Minor	Unlikely	Low	Risk issue are mainly based on Tweed issue. Tweed and Byron have different triggers. Two different water supplies. Byron water supply is safe till 2100- Rouse implications. Tweed will need augmentation around 2015 and further augmentation further down the track eg land purchase for a future dam site. Hoped that demand management to delay augmentation. ACTION: What are the figures for water use reduction as a result of Council programs? (action repeated in item 12 - Decreased water flows into dams or catchments above). ACTION: Check figures - 7% factored in using CC scenariosto determine yeild back in 2006 but did not account for 2070 climate change scenario? Tweed did not have an issue during the last drought period. Challenge will be to match population growth. The lumpy wet and dry seasons may improve the supply issues but this will need further analysis. ACTION: Better regional and season climate change data on rainfall in particularly should be plugged into modelling when available. This could change the risk rating and should be included as a potential control (action repeated in item 12 - Decreased water flows into dams or catchments ab

Climate Change Risk Assessment

							Current Risk									Residual Risk				
							Now			2030			2070							
No	GHG Emissions Scenario	Climate Change Variables	Risk	Risk Category	Current Controls	Specific Consequences / Vulnerability	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Potential Controls	Consequence	Likelihood	Risk Level	Comments
16	High	Increased temperature	Increased evaporation and drought	Human Life and Health	Dam locations Demand management strategies Safe yield projections, Heat stroke and health risk	Heat stress and health related impacts	Insignificant	Rare	Low	Insignificant	Unlikely	Low	Minor	Unlikely	Low	Sewer mining Better climate change data over the next 5 to 10 years Decentralising water supply Increased scale of rates - user pays increase Greywater reuse Dry toilets Dual reticulation Retrofitting depending on economics Potable reuse Landscape design Change in cropping regime (drought			0	**Residual Risk to be rated**
17	High	Increased temperature	Infrastructure services - Degradation of roads	Property & Finance	Road maintenance program	Expansion of pipes Road degradation Wash out of roads from flood and storm events			0			0			0				0	**Risk to be rated**
18	High	Increased temperature	Heat stress	Human Life and Health	Air conditioners Swimming Rehydration Building codes Outdoor staff amended work hours	Heat related stress and injury Death Vulnerable elderly and children Loss of motivation Increased conflict amongst people	Insignificant	Unlikely	Low	Insignificant	Possible	Low	Minor	Likely	Medium	Relocation Tie free - clothing policy Heatwave Management Plan Education Managing public opinion OHS New technology Reduced maintenance requirements - less mowed areas Insulated housing for all existing and future development	Insignificant	Possible	Low	ACTION: High humidity coupled with high temperature worsens heat stess. Check area health data for heat related injuries and death. More vulnerable include the elderly of whom there is higher and growing proportion of the population. Recent data suggests that there is a 0.5 increase in deaths per day based on recent events. High humidity and high temperature creates metabolic stress impacting mainly on the elderly. ACTION: Likely that there will be 1 heatwave in every year under future climatic conditions - check from which year this is predicted to be.
19	High	Sea Level Rise	Increased flood level and frequency	Human Life and Health	DCPs Levies Floodgates Flood pumps Landuse planning framework Drainage maintenance Zoning Voluntary purchase of land Voluntary house raising Local Government Act DECC policy and guidelines and manual (floodplain) Coastline Management Plan with an Asset focus Flood studies Asset Management Plans (Tweed in place, Bryon progressing) Monitoring Grant funding Research Agricultural management - how land is managed, crop type See Items 8, 20, 21, 22, 23	Property damage Devaluation of land Council liability Loss of property Loss of development potential Class Actions Community outrage Loss of agricultural yield Impact on SES Increased cost to develop Loss of income Loss of taxation revenue Insurance - increased property insurance Councils own insurance rating - higher premiums Damage to infrastructure Disruption to utilities Cost to government for natural disaster recovery Disruption to STPs Salinity infiltration to sewage piping Salt instruction - Stormwater pipes	Insignificant	Unlikely	Low	Moderate	Likely	High	Major	Almost Certain	Extreme	Potential rate increase (Climate Change levy) Specific state funded allocation Planned retreat Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastructure Insurance clarification Improved stormwater design standards and drainage See Items 8, 20, 21, 22, 23	Moderate	Possible	Medium	There have been 2 major floods in 15 years. Change from the pattern of annual flood events in the 1980s (this comment will further clarification by the sustainability officers) The 1 in 100 year floods are currently effecting hundreds of properties ACTION: Use Byron Tweed inundation mapping to calculate numbers of properties against the storm surge/sea level impacts. Cross check results with risk rating.
20	High	Increased storm intensity	Increased flood level and frequency	Property & Finance	Disaster Plan Emergency Services Stormwater and drainage Building construction standards Community preparedness Flood plain zoning and Sewer overflow abatement strategy Detention basins Bridges and culverts Road closure programs Tree management Floodplain management Dam construction - management of catchments Dam spillways Road maintenance Personal insurance See Items 8, 19, 21, 22, 23	Property damage Devaluation of land Council liability Loss of property Loss of development potential Class Actions Community outrage Loss of agricultural yield Impact on SES Increased cost to develop Loss of income Loss of taxation revenue Insurance See Items 8, 19, 21, 22, 23	Minor	Possible	Medium	Minor	Likely	Medium	Moderate	Almost Certain	High	Adjusting drainage and engineering controls. Improved planning of infrastructure Improved design standards of at risk infrastructure See Items 8, 19, 21, 22, 23	Minor	Likely	Medium	Minor improvement in how infrastructure will cope

Climate Change Risk Assessment

							Current Risk									Residual Risk				
							Now			2030			2070							
No	GHG Emissions Scenario	Climate Change Variables	Risk	Risk Category	Current Controls	Specific Consequences / Vulnerability	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Potential Controls	Consequence	Likelihood	Risk Level	Comments
21	High	Sea Level Rise	Flooding	Property & Finance	DCPs Levies Floodgates Flood pumps Landuse planning framework Drainage maintenance Zoning Voluntary purchase of land Voluntary house raising Local Government Act DECC policy and guidelines and manual (floodplain) Coastline Management Plan with an Asset focus Flood studies Asset Management Plans (Tweed in place, Byron progressing) Monitoring Grant funding Research Agricultural management - how land is managed, crop type See Items 8, 19, 20, 21, 22	Property damage Devaluation of land Council liability Loss of property Loss of development potential Class Actions Community outrage Loss of agricultural yield Impact on SES Increased cost to develop Loss of income Loss of taxation revenue Insurance - increased property insurance Councils own insurance rating - higher premiums Damage to infrastructure Disruption to utilities Cost to government for natural disaster recovery Disruption to STPs Salinity infiltration to sewarge piping Salt intrusion - Stormwater pipes	Moderate	Possible	Medium	Moderate	Possible	Medium	Major	Almost Certain	Extreme	Potential rate increase (Climate Change levy) Specific state funded allocation Planned retreat Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastrucutre Insurance clarification See Items 8, 19, 20, 22, 23	Minor	Possible	Medium	List of assets at future sea level, flooding risk Salt water instrution - study into which assets are at risk. Get a register followed up with further analysis Councils are carrying out studies to quantify impacts of flooding - check inundation mapping Sea level rise will lead to a big impact on salt marshes. Salt marshes may be able to migrate further inland. On the other hand, migration maybe restricted by existing and/or proposed development (environmental buffers). ACTION: Asset Management and question of how effective it will be. Will potentail impacts of the various climate change varibale be a consideration over the life of each asset? ACTION: Asset Register - check for AHD data (flood risk, tidal range, current and future seal level, flood plain) infrastructure on the coast and in floodplain for eg. sewage pumping, stormwater, roads, public buildings. Currently no assessment on the infrastructure impacts available. ACTION: Register of mapping infrastructure at risk. Salt water incursion due to sea level rise will have major impacts on infrastructure. Rising groundwater levels are componding the sea level rise and storm surge issue. Has this also b Agriculture on the floodplain is very vulnerable.
22	High	Increased storm intensity	Increased flood level and frequency	Human Life and Health	Disaster Plan Emergency Services Communications Stormwater and drainage Building construction standards Community preparedness Flood plain zoning Sewer overflow abatement strategy Detention basins Mosquitoe control programs Bridges and culvets Road closure programs Tree management Floodplain management Dam construction - management of catchments Dam spillways Road maintenance Water sharing Personal insurance	Increased injury and death during events Isolation and reduced access Localising disease Property damage Sewage overflows Sewearge infiltration Stock and crop damage Contamindation of drinking water Loss of income Stress and mental health Vulnerable communities worst hit- caravan parks, aged, agricultural community, Slips on roads See Items 8, 19, 20, 21, 22	Major	Possible	High	Major	Possible	High	Major	Likely	High	Upgrade design standards for infrastructure - better engineering standards Replace infrastructure Potential rate increase (Climate Change levy) Specific state funded allocation Planned retreat Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastrucutre Insurance clarification See Items 8, 19, 20, 21, 22	Major	Possible	High	Depends on convergence with sea level rise, rainfall and secondary impacts such as flooding could exacerbate this problem ACTION: Currently isolated incidences with loss of life - check number of deaths due to server stome events People may voluntarily relocate
23	High	Sea Level Rise	Coastal Erosion	Property & Finance	DCPs LEPs REPs Coastal Management Plan Barriers Sand pumping State SEPP Land tenure - difference bw public and private Coastal dune rehabilitation Set backs Landuse Buliding and construction codes Hazard definitions Hazard identification Defences Submerged offshore reefs Seawalls - 1 retained to protect Byron, the rest to be removed	Potential town flooding for Brunswick Heads and Byron Risk to development and utilities development Immediate risk to persons residing in coastal development Loss of infrastrucutre - particularly raods which are important evacuation routes Coastal innundation Impacts on utilities See items 8, 19, 20, 21, 22	Minor	Possible	Medium	Moderate	Likely	High	Major	Almost Certain	Extreme	Potential rate increase (Climate Change levy) Specific state funded allocation **Planned retreat** Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastrucutre Insurance clarification See Items 8, 19, 20, 21, 22	Moderate	Rare	Low	Convergence of all of the varibales There are currently several sea walls. 1 will be retained in Byron Bay and the other will go. Tweed are planning to build one new seal wall at Brunswick Heads (lands). The Byron sea wall strucuture is at immediate risk of failure, exposing the town/ CBD, roads including evacuation routes and impact on infrastrucutre will need to be taken into account. Estimate cost : Byron - approx $15 000/metre, total cost between $3 - $9 Million to upgrade. Cost not accounted for in any forward work budget - earmarked as future projects. Captial works program for Byron is $3M (mainly water sewerage) Tweed - around $102M (mainly water and sewerage). ACTION: Have available all capital and discreationary annual spending figures, especially for the Adaptation preparation meeting. Roads and drainage - Byron - $6-10M Water - Bryon - $1.3M Can manage down with retreat BUT at a cost. Please clarify with figures as per recent flood study. Currently the 1 in 100 year floods are effecting hundreds of properties. Coastal recession has only been seen to kick in in the last two years. Only just begining to see end There has been an increase in sea level of 17cm since 1970. Are we still able to assess any impact Noted that the coastline has not moved back to the 1990 equivalent Increased storm activity leading to storm surges and negative IPO ACTION: Need to clarify sea level rise esitmates for 2030. GHD to double check estimates of 0.3m
24	High	Increased temperature	Impact on Parks	To be analysed	To be analysed	To be analysed	0			0			0			Increased weed control etc to reduce				Risk to be rated
25	High	Decreased rainfall	Drought	Environment	Regional macro water sharing plans and environmental flows.	loss of habitat, change in ecosystem function and diversity	Insignificant	Unlikely	Low	Minor	Possible	Medium	Moderate	Likely	High	Increased weed control etc to reduce preasure on habitat and environemntal flows for riparian areas	Minor	Possible	Medium	

Appendix E

Issues Raised in the Context Phase

Summary of Current and Potential Controls of Risk Identified

Table 12 Issues raised at the Context Setting Phase

	Issues	Opportunities
Governance, Planning & Legislation	There is generally a lack of answers, knowledge and direction from state and Australian Governments. Processes are generally slow;	Climate change could potentially strengthen the relationship between Federal and local governments
	The scope is too large for local governments. Responsibility considered poor. Scope needs broad coverage.	Would generally like to see themselves leaning towards more of a leadership and direction offering role
	Large gaps in strategic planning	Possible changes in the Local Government Act. 10 year plan by community with a 4 year plan for council to push the 10 year plan.
	Tweed Shire is has a more regulated approach to Byron which is more regulated	
	Tweed utilises 100-year flood line regularly. However, uncertainty exists as to its accuracy/reliability.	
	Planned retreat (Byron) NSW Government's 25-year land use strategy caters for 60,400 more people expected to be living in the region by 2031. Up to 51,000 additional homes will be needed. *NSW Government's 25-year land use strategy Locates future settlement around existing centres and towns, fitting the local character – Does it take into consideration the potential retreat of Byron ?*	
	Uncertainties for employment due to planning and housing issues	NSW Government's 25-year land use strategy supports 32,500 extra jobs through ensuring a sufficient supply of employment land. Industries will be attracted to well located sites with ready access by road, rail and air to capital cities and ports.
	There have been a number of recent court cases considering climate change in planning and approvals particularly where changes in the environment may impact on the use of an activity in the future (eg: residential development).	
	Higher density living potentially inducing social problems.	Given the current landuses and potential for development (urban vs. rural), there may be greater incentives for rural development due to susceptibility and resilience to climate change. NSW Government's 25-year land use strategy provides for rural living. Promotes sustainable growth for inland areas.

	Issues	Opportunities
	Pressures on providing social structures due to affects of increasing costs of general living	Energy may become decentralised Potential for solar panels as an additional/optional power source; Condong sugar mill redundancy. The cogeneration facility is reliant on future viability of the mill.
	Potential for climate change refugees	Increased use of BASIX (Building Sustainability Index) and rainwater tanks. Consideration of the viability of rainwater tank production when considering climate change. Possible new future legislations regarding water usage, quality and recycling options.
	Scope of a Risk Assessment needs to be legislative	
	Landfill charges (increase in levy) to mitigate dumping. Price rises may induce illegal dumping.	
Health	Changes in community age composition due to Climate Change (Warmer climate and its attractiveness to ageing population); - more sensitive – Heat stress In the next 25 years the region's population is expected to grow more than 26% to 289, 000. NSW Government's 25-year land use strategy caters for 60,400 more people expected to be living in the region by 2031. Up to 51,000 additional homes will be needed.	
	Increase in vector bourn disease	
Data	Risk studies and production of opposing opinions regarding the real and actual risks associated with climate change;	
	Problems associated with obtaining hard data for local areas susceptible to severe effects	
	20-year projections may not be accurate regarding extreme rainfall, as variations are continually occurring making quantification difficult. This is leading to questioning on 100 year projections also.	
	Fauna corridors and crossing use is difficult to quantify due to lack of baseline data re: previous use of the area.	
Climate	Bureau of Meteorology presented risks and concerns regarding cyclone occurrence in these areas in 2007.	
	Hailstorm frequency increasing over the last 2-3 years.	
Climate Scenarios	Both Councils are generally concerned as to how risks will be perceived if referring to higher end, extreme scenarios.	
	Both Councils believe that caution needs to be applied as to what is actually identified in risk scenarios	

	Issues	Opportunities
Emergency Response	Problems associated with emergency response already. General feeling that consistency is needed.	
	Existing infrastructure collapse and restricted ability to cope with emergencies induced by climate change; Potential changes to design specifications on sewerage systems etc.	
	Potential isolation of rural dwellings due to cut off from main access roads;	
	Pressure on council budgets on post storms cleanups.	
Biodiversity	Potential for increased aggressiveness in introduced mosquito fish (*Gambusia Holbrooki*)	
	Cane toad population increase induced by warmer climate	
	Exotic vegetation flourishing and out competing native vegetation	
	Concentration of flying foxes potentially increasing transmitted diseases	
	Further spread of exotic vegetation due to altitudinal migration of some species.	
	Potential problems for sustaining populations due to altered existing conditions and/or inducing favourable conditions for pest/exotic species.	
Agriculture	Storm (hail) frequency increases affecting crops.	Opportunities for some crops to increase, others may be adversely affected e.g. stone fruits
	General livestock and native fauna disease migration as a result of climate change;	
	Potential increase in cattle tick activity due to an increase in humid weather;	

Table 13 Eight Areas of Concern - Consolidated Vulnerabilities and Current Controls

Risk Description	Climate Variable	Consequences/ Vulnerability	Current Controls
1. The introduction or proliferation of exotic species	Increased Temperature (Item 1)	Impacts associated with pollution of air, land and water Competition and predation of native flora and fauna Confluence with other risk scenarios such as sea level rise Loss of biodiversity- eg cane toad and red belly black snake reduction Destruction of habitat eg proliferation of weeds - morning glory displaces natives. Fauna - Indian Mynas The loss of existing biodiversity	Byron - Cane toad control programs Tweed/Byron - Indian Myna Weed control - some joint programs - eg work on private property Community education programs and monitoring Cane Toad muster, fences, Biodiversity plans Policy plans and programs State biodiversity plans Zoning - DCPs and other policies Local policies Federal Policies - EPBC Act Funding and grants both State and Federal

Risk Description	Climate Variable	Consequences/ Vulnerability		Current Controls	
2. Increased flood level and frequency/ flooding Impacts on coastal development	Increased Storm Intensity (Item 22 & 20) Sea level rise (Item 19 and 21) Sea level rise (Item 8)	Increased injury and death during events Isolation, reduced access Localising disease Property damage Loss of property Loss of development potential Sewage overflows Sewerage infiltration Stock and crop damage Contamination of drinking water Loss of income Stress and mental health Vulnerable communities worst hit- caravan parks, aged, agricultural community, Slips on roads Devaluation of land Council liability Community outrage Loss of agricultural yield Impact on SES	Insurance - increased property insurance Councils own insurance rating - higher premiums Damage to infrastructure Disruption to utilities Cost to government for natural disaster recovery Disruption to STPs Salinity infiltration to sewage piping Salt instruction - Stormwater pipes Devaluation of land Loss of property Loss of development potential Class Actions (Compensation) Community outrage Loss of income Loss of taxation revenue Increased cost to develop	Disaster Plan Emergency Services Communications Stormwater and drainage Building construction standards Community preparedness Flood plain zoning and Sewer overflow abatement strategy Detention basins Mosquito control programs Bridges and culverts Road closure programs Tree management Floodplain management Dam construction - management of catchments Dam spillways Road maintenance Water sharing Personal insurance	DCPs Levies Floodgates Flood pumps Landuse planning framework Drainage maintenance Zoning Voluntary purchase of land Voluntary house raising Local Government Act DECC policy and guidelines and manual (floodplain) Coastline Management Plan with an Asset focus Flood studies Asset Management Plans (Byron in the process, Tweed in place) Monitoring Grant funding Research Agricultural management - how land is managed, crop type

Risk Description	Climate Variable	Consequences/ Vulnerability	Current Controls
3. Loss of current or existing biodiversity	Sea level rise (Item 2) Habitat displacement due to increased temperature is considered moderate risk (Item 6)	Loss of coastal ecosystems, dunes Loss of estuarine environment Migration of salt marsh Loss of flood plain vegetation Habitat clearing Fragmentation Habitat modification Disturbances Isolation (fragmentation) and reduced resilience due to climate change	Coastal Zone Management Plan (estuary and coastal and floodplain) - protect/retreat strategy maintain current dune structure via engineering works i.e. rock walls, barriers Flood Gates systems and levies Legislative controls - coastal vegetation, endangered communities Land zoning, buffers as coastline retreats Development control plans Funding - State - for planning (biodiversity planning) Vegetation Management Plans across the Shire SEPP's EEC LEP zones
4. Effect on freshwater supply	Sea level rise (Item 7)	Seawater incursion as it overtops current weir height	Operation management system - temporary barrier over the weir

Risk Description	Climate Variable	Consequences/ Vulnerability	Current Controls
5. Coastal Erosion	Sea level rise (Item 23) (Planned retreat)	Potential town flooding for Brunswick Heads and Byron Risk to development and utilities development Immediate risk to persons residing in coastal development Loss of infrastructure - particularly roads which are important evacuation routes Coastal inundation Impacts on utilities	DCPs LEPs REPs Coastal Management Plan Barriers Sand pumping State SEPP Land tenure - difference bw public and private Coastal dune rehabilitation Set backs Land use tables Building and construction codes Hazard definitions Hazard identification Defences Submerged offshore reefs Seawalls - 1 retained to protect Byron, the rest to be removed Brunswick Head Training Walls (risk of failure)
6. Increased bushfire events (and intensity)	Increased temperature [leading to a loss of property] (Item 9) Increased temperature: [leading to loss biodiversity] considered a moderate risk (tem 11) Increased temperature [leading to loss of life and safety issues] considered a moderate risk in the long-term (Item 10)	Increased bushfire events leading to loss of property (infrastructure and community assets), Increased insurance premiums Reduction in community services Increased resource requirements for bushfire management Increased bushfire events leading to loss of biodiversity Increased bushfire events leading to loss of life Safety issues	Asset protection zones Bushfire Management Plans Fire mapping. Ignition management Hazard reduction burning Community education Preparedness - operation readiness Training (Bushfire management plan) Development controls

Risk Description	Climate Variable	Consequences/ Vulnerability	Current Controls
7. Higher evaporation and longer drought periods	Increased temperature (Item 15) Decreased Rainfall (Item 25) Heat stress and health related impacts as a result of increased evaporation drought is considered a low risk over all periods (Item 16) Decreased rainfall: Change in the location of infrastructure leading to loss of property amenity and function is considered a moderate risk in the medium to long term (Item 4)	Loss of habitat, change in ecosystem function and diversity Regional macro water sharing plans and environmental flows. Reduction of yield of water supply Water shortage Impact on community Water quality Reduced irrigation rights Dam locations, demand management strategies, safe yield projections, heat stroke and health risk Water storages and water supply use of recycled water, rainwater tanks etc	Macro water sharing plans (under development) Restriction levels Demand management strategy Integrated Water Cycle Management Strategy Catchment zoning - LEP zoning Catchment Management Plans Augment Management Plans Asset Management Plans Community awareness State government BASIX WSUD User pays/step pricing Stormwater harvesting management Wastewater reuse Heat stress and health related impacts Change in the location of infrastructure loss of property amenity and function
8. Decline in the local economy due to reduced tourism and appeal	Increased Rainfall (Item 3)	Loss of income from tourism	Increased advertising post severe wet weather

Table 14 Eight Areas of Concern - Consolidated Potential Adaptation Controls and additional Workshop Actions /Comments

Risk Description	Potential Controls	Actions /Comments
1. The introduction or proliferation of exotic species	Increased funding for existing controls to be expanded in scale Possible technological controls	Insufficient knowledge to know what will occur in 2070 Need to break down to specific areas of flora and fauna Need to look at the effectiveness of various programs and grants Majority of exotic species control programs are not effective for eg toads and Mynars populations are still increasing No research evidence to back up increase in temperature impacts. Evidence is anecdotal to date for example will the veracity of exotic/invasive species be more prevalent in winter due to increased temperatures Difficult to provide a blanket control across a variety of flora and fauna. For example invasive trees and vines will react differently. ACTION: Will need further analysis to determine the individual risks in order to apply appropriate controls. Research needs to be more precise. Research into existing native species required. For example, Beech forest may be sensitive to a 1.5C increase Comment made that if there was a similar level of funding to tackle invasive species as has been assigned for new parks ($30 million) then an impact could be made.

Risk Description	Potential Controls	Actions /Comments
2. Increased flood level and frequency/ flooding Impacts on coastal development	Upgrade design standards for infrastructure - better engineering standards Replace infrastructure Potential rate increase (Climate Change levy) Specific state funded allocation Planned retreat Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastructure Insurance clarification Improved stormwater design standards and drainage Adjusting drainage and engineering controls Improved planning of infrastructure Improved design standards of at risk infrastructure.	Depends on convergence with sea level rise, rainfall and secondary impacts such as flooding could exacerbate this problem ACTION: Currently isolated incidences with loss of life - check number of deaths due to server storm events People may voluntarily relocate There have been 2 major floods in 15 years. Change from the pattern of annual flood events in the 1980s (this comment will further clarification by the sustainability officers) The 1 in 100 year floods are currently effecting hundreds of properties ACTION: Use Byron Tweed inundation mapping to calculate numbers of properties against the storm surge/sea level impacts. Crosscheck results with risk rating. Minor improvement in how infrastructure will cope List of assets at future sea level, flooding risk Salt-water intrusion - study into which assets are at risk. Get a register followed up with further analysis Councils are carrying out studies to quantify impacts of flooding - check inundation mapping Sea level rise will lead to a big impact on salt marshes. Salt marshes may be able to migrate further inland. On the other hand, migration maybe restricted by existing and/or proposed development (environmental buffers). ACTION: Assessment Management and question of how effective it will be. Will potential impacts of the various climate change variable be a consideration over the life of each asset? ACTION: Asset Register - check for AHD data (flood risk, tidal range, current and future seal level, flood plain) infrastructure on the coast and in floodplain for eg. sewage pumping, stormwater, roads, public buildings. Currently no assessment on the infrastructure impacts available. ACTION: Register of mapping infrastructure at risk. Salt water incursion due to sea level rise will have major impacts on infrastructure. Rising groundwater levels are compounding the sea level rise and storm surge issue. Has this also been taken into consideration under asset management? Agriculture on the floodplain is very vulnerable.

Risk Description	Potential Controls	Actions /Comments
3. Loss of current or existing biodiversity	Ensure connectivity of corridors (biomes links Translocation Development controls - buffer Floodplain defences Seawalls Technology Comprehensive mapping - for planning purposes Biodiversity banking/gene banking Ranking of areas, selection of key areas Identification of at risk habitat Improving connectivity Translocation of species	Should tease out coastal and floodplain later on in detail. Insufficient data on flood plain response to sea level rise to date. Possibly will need study Initial assessment appears lot of money for little improvement, further offline study required for validation Separate habitat from biodiversity as separate lines in the matrix A holistic approach will need to be taken into biodiversity planning. Alignment of all levels i.e. National, State and Local - control, planning & programs, research both existing and proposed. Fine level of profiling of ecosystems and species on the floodplain will be required to appropriately determine risks. ACTION: A study maybe required of the health of ecosystem on the floodplain. Determine if flora and fauna can cope with the rate of change. Need for environmental buffers. Review the risk rating for this CC variable currently classified as catastrophic even with Potential Controls. An offline study will be required to validate ratings. Will expenditure and additional controls make an impact as sea level continues to risk? For example A triple bottom line cost/benefit analysis may assist in the decision-making.
4. Effect on freshwater supply	Weir augmentation before sea level rises 10cm from current level	This is a risk that is specific to the Tweed Shire Legal arguments over the weir in Tweed, which has implications for farmers but can be resolved with a relatively simple engineering solution. (Will need further clarification) There has been a loss of property now. Please clarify to what extent - how much properties/ area. Risk of sea level rise contaminating fresh water supply, especially a concern for Tweed. Current occurs twice a year with King Tides. Weir augmentation will be required before sea levels rise a further 0.1 meters from current level. Note that as sea levels continue to rise, this may possibly become a constant event affecting the functionality of the community ($10-$20 million BAU). [Actioned below: Sea level rise figures being rechecked by GHD. Anywhere between 0.3m - 0.6m rise in sea level by 2030. 0.4m rise by 2050 according to the Summary of climate change impacts document but this does not account for storm surges]

Risk Description	Potential Controls	Actions /Comments
5. Coastal Erosion	Planned retreat Potential rate increase (Climate Change levy) Specific state funded allocation Coastal buffers Levies Other defences Compulsory purchasing Back zoning DCPs LEP state system changed Community awareness and education Major upgrade of emergency response Relocation of critical infrastructure Insurance clarification	Convergence of all of the variables There are currently several sea walls. 1 will be retained in Byron Bay and the other will go. Tweed are planning to build one new seal wall at Brunswick Heads (lands). The Byron sea wall structure is at immediate risk of failure, exposing the town/ CBD, roads including evacuation routes and impact on infrastructure will need to be taken into account. Estimate cost: Byron - approx $15 000/metre, total cost between $3 - $9 Million to upgrade. Cost not accounted for in any forward work budget - earmarked as future projects. Capital works program for Byron is $3M (mainly water sewerage) Tweed - around $102M (mainly water and sewerage). ACTION: Have available all capital and discretionary annual spending figures, especially for the Adaptation preparation meeting. Roads and drainage - Byron - $6-10M Water - Byron - $1.3M Can manage down with retreat BUT at a cost. Please clarify with figures as per recent flood study. Currently the 1 in 100 year floods are affecting hundreds of properties. Coastal recession has only been seen to kick in the last two years. Only just beginning to see enough energy in waves. There has been an increase in sea level of 17cm since 1970. Are we still able to assess any impacts accurately despite the rise as the coastline is very dynamic Noted that the coastline has not moved back to the 1990 equivalent Increased storm activity leading to storm surges and negative IPO ACTION: Need to clarify sea level rise estimates for 2030. GHD to double check estimates of 0.3m or 0.6 m rise in sea level. The 2050 "Summary on climate change impacts" states that "sea level is projected to rise up to 40cm by 2050 and 90cm by 2100". It is noted that these figures are based on CSIRO and IPCC figures and further reviews are being carried out to quantify expected local changes. In addition it should also be noted that storm surges have not been included in the 2050 sea level rise figures above.

Risk Description	Potential Controls	Actions /Comments
6. Increased bushfire events (and intensity)	Increased Bushfire Management Fuel reduction strategies Increased resources Sighting of new infrastructure Community education Improved health services (managing responses to bushfire injuries) WIRES Cool burns	ACTION: Check exiting bushfire controls in the Bushfire Management Plan (repeated against items 12, 13, 14) ACTION: Need to determine what the specific risks and consequences will be at a given location. The suggestion is to divide the area into 9 precincts (eg separate line items perhaps NB each precinct may again need to be categorised by the 3 risk categories i.e. environment, property and health [and analyse on a case by case basis to more tailor the potential controls. Cannot provide a blanket control to determine Residual Risk level. – Rural Fire Service will need to be consulted.(repeated against items 12, 13, 14) ACTION: Check figures for the number of total fire bans / yr now and into the future. Currently there are 4/yr but said to increase 10 fold. (repeated against items 12, 13, 14) Taken for the 2030 timeframe Is there a greater focus on property and people and to reduce risk from fire? Increased fire management may have a negative impact on the environment if the management regimes don't incorporate site-specific environmental considerations.

Risk Description	Potential Controls	Actions /Comments
7. Higher evaporation and longer drought periods	Sewer mining Better climate change data over the next 5 to 10 years Decentralising water supply Increased scale of rates - user pays increase Greywater reuse Dry toilets Dual reticulation Retrofitting depending on economics Potable reuse Landscape design Change in cropping regime (drought hardy species and GM) Increased weed control etc to reduce pressure on habitat and environmental flows for riparian areas Integrated water cycle management including demand management, water sensitive urbane design etc.	Risk issue lies mainly based on Tweed issue. Tweed and Byron have different triggers. Two different water supplies. Byron water supply is safe till 2100- Rouse implications. Tweed will need augmentation around 2015 and further augmentation further down the track eg land purchase for a future dam site. Hoped that demand management to delay augmentation. ACTION: What are the figures for water use reduction as a result of Council programs? (repeated against items 12 & 15) ACTION: Check figures - 7% factored in using CC scenarios to determine yield back in 2006 but did not account for 2070 climate change scenario? Tweed did not have an issue during the last drought period. Challenge will be to match population growth. The lumpy wet and dry seasons may improve the supply issues but this will need further analysis. ACTION: Better regional and season climate change data on rainfall in particularly should be plugged into modelling when available. This could change the risk rating and should be included as a potential control (repeated against items 12 & 15)
8. Decline in the local economy due to reduced tourism and appeal	Diversification of appeal to the area and the economic base (e.g. broader economy not just tourism)	No Actions / Comments

Appendix F

Context Setting in Detail

Byron and Tweed Shire Background

Summary for Byron and Tweed

Parameter	Byron	Tweed
Major Population centres	Major urban areas are Byron Bay (with its satellites Suffolk Park and Ewingsdale); Brunswick Heads; Mullumbimby; Billinudgel/New; Brighton/Ocean Shores; and Bangalow.	Tweed Heads (including Tweed Heads South and West), Bilambil, Terranora, Banora Point and Kingscliff
Area	567m2	1303m2
Population:	30,329 *	81,953 *
Far North Coast Population	N/A	118,750 (2031)**
228 000 (2006)		
289 000(2030)		
Median age of persons		
Far North Coast		
39 years (2006)		
51 years (2031)	41	44
Total Private dwellings	10,711	31,121
Far North Coast Dwellings		
51 000 additional homes by 2030		

*ABS 2006 census

** Tweed Shire Community Profile, May 2008

The Far North Coast Region, also referred to as the “Region” in the document, is the most biologically diverse region in NSW and the third most diverse in Australia. The Region is comprised of the six Local Government Areas (LGAs) of Ballina, Byron, Kyogle, Lismore, Richmond Valley and Tweed. Around half the Region’s population live in coastal or non-coastal villages, smaller communities, hamlets and rural areas. The largest population increases in the Region have been in the coastal Local LGAs of Tweed, Byron and Ballina. Tweed Shire with its proximity to South East Queensland has shown the strongest growth over the past decade.

Byron Shire is situated in far north-eastern New South Wales. It comprises most of the catchment area of the Brunswick River, and part of that of the Richmond River. It adjoins the shires of Tweed (to the north) and Ballina (south), and the City of Lismore (west). The Shire is bounded in the east by the South Pacific Ocean, in the south partly by Skinners Creek and the Wilson River, in the southwest partly by Coopers Creek, and in the north-west partly by the Nightcap Range (Figure 3). The area of the shire is 567 square kilometres and is characterised by the following land uses:

Major Land Uses in Byron Shire (BSC, 2002)

Landuse	Area (ha)	% Total
Rural	29179	48.1
Agricultural	10830	19.2
Environmental Protection	12623	22.4
Forestry	593	1.1
Residential	1137	2.0
Other	1469	2.6
Open Space	392	<1
Extractive	108	<1
Industrial	79	<1
Retail	48	<1
Unassessed	3	<1

Tweed Shire covers 1303 square kilometres and adjoins the NSW Local Government Areas of Byron, Lismore and Kyogle, with the NSW/Queensland border to its north where it divides the twin towns of Tweed Heads and Coolangatta. 64% of the shire's population is located in the Tweed Heads area, which consists of Tweed Heads (including Tweed Heads South and West), Bilambil, Terranora, Banora Point and Kingscliff. (ABS 2006). 25% of the shire's population is located in the rural areas of the shire, which consists of Murwillumbah, Uki, Tyalgum, Chillingham and the other villages surrounding these areas. (ABS 2006). 1% of the Shire's population is located in the coastal areas of the LGA, which consists of the villages and townships south of Kingscliff. (ABS 2006).

Community

In carrying out a Risk Assessment certain characteristics of the population and area are particularly important as they may influence the sensitivity and vulnerability of the population to climate change impacts. The proportion of the population in the Region aged 65 years or more is expected to more than double by 2031. Age distribution and affluence of a community are important to determine the health related effects of extreme changes in climate, in particular the impact of heat stress on infants, young children and the elderly. Affluence indicated by level of income and type of dwellings are important in gauging the ability of a community to either cope with extreme events and ability to adapt to changing climate conditions and secondary impacts associate with these changes. For example caravan parks are particularly vulnerable to extreme weather conditions. The NSW Government's 25-year land use strategy for the Far North Coast Regional Strategy expects an increase in the population by 60 400 people (26% increase) by 2031. The population of the Region is increasing by 2,500 people on average each year. Around half the Region's population live in coastal or non-coastal villages, smaller communities, hamlets and rural areas. Up to 51,000 additional homes will be needed.

Impacts of climate change on the community can include:

» Changes in community age composition due to climate change (warmer climate and its attractiveness to ageing population);

- Potential for a 'climate change refugees' (from within Australia and internationally);
- Uncertainties for employment;
- Pressures on providing social structures due to affects of increasing costs of general living; and,
- Displacement and higher density living potentially inducing social problems.

The following Australian Bureau of Statistics information has been provided in the tables below:

- Population Profile for Byron LGA & Tweed LGA Time Series 1996, 2001 & 2006
- Selected Medians and Averages for Byron LGA & Tweed LGA (2006 census)
- Selected Medians and Averages for Byron LGA Time Series 1996, 2001 & 2006
- Selected Medians and Averages for Tweed LGA Time Series 1996, 2001 & 2006
- Dwelling Profile for Byron LGA & Tweed LGA 2006 census

These tables provide available population projection information

- Tweed Shire Population Projections 2006 to 2031
- Projected population and selected characteristics - Tweed (A)
- North Coast Area population projections by age, December 2008 & 2030.

(Please note to avoid confusion that the North Coast Area population projection includes the 11 LGAs of Ballina, Bellingen, Byron, Clarence Valley, Hastings, Kempsey, Kyogle, Lismore, Nambucca, Richmond Valley and Tweed. The NSW Far North Regional strategy provides projections have been provided in the table 5 above for the six LGAs. Population projections were not available for the Byron Shire LGA.)

Table 15 Population Profile for Byron LGA & Tweed LGA Time Series 1996,2001 & 2006

Population Profile	Byron			Tweed		
	1996	2001	2006	1996	2001	2006
Total persons(a)	27,565	30,245	30,329	66,865	74,380	81,953
Age group(a):						
0-4 years	1,763	1,705	1,656	4,240	4,157	4,289
5-14 years	4,353	4,405	3,960	9,578	10,232	10,464
15-19 years	1,722	2,037	2,026	3,760	4,565	5,088
20-24 years	1,592	1,735	1,692	2,792	2,701	3,446
25-34 years	3,586	3,819	3,454	7,354	7,002	7,235
35-44 years	5,253	5,173	4,520	9,635	10,314	10,207
45-54 years	3,417	5,039	5,550	7,735	9,794	11,503
55-64 years	2,152	2,633	3,687	7,301	8,623	10,625
65-74 years	2,283	1,943	1,894	9,202	9,446	9,681
75-84 years	1,177	1,364	1,433	4,352	6,108	7,370

Population Profile	Byron			Tweed		
	1996	2001	2006	1996	2001	2006
85 years and over	267	392	457	916	1,438	2,046
Overseas visitors	558	1,329	906	346	559	571
Indigenous persons:						
Aboriginal	249	256	375	995	1,349	1,755
Torres Strait Islander	63	51	44	297	252	245
Both Aboriginal and Torres Strait Islander(b)	27	40	34	169	266	310
Total	339	347	453	1,461	1,867	2,310
Birthplace:						
Australia	22,128	22,564	21,956	55,053	59,346	64,217
Elsewhere(c)	3,724	4,273	4,765	8,977	10,638	11,693
Language spoken at home:						
English only	24,921	25,935	25,598	62,973	68,602	74,726
Other language(d)	1,124	1,250	1,491	1,640	2,038	2,506
Australian citizen	24,481	25,574	25,017	61,285	67,170	72,496

(a) Includes overseas visitors.

(b) Applicable to persons who are of both Aboriginal and Torres Strait Islander origin.

(c) Includes 'Australian External Territories', 'Inadequately described', 'At sea' and 'Not elsewhere classified'.

(d) Includes 'Inadequately described' and 'Non-verbal, so described'.

Table 16 Selected Medians and Averages for Byron LGA & Tweed LGA (2006 census)

	Byron	Tweed		Byron	Tweed
Median age of persons	41	44	Median housing loan repayment ($/monthly)	1,200	1300
Median individual income ($/weekly)	383	364	Median rent ($/weekly)	250	210
Median family income ($/weekly)	932	904	Average number of persons per bedroom	1.1	1.1
Median household income ($/weekly)	738	683	Average household size	2.4	2.4

Table 17 Selected Medians and Averages for Byron LGA Time Series 1996, 2001 & 2006

Byron Time Series	*1996*	*2001*	*2006*		*1996*	*2001*	*2006*
Median age of persons	36	39	41	Median housing loan repayment ($/monthly)	728	867	1,200
Median individual income ($/weekly)	225	298	386	Median rent ($/weekly)	150	180	250
Median family income ($/weekly)	486	666	932	Average number of persons per bedroom	1.1	1.1	1.1
Median household income ($/weekly)	450	563	744	Average household size	2.6	2.4	2.4

Table 18 Selected Medians and Averages for Tweed LGA Time Series 1996, 2001 & 2006

Tweed Time Series	*1996*	*2001*	*2006*		*1996*	*2001*	*2006*
Median age of persons	40	43	45	Median housing loan repayment ($/monthly)	780	867	1,300
Median individual income ($/weekly)	220	280	362	Median rent ($/weekly)	135	150	210
Median family income ($/weekly)	495	663	904	Average number of persons per bedroom	1.1	1.1	1.1
Median household income ($/weekly)	444	516	679	Average household size	2.5	2.4	2.4

Table 19 Dwelling Profile for Byron LGA& Tweed LGA 2006 census

Dwelling Type	Dwellings Byron Bay	Persons Byron Bay	Dwellings Tweed	Persons Tweed
Separate house	8,706	22,268	20,362	54,813
Semi-detached, row or terrace house, townhouse etc. with:				
One storey	420	876	4,101	7,810
Two or more storeys	361	790	1,735	3,511
Total	781	1,666	5,836	11,321
Flat, unit or apartment:				
In a one or two storey block	614	1,033	2,032	3,426
In a three storey block	82	133	724	1,306
In a four or more storey block	0	3	505	911

Dwelling Type	Dwellings Byron Bay	Persons Byron Bay	Dwellings Tweed	Persons Tweed
Attached to a house	50	83	59	90
Total	746	1,252	3,320	5,733
Other dwelling:				
Caravan, cabin, houseboat	320	511	1,087	1,711
Improvised home, tent, sleepers out	97	102	415	654
House or flat attached to a shop, office, etc.	56	118	73	158
Total	473	731	1,575	2,523
Dwelling structure not stated			28	54
Total	**10,711**	**25,927**	**31,121**	**74,444**

Table 20 Dwelling Profile for Byron Bay & Tweed Time Series 1996 & 2001

Dwelling Type	Byron Bay		Tweed	
	1996	***2001***	***1996***	***2001***
Separate house	7,577	8,496	16,090	18,661
Semi-detached, row or terrace house,				
Townhouse etc:				
One storey	318	429	2,632	3,292
Two or more storeys	190	387	1,184	1,180
Total	*508*	*816*	*3,816*	*4,472*
Flat, unit or apartment:				
In a one or two storey block	629	567	1,567	2,175
In a three storey block	64	55	852	794
In a four or more storey block	18	6	230	363
Attached to a house	68	73	133	115
Total	*779*	*701*	*2,782*	*3,447*
Other dwelling:				
Caravan, cabin, houseboat	360	322	1,354	1,659
Improvised home, tent, sleepers out	15	18	54	35
House or flat attached to a shop, office etc.	71	125	135	132
Total	*446*	*465*	*1,543*	*1,826*

Dwelling Type	Byron Bay		Tweed	
Dwelling structure not stated	187	88	286	80
Total	**9,497**	**10,566**	**24,517**	**28,486**

Table 21 Tweed Population Projections 2006 to 2031

Population Projections	Low Series			Preferred Series			High Series		
	Tweed Heads	Tweed Part B	Tweed Shire	Tweed Heads	Tweed Part B	Tweed Shire	Tweed Heads	Tweed Part B	Tweed Shire
2006	**53,317**	**29,706**	**83,023**	**53,317**	**29,706**	**83,023**	**53,317**	**29,706**	**83,023**
2011	58,132	31,493	89,626	58,932	31,939	90,871	59,732	32,385	92,116
2016	62,188	33,218	95,406	63,928	34,167	98,095	65,692	35,129	1000,821
2021	65,990	34,879	100,869	68,795	36,388	105,183	71,678	37,940	109,618
2026	69,637	36,425	106,062	73,629	38,547	112,176	77,790	40,760	118,551
2031	**72,866**	**37,825**	**110,691**	**78,147**	**40,607**	**118,754**	**83,730**	**43,550**	**127,281**
Total growth 2006-2031	36.1%	27.3%	33.3%	46.6%	36.7%	43.0%	57.0%	46.6%	53.3%
Annual growth 2006 -2031	1.3%	1.0%	1.2%	1.5%	1.3%	1.4%	1.8%	1.5%	1.7%

Source: http://www.tweed.nsw.gov.au/AboutTheTweed/StatsHome.aspx (Tweed Shire Community Profile, May 2008)

Table 22 Projected population and selected characteristics - Tweed (A)

	Population				% aged 0-14	% Aged 65+	Dependency Ratio	Median Age
Year	Males	Females	Persons	Sex ratio				
2001	36,640	37,930	74,580	97	20%	21%	70	42
2006	**40,920**	**42,100**	**83,020**	**97**	**18%**	**23%**	**67**	**44**
2011	44,830	46,050	90,870	97	16%	24%	67	46
2016	48,400	49,690	98,090	97	15%	27%	72	48
2021	51,910	53,280	105,180	97	14%	30%	78	50
2026	55,340	56,840	112,180	97	14%	33%	86	52
2031	**58,540**	**60,220**	**118,750**	**97**	**13%**	**35%**	**94**	**54**

Source: http://www.tweed.nsw.gov.au/AboutTheTweed/StatsHome.aspx (Tweed Shire Community Profile, May 2008)

Table 23 North Coast Area population projections by age, December 2008 & 2030

	Persons 2008		Persons 2030	
	Population projection	% of Total	Population projection	% of Total
North Coast Area Total Population	**494,747**	**100.0 %**	**611,447**	**100.0 %**
0-4 yrs	25,615	5.1 %	25,052	4.0 %
5-9 yrs	30,245	6.1 %	29,411	4.8 %
10-14 yrs	34,270	6.9 %	31,150	5.0 %
15-19 yrs	32,542	6.5 %	28,506	4.6 %
20-24 yrs	24,238	4.8 %	22,173	3.6 %
25-29 yrs	21,378	4.3 %	22,142	3.6 %
30-34 yrs	24,258	4.9 %	26,136	4.2 %
35-39 yrs	29,082	5.8 %	30,433	4.9 %
40-44 yrs	32,713	6.6 %	33,842	5.5 %
45-49 yrs	37,101	7.4 %	35,285	5.7 %
50-54 yrs	37,811	7.6 %	37,199	6.0 %
55-59 yrs	36,060	7.2 %	42,082	6.8 %
60-64 yrs	33,394	6.7 %	46,350	7.5 %
65-69 yrs	26,610	5.3 %	49,907	8.1 %
70-74 yrs	22,648	4.5 %	47,659	7.7 %
75-79 yrs	18,997	3.8 %	41,163	6.7 %
80-84 yrs	14,877	3.0 %	31,417	5.1 %
85+ yrs	12,909	2.6 %	31,539	5.1 %
All ages	**494,747**	100.0 %	**611,447**	**100.0 %**

Source: ABS estimated resident populations and population projections from the NSW Department of Planning (HOIST)

NB: The North Coast Population projections above cover the 11 LGAs of Ballina, Bellingen, Byron, Clarence Valley, Hastings, Kempsey, Kyogle, Lismore, Nambucca, Richmond Valley and Tweed. It does provide an useful indicator of the percentage of population within each age category.

Employment

The Far North Coast is experiencing an ageing population. The proportion of young people is projected to decline 14% leaving 54% of the population in the working age group. The Far North Coast Strategy estimates that an additional 32,500 jobs will be required in total for the six LGAs that make up the Far North Coast. The Far North Region has traditionally been dominated by agriculture and is now dominated by service sector industries (84%) and manufacturing and construction (12%). The service sector comprises of predominantly retail, hospitality and tourism, education and health sectors with employment in agriculture,

forestry and fishing. The Strategy estimates that a further 32,000 new jobs will be required in the region. The Regional Industry and Economic Plan (2005) prepared by the Northern Rivers Regional Development Board has identified tourism, education, creative inductees, horticulture, health, aquaculture, residential development and construction, forestry, meat and dairy, and transport as key industry growth sectors,

The 2006 statistics on the labour force for the Byron Shire indicated a number of characteristics concerning employment trends compared to the rest of Australia, most notably that there is a very high ratio of part time employment in the shire.

» High unemployment figures in comparison to the national average

» A high ratio of part time employment compared to the national average

» A low ratio of full time employment compared to the national average

Source: Byron Shire Emergency Risk Management Study 2008

51% of the Byron population over 15 years of age had employment in 2006. There are about 3,700 businesses in the Shire of which 60% are sole traders. Of the balance, 60% employ less than 5 persons and 31% employ between 5 and 19 persons.

The proportion of persons over the age of 15 in employment, either full time or part time, increased at the local, regional and State level throughout the 1996, 2001 and 2006 Census periods. In Byron Shire the growth was more pronounced rising by 14.2% during that period compared to 8.4% and 2.0% at the regional and State level respectively.

In 2006, the proportion of full time workers (i.e. working 35 or more hours) to total workers is 1.9% in Byron compared to 59.8% in the region and 69% across the State (*Source: Byron Shire Council Representative).*

Business

Byron Shire boasts a strong network of home-based businesses. A Community Survey conducted in 2007 indicated about 22% of residences in the Shire had at least one home-based business. This business segment covers a range of activities from traditional pursuits such as agriculture and various trades to those involved in creative industries. The Byron lifestyle are attracting an increasing number of people who can 'work from a distance' using the combination of high-speed telecommunication and airports that provide ready access to both domestic and international markets.

In 2007, it is estimated that tourism spending in Byron was $350 million. That level of spending is estimated to create or maintain about 2,650 full time equivalent jobs.

Individual sectors experienced significant employment growth in the Shire over the 2001- 2006 period. Significant increases in mining (albeit from a low base), construction and professional scientific and technical services would have been influenced by major road works. A fall in manufacturing jobs in Byron and for the State was not experienced in the region where manufacturing increased. Agricultural jobs declined across the Shire, region and the State (*Source: Byron Shire Council Representative.)*

Table 24 Industry of Employment for Byron Bay LGA & Tweed LGA Time Series 1996,2001 & 2006

Industry	Byron Bay			Tweed		
	1996	2001	2006	1996	2001	2006
Agriculture, forestry & fishing	697	597	527	1,428	1,304	938

Industry	Byron Bay			Tweed		
	1996	**2001**	**2006**	**1996**	**2001**	**2006**
Mining	45	12	33	54	45	92
Manufacturing	781	882	769	1,578	1,800	1,979
Electricity, gas, water & waste services	76	60	63	167	187	236
Construction	648	792	1,097	1,860	2,154	3,566
Wholesale trade	345	430	423	821	873	832
Retail trade	1,133	1,364	1,491	2,603	3,320	4,135
Accommodation & food services	1,063	1,341	1,440	2,343	2,566	2,966
Transport, postal & warehousing	238	306	323	889	988	1,177
Information media & telecommunications	187	209	229	328	299	345
Financial & insurance services	194	194	187	493	475	536
Rental, hiring & real estate services	223	246	303	507	584	683
Professional, scientific & technical services	387	547	718	772	924	1,181
Administrative & support services	264	382	369	602	806	919
Public administration & safety	372	377	418	925	1,165	1,567
Education & training	809	1,026	1,070	1,439	1,727	2,097
Health care & social assistance	918	1,176	1,382	2,120	2,673	3,610
Arts & recreation services	131	191	237	318	409	504
Other services	380	375	429	945	948	1,108
Inadequately described/Not stated	323	264	340	700	633	788
Total	**9,214**	**10,771**	**11,848**	20,892	**23,880**	**29,259**

Businesses

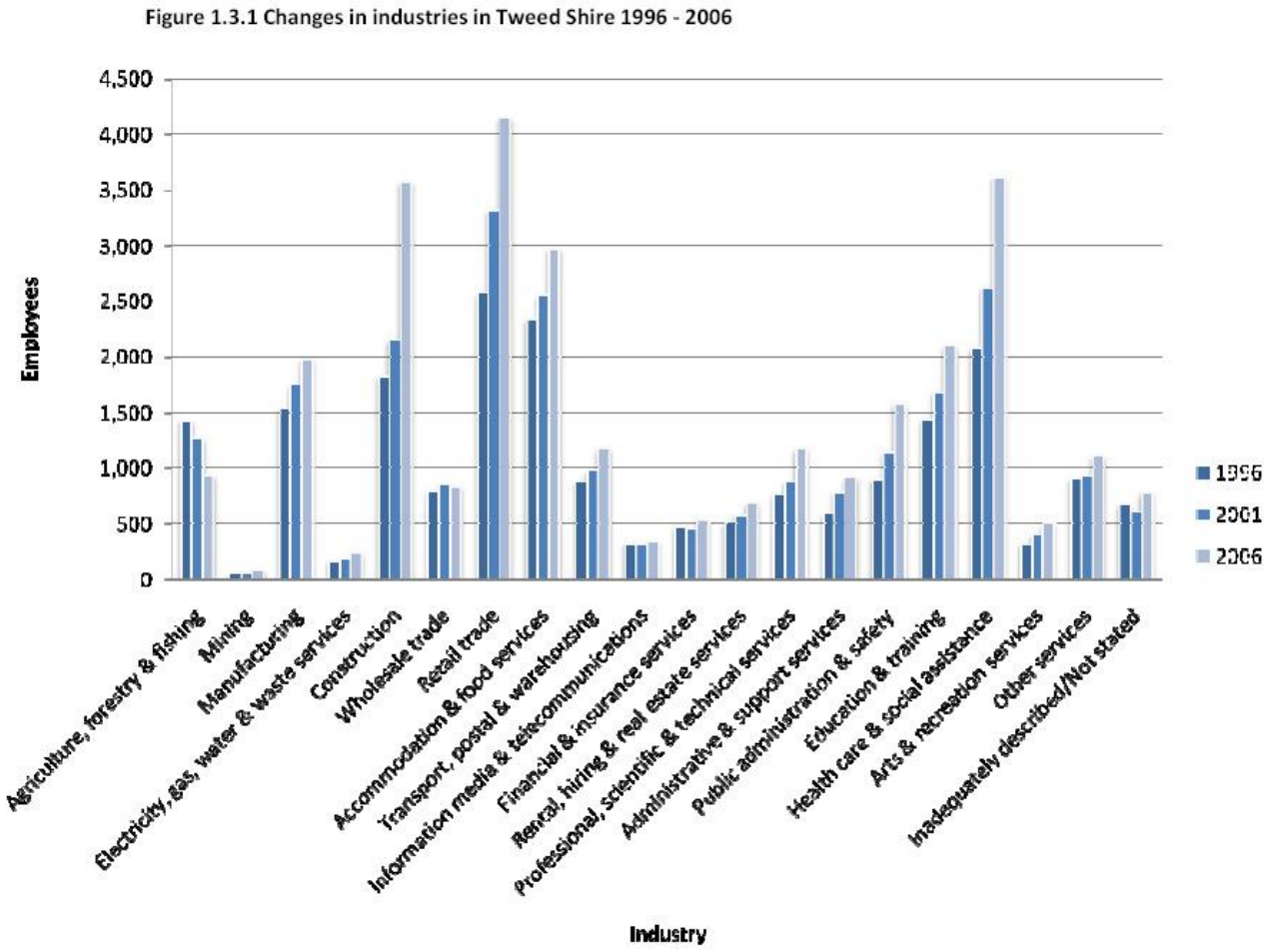


Figure 12 Changes in Industries in Tweed Shire 1996 - 2006

Tweed Shire Community Profile 2008

Industry

Tourism is the predominant source of industry for the Coastal North area of the Byron LGA. Brunswick Heads is a popular holiday destination for many families with three Caravan parks and many holiday rental apartments. The Billinudgel Industrial Estate is home to the majority of Coastal North based business and is situated off the Pacific Highway near Ocean Shores. The other area of industrial development is located in the Byron Bay Arts and Industrial Estate. Tourism success is currently based on aesthetic values in the area.

The Byron Bay Arts and Industrial Estate is located north of Ewingsdale Road along the western entrance to Byron Bay and houses up to 300 business encompassing fashion, art, antiques and home wares, hospitality, health and childcare, sport and dance along with the traditional trade and building supplies.

Source: Byron Shire Council Emergency Risk Study, 2008.

Table 25 Changes in number of employees in industries in Tweed Shire 1996 - 2006

	Number of Persons Employed				
Industry	1996	2001	Percentage change 1996-2001	2006	Percentage change 2001-2006
Agriculture, forestry & fishing	1,427	1,271	-10.93%	939	-26.12%
Mining	55	55	0%	90	63.63%
Manufacturing	1,533	1,751	14.22%	1,981	13.13%
Electricity, gas, water & waste services	164	185	12.80%	234	26.48%
Construction	1,825	2,152	17.91%	3,566	65.70%
Wholesale trade	791	850	7.45%	831	-2.23%
Retail trade	2,575	3,306	28.38%	4,141	25.25%
Accommodation & food services	2,336	2,555	9.37%	2,967	16.12%
Transport, postal & warehousing	881	979	11.12%	1,178	20.32%
Information media & telecommunications	328	303	-7.62%	344	13.53%
Financial & insurance services	475	450	-5.26%	534	18.66%
Rental, hiring & real estate services	509	577	13.35%	687	19.06%
Professional, scientific & technical services	764	884	15.70%	1,177	33.14%
Administrative & support services	593	784	32.20%	920	17.34%
Public administration & safety	901	1,151	27.74%	1,572	36.576%
Education & training	1,437	1,678	16.77%	2,096	24.91%
Health care & social assistance	2,080	2,620	25.96%	3,611	37.82%
Arts & recreation services	314	403	28.34%	499	23.82%
Other services	912	931	2.08%	1,110	19.22%
Inadequately described/Not stated	679	613	-9.72%	783	27.73%
Total	20,579	23,498	14.18%	29,260	24.52%

Source: Tweed Shire Community Profile 2008

Agriculture

The NSW North Coast region supports a wide range of agricultural activities, from intensive horticulture to broad acre cropping and grazing. Approximately 1 in 12 working people on the North Coast are employed in agriculture, and the farm gate value of agricultural production on the North Coast is in excess of $650 million, rising to about $1 billion when processing is included, particularly, in the meat, milk, sugar and macadamia industries (NSW Agriculture, 2000. *North Coast Agriculture*).

Agriculture is the third largest source of income for Byron Shire, after tourism and social security payments, generating approximately between $35 million (ABS 2000/01) and $57.5 million (ABS 1999/2000) annually. Production in the Shire is characterised by relatively smallholdings involved in intensive production with over 53% (derived 2000/01 ABS) of landholders involved in some form of horticulture

Most farmland is used for grazing of beef and dairy cattle in the Tweed Shire. Sugar cane occupies about 7% of the Shire, mostly floodplains (1-2m above sea level). Other agricultural activity includes banana growing, horticulture and market gardens. Agricultural land is protected by council owned levies constructed in the 1960's and this is currently being study.

Infrastructure

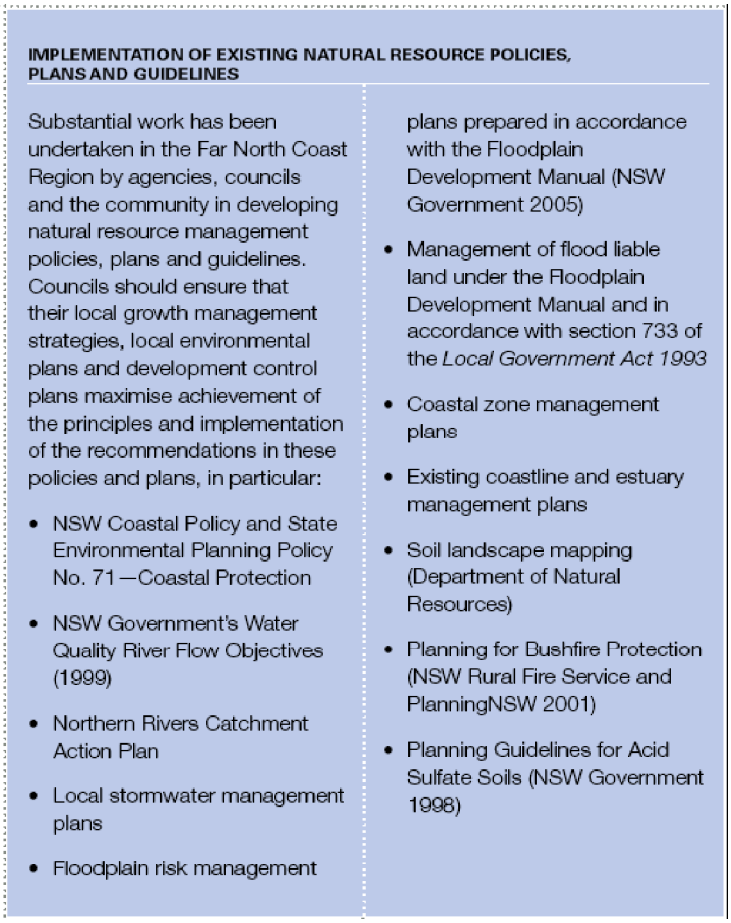
The Far North Coast Strategy envisions the region to by characterise by a series of contained centres with growing towns and villages and the protection of coastal areas from inappropriate development. Lismore and Tweed will continue to be major regional centres, with Ballina emerging as a major centre. Byron Bay is to remain known as a national and international tourist destination and will retain the village character (Far North Coast Regional Strategy, NSW Planning 2006)

The Far North Coast Strategy has mapped Town and Village Growth Boundaries within the six LGAs. The Strategy will reduce the proportion of additional dwellings in the Coastal Area to 60% by limiting future development. A further 51 000 dwellings will be required in the region to keep pace with the projected population growth. 'Green breaks' will be introduced between coastal settlements to protect coastal biodiversity and help strengthen the 'region of villages' concept. For example the strip of vegetation form Broken Head to Lennox Head.

TABLE 1: LOCAL GOVERNMENT AREA DWELLING TARGETS (FOR AN ADDITIONAL 60 400 PERSONS)

LGA	Existing dwellings (2006)	Additional new dwellings to 2031
Ballina	16720	8400
Byron	13090	2600
Kyogle	4110	3000
Lismore	17640	8000
Richmond Valley	8710	9900
Tweed	34650	19100
Totals	**94920**	**51000**

Figure 13 Local Government Area Dwelling Targets (Far North Coast Regional Strategy, NSW Planning 2006, pg.27)



IMPLEMENTATION OF EXISTING NATURAL RESOURCE POLICIES, PLANS AND GUIDELINES

Substantial work has been undertaken in the Far North Coast Region by agencies, councils and the community in developing natural resource management policies, plans and guidelines. Councils should ensure that their local growth management strategies, local environmental plans and development control plans maximise achievement of the principles and implementation of the recommendations in these policies and plans, in particular:

- NSW Coastal Policy and State Environmental Planning Policy No. 71—Coastal Protection
- NSW Government's Water Quality River Flow Objectives (1999)
- Northern Rivers Catchment Action Plan
- Local stormwater management plans
- Floodplain risk management plans prepared in accordance with the Floodplain Development Manual (NSW Government 2005)
- Management of flood liable land under the Floodplain Development Manual and in accordance with section 733 of the *Local Government Act 1993*
- Coastal zone management plans
- Existing coastline and estuary management plans
- Soil landscape mapping (Department of Natural Resources)
- Planning for Bushfire Protection (NSW Rural Fire Service and PlanningNSW 2001)
- Planning Guidelines for Acid Sulfate Soils (NSW Government 1998)

Existing State Natural Resource Policies, Plan and Guidelines (Far North Coast Regional Strategy, NSW Planning 2006, pg.24)

Energy

Transgrid, owned by NSW Government operates the high voltage transmission network whilst the supply to customers is taken care of by Country Energy. The identification of coal seam gas reserves provides the opportunity for the development of a local energy industry (Far North Coast Regional Strategy, NSW Planning 2006) In Byron substations receiving supply are located in Mullumbimby and Ewingsdale, which then provide feeders to the North and South of the Shire. In the event of a major supply disturbance, priority of supply is given to feeders that are supplying critical infrastructure such as Hospitals, Sewer and Water Treatment Plants. In tweed electricity is sourced primarily from the east coast grid. The Condong Sugar Mill has a co-generation facility that has the potential to power more than half of the Tweed. Small methane power plant at the local landfill - generates enough power for 300 homes. All of the Shire's remaining power needs come from the grid.

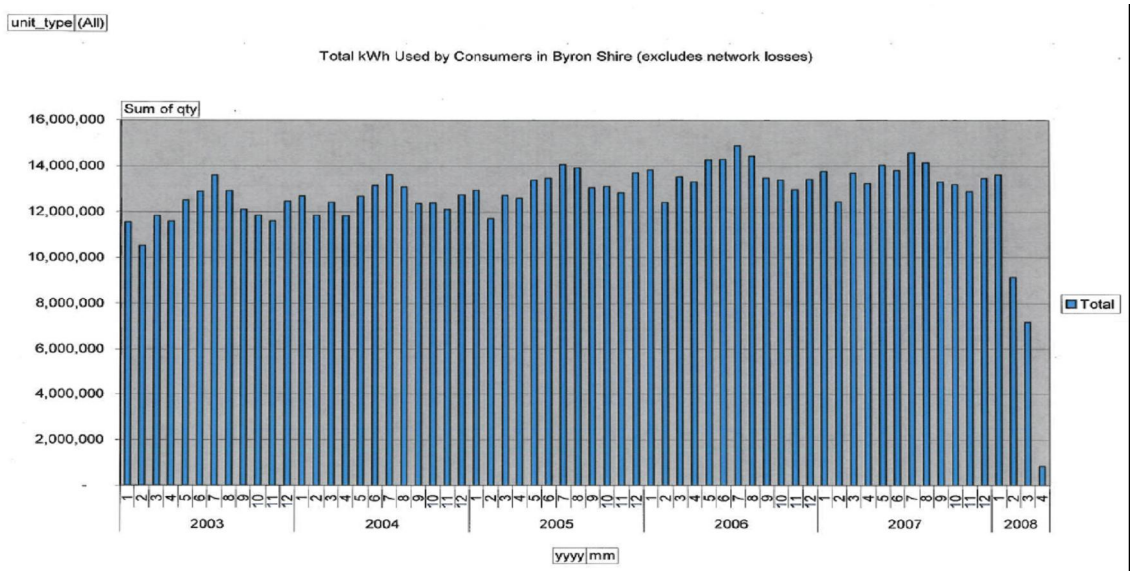


Figure 14 Energy Consumption , Source: Byron Shire Council Emergency Risk Management Study (2008)

Transport

The two main road networks in the Region include the two major north-south corridors; the Pacific Highway and Summerland Way and east-west link, the Bruxner Highway. High traffic region with estimated 380 million trips made by resident and visitors and 20 million tonnes of freight moved. The Pacific Highway is being upgraded to dual carriageway. 140 kilometres of the Pacific Highway runs through the region. The main Sydney to Brisbane rial corridor passes through the western part of the Region. There are three main airports servicing the region. Coolangatta in Queensland (Domestic and some international flights), Ballina providing domestic services and Lismore providing commuter flight services to Sydney. Byron Shire transport assets comprise of approximately 419.74 km of local sealed roads, 96.35km of local unsealed roads, 50.23km of regional roads, and over 28km of state roads. The Casino-Murwillumbah rail line runs through the Shire, but has not been operating since May 2004 (*Source: Byron Shire Council Representative*). Approx 1200km of local roads are under the responsibility of Tweed Council (i.e. does not include the Pacific Highway). The rail-line to Casino is no longer in operation, however a number of lobby groups continue to fight for its re-establishment (*Source: Tweed Shire Council Representative).*

Water

Tweed Shire Council receives water from the Clarrie Hall Dam on the Tweed River and the Rous Water supplies a majority of towns and villages in and around Lismore, Ballina, Byron and the Lowe Richmond Valley. Water is also sourced from Laverty's Gap Weir, which draws its water from the upper reaches of the Wilson's River. Established in 1926, the weir is highly valued by the community in terms of drinking water, historical significance, environment and recreation. In a bid to reduce water extraction from rivers and groundwater, councils in the region are developing Integrated Water Cycle Management Plans. With the projected population growth government is review future supply options and the Department of Natural Resources will determine environmental flow and water access rules for both surface and groundwater through the macro water-sharing process. *(Source: Byron Shire Council Emergency Risk Management Study, 2008).*

Sewerage System and Treatment Plants

Byron Shire Council Water and Recycling Management Services manage the sewerage system and have five (5) sewage treatment plants (STP). Clarrie Hall Dam provides supply to Tweed Shire, water is released from the dam and flows down the Tweed River. The Shire has three further Water Treat Plants (WTP) Bray Park Water Treatment, Uki Water Treatment Plant and Tyalgum Water Treatment plant.

Significant future growth forecast for Tweed Shire will exceed the current capacity of the existing Bray Park Water Treatment Plant (WTP) of 50 million litres per day (50 ML/day) in the next few years. The construction of a new membrane ultra filtration plant will increase capacity to 100ML / day. Completion of the new plant is expected in November 2009.

Table 26 Water Usage

Indicator:												
Annual Water Consumption by Type (ML/year)	**1991**	**%**	**1996**	**%**	**2001**	**%**	**2006**	**%**	**2007**	**%**	**2008**	**%**
Residential	5815	63	5163	60	5833	60	5703	60	6004	64	5251	59.43
Commercial	1584	17	1400	16	1827	19	1563	16	1401	15	1015	11.49
Industrial	201	2	144	2	211	2	241	3	143	1	242	2.74
Rural	162	2	150	2	171	2	166	2	47	0	154	1.74
Institutional	185	2	171	2	195	2	170	2	209	2	600	6.79
Bulk Sales	100	1	70	1	105	1	57	1	38	0	66	0.75
Public Uses	242	3	257	3	260	3	241	3	258	3	181	2.05
Estimated Leakage + Unaccounted for Water	902	10	1170	14	1081	11	1245	13	1465	15	1327	15.01
Total	9190	100	8526	100	9683	100	9386	100	9566	100	8836	100

Table 27 Average Household Water Use by Shire Locality 2004/05

Locality	**Average Annual Water Use / Household (Litres)**	**Average Daily Water Use / Household (Litres)**
Tyalgum	181,000 L	497 L
Tweed Heads & Tweed Heads West	195,000 L	535 L
Fingal, Chinderah, Kingscliff, Cudgen, Salt	203,000 L	558 L
Murwillumbah & surrounding area	203,000 L	558 L
Hastings Point & Pottsville	206,000 L	566 L
Tumbulgum	208,000 L	571 L
Bogangar	213,000 L	585 L
Burringbar	221,000 L	607 L

Locality	Average Annual Water Use / Household (Litres)	Average Daily Water Use / Household (Litres)
Tweed Heads South, Banora Point, Terranora, Bilambil Heights	242,000 L	665 L
Uki	260,000 L	714 L
Casuarina Beach	380,000 L	1,043 L
Shire Average	219,000 L	600 L

Source: Tweed Shire Council Water Unit

Telecommunications

Internet access is relatively high in Byron Shire with 66.4% having a connection of some description in the household, compared with 55.5% and 61.5% for the region and the State. Broadband take up in Byron is comparable to the State and higher than at the regional level (*Source: Byron Shire Council Representative.)* An Optus trunk main runs all the way down the coastal strip. 4 radio towers in the Tweed Heads area, 4 radio towers between Tweed Heads and Murwillumbah, 6 radio towers in Murwillumbah (*Source: Tweed Shire Council Representative).*

Planning Characteristics specific to Byron LGA

- Town planning may become more centralised.
- Seawater/groundwater/salt intrusion affecting agricultural lands/soil and existing infrastructure (e.g. subterranean structures/pipelines) potentially exacerbating future problems;
- Sea level rise (infiltration) is currently affecting the constructed weir at Murwillumbah water supplies as increasing of weir would also affect agricultural land.
- Future legislative changes could include altering water supplies operated by State government as opposed to local government.
- Existing infrastructure collapse and restricted ability to cope with emergencies induced by climate change;
- Potential isolation of rural dwellings due to cut off from main access roads;
- Pressure on council budgets on post storms cleanups.
- More rain expected in the hills (up to 2-3mm), with hinterland acting as large catchment area. (Current estimates suggest that Tweed valley receives 30% of rainfall, coastal flood plains receive 10% and the hinterland receives 60% of annual rainfall).
- Byron Bay displays similar characteristics to Tweed with regards to rainfall and location.
- 20-year projections may not be accurate regarding extreme rainfall, as variations are continually occurring making quantification difficult. This is leading to questioning on 100 year projections also.
- Average sea surface temperatures for the region range from 17^0C in winter to 25^0C in summer.
- Bureau of Meteorology presented risks and concerns regarding cyclone occurrence in these areas in 2007.
- Cyclical weather patterns tend to occur in this region.

- More focussed on summer and winter averages as opposed to annual rainfall.
- Hailstorm frequency increasing over the last 2-3 years.
- Coastline and erosion processes as an area of focus/consideration.
- Tweed utilises 100-year flood line regularly. However, uncertainty exists as to its accuracy/reliability.
- Storm (hail) frequency increases affecting crops.

Source: Byron Shire Council Representative

Health

Each Area Health Service appoints an Area HSFAC to control health operations in an emergency within their boundaries, and to coordinate support from within their Area Health Service. The Area HSFAC controls all area health emergency operations:[Paragraph 304 NSW HEALTHPLAN February 2008].

Byron LGA and T weed LGA are part of the North Coast Area Health Service (NCAHS). NCAHS came into existence on January 1, 2005 as part of the NSW Department of Health's health reform package. The reforms included a reduction in the number of Area Health Services from 17 across NSW to 8 through a series of Area Health Service mergers and boundary changes.

In 2006 Tweed Hospital was the hospital with the highest number of separations (25,805) and Murwillumbah Hospital was ranked eighth with 5,925 separations in the North Coast Area Health Service. The Tweed Hospital was also in the top rankings for overnight bed days and total bed days. The Tweed Hospital also had the highest number of emergency department attendances of any hospital in the North Coast Area Health Service (*Source: Tweed Shire Council Community Profile 2008.)*

Emergency Services

There exists an inter-regional emergency response approach with individual budgets for council cleanup for. A list of emergency services is also provided below, a majority of these services are found in both Councils. These include: the Police, Volunteer Fire Brigade, Volunteer Rescue, Fire Service, SES, North Coast Area Service, St Vincent de Paul Society, Coast Guard (Tweed), Volunteer Marine rescue (Tweed), Volunteer Coastal Patrol, National Parks and Wildlife Service, County Energy, Department of Primary Services; and Centrelink.

Natural Assets

The Far North Coast Region is the most biologically diverse region in NSW and the third most in Australia. The Region has 21 national parks of which several are World Heritage listed and over 1200 public reserves. The area is rich in natural resources such as timber, groundwater, extractives resources and productive soils important to the regional economy. Development pressure will need to be balanced with protection of productive farmland. Some areas in the Region are subject to natural hazards such as acid sulphate soils, flooding, coastal inundation and recession

The Far North Coast Region has experienced many sever floods and as such the Strategy requires that councils develop their local environmental plans (LEPs) consistent with the Government's Floodplain Development manual and in accordance with Coastal Zone Management Plans. Councils are also to undertake investigations of lands with the potential to be affected by sea level risk and inundation and make provision for adequate setbacks to manage the risks associated with climate change before rezoning or approving new development or redevelopment in potential hazard areas (Far North Coast Regional Strategy, NSW Planning 2006)

Byron Shire comprises of natural coastline together with wetlands, estuarine forests, farmland and hinterland rainforest and riparian ecosystems. The Shire is a major international and national tourist destination, famed for beautiful surf beaches, scenic bushwalking, vibrant creative and music industries, healing modalities and alternative lifestyle culture. The region is recognised as one of Australia's most diverse in terms of its natural terrain, flora and fauna. Byron Shire lies within an area of extremely high biodiversity, containing approximately 170 species of endangered or threatened flora and fauna. The biogeographical province is known as the McPherson-Macleay overlap zone (BSC, 2001). Approximately 12 low-lying EEC's containing flood plain species exist within the Byron Shire.

The main threats affecting biodiversity in Byron Shire include:

» Habitat loss resulting from habitat clearing, fragmentation, modification and disturbance

» The introduction and establishment of exotic species

  – loss of local genetic vigour for certain species;

  – direct exploitation; and

  – impacts associated with pollution of air, land and water (BSC, 2001).

Source: Byron Shire Council Representative.

Byron Shire is bounded in the east by the South Pacific Ocean, in the south partly by Skinners Creek and Wilson River, in the southwest partly by Coopers Creek, and in the northwest partly by the Nightcap Range. The Brunswick, Byron and Belongil Creek catchments are the most significant in the Shire.

15% of the Shire comprises National Parks include Border Ranges, Night Cap, Mount Warning, Mebbin, Mooball, Mount Jerusalem and Wollumbin. Nature Reserves in the Shire include Limpinwood, Stotts Island, Cudgen and Nullum. Mount Warning National Park, Nightcap National Park and Border Ranges National Park were added to the World Heritage List in 1996 because of their exceptional natural beauty and ecological importance. This land totals approximately 1400ha of environmental estate. (Source: Tweed Shire Community Profile 2008).

Pressures on waterways in the Shire include those from development, commercial, industrial and recreational uses, structures within waterways, removal of riparian vegetation, the impacts of agriculture and the disturbance of acid sulphate soils (BSC, 2001). The export of sediment and major nutrients, nitrogen and phosphorus, from catchments and the resulting eutrophication of streams and estuaries has been highlighted as one of the major water quality problems in the coastal zone (Pont, 1997).

The Tweed River catchment is covers an area of approximately 1100 km^2. It is comprised of numerous smaller sub-catchments. The Tweed River catchment has three major arms, the Rous, Oxley and Tweed. The Tweed River discharges into the Pacific Ocean at Point Danger. (*Source: Tweed Shire Community Profile 2008).*

Current Climatic Conditions

The future climate of the Northern Rivers Catchment is likely to be warmer. Although projected changes in average rainfall are currently not clear, with projected increases in evaporation, the catchment is likely to be drier. Such climate change would also increase heat waves, extreme winds and fire risk. Nevertheless, despite this trend toward drier conditions, there is also potential for seasonal increases in extreme rainfall events. Modelling of weather patterns along the NSW coast indicates the potential for increases in the frequency of weather events that contribute to extreme winds and, subsequently, storm surges.

Table 28 and Table 29 provide baseline data taken as a historical average to account for natural decadal variations for the Byron and Tweed LGA. Byron current climate data has been sourced from the Cape Byron Lighthouse and is a BOM average from 1961 to 1990. Tweed current climate data has been sourced

from the closest weather station across the Queensland border in Coolangatta. This weather station has been operating only from 1982 and hence the historical average available is from 1982 to 2008. Figures for humidity and wind speed are available from the early 1990s onwards. For climate projections please refer to the table in Section 4 “Summary of Climate Variables for the Northern Catchment”.

Tide Gauge Data

High and Low Tide for the Region Byron

Tidal Range at Mouth of Brunswick River (from DECC Brunswick River Tidal Data Collection);

» HHW(SS) (Higher High Water Spring Solstice) to ISLW (Indian Spring Low Water): 1.92;

» Mean Spring: 1.26;

» Mean: 0.98; and

Mean Neap: 0.71

High and Low Tide for the Region Tweed

» Mean High Water Springs: 1.621

» Mean High Water: 1.497 metres

» Mean High Water Neaps: 1.373

» Mean Sea Level: 0.992 m

» Mean Low Water Neaps: 0.610

» Mean Low Water: 0.486 m

» Mean Low Water Springs: 0.362

Note: Not AHD. AHD is based on the Mean Sea Level

Source: NSW Tide Charts, Page 5, NSW Department of Commerce

Natural Disasters

Storm and Cyclone Events

An East Coast Low (ECL) is an intense low-pressure system, which occurs, on average, several times a year off the eastern coast of Australia. The ECL is most prevalent during the winter and autumn months. A Tropical Cyclone develops over warm tropical waters and has a much longer lifecycle. The severity of a Tropical Cyclone is much higher than that of an ECL with wind speeds that can exceed 180 km/h, heavy rainfall, coastal erosion and inundation caused by storm surge.

In recent years there have been 12 Tropical Cyclones that have had significant impacts on the Byron LGA and five (5) East Coast Lows. It must be noted that the past 25 years has been a period of reduced Cyclonic activity on the East Coast of Australia and subsequently the Byron LGA.

Anecdotal and recorded evidence is that the most severe cyclonic events in memory took place in 1954, 1967 and 1974. Without exception, each of these events occurred in association with high spring tides, and with an accompanying storm surge due to atmospheric pressure and wind stress (S*ource: Byron Shire Council Emergency Risk Management Study, 2008)*

From 26 June to the 30 June 2005 an ECL caused widespread flooding as a result of extreme rainfall with both Mullumbimby and Byron Bay recording their highest ever daily rainfall totals. A 1% AEP flood occurred

in the Coastal North region inundating areas of Ocean Shores, Billinudgel, New Brighton and South Golden Beach. Flooding also occurred in Mullumbimby and Byron Bay with one local resident losing his life in floodwaters surrounding Ewingsdale Road. A total of 150 people were evacuated across the Byron LGA during this event. There were significant land slips in the rural area and also part of Lighthouse Road where the boardwalk and road collapsed.

On October 26 2007, a large storm cell with destructive hail and intense rainfall affected Byron Bay and Mullumbimby. Myocum received 4 (four) inches of rain within a half hour period. The Byron CBD suffered flash flooding with water also over Ewingsdale Road for several hours. The worst affected area was Dunoon located in the Lismore Local Government Area. The storm resulted in a Tornado which devastated the township, decimating the school, destroying the church, the sub station and many homes. Up to 20 homes and buildings were considered severely damaged. The school had three classrooms destroyed and flying debris smashed into the Country Energy substation based at Dunoon causing power outages for approximately 48 hours to some homes. The NSW Government estimated that the cost of the damage is over $1 million. The SES logged over 100 calls for assistance in this small community. (*Source: Byron Shire Council Emergency Risk Management Study, 2008))*

Severe storms have been identified as a number three priority for management under the Tweed Shire Emergency Risk Management Plan (*Source: Tweed Shire Emergency Risk Management*

Flooding

Byron

Flooding which affects the Byron LGA is of a seasonal nature with the majority of recorded floods occurring between February and September. They are generally the result of Cyclones or rain depressions caused from Ex Cyclones and intense rain depressions (East Coast Low's). The Bureau of Meteorology provides a comprehensive warning system for the build up of each of these events and they can generally be tracked long before the effects of them are experienced. Historically, the Byron LGA can expect up to 2-3 types of rain events each year. Byron Shire Council has considered a report and adopted at its meeting of 13 December 2007 a resolution with respect to Climate Change. The report prepared is BSC 100 year Climate Change Flood Planning Scenarios *(Source: Byron Shire Council Emergency Risk Management Study, 2008)*

Belongil

There are a number of low-lying areas in the Byron LGA one of these includes the Belongil Creek Catchment. The Belongil Creek catchment is isolated from all other catchment areas. There is a complex drainage system within the Belongil Creek Floodplain that was built to support agriculture and which impacts on the drainage regime within the floodplain and catchment. There are also two low-lying barrier estuarine wetlands of Cumbebin Swamp and Belongil Swamp contained within the Belongil Creek catchment. The Byron Shire Council opens the mouth of the Belongil Creek when water levels reach above one meter AHD at the Ewingsdale Bridge water level gauge. A Tallow Creek Floodplain Risk Management Study and Plan has also been developed. (*Source: Byron Shire Council Emergency Risk Management Study, 2008)*

Mullumbimby

The section of the Brunswick River Catchment, which affects Mullumbimby, is the Brunswick River and its tributaries. The Brunswick River mouth, which is located at Brunswick Heads, flows west to Mullumbimby and to Main Arm. The Brunswick River is joined near Mullumbimby by Mullumbimby Creek and many tributaries of the Brunswick River traverse Kings Creek The Mullumbimby Floodplain. Mullumbimby Creek and the Brunswick River converge in the centre of the township of Mullumbimby and this constitutes the

main area of the floodplain. As the Brunswick River is tidal, this also contributes to flooding in the township during extreme rain events. Flash flooding also occurs in the town during periods of heavy rain. Mullumbimby has experienced several major floods in its history, which have inundated a large portion of the residential area. Limited flood data is available since 1954 with significant flooding known to have occurred in 1954, 1975, 1976, 1978 and 1987. The main flood liable areas lie to the east of Mullumbimby Creek and the Brunswick River. (Mullumbimby Draft Flood Plain Management Plan)(*Source: Byron Shire Council Emergency Risk Management Study, 2008)*

Tweed

Flooding has been identified as a number one priority for management under the Tweed Shire Emergency Risk Management Plan. *(Source: Tweed Shire Emergency Risk Management V14 July 2007)*

Bushfire history

The regions relatively low fire risk and high average annual rainfall may help insulate it from some of the threat that climate change may pose from bushfires, particularly when compared with more arid regions. Nevertheless, fire and drought risk are projected to increase in the region. The risk of property loss due to bushfire is also likely to increase. Bushfire has however been identified as a number two priority for management under the Tweed Shire Emergency Risk Management Plan. *Source: (Tweed Shire Emergency Risk Management V14 July 2007).*

Table 28 Baseline Data from Cape Byron Lighthouse (1960 to 1990)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		Plot	Map
Temperature																	
Mean maximum temperature (°C)	27.3	27.4	26.4	24.4	22.2	19.5	19.2	20.0	21.6	23.0	24.6	26.3	23.5	13	1974 1990		
Mean minimum temperature (°C)	20.7	20.5	19.7	17.3	15.1	12.1	11.5	12.2	14.0	15.8	17.8	19.7	16.4	13	1974 1990		
Rainfall																	
Mean rainfall (mm)	170.3	184.0	233.5	207.8	204.3	166.7	100.3	100.9	67.0	123.3	131.3	160.1	1850.2	30	1961 1990		
Decile 5 (median) rainfall (mm)	148.4	167.3	190.2	185.0	186.6	141.5	72.4	90.8	53.8	108.4	110.8	124.1	1741.2	30	1961 1990		
Mean number of days of rain ≥ 1 mm	12.2	13.3	14.3	13.3	12.9	10.3	7.6	7.6	6.9	9.6	10.1	11.1	129.2	30	1961 1990		
Other daily elements																	
Mean daily sunshine (hours)																	
Mean number of clear days	7.3	5.4	6.6	8.8	8.6	10.8	13.8	14.6	14.7	10.4	8.9	8.8	118.7	28	1961 1990		
Mean number of cloudy days	12.2	11.7	12.3	10.8	12.1	10.1	8.0	7.2	6.5	9.7	9.7	11.1	121.4	28	1961 1990		
9 am conditions																	
Mean 9am temperature (°C)	23.7	23.4	22.8	20.5	17.7	15.2	14.2	15.4	17.9	19.9	21.3	22.7	19.6	28	1961 1990		
Mean 9am relative humidity (%)	80	82	80	79	75	72	70	69	69	74	77	80	76	25	1961 1990		
Mean 9am wind speed (km/h)	17.9	17.3	16.3	15.5	17.0	19.1	17.9	15.7	15.3	16.7	17.6	17.0	16.9	26	1961 1990		
9am wind speed vs direction plot	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				
3 pm conditions																	
Mean 3pm temperature (°C)	25.6	25.5	24.5	22.6	20.2	18.0	17.4	18.3	19.8	21.0	22.9	24.4	21.7	28	1961 1990		
Mean 3pm relative humidity (%)	73	75	75	73	70	67	65	64	66	72	72	75	71	25	1961 1990		
Mean 3pm wind speed (km/h)	25.2	24.2	24.1	21.3	19.9	19.8	20.2	21.0	24.1	24.9	26.9	26.3	23.2	26	1961 1990		
3pm wind speed vs direction plot	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A				

red = highest value **blue = lowest value**

*Please note that Records preceding 1982 do not exist for the Coolangatta weather station and as such current climate data is based on figures above as a best estimate.

Table 29 Baseline Data from Coolangatta (1982 to 2008)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		Plot	Map
Temperature																	
Mean maximum temperature (°C)	28.0	28.0	27.0	25.2	23.1	21.0	20.5	21.1	23.0	24.2	25.5	26.9	24.5	21	1982 2008		
Mean minimum temperature (°C)	20.9	20.8	19.6	16.9	14.1	11.4	10.2	10.5	13.4	16.0	17.9	19.7	16.0	21	1982 2008		
Rainfall																	
Mean rainfall (mm)	144.0	166.2	176.3	163.3	146.6	130.5	75.2	55.2	42.4	87.9	139.6	140.7	1468.8	24	1982 2008		
Decile 5 (median) rainfall (mm)	115.2	124.0	144.1	114.8	114.1	92.6	66.4	44.4	20.8	68.6	126.4	133.0	1392.8	24	1982 2008		
Mean number of days of rain ≥ 1 mm	10.7	11.5	12.0	11.2	10.3	8.0	6.1	5.5	4.6	7.2	9.2	9.7	106.0	24	1982 2009		
Other daily elements																	
Mean daily sunshine (hours)																	
Mean number of clear days														2	2005 2008		
Mean number of cloudy days														2	2005 2008		
9 am conditions																	
Mean 9am temperature (°C)	25.6	25.4	24.2	22.0	19.5	17.1	16.4	17.7	20.1	21.9	23.2	24.6	21.5	17	1991 2008		
Mean 9am relative humidity (%)	71	72	72	71	71	71	67	62	62	65	68	69	68	16	1993 2008		
Mean 9am wind speed (km/h)	18.0	17.2	17.4	16.1	15.0	13.6	13.4	15.4	18.0	18.9	19.4	18.4	16.7	17	1991 2008		
9am wind speed vs direction plot																	
3 pm conditions																	
Mean 3pm temperature (°C)	26.5	26.4	25.4	23.6	21.7	19.8	19.4	19.9	21.3	22.4	23.7	25.2	22.9	17	1991 2008		
Mean 3pm relative humidity (%)	69	69	67	65	62	60	56	57	62	67	68	68	64	16	1993 2008		
Mean 3pm wind speed (km/h)	22.9	21.7	22.2	19.9	18.2	16.9	18.3	20.4	22.4	22.9	22.6	22.5	20.9	17	1991 2008		
3pm wind speed vs direction plot																	

red = highest value blue = lowest value

*Please note that Records preceding 1982 do not exist for the Coolangatta weather station and as such current climate data is based on figures above as a best estimate.

Appendix G

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