Climate Change Information for Decision Making

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THE PURPOSE OF THIS DOCUMENT

This document summarises key climate indices useful to operational council staff. The climate indices were selected in direct consultation with council personnel and reflect the operational, tactical and strategic climate information needs for decision makers within all of the local councils of southern Tasmania.

This document expands upon previously produced *local profiles* and has been developed to support decision making across Kingborough's strategic, operational, service, adaptation and emergency management planning functions.

BACKGROUND

The Climate Change Information for Decision Making - Kingborough has been developed using outputs from the *Climate Futures for Tasmania Project* and the *Climate Futures Australasian Projections 2019 data archive*, developed by the University of Tasmania's Climate Futures Programme.

All values are based on the projections generated by the Climate Futures Programme, using previously published results. Descriptive documentation and supporting reports can be found here: http://climatefutures.org.au. This document is to be reviewed and updated when more up-to-date information becomes available, or at 5-yearly intervals. It should be considered in conjunction with Kingborough's policies and strategies, alongside technical and industry standards.

Values given are the multi-model mean from an ensemble of six downscaled global climate models based on the *business as usual* high emissions scenario RCP8.5 (the scenario human society is currenty most closely following). Averaging across the ensemble smooths out the inter-annual variability, revealing the forced climate response. For most variables, the range between climate models is not large relative to the percent change projected into the future.

In order to capture the regional variability, the data were separated into *cool* ($< 25^{th}$ percentile), *average* (between the 25^{th} and 75^{th} percentile) or *warm* ($> 75^{th}$ percentile) grid cells, based on average temperature during the baseline period, 1961–1990. These three groups of values were then analysed and presented separately. This provides councils with greater utility when mangaing a diverse landscape (NB: municiaplities with small spatial extents have limited differences captured across the municipality at $10km^2$ resolution). It is the responsibility of the user to determine which values may be most appropriate for a given application. For example, if building a road over Vinces Saddle, it would be more useful to apply values from the cooler table, whereas for estimating future high-intensity rainfall within Kingston CBD, values from the warmer table would be more appropriate.

CURRENT CLIMATE AND RECENT TRENDS

All Tasmanian municipalities have a temperate, maritime climate with relatively mild winters at low elevations, transitioning towards warm alpine winters at higher elevations. Long-term average temperatures have risen in the decades since the 1950s at a rate of up to 0.1 °C per decade, with this rate expected to increase from 2020 onwards.

Despite covering small geographic areas all municipalities experience marked rainfall gradients, with average annual rainfall from about 600 mm per year at lower elevations and about 1500 mm per year at higher elevations. There has been a decline in average annual rainfall since the mid 1970s, and this decline has been strongest in autumn and enhanced over higher elevation regions.

EXTREME EVENTS

The changes in climate that are most likely to impact upon the each municipality's infrastructure, roads, the local community and the environment are an increase in intensity of extreme events. Potential impacts by 2100 are as follows (following the *business as usual* high emissions scenario RCP8.5):

- Increased evaporation and longer dry periods coupled with more extreme temperatures are likely to enhance the occurrence and intensity of bushfires.
- The frequency of extremely hot days (> 40°C) is projected to increase. Heat wave frequency is projected to remain stable, but will increase in intensity (warmer days and nights).
- The Annual Exceedance Probability (AEP) is a measure of the rarity of an event. Rainfall AEPs are expressed as the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. Heavier rainfall events are expected within a warmer climate. High daily runoff events are likely to increase, including those that may lead to erosion or flooding.
- Inundation along all coastal frontage will increase due to sea level rise. This means the coastal indunation AEP values for all probability events will increase in intensity. The current 100-year coastal inundation event may become a 50-year event by 2030, and a 5-year event by 2090.

Table 1: **Kingborough local government area:** ***Cool subregions***
Projected changes in selected climate variables for each 20-year time period from 2001 to 2100 relative to the baseline period 1961–1990. All values are reported following the RCP8.5 emissions scenario. Changes reported relative to the 1961-1990 baseline period.

Climate Variable	1961–1990	2001–2020			2021–2040			2041–2060			2061–2080			2081–2100		
	value	value	change	% change	value	change	% change	value	change	% change	value	change	% change	value	change	% change
Average annual daily mean (°C)	10.4	11	0.6	5.9	11.6	1.2	11.5	12.5	2.1	20	13.4	3	28.8	14.3	3.8	36.8
Average daily maximum temperature (°C)	14.3	14.9	0.7	4.6	15.6	1.3	9.1	16.5	2.3	15.8	17.5	3.3	22.8	18.4	4.2	29.1
Average daily minimum temperature (°C)	6.6	7.1	0.6	8.7	7.7	1.1	16.7	8.5	1.9	29	9.3	2.8	41.9	10.1	3.5	53.5
Hottest daily temperature of the year (°C)	33.3	34	0.8	2.4	35	1.7	5.2	35.7	2.4	7.3	36.8	3.5	10.5	37.3	4	12
Temperature of warmest days [99^{th} percentile] (°C)	27.7	28.6	1	3.5	29.2	1.5	5.4	30.4	2.8	10.1	31.8	4.1	14.9	32.5	4.9	17.6
Temperature of warmest nights [99^{th} percentile] (°C)	14.6	15.4	0.7	5	15.9	1.3	9	17	2.3	16	18	3.4	23	18.8	4.2	28.6
Temperature of coldest nights [1^{st} percentile] (°C)	-1.5	-1.1	0.4	28.1	-0.7	0.8	53.8	-0.1	1.4	91.1	0.5	2	133.8	1.2	2.7	178.5
Average annual frost risk days (<2°C)	38	30	-8	-20.5	24	-14	-35.9	17	-20	-54.2	12	-26	-69.1	8	-30	-79.8
Average annual freeze risk days (<0°C)	12	9	-3	-26.9	7	-5	-44.8	4	-8	-64.6	2	-10	-79.7	1	-11	-88.6
Average annual summer days (>25°C)	7	8	1	21.4	10	3	43.1	12	5	78.4	16	10	137.1	21	14	196.3
Average annual hot days (>30°C)	2	2	1	40.2	3	1	75.8	4	3	168	7	5	303.2	9	8	452.1
Average annual extreme heat days (>40°C)	<1	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA
Mean Minimum Asphalt Critical Viscosity	104900	131400	26500	25.3	162500	57600	54.9	221200	116300	110.9	309500	204600	195	415400	310500	296
Average annual evaporation (mm)	850	893	43	5.1	924	75	8.8	1030	180	21.2	1119	269	31.7	1252	403	47.4
Average annual rainfall (mm)	1044	1023	-20	-2	1002	-42	-4	1007	-37	-3.5	975	-68	-6.5	1049	6	0.6
Seasonal rainfall - Winter (mm)	319	310	-9	-2.8	300	-19	-5.9	318	-1	-0.3	318	-1	-0.2	346	27	8.5
Seasonal rainfall - Spring (mm)	252	249	-3	-1.1	234	-18	-7.2	229	-23	-9.2	232	-20	-8	217	-35	-13.7
Seasonal rainfall - Summer (mm)	226	217	-9	-3.9	231	5	2.3	221	-5	-2.3	202	-23	-10.4	224	-2	-0.8
Seasonal rainfall - Autumn (mm)	264	271	7	2.7	261	-3	-1.2	263	-1	-0.3	246	-18	-6.7	277	13	5
Annual maximum daily rainfall (mm)	85	84	-1	-1	97	13	14.9	93	9	10.3	89	4	5	106	21	25.3
Rainfall Extreme - 24hr 10% AEP (mm)[a]	173	179	5	3.2	184	11	6.2	192	19	10.7	200	27	15.5	207	34	19.8
Rainfall Extreme - 24hr 5% AEP (mm)[a]	199	205	6	3.2	211	12	6.2	220	21	10.7	230	31	15.5	238	39	19.8
Rainfall Extreme - 24hr 1% AEP (mm)[a]	260	268	8	3.2	276	16	6.2	288	28	10.7	300	40	15.5	312	51	19.8
Rainfall Extreme - 24hr 0.5% AEP (mm)[a]	289	298	9	3.2	307	18	6.2	320	31	10.7	334	45	15.5	347	57	19.8
Rainfall Extreme - 48hr 10% AEP (mm)[a]	221	228	7	3.2	234	14	6.2	244	24	10.7	255	34	15.5	264	44	19.8
Rainfall Extreme - 48hr 5% AEP (mm)[a]	250	258	8	3.2	266	15	6.2	277	27	10.7	289	39	15.5	300	50	19.8
Rainfall Extreme - 48hr 1% AEP (mm)[a]	325	335	10	3.2	345	20	6.2	360	35	10.7	375	50	15.5	389	64	19.8
Rainfall Extreme - 48hr 0.5% AEP (mm)[a]	360	372	11	3.2	383	22	6.2	399	39	10.7	416	56	15.5	432	71	19.8
Average annual cummulative Forest Fire Danger Index	847	866	18	2.1	921	74	8.7	973	125	14.8	1063	215	25.4	1138	291	34.3
Sea level - 1% AEP with Freeboard (m)[b]	1.66	1.74	0.08	4.8	1.82	0.16	9.6	1.9	0.24	14.5	2.14	0.48	28.9	2.5	0.84	50.6

[a] *Based on recommendations from Australian Rainfall and Runoff, Book 1 Scope And Philosophy, Chapter 6 Climate Change Considerations, version last updated 14^{th} May 2019.*

[b] *Based on recommendations from Tasmanian Government Department of Premier and Cabinet, Coast Hazards Report, December 2015.*
For exact details reference (from theList): Sea Level Rise Planning Allowances; or Coastal Risk Hazard Bands.

Table 2: **Kingborough local government area:** ***Average subregions***
Projected changes in selected climate variables for each 20-year time period from 2001 to 2100 relative to the baseline period 1961–1990. All values are reported following the RCP8.5 emissions scenario. Changes reported relative to the 1961-1990 baseline period.

Climate Variable	1961–1990	2001–2020			2021–2040			2041–2060			2061–2080			2081–2100		
	value	value	change	% change	value	change	% change	value	change	% change	value	change	% change	value	change	% change
Average annual daily mean (°C)	11.3	11.9	0.6	5.1	12.5	1.1	10	13.3	2	17.3	14.1	2.8	25	14.9	3.6	31.7
Average daily maximum temperature (°C)	15.4	16	0.6	3.9	16.6	1.2	7.9	17.5	2.1	13.5	18.4	3	19.6	19.3	3.8	24.9
Average daily minimum temperature (°C)	7.2	7.8	0.5	7.6	8.3	1.1	14.7	9.1	1.8	25.3	9.9	2.6	36.4	10.6	3.3	46.3
Hottest daily temperature of the year (°C)	34.8	35.6	0.8	2.4	36.6	1.7	5	37.3	2.5	7.2	38.4	3.6	10.3	38.9	4.1	11.8
Temperature of warmest days [99^{th} percentile] (°C)	28.8	29.7	0.9	3.2	30.2	1.4	4.9	31.5	2.7	9.4	32.8	4	13.9	33.4	4.6	15.9
Temperature of warmest nights [99^{th} percentile] (°C)	15.1	15.8	0.6	4.1	16.3	1.2	7.6	17.2	2	13.5	18.1	2.9	19.2	18.7	3.5	23.3
Temperature of coldest nights [1^{st} percentile] (°C)	-0.5	0	0.4	90.6	0.4	0.8	178.8	0.9	1.4	309.4	1.6	2.1	460.3	2.3	2.8	613.2
Average annual frost risk days (<2°C)	24	18	-6	-25.6	14	-10	-42.5	9	-15	-62.9	5	-19	-77.7	3	-21	-87
Average annual freeze risk days (<0°C)	6	4	-2	-31.8	3	-3	-52.7	2	-4	-72.7	1	-5	-87	0	-5	-93.2
Average annual summer days (>25°C)	9	11	2	17.9	13	3	37.2	15	6	65.6	19	10	111.3	23	14	156.9
Average annual hot days (>30°C)	2	3	1	32.6	4	2	63.9	6	3	136.2	8	6	228.9	11	8	324.3
Average annual extreme heat days (>40°C)	<1	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA
Mean Minimum Asphalt Critical Viscosity	134700	167100	32400	24.1	205100	70400	52.3	274800	140100	104	378100	243400	180.7	498800	364100	270.3
Average annual evaporation (mm)	911	947	36	3.9	978	67	7.4	1073	162	17.7	1155	244	26.7	1279	367	40.3
Average annual rainfall (mm)	868	848	-21	-2.4	830	-38	-4.4	831	-37	-4.3	803	-65	-7.5	859	-9	-1
Seasonal rainfall - Winter (mm)	264	255	-9	-3.5	247	-18	-6.7	260	-4	-1.4	259	-5	-1.8	280	16	6
Seasonal rainfall - Spring (mm)	210	207	-3	-1.7	195	-16	-7.4	189	-22	-10.3	191	-20	-9.4	179	-32	-15.1
Seasonal rainfall - Summer (mm)	188	181	-7	-4	192	4	2.3	185	-3	-1.8	168	-20	-10.4	185	-3	-1.4
Seasonal rainfall - Autumn (mm)	220	225	5	2.4	216	-4	-1.8	217	-3	-1.4	203	-16	-7.4	228	8	3.6
Annual maximum daily rainfall (mm)	85	84	-1	-1	97	13	14.9	93	9	10.3	89	4	5	106	21	25.3
Rainfall Extreme - 24hr 10% AEP (mm)[a]	174	179	5	3	184	10	5.8	191	17	10.1	199	25	14.5	206	32	18.5
Rainfall Extreme - 24hr 5% AEP (mm)[a]	199	205	6	3	211	12	5.8	220	20	10.1	228	29	14.5	236	37	18.5
Rainfall Extreme - 24hr 1% AEP (mm)[a]	261	268	8	3	276	15	5.8	287	26	10.1	299	38	14.5	309	48	18.5
Rainfall Extreme - 24hr 0.5% AEP (mm)[a]	290	298	9	3	307	17	5.8	319	29	10.1	332	42	14.5	343	54	18.5
Rainfall Extreme - 48hr 10% AEP (mm)[a]	221	228	7	3	234	13	5.8	243	22	10.1	253	32	14.5	262	41	18.5
Rainfall Extreme - 48hr 5% AEP (mm)[a]	251	258	7	3	265	15	5.8	276	25	10.1	287	36	14.5	297	46	18.5
Rainfall Extreme - 48hr 1% AEP (mm)[a]	326	335	10	3	345	19	5.8	358	33	10.1	373	47	14.5	386	60	18.5
Rainfall Extreme - 48hr 0.5% AEP (mm)[a]	361	372	11	3	382	21	5.8	397	36	10.1	413	52	14.5	428	67	18.5
Average annual cummulative Forest Fire Danger Index	1312	1339	27	2	1434	122	9.3	1514	202	15.4	1649	337	25.7	1735	423	32.3
Sea level - 1% AEP with Freeboard (m)[b]	1.66	1.74	0.08	4.8	1.82	0.16	9.6	1.9	0.24	14.5	2.14	0.48	28.9	2.5	0.84	50.6

[a] *Based on recommendations from Australian Rainfall and Runoff, Book 1 Scope And Philosophy, Chapter 6 Climate Change Considerations, version last updated 14^{th} May 2019.*

[b] *Based on recommendations from Tasmanian Government Department of Premier and Cabinet, Coast Hazards Report, December 2015.*
For exact details reference (from theList): Sea Level Rise Planning Allowances; or Coastal Risk Hazard Bands.

Table 3: **Kingborough local government area:** ***Warm subregions***
Projected changes in selected climate variables for each 20-year time period from 2001 to 2100 relative to the baseline period 1961–1990. All values are reported following the RCP8.5 emissions scenario. Changes reported relative to the 1961-1990 baseline period.

Climate Variable	1961–1990	2001–2020			2021–2040			2041–2060			2061–2080			2081–2100		
	value	value	change	% change	value	change	% change	value	change	% change	value	change	% change	value	change	% change
Average annual daily mean (°C)	12	12.6	0.7	5.8	13.3	1.3	11.2	14.3	2.4	19.7	15.4	3.4	28.4	16.3	4.3	36.4
Average daily maximum temperature (°C)	16.2	17	0.7	4.6	17.7	1.4	8.9	18.8	2.6	15.7	19.9	3.7	22.8	21	4.8	29.3
Average daily minimum temperature (°C)	7.7	8.3	0.6	8.4	8.9	1.2	16	9.8	2.1	28	10.8	3.1	40.2	11.6	3.9	51.3
Hottest daily temperature of the year (°C)	35.4	36.2	0.8	2.3	37.3	1.9	5.4	38	2.6	7.3	39.2	3.8	10.7	39.7	4.3	12.2
Temperature of warmest days [99^{th} percentile] (°C)	29.7	30.8	1.1	3.7	31.4	1.7	5.9	32.8	3.1	10.5	34.4	4.7	15.8	35.2	5.5	18.7
Temperature of warmest nights [99^{th} percentile] (°C)	15.6	16.4	0.8	4.9	17	1.3	8.6	18	2.4	15.2	19	3.3	21.3	19.7	4.1	26.2
Temperature of coldest nights [1^{st} percentile] (°C)	0.4	0.9	0.5	118.3	1.4	1	224.3	2	1.6	371.4	2.9	2.5	568.8	3.7	3.3	756.4
Average annual frost risk days (<2°C)	17	11	-6	-34.8	8	-9	-55.4	4	-13	-76.1	2	-15	-89.6	1	-16	-95.8
Average annual freeze risk days (<0°C)	2	1	-1	-42.6	1	-2	-67.4	0	-2	-85.1	0	-2	-95.2	0	-2	-98.7
Average annual summer days (>25°C)	11	13	2	19.1	15	4	39.8	19	9	80.5	27	16	148.3	35	24	226.3
Average annual hot days (>30°C)	3	5	1	37.5	6	2	69.8	9	5	150	12	9	258.6	17	14	402.8
Average annual extreme heat days (>40°C)	<1	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA	<1	<1	NA
Mean Minimum Asphalt Critical Viscosity	161100	207600	46500	28.9	263800	102700	63.7	374000	212900	132.2	543300	382200	237.2	755500	594400	369
Average annual evaporation (mm)	969	1025	56	5.7	1053	83	8.6	1192	223	23	1303	333	34.4	1469	500	51.6
Average annual rainfall (mm)	658	640	-18	-2.7	628	-30	-4.6	624	-34	-5.2	597	-61	-9.3	634	-24	-3.7
Seasonal rainfall - Winter (mm)	191	180	-11	-5.7	174	-17	-8.9	184	-7	-3.6	181	-9	-5	196	5	2.6
Seasonal rainfall - Spring (mm)	160	158	-3	-1.6	150	-10	-6.4	144	-17	-10.5	143	-18	-10.9	130	-30	-18.8
Seasonal rainfall - Summer (mm)	151	145	-6	-3.8	157	6	4.1	148	-2	-1.6	135	-15	-10	150	-1	-0.7
Seasonal rainfall - Autumn (mm)	167	173	6	3.4	162	-5	-3	163	-4	-2.6	152	-16	-9.4	167	0	0
Annual maximum daily rainfall (mm)	85	84	-1	-1	97	13	14.9	93	9	10.3	89	4	5	106	21	25.3
Rainfall Extreme - 24hr 10% AEP (mm)[a]	172	179	6	3.6	184	12	6.9	194	21	12.2	203	30	17.6	211	39	22.5
Rainfall Extreme - 24hr 5% AEP (mm)[a]	198	205	7	3.6	212	14	6.9	222	24	12.2	233	35	17.6	243	45	22.5
Rainfall Extreme - 24hr 1% AEP (mm)[a]	259	268	9	3.6	277	18	6.9	291	32	12.2	305	46	17.6	317	58	22.5
Rainfall Extreme - 24hr 0.5% AEP (mm)[a]	288	298	10	3.6	308	20	6.9	323	35	12.2	339	51	17.6	353	65	22.5
Rainfall Extreme - 48hr 10% AEP (mm)[a]	220	228	8	3.6	235	15	6.9	246	27	12.2	258	39	17.6	269	49	22.5
Rainfall Extreme - 48hr 5% AEP (mm)[a]	249	258	9	3.6	266	17	6.9	280	30	12.2	293	44	17.6	305	56	22.5
Rainfall Extreme - 48hr 1% AEP (mm)[a]	324	335	12	3.6	346	22	6.9	363	39	12.2	381	57	17.6	397	73	22.5
Rainfall Extreme - 48hr 0.5% AEP (mm)[a]	359	372	13	3.6	384	25	6.9	403	44	12.2	422	63	17.6	440	81	22.5
Average annual cummulative Forest Fire Danger Index	1674	1711	37	2.2	1838	164	9.8	1954	280	16.7	2144	470	28.1	2295	621	37.1
Sea level - 1% AEP with Freeboard (m)[b]	1.66	1.74	0.08	4.8	1.82	0.16	9.6	1.9	0.24	14.5	2.14	0.48	28.9	2.5	0.84	50.6

[a] *Based on recommendations from Australian Rainfall and Runoff, Book 1 Scope And Philosophy, Chapter 6 Climate Change Considerations, version last updated 14^{th} May 2019.*

[b] *Based on recommendations from Tasmanian Government Department of Premier and Cabinet, Coast Hazards Report, December 2015.*
For exact details reference (from theList): Sea Level Rise Planning Allowances; or Coastal Risk Hazard Bands.

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