

## Supporting Information for

# **Hypoxic Blackwater Events – Identifying High Risk Catchments in Estuaries Now and Under Future Climate Scenarios**

K. Waddington<sup>1</sup>, A. Harrison<sup>1</sup>, D. Rayner<sup>1</sup>, T. Tucker<sup>1</sup> and W. Glamore<sup>1</sup>

<sup>1</sup>Water Research Laboratory, School of Civil and Environmental Engineering, UNSW Sydney, NSW 2093 Australia.

## **Contents of this file**

Tables S1 to S30  
Figures S1 to S114

## **Introduction**

This supporting information includes:

- Representative vegetation types and associated risk factors assigned to the various land uses within the study area (Table S1).
- Water level data for each estuary (Figures S1 to S93 and Tables S2 to S15); including maps identifying the locations of water level gauges and floodplain catchments, details of each gauge record and flow distribution curves. Water levels representing the range of inundation durations (1 to 5 days) and recurrence intervals (1 to 5 years) assessed are presented for each water level gauge and the distribution of these levels to each catchment is tabulated. Note that where water gauges are not located within a suitable distance of the catchment drainage connection to the estuary, inundation elevations have been interpolated as tabulated herein. Water level data used and presented for the analysis was obtained from the WaterNSW Water Information Hub [Real-time water data \(waternsw.com.au\)](https://www.waternsw.com.au).
- The results of the analysis, including median inundation level, blackwater contribution factor and ranking of each catchment within each estuary (Tables S16 to S22). The catchment ranking and extents of inundation under median blackwater levels are also mapped in Figures S94 to S107).
- A summary of the results of an analysis of the sensitivity of inundation level and ranking of aggregated blackwater risk factor to changes in inundation duration and flood frequency matrices (Table S23). The rank correlation refers to the correlation between ranking of catchments according to average aggregated blackwater risk factor was determined by comparing the base case with the modified case.
- Average annual temperature ranges within each catchment of the study area (Tables S24 to S30), obtained from the Climate Data Online service of the Australian Bureau of Meteorology [Climate Data Online - Map search \(bom.gov.au\)](https://www.bom.gov.au). The monthly average maximum temperatures presented in these tables refer to the average of all daily maxima for the month, as recorded in the 24 hours prior to 9am local time. The locations of each climate monitoring station are included in Figures S108 to S114, which show the

geographical distribution of average maximum daily temperatures across the various catchments for the warmest months of October to April. Typically, the average maximum daily temperatures do not vary by more than 5°C throughout each of the catchment areas, suggesting that, while higher temperatures are a contributing factor to blackwater events, differences in temperature are unlikely to affect the distribution of blackwater risk within each river system.

Both the water level and temperature data support the use of the methodology within coastal NSW with respect to the limitations discussed in Section 3.2 of the manuscript. This data indicates that there is insufficient variation in altitude or temperature to provide added differentiation in blackwater risk between the catchments studied. Throughout the selected study sites, the High High Water Solstice Spring (HHWSS) tide does not exceed 2.5m AHD (Australian Height Datum) (Couriel et al., 2012). Further, estuarine flood levels (and hence inundation levels across the floodplains) are typically limited to <5m AHD.

With regard to temperature, more frequent and severe blackwater events have been recorded during summer months (Wong et al., 2018). Nevertheless, Vithana et al. (2019) found that grasses inundated for one week produced a similar biochemical oxygen demand at temperatures of 20C, 27.5C and 35C. As demonstrated in this Supplementary Material, these temperatures are representative of the annual range experienced throughout coastal New South Wales (Australia), indicating that, under suitable inundation conditions, blackwater may be generated throughout the year within any of the catchments in the selected study area. Flooding may also occur at any time of the year throughout these catchments, justifying the inclusion of the full annual record of water levels in the analysis. It is noted that in alternative locations, the methodology may need to be modified to incorporate seasonal flooding and regional temperature variations.

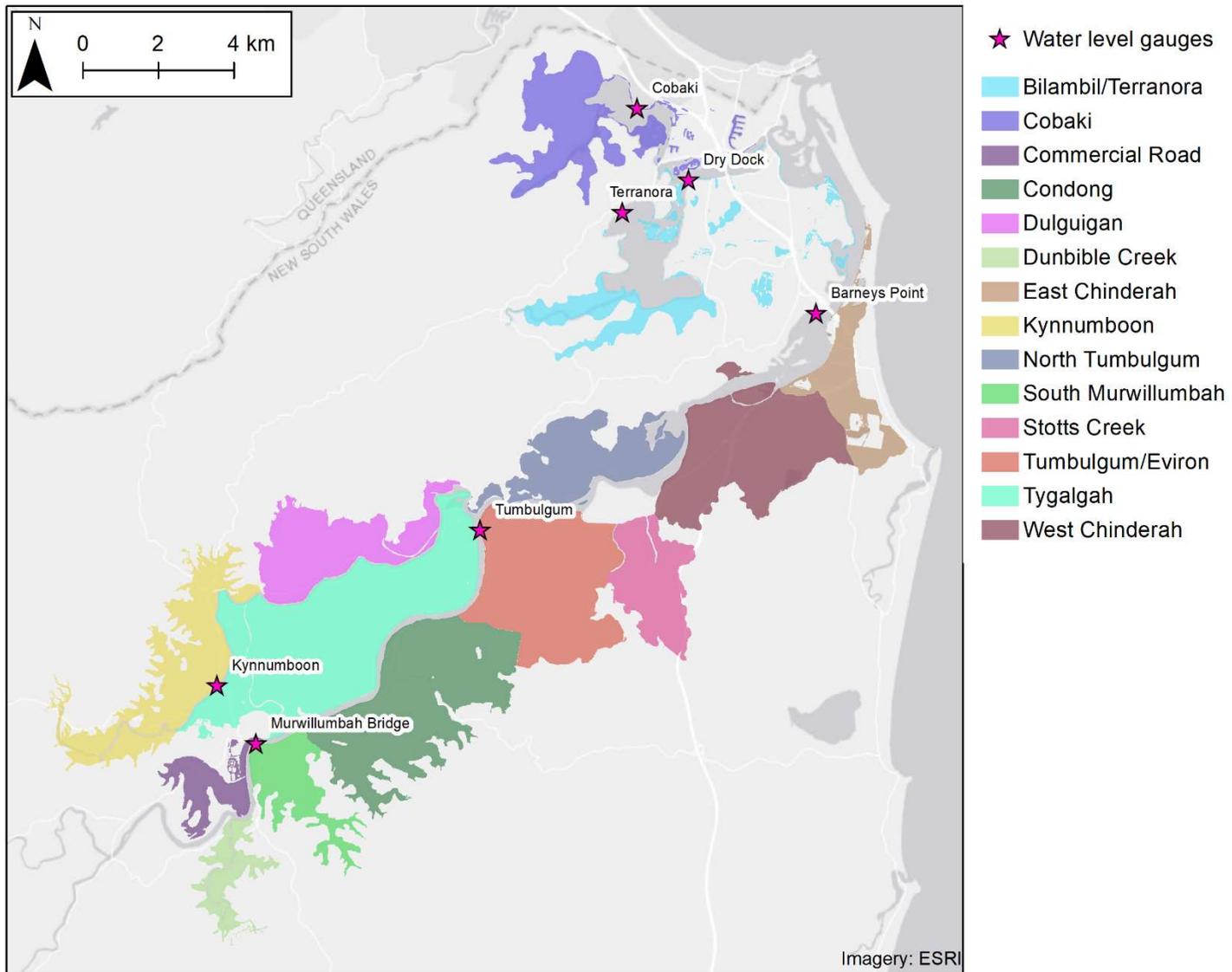
**Table S1.** Blackwater risk factors for land uses associated with various vegetation types

<b>Secondary Land Use Type<sup>1</sup></b>	<b>Assigned Vegetation</b>	<b>Risk Factor</b>
1.1.0 Nature conservation	Forestry	3
1.2.0 Managed Resource Protection	Forestry	3
1.3.0 Other minimal use	Forestry	3
2.1.0 Grazing native vegetation	Dryland Grasses	3
2.2.0 Production forestry	Forestry	3
3.1.0 Plantation forestry	Forestry	3
3.2.0 Grazing modified pastures	Grass	3
3.3.0 Cropping	Sugar Cane	2
3.4.0 Perennial horticulture	Forestry	3
3.5.0 Seasonal horticulture	Forestry	3
3.6.0 Land in transition	Forestry	3
4.1.0 Irrigated plantation forestry	Forestry	3
4.2.0 Grazing irrigated modified pastures	Dryland Grasses	3
4.3.0 Irrigated cropping	Sugar Cane	2
4.4.0 Irrigated perennial horticulture	Forestry	3
4.5.0 Irrigated seasonal horticulture	Forestry	3
4.6.0 Irrigated land in transition	Forestry	3
5.1.0 Intensive horticulture	Forestry	3
5.2.0 Intensive animal husbandry	Industry/Urban <sup>2</sup>	1
5.3.0 Manufacturing and industrial	Industry/Urban <sup>2</sup>	1
5.4.0 Residential and farm infrastructure	Industry/Urban <sup>2</sup>	1
5.5.0 Services	Industry/Urban <sup>2</sup>	1
5.6.0 Utilities	Industry/Urban <sup>2</sup>	1
5.7.0 Transport and communication	Industry/Urban <sup>2</sup>	1
5.8.0 Mining	Industry/Urban <sup>2</sup>	1
5.9.0 Waste treatment and disposal	Industry/Urban <sup>2</sup>	1
6.1.0 Lake	Water <sup>3</sup>	0
6.2.0 Reservoir/dam	Water <sup>3</sup>	0
6.3.0 River	Water <sup>3</sup>	0
6.4.0 Channel/aqueduct	Water <sup>3</sup>	0
6.5.0 Marsh/wetland	Freshwater Wetland	1
6.6.0 Estuary/coastal waters	Water <sup>3</sup>	0

<sup>1</sup> 2017 Australian Land Use and Management (ALUM) classification for NSW (DPIE, 2020)

<sup>2</sup> The runoff from urban and industrial areas is often associated with high BOD (USEPA, 2001), however the impact on water quality is more likely to be associated with the first flush of runoff due to the high proportion of impervious surfaces and with eutrophication due to high nutrient levels in the water column. Further, low levels of vegetation coverage are unlikely to produce as substantial an increase in deoxygenation potential as agricultural or nature conservation areas. Any land uses identified as industry/urban were therefore assigned a blackwater risk factor of one, noting that these areas account for a relatively small portion of the floodplain subcatchments, making the results reasonably insensitive to this assumption. This contrasts strongly to intensely developed catchments, such as those along the south-eastern coast of the USA, where point source loading of human sewage and animal waste have been identified as the principal anthropogenic sources of BOD (Mallin et al., 2002).

<sup>3</sup> Permanent waterbodies were assigned a zero risk factor, as were floodplain areas mapped as mangroves or saltmarsh (identified by macrophyte mapping supplied by NSW Department of Primary Industries – Fisheries). It was considered that these areas would not significantly contribute to blackwater generation as they are frequently inundated by tidal waters.



**Figure S1.** Water level gauge locations and catchment areas, Tweed River

**Table S2.** Details of water level gauges, Tweed River

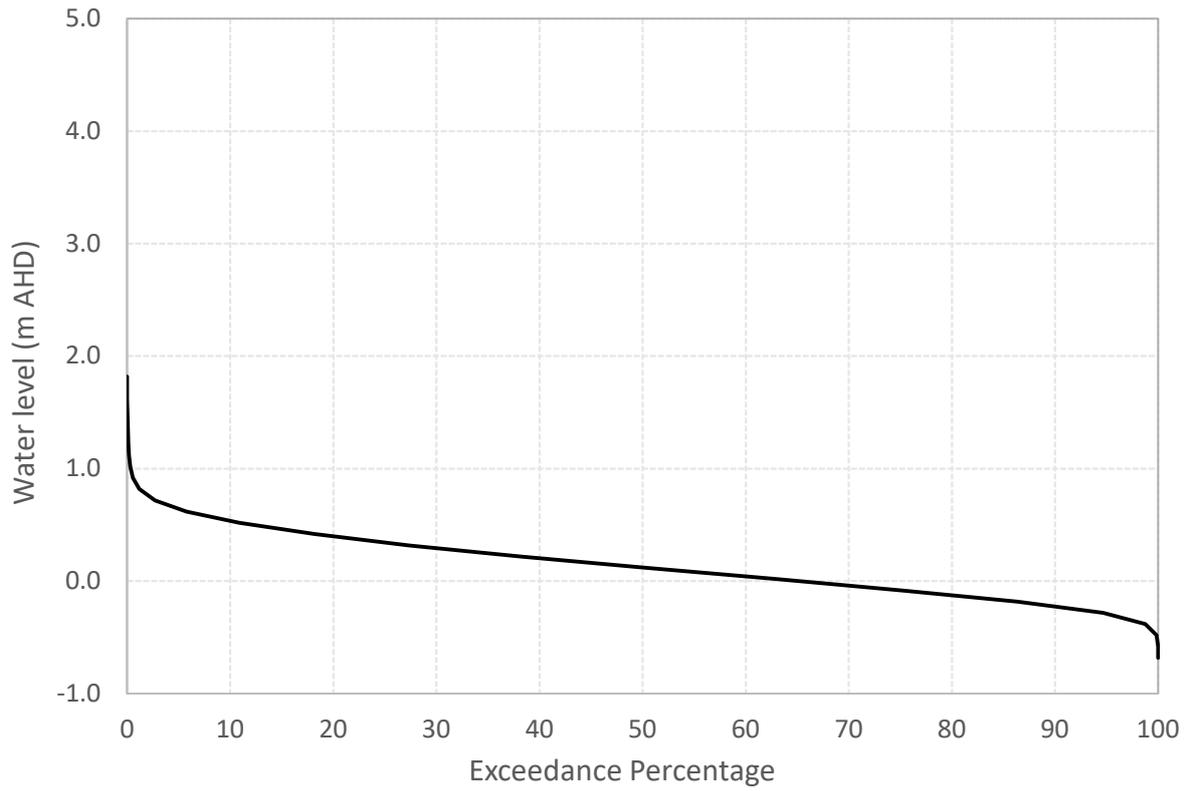
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Barneys Point (201426)	30.4	0.4	0.4*	1.3
Cobaki (201448)	31.2	0.4	0.4*	0.7
Terranora (201447)	30.8	0.4	0.4*	0.7
Tumbulgum (201432)	32.2	0.4	0.9	2.6
North Murwillumbah (201420)	27.8	0.4	0.7	2.8
Kynnumboon (201422)	26.8	0.5	1.4	3.8

\* Mean High Water adopted as minimum blackwater inundation level

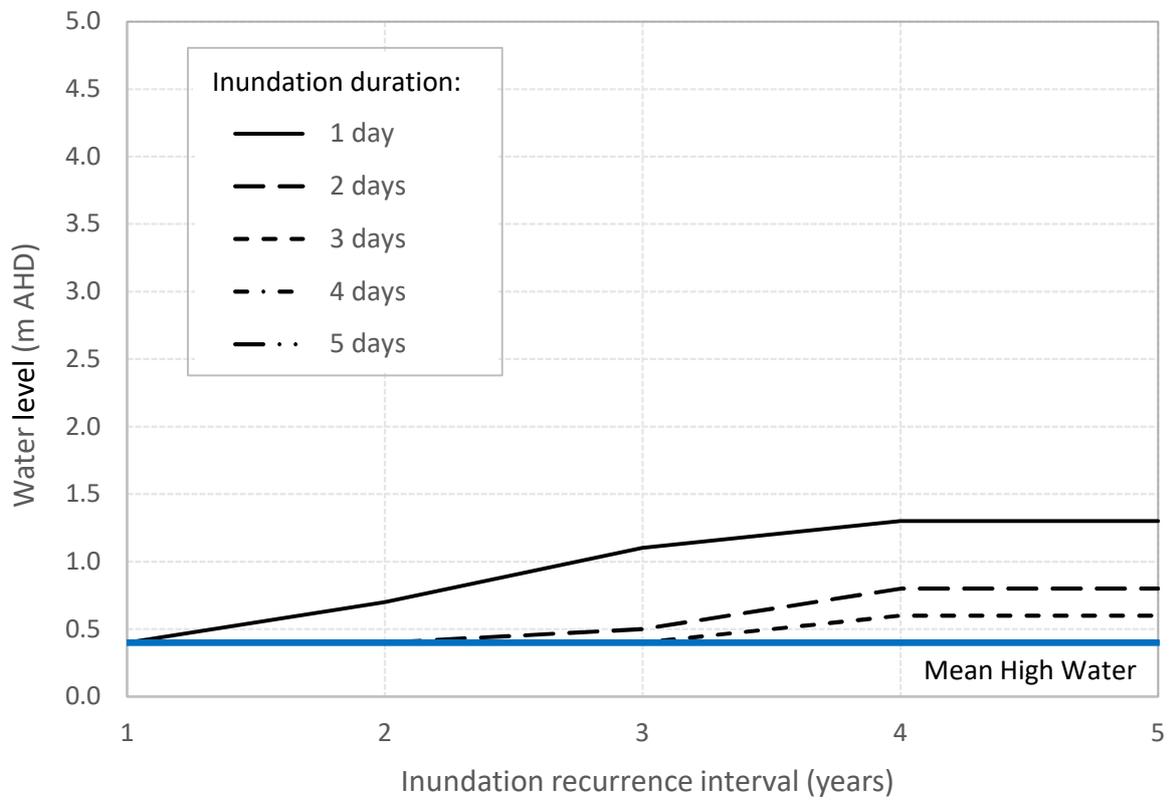
\*\* Excluding data gaps in excess of 6 hours

**Table S3.** Distribution of water level gauges to catchments, Tweed River

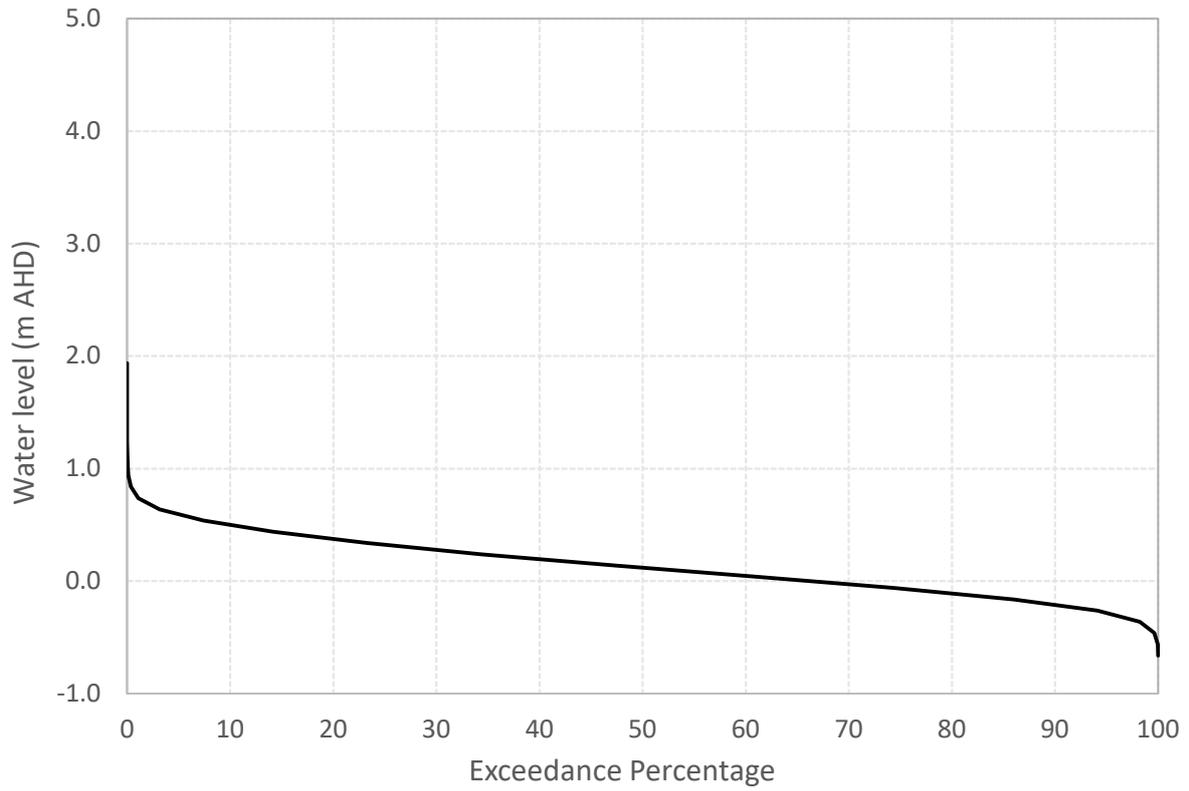
Catchment	Water level station(s) adopted
Bilambil-Terranora	Terranora
Cobaki	Cobaki
East Chinderah	0.91 x Barneys Point + 0.09 x Tumbulgum
West Chinderah	0.76 x Barneys Point + 0.24 x Tumbulgum
Stotts Creek	0.41 x Barneys Point + 0.59 x Tumbulgum
North Tumbulgum	0.32 x Barneys Point + 0.68 x Tumbulgum
Tumbulgum-Eviron	0.22 x Barneys Point + 0.78 x Tumbulgum
Condong	0.69 x Tumbulgum + 0.31 x Nth Murwillumbah
Dulguigan	0.78 x Tumbulgum + 0.22 x Kynnumboon
Tygalgah	0.73 x Tumbulgum + 0.27 x Kynnumboon
Kynnumboon	Kynnumboon
South Murwillumbah	North Murwillumbah
Dunbible Creek	North Murwillumbah
Commercial Road	North Murwillumbah



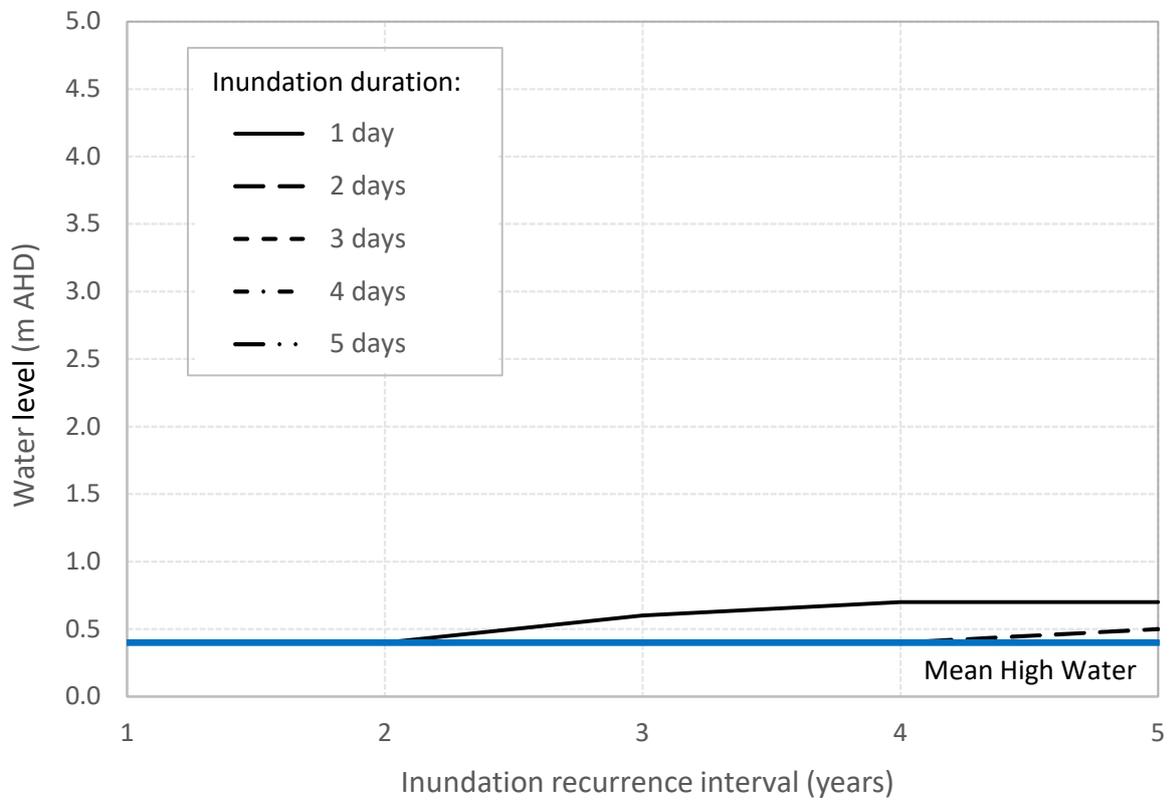
**Figure S2.** Frequency distribution of water levels at Barneys Point (Station 201426)



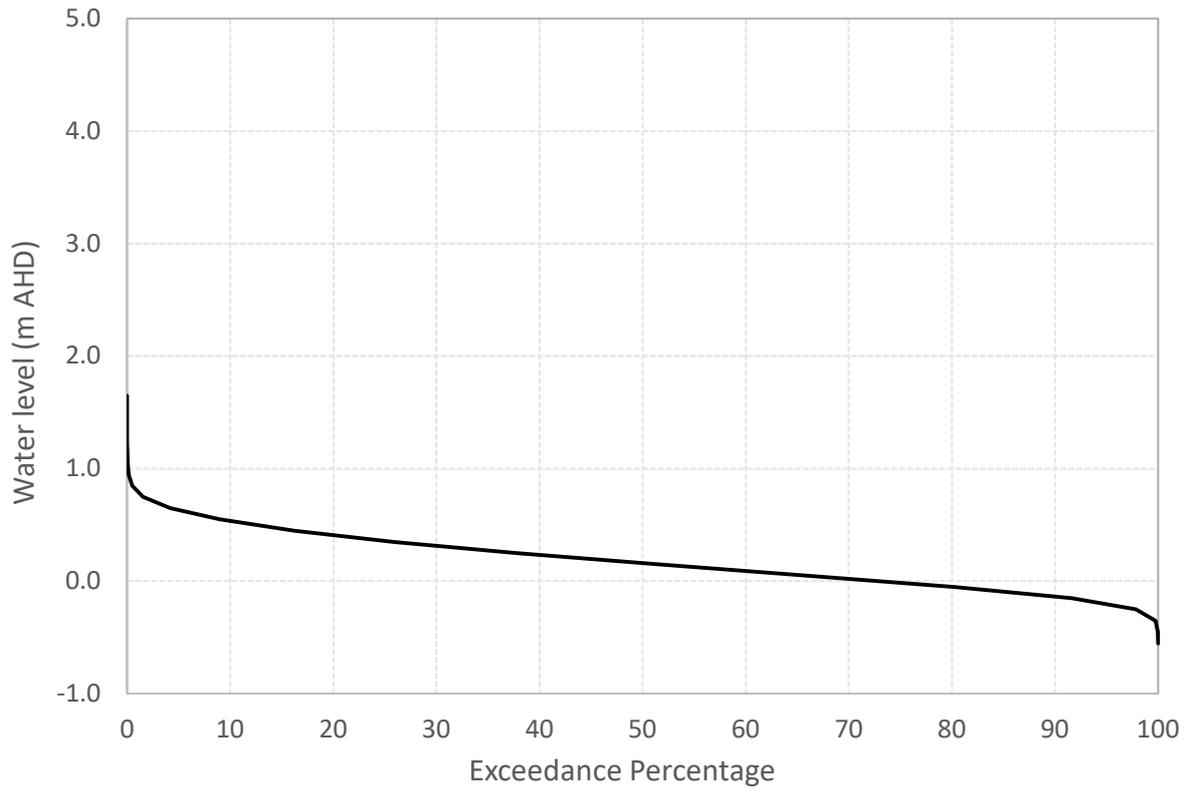
**Figure S3.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Barneys Point (Station 201426)



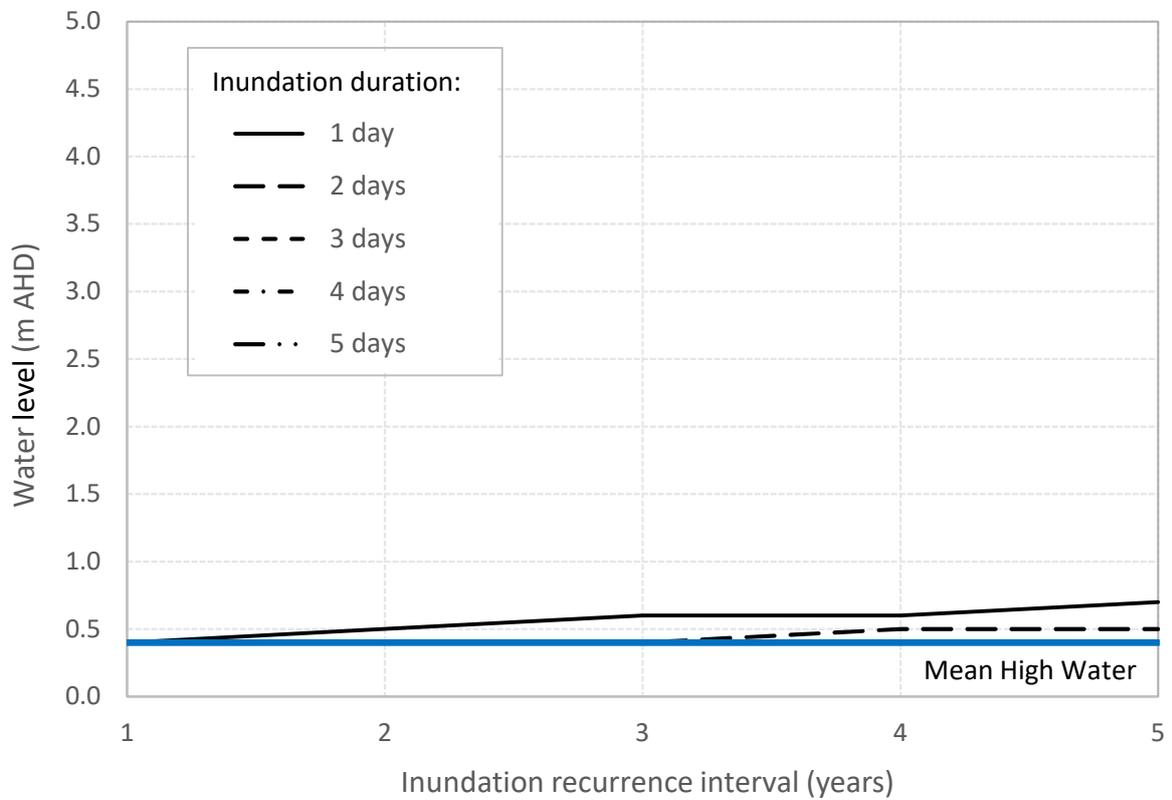
**Figure S4.** Frequency distribution of water levels at Cobaki (Station 201448)



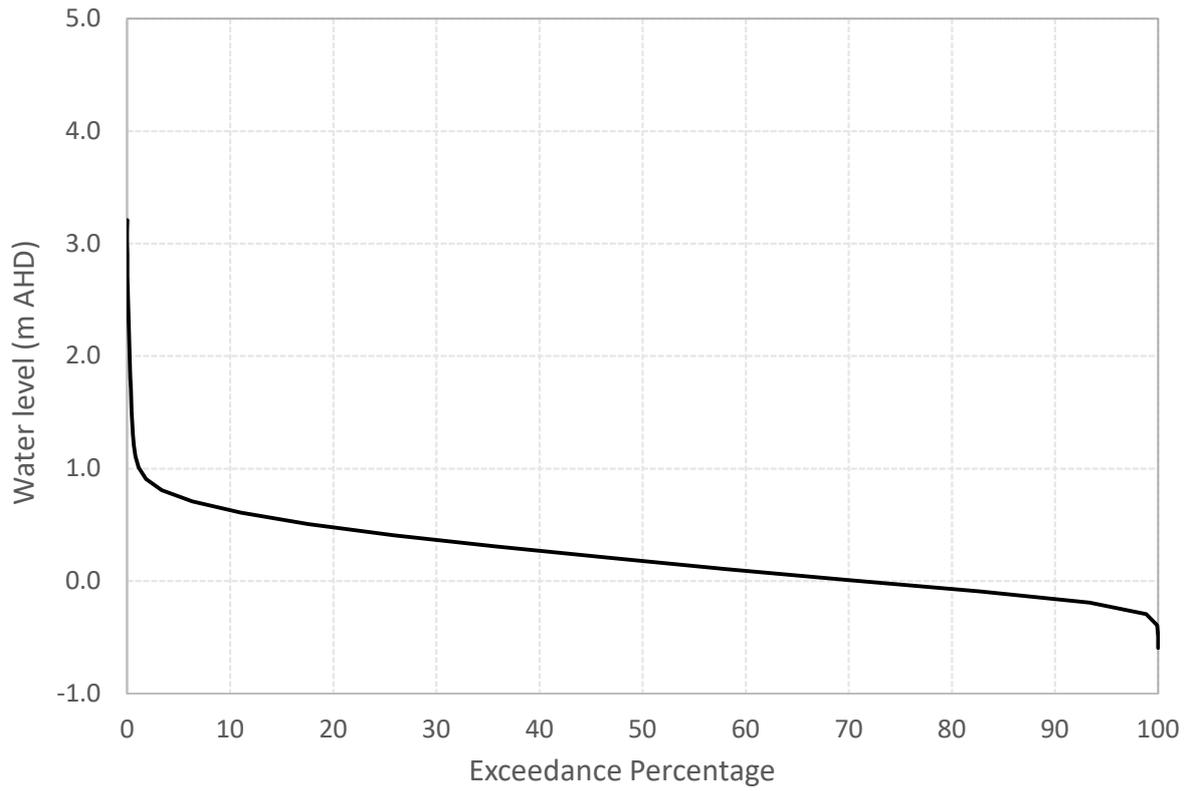
**Figure S5.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Cobaki (Station 201448)



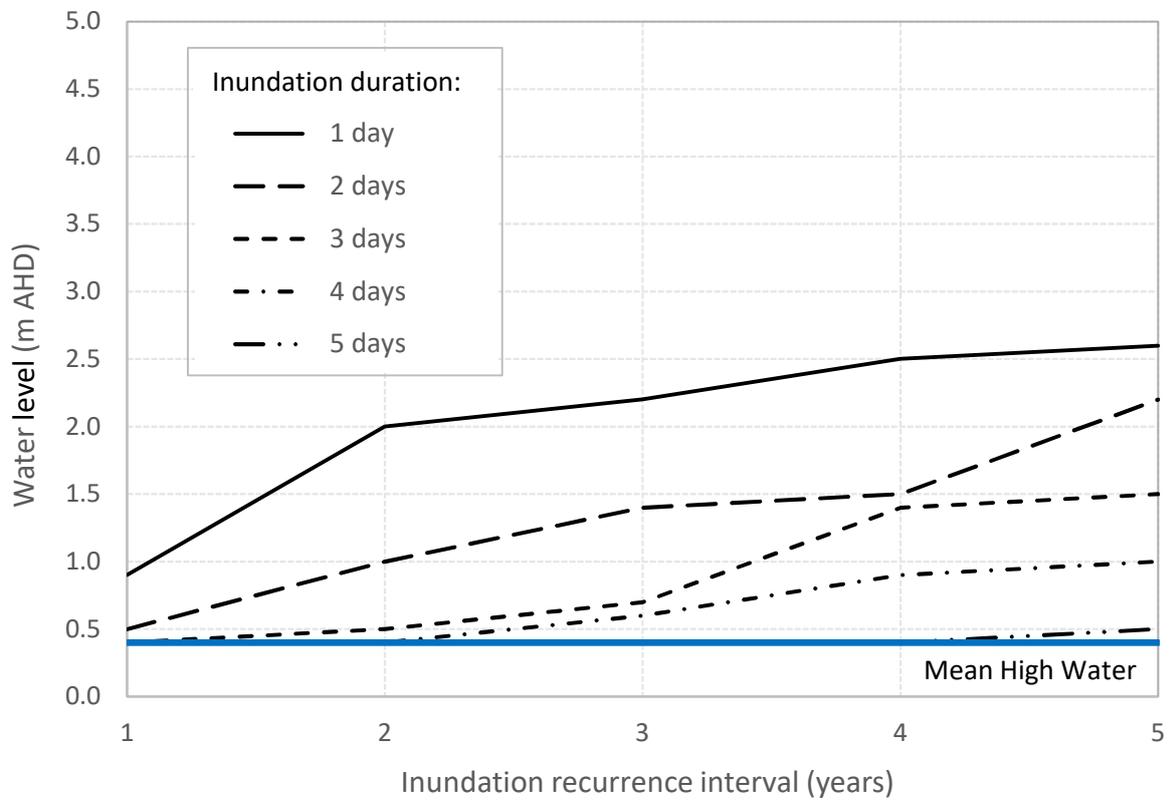
**Figure S6.** Frequency distribution of water levels at Terranora (Station 201447)



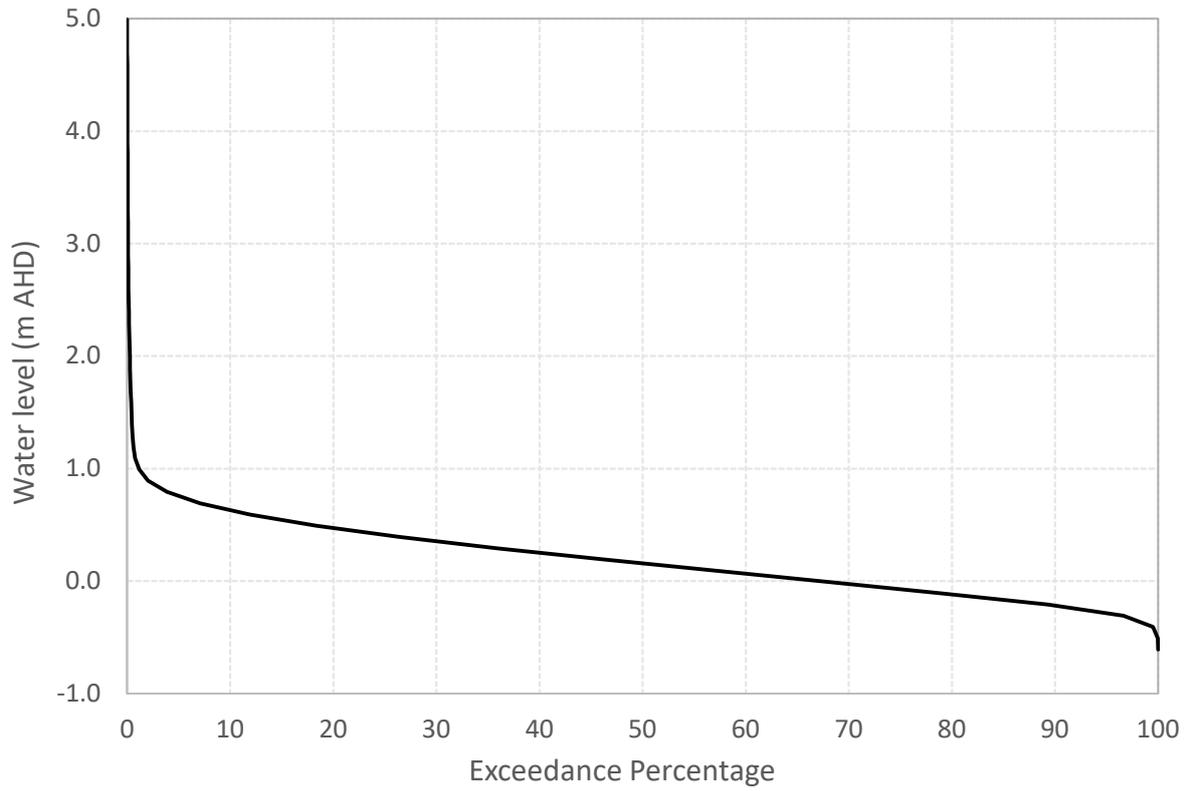
**Figure S7.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Terranora (Station 201447)



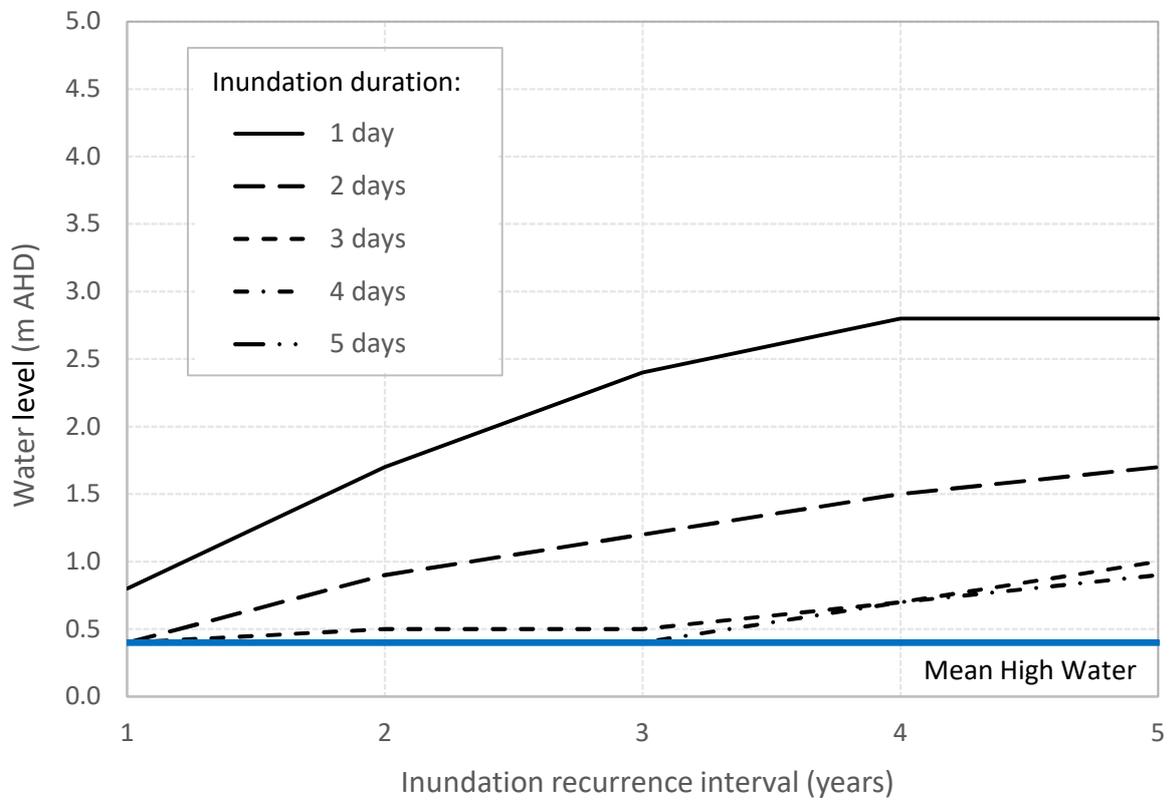
**Figure S8.** Frequency distribution of water levels at Tumbulghum (Station 201432)



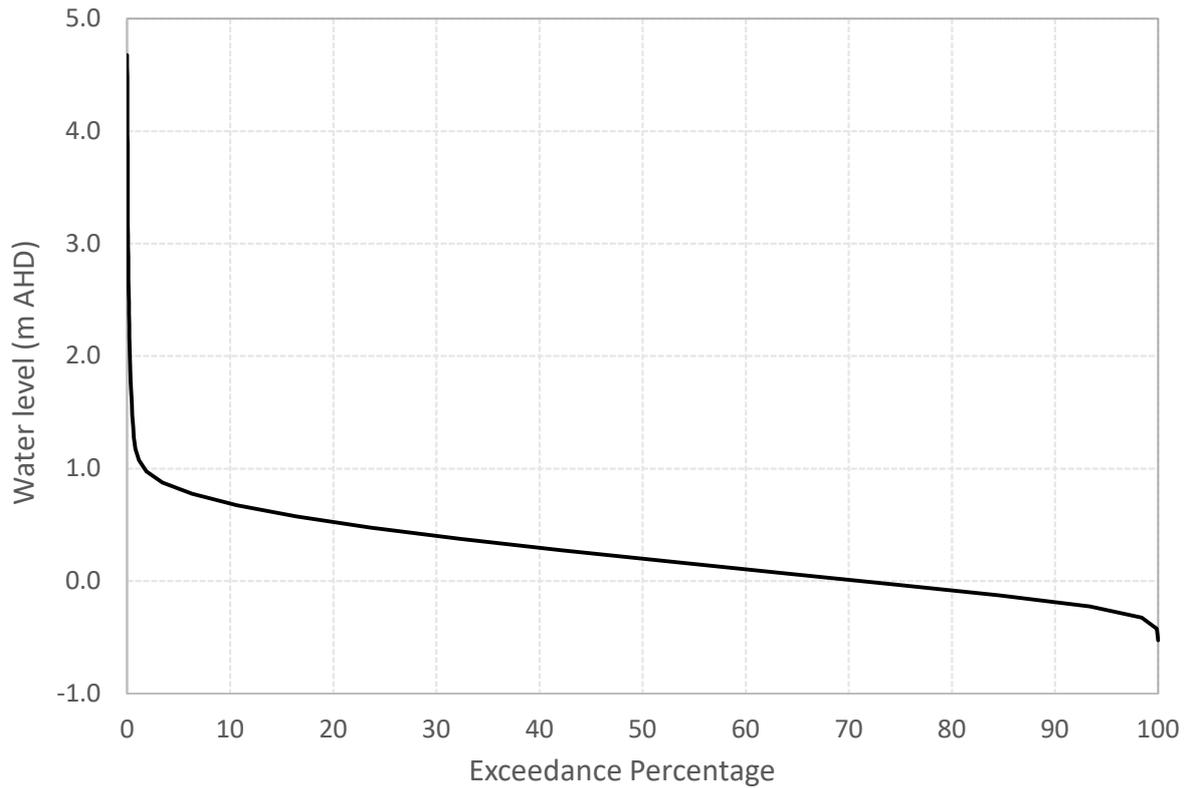
**Figure S9.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Tumbulghum (Station 201432)



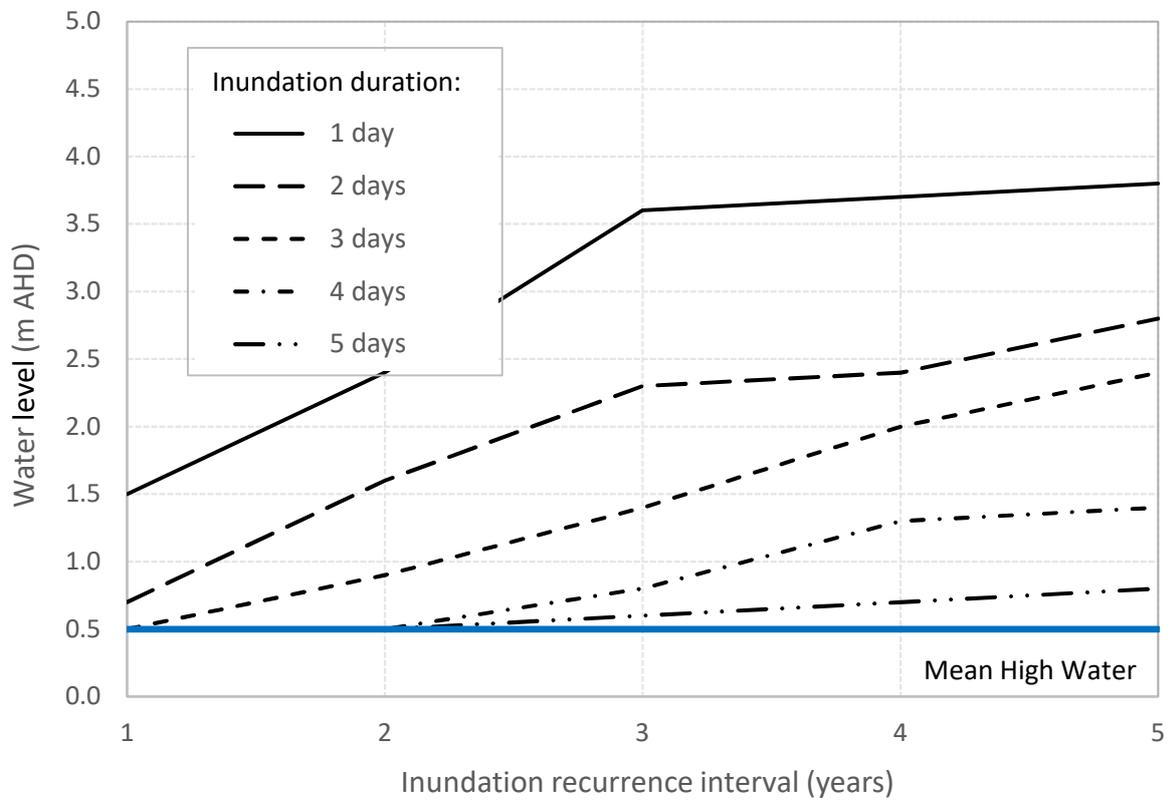
**Figure S10.** Frequency distribution of water levels at North Murwillumbah (Station 201420)



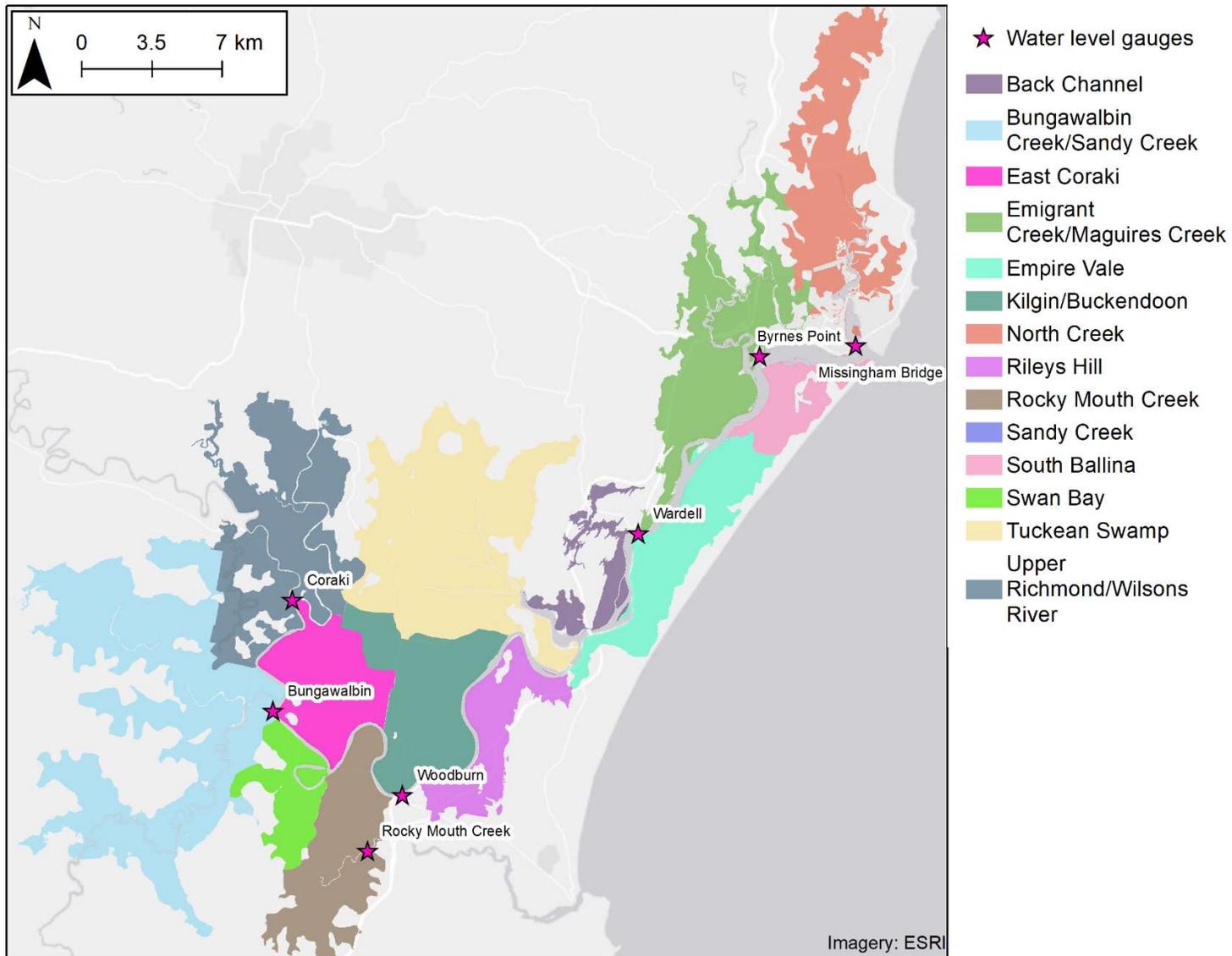
**Figure S11.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for North Murwillumbah (Station 201420)



**Figure S12.** Frequency distribution of water levels at Kynnumboon (Station 201442)



**Figure S13.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Kynnumboon (Station 201442)



**Figure S14.** Water level gauge locations and catchment areas, Richmond River

**Table S4.** Details of water level gauges, Richmond River

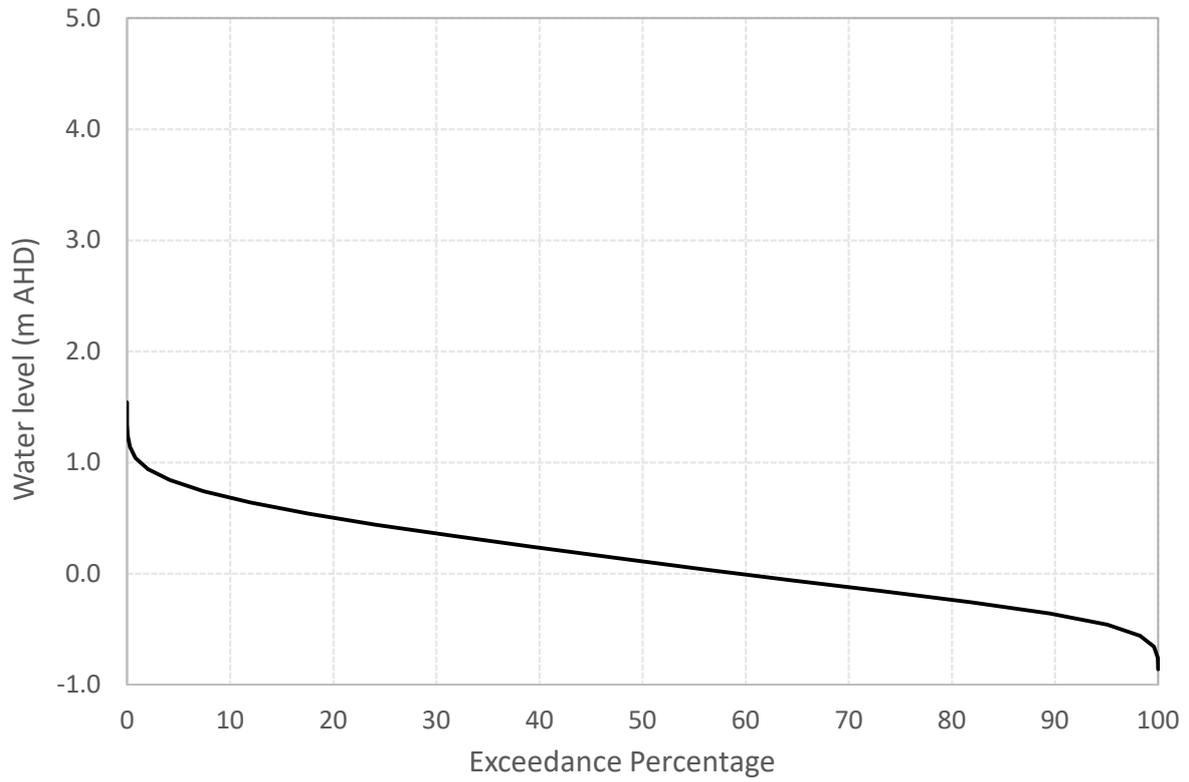
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Missingham Bridge (203465)	16.3	0.5	0.5*	0.5
Byrnes Point (203461)	29.3	0.4	0.4*	0.4
Wardell (203468)	17.3	0.5	0.5*	1.1
Woodburn (203412)	33.75	0.4	2.1	3.0
Bungawalbin (203450)	17.5	0.4	2.9	4.1
Coraki (203403)	32.25	0.4	2.1	1.4
Rocky Mouth Creek (203432)	25.5	0.4	1.5	2.0

\* Mean High Water adopted as minimum blackwater inundation level

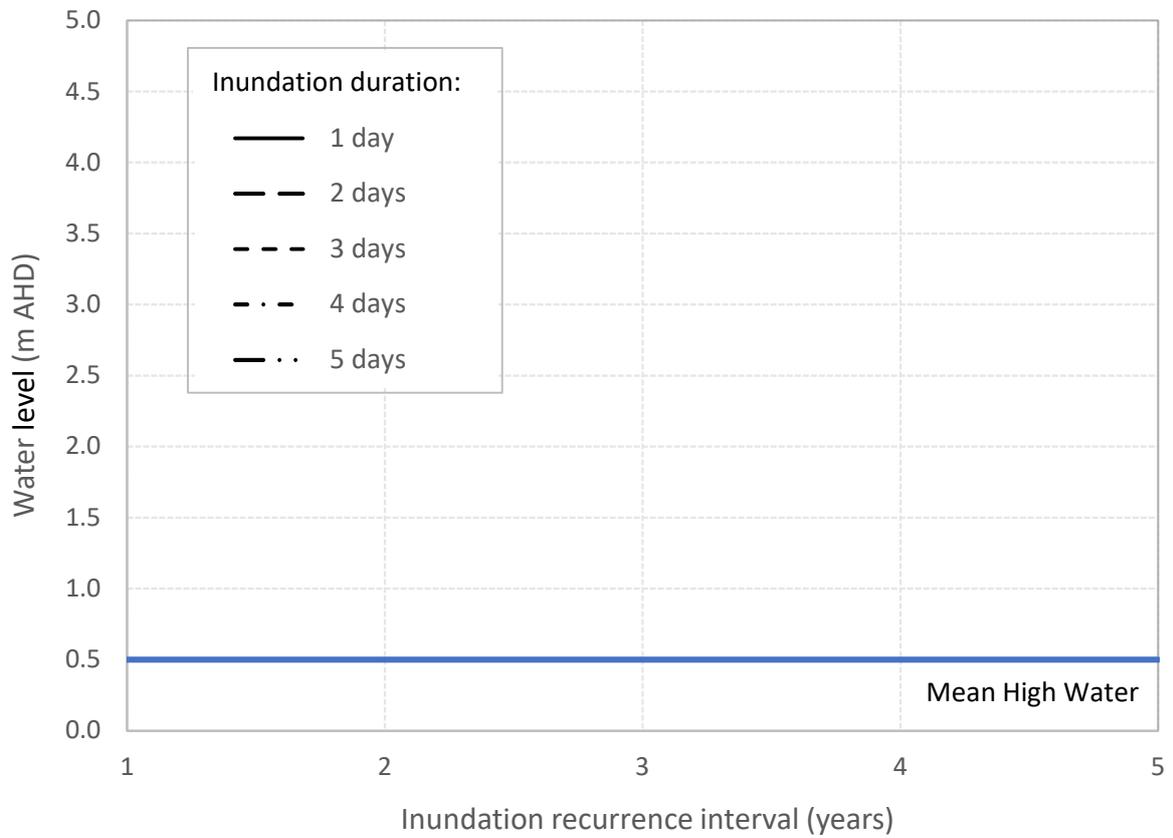
\*\* Excluding data gaps in excess of 6 hours

**Table S5.** Distribution of water level gauges to catchments, Richmond River

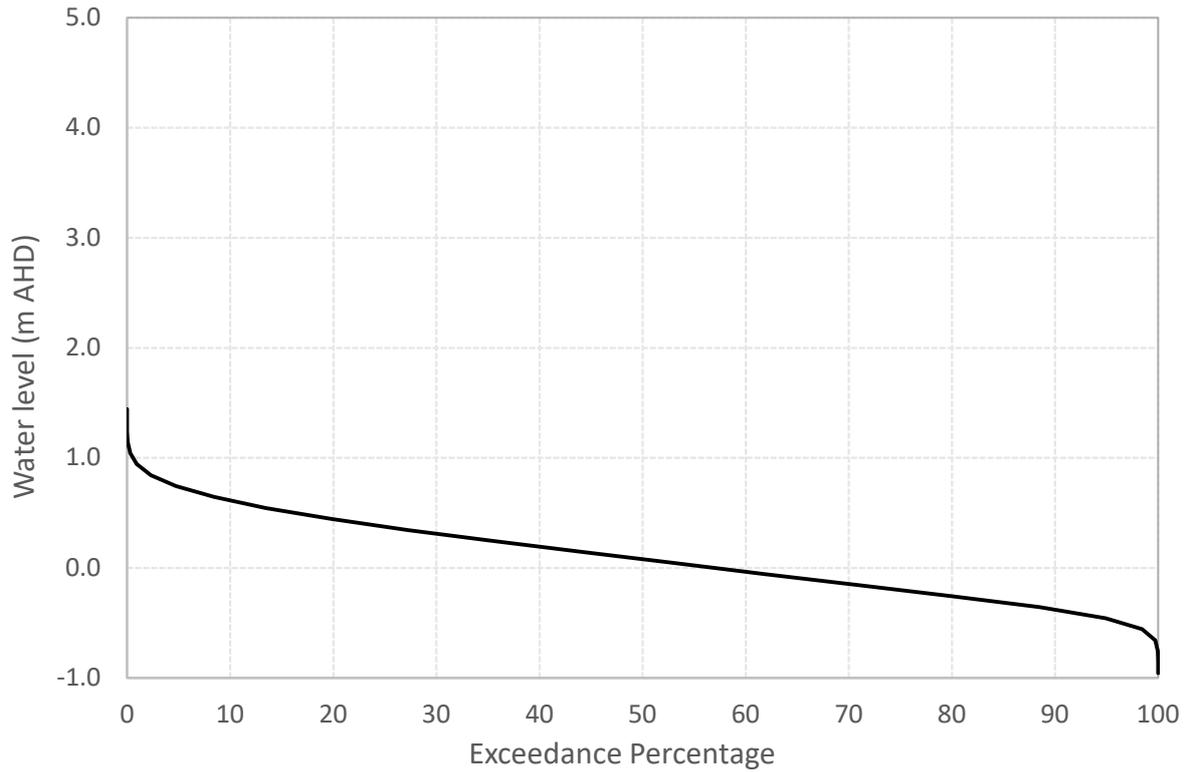
Catchment	Water level station(s) adopted
North Creek	Missingham Bridge
South Ballina	Missingham Bridge
Emigrant Creek/Maguire's Creek	Byrnes Point
Empire Vale	0.18 x Byrnes Point + 0.82 x Wardell
Back Channel	Wardell
Tuckean Swamp	0.82 x Wardell + 0.28 x Woodburn
Rocky Mouth Creek	Rocky Mouth Creek
Rileys Hill	0.41 x Wardell + 0.59 x Woodburn
Kilgin/Buckendoon	0.32 x Wardell + 0.68 x Woodburn
East Coraki	0.38 x Bungawalbin + 0.62 x Woodburn
Swan Bay	Bungawalbin
Bungawalbin Creek/Sandy Creek	Bungawalbin
Upper Richmond/Wilsons River	Coraki



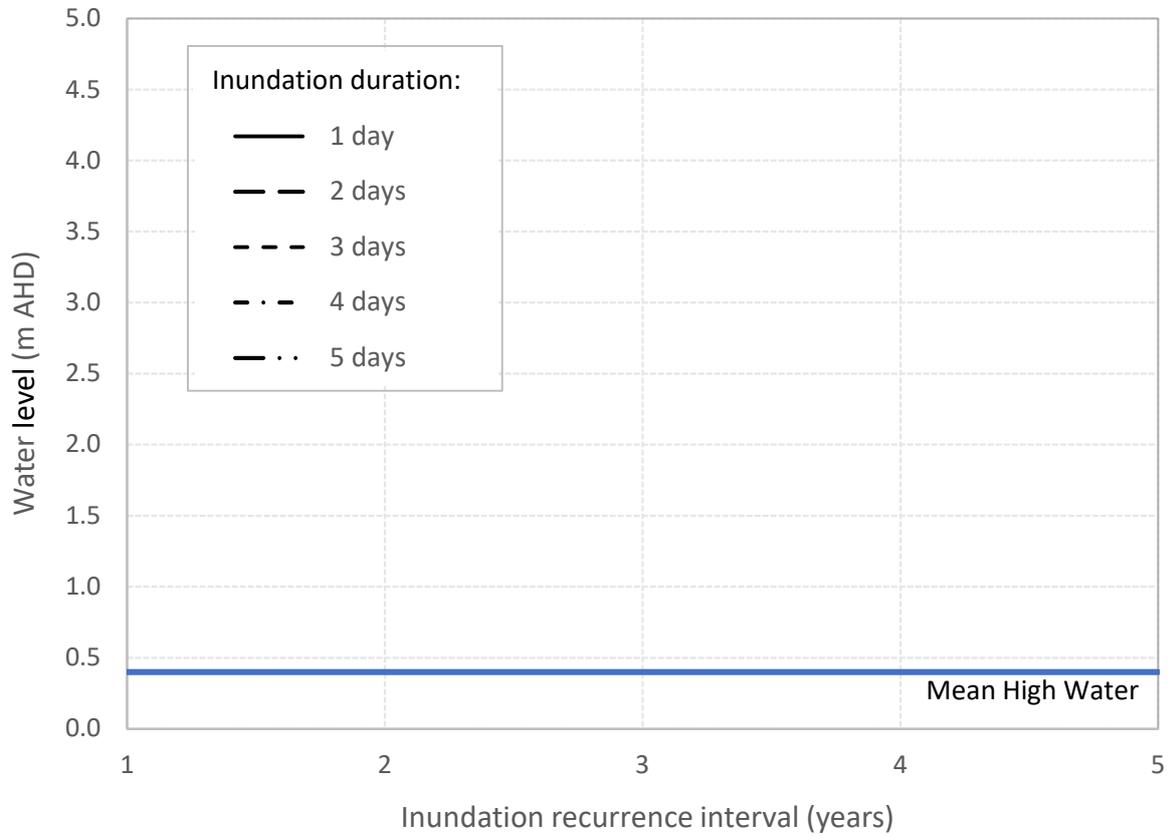
**Figure S15.** Frequency distribution of water levels at Missingingham Bridge (Station 203465)



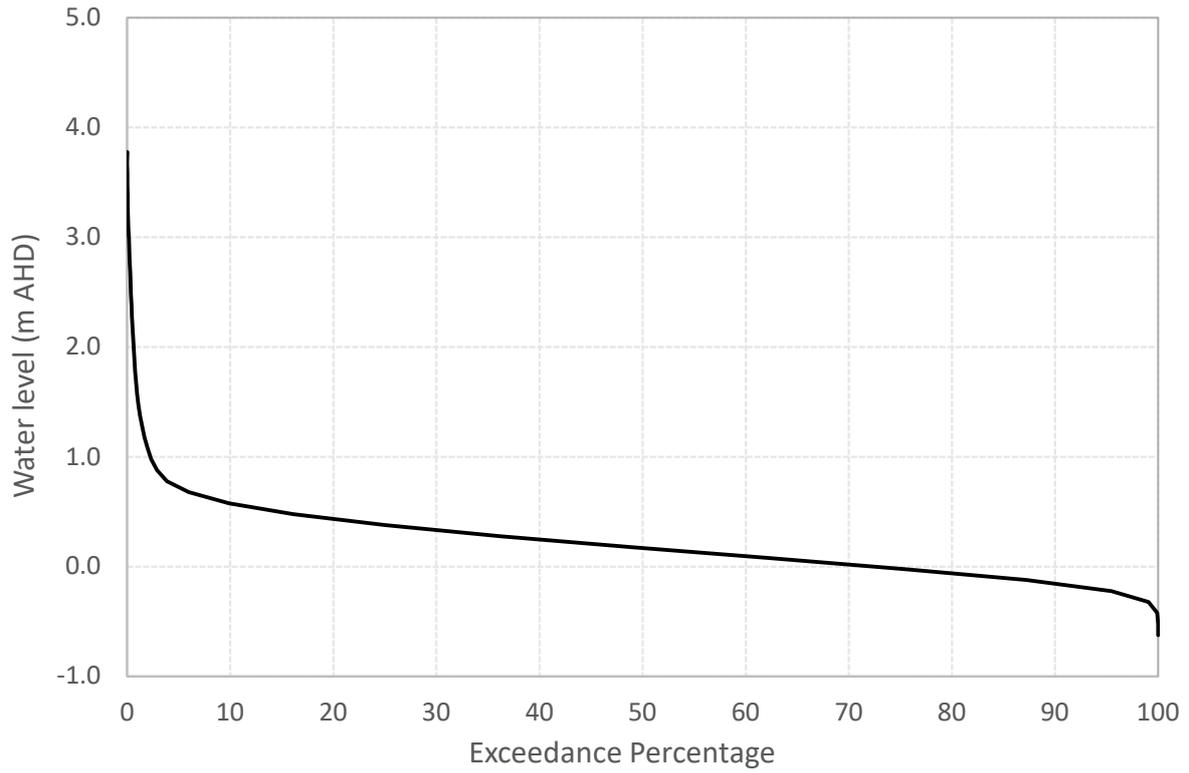
**Figure S16.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Missingingham Bridge (Station 203465)



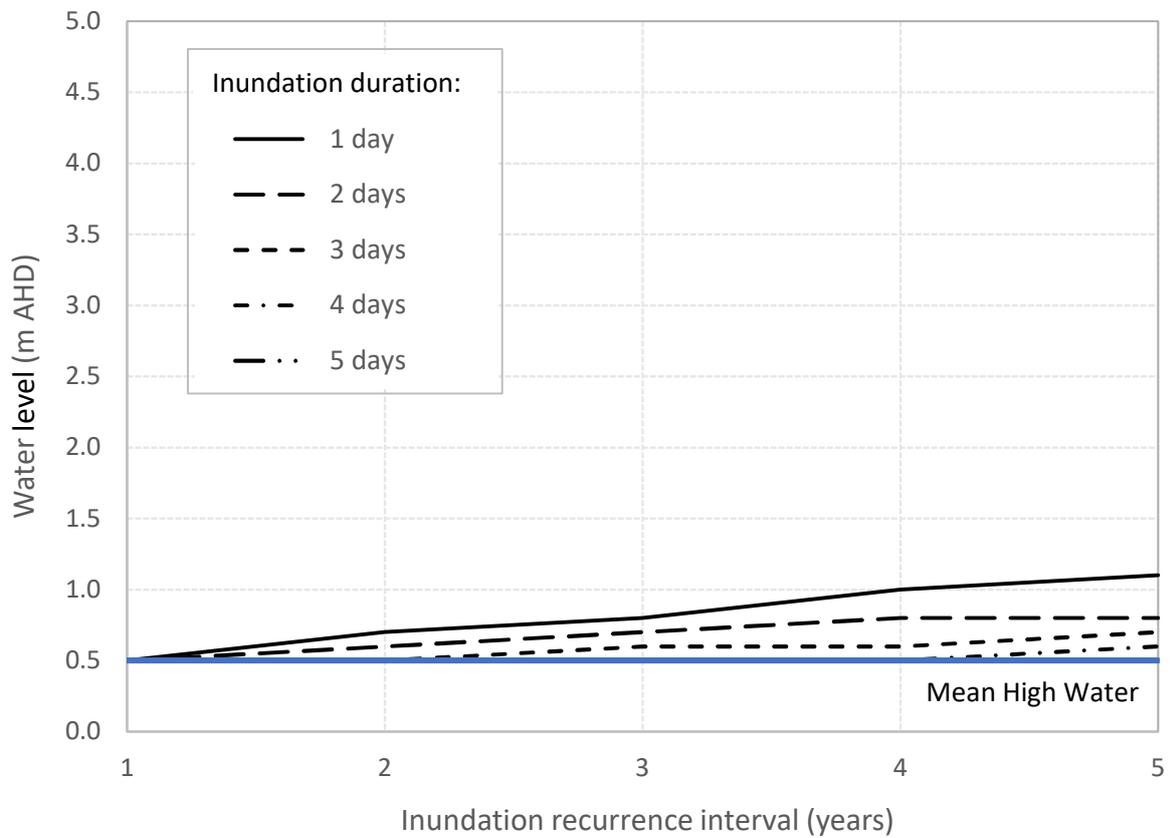
**Figure S17.** Frequency distribution of water levels at Byrnes Point (Station 203461)



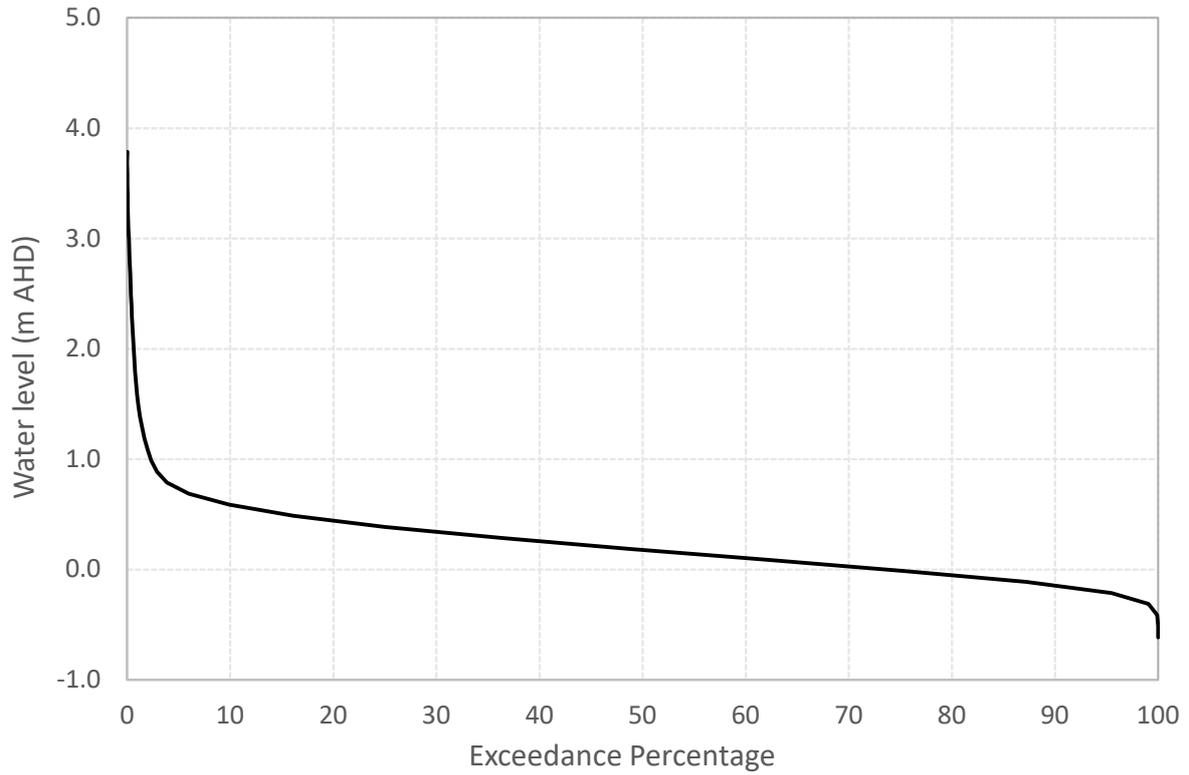
**Figure S18.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Byrnes Point (Station 203461)



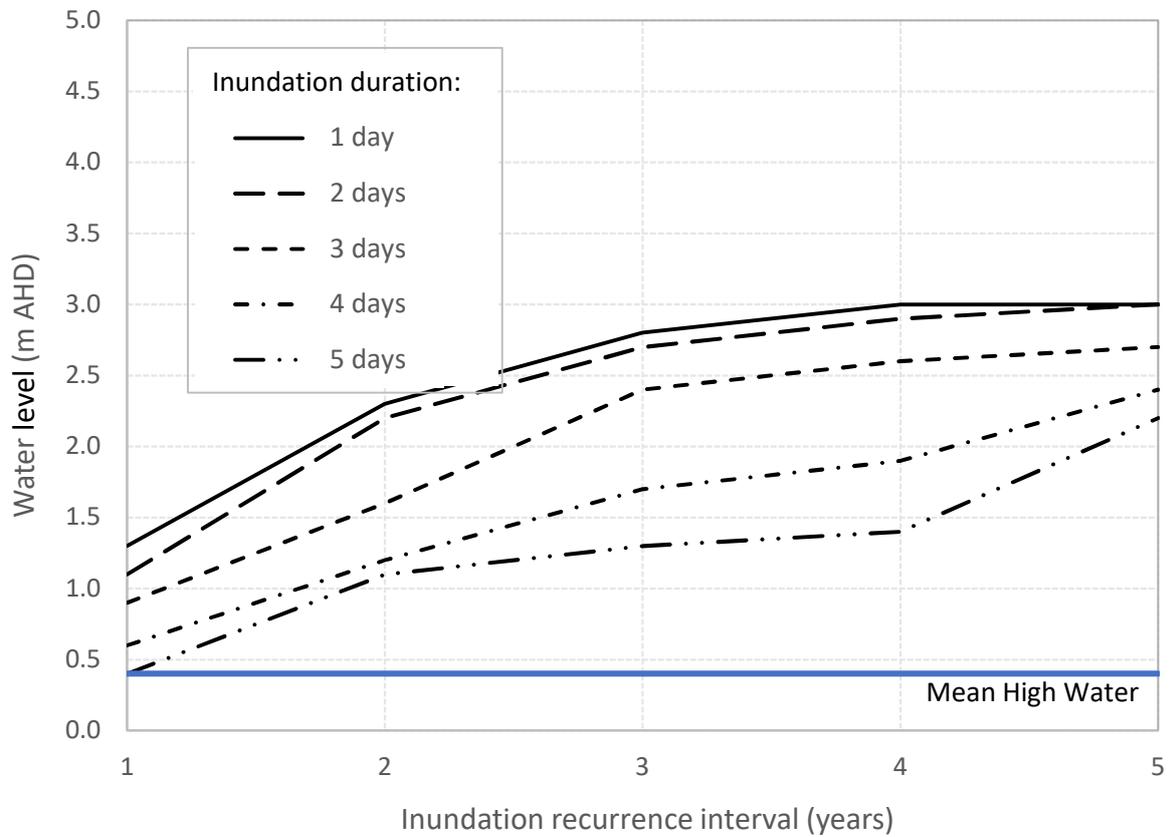
**Figure S19.** Frequency distribution of water levels at Wardell (Station 20)



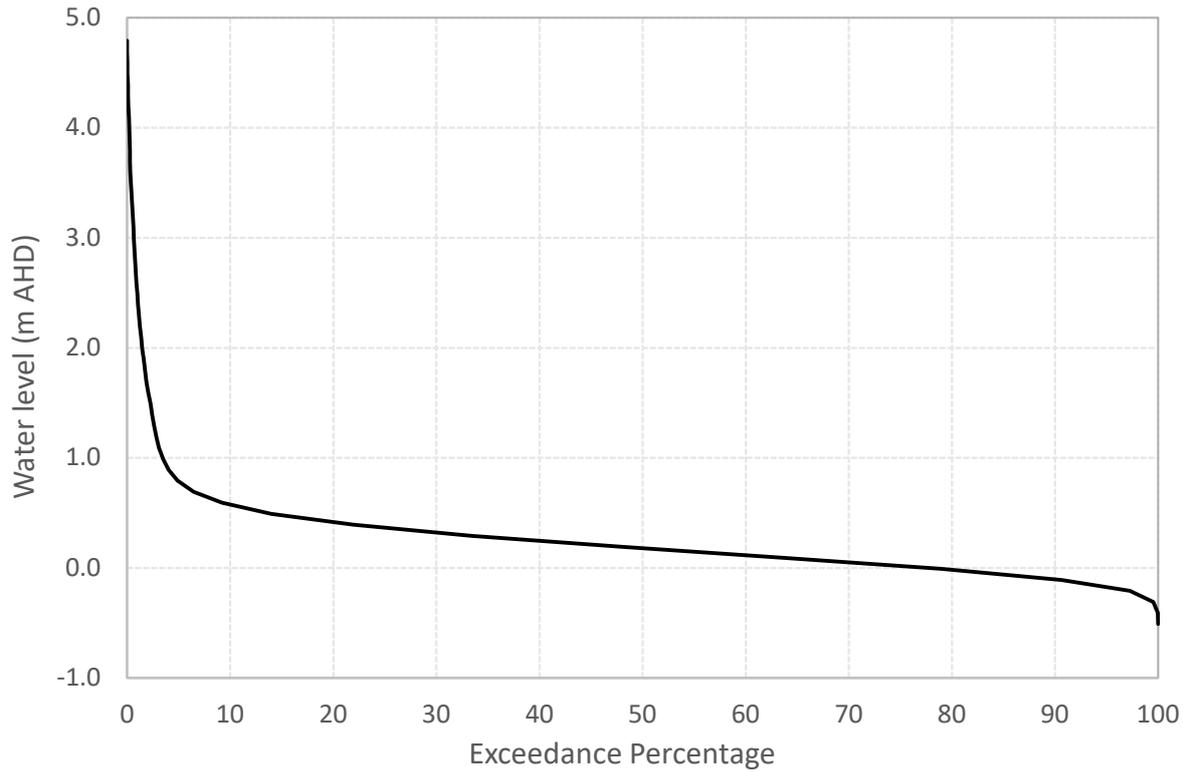
**Figure S20.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Wardell (Station 20)



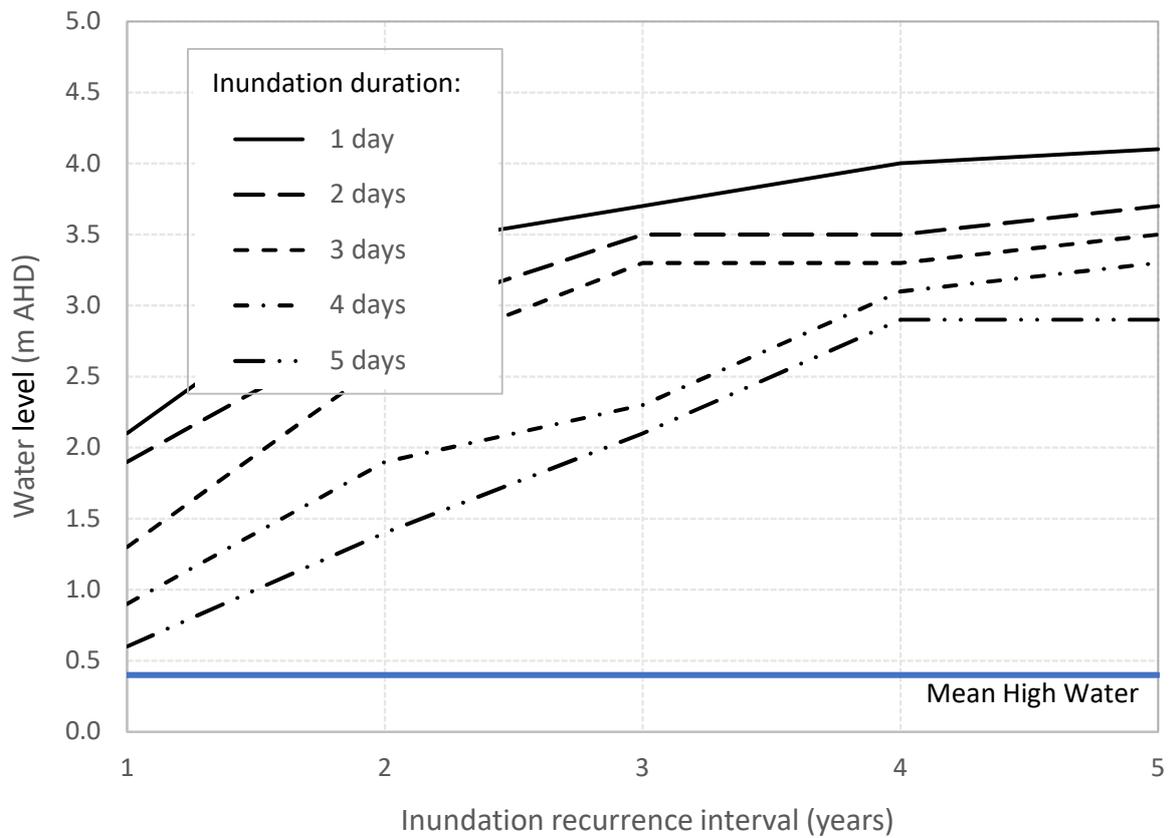
**Figure S21.** Frequency distribution of water levels at Woodburn (Station 203412)



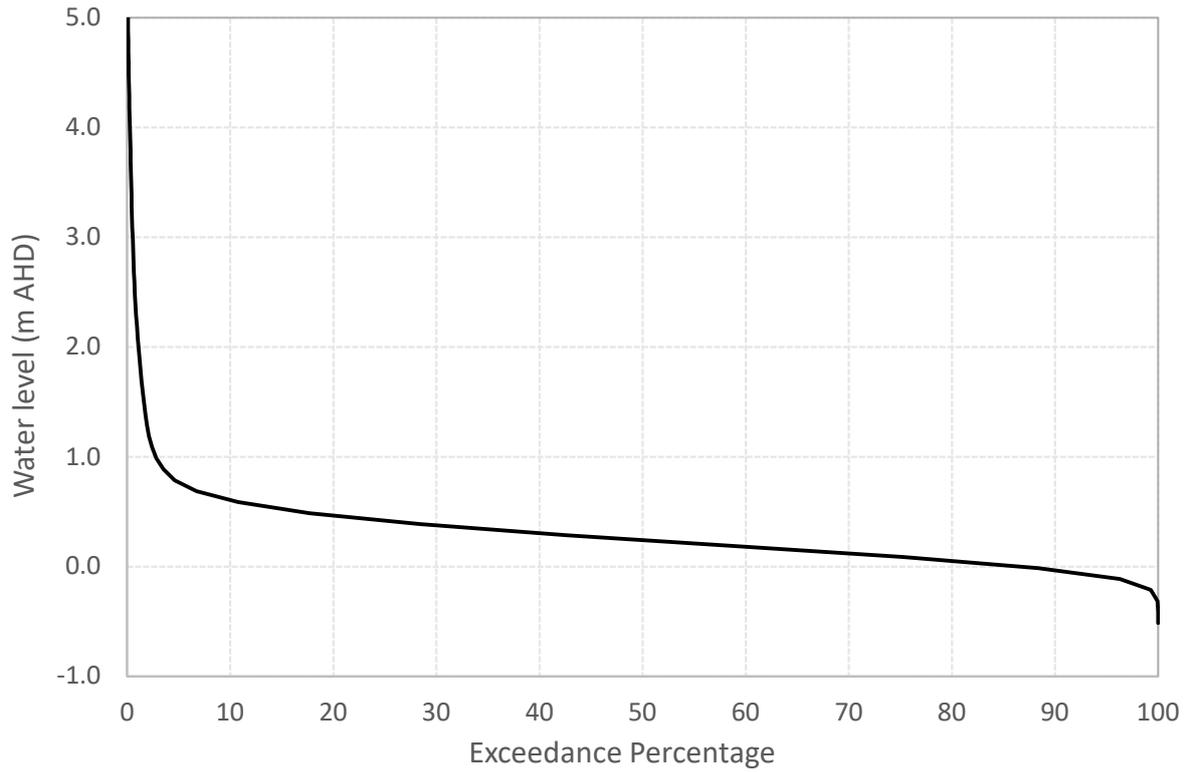
**Figure S22.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Woodburn (Station 203412)



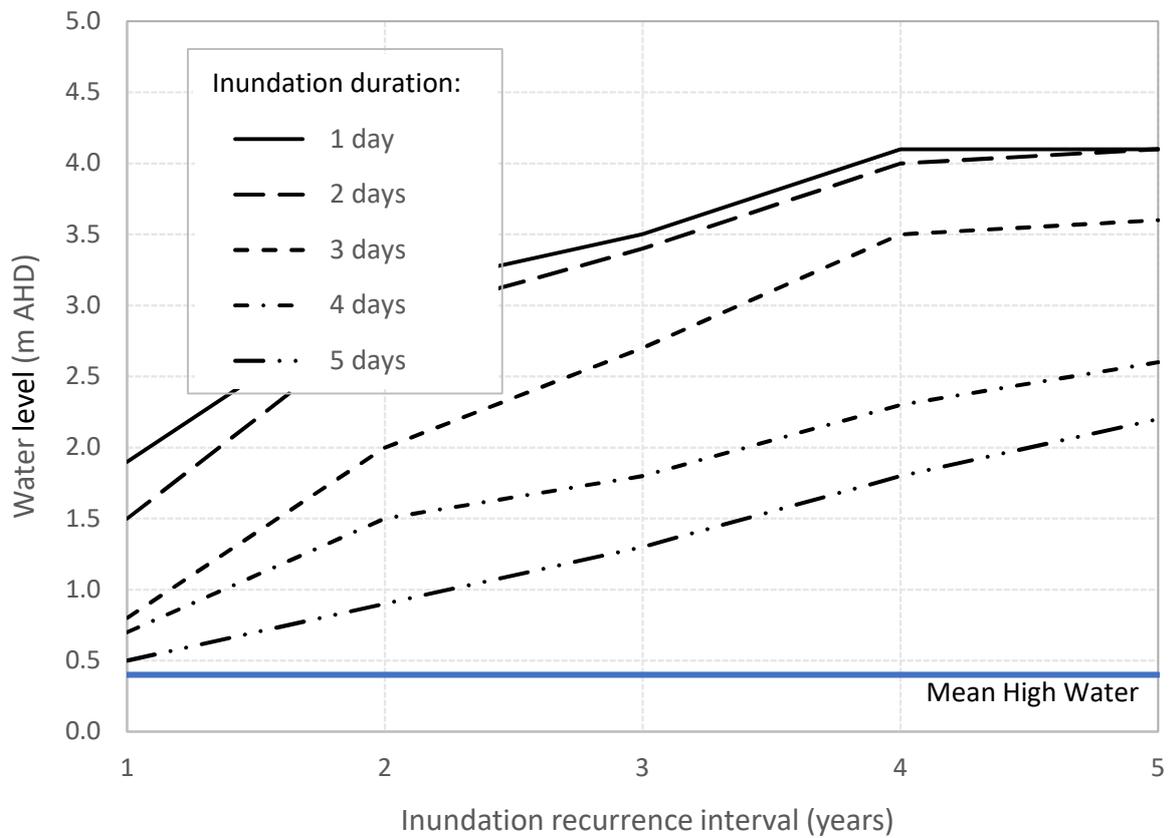
**Figure S23.** Frequency distribution of water levels at Bungawalbin (Station 203450)



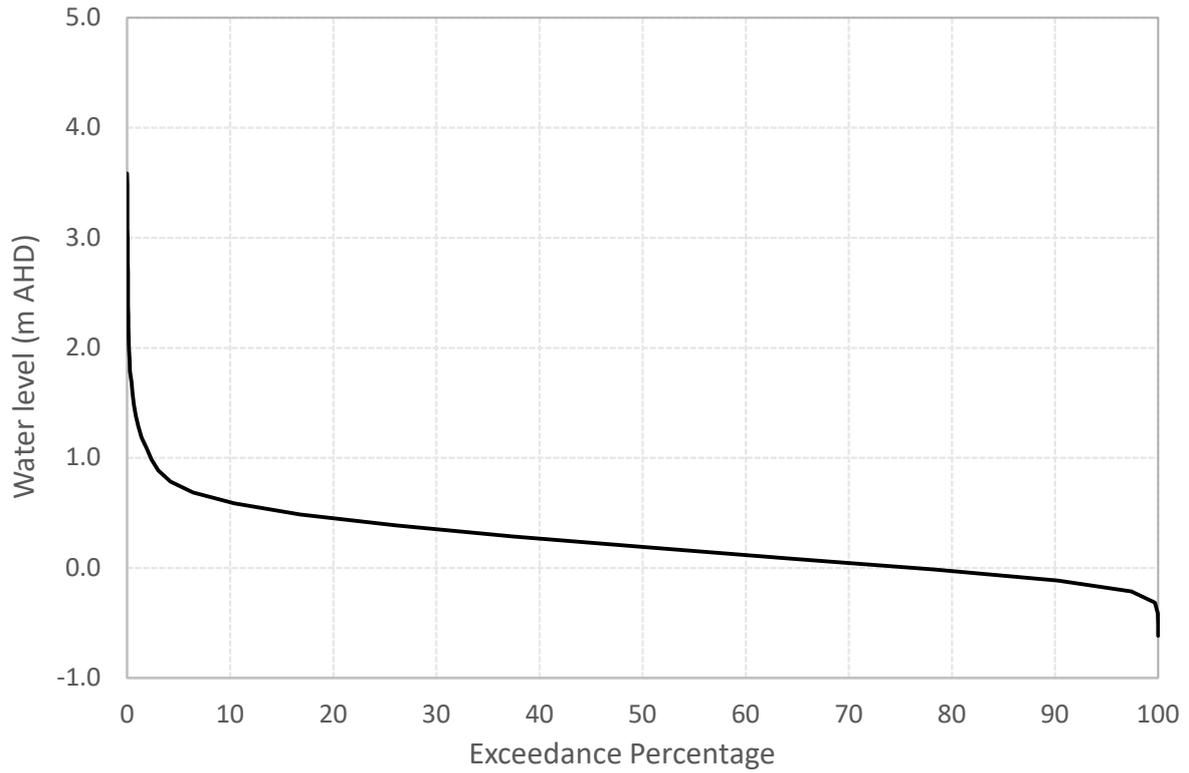
**Figure S24.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Bungawalbin (Station 203450)



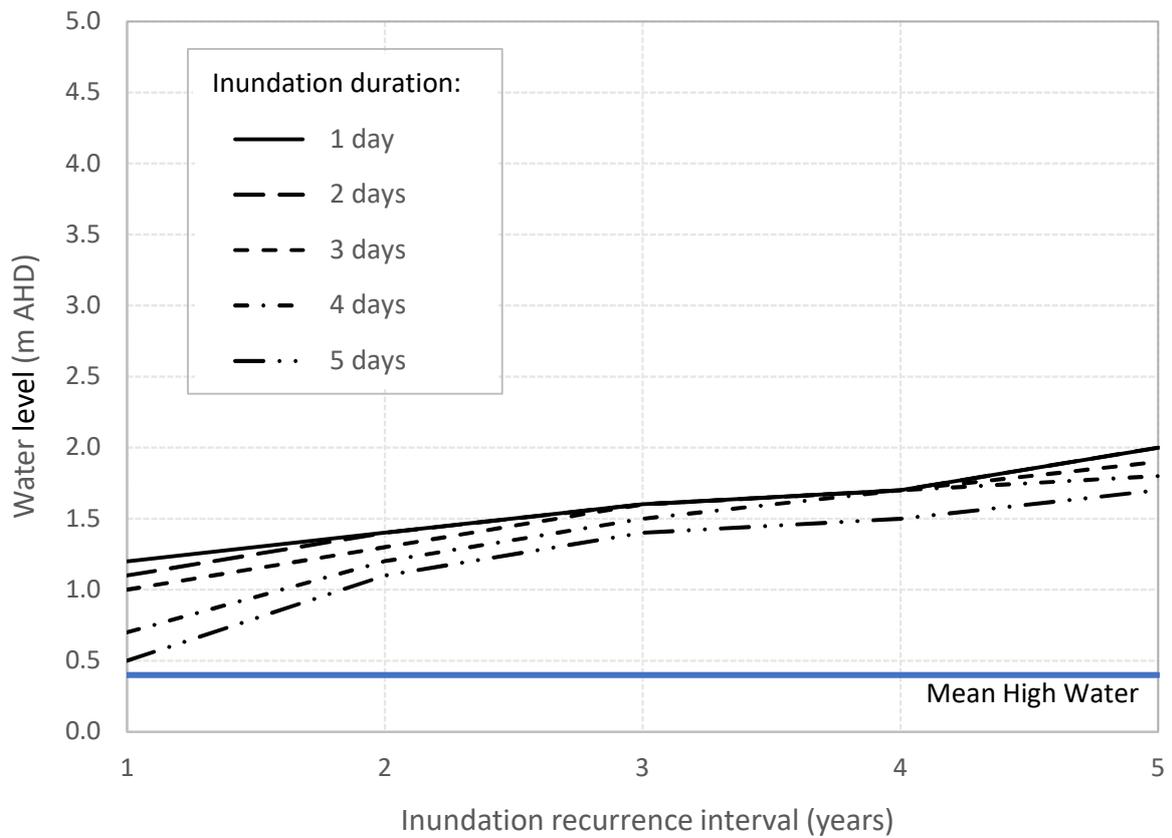
**Figure S25.** Frequency distribution of water levels at Coraki (Station 203403)



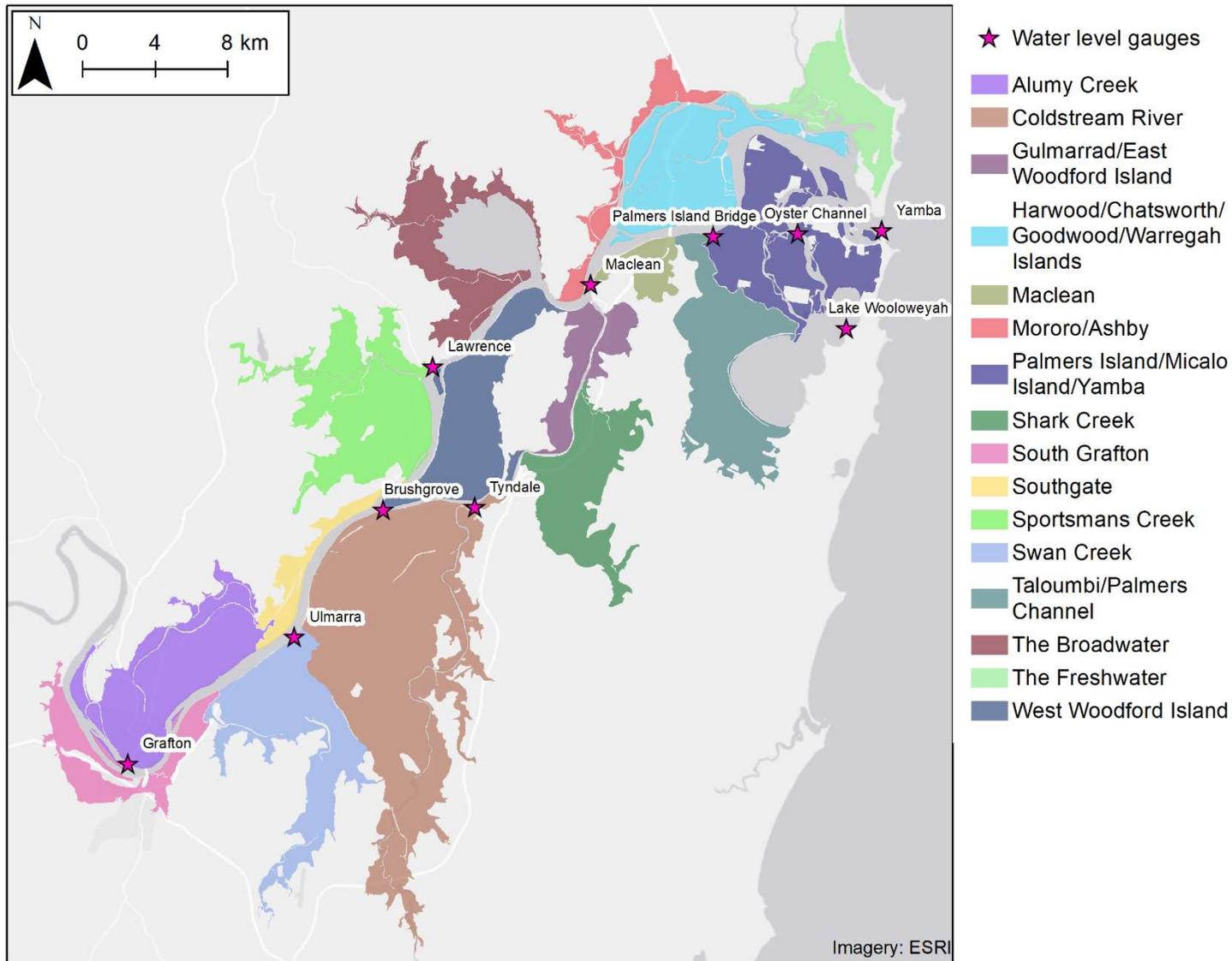
**Figure S26.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Coraki (Station 203403)



**Figure S27.** Frequency distribution of water levels at Rocky Mouth Creek (Station 203432)



**Figure S28.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Rocky Mouth Creek (Station 203432)



**Figure S29.** Water level gauge locations, Clarence River

**Table S6.** Details of water level gauges, Clarence River

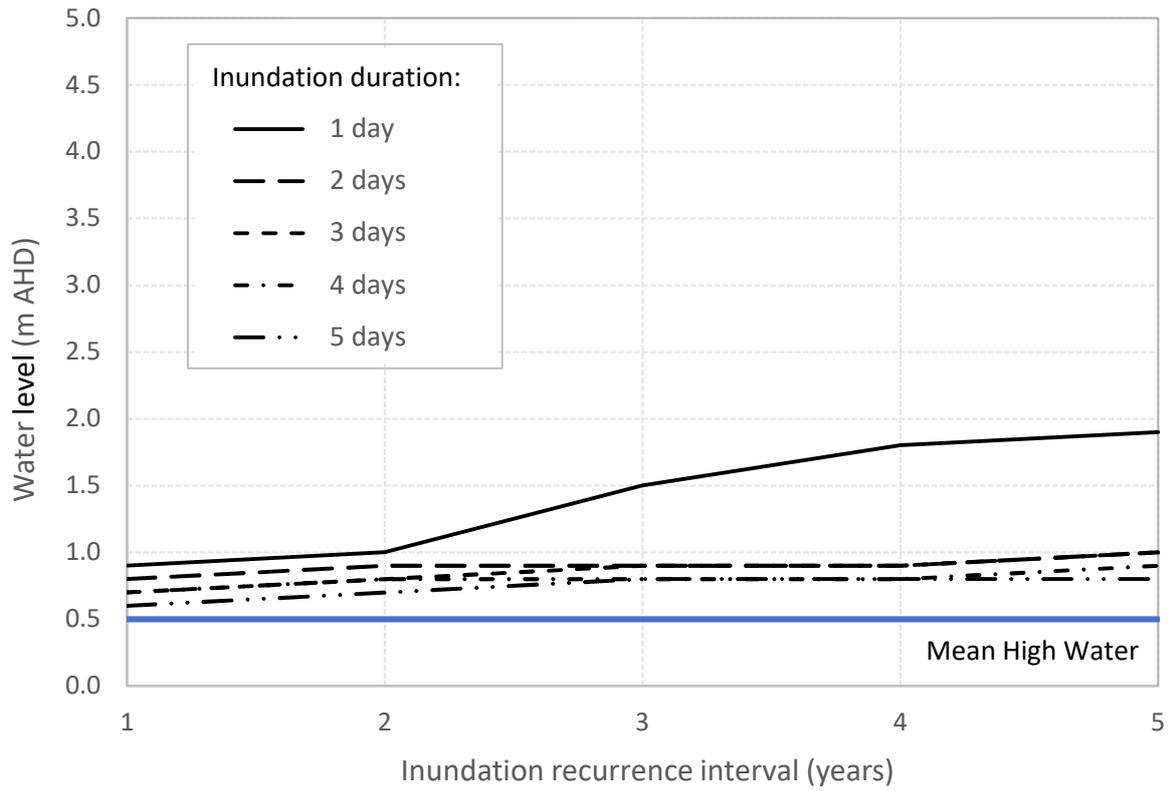
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Yamba (204454)	32.5	0.5	0.9	1.9
Oyster Channel (204451)	15.9	0.3	0.5	0.8
Palmers Island Bridge (204426)	17.8	0.3	0.9	1.8
Maclean (204410)	29.3	0.3	0.8	2.5
Tyndale (204465)	16.3	0.3	1.9	3.8
Brushgrove (204406)	27.7	0.3	1.4	4.1
Lawrence (204453)	10.8	0.3	1.9	3.4
Ulmarra (204480)	15.6	0.4	2.2	5.0
Grafton (204400)	28.9	0.4	1.5	6.2

\* Mean High Water adopted as minimum blackwater inundation level

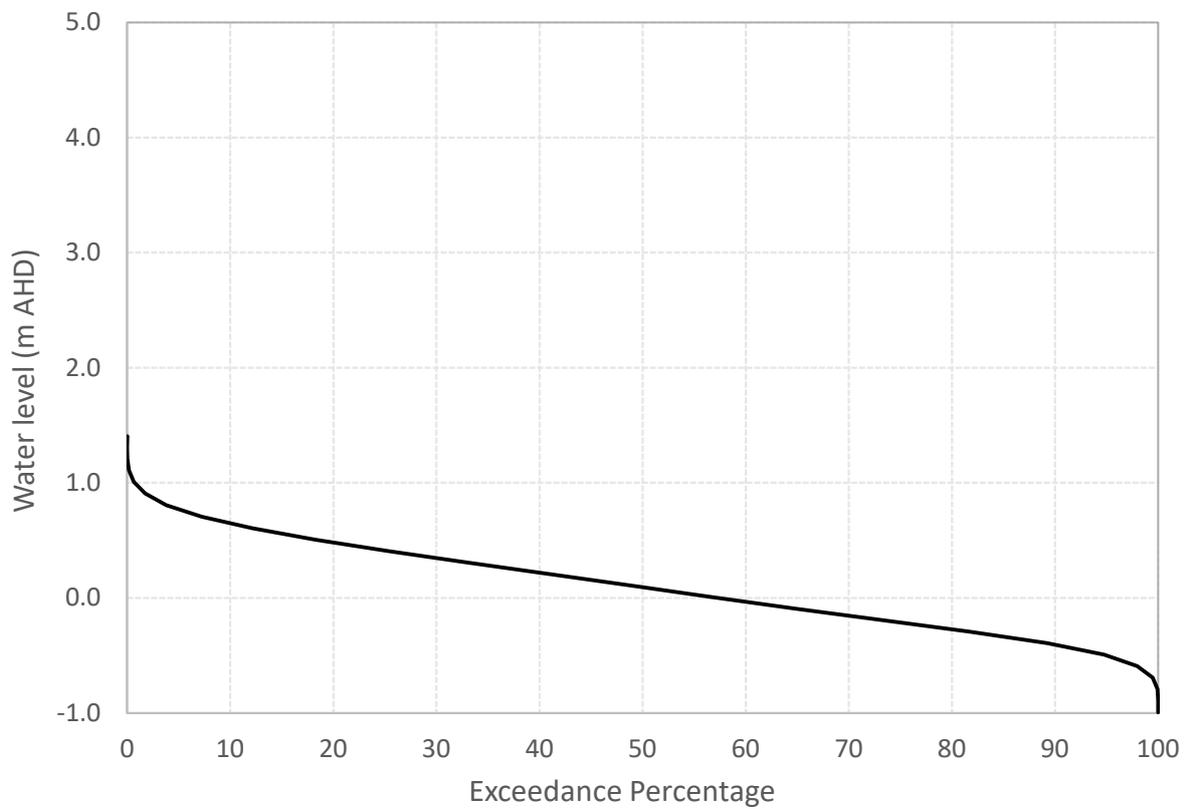
\*\* Excluding data gaps in excess of 6 hours

**Table S7.** Distribution of water level gauges to catchments, Clarence River

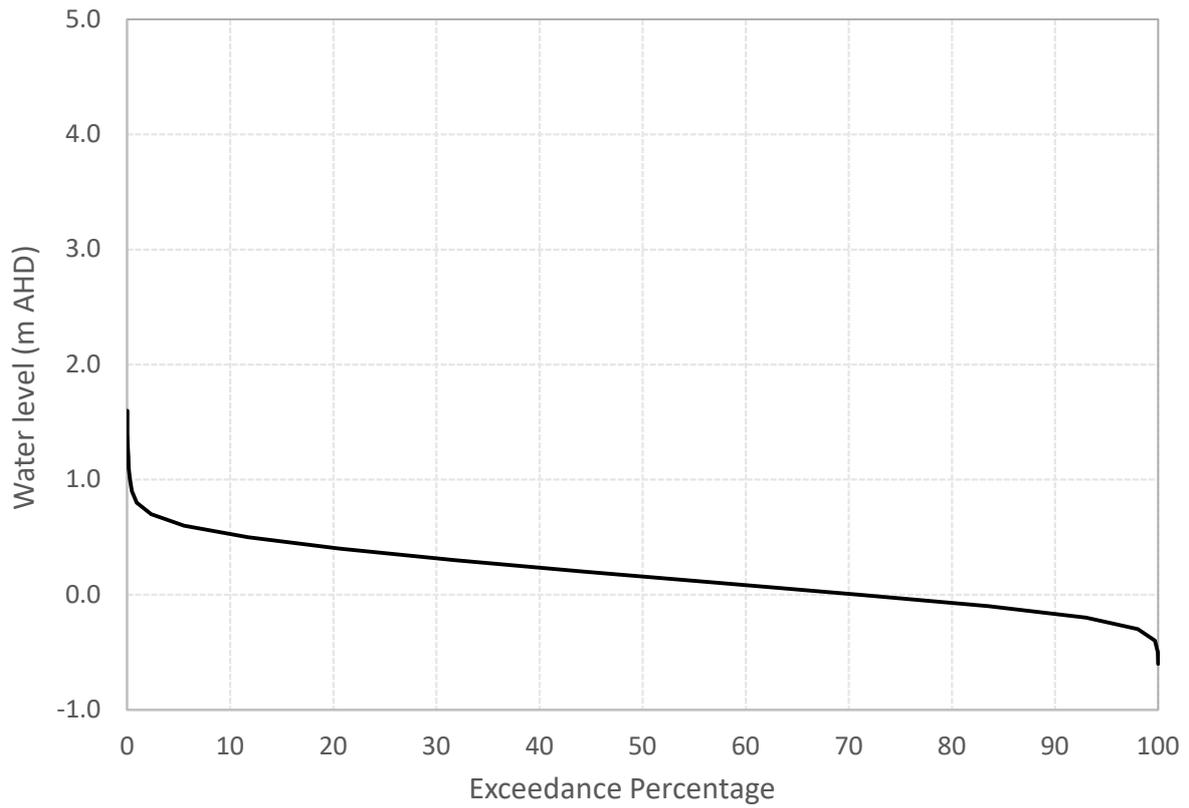
Catchment	Water level station(s) adopted
Palmers Island/Micalo Island/Yamba	Oyster Channel
Taloumbi/Palmers Channel	Palmers Island Bridge
The Freshwater	0.76 x Yamba + 0.24 x Palmers Island Bridge
Mororo/Ashby	Palmers Island Bridge + 0.46 x Maclean
Harwood/Chatsworth/Goodwood/ Warregah Islands	0.31 x Yamba + 0.69 x Palmers Island Bridge
Maclean	0.69 x Palmers Island Bridge + 0.31 x Maclean
The Broadwater	0.64 x Maclean + 0.36 x Lawrence
West Woodford Island	0.23 x Maclean + 0.77 x Lawrence
Gulmarrad/East Woodford Island	0.89 x Maclean + 0.11 x Tyndale
Shark Creek	0.65 x Maclean + 0.35 x Tyndale
Coldstream River	Tyndale
Sportsmans Creek	Lawrence
Southgate	0.46 x Brushgrove + 0.54 x Ulmarra
Alumy Creek	0.83 x Ulmarra + 0.17 x Grafton
Swan Creek	0.60 x Ulmarra + 0.40 x Grafton
South Grafton	Grafton



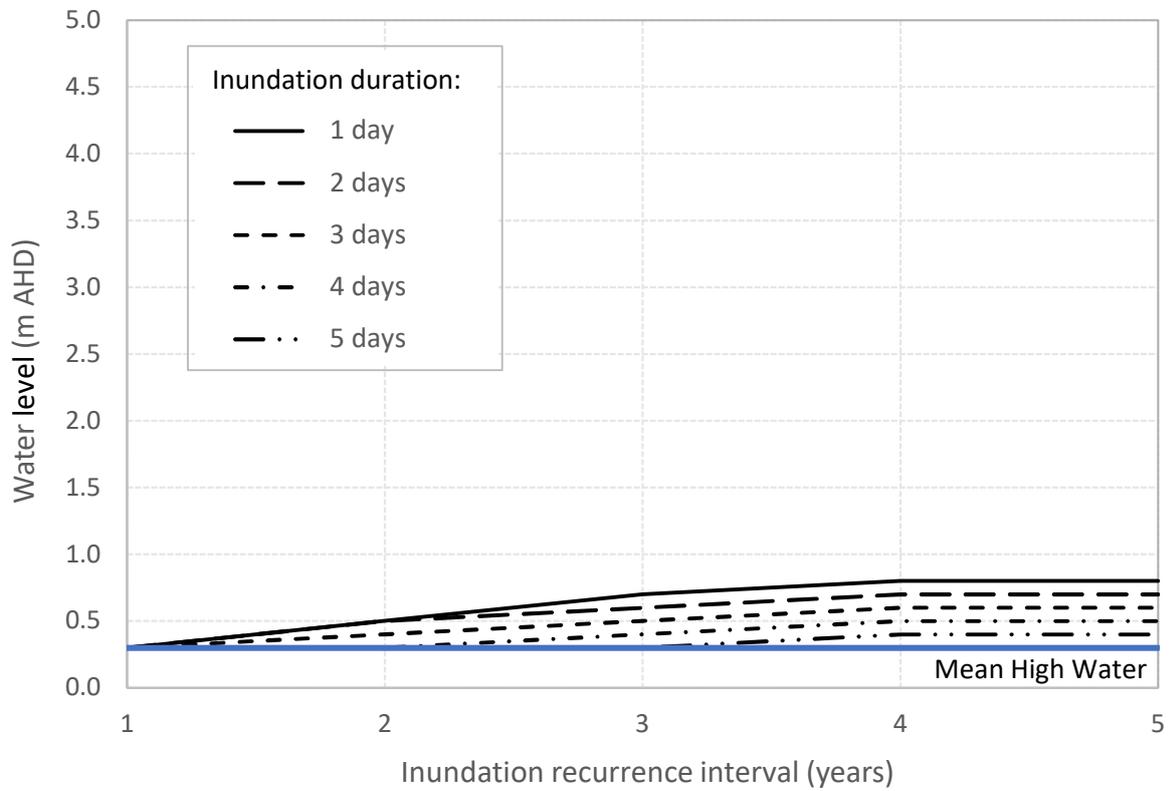
**Figure S30.** Frequency distribution of water levels at Yamba (Station 204454)



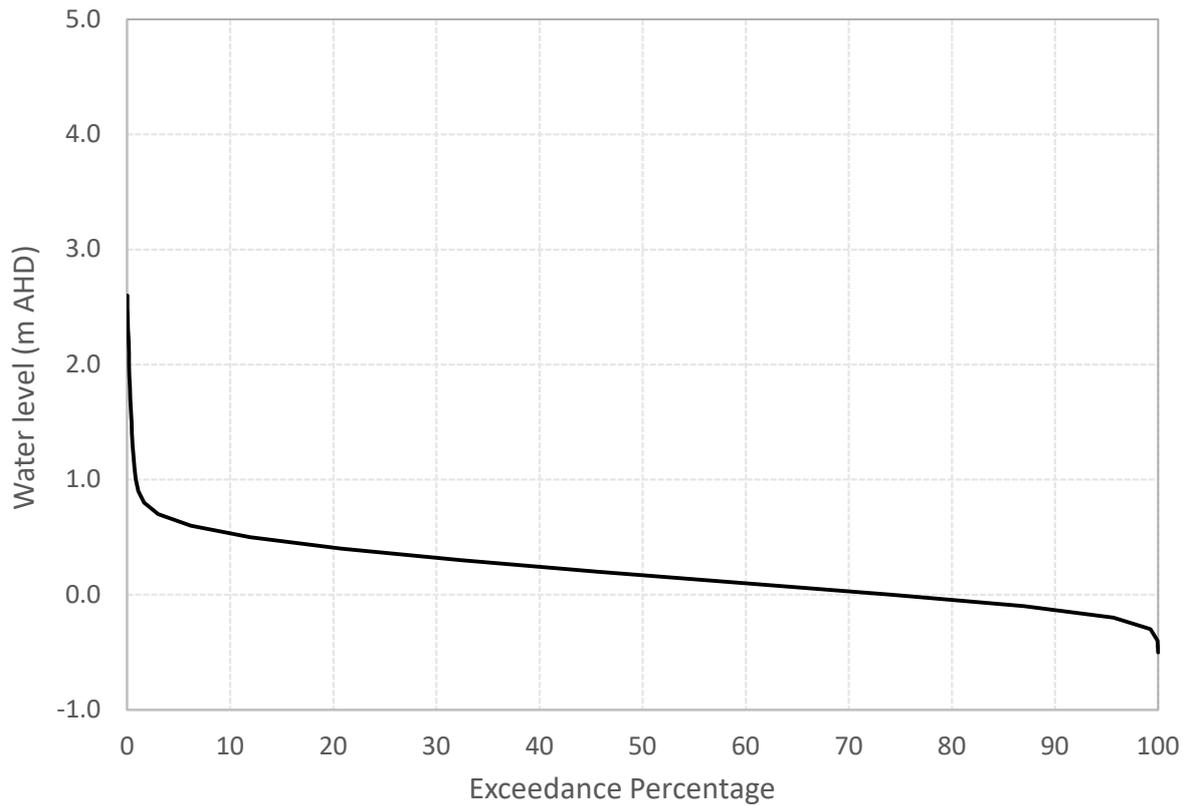
**Figure S31.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Yamba (Station 204454)



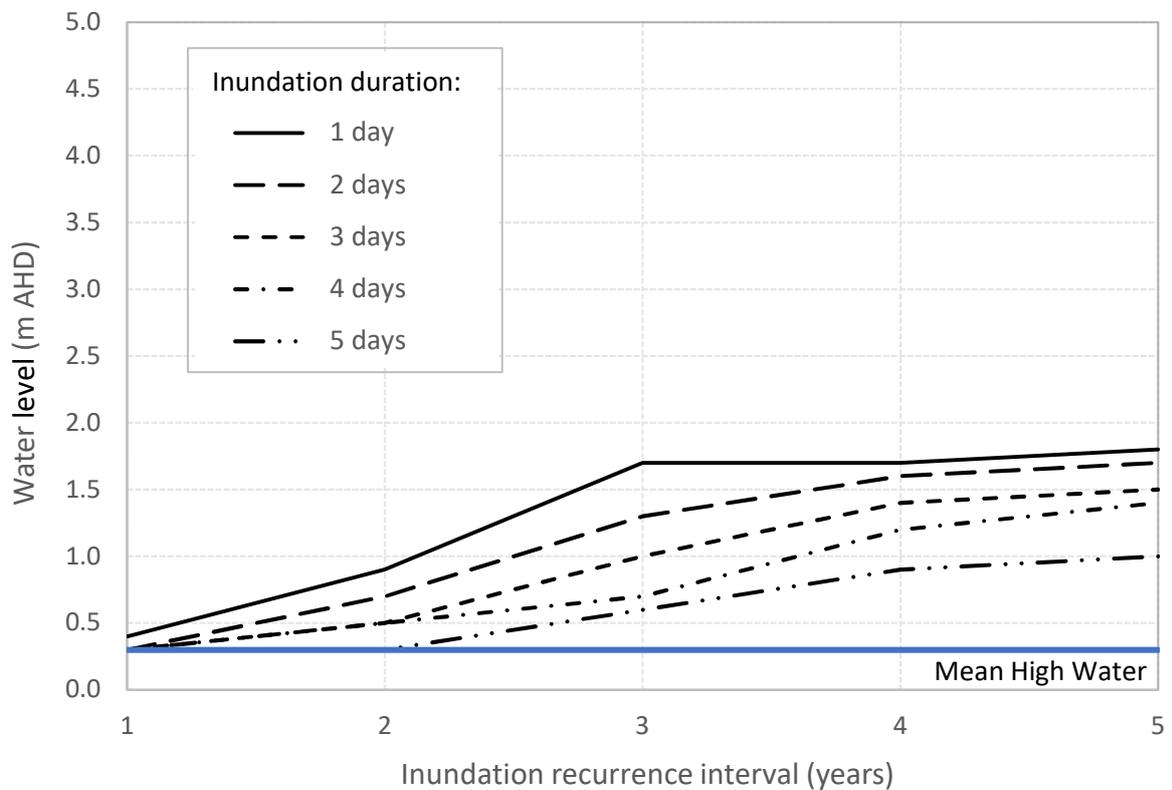
**Figure S32.** Frequency distribution of water levels at Oyster Channel (Station 204451)



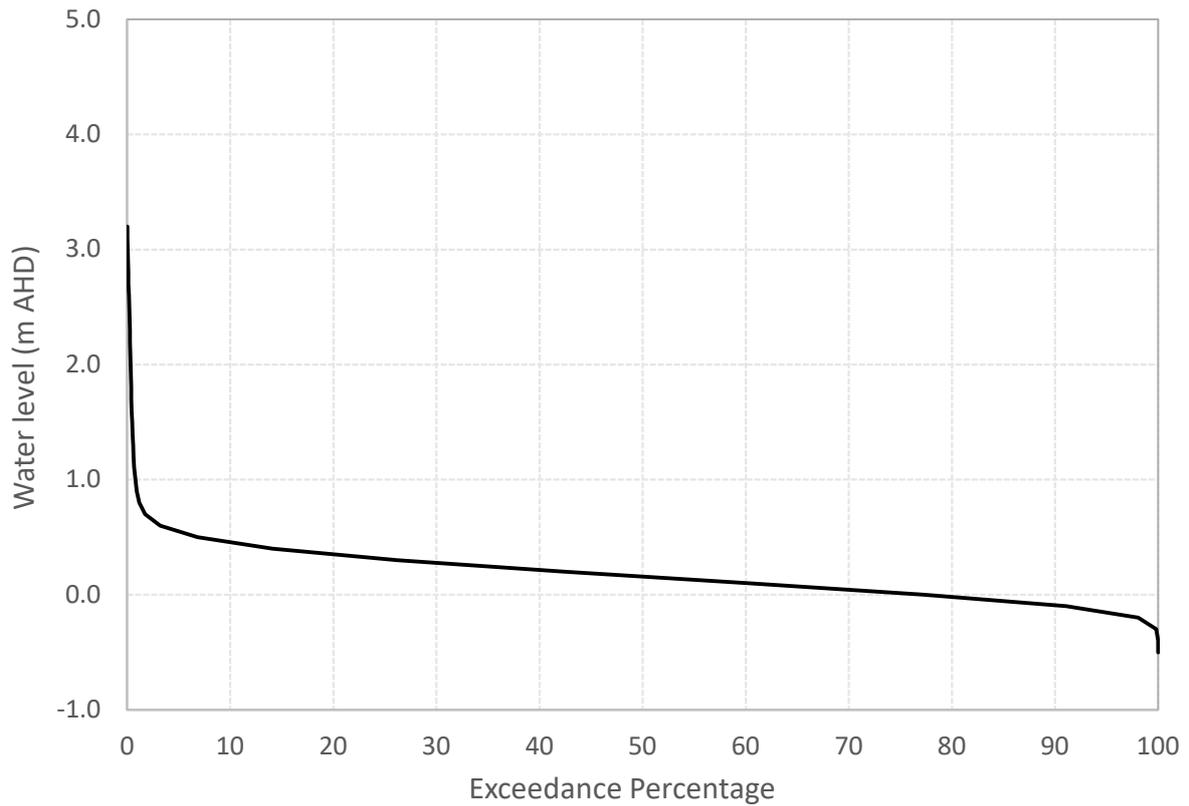
**Figure S33.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Oyster Channel (Station 204451)



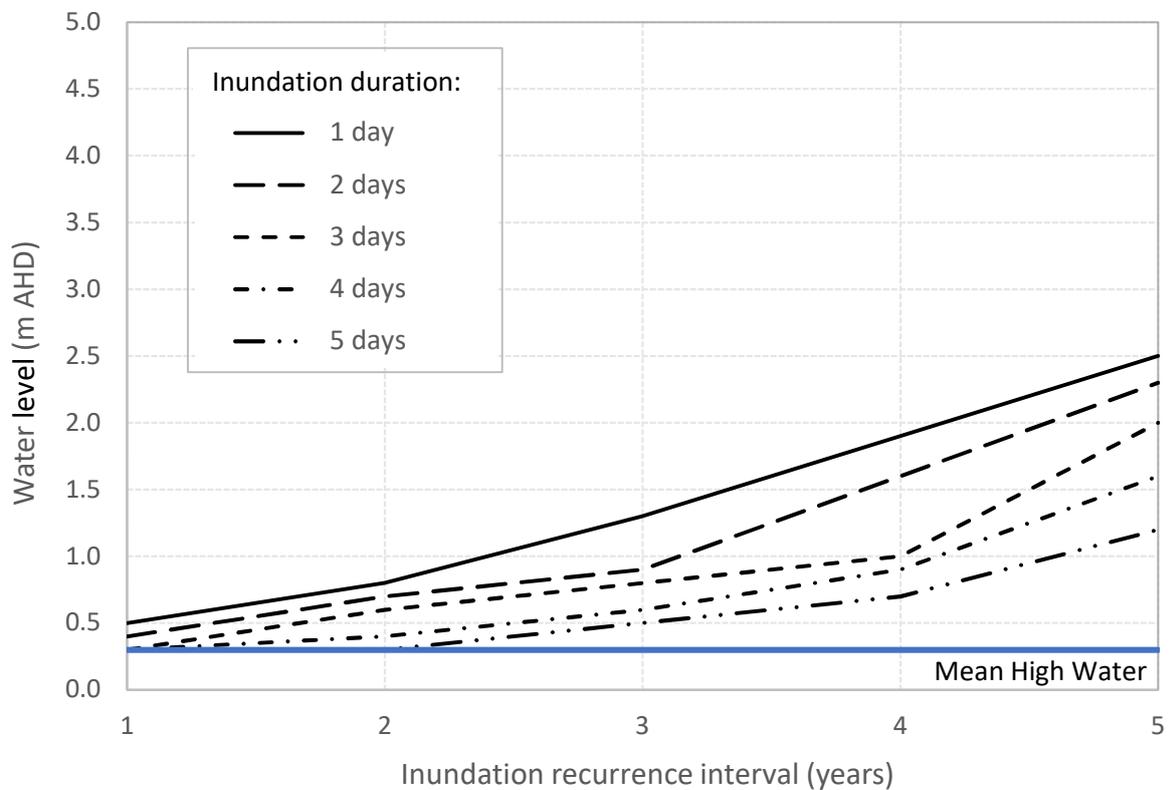
**Figure S34.** Frequency distribution of water levels at Palmers Island Bridge (Station 204426)



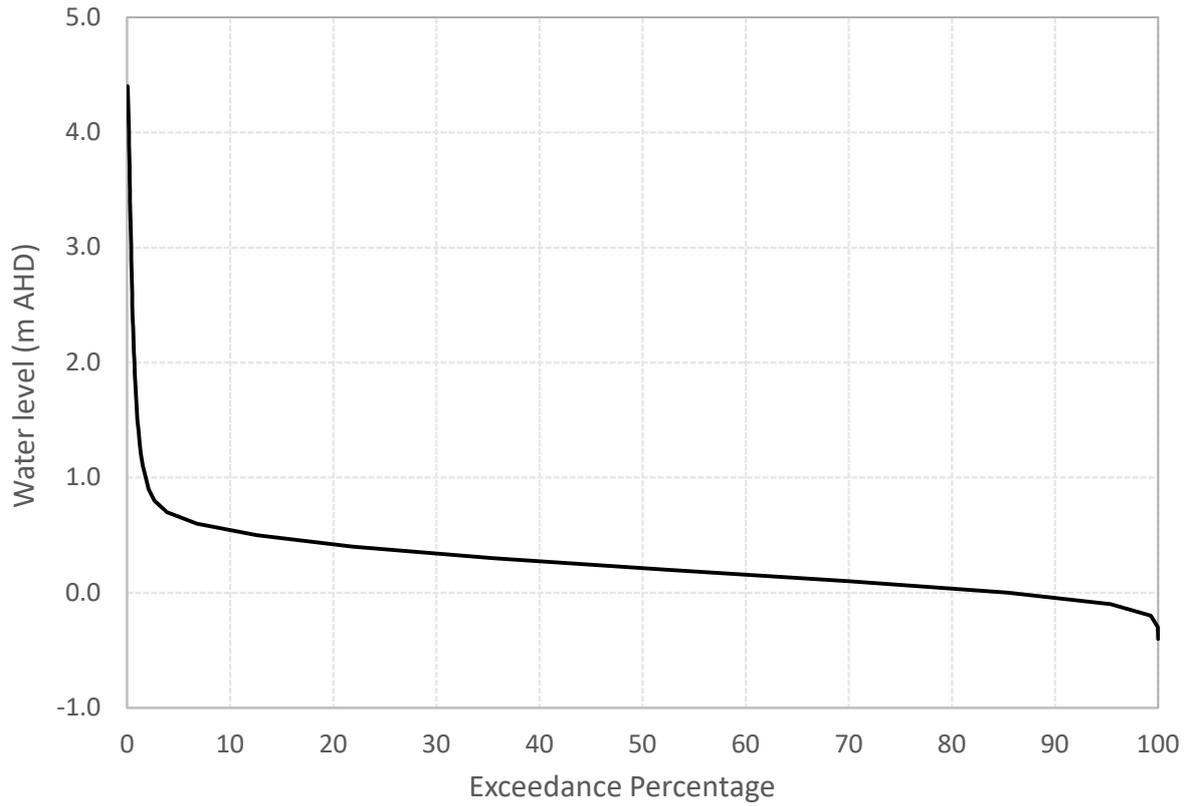
**Figure S35.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Palmers Island Bridge (Station 204426)



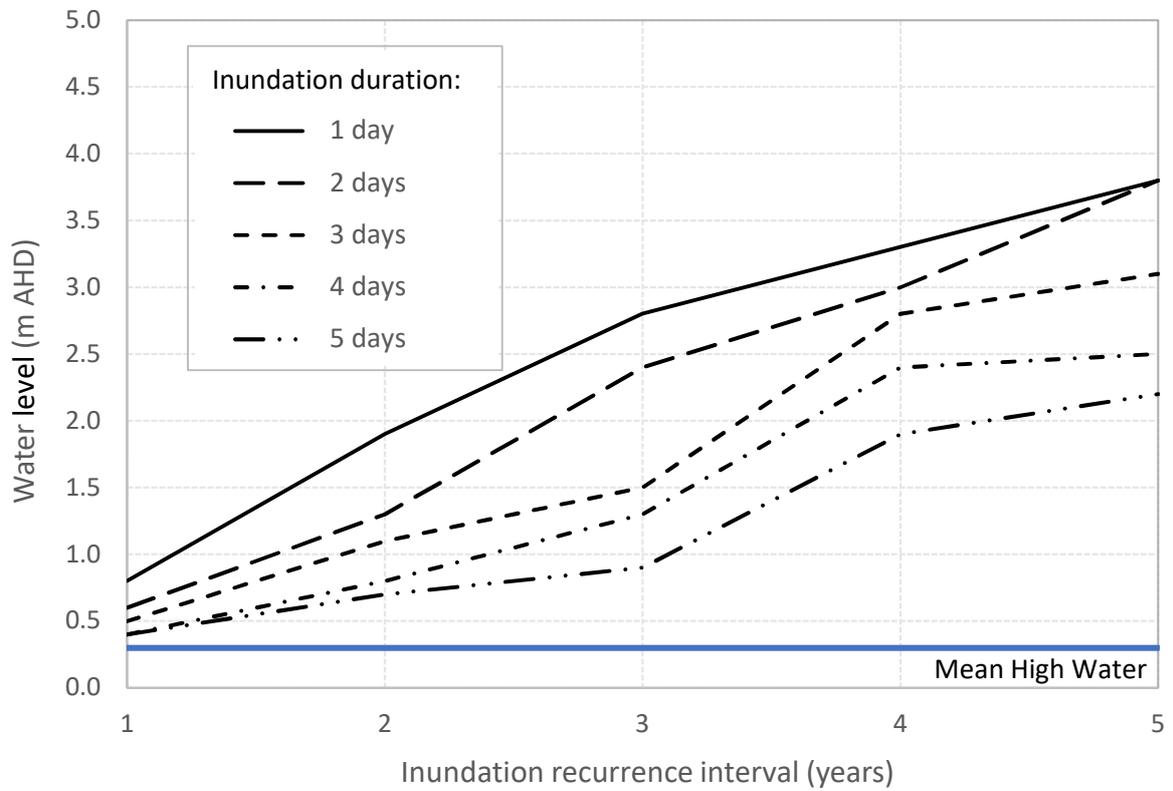
**Figure S36.** Frequency distribution of water levels at Maclean (Station 204410)



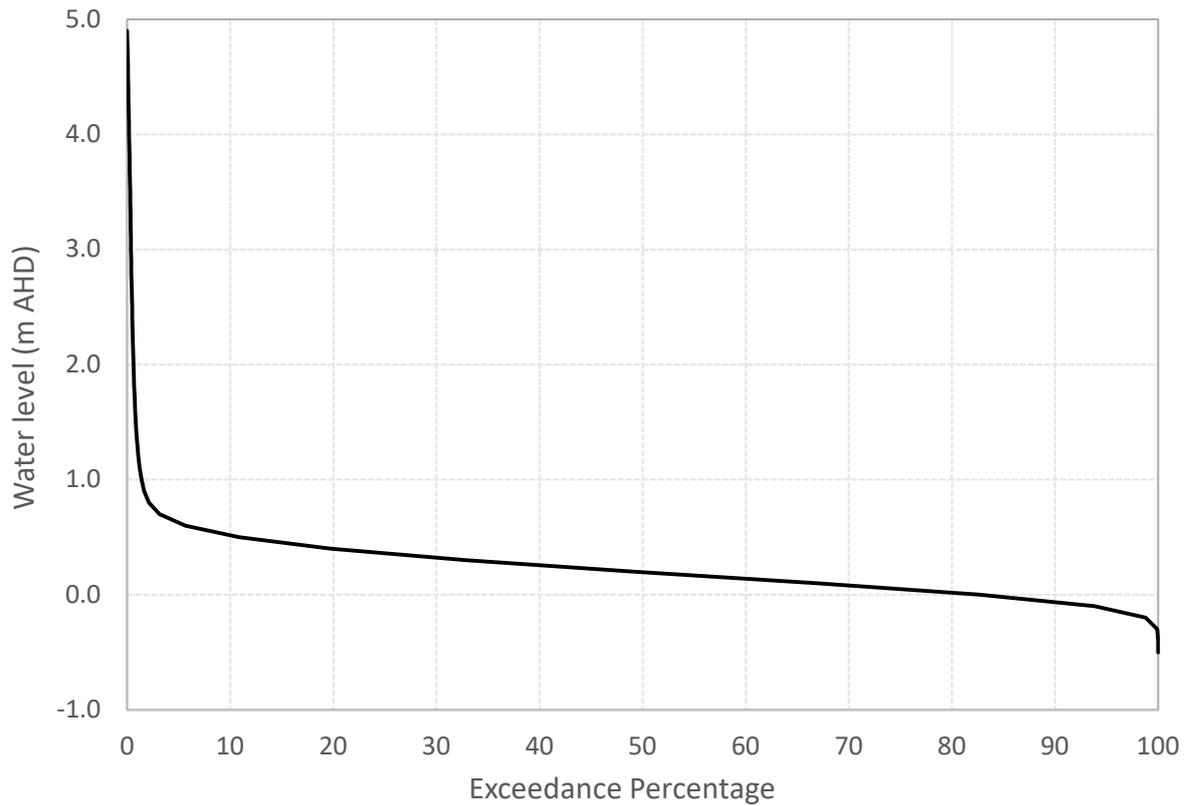
**Figure S37.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Maclean (Station 204410)



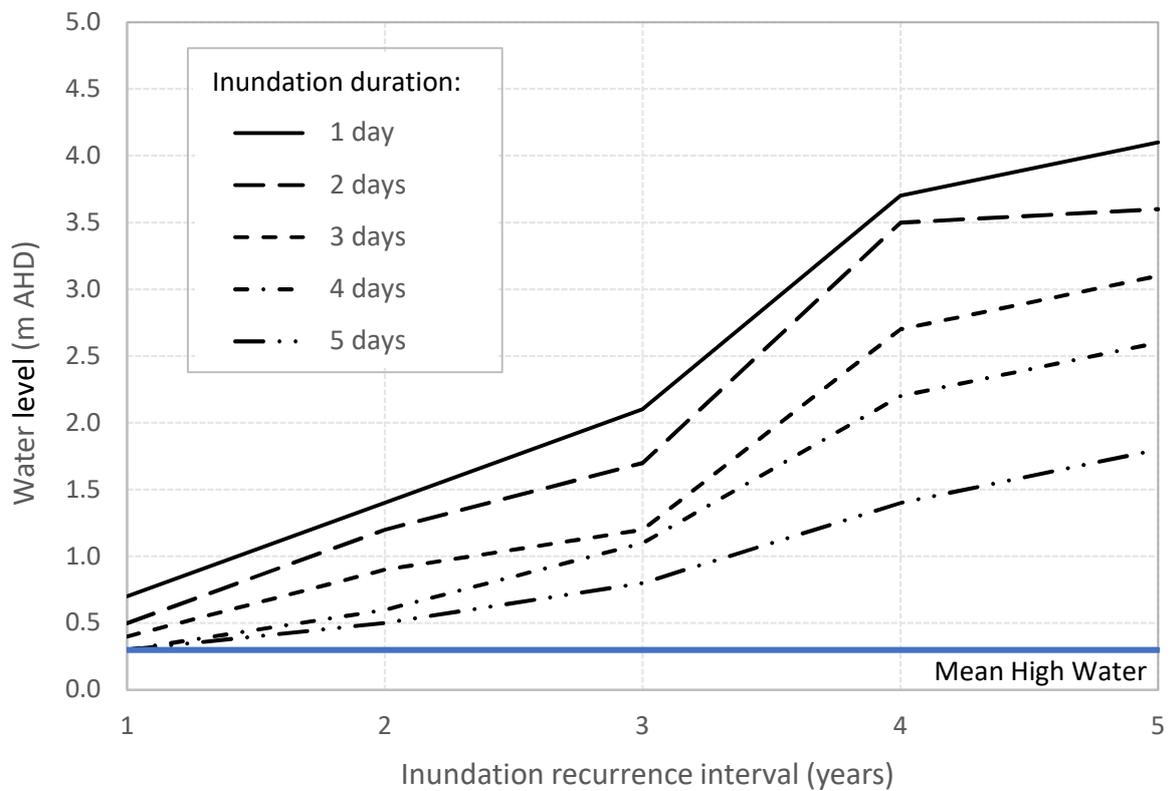
**Figure S38.** Frequency distribution of water levels at Tyndale (Station 204465)



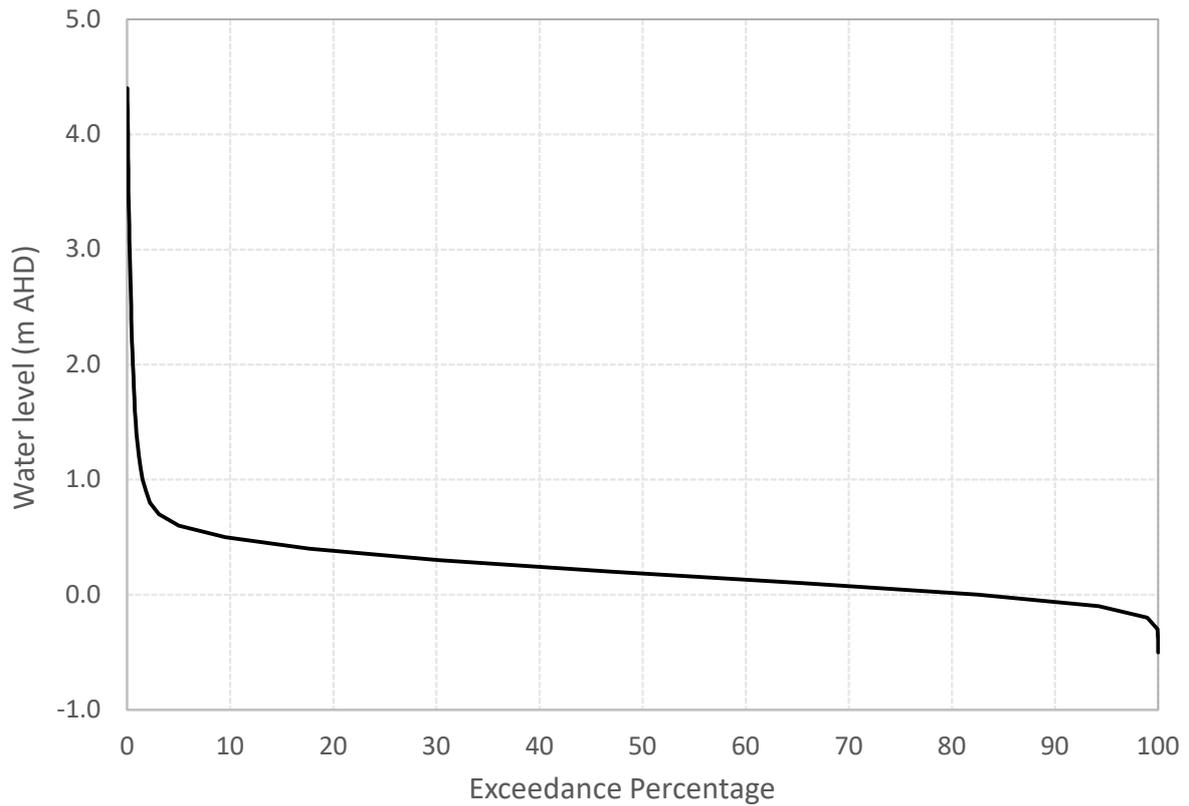
**Figure S39.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Tyndale (Station 204465)



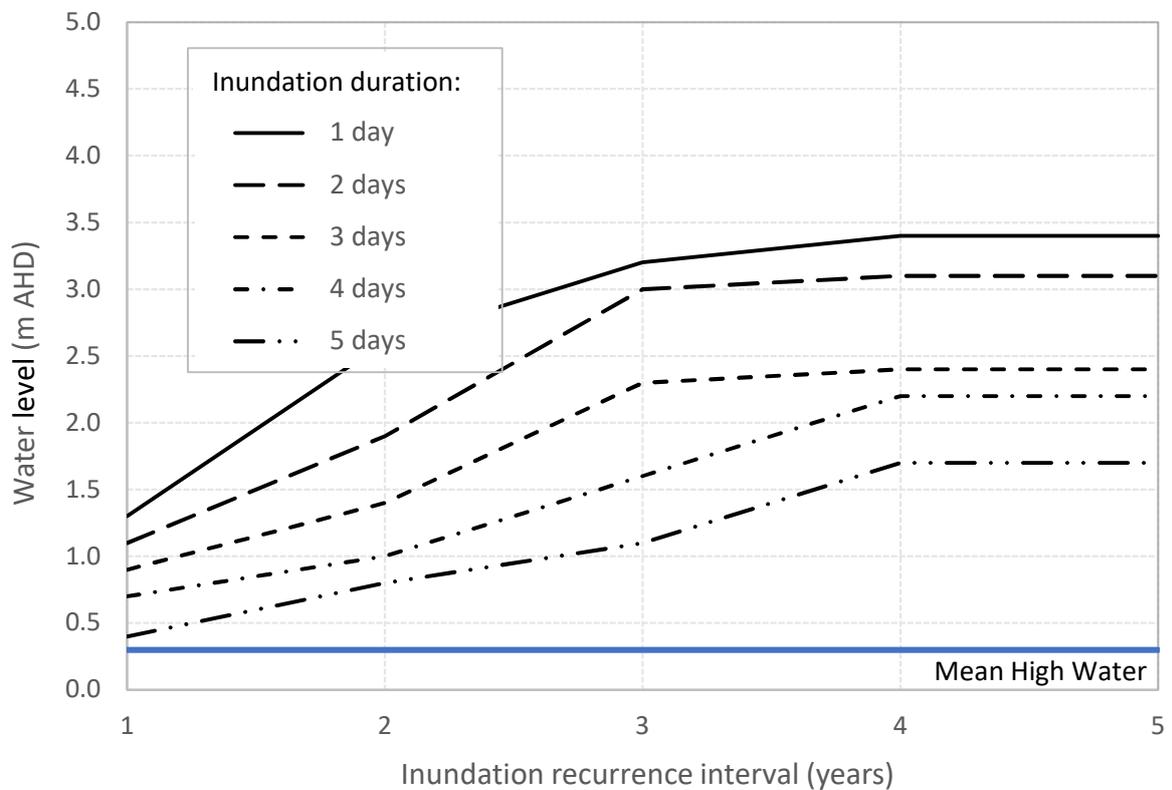
**Figure S40.** Frequency distribution of water levels at Brushgrove (Station 204406)



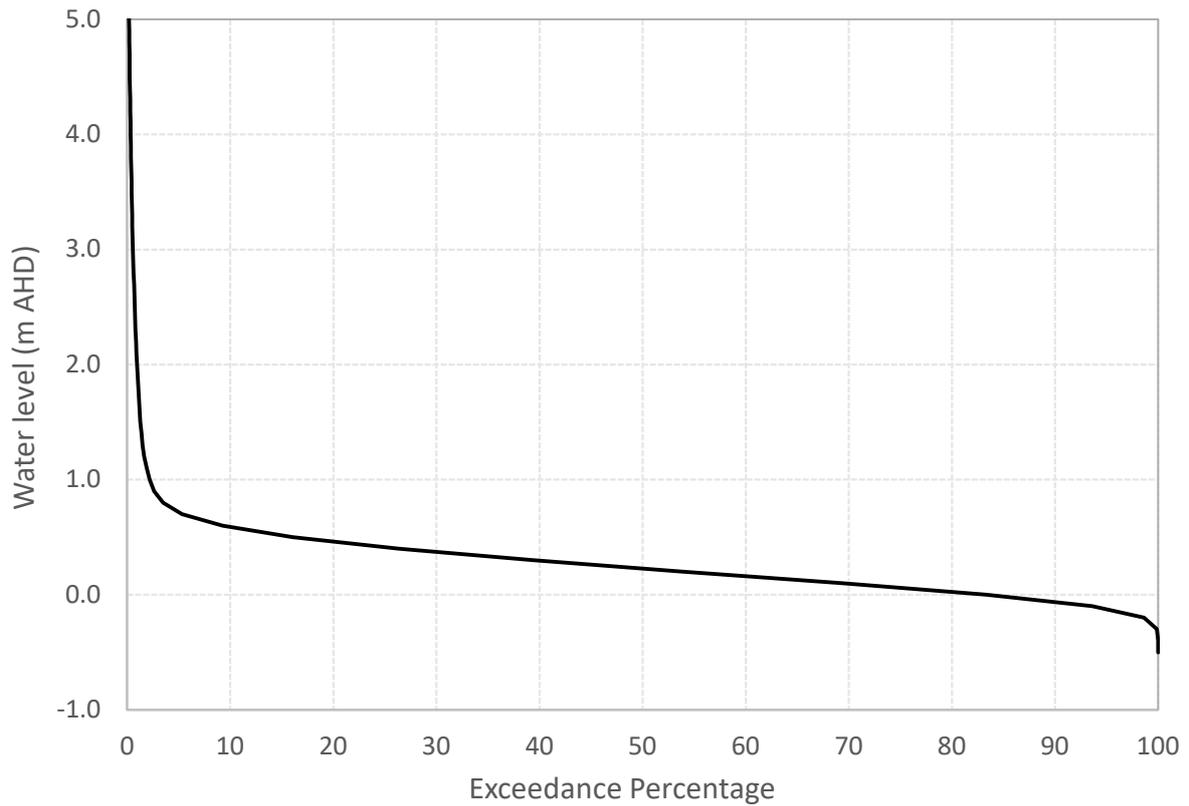
**Figure S41.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Brushgrove (Station 204406)



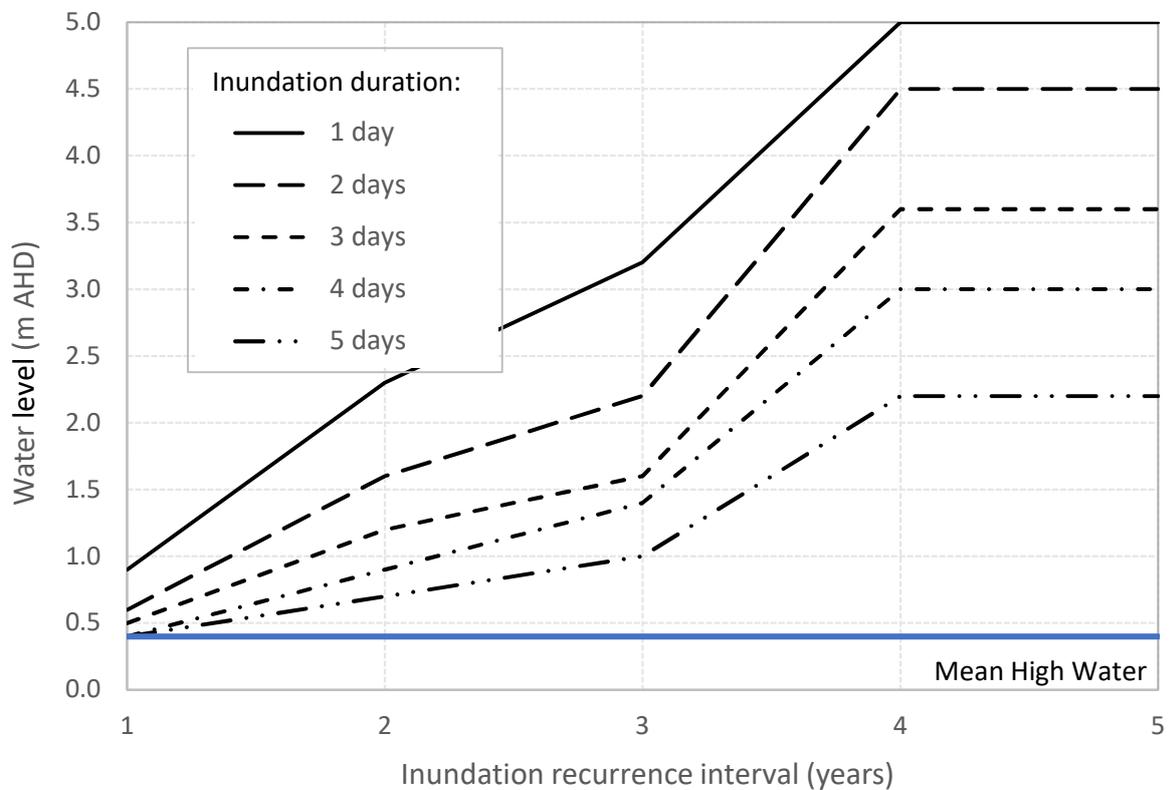
**Figure S42.** Frequency distribution of water levels at Lawrence (Station 204453)



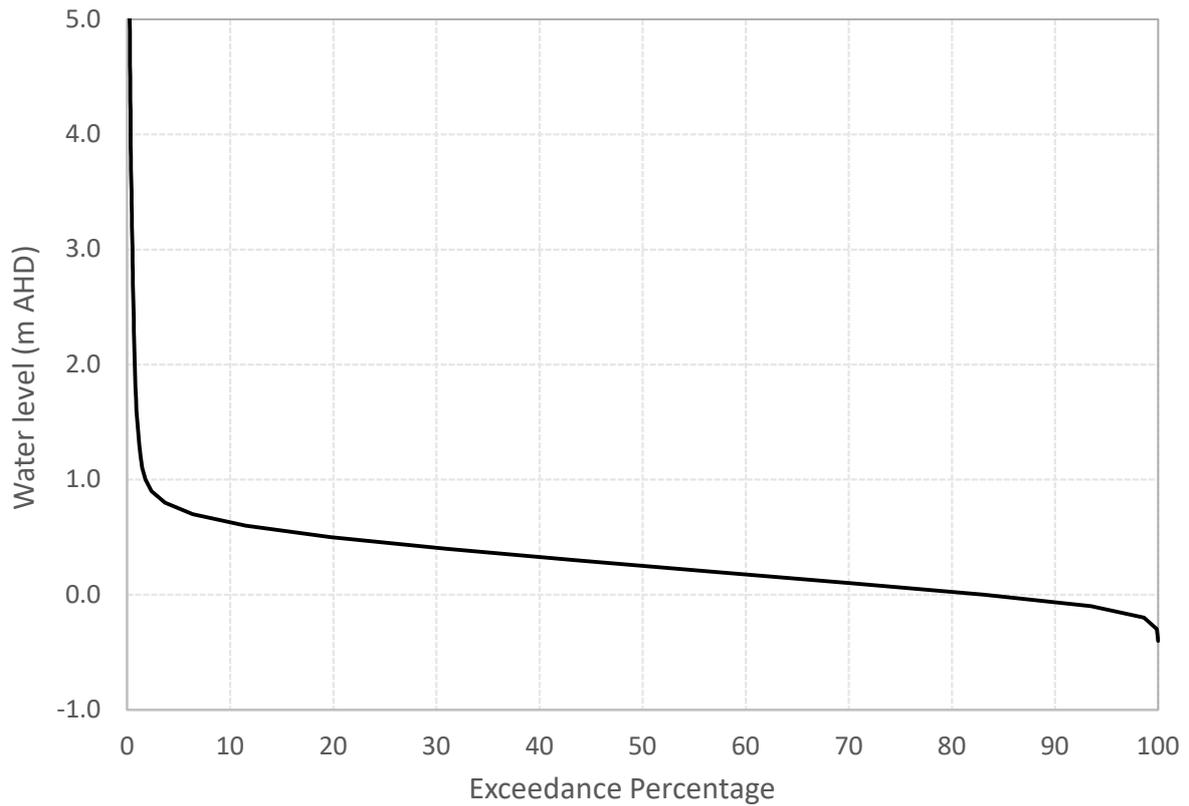
**Figure S43.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Lawrence (Station 204453)



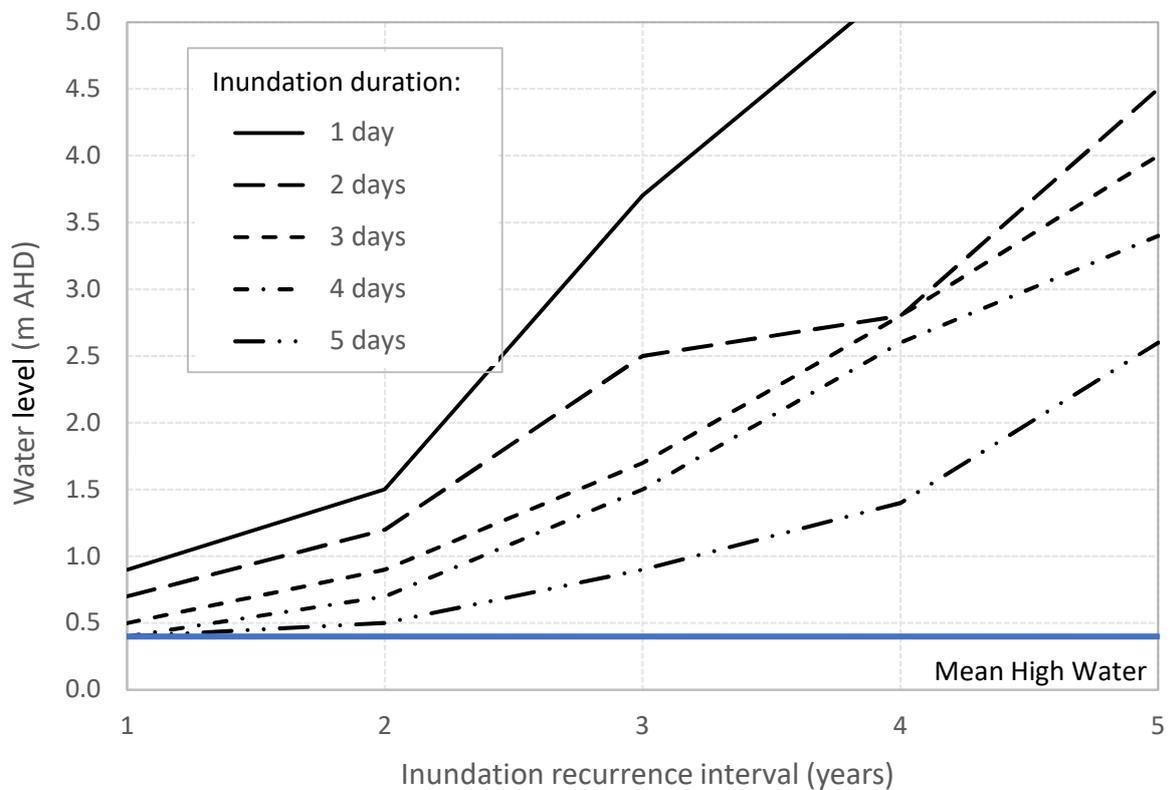
**Figure S44.** Frequency distribution of water levels at Ulmarra (Station 204480)



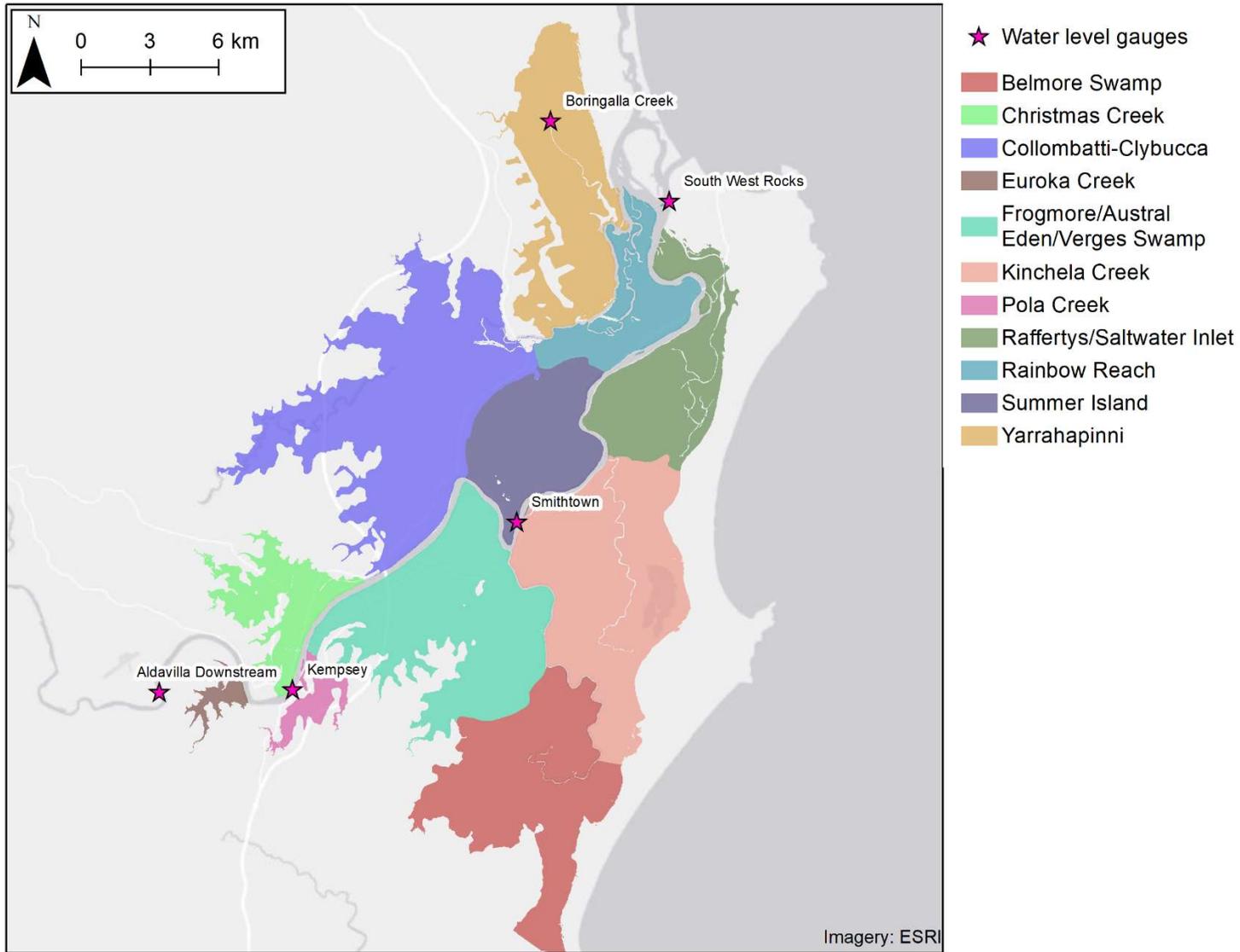
**Figure S45.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Ulmarra (Station 204480)



**Figure S46.** Frequency distribution of water levels at Grafton (Station 204400)



**Figure S47.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Grafton (Station 204400)



**Figure S48.** Water level gauge locations, Macleay River

**Table S8.** Details of water level gauges, Macleay River

Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
South West Rocks (206456)	31.4	0.5	0.5*	0.5
Borigala Creek (206450)	11.9	N/A***	1.1	1.1
Smithtown (206406)	33.2	0.4	1.1	3.7
Kempsey (206402)	35.3	0.5	2.2	5.6
Aldavilla Downstream (206459)	11.9	0.5	1.4	6.7

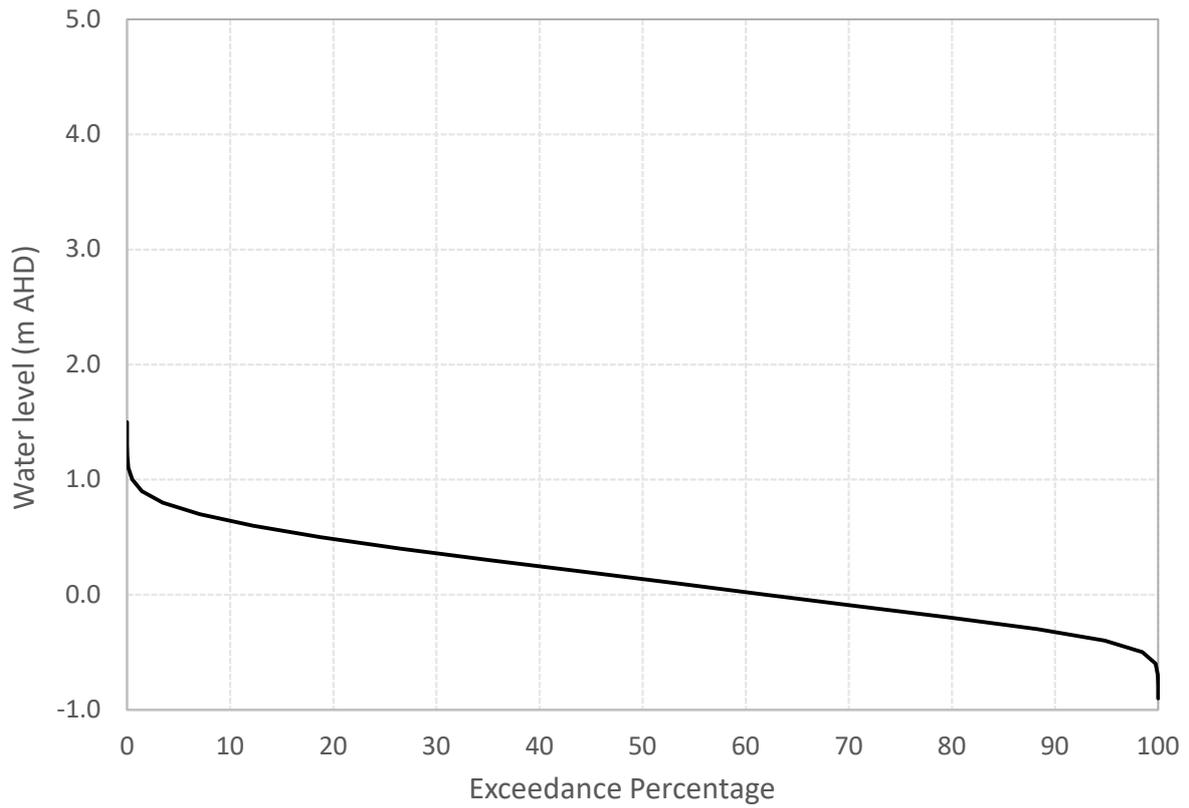
\* Mean High Water adopted as minimum blackwater inundation level

\*\* Excluding data gaps in excess of 6 hours

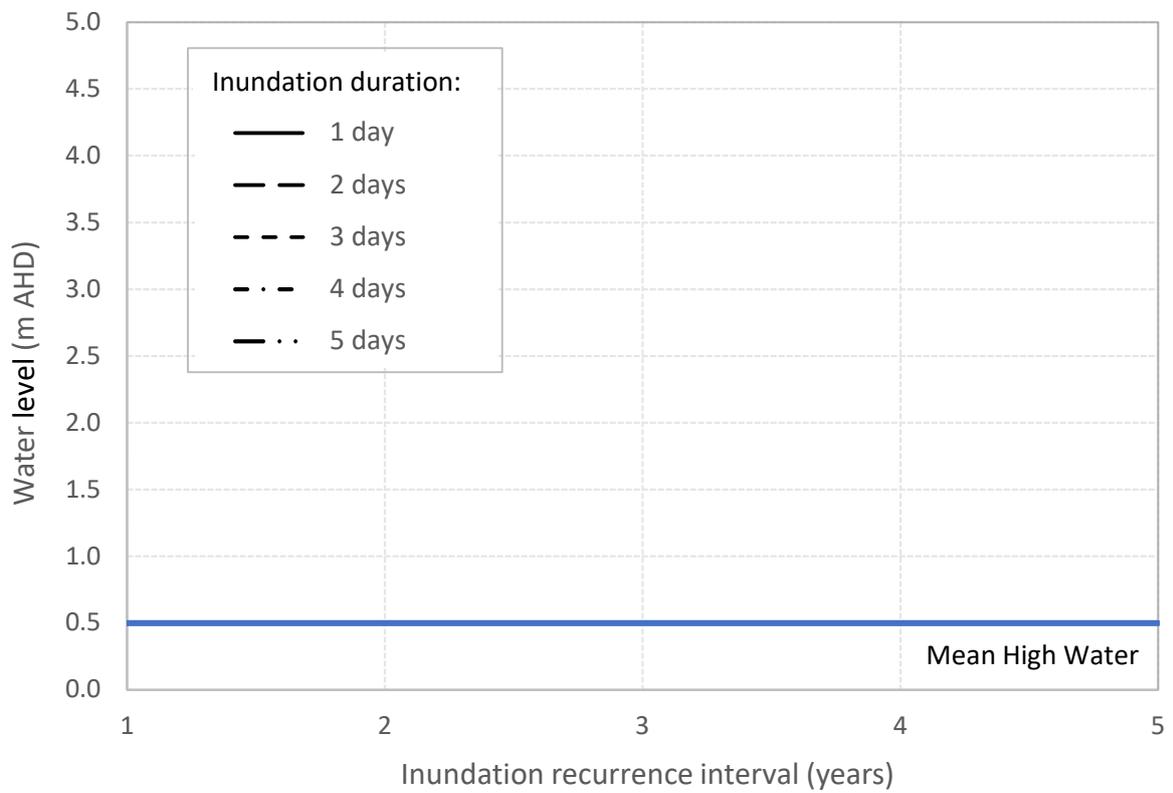
\*\*\* Minimum level of 0.5 assumed from South West Rocks.

**Table S9.** Distribution of water level gauges to catchments, Macleay River

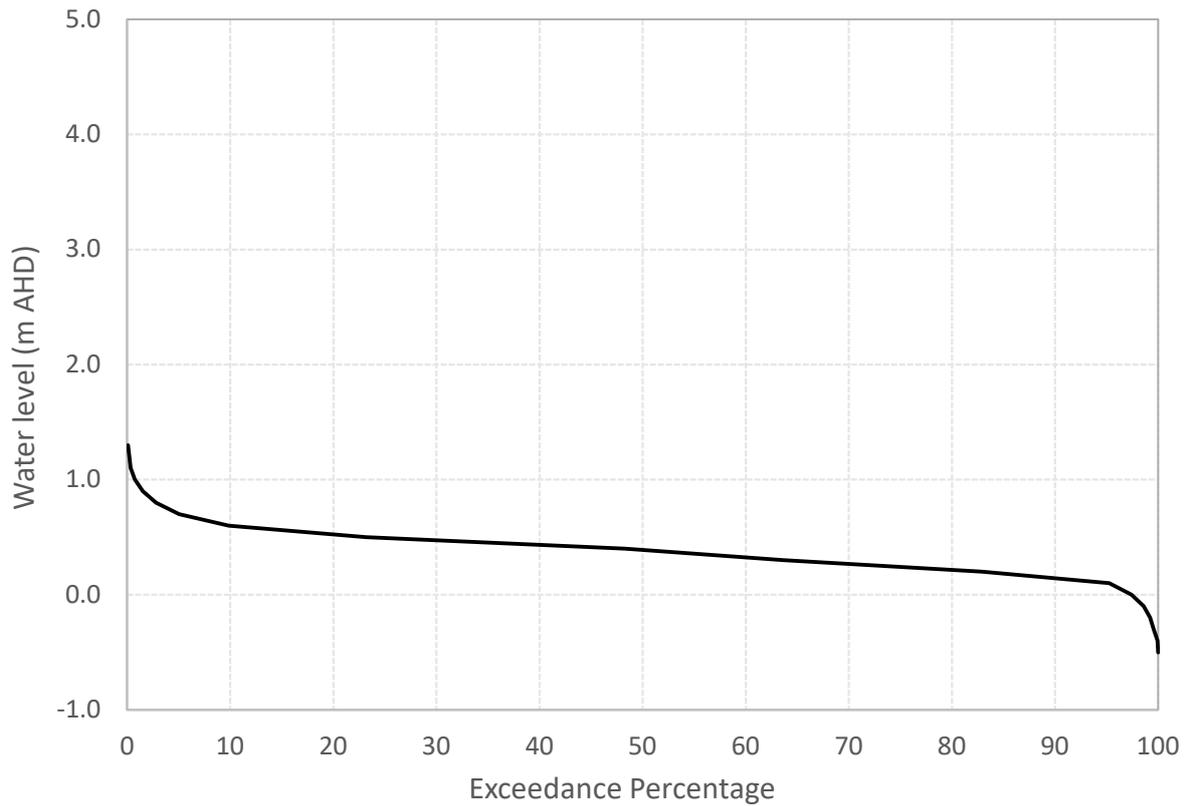
Catchment	Water level station(s) adopted
Belmore Swamp*	Assumed to be the same as Frogmore-Austral Eden-Verges Swamp
Christmas Creek	0.33 x Smithtown + 0.67 x Kempsey
Collombatti-Clybucca*	Assumed to be the same as Yarrahapinni
Euroka Creek	0.77 x Kempsey + 0.23 x Aldavilla Downstream
Frogmore-Austral/Eden-Verges Swamp	0.92 x Smithtown + 0.08 x Kempsey
Kinchela Creek	0.23 x South West Rocks + 0.77 x Smithtown
Pola Creek	0.09 x Smithtown + 0.91 x Kempsey
Raffertys-Saltwater Inlet	0.50 x South West Rocks + 0.50 x Smithtown
Rainbow Reach	0.82 x South West Rocks + 0.18 x Smithtown
Summer Island	0.35 x South West Rocks + 0.65 x Smithtown
Yarrahapinni	Borigala Creek



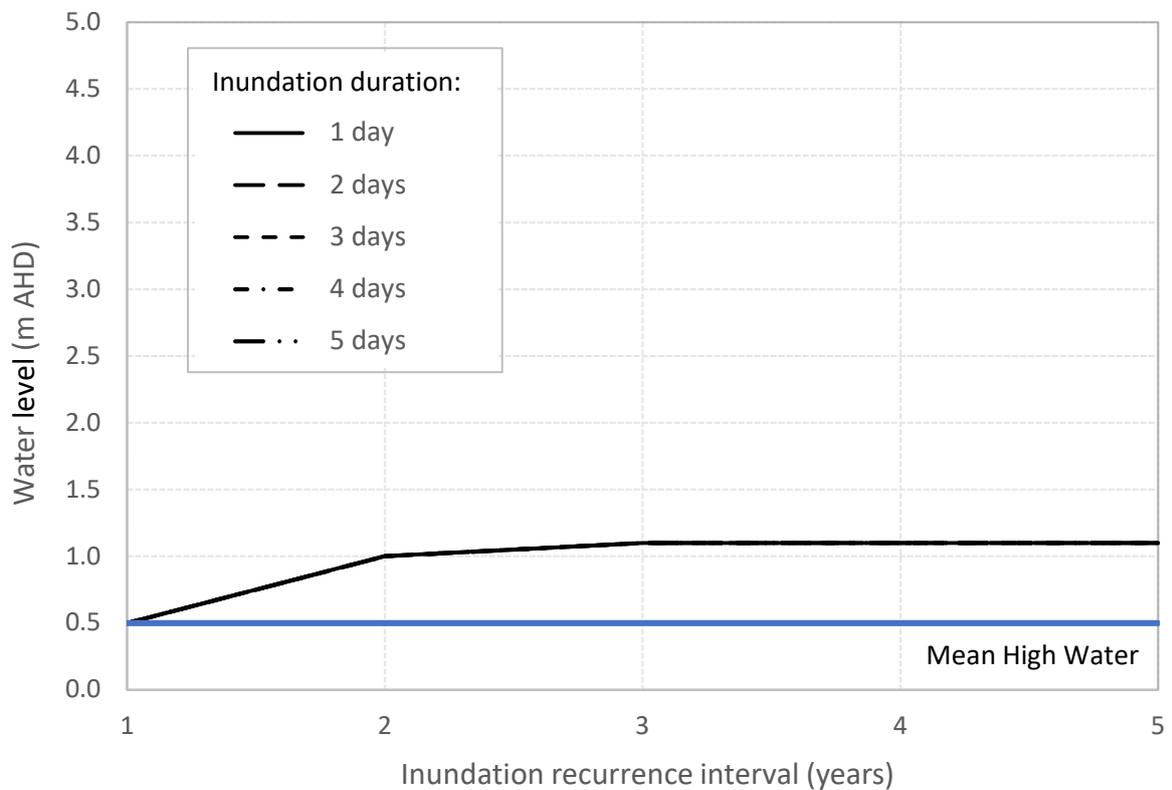
**Figure S49.** Frequency distribution of water levels at South West Rocks (Station 20646)



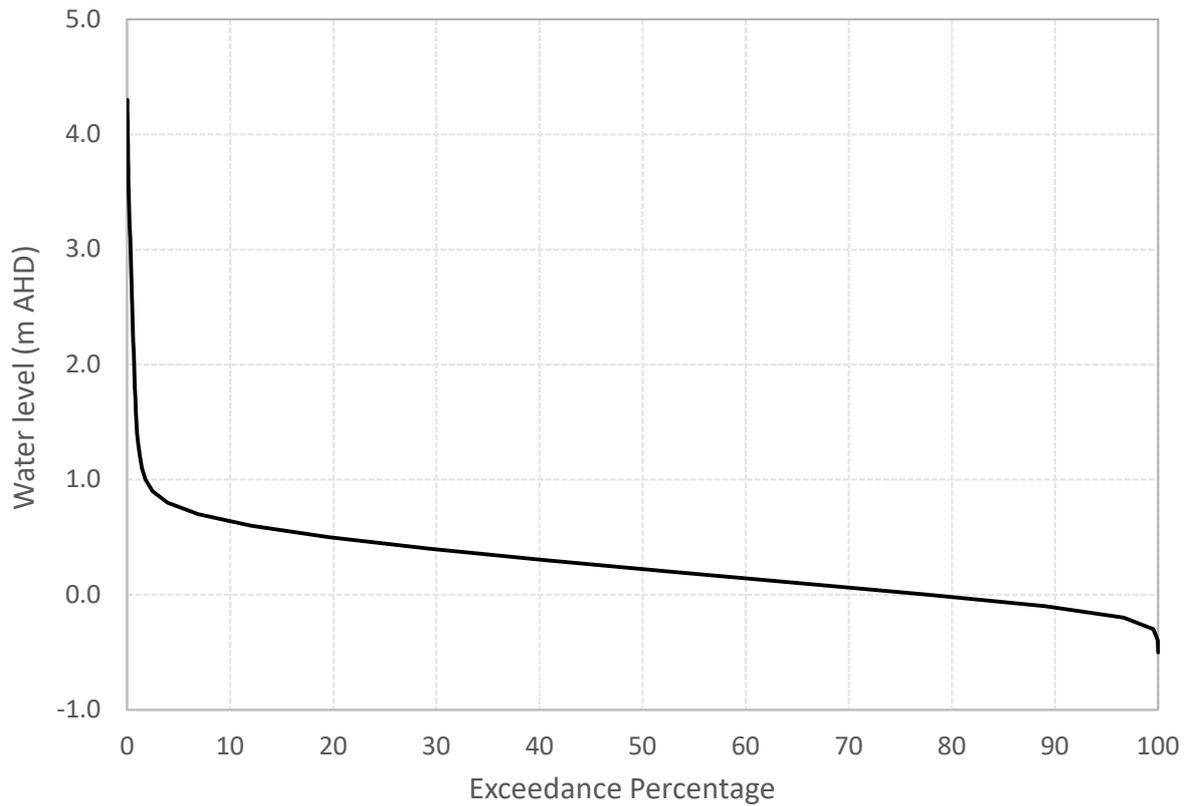
**Figure S50.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for South West Rocks (Station 20646)



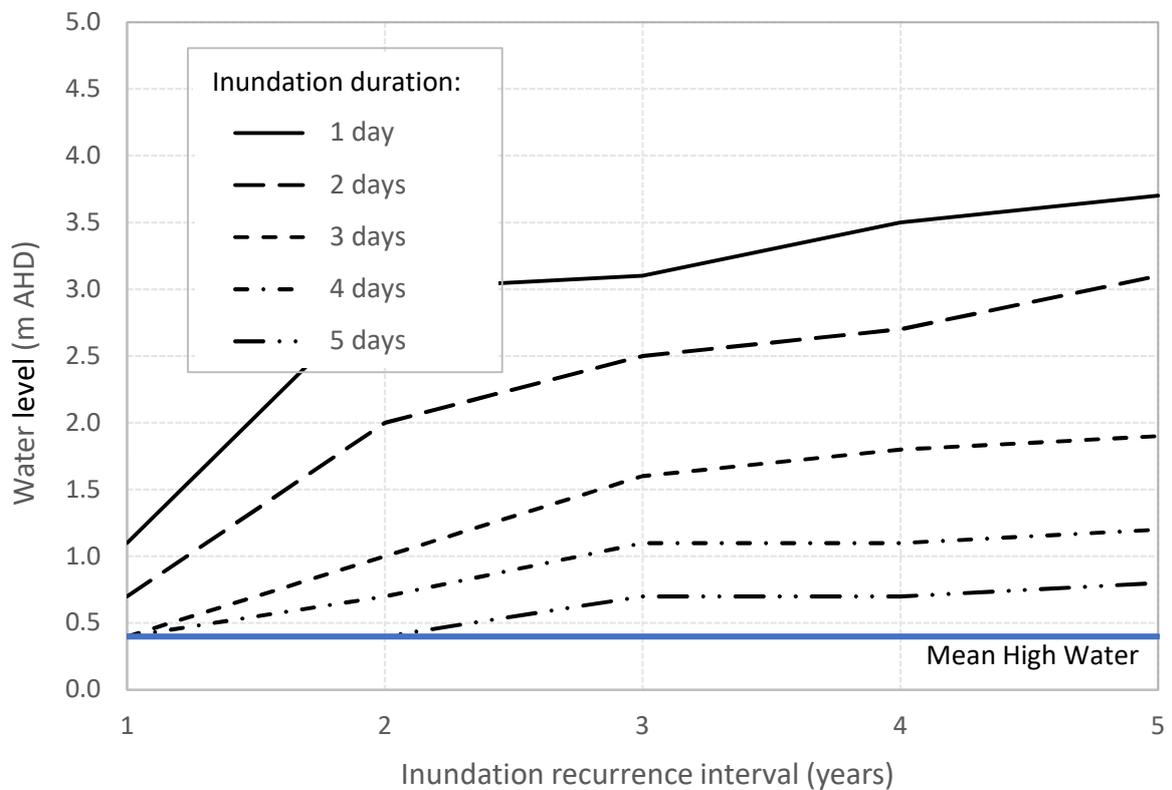
**Figure S51.** Frequency distribution of water levels at Borigala Creek (Station 206450)



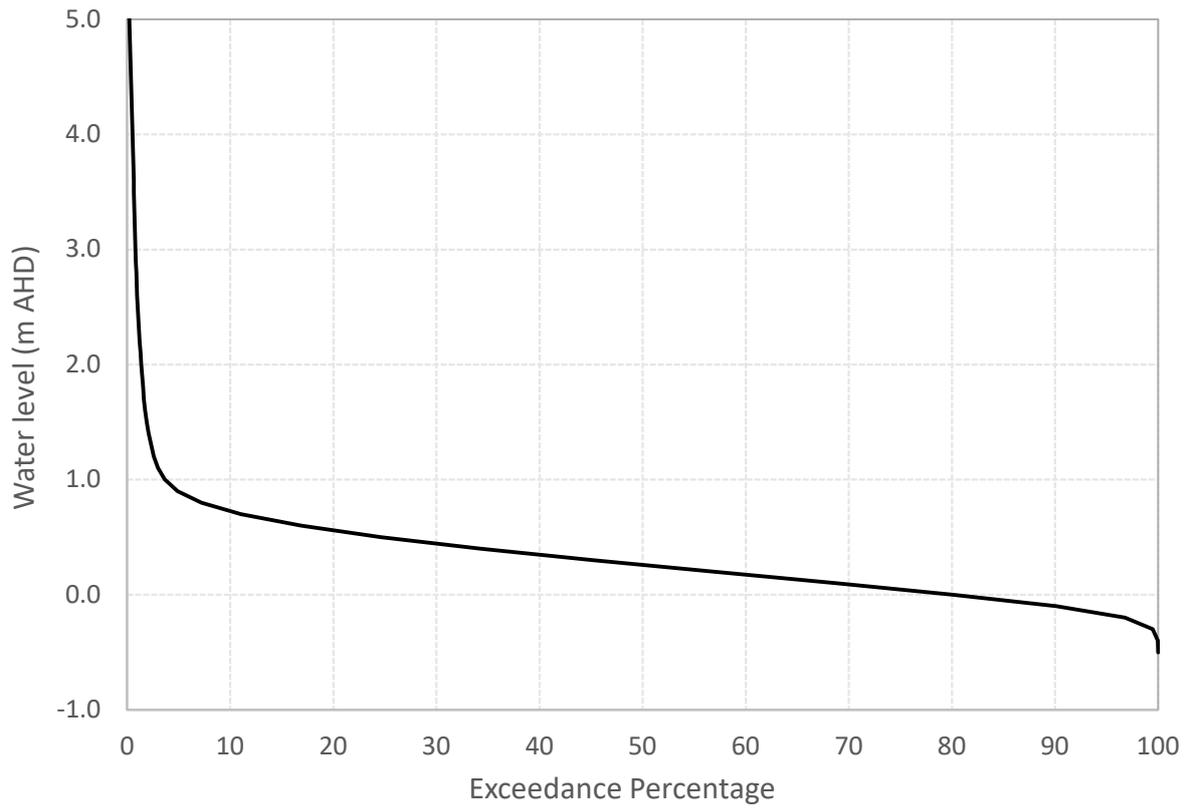
**Figure S52.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Borigala Creek (Station 206450)



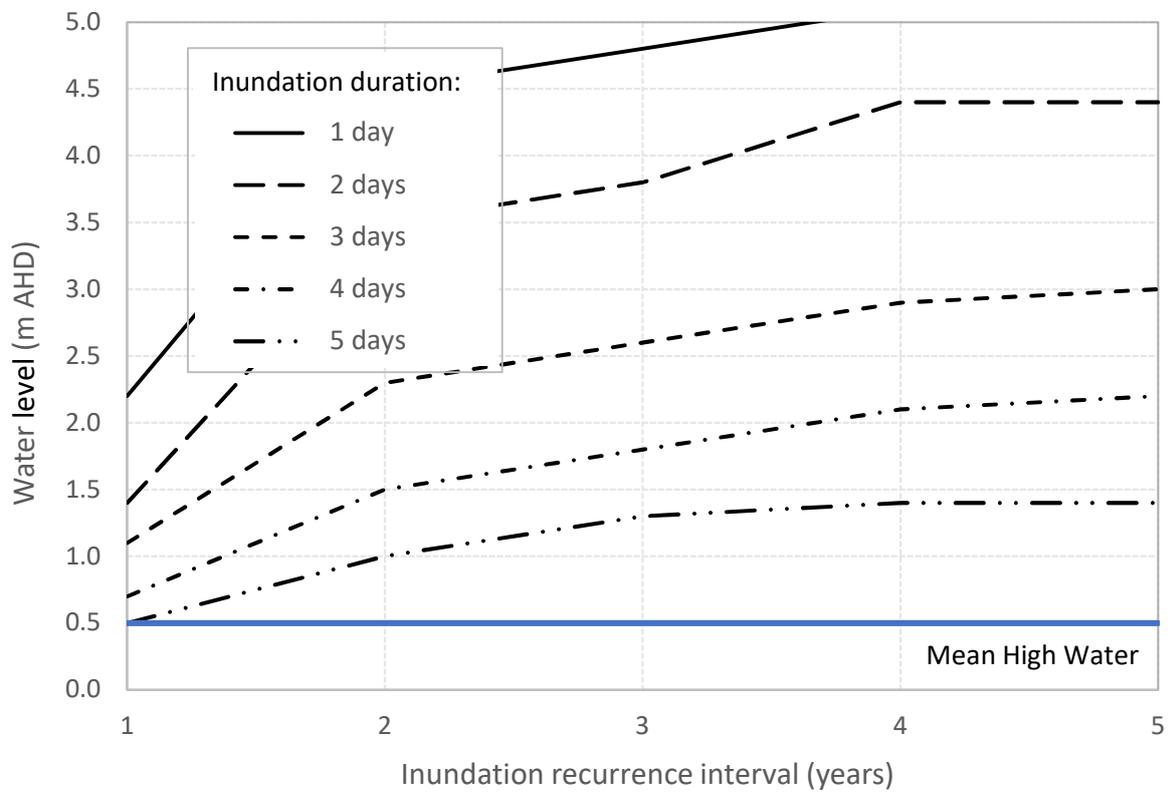
**Figure S53.** Frequency distribution of water levels at Smithtown (Station 206406)



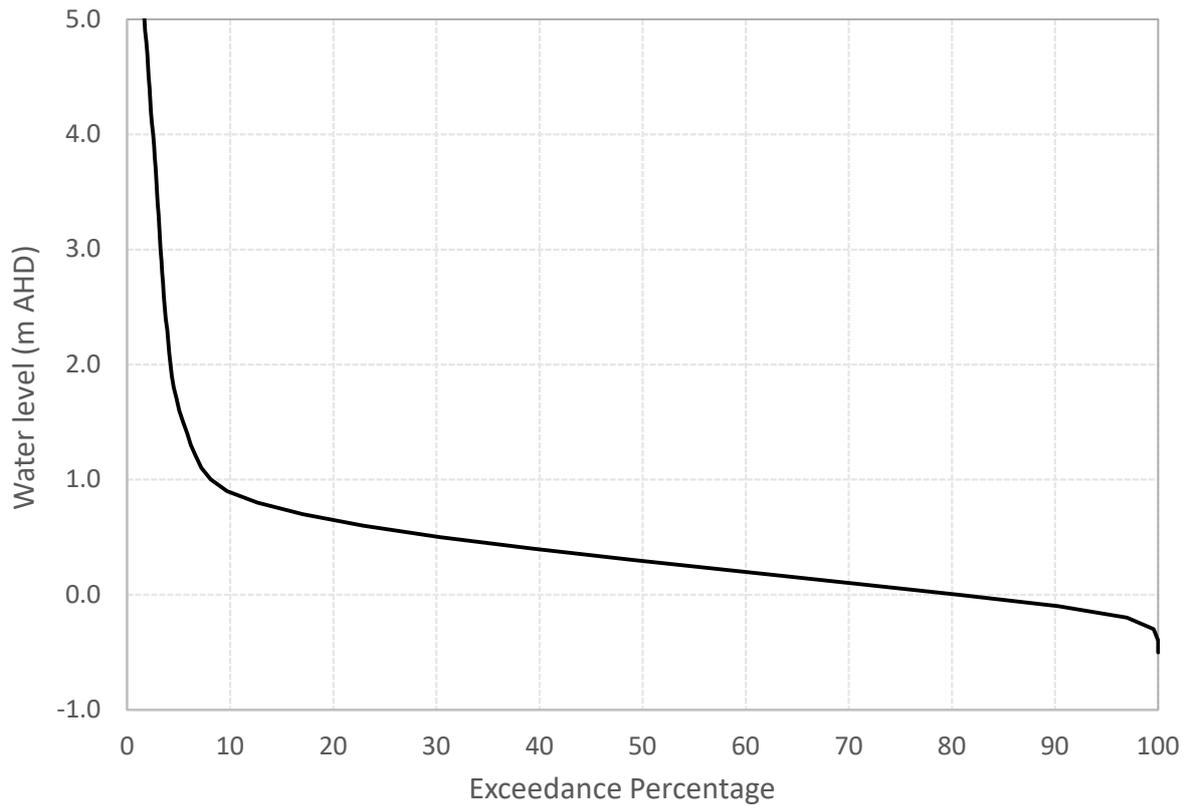
**Figure S54.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Smithtown (Station 206406)



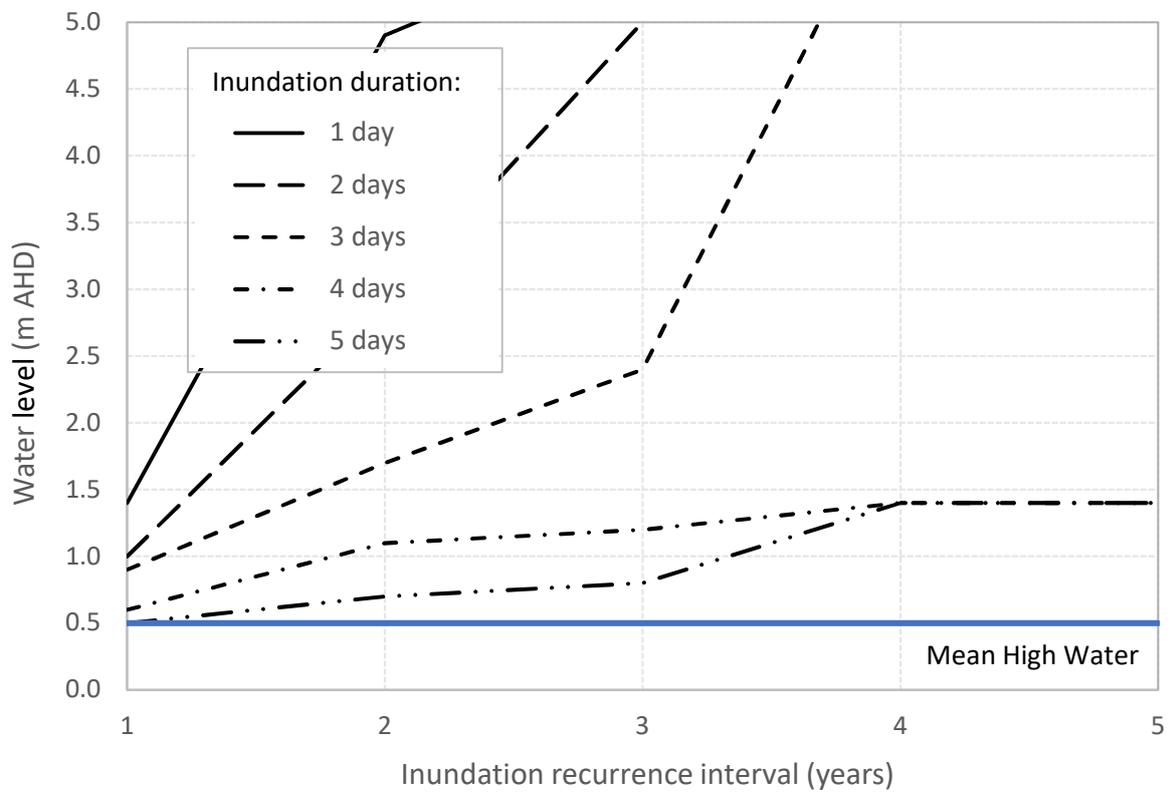
**Figure S55.** Frequency distribution of water levels at Kempsey (Station 206402)



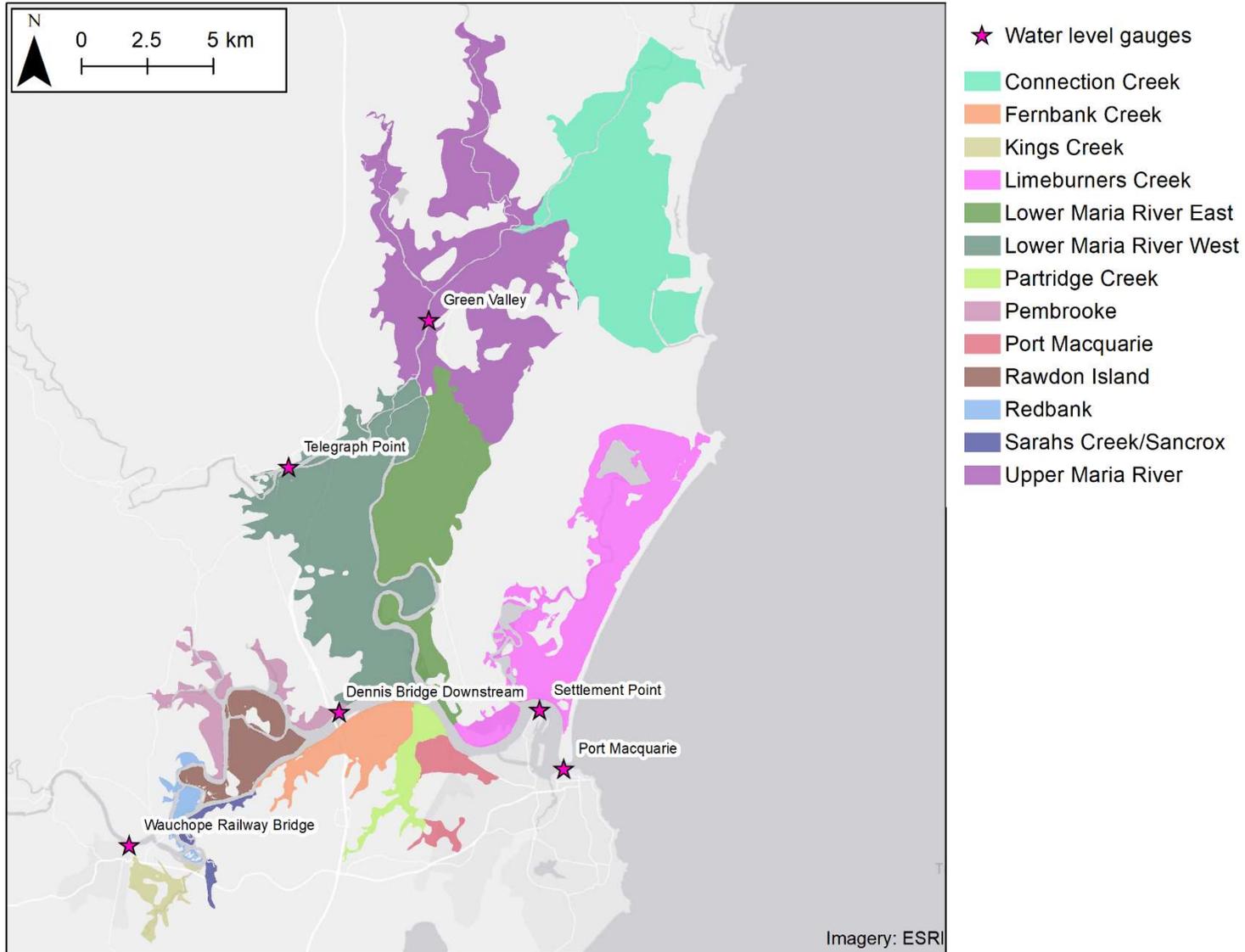
**Figure S56.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Kempsey (Station 206402)



**Figure S57.** Frequency distribution of water levels at Aldavilla Downstream (Station 206459)



**Figure S58.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Aldavilla Downstream (Station 206459)



**Figure S59.** Water level gauge locations, Hastings River

**Table S10.** Details of water level gauges, Hastings River

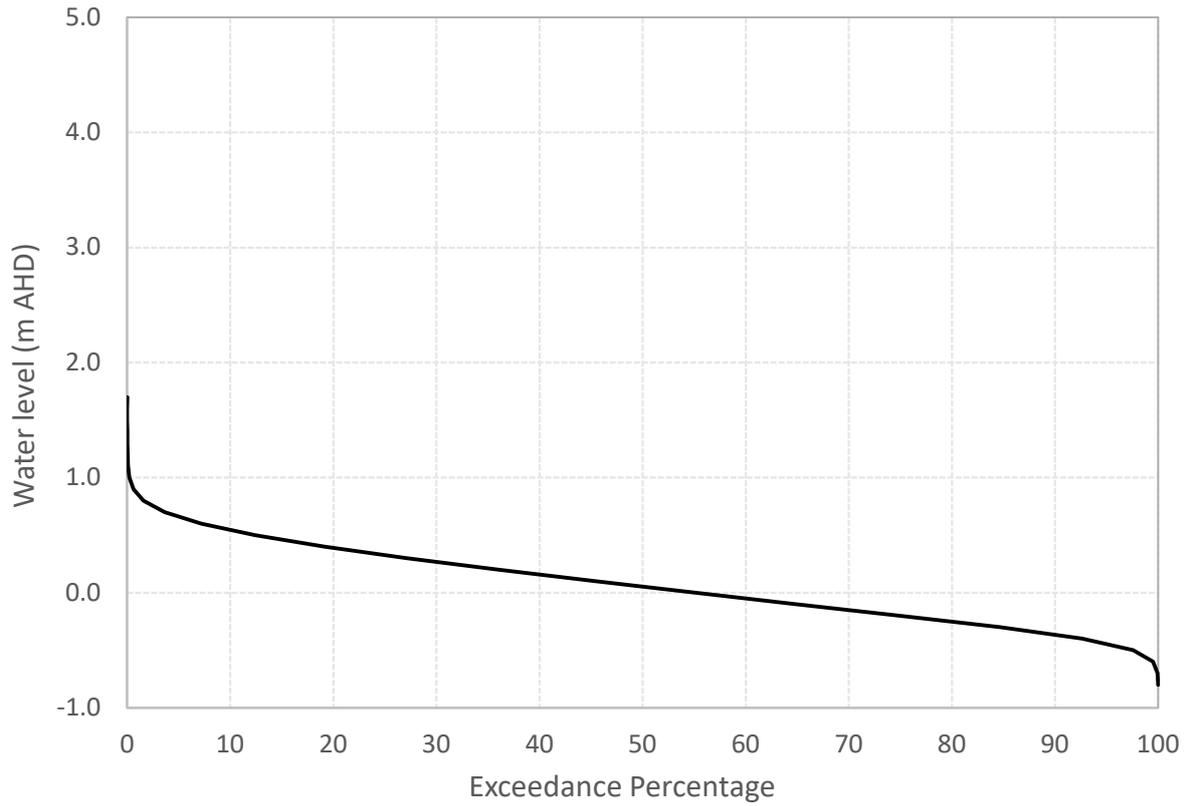
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Settlement Point (207418)	33.6	0.4	0.4*	0.8
Dennis Bridge D/S (207444)	24.8	0.5	0.5*	1.5
Wauchope Railway Bridge (207401)	32.9	0.5	0.8	4.2
Telegraph Point (207415)	30.3	0.4	0.7	2.1
Green Valley (207406)	26.2	0.4	1	1.9

\* Mean High Water adopted as minimum blackwater inundation level

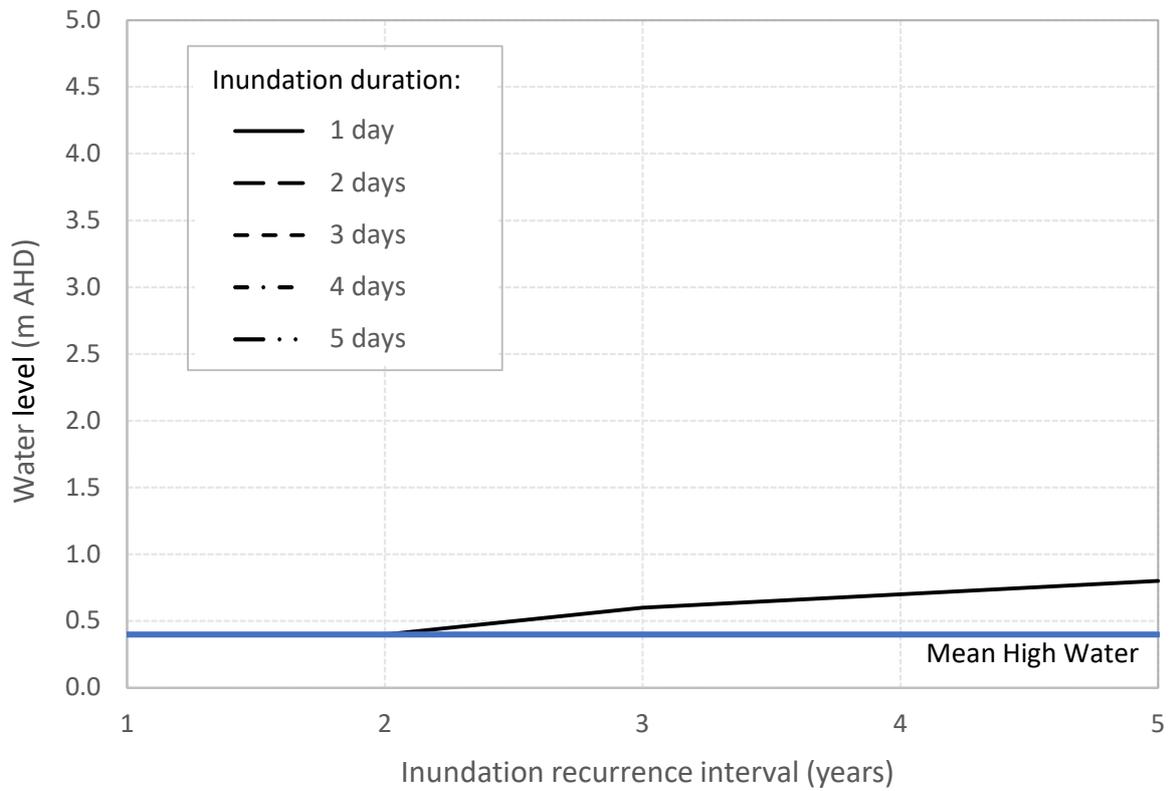
\*\* Excluding data gaps in excess of 6 hours

**Table S11.** Distribution of water level gauges to catchments, Hastings River

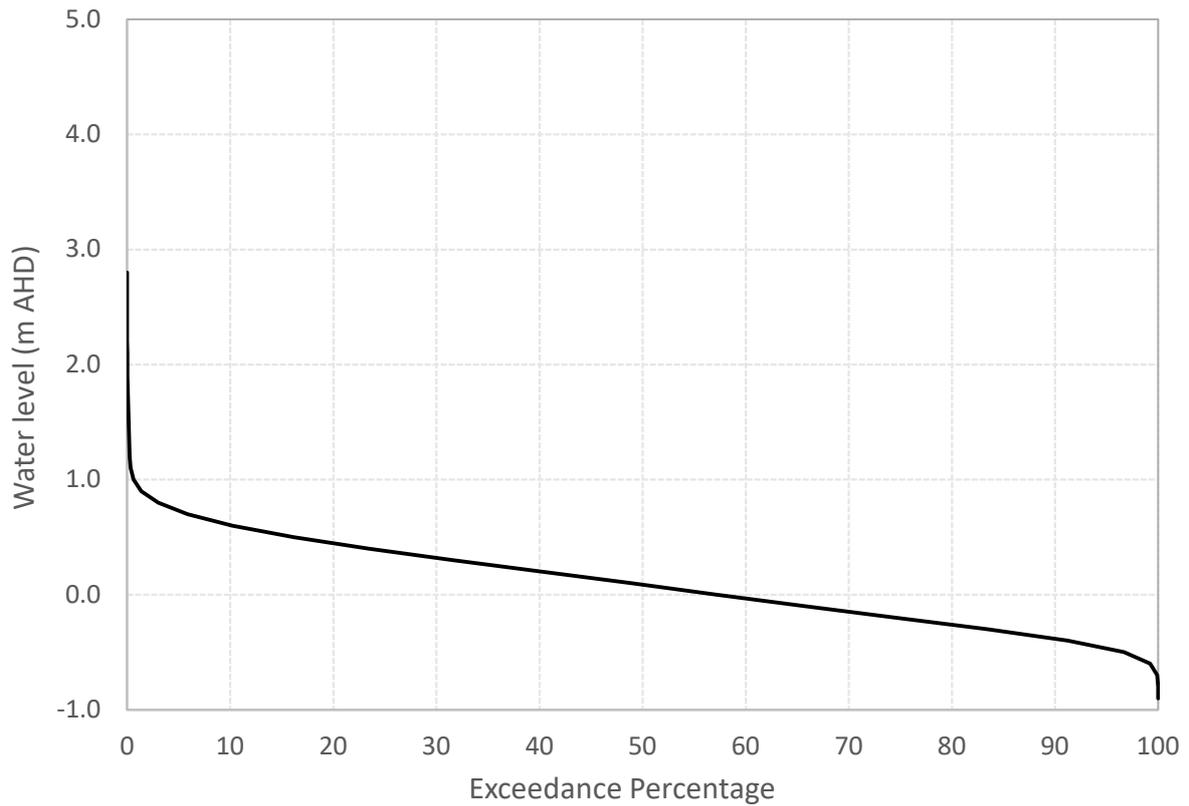
Catchment	Water level station(s) adopted
Limeburners Creek	Settlement Point
Port Macquarie Airport	0.61 x Settlement Point + 0.39 x Dennis Bridge D/S
Partridge Creek	0.49 x Settlement Point + 0.51 x Dennis Bridge D/S
Fernbank Creek	Dennis Bridge D/S
Pembrooke	0.75 x Dennis Bridge D/S + 0.25 x Wauchope Railway Bridge
Rawdon Island	0.75 x Dennis Bridge D/S + 0.25 x Wauchope Railway Bridge
Redbank	0.49 x Dennis Bridge D/S + 0.51 x Wauchope Railway Bridge
Sarahs Creek-Sancrox	0.25 x Dennis Bridge D/S + 0.75 x Wauchope Railway Bridge
Kings Creek	0.23 x Dennis Bridge D/S + 0.77 x Wauchope Railway Bridge
Lower Maria River West	0.19 x Dennis Bridge D/S + 0.81 x Telegraph Point
Lower Maria River East	0.07 x Dennis Bridge D/S + 0.93 x Telegraph Point
Upper Maria River	Green Valley
Connection Creek	Green Valley
Limeburners Creek	Settlement Point



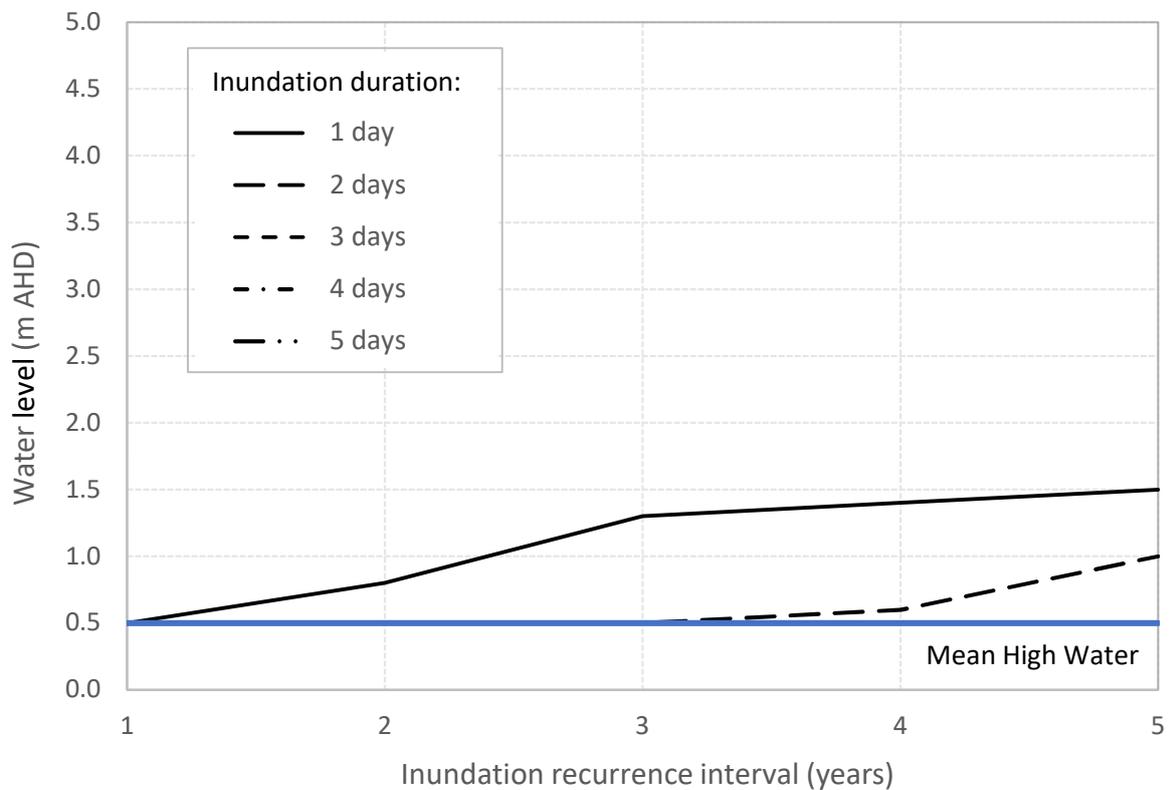
**Figure S60.** Frequency distribution of water levels at Settlement Point (Station 207418)



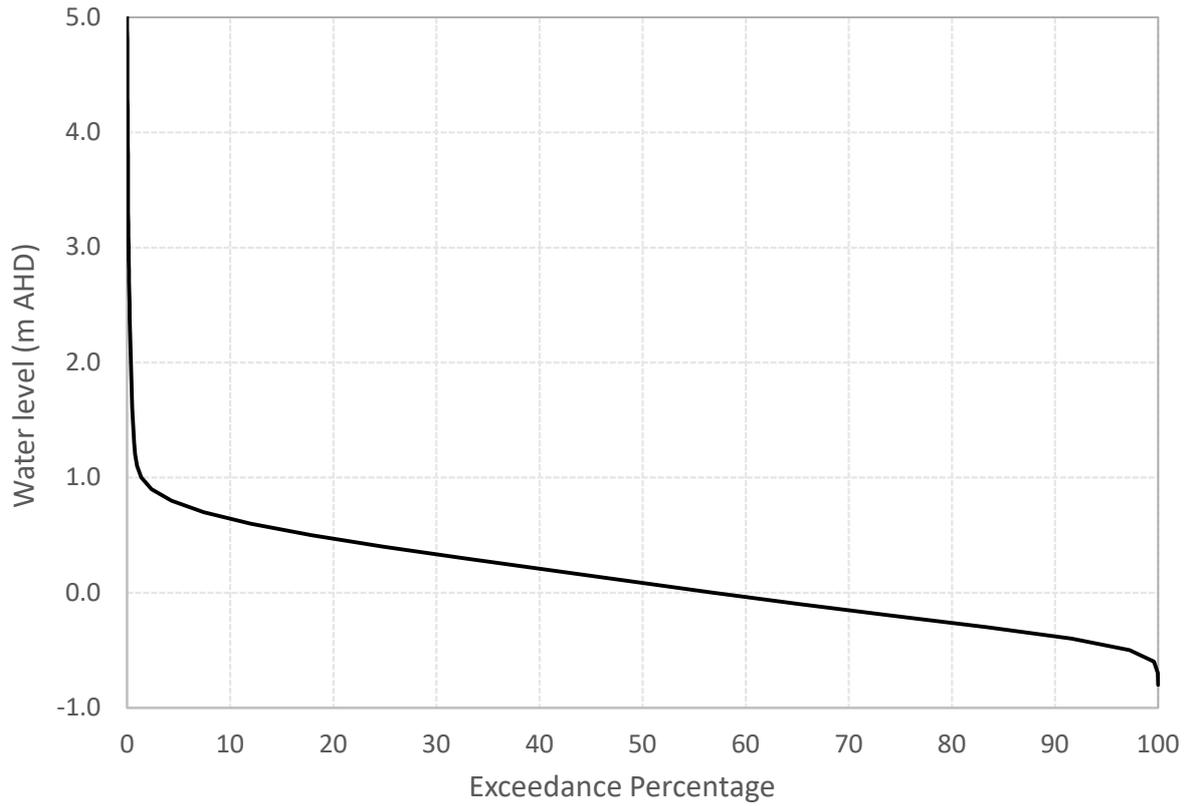
**Figure S61.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Settlement Point (Station 207418)



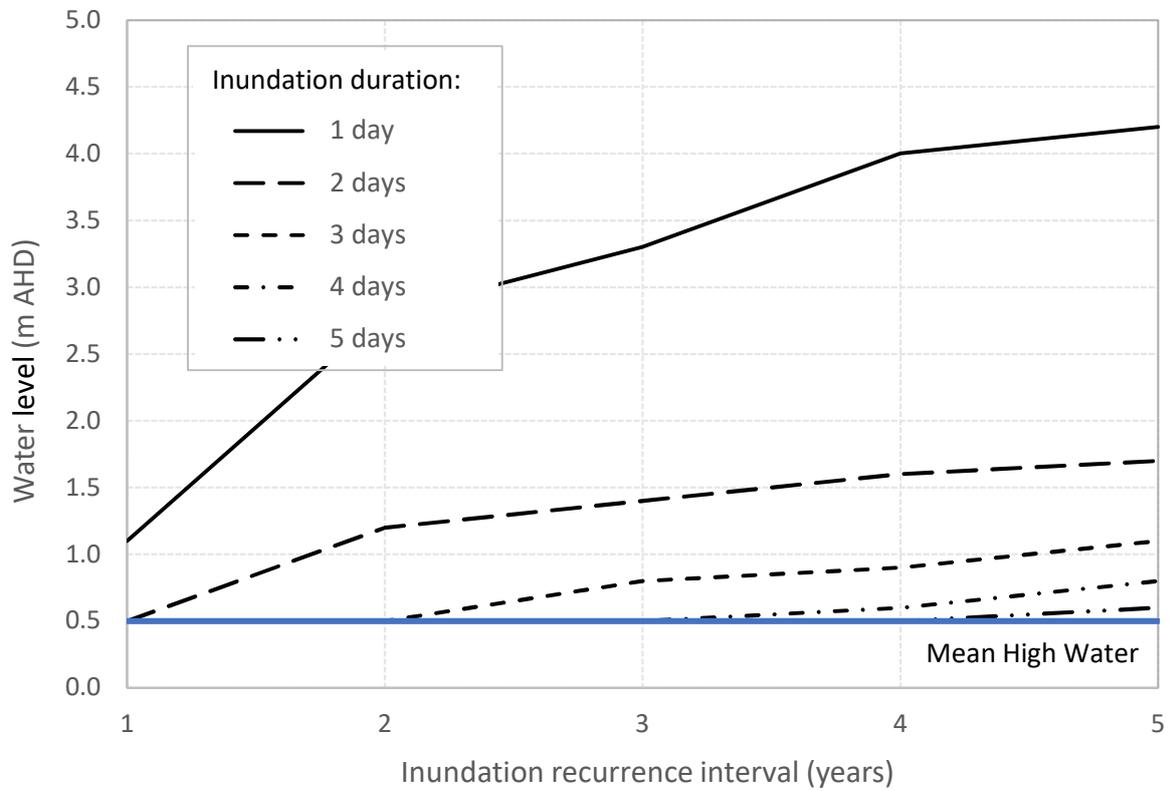
**Figure S62.** Frequency distribution of water levels at Dennis Bridge D/S (Station 207444)



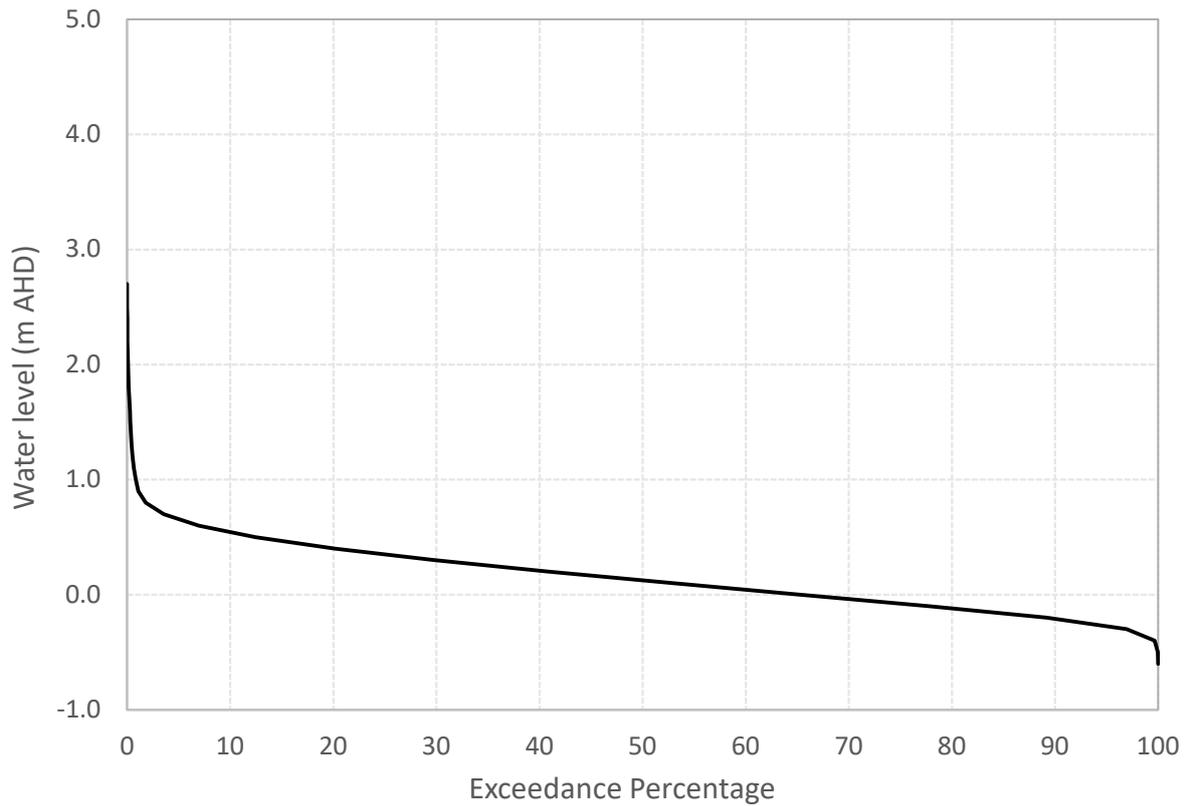
**Figure S63.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Dennis Bridge Downstream (Station 207444)



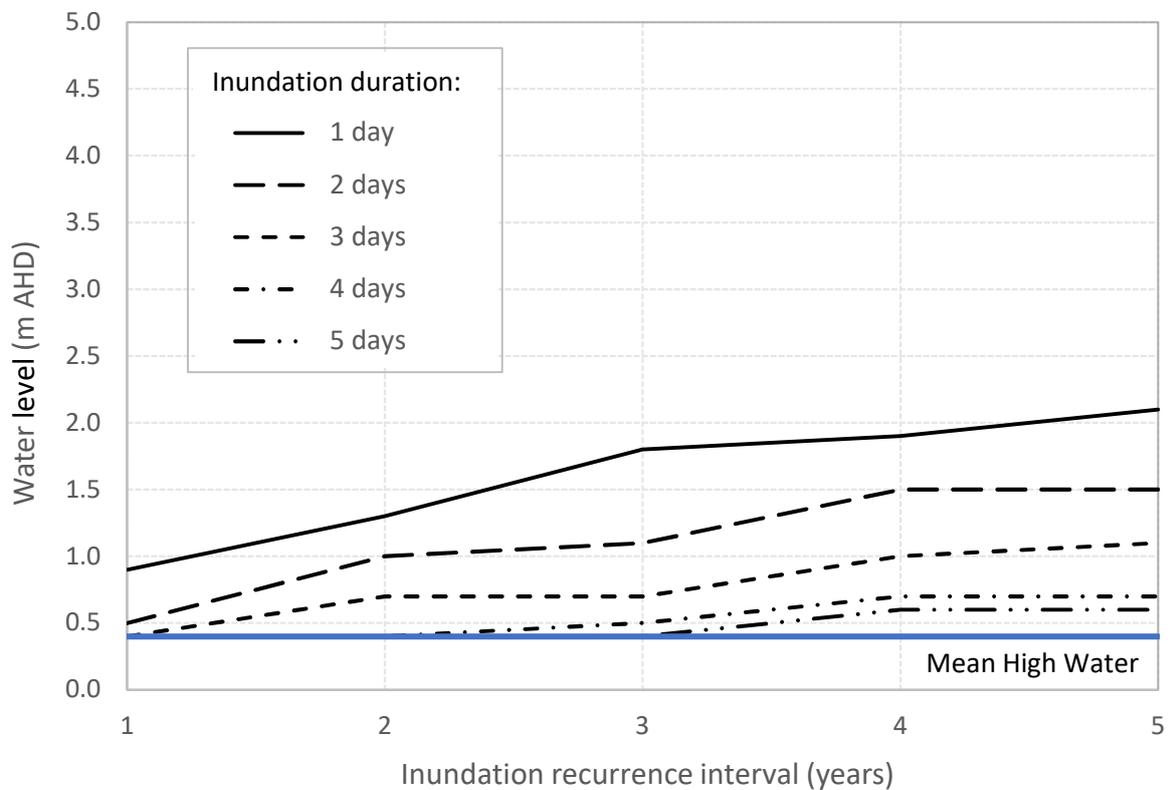
**Figure S64.** Frequency distribution of water levels at Wauchope Railway Bridge (St'n 207401)



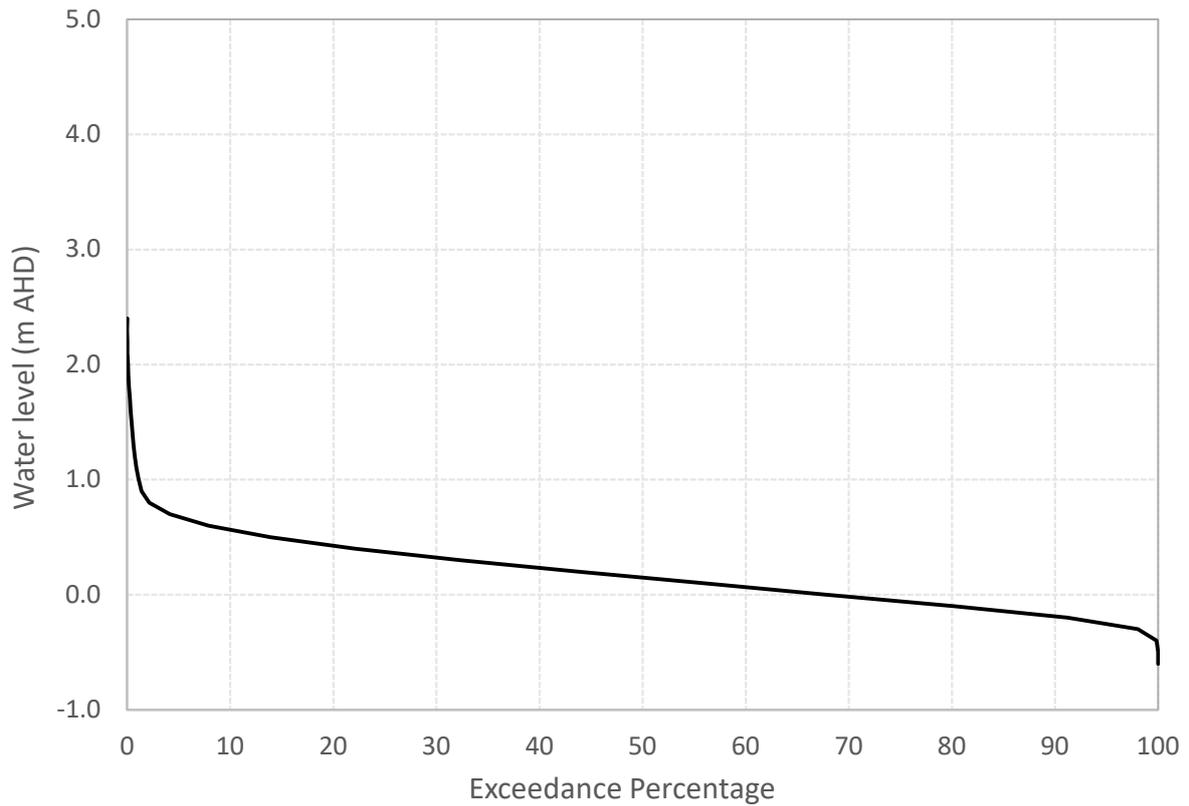
**Figure S65.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Wauchope Railway Bridge (Station 207401)



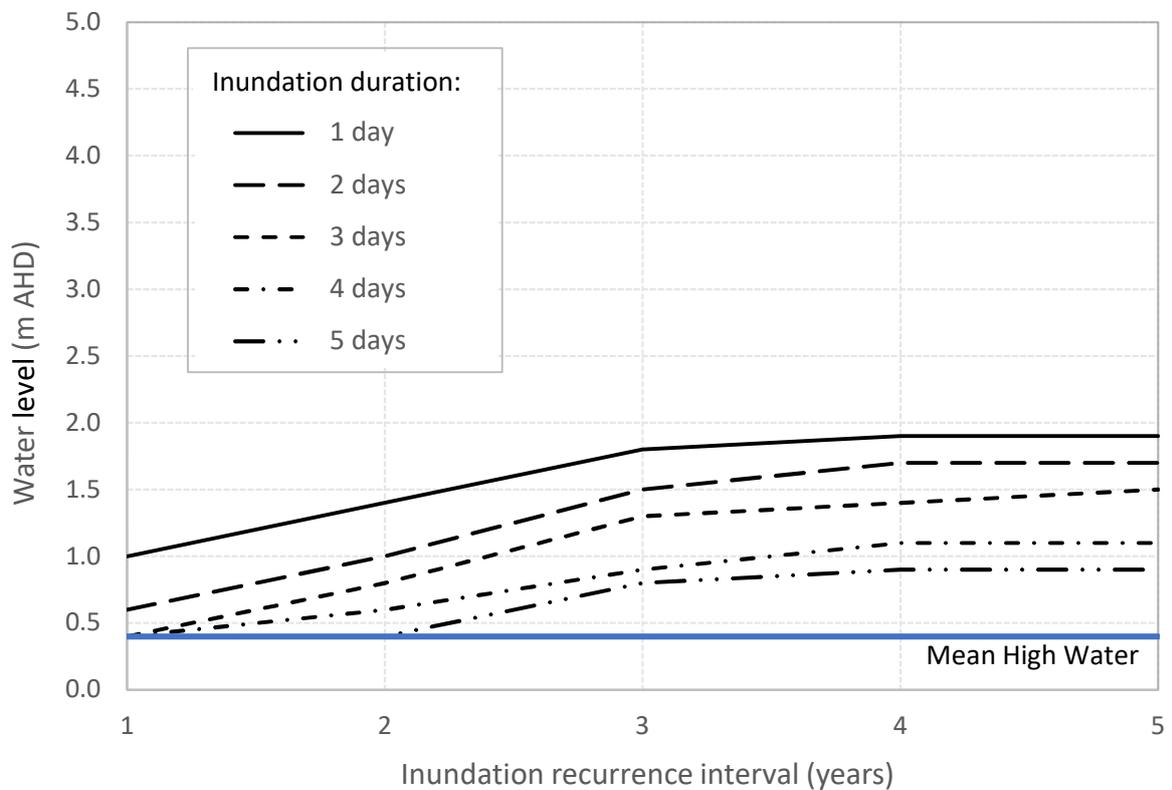
**Figure S66.** Frequency distribution of water levels at Telegraph Point (Station 207415)



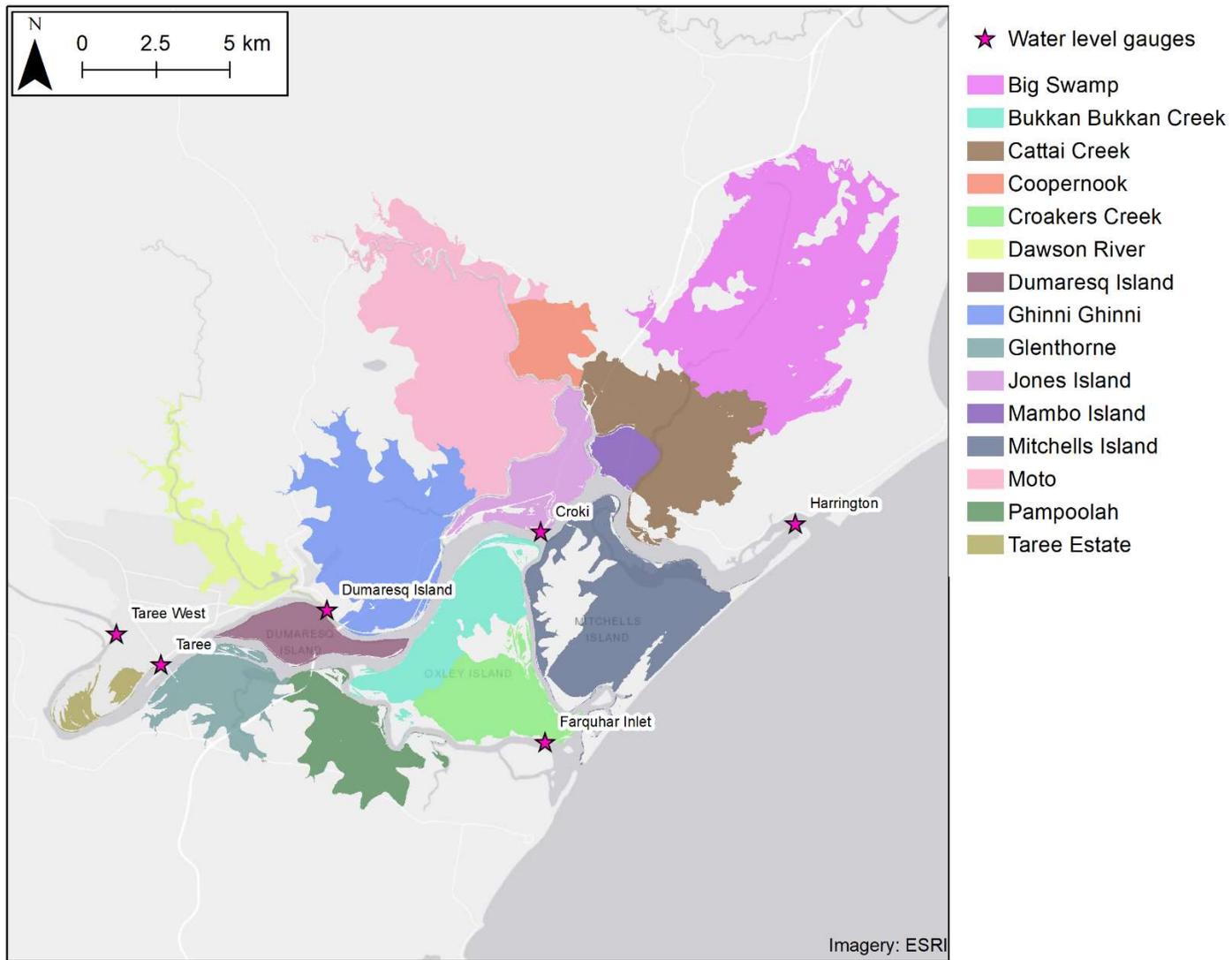
**Figure S67.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Telegraph Point (Station 207415)



**Figure S68.** Frequency distribution of water levels at Green Valley (Station 207406)



**Figure S69.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Green Valley (Station 207406)



**Figure S70.** Water level gauge locations, Manning River

**Table S12.** Details of water level gauges, Manning River

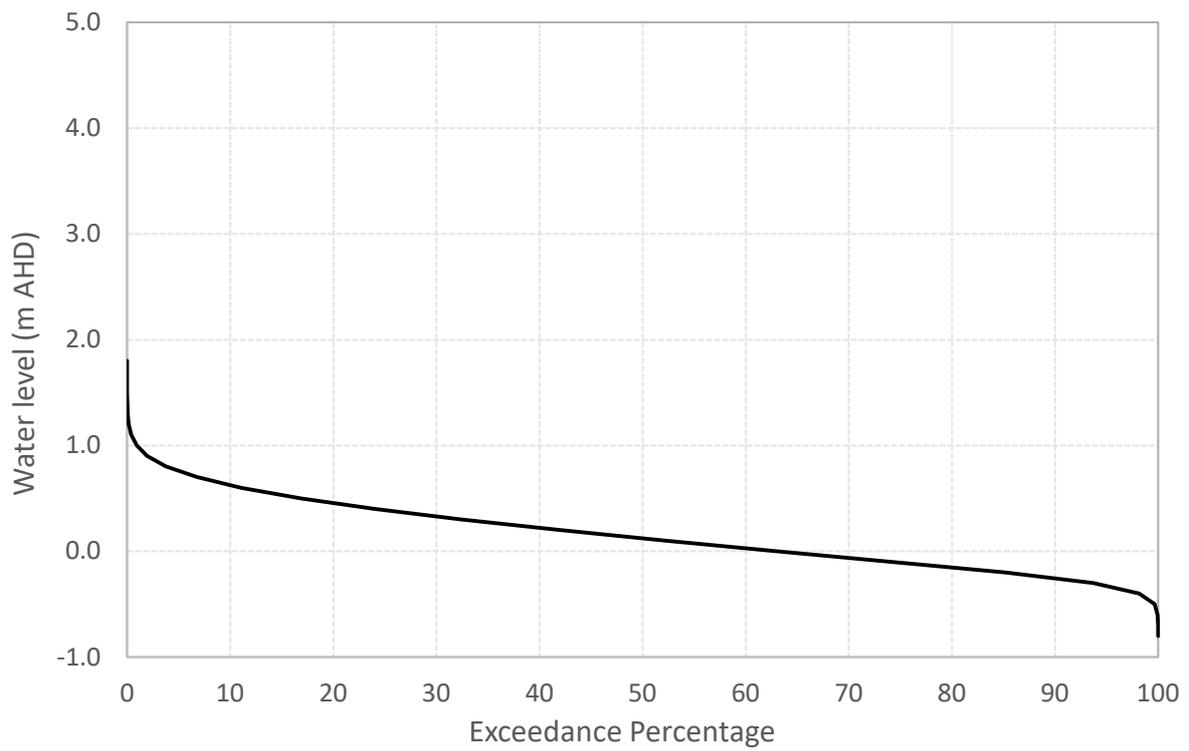
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Harrington (208425)	28.5	0.4	0.4*	0.5
Croki (208404)	27.7	0.4	0.6	1.6
Dumaresq Island (208430)	17.7	0.4	0.7	2
Taree (208410)	33.3	0.5	0.6	2.2
Taree West (208420)	10.0	0.5	1	4.6
Farquhar Inlet (208415)	32.0	0.4	0.5	1.3

\* Mean High Water adopted as minimum blackwater inundation level

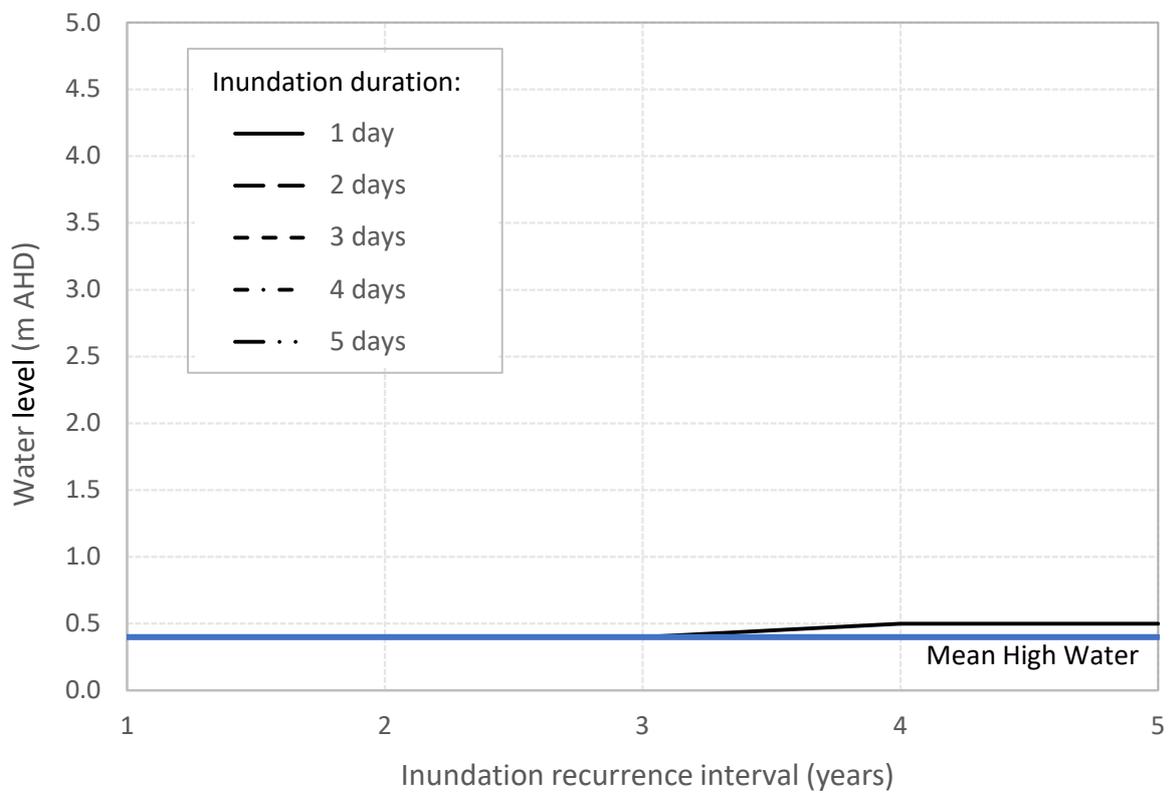
\*\* Excluding data gaps in excess of 6 hours

**Table S13.** Distribution of water level gauges to catchments, Manning River

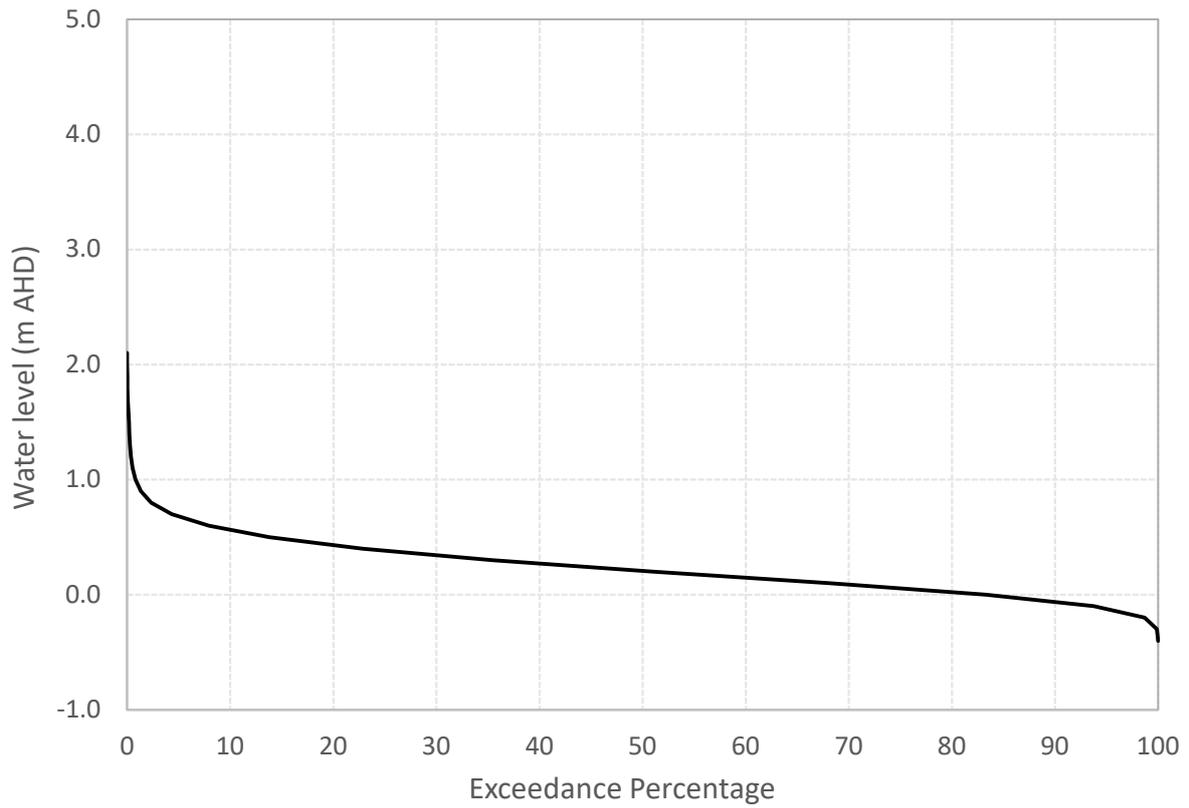
Catchment	Water level station(s) adopted
Harrington	Harrington
Mitchells Island	0.71 x Harrington + 0.29 x Croki
Cattai Creek	0.30 x Harrington + 0.70 x Croki
Big Swamp	Assumed the same levels as Cattai Creek
Mambo Island	0.28 x Harrington + 0.72 x Croki
Moto	0.22 x Harrington + 0.78 x Croki
Coopernook	Assumed to be the same as Moto
Ghinni Ghinni	0.65 x Croki + 0.65 x Dumaresq Island
Jones Island	Croki
Dumaresq Island	Dumaresq Island
Dawson River	Dumaresq Island
Glenthorne	Dumaresq Island
Taree Estate	0.67 x Taree + 0.33 x Taree West
Old Bar	Farquhar Inlet
Croakers Creek	Farquhar Inlet
Bukkan Bukkan Creek	0.34 x Farquhar Inlet + 0.66 x Croki
Pampoolah	0.34 x Farquhar Inlet + 0.66 x Dumaresq Island



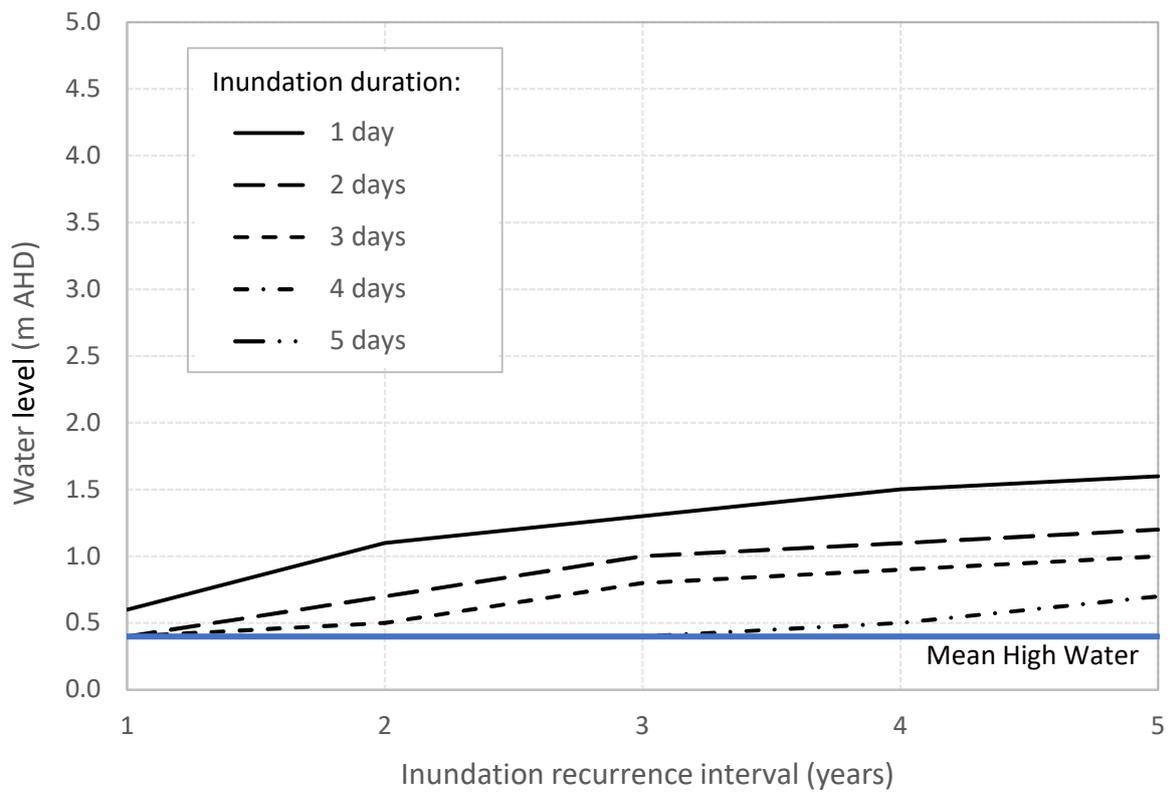
**Figure S71.** Frequency distribution of water levels at Harrington (Station 208425)



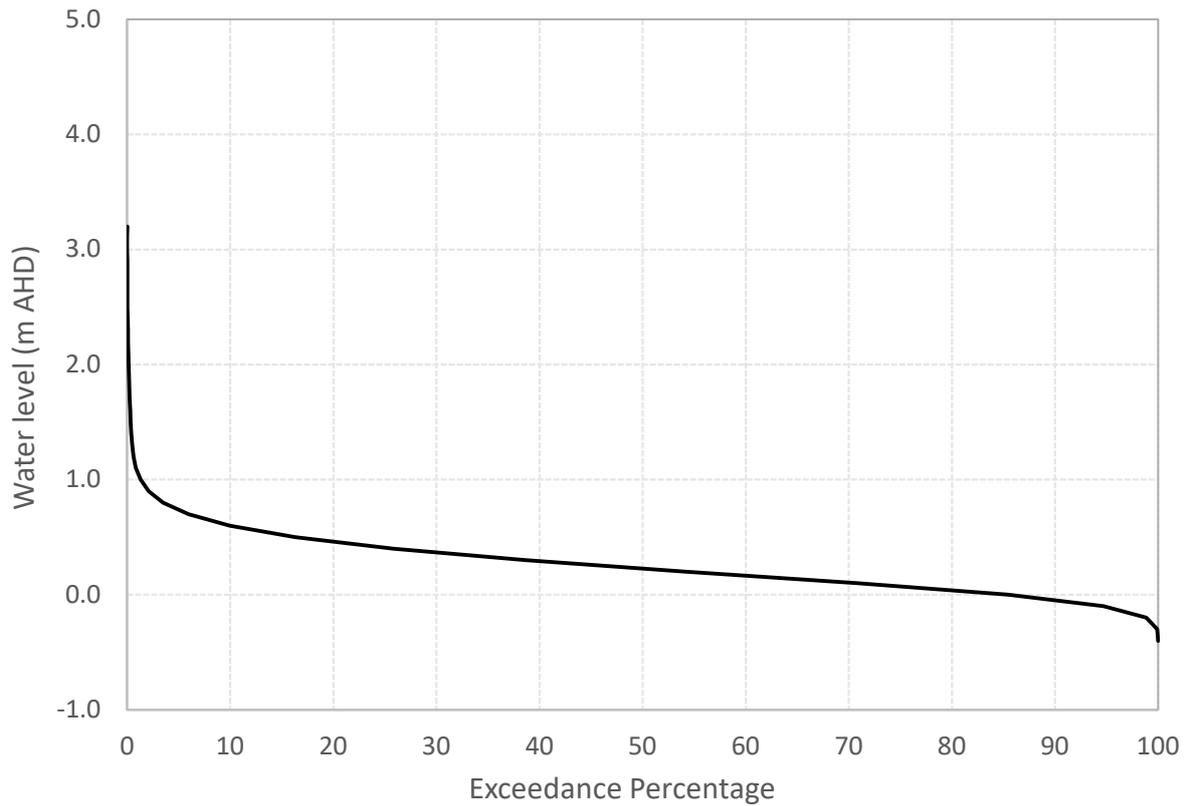
**Figure S72.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Harrington (Station 208425)



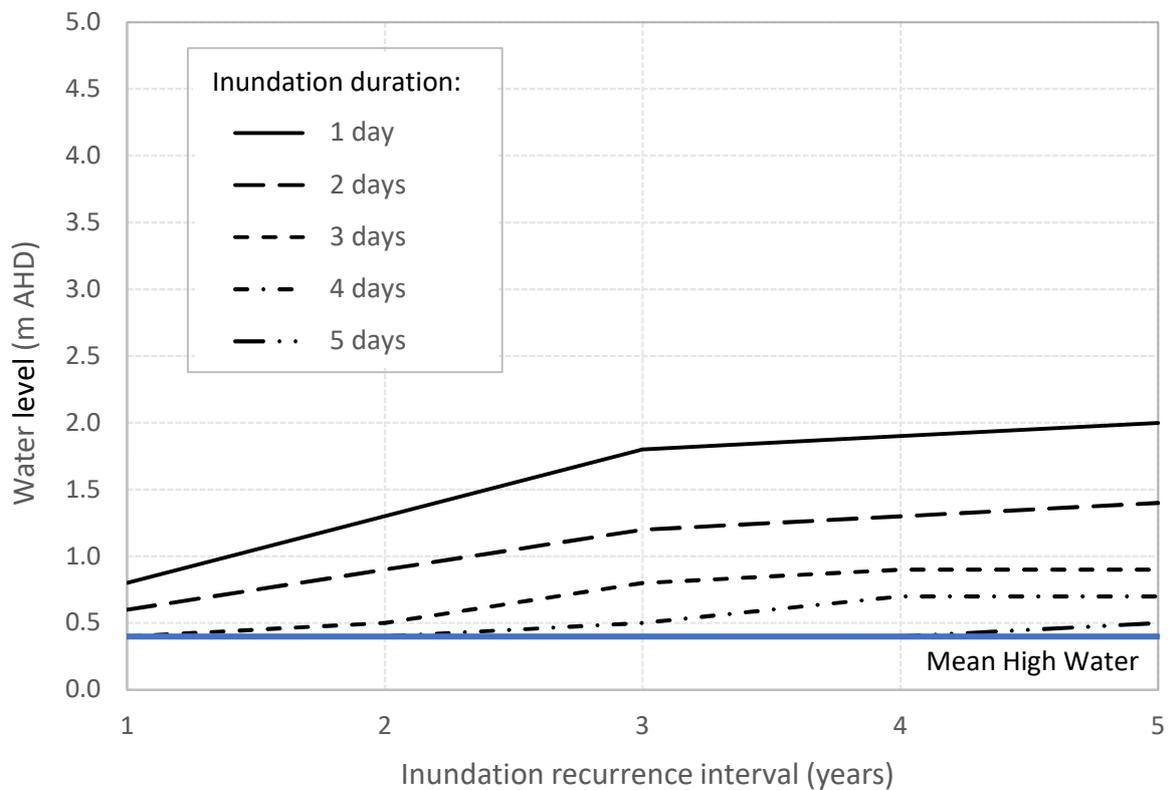
**Figure S73.** Frequency distribution of water levels at Croki (Station 208404)



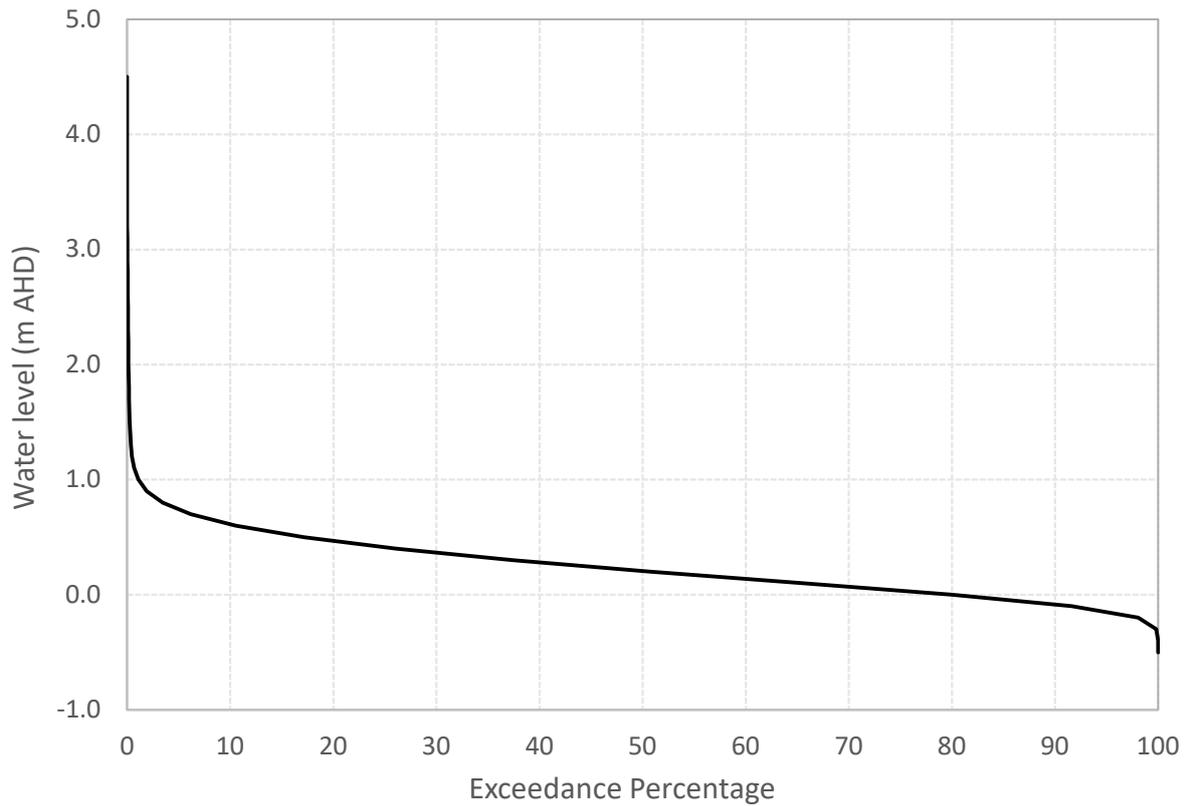
**Figure S74.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Croki (Station 208404)



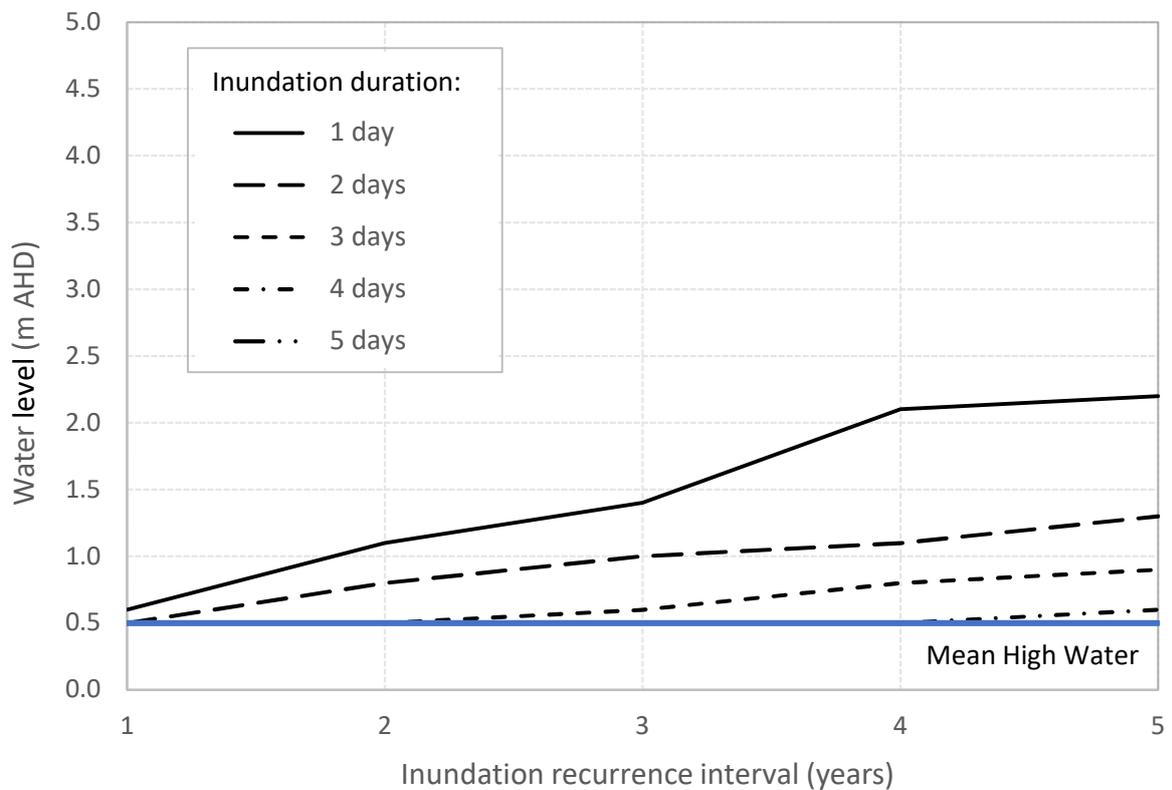
**Figure S75.** Frequency distribution of water levels at Dumaresq Island (Station 208430)



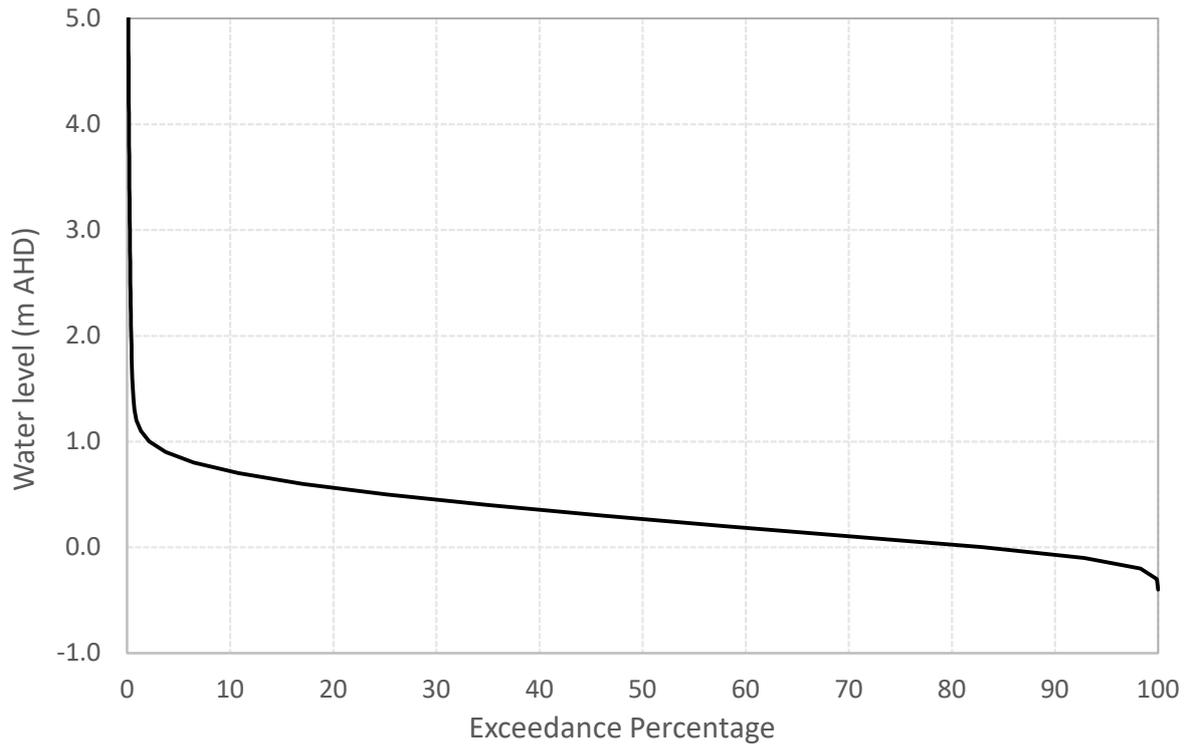
**Figure S76.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Dumaresq Island (Station 208430)



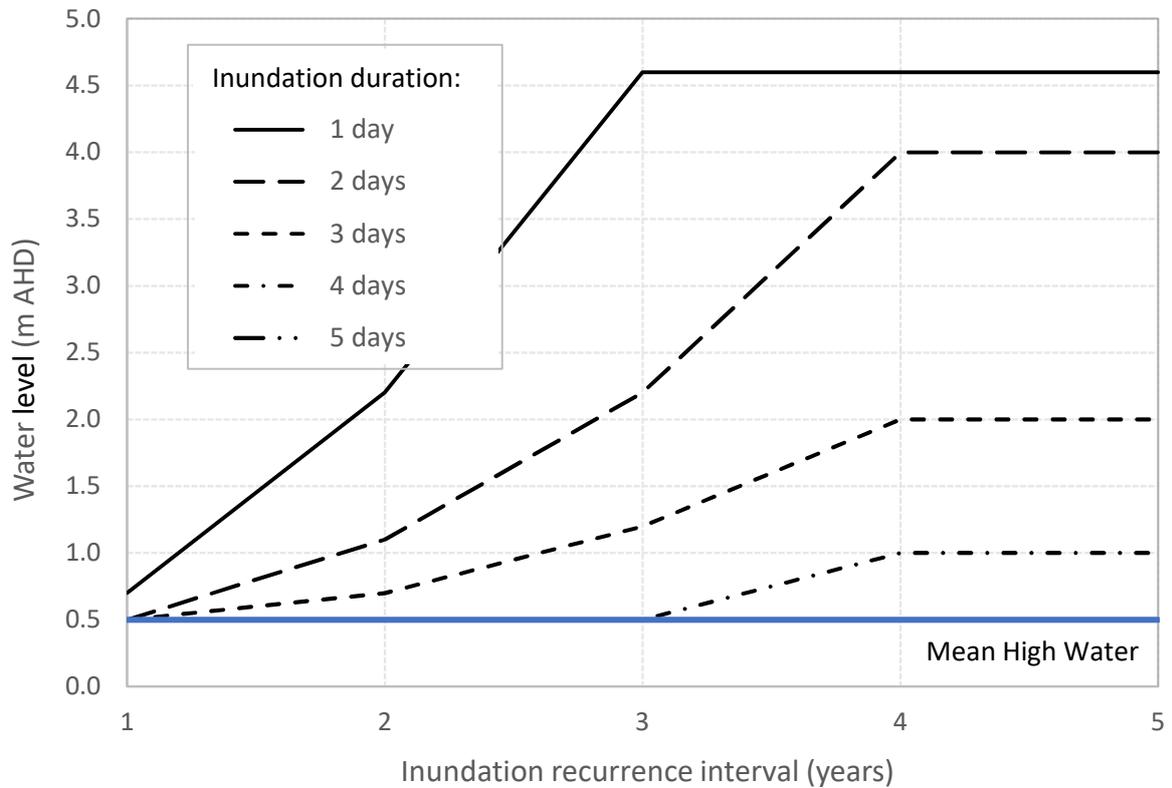
**Figure S77.** Frequency distribution of water levels at Taree (Station 208410)



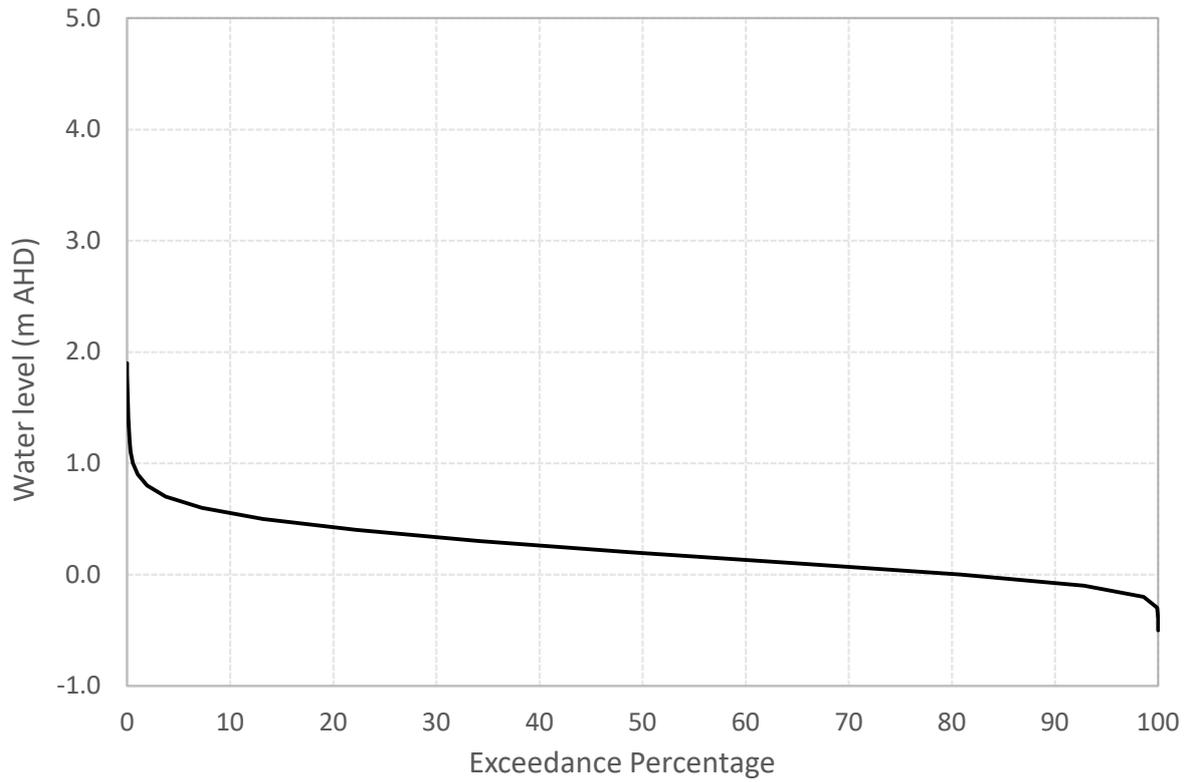
**Figure S78.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Taree (Station 208410)



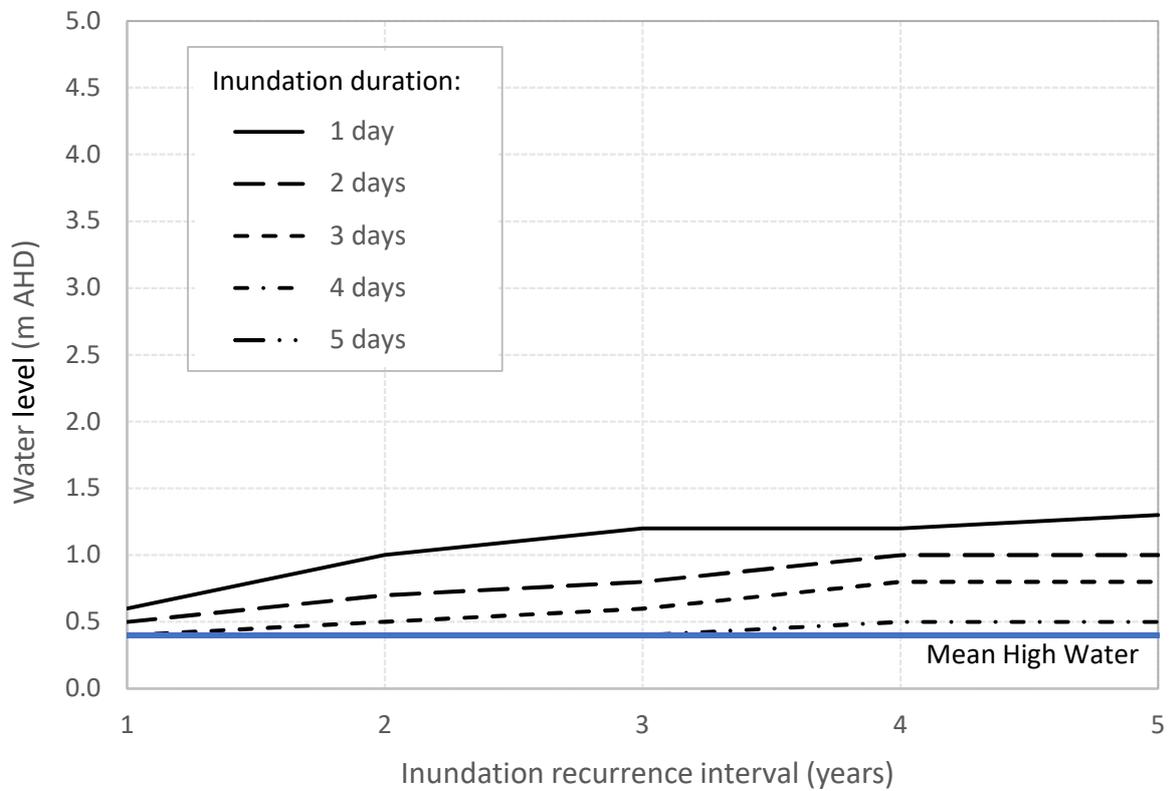
**Figure S79.** Frequency distribution of water levels at Taree West (Station 208420)



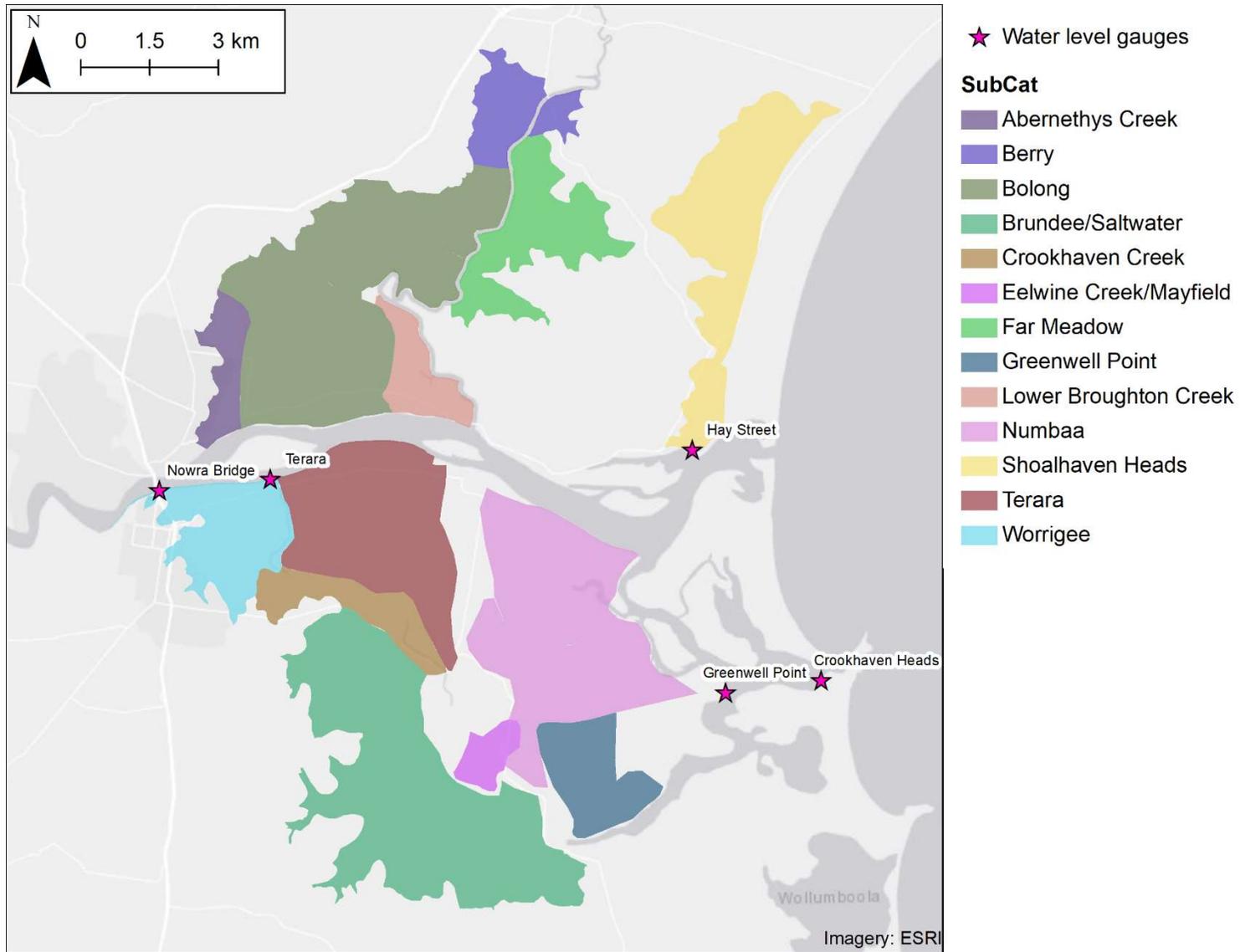
**Figure S80.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Taree West (Station 208420)



**Figure S81.** Frequency distribution of water levels at Farquhar Inlet (Station 208415)



**Figure S82.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Farquhar Inlet (Station 208415)



**Figure S83.** Water level gauge locations, Shoalhaven River

**Table S14.** Details of water level gauges, Shoalhaven River

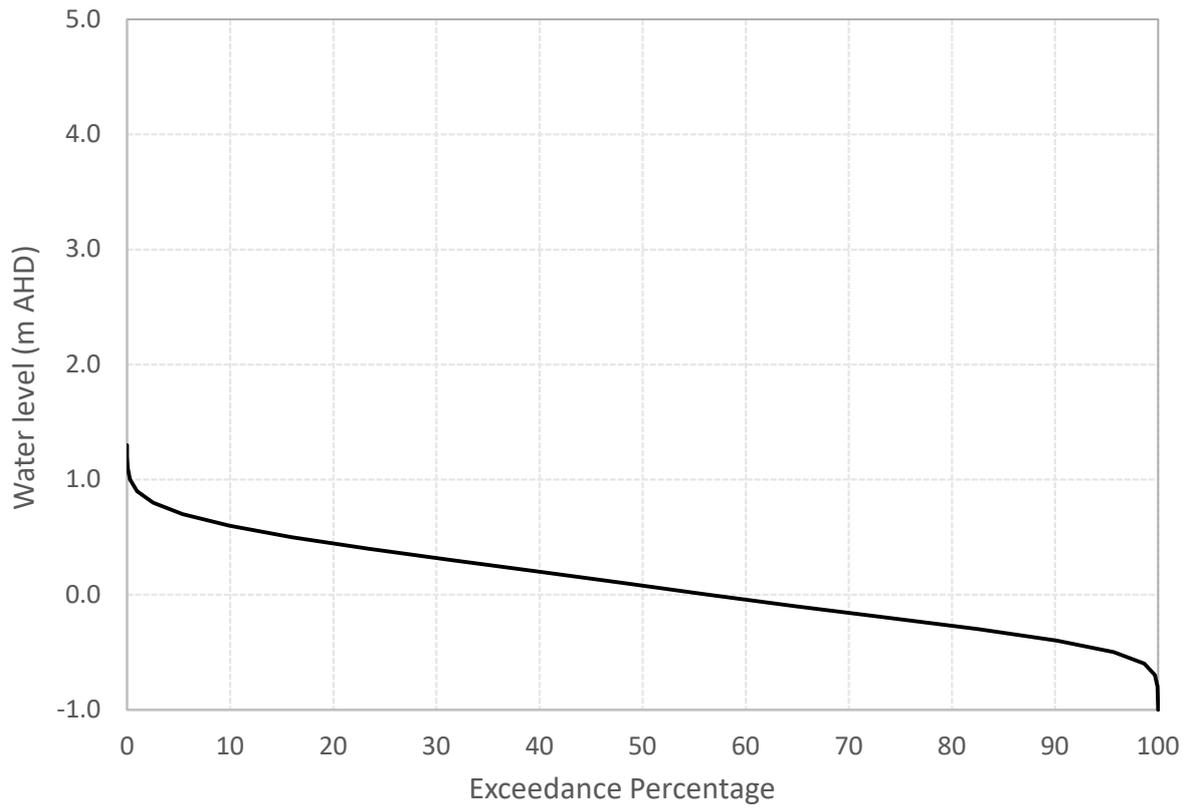
Station	Length of record** (years)	Mean High Water level (m AHD)	Blackwater inundation level (m AHD)	
			Median	Maximum
Crookhaven Heads (215408)	27.4	0.4	0.5	0.5
Hay Street (215415)	17.3	0.4	0.4*	1.2
Greenwell Point (215417)	29.2	0.4	0.4*	0.5
Terara (215420)	17.4	0.4	0.4*	2.6
Nowra Bridge (215411)	28.8	0.4	0.4*	2.9

\* Mean High Water adopted as minimum blackwater inundation level

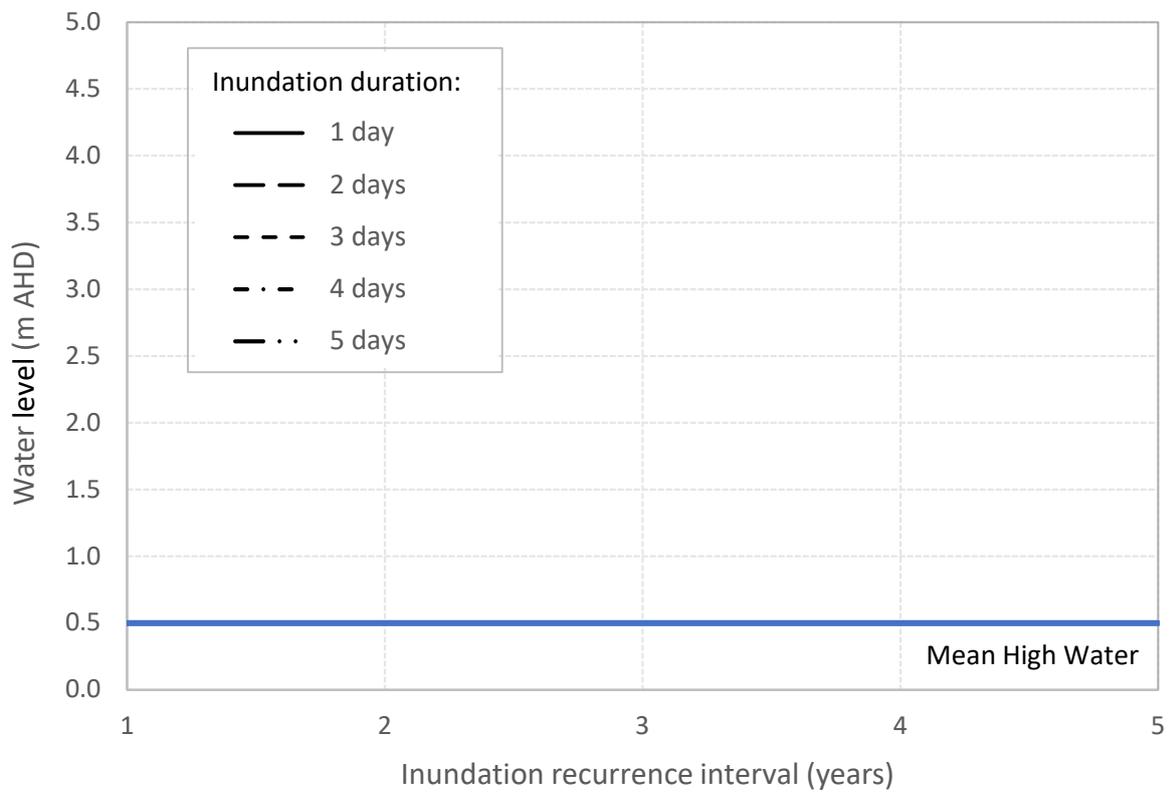
\*\* Excluding data gaps in excess of 6 hours

**Table S15.** Distribution of water level gauges to catchments, Shoalhaven River

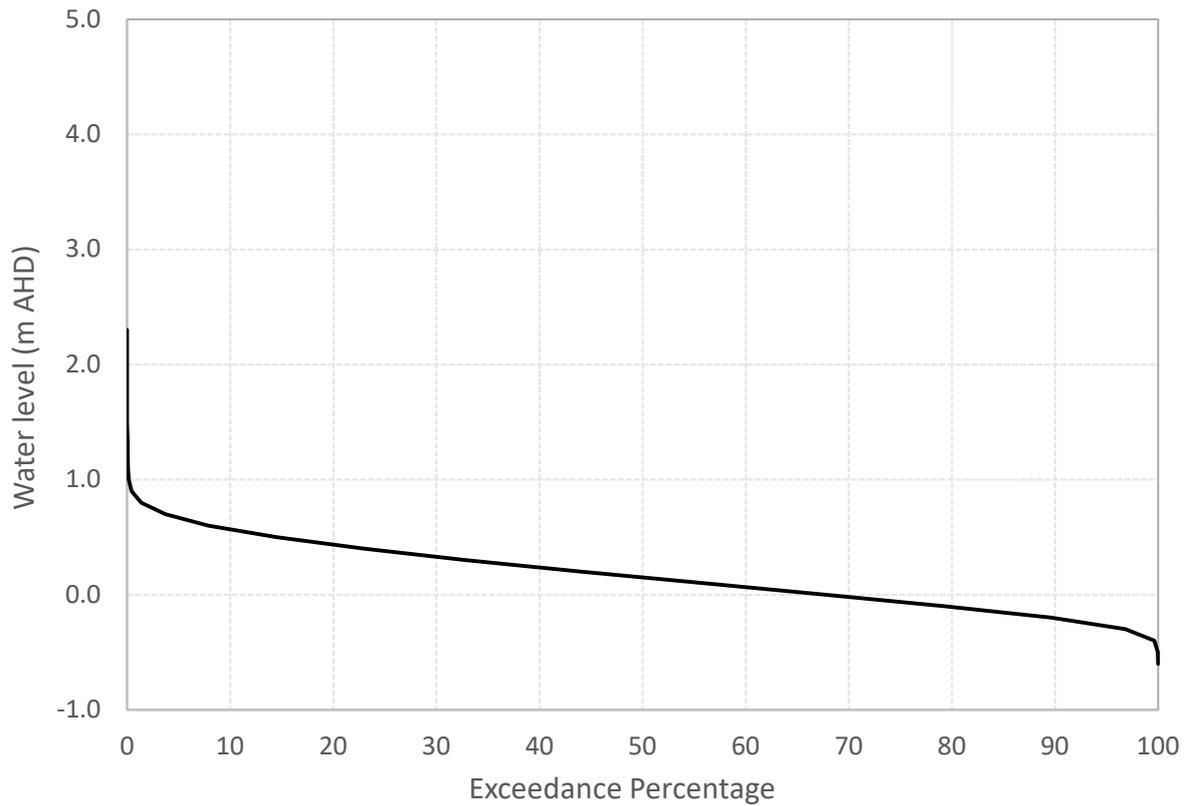
Catchment	Water level station(s) adopted
Shoalhaven Heads	Hay Street
Coolangatta	Hay Street
Greenwell Point	Greenwell Point
Brundee-Saltwater*	Using Greenwell Point as a proxy
Eelwine Creek-Mayfield*	Using Greenwell Point as a proxy
Crookhaven Creek*	Using Greenwell Point as a proxy
Comerong Island*	Using Greenwell Point as a proxy
Numbaa	0.57 x Greenwell Point + 0.43 x Hay Street
Terara	0.43 x Hay Street + 0.57 x Terara
Lower Broughton Creek	0.40 x Hay Street + 0.60 x Terara
Bolong*	Using Lower Broughton Creek as a proxy
Far Meadow*	Using Lower Broughton Creek as a proxy
Berry*	Using Lower Broughton Creek as a proxy
Abernethys Creek	0.52 x Terara + 0.48 x Nowra Bridge
Worrigea	0.57 x Terara + 0.43 x Nowra Bridge



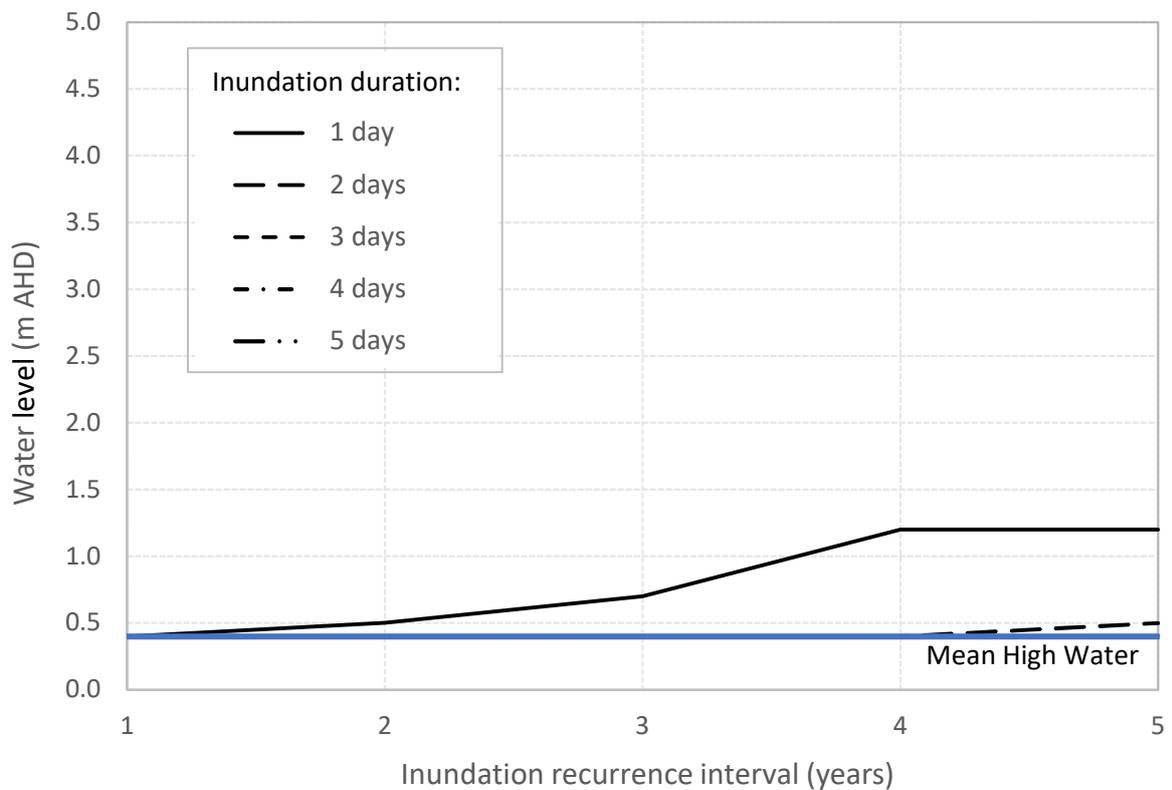
**Figure S84.** Frequency distribution of water levels at Crookhaven Heads (Station 215408)



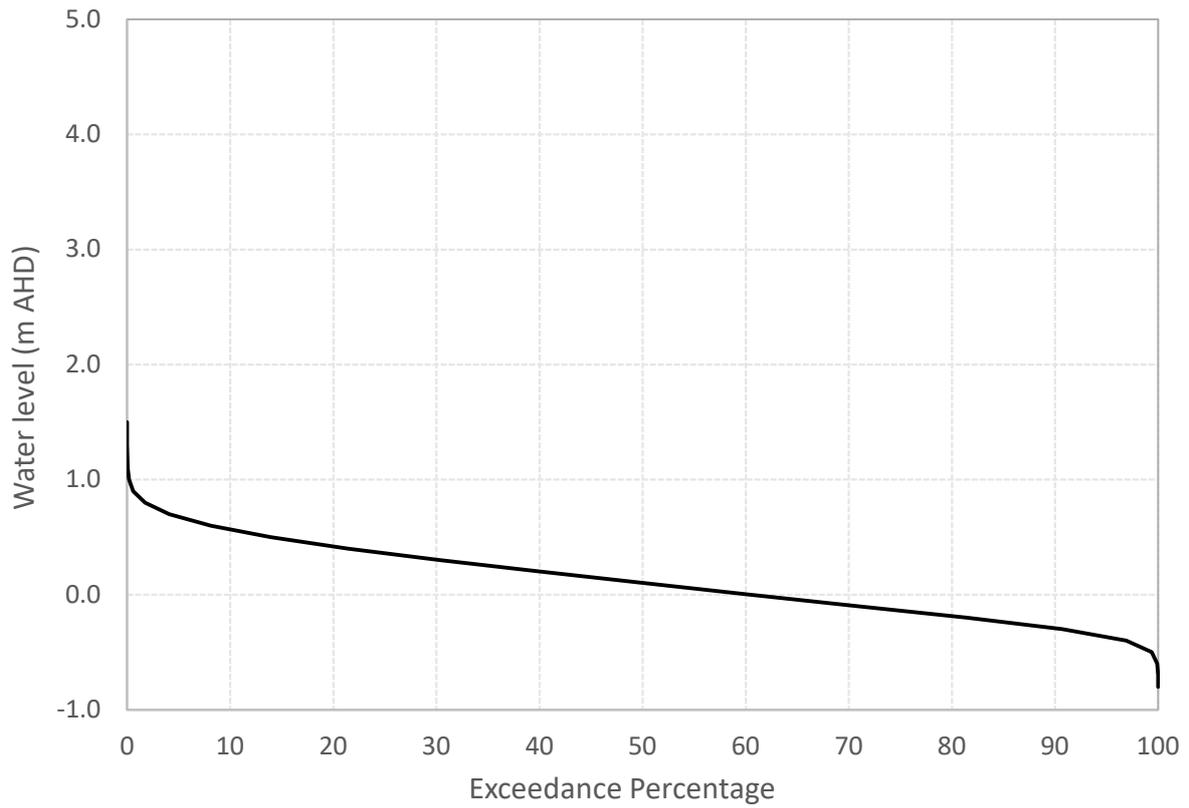
**Figure S85.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Crookhaven Heads (Station 215408)



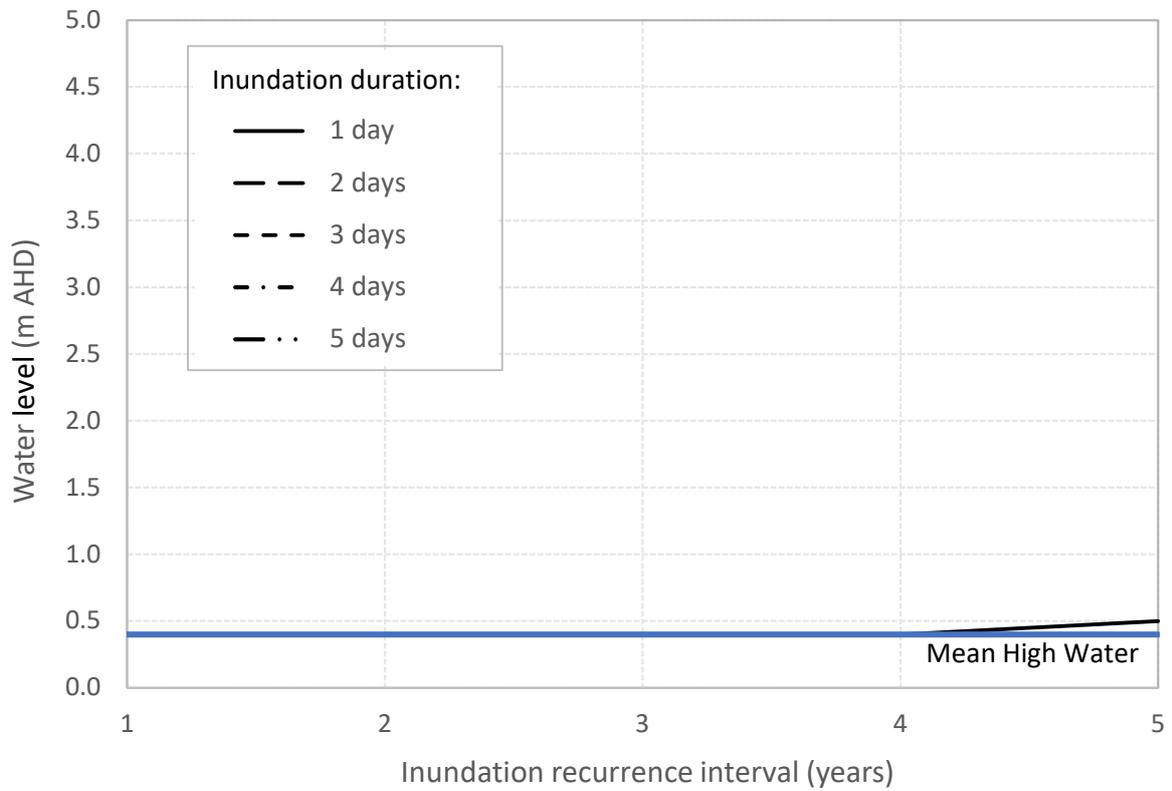
**Figure S86.** Frequency distribution of water levels at Hay Street (Station 215415)



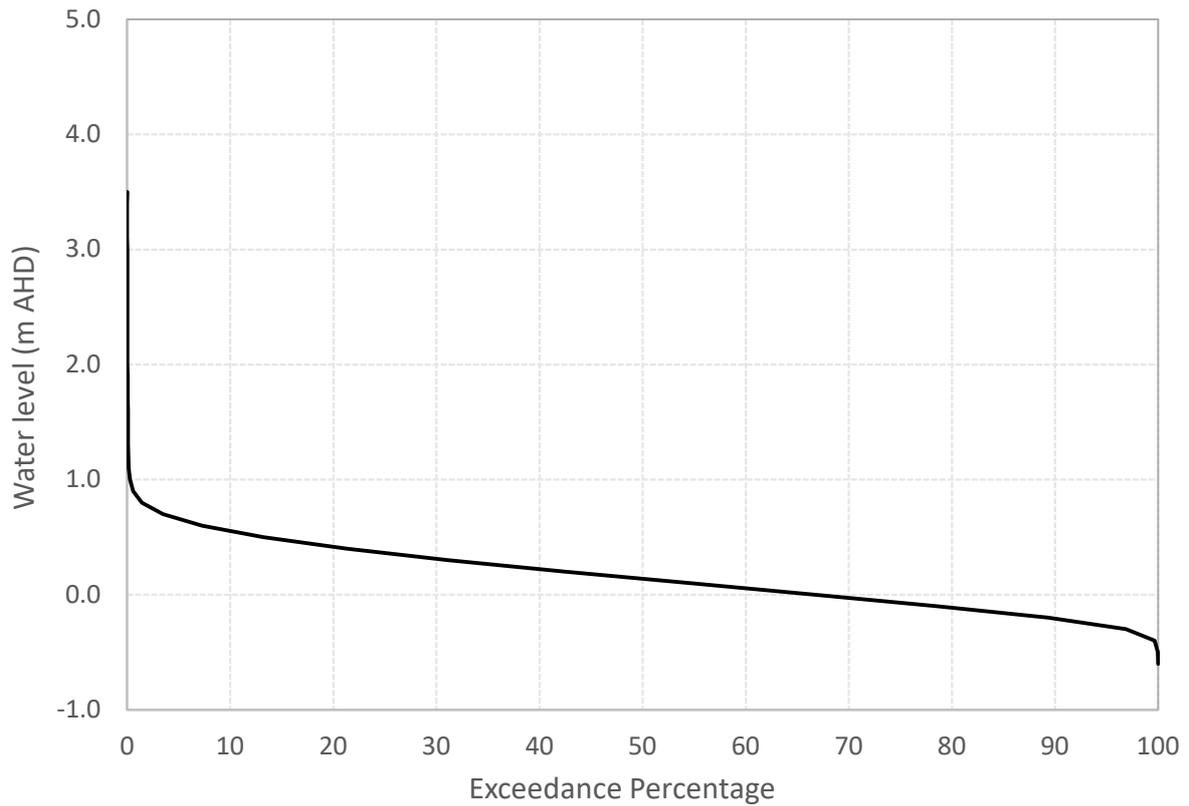
**Figure S87.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Hay Street (Station 215415)



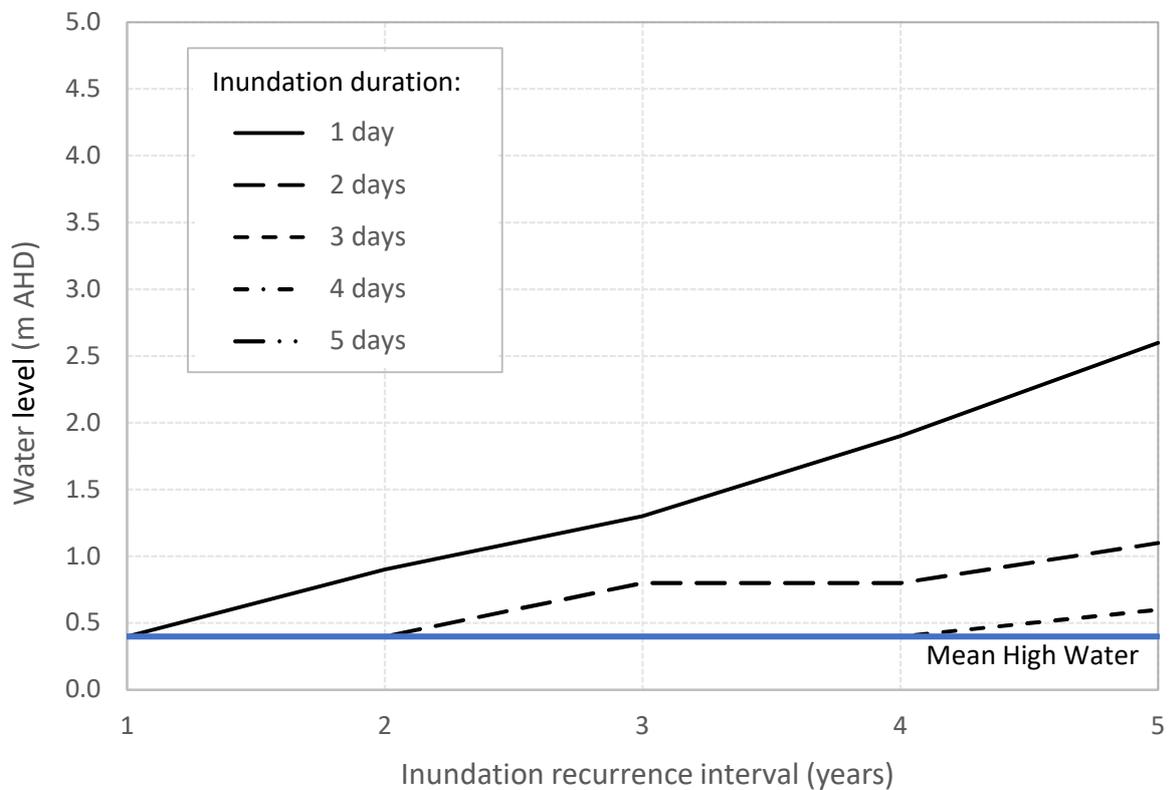
**Figure S88.** Frequency distribution of water levels at Greenwell Point (Station 215417)



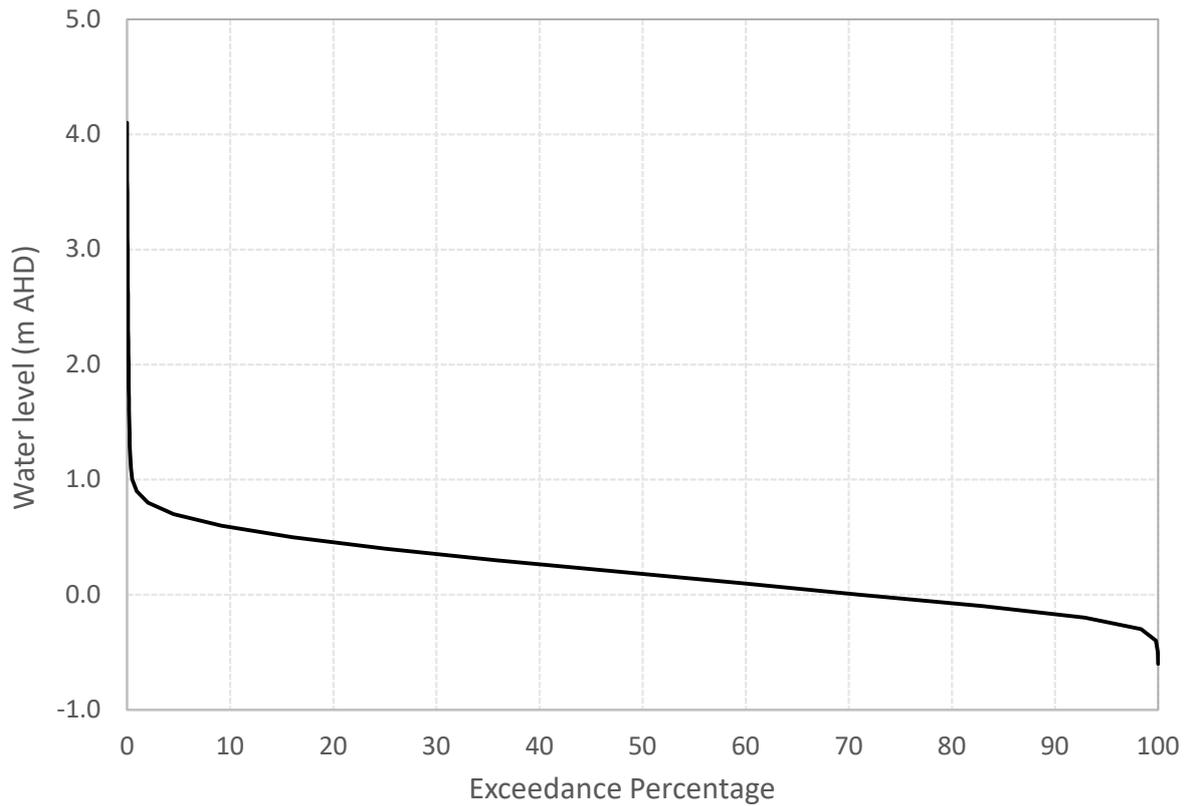
**Figure S89.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Greenwell Point (Station 215417)



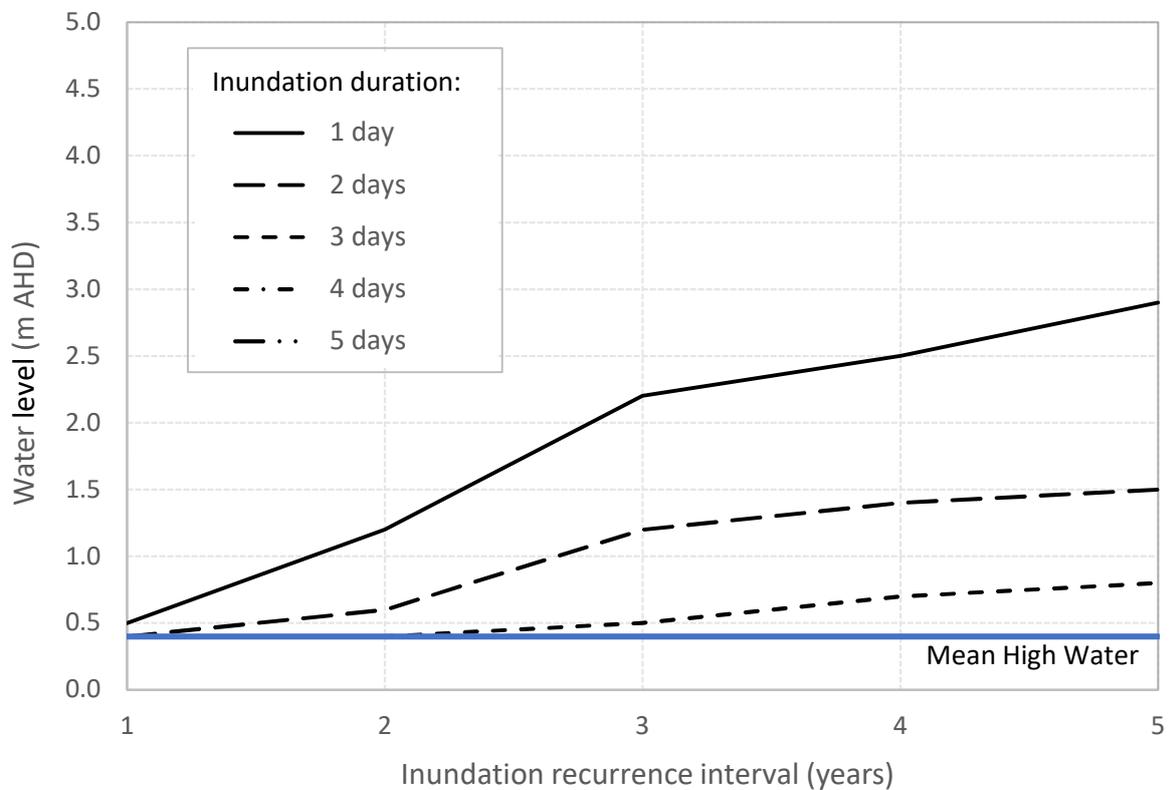
**Figure S90.** Frequency distribution of water levels at Terara (Station 215420)



**Figure S91.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Terara (Station 215420)



**Figure S92.** Frequency distribution of water levels at Nowra Bridge (Station 215411)

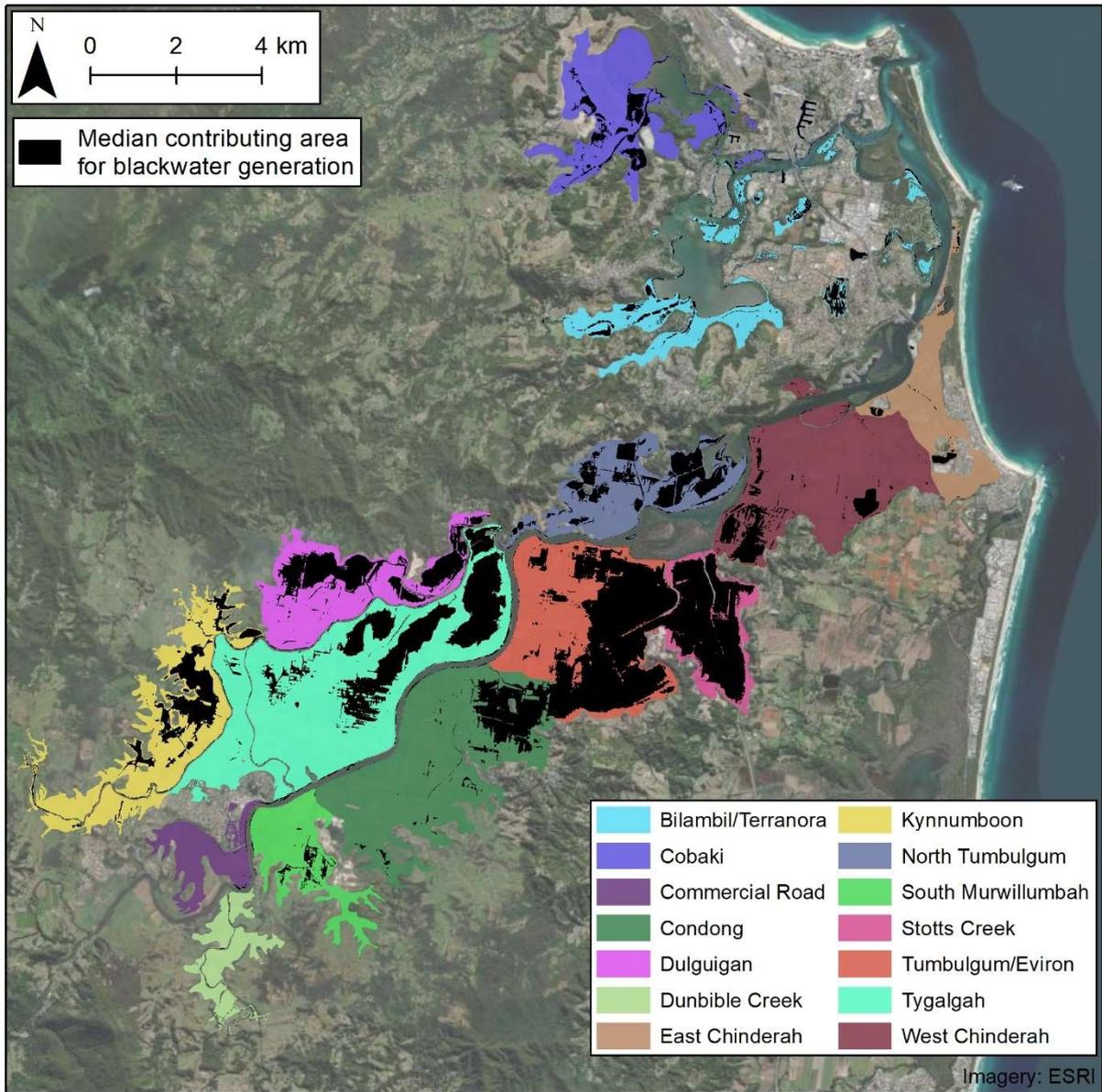


**Figure S93.** Water levels corresponding to inundation durations of 1 to 5 days with recurrence intervals of 1 to 5 years for Nowra Bridge (Station 215411)

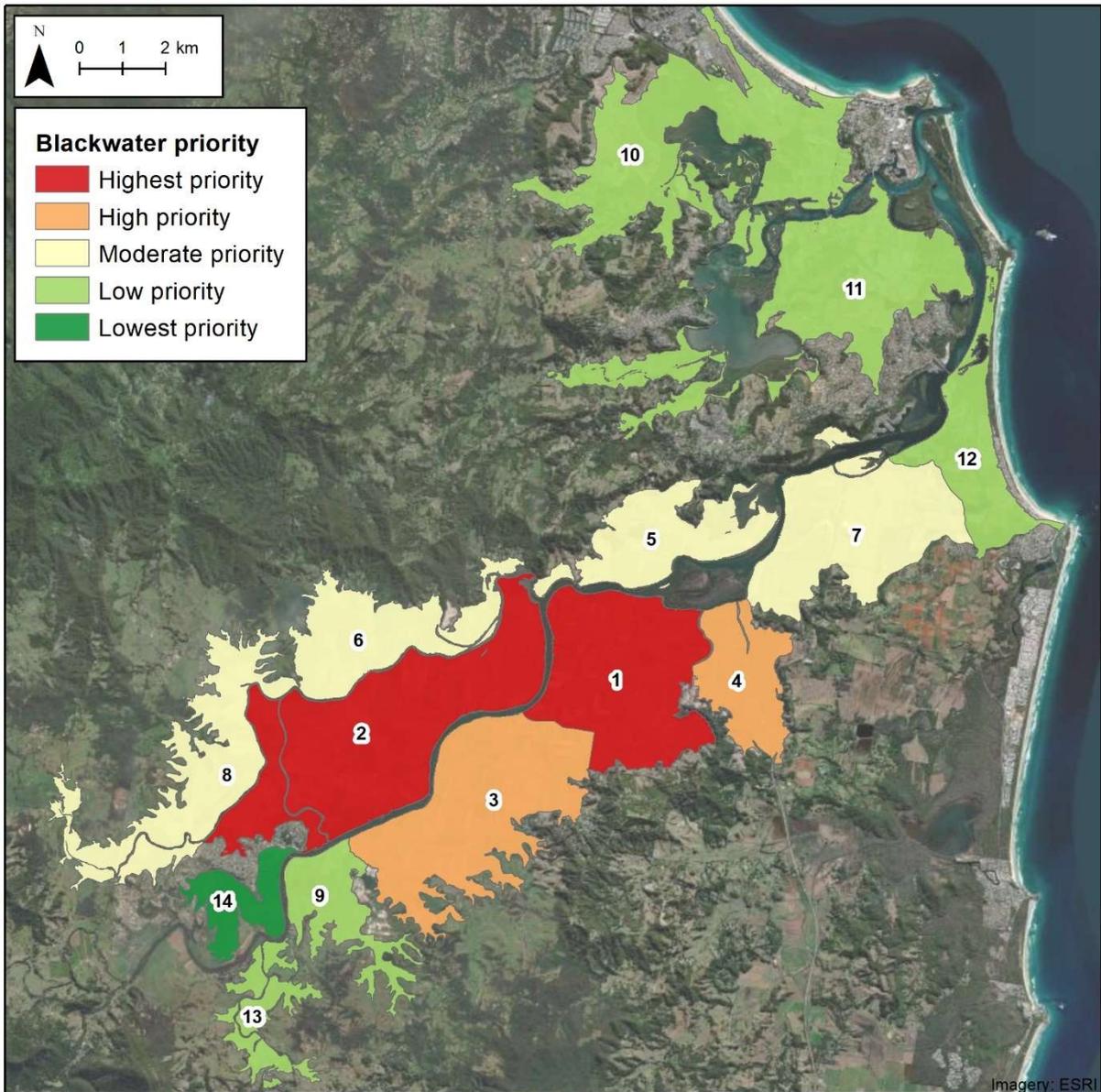
**Table S16.** Median inundation level, blackwater contribution factor and ranking of catchments, Tweed River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Tumbulgum/Eviron	0.8	12.2	1
Tygalgah	1.0	12.1	2
Condong	0.8	7.5	3
Stotts Creek	0.7	6.9	4
North Tumbulgum	0.7	5.9	5
Dulguigan	1.0	5.8	6
West Chinderah	0.5	5.6	7
Kynnumboon	1.4	5.4	8
South Murwillumbah	0.7	1.6	9
Cobaki	0.4	1.2	10
Bilambil/Terranora	0.4	1.1	11
East Chinderah	0.4	0.9	12
Dunbible Creek	0.7	0.8	13
Commercial Road	0.7	0.4	14

\* Mean High Water adopted as minimum blackwater inundation level



**Figure S94.** Extent of area contributing to blackwater generation under median inundation level, Tweed River

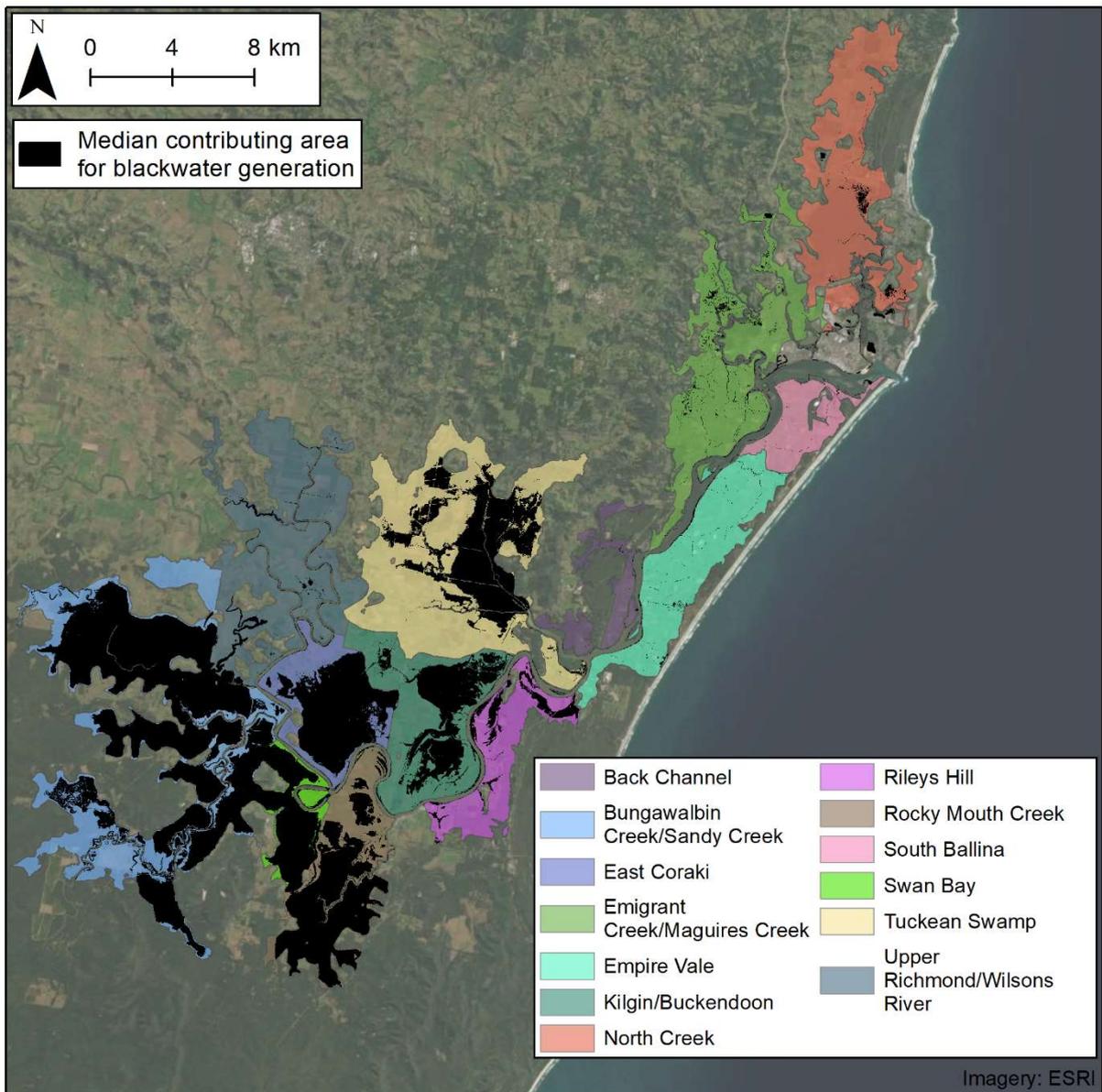


**Figure S95.** Ranking of catchments for blackwater risk, Tweed River

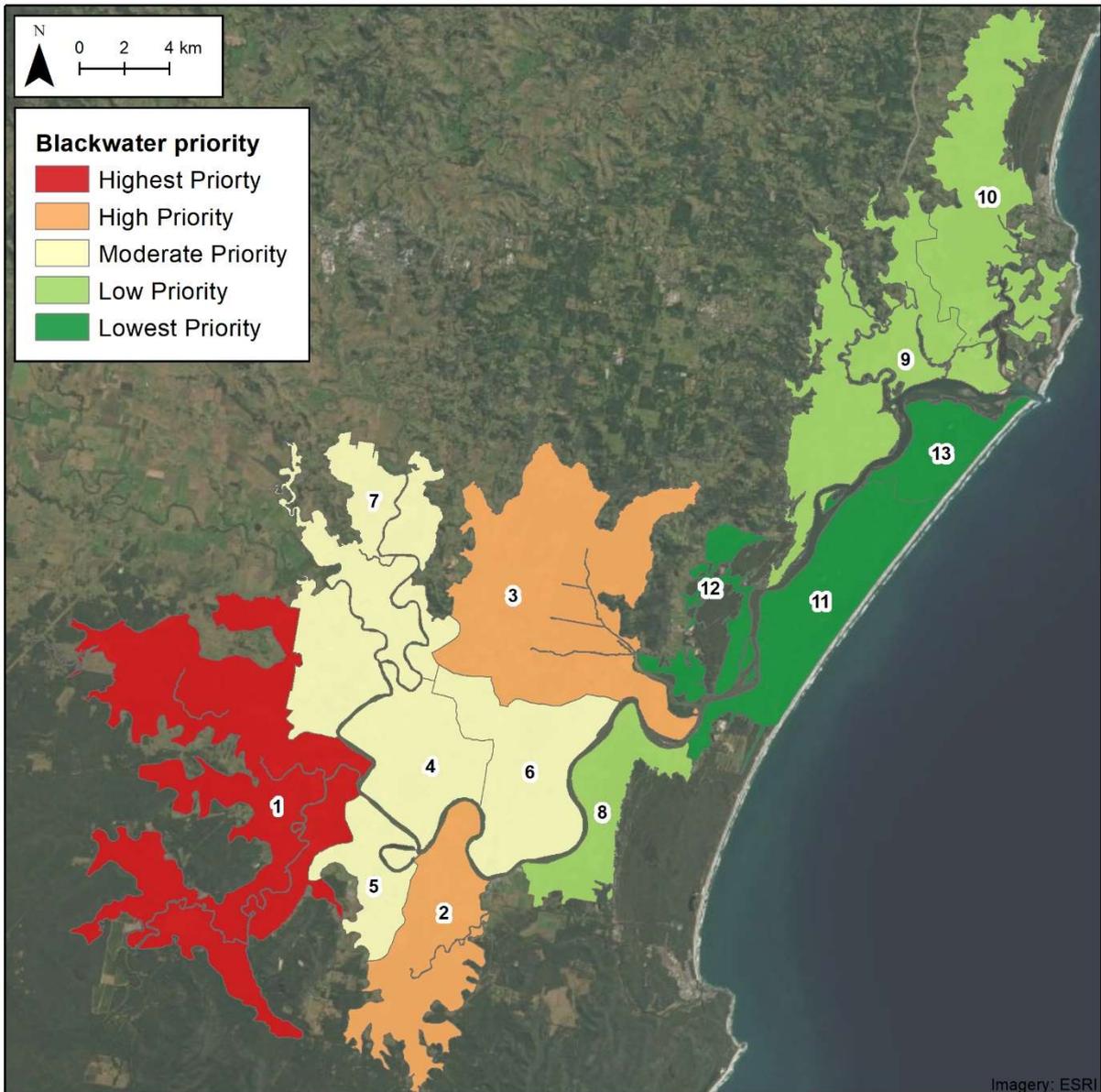
**Table S17.** Median inundation level, blackwater contribution factor and ranking of catchments, Richmond River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Bungawalbin Creek/Sandy Creek	2.9	135.4	1
Rocky Mouth Creek	1.5	44.0	2
Tuckean Swamp	1.0	37.4	3
East Coraki	2.5	33.4	4
Swan Bay	2.9	26.1	5
Kilgin/Buckendoon	1.5	25.6	6
Upper Richmond/Wilsons River	2.3	16.7	7
Rileys Hill	1.5	7.8	8
Emigrant Creek/Maguire's Creek	0.4*	3.0	9
North Creek	0.5*	2.4	10
Empire Vale	0.5*	1.2	11
Back Channel	0.5*	0.9	12
South Ballina	0.5*	0.2	13

\* Mean High Water adopted as minimum blackwater inundation level



**Figure S96.** Extent of area contributing to blackwater generation under median inundation level, Richmond River

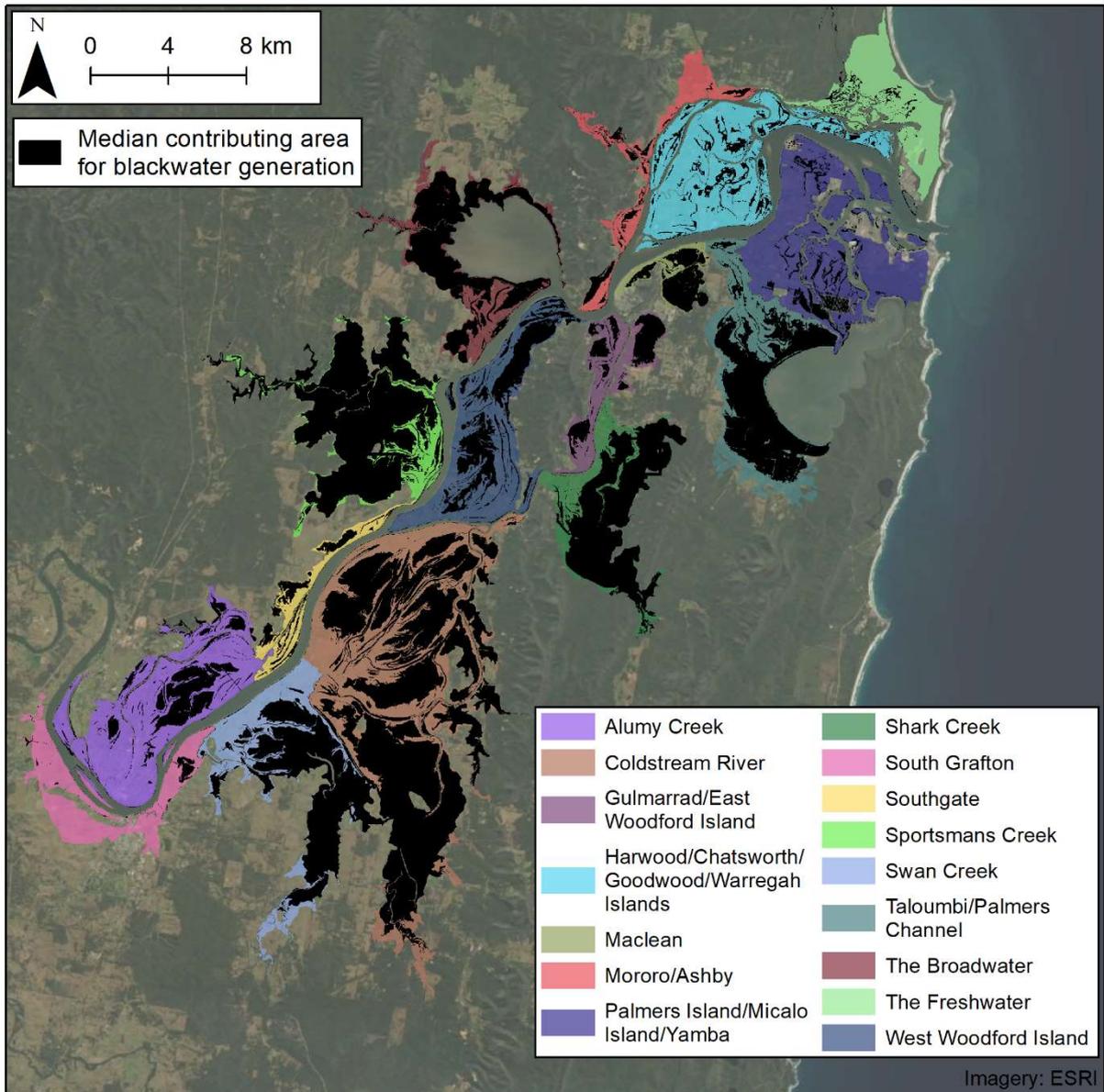


**Figure S97.** Ranking of catchments for blackwater risk, Richmond River

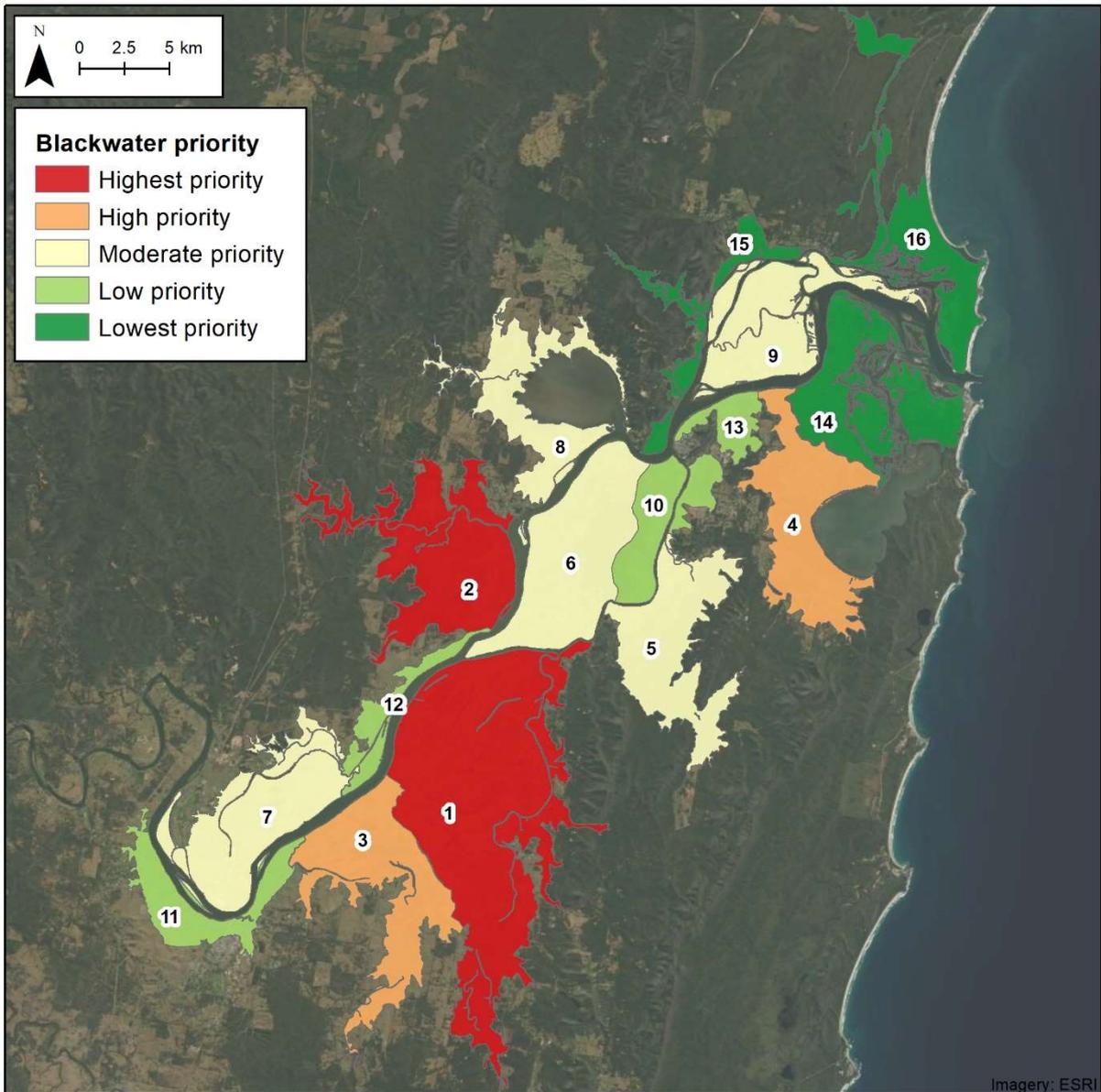
**Table S18.** Median inundation level, blackwater contribution factor and ranking of catchments, Clarence River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Coldstream River	1.9	153.5	1
Sportsmans Creek	1.9	99.3	2
Swan Creek	1.9	62.1	3
Taloumbi/Palmers Channel	0.9	52.2	4
Shark Creek	1.1	43.1	5
West Woodford Island	1.6	32.9	6
Alumy Creek	2.1	32.9	7
The Broadwater	1.3	25.3	8
Harwood/Chatsworth/ Goodwood/Warregah Islands	0.9	20.0	9
Gulmarrad/East Woodford Island	0.9	12.2	10
South Grafton	1.5	11.6	11
Southgate	1.8	10.7	12
Maclean	0.9	10.3	13
Palmers Island/Micalo Island/ Yamba	0.5*	9.2	14
Mororo/Ashby	0.9	8.4	15
The Freshwater	0.9	7.0	16

\* Mean High Water adopted as minimum blackwater inundation level



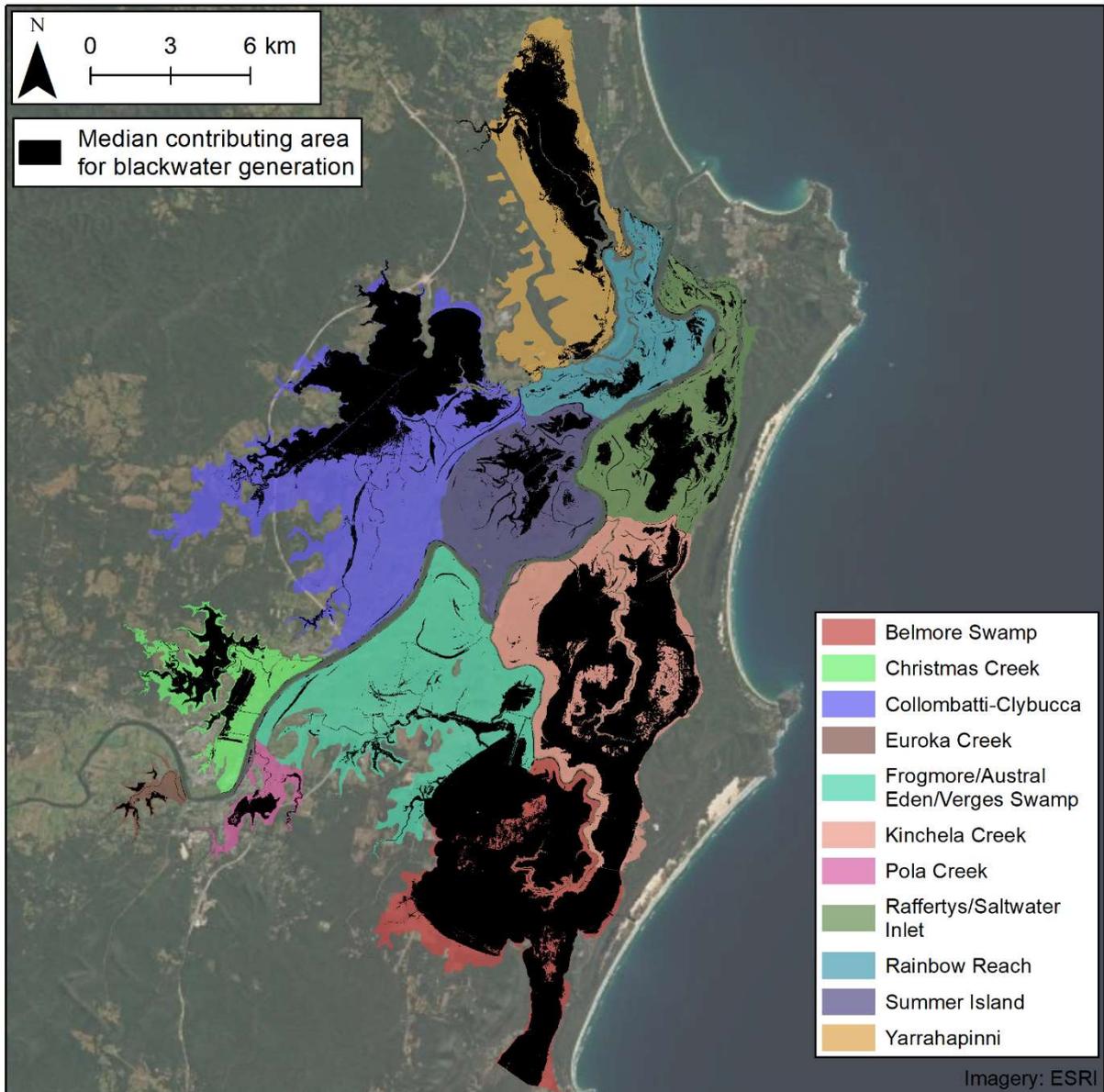
**Figure S98.** Extent of area contributing to blackwater generation under median inundation level, Clarence River



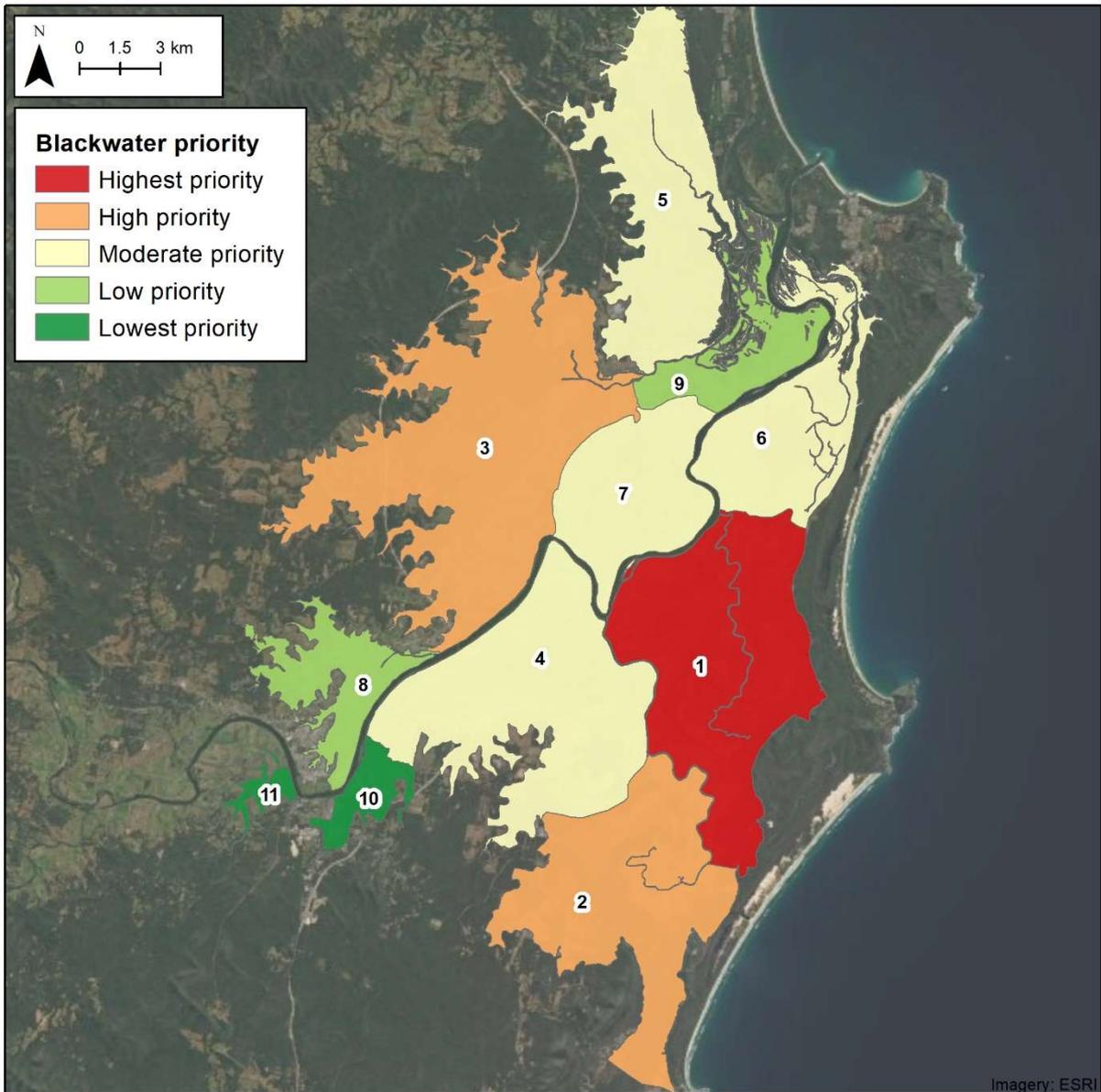
**Figure S99.** Ranking of catchments for blackwater risk, Clarence River

**Table S19.** Median inundation level, blackwater contribution factor and ranking of catchments, Macleay River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Kinchela Creek	1.0	87.0	1
Belmore Swamp	1.2	73.9	2
Collombatti-Clybucca	1.1	69.3	3
Frogmore/Austral Eden/Verges Swamp	1.2	48.6	4
Yarrahapinni	1.1	39.8	5
Raffertys/Saltwater Inlet	0.8	34.8	6
Summer Island	0.9	29.6	7
Christmas Creek	1.9	13.8	8
Rainbow Reach	0.6	9.8	9
Pola Creek	2.1	4.0	10
Euroka Creek	2.0	2.1	11



**Figure S100.** Extent of area contributing to blackwater generation under median inundation level, Macleay River

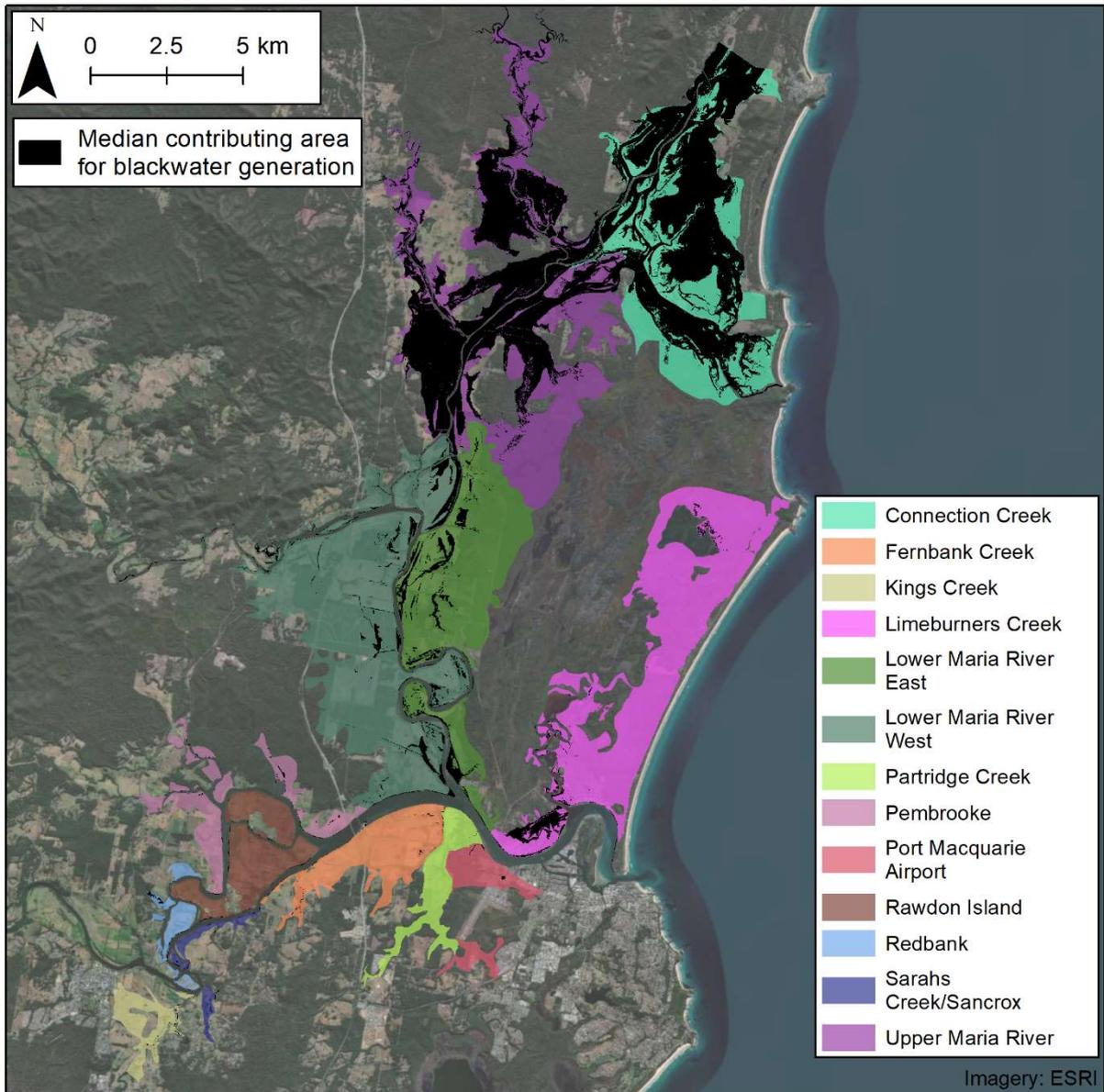


**Figure S101.** Ranking of catchments for blackwater risk, Macleay River

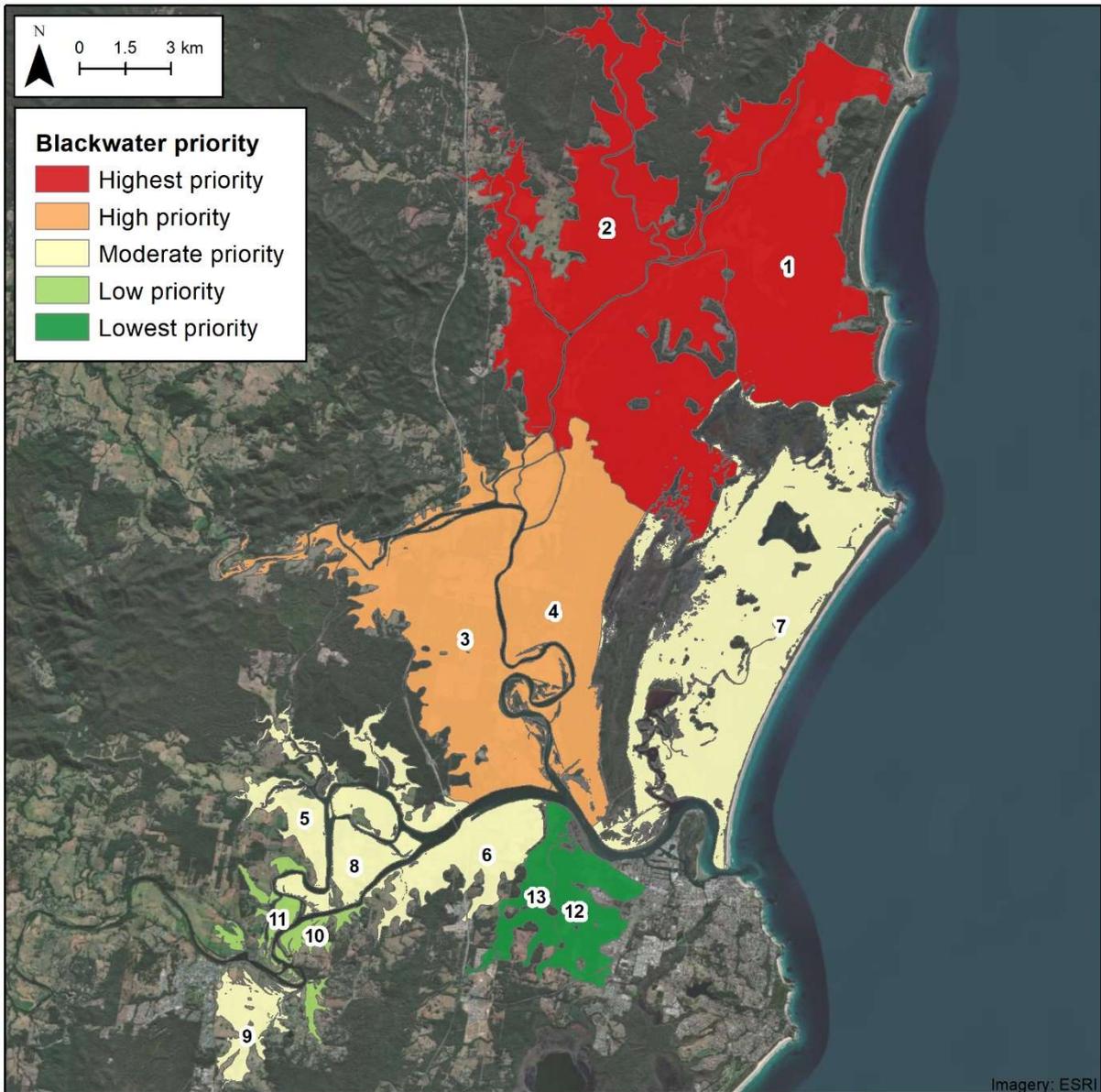
**Table S20.** Median inundation level, blackwater contribution factor and ranking of catchments, Hastings River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Connection Creek	1.0	66.8	1
Upper Maria River	1.0	66.5	2
Lower Maria River West	0.7	19.1	3
Lower Maria River East	0.7	11.4	4
Pembrooke	0.6	1.8	5
Fernbank Creek	0.5*	1.6	6
Limeburners Creek	0.4*	1.3	7
Rawdon Island	0.6	1.2	8
Kings Creek	0.7	1.1	9
Sarabs Creek/Sancrox	0.7	0.5	10
Redbank	0.7	0.5	11
Port Macquarie Airport	0.4*	0.1	12
Partridge Creek	0.5*	0.1	13

\* Mean High Water adopted as minimum blackwater inundation level



**Figure S102.** Extent of area contributing to blackwater generation under median inundation level, Hastings River

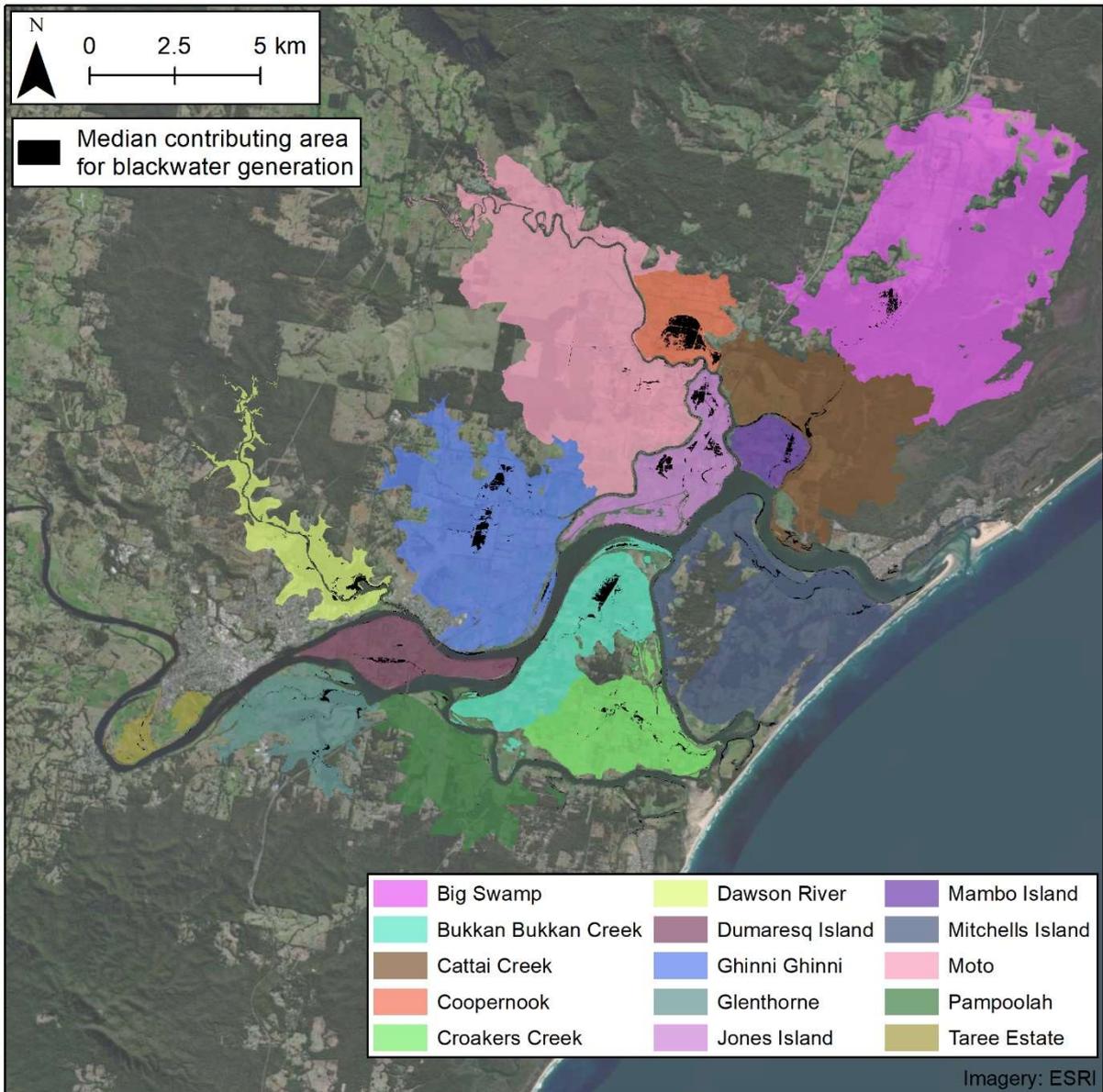


**Figure S103.** Ranking of catchments for blackwater risk, Hastings River

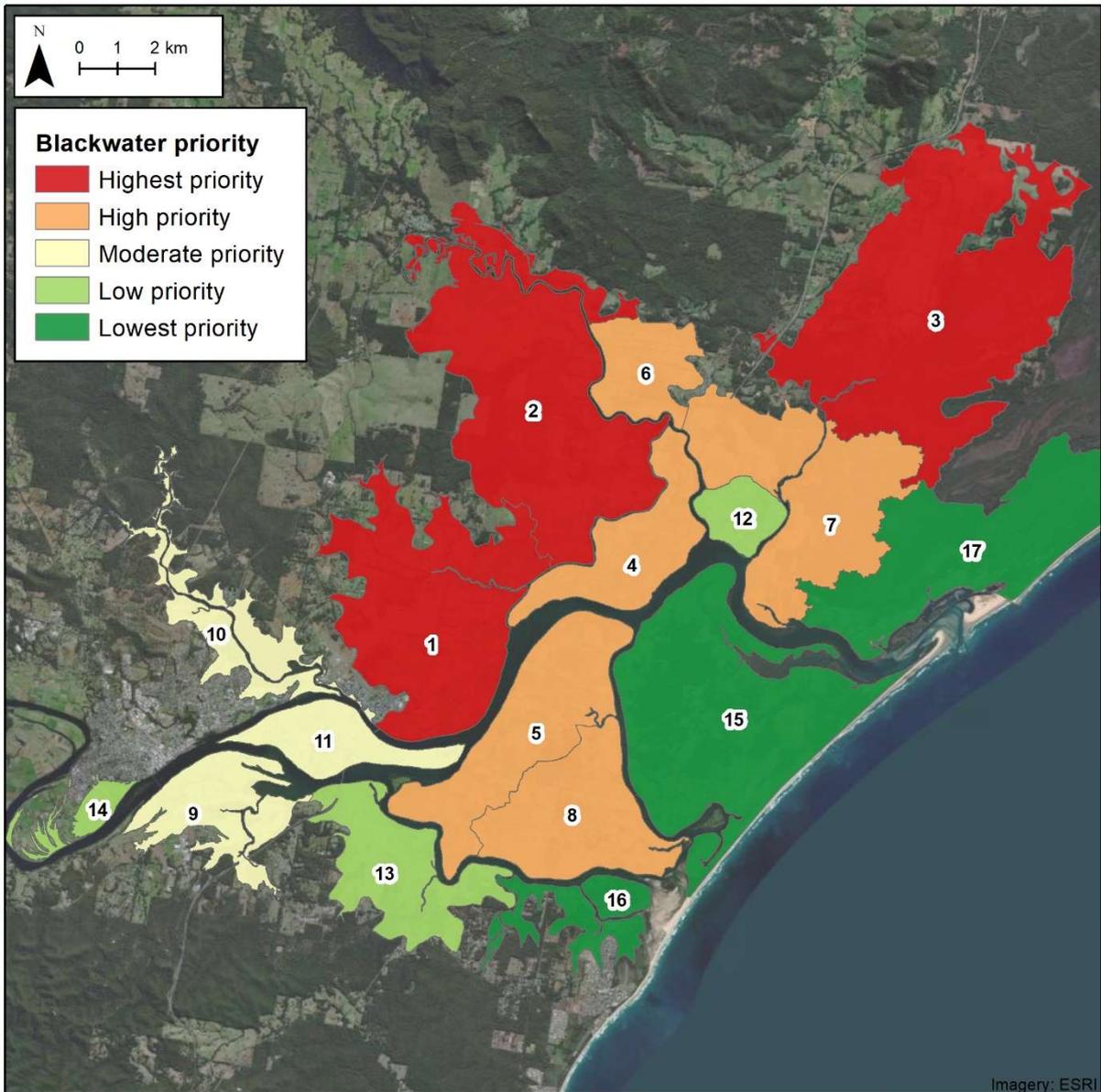
**Table S21.** Median inundation level, blackwater contribution factor and ranking of catchments, Manning River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Ghinni Ghinni	0.7	9.5	1
Moto	0.6	7.7	2
Big Swamp	0.5	6.4	3
Jones Island	0.6	5.4	4
Bukkan Bukkan Creek	0.6	4.5	5
Cooperook	0.6	4.1	6
Cattai Creek	0.5	3.1	7
Croakers Creek	0.5	2.8	8
Glenthorne	0.7	1.8	9
Dawson River	0.7	1.6	10
Dumaresq Island	0.7	1.4	11
Mambo Island	0.5	1.2	12
Pampoolah	0.6	1.1	13
Taree Estate	0.7	0.4	14
Mitchells Island	0.5	0.4	15
Old Bar	0.5	0.2	16
Harrington	0.4*	0.03	17

\* Mean High Water adopted as minimum blackwater inundation level



**Figure S104.** Extent of area contributing to blackwater generation under median inundation level, Manning River

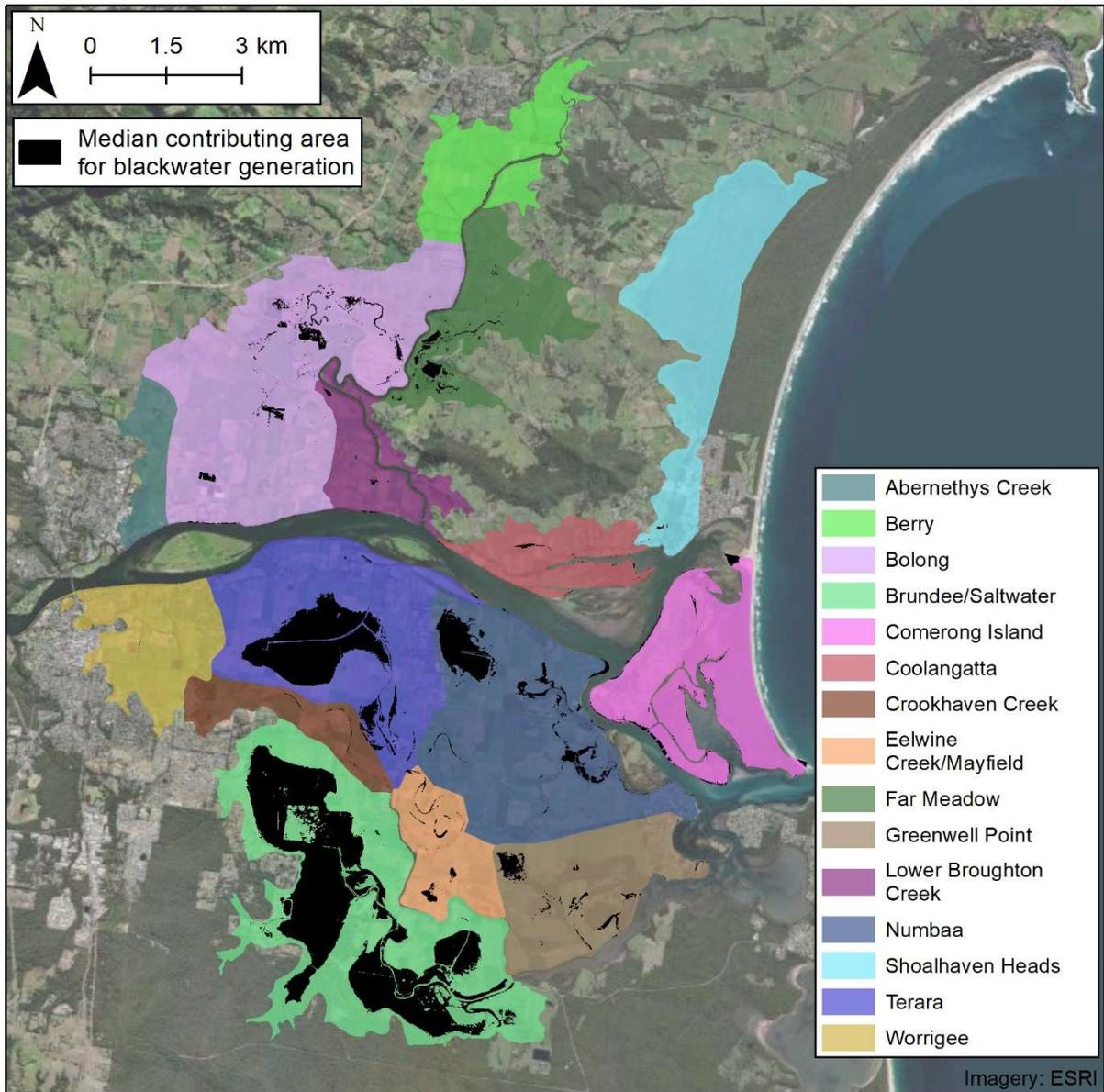


**Figure S105.** Ranking of catchments for blackwater risk, Manning River

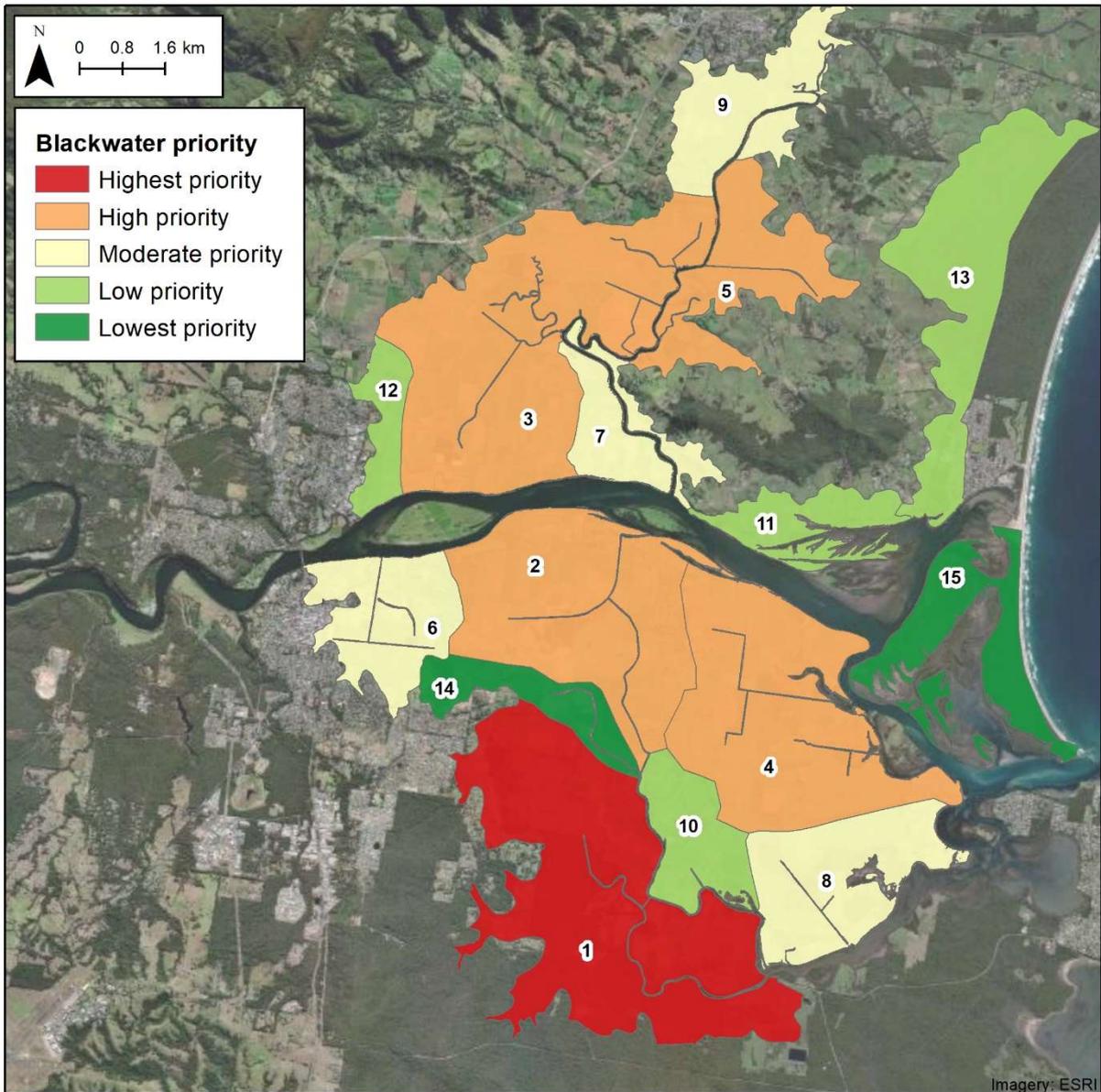
**Table S22.** Median inundation level, blackwater contribution factor and ranking of catchments, Shoalhaven River

<b>Catchment</b>	<b>Median blackwater elevation (m AHD)</b>	<b>Blackwater contribution factor</b>	<b>Rank</b>
Brundee/Saltwater	0.4*	18.4	1
Terara	0.4*	8.0	2
Bolong	0.4*	5.8	3
Numbaa	0.4*	2.9	4
Far Meadow	0.4*	2.2	5
Worrigea	0.4*	0.8	6
Lower Broughton Creek	0.4*	0.8	7
Greenwell Point	0.4*	0.5	8
Berry	0.4*	0.5	9
Eelwine Creek/Mayfield	0.4*	0.3	10
Coolangatta	0.4*	0.2	11
Abernethys Creek	0.4*	0.2	12
Shoalhaven Heads	0.4*	0.1	13
Crookhaven Creek	0.4*	0.1	14
Comerong Island	0.4*	0.05	15

\* Mean High Water adopted as minimum blackwater inundation level



**Figure S106.** Extent of area contributing to blackwater generation under median inundation level, Shoalhaven River

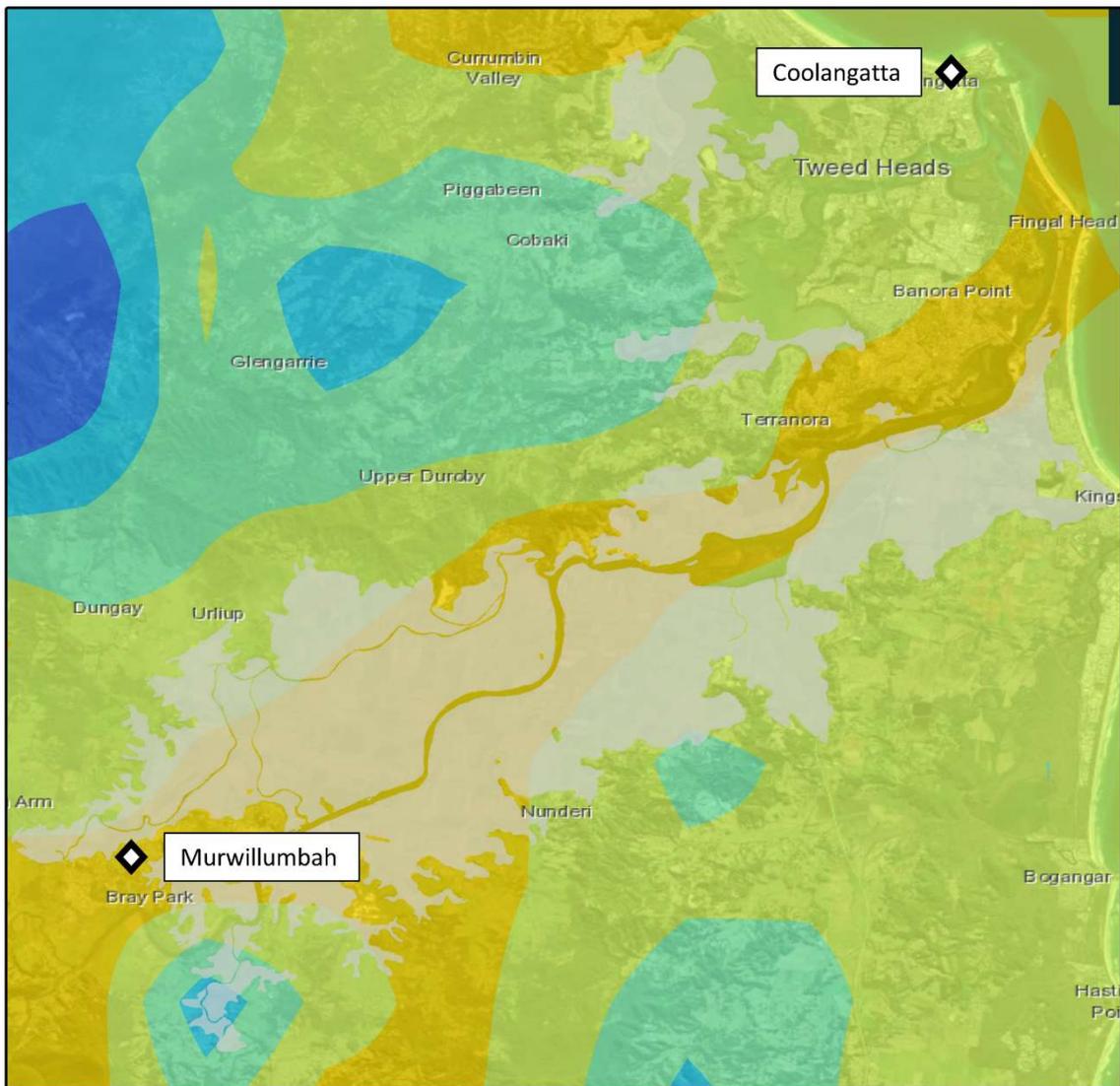


**Figure S107.** Ranking of catchments for blackwater risk, Shoalhaven River

**Table S23.** Sensitivity of inundation level and ranking of aggregated blackwater risk factor to changes in duration and flood frequency matrices

River system		Tweed	Richmond	Clarence	Macleay	Hastings	Manning	Shoalhaven
<b>Base case:*</b>								
	median inundation level	0.7	1.5	1.2	1.1	0.7	0.6	0.4
	max inundation level	3.8	4.1	6.2	5.9	3.6	3.0	2.7
<b>Increased inundation duration:</b>								
2 – 5 days	median inundation level	0.5	1.25	1.0	1.1	0.55	0.45	0.4
	max inundation level	2.8	4.1	4.5	4.9	1.7	2.2	1.3
	rank correlation of results	0.98	1.0	0.99	0.99	0.96	0.99	0.88
3 – 5 days	median inundation level	0.5	1.1	0.9	0.8	0.5	0.4	0.4
	max inundation level	2.4	3.6	4.0	3.7	1.5	1.3	0.7
	rank correlation of results	0.97	0.99	0.99	0.98	0.92	0.95	0.77
<b>Reduced flood frequency:</b>								
2 – 5 years	median inundation level	0.8	1.6	1.4	1.4	0.7	0.65	0.4
	max inundation level	3.8	4.1	6.2	5.9	3.6	3.0	2.7
	rank correlation of results	0.995	0.996	0.997	1.0	0.99	1.0	0.997
3 – 5 years	median inundation level	0.9	1.6	1.4	1.3	0.7	0.6	0.4
	max inundation level	3.8	4.1	6.2	5.9	3.6	3.0	2.7
	rank correlation of results	0.98	0.996	0.996	1.0	0.996	0.998	0.995

\* Base case represents the results for the full matrix of 1 to 5 days inundation and 1 to 5 year event frequency



**Legend:**



Temperature monitoring station

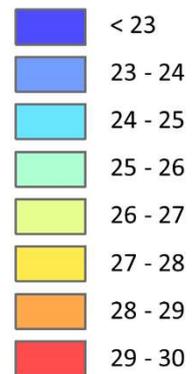


Extent of estuarine subcatchments subject to inundation and subsequent potential blackwater production



0 2 4 km

Temperature (°C)



**Figure S108.** Average maximum temperature (October to April), Tweed River

**Table S24.** Average maximum temperatures within the Tweed River catchments

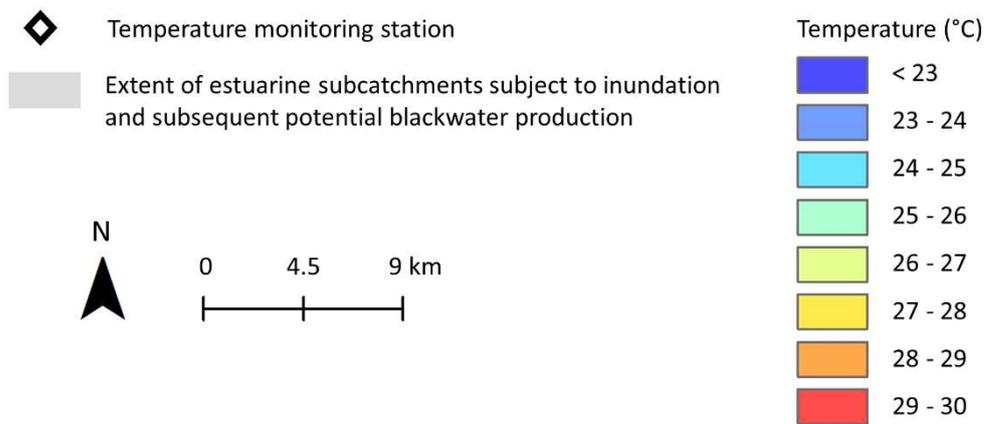
<b>Station: Coolangatta (40717)</b>		<b>Elevation: 4m AHD</b>		
<b>Data period: November 1982 to June 2022</b>				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	26.8	28.5	30.0	28.4
February	27.0	28.4	29.8	28.3
March	25.9	27.5	28.6	27.4
April	24.4	25.5	26.9	25.5
May	22.4	23.1	24.5	23.2
June	20.0	21.0	22.1	21.1
July	19.4	20.9	21.8	20.7
August	20.4	21.5	23.2	21.6
September	22.1	23.3	25.1	23.4
October	23.2	24.6	26.4	24.7
November	24.1	26.0	27.6	26.1
December	26.1	27.4	29.2	27.4

<b>Station: Bray Park, Murwillumbah (58158)</b>		<b>Elevation: 8m AHD</b>		
<b>Data period: October 1972 to June 2022</b>				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	27.9	29.5	31.2	29.6
February	27.5	28.9	30.8	29.0
March	26.6	28.2	29.4	28.1
April	24.9	26.0	27.6	26.2
May	22.5	23.4	25.2	23.6
June	20.4	21.3	22.4	21.3
July	19.9	21.2	22.4	21.1
August	21.3	22.6	24.1	22.6
September	23.4	24.8	27.8	25.1
October	24.5	26.2	28.0	26.4
November	25.8	27.8	29.4	27.8
December	27.0	29.0	31.6	29.1



**Legend:**



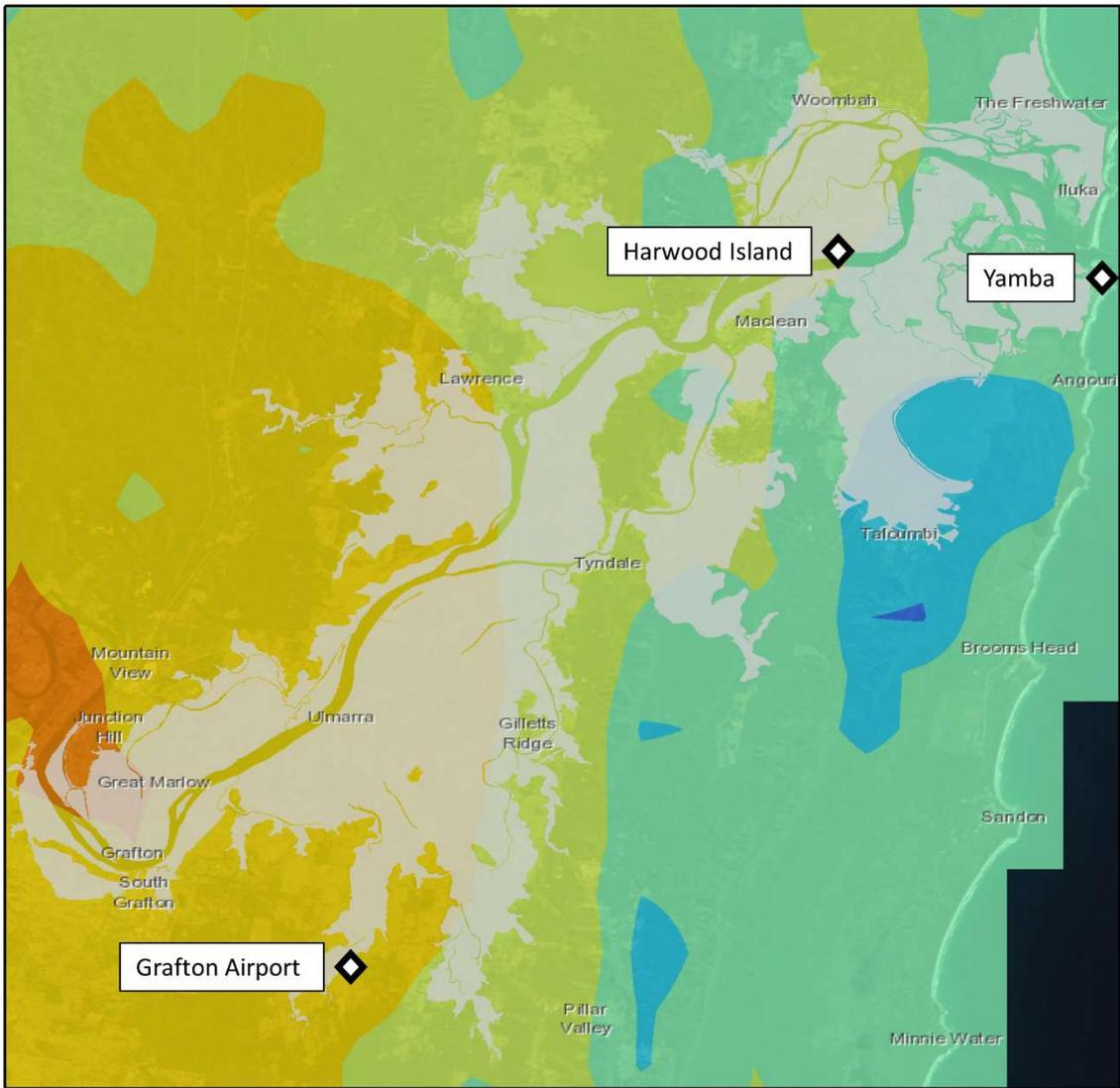
**Figure S109.** Average maximum temperature (October to April), Richmond River

**Table S25.** Average maximum temperatures within the Richmond River catchments

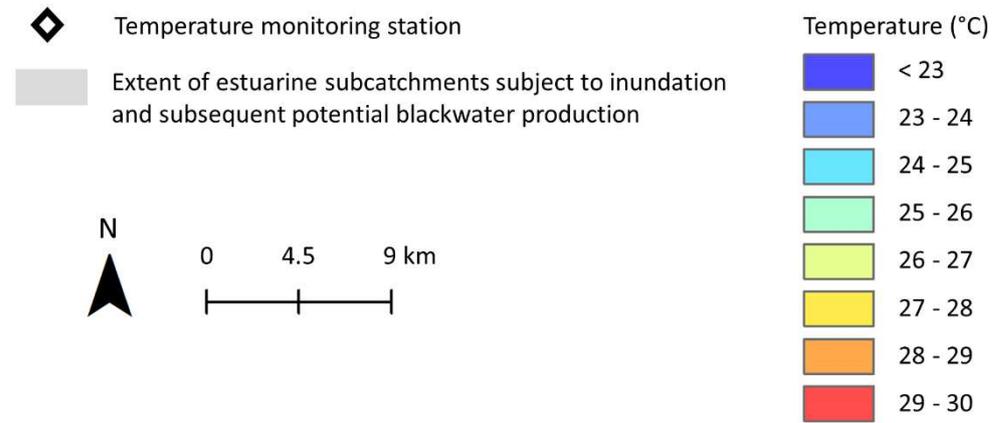
Month	Monthly maximum temperature			
	5%	50%	95%	Average
January	26.7	28.2	30.2	28.4
February	26.8	28.0	29.6	28.1
March	25.8	27.1	28.6	27.1
April	23.7	25.0	26.3	25.0
May	21.7	22.4	23.7	22.5
June	19.5	20.4	21.2	20.3
July	19.3	20.1	21.2	20.1
August	20.2	21.3	23.1	21.4
September	22.2	23.4	25.7	23.6
October	23.6	24.9	26.2	24.9
November	24.4	26.4	28.6	26.3
December	25.5	27.5	29.5	27.6

Month	Monthly maximum temperature			
	5%	50%	95%	Average
January	28.2	30.0	32.5	30.2
February	27.9	29.5	21.7	29.5
March	27.0	28.0	29.9	28.2
April	24.4	26.0	27.3	25.9
May	22.3	23.2	25.3	23.4
June	19.8	20.9	21.9	20.8
July	19.7	20.9	22.1	20.9
August	21.4	22.6	24.2	22.8
September	23.9	25.2	28.1	25.7
October	24.8	27.6	28.7	27.3
November	26.1	29.0	31.1	28.8
December	27.0	29.9	32.2	29.6



**Legend:**



**Figure S110.** Average maximum temperature (October to April), Clarence River

**Table S26.** Average maximum temperatures within the Clarence River catchments

<b>Station:</b> Yamba Pilot Station (58012)		<b>Elevation:</b> 27m AHD		
<b>Data period:</b> June 1887 to June 2022				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	25.1	26.5	28.9	26.8
February	25.3	26.6	28.9	26.8
March	24.5	25.9	28.2	26.1
April	22.9	24.2	26.4	24.3
May	20.5	21.7	23.6	21.8
June	18.4	19.6	21.2	19.7
July	17.8	19.1	20.8	19.1
August	18.5	20.2	21.9	20.2
September	20.3	21.8	24.2	22.1
October	21.6	23.1	25.8	23.4
November	23.0	24.5	27.3	24.7
December	24.3	25.7	28.5	26.0

<b>Station:</b> Harwood Island Sugar Mill (58027)		<b>Elevation:</b> 2m AHD		
<b>Data period:</b> January 1915 to November 1972				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	26.4	29.3	31.3	29.0
February	26.5	28.7	30.9	28.7
March	25.9	27.8	29.7	27.7
April	23.8	25.9	28.2	26.0
May	21.8	23.1	25.8	23.3
June	19.4	21.1	23.0	21.1
July	19.1	20.5	23.1	20.8
August	19.8	21.6	23.8	21.8
September	21.9	23.8	27.0	24.0
October	23.8	26.0	28.0	26.0
November	25.3	27.8	30.6	27.8
December	26.8	28.6	31.7	28.8

**Table S26 (cont'd).** Average maximum temperatures within the Clarence River catchments

**Station:** Grafton Airport AWS (58161)

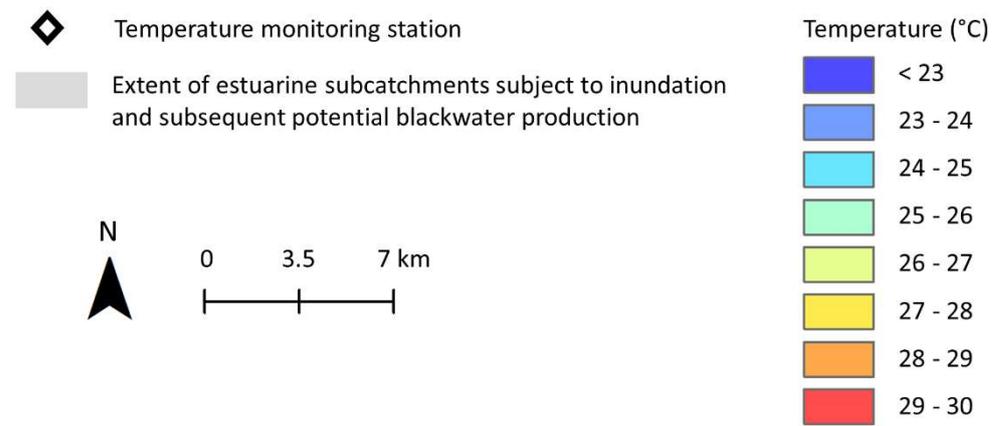
**Elevation:** 25m AHD

**Data period:** April 2006 to June 2022

Month	Monthly maximum temperature			
	5%	50%	95%	Average
January	28.0	30.0	32.5	30.2
February	27.6	29.5	32.0	29.6
March	27.0	27.9	29.6	28.1
April	24.6	25.5	27.0	25.7
May	22.1	22.8	25.0	23.2
June	19.7	20.4	21.9	20.6
July	19.7	20.5	21.9	20.6
August	21.3	22.7	23.9	22.5
September	23.5	24.6	27.1	24.9
October	24.2	26.8	28.8	26.8
November	26.0	29.0	30.06	28.5
December	26.8	29.6	31.6	29.2



**Legend:**



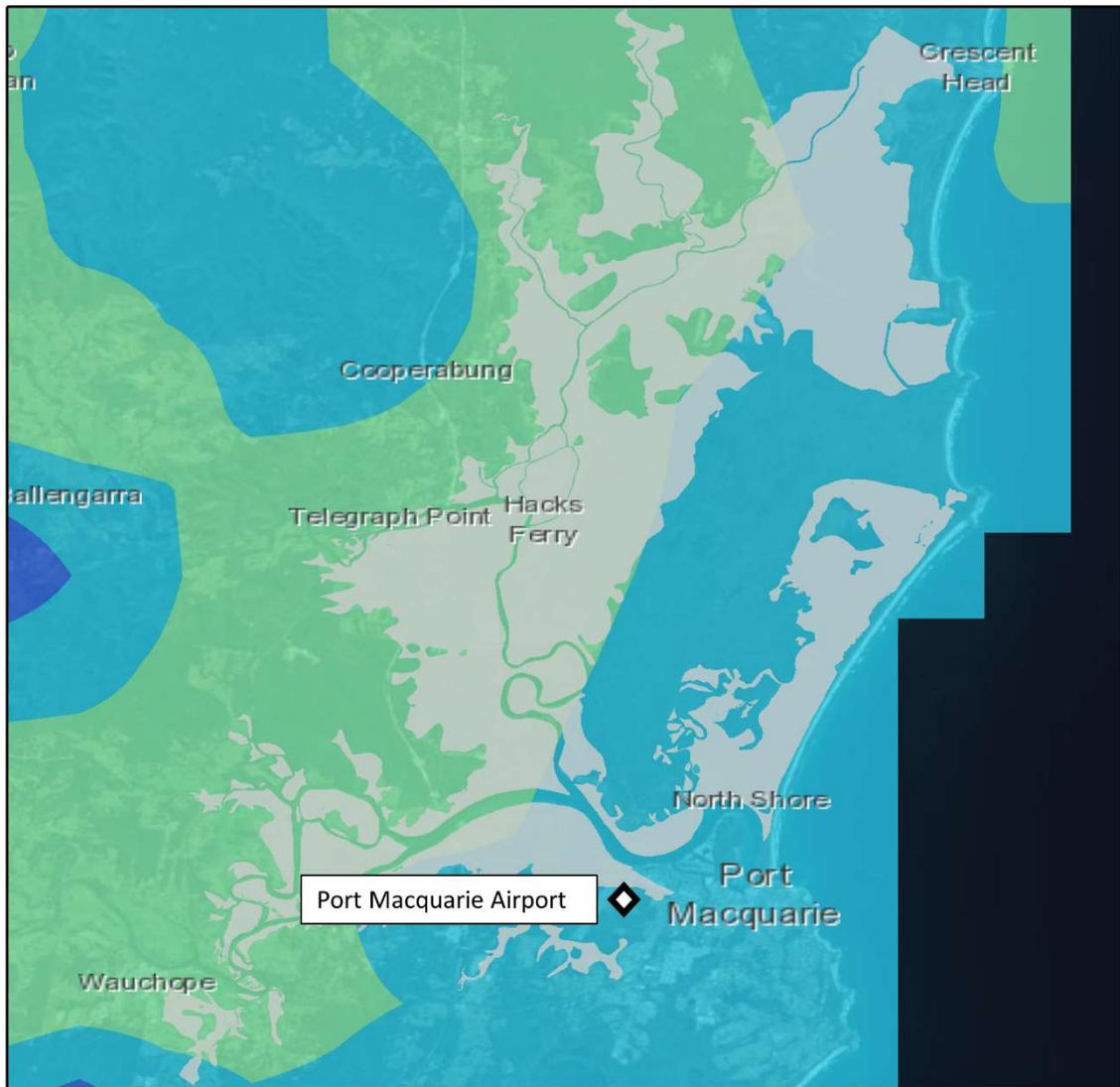
**Figure S111.** Average maximum temperature (October to April), Macleay River

**Table S27.** Average maximum temperatures within the Macleay River catchments

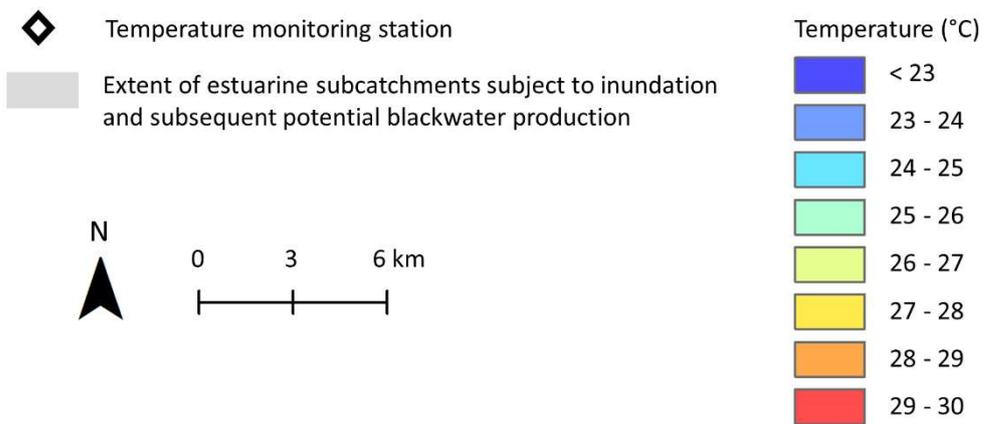
Month	Monthly maximum temperature			
	5%	50%	95%	Average
January	25.4	26.9	28.9	27.0
February	25.6	26.9	29.2	27.1
March	24.9	26.3	27.7	26.3
April	22.7	24.0	25.8	24.2
May	20.4	21.4	23.5	21.6
June	18.2	19.2	20.8	19.3
July	17.7	18.8	20.3	18.8
August	18.6	19.9	22.1	20.0
September	20.3	21.8	24.3	21.9
October	21.7	23.3	25.3	23.4
November	22.9	24.7	26.3	24.7
December	24.5	25.9	28.1	26.1

Month	Monthly maximum temperature			
	5%	50%	95%	Average
January	27.8	29.0	32.4	29.5
February	27.0	28.6	30.8	28.8
March	26.1	27.1	28.8	27.3
April	24.3	25.4	26.8	25.4
May	21.2	22.3	24.3	22.5
June	19.1	20.0	21.3	20.1
July	18.9	20.0	21.0	20.1
August	20.6	21.9	23.4	21.7
September	23.0	24.1	26.6	24.5
October	23.7	25.9	27.7	25.8
November	25.4	27.2	29.1	27.0
December	26.8	28.3	30.6	28.4



**Legend:**



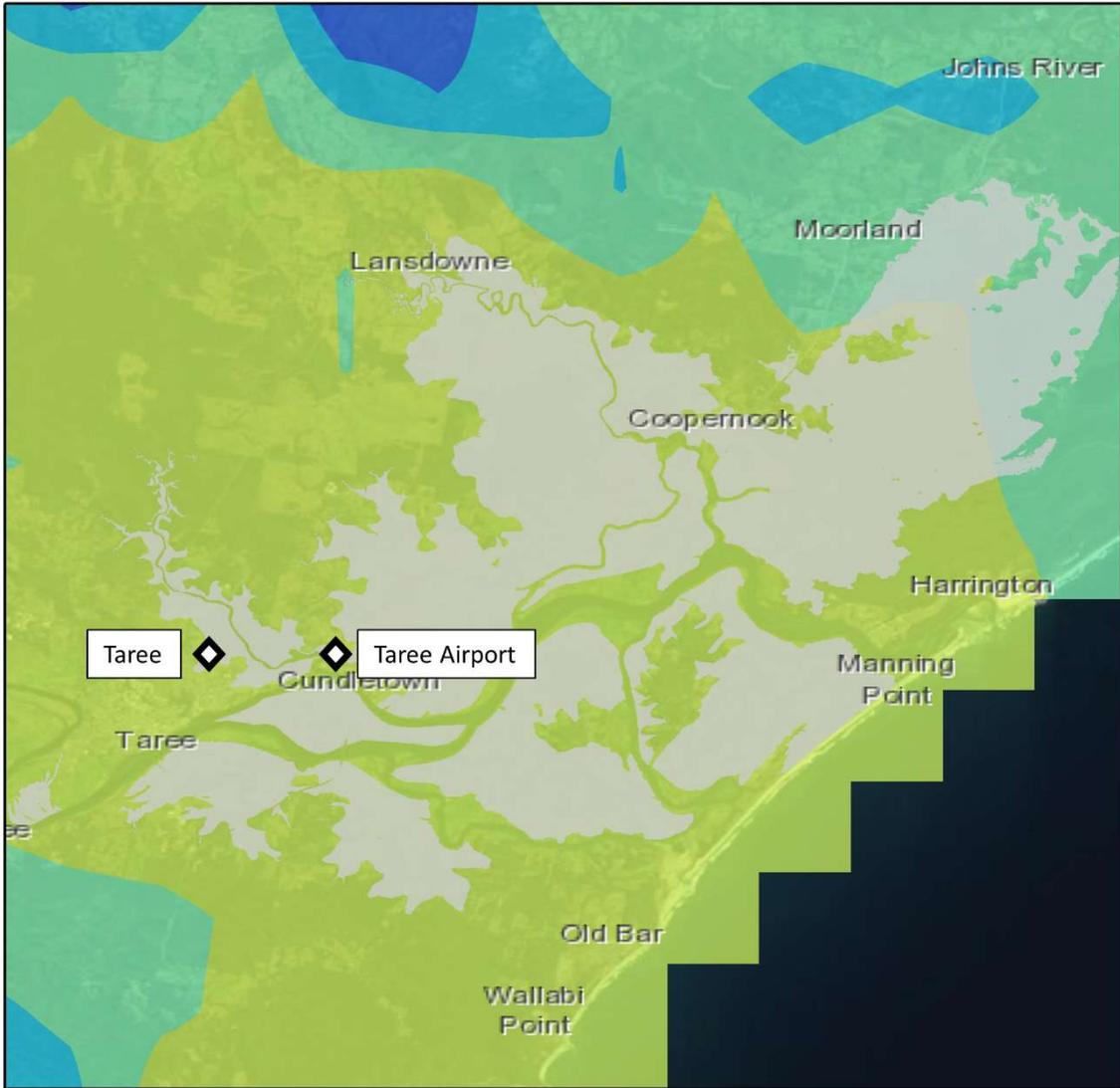
**Figure S112.** Average maximum temperature (October to April), Hastings River

**Table S28.** Average maximum temperatures within the Hastings River catchments

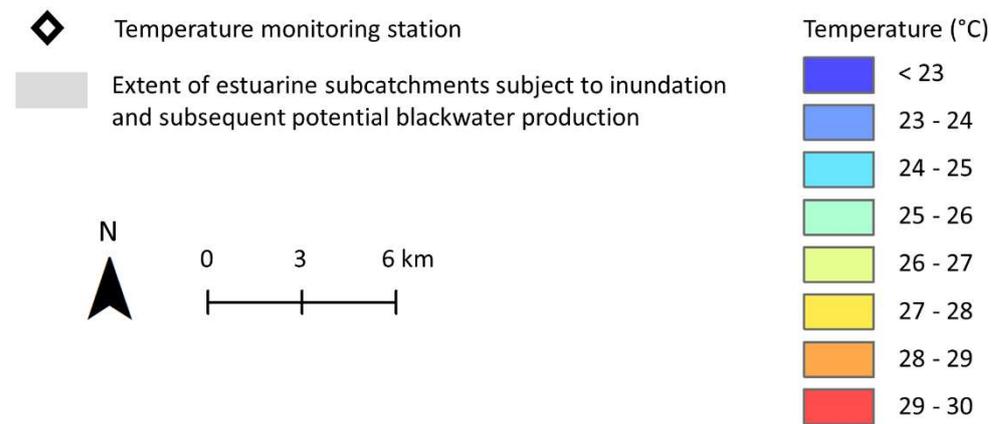
<b>Station:</b> Port Macquarie Airport AWS (60168)		<b>Elevation:</b> 4m AHD		
<b>Data period:</b> October 2020 to June 2022				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>Lowest</b>			<b>Highest</b>
January	27.3			27.5
February	26.4			26.6
March	25.7			25.9
April	24.0			24.3
May	21.5			21.6
June	19.0			19.3
July	19.3			19.3
August	21.4			21.4
September	22.8			22.8
October	24.5			25.1
November	25.0			26.2
December	26.6			26.6

<b>Station:</b> Eloura Street, Laurieton (60022)		<b>Elevation:</b> 12m AHD		
<b>Data period:</b> January 1907 to September 1930				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	23.8	25.6	27.9	25.8
February	22.7	26.0	28.6	25.8
March	21.9	24.8	26.3	24.6
April	19.1	23.4	25.4	22.8
May	15.9	20.7	21.4	19.6
June	14.1	17.9	19.3	17.3
July	12.8	17.8	18.8	16.6
August	14.3	19.0	20.9	18.0
September	16.6	20.8	22.9	20.1
October	19.7	22.2	25.0	22.3
November	21.1	24.0	25.9	23.9
December	23.3	25.0	27.4	25.2



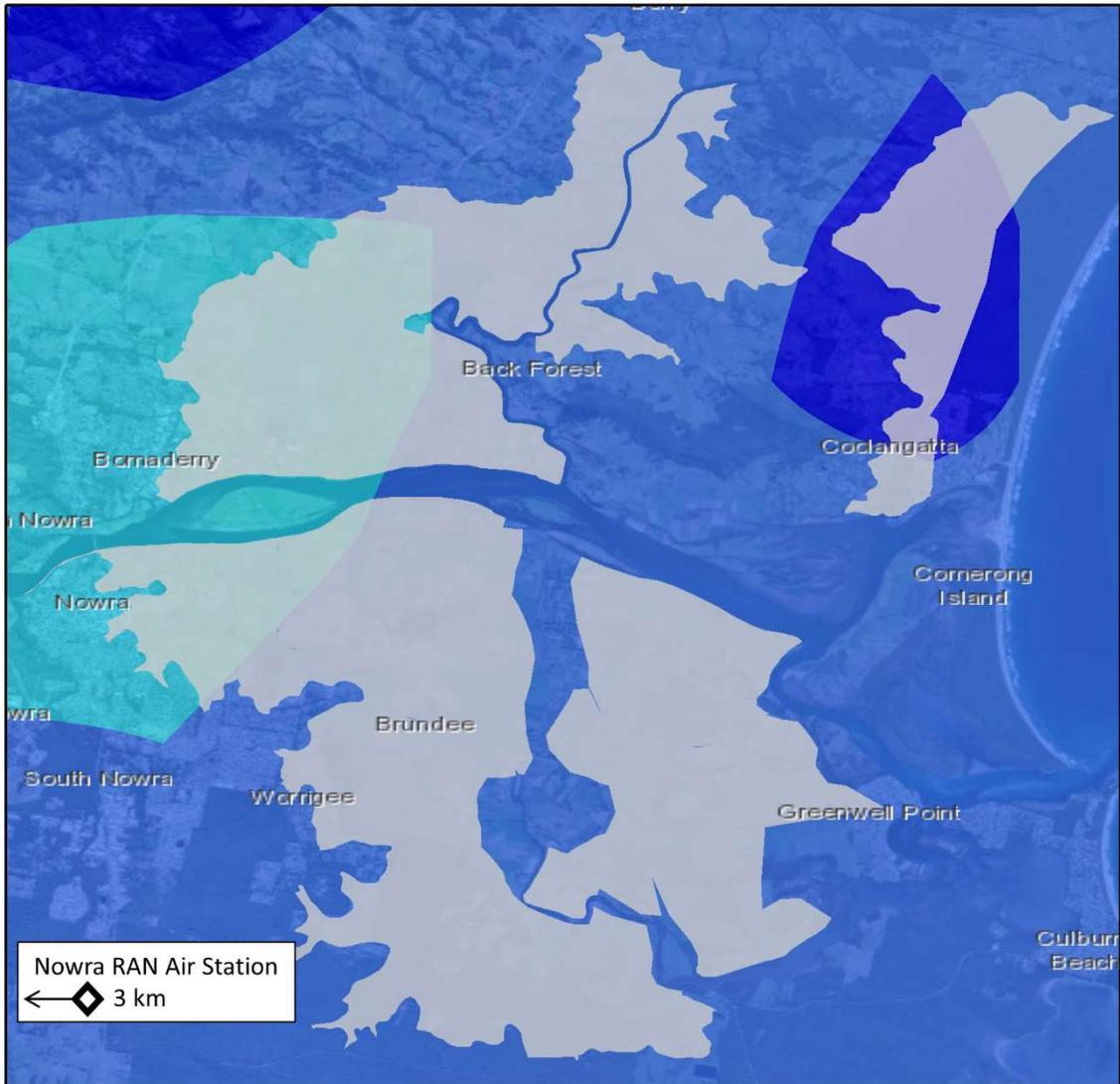
**Legend:**



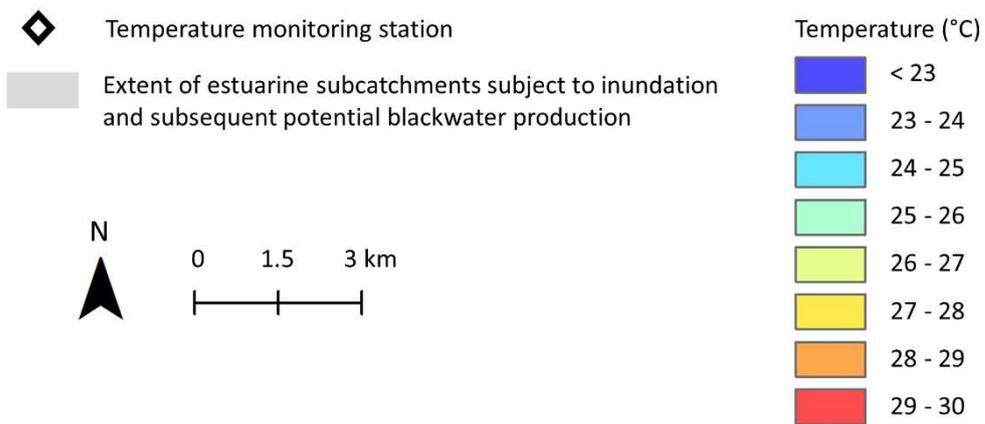
**Figure S113.** Average maximum temperature (October to April), Manning River

**Table S29.** Average maximum temperatures within the Manning River catchments

<b>Station: Taree Airport (60141)</b>		<b>Elevation: 8m AHD</b>		
<b>Data period: July 1997 to June 2022</b>				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	27.2	29.1	30.8	29.0
February	26.3	28.2	30.2	28.3
March	25.5	26.7	28.1	26.8
April	22.4	24.3	25.9	24.4
May	20.3	21.3	23.0	21.5
June	17.9	18.9	20.2	18.9
July	17.8	18.5	19.9	18.7
August	18.7	20.1	21.7	20.2
September	21.4	22.9	25.3	23.1
October	22.8	24.9	26.8	24.8
November	23.6	26.2	28.3	26.1
December	25.7	27.8	29.8	27.8
<b>Station: Patanga Close, Taree (60030)</b>		<b>Elevation: 14m AHD</b>		
<b>Data period: January 1907 to March 2005</b>				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	26.4	28.7	31.7	29.0
February	26.4	28.5	31.2	28.6
March	25.3	27.2	29.2	27.3
April	22.9	24.8	26.7	24.7
May	19.4	21.7	23.0	21.5
June	17.6	19.1	21.0	19.1
July	16.2	18.6	20.4	18.5
August	16.5	20.2	22.1	19.9
September	19.9	22.8	25.2	22.7
October	22.5	24.9	27.1	24.9
November	23.8	26.9	29.6	26.7
December	26.1	28.3	31.0	28.4



**Legend:**



**Figure S114.** Average maximum temperature (October to April), Shoalhaven River

**Table S30.** Average maximum temperatures within the Shoalhaven River catchments

<b>Station:</b> Nowra RAN Air Station AWS (68072)		<b>Elevation:</b> 109m AHD		
<b>Data period:</b> November 2000 to June 2022				
<b>Month</b>	<b>Monthly maximum temperature</b>			
	<b>5%</b>	<b>50%</b>	<b>95%</b>	<b>Average</b>
January	26.5	27.5	29.6	27.7
February	24.2	26.5	27.7	26.4
March	23.2	25.1	26.4	25.1
April	21.4	22.9	24.7	22.9
May	18.3	19.5	21.4	19.7
June	15.3	17.0	18.0	16.9
July	15.7	16.8	17.9	16.8
August	16.9	18.2	19.3	18.2
September	19.7	20.9	22.5	21.1
October	21.0	23.3	25.5	23.2
November	22.5	24.9	27.5	24.8
December	24.2	25.9	28.4	26.1

## References

- Couriel, E., Alley, K., & Modra, B. (2012). OEH NSW Tidal Planes Analysis 1990–2010 Harmonic Analysis (Report MHL2053). *Sydney, Australia*.
- DPIE. (2020). NSW Landuse 2017 Version 1.2. Retrieved from <https://datasets.seed.nsw.gov.au/dataset/nsw-landuse-2017-v1p2-f0ed>
- Mallin, M. A., Posey, M. H., Mclver, M. R., Parsons, D. C., Ensign, S. H., & Alphin, T. D. (2002). Impacts and Recovery from Multiple Hurricanes in a Piedmont–Coastal Plain River System: Human development of floodplains greatly compounds the impacts of hurricanes on water quality and aquatic life. *BioScience*, 52(11), 999-1010. [https://doi.org/10.1641/0006-3568\(2002\)052\[0999:IARFMH\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2002)052[0999:IARFMH]2.0.CO;2)
- USEPA. (2001). *PLOAD version 3.0. An ArcView GIS Tool to Calculate Non-Point Sources of Pollution in Watershed and Stormwater Project: Users Manual*. Retrieved from [https://permanent.fdlp.gov/lps49376/PLOAD\\_v3.pdf](https://permanent.fdlp.gov/lps49376/PLOAD_v3.pdf).
- Vithana, C. L., Sullivan, L. A., & Shepherd, T. (2019). Role of temperature on the development of hypoxia in blackwater from grass. *Science of The Total Environment*, 667, 152-159.
- Wong, V., Walsh, S., & Morris, S. (2018). Climate affects fish-kill events in subtropical estuaries of eastern Australia. *Marine and Freshwater Research*, 69(11), 1641-1648.