Study to Determine Water Requirements for McKerrows Marsh - Great Forester River

Review of Information on hydrology and hydrogeology

Water Assessment and Planning Branch

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Cover Photo: '*The Billabong' at McKerrows Marsh.*

The Department of Primary Industries, Water and Environment

The Department of Primary Industries, Water and Environment provides leadership in the sustainable management and development of Tasmania's resources. The Mission of the Department is to advance Tasmania's prosperity through the sustainable development of our natural resources and the conservation of our natural and cultural heritage for the future.

The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

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Introduction

McKerrows Marsh is located at the bottom of the Great Forester River, just upstream of the limit of tidal influence. The Marsh, as defined by the proposed Nature Reserve (Figure 1) encompasses about 386 hectares, and is a dense blackwood / teatree swamp fringed by sedgeland. Most of this area is subject to flooding from the Great Forester River, which passes through it, and substantial areas around the wetland are waterlogged for much of the winter due to poor drainage. In an attempt to improve drainage and increase productivity, large drainage ditches and straightening of the river channel has been carried out in the eastern arm of the wetland.

The Marsh is roughly divided into two distinct sections; western arm is composed primarily of blackwood and paperbark swamp forest, while the eastern arm is dominated by grassland and sedge species, but also contains some black gum forest. In attempting to identify the water regime required to maintain the health of the wetland into the future, the pattern and frequency of inundation for both these areas is likely to be important (Roberts, *et. al*., 2000). The frequency and duration of low flows, when the majority of the marsh contains no standing water, are also likely to be important for seed germination and plant recruitment.

There are currently no substantial storages in the Great Forester Catchment that are impacting on the frequency of floods or the essential characteristics of the flow regime. During the summer months, there is a heavy reliance by agriculture in the catchment on direct abstraction from the river, and this is likely to have some impact on water levels inside the wetland.

Given that there is no monitoring of the Marsh community, it must be assumed that the present health of the marsh ecosystem is stable, and that the current flow regime is sufficient to maintain the condition of the ecosystem into the future. Therefore, the aim of this review is to characterise the existing hydrology as it relates to the Marsh ecosystem.

Specific metrics that have been identified elsewhere as being relevant to wetland health and ecosystem function (Roberts, *et. al*., 2000) are:

- frequency of inundation (flooding)
- rate of water level rise and fall
- duration of inundation
- inter-flood interval
- seasonality of flooding

The aim of this review to characterise some of these metrics for McKerrows Marsh, keeping in mind that these must be viewed within the context of the physical and biological nature of the wetland. In the first instance this will be done simply using existing data from streamflow stations. However, to better define some metrics (such as duration of inundation and rate of rise and fall), additional information will be needed regarding storage volume at different levels, the porosity and storage capacity of sediments within the wetland, and groundwater influences. This will be done at a later date using a combination of on-ground data collection and GIS-based modelling.

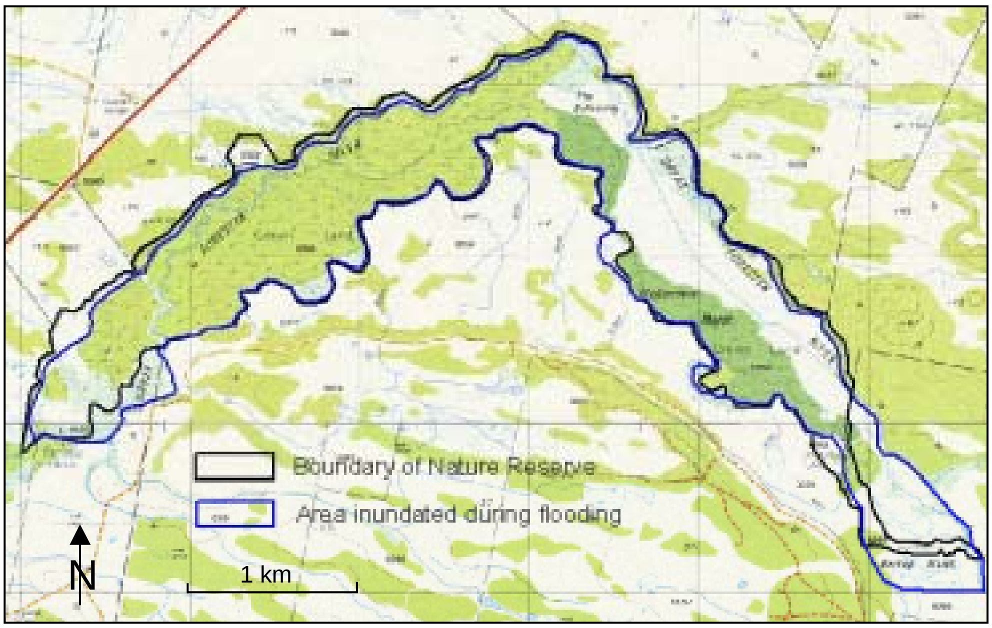


Figure 1: Map showing the boundary of the Nature Reserve at McKerrows Marsh, and the probable area of inundation during larger floods in the Great Forester River.

Existing Data

Streamflow Monitoring Station #19201

The main streamflow monitoring site that is relevant to this study is situated on the Great Forester River (station 19201) about 15 km upstream from the boundary of McKerrows Marsh Reserve. This station (Plate 1) was constructed in 1970 and 35 years of continuous flow data has been recorded. The quality of this record varies between 1 [*Excellent Data*] and 22 [*Good Estimated Data*], with most being classified as 11 [*Good Data*].

Plate 1: Streamflow monitoring station 19201 on the Great Forester River.

The flow data from station 19201 has already been summarised in Graham (1999) as part of the Great Forester River ‘State of Rivers’ report, and the following figures have been taken from that document. The monthly flow statistics in Figure 2 has been updated with data from 1999 to 2005. Figure 3 shows the flood frequency curve for the Great Forester River at this location.

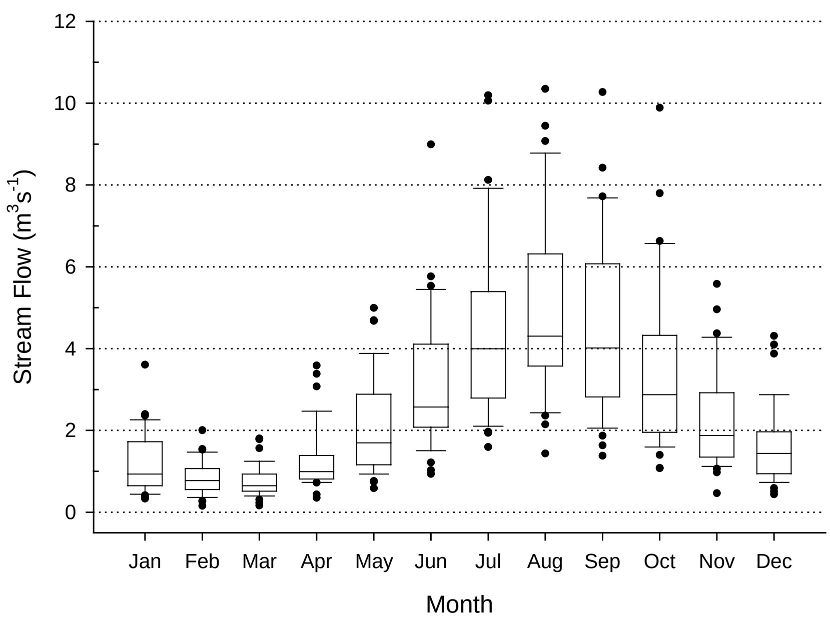


Figure 2: Monthly average flow statistics for Great Forester River streamflow station 19201 (data 1970 to 2004). Units in cubic metres per second (m^3s^{-1}).

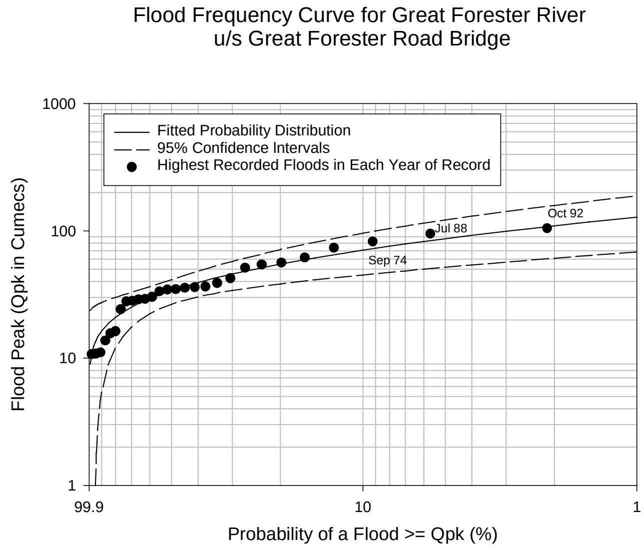


Figure 3: Flood frequency analysis for Great Forester River streamflow station 19201 (from Graham, 1999). Units are 'peak flow in cubic metres per second'

River Level Monitoring Station #3466

The other site of interest to this study is a river level station that has only recently been installed on the Great Forester River in the lower portion of McKerrows Marsh (station 3466). This station was installed in January 2004 primarily to assist with on-ground water management activities, and as well as river level, it records temperature and conductivity. Given its locations within the wetland, and the very low gradient of this area, this station cannot be rated for flow. A plot of the river level data that has been returned from this station during 2004 is shown below in Figure 4. It is apparent that there is about a 1.4 metre variation in water level in this part of the wetland, and a distinct seasonal pattern of variation, although large flood events can still occur during normally dry periods.

The time series in Figure 5 also illustrates distinct differences in the form of event hydrographs when compared to those recorded at station 19201. The main difference is in the recession limb of higher flow events, where it is evident that the rate of recession is slower than what is normal in a typical river channel. Figure 5 shows this more clearly for a single event recorded in August 2004. This is likely to be a result of the influences of wetland water retention and interactions between the surface water and groundwater.

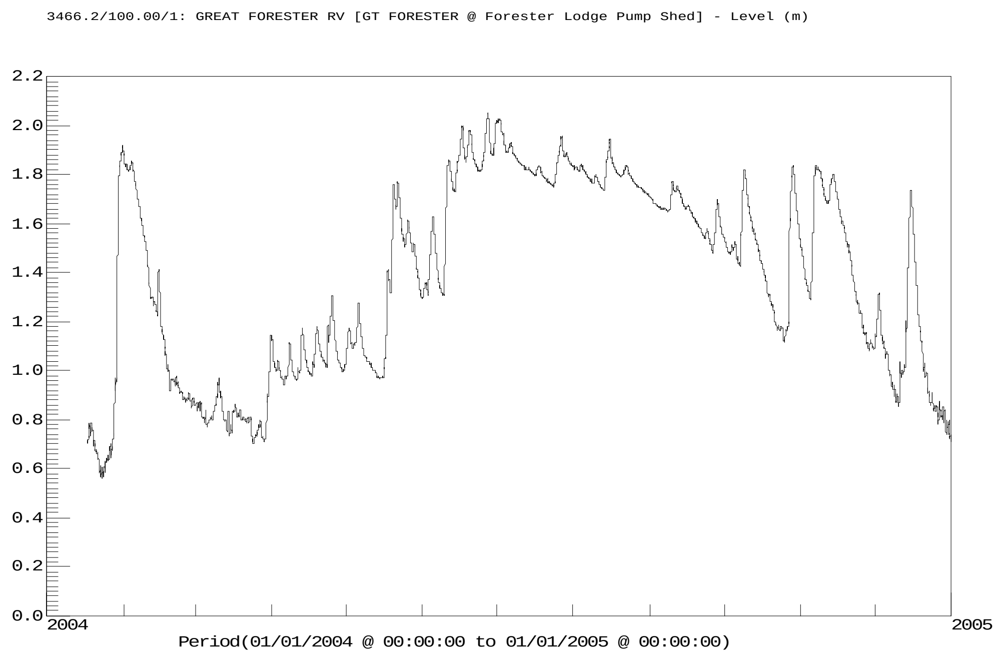


Figure 4: River level (in metres above river-bed) recorded at station 3466 on the Great Forester River at McKerrow Marsh during 2004.

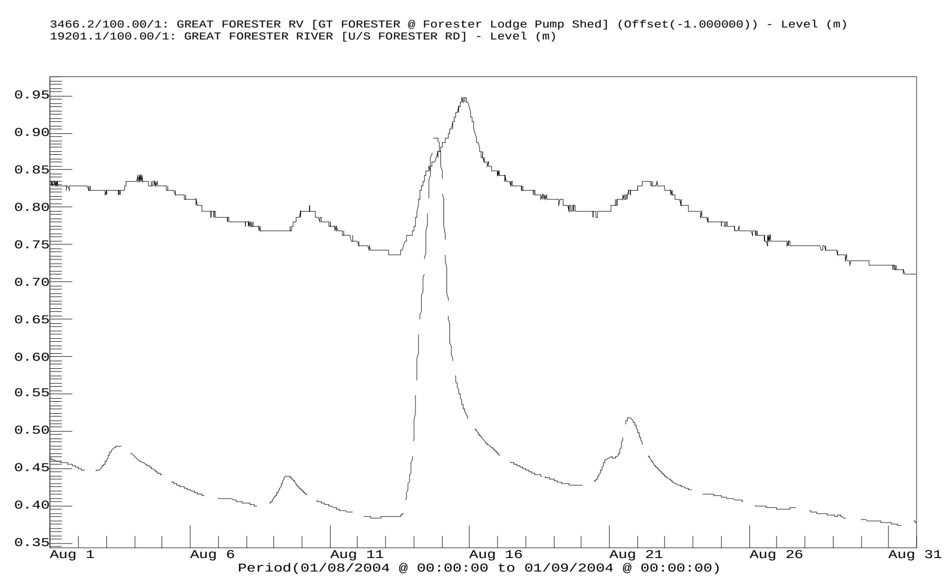
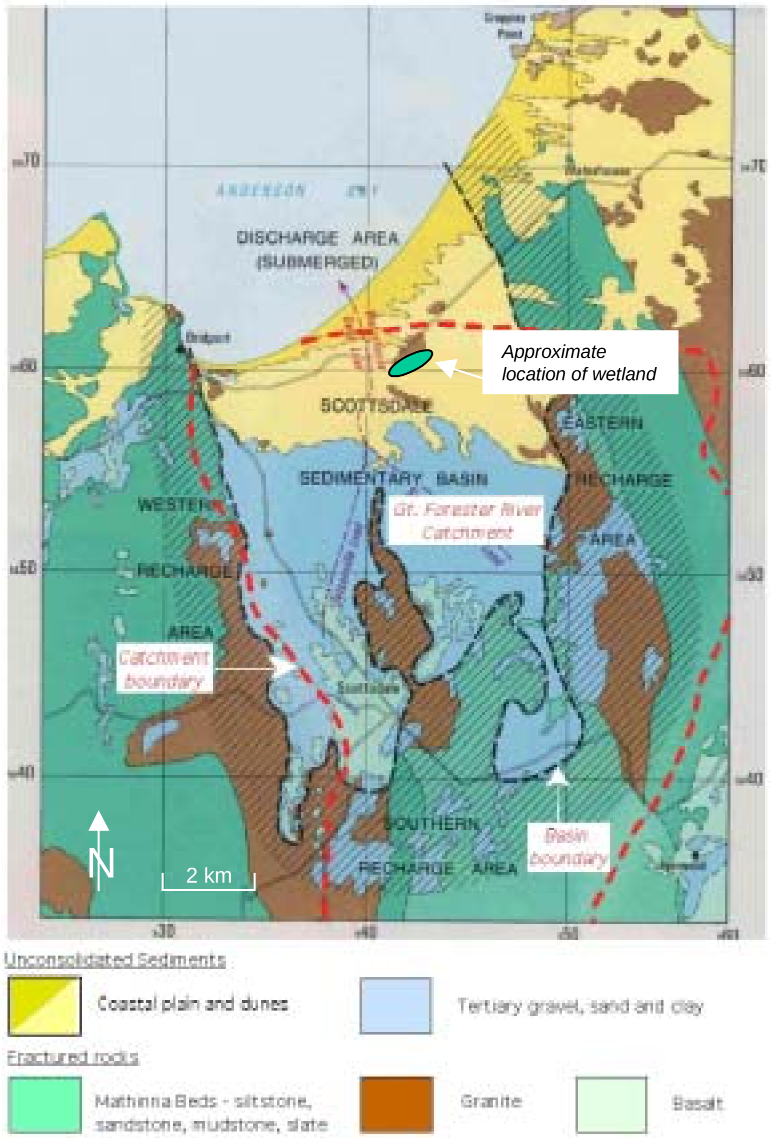


Figure 5: A comparison of event hydrographs recorded at station 19201 (dashed line) and station 3466 (solid line) on the Great Forester River during August 2004. River levels in metres.

Hydrogeology and groundwater

The geology of the Great Forester catchment is dominated by Devonian-aged granodiorite (the Scottsdale Batholith) that has intruded the older Mathinna Bed sequences of rocks, and which are prominent only along the eastern and western boundary of the catchment. In the lower half of the catchment, this granodiorite is overlain by a geologic structure known as the Scottsdale Sedimentary Basin (Figure 6), and this contains a significant groundwater resource. Most of the groundwater occurs in water-bearing layers, or aquifers, within the deeper unconsolidated Quaternary-Tertiary basin sediments (silt, sand, gravel and clay), however smaller, localised perched groundwater is also contained within the shallower wind-blown (aeolian) and coastal plain sands that extend inland from the coast. On a regional scale, groundwater flows northwards towards Andersons Bay, however locally, groundwater discharge is thought to make a significant contribution to summer streamflow in the Great Forester River and its tributaries.

Mineral Resources Tasmania (MRT) currently collects water chemistry and groundwater level data from 35 boreholes state-wide, as part of a baseline monitoring system. The data from one of these boreholes (Waterhouse – station 16544) may provide information that could be useful to this study. The Waterhouse bore is located about 3.5 km west of the river level monitoring station within McKerrows Marsh. Although spot readings of water levels within this bore commenced in the early 1990s, continuous monitoring of water level only began at this location in 1997.



Map based on: Map 2 Hydrogeology of the Scottsdale Sedimentary Basin
published by the Department of Mines, Tasmania, 1992.

Figure 6: Map of hydrogeology of lower Great Forester catchment. Catchment boundary delineated by dashed red line.

A number of boreholes have been installed on properties in the area around McKerrows Marsh, and the lithological logs for these have been stored on the MRT groundwater database. A number of these are deep (>30 metres) and provide a good insight into the stratigraphy around and beneath the wetland. It appears that on the northern side of the wetland, the aeolian sand is about 4 to 5 metres deep. Beneath this there are a number of clay, sand and gravel layers that sit on top of a granite basement that is situated about 32 metres under the surface, or about 15 metres below sea level.

A deep borehole only about 2 kilometres south of the wetland also located the granite basement at about 15 metres below sea level. The lithological log from this borehole indicates a shallower surface sand layer (approximately 2 metres deep) overlying a thin 'hard, sandy clay band' (1.7 metres thick). Between this band and the granite there exists about 11 metres of gravelly clay and 24 metres of decomposed granite gravels. These layers are likely to contain the regional groundwater aquifer mentioned above.

A schematic diagram is presented in Figure 7 in an attempt to draw this information together so as to put the location of the wetland in some hydrogeological context. It shows that local groundwater systems on the northern side of the wetland are likely to be markedly influenced by the depositional layering of the wind-blown aeolian sands and clay bands. On the southern side, these fine sands appear to be a thinner, surface feature and beneath this the gravels are likely to hold a much greater reserve of groundwater. Whether this thick gravel layer intersects with, or corresponds with the bottom of the wetland will be an important factor influencing the linkage between surface water and groundwater. It is hoped that an examination of the sediment samples from the installation of shallow groundwater monitoring bores around the edges of the wetland will refine this picture.

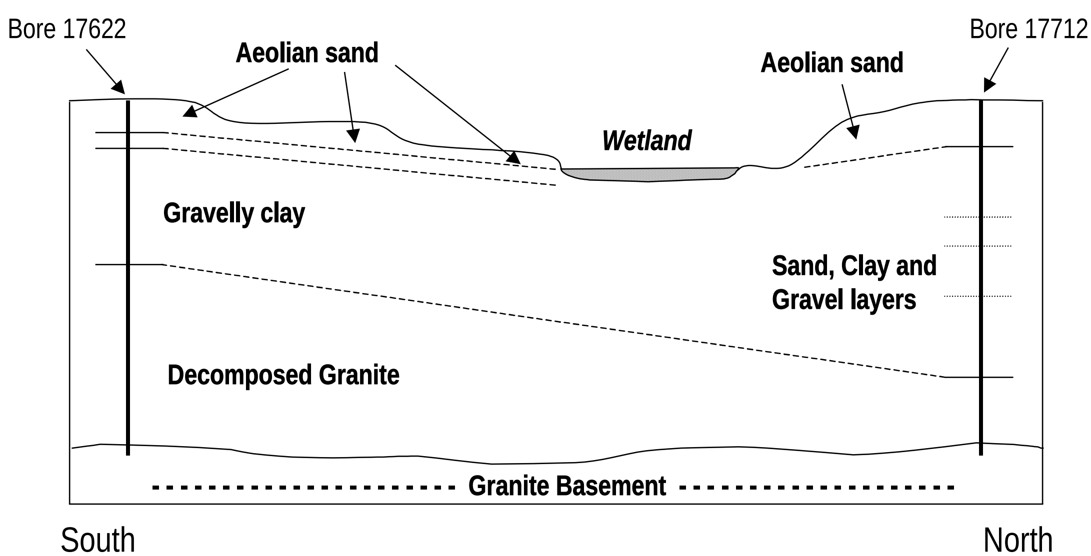


Figure 7: Schematic diagram (not to scale) showing of general stratigraphy in perpendicular section through McKerrows Marsh wetland.

Hydrological Metrics for McKerrows Marsh

From the summary plots in Figures 2 and 3, a number of statements can be made about flows in the Great Forester River:

- July, August and September are the wettest months of the year;
- Median discharge during each of these months equals or exceeds 4 cumec (345 ML/d);
- During the summer and early autumn, median flow is generally less than 1 cumec (86.4 ML/d);
- Streamflow events that exceed 10 cumec (864 ML/d) are very common; and
- Flood events where peak streamflow exceeds 70 cumec are relatively uncommon (ie. have about a 10% chance of occurring in any given year).

High flows

Prior to analysing the frequency of flood events, it is important to try and identify the magnitude of 'overbank floods' that inundate the wetland. To do this, a visual assessment was carried out during higher flow in the river to see what magnitude of flood event at station 19201 causes the river to break out of its channel within McKerrows Marsh, and the corresponding river level at station 3466.

This assessment was carried out in July 2004 (Figure 8), following a significant period of rainfall in the catchment. The assessment revealed that when water level in the lower Great Forester River (as recorded at station 3466) is at or above **1.9 metres**, there is substantial ponding of water throughout much of the lower wetland (defined here as the western arm of the Marsh). Figure 8 also shows the corresponding river level at the upstream monitoring station (19201), where the gauge is rated for conversion to streamflow. Although the antecedent baseflow conditions have some impact on the correlation (as the time series shows), it appears that as a general rule, when river level at station 19201 reaches **0.8 metres.** the water level within the Marsh (as measured at station 3466) is likely to reach 1.9 metres. In other words, a measured discharge of about 12-15 cumec at 19201 (most particularly during the winter months) is adequate to result in broad inundation of the lower wetland.

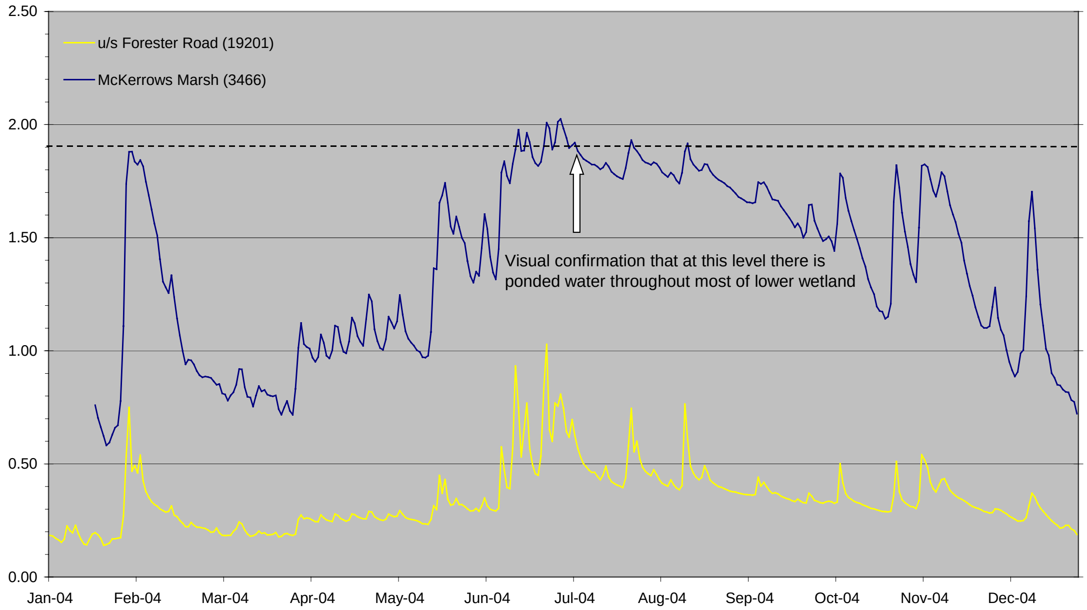


Figure 8: Time series of river level (in metres) for 2004 from stations 3466 and 19201 on the Great Forester River.

Although flood events with peak flows of about 12-15 cumec have been identified as ‘overbank’ flows for the wetland, the areal extent of inundation and depth of water within the wetland is likely to be affected by the shape of the hydrograph. Events that are shorter and have sharper peaks are likely to result in less extensive inundation than events that have a longer duration. The impact of hydrograph shape (ie flood intensity) may be further refined with the development of a volumetric model for the wetland. This is to be undertaken in a later phase of this project in conjunction with the development of a hydrologic model for the catchment and the collection of additional data regarding interactions between groundwater and surface-water.

Having identified the level at which water breaks out of the river channel in the western arm of the Marsh, the entire time series record from station 19201 can be analysed to determine flood frequencies. This information has been tabulated in Table 1 below in the form of an ‘event analysis’. The table shows the number of times that instantaneous streamflow at station 19201 exceeded river flows of various magnitudes (indicated as ‘Event Level’ in the left-hand column) during the entire 35-year period of record. The same analysis has also been conducted for the last 10 years for comparison.

Table 1: Event analysis for station 19201 (Great Forester River 2 km u/s Forester Rd). Minimum duration for events was set at 1 hour and event separation was set at 1 week.

Streamflow Event Magnitude	Corresponding river level	Number events (Entire 35 yr record)	Number events (Last 10 years)
10 cumec	0.7 m	180 [5.1 times per yr]	37
15 cumec	0.85 m	109 [3.1 times per yr]	26
20 cumec	1.05 m	74 [2.1 times per yr]	17
30 cumec	1.45 m	30 [0.85 times per yr]	8
40 cumec	1.82 m	16 [0.45 times per yr]	6

The table presents data that is similar to that shown in Figure 3, in that it gives some idea of the frequency of various sized flow events. From the table it is clear that over the 35-year period of record, flows exceeding 15 cumec (the estimated ‘break-out flow’ for the wetland) have occurred approximately 3 times per year. From the table it is also apparent that during the last 10 years, with the exception of flow events over 40 cumec, the frequency of all high flow event categories has diminished slightly. This may indicate that conditions generally have become drier (climate change), and this trend has been noted for other regions of Tasmania, most particularly catchments in southeast Tasmania (DPIWE, 2003). However this is likely to be confounded by the corresponding growth in agricultural water use and the construction of on-farm water storages that has also taken placed during the period.

The frequency of flow events in excess of 40 cumec appears to have increased slightly, and is in agreement with broad climate change predictions, which indicated that although conditions are expected to become drier, extreme events may become more common (CSIRO, 2001; Nunez, 2004).

A seasonal analysis of these results for >15 cumec events has also been undertaken (Figure 9), and shows that 53% of events occur during the winter months (June to August). Only 6% of events have occurred during the summer months (December to February). If these results are re-calculated based on the two season periods used for defining the irrigation season in Tasmania (summer covers the period November to April), this result translates to 14 events during summer (13%) and 96 events during the winter (87%). From these results it is clear that the periods when inundation flows are most consistently delivered to the Marsh are winter and spring. Preserving this seasonality is likely to be critical to the long term maintenance of the ecosystems within the Marsh.

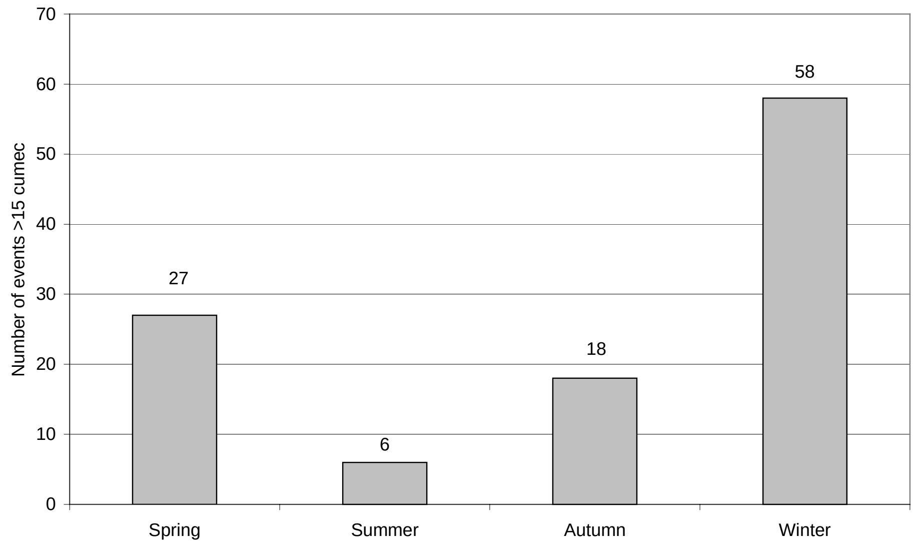


Figure 9: Seasonal distribution of 15 cumec flow events using the 35 years of streamflow record from station 19201 (N_{events} = 109).

Low flows

The pattern and duration of low flows in the lower Great Forester River are likely to be as critical to the health of the Marsh as the delivery of floods. During extended dry periods some plants may be able to access alternative water sources (eg. groundwater), however plants that cannot access water are likely to experience stress that may affect long-term vigour (Roberts, *et. al.*, 2000). It is therefore pertinent to examine this issue in relation to McKerrows Marsh.

A duration analysis of daily average flow during the summer irrigation season (November to April) was undertaken using the record from station 19201. The flow thresholds for this analysis were arbitrarily set at 0.20 cumec intervals between zero and 2.0 cumec, and the output from this analysis has then been converted to show the average number of days in each month that daily average flow falls below the stated thresholds. These data are presented graphically in the form of modified duration curves in Figure 10.

The analysis clearly shows that stream flow in the Great Forester River is lowest in March, when it can be expected that for more than 25 days flow will be less than 1 cumec. For more than two weeks in each of the months of January, February and March, daily average flow does not exceed 0.8 cumecs (70 ML/day). It is also clear that in each of these months, flow will normally not exceed 0.5 cumec (43 ML/day) for 5 days or more.

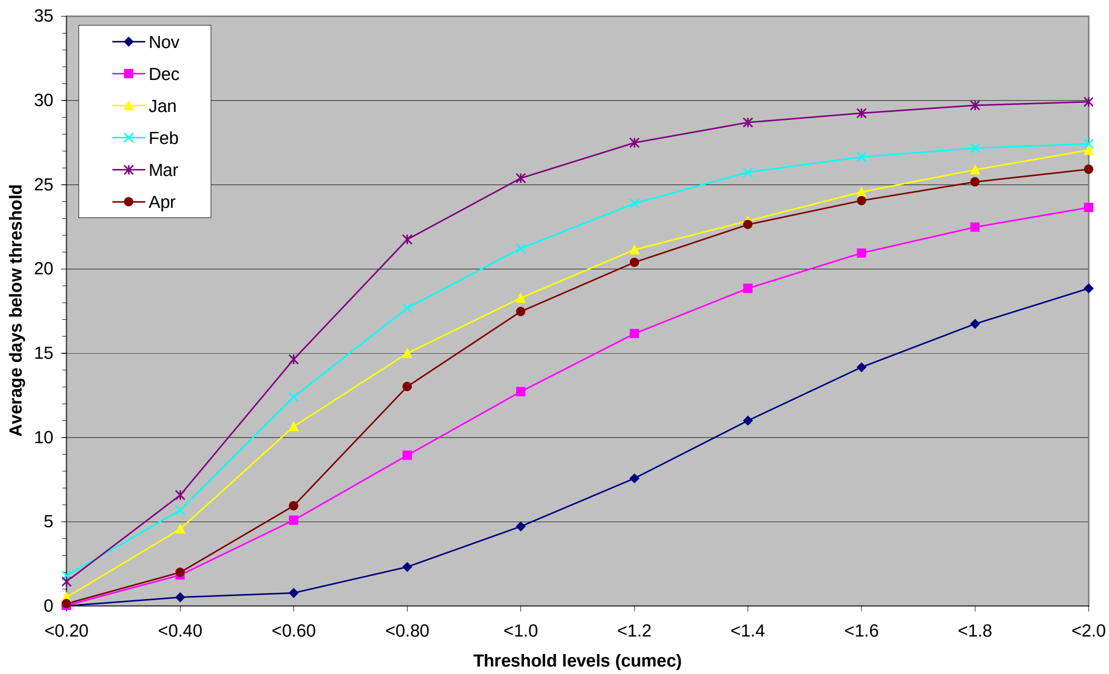


Figure 10: Modified low-flow duration plot for the Great Forester at station 19201, showing the average number of days in each month of the irrigation season when flows are below various threshold values.

Although there are some small tributaries between station 19201 and McKerrows Marsh, it can be assumed that there is only minimal additional flow entering the river from these sources during dry periods.

Conclusion

In this report basic information on the frequency of inundation, the inter-flood interval and the seasonal pattern of flooding has been provided. From this work a flow of 15 cumec (as measured at station 19201) has been identified as the point at which water breaks out of the river channel and inundates land within the Marsh. Flows of this magnitude or greater occur on average about 3 times per year and are most likely to occur in winter or spring.

Further work is required to provide data on the duration of inundation and the interaction of surface and groundwater in the wetland. The development of a simple water balance model for the wetland that also utilises input from a newly developed hydrological model for the catchment will enable significant further refinement of some of the estimates made during this review and address some of the issues raised. In developing this model, shallow groundwater monitoring bores have been installed around the wetland to examine the interactions between surface water and groundwater.

Additional information is also being collected about the plant and animal communities inhabiting the wetland, and this should help to identify then key components of the water regime that may be required to maintain a healthy wetland ecosystem. The ultimate aim for this study is to provide ecologically relevant water management options that will maintain the health of the wetland into the future.

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