Relationships between Water Level, Salinity and the Emergent and Fringing Vegetation of Byenup-Muir Wetlands

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BACKGROUND

This work is part of an extensive study of the flora and fauna of the Byenup-Muir wetlands and is concerned with the relationships of the fringing and emergent flora to inundation, waterlogging and salinity and the likely effects of altered water regimes. A detailed botanical survey has been conducted by Gibson and Keighery (1999) of nine wetland reserves in the area and therefore, the scope of this report compliments the early work and is limited to:

1. Assessment of the water level and salinity record relative to elevational gradients at six Byenup-Muir wetlands.

2. Identification of the water regimes and salinity that influence current wetland vegetation zonation.

3. Comment on the likely impact of altered water regimes on fringing and emergent vegetation at the six Byenup-Muir wetlands.

METHODS

The hydrological data used in this study of wetlands in the Byenup-Muir peat swamp system were collected by CALM as part of a long-term southwest wetland monitoring program. Byenup Lagoon, Poorginup Swamp and Tordit-Gurrup Lagoon were sampled for surface water depth and salinity 4-6 times per year from the late 1970s to 1990, after which, readings were only taken during September and/or November each year, when water levels are usually at or near their annual maxima. Lake Muir, Lake Unicup and Lake Yarnup were sampled once or twice annually from 1986 and less frequently prior to that year. Due to the incomplete record of seasonal variations, data interpretation in this report focussed on peak water levels and minimum (spring) salinities. Mean peak surface water depths and corresponding salinity levels were calculated for the last 20, 10 and 5 year periods to identify any temporal changes and to be representative of current vegetation life spans.

At each of the six study wetlands, transects through fringing and emergent vegetation communities were established. Elevations were recorded at intervals (depending on the change in slope and transect length) and the occurrences of dominant plant communities noted. Detailed flora lists compiled for each major vegetation unit (Gibson and Keighery, 1999) were than compared to field notes to describe vegetation composition and structure across the transects.

The relationships between vegetation communities and hydrology were illustrated though profile diagrams depicting the occurrence of vegetation units in relation to transect elevations, absolute maximum water levels and 20 and 5 year mean maximum water depths. As only surface water data were available, depth to groundwater was estimated as the difference between transect ground surface and mean and absolute maximum surface water levels.

To assess whether altered water regimes at the study wetlands may impact on emergent or fringing vegetation the maximum water level ranges of 7 key species were considered. Comparisons were made between the ranges in maximum water depths experienced at each wetland by the species, and the species total maximum water depth range as determined across 21 Swan Coastal Plain (SCP) wetlands (Loomes, 2000). These key species were

Melaleuca rhaphiophylla, Astartea fascicularis, Hypocalymma angustifolium, Pericalymma ellipticum, Baumea articulata, Baumea juncea and *Baumea vaginalis*. Due to the comparative longevity of *M. rhaphiophylla* 20 year mean water depth ranges were considered with 5 year means used for other shorter-lived species.

RESULTS AND DISCUSSION

Byenup Lagoon

Mean maximum surface water depths at Lake Byenup were higher over the five year period between 1995 and 1999 than between 1977 and 1999 (Table 1), suggesting that water levels have risen slightly at this wetland over this time. The hydrograph (Figure 1) supports this, indicating that annual peak levels have been close to or above the 20 year mean more often in recent years. The graph also showed that absolute maximum water depth was recorded in September 1991 and the lowest maximum in September 1987. Mean minimum salinity levels have also shown a small increase across these time periods (Table 2) with the lowest minimum recorded in November 1988 and highest minimum in September 1995 (Figure 1).

The vegetation profile diagram for Byenup Lagoon transect 1 (Figure 2) indicated that a dense band of the native emergent sedges, *Baumea articulata* and *Baumea juncea,* dominated the wetter end of this 140m long transect. These species continued to persist in the understorey of a closed forest dominated by *Melaleuca rhaphiophylla* before higher elevational gradients lead to wetland species being replaced by a mixed Jarrah/Yate woodland. Despite the more terrestrial nature of this final community, hydrological data suggested that almost the entire transect had been inundated during November 1991 (Figure 1). Mean maximum water levels over 20 and 5 year periods indicated that the *B. articulata/B. juncea* sedgeland and the *M. rhaphiophylla* forest were flooded annually along with the lower half of the Jarrah/Yate woodland and that maximum water depths had increased temporally.

Comparisons of the maximum water depth ranges experienced by key wetland species (Figure 4) suggested that the *M. rhaphiophylla, B. articulata* and *B. juncea* recorded at Byenup Swamp transect 1 all occurred towards the wetter end of their range as determined for these species across SCP wetlands (Loomes, 2000). Increases in water levels may result in movement even further towards the maximum depths and could ultimately lead to the degradation or loss of these communities. As these species are also restricted to freshwater wetlands, further increases in salinity may also have a detrimental effect. Current mean salinity of 4.41 ppt (last 5 years) is approaching what is estimated to be the upper tolerance limit of the *Baumea* species (estimated from author's experience). Avoidance of more saline, low water levels during summer, is a mechanism by which these species can persist at the wetland for many years as salinities gradually increase.

A steeper elevational gradient across transect 2 resulted in lower water levels with only the final few meters of the transect experiencing inundation (Figure 3). Unlike the *Baumea* at transect 1, despite increased maximum water levels, the majority of the closed sedgeland at this site is not annually inundated nor is the *M. rhaphiophylla* forest. In their description of the vegetation units of this area, Gibson and Keighery (1999) suggested that where *M. rhaphiophylla* is more open, species such as *Hypocalymma angustifolium* and *Pericalymma ellipticum* may replace mixed *Baumea* in the understorey.

The ranges in maximum water depths experienced by key wetland species across transect 2 were generally closer to the ranges determined for SCP wetlands (Figure 4). *B. juncea* was the only species whose entire range at this site was wetter than the mean SCP range and as such may be considered as the only species currently under threat from increased water levels. *M. rhaphiophylla, H. angustifolium* and *B. articulata* were all found to occur within the SCP ranges while *P. ellipticum* was found in slightly drier conditions at this site. The comparative steepness of the elevational gradient across this transect may account for shallower surface water than at transect 1.

Byenup Transect 1 Jarrah/Yate woodland

Byenup Transect 1 *Melaleuca rhaphiophylla* forest.

Byenup Transect 1 landward edge of closed Baumea sedgeland.

Byenup Transect 2 *Melaleuca rhaphiophylla* forest.

Lake Muir

The five year period between 1995 and 1999 saw higher mean maximum surface water depths at Lake Muir than were recorded between 1979 and 1999 (Table 1) suggesting that water levels have also risen at this wetland. This finding was supported by the hydrograph (Figure 5) which indicated that annual peak levels occurred above the 20 year mean more frequently in recent years despite the peak maximum having been recorded in 1988. Mean minimum salinity levels declined across the same time periods, however Lake Muir continued to record higher levels than all other study wetlands (Table 2).

The profile diagram for vegetation transect 1 at Lake Muir indicated that the only plant communities to have experienced inundation since 1979 were the samphire flats which occurred along the first 125m of this 450m transect and a small area of *Melaleuca cuticularis* woodland which was recorded further along the elevational gradient (Figure 6). Although these communities had been inundated during the peak water levels of 1988 they were not flooded regularly as was indicated by 20 and 5 year mean maximums showing only the first 10m of the samphire flats flooding. These communities are known to tolerate both saline conditions and inundation (Bell, 1999), however declining salinity and rising water levels may lead to declining health and cover especially for the halophytic species of the samphire flats.

The *M. cuticularis* woodland occurred over an understorey of *Gahnia trifida* flats to a point half way along the transect where the woodland dropped out and the *Gahnia* formed a sedgeland. *M. rhaphiophylla* occurred at the end of the transect, furthest from the water's

edge and highest above the groundwater table. As previously mentioned *H. angustifolium* and *P. ellipticum* occur in the understorey of *M. rhaphiophylla.*

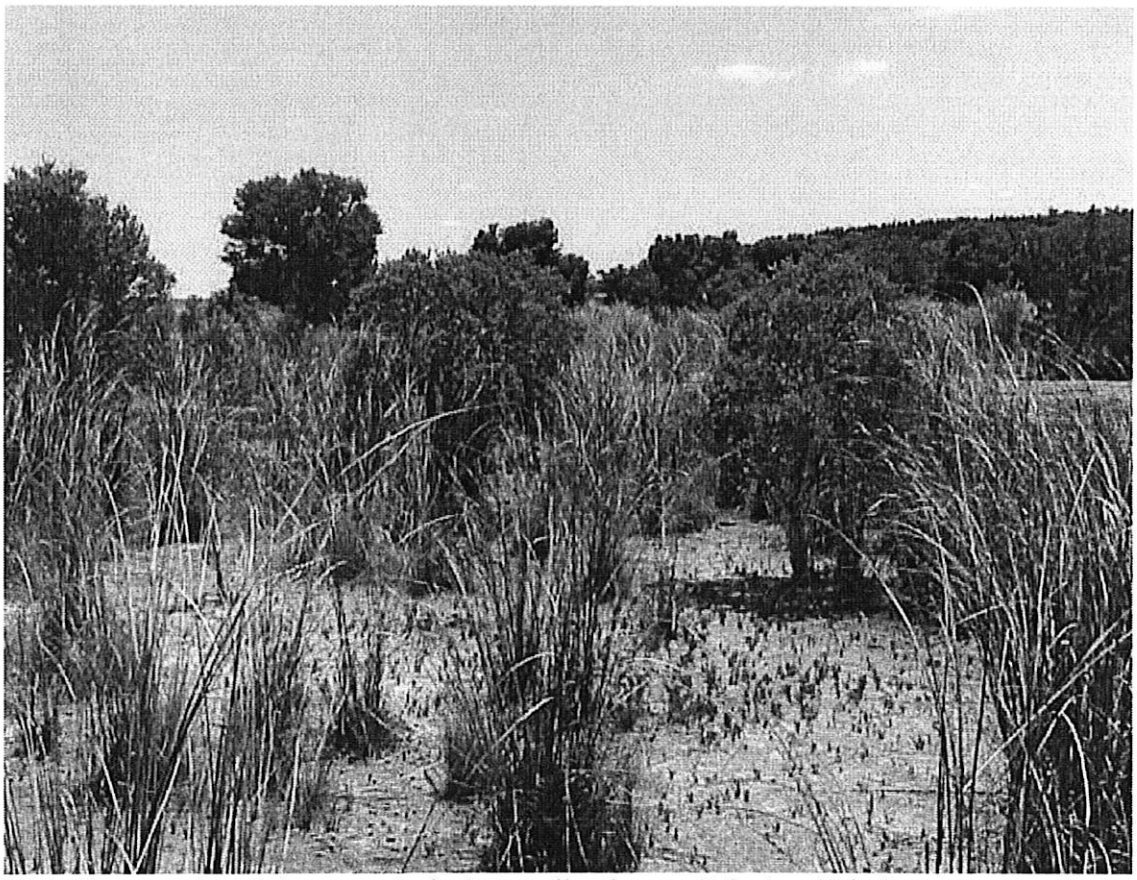
Comparisons of the maximum water depth ranges experienced by key wetland species (Figure 8) suggested that the *M. rhaphiophylla* and *P. ellipticum* at Lake Muir transect 1 occurred beyond the drier end of their ranges while *H. angustifolium* was within the range described across SCP wetlands (Loomes, 2000). As the wetlands used in the SCP study were all freshwater no water depth ranges were established for salt tolerant species, therefore no comparisons can be made.

The lower-lying, second transect at Lake Muir was dominated by a 300m band of samphires which were inundated during most years (Figure 7). The *M. cuticularis* complex found adjacent to the samphires was completely flooded during the period of maximum water depths experienced in 1988, however mean peak levels indicated this community was not flooded frequently. Gibson and Keighery (1999) suggested that *Astartea fascicularis* and *H. angustifolium* could occur in the understorey of *M. cuticularis* woodland. Although these species were considered to occur at this site, the salt tolerant nature of surrounding communities suggests this may be an incorrect assumption.

The *M. cuticularis* woodland persisted further along the elevational gradient occurring over an understorey of *G. trifida* sedgeland. The highest section of the transect was dominated by *Eucalyptus occidentalis* woodland. Neither of these two communities have been inundated since records commenced in 1979.

The ranges in maximum water depths experienced by *A. fascicularis* and *H. angustifolium* at Lake Muir transect 2 fell close to the mean SCP maximums although they were slightly towards the wetter end of their overall range.

Muir Transect 1 interface of samphire flats with *Gahnia trifida* flats.



Muir Transect 1 *Melaleuca cuticularis* woodland over *Gahnia trifida* flats.

Muir Transect 2 *Melaleuca cuticularis* woodland.

Poorginup Swamp

Mean maximum surface water depths at Poorginup Swamp were higher over the five years between 1995 and 1999 than between 1977 and 1999 (Table 1) indicating that water levels have also risen at this wetland over time. This finding was again supported by the hydrograph (Figure 9) despite the fact that the peak maximum water depth was recorded in November 1985. Minimum salinity levels have declined over the same time periods (Table 2).

Only two community types were recorded along the vegetation transect at this site (Figure 10). Open *B. articulata/B. juncea* sedgeland occurred across 30m of the transect closest to the wetland while *M. rhaphiophylla* forest dominated the remaining 30m. The majority of the *Baumea* sedgeland was frequently inundated with a 66cm maximum mean depth over a five year period. A small section of sedgeland was located on higher ground towards the end of the transect and appeared not to have been flooded. The *M. rhaphiophylla* was only inundated at either ends of its range, with the majority of this community remaining some 30cm above the groundwater level at this site.

Comparisons of the maximum depth ranges experienced by *B. articulata, B. juncea* and *M. rhaphiophylla* (Figure 11) suggested that at Poorginup Swamp these key wetland species occurred towards the wet end of their SCP wetland range. *M. rhaphiophylla* and *B. articulata's* ranges at this site were however, generally within the SCP mean range, while *B. juncea* occurred beyond its SCP mean, but still within the absolute range. Continued increases in maximum water depth at Poorginup Swamp could cause a contraction in the distribution of these species, while declining salinity levels would have no impact.

Poorginup Transect *Melaleuca rhaphiophylla* forest

Poorginup Transect *Baumea articulata/B. juncea* sedgeland.

Tordit-Gurrup Lagoon

Water depths at Tordit-Gurrup Lagoon appeared to have declined slightly since records commenced in 1977, with the five year mean 3cm lower than the 20 year average (Table 1). The hydrograph (Figure 12) suggested that peak depths were recorded between 1978 and 1981 after which time there was a steady decline until 1988 when peak levels again started to increase. Salinity levels declined across the same time period (Table 2) showing trends opposite to water depths (Figure 12).

Three vegetation communities were identified across the 70m transect at Tordit-Gurrup Lagoon (Figure 13). Closed *B. articulata/B. juncea* sedgeland dominated a 30m band before forming the understorey of *M. rhaphiophylla* woodland. Jarrah/Marri woodland occurred towards the terrestrial end of the transect.

Hydrological data indicated that almost the entire *Baumea* sedgeland was frequently flooded while the *M. rhaphiophylla* woodland remained dry in most years other than 1978 when peak water depths were recorded. The Jarrah/Marri woodland did not experience flooding.

The range in maximum water depths experienced by *B. juncea* at this site was very similar to that determined for the SCP wetlands (Figure 11). *M. rhaphiophylla* however, was found across the drier half of the SCP range, extending beyond the minimum peak level. The range over which *B. articulata* occurred at Tordit-Gurrup was far greater than that previously established, with groundwater some 2m deeper than at SCP wetlands. This is likely to be due to an error in the field recording of *Baumea* distribution or elevation along the transect.

Tordit-Gurrup zonation.

Lake Unicup

Mean maximum water depths at Lake Unicup were 43cm higher over the five year period from 1980 to 1984 than between 1980 and 1999 (Table 1). Water level increases at this wetland were in fact greater than at any other study site. Annual surface water depth data (Figure 14) indicated that levels rose sharply after 1987 and remained above mean values for the majority of the following 12 years. The lowest salinity level was recorded in 1988 and has gradually increased since than time (figure 14), showing the five year mean higher than the 20 year average (Table 2).

Transect 1 at Lake Unicup was 90m long and encompassed three vegetation communities (Figure 15). *Baumea spp.* formed a sedgeland across the 60m of the transect closest to the wetland with *B. articulata* dominating the lower-lying area and *B. juncea* and *B. vaginalis* co-dominating towards the edge (Gibson and Keighery, 1999). A *Leptocarpus* sedge community occurred further along the elevational gradient while a dense low forest of *M. rhaphiophylla* dominated the terrestrial end of the transect above an understorey of shrubs including *P. ellipticum*. Although both sedge communities were inundated during peak water depths only the *Baumea* was flooded frequently, with the area inundated increasing over time.

Comparisons of the maximum water depth ranges experienced by key wetland species (Figure 17) suggested that *M. rhaphiophylla* and *P. ellipticum* at Lake Unicup transect 1 occurred at the dry end of their range extending beyond that determined for these species across SCP wetlands. *B. articulata, B. juncea* and *B. vaginalis,* however, were found closer to the wet end of their SCP range at this wetland.

Continued increases in surface water depths could lead to the contraction in the distribution of the sedge species as they are lost from areas of deeper water. Increased salinity could cause the degradation of the three freshwater vegetation communities along transect 1.

The 35m at the wetland end of transect 2 at Lake Unicup was also dominated by *Baumea* sedges, which have experienced increased levels and frequency of inundation over time (Figure 16). The remaining 45m of the transect consisted of *Eucalyptus decipiens* open low woodland, only the lowest 10m of which was inundated during peak water levels.

B. articulata was the only species found along transect 2 for which maximum SCP wetland water levels had been determined. It was found to occur towards the wetter half of the absolute range, but was relatively close to the SCP mean maximum. Communities across transect 2 face the same threats from rising surface water and salinity levels as those across transect 1.

Unicup Transect 1 *Baumea* sedges.

Unicup Transect 2 *Eucalyptus decipiens* woodland

Unicup Transect 2 *Baumea* sedges.

Yarnup Swamp

Water depths (Table 1) and salinity levels (Table 2) have risen at Yarnup Swamp since records commenced in 1980 as indicated by five year means being higher than 20 year means. The hydrograph supports these findings showing that annual peak water levels have been close to or above the 20 year mean more often in recent years and that low salinity levels have also increased (Figure 18).

The profile diagram for transect 1 (Figure 19) illustrated that a 22m wide band of *B. articulata, B. juncea* and *B. vaginalis* dominated the wetland end of this 45m transect. Despite rising water levels only the lower half of this area of sedges had been inundated since 1980, with 20 and 5 year means only marginally lower than the peak maximum. A *Eucalyptus marginata* forest/ *Agonis parviceps* thicket occurred across the remainder of the transect.

Comparisons of the maximum water depth ranges experienced by the three *Baumea* species (Figure 21) suggested that the *B. articulata* at this site occurred well within the absolute maximum range determined for the SCP wetlands. *B. juncea* was recorded towards the wet end of its range while *B. vaginalis* was found beyond the wet end of its maximum SCP range.

The vegetation communities along the lower-lying second transect at Yarnup Swamp experienced a greater degree of inundation than the first (Figure 20). The *Baumea* sedges that again dominated the wetter end were, on average flooded to depths of up to 89cm annually between 1994 and 1999. A large portion of the *M. rhaphiophylla* dense low forest that occurred across the first 20m of the transect was also frequently inundated during this time.

The ranges in maximum water depths experienced by the three *Baumea* sedges across transect 2 were slightly narrower than those at transect 1, however peak levels were the same at both sites. The *M. rhaphiophylla* at Yarnup Swamp were found at maximum depths towards the wet end of the SCP range, but remained within the absolute range.

Although there has been an increase in water depths at Yarnup Swamp, further increases are possible before range limits are approached and impacts on the vegetation communities along either transect become evident. Despite rising salinity levels, spring concentrations are not high enough to threaten current emergent macrophyte species.

Yarnup Transect 1 *Eucalyptus marginata* forest interface with *Melaleuca rhaphiophylla*.

Yarnup Transect 2 Melaleuca rhaphiophylla low forest.

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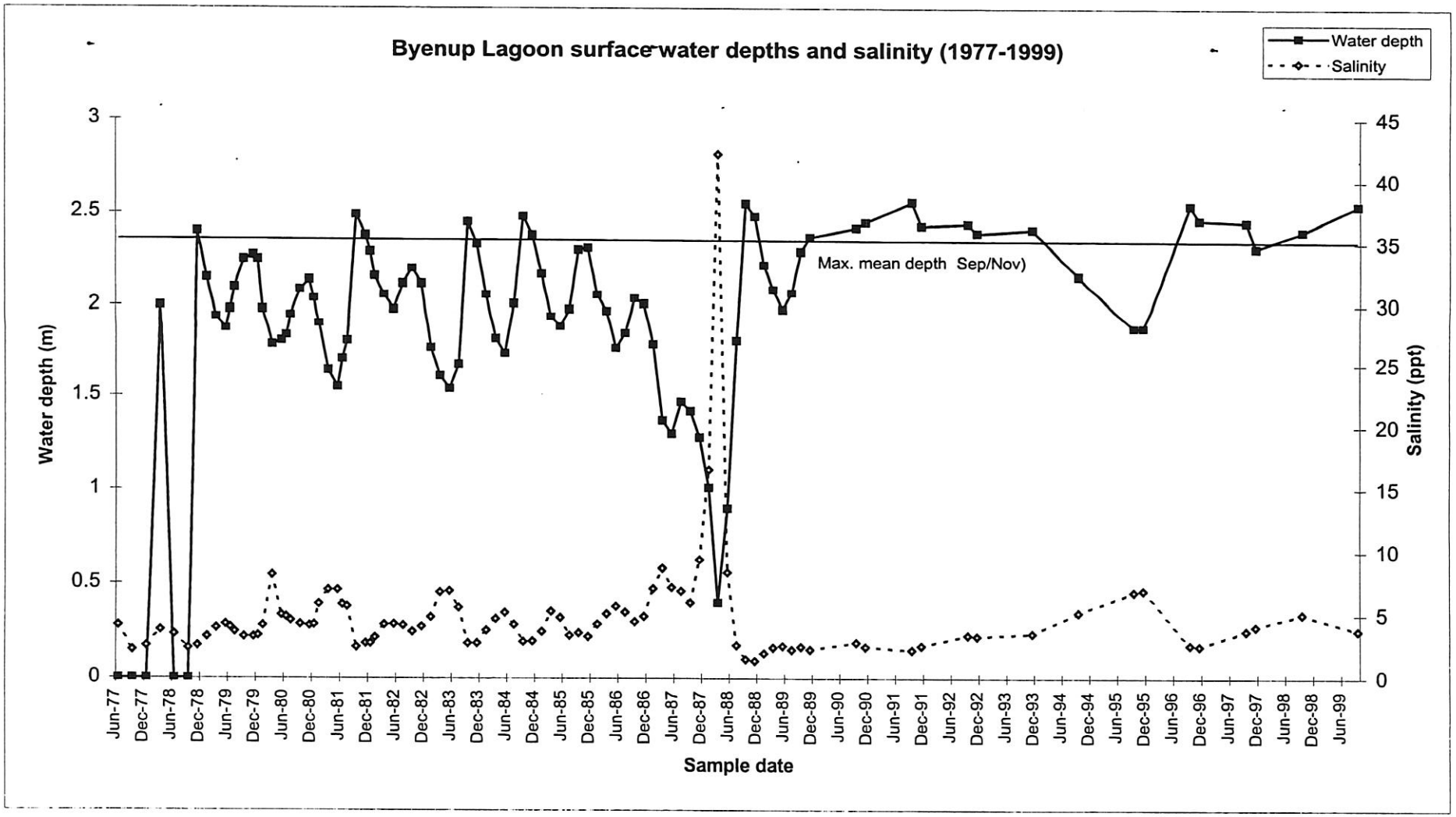

Figure 1

Hydrograph showing surface water depths (m) and salinity levels (ppt) at Byenyup Lagoon between 1977 and 1999.

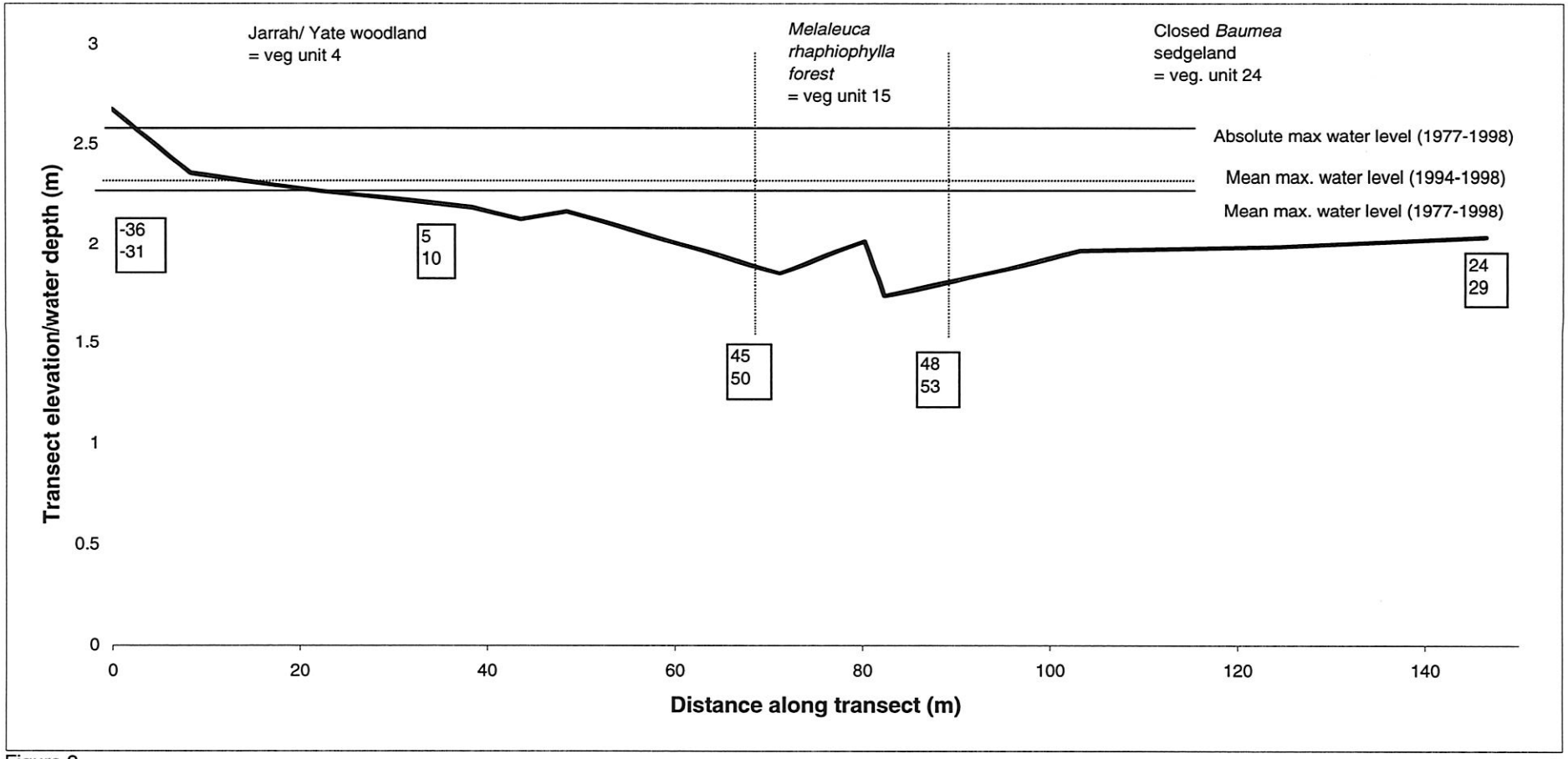

Figure 2

Profile diagram of vegetation transect 1 at Byenup Lagoon showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Lake Muir and Cowerup Nature Reserves. Figures in boxes represent actual depth (cm) of mean peak surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

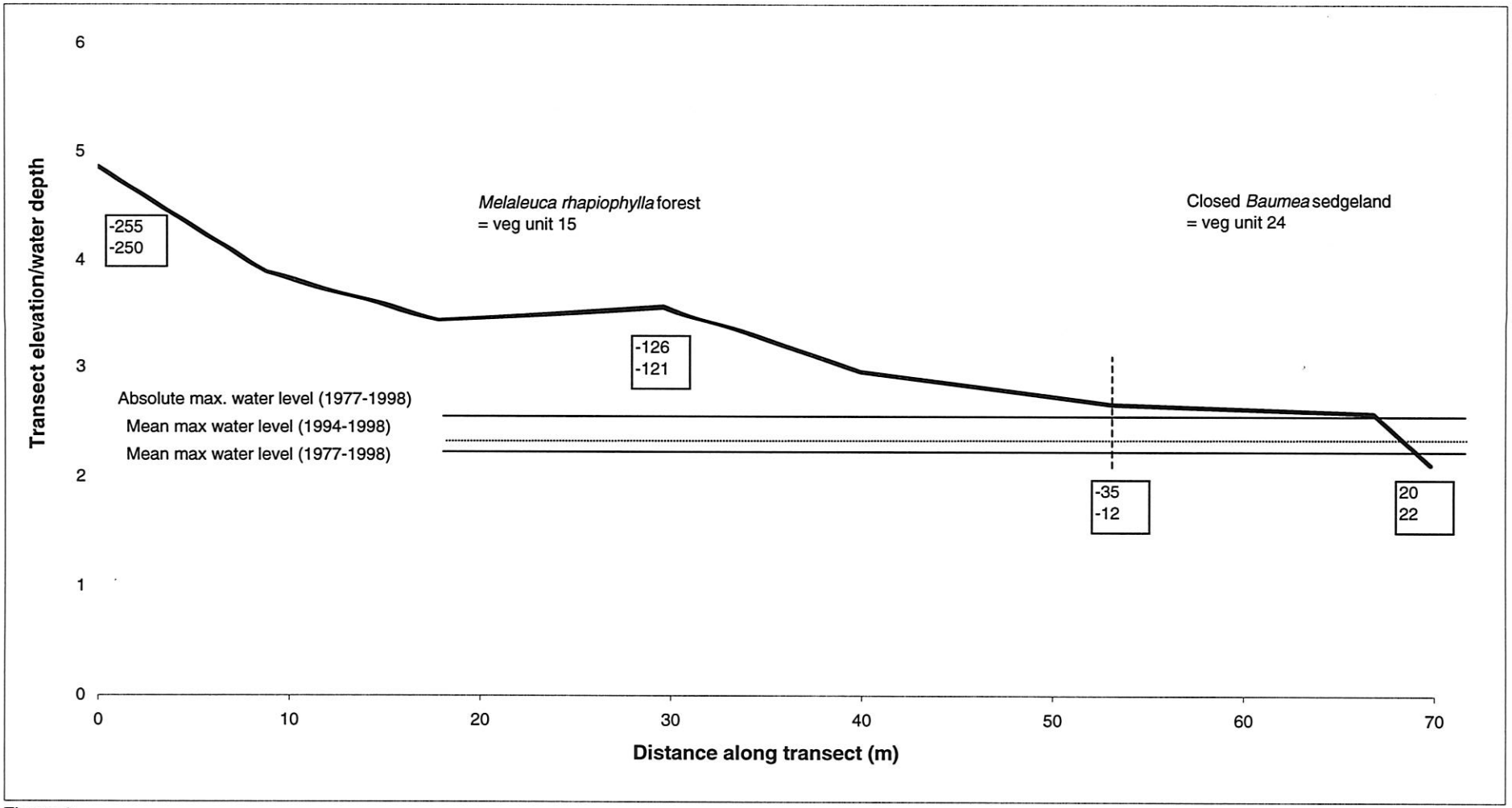

Figure 3

Profile diagram of vegetation transect 2 at Byenup Lagoon showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Lake Muir and Cowerup Nature Reserves. Figures in boxes represent actual depth (cm) of mean peak surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

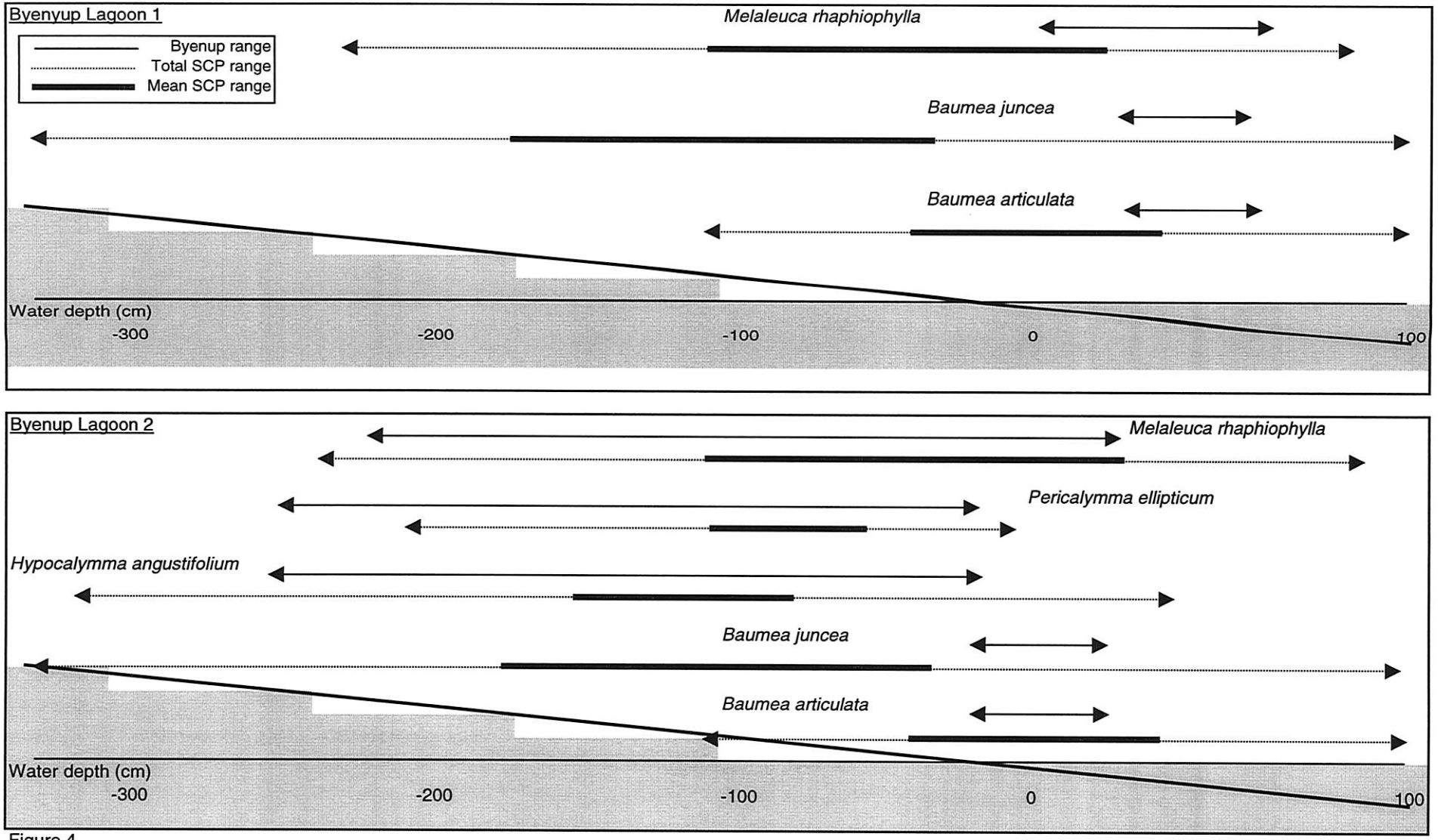

Figure 4

Peak water depth ranges experienced by wetland species at Byenup Lagoon transect 1 and 2 compared to peak and mean peak levels across 21 Swan Coastal Plain wetlands as determined by Loomes (2000).

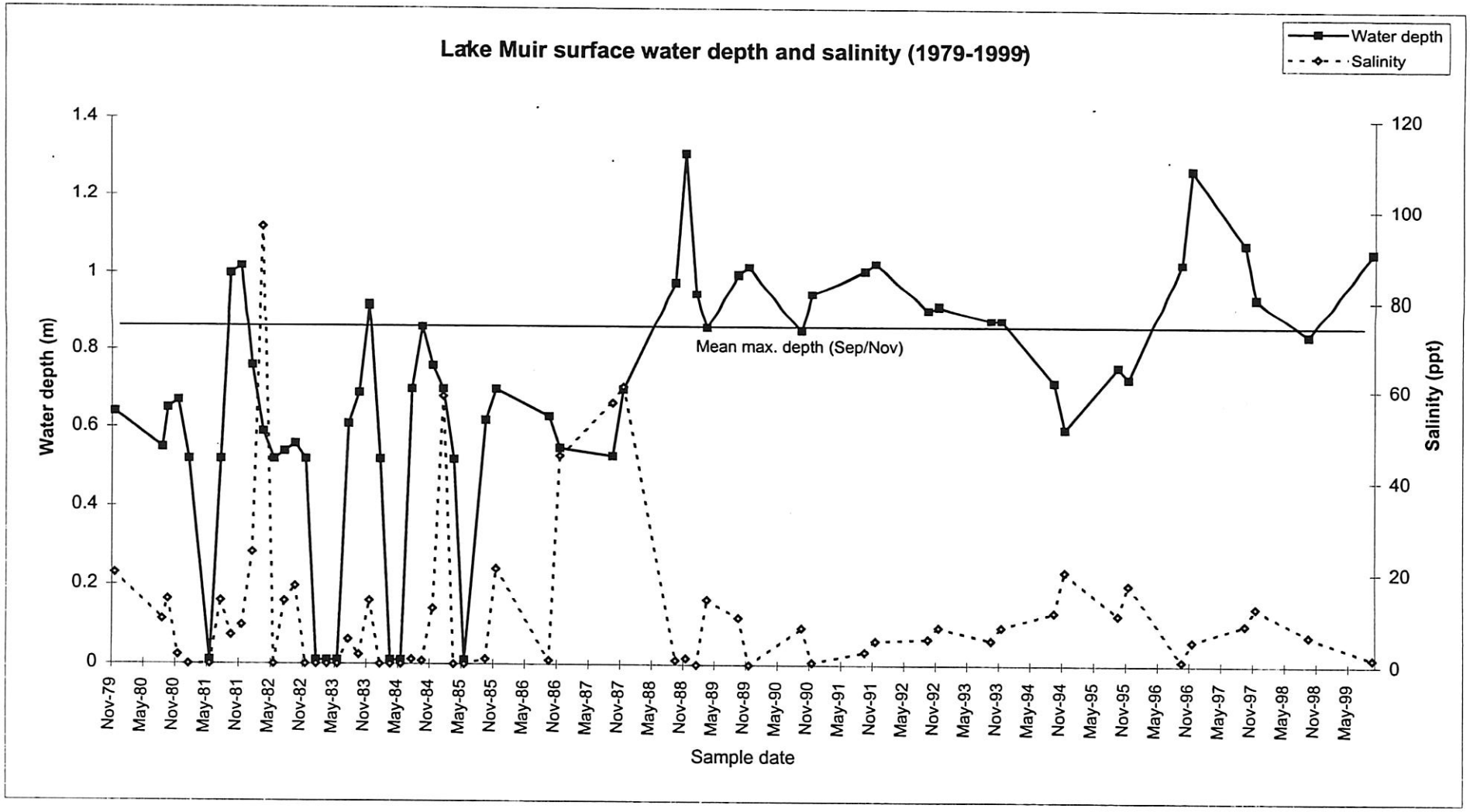

Figure 5

Hydrograph showing surface water depths (m) and salinity levels (ppt) at Lake Muir between 1979 and 1999.

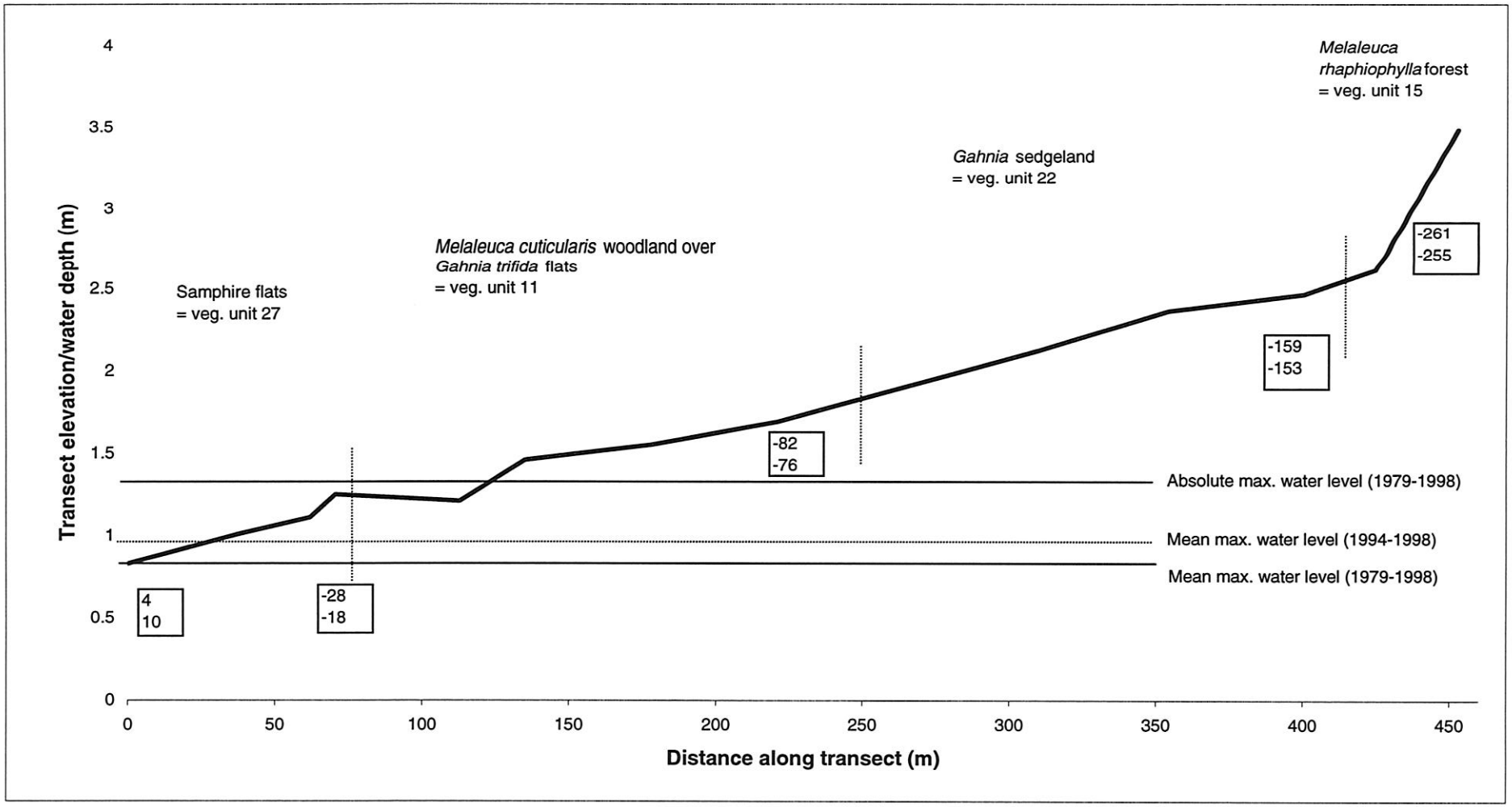

Figure 6

Profile diagram of vegetation transect 1 at Lake Muir showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1979-1998 and 1994-1998). Vegetation units follow those described for Lake Muir and Cowerup Nature Reserves. Figures in boxes represent actual depth (cm) of mean peak surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

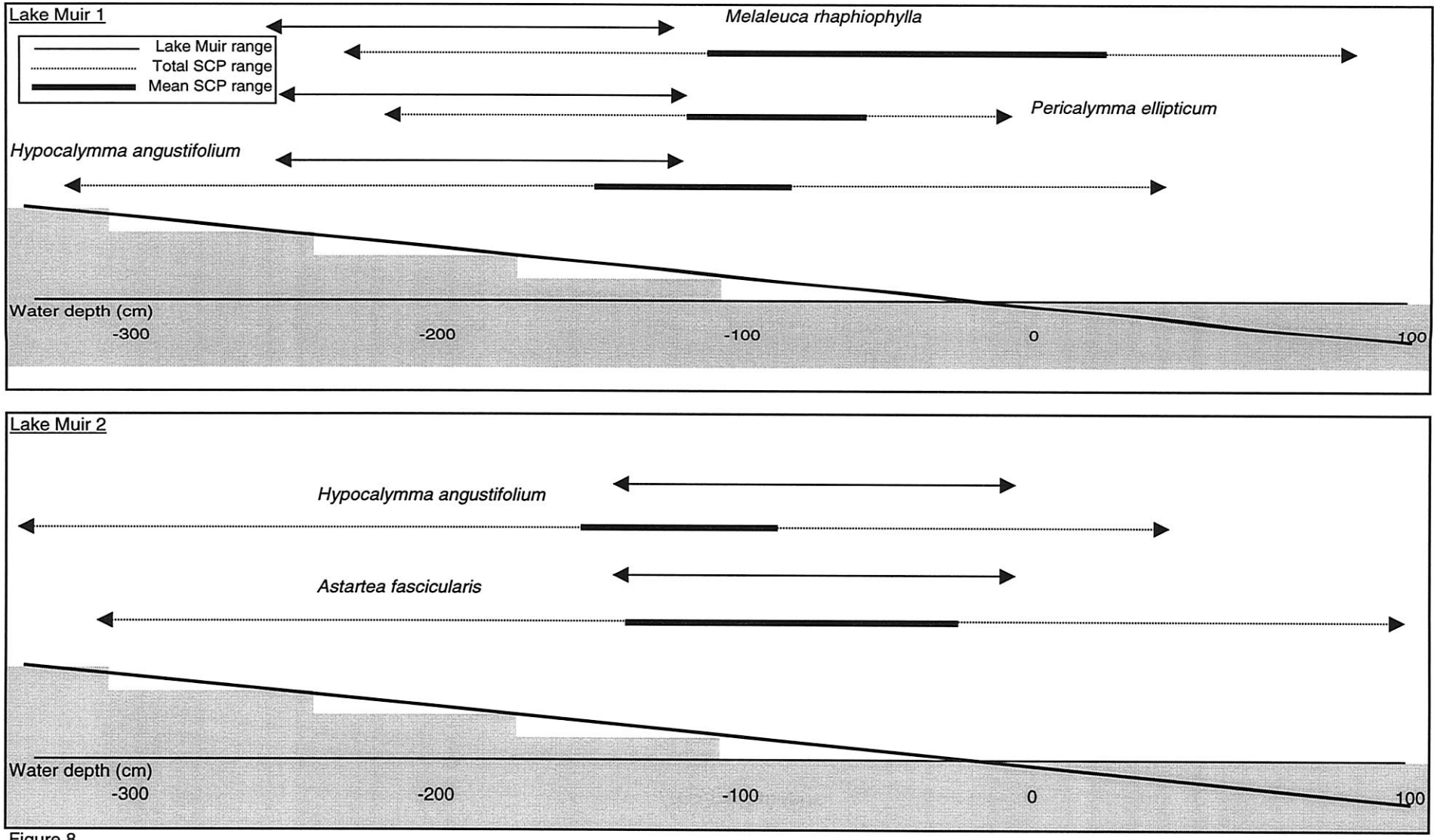

Figure 8

Peak water depth ranges experienced by wetland species at Lake Muir transect 1 and 2 compared to peak and mean peak levels across 21 Swan Coastal Plain wetlands as determined by Loomes (2000).

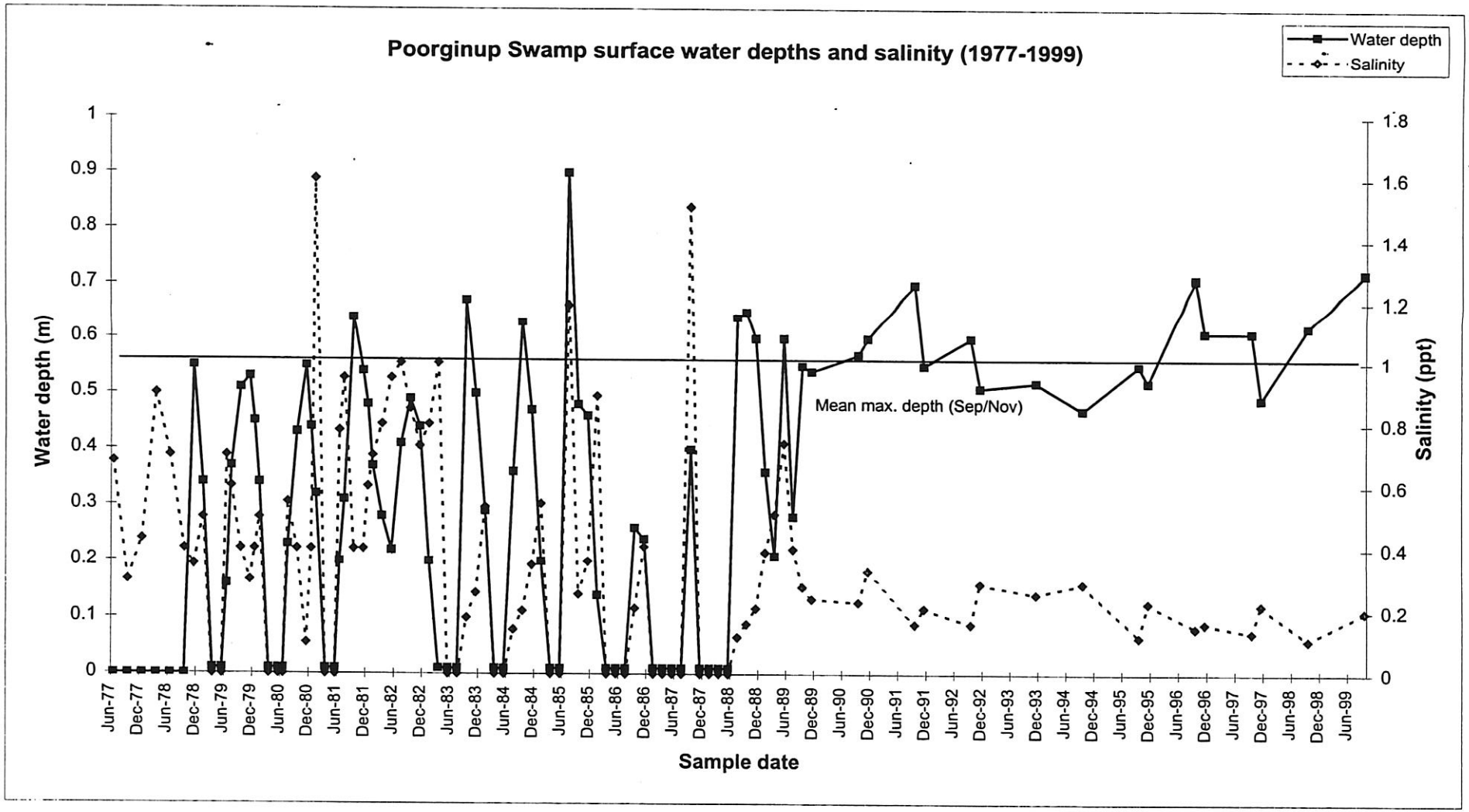

Figure 9

Hydrograph showing surface water depths (m) and salinity levels (ppt) Poorginup Swamp between 1977 and 1999.

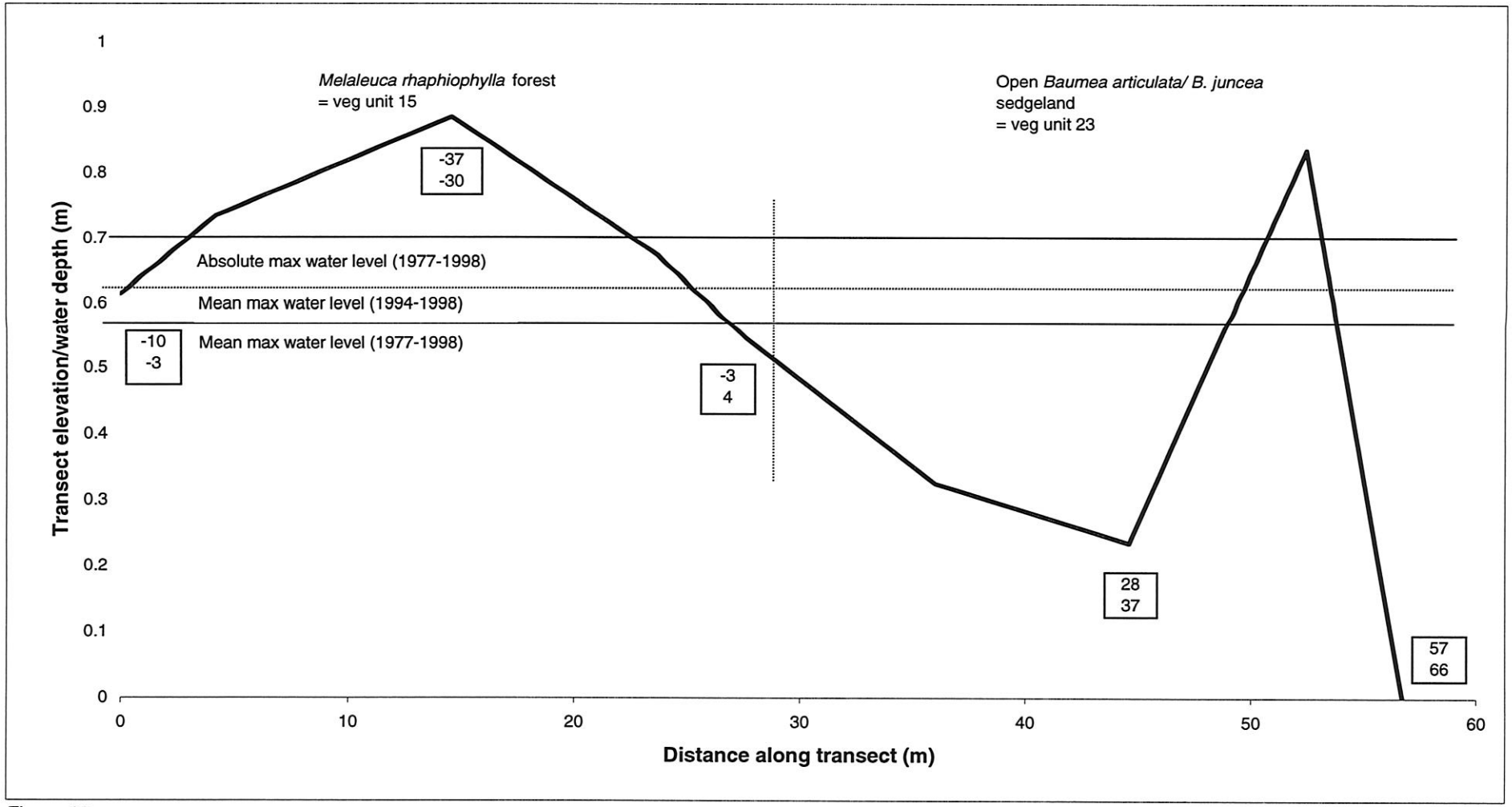

Figure 10

Profile diagram of vegetation transect at Poorginup Swamp showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Lake Muir and Cowerup Nature Reserves. Figures in boxes represent actual depth (cm) of mean peak surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

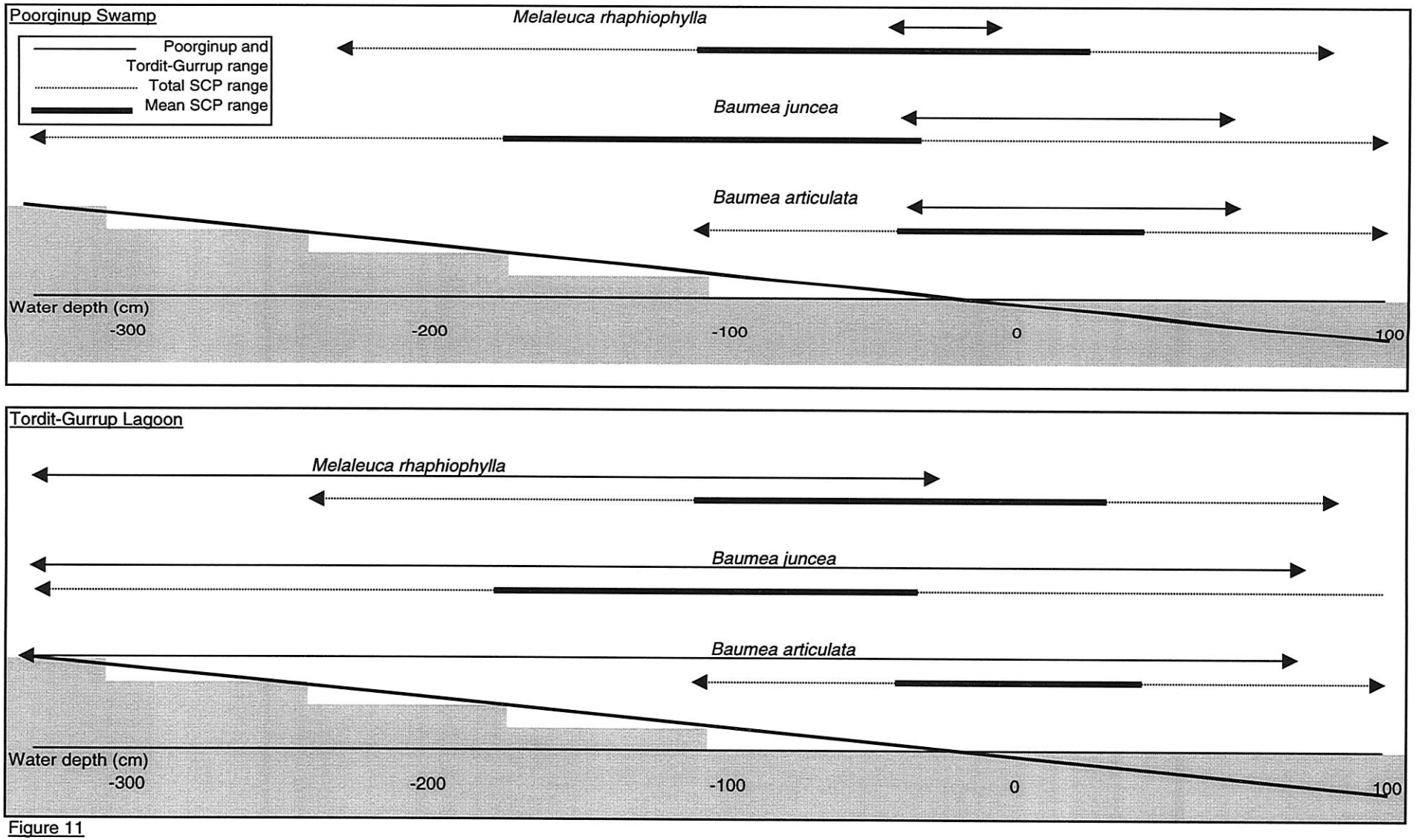

Figure 11

Peak water depth ranges experienced by wetland species at Poorginup Swamp and Tordit-Gurrup Lagoon compared to peak and mean peak levels across 21 Swan Coastal Plain wetlands as determined by Loomes (2000).

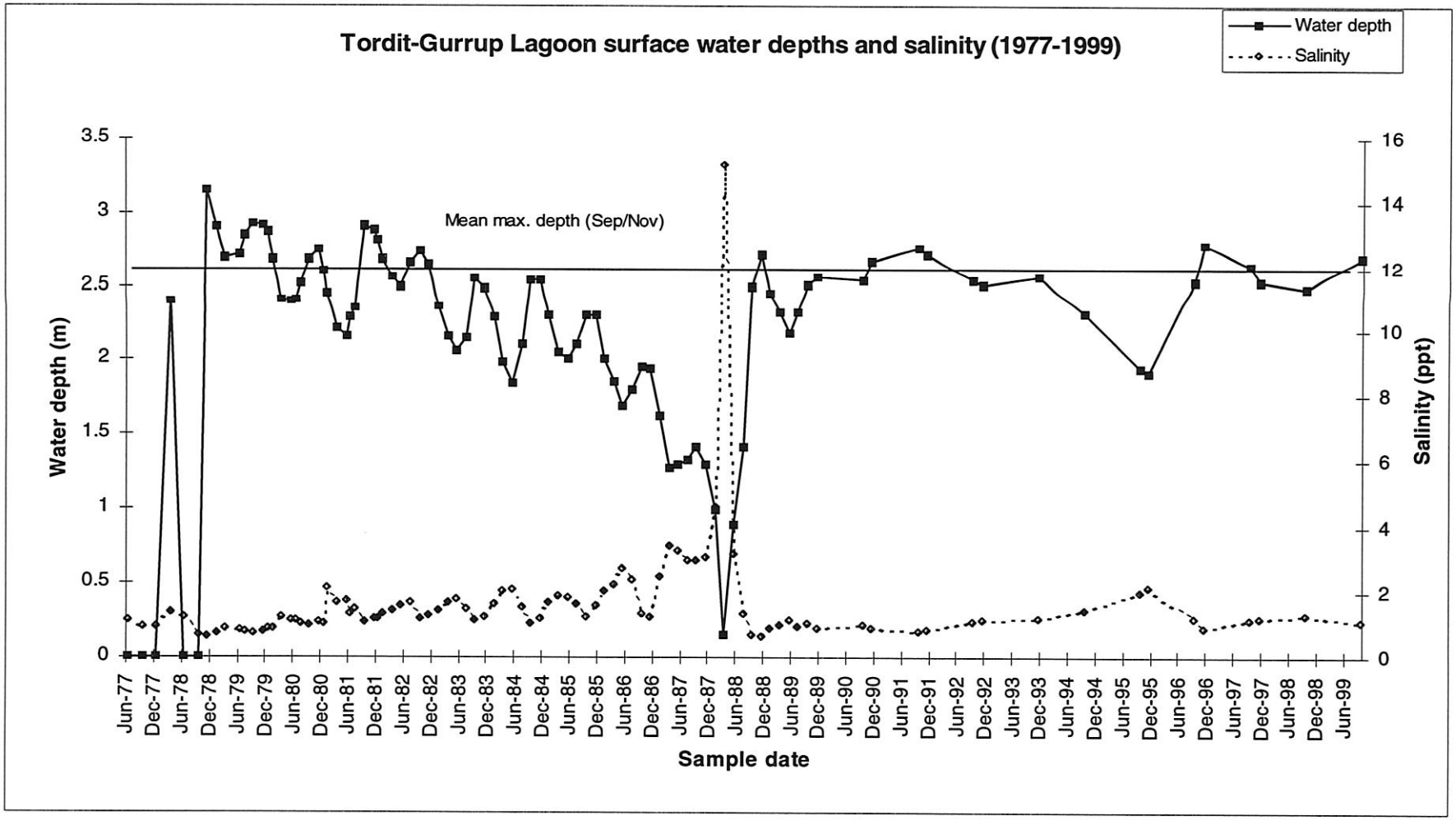

Figure 12
Hydrograph showing water depths (m) and salinity levels (ppt) at Tordit-Gurrup Lagoon between 1977 and 1999.

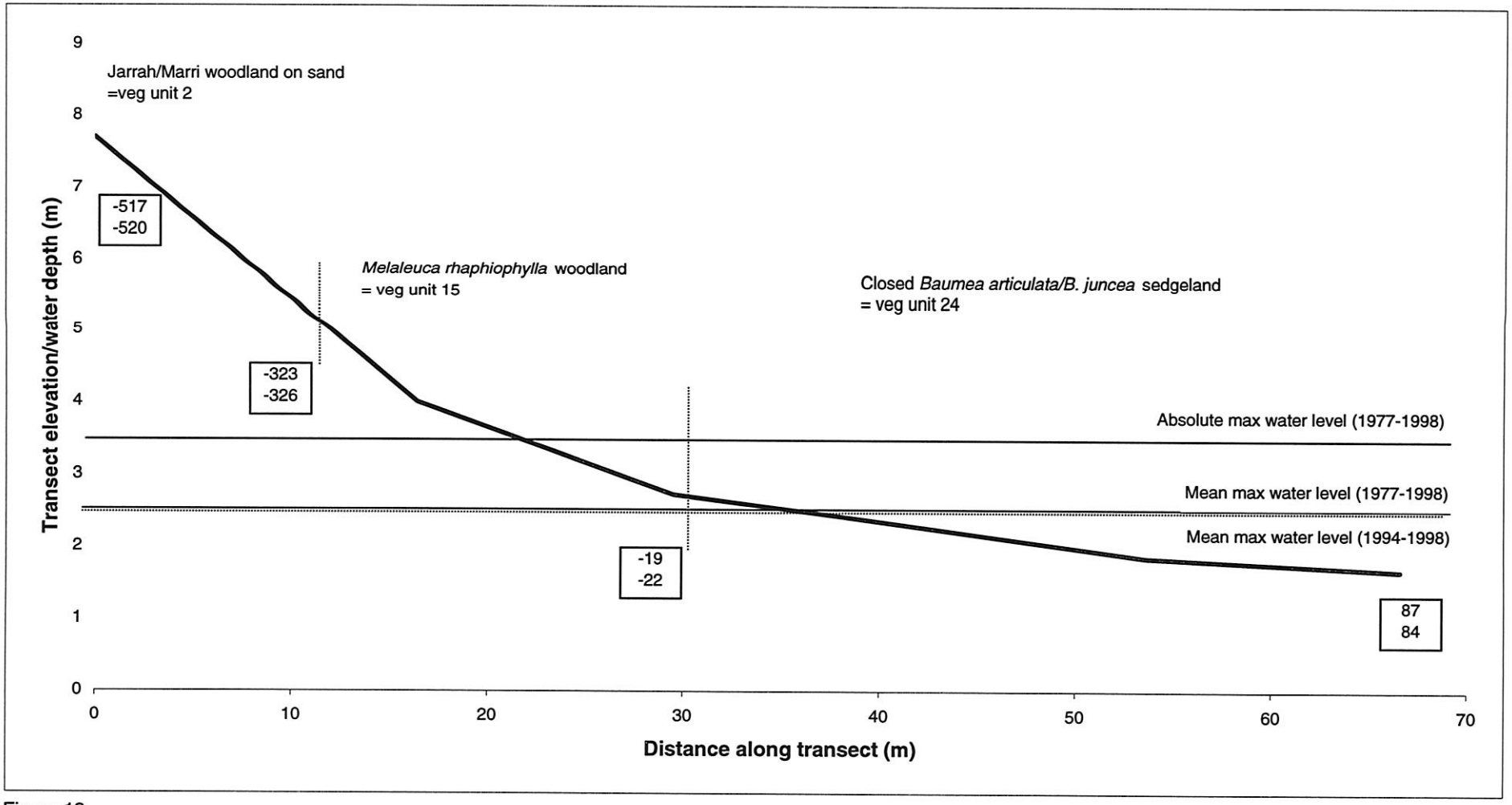

Figure 13

Profile diagram of vegetation transect at Tordit-Gurrup Lagoon showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Lake Muir and Cowerup Nature Reserves. Figures in boxes represent actual dpeth (cm) of peak mean surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

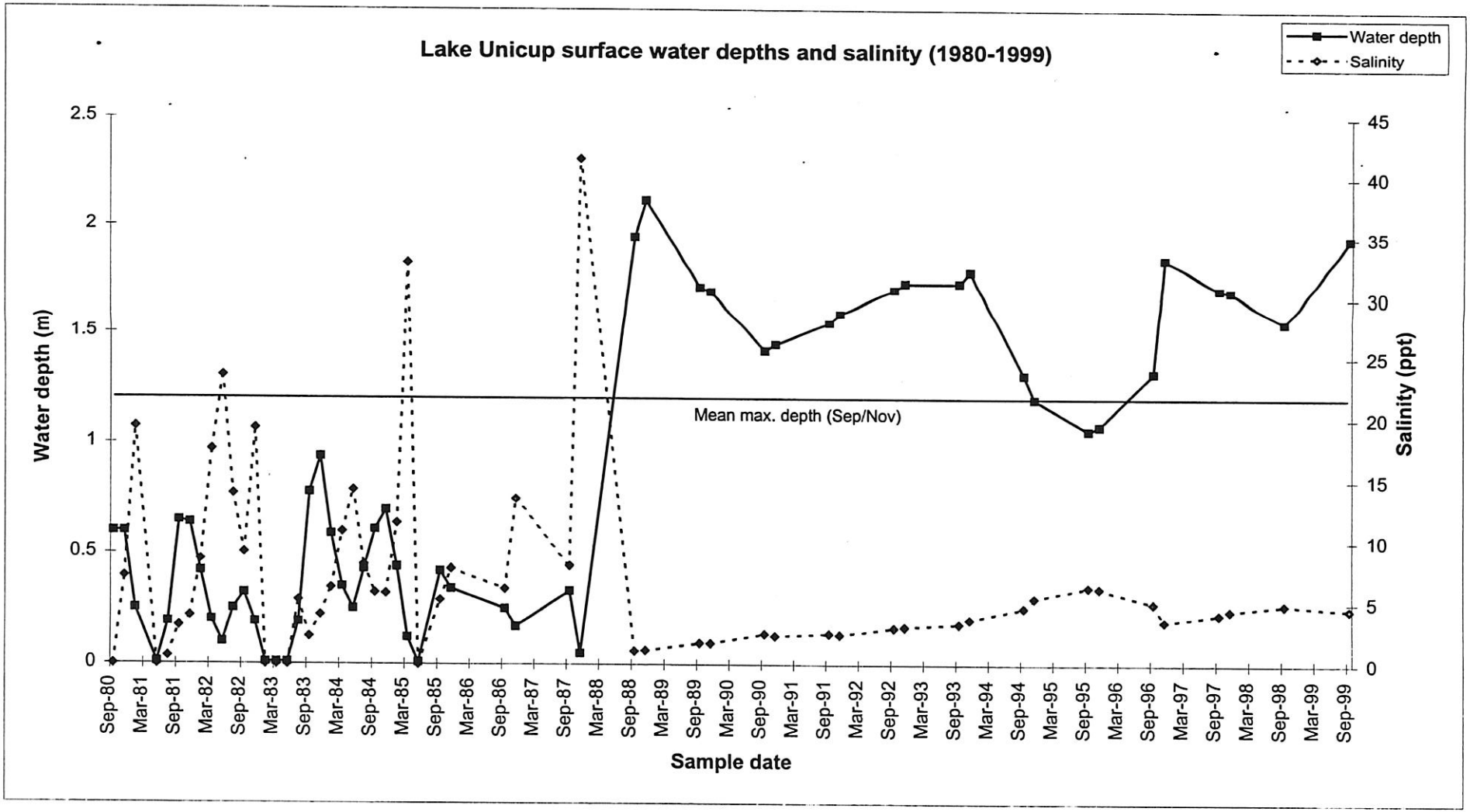

Figure 14

Hydrograph showing surface water depths (m) and salinity levels (ppt) at Unicup Swamp between 1980 and 1999.

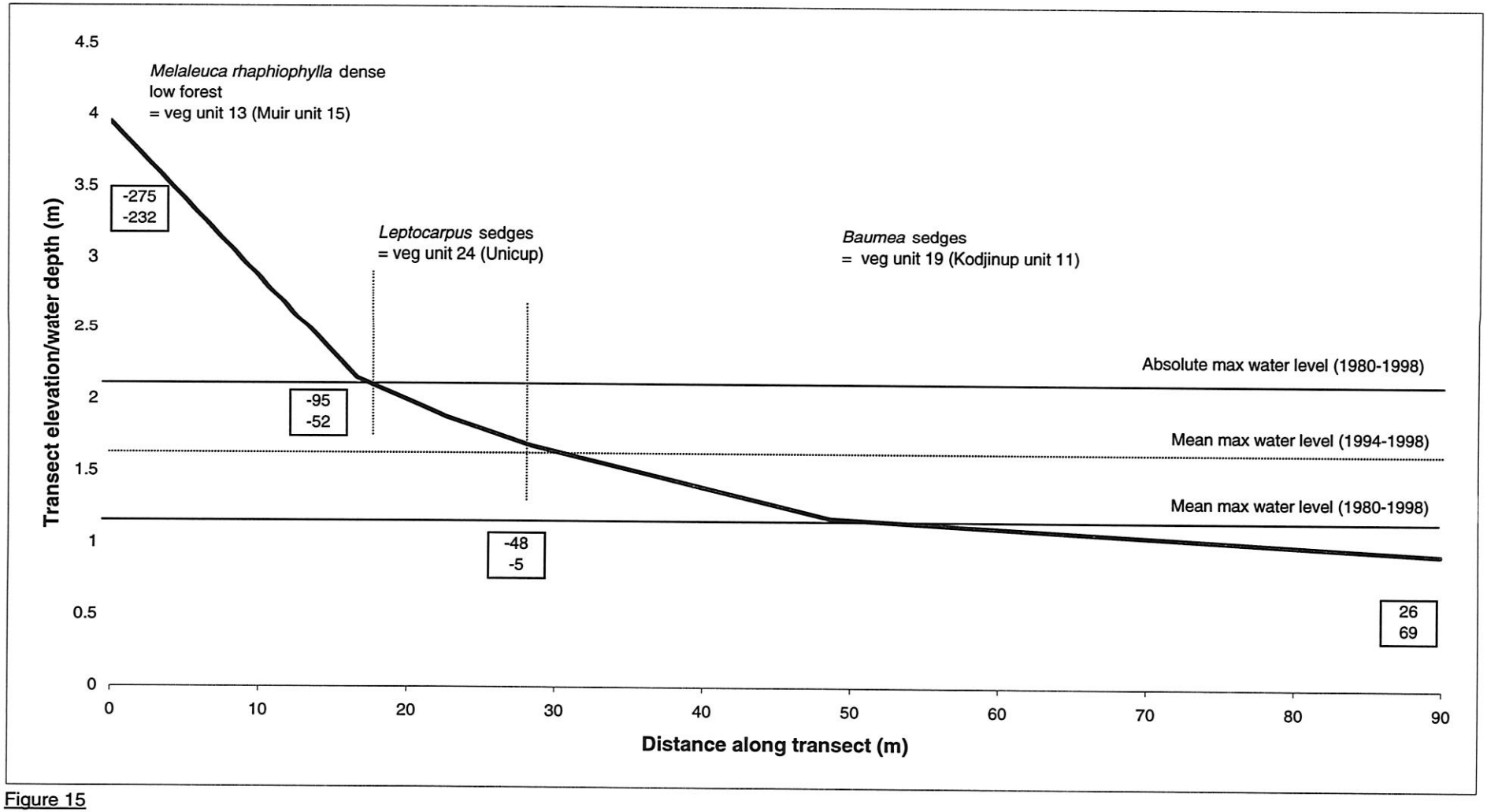

Figure 15

Profile diagram of vegetation transect 1 at Lake Unicup showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Unicup Nature Reserve (Griffin, 1984). Figures in boxes represent actual mean peak depth (cm) of surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

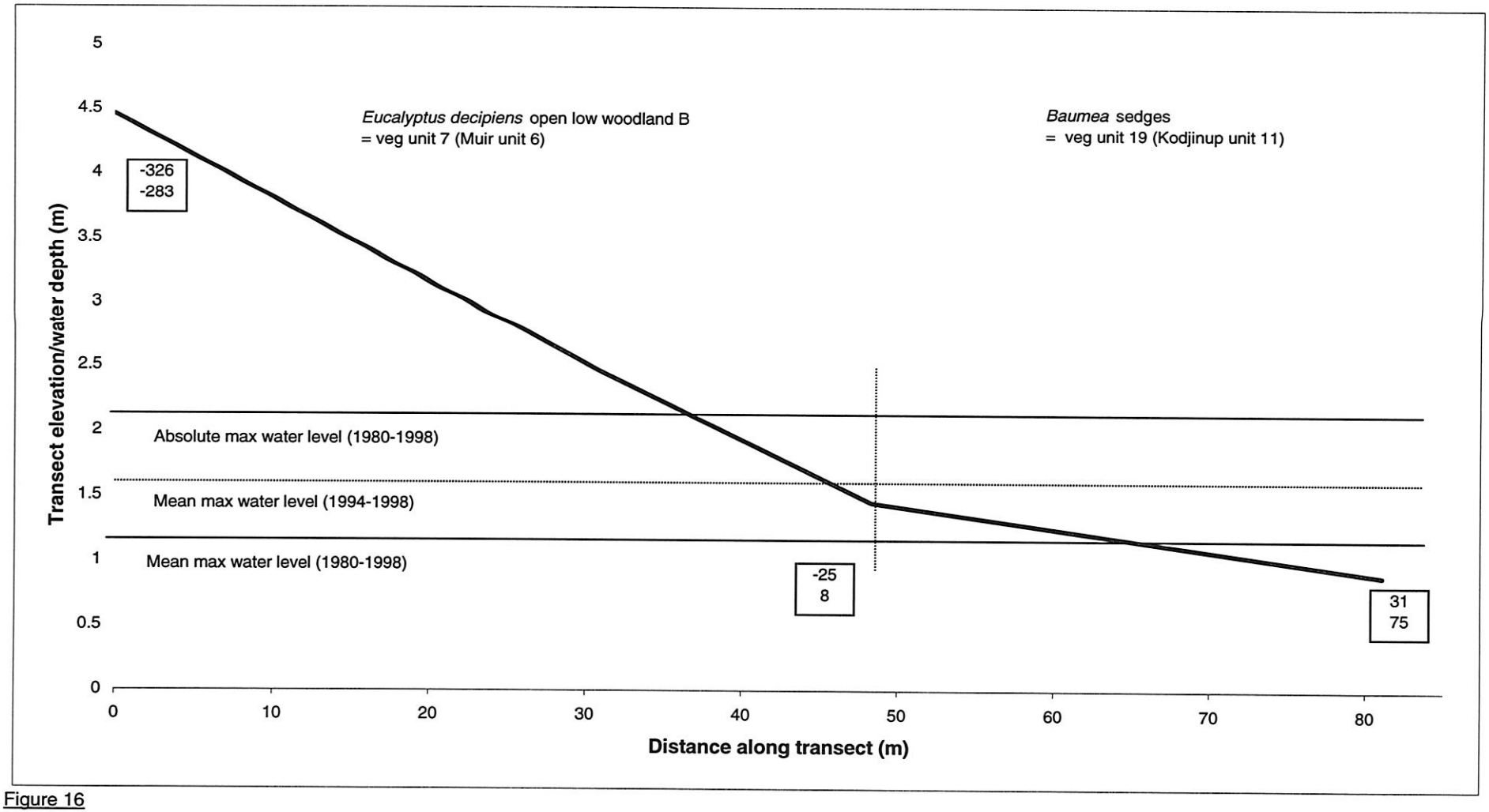

Figure 16

Profile diagram of vegetation transect 2 at Lake Unicup showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Unicup Nature Reserve (Griffin, 1984). Figures in boxes represent actual mean peak depth (cm) of surface water at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

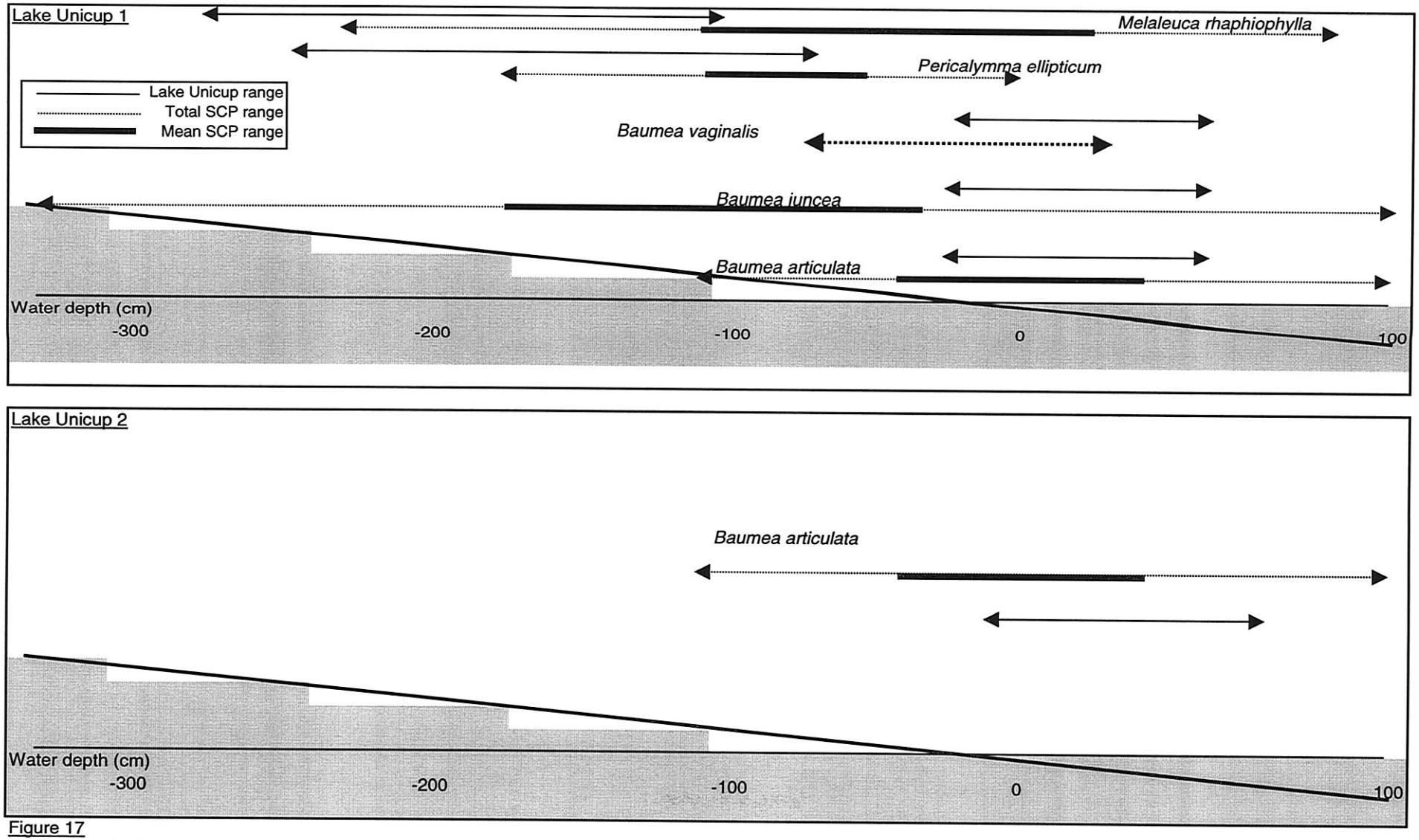

Figure 17

Peak water depth ranges experienced by wetland species at Lake Unicup transect 1 and 2 compared to peak and mean peak levels across 21 Swan Coastal Plain wetlands as determined by Loomes (2000). *Baumea vaginalis* range recorded for one occurrence only on SCP.

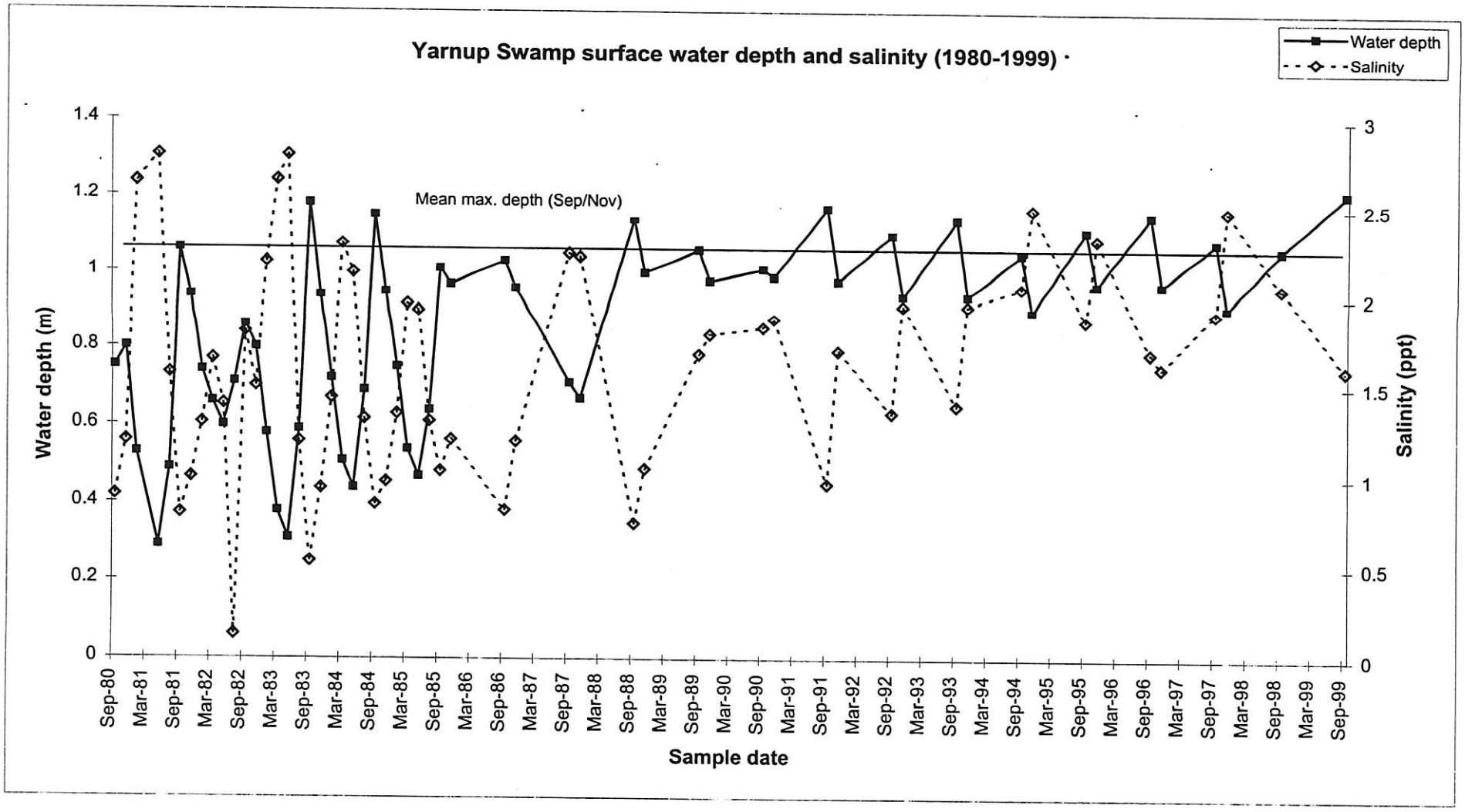

Figure 18

Hydrograph showing surface water depths (m) and salinity levels (ppt) at Yarnup Swamp between 1980 and 1999.

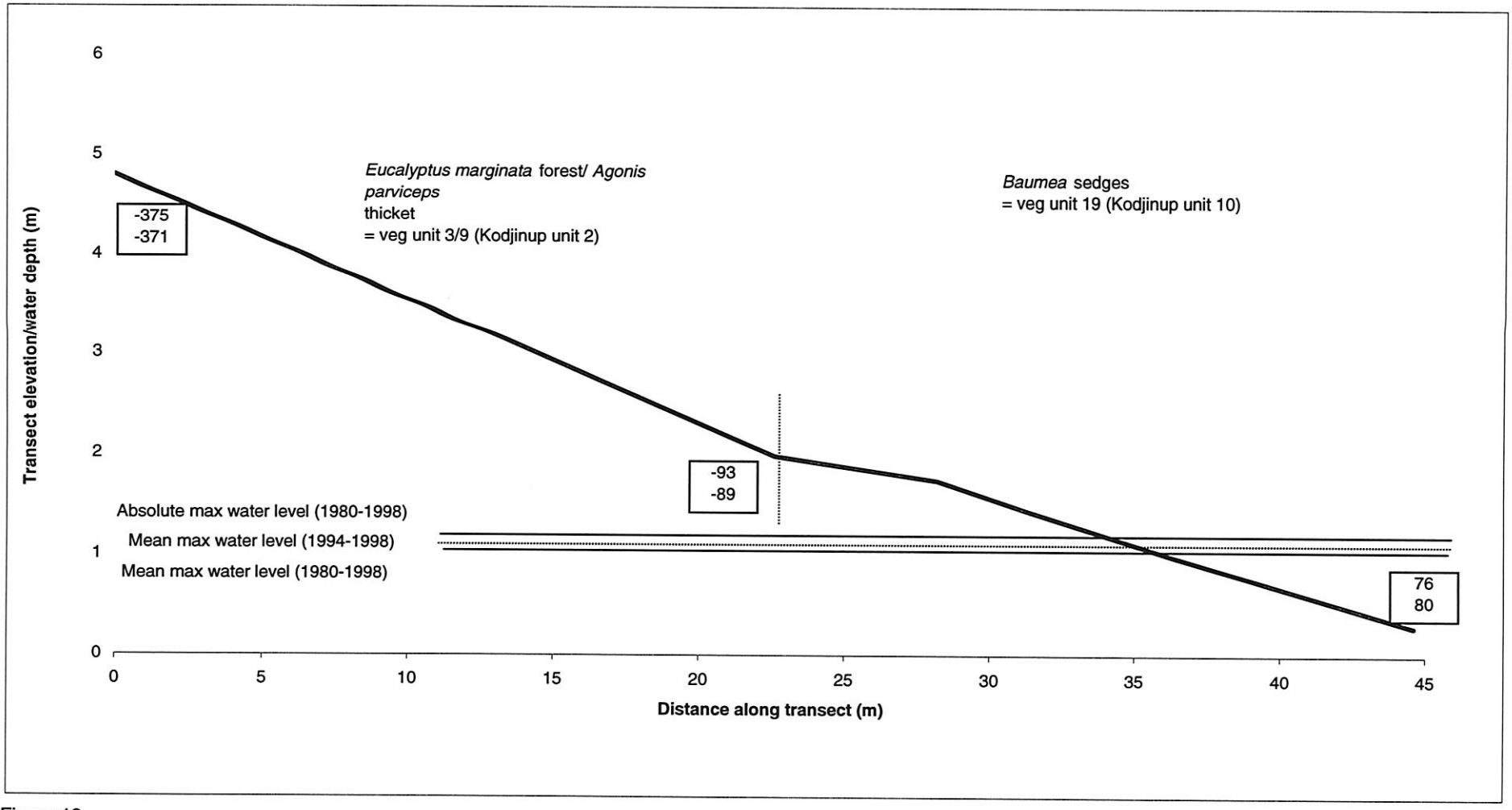

Figure 19

Profile diagram of vegetation transect 1 at Yarnup Swamp showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Yarnup Nature Reserve (Griffin, 1984). Figures in boxes represent actual mean peak surface water depth (cm) at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

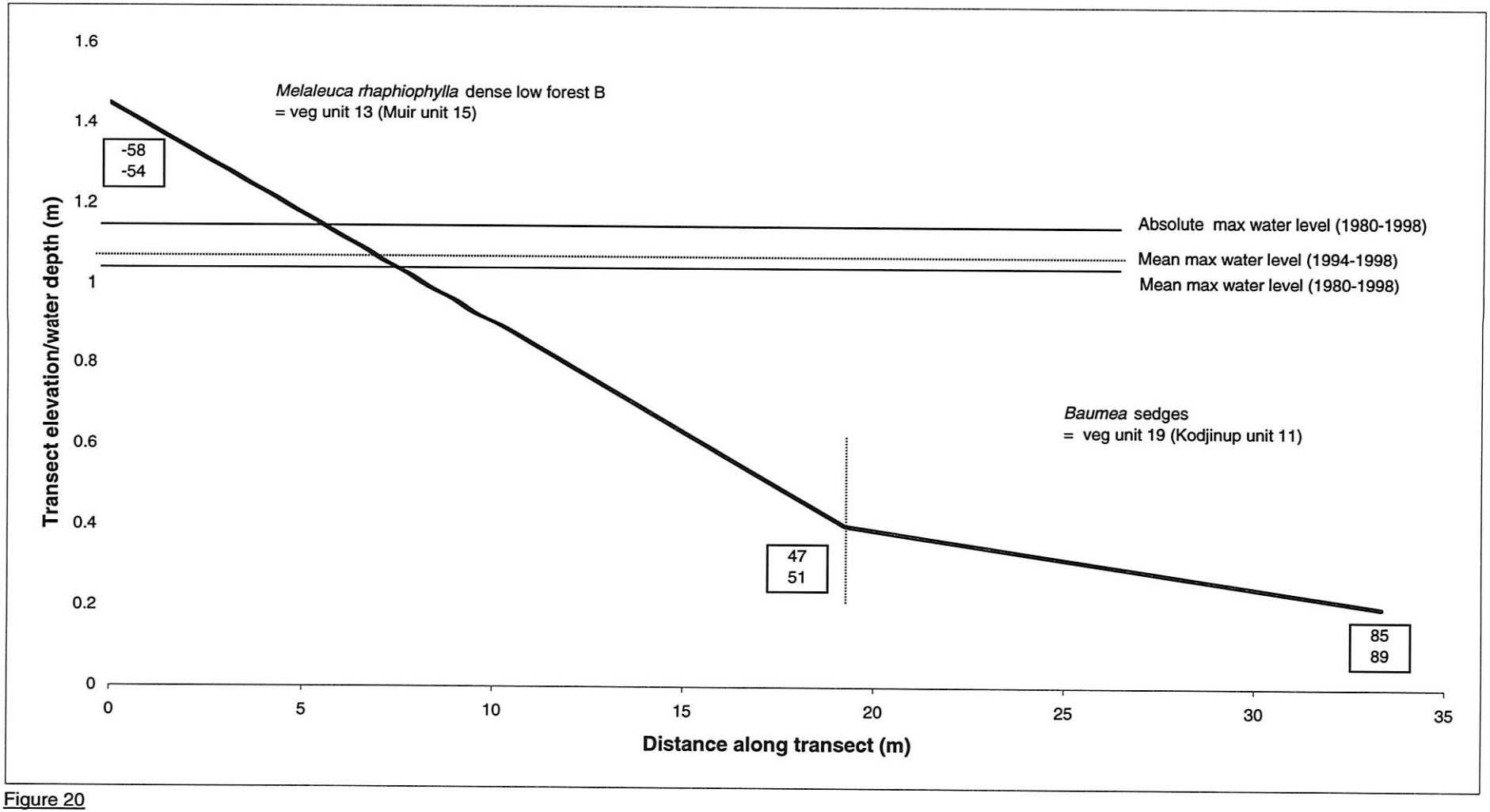

Figure 20

Profile diagram of vegetation transect 2 at Yarnup Swamp showing occurrence of vegetation units in relation to transect elevations, absolute maximum water level and mean maximum water level (1977-1998 and 1994-1998). Vegetation units follow those described for Yarnup Nature Reserve (Griffin, 1984). Figures in boxes represent actual mean peak surface water depth (cm) at ends of vegetation units over 20 (top) and 5 (bottom) year periods.

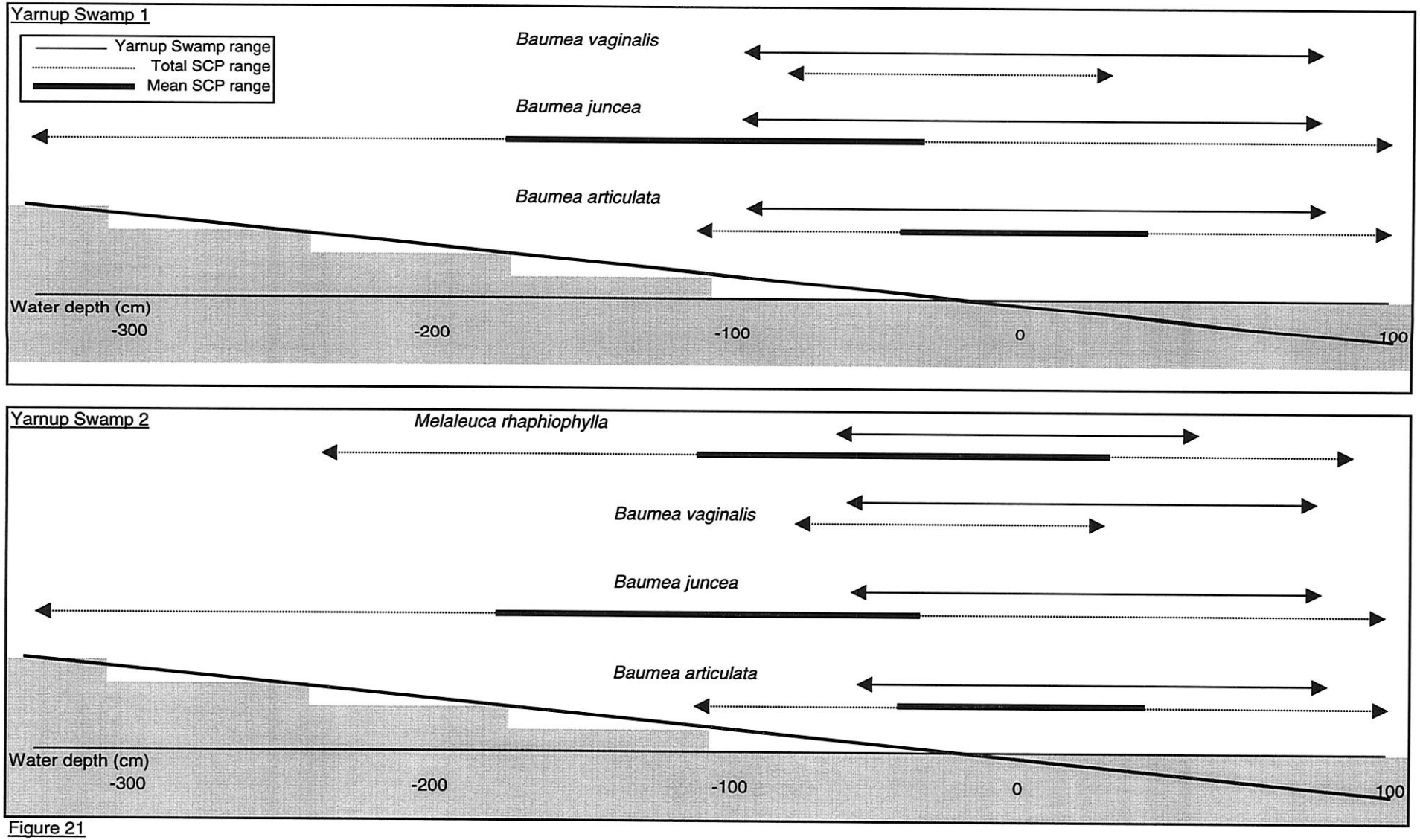

Figure 21

Peak water depth ranges experienced by wetland species at Yarnup Swamp transect 1 and 2 compared to peak and mean peak levels across 21 Swan Coastal Plain wetlands as determined by Loomes (2000). Baumea vaginalis range recorded for one occurrence only on SCP.