Technical Assessment Panel Review
Lower Barwon Wetlands, Flow Ecology Relationships

Summary

This report contains an independent review by the DSE Technical Assessment Panel (TAP) of the report *Flow/ecology relationships and scenarios for the Lower Barwon Wetlands environmental entitlement: Final Report*. The key flow-ecology relationships are reported for two of the Lower Barwon wetlands – Reedy Lake and Hospital Swamps.

The methodology used in the Flow Ecology Report to determine a recommended watering regime for these two wetland systems was adequate, in that hydrological and hydraulic information was first developed and then used to develop adequate watering regimes to maintain and protect the main geomorphological and ecological values (vegetation, water birds, fish) of these assets.

The recommended watering regimes appear to be appropriate.

However, this TAP review has identified a number of issues that need to be addressed before the Flow Ecology Report can be assessed as adequate. In particular:

- Uncertainties associated with several issues associated with the hydrology/hydraulics study (including impact of local runoff, adequacy of the evaporation input to modelling and adequacy of 12 month (April 2008 to March 2009) base data) need to be addressed to ensure that the recommended watering regimes are not compromised.
- The frequencies of the hydrological components for the recommended watering regimes need to be better justified,
- The monitoring and knowledge gaps identified need to be prioritized and linked to the key ecological assets/objectives.

Prof Gerry Quinn
TAP Assesor
29 March, 2012

Prof Tom McMahon
TAP Assessor
29 March 2012

Prof Barry Hart
TAP Chair
28 May 2012

1. Introduction

The purpose of this report is to provide an independent review of the report *Flow/ecology relationships and scenarios for the Lower Barwon Wetlands environmental entitlement: Final Report* designated herein as the Flow Ecology Report (Lloyd et al., 2011b) prepared for the Corangamite CMA and Victoria Department of Sustainability and Environment by Lloyd Environmental, Dahlhaus Environmental Geology, Ecological Associates and Fluvial Systems. The terms of reference of our review are:

1. *Was the methodology used in the Flow Ecology Report appropriate to determine a recommended watering regime for Reedy Lake and Hospital Swamps?*
2. *Was there enough information available to determine a recommended watering regime for Reedy Lake and Hospital Swamps?*
3. *Are the watering recommendations for Reedy Lake and Hospital Swamps based on the best available information?*
4. *Are the watering recommendations for Reedy Lake and Hospital Swamps appropriate to form the basis of future watering decisions?*
5. *Will the recommended watering regimes meet the identified environmental objectives?*
6. *Will the monitoring recommendations (table 20), provide enough information to determine the effectiveness of the new watering regime on achieving the ecological objectives?*

The independent review should seek to identify gaps and /or issues that may have been overlooked or are considered to be pertinent to the project.

In preparing the Flow Ecology Report, the consultants had access to two recently completed documents:

- *Confirming Native Vegetation Objectives for Environmental Watering of the Lower Barwon Wetlands* (Ecological Associates, 2011); and
- *Lower Barwon Wetlands Hydraulic Modelling for the Environmental Entitlement* (Water Technology, 2011).

2. Background

"The Lake Connewarre Complex … consists broadly of Lake Connewarre, Reedy Lake, and Hospital and Salt swamps as well as associated sections of the lower Barwon River. In turn, the complex forms part of the internationally significant Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site. The complex is also a state game reserve (Lake Connewarre State Game Reserve).

Informal flow sharing arrangements have been in place for the complex for many years. During the recent low flow conditions, the need to formalise these requirements and ensure that appropriate regulatory approvals are in place became apparent. Uncertainty has also existed around the effectiveness of the existing water management regime to maintain the "ecological character of the complex" (Lower Barwon Wetlands, Flow Ecology Relationship Project Brief, 2012).

The Flow Ecology Report was commissioned to identify and describe, through the use of conceptual models, the key flow ecology relationships for only two of the Lower Barwon River wetlands namely Reedy Lake and Hospital Swamps. The Report is to inform managers of the Barwon River Environmental Entitlement.

Background material in our brief advises that the draft Estuary Environmental Flow Assessment Methodology was used as the basis for this work (Lloyd et al., 2011a).

Our review includes addressing the six questions noted above followed by a concluding section that lists the key points from the review.

3. Was the methodology used in the Flow Ecology Report appropriate to determine a recommended watering regime for Reedy Lake and Hospital Swamps?

This question is addressed from two points of view – the adequacy of the hydrology and hydraulic information used in the developing the watering regime recommendations, and the links of the hydrology and hydraulic information to the ecology.

Hydrology and hydraulics

Because of the nature of the Lower Barwon Wetlands, both hydrology and hydraulic information are required to develop watering regimes for Reedy Lake and Hospital Swamps. In terms of hydrology, inflows to Reedy Lake include overbank flooding from the Barwon River, local catchment runoff and groundwater discharges. Overbank flooding occurs at ~3,500 ML day^{-1} in the Barwon River (Water Technology, 2011, p 4). Inflows to Hospital Swamp are more complicated. They consist of (potentially) overbank flooding from the Barwon River, local catchment runoff, (potentially) elevated levels in Lake Connewarre and shallow groundwater discharges (Water Technology, 2011, p 5).

In the scenario modelling reported in Section 4 of the Hydraulic Modelling Report (Water Technology, 2011), there is no reference to the magnitude of local catchment runoff (either as a catchment area or as runoff volumes) and no information about groundwater discharge. It maybe that the volume of these inflows compared with inflows from the Barwon River overflows have little impact but such information is not provided in the Hydraulics report. However, because more urban runoff now reaches Reedy Lake and Hospital Swamps than previously, it would be prudent to assess the impact on the Lake and Swamps of not only the volume of runoff but also importantly the water quality of the runoff.

With respect to the overbank flow from the Barwon River to Reedy Lake of 3,500 ML day^{-1} we are unable to assess the reliability of this discharge as the estimate was quoted from as earlier report (Water Technology, 2010), but as there are no references listed in the Water Technology (2011) Hydraulics Report, we were unable to consider this further.

Another factor of concern in relation to the water scenario modelling in the Hydraulics Report relates to the estimation of lake evaporation which is crucial in determining the periods of lake or swamp inundation. From the Hydraulics Report (Water Technology, 2011, page 36), "…the impact of evaporation on salinities and water levels has been simply accounted for by applying a time varying (negative) fresh water flux from the model surface area based on appropriately factored daily pan evaporation rates sourced from the Bureau of Meteorology". Relative to the importance of evaporation in the total water balance, this aspect of the report is inadequate for several reasons. No information is provided about the actual pan data, for example, what is the location of the station, what time step was adopted - annual, monthly or daily data. What pan coefficient/s was used? Was the quality of information assessed? Were there missing data, and if so how were they handled? Were the data from one of the Bureau of Meteorology's high quality class-A pan evaporation stations (Jovanovic et al., 2008, Table 1)? The preferred method to compute lake evaporation is the Penman equation (Shuttleworth, 1992, Section 4.4.4). Moreover, given that "…hyper levels of saline conditions can persist for several months…" during the 'wet' and 'maximum variation' water scenarios (Water Technology, 2011, page 19), evaporation estimates in Lake Connewarre need to be reduced to account for this effect (Grayson et al., 1996, Equation 4.7.4).

The scenario modelling of 'wet', 'maximum variation', and 'dry' is based on the 12 months April 2008 to March 2009 which was a year of very low flow and not typical of average conditions. In view of this it is important to know how the Reedy Lake and Hospital Swamps would be affected by more average conditions. This information may have a significant bearing on the recommended watering requirements for Reedy Lake and Hospital Swamps.

Other issues of concern

a. Appending five and one-half years of observed daily flows at McIntyre Bridge to 55.5 years of REALM estimated daily flows (Water Technology, 2011, p 6) without testing for homogeneity raises doubt about the consistency of the 61-year record.
b. In the overbank flow spells analysis for the Barwon River, a sensitivity analysis based on 15% above and below 3,500 ML day^{-1} was carried out. No justification was given for the choice of 15% (Water Technology, 2011, page 7). A more important metric is the 7-day separation between overbank flow spells. Again, no justification is given of this level of separation. However, small changes to these two values (15% and 7-day separation) will not affect the application of the results.
c. Table 3-2 (Water Technology, 2011, page 11) is important to the hydrology of Hospital Swamps. According to the information in Water Technology (2011, page 11) water levels above 0.5 m AHD will overtop the natural banks separating Lake Connewarre and Hospital Swamps. Table 3-2 lists the annual exceedance probability (AEP) of various Lake Connewarre water levels. There are two issues about this table. The first is that to estimate AEP values, the water level data will be based on the annual series. This means that 100% AEP is incorrect as such analysis does not allow one to estimate certainty. For events with AEP values > 10%, the AEP values should be adjusted using Ladson (2008, Equation 6.7) to represent the partial series (independent values will exceed some threshold), or better, a partial series should be developed from the data and for the Lake Connewarre case, the water level of the one in one-year average recurrence interval estimated.
d. In page 40 of the Hydraulics Modelling Report (Water Technology, 2011), it is stated that "Evaporation within Reedy Lake is reproduced well within the model". Although the modelling result in Figure 5-11 is impressive, it needs to be noted that this is for a calibration result and would be expected to fit well. No validation results are provided for Reedy Lake. Moreover, there are insufficient data associated with Figure 5-13 to be confident that evaporation was modelled well for the two months of water level results displayed for Lake Connewarre.

Links to ecology

The report identifies four main ecosystem process "assets" – geomorphology, vegetation, waterbirds and fish. Each of these is considered separately, and based on conceptual models (similar to those in EEFAM), hydrological components are linked to specific ecological objectives for these assets and then used to recommend a water regime for Reedy Lake and Hospital Swamps. Detailed information about the history of the wetlands is provided, including changes in water (and other) management regimes. This historical context is important for interpreting current patterns and also for linking some key ecological characteristics (e.g. carp abundance) to specific management actions (e.g. drying Reedy Lake).

Geomorphological objectives:

The report describes flow-related geomorphological objectives (Table 2) although it emphasises the recommended hydrological (watering) regime should be determined by biotic ecological objectives because of the slow pace of geomorphological processes. Nonetheless, it would be helpful if Table 2 described the ecological significance of some of the geomorphological objectives. For example, why is a high turbidity disturbance event a desirable objective? What is the value of delivering fine sediment to the wetlands? None of these specific geomorphological objectives are included as "environmental" objectives in the recommended water regime (Tables 17 and 19), although cracking and oxidising sediments to release nutrients upon subsequent inundation will stimulate productivity of macro- and micro-invertebrates.

Vegetation objectives:

Understanding the links between aquatic vegetation and water regimes in these wetlands is greatly enhanced because of (i) the previous surveys of vegetation in these ecosystems (e.g. Yugovic 1985) and (ii) the strong research base in Australia and elsewhere on responses of aquatic plants to changing hydrology. Relatively simple, but appropriate, models are used to describe the distributions of the nine main aquatic plant "communities" along two axes, salinity and water depth. These simple models are then combined into conceptual models for all the plant communities in each wetland (Figs 7 & 8). While these models are generally sensible, labelling is incomplete – what do the solid horizontal lines and dashed and solid vertical arrows represent? Presumably this is about groundwater processes?

The vegetation-based ecological objectives and hydrological requirements for the two wetlands are presented in Tables 3 and 4. These objectives are based on the conceptual models and presumed historical watering regimes and are sensible. For Reedy Lake, the main aim is to promote open water in contrast to reed beds (e.g. *Phragmites*) and to dilute or flush accumulated salt. How is this flushing achieved – simply by filling the lake and then opening the outlet regulator? The timing of the hydrological components makes ecological sense but there is no explanation for the frequencies of overbank flows in Reedy Lake (1 to 5 times per year) – do these represent natural frequencies? For Hospital Swamps, the vegetation objectives are numerous, but are based around maintaining the estuarine (variable salinity regime) nature of this wetland and drying the wetland over summer as would have happened naturally. Again, these ecological objectives are clearly derived from the conceptual models and are sensible.

Waterbird objectives:

As with the other components, environmental objectives relating to waterbirds are linked to hydrological components by a suite of conceptual models. The focus is on foraging habitat (18 foraging guilds of birds were identified) and breeding requirements based on depth and seasonal timing and length of inundation. A large amount of information is presented in the report on waterbirds, especially temporal trends in diversity from 1960 to present, trends in abundance of key species from 1979 to present, and trends in foraging guilds from 1998 to present. While these long-term datasets are interesting, their value in the context of setting water regimes is limited because they cannot be easily linked to inundation (timing or depth) as presented. These data would be much more useful if correlated with at least flows down the Barwon River or any data on extent of inundation of the wetlands.

A "generic" conceptual model for waterbirds is provided (Figure 29; note accidently inserted also on page 80). Focusing on four main foraging habitats (deep/open water, shallow water, reed beds, mudflats), more specific models are presented for each wetland in spring and again in summer. These models are realistic based on the available information on feeding modes from the literature. Finally, ecological objectives for waterbirds are linked to hydrological components in Tables 7 and 8. For Hospital Swamps, these objectives are set for all years. In contrast, some objectives for Reedy Lake are specified with a particular frequency; for example, 3 years in 5 for overbank flows, deep water all year 3 years in 5 but Jul-Feb only 2 years in 5, gradual recession 3 years in 5 and complete recession 2 years in 5. It is not clear why these frequencies are specified for Reedy Lake but not Hospital Swamps, nor how the frequencies are derived – are they based on the natural hydrology for both systems? We agree that the two main objectives for Reedy Lake, stopping the spread of *Phragmites* and control of carp populations, are the highest priority for managing waterbirds in this wetland.

<u>Fish objectives</u>:

The objective setting for fish follows the same strategy as used for other ecosystem components – describe existing taxa and then use conceptual models to set hydrological components for desired ecological objectives. The fish community in these wetlands is remarkably diverse and fish species were classified according to how they use marine, estuarine and freshwater habitats during their life cycles. Two species of fish (Common Jollytail and Yarra Pygmy Perch) were used to illustrate the conceptual models. These two models appear to have been derived from the EEFAM report with little modification. For example, on page 99, second dot point for the Jollytail argues for flows to open the (river?) mouth but the Barwon mouth is permanently open so why do we need flows to open mouth?

The ecological objectives for fish are presented in Tables 14 and 15. The general logic of these objectives is fine having been derived from sensible conceptual models. In particular, we support setting objectives for the fish community as a whole, rather than targeting particular species. But as with the other ecosystem components, it is not clear how the frequencies for some hydrological components (e.g. overbank flows 3 years in 5) were derived nor why such frequencies are only relevant in Reedy Lake and not Hospital Swamps. Some clarification is required for all these ecological objective tables for Reedy Lake that specify frequencies. A species-specific concern relates to Tupong, which are known to move downstream to the estuary in April-July; but no flows are recommended to stimulate this movement and Hospital Swamps are recommended to be dry during this period.

4. **Was there enough information available to determine a recommended watering regime for Reedy Lake and Hospital Swamps?**
5. **Are the watering recommendations for Reedy Lake and Hospital Swamps based on the best available information?**

These two questions are best combined as they are essentially asking the same thing. There was enough information to determine a recommended watering regime for both wetlands and this is generally the best available information.

There were some concerns about the hydrology and hydraulics as detailed above. These concerns need to be assessed to ensure that any uncertainty in the methods and calculations do not compromise the recommended watering regime achieving the ecological objectives.

There was enough information about the major ecosystem assets (vegetation, birds and fish) to set sensible objectives and derive a suitable watering regime, due, in part, to the use of logical conceptual models. The major concern was the recommended frequencies for the specific hydrological components for Reedy Lake – these frequencies need to be justified and their derivation, and why they only apply to Reedy Lake, explained.

6. **Are the watering recommendations for Reedy Lake and Hospital Swamps appropriate to form the basis of future watering decisions?**

Yes, assuming the concerns about some of the data and calculations used to determine the hydrology and hydraulic characteristics of both wetlands do not compromise the likelihood of meeting ecological objectives.

The overall recommended water regimes in Tables 17 and 19 attempt to balance all the ecological objectives to achieve an overall "ecosystem" outcome for both wetlands. One major concern is the lack of detailed explanation for the recommended frequencies of the hydrological objectives. For example, where does the 8 years in 10 and no more than 5 years between events for maintaining water level at or less than 0.3m AHD come from? We also query why such frequencies were not specified for the hydrological components for any of the specific ecological objectives for vegetation, birds and fish for Hospital Swamps but are specified in Table 19 (usually 9 years in 10)?

The key will be appropriate monitoring of key ecological objectives to evaluate if the water regime is achieving desired outcomes. Monitoring reed beds (Table 20) is one example of such monitoring. It would be useful to link each of the key ecological objectives to part of a potential monitoring program, although the design of such a monitoring program deserves a separate study and should be linked to VEFMAP strategies.

7. **Will the recommended watering regimes meet the identified environmental objectives?**

The watering regimes for both wetlands should meet the identified environmental objectives but two points are important to note. First, the overall watering regimes are a compromise across objectives for vegetation, fish and birds. While some of these objectives will have similar hydrological requirements, some will be contradictory and the final regime has to balance all these requirements. Quite reasonably, the authors have taken a longer-term "ecosystem approach" when recommending the overall watering regime, but this may compromise some objectives in the shorter terms. Second, the frequencies recommended for specific hydrological components need to be better justified.

8. **Will the monitoring recommendations (Table 20), provide enough information to determine the effectiveness of the new watering regime on achieving the ecological objectives?**

Table 20 highlights key knowledge gaps and briefly recommends research programs to address these gaps. While filling all of these gaps would provide useful information, it would be helpful if the knowledge gaps could be prioritised to allow the relevant management authorities to make defensible decisions about future investment. For example, it would appear the recommendation #3 about *Phragmites* and *Typha* would be a high priority because of concerns about increasing reed bed extent and reduces open water.

Other comments about these knowledge gaps include (based on row number):

1. This goes without saying, as long as the management authorities have the resources to properly assess the outcomes of management actions and the different authorities with jurisdiction coordinate with each other. The development of a cost-effective monitoring program that targets high priority objectives is critical.
2. This is a reasonable recommendation. Water level data will be required to assess compliance of the proposed water regimes, and similar data will certainly be required to achieve more efficient calibration of the water models in the future.
3. The extent of reed beds is an important indicator because key aspects of the water regime are designed to increase the amount of open water. But ramet recruitment and new ramet density will be very laborious to measure. A few targeted areas might be used for short-term ramet responses, with sampling frequency of perhaps once per year.

Broader remote sensing methods might be useful for longer-term trends across the whole wetlands.

4. Is this relevant for Reedy Lake, which is not really affected by tides because of the sill and floating breakwater?
5. We support the recommendation for a water balance study of Reedy Lake, Hospital Swamps and Lake Connewarre resulting in a water balance model of the three water bodies. Such a model will also allow a better assessment to be made of the salinity changes in Lake Connewarre.
6. We identified this as an inadequacy in the modelling. Our recommendation would be that the water balance model proposed in the previous item would cover a range of hydrology – drought years, average years and flood years.
7. The likely development of the surrounding land, especially Armstrong Creek, means that water-sensitive urban design principles should be required to protect the quality and volumes of water entering these wetlands. An urban stormwater runoff model for this area would be part of the water balance modelling recommended under (5) above.
8. Useful information but not essential – this might be achieved by monitoring water quality in response to changed water regimes.
9. Likely to be an expensive study. Such a study might be justified if threatened species are targeted but such a set of fish surveys needs to be linked to other fish studies on same taxa (check with fish team at ARI).
10. This really implies a much broader ecological study, possibly linked with #9 – maybe ideal for one or more PhD students.
11. This seems a low priority, as these taxa are not a key part of ecological objectives.

9. Minor issues

a. There was no map in any of the reports showing clearly the lakes and swamps, key features like natural levees and the location of the two breakwaters, locations of inlet and outlet channels and pipes showing sill levels, etc.

b. The Hydraulic Modelling report (Water Technology, 2011) contained no reference list.

c. In Table 17, first row – hydrological environment refers to low flows but objective states moderate to high flows?

10. Conclusions

- Several issues (including impact of local runoff, adequacy of the evaporation input to modelling, and adequacy of 12 month (April 2008 to March 2009) base data) in the hydrology/hydraulics study raise concern. Uncertainties associated with these issues need to be assessed to ensure that the recommended watering regimes are not compromised.
- Hydrological components for key ecological assets (vegetation, birds and fish) were derived from sensible conceptual models.
- The recommended watering regimes were appropriate, although the frequencies of hydrological components need to be justified.
- Monitoring of priority outcomes is necessary for an adaptive management framework. The monitoring and knowledge gaps need to be prioritized and linked to the key ecological assets/objectives.

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GP Quinn

TA McMahon

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