SALINITY RESPONSE OF LOVEDAY DISPOSAL BASIN TO EXPERIMENTAL FLOODING

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INTRODUCTION

In the Lower River Murray region, a number of floodplain wetlands were converted into disposal basins during the 20th century to store and evaporate irrigation drainage. The aim was to prevent saline drainage from irrigated areas discharging into the river, at least outside of major flood events. Loveday (Figure 1) was converted into a disposal basin during the 1970's to service the Cobdogla irrigation district. Due to the combination of decreased irrigation drainage disposal and a drought in the Murray-Darling Basin, Loveday has been partially dry since 2000. The partial drying of the wetland has resulted in hypersaline conditions and the production of foul odours (Lamontagne *et al*. 2004; Hicks and Lamontagne 2006). The cause of the foul odour events are not clear but appear related to the presence of elevated concentrations of reduced sulfur compounds in the wetland sediments (Wallace *et al*. 2004), these being a consequence of the elevated salinities (Lamontagne *et al*. 2004). Loveday was selected by management agencies to be a site for an adaptive management project with the aims of: 1) preventing the generation of foul odours; and 2) improving conditions at the site for native fauna and flora. As a first step, flooding of Loveday was initiated in May 2006 to prevent the generation of foul odours and attempt to lower salinity.

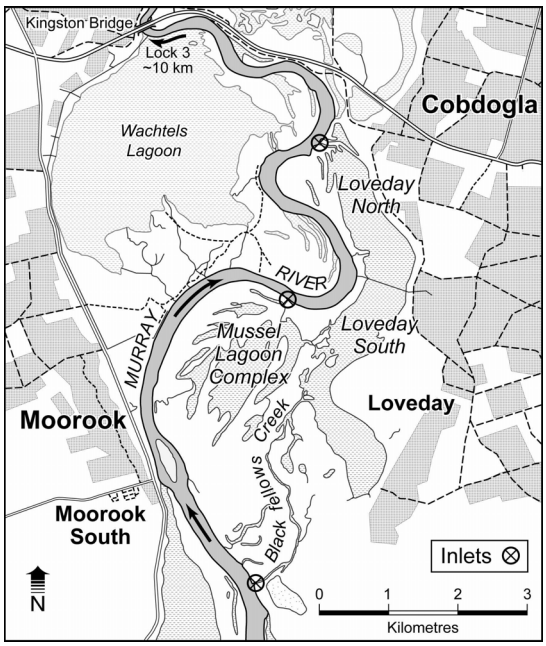

Figure 1: Loveday Disposal Basin (North and South) and the locations of river inlets to the system.

In this paper, we present a summary of the hydrological environment and of the historical salinity changes at Loveday Disposal Basin. We also propose a series of hypotheses on the key processes controlling salinity in this system. We also review the salinity response (as electrical conductivity) for the first four months following the May 2006 flooding event. The implications of the early results of this flooding experiment are discussed.

METHODS

Site Description

Loveday Disposal Basin (330 ha) is located near the township of Barmera, in the South Australian Riverland (Figure 1). The climate is semi-arid, with potential evaporation (~2000 mm yr^{-1}) well in excess of precipitation (100 – 500 mm yr^{-1}). The floodplain at Loveday was formerly an ephemeral lignum – River Red Gum swamp. However, the current vegetation in and around the basin consists solely of halophytes, with extensive areas of bare soils. The primary land-use in the vicinity of Loveday Basin is irrigated vineyards. Loveday consists of a North and a South basin separated by a causeway, but connected through several culverts (which were closed during the reflooding experiment).

Hydrology

Prior to river regulation, Loveday filled during spring floods and dried during the summer months. As for many floodplain wetlands in the Lower Murray, the hydrology of Loveday has now been significantly modified. Regulation of the Murray-Darling River during the 20th century has significantly decreased the frequency, magnitude and duration of flooding events (Jolly 1996). The building of levees at Loveday has further isolated the wetland from the river channel. In addition, the base river level is now raised by weirs along the river, which would result in Loveday being permanently inundated if control structures had not been installed at its various inlets (Figure 1). The North Basin is connected to the River Murray through an inlet at its northern end, while the South Basin's main connection to the River is by flow through from Mussel Lagoon (Figure 1). The nearby irrigated areas are underlain by a drainage network to prevent waterlogging of crops. The drainage network discharges in the North Basin and has brackish salinities (on average ~4.5 mS cm^{-1}). A groundwater mound is also present under the irrigated areas (GHD 2004) and is thought to discharge highly saline groundwater (7.0 – 60.7 mS cm^{-1}) to the wetland. Essentially, Loveday is now a terminal basin because it has the lowest water level in the landscape (Figure 2).

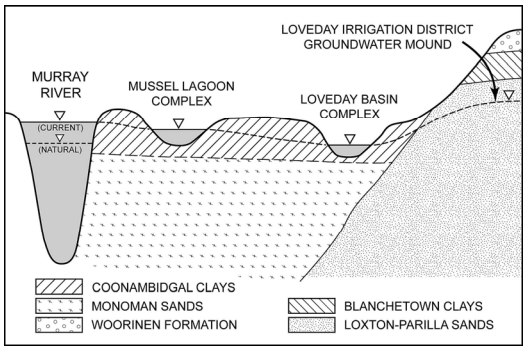

Figure 2: Conceptual representation of the Loveday Disposal Basin hydrological system. Because of raised river levels caused by a nearby weir and the presence of a groundwater mound inland, Loveday is currently a terminal basin.

Historical salinity trends

Loveday is still periodically inundated by larger floods. When these occur, salinity decreases to near freshwater conditions (Figure 3), but salinity tends to rise to pre-flooding levels within months after flooding. There are three processes hypothesised to drive the rapid return of high salinities in Loveday following flooding. Firstly, because the wetland is shallow (<1.5 m) and potential evaporation in the region high, evaporation would tend to rapidly concentrate salts once the basin becomes isolated from the river channel. Secondly, because groundwater is saline in the vicinity of Loveday, groundwater discharge could also contribute to raise salinities in the basin post-flooding. Thirdly, the dissolution of evaporite minerals (such as gypsum and halite) following flooding with freshwater could rapidly increase salinity levels. At present, the relative contribution of each of these processes to the salinity dynamics of Loveday is unknown.

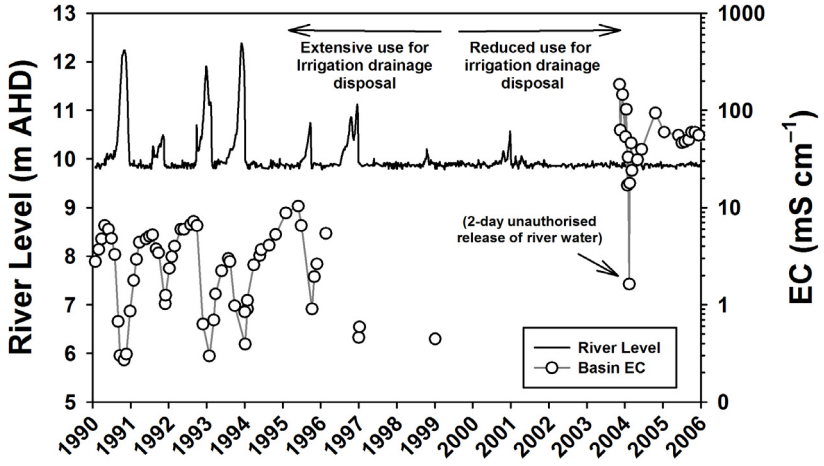

Figure 3: Electrical Conductivity (mS cm^{-1}) time series for Loveday North Basin. High salinities in Loveday are diluted by the input of River Murray water during floods (that is, when river levels is >10 m AHD). Salinity increased post-2000 because there was no large flooding events and the basin no longer received large volumes of brackish (average about 4.5 mS cm^{-1}) excess irrigation water.

Flooding experiment

Flooding was initiated by opening the Northern regulator on 26 May 2006 (for the North Basin) and the Redgate at the outlet from Mussel Lagoon two weeks later (for the South Basin). The northern regulator has a maximum capacity of 30.4 ML d^{-1} and the flow rate for the Southern Basin is about 51.8 ML d^{-1}. Both basins

were filled to river pool level (9.81 m AHD) on 17 July 2006 and kept at full level by keeping the regulators open.

Monitoring program

Water quality changes in the Loveday Disposal Basin before and after flooding were monitored with a detailed monitoring program (see Lamontagne and Hicks 2006), however, only the results of laboratory and field EC measurements (standardised at 25°C) are presented here. The only modification to the sampling design presented in Lamontagne and Hicks (2006) is that from July 2006 onward, vertical EC and temperature profiles were collected from the North Basin using an inflatable rubber boat.

RESULTS

Changes in salinity following flooding

Prior to flooding, EC was variable across the basins but was generally in the hypersaline range (Figure 4). The southern end of the North Basin was partially disconnected from the deeper northern end at low water levels and tended to have higher salinities (Figure 4). The Southern Basin was frequently dry but was occasionally partially filled following rain events or unauthorised releases from the Mussel Lagoon regulator.

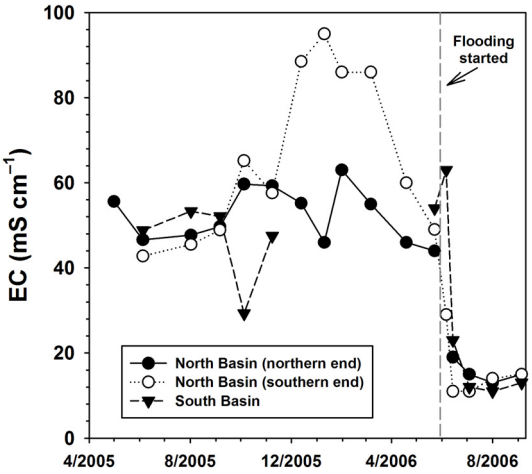

Figure 4: Laboratory EC measurements from Loveday North and South basins, 2005 – 06.

In the early stages of flooding, fresh river water inputs did not completely mix with the resident saline water in the North Basin (Figure 5). However, the depth of the mixed layer gradually deepened and by 1 August the water column was completely mixed. No density stratification was detected in the shallower South Basin. EC in the North and South basins decreased to 11 – 14 mS cm^{-1} in early August and increased slightly by early September (13 – 15 mS cm^{-1}).

DISCUSSION

Flooding of the Loveday Basin was successful in lowering salinity temporarily, but not to the levels required to enable the return of a freshwater aquatic community (Nielsen *et al*. 2003). However, the first goal of the flooding was to cover sediments with water to prevent the generation of foul odours. The SA Department of Water, Land and Biodiversity Conservation has been monitoring H_2S concentration in the nearby township of Cobdogla to assess whether flooding will be able to prevent the occasional "spikes" in H_2S concentrations that were detected prior to flooding. These spikes in H_2S concentrations corresponded to foul odour events described by local residents. However, it is suspected that a range of other S-bearing gases could also contribute to foul odour events (Hicks and Lamontagne 2006). The mechanisms generating the spikes in H_2S concentration when sediments are exposed are not clear at present (Hicks and Lamontagne 2006).

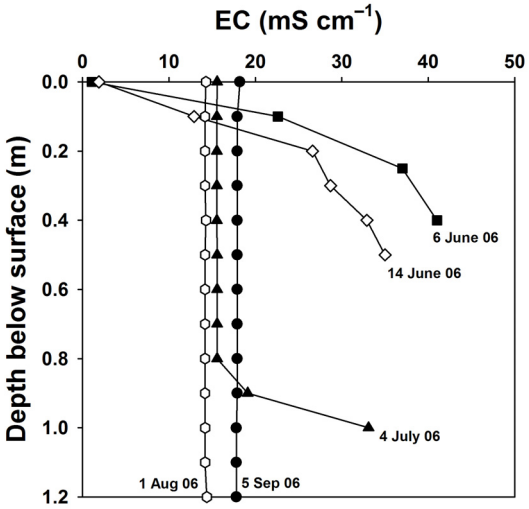

Figure 5: Electrical Conductivity profiles for Loveday North Basin following experimental flooding between May and September 2006.

The presence of a strong density stratification in the North Basin during the early phase of flooding has important implications for the monitoring of hydrological experiments in saline wetlands. The persistence of the density stratification over more than one month was unexpected due to the shallowness (~1.2 m) of the wetland. The experimental design for

monitoring flooding events in shallow saline wetlands should include the measurement of EC or salinity profiles and, when required, the use of sampling methods to collect integrated samples of the water column. Ongoing studies at Loveday will follow the response of salinity in both basins over time and evaluate the role of evaporation, groundwater discharge and evaporite dissolution in controlling the changes in salinity post-flooding.

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