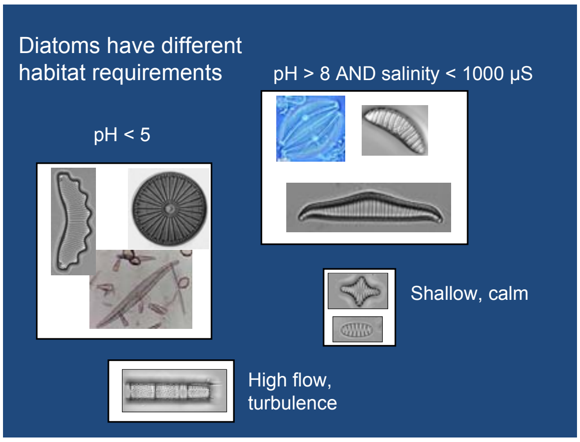
Part B - Workshop Outcomes 1: Ecological Community Description

Setting the Scene Presentations – Key Messages and Issues

The following presentations were provided by invited experts during the workshop to help set the scene for workshop discussions (hence they are current to mid 2009). Key messages and issues from these presentations are summarised below.

Palaeo-history of the Lower River Murray
Jennie Fluin, University of Adelaide

Palaeoecology is the study of aquatic sediments, including physical and chemical properties and the plant and animal remains, to inform about past environmental conditions. Each layer of sediment represents a different slice of time in history, ranging from last year to thousands of years ago (i.e. palaeo-data can provide 10,000 years of evidence for lower River Murray). In particular, diatoms (single-celled algae with a silica skeleton) are extremely abundant in aquatic environments and have excellent preservation, remaining intact for hundreds of millions of years. Diatoms have specialised habitat requirements and are very sensitive to environmental change, with particular species dominating in different environmental conditions.



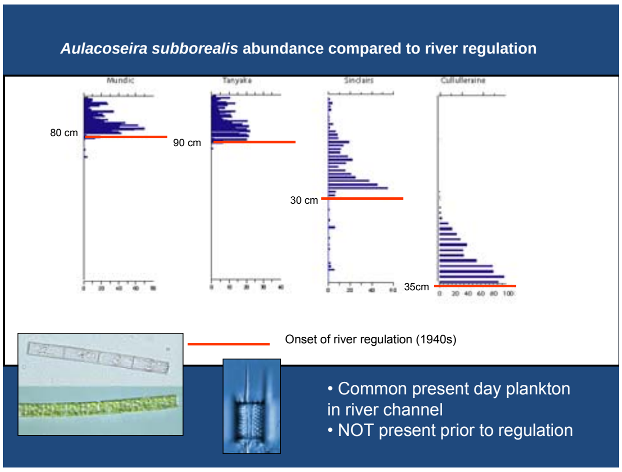
Different diatom types found in different aquatic conditions (Source: Jennie Fluin, University of Adelaide).

Wetlands are generally dominated by diatoms that reflect shallower, calmer conditions. By comparison, the chain diatoms need turbulence and are more abundant in the river channel.

Changes in palaeo-diatom fauna of the River Murray are linked to increased post-regulation sedimentation rates and turbidity. (Importantly, there is a high risk of some wetlands ceasing to exist due to siltation). Much of the sedimentation is coincident with land clearing. A change in species composition and dominance of the diatom fauna is evident post-regulation of the lower River Murray, with some species no longer present. Macrofossil records have also shown the riparian bulrush, *Typha* comes in when the river was regulated, but was not present in the previous 2500 years.

Diatom palaeo-records have shown a cyclical switching between dry and wet, with highly variable flows and 50 to 100 year cycles of high flow versus low flow (i.e. short term (decade) and long term (century) average flow patterns. There is an obvious relationship between palaeo-flow, palaeo-climate, and changes in aquatic vegetation with flow regime.

For the Lower Lakes, a 7000 year record indicated that less than 5 - 10 % of the diatom taxa in lake Alexandrina were marine and that the pH was always alkaline (i.e. no evidence of acidification in cores). For a site just behind the barrages near the mouth, estuarine taxa were consistent pre and post barrage. However, the palaeo-diatom fauna showed the presence of marine taxa prior to the barrage with none post-barrage, and an increase in non-marine sourced salinity in the past 30 years. Similarly, marine foraminifera are no longer present after the barrage was constructed, and periods of their absence prior to the barrage indicates periods of mouth closure. So prior to regulation, for most of the past 700 years, river flow rate was high enough to maintain an open river mouth (the exception is four discernible mouth closure events). There is a massive increase in sedimentation post barrage.

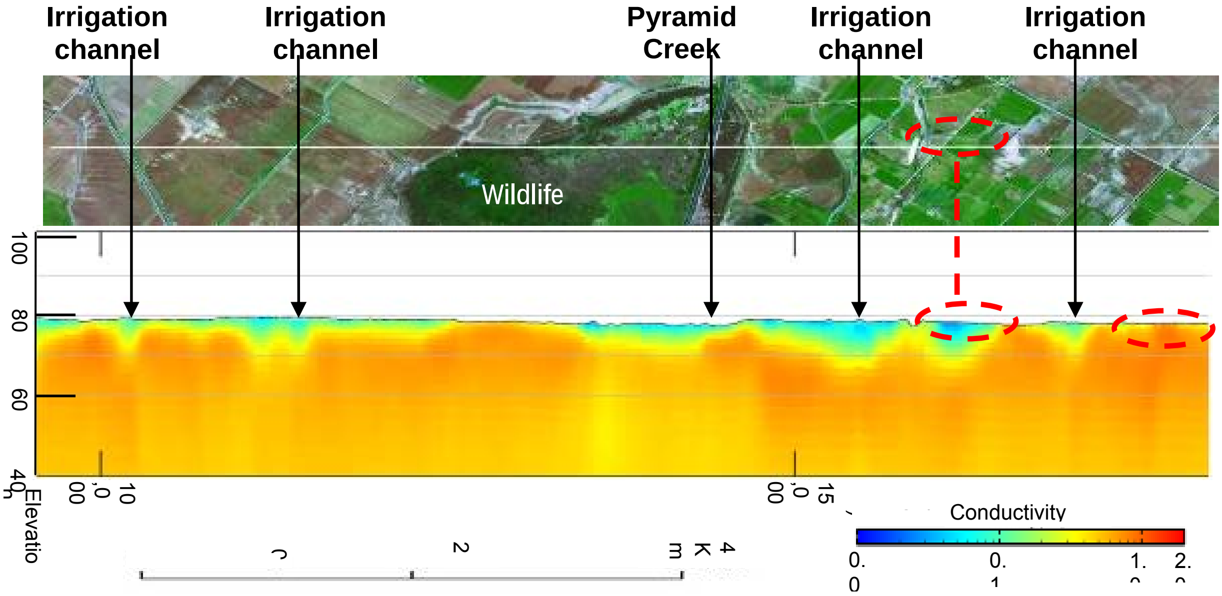


Present day plankton in the river channel, not present prior to regulation (1940s)(Source: Jennie Fluin, Uni. of Adelaide).

Groundwater Connections - Hydrogeology

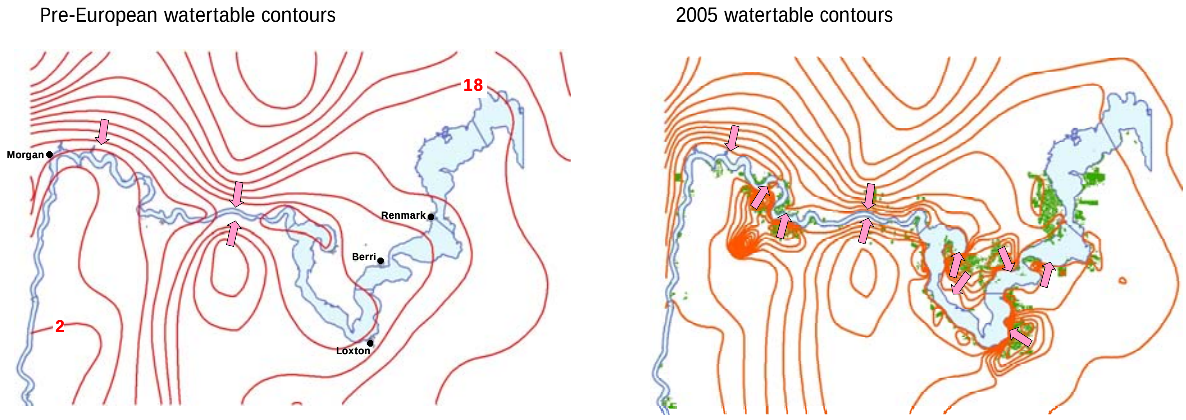
Jane Coram, Laura Gow (Geoscience Australia), Steve Barnett (Department of Water, Land and Biodiversity Conservation SA), Emily Slatter (Bureau of Rural Sciences)

Understanding groundwater processes is important to understanding and delineating groundwater-influenced ecosystems. For example, many wetland and other groundwater influenced ecosystems can be influenced by local out-seepage and/or regional groundwater flow processes (e.g. from 10 – 100 km away). In these instances, the hydrology of the aquifer and the health of the wetland ecosystem can be closely connected. This hydrology can be disrupted by both local and/or more widespread hydrological changes, such as by groundwater abstraction, or by reduced recharge to groundwater aquifers. Mapping of groundwater is currently underway using airborne electromagnetic surveys and remote sensing with field validation. In particular, the aerial electromagnetic surveys have shown leakage at depth from existing irrigation. The presence of flush zones (leakage from river) has implications for the ecosystems that overlay them. For example, there may be the potential for increased resilience to drought and extended dry weather for those ecosystems that overlay a flush zone, compared to those that do not and are fed by highly saline groundwater.

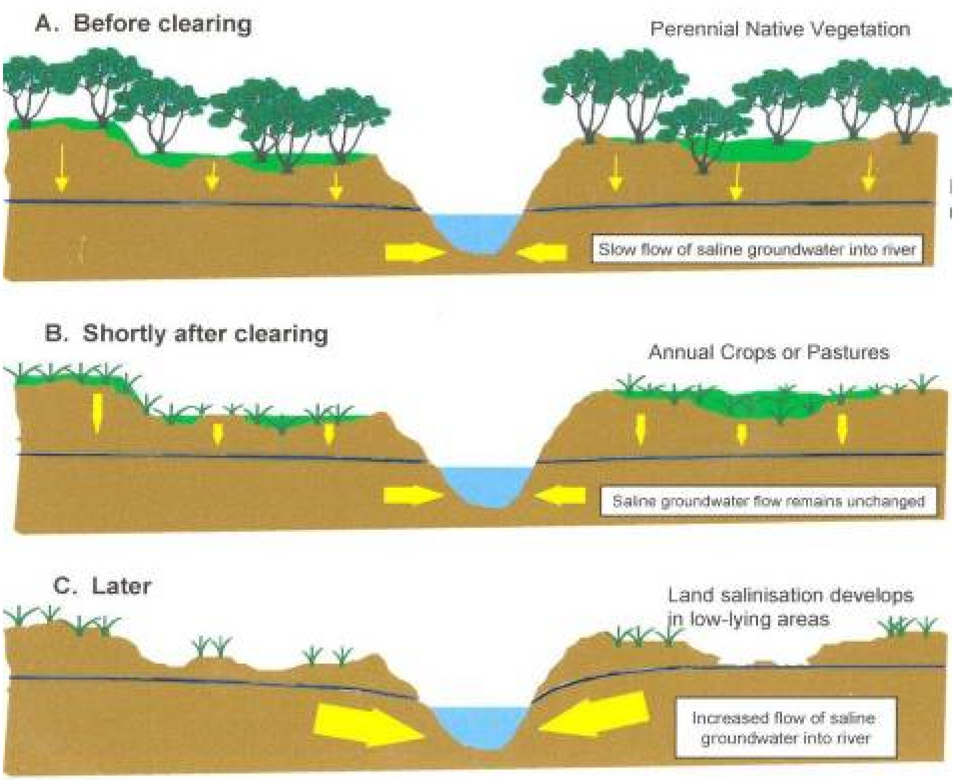


Leakage from existing irrigation in a section of the River Murray (Source: Emily Slatter, BRS).

Importantly, groundwater often connects the River Murray, wetlands and Lower Lakes with salt. The low floodplain of the downstream Murray acts as a drain for the regional aquifer systems of the entire Murray-Darling Basin, which contain mostly saline groundwater. Natural inflows of groundwater are enhanced by irrigation and land clearing. The clearing of deep-rooted native vegetation from the floodplain has led to an increase in recharge, with the watertable rising and increased discharge of groundwater to the river.



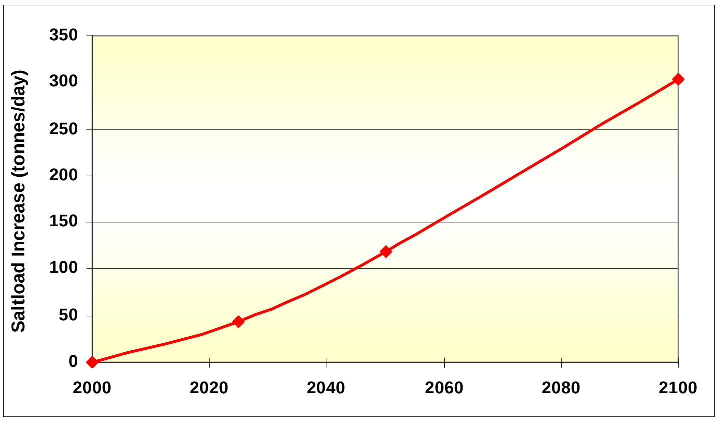
Postulated pre-European (and pre-regulation) watertable contours compared to a recent map from 2005 (i.e. post regulation); over the years irrigation development has led to mounds and enhanced discharge of saline groundwater (Source: Steve Barnett, DLWBC).



Influence of land clearing and removal of deep-rooted native vegetation on groundwater recharge and salinisation (Source: Steve Barnett, DWLBC – diagram by Peter Cook, CSIRO).

Groundwater contributes a considerable amount of salt to the system each year, and there is now a statewide salt interception scheme in South Australia.

During pre-regulation the river channel had a natural gradient. Now the depth of the watertable (i.e. groundwater level) increases as you go upstream to the next Lock – i.e. creating a stepped rise, rather than the previous gradual gradient that would have naturally fluctuated up and down with flow change seasonally and annually.

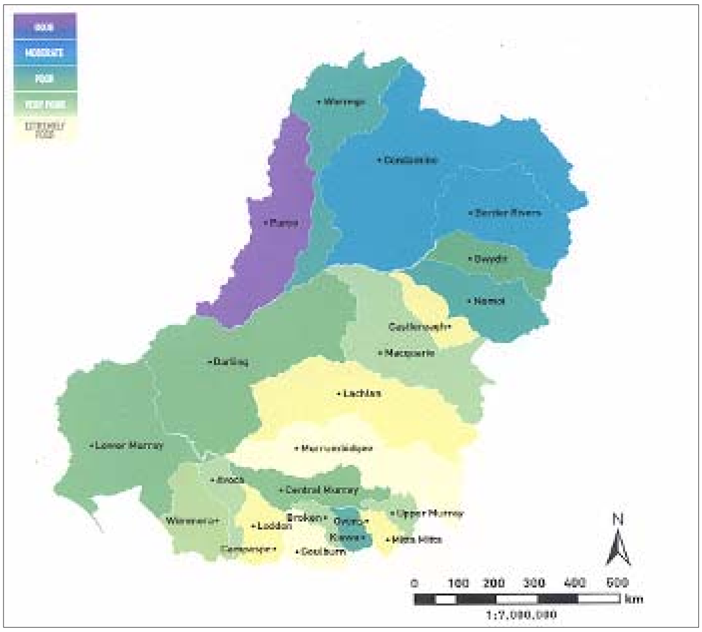


Salt interception bore and control, and projected increase in salt loads to river and floodplain due to land clearing (Source: Steve Barnett, DWLBC).

Sustainable Rivers Audit 2004 – 2007: How did the Lower Murray Valley fare?

Keith Walker (TSSC)

The sustainable rivers audit (SRA) of river ecosystem health surveyed 23 valleys within the Murray-Darling Basin. The first report covers the period 2004 to 2007. The Lower Murray Valley received an overall rating of 'poor'.



Rating	*Valley*	*Rank*
GOOD	***Paroo***	***1***
MODERATE	***Border Rivers, Condamine***	***2***
POOR	***Namoi, Ovens, Warrego*** ***Gwydir*** ***Darling, Lower Murray, Central Murray***	***3*** ***4*** ***5***
VERY POOR	***Upper Murray, Wimmera*** ***Avoca, Broken, Macquarie*** ***Campaspe, Castlereagh,*** ***Kiewa, Lachlan, Loddon, Mitta Mitta*** ***Murrumbidgee, Goulburn***	***6*** ***7*** ***8*** ***9***

Indicators grouped as 'themes' were used as the basis of this first assessment – they were: fish, macroinvertebrates, and hydrology. Future work will introduce physical form and vegetation indicator themes, and possibly waterbirds. For the purposes of this first audit, only the riverine channels were surveyed, not the floodplains. Also, the Lower Lakes and Coorong were not included.

For each indicator theme, the rating was 'poor'; an overview of the assessment follows:

- Fish: POOR
    - indicators - expectedness, nativeness, alien versus native species, biomass
    - 22 sites, including Mt Lofty Zone
    - 40% of expected species, 13 species absent (barrages)
    - dominated by carp and gambusia, (50% of the fish biomass is carp)

- Macroinvertebrates: POOR
  - indicators - expectedness, SIGNAL OE score, family richness
  - 33 sites, including Mt Lofty Zone
  - 15 common families, dominated by crustaceans and molluscs (not insects)
- Hydrology: POOR
  - flows highly modified by diversions
  - massive reductions in flow magnitudes
  - dominated by low flows (<5000 ML/d)
  - pronounced changes in interannual variability and seasonality (to a lesser extent).

Note, the work of this first report of the SRA is considered as ‘provisional – with the focus of future work to expand on indicator themes and incorporate the wider ecological community (for example the floodplain and Lower Lakes). However, this work does indicate things are not well.

Coorong and Lower Lakes – Status Report

Kerri Muller (Kerri Muller NRM)

The terminal systems of the River Murray are the Coorong and Lower Lakes – a region formed some 7000 years ago. It represents the homeland for the Ngarrindjeri people and is a source of spiritual renewal to the community (in the past it also represented a thriving economy). The region was nominated as a Ramsar site in 1985, and a Living Murray Icon Site in 2004. A comprehensive Ecological Character Description (ECD) was published in 2006, which defined ecosystem components, processes and services. In particular, the ECD defined and recorded 23 wetland types, and recorded 77 bird species, 7 endangered or vulnerable plant species, 49 fish species, and 10 frog species (including the EPBC Act vulnerable listed Murray cod and southern bell frog). The ECD is being considered for updating and limits of acceptable change are being investigated.

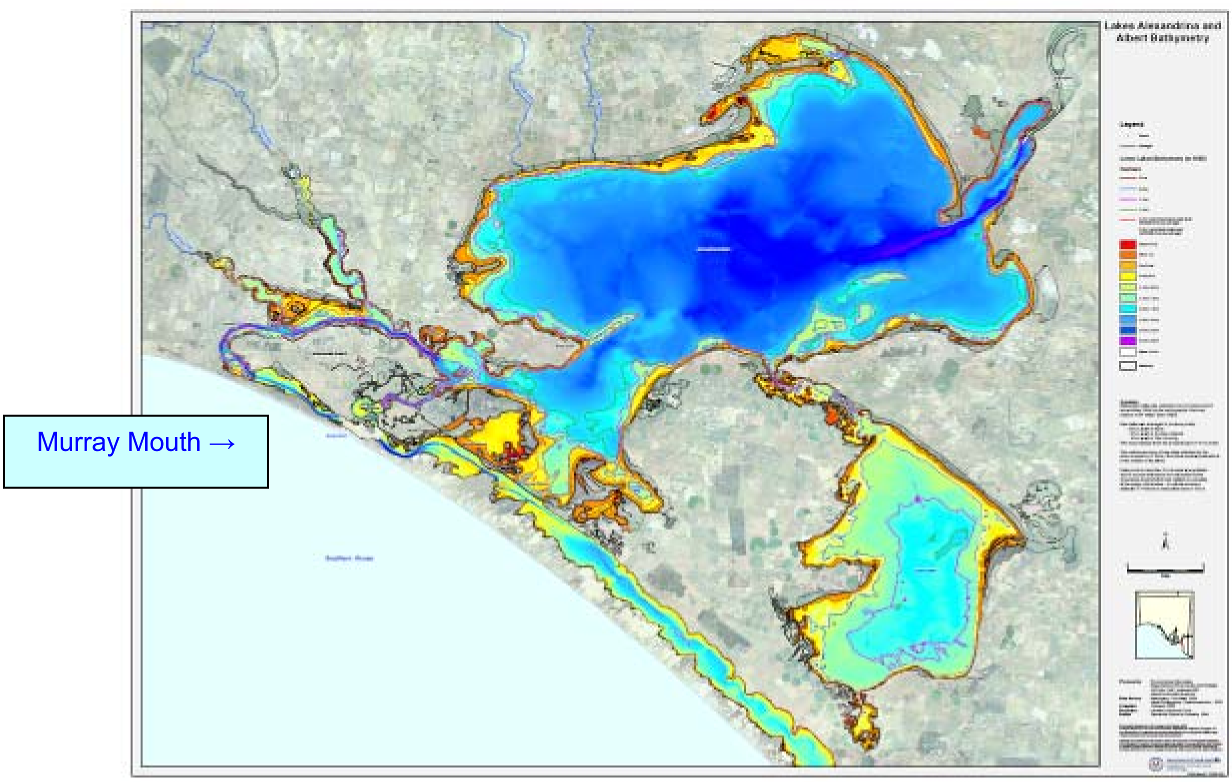


Image of Coorong and Lakes Alexandrina and Albert showing bathymetry contours (Source: Kerri Muller).

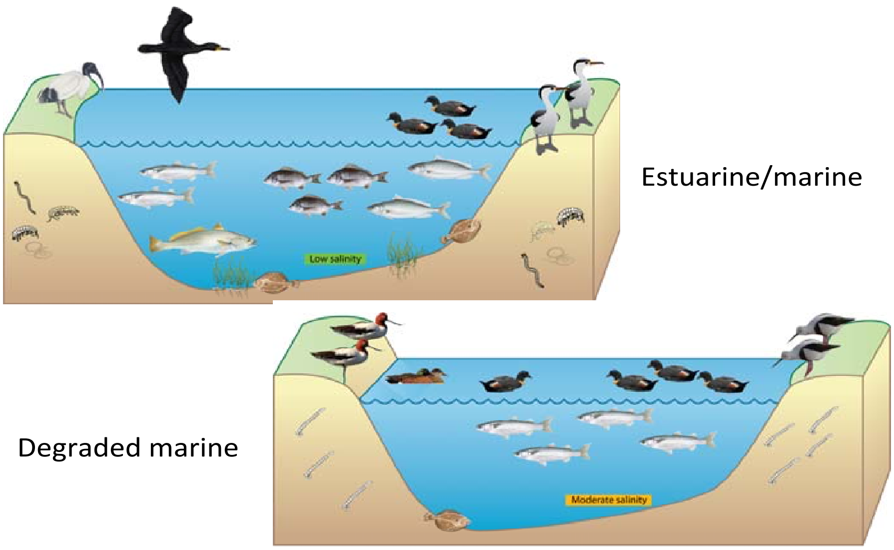
Importantly, waters of this system used to range from fresh to hypersaline - however, now they are saline to hypersaline. The lakes are extremely shallow and are therefore vulnerable. Over the past decade there has been severe degradation of the system. Lake levels are usually 0.8 to

0.6 m AHD which is controlled by Lock 1, with the barrages the only lever for discharge (Note, the barrages have been closed since 2006). Lake Albert was disconnected with bunds in March 2008. As of May 2009, the levels are at -1.0 m below sea level. There was abundant littoral vegetation prior to 2006, now submerged aquatic plants are highly restricted and most persist only in fringing wetlands. Thousands of hectares of acid sulfate soils have been exposed, with the concomitant risks of rewetting and remobilising heavy metals, and acidification and deoxygenation of waters. There has been significant loss of connectivity, habitat, and ecological character and services. Some of the tributaries are able to provide some refuge, as they still contain fresh non-acidic waters. The previous 'healthy' estuary of the Coorong is gone as are keystone plants – it is now effectively an aquatic desert. The next five years are considered critical to the potential recoverability of the region. Bioremediation works are currently underway. At this juncture, it is considered that re-filling the lakes with seawater is a risky option.

Modelling Current and Future Condition of the Coorong

Rebecca Lester and Peter Fairweather (Flinders University)

Recent conceptual modelling of current and future condition of the Coorong (by Flinders University) is exploring the effects of climate change under different management regimes. The aim is to develop an ecosystem response model (ERM) to predict future condition in the Coorong. The CSIRO Murray-Darling Basin 'Sustainable Yields' estimates are being used as a major input to this process, as well as the CSIRO Ecosystem State Model (by Ian Webster). A set of co-occurring biota (vegetation, fish, birds, macroinvertebrates) and environmental conditions are being used in the modelling process.



Some examples of ecosystem states from the Ecosystem Response Model (Source: Rebecca Lester, Flinders University).

Key messages from outcomes of 300 scenarios used in the modelling research to date are:

- Climate change has the potential to devastate the Coorong (salinities expected to rise to supersaturated levels)
    - at current extraction levels
- But relatively small amounts of water will mitigate the worst effects
    - e.g. The Living Murray & other similar initiatives
- Other interventions (e.g. engineering types) are less effective
    - but may be necessary before flows return
- In the absence of barrage flows
    - dredging (or similar) at Murray Mouth to keep it open is absolutely essential
    - SLSRS will have a big short-term impact (south lagoon salt reduction scheme)
        - Channel works + pumping best option for South Lagoon states

  - Additional south east water has a longer lasting impact than SLSRS
- But none replicate the effect of barrage flows.

In conclusion, there is no substitute for barrage flows. Climate change does not have to destroy the Coorong ecosystems – extraction levels play a much bigger role. Additional freshwater is urgently needed for the system – the River Murray should be the major source.

Current major research initiatives – Riverland and Chowilla

Tony Herbert (CSIRO)

Regarding managed and drought related events, weir manipulation (i.e. raising Lock 5 and 6) is an important component. Research assessments here include: biofilm succession, and changes in riparian vegetation, fish recruitment and river red gum condition.

Weir pool raising at Lock 5 - normally about 50 cm below this level (Source: Tony Herbert, CSIRO).

In the Riverland, the only way to get water into the wetland sites is currently through pumping. There have been some great benefits of this, including frog and wading bird recruitment. However, some wetlands are currently closed as a water saving measure.

There are some new initiatives occurring, using gravity around weirs to inundate the floodplain. Locks 5,6,7 and 8 are to use new structures on anabranches around weirs to back flood. At Chowilla, Lock 6, there is a proposal to construct new structures to allow several thousand hectares of inundation. There will be detailed assessments on over and understory vegetation responses, water quality changes, and faunal responses.

Managing for the needs of fish poses a particular challenge – how to provide for management needs for fish, especially those species that require fast flowing conditions. The effects of fishways in anabranches, etc. are being considered, as well as how fish move between habitats and recruit (most of this work is being done by SARDI).

Opportunities for research include the establishment of good baseline datasets and short term and long-term cumulative responses to operating new structures on the river. The Murray-Darling Basin Authority (MDBA) is running projects (e.g. 'Bundled Hypotheses') to answer key questions around managed flows and environmental events (e.g. retaining floodwater on floodplain, food web responses to flow enhancement, water bird responses, and effects on native trees).

The Coorong, Lower Lakes and Murray Mouth: Directions for a Healthy Future

Russell Seaman (Department of the Environment and Heritage, SA)

Prior to 2007, the lakes were full, and operation of the barrages to achieve ecological function was well understood. However, in 2007 we were introduced to a crisis – water level at the terminal end of the River Murray dropped below sea level due to reduced inflows, resulting in problems with acid sulfate soils (ASS) and increased salinity. This led to habitat collapse and lost connectivity within the system of the Lower Lakes. 2008 was a period of learning and increasing understanding of the new conditions and what to do about them. In 2009 we are into 'Emergency' management. The scale of the issue is immense and there have been over 20,000 hectares of sulfuric material in 2008/9. The Lakes, Coorong and River have a high risk from acid, aluminium and other heavy metals, and deoxygenation.

Currency Creek, 3rd April 2009 showing extensive drying and exposure of soils (Source: Russell Seaman, DEH SA).

There are four logical management scenarios:

- do nothing
- remediate
- introduce seawater
- provide freshwater.

The adaptive management approach taken by South Australia has to date focussed on remediation - specifically bioremediation of acid sulfate soils, and better understanding of re-wetting and transport of metals. Soil stabilisation against erosion is a primary objective to assist with managing the acid risk. A medium term (1-3 year) research goal is investigating how to re-establish the carbon cycle and wetland function, along with how to put humates back into the soil and how to buffer toxins.

Bioremediation promotes sulfate reducing bacteria in the system to convert dissolved sulfate to sulphide minerals while consuming the acid – however certain conditions are needed for this, such as saturation, iron, and organic matter to feed the bacteria. Addition of limestone and organic matter helps to buffer the acidity and keep the bacteria functioning.

An overview of the bioremediation option – promote or enhance natural bioremediation of acid sulfate soils follows:

1. Primary management options – maintain saturation of acid sulfate soils, e.g. increase river flows, install regulators, control evaporation;

2. Secondary management options – add limestone, organic matter (revegetation) and/or iron to water bodies and exposed sediments (to allow bacteria to function at depth).

Progression of acid sulfate soils in Lower Lakes (Source: Russell Seaman, DEH SA).

Crop cover trials are currently underway, and a rehabilitation program for lake riparian vegetation, to prepare the edges for refilling at a later time.

The adaptive management cycle is being informed by conceptual modelling to assist with research design and management actions.

Air tractors are being used for seeding and limestone dosing – as of mid 2009, getting good results and germination (Source: Russell Seaman, DEH SA).

Key Findings and Issues for Further Exploration

Detailed results are provided for each focus sub-system in a 'key outcomes matrix' in the following section, along with some suggested workshop insights and guiding principles. A number of key findings were apparent that related to benchmarking the ecological community, its boundaries, its coverage and main features, and conservation goals. These are detailed below. The workshop expert group discussions also led to a number of questions or issues to be explored further. These, detailed below, related specifically to the benchmark state, boundaries and zone of influence, condition thresholds, biota loss, and how islands fit in.

Benchmark State

- For the purposes of the assessment process for this EC, a *benchmark state* will be used as the reference condition against which future evaluative comparison can be made. The benchmark state should reflect as closely and practically as possible, the natural condition of the community with respect to the composition and arrangement of its abiotic and biotic elements and the processes that sustain them. Suggestions for a benchmark state for the EC included pre-European condition (early 1800s, including hydric soil mapping), pre-regulation condition (early 1900s), and pre-drought good flow conditions, for example, the 1970s wet decade prior to the major shift in the system. This latter option was considered as the most appropriate and practicable. [Note: the benchmark state should not necessarily be equated as a target for management].

- The workshop accepted that this EC is a regulated, 'created' or 'constructed' system and is therefore altered from its original, more natural condition. The weirs have been in place a long time (i.e. 72 - 87 years). Now there is a series of stepped pools formed by the weirs rather than a natural gradient through the river. Therefore using pre-European or pre-regulation condition as a benchmark state is less meaningful.

- An equitable balance between water resource use and environmental sustainability may be a useful concept for determining a 'reference condition' (i.e. benchmark state).

Boundaries

- A majority view of the workshop was that the 1956 flood line provides the best overall boundary for the system - biologically, hydrologically and geomorphologically. It is being widely used in South Australia, is legally defensible, and has been well mapped. It has also been used in the Ramsar definition for the Lower Lakes. However, the Eastern Mt Lofty Ranges watershed (which flows to the lower Murray and Lake Alexandrina) is excluded by the 1956 flood line and should be considered for inclusion within the EC.

- The Darling River junction was considered a good upper limit for the EC - with importance from both habitat and cultural perspectives (e.g. Ngarrindjeri creation story). The upper boundary of influence of the weirs was also suggested as an upper limit, although there was less support for an artificial structure as a boundary.

- Overall the workshop highlighted up to six bio-geographical sub-sections within the EC region that have 'strong' ecological identities:

    - *Coorong* – estuarine to hyper-marine, includes river mouth, 'end of system' marker of condition
    - *Lower Lakes* – lake system with marginal wetlands and adjacent ephemeral saline ponds, regional groundwater input, plants different
    - *Eastern Mt Lofty Ranges Watershed* - Swampland section - Wellington to Mannum - abundance of exotics, lack of natural floodplain, strong diadromous influence of fish; Eastern Mt Lofty tributaries are Marne River, Saunders Creek, Reedy Creek, Bremer River, Angas River, Finniss River, Tookayerta Creek, and Currency Creek. All but Marne, Saunders and Reedy feed into Lake Alexandrina.

- o *Lower Swamps section* - reach between Mannum and Wellington; dominated by exotic plant species (e.g. willow, agricultural weeds) and has very little natural floodplain due to conversion to dairy swamps; (Reedy Ck flows into this section)
- o *Gorge section* - Mannum to Overland Corner - valley and gorge plants and fish similar, but birds different, permanent large wetlands due to regulation; Marne and Saunders flow into this section of the Murray
- o *Top Valley section* - junction of the Murray and Darling rivers (Wentworth, also Lock 10) to the beginning of the gorge at the Overland Corner (Lock 3), floodplains, lakes, anabranch systems, river losing water to groundwater.

What's In, What's Out

- The channel is considered the key to the system's ecological functioning and the major driver of biodiversity for the whole ecosystem.

- A 'zone of influence' concept was considered most critical for the groundwater element of the EC. For the riverine element, it was considered the main focus should be on the assets and areas of conservation value, not necessarily all areas of influence. *[But consider next point].*

- Tributaries and anabranches, are seen as critical 'refugia' for flora and fauna in the system, and an important source of recruitment of biota and inputs to bio-geochemical pathways - with two-way exchange occurring between them and the river channel.

  - o In particular, the Darling Anabranch, if in good condition may be a potential refuge habitat for biota of the EC (especially Murray cod) and also has cultural significance.

  - o Similarly, the Eastern Mt Lofty streams are considered significant for refugia and exchange; important for connectivity to local rainfall, and refugia for biota.

- Priority for the EC should be given to healthy and potentially recoverable areas - i.e. not unrecoverable areas. However, experts consider that the majority of the system is recoverable, with the exception of a few highly salinised wetlands and the loss of very old trees, e.g. river red gum, black box - which provide complex habitat and take over 100 years to replace the same level of complexity.

Key Characteristics of the RM-DS EC

There was strong support from the expert community that the River Murray-Darling to Sea is a unique 'environmental unit' that is different from its parent rivers, the Darling and the remainder of the Murray, and therefore warranting of ecological community status in a national context. The following points were raised to this effect regarding the River Murray-Darling to Sea EC:

- the EC extends over 830 river-km from Wentworth NSW to Goolwa SA; it is formed by two dissimilar rivers—the Darling from the north and the Murray from the east—and its ecological character combines features of both
- the hydrology of the RM-DS is influenced more by the Murray than the Darling, and is unaffected by other tributaries (although, the high turbidity of Darling water, due to suspended clays, may also be a feature of the RM-DS, depending on the relative contributions of the parent rivers)
- the flow regime of the RM-DS, hence overbank flows and hydraulic connectivity, are highly modified by 10 weirs on the channel, about 200 km of riverbank levees, numerous offstream wetland regulators and by three temporary weirs (The Narrows, Clayton Bay, Currency Creek) and five barrages on Lake Alexandrina
- deep limestone strata and saline groundwater (and marine fossils in the river cliffs) reflect repeated marine incursions over the last 20 million years
- the regional geomorphology is highly diverse, including four tracts:
  - o Floodplain tract (Wentworth to Overland Corner), with the river meandering westward over a 10-20 km wide floodplain, with extensive wetlands and woodlands

    - Gorge tract (to Mannum), where the river's course is realigned southward and the floodplain is constrained to 4-5 km, within a 30-m deep limestone gorge
    - Swampland tract (to Wellington), with the river flowing through areas that formerly had extensive riparian swamps, now reclaimed for agriculture and protected by levees, and
    - Lakes tract, including the Coorong, Lakes Alexandrina and Albert, and the Murray Mouth
- the geomorphic diversity is reflected in diverse aquatic and terrestrial habitats, and correspondingly high levels of biodiversity
- the RM-DS has a mixed assemblage of zooplankton derived from the Darling, which has a typical lotic assemblage (potamoplankton) dominated by rotifers, and the Murray, which has a lentic assemblage dominated by micro-crustaceans typical of impoundments and wetlands
- the fish fauna shows a strong marine/estuarine influence, owing to the region's proximity to the river mouth. About half of all fish species recorded from the Murray-Darling Basin occur in this region
- regional threats include salinisation of soil and water, extensive areas of acid sulfate soils, severe declines of floodplain trees, changed flows, and sediment accumulation at the river mouth
- the RM-DS EC includes three Ramsar-listed *Wetlands of International Importance*, namely: Riverland (Chowilla-Lindsay-Walpolla); Banrock Station; and the Coorong, Lower Lakes and Murray Mouth
- the Coorong, in particular, is a coastal lagoon dependent on flows from the Murray, but with a strong marine influence; it has a distinctive flora and fauna, and is globally significant as a habitat for migratory waterbirds
- the RM-DS has a distinctive indigenous culture represented mainly by Ngarrindjeri people.

Key Features

- ***Flow*** is the critical feature of the EC system (i.e. the master variable or 'maestro'), sustaining all natural physical and biological processes. Flows provide freshwater, and perform flushing, dilution, and transportation functions. Flow acts to keep the river mouth open. An adequate flow regime is needed (based on volume, frequency and timing) to ensure over-bank flow and wetting/drying requirements of wetlands and the floodplain. Flow enables connectivity.

- ***Hydrological Connectivity*** is central for maintaining a healthy, functioning ecosystem (ecological community) - connectivity is driven by hydrology (i.e. flow). There are three main dimensions for operational connectivity: vertically (i.e. groundwater with surface water), longitudinally (i.e. along river to sea; freshwater to marine), and laterally (i.e. out across banks, wetlands and the floodplain; terrestrial to aquatic). The temporal dimension is also important. Two-way flows are a particularly important aspect of lateral and vertical connectivity.

- ***Salinity*** is a key variable for the system, particularly the lower reaches (Coorong and Lower Lakes) where it controls biological sub-communities and therefore productivity. The system needs a more 'natural' salinity gradient than is currently present.

- ***Temporal variability*** is a key characteristic of the EC's 'natural' ecosystem. However the degree of ecological requirement for temporal variability will differ for the different components (sub-systems) of the EC. Regulation reduces temporal variability and leads to a dominance of spatial variability.

- ***Distinctiveness*** The Lower Murray is ecologically different from its parent rivers, and is a distinctive 'environmental unit' for research and management. The distinctive nature of the region is reflected by the high degree of physical habitat diversity (and see above Key Characteristics). This high level of habitat heterogeneity (or patchiness) in turn reflects high biodiversity, with key unique elements occurring over relatively short distances.

- ***Iconic.*** The region of the EC is a 'one of a kind' system in the national context and different from other river systems due to its complex features, habitat heterogeneity, and high levels of biodiversity over relatively short distances. The River Murray holds an important place in the national 'psyche'. The region of the EC has great significance for the Ngarrindjeri people as it is part of their traditional home and an integral part of their creation story.

Conservation Aspects & Goals for the RM-DS EC

- Maintenance and increased resilience should be the guiding principle for conservation of the EC (i.e. not just biodiversity conservation).

- The optimal EC should include a healthy terminal lake system, with an estuarine component connected to the sea. Characteristics of a healthy ecological community include trophic and habitat complexity, with no loss of key native species and presence of comparatively few alien species.

- Achieving enduring connectivity and temporal variability should be major conservation goals for the EC. A useful indicator may relate to the role of the river to keep the mouth open. Broad-scale connectivity should be the goal, i.e. rather than managing wetlands etc. in isolation.

- Issues were raised regarding the future availability of water for the system and it was agreed the aim should be to hold onto as much ecological character as possible until the water comes. A top priority is the allocation of water to the environment.

- Regulation could be used to benefit certain aspects (e.g. wetland or floodplain refugia) - although rates of change are important when releasing water. However, overall, engineered stability of water levels is causing ecological stability, which in turn favours alien species. Most native species of plants and animals rely on variability of conditions to cue for reproduction and dispersal. Engineering has increased stability of seasonal and inter-annual water levels (although daily levels may be more variable) and this has discouraged native species and favoured non-natives.

- Achieving wetting & drying cycles at an appropriate temporal and spatial scale is a significant goal to maintain ecosystem function of wetlands and floodplains.

- Rather than having an EC with a fixed 'good condition' it was recognised that there are range of acceptable 'states' for each sub-ecosystem type - i.e. there are various states of the essential character of the system.

- Native flora and fauna should be promoted above other species.

- There is a need to consider cultural flows and indigenous interests and these should be considered alongside environmental flows for future planning.

Issues for Further Exploration and Decision

Benchmark State

- Need to determine what the benchmark state is for restoration and maintenance of ecological function for the EC given the step change in rainfall from climate change that has already occurred, likely future climate change related impacts, and other threats or risks such as water allocations, land clearing, salinity, ASS, and invasive species. How much change is acceptable?

- The main objective needs to be identified and articulated for the listing of this EC. Examples raised were:

    - to maintain the full diversity and variability of the systems that are currently there *[but much of this is severely degraded]*
    - to reclaim the 'original' flow regime to support the ecosystems that are currently there *[which implies restoration to degraded aspects]*

- o to attempt to adapt the systems to a new state based on a 'likely' future *[this approach has a lot of uncertainty, but aligns with the concept of increasing resilience]*.

The aim should be to turn the system towards a more sustainable one than we have at present.

Boundary and Zone of Influence

- There is a need to determine and clearly map the boundary for the EC based on the foundation of the 1956 flood line, including quantifying any 'buffer zone' or 'zone of influence' distances (in m or km).

- There needs to be clarity regarding the distance out from the river channel for aspects such as groundwater influence and the inclusion of anabranches, creeks and streams. For example, it was suggested that for groundwater, the radius could be 15 km. *[But this seems rather large and may not be practical].*

- If the 1956 flood line is used, it may be necessary to consider the 'less clear' aspects of the line around tributaries, and the top (Lake Victoria to Wentworth) and bottom (Wellington) ends of system.

- A clearly defined, 'hydrologically' based cut-off point would be needed if the Darling Anabranch were to be included in the EC. [*Note, subsequent to the workshop it was determined that the Darling Anabranch would not be in scope*].

Condition Thresholds

- Only qualitative aspects of 'condition thresholds' were addressed by the workshop.

- Condition thresholds should be set low to allow for natural variability and varying levels of disturbance.

- There are non-biotic and biotic condition thresholds to consider for this EC.

- To achieve more detailed and focussed attention on this aspect, it is recommended that a small technical workshop be held as a follow-up. Attention should also be given to articulating 'tipping points' of irreversible change.

Biota Loss

- There is a need to determine, quantitatively if possible, the degree of loss to date for key species or sub-assemblages in the EC.

Islands

- Islands are an important connectivity feature for the system (terrestrial to aquatic) and they are/were biological hotspots. There is a need to determine if and/or how islands are incorporated within the region of the EC. [*Note, subsequent to the workshop it was determined that islands are within the scope of the RM-DS EC, as they are included within related Ramsar listings*].

River Murray mouth (Source: Keith Walker).

Groundwater and the RM-DS EC

The following statements and summary matrix provide a synthesis of key outcomes from the groundwater sub-system focus group discussions and ensuing workshop plenary deliberations.

Workshop Insights and Guiding Principles

There are three types of groundwater influences in the system - local, regional and subsurface stygofauna. There are also ‘losing’ and ‘gaining’ sections of the system with respect to groundwater.

Groundwater needs to be managed in conjunction with surface water (i.e. they are not two separate systems) and can be an asset or a threat (i.e. if highly salinated).

While the current aim is to maintain a mosaic of different salinity groundwater influenced ecosystems, there is recognition that hydrological systems are now altered due to river regulation (which is unlikely to be changed), thus restoration of pre-European hydrology and ecosystems is unlikely to be a feasible option.

The aim of restoration and management should be to protect what is healthy, recover what can be recovered, and don’t invest in areas that can’t be recovered.

There is a need to understand if we are dealing with regional groundwater processes or local groundwater processes. For a local system, you can use recharge management through vegetation as a way of reducing recharge and movement of salt. But for regional groundwater flow systems, which fill up hundreds of kilometres away, revegetation of such large areas is a less practical option.

Observed features in Coorong (February 2008) giving evidence for past and current groundwater discharge in the South Lagoon. (a) carbonate tube 'tufa' at Policeman Point; (b) stranded pools at Stony Well; (c) active seep showing disturbed sediment south of Parnka Point (Source Geoscience Australia: http://www.ga.gov.au/ausgeonews/ausgeonews200809/groundwater.jsp).

Aspect	Groundwater - Key Outcomes
Major Features	• 3 groundwater dependent/influenced ecosystem types were identified: o local groundwater system river-fed floodplain communities (driven by small-scale groundwater dynamics and ebb/flow discharge from the river, and regional groundwater inputs) - occur all along the lower River Murray, including Darling Anabranch fed by Darling groundwater systems) o regional discharge fed systems at the end of the River Murray flood plain - the Lower Lakes o subsurface stygofaunal communities (i.e. which exist in the groundwater system but not yet documented for the Lower Murray)
Boundaries	• 1956 flood-line considered a pragmatic delineation of the limits of the RM-DS ecological community zone - i.e. mapped, legally defensible, has accord with other management planning approaches • however, this excludes ecosystems/communities fed by groundwater from the Eastern Lofty Ranges, as this is outside the lower Murray floodplain • incorporate a 'zone of influence' concept - i.e. where actions on groundwater have a measurable influence on the ecosystems - up to15 km from 1956 flood-line suggested (includes irrigation district and is basis of a current groundwater model) – this would vary along the system • from a groundwater perspective, there were a few uncertainties regarding boundary between Lake Victoria and the Darling River at top end of system, and the boundary below Wellington, and around the Lower Lakes
Connectivity	• groundwater is integrally connected across local and regional aquifers (laterally and horizontally) • processes of groundwater connectivity well understood for lower Murray (Coonambidgal & Monoman Formations, overlying Blanchetown Clay & Parilla Sands) • main issues for ensuring connectivity are: o river flows and floods, including volume and timing of flows o maintaining beneficial groundwater inputs to ecosystems while preventing detrimental inputs o maintaining groundwater recharge where it supports groundwater influenced ecosystems o extracting groundwater where its discharge would be detrimental to groundwater influenced ecosystems (e.g. salt interception schemes)
Condition Thresholds	• some unrecoverable condition issues are: o accumulation of salts in unflushable zones where flooding cannot move salts - e.g. up-gradient of locks where there are low permeability soils o river regulation where there is little opportunity to alter regulation while weir remains in place • most condition issues are recoverable: o acid sulfate soils can be managed (but not where there are areas with no buffering capacity) - maintain wetting to avoid further acidification o saline groundwater discharge into ecosystems - salt interception schemes can manage (providing knowledge of location; mapping from airborne electromagnetic sensing can help) o high water tables and waterlogging in association with weirs - manipulate weir pool heights to influence river height and dynamics (e.g. timing) • measurable condition indicators include: o vegetation health indicators (e.g. seed production) o remote sensing of vegetation health and groundwater dynamics o salinity and acidity of soil and water o stygofauna monitoring

<table>
<tr><th>Aspect</th><th>Groundwater - Key Outcomes (continued)</th></tr>
<tr><td>Restoration/ Management</td><td>

identification of recoverable areas is a priority and aim to protect what is healthy
manage groundwater and surface water in conjunction with one another
for recoverable and healthy areas, potential management strategies include:

controlling groundwater inflows where they are damaging to ecosystems
introducing fresh water to systems through bank recharge and allowing surface inundation
regulate freshwater pumping and diversion
planning and managing wetting and drying cycles conjunctively to mimic natural flood regimes
regarding clearing-induced increase in salt loads - revegetation schemes for salinity reduction benefit, may be OK for local groundwater systems, but not economic or timely for regional groundwater

different management zones have different issues and require different management strategies

</td></tr>
<tr><td>Variation from 4 map divisions presented at workshop (i.e.

i) Mouth to Tailem Bend (essentially Coorong & Lower Lakes)

ii) Tailem Bend to Lock 1 (Blanchetown) – (essentially river channel and gorge)

iii) Lock 1 to Lock 5 (Paringa) – (essentially river channel bend & wetlands)

iv) Lock 5 to Darling junction (flood plains)</td><td>

5 sections suggested:

1) Top of system, the plains downstream of Darling River junction, including the anabranch systems, down to Lake Victoria - river losing water to the groundwater system or has no interaction with the regional groundwater system; Anabranches and flowing creeks add to environmental diversity; an environmentally diverse area, deserving of separate treatment
2) Valley zone - downstream of Lake Victoria to Lock 3, a broad valley system with anabranches and flowing creeks adding to diversity; river increasingly gaining from the groundwater system, so saline discharge into the river and floodplain assets badly impacted by salinisation; groundwater influenced ecosystems become increasingly important; this is the zone where engineered management options like salt interception schemes become important
3) Gorge zone - of large wetlands which under current river management have become permanent - At gorge zone from Lock 3 down to Mannum; important management includes wetting and drying strategies - however these can lead to acid sulfate soils, and need to manage for that as well
4) Lower Lake zone where the river's held artificially high by the barrage and discharging into adjacent areas - main management issues are maintaining the water in the system, drying of Lake Albert, and acid sulfate soils. High value saline ecosystems in ephemeral saline ponds bordering lakes
5) Coorong a separate system due to connection with ocean (Murray Mouth), as well as input from regional groundwater flow (from south or southeast) and surface water flow (contributions of each unclear)

</td></tr>
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Rivers and Tributaries and the RM-DS EC

The following statements and summary matrix provide a synthesis of key outcomes from the rivers and tributaries sub-system focus group discussions and ensuing workshop plenary deliberations.

Workshop Insights and Guiding Principles

For conservation benefit of the ecological community, the focus should be on the assets and the *area* of conservation.

Connectivity is a central concept for this system - longitudinally, laterally, and vertically with groundwater.

The Lower Murray has limited tributaries - main inflows to the Lower Murray would be the Darling Anabranch (variable) and Marne; flowing into Lake Alexandrina are the streams Angas and Bremer, and the Currency Finniss systems.

Patches in Mt Lofty have been EPBC Act listed - a lot to be learnt from that catchment.

Optimal EC includes - terminal freshwater lakes on Australia's largest river system with an estuary that is connected to the sea, with healthy, productive channels and floodplains.

A central process to maintain ecosystem integrity, is the two-way process of the exporting of resources out of the river channel and the importing of resources back in.

There is a need to determine a 'benchmark state' (reference condition) for the system. What state should condition be judged from in order to determine improvement or decay of condition?

History of management has created the current ecosystem and future management must take this into account.

Can the water be supplied to maintain the ecosystem that we want to persist and list? We should aim to hold onto ecological character as much as possible until the water comes.

Cliffs in Gorge Section (Photo: SA MDB NRM Board)

Aspect	Rivers and Tributaries - Key Outcomes
Major Features	• 3 major components: o 1) Lowland River (from Darling down) characterised by: • salt intrusion; well defined floodplain; low relief; well defined gorge system; limited tributaries (Mt Lofty Ranges - provides freshwater refuge) [defined wetland channel system] o 2) Lower Lakes (terminal lake system) o 3) Coorong (was only estuary in Murray-Darling Basin) • tectonic control of system's course o low relief and no delta o abrupt change in course direction (north/south fault controlled) o key connection with groundwater • channel is a major driver of biodiversity in whole system • biogeochemistry of whole system really important • a fast flowing Darling Anabranch may be best place for fish like Murray cod
Boundaries	• prepared to accept Darling Junction (confluence) as the upper limit of EC • but, recognise for management, a more logical boundary would be the start of the ponding system at the cascades at Mildura - i.e. Lock 11 • Darling Anabranch - importance as habitat, also importance culturally to Ngarrindjeri people (beginning of their creation story), e.g. swan breeding • tributaries should be included, including Eastern Mt Lofty streams (but how far up do you go?) - enhances connectivity • lower limit should extent to the sea (noting, near shore coastal environments supported by river exports of nutrients, lower islands etc.) • note: external influences outside these boundaries are important for management; traditional owners had diffuse boundaries • some question of 1956 flood line around tributaries - as these will supply major conservation benefit (i.e. refugia) • possible boundary for Darling Anabranch - influence of lock 9 weir pool between Oakbank and Worry's Dam
Connectivity	• groundwater to river connectivity (changed balance): o major shallow tables, saline, salt loads into river - a 'gaining' system (but not upstream of lock) o lateral recharge important for wetlands and floodplain vegetation • longitudinal connectivity (critically important): o flooding of surface water down channel o movement of fish (+ spawning) and other species • lateral connectivity: o 2-way process - flooding of surface water into billabongs, wetlands, etc and providing resources to channel when water returns (i.e. exporting out and importing back in nutrients, organisms, etc); o connectivity of tributaries to river - independent of river level? o floodplains and wetlands are threatened if not connected to channel • connectivity with the sea - was the role of the river to keep the mouth open (i.e. sea entry critical for 'freshening' the hypersaline Coorong system; drainage has diverted freshwater from the southern Coorong) • terrestrial/aquatic connectivity - mixing around islands - islands were biological hot spots, e.g. Hindmarsh Island • disconnection - barrages and locks lead to disconnection - we now have a series of stepped pools rather than a natural gradient through the river system; alternatively, weirs give some connectivity in some pockets during low flows (usually lateral rather than longitudinal) • rates of change during wetting and drying are important • biogeochemical cycles have been disrupted • connectivity to rainfall (evaporation; Mt Lofty Ranges) • connectivity to riparian vegetation - e.g. lignum (suffering); river red gums and groundwater connection through root zones (most within 50 m of river)

<table>
<tr><th>Aspect</th><th>Rivers and Tributaries - Key Outcomes (continued)</th></tr>
<tr><td>Condition Thresholds</td><td>flow the critical factor - optimum flow will maintain all natural processes - supplies freshwater and a ‘flow regime’ (<35,000 ML/day - no overbank)
threshold is a sufficient flow to keep the mouth open (i.e. the sea connection) - ‘end-of-system marker’ for condition of Murray
elevated floodplains means that large floods and pattern is important
salinity is a ‘master’ variable in lower reaches (we want a more natural salinity gradient in the Coorong and Lower Lakes - controls biological community); when tip over 30 to up to 240 ppt at top (need marine on outside, truly estuarine 10 - 15, then up to 100 ppt in the South Lagoon of the Coorong - but hard to manage)
temporal and spatial variability important (differs for different components)
thresholds set low to acknowledge natural variability and disturbance level</td></tr>
<tr><td>Restoration/ Management</td><td>A) top priority is the allocation of water to the environment (avoid ‘irrigation ditch to terminal lake’ syndrome) - but with time community will may erode
recognise there is limited water but limited water has been shown to give a good response in floodplains and Coorong
water could solve problems in the channelised part of this EC
B) pumping and engineering works - could be used to help maintain refugia, but not the best or a long-term solution
engineered stability of water levels is causing instability in ecology
manipulation of inundation - if had natural flows, weirs are a barrier for fish, but in low flow they do give scope to regulate - manipulate wetting-drying cycle for refuge areas - but need to slowly wet and flush (i.e. problems with re-wetting parched acid sulfate soils)
rates of change very important - how to release water
don’t yet know what flows will get once the Basin Plan is in place, and allocations for people and environment set, and given the step change in rainfall from climate change
has management created the current ecosystem?
C) what is the benchmark for restoration? - 1920s barrage in; 1956 big flood; 1970s wet decade; 1985 RAMSAR listing…
a Ramsar survey done in 1985 found 23 wetland types
natural flow paradigm - if cannot go back to a ‘natural’ state - then what is the benchmark to judge condition? What can we get for current conditions of climate, water allocation, land clearing?
define what it is about this system that needs saving - it is ‘one of a kind’ (important in national psyche) - go back to defining characteristics of system and determine how much change is acceptable
what does changing character mean for EC listing? - use reference notion - don’t have to go back to pre-regulation - use a period of time when system developing, e.g. system of 1970’s water regime; 1970’s is when there was a major shift in the system
D) view of group is that the system is recoverable -
from ASS (pH and metals) and hypersalinity (except for some heavily salinised wetlands that might not come back)
E) need to consider cultural flows and indigenous interests - put alongside environmental flows for future planning - system a ‘living footprint’</td></tr>
<tr><td>Variation from 4 map divisions presented</td><td>how to break the system up - 3 major divisions (+ 1 subdivision):
1) Coorong and Lower Lakes
2a) Wellington to Swan Reach (tributaries, changes to floodplain, SA potable water diversion) - highly modified part
2b) Up to Lock 3 (Swan Reach to Lock 3) - Gorge section and groundwater accession
3) Locks upstream (above Lock 3) - broader floodplain, lateral connectivity more important, red gum-black box transition
not clear how far up Darling Anabranch would need to go for a clear ‘hydrologically based’ cut-off point</td></tr>
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Wetlands and Floodplains and the RM-DS EC

The following statements and summary matrix provide a synthesis of key outcomes from the wetlands and floodplains sub-system focus group discussions and ensuing workshop plenary deliberations.

Workshop Insights and Guiding Principles

Ecosystem function needs protection, not just biodiversity (e.g. consider the consequences of reducing the amount of floodplain next to the river, e.g. reduction in productivity).

Wetlands and riparian species have evolved to sustain themselves under a range of water regimes.

To aid assessment, classify different assets (including functions, ecosystem services, and habitats) within the system and use conceptual models and diagrams to describe changes between states, etc.

Some suggested it is better to go with hydrology rather than vegetation – as this would pick up the changes in flow regimes that are part of the threats; however, vegetation can represent the long-term plant water availability of an area (i.e. an integrated measure of soil properties, water table depth, groundwater salinity and flooding regime) – 'Ecohydrological' classification is a popular approach at present.

The system has a high degree of 'natural' variation that is temporally driven, and that has been changed by regulation, which has resulted in spatial variation being more dominant.

A goal should be to maintain and increase resilience of the ecosystem to survive future drought or water decline (and potential impacts of climate change).

Characteristics of a healthy ecological community include: dependence and interaction between trophic levels; no loss of key species; trophic and habitat complexity.

There is a need to determine the main objective. Are we trying to maintain the full diversity and variability of the systems that we currently have? OR, Are we trying to reclaim the original flow regime to support the ecosystems that are currently there? OR, Do we attempt to adapt the systems to a new state based on what we're likely to have? (Link to benchmark state).

May need to do more work on managing different states, as opposed to keeping it fixed in one 'good condition' state.

Lower Murray Wetland (Source: SA MDB NRM Board)

Aspect	**Wetlands and Floodplains - Key Outcomes**

Major Features	• terrestrial, semi-aquatic and aquatic vegetation -
	  o red gum, black box, coobah, lignum, semi-aquatic emergent species
	  o distribution (longitudinal, vertical) and variability related to flood dependence on water regime – natural pulses
	  o adds to trophic and habitat complexity
	  o changes in vegetation associations with flood frequency
	  o distinction between upper-river and lower-river vegetation
	• hydrology –
	  o needs to include full variability of hydrologic regime (e.g. duration, frequency, seasonality & quality, etc.)
	  o natural condition – temporal variability on floodplains, but with river regulation variability more spatial now
	• fauna – fish
	  o generalist fish community around Mannum related to flow regimes and permanent connectivity of wetlands
	  o lower lakes & swamps are more diverse
	• trophic and habitat complexity important

Boundaries	• hydric soils (i.e. soils showing signs of flooding) – clearly defined and clear boundary; link to pre-1760 (pre-European – (potential reference condition) mapping and 1956 flood boundary • 1956 flood boundary – used in SA planning laws (regulatory, policy implications); known on ground but does it include riparian zones, buffer zones, etc.? Yes it would include the entire floodplain – use as maximum outer boundary • 1870 flood was bigger (went into black box) – raises interface with Mallee country. (Note: slightly bigger for Murray, but not SA?) • 1760 and pre-settlement for vegetation mapping • need to capture flood dependent species • buffer and management zones are important – are part of recovery/management processes • groundwater probably not a good boundary, much larger area – may be better to think of groundwater dependent species

Connectivity	• connectivity driven by hydrology (process is flowing water and associated habitat)
	• longitudinal, lateral, vertical (river and groundwater) and temporal dimensions – all important
	• temporal connectivity – duration effects e.g. denuding of seed/egg banks of aquatic species, may favour invasive species
	• local rainfall an additional water source linked to flow regimes, also has temporal effects (promotes seed germination, etc.)
	• each weir and its reach may function as distinct ecological units
	• sedimentation is a natural connector, but current levels are a threat
	  o lot of wetlands getting shallower
	  o mainstream pools and stream depressions filling up
	  o flushing mechanisms important
	• if connected, floodplains provide a percentage of carbon regime and contribute to instream food webs (which are generally mainly autochthonous (within), with a small proportion allochthonus (without) in flowing river channels
	• fragmentation of habitat – e.g. less vertical habitat for small fish (e.g. billabongs)

Aspect	Wetlands and Floodplains - Key Outcomes (continued)

Condition Thresholds	• ecosystem function and services highly relevant, and population dynamics, namely the ability to re-establish/regenerate/restore, i.e. from:
	  o propagules & seed/egg banks, population dynamics
	  o access to connectivity pathways
	• degree of maintenance of food sources and trophic interaction (i.e. interaction between trophic levels indicates the degree of health)
	• extent of intactness of the geomorphology of the system (i.e. there are non-biotic and biotic condition thresholds)
	• high quality may relate to pockets where 'original' suite of fish left
	• need to know degrees of loss of key components e.g. woodlands % area
	• characteristics of 'degraded', noting that recoverability is still possible:
	  o high salinity threshold in water; accumulating salt/ no flushing
	  o 'wrong' flow regimes; lack of water
	  o nutrients; declining food sources
	  o lack of ability to regenerate (no propagules, or connectivity)
	  o irretrievable loss of habitat; tree loss (e.g. red gum death)

Restoration/ Management	• aims of restoration/management should be:
	  o focus on restoring functionality
	  o manage Coorong/Lower Lakes as estuarine system with interface between salt and freshwater - i.e. to avoid acid sulfate mess (let nature return to freshwater later if enough water)
	  o manage (control) any shift in state and sustain processes
	  o keep essential character; includes various states via timing & duration
	  o identify riparian areas at greatest risk (e.g. river red gum - already know how much might be lost without watering)
	  o maintain all aspects of hydrological regime
	  o build up resilience of entire floodplain
	  o must address floodplain salinisation due to regional groundwater
	  o need to recognise there are tipping points that may result in irreversible change (e.g. river red gums)
	• maintain trophic and habitat complexity
	• to achieve a more natural water regime with lateral and longitudinal connectivity - tipping point is lack of small floods (<1 in 4 frequency) but large floods/flows also needed for overbanking to re-establish broader lateral connectivity
	• small flood flow = 65 000 ML/day for 60 days is a 1 in 2-3 year flood event, but need to define what processes this will support
	• manage the pool level of the main stream for annual cycles - extremely important (i.e. not just 1 in 5, 1 in 10, etc) - wetting/drying cycle
	• issue of sea level change impacts (i.e. do the barrages need raising – are they at the end of their working life?)
	• would need more active management to restore EC after water returned
	• for restoration:
	  o reduce overallocation (drought not entire cause of current problems)
	  o return water of sufficient quality - use floods to build up resilience of components to resist drought
	  o 2000 GL per annum needed, pulsed with over-bank flows of sufficient duration (see above)
	  o if use engineering solutions - should also aim for ecological benefits
	  o address salinisation and build up resilience
	• in terms of management, may be best to use weir reaches as the ecological functional unit

Variation from 4 map divisions presented	• description at four regions a good high level split - but also need to manage within the reach level • Coorong and Lower Lakes; Lower River; Reclaimed swamps/gorge; Upper reaches

Biota and the RM-DS EC

The following statements and summary matrix provide a synthesis of key outcomes from the biota sub-system focus group discussions and ensuing workshop plenary deliberations.

Workshop Insights and Guiding Principles

The whole is greater than the sum of the parts.

Rivers are connected systems - maintaining connectivity is paramount.

The diversity of habitats in the Lower River Murray area (from Sea to Darling) makes it distinct from the remainder of the Murray and the Darling River, and reflects a higher biodiversity.

Past research suggests that plants and fish are reasonably good indicators of ecological 'units' in the region, but birds, particularly colonial nesting waterbirds (CNW) are now less useful (with several important colonies now extinct). This group of birds, i.e. the CNW, may be the hardest hit by degradation of the MDB.

An equitable balance between water resource use and the environment's sustainability may be a useful concept for 'reference condition' considerations.

There are important timeframe implications for recovery - this varies across communities, e.g. red gum versus understorey of aquatic macrophytes.

Pelicans in gorge section of River Murray (Photo: SA NRM Board)

Murray Cod (Photo: Gunther Schmida, MDBA website)

Aspect	Biota - Key Outcomes
Major Features	• marine influence - past and present - has implications for biota o legacy is limestone and salt in the geomorphic sense o diadromous fish as present ecological linkage to marine influence o groundwater environment has higher salinity below the MD junction • River Murray and floodplain seen as a green corridor through arid zones, and there are gradients of distribution around and within this EC • difficult to distinguish the regional flora and fauna, but quite easy to distinguish groups within the 6 defined regions (see below) • waterbirds - no distinct species in this area • key elements of biota (birds, fish, macroinvertebrates and flora) all show patterns to reinforce 6 sub-divisions (i.e. based on plants/animals present): o Valley section - the top end, lock 10 or lock 11 to Overland Corner o the Gorge - Overland Corner to Mannum (valley and gorge plants and fish similar but birds different; some gorge plants similar to Lower Swamps) o the Lower Swamps - the reach between Mannum and Wellington (plants and fish different from Valley, Gorge and Lower Lakes) o Eastern Mt Lofty Ranges east watershed o Lower Lakes - Alexandrina and Albert (plants different) o Coorong - includes the north and south of Glenelg and Murray Mouth (estuarine birds) • East Mt Lofty is distinctive in terms of fish due to stream habitats and genetically distinct populations – different to Lower Murray floodplain but Eastern Mt Lofty streams should be part of EC due to hydrological influence and refugia potential • Lower Murray swamps (Mannum to Wellington) are distinct due to abundance of exotics, lack of natural floodplain. In terms of fish there is a strong diadromous influence • the Coorong and the Lower Lakes are each unique in their natural state • stygofauna is likely to be unique in the River Murray area- work in progress
Boundaries	• 1956 flood as boundary of floodplain: o a potential boundary (although a 1 in 100 year event) o historically a 1 in 13 year flood equalled the extent of the 1956 flood o probably a useful working boundary – used in SA planning o used for Ramsar definition • biological/hydrological/geological boundary compatible with 1956 flood line (Mt Lofty excluded by 1956 flood boundary) • context for the boundary is the timeframe within which recovery is possible and the state to which we would try to restore the system sets the temporal boundary (i.e. timeframe aspects to boundary) o need to establish more clearly - pre European, pre regulation, legislative context o try -50 and 50 + as reference (remnant natural values as focus) • community boundary also has cultural context o creation stories for this Murray area - has mythological integrity, cultural stories underpin/support the extent of the area under study • Lock 11 (Mildura) is an alternative boundary for the EC - but don't favour using a lock as a recognisable boundary point
Connectivity	• rivers are connected systems - connectivity paramount • connectivity is the key to maintaining biological and ecological integrity • broad scale connectivity should be the goal, i.e. rather than managing wetlands etc. in isolation • marine connection (and marine and fresh connection), as part of connectivity as a whole, laterally and longitudinally, is vital in maintaining a substantial segment of the biota • under Ngarrindjeri culture, all things are 'connected'

Aspect	Biota - Key Outcomes (continued)
Condition Thresholds	• consider definition of a working river (i.e. as per CRC definition) • promotion of native flora and fauna above other species • SRA (Sustainable Rivers Audit) - poor ecosystem health (relative to optimal or reference condition) • consider what is the reference condition? • consider when is the EC too degraded to be ecologically functioning? • seed store/egg banks within wetlands could be used as a measure of presence of a species within a wetland and may allow for recovery even when species are deemed to be absent [potential condition threshold] • using Lake Albert as an example: o altered states are not necessarily bad, maybe just different o alternative ecosystem functions during dry 'degraded' phases o ramifications of alternate states being recognised - needs to be considered during assessment • Ngarrindjeri perspective - wetlands referred to as 'nurseries' • a system is irrecoverable when autochthonous (within) and allochthonous (without) reserves are depleted
Restoration/ Management	• inherent variability of this system points to its resilience timeframe implications for recovery (vary with sub-community) • different elements will be recoverable under differing timeframes • recoverability - impossible versus slow i.e. potential)
Variation from 4 map divisions presented	• 6 geomorphic divisions with strong ecological identities (i.e. ecologically distinctive): o Valley Section - Murray/Darling Junction (Lock 10) to beginning of the gorge at Overland Corner (Lock 3) o Gorge Section - turns southward near Morgan (Lock 2) and leaves the gorge around Mannum o Swampland Tract - Mannum to Wellington o Eastern Mt Lofty Ranges (EMLR) Watershed - includes streams like the Marne, Saunders flowing into the Murray, and the Angas, Bremer and Finniss Rivers, and Currency Creek flowing into Lake Alexandrina o Lower Lakes o Coorong

Key Plenary Discussion Points – Description of Ecological Community

It seems to be accepted that we are dealing with a constructed system that maintains significant biological values, but these values probably need better definition.

Defining the purpose for listing is important - is the EC going to be listed on some fundamental aspect of its ecological, geophysical or biological nature?

It seems to be recognised that the region falls into about six zones, and within each zone there can be a variety of types of ecosystems (i.e. sub-communities).

In circumscribing the community - we need to define the whole, and then we need to define the subdivisions that exist within the whole.

The 1956 flood line seems to be a strong starting point for a boundary of the system. However, a 'zone of management' concept is also relevant - the suggestion was 15 km (this probably varies according to width and location along the river, e.g. Flinders Ranges side or other).

The upper delineation of the community was informed by discussion relating to the Murray/Darling junction, the Darling Anabranch, Lock 10 and Lock 11. The majority view held with the actual junction concept (which also is close to Lock 10 and overlaps with indigenous cultural concerns). There was concern that a man-made structure was less suitable as a delineating boundary for the system.

Change in groundwater behaviour may be an important aspect of circumscription - i.e. where groundwater is being lost from the system as opposed to where it is augmenting the system (around Lock 7).

When considering boundaries of the system, we need to consider longitudinal and natural connectivity and two-way flows. Given that we are dealing with a 'constructed' system, those flows might not necessarily be what was historic - however they still might be for nutrient exchange or other purposes, like movement of biota.

A core component of the system is now a series of stepped lakes (i.e. due to infrastructure), which along with the groundwater - possibly now drive the whole system. However, in terms of the EPBC Act, it may prove challenging to accept as permanent the 10 locks that fall within the system. There were issues raised with using the existing weir pools as a means to delineate the system (at least in the upper reaches), as the weirs are actually a highly modified (i.e. artificial) environment. It was felt that there may indeed be scope for recovery in the future that may possibly involve changing configuration or mode of operation of the weirs. We may need to consider in further detail how the weirs influence flow, groundwater, change in salinity patterns, etc. Where their upper boundary of influence ends, may be a boundary.

River dynamics and groundwater dynamics are considered key to the integrity and functioning of the system, as are the small and large floods.

Connectivity to the sea is important - there may be a decision rule associated with the system to ensure that there is sufficient flow to keep the mouth open [*potential condition threshold*].

There is an emphasis on the need for variability, which reflects the multi-varied character of the system and the fact that the components of the system can exist in various states. (For example, some of the wetlands are probably dry more often than they are wet, but that doesn't take away the notion that they are significant wetlands).

The EPBC Act was discussed with respect to there being a perception of too strong an emphasis on stopping actions and significant impact. The Chair of the TSSC reiterated the purpose of the Act is to protect biodiversity and the environment - which includes positive management actions to improve the environment. The adoption of conservation advices and the like can also contribute toward positive outcomes via directing Commonwealth investment. With regard to listing the River Murray - Darling to Sea EC under the Act, the aim would be to turn back the system towards a more sustainable one than the one we have right now.

It was acknowledged that there are many pre-existing actions in the region of the River Murray - Darling to Sea EC (i.e. occurred prior to the commencement of the EPBC Act) and most of these would be considered as ‘continuing use’ under the related clause of the Act. These could potentially be threats.

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