Lake Eyre Basin Rivers Assessment Implementation Plan Project

Final Report

December 2009

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Kiri-ganai research

LAKE EYRE BASIN MINISTERIAL FORUM

About Kiri-ganai research

Kiri-ganai Research Pty Ltd is a Canberra based company that undertakes consultancy and analytical studies concerned with environmental policy, industry performance, natural resource management and sustainable agriculture. Our strength is in turning knowledge gained from public policy, markets, business operations, science, and research into ideas, options, strategies and response plans for industries, governments, communities and businesses.

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Project team

The LEB River Assessment Implementation Plan Project is managed by Kiri-ganai Research Pty Ltd. The project team comprised Professor Richard Price, Professor Martin Thoms and Dr Samantha Capon. Doug Watkins provided sections on 'pressure' indicators.

Acknowledgements

The project team gratefully acknowledges the many individuals who gave their valuable time, insight and knowledge during meetings, workshops, teleconferences and email exchanges with the consultants. We were impressed by the professionalism of all the people that we dealt with, and we trust that their passion and commitment to achieving a positive contribution to the Lake Eyre Basin is reflected in this report and, in particular, the accompanying Implementation Plan. In particular the team would like to thank Vol Norris for his dedication and commitment to this project and to the health and communities of the Lake Eyre Basin

Disclaimer

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Tables and Figures

Abbreviations

ANZECC	Australian and New Zealand Environment Conservation Council
ARIDFLO	Title given to LEB project: Environmental Flow Requirements of Arid Zone Rivers
CAC	Community Advisory Panel
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Department of Environment, Water, Heritage & Arts (Cmth)
ESD	Ecological Sustainable Development
FARWH	Framework for Assessment of River and Wetland Health
GAB	Great Artesian Basin
GABCC	Great Artesian Basin Coordinating Committee
IMEF	Integrated Monitoring of Environmental Flows
INRM	Integrated natural resource management
ISC	Index of Stream Condition
LEB	Lake Eyre Basin
LEBIA	Lake Eyre Basin Intergovernmental Agreement
LEBMF	Lake Eyre Basin Ministerial Forum
LEBRA	Lake Eyre Basin Rivers Assessment
MDBA	Murray Darling Basin Authority
NRM	Natural resource management
NRMMC	Natural Resource Management Ministerial Council
NWC	National Water Commission
PSR	Pressure State Response
R&D	Research and development
SAM	Strategic Adaptive Management
SAP	Scientific Advisory Panel
SLATS	Statewide Land Cover and Trees Study
SOG	Senior Officers Group
TPCs	Thresholds of Potential Concern

Executive Summary

Overview

The Lake Eyre Basin River Assessment Implementation Project set out to revise the Lake Eyre Basin Rivers Assessment (LEBRA) process in terms of its methods and the governance arrangements to oversee successful implementation of these methods.

The core product of the project is the *Lake Eyre Basin Rivers Assessment Implementation Plan*. This Plan summarises the revised methods and sets out governance arrangements for the period 2010 to 2018, coinciding with the lead-up to and implementation of the next Ten-Year Assessment of the Basin scheduled for 2018.

An important element of the Plan is its basis in strategic adaptive management (SAM). SAM is an important framework within which to guide the LEBRA as it ensures that the Assessment process is not an end in itself, but instead embraces identification, trialling and adaptation of responses as well as continuous improvement in the ongoing monitoring and assessment methods themselves.

In particular, the SAM process involves close engagement with those stakeholders expected to respond to results if the unique values of the LEB are to be maintained or enhanced.

The Implementation Plan seeks a total investment of around $8 million over eight years. These funds cover: annual monitoring, including analysis; stakeholder consideration of the implications of the analysis in terms of required responses (on-ground, policy, regulatory etcetera) and required refinement to methods; a trial assessment at the mid-term point (2013-14) and the Ten Year Assessment in 2017-18. Potential cost-sharing partners in the Assessment are identified in the Plan.

The Lake Eyre Basin Implementation Plan, if adopted, could constitute the world's largest formal application of adaptive management principles in natural resource management.

Recommendations

1. The Lake Eyre Basin Ministerial Forum should agree to the implementation of the *Lake Eyre Basin Rivers Assessment Implementation Plan* to gain an understanding of the LEB's condition in order to:
    i. underpin responses to condition, including a range of on-ground management, government and industry policy, enterprise and personal decision making and local and regional resource planning responses
    ii. form consistent messages appropriate to, and encourage constructive dialogue between, specific target audiences about condition, outlook and appropriate responses

iii. guide ongoing research, investigation and monitoring efforts so that they can form a reliable basis for evidence-based responses.

2. Partners under the LEB Ministerial Agreement should agree on cost-sharing arrangements to cover the $8 million required to implement the *Lake Eyre Basin Rivers Assessment Implementation Plan* over the next eight years.
3. The revised LEBRA methods outlined in the Plan and detailed in Report 2 of the project should be adopted as the basis for an interim Assessment in 2013-14, a full Assessment in 2017-2018 and for ongoing monitoring over the intervening period.
4. The collaborative business governance model outlined in the Plan and in Report 3 should be adopted as the basis for governing the LEBRA over 2010-2018. This involves the establishment of:
   a) a LEBRA Organising Group to oversee the Assessment and ongoing monitoring;
   b) an Operations Group to conduct the Assessment and ongoing monitoring; and
   c) a Technical Reference Group comprising partners involved in the organising Group to ensure integration across States, organisations and disciplines in the conduct of the Assessment and ongoing monitoring,
5. The Scientific Advisory Panel should remain independent of the Assessment process so that it can fulfil its function in providing unfettered advice to the Ministerial Forum and Senior Officers' Group on matters concerning the LEBRA.

Accompanying Reports

Reports accompanying this final report include:

- Milestone 1 Report: Review of achievements
- Milestone 2 Report: Proposed LEB Rivers Assessment Methods
- Milestone 3 Report: Governance arrangements for the LEBRA
- Lake Eyre Basin Rivers Assessment Implementation Plan (incorporating the business governance model).

1. Background

Purpose of the project

The Australian Department of the Environment, Water, Heritage and the Arts (DEWHA) required the development of a Lake Eyre Basin Rivers Assessment Implementation Plan to identify how regular on-going monitoring of key indicators will be implemented within the Lake Eyre Basin Agreement Area. To meet this aim DEWHA engaged the services of Kiri-ganai Research Pty Ltd to undertake a consultancy for this purpose.

The main objectives of this consultancy were to:

- review the achievements to-date under the Lake Eyre Basin Rivers Assessment (Step 1);
- review the Lake Eyre Basin Rivers Assessment methodology and recommend an approach and key indicators to be monitored, their scale and frequency (including rationale for decisions) (Step 2); and
- support development and documentation of governance arrangements; development of a business model (including the cost of monitoring, managing data and report; funding for future monitoring and possible funding arrangements) (Step 3).

This report is submitted in accordance with the terms of reference for this consultancy (Appendix A).

Project relationship to the LEB Action Plan

As its highest priority, the Five Year Action Plan for the Lake Eyre Basin Intergovernmental Agreement (LEBIA) calls for the governing partners of the LEBIA to *re-assess the governance and support arrangements to implement the LEBIA.* The Action Plan states that LEB stakeholders gave particularly strong support for this re-assessment (Action 1) to be undertaken as *a priority on which all other actions rely*. The Action Plan approved by the Ministerial Forum in May 2009 provides for the reorganisation of the Senior Officers Group (SOG) to better drive implementation of LEBMF decisions and engage stakeholders in the process. The SOG will have an important role in advocating this project's findings and recommendations and negotiating the partnership arrangements required to resource its successful implementation

This project relates to Action 5 of the Action Plan (Implement the LEB Rivers Assessment – LEBRA – through the preparation of an Implementation Plan). The Implementation Plan consultancy project was limited by its terms of reference to assessing and making recommendations on the governance arrangements appropriate to successfully implementing the LEBRA.

That said, this report concentrates on the practical and cost-effective arrangements required to enable the LEBRA to be carried out to meet both current and potential future expectations, while drawing attention to other structural and governance issues.

2. Methods

The Kiri-ganai Research team undertook six steps, guided by the project Terms of Reference, in undertaking and completing this project. The following information is further detailed in Section 3 under the sub-headings of '*What we did*' under each project objective.

Step 1: Brief review of achievements to date under the LEB Rivers Assessment

This step involved:

- reviewing documents provided by the LEB Secretariat and National Coordinator (see references Appendix B);
- comparing research, consultancy and workshop findings and outputs with recommendations of key LEB planning documents, including the draft LEBRA methods report;
- consulting with LEB stakeholders (see Appendix C) through regional visits, meetings, teleconferences and workshops; and
- responding to feedback provided by SAP members on Milestone 1 Report: Review of achievements (Accompanying Report #1).

Step 2: Reaching an agreed LEB Rivers Assessment methodology

This step involved:

- reviewing documents provided by the LEB Secretariat and National Coordinator, particularly in respect to stated assessment priorities;
- consulting with LEB stakeholders through regional visits, meetings and teleconferences, particularly in respect to future assessment priorities;
- consulting technical staff in each agency with responsibilities covering resource assessment methods applicable to the LEB; particularly in respect to future assessment priorities
- reviewing literature about adaptive management and resilience, and drawing from these lessons for resource assessment at scales comparable to the LEB;
- dedicating a day to technical aspects of the project at the LEBRA workshop conducted on 11-12 August 2009;
- responding to feedback provided by SAP members on Milestone 2 Report: Proposed LEB Rivers Assessment Methods (Accompanying Report #2).

Steps 3 and 4: Reaching agreed Governance arrangements and Business model

This step involved:

- reviewing documents provided by the LEB Secretariat and National Coordinator, particularly in respect to governance arrangements;
- consulting with LEB stakeholders through regional visits, meetings and teleconferences, particularly in respect to future governance arrangements;
- reviewing literature about adaptive management and resilience, and drawing from these lessons for governance arrangements at scales comparable to the LEB;

- dedicating a day to governance arrangements at the LEBRA workshop conducted on 11-12 August 2009; and
- responding to feedback provided by SAP members on Milestone 3 Report: Governance arrangements for the LEBRA (Accompanying Report #3) and the LEBRA Implementation Plan (incorporating the Business Model).

Step 5: Workshop

The workshop was originally envisaged to be conducted at the completion of the project, however, the research team and the SAP agreed that it should be held earlier to provide significant level of discussion around the draft revised LEBRA methods (Step 2) and options for governance arrangements (Step 4).

The workshop was convened on 11-12 August 2009 and involved all members of the SAP, some SOG members, the National Coordinator and the LEB Secretariat (DEWHA).

Notes taken from the workshop are provided in Appendix D. The workshop resulted in agreement on:

- the indicator sets drafted by the consultants;
- additional indicator sets for hydrology and pressures/drivers;
- a clear purpose for the Assessment;
- adoption of a Strategic Adaptive Management Framework;
- timeline and governance structures for the Assessment and for ongoing monitoring.

Step 5: LEB Rivers Assessment Implementation Plan

This step involved:

- refining the indicator sets following feedback on the Milestone 2 report and the project workshop;
- refining the governance arrangements following feedback on the Milestone 3 report and the project workshop;
- incorporating proposed annual budgets for 2010-2018 based on the costs of implementing the proposed indicator sets and governance arrangements – these costs were based on advice provided by a combination of state agency partners in the LEBIA and other technical service providers such as Griffith University and Sydney University;
- circulating a draft Implementation Plan incorporating a business model for CAC and SAP consideration;
- finalising the draft Implementation Plan based on the totality of feedback provided.

3. Project achievements against the Terms of Reference

This section summarises the achievements of the project against the three objectives set out in the project Terms of Reference (see Section 1 for Objectives and Appendix A for the full ToRs).

Objective 1 Achievements to-date under the Lake Eyre Basin Rivers Assessment

What we did

The project team commenced examination of the existing LEB Rivers Assessment (LEBRA) process by initially grounding stakeholder expectations for the project through an inception meeting on 23rd March 2009, then reviewing background materials provided by sources associated with LEB management, coordination and research interests. In all, around 40 documents were assessed, including the formal LEB Agreement, Ministerial Forum papers and minutes, the agreed Assessment Methods report, workshop and associated reports leading up to Methods report, and finally the first Rivers Assessment report completed in 2008. A list of these documents appears in Appendix B.

To clarify expectations about the LEBRA, seek comment on the first assessment process / outcomes and gain initial perspectives about future governance arrangements, team members consulted with a range of stakeholders in Canberra, Brisbane, Longreach, Adelaide and Alice Springs between 7th April and 8th May 2009. Those consulted (see Appendix C) varied from local LEB producers, administrators, catchment managers and researchers through to State and Federal government officials and ministerial advisers and national and university researchers. Consultation is expected to continue throughout the project, culminating with a stakeholder workshop in August 2009.

Interviews with stakeholders provided valuable feedback on the implementation of the current LEBRA process; its achievements, strengths, limitations and weaknesses. The analysis in this report is informed by both the literature and the consultations.

What we found / recommended

The First Rivers Assessment was completed in 2008-09, coordinated by the South Australian partners. Results were distributed and communicated broadly, with more specific feedback provided to some of the regional groups.

The Kiri-ganai Research team made two sets of observations: one relating specifically to the Rivers Assessment process; the other relating to the higher order issue concerning governance.

At the Assessment level, our three most striking observations were:

i. the assessment indicators and protocols agreed to in 2005 did not appear to bear directly on the Ministerial Agreement's focus of assessing the condition of the LEB as a whole;

ii. irrespective of this, or possibly because of it, the first assessment completed in 2008 did not closely follow the agreed assessment protocols nor argue why a different method was adopted; and

iii. neither did the method adopted fulfil the Ministerial Agreement's focus on assessing the condition of the LEB as a whole.

While good argument was put forward for having changed the assessment method (i.e. other national assessment frameworks had been advanced), the way the initial methods were developed and agreed to and the manner in which they were changed raised issues about the governance arrangements in place below the Ministerial Forum level. This observation had been recognised also by the LEB partners, and as a result, the Senior Officers Group was re-energised in mid-2009.

At the Governance level, another observation stood out. A number of State and Territory officials indicated that the LEB is not a particularly high priority for their organisation in terms of financial and staff allocation vis-à-vis the other regions or NRM issues. To the Kiri-ganai Research team this appeared to contradict having a Ministerial Forum in place. Moreover, it raised questions about higher order visions, expectations and issues that needed to be taken into account in the preparation of the Implementation Plan and Business Model.

Issues

Scale

The LEB is an enormously large area, and it is understandable that the LEBRA has focussed on specific indicators. These indicators are largely associated with in-stream water condition, which in itself does not address the wider issue of Basin condition as required by the terms of the Intergovernmental Agreement. Moreover, in-stream condition indicators focus around select water-holes, a limitation in determining overall LEB rivers let alone overall basin condition.

Various monitoring efforts in the LEB do provide some relevant data in respect to overall Basin condition, and some of these, including broad-scale rangeland and vegetation monitoring were expected to be incorporated into the LEBRA. This did not occur. For reasons such as this, the Kiri-ganai Research team found that the results of the 2008 Assessment, which indicated that much of the LEB was in excellent condition, were questioned by many of the local stakeholders, many of whom were unaware of the LEBRA process and considered that conditions were not as rosy as portrayed in the Assessment.

The issue of scale must be addressed if future Assessment processes are to be consistent with the terms of the Intergovernmental Agreement. This issue will be dealt with more extensively in our next report.

Changing expectations

The 2008 LEB Rivers Assessment essentially followed the FARWH river assessment protocols developed since the time the LEBRA Methodology were agreed to. As a consequence, 35 of 39 actions outlined in the Methodology were not pursued. In many cases there was good reason for the change process, including the need to get a better handle on the stress drivers in the LEB and, if nothing else, to be seen to follow and or test more recent assessment protocols agreed to within the context of other, more recent initiatives. In essence, the expectations of those involved in the LEBRA process evolved over time, and as a consequence, the protocols were subject to adaptation.

Adaptive management is a critically important element of monitoring and evaluation, however when multiple stakeholders are involved it is important that consensus be sought about the adaptations carried out. This was not the case in the 2008 Assessment. Indeed while some research and management stakeholders interviewed understood the need for some form of adaptation, many were not aware that a major adaptation had taken place, and many were concerned that the adaptation may not have been an improvement.

Governance issues

Throughout our consultations, LEB stakeholders raised issues about governance, particularly in respect to ensuring that procedures, more-so than structures, are in place to undertake future assessments in a timely fashion and are fit-for-purpose in respect to the key threats to resource condition across the basin. While some stakeholder comments about the current Assessment process reflecting compromises between researchers with vested interests were unconstructive, it did highlight ongoing contestation around what is deemed an appropriate Assessment process for the LEB. Much of this contestation has taken place around indicators that, to the consultants' minds, do not address the critical issues of scale, high order expectations or fit-for-purpose utility, and suggests a missing link between the Intergovernmental Agreement and implementation of key actions.

High level drivers of interstate NRM arrangements such as the LEB Intergovernmental Agreement usually involve complex factors that cross borders, including water, people, fish, birds, dust or feral animals. In no case has an alarm rung in the LEB over any of these factors, although some bells have sounded in respect to key pressures, including grazing and mining. The current Assessment process is not in tune with this situation, which begs for a different approach to monitoring the condition of the LEB and ascertaining when and how responses are justified.

Further detail in respect to this objective in particular can be found in Accompanying Report #1: Review of Achievements.

Objective 2: Review of the Lake Eyre Basin Rivers Assessment methodology and recommended approach

What we did

The Kiri-ganai Research team reviewed in detail the 2008 assessment process and findings against the originally agreed LEBRA methods. As part of this task Kiri-ganai Research was asked to:

1. identify the monitoring already being undertaken within the Lake Eyre Basin which will be included in the Implementation Plan;
2. identify the recommendations from previous Lake Eyre Basin work that will be included in the Implementation Plan;
3. identify the indicators that were suggested in Method for Assessing the Health of Lake Eyre Basin Rivers that will be included in the Implementation Plan;
4. identify linkages with national monitoring, evaluation and reporting frameworks;
5. identify monitoring actions that can be undertaken immediately – summarise their methods and costs;
6. identify monitoring actions that require further research and development; and
7. advise on the appropriateness of reporting on a ten year basis or other timeframe.

What we found / recommended

1. Current monitoring:

Monitoring activities undertaken within the Lake Eyre Basin can be grouped into the components of hydrology, the physical form of waterholes, biota and water quality and landscape factors. The details of each are provided below.

Hydrology component

- The hydrology of the Lake Eyre Basin has been analysed by McMahon *et al* (2008) using data from gauging stations with >10yrs of data.
- Overall, the hydrology of the Lake Eyre Basin was assessed in the Lake Eyre Basin State of the Basin Report (2008). Here the hydrological condition was assessed by Lake Eyre Basin Scientific Advisory Panel and Lake Eyre Basin Steering Committee using expert opinion and best available data (not specified). This assessment was based on storage water volumes and percentage of flow diverted from the channel network within the basin as monitored by State Agencies.

- There is a surface water monitoring network within the Lake Eyre Basin and this has been reviewed by Ladson et al (2006) who provided recommendations for additional monitoring sites and instrumentation.
- A limited number of water level loggers have been installed in the South Australian section of the Lake Eyre Basin as part of the ARIDFLO project, as outlined in Good et al (2008). Data from these loggers have been downloaded from and analysed by Costelloe (2007; 2008).
- A pilot study is underway to evaluate the potential for use of Remote Sensing (Lake Eyre Basin Scientific Advisory Panel 2009) for the determination of the extent of flooding throughout the Lake Eyre Basin.

Physical form of waterholes component

- The location, permanency and connectivity of various waterholes have been mapped in the Queensland, eastern South Australia and Northern Territory sections of the Basin using a series of remotely sensed images. The methods used and analysis of this exercise is outlined in Lake Eyre Basin Scientific Advisory Panel (2009) report.

Biota component

Regular monitoring of two biotic components has occurred throughout the Lake Eyre Basin:

Fish

- Fish were monitored as part of the ARIDFLO (Good *et al* 2008) and the CRC for Freshwater Ecology Dryland Refugia projects.
- In addition there have been regular surveys of fish within the Queensland section of the Lake Eyre Basin as well as the Northern Territory Section as noted in Bailey and Long (2001) and Duguid *et al* (2005) respectively.
- A project to determine the natural trajectory of fish diversity and abundance in relation to hydrology and season within the Lake Eyre Basin has been undertaken by Humphries *et al* (2007). The resultant model has been tested in the South Australian section of the Lake Eyre Basin by McNeil and Reid (2008) and in the Queensland section by Balcombe and Kerezy (2008).
- Overall fish communities within the Lake Eyre Basin were assessed as part of the Lake Eyre Basin State of the Basin Report in 2008 using the using data outlined above but the actual methods employed were not stated.

Waterbirds

- Surveys of waterbirds have been undertaken in some parts of Lake Eyre Basin for up to 24 years. Kingsford and Porter (2008) have reviewed the validity of using waterbird data for assessing river condition.
- Water birds were assessed in the Lake Eyre Basin State of the Basin report (2008) using the expert knowledge of Professor Richard Kingsford who utilized the above long-term datasets.

Water quality component

- Ongoing water quality monitoring has been undertaken in the Queensland section of the Lake Eyre Basin. Assessments of the water quality of rivers in the Queensland section of the Lake Eyre Basin are provided by Bailey (2001) and Choy *et al* (2002).
- Water quality was a component included in the Lake Eyre Basin State of the Basin report of 2008 and this used data from the State-based water quality monitoring programmes (information has not been provided on this) as well as an expert review of results by the Lake Eyre Basin Scientific Advisory Panel and Steering Committee. This assessment was done using the ANZECC Ecosystem Protection Guidelines.

Landscape stress component

- A landscape stress component was included in the Lake Eyre Basin State of the Basin Report (2008) and was based on the method developed for the National Land and Water Resources Audit. The landscape health assessment as outlined by Morgan (2000), and further elaborated in Herr *et al* (2007), is based on the following variables:
    - percentage of subregion with least impact from total grazing pressures
    - value of native vegetation in land tenures associated with conservative land use practices
    - weed density
    - feral animal density
    - number of threatened species
    - susceptibility of resources to degradation.
- The National Land and Water Resources Audits' landscape stress rating was conducted on a sub-regional basis with the majority of the Lake Eyre Basin being assessed as ‘extensive land use zone’ and ‘intensive land use zone’ for the Cooper catchment headwaters. Conversion to a sub-catchment scale has been undertaken by the Lake Eyre Basin Steering Committee through visually overlaying layers.

2. Recommendation follow-through:

A total of 39 cited actions were noted as part of the implementation recommendations from the Rivers Assessment Methodology and these address the four main themes of Flow and Flood, Riparian and Floodplain, Waterholes and Wetlands and Physical Form. These listed actions can be grouped as addressing 11 different attributes like hydrological variability, fish assemblage diversity and ecosystem processes as examples.

35 of the 39 listed actions have either not been addressed or reported. Completed achievements that have been listed include those on the broad scale assessment of hydrological condition, a review of data logging, the hydrology of the Lake Eyre Basin and a vegetation condition report for the basin.

3. Indicators:

In consultation with LEB stakeholders, eight indicator sets were identified for inclusion in the LEBRA Implementation Plan, including seven 'State' sets and one 'Pressure' set. The State sets include fish assemblages, waterbirds, vegetation (riparian and wetland), physical habitat, water quality and hydrology:

Table 1: Proposed indicator sets

State Indicator	How the indicator relates to condition
Fish assemblages: Species richness, abundance, abundance of alien species, recruitment, population size structure, abundance of detritivores and prevalence of disease	Antecedent flow conditions, waterhole condition , anthropogenic disturbance, phase, introductions of fish species, fish population dynamics.
Waterbirds: Total abundance of colonial waterbirds, species richness of colonial waterbirds, abundance of functional groups of waterbirds, community composition, presence/absence of particular species, abundance of breeding birds and species richness of breeding birds	Altered water quality or flow regime, antecedent flow conditions, assemblage condition, changes in flooding regime, condition of habitat, condition of habitat and food supply
Vegetation (riparian)*:* % cover of 3-5 dominant woody species in upper and middle (layers), % herbaceous ground cover, % cover aquatic vegetation (submerged, floating, emergent), % cover of exotics, native regeneration, width of riparian zone and longitudinal connectivity	Altered flooding regime, anthropogenic disturbance, altered water quality or flow regime, antecedent flow conditions, impacts of exotic species, Vegetation (wetland)
Vegetation (nationally important wetlands)*:* Floristic composition; species richness; % foliage cover of understorey species; % canopy cover; foliage cover; height ranges of vegetation layers (trees, shrubs, understorey); tree vigour; population size structure	Altered flooding regime or anthropogenic disturbance; antecedent flow conditions; altered flow regime or water quality; impacts of exotic species
Physical Habitats: Physical diversity and channel instability	Flow and sediment variability, loss of physical habitat diversity which may be deleterious to aquatic biota, overgrazing and land use which may be deleterious to aquatic biota, physical habitat
Water Quality: Conductivity, pH, dissolved oxygen (diel range), turbidity, water temperature (diel range)	Amount of suspended solids in water, deleterious effects to aquatic biota, health of aquatic biota, light penetration and primary production, pollution load, primary productivity, salinity
Hydrology: Total surface water availability, water storage capacity, water licensing, filling of terminal lakes, floodplain inundation, in-channel events and persistence of key waterholes.	Climate change, floodplain development, land use change, presence of in-channel structures, water resources development

The Pressure set includes indicators for land use change, management of grazing lands, tourism, invasive species and climate change:

Table 2: Proposed pressure indicator sets		
Pressure	**Impacting activities associated with the pressure**	**Indicator areas**
Land use changes, especially those impacting on water use; • Irrigated agriculture • Intensification of grazing • Mining and petroleum extraction • Road construction • Earthworks to harvest water	Water extraction, water storage and diversion, construction of barriers across floodplain surfaces and within the channel network, damming, conversion of floodplain lakes to storages, floodplain harvesting, pumping from shallow groundwater, pumping from water holes	Development applications, Environmental Impact Assessments, water permits issued, updates of water management plans
Management of grazing lands	Increased grazing pressure, vegetation management	Vegetation cover, burnt areas
Tourism	Recreational visitors, localized fishing impacts	Number of visitors
Invasive species	Establishment/spread of exotic animal and plant species (on the floodplains)	Occurrence of Weeds of National Importance, exotic fish species
Climate Change	Changes in the amount and pattern of rainfall and the associated changes in river flows, intensity of storm events	National level conclusions on changes in climate

4. Linkages

The Accompanying Report #2: *Proposed LEB Rivers Assessment Methodology,* provides detail on a range of current assessment initiatives where similar methods to those proposed are utilised, where personnel likely to be involved in the proposed LEBRA are already working or where there may be other forms of synergies. These initiatives include:

- The Sustainable Rivers Audit of the Murray Darling Basin
- Framework for the Assessment of River and Wetland Health
- The Australian Rangelands Information System
- The Index of Stream Condition (ISC)
- Queensland State of the Rivers
- Integrated Monitoring of Environmental Flows (IMEF)

5. Monitoring that can be undertaken immediately

With respect to those monitoring actions that can be undertaken immediately, it is pertinent to note that these represent a combination of 'controlling or slow variables', 'responding or fast variables' and 'potential drivers of change' that

can be used to assess the resilience of the river ecosystems within the Lake Eyre Basin. The six components recommended are Physical Habitat, Fish, Waterbirds, Riparian Vegetation (controlling variables), Water Quality (responding or fast variable) and Hydrology (both a driver of change and a controlling variable). In order for hydrology to be used as a controlling variable, a catchment based hydrological model would need to be constructed. This hydrological model would then enable the effects of climate and land use to be assessed on the spatial and temporal availability of water throughout the Lake Eyre Basin. Details for each of these six components in the Accompanying Report #2 are:

- the value and pressures to the component
- drivers and risks to the component as well as management actions to be taken
- a list of indicators for each component
- recommended sampling methods, including frequency and scale of sampling
- analysis and reporting methods and the costs of undertaking this monitoring exercise.

6. Further research

Monitoring methods that would benefit from further R&D are listed under six key themes:

Flow and flood theme

Development of catchment based flow model is a priority. It would allow the hydrological impacts of climate and land use to be assessed, thereby treating the hydrology of the basin as a response variable. It would also enhance the ability to model these potential impacts on the other ecosystem components of the rivers assessment.

Modelled stream flow is important for any river assessment. There have been several attempts to model flows through the rivers of the Lake Eyre Basin. All of these approaches are constrained by the limited data available, but the results may be useful for assessing hydrologic characteristics and change in Lake Eyre Basin Rivers and floodplains. In some circumstances, modelling could be used to extend the usefulness of measured data and can provide input to ecological studies. A key challenge in modelling the major rivers of the Lake Eyre Basin is to simulate the complex flow patterns on the vast floodplains of these rivers. Each of the main waterways, Cooper Creek, the Diamantina River and the Georgina River has large, multichannelled reaches with wide floodplains and many ecologically important waterholes. There are key stream gauging sites which would assist with monitoring and modelling these reaches.

Flood Extent Attribute

- Flood extent indicator

Objectives: Investigation into relationships between discharge and flood extent relationships using flow data and analysis of satellite imagery are required. Linked projects include WLD wetland mapping, SA projects SGFP (Phelps), Santos and Dave Roshier's work (Notes from March 2005 Lake Eyre Basin Rivers Workshop, March 22 & 23). A recent report by Michael Stewardson et al (University of Melbourne and CSIRO, draft dated March 2009) on using satellite imagery to monitor hydrological change may have addressed some of these knowledge gaps but this report was not reviewed.

Waterholes and wetlands theme

Waterhole and Wetland Biodiversity Attribute

- Iconic species indicator

Objectives: develop conceptual models and identify indicators for species under threat, e.g. frogs, turtles, water rats, monitors, brush tail possum, Cooper Ck catfish etc.

- Cane toads indicator

Objectives: Development of a conceptual model to consider cane toad impacts in LEB is required.

Riparian and floodplain theme

Riparian and Floodplain Biodiversity Attribute

- Bird biodiversity indicator could be developed.

Riparian Vegetation Condition Attribute

- Riparian vegetation composition and extent indicator

Objectives: To develop techniques for assessing regional, catchment and basin-scale indicators of riparian vegetation condition and extent using remotely sensed data and explore collaboration with existing State programmes, eg. SLATS (Qld).

Floodplain Vegetation Condition Attribute

- Floodplain vegetation composition and extent indicator

Objectives: develop techniques for assessing regional, catchment and basin-scale indicators of floodplain vegetation condition and extent using remotely sensed data. Explore collaboration with existing State programmes, eg. Rapid Mobile Data Collection (see http://www.environment.gov.au/land/publications/acris/report08.html) (Qld) or National programmes, eg. ACRIS, AussieGrass.

Physical form theme

Erosion Potential and Land Use and Landscape Change Attribute

- Erosion potential and land use change indicator

Objectives: The development of models that are able to predict responses to events, e.g. expected vegetation cover changes in response to rainfall work (Notes from March 2005 Lake Eyre Basin Rivers Workshop, March 22 & 23).

- Stream network model to assess impact of land use and climate change

Objectives: Development of a model that characterises the entire stream network of the Lake Eyre Basin and compares this against a reference stream network.

Water quality theme

River bed sediment geochemistry audit attribute

- Sediment geochemistry indicator

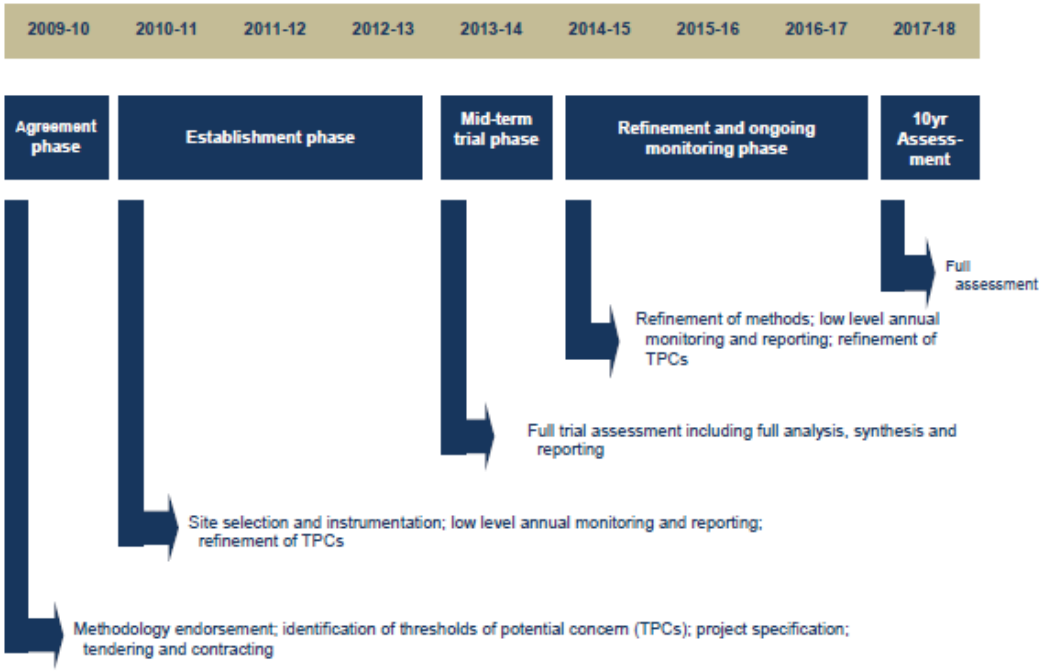
Objectives: Development of a geochemical data base of river bed sediment through out the basin to determine the longer term impact of mining and land uses in the Lake Eyre Basin.

7. Appropriate Timeframe

The timeframe for the Assessment was discussed at length at the workshop on 11-12 August. The SAP members attending that workshop agreed to a timeframe consistent with the LEBIA requirement for Ten Year Assessments. With the First Assessment having been conducted in 2008, the Second Assessment is now scheduled for 2018.

The agreed schedule includes annual ongoing monitoring and a mid-term trial in 2013-14 as per the following:

Figure 1: Implementation plan schedule



Details of the issues covered above are provided in the Accompanying Report #2: *Proposed LEB Rivers Assessment Methodology.*

Objective 3: Development of governance arrangements and business model for the Lake Eyre Basin Rivers Assessment

What we did

Following the consultations outlined previously, the Kiri-ganai Research team detailed a series of observations made about the existing LEBRA process and its governance and about the current values and views held by LEB stakeholders, including those concerning how the LEBRA should be conducted in future. These observations, used as the basis for detailed discussion at the SAP workshop, included:

- The LEBIA does not explicitly deal with the intra-state impacts of the LEB. The implicit assumption is that if partners protect cross-border interests, the condition of the Basin as a whole will be protected. The basis for the assumption lies in the Basin's focus on water resources. The health of the overall LEB relies, in the view of many SAP and other LEB participants, on consideration of both intra and inter-border management.
- The LEB has potential advantages offered by having its own Ministerial-level governance arrangements (the LEB Ministerial Forum), however the arrangements do not share the same head-of-department level of management common to other such inter-governmental forums. Notwithstanding the existence of a Senior Officers Group, the overarching governance arrangements may lack the delegations to ensure that actions are undertaken as rapidly or with the same level of resources that might otherwise be the case. While this is a question for longer-term consideration in respect to broader governance arrangements for the LEB, it does suggest that expectations for resourcing the LEBRA need to be tempered and make best use of existing resources, including partnerships and networks.
- The values articulated by LEB stakeholders span the breadth of the triple bottom line as well as the breadth of natural assets of the Basin. This needs to be taken into account in the governance of the LEBRA implementation process.
- The challenge for the LEBRA of Constitutionally-based NRM arrangements is not so much that resource assessment and ongoing monitoring cannot be undertaken as independent, specifically designated and discrete activities, but rather that the responses to findings about pressures and resource states is more difficult to coordinate. This has implications for building governance arrangements

around a LEBRA based on the Pressure-State-Response model as well as on adaptive management principles.

- The LEBRA can, and should, play a pivotal role in alerting the LEBMF to significant issues requiring coordinated policy responses. The LEBRA should also act to provide a clear understanding of the condition of the Basin to help jurisdictional representatives avoid articulating mixed or inconsistent messages. Both these issues are consistent with widely accepted governance principles of evidence-based decision making.
- The LEBRA should act to provide the kind of information required to guide policy and program responses. In many respects, the SOG is in the fortuitous position to influence the conduct of the LEBRA as well as many of the responses to the information it provides. The SOG needs to play a stronger role than it has to date in the LEBRA process to ensure that the assessment process is aligned to the response mechanisms available through its jurisdictional representatives.
- The CAC shares with the SOG a characteristic vital to the successful implementation of the LEBRA within the context of adaptive management as proposed: the capacity to respond, if necessary, to the information provided by the assessments. More importantly, the CAC comprises those interests with the major personal or corporate motivation to respond, and by implication those with the strongest stake in ensuring that the LEBRA is both rigorous and provides information of utilitarian value.
- The SAP's role as prescribed in the LEBIA is to '*provide advice*'. This is consistent with commonly accepted interpretations of good governance; keeping the SAP independent of monitoring performance, so that it can provide advice not only on what ought to be performed, but how it was performed. Maintaining this independence is a principle that should be adopted in the LEBRA governance arrangements.
- Another important role for the SAP in the LEBRA should be to interpret the implications of the findings for further investigation and research.
- The level to which the regional NRM Boards can undertake LEBRA activities hinges not simply on funding availability, but on the level of trust placed in them by government and industry agencies. Their capacity to motivate and focus existing community networks on wider LEB initiatives should be an important element of advancing the adaptive management approach proposed for the LEBRA.
- The LEB Facilitator can play an important part in ensuring that the findings of the LEBRA inform the diverse range of interests in a position to respond. This can be achieved through guiding the knowledge and communication strategies as well as in helping set the agendas for the various bodies such as the SOG, SAP and CAC.
- While it is important that the LEBRA provide the basis for understanding the condition of the LEB to underpin appropriate management

responses, it is important it also inform the Knowledge Strategy in respect to progress in being able to answer key research questions.

- The key messages outlined in the LEB Communication Plan need to be reflected in the way the LEBRA is conducted. That said, future key messages need to be informed by the results of the LEBRA.
- The LEBMF's responses to the URS Australia review of the LEBIA provide some guidance in respect to future governance arrangements for the LEBRA. Implicitly, the responses reinforce the imperative to focus on integration at the point-of-practice (i.e. in the implementation of specific activities). Governance arrangements for the LEBRA therefore need to be practical, easy to implement, be seen to 'get on with the job' and be couched in an adaptive framework that ultimately stimulates responses on-the-ground.
- While the response to an adaptive management approach has generally been favourable, it has been viewed by some stakeholders as representing a longer-term aspiration that could compromise the shorter-term imperative of undertaking a comprehensive resource assessment in the LEB. The consultants do not consider that adopting an adaptive management approach to the LEBRA will delay its implementation. Indeed, early conduct of the LEBRA can and should help shape the longer-term adaptive management framework not only for future resource assessments, but also for the wider activities under the LEBIA (i.e. the Knowledge Management Strategy, Communication Strategy, ongoing monitoring etcetera).

These observations were used as the basis of structuring five alternative governance models for the LEBRA, all of which involved a Strategic Adaptive Management (SAM) approach. A preferred model based on collaboration was agreed to by SAP and SOG members when they met in Alice Springs in September 2009. The skeleton of the governance arrangements was developed by SAP workshop attendees, fleshed out by the Kiri-ganai Research team in the form of a draft Implementation Plan and Business Model, and considered again by the SAP. The final Implementation Plan and Business Model reflect the feedback from the SAP.

What we found / recommended

Implementation Plan

The Implementation Plan firmly grounds the LEBRA process within a Strategic Adaptive Management framework, involving six steps:

1. All stakeholders will be involved in the process of developing a vision for the desired state of LEB landscape condition.
2. A vision for the desired state of riverine landscape condition will be translated into an objectives hierarchy.
3. Thresholds of Potential Concern (TPCs) will be generated to define acceptable levels of change in LEB landscape form and function.

4. Research and observations of landscape form and function will be used to audit and understand LEB condition in relation to TPCs.
5. Management interventions will occur in the context of TPCs.
6. As learning by doing is an essential part of SAM, knowledge of LEB ecosystems will constantly be reviewed in order to update TPCs and management options.

The Plan also takes the approach that assessments are not concluded without consideration of the implications for responses of the findings. These responses are outlined in the following diagram:

Figure 2: Range of responses to potential indicator implications

Associated with the SAM approach is the concept of thresholds of potential concern (TPCs), which are used to guide the monitoring process and trigger responses where required. While it is important that stakeholders review these TPCs on a regular basis, the initial TPCs proposed include:

Table 3: Thresholds of Potential Concern

Trigger	Thresholds exceeded or expected to be exceeded
Reduction in waterhole persistence	Significant change in the cumulative duration of water availability within the key waterholes of the Lake Eyre Basin
In-channel flow events or flow pulses	Significant change in the flow duration curve of no flow events for gauging within the Lake Eyre Basin
Total surface water availability	Reduction in total annual volume of surface water expected from catchment rainfall at key gauging stations located throughout the Lake Eyre Basin
Silt and pollutant release episode from upstream mining operation	Increased turbidity in waterholes resulting in fish kills
River sedimentation	Loss of physical habitat diversity between and within waterholes
Change in community of native fish	New occurrence of an alien fish with a high index of potential threat Significant change in size distribution of fish communities within the individual sub catchments of the Lake Eyre Basin
Change in riparian vegetation structure	New occurrence of an alien plant with a high index of potential threat

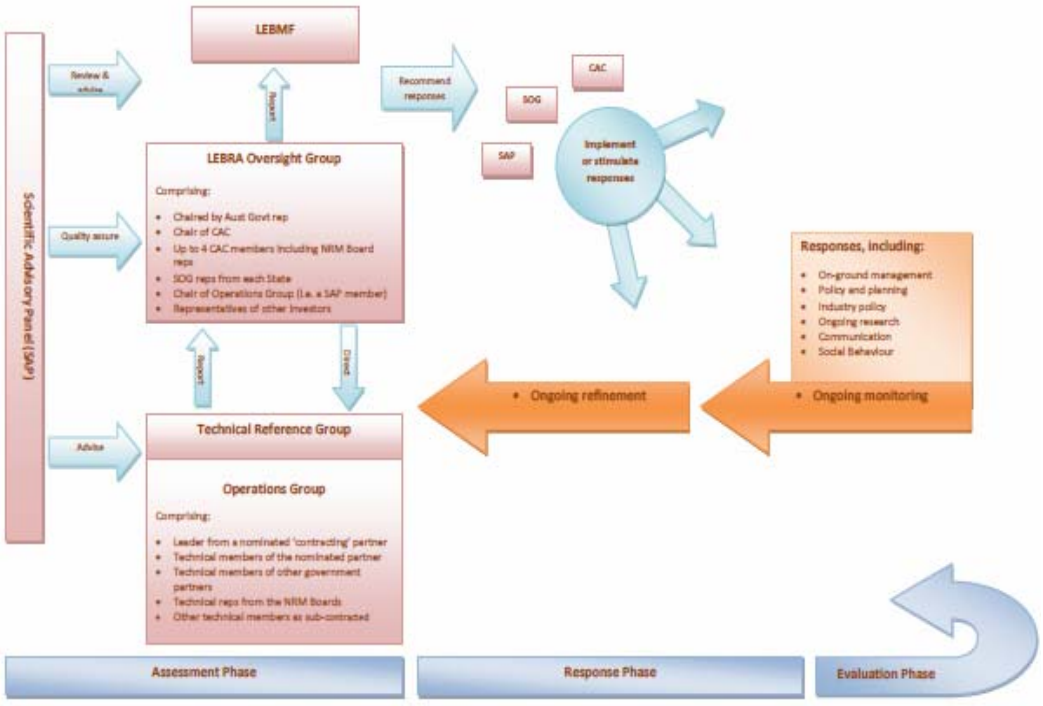
The business governance model outlined included the involvement of four distinct groups:

Table 4: Proposed governance structure

Group	Composition	Role
LEBRA Oversight Group (LOG)	Aust Govt rep (LOG Chair) Chair of CAC SOG reps (x4) Up to 4 CAC members including NRM Board reps Reps of other major investors Chair of Operations Group	- Governance and due diligence - Drivers - Guiding engagement, TCP and SAM - Strategy of data management – where - Annual reporting to Min Forum informed by Ops Group Annual Report - Comms role to stakeholders - persistence - Assessment (State of LEB) to Min Forum & SAM outcomes
Technical Reference Group	Independent Chair by SAP Senior reps of Ops Group agencies, including the NRM agencies	- Ongoing scientific steerage and coordination
Operations Group	The full assessment team as identified by the LOG and sub-contracted by the lead assessment agency. NRM agencies should be involved as part of a wider team.	- Undertake monitoring and analysis - Periodic reporting (4 yr assessment) - Preparation of annual tech/data report
Scientific Advisory Panel	As currently composed	- Advice to LOG , Ops Group and LEBMF at critical stage

Combining the above components, the governance model proposed follows:

Figure 3: Overview of the LEBRA implementation process



The details of these approaches are outlined in the Accompanying Report: *Implementation Plan and Business Governance Model.*

Business model

The business governance model incorporated into the Implementation Plan details the budgets and partnership arrangements required to successfully implement the Plan. A summary of the budget follows:

Table 5: Proposed budget

		Base level monitoring				Governance				
Phase	Year	LEB Assess-ment	Prepar-ation	Surveys	Analysis	Gover-nance[1]	Coordin-ation	Adaptive Mngt[2]	Commun-ication	Total
Establish-ment and monitoring	2009 - 10					$55 800			$10,000	$65 800
	2010 - 11		$259 000[3]	$465 000	$141 000	$75 600	$100 000	$70 000	$10,000	$1 140 600
	2011 - 12			$465 000	$141 000	$75 600	$100 000	$70 000	$10,000	$881 600
	2012 - 13			$465 000	$141 000	$75 600	$100 000	$70 000	$10,000	$881 600
Mid-term assessment	2013 - 14	$325 000		$465 000	(see assessment)	$75 600	$100 000	$70 000	$10,000	$1 065 600
Refinement & monitoring	2014 - 15			$465 000	$141 000	$75 600	$100 000	$70 000	$25 000	$896 600
	2015 - 16			$465 000	$141 000	$75 600	$100 000	$70 000	$10,000	$881 600
	2016 - 17			$465 000	$141 000	$75 600	$100 000	$70 000	$10,000	$881 600
10 year assessment	2017 - 18	$325 000		$465 000	(see assessment)	$75 600	$200 000	$70 000	$25 000	$1 180 600

[1] Includes costs for the LEBRA Oversight Group, Technical Reference Group and Operations Group
[2] Includes costs associated with running an annual workshop with stakeholders to reflect on results, identify responses and refine TPCs
[3] Includes $139,000 for equipment installation for 'state' datasets and $20,000 for identification of 'pressure' data-sets

Other sections of the Implementation Plan relevant to the business governance model include details of:

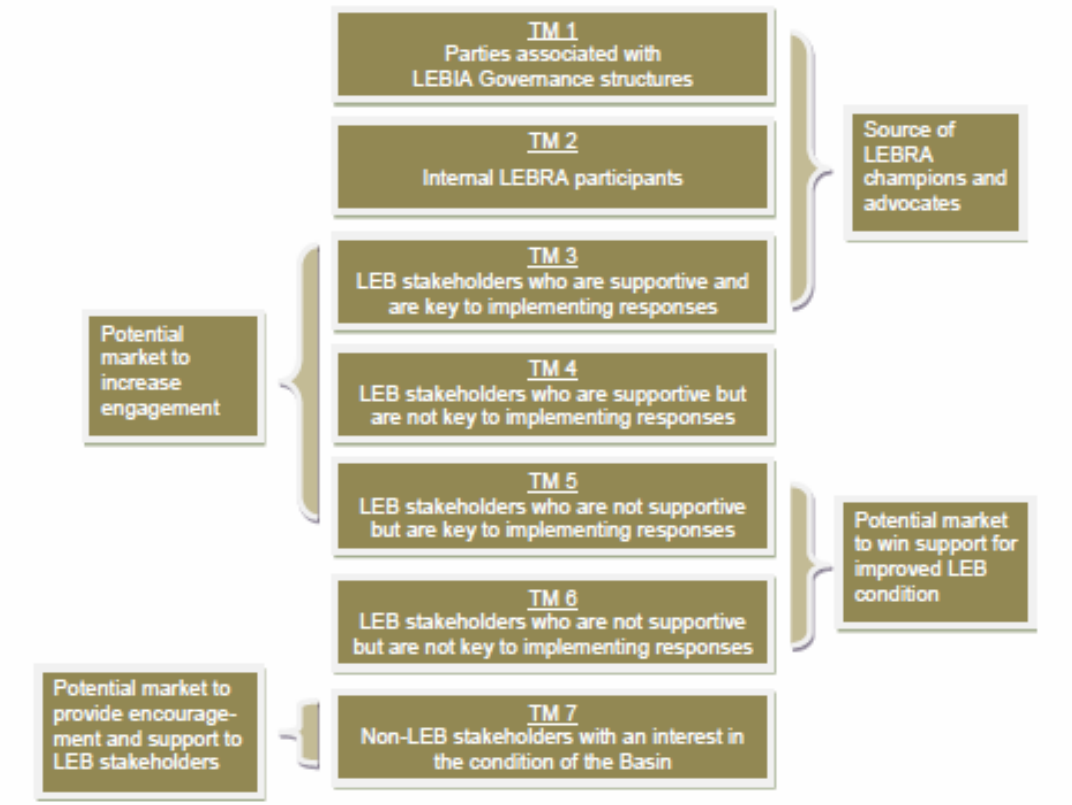
- Timeframe, phases and key actions
- Governance roles and responsibilities
- Coordination of the Plan
- LEBRA milestones 2010 through to 2018
- Scientific review and quality assurance
- Communicating the plan
- Framework for evaluating the implementation process.

4. Project communication

While the Kiri-ganai Research team has communicated the project through the phases of consultation associated with the development of the Implementation Plan, it is critical that a formal communication process take place following final agreement to the Implementation Plan.

Envisioning this need as a critical first step, the Implementation Plan includes a communication strategy based around seven target markets:

Figure 4: Proposed target markets for communicating the LEBRA



Specific details about the characteristics of these markets, the key messages to be conveyed and the desired responses to these messages are outlined in the Implementation Plan.

Appendix A: Terms of Reference

LEB Rivers Assessment Implementation Plan

The Department of Environment, Water, Heritage and the Arts requires the development of a Lake Eyre Basin Rivers Assessment Implementation Plan (Implementation Plan) to identify how regular on-going monitoring of key indicators of the condition of river ecosystems and catchments will be implemented within the Lake Eyre Basin Intergovernmental Agreement Area. The process of developing the Plan will involve:

1) Review of achievements to date under the Lake Eyre Basin (LEB) Rivers Assessment (Milestone 1)

a. A number of activities have been undertaken as part of the LEB Rivers Assessment to date. As part of developing the Implementation Plan, reports from these activities are to be reviewed and recommendations incorporated into the Plan for future on-going monitoring.

b. The Service Provider is to provide a draft report to the Department, for review and comment, indicating how the recommendations have been considered. The Service Provider will be required to address all comments received and provide a final document to the Department. The report should include, but is not limited to:

- the title of the report addressed;
- how the recommendations have been considered in developing the Methodology/Implementation Plan;
- any further action required.

2) An agreed LEB Rivers Assessment Methodology (Milestone 2)

As part of developing the Implementation Plan, the Service Provider is to finalise a methodology for monitoring that can be undertaken immediately, recognising that there will be a need for continued research and development of some indicators for future use.

This task will require the Service Provider to perform services including but not limited to:

a) identify the monitoring already being undertaken within the Lake Eyre Basin which will be included in the Implementation Plan;
b) identify the recommendations from previous LEBRA work that will be included in the Implementation Plan;
c) identify the indicators that were suggested in Method for Assessing the Health of Lake Eyre Basin Rivers that will be included in the Implementation Plan;
d) identify linkages with national monitoring, evaluation and reporting frameworks;
e) identify monitoring actions that can be undertaken immediately – summarise their methods and costs;

f) identify monitoring actions that require further research and development; and
g) advise on the appropriateness of reporting on a ten year basis or other timeframe.

3) Support development and documentation of governance arrangements (Milestone 3)

The Implementation Plan should briefly review the current responsibilities of the jurisdictions with the Agreement area and make recommendations on the options for governance associated with ongoing monitoring. The Service Provider is to provide a draft written report to the Department indicating suggested governance arrangements which includes but is not limited to:

a) reporting requirements;
b) the role of the Lake Eyre Basin Scientific Advisory Panel;
c) the role of Government officers;
d) the role of Regional Natural Resource Management groups;
e) links with Bureau of Meteorology;
f) scientific review of the program;
g) Quality assurance/quality control;
h) research and development issues independent of the assessment.

4) Development of a business model (Milestone 4)

The LEBRA Implementation Plan is to include an outline of how the monitoring activities will be funded or supported.

The Service Provider is to provide a draft report to the Department, for review and comment, indicating suggested governance arrangements. The Service Provider will be required to address all comments received and provide a final document to the Department. The report should include, but is not limited to:

a) the organisation committed to providing funding or support;
b) the funding or support to be provided;
c) the source of the funding or support; and
d) duration of commitment

5) LEB Rivers Assessment Implementation Plan (Milestone 5)

Using information from Milestone Reports 2, 3 and 4 the Service Provider will prepare a draft LEB Rivers Assessment Implementation Plan. The Service Provider will be required to address all comments received and provide a final document to the Department. Detail on what is to be included in the Implementation Plan is to be discussed with the Steering Committee.

6) Workshop (Milestone 6)

After completion of Milestone 5 the Service Provider is required to organise and participate at a workshop with relevant stakeholders. The location and duration of the workshop will be determined by the Steering Committee and the Service Provider together, and may include participation of some stakeholders by telephone. The services that will be required include, but are not limited to:

a) Organisation of the workshop (location to be agreed with the Steering Committee, will be a capital city).
b) Attendance and presentation at the workshop which will include:
    - outlining the approach undertaken to develop the Implementation Plan;
    - feedback received from stakeholders;
    - commitment to regular on-going monitoring of key indicators of the condition of river ecosystems and catchments.

Appendix B: References used in this project

Bailey, V. 2001. Western Streams Water Quality Monitoring Project. Queensland Department of Natural Resources and Mines, Brisbane.

Bailey, V. and Long, P. 2001. Wetland, Fish and Habitat Survey in the Lake Eyre Basin, Queensland: Final Report. Queensland Department of Natural Resources and Mines, Brisbane.

Balcombe, S.R. and Kerezy, A. 2008. Preliminary Fish Sampling for the Lake Eyre Basin Rivers Assessment: Testing the Fish Trajectory Model. Australian Rivers Institute, Griffith University.

Balcombe, S.R. and McNeil, D.G. 2008. Joint Recommendations for fish monitoring in Lake Eyre Basin Rivers: testing the Fish Trajectory Model in Queensland and South Australia.

Biggs H.C., Rogers K.H., 2003. An adaptive system to link science, monitoring and management in practice. In: du Toit J.T., Rogers K.H., Biggs H.C. (Eds). *The Kruger Experience: Ecology and Management of Savanna Heterogeneity.* Island Press: Washington.

Bunn SE, Thoms MC, Hamilton SK and Capon SJ (2006) *Flow variability in dryland rivers: boom, bust and the bits in between*. River Research Applications 22: 179-186

Carpenter S.R., Folke, C., 2006. Ecology for transformation. *Trends in Ecology and Evolution,* 21: 309-315.

Chapin III FS, Kofinas GP and Folke C (2009) *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World* (Springer, New York)

Choy S (2009) *Enhanced Water Resource Assessment and the Aquatic Ecosystem Framework*. (Internal working document) DNRM: Brisbane

Choy SC, Thompson CB and Marshal JC (2002) 'Ecological condition of central Australian aridzone rivers' *Water Science and Technology* **45**(11): 225–232

Commonwealth of Australia (2001) Lake Eyre Basin (Intergovernmental Agreement) Act 2001: Consolidated Agreement.

Costelloe, J. 2008. Updating and Analysis of the ARIDFLOD water level data in the Lake Eyre Basin. Report to the South Australian Department of Water Land and Biodiversity Conservation, Adelaide. University of Melbourne.

Costelloe, J. 2007. Final Report: Maintenance of ARIDFLOD Logger Network. University of Melbourne.

Desert Channels Queensland Inc. (2009) Caring for O*ur Country Application on behalf of LEB Partners*. DCQ: Longreach

Desert Channels Queensland Inc. (2004) *Our country: Our community. A community information paper for the Queensland section of the Lake Eyre Basin*. DCQ: Longreach

Dept of Environment, Water, Heritage and the Arts. (2009) *LEB CAC Rivers Assessment Actions 2003 to 2009*. Internal Working Document. DEWHA: Canberra

Dept of Environment, Water, Heritage and the Arts. (2005) Notes from the LEB Rivers Assessment Workshop March 22 & 23 2005, Brisbane. DEWHA: Canberra

Dept of Environment, Water, Heritage and the Arts. (2003) *LEB Rivers Assessment Brochure.* DEWHA Canberra

Dept of Environment, Water, Heritage and the Arts. (2003) *LEB Rivers Assessment Brochure.* DEWHA Canberra

Dept of Environment, Water, Heritage and the Arts. (2003) *Agreement for Provision of [funds] to Land and Water Australia for managing the project: "Lake Eyre Basin Rivers Assessment"*. DEWHA: Canberra

Dept of Natural Resources & Mining (2009a) *Stream & Estuary Assessment Program Aquatic Ecosystem Monitoring: A new approach* (Brochure) DNRM: Brisbane Dept of Natural Resources & Mining (2009) *Development of Conceptual Pressure-Vector-Response Models for Queensland's Riverine Ecosystems*. (SEAP technical paper 1)

Dept of Natural Resources & Mining (2009b) *Stream & Estuary Assessment Program Aquatic Ecosystem Monitoring: A new approach* (Brochure) DNRM, Brisbane

(2009c) *Development of Conceptual Pressure-Vector-Response Models for Queensland's Riverine Ecosystems*. (SEAP technical paper 1) DNRM, Brisbane

Duguid A, Barnetson J, Clifford B, Pavey C, Albrecht D, Risler J and McNellie M (2005) *Wetlands in the arid Northern Territory. A report to the Australian Government Department of the Environment and Heritage on the inventory and significance of wetlands in the arid NT*. (Northern Territory Government Department of Natural Resources, Environment and the Arts. Alice Springs.) (http://www.nt.gov.au/nreta/wildlife/nature/aridwetlands.html)

Fairweather, P.G. (1999). State of environment indicator of 'river health': exploring the metaphor. *Freshwater Biology* **41**: 211-220

Good, M., Bailey, V., Pritchard, J. and Wedderburn, S. 2008. ARIDFLO Building Our Knolwedge of Lake Eyre Basin Rivers: A Report to the Community. South Australian Department of Water, Land and Biodiversity Conservation, Adelaide

Groffman, P. M., J. S. Baron, T. Blett, A. J. Gold, I. Goodman, L. H. Gunderson, et al. 2006. Ecological thresholds: the key to successful environmental

management or an important concept with no practi-cal application? *Ecosystems* 9:1–13

Gunderson L.H., Holling C.S. (eds), 2002. *Panarchy: Understanding transformations in human and natural systems.* Island Press, Washington, DC.

Hamilton SK, Bunn SE, Thoms MC and Marshal JC (2005) *Persistence of Aquatic Refugia between Flow Pulses in a Dryland River System (Cooper Creek, Australia)* Limnology and Oceanography 50 (3): 743-754

Herr, A., Smith, T. and Brake, L. 2007. Regional Profile of the Lake Eyre Basin Catchments, CSIRO Sustainable Ecosystems, Townsville and Desert Knowledge CRC, Alice Springs

Holling CS (ed.) (1978). Adaptive Environmental Assessment and Management. (Chichester, Wiley)

Humphries, P., George, A., Balcombe, S., van Daele, D., Larson, H., Harris, J. and Kennard, M. 2007. Report on the LEBRA Workshop: Determining the Natural Trajectory of Fish with the Lake Eyre Basin, November 20-21, 2006. Report to the Department for Water, Land and Biodiversity Conservation, South Australia.

Hunt J and Smith D (2007) *Indigenous Community Governance Project: Year two research findings.* (CAEPR, ANU, Canberra)

Jaensch R (2008) F*loodplain wetlands and waterbirds of the channel country*. South Australian Arid Lands NRM: Adelaide

Kingsford, R.T. and Porter, J.L. 2008. Scientific Validity of Using Waterbird Measures to Assess River Condition in the Lake Eyre Basin. University of New South Wales, Sydney

Ladson, T., Weinmann, E. Costelloe, J. and Tillard, J. 2006. Lake Eyre Basin Data Logging Review. Moroko Pty Ltd.

Lake Eyre Basin Community Advisory Committee (2008) *Report to the Sixth Meeting of the Lake Eyre Basin Ministerial Forum 18 April 2008*, Melbourne. DEWHA: Canberra

Lake Eyre Basin Ministerial Forum Scientific Advisory Panel (2009). *Lake Eyre Basin Knowledge Strategy*. (Internal Working Document) DEWHA: Canberra

Lake Eyre Basin Government Officers Working Group (2006) *Lake Eyre Basin Agreement Strategy Implementation*. DEWHA: Canberra

Lake Eyre Basin Ministerial Forum (2005) *Agenda Papers for Ministerial Forum Meeting No.4 (14 October 2005)*. DEWHA: Canberra

Lake Eyre Basin Ministerial Forum (2004) *Agenda Papers for Ministerial Forum Meeting No.3 (10 June 2004).* DEWHA: Canberra

Lake Eyre Basin Ministerial Forum (2002) *Agenda Papers for Ministerial Forum Meeting No.2 (25 October 2002).* DEWHA: Canberra

Lake Eyre Basin Rivers Assessment Project Steering Committee (2004) *Minutes of Meeting Thursday 20 May 2004*. DEWHA: Canberra

Lake Eyre Basin Scientific Advisory Panel (2009) *State of the Basin 2008: Rivers Assessment*. DEWHA: Canberra

Land & Water Australia (2003) *Lake Eyre Basin Rivers Assessment Methodology Development: Project Brief*. LWA: Canberra

LEBSAP. 2009. State of the Basin 2008: Rivers Assessment. Background and Reference. Lake Eyre Basin Scientific Advisory Panel

Likens G.E., 1992. *The Ecosystem Approach: Its Use and Abuse.* Ecology Institute: Germany.

McMahon, T.A., Murphy, R., Peel, M.C., Costelloe, J.F. and Chiew, F.H.S. 2008. Understanding the surface hydrology of the Lake Eyrre Basin: Part 2 – Streamflow. Journal of Arid Environments 72: 1869-1886

McNeil, D. and Reid, D. 2008. Preliminary Fish Sampling for the Lake Eyre Basin Rivers Assessment: Testing the Fish Trajectory Model in South Australia. South Australian Research and Development Institute

McNeil, D., van Dele, J., Larson, H., Humphries, P., Harris, J., Balcombe, S. and Kennard, M. 2006. Report on the LEBRA Workshop: Determining the natural trajectory of fish within the Lake Eyre Basin, November 20-21, 2006

Moran M and Elvin R (2009) 'Coping with complexity: adaptation of the governance system of Aboriginal affairs in desert Australia'. *GeoJournal*: in press.

Morgan, G. 2000. Landscape Health in Australia. A Rapid Assessment of the Relative Condition of Australia's Bioregions and Subregions. Environment Australia and the National Land and Water Resources Audit, Commonwealth of Australia, Canberra.

Norris, R.H., Linke, S., Prosser, I., Young, W.J., Liston, P., Bauer, N., Sloane, N., Dyer, F., Thoms, M.C., (2007). Very-broad-scale assessment of human impacts on river condition. *Freshwater Biology*, **52**, 959-976.

Office of the United Nation High Commissioner for Human Rights (OUNHCHR) (200&) *Good Governance practices for the protection of human rights*. (United Nations, Geneva)

Ostrom E (1999) 'Coping with tragedies of the commons'. *Annual Review of Political Science* **2**:493-535.

Parsons ME, Thoms MC, Norris RH (2004). Development of a standardised approach to river habitat assessment in Australia. *Environmental Assessment and Monitoring*. 98, 109-130.

Phelps D, Lynes BC, Connelly PT, Horrocks DJ, Fraser GW and Jeffery MR (2007) *Sustainable Grazing in the Channel Country Floodplains (phase 2): A technical report on findings between March 2003 and June 2006*. Meat & Livestock Australia: Sydney

Price P and Lovett S (2008) *Consultancy to develop a draft Five Year Action Plan for the Lake Eyre Basin*. DEWHA: Canberra

Rogers K. & Biggs H. (1999). Integrating indicators, endpoints and value systems in strategic management of the rivers of the Kruger National Park. *Freshwater Biology* 41, 439-451

Rogers K.H., Sherwill T., Grant R., Freitag-Ronaldson S., Hofmeyr M., 2008. *A Framework for Developing and Implementing Management Plans for South African National Parks.* South African National Parks, Pretoria. Available from http://www.sanparks.org/parks/kruger/conservation/scientific/key_issues/plans/adaptive/default.php

Sheldon F, McKenzie-Smith F, Brunner P, Hoggett A, Shephard J, Bunn S, McTainsh G, Bailey V and Phelps D (2005) *Lake Eyre Basin Rivers Assessment Methods Development Project Methods for Assessing the Health of Lake Eyre Basin Rivers: Final report to Land & Water Australia*. (LWA, Canberra)

Sheldon F, Brunner P and Hoggett A (2005) *A Lake Eyre Basin Rivers Assessment Methodology Development Project Background Document 2: Classification of the Lake Eyre Basin Rivers*. (Griffith University, Brisbane)

Sheldon F and Leigh C (2005) *Lake Eyre Basin Rivers Assessment Methodology Development Project Background Document 4: Review of Ecological Indicators and Assessment Programs*. (Griffith University: Brisbane)

Sheldon F (2003) Lake *Eyre Basin Assessment Methodology Development Project Milestone Report No. 1* 31st October 2003 (LWA, Canberra)

Stafford Smith M (In publication) 'Contribution to report on Vulnerability of Remote Indigenous Communities in Northern Australia to Climate Change: Adaptive capacity and governance dimensions'

Stafford Smith M (2008) The 'desert syndrome' - causally-linked factors that characterise outback Australia. *The Rangeland Journal* **30**:3-14.

Stafford Smith M and Cribb J (2009) *Dry Times: A Blueprint for a Red Land*. (CSIRO Publishing, Melbourne: forthcoming)

Stafford Smith DM, Abel NO, Walker BH and Chapin III FS (2009). 'Drylands: coping with uncertainty, thresholds, and changes in state' In: *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World*. (Eds F. S. Chapin, III, G. P. Kofinas and C. Folke.) pp. 171-195

Stafford Smith M, Moran M and Seemann K (2008) The 'viability' and resilience of communities and settlements in desert Australia. *The Rangeland Journal* **30**:123-135.

Stewardson M, Costelloe J, Siggins A and Sims N and Turral H (2009) *Using Remote Sensing to Monitor River Health in the Lake Eyre Basin.* Draft report to Department of Water, Land and Biodiversity Conservation (DWLBC, Adelaide)

Townsend C.R. & Riley R.H. (1999). Assessment of river health: accounting for perturbation pathways in physical and ecological space. *Freshwater Biology* 41, 393-405

Thoms, M.C., Dyer, F (2004). Hydraulic diversity in a regulated river. *Fifth International Sympoium on Ecohydraulics. Aquatic habitats: Analysis and restoration*, Madrid, Spain, 1289-1293

Walker B., Salt, D., 2006. *Resilience thinking: Sustaining ecosystems and people in a changing world.* Island Press, Washington, DC.

Walker KF, Puckridge JT and Blanch SJ (1997) *Irrigation development on Cooper Creek, central Australia: Prospects for a regulated economy in a boom-and-bust ecology.* Aquatic Conservation: Marine and Freshwater Ecosystems 7: 63-73

Appendix C: Stakeholders consulted

Place	Name	Organisation
Canberra	Derek White	Dept of Environment, Water, Heritage & Arts
	Don Blackmore	World Bank
	Craig James	Desert Knowledge CRC
	Tim Fisher	Minister Wong's Office
	Mark Sjolander	Parliamentary Sec. Kelly's Office
	Doug Watkins	Wetlands International
	Mark Stafford Smith	CSIRO Sustainable Ecosystems
Brisbane	Stuart Bunn	Griffith University
	Fran Sheldon*	
	Stephen Balcombe	
	Satish Choy	Dept of Environment & Resource Management
	Bill Reurich	
	Peter Old	
Longreach	Vol Norris	LEB Facilitator
	Angus Emmott	LEB Community Advisory C'tee
	David Phelps	Dept of Employment, Economic Development & Innovation (formerly DPIF)
	Luw Markey	
	Mike Chuk	Desert Channels Qld Inc
	Vanessa Bailey	
	Alun Hoggett	
Adelaide	Ben Fee	Dept of Water, Lands & Biodiversity Conservation
	Dale Lewis	
	Henry Manchini	
	Glenn Schulze	
	Jenny Cleary	South Australian Arid Lands (SAAL) NRM Board
	Kirrilie Rowe	
Alice Springs	Ian Fox	Dept of Natural Resources, Environment, the Arts and Sport
	John Wischusen	Geoscience Australia
	Richard Walsh	Centralian Land Management Assoc
	Hugh Pringle	Bush Heritage Australia
Darwin	Kate Andrews*	NT NRM Board
Sydney	John Porter	University of New South Wales

* Teleconference

Scientific Advisory Panel and Senior Officer Group members not listed above were involved in the LEBRA Workshop convened on 22-13 August 2009 (see Appendix D)

Appendix D: Workshop notes

LAKE EYRE BASIN RESOURCE ASSESSMENT
IMPLEMENTATION PLAN
WORKSHOP

MACQUARIE ROOM, BRASSEY HOTEL
CANBERRA

TUESDAY 11 AND WEDNESDAY 12 AUGUST 2009

Mike Williams – Facilitator

Attendees - Angus Emmott, LEB CAC
Bill Young,LEB SAP
Derek White, Australian Government
Glen Scholz, SA Government
Mark Stafford Smith, LEB SAP
Martin Thoms, Technical Consultant, Kiri-ganai Research
Richard Price, Kiri-ganai Research
Satish Choy, Queensland Government
Vol Norris, LEB Facilitator
Richard Kingsford, LEB SAP
Stuart Bunn, LEB SAP

Apologies - Tuesday 11th – Richard Kingsford and Stuart Bunn

Tuesday 11 August

Day 1 - Introduction by Mike Williams.

Purpose of the workshop and call to action by Richard Price.

Presentation on draft indicators by Martin Thoms.

Following lunch –

Key Decision Points – Indicators we can agree to now and get on with it.

- Framework – general approach
- Is there a clear conceptual model driving the choice of indicators – credible/ best available – preliminary TPC (ask Richard and Stuart) – explicit hypotheses – response to TPC – learning from multiple examples/replication
- Are the suggested components the most efficacious – others - preliminary TPC (ask Richard and Stuart) – explicit hypotheses – response to TPC – learning from multiple examples/replication
- Key issues – frequency – regular and/or event; stratification/site choice ; priority ; utility of existing information
- Communication of the model/indictors rationale – triple loop learning

Hydrology – Why is it not a component? - need drivers – need response
- Existing – designing new / or integrating existing
- Is there a conceptual model to provide rationale?
- Knowledge of drivers
- Could capture existing info/data

Outcome: more components required, including Flow/Water regime, Climate and Pressures

Drivers – natural – man made
MARTIN TO COMPLETE – emphasis on compilation, collation, analysis and reporting

Specific Indicators	Pressure - P Drivers - D	Links to pressures/drivers/risks
Land use/mgt – veg clearance/veg cover		
Water Storage		
Water extraction		
Floodplain structures – linear structures – roads etc		
Climate		
Tourism use – fishing		
Fish stocking		

Water/Hydrology/Flow regimes – as a response

Specific Indicators	Report - R Measure – M	Comments
No. of days of no flow	R	Integrated into existing data collection Put into context of Tom McMahon, water data logger, hydrology remote sensing, existing state/territory data collection etc
No. of days of over bank/floodplain inundation	R	
Extent (duration and timing?) of inundation	R	
No. of days in channel flow	R	
Water hole persistence (time & space)	R	
No. of days since last flow	R	
Long term flow variability	R	Action: Flesh out Assess ready to progress Is it in, R&D Examples of TPC
Flow predictability	R	
Water quality?		
Sediment geo-chem?		1 per 5-10 years – stratified sample – 100-150 sites across LEB
Wet/dry cycling?		

Outcomes:
Framework developed on which can proceed – TPC : how, who, etc – learning process - adaptive management

Components – five + pressures and hydrology response as components – bring up to some level of detail in revised Milestone Report - TPCs

Ensure component linkages are unequivocal

Need to address the frequency and stratification issues and consistency with framework and component conceptual models

Costing to include coordination, reporting, engagement and analysis

Engagement of other SAP members to improve confidence

Governance: Issues for 12 August session

Governance of ongoing monitoring not just the 'do it now'

Risks to governance model selection – emphasis on analysis – reporting and comms

Collaborative and project management – leadership

Governance of what? – governance, within an adaptive framework – scope of governance

Who does it and who responds to it – engagement of target audience

Wednesday 12 August – Day 2

Richard Price gave a presentation on Governance for the LEB.

Discussion took place on the principles of 'good governance' and other issues related to governance.

Need to add: Engage – ensure persistence – investor membership

After lunch session –

Two small work groups to report on OH transparency –

Group 1 – Governance
- Roles
- Responsibilities
- Who's in on Group
- To whom do the Group report

Oversight Group
Tech Ref Group
Legal entity who is doing the monitoring Group
. SAP

Group 2 – Critical path

- Tasks and timelines on the critical path
- Strategic Adapt mgmt process – TPC etc
- Finish this project etc
- Get groups up and running

Governance by Group 1 – Stuart, Vol, Richard P, Bill, Derek, Chris
Oversight/Implementation Group –
Role
- governance and due diligence
- drivers
- guiding engagement TCP and SAM
- strategy of data management – where
- annual reporting to Min Forum informed by Ops Group Annual Report
- Comms role to stakeholders - persistence
- assessment (State of LEB) to Min Forum & SAM outcomes

Composition : Chair of CAC and other CAC nominees eg SOG (4) to cover NRM Board interests – skills and rep role (4)
Time, interest, resources
Other investigator(s) – code of conduct?
Chair by Aust Govt – jurisdictional interest (from SOG)

SAP observations :
- Chair Tech Ref Group
- SAP R&D guidance and triple loop
- QA of Min Forum reports and commentary on adequacy, governance, approach

Ops Group – Single consortium – brokered by oversight group/sub-group – inc jurisdictions and NRM Boards - consultants
- - undertake monitoring and analysis
- - periodic reporting, 4 yr assessment
- - annual tech/data report to

Implementation Group & SAP

Sub-group of Ops Tech Ref Group
- ongoing scientific steerage
- independent Chair by SAP
- senior reps

Risks to suggested governance model
- funding
- lack of persistence - real feedback flow on regular basis
- sensitivity of data sharing with significant implications on efficiency of responses
- capacity of individuals – multiple roles on multiple governance gaps – clarity of roles critical
- data sharing protocols – messy and time consuming in past
- engage possible Ops Group early especially NRM Boards
- efficacy of code of conduct for private investor perspective in Implementation Group

Critical path by Group 2 – Satish, Mark, Richard, Glen and Angus

End Sept 2009? - Seven components delivered by Kiri-ganai Research
- Defined conceptual models
- Rough TPCs
- Rough budget and potential co-contributors
- Rough design
- Project duration (Initial phase 4 years, final phase 2018)

End Sept 2009-Commitment by Government (Ministerial Forum) to project – (i.e. $ plus programme); business case; agreement by SOG at Alice Springs Meeting

End Sept 2009-Identification of Implementation Group membership/ Technical Group; terms of reference; by SOG at Alice Springs Meeting

April 2010-Agreement by Ministers on Rivers Assessment Implementation -

Nov 2009- Sign-off by SOG on membership of Implementation Group/ Technical Group

Jan-Mar 2010 - Implementation Group/ Technical Group convene workshop(s)

- Review Conceptual models/
- Develop objective hierarchy/ context/
- TPCs
- Detailed monitoring design (stratification, frequency of sampling, analysis etc)
- Assess projects and prioritise/ access additional funding
- Identify data storage options and outputs
- Coordination of tendering/ contracting/ output

Dates	Base monitoring programme	Assessment process	Evaluation and feedback (learning)
Early 2010	Project specification		Convene workshop(s) for development of conceptual models/ objective hierarchies/ context/ TPCs; preliminary analysis of available data
June-Sept 2010	Tendering and contracting – “identifying deliverer”; Implementation Group decides on “contractors”		Ensuring engagement in projects and interest; succession plans
End of 2010	Implementation by “contractors”		
Year 1 - 2011	Annual reporting on each component/ feedback to TPCs, objectives, study design	Implementation Group decides on assessment of base monitoring programme	Annual reporting - Stakeholders, Implementation Group, Ministers
	Annual data collation and synthesis		

Dates	Base monitoring programme	Assessment process	Evaluation and feedback (learning)
Year 2-2012	Annual reporting on each component/ feedback to TPCs, objectives, study design	Preliminary data analysis and methodology review and development for integration	Review design methodology, using collected data; reviewing TPCs
		Implementation Group Assessment of other research priorities	Annual reporting - Stakeholders, Implementation Group, Ministers
	Biennial analysis and specification of potential baselines for each component	Status relative to TPCs; and assessment of whether any relevance for management	Influence relevant management
2013	Implementation of other research priorities	Implementation Group assessment of budget for other research priorities	Review design methodology, using collected data
	Annual reporting on each component/ feedback to TPCs, objectives, study design		Annual reporting - Stakeholders, Implementation Group, Ministers
End of Initial Phase-2014	End of initial phase and assessment of ongoing programme with synthesis of all component data	Full assessment by Implementation Group (trial run)	Major review of design methodology, using collected data and timely decision on direction of Phase 2
Phase 2 - 2015			
Annual reporting			Review design methodology, using collected data
Final reporting – 2018	Final report for each component. Synthesis report integrated for Rivers Assessment	Full assessment for reporting to Ministers and Community	Major review of design methodology, using collected data and timely decision on direction of next phase; Review Institutional Arrangements

Next Steps

Milestone 2 revised – deadline 21 August. Complete Milestone 3 by 28 August. Min Council to see 18 September and final report by end of September.