

# Sediment Nutrient Transport and Budgetting



**Chris Moran**, Myriam Bormans, Jim Cox, Peter Hairsine,  
Rod Oliver, Jon Olley, Peter Wallbrink, Bill Young

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## PREFACE

The study of catchments has been part of the core business of CSIRO for many years. In no small part due to this research, Australia is more aware of our natural legacy, the importance of our catchments to our well being, the profound changes in catchment function and health we have brought about, and the opportunities and challenges ahead.

Catchment science embodies diverse fields of research, from detailed physics and chemistry, to biology and ecology, to mathematics and statistics, to sociology and economics. The integration of this knowledge is itself a science. The provision of sound technical underpinning to catchment management is a continuing and rewarding scientific challenge.

CSIRO Land and Water maintains a strong commitment to catchment science in aid of improving the lives of Australians and their environment. Part of that commitment involves reviewing our recent scientific accomplishments, our current research portfolio, and the direction our research needs to take into the future.

This series captures CSIRO Land and Water research in catchment science since 1993, some of the current directions, and where our research should take us. We hope that this serves as basis for continual discussion and active debate on the nature and value of science to issues of high national importance like the health of our catchments.

Technical Reports in this series are:

No. 18: Land Use and Catchment Water Balance: Tom Hatton

No. 19: Catchment solute Balance: Glen Walker

No. 20: Sediment Nutrient Transport and Budgetting: Chris Moran (and contributors)

No. 21: Integrated Catchment Science: Rob Vertessy

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## INTRODUCTION

This review covers the research outputs that have positioned CLW to undertake work in sediment and nutrient transport and transformations in large catchments. It is apparent that over the last ten years CLW has not undertaken the majority of our sediment and nutrient work on whole catchment units. We have carried out a large body of work in developing and applying methods to establish the major sources of sediment and attached nutrients. Sources, in this context, include geomorphic features, geological heritage, soil materials and transport pathways. We have also advanced in the area of sediment deposition including applications to residence times, landscape storages and dating of soil and sediments. There has been a strong emphasis on understanding the interaction of sediment, nutrients and the water column in rivers and water storages to help manage algal blooms. We have conducted a limited number of studies aimed at clarifying the sub-catchments that contribute to sediment and attached nutrient loads at important locations in river systems. Our work in catchment modelling is less extensive but demonstrates our capability to use the extensive process understanding to develop whole system models from catchment source to estuary.

The background in the early 1990's to this area of work revolved around examining several commonly held and expressed assertions:

- Surface soil erosion is wide spread. It is a major production and environmental problem which can largely be controlled through earthworks, i.e., contour banks and vegetative strips.
- Surface soil erosion is the dominant source of sediment to our rivers.
- Gullies form because clearing in catchments results in greater water yields and increased overland flow.

- Gully erosion is an active contemporary process whose extent can be controlled through stabilising the gully head above the gully with vegetation or below the gully head with in-filling earth works and/or use of rocks (where available) or cementation.
- Algal blooms are caused by the delivery of phosphorus from fertiliser and sewage treatment plants (natural soil phosphorus was not considered as a contributor to the algal bloom problems).
- The most important aspect of river flows is assured supply of water for production, especially for irrigation.

In 1991 an algal bloom occurred along approximately 1000 km of the Darling River in the West of the Murray-Darling Basin. This resulted in broad press coverage, with the bloom being described as a natural disaster rather than, as previously, an important issue but more of a nuisance than a serious threat to the environment, stock and people. From a technical perspective this response had considerable dubious facets relating to the accuracy of the statements regarding human causation. Nevertheless this event was sufficient to mobilise research and funding agencies to initiate a number of significant programs aimed at improving understanding the causes and dynamics of algal blooms. The LWRDC National Eutrophication Program (NEMP), co-ordinated by Richard Davis from CLW, was a significant example. A second investment was the CSIRO Multi-Divisional Program Dryland Farming for Catchment Care (DFCC) co-ordinated by John Williams from CLW. Partnership in the first round of the Cooperative Research Centre for Catchment Hydrology (CRCCH) permitted significant CLW involvement in catchment-scale studies in the Tarago Catchment (initiated as a result of a toxic algal bloom in the Tarago reservoir – a part of Melbourne’s drinking water supply) and the SE forests of NSW. The latter was an attempt to put a conceptual model and measurements into the politicised question of the extent to which erosion following logging in old growth forests resulted in decreased stream water quality. The CSIRO Algal Research Program facilitated research into the algal and physical environmental dynamics of weir pools (Maude Weir) and rural reservoirs (Chaffey Dam). Partnership in the CRC for Freshwater Ecology (CRCFE) in association with NEMP allowed follow-up work in the Fitzroy River catchment.

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Given the assertions noted above, the questions arising that were relevant to this review were:

- What are the sources of sediment and nutrients to river systems?
- What erosion processes dominate the delivery of sediments to rivers?
- What are the sources of nutrients that trigger and sustain algal blooms?
- What are the links between delivery of sediments and nutrients to waterways and the appearance of algal blooms?
- Is phosphorus the primary limiting nutrient in Australia waterways?
- What are the links between algal blooms and disruption of aquatic food web structures due to changes in physical habitat particularly with respect to sediment smothering of habitat?
- To what extent do the conditions in one part of the river (including water storages) influence the likelihood of algal blooms downstream?
- Are river and storage algal blooms significantly different?
- What land management strategies are useful to prevent sediment and nutrient delivery to waterways?
- In forest environments, is it possible for native forestry operations and pristine streams to co-exist?
- What land use and management regimes are most likely to contribute to algal blooms?
- To what degree is there a co-occurrence of productivity loss from soil (and nutrient) erosion and ecological impact following the arrival of the transported materials in the waterways?

This review does not contain the answers to all these questions but highlights research results that are contributing towards practical management options for algal blooms that balance the land use requirements and waterway condition.

During the period since the Darling River bloom the issue of environmental flows to rivers has arisen through the Council of Australian Governments (COAG) water reforms process. This has led to a broadening of the considerations of waterway and floodplain condition beyond the occurrence of algal blooms, e.g., impacts of sediment on benthic habitat through increased bed material loads (projects include Agriculture, Forestry and Fisheries Australia Fish rehabilitation project, CRCCH Project 2.1, and the National Land and Water Resources (NLWRA) Waterway Condition Project). The research programs initiated as a result of the former have placed CLW in a strong position to respond to requirements of the COAG environmental flows legislation and the National Land and Water Resources Audit. Further, our positioning in these fields has made us attractive research partners as evidenced by CLW partnership in some 13 CRC's including second rounds of Catchment Hydrology and Freshwater Ecology and the new Centre for Coastal Waterways and Estuarine Management.

The work-in-progress is focussed on delivering to the CSIRO Land and Water Sector in

## **Components**

### **1: National Water Reform**

- Understanding of effects of flow changes on physical structure and ecological life of large rivers.
- Model of the transport and transformations of materials down large river system.

### **2: Healthy Coastal Rivers and Estuaries**

- Improved assessment of diffuse and point source contaminant inputs in receiving waters and sediments.
- Targeting of catchment management of nutrient loads and sediment loads.

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- Land management strategies identified that reduce impacts from acid sulfate soils, pesticide applications, toxicant inputs, sediment transport, nutrient release and algal blooms, and that improve the biological function of systems..

### **3: Urban Water Storages and their Catchments**

- Capacity to minimise the risk of water contamination through an understanding and ability to predict the source, fate and transport routes of biological contaminants and identify their source (e.g., human or animal origin).
- Techniques to trace catchment sources of nutrients and sediments.

This review concludes with some indications of work-in-progress and outlines an agenda for extending the research in sediment and nutrient transport to the more general consideration of land use impacts on the terrestrial environment (soil conditions and productivity) and links to the condition of waterways (as evidenced through a biogeochemical process interpretation of long-term water quality monitoring data).

## SEDIMENT AND NUTRIENT SOURCES

When framing the research required to provide management solutions to problems associated with sediment and nutrient delivery to channels the first questions posed are:

- i) what is the course of the majority of sediment and nutrients delivered to the river;  
and
- ii) what erosion processes and/or land uses are responsible for their generation?

The assumption behind these questions being that for long term solutions the source must be controlled ("switched-off") to limit the in-stream problems. In this section we deal with developments in methodology and applications to clarify, for various systems, the major sources (and equally importantly, non-sources) of sediment and nutrients and the erosion processes that generate them.

Here we focus on which landscape features, and to a lesser degree which processes, dominate the supply. We consider the contributions to sources from different sub-catchments in a later section. The controversy relating to surface and subsurface sources has been the major focus as it was necessary to develop robust methods before the sourcing question would be investigated. Consistently these techniques arrived at the result that the majority of sediment is derived from subsoils (there are exceptions to this – for example, the study of Dyer, Olley *et al.* in the Tarago Catchment found surface sources to predominate. Also, Ian Prosser's budget in the Coventry Creek catchment in North Queensland found surface sources to be overwhelmingly dominant.). Investigations on the formation processes and sediment supply capacity of gullies were required to ascertain whether gullies could be **?explanation?** of the sediment supply. It was concluded that bank reworking through the channel network was also a significant source. A program of investigation into the importance of riparian vegetation for bank stabilisation then ensued. This work continues today.

Once we were able to determine the source of sediments, principally using radioactive isotope and geochemical tracing, it has become necessary to examine whether the delivery

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of nutrients is also explained by their being attached to the sediment. We have concluded that sediment and attached phosphorus moves to streams by a range of mechanisms. In environments with active gullying, sediment and P from gully walls and channel banks dominate loads in the channel. For texture contrast soil in southern Australia, P and colloid movement via lateral flow through the solum has been demonstrated. For agricultural landscapes with significant overland flow and surface erosion, sediment and P move via overland flow.

Programs to examine the sources and pathways for nitrogen delivery are currently being developed.

#### *Research results and progress*

- The development and testing of chemical and physical tracer techniques to investigate the spatial sources of sediments and nutrients.
- Developed tracing techniques using a number of fallout and naturally occurring radioisotopes to examine the relative contribution of surface vs. channel erosion processes.
- Established experimentally that gullies are initiated by removal of vegetation from valley bottoms rather than just from increased run-off due to clearing.
- Demonstrated that in gullied catchments gullies are the dominant source of sediment
- Developed understanding of the role of subaerial processes in generating sediments from gully walls
- Concluded that gullies form rapidly after vegetation removal and then stabilise over a long time period. Sediment generation rates from maturing gullies remain an open question.
- In regions where there are few gullies or gullies are mature reworking of riverbanks explains the dominance of subsoil-derived phosphorus in the channel and storages.

- Used tracing techniques in a range of catchments to demonstrate that in the majority of cases subsoil dominated the sediment and/or phosphorus delivered to the channel and in water storages.
- Demonstrated that intensively farmed basalt soil in the Barwon–Darling system was not the major source of phosphorus to the river system.
- Phosphorus fertiliser determined not to be the dominant source of phosphorus to Chaffey Reservoir.
- Sediment and nutrient sources to Tarago Reservoir determined to be from surrounding shoreline and basalt derived soils.
- Estimated the contributions of pastoral land, forestry and cultivated agriculture to catchment sediment load in the Murrumbidgee catchment.
- Used natural radionuclides to determine the impact of forestry on sedimentation rates and by inference sediment generation.
- Developed a range of field and laboratory techniques to ascertain the partitioning of water (and phosphorus) between overland flow and flow through the soil profile.
- Established the existence and potential importance of flow of transport of dissolved and colloiddally-bound phosphorus laterally through the soil profile to waterways via macropores and across the top of the B-horizon.
- In forested landscapes roads and tracks associated with forest operations and recreational road use generate large amounts of sediment. Whether this sediment impacts upon the high value streams depends upon the buffering provided by downslope forest areas.
- Careful road and track design and maintenance can minimise the impact of forest activities on water quality by ensuring track drainage does not initiate below road drainage incision and that non-channelised overland flow is dissipated.

- Empirical methods for estimation of the distribution of soil information been developed. Over small regions, several studies have demonstrated that high resolution spatial information, e.g., digital elevation model, geophysical and other remotely sensed data, geological mapping, combined with a design-based sampling can be used to build convincing models for a range of soil properties. To date specific focus on soil nutrient content has not occurred. Over large regions, methods have been developed to predict the soil type in unmapped areas permitting estimation of nutrient content from look-up tables associated with the soil types.
- Through our work with CMSS and related products we have improved understanding of how nutrient exports vary with spatial scale (order 1 km to 10,000 km), with spatial attributes including slope, rainfall, soil type, land use and land management. We have also clarified how Australian nutrient exports differ in magnitude from Northern hemisphere exports.

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## SEDIMENT AND NUTRIENT TRANSPORT, STORES AND RESIDENCE TIMES

The previous section illustrated that for a nominal position in the landscape, generally a point in a channel, we have made progress in establishing the various sources of materials delivered to that point from the area above it. To construct budgets, it is necessary to allocate a time dimension to the sources and estimate the rate material passes the point. This in turn requires that we are able to identify and quantify hill slope and channel stores and the residence time of the materials through them.

The sediment delivery ration (SDR) relates the quantity of hill slope erosion in a catchment to the quantity arriving at the outlet, or some other datum, in a given period of time (or events). This concept can also be applied to nutrients. International literature, some of which we have contributed, indicates that the sediment and nutrient delivery ratios may differ from one another for a range of reasons, e.g., size selectivity in adsorption (related to surface area and surface activity), size selectivity in sediment delivery, dissolved nutrient sources, denitrification, selective transport of lighter organic matter.

SDR is a blunt tool that summarises a number of processes related to residence time of materials on the hill slope. These include geomorphic/topographic features, e.g., slope length and gradient, roughness (over various scales), in-channel wetlands and riparian zones, and vegetation type and distributions (in space and time). Of critical importance is the relationship between the processes of entrainment and deposition.

It is possible to combine information on rates of soil turnover and formation with the sediment delivery ratios and sediment loads to channels to estimate roughly whether the contemporary soil loss rates are temporally non-stationary and greater than background. This type of analysis attempts to provide a guide as to how much time may be available before the soil will effectively be lost for ecosystem services and/or production. It is also important to determine whether natural sediment and nutrient stores and sinks are becoming net sources, e.g., denudation and even cultivation of riparian areas, incision and/or erosion of foot slopes.

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Below the hill slope, the channel itself is a sediment store with residence time varying between reaches. For the large, internally draining inland rivers in Australia a major sink zone is the floodplains. Previous work has shown that a very large proportion of sediment being carried in a flood can be deposited on the floodplains. Work is in progress to establish the extent of floodplains, their water depth and velocity spatial distributions given certain size events and the related deposition.

To determine variations in sediment and nutrient budgets beyond the period for which monitoring data is available requires the use of proxy records. Typically these come from sediment and soil cores. Proxy records are only of use if accurate sediment dating methods are available. In the early 1990's there were no generally applicable tools for dating young fluvial sediments, so it was not possible to accurately assess the timing of down-core variations in phosphorus concentrations or changes in sedimentation rates. The Division invested in new dating technology and developed new methods for dating soils and fluvial materials. These new dating methods are now being used to determine rates of soil turnover and formation, changes in sediment delivery ratios and sediment loads, and changes in sediment-associated nutrient concentrations. Our work has led to the hypothesis that many of the rivers are "drowned" in sediment generated by incision and massive gully erosion following clearing. Our rivers are in a physically different state to the one they were in prior to European settlement, e.g., changed rates of meander migration, altered hydraulic geometry, different bottom habitat conditions. Whole-of-catchment budgets can only be given a temporal dimension if we are able to estimate the migration rate of sediment and nutrients through channels. It is necessary to determine rates of migration to plan whether we should treat our river systems as permanently altered or as a passing phase. Budgets based on estimating dates and rates are therefore critical to river restoration programs.

While our ability to approach dating of sediment has improved greatly, it is still only minimally applied. Assessment of changes in nutrient supply to our rivers is still in its infancy.

*Research results and progress*

- Developed and tested sophisticated and approximate (suitable for later inclusion into broader scale models) process-based models for the dynamics of sediment net deposition taking into account a range of size classes of material within the sediment.
- Developed and tested models of the temporal dynamics of sediment size sorting associated with the early phases of erosion events. This information provides a boundary condition for our understanding of downstream sediment deposition and delivery.
- Measured and modelled the extent to which grass buffer strips could trap sediment under a range of input (source, slope) and strip (cover type and areal extent) conditions.
- Measured and modelled the formation of sediment plumes describing the interaction between logging tracks and logged coops in a spatially-complex and heterogeneous forestry environment for a range of soil types and duration after logging.
- Estimated the likely sediment delivery ratio in a spatially-complex and heterogeneous forestry environment for a range of soil types and durations after logging.
- Demonstrated that the generally accepted model for the sediment response in large river basins, i.e., that the sediment concentration peak lags the discharge peak, was converse for two floods of the Murrumbidgee River.
- Demonstrated the inefficiency of sediment transport processes in the Murrumbidgee and Darling River systems.
- Developed a technique for estimating sediment residence times and transport rates using natural radioactivity.
- Developed and tested a new dating technique for young (<1000 yrs) fluvial sediments based on optical stimulated luminescence.
- Developed a new method for estimating sediment residence times.

- Demonstrated that sediment associated phosphorus concentrations in the Darling River have not changed significantly in the last 300 years.
- Estimated the likely propagation rate of several sediment slugs in major river systems.

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## WATERWAY ENVIRONMENTS AND PROCESSES

Many of the assertions regarding the importance of understanding the sources and migration rates of sediment are related to ecological response. In the last ten years our understanding of in-stream nutrient dynamics in the water column and the sediments has improved. The assertion that phosphorus supply from sediment entering the channel systems today is related to algal bloom is under question. This is because there appears to be sufficient phosphorus in the channel and reservoir sediments to trigger algal blooms for many years even if the sediment supply could be entirely stopped instantly (which it cannot be). The physical conditions within the water column and the interaction of the water column with the sediment are more important than the phosphorus supply. To initiate a bloom the algae must be supplied with warm water clear enough to transmit light and with sufficient (not excessive) loading of essential nutrients. The growth and dynamics of a given bloom are controlled by processes more subtle than can be quantified by the total phosphorus in the sediment.

Work on the ecology and biology of algal blooms has been undertaken – this will not be reviewed here.

- Our work has demonstrated that a necessary condition for cyanobacterial bloom formation in the turbid rivers is low flow and the development of persistent temperature stratification. In effect, the initiation of algal blooms is triggered by light availability and not nutrients. This condition has been demonstrated in both temperate (Murrumbidgee, Murray) and tropical rivers (Fitzroy).
- The management of algal blooms can be accomplished through flow manipulation and our development of predictive models for riverine thermodynamics and hydrodynamics allows the flow levels to be specified.
- Whereas the presence of stratification appears to control the onset and initial development of cyanobacterial blooms, their climax biomass is likely to be determined by the availability of the necessary nutrients for growth. Phosphorus has traditionally

been regarded as the limiting nutrient and it is likely to be so in many rivers. Phosphorus is highly particle reactive and can be desorbed from both suspended and bed sediments. Consequently, the dissolved phosphorus concentration is not generally the measure of the phosphorus potentially available for algal growth.

- A number of recent investigations demonstrate that nitrogen may be the limiting nutrient for algal growth. Nitrogen can be input into the river system through the process of nitrification and removed through denitrification. In this respect, and in its limited ability to adsorb to sediments, nitrogen is fundamentally different from phosphorus.
- Modified a technique using strips of filter paper coated with iron-oxy-hydroxide to measure algal-available concentrations of phosphorus. Validated this by comparison with quantitative growth bioassays.
- Used the iron strip technique along with tangential flow ultrafiltration to partition algal available phosphorus into dissolved and particle associated forms and compared this with the total phosphorus present. Demonstrated that the exchangeable P associated with particles can be an important source of supply to phytoplankton in many of the rivers in the MDBC, although even within a river the quantity of exchangeable P varies.
- Demonstrated for a series of reservoirs in SE Australia that the iron strip measure of bioavailable-P provided an improved basis for chlorophyll-P models enabling better prediction of summer maximum biomass.
- Attempts have been made to relate the extent of phosphorus adsorption on particles to their chemical composition and size.
- Developed a fluorescence technique that utilises perturbations in the chlorophyll fluorescence signal of phytoplankton to identify N or P limitation. The perturbation occurs in response to addition of a limiting nutrient. Used this technique in conjunction with bioassays to provide first demonstration that nitrogen limitation occurs in MDBC rivers as frequently as phosphorus limitation.

- Our work has also identified a combination of physical, chemical and biological processes which control the delivery of dissolved silica to the coastal zone. In a regulated river, the growth of diatoms, and thus the removal of DSi, depends on a balance between flow that can advect diatoms out of the system before they can grow, and the availability of dissolved Si. In stratified systems the conditions are inimical to diatom growth as they sink to the bottom away from the light necessary for their growth. Simple models which successfully predict diatom distribution over large distances (>1000 km) as well as short (daily) and long time scales (10 years) have been developed.

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## DIFFERENTIATING CATCHMENTS AS SOURCES

This section notes our contributions to deconvolving, within specific river systems, the sub-catchment sources to a specific location within the river system.

Combinations of historical information, e.g., aerial photography, natural and anthropogenic radioisotope tracing and mineral magnetics have been applied to determine the sub-catchments contributing sediment to the Murrumbidgee River below Wagga Wagga and to Lake Burley-Griffin. Contributions of tributaries to the Darling/Barwon system have also been partially deconvolved. These techniques have been applied more widely but this represents work-in-progress or work completed that has not yet been published.

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## CATCHMENT MODELLING

The modelling of sediment and nutrient transport and/or budgets explicitly is a reasonably recent area of work. Two modelling approaches have been developed, viz. explicit spatial representation of the catchment with distributed climatic, vegetation, erodibility and topography; and conceptual modelling. The former approach is currently being applied extensively in work-in-progress under the National Land and Water Resources Audit. This includes estimating catchment sources and transmitting materials to the channels and then through the channels to the estuaries and/or floodplains. The basic modelling approach has been published; however, no applications have yet reached the international literature.

- Description of a distributed river network sediment budget model incorporating spatially variable sources of gully, hill slope and stream bank sediment and deposition in floodplains and in channels.
- Review of empirical and theoretical specification of rules for sediment transport capacity and their application at the catchment scale.
- Development of conceptual catchment models for sediment and nutrient transport.
- Preliminary demonstration of the concept of modelling land management (sediment delivery control) as a pseudo-random spatial process.

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## CURRENT AND FUTURE DIRECTIONS

Much of our current work establishes soundly our future directions for the next 5 years. This chapter will not forecast beyond that time horizon.

Our current activities show a considerable shift from the published work reviewed above. The current outlook is to bring the understanding of the underlying processes into a systems context by a mixture of new field data, historical monitoring and numerical modelling. We have the discipline capacity to deal with the system from the catchment sources through the river/channel physical and ecological conditions to the estuarine physical and ecological impacts. With collaborators, we are moving towards completion of significant contributions to the National Land and Water Resources Audit across this entire domain. Activities which are currently in the initial stages in the three water CRC's (Catchment Hydrology, Freshwater Ecology and Coastal Waterways) are also contributing across the same extent.

We are continuing to pursue process studies where our understanding is insufficient or the data are inappropriate for parameterisation of the systems models. We are continuing to study the dynamic interactions between sediment the water column. We see a necessary shift from focus on phosphorous loads to the dynamics of fluxes and the need to better understand nitrogen dynamics especially the interaction with carbon. The impacts of land salinisation on rivers and the process of salt wash-off from hill slopes are under investigation. We are making efforts to better understand the physical and ecological interactions between floodplains and the river channels. We are developing and testing methods to classify and quantify the physical habitat conditions of river systems. The linkages between the outputs from rivers and the dynamical behaviour of estuaries are also being more fully explored. Our work in physical and ecological structure and behaviour of reservoirs (and other regulation infrastructure), which has not been completely reviewed here, is being more fully integrated with the rivers and catchment work.

Embedded in a number of our current projects is partial corroboration of the NLWRA national predictions or detailing conditions for specific regions, e.g., Murray-Darling Basin, Fitzroy River.

In all this work there is a critical need to bring together systems modelling with signals from water quality monitoring, process knowledge and measurements about soil transformations due to vegetation change. In this regard we are also concerned with understanding the impacts of boosting carbon sequestration (a shift towards more perennials) on the landscape biogeochemical cycles.

Whilst the focus of this review is our science, it is salient to note that CSIRO is a heavily issues-focussed and essentially applied science organisation. Our mission is to listen to and assist stakeholders in enunciating critical problems and proposing the part of the solutions that lie within our disciplinary base. We have made no attempt, given the review terms of reference, to cover material that relates to client interactions, "grey literature", e.g., reports on contracts which cannot or have not yet been published in the reviewed literature. This is important because this material forms a significant component of our total written and intellectual output. Interviews with our clients, based on the information reviewed under the terms of reference, should therefore be approached in a carefully considered manner. For example, very few of our clients would have the background to peer review journal articles. However, the majority are in a position to know whether our reports meet their needs and the contracted objectives. The extent to which our reviewed *scientific* outputs are the direct cause of the influence we play in helping clients meet their objectives is a moot point.