16th December 2010

The Chairman
Murray-Darling Basin Authority
GPO Box 1801
Canberra City 2601

Re. Volume 1 and Volume 2 (Parts I to III) of: *Guide to the Proposed Basin Plan*. Murray-Darling Basin Authority 2010.

Recommendations.

- Because it is based on flawed, biased and alarmist' 'science' the Proposed Basin Plan should be rejected in its entirety.
- The Water Act (2007) (Cwth) should be repealed. The Act has set out to circumvent clauses within the Australian Constitution intended to give effect to the rights of the States. This sets the precedent that the Commonwealth may make international agreements that purposefully erode the intention of the Australian Constitution, thus undermining Australia's democratic process.
- The 'national interest' served by the Commonwealth taking control of the Basin's water resources from the States has not been elucidated in any of the Plan documents. It probably does not exist, and it should not be a factor in deciding the outcome of MDBA's deliberations.

Summary findings.

I have reviewed aspects of the recently released *Guide to the Proposed Basin Plan* and the detailed results of my review are attached.

I have found:

1. **No hard evidence exists that the ecology of the Basin is 'near collapse' because of alleged over allocation of water, predominantly to irrigation.**
   - The reports and papers that I reviewed are biased, alarmist and 'message' focussed. Simply stated, 'the science' has been bought (at considerable cost) to support flawed and socially detrimental 'policy'.
     - More emphasis has been given to projections – the future, than has been given to the reality of the present and its immediate past. It is in the light of this supposed 'future' that the Proposed Plan draws its urgency.
     - The projected 'future' is a fantasy; it may not arise, and it may not exist in the alarmist sense that is continuously portrayed.
   - The oft-quoted major audit report on 'catchments health'[1] (2004-2007) is based on guesswork.

[1] Norris R, Prosser I, Young B. Liston P, Bauer N, Davies N, Dyer F, Linke S, Thoms M (2001). The assessment of river condition (ARC). An audit of the ecological condition of Australian Rivers. Final Report submitted to the National Land and Water Resources Audit Office, September 2001.

  - Even though there were absolutely no data available for the time, it uses as its comparative baseline the condition of catchments as they were in 1770 (pre-European)!
  - Catchment health is a movie, not a single 'photograph', especially a frame captured during the mid-phase of drought. Stuff from modelled audits is not data. It belongs in the virtual world; it has no dynamics, no time-relevance, no history and therefore no believability.
  - The modelling process, designed to show that 'most' catchments are in a poor state, make a mockery of data-rich research and it does not address the capacity of so called 'degraded' systems to revive themselves once overarching conditions (mainly drought) change.

2. **For a rainfall-driven 'working' river system, evidence that the Murray Darling Basin it is not managed appropriately (by the States) is lacking.**
   - Cycles of floods and drought have always been a natural feature of the Basin, and equally these have shaped its inter-linked riverine, wetland and dryland ecology.
     - The use of water for irrigation has not changed the rainfall and evaporation regimes, which are the overarching drivers of the Basin's water balance.
     - 'River-droughts' are less severe now than they would have been had irrigation infrastructure (and the Snowy-Mountains Scheme) not been developed. The Proposed Basin Plan conveniently ignores that these were risky, Nation-building steps for Australia, which in their time, were vital developments in 'moving Australia forward'.
     - Environmentalism conveniently ignores that the greatest contribution to its current status in Australia has been the pragmatic overcoming of limitations to all forms of primary production. Irrigated agriculture in the MDB has been an on-going part of the solution, not the problem.
     - The Proposed Plan and its supporting documentation have consistently presented a 'glass half empty' picture of the Basin. The Basin is in fact more than a "glass ¾ full". It is meeting dural roles of producing food and fibre, while providing, within its natural capacity, unmeasured ecosystem services.
     - Politically, the post-2000 drought, which has been a normal event, has been used to drive messages of despair; breakdown; dysfunction and 'collapse' – messages driven-home by speculative modelling and alarmism, and supported generously by anti-agriculture special interest 'green' groups.
   - Hype, and marketing of branded ideas have dominated much of the public discussion, to the detriment of research and careful, balanced and considered understanding of the true position.

3. **The 'science' that I examined is flawed; much is data-free; it is biased; it is over-managed and presented as spin, particularly by CSIRO and the Wentworth Group.**
   - There is over-dependence on models.
     - Some modelling exercises purport to represent processes that they cannot emulate with any degree of statistical confidence at their scale of implementation.
   - It is a leap of faith to believe that a 'conceptual model' that includes qualitative, semi-quantitative and quantitative components, including, inputs from other models, results in an absolute unambiguous error-free 'answer'.

- In the Proposed Basin Plan, many of the press releases that have gone both before and after it was released, are littered with speculative 'facts'.

4. **Scientists in CSIRO, Universities and State agencies have lost the independence and freedom that in times past, made these organizations strong, responsive and trustworthy.**
    - Science has become focused, 'secret' business where scientific dissent is discouraged, and open discussion of its craft not permitted. It is not necessarily carried out for the public-good.

5. **If it is the case that The Coorong, Lower Lakes and Murray-Mouth are one of Australia's most important wetlands, and are the main focus, and indeed the excuse for Commonwealth intervention in the proposed reforms, consideration needs to be given to removal of the Barrages BEFORE using precious water from the uplands of the Basin to achieve the same ends.**
    - **It is clear from commentary, that if there is a single action that would have a positive impact on the ecology of the end-of-system lakes, it would be to decommission the structures that prevent the lakes from interacting with the ocean, as they have in the past, and should in the future.**
        - This action would largely negate having to run large volumes of fresh water down the rivers from the alpine areas of NSW and Victoria, simply to keep water that should be brackish and saline, relatively fresh; then to dump it into the sea.

6. **I am a retired scientist, with broad-based interest and some expertise in natural resource management; landscape hydrology; soils, agronomy and ecology.**

    I am disconcerted by the Proposed Murray-Darling Basin Plan. The plan under-values data; it subverts true 'science'; it is politically-driven; thus despite all the community passion that its proponents have invoked, beyond reducing food production it is unlikely to make much difference in respect of its projected intentions.

    However, as an individual I do not have the capacity to exhaustively review the hundreds of documents, some, many hundreds of pages long, that have been produced to justify/support the Proposed Plan.

    The material and reports that I have accessed are referenced as footnotes in this report, however, time has been pressing, and in some cases I have not given the attention to issues that they may have deserved.
    - It is suspicious that I have found no documents that are critical or unsupportive, of the Proposed Plan, despite sound and justifiable reasons for cynicism and mistrust of both the 'science' and the political process.
    - I have also not been able to locate evenly balanced, overarching reviews of critical issues such as ecology; farm dams; forestry; modelling; errors and uncertainties; community impacts etc.

7. **It would not be unreasonable to expect MDBA and its predecessor organisation MDBC, to have some objective in-house capacity for over-sight of all the so-called science and its social, economic and ecological implications. However, everything seems to have been out-sourced. As a consequence, there are many critical questions that have not been asked; and 'science' that has either been too-easily believed, or not sufficiently well evaluated.**

- It would not be unreasonable to suggest that everybody involved in this process is marching to an already-agreed-to agenda and outcome, and that whatever objections or criticisms are raised will be politely ignored.

Obviously MDBA/MDBC and the National Water Commission have committed very large sums of public money into the ‘science-industry’ that has been cultivated specifically to support the Plan’s agenda. It is my firm belief that the whole community has been misled and let down by this ‘selective-science’ process, which has implications well beyond the Basin.

Until all the disclaimers are stripped away, and the science is exposed to rigorous independent scrutiny, the plan should simply be rejected.

Yours faithfully,

Dr. WH (Bill) Johnston

A science-based response to the Guide to the Proposed Murray-Darling Basin Plan.

Dr. WH (Bill) Johnston

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Introduction.

The Proposed Murray-Darling Basin plan does not deserve the support of either the communities that love, live and work in the Basin, or the Australian community at-large.

It is based on short-term appraisals of 'condition'; speculative modelling of many interacting, error-prone presumptions; and it draws error-free conclusions, which are not statistically confident predictions, but either forecasts or projections, based on the models being 'right' or nothing else changing.

It is an 'alarmist' plan, loosely shrouded in climate-change rhetoric; supported by the constant chatter of press releases; strategically released 'new reports' that offer no conclusive evidence; and that conveniently ignore the naturalness of natural events, such as floods and droughts.

Although release of the Plan was delayed until after the 2010 Federal Election, it has not escaped the un-planned ending of the post-2000 Basin-wide drought. Basin droughts have always ended; usually signalled by significant rainfalls. The post-2000 drought has been no exception.

Now, after just a single season of replenishing rains that have continued into early summer, the major contributing storages along the upper-Murray; Murrumbidgee; Lachlan; Macquarie and most northern rivers, are at or near capacity. The question needs to be asked – now that nature has 'saved the Basin' (as she always has in the past), **do we really need this plan anyway?**

With the knowledge of all its sham and inaccuracies, the Government, the Murray-Darling Basin Authority and their chief advisors (a well-financed, confounded group including CSIRO and The Wentworth Group; State Departments; several Universities and private organisations such as Sinclair Knight Mertz) universally disclaim responsibility for the accuracy, use, future use and implications of their 'work'.

Typical disclaimers state:

"…The opinions, comments and analysis (including those of third parties) expressed in this document are for consultation purposes only…" **(The Guide to the Basin Plan)**.

The views, opinions and conclusions expressed by the authors in this publication are not necessarily those of the MDBA or the Commonwealth. To the extent permitted by law, the MDBA and the Commonwealth excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this report (in part or in whole) and any information or material contained within it.

("Advice on defining climate scenarios for use in the Murray-Darling Basin Authority Basin Plan Modelling" (MDBA Technical Report Series: Basin Plan: BP01)).

"The results and analyses contained in this Report are based on a number of technical, circumstantial or otherwise specified assumptions and parameters. The user must make its own assessment of the suitability for its use of the information or material contained in or generated from the Report. To the extent permitted by law, CSIRO excludes all liability to any party for expenses, losses, damages and costs arising directly or indirectly from using this Report"

(CSIRO (2010) Climate variability and change in south-eastern Australia: A synthesis of findings from Phase 1 of the South Eastern Australian Climate Initiative (SEACI).

To paraphrase a recent comment in relation to the proposed mining tax "*if you can't trust Government, then who can you trust*?"

The overarching question is: **if august institutions such as CSIRO, MDBA and the Commonwealth will not stand by their work, why should the community be swayed by it or believe in it?**

Based on observing the manipulations of Government over a professional lifetime devoted to research and extension in natural resource management, I have summarised in Box 1 a hypothetical but factual scheme of engagement between the community and Government.

Box 1. A schematic representation of Government engagement with the community over contentious issues.

Step 1	There is a perceived problem bought to the Government's attention by intense interest group lobbying (mostly 'industry' or 'green'); usually via. commissioned 'new reports'.
Step 2	The issue is seized on as a political imperative, usually because the Government (at whatever level) can increase the level of power it can wield. - The Government, seeing an advantage, advisers that has a 'political' answer - It develops a strategy to land it on the people - Announces the seriousness of the problem and that it has found the money (usually $billions) to 'fix' it (usually by way of a more analysis or feasibility studies; rarely by direct action at this stage!)
Step 3	The Government seeks 'independent' advice - Sets up, supports or favours quasi-political/scientific/industry groups to ferment its political answer (e.g. Unions; The Wentworth Group of Concerned Scientists; Australian Industry Group etc.) - Funds organisations (e.g. CSIRO; universities; Access economics; SKM) to support and lend credence to its political position. - Sets in place mechanisms to handle dissenting views (Thank you for your interest … we see that you support the Governments approach … Yours faithfully ..The Government.)
Step 4	The Government sets up handpicked 'independent' notable persons; advisory groups; committees; boards or authorities that will advise by recommending the Governments political position as the only answer to the perceived problem.
Step 5	Many, many reports are prepared (each with a press release), followed by green papers and white papers. These are supported by a public call for submissions and responses (to be received usually within days or weeks). Forewarned, and in synchrony, the in-the-loop quasi-political/scientific groups that the Government supported in the first place, are prominent in advocating the Governments position. As the strategy finds it feet, supported by the limpness of popularised press, the headline of the day becomes .. "A new report has found ….".
Step 6	As part of the overall 'package', Government largely 'back-burns' or ignores dissenting views. Research that may not directly support the Governments 'political' position is discouraged/un-funded/wound-up. (The volume of material in the '…new reports..' is planned to be overwhelming to unresourced dissenters anyway!)
Step 7	The reports get a tick by the 'independent' committees/boards/authorities; the Government, being the arbiter of last resort has to act; so regardless of its accuracy, merit, integrity or longer-term consequences, the political solution (Step 1) is passed into law.
Step 8	The people at large are faced with, or have to pay for, the consequences of an intractable, politically motivated bad decision that favours its supporting interest groups. People who are affected either have to simply go away, or they are paid off!
Step 9	The Government, applauded by its industry 'partners', special interest groups and 'independent' advisors, "looks to the future"; it "moves forward". Departments are re-named, split up, merged and disappear from the public consciousness. Their contact details such as postal addresses, telephone numbers; web addresses all change; they lose connectivity with the past. The basis of decision-making – the reports, submissions etc. are lost in the archive 'ether' by being made hard or impossible to find. In some cases, in order to erase the past, Acts of Parliament are changed by regulation so that Ministerial accountability becomes untraceable.
Step 10	There is another election about police, hospitals and schools. Democratic process, governance and deviousness of Government are momentarily forgotten.

The Proposed Basin Plan currently sits at about Step 6 of this hypothesised scheme.

This submission calls for the current Proposed Basin Plan to be abandoned as a bad idea backed by a confusing array of biased 'science'.

Market mechanisms, such as seeking efficiencies in water use across the Basin that result in 'saving' water, should be supported and encouraged.

However, the water 'saved' should be returned to the communities that saved it in the first place. It should be used to support food production by generating expanded productive agricultural activity. This is the only way that existing communities can grow in a sustainable way, and that agriculture can effectively expand and meet the needs of a growing world.

The 'green' agenda is one-eyed; the 'science' behind the agenda is especially biased. Tackling world population growth by reducing or stabilising food production from Australia's food-bowl is simply bizarre.

Strategically, Australia does not need millions of starving people outside its immediate borders, are armed with nothing more than thousands of leaky boats. Increasing food production while tackling population growth by dealing with it as a specific issue within Australia's aid effort would leave us in a much stronger strategic position than if the Nation became dependent on significant imports of basic food types.

The alarmist ecosystem collapse theory has no basis.

- **Ecologically, the Murray-Darling Basin is not in immanent threat of collapse.** If it were prone to collapse, it would have done so long ago. Species come and go with the seasons and the cycles, and the ecology we see today reflects its capacity to adapt; it will probably always be in a sate of flux, which is one of its strengths.

  (Agriculture is also sensitive to events and cycles. In the latest drought, while precious water went west and south to feed ecosystems, farmers bore much pain; financially, structurally and psychologically.)

- **Throughout the Basin, there are ecosystem refuges everywhere.** National parks; farm dams high in seasonally arid mid-rainfall catchments, watercourses kept wet by continuous river flows, and ephemeral and permanently wet lakes all provide refuges. From time-to-time, some need to be helped, as they have over past drought periods, but mostly they should be left to adapt, as they will, to their changing circumstances.

- **Indicators are positive**. For example, salinity (at Morgan) is declining. During the most recent (2000 to 2010) drought, while irrigated agriculture across most of NSW was severely disrupted, major Basin rivers did not cease to flow.

While Burrinjuck and Hume dams and others declined to low levels, and various professors and the Wentworth Group jumped up and down about the Coorong and closure of the Murray-mouth, tourists still flocked to Mildura and paddle steamers still puffed up and down the Murray at Echuca.

One hundred years or so ago, before the dams were built, evidence is that the river would have run dry at these places. Everything, including paddle-boats and agriculture, as well as the Basin's ecology would have had no option but to shut-down and wait-out the lengthy low and no-flow periods.

Clearly the main issue for the Lower Lakes, Coorong amd Murray-Mouth are the Barrages. The lakes behind the Barrages do not need to be flooded with expensive, scarce, fresh water sent thousands of kilometres south along the Murray from the alpine areas of Victoria and New South Wales to simply fill a void or to be dumped into the ocean.

Returning the lower-lakes to nature must involve removing the Barrages. The collateral advantage of doing this would be that irrigated agriculture would have to move up-stream where because less water would be lost to evaporation during its natural course south, more fresh water would be accessible.

Comments on the planning process.

While the 260-page *Proposed Basin Plan* (Volume 1) has been developed over many years by many people, those interested in reviewing it and providing 'feedback' have been allowed only a small period of time in which to do so. The 3 parts of the *Technical Background* (Volume 2) consisting of a total of 1,188 pages was released several weeks after Volume 1, leaving less time for review.

Clearly it is not possible to review all this information and chase up possibly contentious reference material within the timeframe.

So…. I've looked at some of the material, especially some of modelling work; I've gathered some easy to access data: climate data from the Bureau of Meteorology (BOM) website (http://www.bom.gov.au/); gauging data from NSW Department of Water website (http://waterinfo.nsw.gov.au/), Vicwater data.net (http://www.vicwaterdata.net/vicwaterdata/home.aspx) and other accessible sources. I've gathered comments and looked at reviews in newspapers, including *The Land* and I've undertaken other web-based searches for specific information.

The process that I adopted.

My analysis of data was restricted mainly to portrayal of patterns and change. I have not had time nor access to software to undertake statistical analysis. Trend has been investigated using residual mass or CUSUM (cumulated sum of residuals – residuals being the difference between a data value and the long term average) curves. This is a relatively old-fashioned hydrological approach. CUSUM curves have the property that residuals are distributed around the long-term average; they commence and end on the $Y = 0$ axis; successive positive differences are indicated by rising trends while successive negative differences trend downwards. Step-changes can be analysed, but I have not done this.

The almost-exclusive dependence of the Proposed Basin Plan on modelling is particularly contentious. Despite the complexity of many models, the assumptions underlying them, and 'conclusions' resulting from their application to 'science' are in most cases simplistic and contestable.

Modelled 'results' are NOT data, yet there are numerous examples throughout the MDBA (and its predecessor the Murray-Darling Basin Commission (MDBC)) literature where models feed into models that feed into models.

Models are essentially assumption-driven, but increasingly they are being portrayed as *de-facto* science, which they are not.

Modellers often take a smidge of data, make up what they don't know, then, and produce an un-qualified ambit 'answer', which becomes widely quoted as unambiguously 'true' beyond any reasonable doubt[2].

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[2] Scientific enquiry is analogous to the common-law principle of 'innocent unless proven guilty beyond reasonable doubt'. While the law may use a judge and jury to test its case, scientists use statistics to test theirs. The scientific 'nul' argument (hypothesis) is that there is no difference between 2 means; no association between variables; no 'treatment' effect in a designed experiment. Statistical analysis tests whether the nul argument should stand (differences are not statistically significant (from the nul position) or the counter-argument that 'treatment' effects

There are no error bars or confidence intervals associated with modelled 'data'. For example, Page xvii to xviii of Volume 1 of the Guide (MDBA 2010) contains statistics relating to the Basin's water resources – 500,000 GL/year average rainfall; inflow 32,800 GL; recharge 26,500 GL etc.; all modelled 'data', provided without reservation. Table 1 provides a cross-tabulation of statistics drawn mainly from (MDBA 2010), but also other sources, so they are all similarly scaled and equally comparable.

Table 1. A concise summary and cross-tabulation of equivalent units for modelled data given in the Guide to the Basin Plan (pages xvii and xviii). Note that areas given in different publications are not the same

		Basin area (km^2)	
		Crabb (1997) [3].	MDBA (2010)[4]
		1,061,469	1,042,730
Statistic	mm equivalent	GL	GL
Rainfall long term (BOM) mm	467.2	495,918	487,163
Rainfall long-term MDBA (mm)	457.0	485,091	476,528
Rainfall MDBA 1997-2006 (mm)	469.0	497,829	489,040
Inflow	31.5	33,389	32,800
GW recharge	25.4	26,976	26,500
Consumption- surface water total	13.1	13,946	13,700
Consumption – watercourse	10.5	11,137	10,940
Consumption – interception	2.6	2,789	2,740
Consumption - ground water	1.6	1,731	1,700
Consumption – total	14.8	15,677	15,400
Surface water			
Current volume to the environment	18.3	19,443	19,100
Upper additional env. Need	7.3	7,737	7,600
Lower additional env. Need	2.9	3,054	3,000
Upper total env. Need	25.6	27,180	26,700
Lower total env. Need	21.2	22,497	22,100
Groundwater			
Upper additional env. Need	0.2	231	227
Lower additional env. Need	0.1	101	99

Given that 'average' rainfall is skewed by infrequent extreme values, and that across the MDB rainfall is geographically skewed, are the values in the Guide as precise as implied?

Because of the difficulty of measuring or estimating recharge, evaporation, inflows and other water balance terms, errors about an estimated value may be considerable. This has enormous implications for sharing water. For example, in Table 1, the difference in rainfall between long-

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should stand. Statistics provides a measure or probability (*P*) (usually P less than 0.05) of differences, associations etc. of not being due to chance.

[3] Crabb P (1997) "Murray-Darling Basin Resources". Murray-darling Basin Commission, Canberra ACT.

[4] "Guide to the proposed Basin Plan Volume: Overview" MDBA 2010.

term BOM and MDBA estimates is 10,635 GL. That is almost equivalent to the estimated (modelled) watercourse diversions!

The main (unaddressed) problem is that very small numbers – such as 2.6 mm of equivalent interception, are multiplied by very large numbers [(Basin area (1,042,730 km^2) * 100 to give hectares; *10,000 to give square metres; * mm to give litres; divided by 10^9 to give GL].

Because of this, very small estimation errors, automatically also become very large numbers!

For instance, it can be calculated that an error equivalent to 12 mm of rainfall in any of the Basin's water balance terms (evaporation, recharge, runoff or rainfall) multiplied by its area of 1,061,496km^2 equals 12,738 GL. Figure 2.5 in the Guide (p.21) indicates this to be about the same as the total estimated watercourse diversions from 1984 to about 2001!

Errors of this magnitude are likely; 12 mm is just 2.5% of the Basins estimated annual rainfall; it falls within the error range of measuring annual rainfall (+/- 0.2 mm/measurement); it could easily be accounted for in estimated evaporation, as well as in the estimation of recharge. Failing to deal with estimation error in the documentation that 'advises' the Proposed Basin Plan, gives all the broad statistics a distinctly rubbery feel (see Table 2 for coverage of some of the issues.).

(Many Basin reports use area calculations derived from 2-D topographic maps. These maps assume a 'flat' landscape. Hollows, gullies and valleys have a large impact on hydrological processes and in 'folded' landscapes, if they are ignored, land surface areas become vastly underestimated. (Recharge or 'leakage" of water below the root zone for instance occurs at the scale of ground surface area – not 2-D cartographic area.))

At the scale that all this 'science' is done, even small errors become multiplied up by the very large areas that are involved. So where do the errors (measurement errors, estimation errors, modelling mistakes) go – do they propagate all through the models? Are they ignored; rounded-out somehow? Do we absolutely know that 20 out of 23 catchments within the Basin are in 'poor' to very-poor 'health'; or that average rainfall is absolutely 500,000 GL/yr (471.033 mm)?

The proposed Basin Plan has a long reach.

Every Australian will be affected to some extent by planned changes to water allocations within the Murray-Darling Basin (MDB).

Although the 2 million people who live in the Basin will be affected most acutely, including the many primary producers and their families whose livelihoods are under threat; people outside the Basin, and those within that are not directly engaged in the primary production chain will also bear brunt.

For example, the Plan envisages some $12.6 billion will allocated from the wider economy under the "Water for the Future" program; and another $4 billion to achieve efficiency gains. This equates to about $773 per individual, or $1,540 per employed Australian that will not be available for spending on other things.

The Proposed Plan also will limit Australia's capacity to increase food production, to meet its own and its growing neighbour's needs. It makes much more sense to use water 'saved' through efficiency gains, to increase overall agricultural production, than to just simply flush it down the Rivers to achieve some unnatural theoretically modelled outcome.

The plan directly and unashamedly attacks country people. **These are a minority in the Australian community. It attacks what they do; where they live; their communities; their co-operatives, and it overwhelms and insults their own 'science' and ecological knowledge**.

- The Proposed plan is uncompromising. It attacks these people's hard work; their aspirations; their families; their contribution to Australian society and the legend that has built around that. It directly attacks their productive use of water, and their desire to hand the land on in better condition than they found it.

- It potentially forces many families and individuals out of their occupation to the great advantage of agglomerates, multi-national corporations, tax-dodgers; schemers and the 'traders' that will eventually dominate the virtual world of water and carbon trading.

Table 2. Components of the water balance and an assessment of how accurately they can be measure or estimated.

Water balance component	Accuracy
Rainfall – derived from measured values; (measurement accuracy +/- 0.2 mm.). Actual data spatially or statistically weighted. Measurement networks are reasonably dense, but much data is spatially and temporally interpolated. Dewfall is not usually measured.	**Good**; subject to weighting technique. Arguably the most accurate and the only 'known' term in the water balance.
Potential evaporation – estimated by models (e.g. Penman-Monteith), supported by limited measured (Class-A pan) data.	**Unknown to moderate**. Often estimated using incomplete datasets.
Actual evaporation – usually estimated as less than potential evaporation depending on vegetation characteristics; rooting depth and water availability and soil-moisture release characteristics (which are often inferred from soil texture classes, or more 'robustly' (and less accurately) from soil type classes).	**Moderate to poor.** Water balance of vegetation assumes that potential evaporation combined with (i) the capacity of plants to be 'evaporative' (leaf area and so on) and (ii) the capacity of soil to supply water (mainly 'residual 'available water') determine water loss rates.
Runoff – There are many variables in 'modelling' runoff (soil depth; infiltration capacity; water holding capacity and moisture content; rainfall intensity; slope and slope-length; surface detention; vegetation effects etc.) and there are very few point-scale measurements.	**Poor to very poor.** Usually estimated from rainfall as 'saturated-soil' runoff – the excess of rainfall less evaporation, over a soil's water holding or infiltration capacity, over a fixed time-interval.
Recharge or leakage- usually the 'unknown' water balance component; impossible or impractical to directly measure at a meaningful scale. Can be estimated using parameterised models; but there is little data to check these, consequently they are assumption or 'rules' based.	**At a landscape scale, recharge is guesswork – but as a rule-of-thumb is likely to be 5% or so of the rainfall.** It is whatever is left over in the mass-balance equation. It is here that all the errors end up and its value can neither be measured nor challenged!

- The proposed plan does not consider the direct or indirect costs that will need to be borne by individuals and families forced out – made redundant by the opportunistic ascendency of environmentalism over pragmatism.
- It also does not consider costs and security issues associated with likely reductions in Australia's food production capability.

- Costs will also accrue in the management of once-productive 'vacant' landscapes; wildfire, weed and vermin control for instance, and there are likely to be others.
- There is also an out-of-Basin cost and risk that has not been factored in – industries that depend on Basin products but are not located there.

There are many out-of-Basin industries that directly or indirectly depend on the Basin, including grain millers and distillers; marketers and resellers in Sydney, Melbourne and other places; meat processors; financial advisors, accountants and bankers. It is the case that the Basin reaches right across the broad economy.

Against the backdrop of all the other concerns that Australians are persistently reminded of by the constant deluge of "new reports" (spanning issues from renewable energy, homelessness, border security, housing affordability to the aged care 'time-bomb') **it is a serious question whether the proposed Plan represents either timely, or good value to anyone**.

Climate and climate change issues as they relate to the Basin's ecology.

Central to understanding the impacts of the proposed new Basin plan, and indeed, the risk of it not achieving its stated environmental objectives, is the climate under which *any plan*, past, current or future, must operate.

Aside from continental-scale gradients, due mainly to latitude and altitude, at any location within the Basin, water demand specified in potential evaporation terms has relatively low temporal (time-dependent) variability when summed or averaged over time-spans of weeks, months or years. Thus, over the landscape, potential evaporation is relatively 'fixed' in time and space. In contrast, rainfall is highly variable.

By way of illustration, Table 3 shows rainfall and estimated potential evaporation statistics for Moulamein Post office (1948-2004). (Moulamein is located in the southern NSW semi-arid sector of the MDB.)

These data illustrate 3 points:

1. Annual evaporation exceeds average rainfall by a factor of 4.8. (This is the case over most of the MDB). Even allowing for evaporation 'pan-factors' there is no 'average' month when rainfall exceeds evaporation within a short period of when rain falls.

   Thus there are few 'surpluses' that carry forward from one month into another.

   (Because chances are multiplicative, the likelihood of successive months experiencing on-going moist conditions diminishes rapidly. For example if the 3 winter months all have an equal chance of 'moisture' of say 25%, the chance for adequacy in June is 25%, the chance for June + July is 6.25% and that for all 3 months is 1.5%!).

   This, and other data, together with generalised ecological principles[5] tell us that in order to be abundant in this place (in whatever measure (frequency, dominance, mass, relative abundance etc.)) biota **need** to be specifically adapted.

   For this they need to work together in an environment of generally low fertility, carbonate-rich stratified soils; lignin-rich, high C:N ratio organic matter return (which is out-of-phase with growing seasons and subject to its own random effects); and slow rates

[5] . There are many ecological texts. The Author has taught from and for general information has referred to: Odum, EP (1996) "Fundamentals of Ecology" (WB Saunders USA); in addition to: Krebs CJ (1978) "Ecology: The experimental analysis of distribution and abundance" (Harper International); and: Harper JL. (1977) "The Population Biology of Plants" (Academic Press).

of nutrient cycling. (These are not 'productive' ecosystems – they naturally boom-and-bust, they are episodic.)

Nutrient recycling is highly dependent on the anaerobic methane-cycle (either symbiotic (e.g. termites, cockroaches, millipedes and beetles), or, in-water directly by methanogenic bacteria (methanobacterium)[6]. (The methane cycle is a sub-cycle of the overall C cycle.)

Specifically the biota need to be adapted to infrequent 'good' seasons; lengthy rainless periods which coincide with high terrestrial and aquatic salt ($NaCl_2$) concentrations, causing in addition to dryness, osmotic stress; high solar exposure, radiation and temperature (which may achieve extreme diurnal ranges – for instance, frost is widespread and frequent in winter).

Together with a capacity for "dormancy-when things-get tough", it is the case that while a landscape, river or pond may dry up to a saline pool, or nothing at all, it may also flood the next day.

From north to south, and east to west, that is what the ecosystems of the Basin have always accommodated. Which is why it is, the way it is – a boom-and-bust system.

Ecologically, a dried-up riverbed and dead trees are as important to the adaptiveness of the overall ecosystem as flowing water and verdant green. But the ecological spin is biased towards the latter, spinning the view that the former represents "ecological disaster"; "low ecological 'health'" (whatever that means!) (For example, first paragraph, Page XIV of the "Guide to the Basin Plan".)

There is no doubt that ecosystems depend on, and respond positively to the 'good' seasons. They are also adapted to fall back in the 'bad'; but judgements about 'good' and 'bad' are time dependent and subjective.

2. The overwhelmingly large variation in rainfall makes it the primary 'driver' of the off-river water balance. It is the case that there is no predictable 'season'. If it falls, autumn rain owes its effectiveness to the decline in evaporation from summer to winter (Table 1).

   The context setting for any Basin plan must view its ecology to be a continuum with some million or so years of adaptive history. These ecosystems are driven largely by haphazard, random events – mainly rainfall events, possibly influenced by unpredictable long-term cycles.

   The problem of interpreting current trends is that compared to past long-cyclic, semi-cyclic, or even step-change trends, the 'real' record is extremely short (*c*. <150 data-years *vs* millennia).

   Underpinning possible cyclic events, we have geological and other processes, such as geologic-scale erosion and deposition – insidious processes that are still continuing; CO_2 out-gassing from the interior of the earth – volcanoes are an obvious example, but diffuse

[6] Although not generally stated in eco-or carbon change literature, breakdown (oxidation) specifically of cellulose and lignin, which together account for 99% of the active terrestrial carbon pool, is as important to ecosystems as photosynthesis (primary production). If oxidation ceased, the accumulating carbon would 'lock' up the nutrient pools which would bring the whole process of growth and cycling to a stop. (Lignin breakdown is carried out mainly by fungi (Basidiomycetes – mushrooms, toadstools etc.) either alone, or in association with an alga (where the symbiosis is observed as a lichen). Cellulose is broken down either by aerobic bacteria (which releases CO_2 + energy), or it occurs anerobically as a chained-process, to release CH_4 and energy.) Because 'higher' order organisms, such as arthropods and ruminants cannot directly digest 'fibre', they rely on symbiotic associations with fungi and anerobic bacteria to do the job for them. The organism does the 'mechanical' work, including hunting and gathering, and provides the environment (the anerobic gut); the microbes do the chemical part. This provides food for the organism.

outgassing is believed to occur continuously[7]; the ingress and retreat of biota; the believed to be relatively constant 'rain' of salt from the west and south west, and the influence of human-kind, both indigenous and European.

Table 3. Rainfall and evaporation statistics for Moulamein Post Office (1948-2004)

Month	Average rainfall	Variation (%)[1]	Average evaporation	Variation (%)
January	24.7	123.8	279.2	9.7
February	24.1	116.8	232.7	7.9
March	28.7	119.6	190.1	8.5
April	26.0	110.1	113.2	9.3
May	36.4	71.9	65.3	11.5
June	27.4	71.4	42.7	14.4
July	32.9	64.3	46.7	15.9
August	35.5	67.8	68.7	14.4
September	33.6	66.1	101.7	14.0
October	38.5	76.6	157.0	14.6
November	28.5	77.9	210.5	10.1
December	30.0	100.3	267.2	9.8
Annual	366.5	86.4	1775.0	10.6

[1] Variation is the standard deviation as a percentage of the mean (= coefficient of variation).

3. High rainfall in autumn and low rainfall in spring can have opposite impacts on the biota than the reverse. For example, high autumn rainfall results in an abundant germination of annual C_3 plants, and higher competition against C_4 plants the following spring. This is out-of-phase competition (Johnston *et al*, 2002)[8].

   However, as the data (Table 3) indicates that the reliability of spring rainfall is higher than in autumn (low CV from July to September). Thus for perennial species, water efficiency and responsiveness to short episodic periods of growth, and drought hardiness would be essential.

   Thus, woodland[9] overstory is dominated by long-lived ever-green, deep-rooted C_3 sclerophyllous trees and shrubs (such as species of *Eucalyptus*, *Acacia*, *Callitris*); perennial groundcover layer is dominated also by 'woody' species, including summer growing C_4 species such as saltbushes; C_4 species of sedges and rushes, and C_4 grasses[10].

It is the case that over most of the basin, in most months of most years, most of the rainfall has always been accounted for by evaporation at the point where the rain falls. Thus, taken overall, some 86% of the Basin contributes virtually no runoff to the river systems except during floods

[7] Professor Emeritus Thomas Gold FRS "The outgassing processes of the earth". Chapter 4 in: Carbon, Element of Energy and Life. The Science Foundation for Physics (LE Cream and DA Varval (eds.)) (27th International Science School for high school students; University of Sydney, 1993.)

[8] Johnston WH, Koen TB, Shoemark VF (2002). Water use, competition and a temperate-zone C_4 grass (*Eragrostis curvula* (Schrad.) Nees. Complex) cv. Consol. *Australian Journal of Agricultural Research* 53, 715-728.

[9] See Gillison AN (19994) Chapter 8: Woodlands. *In*: Australian Vegetation (RH Groves Ed.) (Second edition). Cambridge University Press. PP 227-255.

[10] Johnston WH (1994). The place of C_4 grasses in temperate pastures in Australia. New Zealand Journal of Agricultural Research 39, 527-540.

Basin ecosystems are geared to this. Perennial species (grasses, shrubs and trees) exhibit episodic or opportunistic short growth periods followed by dormancy. Annual plants do the same, hiding away as seeds. When it rains, everything comes to life; when the water dries up, ecosystems fold-up and wait for the next event.

Limiting our understanding of longer-term processes is that we have available to us only a very small 'window' of time in which we've observed ecological processes in the Basin.

Compared to data collected through time[11] modelling is a second-rate and highly speculative analysis tool, especially 'predictive' (forecasting) modelling (statistically, errors around a prediction are much larger that errors in regression!).

Take for instance, actual rainfall data for Tumbarumba NSW, which is within a runoff-donor sector of the southern MDB (upper-Murrumbidgee). Data shows that the long-term rainfall average of 974 mm, is made up of numerous short-term oscillations from 'wet' to 'dry' (Figure 1; Table 3).

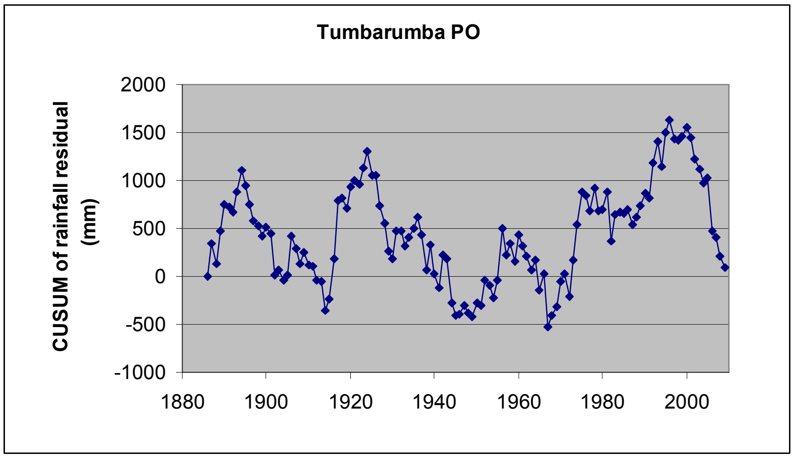

Figure 1. A CUSM[12] (cumulated sums) of deviations from the long-term average rainfall (974 mm) for Tumbarumba NSW. Persistent above-average rainfall periods are indicated by rising CUSUM trends; dry periods are indicated by falling trends. (Statistics for defined periods are given in Table 4).

It is the case that for Tumbarumba and other centres in the high-rainfall southern sector of the Basin that rainfall has oscillated from relatively wet (6 periods in the case of Tumbarumba) to relatively dry (5 periods) for durations of between 5 to 19 years.

(At Tumbarumba, the recent (2001-2009) 'dry' was eclipsed in duration twice before, so it was not 'unique'; the period's average rainfall of 812 mm was similar (in the same percentile) to that between 1925 and 1930; and 1937-1949; so it was not 'historically' dry either.)

The average MDB rainfall anomaly dataset indicates that there were more above-anomaly years post-1954 than in the first half of the record (Table 5).

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[11] CSIRO largely withdrew from MDB rangeland research in the late 1980's; the Soil Conservation Service of NSW largely withdrew their investments in long-running monitoring in the early 1990's.

[12] CUSUM curves are constructed by deducting the long-term average for a datset from each annual data value (preserving the +/- sign). The 'residuals' are then cumulatively summed. Sequential negative data (i.e. values less than the long term average) become more negative as the trend proceeds; sequential positive data show the opposite. Although not applied to the data for Tumbarumba, break-points, where trends reverse, can be evaluated for their statistical significance (this is a test of whether the 'break' has a likelihood that is not due to a chance combination of data).

It seems from these data that it is an alarmist misconception that rainfall in the MDB is declining; and that drought has become more frequent and intense (e.g. Nicholls [13]).

It is impossible to evaluate the statement in the 'Guide to the Basin Plan' that: "Annual rainfall in the southern Murray–Darling Basin was significantly lower than the long-term average for the 10-year period 1997 to 2006" including its use of the word 'significant' without access to more comprehensive datasets.

However, calculating a back-transformed time series of the BOM MDB rainfall anomaly dataset indicates that the driest 10-year period across the basin ended in 1946 (average of 394.1 mm).

(The early 1940's were generally dry; the years included for instance the driest 15 years in the dataset (average of 414.0 mm for the 15 years up to 1946).

Table 4. Rainfall periodicity as indicated in Figure 1, and relevant statistics for Tumbarumba.

Start	End	Wet/dry	Years	AvRain[1]	Av_LTA[2]
1886	1894	Wet	8	1085.8	112.0
1895	1914	Dry	19	900.9	-72.9
1915	1924	Wet	9	1140.3	166.4
1925	1930	Dry	5	786.6	-187.2
1931	1936	Wet	5	1046.9	73.1
1937	1949	Dry	12	893.6	-80.2
1950	1960	Wet	10	1051.0	77.2
1961	1967	Dry	6	836.9	-136.9
1968	1978	Wet	10	1106.3	132.5
1979	1987	Steady	8	930.5	-43.3
1988	2000	Wet	12	1051.5	77.7
2001	2010	Dry	9	812.1	-161.7
Dry:wet period ratios		5:6	51:54		

[1] Average rainfall for the period.
[2] Difference between the period average and the long-term average (LTA) (of 974 mm)

Rainfall for the last 10-years (421.4 mm) was also dry but not unprecedented in the record. (The 2 driest years in the 2010-2009 time series (277.5 and 278.7 mm respectively) had a considerable impact on the 10-year average.)

Table 5. Numbers of dry and wet years, during the first and second half of the MDB rainfall anomaly dataset (1900-2009).

	All	1900-1954	1955-2009
Dry years	64	35	29
Wet years	46	19	26

So despite a popular portrait of gloom-and-doom bought on by climate change; what we really see is boom-and-bust bought on by the natural scheme of things!

The limited long-term data that is available suggests that the post-2000 rainfall trends are not unprecedented; they are either random events or part of long-term oscillations.

Core samples from Lake George (Singh and Geisser (1985)[14] indicate that the climate has been colder, wetter, hotter and drier than it is today; and that in response, the vegetation has changed

[13] Nichols N. 'Drought in southern Australia: trends causes, impacts. (School of Geography and Environmental Science, Monash University, Clayton Victoria.)

from wet forests to dry forests and from fire sensitive species to fire tolerant ones. As some of these changes were not naturally reversed, some species naturally became extinct.

While Singh and Geisser (1985) could look back in time some 700,000 years, the time horizon on which the Basin Plan has been developed represents only the last mere 150 years of this history.

Table 6. MDB rainfall averaged over the driest periods on record of from 1 to 15 calendar years. Thus, the driest single year was 1902 (258.1 mm); the driest 9-year period ended in 1945 (average of 395.2 mm).

Driest number of years	Rainfall (mm)	Ended in:
1	258.1	1902
2	315.1	1902
3	345.8	1967
4	356.5	1946
5	380.3	1944
6	383.1	1945
7	383.3	1946
8	395.0	1944
9	395.2	1945
10	394.1	1946
11	401.1	1945
12	399.7	1946
13	407.8	1946
14	414.4	1946
15	414.0	1946

Statistical analysis of Basin-wide climate trends.

A comprehensive statistical analysis of quality-assured rainfall datasets across the NSW portion of the Basin was undertaken by Rančić *et al* (2009)[15] in the context of understanding links between rainfall, aquifer recharge and discharge, and salinity.

Residual mass (or CUSUM (cumulative sum)) curves of deviations from long-term average values were derived for 'high quality' rainfall stations for their length of record (generally 1880-2004). Data were graphically and statistically analysed to detect trends and step-changes.

Rainfall exhibited 2 abrupt step-changes (Figure 2). In the mid 1890's (1895) rainfall trended from wet to dry; in the late 1940's (1947) it reverted to a wet phase. (Data was only analysed to 2004, which was period too short to test the statistical significance of the downward trend from about 2000 to 2010.)

Rančić *et al* (2009) summarised that: "The 1947 climate shift was most pronounced in the uniform rainfall zone (Macquarie, Lachlan, Murrumbidgee East, upstream of Burrinjuck Dam,

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[14] Singh G, Geissler Elizabeth A. (1985). Late Cainozoic history of vegetation, fire, Lake levels and Climate, at Lake George, New South Wales, Australia. *Philosophical Transactions of the Royal Society of London, series B*, 311:447.

[15] Rančić A, Salas G, Kathuria A, Ackworth I, Johnston W, Smithson A, Beale G (2009)"Climatic influence on shallow fractured-rock groundwater systems in the Murray-Darling Basin, NSW". Department of Environment and Climate Change NSW. February 2009.

and the narrow northern belt of Murrumbidgee close to the border with Lachlan). The rainfall increased by more than 20% at most stations. The residual mass curves typically exhibited a distinct ‘V’ shape, clearly delineating the dry from the wet phase. The 21-year moving-average graphs illustrated a long-term rainfall average that characterised each phase. Shorter-term climatic oscillations linked to the higher-frequency signals were visible, but were not the dominant feature seen in the residual mass curves.”

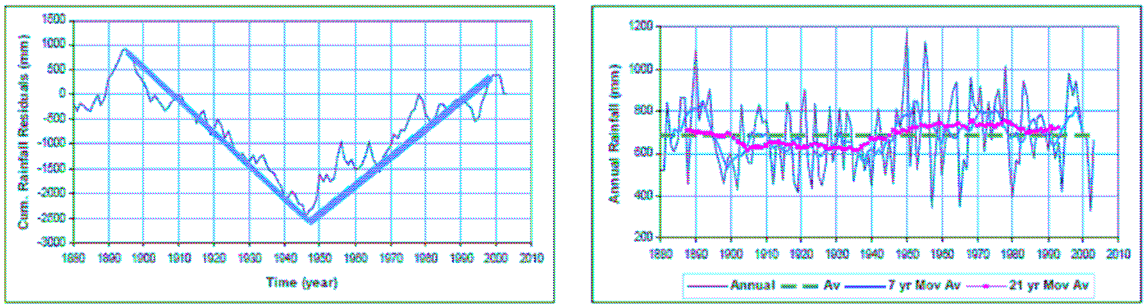

Figure 2. Clear rainfall shift in the summer rainfall zone: residual mass curve (left) and timeseries graph (right) with two degrees of filtering (7- and 21-year moving averages) for the 54003 Barraba Post Office rainfall station.

Looking at MDB-wide data.

The Bureau of Meteorology (BOM) website provides limited Basin-wide annual rainfall and temperature data (1900-2009); temperature data expressed as ‘anomalies’ that is, residuals relative to the average for each element for a ‘standard’ 30 year period of between 1961-1990.

The 30-year period averages are provided, thus anomaly data can be back-transformed into ‘actual’ data.

(The average 1961-1990 ‘standard’ used for calculating rainfall anomalies was 488.7 mm; the long-term average for back-transformed data (1900-2009) was 467.2 mm. The difference of 21.5 mm represents a significant bias[16] in the data (Figure 3).

The long-term average –based data shows the same pattern as in Figure 2: a cumulatively dry period from 1900 to 1947, followed by a rising rainfall trend up to 2000, then a falling trend for the remainder of the record (2009).

For the anomaly dataset, because the average for the ‘anomaly’ (1961-1990) mean is 21.5 mm less than the long-term average, its residual mass curve declined more quickly from 1900 to 1947; it then did not recover during the ‘wet’ phase. This is because; relative to the long-term average the ‘anomaly’ consistently accumulated the 21.5 mm deficit into each year’s rainfall summation.

Thus at the end of 109 years of record, the difference between the curves was 2343 mm (21.5 mm multiplied by 109 years). This rainfall ‘disappeared’ because of the way it was calculated!

For the Basin (and climate-change literature generally), rainfall, and other data including temperature, is consistently shown in ‘anomaly’ terms relative to a 1961-90 average.

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[16] Several forms of bias exist. The bias referred to here is systematic. It arises because the statistical dataset average is greater than the ‘standard’ IPCC 1961-1990 average (which is the one used to calculate ‘anomalies’). In this case the bias becomes larger as time progresses at the rate of 21.5 mm/year. It in turn leads to perceptual bias eg. ‘the worst drought on record’; the longest period of hot days’. It could be fairly said that error is an issue of measurement precision, whereas bias is an issue of data manipulation, presentation and interpretation.

Relative to the long-term 'average', if the base-average happens to be less, accumulations over time will show a decline similar to that illustrated in Figure 3. If the base-average happens to be higher, 'down' trends will 'reduce' and upward trends will be accentuated.

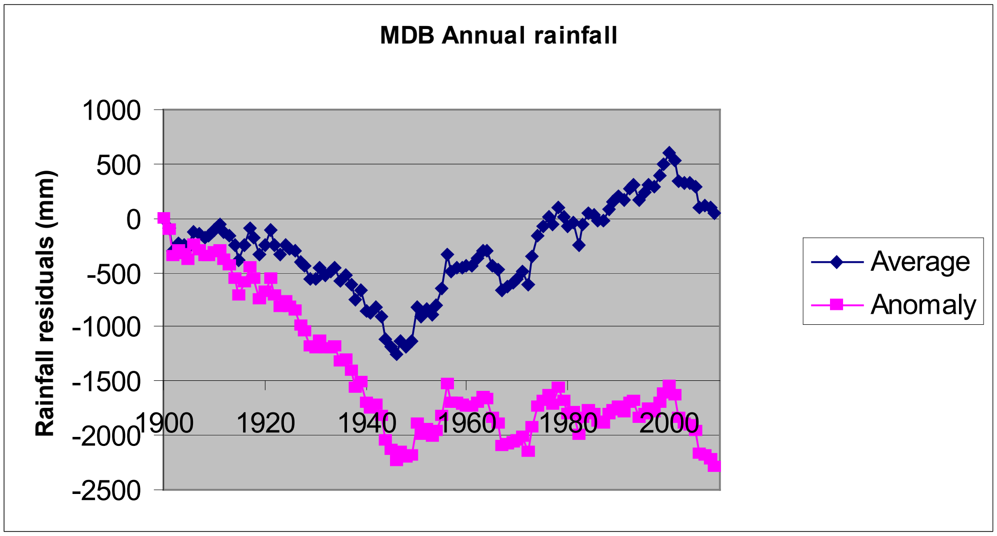

Figure 3. Residual mass curves derived from the MDB average rainfall series showing (i) cumulative sums of residuals based on the back-transformed long-term (1900-2009) average of 467.2 mm (diamonds; blue line) and (ii) the anomaly 'standard' 1961-1990 mean (488.7 mm) (squares; pink lines).

Notable Basin droughts.

The ecology of the Murray-Darling Basin is self-repairing. That it is 'near-collapse' is an outright political myth.

The ecology has to be self-repairing, because although at their source, most major tributaries are perennial, frequent and extensive drying is a feature of the long-term flow patterns of the riverine part of the system (i.e. the majority of the Basin's streams and rivers are historically ephemeral).

Outside Capital cities, early rainfall records date back only to about 1860 (in NSW these include Bathurst: 1858; Deniliquin: 1859 and Buckalong (south-east NSW): 1856)[17].

From an analysis of rainfall datasets using residual mass or cumulative residual curves (the same approach used in Figure 1, and by Rančić *et al* (2009)), coupled with an extensive review of contemporary anecdotal material, such as newspaper and company reports, diaries, water resource department records, Commonwealth Year books and statistical publications, Foley (1957) presented a State by State, region by region overview of droughts in Australia from the earliest years of European settlement to 1955. Foley's research was later summarised and extended by Gibbs and Maher (1967[18]).

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[17] Foley JC (1957). "Droughts in Australia. Review of records from earliest years of settlement to 1955." Bureau of Meteorology Bulletin No. 43.

[18] Gibbs WJ and Maher JV (1967). "Rainfall deciles as drought indicators." Bulletin No. 48, Commonwealth Bureau of Meteorology, Melbourne (January 1967).

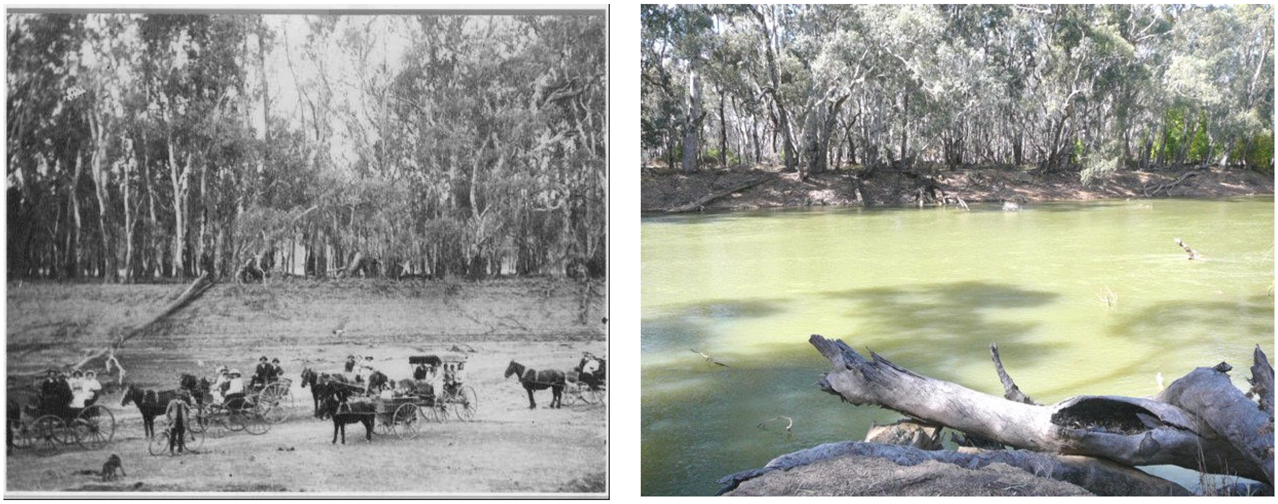

Figure 4. Two photographs of the same location (*Riversdale*), near Myall (15 km west of Barmah) in the central Murray Valley during the drought of 1915 (left) and (right) the drought of 2006. (Note in both scenes, the tree lying obliquely on the far bank.) (Retrieved from: "http://www.jennifermarohasy.com/wiki/Water_levels_in_the_Murray_River")

To quote from Gibbs and Maher (1967) " Much of the Australian continent lies between latitudes 15^o and 35^{o}S, which is the zone of latitude in which the sub-tropical anticyclones (high pressure cells) and subsiding air usually occur …. (the) continent is characterised by clear skies and the absence of rain …. (the) world's hot deserts occur mainly between latitude 15^o and 35^{o}S and in these regions rainfall may be considered as an exceptional circumstance and drought as the norm."

Summarising Foley's data, Gibbs and Maher (1967) listed 29 principal droughts in NSW between 1789 and 1966.

According to Foley, in response to the so called Federation drought (1895-1903), the Victorian Government embarked on a program of water supply developments, including construction of the Waranga Basin and the first Eildon reservoir and the extension of channels for stock and domestic water into the Mallee.

This drought also resulted in the Royal Commission into the Murray River (1902); the next drought (1912-1915) was said to be instrumental in encouraging the Commission to hand down its findings. This was the first step in the establishment of the River Murray Commission; which became the Murray-Darling Basin Commission; which became the Murray-darling Basin Authority; which again responding to drought, this time from 2000 to 2010, is putting forward yet another plan.

From north to south, Foley noted numerous reports of Rivers drying up completely; extended periods of Murray becoming un-navigateable between Mildura, Echuca and Murray-Bridge; of Lake George being dry for periods of 10 years or more; of horse races along the dry bed of the Murrumbidgee River, and of the Darling River and it associated streams, lagoons and wetlands drying to saline ponds or being completely dry

(During the period from 1912 to 1915, rainfall across the high-mountain donor catchments of south-eastern NSW and north-eastern Vic. were depicted in Gibbs and Maher (1967) to be within the first decile range (i.e. very much below average).

It is clear from Foley's and Gibbs and Maher's analyses, that for all reaches of the Murray-Darling system, drought was the norm, not the exception.

That was chiefly the reason why, in order to give security to water supplies, storages with a combined capacity of some 34.5 million ML[19] ($34.5 * 10^{12}$ L) have been constructed across the Basin; the most significant being located in the high-altitude water-yielding southern sector.)

Environmental (or more correctly, specific habitat) water needs are important and need to be protected; but at the end of the day developments along the river systems were designed not to allow excess fresh water, for whatever environmental result, to simply to charge out into the sea beyond the Murray mouth.

The aim was to store the water so it could be used in a predictable prolonged way to meet the needs of a growing and increasingly urbanised human population.

Irrigation developments in the Murray-Darling Basin were truly an amazing feat of foresight, planning, enterprise and endurance!

In the early days, there was no Snowy Mountains Scheme; no Hume Dam or Burrinjuck; no Yarrawonga Weir – in fact no major NSW storages. In Victoria, there was only the Wranga Basin (completed in 1910), several storages on the Coliban River and the Goulburn Weir on the Loddon that offered a water supply buffer to drought (data from Crabb 1997).

Figure 4 evidences that before storages were constructed in NSW, it took just 3 years for the Murray to run dry at Barmah – the wetlands, the forests; everything would have been completely dry!

Since the storages were completed in about the 1960's the main rivers of the Basin have never run dry despite longer than 3-year droughts, and expansion of communities and irrigation industries along their lengths.

The collateral advantage for ecosystems is that they too have not faced the prospect of running out of water completely. This has been ignored in the 'Guide to the Basin Plan'.

In Foley's (*c.*) 300 page report, dry rivers and lakes; high temperatures (>45^{o}C); scorching winds; dying and dead livestock; critical water supplies; abandoned farmlands and raging bushfires were depressingly frequent reminders of the extent to which severe drought dominates the Australian scene. Foley's records show that this was particularly so for the low rainfall (<600 mm) sector of the MDB, and up to the present day, this is still the case.

According to Crabb (1997) the Darling River provides some of the most extreme examples of drought, including that between 1885 and 1960 it ceased to flow at Menindee on 48 occasions; the longest being 364 days in 1902-1903.

Clearly, the ecology of the system would have long-since perished, if it were not adapted to long rainless periods, and lengthy periods of nil to low flows.

Investments in control works such as major storages, channels, locks and barages were implemented to store water and release it later – to prolong and flatten-out flow variability, or in the case of the barrages, keep it fresh.

Although the capacity of these works may be overwhelmed when flood events occur, for the majority of years, they have increased the quantity, reliability, quality, frequency and duration of flow along the river's middle and lower reaches. The works were paid for by productively using the saved water to generate electricity and grow food.

The riverine environment must have been a collateral beneficiary of all this activity. While the impact of developments on infrequent large events would logically be small, since all this work was done major rivers have rarely ceased to flow.

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[19] Crabb (1997). "Murray-Darling Basin Resources". Murray-darling Basin Commission, Canberra ACT

According to Crabb and other data, what we see today is a less variable long-flow river regime. Logically, if there is no rain, and no water, it cannot be pumped out of the rivers; and clearly, if South Australia is guaranteed water, when drought occurs, it is up-stream users that are affected first.

Most of the water that ends up in South Australia commences its journey in spring as runoff in the alpine uplands of NSW and Vic.. 'Purchase' of water in Queensland or Bourke, to somehow offset lack of flow at the Murray Mouth, defies any test of logic, because a large proportion of it evaporates during its passage south along the Darling.

It seems impossible conclude from the historical record, that the present-day ecosystems of the Murray-Darling need to be 'saved'. They are simply experiencing and responding to a dry phase.

Lake Eyre – a story of ecosystem revival

In area, the Lake Eyre system is larger than the Murray-Darling – 1.17M km^2 *vs*. 1.06 M km^2.

However, it is a (salt accumulating) terminal lake; its catchment's rainfall is low and highly seasonal and it fills infrequently (about 1 year in 10).

Lately, there has been great excitement in the popular press that Lake Eyre has (2009-2010) received 'filling' runoff via the 'Channel Country' for the second time in 10 years.

Reported, with graphic footage of country wetting up and turning green (satellite images); the 'wetting front' flowing over parched soils (terrestrial image); of green grass and daisies blooming; fat cattle (helicopter images); of birds flocking (aerial image), mating (close-up) and as a result, many more birds gathering their food, which suddenly appeared virtually from nowhere out of the 'life-giving' water.

Amazing sights were revealed to TV viewers across Australia and around the world, and several charter companies conducted tourist flights over the Lake and its surrounds for visitors.

As the first filling event receded (2008-9), there was graphic footage of dead chicks; of desperate parent birds floundering about, and fish gasping as they perished in the salt and mud.

(At this point there could have been a survey in Adelaide, sponsored by WWF asking respondents if Murray-Darling water should be pumped to Lake Eyre to save the chicks!)

The ecological analogy is that like many wetlands in the MDB system, Lake Eyre is a *terminal* lake – when it dries up, all life that depends on water, but which hangs around too long, terminates. For Lake Eyre, the *median* escapee could be the last that could be expected to live a little longer. Nevertheless, Lake Eyre does not die – contemporary graphic images show that as a result of it and its donor flood plains to become dormant, the system maintains its potential to be triggered back into life by infrequent ephemeral processes.

The ecology of Lake Eyre (and its tributaries) are popularly portrayed to respond instantaneously to 'wetting' – the frogs come out, even fish come from nowhere to swim about; the birds know, and as if by magic, upon its filling everything comes alive and becomes an instant tourist attraction.

Even without detailed knowledge of the specific ecology of Lake Eyre, it is safe to point out that its seeming lifelessness during its lengthy and intense dry periods is as important to its range of species and their persistence, as it's wetting events. It is the cycle that makes the habitat unique and its ecosystems resilient. If it wet more frequently, it would be a different Lake!

Taking a brief look at some ecological studies.

1. Bird surveys (Lowbidgee wetlands; Macquarie Marshes).

For a work of science, the paper by Kingsford and Thomas (2004)[20] relating to the Lowbidgee wetlands presents an aggressive view, rather than an objective and constructive one.

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[20] Kingsford RT and Thomas RF (2004). Destruction of wetlands and waterbird populations by dams and irrigation on the Murrumbidgee River in arid Australia. *Environmental management* 34, 383-396.

For example, it implies that the Murrumbidgee River is *dammed* and it discusses *destruction* of its lower valley wetlands by dams and irrigation. The paper failed to present an overarching climate/rainfall perspective, or that bird populations do not remain constant, but rise and fall in numbers, depending on natural cycles and circumstances.

Obviously development of any kind, non-urban or urban has an ecological footprint. It is probably the case that for the Murrumbidgee, irrigation, provision of infrastructure, and production of food come at some ecological cost.

Nevertheless, despite all the developments, and the livelihoods, and the number of people that it nourishes; despite they being somewhat degraded by the 2000-2010 drought, Kingsford and Thomas stated that some 42% (almost half – a total of 127,688 ha) of the original Lowbidgee wetlands still remain wetland.

Data in the paper's Figure 2 showed that from 1888 to 1998 annual Murrumbidgee River flows at both Wagga Wagga and Hay, were highly variable. There were about 14 occurrences of flows at Wagga Wagga exceeding 5,000,000 ML/year. These would have been flood events. Waterbird surveys undertaken from 1983 to 2001 may have included one such event (1993) but it is difficult to discern this from the Figure.

Rainfall data analysed for Tumbarumba (Figure 1) (and other rainfall stations not shown) indicate that, relative to the long-term average, the bird surveys were conducted during a wet climatic phase (which went from about 1983 to 2000).

Raw river gauge data for Wagga Wagga reflected this, with the residual mass curve rising from about 1983 to 1998 (Figure 5). There was a cap on diversions (for irrigation) from 1995. The decline in the mass curve from 1998 onwards reflected the rainfall decline (see Figure 1) that continued until autumn 2010.

If we look at river data downstream of Wagga Wagga we find for the datasets that I've managed to obtain:

(i) A tight regression relationship between successive gauging stations, which indicated as expected a high degree of linear interdependence (Wagga Wagga *vs*. Hay R^2 = 0.87; Hay vs. Balranald R^2 = 0.95.)

(ii) River flow at Hay and Balranald peaked in 1984, 1989 and 1993; flows declined dramatically with the onset of the subsequent drought (Figure 6).

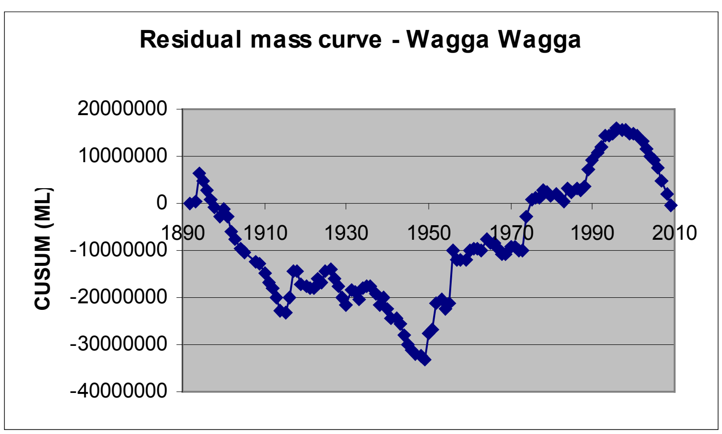

Figure 5. Residual mass curve of raw flow data for the Murrumbidgee River at Wagga Wagga (ML/calendar year.) Note that flow rates were above the long-term average from about 1988 to 1998.

(iii) Gross water loss, inclusive of evaporation, leakage to groundwater, withdrawals due to stock, community and domestic use, and irrigation can be calculated as the balance in river flows between the successive gauging stations.

Some water balance components, such as evaporation and leakage are relatively constant, thus most of the change in the balance over time can be assumed to be due to urban, stock and domestic, environmental and irrigation use (net withdrawals from the river).

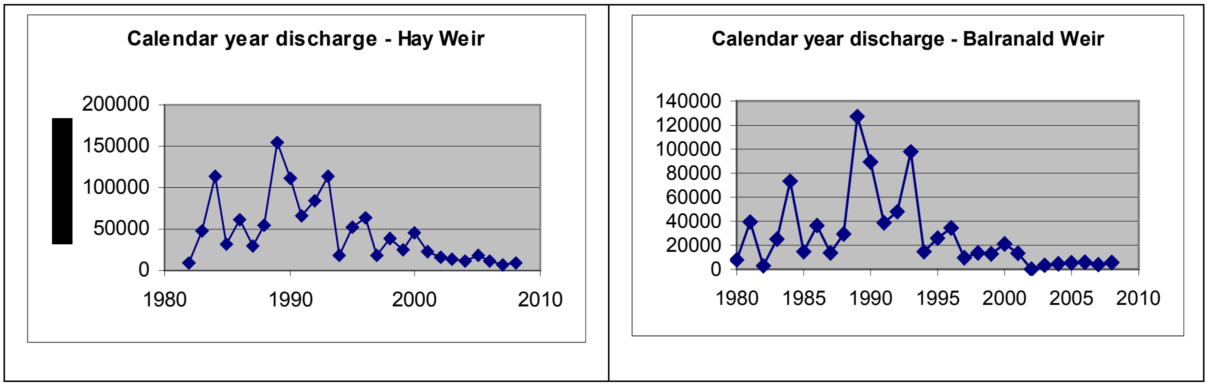

Figure 6. Calendar year flow – Hay and Balranald Weirs. Flow started to diminish in 1994, at a rate that cannot be explained strictly in terms of water use (see Figure 7 below). Note that the MDBC Ministerial Council introduced a Cap on surface water diversions in 1995, which became permanent in 1997. So from 1995, water use declined independently of water allocations.

(iv) For the Wagga to Hay sector, water use declined from a peak of about 7,000,000 ML in 1989, to less than 1,000,000 ML in 2008 (Figure 7). A similar decline in use occurred in the Hay to Balranald sector, with use declining from a peak of about 40,000 ML in 1984, to less than 5,000 ML in 2008 (not shown here).

(v) Clearly, less rainfall from 1990 resulted in less water in the river. This in turn caused a massive decline in the amount of water used to irrigate crops and pastures, and as costs increased, and water still had to go through to South Australia, scarcity resulted in increases in the efficiency of water use.

It is simply misleading to blame the ecological consequences of this dry period on irrigation development and agricultural water use.

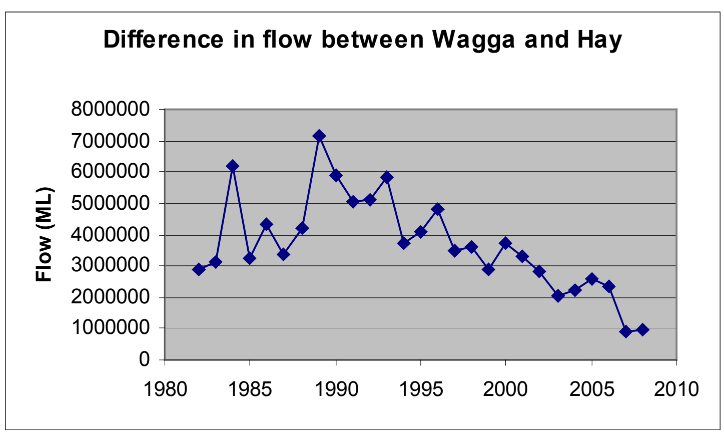

Figure 7. Difference in gauged flow between Wagga Wagga and Hay 1982-2008. (As the difference declined *less* water was taken from the system.) Note the 7-fold decline in water use (accounted for mostly by irrigation), between 1990 and 2008. (Note that the MDBC Ministerial Council introduced a Cap on surface water diversions in 1995, which became permanent in 1997. So from 1995, water use declined independently of variations in water allocations.)

(vi) Despite declining flows, the Lowbidgee bird data (Figure 6 in Kingsford and Thomas (2004) showed breeding-peaks in 1990 and 1992 and again in 1995 and 1996, seemingly independently of the patterns in the water data. Kingsford did not investigate other factors that may affect his results such as lags between flow events and major breeding events. However, there would seem to be other factors at play.

As a criticism, Kingsford and Thomas' 1998 helicopter survey was undertaken during the 'falling' flow phase of the river system. It is therefore unsurprising that the apparent 'health' of its ecosystems was judged to be declining in parallel. (The objectivity of the paper could have benefited by an exploration of this important experimental context.)

A second criticism is that counting birds from an aircraft would be analogous to counting sheep while being driven across a paddock at 100 km/hour. It may be inexpensive broad-scale data, but how accurate is it? What happens to the errors – the birds that were miss-identified, counted twice or not seen at all?

(It is unbelievable that in 1983-86, 139,939 water birds were physically counted across the Lowbidgee wetlands from an aircraft; so how was the standard error of just 15% calculated?)

The question is: do we really have good data, or do we have sketchy *ad-hoc* cheap, imprecise data that has been polished up (by modelling)?

Kingston and Thomas's confounding of water use (by irrigators), with: declining runoff and storage volumes due to sequences of low rainfall years; obligations by NSW to supply water to South Australia, and the States commitment to 'environmental' flows, was a major flaw in their paper.

But their results still stood. **As a result, the community has been left with a flawed and biased perception of the 'true' situation and its causes.**

In reply to an article in The Land newspaper by Jennifer Marohasy[21] that questioned MDBA 'science' Kingsford[22] stated that since 2000, no successful large-scale breeding has occurred (in the Macquarie Marshes).

The capacity of the birds to recover from low-population breeding cycles is obvious from Kingsford's Macquarie Marshes data (as presented by Marohasy), with 'peak' breeding events in 1990/91; 9 years later in 1998/99 and 3 years after that in 2000/01.

Data gathered using ground-surveys that commenced in 1986/87, and given by Marohasy indicates little regularity between breeding events. **So it is not surprising that due to the drought that commenced in 2010, that breeding has been curtailed**.

Now that southern Australia has experienced a good spring (2010), perhaps there will be another major breeding event in the Macquarie Marshes in 2011.

Indeed, recently, Kingsford's group issued a press release, which was published by the *Sydney Morning Herald* (Weekend Edition November 6-7, 2010), headed "Wetland wonderland breeds bird's paradise" (page News 7). The sub-line as "A once parched flood plain has become a bustling "mini-Kakadu" after farmers used irrigation infrastructure to mimic Murrumbidgee flows".

This breeding event, like those before, was actually out of everybody's hands – it was caused by high rainfall commencing in autumn 2010 that filled the major storages by early October, resulting in the October 2010 flood.

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[21] Marohasy J. (2010). MDBA all politics and no science. *The Land* Thursday October 14 2010, 32.

[22] Opinion: *Birds eye view* The Land newspaper Thursday October 21 2010.

But, spin, spin, spin, Kingsford related the story to the Basin Plan – talking of ‘wicked’ consequences such as acidification and more blue-green algae outbreaks if moderate to high flows were not restored …. spin…spin….spin …. if the plan was not adopted.

In his earlier papers and opinion pieces, Kingsford failed to put forward a scientifically-backed argument that bird-breeding would not naturally recover, as it has in the past, once drought conditions ease, as they also have in the past, and now again in the present.

Instead, he has consistently put forward alarmist and biased rhetoric about dams and farmers and irrigation.

The public at large should be aggrieved by the blatant bias evident in Kingsford’s presentation of his data. His lack of impartiality and his seemingly impulsive use of data for political manipulation would seem to valid grounds for questioning continued support of his work.

(Wetland ecology is not just about water in the rivers. It is also about the effect of drought on terrestrial ecosystems that ‘feed’ the rivers. Thus, just providing water will not necessarily ‘revive’ the aquatic ecosystems; widespread good rainfall is what is needed!)

(There are indications from another more objectively presented bird-survey study (Chambers and Loyn 2006[23]) that climate has a major influence on populations; and that the response of bird populations to stream-flow and regional rainfall may lag considerably.)

The water situation across the Murrumbidgee Valley should largely reflect the storage levels in its main storage – Burrinjuck Dam (Figure 8). (Burrinjuck was completed in 1927; but it was enlarged later in 1957 (note the volume step-change apparent in the data).

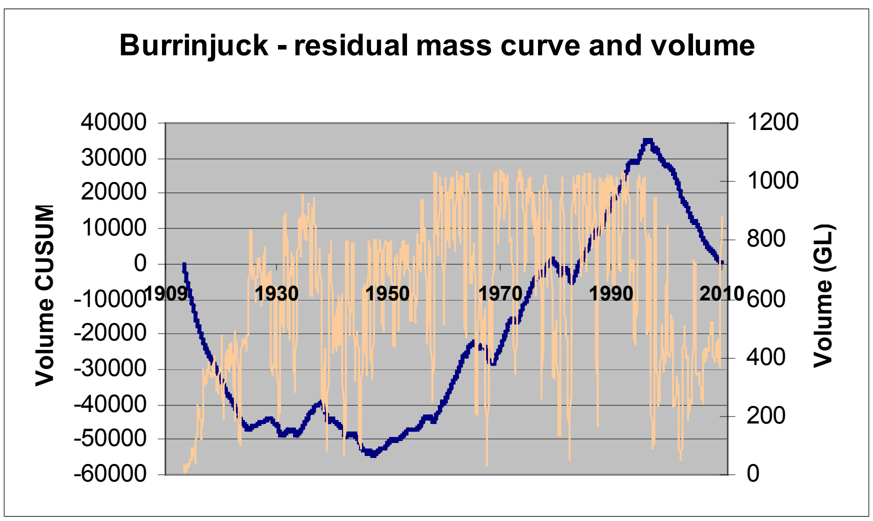

Figure 8. Residual mass curve, showing trends in the volume of water stored in Burrinjuck Dam (thick blue line; left-hand axis) and month-to-month variation in total storage (light tan-coloured line; right-hand axis) (Volumes are in giga-litres (10^9 litres). (Note that the MDBC Ministerial Council introduced a Cap on surface water diversions in 1995, which became permanent in 1997. So from 1995, discharge was not ‘driven’ by increasing water allocation; it was driven by declining rainfall and increased environmental allocations!)

From 1913 to 1948, the Basin experienced a dry rainfall phase (see Figure 3), the volume stored in Burrinjuck Dam reflected this. Oscillations in volume due to water releases, mainly in autumn, were limited by inflows the previous spring. Each ‘dip’ in the CUSUM trend was reflected by increased releases and slower recovery, even as the ‘wet’ phase became entrenched after 1948.

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23 Chambers LE and Loyn RH (2006). The influence of climate variability on numbers of three waterbird species in Western Port, Victoria, 1973–2002. *International Journal of Biometeorology* 50, 292–304

(The volume stored in the dam, was behaving just as it was designed to behave, it was being used to buffer against drought!)

There was no recovery in the volume stored after the CUSUM peak in 1998. Because of a lack of inflow, discharges caused a step-wise depletion in the volume of water stored.

If the dam had not been there, the river would have ceased to flow between Gundagai and Wagga Wagga as it did during the Federation drought. The Lowbidgee wetlands would have been reduced to an acidic saline marsh.

2. The assessment of river condition (ARC) (Norris 2001)[24] (290 pages)

The introduction (page 16, penultimate paragraph.) states that: "Dryland salinity is now seen as a growing problem that is threatening agricultural production, infrastructure and the ecological integrity of rivers nation-wide. Erosion from land surfaces and stream banks has resulted in widespread degradation of aquatic habitat. **These are examples of problems affecting rivers that require management at geographical scales".**

When the report was written (2001), the 'growing' and 'threatening' salinity problem had already not eventuated at the scale and in the time frame that had been predicted by CSIRO, the Wentworth Group and the State Agencies that by 2001 no longer existed.

Soil erosion was also a largely time-gone problem[25]; a legacy of carrying capacity over-optimism in the late 1800's; rabbits; and sequential dry years from 1900 to 1948.

The rainfall step-change in 1948; control of rabbits in the mid to late 1960's; activities of soil conservation agencies that no longer exist; advances in pasture species; removal of the superphosphate 'bounty' in about 1976; and advances in herbicides (especially the release of glyphosphate in about 1969) that allowed the development of minimum-tillage techniques; double cropping etc. etc. etc. contributed to the decline of widespread soil erosion across the Basin.

Many advances were made in the way land management was practiced during the 1970's. Most if not all, would have 'improved' most of the 'catchment health' indices relative to what they would have been (if they were measured) during the first half of the 20th century.

The Audit Report is a keystone report supporting the Proposed Basin Plan. However, in its entirety, it is astoundingly, outrageously and unashamedly biased.

It is based on a comparison with an entirely hypothetical 'condition'; namely the pre-European pre-1770 condition for which there is absolutely no reference data! No rainfall; no species; no areas of wetlands; no nutrient loads; turbidity; salinity; burning; no satellite data; absolutely nothing!

The bias arises because the use of some hypothetical best-case, forces just about every other contrived, largely data-free measure to be 'less' in all catchments that have been influenced by post-1770 settlement!

(Captain Cook recorded that in 1770, the east coast of Australia was ablaze. There could have been drought from 1690; rivers and wetlands nothing more than burnt-out remains by 1710; dust storms; major soil erosion events ending with coastal wildfire in 1770. Because no one knows

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[24] Norris R, Prosser I, Young B, Liston P, Bauer N, Davies N, Dyer, F, Linke S. Thoms M (2001). An audit of the ecological condition of Australian Rivers: Final Report (by CSIRO Land and Water), submitted to the National Land and Water Resources Audit Office September 2001.

[25] Stewart J (1968). Erosion survey of New South Wales eastern and central divisions re-assessment – 1967. Journal of the Soil Conservation Servive of NSW 24 (3), 139-154.

their true state in 1770, it is the case that they may be in better condition today than they were then!)

The ecological Audit Report is pure science fiction!

As noted in the Report, European settlement of Australia and its consequence is not a condition that can ever be reversed. So in a contemporary context, even if everything possible could be done, the virginal condition could never be re-attained!

Table 1.2 of the Report details components, data sources and coverage for each of the 'indices' that were related to unmeasured pre-1770 'data'.

Catchment 'disturbance' as measured by satellite and cartographic data seems comprehensive, but it does not cover some 200 years (pre 1980) of change. Much of the other 'data', including important data such as nutrient and sediment loadings arose from modeling.

The first paragraph of the Executive Summary of the report states that:

"Changes to the Australian landscape such as agriculture and urban development have resulted in many problems that have contributed to the degradation of river condition, suggesting that current use of our water resources is not sustainable. Without intervention and management, the condition of Australia's rivers will continue to deteriorate."

There is no conclusive evidence from the Audit report or anywhere else that current use of water resources is not sustainable; or that the condition of Australia's rivers will continue *ad infinitum* to deteriorate. The Audit Report was contrived during the recent drought, and it failed to acknowledge the capacity of the river system or its ecosystems to re-invigorate themselves once current conditions eased.

Electrical conductivity data for the Murray-Darling system has been measured at Morgan (SA) at least since 1938. Data were obtained from MDBA on about 25th November 2010.

So…

At Morgan, salinity was measured haphazardly, but usually monthly up to January 1962. From January 1962 it was measured daily; data were provided up to the 26th October 2010.

The pre-1962 measurements were probably undertaken in a laboratory, using a wheatstone-type bridge, where the electrical resistance of over a 'fixed' cross section of the unknown sample was 'balanced' using sets of known resistances. Resistance was then inverted to give conductivity (i.e. conductivity = 1/resistance).

For the 'Marconi' instrument that I was familiar with, a nul point was arrived at by turning variously scaled resistances, from 'coarse' to 'fine' and these were added up to give the answer. The answer was then converted to EC or 'salt' content, using tables such as that later provided in USDA Handbook 60 – *Diagnosis and Improvement of Saline and Alkali soils* (1953).

Unfortunately the Marconi instrument (and other DC bridges) was difficult to use. As I recall, its main deficiency was that it was a DC (direct current) instrument, which caused the electrodes between which resistance was being measured, to polarise. As this happened, the resistance 'nul' -point tended to drift ever-downwards.

(I tried unsuccessfully to use a Marconi bridge to calibrate soil moisture resistance blocks in the 1970's. The problem of polarization required using alternating current (AC) meters, and all modern resistance logging equipment does this.

Better, more precise techniques of estimating EC were employed post about 1960, including electronic conductivity meters and specific ion electrodes.

So the short story is that we cannot be confident that the pre-1962 data is well scaled or reliable.

Salinity measured at Morgan has been plotted in Figure 9 for the entire length of record (20th January 1938 to 26th October 2010). The commencement of daily data recording in 1962 is clearly evident. Salinity was somewhat depressed from about 1969 to 1974, which as a period of relatively high and reliable river flows (see for example Figure 5) due to the 'wet' climate cycle (see for example, Figure 3). The period from 1973 to 1975 was particularly wet (with 1974 being one of the wettest years on record) across most of the upland catchments of south-eastern Australia. In response to this, salinity data (Figure 9) shows a major salt wash-out event in 1975, confounded somewhat by reduced river flows following the passage of the 1974 floods.

(Murray River flow at Barham (not shown here) showed a strong rising trend from 1973 to 1976. followed by a steep fall commencing in spring 1976, which lasted until Autumn 1989.)

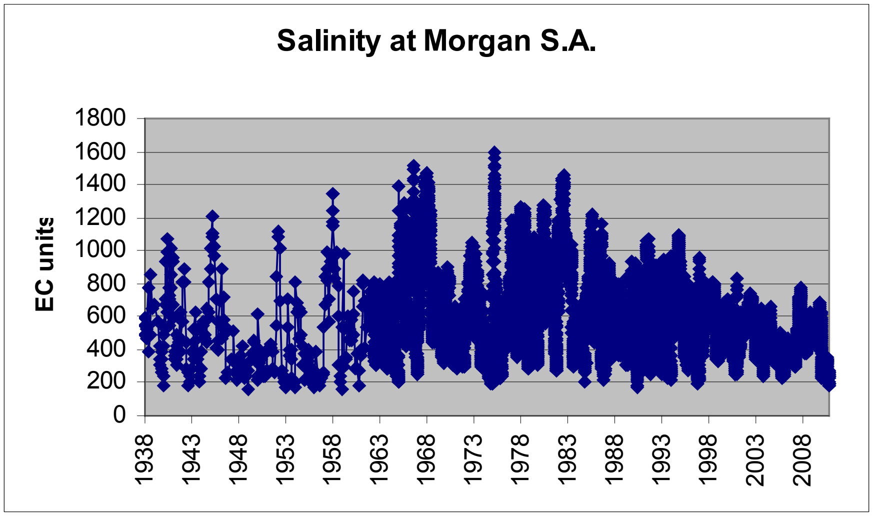

Figure 9. salinity (EC units) at Morgan SA;

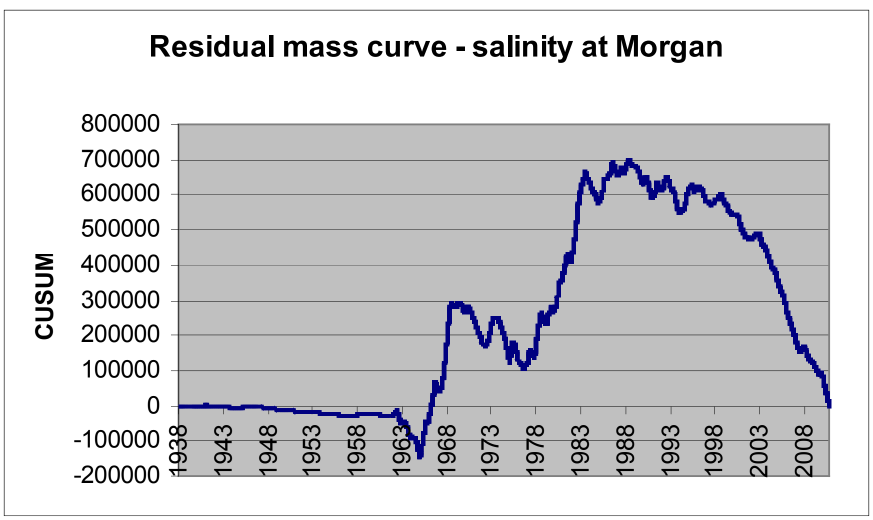

Figure 10. Residual mass curve of salinity measured in the Murray Rive at Morgan SA. Pre-1962 data is suspect but has been included for completeness. (There could be a second technological time-step in these data (1978) due to advances in measurement techniques, which deserves further enquiry.)

Of all the measures of catchment 'health' and despite issues that may be due to the way it was measured, salinity (EC) has the longest currently available continuous record of actual data.

Although suspected to be influenced by measurement issues, the residual mass curve for salinity at Morgan (Figure 10), shows that salinity peaked in about 1983 (which was the end of the 'washout' phase caused by high rainfall in the 1970's), and that it has been declining ever since!

Up-river, along the Murray at Barham, data available since 2000, indicates a likewise decline in river salinity (Figure 11) as does data for other gauging stations such as Wagga Wagga and Balranald (I have not accessed any data for the Darling River system.)

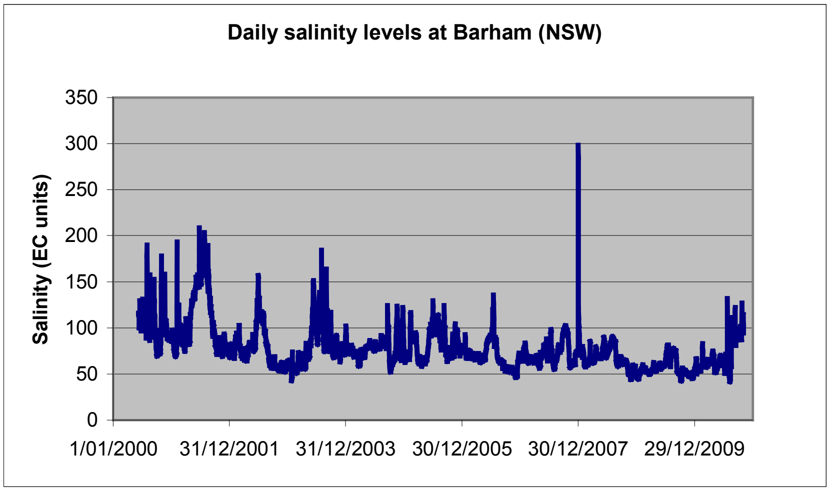

Figure 11. Daily salinity measurements at Barham from 2000 to 2010. (The data point for 30th December 2007 seems to be spurious.)

So the Murray-darling is NOT in catastrophic decline. Its ecosystems, water resources and measured sustainability indicators behave as one could expect for a rainfall-driven system.

There are large areas along all the rivers that are NOT used for agriculture. Birds, fish and its vegetation come and go; everything fluctuates around a 'median' condition just as it should.

Comparing its present day condition with some unmeasured hypothetical 'State' is not credible; it is simply bizarre and biased 'science'.

On cue with the release of the Proposed Basin Plan, the Australian Conservation Foundation released results of a survey relating to 'fixing' the Murray-darling [26].

All the green groups, including the Wentworth Group have been taking turns at thumping the table – publishing 'new reports'; clamoring for air-time; crowing about the 'disasters' unfolding across the Basin.

The ACF survey is typical 'junk'-level manipulation of public opinion.

- 1,500 people were surveyed
- According to Don Henry, executive director of ACF, the survey showed that 75 per cent of people are ***worried*** that without adequate changes, the river system will be ***damaged beyond repair***. In South Australia 87 percent of people **say** the river is badly degraded and needs to be fixed now!

Who among the 1.500 people surveyed would actually know anything about the condition of the Murray, if the alarmist groups had not continuously informed them?

[26] "Most people want Murray-Darling fixed – survey" ABC News, October 24, 2010.

There is no disaster across the Murray-darling that needs fixing; it is a ‘working’ river system, where people work to help feed the world.

There are some ecological off-sets; but the ecology is largely self repairing; the whole system is rainfall-driven; the cap on diversions and the practice of seasonal allocations, based on volumes of water stored in dams and reservoirs has worked, and it is still working well.

Looking at the Basin’s water resources.

Data in Crabb (1997) shows that, under natural conditions just 4 of the MDB’s 26 major sub-catchments, representing about 11% of the total area, contribute >50% of the runoff and >70% of the outflow to the Basin. These are the catchments of the Upper-Murray, Murrumbidgee, Goulburn and Ovens Rivers (Table 1).

In the context of this paper, the data in Table 1, raises some important issues:

1. Runoff in the MDB is highly skewed[27]. Most of the outflow to the system originates in high rainfall areas, especially zones where annual rainfall exceeds annual potential evaporation in more than 50% of the years.

   (A separate transect-based analysis (not shown here) indicates that in the Basin’s southern sector, convergence between median annual rainfall and annual potential evaporation occurs where rainfall exceeds about 800mm/year. This coincides with altitudes of greater than about 800 to 1000 metres.)

2. Clearly, persistent low rainfall periods across the upper reaches of the 4 main runoff-producing basins will have a disproportionate impact on the overall water resource.

   Conversely, a flood, originating in the northern sectors of the MDB, is dissipated considerably by its passage south, reducing its eventual impact on the Basin’s lower reaches.

   Thus the Murray does not pick up much water from the Darling, and the River does not get ‘large’ until it passes its confluence with the Murrumbidgee near Balranald (untitled figure on Page 3 in Crabb 1997). (By then, it has also accumulated waters from the Goulburn and Ovens Rivers as well.)

3. One ML of water originating from low-runoff catchments such as the Gwydir or Namoi for instance, intended for ‘ecological services’ lower down the system, would be depleted considerably by losses to evaporation, transpiration and seepage before it arrived at its intended destination.

   If it were intended for the Murray River, or for South Australia, its volume would have to be ‘made up’ by releases from the high-yielding rivers. (This is taken care of by the various routing models used by State Agencies and to manage the overall system.)

4. Overall the MDB is a highly variable and thus unreliable system, to which its ecology is well adapted.

   For instance, according to Crabb (1997), over the period 1894-1993 estimated ***natural*** annual discharge at the mouth of the Murray has ranged from 1,626 to 54,168 ML (>3,300% difference!), with a mean of 10,090, and a median (50 percentile) of 8,489. Crabb (1997) noted that although storages and other structures smooth out smaller flow variations, their impact is overwhelmed when major floods occur.

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[27] ‘Skew’ is an important concept. It arises when infrequent events are sufficiently large to affect the long-term average. Because it is not possible to experience hydrological events that are less than zero, which would ‘pull’ the average ‘down’, records can only be broken at the high-end of the event spectrum. These inflate the mean relative to what could be expected in half of the years.

Table 7. Water resources of major river basins within the MDB (from Crabb 1997)

Major basin	Area Km2	Runoff (GL)	Outflow (GL)	Area Cumulative %	Runoff Cumulative %	Outflow Cumulative %
Upper Murray	15,300	4,200	4,200	1.44	17.28	26.08
Murrumbidgee	84,000	3,800	2,730	9.34	32.91	43.03
Goulburn	16,800	3,040	3,040	10.92	45.41	61.90
Ovens	7,850	1,620	1,620	11.66	52.08	71.96
Condamine-Culgoa	150,000	1,490	340	25.77	58.21	74.07
Macquarie-Bogan	73,700	1,350	250	32.70	63.76	75.62
Lachlan [1]	84,700	1,270	0	40.67	68.98	75.62
Border	49,500	1,100	840	45.33	73.51	80.84
Namoi	43,100	1,000	600	49.38	77.62	84.56
Gwydir	25,900	860	350	51.82	81.16	86.74
Warrego	72,800	750	10	58.67	84.25	86.80
Paroo	76,200	717	0	65.84	87.19	86.80
Kiewa	2,050	705	705	66.03	90.09	91.18
Lower Darling	58,800	446	130	71.56	91.93	91.98
Wimmera-Avon	23,400	373	0	73.76	93.46	91.98
Broken	7,330	325	325	74.45	94.80	94.00
Campaspe	4,020	280	280	74.83	95.95	95.74
Loddon	15,400	251	251	76.28	96.98	97.30
Castlereagh	17,700	210	100	77.94	97.85	97.92
Moonie	15,800	122	100	79.43	98.35	98.54
Darling	116,000	106	0	90.34	98.79	98.54
Murray-Riverina	16,300	100	100	91.87	99.20	99.16
Avoca	12,000	85	85	93.00	99.55	99.69
Lake George [1]	985	60	0	93.10	99.79	99.69
Benanee	21,400	50	50	95.11	100.00	100.00
Mallee	52,000	0	0	100.00	100.00	100.00
Total	1,063,035	24,310	16,106			

[1] Lake George drains 'internally' and thus does not contribute to the Basin's water resources; the Lachlan is a relatively dry river, and except during extreme flood events it rarely flows into the Murray system (via. the lower Murrumbidgee).

The water resources of the Basin are managed by the Murray-Darling Basin Commission/Authority under the Murray-Darling Basin Agreement (1992). This will be superseded by the new Murray-Darling Basin Plan.

(A handy outline of the complex accounting rules that are currently in place to share and distribute the water resources of the Basin, including for environmental purposes (minimum flows and salinity abatement) and an understanding of how they operate is given by Dyer (2000)[28].)

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[28] Dyer B. "A dummies guide to sharing the River Murray". MDBC Technical Report 2000/04.

Agricultural water use.

Development of agriculture generally, and specifically of irrigation across the Murray-Darling system is by world standards a very recent phenomenon. The drivers were essentially economic, with Government policies geared as they are today, towards ‘growth’.

In the 1800’s up to about the last quarter of the 1900’s growth was about producing things – food, fibre, timber, bricks and manufacturing. Australia had to both ‘pay-its-way’ by exporting goods, chiefly agricultural goods (mainly to England); as well, it had to be relatively self-sufficient in what it needed or consumed.

Since the mid 1980’s aided by Government policies, production of ‘services’ became increasingly more important.

The Nation started importing more of its ‘manufactured goods’ and exporting raw materials to be manufactured, using abundant and cheap labour off-shore, mainly in Asia.

Twenty to 30 years ago, Australia had a strong (and protected) manufacturing base. Today stuff is not made here. Wool is not spun; cheap clothes come from China or Fiji. Australia no longer even has the capacity to manufacture its own nuts, bolts or railway carriages! Hardware is virtually all imported.

In the 1950’s and 60’s, it seemed that almost every city family had a country relative to visit or be foisted onto at holiday-time, and that the country folk would visit at Easter to go to the ‘Easter Show’.

Now, 50 years later, everybody has a relative who is ‘in IT’. As evidenced by the NBN debate, IT is the new ‘services’ paradigm – even though arguably it won’t produce anything tangible, the NBN it is seen by Government to be the new catalyst for ‘growth’.

So, what has this got to do with the Murray-Darling Basin?

Development of the MDB was ‘growth’ inspired. The large ‘runs’ of country taken up by the early settlers were broken up under various schemes including soldier settlement schemes, to create smaller land units that could be more intensively managed and thus achieve higher levels of productivity/hectare. ‘People density’ was increased to make provision of services more economic. Development of water resources, and of irrigation was an integral part of this.

Intensification in turn, created demand for the range of rural ‘service’ industries that exist today – transport, communication, justice, schooling, hospitals, airports and the like.

(Most Murray-Darling towns and cities owe their existence to ‘seeding’ schemes – the getting of people into rural areas. Development of Griffith; siting of the ACT and the city of Canberra; and the twin-city ‘growth centre’ developments (Albury-Wodonga and Bathurst-Orange in NSW) are cases in-point.)

The drive for production efficiency.

When the irrigation areas along mainly the Murray and Murrumbidgee Rivers were initially developed, the main crops were cereals sown over vast areas, which could be flood irrigated at low cost. Dairying was also important, especially in Victoria, but like cereal production, it was supported by flood irrigation of relatively wide areas of pastures, and forage crops.

(I remember viewing black-and-white newsreels of these developments in cinemas in the mid- to late 1950’s; including newsreels of the Snowy Mountains Scheme; complete with a narrative that explained how these schemes were turning vast ‘inland deserts’ into productive crop-land.)

The point is, that technologically, in the early days irrigation methods were low-cost, and relatively crude. They were wasteful of the water resource, and practices at large were degrading of the environment. It was sufficient to use large but unreliable volumes of cheap water to irrigate wide areas, and take the risk that several years out of 10, water would not be available – the 8 years out of 10 that it was available was sufficient to make up for the other two.

Dairy was different! Because it is a day-in day-out enterprise, it needed secure water. Dairying was 'more of a science'; it represented a higher level of personal investment and required more skill than broad-acre agricultural practice. On a per hectare basis, at least before deregulation, it seemed also to be more profitable. Compared with cereal growing, dairying was in general better supported by specialist advisory people and research centres (and arguably it still is!).

With a rush, technological change came to agriculture in general, and irrigation in particular through the 1970's. This drove a trend towards greater irrigated and dry-land water-use efficiency; lower inputs; and less degrading practices.

Two particular 1970's tools that come to mind were (i) Monsanto's release of Roundup (glyphosate) in about 1969 and (ii) the flexibility and widespread adoption of poly-pipe.

Roundup was the first, relatively benign, non-residual chemical that on contact would kill everything! Poly was produced in long coils. It was resilient; it could be ripped into the ground; it was lightweight, non-corrosive and long-lasting and it bought huge benefits to the conduit of water in the bush. (For agriculture in Australia, poly-pipe was arguably the most important invention ever!)

While roundup allowed the frequency of cultivation for cropping and for pasture establishment to be minimised or even eliminated; poly-pipe enabled flood irrigation to be displaced by more efficient and easier to monitor and control, spray and drip systems.

Post the 1970's, agriculture, and irrigated agriculture in particular diversified considerably and there are many examples and production statistics that could be used to illustrate this. In the paddock, efficiencies in the cost of production became a constant quest; irrigation water became more expensive and was used more frugally but by more farmers (i.e. access increased); many successful irrigators came to use computer-based water balance approaches, backed up by monitoring to fine-tune their enterprises.

For many producers, because of their investments, and the perenniality and nature of their enterprises, security of water supplies became more important than the total amount available (which can vary markedly from year to year). (A case in point is that on-going 'fixed' assets, such as fruit trees and grape vines, that take years to reach full production are easily put a risk if water supplies become unreliable and are denied.) This led to conversions of 'general-security' water to 'high-security' on the basis of less general water – more secure water; allocated volume reductions pricing premiums applied accordingly.

There is still a lot of room to improve efficiencies in the way water is delivered (infrastructure); in the way it is used; and the production efficiencies associated with its use (harvested product/unit water use/hectare.)

While it is common for economists to express and compare these variables in terms such as $/useful unit *vs*. costs, all Australians should be concerned if marketisation forces reduce their access to Australian-produced food, or if they restrict the variety of foods grown or the quantities that are grown.

Several outcomes are likely if the gross availability of water for irrigation in the MDB is reduced, or if the cost of water and other inputs increase substantially:

i. Broad-scale flood irrigators who are unable to pass on cost increases to consumers will be hardest hit. These probably include dairy, cereal and rice farmers. Although some of these farmers are amongst the most productive and efficient in the world, they have little power over their costs and are at the mercy of the market (including foreign exchange markets) for the prices they receive.

ii. Dairy farmers and farmers that rely on broad-acre spray irrigation, will face 4 separate cost increases, all the result of 'competition policy'. These are the cost of supply of water; the cost of supply of electricity to pump water and to power other aspects of their business; the cost of water itself, which will increase; and the cost of electricity itself, which is projected to double in the near-term. Even though they are carbon neutral, on top of these costs, dairy farmers potentially face a fudged 'carbon' cost both on their inputs, as well as their productive assets – their cows.

    These combined costs have the potential to cripple the grass-fed irrigated dairy industry, arguably one of the most efficient and ecologically competent dairy production systems on the planet.

This leaves only horticulture and intensive aquaculture, including glasshouse vegetable production as the likely long-term survivors.

(As a case in point, in the Bega Valley where I have a small farming operation, over the past 10 years the number of dairy farmers has steadily declined. The main issues seem to be water availability and cost; cost increases generally; drought; poor economic returns and the 'had-enough' syndrome.

One recent dairy retiree sold his entire milking herd to Chinese interests. The cattle were trucked to Sydney, put on a plane and arrived in China about 3 days after leaving the Bega Valley. These cattle and their genetics are now housed in a Chinese milk factory.

It is hard to value the loss this represents to the genetic base of the Bega Valley dairy herd, let alone the production loss. However, if the trend continues, cumulated losses like this will in the short-term future result in major food security issues for all of Australia.)

Looking at the farm dams issue.

As already stated, most of the water that flows through the Murray-Darling system originates in the southern high rainfall areas (rainfall greater than 800 mm; annual evaporation less than 800 mm; altitudes greater than about 800 M).

In this domain, there are massive water surpluses guaranteed almost every year and water is measured in GL not ML (1 GL = 1000 ML). It is the domain of national parks and forests; although it has been largely shut-down as a result of green-activism, if there is a land-use, it is mainly high country grazing. Creeks are permanently perennial so farm dams are few, and they are not needed in National Parks anyway.

Farm dams used to store water for stock, domestic and amenity purposes (as opposed to on-river storages or dams filled from flows) become important away from the Great Dividing Range, and as pointed out in several MDBA/MDBC and National Water Commission publications, due to their amenity value, the frequency of dams in peri-urban areas is high relative to their numbers across the wider landscape.

Like most aspects of the Proposed Basin Plan, the impact of farm dams on water runoff has been assessed using models backed up with scant data. For instance, in Victoria, SKM seems to be heavily involved in modelling farm dam impacts using a model, which is freely distributed, referred to as TEDI (Tool for Estimating Dam Impacts).

Some aspects of farm dam modelling can be determined precisely – for instance satellite or photographic records can provide confident estimates of the numbers of storages. Determining the size of a dam is less precise, because that involves measuring something from up in space; determining a dam's volume from its surface area, is statistical guesswork.

Although area-volume relationships have been derived (McMurray 2004)[29] statistical relationships have been fudged by forcing least- squares regressions through the origin (*x=0*; *y=0*) and reporting the resulting inflated values of R^2 as the measure of fit. (This practice is common throughout the modelling literature!)

Data plots in McMurray (2004) indicate wide data scatter (Figure 12) would be likely around any prediction, which means that the capacity of particular dams in particular catchments would be estimated poorly by generalised relationships. For example, the measured volume of dams with a surface area of 2,000 m^2 span an eye-estimated range of between 30 and 80 ML (Figure 12)!

Remotely estimating farm dam capacities may be cost effective, and draw on sophisticated GIS and satellite data, but at the end of the day, multiplying even the most precisely determined number by a guess, is still a guess.

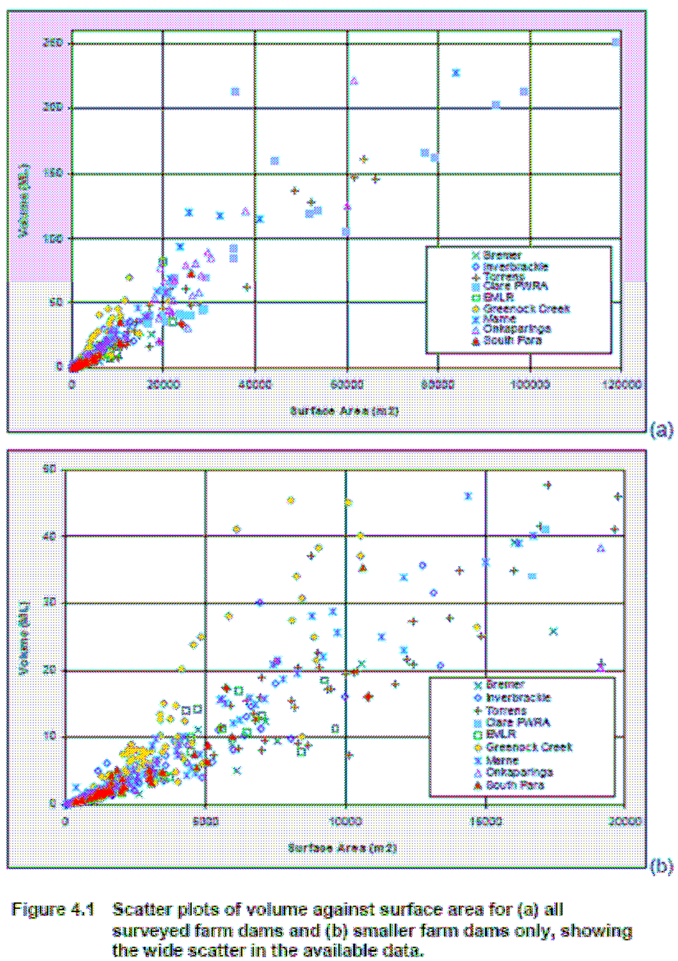

Figure 12. data scatter in McMurray (2004)

It is disturbing to read reports that claim levels of precision that cannot possibly exist.

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[29] McMurray D. (2004). *Farm Dam Volume Estimations from Simple Geometric Relationships Mount Lofty Ranges and Clare Regions South Australia*. SA Department of Water Land and Biodiversity Conservation Report DWLBC 2004/48.

For example, SKM et al. (2010)[30] reports that: "Based on available farm dam datasets, the total impact of farm dams nationally is 1600 gigalitres per year (in 2008)" … and that "The 2008, 2015 and 2030 dam volumes were estimated for each SWMA in each state, and the impacts of these dams were also able to be determined by applying the following formula:
Impact of Dams = 1.1 x Volume of Dams"

(Impact was predicted (Appendix D of SKM *et al*. (2010)) using modelled 'data' from the MDBC Sustainable Yields Project, and modelled farm volume 'data'. From these modelled 'data', relationships between dam volumes and reductions in runoff were 'investigated'.

Projected dam volumes (in 2030) were apparently plotted against the difference between runoff modelled in 2008 and runoff projected in 2030 for each of 445 modelled catchments (presumably to give 445 data points).

Even though there were only 2 apparent time-steps (2008 and 2030), a linear regression through the origin was then fitted (presumably) to the 445 data points, which predicted the impact of dams (in ML/year) from the volume of dams (Figure 31 in SKM *et al*. (2010)) to be 1.1 x Volume of dams.

As if to 'prove' the soundness of the approach, 'actual' dam impact determined from modelling undertaken by SKM in 2007, was compared to 'predicted' impact (from above) using linear regression through the origin.

(The use of log-log scales in Figures 31 and 33 of SKM *et al*. (2010), gives a false visual impression of the spread in the modelled 'data', while the use of R^2 statistic is misleading, and statistically invalid.)

In defiance of all logic, in another paper, Neal *et al*. (2000)[31] states that "for each megalitre of farm dam storage in a catchment, annual downstream flows are typically reduced by between one and three megalitres."

The modelling described in Neil *et al*. (2000) and in the TEDI Users Manual (SKM) does not even vaguely capture the processes of runoff and runoff generation, which are well known[32] and supported by vigorous research through from the 1960's to about the 1990's.

Whereas runoff is generated at a point and daily or hourly scale, the models use a monthly time-step water balance; most of the 'inputs' are outputs from other models. For example, evaporation; sub-soil and groundwater recharge losses; streamflow; farm dam volume-area relationships; 'natural' catchment inflows – all data from the ether.

These inaccuracies and errors 'flow' through the modelling process. Flows at the catchment outlet apportioned to farm dam inflows on the basis of (presumably cartographic) upstream catchment areas, are simply nothing more than guesses.

- It is not argued that farm dams do not impact on small, ephemeral catchments; those that typically only run either when they are saturated, or in response to low

[30] Sinclair Knight Merz, CSIRO and the Bureau of Rural Sciences (2010) *Surface and/or groundwater interception activities: initial estimates* National Water Commission, Canberra (June 2010.)

[31] **Neil BP, Shephard P, Austin KA and Nathan RJ *The effect of catchment farm dams on streamflows – Victorian Case Studies*" (Hydro 2000 : 3rd International Hydrology and Water Resources Symposium of the Institution of Engineers, Australia, 20-23 November 2000, Sheraton Perth Hotel, Perth, Western Australia : proceedings (http://www.oocities.com/floker_2001/VicCaseStudies.pdf).**

[32] Johnston WH, Garden DL, Rančić A, Koen TB, Dassanayake KB, Langford CM, Ellis NJS, Rab A, Tuteja NK, Mitchell M, Wadsworth J, Dight D, Holbrook K, LeLievre R, McGeoch SM (2003) Impact of pasture development and grazing on water-yielding catchments in the Murray-Darling Basin in southeast Australia. *Australian Journal of Experimental Agriculture* **43**, 817-841

frequency, intense rainfall events. However, at a Basin scale, where most of the runoff originates from high-rainfall areas, small 'dry' catchments contribute virtually nothing to overall flows; and when they do the entire system is probably running at or near capacity anyway.

- A second point is that water is not created or destroyed – it can only be stored, flow away, evaporate or disappear to groundwater (from where it can pop up somewhere else in the system). Thus the impact of a farm dam cannot logically exceed its empty volume; and in most years, most farm dams fill from a fill-level greater than empty.

It is therefore not logical that the impact of farm dams = 1.1 times their accumulated volume; or that 1 ML 'stored' results in up to a 3-fold reduction in river flow.

River flow is instantaneous – by the time it is measured, it has gone past! Rivers do not store flow. In contrast farm dams store water from major runoff-producing events for use and enjoyment into the future – for 'ecological services' in otherwise arid catchments; for fire-fighting; stock and domestic use including growing food; and for amenity – the pure joy of viewing naturally collected water across the landscape.

These aspects of farm dams have not been measured or considered, but they are measurable, and they are real and they can be valued. The various reports prepared for MDBA and the NWC, by presenting only one-side of the issue[33] are deliberately biased.

So all this modelling produces a number, but no matter how many times it is quoted within its pool of 'expert' literature, the number is probably not a real number; and it should not be taken as such.

Looking at the forestry issue

CSIRO models that purport to predict the impact of forestry (vs. grassland) on water yield, and thus on the water resources of the Basin are based on simple relationships derived by Zhang *et al*. (1999)[34], which are referred to as the Zhang curves[35].

General knowledge tells us that replacement specifically of grasslands by plantation forestry changes 3 aspects of the water balance.

i. Increased soil surface roughness due to disturbance, such as ripping, vastly increases recharge at the expense of 'quick-flow' runoff. This represents a largely permanent change. Runoff following catchment saturation is little altered.

ii. As trees grow, direct (foliage) evaporation increases, by up to 10% at canopy closure, at the expense of rainfall that reaches the ground. Reductions in recharge and compensated for somewha by increased stemflow and reduced transpiration due to the energy used to evaporate water while the canopy is wet.

iii. During dry periods and seasons, trees withdraw more water from deeper depths than grassland. This reduces antecedent soil moisture, which reduces recharge and runoff.

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33 E.g. Van Dijk, A. et.al 2006 "Risks to the Shared Water Resources of the Murray-Darling Basin" Murray-Darling Basin Commission, Canberra; also, "Approaches to, and challenges of managing interception. A review of current measurement and management practices for the determination of run-off interception and the implications for the implementation of the National Water Initiative" by Kate Duggan, Sara Beavis, Daniel Connell, Karen Hussey, and Ben MacDonald. Waterlines Occasional Paper No. 5, National Water Commission, Canberra, February 2008

34 Zhang L, Dawes WR and Walker GR (1999). Predicting the effects of vegetation change on catchment average water balance. Cooperative Research Centre for Catchment Hydrology, Technical Report 99/12. CSIRO Land and Water.

35 Sinclair Knight Merz, CSIRO and the Bureau of Rural Sciences (2010) "*Surface and/or groundwater interception activities: initial estimates*". National Water Commission, Canberra ACT. and: Van Dijk, A. et.al (2006) *Risks to the Shared Water Resources of the Murray-Darling Basin*, Murray-Darling Basin Commission, Canberra

In published studies where water balances have been partitioned on the basis of measured components, of these 3 specific impacts, increased surface roughness, and reduced antecedent soil moisture conditions are the most important.

Runoff reductions are not simply about the 'trees'. Runoff is also substantially reduced where undisturbed grassland is replaced with a sown pasture, or where pastures are renovated (e.g. Costin, 1980)[36] (thus increasing detention storage); where deep-rooted species replace shallow-rooted ones (thus reducing antecedent soil moisture)[37]; and where over-grazed grasslands are allowed to recover (thus increasing canopy storage). Encroachment of weeds such as woody shrubs in the semi-arid zone can also reduce runoff substantially (e.g. Johns, 1983[38]).

At the end of the day, the impact of 1.7 million hectares of planted forests on the overall water balance of the MDB, compared to the 10's of millions of hectares of sown crops and pastures and other forms of landscape disturbance, including natural vegetation regrowth would be immeasurable, especially given that most viable plantation industries are based outside reserves and national parks in the 700 to 1000 mm rainfall areas where the evaporation difference between forests and grasslands is predicted by the Zhang curves (Figure 13) to be small anyway..

The Zhang curves are conceptually interesting but they do not seem to diverge significantly until rainfall exceeds about 800 mm (i.e. there is probably no significant difference between the curves at rainfalls below this). For x= about 900 mm, the scatter in actual evaporation appears to lie between about 450 and 900 mm, so they are not very 'accurate' either.

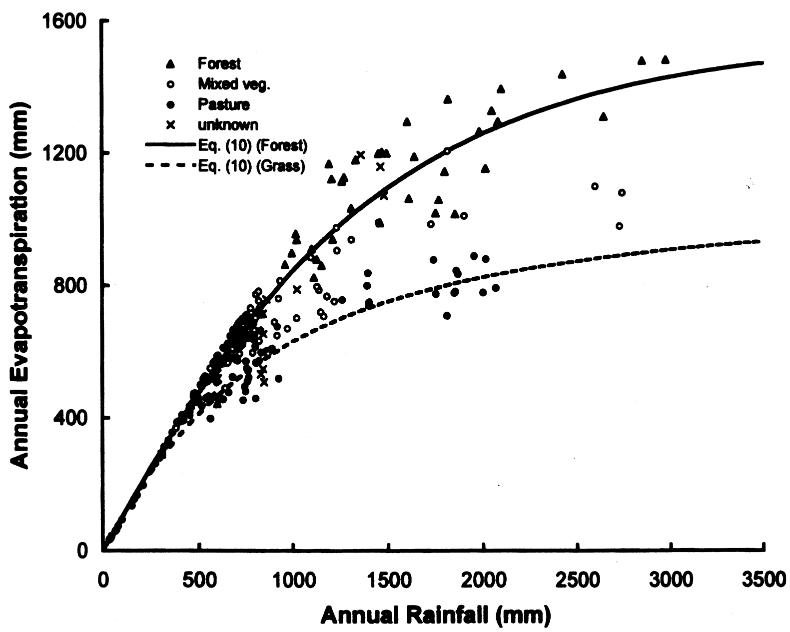

Fig. 10. **Relationship between annual evapotranspiration and rainfall for different vegetation types**

Figure 13. The Zhang curves scanned from Zhang *1t al.* 1999.

[36] Costin AB (1980). Runoff and soil and nutrient losses from improved pasture at Ginninderra, Southern Tablelands, New South Wales. *Australian Journal of Agricultural Research* 31, 533-546.

[37] Johnston WH and Cornish PS (2005). *Eragrostis curvula* (Schrad.) Nees. complex pastures in southern New South Wales, Australia: impact of *Eragrostis curvula*, *Medicago sativa* L. and *Phalaris aquatica* L. pastures on soil water. *Australian Journal of Experimental Agriculture*, 45, 1267–1289

[38] Johns GG (1983). Runoff and soil loss in a semi-arid shrub-invaded poplar box (*Eucalyptus populnea*) woodland. *Australian Rangeland Journal* 5 (1), 3-12.

In the overall ‘partitioning’ of the Murray-Darling Basin’s water resources, it seems that using models, some numbers relating to farm dams and forestry can be guesstimated, but because we don’t measure or estimate everything (pastures and other disturbances, such as the impact of NSW’s native vegetation laws for instance), the water mass-balance contains large missing values.

So, the context of the Proposed Basin Plan why is this important?

The water balance of the MDB is not about the imperfectly understood processes relating to trees and dams and over-allocations; it is mostly about rainfall, specifically, the lack of rainfall for significantly long periods.

It would be reasonable to propose that more than 80% of the overall variation in any measure – bird breeding; catchment health, agricultural production, water use, is due to rainfall (or lack of); and that the rest of everything cobbled together to support the Proposed Plan needs to be apportioned within the remaining 20%.

The history of water use in the Basin, the infrastructure developments, and the administrative arrangements surrounding use and partitioning of its resources are inextricably linked to its post European-settlement rainfall trends, especially drought occurrences. If ‘droughts and flooding-rains’ did not occur, economic circumstances would not have demanded or justified these schemes.

Responses to drought specifically included the Royal Commission into the Murray; establishment of the River Murray Commission; the pre-Second World War dam and lock building phases; construction of the Goolwa Barrages (1940) (which enabled irrigation along the lower-Murray); post-Second World Developments, including the Snowy Mountains Scheme and storage enlargements; and opening up country to take advantage of these investments, including soldier settlement and migration schemes.

At the end of the day, given the huge National investment that it represented, it is reasonable that as more water became available either naturally, due to the 1947 rainfall shift, or as a result of post-1947 infrastructure investments, that the additional water would be used for food production.

This is essentially what has occurred. The issue of ‘over-allocation’ is probably a rhetorical one, inspired very much by the current ‘green’ political climate.

What the Plan is actually about

Despite the proposed stated intention of the Water Act (2007) (Cwth) the Basin Plan is probably not about 'saving' the environment.

The focus on environmental issues justifies the Commonwealth assuming power over the Basin's water resources via. its constitutional 'external affairs' powers.

It is a simple takeover of State powers, using an approach that circumvents the need to ask the people what they think, through a referendum process.

So, what is the Plan about?

It is stated in Anon. (2009)[39] that: "The Basin is under enormous stress as a result of past water-allocation decisions, prolonged drought, natural climate variability and emerging climate change" … and…. that the Plan is "To enable the water resources in the Basin to be managed in the national interest". Section 3.4 of Anon. (2009) goes on to explain that the Plan will be based on computer modelling; that it will include groundwater modelling; and take account of 'climate scenarios' and their *possible* (italics intended) effects on water resources in the future. Socio-economic issues and projected cost:benefit outcomes were said to be of particular relevance.

In short, the intention is vague and unclear; it is revealed, however, that all aspects of the whole system will be modelled; 'KEY' things will be identified, costs allocated; everything will be accounted for in a National Water Accounts framework; which will be analysed, networked and reported on by the Bureau of Meteorology; and the Basin will fall under the control of a giant modelling framework, run presumably by CSIRO!

The Guide to the proposed Basin Plan itself is consistent with, or a step in, the process of, national Competition Policy reforms that commenced in the 1990's. This will eventually result in most aspects of water supply and demand becoming 'marketised'. This is said to create efficiencies in water allocation and use. Based on recent examples from other industries, in reality, it will probably send whole food-production sectors off-shore (dairy to China; rice to Asia; horticulture to the UAE for example).

(In recent years, water price increases, driven by scarcity has encouraged increased efficiency in water delivery and on-farm use. There have also been some environmental water buy-backs and infrastructure investments under various initiatives, mainly aimed at securing environmental flows (e.g. Living Murray.))

The twin objectives of the National Competition Policy agreements were said in the Guide to be: (i) to establish an efficient and sustainable water industry, and (ii) to arrest widespread natural resource degradation partly caused by consumptive water use.

Together with breaking up cooperative water delivery arrangements, the first objective would be facilitated by restricting supply relative to demand, thus making water more expensive, and ownership and trading in water more lucrative. The second objective is linked to the first, in that flowing water out of the system to the sea, or evaporating it within Basin wetlands is the most effective way of disposing of excesses. Whatever environmental benefits may arise would be a by-product of this.

Of all the reasons listed for the proposed Basin Plan, by the Plan itself, and the documentation surrounding the Water Act (2007) (Cwth.), the most likely reasons to change how the Basin is currently managed are:

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39 Issues Paper: Development of Sustainable Diversion Limits for the Murray-Darling Basin November 2009 MDBA publication no. 48/09

(i) Centralise its control and management under a single umbrella 'tool'.

(ii) Value, or increase the value of its 'assets', including the value of its carbon store; and create 'markets' for all these things – the water; distribution of the water; the 'assets' and eventually probably its carbon store.

(iii) It is plausible that under the Act, the Commonwealth's Environmental Water Holder could sell or lease its entitlements to 'grow' carbon in the MDB and that this would appear in the National Carbon Accounts.

Irrespective of the environment, the most pressing apparent need within the Basin is to reduce the amount of water said to be over-allocated. The second most pressing need is improve the reliability (or security) of supply to high-value industries, be they agricultural or urban-based.

Logically, this will require a greater storage 'buffer' (i.e more storages) in the upper catchments to insure against the certainty of recurring drought irrespective of climate change and other issues; but that seem not to be part of the proposed arrangements.

Is the basis of 'the science' sound?

Definitions:

i. **Science**. Science is the political euphemism or popularist 'brand' for what was once referred to as wisdom. However, whereas wisdom was arrived at by comparing the past with a current situation/scenario; science is about predicting/manipulating a future scenario, possibly rule-based, based on a construct of how it may (or may not) all turn out.

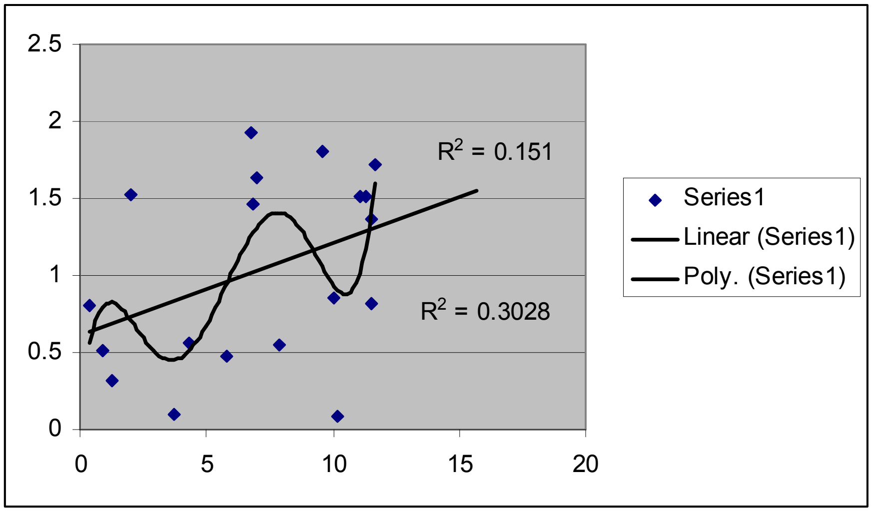
   An example: Based on what we know about the Hume Dam (wisdom), after it fills, it would be easy to calculate how long it takes to empty if water is released at a constant rate.

   However, if we apply 'science' and try to predict what the future holds for inputs to the dam, or water demand into the future, because we don't know the future holds, we are guessing!

   Regardless of its 'branding', if somebody comes up with a figure, and uses words like 'world's best science' or CSIRO said… or there is a 'low level of uncertainty' about the guess, it is still a guess.

ii. **Research**. Research is about finding out. Boiled down to its basic tenet, research sets out an hypothesis, and sets to show that its counter argument is wrong with a stated level of confidence in the outcome. This sounds back-to-front, but research does not set out to 'prove' A = B, or that the size of apples is related to the age of the earth, it actually sets out to test whether they are not.

   An example. Following is a graph of 2 variables (X *vs*. Y) created in Excel. The 20 values of each variable were created using Excel's RAND() function so they are paired random numbers. A straight line (X *vs*. Y) regression as well as a 6 order polynomial function (sometimes called a smoothing spline) has been added to the graph.



Statistically there is no relationship between X and Y, the variables were created out of thin air. A test of the relationship using regression analysis showed the probability of the relationship (slope) being significantly different from zero to be ‘not significant’; this would be more formally written as $P>0.05$.

However, Excel has calculated a loose correlation, which if squared gives the R^2 value on the graph. R^2 is the coefficient of determination; in this case for the straight line, the relationship explains 15% of the variation; for every squiggle that goes into the polynomial, we explain more variation. Thus R^2 is higher – 30%. But it is nonsense; these are random numbers with no predictive value at all.

iii. **Linkages**. Research cannot be conducted ‘in the future’. Although ‘science’ may claim predictive power, it can do so only in a scenario sense; with a low level of statistical confidence. Science does not rely on ‘confidence’, which is a mathematically based measure of chance; it relies on ‘uncertainty’. Measurement of uncertainty, which is covered in several IPCC publications, can be as exact as a statistical test, or as broad as a show of hands. A 10% level of uncertainty could be 1 in 10 dissenting scientists sitting around the table.

iv. **Errors**. Errors are in everything; they perpetuate. Errors add together, they multiply, they never go away.

Towards a conclusion.

While over the years I have personally been a supporter of environmentalism, including the donation of money to various groups and causes, I believe it has gone many steps too far. Looking over the ‘science’ has turned my personal position around.

As a scientist, it has also been disheartening to see the results of work once undertaken for the public good, turned into a political tool.

Time does not permit detailed examination of more of the Basin ‘science’ than I’ve covered. It is probably sufficient using the examples I’ve reviewed, to strongly suggest that the ‘science’ has been used as policy ‘bubble-wrap’ rather than for the development of sound policy.

Science has been ‘managed’; data has been cherry-picked. Through the press, public perceptions have been ‘groomed’ through the uncritical publication of ‘focussed’ MDBA, CSIRO, university, Wentworth-Group; green-brigade and State Agency ‘messages’.

Scientists have not been able to speak publicly about their work without permission, or swim against the tide of perception that their organisations have cultured. Much of the critical scientific data presented in papers are hidden behind ‘pay-walls’, which makes them inaccessible to the general public. For all concerned, Basin science seems to have become a well-funded industry.

Although they did not review the 'science' Access Economics has criticised aspects of modelling work undertaken in support of their preferred position by the Wentworth Group[40]. The same should happen across the 'science' spectrum.

Scientists should be asked to step out from behind the disclaimers that shroud their work, and explain their work, especially its limitations.

Much of CSIRO's focus seems all about themselves; with 'Flagships'; their bold nonsense statements about achieving "a tenfold increase in the economic, social and environmental benefits from water by 2025", as though that could be measured, or that it will happen in an environment where the organisation is 'downsizing' by closing applied-science Divisions, and getting rid of research staff.

As though in third person, CSIRO 'advised' MDBA of the climate scenarios that should be defined for the MDBA modelling, the work was actually done largely by CSIRO[41].

With respect to global warming alarmism, Chiew *et al*. (2009) reported that: "The past 15 years rank among the warmest years in the instrumental record of global average surface air temperature (since 1850). The linear warming trend is about 0.13^{o}C per decade over the last 50 years and about 0.18^{o}C per decade since the mid-1970's".

Average temperature data, back-transformed from the BOM average temperature anomaly dataset for the Murray-Darling Basin, expressed in terms of its cumulative deviation (CUSUM) from the long-term re-calculated mean, indeed supports Chiew *et al*'s statement (Figure 14).

The accessible MDB temperature dataset commenced in 1910. From 1910 to about 1971, average temperature trended downward at the rate of about –0.002^{o}C/year. From about 1978, average temperature has trended upwards. The down-up cycle, of about 50 years duration has tracked the MDB rainfall trend – declining temperature trends being associated with declining rainfall trends and *vice versa*. The trends if they are real and coupled, seem out-of-phase by about 30 years!

If it does not rain, it is bound to be dry and hot, and it is alarmist to make issue of 'dryness' or 'hotness' of the last decade (2000-2009), without referring to the 'wetness' and 'coldness' of other decades.

A spreadsheet analysis of BOM average MDB rainfall data shows that five, 10-year averages were ranked drier than the 2009 10-year average. These, in declining rank order were: 1949, 1947, 1945, 1944 and 1946.

At the 'wet' end, the decades ending in 2000, 2001 and 1999 were ranked the 17th, 22nd, and 23rd wettest since 1900 respectively.

So to balance the point, the last decade embraced some wet years also.

To put the whole 'dryness' *vs*. wetness issue into perspective, Figure 15 shows the position of the 2009 decade relative to a range of decadal rainfall statistics.

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[40] Access Economics (2010). *A critical review of the key literature influencing the current water policy debate within the Murray Darling Basin – preliminary analysis. September 2010.*

[41] Chiew FHS, Cai W and Smith IN (2009). Advice on defining climate scenarios for use in Murray-Darling Basin Authority Basin Plan modelling, CSIRO report for the Murray-Darling Basin Authority

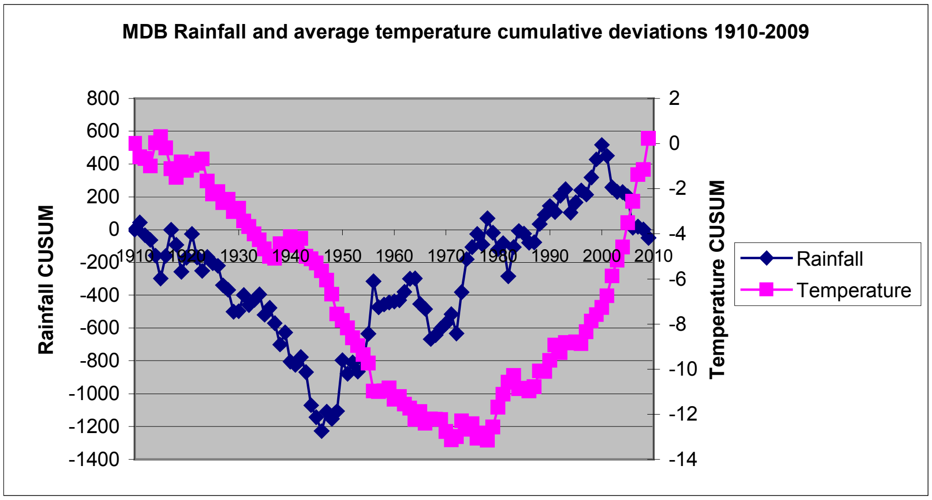

Figure 14. Average Murray-Darling Basin temperature data, back-transformed from BOM 1910-1990 anomaly data, expressed as cumulative deviations from the long-term re-calculated average (purple squares; right-hand axis) graphed with a similarly derived CUSUM or curve for rainfall ((blue squares; left-hand axis.)

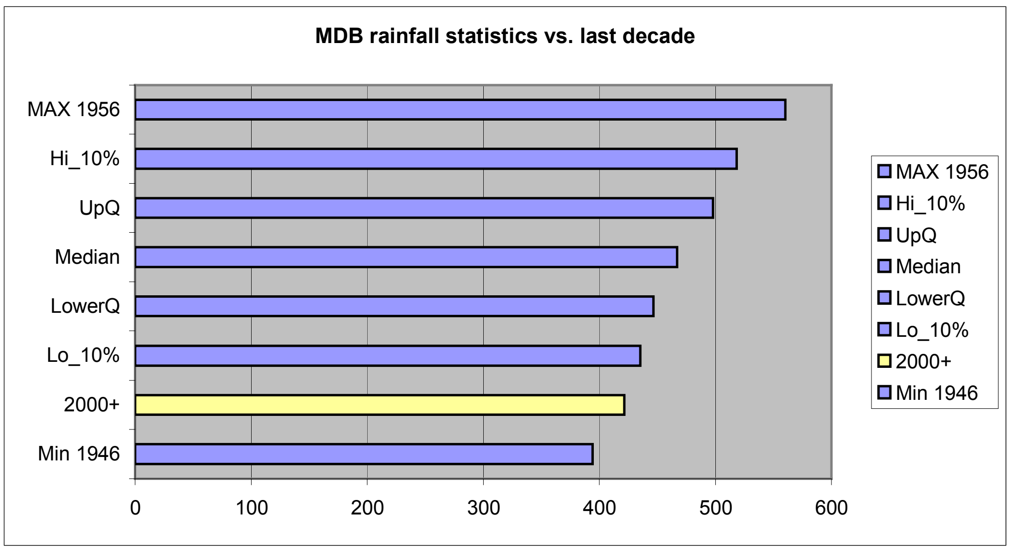

Figure 15. Relative rankings of 10-year period average rainfall statistics (individual rolling 10-year averages) for the MDB rainfall dataset, downloaded from BOM, and the 10-year average for the decade ending in 2009.

A final case in point of the relativity between wet and dry years/periods is that for continuous data such as rainfall, a calendar year does not represent natural break-points.

Using Queanbeyan NSW rainfall data as an example (Table 8), the wettest calendar years have not corresponded with the wettest 12-month periods. The highest annual rainfall of 1043.4 mm was exceeded by all 5 of the wettest 12-month periods!

At the dry-end of the rainfall spectrum, the lowest recorded annual rainfall (1982) of 260 mm was greater than the 5 lowest-ranked 12-month periods.

Four of the 5 lowest-ranked 12-month rainfall periods were associated with the Federation drought and its apparent severity was no doubt in part due to: (i) that the three **highest** 12-month rainfall periods occurred immediately prior to the drought's commencement, which would have been cause for optimism, and (ii) that these good seasons were followed suddenly (within a single year) by the 4 **lowest** 12-month rainfall periods. These were the periods that caused the despair that became synonymous with that particular drought.

Table 8. A comparison of annual and period rainfall statistics for Queanbeyan NSW (BOM site 070072).

Highest annual rainfall (N=139)			Wettest 12-mth period (N=1670)		
Rank	Year	Rainfall	Rank	Ending (mth.yr)	Rainfall
1	1887	1043.4	1	Nov.1887	1105.2
2	1950	996.8	2	Oct.1887	1097.9
3	1934	984.4	3	Jul.1987	1082.4
4	1974	975.6	4	Apr.1989	1074.0
5	1989	906.8	5	Apr.1935	1065.2
Lowest annual rainfall			Driest 12 month period		
Rank	Year	Rainfall	Rank	Ending (mth.yr)	Rainfall
135	1944	304.6	1666	Mar.1983	244.1
136	1895	300.5	1667	Jan.1903	242.6
137	1967	284.5	1668	Jan.1896	237.3
138	1902	265.7	1669	Oct.1902	212.3
139	1982	260.0	1670	Nov.1902	175.0

THE END