Submission
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Prepared
by
Patrick James,

Patrick James & Associates,
Environmental Consultants
5/2 Hardie Street,
Neutral Bay, NSW 2089.
Telephone & fax (02) 9904 1515
e-mail mrjames@ibm.net

Contents.

1 INTRODUCTION.

On 2 June 1999, the Standing Committee on Environment and Heritage of the House of Representatives of the Parliament of Australia resolved to continue its investigation into the management of Australia's water resources, through an inquiry into catchment management. This submission addresses aspects of the first three matters raised in the Committee's Terms of Reference for the Inquiry into Catchment Management:

- the development of catchment management in Australia;
- the value of a catchment approach to the management of the environment; and
- best practice methods of preventing, halting and reversing environmental degradation in catchments, and achieving environmental sustainability.

This report also details a research project into the historical use of catchments, where historic catchment land use can be assessed in the light of contemporary knowledge, with the aim of providing a better understanding of catchments and catchment management.

Although this submission is based on information which at present has a New South Wales focus, with allowances for geography, the concepts apply equally as well to the whole of Australia.

2 DEVELOPMENT OF CATCHMENT MANAGEMENT.

Catchments are the basic, geographic building blocks; the catchments of creeks, gullies and streams combine to form the catchments of small rivers, which in turn combine to form the catchments of major river basins. Within Australia there are twelve Drainage Divisions, with each Division being subdivided into river basins. The four Drainage Divisions in New South Wales are:

- No. 2: South-East Coast,
- No 4: Murray-Darling,
- No. 10: Lake Eyre and
- No. 11: Bulloo-Bancannia.

Drainage Divisions follow geographical boundaries. The Murray-Darling division, a well known example, spreads out over Victoria, South Australia and New South Wales. The South-East Coast division contains 22 river basins and the Murray-Darling division contains 19 river basins. The Drainage Divisions and Drainage Basins within New South Wales are given in Table 1.

Had this information being available in January 1788, nor doubt local government and State boundaries, amongst many other things, would have been different. For example, a single state based on the Murray-Darling catchment would, administratively, be easier than the present catchment management by Queensland, South Australia, Victoria and New South Wales.

3 CATCHMENT BOUNDARIES.

Total Catchment Management (TCM) was introduced in New South Wales as the principal, land development coordination procedure with the enactment of the Catchment Management Act, 1989. administered by the Department of Land & Water Conservation (DLWC). By means of 33 Catchment Management Committees, two Catchment Management Trusts and the State Catchment Management Coordinating Committee, 98% of NSW is under the cover of TCM (TCM 1995).

The purpose of the NSW Catchment Management Act, 1989, is to coordinate all development within a catchment. Significantly in the Act, although a water catchment is recognised, a catchment [1]is not defined. Land boundaries in NSW (and in the other Australian states) such as parish, county, local government and many rural cadastral boundaries often are the natural boundaries

[1] A catchment is defined as a land unit in which all rainfall concentrates to a single exit point. The terms catchment, drainage basin and watershed (in the US) are synonyms (Summerfield 1991).

(bank or middle thread) of rivers and stream (Hallmann 1973). These natural boundaries are within catchments and may be termed intra-catchment boundaries[2].

The immediate point of weakness of Total Catchment Management (TCM) is a boundary conflict where one catchment may consist of two or more local government area. This TCM weakness is exacerbated by the regional boundaries of State government authorities which are based on county and local government boundaries and are also intra-catchment boundaries. The boundaries between the mainland Australian states are either river boundaries (intra-catchment boundaries) or artificial boundaries (trans-catchment boundaries[3]). Neither of these boundaries simplify Catchment Management coordination between states.

Wherever possible boundaries should be re-established to correspond to catchment and sub-catchment boundaries[4]. Change to parish and county boundaries is not required as these land divisions are of cadastral and historic significance. In the case of the regional boundaries of Federal and State government authorities this will be a relatively simple task.

Re-establishment of local government boundaries is feasible. Notwithstanding the economic, historic and cultural reasons for maintaining the status quo of council boundaries, council amalgamation are possible and do occur. When council amalgamations are proposed, the new boundaries could (and should) be catchment boundaries.

Boundaries of Electoral Districts are under periodic review. As a means of expressing the importance of catchments and catchment management, it would be most appropriate that electoral boundaries, wherever possible, should follow catchment boundaries. In practice, as communities live within a catchment, an electoral boundary based on an interfluve should be a simple matter.

4 CATCHMENTS & ENVIRONMENTAL MANAGEMENT

The catchments and sub-catchments are readily defined and vary in size from a few hectares or square kilometres to thousands of square kilometres. As a unit of environmental management a catchment is ideal. A catchment is made up of sub-catchments, where each of the latter is generally a single eco-system of geology, geomorphology, geography, topography, flora and fauna. Differences and variations can be expected between sub-catchments within a catchment. A catchment may vary from undulating hills or alpine mountains at the head or top of a catchment down to very low relief topography at the end of the catchment.

A single eco-system, sub-catchment often supports only a single land use and thus a single economic unit with simple, environmental management requirements. It is easier to manage one land use then to manage a number of conflicting and competing land uses.

5 CATCHMENTS & ENVIRONMENTAL SUSTAINABILITY.

The legal framework for ecological sustainable development (ESD) in NSW is by means of the revised Regulation to the Environmental Planning and Assessment Act, 1979. The Regulation commenced on 1 September 1994 and provides for the justification of developments having regard to the principles of ESD (EPAR 1994). ESD requirements apply to designated developments (developments requiring an Environmental Impact Statement). For other developments there is no legal requirement to consider ESD. This is a major shortcoming of the TCM process.

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[2] Intra-catchment: a natural boundry within a catchment, such as a river.
[3] Trans-catchment: an artifical boundary within or through a catchment, without regard to natural boundaries
[4] The boundary between adjacent catchments is the *interfluve*.

The absence of “ecological” in the description of sustainability reflects the wording of the TCM policy (Soil Con 1988) which predated the *Intergovernmental Agreement on the Environment*, signed and dated 1 May 1992 (IGAE 1992). In theory, since May 1992 and in practice since 1 September 1994, developments in NSW must be ecologically sustainable. The principles of ESD are not clearly defined (EPAR 1994) and require explanation (see for example Amos et al 1993, Harding et al 1994, James 1995). A situation which inhibits their application.

With the introduction of the Protection of the Environment Operations Act 1997 ecologically sustainable development principles have been defined and included in the Protection of the Environment Administration Act 1991. This Act now requires the integration of economic and environmental considerations including the principles of ESD, in the decision-making process. The level of “consideration” is not stated which leaves environmental issues open to interpretation and misinterpretation. A review or re-issue of the *Intergovernmental Agreement on the Environment*, with the principles of ecological sustainable development clearly stated and defined would be a valuable contribution to catchment management and environmental sustainability

Table 1 Drainage Divisions and Drainage Basins within New South Wales

Basin No.	**Basin Name**	**Basin No.**	**Basin Name**
II (200)	SOUTH-EAST COAST DIVISION	IV (400)	MURRAY-DARLING DIVISION
201	Tweed River	401	Upper Murray River
202	Brunswick River	409	Murray Riverina
203	Richmond River	410	Murrumbidgee River
204	Clarence River	411	Lake George
205	Bellinger River	412	Lachlan River
206	Macleay River	413	Benanee
207	Hastings River	414	Mallee
208	Manning River	415	Wimera-Avon Rivers
209	Karuah River	416	Border Rivers
210	Hunter River	417	Moonie River
211	Macquarie-Tuggerah Lakes	418	Gwydir River
212	Hawkesbury River	419	Namoi River
213	Sydney Coast-Georges River	420	Castlereagh River
214	Wollongong Coast	421	Macquarie-Rogan Rivers
215	Shoalhaven River	422	Condamine-Culgoa Rivers
216	Clyde River-Jervis Bay	423	Warrego River
217	Moruya River	424	Paroo River
218	Tuross River	425	Darling River
219	Bega River	426	Lower Murray River
220	Towamba River	X (00)	LAKE EYRE DIVISION
221	East Gippsland	004	Lake Frome
222	Snowy River	XI (01)	BULLOO-BANCANNIA DIVISION
		011	Bulloo River
		012	Lake Bancannia

6 RESEARCH PROJECT: OVERVIEW.

A research project has been commenced by the author as part of his PhD candidure in the Department of Civil Engineering, the University of Queensland. The project is an investigation into the development of dams and dam engineering in Australia, with respect to dam construction, management and catchments, and with particular reference to dams of the period 1850 to 1960.

The objectives of the research project are to obtain a better knowledge and understanding of:

- dams and reservoirs;
- catchments;
- land management and other factors influencing the siltation of dams; and
- safety issues of historic dams,

in order to apply this knowledge and understanding to contemporary dams and catchments and to develop best practice methods of catchment management.

The Department of Civil Engineering at the University of Queensland has had a long standing interest in the engineering of dams; design, construction, modelling, hydraulics and spillway design. Recent interest comprises Total Catchment Management of reservoirs, including the reservoirs of historic dams. Historic dams are often are excellent examples of catchment and reservoirs management. In too many cases, unfortunately, historic dams are sediment filled and are *good* examples of *bad* catchment management. Historic dams offer superb opportunities for study and evaluation of reservoir siltation and catchment management. In summary, historic dams:

- represent data spanning 50 to about 140 years;
- are located in a wide variety of climatic zones;
- have withstood repeated cycles of drought/flood;
- (statistically) have withstood a number of 1 in 50 and 1 in 100 year storm events; and
- have been subjected to different land management practices.

Sediment filled, historic dams are graphic proof of *worst practice* and the poor understanding of catchment processes by land managers, engineers and scientists.

7 PROJECT INTRODUCTION.

From the day the First Fleet arrived in mid summer, January 1788, the need for secure water supplies was apparent. The Tank Stream was the first water supply. Within a couple of years this stream was polluted (Clark 1978) and a clean, alternative sought (Thorpe 1953). In the first 50 years of the colony a number of water supply scheme were built, used, abandoned and superseded (Aird 1961, Henry 1939).

In 211 years since European settlement some 2,500 dams (over 3 metres wall height) have been built. The exact or even an approximate figure is unknown. Some of these dams have being lost and forgotten. For some of the dams, their location, purpose, or design details may be hidden in forgotten archives, and this information is at best difficult to locate. Details of perhaps 65% of the dams are beyond living memory. The dams may have been for towns which did not develop or mines worked out and abandoned. The dams may have become sediment filled, overgrown and abandoned after alternative water resources were developed. Many examples of such dams are readily available.

Dams were constructed in different climate zones, geologies, topographies and land uses. These differences led to differences in siltation rates. Some dams lasted just 10 years before complete siltation while others are still serviceable after about 100 years. Was this the result of design techniques, or the chance combination of rainfall, runoff and catchment conditions? Dams were constructed before and after legislation to protect catchments by controlling land clearing. The success of this legislation has varied from zero protection to complete protection.

The research project will focus on dams, reservoirs and catchment as follows.

- Constructed between 1850 and 1960. These years span the construction dates of Parramatta dam (1856) on Hunts Creek, the first single arch in Australia, and of Tumut Pond (1958) the first variable-radius arch dam in Australia. This period represents the greatest expansion period in Australia: population, rural industries, railways, gold and other mining.
- Constructed from concrete, masonry (stone and brick) and unusual construction materials (e.g. composite structures),
- Original designs and design evolution, and
- Will exclude "small" rural farm dam.

With the completion of the Snowy Mountains Scheme it is assumed that dam engineering and construction in Australia had plateaued. To restrict the research project to structures of concrete, masonry (stone and brick) and unusual construction materials includes dams which had a significant monetary value at the time of construction and therefore had a definite purpose, and excludes minor, low cost, rural or farming structures.

The dams constructed within this period represent a wealth of information and *uncollected data* which could be usefully employed in contemporary dam engineering and enhance the knowledge of Total Catchment Management. The development of Australian dams: their purpose, location, catchment, design, methods and materials of construction, stability and suitability, represents an extremely valuable body of knowledge.

8 DAM DATABASE.

As part of the research project a database of Australian has been commenced. The database is intended for the larger dams with wall heights greater than about 3 metres. For details of dam classifications see Appendix 1. To date the database contains about 2,000 dams from all Australian states and territories. The level of data on each dam varies from a name through to complete engineering and catchment summaries. The purpose of the database is to be able to compare and contrast dams and catchments throughout Australia.

The number of dams, greater that 5 metres wall, built in Australia since European settlement is unknown. About 2000 are known, suggesting that some 2,500 to 3,500 dams in total may have been built. To this figure should be added an unknown, but comparable number of small farm dams.

9 PURPOSE OF DAMS.

The early dams, as with contemporary dams, served one or more of four purposes, town water supplies, water supplies for steam locomotives, irrigation or mining. In the latter case the dam could supply potable water, process water and/or motive power. Junction Reefs dam, near Lyndhurst, NSW, is an example of such a multi-purpose dam. In New South Wales during 1860 to about 1920 the railways constructed about 70 dams as water supplies for steam locomotives.

10 INITIAL DAMS IN AUSTRALIA.

The initial dams in Australia were, probably, modest structures with walls of about 2 or 3 metres height, built from earth and/or wood for potable water and for rural purposes. The genesis of Australian dam construction, as serious civil engineer structures, was the construction of Parramatta dam on Hunts Creek in 1856. This dam was a single arch, masonry dam 12.5 metres high. Later, in 1898, the dam wall was raised 3.3 metres to give an overall height of 15.8 metres. Besides being the first significant dam in Australia, Parramatta dam was the forerunner, possible prototype, of a series of twelve single arch dams built in the period 1896 to 1906, termed Darley-Wade dams, after their designers C W Darley and L A B Wade.

At the time, the Darley-Wade dams, as single arch concrete dams, were revolutionary both in Australia and internationally. The structures were tall, slender walls with crest widths typically of about 1 metres. The design premise was for a cheap, easily constructed dam (Wade 1900). Of the 12 Darley-Wade dams built between 1896 and 1906, most are still sound structures.

11 CONSTRUCTION MATERIALS.

Concrete as a construction material had many advantages in the Australian environment. The choice of concrete as a construction material was determined by the particular features of the Australian environment: remote locations, unskilled workforce, limited tools, limited transport and limited finance. Firstly the distance to Australia from the rest of the world and the distances within Australia required a construction material in concentrated form that was easy to transport with a good shelf life. Cement in wooden barrels of about 100 kg was available from England, Germany and Japan and readily transported by sea and land with minimum spoilage met these criteria (Wade 1900).

Concrete dam construction required little skilled labour; a supervising engineer and possibly two or three foremen with the remainder of the workforce day labourers. The only trade skill required was carpentry to make and fit the form-work. Sand and aggregate was obtained from and processed on or near the site. Concrete batching once demonstrated and learnt would have been supervised by a foreman. Similarly placing of concrete would only require supervision by a foreman.

12 CATCHMENT MANAGEMENT

The catchments of the early Australian dams vary in size from a few hectares to hundreds of square kilometres. The catchment topography varies considerably as well, from undulating hills to alpine mountains. At this stage it is presumed that low to very low relief topography is also included.

The whole suite of catchment geology is represented in the subject dams from granites, basalts, sandstone and metamorphics through to unconsolidated sediments. The soils associated with these country rock support a variety of vegetation and have a range of erosivity. These two factors, among other, determined the rural potential of the land and the susceptibility to soil erosion. Typically land was cleared of trees to increase the grasslands available to stock with the result that in a short period extreme soil erosion took place. This has been the fate of a number of catchments with as a consequence dams lower down the catchment have filled with sediment.

These scenarios suggest that catchment management was not practised. It seems pointless to construct state of the art, concrete arch dams only to have them quickly fill with sediment. Yet this happened on many occasions, even up to the 1940s. For example Coepolly No. 1 dam, built in 1932 was sediment filled and abandoned as a water storage structure by 1955.

The geomorphology of catchments, that is stream form and flow, topography and regolith characteristics, applies to all dams. A study of the geomorphology of dams with and without sediment filling, together with the management of their catchments is expected to give new directions to dam and catchment management.

13 HYDROLOGY.

Within the first few years of settlement it was obvious that Australia had a "special" climate. It was some decades before it was realised that Australia has a stop/start, flood/drought ecosystem. The collection of meteorological data only started in about 1870. The hydrological input into dam design was based on European meteorological data. The use of such European data may well be a significant reason why Australian dams filled with sediment. Dams certainly were designed on short term average rainfall (there were no long term data), and not on the extreme rainfall associated with La Nina conditions.

14 CULTURAL & SOCIAL ASPECTS.

The early dams were constructed to suit the local conditions of large distances, sparse populations, restricted finance, separate colonies, centralised administrations and minimal legislation. No doubt in the early years many dams were built according to very local concepts and external influences were unwelcome. The printed discussion about the Junction Reefs dam suggests that some of the designer's engineering contemporaries thought that the design was flawed. A hundred years later the intact dam remains as a testament to the designer.

Dams as town water supplies played an important role in the development of Australia. With the spread of population came the expansion of the railways, and both people and railways required dams. No doubt railway dams were the catalyst for rural communities to develop, and conversely centres of population typically from mining activities were the catalyst for railway development.

15 CONCLUSIONS.

Within the period 1860 to 1960 the Australian landscape changed dramatically. Included in the change are the construction of an unknown number of dams and reservoirs ranging in design from simple earth banks to multiple arch concrete dams. This range of dams and reservoirs represents a wealth of information on design, materials of construction, dam management, catchments, catchment management, land management, sedimentation rates, dam safety, meteorology, etc. The existing dams and reservoirs can be considered as full scale models of the varied aspects of dams, reservoirs and dam engineering in Australia with testing periods from 50 years to perhaps 150 years or more. Much of this information can be applied to give a better knowledge and understanding of contemporary dams and catchments and the safety of old dams.

16 ACKNOWLEDGMENT.

Besides the references cited, this submission contains extracts from papers prepared by the author alone and together with Dr Hubert Chanson, Department of Civil Engineering, the University of Queensland. Besides being colleague, co-author and friend, Hubert Chanson is also the supervisor for the author’s Ph D project. See Section 17: Reference and Appendix 2 references.

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Appendix 1 Dams in New South Wales

Dam or reservoir size is a subjective term with small dams being <1000 megalitres, medium dams between 1000 to 20,000 megalitres and large dams being >20,000 megalitres. In New South Wales dams are controlled by the Dams Safety Act, 1978. The function of this Act is to ensure the safety of "prescribed" dams. Prescribed dams are dams specified in Schedule 1 of the Act, being dams recommended by the Dam Safety Committee (a statutory corporation of the New South Wales Government) to be prescribed, such prescription is usually based on the hazard rating of the dam and the height of the dam wall, see table below. Some 350 dams have been constructed in New South Wales of which some 250 are prescribed dams.

The Dam Safety Committee defines;

- a dam as any man made barrier, temporary or permanent, including appurtenant works which does or could impound, divert or control water, other liquids, silt, debris or other liquid-borne material, and
- a catchment as the area drained by the streams or watercourses down to the point at which the dam is located.

	High Hazard Rating	Significant Hazard Rating	Low Hazard Rating
Nature of flood affected part of valley downstream and expected losses in hypothetical event of dam failure	extensive development downstream; loss of more than a few lives (say 10 lives) expected; excessive economic loss (ie damage to communities, industrial & commercial facilities, highways and important public facilities)	no urban development and no more than a small number of habitable structures; loss of a few lives expected; appreciable economic loss (ie public utilities, secondary roads, minor railways, agricultural facilities, etc)	no habitation or significant facilities; no loss of life expected; minimal economic loss (ie farm buildings, minor roads, crops, etc.)
dam wall height	High Hazard Rating	Significant Hazard Rating	Low Hazard Rating
>15 metres	Prescribed	Prescribed	Prescribed
<15 metres	Prescribed	Prescribed	Not Prescribed
< 3 metres	not normally prescribed by the Dam Safety Committee		

Dams are also classified by the Australian National Committee on Large Dams (ANCOLD) using criteria from the International Committee on Large Dams (ICOLD). ANCOLD maintains a register of large dams, and according to ANCOLD (and ICOLD), a large dam is

- one with a wall greater than 15 metres high, or
- one with a wall greater than 10 metres high; plus one or more of the following
- a crest length greater than 500 metres; or
- reservoir storage capacity greater than 1,000,000 cubic metres; or
- a maximum flood discharge greater than 2000 cubic metres/second; or
- specially difficult foundation problems; or
- an unusual design.

Dams less than 10 metres are not included in the ANCOLD and ICOLD registers.

A referable dam, according to the Dam Safety Committee is one with

- a wall greater than 10 metres in height and a storage capacity of 20,000 cubic metres or more, or
- a wall greater than 5 metres in height and a storage capacity of 50,000 cubic metres or more.

Appendix 2 Details of the Author.

The author, Patrick James is the principal of Patrick James & Associates, an environmental consultancy founded in 1982, which specialises in environmental impact assessment of resource industry developments, related pollution problems and environmental management. Prior to this environmental Patrick worked on high temperature materials R&D (metals, ceramics and refractories) in the UK, the Netherlands and Australia.

Besides being an environmental consultant, Patrick is also a PhD candidate in the Department of Civil Engineering, the University of Queensland, with reservoir siltation and catchment management being the basis of his research topic. Patrick, and his supervisor Dr Hubert Chanson (Senior Lecturer, Department of Civil Engineering) have written a number of papers on sedimentation of dams.

Publications.

Besides two patents, internal reports and over 30 public, environmental documents Patrick James has authored and co-authored the following papers (* indicates a refereed papers).

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