CIRM Occasional Paper 2/2002
ISSN 1445-9280

Prioritising research on water renewal in Queensland

Report prepared for the Consortium
for Integrated Resource Management

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2002

(+DPI&EPA)

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Acknowledgments:

The preparation of this document would not have been possible without the input of information from many individuals within both the public and private sectors. The author would especially like to thank Ted Gardner from the Department of Natural Resources and Mines who project managed this consultancy on behalf of CIRM and who made detailed comments on the text and structure of the various drafts produced. Appreciation is also extended to Paul Sherman from the Environmental Protection Agency, who provided access to unpublished information from the QWRS project as well as valuable comments on the various drafts of the report.

ISSN: 1445-9280
QNRM: 02005

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BACKGROUND – WHO AND WHAT IS CIRM?

The Consortium for Integrated Resource Management (CIRM) operates as a formal linkage mechanism through a network of key officers from its six partner organisations – three Queensland government departments (Natural Resources and Mines, Primary Industries, and the Environmental Protection Agency), two universities (University of Queensland and Griffith University) and CSIRO. It was formed in 1993 and has evolved as a mechanism for facilitating the planning and coordination of collaborative research initiatives. It has links to the community through its partners and through an association with the Landcare and Catchment Management Council. The CIRM Board acts as a reference group for CIRM's activities, and is composed of the CEOs of each of the partner organisations.

The benefits of implementing such a process include:

- facilitating the coordination and integration of natural resource management research among partner organisations and providing an efficient means of assisting project innovators to move new collaborative proposals forward
- minimising the start-up or 'transaction' costs of joint projects
- minimising the duplication of effort and resources
- access to established communication linkages
- developing and strengthening research partnerships, both with CIRM partners and beyond, including the community.

It is now universally acknowledged that resource management issues extend far beyond the scope of any single agency or organisation – that they are the responsibility of us all and they need to be dealt with in an integrated, holistic way. This means that CIRM's charter is even more relevant today than it was in its beginnings.

Because it is a *process* rather than an entity in its own right, CIRM does not undertake the activities of a centre or other formalised institutional structure. Nor should it be seen as in any way competing with, or usurping the role of, individual partners or their key staff. Rather, its aims are collaboration, brokerage, communication and a shared approach to common issues.

Examples of CIRM-facilitated activities include ARC-SPIRT (now ARC-Linkage) projects worth many millions of dollars, successful establishment of the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, several major wastewater renewal and use programs, an international watershed project, and earlier workshopping of social issues associated with sustainable natural resource management.

More recently, CIRM has concentrated on the following four major priority areas for which it is preparing scoping papers:

- social and community dimensions of natural resource management
- management of aquatic ecosystems
- dryland salinity risk assessment
- water renewal.

This report on the prioritisation of research on water renewal is the second position paper developed around those focus areas for the CIRM partners.

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Executive summary

Water renewal has been recognised both by those in the water industry, and to a lesser extent by the general community, as an area where many advances will occur over the next decade. The most recent figures (Dillon 2000) indicate that presently within Queensland about 12% of treated sewage effluent is recycled, although surveys indicate that these are predominantly opportunistic uses that are mostly not sustainable. This volume of recycling is well above the national average of around 7.3%. A summary of the use of recycled water in Queensland is shown in table 1 below.

Table 1: Use of recycled water in Queensland

Water recycling use	Megalitres per annum	Percentage of total
Golf courses	17 200	43.8%
Agriculture	10 950	27.9%
Parks and gardens	2 808	7.1%
Sporting fields	1 560	4.0%
Industry	1 660	4.2%
Other	5 137	13.1%

The interesting point to note from this table is the high recycling use on golf courses and the relatively low usage within industry.

The main purpose of this report is to determine the priority areas for research in the area of water recycling and what contribution the individual CIRM members can make to the carrying out of these research priorities. In the determination of the research priorities, two main areas were addressed:

1. The main positive and negative drivers affecting the level of recycling occurring in the State, and
2. The determination of the health, social, environmental and economic implications of water recycling that may affect its long-term sustainability.

In the case of positive drivers to recycling, it was determined that for producers of the effluent, the main drivers were associated with regulatory constraints. For third party users, by far the main drivers were economic. It was further noted that it would be land developers, farmers and industries who would drive recycling in the future and the community would in fact be a relatively minor player. The community would still have an important input to the process, however, through an increased role in the final schemes adopted and through monitoring of the projects.

In the case of the negative drivers, or constraints, it was determined that once again economic considerations would be the major issue. Other issues such as health concerns, access to detailed design criteria, and risk and reliability were considered to be important. It was interesting to note that the future decision makers for reuse applications did not give sustainability issues a high priority. This will mean that close monitoring of reuse applications will need to be put into place by the regulators. There will also be a need for research in a number of areas to allow interpretation of results from the monitoring carried out. Regulations, standards and guidelines in place will have to have sound scientific backing as they are expected to be subject to close examination.

A number of studies have already been carried out to determine research priorities in Australia for water recycling. A national survey of regulators in 2000 gave the regulatory point of view, which obviously gave high priority to sustainability issues. The detailed background papers produced as part of the Queensland Water Recycling Strategy also produced priorities for each of the specific areas where recycling will be occurring, including:

- Agriculture
- Groundwater recharge
- Health effects of recycling
- Industrial recycling
- Education needs
- Legislation.

The findings from all studies carried out to date were used in this report to determine future research needs. The report provides detail to justify why individual research projects should be initiated. It groups the research under seven headings, prioritises the individual projects and then determines the resources within the CIRM member organisations that could be linked to individual projects.

A summary of the suggested projects is given in table 2, with a priority rating from low to high. The successful rebid of the CRC for Water Quality and Treatment in 2001 accepted water renewal as one focus and has considerable input from CIRM partners. The priority areas listed here have been used as a basis for developing this program within the CRC and it has been agreed that implementation of research on priority research areas by CIRM partners will be developed in conjunction with the CRC.

Table 2: Summary of identified future research topics

Research area	Research topic	Priority
A. Economics	A(1). Determination of a methodology that can be used easily by water renewal decision makers for pricing environmental, social and health costs associated with urban and rural water supplies	Medium
	A(2). Calculation of the true cost of water and wastewater services in areas of the State where there is expected to be a high water renewal potential	Medium
	A(3). Investigation to determine the most efficient method of expending public funds to introduce sustainable water renewal, where this has been shown to be the best solution	High
	A(4). Comparison of alternative economic methodologies to determine which are the best for addressing long-term environmental and social issues	Medium
B. Social	B(1). A study to determine if there are ethnic and cultural differences within our communities that may hinder the acceptance of water renewal in these communities	Low
	B(2). A study to determine the short- and long-term impact on community attitudes of education and awareness campaigns in the area of water renewal	High
	B(3). A study to determine changes in community perceptions and attitudes, and reasons for the changes, during the introduction of major water renewal schemes	Medium
C. Technical	C(1). A study to determine what types of support documentation such as standards, guidelines or design manuals are needed by industry to ensure that economic, sustainable and efficient water renewal schemes are built	High
	C(2). A project to determine treatment process reliability based on the recently completed treatment facility at Pine Rivers	Medium

Research area	Research topic	Priority
	C(3). An investigation of possible cost reduction methodologies in the design of dual reticulation systems (but also taking into account possible changes to the conventional reticulation system) that deliver acceptable quality of service to residential consumers	High
	C(4). A study to determine the factors necessary for the effective mapping of suitable aquifer storage and recovery sites close to potential water renewal sites	Medium
	C(5). A mapping program to determine such aquifer storage and recovery sites in the State in areas where it is known that large volumes of effluent are presently being generated	Medium
	C(6). A detailed investigation, under Queensland conditions, to determine the changes in chemical and microbiological quality of the effluent over time while in the aquifer	Medium
	C(7). Determination of lower-cost treatment options for use in sewer mining operations	High
	C(8). Research into the efficiency of conventional and advanced treatment methods for the removal of endocrine disrupters and pharmaceutical compounds from sewage effluent	Medium
D. Education	D(1). Development and trial of a methodology for the introduction of an industrial water renewal educational campaign	High
	D(2). Development and trial of methodologies for water renewa l education programs both for general community education and for project-specific situations	High
E. Environment	E(1). Development of a simple procedure to determine which water-sensitive urban design (WSUD) principles are likely to be applicable for specific urban developments, based on issues such as topography, climate population and density	High
	E(2). An investigation of the implications of using highly treated effluent to maintain levels in urban storages through the use of controlled trials and modelling	Medium
	E(3). Further research on the environmental ramifications of aquifer storage and recovery (ASR) using low quality aquifers, covering areas such as nutrient leakage and iron bacteria clogging	Medium
	E(4). Determination of the factors necessary for the effective identification and mapping of areas suitable for aquifer storage and recovery (ASR) in Queensland	Medium
	E(5). A workshop specifically to identify research priorities in the area of environmental impacts of the use of treated effluents for water recycling in urban areas	High
F. Institutional	F(1). An investigation of the beneficial effect of initiatives such as load-based licensing, tradeable permits and effluent fees, to determine if they would have a positive effect on the level of uptake of water renewal	Medium
	F(2). An investigation of the mechanisms for the introduction of a regulatory system for water renewal that protects both the environment and public health as well as providing positive non-financial incentives	Medium
	F(3). Detailed nationwide surveys on a regular basis in cooperation with State authorities and AWA, as part of an overall assessment of all aspects of water renewal in Australia	High
G. Health	G(1). A workshop of experts in water-related risk assessment, to determine future directions in the area of risk assessment	High
	G(2). A detailed analysis to determine the gaps in the data needed to undertake a quantitative microbial risk assessment (in the areas of enumeration, species identification, ingested dose and stochastic variability), and to find how best to fill these gaps	Medium
	G(3). Further tests to document the pathogen removal capacity of all membrane systems, especially microfiltration	High

Research area	Research topic	Priority
	G(4). Research to determine accurate and cost-effective methods of virus numeration based on nucleic acid amplification, and to establish the relationship between the presence of viral nucleic acid in water samples and human health effects	Medium
	G(5). Further research into the use of newer analytical techniques using indicator organisms such as *Clostridium perfringens* and the F-specific coliphage virus	Medium
	G(6). Determination of design criteria for lagoon disinfection in tropical climates for all pathogen reduction	Medium

1.0 Introduction

A survey carried out in Queensland in 1992 (Bryant et al. 1994) showed that of the 300,000ML/year of sewage effluent produced approximately 9.7% was recycled. A further survey carried out in 1997 (unpublished) showed that this had risen to 11.7%. In the five years between the two surveys, there was a huge increase in interest in water recycling, although the amount of water being recycled remained small. Part of the reason put forward for the small increase was the lack of technical data available to both the organisations making the decisions to recycle, and the government agencies regulating the recycling. Further reasons suggested for the small increase were the lack of regulatory drivers to recycle, and the few areas in the State where there were real shortages in new raw water sources.

Preliminary data (Bryant et al. 1994) showed that much of the recycling referred to above was being carried out in an unsustainable manner. Little data presently exist that can be easily assessed and utilised to allow those making the decision to recycle to determine the sustainability of their decisions.

Within the membership of CIRM there exists both researchers available to carry out necessary research projects to fill those gaps, as well as the regulating bodies who will be able to use the techniques developed. While a great deal of work into aspects of water recycling is presently underway both within Queensland and elsewhere, this is being carried out in an uncoordinated manner, which is an uneconomic use of limited resources. The objective of this report is to produce a priority listing of research projects that will help to ensure that water renewal is carried out in an economic and sustainable manner.

2.0 The Queensland situation

Prior to the Queensland Water Recycling Strategy (QWRS), little data were available on water recycling in the State. The QWRS carried out eleven detailed studies into different aspects of water recycling, most of which have now been published. These studies were carried out by private consultants, other Government departments and specialist groups within the then Department of Natural Resources. Some brief details of the situation in Queensland are given in this section.

Based on results from the latest surveys (Dillon 2000) across Australia, Queensland recycles 11.7% of its sewage effluent compared with a national average of 7.3%. Details of usage in other states are given in table 3. Most states reported an expected increase in reuse consumption of 1–3% per year over the next ten years.

Table 3: Comparison of effluent recycling rates across Australia

State	Year	Effluent GL/year	Effluent recycled GL/year	%
Queensland	1998	328	38.0	11.6
New South Wales	1996	548	40.1	7.3
ACT	1998	31	0.2	0.8
Victoria	1999	367	16.9	4.6
Tasmania	1999	43	1.0	2.3
South Australia	1998	91	9.0	9.9
Western Australia	1999	109	6.6	6.1
Northern Territory	1998	21	1.0	4.8
Australia (total)		1538	112.9	7.3

In Queensland, a breakup of the types of recycling occurring in 1998 is given in table 4 below.

Table 4: Effluent recycling uses in Queensland, 1998

Water recycling use	Megalitres per annum	Percentage of total
Golf courses	17 200	43.8%
Agriculture	10 950	27.9%
Parks and gardens	2 808	7.1%
Sporting fields	1 560	4.0%
Industry	1 660	4.2%
Other	5 137	13.1%

It is interesting to note that, with the exception of golf courses, the use of recycled water in urban areas is very small. No dual reticulation schemes or sewer mining presently exists within Queensland. In only a few minor cases does road verge irrigation occur.

In the case of industrial water recycling, the only reliable information available is the use of municipal sewage effluent. No coordinated data are available on the levels of internal recycling within industry.

In agricultural recycling the situation is very similar, with the only reliable data being the volumes of municipal effluent being used in agricultural areas. It is known that substantial recycling does occur with intensive livestock applications such as feedlots and piggeries.

3.0 Determining priority research

As indicated previously, one of the main reasons for this study is to determine which research projects should be carried out by the CIRM partners to maximise the success of water renewal in Queensland. To obtain a better understanding of how these priorities can be determined, we need to understand the reasons for the research. First it is necessary to understand the real, positive drivers to recycling, that is, the factors that will greatly influence organisations to install recycling systems. These factors are discussed below.

Another area that needs to be addressed is to determine the negative drivers, that is, the issues that are preventing recycling projects from going ahead. Once these have been determined, it is possible to undertake research to address these issues. These negative drivers are also discussed in the following sections.

The next area to be addressed following the identification of positive and negative drivers is to determine what issues are likely to emerge once recycling is occurring. Sustainability issues that need to be investigated include those where recycling occurs without sufficient knowledge of the health, social, environmental and economic consequences of such recycling. These issues are discussed in section 6.

3.1 Positive drivers

Although much has been written about the reasons why we should recycle, in most publications on recycling very little is included on the driving forces for recycling. To some extent, the types of drivers that are forcing recycling are dependent on the type of recycling occurring. These drivers are also heavily dependent on location due to the differing functions of organisations across Australia.

One area suggested as a major driver for recycling is community pressure. It should be noted that to date the community has had very little influence in what recycling has occurred except in a small number of high profile cases. In recent times, when the issue of recycling has been raised in the national press, the general public has shown very little interest.

In the dry states of the United States and in countries such and Israel and Tunisia, one of the major drivers of recycling is the overall shortage of water. With the exception of some specific areas of the State, this is generally not the case in Queensland, especially in the short term. In the general Brisbane area (Brisbane and Moreton statistical areas), where in 1998 216GL of effluent was generated, the present water resources are predicted to be sufficient for between 25 and 50 years, depending on whose projections are used. For this reason, shortage of water resources is not seen as a short-term positive driver.

Almost all sewage-based effluent emanates from local government treatment plants. For this reason, local governments have a high influence on whether or not recycling schemes proceed. In a survey of 74 local governments in 1997 (QWRS 1999e), the following responses (table 5) were given as the objectives for local governments to recycle.

Table 5: Queensland local government recycling objectives

Local government recycling objective	% of respondents
Avoid waterways release	36
Conserve water resources	27
Comply with Environment Authority	16
Assure supply to applicants	9
Realise economic benefits	9
Avoid/offset STP upgrade	9
Council policy	7
General environmental considerations	6
Community pressure	4
Other	5
Do not know	4

These Queensland responses would be expected to be quite different from the situation in, say, the irrigation areas in South Australia, where all water is already fully allocated and recycled water is the only possible source of irrigation water. It is interesting to note that overseas, the areas where high levels of water renewal are occurring, such as in California, Florida, Israel, the Middle East and Tunisia, are places where there are already critical water shortages.

Although conserving water resources is a positive driver, in most areas of Queensland impending water shortages are not generally seen as significant drivers, especially compared to South Australia and the west coast of the US. The success of demand management across Queensland has led to existing water resources being sufficient for the near future for most towns and cities.

The survey responses above should be compared to those from the third party users (table 6) who obtained recycled water from local governments (QWRS 1999e).

Table 6: Queensland third party users' recycling objectives

Objective of third party user	% of respondents
Economic	50
Only source of supply	29
Guaranteed supply	21
Environmental grounds	6
Other	4
Do not know	2

The responses from the two groups are interesting as they show that where local governments are concerned, the regulatory drivers are by far the most important, with water conservation – most likely linked with economic issues associated with future upgrading of the water systems – as another major driver. It is assumed that "only source of supply" is really an economic issue. With respect to the third party objectives, the economic issues are thus the only major drivers, and environmental and community issues are of minor concern.

3.2 Negative drivers

The Department of Natural Resources Urban Survey of third party users identified a number of impediments to recycling and these are detailed in table 7.

Table 7: Impediments to water recycling identified by third party users

Impediments to water recycling	% of respondents
Economic considerations	50
Health concerns	42
Physical issues associated with the design of the scheme	41
Legal risk and liability	33
Issues associated with climatic conditions eg long periods of rainfall	23
Guarantee of effluent's quality and quantity	20
Problems associated with the regulatory system	16
Problems associated with operational issues	14
Community concerns	14
Issues associated with designing and operating wet weather storages	13
Opposition from decision makers	8
Other issues	6

There is a great variation in the types of issues identified by respondents. While the results identify the perceived impediments to recycling, many need to be looked at in more depth to identify the real issue. Although economic impediments are probably relatively straightforward and expected, what is meant by 'health concerns' is considered to be more complicated. In general terms, many of the potential water recyclers have limited understanding of risk analysis associated with health implications of water recycling. They need to be convinced that the particular recycling project has an acceptably low risk of producing health problems. Even water professionals often have difficulty understanding the health risks associated with water recycling, with little real agreement on the correct direction to be heading in this area.

The QWRS (2000e) commissioned AC Nielsen in 2000 to undertake a detailed survey of local government employees, commercial water recycling users and the general community. This survey showed that all three groups believed health concerns were a major issue, and that insufficient technical data were available at present to make informed decisions on water recycling projects.

Of similar significance is the response that these groups have concerns about the technical issues associated with the planning and design of recycling systems. In view of the complications associated with the numerous guidelines in use in Australia, this is not really unexpected.

What is quite surprising is that most recyclers do not believe that community concern is a major impediment to non-potable renewal. Although figures are not available for individual local governments, it would be expected that the areas of concern are those where water renewal has become an issue due to pressure groups pushing direct and indirect *potable* recycling as a short-term option. From the surveys that have been carried out in Queensland (QWRS 2000e), in Perth by the CSIRO Urban Water Project and in New South Wales by Sydney Water, it is quite obvious that the community will be strongly opposed to any type of potable renewal at this stage, whereas non-potable uses have a high level of acceptance. From these surveys, individuals in the community have shown that they are fully supportive of recycling except when it comes to uses within the house, where they are worried about both potable and non potable uses.

4.0 Previously identified research priorities

A number of recent studies have suggested the research priorities considered necessary to forward water renewal in Australia. Although they had different terms of reference, their general findings are of relevance to this investigation. As shown below, many of these studies identified the same priority areas for research projects.

Dillon (2000) produced a list of priority areas based on the predictions of water recycling experts around Australia, most of whom were regulators. These priorities are reproduced in table 8.

Table 8: Priority research areas identified in Dillon (2000)

Rank	Field of research	Theme*
1	Factors affecting public acceptance of reuse	H, E, S
2	Viruses	H
3	Public health impacts of reuse Impacts on food quality of reuse on crops	H H, E
4	Publishing a summary of existing research Economics of reuse	All Ec
5	Disinfection effectiveness Environmental impacts of reuse Salinity Pathogenic bacteria Regulation and regulation	H E E H H, E
6	Algae prevention and removal Impact on soils Impacts on groundwater Impacts on fresh surface water Sodicity	E E E H, E E
7	Suspended solids removal	E
8	Algal toxin removal Packaging existing information for regulation Cryptosporidium Insurance for reuse schemes	H H, E H All
9	Endocrine disruption Impacts on estuarine and marine waters Nitrogen	H, E H, E E

**Themes: E = Environment, Ec = Economics, H = Public health, S = Sociological*

These results must be viewed with some caution. Most respondents were state regulators, whose main function is to ensure that there are not undue environmental or health impacts due to recycling. For this reason it would be expected that the results would give a high priority to environmental and health issues and a lower priority to more development-based drivers, such as the economic and engineering/technical issues that would influence the rate of take-up of new water renewal projects. Notwithstanding these limitations, the interesting aspect emerging from this study was the high priority given to the large variety of health issues associated with water renewal. On the other hand, economic issues received a relatively lower priority.

In 1999 the QWRS produced a Demonstration and Research Water Recycling Background Study (QWRS 1999b). This study was based on a literature review of over 1500 references in all areas of water renewal. The study aimed to identify areas where gaps existed and where little research had been carried out. The study produced a comprehensive database of published research areas. The study did have limitations as it addressed the problem from the supply point of view rather than the real demand for specific research areas. It did however identify in general terms many of the gaps. Table 9 is derived from the findings of the report and summarises the future research priority areas.

Table 9: Priority research areas derived from QWRS (1999)

Category	Sub-category	Research area
Health	Contaminants	• Health effects of heavy metals, trace chemicals, carcinogens, endocrine disrupters and radioactive elements • Long-term health effects of drinking recycled water • Health effects of food crops irrigated with effluent
	Risk assessment	• Relationship between indicator organisms and actual microbiological quality of recycled water • Links between guideline criteria and specific health risks • Health risks associated with aerosols • Health risks associated with long-term low-level exposure to waterborne infectious diseases • The survival rate of pathogens in crops and soils • Levels of protozoa and viruses that are dangerous to human health
Sustainability	Economics	• Long-term cost data on operational aspects of water recycling • Development of economic parameters for water recycling models
	Environmental	• Baseline and ongoing operational data on monitoring of existing recycling projects • Effect on groundwater quality associated with groundwater storage and recovery • Relative impacts on a catchment between providing environmental flows based on effluent and reduced flows based on using the recycled water for other recycling schemes
Treatment technology		• Data on the reliability of individual unit treatment processes used for recycled water production • Data from on-line monitoring of complete treatment process trains, including times when there is a lowering of inflow water quality • Effect of different backwashing techniques on filtered water quality
Sociology		• Research into the factors affecting community acceptance of different types of water recycling
Responsibility		• Effect of legislation, regulation and legal liability on the progression of water recycling schemes

Other points to be recognised include that there was no priority given to the various areas of research identified, and secondly that the procedure identified only the gaps in research and did not ascertain if in fact it was necessary for research to be carried out to have these gaps filled.

As well as production of the background study, the QWRS also produced a number of specialist studies covering most of the individual water recycling areas. These reports were produced by specialists in their fields and often contained specific recommendations for areas of future research. Some of these recommendations are summarised in table 10.

Table 10: Research recommendations from specialist studies

QWRS specialist study	Research recommendations
Agricultural Water Recycling Background Study	• Economic methods of implementing sustainable integrated agricultural options • The effect on human health of using effluent generated by pigs and cattle on crops used for human consumption • The relevance of using indicator organisms as a measure of the risk of infection when using recycled water
Groundwater Recharge Background Study	• Determination of the factors necessary for the effective mapping of areas suitable for aquifer storage and recovery (ASR) • Determination of areas in Queensland suitable for ASR
Economic Aspects of Water Recycling in Queensland	• The effectiveness and applicability of load-based licensing, tradeable permits and effluent fees for the encouragement of water renewal in Queensland • Development of national guidelines for water renewal taking into account the instruments discussed above • Determination of the true cost of water, taking into account such factors as headworks contributions, environmental costs and the full cost of treating the wastewater produced • A study to determine the effectiveness of existing subsidy schemes in place in Queensland • A study to determine the imputed value of water, taking into account the scarcity value and opportunity cost of the water
Wastewater Recycling Health Effects Scoping Study	• Establishment of a relationship between the presence of viral nucleic acid in water samples and the human health effects • Investigation of the infective dose range and health effects of *Helicobacter pylori* • For inorganic chemicals, although sampling and analysis methods exist for total levels of elements, there is a need for more knowledge with regard to analysis of metal species • Human uptake of radionuclides in tropical and subtropical climates • The public health effect of pesticides associated with particulates
Industry Water Recycling Background Study	• An in-depth survey of water recycling practices carried out within industry across the State • Examination of financial and non-financial incentives for the promotion of water recycling within industry • Production of industry-specific information kits providing technical data to promote water recycling • Production of a GIS-based industrial recycling model to identify potential industrial water recycling opportunities

QWRS specialist study	Research recommendations
Educational Needs Background Report	• Determination of the components of a public education campaign required to achieve informed public participation • Public health research carried out in conjunction with QWRS demonstration projects, as a basis for accurate public education programs • Production of a public education campaign as part of an overall water-based education campaign
Legislative Environment Water Recycling Background Report	• Alternative legislative frameworks investigated to determine the best regulatory system that will adequately safeguard the environment and public health without unnecessarily inhibiting the growth of water recycling

5.0. Driver-associated research and development issues

5.1 Economic research

Associated with the Queensland Water Recycling Strategy, a number of workshops have been held to determine the drivers for water renewal. The one issue that has come out above all others is that industry will not endorse water renewal unless it is a better economic option when compared with conventional water supplies. This situation applies both to municipal systems for potable water run by local governments and to irrigation systems run by the State Government. Although there have been major reforms over recent years, it has frequently been argued that the present cost for water is still nowhere near the "true" cost. Perkins and MacCormick (1998) have recently produced a number of papers highlighting the anomalies in the current pricing of water – especially urban water – that tend to disadvantage the use of recycled water. These anomalies include:

- Not costing the environmental, social and health costs
- Government subsidies on capital costs
- Not including full subdivider contributions in the real cost of water
- Inadequate provision for future expenditure on asset replacement.

MacCormick argues that if the effect of subdividers' contributions were added to the water price this would add $1.00–$1.50 per KL to the price of water. He further argues that fully costing asset replacement would add a further 16 cents per KL to the price. While very little work has been done to determine the real environmental costs associated with urban water, ACTEW in the ACT have calculated a figure of 17 cents per KL as what the community would accept as the environmental cost. It is obvious that an artificially low price for conventional water supplies would make it difficult for recycled water to compete. Almost no work seems to appear in the literature on the methodology of costing these externalities for urban or rural water in Australia.

Research recommendations:

- *Determination of a methodology that can be used easily by water renewal decision makers for pricing environmental, social and health costs associated with urban and rural water supplies [A(1)]*

- *Calculation of the "true cost" of water and wastewater services in areas of the State where there is expected to be a high water renewal potential [A(2)]*

The State Government is presently providing a large amount of funding for local government capital works (approximately $40M per annum) through its Local Government Capital Works Subsidy. Up to 50% subsidy is provided for projects such as public water supplies and water recycling projects. These subsidies are only available to public projects and not to private or industry-funded projects. No work has been undertaken to determine if this is the most effective way of spending public funds to promote water recycling. Other methods such as operational or research grants, and industry and community education may be more efficient.

Research recommendation:

- *Investigation to determine the most efficient method of expending public funds to introduce sustainable water renewal, where this has been shown to be the best solution [A(3)]*

5.2 Social research

Within Australia as a whole we are becoming more aware of cultural and ethnic differences within our multicultural populations. We presently do not know if these differences are significant in any way in issues related to water renewal. As water renewal comes to individual households through the introduction of initiatives such as dual reticulation schemes, it may be found that there are some negative drivers in these areas. At a number of recent presentations it has been raised that certain ethnic groups may have problems with the general concept of recycling human waste, especially in relation to potable water recycling.

Although direct potable recycling is not likely to be practised in Queensland in the foreseeable future, these social concerns may still be an issue in the community's acceptance of non-potable recycling, especially in some of the ethnic communities.

Research recommendation:

- *A study to determine if there are ethnic and cultural differences within our communities that may hinder the acceptance of water renewal in these communities [B(1)]*

5.3 Technical research

Above all other technical issues the one that stands out as a negative driver is the lack of suitable and consistent guidelines, standards and design manuals. An examination of the health-related criteria of various water recycling guidelines, undertaken as part of the information-gathering for this report, revealed significant discrepancies in several areas. It is not surprising then that when industry views such documents they become so confused that they are scared off the whole area of water renewal.

What is needed now are documents that will lead industry through the whole planning and design process to produce sustainable recycling schemes. This may require technical design manuals to help practitioners understand the significance of the various guidelines. Many of the guidelines in place at present place too much emphasis on water quality acceptance criteria, rather than the design criteria and operational methodology that are required to reach such standards. The medium and format of the information produced is also important. Prior to any guidelines being produced, the potential user and purpose of the document must be determined, so that correct information can be provided in the document, in a format that is meaningful and relevant to the user. During the preparation of these guidelines it should become apparent which criteria are based on scientific data and which are not, thus highlighting potential areas for further research.

Research recommendation:

- *A study to determine what types of support documentation such as standards, guidelines or design manuals are needed by industry to ensure that economic, sustainable and efficient water renewal schemes are built [C(1)]*

It should be realised that in the design of recycling schemes, industry does not take great interest in the reasoning behind the design criteria stated in guidelines. Industry will normally accept figures in standards or guidelines, as water renewal issues are usually just a side issue to the main problem being addressed. This is not to say that the determination of accurate figures is not important, as it is obviously significant for the environmental and health sustainability of the project. These issues will be discussed further in the following section on sustainability.

Reliability of treatment systems is an issue that has been raised by eminent reuse practitioners such as Asano (1998) and by the US National Research Council (IAWQ 1998). Although average water quality produced by individual treatment processes from sewage effluent has been reported extensively in the literature, little information is available on the reliability of such processes and the variation of water quality produced. This is an extremely important issue, as it is likely that many of the plants presently being constructed are conservatively designed because of this lack of data.

As economics is the most important driver for industry, any process that reduces the overall costs of recycling schemes must have a positive impact. A recent paper (Eisenburg et al. 2001) presented by at a Paris recycling conference described a methodology for detailing reliability of treatment systems. It would be expected that the recently completed water recycling demonstration treatment plant owned by the Environmental Protection Agency, presently located at Pine Rivers Shire Council, as well as some full-scale operating plants, would be ideal facilities to undertake further research into treatment reliability.

Research recommendation:

- *A project to determine treatment process reliability based on the recently completed treatment facility at Pine Rivers [C(2)]*

In the states of Florida and California in the US, the number of dual reticulation schemes in residential areas has grown rapidly over the last twenty years. In Australia the number of such schemes is small, with none presently operating in Queensland, although one demonstration scheme is being designed for Springfield in Brisbane. The most publicised Australian scheme is the one at Rouse Hill in Sydney.

The CSIRO's Urban Water Unit is also investigating the economics of such schemes. Many people, especially engineering consultants and urban land developers, believe that such dual reticulation schemes are not economic. It is likely that if a more innovative approach were taken, investigating new design criteria for system reliability and a lower cost system for main construction, then such schemes would become economic. The economics may also depend upon true water pricing being implemented. If dual reticulation systems can be shown to be economic then much higher volumes of recycled water will be able to be used in the urban environment.

Presently it is difficult to justify recycling systems based only on smaller sporting complexes and parks.

Research recommendation:

- *An investigation of possible cost reduction methodologies in the design of dual reticulation systems (but also taking into account possible changes to the conventional reticulation system) that deliver acceptable quality of service to residential consumers [C(3)]*

In Adelaide in recent years, the CSIRO (Dillon & Pavelic 1996) has been investigating the importance of aquifer storage and recovery for treated sewage effluent used for agriculture uses. This research has great potential, as one of the major costs associated with water recycling for agriculture is the high storage costs due to the great variation in both irrigation requirements and seasonal demands associated with Australia's variable climatic conditions. Another advantage is the ability of the aquifers to reduce the levels of pathogens. Although further work is being done by CSIRO in this area, this water quality improvement potential needs further investigation.

One of the interesting aspects of the South Australian research is the recharge of low quality aquifers that have no potential as water sources. As was concluded in the Groundwater Recycling Study (QWRS 2000c), in Queensland there is little information on the potential to use such aquifers, their optimal location, or even the methodology to determine such potential. Localised urban aquifers have never been mapped. These areas of research could have direct short-term benefits for the advancement of water recycling in the State.

Research recommendations:

- *A study to determine the factors necessary for the effective mapping of suitable aquifer storage and recovery sites close to potential water recycling sites [C(4)]*
- *A mapping program to determine such aquifer storage and recovery sites in the State in areas where it is known that large volumes of effluent are presently being generated [C(5)]*
- *A detailed investigation, under Queensland conditions, to determine the changes in chemical and microbiological quality of the effluent over time while in the aquifer [C(6)]*

One area that has been discussed for many years is that of extracting water from sewers, treating the effluent while returning the solids to the sewer, and using the highly treated effluent for local irrigation in the urban context. This is normally referred to as sewer mining. Only a few examples presently exist in Australia, with the major problem being the design of an economic treatment system. Locally produced effluent has an obvious advantage in that it can to be used with minimum lengths of mains, normally the major cost in a recycled water project. It is likely that the use of high-rate physical/chemical processes may deliver an economic solution, and more research in this area is required.

Research recommendation:

- *Determination of lower cost treatment options for use in sewer mining operations [C(7)]*

Over recent years there have been many articles in the technical literature about the occurrence of endocrine disrupters and pharmaceutical compounds or their breakdown products in our raw waters. Many of these have come into the natural environment through domestic and industrial wastes as well as from agricultural pursuits. Little is presently known about the long-term health implications of many of these compounds, on either human health or the environment, or the efficiency of many of our conventional treatment methods for their removal.

Although work is presently being carried out around the world on many issues associated with these compounds, our understanding is still very limited. Any Australian research should take into account what has been done overseas. The lack of knowledge in this area has recently been cited as a cause of some concern by potential water recycling bodies. Until it is seen that the industry has knowledge of both the health effects of these compounds and the efficiency of treatment methods to remove them, this apprehension will continue.

Research recommendation:

- *Research into the efficiency of conventional and advanced treatment methods for the removal of endocrine disrupters and pharmaceutical compounds from sewage effluent [C(8)]*

5.4 Educational research

As can be seen from section two, the types of water recycling schemes in operation in Queensland are generally not particularly innovative, with irrigation of golf courses and spray irrigation of agricultural areas being the main areas of use. Because so much of the effluent is actually being generated within and around urban areas, the use of the effluent within urban areas would make more sense from the economic point of view. Apart from the recycling of water for the irrigation of public space, the two areas where this would be likely to occur would be in industrial areas and within individual premises. It is likely that increased uptake of water recycling in these two areas will only progress if effective educational campaigns take place.

To date, the use of recycled water in industrial areas has had only limited success, with the recently opened dual membrane plant in Brisbane constructed to provide high quality water to the BP oil refinery. This 14ML/d plant (Don et al. 2000) is one of the largest and most sophisticated industrial water recycling plants in the Southern Hemisphere. It was constructed as a fully commercial enterprise between BP Australia and Brisbane Water.

With most industries, water use is only a minor item in their overall operating costs, and as such, most industries do not give investigation into the use of recycled water a high priority. It also has to be realised that industrial recycling has a major advantage over other recycling applications in that the amount of recycled water used is almost independent of rainfall, and so only minor storage is required. In the major cities in the State, about 20% of urban water is used for industrial and commercial consumption, but this potential for industrial recycling is often overlooked. Although other examples exist in Australia, such as the Wollongong steel mills and the South Australian Wool Scour, they still represent only a very small proportion of industrial consumption. As has been shown in the US, industry will only recycle water if it can be shown to be both economic and free from health or social implications. If the amount of recycled water used by industry is to be maximised, an efficient recycling educational program should be developed and trialled.

Research recommendation:

- *Development and trial of a methodology for the introduction of an industrial water renewal educational campaign [D(1)]*

A number of community education schemes have recently been initiated; however these are not really focused campaigns, and are more involved in the production of educational materials. For an education campaign to be successful it is important that an efficient methodology is developed, targeted to achieve predetermined outcomes. It would be expected that such campaigns would be most successful if implemented in conjunction with demonstration projects.

Research recommendation:

- *Development and trial of methodologies for water renewal education programs, both for general community education and for project-specific situations [D(2)]*

5.5 Environmental research

In recent years it is becoming more apparent that it is the national land developers who are making the major decisions on the shape of our new cities. They decide what types of environments will be created, based on what they believe the consumer will be willing to pay for, and generally in conformity with the regulations laid down by State and local governments. While many of the universities around Australia now have units undertaking research into innovative alternative water usage, including water recycling, much of their research in not being adopted by the major developers. Such groups include the Environmental Technology Centre at Murdoch University, the Urban Water Resource Centre at the University of South Australia and the Department of Civil, Surveying and Environmental Engineering (Coombes et al. 2000a,b) at the University of Newcastle.

One of the areas receiving increased attention over recent years is the introduction of water-sensitive urban design (WSUD) into urban subdivisions. These WSUD features to date have been mainly been introduced for environmental reasons. While much has been written in the literature about the qualitative aspects of WSUD, only recently has any quantitative work such as that by the Urban Water Unit of CSIRO been carried out. Although a joint CSIRO/Brisbane City Council/developer project has begun at “Brazil”, south of Brisbane, to develop a subdivision based on alternative systems (many of which will be demonstrating WSUD principles), this is only seen as a start in this area. A high priority project should be to develop the basic generic principles to determine which WSUD methods are applicable in particular instances.

Research recommendation:

- *Development of a simple procedure to determine which water-sensitive urban design (WSUD) principles are likely to be applicable for specific urban developments, based on issues such as topography, climate population and density [(E1)]*

In the area of the environment, it has become apparent that buyers are willing to pay a premium for water features in a new urban development. Because of the problems associated with providing permanent water features in some of our dry climates, in many cases it is difficult to maintain these features at a level acceptable to the community. The use of recycled water here would seem an obvious solution.

Although regulators are willing to consider such uses, developers have been unwilling to trial those schemes because they believe there may be visual and odour problems associated with such proposals. There is also the real possibility of algal blooms associated with high levels of nutrients in the water, as well as a concern that water potentially detrimental to the environment may be released at the head of the catchment. An ideal opportunity exists to trial such systems, with the regulators (EPA and local governments), the developers and research organisations all being involved. The research should investigate issues such as yield and acceptable drawdown, nutrient reduction and algal growth, and need for artificial mixing.

Research recommendation:

- *An investigation of the implications of using highly treated effluent to maintain levels in urban storages through the use of controlled trials and modelling [E(2)]*

5.6 Institutional research

Legislation has tended to have been more negative than positive for recycling, due to the strict discharge standards being placed on both point and non-point discharges. While Sydney, because of its size, has a very high potential for water recycling, regulation has meant that in many cases the lowest risk option is to treat the effluents, mainly to primary standard only, and then discharge to the environment in accordance with the licence requirements.

While there have been innovative reforms in environmental legislation in some of the other states, Queensland seems to be lagging in the area of licensing. The QWRS Economic Background Study recommended that certain environmental reforms such as load-based licensing, tradeable permits and effluent fees be investigated. It is likely that any of these initiatives, along with others recommended by the study, would benefit water renewal schemes.

Research recommendation:

- *An investigation of the beneficial effect of initiatives such as load-based licensing, tradeable permits and effluent fees, to determine if they would have a positive effect on the level of uptake of water renewal [F(1)]*

Presently within Queensland there is no approval or licensing process specifically for water recycling projects, although to some extent some applications are captured through the licensing of sewage treatment plants and the State subsidy for recycling schemes. Discussion with industry shows that there is great confusion regarding the approvals necessary to implement a recycling scheme. Although normally the introduction of any approval or licensing process would be seen as negative, if implemented in the right way it could be seen as being a positive driver for recycling.

Research recommendation:

- *An investigation of the mechanisms for the introduction of a regulatory system for water renewal that protects both the environment and public health as well as providing positive non-financial incentives [F(2)]*

6.0 Sustainability-driven research and development issues

This section covers those issues that should be investigated further to ensure that when water recycling does occur, it does so in a sustainable manner. These would normally be seen as low priority areas by the present proponents of recycling.

6.1 Health issues

There are generally two methods for the possible determination of risk associated with the use of treated effluent as the source of recycled water, the first being epidemiological studies and the second being quantitative or microbial risk assessment. In the case of epidemiological studies, it is now realised by most practitioners such as Crook (Asano 1998) that there are many limitations to their successful use, such as:

- the mobility of the population
- the small size of the population
- the difficulty in determining the actual exposure
- the low illness rate if any resulting from the reuse practice
- insufficient sensitivity of current epidemiological techniques to detect low-level disease transmission
- the high cost.

Quantitative microbial risk assessment (QMRA) is the second alternative. The procedures for undertaking microbial risk assessment have now been well documented by several authors including Haas et al. (1993) and Asano (1998) and generally follow the four step analysis of:

1. hazard identification
2. dose response determination
3. exposure assessment
4. risk characterisation.

Gerba (National Research Council 1998) and others have identified gaps in the available data in all four steps. Filling these gaps would be expensive in most cases, although not as expensive as epidemiological studies. A similar situation exists for epidemiological studies. Because of the gaps in the data it is difficult to gauge the accuracy of risk assessment results obtained from following the recognised procedure.

The QWRS Health Effects Scoping Study was carried out as the first stage of a three-stage process for the determination of risks associated with water renewal. Among other findings, this study did show that many experts in their own fields of health research had a relatively low understanding of the overall risk analysis methodologies associated with water renewal.

The second stage, detailed in the initial scoping report, was estimated to cost over $200,000 due to the large range of possible contaminants that may cause health effects and the need to prioritise them. Estimates by others show this to be a low estimate, which further demonstrates the large volume of funds necessary to get basic health data. A recent research project being funded by the AWWA Research Foundation has estimated that it will cost over a million dollars to determine the efficiencies of treatment methods for endocrine disrupter compounds. Because of the diversity of opinions in the health risk analysis area, a workshop should be convened initially to determine existing knowledge and directions to be followed in the area of risk assessment.

Research recommendation:

- *A workshop of experts in water-related risk assessment, to determine future directions in the area of risk assessment [G(1)]*

Following this workshop the gaps in knowledge to undertake meaningful QMRA should be determined.

Research recommendation:

- *A detailed analysis to determine the gaps in the data needed to undertake a quantitative microbial risk assessment (in the areas of enumeration, species identification, ingested dose and stochastic variability,) and to find how best to fill these gaps [G(2)]*

It is only recently that membranes have been used extensively in the treating of sewage effluent, and their performance compared with their cost has shown their high potential. Membranes have been shown to be effective for turbidity removal as well as almost essential for efficient disinfection. There are still limited data available on the efficiency of membranes for the removal of certain pathogens and further data should be obtained.

Research recommendation:

- *Further tests to document the pathogen removal capacity of all membrane systems, especially microfiltration [G(3)]*

It is now recognised that the threat from pathogens with water renewal is dependent on the type of recycling application but is normally associated with the level of viruses and protozoa. For example the main risks from certain types of spray irrigation would be those associated with aerosols, while that from the use of recycled water in urban storages would be associated with ingestion and absorption through the skin. There is still no economical method for enumerating viruses, which is a limitation in accurately determining the risk from these.

Research recommendation:

- *Research to determine accurate and cost-effective methods of virus numeration based on nucleic acid amplification, and to establish the relationship between the presence of viral nucleic acid in water samples and human health effects [G(4)]*

To date almost all national and international standards are based on the use of indicator organisms such as total coliforms or faecal coliforms, which have completely different die-off rates with different disinfectants than do many of the viral and protozoan pathogens of concern in recycled water. While most health authorities are now saying that little useful data can be obtained from the measurement of total coliforms, the most respected international guideline, the Californian Title 22 code (State of California 1987, 2000), still relies on total coliforms in a strictly defined treatment process.

Research recommendation:

- *Further research into the use of newer analytical techniques using indicator organisms such as* Clostridium perfringens *and the F-specific coliphage virus [G(5)]*

Because of the necessity to provide for the storage of effluent when it is being used for irrigation, especially in rural areas, lagoons are often constructed. These lagoons obviously provide a certain level of disinfection as well as nutrient reduction. The design parameters for these need to be quantified, especially for issues such as Giardia reduction and the effects of climatic differences.

Research recommendation:

- *Determination of design criteria for lagoon disinfection in tropical climates for all pathogen reduction [G(6)]*

6.2 Environment issues

One area of research that has shown great potential is the work on aquifer storage and recovery (ASR) being carried out in South Australia (Dillon & Pavelic 1996, Dillon 2000). While the results of this work are encouraging, we still have little data on the effect these practices have on the local environment surrounding the injection areas.

Research recommendation:

- *Further research on the environmental ramifications of aquifer storage and recovery (ASR) using low quality aquifers, covering areas such as nutrient leakage and iron bacteria clogging [E(3)]*

Little information is presently available on the relevance of ASR to the Queensland environment, or even how the potential could be determined. Because of the potential for large cost savings for users of recycled water if ASR was possible, it should be investigated further.

Research recommendation:

- *Determination of the factors necessary for the effective identification and mapping of areas suitable for aquifer storage and recovery (ASR) in Queensland [E(4)]*

While there is much research on the general effect of effluent discharges on the environment, such as by the South East Queensland Regional Water Management Strategy, little seems to have been written about the environmental effects of long-term use of highly treated effluent in urban areas. Such issues as the effect of endocrine disrupters on the local fauna in natural and artificial wetlands and other aquatic situations still need to be researched. Initially a workshop of experts in the field should be held to determine the priority environmental impacts.

Research recommendation:

- *A workshop specifically to identify research priorities in the areas of environmental impacts of the use of treated effluents for water recycling in urban areas [E(5)]*

6.3 Social issues

In many areas within our society there has been a major increase in the level of community education and involvement in the introduction of new technologies. Very little seems to be known about the long-term effectiveness of some of the campaigns being undertaken. The information coming to light from experts working in the field is that most of the major community education campaigns have been extremely ineffective, especially for the long-term. The only national campaigns cited as really successful are the ‘Life be in it’ and ‘Slip slop slap’ campaigns. More needs to be known about the effectiveness of different approaches for community education campaigns.

Research recommendation:

- *A study to determine the short- and long-term impact on community attitudes of education and awareness campaigns in the area of water renewal [B(2)]*

A comprehensive stakeholders survey (QWRS 1999b) was carried out as part of the Queensland Water Recycling Strategy to determine community attitudes to recycling prior to recycling occurring. This survey showed a high level of acceptance by the community. A similar survey was carried out in Sydney by Sydney Water. The Queensland survey now needs to be followed up during the actual installation of a major recycling project to see if community attitudes change during the progression of a scheme, and if they do, to discover the reasons for such attitude changes. The CSIRO Urban Water Project (CSIRO 2000, Speers) identified a number of community perceptions and attitudes associated with their use of water that need to be further researched.

Research recommendation:

- *A study to determine changes in community perceptions and attitudes, and reasons for the changes, during the introduction of major water renewal schemes [B(3)]*

6.4 Economic issues

As has been indicated in the previous section, economic issues are one of the most important drivers in the area of water recycling. Presently there is still a perception within the water and development industry that water renewal is uneconomic, and the only schemes proceeding are those subsidised by government. This tends to limit interest by the private sector in pursuing schemes.

The methodology used in cost benefit analyses also disadvantages schemes that have major environmental benefits, as in such schemes the costs are incurred in the immediate term whereas the benefits accrue increasingly over the long term. Alternative economic comparison methods need to be examined to find methods that more accurately take into account long-term social and environmental costs and benefits.

Research recommendation:

- *Comparison of alternative economic methodologies to determine which are the best for addressing long-term environmental and social issues [A(4)]*

6.5 Institutional issues

One of the problems in understanding all the issues associated with water renewal is the present lack of accurate data across Australia on water recycling activities. While some States have carried out limited surveys, these have been on an ad hoc basis and it is difficult to get an overall picture of the national scene. Such a data collection exercise should be part of a wider water survey covering urban and rural water uses.

Research recommendation:

- *Detailed nationwide surveys on a regular basis in cooperation with State authorities and AWA as part of an overall assessment of all aspects of water renewal in Australia [F(3)]*

7.0 Future research development

CIRM partners provided major input in the successful rebid for the CRC for Water Quality and Treatment. One new research focus for the CRC was a strong water renewal emphasis in the Sustainable Water Sources Program (see Appendix 1). The key research priorities outlined in this paper have been used as a basis for both development of the program as a whole and as a guide to projects accepted by the CRC for inclusion in its research plan. Details of the history of CIRM involvement in water renewal issues in the broad CRC program are also given in Appendix 1.

Further implementation of research for CIRM partners will be carried out in conjunction with the Water Quality CRC, to ensure that CIRM research is synergistic with the developing CRC research profile. One major area in which the CRC will not be focussing research is in the arena of land-based treatment options and this, in conjunction with biosolids, will be a key focus for the cross-partner group to be formed to forward water renewal research in CIRM.

A preliminary evaluation of potential input from CIRM partners follows, in the form of an indicative listing of the key research areas discussed in this report, showing possible input from individuals within the CIRM partner organisations. This was completed prior to the current development of projects by the Water Quality CRC, however, and the CIRM implementation committee will re-examine options for research in the light of the agreed CRC projects when it meets in early 2002.

7.1 Possible allocation of research projects

Table 11: Proposed research projects and possible CIRM partner contributions

Research area	Research topic	Priority	Research institution	Potential researchers
A. Economics	A(1). Determination of a methodology that can be used easily by water renewal decision makers for pricing environmental, social and health costs associated with urban and rural water supplies	Medium	UQ, EPA, GU	T Loetscher (UQ), J Robinson (UQ), J Mangen (UQ), R Brown (UQ), J Tindell (GU), J Ward (GU)
	A(2). Calculation of the true cost of water and wastewater services in areas of the State where there is expected to be a high water renewal potential	Medium	UQ, EPA, GU	T Loetscher (UQ), J Robinson (UQ), J Mangen (UQ), R Brown (UQ), J Tindell (GU), J Ward (GU)
	A(3). Investigation to determine the most efficient method of expending public funds to introduce sustainable water renewal, where this has been shown to be the best solution	High	NR&M, EPA, GU, UQ	J Tindell (GU), J Ward (GU), J Robinson (UQ), J Mangen (UQ), R Brown (UQ)
	A(4). Comparison of alternative economic methodologies to determine which are the best for addressing long-term environmental and social issues	Medium	UQ, EPA, GU	T Loetscher (UQ), J Keller (UQ), R Brown (UQ), J Robinson (UQ), J Mangen (UQ), J Tindell (GU), J Ward (GU)
B. Social	B(1). A study to determine if there are ethnic and cultural differences within our communities that may hinder the acceptance of water renewal in these communities	Low	GU, UQ, EPA	R Rickson (GU), D Burch (GU), J Fein (GU), D Heck (GU), J Tindell (GU), S Rickson (GU) T Loetscher (UQ), V Uhlmann (UQ), M Hogg (UQ)
	B(2). A study to determine the short- and long-term impact on community attitudes of education and awareness campaigns in the area of water renewal	High	GU, UQ, EPA	D Heck (GU), J Fein (GU), V Uhlmann (UQ), B Beeton (UQ)
	B(3). A study to determine changes in community perceptions and attitudes, and reasons for the changes, during the introduction of major water renewal schemes	Medium	GU, UQ, EPA	S Rickson (GU), R Rickson (GU), D Burch (GU), M Howes (GU), J Fein (GU), D Heck (GU), V Uhlmann (UQ), M Hogg (UQ)
C. Technical	C(1). A study to determine what types of support documentation such as standards, guidelines or design manuals are needed by industry to ensure that economic, sustainable and efficient water renewal schemes are built	High	UQ, GU, EPA, DPI, CSIRO	V Uhlmann (UQ), T Loetscher (UQ), N Diatloff (UQ), J Keller (UQ), D Hart (UQ), J Tindell (GU), J Fein (GU), D Heck(GU), J Whalen (GU), D Low Choy (GU), L Brown (GU), N Sipes (GU)

Research area	Research topic	Priority	Research institution	Potential researchers
	C(2). A project to determine treatment process reliability based on the recently completed treatment facility at Pine Rivers	Medium	UQ, GU, EPA	J Keller (UQ), B Keller (UQ), P Williams (GU), I Agronowski (GU), B Yu (GU), J Yu (GU)
	C(3). An investigation of possible cost reduction methodologies in the design of dual reticulation systems (but also taking into account possible changes to the conventional reticulation system) that deliver acceptable quality of service to residential consumers	High	GU, EPA	R Thomlinson (GU)
	C(4). A study to determine the factors necessary for the effective mapping of suitable aquifer storage and recovery sites close to potential water renewal sites	Medium	GU, EPA, NR&M, UQ	P Williams (GU), I Agronowski (GU), B Yu (GU), J Yu (GU), vice J Hillier (NR&M), D Lockington (UQ)
	C(5). A mapping program to determine such aquifer storage and recovery sites in the State in areas where it is known that large volumes of effluent are presently being generated	Medium	GU, EPA, NR&M, UQ	P Williams (GU), I Agronowski (GU), B Yu (GU), J Yu (GU), vice J Hillier (NR&M), D Lockington (UQ)
	C(6). A detailed investigation, under Queensland conditions, to determine the changes in chemical and microbiological quality of the effluent over time while in the aquifer	Medium	GU, EPA, NR&M, UQ	P Williams (GU), I Agronowski (GU), B Yu (GU), J Yu (GU), vice J Hillier (NR&M), N Menzies (UQ), L Blackall (UQ), D Lockington (UQ)
	C(7). Determination of lower-cost treatment options for use in sewer mining operations	High	UQ, GU, EPA	P Wilderer (UQ), J Keller (UQ), P Williams (GU), I Agronowski (GU), B Yu (GU), J Yu (GU)
	C(8). Research into the efficiency of conventional and advanced treatment methods for the removal of endocrine disrupters and pharmaceutical compounds from sewage effluent	Medium	UQ, EPA	PhD Students (UQ), J Keller (UQ), B Noller (UQ)
D. Education	D(1). Development and trial of a methodology for the introduction of an industrial water renewal educational campaign	High	UQ, GU, EPA	J Keller (UQ), T Loetscher (UQ), B Pagan (UQ), J Fein (GU), D Heck (GU)
	D(2). Development and trial of methodologies for water renewal education programs both for general community education and for project-specific situations	High	UQ, GU, EPA	T Loetscher (UQ), V Uhlmann (UQ), D Hart (UQ), J Fein (GU), D Heck (GU)
E. Environment	E(1). Development of a simple procedure to determine which water-sensitive urban design (WSUD) principles are likely to be applicable for specific urban developments, based on issues such as topography, climate population and density	High	UQ, GU, NR&M, CSIRO, EPA	V Uhlmann (UQ), T Loetscher (UQ), R Hyde (UQ), P Dux (UQ), L Brown (GU), E Gardner (NR&M)

Research area	Research topic	Priority	Research institution	Potential researchers
	E(2). An investigation of the implications of using highly treated effluent to maintain levels in urban storages through the use of controlled trials and modelling	Medium	UQ, GU, EPA	Z Yuan (UQ), K Warburton (UQ), N Menzies (UQ), P Williams (GU)
	E(3). Further research on the environmental ramifications of aquifer storage and recovery (ASR) using low quality aquifers, covering areas such as nutrient leakage and iron bacteria clogging	Medium	GU, EPA, NR&M, UQ	B Hogarth (GU), vice J Hillier (NR&M), N Menzies (UQ), D Lockington (UQ)
	E(4). Determination of the factors necessary for the effective identification and mapping of areas suitable for aquifer storage and recovery (ASR) in Queensland	Medium	NR&M, UQ	vice J Hillier (NR&M), E Gardner (NR&M), D Lockington (UQ)
	E(5). A workshop specifically to identify research priorities in the area of environmental impacts of the use of treated effluents for water recycling in urban areas	High	NR&M, UQ, GU, EPA	E Gardner (NR&M), J Keller (UQ), T Loetscher (UQ), B Keller (UQ), L Brown (GU), B Yu (GU), J Yu (GU)
F. Institutional	F(1). An investigation of the beneficial effect of initiatives such as load-based licensing, tradeable permits and effluent fees, to determine if they would have a positive effect on the level of uptake of water renewal	Medium	UQ, EPA	J Keller (UQ)
	F(2). An investigation of the mechanisms for the introduction of a regulatory system for water renewal that protects both the environment and public health as well as providing positive non-financial incentives	Medium	EPA	J Keller (UQ)
	F(3). Detailed nationwide surveys on a regular basis in cooperation with State authorities and AWA, as part of an overall assessment of all aspects of water renewal in Australia	High	EPA, UQ, GU, NR&M, DPI	AWMC input (UQ), R Rickson (GU), E Gardner (NR&M)
G. Health	G(1). A workshop of experts in water-related risk assessment, to determine future directions in the area of risk assessment	High	GU, EPA, UQ	M Clarke (GU), P Williams (GU), L Brown (GU), B Noller (UQ), L Blackall (UQ), J Keller (UQ)
	G(2). A detailed analysis to determine the gaps in the data needed to undertake a quantitative microbial risk assessment (in the areas of enumeration, species identification, ingested dose and stochastic variability), and to find how best to fill these gaps	Medium	UQ, GU, EPA	L Blackall (UQ), B Noller (UQ), D Bromwich (GU), S Heart (GU), J Yu (GU), B Yu (GU)
	G(3). Further tests to document the pathogen removal capacity of all membrane systems, especially microfiltration	High	UQ, GU, EPA	AWMC input (UQ), L Blackall (UQ), J Keller (UQ), I Agronowski (GU), R Tomlinson (GU), P Williams (GU)

Research area	Research topic	Priority	Research institution	Potential researchers
	G(4). Research to determine accurate and cost-effective methods of virus numeration based on nucleic acid amplification, and to establish the relationship between the presence of viral nucleic acid in water samples and human health effects	Medium	UQ, GU, EPA	L Blackall (UQ), PhD (UQ), B Noller (UQ), B Yu (GU), J Yu (GU), P Williams (GU)
	G(5). Further research into the use of newer analytical techniques using indicator organisms such as *Clostridium perfringens* and the F-specific coliphage virus	Medium	UQ, GU, EPA	L Blackall (UQ), PhD (UQ), B Yu (GU), J Yu (GU), P Williams (GU)
	G(6). Determination of design criteria for lagoon disinfection in tropical climates for all pathogen reduction	Medium	UQ, GU, EPA	L Blackall (UQ), J Keller (UQ), B Noller (UQ), B Yu (GU), J Yu (GU), P Williams (GU)

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Appendix 1: CIRM water renewal initiatives

CIRM has a long history of involvement with the water renewal arena, both in its original structure as a joint venture centre and also over the last three years as an evolving facilitative process between key research providers. Funding of more than $750,000 has been facilitated from outside the CIRM partners for a variety of projects addressing a wide range of related issues, and the focus of responsibility at local government level has meant there is a continuing wide range of players. The Queensland Government also recognised the need for a better-coordinated approach to the issues with the development of the Queensland Water Renewal Strategy (QWRS), which was completed this year by NR&M.

Because of the existence of the QWRS it was agreed that a coordinated approach was essential in the development of a review paper and any subsequent CIRM input into coordination of research in key areas. This CIRM review paper on priority issues for water renewal was developed by Howard Gibson and Ted Gardner, both associated with the QWRS. The paper drew on and analysed a comprehensive coverage of priority research included in the QWRS and was finalised by June 2001. The transfer of lead agency role in water renewal to the EPA took place in early 2001 and close contact was kept with Tad Bagden as Manager of the relevant division in EPA, with that group signing off on the CIRM paper in September 2001.

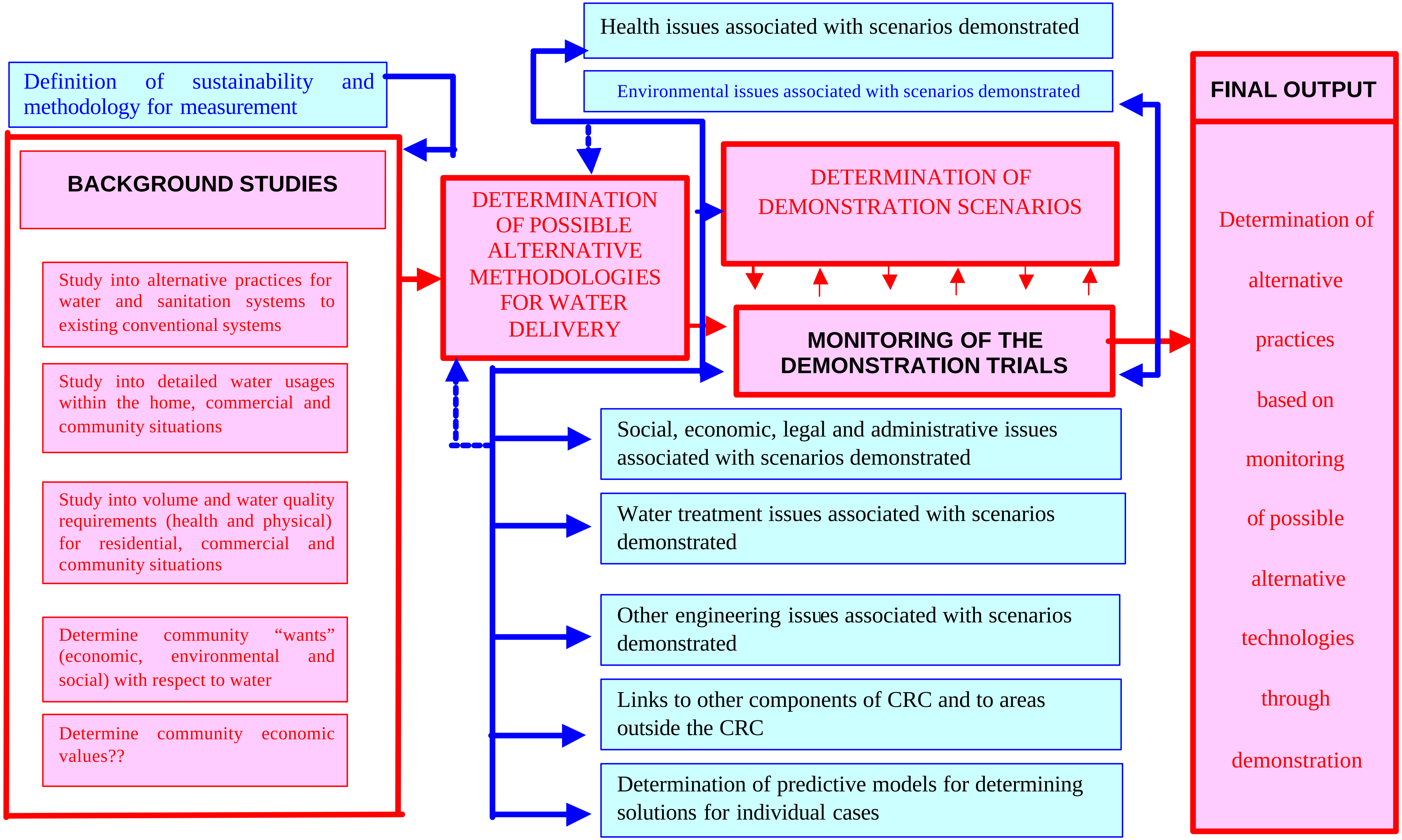
In addition to facilitating development of specific research projects in water renewal, the CIRM process had also supported the development of a cross-agency collaborative group focussed on developing options for funding essential research in the water renewal arena in 2000. This group formed the nucleus of an integrated “northern node” in the successful rebid for the Water Quality CRC in 2000. As an outcome of that success, Howard Gibson was appointed as Program Leader for the Sustainable Water Sources program in the CRC, in which water renewal issues will be addressed.

With support from the EPA, it was agreed by the CIRM coordinators that any implementation of the CIRM water renewal research focus would need to take into consideration priority areas of research proposed by the Water Quality CRC. As Program leader Howard Gibson used the CIRM review as the basis for discussion on potential research for the CRC. In a number of program meetings in September and October 2001, the broad areas for research were agreed by the CRC and incorporated into an overall program science plan (outline follows). Specific projects in this plan are in the process of being ratified and cover a wide area of research.

In parallel with the development of the Water Quality CRC program, an implementation group consisting of representatives from all CIRM partners has been convened and supports the above modus operandi. A number of the group are members of the CRC and it has been agreed to meet again early in 2002, when the CRC project areas are finalised. The group will then investigate opportunities for developing funding and research projects to address priority research areas not being addressed by the CRC.

John Mott
CIRM Coordinator (Interim Inaugural Chair)
November 2001

SUSTAINABLE WATER SOURCES DIRECTION



1 Program 2F – Sustainable Water Sources

(Leader: Howard Gibson, Brisbane City Council)

1.1 Objective

The purpose of this program is to develop drinking water systems based on alternative water sources that are sustainable from the economic, environmental, health and social points of view.

1.2 Specific Objectives

- Ensure that users of water resources have adequate information in the form of guidelines and codes of practice to enable them to make informed decisions on alternative water systems.
- Identify and test alternative water source technologies that have potential environmental social and financial benefits.
- Monitor the efficiency and effectiveness of alternative water systems being trialled and tested within the country.
- Determine the health risks associated with the use of these alternative water systems.
- Develop effective community education programs in relation to the key issues presented by the use of alternative water sources.
- Determine the effectiveness of conventional and advanced treatment technologies for the removal health related parameters from alternative sources.
- Produce an appropriate methodology for assessing economic costs for health, environmental and social parameters.
- Identify and evaluate alternative institutional arrangements that will facilitate the rapid introduction of alternative water systems into the community.

1.3 Strategy

The overall strategy to achieve the sustainable use of alternative sources is based on two basic principles.

The first of these is to overcome the barriers to the use of such alternative systems. Analysis of surveys carried out into the constraints for the use of alternative systems suggests that by far the most important drivers are economic. This means that unless systems can be developed that are of lower total cost that the conventional schemes, they will not be used. Consequently, there is need for much research to show that alternative systems are viable. Such areas as aquifer storage and recovery, rain water systems, localised collection and treatment and the reliability of treatment systems need to be further investigated.

The second principle is that any chosen alternative water system should be sustainable from the health, environmental and social points of view. Unfortunately the methodologies for measuring these different types of sustainability are either not well developed, or inadequate data are available to make the measurement meaningful.

One of the areas of greatest concern is associated with determination of health risks associated with the use of alternative sources. While quantitative microbial risk assessment is often quoted as being the solution to the determination of such risk, the accuracy of the base data can often comprise the results obtained. Much basic research needs to be carried out to put some meaning into such analyses.

1.4 Outputs and Outcomes

- An inventory and analysis of alternative water projects being trialled across Australia
- Simple clear, design manuals/guidelines for the use by designers of alternative urban water systems
- A simple to use methodology for the determination of health risk associated with alternative water systems
- Methodologies for the determination of social, environmental and health costs
- Critical evaluation of alternative water systems that may offer solutions to developments in urban environments
- Estimates for the reliability of conventional and advanced treatment technologies for the removal of pollutants and pathogens from alternative waters
- Determination of optimum institutional arrangements that will lead to rapid uptake of new technologies
- Efficient methodologies for introduction of community education programs

1.5 Milestones

Years 1 & 2

- Collaborative links established
- Inventory of alternative urban water projects compiled, and economic, social and environmental benefits analysed
- Specific urban water projects to be used in subsequent research identified and research work initiated
- Methodologies for comprehensive analysis of alternative water systems identified and application underway

Years 3, 4 & 5

- Pilot plant studies underway
- Methodologies for assessment of health risk associated with alternative water systems tested and confirmed
- Methodologies for assessment of social and environmental costs associated with alternative water systems tested and confirmed
- Reliability of pollutant removal from conventional and advanced treatment technologies understood and quantified

Years 6 & 7

- Design manual for design of alternative water systems produced
- Expert system for critical evaluation of alternative water system designs produced and tested
- Water regulations upgraded to cover design and operation of alternative water systems.

1.6 Staff Resources

In-kind

PROGRAM 2 – CATCHMENT TO CUSTOMER

Name	Organisation	% Time
Mr C Magyar	ACTEW Pty Ltd	10%
Dr A Wade	ACTEW Pty Ltd	5%

Ms P Laver	ACTEW Pty Ltd	5%
Ms R Reid	ACTEW Pty Ltd	10%
Dr A Keegan	Australian Water Quality Centre	40%
Dr D Steffensen	Australian Water Quality Centre	50%
Dr B Nicholson	Australian Water Quality Centre	20%
Dr C Chow	Australian Water Quality Centre	40%
Dr C Pelekani	Australian Water Quality Centre	20%
Dr C Saint	Australian Water Quality Centre	40%
Dr G Newcombe	Australian Water Quality Centre	55%
Dr J Papageorgiou	Australian Water Quality Centre	50%
Dr J van Leeuwen	Australian Water Quality Centre	35%
Dr P Monis	Australian Water Quality Centre	20%
Dr W Grooby	Australian Water Quality Centre	20%
B Robinson	Australian Water Quality Centre	30%
Mr J Morran	Australian Water Quality Centre	40%
M Burch	Australian Water Quality Centre	60%
P Baker	Australian Water Quality Centre	20%
M Drikas	Australian Water Quality Centre	50%
Senior Researcher (vice Spark)	Australian Water Quality Centre	70%
Vacancy (vice Velzeboer)	Australian Water Quality Centre	70%
Mr Howard Gibson	Brisbane City Council	20%
Researcher (TBA)	Brisbane City Council	10%
Dr D Dixon	CSIRO Molecular Sciences	40%
Dr J Bridger	CSIRO Molecular Sciences	20%
Dr R Eldridge	CSIRO Molecular Sciences	20%
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Dr K Grice	Curtain University of Technology	10%
Dr R Demarco	Curtain University of Technology	30%
Mr G Chidlow	Curtain University of Technology	15%
Ms A Heitz	Curtain University of Technology	60%
Post Doc	Curtain University of Technology	20%
Prof R Kagi	Curtain University of Technology	40%
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Mr Pat McCourt	Environmental Protection Agency Qld	10%
Mr Paul Sherman	Environmental Protection Agency Qld	20%
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Dr J Yu	Griffith University	10%
Dr P Teasdale	Griffith University	20%
Dr R John	Griffith University	40%
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M Stevens	Melbourne Water Corporation	30%
Dr R Considine	Melbourne Water Corporation	15%
Mr S Haydon	Melbourne Water Corporation	20%
Dr G Smith	QLD Health Pathology & Scientific Services	5%
Dr H Olszowy	QLD Health Pathology & Scientific Services	10%
Dr R Sadler	QLD Health Pathology & Scientific Services	10%
Mr B Gray	QLD Health Pathology & Scientific Services	5%
Mr D Wruck	QLD Health Pathology & Scientific Services	5%
Mr J Bates	QLD Health Pathology & Scientific Services	10%
Mrs M Hodge	QLD Health Pathology & Scientific Services	10%
Ms M Smith	QLD Health Pathology & Scientific Services	10%
Assoc Prof L Doukas	RMIT University	5%
Dr J Harris	RMIT University	10%

Dr M Waters	RMIT University	10%
Dr N Jayasuriya	RMIT University	20%
Dr N Porter	RMIT University	10%
Dr F Younos	RMIT University	10%
Prof F Roddick	RMIT University	15%
Mr Gordon Logan	South East Water Ltd	10%
Mr G Ryan	South East Water Ltd	15%
Mr J Hearn	South East Water Ltd	5%
Dr D Deere	Sydney Catchment Authority	25%
Ms C Ferguson	Sydney Catchment Authority	100%
D Vintinage	Sydney Water Corporation	50%
Dr I Fisher	Sydney Water Corporation	30%
Mr G Kastl	Sydney Water Corporation	30%
Dr M Angles	Sydney Water Corporation	30%
Mr W Warneke	Sydney Water Corporation	40%
Mr P Duker	Sydney Water Corporation	25%
Researcher	Sydney Water Corporation	40%
Dr J Nixon	United Water	10%
Mr M Holmes	United Water	20%
Dr F Recknagel	University of Adelaide	20%
Dr H Maier	University of Adelaide	10%
Prof G Dandy	University of Adelaide	10%
Dr B Neilan	University of New South Wales	5%
Dr D Waite	University of New South Wales	5%
Dr G Grohman	University of New South Wales	5%
Dr J Ball	University of New South Wales	5%
Dr J Ongerth	University of New South Wales	15%
Dr N Ashbolt	University of New South Wales	25%
Dr R Fane	University of New South Wales	10%
Dr D Lockington	University of Queensland	30%
Dr L Blackall	University of Queensland	20%
Dr P Dart	University of Queensland	20%
Dr P O'Donaghue	University of Queensland	20%
Ms I Burkette	University of Queensland	20%
Mr r Brown	University of Queensland	20%
Researcher	University of Queensland	20%
Assoc Prof D Mulcahy	University of South Australia	20%
Dr D Davy	University of South Australia	10%
Dr S Andrews	University of South Australia	10%
Prof P Pendleton	University of South Australia	10%

CIRM Water Renewal Implementation Team

Tad Bagdon	EPA
Ted Gardner	NR&M
Howard Gibson	CRC Water Quality
Helen Stratton	Griffith University
Tim Streeton	DPI
Barry Noller	University of Queensland
Andrew Speers	CSIRO
John Mott	CIRM Coordinator (Interim Inaugural Chair)