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Research Investment in the Australian Urban Water Industry

Towards an optimal level and a funding model

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ABSTRACT

Recent changes in mechanisms and reduction in funding of research and development (R&D) in the Australian urban water industry have prompted a review of how to value the benefits of such research to Australia, the level of these benefits in relation to the costs, and to whom the benefits accrue. The review also took into account the relationship between the level of R&D investment in other sectors, and for water internationally. Various models of funding of water R&D in Australia historically and in other countries have been documented.

The data show that the level of funding of R&D in the Australian urban water industry has declined markedly in recent years. It is now below that in reference countries, and is lower than most other comparable sectors in Australia. The Benefit Cost Ratio for urban water R&D exceeds 13 for the portfolio of all evaluated research programs (with a total cost of 0.6% water industry revenue) using methods recognised by the Commonwealth Government. Coordinated research programs with initiation and participation of end users of the research have highest returns.

Benchmarking exercises with urban water industry overseas, and with other relevant sectors in Australia suggest that 1.0-1.2% revenue invested in research would be required to minimise future costs of water supply, sanitation, drainage and integrated urban water management with more liveable cities and towns while fostering innovation and sustaining the environment.

An enduring revenue-based funding mechanism derived from industry and Government, if adopted, would stabilise the level of investment, facilitate effective research planning to maximise value to stakeholders, and allow retention of strong research capacity. Extension of the model to all water (urban, rural and industrial) would maximise the benefits to Australia.

It is suggested that the Australian water industry, in its broadest context, armed with greater clarity on the direct benefits of participation in research, effective means of engagement, and documentation of outcomes needs to take a more energetic approach to ensure the level of research and innovation necessary to sustain the industry in the face of the changes confronting it and constructively engage with the Commonwealth to achieve this.

INTRODUCTION

For a long time, the Australian urban water sector has benefited from a productive and capable domestic R&D community. Sustained research investments by governments and the water industry over decades have placed Australia on par with world leaders in water recycling, desalination, groundwater management, integrated water management and asset management. However, between 2010 and 2015 there was a major contraction in water R&D funding from 0.6-0.9% of water utility revenue (0.48% by utilities, the rest largely from government) to 0.3–0.5% (0.23% by utilities). With economic regulation driving the need to not only achieve, but also to demonstrate investment efficiency, now is an opportune time to review Australia's approach to urban water R&D investment.

This paper examines Australia's levels of urban water research investment over time and highlights the multi-faceted value it has delivered. It also compares Australia's urban water industry research investments with other sectors and countries. It is suggested, based on the evidence, that a level of sustained investment of 1.0-1.2% of revenue would maximise broadly based net benefits to utility customers. This would underpin an innovative urban water industry and re-establish Australia on par with international best practice. This paper summarises information from investment reviews of research centres, literature reviews, interviews with international research executives, water utility publications, surveys and working groups, and the work programs delivered under the Commonwealth Government's *National Urban Water Research and Development Forum* that resulted in the National urban water research strategy (WSAA 2016).

For the purposes of this paper, "research" is defined (Department of Industry Innovation and Science 2016) under section 355-25 of the Income Tax Assessment Act 1997, as core R&D which are experimental activities:

- whose outcome cannot be known or determined in advance on the basis of current knowledge, information or experience, but can only be determined by applying a systematic progression of work that is based on principles of established science and proceeds from hypothesis to experiment, observation and evaluation, and leads to logical conclusions; and
- that are conducted for the purpose of generating new knowledge (including new knowledge in the form of new or improved materials, products, devices, processes or services).

Supporting R&D activities are activities undertaken for the dominant purpose of supporting core R&D activities that also relate to producing goods or services, such as construction of experimental facilities.

This definition of eligible research excludes market research, and research in social sciences, routine testing and calibration, exploration drilling and patenting.

WHY IS RESEARCH NEEDED?

Were it not for research, our urban water systems would be delivering water and collecting sewage through wooden stave pipes, discharging only primary-treated effluent, and ignoring urban stormwater, treated effluent and seawater as water supply options. The capital and operating costs of water supply, sanitation and drainage would be many times higher, public and environmental health would be diminished, energy consumption would be greater, and the benefits of green, liveable cities and productive peri-urban agriculture would be foregone.

But these are past gains. So can we dispense with research now and just harvest research done in larger utilities or overseas? Our answer is no, for at least four good reasons.

Firstly, we will face continuing change and challenges relating to city growth and urban consolidation; our changing climate, the need to produce more food requiring more water, increased efficiency of use of that water, increasing energy costs, managing new contaminants, meeting requirements for public health protection, and shifting public and government expectations on reliability, resilience and service standards. There are continuing new opportunities presented by new materials, processes, measurement methods, decentralised information availability, and control systems. The accelerating speed of change requires adaptive organisations capable of innovation, and those who do will cost their customers less, deliver higher service levels, be prepared for disruptive technologies, reduce exposure to emergencies, and shortages, and make better-planned decisions that deliver greater and enduring benefits. The Productivity Commission (2011) review of the urban water sector termed this "dynamic efficiency" an essential part of increasing economic efficiency.

Secondly, research is part of the organisational culture of innovative organisations, and staff have an advantage in being acclimatised to work smarter, respect scientifically founded traditional practices, and question unfounded ones, and lead organisations within a dynamic environment.

Thirdly, in a commercial enterprise, research is an imperative to remain competitive. The Productivity Commission (2011) is also clear that any organisation that regards government ownership as a protection from competition needs to also understand its obligation to society to perform at industry-leading effectiveness. Under-estimating the need for research may be a symptom of an organisation not paying attention to developments outside its own sphere of operations. However economic regulatory arrangements can also impose a disincentive to innovate, as reported by ACTEW Corporation and Yarra Valley Water (submissions to Productivity Commission 2011), penalising customers, and inhibiting outcomes for the greater economic good. Reducing the research budget would be one way to save costs in the current year, but, like reducing maintenance, does not act in the interest of customers. Evidence presented in this paper shows customers would pay considerably more later.

Finally, as a nation, Australia under demising research would miss out on developing capability and technologies that could have been commercialised in Australia, leading to imports rather than exports, and reducing the industry's contribution to the trade balance. For example, the desalination plants installed in multiple Australian cities during the Millennium drought used $4B of imported equipment.

For these reasons, public investment in urban water R&D warrants consideration from both economic and public good perspectives.

HOW ARE RESEARCH BENEFITS MEASURED?

The Australian Research Council (ARC 2015) defined research impact as the demonstrable contribution that research makes to the economy, society, culture, national security, public policy or services, health, the environment, or quality of life, **beyond contributions to academia**. Various approaches have been taken to value the impacts of research. This is fundamentally difficult for public good research because some of the research benefits such as improved public health, a more sustainable environment and avoided problems, are hard to isolate and quantify. In addition, benefits that are easily quantified financially, such as reduced operating costs, may persist for a long time, and will be influenced over that time by changes in the system, the impacts of subsequent research, and changes in interest rate. At the time of investment this is also clouded by the unknown likelihood of success of a project, and the unknown rate and extent of uptake of the research. To address these challenges, a number of tools have been developed.

For water utilities, Ho *et al* (2013) and du Plessis and Killen (2013) proposed qualitative methods that linked prospective research activities to their strategic alignment with corporate goals, their potential to contribute to triple bottom line benefits, and an assessment of the risk of the project not delivering the anticipated benefits. These methods have been used for determining the most attractive projects for investment within a portfolio of potential projects. Generally, these involved staged development of projects with decision making gates based on information generated through the development of a project. A Bayesian decision making process, drawing on new information to update the probability of outcome success, is logical and allows accumulation of information commensurate with the financial risk of maintaining the status quo or proceeding with innovation.

A conceptual example on experimentation to determine treatment requirements for aquifer storage and recovery with treated wastewater is given by Dillon *et al* (2016) where, provided the results were acted on, regardless of whether the experiments failed or succeeded, the financial outcomes for the water utility would be considerably more than if the research were not done.

Triple bottom line (economic, environmental and social) evaluation procedures were developed by Chudleigh *et al* (2006) and Schofield *et al* (2007) for rural water research to determine return on investment by Land and Water Australia. These measures were subsequently adopted in a rolling evaluation of the Australian government's agricultural research and development investment of about $441m per year.

The Commonwealth has also undertaken multiple economic performance evaluations of the Cooperative Research Centres (CRCs) in which it has invested since 1995. It has developed a model, which is well explained by Jones *et al* (2006), that has been applied to the Centres of Excellence in Desalination (pers comm. Neil Palmer) and in Water Recycling (pers comm. Don Begbie), and to the CRC for Water Sensitive Cities (CRC Water Sensitive Cities 2015). Use of this approach relies on being able to identify the rate of productivity growth in an industry and then to assess the impact of research-generated technological change. This focuses on a micro-economic evaluation of consumer and producer surplus (e.g. benefit to the customer and benefit to the water utility) as a result of reduced service costs. Although this oversimplifies and understates the multi-dimensional values of urban water services, it does provide a way to quantitatively evaluate those benefits in monetary values. For now, we will ignore the separation between consumer and producer surplus, on the assumption that even if increased water supply efficiency does not reduce supply charges, the cost savings will result in greater dividends to governments that in turn will reduce tax burdens to utility customers, or provide compensating benefits.

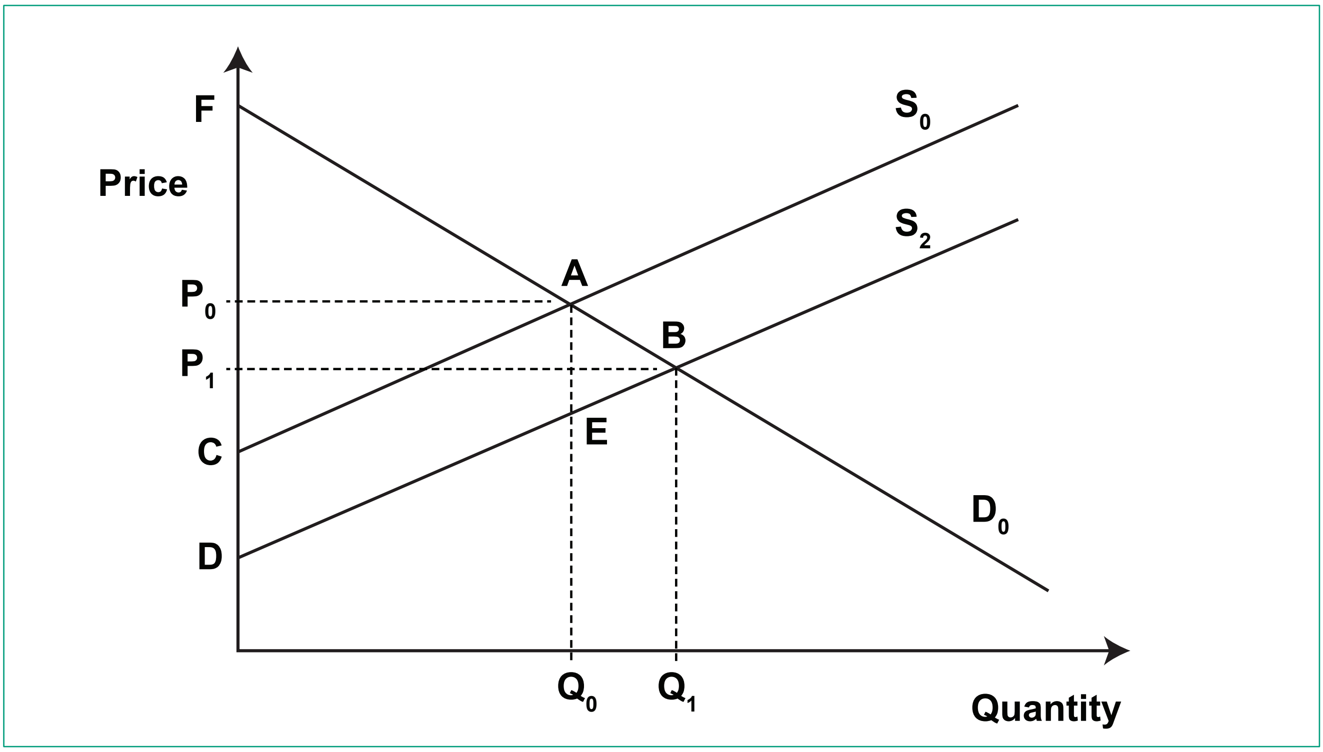

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Figure 1: Typical supply and demand chart showing impact of improved productivity (after Jones *et al* 2006)

Reference to Figure 1 shows that research from which results are adopted, and increase the efficiency of supply (shift the supply curve from S_0 to S_1), increases total surplus from triangle FAC to FBD, assuming no change in the demand curve, D_0. Hence, the annual value of the change resulting from research is given by the area of the quadrilateral CABD (from Jones *et al* 2006).

If demand were completely inelastic, as is sometimes assumed for water supply, the quantity supplied would not increase from Q_0 (in Figure 1) and the annual value of the research would be defined by the area of the quadrilateral CAED. Benefits can continue over the years and may grow as adoption expands. The present value of benefits, *PVB*, is the value of a series of future annual benefits, B_t, for a period of *T* years, discounted to present day value using the discount rate, *r*. That is:

$$PVB = \sum_{t=1}^{T} \frac{B_t}{(1+r)^t} \qquad \text{Equation 1}$$

Present value of costs of research are also calculated in the same way, allowing benefit cost ratios to be calculated. The CRC model of evaluation of benefits of each research program takes into account the probability of project success, lags in R&D, lags in adoption, and adoption ceiling levels (*i.e.* the potential magnitude of national impact) (Jones *et al* 2006). For cases reported by Jones *et al* (2006), the benefit cost analysis was considered for a period, *T*, of 25 years and a discount rate, *r,* of 4%. Research with a high degree of engagement with potential implementing organisations is reflected by a very short lag time in adoption, and research that is relevant to the majority of utilities, and for which outreach is provided to ensure awareness, will have high adoption ceilings. These are factors that can be taken into account in designing projects and selecting a research portfolio and outreach program to maximise net benefit or Benefit/Cost Ratio (BCR).

An evaluation of costs and benefits of the Rural Research and Development Corporations (RRDCs) found 167 project clusters representing 9 of the 15 RRDCs where benefits had been recorded and met the evaluation criteria for the period 2010-2015 (Agtrans Research *et al* 2016). These showed net present benefits of $6.32B for an investment of $1.41B, giving a BCR of 4.5. The majority of projects also reported unquantified positive environmental and social impacts.

When this model was applied to research of the CRC for Water Sensitive Cities, BCR was independently determined to be 3.6. That is, considering only the research value with quantifiable economic impacts, these coordinated research programs with strong industry involvement and active communication and dissemination of results, were considered to produce benefits more than triple the value of the research investment. Significantly, these programs have also produced important non-monetised environmental and social benefits.

MEASURED BENEFIT/COST RATIOS OF AUSTRALIAN WATER RESEARCH

Surprisingly, despite the high profile given by the Australian Water Association to various acclaimed research projects, the authors found relatively few documented cases where Australian water research benefits have been quantified using verifiable methods. Table 1 contains a summary of these, representing all data available relevant to urban water. In other words, this is not a selection of the cream of research, but a representative sample of water research conducted in Australia over recent years.

Table 1: Examples of benefits and costs of research and development programs

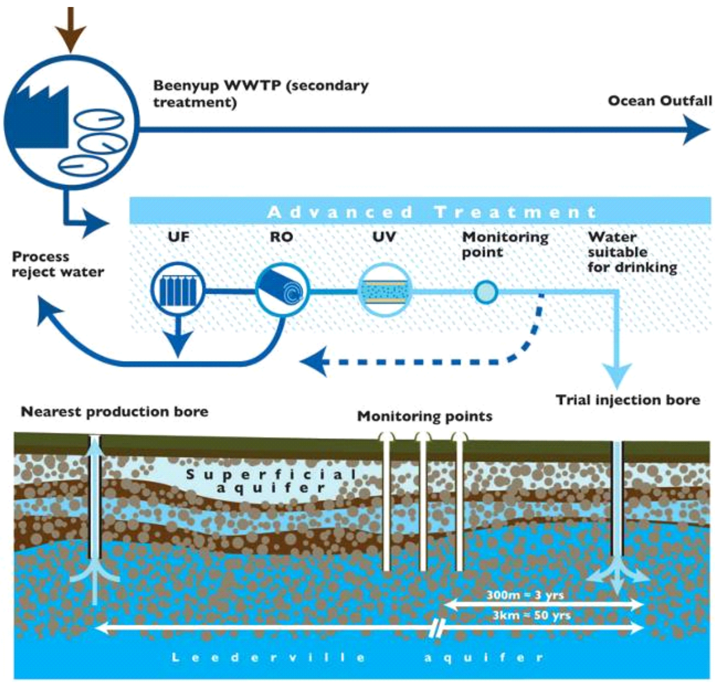
Research Field	Cost $M	Benefit $M	Benefit/ Cost Ratio	Benefits and Beneficiaries, and information source
Cryptosporidium infectivity testing	2	80	40	Single utility used test to demonstrate a planned treatment plant upgrade is not required. Wider benefits have accrued to other water utilities but are not yet evaluated. (pers comm. K Rouse, WRA)
Water Information Research and Development Alliance (WIRADA)	107	2254	21	CSIRO and BoM updating of water forecasting, assessment and water data exchange standards (Acil Allen Consulting 2018) (benefits rural and urban water data users)
Corrosion and odour management in sewers	21	400	19	Australian water utilities – extended asset life, reduced operating costs (Yuan 2016)
Groundwater Replenishment in Perth	30	500	17	Water customers, environment – reduced costs of securing water supplies (RMD STEM 2013; Gao *et al* 2014) (See Box 1)
CRC for Water Sensitive Cities	96	343	3.6	Water utilities and local government – Reduced capital expenditure on infrastructure, cost savings through leakage reduction (CRC for Water Sensitive Cities 2015) (see Box 2)
National Centre of Excellence in Desalination Australia	23	81	3.5	Industry, water utilities, customers (pers comm. N Palmer, NCEDA)
Nationally consistent approach to validating water recycling technologies	7.5	11-84	1.5-11.3	Recycled water facility managers, technology suppliers and regulators through reduced water treatment and management costs. (Rajaratnum 2013)
Aggregate of evaluated projects	**277.5**	**3669**	**13.2**	Conservative value neglecting unaccounted benefits and using lowest benefit where range of benefits is given.

Box 1: Example: Perth Groundwater Replenishment

Facing a severe decline in rainfall since the mid-1970s, with significant reduction of surface inflows to reservoirs, constraints on extraction of groundwater from the Swan Coastal Plains, and onerous restrictions on water use for irrigation, the options for securing Perth's water supply were seawater desalination and recycling of water (Turner and Bendotti 2013). Desalination plants would need to be located some distance from the existing nearby plants so the cost of any new desalination option would increase. There needed to be proof that the treatment of wastewater for replenishing drinking water aquifers beneath Perth was sufficient and in such a way that gave Perth residents confidence that the groundwater quality would be protected.

A consultation process with parliamentarians, government departments, community groups, and residents of Perth was conducted in parallel with the development of a pilot plant and recharge well, with significant investigations and monitoring. This also gave opportunity for operating procedures and governance arrangements to be evaluated. A visitor centre was established at the pilot plant for school tours, public opinion was monitored, and a trial operated for three years before a government decision was made in 2013 to proceed with this as the preferred option.

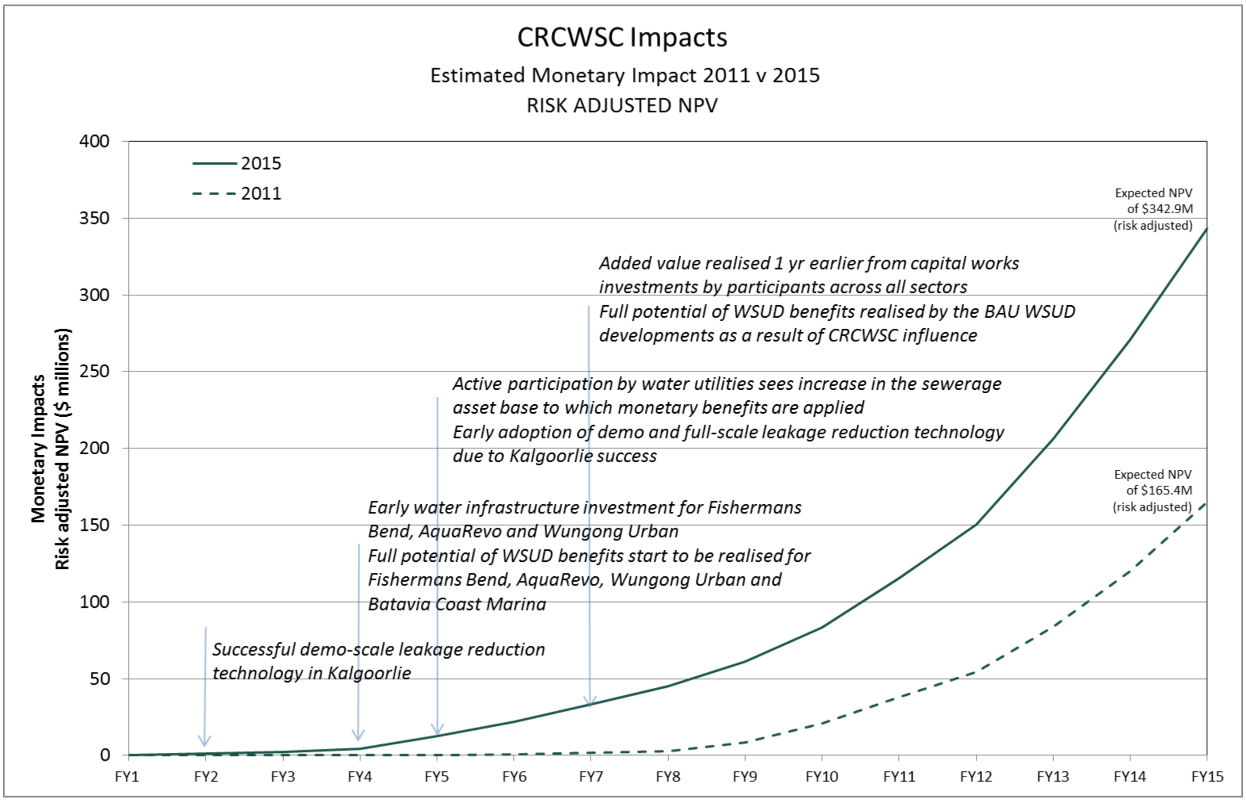
Significant determinants were the success of the trial, demonstrated procedures to ensure safety, public support and significant savings in capital and operating costs compared with seawater desalination, and the ability to expand the supply over time (to 105 GL/yr). The cost of the research and development came to $30M compared with the present value savings of more than $500M (RMD STEM 2013; Gao *et al* 2014) as a result of this option being available. This ensures water security for Perth, a key strategic objective, and the leadership of the utility ensured immediate uptake once approval was obtained. Construction began in 2016 of the 14GL/yr Stage 1 and will expand to 28GL/yr in 2019. Further expansion of groundwater replenishment to 105 GL/yr will involve new site-specific research costs but the investigation methods are now known, and capability to implement, operate and regulate are in place in the utility and its collaborators.



Beenyup trial treatment plant and recharge well was a major research component that resulted in the adoption of the Perth Groundwater Replenishment Program. (Figure courtesy of Water Corporation)

Box 2: Example: Impact assessment for CRC for Water Sensitive Cities

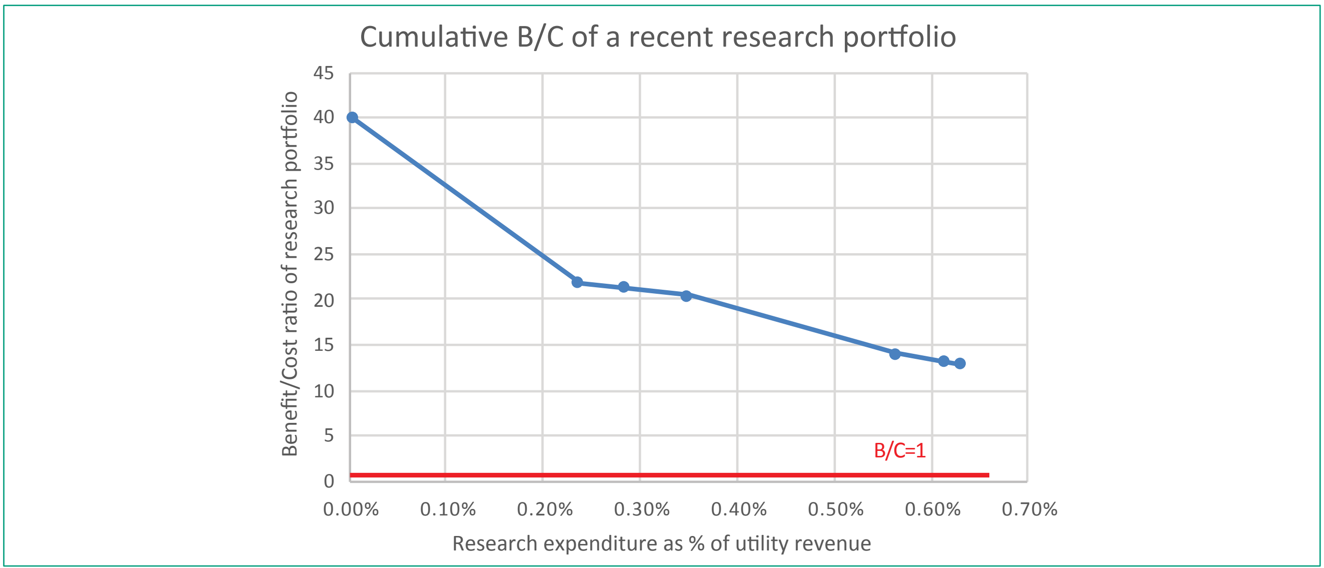
The CRC program has refined a standardised accounting procedure for research benefits which is based on the model described in Jones *et al* (2006). When applied by the CRC for Water Sensitive Cities in 2015 to compare monetary impact with that forecast in 2011 at the outset of the CRC, significant increases were observed as a result of early success in some research projects, early adoption of some results, and raising the adoption ceiling through increased participation of partners in CRC activities as a result of extending outreach activities. The figure below is a composite of a series of research programs, each with various forecast outcomes and defined beneficiaries.



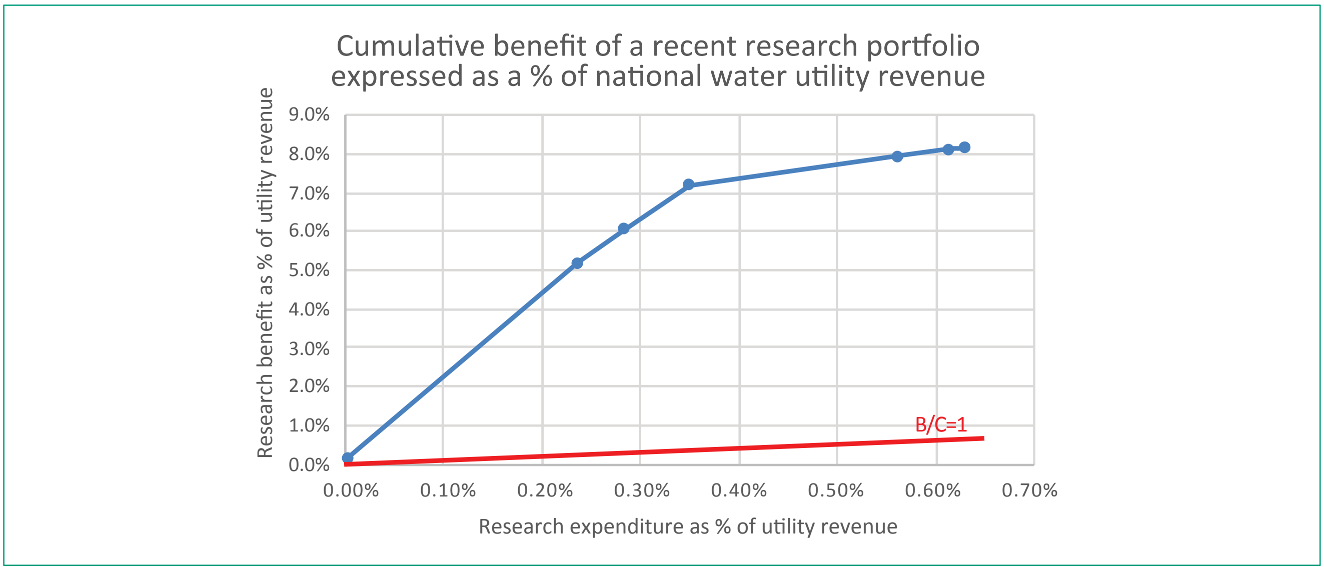
The impact profile over time as forecast in 2011 and 2015 are shown, demonstrating that effective research that strongly engages end users, and is supported by well-coordinated communications and outreach, can significantly increase the value of investment in water research. (Figure is from CRC Water Sensitive Cities 2015).

Assuming that investments in any coordinated portfolio of research would be directed first towards those that are likely to have the highest returns, the data of Table 1 may be used to estimate the extent of the benefits for a range of levels of investment. This is constrained by the number of research projects for which benefit data were available. The total was equivalent to about 60% of the total investment in urban water research in Australia during the period of approximately 2010-2015.

In Figures 2(a) and 2(b), the national annual urban water utility revenue is estimated at $9B (in 2010, WSAA data). It is assumed the average duration of research activities was 5 years, in order to calculate the average annual research expenditure which can be compared to the annual revenue. To simplify presentation, the annual benefits, although they accumulate over a longer time frame, were related to annual revenue in the same way as costs, in order to remain faithful to the present value benefit calculations of the source data.



(a)



(b)

Figure 2: Quantified benefits from research (from Table 1) with respect to level of expenditure expressed as a percentage of water utility revenue

All accessible data on quantified research benefits from a recent portfolio of research (Table 1) were used to show in Figure 2(a) the cumulative benefit/cost ratio for the portfolio for any given level of investment up to the total, expressed in terms of national annual water utility revenue. Figure 2(b) shows the research benefit accruing for the corresponding investment.

Although research expenditure reaches only about 0.6% of utility revenue (Figure 2) from the portfolio of research with quantified benefits, the portfolio BCR is 13 and the marginal BCR is around 3.5 at this level, suggesting that there is considerable room for additional profitable research investment. The “law of diminishing returns” suggests that at some high level of expenditure, the marginal BCR of investments would decline to 1, and further investment would be unprofitable. The portfolio evaluated includes research projects specific to some utilities where there are clearly high returns and immediate applications. But the majority of the research is broadly applicable to most Australian cities.

Investments in nationally coordinated programs raise the adoption ceiling, as has been shown by CRC for Water Sensitive Cities (Box 2), and expand the opportunities for profitable syndicated research, thereby lowering the costs for each partner. National research priorities in urban water research have been debated at length with deep engagement with industry and all major research organisations and research brokers. The results were documented in the Water Services Association of Australia (2016) National Urban Water Research Strategy. In this paper it is assumed that priorities identified, and updated periodically and consultatively, will continue to focus the research portfolio where Australian research will yield highest value.

HISTORICAL AUSTRALIAN WATER RESEARCH PROGRAMS

National programs in water research have been abundant in Australia, with key contributors being the Water Services Association of Australia and its members, and the Commonwealth Government.

Urban Water Research Association of Australia (UWRAA) was a Division of the Water Services Association of Australia (WSAA), which was funded jointly by WSAA and the Commonwealth Government. Annual reports from 1987 show that 154 reports were produced from 1989 to 2000, until it ceased funding new projects in 1999 after the Commonwealth discontinued co-investment with water utilities. It had a well-defined strategic plan (e.g. UWRAA 1993) and an annual open call for proposals in a wide field of urban water research, including stormwater management, improved methods for pathogen detection, pipe failure prediction, assessing customer expectations and international benchmarking of economic effectiveness of utilities (Table 2).

Table 2: Urban Water Research Association of Australia (UWRAA) Catalogue of Research Reports cover the following categories and are available for purchase from the WSAA web site UWRAA (2018)

Algal Toxins
Analysis of water and wastes
Asset Management
Cryptosporidium and Giardia
Drinking water distribution networks
Drinking water quality and health
Drinking water treatment
Economic issues and pricing
Engineering materials and specification
Ground water quality and management
Instrumentation
Planning and research
Resources, environmental water quality and ecology
Sewerage, surface and coastal water management
Wastewater treatment, sludge and land management
Water Conservation, Demand Management and Water Usage

These are enduring research topics, and further research is needed in every category to equip the water industry for the future. The URWAA agenda included integrated urban water resources management and addressed these broader integrative issues, which were identified as important by the Productivity Commission (2011). Any research program will adjust the balance of effort over time to meet the highest current priorities that are based on well-founded strategy, as well as on unsolicited "value for money" proposals that have a clear pathway to impact. Since UWRAA, the Commonwealth has invested in a range of programs that included urban water research, such as: the Better Cities Program ($816M, 1991-96) under which urban renewal with innovative multi-purpose infrastructure investments occurred; the Clean Seas Program ($47M, 1999-2004) under which wastewater treatment and water recycling advanced; and the Raising National Water Standards Program (~ $160M on urban and rural water research to 2012) of the National Water Initiative (NWI). The NWI, overseen by the National Water Commission (itself abolished in 2015), included research to support innovative policies and practices, and led to significant investments in water recycling under the Water Smart Australia Program ($1.5B) and water harvesting under the National Urban Water and Desalination Plan ($655M, including $40M for the Australian Water Recycling Centre of Excellence (based in Brisbane) and the National Centre of Excellence in Desalination (based in Perth)).

These, and other Commonwealth initiatives, such as the National Water Security Plan for Cities and Towns, the Green Precincts Fund and the Water Efficiency Opportunities Program have closed, as have applications for the National Water Infrastructure Development Fund. In 2018, only one national urban water program which included Commonwealth funding was still in existence. This is the CRC for Water Sensitive Cities ($38M, 2012-21).

The outstanding model of enduring water research in Australia was the Land and Water Resources Research and Development Corporation (LWRRDC), established in the late1980s that injected considerable energy into water resources research in Australia. Its predecessor, the Australian Water Research Advisory Council (AWRAC 1962-1980s) ran a program that developed 12 small centres of national concentration of research at $150Kpa each for 5 years. Subsequently some of these specialist centres became the seeds of two water CRCs and the still current National Centre for Groundwater Research and Training (NCGRT). LWRRDC, which became Land and Water Australia (LWA) in 1989, did not have contributions from levies paid by landholders and was entirely Commonwealth funded. However, it sought to attract co-investment from rural research and development corporations (RRDCs) to foster innovation in Australia's agricultural production systems, and equip Australia's farmers and natural resources managers with the best available science and technology to manage soil, water and vegetation (LWA 1990).

LWA undertook 630 research projects before it ceased operation in 2009. At that time, the impact of its work over 20 years was evaluated (Pearson et al 2010). In 2008-9 terms the LWA investment of $125M generated $597M of benefits, giving a BCR of 4.8, and an internal rate of return of 26%. LWA's $125M leveraged partner contributions to a total of $810M resulting in a total return on investment of $3.7B, with a benefit cost ratio that remained steady at around 4.6 over the period. The BCR of LWA investments over rolling 5-year average periods consistently increased from 4.2 in 1991-95 to 6.6 in 2005-09, suggesting leverage by LWA became more efficient over the years, and that research selection and execution of an investment portfolio averaging $40M per annum sustained consistently high-yielding projects.

Economic benefits included the following categories, for which parallels are evident in urban water research investment:

- Cost reductions for government agencies, rural communities, agribusiness, or non-rural sectors of the economy
- Farm productivity improvements such as increased crop yields or variable/capital cost reductions
- Improved policy decision-making in natural resource management by government, including in the areas of monitoring, priority setting and expenditure decisions
- More effective infrastructure management
- Avoidance of contraction of agricultural industries or stimulating new revenue

BCRs of 31 individual projects supported by LWA ranged from 1.7 to 47.6 with a median of 6.0. The simple average length of investment was 6.6 years (and ranged from 2 to 13 years) and the average period from first year of investment to the first year of benefits was 6.5 years (ranging from 0 to 17 years).

Pearson *et al* (2010) reported that "the robust, transparent and conservative methods applied, dramatically increased the credibility of (research project) evaluation with LWA's stakeholders". Evidently, this was except for the Commonwealth Government, which abolished LWA in 2009 as a cost-saving measure. LWA had been very successful in attracting co-investment in projects by industry-supported RRDCs (e.g. grains and rice) which were somewhat optimistically expected by the Commonwealth to fill the funding gap. Unfortunately, the gap remains today.

Analogously, in 1996 the Commonwealth-funded Energy RDC, a sister organisation to LWA, was closed by Ministerial direction, also as a cost-saving measure, at a time when Australia was a world leader in solar energy technology. Subsequently, Australia fell well down the list of solar industry countries, despite our huge natural advantage in that area. The Commonwealth eventually re-established R&D investment, via the Australian Centre for Renewable Energy in 2009 (a $690M program) that was subsequently absorbed into the Australian Renewable Energy Agency in 2012, which now invests ~$200M pa in R&D as part of a $2B innovation demonstration program. Based on the evidence presented for the value of water research, it would be both logical and overdue for the Commonwealth to reinvest in water research.

In 2010, Australia invested $60M-$90M ($34M by WSAA utilities) in a series of major programs, many of which were government supported, and expired by 2015 when research investment dropped to $30M-$50M ($25M by WSAA utilities). Commonwealth programs that once supported water research included Raising National Water Standards ($250M, closed 2012), Australian Water Recycling Centre of Excellence ($20M, closed 2016), and National Centre for Excellence for Desalination ($20M, closed 2016). In addition, state-based water research programs such as Urban Water Security Research Alliance (Queensland) (2007-2012, $50M), and Smart Water Fund (Victoria) ($66M 2002-2017) are closed and urban water research was a casualty of downsizing the Goyder Water Research Institute (SA) from $10Mpa 2010-15, to $4Mpa 2015-2019.

Only WSAA, Water Research Australia, CRC for Water Sensitive Cities, the Goyder Institute and National Centre for Groundwater Research and Training (NCGRT) remain as syndicated water research brokers, whilst CSIRO and multiple universities retain only modest urban water-related research portfolios. Water utilities' collective research budget dropped 27% between 2010 and 2015 while over the same period their revenue rose 22%. However, their proportionate contribution to the reduced total water research rose from between 43 and 49% in 2010 to 60% in 2015 because government had reduced investment even faster. The large and simultaneous decline in R&D investment has had an immediate and continuing detrimental impact on Australia's urban water R&D capacity. Unless rectified, this will seriously impact the future performance, cost and resilience to risk of Australia's urban water systems.

REFERENCE LEVELS FOR RESEARCH

In South Africa, the USA and the UK, a combination of water industry direct funding and syndicated research involving national government contributions is in place, with research coordinated and managed by a distinct entity such as the Water Research Commission (S. Africa), the Water Research Foundation (USA) (covering all areas of drinking water, wastewater, stormwater, and reuse) and United Kingdom Water Industry Research (UKWIR) (Fagan 2014). In the UK, expenditure is similar to Australia at 0.2% of water utility revenue, but UKWIR aims to increase this to 0.6-1.2% of revenue.

Compared to other industries in Australia, the current water industry R&D is significantly below the industry average of 1.0-1.2% of turnover as shown in Figure 3. Gross Domestic Product (GDP) is the total value of goods produced and services provided in a country during one year. Comparing R&D expenditure of an industry with its revenue is consistent with comparing national R&D expenditure with respect to GDP. In 2014-15 Australia's 15 Rural Research and Development Corporations spent $580 million on agricultural R&D, co-funded by statutory levies on the gross value of production (i.e. commodity sales), and matching federal government funding (http://www.ruralrdc.com.au/impact-assessment-performance/).

Factors affecting the level of R&D investment include industry volatility, competition, pace of technological change, complexity, and multisectoral considerations. Given the pace of urban growth and climate change, the international competitiveness of water utilities, and the market opportunities in its region, the Australian water industry has a very low level of investment in R&D (2015 figures shown). Continuing such a low level is not in the public interest.

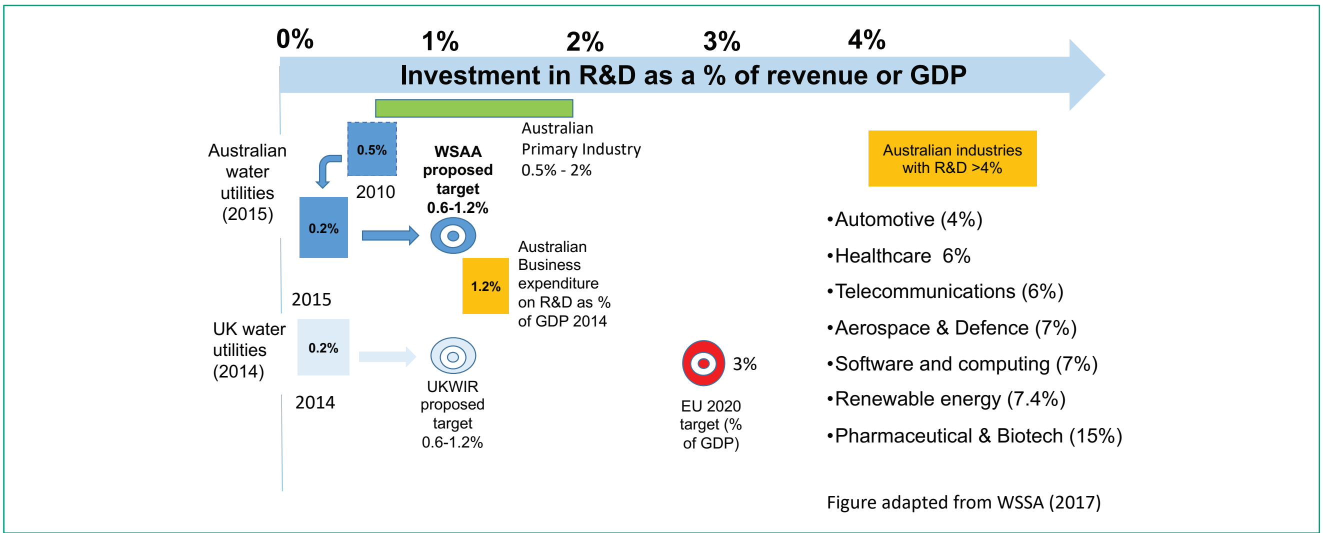


Figure 3: Benchmarking of R&D expenditure as a percentage of revenue for international water research and for Australian research in related sectors

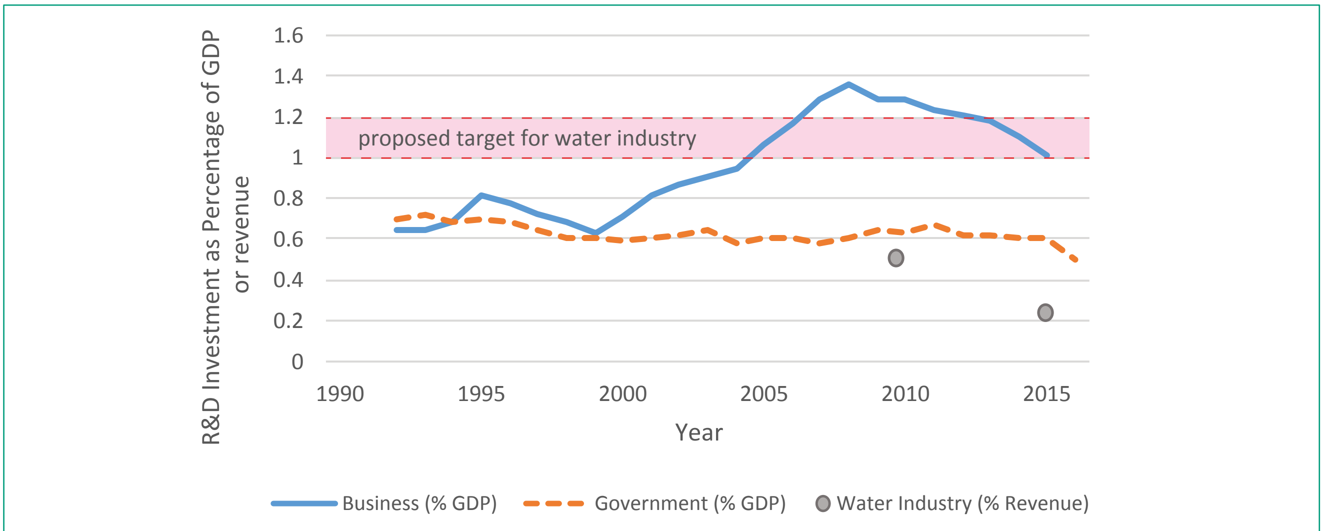


Figure 4: Australian business and government R&D investment 1992-2016 as a percentage of Gross Domestic Product (adapted from Innovation and Science Australia, 2017, p40, fig12) with Australian water utility investment as a percentage of revenue for 2010 and 2015 (grey dots)

MODELS OF RESEARCH FUNDING

In Australia, Water Research Australia acts as a research coordinator for utilities that are members of WSAA. However, since the demise (in 2008) of its parental CRC for Water Quality and Treatment that had Commonwealth government co-investment, industry partners have not shown the same eagerness to invest their own resources in syndicated research. Australia has relied heavily on tax incentives (currently up to 43.5% of expenditure) to encourage R&D in the private sector. It is quite clear that government funding plays an important catalytic role in industry investment in R&D.

Research to facilitate integrated water management requires the involvement and co-investment of local government bodies with responsibility for stormwater management. As these non-profit-generating entities pay no taxes, there is effectively no Commonwealth funding for local government-sponsored research except via CRC WSC (or through ARC Linkage Projects that support only small scale projects $50,000 - $300,000 pa for 2-5 years). It is likely that the BCR of R&D in stormwater and its integration with city greening and water supply objectives would be at least equivalent of that of water utilities, as evident in the earlier example of the CRC for Water Sensitive Cities.

The objectives of the National Urban Water Research Strategy (WSAA 2016) include:

- Raising and stabilising investment in R&D to maximise benefits
- Syndicated investment in highest benefit R&D activities
- Strong participation of water industry
- Co-investment by Commonwealth to address its objectives; to be in the top tier for Science and Innovation by 2030 (Innovation and Science, Australia 2018), to advance the National Water Initiative (National Water Commission 2014 and Productivity Commission 2017) and enhance economic growth (Australian Academy of Science 2016)
- Efficient processes for selecting and establishing projects
- Links with international R&D
- Building needed R&D capability
- Enhancing industry uptake and growth
- Increasing exports

These objectives could potentially be met by several possible models including:

- An industry led R&D institute with Commonwealth co-investment
- A Research and Development Corporation as a statutory body tasked to meet government objectives, with co-investment by the water industry in the form of a levy on water sales
- A series of centres with distinctive capabilities – such as those once supported by AWRAC and the CRC program
- Some or all of the above

It would be highly desirable to have in place a research broker with a sustainable funding source (such as a levy based on water sales) mandated by Commonwealth legislation, governed by a board comprising a majority of industry representatives. It would be appropriate for the Commonwealth to co-invest (as happens with the Rural Research and Development Corporations) for reasons of public good. Of the current 15 RRDCs, five are Commonwealth statutory corporations or authorities, and established under legislation. The remainder are industry-owned, not-for-profit companies established in accordance with Australia's Corporations law and with Statutory Funding Agreements with the Australian Government. They are declared through regulation as the service providers to industry for specific activities. Levy payers are given the opportunity to become members or shareholders and participate in decisions by attending annual general meetings and electing directors. Commonwealth contributions are capped at 0.5% of gross value of production, but it has been noted (Core 2009) that this had restricted research with cross-sectoral benefits, and that there was a case for greater Commonwealth investment in such cases, as would be relevant for water research.

In respect of urban water, the Productivity Commission (2011) observed that "*…economic efficiency should be defined broadly to include environmental, health and other costs and benefits that might not be priced in markets. This objective should apply to the urban water sector as a whole and is not appropriate as an objective for water utilities. This is because pursuing this objective requires difficult judgments to be made about the value that the community places on environmental outcomes and avoiding health risks …Elected representatives are best placed to make these judgments.*"

A series of centres of competency may emerge, regardless of the form of the main research funding conduit, if there is an ongoing supply of high valued projects. This may provide a means of achieving greater research efficiency, assuming such centres collaborate effectively with other participants in integrative projects.

In South Africa, the Water Research Commission is a statutory body established by act of parliament (South Africa 1971) which may receive appropriation from the government, by levy on agricultural land, and on water use in urban and rural areas. In 2017/8, more than 70% of its $US36M annual budget was derived from levies (WRC 2018). As an entity that has been operating for more than 45 years, it has as its first priority to address strategic national needs as identified by the Government of South Africa through its commitment to the National Water Resource Strategy, National Development Plan, Water and Sanitation Master Plan and the United Nations Sustainable Development Goals. It also provides research to assist municipalities with their devolved responsibilities for water and sanitation.

Were the proposed Australian *water research institute* to include urban and rural water, the balance between perceived investment in the two sectors could influence the model selected.

WHAT NEXT?

Australia's urban water industry faces ongoing challenges of increased urban growth and intensification, impacting on water use, sewage and stormwater loads, and urban liveability with changing consumer values in service attributes, such as health, environment, green space, reliability and cost. Efficient and resilient planned responses, based on sound research are needed that harness ageing assets in multiple systems, disruptive technologies and new information systems.

A National Urban Water Research Strategy (WSAA 2016) provides an example of a high-level framework for implementation of a new model. Its benefits will include:

- Strategic alignment between the Australian Government Science and Research Priorities and the urban water research investments
- Efficient use of research funds through enhanced collaboration on common research priorities
- Delivery of research that meets the collective needs of industry and responds to global trends
- Enhanced reputation for the Australian urban water industry through encouraging and promoting Australian-led collaborative research projects
- A platform for influencing the allocation of available research funding to address the needs of the urban water industry and with such wider objectives as Commonwealth co-investment enables
- Greater adoption of research outcomes through improved knowledge transfer
- Ultimately better and cheaper customer service for all water services

From a utility perspective, research can reduce operating costs, extend asset life, defer augmentations, improve customer service, reduce risk exposure, improve workforce health and safety and reduce duplication for industry and regulators. Reversal of the current downturn in urban water research investment is critical to support industry capability for efficient water management on behalf of customers. As identified by the Productivity Commission (2011) this should be in the context of the broader issues of integrated water management for the greater economic good in urban and rural areas and in the peri-urban environment. This was further reinforced by the Productivity Commission (2017) review of urban water reform, commenting (page 19):

"Ongoing research and capacity building will be central to Australia's ability to deliver sustainable management of water resources, and efficient and affordable water services, into the future. There are sound reasons for government funding of water research, and value in maintaining knowledge and capacity in the public sector. To achieve the greatest benefits from investment, governments, water utilities and research institutions should work collaboratively on areas where new knowledge is most needed."

There is a case for action to be taken by industry to strongly encourage the Commonwealth to establish a sustained funding arrangement, with funding derived from a levy on all water sales underpinned with a direct Government contribution.

Following this, we need to establish the necessary planning, governance and funding allocation mechanisms. These should be based on the following principles:

- Proposing an adequate level of research investment that maximises net benefits while concurrently addressing national strategic research priorities;
- Collaborating and leveraging to maximise value from water industry and government investments through syndicated programs with efficient selection and oversight
- Effective knowledge transfer to extract maximum value from existing and past research investments
- Demonstrating the value of research investment
- Periodically updating priorities in research activity and research capacity building in required competencies

Some of these elements, guided by the National Urban Water Research Strategy (WSAA 2016) are delivered by existing entities including WaterRA, WSAA, the CRCWSC, ARC funding and international research memberships. However national funding by industry and government is quite inadequate.

For urban water, current revenue for Australian water utilities is of the order of $9B annually. One percent translates to $90M/y. Based on approximate national annual water use, and assuming half is covered by the industry levy, the cost to customers would be of the order of 1.5 cents/kL, to avoid much larger rises over time. The remaining costs covered by taxpayers through the Commonwealth contribution would also be an efficient way of meeting national objectives in water management, liveable cities and economic growth. This is a small price for customers and taxpayers to pay now for the many enduring economic, environmental and social benefits that would be captured for Australia in the future.

CONCLUSIONS

Given the ongoing perennial challenges facing the water industry, the strong benefit-cost ratio of R&D as measured in recent projects and portfolios, and the example of related industries, a target of 1% water sales is suggested as a reasonable minimum for coordinated R&D investment.

Such research will inform measures for water security, water quality management and environmental protection, improve liveability of cities during urban consolidation and growth, maximise the productivity of water resources, and harness cross sector synergies to benefit all Australians.

The participation of the water industry is vital to ensure research relevance and rapid implementation, as well as the organisational benefits of an infused innovative culture. Syndicated research in coherent programs with good communication at national level has been shown to broaden and accelerate uptake of research outcomes and enhance the benefits of research.

The urban water industry is already well placed to coordinate R&D, and to communicate effectively through the Water Research Access Portal (accessed Dec 2018) established by WSAA in association with a constellation of research providers, and facilitated through a number of national conferences such as Ozwater, the annual conference and exhibition of the Australian Water Association.

There is however a fundamental need to reinvent a national research investment model in Australia to retain efficient research capacity, broaden participation of beneficiaries, and distribute R&D costs more fairly amongst all beneficiaries. Provision for government co-investment is warranted to support beneficiaries beyond water users, and acknowledges the role of R&D in building Australian capability in the science, technology and management of water.

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