



UNIVERSITY  
OF WOLLONGONG  
AUSTRALIA

University of Wollongong  
Research Online

---

Faculty of Commerce - Papers (Archive)

Faculty of Business

---

2009

# Desalinated versus recycled water — public perceptions and profiles of the accepters

Sara Dolnicar

*University of Wollongong*, [s.dolnicar@uq.edu.au](mailto:s.dolnicar@uq.edu.au)

A. I. Schäfer

*University of Edinburgh*

---

## Publication Details

Dolnicar, S. & Schafer, A. (2009). Desalinated versus recycled water — public perceptions and profiles of the accepters. *Journal of Environmental Management*, 90 (2), 888–900.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library:  
[research-pubs@uow.edu.au](mailto:research-pubs@uow.edu.au)

---

# Desalinated versus recycled water — public perceptions and profiles of the accepters

## **Abstract**

Many countries' water resources are limited in both quantity and quality. While engineering solutions can now safely produce recycled and desalinated water from non-potable sources at a relatively low cost, the general public is sceptical about adopting these alternative water sources. Social scientists need to better understand what is causing this lack of acceptance by the general population and how acceptance levels for recycled and desalinated water can be increased. This study is the first to conduct a comparative analysis of knowledge, perceptions, acceptability, and determine segments of residents who are more open-minded than the general population toward the use of recycled and desalinated water. The Australian population once perceived desalinated water as environmentally unfriendly, and recycled water as a public health hazard. The general level of knowledge about these two concepts as potential water sources has historically been low. After nearly five years of serious drought, accompanied by severe water restrictions across most of the country, and subsequent media attention on solutions to water scarcity, Australians now show more acceptance of desalinated water for close-to-body uses, and less resistance to recycled water for garden watering and cleaning uses. The types of people likely to be strong accepters of the two alternative water sources are distinctly different groups, and can be reached through different media mixes. This finding has significant implications for policy makers.

## **Keywords**

water recycling, desalination, public perception and acceptance, public knowledge, market segments

## **Disciplines**

Business | Social and Behavioral Sciences

## **Publication Details**

Dolnicar, S. & Schafer, A. (2009). Desalinated versus recycled water — public perceptions and profiles of the accepters. *Journal of Environmental Management*, 90 (2), 888–900.





## 1 **Introduction**

2 Many countries have increasingly limited water resources in both quantity and  
3 quality. Human water consumption has increased beyond sustainable levels in many  
4 regions, resulting in extended periods of drought, depletion of environmental flows in  
5 natural water systems and the decrease in the quality of drinking water reservoirs,  
6 including groundwater systems. High stress regions have traditionally included  
7 California, Australia, the Middle East and the Mediterranean (International Water  
8 Management Institute (IWMI), 2006).

9 The global water cycle is a closed system, with water molecules continuously  
10 taken in and excreted by living organisms (Suzuki, 1997). Debate is escalating about  
11 the acceptance and suitability of human-engineered water recycling within this  
12 continuum. Water recycling involves the treatment of municipal wastewater for the  
13 replenishment of available freshwater resources. It closes the water cycle on a local  
14 level, and enables the closure of water cycles for individual households, buildings,  
15 factories, towns, or regions. A range of wastewater treatment technologies is available  
16 to achieve recycled water — of a quality that is often superior to existing potable  
17 water standards (Bixio *et al.*, 2005; Wintgens *et al.*, 2005). Despite this, the concept  
18 of drinking wastewater does not have wide public support. Several public consultation  
19 studies explore reasons for this resistance, and how to gain community support (for  
20 example, Marks, 2003; Baggett *et al.*, 2006; Marks, 2006). In some instances cultural  
21 issues or even spiritual or religious relationships to water are important (Strang,  
22 2004). Recycled water is now available in countries with severe water restrictions, but  
23 clients for the product often cannot be found. Several factors combine to hinder  
24 recycled water uptake, including inadequate distribution infrastructure for supply,  
25 existing highly subsidized and cheap potable water resources, and a low level of  
26 community awareness of the limitations of freshwater resources, particularly in urban  
27 areas. New problem solving approaches to water supply are needed (Weber, 2006).

28 Dual reticulation systems are one approach used in Australia (Wintgens *et al.*,  
29 2005; van Roon, 2007), where new developments are fitted with one set of pipes for  
30 potable water (conventional tap water) and another for reused water (treated with  
31 various technologies, depending on the scheme). Other approaches to promote  
32 recycled water acceptance include many countries' implementation of (or plans to  
33 implement) seawater desalination to meet the shortfall in drinking water supplies and

1 avoid public acceptance problems (IDA, 2006). Desalination is well established in  
2 some countries, and reuse is considered to be an alternative (Côté *et al.*, 2005). The  
3 growth of desalinated water production worldwide is near exponential (Dawoud,  
4 2005), which might be explained by the declining costs of desalination technology,  
5 even though it produces water more expensively than does traditional supply  
6 (Dawoud, 2005).

7 Key issues in the desalination debate concern energy consumption, water  
8 quality, and environmental impacts. Introducing alternative water schemes (such as  
9 recycled, desalinated, storm or grey water), while objectively necessary, indispensable  
10 and technically possible, is complicated, because contributions from three sides are  
11 required:

12 (1) Professional knowledge provides the technical foundation to provide safe,  
13 reliable, and affordable alternative water source schemes.

14 (2) The community needs to accept or desire alternative water schemes.

15 (3) Because public acceptance is typically slow to emerge, it requires an issue  
16 management approach to introducing alternative water schemes, which may extend  
17 well beyond a specific location and public consultation at that location. Hartley (2006)  
18 mentions five crucial dimensions of issues management in the context of water reuse  
19 decision making: “managing information; maintaining motivation and demonstrating  
20 organizational commitment; promoting communication and public dialog; ensuring a  
21 fair and sound decision making process and outcome; and building and maintaining  
22 trust.” National social marketing campaigns may be necessary to educate the  
23 population about the importance (necessity) and possible risks (and opportunities)  
24 associated with adopting (and not adopting) alternative water schemes.

25 This paper discusses all these aspects. A brief background on the professional  
26 knowledge on recycling and desalinating water provides the technical knowledge  
27 base. Management implications are discussed in the conclusion. However, this paper  
28 mainly focuses on evaluating public acceptance of recycled and desalinated water. For  
29 this purpose it is necessary to determine: (1) what the main concerns are regarding  
30 household use of recycled and desalinated water, (2) how the community currently  
31 perceives recycled and desalinated water, (3) the level of factual knowledge, and (4)  
32 the stated likelihood of residents to use each of these alternative water sources.

1           Where some people state to be more likely to use recycled and desalinated  
2 water, it is also valuable to ascertain: (5) what the characteristics of those people are,  
3 because they could potentially serve as a market segment for early stages of the  
4 introduction of alternative water schemes. We henceforth refer to them as the “strong  
5 acceptor segment.”

6           Although previous studies extensively examine concerns and levels of public  
7 acceptance, very little research investigates the actual knowledge of the population  
8 about alternative water sources, as well as people’s perceptions of them. Comparisons  
9 of knowledge and perceptions of different alternative water sources are rare, and no  
10 comparisons of strong acceptor segments for different water sources yet exist.

## 12 **Review of prior research into public perceptions**

13           The issue of public acceptance of desalinated water has received scant  
14 attention. This contrasts with work on acceptance of recycled water, which has taken  
15 several directions. The majority of work investigates people’s willingness to adopt  
16 recycled water (Bruvold and Ward, 1970; Bruvold, 1972; Kasperson *et al.*, 1974;  
17 Sims and Baumann, 1974; Stone and Kahle, 1974; Olson *et al.*, 1979; Bruvold *et al.*,  
18 1981; Milliken and Lohman, 1985; Po *et al.*, 2004). Most studies find that the most-  
19 opposed use of recycled water was for food preparation and drinking. More than half  
20 of respondents (on average across all studies) expressed that they did not want  
21 recycled water used for these purposes. However, public uses with less human contact  
22 (such as firefighting and irrigation of public spaces) had high public acceptance  
23 levels.

24           Most studies do not include price in their acceptance questions. However,  
25 Thomas and Syme (1988) found that the price elasticity for water is generally low,  
26 and price increases of conventional water sources have little effect on acceptance  
27 levels for recycled water (Baumann and Kasperson, 1974; Bruvold, 1979). In contrast,  
28 Kaercher *et al.*(2003) and Marks *et al.* (2002) found that cost-benefits are an  
29 important criterion for public acceptance. Alhumoud *et al.* (2003) conclude that  
30 Kuwaitis were willing to pay more for their water in order to avoid having to use  
31 recycled water. Hurlimann and McKay (2007) found that residents of a community

1 that already has recycled water available for domestic non-potable use were willing to  
2 pay more for recycled water if this would ensure a quality improvement.

3 Other prior work investigates the concerns and perceived advantages of using  
4 recycled water. Bruvold (1988) identifies negative environmental consequences, and  
5 economic and health outcomes as concerns. In the context of direct potable use,  
6 Dishman *et al.* (1989) found that public health concerns were central to low  
7 acceptance levels. In Australia, Higgins *et al.* (2002) found that “public health and the  
8 environmental effect of microbiological agents,” together with chemicals such as  
9 endocrine disrupters, were a prime concern. Marks *et al.* (2002) identify quality and  
10 cost as the two main concerns among users. Hamilton (1994) found that opposition to  
11 potable reuse schemes derives from the public’s suspicion of politicians and  
12 organizations involved in the projects. This charged emotional response may be  
13 central to understanding public resistance to alternative water sourcing, and may be  
14 crucial to communicating to residential users which sources are trusted and which are  
15 not.

16 Few studies investigate the perceived advantages of using recycled water.  
17 However, Marks *et al.* (2002) identify three perceived benefits among users at an  
18 Australian site: cost savings, the positive effect on the environment and the nutritional  
19 value of reclaimed water.

20 Several studies identify market segments of likely adopters of recycled water  
21 (Hanke and Athanasiou, 1970; Gallup, 1973; Kasperson *et al.*, 1974; Sims and  
22 Baumann, 1974; Johnson, 1979; Olson *et al.*, 1979; Carley, 1985; Alhumoud *et al.*,  
23 2003; Hurliman and McKay, 2003). The single personal characteristic found  
24 consistently over several studies to be related to stated acceptance levels of recycled  
25 water is education, followed by age and knowledge about reuse, then income and  
26 gender.

27 The most comprehensive study of the acceptance of recycled and alternative  
28 water uses hitherto is Marks *et al.* (2006). This study confirms the preference for non-  
29 potable uses, and uniquely includes other alternative water sources compared to  
30 recycled water. While not all uses were evaluated for all water options, respondents  
31 demonstrated a high willingness to use grey water and stormwater for garden  
32 irrigation and toilet flushing. More than half (52 percent) stated that they were willing



1 without hesitation to use desalinated seawater for all water uses. Experienced users of  
2 recycled water in Australia (these represent a very small minority in pilot  
3 communities) stated that low levels of salt are the determining characteristic of their  
4 acceptance of recycled water for water irrigation, colorlessness for laundry and low  
5 price for toilet flushing (Hurlimann and McKay, 2007).

6 Context is crucial to understanding the stated willingness of the public to  
7 adopt water reuse or recycling. Therefore the following section offers a brief summary  
8 of the comparative water quality issues, energy consumption, and environmental  
9 impacts.

10

11 **Water quality issues — recycled versus desalinated water**

12 The primary source of recycled water is municipal wastewater, and this has  
13 prompted community concerns about water quality. Seawater is seen as a more  
14 pristine source. Wastewater carries what humans excrete and discharge to the drain  
15 from sources such as toilet, bathroom, kitchen, and laundry, or miscellaneous dumps  
16 of household or garden toxins or pharmaceuticals.

17 Toze (2006) summarizes the primary concerns as being microorganisms  
18 including bacteria, viruses, protozoa, and helminthes, which are excreted from ill  
19 persons and carry infectious disease. Such organisms are eradicated by several  
20 “barriers” during water recycling, although the risk of treatment failure exists.  
21 However, this risk is relatively small and requires the combination of multiple,  
22 simultaneous systems failures.

23 A second concern is the presence of trace organic compounds such as  
24 pharmaceuticals or “endocrine disrupting chemicals” (Toze, 2006). According to  
25 current knowledge, such compounds do not generally pose an immediate health risk,  
26 but can be a chronic risk in cases of long-term exposure, which may cause loss of  
27 fertility, affect normal development and behavior functions, contribute to cancer, and  
28 other problems of which the real source is more difficult to identify. Other exposure  
29 routes for such compounds are food, beverages, contact with chemicals (such as  
30 pesticides), or discrete exposure due to accidents, leisure activities, or the workplace.  
31 The production of hazardous chemicals is a further concern in treatment, where  
32 specific chemicals are often added (such as coagulants and anti-scalants) or by-

1 products formed during disinfection or oxidation processes. The removal of the  
2 majority of such chemicals is possible, but the technical effort is extensive and  
3 possibly unnecessary. Guidelines for specific water treatment applications and risk  
4 assessments of possible health effects are presently under discussion worldwide.  
5 Concerns about water quality and possible systems failures continue to stall the  
6 uptake of recycled water for potable purposes, even though many drinking water or  
7 groundwater supplies are not presently free of such contaminants.

8 A technology used for both water recycling and desalination is reverse  
9 osmosis. This technology is used commonly for both application and hence lends  
10 itself for direct comparison. Reverse osmosis can treat both seawater and wastewater  
11 to a quality higher than required for most water applications. This quality achievement  
12 is especially relevant where the majority of water consumption is used for irrigation  
13 (approximately 70 percent in Australia - see Lake and Bond, 2006).

14 Reverse osmosis usually achieves a water quality better than most tap or  
15 bottled waters. Further, water reuse is rarely considered for “direct potable reuse,”  
16 although this issue has been left open here.

17

18 **Energy consumption and cost — recycled versus desalinated water**

19 Energy constitutes a large portion of the cost of water provision, and is a prime  
20 driver of decisions about water and wastewater treatment technology. Generally, the  
21 more advanced the treatment and the further it is transported, the more energy is  
22 required to supply water. Other cost factors include pre-treatment, chemical addition,  
23 cleaning, maintenance, and capital works.

24 Almost identical technology — reverse osmosis — is commonly applied in  
25 large-scale facilities for both water recycling and seawater desalination for potable  
26 purposes. The same technology is used in many desalination and water reuse plants,  
27 especially in Australia, so it is easily comparable. Depending on the nature of the  
28 water to be treated, energy requirements differ. For example, the amount of total  
29 dissolved solids (TDS) to be removed from seawater is significant. The TDS  
30 concentration of municipal wastewater is usually between 0.1-1 g/L; while seawater  
31 TDS is generally above 35 g/L, which is 35 to 350 times greater. Reverse osmosis

1 operates by overcoming the osmotic pressure of water by an applied pressure. Hence,  
2 the higher the TDS, the higher the required energy to supply the necessary pressure.

3 According to Dawoud (2005), 50 percent of the cost of desalinated water is the  
4 energy component. Others (Hinkebein and Price, 2005) estimate it at 44 percent for  
5 seawater. Côté *et al.* (2005) estimate energy costs at 33 percent of the total lifecycle  
6 cost for desalination, and at four times higher a feed pressure and higher feed flow  
7 compared to reuse. They compare desalination with water recycling, and found that  
8 both capital costs and operation and maintenance costs were double for the  
9 desalination plant, with the overall cost for desalination 2.21 times higher than for  
10 reuse (Côté *et al.*, 2005). However, according to Dawoud (2005), the demand for  
11 water is greater than that for energy, and this may be one reason for the frequent  
12 neglect of energy considerations. Adham *et al.* (2005) develop a model that estimates  
13 the order-of-magnitude desalination costing for three water sources: brackish  
14 groundwater, surface water and recycled water (TDS is assumed to be 1 g/L for each).  
15 Power costs are linear with plant capacity, and represent about 25 percent of the  
16 operational cost, where the cost for brackish water desalination is about 50 percent of  
17 water recycling. Unfortunately, no seawater data is available in this comparative  
18 study.

19 Adham *et al.* (2005) note that power costs are the most important and volatile  
20 component of such systems. In a very comprehensive cost comparison, Dreizin (2006)  
21 describes water recycling and brackish water desalination as incurring very similar  
22 costs. Energy is the determining factor in the economics of different source waters,  
23 with the specific energy consumption for surface, brackish or wastewater being 0.4-  
24 1.0 kWh/m<sup>3</sup>, versus that of seawater at 3-3.4 kWh/m<sup>3</sup>.

25 In summary, reuse is more energy efficient than seawater desalination. This  
26 has a significant impact on CO<sub>2</sub> emissions, and consequently, on the global  
27 environment.

28

29 **Environmental issues — recycled versus desalinated water**

30 The most obvious consequences of unsustainable water consumption include  
31 energy and associated CO<sub>2</sub> emissions, variation of environmental flows and  
32 wastewater discharge, with associated impacts on habitats and biodiversity. Natural

1 water bodies, such as rivers, lakes, groundwater and wetlands, are often affected.  
2 While water recycling produces clean water, it also often involves cleaning up  
3 wastewater which might be discharged into the environment without adequate  
4 treatment, causing a range of environmental problems (Beder, 1989; Ternes *et al.*,  
5 1999; Braga *et al.*, 2005; Dawoud, 2005; Sumpter, 2005). Such discharge may also  
6 contaminate drinking water (Heberer, 2002). The environmental impacts resulting  
7 from water recycling and desalination can be summarized in the following categories:  
8 energy consumption, waste production, and other impacts.

9 Energy consumption and related greenhouse gas emissions, as well as air  
10 pollution due to desalination, are high for water recycling and desalination. These  
11 need to be reduced, particularly for seawater desalination. Meerganz von Medeazza  
12 (2005) suggests a reduction of environmental impacts by a target energy consumption  
13 for water production (including transport) at 3 kWh/m<sup>3</sup>. Environmental impacts  
14 depend on the energy source, and are usually associated with significant airborne  
15 emissions (Alameddine and El-Fadel, 2005; Meerganz von Medeazza, 2005).  
16 However, the desalination approach risks shifting the focus from water to energy.  
17 Raluy *et al.* (2006) suggest coupling desalination with renewable energies, because  
18 the environmental impact of desalination plants is dominated by energy.

19 Waste production and discharge/treatment (such as cleaning effluents and  
20 brines/concentrates) affect both the economics and the environmental impact of  
21 desalination (Lattemann, 2003; Lattemann and Höpner, 2007; Lattemann, Submitted).  
22 The concentrate produced in reverse osmosis is a substantial portion of the treated  
23 water, and contains a concentrated amount of the salt and other contaminants retained  
24 by the process. The high salt concentration of brines in seawater desalination can  
25 destroy large areas of ocean floor, due to the high density of such wastes (Einav,  
26 Harussi *et al.* 2002; Meerganz von Medeazza 2005). Discharge of iron can also cause  
27 significant discolouration of the ocean floor (Einav and Lokiec, 2003), and several  
28 desalination plants situated in one region can cause severe regional impacts  
29 (Lattemann and Höpner, 2007).

30 The effects of brine discharge are worsened by chemicals added as antifouling  
31 agents, coagulants, disinfectants, pH adjustments and specific compounds, such as  
32 heavy metals (Meerganz von Medeazza, 2005). These compounds are released with  
33 as-yet-unknown impacts.

1 Land use, noise, visual impact and disturbance of recreation areas are other  
2 environmental impacts on a local scale. Broader environmental issues include  
3 groundwater intrusion, soil salinity, deteriorated catchments, and the spread of  
4 invasive species (Lake and Bond, 2006). Lake and Bond (2006) predict that if  
5 business continues as usual, restoration and conservation efforts “will struggle to keep  
6 pace with the degradation generated by past legacies, and by continued pressure from  
7 resource development.”

8

9 **Data and Methodology**

10 The fieldwork for this study was conducted using an Australian permission-  
11 based Internet panel. This panel maintains a respondent database that is representative  
12 of the Australian population based on the Australian Bureau of Statistic’s (ABS)  
13 census information. Respondents were randomly selected from this panel, were  
14 invited to complete a 30-minute questionnaire online, and received a monetary  
15 compensation for completing it. Such compensation is a standard payment that is  
16 prescribed by the panel company, and depends on the duration of the questionnaire.  
17 The invitation to participate was closed when 1,000 respondents completed the  
18 survey. No follow-up invitations were needed to obtain the required 1,000  
19 respondents.

20 In order to assess potential response bias, the sample was compared to the  
21 2001 Census data provided by the Australian Bureau of Statistics. This comparison  
22 confirmed that the random selection procedure based on a representative panel  
23 produced a sample that was representative of the Australian population with respect to  
24 basic socio-demographic variables. Only the age group of respondents between 55  
25 and 64 was slightly overrepresented in our sample (seven percent of those aged 55-59  
26 according to the Census, compared to 16 percent in the sample; six percent of those  
27 aged 60-64 in the Census, compared to 11 percent in the sample). Sample  
28 representatively is particularly important for all results in which population  
29 percentages are reported; the profiling analysis does not require a representative  
30 sample because the aim is to study an extreme population group, not the entire  
31 population.

1           The questionnaire contained the questions below, which allow comparisons  
2 between the public perception and acceptance of recycled and desalinated water:

3           (1) A perceptions/knowledge question, in which respondents were asked to  
4 state whether or not each of a list of statements was true for recycled and desalinated  
5 water separately. The hypothesis underlying these items was that the general  
6 knowledge level about alternative water sources among the Australian population was  
7 low, and as a consequence, people held erroneous beliefs about recycled and  
8 desalinated water. The authors developed the items to capture both the level of factual  
9 knowledge and water-related perceptions. However, it was not a priori clear if all the  
10 terms used could be included in the survey (particularly terms used in the knowledge  
11 questions). Therefore the questionnaire was pre-tested for relevance and  
12 understanding using a sample of 10 adult respondents. They were presented with the  
13 questionnaire in written form and asked to comment while they were completing the  
14 survey. No major problems occurred, but a few items were slightly reworded, and  
15 some layout changes were made in order to draw attention to essential instructions.  
16 The full instructions and the items are provided in the Appendix.

17           (2) A stated likelihood of use question, in which respondents were asked to  
18 state on a five-point scale how likely they were to use recycled/desalinated water for a  
19 list of purposes. The researchers adopted this question format because it has been used  
20 successfully in most prior studies in which stated acceptance levels were measured  
21 empirically (Bruvold and Ward, 1970; Bruvold, 1972; Kasperson *et al.*, 1974; Sims  
22 and Baumann, 1974; Stone and Kahle, 1974; Olson *et al.*, 1979; Bruvold *et al.*, 1981;  
23 Milliken and Lohman, 1985; Po *et al.*, 2004).

24           In order to avoid bias arising from respondents who assumed different  
25 treatment procedures, respondents were given the following instructions for  
26 answering the question: “For the following questions we will use the term ‘recycled  
27 water’ to describe ‘purified wastewater or sewage,’ and we will use the term  
28 ‘desalinated water’ to describe ‘purified seawater,’ and we will assume that both  
29 recycled and desalinated water are treated to the same level of water quality.” We  
30 deliberately included this information after the perception/knowledge question, which  
31 assessed the general public’s perception of both alternative water sources without  
32 additional information. The full instructions and items are provided in the Appendix.

1 (3) A ranking question, in which respondents were asked to rank uses of water  
2 separately for recycled and desalinated water, indicating in which order they would  
3 adopt the purposes. This is a novel approach to measuring the stated willingness to  
4 use alternative water sources, and was included in order to confront respondents with  
5 a trade-off situation where they were asked to declare their preferences regarding  
6 which uses they would be willing to use desalinated/recycled water sources.

7 (4) An open-ended question, asking respondents to state their primary  
8 concerns with using each water source. This was included to determine reasons for  
9 resistance to using recycled and desalinated water.

10 In addition, several socio-demographic and behavioural variables were  
11 included in the survey: age, gender, education, occupation, and media usage.

12 While the study contains new elements which have not been investigated  
13 previously (knowledge/perceptions about water types in comparison to each other,  
14 ranking of uses, and so on) some of the limitations of traditional public acceptance  
15 studies also apply to our study (Baumann, 1983; Alhumoud *et al.*, 2003; Comrie *et*  
16 *al.*, 2003). For example, the questions about the likelihood of adoption are  
17 hypothetical, given that most of the respondents have had no prior experience with  
18 either recycled or desalinated water. Also, appearance and smell could not be included  
19 in the written online fieldwork as evaluation criteria for their likelihood of use.  
20 Neither does this study assume that the perceptions identified are stable, or can be  
21 generalized beyond Australia (Russell, 2004).

22 Very few Australians have had personal experiences with alternative water  
23 sources, yet recycled water and desalinated water schemes have received wide public  
24 attention in Australia for many years because of continued severe and widespread  
25 drought conditions. Seventy percent of respondents in our sample stated that they  
26 made a small, big or even huge effort to “look for information on water-related issues  
27 (for example, water recycling, desalination, water conservation, rain water and so  
28 on);” 94 percent stated that they had experienced water restrictions and 89 percent  
29 stated that they “had to change [their] behavior because of water restrictions.”

30 Although we assumed that respondents had formed opinions about alternative  
31 water sources, very few would have done so on the basis of personal experience.  
32 Their perceptions of alternative water sources were essentially a “brand image”

1 problem at the time of research. The perceptions/knowledge items in the survey  
2 represent items typical of brand image studies. Items were derived from prior studies  
3 and interviews with Australian residents, they were pre-tested to ensure understanding  
4 and non-redundancy, and presented for evaluation to respondents to enable a  
5 comparative image assessment of recycled versus desalinated water.

6 It should also be noted at this point that Australian do not have a direct choice  
7 to use or not to use recycled or desalinated water. Dual reticulation systems would  
8 have to be installed for consumers to have the actual choice at household level, which  
9 is not possible for individual household but only at the level of residential  
10 developments. Consequently increasing the acceptance levels for alternative water  
11 sources at this state of development of alternative water sources in Australia is not  
12 expected to lead to instant behavioral changes. Instead, high public acceptance level  
13 are essential to make the construction of new recycling and desalination plants which  
14 will have consequences for household water supplies politically viable.

15 Analyses of variance were used to test for differences in metric variables; chi-  
16 squared tests were applied where participants' responses to a nominal answer format  
17 were compared; and t-tests for proportions were used to test differences in population  
18 percentages.

19

## 20 **Results and Discussion**

### 21 Main concerns raised by respondents

22 The open-ended question in which respondents were asked to state their main  
23 concerns with recycled and desalinated water centered on three main themes: health  
24 concerns, environmental concerns, and cost. Recycled water was perceived as more  
25 risky from a health perspective (55 percent of respondents listed health-related  
26 concerns in the open-ended question). Desalinated water was primarily perceived as  
27 bad for the environment (12 percent, and only 23 percent mentioned health-related  
28 concerns), but it was also viewed as the more expensive alternative, with 11 percent  
29 mentioning a cost-related concern. This confirms earlier findings by Bruvold (1988),  
30 Dishman *et al.* (1989), Higgins *et al.* (2002) and Marks *et al.* (2002).

### 31 Perceptions and knowledge about alternative water sources



1 Results derived from the open-ended question do not permit direct  
2 comparisons between recycled and desalinated water, because respondents were free  
3 to express whatever they wanted. We therefore used the set of questions in which  
4 respondents were asked to evaluate their perceptions/knowledge about recycled and  
5 desalinated water to determine this issue. Figure 1 provides the comparison of items  
6 related to environmental issues, sorted in descending order for recycled water.

7 The responses to the open-ended questions are very similar: respondents  
8 perceived recycled water (dark gray columns) as more environmentally friendly, and  
9 they were aware that desalination (white columns) produced higher levels of  
10 greenhouse emissions and required more energy. However, 46 percent of respondents  
11 stated that desalinated water was environmentally responsible. More respondents  
12 believed that desalination could be of environmental concern than did for recycled  
13 water. Recycled water was most frequently perceived as the most environmentally  
14 friendly source of water, and was seen to contribute to reducing the contamination of  
15 beaches.

16 T-tests for proportions were computed to assess whether the visually detected  
17 differences were statistically significant. With respect to two items (“can save  
18 Australia from drought” and “reduces the need for water restrictions”), respondents  
19 did not perceive a difference between recycled and desalinated water. Figure 1  
20 includes comparative values for tap water and bottled water. Both recycled and  
21 desalinated water were generally evaluated as more environmentally friendly than  
22 both tap and bottled water. We assume that the reason for this perception is that  
23 Australians are very aware of the drought and the serious lack of fresh water  
24 resources, and consequently believe that alternative water sources are good for the  
25 environment because they take the pressure off natural resources.

26 Bottled water was perceived as the second-most environmentally unfriendly  
27 source of water, and a large proportion of respondents believed that it used a lot of  
28 energy in production, that it produced greenhouse emissions and that it could be of  
29 environmental concern. With respect to producing high levels of greenhouse  
30 emissions and using a lot of energy, tap water was rated better than both alternative  
31 water sources. These perceptions may indicate several differences between the four  
32 water sources evaluated which could be used for targeted public information  
33 campaigns.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31

[Figure 1]

Figure 2 provides the answers to the health-related items. Sixty-nine percent of respondents believed that desalinated water was healthy, compared to only 46 percent who believed that recycled water was healthy. With respect to all health-related questions, respondents felt that desalinated water was the safer choice. The level of trust indicated towards providers of both recycled and desalinated water was similar, and high, with more than two-thirds expressing their confidence in the water providers.

Despite these results, the lack of knowledge in the population is illustrated by the responses to the knowledge questions, shown in Figures 1 and 2. For instance, 24 percent of respondents agreed that desalinated water is purified sewage; and 20 percent believed that chemicals such as endocrine disruptors are present in desalinated water. Both these statements are incorrect. Differences between attitudes towards desalinated and recycled water regarding the health-related items are highly significant at the 99 percent level, except for the perception that water quality can be affected during transport.

The comparisons with the tap and bottled water (benchmarks) show that, in terms of health, respondents perceived both recycled and desalinated water as inferior to currently available water sources. However, tap water was ranked worst in terms of containing chemicals, with 94 percent of all respondents agreeing with this statement. This compares with only 81 percent of respondents agreeing that recycled water contained chemicals. This perception could offer an opportunity for marketers to position alternative water sources as having a competitive advantage over presently available supplies.

[Figure 2]

The questionnaire included several other, less knowledge-oriented questions, and their responses are provided in Figure 3. The results indicate that the population's

1 reservations about recycled water were more firmly held than those towards  
2 desalinated water. For example, 79 percent of respondents perceived desalinated  
3 water as drinkable; only half classified recycled water as such. Sixty-one percent had  
4 health concerns about drinking recycled water; only 33 percent had those concerns  
5 regarding desalinated water. Even with respect to clarity and odor, respondents  
6 perceived desalinated water to be superior to recycled water. Respondents further  
7 believed that recycled water contains more chemicals (such as disinfectants) as well  
8 as microorganisms. However, they did acknowledge one disadvantage: the higher cost  
9 associated with desalinated water in the production process, and consequently for the  
10 consumer.

11 All the variables in Figure 3 (except creating new jobs) differ significantly for  
12 recycled and desalinated water.

13 Both bottled and tap water elicited more favourable evaluations from  
14 respondents than desalinated and recycled water, regarding drinkability. Bottled water  
15 was perceived as the most clear and odorless water option, but respondents  
16 acknowledged that it also represented the most expensive source of water for the  
17 consumer. Tap water was perceived as the cheapest option, but was evaluated as clear  
18 and odorless by fewer people than was desalinated water. This supports the image of  
19 Australians which emerged in the context of health evaluation questions: that tap  
20 water is perceived as having several negative aspects. This perception may indicate  
21 very favorable conditions for the introduction of alternative water sources.

22

23 [Figure 3]

24

#### 25 Stated likelihood of use

26 The above results lead to the hypothesis that stated acceptance levels of  
27 recycled water will be lower than stated acceptance levels of desalinated water. In  
28 order to assess this statement, the questions about the stated likelihood of use were  
29 analyzed. Figure 4 contains the proportion of respondents who indicated that it was  
30 either “very likely” or “rather likely” that they would use recycled water and  
31 desalinated water, respectively, for each of the listed water uses. Desalinated water  
32 was unlikely to be preferred for use over recycled water for all uses. For water uses

1 that involve human contact, desalinated water was “very likely” to be used by a larger  
2 proportion of the population. For uses not close to the body (such as watering the  
3 garden) recycled water was “very likely” to be used by a larger proportion of  
4 Australians.

5 A step up in stated likelihood was observed for recycled water from garden  
6 watering to clothes washing, while the decrease in stated likelihood is steadier for  
7 desalinated water. The lower stated likelihood of using desalinated water for low body  
8 contact applications may reflect some respondents’ knowledge that such high quality  
9 water is not required for those applications. At the high body contact end of the  
10 spectrum, this result turns, and desalinated water was preferred by approximately 10–  
11 30 percent more respondents than recycled water.

12 Different alternative water sources attract different segments of water users.  
13 Except for the item “washing the house, windows, driveways,” all the differences in  
14 stated likelihood of use between recycled and desalinated water are highly statistically  
15 significant (p-values <0.001, meaning that the stated likelihood that such differences  
16 in perception do not exist is smaller than 0.1 percent).

17

18 [Figure 4]

19

20 While this finding is important, and can be directly compared to prior work  
21 that studies stated acceptance levels or stated likelihood of use, the question format of  
22 the likelihood question does not put respondents into a situation of trade-off.  
23 Theoretically, they might have stated that they would not use recycled or desalinated  
24 water for any use. However, the above findings are validated by studying the ranking  
25 question, in which respondents indicated in which order they would adopt recycled or  
26 desalinated water for different uses. To avoid purely hypothetical questions, the  
27 ranking question was formulated as a scenario. The following instructions were given  
28 to respondents: “Please imagine (1) that water levels drop to a critical level at which  
29 tap water supply is insufficient to cover the populations’ household water  
30 requirements, (2) that you do not have a rainwater tank or any other source of water,  
31 and (3) that tap water prices triple (increase by 300 percent), but recycled water and  
32 desalinated water are available at the current (low) tap water price. Please number the

1 following uses from 1 to 18 in the order in which you would be willing to replace tap  
2 water with recycled/desalinated water. Please use the value ‘1’ for the first thing you  
3 would switch to recycled/desalinated water.” This question format forced respondents  
4 to compare water uses (a trade-off situation) and state the order of adoption of  
5 recycled and desalinated water. Figure 5 provides the results.

6 While the absolute order of ranking shows the typical pattern of close-to-body  
7 uses being adopted last, the conclusions drawn from the expressed willingness to use  
8 question are supported by the ranking task. Items such as watering the garden,  
9 irrigation of parks, and toilet flushing were stated to be adopted earlier in the case of  
10 recycled water. Uses such as refilling the swimming pool, cooking and drinking were  
11 stated to be adopted earlier in the case of desalinated water. The pattern shown in  
12 Figure 5 illustrates that the order of stated adoption of alternative water uses was  
13 influenced more strongly by the actual use than it was by the source of alternative  
14 water.

15

16 [Figure 5]

17

18 Strong Acceptor Profile

19 Strong accepters among residents are a very useful segment for starting a  
20 diffusion process of public acceptance for alternative water sources. Hanke and  
21 Athanasiou (1970) propose the introduction of recycled water in high-status  
22 communities first, a recommendation based on findings that socio-demographic  
23 characteristics of the population are associated with acceptance rates. The more  
24 distinct the profile of such a strong acceptor segment, the better for marketing  
25 purposes, because the segments are known to exist and can be easily reached through  
26 communication channels.

27 This study does not contain behavioural information, so cannot be used to  
28 identify individuals who have actually adopted alternative water sources first. Based  
29 on the differences in expressed adoption likelihoods, we can, however, profile  
30 respondents who are the most open-minded with respect to using alternative water  
31 schemes. This group of respondents will be referred to as “strong accepters.”

1           In order to identify the strong accepters for recycled and desalinated water in  
2 Australia, a summated score across all stated likelihood of use items was computed.  
3 Respondents within the top third were classified as being the most open to the use of  
4 alternative water sources. Their profiles were compared to the other respondents to  
5 assess whether distinct and marketable strong accepters can be identified.

6           To test the hypothesis whether strong accepters of recycled water overlap  
7 strongly with strong accepters of desalinated water, a cross-tabulation of membership  
8 was constructed and a chi-squared test computed. The highly significant test results  
9 produced an unexpected result: the two strong accepter groups are quite distinctly  
10 separate groups of people. Twenty percent of all respondents are classified as “general  
11 strong accepters” for both recycled and desalinated water; 15 percent as “early  
12 desalination adopters;” and 19 percent as “early recycling adopters.” This necessitated  
13 profiling of the three strong accepter segments separately with respect to socio-  
14 demographic characteristics. These emerged in prior work as being associated with  
15 the acceptance of recycled water. Table 1 shows the profiles for all three strong  
16 accepter segments, as well as the contrast group of all other respondents. The  
17 percentages in the table represent the proportion of each segment that gave a specific  
18 answer. Where a number is given instead of a percentage, the dependent variable was  
19 metric in nature, and the number represents the average within each segment. The p-  
20 values in the last column are based on either chi-squared tests (when the dependent  
21 variable was nominal or ordinal) or analyses of variance (when the dependent  
22 variables were metric).

23

24           [Table 1]

25

26           Table 1 indicates that all strong accepters are significantly older than other  
27 respondents. These findings confirm the results of Sims and Baumann (1974), but  
28 contradict findings from Hurliman and McKay (2003) in the Australian context, and  
29 from Hanke and Athanasiou (1970).

30           Across all strong accepter groups, the proportion of men was higher than of  
31 women. These findings align with socio-demographic profiles reported by Olsen *et al.*  
32 (1979) for the US, and Hurliman and McKay (2003) for Australia. However, they

1 contradict the conclusions drawn by Sims and Baumann (1974), Hanke and  
2 Athanasiou (1970), and Johnson (1979): that gender is not associated with the  
3 acceptance of recycled water.

4         Regarding education level, the proportion of strong accepters who had only  
5 completed secondary school was significantly lower than among other respondents in  
6 the present study. This aligns with the findings of all other studies that included  
7 education as a personal characteristic in their empirical studies (Hanke and  
8 Athanasiou, 1970; Olson *et al.*, 1979; Alhumoud *et al.*, 2003; Hurliman and McKay,  
9 2003)

10         Regarding occupation, professionals were overrepresented among “general  
11 strong accepters” and “desalinated water strong accepters;” whereas more managers  
12 and administrators were among “recycled water strong accepters.” These three sub-  
13 segments of the strong accepter segment are named to indicate the kind of alternative  
14 water source that they are more likely than the general population to use at an earlier  
15 stage. For the “general strong accepters” this was the case for both recycled and  
16 desalinated water. No prior studies include this descriptor.

17         Media behavior is an important profiling variable used to develop optimal  
18 communication strategies with these segments. “General” and “recycled water strong  
19 accepters” watch state-run TV channels (ABC and SBS) more frequently than do the  
20 other two segments, which make more use of one particular commercial TV Channel,  
21 Win. Other channels (cable) are most used by non-strong accepters. The proportion of  
22 newspaper readers is higher among all strong accepter groups, which invites the  
23 conclusion that the more-informed respondents were more open towards water reuse  
24 and/or desalination.

25         Respondents were also asked how they would react if they had to switch their  
26 entire household water supply to either recycled or desalinated water. Responses to  
27 these two questions highlighted that “recycled water early adaptors” and “desalinated  
28 water early adaptors” represent two quite distinct market segments with very strong  
29 views about these alternative water sources. Significantly more (46 percent) of the  
30 “desalinated water strong accepters” state that they would not switch their entire  
31 household to recycled water under any circumstances; whereas only 33 percent of the  
32 non-early adaptors reacted as strongly. Responses to the question about switching to

1 desalinated water produced a proportion of refusers approximately equal among  
2 “recycling water strong accepters” and others. The stated willingness to pay the same  
3 or even a higher price for water under this scenario was highest among “general  
4 strong accepters” and “water recycling strong accepters.”

5 No differences were evident between the prior experience of respondents with  
6 water restrictions and their feeling of being limited by these measures. No differences  
7 in income, state of residence, size of the city of residence, frequency of watching TV  
8 and number of years lived in Australia were detected as influences on responses.

9



## 1 **Conclusions**

2           The Australian population discriminates between recycled and desalinated  
3 water. Although responses to the knowledge questions reveal gaps in the population's  
4 general level of knowledge, respondents understand that recycled water is the more  
5 environmentally friendly option, whereas desalinated water is perceived as less risky  
6 from a public health point of view. Responses to emotional items such as "is  
7 disgusting" indicate that Australians currently have fewer reservations about  
8 desalinated water than recycled water, despite the fact that identical water quality is  
9 assumed. This is supported by responses to the question about the stated likelihood of  
10 adoption of both kinds of water, where the stated likelihood for close-to-body uses  
11 was higher for desalinated water.

12           The results also indicate that we cannot state that Australians generally  
13 perceive as preferable either desalinated water or recycled water. Australians  
14 discriminate according to water use. Their stated likelihood of adoption for close-to-  
15 body purposes is comparatively high for desalinated water, compared with irrigation,  
16 cleaning the car, and house maintenance, for which recycled water is ranked higher in  
17 the adoption sequence.

18           The results have implications for water policy makers and managers. The  
19 order of stated adoption of alternative water sources for different household uses is the  
20 same for both types of water, and is determined by closeness to body. This supports  
21 prior recommendations made by water recycling researchers. Baumann and  
22 Kasperson (1974) suggest that a successful strategy should associate the water reuse  
23 program with pleasant activities the public enjoys and approves, for instance, to "put  
24 the reclaimed water in an attractive setting and invite the public to look at it, sniff it,  
25 picnic around it, fish in it, and swim in it" (p. 670). Studies conducted by Bruvold and  
26 Ward (1970) and Bruvold (1972) found that opposition to recycled water dropped  
27 significantly after swimming in it.

28           Results also indicate that Australians are mainly concerned about health issues  
29 that may be related to using water from alternative sources in their households while  
30 at the same time having only a low level of factual knowledge about the true health  
31 risks associated with desalinated and recycled water. Another practical consequence  
32 consequently is to try to fill the public knowledge gap through a range of possible

1 channels, including education in schools, public information campaigns, public  
2 consultations in regions where desalination and recycling plants are planned etc.

3 The contrast perceived between recycled/desalinated water and tap/bottled  
4 water indicates potential for targeted communication messages by public campaigns,  
5 for example, that recycled/desalinated water is cheap, creates new jobs for  
6 Australians, and uses fewer chemicals.

7 While these findings are derived from the aggregate of all respondents, future  
8 work should investigate whether personal characteristics, such as the education level,  
9 prior experience with recycled or desalinated water, prior experience with drought,  
10 and so on, affect knowledge, perception and likelihood of use. In particular, studies of  
11 actual behavior and actual behavior change should provide valuable new insights and  
12 may resolve some of the contradictory findings resulting from prior studies.

13 Additional research directions could investigate in more detail how the current  
14 perceptions of recycled and desalinated water were formed. This would require  
15 qualitative research methods and could use the perceptions/knowledge items  
16 developed for the present study as a starting point.

17

## 18 **Acknowledgments**

19 This project was supported by the Australian Research Council under  
20 Discovery Grant DP0557769 and the International Science Linkages program  
21 established under the Australian Government's innovation statement Backing  
22 Australia's Ability. It is funded by the Commonwealth Department of Education  
23 Science and Training for the project OzAquarec: Integrated Concepts for Reuse of  
24 Upgraded Wastewater in Australia (CG030025).

25

1 **Appendix — Survey items**

2 Perceptions/knowledge items

3 You will now see a list of descriptions of water. Please indicate whether or not you  
 4 think that each of the descriptions applies to the four kinds of water listed on top:  
 5 recycled water, desalinated water, tap water and bottled water by either ticking the  
 6 YES or the NO button. If you are not sure, please tick the option you think is more  
 7 likely.

	Recycled water	Desalinated water	Tap water	Bottled water
Contains chemicals, such as chlorine	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is purified sewage	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Producing it could be an environmental concern	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is drinkable	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Using it reduces the amount of wastewater discharged to the environment	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Could be a health concern, for instance if people would drink it.	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Quality can be affected by the way it is transported to your home	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is expensive for the consumer	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Contains bacteria or viruses	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Uses a lot of energy in production	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Contains substances such as hormones or endocrine disruptors which can affect human fertility	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Increases the amount of available freshwater	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Can save Australia from drought	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is expensive to produce	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Reduces the need for water restrictions	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Requires chemicals to be produced	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Produces greenhouse emissions	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is environmentally responsible	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is odourless	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is the most environmentally responsible water source to use	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is healthy	<input type="checkbox"/> Yes [1]	<input type="checkbox"/> Yes [1]	<input type="checkbox"/> Yes [1]	<input type="checkbox"/> Yes [1]

	Recycled water	Desalinated water	Tap water	Bottled water
	<input type="checkbox"/> No [0]	<input type="checkbox"/> No [0]	<input type="checkbox"/> No [0]	<input type="checkbox"/> No [0]
Is the most responsible water source to use from a public health perspective	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is prone to technology failure	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Because the water cycle is closed, it contains human waste	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Looks absolutely clear	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
I trust the provider that the quality is suitable for the intended usage	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Stains the washing	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Is disgusting	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Creates new jobs	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]
Reduces contamination of beaches	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]	<input type="checkbox"/> Yes [1] <input type="checkbox"/> No [0]

1

2 Expressed willingness to use items

3 Please imagine

- 4 • that level 3 mandatory water restrictions are in place for the use of tap water (only  
5 hand-held hosing of the garden on two days, no watering systems, no refilling  
6 swimming pools, no hosing of hard surfaces and vehicles) and  
7 • that both recycled and desalinated water are available to you at the same price as  
8 tap water without restrictions.

9 You will now see a list of typical water usage purposes. How likely is it that you  
10 would use recycled water and desalinated water for the listed purposes under these  
11 circumstances. Please answer separately for the two kinds of water.

	Recycled Water						
	Very likely	Rather likely	Unsure	Rather unlikely	Very unlikely	Not applicable	
Watering the garden (flowers, trees, shrubs)	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Washing clothes, doing laundry	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Cooking	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Showering	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Taking a bath	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Drinking	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Brushing teeth	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Bathing the baby	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Fish pond or Aquarium	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Toilet flushing	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	
Washing the house, windows, driveways	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999	

Religious / spiritual rituals	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Watering of garden – vegetables, herbs	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Washing the car	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Refilling / topping up the swimming pool	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Air conditioning	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Firefighting	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Irrigation of sports fields	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Irrigation of golf courses	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999
Irrigation of recreational parks	<input type="checkbox"/> 2	<input type="checkbox"/> 1	<input type="checkbox"/> 0	<input type="checkbox"/> -1	<input type="checkbox"/> -2	<input type="checkbox"/> 999

1

2           **References**

- 3     Adham, S., Kumar, M. and Pearce, W. H. (2005). Model developed for brakish and  
4           reclaimed water *Desalination & Water Reuse* **15**, 38-46.
- 5     Alameddine, I. and El-Fadel, M. (2005). Stack emissions from desalination plants: a  
6           parametric sensitivity analysis for exposure assessment *Desalination* **177**, 15-  
7           29.
- 8     Alhumoud, J. M., Behbehani, H. S. and Abdullah, T. H. (2003). Wastewater reuse  
9           practices in Kuwait *Environmentalist* **23**, 117.
- 10    Baggett, S., Jeffrey, P. and Jefferson, B. (2006). Risk perception in participatory  
11           planning for water reuse *Desalination* **187**, 149-158.
- 12    Baumann, D. D. (1983). Social acceptance of water reuse *Applied Geography* **3**, 79-  
13           84.
- 14    Baumann, D. D. and Kasperson, R. E. (1974). Public acceptance of renovated waste  
15           water: myth and reality, 667-673.
- 16    Beder, S. (1989). *Toxic Fish and Sewer Surfing*. Sydney, Allen & Unwin.
- 17    Bixio, D., De Heyder, B., Joksimovic, D., Chikurel, H., Aharoni, A., Miska, V.,  
18           Muston, M., Schäfer, A. and Thoeye, C. (2005). Municipal wastewater  
19           reclamation: where do we stand? An overview of treatment technology and  
20           management practice *Water Science & Technology: Water Supply* **5**, 77-85.
- 21    Braga, O., Smythe, G. A., Schafer, A. I. and Feitz, A. J. (2005). Steroid estrogens in  
22           ocean sediments *Chemosphere* **61**, 827–833.
- 23    Bruvold, W. H. (1972). Public attitudes towards reuse of reclaimed water. In  
24           *Contribution 137*, pp. Contribution 137. California: University of California,  
25           Water Resource Centre.
- 26    Bruvold, W. H. (1979). Human perception and evaluation of water quality. In *CRC*  
27           *Critical Reviews in Environmental Control* **5**, pp. 153-231.
- 28    Bruvold, W. H. (1988). Public opinion on water reuse options *Journal WPCF* **60**, 45-  
29           49.
- 30    Bruvold, W. H., Olson, B. H. and Rigby, M. (1981). Public policy for the use of  
31           reclaimed water *Environmental Management* **5**, 95-107.
- 32    Bruvold, W. H. and Ward, P. C. (1970). Public attitudes toward uses of reclaimed  
33           wastewater *Water & Sewage Works*, 120-122.
- 34    Carley, R. L. (1985). Wastewater reuse and public opinion *Journal of American*  
35           *Waterworks Association* **77**, 72.
- 36    Comrie, D., Evans, S., Gale, R. and Kitney, P. (2003). Taste and odour in drinking  
37           water: a perception versus reality case study. In *OzWater 2003*. Perth, WA.
- 38    Côté, P., Siverns, S. and Monti, S. (2005). Comparison of membrane-based solutions  
39           for water reclamation and desalination *Desalination* **182**, 251-257.

- 1 Dawoud, M. A. (2005). The role of desalination in augmentation of water supply in  
2 GCC countries *Desalination* **186**, 187-198.
- 3 Dishman, C. M., Sherrard, J. H. and Rebhun, M. (1989). Gaining public support for  
4 direct potable water reuse *Journal of Professional Issues in Engineering* **115**,  
5 154-161.
- 6 Dreizin, Y. (2006). Ashkelon seawater desalination project - off-taker's self costs,  
7 supplied water costs, total costs and benefits *Desalination* **190**, 104-116.
- 8 Einav, R. and Lokiec, F. (2003). Environmental aspects of a desalination plant in  
9 Ashkelon *Desalination* **156**, 79 - 85.
- 10 Gallup, G. J. (1973). Water quality and public opinion *Journal of American*  
11 *Waterworks Association* **65**, 513.
- 12 Hamilton, G. R. (1994). Attitudes to potable reuse of reclaimed wastewater. In  
13 *Recycled Water Seminar*, pp. 100-107. Newcastle.
- 14 Hanke, S. H. and Athanasiou, R. B. (1970). Social psychological factors related to the  
15 adoption of reused water as a potable water supply. In *Western resources*  
16 *conference*, pp. 113-124. Boulder, Colorado.
- 17 Hartley, T. W. (2006). Public perception and participation in water reuse *Desalination*  
18 **187**, 115-126.
- 19 Heberer, T. (2002). Tracking persistent pharmaceutical residues from municipal  
20 sewage to drinking water *Journal of Hydrology* **266**, 175-189.
- 21 Higgins, J., Warnken, J., Sherman, P. P. and Teasdale, P. R. (2002). Surveys if users  
22 and providers of recycled water: quality concerns and directions for applied  
23 research *Water Research* **36**, 5045-5056.
- 24 Hinkebein, T. E. and Price, M. K. (2005). Progress with the desalination and water  
25 purification technologies US roadmap *Desalination* **182**, 19-28.
- 26 Hurliman, A. and McKay, J. (2003). Community attitudes to an innovative dual water  
27 supply system at Mawson Lakes South Australia. In *OzWater 2003*. Perth,  
28 Western Australia.
- 29 Hurlimann, A. and McKay, J. (2007). Urban Australians using recycled water for  
30 domestic use - An evaluation of the attributes of price, saltiness, colour and  
31 odour using conjoint analysis *Journal of Environmental Management* **83**, 93-  
32 104.
- 33 IDA (2006). IDA Worldwide Desalting Plant Inventory. In *No 19 in MS Excel format*.  
34 Oxford, UK: Media Analytics Ltd.
- 35 International Water Management Institute (IWMI) (2006). Insights from the  
36 Comprehensive Assessment of Water Management in Agriculture. In  
37 *Stockholm World Water Week*. Colombo, Sri Lanka.
- 38 Johnson, J. F. (1979). Renovated waste water: an alternative supply of municipal  
39 water supply in the United States. In *University of Chicago, Department of*  
40 *Geography Research Paper No.135*.
- 41 Kaercher, J. D., Po, M. and Nancarrow, B. E. (2003). Water recycling community  
42 discussion meeting I (Unpublished Manuscript). In *Australian Research*  
43 *Centre for Water in Society*. Perth.

- 1 Kasperson, R. E., Baumann, B., Dwarkin, D., McCauley, D., Reynolds, J. and Sims, J.  
2 (1974). Community adoption water reuse system in the United States. In  
3 Washington, DC: Office of Water Resources Research, US Dept. Interior.
- 4 Lake, P. S. and Bond, N. R. (2006). Australian futures: freshwater ecosystems and  
5 human water usage *Futures in press*.
- 6 Lattemann, S. (2003). Guidelines for the Environmental Sound Management of  
7 Seawater Desalination Plants in the Mediterranean Region. In  
8 *UNEP/MAP/MEDPOL, Sea Water Desalination in the Mediterranean:  
9 Assessment and Guidelines. MAP Technical Reports Series No. 139*  
10 (UNEP/MAP). Athens.
- 11 Lattemann, S. (Submitted). WHO guidance on desalination: Results of the work group  
12 on environmental impacts. In *Proceedings of the IDA World Congress on  
13 Desalination and Water Reuse*. Maspalomas, Gran Canaria, Spain.
- 14 Lattemann, S. and Höpner, T. (2007). Environmental impact and impact assessment  
15 of seawater desalination *Desalination In Press*, 1-15.
- 16 Marks, J., Cromar, N., Fallowfield, H., Oemcke, D. and Zadoroznyj, M. (2002).  
17 Community experience and perceptions of water reuse. In *IWA World Water  
18 Congress*. Melbourne.
- 19 Marks, J. S. (2003). The sociology of “disgust” towards the use of reclaimed water. In  
20 *Water Recycling Australia 2nd National Conference* (S. I. A. Australian Water  
21 Association, National Water Recycling Forum), pp. 1-11. Brisbane,  
22 Queensland, Australia.
- 23 Marks, J. S. (2006). Taking the public seriously: the case of potable and non potable  
24 reuse *Desalination* **187**, 137-147.
- 25 Marks, J. S., Martin, B. and Zadoroznyj, M. (2006). Acceptance of water recycling in  
26 Australia: National baseline data *Community Consultation*, 151-157.
- 27 Meerganz von Medeazza, G. L. (2005). "Direct" and socially-induced environmental  
28 impacts of desalination *Desalination* **185**, 57-70.
- 29 Milliken, J. G. and Lohman, L. C. (1985). Analysis of baseline survey: Public  
30 attitudes about Denver water and wastewater reuse *Journal of American  
31 Waterworks Association* **77**, 72.
- 32 Olson, B. H., Henning, J. A., Marshack, R. A. and Rigby, M. G. (1979). Educational  
33 and social factors affecting public acceptance of reclaimed water. In *Water  
34 Reuse Symposium*, pp. 1219-1231. Denver, Colorado.
- 35 Po, M., Kaercher, J. D. and Nancarrow, B. E. (2004). Literature review of factors  
36 influencing public perceptions of water reuse. In *CSIRO Land and Water*.
- 37 Raluy, G., Serra, L. and Uche, J. (2006). Life cycle assessment of MSF, MED and RO  
38 desalination technologies *Energy in press*.
- 39 Russell, S. (2004). Community responses and consultation. In. Wollongong:  
40 University of Wollongong.
- 41 Sims, J. H. and Baumann, D. (1974). Renovated waste water: The question of public  
42 acceptance *Water Resources Research* **10**, 659-665.



- 1 Stone, R. and Kahle, R. (1974). Wastewater Reclamation. In *Socio Economics,*  
2 *Technology and Public Acceptance.* Washington, DC: Office of Water  
3 Resource Research, US Department of the Interior.
- 4 Strang, V. (2004). *The meaning of water.* Berg.
- 5 Sumpter, J. P. (2005). Endocrine disrupters in the aquatic environment: an overview  
6 *Acta Hydrochimica Hydrobiologica* **33**, 9-16.
- 7 Suzuki, D. (1997). *The sacred balance.* Allen & Unwin.
- 8 Ternes, T. A., Stumpf, M., Mueller, J., Haberer, K., Wilken, R.-D. and Servos, M.  
9 (1999). Behavior and occurrence of estrogens in municipal sewage treatment  
10 plants - I. Investigations in Germany, Canada and Brazil *The Science of the*  
11 *Total Environment* **225**, 81-90.
- 12 Thomas, J. F. and Syme, G. J. (1988). Estimating residential price elasticity of demand  
13 for water: A contingent valuation approach *Water Resource Research* **24**,  
14 1847-1857.
- 15 Toze, S. (2006). Water reuse and health risks - real vs. perceived *Desalination* **187**,  
16 41-51.
- 17 van Roon, M. (2007). Water localisation and reclamation: Steps towards low impact  
18 urban design and development *Journal of Environmental Management* **83**,  
19 437-447.
- 20 Weber, W. J. J. (2006). Distributed optimal technology networks: an integrated  
21 concept for water reuse *Desalination* **188**, 163–168.
- 22 Wintgens, T., Melin, T., Schäfer, A. I., Khan, S., Muston, M., Bixio, D. and Thoeye,  
23 C. (2005). The role of membrane processes in municipal wastewater  
24 reclamation and reuse *Desalination* **178**, 1-11.
- 25
- 26

# 1 Tables and Figures

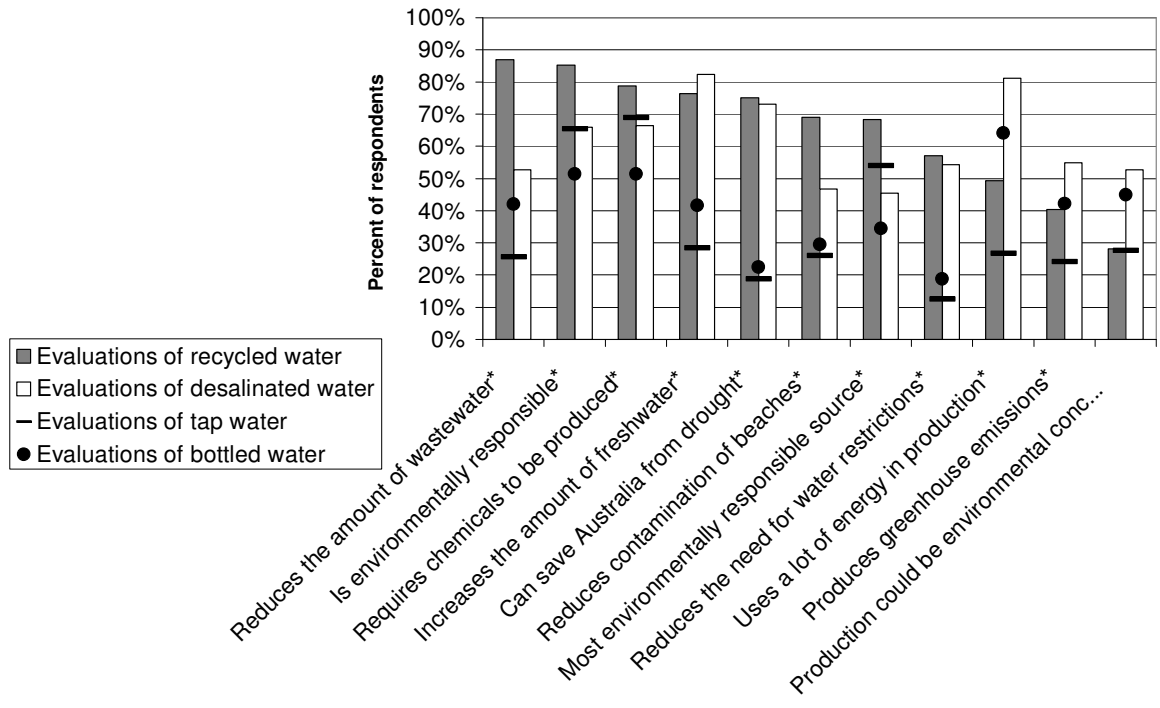
2 Table 1: Segment differences in socio-demographic profiles

	General Strong accepters	Recycled Water Strong accepters	Desalinated Water Strong accepters	Others	p-value
<b>Age</b>					
Mean	46.2	45.3	44.9	42.6	0.013
Std. Deviation	13.9	14.5	14.2	14.8	
<b>Gender</b>					
Male	58	55	57	45	0.004
Female	42	45	43	55	
<b>Education</b>					
some secondary school	8	11	4	15	0.010
school certificate	9	14	14	10	
higher school certificate	18	15	17	19	
other college	11	8	8	8	
university (undergraduate)	15	17	12	16	
university (postgraduate)	22	20	24	21	
<b>Occupation</b>					
Clerical or service worker	10	11	7	12	0.003
professional	33	26	37	23	
unemployed	2	2	6	6	
retired	11	12	12	8	
manager or administrator	18	27	19	17	
sales	8	4	6	8	
tradesperson	2	4	2	3	
small business owner	6	5	6	6	
home-duties	8	7	2	11	
transport worker	2	1	1	3	
labourer	1	2	1	3	
<b>Favourite TV channel</b>					
Channel 4 – WIN	8	5	8	4	0.001
Channel 5 – ABC	20	22	14	12	
Channel 7 - PRIME	20	28	27	26	
Channel 8 – SBS	10	5	3	3	
Channel 10 – ten	17	18	20	22	
Other channel	19	19	18	22	
I do not watch TV frequently	6	3	9	9	
<b>Newspaper use</b>					
Mean	3.7	4.1	4.1	3.3	0.000
Std. Deviation	2.5	2.3	2.4	2.4	
<b>Switch entire water supply to recycled water</b>					
under no circumstances	9	9	46	33	0.000
not pay anything for my water	7	6	13	16	
pay more than half of the current	19	23	20	19	
pay the same price as I am paying now	52	52	21	26	
pay more for water than I am paying now	13	9	1	6	
<b>Switch entire water supply to desalinated water</b>					
under no circumstances	7	20	5	22	0.000
not pay anything for my water	6	7	11	17	
pay more than half of the current	14	23	25	17	
pay the same price as I am paying now	56	40	45	35	
pay more for water than I am paying now	18	11	14	9	

1

Figure 1: Comparative perceptions/knowledge about environmental issues

3



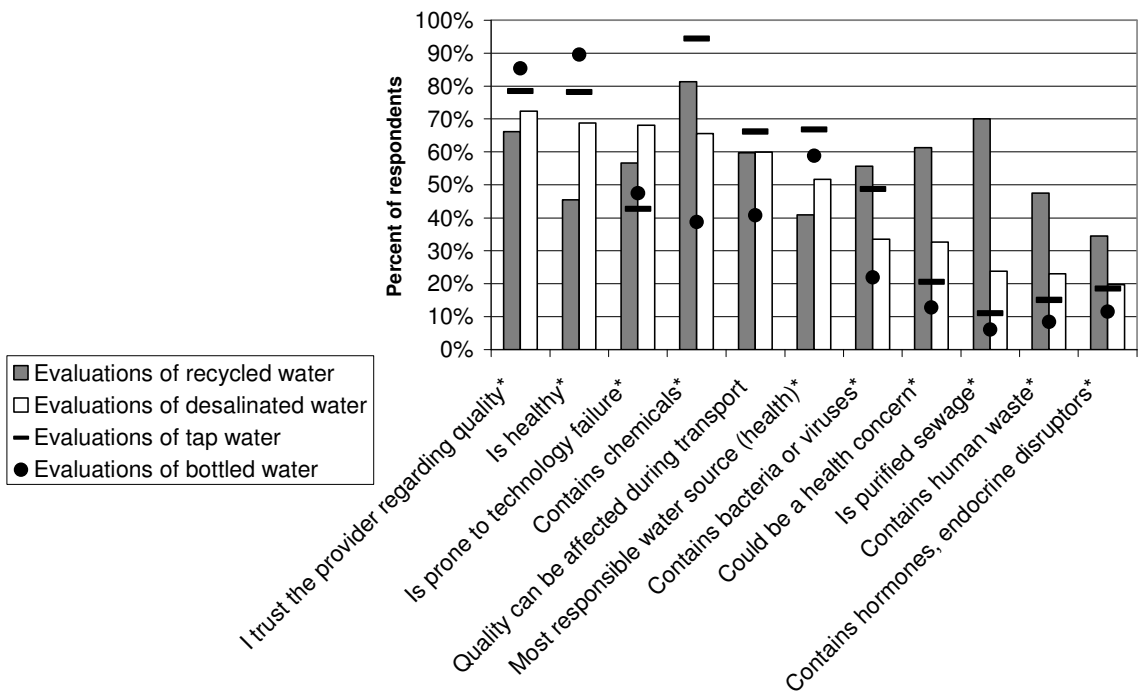
4

5

1

Figure 2: Comparative perceptions/knowledge about health issues

2



3

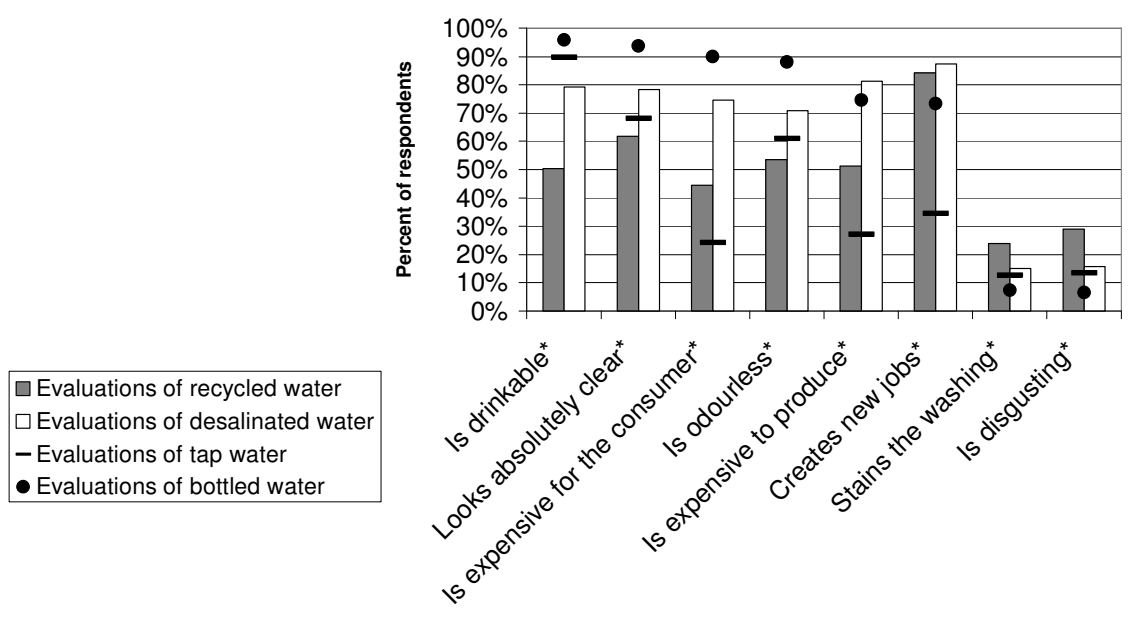
4

5

1

Figure 3: Comparative perceptions of general nature

2



3

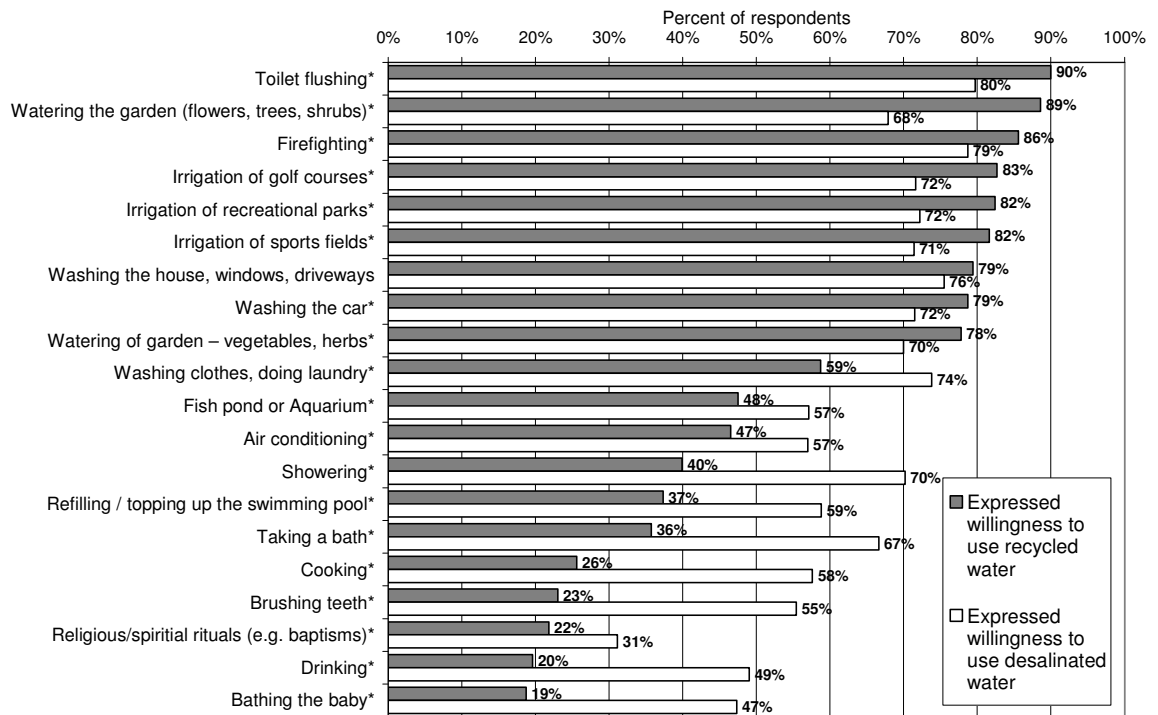
4

5

1

Figure 4: Comparative likelihood of use

2



3

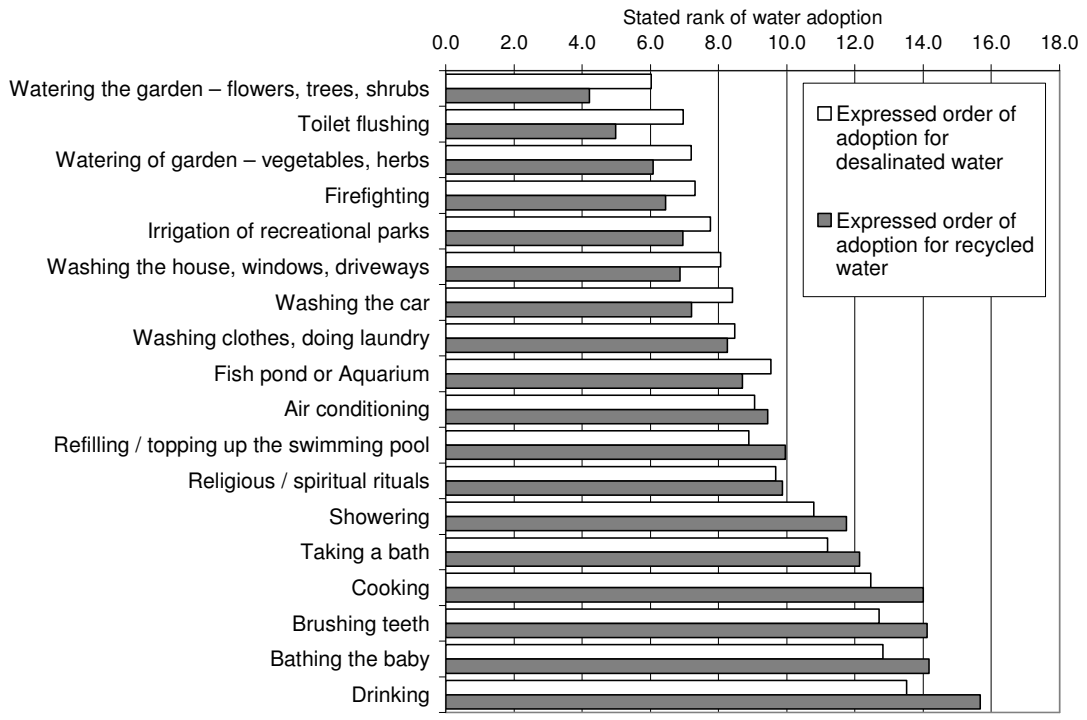
4

5

1

Figure 5: Order of adoption of Recycled and Desalinated water

2



3

4

5

6