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Expert opinion on risks to the long-term viability of residential recycled water schemes: An Australian study

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ABSTRACT

The water sector needs to make efficient and prudent investment decisions by carefully considering the long-term viability of water infrastructure projects. To support the assessment and planning of residential recycled water schemes in Australia, we have sought to clarify scheme objectives and to further define the array of critical risks that can impact the long-term viability of schemes. Building on historical information, we conducted a national survey which elicited responses from 88 Australian expert practitioners, of which 64% have over 10 years of industry experience and 42% have experience with more than five residential recycled water schemes. On the basis of expert opinion, residential recycled water schemes are considered to be highly relevant for diversifying and improving water supply security, reducing wastewater effluent discharge and pollutant load to waterways and contributing to sustainable urban development. At present however, the inability to demonstrate an incontestable business case is posing a significant risk to the long-term viability of residential recycled water schemes. Political, regulatory, organisational and financial factors were also rated as critical risks, in addition to community risk perception and fall in demand. The survey results shed further light on the regulatory environment of residential recycled water schemes, with regulatory participants rating the level and impact of risk factors higher than other survey participants in most cases. The research outcomes provide a comprehensive understanding of the critical risks to the long-term viability of residential recycled water schemes, thereby enabling the specification of targeted risk management measures at the assessment and planning stage of a scheme.

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1. Introduction

Residential recycled water schemes have been operational in Australia for over two decades. Since the first scheme was commissioned in 1994 - Rouse Hill in Sydney, New South Wales - numerous schemes have been developed in New South Wales, Queensland, South Australia and Victoria (West et al., 2016). Despite the lengthy period of operation, water industry practitioners continue to debate the importance and long-term viability of residential recycled water schemes (Radcliffe, 2015; Taylor et al., 2011). The reluctance to develop residential recycled water schemes is due, in part, to the historical performance of schemes and the current economic, political and environmental conditions of Australia (Marsden Jacob Associates, 2013; West et al., 2016). A proportion of schemes have suffered challenges resulting in thirty-percent delayed in commissioning or prematurely decommissioned (West et al., 2016). In recent years, the water sector has been criticised for over-investment in inefficient water services, namely recycled water schemes (Productivity Commission, 2011). Consequently, the Productivity Commission (2014) has called for improved decision making in the assessment, development and implementation of public infrastructure.

Making informed investment decisions requires an understanding of the range of risks and uncertainties which may arise throughout the life-cycle of a project (Institute for Sustainable Futures, 2013a; Samset and Volden, 2016). Building Queensland (2016) highlight the need for risk management to inform, and be informed by, each step in the project assessment process. This is especially the case at the front-end phase of a project when the

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opportunity to reduce risk and uncertainty is greatest (Edkins et al., 2013; Klakegg, 2009; Samset and Volden, 2016; World Bank, 1996).

A comprehensive understanding of risk will aid the development of a robust business case and will enable the specification of targeted measures for managing risks throughout the life-cycle of a recycled water scheme (Department of Infrastructure and Transport, 2010; Poole et al., 2014; Rajaram et al., 2014; Samset and Volden, 2016). Gaining insight to the opinions of project stakeholders will provide a broader understanding of risk and uncertainty and will enable the integration of stakeholder concerns in the decision making process (Linkov and Ramadan, 2005). Identifying and addressing critical risk factors will also aid in informing the development of improved frameworks and guidelines for the planning and operation of residential recycled water schemes (Institute for Sustainable Futures, 2013a; Marsden Jacob Associates, 2013; Moglia et al., 2011).

Despite considerable research on recycled water schemes, few attempts have been made to explicitly define the complex array of risks to the long-term viability of recycled water schemes (Kunz et al., 2016). To address this knowledge gap, West et al. (2016) conducted a detailed investigation of the historical performance of 21 Australian schemes. The research identified and defined 34 risk factors arising from six sources with the potential to impact the long-term viability of schemes. The authors identified that critical risks have historically comprised: 1. unanticipated operational costs, 2. legal and contractual arrangements, 3. regulatory requirements and approval process and 4. customer complaints and expectations not met (West et al., 2016). However, the authors noted that the study was constrained by the limited data and information available to assess the criticality of specific risk factors. In particular, 'soft' risk factors (Crawford and Pollack, 2004), including *organisational change*, were challenging to assess due to a lack of information and the intertwined nature of these risk factors with 'hard' factors (West et al., 2016).

Aven (2016) suggests that, where historical data is limited, available data and information should be supplemented with expert opinion to enable a broader understanding of risk. The elicitation of expert opinion can facilitate the synthesis of available knowledge to inform policies, frameworks and guidelines (Knol et al., 2010). While expert opinions are subjective, they nonetheless aid in supporting the risk assessment and decision making process (Aven, 2016). To date, the elicitation of expert opinion pertaining to the importance of residential recycled water schemes, and risks to the long-term viability of schemes, has been limited. A notable exception was a national survey conducted by Dobbie et al. (2013) which aimed to understand how social and institutional barriers were impeding the transition to sustainable urban water management in Australia. While the survey considered third pipe systems, the survey was not specific to residential recycled water schemes nor was the survey targeted at practitioners with residential recycled water scheme experience. As a result, the ratings of receptivity and risk may have been skewed by practitioners with limited residential recycled water scheme experience. Additionally, the scheme objectives, risk factors and risk rating criteria were inadequately defined and ambiguous, thereby introducing uncertainty to the rating of risk factors.

To aid the assessment and planning process for residential recycled water schemes we have sought to develop a broader understanding of risks to the long-term viability of schemes. Through the elicitation of expert opinion, we have assessed the importance and objectives of residential recycled water schemes and the risks to the long-term viability of schemes. Building on historical knowledge, we have refined the understanding of critical risk factors and have provided recommendations for addressing critical risks at the assessment and planning stage of a residential recycled water scheme.

2. Research method

2.1. Expert survey questionnaire

A national survey questionnaire was conducted to elicit expert opinion on the importance and objectives of residential recycled water schemes and the risks to the long-term viability of schemes. Opinions pertaining to risk are subjective and influenced by a range of social, psychological, contextual and cultural factors (Douglas and Wildavsky, 1982; Kasperson et al., 1988; Slovic, 1987; Tversky and Kahneman, 1974). As such, the aim of the survey was to enable the ranking of risk factors on the basis of expert opinion, rather than to obtain an explicit, quantitative rating of the likelihood of occurrence and impact of risk factors on scheme objectives.

Expert residential recycled water scheme practitioners were targeted for participation in the survey questionnaire: public and private proponents with direct involvement in the planning, implementation, operation, management and/or regulation of one or more residential recycled water schemes in Australia. The survey was conducted online between October and November 2015. The survey responses were anonymous and did not contain any identifying information in excess of the participant's professional background and location.

2.1.1. Survey design

The survey questionnaire was designed to facilitate ease of use for the participants, to ensure specificity and clarity in the wording of questions and to enable the objectives of the research study to be achieved. The introduction stated that the overarching aim of the survey was to elicit expert opinion on risks to the long-term viability of residential recycled water schemes. An explicit definition of 'residential recycled water scheme' was provided: *the provision of treated stormwater, greywater and/or wastewater through dual piping for non-potable residential use comprising toilet flushing, cold washing machine, garden watering and/or other outdoor use*. The full survey questionnaire is provided in the Supplementary Material and each part summarized as follows:

Part One: General background information

Survey participants were requested to provide information relating to their professional background, location, experience and role with respect to residential recycled water schemes.

Part Two: Importance and objectives of residential recycled water schemes

Participants were asked to rate how strongly they personally believed that residential recycled water schemes were important for meeting sustainable urban water management and/or sustainable urban development objectives and how strongly they believed that their organisation agreed with this statement. Ratings were allocated on a five-point Likert scale from negative to positive: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = strongly agree. A five-point rating scale was adopted for ease of use (Baxter et al., 2015; Preston and Colman, 2000). The question itself was positively framed however a negative to positive rating scale was adopted to potentially reduce the risk of bias towards a positive response (Hartley and Betts, 2010; Tourangeau et al., 2004).

Participants were also requested to rate the relevancy of specific objectives of residential recycled water schemes on a five-point, negative to positive rating scale: 1 = not relevant, 2 = somewhat

relevant, 3 = relevant, 4 = very relevant and 5 = essential. Lastly, participants were requested to define and rate additional objectives of residential recycled water schemes which were not previously considered.

Part Three: Risk factor rating for residential recycled water schemes

To enable the expert practitioners to present their knowledge in a consistent and familiar manner (Knol et al., 2010), part three of the survey questionnaire was formulated to represent a risk assessment process commonly used in industry. Thirty-four (34) risk factors[1] arising from six sources, identified and characterised by West et al. (2016), were assessed in the survey questionnaire. The research conducted by West et al. (2016) was the first to comprehensively identify and explicitly define the range of risks to the long-term viability of residential recycled water schemes, and hence these risk factors were adopted for expert assessment.

The objectives and risk rating criteria were clearly defined and presented in a five-by-five risk matrix. A five-point rating scale was adopted to enable ease of use (Baxter et al., 2015; Preston and Colman, 2000) and to reflect the scales commonly used in industry risk assessment (Blackmore et al., 2008; Natural Resource Management Ministerial Council et al., 2006). Participants were requested to rate the risk factors on the likelihood of occurrence: 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high; and impact on objective: 1 = insignificant, 2 = low, 3 = moderate, 4 = high and 5 = severe. Participants were also requested to define and rate additional risk factors which have the potential to impact the long-term viability of residential recycled water schemes.

2.1.2. Survey review and testing

Intensive review and testing of the survey questionnaire was undertaken to ensure that the survey questions, risk rating criteria and risk factor definitions were well-defined and correctly interpreted. The survey was reviewed by personnel with water industry experience: two personnel from independent research bodies, two personnel from independent consulting firms and one public water utility representative. The reviewers were requested to provide comment on the ease of survey completion, the effectiveness of the questions with respect to the survey objectives, the clarity of the survey questions and the validity of the risk factors for categorisation and ranking. The risk factor validation criteria, presented in the Supplementary Material, were based on Morgan et al. (2000) and adapted for relevance to residential recycled water schemes. Specifically, the risk factors were critiqued on consistency, compatibility with administrative systems, equity and compatibility with human cognitive limitations (Morgan et al., 2000). The survey was revised in accordance with the review comments which pertained predominately to improvements in the definition of risk rating criteria. Additional testing was undertaken by a variety of researchers and consultants who have water industry experience. The personnel involved in the review and testing of the survey questionnaire were independent to the personnel who participated in the survey questionnaire.

2.1.3. Survey participants

A range of distribution techniques were employed to increase the sample size, to enable the survey to be disseminated broadly and to reduce the potential for selection bias. These techniques comprised distribution through purposive sampling and snowballing; distribution through the Water Services Association of Australia and the Cooperative Research Centre for Water Sensitive Cities; and distribution through LinkedIn groups including the Australian Water Association and Engineers Australia. To identify expert practitioners for purposive sampling and snowballing, the following steps were undertaken:

1. Residential recycled water schemes developed, or proposed to be developed, in Australia were identified;
2. Where possible, relevant personnel representing the practitioners involved in the planning, implementation, operation, management and/or regulation of each residential recycled water scheme were identified;
3. An email with the survey link was sent to each of the identified personnel with a request for participation and for the survey to be forwarded to other personnel who have the necessary experience to participate in the survey (snowballing); and
4. Authors of grey literature and peer reviewed academic literature specific to residential recycled water schemes were identified. An email with the survey link was sent to each of the identified personnel with a request for participation and for the survey to be forwarded to other personnel who have the necessary experience to participate in the survey.

The purposive sampling identified 41 potential participants. A total of 88 practitioners participated in the survey questionnaire, with 65 surveys completed and an additional 23 partially completed. The population of residential recycled water scheme experts is unknown; however it is likely that the survey sample size was satisfactory due to the range of distribution techniques employed. Background information of the survey respondents is summarized in Table 1 and the location of respondents is shown in Fig. 1.

2.1.4. Data analysis

The risk level for each factor was calculated from the survey results as follows:

$$\textit{Risk level} = \textit{likelihood of occurrence} \times \textit{impact on objective}$$

The survey data were analysed using IBM SPSS Statistics 24. Exploratory data analysis was conducted to report descriptive information for each survey question. Frequency distributions, total sample size (N), group sample size (n), mean (M), median (Mdn) and standard deviation (SD) values have been reported. The box-and-whisker plots present the minimum, lower quartile, mean, median, upper quartile and maximum values of selected questionnaire results, with outliers plotted as individual points. The mean ratings of likelihood, impact and risk level have been presented to enable illustration of the variance in ratings. The median data values have been reported with the results of the non-parametric statistical tests.

Non-parametric statistical techniques have been utilised to investigate statistically significant differences between and within groups. Non-parametric techniques were utilised as (i) data normality could not be assumed, (ii) the survey data was ordinal and (iii) small and variable sample sizes were present in some cases. The Kruskal-Wallis test was applied to identify statistically significant differences in responses between grouping variables. The results of the Kruskal-Wallis test are presented as: chi-square value χ^2 (degrees of freedom df, total sample size N), p-value ($p < 0.05$), effect size r. The Mann-Whitney *U* test, with Bonferroni adjustment, was then applied to identify the source of significant differences between grouping variables. Statistically significant differences for paired comparisons with moderate effect size or greater have been presented only ($r > 0.3$).

[1] One risk factor, *impacts to conventional infrastructure* (factor 21), was unintentionally overlooked during creation of the survey.

Table 1
Background information of survey respondents (N = 88).

Practitioner group		*Years of industry experience*	
Public water utility[2]	29	<10	32
Private water utility[1]	2	10–20	32
Urban development[2]	4	20+	24
Consultant[2]	27		
Research[2]	8		
Local government	9		
Regulator (State government)	9		
Recycled water scheme role		*Gender*	
Planning	30	Female	22
Design and/or construction	17	Male	66
Operation and/or management	12		
Multiple	13		
Regulator	9		
Researcher	7		
Type of residential recycled water scheme that survey participants have experience with		*Number of residential recycled water schemes that survey participants have experience with*	
Stormwater harvesting and reuse	7	<2	37
Wastewater treatment and recycling reuse[3]	37	2–5	23
Greywater treatment and treatment[3]	2	5+	28
Both stormwater and wastewater	42		

Due to the low number of participants in certain categories, the following groupings were made for the purpose of statistical analysis:
[1] Private water utility participants (n = 2) were grouped with public water utility participants (n = 29).
[2] Urban development participants (n = 4) and research participants (n = 8) were grouped with consulting participants (n = 27).
[3] Greywater recycling and reuse (n = 2) were grouped with wastewater recycling and reuse (n = 37).
[+] Northern Territory (n = 1) was grouped with Western Australia (n = 8).

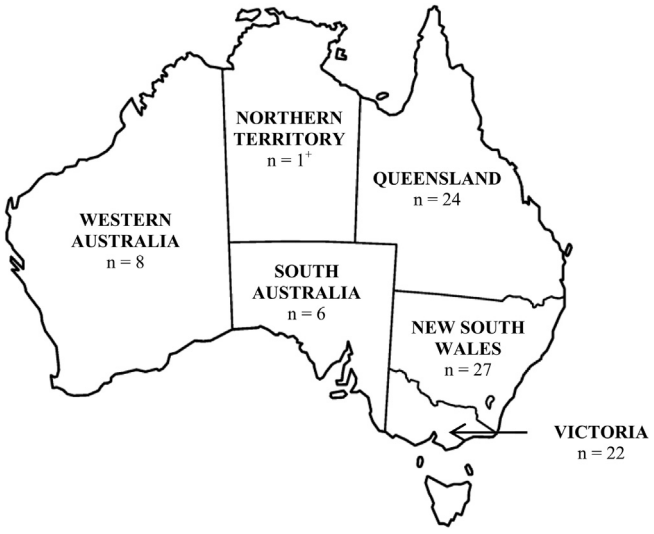


Fig. 1. Location of survey respondents (adapted from Golbez (2006) with permission).

3. Results

3.1. Importance of residential recycled water schemes

Fig. 2 illustrates how strongly the participants personally believed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives (A) and how strongly they believed that their organisation agreed (B).

Seventy-two percent (72%) of the survey participants agreed or strongly agreed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives, while 56% believed that their organisation agreed or strongly agreed. For the participants personal belief (Fig. 2A), 15% neither agreed nor disagreed and 14% disagreed or strongly disagreed in the importance of residential recycled water schemes. Fig. 3 illustrates the variance in the response of sectors (A) and states (B).

Based on the median response, all practitioner groups agreed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives (Fig. 3A). Participants from New South Wales, Queensland and South Australia agreed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives, based on the median response, while participants from Victoria and Western Australia agreed or strongly agreed (Fig. 3B).

The response by Victorian participants was statistically significantly higher than New South Wales participants for how strongly they personally believed, $U = 178.5$, $p = 0.012$, $r = 0.4$, and for how strongly they felt that their organisation believed, $U = 169.5$, $p = 0.008$, $r = 0.4$, in the importance of schemes for meeting sustainable urban water management and/or sustainable urban development objectives. The response by Victorian participants was also significantly higher than Queensland participants with respect to how strongly they felt that their organisation believed in the importance of schemes, $U = 156.0$, $p = 0.013$, $r = 0.4$.

It is important to note that private water utilities, which are driving the development of residential recycled water schemes in New South Wales (West et al., 2016), are under-represented in this study and therefore the results for New South Wales do not reflect the opinions of this important group of stakeholders.

Fig. 4 illustrates the range in survey responses pertaining to the relevancy of objectives of residential recycled water schemes.

Based on the median response, the objectives considered to be relevant ($Mdn = 3$) are: reduce peak potable water demand, defer or reduce capital investment in conventional infrastructure, reduce stormwater runoff and pollutant load to waterways (stormwater harvesting and reuse) and provide for enhanced urban amenity. The objectives considered to be highly relevant ($Mdn = 4$) are: diversify and improve water supply security, reduce wastewater effluent discharge and pollutant load to waterways (wastewater treatment and recycling) and contribute to sustainable urban development. Certain survey participants provided comment on additional objectives which they believed were relevant to residential recycled water schemes, as follows:

- Improve community participation and involvement in decision making, enable the community to contribute to sustainable outcomes, improve public awareness of the challenges facing urban water sustainability and influence consumer behaviour;
- Build stakeholder confidence in recycled water and potentially future indirect potable reuse; and
- Facilitate recycling and recovery of nutrients, provide fit-for-purpose water supply and reuse a valuable resource which would otherwise go to waste.

3.2. Risks to the long-term viability of residential recycled water schemes

Fig. 5 presents the mean likelihood of occurrence and impact

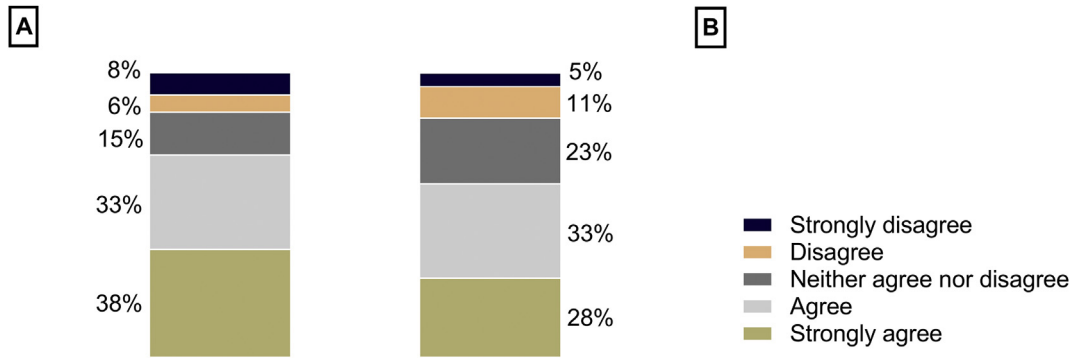


Fig. 2. Importance of residential recycled water schemes for meeting sustainable urban water management and/or sustainable urban development objectives (A - personal, B - organisation).

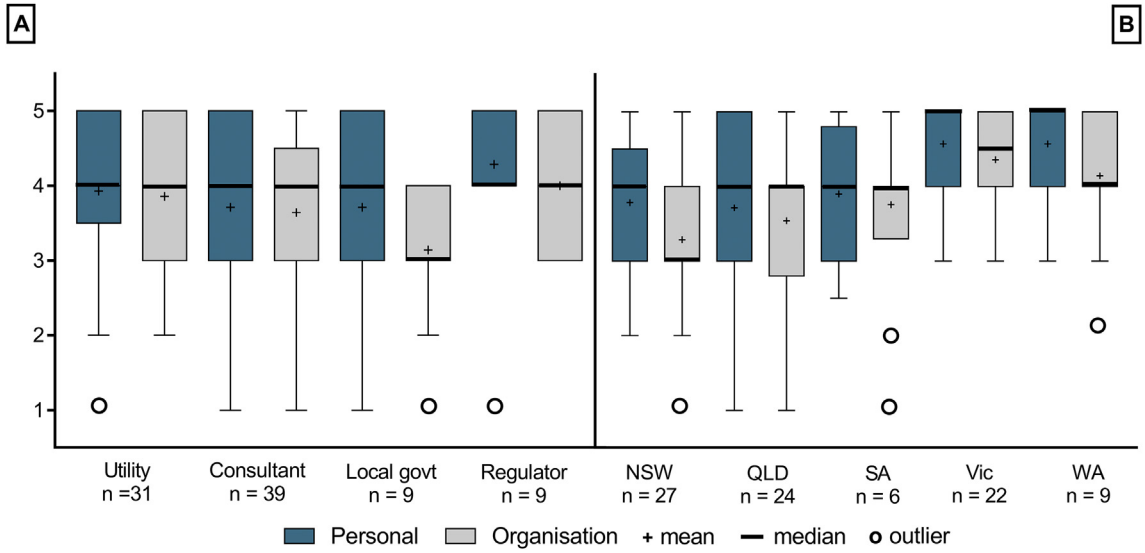


Fig. 3. Importance of residential recycled water schemes for meeting sustainable urban water management and/or sustainable urban development objectives (A – practitioner group, B - state) (1 = strongly disagree, 3 = neither agree nor disagree and 5 = strongly agree).

rating for 33 risk factors, arising from six sources, with the potential to impact the long-term viability of residential recycled water schemes.

Fig. 5 illustrates that high likelihood/high impact risk factors arise from financial and economic, political and regulatory, implementation and operation, and social sources. Based on expert opinion, *inability to demonstrate incontestable business case* (risk factor 27) is the greatest risk to the long-term viability of residential recycled water schemes at present; ranking highest on risk level ($M = 14.7$, $SD = 4.6$) and impact on objectives ($M = 3.9$, $SD = 0.71$). All political and regulatory risk factors were rated as high likelihood/high impact, as were organisational risk factors, namely *organisational change* and *organisational risk perception*. Additional financial and economic risk factors rated as high likelihood/high impact comprised *unanticipated capital costs* (risk factor 28) and *unanticipated operational costs* (risk factor 31). *Community risk perception* (risk factor 3), arising from the social risk source, and *fall in demand* (risk factor 17), arising from the implementation and operation risk source, were also rated as high likelihood/high impact risk factors.

On the basis of expert opinion, *climate change/climate variability* (risk factor 2) is considered to have the highest likelihood of occurrence ($M = 2.4$, $SD = 0.86$). Although *public health risk* (risk factor 25) was rated as high impact ($M = 3.6$, $SD = 1.06$), expert practitioners viewed the likelihood of occurrence as low ($M = 2.8$, $SD = 0.87$). The risk factors rated as lowest likelihood of occurrence and impact on objective were *environmental health risk – compliance related* (risk factor 22) and *equity of access* (risk factor 6), respectively.

Fig. 6 presents the mean risk level rating for each practitioner group. For clarity, only the 15 highest rated risk factors are shown.

Fig. 6 illustrates variances in the risk level ratings of each practitioner group. Based on the mean response of water utility participants, *inability to demonstrate incontestable business case* is the greatest risk the long-term viability of residential recycled water schemes at present, while consultants viewed *change in government* as the greatest risk. Local government participants viewed *regulatory requirements* as the greatest risk the long-term viability of residential recycled water schemes at present while regulatory participants viewed *assessment and design error* and *inability to demonstrate incontestable business case* as the greatest risks.

Clear variances in the risk level ratings of *unanticipated operational cost*, *public health risk* and *assessment and design* can be observed in Fig. 6, with regulatory participants viewing these factors as high risk while other participant groups rated the risk

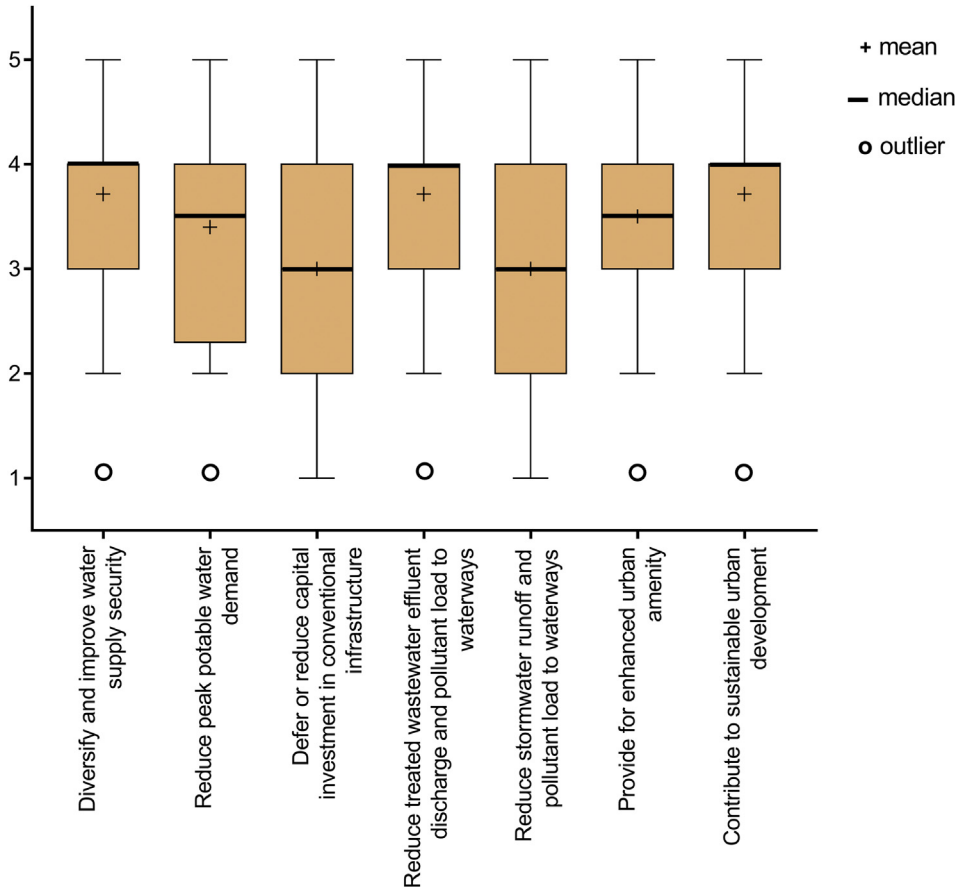


Fig. 4. Objectives of residential recycled water schemes (1 = not relevant, 3 = relevant and 5 = essential).

factors as medium risk. Interestingly, regulatory participants viewed the risk of *regulatory requirements, change in government* and *approval process* higher than that of water utility participants. Local government participants viewed the risk of *regulatory requirements* and *approval process* as high to very high, while water utility participants viewed the risk as high and medium to high, respectively. Local government participants also rated the risk of *perceived benefits do not materialise* statistically significantly lower than utility participants (M = 7.1 and M = 10.9, respectively), U = 41.5, p = 0.01, r = 0.4.

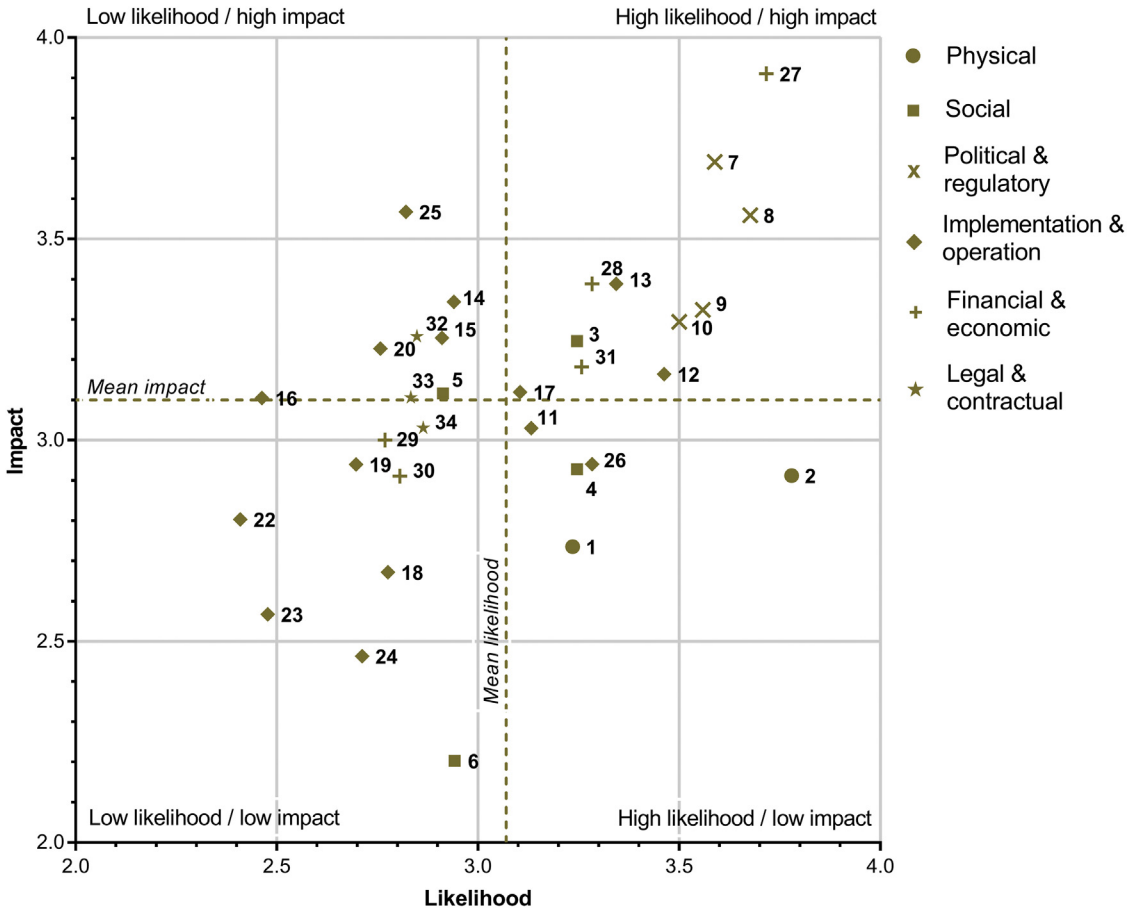
Analysing across all 33 risk factors, variances were noted in the overall mean and median risk rating of practitioner groups. Regulatory participants had the highest overall mean and median risk level rating (M = 11.0, Mdn = 10.5) while local government participants had the lowest overall mean and median risk level rating (M = 9.4, Mdn = 9.0). Water utility participants and consulting participants had a similar overall mean and median risk level rating (M = 9.6, Mdn = 9.0 and M = 9.9, Mdn = 9.0, respectively). A Kruskal-Wallis test, which accounts for variable and small sample sizes (Pallant, 2010), revealed statistically significant variances in the risk level rating for *environmental health risk – compliance related* and *environmental value risk – stormwater related* between regulatory participants and local government participants. Fig. 7 illustrates the variance in risk level rating for environmental health and environmental value risk factors.

Regulators rated the risk of *environmental health risk – compliance related* with a higher score (M = 6.0) than local government participants (M = 4.0), which was statistically significantly different at U = 28.5, p = 0.03, r = 0.7. Regulators also rated the risk level of *environmental value risk – stormwater related* with a higher mean score (M = 9) than local government participants (M = 4), which was statistically significantly different at U = 28.5, p = 0.03, r = 0.7. The difference in risk level rating of *environmental value risk – greywater/wastewater related* between practitioner groups was not statistically significant, although variances can be observed in the risk level rating between practitioner groups (Fig. 7).

Fig. 8 presents the mean impact rating for each practitioner group. For clarity, the 15 risk factors with the highest impact rating are shown.

Fig. 8 illustrates similar trends to that of the risk level ratings, with regulatory participants rating the impact of risk factors higher than other participants in most cases. For all risk factors, excepting *regulatory pricing policy*, regulatory participants rated the impact higher than that of water utility participants. Large variances in the ratings of *assessment and design error*, *inability to agree on contractual terms* and *management and maintenance error* can be observed between regulatory participants and local government and water utility participants. The mean impact rating by regulatory participants for *inability to agree on contractual terms* (M = 4.2) was statistically significantly higher than water utility participants (M = 3.4), U = 30.5, p = 0.01, r = 0.4.

Analysing across all 33 risk factors, variances were noted in the overall mean and median impact rating of practitioner groups. Regulatory participants had the highest overall mean and median impact rating (M = 3.4, Mdn = 3.5) while water utility and local government participants had the lowest overall mean and median impact rating (M = 3.0, Mdn = 3.0). Regulatory participants rated the impact of *environmental health risk – compliance related* with a



Low likelihood / high impact
25 Public health risk
14 Assessment and design error
15 Construction error
32 Inability to agree on contractual terms
20 Management and maintenance error
5 Customer expectations not met
33 Poorly defined contractual arrangements
16 Technology risk

Low likelihood / low impact
34 Conflict between partners
29 Reduction in developer charges
30 Reduction in non-potable water price
19 Operator error
22 Environmental health risk - compliance related
18 Asset condition uncertainty
23 Environmental value risk - stormwater related
24 Environmental value risk - greywater/wastewater related
6 Equity of access

High likelihood / high impact
27 Inability to demonstrate incontestable business case
7 Change in government
8 Regulatory requirements
9 Approval process
10 Regulatory pricing policy
13 Organisational change
28 Unanticipated capital costs
12 Organisational risk perception
31 Unanticipated operational costs
3 Community risk perception
17 Fall in demand

Low likelihood / high impact
11 Optimism bias
26 Perceived benefits do not materialise
4 Customer complaints
2 Climate change / climate variability
1 Change in catchment characteristics

Fig. 5. Mean likelihood and impact of risks to the long-term viability of residential recycled water schemes.

higher mean score ($M = 3.7$) than local government and utility participants ($M = 2.1$ and $M = 2.6$, respectively), which was statistically significantly different at $U = 3$, $p = 0.005$, $r = 0.8$ and $U = 27$, $p = 0.01$, $r = 0.5$ respectively. Regulatory participants also rated the impact of *environmental value risk – stormwater related* and *environmental value risk – greywater/wastewater related* with a higher mean score ($M = 3.2$) than local government participants ($M = 2.1$), which was statistically significantly different at $U = 5$, $p = 0.01$, $r = 0.7$.

Variances in risk level ratings were also observed between states. Based on the mean response, New South Wales, South Australia and Victorian participants viewed *inability to demonstrate incontestable business case* as the greatest risk the long-term viability of residential recycled water schemes at present, while Queensland and Western Australia participants viewed *regulatory requirements* as the greatest risk. Queensland participants rated the risk level of *optimism bias* as medium ($M = 10.7$), while participants from Victoria rated the risk as low ($M = 8.1$), which was statistically significantly different at $U = 100$, $p = 0.02$, $r = 0.4$. Participants from New South Wales rated the risk level of *reduction in developer*

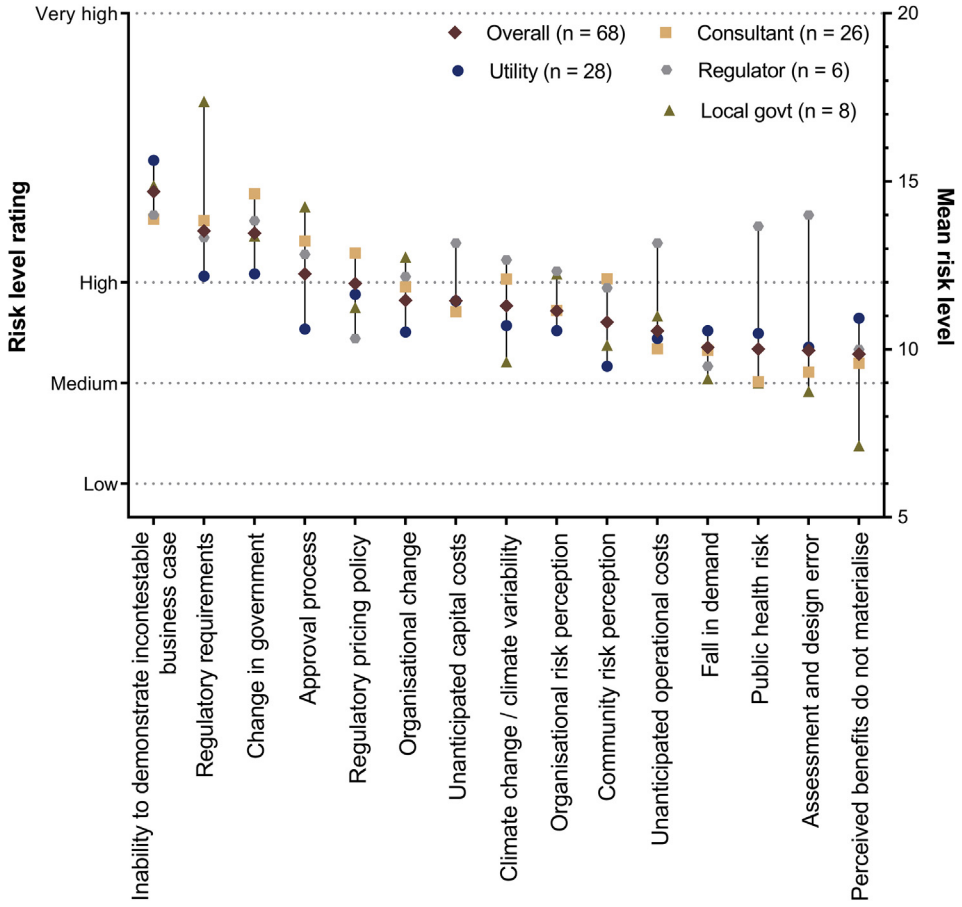


Fig. 6. Mean risk level rating for each practitioner group.

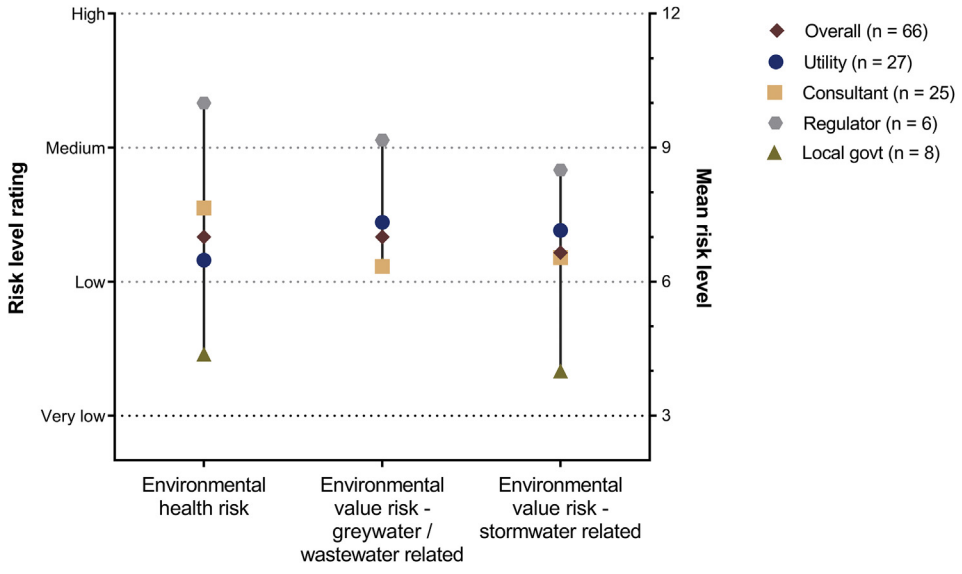


Fig. 7. Mean risk level rating for environmental health and environmental value risk.

charges and *reduction in non-potable water price* as medium (M = 10.8 and M = 10.2), which was statistically significantly different to the low rating by participants from Victoria (M = 7.8 and M = 6.7, respectively).

Analysing across all 33 risk factors, Western Australia had the highest overall median risk level rating (Mdn = 10.5), while New South Wales and Queensland participants had the highest overall mean risk rating (M = 10.3, Mdn = 9.0). Victoria and South Australia had the lowest overall mean and median risk level ratings (M = 9.2, Mdn = 9.0) and (M = 8.1, Mdn = 9.0), respectively. Interestingly,

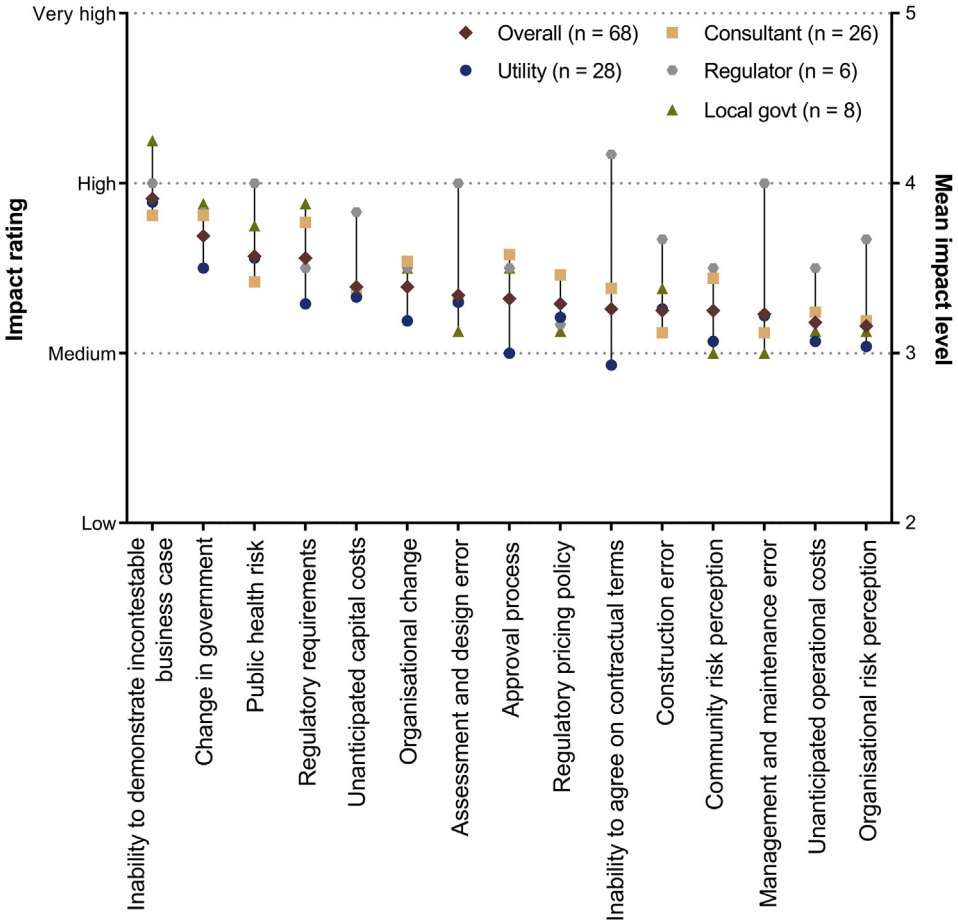


Fig. 8. Mean impact rating for each practitioner group.

variances were noted between organisations in the rating of impact on objective, whereas variances were noted between states in the rating of likelihood of occurrence.

Certain survey participants provided comment on additional risk factors which they believed were relevant to residential recycled water schemes, as follows:

- Over-treatment risk: recycled water treatment plants are likely to achieve a greater log reduction in pathogens than required by regulation due to the addition of non-essential process steps. However, in some cases, log removal credits are not obtained due to the expensive validation testing required;
- Inability of stakeholders to agree on and/or quantify intangible or 'soft' benefits (i.e. amenity of public open space); and
- In some cases, the stakeholder who finances the scheme is different to the stakeholder who benefits from the scheme.

4. Discussion

4.1. Importance and objectives of residential recycled water schemes

Despite challenges in the design and operation of residential recycled water schemes in Australia to date (West et al., 2016), 72% of survey participants agreed or strongly agreed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives. The participants who disagreed or strongly disagreed primarily represented a range of roles in New South Wales (no private water utilities) and design and construction roles in Queensland.

86% of survey respondents from Victoria agreed or strongly agreed in the importance of residential recycled water schemes for meeting sustainable urban water management and/or sustainable urban development objectives. The majority of survey respondents from Victoria represented water utilities (64%), while New South Wales participants primarily represented water utilities and consultancies (41% each) and Queensland participants primarily represented consultancies (58%). Victorian participants also represented a higher percentage of personnel involved at the planning stage of a scheme (50%) as opposed to New South Wales (30%) and Queensland (25%). The higher rating of importance, and the lower overall mean risk rating by Victorian participants, may reflect the familiarity of water utility personnel with residential recycled water schemes, with these personnel being involved in all stages of scheme planning, development and implementation. There is a greater number of schemes in Victoria than other states, with over seven operational schemes at present and plans to significantly expand the service area (West et al., 2016). The success of recycled water schemes in Victoria is likely a result of the drive by water utilities to adopt innovative technologies, in addition to substantive political backing and regulatory support (Ferguson et al., 2013). In Victoria, water utilities have the authority to mandate dual piping in residential developments (Infrastructure Victoria, 2016; Yarra Valley Water, 2015), which is not the case in New South Wales or Queensland. In Queensland, government

agencies have moved from supporting schemes to mandating that recycled water schemes will no longer be considered in residential developments (Gold Coast City Council et al., 2013; Radcliffe, 2015). It is important to note again that the survey results from New South Wales do not represent the opinions of private water utilities which are driving the development of residential recycled water schemes in New South Wales. Only one survey participant was from a regulatory agency in Victoria, and hence the survey results also do not reflect the opinions of Victorian regulators.

The survey results demonstrate the relevancy of residential recycled water schemes for diversifying and improving water supply security and reducing wastewater effluent discharge and pollutant load to waterways. The results also highlight the intangible objectives which are attributed to residential recycled water schemes, namely to contribute to sustainable urban development, to improve community participation and involvement in decision making and to build stakeholder confidence in water recycling. Projects with intangible objectives, or 'soft' projects, require qualitative approaches to the definition and evaluation of success measures (Crawford and Pollack, 2004). Crawford and Pollack (2004) suggest that, in managing soft projects, emphasis should be placed on negotiation and accommodation between stakeholders, the subjective interpretation and judgment of qualitative data and on learning and exploration as opposed to strictly defined, quantitative project goals.

4.2. Risks to the long-term viability of residential recycled water schemes

The survey outcomes illustrate that the greatest risk to the long-term viability of residential recycled water schemes at present is the *inability to demonstrate an incontestable business case*. Since the Millennium Drought ceased in 2012, Government grants have significantly declined and capital and borrowing constraints have been imposed on water service providers (Marsden Jacob Associates, 2013). Non-potable recycled water schemes are costly in comparison to conventional services (Marsden Jacob Associates, 2013; Roefs et al., 2016; Utilities Science and Innovation Committee, 2015), with costs exacerbated when other risk factors arise, namely a *fall in demand* or changes in *regulatory requirements* (Marsden Jacob Associates, 2013; West et al., 2016). Additionally, *unanticipated capital costs* and *unanticipated operational costs*, also identified by survey participants as critical risk factors, have arisen in numerous schemes due to a lack of data necessary to inform accurate cost estimates at the planning stage (Utilities Science and Innovation Committee, 2015; West et al., 2016). In general, information on the risk and returns of water infrastructure investments is lacking (Jin et al., 2015), and this especially the case for innovative and alternative water schemes. The premature decommissioning of some schemes has caused practitioners to reassess the financial viability of residential recycled water schemes, in turn influencing *organisational risk perception* and approval of the business case (Marsden Jacob Associates, 2013; Taylor et al., 2011; West et al., 2016). Additionally, the inability of scheme stakeholders to agree on and quantify the intangible benefits of schemes, and to allocate costs between stakeholders based on beneficiaries, poses a challenge to the development of a robust and incontestable business case (Marsden Jacob Associates, 2013).

The political and regulatory environment of residential recycled water schemes was rated as a critical risk source, comprising the risk factors: *change in government, regulatory requirements, regulatory pricing policy* and *approval process*. This risk source has been ranked consistently high for public sector initiatives (Commonwealth of Australia, 2010), industries and projects (Cheung and Chan, 2011; Holburn, 2012; Luis et al., 2015) and infrastructure investment in both emerging and developed markets (World Economic Forum, 2015). *Change in government* is a significant concern for infrastructure investors as the length of the asset lifetime, contractual relationships and payback period for infrastructure investments far exceeds the political term (World Economic Forum, 2015).

Regulatory requirements and *approval process* were rated higher by local government participants than water utility participants. Local government participants differed from water utility participants in that they had experience with stormwater harvesting and reuse schemes independently from wastewater treatment and recycling schemes. As a result, the higher risk rating by local government participants may represent challenges associated with regulatory requirements and gaining approval for stormwater harvesting and reuse schemes.

Of interest are the higher risk and impact ratings by regulatory participants in comparison to other participant groups. While caution needs to be adopted in the interpretation of these results due to the small sample size of regulatory participants ($n = 6$), the survey results show clear trends in the ratings. In particular, large variances in the ratings of *unanticipated operational cost*, *public health risk*, *assessment and design, environmental value* and *environmental health risk* were noted. Despite minimal adverse environmental or public health impacts to date in Australia (West et al., 2016), the perception of environmental and public health risks held by regulators remains high, in turn influencing the over-design of schemes and the over allocation of capital and operational expenditure (Institute for Sustainable Futures, 2013b). Marsden Jacob Associates (2013) identified that the differing opinions of regulators, private water utilities and public water utilities with respect to commercial and risk related aspects of residential recycled water schemes has introduced complexity to the decision making process and caused proponents to revert to more conventional solutions in some cases. It is interesting to note that regulatory participants recognise the risk of *regulatory requirements, change in government* and *approval process* to the long-term viability of residential recycled water schemes, with regulatory participants rating these factors as high risk.

Organisational change was rated by survey participants as a critical risk factor (high likelihood/high impact ratings) and has occurred historically with associated impact to the timing and cost of recycled water scheme delivery (Brace and Fahrner, 2009). The enhanced experience of Victorian water utilities in the planning, implementation and operation of residential recycled water schemes may be reflected in the statistically lower risk level rating of *optimism bias* and *organisational change*. Increased knowledge and experience is likely to reduce the impact of organisational change and result in improved decision making with respect to alternative water schemes.

Equity of access was rated as low likelihood/low impact, which may suggest that residential recycled water scheme practitioners do not believe that the equitable provision of recycled water services is as important as other risk factors. Although this may not be a significant factor at present, there is potential for *equity of access* to be desired by the community (Mankad et al., 2015), whose opinions are not represented in this study, and required by the government in the future (Productivity Commission, 2014). Reid (2012) suggests that maintaining social justice will aid in mitigating the impact of the politicisation of public sector decision making, of which rights, equity, participation and access to government services comprise social justice.

4.3. Critical risk factors

Table 2 presents a comparison of the historical risks identified in

West et al. (2016) and current risks identified through the survey questionnaire.

Table 2 illustrates that the current opinion of risk held by expert practitioners does not differ significantly to that observed historically, excepting legal and contractual risk factors. Historically, challenges with legal and contractual arrangements were found to occur prior to commissioning or at handover of the recycled water scheme to a public entity, with the impact predominately felt by the private stakeholder (West et al., 2016). As few developers or private water utilities participated in the survey, the risk rating may reflect the lower opinion of impact held by public water utilities. While legal and contractual arrangements may not pose a significant risk to public proponents, these risk factors may be a deterrent to private investment in residential recycled water schemes. It is interesting to note that regulatory participants rated *inability to agree on contractual terms* as high impact, while other participants rated the risk as medium to low impact. This may be a reflection of the experience that regulators have with private water utilities and urban developers.

Although other soft risk factors, including *community risk perception*, *organisational change* and *organisational risk perception*, were identified historically, the impact of these factors was challenging to assess and quantify through investigation of the historical performance of schemes. The survey results indicate that these risk factors are considered as critical to the long-term viability of residential recycled water schemes, thereby reiterating the notion that the collection of expert opinion is an effective approach to increasing the body of knowledge where historical information is limited.

The impact of *public health risk* was rated as high by regulatory participants, although historically there has been low to minimal impact to public health despite the occurrence of cross-connections in at least six residential recycled water schemes (West et al., 2016). Regulatory participants also rated *environmental value* and *environmental health risk* as high and medium, respectively, although adverse environmental impacts have been low to minimal to date. The experience of regulatory participants, based on number of years' experience in the water sector and number of residential recycled water schemes, was slightly less than that of water utility participants. The higher risk and impact ratings by regulatory participants may be reflective of the level of experience, although these results should be interpreted with caution due to the small sample size ($n = 6$).

4.4. Recommendations for improved project risk management

The historical and current critical risk factors influence the ability of proponents to demonstrate an incontestable business case for residential recycled water schemes, and hence improved management of these factors would likely improve the potential for business case approval. As noted by survey participants, agreement between stakeholders on the intangible benefits of residential recycled water schemes, and quantification of these benefits, is required. As far as practicable, intangible benefits should be incorporated in the cost benefit analysis undertaken to support the business case for residential recycled water schemes (Building Queensland, 2016; Marsden Jacob Associates, 2013). The sharing of costs between stakeholders, as opposed to the water utility bearing majority of costs, would aid in reducing the financial burden on water utilities and improving the likelihood of business case approval.

Atkinson et al. (2006) suggest that for projects with qualitative objectives, performance evaluation frameworks should be developed that match the complexity of the project, recognise the different perspectives of stakeholders and consider the varying definitions of project 'success'. Regular reporting to the community and project stakeholders on the performance of a scheme, against the performance evaluation framework, is required to promote understanding and to reduce the risk perceptions held by various stakeholders. Additionally, the water sector would benefit from the adoption of improved contingency planning, handover processes and procedures to minimise the impact of organisational change on the successful delivery of residential recycled water schemes.

A balance should be sought between the fostering of innovative and efficient water services and the regulation of such services. The World Economic Forum (2015) suggest that robust regulation and contracts, stability of laws and regulation, reliable and efficient administration and reliable dispute-resolution mechanisms are required to manage political and regulatory risks associated with public-sector infrastructure investment. Further evidence should be provided to regulatory agencies to demonstrate that *public health*, *assessment and design, environmental value* and *environmental health risk* have been low to date.

A more pragmatic approach to the design of schemes, with respect to the level of treatment and capacity of schemes, would aid in reducing the capital and operational costs of residential recycled water schemes. Staging of schemes, or varied levels of service, may

Table 2
Historical and current risks to the long-term viability of residential recycled water schemes.

Risk source	Historical risks[b]	Current risks[a]
Physical	Climate change/climate variability	
Social	Community complaints[a]	Community risk perception
	Community expectations[a]	
Political & regulatory	Regulatory requirements[a]	Regulatory requirements
	Approval process[a]	Change in government
		Approval process
		Regulatory pricing policy
Implementation and operation	Organisational change	Organisational change
		Organisational risk perception
	Fall in demand	Fall in demand
	Public health risk	
	Technology risk	
Financial & economic	Reduction in water price	Inability to demonstrate incontestable business case
	Reduction in developer charges	Unanticipated capital costs
	Unanticipated capital costs	Unanticipated operational costs
	Unanticipated operational costs[a]	
Legal & contractual	Legal & contractual arrangements[a]	

[a] Critical risk factors.
[b] West et al. (2016).

reduce the risk associated with a fall in demand. Schemes should be designed on the basis of regulatory requirements, rather than risks perceptions (Institute for Sustainable Futures, 2013b), to reduce excess expenditure pertaining to non-essential treatment steps and subsequent over-treatment.

4.5. Study limitations

The research outcomes were limited by the number of regulatory, local government and private water utility participants. An enhanced understanding of regulatory risk opinions would enable revision or confirmation of the study findings and would aid the development of targeted measures for addressing these concerns. Gaining further insight to the opinions of private water utilities, and the challenges that they face in the development and implementation of residential recycled water schemes, would be highly valuable.

The risk assessment component of the survey was formulated to represent an industry standard risk assessment. Additionally, a Likert-style scale was adopted in the study to ensure a consistent and industry standard approach to the rating of risk factors (Baxter et al., 2015). While this facilitated the understanding of likelihood and impact ratings by industry practitioners, it also introduced limitations to the study outcomes. Weaknesses inherent to Likert scales include central tendency bias and acquiescence bias (Choi and Pak, 2005). An alternative approach to the rating of critical risk factors may have comprised the ranking of risk factors by expert practitioners, rather than rating on the basis of likelihood of occurrence and impact on objectives. However, this differs to the traditional risk assessment approach familiar to the water sector and may have introduced confusion and complexity. As the focus of the study was on ranking risk factors, rather than obtaining an explicit, quantitative rating of risk, we believe that the survey design is adequate and effective.

In developing the online survey, we neglected to include risk factor 21, *impacts to conventional infrastructure*, and hence were unable to assess the criticality of this risk factor. However, survey participants did not suggest this as an additional risk factor, suggesting that the risk factor may not pose critical at present. Given the rating of organisational risk factors, namely *organisational change* and *organisational risk perception*, it would be prudent to further investigate organisational risk with respect to residential recycled water schemes. Specifically, assessment of the capacity of organisations to effectively develop and implement residential recycled water schemes would be of benefit.

5. Conclusion

To aid the assessment and planning of residential recycled water schemes, we have sought to develop an improved understanding of scheme objectives and to further define the critical risks to the long-term viability of schemes. A national survey of 88 expert practitioners identified that over 70% of participants agreed or strongly agreed that residential recycled water schemes are important for meeting sustainable urban water management and/or sustainable urban development objectives. On the basis of expert opinion, residential recycled water schemes are considered to be highly relevant for diversifying and improving water supply security, reducing wastewater effluent discharge and pollutant load to waterways and contributing to sustainable urban development.

At present however, the inability to demonstrate an incontestable business case is posing a significant risk to the long-term viability of residential recycled water schemes. This risk factor is influenced by political and regulatory, organisational and financial risks, in addition to community risk perception and fall in demand. The survey results shed further light on the regulatory environment of residential recycled water schemes, with regulatory participants predominately rating risk and impact higher than other survey participants. To aid in reducing judgment of risk, it is recommended that further evidence is provided to regulatory agencies to demonstrate that public health, assessment and design, environmental value and environmental health risk associated with residential recycled water schemes has been low historically.

In correlation with historical knowledge, the survey proved effective in defining the objectives of residential recycled water schemes and the critical risks to the long-term viability of schemes. To improve the assessment and planning of schemes, the quantification of intangible benefits and the improved management of soft risk factors are required. Specifically, we recommend the development of performance evaluation frameworks which reflect the intangible benefits of schemes, the appropriate distribution of benefits and costs between scheme stakeholders and the development of contingency planning and handover processes for managing organisational change.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.watres.2017.04.077.

References

Atkinson, R., Crawford, L., Ward, S., 2006. Fundamental uncertainties in projects and the scope of project management. Int. J. Proj. Manag. 24 (8), 687–698.
Aven, T., 2016. Risk assessment and risk management: review of recent advances on their foundation. Eur. J. Operational Res. 253 (1), 1–13.
Baxter, K., Courage, C., Caine, K., 2015. Understanding Your Users: a Practical Guide to User Research Methods. Elsevier.
Blackmore, J.M., Wang, X., Wang, C.-H., Yum, K.-K., Diaper, C., Zhou, M., McGregor, G.B., 2008. Risk Assessment and Management: a Guide for Integrated Urban Water Systems. eWater Technical Report. eWater Cooperative Research Centre, Canberra.
Brace, C., Fahrner, S., 2009. In-house Validation of the Aurora Class a Recycled Water Plant. Exhibition Centre – Bendigo.
Building Queensland, 2016. Preliminary Business Case Template and Guide. Business Case Development Framework.
Cheung, E., Chan, A.P.C., 2011. Risk factors of public-private partnership projects in China: comparison between the water, power, and transportation sectors. J. Urban Plan. Dev. 137 (4), 409–415.
Choi, B.C.K., Pak, A.W.P., 2005. A catalog of biases in questionnaires. Preventing chronic disease: public Health Research. Pract. Policy 2 (1), 1–13.
Commonwealth of Australia, 2010. Empowering Change: Fostering Innovation in the Australian Public Service. Australian Government.
Crawford, L., Pollack, J., 2004. Hard and soft projects: a framework for analysis. Int. J. Proj. Manag. 22 (8), 645–653.
Department of Infrastructure and Transport, 2010. Infrastructure Planning and Delivery: Best Practice Case Studies. Commonwealth of Australia.
Dobbie, M.R., Brookes, K.L., Brown, R.R., 2014. Transitions to a water-cycle city: risk perceptions and receptivity of Australian urban water practitioners. Urban Water J. 11 (6), 444–460.
Douglas, M., Wildavsky, A., 1982. Risk and Culture: an Essay on the Selection of Technological and Environmental Dangers. University of California Press, Ltd., London, England.

Edkins, A., Geraldi, J., Morris, P., Smith, A., 2013. Exploring the front-end of project management. Eng. Proj. Organ. J. 3 (2), 71–85.
Ferguson, B.C., Brown, R.R., Frantzeskaki, N., de Haan, F.J., Deletic, A., 2013. The enabling institutional context for integrated water management: lessons from Melbourne. Water Res. 47 (20), 7300–7314.
Golbez, 2006. Australia states, via Wikimedia Commons.
Gold Coast City Council, Logan City Council, Queensland Urban Utilities, Redland Water and Water, U, 2013. SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code): Design Criteria.
Hartley, J., Betts, L.R., 2010. Four layouts and a finding: the effects of changes in the order of the verbal labels and numerical values on Likert - type scales. Int. J. Soc. Res. Methodol. 13 (1), 17–27.
Holburn, G.L.F., 2012. Assessing and managing regulatory risk in renewable energy: contrasts between Canada and the United States. Energy Policy 45, 654–665.
Infrastructure Victoria, 2016. Victoria's 30-year Infrastructure Strategy. State of Victoria.
Institute for Sustainable Futures, 2013a. Making Better Recycled Water Investment Decisions; Building Industry Capability to Make Recycled Water Investment Decisions. Prepared by the Institute for Sustainable Futures. University of Technology, Sydney for the Australian Water Recycling Centre of Excellence.
Institute for Sustainable Futures, 2013b. Matching Risk to Treatment; Building Industry Capability to Make Recycled Water Investment Decisions. Prepared by the Institute for Sustainable Futures. University of Technology, Sydney for the Australian Water Recycling Centre of Excellence.
Jin, Y., Li, B., Roca, E., Wong, V., 2015. Water as an investment: liquid yet illiquid! Appl. Econ. 48 (9), 731–745.
Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X., Ratick, S., 1988. The social amplification of risk a conceptual framework. Risk Anal. 8 (2), 177–187.
Klakegg, O.J., 2009. Pursuing relevance and sustainability: improvement strategies for major public projects. Int. J. Manag. Proj. Bus. 2 (4), 499–518.
Knol, A.B., Slottje, P., van der Sluijs, J.P., Lebret, E., 2010. The use of expert elicitation in environmental health impact assessment: a seven step procedure. Environ. Health 9, 19.
Kunz, N.C., Fischer, M., Ingold, K., Hering, J.G., 2016. Drivers for and against municipal wastewater recycling: a review. Water Sci. Technol. 73 (2), 251–259.
Linkov, I., Ramadan, A.B., 2005. Comparative Risk Assessment and Environmental Decision Making. Kluwer Academic Publishers, Dordrecht.
Luis, A., Lickorish, F., Pollard, S., 2015. Assessing interdependent operational, tactical and strategic risks for improved utility master plans. Water Res. 74, 213–226.
Mankad, A., Walton, A., Alexander, K., 2015. Key dimensions of public acceptance for managed aquifer recharge of urban stormwater. J. Clean. Prod. 89, 214–223.
Marsden Jacob Associates, 2013. Economic Viability of Recycled Water Schemes. Prepared by Marsden Jacob Associates for the Australian Water Recycling Centre of Excellence. Queensland, Brisbane.
Moglia, M., Cook, S., Sharma, A.K., Burn, S., 2011. Assessing decentralised water solutions: towards a framework for adaptive learning. Water Resour. Manag. 25 (1), 217–238.
Morgan, M., Florig, H., DeKay, M., Fischbeck, P., 2000. Categorizing Risks for Risk Ranking, 20(1).
Natural Resource Management Ministerial Council, 2006. National guidelines for water recycling: managing health and environmental risks. In: Environment Protection and Heritage Council and Australian Health Ministers' Conference. Biotext Pty Ltd.
Pallant, J., 2010. SPSS Survival Manual: a Step by Step Guide to Data Analysis Using SPSS. Open University Press, Berkshire, England.
Poole, E., Toohey, C., Harris, P., 2014. In: Heath, A., Read, M. (Eds.), Public Infrastructure: a Framework for Decision-making. Reserve Bank of Australia, Sydney.
Preston, C.C., Colman, A.M., 2000. Optimal number of response categories in rating scales: reliability, validity, discriminating power, and respondent preferences. Acta Psychol. 104, 1–15.
Productivity Commission, 2011. Australia's Urban Water Sector. Final Inquiry Report, Canberra.
Productivity Commission, 2014. Public Infrastructure. Inquiry Report, Canberra.
Radcliffe, J.C., 2015. Water recycling in Australia – during and after the drought. Environ. Sci. Water Res. Technol. 1 (5), 554–562.
Rajaram, A., Le, T.-M., Kaiser, K., Kim, J.-H., Frank, J., 2014. The Power of Public Investment Management: Transforming Resources into Assets for Growth. Directions in Development, Group, W.B, Washington, DC.
Reid, M., 2012. Politicisation of the Australian Public Service: Social and Environmental Issues. University of Tasmania.
Roefs, I., Meulman, B., Vreeburg, J., Spiller, M., 2017. Centralised, decentralised or hybrid sanitation systems? Economic evaluation under urban development uncertainty and phased expansion. Water Res. 109, 274–286.
Samset, K., Volden, G.H., 2016. Front-end definition of projects: ten paradoxes and some reflections regarding project management and project governance. Int. J. Proj. Manag. 34 (2), 297–313.
Slovic, P., 1987. Perception of risk. Science 236.
Taylor, B., O'Halloran, K., Otto, A., Geranio, J., 2011. The Pros and Cons of an A+recycled Water Scheme: Two Years on (Twin Waters, South East Queensland).
Tourangeau, R., Couper, M.P., Conrad, F., 2004. Spacing, position, and order: interpretive heuristics for visual features of survey questions. Public Opin. Q. 68 (3), 368–393.
Tversky, A., Kahneman, D., 1974. Judgment under uncertainty: heuristics and biases. Science 185 (4157), 1124–1131.
Utilities Science and Innovation Committee, 2015. Inquiry into Auditor-general Report to Parliament 14 : 2012–13 Maintenance of Water Infrastructure Assets. Department of Energy and Water Supply.
West, C., Kenway, S., Hassall, M., Yuan, Z., 2016. Why do residential recycled water schemes fail? A comprehensive review of risk factors and impact on objectives. Water Res. 102, 271–281.
World Bank, 1996. 1994 Evaluation Results. World Bank Operations Evaluation Department.
World Economic Forum, 2015. Strategic Infrastructure: Mitigation of Political & Regulatory Risk in Infrastructure Projects (Prepared in collaboration with The Boston Consulting Group, Geneva, Switzerland).
Yarra Valley Water, 2015. Recycled Water in Your Area. Yarra Valley Water, 12/22/2015. http://www.yvw.com.au/Home/Waterandsewerage/recycledwater/Developersandplumbers/index.htm.