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RISK PERCEPTIONS & DECISION-MAKING IN THE WATER INDUSTRY

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Abstract

Water shortage issues as a result of drought and population increases have been documented frequently in Australia. Decisions that planners and practitioners make in the future water security arena are imperative in ensuring the viability of population growth and agriculture in Australia. This research considers the decision-making of these practitioners to understand whether these decisions are made objectively, or have bias attached to them. This transparency is vital in considering that these individuals effectively make decisions using public funds, on behalf of many, including future generations.

Much of decision-making in the water sector is predominantly centred on risk assessment outcomes. This applies particularly in the case of options assessments, where many differing proposals are put forward to answer a problem or achieve a particular strategy. The water sector in Melbourne, Australia was assessed in detail in this study to shed light on these approaches. Current risk assessment practices within the water sector in Melbourne were analysed, across four water authorities. All of their risk approaches are similar in nature, as they are required to adhere to the standard ISO31000, therefore taking on a technical approach in risk measurement by way of risk matrices. This research considered these risk practices to understand whether they are effective in ensuring an objective outcome (i.e. regardless of the practitioner undertaking the risk assessment, the risk rating- low, medium, high or extreme- stays the same.) In this study, 77 participants were surveyed from four Melbourne water authorities. They were provided with seven fictional water projects (four that are familiar, three that are unfamiliar) and asked to undertake a risk assessment upon each. The scores obtained varied drastically between individuals, not only across all authorities but also amongst those assessors within each organisation. Results indicate that the current risk assessment practices employed in Melbourne water authorities cannot be considered to be objective.

To understand the variation in the scores between decision-makers, other risk theories were considered. The psychological theory of risk (also known as Cognitive Bias theory) was tested, along with the Cultural theory of risk. The psychological approach required psychometric testing across three of the fictional projects. Results show that dread had a

significant effect across all projects tested. Other factors such as 'dread related to perceived fatal risk' and a 'fear of the unknown' were found to be statistically significant in explaining the risk score for the one project only: using radiation in the treatment of water.

The Cultural theory of risk considers whether the risk scores obtained were due to the worldview of the risk assessors undertaking the measurement. Each respondent responded to a cultural cognition survey which placed them in one of four worldviews: hierarchist, egalitarian, individualist or fatalist. In regressing these worldviews to risk scores, it was found that no statistically significant relationship existed between the two.

Risk scores varied drastically between the respondents, indicating little objectivity, however the psychological theory of risk sheds light on the biases of risk assessors when undertaking these assessments, and especially the effect of dread in imagined scenarios. This research is unique in that the study is undertaken comparing risk matrix scores through to psychological attributes and cultural worldviews in the water sector, a sector fraught with preconceived notions of risk. Water authorities can take heed of these findings in ensuring they understand the bias intrinsic to their risk measurement approaches. This can help to guarantee that they are able to effectively plan for future problems of population growth and climate change in a way that is cognisant of personal bias.

Chapter 1

Introduction

Water shortage issues in Australia are not uncommon, with drought after drought driving poor agricultural output, affecting environmental flows into waterways, while also having an adverse impact upon our social environments such as parks and sporting fields. The Murray Darling Basin, a large key water resource in the South-East of Australia, is a good example of water shortages affecting many sectors. The revitalisation of the Murray-Darling debate in 2018 and 2019 highlights the importance of water as a public and politically-contentious issue. This debate on water shortage crises rears its head in the media and in public discourse every few years, highlighting that it is not new and similarly, not unexpected. This is not a story that is unique to Australia, with many other countries experiencing similar levels of climate variability issues followed by ensuing debate around the management of water. And yet business-as-usual approaches to managing water have been the driving force behind many decisions within the sector, potentially avoiding better solutions that are new or unfamiliar. The lack of take-up of new or unfamiliar projects is of chief concern when forecasts predict that water insecurity as a result of droughts is expected to heighten in the future, leading to increased saliency upon the way water resources are managed.

My experience within the water industry prompted questions of why new approaches are not adopted, leading me to this field of study. In the initial stages of my research, I sought to uncover some explanations for this reliance upon business-as-usual practices. I explored literature both within Australia and overseas to seek to understand any reason as to why new approaches may be shunned by water practitioners. The further I delved into each string of literature, the more I noticed that all the roads point back to an overarching element: risk. It is within the risk realm that I began looking in earnest to attempt to uncover or shed light on attitudes and behaviours. The concept of 'risk aversion' was something I heard highlighted by many within the industry as the culprit for this underdevelopment of new processes and overreliance on existing approaches. I wanted to determine how close to the truth this claim is. My PhD research then shifted from exploring existing innovation research through to one centred on risk-based decision-making. Through this process it highlighted to me that no research has been undertaken in the water sector to specifically understand why risk aversion may occur, in a psychological or cultural sense. Risk aversion may have played a role in the problem, and if so, to what extent?

Within this thesis, I then consider some alternatives to traditional risk management theories in attempting to understand how risk is perceived, and how this then could affect the take up of new projects. The following section describes in greater detail the problem briefly mentioned earlier in this introduction, followed by an outline of innovation in the water sector, taking us through to understanding the journey to risk. This then leads us well into framing the context of the aim of the research, and well as the scope, limitations and overall structure.

1.1. The Problem

The InterGovernmental Panel on Climate Change has predicted that uncertainty in rainfall could result in up to 40% decline in water resources if global warming increases by 2 degree Celsius above the current levels (Reisinger et al., 2014). The impact of climate change will subsequently create significant issues for the water sector globally, including a reduced water supply, lower average long-term stream flows, as well as an increase in the frequency of bushfires (Howe, Jones, Maheepala, & Rhodes, 2005, p. v).

Melbourne, Australia, has been selected as a case study in this research as water has been a contentious issue, in its management, funding, and allocation. Melbourne's climate has increasingly shifted, resulting in long periods of drought that have had a significant impact upon the water security of the region. Average stream flows in Melbourne are projected to be reduced by between 3 and 11% from the measured baseline by 2020, and between 7 and 35% by 2050 (Howe et al., 2005, p. v). As 90% of Melbourne's water supply is sourced directly from above ground catchment areas in the Yarra Ranges (east of the CBD), reduced levels of stream flows are likely to have a significant detrimental effect on water security (Howe et al., 2005, p. 6). In addition to this, Infrastructure Australia anticipates that Melbourne will reach approximately 6 million people by 2031, and 8.5 million people by 2061(Infrastructure Australia 2015, p. 24). These population increases will further strain water resources, prompting action in exploring non-traditional resource management options. For these reasons, a business-as-usual approach to water management will no longer suffice in a resource scarce future. Innovative solutions must be sought by water professionals and implemented to ensure water security for the Melbourne region.

Public infrastructure, including water and sewage services, is essential to the efficient functioning of urban areas. This infrastructure provides the resources necessary to support urban economies, environments and societies. Decisions surrounding the design and maintenance of public infrastructure (including water supply) involve the formal assessment of risk by experts[1]. The importance of understanding public perception of risk associated with urban infrastructure projects has gained prominence over the past two decades. This is in part due to public and political opposition to project proposals, which ultimately led to the abandonment of plans in some cases. This includes, but is not limited to, proposed potable recycled water systems in Toowoomba, Australia (Hurlimann & Dolnicar, 2010) and San Diego, USA in the 1990s (Mills, Karajeh, & Hultquist, 2004).

As water issues become ever-more concerning, this heightens the need for new approaches to dealing with supply and demand issues. Innovative projects exist, and are promoted heavily by private industry, however their take-up is relatively low within the water utilities themselves. This begs the question of why this is the case. Risk aversion comes up time and time again yet is not studied in any further detail.

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[1] The word 'expert' is used in this thesis to refer to a person with specialised knowledge in a particular area, in particular those who have mastered certain skills they utilise in their careers. It is used interchangeably with 'professional'.

1.2. Innovation in the Water Sector

The discussion on the notion of innovation within the context of Melbourne's water sector has increased significantly in recent years (Australian National Audit Office, 2009; Carswell, Dawes, & Walker, 2014; Deloitte, 2012; Hughes, Moore, & Kataria, 2011; Matheson, 2013; Mulgan, 2014; Rogers, Brown, de Haan, & Deletic, 2015; The Australian Federal Government, 2010; Torugsa & Arundel, 2016). Many researchers have noted that there are significant barriers to a fully innovative water industry and have attempted to explain what these may be (Brown, Farrelly, & Keath, 2009; Ferguson, Brown, & Deletic, 2013). However, extensive analysis of risk perceptions as a barrier has not been undertaken. In order to conduct a meaningful discussion on innovation and its barriers, the term needs to be defined. While there are a range of interpretations, the definition that this research will adopt is as articulated by the OECD:

> An innovation is the implementation of a new or significantly improved product (goods or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (Organisation for Economic Co-operation and Development, 2005).

Although this is a broad definition, it nonetheless encapsulates the varied nature of innovation, namely that the term does not exclusively refer to technological innovation, but also social and/or organisational innovation.

In this thesis, references made to innovation in the Melbourne water space relate primarily to the public sector, as the State Government in Victoria holds overall responsibility for the management of water services. Thus, the water authorities hold a monopoly over water services in their respective pre-defined areas. Innovation in this research is then focused exclusively on public sector innovation, not that arising from the private sector. The public sector represents the key decision-makers in water policy in Melbourne, be that at the departmental level, or within water authorities at the service-level. Even though water-related innovation may occur in the private sector, the adoption of new innovations must still go through the public sector. This is not necessarily the case in all low-scale innovations but applies to any major changes to policy or practice. Within the public sector, the motives for innovation tend to be significantly different from that of the private sector. The private sector is driven by profit motives and competition for market share, whereas in the public sector these types of motivations are largely non-existent (Deloitte, 2012). The public sector is heavily reliant on the will of the state Government at that time. As the Board of the water authorities is appointed by the State Government, and the Government is reliant on the public to be elected, the public sector is then by extension attentive to the views of the public. The motivation in the public sector towards innovation exists as a way to ensure public funds can be spent in an efficient way that also meets all the needs of the community. At times, a lack of incentives may be an issue for the public sector to innovate. An innovation is likely to be deemed undesirable by the public sector, if the cost and uncertainty associated with a return on investment is high (Ugur, 2013). Once again, leading to the topic of risk. As such, conducting an analysis of innovation in the public sector varies significantly from that of the private sector.

1.2.1. Relying on 'Need'

Innovation within the Melbourne urban water sector relies heavily on 'need'. In order for innovation to proceed, an external driver (such as drought, population increase or community pressure for action) must exist (Saleth & Dinar, 1999). This may have worked to propel action on water policy, as noted by the Management Advisory Committee, but can also serve to provide a restriction in times outside droughts to further innovation (The Australian Federal Government, 2010). This also applies in the case of the approval of large water projects, rendering it difficult to veer away from this pre-approved pathway at a later date, even if a superior innovation is discovered to take its place (Rogers et al., 2015).

Furthermore, existing stringent regulations within the water sector create a culture of risk aversion that ensures the difficulty of implementing novel technologies (Lundqvist & Turton, 2001). The rules and regulations around water technology and services are constantly changing and can be subjective. As a result, approval of an innovative practice may rely on a single assessor from a regulatory body and how they personally interpret and apply existing regulations (Mukheibir, Howe, & Gallet, 2015).

Water utilities and other water-related arms of the public sector tend to employ technical staff, which results in a prioritisation of technological innovation, to the detriment of social, economic or organisational innovation (Syme, 2008a). This can lead to technical solutions being applied in the context of supply and demand problems, when the problem could be framed in a slightly different way (for example, as a social problem, rather than technological one) to achieve more innovative solutions (Syme, 2008b). Due to this, there tends to be a preference for technological solutions over any other types of remedies.

This leads to the question of who should be the entity that is responsible for innovation in the water sector. A widespread expectation exists from the community that it should be the Government that assumes this position (Australian National Audit Office, 2009). However, this role is not officially articulated anywhere. The underlying expectation of the Government and its departments, acting as innovation champions in the industry, allows projects to be open to political interpretation and subject to criticisms of pork barrelling. In addition to this, the very nature of Government term cycles is at odds with innovative water planning. It is not unusual for a water strategy to require a significant lead-time to ensure proper implementation, and this can extend to ten years or more (Yarra Valley Water, 2006). As the state Government terms in Victoria are four years (and Federal Government terms are three years), a divide exists between the long-term strategies that will produce the best outcomes for the industry, and short-term goals that may provide results for the Government of the time (The Australian Federal Government, 2010, p. 33). If a long-term strategy is implemented and approved by the current Government, the plan runs the risk of termination if there is a change of Government within the project's timeframe.

Relying on need then unsurprisingly is impacted upon by media and public discourse, which can be described as contributing to the securitisation[2] of water. The very nature of invoking a water security discourse impacts previously mentioned risk-averse behaviours

[2] Securitisation refers to the act of forming a link between a particular issue and security. This strategy is used to create urgency, and a higher risk perception of an issue to elicit a response.

through the nature of an ever-increasing public scrutiny. The 'securitisation' literature effectively explores this phenomenon. The aim of securitisation is to shape discourse on water to engender feelings of urgency and panic, framing the issue as an existential crisis and a threat to the established way of life (Fischhendler, 2015). Additionally, the aim is to establish the problem in a position of utmost importance and urgency such that prompt action is required and methods that would not usually be accepted in times of low stress become viable options. Through instilling this sense of urgency, policymakers are given leniency by the media and the public in their decision-making practices (Fischhendler, 2015). This is due to the public anxieties surrounding the issue, prompting fast action to quell the fear and panic that has taken hold.

In the case of water, terms like 'water security' and 'water crisis' are used to create an environment of fear around the resource. These fears can be further exacerbated by way of tactical securitisation by linking a low political issue (water shortage) to a high political issue (loss of jobs, poverty). Invoking such a discourse and thus, the corresponding public fear that stems from it, allows much less scrutiny from the public- allowing actions to be taken that would otherwise have been deemed unpopular. The Murray-Darling Basin issue is an example of this, with images of millions of dead fish floating in the river, an indictment on the effectiveness of management practices. As such, water issues are not immune to this type of media coverage, prompting public outrage and leading to urgent attention from Government actors. This phenomenon has at its very core the underlying acknowledgement of risk, and in particular, its perception in the eyes of actors(Pidgeon, Kasperson, & Slovic, 2004). Securitising an issue, such as water, aims to raise the risk levels of the 'do nothing' option to a high level, so that prompt action is demanded from the public. The risk perception around any form of action is likely to be deemed acceptable in the face of a security crisis. The effectiveness of securitizing an issue then rests in how high the perceived risk on the issue is. The notion of risk is encapsulated in all policy decision-making, and in particular, its perception to the public. For this reason, further exploring notions and perceptions of risk is imperative in understanding why particular projects progress over others.

Evoking security imagery leads to an increase in community interest in water policy, especially in times of drought, prompting greater exposure in the media (Crase, 2011). Public scrutiny of policy options and allocations increase during droughts, heightening the culture of risk aversion in Government policy and the implementation of innovative practices within water utilities. The media is then vitally important in shaping public opinion of water management issues. This remains a key difference between innovation in the public and private sectors. Should an innovation fail in the private sector, there is comparably little (if any) media scrutiny. When innovations fail within the public sector, they are much more likely to garner negative media scrutiny, that impacts on public perception and potentially influencing the popularity of Government (The Australian Federal Government, 2010, p. 36). Therefore, there is a much higher political risk in innovating in the public sector, particularly when taxpayer funds are used to trial new technologies that may not succeed. The politicisation of water has the potential to halt many innovative projects that have a strong scientific evidence-base that are likely to produce good outcomes for the Nation State. It could even further create an environment wherein future Governments are reluctant to introduce new technology, for fear of failure.

In addition to this, the topic of water shortage is very closely tied to the politically sensitive issue of climate change. The debate is further complicated as climate change is politicized, thus engaging an emotive argument that could result in a non-scientific-based decision-making process, relying heavily on perceived values of the community. The scientific evidence is then only likely to have an impact on a water issue if there is a consensus of values within the industry and the public, as well as relatively low uncertainty pertaining to the outcome of action (Pielke, 2007). As neither of these are the case when it comes to implementing sound water policies, decision-making can become more difficult. In considering these factors, it is not surprising that water politics becomes a politically charged issue, particularly during droughts.

1.3. Importance of Risk

All of the barriers to innovation suggested above, such as public scrutiny, the nature of Government term cycles and also the water security discourse, are all permeated by the same underlying factor: risk. The process of securitizing, of increasing the 'need' is, at its core, the practice of increasing the perceived 'riskiness' of a certain approach/event/occurrence. Yet the concept of risk within the water literature is relatively uncharted territory bar a qualitative study by Dobbie (2014; 2014) and the water sector in the Swedish context (Boholm & Prutzer, 2017). Risk is the underlying influence in all of the mentioned barriers, rendering innovation inseparable from the concept of 'risk'. Innovation, in its very conception, is a new idea, process or technology that likely has not been previously trialled or implemented. Consequently, uncertainty unavoidably follows. Uncertainty, as the close cousin to risk, represents a potential undesired future outcome (or in some cases, desired). Keynes (1937) provides a distinction between risk and uncertainty. *Risk* is seen as the probability of a hazard occurring, (in its technical meaning), and if this probability is unknown, then this is called *uncertainty.* One is built on rational calculation, while the other is not. However, as Lupton (2013, p. 10) argues, the recent conceptualisations of risk do not need to be calculated, and that colloquially, "risk and uncertainty tend to be treated as conceptually the same thing" and therefore risk's calculability does not affect its use in parlance. The ISO 31000 standard defines risk as "the effect of uncertainty on objectives", highlighting that calculability is not a key factor in defining a risk (Council of Standards Australia, 2009, p. 1). Therefore, within this study the use of risk and uncertainty are taken as being conceptually interchangeable and risk can be a phenomenon that is not calculable.

Furthermore, the contemporary use of 'risk' in post-modernity is strongly focused upon the negative aspects of risk (Lupton, 2013, p. 9). In particular, the technical risk approach which is explored further in Chapter 2, and upon which all water authorities base risk assessments upon, predominantly views risk as 'bad'. Mary Douglas also highlights this distinction, that in contemporary use, 'the word *risk* now means danger; *high risk* means a lot of danger' (Douglas, 1992, p. 24). This proposes an important aspect of this research: risk as a negative concept. Despite many attempting to highlight so called 'opportunity risk' (the benefits of a risk) this is not generally given attention in technical risk assessments, and thus can be argued not to be salient decision-making factors (Short, 1984, p. 711). This is also highlighted by Prospect Theory, as people are more concerned about a potential loss, rather than a gain (Kahneman & Tversky, 1979). For this reason, this study does not focus on opportunity risk, and such the emphasis is on negative risk.

A key opportunity exists in further outlining and considering the inherent knowledge gap of understanding risk and uncertainty in the context of water. In particular, exploring existing risk theory to determine whether there may be some use in understanding the phenomenon of risk aversion in water. Academic theories in this area have been motivated by the increased interest in risk over the previous 60 years, and some argue, due to the onset of modernity (Castel, 1991). Established initially within a technical/engineering framework, the risk literature has further evolved to include elements of psychology, sociology, cultural studies and also organisational behaviour. However, in practice, risk assessments have nevertheless been modelled from the AS31000 Standards Risk process manual which principally incorporates the engineering, technical approaches to risk developed in the 1960s (Council of Standards Australia, 2009). As this theory is now quite dated, and other approaches have been recognised since, this begs the question of why this has not been further incorporated, or at the very least, investigated, to determine whether elements of recent insights may prove useful for processes. Could existing risk approaches effectively act as a barrier to incorporating new and unique water projects into the struggling sector?

1.3.1. Why is water different from other industries in terms of risk?

Understanding why the water industry is singled out from other areas is pertinent in providing context to this research. In many parts of the world, including Australia, the water industry is part of the public sector. Water authorities are not then, required to respond to a private board, but rather a Government-allocated one. As such, water authorities in Australia are accountable to the elected State Government at that time. Similarly, other nations (for example, New Zealand, France and Canada) also have water and wastewater services run by the state. A publicly-run authority answerable to the

Government, and by extension, the public, is likely to have differing aims to a privately-run company. As water and wastewater is seen as an essential service, its public nature ensures that it is not purely profit-driven, like many private businesses are.

Water, and the allocation of water, continues to be a contentious issue in Australian politics. The underlying tensions surrounding water allocations between urban and farming areas is a source of dispute for a number of decades now. Much of this is due to supply issues, that there is insufficient clean water within certain catchment areas to provide for the demand. At loggerheads are urban demands, agricultural uses and water required to sustain environmental flows (such as the Murray-Darling issue). To further exacerbate the issue, as described earlier, the decline in supply and increase in demand of water (due to population growth) continues to be a planning issue for years to come. In such cases, Governments have turned to allocating funds to large water infrastructure projects, such as the Wonthaggi Desalination Plant, which has caused divisions in society. In addition, policymakers and water practitioners had allocated further funding to a project, the North-South Pipeline which was constructed but never utilised due in much part to political concerns. A pipeline extending from the north of Victoria, to deliver water to the water-scarce south, prompted a classic political dispute between urban water needs and agricultural farming water requirements.

The potential for contention over water issues is high in the case of Australia, much like many other nations throughout the world. Many theorists have highlighted that water is unlikely to be fought over between states, but rather within them (Conca, 2006; Homer-Dixon, 1999; Wolf, 1998). As an essential service, an element that is so closely linked to the livelihood of agricultural farmers and promotion of day-to-day living within the community, it is of no surprise of the passion surrounding its use.

The issue of water differs considerably from other essential services such as electricity, internet and gas. Often, these services are privately run, and are built on profit-motives. Community sentiment, although important to some extent to these private industries, do not carry a similar amount of accountability within the water sector. Water can become an election issue, much like electricity, however the difference is that appointed politicians have oversight and to some extent, direct control, over much of the practices within the water sector, whereas they do not in private industries. In this way, the water industry is highly-scrutinised. Documentation must be made available for 'Freedom of Information' requests, and decision-making must be rational and clear. Risk assessments are required to be undertaken by Government authorities and made available on request, in order to adhere to the Victorian Government Risk Management Framework (Victorian Managed Insurance Authority, 2016). For this reason, there are risk consequences defined in the risk assessment framework that specifically refer to the 'reputation' and the relationship with the State Government at any time. These risk elements are further explored in this research, in particular whether reputation risk is a cited risk on which to base risk scores, and therefore sway decision-making in allocating funding.

1.4. Aim of Research

The problem statement highlighted some potential issues within the way that risk is managed in the public water sector. These issues include elements to do with risk aversion and its impact on the uptake of new or innovative projects. In addition to this, whether individual biases could create a differing risk approach among different risk assessors, resulting in varied outcomes for the water sector.

The outcome of this study arms the water sector with further understanding regarding decision-making in the public sector. This is especially pertinent when considering that each water authority has a Board that dictates its risk appetite statement; a document outlining the acceptability of different risks. Whether this statement is used in decision-making in practice is yet to be determined. In addition to this, risk assessment processes have been predominantly based upon the technical/engineering risk approaches. Other aims of the research also include exploring whether alternative theories of risk more effectively explain the risk perception environment in water sector decision-making. These results can then also be used to help inform new risk assessment processes.

Presupposing all of this, is the central question of whether the current practices of risk assessors in the sector results in an objective outcome. If the outcomes are objective, then one could conclude that the current process and practice are a true reflection of the climate of risk facing the sector, i.e. one where the appetite for taking on a project adequately satisfies the requirements of the sector. For the process and practices to be considered objective one would expect that the result from the processes would be the same, regardless of who undertook the analysis. In other words, an outcome that is considered to be subjective (i.e. not objective) is one where a range of risk assessment scores results when a project is evaluated. The wider the range of scores, the less objective the process.

Thus, the aim of the thesis is to answer the following research questions:

- Do current risk approaches produce objective results?
- Does the psychological risk approach explain any subjectiveness or bias of scores between individuals?
- Does the cultural theory of risk (worldviews) effectively explain the difference in scores?

1.4.1. Overview/Structure

Chapter 2 highlights the key literature in the area of risk, focusing predominantly on technical, psychological and cultural theories. Some sociological, Governmentality and edgework approaches are also explained, however have not been incorporated into the study for a number of reasons that are further highlighted in Chapter 2. The chapter outlines the existing research and is used as the basis for the research design. In particular, the use of psychological and sociological theories provides a foundation for the study and are further analysed in the context of the water sector.

Chapter 3 then provides the reader with the context for the study, with regard to existing risk assessment practices within the water industry. Four water authorities have participated in the study, and their risk assessment procedures are provided in Chapter Three. This chapter also highlights the international standards documents on which these risk processes are based upon, in particular ISO31000 and also IEC31010, the former providing a generalist guide to assessing risk, while the latter providing a thorough risk assessment process to follow. These two documents are closely adhered to in the risk processes of each water authority and result in each organisation having similar risk policies and procedures. Using both the knowledge from Chapter 2 and 3, Chapter 4 provides the framework for the study itself. The chapter covers the research questions and how they will be tested using both psychological, sociological theories up against the risk procedures of each of the organisations. The methodology is covered in this chapter, for both the quantitative and qualitative aspects of the study. Finally, the chapter concludes by explaining the reasoning behind choosing the research method that has been utilised.

Chapter 5 follows from this through stating how the research was conducted and providing some of the core research results. In particular, it aims to provide an account of the case studies that were undertaken on the four Melbourne water authorities, highlighting demographics of the respondents. In addition to this, the chapter delves into how the surveys were undertaken, in what type of environment, finally concluding with some key results and initial observations from the survey.

In a logical step from Chapter 5, the next three chapters (Chapters 6, 7 and 8) then dive further into the results of the study, providing an explanation of the statistical analysis of the results, for the three different parts of the survey: the technical risk theory component, the psychometric study and also the cultural worldviews testing. The results of the statistical analysis are outlined. This then leads into the discussion of the results in Chapter 9. Where the results provide what was found, the discussion chapter aims to provide meaning to the results, in order to fulfil the main aim of the research. The discussion provides theoretical translation of the results into useful key messages, while also highlighting the key implications of the results themselves.

Finally, a Conclusions chapter to the main issues discussed are summarised, the aim is emphasised and addressed, providing a statement of the significance of the study.

1.4.2. Scope and Limitations

In order to effectively address the research aim through the above outline, it should be stressed that the literature review does not, and cannot, consider all schools of thought. Nor are all schools of thought tested within the context of this study. The technical (or engineering) theory of risk is considered first, and much due to this process being currently utilised within the water sector, and within existing standards of risk management. The psychological and cultural theories of risk are also covered extensively in the literature review; however, this is not to say that these theories are the only theories in existence. There are a number of risk theories such as the 'Risk Society' thesis promoted by Ulrich Beck, the theory of Governmentality in risk (Rose, O'Malley, & Valverde, 2006) which adopts a completely constructivist view in risk perceptions, and also Edgework (Lyng, 2004), a theory exploring the individual thrill of risk-seeking behaviour. All of these additional theories stand up in their own right, however some are difficult to test (Risk Society thesis), while others will not provide further insight into predicting behaviours of risk assessors (Edgework). Governmentality instead explores the way that risks are portrayed by those in power (Government) to promote certain actions or behaviours. Both Governmentality and Risk Society theories act on the macro level, not at an individual level, so can be difficult to test due to their wide-reaching impact and varied influences. This underlines a key limitation to the study, the inability to allow for testing of these alternate theories.

Another limitation to the study is the researcher has access to current risk assessments, and a close relationship with these, as they have used them for decision-making for over 8 years. The existing process of risk assessments adopts a macro-level of focus (the approach applies to all who conduct an assessment), in a micro-level setting (it is conducted by individuals). This is a rather interesting take, as the theory takes a large-scale, data-driven approach however the individual undertakes the risk assessment themselves. It assumes that data drives the outcome of the risk assessments, and therefore each assessment outcome should be the same if done properly. As this study considers whether in fact, this process can be seen as objective, I've taken a micro-level approach to testing this. This could lead to some inherent biases in pursuing schools of thought that are also at the micro-level such as the psychological theory of risk. The cultural theory of risk does not take either a macro or a micro-level approach, but somewhere in between: a meso-level approach. It considers communities and worldview aggregations of people. The researcher has chosen these two theories to focus upon, in the belief these are the most likely to produce helpful and practical outcomes for risk assessment processes in the future.

Therefore, the scope of the theoretical basis for the study will rest on psychological and cultural theories and exclude other theories such as Beck's Risk Society thesis.

1.5. Conclusion

Dire forecasts regarding water supply issues within Australia, and other countries, have prompted exploration into the way that water is being managed. In particular, how decisions are adopted, and how they are justified. Risk plays an important role when considering the up-take of new methods and processes in the water industry. Risk assessment of a project often guides business cases and acts as a major decision-making tool for proposed schemes. As such, understanding perceptions of risk can guide us in understanding innovative or unfamiliar projects that proceed, compared to those that do not.

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Chapter 2

Risk Theories

A bushfire. A common occurrence during summers in Australia that leads to catastrophic effects. This, to most, carries an inherent risk. Some of it controllable (eg. backburning), others not (eg. weather) and yet action is often taken to reduce the risk of this event occurring. This action of measuring and managing risk is relatively recent practice. It stems from the mid 20th century, when it was officially put into policy through the United States Nuclear Regulatory Commission (United States Nuclear Regulatory Commission, 1975).

Prior to risks being formalised through standardised risk processes, significant emphasis was placed on the idea of 'fate', especially when considering natural disasters. Faith was placed in God or a higher being, who had total control of the elements, leaving humans powerless in the management of their own futures (Bernstein, 1996). As such, taking action against perceived dangers was not seen as an option. In the example of the bushfire event, this would be seen as an 'act of God', and thus not preventable by thes fatalists. This idea shifted considerably over the 19th and 20th centuries, with the introduction of a 'humanistic' paradigm: the notion that people could act and take control of their own futures. This was naturally closely tied to the concept of risk in considering the probability and consequence of events occurring.

The risk literature is divided into many groups dependant on epistemological viewpoints. This epistemology refers to the notion of whether a 'real' or 'true' risk actually exists. The two main areas of contention consider the objectivity of risk and how it is treated: at a personal individual level (like the psychological risk approach), a meta-level (cultural theory of risk) or at a macro level (technical risk approach).

The epistemology of risk reveals the tension between risk theories, in particular the underlying element of whether risk is seen as either a subjective or objective concept (Lupton, 2013). Perceptions of risk, rather than whether a risk is seen as true or not, is the factor ultimately driving decision-making. Therefore, arguing for or against the real objective risk is not the focus of this study, but instead highlighting personal professional notions of perceived risk.

When discussing risk, especially in a business setting, it is not unusual that it is seen as an objective and measurable value. Existing risk processes and standards have been predicated on this very idea. Risk is often seen as the likelihood of a particular outcome of a hazard occurring. This ignores much of the broad study in risk that also considers cultural and psychological elements, among other theories. This chapter seeks to provide the overarching scholarly debate and theories surrounding risk, providing an alternative viewpoint from that presented by existing standards and risk practices.

The chapter is structured into four components. Initially, a general note on the literature of risk theory is presented. Following this, the chapter provides a description of the literature on each of the technical, psychological and cultural theories of risk. These theories will be tested as part of the main study, and as such, this chapter provides the foundation for the work undertaken.

2.1. A general note on the literature within risk theory

The technical, psychological and cultural theories of risk are described in this Chapter. Other theories of risk do exist however are not appropriate for this study. These theories include the Risk Society thesis, Governmentality and Edgework.

The Risk Society thesis, devised by Ulrich Beck (1992) considers a macro-setting of risk in a weak-constructivist manner. Beck (1992) argues that over the 20th century, risks have vastly changed as a by-product of modernity, to become risks that are imperceptible, indiscriminate and affecting a large number of people at once. These elements, he continues, have changed people into a 'risk society'; a community focused on risks and the fearful of large risks (Beck, 1999). As the risks explored within this study do not necessarily fulfil all of Beck's requirements for a 'new risk' (i.e. imperceptible, indiscriminate and impacting many people at once), the theory is not necessarily helpful in providing further insight into how risks are assessed within the water sector. It also struggles to provide a method of predicting risk behaviours on which to base new risk assessment processes.

Similarly, Governmentality, based on Foucault's (1982) theories can shed light on how societies are influenced by the risks that receive attention from Government departments and also the media (Rose, O'Malley, & Valverde, 2006). Taking a purely constructivist viewpoint, the theory does not see 'risk' as a concept that is devoid of social influence and norms, viewing risk at a macro-level (Lupton, 2013). Governmentality can be difficult to measure through risk assessment processes and makes it challenging to account for individual changes in risk scores when the theory is built on a macro-level approach.

Edgework theory was primarily developed by Stephen Lyng (2004). Edgework considers the individual and their personal risk-taking for the sake of pleasure or self-fulfilment. These individuals often engage in risk-taking behaviours, such as risk of bodily harm or risk of high personal financial losses, all to ensure a chance of obtaining high emotional or financial gain. In a way, the people that participate in these risk-seeking endeavours consider this type of engagement to be a sign of mental toughness through overcoming their fear (Zinn, 2008). They ultimately feel that this mental toughness renders them superior to others. The interesting element in this theory is that these individuals do not see these actions as reckless but place great value in them. The self-actualisation they seek ties in with the idea of regaining control, and as such deliberately contravening societal norms. As a result, this type of risk carries a strong emotive reaction in its use. A fascinating aspect of Edgework, in which it differs from other risk theories, is that risk is not seen as a 'negative', something to be avoided. It is instead something that one seeks out for pleasure and enjoyment. The heightened, intense emotions that Edgework invokes is exactly what the individual is searching for.

While Edgework theory is a unique and fascinating concept, it is difficult to use in the context of this study as it is heavily based on 'thrill-seeking'. Although testing edgework may provide some insight into a select few individuals, it cannot provide broad insight into the general behaviour of water practitioners therefore its use in this study is limited.

As a result of their general inapplicability to the water sector, these three theories of risk are not utilised in this research. Rather, the focus is on theories that may be more suited to achieving the aim of understanding overall risk decision-making in the public sector.

2.2. Technical Perspectives on Risk

The technical approach to risk adopts a positivist attitude - viewing risk assessments as an objective exercise undertaken by experts. The risk assessor first identifies the risks and benefits associated with a project, making an objectified assessment based on certain factors devised by experts. Many Government organisations and regulatory bodies, such as the Environmental Protection Agency in Victoria, Australia, utilise this form of risk theory through the assessment of two inputs: risk consequence and risk probability (Environmental Protection Agency Victoria, 2004). This forms a key decision-making tool of a business case to determine whether to proceed with a particular project or not. This type of risk process stems from the engineering/technical risk approach as emphasised in the risk literature.

Starr (1969) was a major proponent of this type of objectified risk analysis. He promoted the idea that risk assessments can be used to form an ideal scenario wherein there is a calculated risk to benefit approach. This type of assessment relies on legitimate statistical and/or fiscal data being readily available thus creating an arguably quantified approach to assessing a risk within a project. The underlying assumption is that should a 'rational' person assess the risk, it results in one objective risk score regardless of the assessor. Thus, risk is treated as an objective reality that exists, not one that is socially constructed. Furthermore, as risk has become less about engineering and technology since the 1960s, and more about incorporating elements of social behaviour, the traditional technical risk approach may not be entirely appropriate in the field of water where community and political impacts carry great risk. Difficulty in quantifying risk can be argued in areas such as reputational risk, political risk and risks to the public in general.

2.2.1. Economic Analyses of Risk

A form of technical risk assessment is Cost-Benefit Risk Analysis (CBA), which is a central tenet of economic methodology. The CBA embraces consideration of possible costs versus benefits when assessing future actions, with a focus on financial spending and investment (Dasgupta & Pearce, 1972). It relies on costing each part of a project, which can include valuing social benefits, to determine the long-term viability or investment opportunity of a particular option. It considers discounting over time and time-sensitive costings to provide a result in real monetary terms. The focus therefore, is predominantly on quantifying risk in fiscal lexis.

While CBA is one way of assessing the riskiness of a project, others include multi-attribute Utility Theory (which is an overall approach encompassing a variety of methods and techniques), Bayesian techniques etc. All of these can be incorporated under the umbrella of decision-theory or decision analysis involving risk choices. They involve understanding the decision-maker's personal beliefs about the occurrence of uncertain events and the decision-maker's personal consequences (Anderson, Dillon, & Hardaker, 1977). Some of the approaches are complex in nature, requiring the assessor to model and simulate estimated interactions in order to determine the impacts of different risks on the system in question and the derivation of a utility function for the risks faced.

This approach has been used on a multitude of problems, including those in the engineering field and applied to the issues associated with catchment management (Wallenius et al., 2008). Despite this complexity, in essence these approaches involve an individual's belief on the outcome of consequence and likelihood of occurrence.

Self's (1975) seminal piece on 'Econocracy' refutes the nature of cost-based risk analyses, and in particular cost-benefit analyses. He argues that there is an inherent falsehood to these approaches and that they do not aid decision-making. For Self, cost-benefit analyses and their obsession with costing elements such as welfare and social benefit, is flawed and biased, presenting a problematic quantification of risk. In an attempt to generate a more objective and rational approach to decision-making, the method instead creates an assessment that is wholly irrational due to its attempt to quantify elements that cannot necessarily be effectively quantified, thus carrying an inherent risk in its use.

To counter this criticism of costing the elements, Sinden and Worrell (1979) have provided methods to overcome the lack of market prices in CBA approaches. Coupling a CBA with a sensitivity analysis can yield much in identifying the issues an individual project might be susceptible to, and the extent to which it may well be at risk. However, these issues can only be gauged if they are included in the analysis. As Self (1975) rightly points out, that is subject to the choices made by the analyst. Thus, it would appear that the highly rated claim of objectivity that arises from these types of studies may well have some cracks in its façade that arise from the subjective choices of assessors themselves.

2.2.2. Probabilistic Risk Assessment and its criticisms

Current risk assessment measurement approaches date back to the 1970s, with the creation of the Probabilistic Risk Assessment (PRA) (Bradbury, 1989). Not unlike the Australian Standards document (Council of Standards Australia, 2009), the PRA was traditionally made up of a combination of two factors: probability and consequence. A key influential document utilising this risk approach was the "Reactor Nuclear Safety" study undertaken by the United States Nuclear Regulatory Commission, published in 1975 (United States Nuclear Regulatory Commission, 1975). It was the first major project to incorporate the PRA into its planning (Bradbury, 1989). The risk in the report was given by the probability and magnitude of a range of different consequences, many related to the number of fatalities (United States Nuclear Regulatory Commission, 1975). The process is centred on quantitative elements in that it relies on data from testing procedures to score probabilities of failure. As such, it represents a risk analysis process that is value-neutral, with risk being treated as objective fact (Bradbury, 382).

The PRA approach assumes that people are rational beings, thus allowing the realisation of an objective quantification of a risk. Kates and Kasperson (1983) argue that the popularity of the quantitative approaches to risk came about from two key motivations; increased public concern regarding technological risk, and also as a tool to be able to address the ever-challenging area of 'the acceptability of a risk' (Kates & Kasperson, 1983). Technological changes were common in the 20th century and ensuing public anxieties then required some level of control. Beck's (1992) 'new risks' highlight the nature of this change in technology that results in a change of risk perceptions, as many of the risks are no longer indiscriminate and affect a large number of people. Thus, the increased interest in risks is not unexpected.

The PRA, and other similar technical risk approaches, have been criticised in the literature for their rigid management of risk which ignores the nature of human beings as non-rational beings (Beck, 1992; Self, 1975). Humans have been shown to act irrationally in situations, the extent of which differs between each individual. Additionally, it ignores the value-laden decision-making involved in risk analyses. Each decision has an element of the risk assessor's or the organisational values attached to it, as shown through the risk consequence framework (refer to Appendix C for examples of these) . For example, one organisation might see 1,000 people affected by loss of water as being of high risk, yet another may only consider this a medium level risk. These ratings cannot be said to be objective measures, as they were formulated on an underlying value judgement. Why are 1,000 people considered high risk, why not 500 or even 1? These types of risk ratings can be argued to be somewhat arbitrary in their assessment grading and therefore the approach altogether cannot be said to be 'objective'.

This is further complicated through the apparent theoretical disarray between behavioural scientists and risk managers, rendering it difficult to find an effective middle-ground (Rayner, 1992). As risk managers are likely to see their risk assessments as entirely objective, while behavioural scientists approach risk on the basis of psychological and value-based decision-making, it creates a disconnect between the two. Risk managers tend to see technical risk assessment approaches as devoid of value judgements and therefore entirely rational.

2.2.3. Risk Matrices as Risk Assessment Tool

The most widely-used tool in practice in the technical risk space is the risk matrix (Cox, 2008). This matrix considers two inputs: the consequence of a particular risk scenario and its likelihood. The consequence focuses on capturing the outcome of an action, and this is scored based on prescribed factors such as threat of injury, life, reputation, and financial loss. The likelihood is scored based on the probability of this scenario occurring. These probabilities are also pre-defined and often given scores from 1 – 5 based on likelihood (with 5 as the almost certain). With the aid of the risk matrix, which is normally devised by the individual organisation itself, consequence and likelihood scores are used to determine the final 'objective' risk score. This approach has been highlighted in documents such as the Australian Standards on Risk Assessments ISO31000 (Council of Standards Australia, 2009), and therefore followed closely by many Government departments such as the Environmental Protection Agency and the Department on Innovation and Science (Australian Government; Environmental Protection Agency Victoria, 2004). This probabilistic process had already been in use in the engineering sector prior to Starr's seminal work in 1969. Risk Assessments, in practice, diverge from that made in the academic literature. Research in the past decade has described the impracticality and dangers of using risk matrices to measure hazards (Hubbard & Evans, 2010; Pate-Cornell, 2002). Despite these warnings, risk matrices are nevertheless still used and form a key tool of decision-making in the public sector in the water industry.

Aven (2017) highlights the inherent issue in assessors viewing uncertainty and probability as much the same concepts, stating that the two are vastly different. Flage, Aven, Zio, and Baraldi (2014) also explore the inconsistency in the assessors understanding of probabilities in general. This criticism extends further to value-based judgements, and the inability (or resistance) to relying on statistics and data to form the assessment.

A key element of the staying-power of risk matrices exists in its simplicity. As a tool that can be rolled out across an organization with diverse functions, while also allowing for a seemingly rational approach of quantifying risk, it is a tempting template to use. However, behind these risk measurement tools exist some degree of subjectivity, combined with the dangerous nature of hiding any risk aversion on the part of the assessor (Monat & Doremus, 2018).

Decision-making will often carry unexpected, or unpredictable outcomes, and risk matrices may not be the most ideal way of measuring the risk. The practice of reducing two dimensions (consequence and likelihood) into one dimension, is rife across the public sector in Australia (Australian Government; Victorian Managed Insurance Authority, 2016). This carries its own issues in the assumptions that a likelihood score of 3 will be assessed as of equal weight as a consequence of the same value, despite measuring vastly different properties. Within the literature, many academics have devised alternatives to risk matrices (Ruan, Yin, & Frangopol, 2015; Van Der Sluijs et al., 2005) , however the existing matrix approach still pervades industry practice.

These risk matrices are still utilised widely, despite the vast criticism of them in academic literature (Aven, 2017; Ball & Watt, 2013; Cox, 2008; Hubbard & Evans, 2010; Pate-Cornell, 2002). There are many drawbacks to this approach, namely that the assessor may not accurately predict the outcome, together with the lack of knowledge to support their assessment of the probabilities of likelihood (Aven, 2017). As risk assessments rely heavily on the score, or rating, received from risk matrices, this inaccuracy in predicting outcomes and likelihood renders the processes problematic and thus can lead to poor decision-making. This is especially pertinent when considering the impact of this decision-making is made on behalf of the community and could then affect large numbers of people.

Many other risk theories also exist that refute this approach, such as those based on the psychological, sociological and cultural aspects, while also providing alternative viewpoints in the risk debate (Kosovac, Davidson, Malano, & Cook, 2017). Psychological approaches to risk, such as the effect of cognitive bias on risk perceptions, has propagated within the literature, pushed by key theorist Paul Slovic (1992). Furthermore, sociological theories in 'new risks' (Beck, 1992) and also cultural theories (Douglas & Wildavsky, 1982) have also taken a stand in explaining risk, and risk behaviours. These are not commonly reflected in current uses of risk measurement approaches.

2.2.4. Rational Actor Theory and Technical Risk

Both the technical and economic risk assessments rely on the assumption that all decision makers and actors are rational. Through utilising Rational Actor Theory when predicting the consequences and actions of others, they argue this ensures a positivist and objectified approach to risk management. Rational Actor Theory is based on actors taking action based on predictable, consistent goal setting while also maximising expected utility. Neumann and Morgenstern's (2007) expected utility theorem posits that a decision-maker, when faced with potentially risky scenarios, will have a preference for actions that maximize expected utility. Any actor that does not fit this decision-making paradigm is said to be 'irrational'. The rational actor is diametrically opposed to the irrational actor, who is deemed to be spontaneous, random and impulsive. The rational actor is assumed to be acting in self-interest. Many, such as Rothschild (1946), argue that the assumption of rationality is essential in modern economic theory, however Arrow (2012) posits that this is an entirely unnecessary assumption to make in decision theory as "we could just build up our economic theory on other assumptions as to the structure of choice functions if the facts seem to call for it" (Arrow, 2012, p. 21).

Ulrich Beck proposed that due to limits of rationality in individuals, it could not be assumed that all are rational actors in their decision-making. As purely rational actors are fictional, it remains necessary to leave space for an element of subjectivity in the conception of risk. In a stronger iteration of Beck's approach, Slovic (1993) argues that there is simply no such concept as a 'real risk' or 'objective risk'. He argues that in assuming that the probability combined with the consequence of risk is objective and that all assessors are rational in their approach to this analysis, it ignores the very nature of a 'perceived risk'. This assertion hinges primarily on the claim that the way in which a layperson would analyse a risk is likely to differ from the approach taken by an expert in that field, due to the tools one has on hand.

These tools of analysis can be drawn from factors such as education, culture and lived experience in order to determine one's relationship to a risk. The sense of dread associated with a risk, as discussed by Slovic (1993), accounts for a strong emotive response to a risk in decision-making. The higher that factor of 'dread risk', the larger the perceived risk as analysed by the public. For instance, Slovic argues that phenomenon which he terms 'dread risks', which often looms large in the public consciousness due to previous catastrophes (a paradigm example of which would be nuclear power), are likely to be perceived as posing a high level of risk by lay people, even in cases in which this assessment is not reflective of expert opinion. This may not fall in line with experts' assessments of risks when based on a technical risk analysis. This is due to the fact that experts are likely to base their perceptions of risk on potential mortalities or level of harm per capita. The public frequently rejects models of risk devised by scientists using these methods, as they are unlikely to adhere to the value-based perceptions presented by an individual. This is not to state that a particular viewpoint, whether it be the layperson or the expert, is necessarily better than the other, but rather to highlight that there are elements that both groups may not consider that the other group will place importance upon. These risk analyses also fail to effectively take account of social and political elements of risk, which can be difficult to measure quantitatively. Therefore, the argument that technical perspectives on risk are risky themselves is apt when considering the enormous effect that social impacts may have on a project/process.

2.3. Psychological Risk Approach

Not unlike the sociological and cultural theorists, Slovic (1993), a key proponent of the psychological risk approach, recognises that 'danger is real, but risk is socially constructed' (Slovic, 1993, p. 659). Similar to the sociological risk perspective, the psychological view focuses on the individual and how they form judgements based on their underlying beliefs and experiences. Risk perception is closely tied to an individual's worldview, thus linking risk choices to their own values and psychology (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978). These experiences create a personal prism through which the individual assesses risks.

The psychological perspective predominantly focuses on decision-making biases, in particular the intuitive processing of uncertainty. Psychological risk theory promotes the importance of personal and contextual variables in assigning risk to certain factors over others. Kahneman and Tversky (1973) use 'heuristics' to explain decision-making in times of uncertainty, which they argue is most of the time, as information received is ordinarily incomplete.

Slovic, Fischoff and Lichtenstein (1979), argue that the 'availability heuristic' refers to a phenomenon that occurs when people are able to judge an event as more likely when they are faced with it, or if it is easier to recall, despite their exposure to any data that may contradict their perceptions (Fischhoff, 1975).

> "A person is said to employ the availability heuristic whenever he estimates frequency or probability by the ease with which instances or associations come to mind." (Tversky & Kahneman, 1973, p. 208)

For example, a person who has a family member with a particular form of cancer may perceive the rate of this type of cancer to be higher in the population than is actually the case. This 'availability heuristic' is a key element in assessing the psychological risk perspective.

The availability heuristic helps explain the mental calculation of likelihood by risk assessors. The theory posits that the ease by which an individual can bring up examples of a particular hazard then they assign a higher likelihood to that hazard occurring (Taylor, 1982). Current risk processes require the risk assessor to refer to the 'likelihood' of the risk occurring. Therefore, the availability heuristic could introduce some level of personal bias into the risk assessment process.

The elevation of particular risks as a result of an individual's awareness or experience of them can influence the resources the individual allocates to ameliorating that risk, compared to other risks they have no personal affiliation with. This scenario creates a disparity in the homogeneity of behaviours towards a particular risk, which can in turn promote division and debate, leaving the definition of the risk itself open to interpretation. In the case of a Government or society, where the pool of resources that stem from each person's contribution is to be allocated, this differing perspective could create heightened tensions and encourage further public debate. Slovic (1992) argues that a significant difference in the risk perceptions of the public and policymakers can result in a 'crisis of confidence,' leading the public to respond to their own risk perceptions, rather than those undertaken by experts or a regulatory body.

2.3.1. Voluntariness

Research in the field of risk perceptions highlights the importance of the feeling of being able to either 'opt in' or 'opt out' of a risk. This feeling of exposure to a risk being voluntary changes the perceptions of the level of risk attached to a particular event. People tend to see an action as being riskier if it seems as if those exposed are not voluntarily exposed to it. Starr's (1969) work first highlighted the effect of voluntariness upon a risk, stating that the public is 1000 times more likely to accept a voluntary risk rather than one that is seen as involuntary.

2.3.2. Immediacy of Death

A person's perception of an event changes depending on whether death is expected to occur immediately, or at some later date. This has particularly been explored in the context of radiation (Pahner, 1976). The effect of exposure to radiation is slow-acting and can take years to result in death. Another example could be the ongoing effect of pollution. On a day-to-day basis it may not have a noticeable impact, but it could shorten lifespans over a longer period of time. The effect of a delayed risk of death is theorized to affect the way that a risk assessor sees that particular risk (Fischhoff et al., 1978).

2.3.3. Knowledge of risk

Whether those exposed to the risk, or whether scientists have an extensive knowledge of the risk, changes the way that risks are perceived. A lower knowledge of a risk is perceived as a riskier outcome (Fischhoff et al., 1978). As such, the amount of knowledge one has influences the acceptability and decision-making around risks (Slovic, Peters, Grana, Berger, & Dieck, 2010). Slovic et al (2010) explored this in the context of prescription drugs and how the public perceive these related risks. They found that the way that the drugs were perceived was closely tied to the perceived knowledge that participants had about the drugs themselves (Slovic et al., 2010).

2.3.4. Control

Closely tied to the 'voluntariness' of a risk, the risk attribute of control, or the illusion of it, also has an impact on personal risk perception. A feeling of being in control of a potential risk elicits 'an expectancy of a personal success probability inappropriately higher than the objective probability would warrant.' (Langer, 1982, p. 232) Langer (1982) assesses the risk perception of those throwing a die, noting that the risk acceptance is higher when the person throws the die themselves, rather than someone else undertaking this action. While the objective probability does not change, the illusion of control does, driving differing risk acceptability behaviour. The research within the psychological perspective on risk highlights the perception of personal control in affecting the assessment of risk (Fischhoff et al., 1978). People are generally more likely to take risks if it is their own choice and less likely to accept even a lower level of risk if they feel that it is forced on them (Langer, 1982). In addition to this, Alhakami and Slovic (1994) confirmed a strong inverse relationship between perceived benefits from a risk versus the perceived risk.

If the perceived risk rises, its perceived benefits drop. Tversky and Kahneman (1979) demonstrated that individuals are more risk averse if the potential losses are high and risk prone if the stakes for gains are high. Therefore, risk aversion is seen as closely correlated to personal preferences and beliefs (Fischhoff et al., 1978).

2.3.5. Newness of risk

The novelty or unfamiliarity of the risk is closely linked to the risks' knowledge elements, both to those exposed and to the science involved. This characteristic is driven by a sense of uncertainty and the lack of ability to draw on experience to form a reliable psychological risk assessment of the event occurring (Skjong & Wentworth, 2001).

2.3.6. Chronic or one at a time

A risk that kills many people instantly compared to one that kills the same number of people over a longer period of time has a different psychological effect upon a person. Previous research has shown that people are more likely to perceive a risk that kills many people at once (such as an attack) as more risky than one that kills people over many years (such as diabetes) (Bodemer, Ruggeri, & Galesic, 2013). Despite stating that both of these still kill the same number of people, it doesn't change the perception that one is a higher risk than the other (Bodemer et al., 2013).

2.3.7. Dread

A gut feeling or trepidation towards an imagined consequence of a risk has been also shown to act upon responses at a psychological level (Gregory & Mendelsohn, 1993). A feeling of dread is closely linked to an imagined salient outcome of an event or action prompting strong emotional responses by those experiencing the dread. These events often have high consequence and low likelihood perceived risks. Gigerenzer (2004) explores the psychology of dread risks in his research on risk perceptions around terrorist attacks, concluding that people would rather drive than fly to a destination in order to avoid an attack similar to the terrorist attack that occurred on September 11, 2001 (the dread risk) (Gigerenzer, 2004). There would be many more lives lost if people had avoided the risk of flying by driving to their destination. Despite the incidence of fatalities on the road being higher than if one was to fly, the inherent psychological effect of the dread risk renders many to see driving as safer than flying (Gigerenzer, 2004).

2.3.8. Fatal

The perceived likelihood of a fatality increases the perception of risk by assessors (Slovic et al., 1979). This occurs despite quantitatively proving that this perception of the number of fatalities may be wrong. Fischhoff et al (1978) highlights the difference between lay and expert risk perceptions, in particular that expert risk perceptions were more likely to be based on the number of fatalities whereas the public may be more likely to consider consequences based on vivid imagery. Consequently, where only experts in water are being assessed, based on this literature, one would expect that the likelihood of fatality would play a role in the way that risks are perceived, and in turn on the risk scores those assessors calculate.

2.3.9. Fair

A risk that affects people in an unfair way is likely to be judged to be a higher risk than one that is considered to be unjust (Keller & Sarin, 1988). In this context, fairness is determined by whether the consequence of the risk affects everyone equally or whether it detrimentally affects a smaller group, therefore deeming the risk 'unfair'. This is closely aligned with whether there is 'choice' involved in the exposure to risk.

The psychological theory of risk takes into account the role of emotions in decision-making, an area that has only recently been seriously considered by sociologists analysing risk, and is largely ignored in other areas of the field (Zinn, 2008). Approaches that consider past emotional experiences would appear to be imperative in making reasonable and sound decisions (Baumeister, Dewall, & Zhang, 2007). Predominantly, this refers to taking actions based on anticipated emotion. If a strong emotional connection to risk exists it can cloud an individual's capacity to identify the probabilities of certain scenarios, focusing instead on the possible outcomes and the dread factor associated with them. 'Dread' is addressed considerably in psychological risk perception theories. A strong emotional feeling of dread is one of the largest factors in propelling an individual to act upon a risk (Baumeister et al., 2007). The emotional feeling of 'dread' is typically associated with personal impacts, impacts on future generations and catastrophic widespread risks (Baumeister et al., 2007). Emotions that indicate a positive or negative feeling to an individual are key factors in effective decision-making in risk assessments.

2.3.10. Risk perceptions, and how these differ between laypeople and experts

Extensive research has been undertaken on the differences in risk perceptions between laypeople and experts. Predominantly undertaken in the United States, this field of study expanded in the 1980s and continues to provide insights into understanding public perception, particularly in an environment in which participatory democracy is encouraged. Slovic is a key theorist in this field, highlighting the importance of understanding individual psychological factors in the construction of perception (Slovic, 1993; Slovic, Fischhoff, & Lichtenstein, 1985). He argues that the individual's psychological affiliation to a risk, based on personal experience, provides a key explanatory factor in their perception of the risk. As previously discussed, fundamental attributes, such as the 'dread factor' (the sense of dread associated with the risk), or the 'newness' of the risk (how familiar the risk is) are examples of explanatory elements to understanding risk perceptions (Slovic et al., 1985).

When comparing public risk perceptions to that of experts, Slovic et al (1983) showed that laypeople surveyed generally ranked nuclear energy high in risk because of the sense of dread associated with the effects of a negative radioactive fallout. In comparison, laypeople ranked the risk of driving a car very low, despite figures showing the chance of being involved in a car accident is far higher than being caught up in a nuclear one (Slovic et al., 1985). Experts instead ranked driving a car as significantly higher risk than that surrounding nuclear power, which the authors suggest is based on an objective understanding of the safety of nuclear energy. Thus, they concluded that the dread or familiarity factor for experts is dissimilar to the layperson.

This difference in risk perceptions evident between laypeople and experts becomes a challenge when the question of public policy, or deciding on public spending, enters the discussion. Prior to the 1960s, expert assessments were generally accepted by the public, with far less scrutiny than they are today (Nichols, 2017). As such, public consultations and public opinion polling did not carry the relevance it currently does and forms an integral part of project planning. Schon (1995) argues that the loss of faith in professional judgement occurred between 1963 and 1981, much due to the unintended side effects of new technologies and the conflicting recommendations within a professional field itself. The consistent debunking of professional advice and theories also proved to be a large factor in the increasing distrust of professional experts (Nichols, 2017; Schon, 1995). Slovic (1993) also contends that this increase in distrust has flowed on to include public distrust towards risk assessments conducted by these experts.

To show this, a study by Schlosberg et al (2017) in Melbourne, Australia has shown a clear distinction between climate change discourses undertaken by Government authorities and the public. In considering climate change adaptation, local Government bodies used words like risk, water, control, event and management. In contrast, they found that community groups used language that focused more on the impacts of basic needs, such as ‘food’, ‘community’, ‘people’, ‘energy’, ‘water’ and ‘local’ (Schlosberg et al., 2017). The authors highlight the discordant nature of risk discourses between laypeople and experts, and posit that this may be due to lack of public engagement, while Guy, Kashima, Walker, and O'Neill (2014) theorise that it is a knowledge-based distinction.

2.4. A Cultural Risk Approach: Grid- Group Typology and Risk

In contrast to the psychological approach, Mary Douglas and Aaron Wildavsky (1982) argue that the grid-group segment, or worldview that one prescribes to, ultimately alters the way that an individual may perceive a risk. A worldview encompasses the way that people view the hierarchy of systems that they were placed in, and the amount of autonomy afforded to them as a result. This cultural theory sees individuals as part of a conglomerate sharing similar worldviews. Membership to these groupings, they argue, ultimately shapes one’s perception of risk.

“Hierarchy” and “Markets” were previously the two main groupings used in the social sciences to cluster similar cultural worldviews. The groupings are antithetical to one another. The individual has more freedom to explore new approaches to the way they choose to engage in life situations if they are part of a market rather than part of a hierarchy. The ensuing result is based on the individual’s own actions, in what is considered a ‘market-based’ approach. A “Hierarchy” approach is heavily based on the social standing of the individual to how much influence they have over themselves and those around them.

These two main groupings were the basis for many economic and social studies in the 1970s (Lindblom, 1977; Williamson, 1975). Douglas (2013) found that there were key social groupings missing in this initial approach and sought to fill the gaps with the grid-group typology. The grid-group typology that is utilised in this research had been designed by Douglas (2013) to show the ‘variability of an individual’s involvement in social life’ and is captured by two distinct factors; grid and group. The level of individual social control is the key emphasis in the underlying nature of a grid-group approach. They found that not only did it matter how people were grouped into associations and consortiums, but also whether these groupings were structured internally or not. Without a grouping, a social structure can still exist. This created an arrangement similar to a Cartesian plane, made up of grid on one axis with group on the other.

2.4.1. Group

On the group axis (refer to Figure 2-1), the extent to which an individual's life is absorbed and influenced by group membership is considered (Douglas, 1992). This is an important element in understanding the boundaries of a group, how inclusive their membership may be and also how an individual's own perceptions could be altered by their involvement in the group. A low group membership, or low group on the plane, implies a higher level of individuality of a person. Douglas (2013) defines group as 'the experience of a bounded social unit' highlighting that a high group is about the group itself rather than the individuals (Douglas, 1996, p. viii).

2.4.2. Grid

Grid, as distinct from Group (Figure 2-1), describes the level of social structure between people (Douglas, 1992, 2013). This social structure defines how individuals relate to one another. For example, in a low grid, people are less defined by a particular role and their individual social status. In low grid, therefore, decisions are made for all, by all. It implies that the networks between people are relatively the same, regardless of the individual that you may approach. Conversely, a high grid dimension carries clearly defined social regulations that vary based on the individual. In this way, decisions in a high grid scenario, are made for many by a few "elites". Networks between individuals carry different weightings depending on where the individuals are placed on the social hierarchy. These relationships may shift, and change based on existing status frameworks. High grid implies that a socially-imposed structure exists between people that may limit what they can and cannot do, based on their social status or level within the structure.

2.4.3. The Grid-Group Factions

The Cartesian plane made up of grid and group forms four distinct social groupings: Hierarchy, Egalitarianism, Individualism and Fatalism (Figure 2-1).

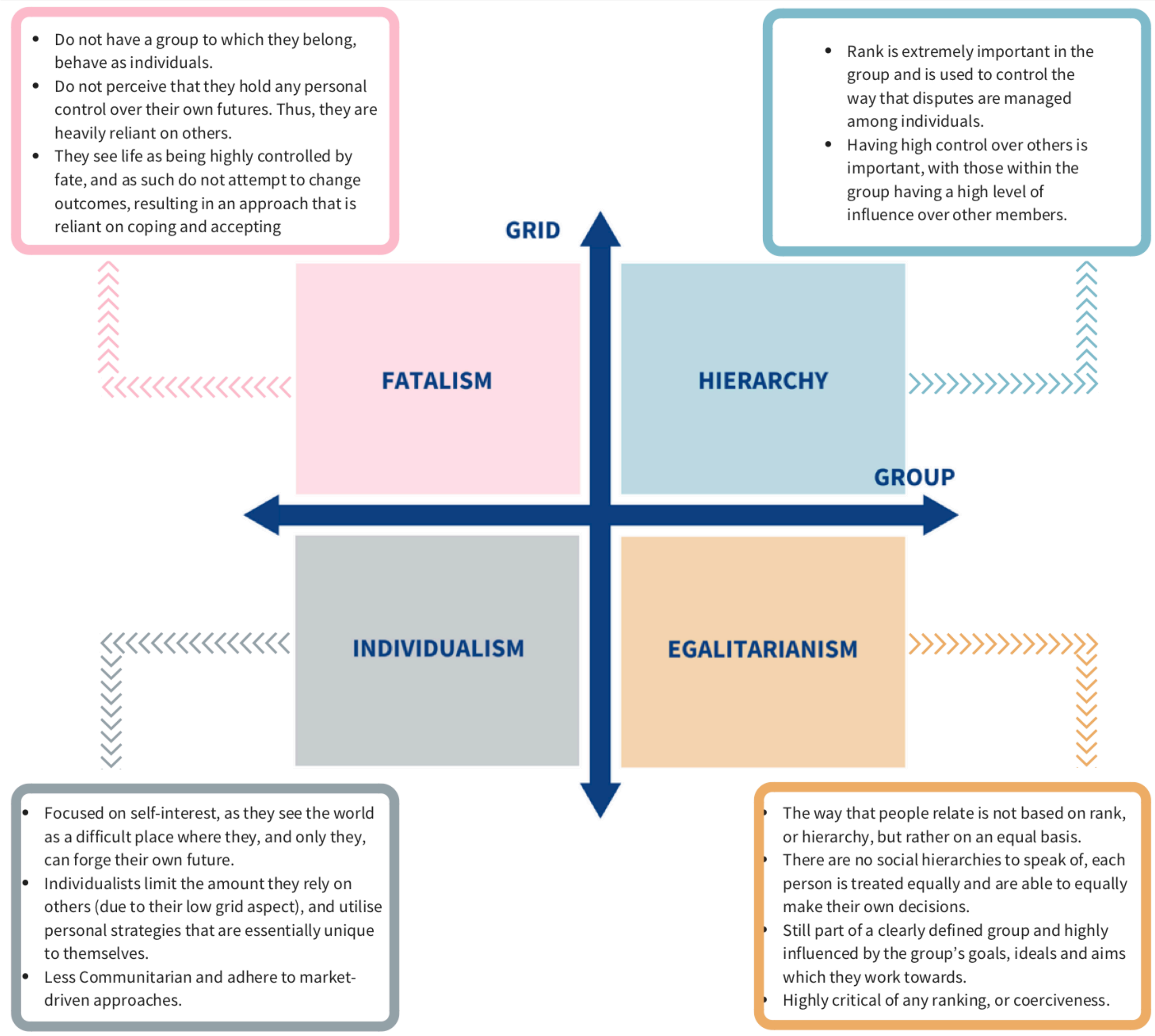

Figure 2-1 Grid-Group Plane with descriptions of Worldviews

High Group/High Grid = Hierarchy

High Group/Low Grid = Egalitarianism

Low Group/Low Grid = Individualism

Low Group/ High Grid = Fatalism

Finally, the literature also explores a fifth group, 'Hermit' as a classification for those individuals that do not fit into any of the above four categories (Douglas, 2013). This group sits outside of the cultural plane, as these individuals are relatively unconcerned with any social structures or make-ups. They actively disengage from social contribution (Thompson, Ellis, & Wildavsky, 1990) and given their disengagement they are not of concern in this study.

Hierarchy

The hierarchy dimension exists in the high group and high grid of the plane. This group has clear exclusive membership, with clearly defined boundaries around its structure. The high grid nature of the hierarchy grouping suggests a rigidly defined structure of the social makeup of the group. Although a group exists, each individual is ranked, unequally, based on their social status.

A member of a hierarchy is within a clear, bounded group with many rules and regulations that stipulate its membership. Rank is extremely important in the group and is used to control the way that disputes are managed among individuals. Having high control over others is important, with a select few within the group holding a high level of influence over other members. Thompson (1990) uses the example of a hierarchy in a high-caste Hindu village. This villager is within a clear, bounded group, and is ranked relatively highly within his or her sphere. This affords them a substantial level of control over others based on their position in the group. They also must adhere to the regulations and rules stipulated by their membership. In this way, their freedom is 'constrained by socially imposed gridiron' (Thompson et al., 1990, p. 7).

Egalitarianism

Egalitarianism carries the same group influences and membership as the hierarchy dimension, however it differs through its internal social structures. The way that one person relates to another is not based on rank or hierarchy, but rather on an equal basis. Egalitarianism provides very little basis for excluding members, unlike the hierarchy faction. Networks between people within the egalitarianism group do not change from person to person, whereas this is not the case with the rigid ranking structure of a hierarchy. Unsurprisingly, egalitarianism focuses on the equal footing of each person within the group, with the desire to abolish coerciveness and inequality (Thompson et al., 1990).

A key example of egalitarianism is a member of a commune. There are no social hierarchies to speak of, each person is treated equally and are able to equally make their own decisions. They are still part of a clearly defined group and highly influenced by the group's goals, ideals and aims which they work collectively towards. The group is highly critical of any ranking or coerciveness, which can then prove difficult to resolve disputes. Thompson (1990) highlights that egalitarians see themselves as effectively having a 'wall of virtue' that outlines and bounds their group.

Individualism

Individualism is housed under the low grid, low group segment. This is due to those in the group coveting freedom from coercion and the influence from others, while also not belonging to any particular faction. They are predominantly focused on self-interest, as they see the world as a difficult place where they, and only them, can forge their own future. In this way, individualists limit the amount they rely on others (due to their low grid aspect), and utilise personal strategies that are essentially unique to themselves (Thompson et al., 1990).

An example of an individualist is a self-made business person, perhaps someone who has established their business on their own. They utilise market-based approaches to get ahead, with self-interest acting as the key motivator to this behaviour. This is a starkly different approach to the other three groups, who either have some element of socially imposed gridiron of rankings, and/or are part of a group with a common goal.

Fatalism

The final quadrant of the plane describes the low-group, highly-controlled social imposition of the fatalists. They ultimately do not have a group to which they belong, and as such behave as individuals. The difference between this and individualism is that fatalists do not perceive that they hold any personal control over their own futures. Thus, they are heavily reliant on others. They see life as being highly controlled by fate, and as such do not attempt to change outcomes, resulting in an approach that is reliant on coping and accepting (Thompson et al., 1990). Luck, fortune and lottery define this group, resulting in a viewpoint that accepts outcomes readily. An example put forward by Thompson (1990) is a non-unionised factory worker. This factory worker's life can be seen to be heavily controlled by others: their bosses, the Government and also their own surroundings. They are resigned to the fact that these entities will have more control over their personal lives than they themselves do. Their worldviews then reflect this approach, as they do not join a union, and do not attempt to change elements of their lives.

2.4.4. Grid-group and Risk

Douglas and Wildavsky (1982) further explore the grid-group approach, highlighting how adherence to a certain category carries with it a likelihood to treat risk in a particular manner, depending on the location of each on the plane. A fatalist may see risk as something that cannot be shifted or altered according to their own actions. That risk is essentially 'there' and 'not controllable'. They would accept decisions made by others in terms of risk acceptability and feel that they have no power in whether they are exposed to the risk or not. In this way, a fatalist may respond differently to a risk than an individualist. The individualist conversely sees risk as something that can be controlled to some extent, but all decisions relating to the exposure to risk should be made by the individuals themselves, not by any other entity or group. For example, an individualist may see the choice to vaccinate as a right of their own. Therefore, the risk that is placed on them should only be as a result of their own decisions, not decisions made by others being imposed upon them. Their worldview encompasses, and is heavily based on personal choice.

An egalitarian may instead take a differing approach, instead focusing on the common good rather than that of an individual's self-interest. For example, in the case of an egalitarian's view of risk the individual risk of receiving a vaccine is more acceptable when it means the herd is immune, thus protecting the whole group. The risk of a person receiving an adverse reaction to the vaccine is considered small when compared to the overall benefits to the whole group. In addition to this, the decision-making power of risk acceptability then lies with the group, not with a select few (highlighting the low grid approach). This can mean that public group perception is extremely important in making a decision for the whole group. Each vote would be treated equally regardless of expertise.

The hierarchy faction is also based on the group adhering to decision-making on behalf of the whole group. However, the key difference with the egalitarian faction is between how the decision on risk acceptability is made. In the case of egalitarianism this decision is made by the whole group, with each member representing an equal proportion of the decision. Within the hierarchy quadrant, it is the decision of a few that outline the approach for the group. In the case of vaccinations, a small group of experts need to highlight their risk acceptability, or risk appetite, when it comes to whether to vaccinate the group or not. Should the expert decision-makers decide to vaccinate, all group members within the hierarchy are expected then to adhere to the decision and receive the vaccination. The decision-making power for risk acceptability then does not fall to the masses, but rather, to a few. This can be seen as an advantage, as quite often these 'few' are chosen based on their position within the hierarchy, or have some expertise within the field. However, a low grid adherer may begrudge the lack of personal autonomy or any element of personal decision-making in the process. The individualist would want to make the decision themselves, and only themselves, affording full autonomy with whether to proceed, based on self-interest. Egalitarians would begrudge the hierarchy for ignoring the risk perceptions of the layperson and treating people who must be exposed to the risk as essentially having no say over their own personal exposure.

As each worldview considers risk and personal risk acceptance in differing ways, this significantly changes the answer to the question of 'who decides on the acceptability of a risk?' For example, hierarchists would always defer to experts, whereas an egalitarian would seek public consultation or public opinion on risk acceptability. Fatalists would take little, if any, action on the decision-making process of a risk. Individualists would like very little decision-making that is group based, but rather desire full autonomy over their own risk exposure. Thus, the worldview of the person undertaking the risk would greatly affect the process by which they decide, or defer decisions, on risk acceptability. Therefore, one could argue that the decision of a hierarchist on a particular issue or project could vary from the decision from someone who sees themselves as an individualist. This inconsistency in decisions ultimately changes whether a project proceeds or not.

2.5. Conclusion

In this chapter the theories of risk were explored, providing a foundation for understanding various risk approaches. While it is recognised that technical risk processes are predominantly used today, it could be considered to be an outdated theory with many drawbacks. More persuasive theories were suggested (the psychological and cultural approaches), which can be used to form the basis for further testing in the water sector.

While the technical approach was found to be somewhat inadequate and beset with problems, it could be the case that the psychological and cultural approaches described may provide insight into the process of risk assessment, albeit one that allows for an adjustment of the risk scores for the psychological and worldviews of the assessor. Whether this process synthesis is even possible will depend on evaluating whether the technical approach is found not to be objective and whether the psychological and cultural theories can adequately explain deviation in scores between assessors. In this chapter the basis for understanding the theories behind the study when testing the technical, psychological and cultural theories of risk was provided. Using this knowledge, it is necessary to consider these theories and to test them in order to determine their validity in explaining any variation in risk scores between participants.

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Chapter 3

Current Risk Assessment Approaches

Risk assessments effectively act as a decision-making tool in allocating funding. This thesis questions to what extent this tool is an objective and ideal choice for this type of analysis. If the hypothesis is proven true, it could prompt for a reassessment of existing methods. Altering risk processes could ensure that personal risk assessor psychological or sociological pressures do not ultimately factor into a large decision on the allocation of public funds. This study may provide insight into how existing risk processes function, and how choice of risk assessor can affect the resulting risk score. The information may be utilised in changing risk assessment methods to ensure that water projects that are approved for progression are not detrimentally affecting the community, or seen as overly risky, especially as the funding for the projects are funded by the community and taxpayers. This does not mean to imply that the process will necessarily become more objective, as arguably this is not achievable due to the very social, psychological and individual nature of humans that will always be present. However, what this study does aim to achieve is to ensure that the extent of the psychological and social elements in risk perception decision-making is understood and accounted for. This can then lead to processes that ultimately moderate these elements to reflect more keenly the agreed values, worldviews and risk appetites of the community.

A number of different ways of assessing risks exist across varied industries. This chapter first turns its focus to understanding how risk is currently quantified and assessed in the water industry while outlining its basis in Risk Management Standards. An overview of differences between each water authority is provided within this chapter, while the detailed explanation of each risk approach is highlighted in Appendix C.

3.1. The Standards

International Standard ISO31000:2009 "Risk Management: Principles and Guidelines" (hereafter "the Standard") outlines a generic approach to managing risk. In defining risk, the standard highlights that "all activities of an organization involve risk" (Council of Standards Australia, 2009, p. iv), wherein employees of the organization then decide on which risks to act on, and what the allowable risk is. Therefore, "all decision-making within the organization, whatever the level of importance and significance, involves the explicit consideration of risks and the application of risk management to some appropriate degree" (Council of Standards Australia, 2009, p. 23). The main aims of the Standard include improving the identification process of risks and allowing for "proactive management" while also establishing a "reliable basis for decision-making and planning". This last point is particularly intriguing in the context of this study to determine whether the process is 'reliable' or whether bias affects this reliability. In particular, there is a need to further explore what the writers of the Standard deem as 'reliable' in this context (Council of Standards Australia, 2009, p. iv). Is it reliable in that the process is consistent, or reliable in the context of a process that works in all circumstances? This is not clear in the Standard. The document proposes some principles for the management of risk, a framework, and a risk management process.

'Risk' is defined within the code as being an 'effect of uncertainty on objectives', which is a relatively broad definition. This is followed by a number of notes highlighting that 'effect' refers to a deviation from the norm, and that risk is "often expressed in terms of a combination of the consequences of an event… and the associated likelihood… of occurrence." (Council of Standards Australia, 2009, p. 1)

Interestingly, the introduction to the Standard states that the intent of the document is not to create uniformity in risk processes throughout industry, but instead to encourage organizations to form their own risk processes that take into account their specific industry and needs (Council of Standards Australia, 2009, p. 1). This is particularly interesting considering the very nature of adopting a standard promotes some level of uniformity, even at a basic level. The standard presents a risk process that is generic, followed by an encouragement of organizations to adopt an approach that works for them.

The ISO31000 Standard explicitly states that risk management forms a key element in decision-making within organizations, allowing decision makers to "make informed choices, prioritize actions and distinguish among alternative courses of action" (Council of Standards Australia, 2009, p. 7). It highlights that risk management should be based on information which includes the experience and judgement of experts. The very nature of allowing experience and judgement introduces individual biases into the process, which is an area not addressed within these guidelines.

Decision-making rests heavily on the risk management process described by ISO31000. The risk framework lays the foundations for decision-making in general, ensuring that all objectives are aligned with risk management processes (Council of Standards Australia, 2009, p. 12). The risk management process within the code is shown in Figure 3-1.

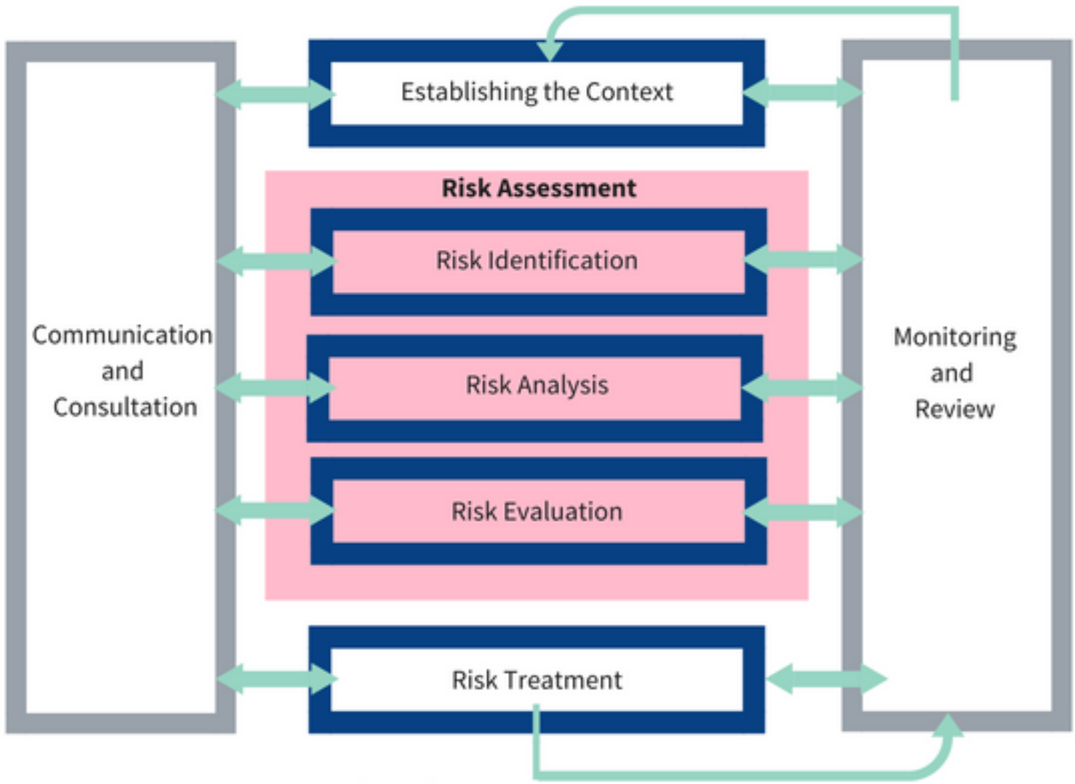

Figure 3-1 Risk Management Process (Council of Standards Australia, 2009, p. 14)

The ISO31000 Standard relies heavily on the measurement of risk, in particular, measuring its likelihood and consequence. It recommends that organizations outline the acceptability of risks, how likelihood is measured, and how consequences will be scored. It can be argued that this is an attempt to create a unified and objective approach to measuring risk, despite stating earlier in the document that "[p]erceptions [of stakeholders] can vary due to differences in values, needs, assumptions, concepts and concerns" (Council of Standards Australia, 2009, p. 15). The underlying assumption is that stakeholders will be swayed by their own perceptions of a risk which is influenced by their personal values and ideals; whereas professionals within an organisation will not be affected by the effect of values, presumably as they have a risk management process to adhere to. Furthermore, these professionals should be 'people with appropriate knowledge' to identify the risks (Council of Standards Australia, 2009, p. 17). The level of 'appropriate' knowledge is not made clear in the Standard and thus can be open to personal and diverse interpretation.

The ISO31000 Standard often refers to IEC31010, is a standard outlining recommended risk measurement techniques that organisations can adopt (International Organization for Standardization, 2009). The water authorities are required to adhere to ISO31000, yet are not required to abide by IEC31010 (Victorian Managed Insurance Authority, 2016).

The IEC31010 standard explicitly defines risk measurement techniques. The importance of engaging stakeholders is stressed early in the IEC document. It provides an outline of the benefits of engaging stakeholders in the risk assessment process which includes 'bringing together different areas of expertise for identifying and analysing risk' and also 'ensuring risks are adequately identified' (International Organization for Standardization, 2009, p. 11). The IEC31010 standard suggests defining risk criteria as part of the risk process. In particular, it defines:

- 'the nature and types of consequence and how they will be measured,
- the ways in which probabilities are to be expressed,
- how a level of risk will be determined,
- the criteria by which it will be decided when a risk needs treatment
- the criteria for deciding when a risk is acceptable
- whether and how combinations of risks will be taken into account. ' (International Organization for Standardization, 2009, p. 12)

It further suggests the risk assessor conduct a consequence analysis to determine outcomes of risks if they are realised. This requires the risk assessor to consider both short-term and long-term impacts of a risk, as well as any secondary consequences that may arise from the risk. The risk consequence table within each water authority covers many of these elements, however there are some aspects that are not included. For example, how combinations of risks will be taken into account is not explored within existing risk processes, with risk assessors expected to act on the most prevalent risk, which is defined as the risk that the assessor deems most 'risky'. In addition, a key standout is 'the criteria for deciding when a risk is acceptable', highlighting the importance of placing risk acceptance boundaries around identified risks. This criterion is often covered within risk appetite statements, which are discussed further below.

A likelihood analysis is used to place a boundary to the risk consequences that have been highlighted. The IEC31010 (2009, p. 16) standard suggests three approaches for estimating probability:

- the use of historical data to gauge likelihood of events occurring,
- fault tree analyses or event tree analyses to forecast probability,
- expert opinion.

Using historical data or fault tree analysis can be difficult to define, as the risk assessor may not have access to either the data, nor have the expertise to conduct probability forecasting (Aven, 2017). These two elements are not covered, or mentioned, in any of the water authorities' risk frameworks. Therefore, risk assessors instead rely on expert opinion alone. As those consulted are considered experts in their field, it is not unreasonable to expect that they can conduct probability judgements themselves. The IEC31010 standard furthermore suggests the Delphi technique, which refers to a group session of experts that results in consensus. Some problematic elements are apparent in this approach such as: Who should be included in the workshop? Further: Who chooses participants in the workshop? Personalities may also affect this workshop, with more vocal or respected opinions holding a larger sway over the consensus.

The IEC31010 standard describes many risk assessment processes that can be used to judge uncertainty, many of which are used in the water industry. For example, HAZOP (Hazard and Operability study) workshops are not uncommon in water engineering projects. However, due to the high cost involved in running these types of workshops, HAZOPs are more likely to be conducted for larger projects and within the planning or construction phase and therefore are less likely to occur in the business case phase (the point at which funding is allocated). A HAZOP requires a group to systematically explore each section of a project to predict any potential risks. Similarly, the HACCP (Hazard Analysis and Critical Control Points) is a similar process also used in these projects. It works to identify and isolate safety risks, another method that is often utilised at the later stage of projects. Both the HAZOP and the HACCP have a key deficiency in highlighting social risks, as their frameworks are not set up to do so.

On a broad level, the water authorities' risk assessment processes follow the IEC31010 risk assessment process standard. The importance of the water authorities' following the standard is due in much part to this document providing the framework for establishing risk processes to guide decision-making throughout the world, and also to adhere to requirements set by the Government.

3.2. Set up of Water Authorities

Management of Melbourne's water supply materialised into a centrally managed institution in 1891, under the name 'Melbourne and Metropolitan Board of Works' (MMBW). Its main aim was to provide clean water and ensure treatment of sewage within Melbourne and the surrounding areas. Parkland in the Yarra Ranges, east of Melbourne, was protected to form Melbourne's water catchment area, one of only five in the world (Melbourne Water). The MMBW controlled water flows throughout Melbourne, being responsible for all activities from source to disposal. In 1992, the MMBW formed Melbourne Water, and two years later, became a wholesale water company. Three water retailers (City West Water, South East Water and Yarra Valley Water) were formed during this time (see Appendix B for map). These retail authorities are responsible for maintaining the assets and provision of water and sewerage services to their own specified geographic regions of Melbourne. Their provision areas do not overlap, and as such are not in competition with one another. Each water retailer is customer-facing, and responsible for billing as well as maintaining smaller reticulation water and sewer systems while Melbourne Water, the bulk water service provider, presides over the large transfer pipelines, and any large treatment plants. The water retailers are in charge of constructing and managing a number of smaller sewage and recycled water treatment plants, while Melbourne Water controls and manages water sources, such as the Thompson and

Sugarloaf Dams in Melbourne's east. Melbourne Water on-sells this water to the water authorities, who in turn sell to water users. Appendix A provides detailed descriptions of each water authority. Refer to Appendix B for the full map of water authority jurisdictions.

The Boards of the water authorities are appointed by the State Government (refer to Figure 3-2). The Managing Director of each organisation is answerable to the Board, while the Board is accountable to the Water Minister. The Water Minister in Victoria is appointed to their position by the Government of the day, and they are an elected Member of State Parliament. The political party that takes on the role of the Government is elected by voters at an election every four years.

Figure 3-2 Water Authority Appointment Chart

Despite all Boards of the water authorities being answerable to the same Water Minister (as they are all within the same state), they all will pursue differing objectives which results in individually devising their own processes and procedures. As such, all have different appetite for risk frameworks that drive decision-making within the organisation. The risk appetite ultimately defines what level of risk is acceptable for the organisation to take on and is ordinarily used hand-in-hand with the risk process. It is in the form of a document that is accessible to all staff. Further information on the risk appetite is provided in Section 3.2.1.

All the water authorities are required to adhere to the Victorian Government Risk Management Framework (VGRFM) that sets out mandatory requirements regarding each utility's risk assessment process (Victorian Managed Insurance Authority, 2016). The VGRFM dictates that all water authorities within the state of Victoria must have risk processes consistent with ISO31000:2009 Risk Management Standard (see Section 3.1). However, each water authority is allowed to devise its own risk framework to be approved by their board, and have a related risk appetite statement to complement the document. This was further refined at lower levels by managers to ensure an appropriate risk guide for others to follow within the organisation.

3.2.1. Corporate Risk Appetite

The Corporate Risk Appetite is a statement or agreed set of risks that are deemed 'acceptable' by the organization. This appetite is ordinarily set in a top-down fashion, i.e. dictated by the Board of the organization, and then filtered down for risk assessors to use. As many risks cannot be controlled, it is imperative to determine what level of risk exposure is to be taken on by an organization. This risk acceptability is defined in a risk appetite statement accessible to all who work within an organization. Furthermore, risk appetite statements also provide the basis for a risk culture that can be embedded through all levels of the company. The statements aim to combine higher level objectives and risk acceptance to provide guidance for day-to-day practices and projects. Essentially, risk appetite statements should be at the basis for scoring risk for each risk assessor. With reference to the statement, they should be able to make systematic, unbiased decisions that are consistent throughout the organization.

The risk appetite statement is written in a way that covers high level strategic risks as well as risk tolerance, in particular what level of risk will be accepted by the organization. The statement defines the level at which a risk is deemed intolerable, and presents an example of this. This can be in a number of areas that cover financial risk, safety, customer, staff, environment or even reputation. The tolerance levels are always measurable, for example number of fatalities, or credit rating limits. Of course, the document does have its limitations and can only offer high-level examples and cover off areas that are directly related to the ongoing strategic objectives. Therefore, these statements cannot cover all areas of risk, but merely provide a high-level guidance. In aligning with the corporate risk appetite statement, it can be difficult to determine the level of acceptable risk at a micro or project level. For this reason, it can only provide a low level of guidance to everyday project managers.

3.2.2. Key Differences in Risk Processes between Organisations

The full risk processes for each Melbourne water authority are shown in Appendix C. Each organization has slightly differing approaches to its risk management. Despite this, there are more similarities than differences. To begin with, the ordering of the categories is different, as is the way the risk consequence tables are set up (refer to Appendix C which shows Melbourne Water (MW), South East Water (SEW) and City West Water (CWW) report the categories by column, yet Yarra Valley Water (YVW) has it by row). Therefore, the emphasis on certain categories may differ slightly based on where they are placed in the table however this is not expected to have a significant impact upon results.

MW is the only organization not to incorporate risks to its own staff in its consequence table. All the other organisations mention the risk of worker strike or poor performance as a potential risk to be considered. The category of safety is almost identical for all, with minor differences that are not notable. Upon considering the environmental category of each risk consequence table (see Appendix C), it is apparent that most of the organisations, bar Melbourne Water, mention regulatory breaches in environment as risks. Melbourne Water covers this off in a separate category on overall regulatory risks.

Each organization has a slightly different approach to its financial risk outline. Melbourne Water, South East Water, and City West Water all base their risks on spend in dollars, whereas Yarra Valley Water additionally includes credit rating reduction risks in its approach, among other elements, which make its financial risk category more detailed than the other approaches.

The reputation category is consistent in that it highlights ‘extensive’ and ‘serious’ negative media exposure as the highest risk, with Yarra Valley Water also stating permanent reputational damage in this category. Public outcry is mentioned in all, except Yarra Valley Water, where complaints to the Water Minister is instead cited.

‘Customer’ risks vary between the organisations. ‘Extreme’ in Yarra Valley Water’s case is by number affected by a service loss (10,000), which does not specifically state that 10,000 people must lose their supply, but state that they are ‘affected’. This could mean secondary or tertiary effects such as family members’ or friends’ loss of water service. Whereas City West Water considers the number who have actually lost service as 500 people. South East Water and Melbourne Water’s guidance is not clear, with no stating of a number of people affected. This risk category is rather vague for all except Yarra Valley Water, whose approach is prescriptive and includes elements of public health category. Other authorities have a separate public health. ‘Compliance’ is included as a category for all except Yarra Valley Water, where these risks are incorporated into other categories.

Overall, although there are differing numbers of categories, all the risks are nevertheless in the table in some location. All the risks though, match one another on consequence score, with all four water authorities scoring consequence from 1 to 5. Analysing the difference in risk consequence tables concludes that there is not a significant difference in the risk consequence scoring approaches between the organizations, and therefore can be readily compared with minimal impact.

Likelihood		Negative Consequence				
		Insignific ant (1or E)	Minor (2 or D)	Moderat e (3 or C)	Major (4 or B)	Severe (5 or A)
	Almost Certain 5	Med	Med	High	Ext	Ext
	Likely 4	Med	Med	High	High	Extr
	Possible 3	Low	Med	Med	High	High
	Unlikely 2	Low	Low	Med	Med	High
	Rare 1	Low	Low	Low	Med	High

Figure 3-3 Example of Risk Matrix (Melbourne Water, 2017)

It is possible, and highly probable, that the same risk rating can be achieved despite scoring completely different risks. For instance, an assessor may allocate a risk consequence of '2' and risk likelihood of '4' for a reputation-based risk (refer to Figure 3-3), then another person may allocate the same two numbers to an operational risk, thus both different types of risks achieving the same overall risk score of 8. Despite both highlighting different risks, their rating of 'medium' remains the same, and this is what is reported on in the business case. The implication of this is that the risk rating itself may not explicitly highlight the type of risk, however further information on the nature of the perceived risk is ordinarily included within the document.

A note on Subjectivity vs Objectivity of Risk Assessments

Meetings with risk assessors have highlighted the varied view of the subjectivity of existing risk approaches. Some risk managers see the process as being very subjective, and open to interpretation. Others see risk as an objective concept that exists, and is calculable. In their view, the responses to risk assessments can change, but it is because the assessor came to the right/wrong risk score, insofar as the right or wrong risk score for each project objectively exists.

3.3. How these processes will be used in research

Risk processes vary in subtle ways in each water authority, however overall have a similar approach that adheres to ISO31000. Risk identification and assessment is a key element in procedures within each organization and helps to aid decision-making in allocating funding for projects for a certain course of action. Understanding the process by which risk assessors reach risk ratings is imperative in understanding how funding is allocated. In this research aims to understand driving forces behind individual risk scoring and how they are undertaken. Using each organisation’s risk assessment framework, this study will provide participants with fictional projects for risk assessment. As the approaches are not vastly different between authorities, they can then be compared. The area that may result in slightly differing results could be the qualitative aspect of the study, wherein the participant is asked an open-ended question about what types of risks are the most prevalent for each hypothetical situation. Trends can be considered for each organization, to determine whether certain risks are mentioned over others, and whether these risks feature in the risk consequence matrix. Through this process, one can use existing risk management frameworks to first determine the objectivity of the practice of risk rating, while also determining whether other psychological or sociological factors may be present in scoring risks.

3.4. Conclusion

This chapter considered the elements of how each organization currently undergoes the process of measuring risk. Not only is risk scored using a risk-matrix approach, but this is also then compared to other projects to inform decision-making in options assessments or business cases. The implications of this approach brings to light the fact that each organization adopts the technical risk approach theory. It also highlights the importance of how these processes stem from existing standards in risk management, which also rely on the technical approach to risk. It is then not surprising that all the organisations take a similar approach, albeit differing ever so slightly. Risk consequence tables are clearly defined, and very descriptive in nature (see Appendix B for more information on individual risk processes). Some elements are measurable, yet others are not. Those that are measurable may be predicted on the basis of previous data. However, many of the outcomes on the table require 'expert-level' predictions to determine consequences including risk that cannot easily be measured (eg. social risks).

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Chapter 4

Research Design

4.1. Theory and Research Design

The 'explanation of observed regularities' (Bryman, 2016, p. 17) provides the basis for the research design. In the study, an attempt is made to measure risk perceptions while providing a theoretical backdrop in explaining the results. The aim is to determine the reasons why one assessor would proceed with a project, while another assessor would not due to having concluded the project 'too risky'. Understanding this could provide key insight into which projects are approved and which are not. It is an attempt to counter the possibilities of missed opportunities merely because the project risk assessor carries certain psychological or cultural barriers which result in the risk being assessed as unacceptably high. Similarly, the opposite is true also. This chapter explains the design behind the study, and how the theories will be tested against the risk scores.

The design of this research is based on the process of deduction, a process wherein the hypothesis was reached on the foundation of existing theories in the risk domain and tested using collected data (Bryman, 2016). The method employed in this research is referred to as a cross-sectional design. This is the collection of a sample of cases that provides quantitative data, and also longer answer approaches to highlight any patterns of association (Bryman, 2016). It is not unusual to use this form of deductive reasoning for sociological experiment design (Bryman, 2016, p. 31). In this way, existing theory drives the structure of the study. This process results in determining the explanatory theory that best relates to the water industry's decision-making processes, on the basis of risk perceptions. The process followed is outlined in the flow diagram in Figure 4-1.

Figure 4-1 Research Design Procedure (Bryman, 2016, p. 21)

The first requirement in this study is to test the objectiveness of existing approaches to assessing risk. At the outset, this test is to assess the degree of objectiveness of risk assessors' approaches when they utilise current risk frameworks. Given the nature of the technical approach, if objective, then the scores between assessors should not vary greatly. Should significant variation in the scores exist, then there is a need to determine whether the psychological risk theory or the cultural risk theory provide a better explanation of the bias in the results.

4.2. The Task at Hand – Addressing the Research Questions

4.2.1. Research Question 1: Do current risk approaches produce objective results?

The first consideration turns a critical eye towards current risk processes, noting that they adopt a technical and engineering approach to risk. Critique within the literature is that the approach is based on its reliance upon a rational decision maker and in particular, the objectivity of the rational assessor (Thompson, Ellis, & Wildavsky, 1990). Rationality, as argued by these critics, is elusive to individuals, as they are not immune to psychological and societal constructions in their thinking (Eckstein, 1997; Green & Shapiro, 1994).

Critical to answering this question is what is meant by the term 'objective'. If a risk score is truly determined by an objective process, then the obtained score should not vary greatly amongst those who determine the score. In other words, giving each assessor the same project should result in all assessors obtaining similar risk scores. Any variation in the scores could be attributed to subjectivity, or bias, in responses. Following this, if the risk approach fails the test of objectivity, it leads one to consider elements that may explain any deviation in scores between individuals. To assess this question, water professionals in Melbourne, Australia were recruited for this study, and were asked to undertake risk assessments on seven projects, both familiar and unfamiliar, to determine whether there exists a substantial difference in scores.

Objectivity in this context assumes that each risk assessor will have the same risk assessment outcome when presented with the exact same information. Presuming rationality in assessors, one can expect that same information and processes would produce similar results from different assessors. This also assumes that there is a predefined risk assessment procedure, which, in this case, is defined by each organisation (the technical risk approach), the process argued to be objective.

The 'objectivity' of the data will be accepted if the risk scores predominantly (95%) fall within the same risk rating (low, medium, high or extreme).

As previously described, risk ratings and scores are the product of two dimensions: risk consequence and risk likelihood. Both of these inputs have possible scores ranging from 1 to 5. Therefore, when multiplying these figures a risk score will be received that ranges from 1 to 25. The 'risk ratings' of these risk scores are shown in Figure 4-2.

Figure 4-2 Risk Scores (Consequence x Likelihood) and Corresponding Risk Ratings

Although to show objectivity in the scores, it is expected that 95% of the results of respondents all within the same risk rating (not necessarily the same risk score), this approach does not truly reflect the degree of objectivity required. It was suggested in the previous Chapter that assessors may have the same score, yet achieve that through different assessments of the likelihood and the consequence. This secondary consideration might arise if all the overall risk scores are similar. If they are similar then it could be argued that the individual likelihood and consequence scores will need to be assessed to see if they are also similar. However, if the overall risk scores are not similar, then clearly the likelihood and consequence components must also be different. In such a situation, there is no need to confirm the differences in the likelihood and consequence scores, as they must differ. Once a degree of non-objectivity has been determined then a consideration of the impacts of the psychological and cultural views on risk scores needs to be undertaken.

4.2.2. Research Question 2: Does the psychological risk approach explain any subjectiveness or bias of risk scores between individual assessors?

Investigating these questions requires applying regression techniques that evaluate the association between an individual's risk score and a range of the psychological factors that are posited by the theory. A factor is considered to be important if it is found to be statistically significant when regressed against the risk score. The level of statistical significance is set at $P = 0.05$ for this research, a level commonly used in statistical analyses.

In testing the applicability of alternative theories, existing pre-verified study methods were adopted. As these methods were widely respected and utilised within their respective fields, they can be directly implemented within this study.

The psychological risk theory framework adopted is created by theorists P. Slovic, Fischhoff, and Lichtenstein (1985). They devised a psychometric survey to explore psychological risk attributes within respondents. The statements in the psychometric survey were taken directly from the study by P. Slovic et al. (1985), thus it can be argued that the statements can be considered to have been pre-validated. The responses to these questions are regressed against the risk scores from each individual. Further information is provided in this chapter in the "Detailed Methodology" section (see Section 4.4).

The qualitative aspect of the study explores the risks water utility experts perceive are associated with new and innovative projects, and how risk perception differs across different projects. An open-ended, qualitative approach is taken to identifying risk perceptions, leaving experts to highlight their own risk factors, rather than presenting pre-defined ones. This allows for a more exploratory approach to the question of risk perceptions. The research also differs from others through highlighting risk factors related to 'new' or 'unfamiliar' projects (projects that have previously never been undertaken by the water authorities) and therefore explains risk attitudes to innovative approaches to water.

4.2.3. Research Question 3: Does the cultural theory of risk (worldviews) effectively explain the difference in scores?

The next approach considers the extent to which the cultural theories explain how risk scores are calculated between persons. As described in Chapter 2, the cultural theory of risk rests on the work of Mary Douglas (2013). The theory suggests two main inputs that explain how a person (or group in this instance), perceives a risk: that of grid, and group. The grid aspect of the theory looks at how the person believes an ideal society should be structured, while the group section asks respondents to determine what level of 'group membership' is important for the ideal society. Refer to Section 2.4 for more information on the theory tested. The respondents are placed into one of four groups (hierarchy, individualist, egalitarian or fatalist) on the basis of how they respond to 30 pre-tested questions.

The theory is based on Mary Douglas' (1992, 2013) work on culture and risk. However, within this study, Douglas' measurement approach was not adopted exactly, but rather one used by another prominent researcher in the field, Daniel Kahan (2008). Kahan implemented an approach that used most elements of Douglas' study, however altered parts within the study that were deemed 'weaknesses' which were adapted to receive favourable Cronbach's alpha scores (Kahan, 2008). Kahan's study, having been highly cited, was deemed more suitable for this study, due to its improvement of the initial testing procedure. Kahan's cultural cognition approach has been used by various other studies and risk research centres (Xue, Hine, N.M, & EB, 2014) being well-recognised in the field of risk perception research.

4.3. The Survey

The methods outlined in Section 4.1 rely on the ability to survey a large number of risk assessors over a range of different projects producing a set of risk scores which reflect each respondent's risk response. A paper-based survey was produced and groups of risk assessors were assembled to undertake the survey. The surveys were supervised in order to answer any questions that the participants might have about the projects, and to control the survey environment (including what materials were provided to each participant).

The survey consisted of four parts and in it participants were asked to score the riskiness of seven different projects using a risk assessment framework. A copy of the survey is presented in Appendix D.

The first section of the survey collected demographic data related to age, gender, role and organization. This allowed further exploration into potential factors in risk trends within these categorizations. Following this, the second part of the survey presented participants with seven different fictional project descriptions related to the following:

- 1. Pipe Replacement
- 2. Pump Station Installation
- 3. Construction of a Recycled Water Treatment Plant
- 4. Save Water Campaign
- 4A. Using Recycled Water as Potable
- 4B. Radiation in the Treatment of Water
- 4C. Removal of Fluoride in Drinking Water

These projects, which can be grouped into either familiar (1 to 4) or innovative (4A to 4C) categories. Familiar projects are those that are not unexpected within the type of work that risk assessors in the sector undertake. The 'unfamiliar' (4A to 4C) projects have not previously been undertaken in Melbourne. All the projects have contentious elements to them, such as drinking treated wastewater, the use of radiation (which carries negative connotations) (Fischhoff, Slovic, & Lichtenstein, 1983) and also removal of fluoride, which can be socially sensitive (Rajagopal & Tobin, 1991).

Participants were asked to provide a 'risk score' for each project. The risk score is derived from the risk consequence score (from 1 to 5) multiplied by its risk likelihood score (1 to 5), thus receiving a risk score ranging from 1 to 25. Each participant was given the risk assessment framework for their organization, as described in Appendix C.

4.3.1. Project Descriptions - 'Familiar' Projects

The project outlines for project descriptions 1 to 4 are included in the following pages.

Project 1 – Pipe Replacement

A DN400 pipe will be replaced on High Street in South Blighton between Edward Street and April Crescent. This section of main is comprised of Abestos Cement (AC) pipe, and will be replaced with a PE (Polyethylene) pipe. The AC main will remain in the ground, but labelled as 'abandoned' on all documentation. The replacement of the main will be 200m of line.

High Street is a busy thoroughfare, acting as a link between the Western road and the Northern freeway. It is expected that approximately 20 houses will experience disruption to their water supply of up to 4 hours, as well as traffic disruptions along Rosanna Road. Cost = $150,000

Project 2 – Pump Station Installation

A pump station at Rosemary, in Melbourne's south-east, has been continually breaking down. This pump station services the Rosemary High Level zone and feeds a total of 928 properties. There are a total of 2 schools, one hospital and one nursing home in the area.

The top water level that the pump is designed to maintain is 131m. The highest elevation in the area is 97m. The back up supply comes from a neighbouring zone, through the manual opening of a shut valve, yet can only provide 120m TWL (Top Water Level). The local councillor has urged decision-makers (and the Water Minister) to upgrade the pumps, due to receiving many letters from residents as a result of water shut offs due to repairs. The total cost is expected to be $630,000 for the upgrade.

Project 3 – Construct STP/RWTP

The urban growth boundary in Melbourne has resulted in a number of new residential suburbs where previously there existed land primarily for farming. This expansion has meant that a new Sewerage Treatment Plant and Recycled Water Treatment Plant is required for the area providing recycled water to the new suburbs and for the safe release of excess treated water into the nearby Sweller River. The developer has been approved to construct 2000 new homes within the area. Further expansion is expected through this corridor, and the STP is expected to service a total of 8,000 new homes and businesses.

At this stage, construction has not yet commenced, with the developer still selling the properties off the plan. So far, 15% of properties have been sold.

Construction on the development is expected to start in May 2018, which will be completed by December 2020. The first property is expected to be completed by August 2018, and will be occupied from this time onward.

Expected Cost = $4.78 million

Project 4 – Save Water Campaign

Save Water campaign aims to educate and promote water-wise behaviours in domestic households. The campaign aims to target:

- *High water usage in showers*
- *Garden watering*
- *Topping up pools*

- *Dishwashing*
- *Machine-washing*

The campaign is expected to save 0.05GL per day. This is expected to equate to $17 million ($2.8 per KL) loss of revenue for the water retailer. In addition to this, the campaign is expected to cost $430,000 per year for the life of the campaign. It is unlikely that water authorities will need to order more desalination water from the recently constructed desalination plant.

4.3.2. Project Descriptions - New/Unfamiliar Projects

The following projects are considered to be more unfamiliar than projects 1-4 specified in 4.3.1. Whereas Projects 1-4 are considered 'common' in the water industry, Projects 4A, 4B and 4C have never been previously undertaken. As such, the risk assessors surveyed in the study have not, in the past, been exposed to these types of projects.

Project 4A – Using Recycled Water as Potable

A Class A Recycled Water Treatment Plant in the historic area of Gumbark will be upgraded to allow for potable-quality water. This water will then be inserted directly into the potable supply, and mixed in with the existing potable water and delivered to residents within the area via the existing two pipe system. Notifications and information sessions will be given to all residents prior to implementing the change. The total cost of the projects is expected to be $3.5million, delivery potable re-use water to approximately 1,200 residential properties and businesses.

Project 4B – Using Radiation in Treatment of Drinking Water

Research has been released following extensive studies at various Water Collaborative Research Centres highlighting a more effective way of treating drinking water that doesn't affect its taste, and colour. The treatment process involves the use of high levels of radiation to exterminate any unsafe elements from drinking water. It results in a one-step process of treating water, and ultimately is cheaper than the existing methods of chlorination, and fluoridation. Research has determined that the use of chlorine results in chemicals known as disinfection by-products. These by-products may be carcinogenic or have other toxicological effects associated with consumption.

The new radiation process ensures that the water doesn't carry these properties, that quality is always consistent regardless of the inflow water quality, and furthermore, quality doesn't deteriorate the further the water travels (as is known to happen with chlorine). The research claims that the water post-radiation treatment is entirely safe for drinking.

Radiation stations will be fitted at the Gumbark Recycled Water Treatment Plant as the first testing scenario.

Project 4C – Removing Fluoride from Drinking Water Supply

Following a significant amount of lobbying from alternative health groups, the State Government is under increasing pressure to remove fluoride from Melbourne's drinking water supply. In doing so, lobbyists argue that consumers could then make a choice about fluoride in water, rather than being forced to consume it.

The Water Minister would like to phase out fluoride in the water supply over the course of 12 months through decommissioning each of Melbourne's fluoridation stations. The first location where fluoridation will be ceased is at the Gumbark Recycled Water Treatment Plant.

In addition to asking each respondent for a numerical risk assessment score for each project, the final three projects (4A, 4B and 4C) also included the following qualitative question: *What do you consider are the main risks arising from this project?*

4.3.3. Psychometric Test Questions

A psychometric test was also attached to each of the unfamiliar projects but not to the familiar projects. The main reason was to understand psychological risk affiliations assessors may have to new projects. In addition, it was recognised that respondents would suffer survey fatigue if all projects were assessed with a psychometric test.

The survey questions from Slovic et al's (1985) study have been directly adopted into this research due to their pre-validated nature, and directs the participant to highlight their response using a 7-point Likert scale. The scale allows for a mid-point ‘neutral’ option in this case. Refer to Appendix D for the full statements used in the survey.

4.3.4. Cultural-Cognition Testing

In order to determine the grid-group positions of assessors, the questions addressed to respondents were taken from Kahan’s (2008) study. These statements and questions are detailed in Figure 4-3. Participants are provided with this set of statements, asking to what extent they agree with each. A six-point Likert scale is used ranging from ‘Totally Disagree’ to ‘Totally Agree’. Each of the responses to these statements were recorded as a score of 1 to 6 (from totally disagree to totally agree), allowing no mid-point.

Cultural-Cognition Statements for assessment

1. It seems like the criminals and welfare cheats get all the breaks, while the average citizen picks up the tab
2. We have gone too far in pushing equal rights in this country
3. Society as a whole has become too soft and feminine
4. Nowadays it seems like there is just as much discrimination against whites as there is against blacks.
5. It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.
6. A lot of problems in our society today come from the decline in the traditional family, where the man works and the woman stays home.
7. The women's rights movement has gone too far.
8. Discrimination against minorities is still a very serious problem in our society.
9. It's old-fashioned and wrong to think that one culture's set of values is better than any other culture's way of seeing the world.
10. We need to dramatically reduce inequalities between the rich and the poor, whites and people of colour, and men and women.
11. Parents should encourage young boys to be more sensitive and less 'rough and tough'.
12. Our society would be better off if the distribution of wealth was more equal.

13. We live in a sexist society that is fundamentally set up to discriminate against women.

14. People who are successful in business have a right to enjoy their wealth as they see fit.

15. If the Government spent less time trying to fix everyone's problems, we'd all be a lot better off.

16. Government regulations are almost always a waste of everyone's time and money.

17. The Government interferes far too much in our everyday lives.

18. Free markets- not Government programs- are the best way to supply people with the things they need.

19. Too many people today expect society to do things for them that they should be doing for themselves.

20. It's a mistake to ask society to help every person in need.

21. The Government should stop telling people how to live their lives.

22. Private Profit is the main motive for hard work.

23. It's not the Government's business to try to protect people from themselves.

24. Society works best when it lets individuals take responsibility for their own lives without telling them what to do.

25. Our Government tries to do too many things for too many people. We should just let people take care of themselves.

26. Sometimes Government needs to make laws that keep people from hurting themselves.

27. Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.

28. It's society's responsibility to make sure everyone's basic needs are met.

29. The Government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.

30. People should be able to rely on the Government for help when they need it.

(Kahan, 2008)

Figure 4-3 Statements for the Cultural Cognition Survey (as taken from (Kahan, 2008))

In measuring worldviews, Dake (1992) developed a methodology that was utilised in various studies (Ellis & Thompson, 1997; Peters & Slovic, 1996) however was criticised because of the reliability of the scale used. Studies such as Marris, Langford, and O'Riordan (1998) and Sjoberg (1998), concluded that Dake's use of a single scale to measure each cultural worldview performed poorly in internal validity for tests such as the Cronbach's alpha test. Kahan (2008) drawing from other recent studies in addition to Dake's approach (Jenkins-Smith & Herron, 2009) instead changed the methodology slightly to incorporate a dual scale system, measuring each worldview category on separate ends of the scale. Participants then indicate to what extent they agree or disagree with the statement on either a six-point or four-point Likert scale. In this study, a six-point scale was used. The responses would indicate where a respondent sat on each of the hierarchy – egalitarian scale, and the intersecting individualism-communitarianism scale, placing the individual within a particular cultural worldview group (Jenkins-Smith & Herron, 2009, p. 731). The individual is placed on the scale according to the extent to which they agree or disagree each statement specified in one of the thirty statements derived by Kahan (see Figure 4-3).

Each statement is either set for testing the respondent's grid or group view. A person agreeing strongly with a statement that aligns with a positive 'grid' approach, will then be placed further up in the positive grid scale, and similarly with any 'group' based questions moving respondents up or down on the group-based scale. For example, the statement: "People who are successful in business have a right to enjoy their wealth as they see fit" as aligned with the 'low group' response, so this would shift those who agree further into either individualism or fatalism. Similarly, with a statement such as "[w]e have gone too far in pushing equal rights in this country", agreement aligns with a strong 'grid' response, placing respondents towards either hierarchist or fatalist worldviews, while disagreement moves respondents towards egalitarianism or individualism. Further information on this analytic approach is included in Section 4.4.3.

After allocating each respondent into one of four worldviews (Hierarchy, Egalitarianism, Individualism or Fatalism), the next consideration is to determine whether there is a significant correlation between the cultural worldview a respondent has, and the risk scores respondents specified for water projects. In practice this means grid-group scores are assessed together with each respondent's corresponding risk scores to assess whether there may be a link between how they perceive the world and how they ranked each project. This can also be assessed for each project to highlight whether there are specific elements in the project that adhere to a particular worldview. This may promote understanding in how a cultural worldview may inform a risk score, providing the opportunity for a reassessment of existing risk processes to align with the corporate risk appetite.

4.3.5. Limitations to the Cross-Sectional Research Design

Bryman (2016) highlights the issue of the weak internal validity associated with cross-sectional research design. Like all social science research, causality amongst the variable cannot be established from the data. The point of this type of research is to detect patters of association which the researcher can establish causal inferences.

The very survey instruments themselves may also disrupt the nature of the research. The location of the risk assessment undertaken in this study was slightly different to where risk assessments are usually undertaken. Normally assessors undertake this work at their desk which is likely to be in a more comfortable, familiar environment for them. These surveys were administered in a meeting room within the participant's organisation. Also, the fact that respondents had the risk management framework on hand meant that they may have been more likely to use it. Whereas if they had been at their desk, they may not have used it, as it is often not readily at hand. Bryman (2016) refers to this as disrupting the 'natural habitat'. Despite this, there is little that can be done to minimise this effect, while also still being able to carry out the survey.

A representative sample of assessors was sought for participation in the survey, however some bias may still have been included in the study when sampling. Risk managers from each organisation were asked to recruit suitable candidates for the study. The risk managers had the knowledge of whom to approach, not the researcher. As a non-random sampling method is used in the form of convenience sampling, human judgement on behalf of the risk managers in each water authority may have biased some element of the sampling. This could have resulted in some water practitioners being more likely to be selected. One way of eliminating this would be to introduce probability or random sampling, however this was not possible within these organisations. The only requirement for participation was that the person had previously undertaken a risk assessment in engineering-based water projects. It was then an opt-in process. However, the researcher cannot explicitly state that no engineers or water practitioners were excluded who may have been eligible to participate. This was due to the fact that the risk managers in each authority had the knowledge to know who to approach, not the researcher. This limits the sampling frame which could present a limitation in the research, and could introduce a small amount of bias, however is not expected to be significant.

Another element of sampling bias could be the non-response from some respondents. This is problematic, as those who agree may be participating for certain reasons that are shared by others participating (Bryman, 2016). However, when considering those that did participate, it was noted that they encompassed close-to the representative sample of all water practitioners when looking at demographic-based questions. A non-response therefore did not affect the research question result as the representative sample was still formed. The response rate is not clear, as the sampling was undertaken by the risk managers within each organisation and they did not pass on the information of how many were asked compared to the number who participated. This was in most part due to privacy issues.

4.4. Detailed Methodology of each approach

Once the data had been collected, it was subjected to a statistical analysis. While an outline of broad assessments has been presented, the aim in this section is to specify the corresponding tests in more detail. This section is broken up into three parts, essentially allowing for three different analyses within the one survey. For quantitative data, a univariate analysis was undertaken to first determine the nature of the risk score data across all projects. The measure of dispersion is tested by means of calculating standard deviations. Following from this, in part 2 of the analysis, bivariate analysis is used to explore the relationship between psychometric attributes and risk scores. A linear regression was used to explore these elements. A test of significance on the relationship is undertaken as part of this work, with the null hypothesis assuming that no linear relationship exists between each psychological attribute and risk scores. More detail is provided in the following sections.

4.4.1. Tests for Whether the Technical Risk Approach Produces an Objective Outcome

The key benefit of the technical risk approach pushed by proponents of the theory is the objective nature of the assessment. Ultimately arguing that taking a consequence and likelihood quantified risk approach, scores can be given to projects to objectively measure the risk that exists. If this is done according to a set process, then essentially, the 'objective risk reality' should be the same in these assessments regardless of who undertakes the assessment. So, if the technical risk approach is truly objective, the risk scores of individual projects should not differ drastically. While the score may differ across the range of project, within each they should all closely surround the mean score.

Following from this brief description, the participant is asked to devise a quantitative risk score (or rating) for each project, based on their organisation's risk process model (which they are ordinarily familiar with). All participants are provided with the risk framework for the organisation they work for. This framework is built on choosing a prevailing negative risk category (the risk the assessor deems to be the most prevalent for the proposed project) and gain a risk score or rating from its consequence and likelihood scores. The consequence score is graded from 1 to 5, and the likelihood is also graded in the same way. Both scales assume 1 to be the lowest consequence/least likely event, while 5 is the highest/most likely event. These scores are both required in order to be multiplied to form the final risk score, which ranges from 1 to 25. Each participant provides their response as a single risk score for each project.

The nature of the data is such that scores range from 1 through to 25. This is due to the fact that the likelihood and consequence scores are multiplied, with each of these scores ranging from 1 to 5. As such, some scores are not possible to obtain through multiplication. These are: 7, 11, 13, 14, 17, 18, 19, 21, 22, 23, and 24. As shown, these 'unattainable' scores are heavily weighted towards the latter end of the risk range. This could produce a large amount of natural skewness that works to the left of the data, as one would expect that the lower scores are more likely to be called upon purely because there are more of them that are obtainable.

To counter this effect, the data needs to be transformed to ensure that it more readily fits into what one may expect of the possible scores: a normal distribution. This research design proposes that two different methods will be used to transform the data, and the method that produces the best ‘fit’ will be carried through for the analysis. Best ‘fit’ assumes the data that more readily removes the existing skewness and produces data that is more ‘normally’ distributed.

The two transformations that will be undertaken are the log transformation and the square root transformation. The former will take each risk score and apply a natural log on it, while the latter will take the square root of each risk score data point. The outcome of which transformation (log or square root) will be used is determined in the data analysis stage, as it requires the data to be obtained, transformed and compared prior to deciding on the most suitable transformation.

The analytical aspect of the research will involve comparing the risk scores between each risk assessor from each organisation to determine how ‘objective’ the risk process actually is. The test of objectivity is determined by the distribution of the data. If the data is widely distributed, then it can be assumed that the risk assessment process is unlikely to produce objective results. One would expect that objective results would ensure that the majority of data is within the same risk ‘rating’. To test this, consideration will be given to the standard deviation of each transformed data set. Assuming normality, the range within one standard deviation of the mean will encompass approximately 68% of the data, while two standard deviations will assume 95% of the data, see Figure 4.4. In order for the process be considered ‘objective’, the range within one standard deviation should be within the one risk rating.

For example, the range within one and two standard deviations should sit within the range of a single risk rating (‘Low’, ‘Medium’, ‘High’ or ‘Extreme’) to be considered objective. If the standard deviation ranges lie outside of these ratings, then it can be concluded that the process must have subjective elements in risk calculation.

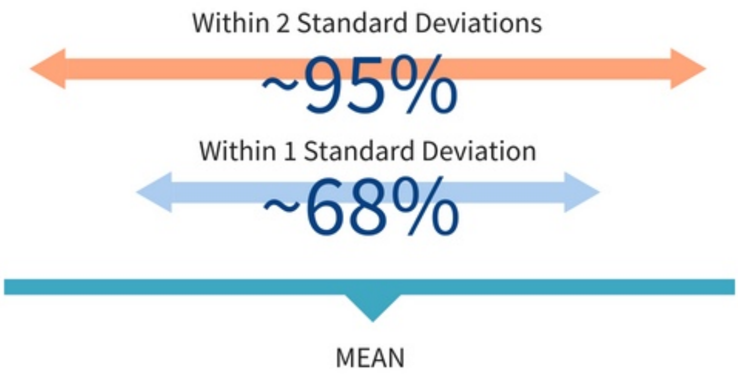

Figure 4-4 Percentage of data incorporated within one and two standard deviations of the mean (assuming normal distribution)

Should the variation in scores be too high, the process cannot then be concluded to be a completely objectified, rational approach. If the spread of the data exceeds these requirements, then it could be argued that other potential factors to explain this variance in scores. Two of these will be tested as part of the research- the impact of psychological affiliations to the risk as well as the bias due to adherence to one of four worldviews.

4.4.2. Psychological Risk Affiliation Methodology

The key difference in this study to others (such as Paul Slovic (1992) and Fischhoff, Slovic, Lichtenstein, Read, and Combs (1978)) is the comparison made between the psychological risk affiliations and the quantitative risk scores of each individual. In particular, the aim is to determine whether there is a type of psychological risk attribute that is likely to produce higher risk scores over other risk attributes. This could result in the one overarching risk attribute, or a combination of a few attributes, that tends to indicate higher or lower risk scores. In this section of the research, the aim is to determine to what extent a particular psychological affiliation produces a higher risk score measurement in the water industry.

The approach adopts a test that is capable of assessing the impact a personal relationship to a risk has upon individual risk scoring. P. Slovic et al. (1985) describes these as risk attributes, which include:

- Voluntariness of Risk – whether people who are faced with this risk, do so voluntarily.
- Immediacy of Effect – whether death occurs immediately, or whether it is delayed (for example, radiation.)
- Knowledge about Risk (to those exposed) – to what extent people who are exposed to risk, know about the risk.
- Knowledge about Risk (to Scientists) – to what extent does the assessor believe that experts understand the risks.
- Control over Risk – whether those exposed to the risk can effectively avoid death or injury through choice, and personal skill.
- Newness – determines how new the assessor feels this risk is (as opposed to old and familiar).
- Chronic-Catastrophic – whether the risk kills people one at a time or all at once (assuming that death is an outcome).
- Common – Dread – assesses how much dread is associated with the risk.
- Severity of Consequence – the likelihood of a risk being fatal.
- Unfairness – assessing how fair the risk seems to the assessor (does it affect all people fairly).

Each participant's Likert score for each statement from 1 to 7 is recorded in SPSS.

The issue is that of these 10 questions, only some will be important. In order to discern what might be important amongst the ten, a Principal Component Analysis can be conducted on the data to ensure that the elements that are most important emerge.

Principal Component Analysis (PCA) is a statistical procedure in which an orthogonal transformation is undertaken to convert a set of observations of variables which may be correlated into a set of what are known as the data's principal components, the values of which are linear and uncorrelated. The order of the derived principal components is from the one that explains the greatest degree of variance to the lowest. The choice regarding the number of principal components to use depends on the degree of variance one chooses to explain. The important point is that the procedure results in a finite set of uncorrelated variables, each being a linear combination of the original variables, that can be used to explain phenomena. However, the procedure is sensitive to the relative scaling of the original variables. This procedure is used to determine the variables considered important in a test of the psychological factors affecting the risk scores of assessors. In order to do this, these determined variables are regressed against the surveyed risk scores provided by the surveyed assessors (in Section 7.3).

Both the new PCA variables, as well as the original individual variables (risk attributes) are linearly regressed against the participant's corresponding risk score. The statistical significance of each of the statements on the risk score can be evaluated. An attribute is considered to be important if the P value for each dependent variable was found to be less than 0.05. Conducting this throughout the project, we can test for the significance of each of the statements in its effect upon the risk scores. This way, agreement with a particular risk attribute is assessed next to the corresponding risk score. This can indicate whether higher scores on this risk attribute produces a change in risk scores across all of the participants and can serve to suggest whether a link may exist between the two variables.

4.4.3. Cultural Grid-Group Risk Methodology

The next test attempts to determine whether there exists a correlation between a particular worldview (the grid-group segment a participant adheres to) and the likelihood of gaining higher risk scores in certain areas/projects. In other words, this component of the analysis- is used to investigate how an individual's risk perception will be informed by their cultural worldviews.

Each statement in the survey (see Figure 4-3) refers to adherence to a particular cultural view on the plane. The responses from the individual are given scores for either the 'grid' variable, or the 'group' variable, depending on the strength of their response, and the statement they are responding to. The following list shows each of the questions, and how they have been coded. The first 13 statements are related to placing respondents on the 'grid' axis (y-axis on the plane). The coding below gives an idea of whether the statement adheres to the 'hierarchy' approach to grid (denoted by a 'H' at the start of the code) or the 'egalitarian' approach to grid (denoted by 'E').

Table 4-1 Altered Scores for grid placing (H refers to 'hierarchy', E refers to 'Egalitarian')

Response	1	2	3	4	5	6	
1. HCHEATS	-3	-2	-1	1	2	3	Altered Scores to fit grid axis
2. HEQUAL	-3	-2	-1	1	2	3	
3. H FEMININ	-3	-2	-1	1	2	3	
4. HREVDIS1	-3	-2	-1	1	2	3	
5. HREVDIS2	-3	-2	-1	1	2	3	
6. HTRADFAM	-3	-2	-1	1	2	3	
7. HWMNRTS	-3	-2	-1	1	2	3	
8. EDISCRIM	1	2	3	-1	-2	-3	
9. EDIVERS	1	2	3	-1	-2	-3	
10. ERADEQ	1	2	3	-1	-2	-3	
11. EROUGH	1	2	3	-1	-2	-3	
12. EWEALTH	1	2	3	-1	-2	-3	
13. EXSEXIST	1	2	3	-1	-2	-3	

The respondent provides a score from 1 (totally disagree) to 6 (totally agree). The scores are adjusted to ensure all responses act in the same direction, ie. More hierarchical the statement, the higher positive score they receive. The egalitarian statements (questions 8-13 in Figure 4-3) instead act in the reverse; they are given negative scores. This similar process was undertaken for the 'group' elements (see questions 14 to 30 in Figure 4.3). They are separated into two main categories: individualism (questions 14 to 25) and communitarianism (questions 26 to 30).

Table 4-2 Altered Scores for group placing (I refers to 'Individualism', C refers to 'Communitarianism')

Response	1	2	3	4	5	6
14.IENJOY	3	2	1	-1	-2	-3
15.IFIX	3	2	1	-1	-2	-3
16.IGOVWAST	3	2	1	-1	-2	-3
17.IINTFRER	3	2	1	-1	-2	-3
18.IMKT	3	2	1	-1	-2	-3
19.INEEDS	3	2	1	-1	-2	-3
20.INEEDY	3	2	1	-1	-2	-3
21.IPRIVACY	3	2	1	-1	-2	-3
22.IPROFIT	3	2	1	-1	-2	-3
23.IPROTECT	3	2	1	-1	-2	-3
24.IRESPON	3	2	1	-1	-2	-3
25.ITRIES	3	2	1	-1	-2	-3
26.CHARM	1	2	3	-1	-2	-3
27.CLIMCHOI	1	2	3	-1	-2	-3
28.CNEEDS	1	2	3	-1	-2	-3
29.CPROTECT	1	2	3	-1	-2	-3
30.CRELY	1	2	3	-1	-2	-3

Altered Scores to fit grid axis

1 = totally disagree, 6 = totally agree.

After respondents had been assigned to particular worldviews, a regression analysis was undertaken, using SPSS, to compare each axis (grid or group) to the individual's risk scores. A test of significance follows between the two groups (grid vs risk scores and group vs risk scores), with a P value of less than 0.05 as the marker for significance. This then determines whether moving in a particular direction along the axes is likely to affect higher or lower risk scores. In undertaking this task it is necessary to use a linear regression technique as the data is specified between known limits.

4.4.4. Qualitative Data Design and Analysis

Within the survey, for projects 4A, 4B and 4C, participants were asked an open-question to list what they believed to be the main risks resulting from each project. These text-based responses were recorded and analysed further to determine whether they may provide further insight into risk perceptions of individuals.

A qualitative content approach, using a thematic analysis, is utilised to explore the text-based data. This approach is highlighted by the Framework approach developed by the National Centre for Social Research (UK) and therefore readily adopted within social science research (Ritchie, Lewis, & O'Connor, 2003). The first step involved undertaking 'open coding' on the data, and then generating an index of terms. This assumes no preconceived codes, allowing them to be developed from the data directly in an exploratory way (Bryman, 2016). This is used to find connections between the codes and developing hypotheses with regard to the themes. The responses were double coded by two of the researchers to verify the findings. A small number of minor differences between the coders was detected and resolved. These were discussed and then revised as a result of the discussion. Given the survey responses were in written form, many of the responses provided were succinct.

Thematic analysis of the open question data involves the use of a two-blind coding technique, arranging them into core themes and even further into sub-themes (Ritchie et al., 2003). These themes were then compared to those highlighted in the literature, to determine whether it verifies or contradicts existing research. When searching for themes, consideration was given to topics that seemed to reoccur, quantitatively analysing repetition. A focus on repetition is the most common measure for establishing a thematic pattern in the data and thus was used in this research (Bryman, 2016). Each project was analysed in this way. The themes were compared across projects to determine whether there may be any overall trends.

4.5. Conclusion

In the case of the public water sector in Melbourne, there is still an adherence to technical, engineering style approaches to risk, based in quantitatively measuring consequence and likelihood to produce a final risk rating. The results of the study utilising the methodology within this chapter is reported upon in Chapters 5-8. The methodology, in testing current approaches, also provides the opportunity to investigate alternative theories of risk, namely the psychological risk approach and cultural worldview theories.

Testing all three (technical, psychological and cultural) theories provides insight into the way that water professionals within Melbourne see risk while using this information to point to a greater understanding of how risk processes can be improved. As many public sector regulators and Government departments, particularly in water, utilise similar risk processes, this study and methodological process can provide a pathway to understanding whether risks are assessed effectively, and ultimately, if these assessments fit within the set risk appetite of the organisation. The subsequent chapter will report on the outcome of the use of this methodology to fulfil the aims of the thesis.

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Chapter 5

Preliminary Survey Results

This chapter then turns to explaining the results of the three-part study that utilized the methodology described: the test of objectiveness of current processes, the psychometric testing, and also cultural worldview testing. Results are outlined in the following three Chapters (6 to 8). All approaches used in this study employed the techniques embodied in the IBM SPSS statistical analysis software package. The aim of the following chapters is to provide the baseline results that were obtained from statistical analysis, which can then be further interpreted in the Discussion in Chapter 9.

The following chapter outlines the test of the objectiveness of current risk approaches, outlining whether there may be some bias within the results. Chapters 7 and 8 consider these biases to determine whether psychological risk theory or cultural risk theory can provide an explanation of the results and provide further understanding in the nature of any bias that may exist in assessing risk.

In this chapter the process of undertaking the surveys is described. Observations were also recorded to highlight any in-person comments or behaviours that were of note in the study. This chapter seeks to describe the survey itself, which can be found in full in Appendix D, and provide a sense of the environment, demographics and recruitment practices adopted by the study. It then provides the contextual framework for understanding and interpreting results, found in the following chapter.

5.1. The survey

The survey was segregated into four distinct sections. The first section collected data on the demographic of the respondent. Questions such as 'to what organisation are you employed by?' and 'What is your gender' were asked to ensure that data is able to be separated by demography to offer insight and track trends. The second section provided a brief outline of four not uncommon water projects (Projects 1, 2, 3 and 4), and each participant was asked for their risk score for each, calculated in reference to their organisational risk process, which was provided for them on the day.

In the third section the three water projects (Projects 4A, 4B and 4C), were presented. Respondents were once again asked to provide risk scores for each of these projects, and an open-ended question in stating what they believed to be the main risks arising from each. Following this, each participant was asked to complete a questionnaire relating to ten psychological risk attributes, indicating their response on a six-point Likert scale. The ten psychological attributes were required to be completed for each of the three projects, ultimately meaning that each respondent was expected to answer a total of 30 psychological attribute questions.

In the final section, participants were asked to highlight to what extent they agree with each of 30 (often controversial) statements. Responses to this section placed each participant into one of four worldviews, which will assist in determining whether there may be a link between cultural worldviews and how one sees and assesses risk within the water sector.

5.2. How the surveys were undertaken

A total of 77 respondents were surveyed within this study. The surveys were undertaken within four water authorities, at their head offices. The respondents were drawn from City West Water, Melbourne Water, South East Water and Yarra Valley Water and surveyed over the months of May- July 2017. The surveys were undertaken in person and they were all in paper, written form. A total of one hour was allocated for the session, however most respondents completed the survey in 35 to 45 minutes. Information on the pilot survey outcomes and observations can be found in Appendix G.

Participants were recruited through the risk managers within their organisation. Each participant was sent through a calendar invite during business hours, for a particular survey session in a booked meeting room within their organisation. This was to ensure that each person has allocated time to undertake the survey, and that it is as convenient as possible for each participant. No incentives were provided for participation in the survey. Every water authority allowed each participant to undertake the survey within their working hours, which may have aided the higher number of registered survey participants. It is not clear how many water project and planning engineers exist within each organisation, however estimates sit at approximately 50-100 in each water authority. All participants completed the survey, bar one, who opted out during the survey session, citing that they did not realise that it was non-compulsory.

5.3. Demographics of main study

The following section explores the demographics of respondents within the main survey. There were 77 respondents in the survey, ranging from four different water organisations. A number of descriptive data was taken as part of a questionnaire in the beginning of the survey. The following pieces of data were collected, regarding the respondent:

- Age
- Gender
- Water organisation employed at
- Position within organisation

5.3.1. Age

The ages of respondents range from 18 through to 65 (refer to Figure 5-1). Each grouping was in blocks of 10, excepting the first age range of 18-25. The majority of respondents were aged between 36 and 45 years, making up 38% of the total data, with over 67% of respondents found to be over the age of 36. This is likely to indicate their level of experience within the water industry. Only four respondents were between 18 and 25, which is typically the age bracket for lower experienced professionals, such as graduates, with approximately 27% sitting at the mid-range of between 26 and 35 years of age.

This does not necessarily reflect the age distribution within the organisation, as there are a higher number of lower experienced professionals as team members (project managers) rather than those in management positions. Although it does not perfectly reflect the age distribution, it nevertheless assesses responses from key decision makers (managers), and their perception of risk, therefore it is useful in this context.

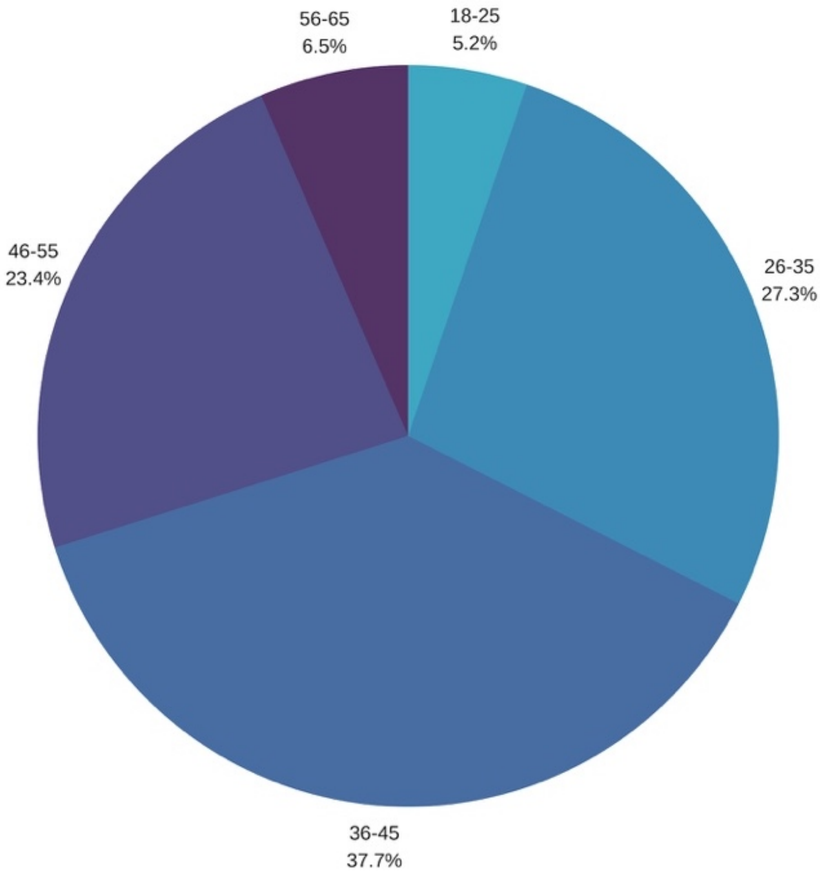


Figure 5-1 Age of Respondents (n=77)

5.3.2. Gender

Unsurprisingly, the majority of respondents were male (74%), in a field that is highly male-dominated (Figure 5-2). Twenty five percent of respondents were women, and 1% responded as 'other'. Although for studies, it is ordinarily preferable to ensure that one gender does not contribute overwhelmingly to the research, as this may ultimately skew the results. In this instance, it is not unreasonable to allow this high level of male respondents as it broadly reflects the gender imbalance within the engineering profession (which is 12% female-identifying) (Kaspura, 2017) . Therefore, if there are differences in risk scores between genders, these are represented in a similar proportion as is in reality.

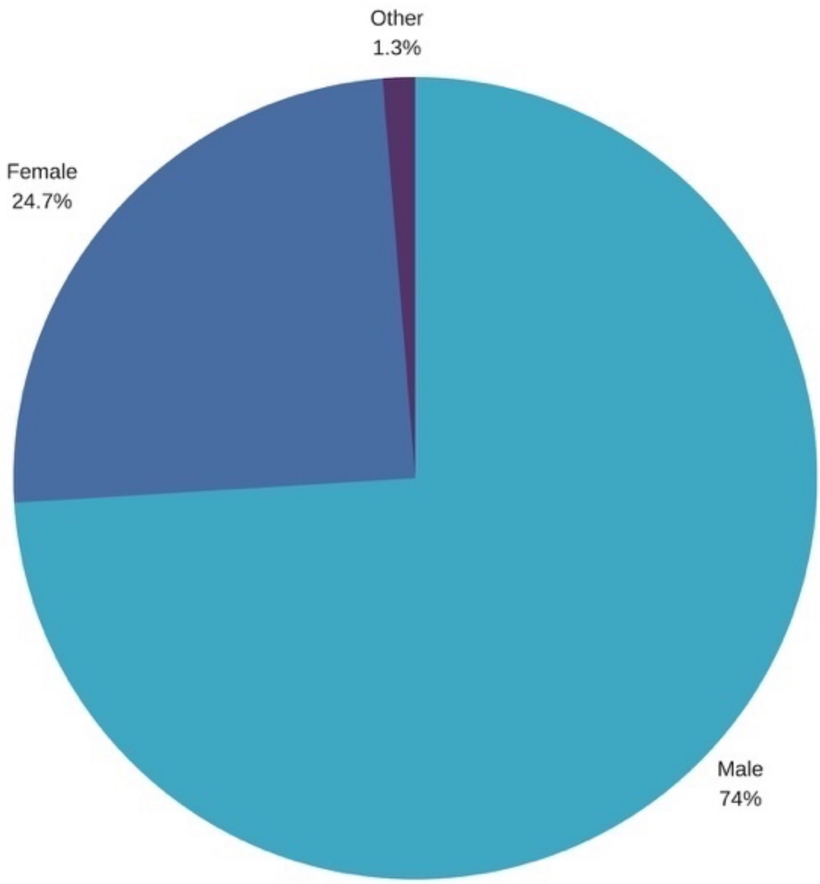


Figure 5-2 Gender of respondents (n=77)

5.3.3. Role

Roles are relatively well spread (Figure 5-3). Project Managers comprise 38% of respondents, while their managers make up 26% of the data. In addition to this, 13% of respondents identify as Divisional Managers, two levels above a Project Manager. This is a satisfactory spread of the data, as Project Managers comprise the highest employment group within each organisation, followed by Team Leader and then by Divisional Manager. This layout is not unusual in a hierarchical business structure. The importance of gaining information on roles can shed light on whether particular roles within water companies are prone to rate risks lower or higher. As position/role is also linked to experience, i.e. the number of years worked at an organisation: this therefore is an important aspect of understanding psychological biases.

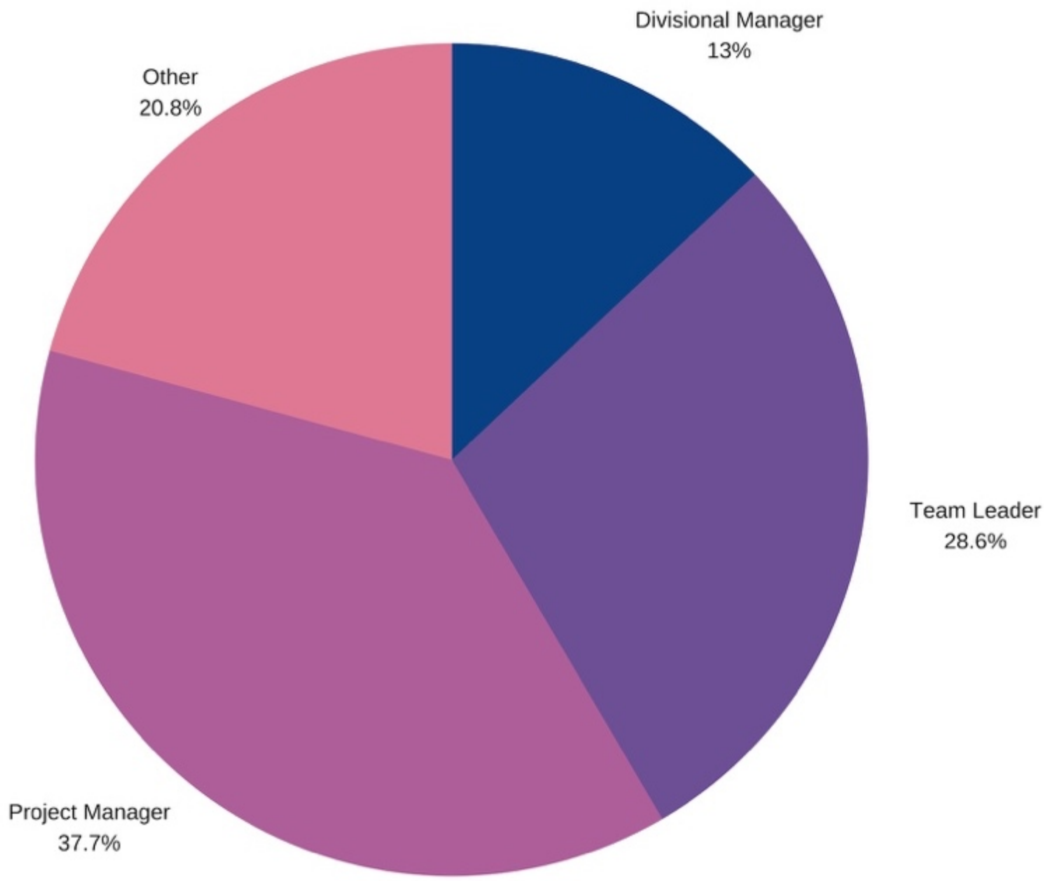


Figure 5-3 Role of Respondents (n=77)

5.3.4. Organisation

All respondents (except one) aligned themselves with one of the four water authorities (refer to Figure 5-4). The highest number of respondents are from Yarra Valley Water which make up 43% of all participants. This is followed by a relatively even split between the final three: 21% from Melbourne Water, 17% from South East Water and 18% from City West Water.

Yarra Valley Water provided the largest number of participants. In order to offset any skewed effect that a higher proportion of Yarra Valley Water respondents may have on the data, the analysis will be separated by organization to determine the extent to which (if any) disproportionate Yarra Valley Water influence occurs on the full data set.

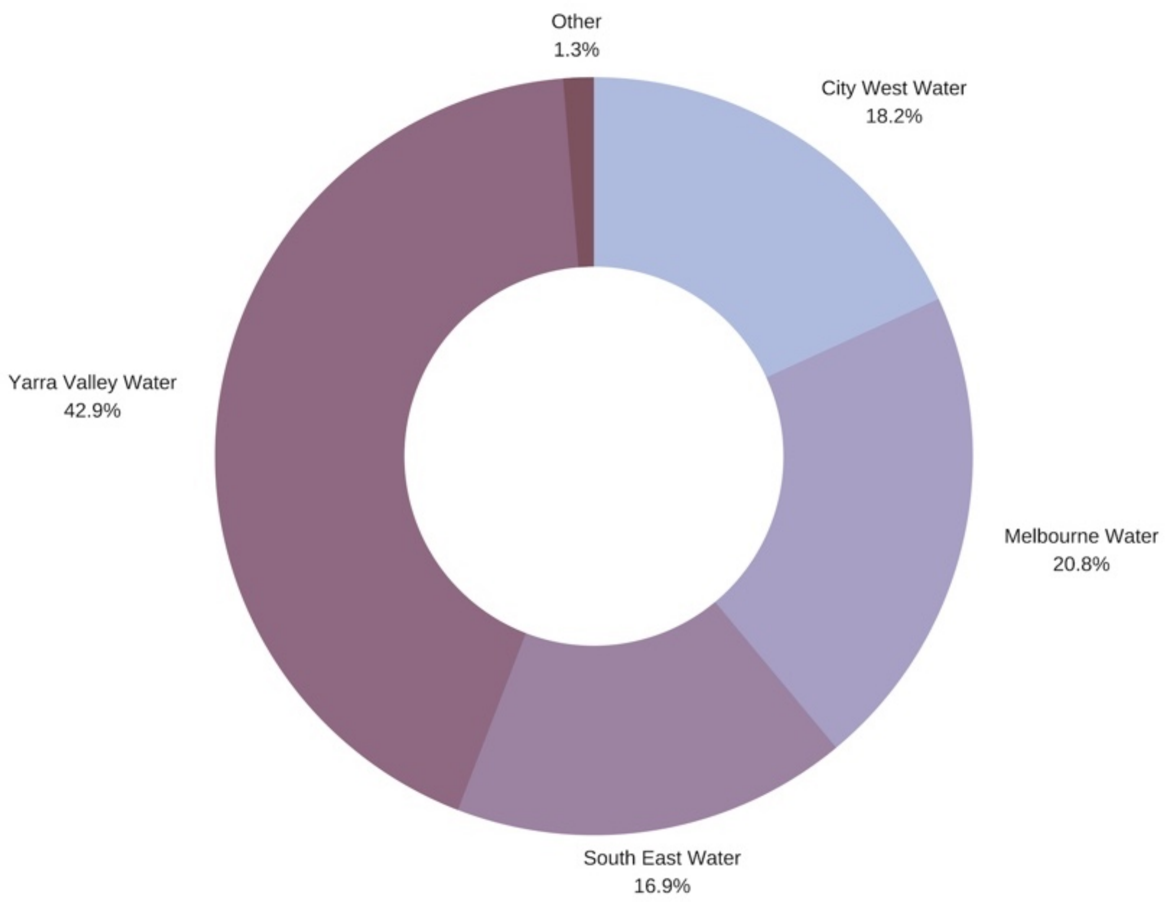


Figure 5-4 Organisation Respondents' work for (n=77)

5.4. A Description of the Data

Scores for each project were assessed using the IBM SPSS program. In analysing the data, much can be gleaned from its descriptive statistics. Each respondent provided risk scores from 0 to 25, with the exception of Melbourne Water respondents, who provided a score from 0 to 10. The Melbourne Water scores were scaled up to ensure they were consistent with all other scores, i.e. they were scaled to fit within the 0 to 25 framework.

As previously described, this risk score was formulated from two separate ratings: risk likelihood and risk consequence. Both scores range from 0 to 5, and are then multiplied to form the final risk score. There are four risk ratings: Low (1-5), Medium (6-10), High (11-16) and Extreme (16+). In analysing the first section of the research, much can be gleaned from considering the descriptive statistics of the data.

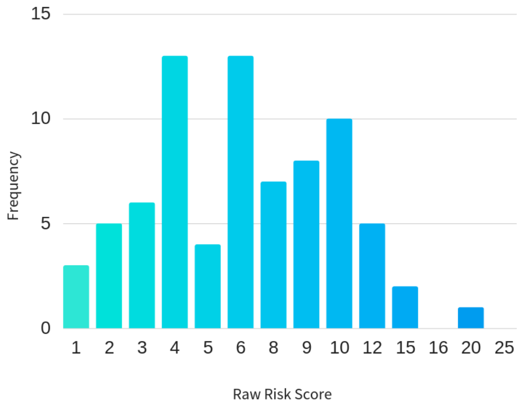
Basic statistical descriptives on the raw data is shown in Table 5-1.

Table 5-1 Basic Statistical Descriptive by Project

Project	N statistic	Range	Mean	Skewness	Kurtosis
1	77	19	6.7	0.80	1.1
2	77	19	10.0	0.20	-0.77
3	77	23	10.7	0.38	-0.47
4	77	19	8.2	0.51	-0.41
4A	76	23	13.7	-0.08	-0.46
4B	76	24	12.7	0.17	-0.27
4C	73	24	10.2	0.62	-0.31

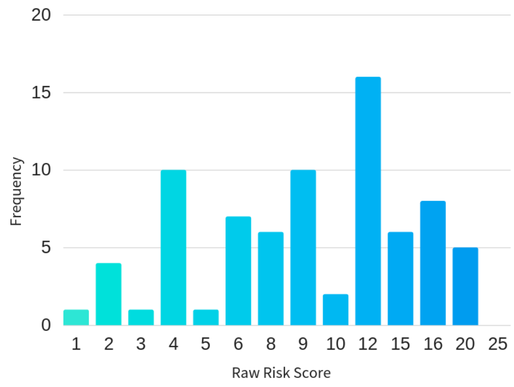
5.4.1. Distribution of the data

Frequency charts (Figure 5-5 a-g) show the distribution of the raw data for each project (from Project 1 through to Project 4C). Please note that the columns for only possible risk scores are shown. For example, it is not possible to receive a risk score of 13, as this is a prime number (must be multiplied by consequence and likelihood). Risk scores are shown on the x-axis, while frequency is on the y-axis.



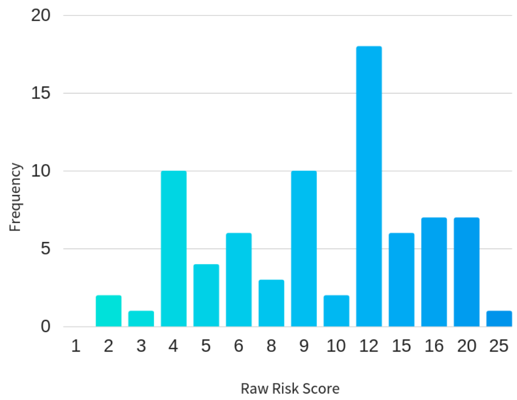
(a)

Project 1 Risk Score Frequencies - Raw



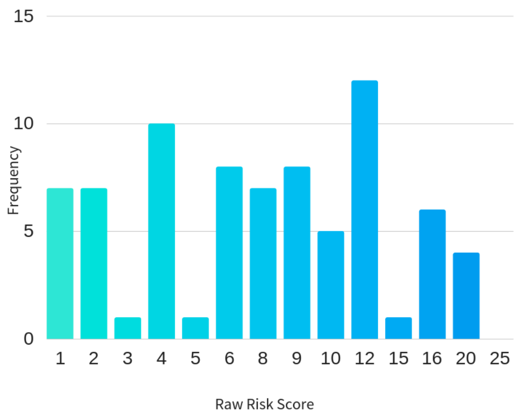
(b)

Project 2 Risk Score Frequencies - Raw



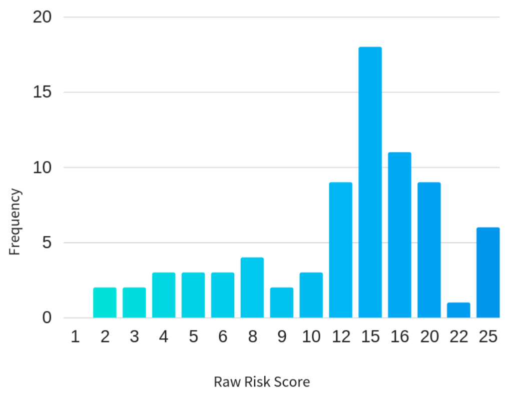
(c)

Project 3 Risk Score Frequencies - Raw



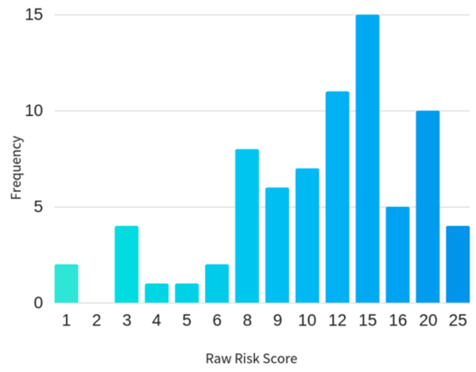
(d)

Project 4 Risk Score Frequencies - Raw



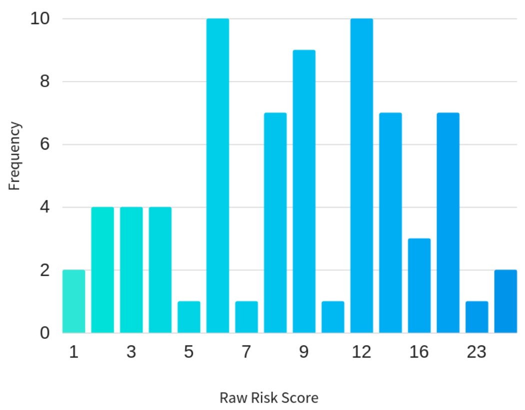
(e)

Project 4A Risk Score Frequencies - Raw



(f)

Project 4B Risk Score Frequencies - Raw



(g)

Project 4C Risk Score Frequencies - Raw

Figure 5-5 Histogram of Raw Risk Scores vs Frequency (n=77)

5.4.2. Transforming Data

As the scores are made up of a multiplication of two factors, consequence and likelihood, a statistical anomaly is created that renders the data more likely to be positively skewed, as the distribution of possible scores is skewed to the right. This is due to the number of possible options not being equal across the range. For example, a score of 7 is not possible and neither is 11, 13 or 14. This creates a skew in the data. The higher up on the scale, the more numbers that are not possible to obtain. To ensure more meaningful results, the scores underwent a natural log transformation, and subsequently became more normally distributed (refer to Table 5-2).

Table 5-2 Skewness and Kurtosis following a Natural Log Transformation (by Project)

Project Number	Skewness	Kurtosis
1	-0.78	0.54
2	-1.00	0.75
3	-0.64	-0.28
4	-0.83	-0.19
4A	-1.30	1.25
4B	-1.76	4.11
4C	-0.87	0.55

As the natural log transformation (see Table 5-2) resulted in a skewness that turns negative, indicating that the transformation overcompensated for the skewness, and potentially that the skewness indicated a less natural skewness than expected as the log transformation should have conserved the data. Transforming the data should have removed the structural skewness, however it moved the skewness to one that is negative. The fact that the log transformation overshoots the skewness, shows a level of conservatism in the data as one would expect the log transformation to have 'fixed' the skewness (i.e. bring it closer to zero.)

5.4.3. Square Root Data Transformation

Each raw risk score was then transformed using a square root function. Upon transforming the data for Project 1, a few items became apparent. Primarily, the mean of the transformed data (2.49) is close to its median (2.45) indicating little skewness. The potential transformed scores can range from 1 through to 5. Within one standard deviation of the values, we receive scores between 1.778 and 3.214, while within two standard deviations give us a range of 1.06 and 3.93. The summary descriptive statistics for this transformation is shown in Table 5-3.

Table 5-3 Skewness and Kurtosis following Square Root Transformation of Risk Scores, by Project

Project Number	Skewness	Kurtosis
1	0.04	-0.22
2	-0.32	-0.64
3	-0.11	-0.77
4	-0.14	-0.80
4A	-0.66	-0.11
4B	-0.61	0.46
4C	-0.02	-0.59

The square root transformation was found to not act as harshly upon the data as the natural log transformation as transformation does not overcompensate for the skewness as much as the log transformation previously did. This is highlighted in the skewness column in Table 5-3, highlighting that risk scores are much less skewed than the log transformation. Skewness ranges from -0.66 to 0.04 for the square root transformation, yet the natural log figures produce more skewed results, ranging from -1.76 to -0.64. For this reason, the square root alteration of the data is a more suitable transformation than the use of natural log and produces an arguably more normalised data set to infer from.

Transformed data graphs are shown in each project in Chapter 6 and they provide an overview of the shape of the data and its range. Some projects, including Projects 1, 2, 3, 4b and 4C generally follow the normal distribution curve while the other remaining projects are not quite as normalised. The following chapter explore the analysis project-by-project allowing for a greater amount of detail.

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Kaspura, A. (2017). *The Engineering Profession: A Statistical Overview*. Retrieved from ACT, Australia: https://www.engineersaustralia.org.au/sites/default/files/resource-files/2017-03/The%20Engineering%20Profession%20-%20A%20statistical%20overview,%2013th%20edition%202017.pdf

Chapter 6

Results Analysis – Technical Risk Approach

The technical risk measurement approach, utilising risk matrices, is arguably one of the major decision-making mechanisms in funding allocations and options assessments within the water industry. Provided a score is within the same risk category (low, medium, high or extreme), it can be said to not affect the outcome of the progression of a project drastically. This process tests the impact of the individual upon risk assessments and therefore, any subjectivity that may arise from personal risk perceptions.

The risk categories are outlined in table 6-1. Please note that due to the multiplication of consequence and likelihood scores (both out of 5), there are some risk scores that cannot be obtained. For example, 17 – 19 are excluded from the table as they are not possible to obtain through the multiplication of two numbers between 1 and 5.

Table 6-1 Risk Rating Score Ranges

Risk Rating	Range from (inclusive)	Range to (inclusive)
Low	1	4
Medium	5	9
High	10	16
Extreme	20	25

As described in section 5.4.2, all raw scores were subjected to a square root transformation, resulting in a normal-type of distribution. Q-Q plots for each project are shown in Appendix E, showing the general adherence to a normal distribution structure. Sections 6.1 to 6.7 outline the results by project of the risk score assessments by participants, highlighting their variability.

Within this thesis, the term 'back-transformed' is used to highlight the figure that has been transformed is then squared to give a useable figure, in real risk score ranges, between 1 to 25 so that risk ratings can be allocated. The Chapter concludes with some overall observations.

6.1. Data Analysis – Project 1

Project 1 involved the replacement of a DN400 pipe in a fictional area. This section of main is comprised of AC (Asbestos Cement) pipe proposed to be replaced with a PE (Polyethylene) pipe. The AC main will remain in the ground labelled as 'abandoned' on all documentation. The replacement of the main will be 200m worth of line. The street is a busy thoroughfare, acting as a link between two key arterial roads. It is expected that approximately 20 houses will experience disruption to their water supply of up to 4 hours, as well as traffic disruptions along the road. The project is estimated to cost $150,000. Refer to Appendix D for the full survey project descriptions.

On transforming the data for Project 1, a few items became apparent (see table 6.2). The mean of the transformed data (2.49) is close to its median (2.45) indicating little skewness. Note that possible transformed scores range from 1 through to 5. Within one standard deviation of the values, the range sits between 1.778 and 3.214, and within two standard deviations provides a range of 1.06 and 3.93. Figure 6.1 shows the shape of the transformed data.

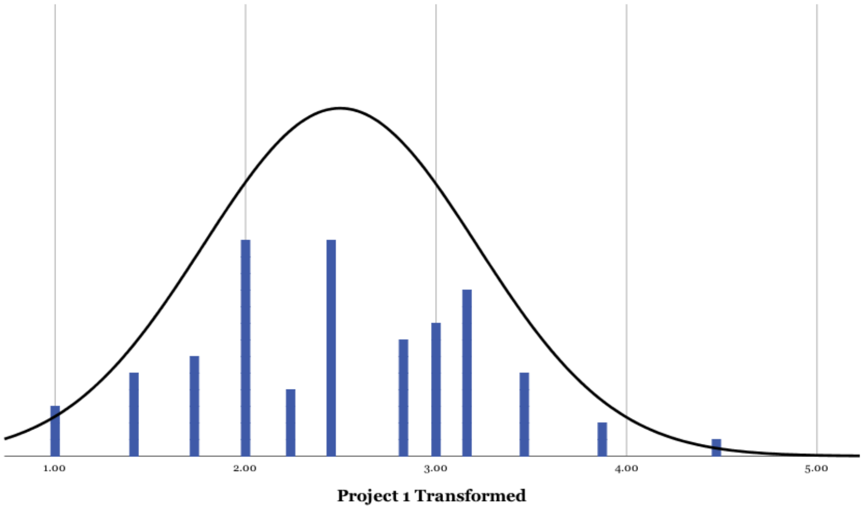


Figure 6-1 Histogram of Scores (transformed) including normal distribution curve

Table 6-2 Basic descriptives for transformed data – Project 1

Project 1	
Mean	2.4963
Variance	0.516
Standard Deviation	.718
Minimum	1
Maximum	4.47
Skewness	0.036

Table 6-3 highlights the ranges for one standard deviation of the mean, and two standard deviations of the mean. Assuming normality, it was found that approximately 95% of the scores sit between 1.12 and 15.44. This range incorporates risk ratings across three categories of 'low', 'medium' and 'high'. This signifies that it can be concluded that there is no consistency in the risk ratings of project managers assessing Project 1. Therefore, one cannot explicitly state that the risk management procedures across all water authorities, with respect to Project 1, is objective.

Table 6-3 Indication of Spread of all Project 1 Risk Scores

	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 1 Risk Scores (Transformed)	1.78	3.21	1.06	3.93
Project 1 (Back-transformed)	3.17	10.33	1.12	15.44
Risk Rating	LOW	HIGH	LOW	HIGH

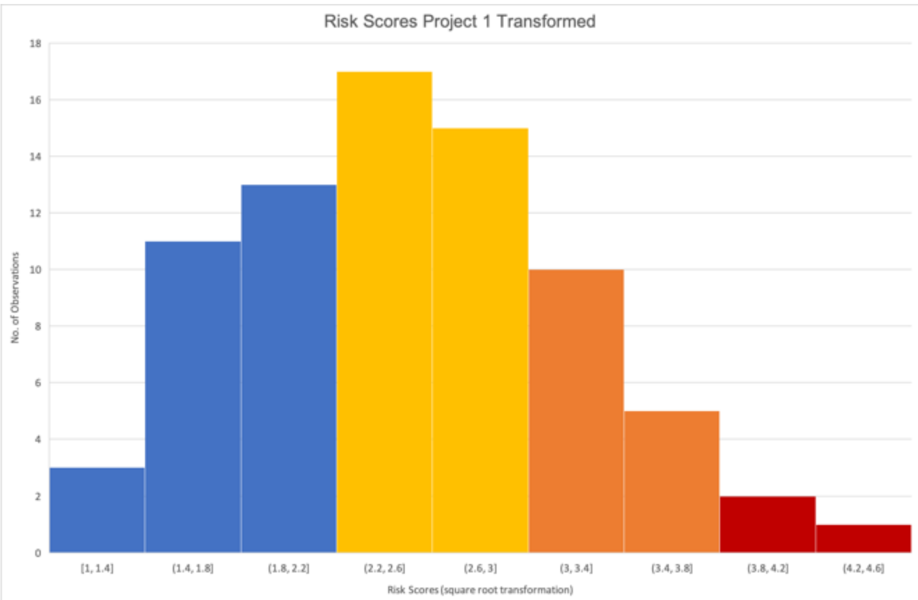


Figure 6-2 Histogram of Project 1 Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

To confirm whether this is a universal finding amongst respondents from all water authorities, or whether this lack of objectiveness is an issue within a specific water authority, a breakdown of each organisation is shown in Table 6-4. It was found that the spread (measured on the square root scale) reveals that respondents from all water authorities produced a diverse result.

Table 6-4 Spread of Project 1 Risk Scores (back transformed) by Organization

Water Authority	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
City West Water (CWW)	3.8 LOW	13.1 HIGH	1.3 LOW	19.8 EXTREME
Melbourne Water (MW)	4.1 LOW	9.7 MEDIUM	2.1 LOW	13.5 HIGH
South East Water (SEW)	2.8 LOW	10.2 HIGH	0.8 LOW	15.6 HIGH
Yarra Valley Water (YVW)	2.8 LOW	9.6 MEDIUM	0.9 LOW	14.6 HIGH

Note: All water authorities in subsequent tables shortened for brevity ie. CWW: City West Water; MW: Melbourne Water; SEW: South East Water; YVW: Yarra Valley Water.

Tables 6-4 and Figure 6-2 highlight that the issues of subjectivity of risk scores is not a problem that is inherent in only one organization, but all. In considering the standard deviation ranges above, it indicates that within one standard deviation, all except Melbourne Water range from low to medium/high whereas within two standard deviations, all water authorities range from low risk scores to a high-risk score, with the exception of City West Water, which ranges from low to extreme. This indicates that the risk assessment scores for Project 1 are highly variable, and are dependent upon the risk assessor themselves. The problem of subjectivity would not appear to be caused within an organisational process, or assigned to the organisation *per se* to which the assessors belong.

6.2. Data Analysis - Project 2

Project 2 involved the installation of a pump station within an existing area in what is known as the Rosemary High Level Zone catchment area. The distribution zone services 928 properties, of which two are schools, one a hospital and one a nursing home. A local councillor has urged decision-makers to upgrade the pumps, as there is a risk of losing water in the area. The total estimated cost is $630,000.

The results of the pump installation project exhibited a slighter higher mean when compared with the first project (3.04 compared to 2.49). However it is not the higher mean scores that attract attention, but rather the spread and variability of the scores in Project 2 (Figure 6-3 and Table 6-5).

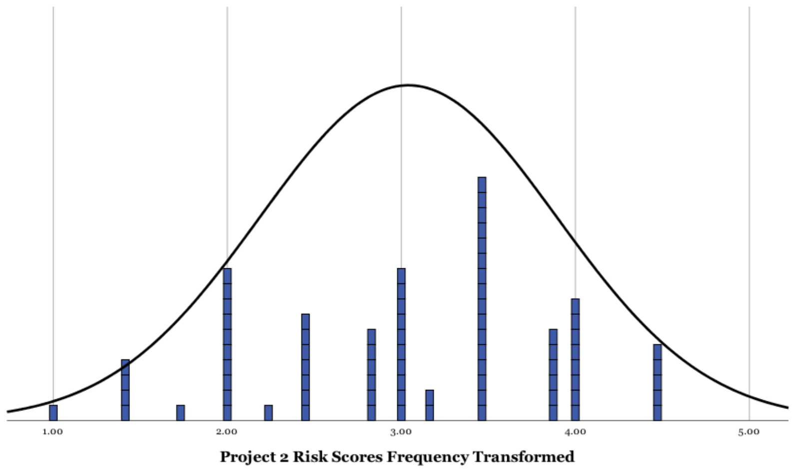


Figure 6-3 Histogram of Project 2 Scores (transformed) including normal distribution curve

Table 6-5 Basic descriptive results for transformed data - Project 2

Project 2	
Mean	3.04
Variance	0.728
Standard Deviation	0.853
Minimum	1
Maximum	4.47
Skewness	-0.321

The ranges for one standard deviation of the mean, and two standard deviations of the mean are shown in Table 6-6.

Table 6-6 Indication of Spread of all Project 2 Risk Scores

	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 2 Risk Scores (Transformed)	2.19	3.89	1.33	4.75
Project 2 (Back-transformed)	4.78	15.16	1.78	22.53
Risk Rating	LOW	HIGH	LOW	EXTREME

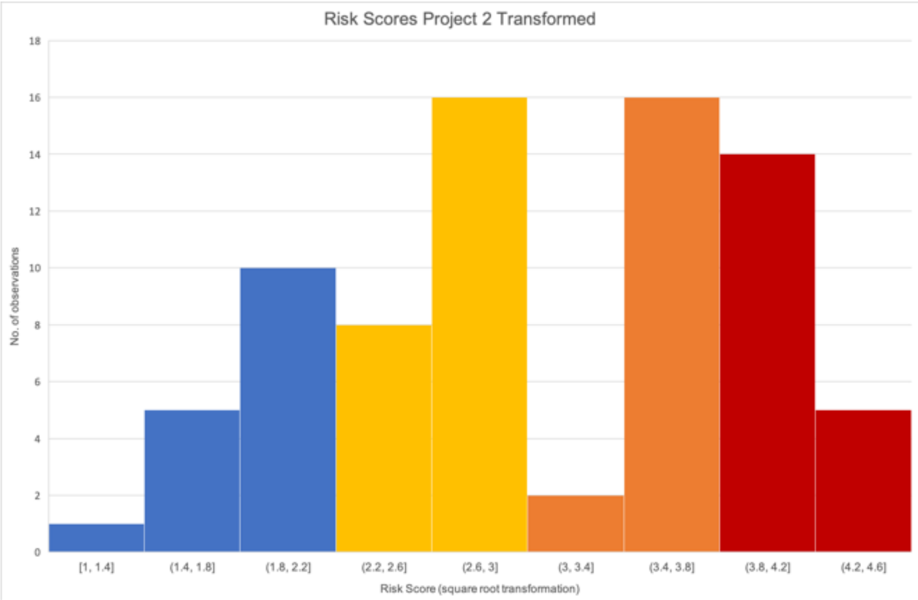


Figure 6-4 Histogram of Project 2 Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

Once back-transformed (through squaring the transformed figure), the risk numbers show a range from low to high risk ratings within one standard deviation of the mean, and low to extreme risk ratings within two standard deviations of the mean. This is an extremely large variation, representing a higher variation than Project 1. Thus, it can be concluded that approximately 95% of risk assessors could have a risk rating that falls in any risk category between (and including) low to extreme. This covers all possible risk ratings and indicates the high variability of risk assessment scores.

Following a back-transformation, a relatively consistent result is received among water authorities (see Table 6-7). Within two standard deviations, possible scores range from a risk rating of low, through to extreme. This highlights that the risk rating for each project is highly dependent upon the individual undertaking the assessment. This finding indicates that if one took a risk assessment score at random, approximately 95% of the ratings would fall between low and extreme, indicating there is little consistency in scoring among individuals.

Table 6-7 Spread of Project 2 Risk Scores by Organization

Water Authority	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	4.1 LOW	18.2 EXTREME	0.8 LOW	28.9 EXTREME
MW	4.9 LOW	15.7 HIGH	1.8 LOW	23.4 EXTREME
SEW	6.7 MEDIUM	16.8 EXTREME	3.3 LOW	23.6 EXTREME
YVW	4.6 LOW	13.1 HIGH	2.0 LOW	19.0 EXTREME

The spread of the scores within each organisation is shown in Table 6-7. Each organisation exhibits similar ranges within two standard deviations, however varies slightly within one standard deviation. Melbourne Water and Yarra Valley Water would appear to have risk scores at the lower end of the spectrum, whereas South East Water's risk scores seem to sit at the higher end.

6.3. Data Analysis – Project 3

The construction of a sewage and recycled water treatment plant was presented to participants as Project 3. Construction of the facility was proposed on existing farmland, providing recycled water to nearby future suburbs. The developer of the suburb has only sold 15% of the properties, with construction expected to start shortly. They will rely on recycled water to be delivered when the first property is completed in August 2018. The expected total cost of this project is $4.78 million.

The construction of a recycled water treatment plant is not uncommon practice for all the water authorities involved, with each of them currently owning and operating a number of these plants. Figure 6-5 and Table 6-8 show the spread of the scores, centred around a mean of 3.15.

As with Projects 1 and 2, in Project 3 the risk scores exhibit a wide variability. The variance on the transformed data was estimated to be 0.707 from a mean of 3.15. The data ranged from 1.41 to 5.00. Across all water authorities, if the data is back-transformed, the scores range from a low of 5.35 to a maximum of 23.39, a range of risk ratings from low to extreme (Table 6-9). Visually, the histogram of results (Figure 6-6) reveals the extremity and spread of the results. What is surprising is that assessing this Project is a common task for the respondents, and yet the spread of results would suggest that there is no objectivity in the outcome.

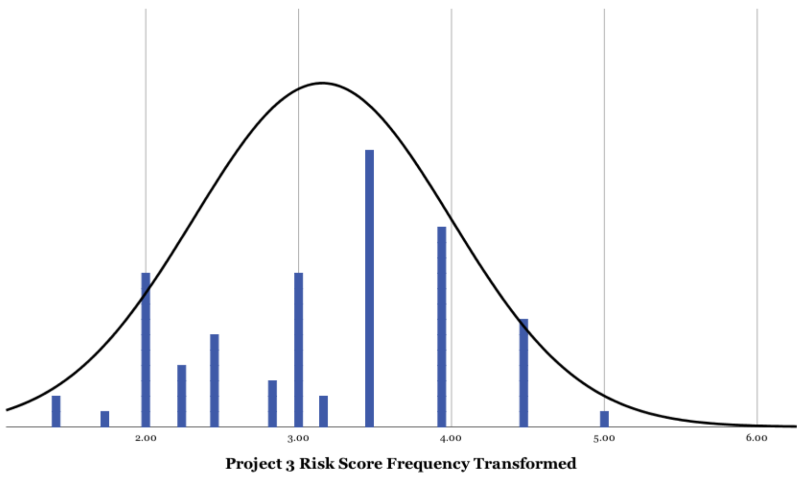


Figure 6-5 Histogram of Project 3 Scores (transformed) including normal distribution curve

Table 6-8 Basic descriptives for transformed data – Project 3

Project 3	
Mean	3.15
Variance	0.707
Standard Deviation	0.84
Minimum	1.41
Maximum	5.00
Skewness	-0.111

Table 6-9 Indication of Spread of all Project 3 Risk Scores

Overall	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 3 Risk Scores (Transformed)	2.31	4.00	1.47	4.84
Project 3 (Back-transformed)	5.35	15.96	2.17	23.39
Risk Rating	MEDIUM	HIGH	LOW	EXTREME

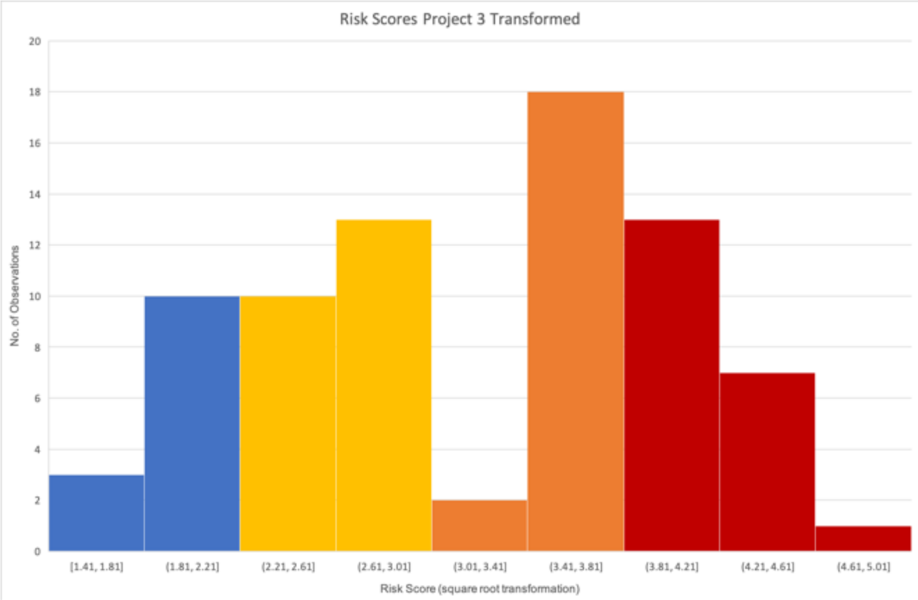


Figure 6-6 Histogram of Project 3 Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

Tables 6-8 and 6-9 exhibit the high variability in the scores for Project 3. Approximately 68% of the data lies within one standard deviation, between risk ratings of medium and high, which when expanded to two standard deviations lies in a range of between low and extreme.

Reducing the figures to 'by organisation' exhibited similar results to the overall findings for the project (see Table 6-10). Once again, it can be confirmed that the variation is not due to the result of the actions of assessors in a single organisation skewing all scores, but an issue that occurs throughout all surveyed water authorities.

Table 6-10 Spread of Project 3 Risk Scores by Organization

Water Authority	Mean (transformed)	SD (transformed)	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	3.33	1.05	5.2 MEDIUM	19.3 EXTREME	1.5 LOW	29.6 EXTREME
MW	3.05	0.72	5.4 MEDIUM	14.3 HIGH	2.6 LOW	20.2 EXTREME
SEW	3.33	0.98	5.5 MEDIUM	18.6 EXTREME	1.9 LOW	28.1 EXTREME
YVW	3.09	0.74	5.6 MEDIUM	14.7 HIGH	2.6 LOW	20.8 EXTREME

Both CWW and SEW achieved similar results in this project. With the same mean, and similar standard deviations, their scores ranged from between medium to extreme. All organisations again had a range of low to extreme within two standard deviations. Both SEW and CWW were leaning towards higher scores, yet all organisations still had a high level of variation between assessors.

6.4. Data Analysis - Project 4

The Save Water Campaign was included as a project with a social element. It is also a project that is not unfamiliar to assessors as all have run a community campaign to reduce water usage in households. This is through campaigns such as Target 155, which was run in Victoria, Australia in the late 2000s (State Government of Victoria, 2019). The proposed campaign had an aim of achieving a reduction in total usage of 0.05 gigalitres per day, equating to $17 million of lost revenue to the water retailer. It is estimated to cost $430,000.

Scores in this project adhered to the normal distribution the least of all the projects (Figure 6-7). Nevertheless, the risk scores exhibit a wide variability. The variance on the transformed data was estimated to be 0.940 from a mean of 2.70, using the transformed data (Table 6-11). The data ranged from 1.00 to 4.47. Across all water authorities, if the data is back-transformed, the scores range from a low of 2.97 to a maximum of 21.44, a range of risk ratings again from low to extreme from all respondents (Table 6-12). Visually, the histogram of results (Figure 6-8) reveals the extremity and spread of the results. Figure 6-8 exhibits the sheer scale of the variability in the scores for this project. The histogram curve is relatively flat, indicating the high number of responses at the two ends of the possible scores. The range within one standard deviation was from low to high, extending to extreme within two standard deviations. As with Project 3, what is surprising is that assessing this Project is a common task for the respondents, and yet the spread of results would suggest that there is no objectivity in the outcome.

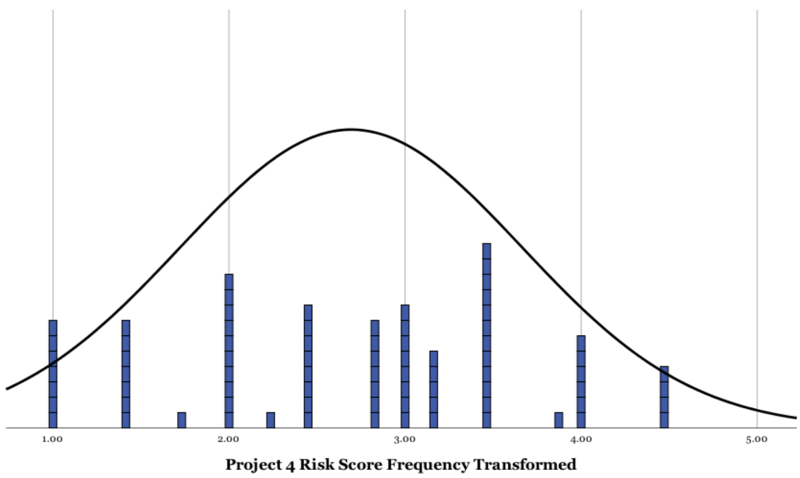


Figure 6-7 Histogram of Project 4 Scores (transformed) including normal distribution curve

Table 6-11 Basic descriptive statistics for transformed data – Project 4

Project 4	
Mean	2.70
Variance	0.940
Standard Deviation	0.970
Minimum	1
Maximum	4.47
Skewness	-0.138

Table 6-12 Indication of Spread of risk scores for all participants Project 4

Overall	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 4 (Transformed)	1.72	3.66	0.76	4.63
Project 4 (Back-transformed)	2.97	13.41	0.57	21.44
Risk Rating	LOW	HIGH	LOW	EXTREME

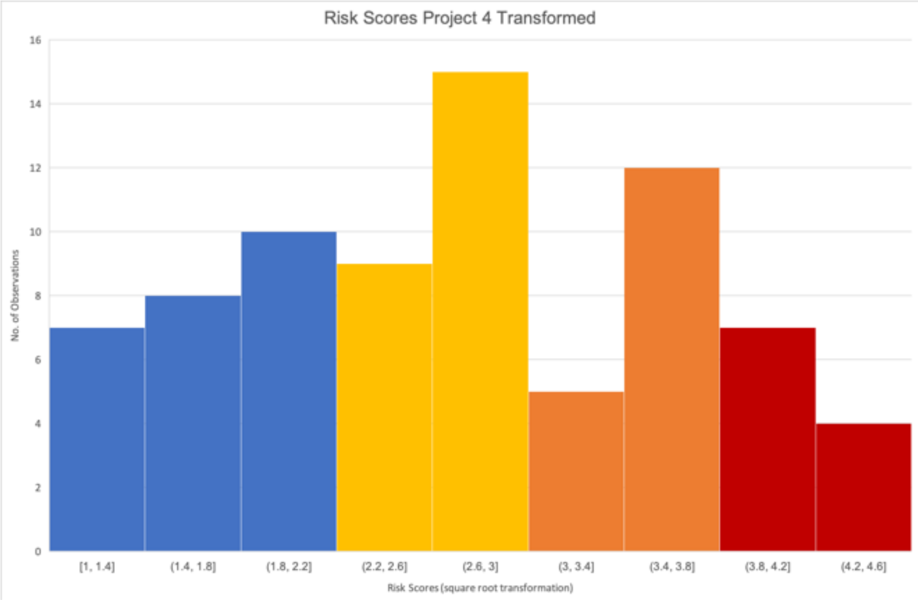


Figure 6-8 Histogram of Project 4 Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

A breakdown of the risk scores determined by participants segregated by organisation is presented in Table 6-13. It was found that the variability occurs across all organisations and is not confined to a single organisation. In this case in all organisations the scale of risk scores ranged from low to extreme, with the mean scores a little higher at South East Water (at 3.00) and a little lower at City West Water (at 2.48).

Table 6-13 Spread of Project 4 Risk Scores by Organisation

	Mean	SD	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	2.48	0.97	2.3 LOW	11.9 HIGH	0.3 LOW	19.4 EXTREME
MW	2.81	0.91	3.6 LOW	13.9 HIGH	1.0 LOW	21.5 EXTREME
SEW	3.00	0.95	4.2 LOW	15.6 HIGH	1.2 LOW	24.1 EXTREME
YVW	2.65	1.00	2.7 LOW	13.3 HIGH	0.4 LOW	21.6 EXTREME

The overall risk score for the Save Water project is unsurprisingly lower than for the other familiar projects (construction of treatment plant, pump station installation and pipe upgrade), as this project does not involve construction with its associated safety risks. The Save Water campaign is a social community behaviour change scheme, and therefore to Engineers may be seen as less risky than the other assessed projects. Despite this, the key finding lies in how varied and spread the data is.

The standard deviation of the Save Water project is not dissimilar to the other projects. Thus, it could be suggested that the different 'type' of project does not exclude it from the risk assessment process producing highly varied results.

6.5. Data Analysis - Project 4A

Projects 4A, 4B and 4C represent projects that are unfamiliar, or haven't been undertaken by any of the water authorities in the past. The first in this series of 'new' projects relates to a strategy providing recycled water within the potable water system. It includes the communication elements to customers within the area affected, amounting to approximately 1,200 residential properties and businesses. The total cost for Project 4A is anticipated to be $3.5 million.

The average (mean) score for Project 4A is higher than any of the previous four projects tested. Much of this could be linked to the unfamiliar and new nature of the proposal. As Figure 6-10 shows, the shape of the histogram is relatively flat, and suddenly peaks at the 16 (extreme) score mark, indicating a large cluster of scores in this category (Figure 6-10). This falls away for scores 20 and 25.

The variance on the transformed data was estimated to be 0.807 from a mean of 3.59 (Table 6-14). The transformed data ranged from 1.41 and 5.00. Across all water authorities, if the data is back-transformed, the scores range from a low of 7.26 to a maximum of 20.16, a range of risk ratings again from low to extreme from all respondents (Table 6-15). Visually, the histogram of results (Figure 6-10) reveals the extremity and spread of the results. The sheer scale of the variability in the scores for this project is large. The histogram curve is relatively flat, indicating the high number of responses at the two ends of the possible scores. The range within one standard deviation was from low to high, extending to extreme within two standard deviations. The spread of results would suggest that there is no objectivity in the outcome displayed by the respondents.

Interestingly, this project provided the highest 'cluster', namely the number of participants providing the same score (in this case, a score of '16', see Figures 6-9 and 6-10). Regardless, the overall spread is still much too high to be considered objective and despite this 'cluster', Project 4A still fails the test of objectivity.

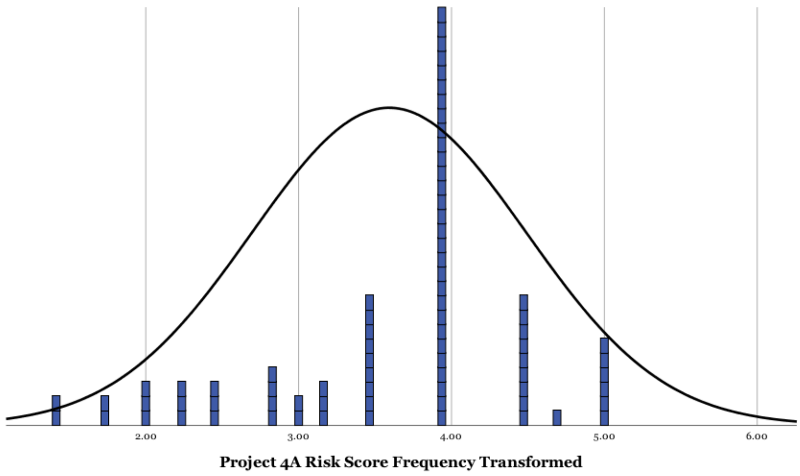


Figure 6-9 Histogram of Project 4A Scores (transformed) including normal distribution curve

Table 6-14 Basic descriptive statistics for transformed data – Project 4A

Project 4A	
Mean	3.59
Variance	0.807
Standard Deviation	0.898
Minimum	1.41
Maximum	5.00
Skewness	-0.655

Table 6-15 Indication of Spread of all Project 4A Risk Scores

Overall	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 4A (transformed)	2.69	4.49	1.80	5.39
Project 4A (Back-transformed)	7.26	20.16	3.22	29.03
Risk Rating	MEDIUM	EXTREME	LOW	EXTREME

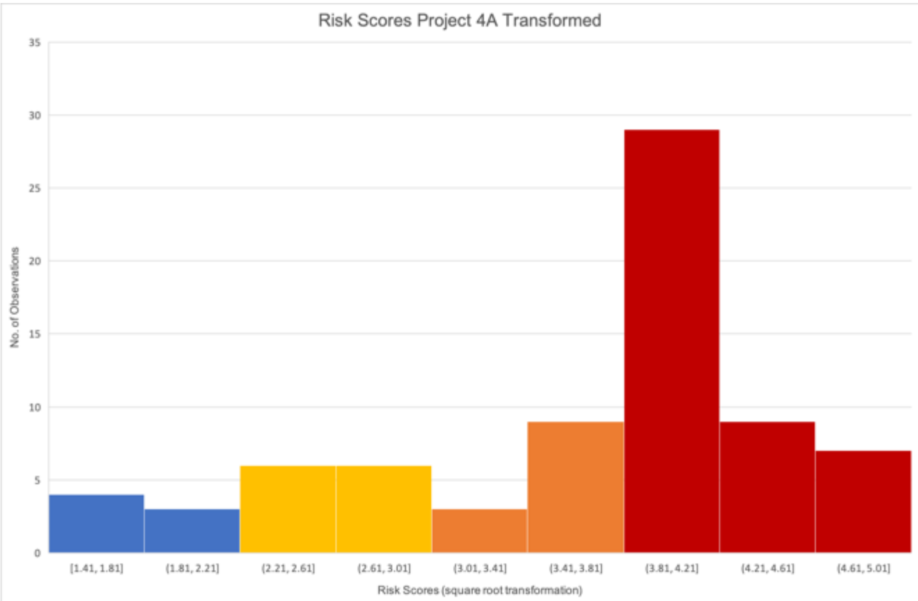


Figure 6-10 Histogram of Project 4A Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

The risk scores by organisation showing the variability of risk scores within each company is presented in Table 6-16.

Table 6-16 Spread of Project 4A Risk Scores by Organization

	Mean	SD	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	3.93	0.69	10.5 HIGH	21.3 EXTREME	6.5 MEDIUM	28.2 EXTREME
MW	3.52	0.95	6.6 MEDIUM	20.0 EXTREME	2.6 LOW	29.5 EXTREME
SEW	4.00	0.84	9.9 MEDIUM	23.4 EXTREME	5.3 LOW	32.3 EXTREME
YVW	3.38	0.87	6.3 MEDIUM	18.1 EXTREME	2.7 LOW	26.2 EXTREME

The spread of scores for Project 4A within each organisation proved to be quite similar. SEW presented the highest mean score, even though all organisations generally showed higher mean scores when compared to previous projects scored (Projects 1-4). The distribution of the scores is skewed slightly more to the left, but despite this, the spread still incorporates all risk levels within two standard deviations of the mean. This highlights that despite the cluster of scores around the '16' mark, there are nevertheless still a large number of responses in the 'low' and 'medium' categories that should be considered.

6.6. Data Analysis – Project 4B

In continuing the theme of typically ‘unfamiliar’ projects, Project 4B was presented to participants as a proposal for a new treatment process. The treatment process involves the use of radiation and sells a one-step process of treating water while also being cheaper than existing treatment methods. The project involves installing one of these new treatment systems at an existing recycled water treatment plant.

On initial examination on the shape of the data, the scores are shown to be negatively skewed slightly (a skewness factor of -0.6). Interestingly, the mean is lower than that of Project 4A, despite elements with negative associations such as ‘radiation’ and unknown treatment methods permeating the project (Figure 6-12 and Table 6-17).

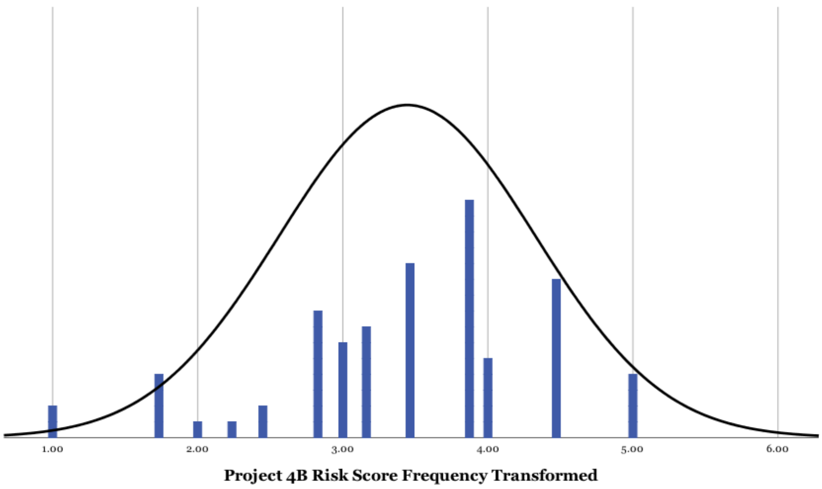


Figure 6-11 Histogram of Project 4B Scores (transformed) including normal distribution curve

Table 6-17 Basic descriptive statistics for transformed data – Project 4B

Project 4B	
Mean	3.44
Variance	0.780
Standard Deviation	0.883
Minimum	1
Maximum	5.00
Skewness	-0.608

Across all water authorities, if the data is back-transformed, the scores range from a low of 6.56 to a maximum of 18.72 within one standard deviation of the mean, representing a range of risk ratings from medium to extreme from all respondents (Table 6-18). At two standard deviations from the mean, the range is from low to extreme. Visually, the histogram of results (Figure 6-12) reveals the extremity and spread of the results. The histogram curve is relatively flat, indicating the high number of responses at the two ends of the possible scores, with a peak in the extreme range, revealing the skewness in the responses.

Table 6-18 Indication of Spread of all Project 4B Risk Scores

Overall	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 4B Transformed	2.56	4.33	1.68	5.21
Project 4B (Back-transformed)	6.56	18.72	2.82	27.14
Risk Rating	MEDIUM	EXTREME	LOW	EXTREME

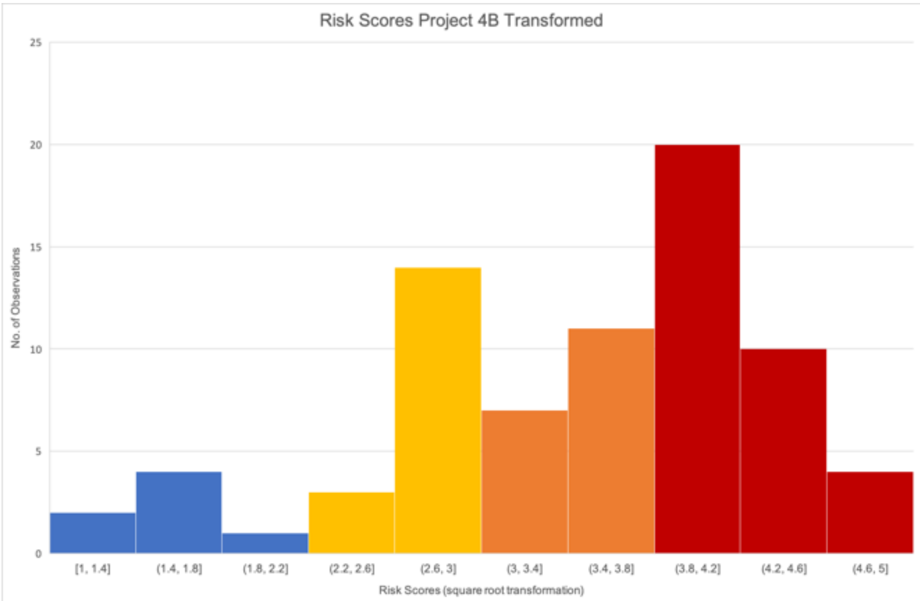


Figure 6-12 Histogram of Project 4B Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

The results by water authority (Table 6-19) reveals the high spread of risk scores by respondents from each water authority. All organisations showed similar patterns in that their results skewed negatively, or towards the higher risk ratings. Within one standard deviation of the mean, the scores varied between medium and extreme, with low risk added once the analysis was expanded to within two standard deviations.

Table 6-19 Spread of Project 4B Risk Scores by Organization

By organisation	Mean	SD	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	3.60	0.45	9.9 MEDIUM	16.4 EXTREME	7.3 MEDIUM	20.3 EXTREME
MW	3.31	0.89	5.8 MEDIUM	17.7 EXTREME	2.3 LOW	26.0 EXTREME
SEW	3.75	1.10	7.0 MEDIUM	23.5 EXTREME	2.4 LOW	35.3 EXTREME
YVW	3.38	0.88	6.3 MEDIUM	18.1 EXTREME	2.6 LOW	26.4 EXTREME

6.7. Data Analysis - Project 4C

The final project in the 'unfamiliar' category was the controversial topic of removal of fluoride from the drinking water supply due to ongoing public pressure. The project is political in its nature, underscoring that the Water Minister would like to phase out fluoride in the water supply over the course of 12 months through decommissioning each of Melbourne's fluoridation stations.

Interestingly, the responses to this project were extremely varied (Figure 6-13). Some respondents saw the outcome of the project as being extremely high-risk, while others did not see it as meriting higher than a low risk rating. The variance on the transformed data was estimated to be 0.96 from a mean of 3.04 using the transformed data (Table 6-20). The transformed data ranged from 1.00 to 5.00. Across all water authorities, if the data is back-transformed, the scores range from a low of 4.24 to a maximum of 16.14 within one standard deviation of the mean, a range of risk ratings again is from low to extreme from all respondents (Table 6-21). Visually, the histogram of results (Figure 6-14) reveals the extremity and spread of the results. The histogram is relatively flat, indicating the high number of responses at the two ends of the spectrum. Again, the spread of scores would suggest that there is no objectivity in the outcome displayed by the respondents.

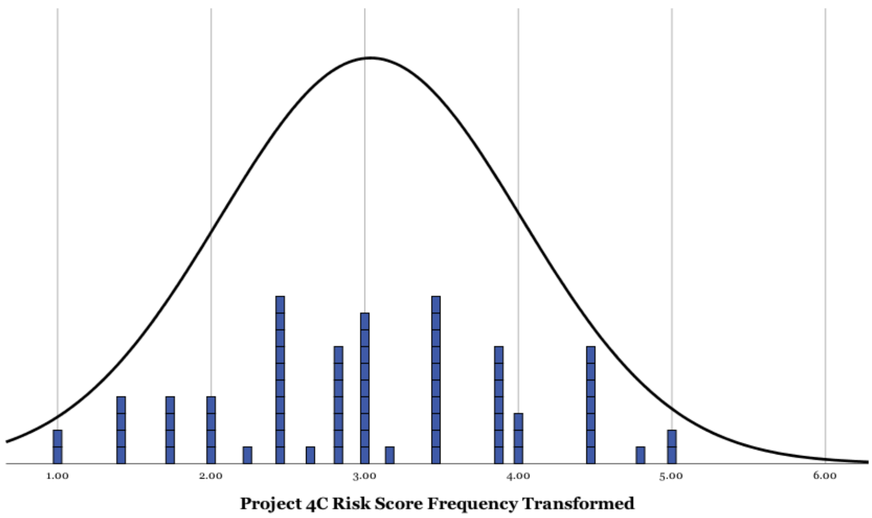


Figure 6-13 Histogram of Project 4C Scores (transformed) including normal distribution curve

Table 6-20 Basic descriptive statistics for transformed data – Project 4C

Descriptives for Risk Scores Project 4C	
Mean	3.04
Variance	0.96
Standard Deviation	0.98
Minimum	1
Maximum	5
Skewness	-0.02

Table 6-21 Indication of Spread of all Project 4C Risk Scores

Overall	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
Project 4C (Transformed scores)	2.06	4.02	1.08	5.00
Project 4C (Back-transformed)	4.24	16.14	1.16	24.98
Risk Rating	LOW	EXTREME	LOW	EXTREME

The spread of scores represents the highest of all projects tested. Within one standard deviation of scores, it encapsulates all possible risk ratings for the project. This indicates the discordant nature of scoring between assessors. The score can be anywhere on the risk rating scale, depending on the individual undertaking the assessment.

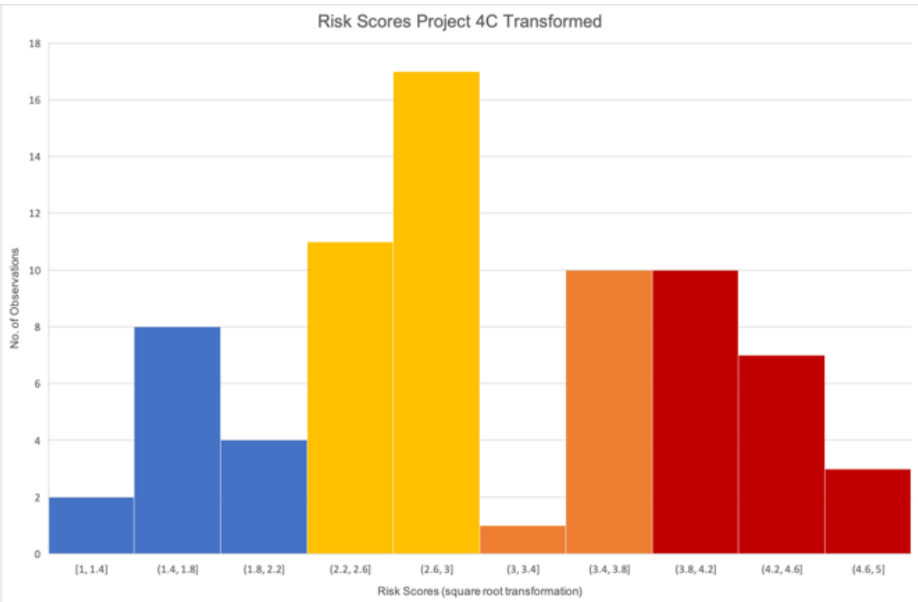


Figure 6-14 Histogram of Project 4C Risk Scores

Note: Bar colours indicate the risk rating ie. Blue = Low; Yellow = Medium, Orange = High, Red = Extreme.

A breakdown of all risk scores by organisation is presented in Table 6-22. This was undertaken (as it was with all other projects assessed) to determine whether the variation in scores is due to one organisation or is a trend within all. It was found that the trend of highly variable scores is apparent across all organisations evaluating Project 4C. YVW represented the lowest mean score, however had a large standard deviation attached to it, indicating that although the average score is low, data points were not clustered close to this figure.

Table 6-22 Spread of Project 4C Risk Scores by Organization

	Mean	SD	Lower limit (1 SD)	Upper Limit (1 SD)	Lower Limit (2 SD)	Upper Limit (2 SD)
CWW	3.14	0.61	6.4 MEDIUM	14.1 HIGH	3.7 LOW	19.1 EXTREME
MW	3.09	0.99	4.4 LOW	16.7 EXTREME	1.2 LOW	25.8 EXTREME
SEW	3.21	1.19	4.1 LOW	19.3 EXTREME	0.7 LOW	31.2 EXTREME
YVW	2.95	1.03	3.7 LOW	15.8 HIGH	0.8 LOW	25.1 EXTREME

6.8. All projects collated

Table 6-23 exhibits the same data as shown earlier in the chapter, but makes for comparison between projects easier. As shown, there is a large amount of variability no matter which project is selected. 68% of the overall data will potentially fall within three different risk ratings, which when extended to 95% of the data, a sample could fall across all risk ratings. This is apparent across all projects, as shown in Table 6-23.

Table 6-23 Variation of risk ratings and ranges across different projects (collated).

Project	1 SD range	1 SD rating	2 SD range	2 SD rating
Project 1	[3.2, 10.3]	[LOW, HIGH]	[1.1, 15.4]	[LOW, HIGH]
Project 2	[4.8, 15.2]	[LOW, HIGH]	[1.8, 22.5]	[LOW, EXTREME]
Project 3	[5.3, 16.0]	[MED, HIGH]	[2.2, 23.4]	[LOW, EXTREME]
Project 4	[3.0, 13.4]	[LOW, HIGH]	[0.6, 21.4]	[LOW, EXTREME]
Project 4A	[7.3, 20.2]	[MED, EXTREME]	[3.2, 29.0]	[LOW, EXTREME]
Project 4B	[6.6, 18.7]	[MED, EXTREME]	[2.8, 27.1]	[LOW, EXTREME]
Project 4C	[4.2, 16.1]	[LOW, EXTREME]	[1.2, 25.0]	[LOW, EXTREME]

6.9. Regression of risk scores by demographic items

While being cognisant of the effect that demographic items may play on risk scores, the next stage of analysis conducted a regression of risk scores on age, gender, role and organisation, with the results tabulated by project in Table 6-23.

Table 6-23 β Scores from regression analysis of demographic factors on project risk scores. Dependant variable: risk scores (transformed). * indicates p<0.05.

Demographic factor	P1	P2	P3	P4	P4A	P4B	P4C
Age	-0.224	-0.096	-0.039	0.267*	0.125	0.082	0.007
Gender	-0.105	-0.187	-0.019	-0.172	-0.129	0.137	0.090
Role	-0.020	-0.057	0.027	0.008	-0.102	0.046	0.172
Organization	-0.237*	-0.107	-0.056	0.088	-0.131	-0.014	-0.072
R squared (model fit)	0.108	0.06	0.005	0.091	0.065	0.029	0.041

Demographic factors are not shown to add heavily upon the risk score outputs. However, there are two notable factors within this regression table: the impact of age on Project 4 ($\beta=0.267$, $p<0.05$), and also the impact of Organization on Project 1 ($\beta=-0.237$, $p<0.05$). However, these are shown to only hold significance when analysed in isolation, and therefore is not a helpful result in the overall analysis, as it cannot apply broadly. Therefore, the results indicate minimal impact of demographic factors upon risk scores.

6.10. Overall Observations

6.10.1. Highly variable scores

Across all the projects, the first area of note is the varied nature of the risk scores. For most projects the scores are within two standard deviations range from a low risk rating, through to an extreme risk rating. This essentially highlights the fact that regardless of the project being assessed, and despite each risk assessors using a pre-established risk process, the scores reported could be given any possible risk rating depending on the risk assessor themselves. As a process that depends on the notion of the technical risk approach, and its reliance on consequence and likelihood, it cannot be said to be overly effective in being objective (Kosovac, Davidson, & Malano, 2019).

An objective approach should have a process with a low variability of scores, ideally all within the same risk rating. For example, if a project is rated 'high' by one risk assessor, it should also be rated 'high' by other risk assessors using the same risk assessment process. This is clearly not the case. As such, the result depends upon *who* undertakes the risk assessment to determine what is risky.

Familiar projects ranged from low, through to extreme for all projects except project 1 (which ranged from low to high). Approximately 95% of scores are expected to be anywhere between these ratings. Similarly, the unfamiliar or new projects (Projects 4A, 4B, and 4C) also had approximately 95% probability that any score would fall between low to extreme, which by all measures is an extremely high range.

6.10.2. Mean Differences between Projects

Upon comparing the means between each project (see Figure 6-15), it was found that there is generally a higher mean for new/unfamiliar projects than the more familiar Business-as-usual projects. However, the mean risk score for Project 4C lies within the range of the familiar projects (Projects 1 to 4).

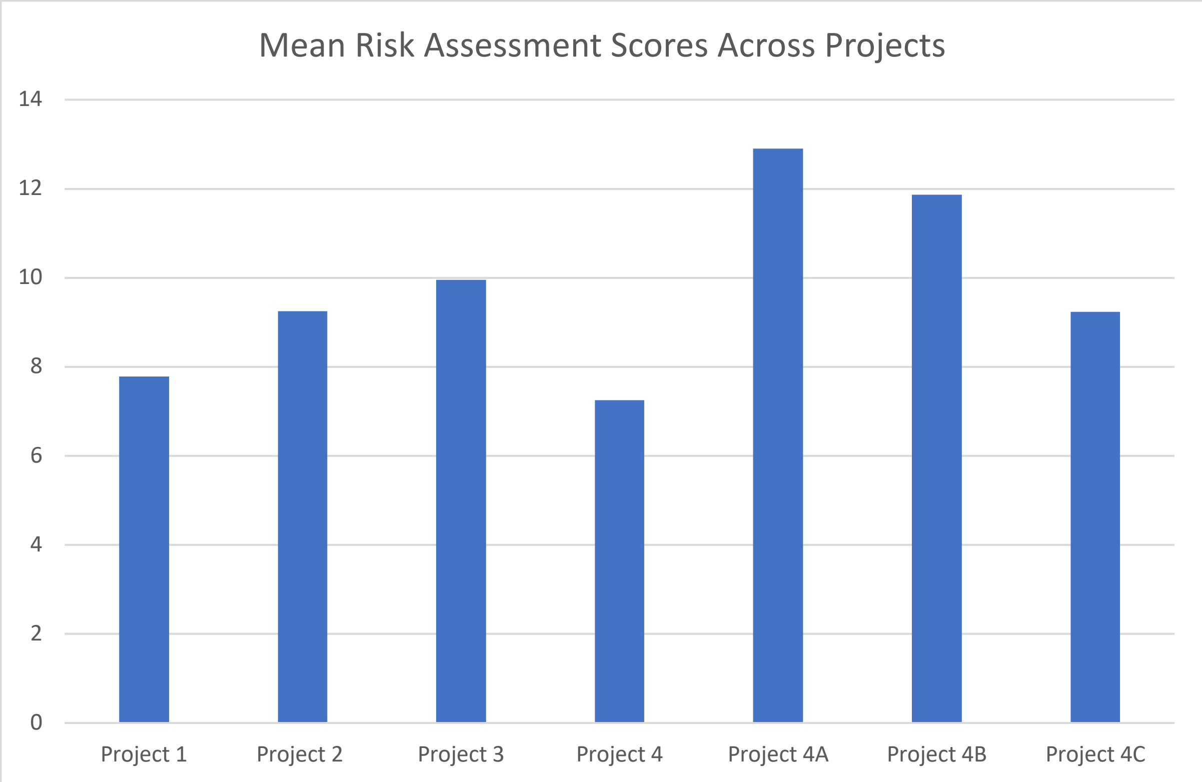


Figure 6-15 Mean Risk Assessment Scores Across Projects

As all projects are quite different, it is hard to argue that on average, assessors tend to rank unfamiliar projects higher in general than business-as-usual ones. At this stage, it is difficult to determine whether this is due to the feeling of unfamiliarity (and its associated risk-aversion) with the project, or whether it is just the project itself, in particular, the choice of project by the researcher, that is seen as higher risk. Assessing the psychological risk attributes associated with 'newness' and 'unfamiliarity' and its effect on risk scores may shed further light on this issue and could provide clarity to these results (see Chapter 7).

6.10.3. Choice of Projects as Impacting upon Scores

Consideration was given to whether the projects themselves, or the choice of fictional projects by the researcher, affects the risk scores in acting as a factor in the variation. The projects were chosen based on differences in scale, cost, type (some are construction-based, others are social) and vary in the amount of information provided. For every project, despite slightly differing ranges within one standard deviation, they all had the full range of possible risk outcomes, from low to extreme ratings within 95% of the data in all the projects. This high variance in scores then, does not point to a difference in the type, scale or cost of each project, but rather, that the choice of risk assessor is the key factor in the change in scores. This is the case for these 'familiar' projects, however, the scores are slightly different when considering 'new' or 'unfamiliar' projects (Projects 4A, 4B and 4C) (see Table 6-23).

Table 6-24 Standard Deviation of 'Unfamiliar Projects' and corresponding risk ratings

'Unfamiliar' Projects	Range within 1 Standard Deviation (~68% of data)		Range within 2 Standard Deviations (~95% of data)	
Project 4A - Using Recycled Water as Potable	7.3 MEDIUM	20.2 EXTREME	3.2 LOW	29.0 EXTREME
Project 4B - Using Radiation in Treatment of Drinking Water	6.6 MEDIUM	18.7 EXTREME	2.8 LOW	27.1 EXTREME
Project 4C - Removing Fluoride from Drinking Water Supply	4.2 LOW	16.1 HIGH	1.2 LOW	25.0 EXTREME

Comparing the 'unfamiliar' projects results to their well-known counterparts, the range of the majority of the data is not dissimilar, it is merely scaled up in terms of its mean. The distribution is still wide, and highlights that even if the projects themselves are changed, the variability of results does not.

6.10.4. Risk Scores by Demographic and Employee Positions

By Gender

The following section highlights the relationship between demographics and risk scores, with the first consideration based on the effect of gender upon perceptions of risk. Almost all respondents either placed themselves in one of two categories: "Female" or "Male" with one respondent selecting "Other". In order to ensure this individual remains de-identified, the other is excluded from the analysis.

The basic descriptive statistics of the Male/Female split are shown in Table 6-24 (familiar projects) and Table 6-25 (unfamiliar projects).

Table 6-25 Average overall risk scores for 'familiar' projects (1-4) by Gender, excludes 'Other'.

Gender	Mean	N	Std. Deviation
Female	11.95	19	.564
Male	11.26	57	.313

Table 6-26 Average overall risk scores for 'unfamiliar' projects (4A-4C) by Gender, excludes 'Other'.

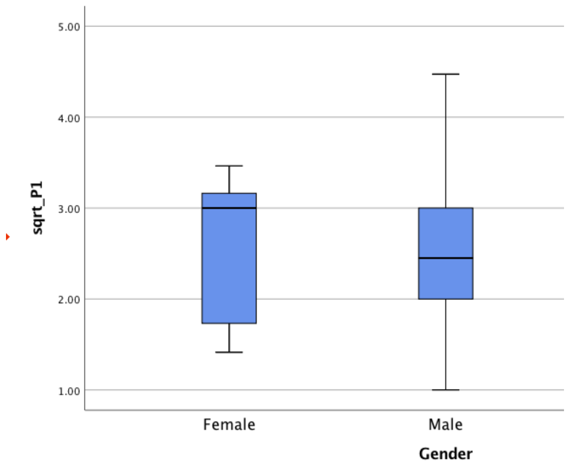
Gender	Mean	N	Std. Deviation
Female	9.53	19	.549
Male	10.30	57	.282

It was found that across all the 'familiar' projects (Projects 1, 2, 3 and 4) females tended to rate them higher risk than men. They were also more varied in score between individuals. Conversely, for 'new and unfamiliar' projects, females tended to rank them *lower* than their male counterparts, with the standard deviation being quite similar.

Existing research suggests that women tend to rate the same actions or items as higher risk than men, which can be argued to be a sociological construct (Booth & Nolen, 2012). However, this is not exactly the case within this research. Women had on average ranked innovation projects as a lower risk than men. The data was then separated by project to further understand risk scoring at a project level.

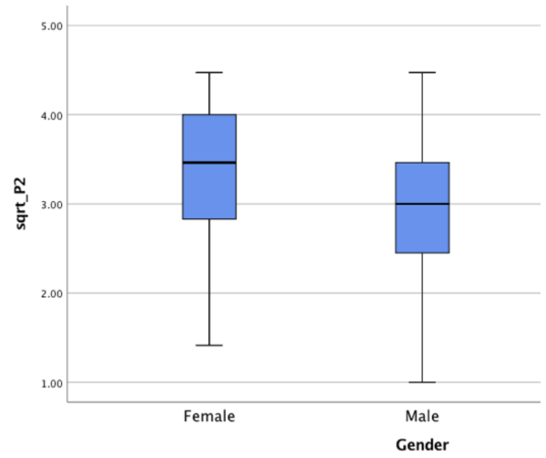
Gender by project

A statistical box and whisker diagrams for risk scores, by project and gender is detailed in Figure 6-16 (a-g).



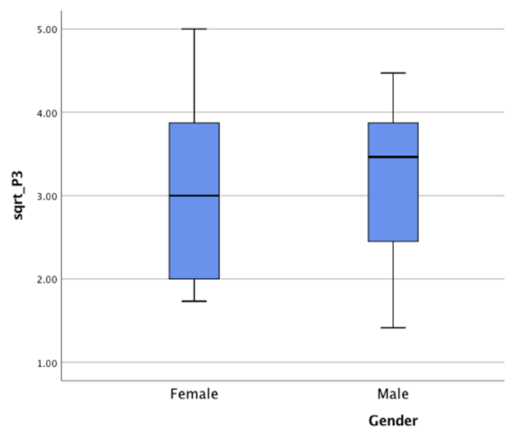
a)

Project 1: Pipe Replacement

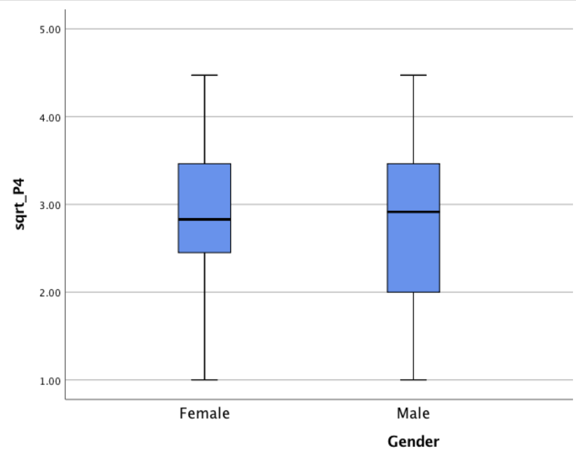


b)

Project 2: Pump Station Installation



c)



d)

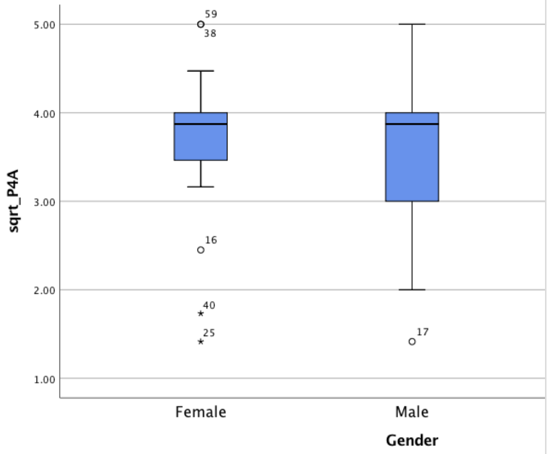
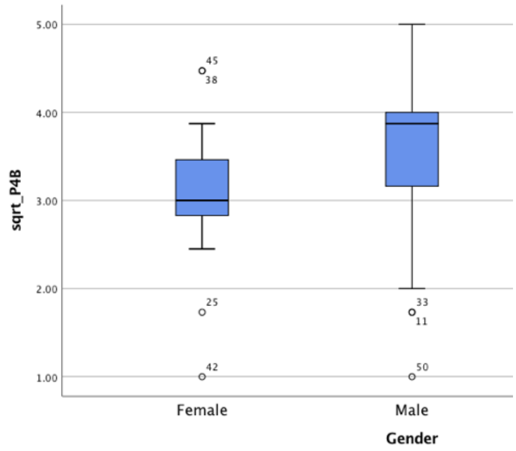
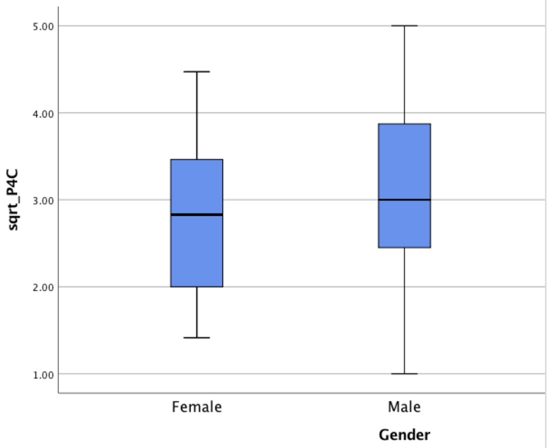
Project 3: Construct STP/RWTP	**Project 4: Save Water Campaign**
 **e)** **Project 4A: Using RW as Potable**	 **f)** **Project 4B: Using radiation in treatment of drinking water**
 **g)** **Project 4C: Removal of fluoride in Drinking Water Supply**	

Figure 6-16 (a-g) Box and Whisker Statistical Diagrams of Gender by Project

The two engineering-based projects (Projects 1 and 2) saw females tending to rank them higher in terms of risk than men. Overall, the range of risk scores for females was also lower (when accounting for outliers). Conversely, the results seem to indicate that women tend to rank the construction of a recycled water treatment plant as lower than men. The Save Water campaign, on the other hand, is not too dissimilar between the genders (mean scores of 2.80 for women and 2.86 for men). For the new or unfamiliar projects, the two did not vary significantly. The main area of note was that the range of scores was lower for women. This could be as a result of less female rather than male participants.

The difference between more typically 'engineering' based projects as generally ranked higher risk by women than men could be as a result of gender identity reaffirmation, as highlighted by Booth and Nolen (2012). In a mixed gender environment, the study also found that women tended to undertake less risky behaviour, or were more risk averse, as this is seen as a feminine trait (Booth & Nolen, 2012). However, other projects such as a social project of the 'Save Water' Campaign, did not carry a noticeable difference between the genders. A theory behind this could be that as a 'social' based behaviour change project, it could be seen as less 'masculine' than the engineering projects, which are traditionally male-dominated. However, this theory is not reflected in the 'new' or 'unfamiliar' projects of Projects 4A, 4B and 4C, which are a mix of both engineering and social projects, yet all are ranked overall lower risk by women, rather than by men.

Although there appears to be a difference in scores broadly between those identifying as 'female' and 'male', this was not found to be statistically significant at the P=0.05 level.

Risk Scores by Role

In assessing risk scores by role, little difference was found to exist. The sum of the mean scores between roles is shown in Figure 6-17, which reveals that there is no notable difference between the roles.

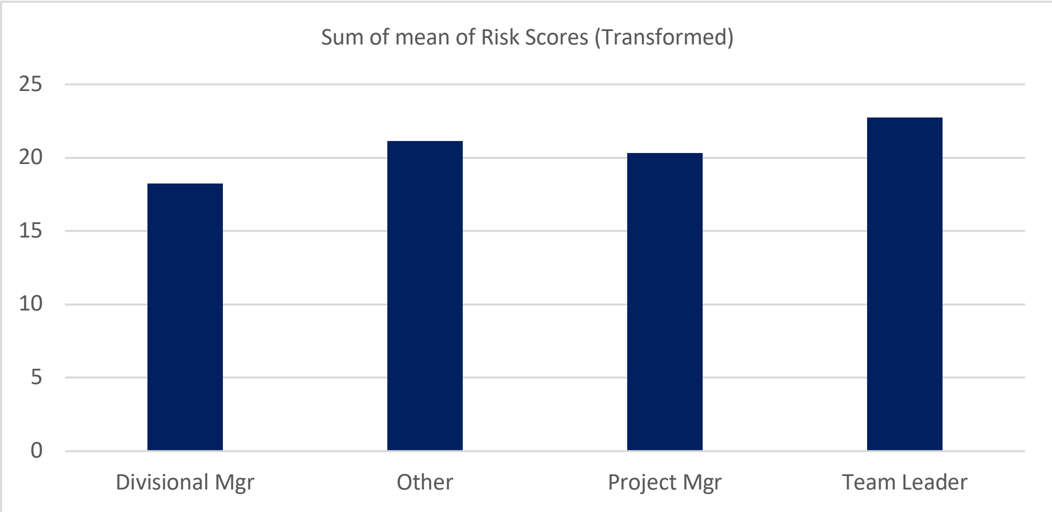
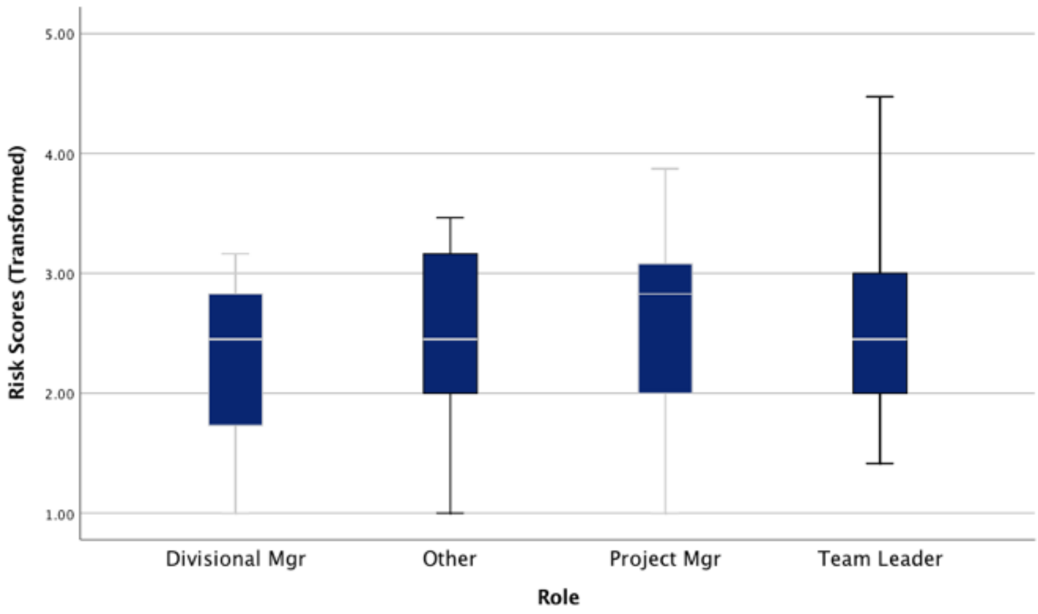
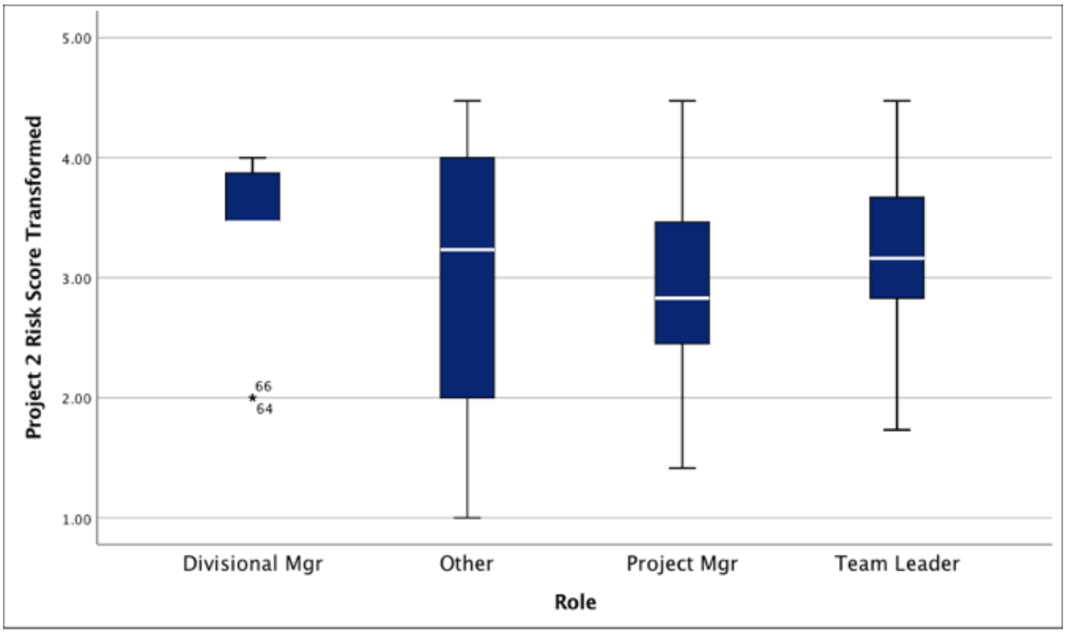


Figure 6-17 Sum of mean of risk scores transformed

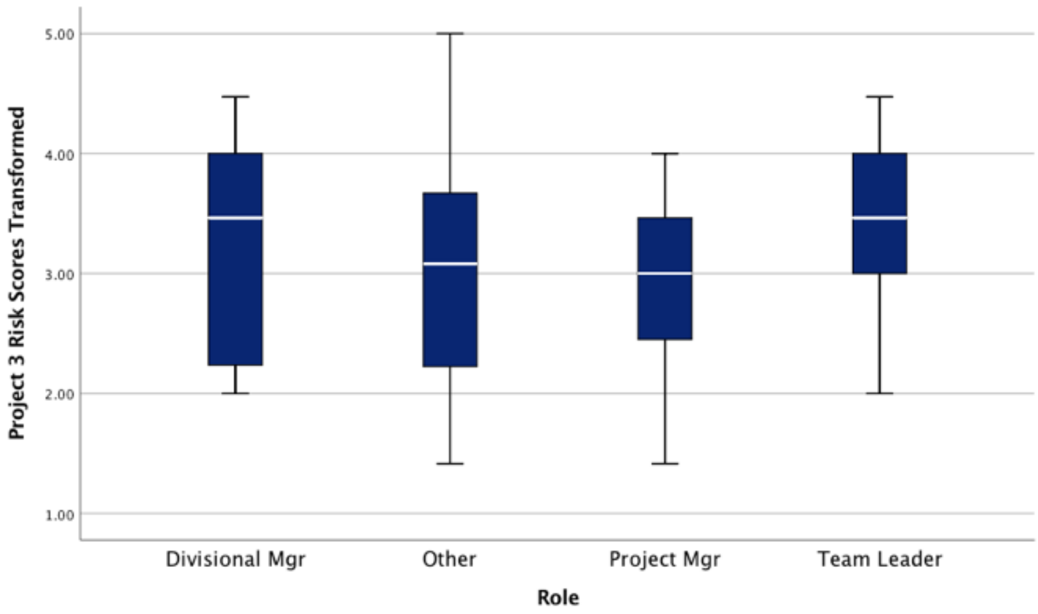
Analysing the role-based factor further, Figure 6-18 exhibits the data by project, emphasising the diverse nature of responses within job role classifications. It is also important to note the difference in number of respondents in each category. Project Managers made up 29 of the respondents, there were 22 Team Leaders, and ten Divisional Managers, with 16 responding as 'other'. This is likely to be reflected in the dissimilarity of risk scores between respondents, as the roles with greater numbers of respondents accounted for a higher amount of variation in risk scores. However, the overall average scores are not dissimilar enough to indicate that role plays a factor in risk perception.



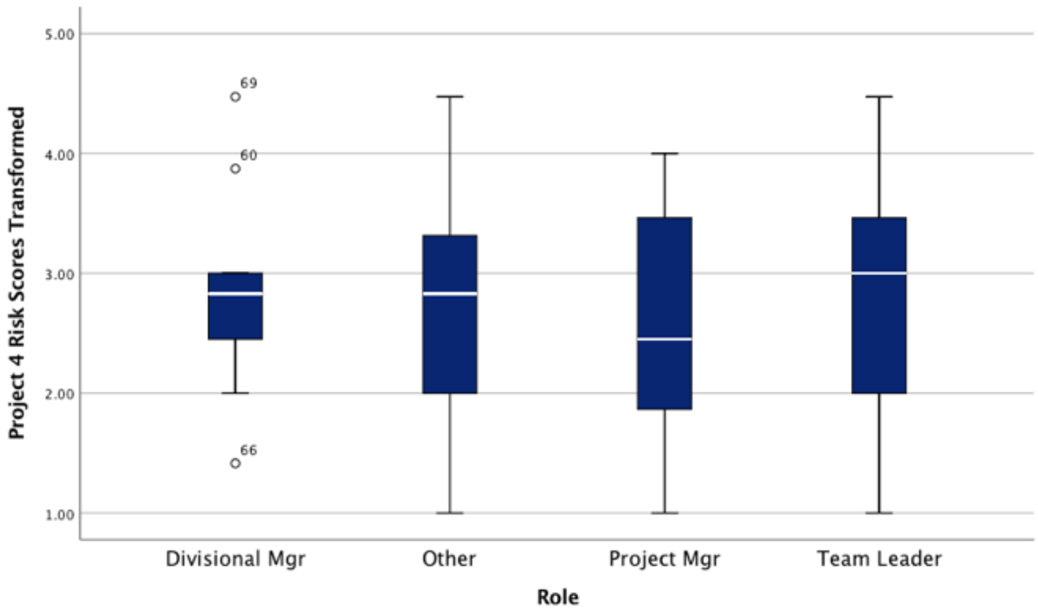
a) Project 1 (Pipe Replacement)



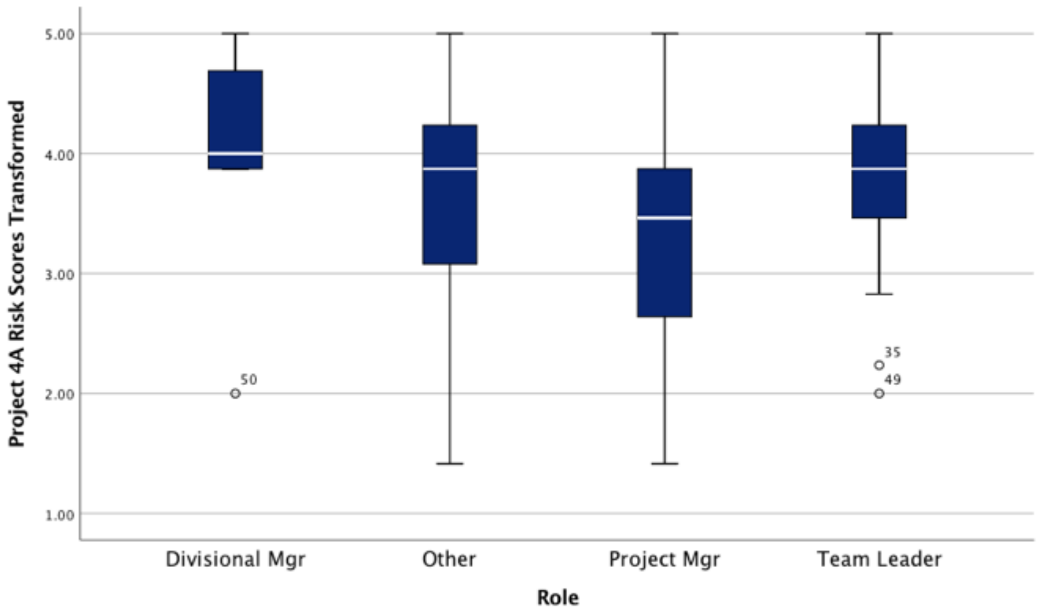
b) Project 2 (Pump Station)



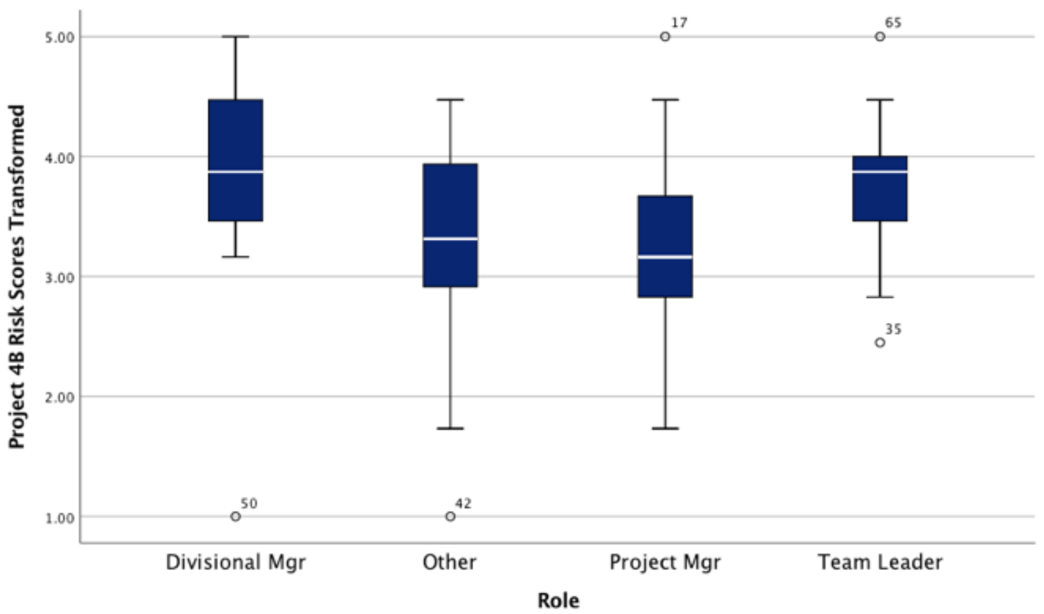
c) Project 3 (RWTP Construction)



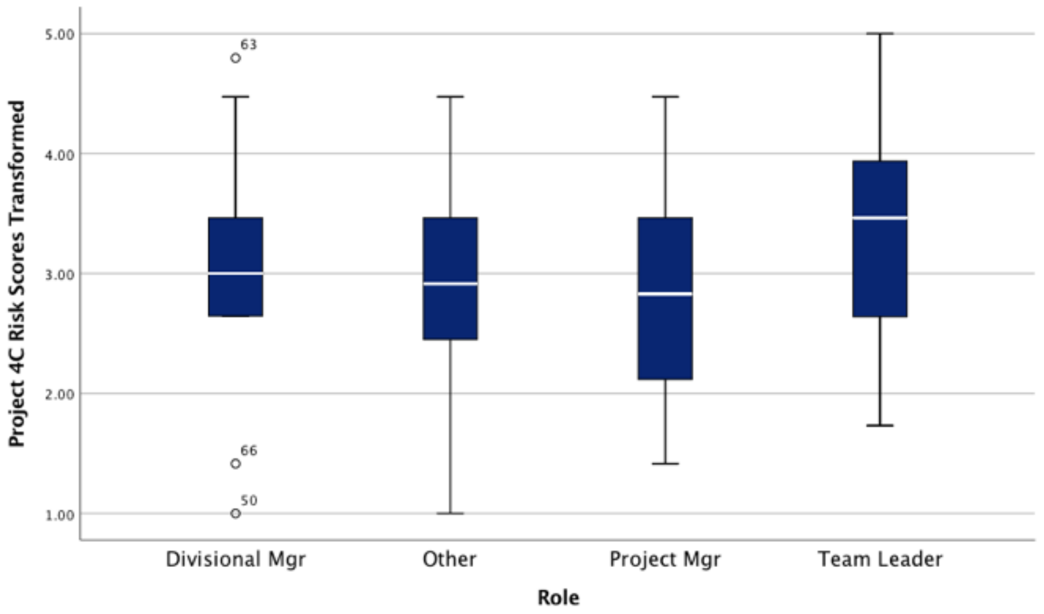
d) Project 4 (Save Water Campaign)



e) Project 4A (RW in Potable System)



f) Project 4B (Radiation Treatment for Water)



g) Project 4C (Removal of Fluoride)

Figure 6-18 Projects 1-4C (a-g) Box and Whisker Plots by Job Title

6.10.5. Risk Scores by Age

Finally, risk scores from respondents were segregated by age to determine whether this may provide insight into risk perceptions through demographics (Figure 6-19). It was found that the average risk scores did not vary between different age groups (note the risk score scale).

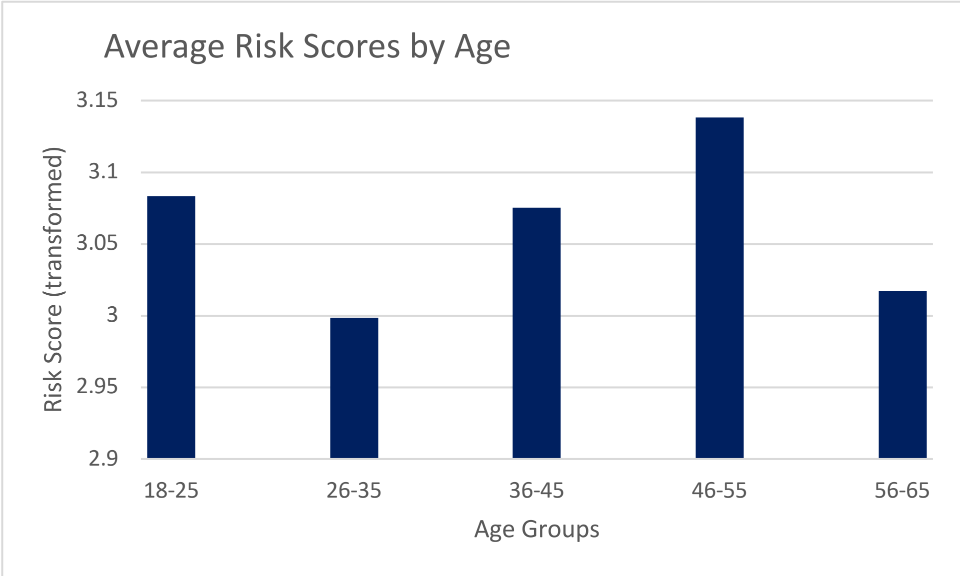
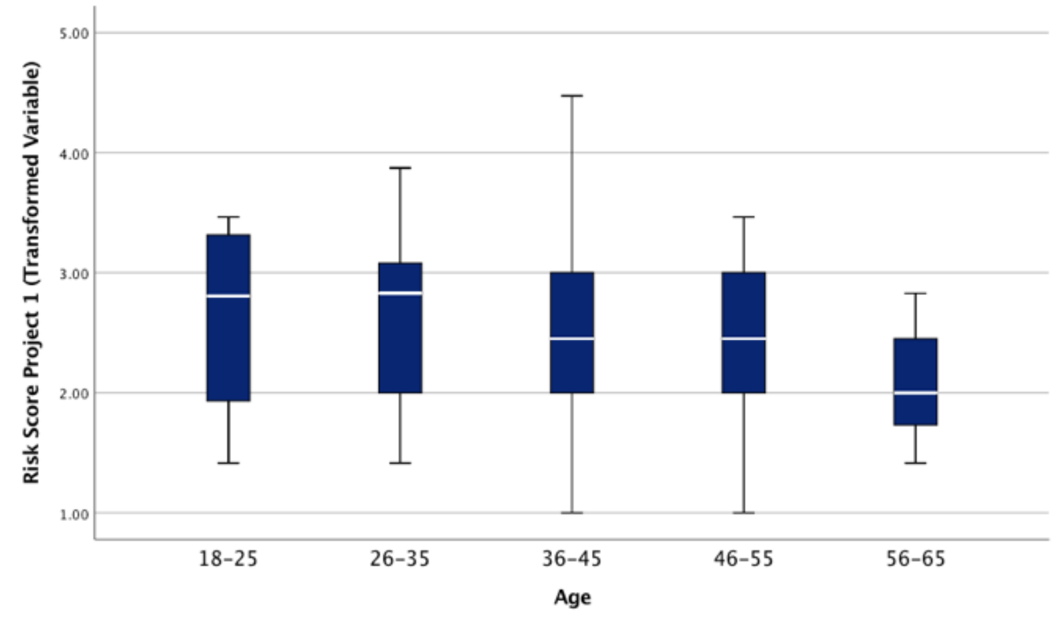
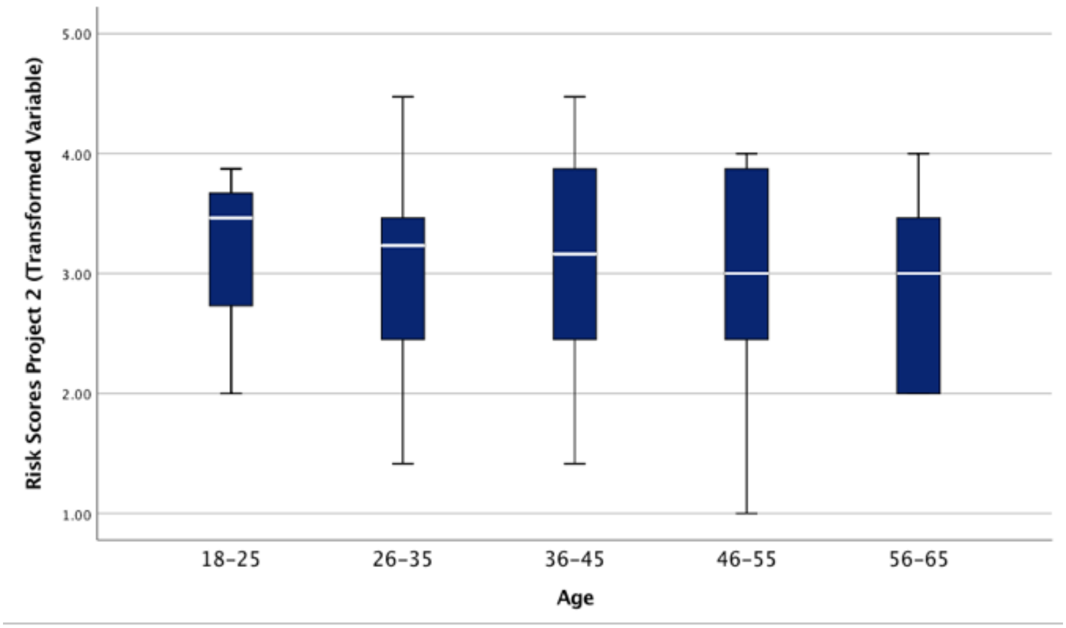


Figure 6-19 Average Risk Scores by Age

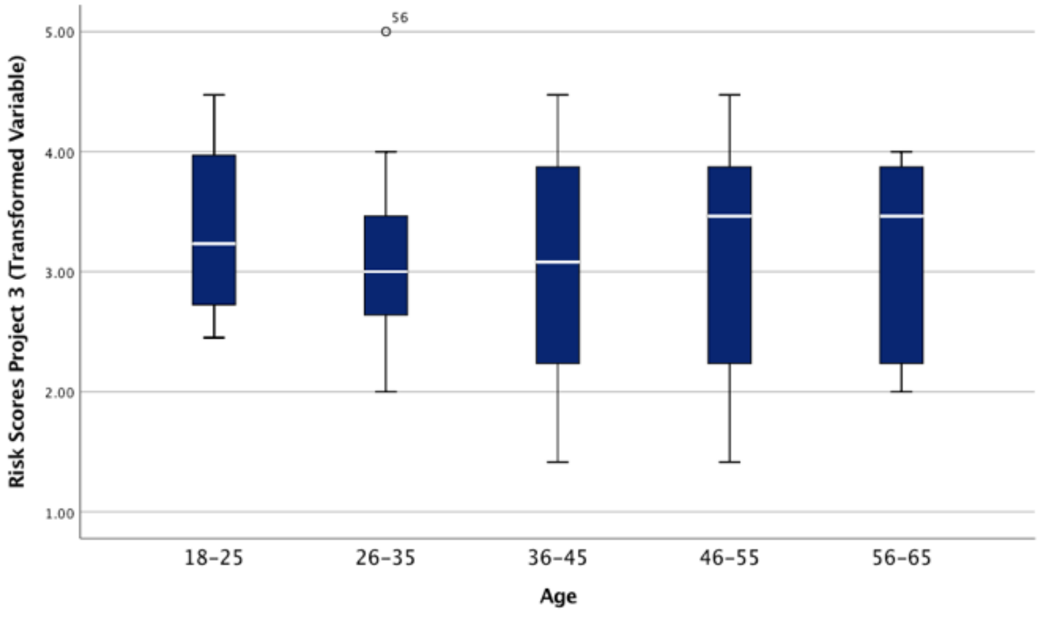
Exploring the impact age might have on each project separately is shown in Figure 6-20 (a-g).



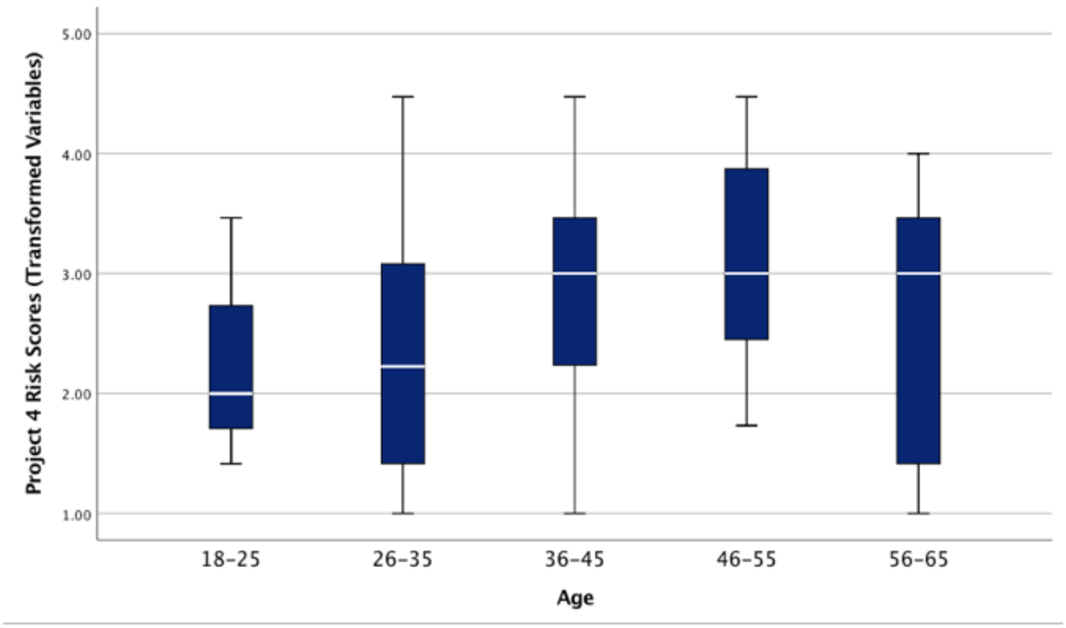
a) Project 1 (Pipe Replacement)



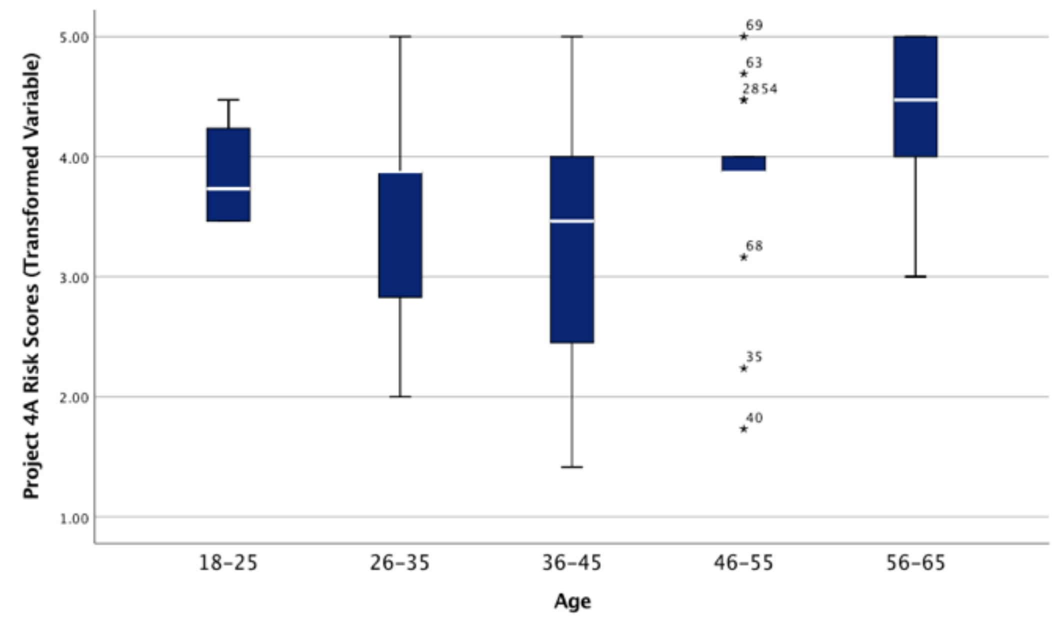
b) Project 2 (Pump Station)



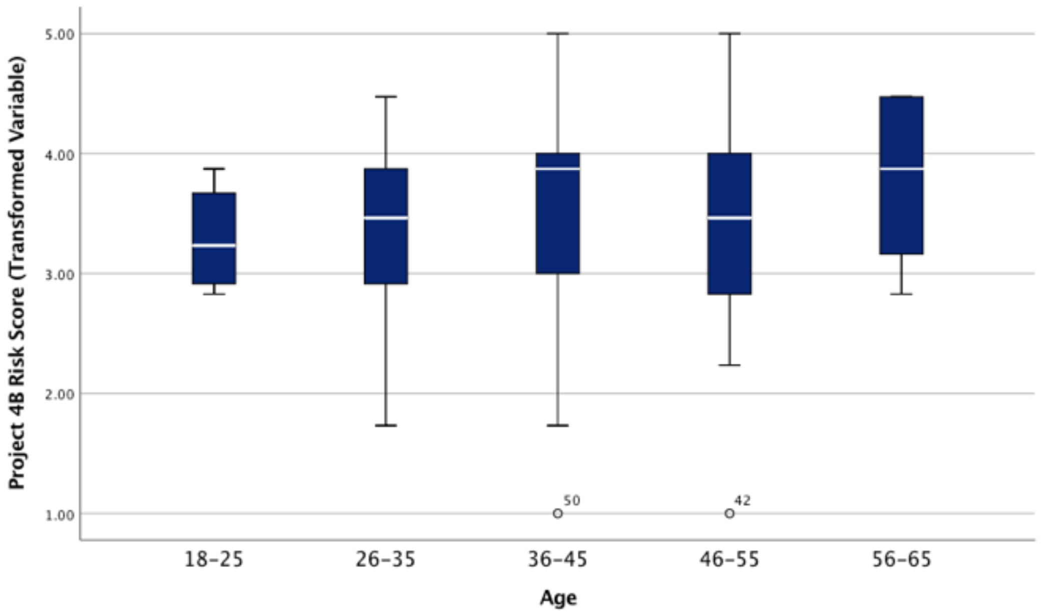
c) Project 3 (Recycled Water Treatment Plant Construction)



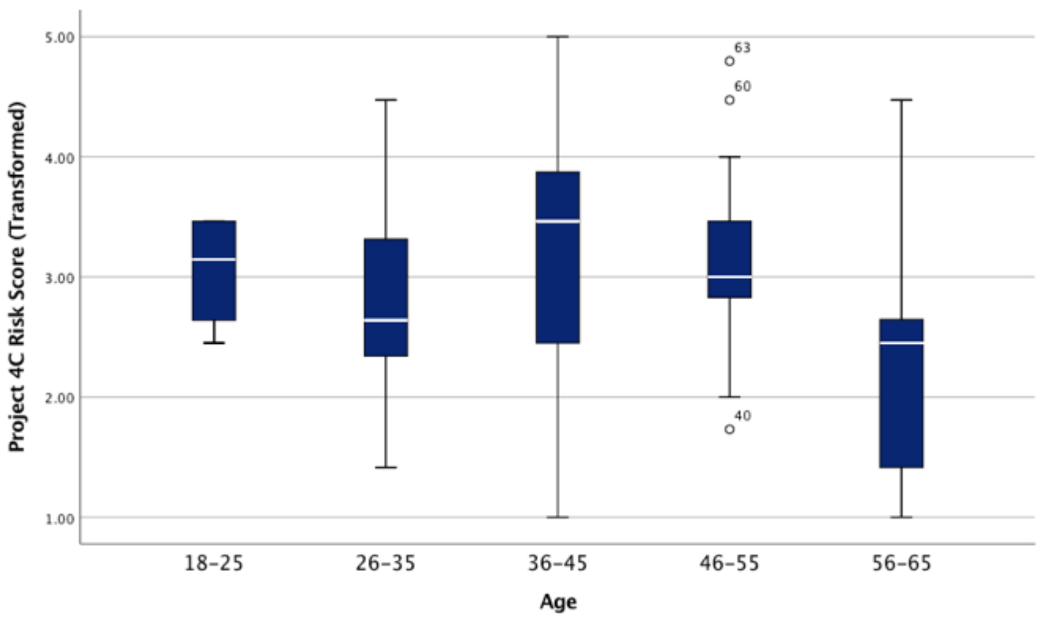
d) Project 4 (Save Water Campaign)



e) Project 4A (Recycled Water in Potable System)



f) Project 4B (Radiation Treatment for Water)



g) Project 4C (Removal of Fluoride)

Figure 6-20 Box and Whisker Plots of Projects 1-4C (a-g) by Age

Interestingly, age does not necessarily reflect a trend in risk scores. The older age group (56-65) recorded higher average scores for the majority of projects tested. It is a similar trend in the opposite direction for age group 18-25. There is insufficient clarity in the study to determine whether a trend exists for those within the 26 to 55 age range.

6.11. Conclusion

Considering the range and wide distribution of risk assessment scores within this study, one cannot explicitly state that the risk assessment process could be considered to be objective. It was found that the risk rating itself is highly dependent upon the individual undertaking the assessment, despite the risk assessor being provided with identical information to other assessors and using the same organizational risk assessment process.

This finding provides a pathway to understanding decision-making within the water sector, and its role within risk assessment processes. Furthermore, the risk assessment forms a key component in determining funding allocations for projects. A high-risk option may not be allocated funded over a low risk scenario. In many cases around the world, funds for water-based projects are sourced from taxpayers, and therefore some level of scrutiny into how these funds are allocated is fair and reasonable in the public domain.

Understanding the role of risk assessments in a water project, and particularly its subjective nature, can provide a pathway to implementing new approaches that create a less biased outcome. Further results from the research is described in Chapter 7 and 8, and will explore the key elements that separate each risk assessor's scores from one another. The psychological (a personal affiliation to a risk drives decision-making) and sociological risk theories (membership of a grid-group affects how each person rates a risk) are utilised within this study to provide a pathway to understanding the way in which risk is perceived by each assessor (Kosovac, Davidson, Malano, & Cook, 2017). This approach allows greater insight into how risk assessment processes may be altered to more effectively encompass the organizational risk appetite into its processes, with the aim of creating more objectified practice.

References

Booth, A. L., & Nolen, P. (2012). Gender differences in risk behaviour: does nurture matter? *Economic Journal, 122*(558), F56-F78. doi:10.1111/j.1468-0297.2011.02480.x

Kosovac, A., Davidson, B., & Malano, H. (2019). Are We Objective? A Study into the Effectiveness of Risk Measurement in the Water Industry. *Sustainability, 11*(5), 1279. doi:10.3390/su11051279

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Chapter 7

Data Analysis – Psychological Risk Approach

Chapter 6 tested the level of homogeneity to risk assessments when respondents are provided with identical project information and reference material. The results indicated that the process cannot be without some level of personal bias, as scores for each and every project varied drastically between individuals. Henceforth, the research is designed to explore whether psychological affiliations, both qualitative and quantitative responses to a risk, effectively explain this variation in the scores. Previous research undertaken by Slovic, Fischhoff, and Lichtenstein (1985), suggests that risk perceptions are heavily affected by an individual's relationship to the particular risk. The following sections considers to what extent this theory stands true for water professionals in the public sector.

In this chapter, the results of the objectiveness of current processes, the psychometric testing and the cultural worldview testing are presented. These results were obtained using the SPSS statistical software. The aim in this chapter is to provide the baseline results that were obtained from statistical analysis. These results are further interpreted in Chapter 9.

7.1. Qualitative Data Analysis

This section of the data analysis first considers the qualitative responses of risk assessors. Respondents were asked to indicate the risks they see as the most prevalent for Projects 4A, 4B and 4C through an open answer question. As described in Chapter 4, these were coded, and the results shown below.

7.1.1. Identified perceived risks

Through the use of a qualitative content analysis approach (coding), fourteen key risk factors were observed across respondents, for each hypothetical water project. A brief description of each risk factor coded is found below:

- *Public health - direct:* this category included a direct statement from respondents about the potential public health risk associated with the project. For example with the fluoride project (Project 4C) "*possible risk of increased dental health issues, especially kids that don't practice proper dental hygiene*" (female team leader, 36-45 years of age)
- *Process related risk with public health implication:* This category was used when a respondent identified a process related issue that would have a public health implication, but that the public health implication was not directly stated. For example, in relation to the potable recycled water system "*off specification water reaching potable system*" (female project manager, 26-35 years of age)
- *Community Opposition* – Responses relating to community opposition highlight a risk from public backlash due to the project.
- *Reputation* – This risk factor refers to reputation to the water authority, as this is how it is framed in the risk management processes of each water authority. For example, "*public concern over health impacts leading to reputational damage*" (Male Divisional Manager, 36-45 years of age)
- *Safety* – Safety refers to construction-based safety issues, worker safety, as well as any general mentions of safety.
- *Questioning Research/Research Not Tested* – This category was used for responses that critiqued studies presented. For example, in relation to the use of radiation in the

water treatment process (Project 4B) *"what research has been done to support findings? Scientific evidence to back up? Risk of unknown and lack of evidence to support the project" (*Female, 26-35 years of age)

- *Cost* – Any responses that mentioned financial considerations of risk to the project.
- *Governance and Regulation* – This risk factor grouped any responses relating to regulatory approvals for example, "*project could go over time, approvals may not be granted on time*" (Male Team Leader, 26-35 years of age)
- *Environmental* – This refers to responses that highlighted any risks to the environment due to the project. "*Environmental* [sic] *will be impacted if system fails"* (Male Divisional Manager, 46-55 years of age)
- *New Technology* – Responses in this category highlighted the new or unfamiliar risk related to the project.
- *Operational* – This risk factor included responses that referred to the way the technology would be run, or operated.

The number of respondents who made a comment regarding each of these identified perceived risk, by each of the unfamiliar project (4A, 4B and 4C) is shown in Figure 7-1. Most respondents commented on Reputation, Public Health, Illness and Community Opposition (Kosovac, Hurlimann, & Davidson, 2017).

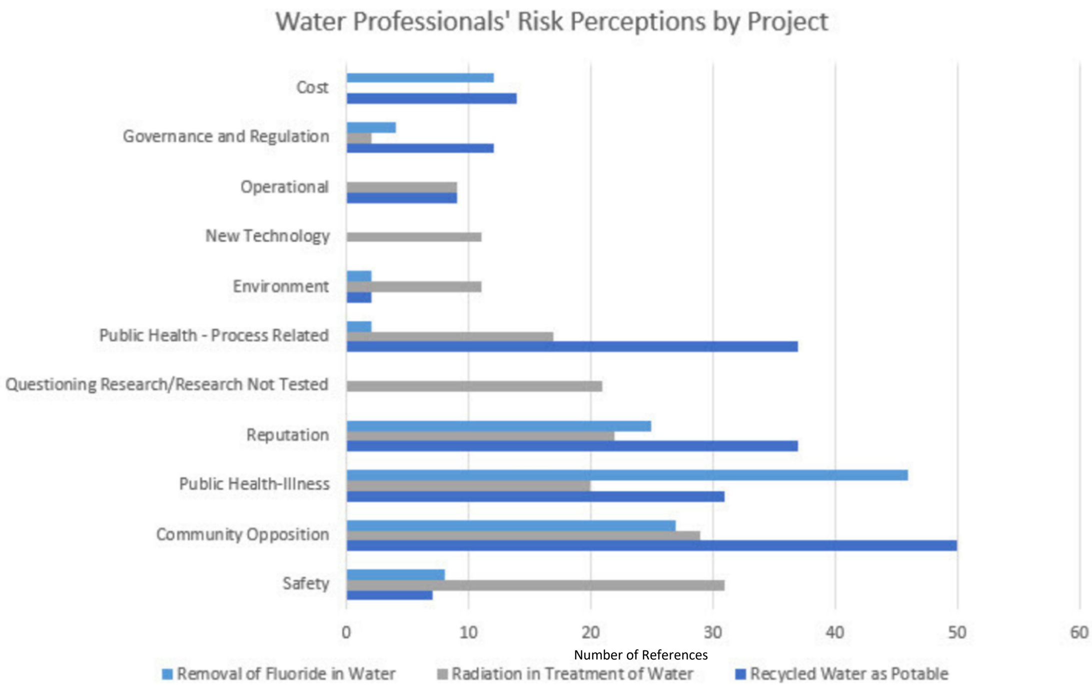

Figure 7-1 Water Professionals' Risk Perceptions by Project (overall)

7.1.2. Risk perceptions for Project 4A - Potable Recycled Water Use

The perceived risks associated with the potable recycled water use scenario are shown a dark blue line in Figure 7-1.

As shown in the results, community opposition was mentioned by the majority of respondents when considering the inclusion of recycled water in the potable supply. This is not an unfounded concern, as studies have shown that public perceptions relating to drinking recycled water are generally negative (Dolnicar & Hurlimann, 2009). This was followed by a concern over the risk to the reputation of the organization, which could be closely linked to the impression that the public would not be in favour of the project. As discussed in the literature review (Chapter 2), this could also be as a result of an increasing public distrust in expert risk perceptions. This distrust can lead to increased chance of public backlash, as project-based decisions are scrutinized. This points to whether water professionals seem to be cognizant of the effect of community action on projects, and its potential to become a politicized issue in the media. Unsurprisingly, public health is also a highly cited risk category and in particular, fearing risk of illness as a result of the use of treated wastewater in drinking water supply. References to the environment featured the least, with financial and regulatory risk having a moderate influence.

Table 7-1 Expert risk perceptions associated with the potable recycled water project, and frequency of occurrence

Risks raised by respondents (n= 77)	n
1. Community Opposition	50
2. Reputation	37
3. Public Health - Process related	37
4. Public Health - Illness	31
5. Cost	14
6. Governance and Regulation	12
7. Safety	10
8. Operational	9
9. Environment	2

7.1.3. Risk perceptions for project 4B - radiation treatment of potable water

Radiation was used in this project to draw out any historically negative connotations associated with the technology. Unsurprisingly, as shown in Table 7-2, safety features as the highest risk factor while regulation was mentioned the least. Community opposition and reputation appear high on the list, which may be a result of an expected negative public response to the technology. This view is explored by Fischoff et al (1978) in their work in risk perceptions.

The theme of questioning established research appeared as a risk factor for Project 4B, which could be either interpreted as distrust of research, or healthy scrutiny of previous studies. In much the same way as the community expects to be engaged on projects, water professionals expect further information and reassurance from researchers. Interestingly, public health did not feature as high in responses as Project 4A, even though as this was a new method altering existing water treatment processes.

Table 7-2 Expert risk perceptions associated with the radiation-based treatment system for water, and frequency of occurrence

Risks raised by respondents (n= 76)	n
1. Safety	31
2. Community Opposition	29
3. Reputation	22
4. Questioning Research/Research Not Tested	21
5. Public Health - Illness	20
6. Public Health - Process Related	17
7. Environment	11
8. New Technology	11
9. Operational	9
10. Governance and Regulation	2

7.1.4. Risk perceptions for project 4C - removal of fluoride from potable water source

Project 4C had the highest mention of public health as a risk factor (Table 7-3), which could be interpreted due to the nature of the removal of a dosing process, rather than the addition of a process (as occurs with the other projects). Most respondents were concerned about the effect on dental health if fluoride was removed, for example "possible risk of increased dental health issues, especially kids that don't practice proper dental hygiene" (Male Team Leader, 36-45 years old).

Many respondents also mentioned the issue of pro-fluoride groups protesting, while others highlighted that they will be seen as 'giving in' "giving luddites victory" (Male Project Manager, 36-45 years old), and heeding to a movement not backed by evidence:

> *"it's not based on science, it's based on the opinion of people (generally) that have a poor understanding of science. These decisions need to be backed by science. It's a poor response to the problem and focuses on pleasing minorities at the expense of legitimate health benefits for everyone else. Why not allow minorities to use household-based filters to remove the fluoride?" (Male, 18-25 years old)*

These comments highlight the controversial nature of the project and the opinions of the experts towards a vocal minority in the community.

Table 7-3 Expert risk perceptions associated with the removal of fluoride from the potable supply, and frequency of occurrence

Risks raised by respondents (n=75)	n
1. Public Health - Illness	46
2. Community Opposition	27
3. Reputation	25
4. Cost	12
5. Safety	8
6. Governance and Regulation	4
7. Environment	2
8. Public Health – Process Related	2

7.2. Quantitative Psychological Risk Attributes

Respondents were asked to provide a risk score, using their organizational risk framework, and required to answer 10 questions on a Likert scale regarding their affiliation to the risk. The questions referred to the following areas:

- Voluntariness of those exposed to risk;
- How immediate the risk of death is;
- Whether the risk was known to the persons exposed;
- Whether the risk was known to Science;
- The level of control of the risk by those exposed;
- How new/unfamiliar the risk is to the respondent;
- Whether the risk kills people one at a time, or all at once;
- The feeling of dread towards the risk;
- Likelihood of a fatal outcomes as a result of the risk;
- Whether the risk is seen as fair.

Participants provided responses for each of the statements on a 7-point scale. This number was recorded against each respondent and used to form the analysis.

The scores were recorded and analysed using the statistical package, IBM's SPSS . The analysis sought to determine whether there is any correlation between the responses to the 10 psychological attributes and the risk scores provided by each respondent for each project. In undertaking this approach, the aim was to consider whether these psychological variables may explain the variation in the risk scores derived from the unfamiliar projects (4A, 4B and 4C) between participants.

7.2.1. Reducing the number of variables

The process of reducing the number of factors was described in Section 4.7.2. This process is known as a Principal Components Analysis (refer to section 4.4.1). Within this study, 10 different dimensions (the number of psychological variables) have been tested. The analysis aimed to create a new variable that limits the number of dimensions in order to be able to explore data more easily and notice any trends and associations. This approach utilized Principal Component Analysis principles to convert possibly correlated variables into a smaller number of variables, called principal components. It aims to use a vector space transform to lower the number of variables to those that are possibly correlated, thus creating a new factor variable out of previous variables. The analysis was wholly undertaken within SPSS. The aim of the analysis is to find a principal component (a combination of the tested variables) that explains the highest amount of variation.

Each principal component will highlight the extent to which it explains the variation in the data, followed by other principal components, until the majority of the data can be explained. It is ordinarily sufficient to ensure 70-80% of the data is explained by the factors. The total variance explained by the first 5 factors is shown below, for projects 4A, 4B and 4C (Table 7-4).

Table 7-4 Principal Component Analysis, Total Variance Explained

Component	Project 4A		Project 4B		Project 4C	
	% of Variance	Cumulative %	% of Variance	Cumulative %	% of Variance	Cumulative %
1	18.0	18.0	27.9	27.9	27.4	27.4
2	14.4	32.4	15.4	43.3	15.1	42.6
3	13.7	46.1	12.1	55.4	13.6	56.2
4	12.6	58.7	10.6	66.0	11.7	67.9
5	10.6	69.3	9.3	75.2	8.1	76.0

The total variance explained table highlights similar results from Projects 4B and 4C, with approximately three-quarters of the variation in results being explained by the first five principal components (Table 7-4). Although Project 4A is not substantially different, it nevertheless requires some explanation as to the reason for the lower explanatory results. This phenomena is explained later in section 7.3.5.

7.3. Principal Components

Table 7-4 shows that using the first three principal components provided just over half the explanation of the variation. This now provides the opportunity to delve further into these new variables, to determine whether there are meaningful results that can be gleaned from the grouping of the attributes.

7.3.1. Principal Component 1

The first principal component of projects 4A, 4B and 4C is outlined in Figures 7-1, 7-2 and 7-3. The attributes that make up each new variable (or Principal Component) are highlighted, and most importantly, are given consideration as to whether they meaningfully provide a measure that will help to explain the variation in scores. Principal Component number 2 for each project is not included in any further analysis as the explanation of variation falls drastically to approximately 15% for all projects. It will also result in six new variables, (2 for each project), which is too many to meaningfully conduct an analysis, thus rendering the variable reducing exercise as redundant. As a result, only Principal Component number 1 is provided for each project in the following sections.

7.3.2. New variable: Dread related to Perceived Fatal Risk

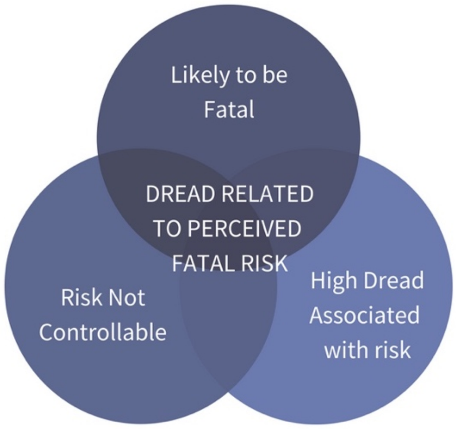

Figure 7-2 Principal Component 1 Project 4A 'Dread-related to Perceived Fatal Risk'

A new variable was created out of running a principal component analysis on Project 4A, providing recycled water within a potable supply. These attributes are grouped together as they are the highest acting in the Principle Component Analysis (as shown in Table 7-4). The highest acting attributes were 'likely to be fatal', 'risk not controllable' and 'high dread associated with the risk'. All attributes are grouped together as the high sense of dread is likely to result from a risk that is perceived to be fatal, and uncontrollable. Therefore, this grouping can meaningfully describe the data and is used in further analysis.

7.3.3. New variable: Fear of the Unknown

Figure 7-3 Principal Component 1 Project 4B 'Fear of Unknown'

Project 4B related to the use of radiation in the treatment of water, provided a principal component variable that was meaningful, and included the following risk attributes: Risk Unknown by those Exposed, Risk Unknown to Science, Newness of Risk and Level of Control of Risk. These factors were grouped into one new variable, titled 'Fear of the unknown'. When testing this new variable against all of the risk project scores, the R^2 score was 0.05, and the P value was 0.00 (thus rejecting the null hypothesis). This indicates a low-level explanation of the variation in the risk scores across the three projects, and across respondents.

7.3.4. Unspecified Grouping

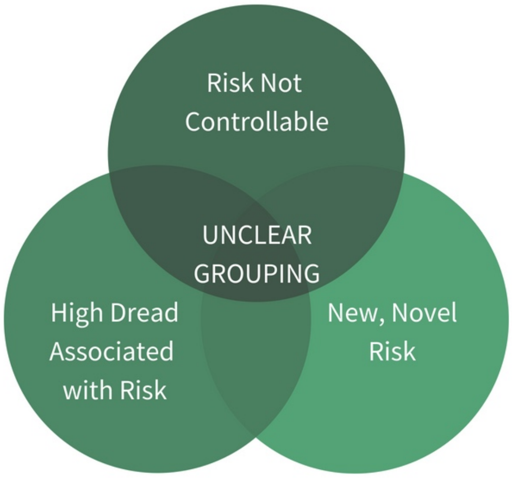

Figure 7-4 Principal Component 1 Project 4C Unclear grouping

In running a principal component analysis on the final project, which explores the idea of removing fluoride from a drinking water supply, the key attributes that were singled out were: 'risk not controllable', 'high dread associated with the risk' and 'new, novel risk'. A suitable link could not be found between these variables that clearly and concisely defines the new variable. As such, the grouping of these attributes is unclear, providing difficulty in gleaning practical meanings and outcomes from this variable and therefore not used for further analysis.

7.3.5. What does the Principal Component Analysis tell us?

Project 4A describes a scenario wherein recycled water is provided in the potable supply therefore it is not surprising that elements such as 'risk known to those exposed is high', as well as perceived 'fairness of the risk' and 'risk control' feature in this analysis. All of these factors relate to the person who is drinking the recycled water, perhaps referring to a low knowledge of the risks personally experienced, and the lack of choice regarding whether they are provided with recycled water in their potable water mains. It is not surprising then, that these factors are grouped together. Project 4B and 4C have very similar principal attributes acting upon their first principal component: the risk is known to persons exposed, known to science, has a level of control of the risk, and how new or unfamiliar the risk is to those exposed. The factor of feeling of dread toward risk and risk of fatality also feature highly. Project 4B refers to the use of a new radiation process in the treatment of water. Psychometric testing in radiation has brought about similar results to what has been found here (Fischhoff, Slovic, & Lichtenstein, 1983).

7.3.6. Regression Analysis

Running a regression of risk scores of all the transformed project risk scores combined against the two new variables, "Dread Related to Perceived Fatal Risk" and "Fear of Unknown" received a P value of 0.001, and R^2 of 0.05. The following table also shows the results of the regression analysis of the new risk variables with Projects 4A, 4B and 4C.

Table 7-5 Regression Analysis using new PCA Variables

New Risk Variables	All Projects Combined	Project A (Recycled Water to Potable Water)	Project B (Use of radiation in the treatment of potable water)	Project C (Removing Fluoride from potable water supply)
Dread related to Perceived Fatal Risk	R^2=0.10*	R^2=0.02	R^2=0.24*	R^2=0.01
Fear of the Unknown	R^2=0.05*	R^2 = 0.02	R^2 =0.16*	R^2 = 0.01
PC1 Project C variable not tested	NA	NA	NA	NA

Note: *Significant at P=0.01 level. P-values for tests of significance in regression analysis. Dependent variable: Risk Scores.

Testing project A and C resulted in a P value that was higher than 0.05, indicating that the null hypothesis cannot be rejected (that the 'fear of the unknown' variable plays a role in predicting the variation of risk scores between respondents). However, interestingly, running a regression against project B 'fear of the unknown' variable and its corresponding risk score, resulted in P=0.00 with R^2 =0.16. This result could be rather telling and is not insignificant in highlighting a variable that can be used to predict an element of how risk is perceived psychologically by risk assessors in water.

7.3.7. Regression of psychological attributes separately

The next stage of the analysis sought to consider each risk attribute separately, rather than a grouping of these attributes (as was undertaken using the Principal Component Analysis), through conducting a regression analysis to determine the extent to which it acts upon overall risk scores. Results are collated in Table 7-6.

Table 7-6 Multiple Regression Analysis across all projects. Dependent variable: Risk scores.

Risk Attribute	Sig. (P value)
Voluntary	0.94
Death Immediate	0.99
Known to Persons Exposed	0.98
Known to Science	0.40
Control	0.24
Newness	0.43
Chronic	0.21
Dread	0.01
Fatal	0.14
Fair	0.52

'Dread' is the only variable that shows any level of significance (P<0.001). Further information on the regression analysis of this variable against the dependent variable "Risk Score" provides an R^2 value of 0.09. R squared values within the range seen in this research (Table 7-6 and Table 7-5) are not unusual in psychometric testing (Slovic et al., 1985). This is in much part due to the many environmental factors that could alter results when testing cognition. Therefore, the R squared values are still reportable and despite their seemingly low values, provide important explanatory insight in this study.

Dread was only the only risk attribute, when regressed against demographic factors, that was significant at the P=0.05 level. The only demographic factor that this was true for was for age, and in particular, for the lowest age group: 18-26, and the highest age group: 56-65.

In summary, the three significant variables found in this study are dread related to perceived fatal risk (in Project 4B), the fear of the unknown (in Project 4B) and Dread (in all projects).

7.4. Summary of Psychological Risk Results

Across all projects, an increase in the feeling of dread experienced by the respondent corresponded with higher risk scores. This could be as a result of this evoked feeling being linked to the feared consequence of a particular action, especially if imagined to be fatal. This is particularly insightful considering one of the two inputs into the risk score matrix is 'consequence', or the likely outcome of the risk being realized in practice. The dread factor could then highlight a key element in understanding how consequence is scored in the risk matrix, affecting and influencing the feeling of dread in assigning this score. As dread is 'imagined' in these contexts, it could be posited that water professionals carry through their imagined fears into the risk assessment.

The creation of two new variables, 'dread related to perceived fatal risk' and 'fear of the unknown' (a result of conducting the Principal Component Analysis) provides nuanced insight into the psychological affiliations of the risk assessor. In particular, the factor 'dread related to perceived fatal risk' is interesting in the context of Project 4B, the use of radiation in the treatment of water. Explaining over a quarter of variation in Project 4B risk scores, this factor of dread and its closeness to perceived fatality drives higher risk scores in this project. This pattern could be considered to be rather distinct from that of 4A and 4C, due to the preconceived negative risk connotation to the word 'radiation', a fear-based response highlighted by previous literature (Fischhoff et al., 1983). Project 4B proposes a process that is unfamiliar to water professionals, a factor highlighted by Principal Component Analysis variable 'fear of the unknown'. Projects 4A and 4C are based on altering the water supply in a way that is not unusual or unimaginable in the water sector, and have never been undertaken. Whereas, the lack of knowledge and awareness of new technologies in radiation treatment could be said to provide a level of healthy scepticism in rating its riskiness. This is suggested by the exhibited influence that 'fear of the unknown', a knowledge-based factor, has on the risk assessor's score.

'Fear of the unknown' is made up of knowledge-based attributes such as the 'newness' and 'unfamiliarity' of the project, in combination with a clear understanding of the risk by both those exposed and science. This amalgamation of psychological attributes provides a glimpse into explaining approximately 5% of the variation in the risk scores across all projects. This rises to 16% in the case of Project 4B, the use of radiation in the treatment of water. This suggests that the risk score could be then guided by a perceived lack of knowledge by both science and those exposed. Although other projects have been rated in the extreme category of risk, none have been as clearly linked to the psychological attribute of 'fear of the unknown' quite so starkly as Project 4B.

This finding is not unlike previous studies in this area. Although undertaken in different contexts and using ranking instead of risk scores, Slovic's (1985) study also highlighted attributes led by knowledge-based psychological factors. This factor in Slovic's study was primarily driven by risks unknown to persons exposed, and unknown to science. Controllability was linked to his study, which is not dissimilar to what was found here (Slovic et al., 1985). The effect of dread on risk scores then shows that not only do assessors consider it in their own risk perceptions (as Slovic's study shows) but that it also translates into risk scoring practices.

7.5. Explanation using Heuristics

In making judgements, people infer a lot of information, the rules around this process is called heuristics. Tversky and Kahneman's work on heuristics relies on the basis that judgements often need to be made in times of uncertainty, or in times of incomplete information, both scenarios which are not uncommon (Tversky & Kahneman, 1973). Heuristics are generally used to reduce individual mental load, rendering decision-making quicker and easier (Slovic, Fischhoff, & Lichtenstein, 1982). Heuristics act as an explanatory theory in understanding the results of this section of the study, particularly in the way that assessors decide upon the probability or likelihood of an event in risk assessments.

7.5.1. Simulation heuristics

It is theorised that in each of the scenarios presented to respondents (Projects 4A, 4C and 4C), assessors would essentially run a mental 'simulation' model to construct a new social reality. The reason for running this model, is that respondents would have no other way of judging the situation, as none of the participants would have experience to draw from on any of the cases (as none of the projects have been undertaken in the Melbourne-based context). The process of running this internal model is referred to as 'simulation heuristics', a term coined by Kahneman and Tversky (2009). Respondents ultimately use this newly constructed reality to undertake two actions: to assess the probability of an imagined event, and also to assess the consequences of the event. They are required to highlight remote contingencies in their assessment of these two areas, both of which ultimately are scored in the risk assessment process.

Simulation heuristics is linked to the 'availability' heuristic- the ease of which a particular outcome or examples come to mind highlights its relevance or importance to the assessor. The more likely a particular scenario comes to mind, regardless of how unlikely it actually is, will be perceived by the risk assessor to be far more probable, (Kahneman & Tversky, 1982).

The availability heuristic can come in the form of either 'retrieval' of information/memory to form an assessment, or the construction of one. The 'retrieval' of information is more likely to occur in projects where the assessor relies on experience and memory to form an assessment. The simulation heuristic describes a scenario wherein the construction of an outcome is the cognitive process by which likelihood and consequence are assessed. This is more likely to be projects such as 4A, 4B and 4C which have previously never been undertaken by the participants of the survey. In these cases, where history and experience cannot help evaluate the risk, people create scenarios. However, as Tversky and Kahneman (1973) suggest, it is difficult for a human to imagine scenarios that are complex, and instead create overly simplistic outcomes of events, therefore the 'most obvious variations take place' with little intersecting factors that produce complexity (Tversky & Kahneman, 2009, p. 20).

7.6. Qualitative Data in Explaining Results

Simulation Heuristics arguably play a role in determining the likelihood and consequence ratings of projects (in particular Project 4B). In order to gain further insight into this supposition, the qualitative data that was obtained through the survey provides a useful reference.

Respondents were asked to list the main risks associated with each particular project, in their own words. This provides an understanding of what element of dread is linked to the project (that affects scores), and also how the fear of the unknown is linked to these coded areas. Figure 7-5 repeats the information shown earlier in this chapter, (for convenience) to show the coded results of the qualitative risk question.

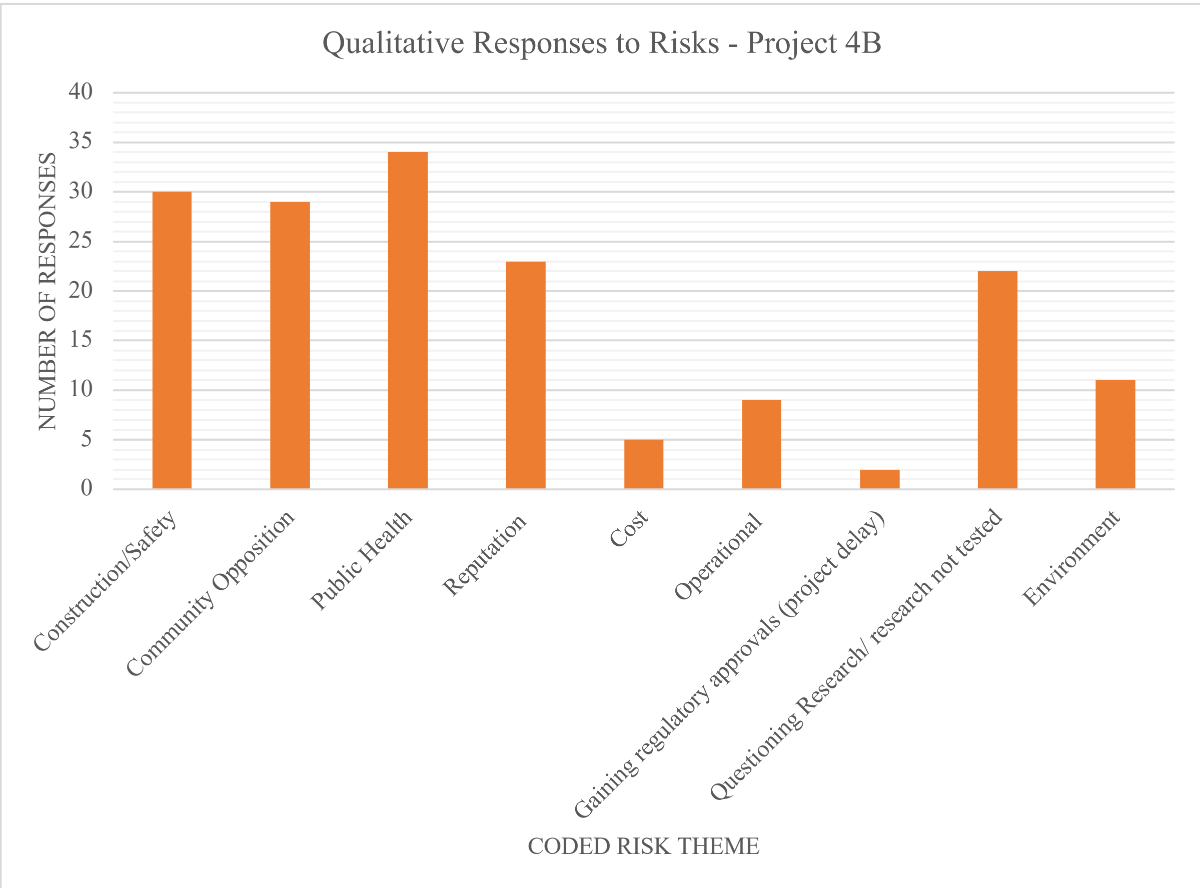

Figure 7-5 Qualitative Responses to Risks for Project 4B

Table 7-7 highlights any relationships between these risks and the risk attributes that have been deemed significant in the study are highlighted. The information in this table was devised by first considering whether the coded themes related to any of the risk attributes. For example, 'public health' is a theme that may invoke dread and fatal outcomes, whereas the responses to community opposition were more focused on project literacy levels of the community and its effect on projects.

Table 7-7 Language analysis of Qualitative Themes and Psychological Risk Attributes

		Psychological Risk Attributes		
Theme	No. of responses	Dread	Fatal	Knowledge-based
Public Health	34	X	X	
Construction/Safety	30	X	X	
Community Opposition	29			X
Reputation	23			X
Questioning Research	22			X

"X" refers to a thematic relationship.

7.7. Links between Qualitative Data and Psychological Risk Attributes

The link between public health and dread can be exhibited through examination of responses. For example, participant no. 55 (Male, 18-25) wrote 'public could get radiation poisoning' as one of the main risks of the projects, which is echoed by many respondents including participant 71 (Male, 46-55, Divisional Manager), who stated 'potential risk to health due to unknown impact of consumption of radiated water'. The mention of 'radiation' was high, as was the word 'illness'. Dread often refers to catastrophic potential, and in the public health sphere this can signify potential fatalities. It is of no surprise then, that 'radiation', 'illness' is linked to a feeling of dread and a fear of fatalities in risk assessors. This may be open to salience bias, and also availability heuristics when forming these assessments.

Once again, the use of the word 'radiation' permeates much of the qualitative data related to risks of Project 4B. When related to construction and safety, respondents consider how workers on the future radiation treatment plant would be affected by the project. In particular, the respondents consider employees and their exposure to radiation as a key risk: "damage to radiation unit or unsafe use causes radiation to exposure to ppl[sic]" (Male, 26-35, Project Manager) and "operator risks in handling radioisotopes" (Male, 36-45, Team Leader). This can be linked to a feeling of dread and fatality on safety of workers at the treatment plant. "Operators being exposed to high levels of radiation, long term effects vs. immediate effects of this on operators" (Female, 18-25, Project Manager).

The effect of a lack of knowledge surrounding hazards factors highly in the data, and in particular, the likely links to these risk attributes are in community opposition, reputation, and questioning research codes. In particular, the lack of knowledge referred to two main areas: lack of knowledge of those exposed, and lack of knowledge to science. Community opposition may be as a result of 'fear of the unknown', a fear that the community may be against the project due to the uncertainty or lack of layperson knowledge surrounding this technology. This can then be linked to organizational reputation and questioning research, both of which can be argued to link to the knowledge to science element of the risk attribute list. A perceived lack of knowledge to science or experts could reflect poorly upon the organization, leading the public to further scrutinize decision-making. Furthermore, respondents carried a scepticism of the research, and this links closely to the lack of knowledge to science element.

7.8. Conclusion

In attempting to understand the decision-making elements regarding water projects in the public sector, this section of the survey could indicate the impact of both the feeling of dread, and also the fear of the unknown of a particular course of action on risk scores. The nature of a feeling of dread and the fear of the unknown may elicit higher scores in the area of 'consequence', when assigning risk scores. A high feeling of dread carries with it a perception of a catastrophic event, which ultimately would result in a higher consequence score. The availability heuristic explains the effect that this feeling of dread may have on likelihood outcomes, as higher dread is often a salient construction that comes to mind readily, and therefore can be perceived to be probable (Gigerenzer, 2004).

These findings reinforce similar conclusions presented in other studies undertaken on risk perception. The uncertainty and dread are highlighted as the key factors in driving risk perception (Fox-Glassman & Weber, 2016; Slovic et al., 1985). A study undertaken by Fox-Glassman and Weber (2016) concluded these attributes as being significant in how risks are perceived, however their methodology was quite different to that employed in this study. Their study had a similar number of participants (83) however did not compare risk attribute responses to risk scores, but instead to perceived risks and benefits of each scenario. Nevertheless, they found that the psychological attributes that most acted upon the respondents' perceptions were dread and uncertainty. This study then, not only highlights that dread and fear of the unknown acts upon risk perceptions, but most importantly, influences *risk assessment scores* themselves. This is particularly important as the risk scores play a key role in options assessments.

However, the effect of dread and fear of the unknown on risk scores should not be overstated. Due to the nature of social science, and the many factors that may be acting on the respondent at time of undertaking the survey, these elements may only describe a relatively moderate variation in the scores for the radiation project (Project 4B) and explain only a minor element of the variation in scores for all projects assessed. For this reason, there is a need to explore the sociological risk perception theories in the next section (see Chapter 8) to determine whether there may exist a theory which explains the seemingly subjective variation in risk scores to a greater extent than the psychological risk attributes.

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Chapter 8

Data Analysis – Cultural Theory

Chapter 7 considered the theory of psychological risk approaches, in particular that the impact of the individual's personal affiliations to a risk will drive their perception of it. This was shown to exist to a small extent in the data tested, in the feeling of dread, and also the impact of knowledge in the assessment of risk. However, it still left a fair proportion of the variation in risk scores relatively unexplained.

As described in Section 2-4, grid and group represent two measurable elements of the Cultural Worldview theory. Grid refers to the social structures between people, and whether the extent to which these structures define people by their particular roles. Group instead refers to the level by which people are absorbed by and influenced by membership within a community, or group. In Cultural Theory, adherence to these groups suggests differing risk perceptions. The following results explore the outcome of the survey to determine whether membership of a particular cultural worldview changes the risk scores one gives a project.

8.1. Worldviews Plotted

Using the methodology described in Section 4.4.3, each participant's responses to each statement either represented a positive score in the direction of either grid or group, depending on the statement. Each statement is either testing for grid or group, and therefore the reported Likert scores will exhibit the extent of adherence to the statement (and therefore their location on the plane below). This position has been calculated for every participant. Each individual score is shown on the grid-group plane as a point (Figure 8-1). Grid represents the y-axis, while group is represented on the x-axis. Each quadrant of the plane represents one of four worldviews: Hierarchy, Egalitarianism, Individualism and Fatalism. In addition, on Figures 8-2 to 8-5, the plots for each individual water authority are presented.

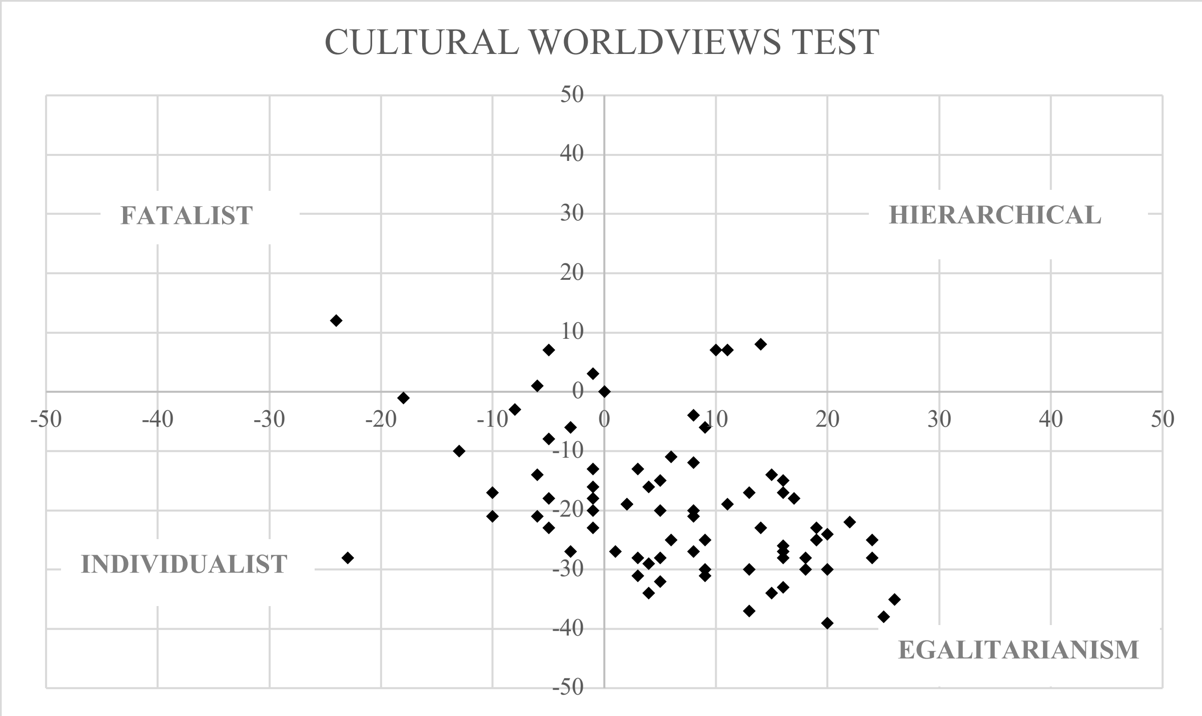


Figure 8-1 Results from Cultural Worldviews Test. Each marker represents one participant.

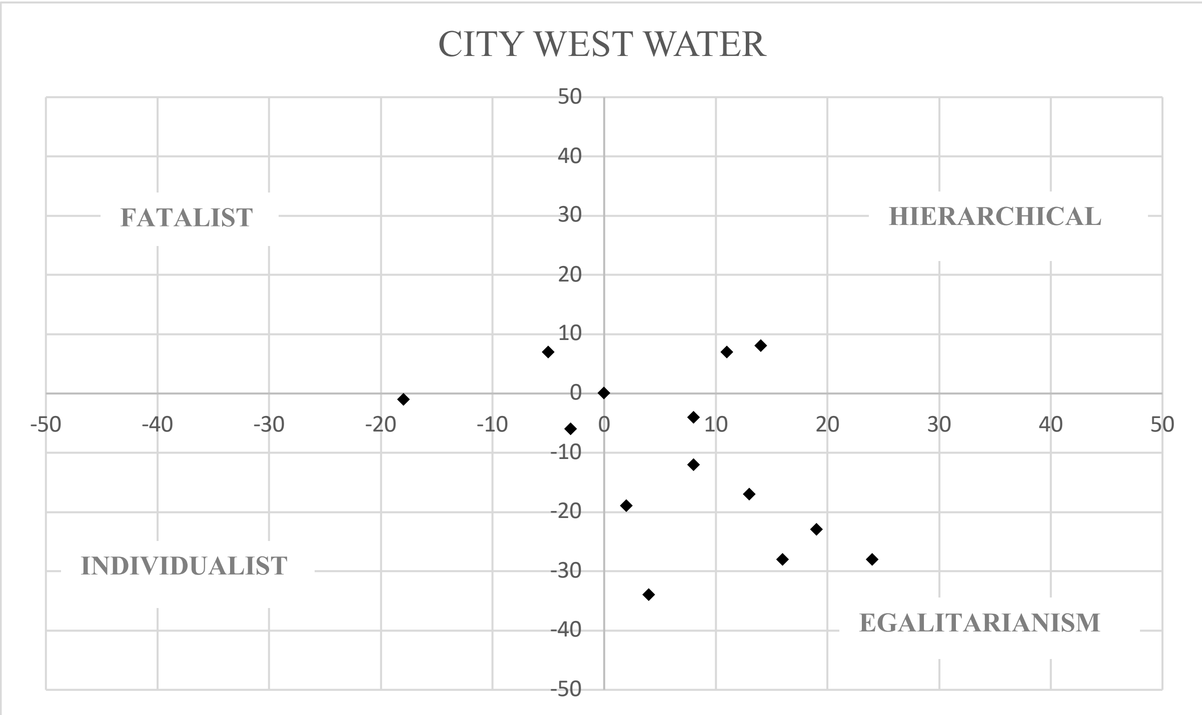


Figure 8-2 Results from Cultural Worldviews Test for City West Water. Each marker represents one participant.

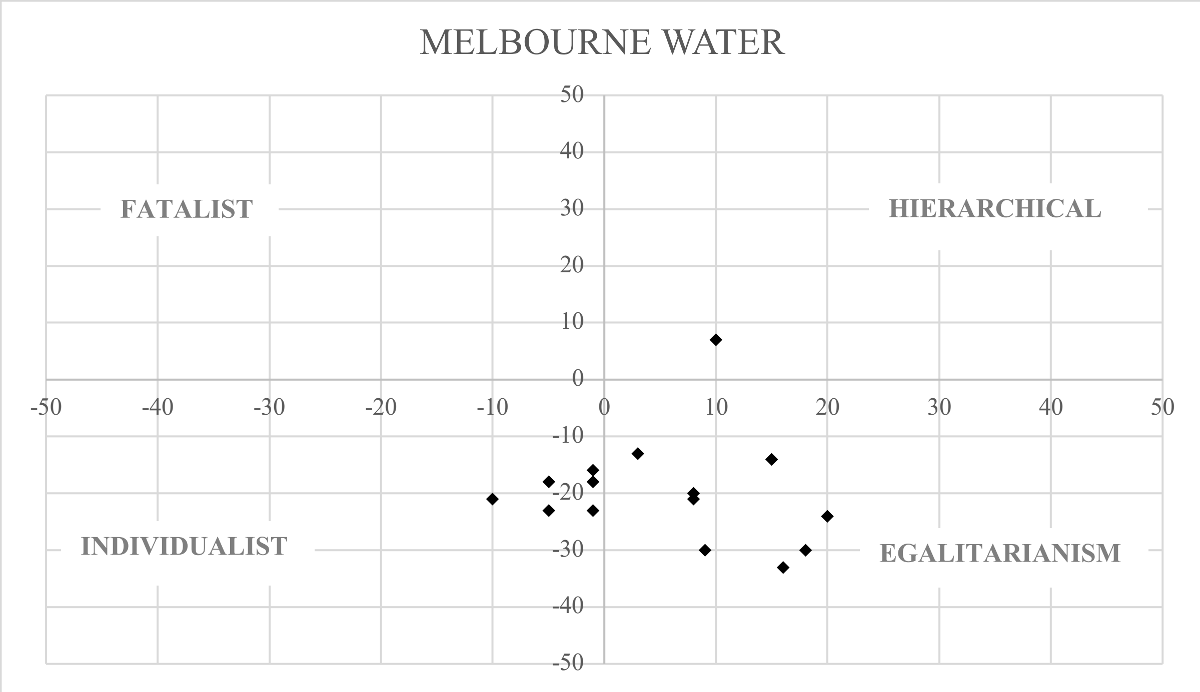


Figure 8-3 Results from Cultural Worldviews Test for Melbourne Water. Each marker represents one participant.

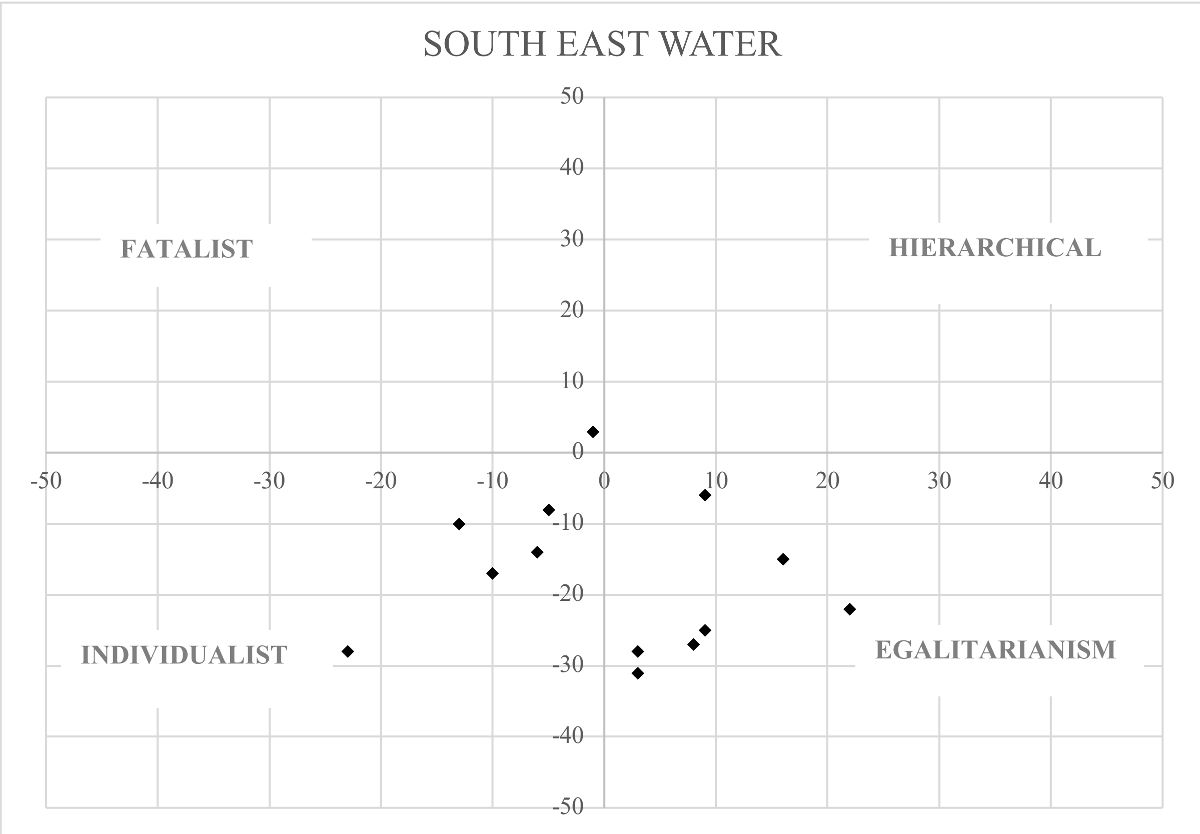


Figure 8-4 Results from Cultural Worldviews Test for South East Water. Each marker represents one participant.

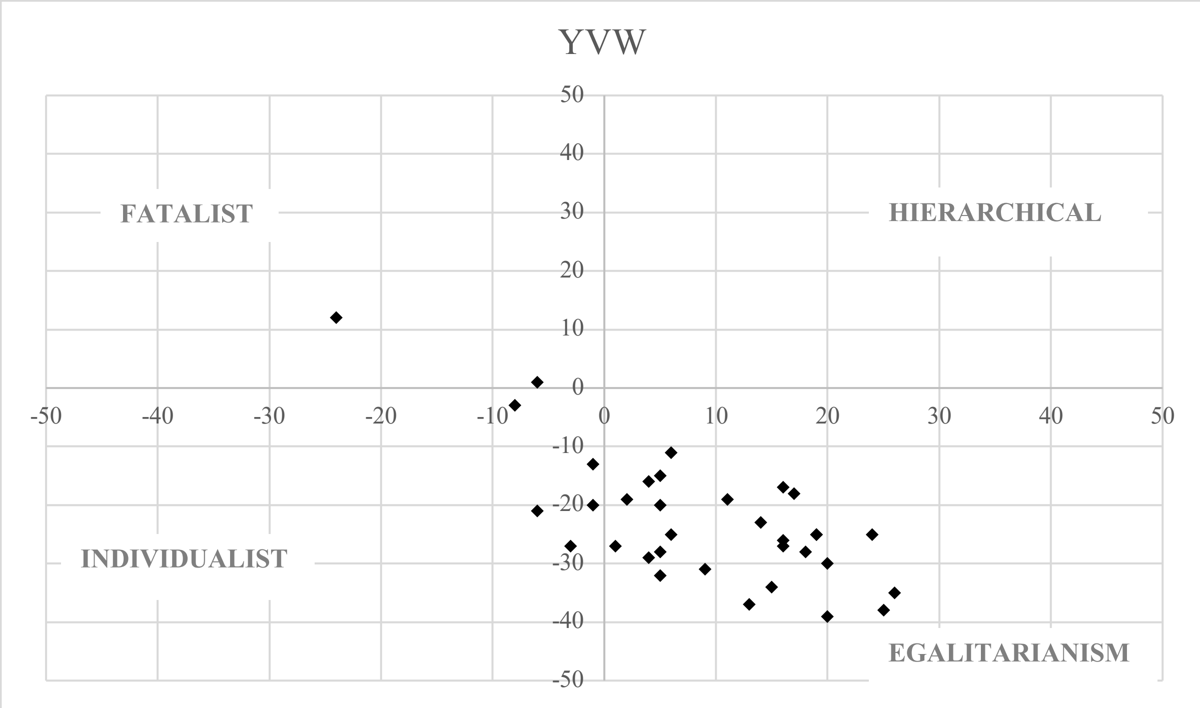


Figure 8-5 Results from Cultural Worldviews Test for Yarra Valley Water. Each marker represents one participant.

Egalitarianism is the most prevalent worldview amongst those surveyed, making up 68% of respondents. This may not be surprising considering all participants are employed within the public sector. Within the public sector, employees make decisions on behalf of the population, but these decisions are often under scrutiny and must be transparent. Decisions and allocations of funding by public servants can be overturned, or have pressure applied, by the Water Minister, an individual elected by citizens. In this way, democratic principles are still upheld, a central tenet of an egalitarian approach. It is less about experts having a final say, on the basis of their hierarchical position, but rather allowing a communitarian approach wherein the public can be involved in public sector decision-making. Therefore, the very nature of a public servant is congruent with the egalitarian worldview. It is unclear whether this is because of recruitment and attainment to have so many people of similar worldviews, or whether employees within the public sector in water adhere to the culture and worldview of the organisation. There was then a marked cultural shift within the water industry towards greater inclusivity of the community in the decision-making process, thus explaining the clustering of participants in the 'egalitarianism' quadrant.

The individualist worldview also represented a sizable proportion of the participants in the water industry as well- approximately 23% of participants. Although not as large as the membership of the egalitarianism camp, it nevertheless represents a noteworthy proportion. Interestingly, Individualists consider that the position of a person should not determine what decision-making power they may have- that all should essentially have relatively equal power. However, where they deviate from egalitarians, is the way that decisions should be made. It is fascinating that public sector workers should consider that decisions are better if made by the individual, not by a group- as is the case in the area of water. Individuals may have power over certain aspects of the water system, in terms of whether to use recycled water over potable water, or whether to buy bottled drinking water over drinking from the tap. However, due to the relatively centralized nature of water systems, in that each resident is linked to the water network rather than having their own private water supply, decision-making is also centralised. The decision to, for example, build a treatment plant for your own supply cannot be made by the individual alone, but must be made by either one person, or a group, on behalf of others. This also relates to the spending of public funds. Each resident pays a set service charge as a contribution to build new and maintain existing water and sewerage services. The fact that almost a quarter of respondents from the public sector in water were in favour of seeing individuals make their own decisions is rather telling, as this scenario is virtually impossible to achieve in the current water and sewer governance structure.

8.2. Regression analysis of worldviews and demographic factors

This stage of the analysis also sought to determine the impact of demographic factors upon worldviews. A linear multiple regression analysis was undertaken, with results shown in Table 8-1. None of the relationships were shown to be statistically significant at the $p=0.05$ level. These results highlight that there is little impact of demographic factors upon the worldviews of the individual.

Table 8-1 β values of regression analysis of worldview (categorised) by risk score. Dependant variable: risk score.

Demographic factor	Worldview (categorised)

Age	0.054
Gender	0.124
Role	-0.121
Organization	-0.0147
R squared (model fit)	0.059

8.3. Regression analysis of worldviews and risk scores

Cultural risk theory promotes the idea that worldviews drive risk perception. In particular, that the way that risk is seen is influenced significantly by which cultural grid/group classification one belongs to. For this reason, this theory is tested to see whether it could explain the variation in the risk scores provided by respondents.

On first glance, it seems unlikely that risk scores will necessarily correlate well with worldviews, as most respondents fall within the egalitarianism category and risk scores vary significantly in each project (Figure 8-6).

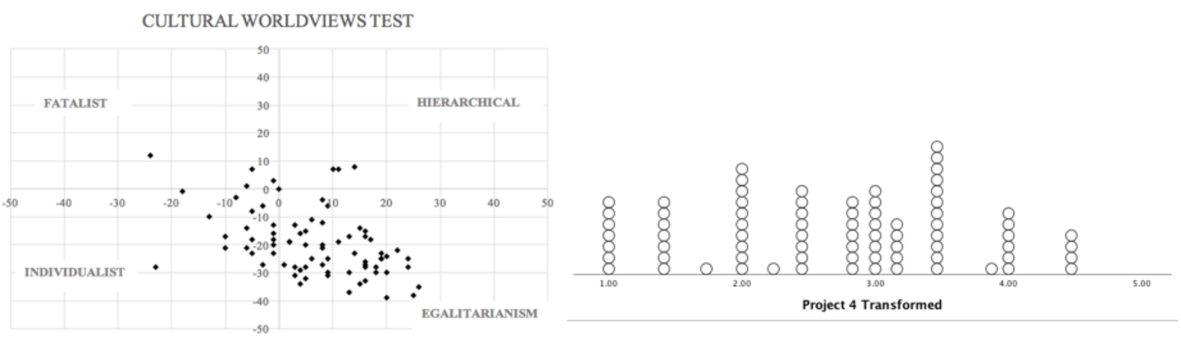


Figure 8-6 Cultural Worldviews test vs example of spread of risk scores (possible scores range from 1-5).

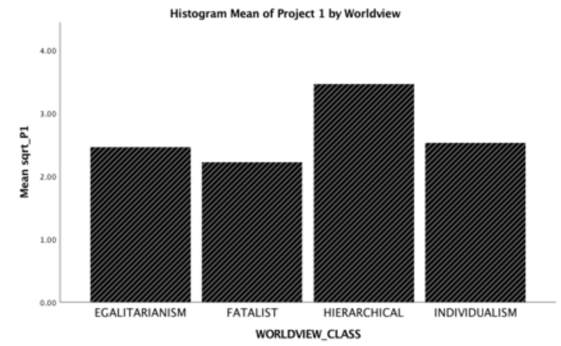
Table 8-2 provides a summary of the regression results when linearly modelling each risk score (post- square root transformation) as the dependent variable, and the grid or group as independent variables.

Table 8-2 Regression results of risk scores by project and Grid/Group. Dependant variable: risk score. * p<0.05, **p<0.01

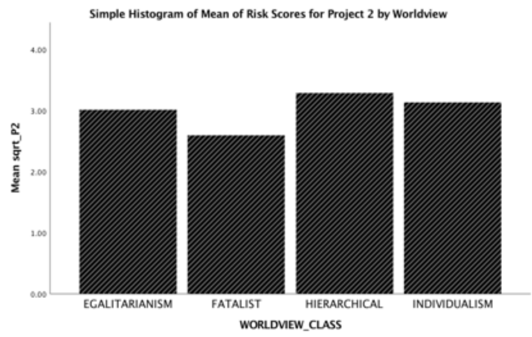
Project	**Grid (β values)**	**Group (β values)**	**R^2**
Project 1 – Pipe Replacement	0.252*	0.244	0.068
Project 2 – Pump Station Installation	0.170	0.084	0.023
Project 3 – Construct STP/RWTP	-0.006	-0.080	0.006
Project 4 – Save Water Campaign	0.074	0.132	0.014
Project 4A – Using RW as Potable	0.079	0.157	0.020
Project 4B – Radiation in Treatment of Water	0.096	-0.215	0.074
Project 4C – Removal of Fluoride in Water Supply	0.106	0.036	0.009

Referring to Table 8-1, only in the first project (grid) can the hypothesis be rejected, however this is not the case for any of the other projects or for even the 'group' element of that same project. On the basis of these results, it could not be concluded that there is a link between adherence to a worldview by grid and group, as proposed by Douglas (1992), and to the risk scores put forward by each risk assessor. Furthermore, r square values are also rather low, indicating that even if a significant link could be found between the two variables, it would explain very little of the variation in the scores.

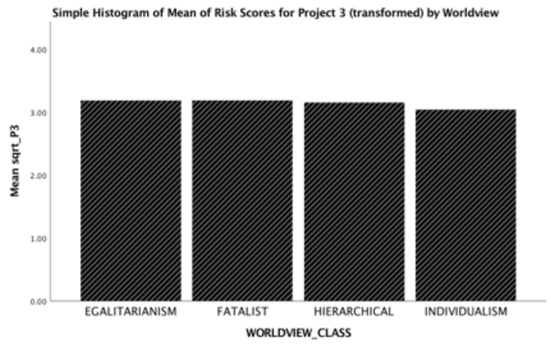
Figure 8-7 shows the average risk scores for each project, by worldview aggregations.



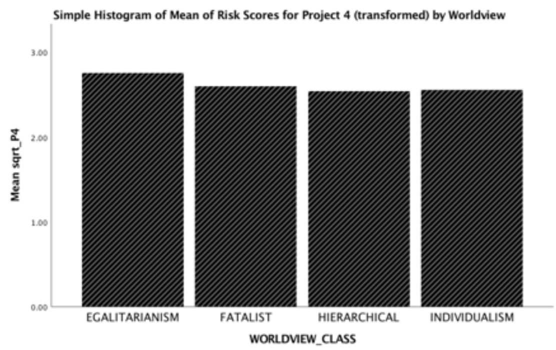
a) Project 1 Mean Risk Scores by Worldview



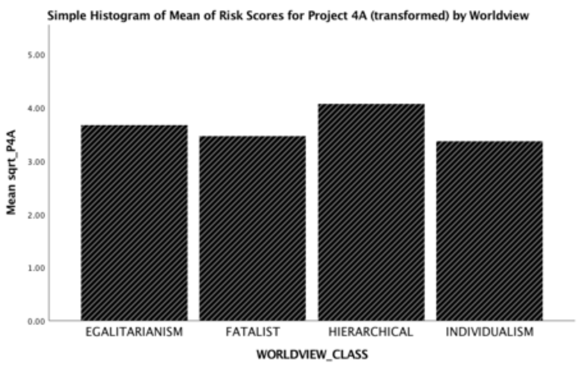
b) Project 2 Mean Risk Scores by Worldview



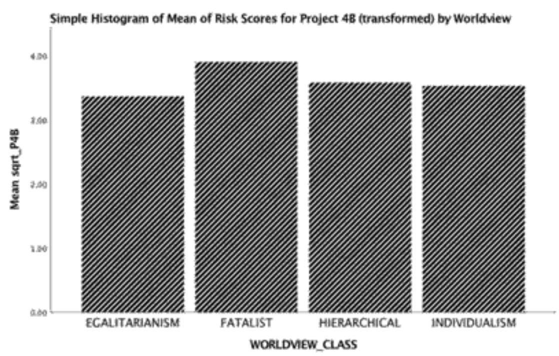
c) Project 3 Mean Risk Scores by Worldview



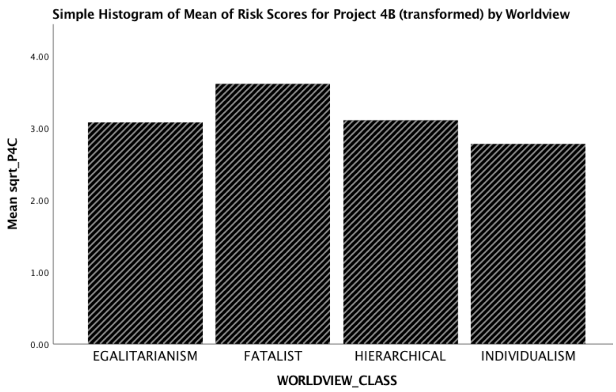
d) Project 4 Mean Risk Scores by Worldview



e) Project 4A Mean Risk Scores by Worldview



f) Project 4B Mean Risk Scores by Worldview



g) Project 4C Mean Risk Scores by Worldview

Figure 8-7 Project Risk Scores (transformed) average scores by worldview (a-g).

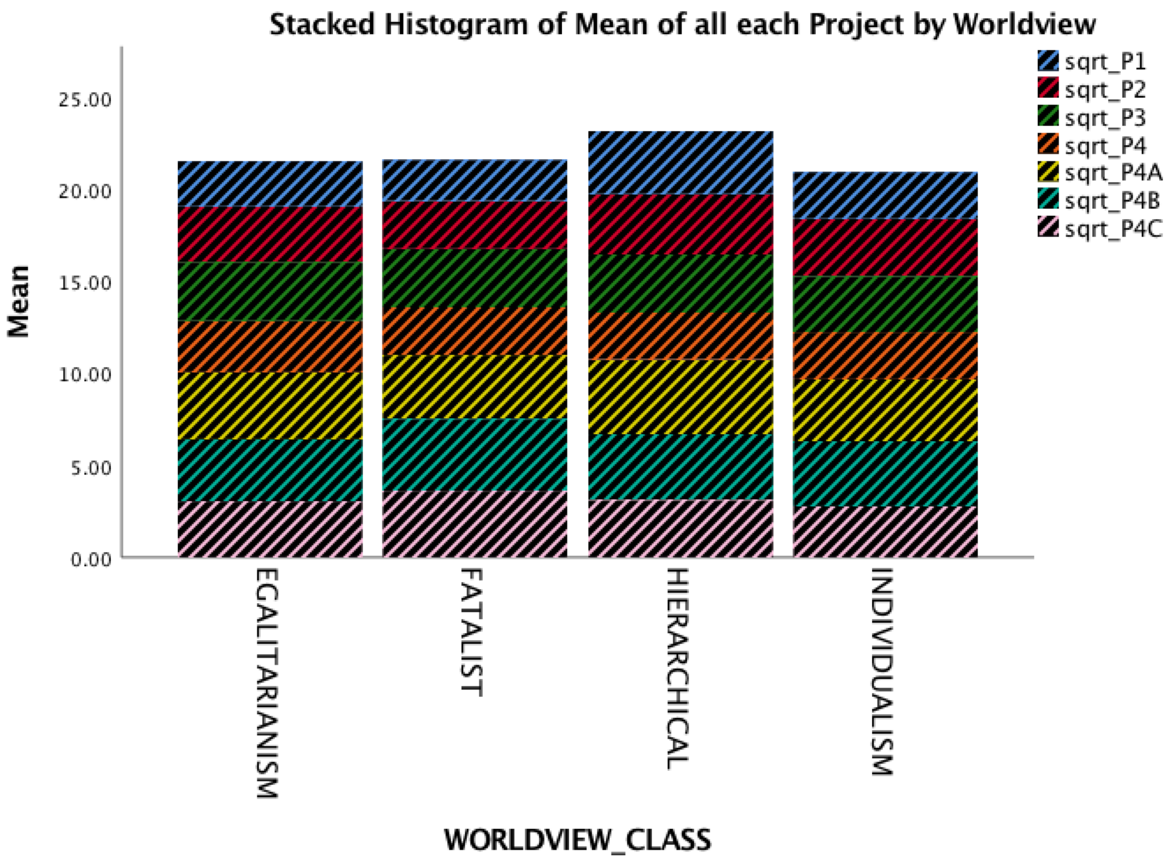


Figure 8-8 Stacked histogram of mean of each project by worldview.

All except Project 1, the mean of project risk scores across each worldview does not show a notable difference. Therefore, it can be concluded that it is unlikely, according to these results, to state there is a link between the worldview one adheres to, and how risky they perceive a particular project.

Each average worldview response in risk scores changed position relative to one another depending upon the project, indicating the average risk scores were more a reflection of the project assessed rather than the worldview of the assessor. The variation between the risk scores between each worldview is minimal. Overall, as shown by the stacked bar chart (Figure 8-8), the hierarchical worldview tended to rank the risks slightly higher than the other worldviews, but not substantially enough to say that there is any significance to the findings.

8.3.1. Regression of worldviews (categorised) and risk scores

A linear regression was performed on the categorised worldviews and their corresponding risk scores. The r values and model fit results are shown in table 8-3, by project. None of the results showed any statistical significance at the 0.05 level. These results indicate that when handling the worldviews in categories (ie. Create dummy variables for each worldview), there is little relationship between worldview and corresponding risk scores.

Table 8-3 Regression analysis of project risk scores on worldview categorisations. Dependant variable: risk scores (transformed).

	Project 1	Project 2	Project 3	Project 4A	Project 4B	Project 4C
Worldview (r values)	0.098	0.054	0.076	0.094	0.086	0.123
R squared (model fit)	0.010	0.003	0.006	0.009	0.007	0.015

8.4. Regression analysis of worldviews and psychological risk attributes

There is a need to consider whether there may be a link between participant's worldviews and their psychological attributes for Projects 4A, 4B and 4C. To do this the worldview grid and group scores were regressed against the project attributes for Project 4A, 4B and 4C (Tables 8-4 to 8-6).

Table 8-4 Regression analysis of Project 4A Psychological Risk Attributes and Grid/Group. Dependant variable: Psychological risk attributes.

Project 4A Risk Attributes	GRID	GROUP	R^2
Voluntariness	P=0.246	P=0.442	0.019
Immediacy of Death	P=0.722	P=0.694	0.007
Knowledge of Risk (to those exposed)	**P=0.045**	P=0.453	0.054
Knowledge of Risk (to Science)	P=0.844	P=0.145	0.033
Control	P=0.777	P=0.405	0.010
Newness	P=0.768	P=0.584	0.009
Chronic	**P=0.034**	P=0.685	0.064
Dread	P=0.459	P=0.672	0.017
Fatal	P=0.956	P=0.576	0.006
Fairness	P=0.295	P=0.680	0.028

The results of Table 8-4 indicate that there are only two psychological risk attributes that presented any level of significance ($P<0.05$) to the adherence of the assessor to a grid/group figure: whether the risk kills people all at once, or one at a time, and also whether those who are exposed have knowledge of the risk itself. However, both attributes only explain 6.4% and 5.4% of the change, respectively. Therefore, the result is not impactful in its potential to explain how water professionals perceive risk.

Table 8-5 Regression analysis of Project 4B Psychological Risk Attributes and Grid/Group. Dependant variable: Psychological risk attributes.

Project 4B Risk Attributes	GRID	GROUP	R^2
Voluntariness	P=0.355	P=0.753	0.021
Immediacy of Death	P=0.610	**P=0.017**	0.082
Knowledge of Risk (to those exposed)	P=0.132	**P=0.021**	0.074
Knowledge of Risk (to Science)	P=0.992	P=0.637	0.004
Control	P=0.594	P=0.139	0.030
Newness	P=0.527	P=0.246	0.040
Chronic	P=0.899	P=0.276	0.023
Dread	P=0.691	P=0.086	0.043
Fatal	P=0.259	**P=0.034**	0.061
Fairness	P=0.277	P=0.726	0.028

Similarly, the regression analysis with Project 4B, the use of radiation in the treatment of water, worldviews did not explain the variation in the psychological data effectively. Two attributes, the likelihood of the risk being fatal, and also knowledge of risk to those exposed, had some level of significance ($P<0.05$) however both only had an r square value of 0.06 and 0.07, respectively indicating a low explanation of the variation. Once again, the results do not suggest that worldviews play a key role in risk perceptions.

Table 8-6 Regression analysis of Project 4C Psychological Risk Attributes and Grid/Group. Dependant variable: Psychological risk attributes.

Project 4C Risk Attributes	GRID	GROUP	R^2
Voluntariness	P=0.052	P=0.876	0.071
Immediacy of Death	P=0.857	P=0.410	0.016
Knowledge of Risk (to those exposed)	P=0.288	P=0.163	0.031
Knowledge of Risk (to Science)	P=0.863	P=0.575	0.008
Control	P=0.103	P=0.353	0.084
Newness	P=0.718	P=0.872	0.004
Chronic	P=0.198	P=0.485	0.057
Dread	P=0.995	P=0.882	0.000
Fatal	P=0.979	P=0.595	0.005
Fairness	P=0.919	P=0.335	0.015

The final regression results involving Project 4C, indicated no significant ($P<0.05$) link between Project 4C risk attribute responses and membership of a particular worldview.

8.5. Regression analysis of individual responses to worldview questions and risk scores

It does not seem that there is enough evidence to state that worldviews (as aggregates) plays an important role in how risk is scored, according to the set processes within the water industry. However, it would be amiss to not further explore whether responses to individual worldview questions link to how risks are scored[3]. Table 8-7 displays the results of the regression analysis undertaken on the 30 worldview questions. W1 refers to worldview question 1, W2 refers to worldview question 2 and so on. Please refer to the footnote for a reminder of the projects assessed. These are regressed against the risk scores from all seven projects to see whether there may be some link that may suggest an explanatory factor.

Table 8-7 Regression Analysis Results (P values) of Individual Statements and Project Risk Scores

	Project 1	Project 2	Project 3	Project 4	Project 4A	Project 4B	Project 4C
R square	0.322	0.354	0.227	0.430	0.434	0.370	0.363
W1	0.781	0.345	0.685	0.188	0.137	0.427	0.504
W2	0.713	0.125	0.599	0.036	0.681	0.896	0.037

[3] P1: Pipe replacement

P2: Pump Station Installation

P3: Construction of STP/RWTP

P4: Save Water Campaign

P4A: Using RW as Potable

P4B: Using radiation in treatment of drinking water

P4C: Removing fluoride from water supply

W3	0.769	0.109	0.875	0.383	0.342	0.833	0.17
W4	0.915	0.999	0.983	0.953	0.262	0.936	0.695
W5	0.692	0.259	0.25	0.202	0.572	0.379	0.679
W6	0.605	0.213	0.799	0.586	0.259	0.88	0.859
W7	0.38	0.213	0.208	0.533	0.852	0.291	0.935
W8	0.993	0.865	0.948	0.153	0.254	0.451	0.608
W9	0.136	0.589	0.9	0.255	0.283	0.169	0.187
W10	0.45	0.762	0.834	0.9	0.424	0.824	0.972
W11	0.269	0.742	0.845	0.541	0.932	0.456	0.902
W12	0.481	0.885	0.644	0.121	0.697	0.692	0.43
W13	0.363	0.642	0.735	0.35	0.544	0.348	0.952
W14	0.446	0.461	0.171	0.621	0.285	0.228	0.168
W15	0.933	0.308	0.512	0.77	0.781	0.731	0.571
W16	0.571	0.517	0.884	0.657	0.187	0.698	0.245
W17	0.615	0.189	0.992	0.823	0.268	0.681	0.354
W18	0.575	0.542	0.836	0.015	0.915	0.754	0.383
W19	0.701	0.344	0.483	0.402	0.416	0.259	0.911
W20	0.676	0.396	0.961	0.129	0.593	0.638	0.529
W21	0.667	0.181	0.619	0.027	0.66	0.976	0.348
W22	0.189	0.923	0.715	0.38	0.715	0.497	0.322
W23	0.85	0.465	0.89	0.217	0.323	0.88	0.75
W24	0.482	0.622	0.746	0.172	0.961	0.793	0.529

W25	0.54	0.051	0.989	0.938	0.635	0.212	0.654
W26	0.867	0.296	0.699	0.793	0.097	0.184	0.494
W27	0.82	0.21	0.571	0.031	0.215	0.25	0.096
W28	0.426	0.366	0.056	0.873	0.79	0.875	0.569
W29	0.987	0.299	0.631	0.009	0.272	0.612	0.323
W30	0.293	0.986	0.839	0.194	0.757	0.932	0.514

A

number of projects, when regressed with each worldview question, provided a result that leads to rejecting the null hypothesis: the null hypothesis being that the responses to each particular worldview question does not have an effect upon risk scores of an individual. Section 8.4.1 details this result, accentuating whether the results are meaningful and whether they produce any level of insight into the mind of the assessor.

8.5.1. Project 2: Pump Station installation

Upon conducting a regression analysis, this project had only one statement that indicated a significant link with the risk scores: W25. This statement was "*Our Government tries to do too many things for too many people. We should just let people take care of themselves*". The two variables seem to be negatively correlated to one another, indicating that those who *agree* with the statement, are more likely to give lower risk scores to this project, whereas those who *disagree* tend to give higher risk scores.

8.5.2. Project 3: Construction of Sewerage and Recycled Water Treatment Plant

In a similar way, the statement that best aligned with the risk scores was "*[i]t's society's responsibility to make sure everyone's basic needs are met.*" This response is again negatively correlated, indicating that with higher agreement to this statement, the lower the risk scores they place for Project 3.

8.5.3. Project 4: Save Water Campaign

This project had the highest number of worldview statements that likely influenced risk scores. They were:

W2: We have gone too far in pushing equal rights in this country.

W18: Free markets- not Government programs- are the best way to supply people with the things they need.

W21: The Government should stop telling people how to live their lives.

W27: Government should put limits on the choices individuals can make so they don't get in the way of what's good for a society.

W29: The Government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.

W2, W18 and W29 were positively correlated, so a higher agreement in this statement will result in a higher risk score. W18, W21 and W27 were all negatively correlated, so a higher agreement in the statement is more likely to lead to a lower risk score.

Projects 4A and 4B reported no significance when conducting a regression analysis of worldview statement responses and risk scores.

Project 4C: Removal of Fluoride from Water Supply

The last project tested only had one statement whose responses carried a level of significance with risk scores: W2. Interestingly, the regression line was positive, indicating that the higher the agreement to the statement, the more likely they are to rate this project as riskier.

8.6. Conclusion

The outcome of the survey on Cultural Theory and risk scores shows very little relationship between the two. It does not mean to say that culture does not play a role in risk scores, but rather that this test did not exhibit meaningful significant connections. Adherence to a particular worldview did not significantly affect risk scores of the individual.

There were found to be mixed results in the findings of the three parts of the result statistical analysis. The finding that existing approaches to risk cannot be deemed objective has wide-ranging implications in its very nature, much due to the predominance of the use of this type of risk assessment, not only in the water sector but other Governmental departments more generally. The psychometric study provides insight into the bias shown in Chapter 7, indicating that dread plays a role in the variation in scores. This sense of dread, as such a personal, individual element based on experience, is a salient item in that the response are higher risk scores. Chapter 9 discusses the implications of the findings from Chapters 6, 7 and 8. The findings are further explored, in the context of existing literature to understand why they are connected in the way that they are, and just as importantly, why some of them are not. Then it should be possible to determine whether there is some basis from which we can formulate a theoretical concept to effectively describe the phenomena.

References

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Chapter 9

Discussion

On the back of reporting the results in Chapter 8, this chapter then moves to providing meaningful interpretations. The findings are interpreted in a useable and practical way for practitioners to employ. This synthesis of the findings aims to bring together all the results of the research to provide a greater understanding of how water practitioners engage with risk. The discursive nature incorporates the results together with existing research to provide a coherent response to the research question posed in Chapter 1.

Initially, each section within this chapter considers every finding separately starting with assessing existing risk measurement approaches, then moving through the psychometric results, ending with the cultural worldview analysis. The aim in these sections is to outline interpretations and meaning behind each discovery and how they may provide insight into answering the research questions. Previous research is drawn upon to augment the interpretations and provide a robust and evidence-backed explanation. A synthesis of all the findings is presented in order to discuss how each individual finding may interact with one another. Subsequently, the outcomes of the study are seen in light of its implications, and how they may impact upon the water industry. It can also be used to provide a guide into how these results may be used in practice. The chapter then concludes with a presentation of the limitations and suggestions for further research, to provide a more robust understanding of risk perceptions in the water sector.

9.1. Risk processes between water companies are relatively consistent

The four Melbourne water organisations assessed in this study all had similar risk processes. All followed the ISO13001 Risk Management Standard, requiring them to outline an internal risk management process that identifies a risk, measured through a risk matrix to provide a final risk score. Each water authority had clear methods through which risks are identified, requiring the risk assessor to highlight them. Next, the process required that risks are measured quantitatively through the use of risk consequence and risk likelihood tables. Each water authority had devised their own tables for use internally (please refer to Appendix C more information), but were very similar regardless. The risk consequence table outlines a number of different categories such as financial, regulatory, reputation etc. These categories carry examples of possible risks in each area, ranging from a minor, or low risk through to extreme risk outcomes. Following this, the risk assessor would refer to a risk likelihood table to determine (between 1 to 5) the probability of this particular risk occurring. Guidance was provided on how often this event is expected to happen, in the expert opinion of the risk assessor.

Across the four water authorities, these processes are very similar, and are required by the Victorian Managed Insurance Agency (Victorian Managed Insurance Authority, 2016). In addition to this, these risk procedures are not unusual, being used to identify and analyse risks in a more general nature, outside of the water sector.

Minor differences exist between the water utilities in the types of consequences they list, and their associated severity. What may be seen to one water authority to be of medium consequence, another may consider it to be of high consequence. Despite this, there were also many areas of similarity for example, all water utilities were united in their zero tolerance for issues that threatened public health. Overall, there were more similarities than differences in risk approaches.

In practice, it is not uncommon for the project manager themselves to form the assessment. The alternative is that the project manager consults one other expert within the field to help form the risk scores. This could arguably carry its own biases through the choice of expert, introducing elements of confirmation bias as one is more likely to consult and interact with those that think in a similar way to them (International Organization for Standardization, 2009). The fact that all water authorities assessed in this study enacted similar risk procedures is helpful, as this can then provide a level of consistency across the board, providing findings that apply to all the organisations equally.

9.2. Risk scores highly varied between individuals, but scores did not shift across organisations

Assessing the risk scores of all seven projects tested did not highlight differences between the risk scoring *between* organisations broadly, which could be explained by all holding similar risk processes. The scores nevertheless varied greatly between individuals, which was consistent across all organisations tested. Therefore, this suggests that any differences and problems at a micro level cannot be sheeted home to a particular organisation *per se*.

However, risk scores *within* each organization were found to be extremely varied. This variation was highlighted through testing the distance between two standard deviations, thus accounting for approximately 95% of the data. This suggested that any given assessor could provide a risk rating of anywhere between 'low' and 'extreme' and still fall within two standard deviations of the mean score. This is obviously a problem when undertaking risk assessments in a way that is deemed to be objective and without biases. The assessment by an individual could be as a result of personal biases and/or sociological issues that seek to have an impact upon an individual's score, as described by the literature (see Chapter 2).

The very notion that the problem does not exist in only one organization, but all, lends itself to potentially being a systemic issue. What is clear is that the risk process itself cannot be deemed objective. If any two assessors, no matter how biased or how swayed by opinion they are, systematically follow a particular process that is predefined, clear and understandable and still provide vastly differing results from one another, there is likely be some level of individual partiality at play.

There is a notable difference between the scoring for projects 1-4 than projects 4A-4C (refer to sections 6-8-2), particularly that the scores for the latter were higher across the board. The choice of projects was purposely undertaken in order to consider an array of different scales of projects, from different financial considerations (some more expensive than others), some predominantly construction-based projects, while others were social-based. This provides the opportunity to be able to test for a variety of differing projects. The new/unfamiliar projects (4A, 4B, 4C) received higher average risk scores compared to familiar/business-as-usual projects. This is in line with literature highlighting unfamiliarity as acting positively upon risk perception (Skjong & Wentworth, 2001). Unfamiliar projects therefore, could be given higher risk scores, much due to the uncertainty surrounding the project and its perceived outcomes.

Availability heuristics describes the effect of how easily an event is to come to mind of the perceiver thus how likely they are to perceive the event happening (see Section 7.5). In other words, if an event is more easily brought to mind, the perceiver is then to believe it is more likely to happen rather than an event that is more difficult to bring to mind (Tversky & Kahneman, 2009). The uncertainty surrounding unfamiliar projects could also produce *more* events coming to mind, also increasing the perceived riskiness of the project. This could explain the difference between the scores of unfamiliar projects and business-as-usual ones. The implications of this could result in an aversion to projects of an unfamiliar nature, particularly if more familiar business-as-usual alternatives exist. Unfamiliar projects could extend to any types of innovation, and therefore could have an impact upon the likely allocation of funding towards these new ventures.

The implications of this finding emphasises that many within an organization rely heavily upon risk management processes to identify and measure risks 'accurately', whereas current risk processes suggest that judgement of the risk is reserved to a large extent by the individual themselves. These assessments stemmed from approaches undertaken by the Nuclear Regulatory Agency in the United States and have thus been used for over 50 years. Despite much criticism against the process, in particular, the inability to measure elements that are considered difficult to measure, this process is still very much in use today. No other risk assessment process has taken its place within the water sector. These findings are in line with outcomes of similar studies undertaken in this area (refer to section 2-2-3).

Regulatory requirements within the Victorian Government sector compel organisations to follow ISO31000, however this document itself does not state exactly *how* the risk is to be measured and analysed, but rather just states that there should be a process to do this (Council of Standards Australia, 2009). The standard that stands alongside ISO31000 is IEC31010 on Risk Management Procedures (International Organization for

Standardization, 2009) and provides tools and recommendations for how risk should be assessed, however Government agencies are not bound to use this second document. For this reason, there is scope to change risk assessment practices if they are not doing what they are meant to be doing: which is to provide an objective quantification of risk.

Results discussed in Section 6-8-1 on the degree of objectivity (or lack thereof) exposes some alarmingly diverse scores in risk assessors, warranting further exploration. The following Sections in this Chapter then consider the results of the psychometric testing, as well as the results of the worldview analysis, in an attempt to interpret the findings. As the scores from the initial stage of testing were so varied, the psychological theory of risk was tested to determine to what extent personal affiliations to a risk had an impact upon the difference in scores between individuals (see section 7-1). In addition to this, the cultural theory of risk also was tested to help explain the results. Due to the time consuming and mentally taxing nature of the undertaking the psychometric testing, (ten additional questions for each project) only three of the projects were tested, all new and unfamiliar projects.

9.3. Water Practitioners are concerned about risk to reputation over and above all other risk factors

In measuring the qualitative responses to prevalent risks for each project, "community opposition" was a risk factor that featured most prevalently. This was closely followed by risks related to reputation of the organisation (see Figure 9-1). Both of these topics were ultimately related to a negative public perception of the project that led to some form of protest or action. This is not surprising in a participatory democracy, with the State Government's position as water authorities' key stakeholder. A focus towards active public decision-making has become more ubiquitous in the way water projects are managed in Australia (Yarra Valley Water, 2017) and therefore unsurprisingly, community opposition is shown to be a key concern in managing project risks.

Public sentiment, or backlash, can halt or stop projects altogether, and thus plays a key role in the project management process. Hurlimann and Dolnicar (2010) analysed the reasons why an indirect potable recycled water system proposed in 2006 for Toowoomba, Australia failed. A plebiscite was held, and over 60% of the community voted against the scheme. The authors found that the failure of the plan, was not just associated with community opposition, but also due to political involvement, the timing of the plebiscite, vested interests and information manipulation. Public opposition also had a role to play in other potable reuse schemes including that proposed for San Diego in the USA in the 1990s (Mills, Karajeh, & Hultquist, 2004) and for a Desalination Plant in Sydney in the 2000s (Davies, 2006). Po and Nancarrow (2004) have attributed a DAD 'decide, announce, defend' approach to the demise of these schemes (Forester, 1999).

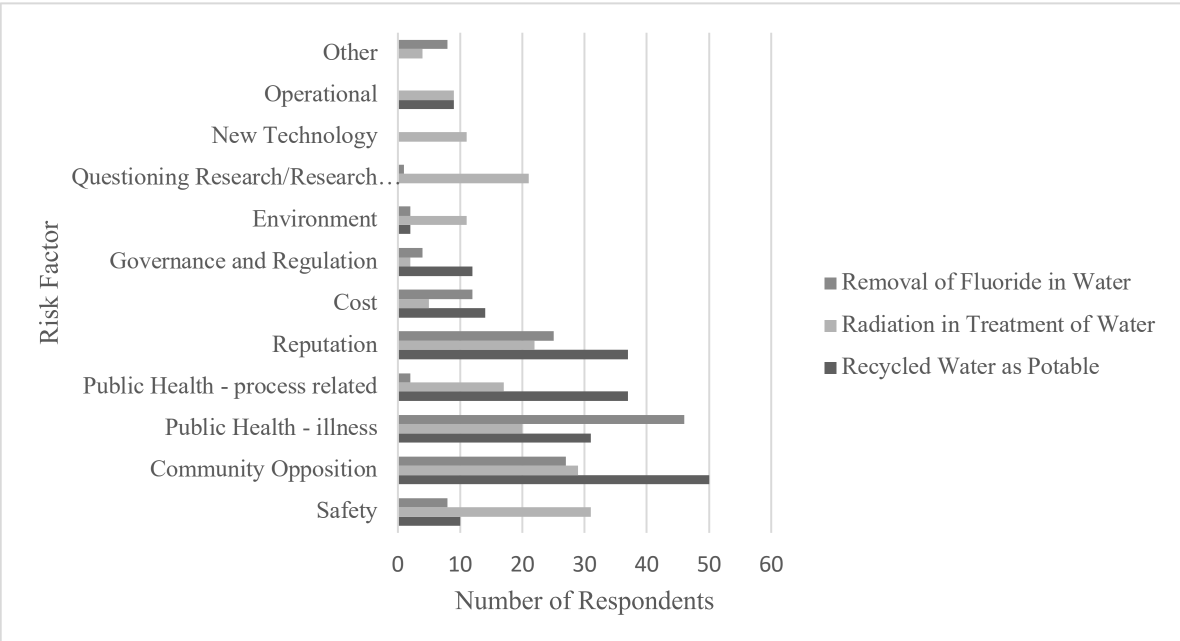

Figure 9-1 Water professionals' risk perceptions by project n=77

While the majority of the respondents had technical backgrounds (either in engineering or in operations), two of the three main risks highlighted were not technical in nature, but social. The highest risk noted is the perception that community backlash could alter or stop new or unfamiliar projects from proceeding. This was raised for all of the three projects but had more responses for the potable recycled water project scenario. To address this perceived risk, water practitioners could place a high emphasis on engaging the community early in the project. This also highlights the varied role of engineers and operational staff to consider public sentiment and social relations in their historically technical position. Thus it can be concluded that there may be a need for greater in-house expertise on the public communications side of the project planning and implementation.

Risk to reputation of the water authority also featured highly in the findings across each of the projects. Engaging Government stakeholders early, while also managing media effectively could help reputation-based risk. Ross, Fielding, and Louis (2014) highlight risk to reputation is a factor that relates to trust in the water authority therefore conducting trust-building activities between water practitioners and the public could provide a solution to counter the effects of distrust towards experts (Siegrist, Cvetkovich, & Roth, 2000) .

One area of difference between projects was in the issue of safety. For the radiation-treated water, this was raised by over 30 participants, but was raised by only 10 or less for the other projects. The process of the radiation treatment of the water gave rise to a greater number of perceived risks associated with safety and *"operational risks, operators being exposed to high levels of radiation, long term effects vs. immediate effects of this on operators and in water supply"*

Female, Project Manager, 18-25 years of age

"[U]nknown long-term exposure to radiation ..... catastrophic failure of radiation facility, risk of harm to the environment, fatality" Male, Other, 26-35 years of age

9.4. Risk perception – Not in accordance with existing literature

Cost does not feature highly in the risk perception findings yet plays a large role in business case development. This is in contrast to findings reported by West, Kenway, Hassall, and Yuan (2016); (2017), which highlighted cost as a major risk factor. An interpretation could be that the difference existed in the familiarity or unfamiliarity of projects presented.

The results differ to both West et al's (2016) and Dobbie et al's (2014) studies on risk perceptions of water practitioners in Australia. Both studies showed cost to be the major risk factor identified in water projects, with customer complaints coming in at third. Boholm and Prutzer's (2017) Swedish study on the same topic found the two main risks identified by experts in water projects were delivery failure, and quality failure. Although 'operational' issues did feature in our study, it was not a dominant risk factor.

Interestingly, West's study did not include 'safety' as a risk factor despite 34 other factors being assessed. In the results (see Section 7.1), either construction/worker safety or general safety featured 31 times for Project 4B (radiation), while in Projects 4A and 4B the concept featured ten and nine times, respectively. The word 'fatality' or similar, appeared three times in the data. The 'availability heuristic' explored by Tversky and Kahneman (1973) might explain this focus on safety and fatalities. Serious incidents in construction and operations within the water sector are communicated throughout the industry through either Worksafe (a State Government safety authority) or through internal organization processes. The availability heuristic highlights that if a particular issue comes to mind more readily, which occurs in the case of personal affiliation with a risk or experience with one, it is seen as more likely, therefore, riskier than those that do not carry this personal connection (Tversky & Kahneman, 1973). This may provide an explanation for the increased awareness of safety and the repeated mention of fatalities, if workers often either experience or speak about safety issues. Testing of the availability heuristic may have been possible should the researcher have collected separate likelihood and consequence scores, rather than solely risk scores. A regression analysis could have been undertaken between likelihood and dread, to highlight whether the availability heuristic is a suitable explanatory variable. Therefore, this presents a limitation in the work.

Public health also features in the risk attribute data, however once again it is not highlighted in West et al. (2017) as an area water experts see as 'high risk'. Dobbie et al. (2014) instead report public health to be a medium risk by experts in the case of potable reuse schemes, a similar result to Boholm and Prutzer's study (2017). West et al. (2017) argue that the high risk to public health is not revealed in comments because current risk assessment and management guidelines effectively address these issues. As the issue of public health has arisen in all the projects assessed in this study, one interpretation could be that this is due to the risk assessor's unfamiliarity with the projects in question, as all are new and never been undertaken at any of the water authorities that were part of the survey sample. A recycled water scheme, the issue addressed in West's study, is a common innovation across water authorities in Australia, and their sample pool came from across the country. Therefore, it could be argued that their familiarity with the project may reduce perceived risk (West et al., 2017). Shrader-Frechette (1991) highlights the phenomenon of uncertainty acting as a large factor in how risks are perceived, with higher uncertainty leading to higher risk perceptions. As all three projects presented have elements of uncertainty, it may explain the role of safety and public health as major factors in perceived risk of water experts. In particular the greatest uncertainty across the three projects was for the radiation project, which is arguably the least familiar for the respondents.

9.5. Dread a factor across all projects tested

In testing the psychological affiliations to each of the three unfamiliar projects, two new factors were created: 'perceived dread due to fatal risk' and 'knowledge-based risk' (see Section 7.3). The former considers the effect of the risk assessor imagining a scenario within the project that results in a fatality, and therefore conjures a feeling of dread. Unsurprisingly, with this feeling also comes a heightened sense of perceived risk, and higher risk scores. However, this only had a significant effect when tested on Project 4B: the use of radiation in the treatment of water. Explaining 27% of the variation in the risk score, this variable explains a sizable aspect of the psychological affiliations to the risk score. An interpretation for the significance in this project rather than the others could lie-in the fact that Project 4B differs from the other two projects due to its link to 'radiation'. Radiation carries many negative connotations in the minds of a layperson who does not often deal with this type of technology (Pahner, 1976). This is backed by a number of studies in this area, highlighting risk perceptions of radiation and nuclear-technology as being high compared to other activities such as driving a car, or smoking, which carry far higher mortality rates (Shrader-Frechette, 1991). Evoking affect heuristics once more, the devastation from nuclear accidents such as Chernobyl and Three Mile Island still exist vividly in the minds of people, even in the context of Australia, where only one nuclear reactor currently operates. This aversion to nuclear technology could then account for the higher uncertainty, and higher chance of fatalities coming to mind quickly, evoking the availability heuristic in deeming this risk of higher calibre than otherwise.

The other factor, 'uncertainty due to lack of knowledge' also carries with it the sense of the unknown. In particular, the feeling of a lack of knowledge, in both to those exposed and to science, is congruent with existing risk perception literature (Slovic, Peters, Grana, Berger, & Dieck, 2010). An alternative theory could also be the lack of information offered in the synopsis of the project itself (see Appendix D for full survey details). Interestingly, although a similar amount of information was provided for other projects, there was no significant link between the knowledge risk attribute and risk scores. Therefore, risk assessors may well have preferred more information on the project around radiation than the other two equally unfamiliar projects. However, despite highlighting a lack of knowledge to those exposed, they also rated highly the lack of knowledge to science. This could point to an issue of trust. The description of the project highlights a new radiation-based treatment found by researchers that was available for use. This would require some level of trust from the water professional that this research was accurate, as they would be relying on knowledge of the technology by science. Yet respondents ranked highly the lack of knowledge by science, indicating that perhaps the trust was not there. Does this mean they would like further information, to be able to trust the researchers proposing this new system? This could be seen as having a healthy scepticism of new technology, or a distrust of research, especially in the area of radiation, with its negative inferences.

Observing the qualitative responses provided in project 4B provides some insight into the issue. Compared to Projects 4A and 4C, distrust or questioning of current research seems to feature highly in Project 4B. Previous research in heuristics sheds some light on these findings. Heuristics states the importance of relying on trust in expert knowledge in decision-making. As individuals cannot possibly know all there is to know about all levels of technology, it is therefore important to rely on others that individuals trust to provide guidance on areas that they feel they have inadequate knowledge (Slovic, 1993). Therefore, when new technologies arise, as in the case of innovations such as that is proposed in Project 4B, the importance of trust in the researchers that have undertaken the studies is pertinent in guiding the risk perception of water practitioners in this study (Siegrist & Cvetkovich, 2000). Therefore, with the combination of questioning research as well as 'feeling' that they have inadequate knowledge, can be explained by this trust factor in heuristics (Wu et al., 2016). The importance of trusting those with knowledge is very high in areas of uncertainty, and therefore, when exploring new or innovative projects, the impact of trust or reliance upon other experts cannot be understated, and shows through this work.

Despite the fact that Projects 4A and 4C did not carry a significant link to the two new variables created, they did nevertheless have a significant link to one of the risk attributes: the feeling of dread. The higher the sense of dread surrounding the risk, the higher the risk score given. This explained approximately 9% of the variation in the risk scores, which, although not high, is still notable for a psychometric study (Slovic, Fischhoff, & Lichtenstein, 1985). None of the other risk attributes were found to be statistically significant in explaining the risk scores. In considering previous studies in the psychology of risk perceptions, dread seems to arise frequently as a significant risk attribute in risk perceptions (Gigerenzer, 2004). Slovic, Fischhoff, and Lichtenstein (1981) also found this in many of their risk perception studies. The difference is that within these studies, they were not comparing risk scores to psychological risk attributes, but rather measuring these attributes on a dimensionless scale to compare them to other activities. It is helpful to know that this study provides an insight into the risk scores themselves are provided, which has practical and tangible outcomes in business processes.

So, what are the implications of a feeling of dread on scoring of future projects? Previous research suggests that the more the individual visualizes a scenario that evokes a feeling of dread, the higher the risk score. This is particularly helpful when considering that one of the two inputs to determine the risk score or rating is consequence. The determination of 'consequence' heavily relies upon the risk assessor imagining scenarios on which to base their rating. The consequence then, can be said to be heavily weighted towards the images enacted and created within the individual's mind. The worse the perceived imagery, the worse the consequence, thus the higher feeling of dread attached to it. In addition to this, the lower the consequence, the less likely that one would experience a high feeling of dread. Unsurprisingly, the worse the perceived consequence, the higher the feeling of dread. In this way, it can be posited that the internal imaginings of the risk assessor, in particular whether they catastrophise, points to whether a high-risk rating is afforded to the project.

9.6. Dread higher due to greater life experience, but not necessarily role

The availability of imagining a dreaded scenario can be highly dependent upon the experience of the risk assessor. Therefore, the link between age and the feeling of dread was tested across all projects. The results indicated a higher average score for those in the 56-65 age group category, compared to other age groups (see Section 7.3.7). The only clear differences in dread and age seemed to exist at the two extreme ends of the age spectrum. Those aged 56-65 were more likely to provide a higher dread score than those aged 18-25 (at $P<0.05$). Similarly, when the spread of the data is compared, the data for the higher age group is also more compact, with the interquartile range at 2, while other age groups (bar 18-25) had an interquartile range of 3. This is a large shift, considering the possible scores range from 1 to 7.

Those in the 18-25 age group reported, on average, lower scores than all of the older age categories. However, despite the mean being lower, the notable difference lies in the spread of the data. The 18-25 age group is heavily negatively skewed, indicating a large proportion of the data is at the lower end of the spectrum. This could indicate the lower dread scores attached to this age group (see Section 6.8.5). However, these results should be taken with caution, as the number of respondents in each of the two groups (56-65 and 18-25) were substantially lower than other age groupings.

This outcome on the impact of age upon a reported sense of dread, although not conclusive, corroborates previous research undertaken in this space, highlighting the impact of age upon a reported sense of dread. Previous research has emphasized this shift in older participants (Matthews & Moran, 1986; O'Connor, Bard, & Fisher, 1999). An explanation for this lies in the experiences of the individual. As the individual is older, they would have had exposure to far more scenarios that can be easily recalled. They are more likely then, to invoke a sense of dread when considering negative experiences that have occurred (Kahneman & Tversky, 1982). Negative experiences are more readily accessed psychologically than positive experiences and therefore, the impact of these can be shown through risk scores on more experienced individuals, many of whom have had, in turn, more negative experiences to draw from and to remember than the younger age groups. This is in contrast to the 18-25 age group, who, without the benefit of experience to draw from when visualizing outcomes, are less likely to evoke a sense of dread and more likely to hold an optimistic view of the situation.

Interestingly, there is no notable difference in the three age groups that range from 26 to 55 (see 6.8.5). Participants had a wide spread of scores, ranging between all possible options. This could be explained through different sets of experiences, some that evoked dread and others that did not. However, the results are too varied to be able to make any firm inferences regarding experience-based responses.

Age is often closely associated with position within an organization. In fact, when comparing the two, a relationship of significance ($P<0.05$) was found. The older one is, the more likely they will be a Manager or Divisional Manager. A Project Manager reports to a Team Leader, while the Team Leader reports to a Divisional Manager. No General Managers took part in the survey, so the next higher level in the hierarchy was excluded. 'Other' refers to any participants who did not fit in any of these three categories.

There was no notable difference found in dread scores by role within organizations. It seems that age was found to be a larger factor than role, despite age being related to the role one has. This could also be due to a sizable proportion of respondents identifying themselves in the 'other' category. The 'other' category had a varied age group, unlike the other role classifications, so this may have an effect on the results.

As the results indicate, there is no link between role and dread and yet, there is an albeit tenuous link in age and dread, it could indicate that individuals may not draw only from their professional experience within that organization or industry in forming judgements, especially those related to dread. Rather, they may draw from more general life experiences to form this assessment. The other aspect of this could be the unknown nature of the projects themselves. The idea that the projects are unfamiliar, and have previously not be undertaken, could point to one not being able to draw from *only* professional experience, as they have no personal experience with the technology itself, but rather from their *idea* or personal *feeling* towards the uncertainty. As an older person may have experienced more, and are generally less open to new and unfamiliar technology (Morris & Venkatesh, 2000), this could be affecting the results.

The implications of this finding could point to a higher age group providing greater risk scores, and therefore are less likely to consider new or unfamiliar technologies rather than the younger age group. The age groups between 26-55 were found to be inconclusive, and potentially more research should be undertaken in this space to understand the nuanced nature of this age group and how they react to experience and dread. It is the final decision of each organization to determine their risk appetite in this arena, and therefore this research provides an insight into how dread effects have an impact upon risk scores. Understanding this will give organisations the opportunity to decide to whom to allocate projects for assessment, an allocation that can effectively align assessors with the risk acceptance of the organisation.

9.7. Worldviews – Majority of respondents were egalitarian

The majority of respondents aligned with the 'egalitarian' worldview of cultural theory. Adherents of this worldview see individuals as being equal despite their standing as either 'experts' or 'laypeople' (see Section 2.4 for the full explanation of Cultural Theory), they assume that decision-making should occur as a group, for the group, in everyone's best interests (Douglas, 2013). This is not surprising considering that the respondents are employees of a Government agency, and thus, are less likely to be individualists or fatalists. This could be in part due to the nature of Government, and the very premise of democracy. Democracy has an egalitarianism underpinning in its very makeup. The notion of one vote per person (regardless of standing) and the opportunity for many to make the decision together are shared qualities between egalitarianism and democratic values. These individual values may very well be the reason for individuals opting for a Government job. There was then a marked cultural shift within the water industry towards greater inclusivity of the community in the decision-making process, thus explaining the clustering of participants in the 'egalitarianism' quadrant.

Despite the unsurprising nature of the number of egalitarians, the results showed a lack of individuals who fit within the hierarchical faction. This is an unexpected result, especially in the context of participants seeing themselves as 'experts' and regularly making a decision on behalf of many. There has been a shift in the culture of the water industry in Melbourne towards inclusiveness of the community. Many organisations now consult the community in helping to make decisions for certain parts of projects (Melbourne Water, 2019; Yarra Valley Water, 2017). This could be then related to how they are expected to take into account the views of 'laypeople' and respect their views as valid. Either these water professionals are being primed to be 'more egalitarian' thus taking on the cultural expectations of the organisation, or this type of person is more likely to be hired within the Government sector.

Considering the qualitative findings, it is then not surprising to see that reputation and community sentiment being mentioned as risks for projects. As egalitarians consider the importance of collective decision-making, the impact of what others think matters and factors into their risk perceptions. It also could be said to be a result of the structure they work in. The water authorities answer to the State Government Water Minister, and the same Government appoints the Board of all the organisations. Therefore, community sentiment toward the Government has an impact upon the Water Minister, and indirectly on the water authority. This is then in line with many of the questions within the worldview survey prompting the respondent to consider the role of the Government and society when making decisions for others.

9.7.1. Where are all the fatalists?

Fatalism did not play a large role in the results of worldviews of respondents. Only one person was identified in this sector. Fatalists consider the importance of hierarchy, but believe decision-making to be out of their hands, thus resigning themselves to others higher than them. They do not adhere to a social group and see decision-making as being made by individuals other than themselves. Therefore, the participants *feel* they have some decision-making power or authority, in particular the idea of collective decision-making. With only one person identifying in this role, these considerations were not found to play a great part in the water sector.

9.7.2. Hierarchists

The previous ethos of the water authorities, particularly when they were under the one organization called the Victorian Board of Works (abolished in 1992), promoted a hierarchical culture of decision-making. It was expected that experts had the final say in what work would proceed with little consultation with the community. It was not unusual to conduct construction work without notification or consultation, and it was also not unusual to forcibly acquire property to progress projects, without the consent of current landowners. Therefore, it can be expected that those adhering to a hierarchy point of view are more likely to be older participants, perhaps working during the Board of Works days. However, the three people that adhere to the hierarchical point of view all identify as male between the ages of 36 and 65, which is a large age gap. It is difficult to determine whether this is as a result of the impact from previous work culture, or personal worldviews, as the younger participants would not have had the chance to be employed by the Board of Works.

9.8. Worldview statements aligning with risk scores

As outlined in Chapter 8, a number of worldview statements align with risk scores in specific projects. For Project 2, which considers the installation of a new water pump station, the statement which aligns with risk scores is: "*Our Government tries to do too many things for too many people. We should just let people take care of themselves*". The implication is that those who agree give lower risk scores, and *vice versa*. This could point to the idea that, for this business-as-usual project, faith in the role of bigger Government results in lower risk scores. Similarly, for Project 3 where the construction of a sewerage and recycled water treatment plant is evaluated, a similar pattern was observed. "*It's society's responsibility to make sure everyone's basic needs are met.*" Agreement with the statement resulted in generally lower risks cores. This could point to a greater stewardship, that if those within the Government sector make the decision, they see less risk. However, if the participant believed decision-making should be placed on the individual, an implication is that the risk assessor sees a greater risk to the project. Qualitative responses were not included as part of the risk assessment of Projects 2 and 3, therefore the nature of the imagined risks can only be speculated on. Both projects are nevertheless technical based projects of different scales. A water pump station is a medium-sized project, while the treatment plant is a large project, both with large construction elements to them.

The project that had the highest link between individual statements and their risk scores was Project 4, the social project aimed at encouraging domestic users to lower their water use: the Save Water campaign (see Section 8.4.3).

This project had the highest number of worldview statements that likely influenced risk scores. They were:

+ve "Free markets- not Government programs- are the best way to supply people with the things they need."

-ve : The Government should stop telling people how to live their lives.

+ve "The Government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals."

-ve : Government should put limits on the choices individuals can make so they don't get in the way of what's good for a society.

+ve "We have gone too far in pushing equal rights in this country."

The statements cited above consider the role of Governments, and their effect on risk scores. However, they seem to be at odds with one another. Grouping the statements together reveals how incongruent and contradictory the results are. The first two statements promote the idea of a small Government, and greater individualism, each that which send risk scores in opposite directions. Similarly, the next two statements promote a bigger Government making decisions for others, thus promoting more of a hierarchical perspective, which also promotes risk scores in opposite directions. Therefore, the results for this aspect of the worldview statements were found to be inconclusive.

However, the final statement "We have gone too far in pushing equal rights in this country" considers the idea of social justice. An agreement with this view prompted higher risk scores. This same statement also appears to correlate with higher risk scores for Project 4C: the removal of fluoride. Both of these projects rely on community sentiment, and both are social-based projects. When the qualitative elements of Project 4C are included, it highlighted that community opposition and its effect on reputation was the most cited risk. This leads to a question of whether those who are more egalitarian, and who believe each person might have an equal say in a matter, are those who are most concerned about community opposition, and therefore reputation. Egalitarians may then increase their risk score, seeing a large risk in giving voice to those who are non-experts, and who should not, in fact, have a voice. Therefore, those who are more likely to agree with this statement could also be less likely to respect community voices, but rather see them as a risk to be managed.

Likewise, with the Save Water campaign (Project 4). Those who may believe too many rights are being afforded to people may not fully understand why some may be against a campaign to save water, or the removal of fluoride as they may both be projects that the water professional has a strong opinion on, an opinion that they may deem 'expert' and thus of higher weight. In this way, by allowing rights to others, it sets to diminish the weight of their own expert opinion, becoming increasingly concerned about community backlash.

Therefore, it can be concluded that the worldview statements provide some level of insight into the effect of an assessor's beliefs regarding the role of Government and their stance on social justice issues on the risk scores they report.

Interestingly, what does not appear in the data could be also rather compelling. Both Projects 4A and 4B had risk scores that did not correlate with any of the statements in the worldview survey. This could point to how one sees the role of Government, decision-making and hierarchy as not having a large impact on whether the project should proceed. This is particularly interesting considering that Project 4A involves replacing potable water with recycled water, a social project that could have major community backlash, especially considering previous research around the public perceptions of recycled water (Hurlimann & Dolnicar, 2010). Community Opposition combined with Reputation is the most highly cited risk for this project, and this did not have an impact upon how the risk assessor saw the role of Government. It is noteworthy that worldviews did not have an effect on this, despite having an effect on other social-based projects (such as Projects 4 and 4C).

Therefore, the results from the worldview statement assessment are mixed, and fraught with contradiction. For this reason, it is difficult to provide any overarching theories surrounding the effect of worldview statements on risk scores. It can then be determined that the results from this aspect of the assessment are inconclusive.

9.9. Worldviews are not a predictor of risk scores

Cultural Theory considers people as aggregates (in social groupings) thus taking a meso-level approach to assessing risk. This is in stark contrast to the micro-level approach the proponents of cognitive bias theory (see Section 2.4). The meso level does not consider risk assessors individually, nor look at society overall to explain a phenomenon, like Beck's (1992) 'Risk Society' thesis, but rather it considered how people are banded together by the their beliefs of how society should be structured, and how decision-making should be undertaken. The fact that the cultural risk theory predicates itself on measurements of aggregates of people, the nature of this study may not adequately reflect this, as the research design was one that is based on micro-level nuances.

From the results presented in Section 8.2, it was found that worldviews would not appear to be a predictor of risk scores. When regressing worldviews against risk scores, no statistical significance was found. This was also the case when regressing grid and group separately. Risk scores are varied highly between individuals, and this did not correlate to membership of a particular worldview. The majority of the respondents adhered to the egalitarianism aspect of the grid-group plane. Therefore, the wide variation in risk scores does not correspond to the narrow variations in worldview scores, either by grid or by group. This is not to say that Mary Douglas and Aaron Wildavsky's theory (Douglas & Wildavsky, 1982) on cultural risk is not applicable. The theory may still be true, as this study did not compare all ways of perceiving risk to cultural worldviews. Rather, it judged risk perception on the basis of a measurable: risk scores. These assessors may still carry certain risk perceptions, but all that can be said is that this is not reflected in their scoring. This is important, as the person's worldview is unlikely to affect risk scores.

Consequently, it could be that the existing risk processes are not affected by judgements upon the how society should be organized, who has decision-making authority etc. However, the implications could be quite relevant. A person's view of whether women's rights have gone too far, or whether Governments should place limits on people did not have a significant effect on their risk score. Those that are egalitarian could produce a high score for a particular project, while another egalitarian sees the risk as low. In much the same vein, a person with a high-risk score for a particular project does not necessarily mean they hold a commonality with a certain worldview cluster. Thus, it cannot explicitly be stated that the worldviews approach definitely does not have an impact, as some statements have correlated to risk score, but rather that the impact is not substantial enough to have an impression statistically significant upon public allocation funding.

9.10. However, worldview is closely related to sense of fairness

Worldviews of the risk assessor, when compared against the psychometric results, showed correlation with one area: that of fairness. The question in the psychometric assessment asked of participants: 'To what extent do you believe this risk affects all people equally?" It was asked of respondents for three of the seven proposed projects. The link between worldviews and responses to this question are indicative of the belief that the more a person may consider the projects to be unfair, the more they are likely to be egalitarian. Egalitarians place equality and fairness at the forefront of their value system, and as such the link to this question is reasonable. The very action of asking the question may prompt the response of the egalitarian, in seeing the world as being an arena that could do with greater equality and justice. With an R^2 of 0.28, this explains a sizable proportion of the difference between egalitarians and others (see Section 8.3). The sense of fairness in projects is understandably linked to the worldview, as the basis for grid and group weighs on how just certain elements should be. The very nature of grid is about the decision-making authority and power, whether this rests with many and whether an individual can have some level control over decisions that affect their own life. This can be seen as being linked to a sense of fairness, as some may believe that it's only fair for an individual to take part in decisions that affect their own life. In addition, the group variable considers how people are organized, and whether this is in an individual sense, or in clusters. Some may see a sense of fairness in being grouped to make decisions, rather than each individual making a choice. Also, a higher sense of fairness in projects also affects those that believe in a hierarchical society, in particular, that there should be a set tiered group structure wherein decision-making lies at the top. It also assumes decision-making for many. Those who are egalitarian would likely see this as unfair, much like individualists. Therefore, the psychological responses to a sense of fairness provides meaningful results when compared to worldviews.

9.11. Synthesis of Results

A number of key elements have emerged in the discussion of the results. To reiterate, current risk processes cannot be deemed as objective ways of measuring risk. They would appear to be driven by individual biases that significantly alters the scores between respondents. This is despite providing detailed consequence tables and probability outlines. Ultimately, how one 'imagines' the risk coming to fruition is the underlying basis for the risk assessment. For many projects, especially those assessed at a concept stage, which often the case when undergoing options analysis, the risk assessor must essentially use a 'crystal ball' to determine what they *think* may occur in the project. For example, one could imagine a number of processes failing, resulting in a catastrophic event, while this mental episode might not even occur to another assessor. Therefore, each assessor will assess a project based on what they believe will happen. This is likely to be the reason for the variation in the scores. This is also underscored by the qualitative findings, with each assessor coming up with differing risk scenarios, and even when they voice similar risks, the consequence of each risk alters again between each individual. To compound this issue further, the likelihood score is a matter of personal prediction. For some risks, such as a pipe failure, or a storm event, assessors can be provided with adequate data to form a consequence and probability score. For example, a water authority may have data on diameter 300 steel water mains, and when each has failed. They can use this data to predict the life of a typical 300mm diameter steel main, and therefore the likelihood can be mathematically calculated. Similarly, if they have data on failure modes, and effects for each of the failed pipes, they are able to determine the likely consequence for their new, proposed pipe.

However, this may only correspond to one of the risks. Other risks, such as financial, regulatory, and especially community-based risks, can be harder to predict. Social based risks are mentioned by many risk assessors, and these can be the hardest to predict. The main reason is the sheer number of factors affecting how a social-based scenario comes about. It could be the socio-demographics of a region, the political slant, employment status, education of those around, other projects that might come into conflict, past experience of the community, etc. Therefore, when making an assessment, risk assessors must use some level of heuristics- in particular, availability heuristics (refer to Section 7.5). In times of uncertainty, they are likely to consider scenarios that come most readily to mind. This can be as a result of previous experience, or perhaps information they deem salient.

The feeling of dread also explains this variation, as does age. The imagined risk of the assessor carries a higher feeling of dread with more personal life experience, resulting in higher risk scores. The literature on psychological risk perceptions brings to light the sense of a lack of knowledge to both those exposed to a risk, and to science, in heightening risk perceptions, a factor which resulted in higher risks scores for one of the projects in this study (see Chapter 2 for a full review of the literature). It is also imperative to consider the underlying negative or positive connotations with a perceived risk. Radiation carries much baggage in its perception, and this should be further explored prior to undertaking risk analyses.

As water resources continue to become strained due to both demand and supply issues, new and alternative water sources must be sought and implemented to retain water security. However, new technologies and processes may not be considered and even discriminated against in favour of existing business-as-usual methods. Experts risk perceptions of unfamiliar water projects have been the central element in this study. It was found that experts are sensitive to community sentiment (see Section 7.1). Experts have also indicated concern about the water authorities' reputation (see Section 7.1). Previous studies into risk perceptions highlighted the difference between the risks perceived by a layperson and an expert. It was found that experts within Melbourne water authorities have concerns regarding what this public risk perception is, especially as it is likely to differ from their own. Experts then, *do* consider laypeople's views on these new and unfamiliar water projects. This can be linked to the public's effect on the water authority's key stakeholder, the State Government. Studies such as Sjoberg and Sjoberg-Drottz (2008) show that risk perceptions by politicians are very similar to the public, both of which generally differ from that of experts. As the Government, and therefore politicians, are a key stakeholder of the water authority, public sentiment and opinion plays a role in driving water policy. Due to the nature of a participatory democracy, acting in accordance with public opinion as opposed to ignoring the community, is preferred.

For new and unfamiliar projects, water experts were found to consider other elements such as public health as high, risk yet this factor does not appear in other studies of business-as-usual projects such as building a recycled water scheme. Safety as a predominant risk factor appears in these projects (while not appearing in other studies) and cost was not a theme that featured prominently in the data. Highlighting these risk factors paves the way to understanding potential barriers or risk aversion towards the take up and approval of new and unfamiliar water projects in the future. These can then be considered when determining an organizational risk appetite statement, as well as updated risk assessment processes, for new projects especially if the authority would like to promote alternative pathways to combat a changing climate.

9.12. Implications of Findings

9.12.1. Current risk assessment approaches

An important finding from this study indicates that there may be an issue with the current risk assessment approach, in that bias is introduced into the scoring. This could prompt a reassessment of how risk is calculated across the organization, in particular to ensure a better fit with the organizational risk appetite. This may prompt the need for more training into current risk approaches, or other methods with which to ensure more consistent scoring practices. IEC 31010 (International Organization for Standardization, 2009) suggests that more than one expert undertake the risk assessment, to ensure that there is some level of consistency. Hemming, Burgman, Hanea, McBride, and Wintle (2018) assert that there should be a minimum of four experts consulted as part of the risk assessment process, as shown through their study. However, this approach can introduce many other biases into the process. Heuristics highlights the importance of trust as an element in decision-making in uncertain times (Tversky & Kahneman, 1973). Relying on the knowledge of experts to provide advice in certain areas may be needed, and with this reliance comes trust. Therefore, decisions are not made on the basis of advice received from perceived non-trustworthy sources. When making the choice of which experts to consult, the practitioner may turn to those they trust, or even those that they share an affiliation or similar views with. This should be further explored in future research to determine whether this choice of expert in itself promotes the bias that is to be minimized, especially in the face of experts choosing other experts that may share views with.

9.12.2. Dread as having an impact

Another important finding is the impact of a perceived sense of dread in higher risk scores. It was found that those that may catastrophize an event, thus bringing about a sense of dread, may result with higher risk ratings than the average risk assessor. In addition to this, those with more life experience (in years) are also likely to experience dread more readily. It is then up to the determination of the organization to define its risk appetite and thus allocate projects accordingly. A more risk averse organization may opt to allocate a project to a Project Manager with more life experience, as this could be reflected in their risk approach. Whereas an organization that may strive to encourage new and innovative project, could look to allocate these to a younger employee. Alternatively, an option could be to use these results to create a balance, creating a diverse risk assessment panel that varies in age.

9.13. Limitations

There are many limitations that need to be accounted for within this research. The fact that the survey was undertaken in sessions in-person, heightened the barrier for entry to participate in the study. Survey sessions were set up and there may have been individuals who were not available during these times. No alternative arrangements were made for those who could not attend the sessions. This could have resulted in a lower turnout than if this was an online-based study. However, an online based study was not possible as the materials for conducting the risk assessment were standardized throughout (and allowed all participating to form their own judgements.)

The worldview questionnaire had many controversial statements. As all the surveys were conducted within a work environment, respondents may have selected options that they feel they *should* respond to, rather than how they genuinely feel. Another element of this is the fact that one of the researchers is known to many within the water sector, which could affect their likelihood to answer accurately. This could result in higher egalitarian-based responses. There was no alternative for conducting the assessment, other than to employ an external invigilator to conduct the tests. Also, the researcher was required to be present to take notes and answer questions throughout the survey. This is another limitation, as the live nature of the surveys could act as a barrier to entry.

The findings presented in this study are based on written surveys. If the research had been undertaken in a focus group, or verbally, respondents may have been provided with the opportunity to introduce more contextual elements to their responses and further probing would have been possible. This presents an opportunity for further investigation into understanding relative features of each risk perception attribute, to fine-tune these results. Broadening the study to a water context beyond Melbourne's borders would also be of interest. Although Melbourne represents an interesting case study, the premise of the Cultural Theory of Risk may be deviant from the cultural environment within Melbourne, especially as the Cultural theory was predicated on a United States context. The questions were also quite generalised, utilising a previous cultural theory research questionnaire. This lack of specific, targeted questions- particularly those targeted towards water- is admittedly a weakness in the research. However, the researcher does recognise that incorporating a pre-validated generalised questionnaire provides a high level of benefit to the study.

The other limitation involved survey fatigue. It would have provided a richer source of information if the psychometric testing had been able to be conducted for every project, in particular familiar projects 1 to 4. For this reason, there was no control project included (familiar project) to enrich the analysis. The researcher recognises this as a key limitation in the study only fixed through including more psychometric testing. However, this is time-consuming to do and introduces research fatigue. The completion time for the survey already averaged between 30-40 minutes. This would have extended to one hour if psychometric testing was included for each project. In addition to this, the repetitive nature of the questions could have introduced boredom, resulting in participants not answering accurately.

Although Chapter 9 attempted to provide interpretation of the results of the survey, particularly using heuristics, a limitation must be highlighted in that these heuristic elements are not tested for causality within this research, and as such, can only be provided as a possible interpretation, rather than a concrete causation. Further studies could consider testing this.

9.14. Further research

In progressing this work, further studies should be designed to explore the other elements of bias in risk assessment. This research has uncovered that dread forms a factor, however this could only seek to explain some element of the variation in risk scores.

An analysis should also be conducted into how trust changes the ways with which risk is perceived from those around us, in particular whether our choice of expert exhibits confirmation bias or other factors in potentially reaffirming our own perceptions. Additionally, the impact of the community may have upon risk scores, before and after consultation should be subject to further research. This is particularly pertinent considering the number of participants in this study that adhere to the egalitarian worldview.

Furthermore, an exploration of the feeling of dread in risk perceptions would be beneficial, in order to create a priming exercise for those completing a risk assessment. This would help or to place some level of weighting upon the scores according to the answers to a questionnaire, or to the demographics of the assessor. This could serve to tighten the risk assessment outcome so that scores are in line with organizational strategy.

These findings add to the existing research by providing a further understanding of expert risk perceptions for new and unfamiliar projects within the water industry. Growing and urbanizing populations increase the demand on existing water infrastructure, while a changing climate alters water supply levels, leading to challenges to the delivery of sufficient water to residents. New and innovative water practices will need to be adopted to address these changes.

Placing emphasis on the outcomes of the study, we can begin to highlight how this may be useful to not only the water sector, but other public or Governmental sectors that utilize similar risk processes. The findings are in line with previous research in the psychometric area, however does not readily reflect previous work in the cultural risk research space. This study nevertheless provides a deeper understanding of the effect of dread upon risk assessors, and how risk assessors use conjured images to form expected or likely scenarios of risk. In addition to this, the implications of the effect of experience should be considered by organisations in how it changes the visualizing of potential consequences. These are used to form the basis for consequence and likelihood risk scores and should be then considered in light of existing risk assessments.

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Chapter 10

Conclusion

In the very first issue of the Risk Analysis Journal in 1981, the editor Robert Cumming wrote an article addressing a topic that many have asked before him: is risk analysis a science? Unpacking this loaded question, he states that Risk Assessments can "help with the decision-making process, if decisions based in part on [risk] analyses are to be optimized" (Cumming, 1981, p. 2) He explores this further by highlighting that:

> *"Risk analyses will be made. If decisions, based in part upon these analyses, are to be optimized, it is important that they be as impartial and as accurate as it is possible to make them. Risk assessments are a part of the larger societal risk management structure which allows decisions to be made in the face of risk and uncertainty." (Cumming, 1981, p. 2)*

This passage encapsulates the essence of the research undertaken within this thesis. Risk assessments form a required and important part of decision-making. They are not in the process of becoming extinct, nor have there been major overhauls in their processes in the last 50 years (many still utilise risk matrices in the public sector in Australia). Risk ratings and assessments are relied upon more than ever when it comes to decision-making, especially so in the public sector when decisions are often scrutinized. Further than this, risk assessments are trusted, and seen as a source of truth by practitioners making decisions using public funds.

Many analysts have turned a critical eye to risk assessments in the literature, but as yet have not considered the water sector in depth. This is surprising, especially when water is as politically contentious as it is in Australia. Water projects have been approved, built and paid for, based on the assessments of practitioners such as those participating in this study. Some of these projects have resulted in vast public funds being spent, with the infrastructure now lying dormant due, in much part, to the politically contentious issue of water itself.

In tandem with understanding the nature of these decisions that underpin these types of approvals, it is also equally as important to discuss those schemes that have not been taken up, especially in light of climate change adaptation measures. Therefore, to understand these elements, the following research questions were posed in Section 1-4.

- Do current risk approaches produce objective results?
- Does the psychological risk approach explain any subjectiveness or bias of scores between individuals?
- Does the cultural theory of risk (worldviews) effectively explain the difference in scores?

The first aim was to determine whether existing risk processes could be deemed objective. As outlined in Chapter 2, many proponents of the technical and engineering risk theory see that risk can, in fact, be an objectified process. Therefore, the current risk processes in use within the water industry were modelled on ISO31000 (Council of Standards Australia, 2009), a standard outlining suggested risk assessment practices. This standard, in turn, based its own process on a similar probability-likelihood exercise that was first used by the Nuclear Regulatory Agency in the United States in the 1970s (United States Nuclear Regulatory Commission, 1975). This risk process, utilised through a risk matrix tool, has not been changed in practice for over half a century, despite vast amounts of criticism in the literature (see section 2.2.3).

In assessing these current processes, this research was aimed at determining the claim that it is objective. It was found that, in line with the technical risk theory's critics, it is not devoid of bias. This has wide-ranging ramifications for the processes of risk, as there is the potential for many past projects to have been assessed as low/high risk, had funding allocated or not allocated to them, when there was a significant amount of underlying bias in the results. The fact that another water practitioner could undertake the same assessment and achieve vastly differing results is worrying, especially in the case of allocating public funds.

In the case of allocating taxpayer dollars, decision-making must be recorded, and must be transparent. The use of current risk assessments cannot be transparent in their current state, as often, the risk assessor themselves are not aware of their own personal biases. Therefore, an alternative to the current arrangement of risk assessment should be sought, if an objective process is the aim. The other option is to highlight biases when they may be apparent or ensure risk assessors are aware of their own biases prior to undertaking an assessment. Although awareness does not always eradicate the bias, it can provide a disclaimer to others reading the assessment.

To further understand biases within the assessment, the next aim explored in the research considered the effect of individual psychological bias in explaining variation in risk scores. Although psychometric testing was only undertaken on 3 of the 7 projects to limit survey fatigue, it nevertheless provided insight into the impact of individual psychology. With dread being found to be a factor that appeared across all projects, the concept warranted further understanding. The link between age of respondent and dread provides a pathway to understanding how dread might materialise. As discussed in Section 7.3.2, dread is drawn from previous experiences. As the imagined outcome of the risk is devised by the risk assessor themselves, they will most likely rank the risk of the image that comes most readily to mind evoking the availability heuristic. In conjunction to this, the more times they are able to conjure this image, or the repeated nature of it, the greater salience it holds in their mind, therefore placing further importance on it (refer to Section 7.3.10). This has wide-ranging implications for risk assessments as the impact of experience plays a pivotal role in perception. Quite often, older, more experienced professionals are consulted as risk assessors, and the impact of this research indicates that assessments from this group are more likely to result in higher risk ratings than a younger cohort (18-25 years). Similarly, when consulting with younger professionals, they will carry less risk aversion in their assessments.

Projects that have underlying connotations (especially negative, such as radiation) that lie outside of the expertise of the risk assessor are also likely to be ranked higher, with the effect of knowledge-based factors playing a role (see Section 9.6). The same project that was assessed in this capacity, Project 4B, also had many qualitative findings that supported this conclusion (section 9.3). This is in line with the psychometric finding of higher risk scores as linked to knowledge-based factors. The trust of the respondent towards researchers affects these findings, as they are reliant on others' knowledge when they perceive their own as insufficient. This is particularly pertinent as each water practitioner will not have all the knowledge possible within their area, or within new or innovative pieces of work. They will instead have to rely on trusting the knowledge and judgement of another.

An implication of this finding is the importance of a strong relationship between the risk assessor and the consulting party, whether this is a researcher, another practitioner, or a consultant. This relationship should be built on trust, otherwise it is not surprising that higher risk scores result, as rather than the risk assessor feeling at ease in the case of an uncertainty, they instead feel a sense of apprehension, which could evoke the psychological factor of 'knowledge-based risk' found in this study. The implications of this are clear: higher risk scores which could result in less approvals of new or unfamiliar projects. A recommendation could be to heighten trust between water professionals, or to ensure they actually consult those that they trust. In addition, the nature of networking between different areas of water (from researchers to consultants, and operators) could help to establish these bonds where people would use the knowledge-based heuristics and rely on others' knowledge for risk assessment formation. This could result in limiting the number of projects that may be rejected purely on the basis of a feeling of personal inadequate knowledge.

As expressed in Chapter 8, worldviews were relatively homogenous in their membership base across the four organisations. The clear majority of respondents adhere to the egalitarian worldview, and thus the change in risk assessment scores did not pose a direct link through to worldview membership. This was further augmented by the regression analysis, indicating no significance between grid/group adherence and risk scores.

Despite the fact that there was no correlation between worldviews and scores, there are some elements that organisations could consider when it comes to the worldviews of their employees. To begin with, the very nature of employees adhering to egalitarian worldviews is in line with those that are likely to be Government employees. The premise of Government in Australia is about upholding democratic principles, such as giving each person a voice and a right to action this in the form of voting. This is in turn strengthened by the qualitative results, which indicate that community sentiment and reputation of the organisation is front of mind of many water practitioners. This aligns with the principles of egalitarianism, of equally respecting the opinions of others, including that of laypeople, and not adhering to a hierarchical structure of experts at the top and laypeople at the bottom. The implication is that the voices of the community matters, allowing for decisions to be influenced at a community-level. Reinforcing this is the effect of the psychometric question on fairness and adherence to worldview, that a sense of fairness in the projects is closely linked to one's worldview. Water authorities may be rest assured to know that the majority of their workforce that had participated in the study carry this line of worldview, which is congruent with the nature of Government work, and the nature of democracy.

These findings can start to provide a pathway through to improvement of risk processes through understanding personal biases, and insight into current process use. This is essential in the context of the allocation of public funds thus providing insight into the decision-making behind its allocation. The effect of personal biases, demographic factors, and worldviews can provide a part of the picture of transparency in choices. This is particularly pertinent in the context of climate change, and the predictions of a decrease in supply of freshwater resources (see Section 1.1). This will be important in comparing the riskiness of projects against the perceived risk in climate change. The literature on Cultural Theory has described this effect, in particular in the context of individualists not seeing climate change as a risky transformation and therefore less likely to take action. Egalitarians, conversely, are more likely to see climate change as risky, and may then be prone to take on projects that may be seen as riskier in the effort to combat the effects (as climate change effects are perceived as even riskier than the project) (Guy, Kashima, Walker, & O'Neill, 2014; Xue, Hine, N.M, & EB, 2014). Therefore, when determining innovative practices in water resource management in combating climate change, worldviews may have some effect. However, this was not confirmed in this study.

The varied nature of risk, and how perceptions differ between stakeholders has not been fully considered in the water sector previously, especially from a cultural and psychological perspective (Kosovac, Davidson, Malano, & Cook, 2017). In particular, there is a lack of research regarding water utilities' perceived risks associated with new and unfamiliar projects. Perceptions of risk influence decisions made about water infrastructure projects and are hence an important consideration. Climate change, along with population growth and other socio-economic factors, are impacting the availability of freshwater resources (Kabat, Ludwig, van der Valk, & van Schaik, 2012). This has implications for the need to consider alternative water supply projects to those that are business-as-usual. Hence, the need to understand utilities' risk perceptions of alternative water projects, so as to best design and facilitate their project implementation if, and when, necessary. This study contributes to closing this gap in the research.

The impact of this study has already been utilised in practice, with one of the water authorities in Melbourne changing their risk processes as a result of this research (see research summary sent to industry in Appendix F). These type of evidence-based changes can have a substantial impact upon water decisions in the future and may allow for a greater rate of uptake of projects that are unusual and innovative in nature, to counter the predicted increased water demand of users. Adaptation measures in the face of a changing climate are openly discussed, however alternatives to business-as-usual will always face the risk perceptions of current assessors. Through increasing awareness of biases, effective planning approaches can be enacted without the impact of personal affiliations to a risk impacting upon results. Ultimately, it is about working towards Cumming's approach of creating a risk measurement approach that is as "impartial and as accurate as possible" (Cumming, 1981, p2). With this research, we're on our way there.

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Appendix A | Detailed Explanation of each Water Authority

Melbourne Water

As previously mentioned, Melbourne Water acts as a bulk water wholesaler, selling water to the three water authorities: City West Water, South East Water and Yarra Valley Water. Melbourne Water manages on-stream and off-stream reservoirs, of which there are ten. Melbourne's water supply is sourced directly from one of these protected catchments and is moved through the use of MW-managed transfer lines throughout Melbourne. These pipelines link up to pipes and smaller reservoirs managed by one of the water authorities to deliver water to residential homes, farms, and businesses.

Melbourne Water manages:

- 10 storage reservoirs
- 2 major treatment plants
- 12 minor treatment plants
- 38 service reservoirs
- Transfer pipelines (Melbourne Water, 2018).

City West Water

City West Water's jurisdiction is located within the western and northern suburbs of Melbourne, as well as the Central Business District. The water authority serves approximately 444,000 properties, covering 1 million customers. City West Water manages $1.7 billion worth of infrastructure across their service area that spans more than 700 square kilometres. The organisation also has a number of 'alternative water schemes' such as Class A Recycled Water Treatment Plants for use in garden watering, toilet flushing and washing clothes (City West Water, 2017).

South East Water

Like all the other water retailers, South East Water purchases fresh drinking water from the Government's water wholesaler, Melbourne Water, and subsequently manages the supply network that delivers water to residences and businesses. These include:

- 24,000 kilometres of pipeline (smaller transfer lines, as well as reticulation mains)
- 81 water pump stations

- 259 sewage pump stations
- 9 recycled water pump stations
- 8 recycled water treatment plants
- 1 stormwater treatment plant

(South East Water Corporation, 2018)

South East Water's service area is located in the east and south of Melbourne, and extends as far south as the Mornington Peninsula and as far east as South Gippsland. The total area covers 3,640 square kilometres.

Yarra Valley Water

Yarra Valley Water is the largest of the three water retailers, covering a total service area of 4,000 square kilometres. This service area is predominantly located in the northern and eastern suburbs of Melbourne, bounded by Wallan to the north, and Warburton to the east. Overall, Yarra Valley Water manages:

- 9,519 kilometres of sewer mains
- 9,854 kilometres of water mains
- 104 sewage pump stations
- 76 water pumping stations
- 10 sewage treatment plants
- 46 water supply tanks (Yarra Valley Water, 2016-17)

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Appendix B | Water Authority Map

Figure B-1 A map of the water authorities' jurisdictions within Melbourne. (Department of Environment)

Reference

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Appendix C | Detailed Description of Risk Processes

Yarra Valley Water, Melbourne Water, City West Water and South East Water all had similar risk assessment approaches, with slight variations in their detailed consequence tables. Using ISO31000 standards as the basis for the framework, risk scoring is predominately based on considering the consequence and related likelihood of risks (Council of Standards Australia, 2009). A score is given to each of these (the consequence and the likelihood separately) based on an assessment undertaken by the project manager. These scores are multiplied to ultimately reach a final risk score, as recommended by IEC 31010 (International Organization for Standardization, 2009).

Risks consequences are also categorised in the risk framework. These include elements such as safety risk, reputational risk, financial risk, customer risk, etc. In all three water authorities, they ensure all of these risks and their examples of consequences are highlighted in a negative consequence table.

Melbourne Water Risk Process

The Melbourne Water risk assessment process closely follows the standard approaches highlighted in AS/NZS ISO31000:2009 Risk Management: Principles and Guidelines (Melbourne Water, 2017).

A risk assessment is undertaken at the concept stage of the project and is revised as the project progresses. For this reason, a project could be ceased at initial stages if its risk rating is deemed too high, or outside the scope of the risk appetite of the organisation. In the capital planning stage, according to the risk management procedure, the final risk score is devised through not only the negative score of undertaking the project, but also of the risk of not doing the project (ie. The 'before risk'). The 'After Project' risk score is subtracted from the 'Before Project' risk score to assess the relative risk of proceeding with the project. The higher this risk score, the more effective the project is expected to be in alleviating any risk that was previously there.

The broad overview of undertaking risk management is highlighted in Figure C-1:

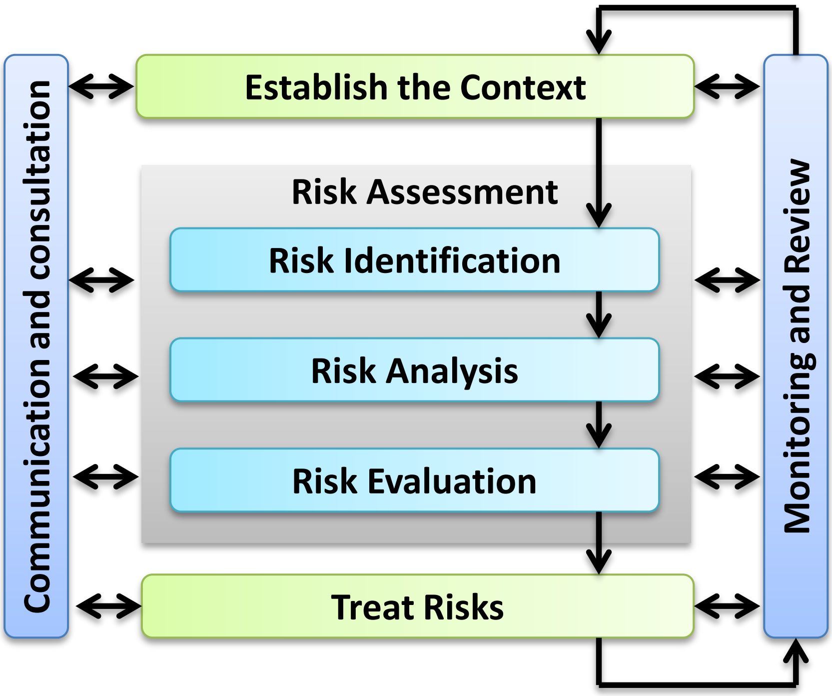

Figure C-1: Melbourne Water Risk Management Process (Melbourne Water, 2017)

Similar to other risk approaches within the water industry, it focuses on first defining the context through establishing what the key objectives are of the activity, what defines success and also identifying key stakeholders. The guidance document also highlights that all assumptions should also be documented. Next, they identify any risks- with risk being defined as the 'effect of uncertainty on objectives' through identifying a description of the risks themselves:

How is the risk caused?

What is there a risk of?

What could the risk result in? (Melbourne Water, 2017, p3)

Melbourne Water has main groupings through which they identify their risks. These are:

- Public Health and Safety
- Environment
- Safety and Wellbeing
- Customer/Service
- Reputational/Political
- Regulation

- Financial
- Schedule (Projects)
- Outcomes (Projects)

Public Health and Safety

Refers to elements such as illness or injury to members of the public.

Environment

This category can refer to any impact to land, air or water and also includes impact on fauna. Contamination of land forms a strong theme in this category, as does impact on (or loss of) species, and community amenity.

Safety and Wellbeing

Whereas the previous category 'public health and safety' referred to the risk posed on the public, this category instead focuses on Melbourne Water staff, contractors and visitors. It considers the risk of injury and illness to staff, using 'lost time injury' (a unit of measure in hours of work time lost due to injury or illness) as its key measurable.

Customer/Service

Loss of water services is the key risk highlighted in this category. This loss of service refers to any member of the public within the Melbourne water distribution zone that loses their access to water over a specified time.

Reputational/Political

Adverse media coverage and community loss of trust forms the basis for the risk assessment in this classification. This could stem out into community based protests and other forms of action, and loss of confidence from stakeholders (such as the Government).

Regulation

This legal-based category considers the adverse effects of breaching legislation, regulation or any other forms of agreements as a result of the project/decision. It can range anywhere from a warning through to civil action and criminal prosecution.

Financial

The financial category focuses only on the spending for the project, and its impact upon cash flow of the organisation. This project is also considered in terms of riskiness of 'overspending' the budget, measured by percentage of budget overspent.

Schedule

Considers the effect of not meeting project timelines and whether the delay in delivery is accounted for within the time contingency allowed for the project.

Outcomes

This risk category questions whether there is a risk of not meeting the outlined objective and aims of the project.

The above categories are further defined in the Melbourne Water "Risk Management Assessment Criteria" consequence table, stipulating what constitutes each rating (rated from 1- insignificant through to 5 – severe). The risk assessor focuses on the category with the highest rating to assess likelihood of risk.

Undertaking this assessment involves understanding the chance of the risk occurring. This is also defined in a ratings-based approach.

Table C-2 Melbourne Water Risk Probability Definitions (Melbourne Water, 2017)

Rating	Description	Probability per year
5 Almost Certain	Risk will occur	0.99
4 Likely	Risk is likely to occur	0.98 - 0.50
3 Possible	Risk may occur	0.49 - 0.20
2 Unlikely	Risk not likely to occur	0.19 - 0.05
1 Rare	Risk will only occur in exceptional circumstances	0.04 - 0.02

Table C-3 Melbourne Water Risk Matrix (Melbourne Water, 2017, p10)

		Negative Consequence					Positive Consequence (Opportunity)				
		Insignificant (1 or E)	Minor (2 or D)	Moderate (3 or C)	Major (4 or B)	Severe (5 or A)	Severe (5 or A)	Major (4 or B)	Moderate (3 or C)	Minor (2 or D)	Insignificant (1or E)
Likelihood	**Almost Certain 5**	Med	Med	High	Ext	Ext	Ext	Ext	High	Med	Med
	Likely 4	Med	Med	High	High	Extr	Ext	High	High	Med	Med
	Possible 3	Low	Med	Med	High	High	High	High	Med	Med	Low
	Unlikely 2	Low	Low	Med	Med	High	High	Med	Med	Low	*Low*
	Rare 1	Low	Low	Low	Med	High	High	Med	Low	Low	Low

After identifying risks, the process then requires the assessor to consider the corresponding controls to reduce the likelihood or consequence of the specified risk. Additionally, the overall control effectiveness of these controls are also assessed. Finally, using both the risk consequence and the risk likelihood scores, a risk rating can be obtained through the risk matrix below. This establishes the overall level of the risk.

Melbourne Water's approach to risk slightly differs from many other approaches in the water sector. Their final risk rating is devised not from multiplying the likelihood and consequence ratings, but rather, to add them. This produces slightly differing results from other approaches (such as Yarra Valley Water's risk process) and the risk ratings are then less varied (instead of ranging from 0 to 25, the risk ratings range from 0 to 10.) This could produce less deviation between scores from different assessors. The table below shows the risk rating, ranging from low through to extreme, based off the scores received for consequence and likelihood.

This risk rating is then compared to the Melbourne Water risk appetite framework (please see below) to determine whether the risk is deemed acceptable. For example, a project that has a negative risk rating of extreme, could mean that the project falls outside of the prescribed risk appetite and therefore should be reassessed whether to proceed or not. If it proceeds, needs to have clear risk treatment plan to be implemented alongside the project.

Table C-4 Melbourne Water Risk Consequence Table (Melbourne Water, 2017)

Level of Residual Risk	Risk Treatment and reporting requirements	Level of Residual Opportunity	Opportunity Treatment and reporting requirements
Extreme	• Falls outside our risk appetite. • A risk treatment plan must be immediately established. • All actions should be assigned a priority rating of High as per Table 9 • The timeframes for completion of the actions must be given urgency and prioritisation of resources, and should be completed as soon as reasonably practicable. • To be managed to a level that is As Low As Reasonably Practicable (ALARP) and in alignment with the risk control principles of the Risk Appetite Statement	**Extreme**	• Considered quick wins with big benefits • A risk treatment plan must be immediately established. • All actions should be assigned a priority rating of High as per Table 9 • The timeframes for completion of the actions must be given urgency and prioritisation of resources, and should be completed as soon as reasonably practicable.

High	• May fall outside our risk appetite. • A risk treatment plan must be established. • It is expected that (as a minimum) the action that makes the most contribution to the reduction of the risk be prioritised as High as per Table 9 • The action priority rating will determine the timeframe and resource allocation but all High Priority Actions must be completed as soon as reasonably practicable. • To be managed to a level that is As Low As Reasonably Practicable (ALARP) and in alignment with the risk control principles of the Risk Appetite Statement	**High**	• Worth pursuing, may be harder to obtain but results in significant benefits • A risk treatment plan should be established. • It is expected that (as a minimum) the action that makes the most contribution to the delivery of the opportunity be prioritised as High as per Table 9 • The action priority rating will determine the timeframe and resource allocation but all High Priority Actions must be completed as soon as reasonably practicable.
Medium	• Managerial discretion with potential to be managed or accepted without further treatment, provided an adequate monitoring regime is established • Should be managed in alignment with the risk control principles of the Risk Appetite Statement • It is expected that the actions would not be higher than Medium priority as per Table 9 • The timeframe and allocation of resources should be at the discretion of the Risk Owner.	**Medium**	• Lower value benefits • Managerial discretion as to their pursuit • Timeframes and allocation of resources limited
Low	• Expected alignment with our risk appetite. • Accountability to be managed by the appropriate risk owner. • May be reviewed to assess whether the risk is being over controlled, and whether some reduction in active controls may be considered subject to alignment with the Risk Appetite Statement • It is expected that the priority for all actions in most instances be Low.	**Low**	• Considered low value opportunities • Not likely to be pursued but based on managerial discretion

Yarra Valley Water Risk Process

Yarra Valley Water has a risk management process (Yarra Valley Water, 2016) that incorporates the same steps as the Victorian Government Risk Management Framework requirements stipulate, ie. It must adhere to ISO31000 and have the following key steps:

- Establish the context
- Risk Identification
- Risk Analysis
- Risk Evaluation
- Risk Treatment

The area of interest within this study is the process by which Risk Analysis is undertaken- where risks are analysed by their consequence and likelihood. 'Consequence' is defined as 'the impact of the risk has [sic] on the business' (page 15, Risk Management process yvw). A consequence table is outlined, and provided to all staff as part of the risk assessment framework. It covers six categories:

- Safety Impacts
- Reputational Risk
- Financial Impact
- Environmental Impact
- Cultural Risk
- Customer Impact Risk

Safety Impacts

Safety risk refers to the risk posed by physical or mental injury from the work/project carried out. This is what can be reasonably expected to occur within the work carried out. This risk also refers to the any injury or disability that may happen as a result of the project.

Reputational Risk

Reputational Risk is the negative effect on the organisation that could reasonably be expected to occur as a result of the project. This can be as a result of negative media attention, complaints from customers etc. Elements such as loss of confidence from Government or a breach of licence. It may also incorporate complaints to the members of parliament about a particular issue. The media plays a large role in reputational risk, in particular on the organisation itself, as its effect on the confidence of its stakeholders.

Financial Impact

Financial risk has been utilised in most risk assessments in the past. At times, it is the only risk considered. Often, it is summarised as the amount of sunk funds that goes into the project. These are generally highlighted very clearly in terms of consequence in a quantitative fashion. However, despite its quantitative nature, it heavily relies on fiscal estimations undertaken by the project manager. It could also result in the organisation not being able to deliver on its corporate plan, due to budgeting restraints.

Environmental Impact

Environmental risk refers to the potential effect on the natural environment due to the project. An example of the most severe environmental risk could stem from the local extinction of native flor or fauna, while minor elements may refer to continued sewage d ischarge into the natural environment. Environmental risk also highlights any actions/enforcements put forward by the Environmental Protection Agency.

Cultural Risk

Culture impact looks at the way the business will be affected which could result in items such as low performance, high stress and emotional trauma. Lower levels of this refer to loss of key personnel or a lower morale in some areas. Many of these could result in high absenteeism or difficulty in attracting good candidates for future roles.

Customer Impact Risk

As water authorities are driven in large part by its stakeholders, one of which is the customer, a risk exists in not providing quality standards of service and water delivery. This may have flow on effects due to impacts upon the elected state Government of the time (the boards of the water authorities are assigned by the Government) and therefore, customer impacts and public perception may carry risks on the popularity of the Government of the time. Furthermore, customer impact refers to the actual delivery of clean water and ensuring minimal failures along a water supply system.

Risk is assessed according to the consequence table and then this risk is then followed up by determining its likelihood, once again guided by a probability table (shown in Table C-5).

Table C-5 Yarra Valley Water Risk Probability Table (Yarra Valley Water, 2016, p16)

Rating	**Description** (**Note**: usually for a 5-year business planning cycle as a guide; this may vary depending on the context)	**Likelihood (for Safety Hazards)**	**Likelihood (for Environmental Hazards)**
5 Almost Certain	Risk is expected to occur in most circumstances (i.e. within the next 12 months at least once but more likely multiple times).	1 in 10 chance	1 per week
4 Likely	Risk will probably occur in most circumstances (within 18 months).	1 in 100 chance	1 per month
3 Possible	Risk could occur in some circumstances (within the next 3 years).	1 in 1,000 chance	1 per year
2 Unlikely	Risk may occur in limited circumstances (risk is not expected within the next 5 year time frame).	1 in 10,000 chance	1 per 5 years
1 Rare	Risk may only occur in exceptional circumstances.	1 in 100,000 chance	1 per greater than 5 years

The consequence score ranges from 1 to 5, as well as the likelihood score. This is combined for each risk using the table below to provide a risk rating for that particular risk.

Table C-6 Yarra Valley Water Risk Rating Matrix (Yarra Valley Water, 2016)

Risk/ Opportunity Rating Matrix

Risk / Negative Consequences

Likelihood	Insignificant -1	Minor -2	Moderate -3	Major -4	Severe -5
5 (almost certain)	MR -5	HR -10	HR -15	ER -20	ER -25
4 (likely)	LR -4	MR -8	HR -12	HR -16	ER -20
3 (possible)	LR -3	MR -6	MR -9	HR -12	HR -15
2 (unlikely)	LR -2	LR -4	MR -6	MR -8	HR -10
1 (rare)	LR -1	LR -2	LR -3	LR -4	MR -5

Yarra Valley Water's Negative Consequence Table. LR – low risk, MR- medium risk, HR – high risk, ER – extreme risk. (Page 18 yvw risk assessment framework.)

Each risk is assessed by the project manager, with the risk that has a rating that is the highest ultimately becoming the risk score that is reported in the business case. Therefore, when comparing highest scores across different projects, they may refer to different categories. For example, Project A may have a risk score of 12, (High Risk), yet Project C has a risk score of 20 (Extreme Risk). Project A has a score based on financial risk, whereas Project B has a score based on a reputation risk. Therefore, the score or rating itself may not necessarily highlight the category.

The risk assessment approach represents a form of technical risk theory- highlighting a quantitative, objective way of assessing a risk. The final risk score is designated a risk rating of low, medium, high or extreme. This score ultimately aids decision-making in whether to proceed with a project in options assessments or within business cases. The score could be included in a business case, revised in a green (request for funding), and again when the project is registered within the Contract Management System. During this time, there may be many different risk assessors, as the person who initiated the project may not necessarily be the one to project manage the construction phase. However, the point at which the project is allocated funding (the business case phase) is that which is of most interest when exploring risk and decision making.

CWW Risk Process

The City West Water risk process is not dissimilar to other risk processes in the water sector (City West Water, 2016). Based on the ISO31000 Risk Standards, it predominantly relies on a risk likelihood and risk consequence score which then gives a rating from low risk to high risk. There are 4 risk ratings overall: low, medium, significant, high. The consequence table titled the "CWW Triple Bottom Line Consequence Matrix" gives the qualitative measures of consequence on which to base each project. This table is shown below.

Table C-7 City West Water Risk Consequence Table (City West Water, 2016)

Descriptor/ Score	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Safety	• No threat of injury to the public/staff.	• Low potential for injury to the public/staff. • First aid satisfactory. • No lost time injury.	• Potential for injury to the public/staff • Medical assistance required • Lost time injury incurred	• Hazardous situation • Hospitalisation. • Lost time injury incurred.	• Death/disability occurs.
Financial	• Revenue or expense impact of approximately less than or equal to $250K	• Revenue or expense impact of approximately less than or equal to $1M but greater than $250K	• Revenue or expense impact of approximately less than or equal to $10M but greater than $1M	• Revenue or expense impact of approximately less than or equal to $20M but greater than $10M	• Revenue or expense impact of approximately greater than $20M
Compliance	• No intervention by regulator(s) • No obligation to report to a regulator or other authority	• Investigation by regulator(s) • Obligation to report to a regulator or other authority	• Investigation by regulator(s) requiring management action (eg agreed medium term reparatory actions) • Obligation to report to a regulator or other authority	• Short-medium term sanction(s) imposed by the regulator(s) (eg agreed immediate reparatory actions) • EPA fine (minor) / PIN issued • Obligation to report to a regulator or other authority	• Long term sanction(s) imposed by the regulator(s) (eg enforceable undertakings, detailed monitoring &/or financial penalty). • Major fine incurred • Obligation to report to a regulator or other authority
Environment	• Negligible effect on the environment • No breach of legal or other obligations • No public concern or detriment to CWW image • No rehabilitation works required	• Minor, short term stress on the environment • No breach of legal obligations, possible non conformance with internal business objectives • Isolated local media exposure, low level of public concern • Simple, low cost rehabilitation required	• Environment stress observed • Minor breach of legal or other obligations, prosecution unlikely, internal management response • Moderately difficult or expensive rehabilitation required • Several public complaints & possible detriment to CWW image with local media exposure, isolated state media exposure	• Significant damage to the environment observed • Breach of legal or other obligations, regulator investigation • Difficult, long term or high cost rehabilitation required • Short term detriment to CWW image with ongoing state media coverage, repeated attention from stakeholders.	• Localised environment destruction, irreversible damage • Severe breach of legal or other obligations, high probability of prosecution • Widespread public outrage and long term detriment to CWW image with extensive ongoing state and/or national media coverage.

Reputation	• No media exposure. • Isolated attention from a minor stakeholder with no publicity.	• Isolated local media exposure. • Isolated attention from one key stakeholder or a number of minor stakeholders with little or no publicity.	• Isolated state media exposure and/or ongoing local media exposure. • Attention from a limited number of key stakeholders with restricted publicity.	• Ongoing state media exposure. • Repeated ongoing publicised attention from numerous or significant key stakeholders. • Some degree of public outrage.	• Extensive ongoing State and/or National media exposure. • Extensive ongoing publicised attention from numerous or significant key stakeholders (eg customers, community groups, environmental groups and peer organisations). • Sustained degree of public outrage.
Customer	• Service disruption for less than 10 customers. • No public interruption and inconvenience.	• Service disruption for between 10 to 100 customers. • Minimal public interruption and inconvenienc e.	• Service disruption for between 100 to 200 customers. • Short-term disruption to key public services.	• Widespread service disruption for between 200 to 500 customers • Prolonged disruption to key public services.	• Widespread service disruption for greater than 500 customers. • Long term loss of infrastructure and services.
People	• Management intervention required with existing internal CWW resources.	• Management intervention required with possible use of external resources.	• Substantial management intervention required may require some possible external assistance.	• Significant senior management intervention required, may require significant mobilisation of resources, including external assistance. • Ongoing resource diversionary potential.	• Significant and sustained resource diversionary potential. • Immediate senior management and Board intervention required.

The categories on the consequence table are safety, financial, compliance, environment, reputation, customer and people. Each category is described further below.

Safety

Safety elements consider threats to injury to either the public or City West Water staff. This ranges from no threat of injury, through to death or disability. It does not highlight whether the threat of injury is physical or psychological and is rather vague in some circumstances (for example, 'hazardous situation' in the Major (4) category.)

Financial

Risks to finances refer to monetary risk to the organisation, not to the public in general. These are quantitatively measured, from an expense impact of up to $250,000 (insignificant risk) through to a revenue or expense impact of greater than $20 million (catastrophic risk).

Compliance

This category refers to the regulatory requirements imposed on the water utility, and risks that they may be unmet. These highlight levels of anticipated outcomes such as of investigations by regulators, or fines/sanctions imposed on the water authority.

Environment

A number of environmental stressors are highlighted in the risk consequence table ranging from 'negligible effect on the environment' through to 'localised environment destruction, irreversible damage'. Other impacts include 'Environmental stress observed', an element which can be difficult to foresee or expressly define. The environment category also interestingly includes reference to public outcry and media, included as a dot point in all risk ratings.

Reputation

Reputational risks predominantly refer to media exposure and its impact upon the organisation however does not state whether the media exposure is expected to be negative or positive. The two highest risk ratings, 'Major' and 'Catastrophic' are the only ratings that mention negative impacts resulting from media, the impact of public outrage. These components provide some level of overlap with the environment category, especially between Reputational consequence 'major' ('[s]ome degree of public outrage') and Environmental consequence 'moderate' ('[s]everal public complaints with … isolated state media exposure'). This crossover, and particularly the differing nature of these two categories may make it difficult for risk assessors to choose one category over another when highlighting risks.

Customer

The customer risk consequence highlights negative service impacts upon City West Water customers. It is quantitatively measured in terms of customers affected. This, often, can be difficult to measure for project managers- as often, the number of people per dwelling can change between each household and as such the difference between insignificant (less than 10 customers) and minor (10 to 100 customers) can be a matter of personal estimation factors that may not be entirely accurate. Catastrophic refers to disruptions of services affecting over 500 customers. Interestingly, this does not factor in length of disruption into the risk rating.

People

This category refers to risks posed to staff of City West Water, not safety-related, but rather internal process-related. In particular, the term 'management intervention' is used to describe this element. The table does not state what type of behaviour or occasion might warrant management intervention, not what 'management intervention' specifically involves.

These qualitative measures are then combined with the likelihood to form a final risk score. The qualitative measures of likelihood are also defined in a table, spanning from category A (almost certain) through to category E (Rare).

Table C-8 City West Water Risk Probability Table (City West Water, 2016)

CATEGORY	PROBABILITY or LIKELIHOOD
A	**Almost certain** The even is expected to occur in most circumstances. The event could occur daily
B	**Likely** The event will probably occur in most circumstances The event could occur weekly
C	**Possible** The even should occur at some time The event could occur monthly.
D	**Unlikely** The event could occur at some time The even could occur annually
E	**Rare** The event may occur only in exceptional circumstances The event could occur once in five years.

Risks are then categorised through a risk consequence and likelihood table after ranking each of these elements. The risk is scored as a letter (likelihood) and a number (consequence). For example, a risk score of 2B would refers to a consequence score of 2, and a likelihood rating of B. With reference to the likelihood and consequence table, risk ratings can be determined with the use of the risk score. This table is shown below.

Table C-9 City West Water Risk Rating (City West Water, 2016)

LIKELIHOOD	CONSEQUENCE				
	1	2	3	4	5
A	Medium	Significant	High	High	High
B	Low	Medium	Significant	High	High
C	Low	Medium	Significant	Significant	High
D	Low	Low	Medium	Medium	Significant
E	Low	Low	Low	Medium	Significant

In the case of our example, a risk score of 2B would result in a risk rating of 'Medium'. The risk rating labels of each water authority differ slightly, although all have a total of four ratings overall.

The final risk rating is then used to inform decision making on whether to proceed with a project. This is often compared to the risk appetite of the organisation, and is added to business case documents and any documents that may ask for a decision, or for funds to be allocated. At times, the project manager themselves will make the decision with whether to proceed with the project if they deem the risk too high. Or they are able to justify the project itself if they believe it should proceed and have not highlighted any other residual risks.

SEW Risk Process

The South East Water risk management framework is a detailed document that covers various elements of the risk process such as controllability of risks, accountability, and also the risk identification measurement process (South East Water, 2017). Much like the other water authorities, South East Water must establish a risk management framework as required in the Victorian Government Risk Management Framework (VGMRF). The aims of the risk management framework document are to provide guidance on ensuring a systematic approach to managing risks within the organisation.

Upon identifying risks, South East Water also has a '3 lines of defence' process to control each identified risk. The first line of defence includes 'operational controls' and set control measures as previously determined. The second line of defence refers to the use of quality assurance systems, finance and compliance teams to ensure risks can be controlled. Both of these lines of defence report to senior management. The final line of defence is conducting an internal audit on the project, an audit run by and answerable to the audit committee. It is unclear when this audit is undertaken, and can be assumed to be done following completion of a project, much like external audits.

Individual project risks are to be reported to management, while those rated as 'extreme' are also to be presented to the Board and the Finance, Assurance & Risk Management Committee. While reporting of risks goes to these areas, the person responsible for undertaking the risk assessment itself are project managers.

The risk management procedure for South East Water is highlighted in Figure C-2.

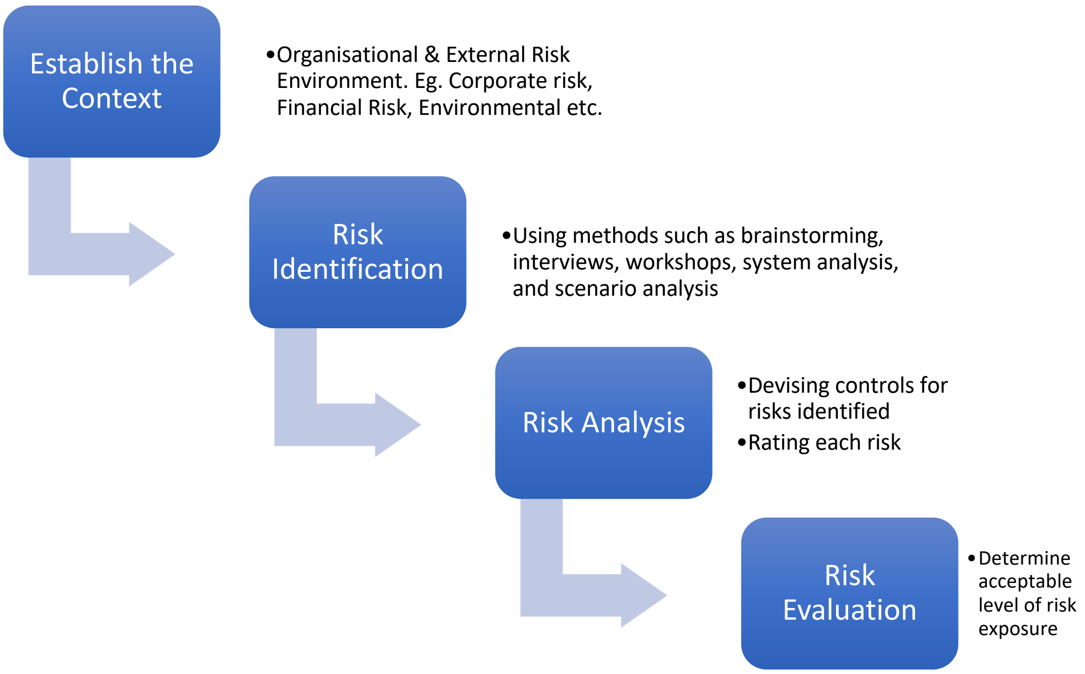

Figure C-2 South East Water Risk Process (South East Water, 2017)

The process also highlights some treatment options for risks (as taken from the Risk Management Framework):

Table C-7 South East Water Risk Treatment Options (South East Water, 2017)

Treatment Options	Description
Avoid	Avoid the activity that leads to the risk. Generally, the decision to avoid a risk is an option for new or proposed activities, rather than for ongoing operational tasks.
Treat	Implement measures that reduce the likelihood of the risk occurring and / or reduce its consequence
Share	Sharing the risk with suppliers, business partners or other organisations typically through contractual arrangements
Transfer	Transfer the risk or part of the risk to another party that can exercise the most effective controls over the risk. This may include outsourcing or insurance policy
Retain	Retain the risk where the risk exposure fits within a tolerable level, no other options exist, or effective controls are in place to monitor and manage the risk
Exploit (opportunity)	In relation to opportunities, enablers may include increasing capital, diversifying assets, creating new products / services, price options, or redesign of a business / delivery model

The document also notes the importance of accepting a risk exposure, stating "[b]eing innovative and driving efficiency comes with inherent uncertainty." (page 15) The framework does not state who decides on the acceptability of risks, whether this is the risk assessor themselves or others.

As part of the risk process, risk ratings are undertaken by risk assessors. In line with other water authorities, South East Water has a Risk Likelihood and Consequence matrix for assessors to refer to.

The likelihood ratings are shown below. These are guided by quantitative measures and require the risk assessor to hypothesize how often a particular risk may occur. The far right column also explains the level of certainty that a risk would occur. This may be confusing- does one score according to the percentage likelihood of a risk occurring, or score according to the suggested timelines. This is not clear in the document.

Table C-8 South East Water Risk Probability Definitions (South East Water, 2017)

Rating	Likelihood Description	%
Almost Certain (5)	Event ***will occur***, almost certainly, at least once every year	>98%
Likely (4)	Event is ***likely to occur*** (once every 1 to 2 years)	50-98%
Possible (3)	Event ***may occur*** (between once every 2 to 5 years)	20-49%
Unlikely (2)	Event is ***not likely to occur*** (between once every 5 to 20 years)	5-19%
Rare (1)	Event will ***only occur in exceptional*** circumstances (less than once every 20 years)	<5%

The risk is rated according to the risk negative consequence table.

Table C-9 South East Water Consequence Table (South East Water, 2017)

Rating	Financial	Safety	Service	Regulatory	Reputation	Environment	People	Product Quality
Catastrophic (5)	Unplanned reduction of more than $26M or 20% (the lesser of) in Net Cash Inflows from Operating Activities	Single or multiple fatalities Permanent life-changing disability or Illness (physical/mental) of staff, visitor, contractor or member of public	Unavailability of critical services or systems* (despite mitigation measures) for > 5 days affecting a large number of people or important community facilities (e.g. 10,000+ customers, multiple health facilities, multiple top tier non-residential customers, transport infrastructure)	Very serious breach of legislation, regulation, agreements or contracts, that is difficult to rectify and results in one or more of: Prosecution or civil action leading to imprisonment or significant sanction Ministerial or formal intervention by regulator Licence/permit revocation Public inquiry	Very serious public outcry (community action or protests, including online) (3+ days) Sustained negative media coverage at state or national level (3+ days) Lasting impact to reputation (1+ year) Critical impact on relations with key stakeholders (loss of Government support)	Permanent, widespread and irreversible contamination to land, air, groundwater or surface water environment Permanent loss of species, habitat, community amenity or heritage sites Enforcement action undertaken by EPA in the form of licence revocation	Unavailability or loss of resources that creates a material and/or sustained impairment to delivery of a critical service Industrial action (long term) Unplanned turnover in large numbers of key staff in business critical roles that are difficult to replace	Direct or indirect product exposure (water, sewage, by products) causing: Death, permanent disability or widespread incapacitating illness
Major (4)	Unplanned reduction of between $13M and $26M or 10% to 20% (the lesser of) in Net Cash Inflows from Operating Activities	Permanent injury or illness (physical/mental) of staff member, visitor, contractor or member of public	Unavailability of critical services or systems* (despite mitigation measures) for between 1 and 5 days affecting a large number of people or important community facilities (e.g. up to 10,000 customers, health facility, top tier non-residential customer, transport infrastructure)	Serious (but isolated) breach of legislation, regulation, agreement or contracts, that requires considerable investment to rectify and results in one or more of: Prosecution or civil action with high compensation (or fine) and -ve precedent Ministerial or formal intervention by regulator (enforceable undertaking) Restrictions or conditions placed on licence/permit	Serious public outcry (community action or protests, including online) (2 to 3 days) Adverse state media coverage (2 to 3 days) Negative impact to reputation but repairable (within 1 year) Adverse impact on relations with key stakeholders (expressed displeasure by department or Government)	Very serious contamination to land, air, groundwater or surface water environment (clean up / recovery 1 to 4 years) Major impact on species, habitat, community amenity or heritage sites (restoration period 1 to 4 years) Enforcement action undertaken by EPA in the form of an enforceable undertaking or court prosecution	Unavailability or loss of resources that creates noticeable and/or temporary impairment to delivery of a critical service Industrial action (short term) Unplanned turnover of a number of key staff in business critical roles that are difficult to replace Widespread morale and engagement issues particularly in customer facing roles	Direct or indirect product exposure (water, sewage, by products) causing: Isolated, incapacitating illness Widespread exposure to a contaminant that could cause illness in healthy people
Moderate (3)	Unplanned reduction of between $3M and $13M or 2% to 10% (the lesser of) in Net Cash Inflows from Operating Activities	Injury or illness (physical/mental) requiring in-patient hospitalisation of staff member, visitor, contractor or member of public	Unavailability of critical services or systems* (despite mitigation measures) for up to 1 day affecting a large number of people or important community facilities	Non-compliance with legislation regulation, agreements or contracts that is reportable and/or requires an immediate response to an external party. This may result in: Infringement notice (or similar) External review or audit	Public outcry (sustained and numerous customer complaints including online) Adverse state media coverage (1 to 2 days) Limited, repairable damage to reputation Some concern on relations with key stakeholders (explanation required)	Serious contamination to land, air, groundwater or surface water environment (clean up / recovery within 1 year) Moderate impact on species, habitat, community amenity or heritage sites (restoration within 1 year) Enforcement action undertaken by EPA in the form of an Penalty Infringement Notice (or similar)	Unavailability or loss of resources with a moderate impairment to the delivery of a core business process or business outcome Unplanned turnover of staff well above expectations across the business Morale and engagement issues affecting certain groups	Direct or indirect product exposure (water, sewage, by products) causing: Isolated, non-incapacitating illness Isolated exposure to a contaminant that could cause illness to healthy people Widespread exposure to a contaminant that could cause illness in vulnerable people (immune deficient, people in care or receiving medical treatment, children) only

Minor (2)	Unplanned reduction of between $0.6M and $3M or 0.5% to 2% (the lesser of) in Net Cash Inflows from Operating Activities	Injuries or illness (physical/mental) requiring medical attention of staff member, visitor, contractor or member of public (nothing notifiable* will be considered as minor) **As per BS 2086 (Statutory reportable injury and/or dangerous occurrences)*	Unavailability of critical services or systems* (despite mitigation measures) for up to 5 hours affecting separate groups of people or important community facilities (slightly inconvenienced)	Minor non-compliance with legislation, regulation, agreements or contracts that is reportable but has minimal impact to operations and no urgency for rectification	Localised complaints that can be managed to achieve an effective outcome Limited, adverse local media attention (single instance) Negligible impact to reputation with freedom to operate unaffected	Minor contamination to land, air, groundwater or surface water environment (clean up / recovery of a localised event within weeks) Minor impact on species, habitat, community amenity or heritage sites (restoration within weeks) Enforcement action undertaken by EPA in the form of a warning	Unavailability or loss of resources with some impairment to the delivery operational processes or business outcome Annual turnover slightly above expectations but with no difficulty in recruitment Staff disgruntlement, complaints	Direct or indirect product exposure (water, sewage, by products) causing: Widespread exposure to a contaminant that will not cause illness
Insignificant (1)	Unplanned reduction of less than $0.6M or <0.5% (the lesser of) in Net Cash Inflows from Operating Activities	No injury or illness sustained No staff downtime	Unavailability of critical services or systems* (despite mitigation measures) that has a negligible impact to people or important community facilities ** Critical services or systems as defined in South East Water's Business Continuity Command Plan*	Insignificant non-compliance with legislation, regulation, agreements or contracts that has no impact to operations and/or no requirement to report	Local complaint, no media coverage Quickly forgotten with freedom to operate unaffected	Temporary contamination (days) to land, air, groundwater or surface water environment to immediate area around asset or activity No lasting impact (days) on species, habitat, community amenity or heritage sites Self reporting or notification to EPA	Unavailability or loss of resources with negligible impairment to the delivery of operational processes Normal annual turnover with no difficult in recruitment	Direct or indirect product exposure (water, sewage, by products) causing: Isolated exposure to a contaminant that will not cause illness

Risks are rated by assessing their likelihood and consequence on a scale of 1 to 5 for each factor. The guidance consequence table highlights 8 risk categories:

- Financial
- Safety
- Service
- Regulatory
- Reputation
- Environment
- People
- Product Quality

Financial

Financial risks, unlike those of other water authorities, refer to unplanned spend, rather than planned expenditure from operating activities, assuming then it doesn't relate to unplanned spend from capital expenditure projects. Insignificant unplanned spend starts below $0.6 million, and steadily increases for each risk rating until it reaches 'catastrophic', a spend of more than $26 million.

Safety

Safety risks refer to both staff, visitors, contractors and the public and can be both physical and mental injuries. Safety is ranked according to the level of injury of at least one person, with the risk rating remaining unchanged the more people injured.

Service

Other water authorities call this category 'customer' and it refers to the disruption of services to customers. It provides measures for each risk rating according to the number of people affected, and also the length of time they are affected. It is unclear when the guide states 'affecting a large number of people', the term 'large' being rather subjective. The term 'critical services' is used, and is defined in South East Water's Business Continuity Command Plan, however is not defined explicitly in the risk management procedure document.

Regulatory

The main contention of this category regards the risks posed by not following regulatory and legal requirements. The table clearly distinguishes between the ratings through the impact of the regulatory breach, and also reporting requirements. For examples, a breach that must be reported will be ranked higher than one that is not.

Reputation

This category hinges greatly on the concept of 'freedom to operate', ie. Whether the water authority is able to continue its operation with no external input. Events that may affect this include public outcry and negative media coverage.

Environment

Risks to the environment range from temporary contamination through to permanent destruction of the environment. The length of recovery also factors into how the risk is classed, ie. Longer recovery time will result in a higher risk rating. In addition to this, some overlap with the regulatory risk category takes place here. Enforcement action by the Environmental Protection Agency as a result of a regulatory breach factors in each of the higher risk ratings. The risk ratings related to the regulatory actions for the environment are consistent with those that overlap in the regulatory risk category (ie. The same types of risk carry the same risk ratings.)

People

The People category refers to South East Water staff and the impact of events upon staff morale and turnover. It also highlights the impact upon the availability of resources that may affect work output and delivery of services.

Product Quality

The final risk category is the impact of poor quality water, sewage or byproducts on the community. The matrix categorises each level through whether those exposed will fall ill or not. The 'moderate' risk category involves exposing a poor quality product and causing illness in vulnerable people, while the 'catastrophic' risk category describes a scenario wherein those exposed suffer from permanent disability or death.

Similar to other water authorities' risk approaches, South East Water also has a risk rating matrix they call a 'heatmap'. This is shown in Table C-10.

Table C-10 South East Water Risk Rating Table (South East Water, 2017)

	Negative Consequence (Threat)					Positive Consequence (Opportunity)				
Likelihood	1	2	3	4	5	5	4	3	2	1
5	Med	High	Ext	Ext	Ext	High	High	High	Med	Low
4	Low	Med	High	Ext	Ext	High	High	Med	Med	Low
3	Low	Low	Med	High	Ext	High	Med	Med	Med	Low
2	Low	Low	Med	Med	High	Med	Med	Med	Low	Low
1	Low	Low	Med	Med	High	Low	Low	Low	Low	Low

This heatmap highlights both negative and positive risk consequences, with four risk ratings in the negative section. The risk framework explains that the highest consequence risk should be that which is reported. The risk assessor must then choose which category carries the highest rating when its likelihood and consequence is combined (for example, the financial risk may be higher than the environmental one).

These risk ratings are then used to help to guide decision making in projects throughout the organization.

City West Water, "Risk Management Process." Internal Document. 2016.

Council of Standards Australia. (2009). Risk Management - Principles and Guidelines. In (Vol. AS/NZS ISO 31000:2009). Sydney: Standards Australia.

International Organization for Standardization. (2009). *Risk Management - Risk assessment techniques* (IEC31010:2009). Retrieved from https://www.iso.org/standard/51073.html

Melbourne Water, "Risk Management Process." Corp Gov Pro Risk Management Version 9. Doc ID: 22833104. April 2017.

South East Water. "BS1026 South East Water Risk Management Framework." Internal Document. 2017.

Yarra Valley Water. "YSGD0042 YVW Risk Mgmt Process." Internal Document. 2016.

Ethics ID: 1748826.1

Appendix D | Copy of Survey

Faculty of Veterinary and Agricultural Sciences

Project: Assessing the Impact of Risk Perception in Water Innovation Projects

Plain Language Statement

Associate Professor Brian Davidson (Responsible Researcher)

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Ms Anna Kosovac (PhD Candidate) Email: kosovaca@student.unimelb.edu.au

Introduction

Thank you for your interest in participating in this research project. The following few pages will provide you with further information about the project, so that you can decide if you would like to take part in this research.

Please take the time to read this information carefully. You may ask questions about anything you don't understand or want to know more about.

Your participation is voluntary. We would like to get your response as you are considered an expert in the field of water. If you do not wish to take part, you do not have to. If you begin participating, you can also stop at any time.

What is this research about?

This research considers the role of risk perception in water industry projects. In particular, it aims to determine how risk differs due to worldviews, and also due to unfamiliarity. The research wishes to determine the extent to which theories of risk perception approaches explain any subjectivity in risk scores. This could provide further insight into understanding risk aversion culture within the water industry, and also provide a roadmap to promotion of innovation practices.

What will I be asked to do?

Should you agree to participate, you will be required to assess the risk surrounding a number of water projects. Some of these water projects may be familiar, others will not be. All projects are completely fictional. To the best of your ability, please assess the risk associated with each project based on the information provided. The second stage will require you to answer a few questions on the risk attributes of each project.

The final aspect will consider your worldviews. In order to achieve the most meaningful results, please be as honest as possible in this section. Your name will not be linked to your responses, and your responses will not be identifiable. As such, your responses to the survey will be completely confidential.

The survey is expected to take approximately 20-30 minutes to complete.

What are the possible benefits?

This research (and your involvement in it) will help us add to scholarly research into understanding the ways in which people assess risk psychologically, and whether cultural affiliations present trends to how a risk is assessed. It will also aim to frame the discussion around how risk is perceived in relation to water and ultimately will shape how risk is assessed in future water projects. In particular, this research can help to determine the effect of risk perception on innovation.

What are the possible risks?

An element of the study will require you to put forward your worldviews through agreeing/disagreeing with a set of statements. This will be completely confidential, and full honesty will ensure the integrity of the research. However, the topics raised may be quite sensitive in nature, and therefore, if you begin to find the questionnaire upsetting, we recommend that you cease the study and we will direct you to a service that will be able to help you. Should this survey raise any uncomfortable or distressing feelings, please do not hesitate to contact Lifeline on 13 11 14 where a trained support person will be able to help you.

Do I have to take part?

No. Participation is completely voluntary. You are able to withdraw (quit) at any time. You are able to withdraw any data you provide at any time during the duration of the study.

Will I hear about the results of this project?

The final page of the survey will ask whether you would like to be sent the results and conclusions of the study. To do this, you will need to provide a contact email address. Please note that there is no way that your individual response will be identifiable from the group. As such, results will all be represented as a group. This page will be treated confidentially, and will be separated from your other responses.

What will happen to information about me?

The information about you will be stored at the Faculty of Veterinary and Agricultural Sciences system for a maximum of five years. The information will be fully confidential and will not be used for any other research.

Is there any potential conflict of interest?

Yarra Valley Water is a key funding body of this study. The responsible researcher is also employed by Yarra Valley Water, however this is not expected to affect the integrity of the research. The research is still undertaken independently. The research will comply with all University of Melbourne policies and procedures.

Who is funding this project?

Yarra Valley Water and The University of Melbourne have provided funding for this project. This research is conducted independently of Anna Kosovac's role at Yarra Valley Water.

Where can I get further information?

If you would like more information about the project, please contact the researcher; Ms Anna Kosovac (PhD Candidate) Email: kosovaca@student.unimelb.edu.au or Associate

Professor Brian Davidson (Responsible Researcher), Tel (03) 8344 8633 Email: b.davidson@unimelb.edu.au

Who can I contact if I have any concerns about the project?

This research project has been approved by the Human Research Ethics Committee of The University of Melbourne. If you have any concerns or complaints about the conduct of this research project, which you do not wish to discuss with the research team, you should contact the Manager, Human Research Ethics, Office for Research Ethics and Integrity, University of Melbourne, VIC 3010. Tel: +61 3 8344 2073 or Email: HumanEthics-complaints@unimelb.edu.au. All complaints will be treated confidentially. In any correspondence please provide the name of the research team or the name or ethics ID number of the research project.

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Research Questions

Instructions

Answer questions as they relate to you. For most answers, check the box, or circle the score on the scale most applicable to you. Please note that this survey is completely confidential.

About You

1. Your Age

(Select only one.)

- ☐ 18-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 66-75
- ☐ 76 or more

2. Your Gender

(Select only one)

- ☐ Female
- ☐ Male
- ☐ Other

3. Which option best describes your role?

(Select only one)

- ☐ Project Manager
- ☐ Team Leader
- ☐ Divisional Manager
- ☐ General Manager
- ☐ Other

3. Which organization are you employed at (or you predominantly undertake work for)?

(Select only one)

- ☐ City West Water
- ☐ Melbourne Water
- ☐ South East Water
- ☐ Yarra Valley Water
- ☐ Other

Part 1: Risk in Projects

The following survey will first outline a number of projects and you will be asked to provide a risk assessment score for each. The risk assessment approach that you should use is the provided company-based approach.

Please read each of the project descriptions on the following pages and record the risk score where specified.

The risk assessment score must be an integer (no decimal places) and must fit within the existing risk assessment plausibility of scores.

Project 1 – Pipe Replacement

A DN400 pipe will be replaced on High Street in South Blighton between Edward Street and April Crescent. This section of main is comprised of AC pipe, and will be replaced with a PE pipe. The AC main will remain in the ground, but labelled as 'abandoned' on all documentation. The replacement of the main will be 200m of line.

Project Outlines

High Street is a busy thoroughfare, acting as a link between the Western road and the Northern freeway. It is expected that approximately 20 houses will experience disruption to their water supply of up to 4 hours, as well as traffic disruptions along Rosanna Road. Cost = $150,000

Risk Assessment Score: ____________

Project 2 – Pump Station Installation

A pump station at Rosemary, in Melbourne's south-east, has been continually breaking down. This pump station services the Rosemary High Level zone and feeds a total of 928 properties. There are a total of 2 schools, one hospital and one nursing home in the area. The top water level that the pump is designed to maintain is 131m. The highest elevation in the area is 97m. The back up supply comes from a neighbouring zone, through the manual opening of a shut valve, yet can only provide 120m TWL. The local councillor has urged decision-makers (and the Water Minister) to upgrade the pumps, due to receiving many letters from residents as a result of water shut offs due to repairs. The total cost is expected to be $630,000 for the upgrade.

Risk Assessment Score: ____________

Project 3 – Construct STP/RWTP

The urban growth boundary in Melbourne has resulted in a number of new residential suburbs where previously there existed land primarily for farming. This expansion has meant that a new Sewerage Treatment Plant and Recycled Water Treatment Plant is required for the area providing recycled water to the new suburbs and for the safe release of excess treated water into the nearby Sweller River. The developer has been approved to construct 2000 new homes within the area. Further expansion is expected through this corridor, and the STP is expected to service a total of 8,000 new homes and businesses.

At this stage, construction has not yet commenced, with the developer still selling the properties off the plan. So far, 15% of properties have been sold.

Construction on the development is expected to start in May 2018, which will be completed by December 2020. The first property is expected to be completed by August 2018, and will be occupied from this time onward.

Expected Cost = $4.78 million

Risk Assessment Score: ____________

Project 4 – Save Water Campaign

Save Water campaign aims to educate and promote water-wise behaviours in domestic households. The campaign aims to target:

- High water usage in showers
- Garden watering
- Topping up pools
- Dishwashing
- Machine-washing

The campaign is expected to save 0.05GL per day. This is expected to equate to $17 million ($2.8 per KL) loss of revenue for the water retailer. In addition to this, the campaign is expected to cost $430,000 per year for the life of the campaign. It is unlikely that water authorities will need to order more desalination water from the recently constructed desalination plant.

Risk Assessment Score: ____________

Part 2: Risk Attributes

Project 4A – Using Recycled Water as Potable

A Class A Recycled Water Treatment Plant in the historic area of Gumbark will be upgraded to allow for potable-quality water. This water will then be inserted directly into the potable supply, and mixed in with the existing potable water and delivered to residents within the area via the existing two pipe system. Notifications and information sessions will be given to all residents prior to implementing the change. The total cost of the projects is expected to be $3.5million, delivery potable re-use water to approximately 1,200 residential properties and businesses.

Risk Assessment Score: ____________

What do you consider as the main risks arising from this project?

____

____

____

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____

Take into account the above risks, and answer the respond to the following statements in your opinion. Please circle the response that best fits your view for each statement.

Do people* face this risk voluntarily? If some of the risks are voluntarily undertaken and some are not, mark an appropriate spot towards the centre of the scale. *those exposed to risk	Risk Assumed Voluntarily					Risk Assumed Involuntarily
	1	2	3	4	5	6	7

To what extent is the risk of death immediate- or is death likely to occur at some later time?	Effect Immediate					Effect Delayed
	1	2	3	4	5	6	7

To what extent are the risks known precisely by the persons who are exposed to those risks?	Risk Level Known Precisely					Risk Level Not Known
	1	2	3	4	5	6	7

To what extent are the risks known to science?	Risk Level Known Precisely					Risk Level Not Known
	1	2	3	4	5	6	7

If you are exposed to the risk, to what extent can you, by personal skill or diligence, avoid death?	Personal Risk Can't Be Controlled						Personal Risk Can Be Controlled
	1	2	3	4	5	6	7

Is this risk new and novel or old and familiar?	New/ Novel						Old/Familiar
	1	2	3	4	5	6	7

Is this a risk that kills people one at a time (chronic risk) or a risk that kills large numbers of people at once (catastrophic risk)?	Chronic						Catastrophic
	1	2	3	4	5	6	7

Is this a risk that people have learned to live with and can think about reasonably calmly or is it one that people have great dread for - on the level of a gut reaction?	Common						Dread
	1	2	3	4	5	6	7

When the risk from the activity is realised in the form of a mishap or illness, how likely is it that the consequence will be fatal?	Certain Not To Be Fatal						Certain To Be Fatal
	1	2	3	4	5	6	7

To what extent is the risk fair (ie. affects all people equally?)	Risk Level Is Fair						Risk Level Unfair
	1	2	3	4	5	6	7

Project 4B – Using Radiation in Treatment of Drinking Water

Research has been released following extensive studies at various Water Collaborative Research Centres highlighting a more effective way of treating drinking water that doesn't affect its taste, and colour. The treatment process involves the use of high levels of radiation to exterminate any unsafe elements from drinking water. It results in a one-step process of treating water, and ultimately is cheaper than the existing methods of chlorination, and fluoridation. Research has determined that the use of chlorine results in chemicals known as disinfection by-products. These by-products may be carcinogenic or have other toxicological effects associated with consumption.

The new radiation process ensures that the water doesn't carry these properties, that quality is always consistent regardless of the inflow water quality, and furthermore, quality doesn't deteriorate the further the water travels (as is known to happen with chlorine). The research claims that the water post-radiation treatment is entirely safe for drinking.

Radiation stations will be fitted at the Gumbark Recycled Water Treatment Plant as the first testing scenario.

Risk Assessment Score: ____________

What do you consider as the main risks arising from this aspect of the project?

____

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____

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____

Take into account the above risks, and answer the respond to the following statements in your opinion. Please circle the response that best fits your view for each statement.

Do people face this risk voluntarily? If some of the risks are voluntarily undertaken and some are not, mark an appropriate spot towards the centre of the scale.	**Risk Assumed Voluntarily**						**Risk Assumed Involuntarily**
	1	2	3	4	5	6	7

To what extent is the risk of death immediate- or is death likely to occur at some later time?	Effect Immediate						Effect Delayed
	1	2	3	4	5	6	7

To what extent are the risks known precisely by the persons who are exposed to those risks?	Risk Level Known Precisely						Risk Level Not Known
	1	2	3	4	5	6	7

	Risk Level Known Precisely						Risk Level Not Known

To what extent are the risks known to science?	1	2	3	4	5	6	7

If you are exposed to the risk, to what extent can you, by personal skill or diligence, avoid death?	Personal Risk Can't Be Controlled						Personal Risk Can Be Controlled
	1	2	3	4	5	6	7

Is this risk new and novel or old and familiar?	New/Novel						Old/Familiar
	1	2	3	4	5	6	7

Is this a risk that kills people one at a time (chronic risk) or a risk that kills large numbers of people at once (catastrophic risk)?	**Chronic**						**Catastrophic**
	1	2	3	4	5	6	7

	Common						Dread

Is this a risk that people have learned to live with and can think about reasonably calmly or is it one that people have great dread for - on the level of a gut reaction?	1	2	3	4	5	6	7

When the risk from the activity is realised in the form of a mishap or illness, how likely is it that the consequence will be fatal?	**Certain Not To Be Fatal**						**Certain To Be Fatal**
	1	2	3	4	5	6	7

To what extent is the risk fair (ie. affect all people equally?)	Risk Level Is Fair						Risk Level Unfair
	1	2	3	4	5	6	7

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Project 4C – Removing Fluoride from Drinking Water Supply

Following a significant amount of lobbying from alternative health groups, the State Government is under increasing pressure to remove fluoride from Melbourne's drinking water supply. In doing so, lobbyists argue that consumers could then make a choice about fluoride in water, rather than being forced to consume it.

The Water Minister would like to phase out fluoride in the water supply over the course of 12 months through decommissioning each of Melbourne's fluoridation stations. The first location where fluoridation will be ceased is at the Gumbark Recycled Water Treatment Plant.

Risk Assessment Score: ____________

What do you consider as the main risks arising from this aspect of the project?

____
____
____
____
____
____
____

Take into account the above risks, and answer the respond to the following statements in your opinion. Please circle the response that best fits your view for each statement.

Do people face this risk voluntarily? If some of the risks are voluntarily undertaken and some are not, mark an appropriate spot towards the centre of the scale.	**Risk Assumed Voluntarily**						**Risk Assumed Involuntarily**
	1	2	3	4	5	6	7

To what extent is the risk of death immediate- or is death likely to occur at some later time?	Effect Immediate						Effect Delayed
	1	2	3	4	5	6	7

To what extent are the risks known precisely by the persons who are exposed to those risks?	Risk Level Known Precisely						Risk Level Not Known
	1	2	3	4	5	6	7

To what extent are the risks known to science?	Risk Level Known Precisely						Risk Level Not Known
	1	2	3	4	5	6	7

If you are exposed to the risk, to what extent can you, by personal skill or diligence, avoid death?	Personal Risk Can't Be Controlled						Personal Risk Can Be Controlled
	1	2	3	4	5	6	7

Is this risk new and novel or old and familiar?	New/ Novel						Old/Familiar
	1	2	3	4	5	6	7

Is this a risk that kills people one at a time (chronic risk) or a risk that kills large numbers of people at once (catastrophic risk)?	Chronic						Catastrophic
	1	2	3	4	5	6	7

	Common						Dread
Is this a risk that people have learned to live with and can think about reasonably calmly or is it one that people have great dread for - on the level of a gut reaction?	1	2	3	4	5	6	7

	Certain Not To Be Fatal						Certain To Be Fatal
When the risk from the activity is realised in the form of a mishap or illness, how likely is it that the consequence will be fatal?	1	2	3	4	5	6	7

	Risk Level Is Fair						Risk Level Unfair
To what extent is the risk fair (ie. affect all people equally?)	1	2	3	4	5	6	7

Part 3: Worldviews

The following section will aim to determine your personal worldviews. Please be as honest as possible, to ensure the integrity of the research. As with the whole survey, you will be completely anonymous, and your responses will be treated with full confidentiality.

Circle the number that best describes to the extent to which you agree with the statement. The scale ranges from 1 (Totally Disagree) to 6 (Totally Agree). Assume that all intervening figures are evenly distributed on the scale.

	Totally Disagree					Totally Agree
1. It seems like the criminals and welfare cheats get all the breaks, while the average citizen picks up the tab	1	2	3	4	5	6
2. We have gone too far in pushing equal rights in this country	1	2	3	4	5	6
3. Society as a whole has become too soft and feminine	1	2	3	4	5	6
4. Nowadays it seems like there is just as much discrimination against whites as there is against blacks.	1	2	3	4	5	6

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5. It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.	1	2	3	4	5	6
6. A lot of problems in our society today come from the decline in the traditional family, where the man	1	2	3	4	5	6
7. The women's rights movement has gone too far.	1	2	3	4	5	6
8. Discrimination against minorities is still a very serious problem in our society.	1	2	3	4	5	6

	Totally Disagree					Totally Agree
9. It's old-fashioned and wrong to think that one culture's set of values is better than any other culture's way of seeing the world.	1	2	3	4	5	6
10. We need to dramatically reduce inequalities between the rich and the poor, whites and people of colour, and men and women.	1	2	3	4	5	6
11. Parents should encourage young boys to be more sensitive and less 'rough and tough'.	1	2	3	4	5	6
12. Our society would be better off if the distribution of wealth was more equal.	1	2	3	4	5	6
13. We live in a sexist society that is fundamentally set up to discriminate against women.	1	2	3	4	5	6

14. People who are successful in business have a right to enjoy their wealth as they see fit.	1	2	3	4	5	6
15. If the Government spent less time trying to fix everyone's problems, we'd all be a lot better off.	1	2	3	4	5	6
16. Government regulations are almost always a waste of everyone's time and money.	1	2	3	4	5	6
17. The Government interferes far too much in our everyday lives.	1	2	3	4	5	6
18. Free markets- not Government programs- are the best way to supply people with the things they need.	1	2	3	4	5	6
19. Too many people today expect society to do things for them that they should be doing for themselves.	1	2	3	4	5	6

20. It's a mistake to ask society to help every person in need.	1	2	3	4	5	6

	Totally Disagree					Totally Agree
21. The Government should stop telling people how to live their lives.	1	2	3	4	5	6
22. Private Profit is the main motive for hard work.	1	2	3	4	5	6
23. It's not the Government's business to try to protect people from themselves.	1	2	3	4	5	6
24. Society works best when it lets individuals take responsibility for their own lives without telling them what to do.	1	2	3	4	5	6
25. Our Government tries to do too many things for too many people. We should just let people take care of themselves.	1	2	3	4	5	6
26. Sometimes Government needs to make laws that keep people from hurting themselves.	1	2	3	4	5	6

27. Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.	1	2	3	4	5	6
28. It's society's responsibility to make sure everyone's basic needs are met.	1	2	3	4	5	6
29. The Government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.	1	2	3	4	5	6
30. People should be able to rely on the Government for help when they need it.	1	2	3	4	5	6

If you would like to receive the results of the research study, please fill out the following:

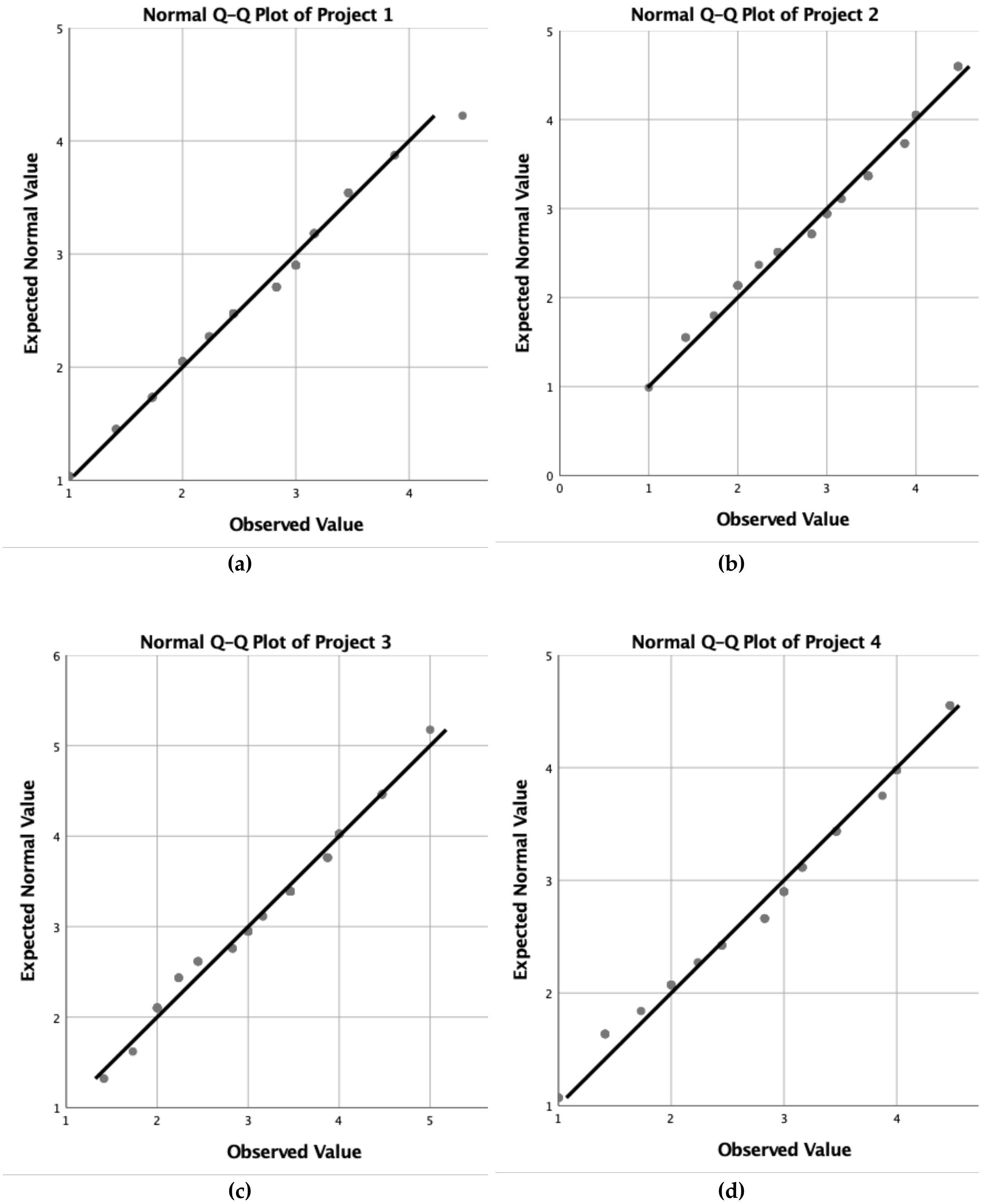
Name: ____________________________________

E-mail: ____

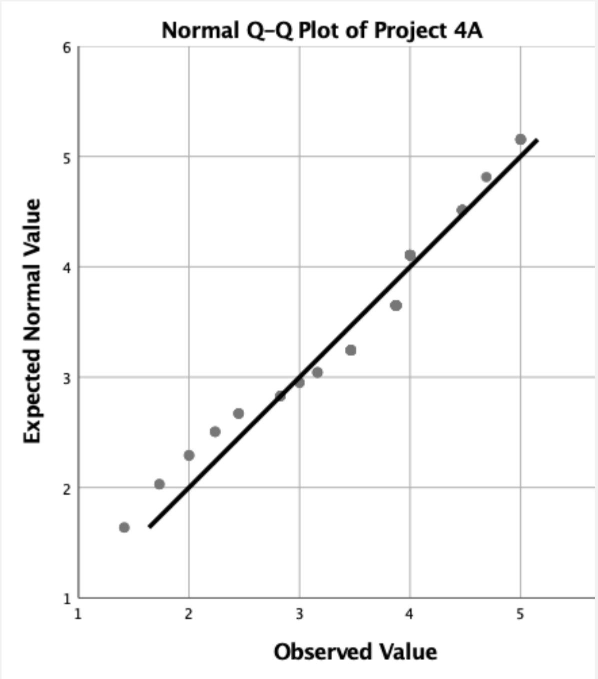
Please note that your individual responses will not be identifiable from the group's responses.

Thank you for your participation in this research study.

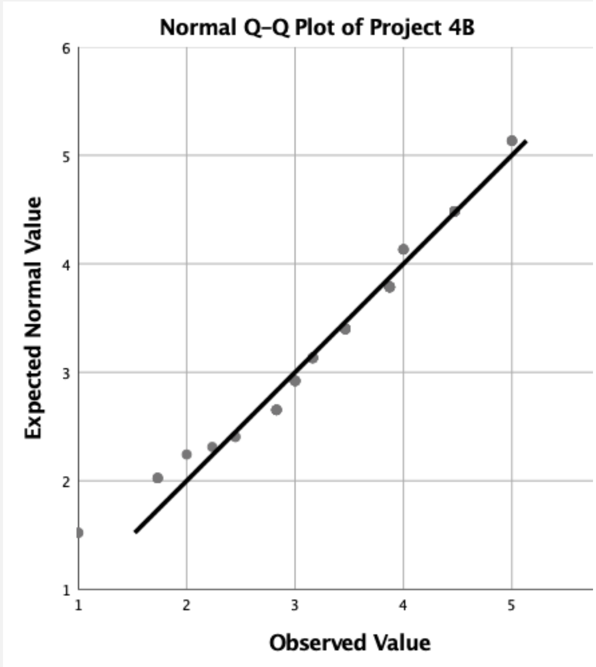
Appendix E | Q-Q Plots by Project



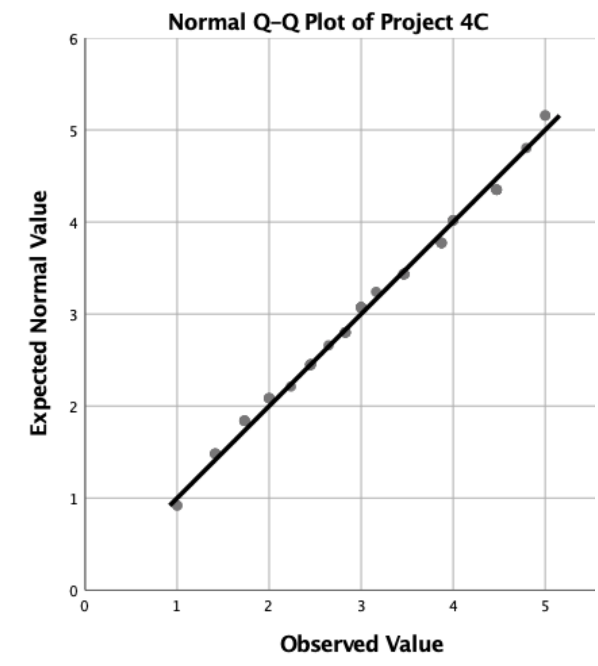
(a) (b) (c) (d)



(e)



(f)



(g)

Figure E-1. Normal Q-Q Plots by Project (a) Project 1 (b) Project 2 (c) Project 3 (d) Project 4 (e) Project 4A (f) Project 4B (g) Project 4C

Appendix F | Research Summary Sent to Industry

Appendix G | Pilot Survey Outcomes

Prior to commencing surveys, a pilot study was undertaken with project managers within Yarra Valley Water. The main purpose of the study was to ensure that the survey is clear and interpreted in the same way for each participant, to highlight any errors in the survey, and to ensure that the directions for the survey are clear.

The initial group consists of 4 project managers within the water industry. These project managers were invited to the study via email, and were chosen on the basis of their employment at Yarra Valley Water (ease of attending the pilot session), and also their varied roles and experience within project management. The study takes place at Yarra Valley Water offices from 2pm-3pm on Friday 7th April. This session was facilitated by Anna Kosovac.

The session first begins with an introduction highlighting the study, and things that the study will be looking for. The participants are told that their responses will be de-identified. A number of tasks took place during the study by the facilitator. These included timing the participants, asking and recording feedback and establishing whether replies can be interpreted in terms of the information that is required. Following the study, this information was used to re-word, or re-scale any questions not answered as expected. Any unnecessary, difficult or ambiguous questions were also discarded.

The following statement was provided by the facilitator prior to starting the study:

> "I am here as an independent researcher for the purpose of conducting this study in assessing risk perceptions. This study focuses on how risk perceptions alter the way we see innovation, or new, projects. Particularly, whether they proceed. You are provided with: Your company's risk assessment process, Consent form, Survey, Optional form if you would like to be kept aware of the results. Please note that your personal results cannot be provided to you as all results will be de-identified. You can stop this study at any point. Should the study raise any discomfort, please cease the study immediately and consider phoning Lifeline to discuss on 13 11 14. This study is broken up into 3 sections, please try to answer every section. I will be here the whole time during the study, so please feel free to ask any questions that you may have."

Timings:

The average time taken to complete the pilot study was 33 minutes. This is slightly above the estimated timing of 20 to 30 minutes. For this reason, the main study ensured that the survey time is announced in future correspondence as an expected completion time of 30-35 minutes. The initial explanation by the facilitator took approximately 5 minutes, and there were no questions from participants during this stage.

Participant 1: 1:50pm - 2:24pm - **34 minutes** (note that the facilitator was introducing the study to the others after participant 1 started, so may have been delayed because of this.)

Participant 2: 2:08pm – 2:37 **29 minutes**

Participant 3: 2:08- 2:43 **35 minutes**

Participant 4: 2:08- 2:43 **35 minutes**

Person 1 was unable to stay past 2:30pm, so it was organised so that they could begin the pilot survey earlier than the rest of the group. They began the study at 1:30pm, and were still doing the survey while others began entering the room at 2pm. This may have led to some distraction on the part of Person 1's responses.

The Lifeline number, 13 11 14, was written on the whiteboard in the room for reference as required by the Ethics committee.

Feedback and Observations of Pilot Study:

The researcher facilitating the survey observed the pilot study, noting that the front matter of the survey took respondents approximately 5 minutes to read. Following this, it took approximately 3 minutes to go through the survey to understand what is expected. In addition to this, the facilitator spent 5 minutes covering the introductions and instructions for the survey.

A number of changes were made to the survey as a result of the pilot study:

- 'People' in the first statement for psychological risk assessment – make clear that it is meant to imply 'people who are exposed to the risk'.
- A participant wanted clarification as to whether the psychological aspect should be assessed as a water authority employee, or as a member of the public. Facilitator confirmed that they should assess it as a water authority employee. This was included in all future introductions.
- Ensure adequate space in the room, so that it does not get uncomfortable for the respondents.
- A participant asked whether they should include the likelihood and consequence scores, as well as the overall risk score. Facilitator confirmed that the final risk score is sufficient for the assessment. This was then included as part of the overall introduction.
- Participants were also wanting to know whether to assume that day's date in the assessment, and the facilitator confirmed that assuming the day of the assessment is okay.
- Typo in section 2 was updated.
- Updated Project 4B description with how many customers are being supplied.
- Updated Project 4C description to highlight that water minister wants to phase out fluoride in water.

Other feedback received was that the survey was generally rather difficult to complete and sections of it took significant brainpower, in particular the psychometric testing. However, removing this element would not effectively test the psychological element of the survey. These questions were taken directly from previous studies and therefore have already been validated. The survey then was not changed in order to ensure that pre-validation can still be upheld.

Appendix H | Raw Data

Appendix I | Published Papers from PhD Research